Draft

Fishery Management Plan For Coral Reef Ecosystems of The Western Pacific Region

(Including Regulations) And Regulatory Impact Review/ Initial Regulatory Flexibility Analysis

December 2000

Volume I

Western Pacific Regional Fishery Management Council

MEMORANDUM 5 January 2001

TO: Interested Agencies, Groups and Individuals

FROM: Kitty M. Simonds
Executive Director

SUBJECT: Draft Fishery Management Plan for Coral Reef Ecosystems

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The Draft Coral Reef Ecosystem Fishery Management Plan (FMP) of the Western Pacific Region, and associated documents, is provided here for your review. It is the product of over five years of work by the Council, its advisory bodies, contractors and staff. It represents the first ecosystem-based FMP developed in the nation.

Volume I includes the main body of the FMP, several appendices (including draft regulations and gear catalog), and the draft Regulatory Impact Review/Initial Regulatory Flexibility Analysis (RIR/IRFA). Volume II includes the Draft Environmental Impact Statement (DEIS). The DEIS includes the impact analyses for amendments to our four existing FMPs (bottomfish, crustaceans, pelagic and precious corals) required to make the no-take Marine Protected Areas truly no-take to all fisheries. Volume III includes essential fish habitat (EFH) descriptions for management unit species. Attached is a summary of how these documents meet the required provisions of the Manson-Stevens Act for FMPs.

A public review period is open for the DEIS until 26 February 2001. You are encouraged to send (mail or fax) any written comment to:

Western Pacific Regional Fishery Management Council
1164 Bishop Street, Suite 1400
Honolulu, HI 96813
Fax (808) 522-8226

Comments will not be accepted if submitted via e-mail or Internet. A schedule for public hearings on the plan around the Western Pacific Region is attached.

Additional copies are available in three optional forms: CD-ROM, Council's website (*www.wpcouncil.org*), and bound hard copies or summaries, upon request.

Mahalo!

Dates, Times, and Locations for Public Hearings on the Coral Reef Ecosystem FMP DEIS

1. Agana (Hagatna), Guam: January 16, 2001, 8 to 10 p.m., Guam Fishermen's Cooperative Association, Hagatna Boat Basin, Agana (Hagatna), Guam (hearing on coral reef DEIS will follow public meeting on pelagics DEIS).

2. Susupe Village, Saipan, CNMI: January 17, 2001, 8 to 10 p.m., Saipan Diamond Hotel, Hibiscus Room. No street address, Susupe Village, P.O. Box 66, CNMI (hearing on coral reef DEIS will follow public meeting on pelagics DEIS).

3. Kahului, Maui, HI: January 19, 2001, 6 to 9 p.m. Lehi Kai Elementary School, 335 S. Papa Ave., Kahului, HI 96732

4. Kaunakakai, Molokai, HI: January 22, 2001, 8 to 10 p.m., Mitchell Pauole Center, 90 Ainoa St., Kaunakakai, HI 96748 (hearing on coral reef DEIS will follow public meeting on pelagics DEIS).

5. Kona, Hawaii, HI: January 23, 2001, 8 to 10 p.m., King Kamehameha Hotel, 75-5660 Palani Road, Kona, HI 96740 (hearing on coral reef DEIS will follow public meeting on pelagics DEIS).

6. Hilo, Hawaii, HI: January 24, 2001, 8 to 10 p.m. Cooperative Extension Services, College of Agriculture, Conference Room B, 875 Komohana Street, Hilo, HI 96720 (hearing on coral reef DEIS will follow public meeting on pelagics DEIS).

7. Lihue, Kauai, HI: January 25, 2001, 6 to 9 p.m. Wilcox Elementary School, 4319 Hardy St., Lihue, HI 96766

8. Lanai, HI: January 26, 2001, 8 to 10 p.m., Lanai Airport Conference Room, Lanai, HI 96763 (hearing on coral reef DEIS will follow public meeting on pelagics DEIS).

9. Honolulu, Oahu, HI: January 29, 2001, 6 to 9 p.m., McCoy Pavilion, Ala Moana Regional Park, Ala Moana Blvd., Honolulu, HI 96814 (tel 808-592-2288)

10. Fagatogo, AS: February 5, 2001, 3 to 5 p.m. Dept. of Marine & Wildlife Resources (DMWR) conference room, Faratogo, AS.

Required Provisions for FMPs

1. Contain necessary and appropriate conservation and management measures.
The FMP contains these measures (Section 5).

2. Contain a description of the fishery (# of vessels, gear used, species, etc.)
All aspects of the fishery are described (Section 3).

3 Assess and specify MSY and OY.
Quantitative assessment cannot be made for ecosystem as a whole. A proxy (effort)is to specify these parameters (Section 4).

4. Assess and specify domestic harvesting and processing capacity relative to OY.
Domestic harvesting/processing capacity can take the entire OY (Section 4).

5. Specify data to be reported for commercial, recreational and charter fisheries.
Data reporting will be required by permits; example forms provided (Sections 3.2, 9.4).

6. Consider adjustments for safety if weather bad.
No adjustments are needed as there are no quotas and resulting race for fish.

7. Describe and identify essential fish habitat; minimize adverse effects.
EFH described in FMP (Section 6 and Volume III), and measures contained in FMP.

8. Assess scientific data needed for plan implementation.
Data collection is part of plan (Section 7) Research needs are identified (Section 7).

9. Include a fishery impact statement for participants and communities.
A fishery impact statement is incorporated into the DEIS.

10. Specify criteria to define overfishing and overfished.
Based on effort as a proxy (Section 4).

11. Establish reporting to assess bycatch, and reduce bycatch.
Bycatch assessed and reduced by management measures (Sections 5.3.2, 3.5).

12. Assess the amount of fish released alive in recreational fisheries.
Virtually none of the fish caught in recreational fisheries are released alive (Section 3).

13. Describe the commercial, recreational, and charter fishing sectors.
These sectors are fully described in the FMP (Section 3).

14. Allocate harvest restrictions fairly among sectors, if necessary.
The plan contains no allocations among the commercial, recreational, and charter sectors.

Fishery Management Plan for
Coral Reef Ecosystems of the Western Pacific Region

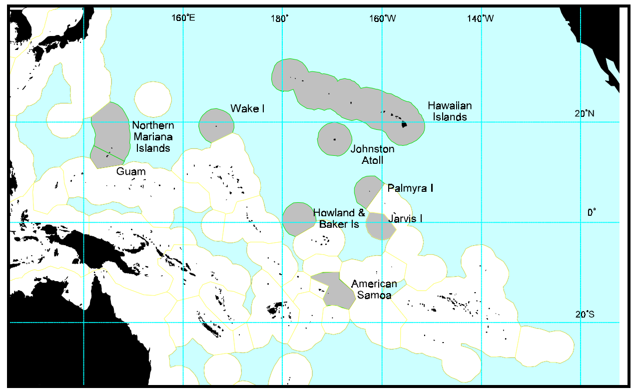
including amendments

Amendment 7 - Bottomfish and Seamount Groundfish Fisheries
Amendment 11 - Crustaceans Fisheries
Amendment 5 - Precious Corals Fisheries
Amendment 10 - Pelagics Fisheries

EXECUTIVE SUMMARY

The Fishery Management Plan (FMP) for Coral Reef Ecosystems of the Western Pacific Region was developed by the Western Pacific Regional Fishery Management Council based on the ecosystem-based approach. A recent report to Congress by the Ecosystem Principals Advisory Board recommends that FMPs be developed as "Fisheries Ecosystem Plans" covering the ecosystems under Council jurisdiction. This FMP represents the first fishery ecosystem plan developed in the United States.

About 70% of the world's coral reefs and 94% of the coral reefs under US jurisdiction are located in the Pacific Ocean. Coral reefs cover an estimated 15,852 km^2 of the shallow ocean bottom around US Pacific island areas served by the Council, which includes the State of Hawaii, the Territories of American Samoa and Guam, the Commonwealth of the Northern Mariana Islands, and the unincorporated remote areas of Johnston Atoll, Kingman Reef, Palmyra, Midway Atolls, and Jarvis, Howland, Baker, Midway and Wake Islands. Some 90 % of coral reefs in the region's exclusive economic zone (EEZ; the 200-mile limit) are found in remote areas, away from fishing communities.



Location of the US EEZ (grey shading) in the Pacific Ocean.

Coral reefs are very diverse ecosystems that provide many benefits to mankind. They build atolls, protect island shores from coastal erosion and wave damage, support fisheries of cultural and economic value, provide a natural medicine cabinet for traditional healing and biomedical research, and serve as museums of the world's tropical marine biodiversity.

Pacific islands were settled long ago and these indigenous people represent an important part of US Pacific island populations today. Their cultures historically depended on coral reefs to meet varied social-subsistence, economic and spiritual needs. These needs and values continue to shape and support these distinct cultures in the present. Resident and tourism-related recreation, important parts of contemporary island economies, also depends on healthy nearshore coral reef resources.

This FMP implements the precautionary approach in that it addresses potential problems before they can occur and establishes a management regime that can quickly adapt to changes. Local regulations control most of the impacts of resource exploitation on nearshore coral reefs in settled areas. This FMP provides the conservation needed for coral reef ecosystems in EEZ. Although these areas have been minimally exploited to date, there is potential for fisheries to expand in these areas. These potential expansions include current nearshore fisheries for coral reef species, new fisheries for the live fish markets in Southeast Asia, expanded fisheries for coral and "live rock" for the US aquarium trade, and developing fisheries for pharmaceutical uses. In addition, a holistic plan provides for better understanding of impacts due to natural environmental changes, other FMP managed fisheries, and non-fishing anthropogenic impacts such as dredging.

Objectives of the FMP

The Council established eight objectives for the Coral Reef Ecosystems FMP, which are consistent with an ecosystem-based management approach. The objectives promote sustainable use of coral reef resources, especially by fishing communities and indigenous fishermen in the region, an adaptive management approach based on fishery-dependent and fishery-independent research, marine protected areas and habitat conservation, cooperative and coordinated management by the various agencies concerned with the conservation of coral reef resources and education to foster public support for management.

Objectives of the Coral Reef Ecosystems FMP.

Objective 1: To foster sustainable use of multi-species resources in an ecologically and culturally sensitive manner, through the use of the precautionary approach and ecosystem-based resource management.

Objective 2: To provide a flexible and responsive management system for coral reef resources, which can rapidly adapt to changes in resource abundance, new scientific information and changes in fishing patterns among user groups or by area.

Objective 3: To establish integrated resource data collection and permitting systems, a research and monitoring program to collect fishery and other ecological information, and to develop scientific data necessary to make informed management decisions about coral reef ecosystems in the EEZ.

Objective 4: To minimize adverse human impacts on coral reef resources by establishing new and improving existing marine protected areas, managing fishing pressure, controlling wasteful harvest practices, reducing other anthropogenic stressors directly affecting them, and allowing the recovery of naturally-balanced reef systems. This objective includes the conservation and protection of essential fish habitats.

Objective 5: To improve public and government awareness and understanding of coral reef ecosystems and their vulnerability and resource potential in order to reduce adverse human impacts and foster support for management.

Objective 6: To collaborate with other agencies and organizations concerned with the conservation of coral reefs, in order to share in decision-making and to obtain and share data and resources needed to effectively monitor these vast and complex ecosystems.

Objective 7: To encourage and promote improved surveillance and enforcement of the plan.

Objective 8: To provide for sustainable participation of fishing communities in coral reef fisheries and, to the extent practicable, minimize the adverse economic impacts on such communities.

Management Measures

To achieve the objectives of the FMP, the following management measures are established.

Marine Protected Areas (MPAs)

EEZ coral reefs in unpopulated areas are designated MPAs (that is, the Pacific remote island areas, the Northwestern Hawaiian Islands, Guam's Southern Banks and Rose Atoll in American Samoa). The outer boundary for these MPAs is the 50-fm isobath. A zone-based management approach is applied to MPA design and designation. The two types of MPAs are: no-take and low-use. No fishing is allowed at no-take MPAs, including that by existing FMP fisheries. No-take MPAs are delineated by the 10-fm isobath except for certain ecologically sensitive areas where the boundary is extended to the 50-fm isobath. These areas are French Frigate Shoals, Laysan Island, the north half of Midway Atoll, Jarvis Island, Howland Island, Baker Island, Kingman Reef, Palmyra Atoll and Rose Atoll. All other areas within the 50-fm isobath would by default become low-use MPAs, where fishing is tightly controlled by a special permit requirement and other conditions for fishing.

All extractive activities would be prohibited in no-take MPAs, except for small harvests related to scientific research and resource management. Existing FMPs are amended to prohibit take of their respective MUS from no-take MPAs. In low-use MPAs existing fishing activities and recreational fisheries by residents on certain remote islands would be allowed under special permits. New fisheries and fishing by indigenous people could be allowed under special permits. Existing FMP fisheries in low-use MPAs would follow permit and reporting requirements already established in their FMPs.

Fishing vessels transiting MPAs would be required to carry insurance in order to pay for the costs of vessel removal and habitat damage mitigation in the event of a grounding. The Council felt that prohibiting large non-fishing vessels, and in particular cruise ships, from entering MPAs would be beneficial. However, the Council does not have the authority to regulate these vessels. Several longer term, cooperative efforts are proposed to manage the potential impacts of these vessels.

Using the framework process, vessel anchoring areas may be designated in MPAs at a future date. The only immediate restriction in this FMP applies to large fishing vessels (i.e., > 50 feet) at Guam's Southern Banks, which would be prohibited from anchoring at that low-use MPA.

Permits and Monitoring

If needed, a general permit could be developed and implemented for EEZ reef fisheries, using the framework process. For unpopulated areas, where coral reefs would be designated as marine protected areas, special permits would regulate fishing and other types of fishing-related resource use. Under this permit regime the harvesting of live rock and coral would be specifically prohibited. However, the Council identified four exemptions to this permit regime. Permit holders in other FMP-managed fisheries would not have to obtain an additional permit for incidental catch of coral reef taxa. Indigenous people, aquaculture operations, and scientific management activities would be exempted from the prohibition on the harvest of coral and live rock. But these three activities would require a special permit and the allowable take would be limited.

Fishing Gears and Methods

Three conditions on gear use, in order to minimize habitat impacts, are incorporated into this FMP. The Council also developed a list of allowable gear types, which includes the following: hand harvest, spear, slurp gun, hand/dip net, hoop net for Kona crab, throw net, barrier net for aquarium fish, surround/purse set net for targeted schooling fish (e.g., akule, baitfish, weke) with a minimum of bycatch, hook-and-line (powered and unpowered handlines, rod and reel, and trolling), traps (with conditions), and remote operating vehicles/submersibles. The following gears are specifically prohibited for coral reef species: gillnets, trawls, dredges, tanglenets, longlines, explosives, and poisons. Finally, SCUBA assisted fishing is prohibited at night in the Pacific remote island areas and the northwestern Hawaiian Islands.

Other Management Measures

ADAPTIVE MANAGEMENT: A framework process, providing an administratively simplified procedure for FMP modification, is an important component of the FMP.

NON-REGULATORY MEASURES: A set of measures, consistent with FMP objectives, will be implemented by the Council outside of the regulatory regime. This includes the process and criteria for essential fish habitat consultations, formal plan team coordination to identify and address ecosystem impacts from existing FMP fisheries, facilitating consistent state and territorial level management and research and education efforts.

FREQUENTLY ASKED QUESTIONS

What are the jurisdictional boundaries for the proposed fishery management plan (FMP) for coral reef ecosystems? The area of authority for all FMPs prepared by the Western Pacific Regional Fishery Management Council (the Council) is clearly defined by the Magnuson-Stevens Fishery Conservation and Management Act as the Exclusive Economic Zone (EEZ) around US Pacific islands. The EEZ extends 200 nautical miles offshore from the seaward boundary of the territorial sea (around the State of Hawaii and territories of American Samoa and Guam and, for the purpose of this plan, from 3 nmi around the Commonwealth of the Northern Mariana Islands). Around other US Pacific islands, under the jurisdiction of various federal agencies, the EEZ extends to the shoreline. In some areas, the EEZ overlaps with areas where other agencies claims management of natural resources, including coral reefs. The recommendations of the proposed FMP recognize and reinforce existing resource management efforts and establish consultative procedures that would improve inter-agency coordination.

Were diverse stakeholders and users of coral reefs considered during FMP preparation? FMP preparation is based on a consensual management approach, with decisions made by the Council after receiving recommendations from various advisory bodies comprised of scientists, government resource managers, resource users, and the general public. The process encourages participation by stakeholders representing different views and cultures, facilitating dialogue even in an adversarial environment of competing demands for resource use. The principal groups that advised in the preparation of the FMP for Coral Reef Ecosystems (CRE) are the CRE plan team, which is comprised of non-fishing representatives; the Ecosystem and Habitat Advisory Panel, which is comprised of diverse stakeholders representing consumptive and non-consumptive interests in coral reef resources; and the Scientific and Statistical Committee.

What fisheries resources would be managed by the proposed FMP for Coral Reef Ecosystems? Coral reefs and reef-building organisms are confined to the shallow, upper photic zone and are normally restricted to depths less than 50-100 meters (25-50 fathoms). Maximum reef growth and productivity occurs between 5-15 m, whereas maximum diversity of reef organisms occurs between 10-30 m. Coral reefs represent some of the most biologically diverse ecosystems on Earth, and only a small percentage of species are presently harvested in the EEZ around the US Pacific islands. Most of the targeted resources (i.e. lobster in the Northwestern Hawaiian Islands (NWHI), bottomfish) are already managed under other FMPs or by island government regulations. Because coral reef ecosystems are comprised of multi-species resources that share a long co-evolutionary history, removal of some species can have undesirable secondary effects on others through food web or other types of interactions. Adverse effects on the ecosystem cannot necessarily be prevented through existing FMP and island government regulations that aim to maintain optimum yield, while preventing overfishing of target stocks. The FMP for Coral Reef Ecosystems is needed to incorporate additional ecosystem principles into the regulatory structure already established.

How would the proposed FMP affect existing coral reef-related fisheries? Fishing for currently harvested coral reef resources in the EEZ around the islands of Tutuila, Swains and Manua group in American Samoa would continue with catch and effort information obtained by coordination with the local fishery agency. Fishing activities for currently harvested coral reef resources in the EEZ around Guam, the main Hawaiian Islands and the Commonwealth of the Northern Marianas Islands would be reported similarly. Temporary workers who engage in recreational and subsistence fishing for coral reef resources at Midway, Johnston and Wake Atolls could continue these activities by applying for special Federal permits and making reports. No off-island use of their catches would be allowed. Tourists who visit Midway (or more likely their tour agency) to engage in sportfishing would be subject to the same requirements. Waters bordering the north half of Midway Atoll would be designated as a “no take” marine protected area (MPA) extending 0-50 fm and would closed to all fishing.

How would the proposed FMP affect existing FMP fisheries? Removal of any living marine resource is prohibited in no-take MPAs including that by existing FMP fisheries. This FMP, and associated DEIS, amends the Council’s four existing FMPs to ensure MPAs are managed consistently across all FMPs. Wherever the EEZ is described as a no-take MPA, no biological removal of any MUS from any of these FMPs will be allowed. The DEIS includes a summary of the four existing FMPs (see section on description of the coral reef ecosystem), and an analysis of the impacts of these area closures on these FMPs (see section on environmental consequences). FMP-managed fisheries for bottomfish and lobster in the NWHI would be displaced from no-take MPAs extending from the seaward boundary of the territorial sea to a depth of 50-fm offshore of French Frigate Shoals and Laysan. Fishing for bottomfish and lobster could continue in low-use MPAs extending from 10-50 fm around all other NWHI under existing permits and management programs, as provided in the FMPs for Bottomfish and Crustaceans. Both plans provide for protected species zones, where no fishing is allowed. Vessels operating in MPAs would be required to have insurance to cover wreck removal and pollution liability in the event of grounding.

Fishing by Hawaii handline vessels for bottomfish and shark that has occurred irregularly off Palmyra and Kingman Reef would be displaced from no-take MPAs extending 0-50 fm around the latter islands. Sporadic fishing activities at Rose Atoll would be displaced from the no-take MPA extending from 0-50 fm.

How would the proposed FMP affect new coral reef fisheries? Coral reef resources in the EEZ around the US Pacific islands are likely targets for the rapidly expanding live reef fish and ornamental industry and the emerging industries for pharmaceutical and natural products. These fisheries have the potential to collect organisms about which little or nothing is known, whether about resource potential or possible ecosystem effects from harvesting. To initiate a new fishery for any potentially harvested coral reef taxa anywhere in the EEZ would require application for a special permit. This mechanism would allow harvest of new target resources to be kept at a safe level while information is acquired through detailed reporting about resource potential and possible ecosystem effects. Special permits would include restrictions on all facets of the proposed activity, including vessel operation. The permits would be conditional, subject to being renewed or revoked based on fishery monitoring as well as consideration of unforeseen changes, such as a coral bleaching event or an oceanographic regime shift. Special permits (or permits operating under FMPs for Bottomfish or Crustaceans) would be required for all fishing activities in low-use MPAs. In the NWHI, low-use MPAs extend seaward from the outer boundaries of no-take MPAs, providing a buffer zone where all fishing activities would be carefully scrutinized and monitored. No permits would be issued to allow fishing in no-take MPAs. Scientific research could be conducted in no-take MPAs under special permits, however.

Does the proposed FMP address non-fishing impacts? Historical and contemporary impacts on coral reef habitats and ecosystems by non-fishing activities are reviewed in the proposed FMP. The most severe impacts have occurred on nearshore reefs under island government jurisdiction rather than in the EEZ. Few reefs in the EEZ are close enough to inhabited land areas to be significantly affected by tourism, shoreside development, upland runoff, beach erosion and other terrestrial impacts. However, reefs in the EEZ at Midway, Johnston, Wake and Palmyra Atolls and off Farallon de Medinilla in the Commonwealth of the Northern Marianas Islands have been degraded as a result of past and on-going military use. The Magnuson Act does not provide the authority for FMPs to directly manage non-fishing activities. By designating essential fish habitat (EFH) and habitat areas of particular concern, the proposed FMP would guide EFH consultations on proposed Federal actions that could adversely affect coral reefs anywhere in the US Pacific, whether in or outside the EEZ.

How does the proposed FMP demonstrate an ecosystem-based approach to coral reef management? There is poor understanding of the basics, much less the intricacies, of coral reef ecosystems. Ecosystem-based management, therefore, can only be completely achieved over time as new information allows management to improve. It should be recognized that the technical data available for management decisions are almost always uncertain and incomplete. Hence, the proposed FMP applies the precautionary approach by designating and zoning MPAs, requiring special permits and detailed reporting for low-use zones and for potentially-harvested resources for which no information has been generated by previous fishing, prohibiting the commercial collection of live rock and coral and allowing only non-destructive, selective fishing methods. The proposed CRE-FMP would also establish a procedure for interface between different FMPs to monitor and resolve possible ecosystem effects of reef-related fisheries) and a procedure which incorporates feedback from detailed fishery monitoring of special permit activities, fishery-independent research and unforeseen environmental impacts (e.g., coral bleaching, oceanographic climate shift, hurricane damage to living coral) into an adaptive management process. Through this process, informed and timely regulatory changes could be made in the future, including such possibilities as expanding existing MPAs, designating new MPAs, setting limits on the number of special permits available, evaluating new and innovative methods of harvest or adjusting reef-related fisheries managed under other FMPs if undesirable ecosystem effects are detected.

The proposed CRE-FMP includes several types of “ecosystem insurance,” as recommended by the Ecosystem Principles Advisory Panel (EPAP 1999). Requiring insurance for vessels operating in areas of particular concern to cover the cost of vessel removal and pollution liability, in the event of a grounding, can provide incentive for more responsible operations. Another form of “insurance” is provided by zoning of MPAs for alternative uses. For example, no-take MPAs prohibit consumptive uses in areas highly sensitive to impacts and in biogeographically diverse ecosystem types representing a substantial reservoir of spawning biomass and biodiversity. Low-use zones allow fishing but only under a special permit that tightly controls activity. Zones can also be established for indigenous fishing and research.

Which places in the US Pacific islands constitute “fishing communities”? The Magnuson-Stevens Act defines the term “fishing community” as a “community which is substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs, and includes fishing vessel owners, operators, and crew and United States fish processors that are based in such community” [Section 3(16)]. A community results from webs of social interaction that people create by taking advantage of shared cultural understandings and identities. Fishing communities in the US Pacific islands are not based on geographic residence but on shared participation in fishing-related activities that occur over larger geographical scales than single villages or towns. At least one-third of the resident population of the US Pacific islands participates in some level of fishing, and all populated areas include some residents who are at least part-time fishermen. Fishermen from one area travel to other parts of the island and between islands to visit family and friends. Fishing is one of the most commonly shared activities at such gatherings. Fishermen frequently trailer small boats from one side of an island to the other to take advantage of seasonal fish availability and weather conditions. Fishing cooperatives in the US Pacific islands have island-wide membership and seafood markets are supplied by a widespread network of harvesters. The technology, customs, terminology, attitudes, and values related to fishing are thus shared on an island-wide and inter-island scale, and the web of social relationships that define communities are not confined to local enclaves living near harbors.

The US Pacific islands vary significantly in land area, population levels and the size of their associated EEZs. They have had significantly different courses of political development and historical relationships with the US but they share a common economic and social dependence on marine fisheries, especially coral reef resources. This dependence traces back several thousands of years, when the islands were first settled by sea-faring peoples. Their dependence on fishing for food security shaped the social organization, cultural values, and spiritual beliefs of the indigenous cultures. Contemporary island societies are pluralistic in population and culture, and few people depend solely on fish catches for protein. Most residents still have daily interactions with the ocean to obtain food, recreation, income, and other benefits that contribute to the high quality of island life. Given the importance of fishery resources, particularly coral reef resources, to all of the populated US Pacific island groups and taking into account the islands' distinctive geographic, demographic, and cultural attributes, the Territories of American Samoa and Guam and Rota, Saipan and Tinian Islands of the Commonwealth of the Northern Mariana Islands are each characterized as "fishing communities." Each inhabited island of the main Hawaiian Islands – Niihau, Kauai, Oahu, Maui, Molokai, Lanai and Hawaii – has been divided, where possible, into distinct geographic communities based on their potential to utilize and benefit from the harvest of coral reef resources. Defining the boundaries of the communities broadly helps ensure that the analysis of social and economic impacts considers all segments of island populations that are dependent on, or engaged in, coral reef fishing-related activities.

Why are marine protected areas (MPAs) an attractive option for coral reef management? MPAs do not require detailed knowledge of each managed species, while being holistic in conserving multi-species resources and the functional attributes of coral reef ecosystems. They can also provide "insurance" against periods of poor recruitment of individual stocks.

Do MPAs have to be "no take"? MPAs can vary in scope and extent. They can be areas designated for limited use or seasonal use or areas completely restricted from consumptive use (no take). Although no-take areas are thought to provide the highest degree of protection to coral reef ecosystems, less restrictive areas also provide some protection with fewer economic and social impacts. Some argue for complete protection from fishing, whereas others believe MPAs are more valuable when they can serve as natural laboratories for fishing experiments and testing of adaptive management strategies while providing for food, medicine, recreation and other benefits.

What is the optimum size of a MPA? The optimum size depends on many factors, including the resources managed, management goals, enforcement capabilities, and social and economic constraints. Researchers do not yet fully understand the relationship between the area designated as MPA and resulting benefits in the form of ecologically complete coral reef ecosystem protection. Previous MPAs established by the island governments for some nearshore reefs are small and fragmented. They have been criticized for not encompassing sufficient depth range and high quality habitat to provide broad ecosystem protection or stock recruitment benefits. The US Coral Reef Task Force has established a 10-year target to designate 20 percent of US coral reefs as no-take MPAs, and that goal is incorporated in the proposed CRE-FMP.

If MPAs are closed to fishing, will they restock areas that remain open to fishing? To be useful to fisheries and to promote the conservation of coral reef resources on a broad scale, MPAs should serve as sources of reproductive output to replenish larger surrounding areas. It has been suggested that linking populations among MPAs over a broad area is necessary to assure restocking. Individual sub-populations of larger stocks of reef species may increase, decrease, or cease to exist locally without adversely affecting the overall population. The condition of the overall populations of particular species is linked to variations among sub-populations: the ratio of sources and sinks, their degrees of recruitment connection, and the proportion of the sub-populations with high variability in reproductive capacity. Recruitment depends largely on the pathways of larval dispersal and whether down-current connections are sufficient to actually enhance distant sub-populations or only enough to maintain a homogenous genetic stock.

What criteria were used to select the MPA locations proposed in the CRE-FMP? The Council considered the following criteria in determining the MPA locations in the proposed CRE-FMP:

- Natural resource values: biogeographical representation, biodiversity, ecosystem integrity, ecological significance, species maintenance, habitat structure/features, and special elements protection;

- Human use and historical values: renewable resources of importance for sustainable uses, recreational resources, research and monitoring, educational and interpretive opportunity, historical and cultural resources, and aesthetic resources;

- Impacts of human activities: observed environmental impacts and projected impacts; and

- Management concerns: coordination with other programs, size and boundary considerations, accessibility, surveillance and enforcement, economic considerations, network-wide activities, and urgency of threats.

As new information is acquired through resource monitoring, the initial MPA designations could be adjusted and additional MPAs added in the future through the adaptive management process.

Why doesn't the CRE-FMP propose designation of MPAs in the EEZ adjacent to the inhabited islands of American Samoa, Guam, Hawaii, and the Commonwealth of the Northern Marianas Islands? Immediate designation of no-take MPAs in these areas without considerably more consultation with local stakeholders and island governments would likely cause significant adverse social and economic impacts. Compliance with no-take zones can be improved by involving fishing communities in site selection and self-policing. Local initiatives by all island governments are underway to develop proposals for MPAs in nearshore reef areas. Immediate designation of MPAs in the EEZ alone would not be as effective as coordination with island governments to establish MPAs that cross jurisdictional boundaries. This would best be accomplished by future adjustments through the process for adaptive management.

Why is 50 fathoms, rather than 100 fathoms, the depth limit of the proposed MPAs? Coral reefs and reef-building organisms are confined to the shallow upper photic zone and are normally restricted to depths less than 50-100 meters (25-50 fathoms). Maximum reef growth and productivity occurs between 5-15 m, whereas maximum diversity of reef organisms occurs between 10-30 m. At depths below 50 fm, there is a transition to a deep slope benthic ecosystem and then to the sub-photic zone (> 300m). Hawaiian monk seal adults from the French Frigate Shoals (NWHI) population are believed to forage around colonies of gold corals in the sub-photic zone (> 300 m deep). Because of the poor nutritional condition of young monk seals at French Frigate Shoals (FFS), the future harvest of gold coral at nearby banks might have an adverse impact on this endangered species. The potential conflict is being addressed through a regulatory adjustment to the precious corals FMP that would suspend the harvest quota for gold coral in the NWHI until additional scientific evidence becomes available about the impact of harvesting on monk seal foraging habitat. These type of larger ecosystem issues will continue to be addressed through formal coordination among all Western Pacific FMPs in the EEZ, as prescribed in the CRE-FMP.

Why did the Council choose the preferred alternative that it did for the CRE-FMP? While a minimal amount of fishing pressure currently exists in the coral reef ecosystem management area for the proposed management unit species, this Fishery Management Plan has been developed as a framework upon which to address potential management needs. The plan has been drafted to immediately protect large portions of coral reef and associated resources, while allowing flexibility to adapt to a wide variety of potential management issues as resource utilization develops. Thus, this FMP should be viewed as a preemptive management regime as well as a work in progress. The preferred alternative is comprised of the following four management measures. The rationale for these measures is as follows:

<u>No-Take Marine Protected Areas</u>: The preferred alternative's no-take areas have been selected to provide protection to ecologically sensitive areas while allowing for the continued existence of carefully controlled commercial bottomfish and lobster fisheries in the NWHI , as well as recreational fishing by visitors to Midway Island. Consideration was also given to the desire for continued recreational fishing by residents of Johnston Atoll and Wake Island. Under the preferred alternative, the seaward boundaries for no-take MPAs would be delineated by following the relevant isobath around the indicated areas (depth contours). Basing these seaward boundaries on either the closest State of Hawaii commercial catch reporting grid square inclusive of the relevant contours (for the NWHI) or on circles drawn around islands or banks that are inclusive of these areas was considered but rejected due to the significantly larger closed area that would result. Most of this additional closed area would be beyond the depth of coral reefs and would result in a major impact on existing fisheries.

Under the preferred alternative, all EEZ coral reefs in unpopulated areas would be designated MPAs (that is, in the NWHI and PRIA, and at Guam's Southern Banks and Rose Atoll in American Samoa). The ecological significance of these areas as remote and near-pristine reefs were driving factors in choosing these areas as the initial MPAs for this FMP. Consideration of proximity to important monk seal colonies was a further rationale for these choices. The outer boundary for these MPAs is the 50 fm isobath. A zone-based management approach is applied to MPA design and designation. First, two types of MPAs are proposed: no-take and low-use. No fishing is allowed in no-take MPAs including that by existing FMP fisheries. No-take MPAs are delineated by the 10 fm isobath except for certain ecologically sensitive areas where the boundary is extended to the 50 fm isobath. These areas are French Frigate Shoals, Laysan Island, the north half of Midway Island and

Jarvis, Howland and Baker Islands, Kingman Reef, and Palmyra and Rose Atolls. The remaining EEZ waters around the NWHI and PRIA (within the 50 fm isobath) would become low-use MPAs, which require a tightly controlled special permit and conditions for fishing. All extractive activities would be prohibited in no-take MPAs, except for small harvests related to scientific research and resource management. In low-use MPAs existing fishing activities, including other FMP fisheries and recreational fisheries by residents on certain remote islands, would be allowed. The permit regime and its specific exemptions would regulate these activities as well as allowing for indigenous or cultural uses.

Amendments to Existing FMPs for No-take: The Coral Reef Ecosystem FMP has designated no-take marine protected areas within the Management Area. Commercial, recreational, subsistence or cultural take of any marine species within these areas is prohibited. No described or undescribed gear is exempt from this designation. While the four existing FMPs implemented by the WPRFMC (bottomfish and seamount groundfish, crustaceans, pelagics and precious corals) are exempt from the regulations outlined in the CRE FMP and will observe the management regime of their respective FMPs, the no-take marine protected areas will be in effect for all Council-managed fisheries. These fisheries and their FMPs are summarized in the section of the DEIS on description of the coral reef ecosystem. An analysis of the impacts of these area closures on the four existing FMPs is included in the section on environmental consequences of the DEIS. To ensure designated no-take MPAs are effective for all FMPs, each of the following FMPs will be amended to ensure the no-take status of these areas, as follows:

Low-use Marine Protected Areas: The Council proposes a zone-based management approach to designate geographic areas for prescribed uses. Zone-based management allows for unique regulations for areas of varying ecological and socio-cultural importance, which has been successfully employed in other coral reef ecosystems and was preferred by the Council. The designation of low-use marine protected areas combines preferences for (a) their location; (b) their extent; and (c) how seaward boundaries for low-use MPAs are best defined. Under the preferred alternative, all EEZ coral reefs (e.g. those federal waters and substrate within the 50 fathom contour) around the Northwestern Hawaiian Islands not designated for no-take areas are designated as low-use MPAs. Other low-use MPAs are designated for coral reefs in the EEZ around Johnston and Wake atolls and on offshore banks south of the island of Guam. The seaward boundaries preferred for all low-use MPAs would extend to a uniform depth of 50 fm. Those adjacent to no-take MPAs around French Frigate Shoals, Laysan Island would begin at 10 fathoms (the outer boundary of the no-take MPA) while all others (and anchoring restrictions for the offshore banks south of Guam) would begin at 0 fathoms (the southern half of Midway Island, Johnston and Wake). As for no-take MPAs, these boundaries would be delineated by following the relevant isobath around the indicated areas (depth contours).

Using the framework process, vessel anchoring areas may be designated in MPAs at a future date. The only immediate restriction proposed in this FMP applies to large fishing vessels at Guam's southern banks, which would be prohibited from anchoring at that low-use MPA. Fishing vessels transiting MPAs would be required to carry insurance in order to pay for the costs of vessel removal and habitat damage mitigation in the event of a grounding. The Council felt that prohibiting large non-fishing vessels, and in particular cruise ships, from entering MPAs would be beneficial. However, the Council does not have the authority to regulate these vessels. Several longer term, cooperative efforts are proposed to manage the potential impacts of these vessels.

Permits and Reporting: The preferred alternative would implement permit requirements for the harvest of coral reef resources in the low-use marine protected areas (MPAs) proposed for designation in the EEZ around the Northwestern Hawaiian Islands (NWHI), Johnston Atoll and Wake Island. Vessels regulated and targeting species managed by other FMPs would be exempt from this requirement. Regional permit and reporting requirements for the remaining EEZ waters would continue for currently harvested coral reef taxa where reef resources are actively fished and managed under local laws and regulations. The Council preferred to retain regional reporting requirements for current practices in the populated regions, enacting general or special permit requirements under a framework provision at a later date if deemed necessary.

However, the preferred alternative would also require detailed permit and reporting for potentially (but not previously) harvested coral reef taxa throughout the region's EEZ. In this manner, the expanding marine ornamentals fishery and emerging bioprospecting industries, which target a broader spectrum of coral reef resources including species about which little is known, can be controlled and managed appropriately.

Due to their ecological vulnerability, the preferred alternative would prohibit the of collection live stony coral or live rock for commercial purposes, except small amounts to be collected under a special permit for use as seed stock for aquaculture, for bioprospecting, or for customary and traditional indigenous purposes.

Allowable Gears and Methods: The preferred alternative's list of allowable gears is based first on its potential for minimizing damage to essential fish habitat (EFH). Adverse impacts from fishing gear may include physical, chemical or biological alterations of the substrate and loss of, or injury to, benthic organisms, prey species and their habitat and other components of the ecosystem. A second criteria for allowable gear is its catch selectivity. There is a list of allowable gear types, which includes the following: hand harvest, spear, slurp gun, hand/dip net, hoop net for kona crab, throw net, barrier net for aquarium fish, surround/purse set net for targeted schooling fish (e.g., akule, baitfish, weke) with a minimum of bycatch, hook-and-line (powered and unpowered handlines, rod and reel, and trolling) traps (with conditions), and remote operating vehicles/sumbersibles. There are several gears specifically prohibited for the harvest of coral reef ecosystem management unit species: gillnets, trawls, dredges, tanglenets, longlines, explosives, and poisons. And SCUBA assisted spear fishing is prohibited at night in EEZs of the Pacific Remote Island Areas and the Northwestern Hawaiian Islands.

Bottom line: The preferred alternative's combination of management measures is anticipated to provide enhanced levels of protection and increased opportunities for appropriate management of the region's coral reef ecosystem resources. Under this regime, the proposed Coral Reef Ecosystem FMP is expected to combine harvest controls with careful monitoring in a manner which allows for the controlled utilization of these vital resources in an ecologically sensitive manner.

1.0 INTRODUCTION TO THE PLAN

1.1 Prologue

Long before Western contact and association with the US, what are now the US Pacific islands were settled by sea-faring peoples whose continued survival depended on fishing wisely. This is the basis for indigenous islanders' cultural and spiritual relationship with marine resources, especially coral reef resources. It is not surprising, therefore, that the indigenous cultures of the US Pacific Islands abound in proverbs, myths, and legends about coral reef resources. A few of these follow.

<u>Hawaiian</u>
Translated from the Hawaiian chant of creation, *Kumulipo*,(Beckwith 1951):

> The night gave birth
> Born was *Kumulipo* in the night, male
> Born was *Po`ele* in the night, female
> Born was the coral polyp, born was the coral, came forth
> .....(over 2,000 more lines of the creation chant follow)

Hawaiians of old used products of the coral reef for nearly every purpose. Some organisms were collected to extract medicine. Some organisms had a darker purpose. *Limu make*, a soft coral *(Palythoa toxica)*, contained a deadly poison. Scientists from the Hawaii Institute of Marine Biology traveled to Kanewai, Hana, island of Maui in December 1961 to collect specimens for research. They were warned by native residents of the area that *limu make* was *kapu* (forbidden). That same day, a fire of undetermined origin occurred at their Coconut Island marine laboratory, completely destroying the main building (Titcomb 1978).

<u>Samoan</u>
The *tulavae* is a portion of the fish net made by one person. All of the *tulavae* made by a section of the village are joined into a *fata*. The totality of the *fata* forms the complete net. A person who has supplied a *tulavae* for the *fata* is entitled to take part in the fishing and to share in the catch (Source: Schultz 1980).

Ua `ou seuseu ma le fata. "I am fishing because I have helped to make a *fata*."

The saying means: I have the right to take part in the discussion.

<u>Chamoru</u>
Long ago, Guam was inhabited by a race of superhuman people (known as the Ttaotaomona) who were capable of magic. One day, fishermen noticed that Hagatna Bay and Pago Bay were growing. They saw that a giant parrotfish was nibbling at the shoreline and eating away the island. "If this keeps up, our island will be cut into two pieces," they said. Their search could not find the fish, however.

Every day, maidens would gather at Hagatna Springs to wash their beautiful long hair and rinse it with the juice of lemons. The maidens noticed that the discarded lemon peels they had thrown into Hagatna Bay later appeared in Pago Bay. Thinking that the giant fish was tunneling between bays, they were determined to trap it. The maidens cut off their long hair and wove it into a magic net.

They sang into the tunnel to lure the fish into Hagatna Bay where it became tangled in the net made from their hair. This is how their island was saved from destruction (Wintterle 1999).

Pacific Remote Island Areas

In Marshallese tradition, Eneen-Kio (Wake Island) was associated with a large bird whose bones were used to fashion tattooing chisels. Legend recounts that when a chief required a tattoo the only suitable chisels were made from human bones or the bones of this large bird, most likely the albatross. The albatross nested on Eneen-Kio but only flew over the other Marshall Islands. When a human sacrifice was selected, he could be spared if he was able to procure the proper bird bones for the tattooing chisel. This required a voyage to Eneen-Kio.

1.2 History of Coral Reef Resource Use and Management

Long before western contact and affiliation with the US, the Samoa, Hawaii and Mariana Islands were settled by sea-going peoples. For protein sources, the original inhabitants depended on marine fisheries, especially coral reef resources. Through much trial and error, the indigenous people devised social and cultural controls to foster, in modern terminology, "sustainable" use of these resources several thousand years before Western forms of marine resource management were introduced. After European contact, island cultures and subsistence economies were eroded through the process of Westernization but some of the ancestral fishing techniques, sophisticated knowledge of marine resources, and code of fishing conduct have been perpetuated.

Fisheries for coral reef resources in the US Pacific islands are multi-species and multi-gear. Harvesting methods include hand gathering, hook-and-line, spear, and various types of nets and traps. The existing fisheries target several hundred different species of inshore fishes, invertebrates and (in Hawaii) seaweeds, with most of the harvest from reef areas near the main populated islands. Many of the fisheries that currently harvest coral reef resources in the US Pacific islands can be traced back to fishing methods that were practiced by indigenous populations hundreds to thousands of years ago. Population growth, cash economies, Western laws regarding the oceans as a common, breakdown of traditional knowledge, and the introduction of modern, manufactured gear have magnified the impact of these fisheries in modern times. They are managed under laws and regulations of the island governments (Territories of American Samoa and Guam, State of Hawaii and CNMI). More recently established fisheries that target coral reef resources for the marine ornamental products market are also controlled, to varying degrees, by island governments.

Fishing controls vary among the different island governments but they include commercial fishing licenses, gear restrictions, bag limits, seasonal closures and minimum size restrictions for possession and sale. In addition to specific limitations on fishing effort and catch, some island governments have closed particular reefs indefinitely to most types of fishing and have zoned other areas to separate competing uses. Destructive fishing methods, such as explosives and poisons, are prohibited by the island governments.

A few fisheries resources that can be considered reef-related are harvested in the US Exclusive Economic Zone (EEZ) farther offshore of the US Pacific Islands. These are commercial and semi-commercial activities which require boats. Bottomfish are taken by hook-and-line on deep slopes in the EEZ around American Samoa, Guam, Hawaii and CNMI. Spiny and slipper lobster are trapped in some areas of the NWHI.

These and other fisheries in the EEZ around US Pacific islands are managed by the Western Pacific Regional Fishery Management Council (Council). The Council is comprised of government officials and members of the public who reflect various resource interests. Its primary function is to prepare, evaluate and revise FMPs that balance long term conservation of fish stocks and fish habitats with optimal use of these resources. Plans must be approved by the National Marine Fisheries Service before implementation.

1.3 Purpose and Need for Action

Coral reefs are relatively robust and have survived millions of years of natural disturbances. Despite such long-term resiliency, however, reefs undergo episodes of high natural stress. Human uses of and impacts on reefs have never been higher, and there is growing concern that human stressors could add to cumulative natural impacts on reefs in the Western Pacific Region. A Fishery Management Plan (FMP) for Coral Reef Ecosystems of the Western Pacific region is needed:

- To anticipate and avoid potential damage to essential and non-renewable coral reef habitat.

- To address the secondary effects of all reef-related fisheries on non-target coral reef resources, thereby encouraging ecosystem-scale management.

- To manage newly emerging coral reef fisheries using the best available information in a precautionary manner.

- To manage new underwater harvesting technologies that are extending the depth and time limits at which coral reef resources can be harvested.

- To encourage coherent and coordinated coral reef management, monitoring and enforcement across jurisdictional boundaries.

- To facilitate consensual management that considers all types of stakeholders and adaptive management that considers new data and unforeseen impacts.

- To allow sustained use of coral reef resources that are important for the continuity of indigenous cultures in the US Pacific islands.

Stony corals are among the principal reef framework building organisms in the US Pacific Islands. In 1998, global coral bleaching and die-off was unprecedented in geographic extent, depth and severity (Pomerance 1999). Several studies have related bleaching to the combination of increased ultraviolet radiation and ocean warming, phenomena that may be exacerbated by human activities. Projected long-term climatic changes are likely to expose stony corals to an increasingly hostile environment and could possibly lead to mass extinctions.

Of foremost concern is the degradation and destruction of habitats essential for the reproduction and recruitment of many coral reef species. Much of the previous damage to coral reef habitats in the US Pacific Islands has occurred as a result of non-fishing activities such as coastal and harbor development, watershed land use practices and runoff, industrial discharges and military use. Fishing and non-fishing vessels have the potential to degrade habitat through vessel grounding, anchoring, introduction of invasive exotic marine species, and substrate scouring and ghost fishing by derelict gear and other marine debris. Removing live rock and the use of destructive fishing techniques, such as explosives and poisons, can also directly affect coral reef habitats. Because many resources that contribute to coral reef habitat are essentially non-renewable (in human time dimension), prevention is a far more effective strategy than mitigation of damage after it has occurred.

1.3.1 Ecosystem Effects of Established Fisheries

Reef-related fisheries that are already established in the US Pacific islands are regulated by island governments or, in the EEZ, the Council FMPs. The main objectives of conventional fishery management are to prevent overfishing, minimize bycatch and produce optimum yield of target resources. The potential for secondary effects on non-targeted resources through habitat and other interactions may be overlooked. Such effects, if severe enough, can bring about undesirable structural or functional changes in reef ecosystems. There are no procedures or requirements for monitoring or managing ecosystem effects of reef-related fishing activities conducted under other FMPs. The CRE-FMP proposes, therefore, to establish a formal process for coordination among plan teams to identify and control possible secondary effects of bottomfish, lobster and precious coral fisheries that are operating under established FMPs. The CRE-FMP also provides provision for coordination and cooperation with State, territorial and other agencies managing Coral reef resources in the Western Pacific Region.

Fisheries for coral reef resources are well established around the inhabited US Pacific islands. Most of the existing fisheries are conducted in nearshore coral reef areas utilizing a wide variety of gear which is regulated by the island governments. Some of the gear types or the ways in which they are used have the potential to cause habitat degradation. For example, a new method of reef fishing with gill nets was recently introduced to Hawaii. When retrieved by hydraulically-powered reels from depths of 10 to 100 m, the nets snag and damage the bottom. Lobster tangle nets used in nearshore areas around the main Hawaiian Islands have the same impact. The State of Hawaii has taken action to control destructive gill netting in state waters around the main Hawaiian Islands. If such gear is used in the EEZ offshore of American Samoa, Guam, the main Hawaiian Islands or the Commonwealth of the Northern Marianas Islands, there are no comparable federal regulations to prevent adverse impacts.

Under the established FMPs for Bottomfish, Crustaceans, Precious Corals and Pelagic Fisheries, the Council is required to act to prevent, mitigate or minimize any adverse effects from fishing if there is evidence that a fishing practice is having an identifiable adverse effect on EFH. Adverse fishing impacts may include physical, chemical or biological alterations of the substrate and loss of, or injury to, benthic organisms, prey species and their habitat and other components of the ecosystem. The predominant gear types—hook-and-line, longline, lobster traps, hand harvest,—used in the EEZ fisheries managed by the Council are not known to cause significant adverse impacts to coral reef habitat (Dames and Moore, in prep.). The established FMPs do not allow the use of potentially destructive fishing gear such as bottom trawls, bottom-set nets, explosives and poisons. The use of non-selective gear to harvest precious corals in the MHI is prohibited. A regulatory adjustment to the Precious Coral FMP, currently being developed by the Council, will prohibit the use of non-selective gear in the EEZ throughout the Western Pacific Region.

1.3.2 Ecosystem Effects of Developing Fisheries

Coral reefs represent one of the Earth's most genetically and biologically diverse and undocumented environments (Birkeland 1997a). Because a coral reef ecosystem is comprised of multiple species with a long co-evolutionary history, removal of certain species may result in undesirable changes in ecosystem structure or function, such as a predominance of less valuable generalist species. Most species of reef organisms are small in body size, have restricted dispersal and small geographic ranges (Reaka-Kudla 1999). They often have low population densities and low turnover rates which limit the potential harvest of any single species.

The expanding trade in live reef fish marine ornamental products and the emerging industries for biomedical and natural products have the potential to harvest organisms about which little or nothing is known, whether of their particular life cycle, their place in the food web or their abundance and distribution. Like their terrestrial equivalent the tropical rainforest reefs harbor hundreds of thousands of species, the majority of which are cryptic and unnamed.

Bioprospecting

The search for promising new medicines provides strong incentives to explore coral reef ecosystems for potentially useful resources. This activity is known as "bioprospecting." This search for novel natural products for medicine, industry and agriculture has become an established field over the past quarter century. About half of the potential pharmaceuticals being explored are from the ocean, many from coral reef ecosystems (Fenical 1996; Hay and Fenical 1996).

The companies involved in the business are often billion dollar corporations. Due to the high profiles of bioprospectors and some initial harmful bioprospecting, advocate groups have been active in impeding wholesale harvest and protecting the rights of local indigenous groups throughout the world. In addition, the Convention on Biological Diversity (CBD), drafted at the Rio Earth Summit, recommends strong measures of protection against harmful bioprospecting. These companies now write detailed contracts with local and indigenous groups strictly regulate harvest, negotiate up front cash and royalties for successful products, train local people in the field and offer means for environmental protection.

The interest of pharmaceutical companies is to collect only enough material from the wild to screen for active ingredients at the cellular and molecular level that could be useful for biomedical applications. Virtually any coral reef resource could become a target for bioprospecting, including species that are presently not known to science and for which there is no understanding of sustainable yield. Grants for millions of dollars have been given for medical bioprospecting of coral reef resources in the Pacific basin, although not yet in the US Pacific islands. Coral reef resources that have already attracted research interest include bryozoans, sponges, tunicates, coral and seaweeds. The most interesting chemicals are usually species-specific; the species may be rare or patchily distributed and the natural production of the active chemical may vary in time and space (Birkeland 1997a).

Initial screening of the organisms, generally algae, sponges and lower invertebrates, requires less than 1 kilogram of sample. If a potentially useful bioproduct is discovered, the laboratory will make every attempt to synthesize the product in the lab without collection of additional samples. The reason for this is two-fold. Most importantly, because this research requires multiple replications under strict protocols to verify the nature and intensity of bioactivity, natural variation between samples of the same species can confound research in the lab. Therefore, laboratory grown samples or synthesized products are necessary for large-scale development and production. The second reason is the high cost of field sampling as well as the often poor condition by which some samples arrive to the laboratory for screening.

At least two examples of such research are being conducted in or near the US Pacific islands. The US National Cancer Institute has contracted the Coral Reef Research Foundation, a non-profit organization based in the Republic of Belau, to collect and identify coral reef and other marine organisms for anti-cancer and anti-AIDS screening tests (Coral Reef Research Foundation website). In addition, the Marine Laboratory of the University of Guam is seeking new examples of the chemical deterrents that coral reef organisms possess to deter predators (Guyer, n.d.). This study is being conducted in collaboration with researchers at the University of Hawaii who are examining the properties of the chemical deterrents. Some of these substances could have biomedical uses they might kill cancer cells, halt inflammatory responses, or deter microbes and viruses and others may be effective insecticides for use in agriculture.

The Marine Biotechnology Engineering Center (MarBEC) in the Department of Oceanography at the University of Hawaii has been actively screening organisms from the marine environment since its founding in 1999. This multi-disciplinary group combines research across departments in the University with industry sponsors. In addition, the Governor of Hawaii has made biotech industry development a priority for State economic development, with the most prestigious biotech conference in the world scheduled for 2004. Bioprospecting in the EEZ around US Pacific islands can be socially beneficial with minimal adverse effects if it is carefully monitored and managed so that the take of potentially-harvested coral reef resources is maintained at safe levels while new resource information is gathered to estimate biological reference points, assess sustainable yields and learn how to improve management of new fisheries.

Marine ornamentals collection

With dramatic improvements in husbandry techniques and distribution abilities, the marine aquarium trade in the private sector has expanded considerably in the past decade. This trade, encompassing both public and private aquaria and including pet shop retailing, imports hundreds of species of reef-dwelling fish, corals and other invertebrates.

Coral reef organisms are collected for the marine aquarium trade predominantly from the Indo-Pacific. This trade involves numerous species of reef fish (especially angelfish, butterflyfish and damselfish), as well as a widening spectrum of invertebrates, including corals, anemones, crustaceans, molluscs, polychaetes, echinoderms and sponges. Coral reef resources that are highly endemic could be made locally extinct if heavily collected in their limited range of distribution.

Few marine ornamental products are collected from reef areas in the EEZ around US Pacific islands. The aquarium trade is striving toward several plans of education and conservation to improve fish survivability. These plans include captive breeding of fishes, propagation of corals and education about advanced husbandry techniques, with the goal being to significantly lower the number of species harvested from the wild (Lowrie and Borneman 1999). Nevertheless, the rapidly expanding reef ornamentals industry has the potential to expand into the EEZ in some areas of the US Pacific Islands.

Live rock harvest

The harvesting of coral reef habitat itself, in the form of "live rock," is rapidly increasing in the marine ornamentals trade. These rocks consist of stony corals, soft corals and other attractive reef substrates. Their removal is harmful because many species of corals extracted grow so slowly that they can be considered non-renewable resources (in human time dimension). In addition to a direct loss of valuable habitat, the harvest of live rock substratum unavoidably includes an incidental harvest of commensal and infaunal organisms which are removed with the rock.

The harvest and possession of live rock and certain coral is prohibited, with limited exceptions, by island governments in the US Pacific islands. Collection of live rock and hard coral in the EEZ is completely unregulated, however. Both Hawaii and Guam have recently faced cases in which live rock or coral was being exported but prosecution was impeded by claims that the collection took place outside territorial waters in the EEZ. Hence, existing management and enforcement is considered inadequate to control this threat in the EEZ around the US Pacific islands.

Improvements in underwater harvesting technology

Reef-related fisheries which are long established in the US Pacific islands employ conventional types of gear subject to regulation by the island governments and through FMPs. Advances in SCUBA technology (e.g., mixed gas, rebreather) and manned and unmanned submersibles are providing greater access to deep-water coral reef resources. As this technology becomes more affordable, fishing pressure will increase on high-value species that are already heavily exploited at more shallow depths. Unless new harvesting technologies are monitored and controlled, they could harm the reproduction capacity of species which have slow population turnover or for which heavy fishing in shallow habitats has removed most reproductive-size adults.

Recently, the demand for small, immature black coral colonies has increased with the growing popularity of household marine aquaria. To date, black coral in Hawaii has been hand harvested by a small group of divers using conventional SCUBA gear with compressed air. The maximum depth to which divers using this gear can safely descend is less than 75 m. However, it is likely that in the near future, black coral divers will be using mixed-gas diving methods or re-breathers that enable divers to increase the depth at which they can safely dive as well as their bottom time. Already, some harvesters are experimenting with towed underwater camera systems and other devices that may increase the output from old harvest areas and lead to the discovery of new beds (Dames and Moore, in prep.).

Manned submersibles and remotely-operated vehicles are still very expensive, but innovations in submersible technology within the petroleum and defense industries during the past two decades have significantly reduced the capital and operating costs (Dames and Moore, in prep.).

1.3.3 Need for Comprehensive Ecosystem-Based Management, Monitoring and Enforcement

Reefs extend across jurisdictional boundaries, and mechanisms for coordinated management among different government agencies are largely *ad hoc*. Reef areas in nearshore areas are under the jurisdiction of the island governments. Other reefs are in areas managed by various Federal agencies (e.g., national parks, marine sanctuaries, national wildlife refuges, naval defense areas). Coral reef fisheries throughout the US EEZ are subject to management under the authority of the Magnuson Fishery and Conservation Act of 1997 (MSFCMA) (as amended), which delegated much of the responsibility to regional councils. The reef-related bottomfish and lobster fisheries conducted in the EEZ around the NWHI have been actively managed by the Council for more than a decade.

The management objectives of the various agencies are not consistent. Even when effective regulations are in place, enforcement is difficult, labor intensive and often inadequate. Fragmented jurisdiction and management authority complicate prosecution of violators. Coral reefs represent an extreme in biological diversity, habitat complexity and competing demands for resource use. The only form of management likely to be effective is holistic.

1.3.4 Need for Consensual and Adaptive Management

There are competing demands for coral reef resources by a wide range of consumptive and non-consumptive activities, commercial and non-commercial uses, resident and non-resident populations. Residents of the US Pacific islands include significant numbers of indigenous people whose cultures are dependent on fishing and seafood. As a result of increasing tourism-related ocean recreation in Hawaii, CNMI and Guam, island visitors have placed a premium on non-consumptive uses of nearshore coral reef resources (Pooley 1993a).

There is almost universal agreement about the need for sustainable resource use, but users are divided by fundamentally different views of marine resources, how to study them, analyze them and manage them. It is difficult, therefore, to define management objectives and “preferred” ecosystem outcomes that are clearly desirable and recognizable by all interests.

The management of fisheries resources in the US EEZ is more decentralized than other forms of living resource management by US government agencies (e.g., national parks, forests and wildlife refuges; endangered species). The MSFCMA of 1997 (as amended) gave much of the authority for managing US fisheries to regional councils. Fisheries in the EEZ around US Pacific islands are managed by the Council.

Management policies for EEZ fisheries evolve through the preparation and amendment of FMPs. Participants in plan development are diverse - regulators, scientists, resource users – and the process is very open, with early, systematic and meaningful public participation through advisory panels and at meetings. The process encourages the participation of stakeholders representing different views and cultures, facilitating dialogue even in an adversarial environment. Decision making relies heavily on consensual management. Typically, the technical data available for management decisions are uncertain and incomplete. The Council, therefore, follows an adaptive management strategy that allows for improvement of FMPs as new information is gained.

An adaptive management process is well suited to coral reef fisheries management because of the diverse stakeholders and poor biological and ecological understanding of the resource base.

1.3.5 Dependence of Indigenous People on Coral Reefs

The indigenous people of the US Pacific islands have centuries-old involvement with coral reefs that pre-dates European contact and Western concepts of coral reef management. From the time the islands were first settled, indigenous cultures evolved from a physical, economic and spiritual life defined by dependence on marine fisheries for food security. The indigenous people of old had a holistic perspective of the natural world (ocean and land environments connected), and they conceived of themselves as an integral part of the ecosystem. Because of their intimacy with local inshore marine environments, indigenous communities developed a far more detailed understanding of coral reefs than that of modern-day resource users and managers. Social and cultural controls were placed on fishing at the times and places when it could disrupt basic life processes, particularly spawning. Traditional conservation measures can be thought of as a “rifle” rather than “shotgun” approach to fishery management.

The Council is required to take into account the various traditional fishing practices of indigenous island residents in preparing FMPs. Moreover, in the establishment of a limited access system (as MPAs could be construed), the Council must take into account “historical fishing practices in, and dependence on the fishery” and “the cultural and social framework relevant to the fishery.”

Apart from considerations of traditional participation and cultural dependence on coral reef fisheries is the Council’s concern that communities consisting of descendants of indigenous peoples in the US Pacific islands have not been appropriately sharing in the benefits from the area’s fisheries. The MSFCMA provides for the establishment of a community development program for western Pacific fisheries. This provision is intended to increase opportunities for indigenous communities to participate in and benefit from fisheries in the Council’s jurisdiction.

It is also important to note that the US Congress has afforded special considerations to aboriginal Hawaiians in numerous statutes because of their socio-economic disadvantage and because of federal trust obligation by virtue of Section 5 of the Admissions Act. In addition to the special legal status afforded to Hawaiians by Congress and the fact that neither the state nor federal courts have ruled on the trust obligation, the circumstances by which the US gained control of Hawaii should be taken into account. In 1993, the US Congress passed the Apology Bill, which states that “...the indigenous Hawaiian people never directly relinquished their claims to their inherent sovereignty as a people or over their national lands to the United States, either through their monarchy or through a plebiscite or referendum.” In the absence of any treaty or voluntary relinquishment, the lingering sovereign claim by Hawaiians may dictate caution in establishing regulations that restrict the right of Hawaiians to harvest coral reef marine resources, particularly in areas held by the State of Hawaii as part of the Ceded Lands Trust for the benefit of native Hawaiians. Many of the submerged lands surrounding the NWHI are part of the Ceded Lands Trust.

1.4 Management Plan Objectives

The Council prepares FMPs under the authority of the MSFCMA. The purposes of the MSFCMA are to achieve optimum yield from fisheries resources of the US, while preventing overfishing. In 1999, the Ecosystems Principles Advisory Panel (EPAP) provided a report to Congress on the basic principles, goals, and policies for ecosystem-based management of fisheries. Heeding the EPAP’s recommendation to develop an overall “Fisheries Ecosystem Plan” for each major ecosystem under Council jurisdiction (EPAP 1999), the has developed the CRE-FMP as a mechanism for incorporating ecosystem approaches into the present regulatory structure created through earlier FMPs for Bottomfish, Lobster and Precious Corals and Pelagics.

The Council established eight objectives for the CRE-FMP of the Western Pacific Region. The objectives promote sustainable use of coral reef resources, especially by fishing communities and indigenous fishermen in the region, an adaptive management approach based on fishery-dependent and fishery-independent research, marine protected areas and habitat conservation, cooperative and coordinated management by the various agencies concerned with the conservation of coral reef resources and education to foster public support for management.

Objective 1
To foster sustainable use of multi-species resources in an ecologically and culturally sensitive manner, through the use of the precautionary approach and ecosystem-based resource management.

Objective 2
To provide a flexible and responsive management system for coral reef resources, which can rapidly adapt to changes in resource abundance, new scientific information and changes in fishing patterns among user groups or by area.

Objective 3
To establish integrated resource data collection and permitting systems, a research and monitoring program to collect fishery and other ecological information and to develop scientific data necessary to make informed management decisions about coral reef ecosystems in the EEZ.

Objective 4
To minimize adverse human impacts on coral reef resources by establishing new and improving existing marine protected areas, managing fishing pressure, controlling wasteful harvest practices, reducing other anthropogenic stressors directly affecting them, and allowing the recovery of naturally-balanced reef systems. This objective includes the conservation and protection of essential fish habitats.

Objective 5
To improve public and government awareness and understanding of coral reef ecosystems and their vulnerability and resource potential in order to reduce adverse human impacts and foster support for management.

Objective 6
To collaborate with other agencies and organizations concerned with the conservation of coral reefs, in order to share in decision-making and to obtain and share data and resources needed to effectively monitor this vast and complex ecosystem.

Objective 7
To encourage and promote improved surveillance and enforcement of the plan.

Objective 8
Provide for sustainable participation of fishing communities in coral reef fisheries and, to the extent practicable, minimize the adverse economic impacts on such communities.

1.5 Management Plan Approach

Coral reefs are complex, multi-resource marine ecosystems comprised of thousands of species, few of which are targeted by existing fisheries. They represent an extreme in biological diversity, ecological complexity and competing demands for resource use. The only form of management likely to be effective is holistic.

There is poor understanding of the basics, much less the intricacies, of coral reef ecosystems.

Ecosystem-based management of coral reefs, therefore, is a long-term goal that can only be achieved over time as new information allows for improved understanding and decision-making. EPAP (1999) made recommendations to guide the further development of ecosystem management for fisheries, built around the following policies:

- Change the burden of proof.
- Apply the precautionary approach.
- Purchase "insurance" against unforseen, adverse ecosystem impacts.
- Learn from management experience.
- Make local incentives compatible with global goals.
- Promote participation, fairness, and equity in policy and management.

The CRE-FMP attempts to incorporate the concepts suggested by the Ecosystems Principles Advisory Panel to the extent possible. It is doubtful, however, if there will ever be enough data available to calculate total removals– including incidental mortality– and show how they relate to standing biomass, production, optimum yields, natural mortality, and trophic structure. The following is a review of how the FMP addresses each suggested provision.

Delineate the geographic extend of the ecosystem(s) that occur(s) within Council authority, including characterization of the biological, chemical, and physical dynamics of those ecosystems

> The geographic extent and ecological characterization of coral reef ecosystems around the US Pacific islands is described in the FMP. High biological and environmental variability is a natural characteristic of these ecosystems, with or without fishing. Irregular pulses of new recruits cause cycles in the abundance and harvest potential of individual reef species. Environmental variability is both spatial (related to differences in the quality of habitat) and temporal, related to monthly moon phase, seasonal and longer-term environmental changes. Coral reef resources are also affected by large-scale climatic shifts. Natural disturbance cycles in areas exposed to large storm waves can dramatically alter coral cover and resulting habitat quality.

Develop a conceptual model of the food web.

> The FMP contains a review of the ECOPATH model applied to coral reef ecosystems. ECOPATH is a simple mathematical model that estimates mean annual biomass, production and food consumption for major components (species groups) of an ecosystem. Application of ECOPATH to French Frigate Shoals found that the coral reef ecosystem is controlled mainly by predation from the top down and primary production is controlled mainly by nutrients, photosynthetic rate limits, and habitat space

Describe the habitat needs of different life history stages for all plants and animals that represent the "significant food web"

> The FMP and appendices thoroughly describe habitat needs of different life history stages for all species managed under this FMP, based on available scientific information.

Assess how uncertainty is characterized and what kind of buffers against uncertainty are included in conservation and management actions.

The FMP acknowledges that there is uncertainty regarding the impacts of fishing and other human activities on coral reef ecosystems. As a buffer gains uncertainty, the FMP establishes marine protected areas as insurance against this risk, and reporting requirements to monitor changes in the fisheries.

Describe available long-term monitoring data and how they are used.

The FMP includes an overview of long-term monitoring data available. Fishery monitoring and fishery-independent research activities will generate information that may be used for future adjustments of the proposed CRE-FMP under a framework procedure that allows for timely action.

Develop indices of ecosystem health as targets for management.

What constitutes a "healthy" reef in the US Pacific islands is difficult to define, but should be considered within a specific geographic and temporal context, considering the quality of natural habitat, environmental variability and natural disturbance cycles, as well as the history of human impacts. Measuring changes and differentiating natural rhythms from fisheries' effects, even in specific localities, present major challenges because of the highly dynamic ecosystem. Because of these factors, no indices of ecosystem health have yet been established under this FMP beyond the MSY, OY and overfishing reference points.

Assess the ecological, human, and institutional elements of the ecosystem which most significantly affect fisheries, and are outside Council/Department of Commerce authority. Included should be a strategy to address those influences in order to achieve both FMP and FEP objectives.

Much of the previous damage to coral reefs around US Pacific islands has occurred as a result of non-fishing activities such as coastal and harbor development, watershed land use practices and runoff, industrial discharges, non-fishing vessel operation, military and tourist use. The most severe impacts have occurred on nearshore reefs under island government jurisdiction. Few reefs in the EEZ are close enough to inhabited land areas to be significantly affected by tourism, coastal development, upland runoff, beach erosion and other terrestrial impacts. Some impacts occur at a scale too large to be mitigated by unilateral management actions for the western Pacific region. These include: overpopulation, ocean warming and increased ultraviolet radiation, introduction of invasive exotic marine species, and accumulation of marine debris.

Reefs extend across jurisdictional boundaries and mechanisms for coordinated management among different government agencies are largely ad hoc. Inter-regional and international management will be necessary to find solutions to this problem. Reef areas in nearshore areas are under the jurisdiction of the island governments. Other reefs are in areas managed by various Federal agencies (e.g., national parks, marine sanctuaries, national wildlife refuges). The management objectives of the various agencies are not consistent. Even when effective regulations are in place, enforcement is difficult, labor intensive and often inadequate. Fragmented jurisdiction and management authority complicate prosecution of violators.

To address these problems, several steps could be taken, such as securing MOU's on MPA areas with States, use the FMP's continuing reliance on island government permit and reporting for the EEZ adjacent to populated islands, and to expand FMP authority (Magnuson Act amendment) to non-fishing vessel impacts on habitat, and to encourage and enhance the EFH consultations process. These steps are described in more detail in other sections of the FMP.

1.6 Management Unit

1.6.1 Management Area

The Coral Reef Ecosystems Management Area (CRE management area, or management area) include the EEZ surrounding Hawaii, Guam, Samoa, CNMI and PRIAs i.e., EEZ waters which are outside of territorial waters and within 200 miles from shore. For purposes of the CRE-FMP, the water 0-3 miles offshore CNMI is the management responsibility of CNMI. Management of inshore waters around CNMI remains with the regional authorities because (1) cooperation between the regional government and the Council relies on recognition of local management authority of the near-shore waters, (2) the CNMI-based small vessel fishers are best managed by a local regime with hands on interaction and knowledge of the issues, and (3) this regime retains consistency with the other areas under Council jurisdiction.

The management area for this FMP includes at least 11,382 km^2 of reef area (shown as shaded blocks in the adjacent Table. The PRIAs include Palmyra Atoll, Kingman Reef and Howland, Baker, Islands in the central south Pacific; Midway at the northwest end of the Hawaiian archipelago; Johnston Atoll southwest of the main Hawaiian Islands; and Wake Island in the Marshall Islands Archipelago. Approximately 80% of the coral reef area that would be managed under the CRE-FMP in the NWHI.

Coral reef area (in km^2 <100m deep) in nearshore waters (0-3 nmi from shore) and offshore waters (3-200 nmi from shore) in each location in the western Pacific region (Hunter 1995)

Location	0-3 mni	3-200 nmi	Total Coral Reef Area
American Samoa	271	25	296
Guam	69	110	179
Hawaii			
Main Hawaiian Islands	1,655	880	2,535
Northwestern Hawaiian Islands	2,227	9,104	11,331
Commonwealth of the Northern Marianas Islands	45	534	579
Remote US Pacific Island Areas	620	89	709
Midway*	203	20	223
TOTAL	5,090	10,762	15,852

***** Midway is a PRIA located in the Hawaiian Archipelago

American Samoa

American Samoa is comprised of seven islands in the eastern portion of the Samoan Archipelago (14^{o}S, 168-173^{o}W). The islands are small, ranging in size from the densely populated high island of Tutuila (145 km^2) to the remote and uninhabited Rose Atoll (4 km^2). Mean air and sea surface temperatures (27.0^o C and 28.3^o C, respectively) vary little seasonally, although average air temperatures rose sharply (2^o C) in the 1990s. The high islands receive heavy annual rainfall (300-500 cm on Tutuila) (Craig et al., in press).

Coral reefs are limited in area (296 km^2) and only a small fraction is located within the EEZ (25 km^2), mostly on offshore banks (Green 1997). The main islands are volcanic mountains that descend steeply below sea level. They are fringed by narrow reef flats (50-500 m) that drop to a depth of 3-6 m and descend gradually to 40 m. From this depth, the ocean bottom drops rapidly, reaching depths of 1,000 m within 1-3 km from shore (Craig et al., in press). Almost 300 coral species occur in American Samoa (Green 1997). The reefs also support a diverse assemblage of nearly 900 fish species. Dominant families are damselfish, surgeonfish, wrasse and parrotfish. Spawning for some, and perhaps most, species occurs year-round, although peak spawning may be seasonal (Craig et al., in press).

Little is known about the biological assemblages on offshore banks in the EEZ around American Samoa. Species composition on the offshore reefs may be similar to that on the outer reef slopes, although species diversity may be less because of the absence of estuarine, reef flat and shallow lagoon habitats (Green 1997).

Guam

Situated at 13°N latitude and 144°E longitude, Guam is the southernmost and largest island (550 km^2) of the Mariana Island Archipelago. Guam's climate is warm and humid year round. Annual rainfall ranges from approximately 200 cm along the coast to 220 cm at higher elevations. The rainy season is generally from July through November. Sea surface temperatures range from a monthly mean of 27-28° C in February to 30° C in August. Guam regularly experiences typhoons, with winds greater than 65 knots. Typhoons are possible throughout the year but their likelihood is greatest from July through December.

Guam is largely a raised limestone island on a volcanic base. Approximately half of the shoreline is bordered by well-developed coral reefs with reef flats as wide as 600 m. A broad barrier reef encloses Cocos Lagoon at the southwest tip of the island. A raised barrier reef, a greatly disturbed barrier reef and a coral bank enclose the deep lagoon of Apra Harbor. Coral reefs on offshore banks in the EEZ (110 km^2) account for about 60% of the total reef area in Guam (Green 1997).

Over 250 stony coral species have been recorded in the southern Mariana Islands (Birkeland 1997b). Guam's reefs also support a diverse assemblage of about 800 fish species. Fish families with the most species that are important in coral reef fisheries are wrasses, groupers, surgeonfish, jacks, squirrelfish, snappers, parrotfish, emperors and goatfish (Green 1997).

Little is known about the biological assemblages on offshore banks in the EEZ around Guam. The tops of these banks are relatively deep (20-40 m) (Green 1997). Myers (1997) has suggested species composition on these banks may be similar to that on the outer reef slope around the island of Guam, although the relative abundance of species would probably be different because of the isolation of the banks from continuous reef tracts and from heavy fishing pressure.

Hawaii

The Hawaiian Islands are the exposed portions of an elongated submarine ridge that extends for a length of nearly 2,400 km, between latitudes 19°-28°N and longitudes 155°-178°W. Based on geologic age, the Hawaiian chain is divisible into a southeastern portion composed of eight major volcanic islands, a middle portion of small islets and pinnacles and a northwestern portion of low atolls, sand islets and shoals. The islands have a combined land area of over 16,600 km^2.

The northernmost atolls of Midway and Kure are exposed to cool temperatures during the winter months, but the rest of the chain is sub-tropical. The climate is determined by prevailing northeast trade winds.

Reefs in Hawaii constitute the vast majority (89%) of coral reef area in the US Pacific islands. By far the largest coral reef area in the EEZ is located in Hawaii (10,004 km^2), of which 90% is in the NWHI (9,124 km^2). The EEZ around the main Hawaiian Islands (MHI) also includes a sizeable area of coral reef (880 km^2), almost all of which is located on the Penguin Bank between the islands of Molokai and Oahu.

The islets and atolls between Nihoa Island and Kure Atoll (excluding Midway Atoll), are known as the Northwestern Hawaiian Islands (NWHI). Except for Kure, these islands are national wildlife refuges, providing habitat for several protected species, including the green sea turtle and Hawaiian monk seal.

The main Hawaiian Islands represent the young portion of the Hawaiian Archipelago; consequently, they have less well-developed fringing reefs that have not subsided as far below sea level as those in the NWHI (Green 1997). The best reef development and highest live coral cover in the MHI are found in areas sheltered or partially sheltered from open ocean swell (Grigg 1997).

Coral reef resources in Hawaii are characterized by relatively low biological diversity but a high degree of endemism. Hawaii's isolation has produced a large proportion of endemic coral reef species. It is estimated that 20-30% of the fish, 18% of the algae and 20% of the molluscs are endemic to Hawaii. Hawaii's coral reefs are also unique in that some species that are relatively uncommon in other areas of the Pacific are quite abundant in Hawaii (Fielding and Robinson, 1987). Only 47 species of reef-building corals have been recorded. Coral species richness tends to be higher in the NWHI, where the genus *Acropora*, not found in the MHI, is present. Many reefs in the NWHI are comprised of calcareous algae (Green 1997). Black corals are found off promontories at depths of 30-100 m in both state and federal waters around the MHI (Dames and Moore, in prep.).

A total of 557 marine reef fish have been identified from the Hawaiian Islands, and about 24% of these are considered endemics. Reef and coastal pelagic fish families with species valued for food include surgeonfish, goatfish, parrotfish, jacks, bigeye scad, mackerel scad and soldier fish. Coral reefs in Hawaii also provide habitat for over 1,000 mollusks; 1,350 other macroinvertebrates, and 400 seaweeds.

In general, fish species diversity appears to be lower in the NWHI than in the MHI. Although the inshore fish assemblages of the two regions are similar, fish size, density and biomass are higher in the NWHI. Fish communities in the NWHI are dominated by apex predators (sharks and jacks), whereas those in the MHI are not. Some fish species are common in parts of the NWHI that are rare elsewhere in the archipelago (Green 1997).

Perhaps the most important factor in the population dynamics of many coral reef species in the NWHI and the ecosystem as a whole are cyclical oceanographic events which affect productivity over large areas and may account for large fluctuations in population abundance. In a comprehensive study of recent climatic and oceanographic events and their effect on productivity in the NWHI, Polovina et al. (1994) found that declines of 30-50% in a number of species from various trophic levels, from the early 1980s to present, could be explained by a shift in oceanographic conditions. Prior to this, oceanographic conditions that lasted from the late 1970s until the early 1980s moved nutrient-rich deep ocean water into the euphotic zone, resulting in higher survival of reef fish, crustaceans, monk seals and sea birds. The researchers caution that "resource managers need to be aware that target levels of productivity (in the NWHI), for protected species, or sustainable yield for fishery resources, may vary with interdecadal climate events."

Commonwealth of the Northern Mariana Islands

The Commonwealth of the Northern Mariana Islands (CNMI) is a subset of the Mariana Archipelago. It encompasses 14 islands (15-21º latitude, 144-146º longitude) oriented along a north-south axis stretching over a distance of 740 km. The islands can be divided into two sections based on age and geology. In the southern part of chain are old, raised limestone islands (Saipan, Tinian, Rota, Aguijan and Farallon de Medinilla).

The CNMI accounts for the second largest coral reef area (579 km^2) in the US Pacific islands. Offshore reefs (3-200 nmi from shore) account for the majority of this area (534 km^2). The largest single tract is off Farallon de Medinilla (311 km^2).

In nearshore areas (0-3 nmi) Saipan has the best developed reefs, including fringing reefs, inshore and offshore patch reefs and a well-developed barrier reef-lagoon system along most of the leeward coast. In contrast, the northern islands (Anatahan, Sarigan, Guguan, Alamagan, Pagan, Agrihan, Asuncion, Maug and Uracas) are geologically young, volcanic islands having steep seaward slopes. In the northern islands in general, reef development is poor to non-existent. In addition, there are numerous shoals along the island chain (Green 1997). A chain of small shallow banks topped with coral reefs lie in a parallel arc 240 to 320 km to the west of the Marianas (Myers 1997).

The number of stony coral and reef fish in the southern portion of the CNMI is similar to that of Guam. Diversity drops markedly off the northern volcanic islands, where only 159 species of stony coral and only about 360 species of reef fish have been recorded (Birkeland 1997c). Dominant fish families are the same as in Guam.

Island Areas

Howland, Jarvis and Baker are arid coral islands located close to the equator in the southern Line Island group. Kingman Reef is a coral reef shoal in the northern Line Islands. Palmyra Atoll is a wet atoll located in the central Pacific. It is comprised of three sub-lagoons and over 50 separate islets that have been modified by construction activity. Johnston Atoll is an open atoll in the north central Pacific. Until the 1940s, there were only two islands, but, by 1964, massive dredge and fill operations had expanded significantly the original area of Johnston Island. Wake island is an isolated island north of the Marshall Islands, and consists of three islets and a reef enclosing a sheltered lagoon.

The total reef area around remote US Pacific islands (not including Midway) is 709 km^2, of which 89 km^2 is offshore (3-200 nmi). The remote US Pacific island possessions range from less than 1° south latitude to 20° North latitude and from 162° West to 167° East longitude. The climate regimes range from arid to wet and equatorial to sub-tropical. Marine resources are similarly varied. Several of these islands are of extreme scientific interest because of their age, with origins in the Mesozoic era, and the majority are designated or proposed as national wildlife refuges. The biological diversity of coral reef ecosystems in these areas varies considerably from island to island. Fish densities and biomass are higher than around the populated islands in the region. Rare species occur in some areas. For example, giant clams are prolific throughout the lagoon at Wake Atoll (Green, 1997).

Johnston Atoll has a unique mix of coral reef species not duplicated elsewhere in the Pacific.

Invertebrates from both the western and central Pacific are present, indicating that the atoll serves as a bridge connecting distributions of Polynesian and Micronesian invertebrate fauna. The coral fauna has a strong affinity with that of Hawaii, but the appearance of the reef is quite different. This is due to the dominance of *Acropora*, not found in the main Hawaiian Islands, and the lack of common Hawaiian species, *Porites compressa*. Endangered Hawaiian monk seals occasionally visit the atoll but are not known to pup there. NMFS has released bachelor male monk seals there to reduce harassment of females in the NWHI. The extremely rare Cuvier's beaked whale is regularly seen offshore and may actually calve in the lagoon (Green 1997).

1.6.2 Management Unit Taxa

The coral reef management unit species (MUS) are divided into two groups of species or taxa: 1) "Currently Harvested Coral Reef Taxa (CHCRT)," i.e., coral reef organisms that are currently harvested (e.g. from catch report records in federal waters) but not covered by existing FMPs, for which adequate information is available to begin management; and 2) "Potentially Harvested Coral Reef Taxa (PHCRT)," i.e., coral reef organisms that are not known to be currently harvested in the EEZ, or are minor harvests for which adequate information is not available upon which to base management, but have potential to be harvested in new emerging coral reef fisheries (e.g., the rapidly expanding marine ornamental products trade and the emerging industries for pharmaceutical and natural products). The coral reef ecosystem includes not only numerous taxa but also interactions among them and with their habitats that structure the ecological relationships.

Currently Harvested Coral Reef Taxa

Acanthuridae	Yelloweyed surgeonfish (*Ctenochaetus strigosus*) Orangespot surgeonfish (*Acanthurus olivaceus*) Yellowfin surgeonfish (*Acanthurus xanthopterus*) Convict tang (*Acanthurus triostegus*) Eye striped surgeon fish (*Acanthurus dussumieri*) Unicornfish (*Naso spp.*)
Balistidae	Triggerfish (*Xyrichthys pavo*)
Carcharhinidae	Gray reef shark (*Carcharhinus amblyrhynchos*)
Holocentridae	Soldierfish (*Myripristis spp*.)
Kuhliidae	Hawaiian flag-tail (*Kuhlia sandvicensis*)
Kyphosidae	Rudderfish (*Kyphosus spp*)
Labridae	Napoleon wrasse (*Cheilinus undulatus*) Saddleback hogfish (*Bodianus bilunulatus*) (*Xyricthys* spp.)
Lethrinidae	Smalltooth emperor (*Lethrinus microdon*)

Mullidae	Goatfish (*Mulloidichthys spp.*) Striped mullet *(Mugil cephalus*) Yellowfin goatfish (*Mulloidichthys vanicolensis*) Goatfish (*Parupeneus porphyreus*) -Ku-mu Multi-barred goatfish (*Parupeneus multifaciatus*)
Octopodidae	Octopus (*Octopus cyanea, O. ornatus*)
Polynemidae	Threadfin (*Polydactylus sexfilis*) – Moi
Priacanthidae	Bigeye (*Priacanthus spp.*)
Scaridae	Bumphead parrotfish (*Bolbometopon muricatum*) Parrotfishes (*Scarid spp.*)
Serranidae	Groupers/Sea Bass (*Cephalopholis spp*.) Groupers/Sea Bass (*Epinephelus spp.*)
Sphyraenidae	Barracuda (*Sphyraena helleri*)

Aquarium Taxa/Species	Yellow tang (*Zebrasoma flavescens*) Yellow-eyed surgeon fish (*Ctenochaetus strigosus*) Achilles tang (*Acanthurus achilles*) Morrish idol (*Zanclus cornutus*) Masked angel (*Genicanthus personatus*) Angelfish (*Centropyge shepardi* and *C. flavissimus*) Dragon eel (*Enchelycore pardalis*) Flame hawkfish (*Neocirrhitus armatus*) Butterflyfish (*Chaetodon auriga, C. lunula, C. melannotus* and *C. ephippium*) Damselfish (*Chromis viridis, Dascyllus aruanus* and *D. trimaculatus*) Turkeyfish (*Pterois sphex*) Featherduster worm (*Sabellidae*)

* Currently harvested MUS were identified by their presence on catch reports from fisheries in federal waters.

Potentially Harvested Coral Reef Taxa

Other Labridae spp. (wrasses)	Ephippidae (batfish)
Carcharhinidae, Sphyrnidae, *Triaenodon obesus* (sharks), except those managed under PFMP	Monodactylidae (mono)
Dasyatididae, Myliobatidae, Mobulidae (rays)	Haemulidae (sweetlips)
Other Serranidae spp. (groupers) except those managed under BFMP	Echineididae (remoras)
Carangidae (jacks/trevallies), except those managed under BFMP	Malacanthidae (tilefish)

Decapterus/Selar spp. (scads)	Acanthoclinidae (spiny basslets)
Other Holocentridae spp. (soldierfish/squirrelfish)	Pseudochromidae (dottybacks)
Other Mullidae spp. (goatfish)	Plesiopidae (prettyfins)
Other Acanthuridae spp. (surgeonfish/unicornfish)	Tetrarogidae (waspfish)
Other Lethrinidae spp. (emperors), except those managed under BFMP	Caracanthidae (coral crouchers)
Muraenidae, Chlopsidae, Congridae, Moringuidae, Ophichthidae (eels)	Grammistidae (soapfish)
Apogonidae (cardinalfish)	*Aulostomus chinensis* (trumpetfish)
Other Zanclidae spp. (moorish idols)	*Fistularia commersoni* (coronetfish)
Other Chaetodontidae spp. (butterflyfish)	Anomalopidae (flashlightfish)
Other Pomacanthidae spp. (angelfish)	Clupeidae (herrings)
Other Pomacentridae spp. (damselfish)	Engraulidae (anchovies)
Scorpaenidae (scorpionfish)	Gobiidae (gobies)
Blenniidae (blennies)	Lutjanids, except those managed under BFMP
Other Sphyraenidae spp. (barracudas)	Other Ballistidae/Monocanthidae spp.
Pinguipedidae (sandperches)	Siganidae
Gymnosarda unicolor	Other Kyphosidae spp.
Bothidae/Soleidae/Pleurnectidae (flounder/sole)	Caesionidae
Ostraciidae (trunkfish)	Cirrhitidae
Tetradontidae/Diodontidae (puffer/porcupinefish)	Antennariidae (frogfishes)
	Syngnathidae (pipefishes/seahorses)
Stony corals	Echinoderms (e.g., sea cucumbers, sea urchins)
Heliopora (blue)	Mollusca
Tubiphora (organpipe)	Sea Snails (gastropods)
Azooxanthellates (non-reefbuilders)	Trochus spp.
Fungiidae (mushroom corals)	Opistobranchs (sea slugs)
Sm/Lg Polyped Corals (endemic spp.)	*Pinctada margaritifera* (black lipped pearl oyster)
Millepora (firecorals)	Tridacnidae
Soft corals and Gorgonians	Other Bivalves

Anemones (non-epifaunal)	Cephalopods
Zooanthids	Crustaceans, except those managed under CFMP
Sponges (non-epifaunal)	Lobsters, except those managed under CFMP
Hydrozoans	Shrimp/Mantis
Stylasteridae (lace corals)	Crabs
Solanderidae (hydroid fans)	Annelids
Bryozoans	Algae
Tunicates (solitary/colonial)	Live rock
All other coral reef ecosystem marine plants, invertebrates and fishes not listed under existing FMPs.	

1.7 Definitions and Acronyms Applicable to the Coral Reef Ecosystem FMP

Coral reef ecosystem those species, interactions, processes, habitats, and resources associated with all substrate from 0-50 fathoms deep.

Coral Reef Ecosystem Management Area *(CRE management area, or management area)*:all Hawaii, Pacific Remote Island Areas (PRIA), American Samoa, Commonwealth of the Northern Mariana Islands (CNMI) and Guam Exclusive Economic Zone (EEZ) waters (from surface to ocean floor) which are outside of state or territorial waters and within 200 miles from shore. Because the EEZ of the Commonwealth of the Northern Mariana Islands currently extends to the shoreline, it is be separated into two zones; the inshore zone (0-3 miles from shore) and the offshore zone (3-200 miles from shore) with federal management of the coral reef ecosystem proposed for the offshore zone only and continuing management of the inshore zone left to local authorities. Daily management of these inshore waters remains with regional government authorities because (1) cooperation between the regional government and the Council relies on recognition of local management authority of the near-shore waters, (2) the CNMI-based small vessel fishers are best managed by a local regime with hands on interaction and knowledge of the issues, and (3) this regime retains consistency with the other areas under Council jurisdiction.

Coral Reef Ecosystem Management Unit Species *(CRE MUS or MUS)*: an extensive list, many included by family. Includes some management unit species from existing FMPs (bottomfish, crustaceans, precious corals) for which primary management would remain under their current FMPs but ecosystem effects would be addressed via the CRE-FMP. Coral reef MUS are separated into two categories:

Currently Harvested Coral Reef Taxa (CHCRT) : have appeared on catch reports of EEZ fisheries, relatively well understood. Due to ecosystem effects, overfishing limits and reference points will be established based on the coral reef ecosystem as a whole. In accordance with the National Standard Guidelines, the MSY control rule is to be applied to individual species within a multispecies stock whenever possible. Existing catch and effort data will be used to estimate these overfishing reference points; if insufficient data is available, data from similar species will be used as a proxy.

Potentially Harvested Coral Reef Taxa (PHCRT) : have not been reported caught or are minimally caught, little available information. As potential fisheries for these taxa develop, they will be moved into the Currently Harvested category and MSY, etc., will be determined.

No-Take MPA an area in which no fishing or other harvest of marine species is allowed (except for scientific purposes under special permits).

Low-Use MPA*:* an area in which controlled harvests of coral reef MUS is allowed.

Coral reef ecosystem general permit (CRE general permit, or general permit): a permit which would be required under some alternatives to harvest Currently Harvested Coral Reef Taxa from all non-MPA coral reef management areas. This permit would involve simple application procedures and reporting requirements.

Coral reef ecosystem special permit (CRE special permit, or special permit): a permit which would be required under some alternatives to 1) fish for any coral reef MUS (both Currently Harvested and Potentially Harvested Taxa) within low-use MPAs (with some exceptions), and 2) fish for any Potentially Harvested Coral Reef Taxa outside of MPAs. This permit would be approved and issued on a case-by-case basis and would have more complex application procedures and reporting requirements.

Small vessel: a vessel < 50' length overall (exempt from alternatives for anchoring prohibition on Guam's southern banks)

Large vessel: a vessel =>50' length overall (prohibited from anchoring on Guam's southern banks)

2.0 DESCRIPTION OF THE CORAL REEF ECOSYSTEM

2.1 Coral Reef Ecosystems

Coral reefs are carbonate rock structures at or near sea level which support viable populations of scleractinian or reef-building corals. Apart from a few exceptions coral reefs are confined to the warm tropical and sub-tropical waters lying between 30°N and 30°S . Coral reef ecosystems are arguably, the oldest and certainly the most diverse and complex ecosystems on earth. Their complexity is manifest on all conceptual dimensions, including geological history, growth and structure, biological adaptation, evolution and biogeography, community structure, organism and ecosystem metabolism, physical regimes, and anthropogenic interactions (see sources cited by Hatcher et al 1989). There is a voluminous and expanding literature on coral reefs and coral reef ecosystems (see Birkland 1997), beginning with Charles Darwin's 1842 volume; The Structure and Distribution of Coral Reefs, which remains the seminal volume on reef formation and structure, including reefs in the Western Pacific Region. A key feature of reef building corals is the symbiotic relationship of the animal coral polyps, which incorporate algal cells known as zooxanthellae into their tissue and which provide the coral with much of its nutritional needs, principally carbohydrates through photosynthesis. Most corals supplement this food source by actively feeding on zooplankton or dissolved organic nitrogen due to the low nitrogen content of the carbohydrates derived from photosynthesis.

The corals and coral reefs of the Pacific are described in Wells & Jenkins (1988) and Veron (1995), The number of species of coral declines in an easterly direction across the Western and Central Pacific in common with the distribution of fish and invertebrate species, with over 330 species contained in 70 genera on the Australian Barrier Reef compared with only 30 coral genera present in the Society Islands of French Polynesia and 10 genera in the Marquesa and Pitcairn Islands. Hawaii, by virtue of its isolated position in the Pacific, also has relatively few species of coral (about 50 species in 17 genera) and, more importantly, lacks most of the branching or "tabletop" *Acropora* species which form the majority of reefs elsewhere in the Pacific. The Acropora species provide a large amount of complex three dimensional structure and protected habitat for a wide variety of fishes and invertebrates. As a consequence, Hawaiian coral reefs provide limited 'protecting' three dimensional space and is thought to account for the exceptionally high amount of endemic Hawaiian marine species. Further it is believed by many to account for the reason certain species of fish and invertebrates look and act radically different than similar members of the same species found in other parts of the South Pacific (Gulko 1999)

Most forms of coral reef development can be found in the Western Pacific Region including barrier reefs in Guam and Saipan, fringing reefs in the Samoas and Hawaii, and patch and submerged reefs, banks and shoals throughout the region, but particularly abundant in the Northwestern Hawaiian Islands and with in the US EEZ of the Northern Mariana Islands. Other habitats commonly associated with coral reefs include mangrove forests, particularly in estuarine areas. The natural eastern limit of mangroves in the Pacific is American Samoa, although the Red Mangrove Rhizophora mangle was introduced into Hawaii in 1902 and has become the dominant plant within a number of large protected bays and coastlines on both Oahu and Molokai (Gulko 1999). Apart from the usefulness of the wood for building, charcoal and tannin, mangrove forests act to stabilize areas where physical sedimentation is occurring and, from a fisheries perspective, are important as nursery grounds for peneaeid shrimps and some inshore fish species, and form the habitat for some commercially valuable crustaceans.

Sea grasses are common in all marine ecosystems and are a regular feature of most of the inshore areas adjacent to coral reefs in the Pacific islands. According to Hatcher et al (1989), sea grasses stabilize sediments because leaves slow current flow, thus increasing sedimentation of particles. The roots and rhizomes form a complex matrix which binds sediments and stops erosion. Sea grass beds are the habitat of certain commercially valuable shrimps, and provide food for reef-associated species such as surgeonfishes (Acanthuridae) and rabbitfishes (Siganidae). Sea grasses are also important sources of nutrition for higher vertebrates such as dugongs and green turtles. A concise summary of the seagrass species found in the western tropical South Pacific is given by Coles and Kuo (1995). From the fisheries perspective, the fishes and other organisms harvested from the reef coral and associated habitats such as mangroves, seagrass beds, shallow lagoons, bays inlets and harbors, and the reef slope beyond the limit of coral reef growth contribute to the total yield from coral reef associated fisheries. Unlike other Council FMP's which are broadly species based, a key concept of this FMP is that it is ecosystem based, concerned not only with the health of target stocks, but also with the preservation of the coral reef ecosystems within the Western Pacific Region. To do this requires an understanding of the ecosystem components an ecosystem and how these various components interact.

Reef Productivity

Coral reefs are among the most biologically productive ecosystems in the world. The global potential for coral-reef fisheries has been estimated at 9 million tons per year, which is impressive given the small area of reefs compared to the extent of other marine ecosystems which collectively produce between 70 - 100 million tons/year (Smith 1978; Munro 1984). An apparent paradox of coral reefs, however, is their location in the nutrient deserts of the tropical oceans, i.e. water of high clarity and generally low gross primary productivity, generally ranging between 20 to 50 $gCm^{-2}yr^{-1}$. Coral reefs themselves are characterized by the highest gross primary production in the sea with reef flats and margins sustaining primary production rates of between 1,800-3700 $gCm^{-2}yr^{-1}$, and sand and rubble zones about 370 $gCm^{-2}yr^{-1}$. The main primary producers on reefs are the benthic microalgae, macroalgae, symbiotic microalgae of corals and other symbiont-bearing invertebrates. Zooxanthellae living in the tissues of hard corals make a substantial contribution to primary productivity in zones rich in corals due to their density (e.g. $>10^6$ cells cm^{-2} of live coral surface) and the high rugosity of the surfaces on which they live as well as their own photosynthetic potential. However, zones of high coral cover comprise only a small portion of entire coral reef ecosystems, and so their contribution to total reef gross primary productivity is small.

Although the ocean surface waters in the tropics generally have low productivity, these unproductive waters which bathe coral reefs are continually moving. Reefs therefore have access to substantial open-water productivity. Thus particularly in inshore continental waters, shallow benthic habitats such as reefs must not always be considered the dominant sources of carbon for fisheries. Outside sources may be important for reefs , and while this significance is rarely estimated, its input may be living (plankton) or dead (detrital) forms. In coastal waters detrital matter from land, the plankton and fringing marine plant communities is particularly abundant. There may be passive advection of particulate and dissolved detrital carbon onto reefs, and active transport on to reefs via fishes which shelter on reefs but feed in adjacent habitats. There is therefore greater potential for nourishment of inshore reefs than offshore reefs by external carbon sources and this inshore nourishment will be enhanced by large land masses.

For most of the Pacific islands rainfall typically ranges from 2,000 to 3,500 mm/yr. Low islands such as makateas and atolls tend to have less rainfall and may suffer prolonged droughts. Further, when rain does fall on coral islands and makateas where there is no major catchment area, there is little allochthonous nutrient input into surrounding coastal waters and lagoons. Lagoons and embayments around high islands in the South Pacific are therefore likely to be more productive than atoll lagoons. The productivity of high island coastal waters, particularly where there are lagoons and sheltered waters, is possibly reflected in the greater abundance of small pelagic fishes such as anchovies, sprats, sardines, scads, mackerels and fusiliers (Anon 1984). Furthermore, the range of different environments that can be found in the immediate vicinity of the coasts of high islands also contributes to the greater range of bio-diversity found in such locations.

Studies on coral reef fisheries are relatively recent, commencing with the major study by Munro & co-workers during the late 1960s in the Caribbean (Munro 1983) and even today, only relatively few examples are available of in-depth studies on reef fisheries. It was initially thought that the maximum sustainable yields for coral reef fisheries were in the range of 0.5 - 5 $t/km^{-2}yr^{-1}$, based on limited data (Stevenson & Marshall 1974, Marten & Polovina 1982). Much higher yields of around 20 $t/km^{-2}yr^{-1}$, for reefs in the Philippines (Alcala 1981; Alcala & Luchvez 1981) and American Samoa (Wass 1982) were thought to be unrepresentative (Marshall 1980), but high yields of this order have now been independently estimated for a number of sites in the South Pacific and Southeast Asia (Dalzell 1996; Dalzell & Adams 1997). These higher estimates are closer to the maximum levels of fish production predicted by trophic and other models of ecosystems (Polunin et al 1996). Dalzell & Adams (1997) suggest that the average MSY for Pacific reefs is in the region of 16 $t/km^{-2}yr^{-1}$ based on 43 yield estimates where the proxy for fishing effort was population density.

However, Birkeland (1997) has expressed some scepticism about the sustainability of the high yields reported for Pacific and SE Asian reefs. Among other examples, he notes that the high values for American Samoa reported by Wass (1982) during the early 1970s were followed by a 70% drop in coral reef fishery catch rates between 1979 and 1994. Saucerman (1995) ascribed much of this decline to a series of catastrophic events over the same period beginning with a crown of thorns infestation in 1978, followed by hurricanes in 1990 and 1991 which reduced the reefs to rubble and a coral bleaching event in 1994, probably associated with the El Nino phenomenon. These various factors reduced live coral cover in American Samoa from a mean of 60% in 1979, to between 3-13% in 1993.

Further, problems still remain in rigorously quantifying the effects of factors such as primary productivity, depth, sampling area or coral cover on yield estimates. Polunin et al (1996) noted that there was an inverse correlation between estimated reef fishery yield and the size of the reef area surveyed, based on a number of studies reported by Dalzell (1996). Arias-Gonzales et al (1994) have also examined this feature of reef fisheries yield estimates also noted that this was a problem when comparing reef fishery yields, noting that estimated yields are based on the perception of the investigator as to the maximum depth at which true reef fishes occur. Small pelagic fishes such as scads and fusiliers may comprise large fractions of the inshore catch from a particular reef and lagoon system and if included in the total catch can greatly inflate the yield estimate. The great variation in reef yield summarized by authors such as Arias-Gonzales et al (1994), Dalzell (1996) and Dalzell & Adams (1997) may also be due in part to the different size and trophic levels included in catches.

Another important aspect of the yield question is the resilience of reefs to fishing and recovery potential when overfishing or high levels of fishing effort have been conducted on coral reefs. Evidence from a Pacific atoll where reefs are regularly fished by community fishing methods such as leaf seeps and spearfishing indicated that depleted biomass levels may recover to pre-exploitation levels within 1-2 years. In the Philippines, abundances of several reef fishes have increased in small reserves within a few years of their establishment (White 1998; Russ & Alcala 1994), although recovery in numbers of fish is much faster than recovery of biomass, especially in larger species such as groupers. Other studies in the Caribbean and SE Asia (Polunin et al 1996) indicate that reef fish populations in relatively small areas have the potential to recover rapidly from depletion in the absence of further fishing. Conversely, Birkeland (1997) cites the example of a pinnacle reef off Guam fished down over a period of 6 months in 1967 and which has still not recovered 30 years later.

Estimating the recovery from and reversibility of fishing effects over large reef areas appears more difficult to determine. Where growth overfishing predominates, recovery following effort reduction may be rapid if th fish in question are fast growing, as in the case of goat fish (Garcia & Demetropolous 1986). However, recover may be slower if biomass reduction was due to recruitment overfishing as it takes time to rebuild adult spawning biomasses and high fecundities (Polunin & Morton 1992). However, many coral reef species have limited distributions, confined to a single island or a cluster of proximate islands. Widespread heavy fishing could cause global extinctions of some such species, particularly if there is also associated habitat damage. Ironically the majority of species with a limited range are also valuable. to the aquarium trade, and in the future restrictions on capture, possibly through CITES listing, may be appropriate to prevent overfishing.

Extent and distribution of coral reefs

Roughly 70 % of the world's coral reefs, or 420,000 km^2 are located in the Pacific Ocean (Bryant et al. 1998). Of all reefs under U.S. jurisdiction, 94 percent (Clark and Gulko 1999), or an estimated 15,852 km^2 of reef area, are associated with US Pacific islands (Hunter 1995). The table below shows their geographical distribution. Note that the much of this coral reef is located in areas where there is no human population (NWHI, remote US territories) or in island archipelagos where populations are concentrated on one or two islands (American Samoa, CNMI).

Coral reef area (in km^2 <100m deep) in nearshore waters (0-3 nmi from shore) and offshore waters (3-200 nmi from shore) in each location in the western Pacific region (Hunter 1995)

Location	0-3 mni	3-200 nmi	Total Coral Reef Area
American Samoa	271	25	296
Guam	69	110	179
Hawaii			
Main Hawaiian Islands	1,655	880	2,535
Northwestern Hawaiian Islands	2,227	9,104	11,331
Commonwealth of the Northern Marianas Islands	45	534	579
Remote US Pacific Island Areas	620	89	709
Midway*	203	20	223
TOTAL	5,090	10,762	15,852

***** Midway is a PRIA located in the Hawaiian Archipelago

2.2 Coral Reef Ecological Characteristics and Resource Dynamics

Coral reefs and reef-building organisms are confined to the shallow upper photic zone and area normally restricted to depths less than 50-100 m (25-50 fm) (Holthus and Maragos 1995). Maximum reef growth and productivity occurs between 5-15 m (Hopley and Kinsey 1988) and maximum diversity of reef species occurs at 10-30 m (Huston 1985).

Available biological and fishery data are poor for all species and areas covered by the CRE-FMP and it is not possible to implement EPAP principle 4 (i.e., calculate total removals– including incidental mortality– and show how they relate to standing biomass, production, optimum yields, natural mortality, and trophic structure). Furthermore, high biological and environmental variability is a natural characteristic of coral reef ecosystems around the US Pacific islands, with or without fishing. Irregular pulses of new recruits (Walsh, 1987) cause cycles in the abundance and harvest potential of individual reef species. Environmental variability is both spatial, related to differences in the quality of habitat (Friedlander and Parrish, 1998a) and temporal, related to monthly moon phase, seasonal and longer-term environmental changes (Friedlander and Parrish, 1998b).

Polovina et al. (1994) examined a large-scale climatic shift that affected coral reef resources in the NWHI from the mid-1970s to the late 1980s. During this period, the central North Pacific experienced increased vertical mixing, with a deepening of the wind-stirred surface layer into nutrient-rich lower waters and probable increased injection of nutrients into the upper ocean. Resulting increased primary productivity likely provided a larger food base for fish and animals at higher tropic levels. In the NWHI, changes of 60 to 100 percent over baseline levels in productivity for lobsters, sea birds, reef fish and monk seals were observed and attributed to deeper mixing during 1977-1988.

The highest quality habitat on a coral reef is often where abundant living coral has created high bottom relief. Natural disturbance cycles in areas exposed to large storm waves can dramatically alter habitat quality. For example, periodic storms in the Northwestern Hawaiian Islands (NWHI) reduce live coral cover to 10 percent in some areas. Coral cover eventually returns to 50 percent or more, depending on how protected the area is (R. Grigg, 104th Council meeting, June 2000).

Unlike pelagic ecosystems, which are driven primarily by oceanographic forces operating on a large scale, coral reef ecosystems are strongly influenced by biological processes, habitat utilization and environmental conditions at a relatively small scale. Innumerable animals and plants shelter, attach or burrow into the reef structure, creating some of the most biologically diverse and complex ecosystems on earth.

Ecological relationships

Coral reef ecosystems have existed in geological terms for nearly twice as long as flowering plants and some of the coral genera are more ancient than any grasslands. Therefore, the ecological relationships have had more time to develop complexity in coral reefs. A major portion of the primary production of the coral reef ecosystem comes from complex inter-kingdom relationships of animal/plant photo-symbioses hosted by animals of many taxa, most notably stony corals. Most of the geological structure of reefs and habitat is produced by these complex symbiotic relationships.

Complex symbiotic relationships for defense from predation, removal of parasites, building of domiciles and other functions are also prevalent. About 32 of the 33 animal phyla are represented on coral reefs (only 17 are represented in terrestrial environments) and this diversity produces complex patterns of competition. The diversity also produces a disproportionate representation of predators which have strong influences on lower levels of the food web in the coral reef ecosystem (Birkeland, 1997a). The Figure on adjacent page shows how a simplified diagram of how inter-relationship with other organisms and the surrounding environment can effect the population dynamic of reef species during different life phases.

Interrelationships Within Coral Reef Ecosystem

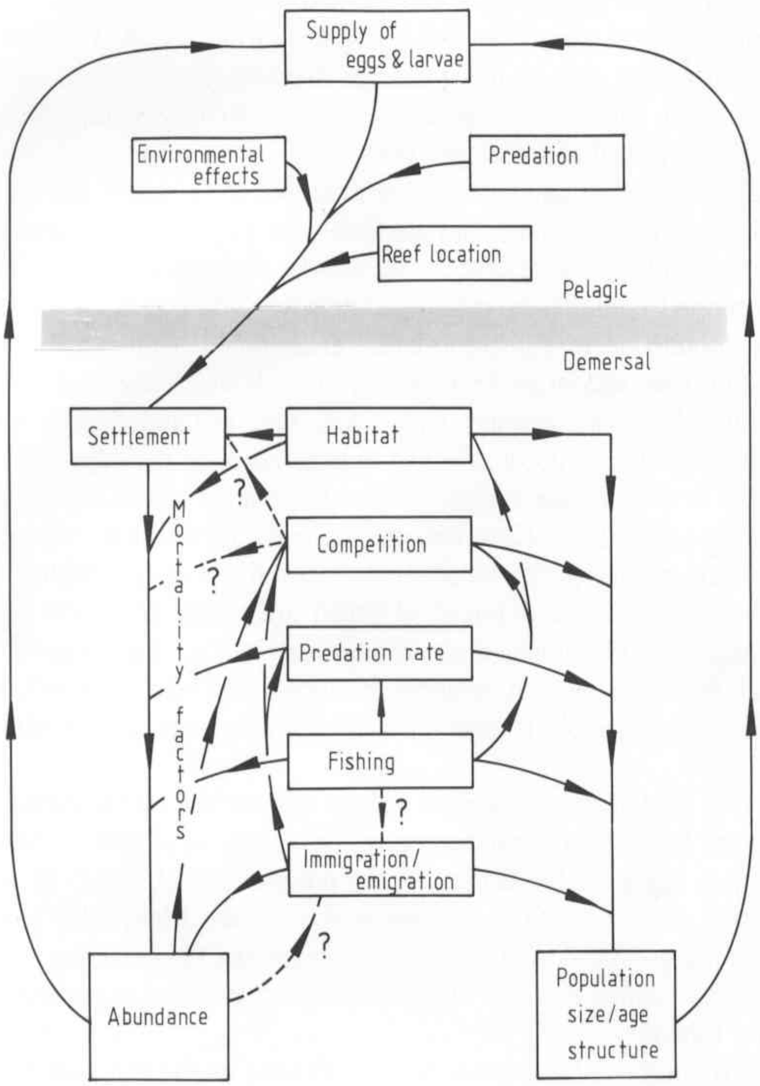


Fig. 3. Flow diagram illustrating factors determining the abundance and size/age structure of populations of reef fishes and their interrelationships. Arrows show the direction of effects, and solid links indicate those relationships supported by field evidence. Dashed links with question marks indicate expected relationships for which supporting evidence is as yet unavailable. Fishing mortality affects abundance and size/age structure of populations both directly and indirectly. Removal of fishing mortality may therefore be expected to result in pronounced changes in population structure.

Source: Roberts and Polunin 1991.

In areas with high gross primary production but low net primary production or yield (e.g., rain forests and coral reefs), animals and plants tend to have a higher variety and concentration of natural chemicals as defenses against herbivores, carnivores, competitors and microbes. Because of this tendency and the greater number of phyla in the system, coral reefs are now a major focus for bioprospecting, especially in the southwest tropical Pacific (Birkeland, 1997a).

Coral reef habitat

Even within a thriving coral reef habitat, not all space is occupied by corals or coralline algae. Reefs are typically patchworks of hard and sediment bottoms. A reef provides a variety of environmental niches, or combination of resources. The wide variety of survival strategies of coral reef organisms allows different species to exploit some combination of resources better than their competitors. The ecosystem is dynamic, however. If conditions change, a very specialized species may not be able to survive the rigors of the new environment or may be forced out by another species more adept at using the available resources, including space, food, light, water motion and temperature.

Long-term Ecosystem Variability

Climate and ecosystem shifts may occur over decadal scale cycles or longer, meaning that resources management decisions need to consider changes in target level productivity over the long term as well as short term inter-annual variation.

For example the climatic shift that occurred in the central North Pacific in the late 1980s (see above) produced an ecosystem shift in the NWHI to a lower carrying capacity, with a 30-50% decline in productivity (Polovina et al. 1994) . This in turn had a concomitant negative effect on recruitment and survival of monk seals, reef fish, albatross and lobsters. Under the lower carrying capacity regime, fishing alters the age-structure of the population and may also lead to stock depletion.

At Laysan Island, where lobster fishing is prohibited, spawning biomass of lobsters was also depleted by natural mortality. This suggests that marine reserves may not guarantee the protection that is typically assumed (Polovina & Haight 1999). In response to this natural variability the Council adjusted its management measures (e.g., limited entry, annual quota) to reduce catch and effort to about 25% of its pervious level of the 1980s.

The destruction of coral reefs around the principal island in American Samoa, Tutuila, as described earlier, forced fishermen to move into predominantly pelagic fishing, initially trolling and latterly small scale longline fishing. Much of American Samoas reef fish now comes from Western Samoa. The reduction of fishing on coral reefs may also aid in the recovery of the live coral cover, but the long term recovery of the reefs around Tutuila is going to depend principally on a benign climate and marine environment over the next decade. Further, these destructive events occurred during a long-term shift in the physical environment of the equatorial Pacific Ocean which began in 1977 (Miller et al. 1994). Conditions included more clouds, more rainfall, warmer sea surface temperatures and weaker trade winds, similar to a weak decadal El Nino state. They were most pronounced in the central equatorial Pacific, so American Samoa was close to the center of this shift, which persisted until 1999, when conditions began to change. Whether 1999 marks another regime shift will not be known for several years (J. Polovina, pers. comm.).

The destruction of American Samoan coral reefs included a period of bleaching in 1994, which was also occurred to reefs in the Cook Islands and French Polynesia and was due to unseasonably high sea water temperatures. Coral bleaching occurs when corals lose or expel their zooxanthellae in large numbers, usually due to some trauma such as high or low temperatures or lower than usual salinities (Brown 1997). The corals that lose zooxanthellae also their color, becoming white and hence the term ‘bleaching’ Although first described in the 1900s, interest in this phenomenon was heightened in the 1980s and 1990s after a series of major bleaching events in the Atlantic and Pacific Oceans. Some of these episodes were linked to the El-Nino Southern Oscillation or ENSO events (Gulko 1999).

When bleaching occurs, some corals are able to slowly re-infect themselves with zooxanthellae or through the reproduction of remaining zooxanthellae within the colony. Frequently, the loss of large amounts of symbiotic algae results in the colony becoming energy deficient, where it expend more energy than it is consuming, and if this occurs over the long term the colony dies (Gulko 1999, Brown 1997). Coral bleaching events require only a 1-2 °C change upwards of water temperature, and hence there are concerns that bleaching will become an increasing phenomenon due to global warming. Goreau et al (1997) note that corals in the Atlantic and the Indian Oceans also show that corals world wide are acclimated close to their upper temperature limits and are unable to adapt rapidly to an anomalous warming (Goreau et al 1997). consequently global warming represent a very serious threat to the survival of coral reefs.

Other physical phenomena that may bring long term change to coral reef systems include the impact of hurricanes and tectonic uplift. Bayliss-Smith describes the changes in reef islands at Ontong-Java Atoll over a 20 years period following severe hurricane. Most atoll islands are on reef flats in what are frequently high wave-energy locations near to seaward reef margins, and so would not be stable unless composed of coarse shingle and rubble. Hurricanes will destroy such small cays and scour motu beaches, and strip small or narrow islands of fine sediment during over-wash periods. Bayliss Smith notes that hurricanes tend to erode existing islands, but at the same time produces the material for their reconstruction. More frequent lower magnitude storms contribute to the process by transporting the rubble ramparts thrown up by hurricanes so as to reconstruct scoured beaches and eroded shore lines. Clearly such destruction and reconstruction activity on reef flats will have an effect on reef organisms including fish and invertebrates, particularly where large areas of reef are smothered by sand and silt following a hurricane.

A much slower but nonetheless profound influence on coral reef systems is the process of tectonic uplift, which although slow may create major change over the period of several centuries or millenia. A productive reef flat through time may be raised above the surface to become a terrace and thus reduce the amount of available reef area for fishing, as occurred at Niuatoputapu and in the Tonga archipelago (Kirch & Dye 1979). Tectonic uplift was also partially responsible for the change of the central lagoon of the island of Tongatapu from a marine to a brackish water environment, and the loss of an important reef mollusc resource *Anadara antiquata* which could not survive the reduced salinity. A similar event occurred at Tikopia in the Solomon Islands where a circular bay with a narrow entrance became a brackish coastal lake as the bay entrance was sealed through a combination of tectonic uplift, and increased sedimentation in the runoff from agriculture on neighboring slopes. Again this major habitat change wiped out a major food source in the form of reef and lagoon associated molluscs (see sources cited in Dalzell 1998).

2.3 Coral Reef Communities

Coral reef communities are among the most diverse and ecologically complex systems known. The structure of reef communities is usually defined in terms of the diversity and relative abundances of species characteristic of a habitat type. Commonly, only a few species compose over half the abundance, while hundreds of others are present in low numbers.

Life History

The literature on coral reef fish life histories is voluminous, but convenient entries into the literature are provided by Sale (1991); Polunin and Roberts (1996) and Birkeland (1997). The life of a coral reef fish includes several stages. Typically spawning occurs in the vicinity of the reef and is characterized by frequent repetition throughout a protracted season of the year, a diverse array of behavioral patterns, and extremely high fecundity. The eggs of many species are fertilized externally and dispersed directly into the pelagic environment as plankton. Other species have demersal eggs which upon hatching disperse larvae into the pelagic realm. Planktonic mortality is very high and unpredictable. Recruitment is the transition stage form the planktonic larval life to demersal existence on a coral reef. Recruitment is highly variable both spatially and temporally. This is when post-larval juveniles begin their residence on reefs where many remain for life. Highest predation mortality occurs within the first few days or weeks while growth out of the juvenile size is rapid.

The populations of terrestrial animals are usually dispersed by adults who deposit eggs or build nests in selected locations. In contrast, the most frequent pattern of coral reef organisms is dispersion of eggs and larvae in water currents which determine the final location of adults. The adults are often sedentary or territorial. The differences in factors which bring about success in these two phases of life histories complicate fisheries management (Birkeland, 1997a).

Species distribution and abundance

Species diversity declines eastwards across the Pacific from the locus of maximum species richness in Southeast Asia (Philippines/Indonesia) and is related in part to the position of land masses in relation to the Pacific Plate, the earth's largest lithospheric plate (Springer 1982). In general, the species richness is greatest along the plate margin and declines markedly on the plate itself. The net result is that islands in the Central Pacific have a lower reef organism diversity but also a high degree of endemism. For example, Guam has about 269 species of zooxanthellate Scleractinia, about 40 Alcyonacea and just under a thousand species of fishes, compared to far fewer in Hawaii. The proportion of endemic species increases in the opposite direction. For example, the Hawaiian Islands have about 18% endemic zooxanthellate corals, 60% endemic Alcyonacea and 25% endemic reef fishes, compared to the islands in the southwest portion of the Western Pacific Region. Likewise, the proportion of alien species in Hawaiian waters is greater and is increasing (Birkeland, 1997a).

Among the diverse array of species in each taxa on coral reefs, there are usually only a few that are consistently abundant, with the relative numbers of species within a taxa possibly approximating a log-normal distribution. The majority of species are relatively uncommon or only episodically abundant, following unusually successful recruitment (Birkeland, 1997a).

Individual sub-populations of larger stocks of reef species may increase, decrease or cease to exist locally without adversely affecting the overall population. The condition of the overall populations of particular species is linked to the variability among sub-populations: the ratio of sources and sinks, their degrees of recruitment connection, and the proportion of the sub-populations with high variability in reproductive capacity. Recruitment to populations of coral reef organisms depends largely on the pathways of larval dispersal and "downstream" links. Are the connections sufficient to actually restock distant sub-populations or only enough to maintain a homogenous genetic stock?

Reproduction and recruitment

The majority of coral reef animals are very fecund but temporal variations in recruitment success have been recorded for some species and locations. Many of the large, commercially targeted coral reef animals are long-lived and reproduce for a number of years. This is in contrast to the majority of commercially-targeted species in the tropical pelagic ecosystem. Long-lived species adapted to coral reef systems are often characterized by such complex reproductive patterns as sequential hermaphroditism, sexual maturity delayed by social hierarchy, multi-species mass spawnings and spawning aggregations in predictable locations (Birkeland, 1997a).

Growth and mortality rates

Recruitment of coral reef species is limited by high mortality of eggs and larvae, as well as by competition for space to settle out on coral reefs. Intensity of predation from a disproportionate number of predators limits the survival of juveniles (Birkeland 1997a).

Some fishes such as parrotfish and wrasses grow rapidly compared with most coral reef fishes, but they still grow relatively slowly compared to pelagic species. In addition, scarids and labrids may have complex haremic, in the case of parrotfish, territorial social structures that contribute to the overall affect of harvesting these resources. It appears that many tropical reef fishes grow rapidly to (near) adult size, and there often grow relatively little in length over a protracted adult life span, thus are relatively long–lived. In some groups of fishes, such as damselfish, individuals of the species are capable of rapid growth to adult size, but sexual maturity is still delayed by social pressures. This complex relationship between size and maturity makes resource management more difficult (Birkeland, 1997a).

Community Variability

High temporal and spatial variability is characteristic of reef communities. At large spatial scales, variation in species assemblages may be due to major differences in habitat types or biotopes (e.g., seagrass beds, reef flats, lagoonal patch refs, reef crests, seaward reef slopes).

Reef fish communities from the geographically isolated Hawaiian Islands are characterized by low species richness, high endemism, and exposure to large semiannual current gyres, which may help retain planktonic larvae. The NWHI is further characterized by 1) high latitude coral atolls, 2) a mild temperate to subtropical climate, where inshore water temperatures can reach below 18^{o}C in late winter, 3) species which are common on shallow reefs and attain large sizes, which occur only rarely or in deep water to the southeast, and 4) inshore shallow reefs that are largely free of fishing pressure.

2.4 Ecosystem Models

Several approaches to model multi-species fisheries have been used by coral reef fisheries scientists with varying levels of success. The simplest approach has been to consider a community to be the sum of its species. Unfortunately, with highly diverse systems such as coral reefs, this leads to an extremely complex model with potentially hundreds of parameters. An alternative is to divide the assemblage into separate trophic levels and model the energy flow through the system to estimate potential yields (e.g., ECOPATH).

General multi-species models have also been applied by several researchers to estimate yields in coral reef fisheries. These models are based on simultaneous Lotka-Voltera equations which incorporate the impact of each species population size on every other species through use of shared resources. These models may be extended to incorporate predation and harvesting. These approaches are mentioned as possible avenues for future assessment methodologies, although at present the lack of data precludes their usage.

ECOPATH

ECOPATH is a simple mathematical model that estimates mean annual biomass, production and food consumption for major components (species groups) of a coral reef ecosystem (Polovina 1984). Species groups include tiger shark, monk seal, seabirds, reef sharks, sea turtle, small pelagics, jacks, reef fish (and octopus), lobsters and crabs, deepwater bottomfish, nearshore scombrids, zooplankton, phytoplankton, herterotrophic benthos and benthic algae. A box model illustrates a biomass budget schematic for major predator-prey pathways and lists annual production and annual biomass for each group. The model shows a high percent of internal predation which partially explains why fishery yields from coral reefs are generally low despite high primary productivity. A constraint of the ECOPATH approach is the allocation of species to trophic compartments, which imposes an artificial structure and may not coincide with actual community structure. This approach is also data intensive and requires information on each species' diet, mortality, and growth rates.

Extensive field work from French Frigate Shoals provided estimates of parameters used to validate the model. Application of ECOPATH to French Frigate Shoals found that the coral reef ecosystem is controlled mainly by predation from the top down and primary production is controlled mainly by nutrients, photosynthetic rate limits, and habitat space (Grigg et al. 1984). Fishery yields can be maximized by targeting lower trophic levels and cropping top predators to release pressure on prey. A fishery targeting tiger sharks at French Frigate Shoals should help ease predation pressure on endangered Hawaiian monk seals and threatened Hawaiian green turtles. Coral reef ecosystems are susceptible to overfishing due to high levels of natural mortality and low net annual production. A study of coral reef fish communities on patch reefs at Midway Atoll found a relative degree of resilience to several years of fishing pressure on top predators, while some control by predation was detected (Schroeder 1989).

ECOSIM

ECOSIM is a computer model that uses the output of the ECOPATH model. Input parameters, by species (or species group), include natural and fishing mortality, diet composition and production to biomass ratio. The vulnerability level of prey to predators can be adjusted. Gear selectivity levels can also be set. Predation levels are then determined. The model can be run for several decades to indicate qualitative changes in the structure of the resource community. Applying various levels of fishing pressure can indicate which target and non-target species increase and which decrease in abundance, considering predator-prey interactions (Kitchell et.al.1999). For example, a simulation run where most sharks were removed was found to produce little change on lower trophic-level species (i.e., sharks were not found to be important in stabilizing the ecosystem) (C. Boggs, pers. comm.).

2.5 Ecosystem Overfishing

The special vulnerability of targeted coral-reef resources comes from life-history traits of these economically valuable species that live in diverse communities with strong predatory and competitive forces. Coral-reef species are adapted for multiple reproduction because of improbable survival of progeny and therefore grow slowly, delay first reproduction, and are territorial compared with pelagic species. These life-history traits of coral-reef species make recovery from overfishing very uncertain. Some coral-reef ecosystem, driven by biological interactions, have not recovered for decades following intensive harvest and there are no indications that they will recover, while pelagic fisheries driven by oceanographic processes usually recover. For example, black-lipped pearl oysters at Pearl & Hermes Atoll in the NWHI were over-harvested to commercial extinction in the late 1920s, and recent surveys have demonstrated that the stocks have still not recovered after 70 years. Holothuroids or sea cucumbers were over-harvested in the late 1930s in Chuuk, Eastern Carolines, and recent surveys have shown the stocks have not recovered after 60 years. Dalzell et al (1996) cite several other examples of pearl oyster and sea-cucumber over-harvesting in the Pacific Islands where populations have failed to recover after several decades of no fishing.

Fishing activities that may degrade coral reef ecosystems, such as overfishing, can ultimately affect ecosystem processes (e.g., the removal of herbivorous fishes can lead to the overgrowth of coral by algae) and destroy the availability of coral reef resources (e.g., extraction of fishing aggregations of groupers). Munro (1983; 1999) has suggested that overfishing of reef predatory species may lead to a decline in the natural mortality of herbivores which will respond by increasing in biomass. When these in turn are overfished, there will be no control of algal production and biomasses of algae and sea-grasses will increase, with most production turning to detritus. However, there are few well documented examples of such effects cascading through ecosystems.

Munro (1999), cites the example of the north coast of Jamaica where reefs are almost entirely overgrown by macro-algae and the cover of live coral is extremely low. Although there is not full agreement between scientists, it appears that this can be attributed to the long term effects of overfishing. The island shelf is very narrow (<1km) and was covered by flourishing coral reefs until 1984. Then several events combined to change the situation. The herbivorous long-spined sea urchin, *Diadema antillarum* suffered a catastrophic epidemic that spread rapidly through the Caribbean and the north coast of Jamaica took a direct hit from a major hurricane. The reefs were pulverised by heay seas and large corals were stripped of tissue. Macroalgae colonized all the newly exposed surfaced and in the absence of sea urchins and herbivorous fish have remained dominant up to the present (Hughes 1994). Other parts of the Caribbean with less heavily exploited fish stocks lost their urchin populations and suffered hurricanes but the reefs were not massively overgrown with algae. While it cannot be proven that overfishing was the cause of this catastrophe, the evidence points in that direction.

The Magnuson-Stevens Act requires fishery management units to be considered as individual species or taxonomic groups of species and Maximum Sustainable Yield (MSY) to be calculated for each species or group. There are thousands of potentially economically valuable species on coral reefs, a major portion of which have not been given scientific names and officially described. The major economic utilization of reef resources in the immediate future is bio-prospecting. The approach is to find as many species for pharmaceuticals as possible, whether officially described or not. If a species by species approach and a MSY for each resource are required, it will be many decades before a FMP can be completed and economic development can be initiated. The complex multispecies interactions on coral reefs requires an ecosystem-level approach as espoused by the NMFS Ecosystems Principles Advisory Panel.

Ecosystem overfishing occurs when fishing pressure causes changes to the species composition in a multispecies setting, often resulting in changes in ecosystem function (DeMartini et al., 1999). The concept of ecosystem overfishing may be most appropriate for the CRE-FMP, detected by shifts in species composition or trophic web dynamics, while simultaneously guarding against single stock recruitment overfishing where applicable. Because the coral reef ecosystem is a multispecies community removal of certain species may disrupt species diversity and possibly lead to the unwanted predominance of often less valuable generalist species. Changes in species dominance patterns in coral reefs experiencing fishing pressure have been reported for a number of tropical stocks from various areas around the world. It is also well known that the sensitivity of multispecies systems to environmental fluctuations increases as the level of exploitation increases.

3.0 DESCRIPTION OF THE FISHERY AND FISHING COMMUNITIES

3.1 Description of Coral Reef Uses

An underlying principle behind the ecosystem approach to fisheries management, as applied in this FMP, is that extractive fisheries and other types of coral reef ecosystem harvesting and activity will affect not just the targeted species, but other species (including their habitats), as well as other fisheries and non-fishery uses and values. Each of the affected fisheries, uses and values will be termed "sectors," of which there are three groups. Only the first, "coral reef fisheries," is directly managed by the FMP. This sector includes all harvest of coral reef resources (coral reef MUS taken from federal waters between 0-50 fathoms) including those incidentally caught under existing FMP fisheries.

Coral Reef Fishery Sectors

Food	All commercial, subsistence and recreational harvest of coral reef resources generally towards food production.
Sport	Fishing for coral reef resources with the primary motivation of recreation.
Ornamentals	Harvest of coral reef resources including fishes, invertebrates, and live rock for use as ornamentals, for home and local use and commercial trade.
Natural products	Harvest of coral reef resources for all other purposes, such as coral for bone grafts and production of pharmaceuticals.
Mariculture	At-sea mariculture of coral reef resources, and harvest of coral reef resource broodstock for land-based mariculture.

Non-coral Reef Fishery Sectors

Deep-water bottom fisheries	Fisheries for finfish, crustaceans and precious corals, in benthic environments deeper than 50 fathoms, including for food, sport and ornamentals, as described above for coral reef fisheries.
Pelagic fisheries	Fisheries for finfish in pelagic ecosystems, including for food and sport. In general the pelagic fisheries are not directly related to the coral reef ecosystem.

Non-fishery Sectors

Tourism (non-fishing)	Visitors engaging in scuba diving, snorkeling, boating, swimming, viewing of coral reefs and other coral reef-related activities, including eco-tourism.
Recreation (non-fishing)	Residents engaging in scuba diving, snorkeling, boating, swimming, viewing of coral reefs and other coral reef-related activities.
Mining	Extraction of fossil coral and sand from the coral reef ecosystem.
Breakwater	Coral reef ecosystems functioning to protect shorelines from erosion and to provide shelter for navigation and mooring, and other activities.
Ecological support	Coral reef ecosystems functioning as nursery areas, spawning areas, or otherwise in support of resources, protected species, essential fish habitat, fisheries, and ecological services in other ecosystems.
Information	Coral reef ecosystems providing values associated with gaining and sharing information that is, the non-extractive, "discovery," aspects of research and education, and the values associated with the consequential development and production of marine natural products.
Biodiversity	Coral reef ecosystems providing values associated with varied genetic resources.

3.2 Description of the Coral Reef and Non-Coral Reef Fishery

Data Available

The State of Hawaii requires fishers who sell any portion of their catch to hold a commercial marine license and to complete and submit a Division of Aquatic Resources' Fish Catch Report for every trip. The licensee must report the type of fishing gear used (e.g., trap, diving, net, etc.), area fished and number and/or weight of each species caught.

Hawaii is one of the few coastal states that does not require a marine recreational fishing license and associated reporting. Therefore, obtaining estimates of the recreational catch or effort in the coral reef fisheries is very difficult. However, there is some information available on the nearshore recreational catch from past creel surveys. Several of these surveys have shown the recreational catch to be the equivalent or greater than that reported in the commercial fisheries landing data (Friedlander 1996).

In American Samoa, the Offshore Creel Survey administered by the Department of Marine and Wildlife Resources (DMWR) collects fishery information from both commercial and recreational fishers on the number and weight of each species, method of fishing, time fished and area fished. In addition, the survey includes information on the disposition of the catch. DMWR applies a set of algorithms to estimate the commercial landings based on the estimate of total landings and catch disposition information derived from the survey. DMWR also directly monitors the commercial fishery by collecting "trip-ticket" receipts from fish sales to local fish markets, stores, hotels and restaurants.

In Guam, the Division of Aquatic and Wildlife Resources (DAWR) administers both the Offshore and Inshore Creel Surveys. The surveyors interview fishers to collect information on the length and weight of each species caught during fishing trips, method of fishing, number of gear used, time fished, area fished and weather conditions. The disposition of the catch is only recorded as part of the Offshore Creel Survey; therefore, differentiating commercial and recreational landings in the inshore fishery is almost impossible. Total landings are estimated from survey data by applying fairly complex stratum-based expansion factors, which are calculated by integrating data collected on participation surveys with the creel intercept and interview data. DAWR also collects information on commercial landings through a voluntary trip ticket receipt program with major fish dealers. Estimates of total commercial landings are calculated by applying expansion factors to the receipt book data.

In the Commonwealth of the Northern Mariana Islands (CNMI), data on commercial landings are collected by the Division of Fish and Wildlife (DFW) through the Commercial Sales Receipt, or "trip ticket", Program, which documents local fish sales to commercial establishments similar to Guam and American Samoa. Landings, species composition, revenue and the number of fishers or boats selling catch are estimated from information provided on the forms. The Offshore and Inshore Creel Surveys administered by DFW were suspended in 1996. The information collected from surveys included the number and weight of each species caught during commercial and recreational fishing trips, fishing method used, number of gear used, area fished, fishing time, weather conditions and percentage of the total catch that is sold. In 2000, the boat-based Offshore Creel Survey was reimplemented and redesigned to also include the charter boats in addition to the recreational and commercial vessels. The Council supports DFW's efforts to reestablish the inshore survey to collect information on coral reef fisheries.

No other recreational fishing surveys have been conducted recently in US Pacific to supplement information collected by local creel survey programs. The Council fully supports proposals by NMFS to conduct such marine recreational fishing surveys. For the time being, the portion of the catch reported as sold in creel surveys is considered the commercial component, whereas the unsold portion represents the recreational/subsistence component. According to the MSFCMA, unsold fish should be classified as commercial if traded or bartered. It is not practical or appropriate for data collection systems in the region to make this distinction. The customary exchange of fish with no immediate expectation of return is not regarded in Pacific island societies as a commercial activity, but represents a traditional use.

This FMP will require detailed reporting (logbook) as a condition for holding a permit to harvest coral reef resources in the EEZ. The Council recommends that no exception be granted for subsistence fishers from permitting or reporting. This revision should not greatly affect exclusive subsistence fishers since they generally do not fish in federal waters. The logbook would report types and quantities of gear used, numbers and weights of species kept, number released alive, number released unknown, area fished, length of trip, specific effort information and other information required as a condition of holding the permit. The annual report required under the CRE-FMP would summarize and analyze the information collected.

Summary of data availability for major fishing sectors in the Western Pacific Region

	Commercial	Recreational/Subsistence	Charter
American Samoa	Yes	Yes	N/A
Guam	Yes	Yes	Yes
Hawaii	Yes	Limited**	Yes, needs improvement*
CNMI	Yes	Limited***	Yes, under improvement

* data collected through reporting forms but not separated from commercial information.
** Some recreational information available from past creel surveys.
*** Data only available from boat-based fishing activity. Current survey program does not collect information from shore-based fishers.

Food Sector

Pooley (1993) noted that "the distinction between 'commercial' and 'recreational and subsistence' fishing in Hawaii is a weak distinction." The same is true of other US Pacific islands. The coastal fisheries of the region are dominated, at least in terms of numbers, by small-scale part-time fishers who have variously mixed motivations to fish. They derive benefits as both producers and consumers—that is, consumers of both seafood and enjoyment. For example, the category of small-boat fishers in Hawaii termed expense fishermen by Hamilton and Huffman (1997) sell at least part of their catch to offset their fishing expenses, but their expenses still outweigh their revenues. These fishers are undoubtedly receiving enough consumer surplus (i.e., enjoyment) to offset that negative.

In each of the island areas it is almost impossible to label the majority of these fishers or fishing vessels as commercial or recreational. It is more appropriate to categorize the fish caught as commercial or recreational/subsistence during a particular trip. Most of the fish caught in 'recreational fisheries' are not released alive.

Although some harvest occurs in the EEZ, existing fisheries for coral reef resources are concentrated in the nearshore waters (0-3 miles) around American Samoa, Guam, Hawaii and CNMI. Harvesting of inshore resources is frequently shore-based, whereas fishing offshore reefs is small boat-based.

Recreational fishers tend to harvest a greater variety of species than do commercial fishers, so the diversity of the recreational catch is underestimated in commercial databases. For example, the Hawaii DAR database contained only 28 commercial taxa for Hanalei Bay, whereas a creel survey of the area included 95 taxa, although the catches of many taxa were trivial (Friedlander 1996).

Commercial and recreational components employ the same fishing methods, although the recreational fishery typically utilizes a wider range of harvesting methods than the commercial fishery (Friedlander 1996). Inshore gear types with the highest proportion of commercially sold catch (50% +) are fish traps, crab nets, surround nets and gill nets. Spearing and mid-depth handline are less important for commercial harvest (30–35% of catch sold) and casting is almost exclusively for recreation (< 6% of commercial catch) (Friedlander 1996 after Hamm and Lum 1992). Creel surveys show that gear types used primarily for recreational/subsistence purposes contribute much more to the total catch than the gear types used for commercial purposes (Green 1997).

Sport Sector

Of the five regions under the management of the Council, American Samoa is the only area without a real charter boat fleet. Infrequently, private vessels are used for "charter" trips but to very limited extent. Recently, a bottomfishing charter fishery developed in Guam in addition to the traditional trolling charters to target the deep and shallow-water emperors, groupers and snappers, as well as wrasses, squirrel fish, triggerfish and other coral reef species. The size of the vessels range from typical charter boats carrying 3–6 anglers to larger party boats accommodating up to 30 persons. During the tourist season, boats make 1 to 3 trips per day at 2 to 6 hours each trip. Fish are frequently released on shallow-water bottomfishing charters. DAWR estimates 1,700 charter trips in 1999 totaling 4,000 hours bottomfishing. From an effort of 35,000 gear-hours and a total catch of 13,000 lb, the catch rate was estimated at 0.38 pounds per gear-hour.

Of the dozen or so charter vessels in the CNMI, several are targeting bottomfish. DFW reports that shallow-water charters generally last 2 hours and are conducted up to 4 times per day that could include occasional night trips. Charters generally focus outside the barrier reef in 80-200 feet of water from Chalan Kanoa in the south, up to areas off Nikko Hotel in the north. To date in 2000, there are two vessels that strictly charter for shallow-water bottom/reef fish. With the re-implementation of the offshore creel survey, routine sampling of the charter fleet includes detailed interviews for bottomfish charters, including numerating and measuring all retained catch.

Shallow-water bottomfish charters have also recently begun in Hawaii. Charter vessels range from smaller boats accommodating 4 to 6 passengers to larger party boats of 30 or more. Trips are generally 4 hours conducted twice daily. Vessels routinely operate within 3 miles of their port. Average depth of operation is from 80 to 200 feet. It is estimated that less than a dozen bottomfish charters operate in Hawaii.

Catch and effort information from bottomfish charter operators are collected through the HDAR Commercial Marine Licenses or sales reporting forms (C-3). However, because bottomfish chartering is relatively new in Hawaii, HDAR is not able to differentiate whether reported bottomfish landings are taken during a charter trip or commercial trip. Fish sold from a bottomfish charter operation would be included on a C-3 form and probably credited toward a normal commercial trip. The C-3 form does not require bottomfish charter operators to indicate if the fish was taken during a charter trip. Fish that are released or consumed may not be reported under the current system. A new form may need to be specifically developed to ensure catch and effort data is collected from the Hawaii bottomfish charter sector. HDAR has developed and will soon implement a new charter troll report form.

Low levels of recreational and subsistence fishing occur at Johnston, Wake and Midway Atolls. Sportfishing is a major attraction at Midway for ecotourists. The no-take zone MPA proposed for Palmyra and most of the other PRIAs will deter future tourism development at these remote locations.

3.3 Economic Environment

3.3.1 Overview

American Samoa

American Samoa has a small developing economy, dependent mainly on two primary income sources: the American Samoa Government (ASG), which receives income and capital subsidies from the United States, and two tuna canneries on the island of Tutuila. The two primary sources have given rise to a third: a services sector that derives from and complements the first two (Bank of Hawaii 1997a). American Samoa is lowest in gross domestic product and highest in donor aid per capita among the US Pacific islands (Adams et al., 1999). Donor aid refers to remittances of American Samoans from overseas.

Because of its tuna canneries, Pago Pago is the leading US port in terms of dollar value of fish landings. Star-Kist Samoa has become the largest tuna cannery in the world. Ancillary businesses associated with the tuna processing industry also contribute significantly to American Samoa's economy. Pago Pago Harbor supports mostly large fishing vessels, tankers and container ships. Shoreside infrastructure for small domestic fishing vessels is minimal. Commercial fisheries for bottomfish and reef fish make a minor contribution to the territories overall economy. The social and cultural importance of coral reef resources in American Samoa dwarfs their commercial value.

Guam

Guam's economy has become so dependent on tourists from East Asia, particularly Japan, that any significant economic, financial and foreign exchange development in the region has had an immediate impact on the territory. During the mid- to late-1990s, as Japan experienced a period of economic stagnation and cautious consumer spending, visitor arrivals from Japan dropped and the impact was felt as much on Guam as in Japan. The US military presence on Guam has diminished to the lowest level in decades. Nevertheless, the military remains a vital stabilizing economic factor for Guam, particularly in times of regional economic crises. The Government of Guam currently supplies more than 20% of all civilian jobs in the territory. Recent deficits have resulted from a steady rise in government spending at the same time that tax bases have not kept up with spending demands (Bank of Hawaii1997c).

With regard to commercial fishing, the most significant attribute of Guam is its status as a regional tuna transshipment center and re-supply base for foreign tuna fleets (Hamnett and Pintz 1996). Guam is the fourth leading US port in terms the dollar value of fish landings, which are mostly for transshipment to tuna markets in Japan. Commercial domestic fisheries for reef fish and bottomfish make a relatively minor contribution to the Guam economy. The social and cultural importance of coral reef resources in Guam dwarfs their commercial value.

Commonwealth of the Northern Mariana Islands

Tourism has become CNMI's largest income source. In the late 1990s, however, the Asian financial crisis caused visitor arrivals from Japan and Korea to drop by one-third. At present, garment production is CNMI's fastest growing industry and is credited with preventing an economic depression following the decline of the tourist industry. The development of tourist and garment industries based on foreign labor has had a dramatic impact on CNMI's population growth, which increased from 16,780 in 1980 to 79,429 in early 1999 (Bank of Hawaii Economic 1997b). With the exception of a purse seine support base (now defunct) on the island of Tinian, CNMI has never had a large infrastructure dedicated to commercial fishing. Commercial domestic fisheries for reef fish and bottomfish make a minor contribution to the overall economy. The social and cultural importance of coral reef resources in the CNMI dwarfs their commercial value.

Hawaii

Hawaii's economic situation changed dramatically in the 1990s. Several major economic sectors, such as plantation agriculture, tourism and military, suffered downturns. As a consequence, Hawaii never entered the period of economic prosperity that many US mainland states are now experiencing. Since 1998, Hawaii's tourism industry has recovered, mainly because the strength of the national economy promoted growth in visitor arrivals from the continental US. Efforts to diversify the economy, and thereby render it less vulnerable to future economic downturns, have met with little success to date. Commercial fishing has historically represented a small share of Hawaii's total economic activity. In contrast to the sharp decline in some industries of long-standing importance in Hawaii, however, the fishing industry has been fairly stable during the past decade. More importantly, fisheries resources, especially coral reef resources, represent an important source of subsistence for Hawaii's residents during periods of economic recession. As a result of the rise in tourism-related ocean recreation in Hawaii, a premium has been placed on non-consumptive uses of nearshore marine resources (Pooley 1993a).

Pacific Remote Island Areas

During the 19th century, the United States and Britain actively mined guano deposits on Howland, Jarvis and Baker Islands. They became possessions of the US in 1936 and have been under the jurisdiction of he Department of the Interior since that time. From 1935 to 1942, the three islands were occupied by Hawaiians sent to consolidate US claims. They were used as weather stations an military outposts during World Was II years, and debris from that period remains. The three atolls are presently National Wildlife Refuges administered by the US Fish and Wildlife Service. They are presently uninhabited but are visited periodically by scientists, researchers and, occasionally, expeditions of ham radio operators. Entry is controlled by special permit. The US Navy currently has jurisdiction over Kingman Reef.

Palmyra was claimed by the American Guano Company in 1859. It was annexed to the Kingdom of Hawaii in 1862 but in 1911 became privately owned and later was excluded from the Territory and State of Hawaii. A seaplane base and other defense facilities were constructed on Palmyra in the late 1930s in preparation for World War II. The atoll was continuously occupied by the US Navy or other Federal installations after the war until 1949 and was also occupied during nuclear testing programs in 1962. The Navy attempt to regain control of Palmyra after World War II ended with a US Supreme Court decision to return the atoll to the private owners, the Fullard-Leo family. The Nature Conservancy has negotiated exclusive purchasing rights of Palmyra Island, with final sale no later than January, 2001. They report that two-thirds of the island will be designated as a National Wildlife Refuge run by the USFWS and one-third utilized for ecotourism. The Service initially has proposed a 12 nm boundary for the seaward delineation of the refuge. The Magnuson-Stevens Act establishes the Council's jurisdiction over EEZ waters surrounding Palmyra to the mean high water mark including the waters of the lagoon. The Council opposes the proposed 12 nm Refuge boundary. On January 28, 1999, Council staff met with representatives of the US Fish and Wildlife Service (USFWS), to discuss the USFWS's plans to purchase Palmyra Island and the proposed seaward boundary of the wildlife refuge.

The written historical record provides no evidence of prehistoric populations on Wake atoll but Marshall Islanders occasionally visited Wake, giving it the name Enenkio. The island was annexed by the United States in 1899. Prior to the 1930s the only visitors were scientists and survivors of shipwrecks. The Navy received administrative control of Wake in 1934, and an air base was established on the atoll in January 1941. Wake Island figured prominently in World War II. The US re-occupied the atoll after the war, and administrative authority was held by the Federal Aviation Administration until 1962, when it was transferred to the Department of the Interior, which in turn assigned authority to the US Air Force.

Johnston Atoll was claimed by Hawaii and the United States in 1858. Guano deposits found on the island were exploited for a short period in the 19th century. Johnston Atolls is still controlled by the US military. Starting in the late 1940s, Johnston Atoll played an important role in the US nuclear testing program. In 1962, three rockets accidentally exploded on or above Johnston Island. Chemical munitions have been stockpiled on Johnston for storage and destruction by means of a specially designed chemical munition incinerator.

Since 1996, there has been limited eco-tourism and public use within the Midway Atoll National Wildlife Refuge in the form of charter fishing, diving and wildlife observation. Midway Phoenix

Corporation's agreement with the USFWS allows 100 visitors to enjoy the atoll per week. The privately owned company advertises wildlife tours that let visitors "gain first hand knowledge of the albatross, resident seabirds, migrant shorebirds, threatened green sea turtles and endangered monk seals" (Midway Phoenix Corporation, undated). Additional outdoor recreational activities for the public are suggested in the Public Use Plan for the refuge and may be offered to visitors in the future (USFWS 1997). Among these activities are shoreline fishing, lobstering, night diving, night fishing, kayaking tours and glass-bottomed boat excursions. Midway also serves as an aircraft refueling stop and provides excellent logistical support to research on the remote atoll.

3.3.2 Exvessel Value of Coral Reef Resources

The following tables provide a summary of the approximate, recent, total annual ex-vessel values for each of the domestic marine fisheries of the Western Pacific Region's island groups. The focus is on fisheries for coral reef resources (coral reef MUS taken from 0-50 fathoms), but rough estimates of the deep bottom, (crustacean and precious corals) and pelagic fisheries are also provided, both for comparison and because they may be affected by the management measures. Values presented are for the total value (in 1999 dollars) of landings from each area, as well as for the portion located in the FMP management area. Ex-vessel values are the estimated total annual gross value of landings from each fishery, whether sold or not. The ex-vessel values for the sport sectors are the charter fees; the value of the landings in the sport fisheries are included in the food sector. The details behind these values, including the volume of landings on which they are based, are provided for each of the island groups in following tables. The uncertainty associated with these estimates is variable and in some cases quite high.

The total annual ex-vessel value of the region's fisheries for coral reef resources (coral reef MUS taken from 0-50 fathoms) in recent years was about $15 million, $14 million of which was in food fisheries (mostly bottomfish and lobsters), $1 million in ornamentals (from 0.5 million pieces) and $0.6 million in sport fisheries (from 12,000 angler-trips). The deep bottom fisheries (mostly bottomfish and lobsters harvested from greater than 50 fathoms) realized an approximate ex-vessel value of $4 million annually. The value of the natural products and mariculture sectors were assumed to be minimal, but more in-depth investigation might reveal otherwise.

Hawaii's share of total coral reef resource harvests was about 77 percent, or $12 million, of which 88 percent was in the main islands and 12 percent in the Northwestern Hawaiian Islands. The ex-vessel value of Guam's harvested coral reef resources was about $1.6 million, the CNMI's about $1.3 million, and American Samoa's about $0.7 million.

Overall, it was very roughly estimated that 10 percent of the total ex-vessel value of harvested coral reef resources was taken in federal waters (or the "management zone" of the CNMI). The estimated percentages of total ex-vessel value caught in the FMP area (federal waters or management zone between 0-50 fathoms) were 1 percent in American Samoa, 4 percent in the CNMI, 8 percent in Guam, and 11 percent in Hawaii.

Summary of Fisheries Annual Ex-vessel Value ($1,000/year)

	Am. Samoa		CNMI		Guam		MHI		NWHI		Other islands		All islands	
	Total	**FMP**	**Total**	**FMP**	**Total**	**FMP**	**Total**	**FMP**	**Total**	**FMP**	**Total**	**FMP**	**Total**	**FMP**
Coral reef:														
Food	671	8	1,217	54	1,214	118	9,391	1,075	1,295	12	22	21	**13,809**	**1,287**
Sport	m	0	80	4	306	15	71	7	159	159	0	0	**616**	**186**
Ornamentals	10	0	m	0	48	0	1,004	0	0	0	m	m	**1,062**	**m**
Natural products	0	0	0	0	0	0	?	?	0	0	0	0	**?**	**?**
Mariculture	m	0	0	0	0	0	?	0	0	0	0	0	**m**	**0**
Total coral reef	**681**	**8**	**1,297**	**58**	**1,567**	**133**	**10,465**	**1,082**	**1,454**	**171**	**22**	**21**	**15,486**	**1,472**
Deep bottom:														
Food	64	0	166	0	158	0	1,455	0	1,161	0	0	0	**3,004**	
Sport	m	0	30	0	306	0	707	0	m	0	0	0	**1,043**	
Ornamentals	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
Total deep bottom	**64**	**0**	**196**	**0**	**463**	**0**	**2,162**	**0**	**1,161**	**0**	**0**	**0**	**4,047**	
Pelagic:														
Food	444	0	950	0	858	0	48,200	0	8,764	0	10	0	**59,226**	
Sport	10	0	900	0	1,238	0	14,000	0	159	0	0	0	**16,307**	
Total pelagic	**454**	**0**	**1,850**	**0**	**2,096**	**0**	**62,200**	**0**	**8,923**	**0**	**10**	**0**	**75,533**	
TOTAL	**1,199**	**8**	**3,343**	**58**	**4,127**	**133**	**74,827**	**1,082**	**11,538**	**171**	**32**	**21**	**95,066**	**1,472**

Values are approximate, recent, annual gross values of the production side of these fisheries, expressed in 1999 dollars (x 1,000).
"m" means minimal and unquantifiable.

American Samoa Fisheries by Area : Annual Volume and Ex-vessel Value

	Annual Total		% of harvest from FMP area	FMP portion	
	Volume (lbs)	Value ($1,000)		Volume (lbs)	Value ($1,000)
Coral reef area harvests:					
Food					
Finfish:					
live	0	0	0	0	0
dead	216,000	393	2	4,000	8
Crustaceans:	7,000	26	0	0	0
lobster					
other crustaceans					
Echinoderms	43,000	87	0	0	0
Molluscs:	73,000	146	0	0	0
mother-of-pearl					
other molluscs					
Other invertebrates	2,000	20	0	0	0
Seaweeds	min	min	0	0	0
Sport	min	min	0	0	0
Ornamentals					
Fishes and other	5,000	10	0	0	0
Hermatypic coral/live	min	min	0	0	0
Black coral	0	0		0	0
Marine natural products	0	0		0	0
Mariculture	min	min	0	0	0
Total coral reef area		**681**			**8**
Deep bottom area harvests:					
Food	27,000	64	0	0	0
Sport	min	min	0	0	0
Ornamentals	0	0	0	0	0
Total deep bottom		**64**			**0**
Pelagic fisheries:					
Food	400,000	444	0	0	0
Sport	120	10	0	0	0
Total pelagic harvests		**454**			**0**
Total all fisheries		**1,199**			**8**

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.
"min" means minimal.

Northern Mariana Islands Fisheries by Area: Annual Volume and Ex-vessel Value

	Annual Total		% of harvest from FMP area	FMP portion	
	Volume (lbs)	Value ($1,000)		Volume (lbs)	Value ($1,000)
Coral reef:					
Food					
Finfish:					
live	0	0		0	0
dead	446,000	1,070	5	22,000	54
Crustaceans:					
lobster	4,000	19	0	0	0
other crustaceans					
Echinoderms	25,000	68	0	0	0
Molluscs:					
mother-of-pearl	20,000	60	0	0	0
other molluscs					
Other invertebrates					
Seaweeds	min	min	0	0	0
Sport	1,600	80	5	80	4
Ornamentals					
Fishes and other inverts	min	min	0	0	0
Hermatypic coral/live	min	min	0	0	0
Black coral	0	0		0	0
Marine natural products	0	0		0	0
Mariculture	0	0		0	0
Total coral reef		**1,297**			**58**
Deep bottom:					
Food	50,000	166	0	0	0
Sport	300	30	0	0	0
Ornamentals	0	0		0	0
Total deep bottom		**196**			**0**
Pelagic:					
Food	500,000	950	0	0	0
Sport	9,000	900	0	0	0
Total pelagic		**1,850**			**0**
Total all fisheries		**3,343**			

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.

Guam Fisheries by Area: Annual Volume and Ex-vessel Value

	Annual Total		% of harvest from FMP area	FMP portion	
	Volume (lbs)	Value ($1,000)		Volume (lbs)	Value ($1,000)
Coral reef:					
Food					
Finfish:					
live	0	0		0	0
dead	400,000	1,176	10	40,000	118
Crustaceans:					
lobster	5,000	19	0	0	0
other crustaceans					
Echinoderms					
Molluscs:					
mother-of-pearl	3,000	6	0	0	0
other molluscs	4,000	9	0	0	0
Other invertebrates	1,000	2	0	0	0
Seaweeds	some	unknown	0	0	0
Sport	10,000	306	5	510	15
Ornamentals					
Fishes and other inverts	24,000	48	0	0	0
Hermatypic coral/live	min	min	0	0	0
Black coral	0	0		0	0
Marine natural products	0	0		0	0
Mariculture	0	0		0	0
Total coral reef		**1,567**			**133**
Deep bottom:					
Food	45,000	158	0	0	0
Sport	10,000	306	0	0	0
Ornamentals	0	0			0
Total deep bottom		**463**			
Pelagic:					
Food	660,000	858	0	0	0
Sport	21,000	1,238	0	0	0
Total pelagic		**2,096**			**0**
Total all fisheries		**4,127**			**133**

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.

Main Hawaiian Islands Fisheries by Area: Annual Volume and Ex-vessel Value

	Annual Total		% of harvest from FMP area	FMP portion	
	Volume (lbs)	Value ($1,000)		Volume (lbs)	Value ($1,000)
Coral reef:					
Food	1,004,900	9,391		540,001	1,076
Finfish:					
live					
dead	443,900	7,571	10	439,000	750
Crustaceans:					
lobster	10,000	128	0	0	0
other crustaceans	100,000	417	41	41,000	173
Echinoderms	1,000	11	3	0	0
Molluscs:					
mother-of-pearl					
other molluscs	369,000	925	16	60,000	150
Other invertebrates					
Seaweeds	81,000	339	1	1	3
Sport	500	71	10	50	7
Ornamentals					
Fishes and other	430,000	937	0	0	0
Hermatypic coral/live	min	min	0	0	0
Black coral	3,000	66	0	0	0
Marine natural products	unknown	unknown	unknown	unknown	unknown
Mariculture	unknown	unknown	0	0	0
Total coral reef		**10,465**			**1,082**
Deep bottom:					
Food	418,000	1,455	0	0	0
Sport	5,000	707	0	0	0
Ornamentals	0	0		0	0
Total deep bottom		**2,162**			**0**
Pelagic:					
Food	22,000,00	48,200	0	0	0
Sport	99,000	14,000	0	0	0
Total pelagic		**62,200**			**0**
Total all fisheries		**74,827**			**1,082**

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.

Northwestern Hawaiian Islands Fisheries by Area: Volume and Ex-vessel Value

	Annual Total		% of harvest from FMP area	FMP portion	
	Volume (lbs)	Value ($1,000)		Volume (lbs)	Value ($1,000)
Food					
Finfish:					
live	0	0		0	0
dead	19,000	14	82	16,000	11
Crustaceans:					
lobster	246,000	1,280	0	0	0
other crustaceans	min	1	51	min	min
Echinoderms	0	0		0	0
Molluscs:					
mother-of-pearl					
other molluscs	0	0		0	0
Other invertebrates	0	0		0	0
Seaweeds	0	0		0	0
Sport	375	159	100	375	159
Ornamentals					
Fishes and other inverts	0	0		0	0
Hermatypic coral/live	0	0		0	0
Black coral	0	0		0	0
Marine natural products	0	0		0	0
Mariculture	0	0		0	0
Total coral reef		**1,454**			**171**
Deep bottom:					
Food	371,000	1,161	0	0	0
Sport	min	min	0	0	0
Ornamentals	0	0		0	0
Total deep bottom		**1,161**			**0**
Pelagic:					
Food	4,000,00	8,764	0	0	0
Sport	375	159	0	0	0
Total pelagic		**8,923**			**0**
Total all fisheries		**11,538**			**171**

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.

Other Islands Fisheries by Area: Annual Volume and Ex-vessel Value

	Annual Total		% of harvest from FMP area	FMP portion	
	Volume (lbs)	Value ($1,000)		Volume (lbs)	Value ($1,000)
Coral reef:					
Food					
Finfish:					
live	0	0		0	0
dead	10,000	20	100	10,000	20
Crustaceans:					
lobster	200	1	0	0	0
other crustaceans	200	min	100	200	min
Echinoderms	0	0		0	0
Molluscs:					
mother-of-pearl					
other molluscs	100	min	100	100	min
Other invertebrates	0	0		0	0
Seaweeds	0	0		0	0
Sport	0	0		0	0
Ornamentals					
Fishes and other inverts	min	min	100	min	min
Hermatypic coral/live	min	min	100	min	min
Black coral	0	0		0	0
Marine natural products	0	0		0	0
Mariculture	0	0		0	0
Total coral reef		**22**			**21**
Deep bottom:					
Food	min	min	0	0	0
Sport	0	0		0	0
Ornamentals	0	0		0	0
Total deep bottom		**0**			**0**
Pelagic:					
Food	5,000	10	0	0	0
Sport	0	0		0	0
Total pelagic		**10**			**0**
Total all fisheries		**32**			**21**

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.

3.4 Historical and Present Coral Reef Uses

Coral reef resources sustained indigenous populations in the US Pacific Islands for hundreds to thousands of years before European contact. More recently, coral reef resources have been harvested for recreational and commercial purposes as well. Reef species have been harvested for food, the aquarium trade, construction materials, curios, jewelry, pharmaceuticals and traditional medicines.

In modern times, some reefs have been degraded by a range of human activities. Comprehensive lists of human threats to coral reefs in the US Pacific islands are provided by Maragos, et al. (1996), Birkeland (1997), Grigg (1997), Jokiel (1999), Clark and Gulko (1999). In general, reefs closest to human population centers are more heavily used and are in worse condition than those in remote locations (Green, 1997).

Summary of coral reef resource use levels in nearshore areas (0-3 nmi from shore) and offshore areas (3-200 nmi from shore) in sub-areas of the US Pacific Islands (modified from Green, 1997)

Location	**0-3 nmi**	**3-200 nmi**
American Samoa	Nil-Moderate	Nil-Light
CNMI	Nil-Heavy	Nil-Heavy
Guam	Light-Heavy	Nil-Heavy
Hawaii		
Main Hawaiian Islands	Light-Heavy	Nil-Heavy
Northwestern Hawaiian Islands	Mostly Nil	Nil-Moderate
Remote Islands	Nil-Light	Mostly Nil
Overall	Nil-Heavy	Nil-Moderate

American Samoa

Coral reef fishes and invertebrates are harvested in subsistence and small-scale commercial fisheries. In 1994, the only year when both components of this fishery were measured, catches were 86 mt and 76 mt, respectively, and consisted primarily of surgeonfish, parrotfish, groupers, octopus and sea urchins (Craig, et al., in press). Sixty-nine different taxa were harvested in 1991. The migratory atule (Selar crumenophthalmus, or bigeye scad) is an important catch component (Green, 1997).

As recently as 20 years ago, the harvest of reef fish and invertebrates from reef flats fronting the most densely populated section of coast on Tutuila was as high as 26.6 mt/km^2 per year (Wass, 1982). A decreasing trend in reef-related fish catches was observed in the early 1990s. At least one favored invertebrate (giant clams) has been overfished in most areas, except Rose Atoll (Craig, et al., in press). In general, the reefs adjacent to human population centers (Tutuila Island) appear to be in worse condition than those near less populated or unpopulated islands (Green, 1996).

Most of the coral reef fisheries in American Samoa occur in nearshore waters. Much of the bottom fishing activity by small boats is conducted on banks in the EEZ and some of the shallow-water snappers and emperors taken can be considered reef fish species. At present, the catch from the latter fishery is minor (Green, 1997). Ornamental fish collection has occurred on a small scale in recent years. Live rock taken from shallow reef areas was exported during 1999, but this fishery has since been prohibited by the fono (American Samoa Legislature).

Fisheries statistics show that coral reef fisheries have accounted for 62% of the annual catch (154 mt) and 70% of the annual catch value ($619,000) in recent years. This estimate is low because it does not include the shoreline subsistence harvest, which is assumed to be substantial. Nor does the estimate include shallow-water species of bottom fish which are taken in a commercial small-boat fishery. The annual harvest of the latter fishery has been small (11 mt valued at $46,000) in recent years, so the contribution to the total reef fish harvest is insubstantial.

Most of the landings in the known reef-related fisheries in American Samoa are fish (98 mt/year), molluscs (33 mt/year) and echinoderms (19 mt/year), but small amounts of crustaceans (3 mt/year) are also reported (Green, 1997). A much smaller commercial fishery, using 10-m boats, catches bottomfish (principally emperors and snappers) by hook and line around the islands and offshore banks. In 1997, this fishery harvested 12 mt (Craig, et al., 1999). Chambered nautilus has occasionally been taken by researchers and public aquaria at depths of about 200 m on offshore reef slopes (D. Itano, pers. comm.). Virtually nothing is known of the reefs on offshore banks because they are relatively inaccessible. It is assumed, however, that they are in better condition than the nearshore reefs because they are deep and remote from most human activities.

Coral reefs around American Samoa are recovering from a series of natural disturbances over the past two decades: a crown-of-thorns invasion (1978), three hurricanes (1986, 1990, 1991) and mass coral bleaching (1994), as well as chronic human-induced impacts along the populated coasts. There have been extensive alterations of coastal habitats (sandy beaches, wetlands, coral reefs) due to highway construction and urban expansion, particularly along the south shore of Tutuila. Coastal erosion is amplified by the removal of large quantities of beach sand and coral rubble from the shoreline for use around homes. Together, these shoreline alterations have largely eliminated the use of the central south coast by nesting sea turtles. Direct losses of coral reef habitats are related to dredging for harbors and filling to build the international airport runway.

Degradation of reefs has occurred due to chronic water quality and sedimentation problems. Because of the main islands' steep terrain and high rainfall, hillside runoff and erosion into adjacent coastal waters is heavy. Other activities that have had a major impact on the reef environment are landfills, sewage disposal and – in Pago Pago Harbor – discharges from shoreside industries and spills from vessels in port. (Craig, et al., in press). Remote Rose Atoll, protected as a National Wildlife Refuge, was damaged in 1993 by a ship grounding and related oil spill.

The condition of near shore reefs around American Samoa varies according to location. Reefs on the main island of Tutuila are in the worst condition because of a combination of natural and human effects (hurricanes, coral bleaching, pollution, sedimentation), whereas the reefs on the more remote and less populated islands tend to be in good condition (Green, 1997). There is evidence from recent fisheries statistics, scientific resource surveys and interviews with village elders and fishermen to suggest that the more accessible coral reefs are seriously overfished. A major contributor to this problem is SCUBA assisted fishing, especially at night (American Samoa Coral Reef Task Force, 1999). Green sea and hawksbill turtle populations have seriously declined due to harvesting of turtles and eggs and degradation of nesting and inshore habitats.

Guam

Since World War II, coral reef fisheries have shifted from an exclusively subsistence focus to an artisanal fishery which blends subsistence, recreational and commercial purposes (Hensley and Sherwood, 1993). The more accessible reefs are considered overfished because of declining catch rates, declining size of target fish species and greater prevalence of less desirable species (Katnik 1992; Birkeland, 1997c; Green, 1997).

Prior to World War II, trochus (top shell) was taken in large quantities for food and jewelry work. By the 1970s, the top shell population had recovered sufficiently to allow a limited fishery that is currently regulated with size restrictions. Stony and precious corals have been harvested in the past for ornamental use and jewelry work. Residents and visitors, including foreign fishing crews, collect stony corals and mollusks as curios. Coral harvesting is illegal on Guam without a permit and there have been several convictions of violators (Green, 1997).

Since the late 1970s, the percentage of live coral cover on Guam's reefs and the recruitment of small corals has decreased. Possible explanations for this trend are poor recruitment by coral larvae, increased sedimentation of reef habitat and domination of reef habitat by fleshy algae. Corals have also been impacted by natural disturbances (starfish predation in 1968-1970; emergence during El Nino events; and, in more localized areas, by heavy wave action associated with typhoons (Birkeland, 1997c).

Shore-based fishing accounts for most of the fish and invertebrate harvest from coral reefs around Guam. In recent years, the estimated inshore harvest has ranged from 38 to 108 mt. This estimate excludes highly variable catches of juvenile rabbitfish and bigeye scad by traditional fisheries that are still practiced seasonally (Myers, 1997). While spearfishing is the principal method of harvesting, it is highly seasonal because of weather conditions. During FY85 to FY91, parrotfishes (36%), surgeonfishes (17%) and wrasses (7%) were the primary species landed by spearfishing (Myers, 1997).

The coral reef fishery harvests more than 100 species of fish, including the families Acanthuridae, Carangidae, Gerreidae, Holocentridae, Kyphosidae, Labridae, Lethrinidae, Lutjanidae, Mugilidae, Mullidae, Scaridae and Siganidae (Hensley and Sherwood, 1993). Myers (1997) noted that seven families (Acanthuridae, Mullidae, Siganidae, Carangidae, Mugilidae, Lethrinidae and Scaridae) were consistently among the top 10 species in any given year from FY91 to FY95 and accounted for 45% of the annual fish harvest. Approximately 40 taxa of invertebrates are also harvested by the nearshore fishery, including 12 crustacean taxa, 24 mollusc taxa and 4 echinoderm taxa (Amesbury, et al., 1986 and 1991 in Hensley and Sherwood, 1993; Myers, 1997). Species that became rare on shallow reefs due to heavy fishing include bumphead parrotfish, humphead wrasse, stingrays, parrotfish, jacks, emperors and groupers (Green, 1997).

Many of the nearshore reefs around Guam appear to have been badly degraded by a combination of natural and human impacts, especially sedimentation, tourist overuse and overharvesting. In the last few years, there has been an increase in commercial spearfishing using SCUBA at night. Catch rates have increased because of improved technology (high capacity tanks, high tech lights and bang sticks) that allows spearing in deeper water (30–42 meters). As a result, many larger species that have already been heavily fished in shallow waters are now reappearing in the fishery catch statistics (e.g., Bolbometopon muricatum, Cheilinus undulatus, stingrays and larger scarid species) (DAWR personnel and M. Duenas pers. comm. in Green 1997).

Virtually no information exists on the condition of the reefs on offshore banks. On the basis of anecdotal information, most of the offshore banks are in good condition because of their isolation. Observations by divers suggest that anchor damage is having a major impact on branching coral formations on some of the offshore banks. Anchors dragged by small boats dig small furrows but anchors from large fishing vessels leave large craters in the surfaces of offshore banks.

According to Myers (1997), less than 20% of the total coral reef resources harvested in Guam are taken from the EEZ, primarily because they are associated with less accessible offshore banks. Finfish comprise most of the catch in the EEZ. Most offshore banks are deep, remote, shark infested and subject to strong currents. Generally, these banks are only accessible during calm weather in the summer months (May to August/September). Galvez Bank is the closest and most accessible and, consequently, fished most often. In contrast, the other banks (i.e., White Tuna, Santa Rose and Rota) are remote and can only be fished during exceptionally good weather conditions (M. Tenbata and J. Cruz pers. comm. in Green 1997). Local fishermen report that up to 10 commercial boats (2–3 people per boat) and some recreational boats use the banks when the weather is good (M. Duenas, pers. comm., in Green, 1997).

At present, the banks are fished using two methods: bottomfishing by hook and line and jigging at night for bigeye scad (Myers, 1997). In recent years, the estimated annual catch in these fisheries has ranged from 14 to 22 mt (shallow bottomfish) and 3 to 11 mt (atulai) (Green, 1997). The shallow-water component comprised almost 68% (35,002 to 65,162 lb) of the aggregate bottomfish landings in FY92–94 (Myers, 1997). Catch composition of the shallow-bottomfish complex (or coral reef species) is dominated by lethrinids, with one species (Lethrinus rubrioperculatus) alone accounting for 36% of the total catch. Other important components of the bottomfish catch include lujanids, carangids, serranids and sharks, while holocentrids, mullids, labrids, scombrids and balistids are minor components. It should be noted that at least two of these species (Aprion virescens and Caranx lugubris) also range into deeper water and some of the catch of these species occurs in the deepwater fishery.

The majority of bigeye scad (Selar crumenophthalmus) fishing occurs in territorial waters but also occasionally takes place in federal waters. Estimated annual offshore landings for this species since 1985 have ranged from 6,393 to 44,500 lb, with no apparent trend (Myers, 1997). It is unclear how much of this offshore atulai fishery has occurred in the EEZ.

Hawaii

In recent decades, there has been a notable decline in near shore fishery resources in the main Hawaiian Islands (Shomura, 1987). Overfishing is considered to be one of the major causes of this decline (Harman and Katekaru, 1988; Grigg, 1997) but coastal construction, sedimentation and other effects of urbanization have caused extensive damage to coral reefs and benthic habitat near the populated islands.

Fishing gear types that are primarily used to target inshore and coastal pelagic species accounted for about 10% (1.5 million lb) of the mean annual commercial fish catch in the State of Hawaii during the 1990-1995 period. The recreational and subsistence catches are not reported in Hawaii, but creel surveys at Kaneohe, Hanalei and Hilo Bays suggest that the total inshore catch from reef areas are at least equivalent and may be two or three times greater than the reported commercial catch (Friedlander, 1996).

The majority of the total commercial catch of inshore fishes, invertebrates and seaweed comes from nearshore reef areas around the main Hawaiian Islands. The exceptions are crustaceans, with over 90% of the spiny lobster landings from the NWHI and over 50% of Kona crab landings from the Penguin Bank. Nearshore reefs in the MHI are also the focus for commercial reef ornamentals harvesting and black coral collecting (Friedlander, 1996).

The collection of black coral from depths of 30 to 100 m by SCUBA divers has continued in Hawaii since black coral beds were discovered off Lahaina, Maui, in the late 1950s, although harvest levels have fluctuated with changes in demand. Since 1980, virtually all of the black coral harvested around the Hawaiian Islands has been taken from the bed located in the Auau Channel. Most of the harvest has come from State of Hawaii waters and no black coral diver has ever received a federal permit to harvest precious coral in the EEZ. However, a substantial portion of the black coral bed in the Auau Channel is located in the EEZ. Recently, the demand for small, immature black coral colonies has increased with the growing popularity of household marine aquaria. In 1999, concern about the potential for greater harvesting pressure on the black coral resources led the State of Hawaii to prohibit the take of black coral with a base diameter of less than 3/4 inches from state waters. The Council has recommended that a minimum size limit also be established for black coral harvested in the EEZ (WPRFMC 1999).

After two decades of minimal activity, the domestic fishery for pink, gold and bamboo precious corals in the EEZ of Hawaii resumed in December 1999. One company utilizes two one-manned submersibles to survey and harvest the resource at depths between 400-1,500 m. These technologically advanced devices are capable of diving to 2,000 feet with a maximum bottom time of six hours. To date, surveys and harvesting have only occurred around two of the seven known beds between the islands of Oahu and Hawaii. The company has plans to survey the NWHI as well as other locations in the MHI for additional beds.

The deep-slope bottomfish fishery in Hawaii concentrates on species of eteline snappers, carangids and a single species of grouper concentrated at depths of 30-150 fm. The fishery can be divided into two geographical areas: the inhabited main Hawaiian Islands (MHI) with their surrounding reefs and offshore banks; and the NWHI. In the MHI approximately 80% of the bottomfish habitat lies in state waters. Bottomfish fishing grounds within federal waters include Middle Bank, most of Penguin Bank and approximately 45 nm of 100-fathom bottomfish habitat in the Maui-Lanai-Molokai complex. For management purposes the NWHI fishery has been separated into the Mau Zone, closer to the MHI, and the Ho'omalu Zone.

Historically, Penguin Bank is also one of the most important bottomfish fishing grounds in the MHI, as it is the most extensive shallow shelf area in the MHI and within easy reach of major population centers. Penguin Bank is particularly important for the MHI catch of uku, one of the few bottomfish species available in substantial quantities to Hawaii consumers during summer months. A comparison of the percentage of the total commercial landings of five major bottomfish species in the MHI represented by Penguin Bank from 1980 to1984 and 1991 to 1995 shows that the bank has increased in importance over the years.

Average percentage of total MHI commercial catch and average commercial catch of major bottomfish species harvested from Penguin Bank.			
	Average annual percent of total MHI catch		Average annual catch (lbs.)
	1980-1984	1991-1995	1997-1999
Opakapaka	9.63	16.11	20,609
Uku	12.06	44.04	28,785
Onaga	14.87	20.24	9,277
Ehu	12.15	17.60	3,380
Hapuupuu	4.31	6.64	905
Sources: WPRFMC (1996); HDAR (2000)			

For the period 1991 to 1995, 8% of the licensed commercial fishermen who participated in the MHI bottomfish fishery reported catches from Penguin Bank (WPRFMC 1996). Penguin Bank is also a popular bottomfish fishing ground for recreational anglers (Friedlander, 1996). However, the magnitude of the recreational landings is unknown.

Surveys of the NWHI indicate that coral reefs are in good condition with high standing stocks of many reef fish. Nearshore coral reefs receive little human use because of their remoteness, exposure to harsh seasonal ocean conditions and their protected status as part of a national wildlife refuge. Most of the shallow reefs of the NWHI lie within the boundaries of the Hawaiian Islands National Wildlife Refuge, where access and resource use is controlled by special permit. Some recreational fishing is done by occasional visitors, including federal government personnel and contract workers at Midway (Graham, 1999). Public access to the NWHI has been improved by the establishment of an eco-tourism operation in the Midway Atoll National Wildlife Refuge.

Two domestic commercial fisheries (lobster trapping, bottomfish hook-and-line) have operated in the NWHI for several decades. Both fisheries are presently managed by the Council under limited access programs with fixed numbers of permits. The lobster trap fishery is also subject to a harvest quota that is set annually at 13% of the Maximum Sustainable Yield (MSY). The lobster fishery in the NWHI is one of the most intensively managed fisheries within the US EEZ. Conservative measures are in place to reduce the risk of overfishing, and to prevent interaction with protected species. The lobster fishery is managed with a low fishing mortality, which is spread across a wide geographic region. There is some uncertainty however, regarding the population structure of the lobster population in the region as a whole, and the magnitude of oceanographic changes on the recruitment dynamics of the population.

Spiny and slipper lobsters are harvested at many banks and on reefs deeper than 10 fathoms. The lobster trap fishery makes incidental catches of octopus and hermit crabs. The incidental catch of reef fish is minimal because the lobster traps have escape vents. Bank-by-bank allocation of the 1999 harvest guideline caused permit holders in the lobster trap fishery to distribute effort into new trapping sites, including some areas where retrieval of trap lines may damage live coral. Commercial trolling for ono occurs seasonally in some areas of the NWHI. For a short period in 1999, experimental fishing for coastal sharks was permitted. Many of the shallow reefs are in the NWHI are within the national wildlife refuge and will likely remain off limits to fishing. Documented and potential fisheries interactions with protected species in the NWHI are discussed in the document.

There is a long history of fishing in the NWHI. Iverson, et al. (1990) found ample evidence of a long history of fishing by the ancient Hawaiians as far northwest as Necker Island. Starting in the 1920s, a handful of commercial boats ventured into the NWHI to fish for shallow and deepwater bottomfish, spiny lobsters and other reef and inshore species (Iverson, et al., 1990). Black-lipped pearl oysters at Pearl and Hermes Reef in the NWHI were overfished in the late 1920s and recent surveys indicate that stocks have still not recovered due to lack of suitable habitat (i.e., oyster shells) (Green, 1997).

For about ten years, from the late 1940s to the late 1950s, there was a fishery for akule and reef fish around French Frigate Shoals and Nihoa Island, with the catch flown from the former to Honolulu. By the mid-1950s, vessel losses and depressed fish prices from large catches reduced the number of fishermen in the NWHI and by the 1960s, only one vessel remained in operation in the area (Iverson, et al., 1990).

During the 1960s and as recently as 1978, Asian fleets harvested tuna, billfish, precious corals and groundfish in and around the NWHI using longliners, pole-and-line vessels, draggers and trawlers. Foreign fleets were not excluded from the 200-mile zone surrounding the islands until after the Fishery Conservation and Management Act was signed into law in 1976 and the Council began developing management plans for domestic fisheries in 1978. Even so, over the two decades from 1965 to the late 1980s, dozens of foreign vessels intermittently and illegally harvested precious corals in the waters around the NWHI, causing major destruction of deepwater habitat by using tangle-net bottom dredges (Grigg, 1993)

There was renewed interest in the fisheries resources of the NWHI in the mid-1970s, when state and federal agencies collaborated in a study focusing on this region (Haight, et al., 1993). A fishery for deepslope bottomfish grew rapidly from the early 1980s until the late 1980s, with a peak of 27 vessels in 1987. It quickly declined after 1988, when the Council adopted a limited access system for areas northwest of Necker Island. In 1997, there were 14 vessels active in the NWHI bottomfish fishery (WPRFMC, 1998b). Currently, there are 17 limited entry permits for the bottomfishing in the NWHI. Ten permits are allowed in the nearer Mau Zone bottomfish fishery aroun Nihoa and Necker Islands and seven permits for the farther Ho`omalu Zone. The NWHI lobster fishery, centered around Necker Island, underwent a similar evolution. It developed in the late 1970s, reached a peak of 16 vessels in 1985-86 and subsequently declined, with 9 vessels active in 1997 (of 15 permitted under a limited access system adopted by the Council) (Pooley and Kawamoto, 1998).

Since 1996, there has been limited eco-tourism and public use within the Midway Atoll National Wildlife Refuge in the form of charter fishing, diving and wildlife observation. Midway Phoenix Corporation's agreement with the USFWS allows 100 visitors to enjoy the atoll per week. The most common way for visitors to access the Midway Atoll National Wildlife Refuge is by air service from Honolulu. The privately-owned company advertises wildlife tours that let visitors "gain first hand knowledge of the albatross, resident seabirds, migrant shorebirds, threatened green turtles and endangered Hawaiian monk seals" (Midway Phoenix Corporation, undated). Additional outdoor recreational activities for the public are suggested in the Public Use Plan for the Refuge and may be offered to visitors in the future (USFWS, 1997). Among these activities are shoreline fishing, lobstering, night diving, night fishing, kayaking tours and glass-bottom boat excursions.

The most serious problems in the NWHI at present are accumulation of marine debris and vessel groundings and oil spills. Most of the debris is derelict gear lost from North Pacific fisheries. In addition to the physical damage to coral reefs, the debris entangles protected species, ghost fishes and may introduce alien marine species (Green, 1997). Dredging, filling and contamination by the release of toxins from dumped transformers are significant impacts associated with prior military occupation at Kure Atoll, Midway Islands and French Frigate Shoals (Green, 1997).

Commonwealth of the Northern Mariana Islands

Prior to World War II, the Japanese exploited many coral reef resources (sea cucumbers, top shells, precious corals) in the Japanese Mandated Islands, which included the present Commonwealth of the Northern Mariana Islands. Commercial fisheries for trochus and sea cucumbers were re-opened during the mid-1990s for the first time in recent history. Over an 18-month period in 1995-1996, 268,000 sea cucumbers were collected (Green, 1997). Sea turtles are a traditional food.

It is difficult to assess the total harvest of present-day coral reef fisheries in the CNMI because of shortcomings in fisheries statistics. Virtually no recent information is available for inshore subsistence and recreational catches of coral reef resources. This harvest is assumed to be substantial, especially in the more accessible areas like Saipan Lagoon. Coral reef fisheries in the CNMI are mostly limited to near shore areas, especially off the islands of Saipan, Rota and Tinian. Finfish and invertebrates are the primary targets but small quantities of seaweed are also taken. All of the recent data analyzed are only for commercial landings: 62 - 80mt/year of reef fish and 1 - 1.5 mt/year of spiny lobster. An unknown proportion of the bottomfish landings in the CNMI are shallow-water snappers, emperors and groupers which may be considered part of the coral reef fishery (Green, 1997).

Little is known of the coral reef fisheries in the northern islands of CNMI but the catch by domestic fishermen is believed to be minor. The exception was in 1995, when the near shore reefs around six of the northern islands (especially Anatahan and Sarigan) were fished commercially for several months. During that time, these areas yielded a harvest of 15 mt of reef fish and 380 pieces of spiny lobster. Poaching by foreign fishing boats may occur in some places (Green, 1997).

Coral reefs near some heavily populated areas in the southern islands of the CNMI have been degraded by heavy fishing, sedimentation and tourist recreation (Green, 1997). Limited information suggests that most of the nearshore reefs elsewhere in the CNMI are in good condition. Reefs off the southern islands experienced a massive starfish outbreak in late 1960s but corals recovered rapidly from this disturbance. Reefs around the northern islands are in good condition because of their isolation from human activities. Localized areas may have been damaged by storm waves, volcanic eruptions or military activities (e.g., Pagan, FDM) (Birkeland, 1997c; Green, 1997).

Virtually nothing is known about the condition of offshore reefs but they are assumed to be in good condition because of their isolation. Offshore reefs generally receive little fishing pressure because of the limited range of the small-boat fishery. The exceptions are banks that are relatively close to the main islands (e.g., Esmeralda) and the extensive bank off Farallon de Medinilla, where a fishery for shallow-water bottomfish is conducted by small boats.

Remote US Pacific Islands

Little is known about the present status of coral reefs in most of the remote US island possessions, although anecdotal reports suggest that they are mostly in good condition. Localized impacts on coral reefs have occurred due to coastal construction and pollution on some islands occupied by the US military. Hurricanes and starfish infestation have occasionally affected some areas.

Fishing is light in most areas. Hawaii-based vessels make sporadic commercial fishing trips to Palmyra and Kingman Reef for bottom fishing, harvesting coastal sharks for finning and possibly aquarium fish collecting. The past extent of harvesting by passing yachts or poaching by foreign fishing vessels in unknown (Green, 1997).

There are no permanent residents on any of these islands, although on Wake and Johnston, there are temporary work forces who have a long history of recreational fishing and shell collecting. The fishery at Johnston Atoll was described over a six-year period (1985–1990), based on the results of a creel census by Irons, et al. (1990). Irons, et al. (1990) found that the majority of fishing activity and a large proportion of the catch were generated by long-term ‘residents’ —almost all employees of the prime contractor for Johnston Atoll operations. These residents fished for enjoyment, to add fresh fish to their diet and to accumulate fish to take home on leave. The remainder of the catch was harvested by ‘transients,’ personnel (military and contractors) stationed on the island for one or two years.

Irons et al. (1990) reported that the soldierfish Myrispristis amaenus comprised the largest proportion of catch of reef fishes at Johnston (see Table 72 in Green, 1997). Other important fish species included bigeyes (Priacanthus cruentatus), flagtails (Kuhlia marginata), mullet (Chaenomugil leuciscus), goatfishes (Mulloides flavolineatus, Pseudupeneus bifasciatus, P. cyclostomus and P.

multifasciatus), jacks (Caranx melampygus and Carangoides orthogrammus), parrotfish (Scarus perspicillatus), surgeonfishes (Acanthurus triostegus and Ctenochaetus strigosus) and bigeye scad (Selar crumenophthalmus). Gear types varied with the target species and included hook-and-line fishing, spearfishing and throw nets. All of the more heavily fished areas at Johnston are located in nearshore waters. Irons, et al. (1990) also noted that recreational divers at Johnston collected pieces of coral for souvenirs. Acropora cytherea and the red coral Distichopora violacea were the two main species collected, although smaller quantities of Acropora valida, Millepora and Fungia were also collected.

The original Johnston Atoll has been extensively modified by dredging and filling. An estimated 4 million square meters of coral were destroyed by construction and an additional 25 million square meters were damaged by the resulting sedimentation. By 1964, dredge and fill operations had enlarged the original island by over tenfold and had added two manmade islands.

Fishing regulations have changed at Johnston Atoll in recent years because of concerns that fish were being exported and that coral collecting had become excessive and was incompatible with the philosophy of the refuge (B. Flint, pers. comm., in Green 1997). Current DOI regulations prohibit coral collecting and the export of any reef fish or invertebrates from the island. However, collection of selective organisms and shells is permitted in restricted areas by recreational divers. Since Johnston is a closed military base, only local residents partake in such activities. No recent fisheries statistics are available for the area.

National wildlife refuges (NWR) have been established at Baker, Howland and Jarvis Islands and at Johnston Atoll. Natural resources are managed by the US Fish and Wildlife Service and access is by special permit only. Palmyra Atoll and Kingman Reef and Wake Atoll are candidates for NWR status.

3.5 Description of Fishing Gear Used and Associated Bycatch

Existing Bycatch Management Measures

Although the Council's existing FMPs do not specifically address coral reef fisheries, there are aspects of these plans and their amendments which may have an influence on coral reef fishery bycatch and on the potential for reporting bycatch. The bottomfish FMP prohibits certain destructive fishing techniques, including explosives, poisons, trawl nets and bottom-set gillnets, all of which have the capacity to generate high levels of bycatch, especially the use of trawl nets. The bottomfish FMP's framework provisions have the potential to regulate the level of bottomfishing and hence the volume of bycatch, while the permit and reporting system for bottomfish fisheries in the NWHI permits the reporting of catch and discards.

The Crustaceans FMP, adopted in 1983, included a minimum size limit for spiny lobster in the NWHI trap fishery, with a minimum size for and slipper lobsters implemented later under Amendment 5, ban on egg-bearing females and mandatory logbook program. Bycatch from the NWHI fishery initially included regulatory discards of undersized or egg-bearing females, while the logbook program provided means to monitor the bycatch of target species. Amendment 9 to the FMP implemented a retain-all fishery, thus minimizing the volume of undersized or egg-bearing female discards. Some discarding was believed to take place through high grading, but subsequent observer records from the fishery showed this was minimal. A large range of coral reef fishes and invertebrates can be taken potentially in the lobster traps, but the use of escapement panels in the trap minimizes the retention of other non-target species. A limited entry program implemented through Amendment 7 to the FMP and the establishment of an annual harvest guideline for the NWHI fishery also act to minimize the catch volume and the associated bycatch

Fishing targeting highly migratory species rarely interacts with reef fishes, however, some of the provisions of the FMP and amendments have tangentially influenced potential bycatch from coral reefs. The FMP management unit contains four shark families, Alopiidae, Lamnidae, Sphyrnidae and Carcharhinidae, which include many inshore shark species found on and around coral reefs. The FMP contains a ban on the use of drift gillnets which can take large numbers of sharks, some of them found in the coastal zone on and around coral reefs (e.g. tiger sharks, Galapagos sharks, hammerheads etc). The FMP also established a 50 nm longline closed areas around the NWHI and a 50-75 nm closed area around the MHI, which also reduced the potential for longliners to catch sharks associated with near shore areas and coral reefs. Lastly, the FMP was used specifically to implement a ban in federal waters of bottom set longline fishing to target coastal shark species included in the management unit (Amendment 9). Amendment 2 of the FMP implemented a log book program which included provision for catch and discards, including shark species.

Coral Reef Bycatch

All gears used to catch coral reef species are essentially artisanal in nature, with minimal catch rates, usually in only a few pounds per man-hour or other unit of effort. Large catches from coral reefs only result as a function of number of individuals participating in fishing, i.e. group fishing activity such as driven-in-net fishing or group spear fishing. Bycatch from coral reef fishing is in most cases extremely small as almost all reef fish taken are eaten.

Discards in the Pacific Islands ,where they occur, are usually associated with customary taboos, such as avoidance of near shore copraphageous scavengers such as surf perches (Theraponidae), fishes customarily associated with individual human genders such as moorish idols (Zanclidae), fishes commonly associated with ichthyotoxins such as puffers, toad and porcupine fishes (Tetraodontidae, Diodontidae) or ichthyosarcotoxicity (ciguatoxins and related toxins) such as the snapper Lutjanus bohar, surgeon fish Ctenochaetus spp, moray eels (Muraenidae), groupers (Serranidae), amberjack (Seriola dumerilli) and barracuda (Sphyraenidae). Reef fish preference is also strongly influenced by urbanization such that many city dwellers of native populations will eat a narrower range of reef fish than people in traditional villages. In Guam, triggerfish, butterflyfish angelfish and damselfish are typically rejected as being too boney with not enough meat, while in other rural locations in Micronesia these species are readily consumed. Some reef fish in Hawaii state waters are also subject to minimum size and weight restrictions for sale or for capture by spearfishing. These include species of parrotfish, goatfish, jacks, surgeonfish, mullet, milkfish and threadfins.

A wide range of invertebrates are consumed by people living in the Western Pacific Region. Titcomb (1978) catalogs and extensive list of invertebrates used by Native Hawaiians including many types of crustaceans, sea cucumbers, sea urchins sponges, corals and various marine worms. In the Samoan Islands, the annual appearance of the gonadal stages of the marine polychaete worm, or “palolo” is awaited with great anticipation as this is regarded as a delicacy (Itano 1988). Some traditionally consumed marine invertebrates may be avoided by some people in the Western Pacific, particularly as dietary habits become more westernized. Also, some religions such as the Seventh Day Adventist faith follow diet similar to the Jews and avoid pork and shellfish. Inadvertent catches of shellfish would likely be discarded by Adventist and be included as bycatch.

Hook and Line Catches

Hook and line catches generally target carnivorous species of fish although herbivores can be enticed to take baited hooks. Catch and selectivity of hook and line gear is a function of hook size, bait used and the depth fished. Hook size and bait can select for size, with larger hooks and harder baits tending to catch larger fish. Similarly, fish size tends to increase with depth on the reef slope, although species diversity tends to decrease. Fishermen may use combinations of these factors to sharpen the focus of their fishing, particularly on the deep reef slope targeting bottomfish.

Association with ciguatera is the reason that large catches of the amberjack Seriola dumerilii are discarded from deep slope bottomfish catches in the NWHI. Sale of this species is prohibited in Hawaii due to the association with ciguatera. However, bottomfish fishermen catching the amberjack will deliberately kill it so it is not taken again, rather than release it alive. Some small amount of amberjack may be retained for use as bait in crab pots. The other major discard in this fishery is the thick-lipped trevally or butaguchi (Pseudocaranx dentex) which has a fairly short shelf life and commands a low price in local markets and is therefore often discarded in the early days of a trip to avoid losing room for more valuable fishes.

Spearfishing

Underwater fishing with spearguns, either with SCUBA or snorkels is extremely selective, since the act of capture involves a deliberate choice of target. Bycatch is likely to be restricted to speared fish that escape with minor wounds. Spear fishing tends to select by size with bias towards larger sized fish and larger sizes in a given species (Dalzell 1996). Catch composition may also be different between day and night when different groups of fish are active or sedentary. Night divers can take advantage of the sleeping habits of some parrotfish to cluster in “dormitories” on the reef and therefore be especially vulnerable to spearing.

Hawaiian spearfish catches are dominated by parrotfish, surgeonfish, octopus and squirrelfish. In areas with greater reef fish diversity, such as Guam, spearfish catches are still mainly dominated by surgeonfish, parrotfish, with other common families such as rabbitfish, emperors, snappers and jacks also contributing to catches.

Fish Traps

Fish trapping for finfish is not widely practiced in the Western Pacific Region, and is only conducted with any frequency in Hawaii. Traps like nets take a large random assortment of different species and probably reflect the proportions of different species groups on coral reefs. Surgeonfish markedly dominate catches in Hawaii, comprising 31 % of commercial landings, and are comparable to reef fish catches in traps elsewhere in the Pacific (Dalzell 1996).

The main commercial trap fishery on coral reef in Hawaii is for spiny and slipper lobster in the NWHI, rather than for reef fish. The fortunes of this fishery have waxed and waned over two decades, with catches in excess of a million lobsters annually in the 1980s, but with much more modest catches of between 100,000-300,000 lobsters in the late 1990s. The lobster traps also catch a wide range of other coral reef species, mainly reef fish and reef crustaceans. In the initial years of the fishery, large volumes of octopus were also caught and kept but octopus catches dropped off to negligible amounts by the 1990s. The lobster traps are two piece plastic halves joined with pins that will dissolve in seawater to prevent ghost fishing by lost traps. They also have a series of small holes in the trap walls to allow undersized lobster and other small bycatch species to escape.

Selection effects in traps are a function of the soak time, mesh size and materials used to construct the traps, trap design, and the depth and position of the set. Traps set in relatively shallow water with little or no bait will generally maximize catches within 4-5 days. Traps baited with fish such as aku or sardines and set on deep reef slopes may catch sizeable quantities of fish in a matter of hours rather than days, but the composition is very different reflecting the generally large highly mobile carnivore complex of the deep reef slope. Lost traps may become a problem through ghost fishing, although eventually ingress and egress from the traps reaches an equilibrium. As with the lobster traps, seawater-degradable pins or panels can be built into traps so that they lose their ability to hold fish.

Nets

Three fishing gears predominate in Pacific Island coral reefs and lagoons, namely hook and lines or handlines, spearguns and gillnets. The main feature of gillnet catches in Hawaii is the bigeye scad or akule. Other dominant species include surgeonfish, snappers, goatfish and rudderfish. Goatfish, surgeonfish, parrotfish and siganids are dominant features of gillnet catches in Guam. There are differences between night and day gillnet catches with some nocturnally active species such as slipmouths comprising part of night gillnet sets.

Selection in gillnets with smooth fusiform or cigar shaped fish tends towards a normal curve with lower and upper size limits depending on mesh size. Spiny fishes may be very vulnerable to gillnet catches regardless of mesh size through tangling. Seasons can also influence gillnet catches with fish becoming more vulnerable in spawning season as their girth increases with gonad development and spawning changes behavior (Ehrhardt & Die 1988). The selection effects of gillnets are further complicated by the type of material used, the hanging ratio or measure of meshes per unit of length, the way the net is deployed on a reef, the time of day set, and length of soak. Where gillnets are not checked regularly, then bycatch may result through negligence as catches build up in the net but are not removed, and are either preyed on or rot and become unsaleable..

Seine nets are actively deployed around schools of fish as opposed to gillnets, which like fish traps are a passive gear. Beach seines, as the name implies are set in an arc from the beach with both wings drawn together on the beach and hauled to concentrate the fish in the head of the net, from where they can be bucketed ashore. Seine nets can also be used for drive-in-net or muro-ami fishing, where a barrier net is set in the lagoon or on a reef, and fish driven with scare lines into the apex of the net which is then closed to catch the fish. Bycatch from this type of fishing is again largely relative, depending on whether people are largely urbanized and used to a eating a narrow range of reef fish, or whether they rely greatly for subsistence on fishing and eat a broader range of fish.

Surround seines can also be set on open schools in a lagoon the same manner as a beach seine. This method of fishing is employed in Hawaii to catch big-eye scad or akule, schools of which are located by spotting from light aircraft. This method of fishing is extremely selective, bycatch can result as not all the school will be retained for capture and excess fish will be released. In such cases the release of fish is commendable since they are not wasted as dead bycatch.

Lastly, cast or throw nets are also common in parts of the Pacific, where fishermen want to make modest catches, usually of small nearshore schooling reef species. These catches are taken mainly for subsistence and fishermen will select and stalk on foot schools of fish such as surgeonfish, herrings, rabbitfish and mullets in the hope of obtaining a catch (Dalzell 1996). As with spearfishing, there is a high degree of selectivity in the target catch such that bycatch is negligible.

Bycatch Reduction

It is important to understand that virtually all coral reef fisheries production in the Western Pacific comes from state or territorial waters and not from waters under federal control. Consequently, It might be argued that there is no bycatch problem for coral reef fisheries under federal control. However, under the Magnuson Stevens Act there is no threshold at which bycatch becomes acceptable. In which case whatever the level of bycatch present, the Council is duty bound to attempt to reduce this further, where practicable.

The focusing of fishing gear to catch only the target species is difficult if not impossible for the simple gears deployed on coral reefs. Very specialized gears such as kites and spider-web lures to catch garfish are employed in the Pacific Islands, including those of the Western Pacific, but many of the other gears which are universally employed will invariably take species which are not universally welcomed as eating fish. Trianni (M. Trianni, Department of Natural Resources, Saipan, pers comm.) suggests that in the Marianas, the red snapper L. bohar, groupers of the genus Variola and Cephalopholis, jacks and large barracuda are avoided due to ciguatera. Similarly, more or less the same species are avoided for the same reason in American Samoa. In Hawaii, as mentioned earlier, major bycatch species in the deep-slope handline catches are the amberjack and thick-lipped trevally, for health and safety reasons, and economic discards respectively.

Incentives to reduce bycatch are limited. People will not eat suspected ciguatoxic fish and may regard any attempts to subvert taboos on other species as cultural insensitivity. The basic nature of coral reef fisheries are composed of many fishers and small vessels without observer programs. This limits how enforceable any regulations would be that required a "take-all fishery" to eliminate bycatch. Further, where fish are suspected of being ciguatoxic, then prudence dictates that catches should continue to be discarded. Ciguatera test kits do exist but these are relatively costly and are for amateur fishermen wishing to test individual catches, and not a test that can be applied wholesale on a cost effective basis to even a modest commercial reef fish catch.

Regulations and incentives may be best addressed to those gears which have the potential to generate the most bycatch. This would include mainly passive gears such as traps and gillnets. Fish traps may be regulated by varying mesh size to exclude small undersized or non-target species, or by including escapement vents for the same purpose. As mentioned earlier, some form of degradable panel or fastening may be employed to open traps after a given amount of time so ghost fishing is minimized when traps are lost. Limits might also be placed on the numbers of traps that an individual be allowed to set, and a maximum soak time may also implemented to reduce unnecessary loss of fish in traps left during long sets. Similarly, gillnets can be regulated not only by mesh size, but by length of net and duration of soak time.

Education campaigns might be run to advise fishermen to be aware of bycatch as an issue and to avoid damaging fish that must be returned to the sea. Where fish have suffered as a result of raising them from depth, fishermen may be convinced to return fish by first deflating distended swim bladders. Similarly, greater care and attention to releasing fish from the common gears may minimize release mortality. Use of circle hooks for example to hook in the mouth rather than the stomach or gills of fish could effectively reduce bycatch mortality of discarded handline caught fish. Trap caught reef fishes can also be returned to the sea in good condition if handled appropriately with gloves and rapidly removed from the traps with minimal trauma.

It is difficult however to conceive of ways in which speared fish can be safely released without trauma although it has been used successfully in some reef fish tagging experiments (Robertson et al 1979). Further, the selection by fishermen of fish to spear should minimize most bycatch in spearfishing. More difficult are gillnets and other seines where fish are gilled or tangled and release without serious damage is just not feasible. Otherwise there is very little direct action that can be taken to minimize bycatch.

Reef Fish Bycatch Data

Data on bycatch in the Western Pacific has recently begun to be collected in the three Territories as part of the creel surveys being conducted on a routine basis under the WPacFIN program. Members agreed at recent Council Plan Team meetings that the most critical and plausible information to collect on bycatch during creel surreys was species identification, number of fish discarded and wether alive or dead/injured. The overall coverage rates of these surveys and the experience of the personnel involved is sufficient to achieve good estimates of bycatch species and bycatch rates in most fisheries. Voluntary observer programs are also being discussed to obtain more reliable estimates from certain sectors such as the charter bottomfish fishery.

In Hawaii the main commercial catch data base does not in general contain discard data except for the NWHI bottomfish catch. This fishery has also been monitored in the past by observers. However, creel surveys, initially focused on shore line catches on the Big Island of Hawaii, are being expanded to Maui and will include boat landings also. The surveys will include questions on discards in common with those in the Territories, and there are plans to seek funding to spread the surveys further to the entire MHI archipelago.

Finally, it should be clearly understood that most of the foregoing uses data on reef fish catches in state or territorial waters. Coral reef fish catches in Council controlled federal waters are relatively small, and hence the bycatch volume is negligible. Nevertheless, the foregoing deals with the nature and likely scale of bycatch in reef fisheries in the Western Pacific and examines likely ways in which this can be reduced. The main conclusion is that regulatory action would not be enforceable and therefore meaningless and more might be achieved by raising fishermen's awareness of the need to minimize discard volume and mortality, although these ethics are usually intrinsic in traditional Pacific Island societies as well part of NMFS promotion of ethical awareness for fishermen, particularly in the recreational sector.

3.6 Description of Fishing Communities

The Magnuson-Stevens Act requires that FMPs take into account the importance of fishery resources to fishing communities in order to (a) provide for the sustained participation of such communities and (b) to the extent practicable, minimize adverse economic impacts on them.

A community results from webs of social interaction that people create by taking advantage of shared cultural understandings and identities. Fishing communities in the US Pacific islands are based on shared participation in fishing-related activities that occur over larger geographical scales than single villages or towns. At least one-third of the resident population of the US Pacific islands participates in some level of fishing and all towns and villages include some proportion of residents who are part-time fishermen. Fishermen from one town travel to other parts of the island and between islands to visit family and friends. Fishing is one of the most common shared activities at such gatherings. Fishermen frequently trailer small boats from one side of an island to the other to take advantage of seasonal fish availability and weather conditions. Fishing cooperatives in the US Pacific islands have island-wide memberships and seafood markets are supplied by widespread on- and off-island harvesters. The technology, customs, terminology, attitudes and values related to fishing are thus shared on an island-wide and inter-island scale.

The US Pacific islands vary significantly in land area, population levels and the size of their associated EEZs. They have had significantly different courses of political development and historical relationships with the USA but they share a common economic and social dependence on marine fisheries, especially coral reef resources. This dependence traces back thousands of years, when the islands were first settled by sea-faring peoples. Their dependence on fishing for food security shaped the social organization, cultural values and spiritual beliefs of the indigenous cultures. Contemporary island societies are pluralistic in population and culture and few people depend solely on fish catches for protein. Most residents still have daily interactions with the ocean to obtain food, recreation, income and other benefits which contribute to the high quality of island life.

3.6.1 Local Fishing Communities

For the purposes of the Coral Reef Ecosystems FMP there are no communities substantially engaged in or substantially dependent on the harvesting and processing of coral reef resources from the EEZ. Furthermore, there are no coral reef resources being harvested in the Northwestern Hawaiian Islands. Bottomfish and crustaceans are listed as MUS in the CREFMP for consultation purposes and are managed under their respective FMPs. There are coral reef species being harvested in the EEZ of the main Hawaiian Islands at Penguin Banks in the EEZ. These species are harvested by the bottomfishing fleet primarily from the islands of Maui, Moloka`i and O`ahu. This activity involves hundreds of boats from all over the state harvesting over 15 species of non-BMUS reef species at Penguin Banks within the federal zone. A very small portion of these boats harvesting coral reef resources are commercial vessels. Interpretation and data analysis about this activity is lacking and new research must be conducted to assess the impact of this fishing activity.

The Coral Reef Ecosystems FMP is a proactive measure. However, there is a potential for the utilization of these coral reef resources in the EEZ by communities in the Western Pacific Region. It is this potential that is addressed by the discussion of communities. The communities of Guam, Commonwealth of Northern Mariana Islands and American Samoa are geographically segregated on an island by island basis. Each island's culture has developed utilization of coral reef resources and could potentially impact the coral reef resources in the EEZ. The State of Hawaii is divided into 18 communities based upon access opportunities available for residents' harvest of coral reef resources. Three communities in the Pacific Remote Island Areas are also described.

There are a few rural villages in Hawaii where most of residents are at least partially economically dependent on fishing (Glazier, 1999). In general, those who are dependent on or engaged in the harvest of fishery resources to meet social and economic needs do not comprise entire cities or towns, but rather subpopulations of metropolitan areas and towns. These subpopulations comprise fishing communities in the sense of social groups whose members share similar lifestyles associated with fishing.

It is important to note that without a voting member of Congress and the inability to vote in a national election, the U.S. territories of American Samoa, Guam and the Commonwealth of the Northern Mariana Islands depend upon their participation in the Western Pacific Region Fishery Management Council to influence the coordination and management of their fishery resources.

Major Geographic, Demographic and Economic Characteristics of American Samoa, Guam, Hawaii and the Commonwealth of the Northern Mariana Islands.

TERRITORY	POPULATION	LAND AREA	REEF AREA	NOTABLE CHARACTERISTICS	DISTANCE FROM CAPITAL	GDP (Millions US$)
GUAM	163,373 (47% Indigenous)	212 sq. mi.	179 sq. mi.	One island, major US naval base, regional transshipment center at Apra. In Typhoon path.	Agana/Honolulu 3,800 miles Agana/Tokyo 1,600 miles Agana/Washington, DC 8,600 miles.	3,065.80
COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS	69,398 (29% Indigenous)	177 sq. mi.	579 sq. mi.	Saipan largest island, Tinian Rota, 14 others, 125 miles north of Guam. US territory closest to Asia	Garapan/Honolulu 3,700 mi. Garapan/Tokyo 1,500 miles Garapan/Washington 8,500 mi	664.6
AMERICAN SAMOA	63,786 (89% Indigenous)	76 sq. mi.	296 sq. mi.	5 islands, 2 atolls, Pago Pago Harbor. Newest US national park in hurricane path.	Pago Pago/Honolulu 2,600 Pago Pago/Washington 7,400 miles	253
HAWAII	1,205,126 (19% Indigenous)	6,423 sq. mi.	2,535 sq. mi.-Main Hawaiian islands, 11,535 sq. mi.-NWHI	4 main islands - Hawaii, 4,028 sq. mi., Maui, 727 sq. mi., Oahu, 597 sq. mi., Kauai, 552 sq. mi. In hurricane path.	Honolulu/Tokyo 2,500 miles Honolulu/Los Angeles 2,600 miles Honolulu/Washington 4,800 miles	35,146.40

TERRITORY	GDP PER CAPITA	MAJOR INCOME SOURCES	POLITICAL STATUS	MAJOR INVESTMENT SOURCES
GUAM	18,766	Tourism, military, trade and services.	US territory since 1898, 1950-Guam Organic Act conferred US citizenship in US national elections. Organic Act never ratified by Guam referendum.	US, Japan, Korea
COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS	8,367	Tourism, garment manufacture, trade and services.	After WWI under Japanese Mandate. 1947-became US Trust territory of the Pacific. 1978-Commonwealth. Islanders are US citizens but do not vote in US elections	Japan, Korea, Hong Kong, US.
AMERICAN SAMOA	4,295	Tuna canneries, government services, remittances from Samoans overseas.	US territory since 1899, Samoans are US citizens but do not vote in US elections	US
HAWAII	29,164	Tourism, services,	Kingdom overthrown by American businessmen,1893. Annexed in 1898 by "Newlands Resolution." Organic Act in 1900 creates US Territory. 1959-Admissions Act creates State of Hawaii.	US, Japan, Australia.

American Samoa

American Samoa has a land area of 77.3 square miles on a total of 7 islands and islets and has an estimated population of 56,350. The main island of Tutuila covers 54.2 square miles and some 96 percent of the population resides there, with a population density of 998 persons/square mile. Four other islands are high, volcanic islands and are inhabited. Two coral atolls complete the territory.

American Samoa's history is not different from the history of the rest of Samoa until the end of the 19th century when the islands were ceded to the United States. For the purposes of the CREFMP, the inhabited islands in American Samoa will be considered a geographically discrete fishing community.

American Samoa is the only U.S. territory which lies south of the equator, and is located in Polynesian archipelago. Some 89 percent of the population is of Samoan descent and the Samoan language is spoken commonly in the territory. The population is increasing, with the main growth occurring on Tutuila Island. This population growth reflects improved health and living conditions as well as migration of Samoans from the western islands to American Samoa.

Nearly all land in American Samoa is communally held with a matai or higher chiefly title assigned to the person who allocates use and manages the land and its resources for the Aiga, the Samoan extended family. Following Fa a Samoa, (Samoan native usage and custom) the village chiefs may individually or collectively assert control over shorelines adjacent reefs and nearshore waters through their Pulenuu, A government appointed village spokesperson and chief. Villages may thus limit fishing to village residents, prohibit the taking of certain species, or otherwise assert customary regulation over coral reef resources.Nearly all the land area of American Samoa is assigned to a village. The villages are based on traditional communities which regulate the use and occupancy of land and marine areas by Samoan native usage and custom. The villages are nested in 14 districts, each with its own chief and council.

1990 U.S. Bureau of Census Data for American Samoa

	Population (n)	Population (%)	Land Area (sq. miles)	Land Area (%)
American Samoa	**46, 773**	**100.0**	**77.3**	**100.0**
Tutuila Island	44,580	95.3	54.2	70.1
(Eastern District)	21,175	45.3	25.9	33.5
(Aunu'u Island)	463	1.0	0.6	0.8
(Western District)	23,868	51.0	28.9	37.4

Manu’a Islands	1,714	3.7	21.9	28.3
(Ofu and Nu’u Islands)	353	0.8	2.8	3.6
(Olosega Island)	225	0.5	2.0	2.6
(Ta’u Island)	1,136	2.4	17.1	22.1
Rose Island	0	0.0	0.1	0.1
Swains Island	16	<0.05	0.6	0.8

Direct employment in tuna processing (29 percent of the workforce), the commercial fisheries of American Samoa, and the involvement of the local communities in subsistence fisheries, show substantial engagement in and dependence on fishery resources to meet community social and economic needs. American Samoa and its villages are considered to be “fishing communities” within the meaning of the MSA.

Guam

For the purposes of the Coral Reef Ecosystems FMP the island of Guam will be considered a fishing community.

Guam is the largest and southernmost of a chain of volcanic islands known as the Marianas Archipelago. It is an organized, unincorporated territory of the United States with a land area of 209.8 square miles. Bureau of Census data is available for the island as a whole and for island communities at the level of “census designated places” (CDP). There are 32 villages on the island which qualify as CDPs. Six of these communities are military housing areas. In 1990, the island’s population numbered 133,152 persons, with a population density overall of 634.6 persons per square mile. In 1999, the estimated population of the island had grown to 163,373 persons and, of these, some 47 percent were of Chamorro descent. Some 18 percent of the population lived on military bases on the island in 1990.

Inhabited for more than 3,500 years, the island first had European contact in 1521 when it was found by the Spanish voyager, Ferdinand Magellan. Spain claimed Guam and the Marianas in 1565, and established a supply station on Guam in 1566. Guam was ceded to the United States by Spain in the Treaty of Paris in 1898.

Intermarriage with Spanish and Filipino settlers in the 18^{th} and 19^{th} centuries resulted in the modern Chamorro race and culture, and Chamorro is still commonly spoken in Guam. In the past 100 years, American influence (and that of the Japanese during the World War II occupation of the island) has changed the pattern of life and communities on the island. The U.S. Navy administered Guam from 1898 until 1950, when administration was transferred to the Department of the Interior. The Organic Act of 1950 created an elected legislature and, since

1970, the Guamians have elected their own governor. Since 1973 the islanders have elected a non-voting representative to Congress.

Commonwealth of Northern Mariana Islands

A U.S. commonwealth since 1978, CNMI has a total of 14 islands. 90% of the population of 79,429 in CNMI resides on the island of Saipan. CNMI has a total land area of 176.5 square miles spread over 264,000 square miles of ocean. For the purposes of the CREFMP each of the inhabited islands will be considered a geographically discrete fishing community.

The Northern Mariana Islands is part of the former Trust Territory of the Pacific Islands. It consists of three main islands–Saipan, Tinian, and Rota–and several small islands and atolls. The southernmost island, Rota, lies some 50 miles northeasterly of Guam. The Commonwealth of the Northern Marianas extends some 430 miles northerly from Rota to Uracus Island. The small islands and atolls of the northern part of the chain are lightly populated. In 1990 the population of the northern islands was 36, and was further reduced in 1992. The main islands are grouped together in the southern part of the chain. The Commonwealth's capital is Saipan, but no locality on that island is recognized specifically as the capital; several government offices are located in the CDP of Capital Hill, but the legislature meets in Susupe. Almost 90 percent of the Commonwealth's population lives on Saipan Island. Chamorro is the most commonly spoken native language.

The Bureau of the Census estimated that the population of the Northern Mariana Islands had grown by 25,179 persons between the 1990 census and 1999. The estimated population for 1999 was 69,216 persons. Of this increase, 59 percent (14,803 persons) was through migration to the islands, principally from Asian countries (Bureau of Census, International Data Base, 12/29/99.) The Chomorro and Carolinan ethnic groups native to the islands represented some 27 percent of the population in 1999.

The early history of the Northern Mariana Islands parallels that of Guam. Spanish and other explorers first visited the islands in the 16th century, and they were colonized by Spain in the 17th century. Spain sold the islands in 1899 to Germany, following the end of the Spanish-American War. In 1914, Japan entered World War I on the side of the Allies and took possession of the islands. After the war, Japan retained the islands under a mandate from the League of Nations. In 1944, the United States gained control of the islands from Japan and received a mandate from the United Nations in 1947 to administer them. The islands were controlled by the Defense Department until 1961, however administrative authority was vested in the Department of the Interior in 1951. In 1978, a separate government for the Northern Mariana Islands was established and Commonwealth status was granted in 1986.

The main islands are each organized as a single muncipality, with its own elected mayor and municipal council. Saipan's municipal council also serves the Northern Islands municipality. In

1990 Bureau of Census Data for the Northern Mariana Islands

	Population (n)	**Population (%)**	**Land Area (sq. Miles)**	**Land Area (%)**
Northern Marianas	**43,345**	**100.0**	**179.0**	**100.0**
Northern Islands	36	0.1	59.8	33.4
(Agrihan Island)	9	<0.05	18.0	10.1
(Alamagan Is.)	5	<0.05	4.0	2.2
(Anatahan Is.)	22	<0.05	12.0	6.7
(Pagan Island)	0	0	18.0	10.1
Rota Island	2,295	5.3	33.0	18.4
Saipan Island	38,896	89.7	44.6	24.9
Tinian Island	2,118	4.9	41.7	23.3

1990 there were 16 CDPs identified at the time of the Census. Each of these communities had locally recognized boundaries, a population of more than 300 people, and was enumerated in the decennial and economic censuses.

Hawaii

Economic and demographic data is available for the State of Hawaii. Some data is available on an island by island basis. With information that is available some economic information may be extrapolated about Hawai`i's overall dependence on the fisheries. Economic data in as fine a scale as required for the individual communities cited in this FMP is unavailable and new research to support these geographic divisions is indicated. Of greater importance in these divisions is the health of the communities that benefit from the utilization of the coral reef resources.

The islands of the State of Hawaii were discovered and settled by Polynesians between the 3rd and 7th centuries A.D. The first European contact was in 1778. European and Asian settlement of the islands occurred in the 19th century with the development of pineapple and sugar plantations. In 1898 the islands were ceded to the United States and Hawaii became the 50th state in 1959.

Hawaii is a string of 137 islands extending in an arc across the Pacific Ocean from the northwest to the southeast. The major islands–in size, population and economic activity--are at the southeastern point of the arc, some 2,400 miles from the United States. The land area of the island chain is estimated to be 6,423 square miles.

The State of Hawaii has a resident population of 1,193,001. It consists of 137 islands encompassing a land area of 6,423.4 square miles. There are eight main islands divided into four municipal counties: Hawai`i County, Maui County, City and County of Honolulu and Kaua`i County.

The State of Hawaii is broadly engaged in management of the ocean and oceanic resources. Tourism, the largest industry in Hawaii, is heavily dependent on oceanic resources. The population, indigenous and non-indigenous, depends upon the ocean and oceanic resources for recreation and social interactions. The indigenous population continues to assert their rights of access to oceanic resources. In Hawai`i, all shoreline to the highwater mark and undeveloped areas mauka (inland, toward the mountains) are public areas that can be accessed for cultural and traditional practices, a holdover from the days of the kingdom.(Mackenzie and Murakami, 1989).

Hawaii's population has been growing at the rate of 7 percent during the past decade, and was estimated to be 1,193,001 in 1998. The proportion of persons of Hawaiian or part-Hawaiian descent was estimated to be 21 percent by DBEDT, with other residents of Asian and Pacific Island descent comprising 41.3 percent of the population. Some 22 percent of residents were Caucasian.

1998 DBEDT estimates of population, employment and unemployment in Hawaii

	Population(n)	Population (%)	Civilian Labor Force (n)	Unemployment (%)
State of Hawaii	1,193,001	100.0	597,800	6.2
Kauai County	56,603	4.7	28,700	9.8
Kauai Island	50,947	4.3	n/a	n/a
Niihau Island	230	<0.0001	n/a	n/a
City & County of Honolulu	872,478	73.1	427,650	5.4
Maui County	120,785	10.1	71,650	6.6
Maui Island	105,336	8.8	66,850	n/a
Molokai Island	6,838	0.005	3,050	n/a
Lanai Island	2,989	0.003	1,750	n/a
Hawaii County	143,135	12.0	68,650	9.7

Island of Oahu

Oahu is the most populated island of the Hawaiian Archipelago with a residential population of 872,478 on the smallest (597.1 square miles) of the four counties in the State. The City and County of Honolulu comprises the entire Island of O`ahu, The Northwestern Hawaiian Islands and Ka`ula Rock. Oahu, and specifically Honolulu Harbor, has the greatest potential to be engaged in the harvest and processing of the coral reef resources from the Northwestern Hawaiian Islands. The size of the community and its economic power make Honolulu Harbor most capable of benefitting from the harvest of coral reef resources.

Honolulu, Oahu

The Honolulu fishing community has the most potential to be substantially engaged in the harvesting and processing of the coral reef resources of the Northwestern Hawaiian Islands. The Honolulu waterfront is the main fishing center for the state. Honolulu waterfront is the location of all of the support for the fishing fleet. The United Fishing Agency Fish Auction, the state's largest fish auction, is located on the Honolulu waterfront along with all of the major support industries for Hawaii's commercial, charter and recreational fishing fleets. Nearly all of the state's fishermen, divers and boaters, along with a great number of fishermen and boaters from all over the Pacific Region, will find their way to the Honolulu waterfront for services, supplies, products or materials necessary to support their fishing activity. With the highest per capita income of any island or county in the state, Oahu is the center of commerce for Hawaii. The Honolulu fishing community includes the East Honolulu area from Kahala to Hawai`i Kai (sometimes called the Kona district of Oahu). Hawaii Kai was built on ancient Kuapa fishpond and most of the waterfront homes have piers.

It also includes Kewalo Basin, Ala Wai Boat Harbor, Keehi Lagoon and Sand Island harbor areas. Small boat launch ramps at Maunalua Bay, and Keehi lagoon are included in this community.

There is a clear current and historic dependence on fishing and oceanic resources in this community. Bioprospecting, black coral and aquaria collecting are activities that would benefit from being centered in Honolulu.

Waianae/Pokai Bay, Oahu

Waianae is a cultural fishing community found on the Western side of the island of Oahu. The large Hawaiian community practices the cultural dependence upon oceanic resources that is the hallmark of Pacific island culture. The center of fishing activity has shifted from Pokai Bay to Waianae Small Boat Harbor, but Pokai Bay remains, arguably, the center of Hawaiian community activity. A small number of charter and commercial fishing boats operate out of the

Waianae Boat Harbor. Much of the community still maintains that the Waianae Small Boat Harbor was not an improvement for the trailer boat fleet of the community. While Pokai Bay provided easy access and safe launching of small craft, the Waianae Boat Harbor is subject to dangerous surges and tidal movements that have damaged more than a few boats. The Waianae Harbor is located next to Pokai Bay. The community remains a strong and unified population in support of native Rights in Hawaii. The area is economically depressed and maintains a high dependence on the ocean and oceanic resources to provide food and maintain social linkages.

Ice, fuel and provisions are available in the commercial area of Wai`anae. Much of the harvest of ocean resources finds its way into local retail outlets. Fish and fish products are sold by the side of the road, the swap meet and the farmer's markets. Fish trappers, who harvest primarily coral reef species, bring their products into Honolulu for re-sale at the open market in the Chinatown.

Koolau, Oahu

Koolau, Oahu fishing community. The center of fishing activity for the Koolau, Oahu fishing community would arguably be Heeia Kea Pier. However, fishing supplies are purchased in the nearby Kaneohe urban area or in the Honolulu urban area. Koolau encompasses the second and third largest urban centers on the island of Oahu, Kailua and Kane`ohe, with a combined resident population of 72,266, as well as Waimanalo, Kahaluu, Heeia Kea, Ahuimanu, Waiahole, Waikane, Kualoa of the Ko`olaupoko District and Kaoio, Kaaawa, Punaluu, Hauula, Laie and Kahuku of the Koolauloa District. Mokapu is included in this community, though it is located on the Kaneohe Marine Base Hawaii. Mokapu is an important fishing koa and spiritual site to those at Koolaupoko. A koa can be loosely translated to mean "fishery" keeping in mind that there is a strong spiritual relationship and cultural component in established koa. There are unique characteristics of each location and these would be revealed the names and legends of each site, i.e, Heeia Kea means "white octopus," Kaoio means "the bonefish (albula vulpes)," all signify important foods and materials to be found at those locations (it is important to note that many place names have kaona, secret and often multiple meanings that may be divined from a study of the chants, songs, myths and history of that area). Koolau is the location of numerous ancient fishponds, fishing shrines and fishing koa.

There are four public small boat launch ramps in this area at Kaiona in Waimanalo, Kailua, He`eia Kea, and Kahana. There are numerous private and individual launch ramps. There are beach sites that are used to launch small boats. The fishing community is made up of small, artisanal, multi-species, multi-gear subsistence fishers, trappers, netters and divers that harvest a wide variety of vertebrate, invertebrate, and algal foods.

Haleiwa, Oahu

Haleiwa, Oahu is an historic and active fishing community on the north shore of O`ahu.  The ice house that once provided ice to the fishermen departing Hale`iwa Harbor is gone, a casualty of the changing economy and demographics of the north shore. The main fishing activity at Haleiwa Harbor is the small recreational/subsistence/part-time commercial fishing fleet that plies the waters off the north shore. Trailer boat activity is high at Haleiwa harbor. Coral reef resources are extracted all along the shoreline from Kahuku to Mokuleia by pole and line, net, trap and spear. Haleiwa Harbor is also the location of a small but active charterboat community.

Ewa/Ko olina, Oahu

Ewa is part of an ancient fishing koa named Puuloa, that is now a part of Pearl Harbor. The shoreline from Puuloa to Kalaeloa (sometimes called Barber's Point) is still an important fishing and gathering area. Legend has it that Ewa is the seed bed for limu (algae, up to 70 varieties were once harvested for food, medicinal and other purposes). Limu is the primary food source for fishes and other marine fauna.

Kapolei is the site of a new suburban development to re-distribute the population of Oahu. A harbor with a launch ramp has been developed for the Ewa/Ko Olina area and a new population of mobile trailerboat recreation and subsistence fishers has developed to fish these grounds.

There are currently community derived and community based activities to re-seed many varieties of limu in the `Ewa area. The development of the Ko Olina Resort in the `Ewa/Kapolei community has become a flashpoint for traditional fishers and gatherers in the area. The resort's development of three private lagoons may have seriously damaged the traditional fishing grounds of the area. The information on damage to the near shore fishing grounds and coral reef resources is anecdotal but points to the importance of properly developed Environmental Assessments and Impact Statements.

Offshore mariculture is being proposed for the `Ewa/Ko Olina area. A pilot project to test the feasibility of moi (Pacific threadfin - Polydactylus Sexfilis) mariculture is being conducted in this area. Also being developed is a deep water harbor and a housing development with private piers like Kuapa fishpond in Hawaii Kai.

Island of Niihau

The proximity of the Ni`ihau Island fishing community to the Northwestern Hawaiian Islands makes it potentially capable of being substantially engaged in the harvest and processing of the coral reef resources in the Northwestern Hawaiian Islands. Until the late 1800's native Hawaiians from Niihau reportedly traveled to Mokumanamana (Necker Island) and Nihoa to collect coral reef resources.

Niihau is part of the County of Kauai.

The nearby uninhabited Ka`ula Rock is under the jurisdiction of the City and County of Honolulu. Like Ford Island in Pearl Harbor, Ka`ula is administered by the Department of Defense. It is a target island but there are strong spiritual ties of the native population to the island and archeological surveys have never been completed. The Bishop Museum has extracted archeological material from the island that indicates, at the very least, regular visitation and possible burials by ancient Hawaiians.

69.5 square miles, Population 230, wholly owned by the Robinson family, the island is populated by native Hawaiians who are mostly employed by sheep ranching. Ni`ihau is in Kaua`i county. The unique feature of this community is that it is fully native Hawaiian. The Hawaiian language and many ancient cultural traditions and beliefs are practiced on the island. Access to the island is controlled by the Robinson family so information about the community is wanting. There are no hotels or other accommodations on the island, and tourism is restricted to charter and tour helicopter landings on two beaches, and charter boat eco-tourism and fishing operations visiting the island from Kauai and Molokai.First hand accounts of life on Ni`ihau indicate a strong dependence on the ocean resources by the community.

Ni'ihau had a population in 1990 of 240 persons (36 families in 36 households). Eleven persons were employed on the island, and the median household income in 1989 was $16,250. All 240 persons were Native Hawaiian or part Hawaiian, and the Hawaiian language was spoken by 97 percent of the islanders. That the population is stable is represented by the 234 residents who were born locally.

The residents' of Ni`ihau utilize coral reef resources as traditional practices, a continuity of cultural traditions broken only between 1915 and 1925 (Iversen et al, 1990). Use of coral reef and fishery resources by islanders is for commercial and personal use, in particular Niihau shell and coral necklaces and jewelry are prized. At this time it is likely that Ni'ihau island is a fishing community in the terms of the MSFCMA in that the local population use fishery resources to satisfy local domestic economic and social needs and are substantially dependent on fishery resources to supplement their sheep-herding economy.

Island of Kauai

Kaua`i Island is in the county of Kaua`i. For the purposes of fulfilling the requirements of describing fishing communities for the Coral Reef FMP Kaua`i Island has been separated into four fishing communities based upon four centers of fishing activity. Ni`ihau will be treated as a discrete fishing community. It must be noted that the communities are not discrete and that there is travel, intercourse and interaction with regard to fishing and fishing activities across the entire island. Fishers from every part of the island can be found at all of the centers of fishing activity at any given time. The population of Kaua'i county is 55,603. It is important to note that, unlike temperate areas where there is a large abundance of single species, fishing effort in a tropical area often results in small amounts of many species. The Pacific Missile Range Facility is located on Kaua`i.

Anahola, Kauai

On the eastern side of Kaua`i, Anahola is the de facto center of Hawaiian activism on the island. Anahola is the location of Hawaiian Home Lands. The ocean, fishing and oceanic resources are at the heart of the community forming social, cultural and recreational webs of interactions. The fishing activities are artisanal and subsistence. Anahola is located in the Kawaihau district of Kauai.

Nawiliwili, Kauai

Nawiliwili is the main industrial port for the island of Kauai and provides vessel support and repair facilities, ice and support industries for the fishing fleet on the island of Kauai. Many charter and tour operators are based at Nawiliwili. Nawiliwili is the the Lihue city and district of Kauai.

Port Allen, Kaua`i

Port Allen, Kaua`i is a center of activity for a commercial and part-time fishing community. Fishing vessels are berthed at Port Allen. An area is set aside for the fishing association. Some Charter and tour boat operations are located at Port Allen. Located in the Koloa district of Kauai, Port Allen also serves fishers residing in the district of Waimea.

Hanalei, Kaua`i

Hanalei is a unique community in the State of Hawaii. The Hanalei river is a national heritage site. The activity is primarily agricultural with extensive development of wetland taro cultivation. Hanalei is legendary from pre-historic times with songs and chants describing its unique characteristics. Hanalei is a near-classic example of the ahupuaa system of husbanding natural resources for the beneficial use by the community. The ahupuaa land tenure system that provided a community's residents with fair and equitable access to the natural resources of an area for the benefit of the entire community. The concept recognizes a land division that stretches from the mountains to the sea, often in a valley, to provide access to mountain, valley, forest and oceanic resources. A major component of the ahupuaa system is the recognition and support of use and user rights of the tenants of the land division. Hanalei is selected as a center of fishing activity to preserve the unique character of the ahupuaa system.

Hanalei has also become a major tourist destination.

Island of Hawaii

Hawai`i, also known as the Big Island, is the largest island of the Hawaiian Archipelago with and area of 4,028 square miles. A population of 143,135 brings the density to 34 persons per square mile. For the purposes of the fishing communities section of the Coral Reef FMP, Hawaii will be divided into four fishing communities: Kohala, Kailua-Kona, Puna, and Hilo/Hamakua.

Hawaii Island has the technology and infrastructure in place for the collection of marine fauna for ornamental use in aquaria. Fishing communities from the island have the potential to be engaged in collecting for aquaria from the Northwestern Hawaiian Islands. Recent restrictions on aquaria collecting in the Kona area could displace that fishery to other grounds.

Kohala, Hawaii

The Kohala district of the Big Island stretches from the Kohala mountains to the north to Hualalai to the south and Hamakua to the east. Numerous coastal fish ponds in the Kohala district attest to the importance of the ocean and oceanic resources to the people of the Kohala district. Legends from the area indicate that there was a large and vital population at Kohala in ancient times. Archeological materials seems to indicate that there was a large population of high born in the area (Ching, 1971). Kamehameha was born at Hawi at the northern tip of the moku of Kohala. War and introduced diseases decimated the native population in historic times and the region became sparsely populated. Ranching dominated the economic life of the region for a while. Currently, the area is still sparsely populated. A large portion of the population is engaged in fishing activities and the harvesting of coral reef resources. There is dependence on fishing in this community for subsistence, economy, culture and social interaction.

Kailua-Kona, Hawaii

Kailua-Kona, Hawaii is bound by Hualalai to the north and Kalae, south point, to the south. Within this area is the Kailua-Kona resort area with its high dependence on the fishing and oceanic resources for tourism and fishing villages such as Milolii. Milolii has been regarded as a fishing village for more than a century. Native techniques and knowledge are still employed for nearshore and oceanic fishing and harvesting of coral reef resources in these villages. These fish are still marketed by the native communities for economic gain. The fishing community consists of small, artisanal, native subsistence fishers and a large charter fishing fleet as well as aquaculture for ocean species and research facilities for ocean research. The fishery for collecting marine fauna for aquaria is located in Kona. There is a strong cultural, economic and social dependence on ocean and oceanic resources in this community.

Hilo/Hamakua, Hawaii

The Hilo/Hamakua area is the large eastern coast of the Big island of Hawaii. It stretches south from Kukuihaele to the north to Kilauea and Kaimu/Kalapana to the South and includes Hilo Bay and Hilo. The Suisan fish auction has been a fixture in Hilo and has been the marketplace for the ika shibi (tuna handline) fleet.

Hilo/Hamakua fishing community is composed of fishermen with diverse ethnic backgrounds in diverse fishing activities from the hand gathering of `opihi (limpets) and limu (algae) from the nearshore benthic areas to the shore casting hunters stalking 100 lbs. ulua to the handline tuna fleet.
Hilo is noted for its ika shibi form of tuna fishing, night handline fishing for large tuna off the coast of Hilo for `ahi po`onui (Thunnus obesus). Kona is noted for its palu ahi style of tuna fishing, offshore day-time handlining for `ahi kanana (Thunnus albacares).

The beaches and shoreline are very narrow along the Hamakua coast, and there are few references to fisheries that existed in the district. An excerpt from the Boundary Commission Book, 1870-1880, contains an excerpt that sheds a little light on the extent of management and control that was exercised over the nearshore fisheries and coral reef resources. Keahua 2 (an ahupua`a of the Hamakua District) held rights to an uhu (Scaridae) fishery that extended to "the outside of of the breakers where it is cut off by the Kalopa (the neighboring ahupua`a) fishing rights." (Cordy, 1994)

There is a strong dependence on fishing and oceanic resources for subsistence, culture and social interactions in this community.

Puna/Kau, Hawaii

From Kaimu to Ka Lae is the Puna/Kau area. The cliffs of Ka Lae is the staging area for many of the small boat fisherman in Puna/Kau. The small boats are launched over a lava rock strewn beach and motored to the cliff area at Ka Lae. Boats are anchored below the cliffs for the fishing season and the crews dive into the ocean from the cliffs to attend their boats. Supplies are lowered by winch for the fishing trips. Along the coast eastward from Ka Lae to Kamehame are numerous sites used for oceanic access and various fishing activities, much of which is harvesting of coral reef resources. From Kamehame to Kaimu are fragments of the ancient coastal foot trail. The community has a strong and historic dependence on the ocean and oceanic resources.

Island of Maui

Maui County is the largest county in the State of Hawaii. It includes four islands: Maui Island, Lana`i Island, Moloka`i Island and Kaho`olawe Island. Maui Island is 727.3 square miles. Lana`i is 140.6 square miles. Moloka`i is 260 square miles. Kaho`olawe is 44.6 square miles. The resident population of Maui County is 120,785.

Maui island will be discussed as two fishing communities: Lahaina/Maalaea and Hana, Maui whose fishing community is uniquely Hawaiian.

Lahaina/Maalaea

There are two Harbors that serve the fishing community on Maui Island: Lahaina and Maalaea. For the purposes of defining fishing communities the activities at both of these harbors will be combined as they both serve the Maui fishing community in a complementary fashion. Dependence on coral reef resources for subsistence and cultural use continues in the native and kamaaina communities. Dependence on the ocean and ocean resources for economic, social, and recreational purposes is an important characteristic of the Maui community. Charter and tour boat operators work out of both harbors.

Hana, Maui

At the eastern end of Maui Island is Hana which is accessible on land by a rugged rural road. Hana Bay is centrally located on the Hana shoreline which extends from Mokupupu in the north to Puualu and Ohai Point in the south. Lines starting at these north and south points and following the ridge line landward to Pohaku Palaha describe this area. All of the ahupuaa on the east side of Maui were bound by lines that radiated from a rock located on Haleakala called Palaha. The lines end makai (seaward), at the ocean. The lands bound by these lines were ahupuaa. The primarily native community in Hana is rural, agricultural and dependent on fishing and oceanic resources for subsistence, culture and social interactions.

Island of Lanai

Lanai is part of Maui County. It consists of 140.6 square miles. Lanai City, the only town, has a population of 2,400. The islandwide pineapple plantation agriculture industry was replaced in the early 1990's by two luxury resorts. There is a strong dependence on the harvesting of coral reef resources on Lanai. Lanai reefs are frequently used by the charter and recreational boaters and tourists. The State of Hawaii has established a Marine Life Conservation District (MLCD) at Manele-Hulupoe. The fishing activity is largely subsistence and artisanal with a strong dependence on ocean and oceanic resources. A current conflict has arisen in the fishing community at the Manele-Hulupoe MLCD regarding the use of throw nets to take akule (Selar crumenophthalmus) in the MLCD. The island is largely a private island, 98% of which is under a single corporate ownership. It was said that the exceptional fishing at Kaunolu, Lanai attracted Kamehameha V to fish at a favorite fishing site of his grandfather, Kamehameha I.(Emory, 1969). Lanai City is a company town and depends on the fishing and oceanic resources for subsistence, recreational, and social interactions.

Island of Molokai

Molokai is part of Maui County and consists of 260 square miles, it has maintained its Hawaiian culture and character. The cultivation of limu (edible algae) is becoming an important product from Molokai. Numerous projects to restore ancient fishponds and fishing areas are being conducted. Molokai has two harbors at Kaunakakai and Hale-o-Lono. There is a fisherman’s co-op at Kaunakakai. Halawa Valley at the East end of the island is a Hawaiian agricultural community with a dependence on the ocean and oceanic resources and a dependence on coral reef resources. There is a strong dependence on ocean and oceanic resources for subsistence, culture and social interactions by the fishing community on Molokai. There is a fishing co-op at Kaunakakai.

Palmyra Atoll

Palmyra is a small (7.4 square mile) privately owned atoll. The few residents are dependent at least partially on fishing for employment. The owners have an agreement with a fishing company to service and provision fishing vessels and transship catches. The Honolulu longline fleet has been known to fish near the atoll to fill their holds with tuna for sale in Hawaii. A sport bonefishing enterprise has been started. Negotiations have begun for the sale of the island to the Nature Conservancy.

Midway Atoll

Midway consists of three main islands, Sand, Eastern and Spit. Midway is administered as a NWR by USFWS, Department of the Interior, which allows recreational and subsistence fishing for tourists and residents.. Tourism is managed by the Midway Phoenix Corporation through a long term agreement. A maximum of 100 visitors are allowed at a time to visit the island. There are 120 residents mostly from Sri Lanka, Phillipines and Thailand that form a permanent residential community on the island. Lobsters may be taken for on-island consumption. Fishing and oceanic resources form an important economic basis for the island's tourism. USFWS has established regulations to manage the fishing activity on the island.

Johnston Atoll

Johnston Atoll is administered by the U.S. Fish and Wildlife Service as a National Wildlife Refuge. In the 1960's it was used for staging atmospheric testing of the nuclear weapons. It is currently being used as a repository and incineration facility for chemical and chemical munitions. The community is dependent upon fishing for recreation and subsistence. The location and unique stresses on the environment at Johnston make this an ideal location to study the ability of the coral reef ecosystem and marine environment to overcome pollution, exploitation and development.

3.6.2 Island Communities in the US Pacific

The socio-cultural aspects of a fishery include the shared technology, customs, terminology, attitudes and values related to fishing. While it is the fishermen that benefit directly from the fishing lifestyle, individuals who participate in the marketing or consumption of fish or in the provision of fishing supplies may also share in the fishing culture. An integral part of this framework is the broad network of inter-personal social and economic relations through which the cultural attributes of a fishery are transmitted and perpetuated. The relations that originate from a shared dependence on fishing and fishing-related activities to meet economic and social needs can have far-reaching effects in the daily lives of those involved.

Island cultures are maintained by systems of interdependence and social reciprocity, including sharing of seafood gathered by fishing. Beyond their dietary importance, fish have value for exchange and gift giving that promote social harmony, community cohesion and cultural identity. Various types of seafood served on holidays or during celebrations may become imbued with specific symbolic meanings.

Finally, the socio-cultural context of fishing may include the contribution fishing makes to the cultural identity and continuity of the broader community or region. As a result of this contribution the activity of fishing may have existence value for some members of the general public. Individuals who do not fish themselves and are never likely to may derive satisfaction and enjoyment from knowing that this activity continues to exist. They may value the knowledge that the traditions, customs and life ways of fishing are being preserved (Dames and Moore, in prep.).

The social and economic histories of the populated US Pacific islands differ considerably from that of the continental US. The Samoa, Hawaiian and Mariana islands were originally settled in ancient times by sea-faring peoples. The lack of terrestrial resources in most areas led to great dependence on fishing for food security. This dependence shaped the social organization, cultural values and spiritual beliefs of the indigenous populations.

The era of European discovery brought the island cultures in direct conflict with Western traditions of proprietorship. Repeated contacts with Western culture eroded the stability of the social structures and subsistence economies created by indigenous people. The beginning of the 20th century brought American administrators to the Pacific and accelerated the process of Westernization.

World War II caused dramatic changes in all of the populated US Pacific island groups. World War II also caused an influx of Caucasians into Hawaii. Construction of harbors, airports and other infrastructure linked the islands closer to the US mainstream, increasing importation of goods and exposure to American laws, education, media and technology. The islands moved rapidly away from subsistence toward cash economies.

With the exception of American Samoa and small enclaves in Guam, Hawaii and the Commonwealth of the Northern Mariana Islands, the modern-day indigenous descendants are dispersed as part of cosmopolitan populations. Island societies have become pluralistic and many aspects of their economies and cultures have evolved in modern times. Yet, the vast majority of contemporary island inhabitants continue to be dependent on coral reef resources for consumptive and non-consumptive uses. Most are consumers of seafood and many are at least part-time fishermen. In addition to providing food and recreation, the harvest of coral reef resources is also important as a means of preserving and perpetuating indigenous cultural identities and values.

The Magnuson-Stevens Fishery Conservation and Management Act has recognized that Pacific insular areas “contain unique historical, cultural, legal, political and geographic circumstances which make fisheries resources important in sustaining their growth.”

Major Geographic, Demographic and Economic Characteristics of American Samoa, Guam, Hawaii and the Commonwealth of the Northern Mariana Islands.

TERRITORY	POPULATION	LAND AREA	REEF AREA	NOTABLE CHARACTERISTICS	DISTANCE FROM CAPITAL	GDP (Millions US$)
GUAM	163,373 (47% Indigenous)	212 sq. mi.	179 sq. mi.	One island, major US naval base, regional transshipment center at Apra. In Typhoon path.	Agana/Honolulu 3,800 miles Agana/Tokyo 1,600 miles Agana/Washington, DC 8,600 miles.	3,065.80
COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS	69,398 (29% Indigenous)	177 sq. mi.	579 sq. mi.	Saipan largest island, Tinian Rota, 14 others, 125 miles north of Guam. US territory closest to Asia	Garapan/Honolulu 3,700 mi. Garapan/Tokyo 1,500 miles Garapan/Washington 8,500 mi	664.6
AMERICAN SAMOA	63,786 (89% Indigenous)	76 sq. mi.	296 sq. mi.	5 islands, 2 atolls, Pago Pago Harbor. Newest US national park in hurricane path.	Pago Pago/Honolulu 2,600 Pago Pago/Washington 7,400 miles	253
HAWAII	1,205,126 (19% Indigenous)	6,423 sq. mi.	2,535 sq. mi.-Main Hawaiian islands, 11,535 sq. mi.-NWHI	4 main islands - Hawaii, 4,028 sq. mi., Maui, 727 sq. mi., Oahu, 597 sq. mi., Kauai, 552 sq. mi. In hurricane path.	Honolulu/Tokyo 2,500 miles Honolulu/Los Angeles 2,600 miles Honolulu/Washington 4,800 miles	35,146.40

TERRITORY	GDP PER CAPITA	MAJOR INCOME SOURCES	POLITICAL STATUS	MAJOR INVESTMENT SOURCES
GUAM	18,766	Tourism, military, trade and services.	US territory since 1898, 1950-Guam Organic Act conferred US citizenship in US national elections. Organic Act never ratified by Guam referendum.	US, Japan, Korea
COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS	8,367	Tourism, garment manufacture, trade and services.	After WWI under Japanese Mandate. 1947-became US Trust territory of the Pacific. 1978-Commonwealth. Islanders are US citizens but do not vote in US elections	Japan, Korea, Hong Kong, US.
AMERICAN SAMOA	4,295	Tuna canneries, government services, remittances from Samoans overseas.	US territory since 1899, Samoans are US citizens but do not vote in US elections	US
HAWAII	29,164	Tourism, services,	Kingdom overthrown by American businessmen,1893. Annexed in 1898 by "Newlands Resolution." Organic Act in 1900 creates US Territory. 1959-Admissions Act creates State of Hawaii.	US, Japan, Australia.

American Samoa

American Samoa is an unincorporated territory of the USA comprised of 7 islands totaling only 77 square miles in land area. Most of the islands are mountainous with limited flat area suitable for a agriculture. The Territory's population is about 60,000 and is growing rapidly, with a doubling time of only 20 years (Craig et al. in press). American Samoa is lowest in gross domestic product and highest in donor aid per capita among the US Pacific islands (Adams et al. 1999).

American Samoa has a small developing economy, dependent mainly on two primary income sources: the American Samoa Government (ASG), which receives income and capital subsidies from the United States, and two tuna canneries on the island of Tutuila. The two primary sources have given rise to a third: a services sector that derives from and complements the first two. In 1993, the latest year for ASG has compiled detailed labor force and employment data, the local government employed 4,355 people, or 32.2% of total employment, followed by the two canneries with 3,977 people (29.9%) and the rest of the services economy with 5,211 workers (38.4%). Altogether, the three segments employed 13,543 workers, while 2,718 people were registered as unemployed (that is, actively seeking employment). This gives a total labor force of 16,621 and an unemployment rate of 16.7%. A large proportion of the territory's workers is from Samoa, formerly Western Samoa. While Samoans working in the territory are legally alien workers under US law, they are the same people as American Samoans by culture, history and family ties.

With a total population in 1993 estimated at 52,900, the labor force represented 30.7% of the population, which is very low when compared with the overall US labor force ratio (well over 50 percent) but typical of the smaller developing Pacific island economies. Of the 31,822 residents 16 years or older, the total labor force was equivalent to 51.1%. That half of the 16 years-plus population is not in the labor force is explained by American Samoa's lack of major industry other than government and fish canning. Work opportunities are certainly limited, but not having a job in the money economy does not necessarily equate with unemployment in the territory, as subsistence activity contributes to the extended family's total well-being.

Official data notwithstanding, by many measures, American Samoa is not a poor economy. Its estimated per capita income of $5,000 is almost twice the average for all the Pacific island economies (at $2,700) (Bank of Hawaii 1997). Per capita income in American Samoa does not represent the same market basket and value as it would, for example, in Honolulu. There are aspects of work and the creation of value in communal societies of the Pacific islands that are not captured by market measures. For instance, American Samoa's tightly organized aiga (extended family) system helps to keep young people from becoming economically unproductive and socially disruptive. Another avenue for American Samoan youth not available to the vast majority of youth in the Pacific islands, is emigration to the United States, where an estimated 70,000 Samoans live, 20,000 of them in Hawaii.

The policy of the ASG, as expressed in the Revised Constitution (1966) is "... to protect persons of Samoan ancestry against ... the destruction of the Samoan way of life ... [and] to protect the lands, customs, culture, and traditional Samoan family organization of persons of Samoan ancestry, and to encourage business enterprises by such persons...."

Guam

Guam and the Mariana Islands were first settled about 3,000 years ago but their present social and demographic structure is largely the result of colonial experiences of the last 300 years. Guam's total population is estimated to have reached 163,000 in 1999, nearly doubling the 1970 total of 85,000. Of the total reported labor force of 72,700 (June 1999), 61,460 were employed and 11,060 were unemployed, for an official jobless rate of 15.2%. In September 1997, at the beginning of the current economic and employment downturn on Guam, the unemployment rate was only 9.2% (Bank of Hawaii 1999).

Guam's economy has become so dependent on tourists from East Asia, particularly Japan, that any significant economic, financial and foreign exchange development in the region has had an immediate impact on the territory. During the mid- to late-1990s, as Japan experienced a period of economic stagnation and cautious consumer spending, visitor arrivals from Japan dropped and the impact was felt as much on Guam as in Japan. The US military presence on Guam has diminished to the lowest level in decades. Nevertheless, the military remains a vital stabilizing economic factor for Guam, particularly in times of regional economic crises. The Government of Guam currently supplies more than 20% of all civilian jobs in the territory. Recent deficits have resulted from a steady rise in government spending at the same time that tax bases have not kept up with spending demands (Bank of Hawaii 1999).

With regard to commercial fishing, the most significant attribute of Guam is its status as a regional tuna transshipment center and re-supply base for foreign tuna fleets (Hamnett and Pintz 1996). Guam is the fourth leading US port in terms the dollar value of fish landings, which are mostly for transhipment to tuna markets in Japan.

Commonwealth of the Northern Mariana Islands

In the two decades since the Commonwealth of the Northern Mariana Islands (CNMI) came into being, its demographic, economic and social structures have changed dramatically. When CNMI opened to foreign capital and labor, it was transformed from a small economy supported largely by subsistence and government to a large regional tourist destination and a garment-manufacturing haven. The total population increased 373% between 1980 and 1999, when it reached 79,000. Ninety percent of the population is concentrated on Saipan, which is the CNMI's commercial and government center. Tinian and Rota support populations of 3,000 and 4,600, respectively (Bank of Hawaii 1999). The northern islands are largely uninhabited, except for two with very small populations.

The aboriginal people of the CNMI include the indigenous Chamorro as original inhabitants of the islands and the Carolinians, who are Micronesians that resettled on Saipan during the 1840s. Carolinians represent a small minority of the population, but they are well known for their seafaring and fishing skill. The majority of the current population are non-resident workers from the Philippines and other parts of Asia. There are also workers from Belau and the Federated States of Micronesia. Only 28% of the 72,000 people estimated to be living on Saipan in early 1999 were US citizens. At that time, the labor force on Saipan totaled 46,000, of whom only 22.6% were US citizens. Foreign workers predominate in the garment industry and the construction, hotel and retail sectors. The government provides approximately 12% of the jobs and US citizens comprise most of this work force. They also make up 55% of the unemployed. The unemployment rate among Saipan's US citizen labor force in early 1999 was 13.4%, compared to 3.2% among foreign workers (Bank of Hawaii 1999).

Hawaii

Hawaii's economic situation changed dramatically in the 1990s. Several major economic sectors, such as plantation agriculture, tourism and military, suffered downturns. As a consequence, Hawaii never entered the period of economic prosperity that many US mainland states are now experiencing. Since 1998, Hawaii's tourism industry has recovered substantially, mainly because the strength of the national economy promoted growth in visitor arrivals from the continental USA. Efforts to diversify the economy, and thereby render it less vulnerable to future economic downturns, have met with little success to date (Bank of Hawaii 2000). Commercial fishing has historically represented a small share of Hawaii's total economic activity. In contrast to the sharp decline in some industries of long-standing importance in Hawaii, however, the fishing industry has been fairly stable during the past decade. More importantly, fisheries resources, especially coral reef resources, represent an important source of subsistence for Hawaii's residents during periods of economic recession. As a result of the rise in tourism-related ocean recreation in Hawaii, a premium has been placed on non-consumptive uses of nearshore marine resources (Pooley 1993a).

People of native Hawaiian ancestry comprised about 19% of the 1999 population. By most statistical measures, they have the lowest incomes and poorest health of any ethnic group in the State (OHA, 1998). In 1998, the ethnicity of Hawaii was Caucasian (22%), Hawaiian/Part Hawaiian (21%), Japanese (18%), Filipino (13%), Chinese (3%), Black (1%), Hispanic (1990) (7.3%) (DBEDT 1999). Federal, state and private programs have been established to benefit Hawaiians (OHA data indicates a significant portion of the population as ethnicity "other/unknown"). There is an active cultural renaissance with efforts to restore the language, arts and subsistence activities, including traditional fishing practices. Shoreline access and gathering rights of native Hawaiians have been reaffirmed in court decisions.

3.6.2.1 Community Dependence on Coral Reef Resources

The harvest and consumption of coral reef resources has been a part of the way of life since the islands were first settled several thousand years ago. Pacific islanders of old were considered masters in their knowledge of fish, their habits and means of capturing them. Information passed orally from one generation to the next taught an understanding of the dynamics of inshore marine resources and the skills for harvesting them. Based on their familiarity with specific places and through trial and error, the indigenous people of the islands were able to devise social controls to foster, in modern terminology, “sustainable use” of marine resources in localized areas. Periods of scarcity brought about an early awareness that marine resources were limited and led to a strongly perceived social obligation to exercise self-restraint in resource exploitation. Irresponsible resource use was tantamount to denying future generations their birthright and means of survival. Virtually every method utilized in modern fisheries management was in use in the Pacific islands centuries ago. Many of the ancient fishing techniques survived into the 20th century but culturally-appropriate fishing behavior has been compromised in contemporary times.

The methods and patterns of coral reef fisheries that have evolved over the years in the US Pacific islands grew out of these traditions. Fishing for pelagic fish in offshore waters is constrained by the need for seaworthy vessels, distance to fishing grounds and weather. In contrast, nearshore coral reef resources can be harvested with low capital outlay, less time and risk. Relative to other fisheries resources in the US Pacific islands, coral reefs are more accessible and are used by a larger and more diverse population of fishermen who employ a wider variety of gear. The following table lists the broad spectrum of coral reef taxa which are harvested for many purposes.

Coral Reed Taxa Harvested by Indigenous People and Contemporary Fishermen in the US Pacific Islands

TAXA	HARVESTED BY INDIGENOUS PEOPLE	HARVESTED BY CONTEMPORARY FISHERMEN
Acanthuridae (Surgeonfish)	**F, C, M, 1)**	**F, A**
Algae (Seaweeds)	**C, F, M, B**	**F, A**
Annelid (Seaworms)	**M**	**B, A**
Antipathes spp. (Black coral)	**M**	**A**
Apogonidae (Cardinal fishes)	**F**	**F, A**
Architeconicidae (Sundial shells, Sea hares)	**F, C**	**A**
Aulostomidae (Trumpetfish)	**F**	**A**
Balistidae (Triggerfish)	**F**	**A**
Blennidae (Blennies)	**B**	**B, A**
Carangidae (Jacks, Trevally)	**F**	**F, A**
Carcharhinidae (Sharks)	**F, C, (1**	**F, M, (1**
Cassididae (Helmet Shell)	**F, T**	**F, A**
Chaetodontidae (Butterflyfish)		**A**
Cheloniidae (Sea turtles)	**F, M, T**	**FF, A**
Cirrhitidae (Hawkfish)	**F**	**A**
Clupeidae (Herrings)		**B**
Cnidara (Sea anemones)	**F**	**A**
Conidae (Cone shells)	**F, A, T**	**A**
Crustacea (Crabs, shrimps, lobsters)	**B, F, M**	**B, F, A**

TAXA	HARVESTED BY INDIGENOUS PEOPLE	HARVESTED BY CONTEMPORARY FISHERMEN
Cypraeidae (Cowries)	**F, A, T, M**	**A, T**
Dasyatididae, Myliobatidae, Mobulidae (Rays)		**F, A**
Decapterus/Selar spp (Scads)	**B, F**	**B, F**
Echinoderms (Sea cucmbers, sea Urchins)	**B, F, T,**	**F, A**
Engraulidae (Anchovies)		**B**
Fasciolariidae (Spindleshell)	**T**	**A**
Fistularidae (Cornetfish)		**A**
Gobiidae (Gobies)	**B, F, C**	**B, A**
Holocentridae (Soldierfish)	**F**	**F**
Kuhliidae (Flagtail)	**C, F**	**F**
Kyphosidae (Rudderfish)	**F, M,**	**F**
Labridae (Wrasses)	**F, C**	**F**
Lethrinidae (Emperor fish)	**F**	**F**
Littorinidae (Kukae kolea)	**F**	
Lutjanidae (Snappers)	**F**	**F**
Melampidae (Oe)	**F**	
Moringidae, Muraenidae, Chlopsidae, Congridae, Ophichthidae (Eels)	**F**	**F, A, B**
Mullidae (Goatfishes)	**F**	**F**

TAXA	HARVESTED BY INDIGENOUS PEOPLE	HARVESTED BY CONTEMPORARY FISHERMEN
Neritidae (Snails)	**F, A, T**	**F, A**
Octopodidae (Octopus)	**F**	**F**
Patellids (Opihi)	**F, M, C, T**	**F**
Polynemidae (Threadfin)	**F**	**F**
Pomacanthidae spp (Angelfish)		**A**
Pomacentridae spp (damselfish)		**A**
Priacanthidae (Bigeye)	**F**	**F**
Pteridae (Oysters)	**F, T**	**F, A**
Scaridae (Parrotfish)	**F**	**F**
Scorpaenidae (Scorpion fishes)	**F**	**F, A**
Serranidae (Grouper, Sea bass)	**F**	**F, A**
Siganidae (Rabbitfish)	**F**	**F**
Sphyraenidae (Barracuda)	**F**	**F**
Terebridae (Auger shells)	**T**	
Verenidae (Clams)	**F, T**	**F**
Zanclidae (Moorish Idol)		**A**
Zooanthids (Soft Corals)	**M**	**A**

1) Skins of some species used for drums

A. Aquaria or ornamental uses B. Used for bait
C. Ceremonial Uses F. Used for Food
M. Medicinal Uses T. Tool Uses

American Samoa

Fishing has been interwoven with all aspects of Samoan community life and cultural identity since the islands were first settled 3,500 years ago. It shaped the traditional Samoan religion, diet, material culture, oral traditions and calendar (Severance and Franco, 1989). Fishing and its products also played a fundamental role in the social structure. Ceremonial and cultural demands involve exchange of food and other resources to support extended families and traditional leaders. Participation in commercial activities, wage labor and a cash economy has not weakened this network of social obligations as much as provided new opportunities for customary exchange of goods and services within American Samoa's tightly held aiga (extended family) system.

Fishing contributes not only to the extended family's welfare, but also to social cohesion within the broader island community. It offers individuals an occupation that is consistent with Samoan cultural values and the island lifestyle. Furthermore, to the extent that unemployment among the younger population can cause both economic and social ills, commercial fishing provides an additional opportunity for young people to be economically productive and socially responsible.

In contemporary Samoa, seafood harvested from inshore coral reefs continues to be a major component of the local diet. Wass (1982) reported that annual per capita consumption of seafood in American Samoa is 148 lb, which is several times higher than the US national average. Local catches are insufficient to meet such high demand and they are supplemented by imports of reef fish and bottomfish from neighboring Samoa.

Despite increasing commercialization, fishing continues to contribute to the perpetuation of Samoan culture and social cohesion of American Samoa communities. The role of fishing in cultural continuity is at least as important as the contributions made to nutritional and economic well-being of island residents. Continuing access to fish is important for the perpetuation of fa`a Samoa (the Samoan way of life), as well as for food.

Traditional Samoan values still exert a strong influence on when and why people fish, how they distribute their catch and the meaning of fish within the culture. Fish catches are distributed according to a strict protocol. Fishing has become increasingly commercialized, but fish, whether caught or purchased, remains a significant component of the customary exchange system. Even the fish that is sold may be fulfilling obligations to friends and members of the extended family. A recent survey of American Samoan fishermen indicated that a significant portion of the catch that is sold is done so at a reduced price to friends and kinsmen as an expression of a established social relationship (Severance et al. 1998). When distributed, fish and other resources move through a complex and culturally embedded exchange system that supports the food needs of the aiga, as well as the status of the matai (matai is the authority, chief, or specialist on land; tautai is the authority, chief or specialist on the sea) and village ministers (Severance, et al., unpublished research). Customary exchanges include:

Fa`alavelave
As a noun, mutual assistance to kinsmen in times of need; as a verb, to provide assistance in times of need. This assistance can be in the form of food from the land or sea, or money derived from local or overseas labor markets.

Tautua
As a noun, service to the kin group and to the matai as leader of the kin group; as a verb, to serve the kin group and its matai.

Fesoasoani
To help out; a less formalized, more individualized, response to a less serious need than in the case of fa`alavelave.

To`onai
A ceremonial need served after Sunday service, where ministers, matai, other village leaders and important visitors to the village reaffirm cultural and spiritual solidarity.

Fa`ataualofa
To give away or sell at a reduced price to friends or kin as an expression of an ongoing, sustained relationship.

Meyer (1987b) emphasizes that reef-associated fish are not important just as food resources but that "fish and fishing are embedded in Samoan culture and wisdom." Both Severance and Franco (1989) and Meyer (1987b) illustrate the importance of fish in Samoan culture through long lists of proverbs that feature fish and fishing gear. An important community event and one of the few remaining group fishing activities, is the harvest of palolo worms (Eunice viridis). During just a few nights each year, the reef-burrowing polychaete releases egg- and sperm-filled body segments that are delicacies in Samoa (Des Rochers and Tuilagi, 1993).

Guam and The Commonwealth of Northern Mariana Islands

Fishing of coral reef resources has occurred throughout the island's history. Archaeological evidence reviewed by Amesbury et al. (1989) suggested "... an apparent tendency throughout prehistory and historic times for Mariana Island native groups to have relied more on inshore fish species than offshore ones ... ."

In the late 1880s, the Spanish governor of the Mariana Islands wrote of Guam that "inside the reef (indigenous people) catch different varieties (of fish) all year long" (Garcia 1984). Whether the preference for reef fishing had anything to do with restrictions on the use of ocean-going canoes (flying proa) is not clear. The Governor also observed the importance of the seasonal arrival of rabbitfish (manahak) in inshore areas ("the populace then appears en masse to fish") (Garcia, 1984), which is still an important event in Guam's reef fishery in modern times. Hensley and Sherwood (1993) note that the traditional practice of sharing the catch of atulai

(Selar crumenophtalmus) from a surround net continues today, with equal portions given to the owner of the net, the village where the fish were caught and the group that participated in the harvest.

Amesbury et al (1989) concluded that “in the decades prior to the Second World War, inshore but not offshore fishing was part of the subsistence base of the native people.” One document reviewed was a list of the “principal fishes of Guam” written by a scientifically trained naval officer. Nearly all the fishes listed were reef associated. The first year that a pelagic fish species was included in the catch reports of the post-war Guam civilian government was 1956. Until then, all catch reports were of reef-associated species (Amesbury et al. 1999).

Based on creel surveys of fishermen, only about one-quarter to one-third of the inshore catch is sold. The remainder enters non-commercial channels (Knudson 1987). Reef fish continues to be important for social obligations, such as fiestas and food exchange with friends and families. One study found a preference for inshore fish species in non-commercial exchanges of food (Amesbury et al. 1989). The local harvest of reef fish is insufficient to meet commercial demand and there are substantial imports from the Federated States of Micronesia and the Philippines (Graham 1999). Annual seafood consumption in Guam is on the same order as that in the CNMI – 56 lb per capita (Graham 1999).

Over the centuries of acculturation beginning with the Spanish conquest in the late seventeenth century, many elements of traditional Chamorro and Carolinian culture in Guam and the Northern Mariana Islands were lost. But certain traditional values and attitudes were retained and have been melded with elements of Western culture that are now a part of local life and custom. High value is placed on sharing one’s fish catch with relatives and friends. Sometimes fish are sold in order to earn money to buy gifts for friends and relatives on important religious (Catholic) occasions such as novenas, births and christenings, and other holidays (Amesbury et al. 1989).

In addition, the people of Guam and the CNMI participate in many banquets throughout the year associated with neighborhood parties, wedding and baptismal parties and especially the village fiestas that follow the religious celebrations of village patron saints. All of these occasions require large quantities of fish and other traditional foods (Orbach 1980).

Commonwealth of the Northern Mariana Islands

Fishing in Guam and the CNMI continues to be important not only in terms of contributing to the subsistence needs of the Chamorro and Carolinian people of the Mariana Islands but also in terms of preserving their history and identity. Many aspects of traditional Chamorro and Carolinian culture have been lost. Fishing has assisted Chamorros and Carolinian in keeping alive what remains of the maritime attributes of their traditional culture and helped them maintain their connection to the sea and its resources.

The social obligation to share one's fish catch extends to part-time and full-time commercial fishermen. In Guam and the CNMI locally caught fish are often sold informally (Amesbury and Hunter-Anderson 1989; Amesbury et al. 1989). The buyers are mainly friends, neighbors, and relatives, especially in the CNMI. This non-anonymous, very personal "market" tends to restrain the price asked and paid.

In 1980, an observer wrote that "although subsistence fishing is clearly not as prevalent as it has been in the past, subsistence and mixed economy fishing are important to all segments of the population as income and nutrition sources, as recreation, and as an integral part of family and community life and reinforcement of cultural traditions" (Orbach 1980).

The CNMI (and Guam) are well known for their community celebrations known as fiestas, which are held on such occasions as birthdays, baptisms, marriages and village patron saints' days. The fiesta serves several social functions, one of which is to promote and cement social cohesion. A large assortment of food, including locally-caught reef fish, is served in prodigious quantities (McCoy 1997).

There continues to be high demand for coral reef resources as seafood in the CNMI because of the indigenous cultures and the presence of a large population of non-resident workers from Asia. Total seafood consumption in the NMI has been estimated at about 56 lb per person (including tourists). Locally-harvested products accounted for slightly less than half of the total supply. Reef fish landings, by weight, were a more important component of the local catch than bottomfish or pelagic fish. Estimates of the annual catch of reef fish in the CNMI are about 150,000 lb for sale and 280,000 lb for subsistence. The major commercial outlets for locally caught reef fish are small retail markets, hotels and restaurants on Saipan. Chamoru and Carolinian consumers are the most important retail fish buyers (Radtke and Davis 1995).

Hawaii

Archaeological evidence indicates that seafood, particularly coral reef species, was part of the customary diet of the earliest human inhabitants of the Hawaiian Islands (Goto 1986). Nineteenth- century immigrants to Hawaii from Asia also possessed a culture in which fish was not only an integral part of the diet but also imbued with symbolic meaning. Today, seafood is not the only source of protein but seafood consumption in Hawaii is still at least twice as high as the US national average (Dames and Moore, in prep.).

Fishing and related activities in traditional Hawaii were often highly ritualized and were important in religious beliefs and practices. The Kumulipo, or Hawaiian creation legend, had fishes created after corals and mollusks, but before insects and birds (Beckwith 1951). Certain species of fish were venerated as personal, family or professional gods (aumakua).

The introduction of a cash economy into Hawaii and the establishment of communities of foreigners in the islands led to the development of a local commercial fishery. Because seafood was such a significant item in the diets of local residents, the fish markets themselves became important institutions in Hawaii society.

Much of the retailing of fish now occurs through self-service supermarkets, but Honolulu's fish market has endured and continues to be a center of social interaction for some island residents. The market is comprised of retail units the majority of which are single proprietorship-family type operations. Close social connections have developed between retailers and consumers, as the success of the dealers is largely a function of their ability to maintain good relations with their customers and maintain a stable clientele (Garrod and Chong 1978). The large variety of seafood typically offered in Hawaii's seafood markets reflects the diversity of ethnic groups in Hawaii and their individual preference, traditions, holidays and celebrations (Dames and Moore, in prep.).

Over the past 125 years the socio-cultural context of fishing in Hawaii has been shaped by the multi-ethnicity of local fisheries. Although certain ethnic groups have predominated in Hawaii's fisheries in the past and ethnic enclaves continue to exist within certain fisheries, the fishing tradition in Hawaii is generally characterized by a partial amalgamation of cultures. An examination of the way in which the people of Hawaii harvest, distribute and consume seafood reveals remnants of the varied technology, customs and values of Native Hawaiians and immigrant groups from Japan, China, Europe, America, the Philippines and elsewhere. Many of the immigrants groups that came to Hawaii brought with them cultures in which fish were not only an integral part of the diet but also imbued with symbolic meaning.

An insistence on quality, as well as quantity and variety, has also long been a hallmark of Hawaii's seafood markets A strong preference for high quality, fresh fish continues to characterize Hawaii seafood consumers. Both the discriminating tastes of local residents and the symbolic meaning with which some fish are imbued are linked to the importance of fish as gifts from one person or family to another. Such sharing and gift giving may play an important role in maintaining social relations, as exemplified by the traditional Japanese obligation to engage in reciprocal exchanges of gifts according to an intricate pattern of established norms and procedures (Ogawa 1973). Those who neglect the obligation to reciprocate risk losing the trust of others and eventually their support.

The sharing of fish among members of the extended family and community is also an early tradition of the indigenous people of Hawaii. The social responsibility to distribute fish and other resources among relatives and friends remains a salient feature of the lives of many Native Hawaiians that is enacted on both a regular basis and during special occasions (Glazier 1999). Among Native Hawaiians fish is considered a customary food item for social events such as a wedding, communion, school graduation, funeral or child's first birthday (baby luau) (Glazier 1999).

Commercial fishing has been part of Hawaii's economy for nearly two centuries. Long-established fishing-related infrastructures in Honolulu such as the fish market and the Kewalo Basin mooring area have helped define the character of the city. And for some major ethnic groups in Hawaii, such as the Japanese and Native Hawaiians, the role that their forebears played in the development of commercial fisheries in the islands remains an important part of their collective memory. In 1999, for example, the Japanese Cultural Center of Honolulu organized an exhibition commemorating the past involvement of Japanese in Hawaii's commercial fishing industry.

Finally, some Hawaii fishermen feel a sense of continuity with previous generations of fishermen and want to perpetuate the fishing life style. A 1993 survey of participants in the NWHI bottomfish fishery found that half of the respondents who fish in the Ho'omalu Zone were motivated to fish by a long term family tradition (Hamilton, 1994). This sense of continuity is also reflected in the importance placed on the process of learning about fishing from "old timers" and transmitting that knowledge to the next generation.

Fulfillment of social obligations may also at times be an important reason for fishing. Fish are an important food item among many of the ethnic groups represented in Hawaii, especially during various social events. Fishermen are expected to provide fish during these occasions and may make a fishing trip especially for that purpose (Glazier 1999).

Given the historical significance of commercial fishing in Hawaii, it's likely that some local residents consider the fishing industry to be important in the cultural identity and heritage of the islands. Individuals who have never fished and do not intend to may nonetheless value the knowledge that others are fishing and that this activity is continuing to contribute to Hawaii's social, cultural and economic diversity. This existence value may be expressed in various ways. For example, some individuals may engage in vicarious fishing through the consumption of books, magazines and television programs describing the fishing activities that others are pursuing in the waters around Hawaii.

Just as Hawaii's fishing tradition is an integral part of the islands' heritage and character, the image of Hawaii has become linked with some types of locally caught seafood consumed. Among the fish species that have become closely identified with Hawaii are opakapaka and onaga. As noted by a national seafood marketing publication, this symbolic association has an important economic aspect:

> When it comes to selling seafood the Hawaiians have a distinct advantage. Their product comes with built-in aloha mystique, and while they've emphasized the high quality of the fish taken from their waters, they've also taken full advantage of the aura of exotic Hawaii itself in promotion on the mainland and, now, in Europe (Marris 1992:75)

The availability of seafood is also important to Hawaii's tourist industry, the mainstay of the state economy. Japanese tourists visiting Hawaii often want to enjoy the traditional foods and symbols of Japan while they vacation in Hawaii, including various types of high quality fresh fish (Peterson 1973). Hawaii tourists from the U.S. mainland and other areas where fish is not an integral part of the customary diet typically want to eat seafood because it is part of the unique experience of a Hawaii vacation. Consuming fish that is actually caught in the waters around Hawaii further enhances that experience (WPRFMC, 2000).

Hawaii's commercial catch statistics show an increase from about 6 million pounds in 1900 to about 19 million pounds in 1953 and a subsequent decrease to 11 million lb in 1986. Not surprisingly, most of the increase was in the pelagic fishery. The reported commercial catch of the "coastal" fishery (reef, bays and nearshore habitats), in fact, declined from about 3.6 million to 0.6 million lb from 1900 to 1986 (Shomura, 1987).

3.6.2.2 Community Participation in Coral Reef Fisheries

Contemporary participation in coral reef fisheries in the US Pacific islands has grown out of ancient traditions. Near the more populated islands, however, the impacts of fishing have been magnified by population growth and the introduction of modern, manufactured gear (e.g., monofilament nets, SCUBA).

Coral reef products that enter commercial markets typically undergo very little processing and the chain of sale is very short – from harvesters to retailers to consumers. There are no known participants whose primary business is processing coral reef products. Wholesalers of coral reef products are also rare. The predominant use of coral reef resources is for subsistence, where the product moves directly from harvester to consumer, often within the same family or village (Graham, 1999).

American Samoa

The majority of fishermen in American Samoa harvest coral reef resources for subsistence and do not sell their catches. Samoans have cultural obligations to extended families, traditional leaders and village ministers that require the exchange of food and other resources. Undertaking fishing on a part-time basis, rather than as a full-time business, provides residents with the flexibility to fulfill these obligations, which are an integral part of fa`a Samoa (the Samoan way of life).

There are no data available on the proportion of the population that engages in fishing, but the number must be greater than 50%. Interviews with men and women in 42 villages of Tutuila, revealed that most men and women fished in the reef environment between 1 and 4 times per week and that they ate meals of those fish between 1 and 6 times per week (Rochers and Tuilagi 1993). The number of sometime food fishermen probably ranges from 10,000 to 30,000, with less than one percent of these involved in commercial harvesting (Graham, 1999).

Guam

Prior to the arrival of Europeans in Guam and the other Mariana Islands in the sixteenth century the Chamorros, as the original inhabitants of these islands were called, possessed large sailing canoes that enabled them to fish on offshore banks and sea mounts (Amesbury and Hunter-Anderson, 1989). However, during the 1700s the large, oceangoing canoes of the Chamorros were systematically destroyed by the Spanish colonizers of the Mariana Islands in order to concentrate the indigenous population in a few settlements, thereby facilitating colonial rule as well as religious conversion (Amesbury and Hunter-Anderson 1989). After the enforced demise of the sailing canoes, fishing for offshore species was no longer possible. By the mid-nineteenth century, there were only 24 outrigger canoes on Guam, all of which were used only for fishing inside the reef (Meyers, 1993). Another far-reaching effect of European colonization of Guam and other areas of the Mariana archipelago was a disastrous decline in the number of Chamorros, from an estimated 40,000 persons in the late seventeenth century to approximately 1,500 persons a hundred years later (Amesbury and Hunter-Anderson 1989).

After the U.S. acquired Guam in 1898 following the Spanish-American War the U.S. colonial government held training programs to encourage local residents to participate in offshore commercial fishing (Amesbury and Hunter-Anderson, 1989). However, the residents were deterred from this endeavor by a lack of capital to purchase and maintain the necessary large boats and a reticence to be at sea overnight or longer. Shortly after the end of World War II the U.S. military assisted several villages in developing an inshore commercial fishery using nets and traps (Anon. 1945). Post-World War II wage work enabled some fishermen to acquire small boats with outboard engines and other equipment for offshore fishing (Amesbury and Hunter-Anderson, 1989). However, even as late as the1970s, relatively few people in Guam fished offshore even on the protected (leeward) side of the island because the cost of a boat and deep-sea fishing equipment was prohibitive for most residents (Jennison-Nolan, 1979).

In the decades following the end of World War II the ethnic composition of Guam's population changed markedly. By 1980, Chamorros constituted less than half of the total inhabitants (Amesbury, 1989). In the late 1970s, a group of Vietnamese refugees living on Guam fished commercially on a large scale, verifying the market potential for locally caught reef fish, bottomfish, tuna and mackerel (AECOS, Inc.1983). Also during that time the Guam Fishermen's Cooperative Association began operations. Until the co-op established a small marketing facility at the Public Market in Agana, fishermen were forced to make their own individual marketing arrangements after returning from fishing trips (AECOS, Inc.1983). In 1980, the co-op acquired a chill box and ice machine and emphasis was placed on wholesaling. Today, the co-op's membership includes over 160 full-time and part-time fishermen, and it processes and markets (retail and wholesale) an estimated 80% of the local commercial catch (Duenas, undated).

As Guam's tourism industry grew in the1980s a fleet of marina-berthed charter vessels developed that were used by tourists and residents for bottomfish fishing (Meyers, 1993). The charter boats made multiple 2-hour to 4-hour trips daily. Two types of charter bottomfish fishing trips were organized. The more typical charter boats involved 3 to 6 patrons, while the larger "party-boat" vessels carried up to as many as 30 patrons on a single trip. Most of these bottomfish charters operate out of the Agat Marina and primarily target the shallow water complex of bottomfish. Since most of the charter fishing trips are of short duration, it is unlikely that many of the trips are conducted in federal waters (WPRFMC 1999).

Participants in inshore (reef) fisheries are predominantly of indigenous Chamoru ancestry. Their harvest accounts for 79 percent of the non-commercial component of the inshore catch. One study concludes that "probably no one was supported full-time by this fishery, but probably a great many people added a useful income for themselves and their families through it" (Knudson 1987). In characterizing Guam's fisheries, Knudson (1987) concludes that "the commercial fishery on Guam is the product of many relatively small sales by a large number of 'semi-commercial' fishers and that the non-commercial fishery is the product of a considerable pool of subsistence fishers plus another sizeable pool of recreational fishers," and that, "on the whole, catches in the Guam fishery are small, but that the number of participants is quite large." The number of sometime food fishermen who harvest coral reef resources in Guam may be on the order of 20,000, with less than one percent engaged in commercial harvesting (Graham, 1999).

For the past two decades bottomfish fishing around Guam has been a highly seasonal small-scale commercial, subsistence and recreational fishery. The majority of the participants in the bottomfish fishery operate vessels less than 25 feet long and primarily target the shallow-water bottomfish complex (WPRFMC 1999). The shallow-water component is the larger of the two in terms of participation because of the lower expenditure and relative ease of fishing close to shore (Meyers, 1993). Participants in the shallow-water component seldom sell their catch as they fish mainly for recreational or subsistence purposes (WPRFMC 1999). The commercially-oriented highliner vessels tend to be longer than 25 feet, and their effort is usually concentrated on the deep-water bottomfish complex.

Northern Mariana Islands

Following the arrival of Europeans in 1521, the Northern Mariana Islands were colonies of Spain (1521-1898), Germany (1899-1914) and Japan (1915-1944). The Chamorros of the Northern Mariana Islands suffered the same deprivations under early Spanish colonial administration as those living on Guam. During the early 1800s people from the Caroline Islands were encouraged by the Spanish government to establish permanent settlements in the Mariana Islands (Amesbury et al. 1989). The Carolinians who settled in the Mariana Islands came with a well-developed sea-faring tradition. Their fishing activity largely centered on the harvest of lagoon and reef species, but small paddling canoes were sometimes used to fish a short distance outside the reef (Amesbury, et al., 1989).

Under Japanese rule the Northern Mariana Islands became a major fishing base, primarily for the harvest of skipjack tuna. However, the Chamorros or Carolinians of the Northern Marianas had little or no involvement in these industrial-scale fish harvesting or processing operations. According to Joseph and Murray (1951), the colonial policy of the Japanese prohibited the Chamorros and Carolinians from engaging in commercial fishing and most other remunerative enterprises. During this period the Chamorros and Carolinians presumably relied heavily on subsistence use of inshore marine resources (Amesbury, et al., 1989). When the Americans assumed control of the islands at the end of World War II the fishing industry was left in the hands of Japanese civilian prisoners until their repatriation in 1946.

The post-World War II years saw a gradual involvement of the Chamorros and Carolinians of the Northern Marianas in commercial fishing. According to Orbach (1980), the Carolinians were the leaders in forming crews for fishing enterprises involving larger craft and offshore fishing. Orbach attributed the predominance of Carolinians in these initial offshore fishing ventures to the importance of fishing in traditional Carolinian culture and the closely-knit family and community structures within Carolinian settlements on Saipan that facilitated cooperative efforts in fishing.

By 1980, several boats over 25 ft. in length were actively engaged in commercial fishing for bottomfish and pelagic species (Orbach, 1980). One vessel was operated by a Carolinian company, one was owned and operated by the Tinian Fishing Cooperative whose membership was Chamorro and two other boats were skippered and crewed mainly by Japanese fishermen. In addition, some of the charter vessels that had been operating in the CNMI since 1978, catering to the Japanese tourists, were also being used to catch fish for sale to hotels and restaurants on Saipan (Orbach, 1980).

Many of the early offshore commercial fishing ventures involving large vessels received support from the CNMI government in the form of loans and fishing supplies (Orbach, 1980). However, all of the fishing enterprises failed within a few years because of inadequate markets, lack of management expertise and other factors. After some time a number of other large vessels entered the bottomfish fishery, but they too eventually dropped out. This considerable turnover pattern of entry and exit has continued over the past two decades. In 1999, there were two major bottomfish fishing operations. One of the owners suspended his entire operation toward the end of the year because of financial problems. The downturn in the Asian economy has had a severe impact on the tourism industry in the CNMI, and the demand for bottomfish by local hotels has declined. However, another company has started its own fishing operation with two multi-purpose vessels. In addition, another individual is considering converting a deep-sea shrimp boat to bottomfish fishing (M. Trianni, CNMI Division of Fish and Wildlife, pers. comm.).

The CNMI bottomfish fishery consists mainly of small (<24 ft.) boats engaged in commercial and subsistence fishing within a 20-mile radius around the islands of Saipan, Tinian, and Rota. However, larger vessels have periodically entered the fishery that are capable of traveling to the northernmost islands of the NMI. The larger vessels fish primarily for commercial purposes and target both deep-water and shallow-water bottomfish species, the latter primarily on the extensive banks and reefs surrounding Farallon de Medinilla (WPRFMC 1999). The smaller vessels fish both commercially and for subsistence and target shallow water species.

The number of sometime food fishermen in the NMI may be 10,000 to as many as 30,000 (Graham 1999), depending on how actively the large population of non-resident Asian workers is engaged in fishing. Few depend on fishing for all of their income (Hamnett et al. 1999). The primary motivation for fishing is to provide food for home consumption and gifts to family and friends (Graham, 1999).

According to Hamnett et al. (In prep.), each fishing trip had multiple purposes and the catch was used in a variety of ways, even though the primary reason for the fishing trip may have been associated with a specific event. Sixty-five percent of those surveyed contributed fish to a family or church fiesta. All of those who contributed fish to an event also took some of their catch home, gave fish to extended relatives or sold some of their catch. Interviews with those surveyed revealed that fishers who fished with the primary intent of make a contribution to an event, rarely sold part of their catch and usually took home fish for consumption.

Orbach (1980) notes that the fisheries in CNMI are inextricably involved with the lifestyles and plural-occupational patterns of the participants. Part-time fishing performed in conjunction with other activities has a prominent place in the socio-economic adaptations of local residents. People fish for bottomfish and pelagic species to supplement their family subsistence, which is gained by a combination of small scale gardening and wage work (Amesbury, et al., 1989). Orbach suggests that the availability of economic activities such as part-time fishing is among the major reasons that CNMI has not experienced more of the problems of other island entities such as out-migration or high rates of crime and juvenile delinquency.

Because they are acculturated to fishing and seafood consumption practices in their home countries, the Asians are likely to harvest a wider spectrum of coral reef resources for food and declining catch rates are less likely to be a disincentive to the continuation of fishing as for indigenous islanders. Such attitudes differ from those of indigenous islanders.

Hawaii

Commercial fishing first became important in the Hawaiian Islands with the arrival of the British and American whaling fleets during the early nineteenth century. Initially, commercial fishing in Hawaii was monopolized by Native Hawaiians, who supplied the local market with fish using canoes, nets, traps, spears and other traditional fishing devices (Jordan and Evermann, 1902; Cobb, 1902; Konishi, 1930). However, the role that Native Hawaiians played in Hawaii’s fishing industry gradually diminished through the latter half of the nineteenth century. During this period successive waves of immigrants of various races and nationalities arrived in Hawaii increasing the non-indigenous population from 5,366 in 1872 to 114,345 in 1900 (OHA 1998). The new arrivals included Americans, Chinese, Portuguese and Filipinos, but particularly significant in terms of having a long-term impact on the fishing industry was the arrival of a large number of Japanese. The Japanese, like the majority of the early immigrants, were contracted to work on Hawaii’s sugar cane plantations. When contract terms expired on the plantations many of the Japanese immigrants who had been skilled commercial fishermen from the coastal areas of Wakayama, Shizuoka and Yamaguchi Prefectures in Japan turned to the sea for a living (Okahata, 1971). Later, experienced fishermen came from Japan to Hawaii for the specific purpose of engaging in commercial fishing. During the early years of the commercial bottomfish fishery vessels restricted their effort to areas around the MHI. The fishing range of the sampan fleet increased substantially after the introduction of motor powered vessels in1905 (Carter, 1962). Fishing activity was occurring around the NWHI at least as early as 1913, when one commentator recorded: “Fishing for ulua and kahala is most popular, using bonito for bait, fishermen seek this [sic] species in a 500 mile range toward Tori-Jima [NWHI]” (Japanese Consulate 1913, as cited in Yamamoto 1970:107). Within a few years more than a dozen sampans were fishing for bottomfish around the NWHI (Anon. 1924; Konishi 1930). Fishing trips to the NWHI typically lasted 15 days or more, and the vessels carried seven to eight tons of ice to preserve their catch (Nakashima, 1934). The number of sampans traveling to the more distant islands gradually declined due to the limited shelter the islands offered during rough weather and the difficulty of maintaining the quality of the catch during extended trips (Konishi, 1930). However, during the 1930s, at least five bottomfish fishing vessels ranging in size from 65 to 70 ft. continued to operate in the waters around the NWHI (Hau, 1984). In addition to catching bottomfish, the sampans harvested lobster, reef fish, turtles and other marine animals (Iversen, et al., 1990).

During much of the twentieth century Japanese immigrants to Hawaii and their descendants were preeminent in Hawaii's commercial fishing industry. Over the years, succeeding generations of fishermen of Japanese ancestry in Hawaii became more "Americanized," but many Japanese fishing traditions persisted. During World War II the bottomfish fishery in Hawaii virtually ceased operations, but it recommenced shortly after the war ended (Haight, et al., 1993). The late 1940s saw as many as nine vessels fishing around the NWHI, but by the mid-1950s, vessel losses and depressed fish prices resulting from large catches had reduced the number of fishery participants. The Pacific Ocean Fishery Investigation in 1948 began research for potential commercial fishery yield in the Northwestern Hawaiian Islands. In 1950, Leo Ohai, owner and captain of the Sea Queen, transported a small aircraft to French Frigate Shoals to support akule fishing and Buzzy Agard flew catches of akule in a DC3 cargo aircraft from French Frigate Shoals to Honolulu. Buzzy Agard captained the Koyo Maru to catch akule at Nihoa. During the 1960s, only one or two vessels were operating around the NWHI.

As late as the 1970s, the full-time professional fishermen in Hawaii were predominately of Japanese descent (Garrod and Chong, 1978). However, by that period hundreds of local residents of various ethnicities were also participating in Hawaii's offshore fisheries as part-time commercial and recreational fishermen.

There were 2,000 to 2,500 commercial fishermen in 1900 (Cobb, 1902). In 1947, the number was about 3,500 (Hida and Skillman, 1983), but by 1985, the number had decreased back to about 2,600 (Shomura, 1987). Thus, while Hawaii's motorized fleet grew remarkably during this century, participation in the commercial fisheries did not.

There was renewed interest in harvesting the bottomfish resources of the NWHI in the late-1970s following a collaborative study of the marine resources of the region by state and federal agencies (Haight, et al., 1993). The entry of several modern boats into the NWHI fishery and the resultant expanding supply of high-valued bottomfish such as opakpaka and onaga made possible the expansion of the tourism-linked restaurant market by allowing a regular and consistent supply of relatively fresh fish (Pooley, 1993a). Markets for Hawaii bottomfish further expanded after wholesale seafood dealers began sending fish to the U.S. mainland. By 1987, 28 vessels were active in the NWHI bottomfish fishery, although only 12 were fishing for bottomfish full time. Some of the non-full time vessels also engaged in the pelagic or lobster fisheries (Iversen et al. 1990). In 1989, the Western Pacific Regional Fishery Management Council developed regulations that divided the fishing grounds of the NWHI bottomfish fishery into the Ho'omalu Zone and Mau Zone. Limited entry programs were established for the Ho'omalu Zone and Mau Zone in 1989 and 1999, respectively, to avoid economic overfishing (Pooley, 1993b). Since 1995, the number of vessels allowed to fish in the Ho`omalu Zone has been capped at seven. Currently, only 10 vessels are allowed to bottomfish in the Mau zone (Dames and Moore, in prep.). The NWHI lobster fishery, centered around Necker Island, underwent a similar evolution. It developed in the late 1970s, reached a peak of 16 vessels in 1985 and 1986 and subsequently declined, with 9 vessels active in 1997 (of 15 allowed under the limited access system) (Pooley and Kawamoto, 1998).

The 1970s also saw major changes in the composition and operations of the bottomfish fishery around the main Hawaiian Islands. The fishery changed from one dominated, in terms of catch and effort, by a relatively small number of full-time professional fishermen to one dominated by hundreds of part-time commercial and recreational fishermen. This change was the result of a number of factors. The popularity of offshore fishing increased in Hawaii with the increase in the availability of locally-built and imported small fiberglass boats. In addition, the rise in fuel prices during the 1970s made fishing for bottomfish particularly attractive to fishermen as it consumed less fuel than trolling and generated higher-value fish catches to offset fuel costs. Finally, as navigation systems, bottom-sounders and hydraulic or electric powered reels became more affordable, the skill level and experience necessary to fish bottomfish successfully was reduced and the labor associated with hauling up the long lines was considerably lightened.

During the early 1980s, with the development of a much larger market for bottomfish, bottomfish fishermen fishing around the main Hawaiian Islands were able to obtain premium prices for their catches, and thus were motivated to increase their landings (Pooley, 1993a). However, the number of vessels participating in the MHI fishery declined after reaching a peak of 583 in 1985. This decrease in fishing effort suggests that some bottomfish fishermen perceived a growing shortage of bottomfish in the MHI fishery and switched to other fisheries. In 1998, concerns about decreasing catch rates led the State of Hawaii to close certain areas around the MHI to bottomfish fishing, including areas of Penguin Bank within the EEZ. In addition, new state rules established a recreational bag limit of five onaga or ehu, or a mix of both, per person.

Today, the people who participate in Hawaii’s reef-related fisheries comprise an ethnically mixed and spatially dispersed community numbering thousands of individuals. A large percentage of the population harvests coral reef resources for subsistence and customary exchange of food with friends and family. Although actual numbers are difficult to ascertain, it has been estimated that sometime food fishermen range between 100,000 to 400,000 individuals (Graham, 1999).

There are a few rural villages in the state where most residents are at least partially economically dependent on fishing (Glazier, 1999). In general, however, those who are dependent on or engaged in the harvest of fishery resources to meet social and economic needs do not include entire cities and towns, but subpopulations of metropolitan areas and towns. These subpopulations comprise fishing communities in the sense of social groups whose members share similar lifestyles associated with fishing.

The motivations for fishing among contemporary Hawaii fishermen tend to be mixed even for a given individual (Glazier, 1999). In the small boat fishery around the MHI the distinction between “recreational” and “commercial” fishermen is extremely tenuous (Pooley, 1993a). Hawaii’s seafood market is not as centralized and industrialized as U.S. mainland fisheries, so that it is has always been feasible for small-scale fishermen to sell any or all of their catch for a respectable price. Money earned from part-time commercial fishing is an important supplement to the basic incomes of many Hawaii families.

Even those fishermen who rely on fishing as their primary source of income have other reasons for their occupational choice besides financial gain. For example, a 1993 survey of owner-operators and hired captains who participate in the NWHI bottomfish fishery found that enjoyment of the lifestyle or work itself is an important motivation for fishing among fishery participants (Hamilton, 1994).

Hawaii is the only area of the US Pacific Islands where a significant reef ornamentals fishery has developed. The State of Hawaii regulates ornamental collecting by permit. Most of the commercial collecting occurs around the island of Hawaii (Miyasaka, 1997). At least 60 businesses, employing at least 255 people, are involved in collecting, wholesaling, retailing, importing and exporting of reef ornamental products in Hawaii (Miyasaka, 1991).

In addition to its commercial fisheries, Hawaii has a large and apparently still growing recreational fishery, which overlaps considerably with the commercial and subsistence components. In a 1996 national survey of recreational fishing (in which "recreation" included charter fishing), it was estimated that 244,000 recreational marine anglers, about half of them residents of Hawaii, made 2.3 million angler-trips (2.9 million angler-days) in Hawaii (FWS and BC, 1998).

Native Hawaiians participate at all levels of coral reef fisheries from subsistence to commercial fishing. Possible historic and economic barriers to greater Hawaiian participation in commercial aspects of coral reef fisheries include lack of capital and of training.

3.6.2.3 Description of Indigenous Cultural Framework

Coral reef resources do not merely feature strongly in Pacific island societies, they have shaped the social and cultural fabric of the islands. The indigenous people of the US Pacific islands have a particularly deep traditional, historical and contemporary involvement with coral reef resources. Fishing of coral reef resources not only provides food but cultivates intimacy and harmony with the ocean, reinforcing a sense of kinship with nature and relationships with places that perpetuate cultural identities and beliefs.

The indigenous people of old depended on fishing for survival. The need for food security motivated them to acquire a sophisticated understanding of the factors that caused limitations and fluctuations in marine resource availability. Complex interactions of resource dynamics, ocean, weather and lunar cycles and human use were considered in a holistic perspective. Based on their familiarity with specific places and through much trial and error, indigenous communities were able to devise systems that fostered, in modern terminology, "sustainable use" of coral reef resources. These social and cultural controls pre-date western concepts of fishery management by several thousand years. Behavior before, during and after fishing was disciplined by a strict code of conduct and transgressions were harshly punished. Expected norms grew from awareness that marine resources were limited and a strongly perceived social obligation to exercise restraint in resource exploitation. Rather than controlling fishing based on the number of fish harvested, as in western management, traditional Pacific island controls emphasized how fishing should be conducted to avoid disrupting the critical life processes of target resources. The code of conduct was based on an intimate understanding of coral reef fishery dynamics far more detailed than found in modern-day fishery management. The extensive knowledge of indigenous Pacific island fishing communities has been much studied and celebrated but it is rarely incorporated in contemporary management of coral reefs.

One of the strongest testaments to the importance of coral reefs is the marine tenure systems of the US Pacific islands. Control by villages, clans and families was typically not limited to the resources of the land but extended to the seaward edge of adjacent reefs. Boundaries on the reef were, and in some areas still are, as distinct and well-known as those on land. The political systems of most islands included leadership positions that dealt solely with marine and reef resources. These leaders controlled and directed fishing and the distribution of the catch, both of which activities were highly ritualized (Graham, 1999).

Indigenous Claims and Visions for Coral Reef Ecosystems

Indigenous values are powerfully expressed in the vision statement of the Council's Native and Indigenous Rights Advisory Panel adopted April 20, 1999:

> The Pacific islands are the homes we inherited from our ancestors. We who live here choose not to be strangers in our own land. The values of love and care for the land guide our stewardship of our natural resources, which nourish our families both physically and spiritually. We live by our elders' historic legacy of powerful prayer. We honor our islands' cultural heritage and these cultures are practiced in our everyday lives. Our true wealth is measured by the extent of our generosity.

- We envision strong families who steadfastly preserve, protect and perpetuate these core Pacific island values.
- We envision wise and caring communities that take pride in their resourcefulness, self-sufficiency and resiliency.
- We envision resolute Pacific islanders who are firmly in charge of the resources and destinies of their island states.
- We envision Pacific islands that leave for its children a visible legacy: islands abundant with natural and cultural resources, people who help and look after one another, and communities that strive to build an even better future on the firm foundation left to us by our ancestors whose bones guard our land.

History of the Hawaiian Ceded Lands Trust and the Claim for Hawaiian Rights

The Ceded Lands were former Government and Crown lands that, after the overthrow of the Kingdom of Hawaii, were ceded to the United States by the Provisional government of Hawaii. The provisional government was seeking annexation by the United States. In 1898, after passage of the “Newlands Resolution,” Hawaii was considered a territory of the United States. In 1899, the United States Attorney General, interpreting the language of the Newlands Resolution, consigned all the “public” lands, former Government and Crown lands, to a special trust limiting the revenue from or the proceeds of the lands to the uses of the inhabitants of the Hawaiian Islands for educational and other purposes (Mackenzie, 1991).

In 1900, the passage of Hawaii’s Organic Act confirmed the cession of the ceded lands to the United States and provided specific laws for administering the public lands. The federal government recognized that, though they had received absolute title from the Republic of Hawaii, the beneficial title to the lands belonged to the inhabitants of Hawaii.

The special relationship the federal government had with native Hawaiians was demonstrated with the passage of the Hawaiian Homes Commission Act of 1920.

188,000 acres were withdrawn from the Ceded Lands trust and placed under the authority of the Hawaiian Home Lands Commission (Murakami, 1991).

In 1959, Hawaii became a State. It is apparent that the framers of the Admission Act were concerned with the survival and existence of Hawaiians. Native Hawaiians had been displaced from their ancestral lands and their rights had not been adequately protected. The disinheritance from their lands resulted in a dismal economic, social and physical conditions for native Hawaiians. The existence of the race and culture was in jeopardy. The former Government and Crown lands were conveyed to the State as trustee under section 5 of the Admission Act. Under Section 5f of the Admission Act are five stated purposes for the income and proceeds derived from these lands. One of the purposes of section 5f is “for the betterment of the conditions of Native Hawaiians as defined in the Hawaiian Homes commission Act of 1920.” In 1978 the Hawaii Constitutional Convention created the Office of Hawaiian Affairs to receive a pro rata share of the proceeds and income from the Ceded lands trust. The State legislature set the share at 20%. The federal recognition of native Hawaiians and the special relationship between Hawaiians and the United States is exemplified in the actions regarding the former Government and Crown Lands, now referred to as the Ceded Lands. The 20% pro rata share of the proceeds and income from the ceded lands is the basis of the claims for 20% share of the resources of the State.

In 1953, an executive order by the President of the United States placed all submerged lands under the authority of the States. Submerged lands were defined in 1892, by the US Supreme Court, as all those lands under navigable waters of the State. The Supreme Court further recognized that this was a special class of land. Though States would hold title and authority over these lands they could not be treated as any other lands held by the States. Submerged lands were addressed in Section 5i of the Admission Act. Because of the position of the lands below navigable waters these lands could not be sold, leased or utilized unless it was by a special provision for the purpose of building piers or other structures that would benefit their use by the public.

The Northwestern Hawaiian Islands

In the late 19th century, King Kalakaua claimed all the islands to Kure Atoll for the Kingdom of Hawaii. The Northwestern Hawaiian Islands are part of the Government and Crown Lands that became the Ceded Lands Trust held by the State of Hawaii(source,).

To enhance the revitalization of Native Hawaiian Culture and to correspond with the vision of the State and Federal government's view of native culture, management of the Northwestern Hawaiian Islands must allow for the inclusion of the native voice in the decision-making process. Native access rights and cultural practices must be allowed. Reservation of rights to resources must be allowed. Additionally, the ability of the Hawaiian culture to perpetuate and accumulate cultural resources must be allowed. Culture must be practiced and allowed to grow to be viable, otherwise it is relegated as a museum piece, evidence of something that was.

Cultural and Spiritual Uses

Necker Island has 33 identified shrines, "heiau," and was undoubtedly a place of spiritual and religious importance. The number of shrines indicates that the purpose for visiting Necker Island was religious (Cleghorn, 1988). This use should be allowed so that Hawaiian spiritual beliefs and practices can be continued.

The American Indian Religious Freedom Act of 1978 was enacted to protect the religious rights of the Native American to access recognized sacred sites and burial sites. The Native American Graves Protection and Repatriation Act protects religious sites burial sites and funerary objects and establishes a process for the repatriation of the native remains and objects.

Nihoa Island has yielded burial sites. The burial sites, agricultural terracing and evidence of settlement indicates at least a semi-permanent settlement at Nihoa (Cleghorn, 1988). Access to Nihoa must be allowed for cultural and spiritual purposes.

Ka`ula Rock, Nihoa Island, and Necker (Mokumanamana) Island were known as the triplets in Hawaiian mythology and they marked the gateway to Hawaii. The Renaissance of Polynesian Voyaging makes access to the waters and terrestrial sites of these islands important to the future life of Hawaiian culture.

Access to the waters and terrestrial sites of Ka`ula, Nihoa and Necker is important for the education about and revitalization of Hawaiian culture. Gathering for customary and traditional practices shall be allowed in the Northwestern Hawaiian Islands. Resources for these materials have been greatly damaged by unregulated harvest in the Main Hawaiian Islands.

Economic Opportunity

Fisheries must be established in the Northwestern Hawaiian Islands to replace the lost capacity of the native culture to manage and exploit the marine environment. The loss of traditional fishing grounds in the Main Hawaiian Islands to public uses, resorts, harbors, airlines and other development have greatly damaged Kanaka Maoli culture. Native Hawaiian traditions and culture were based upon the understanding and appreciation of the ocean and marine resources. Cultural values and traditions are tied to an Oceanic perspective. To maintain and revitalize Hawaiian culture, the host culture, the oceanic perspective must be preserved and enhanced.

When King Kalakaua claimed all of the archipelago to Kure Island for the Kingdom of Hawaii it was for the enhancement of the economy of the Kingdom. Internal political assaults upon the Kingdom of Hawaii had diminished the power of the sovereign. Military power was subject to the legislature. Executive powers were held by the cabinet, whose appointment needed legislative approval. There were property qualifications necessary for the right to vote which disenfranchised many native Hawaiians. 75% of private property was owned by Westerners. The Native Hawaiian population was in serious decline. In 1891, the US government applied a tariff on sugar imported to the United States that increased the pressure to seek annexation by the Westerners. Through this difficult period Kalakaua worked to make Hawaii the hub of a wheel of commerce that united the Pacific Area. Through treaty he tried to ensure the independence of Hawaii. By immigration he tried to increase his people and level the economic playing field for the common citizen. Kalakaua died in 1891. The Kingdom of Hawaii ended with the invasion and overthrow on January 17, 1893 (Kuykendall, 1953).

Kalakaua claimed the archipelago to Kure Island for the Kingdom. Kalakaua battled for the economic life of the Kingdom. It is clear that he wished the economic resources of the entire archipelago to enhance the economy of the Kingdom and to benefit the people of Hawaii. He was clearly concerned with the Native Hawaiian people, his people, the kanaka maoli. The native trusts should be served by reserving 20% of all limited entry permits to all of the fisheries in the Northwestern Hawaiian Islands for the betterment of the native people of Hawaii. The disposition of such permits should be determined by the native people or their organizations. If quotas are established for the management of these fisheries then 20% of the quotas shall be reserved for the benefit of the Native Hawaiians. Any research for pharmaceutical, cosmetic, other natural products shall be allowed by contract, negotiated with the Kanaka Maoli or their agents reserving rights to the data, products or results of that research for the native people of Hawaii. In this manner the responsibilities and desires of the native Hawaiians, Kanaka Maoli, can be served.

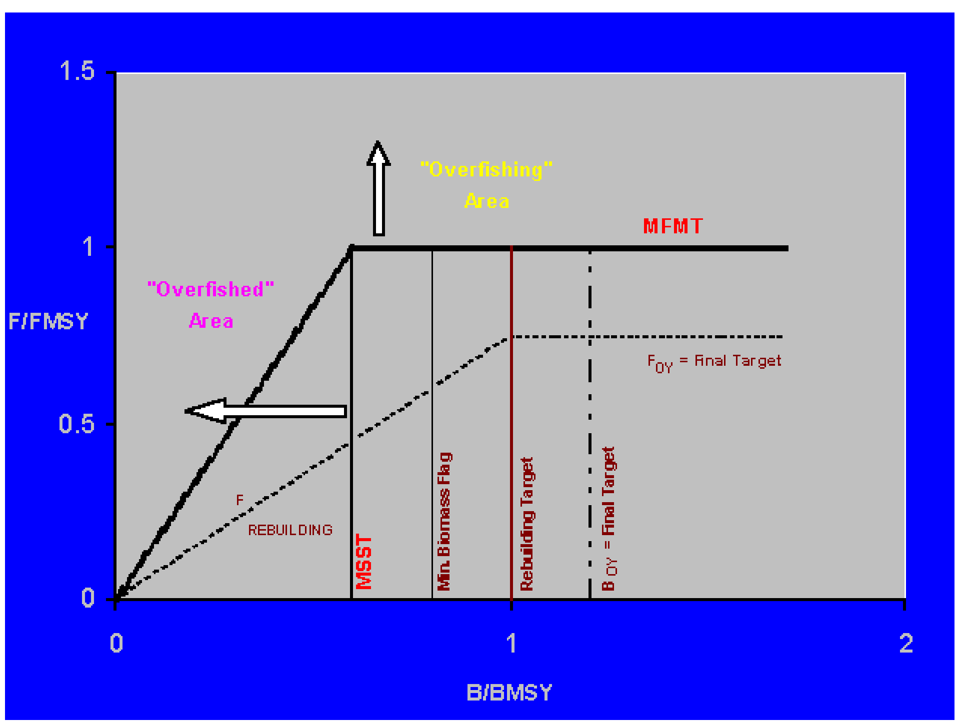
The reservations will serve multiple functions. By reserving a 20% share of the commercial value of the resource, economic opportunity is created for the native people. A 20% share of the resource can provide impetus for the development of capital ventures that would benefit the native community. An educational component can be negotiated with researchers to provide additional educational opportunities for the Native community. Kanaka Maoli can form partnerships to exploit their economic opportunities. If nothing is done with the reservations for Native Hawaiians, the 20% reservation would contribute to conservation of species.

4.0 SPECIFICATION OF MSY, OY, AND OVERFISHING, AND DOMESTIC HARVESTING/PROCESSING CAPACITY

MSY, OY, and Overfishing

The goal of the Magnuson-Stevens Fisheries Conservation and Management Act (MSFCMA) is to ensure long term fishery sustainability by halting or preventing overfishing and by rebuilding any overfished stocks. Overfishing is defined to occur when fishing mortality (F) is higher than the level at which fishing produces the maximum sustainable yield (MSY). The MSY is the maximum long term average yield that can be produced by a stock on a continuing basis. A stock is overfished when stock biomass (B) has fallen to a level substantially below that which can produce MSY. So there are two aspects that managers must monitor to determine the status of a fishery: the level of F in relation to F at MSY (F_{MSY}), and the level of B in relation to B at MSY (B_{MSY}).

The Technical Guidance for National Standard 1 (Restrepo et al., 1998) requires that "control rules" be developed which identify "good" versus "bad" stock conditions, and which describe management action that will influence a control variable (e.g. F) as a function of some stock size variable (e.g. B), to achieve "good" stock conditions. Each control rule must identify reference points called "status determination criteria": one for F that identifies when overfishing is occurring, and one for B that indicates when the stock is overfished. The status determination criteria for F is the maximum fishing mortality threshold (MFMT) and the status determination criteria for B is the minimum stock size threshold (MSST). When F/F_{MSY} exceeds the MFMT overfishing is occurring, and when B/B_{MSY} falls below MSST the stock is overfished.. When either of these two conditions occur NMFS must notify Congress that the stock is overfished, and fishery managers must take action to halt overfishing, and/or rebuild the stock. A reasonable MSY control rule template for application to the Western Pacific coral reef ecosystems may be derived from the default MSY control rule suggested by Restrepo et al. (1998).



The y-axis labeled F/F_{MSY} in the adjacent figure indicates the variable over which managers must exert some control as a function of B/B_{MSY} on the x-axis. The default MFMT recommended by the Technical Guidelines (Restrepo et al., 1998) is an upper limit set at

F_{MSY}, shown as a horizontal line at 1 = MFMT = F/F_{MSY}. In applying the MSY control rule, F (or rather the ratio F/F_{MSY}) must not be allowed to exceed the MFMT, although a stock with a B level well above B_{MSY} can support larger F values for a limited time while B declines towards B_{MSY}. Other types of control rules would allow higher F levels under specified conditions, but such rules require reliable measures of B and a very good understanding of stock dynamics.

The MSST is a vertical line at a B level substantially below B_{MSY}. This allows for some natural fluctuation of biomass around B_{MSY} under an MSY harvest policy. When B falls below MSST however, the stock is considered to be overfished and then F must be reduced below the MFMT by an amount that depends on the severity of the stock depletion, the stocks capacity to rebuild, and the desired recovery time for the stock. A minimum biomass flag (above figure) should also be defined so that if B drops below it managers are prompted to implement remedial action before biomass reaches the MSST.

Rebuilding plans are required when stock biomass falls below the MSST. Different control rules may be used in rebuilding plans. It is precautionary to follow an "optimal yield" (OY) control rule as illustrated by the line labeled $F_{REBUILDING}$ in the above figure. OY is MSY as reduced by relevant socioeconomic factors, ecological considerations and fishery biological constraints to provide the greatest long-term benefits to the nation. Under the suggested OY control rule (adapted from the Restrepo et al., 1998 default guidelines), when B is below B_{MSY} , F is controlled as a linear function of B, until a rebuilding target of B_{MSY} is reached at F_{OY}. A final OY target (B_{OY}) somewhat greater than B_{MSY} is achieved by keeping fishing effort at F_{OY} (above figure). Simulation results have indicated that when fisheries are managed at F_{OY} , equilibrium biomass will be maintained at about 1.30 B_{MSY} and resulting equilibrium yield (OY) will be at about 95% of MSY (Mace, 1994).

Application of the MSY Control Rule to the Coral Reef Ecosystem

Background: The Western Pacific Regional Fisheries Management Council is responsible for the management of coral reef ecosystem resources within the EEZ surrounding American Samoa, the Commonwealth of the Northern Mariana Islands (CNMI), Guam, and Hawaii. The coral reef ecosystem consists of thousands of species; regulation of the enormous number of species with individual harvest control rules would prove unwieldy and is unnecessary. To prevent overfishing of taxa currently being harvested, and to provide the scientific data to estimate biological reference points for those taxa with few data, the CRE-FMP will manage coral-reef ecosystem taxa under the following two categories: Currently Harvested Coral Reef Taxa (CHCRT) and Potentially Harvested Coral-Reef Taxa (PHCRT). For the CHCRT, existing catch and effort data if available will be used to estimate reference points. If insufficient data exists, but information from similar areas or species exists, these data will be used to estimate reference points. If no data or information exists the reference points may be estimated by proxy using data collected from the developing fishery. As potential fisheries for PHCRT develop, those taxa will be moved to the CHCRT category.

Overfishing criteria in coral reef ecosystems: Because of the multispecies nature of the coral reef ecosystem and its inherent complex web of ecological interrelationships, determining overfishing criteria for coral reef fisheries is problematic. Russ (1991) defines four non-mutually-exclusive categorizations of overfishing: growth, recruitment, economic, and ecosystem. Growth overfishing occurs when fishing intensity prevents fish from reaching the older age classes; recruitment overfishing occurs when the spawning stock of a population is reduced below the level at which adequate reproduction can maintain the population; economic overfishing occurs when a fishery is no longer cost-effective; and ecosystem overfishing occurs when fishing pressure causes changes to the species composition in a multispecies setting, often resulting in changes in ecosystem function (DeMartini et al., 1999). The majority of extant fisheries in the EEZ are currently managed under the Council's other FMPs, and historically have based overfishing criteria on some aspect of recruitment overfishing (e.g., spawning potential ratio or SPR) or growth overfishing (e.g., MSY methods). However, the concept of ecosystem overfishing may be most appropriate for the CREFMP, detected by shifts in species composition or trophic web dynamics, while simultaneously guarding against single stock recruitment overfishing where applicable. Because the coral reef ecosystem is a multispecies community with a long coevolutionary history, removal of certain species may disrupt species diversity and possibly lead to the unwanted predominance of often less valuable generalist species. Changes in species dominance patterns in coral reefs experiencing fishing pressure have been reported for a number of tropical stocks from various areas around the world. It is also well known that the sensitivity of multispecies systems to environmental fluctuations increases as the level of exploitation increases.

Data Richness: Available biological and fishery data are poor for all species and island areas covered by the CREFMP. Data collection systems are managed by the local island governments and vary widely in format and coverage. Data is generally restricted to commercial landings for a handful of species. Total effort cannot be adequately partitioned between the various Management Unit Species (MUS) for any fishery or area. Biomass (B), maximum sustainable yield (MSY), and fishing mortality (F) estimates are not available for any single MUS. There is scant information on the life histories, ecosystem dynamics, fishery impact, community structure changes, yield potential and management reference points for many of the coral reef ecosystem resources, despite the fact that a large potential exists for the exploitation of coral reef ecosystem resources and fisheries in the near future.

With this level of available data we will establish limits and reference points based on the multispecies coral reef ecosystem as a whole. In accordance with the National Standard Guidelines, the MSY control rule is to be applied to individual species within a multispecies stock whenever possible. When this is not possible, MSY may be specified for one or more species and used as an indicator for the multispecies stock. Since each species stock within the multispecies complex will be affected differently when fished at species complex F_{OY}, we are obligated to protect each species stock from mortality rates that would lead to required protection under the ESA. For the fisheries encompassed by the CRE-FMP, the multispecies complex as a whole will be used to establish limits and reference points for each area. Where possible, available data for a particular fishery/species will be used to evaluate the status of individual MUS stocks in such a manner to prevent recruitment overfishing. When better data and the appropriate multispecies stock assessment methodologies become available all stocks will be evaluated independently without proxy. Spatial bounds will initially follow the four identified island groups within management jurisdiction (American Samoa, CNMI, Guam, and Hawaii), but will be suitably refined as stock bounds and ecosystem structure become better understood.

Several approaches to model multi-species fisheries have been used by coral reef fisheries scientists with varying levels of success. The simplest approach has been to consider a community to be the sum of its species. Unfortunately, with highly diverse systems such as coral reefs, this leads to an extremely complex model with potentially hundreds of parameters. An alternative is to divide the assemblage into separate trophic levels and model the energy flow through the system to estimate potential yields (e.g., ECOPATH). Ecopath is a simple mathematical model that estimates mean annual biomass, production and food consumption for major components (species groups) of a coral reef ecosystem (Polovina 1984). Application of ECOPATH to French Frigate Shoals found that the coral reef ecosystem is controlled mainly by predation from the top down and primary production is controlled mainly by nutrients, photosynthetic rate limits, and habitat space (Grigg et al. 1984). ECOSIM is a computer model that uses the output of the ECOPATH model. Applying various levels of fishing pressure can indicate which target and non-target species increase and which decrease in abundance, considering predator-prey interactions (Kitchell et al. 1999). A problem with this approach lies in the allocation of species to trophic compartments, which imposes an artificial structure and may not coincide with actual community structure. This approach is also data intensive and requires information on each species' diet, mortality, and growth rates. General multi-species models have also been applied by several researchers to estimate yields in coral reef fisheries. These models are based on simultaneous Lotka-Voltera equations which incorporate the impact of each species population size on every other species through use of shared resources. These models may be extended to incorporate predation and harvesting. These approaches are mentioned as possible avenues for future assessment methodologies, although at present the lack of data precludes their usage.

Establishing Reference Point Values: Standardized values of CPUE and effort (E) will be used for the purpose of establishing limit and reference point values as proxies for relative biomass and F, respectively. Limits and reference points will be calculated in terms of $CPUE_{MSY}$ and E_{MSY} as follows:

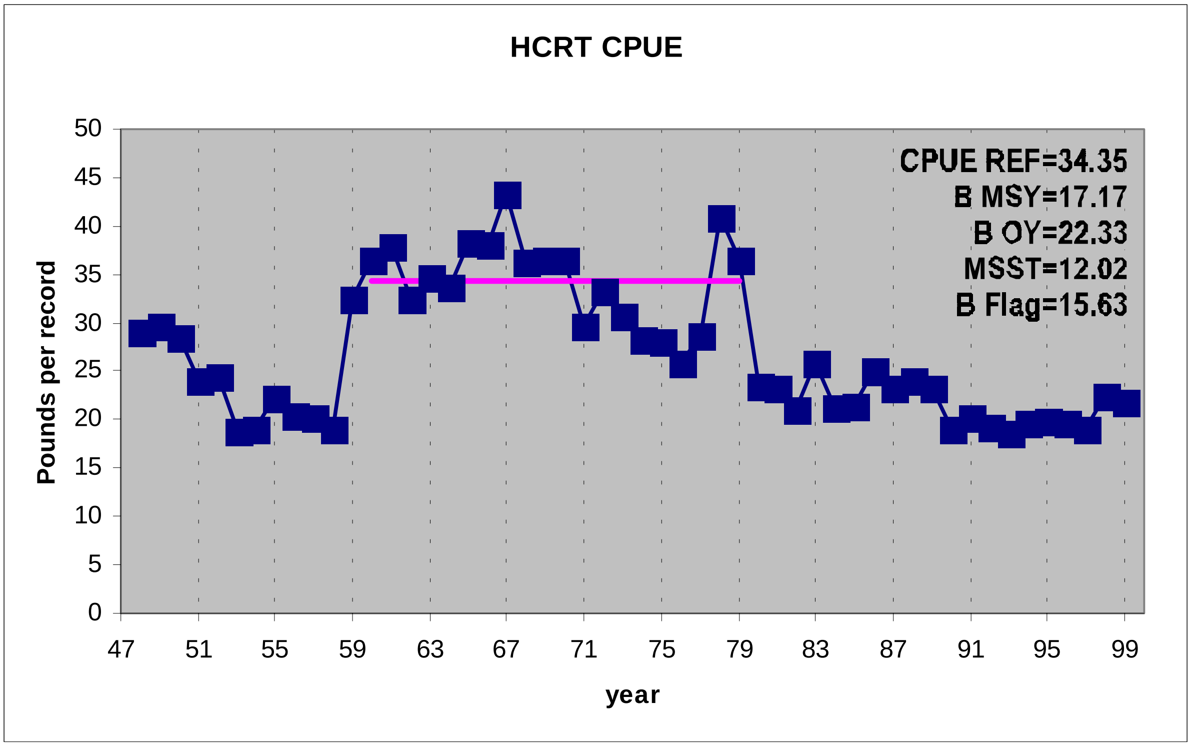
Value	Proxy	Explanation
MFMT (F_{MSY})	E_{MSY}	operational counterpart
F_{OY}	0.75 E_{MSY}	suggested default scaling for target
B_{MSY}	$CPUE_{MSY}$	operational counterpart
B_{OY}	1.3 $CPUE_{MSY}$	simulation results from Mace (1994)
MSST	0.7 $CPUE_{MSY}$	suggested default (1-M)B_{MSY} with M=0.3*
B_{FLAG}	0.91 $CPUE_{MSY}$	suggested default (1-M)B_{OY} with M=0.3*

*interim value of M=0.3 is applied.

When reliable estimates of E_{MSY} and $CPUE_{MSY}$ are not available they will be estimated from the available time series of catch and effort values standardized for all identifiable biases using the best available analytical tools. $CPUE_{MSY}$ will be calculated as one half a multi-year moving average reference CPUE ($CPUE_{REF}$). This value has not been finalized yet; however, preliminary values from the type of data presently available for Hawaii are shown in the adjacent figure. This is a time series of data from State of Hawaii commercial catch reports screened to only include HCRT taxa. $CPUE_{REF}$ and E_{MSY} could be estimated directly from this as shown or, following Restrepo et al. (1998), $E_{MSY} = E_{AVE}$ where E_{AVE} represents the long term average effort prior to declines in CPUE.

When multiple estimates are available, the more precautionary value will be used. All values will be calculated using the best available data. When new data becomes available, reference point values will be recalculated.

Time series of CHCRT CPUE from HDAR Data



Prevention of Recruitment Overfishing: The above limits and reference points are applied to the multispecies stocks and not to individual component species stocks. While managing the multispecies stock to provide maximum benefit, we must also ensure that the resulting fishing mortality rate does not reduce any individual species stock to a level requiring protection under the ESA. Preventing recruitment overfishing on any component stock will satisfy this need in a precautionary manner. Best available data will be used for each fishery to estimate these values. These reference points will be related primarily to recruitment overfishing and will be expressed in units such as spawning potential ratio (SPR) or spawning stock biomass (SSB).

Prevention of Ecosystem Overfishing: Changes in species abundance/composition will be monitored using the best available data. As a preliminary approach for Hawaii, the HDAR data were aggregated into two five year bins for comparison, an early bin comprising 1948-1952 and a recent bin comprising 1995-1999. Species in the HCRT category were examined, tabulated, and ranked in the following table. It is difficult to draw conclusions at this point in time but it serves as a preliminary insight into species composition changes over time in an exploited ecosystem.

Species Composition Changes

			1948-1952 aggregate			1995-1999 aggregate		
Local name	English name	Latin name	Pounds	Percent	Rank	Pounds	Percent	Rank
Menpachi	Soldierfish	Myripristis spp.	415252	18.54%	1	218781	15.04%	1
Amaama	Striped mullet	Mugil cephalus	321480	14.35%	2	27285	1.88%	12
Weke	Yellow goatfish	Mulloidichthys spp.	305108	13.62%	3	148149	10.18%	4
Moano	Banded goatfish	Parupeneus spp.	172493	7.70%	4	20656	1.42%	19
Wekeula	Pflugers goatfish	Mulloidichthys spp.	101189	4.52%	5	104909	7.21%	5
Moi	Threadfin	Polydactylus sexfilis	96385	4.30%	6	5126	0.35%	28
Manini	Convict tang	Acanthurus triostegus	88335	3.94%	7	70448	4.84%	7
Kumu	Whitesaddle goatfish	Parupeneus porphyreus	86445	3.86%	8	23620	1.62%	13
Kawelea	Hellers barracuda	Sphyraena helleri	84075	3.75%	9	15589	1.07%	21
Kaku	Great barracuda	Sphyraena barracuda	82062	3.66%	10	14847	1.02%	22
Tako	Octopus	Octopus spp.	80950	3.61%	11	98016	6.74%	6
Uhu	Parrotfish	Scaridae	49795	2.22%	12	159252	10.95%	3
Pualu	Yellowfin surgeonfish	Acanthurus xanthopterus, A. blochii	46338	2.07%	13	28020	1.93%	11
Palani	Eyestriped surgeonfish	Acanthurus dussumieri	43054	1.92%	14	165164	11.35%	2
Aweoweo	Bigeye	Priacanthidae	32058	1.43%	15	22133	1.52%	14
Aholehole	Flagtail	Kuhlia sandvicensis	31637	1.41%	16	21627	1.49%	18
Kala	Unicornfish	Naso spp.	27727	1.24%	17	66686	4.58%	8
Nenue	Rudderfish	Kyphosus spp.	27156	1.21%	18	56628	3.89%	9

Puhiuha	Conger eel	Conger cinereus	20616	0.92%	19	1378	0.09%	33
Aawa	Hogfish	Bodianus bilunulatus	20173	0.90%	20	13576	0.93%	25
Nabeta	Razorfish	Xyrichthys spp., Cymolutes lecluse	17559	0.78%	21	22014	1.51%	15
Mu	Porgy	Monotaxis grandoculis	15937	0.71%	22	11479	0.79%	26
Uouoa	False mullet	Neomyxus leuciscus	15873	0.71%	23	2658	0.18%	30
Humuhumu	Triggerfish	Balistidae	14460	0.65%	24	873	0.06%	36
Kamanu	Rainbow runner	Elagatis bipinnulatus	10540	0.47%	25	21867	1.50%	17
Maiko	Bluelined surgeonfish	Acanthurus nigroris	10067	0.45%	26	17953	1.23%	20
Alaihe	Squirrelfish	Neoniphon spp., Sargocentron spp.	9718	0.43%	27	1376	0.09%	34
Panuhunuhu	Parrotfish	Calotomus spp.	8117	0.36%	28	5316	0.37%	27
Kupoupou	Cigar wrasse	Cheilio inermis	2035	0.09%	29	227	0.02%	39
Kihikhi	Moorish idol	Zanclus cornutus	1768	0.08%	30	0	0.00%	43
Naenae	Orangespot surgeonfish	Acanthurus olivaceus	945	0.04%	31	28590	1.97%	10
Amaama	Summer mullet	Moolgarda engeli	376	0.02%	32	421	0.03%	38
Pakuikui	Achilles tang	Acanthurus achilles	253	0.01%	33	2233	0.15%	32
Kole	Goldring surgeonfish	Ctenochaetus strigosus	65	0.00%	34	13882	0.95%	23
Maikoiko	Whitebar surgeonfish	Acanthurus leucopareius	44	0.00%	35	0	0.00%	44
Uukanipou	Squirrelfish	Sargocentron spiniferum	32	0.00%	36	873	0.06%	37
Pala	Yellow tang	Zebrasoma flavescens	23	0.00%	37	47	0.00%	41
Lauwiliwili	Longnose butterflyfish	Forcipiger spp.	11	0.00%	38	1	0.00%	42
Wekepueo	Bandtail goatfish	Upeneus arge	8	0.00%	39	60	0.00%	40

Opelu kala	Unicornfish	Naso hexacanthus	0	0.00%	40	22001	1.51%	16
Munu	Striped goatfish	Parupeneus bifasciatus	0	0.00%	41	1072	0.07%	35
Moanokea	Blue goatfish	Parupeneus cyclostomus	0	0.00%	42	13821	0.95%	24
Roi	Seabass	Cephalopholis argus	0	0.00%	43	2304	0.16%	31
Poopaa	Hawkfish	Cirrhitidae	0	0.00%	44	3744	0.26%	29

Specification of Harvesting and Processing Capacity

The MSFCMA requires that all FMPs assess and specify-- (A) the capacity and the extent to which fishing vessels of the United States, on an annual basis, will harvest the optimum yield, (B) the portion of such optimum yield which, on an annual basis, will not be harvested by fishing vessels of the United States and can be made available for foreign fishing, and (C) the capacity and extent to which United States fish processors, on an annual basis, will process that portion of such optimum yield that will be harvested by fishing vessels of the United States.

Information contained in this FMP, together with information in the other Western Pacific Council's FMPs (Bottomfish, Crustaceans, Precious Corals, and Pelagics) and related documents were examined to assess and specify the United States fishing and processing capacity in this region. FMPs from other regions and related documents including 'Our Living Oceans' (available on request from the NMFS headquarters office in Silver Spring, Maryland) provided additional information on United States harvesting and processing capacity. This information clearly indicated that fishing vessel of the United States currently have the capacity to harvest the optimum yield on an annual basis. As such, no portion of the optimum yield will be made available for foreign fishing. Similarly, the capacity of United States fish processors is of sufficient size to process the entire optimum yield.

5.0 MANAGEMENT REGIME

5.1 Management Objectives

The Council prepares FMPs under the authority of the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). The purposes of the MSFCMA are to achieve optimum yield from fisheries resources of the US, while preventing overfishing. Heeding the EPAP's recommendation to develop an overall "Fisheries Ecosystem Plan" for each major ecosystem under Council jurisdiction (EPAP 1999), the Western Pacific Regional Fishery Management Council has developed the CRE-FMP as a mechanism for incorporating ecosystem approaches into the present regulatory structure created through earlier FMPs for Bottomfish, Crustaceans, Precious Corals and Pelagics.

The Council established eight objectives for the CRE-FMP of the western Pacific region. The objectives promote sustainable use of coral reef resources, especially by fishing communities and indigenous fishermen in the region, an adaptive management approach based on fishery-dependent and fishery-independent research, marine protected areas and habitat conservation, cooperative and coordinated management by the various agencies concerned with the conservation of coral reef resources and education to foster public support for management. The objectives also embody policies recommended by EPAP (1999).

Objective 1
To foster sustainable use of multi-species resources in an ecologically and culturally sensitive manner, through the use of the precautionary approach and ecosystem-based resource management.

Objective 2
To provide a flexible and responsive management system for coral reef resources, which can rapidly adapt to changes in resource abundance, new scientific information and changes in fishing patterns among user groups or by area.

Objective 3
To establish integrated resource data collection and permitting systems, a research and monitoring program to collect fishery and other ecological information and to develop scientific data necessary to make informed management decisions about coral reef ecosystems in the EEZ.

Objective 4
To minimize adverse human impacts on coral reef resources by establishing new and improving existing marine protected areas, managing fishing pressure, controlling wasteful harvest practices, reducing other anthropogenic stressors directly affecting them, and allowing the recovery of naturally-balanced reef systems. This objective includes the conservation and protection of essential fish habitats.

Objective 5
To improve public and government awareness and understanding of coral reef ecosystems and their vulnerability and resource potential in order to reduce adverse human impacts and foster support for management.

Objective 6
To collaborate with other agencies and organizations concerned with the conservation of coral reefs, in order to share in decision-making and to obtain and share data and resources needed to effectively monitor this vast and complex ecosystem.

Objective 7
To encourage and promote improved surveillance and enforcement of the plan.

Objective 8
Provide for sustainable participation of fishing communities in coral reef fisheries and, to the extent practicable, minimize the adverse economic impacts on such communities.

5.2 Management Approach

Coral reefs are complex, multi-resource marine ecosystems comprised of thousands of species, few of which are targeted by existing fisheries. They represent an extreme in biological diversity, ecological complexity and competing demands for resource use. The only form of management likely to be effective is holistic. The 1996 Sustainable Fishery Act (SFA) amendments to the MSFCMA were a step in the direction of more holistic management (e.g., set harvest rates below MSY, minimize bycatch, identify essential fish habitat).

There is poor understanding of the basics, much less the intricacies, of coral reef ecosystems. Ecosystem-based management of coral reefs, therefore, is a long-term goal that can only be achieved over time as new information allows for improved understanding and decision-making. EPAP (1999) made recommendations to guide the further development of ecosystem management for fisheries, built around the following policies:

- Change the burden of proof.
- Apply the precautionary approach.
- Purchase "insurance" against unforseen, adverse ecosystem impacts.
- Learn from management experience.
- Make local incentives compatible with global goals.
- Promote participation, fairness, and equity in policy and management.

The Coral Reef Ecosystems FMP attempts to incorporate the contents suggested by the Ecosystems Principles Advisory Panel to the extent possible. It is doubtful, however, if there will ever be enough data available to calculate total removals– including incidental mortality– and show how they relate to standing biomass, production, optimum yields, natural mortality, and trophic structure. The following is a review of how the FMP addresses each suggested provision.

Delineate the geographic extend of the ecosystem(s) that occur(s) within Council authority, including characterization of the biological, chemical, and physical dynamics of those ecosystems

> The geographic extent and ecological characterization of coral reef ecosystems around the US Pacific islands is described in the FMP. High biological and environmental variability

is a natural characteristic of these ecosystems, with or without fishing. Irregular pulses of new recruits cause cycles in the abundance and harvest potential of individual reef species. Environmental variability is both spatial (related to differences in the quality of habitat) and temporal, related to monthly moon phase, seasonal and longer-term environmental changes. Coral reef resources are also affected by large-scale climatic shifts. Natural disturbance cycles in areas exposed to large storm waves can dramatically alter coral cover and resulting habitat quality.

Develop a conceptual model of the food web.

The FMP contains a review of the ECOPATH model applied to coral reef ecosystems. ECOPATH is a simple mathematical model that estimates mean annual biomass, production and food consumption for major components (species groups) of an ecosystem. Application of ECOPATH to French Frigate Shoals found that the coral reef ecosystem is controlled mainly by predation from the top down and primary production is controlled mainly by nutrients, photosynthetic rate limits, and habitat space.

Describe the habitat needs of different life history stages for all plants and animals that represent the "significant food web"

The FMP and appendices thoroughly describe habitat needs of different life history stages for all species managed under this FMP, based on available scientific information.

Assess how uncertainty is characterized and what kind of buffers against uncertainty are included in conservation and management actions.

The FMP acknowledges that there is uncertainty regarding the impacts of fishing and other human activities on coral reef ecosystems. As a buffer agains uncertainty, the FMP establishes marine protected areas as insurance against this risk, and reporting requirements to monitor changes in the fisheries.

Describe available long-term monitoring data and how they are used.

The FMP includes an overview of long-term monitoring data available. Fishery monitoring and fishery-independent research activities will generate information that may be used for future adjustments of the proposed CRE-FMP under a framework procedure that allows for timely action.

Develop indices of ecosystem health as targets for management.

What constitutes a "healthy" reef in the US Pacific islands is difficult to define, but should be considered within a specific geographic and temporal context, considering the quality of natural habitat, environmental variability and natural disturbance cycles, as well as the history of human impacts. Measuring changes and differentiating natural rhythms from fisheries' effects, even in specific localities, present major challenges because of the highly dynamic ecosystem. Because of these factors, no indices of ecosystem health have yet been established under this FMP beyond the MSY, OY and overfishing reference points.

Assess the ecological, human, and institutional elements of the ecosystem which most significantly affect fisheries, and are outside Council/Department of Commerce authority. Included should be a strategy to address those influences in order to achieve both FMP and FEP objectives.

Much of the previous damage to coral reefs around US Pacific islands has occurred as a result of non-fishing activities such as coastal and harbor development, watershed land use practices and runoff, industrial discharges, non-fishing vessel operation, military and tourist use. The most severe impacts have occurred on nearshore reefs under island government jurisdiction. Few reefs in the EEZ are close enough to inhabited land areas to be significantly affected by tourism, coastal development, upland runoff, beach erosion and other terrestrial impacts. Some impacts occur at a scale too large to be mitigated by unilateral management actions for the western Pacific region. These include: overpopulation, ocean warming and increased ultraviolet radiation, introduction of invasive exotic marine species, and accumulation of marine debris.

Reefs extend across jurisdictional boundaries and mechanisms for coordinated management among different government agencies are largely ad hoc. Inter-regional and international management will be necessary to find solutions to this problem. Reef areas in nearshore areas are under the jurisdiction of the island governments. Other reefs are in areas managed by various Federal agencies (e.g., national parks, marine sanctuaries, national wildlife refuges). The management objectives of the various agencies are not consistent. Even when effective regulations are in place, enforcement is difficult, labor intensive and often inadequate. Fragmented jurisdiction and management authority complicate prosecution of violators.

To address these problems, several steps could be taken, such as using the framework procedure to secure MOUs on MPA areas with State, use the FMP's continuing reliance on island government permit and reporting for the EEZ adjacent to populated islands, and to expand FMP authority (Magnuson Act amendment) to non-fishing vessel impacts on habitat, and to encourage and enhance the EFH consultations process. These steps are described in more detail in other sections of the FMP.

5.3 Management Program

The overall goal of the management program is to maintain sustainable coral reef fisheries while preventing any adverse impacts to stocks, habitat, protected species, or the ecosystem. The program is based on the ecosystem-based approach, and is designed to meet management objectives.

5.3.1 Marine Protected Areas

Marine protected areas (MPAs) are an attractive option for ecosystem-based fisheries management because they do not require detailed knowledge of the management unit species while being holistic in conserving multi-species resources and the functional attributes of marine ecosystems. They can also provide "insurance" against periods of poor recruitment of individual stocks.

MPAs can vary in scope and extent. They can be areas designated for limited use, seasonal use, or areas that are completely restricted from consumptive use (no-take). Although completely restricted areas are thought to provide the highest degree of protection to marine ecosystems, less restrictive areas also provide some protection with fewer economic and social impacts.

The optimum size of a MPA depends on many factors, including the resources managed, management goals, enforcement capabilities and social and economic constraints. However, researchers do not yet fully understand the relation between the area covered by an MPA and resulting benefits in the form of ecologically complete coral reef ecosystem protection. To be useful to fisheries and to promote the conservation of coral reef resources on a broader scale, MPAs should serve as sources of reproductive output to replenish larger surrounding or down-current areas. The present approach of establishing small and isolated MPAs is inadequate for this purpose.

Few, if any, studies have sought to verify whether MPAs established in the US Pacific islands do actually benefit nearby fisheries. It is clear that fish populations which build up in small areas temporarily closed to fishing are quickly reduced when fishing is resumed, as evidenced by studies in Hawaii and the Philippines. Existing marine protected areas in the US Pacific islands have been criticized for being either too small and fragmented or for not encompassing sufficient depth range and high quality habitat to provide broad coral reef ecosystem protection or recruitment benefits to fisheries.

It has been suggested that linking populations among MPAs over a broad area is necessary to assure long-term sustainability of coral reef fisheries. Some argue for complete protection from fishing, whereas others believe MPAs are more valuable when they can serve as natural laboratories for fishing experiments and testing of adaptive management strategies.

5.3.1.1 Area Restrictions

Waters considered under this FMP include National Wildlife Refuges, low-use MPAs, no-take MPAs, State and Federal waters although regulations only apply to Federal waters. Management falls to a number of organizations including state, territorial and commonwealth governments, USFWS and the Council. The CRE-FMP attempts to simplify regulations between areas by working to achieve consistent regulations across the various management regimes.

5.3.1.1.1 No-take Marine Protected Areas

Currently proposed no-take MPAs regulated under this plan include only federal waters (i.e., those waters other than state, commonwealth and territorial waters, 0-3 nm) shallower than 10 fathoms in the NWHI and waters shallower than 50 fathoms around Jarvis, Howland, Baker, Kingman, Palmyra, Laysan, French Frigate Shoals, the north half of Midway Island and Rose Atoll in American Samoa. Additional protection from the Crustacean FMP prohibits fishing for lobster within 20 miles around Laysan island. No-take MPAs are specifically defined in the draft regulations of this FMP.

Amendments to Existing FMPs for Compliance with No-take MPAs

The Coral Reef Ecosystem FMP has designated no-take marine protected areas within the Management Area. Commercial, recreational, subsistence or cultural take of any marine species within these areas is prohibited. No described or undescribed gear is exempt from this designation. While the four existing FMPs implemented by the WPRFMC (bottomfish and seamount groundfish, crustaceans, pelagics and precious corals) are exempt from the regulations outlined in the CRE FMP and will observe the management regime of their respective FMPs, the no-take marine protected areas will be in effect for all Council-managed fisheries. These fisheries and their FMPs are summarized in the section of the DEIS on description of the coral reef ecosystem. An analysis of the impacts of these area closures on the four existing FMPs is included in the section on environmental consequences of the DEIS. To ensure designated no-take MPAs are effective for all FMPs, each of the following FMPs will be amended to ensure the no-take status of these areas, as follows:

Amendment 7 to the Bottomfish and Seamount Groundfish FMP

Harvest of bottomfish management unit species, listed in table below, as well as all future additions to the bottomfish MUS list, is prohibited in the no-take marine protected areas defined below as well as for all future no-take marine protected area designations:

(1) federal waters shallower than 10 fathoms in the Northwestern Hawaiian Islands

(2) federal waters shallower than 50 fathoms around Jarvis Island (0˚23' S, 160˚01' W), Howland Island (0˚48' N lat., 176˚ 38' W long.), Baker Island (0˚ 13' N lat., 176˚38' W long.), Kingman Reef (6˚23' N lat., 162˚24' W long.), Palmyra Atoll (5˚53' N lat., 162˚05' W long.), Laysan Island (25˚ 45' N lat., 171˚45' W long.), French Frigate Shoals (23˚ 45' N lat., 166˚15' W long.), the North half of Midway Atoll (28˚ 45' N lat., 177˚22' W long.), and Rose Atoll (14˚ 33' S lat., 168˚09' W long.).

Bottomfish Management Unit Species List

Scientific Name	**English Common Name**
Aphareus rutilans	red snapper/silvermouth
Aprion virescens	gray snapper/jobfish
Caranx ignobilis	giant trevally/jack
C. lugubris	black trevally/jack
Epinephelus fasciatus	blacktip grouper
E. quernus	sea bass
Etelis carbunculus	red snapper
E. coruscans	red snapper
Lethrinus amboinensis	ambon emperor
L. rubrioperculatus	redgill emperor
Lutjanus kasmira	blueline snapper
Pristipomoides auricilla	yellowtail snapper

P. filamentosus	pink snapper
P. flavipinnis	yelloweye snapper
P. seiboldi	pink snapper
P. zonatus	snapper
Pseudocaranx dentex	thicklip trevally
Seriola dumerili	amberjack
Variola louti	lunartail grouper
Beryx splendens	alfonsin
Hyperoglyphe japonica	ratfish/butterfish
Pseudopentaceros richardsoni	armorhead

Amendment 11 to the Crustaceans FMP

Harvest of crustacean management unit species, listed in the table below, as well as all future additions to the crustacean MUS list, is prohibited in the no-take marine protected areas defined below as well as for all future no-take marine protected area designations:

(1) federal waters shallower than 10 fathoms in the Northwestern Hawaiian Islands

(2) federal waters shallower than 50 fathoms around Jarvis Island (0˚23' S, 160˚01' W), Howland Island (0˚48' N lat., 176˚ 38' W long.), Baker Island (0˚ 13' N lat., 176˚38' W long.), Kingman Reef (6˚23' N lat., 162˚24' W long.), Palmyra Atoll (5˚53' N lat., 162˚05' W long.), Laysan Island (25˚ 45' N lat., 171˚45' W long.), French Frigate Shoals (23˚ 45' N lat., 166˚15' W long.), the North half of Midway Atoll (28˚ 45' N lat., 177˚22' W long.), and Rose Atoll (14˚ 33' S lat., 168˚09' W long.).

Crustacean Management Unit Species List

Scientific Name	English Common Name
Panulirus marginatus	Spiny lobster
Panulirus penicillatus	Spiny lobster
Family Scyllaridae	Slipper lobster
Ranina ranina	Kona crab

Amendment 5 to the Pelagic FMP

Harvest of Pacific pelagic management unit species, listed in the table below, as well as all future additions to the bottomfish MUS list, is prohibited in the no-take marine protected areas defined below as well as for all future no-take marine protected area designations:

(1) federal waters shallower than 10 fathoms in the Northwestern Hawaiian Islands

(2) federal waters shallower than 50 fathoms around Jarvis Island (0˚23' S, 160˚01' W), Howland Island (0˚48' N lat., 176˚ 38' W long.), Baker Island (0˚ 13' N lat., 176˚38' W long.), Kingman Reef (6˚23' N lat., 162˚24' W long.), Palmyra Atoll (5˚53' N lat., 162˚05' W long.), Laysan Island (25˚ 45' N lat., 171˚45' W long.), French Frigate Shoals (23˚ 45' N lat., 166˚15' W long.), the North half of Midway Atoll (28˚ 45' N lat., 177˚22' W long.), and Rose Atoll (14˚ 33' S lat., 168˚09' W long.).

Pacific Pelagic Management Unit Species List

Scientific Name	English Common Name
Coryphaena spp.	Mahimahi (dolphinfishes)
Acanthocybium solandri	Wahoo
Makaira mazara: *M. indica*	Indo-Pacific blue marlin Black marlin
Tetrapturus audax	Striped marlin
T. angustirostris	Shortbill spearfish
Xiphias gladius	Swordfish
Istiophorus platypterus	Sailfish
Alopiidae, Carcharinidae, Lamnidae, Sphynidae	Oceanic sharks
Thunnus alalunga	Albacore
T. obesus	Bigeye tuna
T. albacares	Yellowfin tuna
T. thynnus	Northern bluefin tuna
Katsuwonus pelamis	Skipjack tuna
Euthynnus affinis	Kawakawa
Gymnosarda unicolor	Dogtooth tuna
Lampris spp	Moonfish
Gempylidae	Oilfish family
family Bramidae	Pomfret
Auxis spp, *Scomber* spp; *Allothunus* spp	Other tuna relatives

Amendment 5 to the Precious Corals FMP

Harvest of precious corals management unit species, listed in the table below, as well as all future additions to the bottomfish MUS list, is prohibited in the no-take marine protected areas defined below as well as for all future no-take marine protected area designations:

(1) federal waters shallower than 10 fathoms in the Northwestern Hawaiian Islands

(2) federal waters shallower than 50 fathoms around Jarvis Island (0˚23' S, 160˚01' W), Howland Island (0˚48' N lat., 176˚ 38' W long.), Baker Island (0˚ 13' N lat., 176˚38' W long.),

Kingman Reef (6˚23' N lat., 162˚24' W long.), Palmyra Atoll (5˚53' N lat., 162˚05' W long.), Laysan Island (25˚ 45' N lat., 171˚45' W long.), French Frigate Shoals (23˚ 45' N lat., 166˚15' W long.), the North half of Midway Atoll (28˚ 45' N lat., 177˚22' W long.), and Rose Atoll (14˚ 33' S lat., 168˚09' W long.).

Precious Corals Management Unit Species List

Scientific Name	**English Common Name**
Corallium secundum	Pink coral (also known as red coral)
Corallium regale	Pink coral (also known as red coral)
Corallium laauense	Pink coral (also known as red coral)
Gerardia spp.	Gold coral
Narella spp.	Gold coral
Calyptrophora spp.	Gold coral
Lepidisis olapa	Bamboo coral
Acanella spp.	Bamboo coral
Antipathes dichotoma	Black coral
Antipathes grandis	Black coral
Antipathes ulex	Black coral

5.3.1.1.2 Low-use Marine Protected Areas

Low-use MPAs are subject to special considerations and require a special permit. Operational considerations are outlined and will be further defined during the permitting process. Discussions of indigenous use subzones within low-use MPAs are included in the alternative section. As the details of size, location and specific rights have not been determined, indigenous use subzones will remain as a framework procedure for new measures (i.e., amendment to the FMP). Specific considerations are made for traditional and ceremonial uses in MPAs in the special permit application. Currently, catch and release and on-island consumptive fishing occurs at the remote islands of Wake, Johnston and Midway. Users in this existing fishery will be required to obtain a special permit as it is not currently regulated under any Council FMP. The USFWS does regulate and monitor this activity and their protocol will be considered by the Council in the application process.

Currently proposed low-use MPAs regulated under this plan include only federal waters (i.e., those waters other than state, commonwealth and territorial waters, 0-3 nm) 10 to 50 fathoms in the NWHI and waters shallower than 50 fathoms around Wake Island, Johnston Atoll and the south half of Midway Island. Low-use MPAs are specifically defined in the draft regulations of this FMP.

Any vessel intending to fish in a low-use MPA shall provide a notice to the Regional Administrator at least 72 hours (not including weekends and Federal holidays) before the vessel leaves port. The vessel operator will be presumed to be an agent designated by the permit holder unless the RA is otherwise notified by the permit holder. The notice must be provided to the office or telephone number designated by the RA. The notice must provide the official number of the vessel, the name of the vessel, the intended departure date, time, and location, the name of the operator of the vessel, and the name and telephone number of the agent designated by the permit holder to be available between 8:00 a.m. to 5 p.m. (Hawaii time) on weekdays for NMFS to contact.

5.3.1.2 Operational Restrictions

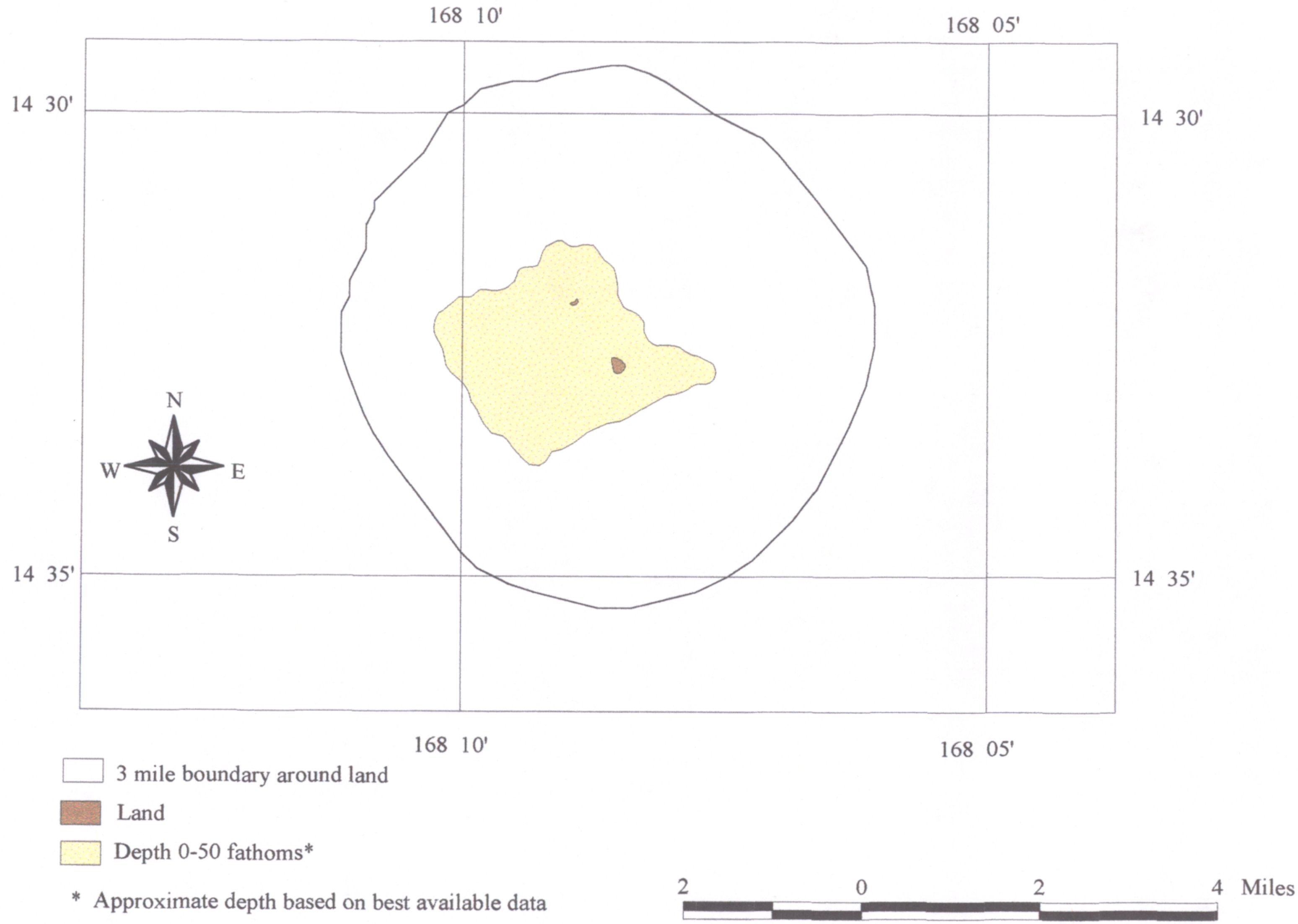
Anchoring will not be permitted by vessels larger than 50 feet on Guam's Southern Banks. Exceptions will be granted in the event of an emergency caused by ocean conditions or by a vessel malfunction that can be documented.

Council will work with the relevant authorities to prohibit cruise ships from operating within MPAs.

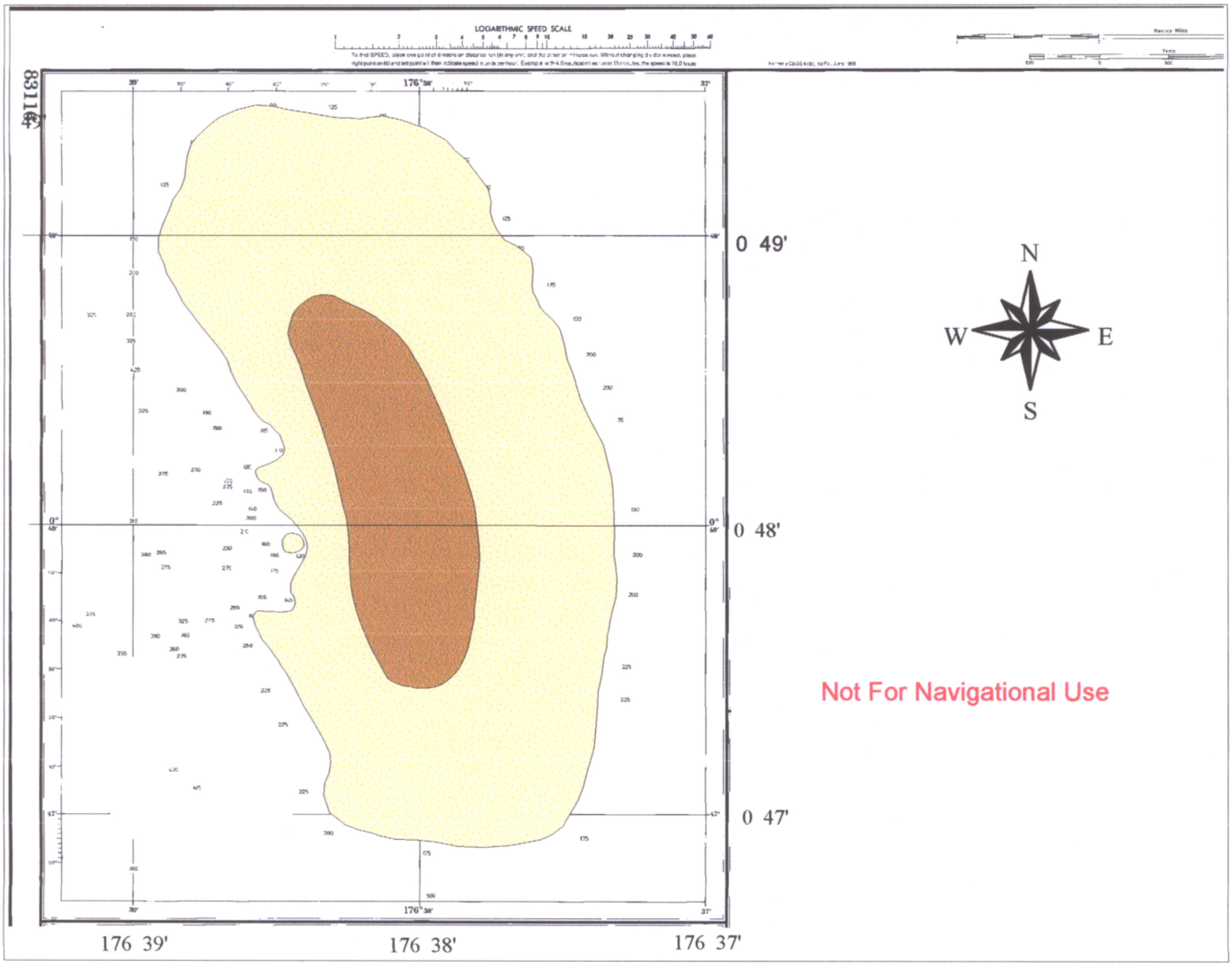
All fishing vessels operating or transiting in an MPA must carry insurance to cover the cost of vessel removal and pollution liability in the event of a grounding.

Council will work with the relevant authorities to authorize other vessels operating within MPAs to carry similar insurance required for fishing vessels as stated above.

Rose Atoll
Proposed Marine Protected Area



Howland Island
Proposed Marine Protected Area



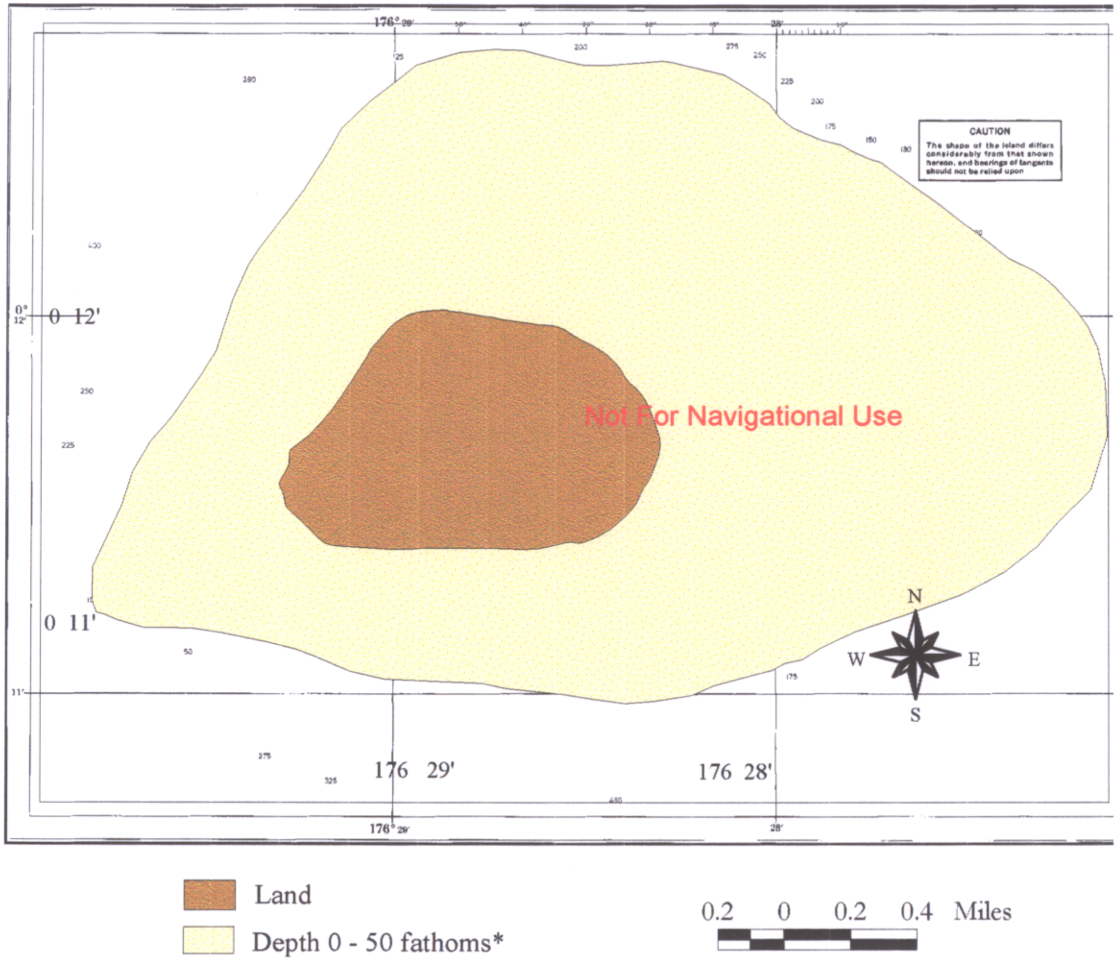
Land

Depth 0-50 fathoms*

* Approximate depth based on best available data

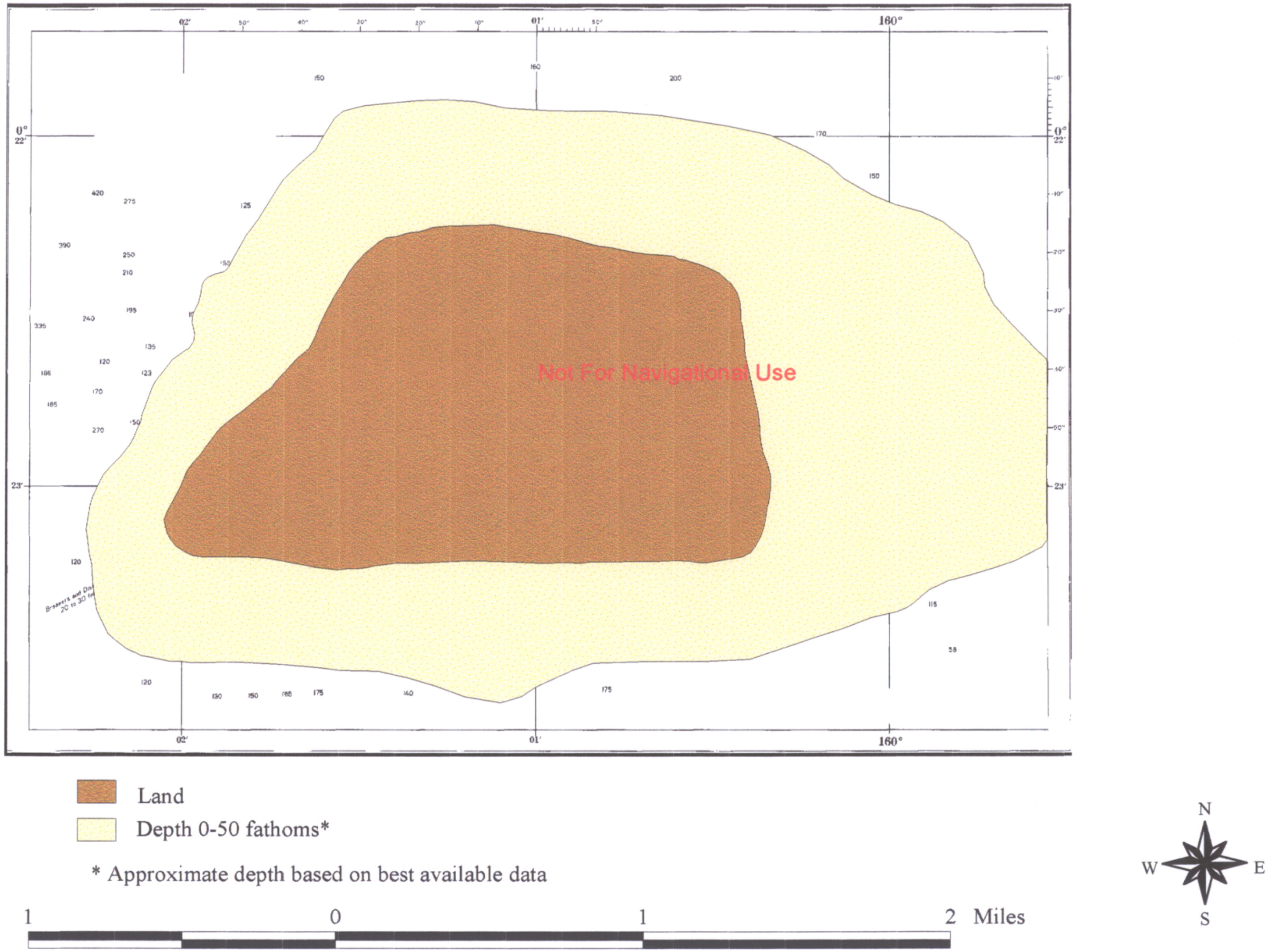
1 0 1 2 Miles

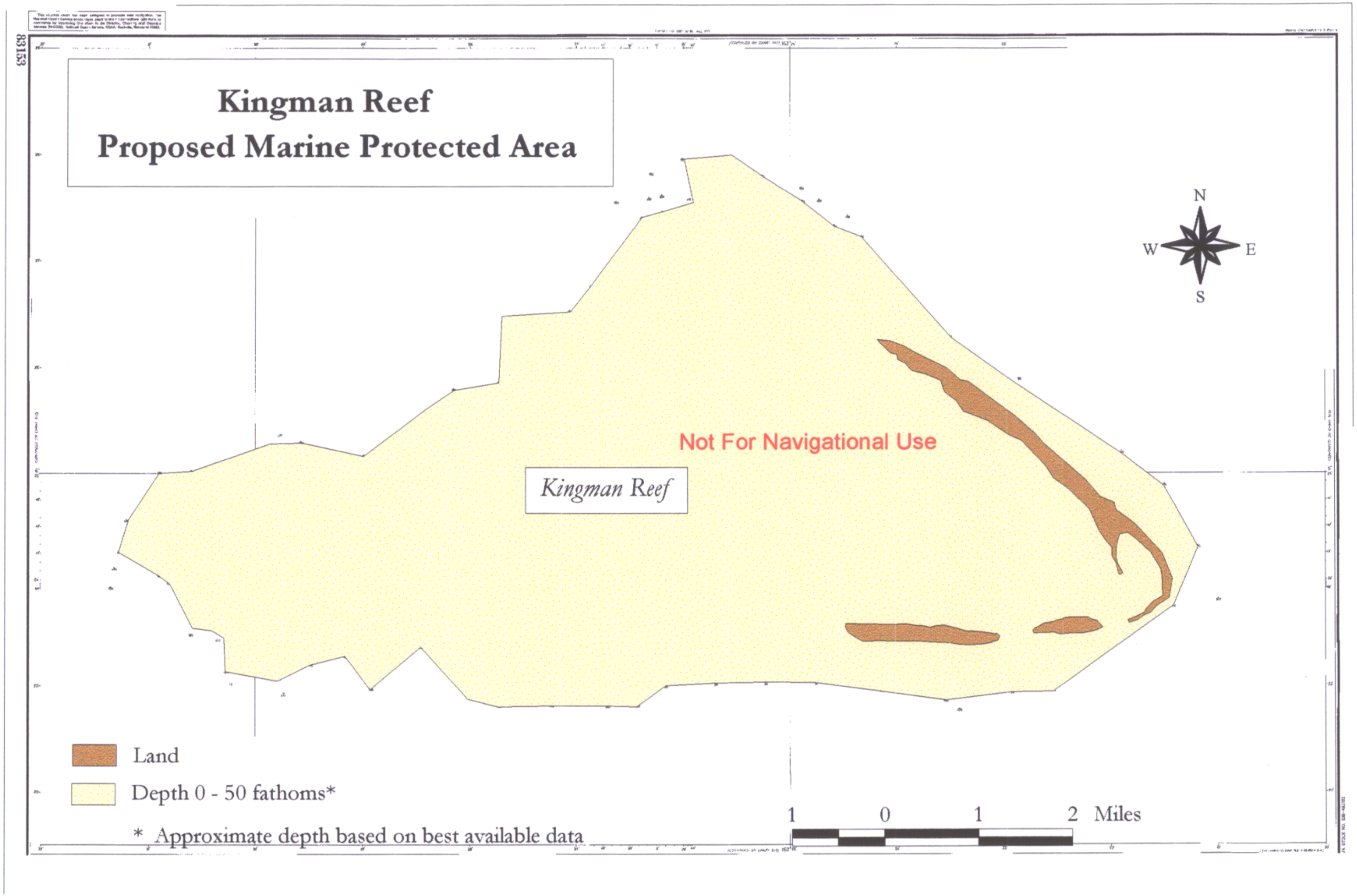
Baker Island
Proposed Marine Protected Area



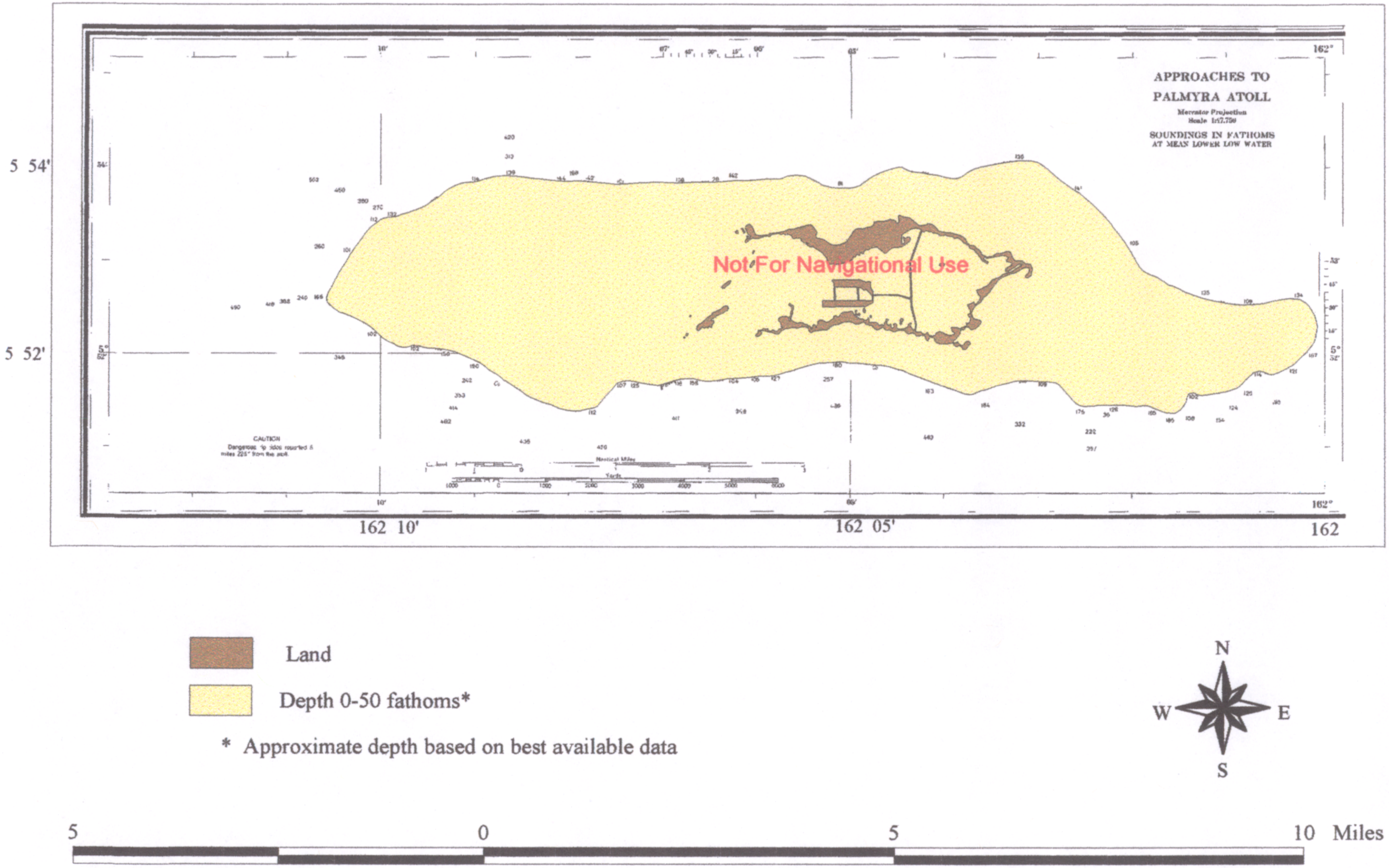
* Approximate depth based on best available data

Jarvis Island
Proposed Marine Protected Area

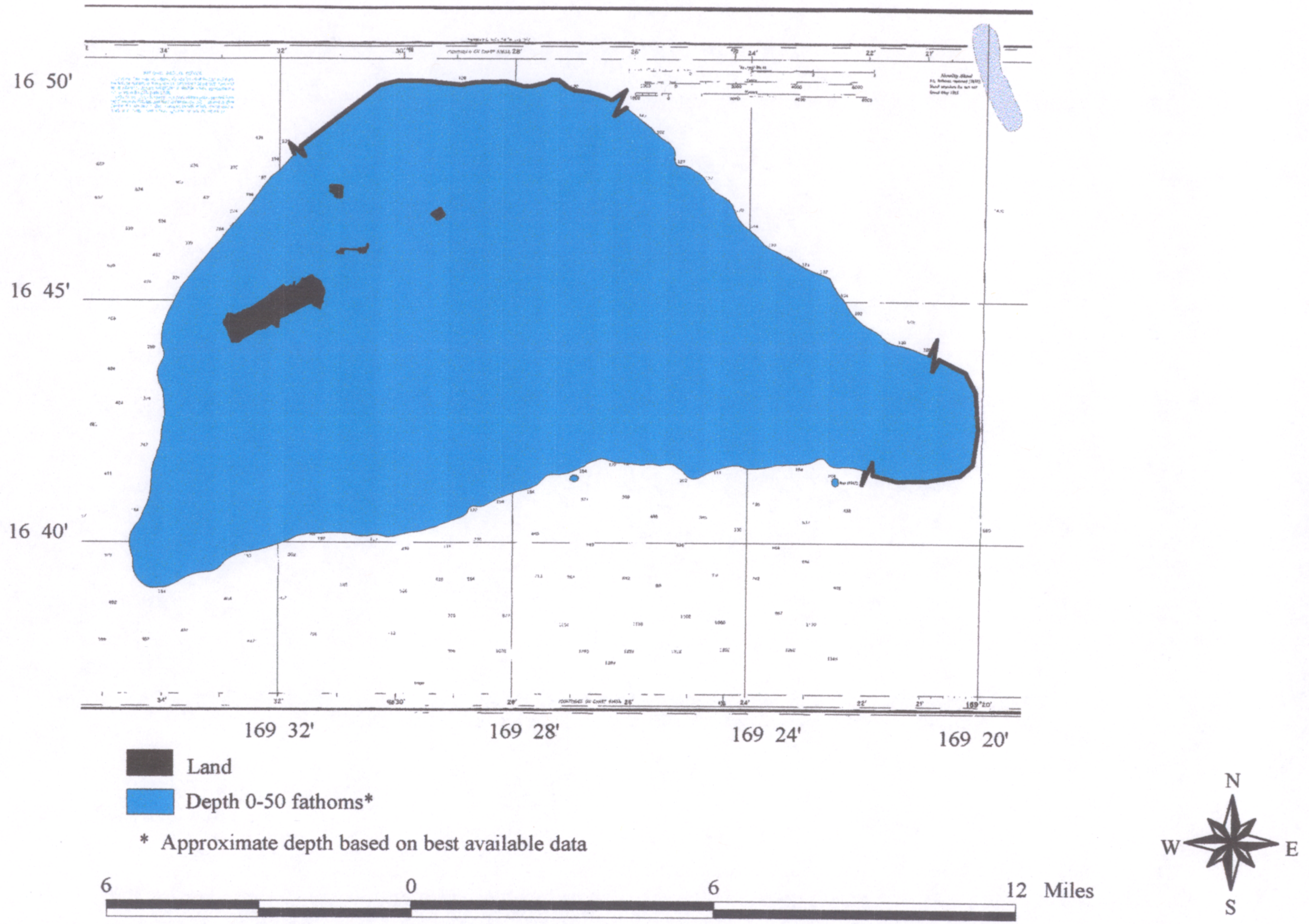


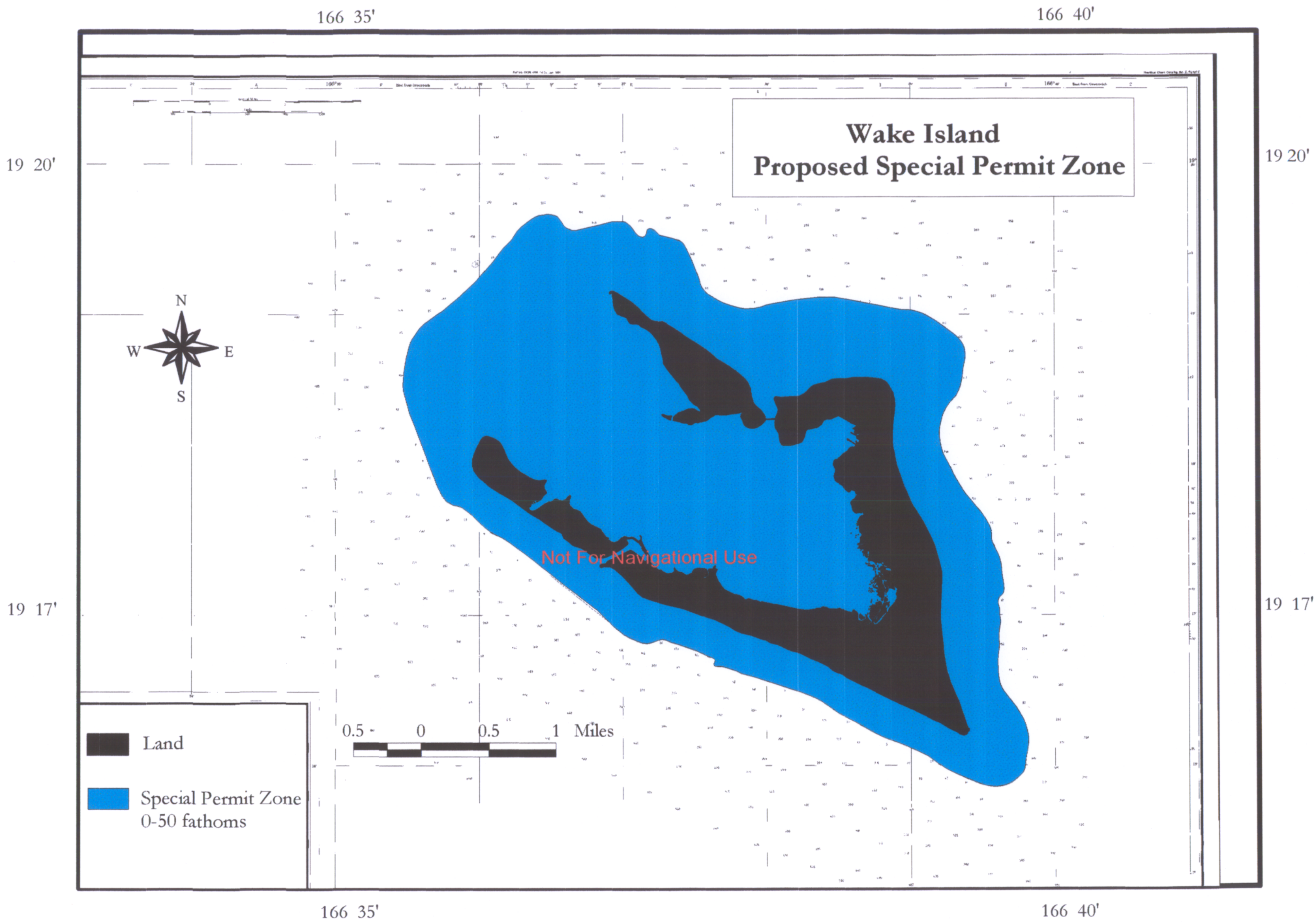

83153
Kingman Reef
Proposed Marine Protected Area
N
W
E
S
Not For Navigational Use
Kingman Reef
Land
Depth 0 - 50 fathoms*
* Approximate depth based on best available data
1
0
1
2 Miles

Palmyra Atoll
Proposed Marine Protected Area



Johnston Atoll
Proposed Special Permit Zone



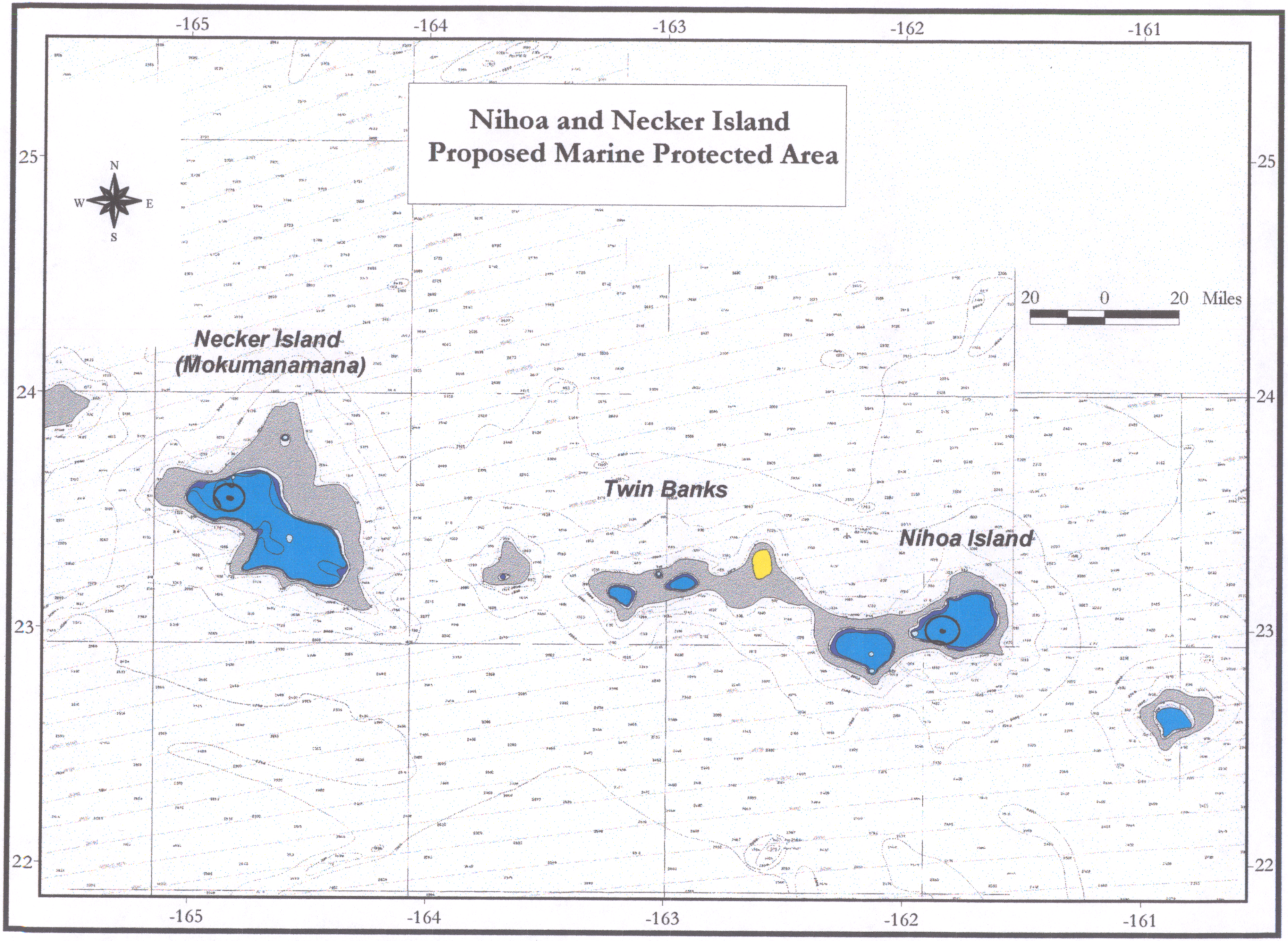


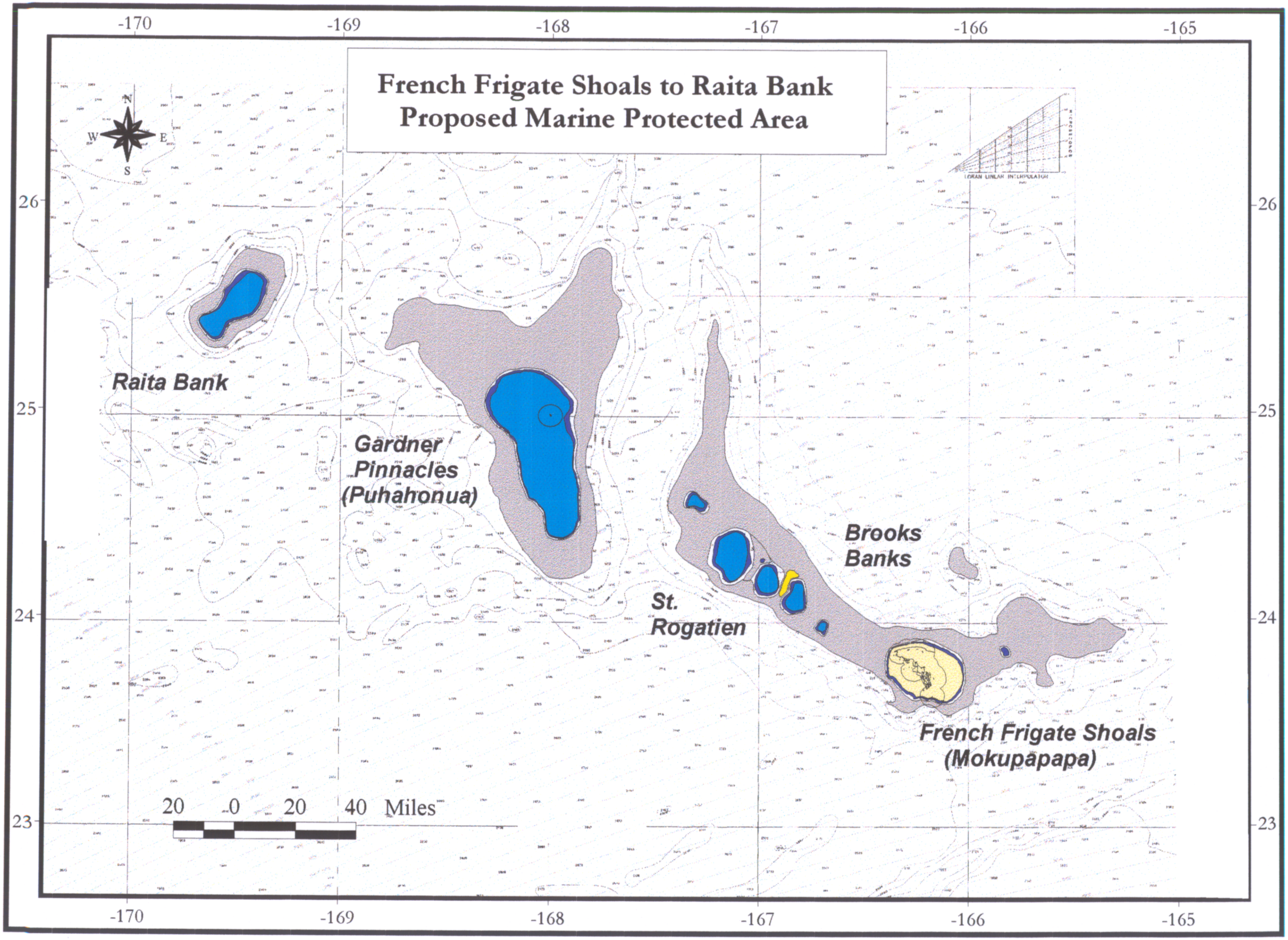
166 35'
166 40'
19 20'
19 17'
Wake Island
Proposed Special Permit Zone
N
W
E
S
Not For Navigational Use
0.5
0
0.5
1
Miles
Land
Special Permit Zone
0-50 fathoms

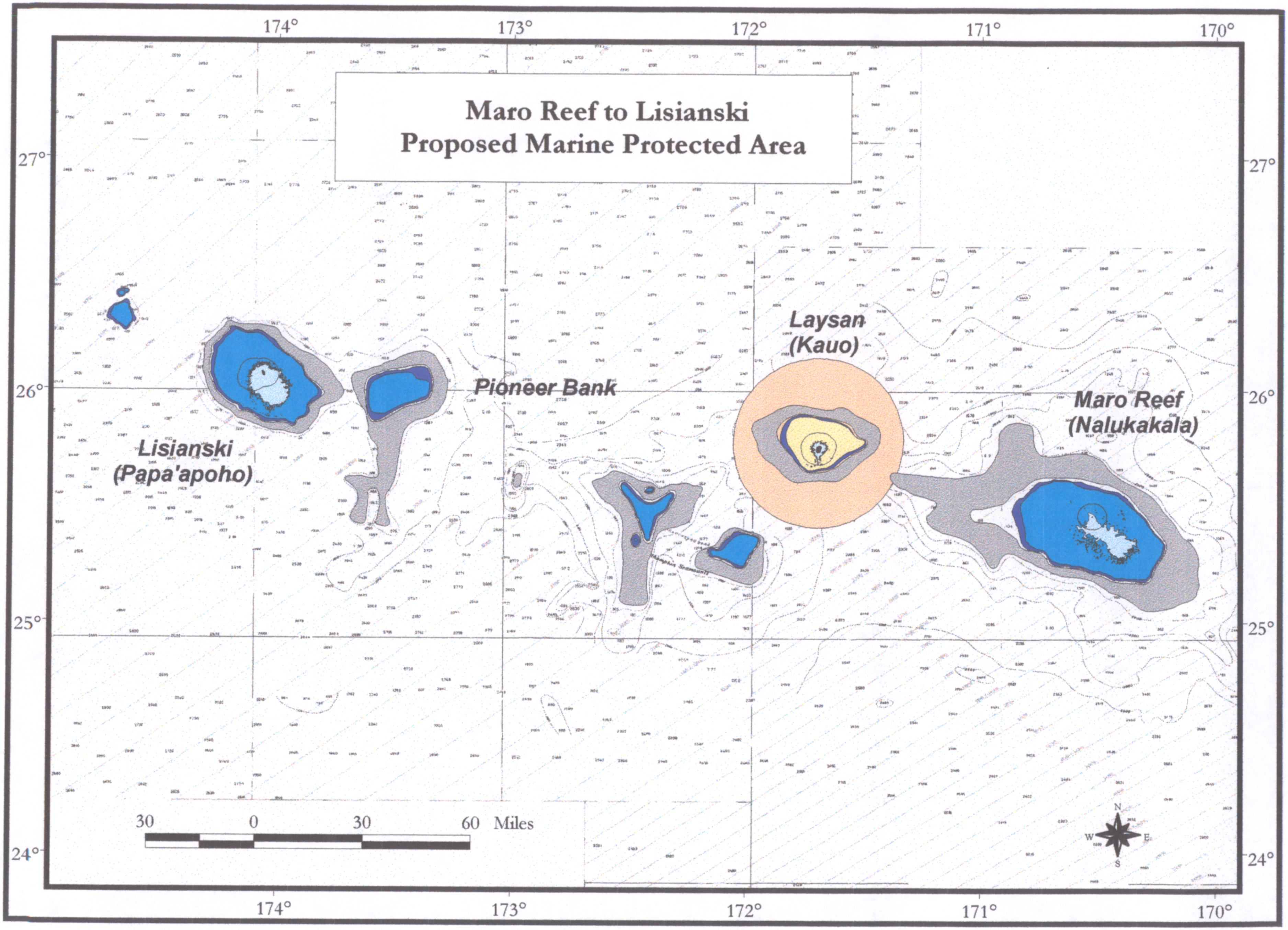
Map Legend for the Northwestern Hawaiian Islands

- Land
- Current no-take zone for lobster/proposed coral reef resource no-take zone (0-10 fm)
- Proposed coral reef resource low-use special permit zone (10-50 fm)
- Current no-take lobster zone (20 mile radius)
- Proposed no-take (kapu) zone (0-50 fm)
- Deepwater precious coral permitted zones
- 50-100 fm) bathymetric contour
- 3 Miles boundary around land
- Potential deepwater coral habitat (150-750 fm)

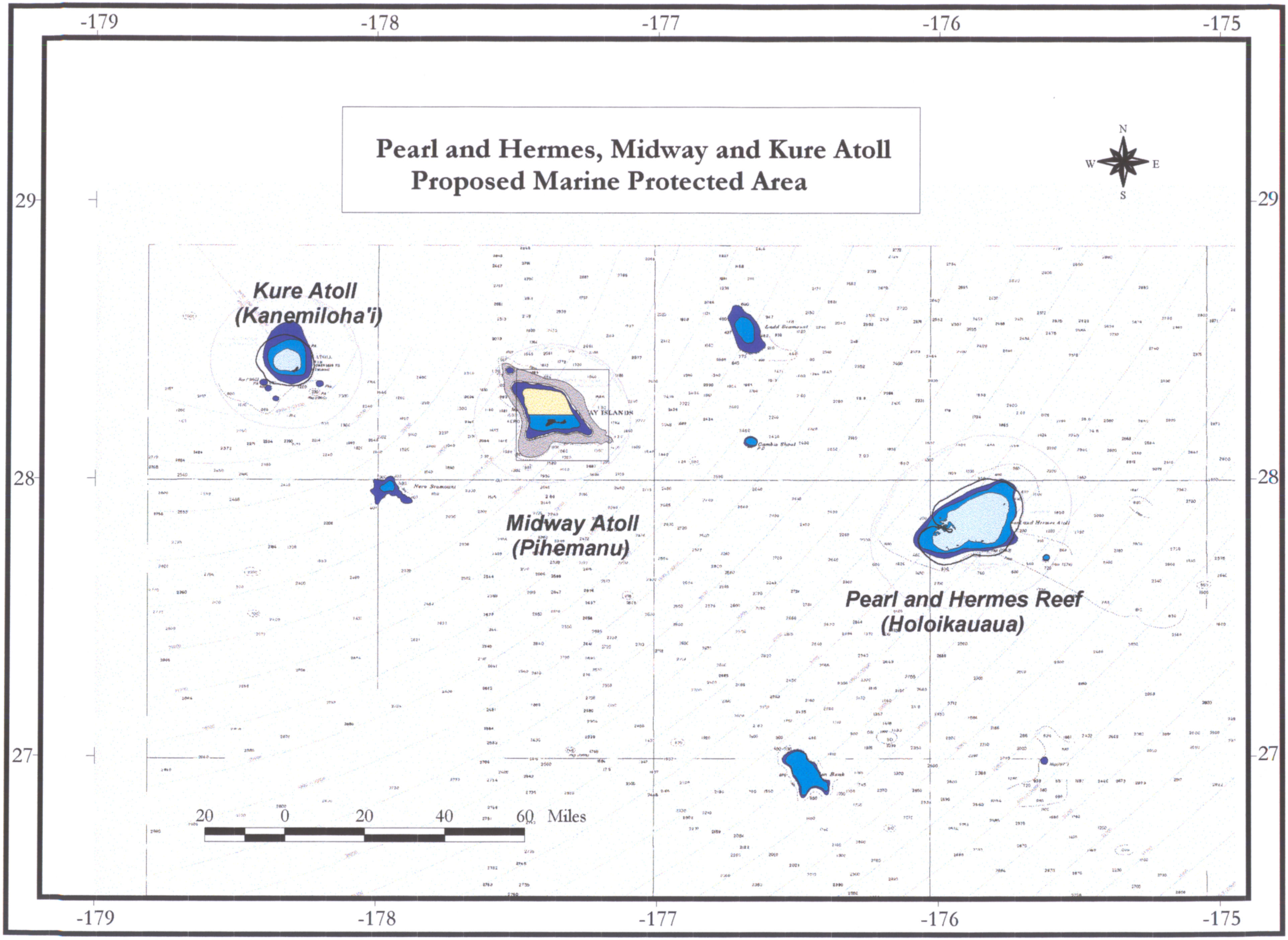
* For Midway Atoll, the proposed coral reef resource low-use special permit zone encompasses all benthic substrates (0-50 fm)


Nihoa and Necker Island
Proposed Marine Protected Area
N
S
E
W
Necker Island
(Mokumanamana)
Twin Banks
Nihoa Island
20
0
20
Miles
-165
-164
-163
-162
-161
25
24
23
22


French Frigate Shoals to Raita Bank
Proposed Marine Protected Area
Raita Bank
Gardner Pinnacles (Puhahonua)
St. Rogatien
Brooks Banks
French Frigate Shoals (Mokupapapa)
20 0 20 40 Miles
-170
-169
-168
-167
-166
-165
26
25
24
23
N
S
E
W



Maro Reef to Lisianski
Proposed Marine Protected Area
174°
173°
172°
171°
170°
27°
26°
25°
24°
Lisianski
(Papa'apoho)
Pioneer Bank
Laysan
(Kauo)
Maro Reef
(Nalukakala)
30
0
30
60
Miles
N
E
S
W


Pearl and Hermes, Midway and Kure Atoll
Proposed Marine Protected Area
N
W
E
S
-179
-178
-177
-176
-175
29
28
27
Kure Atoll
(Kanemiloha'i)
Midway Atoll
(Pihemanu)
Pearl and Hermes Reef
(Holoikauaua)
20
0
20
40
60
Miles

5.3.2 Fishing Permits and Reporting Requirements

Permits are a fundamental management tool, and used as a basis for participation in the fishery. Permits establish the legal rights, privileges and obligations of fishermen. They also provide base data for fishery monitoring and management. Standards of performance can be set as qualifying criteria for obtaining and renewing permits. Permits will be issued only to a U.S. Citizen. Permits are not assigned to specific vessels, although the vessel being used during fishing operations will be identified. Finally, permit holders' records of compliance with permit requirements can be evaluated to maintain a register of those in good standing.

A permit process that allows for monitoring of participation, effort and catch contribute to seven of the eight FMP objectives, particularly Objective 4, calling for measures to minimize adverse human impacts. More specifically, special permit conditions will allow managers to carefully monitor existing and emerging coral reef fisheries in MPAs. Permits focus management attention on details–the specific reef resources and areas to be exploited and the harvest methods to be used. Periodic analysis of catch/effort data collected through permit reporting facilitates adaptive management. Finally, special permits can encourage applicants to more carefully consider their proposed activities and the potential impacts.

The permit regime adopted through the FMP would regulate coral reef fisheries under Council jurisdiction, except those already managed by existing FMPs. As already noted, this jurisdiction covers EEZ coral reef resources in the Council region, except for the remote US island possessions directly under federal control, where permits would apply to fishing from the shoreline to the outer edge of the EEZ.

5.3.2.1 Exemptions

5.3.2.1.1 Scientific Research

Scientific Research is permitted in all areas of the EEZ, including both no-take and low-use MPAs, conditional upon proper approval. Scientific permits are issued through the SWFSC Regional Administrator. The RA will, upon a formal request for a scientific permit for a given project in a designated area, contact the regional authority and consult with both the Council and the regional management agency at a subsequent Council meeting and prior to issuance of a scientific permit.

Foreign scientists wishing to conduct research in the EEZ of the Western Pacific region must also contact the RA with a formal request. The RA will also contact the appropriate regional authority and the consult with the Council in the same manner as for domestic scientific permits.

5.3.2.1.2 Other FMPs

Those fishing for species managed under a separate FMP will require a permit according to that FMP's protocol, but not under this FMP. Incidental catch of coral reef taxa will be reported per that FMP's protocol as well.

5.3.2.1.3 Regional Permitting

Existing coral reef fisheries throughout the western Pacific region EEZ will maintain their current regional permitting protocols. Exceptions to regional management are listed in the general and special permit sections. Regional coral reef fisheries have management regimes in place which include, to the extent these fisheries currently operate, sufficient permitting requirements. Hawaii and American Samoa have locally-based permitting systems. For Hawaii, any person who sells their catch in Hawaii is required to have a commercial fishing licence granted by the Department of Land and Natural Resources. In American Samoa, the Department of Marine and Wildlife Resources issues a variety of fishing permits and commercial licences via a regional general form. Fishing for Currently Harvested MUS in CNMI or Guam does not require a permit. Nevertheless, information on numbers of vessels fishing, fishing effort and catch are collected through standardized sales receipts. For these regions, and for any coral reef fishery in American Samoa or Hawaii, a framework procedure outlined in the FMP can require federal permitting and / or data reporting for these fisheries when it is deemed necessary.

5.3.2.2 General Permit

General permits could be required in any area of the EEZ not designated a low-use MPA. General permits will initially not be required for existing CRE fisheries, but the option is retained as a potential framework measure. General permits are issued based on minimum requirements (e.g., eighteen years of age, U.S. citizen, no criminal record, completion of application form). Denied applications will be based on not meeting any one of these requirements and/or possible previous non-compliance with regulations and reporting. The general permit requirement allows fishery managers to assess individual fishing effort and methods for given target species and associated bycatch. More effective and adaptive management through specific data collection (mandatory reporting) is the primary result of this framework measure. There is an appeal process for denied applications.

Where the Council determines that a regional system is inadequate to address the needs of the FMP for an existing fishery harvesting coral reef taxa and operating within the EEZ but not in a MPA, this framework measure can be enacted to require a general permit through NMFS-PIAO (National Marine Fisheries Service-Pacific Islands Area Office).

This framework procedure can be instigated by a number of methods; (1) the Council will review the Coral Reef Ecosystem annual report for adequate data collection, overfishing or potential for overfishing, and other relevant scientific data which reflects the need for additional management measures, (2) the coral reef plan team can issue a report outlining concerns to the Council to be addressed at the following scheduled Council meeting, (3) regional management authorities may bring concerns to the attention of the Council at any time.

Anyone wishing to fish in the EEZ should contact their regional marine fisheries office to confirm if a permit is needed based on the specific target resources sought. Regional offices will handle requests for all existing fisheries in coordination with NMFS-PIAO, unless the Council has otherwise specified (through framework). If appropriate, the PIAO will instruct the fisher as to proper procedure and make available permit and logbook forms as needed.

5.3.2.3 Special Permit

Special permits will always be required for fishing for coral reef taxa in a low-use MPA. If permitted under the exemptions outlined in this FMP, a special permit is required for harvesting live hard coral for (1) seed stock in aquaculture and (2) for traditional and ceremonial purposes by indigenous peoples. Special permits will also be required for (1) all scientific collection, (2) bioprospecting, and (3) all Potentially Harvested MUS. The special permit requirement for Potentially Harvested MUS fisheries can be changed via framework action to a general permit for those fisheries which the Council believes enough information is known about the fishery. Any person wishing to employ gear not already included on the allowable gear list must complete a special permit application, fully describing the gear and its mode of deployment. Special permit applications for non-approved gear will be subject to the same approval process as any special permit application.

Anyone wishing to fish in the EEZ whose fishing can be categorized as one of the above methods must contact either the PIAO directly or will be directed to contact the PIAO by their regional marine fisheries office. Special permit applications are obtained from the PIAO. A completed application must be submitted along with any specified fees at least 60 days prior to the desired date of permit action. The applicant will follow the directions to fill out example form. Necessary information includes (1) species/taxa to be targeted by the fishery, (2) estimated levels of catch, daily, by trip, and trips per year, (3) locations of areas/banks to be fished, (4) gear to be used and methods of collection, and (5) other criteria as determined by the Council, consistent with its authority under the MSFCMA. Applicants will be notified within 10 business days of receipt of the application whether additional information is required for processing. Incomplete applications will not be processed until corrected in writing.

For residents living on islands surrounded by a low-use MPA (currently Johnston, Wake and Midway Islands), a special permit must be issued. Those residents taking coral reef resources for personal on-island consumption (e.g., limu for poke) will be able to check a box on the application designating this intention. Total quantity of take must be pre-determined by the permittee and approved by a local authority. Given these concerns are addressed, it may be possible to issue permits by the resource manager on-site and then sent within one month of issuance to PIAO to ensure the appropriate usage of the “fast track” approval. Abuse of “fast track” permitting is cause for disallowing further permit approvals in the given area. The Council will determine whether the current management regime at these locations is adequate for MSFCMA requirements.

The PIAO Administrator will consult with the Council and the director of the affected state fishery management agency at the Council Meeting following the receipt of a completed application. The applicant will be notified and will be invited to appear in support of the application at the Council Meeting. The Council will consider cumulative effects of fishing and other activities in the proposed area, environmental factors which could compound effects of fishing pressure, and all other relevant scientific information available before making recommendations. After reviewing the Council’s decision and supporting material, the PIAO Administrator will notify the applicant in writing whether the application is approved or denied. If the application is denied, reasons for denial will be sent to the applicant in writing within 60 days. Permits can be denied for a number of reasons. Reasons include but are not limited to;

- The applicant has failed to disclose material information required, or has made false statements as to any material fact, in connection with his application;

- According to the best scientific information available, the harvest to be conducted under the permit would be significantly detrimental to the population of any species of fish;

- Activities to be conducted would be inconsistent with the intent of the special permit program or the management objectives of the FMP;
-
- Issuance of the special permit would inequitably allocate fishing privileges among domestic fishermen or would have economic allocation as its sole purpose;

- The applicant has failed to demonstrate a valid justification for the permit;

- The activity proposed under the special permit would create a significant enforcement problem.

Appeals for denied permits are outlined in the following section.

5.3.2.4 Appeals Process

Within 30 days of receiving reasons for denial of a special or general permit application from the PIAO Administrator, the applicant must submit in writing to the NMFS Southwest Regional Administrator (RA) the grounds for the action being appealed, including supporting material for the appeal, as well as copies of the original application and reasons for denial. The applicant may request an informal hearing as well.

Appeals to decisions shall be heard by the RA, who will consult with the Council prior to making a determination. The RA has the discretion to grant the informal hearing. If no hearing is granted, the RA will notify the applicant and other interested parties in writing the decision within 30 days of receipt of sufficient information.

If a hearing is determined necessary by the RA, a notice of the time, place and subject will be published in the Federal Register. The hearing shall normally be held within 30 days of the FR notice before a hearing officer. The appellant and all interested parties are invited to give testimony. Within 30 days of the close of the hearing, the hearing officer shall recommend in writing a decision to the RA. Within 30 days of receiving this recommendation, the RA will notify the appellant and other interested parties the final action.

Time limits may be extended for a period no longer than 30 days by either the RA or through a request from the appellant, based upon a written request stating good cause.

5.3.2.5 Fishing Regulations

Upon receipt of a general or special permit, the user affixes the permit to the vessel for which this permit was issued in a manner as outlined in 50 CFR 660.106. Regulations which will affect fishing operations include, among others, gear and area restrictions.

5.3.2.6 General Permit Logbooks

For existing targeted coral reef fisheries in the populated areas (i.e., non-MPAs), data reporting will be coordinated through local management operations. This includes data reporting for subsistence, recreational and commercial fishers operating within the EEZ. In American Samoa, Guam and the CNMI, dockside creel surveys will continue to function as they have. American Samoa, CNMI, Guam and Hawaii all collect data through commercial purchases. CNMI has requested all fish buyers to fill out data forms since 1983. While reporting of commercial fish catch is also still voluntary in Guam, a relatively high percent coverage has been maintained since 1982 through cooperation of the major fish dealers on Guam. In American Samoa, the DAWR requires fish buyers to fill out a form which includes the date, species, weight and economics information. Fishermen who land their catch in Hawaii are required to fill out a fish catch report which includes area fished, type of gear, weight and numbers of fish caught by species.

If the Council determines data collection to be inadequate for the given fishery, a "general coral reef taxa daily catch report" will be provided by NMFS. NMFS can coordinate with local fisheries agencies to facilitate the distribution, data collection and processing via established WPacFIN protocols. Additionally, this catch report can be required through the general permit, if that framework measure was initiated for a given fishery. An example form and associated directions are at the end of this section. Requirements may include the following (although the PIAO Administrator may, after consultation with the Council, initiate rule making to modify these or any fishing record forms).

1. Report catch, effort and discards by species, location, time and other factors as specified by the Council

2. Report protected species observations

3. Report any lost gear or damage to the coral reef (no penalty to permittee)

4. Complete daily logsheet within 24 hours after completion of the fishing day

5. Submit reports within 30 days of returning to port

5.3.2.7 Special Permit Logbooks

In the remote islands of Wake, Johnston and Midway, only recreational and on-island consumption fishing is allowed. The USFWS has programs in place to monitor these fisheries. If, after applying for a special permit through PIAO, the Council determines this reporting is adequate for the

Magnuson-Stevens Act and data is properly processed and provided to the appropriate Council advisory bodies, no further data collection will be required.

For the low-use MPAs, including the NWHI and Guam's southern banks, reporting is required through the special permit process. For emerging fisheries (i.e., Potentially Harvested MUS), data reporting methods will be determined during the permit approval process. If local monitoring systems are not deemed sufficient, a federal logbook will be required. Federal reporting requirements may include the following, although specific requirements may be stipulated in the permitting process.

1. Report catch, effort and discards by species, location, time and other factors as specified by the Council

2. Report protected species observations

3. Report any lost gear or damage to the coral reef (no penalty to permittee)

4. Complete daily logsheet within 24 hours after completion of the fishing day

5. Submit reports within 30 days of returning to port

For a more complete description, an example special permit daily catch report and the directions to fill out the form are at the end of this section.

The operator of a harvested coral reef resources in a low-use marine protected area must contact the USCG, by radio or otherwise, at the 14th District, Honolulu, HI; Pacific Area, San Francisco, CA; or 17th District, Juneau, AK, at least 24 hours before landing, and report the port and the approximate date and time at which the coral reef resources harvested on the trip will be landed.

5.3.2.8 Transshipment Logbooks

Any vessel engaged in transshipment of coral reef ecosystem resources in the EEZ must have a permit issued for such activity as outlined in CFR 660.103. These vessels must have an accurate and complete NMFS transshipment logbook. An example form and directions are at the end of this section. All required information must be recorded on the form within 24 hours after the day of transshipment. All original forms must be submitted to NMFS within 7 days of landing transshipment.

5.3.2.9 State Reporting

Vessels required to complete a federal logbook must still follow any state laws and regulations regarding reporting and submit those forms to the appropriate state agency. These records shall be made available for Federal inspection and copying upon request by an authorized officer.

5.3.2.10 Processing of Data and Annual Reports

Data processing has been established for Hawaii, Guam, the Commonwealth of the Northern Marinanas, and American Samoa for other FMPs. The CRE-FMP will follow these established procedures. Logbooks and/or commercial buyer's data sheets will go to the appropriate regional agency, where data entry and error checks will occur. NMFS staff make regular visits to the insular areas to coordinate the annual report modules of other FMPs. Coordination of the data for the coral reef FMP modules will also be handled during these visits. This information will then be sent to the NMFS-HL, where a designated NMFS employee will coordinate the production of the annual report. Federal logbooks are submitted directly to the NMFS-HL. Annual reports are due by July 31 of each year. The annual reports are divided into regions (MHI, NWHI, PRIA, American Samoa, Guam and CNMI). Included in the annual reports are summaries of the status of the fisheries, the health of the ecosystem, status of current research, economics of the fisheries and the future potential. A section addressing fishing and non-fishing impacts to EFH and HAPC for both nearshore and EEZ waters is included for all areas. Also included are actions taken in the past year by the Council, recommendations from the plan team, advisory panel and SSC, reports from enforcement and status of protected species.

5.3.3 Fishing Gears and Methods

Pacific islanders have fished on coral reefs for several thousand years. Sustainability resulted in part from the inefficiency and selectivity of the gear that they used. Many of the traditional methods are still used in contemporary fisheries, although the introduction of manufactured gear and population growth have increased the impacts. Today's fishermen employ a wide variety of gear and methods to harvest extremely diverse resources (hundreds of species). Most of these methods are very inefficient when compared to industrial fishing technology, such as bottom trawls, all-terrain trawls, bottom dredges or industrial netting, used in US continental shelf fisheries but prohibited in many benthic fisheries around the Pacific. However, several potential threats to coral reef resources in the EEZ around US Pacific islands remain, due to the use of destructive fishing methods.

Unregulated live reef fish harvesters for food and ornamental markets, already a problem in Southeast Asia, could find their way to US EEZ waters, especially in remote, difficult to monitor areas. Controls are needed to prevent the possession or use of destructive gear such as poisons, explosives, intoxicating substances and non-attended gill nets that damage coral reef ecosystems. Bioprospecters may also wish to harvest reef resources. Despite the potential benefits to society, any harvesting must be carried out in a controlled manner. The collection of these organisms, many of which are still unknown, will utilize novel techniques that are difficult to anticipate.

Gear restrictions are also needed in order to address several other issues. Non-selective gears and methods could result in substantial incidental catch or bycatch. SCUBA assisted fishing at night can be so efficient for highly-prized fish which are sleeping as to provide no refuge. Lastly, FMPs are required to list allowable gear types. (It should be noted that even when allowable gear types are specified, a special permit application may be submitted to PIAO which fully describes the gear and method of deployment.)

Placing limits on allowable gear types addresses several FMP objectives including 1: sustainable use of resources, 4: minimizing adverse human impacts, and 7: effective surveillance and enforcement.

Fishing gear which has been or may be used in the coral reef ecosystem environment has been rated on (1) selectivity (how well it catches the target species), (2) potential impacts to EFH and (3) refuge (does the method allow for refuge for the species).

5.3.3.1 Restricted Gear

The use of poisons, explosives and intoxicating substances are specifically banned in all areas of the EEZ. SCUBA-assisted spearfishing at night is prohibited in the PRIA and NWHI, and in other areas SCUBA-assisted spearfishing could be prohibited via framework action so as to be consistent with local regulations.

5.3.3.2 Allowable Gear

Existing FMP fisheries shall follow the allowable gear and methods outlined in their respective plans. For coral reef fisheries, only the following selective, non-destructive fishing gears shall be allowed: hand harvest, spear, slurp gun, hand net/dip net, hoop net (for kona crab), throw net, barrier net (for aquarium fish), surround/purse nets for targeted schools (e.g., akule, baitfish, weke) with a minimum of bycatch, hook-and-line (includes handline [powered or not], rod-and-reel, and trolling), and remote-operating vehicles/submersibles. Anyone wishing to fish with gear not included in this list must describe the gear and its method of deployment in the special permit application. A ruling on this gear type will be determined by the PIAO Administrator after consultation with the Council and the director of the affected state fishery management agency. Possession of any gear not approved under 660.108 (a) or approved by the PIAO Administrator in the permit process while established to be fishing for coral reef resources in the EEZ is prohibited.

5.3.3.3 Unattended Gear and Gear Identification

Because any allowable gear type, if improperly used, has the potential to cause damage, specific conditions of operation are outlined in the gear description. In short, nets shall be tended at all times (except hoop nets for kona crabs) and traps shall be allowed in appropriate areas and operated under appropriate conditions (e.g., minimal bycatch mortality, negligible habitat impact, and provisions to minimize the possibility of ghost fishing).

Unattended traps not in compliance with CRE regulations and found deployed in the EEZ may be disposed of by NMFS or an authorized officer. Unattended surround nets or bait seine nets may also be disposed of by NMFS or an authorized officer.

All traps on board a vessel possessing a coral reef ecosystem permit or deployed by this vessel in the EEZ must be permanently and legibly marked to identify owner. The U.S. Coast Guard has authority to board any vessel in the EEZ to check for violations. This includes gear compliance.

5.3.4 Other Management Measures

Since the status of coral resources and their exploitation can change, any management regime must be able to change in response. Management program provisions can be implemented in an administratively simpler manner using a framework process, in comparison to amending the CRE-FMP. Several measures are identified for possible later implementation using this procedure, including restrictions on anchoring in MPAs, and requiring vessels operating in MPAs to carry VMS. The framework procedure would also simplify reassignment of MUS between the "currently harvested" and "potentially harvested" categories. In general, other measures can be implemented through the framework process if their impacts have been evaluated in this FMP or its amendments; otherwise a full amendment is required.

The ecosystem approach used in this FMP, which must take into account interactions with island government-managed and other FMP managed fisheries, calls for effective coordination between agencies and organizations involved in coral reef management. For example, coordination with local agencies could allow expansion of MPAs to inshore areas and EEZ areas adjacent to populated islands. Essential Fish Habitat and Habitat Area of Particular Concern designations also entail consultations in relation to federal actions with potentially major environmental impacts. The process and criteria for these consultation can be established without new regulations. A formal process for coordination among plan teams is also proposed. More generally, research and education efforts can also further FMP objectives by improving understanding of the social and biological components of the ecosystem and sensitizing resource users to coral reef ecosystem values.

5.3.4.1 Adaptive Management

Due to the uncertainty regarding management of the fishery resources of coral reef ecosystems, a framework provision is included to provide for a timely adjustment of management measures as permit processes are developed and implemented, and as more information on ecosystem function, productivity limits and responses to alterations becomes available.

This section describes changes to the FMP that may become necessary based on recommendations identified in the annual report and/or Council or other advisory body meetings. Changes to the management regime under the FMP can occur through framework action or FMP amendment. Current options being considered for future framework action include: (1) restrictions on mooring and anchoring in no-take MPAs except in emergencies, (2) requiring fishing vessels operating in MPAs to carry individual VMS (if funded by NMFS), (3) implementing a general permit requirement for existing fisheries in areas other than MPAs in which regional systems do not meet the needs of the FMP, (4) changing permitting and reporting requirements for emerging fisheries for which sufficient information has been collected (movement of management unit species between currently-harvested and potentially-harvested lists), and (5) designating an indigenous sub-zone within low-use MPAs.

In addition to recommendations for Council action in response to assessments described in the annual report, the coral reef ecosystem plan team may present recommendations to the Council at any time. If the recommendations relate to activities covered under another FMP, the team will confer with other plan teams. This consultation process is outlined in a later subpart of this section.

5.3.4.1.1 Framework Actions for Established Measures

Established measures are measures that have been evaluated in this FMP or one of its amendments. The five current actions slated for framework adjustment have been listed and described in this section. Adjustments under the framework procedures must be consistent with the original intent of the measure and within the scope of analysis in any previous documents supporting the existing measures. All adjustments will address the objective of this FMP to provide for sustainable resource management of coral reef ecosystems.

Provided that the requirements of the above paragraph are met, a draft document outlining the need for action, an analysis of alternatives, supporting material and the applicability to other federal laws will be prepared. A notice will be placed in the Federal Register and the document will be available for public comment. A public hearing may also be required. Upon receiving and addressing all public comments, the document will be revised prior to the following Council meeting, at which time the measure will be voted. If the measure is approved, the Regional Administrator will be requested to initiate rule making.

The following measures, slated for framework action, are not presently included in the management regime for one of two reasons. Details for actions 1, 2 and 5 still need to worked out. Locations of mooring buoys have not yet been determined, although all agreed on their importance (#1). A closer look at the needs of vessels operating in MPAs and a better understanding of EFH and HAPC will be required. It is not yet determined whether the federal government will pay for the installation and operation of VMS in this fishery (#2). Size and location of indigenous sub-zones were not decided upon and legal issues were not fully explored (#5). Framework measures 3 and 4 are part of adaptive management. They have been crafted to be enacted as new information on the fishery and its environment become available. Thus, the management aspects of these two framework measures have been explored, but proper action awaits necessary scientific data.

1. Designate zones in the EEZ where mooring buoys will be installed in order to protect EFH from anchor damage. In areas with approved mooring buoys, prohibit anchoring of fishing vessels within a radius indicated on the buoy.

Rationale: "No anchor zones" in specific habitat areas would protect coral reefs from devastating damage done by anchors. Mooring buoys have been used successfully in Hawaii and elsewhere in the Pacific as an alternative to anchoring, particularly in high use areas. The use of these buoys by fishers and others would reduce habitat damage caused by anchoring. The buoys would be used on a first-come-first-served basis and allowable time limits would be specified so that no one boat monopolizes a buoy. This process would ensure that the use of these buoys and the concomitant access to the resources would be fair and equitable to all fishers, consistent with National Standard 4. Only one boat would be allowed to moor at a time at each buoy. The prohibition of anchoring would limit the number of secured boats fishing an area to the number of mooring buoys at the site. While this may concentrate fishing effort around the buoys, it would also limit the number of vessels fishing at one time, increasing vessel safety and minimizing fishing pressure on coral reef resources.

Beneficial Impacts:

- prevents anchor damage to reef habitats

- allows anchoring for safety reasons in EFH and/or HAPC
- limits number of vessels fishing on the banks at one time, increasing vessel safety and minimizing fishing pressure on coral reef resources
- increases safety of fishers by making anchoring (and its hazards) unnecessary and reducing risk of anchor dragging
- is consistent with requirements of the Sustainable Fisheries Act by minimizing degradation of coral reef habitats

Adverse Impacts:

- limits number of vessels able to fish in a designated mooring zone at one time
- mooring buoy maintenance may be difficult
- may concentrate fishing effort in areas with buoys
- includes a cost for installation and maintenance of buoys
- may encourage "rafting" of vessels at each mooring buoy (even though it would be prohibited under the measure), which is a safety concern

2. Require fishing vessels to carry remote electronic vessel monitoring systems (VMS) as part of an effective monitoring and enforcement system for state, territorial, commonwealth and federal agencies. This requirement could be applied to coral reef fisheries in specific geographical areas (e.g., NWHI). This measure will only be enacted if the cost of such a system is fully subsidized with federal funding.

Rationale: VMS is an effective system for managing vessels operating in areas with different use zones, such as the MPAs, and with different licenses/permits, and for encouraging and documenting compliance with permit conditions. The vessel's precise location would be transmitted via satellite to a Land Earth Station (LES) and from there to a computerized monitoring station where the information would be kept in a secure and confidential database. If the vessel enters a designated buffer zone or MPA, an automatic signal is sent to both the ship's captain and the appropriate management agency. Such a system may prove to be a cost-effective compliance tool for real time and accurate positioning of vessels and instant recognition of a breach of permitted activities, as well as a tool to locate vessels in distress. VMS also has been shown to be an effective tool for monitoring of vessels and, when used in conjunction with automated buffer zones, for preventing vessel groundings.

Beneficial Impacts:

- protects coral reef resources by providing early warning of a vessel approaching too close to a reef slope, thereby protecting both the reef and the vessel from grounding damage
- protects coral reef resources by providing a tool that can dramatically improve compliance with FMPs
- is consistent with the requirements of the Sustainable Fisheries Act
- provides precise location information to assist in emergencies and rescues

- provides documentation on vessel movements, which can be used to clear up misunderstandings regarding liability or accusations of responsibility for environmental damage
- requires no input by captain or crew to run the automatic system
- can make enforcement easier and potentially much less costly

Adverse Impacts:

- cost of implementation may be burdensome to federal government
- implementation will require fiscal and personnel resources
- fishermen are concerned over the use of VMS information (security and confidentiality of data)

3. Require general permits to fish for currently-harvested CRE MUS in non-MPAs in the EEZ, in the event that regional management is determined inadequate to protect the species and/or ecosystem.

Rationale: This framework measure is described fully in section 5.3.2.2, under the management regime. General permits will initially not be required for existing CRE fisheries. The general permit requirement allows fishery managers to assess individual fishing effort and methods for given target species and associated bycatch prior to any vessel fishing. More effective and adaptive management through specific data collection (mandatory reporting) is the primary result of this framework measure.

Where the Council determines that a regional system is inadequate to address the needs of the FMP for an existing fishery harvesting coral reef taxa and operating within the EEZ but not in a MPA, this framework measure can be enacted to require a general permit through NMFS-PIAO.

This framework procedure can be instigated by a number of methods; (1) the Council will review the Coral Reef Ecosystem annual report for adequate data collection, overfishing or potential for overfishing, and other relevant scientific data which reflects the need for additional management measures, (2) the coral reef plan team can issue a report outlining concerns to the Council to be addressed at the following scheduled Council meeting, (3) regional management authorities may bring concerns to the attention of the Council at any time.

Beneficial Impacts:

- requires specific data reporting of catch, effort, area and method of fishing
- allows for a thorough understanding of the total fishing effort for given areas and given target species
- provides information on bycatch and protected species
- allows for standardization of reporting, assisting fishery managers assessment of impacts
- makes fishers more aware of concerns of impacts from fishing through completing both permit form and logbooks
- assists adaptive management with crucial data on fishery

Adverse Impacts:

- increases administrative burdens (time and costs) due to the permit process
- increases burdens to fishermen not used to completing this type of paperwork
- removes management from regional authority which had traditionally managed these fisheries

4. Allow for movement of potentially-harvested MUS to the currently-harvested MUS list when sufficient information has been gathered for less restrictive management.

Rationale: If a market develops for a potentially-harvested species, fishers will request to fish that (those) species under the special permit. The special permit is designed to use the precautionary approach. Approval of the permit requires a thorough description and evaluation of all aspects of the fishing method for each applicant. Additionally, strict reporting requirements, including bycatch and discards, must be submitted. The data gathered from the vessels will help managers determine MSY, OY and potential for overfishing. When enough data has been gathered for a given species or species complex and its associated bycatch to understand cumulative impacts on the species and ecosystem, the Council can determine whether to lessen the stringent requirements. This reduces administrative and regulatory burdens at the appropriate time without causing risk to the resource.

Beneficial Impacts:

- relieves unnecessary administrative burdens on species for which management is understood
- reduces burden to the Council and the PIAO Administrator for permit approval
- eases burdens on fishermen who have complied with regulations, allowing for given species to be re-listed as currently-harvested MUS
- procedure to re-list MUS prompts fishery managers to better understand species and ecosystem to facilitate effective management

Adverse Impacts

- has the potential to put species at risk which could require more stringent management measures
- could facilitate additional fishing pressure for given species due to a simpler permitting process

5. Designate a set percentage within low-use MPAs for sole use by indigenous peoples, with the percentage based upon percentage of indigenous population in the area around the low-use MPA

Rationale: Discussions during the planning process centered around access for native Hawaiians to the NWHI for traditional and ceremonial purposes. Tangentially, other island cultures were included with details to be worked out in the future as new MPAs were designated in those EEZs. Full details were not worked out for the NWHI as well. These include where these locations would be, the exact percentage of low-use MPA that would be set aside as well as legal issues surrounding the proposal. Nevertheless, the CRE plan team and other groups strongly believe in the premise.

The Samoa, Hawaii and Mariana islands were originally settled in ancient times by sea-faring peoples. The lack of terrestrial resources in most areas led to great dependence on fishing for food security. This dependence shaped the social organization, cultural values and spiritual beliefs of the indigenous populations. Repeated contacts with Europeans and North Americans eroded the stability of the social structures and subsistence economies created by indigenous people. Fishing not only provides food but cultivates intimacy and harmony with the ocean, reinforcing a sense of kinship with nature and relationships with places that perpetuate cultural identities and beliefs. Increasing restrictions on customary and traditional uses of marine resources are jeopardizing cultural continuity in many areas of the US Pacific. The designation of no-take zones in the NWHI could result in some negative impact on the Hawaii fishing community by causing a loss of earning potential, investment value and lifestyle some bottomfish and lobster fisheries participants.

A 1993 survey of participants in the NWHI bottomfish fishery found that half of the respondents who fish in the Ho'omalu Zone were motivated to fish by a long term family tradition (Hamilton, 1994). This sense of continuity is also reflected in the importance placed on the process of learning about fishing from "old timers" and transmitting that knowledge to the next generation. Hawaii's commercial fishing industry dates back nearly 200 years and closure of some fishing grounds in the NWHI would also likely have a negative impact on those who value the continued existence of Hawaii's maritime tradition and culture. In view of the historic and cultural importance of fishing over the last 2,000 years for Native Hawaiians, this deprivation of the right to make a living at *koa* (see Kahaulelio 1902, pp. 22, 24), which they have been accustomed to frequent in the NWHI, is an especially onerous penalty. This is exacerbated by the fact that annexation of Hawaii by the U.S. opened access to fishery resources to any U.S. citizen (Kosaki 1954), increasing fishing pressure on resources customarily used by Native Hawaiians and weakening cultural norms that controlled the proper conduct of fishing.

Beneficial Impacts

- helps preserve and reestablish island cultures and families whose history of traditional and ceremonial use of coral reef resources dates back thousands of years
- adds additional protection within low-use MPAs, by effectively limiting the amount of users in the area
- will make the permitting process for certain activities simpler as usage in these areas can be expected to be typical across these select user groups
- potential to support subsistence fishing

Adverse Impacts

- could be challenged legally on grounds of discrimination
- locations and size of the sub-zones could cause contention between user groups
- concerns have been expressed regarding what constitutes cultural take (e.g., modern gear and techniques could alter the purpose of the sub-zone)

Requiring general permits for a given fishery in a given area is one example of a framework measure. Reef fisheries occur both in territorial and federal waters around American Samoa. The DAWR issues permits to fish for these species and collects data through both creel surveys and commercial purchases. These reef fisheries are small scale operations, with individuals catching a few to a couple hundred pounds of fish on a given day. If one or more large scale operations began efficiently targeting these species in the EEZ, increasing the total catch substantially, regional management might not be sufficient to address this development. The Council could then initiate the framework process to require a general permit for reef fisheries in the EEZ of American Samoa. While details as to who would be affected and how the measure would affect fishing are subject to a unique, unforeseeable situation, general procedures are as follows with additional clarification in 50 CFR 660.13. Permits would be valid only for the fishery management subarea specified on the permit and remain valid for the period specified unless transferred, revoked, suspended or modified. A permittee first requests an official Southwest Region Federal Fisheries application form. After filling out all required information and attaching necessary documents as outlined in the example form, the permittee returns the application along with any fees, as specified. PIAO will review and process all completed applications within 15 business days. Permittees will be notified of incomplete or incorrect applications. If deficiencies are not corrected within 30 days following notification, the application will be considered abandoned. Within 15 business days after receiving a completed application, the administrator of the PIAO will issue a permit to the applicant under the CRE-FMP or send a written notification of denial which will include the reasons for the denied application.

5.3.4.1.2 Procedure for New Measures (Amendments)

Procedures for new measures apply to regulatory measures that have not been included in previous regulations or whose impacts have not been analyzed previously in the FMP. These new measures include, but are not limited to, catch limits, resource size limits, closures, and effort limitations. New regulatory measures will follow the procedure outlined for amendments in NMFS' Operational Guidelines, Fishery Management Plans (May 1, 1997 revision).

A Federal Register notice will be published describing any proposed new management measure. The notice will solicit public comment. At the following Council meeting, the Council will formally address the specific measure where they will consider recommendations. A Federal Register notice will be prepared summarizing the Council's deliberations, rationale and analysis for the preferred action, and include the time and place for any other Council meetings to consider the measure. At subsequent meetings, the Council will consider public comments and other information received and will draft a document with a recommendation to the Regional Administrator.

The Regional Administrator will propose regulations to carry out the action or offer a written explanation supporting the denial of the recommendation within two weeks of the decision. The Council may appeal a denial by writing to the Assistant Administrator. The Assistant Administrator must respond to the Council within 30 days. If the RA agrees with the recommendation, the RA and the Assistant Administrator will make their decision in accordance with the Magnuson Stevens Act and other applicable laws. Finally, NMFS may implement the Council's recommendation by rule making if approved by the Regional Administrator.

5.3.4.2 Enforcement

Enforcement burdens and costs have been analyzed in the draft RIR/IRFA. Enforcement can occur either at sea with use of air and / or boat patrols or dockside through vessel and logbook inspection.

5.3.4.2.1 At-Sea Enforcement

The major additional enforcement burden required by this FMP is directly related to the designation of no-take and low-use MPAs. In the NWHI, these areas follow the 10 or 50 fathom depth contour. As these MPAs are not simple shapes, this may create difficulties for determining whether a vessel is inside or outside an MPA. Large scale maps of the resource with boundary coordinates will help determine the issue. Mapping of the coral reef resource is a priority for both the Council and NOAA.

As mandatory VMS for every vessel operating in any MPA has been slated as a framework measure, pending Council action and federal funding, the only method to enforce MPA regulations is through direct at sea monitoring with either aerial or vessel patrols. The cost and time needed to patrol the coral reef ecosystem of the NWHI, the PRIA and the other insular areas is analyzed in another section. Mandatory installment and use of VMS for every vessel operating in MPAs would greatly reduce the need for at sea patrols, simplify the process of determining whether vessels are operating within or outside an MPA, and greatly reduce the cost while increasing overall coverage.

Enforcement may, if they feel it necessary, board any vessel and request to conduct an at-sea inspection of the catch, gear and logbooks. Retained catch should be reflected in the logbook entries. Fishing data forms should be filled out within 24 hours of completing fishing. If on-board gear should be specifically identified (e.g., traps), compliance can be checked.

Unattended surround nets or bait seine nets or traps which do not identify ownership as described in the CRE regulations found deployed in the EEZ will be considered unclaimed or abandoned property. Enforcement may dispose of these in any manner considered appropriate.

5.3.4.2.2 Dockside Inspection

While many of the activities stated above could occur at sea, it is much more effective to inspect gear compliance, validity of permits, logbooks and reporting of catch when a boat returns from a fishing trip. Vessels that have fished in an MPA are supposed to notify the Coast Guard at least 24 hours prior to returning to port. This makes dockside inspection much easier than at sea inspection.

5.3.4.3 Non-regulatory Actions

5.3.4.3.1 Strengthen Inter-agency Cooperation

Coherent management of coral reefs and better enforcement of island government fishing regulations (i.e., consistency between state/territorial and federal waters) are achievable through cooperative agreements between federal and island government natural resource management and enforcement agencies. Examples of such cooperation are the cooperative enforcement agreements between the

National Marine Fisheries Service Southwest Law Enforcement and enforcement agencies in the Territory of American Samoa, Territory of Guam and State of Hawaii. Such agreements may vary from area to area. They are manpower intensive and require a substantial commitment to training. With joint enforcement by island government and Federal agencies, local regulations might be enforced as landing laws to control the harvest of coral reef resources in areas outside State and territorial waters. Coral reef areas where fishing is prohibited or restricted and which function as *de facto* MPAs could be expanded by island government and Federal agency designations.

5.3.4.3.2 Process to Facilitate Interagency Coordination to Assess Non-fishing Impacts and Threats to Coral Reef Habitat

Marine Protected Areas, Essential Fish Habitat (EFH) and potential Habitat Areas of Particular Concern (HAPC) have been identified within this document. Designation of these specific areas within the whole management area will help to provide additional focus for conservation efforts. Many of these areas fall under state or territorial jurisdiction (i.e., within 3 nm from shore). Still others carry partial jurisdiction by Interior or Defense (MPAs in the NWHI and the National Wildlife Refuges and Defensive Seas around the PRIA). In the populated areas, much of the non-fishing impacts are land-derived. The potential impacts from these activities will first affect the waters not under Council jurisdiction. For each of these reasons, efficient inter-agency coordination to address these issues is vital.

The criteria necessary to facilitate interagency coordination to assess the impacts of non-fishing activity are presented below. Specific concerns which would instigate interagency coordination include, but are not limited to, the following major federal action which meet the below criteria;

1. Significant damage to habitat or high likelihood of significant damage

2. Size of a coastal construction project (dredging, likelihood of erosion)

3. Large-scale agricultural activity (pesticides, herbicides, nutrient loading)

4. Increase of marine tourism (anchoring, shell collecting, cruise ships)

5. Military activities (bombing and training operations, construction)

6. Boat activity (oil / fuel spills, vessel grounding)

7. Offshore mining (sand, coral, manganese)

8. Power plant and water treatment plant discharge

9. Scientific projects

10. Marine debris (fishing gear)

11. Introduction of exotic species (ballast/bilge waters, aquaculture)

The National Environmental Policy Act requires that an environmental impact statement be prepared for any major federal action that significantly affects the environment. With respect to essential fish habitat, if the permitting agency believes that the proposed project will affect essential fish habitat, they will request consultation with the National Marine Fisheries Service and the Council. After this consultation, the permitting agency must make an initial assessment of how the proposed activity may affect EFH and must respond to any recommendations provided by NMFS or the Council. This consultation merges the requirements of other environmental laws (e.g. Clean Water Act, Endangered Species Act, etc.) so as to not cause undue burden on the permittee, the permitting agency, NMFS or the Council.

5.3.4.3.3 Formal Process for Coordination among Plan Teams to Identify and Address Impacts to Coral Reef Ecosystems

The procedure for ecosystem-based interaction between plan teams will occur as follows. The CRE Plan Team identifies an ecosystem issue pertinent to the activities of another Council FMP and submits to that FMP's plan team a written description of the problem. Receiving the description, the plan team of the sister FMP will prepare and propose alternatives to mitigate identified impacts or respond at its next regularly scheduled meeting. CRE Plan Team will review and recommend one of the proposed alternatives. If CRE Plan Team believes none of the proposed alternatives is effective, it will draft an alternative recommendation and provide it with the sister plan team's recommendation to the Council for review and resolution. Other plan teams, the Science and Statistical Committee, the Council, fishers and federal-state-territorial-commonwealth agencies may also bring ecosystem issues to the attention of CRE Plan Team for review. The Council's program planning "milestones" document, which is regularly updated, illustrates cross-FMP activities and needs, including research.

5.3.4.3.4 Education

The Council has established an education and public outreach program for FMP-managed fisheries. The program will be expanded to include a strong educational outreach component to raise public awareness of coral reef ecosystems and to improve compliance with regulations controlling the harvest of coral reef resources.

6.0 IDENTIFICATION AND DESCRIPTION OF ESSENTIAL FISH HABITAT

6.1 EFH Background

The M-S Act requires Councils to identify and describe essential fish habitat (EFH) for all managed species in any FMP. EFH is defined in the M-S Act as "those waters and substrate necessary to fish for spawning, breeding or growth to maturity". The definition of EFH may also include habitat for an individual species or an assemblage of species, whichever is appropriate within each FMP.

This new mandate represents a significant shift in fishery management policy. The EFH provisions of the M-S Act requires Councils to move beyond traditional single-species and multi-species management and to begin to consider a broader, ecosystem-based approach to fishery management. The Councils are now required to begin to consider the ecological role (e.g., prey, competitors, trophic links within food webs etc) played by MUS. Further, Councils are now required to identify and minimize adverse impacts to EFH that result from both fishing and non-fishing activities.

Provisions specified in the M-S Act require Federal agencies to consult with the Secretary with respects to any actions authorized, funded, or undertaken by such an agency that may adversely affect any EFH identified under the Act. Furthermore, additional provisions allow Councils to provide comments and make recommendations to Federal or State agencies that propose actions which may affect the habitat, including EFH, of an anadromous fishery resource under its authority.
In a recent report to Congress, the NMFS Ecosystem Principles Advisory Panel stated that the Councils already apply many of the principals of ecosystem-based fishery management. The Panel concludes that the successful application of ecosystem principals and policies depends on the full implementation of many existing measures already contained in the M-S Act, particularly the EFH provisions.

The designation of EFH for the Coral Reef Ecosystem FMP was based on the best available scientific information and included both environmental and fisheries data. This information was obtained through an iterative process consisting of a series of public meetings of the Council, SSC, FMP plan teams and fishing industry advisory panels. In addition, the Council worked in close cooperation with scientists in the NMFS.

Description of EFH

The NMFS guidelines intended to assist Councils in implementing the EFH provision of the M-S Act set forth the following four broad tasks:

- Identify and describe EFH for all species managed under an FMP;
- Describe adverse impacts to EFH from fishing activities;
- Describe adverse impacts to EFH from non-fishing activities; and
- Recommend conservation and enhancement measures to minimize and mitigate the adverse impacts to EFH resulting from fishing and non-fishing related activities

The guidelines suggest that each Council prepare a preliminary inventory of available environmental and fisheries information on managed species. Such an inventory is useful in describing and identifying EFH, and helps to identify missing information about the habitat of particular species. The guidelines note that a wide range of basic information is needed to identify EFH including data on current and historic stock size, the geographic range of the managed species, the habitat requirements by life history stage and the distribution and characteristics of those habitats. Since EFH has to be identified for each major life history stage, information about a species' distribution, density, growth, mortality and production within all the habitats it occupies, or formerly occupied, is also necessary.

The guidelines further state that the quality of available data should be rated based on the following four levels of information:

Level 1: All that is known is where a species occurs based on distribution data for all or part of the geographic range of the species.

Level 2: Data on habitat-related densities or relative abundance of the species are available.

Level 3: Data on growth, reproduction or survival rates within habitats are available.

Level 4: Production rates by habitat are available.

With higher quality data those habitats most highly valued by a species can be identified, allowing a more precise designation of EFH. Habitats of intermediate and low value may be essential depending on the health of the fish population and the ecosystem. For example, if a species is overfished, and habitat loss or degradation is thought to contribute to its overfished condition, all habitats currently used by the species may be essential.

At present, there is not enough data on the relative productivity of different habitats to develop EFH designations based on Level 3 or Level 4 guidelines for any of the Council's Coral Reef Ecosystem MUS.

The Council used the best available scientific information to describe EFH in text and tables that provide information on the biological requirements for each life stage (egg, larvae, juvenile, adult) of all MUS. Careful judgement was used in determining the extent of the essential fish habitat that should be designated to ensure that sufficient habitat in good condition is available to maintain a sustainable fishery and the managed species' contribution to a healthy ecosystem.. Because there are large gaps in scientific knowledge about the life histories and habitat requirements of many Coral Reef Ecosystem MUS in the western Pacific region, the Council adopted a precautionary approach in designating EFH and endorses the designation of EFH for all Coral Reef Ecosystem MUS as 0-50 fathoms and to the extent of the EEZ. This broad designation of EFH ensure that enough habitat is protected to sustain managed species.

In addition to the narratives, the distribution and geographic limits of EFH for Coral Reef FMP MUS in general are presented in the forms of maps. The Council incorporated these data into a geographic information system to facilitate analysis and presentation. More detailed and informative maps will be produced as more complete information about population responses to habitat characteristics (e.g., growth, survival or reproductive rates) becomes available.

The Western Pacific Region comprises a range of marine ecosystems used as habitat by coral reef organisms. Protection of habitat is an essential component of a management regime for coral reef ecosystems. Numerous studies have shown that habitat is fundamental to the health and survival of coral reef species. At the same time, very little data is available to adequately document the extent of these habitats, to identify those that may be particularly critical to various life phases of significant commercial and recreational species, or to best locate marine reserves.

Geomorphic Table

	AS	CNMI	Guam	HI	Other
Estuaries	x			x	
Fringing Reefs	x	x	x	x	x
Atolls	x			x	x
Barrier/Lagoon	x	x	x	x	
Non-structural Reef	x	x	x	x	
Banks and Shoals	x	x	x	x	x
Seagrass Beds		x		x	x
Mangroves	x	x		x	x
Pelagic/Open Ocean	x	x	x	x	x
Deep Slope Terraces	x	x	x	x	x
Patch Reefs	x	x		x	x

Reef Communities/ Apron Reefs	x	x		x	x

EFH Designation for MUS

Due to the large gaps in scientific knowledge about the life histories and habitat requirements of many coral reef ecosystem species, the Council has adopted a precautionary approach in designating EFH. Several alternative approaches for EFH designation were considered, including (1) no action/status quo; (2); species by species; (3) family by family; (4) habitat/behavioral group; (5) reef obligate species/ reef associated species; (6) designate MUS at a higher taxonomic order; (7) representative species; (8) indicator species; (9) habitat composites; and (10) designate EFH for the sessile benthos (MUS) as the Coral Reef Ecosystem EFH and associated species.

The Council endorses an approach to designating EFH similar to one previously used by the South Atlantic and Pacific Fishery Management Councils. MUS are linked to specific habitat "composites" (*i.e.*, sand, live coral, seagrass beds, mangrove, etc.) for each life history stage, consistent with the depth of the ecosystem to 50 fathoms and to the limit of the EEZ. The proposed EFH may also protect the habitats of species managed under other FMPs in the Western Pacific.

Except for several of the major coral reef associated species, very little is known about the life histories, habitat utilization patterns, food habits or spawning behavior of most coral reef associated species. For this reason, the Council has used a two-tiered approach in designating EFH consistent with the use of habitat composites.

Currently Harvested MUS

EFH has been identified for species which are (1) currently being harvested in federal waters or (2) likely to be harvested in the near future. Species of particular concern are designated as harvested MUS.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for species assemblages pursuant to Section 600.815 (2)(ii)(E) of 62 FR 66552. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. These species complexes are grouped by the known depth distributions of individual MUS. For a broader description of the life history and habitat utilization patterns of individual Harvested MUS, see Volume III.

Potentially Harvested MUS

Based on the level 1 guideline, EFH has been designated for potentially harvested MUS. These taxa include literally thousands of species that encompasses virtually the entire range of coral reef fauna and flora. There is very little scientific knowledge about the life histories and habitat requirements of the thousands of species of organisms that comprise these taxa. In fact, a large percentage of these biota have not been described by science. Therefore, the Council has adopted a precautionary approach in designating EFH to ensure that enough habitat is protected to sustain managed species.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for species assemblages pursuant to Section 600.815 (2)(ii)(E) of 62 FR 66552. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. These species complexes are grouped by the known depth distributions of individual MUS. For a broader description of the life history and habitat utilization patterns of Potentially Harvested MUS, see Volume III.

The following table summarizes the habitat types utilized by the individual species that comprise the higher taxonomic orders that have been designated as Coral Reef Ecosystem MUS. Based upon this analysis the Council has designated EFH for the both Harvested and Potentially Harvested MUS as all habitat composites occupied by the MUS to the extent of the coral reef ecosystem as defined in the FMP (0-50 fm). However due to the lack of available data on distribution, habitat-related densities or relative abundance for the Coral Reef Ecosystem MUS, more informative tables identifying EFH for each life history stage will be produced as more complete information becomes available.

Occurrence of Currently Harvested Management Unit Species

Mangrove (Ma)	Egg (E)
Lagoon (La)	Larvae (L)
Estuarine (Es)	Juvenile (J)
Seagrass Beds (SB)	Adult (A)
Soft substrate (Ss)	Spawners (S)
Coral Reef/Hard Substrate (Cr/Hr)	
Patch Reefs (Pr)	
Surge Zone (Sz)	
Deep-slope Terraces (DST)	
Pelagic/Open Ocean (Pe)	

Management Unit Species (MUS)	**Ma**	**La**	**Es**	**SB**	**Ss**	**Cr/Hs**	**Pr**	**Sz**	**DST**	**Pe**
Acanthuridae spp. (surgeonfishes) Yelloweyed surgeonfish (*Ctenochaetus strigosus*) Orangespot surgeonfish (*Acanthurus olivaceus*) Yellowfin surgeonfish (*Acanthurus xanthopterus*) Convict tang (*Acanthurus triostegus*) Eye striped surgeon fish (*Acanthurus dussumieri*)	J	A, J, S	A, J, S	J	A, J, S	A, J, S	A, J, S		A, J	E, L
Unicornfish (*Naso spp.*)	J	A, J, S	J		A, S	A, J, S	A, J, S		A, S	All
Balistidae (Trigger Fish) Triggerfish (*Xyrichthys pavo*)	J	A, J, S	J	J		A, J, S	A, J, S	A	A, S	E, L
Carcharhinidae Gray Reef Shark (*Carcharhynus amblyrhynchos*;)	A, J	A, J	A, J	J	A, J	A, J	A, J		A, J	A, J
Holocentridae (soldierfish/squirrelfish) Soldierfish (*Myripristis spp*.)		A, J, S	A, J, S	J		A, J, S	A, J, S		A, S	E, L
Kuhliidae (flagtails) Hawaiian Flag-tail (*Kuhlia sandvicensis*)	A, J	A, J	A, J	A, J				A		E, L
Kyphosidae (rudderfishes) Rudderfish (*Kyphosus spp*)	J	A, J, S	A, J, S		A, J	A, J, S	A, J, S	A, J		All
Labridae (wrasses) Saddleback hogfish (*Bodianus bilunulatus*) (*Xyricthys* spp.)		J	J	J	A, J, S	A, J, S	A, J, S		A, J, S	E, L

Management Unit Species (MUS)	**Ma**	**La**	**Es**	**SB**	**Ss**	**Cr/Hs**	**Pr**	**Sz**	**DST**	**Pe**
Napoleon wrasse (*Cheilinus undulatus*)	J	J		J		A, J, S	A, J, S		A, S	E, L
Lethrinidae (emperors) Smalltooth emperor (*Lethrinus microdon*)	J	A, J, S	J	J	A, J, S	A, J, S	A, J, S		A, S	E, L
Mullidae (goatfish) Goatfish (*Mulloidichthys spp.*) Striped mullet *(Mugil cephalus*) Yellowfin goatfish (*Mulloidichthys vanicolensis*) Goatfish (*Parupeneus porphyreus*) -Ku-mu Multi-barred goatfish (*Parupeneus multifaciatus*)		A, J	A	A, J	A, J	A, J	A, J			E, L
Octopodidae (octopuses) *Octopus cyanea* *O. ornatus*	A, J, S	All	A, J, S	All	All	All	All		All	L
Polynemidae (threadfins) Threadfin (*Polydactylus sexfilis*) – Moi	A, J	A, J, S	A, J, S		A, J, S			A, J		E, L
Priacanthidae (bigeyes) Bigeye (*Priacanthus spp.*)						A, J	A, J		A, J	E, L
Scaridae (parrotfishes) Parrotfishes (*Scarid spp.*)	J	A, J, S		A, J		A, J, S	A, J, S			E, L
Bumphead parrotfish (*Bolbometopon muricatum*)	J	J		J		A, J, S	A, J, S		A, J	E, L
Serranidae (groupers) *Cephalopholis spp*. *Epinephelus spp.*	J	A, J		J	A, J, S	A, J, S	A J, S		A, S	E, L

Management Unit Species (MUS)	Ma	La	Es	SB	Ss	Cr/Hs	Pr	Sz	DST	Pe
Sphyraenidae (barracudas) Barracuda (*Sphyraena helleri*)	A, J	A, J, S	A, J, S	J		A, J, S	A, J, S		A, S	All
Aquarium Taxa/Species										
Acanthuridae (surgeonfishes) Yellow tang (*Zebrasoma flavescens*) Yellow-eyed surgeonfish (*Ctenochaetus strigosus*) Achilles tang (*Acanthurus achilles*)	J	A, J, S	A, J, S	J	A, J, S	A, J, S	A, J, S		A, J	E, L
Zanclidae Moorish Idol (*Zanclus cornutus*)	J	A, J, S	J	J		A, J, S	A, J, S			E, L
Pomacanthidae (angelfishes) Masked angel (*Genicanthus personatus*) *Centropyge shepardi* *C. flavissimus*		A, J				A, J	A, J	A	J	E, L
Muraenidae Dragon moray (*Enchelycore pardalis*,)	A, J, S	A, J, S	A, J, S	A, J	A, J, S	A, J, S	A, J, S	A	A, J, S	E, L
Cirrhitidae (hawkfishes) Longnose hawkfish (*Oxycirrhites typus*) Flame hawkfish (*Neocirrhitus armatus*)		A, J, S				A, J, S	A, J, S	A	A, J, S	All
Chaetodontidae (butterflyfishes) Threadfin butterflyfish (*Chaetodon auriga*) Raccoon butterflyfish (*Chaetodon lunula*) Black-backed butterflyfish (*Chaetodon melannotus*) Saddled butterflyfish (*Chaetodon ephippium*)		A, J				A, J	A, J			E, L

Management Unit Species (MUS)	Ma	La	Es	SB	Ss	Cr/Hs	Pr	Sz	DST	Pe
Pomacentridae (damselfishes) Blue-green chromis (*Chromis viridis*) Humbug dascyllus (*Dascyllus aruanus*) Threespot dascyllus (*Dascyllus trimaculatus*)		A, J				A, J	A, J	A	A, J	E, L
Scorpaenidae (turkeyfishes) Hawaiian turkeyfish (*Pterois sphex*)	J	A, J, S	J	J		A, J, S	A, J, S	A	A, J, S	E, L
Sabellidae (feather-duster worms)	A, J, S	A, J, S	A, J, S		A, J, S	A, J, S	A, J, S	A	A, J, S	E, L

Summary of EFH Designations for Harvested MUS

Species Complex	EFH (Egg and larvae)	EFH (Adult and Juvenile)
Acanthuridae	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.	All bottom habitat and the adjacent water column from 0 to 50 fm.
Balistidae	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.	All bottom habitat and the adjacent water column from 0 to 50 fm.
Gray Reef Shark	N/A	All bottom habitat and the adjacent water column from 0 to 50 fm to the outer extent of the EEZ.
Holocentridae	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.	All rocky and coral areas and the adjacent water column from 0 to 50 fm.
Kuhliidae	The water column from the shoreline to the outer limits of the EEZ to a depth of 50 fm.	All bottom habitat and the adjacent water column from 0 to 25 fm.

Species Complex	EFH (Egg and larvae)	EFH (Adult and Juvenile)
Kyphosidae	Egg, Larvae and Juvenile: the water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.	All rocky and coral bottom habitat and the adjacent water column from 0 to 15 fm.
Labridae	The water column and all bottom habitat extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.	
Lethrinidae	The water column 0-50 fm from the shoreline to the limits of the EEZ.	All bottom habitat and the adjacent water column from 0 to 50 fm.
Mullidae	The water column extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.	All rocky/coral and sand-bottom habitat and adjacent water column from 0 to 50 fm.
Mugilidae	The water column from the shoreline to the outer limits of the EEZ to a depth of 50 fm.	All sand and mud bottoms and the adjacent water column from 0 to 25 fm.
Octopodidae	Larvae: The water column from the shoreline to the outer limits of the EEZ to a depth of 50 fm.	EFH for the adult, juvenile phase and demersal eggs is defined as all coral, rocky and sand-bottom areas from 0 to 50 fm.
Polynemidae	The water column extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.	All rocky/coral and sand-bottom habitat and the adjacent water column from 0 to 50 fm.
Priacanthidae	The water column extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.	All rocky/coral and sand-bottom habitat and the adjacent water column from 0 to 50 fm.
Scaridae	The water column from the shoreline to the outer limit of the EEZ to a depth of 50 fm.	All bottom habitat and the adjacent water column from 0 to 50 fm
Serranidae	The water column from the shoreline to the outer limit of the EEZ to a depth of 50 fm.	All bottom habitat and the adjacent water column from 0 to 50 fm

Species Complex	EFH (Egg and larvae)	EFH (Adult and Juvenile)
Sphyraenidae	EFH for all life stages in the Sphyraenidae is designated as the water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.	
Aquarium Species/Taxa	All waters from 0-50 fm from the shoreline to the limits of the EEZ.	All coral, rubble, or other hard-bottom features and the adjacent water column from 0-50 fm.

Occurrence of Potentially Harvested Management Unit Species

Mangrove (Ma)
Lagoon (La)
Estuarine (Es)
Seagrass Beds (SB)
Soft substrate (Ss)
Coral Reef/Hard Substrate (Cr/Hr)
Patch Reefs (Pr)
Deep-slope Terraces (DST)
Pelagic/Open Ocean (Pe)

Egg (E)
Larvae (L)
Juvenile (J)
Adult (A)
Spawners (S)

Management Unit Species/Taxa	**Ma**	**La**	**Es**	**SB**	**Ss**	**Cr/Hs**	**Pr**	**DST**	**Pe**
Labridae spp. (wrasses)	J	A, J, E	J	J	A, J	A, J, S	A, J, S	A, J	E, L
Kuhliidae	A, J	A, J	All	A, J		A, S	A, S		E, L
Carcharhinidae*, Sphyrnidae*, *Triaenodon obesus* (sharks)	A, J	A, J	A, J		A, J	A, J	A, J	A, J	A, J
Dasyatididae, Myliobatidae, Mobulidae (rays)	A, J	A, J	A, J		A, J	A, J	A, J	A, J	A, J
Serranidae spp.* (groupers)	J	A, J		J	A, J, S	A, J, S	A J, S	A, S	E, L
Carangidae* (jacks/trevallies), except those managed under BFMP	A, J, S	A, J, S	A, J, S	J	A, J, S	A, J, S	A, J, S	A, J, S	All
Decapterus/Selar spp. (scads)		A, S	A, J, S			A, S	A, S	A, J, S	All
Holocentridae spp. (soldierfish/squirrelfish)		A, J, S	A, J, S	J		A, J, S	A, J, S	A, S	E, L
Scaridae	J	A, J, S		A, J		A, J, S	A, J, S		E, L
Bumphead parrotfish (*Bolbometopon muricatum*)	J	J		J		A, J, S	A, J, S		E, L

Management Unit Species/Taxa	Ma	La	Es	SB	Ss	Cr/Hs	Pr	DST	Pe
Mullidae spp. (goatfish)	A, J, S	A, J, S	A, J, S	A, J	A, J, S	A, J, S	A, J, S	A, J	E, L
Acanthuridae spp. (surgeonfish/unicornfish)	J	A, J, S	A, J, S	J	A, J, S	A, J, S	A, J, S	A, J	E, L
Lethrinidae spp. (emperors), except those managed under BFMP *	J	A, J, S	J	J	A, J, S	A, J, S	A, J, S	A, S	E, L
Muraenidae, Chlopsidae, Congridae, Moringuidae, Ophichthidae (eels)	A, J, S	A, J, S	A, J, S	A, J	A, J, S	A, J, S	A, J, S	A, J, S	E, L
Apogonidae (cardinalfish)	A, J, S	A, J, S	A, J, S	A, J, S		A, J, S	A, J, S	A, J, S	E, L
Zanclidae spp. (moorish idols)		A, J				A, J	A, J		E, L
Chaetodontidae spp. (butterflyfish)	J	A, J, S	J	J		A, J, S	A, J, S	A, S	E, L
Pomacanthidae spp. (angelfish)	J	A, J, S	J	J		A, J, S	A, J, S	A, S	E, L
Pomacentridae spp. (damselfish)	J	A, J, S	J	J		A, J, S	A, J, S	A, S	E, L
Scorpaenidae (scorpionfish)	J	A, J, S	A, J, S	J		A, J, S	A, J, S		E, L
Blenniidae (blennies)		A, J, S	A, J, S		A, J, S	A, J, S	A, J, S	A, J, S	E, L
Ephippidae (batfish)	J	A, J, S	J		A, S	A, J, S	A, J, S	A, S	All
Monodactylidae (mono)	A, J, S	A, J, S	A, J, S			A, J, S	A, J, S		E, L
Haemulidae (sweetlips)	J	A, J, S	A, J, S	J		A, J, S	A, J, S		E, L
Echineididae (remoras)						A, J, S	A, J, S	A, J, S	E, L
Malacanthidae (tilefish)		A, J, S			A, J, S	A, J, S	A, J, S		E, L
Acanthoclinidae (spiny basslets)						A, J		A, J	E, L
Pseudochromidae (dottybacks)	J	J		J		A, J, S	A, J, S		E, L
Plesiopidae (prettyfins)	J	A, J, S				A, J, S	A, J, S		E, L

Management Unit Species/Taxa	**Ma**	**La**	**Es**	**SB**	**Ss**	**Cr/Hs**	**Pr**	**DST**	**Pe**
Tetrarogidae (waspfish)	J	A, J, S				A, J, S	A, J, S		E, L
Caracanthidae (coral crouchers)						A, J, S	A, J, S		E, L
Grammistidae (soapfish)						A, J, S	A, J, S		E, L
Aulostomus chinensis (trumpetfish)	J	A, J, S		A, J	A	A, J, S	A, J, S		E, L
Fistularia commersoni (coronetfish)	J	A, J, S		A, J		A, J, S	A, J, S		E, L
Anomalopidae (flashlightfish)						J	J	A, J, S	E, L
Clupeidae (herrings)	A, J, S	A, J, S	A, J, S			A, J, S	A, J, S	A, S	All
Engraulidae (anchovies)	A, J, S	A, J, S	A, J, S			A, J, S	A, J, S	A, S	All
Gobiidae (gobies)	All	All	All	All	All	All	All	All	All
Lutjanids, except those managed under BFMP*	A, J, S	A, J, S	A, J, S	J		A, J, S	A, J, S	A, S	E, L
Ballistidae/Monocanthidae spp.	J	A, J, S	J	J		A, J, S	A, J, S	A, S	L
Siganidae	A, J, S	A, J, S	A, J, S	J		A, J, S	A, J, S		E, L
Kyphosidae	J	A, J, S	A, J, S			A, J, S	A, J, S		All
Caesionidae	J	A, J, S			A, S	A, J, S	A, J, S	A, S	All
Cirrhitidae		A, J, S				A, J, S	A, J, S	A, J, S	All
Antennariidae (frogfishes)		All		All		All	All		L
Syngnathidae (pipefishes/seahorses)	All	All		All		All	All		L
Sphyraenidae spp. (barracudas)	A, J	A, J, S	A, J, S	J		A, J, S	A, J, S	A, S	All
Priacanthidae	J	A, J, S	J			A, J, S	A, J, S	A, S	E, L

Management Unit Species/Taxa	Ma	La	Es	SB	Ss	Cr/Hs	Pr	DST	Pe
Stony corals		A, J, S	A, J, S			A, J, S	A, J, S	A, J, S	E, L
Heliopora (blue)		A, J, S	A, J, S			A, J, S	A, J, S	A, J, S	E, L
Tubiphora (organpipe)						A J	A, J		
Azooxanthellates (non-reefbuilders)		A, J, S	A, J, S		A, J, S	A, J, S	A, J, S	A, J, S	E, L
Fungiidae (mushroom corals)		A, J, S	A, J, S			A, J, S	A, J, S	A, J, S	E, L
Sm/Lg Polyped Corals (endemic spp.)		A, J				A, J	A, J	A, J	
Millepora (firecorals)		A, J, S				A, J, S	A, J, S	A, J, S	E, L
Soft corals and Gorgonians		A, J, S			A, J, S	A, J, S	A, J, S	A, J, S	E, L
Anemones (non-epifaunal)	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	E, L
Zooanthids	A, J, S	A, J, S	A, J, S		A, J, S	A, J, S	A, J, S	A, J, S	E, L
Sponges	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	E, L
Hydrozoans	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	E, L
Stylasteridae (lace corals)	A, J, S	A, J, S	A, J, S			A, J, S	A, J, S	A, J, S	E, L
Solanderidae (hydroid fans)	A, J, S	A, J, S	A, J, S			A, J, S	A, J, S	A, J, S	E, L
Bryozoans	A, J, S	A, J, S	A, J, S	A, J		A, J, S	A, J, S	A, J, S	E, L
Tunicates (solitary/colonial)	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	E, L
Feather duster worm (Sabellidae)	A, J, S	A, J, S	A, J, S		A, J, S	A, J, S	A, J, S	A, J, S	E, L
Echinoderms (e.g., sea cucumbers, sea urchins)	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	E, L
Mollusca	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	E, L

Management Unit Species/Taxa	**Ma**	**La**	**Es**	**SB**	**Ss**	**Cr/Hs**	**Pr**	**DST**	**Pe**
Sea Snails (gastropods)	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	E, L
Trochus spp.		A, J, S				A, J, S	A, J, S		E, L
Opistobranchs (sea slugs)	A, J	A, J, S		A, J, S	A, J, S	A, J, S	A, J, S	A, J	E, L
Pinctada margaritifera (black lipped pearl oyster)	A, J	A, J, S				A, J, S	A, J, S	A, J, S	E, L
Tridacnidae		A, J, S			A, J, S	A, J, S	A, J, S		E, L
Other Bivalves	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	E, L
Cephalopods		All	A, J, S	All	All	All	All	All	E, L
Octopodidae	A, J, S	All	A, J, S	All	All	All	All	All	L
Crustaceans*	A, J	All	A, J	A, J	A, J	All	All	All	L
Lobsters		All			A, J	All	All	All	L
Shrimp/Mantis		All	A, J	A, J	A, J	All	All	All	L
Crabs	A, J	All	A, J	A, J	A, J	All	All	All	L
Annelids	A, J, S	A J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	A, J, S	E, L
Algae	All	All	All	All	All	All	All	All	
Live rock		A, J	A, J			A, J, A	A, J, A	A J, A	E, L

6.2 Habitat Area of Particular Concern

In addition to EFH, the Council also identified potential areas for designation as habitat areas of particular concern (HPAC). HAPCs are those areas that are essential to the life cycle of important coral reef species. In determining whether a type or area of EFH should be designated as a HAPC, one or more of the following criteria must be met: (1) ecological function provided by the habitat is important; (2) habitat is sensitive to human-induced environmental degradation; (3) development activities are, or will be, stressing the habitat type; or (4) the habitat type is rare. Although an area meets one of the HAPC criteria, does not mean that it must be designated an HAPC.

The Council, in consultation with its Coral Reef Ecosystem Plan team and NMFS PIAO staff, refined HAPC designation for the Coral Reef Ecosystem under its jurisdiction. All of the following areas identified as HAPC under this FMP have met at least one of the criteria listed above however, a great deal of life history work needs to be done in order to adequately identify HAPCs.

The Following Areas Have Been Identified as HAPC under the CRE FMP:

Northwestern Hawaiian Islands	All substrate less than 10 fathom All substrate 0-50 fm at French Frigate Shoals All substrate 0-50 fm at Laysan All substrate 0-50 fm at Midway
Main Hawaiian Islands	
Kaula Rock	Entire Bank
Niihau	Lehua
Kauai	Kaliu Point

Oahu	• Hanauma Bay (MLCD)
	• Pupukea (MLCD)
	• Makapuu Head/Tide Pool Reef Area
	• Kanehoe Bay
	• Sharks Cove (MLCD)
	• Kaena Point
	• Kahe Reef
	• Waikiki (MLCD) - Diamond Head
	• Offshore Islets, Windward side
	    • Mokumanu
	    • Mokulua Islands
	    • Manana Island
	    • Kaohikapu

Molokai	• South Shore Reefs

Lanai	• Halope Bay • Manele Bay • Five Needles
Maui	• Molokini • Oalowalo Reef Area • Honolua-Mokuleia Bay (MLCD) • Ahihi Kinau Natural Area Reserve
Hawaii	• Lapakahi State Park (MLCD) • Puako Bay and Reef (MLCD) • Kealakekua • Lapakahi Bay (MLCD) • Waialea Bay (MLCD) • Kawaihae Harbor-Old Kona Airport (MLCD)
Additional	• All long-term research sites • All CRAMP sites
American Samoa	• Fagatele Bay • Larsen Bay • Steps Point • National Park of American Samoa, Pago Pago (North Coast Tutuila) • Aunuu Island • Rose Atoll • South coast Ofu, (underwater portion of the national park) • Aua Transect – Pago Pago harbor, oldest coral reef transect • Tau Island
Guam	• Cocos Lagoon • Orote Point Ecological Reserve Area • Haputo Point Ecological Reserve Area • Ritidian Point • Jade Shoals
Northern Mariana Islands	
Saipan	• Saipan Lagoon

US Pacific Remote Islands	• Wake Atoll • Johnston Atoll • Palmyra Atoll • Kingman Reef • Howland Island • Baker Island • Jarvis Island

The Following Is a List of Potential Areas Within the Council's Jurisdiction That Meet the Criteria for Designation as HAPC Used by the Council to Identify HAPC

	Rarity	Ecological Function	Susceptibility to Human Impacts	Likelihood of developmental Impacts
Guam				
Offshore banks and nearshore fringing reef	x	x	x	x
Cocos Lagoon	x	x	x	x
Mangrove areas	x	x	x	x
Brackish waters (rivers/streams)	x	x	x	x
Apra Harbor, including Arote area	x	x	x	x
Merizo Lagoon	x	x	x	x
Western Shoals	x		x	x
North coast		x		
Southwest coast	x	x	x	x
American Samoa				
Offshore banks	x	x	x	x
Nearshore fringing reefs	x	x	x	x
Leone Lagoon	x	x	x	x
Pala Lagoon	x	x	x	x
South Tutuila		x	x	x
Nafanua and Tiema	x	x	x	
South Aunuu	x	x		
Southwest Ofu	x	x	x	x

	Rarity	Ecological Function	Susceptibility to Human Impacts	Likelihood of developmental Impacts
West Olosega	x	x		
Rose Atoll	x	x	x	x
Swain's Atoll	x	x	x	x
North Ta`u	x	x		
CNMI				
Marpi Reef		x	x	x
Farallon de Medinilla		x	x	x
Tourist Reef		x	x	x
Saipan Lagoon	x	x	x	x
Saipan nearshore reefs		x	x	x
Tinian nearshore reefs		x	x	x
Rota nearshore reefs		x	x	x
Offshore banks	x	x	x	x
NWHI				
French Frigate Shoals	x	x	x	x
Laysan	x	x		
Lisianski (Neves Shoals)	x	x	x	x
Pearl and Hermes	x	x		x
Maro Reef	x	x		x
Midway	x	x	x	
Kure	x	x	x	x
Submerged banks and shoals	x	x	x	x
Main Hawaiian Islands				
Niihau (west coast, Lehua)	x	x		
Kaula Rock (5-fathom pinnacle)	x	x	x	x
Hawaii (west coast)	x	x	x	x
Kahoolawe (whole island)	x	x		

	Rarity	Ecological Function	Susceptibility to Human Impacts	Likelihood of developmental Impacts
Maui (south and west coast) and Molokini islet		x	x	x
Molokai (south coast)	x	x	x	x
Lanai (NW coast and south coast)	x	x		
Oahu (entire island and associated islets)	x	x	x	x
Kauai (north and south coasts; Lehua islet)	x	x	x	x
Penguin Banks	x		x	x
Pacific Remote Islands				
Wake Atoll	x	x		
Johnston Atoll	x	x		x
Jarvis Island	x	x		
Palmyra Atoll	x	x	x	
Kingman Reef	x	x	x	
Howland Island	x	x		
Baker Island	x	x		

6.3 Fishing Activities that may adversely affect EFH

The Council is required to act to prevent, mitigate or minimize any adverse effects from fishing if there is evidence that a fishing practice is having an identifiable adverse effect on EFH. Adverse fishing impacts may include physical, chemical or biological alterations of the substrate and loss of, or injury to, benthic organisms, prey species and their habitat and other components of the ecosystem. FMPs must also contain an assessment of the potential adverse effects of all fishing equipment types used in waters described as EFH. This assessment should consider the relative impacts of all fishing equipment types used in EFH on different types of habitat found within EFH.

The predominant fishing gear types—hook-and-line, longline, troll, traps—used in the fisheries managed by the Council cause few fishing-related impacts to the benthic habitat of bottomfish, crustaceans and precious corals. The current management regime prohibits the use of bottom trawls, bottom-set nets, explosives and poisons. The use of non-selective gear to harvest precious corals in the MHI is prohibited. The Council has determined that current management measures to protect fishery habitat are adequate and no additional measures are necessary at this time. However, the Council has identified the following potential sources of fishery-related impacts to benthic habitat that may occur during normal fishing operations:

- Anchor damage from vessels attempting to maintain position over productive fishing habitat.
- Heavy weights and line entanglement occurring during normal hook-and-line fishing operations.
- Lost gear from lobster fishing operations.
- Illegal fishing for precious corals with tangle nets.
- Remotely operated vehicle (ROV) tether damage to precious coral during harvesting operations.

Trash is sometimes discarded by fishing vessels operating in the EEZ and fishing hardware, such as leaders, hooks and weights, are occasionally lost after becoming snagged on the bottom. The Council determined that the effects of this marine debris on habitat are not adverse. However, the Council is concerned that marine debris originating from fishing operations outside the Council's area may have impacts on habitat. The source of this debris and its impacts are being investigated by NMFS. International cooperation will be necessary to find solutions to this broader problem.

Because the habitat of pelagic species is the open-ocean water column and managed fisheries employ variants of hook and line gear, there are no direct impacts to EFH. Lost gear may be a hazard to some species due to entanglement but has no direct effect on habitat. A possible impact would be caused by fisheries that target and deplete key prey species, but currently there is no such fishery.

While the Council has determined that current management measures to protect fishery habitat are adequate, should future research demonstrate a need the Council will act accordingly to protect habitat necessary to maintain a sustainable and productive fishery in the western Pacific Region. For a full assessment of potential adverse impacts to EFH from fishing gear currently used in areas designated as EFH see Volume III.

In modern times, some reefs have been degraded by a range of human activities. Comprehensive lists of human threats to coral reefs in the US Pacific islands are provided by Maragos, et al. (1996), Birkeland (1997), Grigg (1997), Jokiel (1999), Clark and Gulko (1999). In general, reefs closest to human population centers are more heavily used and are in worse condition than those in remote locations (Green, 1997).

Human Threats to Coral Reefs in the US Pacific Islands (after Maragos, et al., 1996; Grigg, 1997; Birkeland 1997; Jokiel, 1999; Clark and Gulko, 1999)

Activity	American Samoa	Guam	Hawaii		CNMI	Remote US island possessions
			MHI	NWHI		
Coastal construction	X	X	X		X	X
Destructive fishing	X		X		X	
Flooding	X	X	X			
Industrial pollution	X				X	
Overuse/over harvesting	X	X	X		X	
Nutrient loading (sewage/eutrophication)	X	X	X		X	
Poaching/depletion of rare species	X				X	X
Soil erosion/sedimentation	X	X			X	
Vessel groundings/oil spills	X	X		X	X	

Military activity		X	X	X	X
Hazardous waste		X		X	
Tourist impacts		X	X		X
Urbanization		X	X		
Thermal pollution			X		
Marine debris			X	X	
Introduced species			X		

It is difficult to generalize about the present condition of coral reefs in the US Pacific islands because of their broad geographic distribution and the lack of long-term monitoring to document environmental and biological baselines. Coral reef conditions and use patterns vary throughout the US Pacific Islands.

A useful distinction is between coral reefs near inhabited islands of American Samoa, CNMI, Guam and the main Hawaiian islands and coral reefs in remote areas (NWHI, remote Pacific island possession, portions of CNMI). Reefs near the inhabited islands are heavily used for small-scale artisanal, recreational and subsistence fisheries and those in Hawaii, Saipan (CNMI) and Guam are also the focus for extensive non-consumptive marine recreation. Numerous fishermen individually deploy limited amounts of gear. Offshore reefs in the FMP management area that are most heavily fished are the more accessible banks in the main Hawaiian Islands (Penguin Bank, Kaula Bank), Guam (southern banks, Rota bank) and the Commonwealth of the Northern Mariana Islands (Esmeralda Bank, Farallon de Medinilla).

The vast majority of the reefs in the CRE-FMP management area are remote and, in some areas, they have protected status. Most of these are believed to be in good condition. Existing fisheries are limited. The major exception is in the NWHI, where there are commercial fisheries for spiny lobster and deep slope bottomfish (Green, 1997). Poaching by foreign fishing fleets is suspected at Guam's southern banks, in the remote US Pacific island possessions and possibly other areas. The targets of poachers are usually high value, often rare or overfished coral reef resources. These activities are already illegal but are difficult to detect.

Summary of coral reef condition in nearshore areas (0-3 nmi from shore) and offshore areas (3-200 nmi from shore) in sub-areas of the US Pacific Islands (after Green, 1997)

Location	**0-3 nmi**	**3-200 nmi**
American Samoa	Poor-Excellent	Good-Excellent
CNMI	Poor-Excellent	Good-Excellent
Guam	Poor-Good	Good-Excellent
Hawaii		
Main Hawaiian Islands	Poor-Good	Good-Excellent

Northwestern Hawaiian Islands	Excellent	Excellent
Remote Islands	Poor-Excellent	Excellent
Overall	**Poor-Excellent**	**Good-Excellent**

6.4 Non-fishing related activities that may adversely affect EFH

Based on the guidelines established by the Secretary under Section 305 (b)(1)(A) of the MSFCMA, the NMFS developed a set of guidelines to assist Councils in implementing the EFH provision of the MSFCMA that included descriptions and identification of essential fish habitat (EFH) in fishery management plans (FMP) and, descriptions of adverse impacts to EFH from non-fishing activities. The Council notes that there are a wide range on non-fishing activities which contribute to EFH degradation throughout the US Pacific Islands and that the CRE-FMP will not able to manage all of these activities.

The Council is required to identify non-fishing activities that have the potential to adversely affect EFH quantity and, for each activity, describe its known potential adverse impacts and the EFH most likely to be adversely affected. The descriptions should explain the mechanisms or processes that may cause the adverse effects and how these may affect habitat function. The Council considered a wide range of non-fishing activities that may threaten important properties of the habitat utilized by managed species and their prey, including dredging, dredge material disposal, mineral exploration, water diversion, aquaculture, wastewater discharge, oil and hazardous substance discharge, construction of fish enhancement structures, coastal development, introduction of exotic species and agricultural practices. A summary of these activities and impacts is provided in a table at the end of this chapter.

6.5 Habitat Conservation and Enhancement Recommendations

The FMP must describe options to avoid, minimize or compensate for the adverse effects to and promote the conservation and enhancement of EFH. Generally, non-water dependent actions should not be located in EFH if such actions may have adverse impacts on EFH. Activities that may result in significant adverse affects on EFH should be avoided where less environmentally harmful alternatives are available. If there are no alternatives, the impacts of these actions should be minimized. Environmentally sound engineering and management practices should be employed for all actions that may adversely affect EFH. Disposal or spillage of any material (dredge material, sludge, industrial waste, or other potentially harmful materials) that would destroy or degrade EFH should be avoided. If avoidance or minimization is not possible, or will not adequately protect EFH, compensatory mitigation to conserve and enhance EFH should be recommended. FMPs may recommend proactive measures to conserve or enhance EFH. When developing proactive measures, Councils may develop a priority ranking of the recommendations to assist federal and state agencies undertaking such measures. FMPs should provide a variety of options to conserve or enhance EFH, which may include, but are not limited to:

Enhancement of Rivers, Streams, and Coastal Areas
Initiation of federal, state or local government planning processes to restore watersheds associated with such rivers, streams or coastal areas may be recommended.

Water Quality and Quantity
This category of options may include use of best land management practices for ensuring compliance with water quality standards at state and federal levels, improved treatment of sewage, proper disposal of waste materials and appropriate in-stream flow to prevent adverse effects to estuarine areas.

Habitat Restoration or Creation
Under appropriate conditions, habitat creation (converting non-EFH to EFH) may be considered as a means of replacing lost or degraded EFH. However, habitat conversion at the expense of other naturally functioning systems must be justified within an ecosystem context.

Background

From a broad perspective, coral reef habitat is the geographic area where coral reef species occur at any time during their life cycles. This area can be described in terms of ecological characteristics, location and time. Ecologically, essential habitat includes waters and substrate that focus distribution (*e.g.*, coral reefs) and other characteristics that are less distinct (*e.g.*, turbidity zones, salinity gradients). Spatially, habitats and their uses may shift over time due to climatic change, human activities and impacts. The type of habitat available, its attributes and its functions are important to species productivity, diversity, health and survival.

The final rule for EFH (Federal Register 62, No. 244 December 19,1997) requires that Management Councils, through FMPs, identify non-fishing impacts to EFH and provide general conservation measures.

Measures

Established policies and procedures of the WPRFMC and NMFS provide the framework for conserving and enhancing EFH. Components of this framework include adverse impact avoidance and minimization; provision of compensatory mitigation whenever the impact is significant and unavoidable; and incorporation of enhancement. New and expanded responsibilities contained in the Magnuson-Stevens Act will be met through appropriate application of these policies and principles. In assessing the potential impacts of proposed projects, the WPRFMC and the NMFS are guided by the following general considerations:

- The extent to which the activity would directly and indirectly affect the occurrence, abundance, health and continued existence of fishery resources;
- The extent to which the potential for cumulative impacts exists;

- The extent to which adverse impacts can be avoided through project modification, alternative site selection or other safeguards;

- The extent to which the activity is water dependent if loss or degradation of EFH is involved; and
- The extent to which mitigation may be used to offset unavoidable loss of habitat functions and values.

The following non-fishing activities have been identified as directly or indirectly affecting the habitat utilized by management unit species: habitat loss and degradation; pollution and contamination; dredging; marine mining; water intake structures; aquaculture; and introduction of exotic species. The following measures are not all inclusive, but are good examples of measures that will aid in minimizing or avoiding adverse effects of these non-fishing activities on EFH.

Habitat Loss and Degradation

1. To the extent possible, fill materials resulting from dredging operations should be placed on an upland site. Fills should not be allowed in areas with subaquatic vegetation, coral reefs or other areas of high productivity.

2. The cumulative impacts of past and current fill operations on EFH should be addressed by federal, state and local resource management and permitting agencies and considered in the permitting process.

3. The disposal of contaminated dredge material should not be allowed in EFH.

4. When reviewing open-water disposal permits for dredged material, state and federal agencies should identify the direct and indirect impacts such projects may have on EFH. When practicable, benthic productivity should be determined by sampling prior to any discharge of fill material. Sampling design should be developed with input from state and federal resource agencies.

5. The areal extent of the disposal site should be minimized. However, in some cases, thin layer disposal may be less deleterious. All non-avoidable impacts should be mitigated.

6. All spoil disposal permits should reference latitude-longitude coordinates of the site so information can be incorporated into GIS systems. Inclusion of aerial photos may also be required to help geo-reference the site and evaluate impacts over time.

7. Further fills in estuaries and bays for development of commercial enterprises should be curtailed.

8. Prior to installation of any piers or docks, the presence or absence of coral reefs and submerged aquatic vegetation should be determined. These areas should be avoided. Benthic productivity should also be determined, and areas with high productivity avoided. Sampling design should be developed with input from state and federal resource agencies.

9. The use of dry stack storage is preferable to wet mooring of boats. If that method is not feasible, construction of piers, docks and marinas should be designed to minimize impacts to the coral reef substrate and subaquatic vegetation.

10. Bioengineering should be used to protect altered shorelines. The alteration of natural, stable shorelines should be avoided.

11. Filling of estuaries and bays for commercial enterprises should be curtailed.

Pollution and Contamination

1. Outfall structures should be placed sufficiently far enough offshore to prevent discharge water from affecting areas designated as EFH. Discharges should be treated using the best available technology, including implementation of up-to-date methodologies for reducing discharges of biocides (*e.g.*, chlorine) and other toxic substances.

2. Benthic productivity should be determined by sampling prior to any construction activity. Areas of high productivity should be avoided to the maximum extent possible. Sampling design should be developed with input from state and federal resource agencies.

3. Mitigation should be provided for the degradation or loss of habitat from placement of the outfall structure and pipeline as well as the treated water plume.

4. Containment equipment and sufficient supplies to combat spills should be on-site at all facilities that handle oil or hazardous substances.

5. Each facility should have a "Spill Contingency Plan," and all employees should be trained in how to respond to a spill.

6. To the maximum extent practicable, storage of oil and hazardous substances should be located in an area that would prevent spills from reaching the aquatic environment.

7. Construction of roads and facilities adjacent to aquatic environs should include a storm-water treatment component that would filter out oils and other petroleum products.

8. The use of pesticides, herbicides and fertilizers in areas that would allow for their entry into the aquatic environment should be avoided.

9. The best land management practices should be used to control topsoil erosion and sedimentation.

Dredging

1. To the maximum extent practicable, dredging should be avoided. Activities that require dredging (such as placement of piers, docks, marinas, etc.) should be sited in deepwater areas or designed in

such a way as to alleviate the need for maintenance dredging. Projects should be permitted only for water-dependent purposes, when no feasible alternatives are available.

2. Dredging in coastal and estuarine waters should be performed during the time frame when MUS and prey species are least likely to be entrained. Dredging should be avoided in areas with submerged aquatic vegetation and coral reefs.

3. All dredging permits should reference latitude-longitude coordinates of the site so information can be incorporated into Geographic Information Systems(GIS). Inclusion of aerial photos may also be required to help geo-reference the site and evaluate impacts over time.

4. Sediments should be tested for contaminants as per Environmental Protection Agency and US Army Corps of Engineers requirements.

5. The cumulative impacts of past and current dredging operations on EFH should be addressed by federal, state and local resource management and permitting agencies and considered in the permitting process.

6. If dredging needs are caused by excessive sedimentation in the watershed, those causes should be identified and appropriate management agencies contacted to assure action is done to curtail those causes.

7. Pipelines and accessory equipment used in conjunction with dredging operations should, to the maximum extent possible, avoid coral reefs, seagrass beds, estuarine habitats and areas of subaquatic vegetation.

Marine Mining

1. Mining in areas identified as coral reef ecosystem should be avoided.
2. Mining in areas of high biological productivity should be avoided.
3. Mitigation should be provided for loss of habitat due to mining.

Water Intake Structures

1. New facilities that rely on surface waters for cooling should not be located in areas where coral reef organisms are concentrated. Discharge points should be located in areas that have low concentrations of living marine resources, or they should incorporate cooling towers that employ sufficient safeguards to ensure against release of blow-down pollutants into the aquatic environment.

2. Intake structures should be designed to prevent entrainment or impingement of MUSlarvae and eggs.

3. Discharge temperatures (both heated and cooled effluent) should not exceed the thermal tolerance of the plant and animal species in the receiving body of water.

4. Mitigation should be provided for the loss of EFH from placement of the intake structure and delivery pipeline.

Aquaculture Facilities

1. Facilities should be located in upland areas as often as possible. Tidally influenced wetlands should not be enclosed or impounded for mariculture purposes. This includes hatchery and grow-out operations. Siting of facilities should also take into account the size of the facility, the presence or absence of submerged aquatic vegetation and coral reef ecosystems, proximity of wild fish stocks, migratory patterns, competing uses, hydrographic conditions and upstream uses. Benthic productivity should be determined by sampling prior to any operations. Areas of high productivity should be avoided to the maximum extent possible. Sampling design should be developed with input from state and federal resource agencies.

2. To the extent practicable, water intakes should be designed to avoid entrainment and impingement of native fauna.

3. Water discharge should be treated to avoid contamination of the receiving water and should be located only in areas having good mixing characteristics.

4. Where cage mariculture operations are undertaken, water depths and circulation patterns should be investigated and should be adequate to preclude the buildup of waste products, excess feed and chemical agents.

5. Non-native, ecologically undesirable species that are reared may pose a risk of escape or accidental release, which could adversely affect the ecological balance of an area. A thorough scientific review and risk assessment should be undertaken before any non-native species are allowed to be introduced.

6. Any net pen structure should have small enough webbing to prevent entanglement by prey species.

7. Mitigation should be provided for the EFH areas impacted by the facility.

Introduction of Exotics

1. Vessels should discharge ballast water far enough out to sea to prevent introduction of non-native species to bays and estuaries.

2. Exotics should not be introduced for aquaculture purposes unless a thorough scientific evaluation and risk assessment are performed (see section on aquaculture).

3. Effluent from public aquaria displays and laboratories and educational institutes using exotic species should be treated prior to discharge.

Summary of Non-Fishing Activities, Impacts and Conservation Measures

Activity	Impacts	Conservation Measures
1. Habitat Loss and Degradation	• Infaunal and bottom-dwelling organisms • Turbidity plumes • Biological availability of toxic substances • Damage to sensitive habitats • Current patterns/ water circulation modification • Loss of habitat function • Contaminant runoff • Sediment runoff • Shoreline stabilization projects	• Place dredge spoils upland if possible; avoid fills in productive areas • Address cumulative impacts • Don't dispose contaminated dredge material in EFH • Identify direct and indirect impacts on EFH • Minimize areal extent of the disposal site • Geo-reference the site • Explore beneficial use of clean dredged material • Avoid shoreline construction in productive areas • Use dry stack storage over wet mooring • Curtail fills in estuaries, wetlands and bays
2. Pollution and Contamination	• Introduction of chemicals • Introduction of animal wastes • Increased sedimentation • Wastewater effluent with high contaminant levels • High nutrient levels down-current of outfalls • Biocides to prevent biofouling • Thermal effects • Turbidity plumes • Affected submerged aquatic vegetation sites • Stormwater runoff • Direct physical contact • Indirect exposure resulting • Cleanup	• Avoid migration of pesticides, herbicides and fertilizers into aquatic environments • Avoid livestock impacts to tidal wetland areas • Avoid areas of high productivity • Mitigate as required for water quality/habitat losses • Treat stormwater and polluted runoff • Maintain on-site containment equipment and supplies • Have on-site "Spill Contingency Plan" • Prevent spills from reaching the aquatic environment.

Activity	Impacts	Conservation Measures
3. Dredging	• Infaunal and bottom-dwelling organisms • Turbidity plumes • Bioavailability of toxic substances • Damage to sensitive habitats • Water circulation modification	• Curtail/minimize dredging activities as practicable • Take actions to prevent impacts to flora/fauna • Geo-reference all dredge sites • Assay contaminants • Reference past/current dredging operations • Curtail sources of excessive sedimentation • Maintain seafloor contours as practicable • Curtail sloughing events • Avoid impacts of accessory equipment • Minimize turbidity • Provide compensatory mitigation
4. Marine Mining	• Resuspension of fine-grained mineral particles • Composition of the substrate altered • Loss of habitat function • Turbidity plumes	• Avoid juvenile bottomfish habitat • Avoid areas of high productivity • Provide mitigation
5. Water Intake Structures	• Entrapment, impingement, and entrainment • Loss of prey species	• Locate facilities away from productive areas • Prevent entrainment or impingement of prey species. • Contain discharge temperatures • Mitigate habitat/fishery losses

Activity	Impacts	Conservation Measures
6. Aquaculture	• Discharge of organic waste from the farms • Impacts to the seafloor below the cages or pens	• Minimize water/habitat quality impacts • Avoid entrainment and impingement losses • Treat and mix water discharges • Preclude waste product buildups • Undertake risk assessment prior to introducing non-native species • Prevent entanglement of prey species. • Mitigate impacts
7. Introduction of Exotic Species	• Habitat alteration • Trophic alteration • Gene pool alteration • Spatial alteration • Introduction of disease	• Take precautions to prevent non-native species introductions by vessels • Undertake risk assessment prior to introducing non-native species for aquacultural purposes • Treat effluents prior to discharge • Avoid livestock grazing in areas with invasive, non-indigenous vegetation

6.6 EFH Research Needs

Additional research is needed to make available sufficient information to support a higher level of description and identification of EFH. Additional research may also be necessary to identify and evaluate actual and potential adverse effects on EFH, including, but not limited to, direct physical alteration; impaired habitat quality/functions; cumulative impacts from fishing; or indirect adverse effects, such as sea level rise, global warming, and climate shifts.

The following scientific data are needed to more effectively address the EFH provisions:

- distribution of early life history stages (eggs and larvae) of MUS by habitat;
- juvenile habitat (including physical, chemical, and biological features that determine suitable juvenile habitat);
- food habits (feeding depth, major prey species, etc.)
- habitat-related densities for all management unit species life history stages;
- habitat utilization patterns for different life history stages and species;
- growth, reproduction, and survival rates for management unit species within habitats;
- inventory of coral reef ecosystem habitats in the EEZ of the Western Pacific Region;
- important spawning sites;
- identification of post-larval settlement habitat;
- establishment of baseline parameters (CPUE) for coral reef ecosystem resources; and
- high resolution mapping of bottom topography, bathymetry, currents, substrate types, algal beds, habitat relief.

The NMFS guidelines suggest that the Council and NMFS periodically review and update the EFH components of FMPs as new data become available. The Council recommends that new information be reviewed, as necessary, during preparation of the annual reports by the CRE Plan Team. Designations of EFH may be changed under the FMP framework processes if information presented in an annual review indicates that modifications are justified.

7.0 SCIENTIFIC DATA AND RESEARCH NEEDS

In response to threats to coral reef ecosystems, President Clinton issued Executive Order 13089 - Coral Reef Protection in June 1998 to direct federal, state, territorial, and commonwealth agencies to identify actions that may affect U.S. coral reef ecosystems and to utilize programs and authorities to protect and enhance the condition of these ecosystems.

Prior to the signing of the executive order, federal, state and territorial government authorities, in collaboration with NGOs and international government authorities, recognized the necessity of preserving coral reef resources. Each region began formulating a plan of action to strengthen coral reef resource management in response and with support from the US Coral Reef Initiative. These plans focus on the collection of baseline assessments and identifying problems and areas of concern.

The following tables summarize the variety of coral reef projects ongoing or proposed around the Pacific Ocean. The Council supports these research initiatives, as much of the information gained from these projects will complement the Council's research initiatives proposed in the Section. While the extent of possible research on coral reef ecosystems is tremendous, the Council and its advisory bodies focused on research questions directly related to ecosystem management needs and issues which cut across the various FMPs.

Ongoing Coral Reef Initiatives

	monitor	fishing impacts	management	MPAs	Protected species	education	mapping	debris	fisheries research	other	socio-economic	land pollution
National Marine Fisheries Service	Rapid and long term assessments, with ships, satellites, buoys in NWHI, PRIA	habitat and trophic linkages	work with Council and Coral Reef Ecosystem Fishery Management Plan	effectiveness and EFH	seal and turtle studies	marine debris	reef habitat and oceanographic properties	remove, assess, identify source and impacts	biology and ecology of coral reef fish	determine indicator taxa for quick assessment	small boat survey	
US Fish & Wildlife Service	reef fish stock assessments, seabirds in NWHI		review refuge & ecol. services programs		seal trophic study, green sea turtle, dolphin			monitor and removal at Tern	Ulua tagging	alien species control eradication		PCBs and asbestos on Tern Island
ICRI	seeks to develop, coordinate and implement policy, coastal and marine management, law enforcement and education programs in collaboration with governments and other organizations for the protection of coral reefs. Int. Coral Reef Initiative will also produce an annual report evaluating the health, status and success of implemented programs.											
Global Coral Reef Monitoring Network	tourist monitoring program, rapid assessments		strengthen institutional linkages			produce annual reports					link regional soc-econ-cultural organiz.	
Great Barrier Reef Marine Park Authority	assess natural variability		advise marine park managers			increase info. dissemin-ation						
James Cook University	resource assessment			response to fishing pressures					life history, age demo-graphics	coral recruitment	tourism impacts	
South Pacific Commission		analyze fisheries data	advise countries; management of live reef fisheries			training and gear develop			sustainabil-ity of live reef fish fisheries			

Proposed Coral Reef Initiatives

	monitor	fishing impacts	management	MPAs	protected species	education	mapping	debris	alien species	other	socio economic	land pollution
Coral Reef Task Force	national coordination, web-based data system	stop destructive practices	link marine and land practices, foster ecosystem approach to fisheries management	strengthen protection, 20% by 2010		education coordinator, user groups, decision makers	high and low resolution; emphasizes MPAs, change		work with coral reef aquaculture	Create *coral reef disease consortium*, foster international cooperation	user conflict, community-based managemen t	water quality, create partner-ships, control discharge
Management needs and strategies below come from the US Island Coral Reef Initiative, funded by NOAA and DOI, Office of Insular Affairs												
Am. Samoa	reef fish and invertebrate surveys,		revise laws, enhance enforcement	educate public on importance		marine resource ed. center				laws & enforce		water quality assessment
CNMI	bottomfish surveys, standardize protocol			identify areas & collect baseline info		State of the Reef Report				deploy 8 FADs		
Guam	Territorial Seashore Reserve Plan, restore Tumon Bay	gillnet impact on resource				Project Reef Check, Tumon Bay outreach		remove gillnets		coral cultivation, recruitment, reseeding & settlement		runoff in Tumon Bay reef
Hawaii	CRAMP: monitor 30 sites; Rapid Ecol. Assess. in NWHI					community-based education and monitoring	purchase satellite images					

Websites:

NMFS: http://swfsc.ucsd.edu/swfschn.html;
USFWS: http://www.r1.fws.gov/visitor/states.html;
ICRI: http://www.icri.org.uk/
GCRMN: http://coral.aoml.noaa.gov/gcrmn/

GBRMPA: http://www.gbrmpa.gov.au/
James Cook U: http://www.jcu.edu.au/
S. Pac. Comm.: http://www.spc.org.nc/coastfish/
Coral Reef TF: http://coralreef.gov/

Website for all the individual island areas is:
http://www.hawaii.edu/ssri/Is_CRI.html

7.1 Council Recommendations

The coral reef ecosystems covered under this FMP are geographically distinct, with management areas separated by 5,000 miles of Pacific Ocean. Species composition and richness vary widely between regions as do fishing and non-fishing threats to the coral reef.

As this Fishery Management Plan is based on ecosystem principles, the Council has outlined many needs required for the adaptive management strategy set forth in this FMP. The research outlined in the adjacent table emphasizes research based on traditional species-specific management questions. While these projects can be integral in answering ecosystem-related questions, the Council's research recommendations more specifically support ecosystem management.

Specific questions focus on the multi-use nature of coral reefs, the role of the various coral reef habitats, trophic interactions and the effect of fishing, the value and function of MPAs and the individual and synergistic effects that anthropogenic and natural disturbances have on the ecosystem. Research of particular importance includes questions addressing the interactions between fisheries, as the established crustacean, bottomfish and precious coral fisheries all occur to some extent in the coral reef ecosystem. The following recommendations are derived from needs outlined by the Plan Teams for each of the FMPs, the Ecosystem and Habitat and Indigenous Rights Advisory Panels, and the Scientific and Statistical Committee.

Summary of Council-Proposed Research

American Samoa	1.	Examine recovery rates and yields of coral reefs which have been severely damaged and sustained high fishing pressures (Tutuila), with those where fishing pressure is much lower (Manu'a) or entirely absent (Rose atoll MPA).
CNMI/ Guam	2. 3.	Socio-economic and cultural study of the fishing communities with respect to potential resource allocation Various projects addressing the multiple land-based threats to the near-shore coral reef ecosystem
Main Hawaiian Islands	4. 5. 6.	Effect of alien species on ecosystem, speed of dispersion Standardizing of data collection to facilitate use in management Study of historic fisheries data
North West Hawaiian Islands	7. 8. 9. 10.	Protected species Effects of ecotourism Study of deep benthic habitat in relation to ecosystem Interactions between fisheries operating within the coral reef ecosystem
PRIA	11.	Assessments and monitoring as benchmarks for total and species specific biomass, species composition and how habitat structure relates to species density
All Areas	12. 13. 14. 15. 16. 17. 18. 19. 20. 21.	Mapping Rapid ecological assessments, biomass surveys, long-term remote and direct monitoring Education Marine debris Effectiveness of MPAs as management tools Archaeo-ichthyological studies Relationship between habitat and stock abundance Determination of indicator species for rapid assessment of reef's health Relation of natural and anthropogenic stressors Trophic interactions for ecosystem modeling

Region Specific Research Needs

The islands of the Western Pacific region extend in a great arc over the Central and Western Pacific, and including Micronesia and part of Polynesia. The four inhabited archipelagos – Hawaii, Northern Marianas, Guam and American Samoa – all have different geographic, social and economic characteristics which will influence the types of coral reef fisheries research required in each location. Further, large areas of the Western Pacific Region are uninhabited or under military control and therefore off-limits to commercial fishing. Research in these areas may not be primarily driven by fishery related issues but by other concerns, such as protected species interactions in the case of the Northwestern Hawaiian Islands, or as benchmarks for comparison between fished and unfished sites.

American Samoa

American Samoa has a rapidly increasing population, most of which is found on the main large island of Tutuila. The islands population are mainly Polynesians and they are strongly linked through ancestral ties with the people of neighboring (Western) Samoa[1]. Population growth is driven by both new births and the migration of Western Samoans who can get work permits for American Samoa. Wass (1980) documented very high harvests of reef fish and invertebrates from American Samoan reefs in the late 1970's.

However, a combination of natural and anthropogenic effects has had a serious impact on American Samoan reefs, particularly on Tutuila, with the effect of depressing catch rates and the volume of fish produced through reef fishing. These include a crown-of-thorns outbreak in the 1970's which ultimately destroyed 95 % of live coral cover in some locations (Wass 1979), followed by two severe cyclones in 1990 and 1991. The cyclones destroyed most of the coral growth to a depth of 10-15 m, particularly on the north side of the island. This was followed by a mass coral bleaching event in 1994, probably connected with El-Nino. These disturbances, coupled with increasing human impacts such as sedimentation on the reefs, eutrophication of nearshore waters, coastal construction, solid and chemical wastes have resulted in major changes to coral reef habitats and associated reef fish assemblages.

Successive damage to the Tutuila reefs means that American Samoa may be a natural laboratory to look at the behavior and recovery of fish populations in conditions where production has declined through a mix of habitat destruction and high fishing pressure. In response, the commercial fishery has changed its focus over the years from reef fishing to bottom fishing and currently to longline fishing for albacore and other pelagic fish. Consumer demand for reef fish is now being met in large part by exports from Western Samoa. Fishing pressures on reef fish stocks in the less populated Manu'a Islands, to the east of Tutuila, have not changed in the same manner. Fish stocks are not considered over-exploited and traditional coral reef fishing is currently practiced. With the proposed establishment of regional MPAs including Rose atoll, American Samoa offers the potential to examine the recovery rates and yields of coral reefs which have been severely damaged and sustained high fishing pressures, with those where fishing pressure is much lower or entirely absent.

Commonwealth of the Northern Mariana Islands and Guam

High population growth from migrants is a feature of both Guam and the Northern Marianas. Most of the migrants are from East and Southeast Asia and have a strong culture of eating fish and other seafood, and will add to the demand for fishery production from coral reef areas. Small boat fishermen dominate the fishing of the near-shore areas, catching deep and shallow water reef fish and bottomfish species. Due to the proximity to Asia, the potential for a live reef fish fishery exporting to Asia is greatest in this region. Influx of a Southeast Asian population to work in the garment industry with a tradition of eating fish will apply additional pressure to the coral reef

[1] Western Samoa renamed itself Samoa in 1998, despite protest from American Samoa.

resources. Because of this potential increase in fishing pressure, a socio-economic and cultural study of the fishing communities with respect to potential resource allocation has been suggested.

The other major influence on the reefs of the Mariana Archipelago stems from the growth of the tourist industry in both Guam and CNMI. This has led to the landscaping of large areas of the coast for hotels, golf courses, shops and other leisure activities. Construction brings with it the threat of sedimentation and smothering of live corals, while the development of extensive golf courses may have an effect on near shore lagoon waters through eutrophication from fertilizer enriched runoff. Finally, tourists themselves can be detrimental to reefs by adding to the local fishing pressure through spearfishing and charter fishing, removing shells and corals for souvenirs, and habitat destruction by walking on reefs in boots and diving fins and the excessive use in shallow water of jet skis. The latter activity has been blamed for diminishing habitat for rabbitfish which are a popular target species on Guam.

CNMI is also subject to military activity on the island of Farallon De Medinilla (FDM), which is the only northern island in the Mariana chain with substantial coral reefs. FDM is also one of the few potential locations where fisheries can expand in the future. FDM has been used as a target in U.S. military activities for many years with subsequent disturbance to the reef from direct bombing as well as accelerated erosion of the island.

Coral reef fisheries research in this archipelago will need to focus on how to achieve the best balance between tourism and fishing, given that the leisure industry is the single largest industry in both CNMI and Guam. Bombing of FDM may have only a limited direct effect on the coral reef but it removes a large area of coral reef from use by fishermen who must fish more intensively on the remaining reef areas, thereby risking overfishing. Clearly some solution to the FDM question needs to be addressed which can allow fishermen access to this extensive reef area.

Main Hawaiian Islands

Like the Mariana Archipelago, the Main Hawaiian Islands (MHI) reefs are affected by the growing tourist industry in Hawaii, where large parts of the coastline have been landscaped for hotels, golf courses and other leisure activities. Over 6 million people visit Hawaii each year, while the state has a resident population of about 1 million people. However, the Hawaiian Islands are much larger than their Micronesian counterparts and larger areas of the coast are also untouched.

The coral reef resources of the MHI are fished by the largest diversity of fishing gears and fisheries. These include specialist targeting of small reef fish for the aquarium industry, fish trapping, a variety of crustacean trapping, directed fisheries for near shore small pelagic fisheries and the more typical hook and line, gill net, seine net, cast net and spear fishing. Alien species have been introduced into Hawaii through bilge/ballast water, by well-intentioned projects, and through federally supported aquaculture programs. One of most contentious introductions was the blue lined snapper (*Lutjanus kasmira*) which has proliferated throughout the state since its original introduction from French Polynesia. It has been blamed for the subsequent decline of bottomfish species, even though there is no evidence for this. While this is a popular species throughout the Pacific, its unfamiliarity to Hawaii's population means that although common it is not a popular eating fish.

Extensive research has been conducted on Hawaii's reefs but little is known comparatively about reef fisheries in Hawaii. Ironically, large volumes of data are compiled by the State of Hawaii Division of Aquatic Resources on commercial landings and nominal effort of coral reef fisheries by various gear types, with some data extending back to the late 1940s. Further, an important bench mark exists from a detailed survey of fishing in the Hawaiian Islands in the early 1900's. Besides landings and nominal effort, there are also indices of fishing effort contained in other databases such as the Department of Boating and Ocean Recreations (DBOR) small vessel registration records. These data include registration of vessels for commercial fishing and for pleasure, with breakdown by size class and propulsion type. Much of this data remains unanalyzed and its utility for management unrealized. As an example, this type of data was used to generate production models and MSY for bottomfish fisheries in the Main Hawaiian Islands (Ralston & Polovina, 1982).

In summary, the MHI has comparable problems to the Mariana Archipelago with respect to urbanization and the effects of coastal landscaping driven by tourism and population expansion. The size of the MHI and the inaccessibility of some coasts means that there are also extensive areas of the coastline that are free from these anthropogenic influences and allow for comparisons in terms of impacts on coral reef fisheries. Further, there are unresolved questions about the impacts of exotic species on indigenous fauna, particularly the successful proliferation of the blue lined snapper. Lastly, unlike other areas of the western Pacific region, large volumes of data extending over several decades are available on commercial reef fisheries in Hawaii. It should also be noted that there are many different surveys and sampling programs in Hawaii for both commercial and recreational fisheries. All these data sources need to be assessed for what they can offer in terms of generating management information for Hawaii's coral reef fisheries.

Low-use Marine Protected Areas

The northwestern Hawaiian Islands are a special concern nationally as well as regionally. Fishing has occurred in this area for hundreds of years by native peoples as well as foreign fishermen. Very little is known regarding fishing pressures prior to implementation of Council management. The low-use MPA proposed for the NWHI will surround what is currently a *de facto* no-take MPA (out to 10 fathoms) based on current regulations and fishing practices. MPAs have been hypothesized as havens where large, fecund species can repopulate the surrounding reef. It is necessary to study this hypothesis in the presence of regulated fishing pressure. This makes the low-use MPAs of the NWHI an ideal location.

No-take Marine Protected Areas

The Pacific remote island areas of Howland, Baker, Jarvis, Kingman reef and Palmyra atoll are also proposed no-take MPAs locations. These islands have experienced the least fishing pressure of any location under Council jurisdiction. They are also far removed from non-fishing impacts. These islands are the best sites to determine a benchmark for total and species-specific biomass, species composition and how habitat structure relates to species density. Assessments are currently underway for many of these locations, with many coral reef scientists wanting to conduct projects in these near-pristine environments. In order to utilize the research in these areas for fisheries management, the Council recommends that the work be coordinated between scientists so independent data sets can be used in coordination with research being conducted elsewhere working on management questions.

Council Recommendations for Ecosystem-based Research

Each of the topics below has been suggested by one or more of the plan teams and advisory panels involved in the drafting of the Coral Reef Ecosystem FMP. They are the Coral Reef Ecosystem, Bottomfish, Crustacean, Ecosystem and Habitat, Precious Corals Plan Teams and Advisory Panels, the Indigenous People Advisory Panel and the Scientific and Statistical Committee.

Interactions of Other FMP's MUS in the Coral Reef Ecosystem

This FMP proposes close coordination between the plan teams of the Bottomfish, Crustacean and Precious Coral FMPs and the Coral Reef Ecosystem Plan Team. Each of the plan teams recommended research on various associations and interdependencies, thus giving a more integrated picture of the coral reef ecosystem. A greater understanding of these interactions will aid in identifying and addressing issues for resolution between the various FMPs.

Effects of Gear and Marine Debris on Coral Reef Habitat

Marine debris is an important concern, especially in the NWHI. But this debris, with the exception of light sticks, generally comes from North Pacific fisheries not under Council jurisdiction. A multi-agency effort has been active in removing and cataloguing tons of this debris. The Council supports this effort but believes issues regarding gear and debris originating from Western Pacific fisheries is of greater value. The Council has recommended to research gear and debris effects on the deeper benthic environment. Concern has been raised on several occasions regarding the impact lobster traps have on the coral reef habitat, but almost no research has been conducted to date. Tangle nets were used in the late 1980's to harvest precious coral from the NWHI. The effects from this fishing have also never been analyzed. The NWHI omnibus proposal will have a far greater impact on management issues within the Council's jurisdiction, and has been recommended by the crustacean and precious corals plan teams and advisory panels.

Trophic Interactions

Simulation models for coral reef ecosystems (ECOPATH and ECOSIM) have become sophisticated tools which can aid resource managers in predicting cascading effects from changes in the system. While these models can provide valuable insight, they require some basic data on trophic interactions. These models will never be able to include the thousands of species found in the ecosystem simultaneously. Research must first determine appropriate model species to use in a given coral reef ecosystem. This will require an understanding of the trophic interactions between habitat, primary production, and representative species of herbivores, omnivores and top predators.

Role of Habitat in Stock Abundance

Correlations have been observed in a number of environments between habitat and stock abundance. Each of the plan teams for the established fisheries were interested in designing projects which would address specific questions under this heading.

The Bottomfish Plan Team proposed a project on the importance of precious coral habitat and coral reef habitat in the survivability of juvenile BMUS. The Crustacean Plan Team proposed a project to differentiate the habitat qualities of the known lobster banks and how these differences contribute to successful recruitment and survival of lobster. The Precious Coral Plan Team is interested in how recruitment of gold coral is affected by bottom habitat. This question relates directly to questions on the role precious coral habitat has with abundance of bottomfish, eels, octopus and other species which use precious coral as refuge.

The teams have also been put forth more general questions regarding how the percent of live coral affects overall species abundance. The percent of live coral cover varies widely due mainly to land-based activities in populated areas and level of shelter from storm events in remote areas. Percent of live coral cover at shallow depth (< 10 m) can be determined through satellite imagery, which has become very accessible to scientists in recent years. Combining this information with stock assessments could be very useful in determining productivity and sustainable yields.

Effect of MPAs in the Ecosystem and Their Role as Management Tools

Marine protected areas have become a high profile conservation tool over the past decade. The President's initiative to designate 20% of all U.S. coral reefs as MPAs by 2010 emphasizes the belief in their need on a national level. For all of their acceptance as valuable conservation and fishery management tools, very little definitive evidence is available on the effect of MPAs beyond their immediate boundaries. Thus, to best determine in the future the most effective size and locations of MPAs, additional research is needed to make these truely effective management tools.

The NWHI and PRIA have been recommended as MPAs. The PRIA have never had much fishing pressure and relatively little anthropogenic disturbance in the past. Designating the entire coral reef habitat as "no-take" for most of these islands ensures that these sites are preserves and not tools for management. The NWHI, in contrast, has experienced fishing pressures in the past and will continue to experience it in the low-use MPAs. Interactions between the low-use and no-take MPAs under varying oceanographic conditions and fishing pressure along the NWHI archipelago should be examined to better understand what makes MPAs more or less successful in terms of fisheries management and sustainable yield.

Interactions and Individual Effects of Anthropogenic and Natural Stressors

Coral reefs throughout the Pacific are subject to strong seasonal storms with associated high surf and surge. Reefs found near populated areas are subject to land-based stressors and various other human activities. In areas with less shelter from storm, natural events determine the state of the reef. In sheltered areas, which are often near population centers, anthropogenic activities have a greater effect on the reef.

Much research has been carried out assessing the causes, effects and mitigation options in regards to many of the threats to coral reefs. Less research has been conducted to determine the synergistic effects of natural and anthropogenic stresses or combined anthropogenic stresses. In order to focus on the most serious threats to the ecosystem, and to foster interagency cooperation to address these threats, more research of this type is needed.

Determining Indicator Species or Using the Most Commonly Landed Species to Assess Ecosystem Health

Monitoring of coral reefs is an expensive and time-consuming process. The value of intensive monitoring has been questioned by some scientists while deemed vital by others. It is impossible to study every organism in the coral reef ecosystem to determine the state of their health. Thus, as is done in terrestrial and fresh water environments, appropriate indicator species need to be identified in order to extrapolate the health of the ecosystem as a whole. Baseline studies on their population densities, age structure and seasonal variation could then be completed. By accomplishing this goal, intensive monitoring can be reduced and research money will be available to address emerging issues and specific management needs.

Protected Species

Many protected and endangered species rely on the coral reef environment, especially in the northwestern Hawaiian Islands. Specific research programs are in place to study monk seals, sea turtles and seabirds. These are very important programs for the FMP as protected species are a major factor in fisheries regulations. The Council continues to use data derived from these programs and continually puts forth new questions to help address issues in fisheries management.

7.2 Other Research Addressing Ecosystem Management

A great deal of research effort has been expended studying the coral reefs of the Hawaiian islands over the past 100 years. This includes fishery data, reef surveys and monitoring, trophic studies, and a host of other topics. The National Marine Fisheries Service, the Fish and Wildlife Service and the Hawaii Department of Land and Natural Resources undertook a tripartite study of the Northwest Hawaiian Islands in the late 1970's and early 1980's culminating in two symposia in 1980 and 1983. This wide scope of research is a benchmark for future research in the NWHI.

Anthropogenic threats are limited in the NWHI. Land-based activities, which cause the greatest damage to reefs in populated areas, are virtually absent. Threats from fishing activities are also limited due to the limited entry program and other regulatory controls for the two established NWHI fisheries. Seventeen permits for the bottomfish fishery and 15 permits for the crustacean fishery (generally between 5-7 lobster vessels actively fish about 1-2 months a year) are able to fish over a distance of 1100 miles covering 11,554 km^2 of coral reef habitat. The renewed precious coral fishery has yet to venture to the NWHI, but substantial potential for harvest has been identified.

Potential threats from emerging fisheries, marine debris accumulating on the reefs from north Pacific fisheries, and the health of the resident endangered species are the major concerns for the NWHI.

In addition, this FMP is a demonstration plan for the ecosystem approach to fisheries management. The following proposed projects were developed taking into account the abundance of accumulated knowledge, the true threats to the various reefs under the Council's authority, the emerging importance of the ecosystem approach to fisheries management and guided principally by specific management questions for all of the FMPs.

NWHI Omnibus Research Proposal

Project Deep Reef is a two-year study of the deep reef benthic fishery in the Northwestern Hawaiian Islands utilizing Deepworker 2000 submersibles. The goal of the project is to obtain information of deepwater habitats, by conducting habitat and stock assessment for lobsters, bottomfish, precious corals and coral reef ecosystems for the purpose of extending all FMPs to include all resources of the deep reef habitat of the NWHI.

For lobsters, specific projects may deal with:
- Monk seal prey dependency
- Habitat specifics for productive vs. unproductive area comparisons
- Impact of ghost fishing on lobsters
- Impact of lobster traps on coral reef habitats
- Night vs. day behavior and stock density differences
- Characterization of steep wall habitats for lobsters

For bottomfish, specific projects may deal with:
- Characterization of juvenile and adult bottomfish habitats
- Placement of potential reserves

For precious corals, specific projects may deal with:
- Stock assessments for deep banks and pinnacles particularly around Midway
- Impact of past dredging by foreign fleets at 180 Fathom Bank (north of Midway)
- Definition of habitat requirement of monk seals for gold coral and arrowtooth eels

For coral reef ecosystems, specific projects may deal with:
- Depth and range extensions for deep coral reef ecosystems
- Impacts of the other benthic fisheries in the NWHI on coral reef ecosystems
- Designation of "protected areas"to establish marine preserves

Archaeo-ichthyological Research

The archaeological, historical and socio-cultural records from Pacific Islands are being increasingly recognized as important data sources for fishery management. Most fishery biology studies are short term, being conducted over a few years at best, rarely over several decades and represent only snapshots of a fishery in time. The period of study may include years during which conditions in the fishery were extremely favorable, or years when the fishery in a production trough. A good example of this is the NWHI lobster fishery which grew and expanded during a favorable oceanic interdecadal cycle, which produced over-optimistic estimates of fishery production. Landings then fell by an order of magnitude during a subsequent regime shift to a less productive oceanic cycle.

Data from archaeological investigations may cover many centuries rather than a few years and give a much more balanced perspective on resource use and sustainability. Dalzell (1998) has reviewed a number of different archaeological studies which contain insights into coral reef resources use in the Pacific Islands. Excavation of mollusc shell and fish bones allows reconstruction of the species composition of pre-historic fishing and in some instances it is possible to reconstruct size frequencies from the data, and in turn generate life history parameters of exploited fish stocks over many centuries.

Another important aspect of the archaeological and historical record is its potential to reinforce the social and cultural importance of fisheries, and traditional property rights, even though these may have declined through progressive urbanization and European colonization in the Pacific Islands. This has been amply demonstrated in New Zealand (Aotearoa), where the original Polynesian Maori population was economically and socially marginalized following European settlement in the nineteenth century. As a consequence of European settlement, indigenous Maori property concepts and rights with respect to fisheries resources were not recognized and the rights of indigenous fisheries were generally usurped.

However, archaeological studies have also produced evidence of a diverse range of Maori fishing activities exploiting a wide range of fishes and marine mammals, such as seals, including the preservation of large amounts of fish. Indeed in some areas, such as the Muriwhenua region of New Zealand's North Island, fishing became a principal source of nutrition as human populations increased and food from hunting and agriculture became increasingly limited. Such evidence has been successfully used by the Maori people in New Zealand in seeking restoration of the recognition of traditional fisheries property rights, as were guaranteed under the 1840 Treaty of Waitangi (Dalzell 1998).

Johannes (1998) has argued that traditional fishery knowledge and folklore of Pacific Islanders is an invaluable assemblage of observations on the biology and ecology of reef and lagoon fishes. Johannes (1978) published a landmark paper in which he used traditional knowledge of fishermen to illustrate the spawning strategies of reef and lagoon fish in the Pacific Islands. Johannes (1998) has discussed at length the value of traditional knowledge and traditional tenure systems and other customs for the management of Pacific reef and lagoon fisheries. Much of Hawaii's cultural fishing heritage has been lost following contact and colonization, however, Carlos Andreade (pers. comm. to Paul Bartram) has suggested that the songs and chants of the people of Ni'ihau Island may be an important source of traditional knowledge on resource use and abundance in the NWHI in pre-history. In Northern Europe a similar oral knowledge source, the Icelandic Sagas, have been used to establish the long term history of herring and cod fisheries (Beverton 1962).

In summary, conventional scientific studies on reef fisheries are needed to manage the resources. There are also other sources of information from archaeological, historical and socio-cultural sources that can provide inputs for fishery management. Fishery managers in the Western Pacific need to acquaint themselves with these sources and evaluate them for their utility.

Hawaii Coral Reef Initiative

The University of Hawaii, in collaboration with the DLNR Division of Aquatic Resources, have established the Hawaii Coral Reef Initiative Research Program. The primary purpose of the program is to support monitoring and research activities aimed at building capacity to manage Hawaii's coral reef ecosystems. To fulfill its mission, the program works with local, state and federal agencies, as well as private organizations in order to achieve the following goals:

- Assess major threats to coral reef ecosystems and provide information for more effective management
- Advance understanding of biological and physical processes that affect the health of coral reefs
- Develop database and information system to store and access data and results
- Conduct public awareness programs on threats to coral reef ecosystems and
- Implement education and training for coral reef scientists and managers

Specific objectives of the program are to:

- Monitor coral reef health at sites around the main Hawaiian Islands
- Monitor of impacts of aquarium fish harvesting to West Hawaii coral reef
- identify algae and the develop a quantitative sampling method that supports coral reef monitoring
- Develop real-time water quality monitoring of some coral reefs and the impact of runoff, utilizing macro algae as an indicator of pollution
- Develop a rapid assessment method for describing coral reef resources of the NWHI
- Assess the effectiveness of MPAs to conserve fishery resources and the impact of fishing in an management area.

For 1999-2000, the HCRI Research Program will sponsor four projects, including the state wide Coral Reef Assessment and Monitoring Program (CRAMP), which is designed to identify the controlling factors, both natural and anthropogenic, contributing to the overall health and condition of Hawaii's coral reefs. In addition, the HCRI Research Program will provide professional training for DAR staff, broaden public outreach and education efforts, and develop a website to profile management initiatives, research and the ecosystem.

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9.0 APPENDICES

9.1 Glossary and Acronyms

Adaptive Management: A program that adjusts regulations based on changing conditions of the fisheries and stocks.

Bycatch: Any species caught in a fishery, but which are not sold or kept for personal use, and includes economic discards and regulatory discards.

Barrier Net: A small-mesh net used to capture coral reef or coastal pelagic fishes.

Bioprospecting: The search for commercially valuable biochemical and genetic resourcesin plants, animals and microorganisms for use in food production, the development of new drugs and other biotechnology applications.

Bottomfish Fishery Management Plan: Council's FMP for bottomfish and seamount groundfish of the Western Pacific Region

Charter Fishing: Fishing from a vessel carrying a passenger for hire (as defined in section 2101(21a) of Title 46, United States Code) who is engaged in recreation fishing.

Commercial Fishing: Fishing in which the fish harvested, either in whole or in part, are intended to enter commerce or enter commerce through sale, barter or trade. For the purposes of this Fishery Management Plan, commercial fishing includes the commercial extraction of biocompounds.

Consensual Management: Decision making process where stakeholders meet and reach consensus on management options to implement.

Coral Reef: All benthic substrata from 0 to 50 fathoms deep.

Coral Reef Ecosystem (CRE): Those species, interactions, processes, habitats and resources of the water column and substrate located within any waters less than or equal to 50 fathoms in total depth.

Coral Reef Ecosystem Management Unit Species (*CRE MUS or MUS*): an extensive list, many included by family. Includes some management unit species from existing FMPs (bottomfish, crustaceans, precious corals) for which primary management would remain under their current FMPs but ecosystem effects would be addressed via the CRE-FMP.

Coral Reef Resources: The currently or potentially exploitable resources in coral reef ecosystems.

Council: The Western Pacific Regional Fishery Management Council (WPRFMC).

Critical Habitat: Those geographical areas that are essential for bringing an endangered or threatened species to the point where it no longer needs the legal protections of the ESA, and which may require special management considerations or protection (i.e., the critical habitat consists of those areas that must be managed to permit an endangered or threatened species to recover to a level where it is safe, for the foreseeable future, from the danger of extinction)

Currently Harvested Management Unit Species/Coral Reef Taxa: Organisms that are currently harvested from EEZ reef areas (e.g., from catch report records in federal waters) but not covered by existing FMPs.

Dealer: One who buys and sells species in the fisheries management unit without altering their condition.

Depleted Coral Reef Taxa: Species or taxa that is locally in low abundance but not overfished (by definition).

Dip Net: A hand-held net consisting of a mesh bag suspended from a circular, oval, square or rectangular frame attached to a handle. A portion of the bag may be constructed of material, such as clear plastic, other than mesh.

Ecology: The study of interactions between an organism (or organisms) and its (their) environment (biotic and abiotic).

Ecological Integrity: Maintenance of the standing stock of resources at a level that allows the ecosystem processes to continue. Ecosystem processes include replenishment of resources, maintenance of interactions essential for self-perpetuation and, in the case of coral reefs, rates of accretion that are equal to or exceed rates of erosion. Ecological integrity cannot be directly measured but can be inferred from observed changes in coral reef ecology.

Economic Discards: Coral reef resources that are the target of a fishery but which are not retained because they are of an undesirable size, sex or quality or for other economic reasons.

Ecosystem: The interdependence of species and communities with each other and with their non-living environment.

Ecosystem-Based Fishery Management: Fishery management actions aimed at conserving the structure and function of marine ecosystems, in addition to conserving the fishery resource.

Ecotourism: Observing and experiencing, first hand, natural environments and ecosystems in a manner intended to be sensitive to their conservation

Environmental Impact Statement (EIS): A document required under the National Environmental Policy Act, that assesses alternatives and addresses the impact on the environment of a proposed major federal action.

Essential Fish Habitat (EFH): Those waters and substrate necessary to coral reef resources for spawning, breeding, feeding or growth to maturity.

Exclusive Economic Zone (EEZ): The zone established by Proclamation numbered 5030, dated March 10, 1983. For purposes of application, the inner boundary of that zone is a line coterminous with the seaward boundary of each of the coastal states, commonwealths, territories or possessions of the United States.

Existing CRE Fishery: A fishery targeting organisms that are currently harvested from coral reef areas, but not covered by existing FMPs

Exporter: One who sends species in the fishery management unit to other countries for sale, barter or any other form of exchange (also applies for shipment to other states, territories or islands).

Fish: Finfish, mollusks, crustaceans and all other forms of marine animal and plant life other than marine reptiles, marine mammals and birds.

Fishery: One or more stocks of fish that can be treated as a unit for purposes of conservation and management and that are identified on the basis of geographical, scientific, technical, recreational and economic characteristics; and any fishing for such stocks.

Fishery Management Plan (FMP): A plan prepared by a Regional Fishery Management Council or by NMFS (if a Secretarial plan) to manage fisheries and/or their impact(s) on coral reef ecosystems.

Fishery Management Unit Species (MUS): The coral reef resources in the FMP, including fish, corals, certain species associated with live rock, reef-associated invertebrates and plants. The resources included in the MUS of this Plan are listed in Tables 1 and 2.

Fishing: The catching, taking or harvesting of fish; the attempted catching, taking or harvesting of fish; any other activity that can reasonably be expected to result in the catching, taking or harvesting of fish; or any operations at sea in support of, or in preparation for, any activity described in this definition. Such term does not include any scientific research activity that is conducted by a scientific research vessel.

Fishing Community: A community that is substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs and includes fishing vessel owners, operators and crews and United States fish processors that are based in such community. The FMP defines fishing communities as: American Samoa, the Northern Mariana Islands and Guam, and each of the inhabited main Hawaiian Islands.

Food Web: Inter-relationship among species that depend on each other for food (predator-prey pathways).

Framework Measures: Management measure listed in FMP for future consideration. Implementation can occur through an administratively simpler process than a full FMP amendment.

General Permit: Permit, for possible future implementation under framework process, to harvest and report take of coral reef taxa in non-MPA areas, issued upon meeting basic minimum requirements.

Ghost Fishing: The chronic and/or inadvertent capture and/or loss of fish by lost or discarded fishing gear.

Habitat: Living place of an organism or community, characterized by its physical or biotic properties.

Habitat Area of Particular Concern (HAPC): Those areas of EFH identified pursuant to Section 600.815(a)(9). In determining whether a type or area of EFH should be designated as a HAPC, one or more of the following criteria must be met: (1) ecological function provided by the habitat is important; (2) habitat is sensitive to human-induced environmental degradation; (3) development activities are, or will be, stressing the habitat type; or (4) the habitat type is rare.

Hand Harvest: Harvesting by handline.

Harvest: The catching or taking of a marine organism or fishery MUS by any means. Marine organisms or MUS that are caught but immediately returned to the water free alive and undamaged are bycatch.

Hook and line: Fishing gear that consists of one or more hooks attached to one or more lines.

Incidental Catch: Any non-targeted species harvested while fishing for the primary purpose of catching a different species.

Large Fishing Vessels: Fishing vessels greater than or equal to 50 feet in overall length.

Live Rock: Any natural hard substrate (including dead coral or rock) to which is attached, or which supports, any living marine life-form associated with coral reefs.

Longline: A type of fishing gear consisting of a main line which is deployed horizontally from which branched or dropper lines with hooks are attached.

Low-Use MPA: Marine Protected Area zoned to allow limited fishing activity controlled under special permit.

Main Hawaiian Islands (MHI): The high islands of the State of Hawaii consisting of Niihau, Kauai, Oahu, Molokai, Lana`i, Maui, Kahoolawe, Hawaii and all of the smaller associated islets (from 154°W longitude to 161°20'W longitude).

Marine Protected Area (MPA): Designated area within the federal EEZ, which is used as a management measure to allow or prohibit certain fishing activities.

Maximum Sustainable Yield: A management goal specifying the largest long-term average catch or yield (in terms of weight of fish that can be taken, continuously (sustained) from a stock or stock complex under prevailing ecological and environmental conditions, without reducing the size of the population.

National Marine Fisheries Service (NMFS): The component of the National Oceanic and Atmospheric Administration (NOAA), Department of Commerce, responsible for conservation and management of living marine resources.

No-Take MPA: Marine Protected Area where no fishing or removal of living marine resources is authorized.

Northwestern Hawaiian Islands (NWHI): The EEZ of the Hawaiian islands archipelago lying to the west of 161°20'W longitude.

Optimal Economic Productivity: The greatest long-term net economic benefit from the resources. Economic benefits are defined as both market price-based benefits and non-market benefits.

Optimum Yield (OY): With respect to the yield from a fishery "optimum" means the amount of fish that (a) will provide the greatest overall benefit to the nation, particularly with respect to food production and recreational opportunities and taking into account the protection of marine ecosystems; (b) is prescribed as such on the basis of the MSY from the fishery, as reduced by any relevant economic, social or ecological factor; and (c) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the MSY in such fishery.

Overfishing: Fishing at a rate or level that jeopardizes the capacity of a stock or stock complex to produce maximum sustainable yield on a continuing basis.

Pacific Island Area: American Samoa, Guam, Hawaii, the Commonwealth of the Northern Mariana Islands, Baker Island, Howland Island, Jarvis Island, Johnston Atoll, Kingman Reef, Midway Island, Wake Island or Palmyra Atoll, as applicable, and includes all islands and reefs appurtenant to such island, reef or atoll.

Pacific Remote Islands: Baker Island, Howland Island, Jarvis Island, Johnston Atoll, Kingman Reef, Midway Island, Wake Island and Palmyra Atoll and includes all islands and reefs appurtenant to such islands, reefs and atolls.

Passive Fishing Gear: Gear left unattended for a period of time prior to retrieval (e.g., traps, gill nets).

Plan Team (PT): A team appointed by the Council to help prepare an FMP under the direction of the Council. The PT utilizes input from all committees and panels as well as outside sources in developing the FMP and amendments.

Potentially Harvested Management Unit Species/Coral Reef Taxa: Organisms that are not known to be currently harvested from EEZ, or are minor harvests for which adequate information is not available upon which to base management, but have potential to be harvested in new emerging fisheries.

Precautionary Approach: The implementation of conservation measures even in the absence of scientific certainty that fish stocks are being overexploited.

RA: Regional Administrator, NMFS

Recreational Fishing: Fishing primarily for sport or pleasure.

Recruitment: A measure fo the weight or number of fish which enter a defined portion of the stock such as fishable stock (those fish above the minimum legal size) or spawning stock (those fish which are sexually mature).

Reef: A ridgelike or moundlike structure built by sedentary calcareous organisms and consisting mostly of their remains. It is wave-resistant and stands above the surrounding sediment. It is characteristically colonized by communities of encrusting and colonial invertebrates and calcareous algae.

Reef-Obligate Species: An organism dependent on coral reefs for survival.

Regulatory Discards: Any species caught that fishers are required by regulation to discard or to retain but not sell.

Regulatory Impact Review (RIR): Assessment of all costs and benefits of available regulatory measures, including the alternative of not regulating (per Executive Order 12866). The emphasis of the analysis is on the changes in the stream of net benefits that will occur as a result of each of the alternative management measures. NOAA requires that this analysis, through a Regulatory Impact Review, be done for all regulatory actions that are of public interest, such as those associated with new fishery management plans.

Resilience: The ability of a population or ecosystem to withstand change and to recover from stress (natural or anthropogenic).

Restoration: The transplanting of live organisms from their natural habitat in one area to another area where losses of, or damage to, those organisms has occurred with the purpose of restoring the damaged or otherwise compromised area to its original, or a substantially improved, condition; additionally, the altering of the physical characteristics (e.g., substrate, water quality) of an area that has been changed through human activities to return it as close as possible to its natural state in order to restore habitat for organisms.

Rock: Any consolidated or coherent and relatively hard, naturally formed, mass of mineral matter.

Rod and Reel: A hand-held fishing rod with a manually or electrically operated reel attached.

Scuba Assisted Fishing: Fishing, typically by spear or by hand collection, using assisted breathing apparatus.

Secretary: The Secretary of Commerce or a designee.

Sessile: Attached to a substrate; non-motile for all or part of the life cycle.

Slurp Gun: A self-contained, typically hand-held, tube–shaped suction device that captures organisms by rapidly drawing seawater containing the organisms into a closed chamber.

Small Fishing Vessels: Fishing vessels less than 50 feet in overall length.

Social Acceptability: The acceptance of the suitability of the FMP by stakeholders, taking cultural, traditional, political and individual benefits into account.

Spear: A sharp, pointed, or barbed instrument on a shaft, operated manually or shot from a gun or sling.

Special Permit: Permit with stringent criteria for issuance and operation. Required for fishing for coral reef taxa in low-use MPAs or for potentially harvested coral reef taxa in non-MPA areas. Also required for harvesting live hard coral for aquaculture seed stock, traditional indigenous use, scientific collecting and bioprospecting.

Stock Assessment: An evaluation of a stock in terms of abundance and fishing mortality levels and trends, and relative to fishery management objectives and constraints if they have been specified.

Stock of Fish: A species, subspecies, geographical grouping or other category of fish capable of management as a unit.

Submersible: A manned or unmanned device that functions or operates primarily underwater and is used to harvest fish.

Subsistence Fishing: Fishing primarily to obtain food for personal use rather than for sale or recreation.

Sustainable Use: The use of components of an ecosystem in a way and at a rate that does not lead to the long-term decline of biological diversity, size structure or abundance of any of its components, thereby maintaining their potential to meet the needs and aspirations of present and future generations.

Target Resources: Species or taxa sought after in a directed fishery.

Total Allowable Level of Foreign Fishing (TALFF): The portion of the OY on an annual basis that will not be harvested by US vessels.

Trophic Web: The network that represents the predator/prey interactions of an ecosystem.

Trap: A portable, enclosed, box-like device with one or more entrances used for catching and holding fish or marine organism.

Unincorporated US Island Possessions: Johnston Island, Wake Island, Midway Island, Palmyra Atoll, Kingman Reef, Jarvis Island, and Howland and Baker Islands.

Western Pacific Regional Fishery Management Council (WPRFMC or Council): Representatives from the State of Hawaii, the Territories of American Samoa and Guam and the Commonwealth of the Northern Mariana Islands with authority over the fisheries in the Pacific Island Area EEZ.

LIST OF ACRONYMS

AFPI:	American Flag Pacific Islands
ASCMP:	American Samoa Coastal Management Program
ASEPA:	American Samoa Environmental Protection Agency
ASG:	American Samoa Government
BSGFMP:	Bottomfish and Seamount Groundfish Fisheries Management Plan,
BMPs:	Best Management Practices
CBD:	Convention on Biological Diversity
CITES	Council on International Trade and Endangered Species
CNMI:	Commonwealth of the Northern Mariana Islands
CPUE:	Catch per unit effort
CRAMP:	Coral Reef Assessment and Monitoring Program
CRE:	Coral Reef Ecosystem
CRE-FMP:	Coral Reef Ecosystem Fishery Management Plan
CRM:	Coastal Resources Management, CNMI
CUC:	Commonwealth Utilities Corporation, CNMI
CZM:	Coastal Zone Management Program, Hawaii
CZMA:	Coastal Zone Management Act
DAR:	Division of Aquatic Resources, Dept Land and Natural Resources, Hawaii
DAWR:	Division of Aquatic and Wildlife Resources, DOA, Guam
DBOR:	Department of Boating and Ocean Resources, Hawaii

DEIS:	Draft Environmental Impact Statement
DEQ:	Division of Environmental Quality, CNMI
DFW:	Division of Fish and Wildlife, CNMI
DLM:	Department of Land Management, Guam
DLNR:	Department of Land and Natural Resources, Hawaii
DLNRM:	Department of Lands and Natural Resource Management, CNMI
DMWR:	Department of Marine and Wildlife Resources, American Samoa
DOA:	Department of Agriculture, Guam
DOH:	Department of Health, Hawaii
DPS:	Department of Public Safety, Hawaii
EEZ:	Exclusive Economic Zone
EFH:	Essential Fish Habitat
EIS:	Environmental Impact Statement
EPAP:	Ecosystem Principals Advisory Panel
ESA:	Endangered Species Act
FBNMS:	Fagatele Bay National Marine Sanctuary, American Samoa
FCIS:	Fishing Community Impact Statement
FDM:	Farallon de Medinilla, CNMI
FFS:	French Frigate Shoals, NWHI
fm:	fathoms
FMPs:	Fisheries Management Plans
FMU	Fishery Management Unit
GCMP:	Guam Coastal Management Program
GEPA:	Guam Environmental Protection Agency
GVB:	Guam Visitors Bureau
HAPC:	Habitat Areas of Particular Concern
HCRI:	Hawaii Coral Reef Initiative Research Program
HOMRC:	Hawaii Ocean and Marine Resources Council
ICRI:	International Coral Reef Initiative
IRFA:	Initial Regulatory Flexibility Analysis
IUCN:	International Union for Conservation of Nature and Natural Resources
JMI:	Japanese Marianas Islands (prior to World War II)
m:	meters
MarBEC:	Marine Biotechnology Engineering Center, Dept. of Oceanography, UH
MHI:	Main Hawaiian Islands
MMPA:	Marine Mammal Protection Act
MPA:	Marine Protected Area
M-S ACT:	Magnuson-Stevens Fisheries Conservation and Management Act
MSFMCA:	Magnuson-Stevens Fisheries Conservation and Management Act
MSY:	Maximum Sustainable Yield
MVB:	Marianas Visitors Bureau
MUS:	Management Unit Species
NEPA:	National Environmental Policy Act
nm:	nautical miles
NMFS:	National Marine Fisheries Service

NMFS-HL:	National Marine Fisheries Service - Honolulu Laboratory
NOAA:	National Oceanic and Atmospheric Administration
NPDES:	National Pollution Discharge Elimination System
NWHI:	Northwestern Hawaiian Islands
NWR:	National Wildlife Refuge
OY:	Optimum Yield
PBDC:	Pacific Basin Development Council
PIAO:	Pacific Islands Area Office
PRA:	Paperwork Reduction Act
PRIA:	Pacific Remote Island Areas
PRNS:	Project Review and Notification System, American Samoa
RFA:	Regulatory Flexibility Act
RIR:	Regulatory Impact Review
SFA:	Sustainable Fisheries Act
SPREP:	South Pacific Regional Environment Programme
SSC:	Scientific and Statistical Committee
USFWS:	United States Fish and Wildlife Service
USCG:	United States Coast Guard
USCRI:	United States Coral Reef Initiative
USPI:	United States Pacific Islands
VMS:	Vessel Monitoring System
WpacFin:	Western Pacific Fisheries Information Network
WPRFMC:	Western Pacific Regional Fishery Management Council

9.2 Consistency with National Standard Guidelines and other Laws

9.2.1 National Standards for Fishery Conservation and Management

National Standard 1 – *Prevent Overfishing, Achieve Optimum Yield – Conservation and Management Measures Shall Prevent Overfishing While Achieving, on a Continuing Basis, the Optimum Yield from Each Fishery for the United States Fishing Industry.*

The CRE-FMP would, through permit and reporting requirements, monitor and control fishing effort in the EEZ to prevent overfishing of coral reef resources. A special permit and reporting system would be established for new fisheries in the EEZ targeting previously unharvested coral reef resources for which there is insufficient information to define overfishing or optimum yield. A special permit would also be required for any CRE fishing in low-take MPAs. In addition, large tracts of coral reef in the EEZ would be designated as no-take MPAs. These would conserve a large reservoir of spawning biomass and provide “insurance” against periods of poor recruitment or overexploitation of downcurrent sub-populations. Furthermore, deep water spawning stocks of fish species that have already been heavily exploited at shallow depths would be protected from intensive harvest using SCUBA assisted fishing.

National Standard 2 – *Best Scientific Information – Conservation and Management Measures Shall Be Based upon the Best Scientific Information Available.*

For coral reef resources already targeted by existing fisheries and for which there is sufficient information to define sustainable yield, the CRE-FMP would prevent overfishing according to the protocol described the FMP. For previously unharvested MUS, the FMP would collect detailed fishery-dependent information through a special permit and reporting system. This would be supplemented by fishery-independent data collected through research. Through a framework procedure, the FMP would remain adaptive to new information and unforeseen impacts. An evaluation of new data and the biological, economic and social impacts of the management system would be made each year as part of the annual status report prepared by the Council for the coral reef fisheries managed in the western Pacific.

National Standard 3 – *Manage Stocks as a Unit – To the Extent Practicable, an Individual Stock of Fish Shall Be Managed as a Unit Throughout its Range, and Interrelated Stocks of Fish Shall Be Managed as a Unit or in Close Coordination.*

Individual sub-populations of larger stocks of reef species may increase, decrease or cease to exist locally without adversely affecting the overall population. The condition of the overall populations of particular species is linked to the variability among subpopulations: the ratio of sources and sinks, their degrees of recruitment connection, and the proportion of the sub-populations with high variability in reproductive capacity. Recruitment to populations of coral reef organisms depends largely on the pathways of larval dispersal and "downstream" links. Are the connections sufficient to actually enhance distant sub-populations or only enough to maintain a homogenous genetic stock? There is poor understanding of the basics, much less the intricacies, of individual stocks and of their interrelationships in the coral reef ecosystem. To compensate, the CRE-FMP proposes extensive no-take MPAs. They do not require detailed knowledge of species while being holistic in conserving multi-species resources and the functional attributes of coral reef ecosystems.

National Standard 4 – *Do Not Discriminate Between States – Conservation and Management Measures Shall Not Discriminate Between Residents of Different States. If it Becomes Necessary to Allocate or Assign Fishing Privileges among Various United States Fishermen, Such Allocation Shall Be (A) Fair and Equitable to All Such Fishermen; (B) Reasonably Calculated to Promote Conservation; and (C) Carried out in Such Manner That No Particular Individual, Corporation, or Other Entity Acquires an Excessive Share of Such Privileges.*

The allocation of fishing privileges to indigenous participants in coral reef fisheries resulting from the preferred alternatives is rationally connected to the furtherance of CRE-FMP objectives. Furthermore, the total potential benefits that indigenous participants may receive from the preferred alternatives outweigh the potential hardship may be imposed on non-indigenous participants when the centuries-old dependence of native people on coral reefs and the social importance of indigenous cultural continuity are considered. The measure is reasonably calculated to promote conservation, and no particular individual, corporation or other entity is expected to acquire an excessive share of fishing privileges allocated to indigenous participants. Participation in coral reef fisheries will not be limited to residents of the US Pacific islands.

National Standard 5 – *Efficiency in Utilization – Conservation and Management Measures Shall, Where Practicable, Consider Efficiency in the Utilization of Fishery Resources; Except That No Such Measure Shall Have Economic Allocation as its Sole Purpose.*

Coral reefs harbor a great diversity of marine organisms but the relative productivity and potential harvest of any single species is limited. Existing methods of harvesting coral reef resources in the US Pacific are highly inefficient and the CRE-FMP purposely does not promote greater efficiency in these fisheries. In fact, the proposed conservation and management measures would create additional inefficiencies in the form of area closures (i.e., no-take MPAs), special permit and reporting requirements and fishing gear restrictions.

The preferred alternatives emphasize the need to sustain existing small-scale fisheries for coral reef resources, while limiting the harvest of new resources targeted by new fisheries until sustainable use can be demonstrated. Particular support is given to fishing communities and indigenous participants because of the importance of coral reef resources as a source of food for local consumption and as a means of preserving and perpetuating indigenous cultural values. The many economic and social benefits of coral reefs to island societies would be maintained by the conservation measures that are proposed.

It is impossible to provide a quantitative estimate of how many more coral reef resources would be available if the CRE-FMP is approved and implemented or how much additional benefit would accrue to the Nation by this increase. It is clear, however, that the value of the potential economic and social benefits derived from the proposed conservation and management measures outweigh the costs that may be imposed on fishing activities affected by the closure of MPAs, special permit and reporting requirements and gear limitations.

National Standard 6 – *Allow for Variations – Conservation and Management Measures Shall Take into Account and Allow for Variations Among, and Contingencies In, Fisheries, Fishery Resources and Catches.*

The special permit and report requirements for low-use MPAs and for new coral reef resources targeted by new fisheries are expected to produce new information, especially for coral reef taxa for which there is poor understanding and little data to define sustainable yield. An evaluation of new data and unforeseen impacts (biological, economic and social) of the FMP management system will be made each year as part of the annual status report prepared by the Council for the coral reef fisheries managed in the western Pacific region. During the evaluation, the views and opinions of the full range of stakeholders, including consumptive and non-consumptive users of coral reefs, will be solicited. The conservation and management measures may be adjusted as new information becomes available.

National Standard 7 – *Management Measures Shall Minimize Costs – Conservation and Management Measures Shall, Where Practicable, Minimize Costs and Avoid Duplication.*

Several of the proposed conservation and management measures would add substantially to the responsibilities and costs of fishery administration and enforcement. Specific elements likely to increase the difficulty and cost of fishery management are (a) the designation of seaward boundaries for no-take MPAs; (b) zoning of low-use MPAs; (c) the requirement for wreck removal and pollution liability insurance for vessels making passage through MPAs; and (d) the highly discretionary special permit application and reporting process. The preferred alternatives, however, avoid duplication with existing local permits issued by island governments and with federal permits for fishing activities conducted in the EEZ under existing FMPs for lobster, bottomfish and precious corals.

National Standard 8 – *Importance to Fishing Communities – Conservation and Management Measures Shall, Consistent with Conservation Requirements of this Act (Including the Prevention of Overfishing and Rebuilding of Overfished Stocks), Take into Account the Importance of Fishery Resources to Fishing Communities in Order to (A) Provide for the Sustained Participation of Such Communities; and (B) to the Extent Practicable, Minimize Adverse Economic Impacts on Such Communities.*

The social and economic history of the populated US Pacific islands differs considerably from that of the continental USA. The Samoa, Hawaii and Mariana islands were originally settled in ancient times by sea-faring peoples. The lack of terrestrial resources in most areas led to great dependence on fishing for food security. This dependence shaped the social organization, cultural values and spiritual beliefs of the indigenous populations.

The era of European discovery brought the island cultures in direct conflict with western traditions of proprietorship. Repeated contacts with western culture eroded the stability of the social structures and subsistence economies created by indigenous people.

With the exception of American Samoa and small enclaves in Guam, Hawaii and the Northern Mariana Islands, the modern-day indigenous descendants are dispersed as part of cosmopolitan populations. Island societies have become pluralistic and many aspects of their economies and cultures have evolved in modern times. Yet, the vast majority of contemporary island residents continue to be dependent on coral reef resources for consumptive and non-consumptive uses. Most are consumers of seafood and many are at least part-time fishermen. The harvest of coral reef resources is important to US Pacific island inhabitants as a source of food for local consumption, for local income and employment and as a means of preserving and perpetuating indigenous cultural values.

The MSFCMA has recognized that Pacific insular areas "contain unique historical, cultural, legal, political and geographic circumstances which make fisheries resources important in sustaining their growth." The proposed conservation and management measures take into account the centuries-old relationships of indigenous people with coral reef resources and the continuing dependence of modern-day, pluralistic island communities on these resources. The siting of no-take MPAs in remote areas of the EEZ, proposed allocation of a portion of low-use MPAs for indigenous fishing activities and the reliance on proposed local reporting requirements in portions of the EEZ adjacent to existing fishing communities and indigenous activities are expected to minimize adverse economic impacts.

National Standard 9 – *Minimize Bycatch – Conservation and Management Measures Shall, to the Extent Practicable, (A) Minimize Bycatch and (B) to the Extent Bycatch Cannot Be Avoided, Minimize the Mortality of Such Bycatch.*

Existing coral reef fisheries in the US Pacific islands produce little bycatch because of relatively selective gears and diverse food preferences of island seafood consumers. The restrictions on gear and fishing methods are intended to minimize bycatch. A condition of the permit system will require that all bycatch be reported. If a particular fishery, gear or method is shown to produce excessive bycatch, regulatory or administrative action can be taken.

National Standard 10 – *Promote Safety – Conservation and Management Measures Shall, to the Extent Practicable, Promote the Safety of Human Life at Sea.*

The FMP proposes to designate MPAs where vessel anchorage and passage would be restricted. These measures would not promote vessel safety but neither are they expected to put vessels at risk because anchoring and passage would not be restricted in emergency situations. The latter are recognized under maritime law (force majeure) regardless of any regulations implemented through the FMP.

9.2.2 Other Applicable Laws and Policies

Coastal Zone Management Act (CZMA)

Section 307 (C) of the CZMA requires that any Federal activity affecting the land or water uses or natural resources of a states coastal zone be consistent with that states' approved coastal management program, to the maximum extent practicable. In this instance, Hawai'i, Guam, American Samoa and CNMI all have approved Coastal Zone Management programs. This Fishery Management Plan, therefore, must be reviewed to determine if the measures will or are likely to affect the coastal zone. The management measures in this CRE-FMP will be implemented in a manner that is consistent to the maximum extent practicable with the approved coastal zone management programs of American Samoa, CNMI, Guam, and Hawai'i. The Council will send a copy of the draft FMP to the state coastal agencies for concurrence.

Endangered Species Act (ESA)

The Endangered Species Act provides for the protection and conservation of endangered and threatened species. Once a species is listed as endangered or threatened, it is afforded protection under the ESA and takings are prohibited. The process ensures that projects authorized, funded, or carried out by federal agencies do not jeopardize the species existence or result in habitat destruction or modification critical to the species existence. Consultation takes place by NMFS, and USFWS as appropriate, and is required if the fishery affects, directly or indirectly, endangered or threatened species or any designated critical habitat. While developing the CRE-FMP, the Council included measures to minimize any adverse impacts. Therefore, the Council has determined that this FMP is not likely to have any significant adverse effects to listed species or their critical habitats.

Under the ESA, NMFS is required to prepare an impact assessment, which may serve as biological assessment for consultation under Section 7 of the ESA. This document assesses the impacts to endangered and threatened species and their habitats from the management measures in the CRE-FMP.

The species that have been listed as endangered or threatened under the Endangered Species Act and have been observed in the region where reef-related fisheries operate are as follows:

Species listed as endangered or threatened

Hawaiian monk seal
(Monachus schauinslandi)
Olive ridley turtle (Lepidochelys olivacea)
Leatherback (Dermochelys coriacea)
Loggerhead (Caretta caretta)
Hawksbill turtle (Eretmochelys imbricata)
Green sea turtle (Chelonia mydas)
Humpback whale (Megaptera novaeangliae)
Sperm whale (Physeter macrocephalus)
Blue whale (Balaenoptera musculus)
Fin whale (B. Physalus)
Sei whale (B.Borealis)

Marine Mammal Protection Act (MMPA)

The Marine Mammal Protection Act of 1972, as amended, allows for the incidental take of marine mammals during commercial operations under certain limited circumstances, including incidental takings during commercial fishing. However, all fisheries in the Western Pacific Region are classified as Category III, which designates the fishery as having a remote likelihood or no known incidental taking of marine mammals. If any interactions do occur, the fishermen are required to report them. In developing the CRE-FMP, the Council considered actions which would minimize adverse impacts from the fishery, and developed mitigation measures.

Several species of marine mammals (cetaceans) that are protected under the MMPA, but not listed as endangered or threatened, occur in the areas where reef-related fisheries operate and are as follows:

Pacific white sided dolphin (Lagenorhynchus obliquidens)
Rough-toothed dolphin (Steno bredanensis)
Risso’s dolphin (Grampus griseus)
Bottlenose dolphin (Tursitops truncatus)

Spotted dolphin (Stenella attenuata)
Spinner dolphin (Stenella longirostris)
Striped dolphin (Stenella coeruleoalba)
Melon-headed whale (Peponocephala electra)
Pygmy killer whale (Feresa attenuata)
False killer whale (Pseudorca crassidens)
Killer whale (Orcinus orca)
Pilot whale (Globicephala melas)
Blainsville's beaked whale (Mesoplodon densirostris)
Cuvier's beaked whale (Ziphius cavirostris)
Pygmy sperm whale (Kogia breviceps)
Dwarf sperm whale (Kogia simus)
Bryde's whale (Balaenoptera edeni)

Environmental Impact Statement (EIS)

The National Environmental Policy Act (NEPA) requires that any major federal action significantly affecting the human environment must disclose the environmental consequences of the proposed action through an Environmental Impact Statement (EIS). An EIS was prepared for this FMP, and all required components of the EIS are contained in Volume II, including issues relating to public scoping periods, consulted agencies, impacts and alternatives.

Paperwork Reduction Act (PRA)

The purpose of the PRA is to control the burden on the public (i.e, fishers), businesses, county, state, and territorial governments, and other entities of providing information to the federal government. The Act is intended to ensure that the information collected under the proposed action is needed and collected in an efficient manner. (44 U.S.C. 3501(1)).

Proposed Data Collection Program:
This FMP will not initially require additional reporting requirements in the populated areas (AS, GU, CNMI, MHI) for currently harvested coral reef taxa. In these areas where local data collection and fishery monitoring exists, the Council will coordinate through these existing reporting requirements to obtain data. In areas where no reporting systems exist, the Council will develop local-specific mechanisms for monitoring and reporting. Reporting requirements for these areas could include reporting types and quantity of gear used, units of gear set, time at start and end of set, units of gear lost, numbers and weights of species kept, numbers released, reason for discards, how the catch is processed, area(s) fished, length of the trip, average weather conditions, depth of area fished, and observed damage to the coral reef, all protected species interactions. For all fishing (where allowed) in the NWHI and the PRIA, and for emerging fisheries harvesting previously unharvested taxa in the CNMI and MHI, reporting will be conducted via special permits. The annual report required under the FMP would summarize and analyze the information collected.

This FMP will not require additional permits for currently harvested coral reef taxa in the populated areas (AS, GU, CMNI, MHI). However, in the low-use MPA of the NWHI and Johnston and Wake a special permit will be required for currently harvested coral reef taxa. Also, for emerging fisheries in the CNMI and MHI, a special permit will be required for targeted coral reef taxa. For all areas, incidental catch of coral reef taxa taken under other FMP-managed fisheries will require no additional permit or reporting other than existing systems.

Estimate of Permit Application and Reporting Burden and Cost:
The permit application and reporting requirements would require a certain level of scientific expertise, which would bring a certain level of costs. The special permit reporting requirements could be fulfilled with the expertise of a typical fisherman. Because reporting costs are variable costs, the differential effects among entities would be small. Relatively few of the region's coral reef fishery participants would be affected by the preferred measures outlined in the CRE-FMP, and of these participants only a few would be significantly affected.

It is estimated that between 10 - 20 permits will be issued annually to coral reef-related fisheries in the EEZ of the western Pacific region. The general permit is estimated to require 1 hour to complete, therefore the permitting burden for general permits would be 10 - 20 hours annually. The special permit is estimated to require 2 hours to complete, totaling 20 - 40 hours for the special permit annual burden.

The total reporting burden hours are estimated to be 1,125 hours per year, assuming 15 vessels in the fleet make an average of 10 trips per year, averaging 15 days per trip and the additional daily burden is 30 minutes. The total burden hours for the special permit are estimated to be 750 hours per year, assuming 5 vessels in the fleet make an average of 10 trips per year averaging 15 days per trip and the additional daily burden is 1 hour.

See Draft Regulatory Impact Review for additional information on estimated reporting burden and cost.

Regulatory Flexibility Act (RFA)

The Regulatory Flexibility Act requires that agencies assess and present the impacts of their proposed actions on small business entities. This section provides the determination that an initial RFA is required and also the IRFA itself. After public review, a final RFA may be required.

National Wildlife Refuge Administration Act of 1966 (NWRAA)

The NWRAA establishes guidelines and directives for the administration and management of areas within the National Wildlife Refuge System. The NWRAA authorizes the Secretary of the Interior to administer the System for the conservation and management of wildlife and plant resources, while providing for compatible wildlife dependant recreational activities within the NWRS boundaries. Under this FMP, no USFWS-managed resources are expected to be negatively affected as any proposed activity outside the NWR boundary would require a thorough evaluation through a special permitting system.

Executive Order 8682

Executive Order 8682 established Naval Defensive Sea Areas and Naval Airspace Reservations around the territorial waters of several islands and reefs in the PRIA. The Order authorizes the Secretary of the Navy to control entry into areas designated as naval defensive seas areas. The Coral Reef FMP recognizes the authority of the DOD to control entry into naval defensive sea areas around those territories at any time to facilitate military preparedness. Thus, the Coral Reef Ecosystem FMP will in no way affect the authority of the DOD to conduct activities in any area administered by the DOD.

Executive Order No. 12866-Regulatory Impact Review

Executive Order 12866 requires that a Regulatory Impact Review (RIR) be prepared for all regulatory actions that are of public interest. This review provides an overview of the problem, policy objectives, and anticipated impacts of the action, and ensures that management alternatives are systematically and comprehensively evaluated so that the public welfare can be enhanced in the most efficient and cost effective way. Also, the RIR requires analysis of distributive impacts and costs of government administration and private compliance with the proposed measures.

The general purpose of the RIR, as well as the RFA described above, is to make the regulatory process open and transparent so that the steps in the regulatory decision-making process are easily followed. The economic analysis provide decision-makers and the public with the agency's best estimate of the impacts of proposed actions and their alternatives.

In compliance with this E.O., an analysis of impacts of regulatory actions is provided in the draft Regulatory Impact Review.

Executive Order No. 13089-Coral Reef Protection

In June, 1998 the President signed an Executive Order for Coral Reef Protection which established the Coral Reef Task Force(CRTF) and directed all federal agencies with coral reef-related responsibilities to develop a strategy for coral reef protection. The Federal agencies were directed to work cooperatively with state, territorial, commonwealth and local agencies; non-governmental organizations; the scientific community and commercial interests to develop the plan. The Task Force was directed to develop and implement a comprehensive program of research and mapping to inventory, monitor and address the major causes and consequences of degradation of coral reef ecosystems. The order directs federal agencies to use their authorities to protect coral reef ecosystems and, to the extent permitted by law, prohibits them from authorizing, funding, or carrying out any actions that will degrade these ecosystems.

Of particular interest to the WPRFMC is the implementation of measures to address (a) fishing activities that may degrade coral reef ecosystems, such as overfishing, which could affect ecosystem processes (e.g., the removal or herbivorous fishes leading to the overgrowth of corals by algae) and destroy the availability of coral reef resources (e.g., extraction of spawning aggregations of groupers); (b) destructive fishing techniques, which can degrade essential fish habitat (EFH) and are thereby counter to the Magnuson-Stevens Act; (c) removal of reef substrata; and (d) discarded and/or derelict fishing gear, which can degrade EFH and cause "ghost fishing".

To meet the requirements of Executive Order No.13089, the Coral Reef Task Force issued the *National Action Plan to Conserve Coral Reefs* in March 2000. In response to the recommendations outlined in the *Action Plan*, the President announced Executive Order 13158 designed to strengthen and expand Marine Protected Areas.

Executive Order No. 13158–Marine Protected Areas Memorandum of Understanding on Protection of U.S. Coral Reefs in the Northwest Hawaiian Islands

On May 26, 2000, the President announced his commitment to protect the natural and cultural resources found within the marine environment by strengthening and expanding the Nation's system of marine protected areas (MPAs) to protect the natural and cultural marine heritage for future generations. This is to be accomplished by all pertinent federal agencies sharing information, tools, and strategies to develop a National system of MPAs. The Department of Commerce and the Department of Interior are required to consult with those states that contain portions of the marine environment, and Regional Fishery Management Councils, among others, to promote coordination when establishing and managing MPAs.

Under Executive Order 13158, each federal agency whose authorities provide for the establishment or management of MPAs shall take appropriate actions to enhance or expand protection of existing MPAs and establish or recommend, as appropriate, new MPAs. Throughout the development of the CRE-FMP, the Council, along with the advisory bodies and plan teams, have analyzed existing MPAs and developed recommendations to establish new ones in all areas under Council jurisdiction. This FMP includes those recommendations.

Concurrent with the announcement of Presidents executive order 13158, a Memorandum of Understanding was delivered by the President. In this memorandum, the President determined that the coral reef ecosystem in the Northwestern Hawaiian Islands deserved strong and lasting protection. To this end, he directed the Secretary of the Interior and the Secretary of Commerce, working cooperatively with the State of Hawaii and consulting with the Western Pacific Regional Fishery Management Council, to develop recommendations within 90 days for a new, coordinated management regime to increase protection of the ecosystem and provide for sustainable use.

In the process of developing the CRE-FMP, the Council has consistently worked cooperatively with the Department of Interior, the Department of Commerce, and the State of Hawaii, as well as numerous other agencies. Currently, the Chairman of the State of Hawaii Department of Land and Natural Resources is a designated voting member of the Council, and the Pacific Islands Manager of the U.S. Fish and Wildlife Service serves as a non-voting member. In addition, in developing the CRE-FMP the Council relied on members of the various plan teams to develop recommendations based on their combined expertise. Staff members of the U.S. Fish and Wildlife Service as well as

State of Hawaii Department of Aquatic Resources are represented on the coral reef ecosystem plan team.

The prominent issues which are to be included in the recommendations already exist in the CRE-FMP. For example, after much discussion a network of MPAs was developed by the advisory panels to identify coral reef areas of special value in the NWHI. The Council is advocating for 24% of the coral reefs present in the NWHI to be classified no-take MPAs. In the areas where human activities are allowed, the FMP focuses on ensuring that the actions will not degrade the condition of the coral reef ecosystem. In addition, consistently throughout the FMP the Council has considered the potential for human impacts on threatened and endangered species, and developed alternatives designed to afford the greatest protection.

The cooperative recommendations should identify any further measures necessary to protect cultural and historic resources and artifacts, as well as provide for culturally significant uses of the Northwestern Hawaiian Islands marine resources by Native Hawaiians. History clearly demonstrates how coral reef ecosystems have been vital to Native Hawaiians, and throughout the CRE-FMP this relationship is documented. The Council developed a Fishery Rights of Indigenous Peoples Advisory Panel to work closely with other advisory bodies, ensuring that the rights of the indigenous peoples are not overlooked.

In addition, the cooperative recommendations should establish a framework for scientific research and exploration, as well as establish a framework for facilitating recreation and tourism in the Northwestern Hawaiian Islands. An important focus of the CRE-FMP is to balance the conservation of the ecosystem while still allowing human activities to occur. The scientific data obtained in the Northwestern Hawaiian Islands is critical to promote understanding of the coral reef ecosystems, thereby ensuring comprehensive management.

Executive Order No. 13178-Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve

On December 4, 2000 President William J. Clinton announced executive order 13178 which established the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve. The reserve is approximately 1200 nautical miles (nm) long and 100nm wide, and includes all submerged lands and waters seaward of the seaward boundaries of the State of Hawaii and the Midway Atoll National Wildlife Refuge in the Northwestern Hawaiian Islands. It is approximately 99,500 square nautical miles. Currently it is undecided whether Hawaii State submerged lands and waters will be included in the Reserve. Fifteen Reserve Preservation Areas were designated within the Reserve where additional conservation measures are imposed.

The Secretary of Commerce was given the authority to manage the Reserve under the National Marine Sanctuaries Act, and in consultation with the Secretary of Interior and the Governor of Hawaii will develop a Reserve Operations Plan. A Reserve Council, comprised 15 voting and 9 nonvoting members, will provide advice and recommendations on the Reserve Operations Plan and management. The Secretary will initiate the process to designate the Reserve as a National Marine Sanctuary.

Public hearings were held on all the main Hawaiian islands (with the exception of Lanai) and in Washington D.C. to hear public viewpoints on establishing permanent Reserve Preservation Areas, in addition to the conservation measures proposed in the EO. The hearings were held from December 11th through December 15th, and the public may submit written comments through January 8, 2001. Modifications to the executive order could occur in response to the views expressed during the public comment period.

Fishing is prohibited in all Reserve Preservation Areas, with certain exceptions allowed for bottomfishing. The Reserve Preservation Areas include all waters and submerged lands seaward of State waters to a depth of 100 fathoms around Nihoa, Necker, French Frigate Shoals, Gardner Pinnacles, Maro Reef, Laysan, Lisianski, Pearl and Hermes Atoll and Kure. In addition, Reserve Preservation Areas are established around six NWHI banks to twelve nautical miles. Where fishing is allowed in the Reserve, the level of effort for both commercial and recreational fishing is capped at current or recent level of take. The amount of permits are capped at the 1999 level.

Other activities which are prohibited in Reserve Preservation areas are: anchoring where buoys are available or outside a designated area; taking or touching living or dead coral; and discharging or depositing any material except cooling water or engine exhaust. Activities which are prohibited throughout the Reserve include: exploring for, developing or producing oil, gas or minerals; anchoring on any living or dead coral; drilling into or otherwise altering the seabed; discharging or depositing any material into the Reserve except fish parts or discharges incidental to vessel use; and harvesting, taking or moving any living or non-living resource.

Non-commercial, Native Hawaiian subsistence, cultural and religious uses are allowed to continue within the Reserve and the Reserve Preservation Areas, providing these uses do not injure the coral reef ecosystem and related marine resources.

Several important stipulations in the EO are not clearly defined, however. Regarding future levels of allowable take, the EO states that the annual level of aggregate take under all permits may not exceed the aggregate level of take under all permits in the years preceding the date of this order. Exactly which years will be calculated to determine the future level of take is never defined in this EO. In addition, it is then stated that the Secretary shall equitably divide the aggregate level into individual levels per permit. This language is contrary to the Magnuson-Stevens Fishery Conservation and Management Act, as well as Congress who recently re-established the moratorium on quotas for individual vessels. Individual Fishery Quotas are problematic and very difficult to allocate to specific vessels by the fishery managers. The EO is also unclear about the level at which the number of permits are capped. Again it states that there shall be no increase in the number of permits beyond the number of permits in effect the year preceding the date of the order. It is unclear exactly which time period in 1999 will be considered when establishing the future number of permits.

Ecosystem-Based Fishery Management

Recognizing the potential of an ecosystem-based management approach to improve fisheries management, Congress requested that NMFS convene a panel of experts to: assess the extent to which ecosystem principles are currently applied in fisheries research and management, and recommend how best to integrate ecosystem principles into future fisheries management and research. In April 1999, this Ecosystems Principles Advisory Panel (EPAP) submitted a report to Congress titled *Ecosystem-Based Fishery Management*. It concludes that the US must develop - governance systems that have ecosystem health and sustainability, rather than short-term economic gain, as their primary goals. In addition, it states that the benefits of adopting ecosystem-based fishery management and research are more sustainable for fisheries and marine ecosystems, as well as more economically-healthy coastal communities. The panel provides fisheries management and policy recommendations for implementation by NMFS and the Councils.

As mentioned previously in this FMP, the Council developed the CRE-FMP to incorporate ecosystem approaches into the present regulatory structure. In the *Ecosystem-Based Fishery Management Report*, the EPAP stressed that "FMPs for single species or species complexes should be the basic tool of fisheries management for the foreseeable future. However, management actions alone are not sufficient to implement an ecosystem approach." The mechanism to integrate FMPs with ecosystem principles, goals and policies recommended by the EPAP is a demonstration Fisheries Ecosystems Plans. This CRE-FMP is intended to serve as the demonstration plan.

Coral Reef Legislation

Several bills have been initiated in response to Executive Order 13089 addressing coral reef conservation, restoration and preservation. These bills, introduced by both the House and the Senate, would provide grants to State, Federal, territorial and commonwealth natural resource management authorities, or any educational or NGO with coral reef conservation expertise, if passed. A brief description of the language of the bills as they exist in their current form are outlined below.

Coral Reef Conservation and Restoration Partnership Act of 1999, H.B. 3919

This Bill was introduced by Representative Saxton to preserve and restore the health of coral reefs and coral reef ecosystems; promote cooperative coral reef conservation projects that involve affected local communities; enhance compliance with laws that regulate the taking of coral reef species; develop scientific information on the conditions of coral reefs; and coordinate activities and programs related to coral reefs that are conducted by the Federal government. Any State or local government agency, educational institution or non-profit organization is eligible to apply for the grant, if they demonstrate expertise in coral reef conservation. If passed, appropriations of $14 million would be available for each fiscal year 2000 - 2004.

Coral Reef Conservation Act of 1999, S.725

This Bill was introduced by Senator Snowe to preserve, protect and restore the health of coral reefs and coral reef ecosystems; to assist in the conservation of protection of coral reefs by supporting conservation programs and providing financial resources for such programs; and to establish a formal mechanism for collecting and allocating monetary donations from the private sector to be used for coral reef conservation projects. Any natural resource management authority of a State or territory of the US, other government agency with jurisdiction over coral reefs, or any educational institution or NGO with demonstrated expertise in conservation of coral reefs is eligible to apply for the grant. If passed, appropriations of $15 million would be available for each fiscal year 2001 - 2004.

Coral Reef Protection Act of 1999, S.1253

This Bill was introduced by Senator Inouye to preserve and restore the health of coral reef ecosystems; support coordinated conservation programs; provide financial assistance; and establish a funding allocation mechanism. This grant would be open to any State, Federal, or territorial agency with coral reef jurisdiction, or any organization with coral reef expertise. If passed, appropriations of $20 million for each fiscal year 2000 - 2004 would be available.

State, Local, and Other Applicable Laws and Policies

Green (1977) summarizes existing state/territorial/commonwealth laws and policies that relate to the management of coral reef ecosystems. Every effort has been made to ensure that the management measures in this FMP are compatible with state/ territorial/ commonwealth laws and policies in order to simplify implementation and assist enforcement efforts.

9.3 Jurisdictional Issues

Introduction

This briefing is intended to provide an overview of the complexity of issues concerning marine boundaries in the Western Pacific Region. Delineation of current marine boundaries is included along with a summary of specific areas of contention between various federal and state authorities.

Exclusive Economic Zone

The Fishery Conservation and Management Act (FCMA or Magnuson Act[2]) of 1976 established U.S. jurisdiction from the seaward boundary of the territorial sea out to 200 miles for the purpose of managing fishery resources. Passage of the Magnuson Act was the first unilateral declaration of jurisdiction over a 200-mile zone by a major power. Presidential Proclamation 5030 of March 10, 1983, expanded Magnuson Act jurisdiction by establishing the U.S. exclusive economic zone (EEZ) which declared, "to the extent permitted by international law ... sovereign rights for the purpose of exploring, exploiting, conserving and managing natural resources, both living and non-living, of the seabed and subsoil and the superjacent waters"in the 200-mile zone. The assertion of jurisdiction over the EEZ of the United States provided a basis for economic exploration and exploitation, scientific research and protection of the environment under the exclusive control of the U.S. Government. Congress confirmed presidential designation of the EEZ in1986 amendments to the Magnuson Act. Under the Magnuson Act, fishery management authority in the EEZ off American Samoa, Guam, Hawaii, the Commonwealth of the Northern Mariana Islands, and other U.S. islands

[2] The FCMA was initially referred to as the Magnuson Fishery Conservation and Management Act which was changed to the Magnuson-Stevens Fishery Conservation and Management Act by the 1996 amendment to the Act.

in the central and western Pacific is the responsibility of the Western Pacific Regional Fishery Management Council as established.

The EEZ is measured from the "baseline" of U.S. states and overseas territories and possessions out to 200 nautical miles. Under the Magnuson Act , the shoreward boundary of the EEZ is a line coterminous with the seaward boundary, baseline, of each "state." U.S. territories and possessions of the western Pacific fall within the definition of "state" under the Magnuson Act (16 U.S.C. 1802 M-S Act § 3 104-297). In the case of the Commonwealth of the Northern Mariana Islands (CNMI) and the Pacific Remote Island Areas (PRIAs[3]), the EEZ extends to the shoreline (Beuttler 1995).

Seaward boundaries (territorial seas) for "states" are recognized as extending out to a distance of three miles from the ordinary low-water mark, as established by the Submerged Lands Act (SLA) of 1953[4]. The Territorial Submerged Lands Act (TSLA) of 1960 was enacted to convey to the governments of American Samoa, Guam and Virgin Islands the submerged lands from the mean high-tide line out to three geographic miles from their coast lines (Beuttler 1995).

The CNMI was part of the U.S. Pacific Trust Territories until 1978 when it was given the status of Commonwealth by the United States. Although title of the emergent land was conveyed to the Commonwealth, the U.S. government withheld title to the submerged lands of the archipelago.[5] Submerged lands and underlying resources adjacent to CNMI remain owned by the Federal government and subject to its management authority (Beuttler 1995).

In the PRIAs, for which there are no sovereign entities similar to states or territories, various federal agencies have jurisdictional authority. Authority is often established through Statutes, Executive Orders and Presidential Proclamations and marine boundaries are often unclear. For this reason, the extent to which an agency exercises its jurisdictional authority is subject to legal interpretation.

Territorial Seas

State of Hawaii

The State of Hawaii consists of all islands, together with their appurtenant reefs and territorial waters, which were included in the Territory of Hawaii under the Organic Act of 1900. Under the Admissions Act of 1959, Congress granted to Hawaii the status of statehood and all amenities of a

[3]Pacific Remote Island Areas (PRIAs) Baker, Howland, Jarvis and Wake Islands, Kingman Reef, and Palmyra, Johnston and Midway Atolls.

[4]Under the SLA, the term "boundaries" or the term "lands beneath navigable waters" is interpreted as extending from the coast line to three geographical miles into the Atlantic Ocean or the Pacific Ocean, or three marine leagues (9 miles) into the Gulf of Mexico.

[5] The Territorial Submerged Lands Act was enacted for CNMI on October 5, 1974 (Beuttler 1995). Congress approved the mutually negotiated "Covenant to Establish a Commonwealth of the Northern Marianas (CNMI in political union with the US)". However the Covenant was not fully implemented until 1986 pursuant to the Presidential Proclamation number 5564, which terminated the trusteeship agreement (Beuttler 1995).

state which included the reversion of title and ownership of the lands beneath the navigable waters from the mean high-tide line seaward, out to a distance of 3 miles as stated by the SLA of 1953. Congress excluded Palmyra Atoll and Kingman Reef, Johnston Atoll, including Sand Island from the definition of the State of Hawaii in 1959. The U.S. government also retained 1,765 acres of emergent land in the Northwestern Hawaiian Islands (NWHI) which had been set aside by Executive Order 1019 in 1909, establishing the Hawaiian Islands Reservation (HIR). The HIR was later renamed the Hawaiian Islands National Wildlife Refuge (HINWR) after transference from the Department of Agriculture(DOA) to the Department of Interior (DOI) in 1939 (Yamase 1982).

Territories of Guam and American Samoa

Pursuant to the TSLA of 1960, the Territories of Guam and American Samoa own and have management responsibilities over the marine resources out to 3 "geographic" miles. In general, the authority of the Magnuson Act begins at 3 nautical miles from the shoreline at Guam and American Samoa. There are, however, exceptions to the management authority in the Territories, example for waters that are administered by the Federal government as national wildlife refuges (NWR) and naval defense sea areas (NDSA)(see below).

US Fish and Wildlife Refuges and Units

The U.S. Fish and Wildlife Service (USFWS) has been given authority to manage a number of NWRs in the Western Pacific Region. The USFWS asserts the authority to manage marine resources and activities, including fishing activities within Refuge boundaries pursuant to the National Wildlife Refuge System Administration Act (NWRSAA) of 1966, as amended by the National Wildlife Refuge System Improvement Act of 1997, and other authorities (Gillman 2000).[6] The USFWS asserts that NWRs are closed to all uses until they are specifically opened for such uses and that the USFWS is "solely" charged with making decisions whether to open NWRs for specific purposes for any use that is compatible with the refuge's primary purpose(s) and mission of the NWR (Smith 2000).

Executive Order 1019 reserved and set apart certain islets (i.e. Laysan Island, Lisanski Island) and reefs (i.e. Maro Reef, Pearl and Hermes Reef), excluding Midway, "as a preserve and breeding ground for native birds" to be administered by the Department of Agriculture. The HIR was

[6]Legal opinion by Randolph Moss, Assistant Attorney General, U.S. Department of Justice, September 15 2000, states that they are "unconvinced that the President has the authority to establish or expand a wildlife refuge within the U.S. territorial sea (12 miles) or the EEZ using presidential authority recognized in *Midwest Oil*." Because the National Wildlife Refuge System Administration Act does not itself contain a provision authorizing the President to withdraw land for a wildlife refuge, the DOI argues that the President could rely on the implied authority to reserve public lands recognized in *United States v. Midwest Oil Co.* 236, U.S. 459 (1915). The Federal Land Policy and Management Act (FLPMA) of 1976 repealed the Presidents authority, effective on and after approval of the Act, to make withdrawals and reservations resulting from acquiescence of Congress (*U.S. v. Midwest Oil Co*.). Moss continued by stating that they find "it likely that a court would find that §704(a) of the FLPMA prohibits the President from relying on the implied *Midwest Oil* authority to withdraw lands, regardless of where those lands are located." Also, that "they do not think history makes it clear that the President may continue make *Midwest Oil* withdrawals in the territorial sea or EEZ following the enactment of the FLPMA."

transferred to the DOI in 1939 and later renamed the HINWR in 1040 through Presidential Proclamation 2466, with control transferred to the USFWS. Within the HINWR, the USFWS asserts management authority over coral reef resources to a depth of 10 fathoms around all islands with the exception of Necker Island where it asserts a 20 fathom boundary. The USFWS acknowledges that all HINWR islands are part of the State of Hawaii, but asserts that the islands are federally owned and administered as a NWR by the USFWS (U.S. Fish and Wildlife Service 1999, Smith 2000).

Kure Atoll was initially included in Executive Order 1019 in 1909, which establish the HIR. However, Kure Atoll was returned to the Territory of Hawaii in 1952 by Presidential Executive Order 10413. Kure Atoll is the only State Wildlife Refuge in the NWHI and extends only out 3 miles, to the State's seaward boundary (Feder Pers. Com.)

In the PRIAs, the USFWS based on interpretation of Executive Order 7358 asserts its refuge boundaries extend to the extent of the Naval Defensive Seas Area (NDSA) administered by the Department of Defense prior to the transfer of surplus land to the USFWS. At this time, the USFWS manages five wildlife refuges in the PRIAs, Jarvis, Baker and Howland Islands and Johnston and Midway Atolls (Smith 2000).

Midway Atoll NWR, established under Executive Order 13022 in 1996, is located in the NWHI and has a refuge boundary that is within a 22 by 22 mile quadrant surrounding the atoll (the exact boundary is disputed). Under the U.S. Navy, Midway was established as a Naval Air Facility in 1941. The USFWS established an overlay refuge in 1988 to manage the fish and wildlife on the Atoll. Through the Base Alignment Closure Act of 1990, as amended, the Naval Air Facility closed in 1993 and the property was transferred to the USFWS in 1996 (US Fish and Wildlife Service 1999). The mission of the refuge is to protect and restore biological diversity and historic resources of Midway Atoll, while providing opportunities for compatible recreational activities, education and scientific research (Shallenberger 2000). Through a long-term cooperative agreement with a private company (Midway Phoenix Corp.), the refuge has been open to the public for marine recreation and education (Shallenberger 2000).

Johnston Atoll NWR is managed cooperatively with the U.S. Navy. The atoll was first established as a federal bird refuge on June 29,1926, through Presidential Executive Order 4467 to be administered by the Department of Agriculture. In 1934, through Executive Order 6935, the atoll was placed under the jurisdiction of the U.S. Navy for administrative purposes and has been used as a military installation since 1939. In 1941, Executive Order 8682, designated Johnston and other Pacific atolls NDSAs. In 1976, the USFWS, under agreement with the military, assists in management of fish and wildlife resources on the Atoll. The USFWS manages a recreational fishing program in the NWR (Smith 2000).

Administration of Jarvis, Howland and Baker Islands were transferred from the Office of Territorial Affairs to the USFWS in 1936 to be run as NWRs. The USFWS asserts refuge boundaries out to 3 nautical miles where it prohibits fishing and any type of unauthorized entry (Smith 2000). The USFWS acknowledges fishery management authority under the WPRFMC in coordination with the NMFS within the "200-nautical mile EEZ" (Smith 2000).

Rose Atoll NWR, located in American Samoa, was established through a cooperative agreement between the Territory of American Samoa and the USFWS in 1973. Presidential Proclamation 4347 exempted Rose Atoll from a general conveyance of submerged lands around American Samoa to the Territorial Government. The boundary of the refuge extends out to 3 miles around the atoll and is under the joint jurisdiction of the Department of Commerce (DOC) and the DOI in cooperation of the Territory of American Samoa. The USFWS acknowledges fishery management authority of the WPRFMC in coordination with the NMFS within the "200-nautical mile EEZ"(Smith 2000).

In the Ritidian Unit of the Guam National Wildlife Refuge, USFWS has fee title which includes 371 acres of emergent land and 401 acres of submerged lands down to the 100 foot bathymetric contour (Smith 2000). The submerged lands adjacent to Ritidian were never transferred to the Territory of Guam pursuant to the TSLA by the Federal government (Smith 2000). In 1993, the USFWS acquired the emergent land of the Ritidian Unit and the surrounding submerged lands from the U.S. Navy at no cost in 1996 (Smith 2000).

Department of Defense Naval Defensive Sea Areas

A number of Executive Orders have given administrative authority over territories and possessions to the Army, Navy or the Air Force for use as military air fields and for weapons testing. In particular, Executive Order 8682 of 1941 authorizes the Secretary of the Navy to control entry into NDSAs around Palmyra, Johnston and Midway Atolls, Wake Island, and Kingman Reef. The NDSA includes "territorial waters between the extreme high-water marks and the three-mile marine boundaries surrounding" the areas noted above. The objectives of the NDSA controls over entry into naval defensive sea areas are to provide for the protection of military installations and to protect the physical security of, and ensure the full effectiveness of, bases, stations, facilities and other installations (32 CFR Part 761). In addition, the U.S. Navy has joint administrative authority with the USFWS of Johnston Atoll and sole administrative authority over Kingman Reef. More recently, the Midway Atoll NDSA was rescinded by Executive Order 13022 in 1996 and Wake Island NDSA has been suspended until further notice.

The U.S. Navy exerts jurisdiction over Farallon de Mendinilla in the CNMI and Ka'ula Rock in the main Hawaiian Islands, which are used as military bombing ranges. The Navy also exerts jurisdiction over a variety of waters offshore from military ports and air bases in Hawaii, PRIAs, Guam, and the CNMI.

Issues

Due to jurisdictional disputes between "state" and federal agencies regarding individual islands, reefs and atolls, points of contention have arisen between various management authorities in the Western Pacific Region.
<u>State of Hawaii</u>

Points of contention exist between the State of Hawaii and USFWS concerning refuge boundaries and submerged lands in the NWHI (US Fish and Wildlife Service 1986). The State of Hawaii asserts that the HINWR boundary never legally included more than the emergent lands of the NWHI, excluding Midway (US Fish and Wildlife Service 1986). The USFWS claims that the HINWR includes 252,000 acres of submerged lands as their interpretation of Executive Order 1019 based on the inclusion of the terms "reef and inlets" (US Fish and Wildlife Service 1986). However, following the Admissions Act of 1959, which required all federal agencies in Hawaii to inventory all lands for which there was a continual need, the USFWS in 1963 reported a continuing need of 1,765 acres of land in the NWHI. This area consisted of only the emergent land in the NWHI as was claimed by the Department of Agriculture as the original boundary of the HIR (Yamase 1982). This did not include the 252,000 acres of submerged lands that are now being claimed by the USFWS. Other jurisdictional disputes also involve East and Tern Islands in French Frigate Shoals.[7, 8]

Contention exists between the USFWS and WPRFMC regarding primary fishery management responsibilities in EEZ waters within NWR boundaries. Since the late 1960's, citing USFWS interim administrative policy and interpretation of Executive Order 1019, the USFWS announced that they would enforce refuge regulations within the "de facto" boundaries of the HINWR that include all emergent land and their surrounding waters out to a depth of 10 fm for all islands and later 20 fm around Necker Island(*Smith R. P., 104th WPRFMC Meeting, Maui, June, 2000).* Under the authority of the Magnuson Act, the WPRFMC promulgated fishery regulations within Federal waters that correspond with USFWS refuge boundaries of 0-10 fathoms within NWHI federal waters, except at Necker where it is 20 fm (WPRFMC *1986*). The WPRFMC recognizes state waters in the NWHI from 0-3 miles and asserts management authority over fishery resources in all Federal waters (3-200 miles, except at Midway were it asserts authority from 0-200 miles)(Gillman 2000).

The State of Hawaii has on occasion claimed jurisdiction beyond its territorial seas of 0-3 nautical miles by claiming jurisdiction over channel waters between the main Hawaiian islands (MacDonald and Mitsuyasu, 2000). The authority of the Magnuson Act begins at 3 miles from the shoreline around all main Hawaiian islands in the State of Hawaii. The Federal Government does not recognize the State's claim of archipelagic jurisdiction, but interprets the State's seaward authority to stop at 3 nautical miles from the baseline (Feder 1997, MacDonald and Mitsuyasu 2000).

CNMI

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[7] In 1940, Territorial Governor Poindexter, issued an Executive Order in concurrence with the President of the U.S. to set aside East Island, for the use and purpose of the United States as a radar station communication base under the DOC (Yamase, 1982). Prior to statehood, the DOC returned East Island to the Territory of Hawaii (Yamase, 1982). However, the DOI contends that East Island was part of the HIR as established by Executive Order 1019 in 1909 and later transferred to the DOI in 1939. Therefore, East Island remains included in the HINWR and under authority of DOI.

[8] Tern Island was expanded from 11 to 37 acres in 1942 by military dredging (Yamase 1982). In 1948, the Navy conveyed Tern Island to the Territory of Hawaii which then permitted the US Coast Guard in 1952 to establish a navigational Loran station (Yamase 1982). In 1979, USCG operations were terminated and the Hawaii State Legislature adopted resolutions requesting the Governor to take immediate action to acquire and return Tern Island for use as a fishing base to support commercial activities (Yamase 1982). The Federal government asserts that it retains jurisdiction over Tern Island based on Executive Order 1019 and that the Navy did not have the authority to legally convey title to the Territory of Hawaii, therefore, the conveyance is void (Yamase 1982).

Currently, the EEZ includes all waters surrounding CNMI from shore out to 200 miles. However, CNMI through the legal system is pursuing a claim for the U.S. to recognize Commonwealth authority out to 12 miles from the archipelagic baseline.

Guam

The Territory of Guam questions the legality of the transference of the Ritidian Unit to the USFWS. The U.S. Navy listed, in its property inventory to the General Services Administration, Ritidian Unit as excess lands, not of continual need and available for reversion to the Territory (Guthertz 2000). Therefore, the Territory asserts that the fee title should have been returned to the Territory and not the USFWS (Guthertz 2000).

PRIAs

In the PRIAs, primary jurisdiction over fisheries is an ongoing issue between the USFWS and WPRFMC. Management authority is currently unresolved because no clear baseline boundary has been designated for which the seaward boundary of the PRIAs are measured. Seaward boundaries are not clearly defined because some islands in the PRIAs do not appear to have a seaward boundary as defined by U.S. law (i.e., Magnuson, SLA)(Beuttler 1995). For this reason, jurisdictional boundaries have been claimed by federal agencies in terms of fathoms, miles or territorial seas. Furthermore, it is recognized that various Executive Orders have given administrative authority of the PRIAs to either the DOD or DOI. However, Executive Orders themselves do not convey title of submerged lands unless specifically stated, as in the case of Ritidian Unit in Guam. In any case, based on interpretation by the National Ocean and Atmospheric Administration legal counsel, Magnuson Act authority applies to all marine waters around Federally owned possessions (i.e., PRIAs), including marine resources within bays, inlets, and other marine waters to the shoreline (Beuttler 1995).

Additionally, because the NWRSAA does not itself contain a provision authorizing the President to withdraw land for a wildlife refuge, the DOI agues that the President could rely on the implied authority to reserve public lands recognized in *United States v. Midwest Oil Co.* 236, U.S. 459 (1915).[5] However, since the Federal Land and Policy Act (FLPMA) of 1976 repealed the President's authority, effective on and after approval of the Act, to make withdrawals and reservations resulting from the acquiescence of Congress (*U.S. v. Midwest Oil Co*.), it appears that since 1976 the President has not had the authority to establish or expand a wildlife refuge within the U.S. territorial sea (12 miles) or the EEZ using presidential authority recognized in *Midwest Oil* (Moss 2000). This could call into question asserted marine boundaries of any NWRs established after enactment of the FLPMA.

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Area	State/Territory		Commerce (WPRFMC)	Other Authorities		WPRFMC Coral Reef FMP Preferred Alternative (For Federal Waters Only) No-Take MPA	Low-Take MPA
Pacific Remote Islands Areas							
Howland Island			0-200 nmi	FWS	0-3 nmi	0-50 fm	
Baker Island			0-200 nmi	FWS	0-3 nmi	0-50 fm	
Jarvis Island			0-200 nmi	FWS	0-3 nmi	0-50 fm	
Johnston Island			0-200 nmi	FWS/Navy	0-3 nmi		0-50 fm*
Kingman Reef			0-200 nmi	Navy	0-3 nmi	0-50 fm	
Palmyra Atoll			0-200 nmi	FWS	0-3 nmi	0-50 fm	
Wake Island			0-200 nmi	Air Force	0-3 nmi		0-50 fm*
Midway Atoll			0-200 nmi	FWS 22x22 nmi quadrant		0-50 fm*	0-50 fm*
Hawaii							
Main Hawaiian Islands	Hawaii	0-3 nmi	3-200 nmi				
Nihoa	Hawaii	0-3 nmi	3-200 nmi	FWS	0-10 fm**	0-10 fm	10-50 fm
Necker	Hawaii	0-3 nmi	3-200 nmi	FWS	0-20 fm**	0-10 fm	10-50 fm
French Frigate Shoals	Hawaii	0-3 nmi	3-200 nmi	FWS	0-10 fm**	0-50 fm	
Gardner Pinnacles	Hawaii	0-3 nmi	3-200 nmi	FWS	0-10 fm**	0-10 fm	10-50 fm
Maro Reef	Hawaii	0-3 nmi	3-200 nmi	FWS	0-10 fm**	0-10 fm	10-50 fm
Laysan	Hawaii	0-3 nmi	3-200 nmi	FWS	0-10 fm**	0-50 fm	
Lisanski	Hawaii	0-3 nmi	3-200 nmi	FWS	0-10 fm**	0-10 fm	10-50 fm
Pearl and Hermes	Hawaii	0-3 nmi	3-200 nmi	FWS	0-10 fm**	0-10 fm	10-50 fm
Kure	Hawaii	0-3 nmi	3-200 nmi			0-10 fm	10-50 fm
Guam	Guam	0-3 nmi					
Ritidian Unit			0-200 nmi	FWS 100 ft. isobath			
Northern Mariana Islands	(CNMI	0-3 nmi***)	3-200 nmi				
American Samoa (A.S.)	A.S.	0-3 nmi	3-200 nmi				
Rose Atoll				FWS	0-3 nmi	0-50 fm	

* At Johnston, Wake and Midway, special permit fishing is only for recreational and on-island consumption.
At Midway, the north half of the atoll would be a no-take MPA and the south half a low-use MPA.

** Fish and Wildlife Service (FWS) boundary begins at the shoreline; legally defined boundary is unresolved

*** The Coral Reef Ecosystem Fishery Management Plan proposes to designate jurisdiction over 0-3 nmi to the Commonwealth of the Northern Mariana Islands while retaining jurisdiction over 3-200 nmi in the EEZ.

9.4 Draft Permit Application and Data Entry Forms

The following five forms and their associated directions are examples of the forms that will be required as specified earlier in this section. These forms have been generated by combining the suggestions from each advisory body. As the general permit and data entry forms will be implemented through a framework process at the recommendation of the Council, and the requirements of the special permit and data entry forms are determined on a case by case basis, these forms should only be viewed as examples of what will likely be required.

(Draft) General Coral Reef Ecosystem Fishing Permit Application Form

Date: ____/____/____

Applicant Information:

Name:_________________________________ Phone:_________________ Fax: ______________

Address:____

Street Apt # City State Zip Code

Vessel Name: ___________________ Home Port: ___________________

Length:___________ Net Tonnage:____________ Gross Tonnage:_____________

Vessel USCG Documentation / State License / Vessel Registration (circle one) Number:____________

Vessel operator:

Name:__________________________________ Phone:_________________ Fax: ______________

Address:____

Street Apt # City State Zip Code

Is this permit solely to transship coral reef ecosystem taxa received from another vessel around the EEZ of American Samoa, Guam, the main Hawaiian Islands or CNMI?_______

In which EEZ Management Subarea will fishing be conducted ? (circle only one)

Main Hawaiian Islands Guam American Samoa CNMI

Describe the fishing gear (size, amount, type, identification, intended usage).______________________

____

____

Target Species			Expected Incidental Species		
Species Name	Expected Catch (#, wt.)	Why harvested? [1]	Species Name	Expected Catch (#, wt.)	keep?

Use back, if necessary

[2] Food, ornamental, research, other

Attach any additional information to support approval of this application.

This information is true to the best of my knowledge.

Signature:_______________________________________

Return to: Pacific Islands Area Office, Southwest Region, NMFS;

Tel: (808) 973-2937; Fax: (808) 973-2941

(Draft) Instructions for General Coral Reef Ecosystem Fishing Permit Application Form

1. Date the application. A response will be sent to the applicant within 15 days after the receipt of a completed application.

2. Write the name of the vessel for which this permit will be affixed per CFR 660.13 (k). Circle the type of registration the vessel is under and give the appropriate number.

3. Specify whether this permit is for transshipment. If so, describe where and when transshipment will occur as well as which species are likely to be transhipped and for what purpose. This can be done as an attachment. No other information will be needed. Only sign the document. Vessels wishing to transship coral reef ecosystem management unit species shoreward of the outer boundary of the EEZ around the Northwestern Hawaiian Islands and remote U.S. Pacific island possessions must fill out a special permit application.

4. Specify the subarea in which fishing will take place. Each permit will be valid for fishing only in the fishery management subarea specified on the permit.

5. In describing the fishing gear, traps must have permanent legible identification. Describe what the identification is, if applicable. Describe how the gear intends to be deployed and retrieved.

6. List all target species in the table along with as much information for the remaining columns. If it is appropriate to give both numbers and weight for the catch, provide both. Any information on incidental catch from previous knowledge that is relevant should be included.

7. Sign

If an incomplete or improperly completed application is filed, the applicant will be sent a notice of deficiency. If the applicant fails to correct the deficiency within 30 days following the date of notification, the application will be considered abandoned.

(Draft) Special Coral Reef Ecosystem Fishing Permit Application Form

Applicant Information Date: ____/____/___

Name:_____________________________ Phone:______________ Fax: _______________

Address:____
Street Apt # City State Zip Code

Vessel Name: ___________________ Home Port: ___________________

Length:___________ Net Tonnage:____________ Gross Tonnage:_____________

Vessel USCG Documentation / State License / Vessel Registration (circle one)

Number:____________

Vessel operator:

Name:__________________________________ Phone:_____________ Fax: __________________

Address:____
Street Apt # City State Zip Code

Is this permit solely to transship coral reef ecosystem taxa received from another vessel around the EEZ of the Northwest Hawaiian Islands, the Pacific Remota Island Areas, or any other MPA?_______

Do you agree to accommodate an observer on board while fishing, if required?______

Does vessel have an individual Vessel Monitoring System?______

Does vessel have insurance covering removal/clean-up in event of a grounding?_____Name of Insurer:__________

Do you agree to submit data within 30 days of returning to port?______

Do you agree to submit additional data to NMFS if fishing in virgin fishing grounds?______

Circle any special exemption to which you qualify and would like to be eligible for under this permit application (attach description of conditions under which you apply to this document): Other FMP

Scientific Bioprospecting General Indigenous Indigenous use of live rock/coral Aquaculture seed stock of coral

In which EEZ Management Subarea will fishing be conducted ? (circle only one)

Main Hawaiian Islands Northwest Hawaiian Islands Guam Guam's Southern

American Samoa CNMI PRIA (specify all) __________________________

Estimated coral reef area affected (km^2):________

Describe the hours per day, days per season, and seasons you intend to fish. ______________________
____

Describe the specific approved fishing gear (size, amount, type, identification, intended usage). Include type of anchor and anchoring practices to be used.____
____

Target Species				Expected Incidental Species		
Species Name	Expected Catch (#, wt.)	How will it be processed?[1]	Why harvested? [2]	Species Name	Expected Catch (#, wt.)	keep?

Use back, if necessary; total expected catch during permit period for target species required for permit approval

[1]Live, fresh, frozen, preserved, other

[2] Food, ornamental, research, other

Attach statement regarding goals, new information likely to result, estimated ecosystem, essential fish habitat and protected species impacts, and any additional information to support approval of this application (be concise, please).

This information is true to the best of my knowledge. Signature:_____________________________

Return to: Pacific Islands Area Office, Southwest Region,
NMFS; Tel: (808) 973-2935; Fax: (808) 973-2941

(Draft) Instructions for Special Coral Reef Ecosystem Fishing Permit Application Form

1. Date the application. A response will be sent to the applicant within 15 days after the receipt of a completed application.

2. Write the name of the vessel for which this permit will be affixed per CFR 660.13 (k). Circle the type of registration the vessel is under and give the appropriate number.

3. Answer the five questions after the information for the vessel operator yes or no. Give the name of the insurer of the vessel for which this permit is being applied. All vessels fishing in a marine protected area must have insurance to cover removal and clean-up.

4. If you intend to harvest live rock or coral, additional information must be attached to show why you are eligible for this exemption. If you intend to harvest in an MPA designated for indigenous use, attach relevant information as well. Scientific and bioprospecting permits may require additional information. Those applying under these circumstances should contact the PIAO before submitting an application.

5. Describe as specifically as possible the expected effort and the seasons in which you will fish.

6. In describing the fishing gear, traps must have permanent legible identification. Describe what the identification is, if applicable. Describe how the gear intends to be deployed and retrieved. Also describe anchoring deployment and retrieval as well as locations intended to anchor.

7. List all target species in the table along with as much information for the remaining columns. If it is appropriate to give both numbers and weight for the catch, provide both. Total expected catch of the target species in weight and numbers is required for proper evaluation of the application. Any information on incidental catch from previous knowledge that is relevant should be included.

8. Sign

If an incomplete or improperly completed application is filed, the applicant will be sent a notice of deficiency. If the applicant fails to correct the deficiency within 30 days following the date of notification, the application will be considered abandoned.

(Draft) General Coral Reef Taxa Daily Catch Report

Name of Licensee:____________________ Coral Reef Ecosystem Permit No.___________________
Vessel Name:__________________ Radio Call Sign:________Vessel Number:___________________
Area Fished:_________________________ (follow regional fishing area designations, where applicable)
Type of Gear Used (one report form for each haul with each gear type per day):_________________
Date Gear Set: ____/____/____ Time at Start:_______ Units of Gear Set: ______
Date Gear Hauled: ____/____/____ Time at End: _______ Units of Gear Lost:______
Wind Speed:______ Wind Direction:______ Sea Surface Temperature:______ Average Depth:_____
Target Species (list all):____
If gear was lost, give explanation as to reason why (no penalty for lost gear).______________________
____

Describe any observed damage to the coral reef and how it occurred.___________________________
____
____
____

Species	No. Caught	Lbs. Caught	No. Kept	Lbs. Kept	If discarded, why ?	How processed?

Protected Species Observation			
Enter Seal & Turtle numbers; identify other in	Monk Seal	Turtle	Other
Observed in area			
Observed in vicinity of gear			
Interfering with fishing operations			
Preying on catch			
Entangled, released alive			
Entangled, released dead			

Print Name:_____________________ Signature:_______________________ Date:____/____/____

All information must be logged within 24 hours after the completion of the fishing day.
Submit this form to NMFS within 30 days of each landing of coral reef harvest.
NMFS Honolulu Laboratory, 2570 Dole St., Honolulu, HI 96822; fax: (808) 983-2902

(Draft) Instructions for General Coral Reef Taxa Daily Catch Report

1. From the coral reef ecosystem permit, record the permittee and permit number.

2. If the area fished has a specific regional designation, use it. Otherwise use an understandable description or latitudinal and longitudinal coordinates.

3. List units of gear lost and provide an explanation as to why (strong current, storm, bottom topography, etc). There is no penalty for lost gear. This information is solely used for management purposes.

4. Describe damage to the reef. Again, as long as operating within the regulations, there is no penalty for this. This information is solely used for management purposes.

5. Fill the table as specifically as practical. If a percentage of number or pounds kept is more appropriate, be as accurate in your estimate as possible. Give reasons for any discarded catch. Describe how processed (e.g., live, fresh, frozen, preserved, etc.).

6. Give numbers for all protected species observed in most appropriate box. Do not list same animal in two separate boxes for the same day. List it in the most specific category (generally more specific down the list).

7. All information must be logged, signed and dated within 24 hours after completion of the fishing day.

8. All daily catch reports must be submitted to NMFS within 30 days of landing catch.

(Draft) Special Permit/low-use Marine Protected Areas Coral Reef Taxa Daily Catch Report

Name of Licensee:_________________________Coral Reef Ecosystem Permit No.____________
Vessel Name:___________________ Radio Call Sign:________Vessel Number:____________________
Area Fished:______________________________ (follow regional fishing area designations)
Type of Gear Used (one report form for each haul with each gear type per day):_____________
Date Gear Set: ____/____/____ Time at Start:_______ Units of Gear Set: ______
Date Gear Hauled: ____/____/____ Time at End: _______ Units of Gear Lost:______
Wind Speed:______ Wind Direction:______ Sea Surface Temperature:______ Average Depth:_____
Target Species (list all):____
Observer on board?_______
If gear was lost, give explanation as to reason why (no penalty for lost gear).______________________
____
Describe any observed damage to the coral reef and how it occurred.___________________________
____
____

Species	No. Caught	Lbs. Caught	No. Kept	Lbs. Kept	If discarded, why ?	How processed?

Protected Species Observation

Enter Seal & Turtle numbers: identify other in appropriate box	Monk Seal	Turtle	Other
Observed in area			
Observed in vicinity of gear			
Interfering with fishing operations			
Preying on catch			
Entangled, released alive			
Entangled, released dead			

Print Name:_______________________Signature:_______________________ Date: ____/____/____
All information must be logged within 24 hours after the completion of the fishing day.
Submit this form to NMFS within 30 days of each landing of coral reef harvest.

NMFS Honolulu Laboratory, 2570 Dole St., Honolulu, HI 96822; fax: (808) 983-2902

(Draft) Instructions for Special Permit Coral Reef Taxa Daily Catch Report

1. From the coral reef ecosystem permit, record the permittee and permit number.

2. If the area fished has a specific regional designation, use it. Otherwise use an understandable description or latitudinal and longitudinal coordinates.

3. List units of gear lost and provide an explanation as to why (strong current, storm, bottom topography, etc). There is no penalty for lost gear. This information is solely used for management purposes.

4. Describe damage to the reef. Again, as long as operating within the regulations, there is no penalty for this. This information is solely used for management purposes.

5. Fill the table as specifically as practical. If a percentage of number or pounds kept is more appropriate, be as accurate in your estimate as possible. Give reasons for any discarded catch. Describe how processed (e.g., live, fresh, frozen, preserved, etc.).

6. Give numbers for all protected species observed in most appropriate box. Do not list same animal in two separate boxes for the same day. List it in the most specific category (generally more specific down the list).

7. All information must be logged, signed and dated within 24 hours after completion of the fishing day.

8. All daily catch reports must be submitted to NMFS within 30 days of landing catch.

(Draft) NMFS Transshipment Log for Coral Reef Ecosystem Management Unit Species

Vessel:___________________ Permit No.:___________________ Date: ____/____/____

(Vessel receiving fish)

Broker or Shipping Agent:____

Vessel:____________________________________ Radio Call Sign:________________

(Vessel offloading fish) Permit

Number:_________________

Total number of days fished:________ Type of Gear Used: _______________________

Average units of gear set per day:____________ Area of Catch:_____________________

Species	Number Received	Total Weight Received (Lbs.)

Print Name:_____________________ Signature:___________________ Date:____/____/____

(Vessel captain / operator)

All required information must be recorded on the form within 24 hours after the day of transshipment.

Submit report to National Marine Fisheries Service within 7 days following the date the vessel arrived in port to land transshipped fish.

NMFS Honolulu Laboratory, 2570 Dole St., Honolulu, HI 96822; fax: (808) 983-2902

(Draft) Instructions for Transshipment Log Report

1. Vessel receiving ship is the vessel registered to land or transship, shoreward of the outer boundary of the fishery management area, coral reef ecosystem management unit species that were harvested by a vessel in accordance with the CRE FMP.

2. Permit number is the number of the CRE fishing permit issued to the vessel owner by NMF.

3. Date is the month/day/year that the fish were offloaded to (received by) the vessel.

4. The broker/agent, if any, is the shipping agent handling the transshipment operations for the vessel.

5. Name the vessel offloading the fish (the vessel transferring fish to the receiving vessel).

6. If the vessel offloading fish is a fishing vessel, list type of gear used for fishing and average units of gear set per day. Also list the area (lat/long or sector) that was fished.

7. For each management unit species transferred, enter the number and total weight received.

8. Print the name of the vessel captain/owner submitting the report.

9. Sign and date upon completion of the form.

9.5 Draft Regulations

Purpose and Scope

This subpart, Subpart J implements the Fishery Management Plan for Western Pacific Coral Reef Ecosystems.

(a) The regulations in this subpart govern fishing for coral reef ecosystem resources by vessels of the United States that operate or are based inside the outer boundary of the EEZ off U.S. Pacific islands.

(b) General regulations governing fishing by all vessels of the United States and by fishing vessels other than vessels of the United States are contained in part 600 of this chapter.

660.12 Definitions

(See FMP for additional definitions)

Coral reef ecosystem management unit species means all of the taxa listed in the Table 3, Currently Harvested Coral Reef Ecosystem Management Unit Species, and Table 4, Potentially Harvested Coral Reef Ecosystem Management Unit Species, of this part and do not include the species defined as “bottomfish management unit species”, “crustaceans management unit species”, “Pacific pelagic management unit species” and “precious corals management species”:

Northwestern Hawaiian Islands means the EEZ of the Hawaiian Islands Archipelago lying to the west of 161º20'. For purposes of the regulations issued under this subpart, Midway Island is treated as part of the Northwestern Hawaiian Islands.

No-take marine protected area means an area of the EEZ that is closed to fishing/harvesting coral reef resources. The no-take areas designated in the Coral Reef FMP apply to harvesting of MUS from every Western Pacific Council Fishery Management Plan. These areas are defined as follows: Federal waters shallower than 10 fathoms in the Northwestern Hawaiian Islands and federal waters shallower than 50 fathoms around Jarvis Island (0˚23' S, 160˚01' W), Howland Island (0˚48' N lat., 176˚ 38' W long.), Baker Island (0˚ 13' N lat., 176˚38' W long.), Kingman Reef (6˚23' N lat., 162˚24' W long.), Palmyra Atoll (5˚53' N lat., 162˚05' W long.), Laysan Island (25˚ 45' N lat., 171˚45' W long.), French Frigate Shoals (23˚ 45' N lat., 166˚15' W long.), the North half of Midway Atoll (28˚ 45' N lat., 177˚22' W long.), and Rose Atoll (14˚ 33' S lat., 168˚09' W long.).

Low use marine protected area means an area of the EEZ where fishing/harvesting coral reef resources is allowed only under a special permit, as specified. Low-use areas are defined as the EEZ around the Northwestern Hawaiian Islands shallower than 50 fathoms which have not been designated no-take, waters shallower than 50 fathoms around Johnston Atoll (16˚45'

N lat., 169˚31' W long.), Wake Island (19° 18' N lat., 166° 35' E long.) and the southern half of Midway Atoll (28˚ 45' N lat., 177˚22' W long.).

Remote U.S. Pacific island possessions means the islands of Wake, Johnston, Howland, Baker, Jarvis, Palmyra and Kingman Reef.

Special permit means a permit issued to allow fishing of coral reef ecosystem resources in restricted marine protected areas and to fish for any potentially-harvested coral reef taxa.

Permit

Vessel Insurance

(a) *Applicability*.

(1) All fishing vessels operating or transiting in areas designated as marine protected areas shall be required to have insurance to cover the cost of vessel removal and pollution liability in the event of a grounding, depending on category of vessel, type of permit, and fishing area.

(2) Any vessel of the United States fishing for, taking or retaining coral reef ecosystem management unit species must have a special permit if that vessel is used:

(i) To fish for any coral reef ecosystem management unit species in restricted marine protected areas around the Northwestern Hawaiian Islands or remote U.S. Pacific island possessions, as defined in 660.12.

(ii) To fish for any non-harvested coral reef ecosystem management unit species in the EEZ around American Samoa, Guam, the main Hawaiian Islands, or the portion of the EEZ measured from a baseline drawn in such a manner that each point on it is 3 nautical miles from the Northern Mariana Islands; or

(iii) To transship, shoreward of the outer boundary of the EEZ around the Northwestern Hawaiian Islands and remote U.S. Pacific island possessions, coral reef ecosystem management unit species.

(iv) To fish for any coral reef ecosystem management unit species which has been specifically required to obtain a special permit through framework action.

(v) to fish for any coral reef ecosystem management unit species with any gear not specifically allowed in this subpart

(3) Exceptions:

(i) Any vessel fishing for MUS covered under a separate FMP does not need a permit as outlined by this FMP

(ii) Any vessel fishing for coral reef ecosystem MUS unless specifically enacted via a framework measure

(b) *Validity*. Each permit will be valid for fishing only in the fishery management subarea specified on the permit.

(c) *General requirements*. General requirements governing application information, issuance, fees, expiration, replacement, transfer, alteration, display, sanctions and appeals for permits are contained in 660.13.

(d) *Low use marine protected area special permit*. No direct or incidental harvest of coral reef ecosystem management unit species may be conducted in low use marine protected areas unless authorized by a special permit issued by the PIAO Administrator in accordance with the criteria and procedures specified in this section.

(1) *Application*. An applicant for a special permit must submit to the PIAO Administrator, at least 60 days before the desired date of permit action, a written application including, but not limited to, the following information:

(i) The date of the application.
(ii) The applicant's name, mailing address, and telephone number.
(iii) A statement of the purposes and goals of the fishing activity for which a special permit is needed, including a general description of the disposition of the resources harvested under the permit (i.e., stored live, fresh, frozen, preserved; sold for food, ornamental, research, or other use).
(iv) A statement of the new information about coral reef resources likely to result from the proposed fishing activity.
(v) For each vessel to be covered by a special permit:

(A) Vessel name
(B) Name, address, and telephone number of owner and operator
(C) USCG documentation, state license, or registration number
(D) Home port
(E) Length of vessel
(F) Net tonnage
(G) Gross tonnage
(H) Documentation of vessel insurance to cover cost of vessel removal and pollution liability

(vi) A description of the resources (directed and incidental) to be harvested under the special permit, the amount of such harvest, and estimated ecosystem-level, essential fish habitat, bycatch and protected species impacts of the proposed harvest.
(vii) For each vessel covered by the special permit

(A) The approximate times and places fishing will take place
(B) The type, size, and amount of fishing gear to be used
(C) Estimate of coral reef area affected by fishing

(D) Type of anchor and anchoring practices to be used

(E) Name of insurer and amount of insurance coverage against accidental grounding and oil spill

(viii) The signature of the applicant

(2) *Incomplete applications*. The PIAO Administrator may request from an applicant additional information necessary to make the determinations required under this section. An applicant will be notified of an incomplete application within 10 working days of receipt of the application. An incomplete application will not be considered until corrected in writing.

(3) *Issuance*.

(i) If an application contains all of the required information, the PIAO Administrator will forward copies of the application to the Council, the USCG, the fishery management agency of the affected state, and other interested parties, accompanied by the following information:

(A) The current utilization of domestic annual harvesting and processing capacity of the directed and incidental species for which a special permit is being requested.

(B) The current status of resources to be harvested (direct and incidental) in relation to the overfishing definition in the FMP

(C) Estimated ecosystem effects of the proposed activity

(D) Estimated essential fish habitat impacts of the proposed activity

(E) Estimated bycatch of proposed activity

(F) Estimated protected species impacts of the proposed activity

(G) And other biological and ecological information relevant to the proposal.

(ii) At a Council meeting following receipt of a complete application, the PIAO Administrator will consult with the Council and the Director of the affected state fishery management agency concerning the permit application and will receive the Council's recommendation for approval or disapproval of the application. The applicant will be notified in advance of the meeting at which the application will be considered, and invited to appear in support of the application, if the applicant desires.

(iii) Following a review of the Council's recommendation and supporting rationale, the Regional Administrator may:

(A) Concur with the Council's recommendation and, after finding that it is consistent with the goals and objectives of the FMP, the national standards, and other applicable laws, approve a special permit; or

(B) Reject the Council's recommendation, in which case, written reasons will be provided by the Regional Administrator to the Council for the rejection.

(iv) Within 30 working days after the consultation in paragraph (e)(4) of this section, or as soon as practicable thereafter, NMFS will notify the applicant in writing if the decision to grant or deny the special permit and, if denied, the reasons for the denial. Grounds for denial of a special permit include the following:

(A) The applicant has failed to disclose material information required, or has made false statements as to any material fact, in connection with his or her application.

(B) According to the best scientific information available, the harvest to be conducted under the permit would detrimentally affect any coral reef resource or coral reef ecosystem in a significant way.

(C) Issuance of the special permit would inequitably allocate fishing privileges among domestic fishermen or would have economic allocation as its sole purpose.

(D) Activities to be conducted under the special permit would be inconsistent with the intent of this section or the management objectives of the FMP.

(E) The applicant has failed to demonstrate a valid justification for the permit.

(F) The activity proposed under the special permit would create a significant enforcement problem.

(G) The applicant has failed to provide documentation of vessel insurance which provides for the cost of vessel removal and pollution liability.

(v) The Regional Administrator may attach terms and conditions to the special permit, if it is granted, consistent with the management objectives of the FMP, including but not limited to:

(A) The maximum amount of each resource that can be harvested and landed during the term of the special permit, including trip limits, where appropriate.

(B) The number, sizes, names and identification numbers of the vessels authorized to conduct fishing activities under the special permit.

(C) The times and places where fishing may be conducted.

(D) The type, size, and amount of gear which may be used by each vessel operated under the special permit.

(E) Data reporting requirements.

(F) Such other conditions as may be necessary to ensure compliance with the purposes of the special permit consistent with the objectives of the FMP.

(4) *Duration*. Unless otherwise specified in the special permit or a superceding notice or regulation, a special permit is effective for no longer than one year, unless revoked, suspended, or modified. Special permits may be renewed following the general procedures in section 660.13.

(5) *Alteration*. Any special permit that has been altered, erased, or mutilated is invalid.

(6) *Validity*. A permit is valid only for the particular vessel(s) named in the application.

(7) *Inspection*. Any special permit must be carried aboard the vessel(s) for which it was issued. The special permit must be presented for inspection upon request of any authorized officer.

(8) *Sanctions*. Failure of the holder of a special permit to comply with the terms and conditions of a special permit, the provisions of section 660.13, any other applicable provisions of this part, the Magnuson Act, or any other regulation promulgated thereunder, is grounds for revocation, suspension, or modification of the special permit with respect to all persons and vessels conducting activities under the special permit. Any action taken to revoke, suspend, or modify a special permit will be governed by 15 CFR part 904 subpart D. Other sanctions available under the statute will be applicable.

(9) *Protected species*. Persons fishing under a special permit must report any incidental take or fisheries interaction with protected species (i.e., all species of sea turtles, seabirds and marine mammals) on a form provided for that purpose. Reports must be submitted to the Regional Administrator within 3 days of arriving in port.

(10) *Appeals of permit actions*.

(i) Except as provided in subpart D of 15 CFR part 904, any applicant for a permit or a permit holder may appeal the granting, denial, conditioning, or suspension of their permit or a permit affecting their interests to the Regional Administrator. In order to be considered by the Regional Administrator, such appeal must be in writing, must state the action(s) appealed, and the reasons therefore, and must be submitted within 30 days of the original action(s) by the Regional Administrator. The appellant may request an informal hearing on the appeal.

(ii) Upon receipt of an appeal authorized by this section, the Regional Administrator will notify the permit applicant, or permit holder as appropriate, and will request such additional information and in such form as will allow action upon the appeal. Upon receipt of sufficient information, the Regional Administrator will decide the appeal in accordance with the permit eligibility criteria set forth in this section and the FMP, as appropriate, based upon information relative to the application on file at NMFS and the Council and any additional information, the summary record kept of any hearing and the hearing officer's recommended decision, if any, and such other considerations as deemed appropriate. The Regional Administrator will notify all interested persons of the decision, and the reasons therefor, in writing, normally within 30 days of the receipt of sufficient information, unless additional time is needed for a hearing.

(iii) If a hearing is requested, or if the Regional Administrator determines that one is appropriate, the Regional Administrator may grant an informal hearing before a hearing officer designated for that purpose after first giving notice of the time, place, and subject matter of the hearing in the Federal Register. Such a hearing shall normally be held no later than 30 days following publication of the notice in the Federal Register, unless the hearing officer extends the time for reasons deemed equitable. The appellant, the applicant (if different), and, at the discretion of the hearing officer, other interested persons, may appear personally or be represented by counsel at the hearing and submit information and present arguments as determined appropriate by the hearing officer. Within 30 days of the last day of the hearing, the hearing officer shall recommend in writing a decision to the Regional Administrator.

(iv) The Regional Administrator may adopt the hearing officer's recommended decision, in whole or in part, or may reject or modify it. In any event, the Regional Administrator will notify interested persons of the decision, and the reason(s) therefore, in writing, within 30 days of receipt of the hearing officer's recommended decision. The Regional Administrator's action constitute final action for the agency for the purposes of the Administrative Procedures Act.

(v) Any time limit prescribed in this section may be extended for a period not to exceed 30 days by the Regional Administrator for good cause, either upon his or her own motion or upon written request from the appellant or applicant stating the reason(s) therefore.

(11) *Fees*. A fee is charged for each application for a restricted marine protected area special permit, including permit transfers and permit renewals. The amount of the fee is calculated in accordance with the procedures of the NOAA Finance Handbook, available from the Regional Administrator, for determining the administrative costs of each special product or service. The fee may not exceed such costs and is specified with each application form. The appropriate fee must accompany each application. Failure to pay the fee will preclude issuance of a special permit.

Reporting and recordkeeping

(a) *Fishing report forms*. The operator of any fishing vessel subject to the requirements in these regulations must maintain on board the vessel an accurate and complete record of catch, effort, and other data on report forms provided by the PIAO Administrator (see sample report form at Section 11.8 of FMP). All information specified on the forms must be recorded within 24 hours after completion of each fishing day. The original logbook form for each day of the fishing trip must be submitted to NMFS PIAO within 3 days of each landing of management unit species. Each form must be signed and dated by the fishing vessel operator.

(b) *Transshipment logbooks*. Any holder of a special permit and who is engaged in transshipment of coral reef resources in the EEZ must maintain on board the vessel an accurate and complete NMFS transshipment logbook containing report forms provided by the Regional Administrator. All information specified on the forms must be recorded on the forms within 24 hours after the day of transshipment. The original logbook for each day of transshipment activity must be submitted to the PIAO Administrator within 7 days of each landing of management unit species. Each form must be signed and dated by the receiving vessel operator.

(c) *State reporting*. Any person who has a Coral Reef Ecosystem permit and who is required by state laws and regulations to maintain and submit records of catch and effort, landings and sales for coral reef ecosystem management unit species must:

(1) Maintain and submit those records in the exact manner required by state laws and regulations; and

(2) Make those records immediately available for Federal inspection and copying upon request by an authorized officer.

Prohibitions

In addition to the prohibitions in 600.725 of this chapter, it is unlawful for any person to:

(a) Fish for, take, retain, possess or land any coral reef resource in any portion of the management area as defined in 660.12 unless:

(1) A valid permit has been issued for the fishing vessel and area, as specified;

(2) A permit is not required, as outlined in the permit section of these regulations; or

(3) The coral reef resources possessed on board the vessel originated outside the management area and this can be demonstrated through receipts of purchase, invoices, fishing logbooks or other documentation.

(b) Fish for, take, or retain any coral reef ecosystem resource:

(1) That is determined overfished and announced by the Regional Administrator
(2) By means of gear or methods prohibited under Allowable and restricted gear in this subpart.
(3) In no take marine protected areas.
(4) In low use marine protected areas unless a valid special permit has been issued
(5) In violation of any permit issued under 660.13 or in the permit section of this subpart.

(c) Fish for, take, or retain any wild live rock or live hard coral for commercial purposes except under a valid special permit for scientific research, aquaculture seed stock collection or traditional and ceremonial purposes by indigenous people.

(d) Engage in fishing without a valid permit or facsimile of a valid permit on board the vessel and available for inspection by an authorized officer, when a permit is required under 660.13 or in the permit section of this subpart, unless the vessel was at sea when the permit was issued, in which case the permit must be on board the vessel before its next trip.

(e) File false information on any application for a general permit under 660.13 or a special permit.

(f) Fail to file reports in the exact manner required by an state law or regulation, as required, provided that the person is required to do so by applicable state law or regulation.

(g) Falsify or fail to make, keep, maintain, or submit any logbook or logbook form or other record or report required.

(h) Refuse to make available to an authorized officer or designee of the Regional Administrator for inspection or copying, any records that must be made available.

(i) Fail to affix or maintain vessel or gear markings, as required

(j) Violate a term or condition of a special permit.

(k) Fail to report any take or interaction with protected species as required.

(l) Fail to notify officials as required.

Vessel Identification

(a) The operator of each fishing vessel that is granted a special permit must:

(1) Display its official number on the port and starboard sides of the deckhouse or hull, and on an appropriate weather deck, so as to be visible from enforcement vessels and aircraft.

(2) Ensure that the official number is clearly legible and in good repair.

(3) Ensure that no part of the vessel, its rigging, or its fishing gear obstructs the view of the official number from an enforcement vessel or aircraft.

Notifications

(a) *Before fishing in low-use marine protected area.* The permit holder for a fishing vessel subject to the requirements of the special permit, or agent designated by the permit holder, shall provide a notice to the Regional Administrator at least 72 hours (not including weekends and Federal holidays) before the vessel leaves port on any fishing trip, any part of which occurs in any portion of the EEZ designated as a low-use marine protected area. The vessel operator will be presumed to be an agent designated by the permit holder unless the PIAO Administrator is otherwise notified by the permit holder. The notice must be provided to the office or telephone number designated by the PIAO Administrator. The notice must provide the official number of the vessel, the name of the vessel, the intended departure date, time, and location, the name of the operator of the vessel, and the name and telephone number of the agent designated by the permit holder to be available between 8:00 a.m. to 5 p.m. (Hawaii time) on weekdays for NMFS to contact.

(b) *Before landing after fishing in restricted marine protected area.* The operator of a fishing vessel that has been granted a special permit under 660.xxx and that has made a trip that harvested coral reef resources in a low use marine protected area must contact NMFS Enforcement at least 24 hours before landing, and report the port and the approximate date and time at which the coral reef resources harvested on the trip will be landed.

Allowable and Restricted Gear

(a) *Allowable gear and methods*. Coral reef ecosystem resources may be taken only with allowable gear and methods, as follow:

(1) Hand collection
(2) Hook and line, except for longline
(3) Rod and reel
(4) Dip net
(5) Scoop net
(6) Slurp gun
(7) Use of barrier net for the collection of ornamental fish only
(8) Use of spear when diving without SCUBA
(9) Use of spear when SCUBA diving from 6 am to 6 pm only.
(10) No use of fish traps or Kona crab traps unless marked of owner's identification on traps
(11) No use of surround nets or seine nets unless nets are attended by swimmers or divers
(12) Remotely operated vehicle
(13) Submersible, manned or unmanned

(b) *Poisons, explosives, intoxicating substances*. Coral reef resources may not be taken by means of poisons, explosives, or intoxicating substances. Possession of these materials by any vessel having a coral reef ecosystem permit or that is otherwise established to be fishing for coral reef ecosystem resources in the EEZ is prohibited.

(c) *Spearfishing with scuba.* Coral reef resources may not be taken by means of spearfishing with SCUBA at night in the Northwestern Hawaiian Islands or the Pacific Remote Island Areas.

(d) *Possession of gear*. Possession or use of trawl nets, gill nets, hookah breathers, and any other gear that is not expressly allowed under these regulations by any vessel holding a permit or that is otherwise established to be fishing for coral reef ecosystem resources in the EEZ is prohibited.

Unattended gear and gear identification

(a) *Identification*. The owner's identification must be marked legibly on all fish and crab traps on board the vessel or deployed in the water by any vessel holding a permit under section 660.13 or in this subpart or that is otherwise established to be fishing for coral reef ecosystem resources in the EEZ.

(b) *Enforcement action*.

(1) Unattended traps not marked in compliance with these regulations and found deployed in the EEZ will be considered unclaimed or abandoned property, and may be disposed of in any manner considered appropriate by NMFS or an authorized officer.

(2) Unattended surround nets or bait seine nets found deployed in the EEZ will be considered unclaimed or abandoned property, and may be disposed of in any manner considered appropriate by NMFS or an authorized officer.

Area restrictions

(a) Fishing for coral reef ecosystem resources is prohibited:

(1) Within the EEZ landward of the 10-fathom curve, as depicted on National Ocean Survey Charts, Numbers 19016, 19019 and 19022, around the Northwestern Hawaiian Islands.

(2) Within the EEZ landward of the 50-fathom curve, as depicted on National Ocean Survey Charts, Numbers 19019, 19401 and 19481, around the Northwestern Hawaiian Islands of Laysan, French Frigate Shoals, and the north half of Midway, as defined in the no-take Marine Protected Area definition.

(3) Within the EEZ landward of the 50-fathom curve, as depicted on National Ocean Survey Charts, Numbers 83116, 83153 and 83157, around the Pacific Remote Island Areas of Jarvis, Howland and Baker Islands, Palmyra Atoll and Kingman Reef as defined in the no-take Marine Protected Area definition.

(4) Within the EEZ landward of the 50-fathom curve, as depicted on National Ocean Survey Charts, Number 83484, around Rose Atoll, as defined in the no-take Marine Protected Area definition.

(b) Fishing for coral reef ecosystem resources in restricted marine protected areas is allowed only by vessels for which a special permit has been issued:

(1) Within the EEZ to an inner boundary coterminous with the 10-fathom curve, as depicted on National Ocean Survey Charts, Numbers 19016, 19019 and 19022, around the Northwestern Hawaiian Islands, except for the EEZ landward of the 50-fathom curve around Laysan, French Frigate Shoals, and the north half of Midway, as defined in 660.12.

(2) Within the EEZ, as depicted on National Ocean Survey Charts, Numbers 83637 and 81664, around the Pacific Remote Island Areas of Johnston Atoll and Wake Island.

(c) Anchoring by fishing vessels over 50 feet in overall length is prohibited in the EEZ seaward of the Territory of Guam west of 144.5 E longitude except:

(1) In the event of a emergency caused by ocean conditions or by a vessel malfunction that can be documented.

Framework for regulatory adjustments

(a) *Annual reports*. By July 31 of each year, a Council-appointed coral reef ecosystem monitoring team will prepare an annual report covering the following topics:

(1) Fishery performance data, with detailed catch-effort information for target, non-target (incidental) resources and bycatch.
(2) Summary of new coral reef resource information obtained from fishery-dependent and non-fishery dependent sources.
(3) Essential fish habitat conditions and sources of degradation including fishing and non-fishing impact to EFH and HAPC in all areas.
(4) Coral reef ecosystem-level impacts associated with fishing activities regulated under other fishery management plans
(5) Enforcement activities and problems.
(6) Administrative actions (e.g., data collection and reporting, permits).
(7) State and territorial management actions.
(8) Assessment of need for Council action (including biological, economic, social, enforcement, administrative, and state/territorial/Commonwealth/ Federal needs, problems, and trends). Indication of potential problems warranting further investigation may be signaled by the following indicator criteria:
(i) Significant change in habitat structure or stability.
(ii) Significant change in trophic structure or biodiversity.
(iii) Significant change in interactions among different fisheries.
(iv) Significant change in mean size of the catch of any species or species group
(v) Significant change in catch per unit effort for any species or species group.
(vi) Significant change in gear types or methods of fishing.
(vii) Interactions with protected species
(viii) Significant coral reef ecosystem cumulative effects
(9) Recommendation for Council action.
(10) Estimated impacts of recommended action.

The coral reef ecosystem monitoring team may present management recommendations to the Council at any time. If the recommendations relate to potential or actual coral reef ecosystem-level impacts associated with fishing activities permitted under other FMPs, the team will confer with other monitoring teams. Consultation between different teams may result in recommendations for management action under other FMPs. Recommendations by monitoring team for the CRE-FMP may cover actions suggested for Federal regulations, state/territorial/Commonwealth action, enforcement or administrative elements, and research and data collection.

(b) *Recommendation of management action.*

(1) The Council will evaluate the team's reports and recommendations and may recommend management action by either the State/territorial/Commonwealth governments or by Federal regulation.

(2) If the Council believes that management action should be considered, it will make specific recommendations to the Regional Administrator after requesting and considering the views of its Scientific and Statistical Committee and Ecosystem and Habitat Advisory Panel. The Council will assess the need for one or more of the following types of Federal management action:

(i) *Procedure for established measures*.

(A) Established measures are management measures that, at some time, have been included in regulations implementing the FMP, or for which the impacts have been evaluated in Council/NMFS documents in the context of current conditions.

(B) Following framework procedures of the CRE-FMP, the Council may recommend to the Regional Administrator that established measures be modified, removed, or re-instituted. Such recommendation shall include supporting rationale and analysis, and shall be made after advance public notice, public discussion and consideration of public comment. NMFS may implement the Council's recommendation by rule making if approved by the Regional Administrator.

(ii) *Procedure for new measures*.

(A) New measures are management measures that have not been included in regulations implementing the FMP, or for which the impacts have not been evaluated in Council/NMFS documents in the context of current conditions. New measures include but are not limited to catch limits, resource size limits, closures, effort limitations, permit requirements, reporting and recordkeeping requirements.

(B) Following the framework procedures of the FMP, the Council will publicize, including by Federal Register notice, and solicit public comment on, any proposed new management measure. After a Council meeting at which the measure is discussed, the Council will consider recommendations and prepare a Federal Register notice summarizing the Council's deliberations, rationale, and analysis for the preferred action, and the time and place for any subsequent Council meeting(s) to consider the new measure. At subsequent public meeting(s), the Council will consider public comments and other information received to make a recommendation to the Regional Administrator about any new measure. NMFS may implement the

Council's recommendation by rule making if approved by the Regional Administrator.

(2) The Regional Administrator will consider the Council's recommendation and supporting rationale and analysis, and, if he or she concurs with the Council's recommendation, will propose regulations to carry out the action. If the Regional Administrator rejects the Council's proposed action, a written explanation for the denial will be provided to the Council within two weeks of the decision.

(3) The Council may appeal denial by writing to the Assistant Administrator, who must respond in writing within 30 days.

(4) The Regional Administrator and the Assistant Administrator will make their decisions in accord with the MSFCMA, other applicable laws, and the CRE-FMP.

(5) To minimize conflicts between the Federal and state/territorial/commonwealth management systems, the Council will use the procedures in paragraph (b) in this section to respond to state/territorial/commonwealth management actions. Council consideration of action would normally begin with a representative of the state, territorial or commonwealth government bringing a potential or actual management conflict or need to the Council's attention.

Management Subareas

(a) The fishery management area is divided into six subareas for the regulation of fishing for coral reef ecosystem management unit species:

(1) Main Hawaiian Islands means the EEZ of the Hawaiian Islands Archipelago lying to the east of 161°20' long.

(2) Northwestern Hawaiian Islands means the EEZ of the Hawaiian Islands Archipelago lying to the west of 161°20'. For purposes of the regulations issued under this subpart, Midway Island is treated as part of the Northwestern Hawaiian Islands.

(3) Guam means the EEZ seaward of the Territory of Guam.

(4) American Samoa means the EEZ seaward of the Territory of American Samoa.

(5) Commonwealth of the Northern Mariana Islands (CNMI) means that portion of the EEZ seaward from a baseline line drawn 3 nautical miles offshore of the Northern Mariana Islands.

(6) Remote U.S. Pacific island possessions means the EEZ seaward of the islands of Johnston, Wake, Palmyra, Kingman Reef, Howland, Jarvis and Baker.

(b) The inner boundary of the fishery management area is a line coterminous with the shoreline of the Midway Islands, and the Remote U.S. Pacific Island Possessions, with the seaward boundaries of the State of Hawaii, the Territory of Guam, the Territory of American Samoa, and with a baseline drawn 3 nautical miles offshore of the Commonwealth of the Northern Mariana Islands.

(c) The outer boundary of the fishery management area is a line drawn in such a manner that each point on is 200 nautical miles from the baseline from which the territorial sea is measured, or is coterminous with adjacent international maritime boundaries. The outer boundary of the fishery management area north of Guam will extend to those points which are equidistant between Guam and the island of Rota in CNMI.

9.5.1 Draft Regulations for other western Pacific fisheries Fishery Management Plans

The Coral Reef Ecosystem Fishery Management Plan amends the Bottomfish and Seamount Groundfish, Crustaceans, Pacific Pelagics and the Precious Corals Fishery Management Plans in regards to no-take areas defined in the Coral Reef Ecosystem FMP and in the CFR 660.12 definitions for western Pacific fisheries.

The CFR 660 Subpart C, Western Pacific Pelagic Fisheries, will be amended with the addition of the following line in 660.22 (Prohibitions):

> 660.22 (z) Fish for Pacific pelagic management unit species in any no-take marine protected area as defined in 660.12.

The CFR 660 Subpart D, Western Pacific Crustacean Fisheries, will be amended with the addition of the following line in 660.42 (Prohibitions):

> 660.42 (c) Fish for, take or retain Crustacean management unit species in any no-take marine protected area as defined in 660.12.

The CFR 660 Subpart E, Bottomfish and Seamount Groundfish Fisheries, will be amended with the addition of the following line in 660.62 (Prohibitions):

> 660.62 (g) Fish for bottomfish management unit species in any no-take marine protected area as defined in 660.12.

The CFR 660 Subpart F, Precious Corals Fisheries, will be amended with the addition of the following line in 660.82 (Prohibitions):

> 660.82 (d) Harvest any precious coral management unit species in any no-take marine protected area as defined in 660.12.

Table 3 to Part 660. – Currently Harvested Coral Reef Ecosystem Management Unit Species

Acanthuridae	Yelloweyed surgeonfish (*Ctenochaetus strigosus*) Orangespot surgeonfish (*Acanthurus olivaceus*) Yellowfin surgeonfish (*Acanthurus xanthopterus*) Convict tang (*Acanthurus triostegus*) Eye striped surgeon fish (*Acanthurus dussumieri*) Unicornfish (*Naso spp.*)
Balistidae	Triggerfish (*Xyrichthys pavo*)

Carcharhinidae	Gray reef shark (*Carcharhinus amblyrhynchos*)
Holocentridae	Soldierfish (*Myripristis spp*.)
Kuhliidae	Hawaiian flag-tail (*Kuhlia sandvicensis*)
Kyphosidae	Rudderfish (*Kyphosus spp*)
Labridae	Napoleon wrasse (*Cheilinus undulatus*) Saddleback hogfish (*Bodianus bilunulatus*) (*Xyricthys* spp.)
Lethrinidae	<u>Smalltooth emperor (*Lethrinus microdon*)</u>
Mullidae	Goatfish (*Mulloidichthys spp.*) Striped mullet *(Mugil cephalus*) Yellowfin goatfish (*Mulloidichthys vanicolensis*) Goatfish (*Parupeneus porphyreus*) -Ku-mu Multi-barred goatfish (*Parupeneus multifaciatus*)
Octopodidae	Octopus (*Octopus cyanea, O. ornatus*)
Polynemidae	Threadfin (*Polydactylus sexfilis*) – Moi
Priacanthidae	Bigeye (*Priacanthus spp.*)
Scaridae	Bumphead parrotfish (*Bolbometopon muricatum*) Parrotfishes (*Scarid spp.*)
Serranidae	Groupers/Sea Bass (*Cephalopholis spp*.) Groupers/Sea Bass (*Epinephelus spp.*)
Sphyraenidae	Barracuda (*Sphyraena helleri*)

Aquarium Taxa/Species	Yellow tang (*Zebrasoma flavescens*) Yellow-eyed surgeon fish (*Ctenochaetus strigosus*) Achilles tang (*Acanthurus achilles*) Morrish idol (*Zanclus cornutus*) Masked angel (*Genicanthus personatus*) Angelfish (*Centropyge shepardi* and *C. flavissimus*) Dragon eel (*Enchelycore pardalis*) Flame hawkfish (*Neocirrhitus armatus*) Butterflyfish (*Chaetodon auriga, C. lunula, C. melannotus* and *C. ephippium*) Damselfish (*Chromis viridis, Dascyllus aruanus* and *D. trimaculatus*) Turkeyfish (*Pterois sphex*) Featherduster worm (*Sabellidae*)

* Currently harvested MUS were identified by their presence on catch reports from fisheries in federal waters.

Table 4 to Part 660. – Potentially Harvested Coral Reef Ecosystem Management Unit Species

Other Labridae spp. (wrasses)	Ephippidae (batfish)
Carcharhinidae, Sphyrnidae, *Triaenodon obesus* (sharks), except those managed under PFMP	Monodactylidae (mono)
Dasyatididae, Myliobatidae, Mobulidae (rays)	Haemulidae (sweetlips)
Other Serranidae spp. (groupers) except those managed under BFMP	Echineididae (remoras)
Carangidae (jacks/trevallies), except those managed under BFMP	Malacanthidae (tilefish)
Decapterus/Selar spp. (scads)	Acanthoclinidae (spiny basslets)
Other Holocentridae spp. (soldierfish/squirrelfish)	Pseudochromidae (dottybacks)
Other Mullidae spp. (goatfish)	Plesiopidae (prettyfins)
Other Acanthuridae spp. (surgeonfish/unicornfish)	Tetrarogidae (waspfish)
Other Lethrinidae spp. (emperors), except those managed under BFMP	Caracanthidae (coral crouchers)
Muraenidae, Chlopsidae, Congridae, Moringuidae, Ophichthidae (eels)	Grammistidae (soapfish)
Apogonidae (cardinalfish)	*Aulostomus chinensis* (trumpetfish)
Other Zanclidae spp. (moorish idols)	*Fistularia commersoni* (coronetfish)
Other Chaetodontidae spp. (butterflyfish)	Anomalopidae (flashlightfish)
Other Pomacanthidae spp. (angelfish)	Clupeidae (herrings)
Other Pomacentridae spp. (damselfish)	Engraulidae (anchovies)
Scorpaenidae (scorpionfish)	Gobiidae (gobies)
Blenniidae (blennies)	Lutjanids, except those managed under BFMP
Other Sphyraenidae spp. (barracudas)	Other Ballistidae/Monocanthidae spp.
Pinguipedidae (sandperches)	Siganidae
Gymnosarda unicolor	Other Kyphosidae spp.
Bothidae/Soleidae/Pleurnectidae (flounder/sole)	Caesionidae
Ostraciidae (trunkfish)	Cirrhitidae
Tetradontidae/Diodontidae (puffer/porcupinefish)	Antennariidae (frogfishes)
	Syngnathidae (pipefishes/seahorses)
Stony corals	Echinoderms (e.g., sea cucumbers, sea urchins)

Heliopora (blue)	Mollusca
Tubiphora (organpipe)	Sea Snails (gastropods)
Azooxanthellates (non-reefbuilders)	Trochus spp.
Fungiidae (mushroom corals)	Opistobranchs (sea slugs)
Sm/Lg Polyped Corals (endemic spp.)	*Pinctada margaritifera* (black lipped pearl oyster)
Millepora (firecorals)	Tridacnidae
Soft corals and Gorgonians	Other Bivalves
Anemones (non-epifaunal)	Cephalopods
Zooanthids	Crustaceans, except those managed under CFMP
Sponges (non-epifaunal)	Lobsters, except those managed under CFMP
Hydrozoans	Shrimp/Mantis
Stylasteridae (lace corals)	Crabs
Solanderidae (hydroid fans)	Annelids
Bryozoans	Algae
Tunicates (solitary/colonial)	Live rock
All other coral reef ecosystem marine plants, invertebrates and fishes not listed under existing FMPs.	

9.6 Catalogue of Fishing Gear and Impacts on EFH

Definitions

Hook and Line Methods

Albacore trolling means fishing consisting of towing or dragging multiple lines with artificial lures with a vessel underway.

Buoy gear means fishing gear consisting of a float and one or more lines suspended therefrom. A hook or hooks are on the lines at or near the end. The float and line(s) drift freely and are retrieved periodically to remove catch and rebait hooks.

Casting means fishing from shore or a vessel using a pole and casting reel. Includes techniques such as whipping, jigging, dunking, slide baiting, fly-fishing or any technique using a pole and line.

Deep-sea handline means fishing from a vessel using a vertical mainline with single/multiple baited hooks and weight, lowered near the bottom.

Flagline (Longline) means fishing with a mainline one nautical mile or longer in length, suspended horizontally from the surface by floats from which branch lines with baited hooks are attached.

Floatline means fishing using a horizontal mainline, less than one nautical mile in length and suspended from the ocean surface with floats, from which leaders with baited hooks are suspended.

Handline means fishing gear that is set and pulled by hand and consists of one vertical line to which may be attached leader lines with hooks.

Hook and line means one or more hooks attached to one or more lines (can include a troll). Bandit gear means vertical hook and line gear with rods that are attached to the vessel when in use. Lines are retrieved by manual, electric, or hydraulic reels.

Ika-Shibi means fishing (mainly at night) using a vertical mainline with high-test monofilament leader, from which is suspended a baited hook. Muhe'e ("true squid") or opelu typically used as bait.

Inshore handline same as deep-sea handline to include artificial lures (damashi). With the exception of fishing tackle usually consisting of lighter gear than deep-sea handline.

Kaka line (set line) means fishing with a mainline less than one nautical mile in length from which branch lines of baited hooks are attached. Line is set horizontally, on or near the bottom, or in shallow mid water.

Longline means a line that is deployed horizontally and to which gangions and hooks or pots are attached. Longlines can be stationary, anchored, or buoyed lines that may be hauled manually, electrically, or hydraulically.

Palu Ahi (similar to “Ika-shibi”) means fishing (usually daytime) with a baited hook and cut pieces of bait (“chum”). This method also includes the use of “danglers” for reporting purposes

Pole and line (Aku boat) means fishing for aku (skipjack tuna) using live bait and artificial lures. Fish are hooked with pole and line, using a barb less hook (feathered, baited or not).

Rod and reel means a hand-held (including rod holder) fishing rod with a manually or electrically operated reel attached.

Tuna handline means a mixture of fishing methods used to catch pelagic species primarily on offshore sea-mounts and near NOAA weather buoys. It is generally a combination of hand-lining, trolling, and baiting techniques used simultaneously.

Trolling means fishing by towing or dragging line(s) with artificial lure(s) or dead or live bait using a sail, surf or motor-powered vessel.

a) Trolling with Bait: Trolling with bait (dead or alive.)
b) Trolling with Lures: Trolling with artificial lures.c)
c) Trolling with Green Stick: Trolling with the bird, green stick and danglers.

Nets:

Aquarium Collecting means fishing with small meshed nets, except throw-nets, and small meshed traps for aquatic life that is kept alive for display.

Bait net means a seine net with very small mesh used to catch certain kinds of fish for bait.

Barrier net means a small-mesh net used to capture coral reef or coastal pelagic fishes.

Bullpen trap means net(s) fixed in position to form a large stationary enclosure.

Bully net means a circular frame attached at right angles to a pole and supporting a conical bag of webbing.

Cast net means a circular net with weights attached to the perimeter.

Cast net (Talaya) means a circular net with weights or chain around the perimeter which is thrown for the purpose of taking or capturing marine animals

Crab net means a small lift net that is used to catch crabs.

Dip net means a small mesh bag, sometimes attached to a handle, shaped and framed in various ways. It is operated by hand or partially by mechanical power to capture the fish.

Gillnet means a panel of netting, suspended vertically in the water by floats along the top and weights along the bottom, to entangle fish that attempt to pass through it.

Gill net (fence net, cross net, lay net, and pai pai net, etc.) means a curtain like net suspended in the water with mesh openings large enough to permit only the heads of the fish to pass through, ensnaring them around the gills when they attempt to escape.

Gill net (tekin) means any net in which the mechanism for capturing fish is entanglement

Hoop net means a cone-shaped net having throats and flues stretched over a series of rings or hoops for support.

Kona crab net means a fine stranded netting stretched over a metal frame to form a flat net. Multiple baited nets are set on sandy bottoms trapping crabs when they get entangled in the mesh.

Lift net means a net that captures fish by raising the net from beneath a school of fish. Normally fish are encouraged over and into the net with chum.

Lampara net means a surround net with the sections of netting made and joined to create bagging. It is hauled with purse rings and is generally much smaller in size than a purse seine net.

Lobster net means a net with large eye mesh used to entangle lobsters.

Purse seine means a floated and weighted encircling net that is closed by means of a drawstring threaded through rings attached to the bottom of the net.

Purse seine net means a net that is used to surround a school of fish and is closed by drawing the bottom of the net together to form a bag.

Set net means a stationary, buoyed, and anchored gill net

Seine net means a net with long narrow wings, that is rigged with floats and weights.

Seine net (hukilau, beach seine, dragnet, pen, surround, etc.) Fishing with a net by moving it through the water to surround fish by corralling and trapping them within the walls of the net.

Surround net (Chenchulum Managam) means any vertical net set to act as a barrier to detain fish in which the fish are not gilled by the net. A surround net is not pursed and therefore is not a type of purse seine

Throw net means a round shaped weighted outer perimeter net that is thrown over fish.

Trammel net means a net consisting of two or more panels of netting, suspended vertically in the water column by a common float line and a common weight line. One panel of netting has a larger mesh size than the other(s) in order to entrap fish in a pocket.

Trawl means a cone or funnel-shaped net that is towed through the water, and can include a pair trawl that is towed simultaneously by two boats.

Trawl (shrimp trawl) means a net that is dragged through the water by the vessel.

Traps:

Trap fishing means fishing with any of the various fishing devices made into the shape of a box, or enclosure, with one or more openings that allow marine life to enter but keep them from leaving.

Fish trap means a trap primarily used to target fish.(Need description of trap and method of use)

Lobster trap means a trap primarily used to target lobsters (Need description of trap and method of use).

Crab trap means a trap primarily used to target crabs. (Need description of trap and method of use).

Pot means trap.

Shrimp trap means a trap primarily used to target shrimp.

Trap means a portable, enclosed device with one or more gates or entrances and one or more lines attached to surface floats. Also called a pot.

Other Methods

Black coral dive means divers harvesting black coral using SCUBA or re-breathers.

Diving Fishing while swimming free dive (skin diving) or swimming with the assistance of compressed gases (SCUBA, re-breathers, etc.). Examples are lobster or namako diving. Does not include diving with a spear (see spearfishing), a net (see various nets), or for limu or opihi (see handpicking).

Fish Aggregation Device (FAD) means any device deployed in the water or water column that is intended to attract and increase the potential yield of fish species. FADs can be anchored or free floating and include devices such as: rafts, buoys, plastic bottles, steel canisters, marine debris and artificial reefs. The use of FADs have generally been associated with pelagic fisheries however, the use of this method is now being expanded to target coral reef species occurring at Penguin Banks in the Main Hawaiian Islands.

Fishpond means an enclosed or semi-enclosed coastal body of water used for fish culture. Fishponds are typically stocked with pua (juvenile striped mullet) or enter through a makaha (gate).

Hand harvest means harvesting by hand.

Handpicked means hand harvesting marine life by various methods.

Powerhead means any device with an explosive charge, usually attached to a spear gun, spear, pole, or stick, that may or may not fire a projectile upon contact.

Tangle net dredge means dredge gear consisting of weights and flimsy netting that hangs loosely in order to immediately entangle fish.

Slurp gun means a tube-shaped suction device that operates somewhat like a syringe by sucking up the fish.

Snare means a device consisting of a pole to which is attached a line forming at its end a loop with a running knot that tightens around the fish when the line is pulled.

Spear means a sharp, pointed, or barbed instrument on a shaft. Spears can be operated manually or shot from a gun or sling.

Spearfishing means fishing with a shaft with one or more sharpened points at one end usually associated with diving. Includes bow and torch fishing and bluewater spearfishing. Spearfishing in federal waters primarily occur at Penguin Bank in the Main Hawaiian Islands.

Submersible means a manned or unmanned device that functions or operates primarily underwater and is used to harvest fish, i.e., precious corals, with mechanical arms.

Submersible (for precious coral) means a vessel (manned or unmanned) capable of diving and/or remaining underwater for selectively harvesting deepwater precious corals.

Pelagic Methods
Aku boat, Pole and line, Ahi boat, Flagline, Longline, Ikashibi (tuna handline), Paluahi (tuna handline), Trolling

Benthic Methods
Deepsea handline, Bottom handline, Inshore handline, Kaka line, Set line

Traps
Crab trap, Fish trap, Lobster trap, Shrimp trap

Nets
Gill net, Fence net, Lay net, Cross net, Seine net, Drag net, Bull, pen, Pen, Akule net, Bag net, Opelu net, Hukilau net, Kona crab net, loop net, Lobster net, Throw net, Cast net, Purse Seine, Surround net, Bait net, Shrimp trawl

Diving Methods
Spearing, Lobster dive, Coral dive

Impact Definitions

Impacts

Criteria for Ranking

Low:
Gear and/or method as used has no significant impact on habitat.

Medium:
Gear and/or method as used may have the potential for minor impacts on habitat, however, impacts do not adversely impact EFH.

High
Gear and/or method as used may result in impacts to habitat that do result in a reduction in quantity or quality of EFH. To the extent practicable, these impacts must be minimized through management measures.

Bycatch

Bycatch is a direct measurement of a gear selectivity.

Criteria for Ranking

Low:
Gear and/or method as used is able to target specific individual species or species complexes. Fishermen are able to target species with a high degree of certainty. Non-target species generally are able to avoid the gear or capture. If gear interaction occurs, the non-target species are generally able to escape capture. Generally most of the catch are retained. The overall mortality of incidentally caught species is low.

Medium:
Gear and/or method as used is able to target specific species assemblages. Gear includes specific features that allow for incidentally caught species to escape. Gear features and method of use are capable of specific modifications that enable fishermen to target specific species and size classes. Additionally, gear design may be modified to exclude undesirable species. Further, the gear is capable of being deployed to target specific species. Generally a majority of the catch are retained. The overall mortality of incidentally caught species is generally low to moderate.

High:
Gear and/or method as used is has limited ability to target specific species assemblages. Gear usually does not include specific mechanism(s) that allow for incidentally caught species to escape. Gear design features and method of use are capable of only limited modifications that enable the fishermen to target specific species and size classes. The use of gear may result in significant amounts of incidentally caught species being discarded. Mortality of incidentally caught species is typically moderate to high.

Gear		Impacts to Habitat			Bycatch		
		Low	Medium	High	Low	Medium	High
HOOK and LINE							
Trolling	Trolling w/bait: (Dead or Alive)	✓			✓		
	Trolling w/Lures: (artificial lures)	✓			✓		
	Trolling w/Green stick)	✓			✓		
Handline							
Bottomfish gear							
Deep-sea handline		✓			✓		
Inshore handline		✓				✓	
Kaka line			✓			✓	
Pelagic gear							
Ika-Shibi		✓			✓		
Palu Ahi		✓			✓		
Longline		✓				✓	
Pole and Line		✓				✓	
Rod and Reel		✓				✓	
NET							

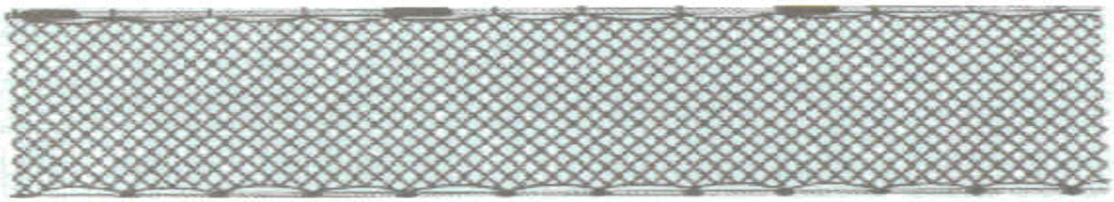
Gear		Impacts to Habitat			Bycatch		
		Low	Medium	High	Low	Medium	High
Gill Net							
Moi moi net (unattended)				✓			✓
To be completed							
Surround Net (Fence net, surround net, pai pai net, laynet etc., attended)							
Akule Surround Net			✓			✓	
Opelu Net			✓			✓	
Purse seine		✓				✓	
Seine Net (Hukilau net)				✓			✓
Hoop net							
Kona crab net		✓			✓		
Trawl				✓			✓
Bait net		✓			✓		
Barrier net			✓			✓	
Cast net			✓		✓		
Crab net		✓			✓		
Dip net		✓				✓	
Lobster net			✓		✓		
TRAP							
Fish Trap (deepwater)			✓			✓	

Gear		Impacts to Habitat			Bycatch		
		Low	Medium	High	Low	Medium	High
Fish Trap (handset)		✓				✓	
Lobster Trap*			✓	✓	✓		
Crab Trap		✓			✓		
Shrimp Trap			✓			✓	
OTHER							
Diving		✓			✓		
Hand harvest		✓			✓		
handpicked	✓	✓			✓		
Slurp gun		✓			✓		
Snare		✓			✓		
Spear fishing		✓			✓		
Submersible		✓			✓		
Tangle nets				✓		✓	

Fishing Gear Catalogue NET

Gear Type: **Akule Surround Net**

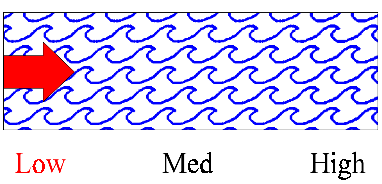
Diagram of typical gear:



Deployment/retrieval:
Akule is known as atule in American Samoa, atulai in Guam and akule in Hawaii, Bigeye scad *Selar crumenophthalmus*) and is abundant in the Pacific Islands. Akule surround nets are constructed of nylon and range in length from 1250-5000 feet and are 40 feet high. The typical mesh size used in net construction is 1 ½ inches. The net is a single panel with a floats on the top and a leadline on the bottom.

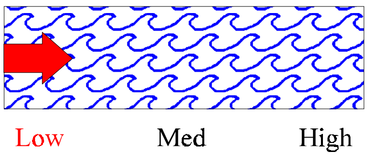
Some fishermen use airplanes flying at low altitudes (1,000-1,500 ft) to spot schools of fish and direct the vessel where to set the net. Once a school is located in calm waters with soft bottom, a skiff is used to surround the fish with the net. The skiff is powered by oars, as a motor would scare the fish. After the school is surrounded, several scuba divers are sent down to bring the lead lines together and secure the nets lead lines together. The divers then scare the fish to one side of the net and divide the net in half. The process is repeated until the net is about one fourth of its original size. It is then taken to the vessel and the fish are brailed aboard. In order to successfully entrap the school, nets must be suspended through the entire water column from surface to bottom. The depth fished is approximately 20 ft, not deeper than 40 ft.

Habitat Impacts:



Surround nets for akule have low impact on coral reef habitat. Akule are found in shallow, nearshore waters of bays and harbors. Fishing usually occurs seaward of the reef in fairly shallow sandy areas. Akule fishermen actively avoid substrates with high or varied benthic relief because of the difficulty such areas present to successfully encircle and capture the targeted school of fish. In areas of high relief or numerous coral outcrops, the net would become entangled, damaging both the net itself and allowing the school of akule to escape. Use of scuba divers to retrieve the net further minimizes potential impacts to benthic habitat, including coral reefs.

Bycatch:

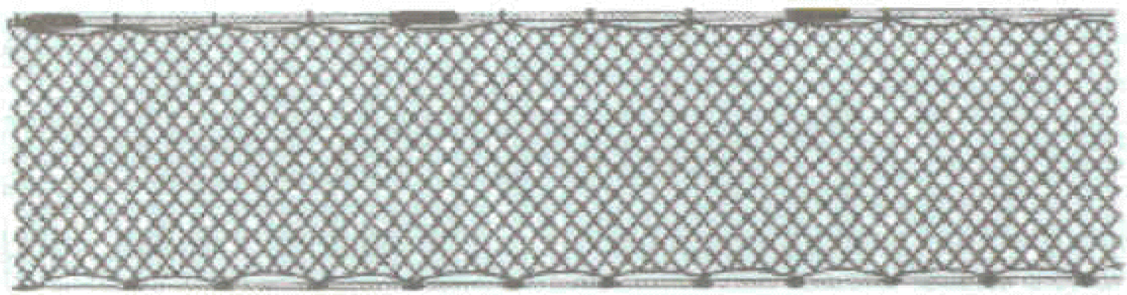


Deployment and retrieval of akule nets make this gear relatively selective. Substantial effort is made prior to deployment of the net to identify a school of akule in a suitable area, sandy flat sub-straights. During net retrieval, efforts are made by scuba divers to cull out any unwanted species that may have been inadvertently encircled during net deployment. Species culled include sharks and large jacks.

Fishing Gear Catalogue

Gear Type: “Moi moi” Net

Diagram of typical gear:

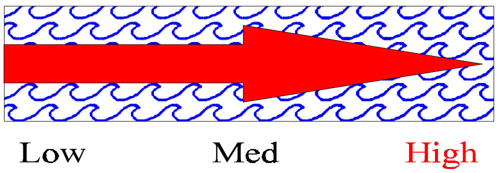


Deployment/retrieval:
“Moi moi” method uses gill nets that are deployed, left unattended for a period of time, then retrieved. Nets are typically made of 12 to 20 pound monofilament. Length can range from 75 to 150 feet and average height is 7 feet. Mesh or eye size is typically 2.75 inches, but can vary depending on species targeted. Most local fishery management agencies have minium mesh size limits for this type of net. The net is a single panel with floats on the top and a leadline on the bottom. Nets can be set on the bottom, in mid-water or on the surface. Most fishers using this type of net set on the bottom.

It is common for several segments (10-12) of moi moi net to be tied together when deployed. Most fishers target depths ranging from the shore line to 30+ feet. To avoid gear loss and damage, fishers avoid high surge and surf areas. Nets are targeted for sandy areas adjacent to the reef or set along the reef. Gear is usually deployed from a floating platform, eg. large inner tube, dingy, or small boat. A heavy object, ie. lead, rebar, or concrete, is attached to the lead line as an anchor and a large float attached to the float line to mark one end of the net. The rest of the net is then layed out until the other end is reached to which another anchor and float is attached. The Hawaiian term “moi moi” is to sleep. This term is used for this gear because of the timing of deployment and retrieval. Nets are commonly set in the late afternoon or early evening and retrieved in the morning. Fishers check the net every 2-3 hours. Nets are also set during the day for 2-4 hour periods or set in the late afternoon and retrieved before mid-night. When retrieving the gear, it is common for a diver to swim along and untangle the leadline as the net is being pulled and loaded into an inner tube of boat. This helps minimize damage to the net.

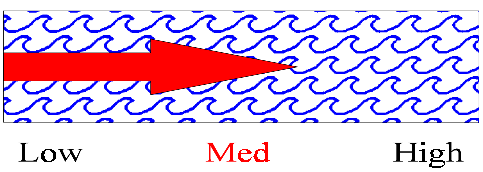
The practice of using moi moi nets in deeper waters, from 150 to 200 feet, has recently become more common. Longer strings of net (up to 3000 feet) are deployed from vessels in these targeted depths. Like the shallow water moi moi net, it is left for a period of time and later retrieved using hydraulics.

Habitat Impacts:



Recent use of large amounts of gill nets set between 10-100 m in depth to catch reef fish in state waters in the Main Hawaiian Islands may adversely impact EFH. The nets are highly unselective and take indiscriminate cross-sections of the fish community and dredge and have a potential to damage substantial areas of coral if it is retrieved by power block. Under the CRE FMP, the use of gillnets are prohibited in federal waters. Potential impacts to habitat include entanglement and breakage of corals.

Bycatch:



Gill nets as used in the moi moi method catch wide range of reef species. Selectivity of fish size can be controlled by varying the mesh. However, in most cases, all species caught in the net are utilized.

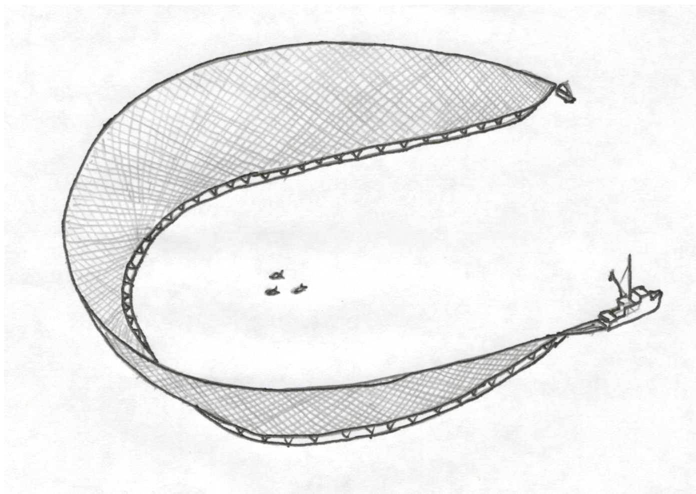
Measures to mitigate potential adverse impacts to EFH

Gear prohibitions:

Currently, gillnet fishing is allowed by some local governments in the Western Pacific Region. Although this type of fishing is seldom used in federal waters, there is a potential for this type of fishing to expand into shallow federal waters adjacent to state waters. Under the CRE FMP, fishing gillnets will be prohibited.

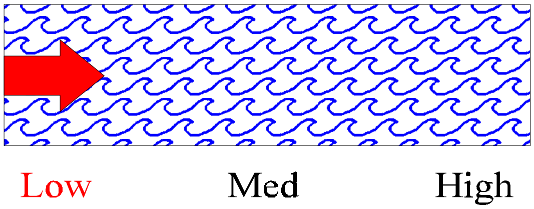
Gear Type: Purse Seine

Diagram of typical gear:



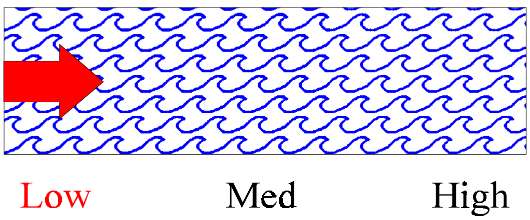
Deployment/retrieval:
The purse seine technique consists of setting, pursing, hauling net, "sacking up" and brailing. After spotting a suitable school, the net is set at high speed with the help of a powerful skiff to encircle the entire school. A winch then hauls the ends of the net together and closes, or "purses", the bottom of the net to trap the fish school by hauling in the purse cable. When pursing is complete, one end of the net is fed through the hydraulic power block which hauls in the net. The net is stacked on the deck by the crew to prepare for the next set. When most of the net is on board, the net is sacked up, which concentrates the fish next to the hull. The catch is then brailed from the net to refrigerated fish holds using a brailer net that can hold about two tons of fish per scoop. Most modern tuna purse seiners usually do not return to port until their fish holds are completely filled, which may take 3-8 week or more. Western Pacific seiners set their nets on free tuna schools sighted on the surface of the ocean during daylight hours, or before dawn on schools found associated with drifting logs or man-made rafts. Pre-dawn log sets are usually successful as the tuna are very close to the log, and setting and pursing can be completed before the fish can avoid the net. Daytime sets are often less successful, but are beginning to account for larger catches due to experience and improvements in fishing technology.

Habitat Impacts:



Purse seine is a surface pelagic gear that poses minimal impacts, if any, to habitat.

Bycatch:



Because tunas are usually not associated with porpoises in the western Pacific region, seiners operating there do not have an associated porpoise bycatch. Some purse seine sets do have a large catch of non-target species, and these bycatch levels are higher when setting on schools that are associated with drifting logs and rafts due to the attraction of many fish species to drifting debris in the open ocean. Typical purse seine bycatch includes rainbow runner, dolphinfish, wahoo, marlin, pelagic sharks, mackerel scad, oceanic trigger-fish and rudderfish. The reported bycatch from the US purse seine fleet in the western Pacific has consistently been less than 1% of the total catch.

Gear Type: **Tangle net dredge**

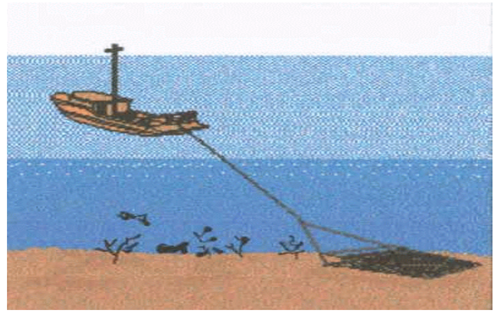


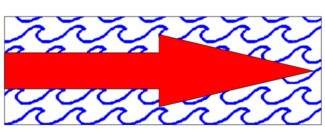
Diagram of typical gear:

Historically, the primary method used to harvest precious corals has been the use of dredges, or tangle nets. There are only two known instances of domestic fishermen using tangle nets to attempt to harvest deepwater precious corals. During the late 1960s a small group of fishermen dredged for pink coral off of Oahu in the Makapuu Bed on a small scale using tangle nets. In 1988 a domestic fishing vessel attempted to harvest deepwater precious coral on the Hancock seamounts. The amount of coral harvested was extremely limited and of poor quality.

The basic gear design of these dredges consists of weighted tangles (a dredge) with attached netting. The weights serve to keep the dredge on the bottom as well as to dislodge the coral, and the attached nets entangle the coral.

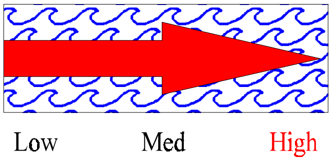
Foreign dredge haulers used in the precious coral fishery range in size form 40 to 100 ft. Dredges are deployed with the aid of hydraulic line haulers located amidship. The dredges are raised and lowered over the side of the vessel. Once the dredges are deployed the vessel is allowed to drift positioned at right angles to the current. Japanese vessels normally deploy from 4 to 8 simultaneously. Larger vessels may use as many as sixteen dredges simultaneously. Fishing operations are typically conducted around the clock with crews rotating. The same grounds are often redredged

Habitat Impacts:



Tangle nets may be ecologically destructive, as other species and habitat may be disturbed, and it may be wasteful, as some coral dislodged from the bottom may not be recovered.

Bycatch:



This method of harvesting precious corals is non-selective; the dredge simply knocks down all corals in its path. This gear cannot discriminate between types, size, quality or characteristics of living or dead corals. Based on simulated harvests studies conducted in shallow water, it is estimated that dredges only recover 40% of the total amount of corals initially knocked down. Because an area is often redredged several times the overall recovery rate of dislodged coral is probably significantly greater.

Existing measure to mitigate potential adverse impacts to EFH

***Gear restrictions*:**
In the main Hawaiian Islands, the use of non-selective gear is prohibited to harvest precious corals.

***Closed Areas*:**
The harvest of precious coral from the WestPac Refugia Bed, located in the NWHI, is prohibited.

Harvest Limitation Program
Quotas have been established for pink, gold, and bamboo corals for Makapuu Bed and the conditional beds in the NWHI.

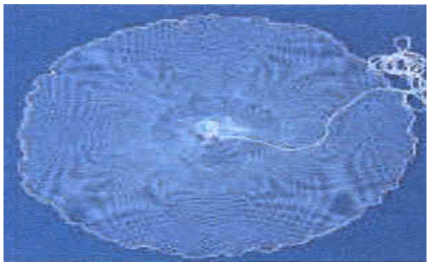
Proposed measures to mitigate potential adverse impacts to EFH

Under a framework adjustment to the Fishery Management Plan for the Precious Coral Fisheries the Western Pacific Region Amendment approved by the Council and currently under review by the NMFS, only selective gear will be allowed to harvest precious corals from all permit areas.

Fishing Gear Catalogue NET

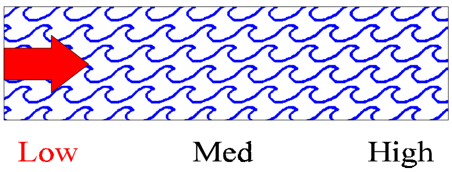
Gear Type: **Throw net**

Diagram of typical gear:



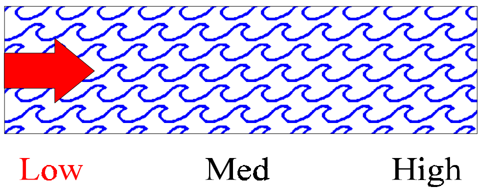
Deployment/retrieval:
Throw nets are circular with a radius that can vary from 8-12 feet. Net are weighted around the edge and are generally made of monofilament but can also be constructed of cotton, nylon, or other material. For example, in Guam traditional throw nets called "talaya" were made of pineapple leaf fibers. Throw nets can include a pocket on the outer edge of the net to trap fish. Pockets are made by layering a larger mesh net on the inside of the nets outer edge. The net is deployed by a skillful fisher who tosses the net over and around a school of fish. The fisher then enters the water to gather the open bottom of the net to trap the fish. Throwing the net so that it fully opens as it enters the ocean surface requires skill and practice. A more difficult aspect of throw net fishing is to develop the skill to approach a school of fish without notice and within a distance from which the net can be successfully deployed. Nets are generally thrown in or near the surf zone.

Habitat Impacts:



Throw nets have a low to moderate impact on coral reef habitat. Nets can be deployed on hard, sandy or a combination of substrates that are immediately adjacent to the shoreline. Fishers generally attempt to target flat areas with minimal rock or coral outcrops to limit the changes of fish to escape. Fishers retrieve nets by hand which serves to minimizes impacts to benthic habitat, including coral reefs.

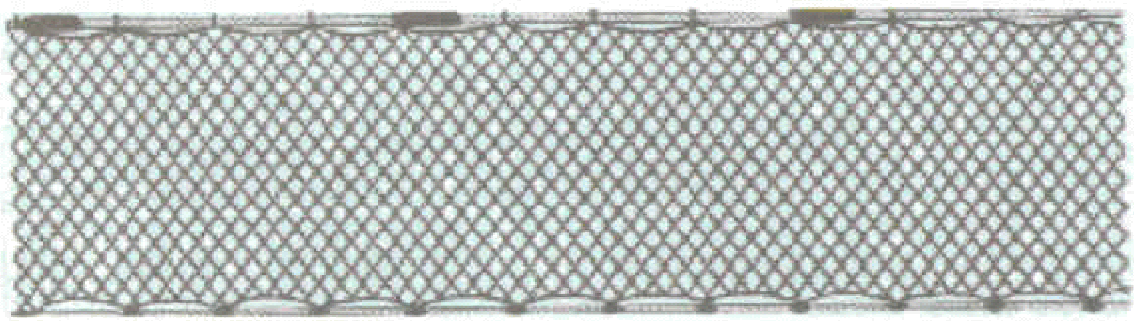
Bycatch:



Throw nets are generally selective due to specific targeting of species by fishers, eg. moi, kala, moana, manini, aholehole and mullet that swim in schools close to shore. However, because fishing is taking place in the surf zone, it is difficult to see all fish that are in the area where the net is to be deployed. Most species that are caught in throw net fishing are retained. Fish that are undersized or undesired are generally returned alive.

Gear Type: **Weke/Taape Surround Net**

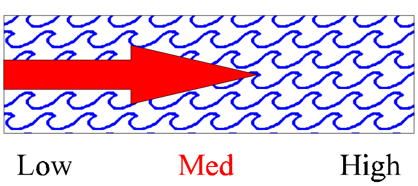
Diagram of typical gear:



Deployment/retrieval:
Goat fish and snapper surround nets are constructed of nylon and range in length from 75-100 feet and are 18 feet high. The typical mesh size used in net construction is 2 inches. The net is a single panel with a floats on the top and a leadline on the bottom. A bag net is constructed of nylon with 1.5 inch eyes and is used exclusively to transport fish from the surround net to the surface.

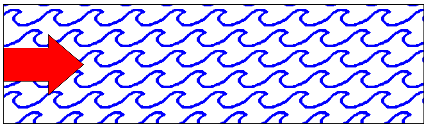
Once a school is located in calm waters with soft bottom, the fish is surrounded with sections of net deployed under water by SCUBA divers or on the surface by skiff. After the school is surrounded, several scuba divers bring the lead lines together and tie the nets together to encircle the school. The net is slowly collapsed by concentrating the fish and removing sections of net until the bag net can be attached and fish corralled into the bag net. Once fish enter the bag net, it is tied off and taken to the vessel where the fish are brailed aboard. Unlike the akule net, this net does not have to be suspended through the entire water column from surface to bottom.

Habitat Impacts:



Surround nets for weke and taape have minimal impact on coral reef habitat. Fishing usually occurs seaward of the reef in shallow sandy areas. Fishermen actively avoid substrates with high or varied benthic relief because of the difficulty such areas present to successfully encircling and capturing the targeted school of fish. In areas of high relief or numerous coral outcrops, the net would become entangled, damaging both the net itself and allowing the school of fish to escape. Use of scuba divers to set and retrieve the net further minimizes potential impacts to benthic habitat, including coral reefs.

Bycatch:



Low Med High

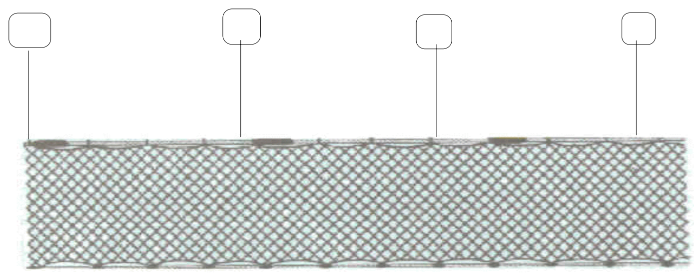
Surround nets are relatively selective as deployed and retrieved for weke and taape. Substantial effort is made prior to deployment of the net to identify a school in a suitable area, sandy flat substrate. During net retrieval, efforts are made by scuba divers to cull out any unwanted species that may have been inadvertently encircled during net deployment. Species culled include sharks and large jacks.

Measures to mitigate potential impacts to EFH

Under the CRE FMP, anyone wishing to fish with weke surround net must describe the gear in the special permit section application. A ruling on this gear type will be determined by the NMFS PIAO Administrator after consultation with the Council and the director of the affected state fishery management agency.

Gear Type: **Barrier Net**

Diagram of typical gear:



Deployment/retrieval:
The vast majority of aquarium fishes collected in the Pacific region are capture through the use of barrier nets and hand nets. Pyle (1993) provides a detailed description barrier nets and their use. The following draws heavily upon this description.

The general design of a barrier net is a rectangular section of monofilament netting, weighted along the bottom with lead or chain, and buoyed along the top with small floats. Although barrier nets vary in size from less than one meter in length to as long as 20 meters, they generally fall into one of two categories: small and large.

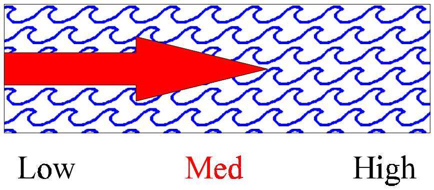
Small barrier nets are typically less than 5 m in length and less than 0.5 m in height. Small barrier nets are deployed by a single diver. The lead line is comprised of a chain or lead weights closely spaced. This allows the net to conformed to the contours of the bottom where it is set. Small barrier nets are set either in a v-shaped configuration or stretched out. The diver uses hand nets to drive the fish into the net.

Large nets are characterized by typically being longer than 10 m in length and one meter in height. Large barrier nets usually are deployed by two or more divers. Large nets are used to target schooling fish such as the surgeonfish, tangs and wrasses.

The net is set in a v-shaped configuration. The divers then carefully drive fish into the net using hand nets. Once the fish are concentrated in the apex of the net, the divers bring the net together, completing the enclosure of the fish within the net.

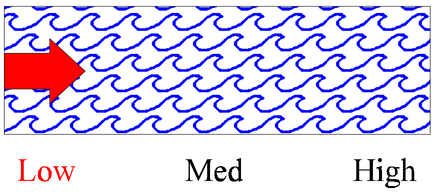
Nets are deployed contingent upon the targeted species particular habitat preferences.

Habitat Impacts:



Barrier nets for aquarium fish have a low to moderate impact on coral reef habitat. Nets are typically deployed on or immediately adjacent to coral reef habitat. The use of scuba divers to deploy and retrieve the net serves to minimizes impacts to benthic habitat, including coral reefs.

Bycatch



Aquarium fish collectors are highly selective when collecting coral reef and other marine organisms. Usually, a collector will target a specific species in locations where they are most abundant and attempt to capture only those which are of value. Other fish may be captured with the target species however, they are usually released back since they have no commercial value.

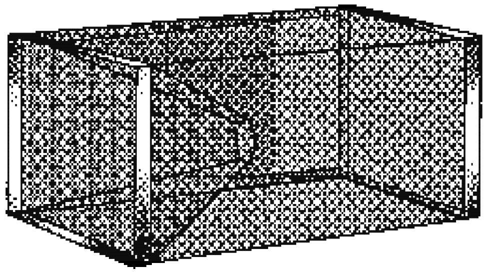
Measures to mitigate potential impacts to EFH

Although aquarium fish collection with barrier net will be allowed under the CRE FMP, anyone wishing to collect aquarium fish species may be be required to apply for a permit with the appropriate local government agency. Anyone wishing to collect an aquarium fish listed as a Potentially Harvested MUS, or anyone wishing to fish in a low-use MPA in the EEZ, must contact either the PIAO directly or will be directed to contact the PIAO by their regional marine fisheries office. If it is determined that the person(s) must complete a special permit application, a ruling will be determined by the NMFS PIAO Administrator after consultation with the Council and the director of the affected state fishery management agency.

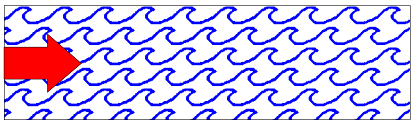
Fishing Gear Catalog **TRAP**

Gear Type: **Crab Trap**

Diagram of typical gear:



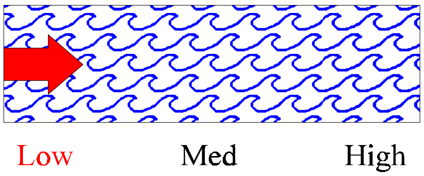
Deployment/retrieval:
Traps are deployed individually or on a string set up to 200 feet apart. Floaters are used to mark individual trap locations or the ends of trap strings. Primary species targeted is white crab which live in sandy areas. Depth range for deployment range from 40 to 300 feet. Crab traps are constructed with similar material as used for fish traps but often have heavier frames. A variety of trap designs are used by fishermen. Traps are generally smaller than fish traps and can have multiple compartments. The trap entrance is modeled after a ramp allowing crabs to crawl up the ramp and fall into the trap while prohibiting escape. Soak time can vary between 1 to 3 days and depends on location, season, density of fish and other personal variables. The average soak time is one week. Retrieval is done by hand or with hydraulics. Bait (ahi head, mackerel) is always used in traps for white crabs.



Habitat Impacts:

Portable traps for white crabs pose minimal potential habitat damage due to selective placement in areas with extensive sandy habitat. Coral and other hard substrate are highly avoided.

Because of the low number of traps used and floater lines, fishermen rarely lose traps. Trap door hinges are secured with low quality wire that decompose quickly in the marine environment. This wire will completely corrode within as short of period of time as a month, leaving the trap door open. The galvanized chicken wire used to construct traps also rapidly corrodes in the marine environment. Some fishermen attach zinc to extend the life of traps.



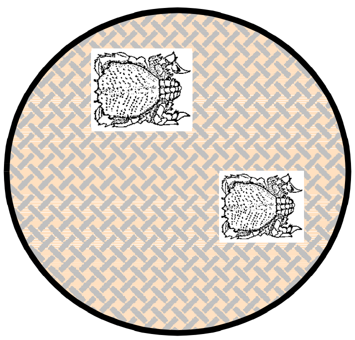
Bycatch:

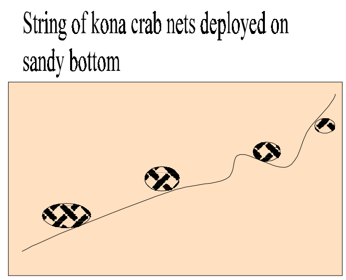
Ghost fishing due to lost traps is rare Crab traps are species selective based on targeted habitat. Traps are placed on sandy substrate**.**

Fishing Gear Catalogue NET

Gear Type: **Kona Crab Net**

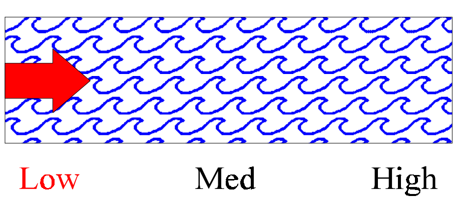
Diagram of typical gear:





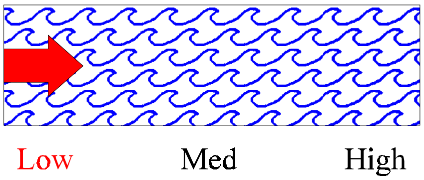
Deployment/retrieval:
Nets are deployed on a string with 25 traps per string. 3 strings are often used simultaneously. Floaters are attached to mark and retrieve individual strings. Each net consists of a heavy gauge metal hoop or rectangle with monofilament netting stretched tightly across to entangle the legs crab as they approach bait which is placed in the center. The Primary species targeted is kona crab which live exclusively in sandy areas. Depth range for deployment range from 40 to 300 feet. Soak time for each string is short varying from 30 minutes to 1 hour. Strings are retrieved by hand. Kona crab typically do not enter the net during the night therefore fishing is exclusively conducted during the day.

Habitat Impacts:



Kona crab nets have minimal habitat impacts due to selective placement in areas with exclusive sand substrate. Coral and other hard substrate are actively avoided. Ghost fishing due to lost strings or traps are rare. Fishermen rarely lose traps due to the low number used. Lost nets can continue to tangle crabs while bait is still present.

Bycatch:

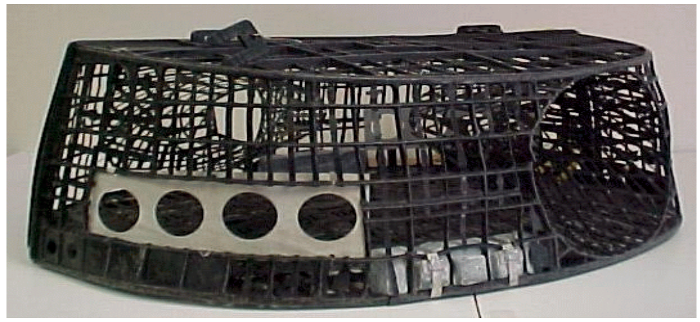


Kona crab nets are highly selective and rarely take other species.

Fishing Gear Catalogue TRAP

<u>Gear Type:</u> **Lobster Trap**

Diagram of typical gear:

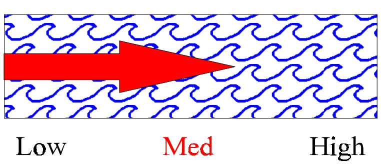


Deployment/retrieval:
The commercial lobster fishery in the NWHI is a trap fishery. The principal species targeted by this fishery is the spiny lobster (*Panulirus marginatus*) and the common slipper lobster (*Scyllarides squammosus*).

All vessels participating in the NWHI lobster fishery use traps manufactured by Fathoms Plus. The trap is dome-shaped and molded from black polyethylene. The trap dimensions are approximately 2.5' x 3.2' x 1'. To ensure traps deploy upright on the bottom, lead weights are secured inside the trap. Each trap has two entrance cones located on opposite sides of the traps. The traps also have two escape vents that allow for the escape of undersized lobsters and other incidental catch such as octopus.

Traps are set in strings of several hundred at depths between 10 to 35 fathoms. The traps are baited with chopped mackerel. Vessels typically set about 800 hundred traps per day.

Habitat Impacts:



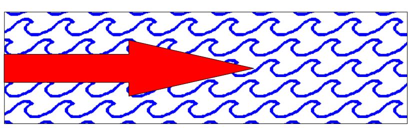
Recently, the NMFS NWHI Observer logs and follow-up interviews with observers indicate that both pieces of live coral and entire coral heads are caught in some lobster traps and ground line and landed onboard the lobster vessel. One observer noted that "small broken pieces of coral were frequently (as many as one piece per five traps) wedged in the holes of the traps. Numerous softball-sized and a few basketball-sized whole coral heads came up stuck to the mainline." Typically the coral landed on a fishing vessel is thrown overboard, although there have been reports of pieces kept in live tanks.

In 199X the Council, based on the NMFS recommendation, instituted a bank specific quota for the NWHI lobster fishery. This new management regime established quotas for the primary lobster fishing grounds, Maro, Necker and Gardner and one for all other banks. The effect of this action was that lobster vessels were forced to begin exploratory fishing at banks traditionally not fished. Anecdotal reports indicate that the increased observation of coral caught in traps may be due to this exploratory fishing on unfamiliar grounds. Further, members of the Council's Crustacean Plan Team and Advisory Panel report that the problem may have been exacerbated by the inexperience of one vessel's captain.

Typically traps are set in areas of relatively low structural relief, away from coral reef habitat. If traps are set too close to coral reef and other high relief habitats, lobsters cannot be enticed to enter the traps.

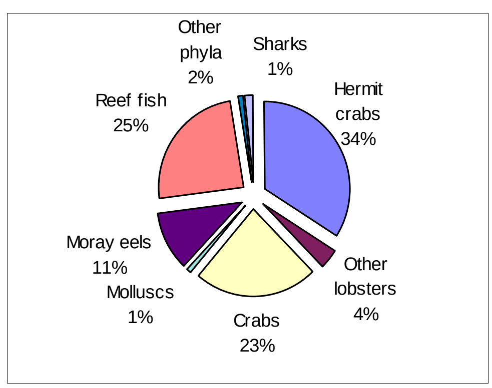
The impact of lobster trapping on coral reef habitat is difficult to estimate. Only a portion of the damaged coral reaches the vessel to be seen by observers. Further, the fate of the damaged coral is unknown. Some of the damaged coral may continue growing while others may be covered in sand or swept off the banks. The damage may vary from bank to bank. Trapping at atolls where lobster habitat is limited and coral reef density high may result in more coral damage than islands with large flat algal or sand bank areas.

Research is needed to determine the impact of lobster trapping on coral reef habitat. This research may include both expanded observer documentation of coral brought up during trapping and research surveys of coral beds located in areas with and without trapping.


Low Med High

Bycatch:

Current gear restrictions mandate that lobster traps have two entrance cones located on opposite sides of the traps. The traps must also have two escape vents, comprised of four circular holes at least 2 ½ inches in diameter, that allow for the escape of undersized lobsters and other incidental catch such as octopus. This gear restriction has resulted in significant reduction in the incidental take of non-target species.



Because lobster fisheries in Guam, American Samoa, and NMI depend on spearing lobsters or collection by hand, both of which are highly selective methods, the amount of bycatch is likely to negligible.

Polovina (1993) reports that an estimated 2000 traps are lost annually in the NWHI. Parrish and Kazama (1992) found that while lobsters may enter these traps they were also able to exit and there was no observed mortality associated as with ghost fishing. These researchers concluded that lobsters utilized the traps as shelter.

Existing measure to mitigate potential adverse impacts to EFH

Gear restrictions:
Lobsters may only taken by lobster traps or by hand. The use of nets, chemicals, explosives, hook or spears is prohibited.

Closed Areas:
1) All lobster fishing is prohibited within 20 nm of Laysan Island.
2) Within the EEZ shallower than 10 fathoms.

Closed Seasons:
Lobster fishing is prohibited in the NWHI between January and June.
Lobster fishing is prohibited in the EEZ around the MHI during the months of May, June, July and August.

Harvest Limitation Program
The NWHI lobster fishery is a quota based fishery. This serves in effect to limit the total amount of fishing effort that may occur and thus limits the amount of potential adverse impacts that may result from lobster traps to EFH. The NMFS annually sets a harvest guideline, expressed as quota of the total number of lobsters that may be taken in the NWHI. Because the harvest quota is bank specific it further limits the potential adverse impacts to EFH that may result from lobster traps..

Other Measures:
Limited entry Fishery (maximum of 15 permits may be valid at any one time) Currently there are approximately.

Traps may not be left unattended in the water except in the event of an emergency

Vessels may not maintained more than 1200 traps on board with no more than 1100 assembled at any one time.

Proposed measures to mitigate potential adverse impacts to EFH

Closed Areas:
Under proposed regulations, lobster fishing will be prohibited at French Frigate Shoals to

a depth of 50 fm and at Midway to a depth of 50 fm.

References:

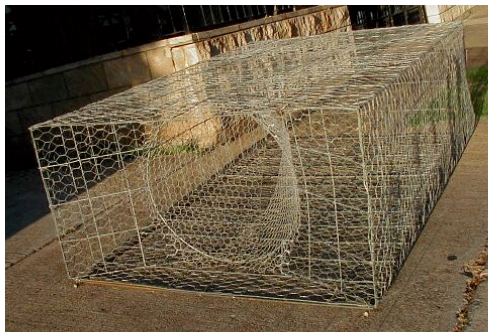
Parrish, F.P., and T.K. Kazama. (1992) Evaluation of ghost fishing in the Hawaiian lobster fishery. Fishery Bulletin. 90: 720-725.

Polovina, J. (1993) The lobster and shrimp fisheries in Hawaii. Marine Fisheries Review. 55(2): 28-33.

Fishing Gear Catalogue TRAP

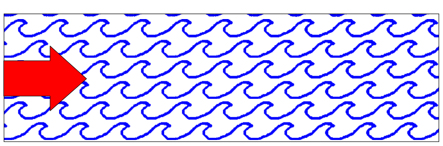
Gear Type: **Portable Fish Trap: Shallow to medium depth deployment (20-100 feet)**

Diagram of typical gear



Deployment/Retrieval
Traps are set individually by divers using SCUBA. A series of traps can range from 8 to18 traps. Range of deployment is from 20 to 110 feet. Shallow set traps are can be damaged from surge and are more easily tampered with. Fish traps are generally constructed of concrete wire for the trap frame which is covered with a finer mesh chicken wire. Typical trap dimensions are 2.5 feet high by 6 feet long by 4 feet wide. Soak time can vary between 4 to 14 days and depends on location, season, density of fish and other personal variables. The average soak time is one week. Bait is rarely used in the shallow to mid-depth traps. Fishermen note that bait may increase the number of fish that enter the trap but also draws undesirable species such as eels and sharks which can damage catch and increase risks to divers. Trap retrieval is assisted by flotation devices. The retrieval process is as follows: landmarks or GPS is used to locate trap; a new trap is dropped from a vessel behind the existing trap, existing trap is stood on end, air bag is attached, the bag is inflated and the trap is lifted to the surface.

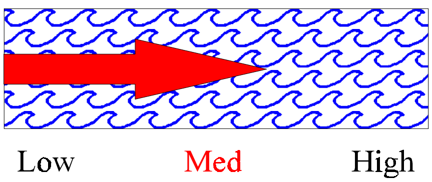
Habitat Impacts:



Low Med High

Portable fish traps as used in the Western Pacific Region in shallow to mid water depths pose minimal potential habitat damage due to hand placement and retrieval. Trap placement is critical to produce successful catch. raps are strategically hand placed near fish houses or koa which typically include areas with high relief ledges or reef edges. Fish enter and are also able to exit these traps making mortality associated with lost traps or ghost fishing minimal. Traps are often utilized as shelter or habitat. In some area in the region, fishermen purposely place rocks and coral rubble on and around traps to entice fish to use it as habitat. Because of the low number of traps used, fishermen rarely lose traps. Fishermen note that the largest factor affecting trap lost is due to theft by humans. Trap door hinges are secured with low quality wire that decompose quickly in the marine environment. In general, chicken wire used to construct traps are also highly corrosive. Some fishermen attach zinc to extend the life of traps.

Bycatch:



Overall, fish traps are relatively unselective. Selectivity is increased through trap location and construction. Fish size is controlled by wire mesh size, varying funnel entrance size, and inclusion of vent holes. Small round holes in the corners allow small fish and eels to escape. Using smaller funnel entrances prohibits large jacks from entering and damaging traps. Target species generally include jacks, surgeon fishes, goat fishes, snappers, groupers, etc. Fish traps occasionally catch octopus, lobsters, crabs, and other crustaceans. Discards include aquarium and undersized fish including butterfly, damsels, etc. Fishermen estimate that 90% of discards survive.

Measures to mitigate potential impacts to EFH

Anyone wishing to fish in the low-use MPAs will be required to complete a special permit subject to approval by the NMFS PIAO Administrator after consultation with the Council.   Reporting is required through the special permit process and is subject to the following requirements.

1. Report catch, effort and discards by species, location, time and other factors as specified by the Council.

2. Report protected species interactions

3. Report on any lost gear or damage to coral reef

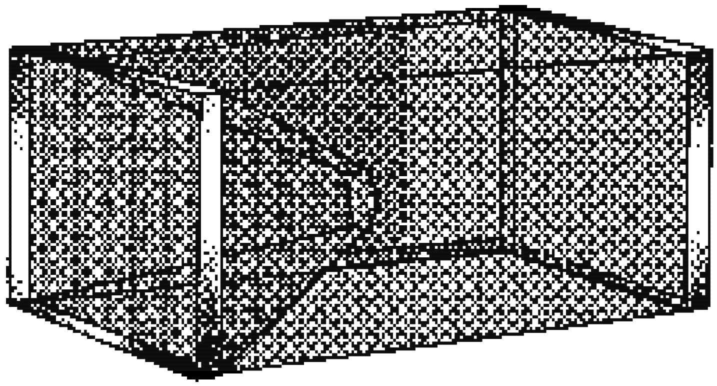
4. Complete daily log sheets within 24 hours after completion of the fishing day

5. Submit reports within 30 days of returning to port

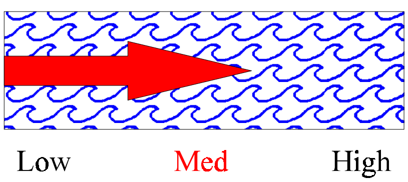
Fishing Gear Catalogue TRAP

Gear Type: **Portable Fish Trap: deep water deployment (100-300 feet)**

Diagram of typical gear:



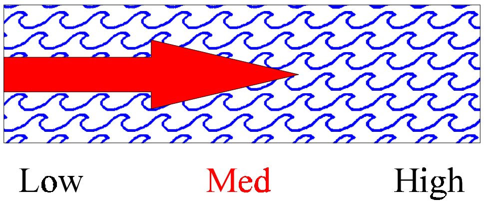
Deployment/retrieval:
Traps are deployed individually with up to 30 traps used in a series. Floaters are used to mark trap locations. Fish traps are generally constructed of concrete wire for the trap frame which is covered with a finer mesh chicken wire. Deepwater traps vary in size but are generally slightly larger than shallow to mid-depth traps. Soak time can vary between 4 to 14 days and depends on location, season, density of fish and other personal variables. The average soak time is one week. Traps are hauled using hydraulic lifts.



Habitat Impacts:

Portable fish traps as used in the Western Pacific Region in deep water depths pose only a moderate potential to damage habitat due to selective independent placement and retrieval methods used. Trap placement is critical to produce successful catch. Large schools or specific species (weke ula, kumu and taape) are generally scouted with fish finders and targeted. Species include weke ula, moana kale, papio, kumu, and uku. Preferred substrate include hard flat areas mixed with sand, ledges, etc. Bait (ahi head, mackerel) is sometimes used in deep water traps.

Fish enter and are also able to exit these traps making mortality associated with lost traps or ghost fishing minimal. Traps are often utilized as shelter or habitat by reef species. Because of the low number of traps used and floater lines, fishermen rarely lose traps. Trap door hinges are secured with low quality wire that decompose quickly in the marine environment. In general, chicken wire used to construct traps are also highly corrosive. Some fishermen attach zinc to extend the life of traps.



Bycatch:

Overall, fish traps are relatively unselective. Selectivity is increased through trap location and construction. Fish size is controlled by wire mesh size, varying funnel entrance size, and inclusion of vent holes. Small round holes in the corners allow small fish and eels to escape. Using smaller funnel entrances prohibits large jacks from entering and damaging traps. Target species generally include jacks, surgeon fishes, goat fishes, snappers, groupers, etc. Fish traps occasionally catch octopus, lobsters, crabs, and other crustaceans. Discards include aquarium and undersized fish including butterfly, damsels, etc. Fishermen estimate that 90% of discards survive.

Measures to mitigate potential impacts to EFH

Anyone wishing to fish in the low-use MPAs will be required to complete a special permit subject to approval by the NMFS PIAO Administrator after consultation with the Council. Reporting is required through the special permit process and is subject to the following requirements.

1. Report catch, effort and discards by species, location, time and other factors as specified by the Council.

2. Report protected species interactions

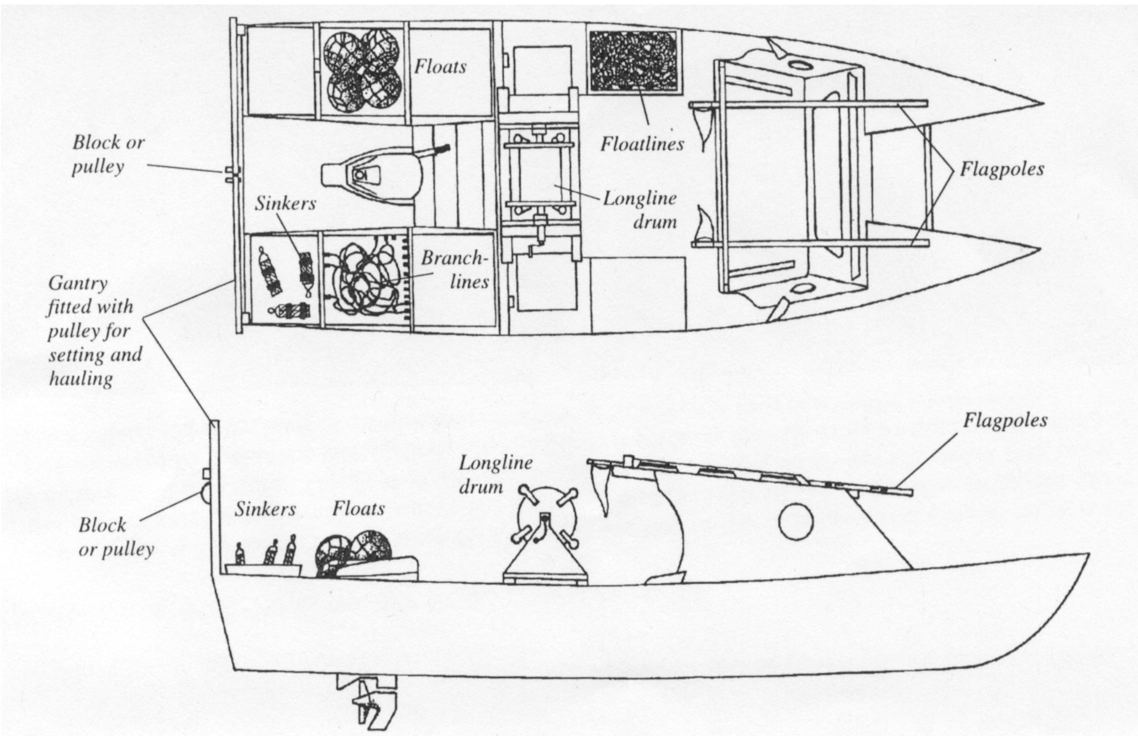
3. Report on any lost gear or damage to coral reef

4. Complete daily log sheets within 24 hours after completion of the fishing day

5. Submit reports within 30 days of returning to port

Gear Type: **Pelagic Longline/Alia**

Diagram of typical gear:

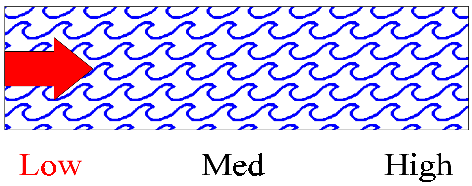


The advent of outboard motors in American Samoa in the 1950s and 1960s meant that the traditional fishing methods declined in favor of the use of motorized dinghies and skiffs for trolling and handlining. The development of offshore artisanal fisheries began in earnest during the early 1980s. It was at this time that the FAO-designed *alia* catamaran was introduced into the islands.

The extensive use of longline gear by the artisanal fleet in American Samoa is a recent phenomenon, with longline catches rising from zero prior to 1994 to almost 800,000 lbs in 1997. The stimulus for fishermen, who generally used only troll gear or handlines, to shift to longline gear was the fishing success experienced by small longline vessels in Western Samoa. The artisanal longline fleet in American Samoa presently consists mainly of 28-32 ft *alia* catamarans, although at least one larger (39 ft) *alia* has been locally constructed and outfitted for longline fishing.

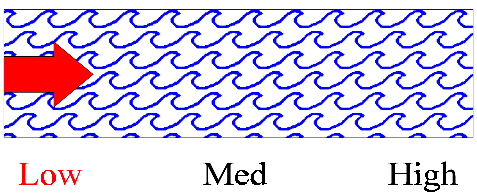
The vessels deploy a short monofilament longline with 200-300 hooks from a hand powered reel through a block or pulley located at the stern The block or pulley is rigged above the transom of the boat so that the line can be set and hauled over the stern of the vessel. The longlines harvest mainly albacore tuna, which are sold to the local tuna canneries. The use of longline gear requires the acquisition of a federal permit from the NMFS Pacific Islands Area Office, but there no restrictions on the number of permits issued. To date, 40 permits have been issued, although only about 17 vessels are active on a regular basis.

Habitat Impacts:



Pelagic longline gear does not adversely affect essential fish habitat. All gear is deployed in the water column and does not interact with bottom substrate. The habitat of pelagic species targeted by longline gear is the open-ocean water column.

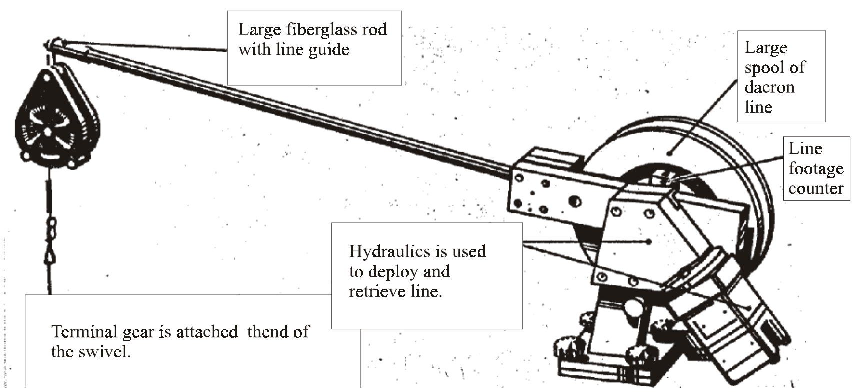
Bycatch:

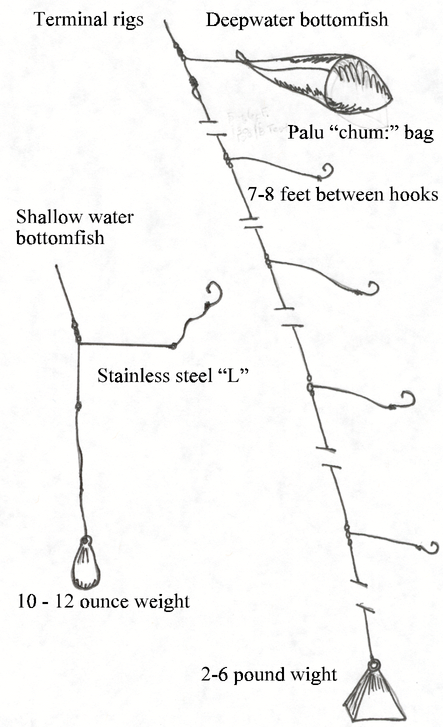


Pelagic longline gear is a relatively selective gear. In addition to tuna or swordfish, usual longline catch includes dolphinfish, wahoo, barracuda, moonfish, pomfrets and sharks.

Gear Type: Bottomfish Handline

Diagram of typical gear:

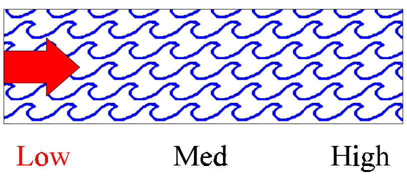




Deployment/retrieval:
The domestic bottomfish fishery for deep-sea snappers and groupers (onaga, ehu, opakapaka and hapuupuu) relies primarily on hydraulic or electric handline gear as diagramed above. The standard deep-sea bottom fishing rig consists of a 130 lb test mainline, to which a terminal rig is attached. The terminal rig consists of a drop line, hook lines three feet in length (40-60 lb hard monofilament), circle hooks and a lead weight. Four to 12 hooks are spaced at 7-8 feet intervals along the main line. A chum bag is attached just above the last hook and filled with finely chopped fish. Each hook is baited with fish or squid. The gear is lowered to the bottom. Depending on species targeted, the gear is fished at depths ranging from 50-150 fathoms. Once at the bottom, the gear is jerked sharply to release the chum bag. The gear is then raised to fish approximately 1 fathom off the bottom. The mainline is hauled either by hand, hydraulic gurdy or electric reel. A hand operated wooden reel is commonly used in American Samoa. Vessels drift or anchor during gear deployment depending on weather conditions, ocean currents, species targeted, and other variables.

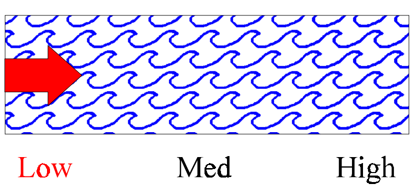
Shallow water bottom fishing is conduced in depths from 30-200 feet. Two primary methods include use of rod and reel or handline. Rod and reel is commonly used by recreational and charter fishers. Gear includes use of a stiff rod, spinner reel, 30 pound test line, single baited hook, and sinker. Handline fishers typically use 100 pound test monofilament spun on wooden spools. Terminal gear includes a stainless steel "L" spreader, single baited hook and 10-12 ounce sinker. Fishing is primarily conducted while drifting.

Habitat Impacts:



Bottomfish gear has very limited impacts on habitat. Habitat damage may occur from deployment of anchors during deep water fishing activities. However, damage is highly localized as the total targeted fishing habitat is limited to 100 fathoms contours areas with high relief. Anchoring during fishing operations is generally conducted at depths from 40-60 fathoms, with depths ranging from 30 to 175 fathoms. Reef building corals are generally not found below 50 fathoms, the lower extent of light attenuation. It is estimated that suitable bottomfish habitat where vessel anchoring might occur represents approximately 1% of the total bank habitat. Shallow water bottomfish activities are conducted while drifting therefore minimizing the potential for anchor damage.

Bycatch:



Being a hook and line rig, this gear is relatively selective, with the ability to successfully target particular species groups dependant upon the skill of the fisher. Experienced vessel crews have the ability to catch the desired species with very little bycatch. Gear is deployed at specific depths and in areas of certain habitat characteristics, eg high relief. Fishers target these areas using sophisticated electronic equipment such as depth/fish finders and global positioning devices. It is, however, impossible to completely avoid non-target species.

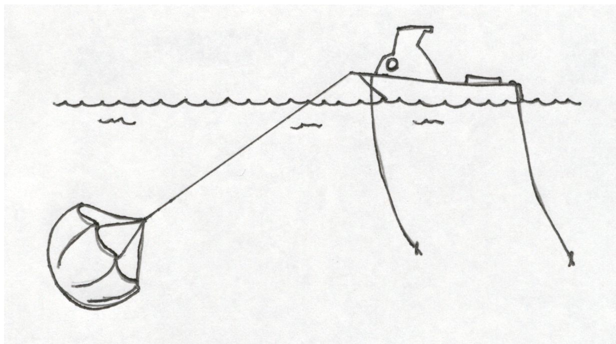
Logbook data and research programs conducted by the State of Hawaii and the NMFS indicate that bycatch accounts for approximately 8-19% of the total catch in bottomfish fisheries in the Hawaiian archipelago. Sharks, oilfish, snake mackerel, pufferfish, and moray eels are the most numerous discard species; they are not kept by vessels because of their unpalatability. With the recent increase in market demand for shark fins, more sharks are now "finned" before they are discarded. Some carangids (large jacks and amberjacks) are also discarded because of concerns of ciguatera poisoning. The major discard species in the NWHI bottomfish fishery **are given in Table below. It should be** noted that a large percentage of the snappers and the grouper listed below are included as bycatch because of damage from sharks.

Table. NMFS logbook estimates of discards in the NWHI deepwater bottomfish fishery, 1997

Scientific Name	Common Name	No. Discarded
Seriola dumerilli	amberjack	2,120
Caranx ignobilis	black trevally	1,298
P. filamentosus	pink snapper	215
Charcarhinidae	misc. sharks	166
Epinephelus quernus	seabass	114
Etelis carbunculus	red snapper	98
P. zonatus	yellowband snapper	98
Aprion virescens	jobfish	87
Pristipomoides auricilla	yellowtail snapper	19
Carangidae	misc. jacks	7
Galeocerdo cuvier	Tiger shark	5
Aphareus rutilans	red snapper	2

Gear Type: **Pelagic Handline**

Diagram of typical gear:



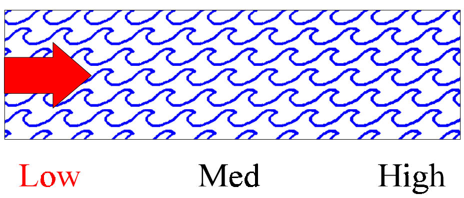
Deployment/retrieval:
Handline fishing is an ancient technique used to catch tunas with simple gear and small boats. This technique was developed by Polynesians and Micronesians living on atolls and small islands to catch yellowfin and bigeye tuna. This fishery continues in isolated areas of the Pacific, and is the basis of an important commercial fishery in Hawaii.

The Hawaii handline fishery has nearshore and offshore components. The nearshore fishery operates within a few miles of shore, and targets large yellowfin and bigeye tunas. The full and part-time commercial boats engaged in the nearshore fishery are about 7-10 in (23-33 ft) long, and typically operate with a captain and sometimes one crew. In comparison, the mostly full-time commercial offshore handline boats are about 10-17 in (33-56 ft) long, and typically operate with a captain and one or two crew. The offshore fishery targets juvenile bigeye and yellowfin tuna around seamounts and weather buoys that are 50-320 km (35-200 nm) from shore.

When the fishing area is reached, a parachute sea anchor is deployed to slow the vessel's drift while the fishermen engage in either night *("ika-shibi"* or squid-tuna) or day *("palu-ahi"* or chum-tuna) fishing.

In the nighttime *ika-shibi* fishery, three to four handlines are set, each consisting of a long nylon rope connected to dacron or polypropylene mainline, which is attached to a monofilament nylon leader. The hook is usually baited with mackerel scad, and is lowered with the help of a lead weight. To attract baitfish and tuna to the area, a low wattage light bulb is placed in the water, and the surface is chummed with chopped squid and/or whole or chopped anchovies. The daytime *palu-ahi* technique adds a weighted, retrievable bag stuffed with chum that is released at a depth of 120-140 in (400-460 ft) to attract tunas to the baited hook. When a fish is hooked, it is manually hauled in, gaffed and then killed by a hit to the head with a bullet or wooden bat. Once the fish is on board, fishermen may bleed it and remove its head and viscera, and then place the fish in a mixture of ice and saltwater. These handling methods help to quickly cool the flesh so it will not become “burnt” (discolored and/or soft).

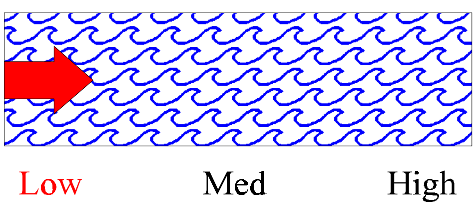
A nearshore handline trip usually lasts 1-2 days, while an offshore trip may last 1-5 days. Individual fish caught in the nearshore fishery typically weigh 18-90 kg (40-200 lb), and a good trip might land 130-180 kg (300-400 lb). Individual fish caught in the offshore fishery range from 4-32 kg (10-70 lb), and a good offshore trip might land 1,300-1,800 kg (3,000-4,000 lb). Much of the handline fish is sold directly to grocery stores and restaurants or peddled along the roadside, and some is shipped fresh by brokers to the various islands.



Habitat Impacts:

Pelagic handling gear has minimal habitat impacts. All gear is deployed in the water column without impacting the bottom substrate.

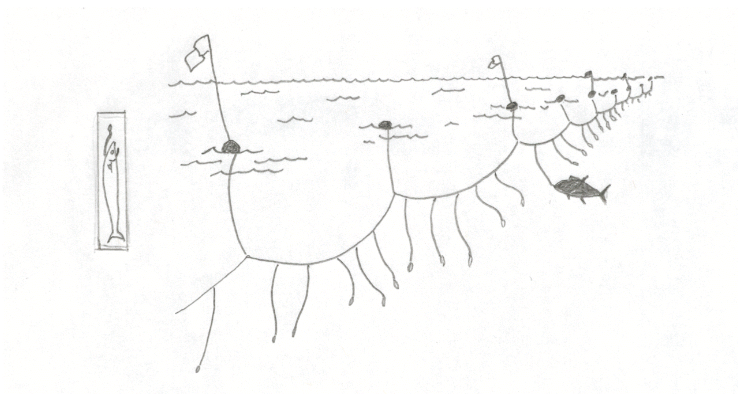
Bycatch:



Handline bycatch is mostly utilized, and includes swordfish, dolphinfish and wahoo. Sharks are also caught, but usually not kept. The handline fishery is active year-round, and many handliners also anticipate in the bottomfish and troll fisheries.

Gear Type: **Pelagic Longline**

Diagram of typical gear:



Deployment/retrieval:
Modern tuna longlining evolved from techniques developed in Japan several hundred years ago as a relatively simple method to harvest large yellowfin tuna and albacore. This technique is preferred for harvesting large tunas for *sashimi* markets, and swordfish. Longline gear consists of a mainline that is set horizontally near the surface, to which branch lines ('gangions") are clipped at regular intervals, each with a single baited hook.

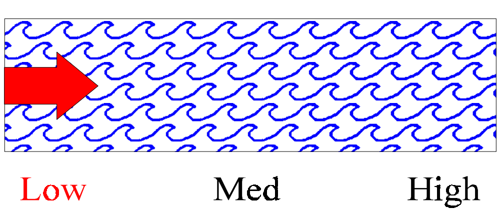
The mainline is typically 30-100 km (18-60 nm) long, with 400-2,000 baited hooks set each day (with an average of 800 in the Hawaiian fishery). The branch lines are typically 11-15 in (35-50 ft) long. When targeting swordfish, buoys are hooked to the mainline at about 500 m (1,650 ft) intervals, with 10-20 in (30-70 ft) of line to keep the mainline below the surface. Radar reflectors and radio beacons are used to keep track of the line. To target deeper-swimming bigeye tuna, line shooters are sometimes used to put slack into the mainline to make it sink deeper. These deeper sets use no light sticks and often have 6-7 branch lines between the floats, as compared to 2-3 gangions used when targeting swordfish.

Longliners set and retrieve their gear once a day, with the time of setting and hauling determined by the fish being targeted and prevailing fishing conditions. The mainline is set while the vessel steams across the prevailing current at about 15 kim/hr (8 knots, kt) while the crew snaps baited branch lines, typically 18-27 m (60-90 ft) long, to the mainline about every 150 feet (46 in). The hooks are typically baited with sardine, scad, squid or saury, and a buoy is attached to the mainline about every 12 hooks. To set the mainline deeper where valuable bigeye tuna are found, more branch lines are attached between buoys, longer buoy lines are used, and a line shooter releases more of the mainline to create slack during setting. Marker flags, lighted buoys and radio beacons are attached at regular intervals to mark the line.

Once set, the vessel may drift nearby or steam slowly along the line looking for bobbing floats that signal the presence of a struggling fish, in which case that section of the line is hauled and hooks are re-baited. Otherwise, the line may be left to soak until noon, when the hauling process begins. Retrieval of the gear may take as long as 12 hours. When hauling the line, the vessel must be kept constantly underway at 3-6 km/hr (2-3 kt), with the ship at a 150 to 450 angle to the mainline, as the line is too heavy to haul from a stationary vessel. Retrieval of the line is assisted by a hydraulic line hauler mounted near the foredeck rail. As the mainline is retrieved, the crew removes branch lines, buoy lines, lights and radio buoys, which are readied for the next day's set. After the hauling is complete, damaged sections of the mainline are replaced, and all gear and bait are made ready for the next morning's set.

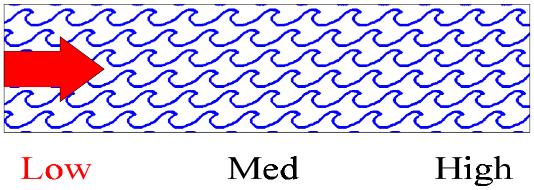
Longlining for swordfish in the North Pacific is a relatively new fishery for the USA, and the introduction of chemical light sticks in the late 1970s revolutionized the industry. Lights are attached by rubber bands or line clips to the branch lines about 2 in (6 ft) above the hook. The light sticks produce a chemical luminescence for up to 24 hr. The lights are available in a variety of colors and are thought to attract either the bait upon which swordfish prey, or the swordfish themselves. The light sticks are positively buoyant and of a shape and size that, if inadvertently lost from the branch line or discarded improperly, could create problems if ingested by marine mammals, seabirds or marine turtles.

Habitat Impacts:



Pelagic longline gear does not adversely affect essential fish habitat. All gear is deployed in the water column and does not interact with bottom substrate. The habitat of pelagic species targeted by longline gear is the open-ocean water column.

Bycatch:

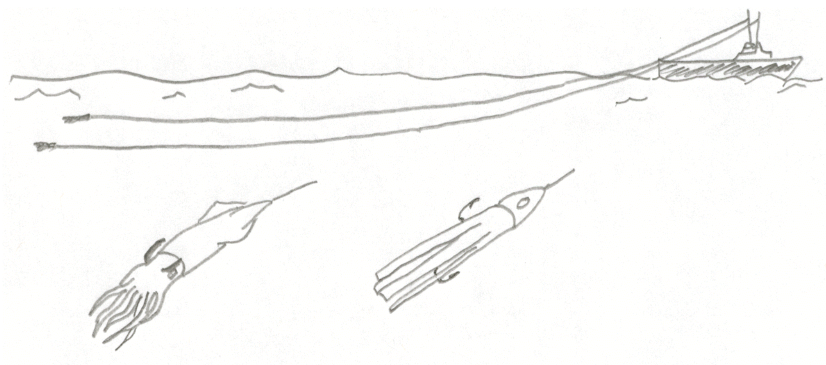


Pelagic longline gear is a relatively selective gear. In addition to tuna or swordfish, usual longline catch includes dolphinfish, wahoo, barracuda, moonfish, pomfrets and sharks, nearly all of which are kept and utilized. Typically, however, only the fins of sharks are kept and dried for shark fin soup, and usually only mako and thresher shark carcasses are landed whole.

Only a small percentage of the hooks on a given longline catch fish; typical catch rates for 1,000 hooks set from an Asian longliner may average 10-13 albacore, and 5-15 yellowfin or bigeye tuna, and a few billfish. Albacore taken on longline gear are mostly large, mature fish over four years old, weighing over 16 kg (35 lb). Yellowfin and bigeye tuna are also larger, older fish ranging to well over 90 kg (200 lb). The large number of hooks set, long trips, lower operating expenses (compared to purse seine vessels), and high value of the catch maintain the economic viability of the fishery.

Gear Type: **Trolling**

Diagram of typical gear:



Deployment/retrieval:
Trolling refers to the towing of artificial lures or natural baits near the surface from a moving boat ("trolling" and "trawling" are sometimes confused, but trawling refers to a vessel towing a net along the bottom or in the water column to harvest fish, shrimp or shellfish). Most areas of the Pacific have a relatively large number of small recreational and commercial trolling vessels, and trolling from chartered boats is popular in some areas. In addition, a fleet of high seas albacore trollers is also active throughout the Pacific.

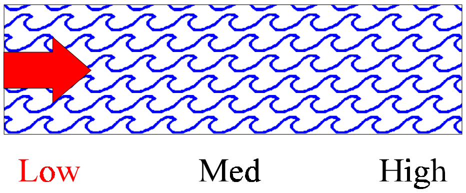
Trolling is the most popular pelagic fishing method in the region and includes full and part-time commercial (including charter boats) and recreational/subsistence participants. The pelagic troll fishery targets blue marlin, yellowfin tuna, dolphinfish, wahoo and skipjack tuna, and also lands bycatch of sailfish, spearfish, kawakawa, albacore, rainbow runner and sharks. Nearshore trolling target higher level carnivores such as jacks, baracuda, and other predators. Up to six lines rigged with artificial lures may be trolled when outrigger poles are used to keep the lines from tangling. Trolling gear usually consists of short, stout fiberglass poles and lever-drag hand-cranked reels. In addition to lures, trollers occasionally use live or dead bait. For example, small tuna are used to attract marlin, which is the prized catch for chartered vessels. Bigeye scad, mackerel scad, or strips of skipjack tuna are often used when a school of dolphinfish is encountered. Shallow water trolling uses juvenile goat fish or "oama" or juvenile scad “halalu”. When using live bait, the vessel slows to allow the bait to swim naturally.

Another form of pelagic trolling utilizes a single large fiberglass pole in the center of the vessel called a “green stick”. A large wooden or plastic lure, often referred to a “bird”, is trolled on the surface behind the vessel. The bird is attached to the green stick with heavy monofilament or nylon line. A series of plastic squid lures with single hooks are attached to a separate main line. The squid lures are then attached to the green stick line with rubber bands allowing the lures to skip along the surface of the ocean. When trolled properly, the bird creates excessive surface agitation and appears to be chasing the squid lures which skim along the surface. When fish take the lure, the line breaks away and the fish is fought separately on a rod and reel or by hand.

Trollers fish in areas where water masses converge and where the underwater topography changes dramatically, such as near submarine cliffs or oceanic seamounts. Trollers also frequent fish aggregation devices (FADs), or search for drifting logs or flotsam that aggregate tunas, dolphinfish and wahoo. The various segments of the fishery use the same gear and techniques, but differ in catch composition, vessel size, fishing effort and catch disposition. Charter boats target and catch more marlin (40-50% by weight) while non-charter commercial trollers target and catch more yellowfin (about 80% by weight). Charter boats typically measure 10-13 in (33-43 ft) whereas non-chartered trolling vessels are usually trailered boats ranging from 5-8 in (16-26 ft) in length. Full-time commercial vessels that are not engaged in charters expend the most effort, with an average trip lasting more than eight hours, whereas charterboats stay out 4-8 hr/trip. Part-time commercial and recreational vessels typically fish about 6 hr/trip. In Hawaii, about 70% of the charterboat catch, and 60% of the “recreational” and part-time commercial catch, is sold for food.

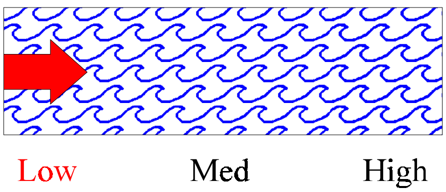
Commercial albacore trollers tow 12-18 lines simultaneously from the vessels’s stern and from long outrigger poles mounted amidships. The line lengths or depths are adjusted or to permit hauling of any one line without tangling or interfering with the others. The lines are either braided polypropylene, dacron or monofilament nylon and are pulled by hand or hydraulic haulers. Lures have metal heads and feather or plastic skirts, and are rigged with barbless double hooks. Troll vessels never stop when fishing during the day, but may slow and make tight circles or short, straight runs when fishing on an albacore school. Fish are hauled directly to the stern of the vessel where they are quickly taken from the water and unhooked before being stored whole in blast or spray brine freezer holds.

Albacore vessels usually drift at night or steam toward promising fishing grounds as determined by recent fishing activity, sea surface temperatures, or observations of baitfish and albacore on sonar or depth sounding equipment. The use of cooperative, or “code”, groups also increases efficiency of the fleet. At dawn, the jigs are deployed and the rest of the day is a continuous cycle of pulling fish, changing lures, storing the catch, and searching for birds, water temperature fronts or other vessels that might indicate productive fishing areas. At dusk, the jigs are retrieved and stored for the next day of fishing.



Habitat Impacts:

Trolling has no impact on habitat.

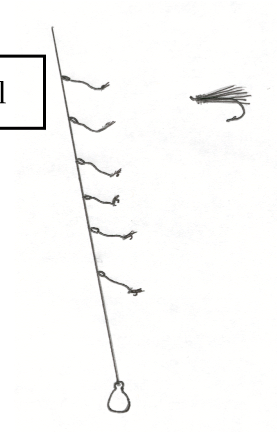


Bycatch:

Trolling has very few, if any, bycatch. Trolling effectively targets high level predators which are sought after for consumption or recreation.

Gear Type: **Handline (Big eye/scad/Akule/Atulai/Atule/Mackerel)**

Diagram of typical gear:

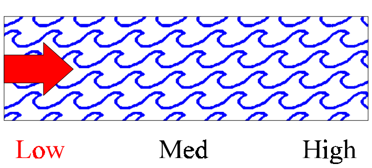

Terminal rig for Mackerel

Deployment/retrieval:

Handline fishing is an old technique used to catch akule/atulai/mackerel with simple gear and small boats. The mainline consists of 300 feet of 30 pound test monofilament that is laid in a basket to avoid tangling. The terminal rig can vary but generally is made using 15-20 feet of 20 pound monofilament to which a 3-9 ounce wight is attached. Six or seven small loops are made in the line by tying two overhand knots in 1 foot intervals along the line. Leaders of 6-8 pound test to which hooks are attached are tied to the loops. Artificial lures, such as plastic curly tails with glow beads or nylon strands tied to the hooks with red string, are common for this type of fishing. Japanese ready made leaders can be purchased from fishing stores.

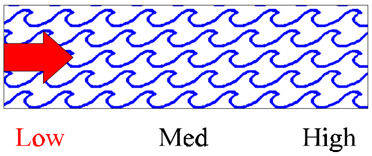
Fishing is conducted at night, moonless nights are generally more productive. Boats anchor in depths of 40 to 50 fathoms before dark or in the early evening. Lights are shown on in the water to attract bait which will in turn attract the mackerel. Mackerel primarily aggregate between 25-75 feet from the surface. The handline rig is dropped to these depths and retrieved slowly by jigging it to the surface. Although there are multiple hooks, fish are brought to the surface once hooked to reduce chances of predators taking the fish or chances of the fish breaking the leader. Once fish start biting, the light is dimmed to concentrate the school below the boat.

Habitat Impacts:



Mackerel handling gear has minimal habitat impacts. All gear is deployed in the water column without impacting the bottom substrate.

Bycatch:



Bycatch is extremely minimal. The handline fishery is active year-round, and many handliners also participate in the bottomfish and troll fisheries.

Regulatory Impact Review (RIR)
Initial Regulatory Flexibility Analysis (IRFA)

December 2000

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INTRODUCTION: ECONOMIC ANALYSIS OF REGULATORY ALTERNATIVES

Executive Order 12866 (E.O. 12866) requires that a Regulatory Impact Review be prepared for all regulatory actions that are of public interest. This review provides an overview of the problem, policy objectives, and anticipated impacts of the action, and ensures that management alternatives are systematically and comprehensively evaluated such that the public welfare can be enhanced in the most efficient and cost effective way. In accordance with E.O. 12866, the following is set forth: (1) This rule is not likely to have an annual effect on the economy of more $100 million or to adversely affect in a material way the economy, a sector of the economy, productivity, jobs, the environment, public health or safety, or state, local, or tribal governments or communities; (2) This rule is not likely to create any serious inconsistencies or otherwise interfere with any action taken or planned by another agency; (3) This rule is not likely to materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights or obligations of recipients thereof; (4) This rule is not likely to raise novel or policy issues arising out of legal mandates, or the principles set forth in the Executive Order. Based on these findings, this rule is determined not be significant under E.O. 12866.

The Regulatory Flexibility Act (5 U.S.C. 601 et seq.)(RFA) requires that agencies assess and present the impacts of their proposed actions on small business entities. In accordance with the RFA, the following is set forth: (1) Details on the need for, and objective of, the measures are outlined in the draft FMP which accompanies this document; (2) The proposed measures would apply to individuals who wish to harvest coral reef resources in the federal waters of the western Pacific region; (3) All affected individuals are expected to be small business entities; (4) The proposed measures include new reporting requirements; and (5) Some Federal rules are known to duplicate, overlap, or conflict with the proposed measures.

The general intent of the RIR and RFA analytical and process requirements is to make the decision process open and transparent so that all can understand the what, where, and why of regulatory decision-making and can agree that the required steps of the process were followed. The economic analyses provide decision-makers and the public with the agency's best estimates of the impacts of proposed actions and their alternatives. "In deciding whether and how to regulate, agencies should assess all costs and benefits of available regulatory measures, including the alternative of not regulating" (EO 12866, Section 1). Further, "agencies should select those approaches that maximize net benefits...." The emphasis of the analysis is therefore on the changes in the stream of net benefits that will occur as a result of each of the alternative management measures. The RIR also requires analysis of distributive impacts and the costs of government administration and private compliance with the proposed measures.

1.0 REGULATORY IMPACT REVIEW

1.1 Management Objectives

The objectives of the proposed regulatory actions are reflected in the objectives of the Fishery Management Plan for Coral Reef Ecosystems (FMP) , described in Section 1 of the FMP. These are:

Objective 1:
To foster sustainable use of multi-species resources in an ecologically and culturally sensitive manner, through the use of the precautionary approach and ecosystem-based resource management.

Objective 2:
To provide a flexible and responsive management system for coral reef resources, which can rapidly adapt to changes in resource abundance, new scientific information and changes in fishing patterns among user groups or by area.

Objective 3:
To establish integrated resource data collection and permitting systems, a research and monitoring program to collect fishery and other ecological information and to develop scientific data necessary to make informed management decisions about coral reef ecosystems in the EEZ.

Objective 4:
To minimize adverse human impacts on coral reef resources by establishing new and improving existing marine protected areas, managing fishing pressure, controlling wasteful harvest practices, reducing other anthropogenic stressors directly affecting them, and allowing the recovery of naturally-balanced reef systems. This objective includes the conservation and protection of essential fish habitats.

Objective 5:
To improve public and government awareness and understanding of coral reef ecosystems and their vulnerability and resource potential in order to reduce adverse human impacts and foster support for management.

Objective 6:
To collaborate with other agencies and organizations concerned with the conservation of coral reefs, in order to share in decision-making and to obtain and share data and resources needed to effectively monitor this vast and complex ecosystem.

Objective 7:

To encourage and promote improved surveillance and enforcement of the plan.

Objective 8:
To provide for sustainable participation of fishing communities in coral reef fisheries and, to the extent practicable, minimize the adverse economic impacts on such communities.

1.2 Statutory Basis

These management actions are proposed under the Magnuson-Stevens Fishery Conservation and Management Act (as amended in 1996), 50 CFR Part 660. Particular attention has been paid to requirements concerning essential fish habitat as defined in the Sustainable Fisheries Act of 1996. The relationship between the proposed measures and other national laws and policies is described in the Other Applicable Laws and Policies section of the FMP. A summary of existing laws and management measures in the state and territorial waters adjacent to those controlled by the proposed measures is provided in Appendix V (Green 1997) of the FMP.

1.3 Problem to be Resolved and Summary Economic Information

The rationale for the proposed management measures is described in detail in the FMP. In summary, many types of human activities have impacted, or have the potential to impact, coral reef resources around the US Pacific islands. The scale of different impacts can range from ocean wide to specific islands and watersheds, to specific reefs.

Stony corals are among the principal reef framework building organisms in the US Pacific Islands. In 1998, global coral bleaching and die off was unprecedented in geographic extent, depth and severity. Several studies have related bleaching to the combination of increased ultraviolet radiation and ocean warming, phenomena that may be exacerbated by human activities. Projected long-term climatic changes are likely to expose stony corals to an increasingly hostile environment and could possibly lead to mass extinctions. Of foremost concern is the degradation and destruction of habitats essential for the reproduction and recruitment of many coral reef species. Much of the previous damage to coral reef habitats in the US Pacific Island has occurred as a result of non-harvesting activities such as coastal and harbor development, watershed land use practices and runoff, industrial discharges and military use. Harvesting and non-harvesting vessels have the potential to degrade habitat by grounding, anchoring, introduction of invasive species, derelict gear, and other marine debris. The removal of live rock and the use of destructive harvesting techniques, such as explosives and poisons, can also directly affect coral reef habitats. Because many resources that contribute to coral reef habitat are essentially non-renewable (in human time dimension), prevention is a far more effective strategy than mitigation of damage after it has occurred.

The current regulatory regime in the western Pacific allows for open access with uncontrolled and unregulated harvesting of coral reef resources from many of the domestic coral reef ecosystems in the western Pacific. Although deep water bottom fisheries for bottomfish (snappers, groupers and jacks), trap fishing for crustaceans (primarily spiny and slipper lobster), and selected harvest of precious corals (which generally inhabit deeper depths than the coral reef ecosystem) are regulated by their own Western Pacific Regional Fishery Management Council FMPs (which include limited entry and other regulatory measures to control access and harvest levels), these FMPs fail to fully integrate an ecosystem approach to coral reef management. While fishing and other marine harvesting activities of domestic coral reef ecosystems are at present relatively quite limited, (particularly if excluding the bottomfish, crustacean, and precious coral fisheries), there are a number of possibilities for rapid and relatively unanticipated development of marine resource harvesting potential in this region. Particular opportunities exist for the marine ornamental products trade (including aquarium species and live rock), mariculture, bioprospecting and bio-harvesting (e.g., algae), and ecotourism activities including snorkeling and diving. Although there are some State and/or Territorial/Commonwealth licensing requirements for some of these activities, there are few requirements for the unincorporated U.S. Pacific islands (PRIAs) and little if any controls on access or total harvest. As a result, coral reef fisheries or other types of marine product harvesting could develop relatively unchecked.

Most of the problems addressed by this FMP are anticipated to derive from future developments rather than from current practices. This means the FMP is largely precautionary, which suggests a risk of unnecessarily precluding activities (which might have lower ecological impacts than anticipated), and thus foregoing the income and human welfare which a renewable natural resource can be expected to generate. The task of economic analysis in this FMP is to provide information to decision-makers and the public which will allow an informal calculus of the trade-offs between future risks and returns (information does not exist for a detailed quantitative cost-benefit analysis).

The following is a brief summary of what is known about the value of coral reef resources in the US Pacific Islands. The information sources for this information appears subsequently in this RIR.

1. The annual ex-vessel value of harvests from coral reef fisheries in the US Pacific Islands is about $15 million, out of a total ex-vessel value of all domestic marine fisheries in the region of roughly $95 million. In general, the coral reef resources component is much greater than the deep bottom component but much smaller than the pelagic component. The relative ex-vessel value of coral reef fisheries compared to other fisheries varies greatly among islands groups, being greatest in American Samoa and least in Hawaii.

2. About 10 percent of the coral reef resource ex-vessel value is from reef area under federal jurisdiction (or in the case of the CNMI, from the “offshore management zone”).

3. At least $3 million per year is spent on managing the coral reef fisheries of the region. In American Samoa, management costs are equal to about 75 percent of the fishery’s ex-vessel value. In Hawaii, the relative inputs into management are much lower–roughly 15 percent

of ex-vessel value, and in the CNMI and Guam, the relative costs of management are intermediate–in the range of 25 to 35 percent of ex-vessel value.

4. The net value of the region's coral reef fisheries is difficult to estimate because of the lack of information on harvesting costs and consumer surplus, including the non-market values that accrue to both seafood consumers and fishermen, including recreational, subsistence, and commercial fishermen. Based on tentative assumptions about the non-market benefits that accrue to fishermen, a plausible range of net value is \$0 to \$15 million per year, or assuming no change in the future trajectory of coral reef utilization, a net present value (NPV) of \$0 to \$175 million. That is, if the fisheries are operating at the open access equilibrium represented by minimal fisheries management, they may be generating no net value (profits) at all, or they may be generating net values of as much as the total ex-vessel value if there is considerable consumer and producer surplus, as well as non-market value.

5. In terms of the potential net value of coral reef fisheries in the region, the "nearshore" reefs–those within easy access of populated areas and ports–have the advantages of lower harvesting costs but potentially greater harvesting pressure and dangers of over-fishing: given the higher population levels, management costs may be substantial. Remote reefs may have the advantage of less degraded habitat and higher productivity.

6. The region's coral reefs generate economic value (both market and non-market values) in a number of non-fishery "sectors," including tourism and recreation, the reef as a breakwater, support for other ecosystems, etc. These values accrue to varying degrees to both local communities and to the nation and the world as a whole and their long-term value and utilization depends on their resilience to human, including fishing and other types of harvesting, and other non-human natural processes. Although accurate assessment of the value of all these reef-dependent sectors and sources of value is not possible in the context of this FMP (and has barely been attempted in a few marine park and marine pollution settings), it is apparent that the value of coral reef fisheries are, in general, smaller than the non-fishery values of coral reef ecosystems. For example, a tentative assessment of the annual net value of marine-based tourism in the US Pacific Islands is \$400 million to \$1.6 billion, or assuming no change in the future, a net present value of \$5 to \$19 billion. The extent to which this tourism relies on the coral reef ecosystem, and the marginal value of "units" of the coral reef ecosystem to those tourism values, has not been determined.

7. While coral reef fisheries and other forms of harvesting, through extraction of fish and degradation of habitat, have some capacity to degrade the non-fishery values of coral reef ecosystems, compared to impacts from other sources, such as oceanographic conditions and land-based disturbances – including shoreline development – the potential impacts from coral reef fisheries appear small if properly managed.

8. Although the actual and potential net values of the region's coral reef fisheries are modest, especially in comparison with the non-fishery values of the reefs, coral reef fisheries are very

important in terms of the indirect economic benefits and social benefits that they generate. The fishing communities and economies of the US Pacific Islands have a high degree of dependence on these fisheries and derive great benefits through the production of food, income, recreation, and values associated with culture and tradition.

9. Indirect economic benefits derived from local coral reefs include local spending by resident consumers, fishermen, and dealers, employment of fishermen and dealers and their suppliers, and expenditures by visiting anglers, divers, and other tourists. Federal funds applied to the management and development of local coral reef fisheries also generate substantial indirect benefits for local economies.

10. The dependence of fishing communities on coral reef fisheries is mostly limited to nearshore reefs close to populated areas. Only small portions of these reefs are under federal jurisdiction.

1.4 Proposed Actions

This FMP proposes management, under federal regulation, of the coral reef resources in the waters of the EEZ around American Samoa, Guam, Hawaii, Northern Mariana Islands and the unincorporated U.S. Pacific islands. The Fishery Management Unit is the entire region from the boundary of territorial waters (generally 3 miles offshore) to the limit of the EEZ (200 miles offshore) with special attention to waters within 50 fathoms. The proposed regulatory and non-regulatory measures are fully described in the FMP.

For the purposes of this FMP, the coral reef ecosystem is defined as substrate from 0-50 fm deep. In most areas, a large portion of these ecosystems fall within state or territorial waters (generally 3 miles from shore). The FMP proposes to regulate those portions which are outside of state or territorial waters and within 200 miles from shore (with an exception made for the Commonwealth of the Northern Mariana Islands where federal waters extend to the shoreline but management activities under this FMP will nevertheless begin at 3 miles from shore). Species to be managed under this FMP are termed management unit species (MUS) and are divided into two groups; Currently Harvested Coral Reef Taxa, which are relatively well understood; and Potentially Harvested Coral Reef Taxa, which have not been historically harvested or are not well understood. Some species already managed under existing FMPs are included as MUS under this FMP as well. These overlapping species would continue to be managed primarily under their current FMPs (Bottomfish, Crustaceans, Precious Corals), however broader ecosystem effects of these harvesting activities would now be addressed via this Coral Reef Ecosystem FMP.

The FMP proposes four (4) alternatives for managing the western Pacific coral reef ecosystem:

Alternative 1 (No Action) would implement no new regulations, i.e., only the existing Bottomfish, Crustacean, and Precious Coral FMPs would regulate activity in the western Pacific coral reef ecosystem;

Alternative 2 (Minimal Additional Protection) would designate several low-use MPAs, require permits for some takes of Coral Reef Ecosystem Management Unit Species (CRE MUS), limit takes of live rock and coral, and prohibit the use on non-selective gears to harvest CRE MUS throughout the EEZ;

Alternative 3 (Substantial Additional Protection - the Preferred Alternative) would encompass regulations in Alternative 2 and in addition designate several no-take MPAs, require all harvesting vessels transiting MPAs to carry wreck clean up and removal insurance, and prohibit the use of nighttime spearfishing for CRE MUS with SCUBA and/or hookah gear in the EEZs of the Northwestern Hawaiian Islands (NWHI) and the Pacific Remote Island Areas.

Alternative 4 (Maximum Additional Protection) would incorporate regulations in Alternatives 2 and 3 and in addition establish no-take MPAs out to 100 fathoms around all of the region's islands and atolls.

The Preferred Alternative for the Coral Reef Ecosystem FMP, i.e., Alternative 3, as approved by the Western Pacific Regional Fishery Management Council (Council) at a meeting in June 2000, would result in three major regulatory actions: (a) designation of marine protected areas; (b) harvesting permit and reporting requirements for harvesting of coral reef resources; and (c) definition of allowable gear and methods of harvesting for coral reef resources. The Council also proposes that the regulations include framework procedures to allow for timely, adaptive management based on new resource information, unforeseen effects, or changes in fisheries. In addition, the Council recommends that a formal procedure be established (under Standard Operating Procedures and Practices) for assessing and controlling ecosystem effects of reef-related fisheries which are managed under the existing FMPs for Bottomfish, Crustaceans and Precious Corals.

Alternative 1 (the No Action alternative) is essentially the existing baseline on which analysis of the action alternatives is based. The difference between the Preferred Alternative (Alternative 3) and the other two action alternatives (Alternatives 2 and 4) is essentially the extent of no-take MPAs designated by the FMP. These differences are delineated in detail in the text of the FMP.

Regarding marine protected areas (MPAs), the Council proposes to designate a series of areas as MPAs, which would be grouped into two types. The first is no-take MPAs in which no fishing or other harvest of coral reef resources would be permitted. The second is low-use MPAs in which controlled harvests of coral reef resources would be permitted. Under the Preferred Alternative waters out to 50 fathoms surrounding the NWHI islands of Laysan, French Frigate Shoals, and half of Midway would be designated as no-take MPAs. Proposed as no-take MPAs are the waters out to 50 fathoms surrounding Rose Atoll (American Samoa), Jarvis, Howland, Baker, Kingman Reef and Palmyra. Finally, waters out to 10 fathoms surrounding all other NWHI would also be designated as no-take MPAs under the Preferred Alternative. Low-use MPAs would consist of all remaining coral reef management areas (waters 0-50 fathoms) surrounding the NWHI, Johnston and Wake Atolls, and Guam's offshore southern banks.   Anchoring by harvesting vessels more than 50 feet in length would be prohibited in Guam's low-use MPA, and could be prohibited elsewhere at a later date under the FMP's framework process.

Regarding harvesting permits and reporting requirements, the Council's Preferred Alternative includes two types of permits, each with its own reporting requirements. The Special permit would be required for the harvest of any coral reef resources from low-use MPAs, as well as for the harvest of any Potentially Harvested Coral Reef Taxa from any coral reef management area. This permit would be issued on a case-by-case basis pending NMFS review and approval of the proposed activity. Accompanying this permit would be a mandatory detailed catch report form. Harvest of Currently Harvested Coral Reef species from all non-MPA coral reef management areas would require a General Permit, with a simplified catch report form. Exceptions to these requirements would be made for NWHI bottomfish, lobster, or precious corals fishery permit holders who are targeting species managed under their respective FMPs. These individuals would be prohibited from any harvesting within no-take MPAs, but would be allowed to fish within low-use MPAs under their current permit and reporting requirements. No permits would be issued for the collection of live stony coral or live rock for commercial purposes. Preferences would be given for the granting of Special Permits for indigenous harvesting activities in low-use MPAs, with a portion of each such area set aside for such activities.

A detailed list of proposed allowable gears is available in the FMP. In general, the Council proposes to prohibit the use of gears which would destroy coral reef habitat or have the potential for non-selective use. These include poisons, explosives, and intoxicating substances. Certain nets would be allowed if they are tended, and fish traps would be allowed in some areas. The use of manned and remotely operated submersibles would be permitted, as would hook and line fishing, and spear fishing. However, night spear fishing with SCUBA in coral reef areas around the NWHI, and the PRIA would be prohibited. These gear restrictions would apply only in low-use MPAs, such that harvesting in coral reef areas around the Main Hawaiian Islands, the Commonwealth of the Northern Mariana Islands, and most of American Samoa and Guam, would continue as currently allowed under state and local rules.

Finally, the Council's Preferred Alternative includes a requirement that all vessels (harvesting and non-harvesting) passing through low-use MPAs (except in Guam) would be subjected to insurance requirements to cover wreck removal and pollution clean up in the event of a grounding.

1.5 Description of Coral Reef Sectors

An underlying principle behind the ecosystem approach to fisheries management, as applied in this FMP, is that extractive fisheries and other types of coral reef ecosystem harvesting and activity will affect not just the targeted species, but other species (including their habitats), as well as other fisheries, and non-fishery uses and values. Each of the affected fisheries, uses, and values will be termed "sectors," of which there are three groups. Only the first, "coral reef fisheries," is directly managed by the FMP. This sector includes all harvest of coral reef resources (coral reef MUS taken from federal waters between 0-50 fathoms) including those currently managed under the Bottomfish, Crustaceans, and Precious Corals FMPs.

Types of Activities[1]

Coral Reef Fishery Sectors:

Food	All commercial, subsistence, and recreational harvest of coral reef resources generally towards food production.
Sport	For-hire fishing for coral reef resources with the primary motivation of recreation.
Ornamentals	Harvest of coral reef resources for use as ornamentals, for home and local use and commercial trade, and including fishes, invertebrates, and live rock.
Natural products	Harvest of coral reef resources for all other purposes, such as coral for bone grafts and production of pharmaceuticals.
Mariculture	At-sea mariculture of coral reef resources, and harvest of coral reef resource broodstock for land-based mariculture.

Non-coral Reef Fishery Sectors:

Deep water bottom fisheries	Fisheries for finfish, crustaceans, and precious corals, in benthic environments deeper than 50 fathoms, including for food, sport, and ornamentals, as described above for coral reef fisheries.
Pelagic fisheries	Fisheries for finfish in pelagic ecosystems, including for food and sport. In general the pelagic fisheries are not directly related to the coral reef ecosystem.

Non-fishery Sectors:

Tourism (non-fishing)	Visitors engaging in scuba diving, snorkeling, boating, swimming, viewing of coral reefs, and other coral reef-related activities, including eco-tourism.
Recreation (non-fishing)	Residents engaging in scuba diving, snorkeling, boating, swimming, viewing of coral reefs, and other coral reef-related activities.
Mining	Extraction of fossil coral and sand from the coral reef ecosystem.
Breakwater	Coral reef ecosystems functioning to protect shorelines from erosion and to provide shelter for navigation and mooring, and other activities.
Ecological support	Coral reef ecosystems functioning as nursery areas, spawning areas, or otherwise in support of resources, fisheries, and ecological services in other ecosystems.
Information	Coral reef ecosystems providing values associated with gaining and sharing information–that is, the non-extractive, "discovery," aspects of research and education, and the values associated with the consequential development and production of marine natural products.
Biodiversity	Coral reef ecosystems providing values associated with varied genetic resources.

Location of Activities

Table 1 presents the size and locations of western Pacific domestic coral reef ecosystems (coral reefs located in waters between 0 and 50 fathoms in depth), as well as the portions which would be included within the proposed FMP management area (those coral reefs located between 0 and 50 fathoms in depth and between 3 and 200 miles from shore).

Table 1. Domestic Coral Reef Areas of the Western Pacific Region

Location	Total coral reef area (km^2)	Coral reef area between 0-3 miles from shore (percent of total)	Coral reef area between 3-200 miles from shore (percent of total)

American Samoa	296	271 (92%)	25 (8%)
Guam	179	69 (39%)	110 (61%)
Hawaii			
Main Hawaiian Islands	2,535	1,655 (65%)	880 (35%)
Northwestern Hawaiian Islands	11,554	2,430 (21%)	9,124 (79%)
Commonwealth of the Northern Marina Islands	579	45 (8%)	534 (92%)
Remote US Pacific Islands	709	620 (87%)	89 (13%)
TOTAL	15,852	5,090 (32%)	10,762 (68%)

Source: Hunter, 1995.

Overall, 68 % of domestic western Pacific coral reefs would be managed under this FMP, however the distribution of reefs between local and federal authorities varies dramatically by area.

Appendix II of the FMP (the draft EIS) provides a summary of the known historical and present uses of domestic coral reefs. Table 2 is a summary of the approximate, recent, total annual ex-vessel values for each of the domestic marine fisheries of the western Pacific region's island groups. The focus is on fisheries for coral reef resources (coral reef MUS taken from 0-50 fathoms), but rough estimates of the deep bottom and pelagic fisheries are also provided, both for comparison and because they may be affected by the management measures. Values presented are for the total value (in 1999 dollars) of landings from each area, as well as for the portion located in the proposed FMP management area. Ex-vessel values are the estimated total annual gross value of landings from each fishery, whether sold or not. The ex-vessel values for the sport sectors are the charter fees; the value of the landings in the sport fisheries are included in the food sector. The details behind these values, including the volume of landings on which they are based, are provided for each of the island groups in Tables 3 through 8. The uncertainty associated with these estimates is variable and in some cases quite high; refer to Section 4 for data sources, assumptions, qualifiers, and the periods upon which the estimates are based

Table 2. Summary of Fisheries Annual Ex-vessel Value ($1,000/year)

	Am. Samoa		CNMI		Guam		MHI		NWHI		Other islands		All islands	
	Total	FMP	Total	FMP	Total	FMP	Total	FMP	Total	FMP	Total	FMP	Total	FMP
Coral reef:														
Food	671	8	1,217	54	1,214	118	9,391	1,075	1,295	12	22	21	**13,809**	**1,287**
Sport	m	0	80	4	306	15	71	7	159	159	0	0	**616**	**186**
Ornamentals	10	0	m	0	48	0	1,004	0	0	0	m	m	**1,062**	**m**
Natural products	0	0	0	0	0	0	?	?	0	0	0	0	**?**	**?**
Mariculture	m	0	0	0	0	0	?	0	0	0	0	0	**m**	**0**
Total coral reef	**681**	**8**	**1,297**	**58**	**1,567**	**133**	**10,465**	**1,082**	**1,454**	**171**	**22**	**21**	**15,486**	**1,472**
Deep bottom:														
Food	64	0	166	0	158	0	1,455	0	1,161	0	0	0	**3,004**	
Sport	m	0	30	0	306	0	707	0	m	0	0	0	**1,043**	
Ornamentals	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
Total deep bottom	**64**	**0**	**196**	**0**	**463**	**0**	**2,162**	**0**	**1,161**	**0**	**0**	**0**	**4,047**	
Pelagic:														
Food	444	0	950	0	858	0	48,200	0	8,764	0	10	0	**59,226**	
Sport	10	0	900	0	1,238	0	14,000	0	159	0	0	0	**16,307**	
Total pelagic	**454**	**0**	**1,850**	**0**	**2,096**	**0**	**62,200**	**0**	**8,923**	**0**	**10**	**0**	**75,533**	
TOTAL	**1,199**	**8**	**3,343**	**58**	**4,127**	**133**	**74,827**	**1,082**	**11,538**	**171**	**32**	**21**	**95,066**	**1,472**

Values are approximate, recent, annual gross values of the production side of these fisheries, expressed in 1999 dollars (x 1,000).
"m" means minimal and unquantifiable.

Table 3. American Samoa Fisheries by Area : Annual Volume and Ex-vessel Value

	Annual Total		% of harvest from proposed FMP area	FMP portion	
	Volume (lbs)	Value ($1,000)		Volume (lbs)	Value ($1,000)
Coral reef area harvests:					
Food					
Finfish:					
live	0	0	0	0	0
dead	216,000	393	2	4,000	8
Crustaceans:	7,000	26	0	0	0
lobster					
other crustaceans					
Echinoderms	43,000	87	0	0	0
Molluscs:	73,000	146	0	0	0
mother-of-pearl					
other molluscs					
Other invertebrates	2,000	20	0	0	0
Seaweeds	min	min	0	0	0
Sport	min	min	0	0	0
Ornamentals					
Fishes and other	5,000	10	0	0	0
Hermatypic coral/live	min	min	0	0	0
Black coral	0	0		0	0
Marine natural products	0	0		0	0
Mariculture	min	min	0	0	0
Total coral reef area		**681**			**8**
Deep bottom area harvests:					
Food	27,000	64	0	0	0
Sport	min	min	0	0	0
Ornamentals	0	0	0	0	0
Total deep bottom		**64**			**0**
Pelagic fisheries:					
Food	400,000	444	0	0	0
Sport	120	10	0	0	0
Total pelagic harvests		**454**			**0**
Total all fisheries		**1,199**			**8**

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.
"min" means minimal.

Table 4. Northern Mariana Islands Fisheries by Area: Annual Volume and Ex-vessel Value

	Annual Total		% of harvest from proposed FMP area	FMP portion	
	Volume (lbs)	Value ($1,000)		Volume (lbs)	Value ($1,000)
Coral reef:					
Food					
Finfish:					
live	0	0		0	0
dead	446,000	1,070	5	22,000	54
Crustaceans:					
lobster	4,000	19	0	0	0
other crustaceans					
Echinoderms	25,000	68	0	0	0
Molluscs:					
mother-of-pearl	20,000	60	0	0	0
other molluscs					
Other invertebrates					
Seaweeds	min	min	0	0	0
Sport	1,600	80	5	80	4
Ornamentals					
Fishes and other inverts	min	min	0	0	0
Hermatypic coral/live	min	min	0	0	0
Black coral	0	0		0	0
Marine natural products	0	0		0	0
Mariculture	0	0		0	0
Total coral reef		**1,297**			**58**
Deep bottom:					
Food	50,000	166	0	0	0
Sport	300	30	0	0	0
Ornamentals	0	0		0	0
Total deep bottom		**196**			**0**
Pelagic:					
Food	500,000	950	0	0	0
Sport	9,000	900	0	0	0
Total pelagic		**1,850**			**0**
Total all fisheries		**3,343**			

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.

Table 5. Guam Fisheries by Area: Annual Volume and Ex-vessel Value

	Annual Total		% of harvest from proposed FMP area	FMP portion	
	Volume (lbs)	Value ($1,000)		Volume (lbs)	Value ($1,000)
Coral reef:					
Food					
Finfish:					
live	0	0		0	0
dead	400,000	1,176	10	40,000	118
Crustaceans:					
lobster	5,000	19	0	0	0
other crustaceans					
Echinoderms					
Molluscs:					
mother-of-pearl	3,000	6	0	0	0
other molluscs	4,000	9	0	0	0
Other invertebrates	1,000	2	0	0	0
Seaweeds	some	unknown	0	0	0
Sport	10,000	306	5	510	15
Ornamentals					
Fishes and other inverts	24,000	48	0	0	0
Hermatypic coral/live	min	min	0	0	0
Black coral	0	0		0	0
Marine natural products	0	0		0	0
Mariculture	0	0		0	0
Total coral reef		**1,567**			**133**
Deep bottom:					
Food	45,000	158	0	0	0
Sport	10,000	306	0	0	0
Ornamentals	0	0			0
Total deep bottom		**463**			
Pelagic:					
Food	660,000	858	0	0	0
Sport	21,000	1,238	0	0	0
Total pelagic		**2,096**			**0**
Total all fisheries		**4,127**			**133**

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.

Table 6. Main Hawaiian Islands Fisheries by Area: Annual Volume and Ex-vessel Value

	Annual Total		% of harvest from proposed FMP area	FMP portion	
	Volume (lbs)	Value ($1,000)		Volume (lbs)	Value ($1,000)
Coral reef:					
Food	1,004,900	9,391		540,001	1,076
Finfish:					
live					
dead	443,900	7,571	10	439,000	750
Crustaceans:					
lobster	10,000	128	0	0	0
other crustaceans	100,000	417	41	41,000	173
Echinoderms	1,000	11	3	0	0
Molluscs:					
mother-of-pearl					
other molluscs	369,000	925	16	60,000	150
Other invertebrates					
Seaweeds	81,000	339	1	1	3
Sport	500	71	10	50	7
Ornamentals					
Fishes and other	430,000	937	0	0	0
Hermatypic coral/live	min	min	0	0	0
Black coral	3,000	66	0	0	0
Marine natural products	unknown	unknown	unknown	unknown	unknown
Mariculture	unknown	unknown	0	0	0
Total coral reef		**10,465**			**1,082**
Deep bottom:					
Food	418,000	1,455	0	0	0
Sport	5,000	707	0	0	0
Ornamentals	0	0		0	0
Total deep bottom		**2,162**			**0**
Pelagic:					
Food	22,000,00	48,200	0	0	0
Sport	99,000	14,000	0	0	0
Total pelagic		**62,200**			**0**
Total all fisheries		**74,827**			**1,082**

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.

Table 7. Northwestern Hawaiian Islands Fisheries by Area: Volume and Ex-vessel Value

	Annual Total		% of harvest from proposed FMP area	FMP portion	
	Volume (lbs)	**Value ($1,000)**		**Volume (lbs)**	**Value ($1,000)**
Food					
Finfish:					
live	0	0		0	0
dead	19,000	14	82	16,000	11
Crustaceans:					
lobster	246,000	1,280	0	0	0
other crustaceans	min	1	51	min	min
Echinoderms	0	0		0	0
Molluscs:					
mother-of-pearl					
other molluscs	0	0		0	0
Other invertebrates	0	0		0	0
Seaweeds	0	0		0	0
Sport	375	159	100	375	159
Ornamentals					
Fishes and other inverts	0	0		0	0
Hermatypic coral/live	0	0		0	0
Black coral	0	0		0	0
Marine natural products	0	0		0	0
Mariculture	0	0		0	0
Total coral reef		**1,454**			**171**
Deep bottom:					
Food	371,000	1,161	0	0	0
Sport	min	min	0	0	0
Ornamentals	0	0		0	0
Total deep bottom		**1,161**			**0**
Pelagic:					
Food	4,000,00	8,764	0	0	0
Sport	375	159	0	0	0
Total pelagic		**8,923**			**0**
Total all fisheries		**11,538**			**171**

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.

Table 8. Other Islands Fisheries by Area: Annual Volume and Ex-vessel Value

	Annual Total		% of harvest from proposed FMP area	FMP portion	
	Volume (lbs)	Value ($1,000)		Volume (lbs)	Value ($1,000)
Coral reef:					
Food					
Finfish:					
live	0	0		0	0
dead	10,000	20	100	10,000	20
Crustaceans:					
lobster	200	1	0	0	0
other crustaceans	200	min	100	200	min
Echinoderms	0	0		0	0
Molluscs:					
mother-of-pearl					
other molluscs	100	min	100	100	min
Other invertebrates	0	0		0	0
Seaweeds	0	0		0	0
Sport	0	0		0	0
Ornamentals					
Fishes and other inverts	min	min	100	min	min
Hermatypic coral/live	min	min	100	min	min
Black coral	0	0		0	0
Marine natural products	0	0		0	0
Mariculture	0	0		0	0
Total coral reef		**22**			**21**
Deep bottom:					
Food	min	min	0	0	0
Sport	0	0		0	0
Ornamentals	0	0		0	0
Total deep bottom		**0**			**0**
Pelagic:					
Food	5,000	10	0	0	0
Sport	0	0		0	0
Total pelagic		**10**			**0**
Total all fisheries		**32**			**21**

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.

Based on the estimates in the preceding tables, the total annual ex-vessel value of the region's fisheries for coral reef resources (coral reef MUS taken from 0-50 fathoms) in recent years was about $15 million, $14 million of which was in food fisheries (mostly bottomfish and lobsters) $1 million in ornamentals (from 0.5 million pieces), and $0.6 million in sport fisheries (from 12,000 angler-trips). The deep bottom fisheries (mostly bottomfish and lobsters harvested from greater than 50 fathoms) realized an approximate ex-vessel value of $4 million annually. The value of the natural products and mariculture sectors were assumed to be minimal, but more in-depth investigation might reveal otherwise.

Hawaii's share of total coral reef resource harvests was about 77 percent, or $12 million, of which 88 percent was in the main islands and 12 percent in the Northwestern Hawaiian Islands. The ex-vessel value of Guam's harvested coral reef resources was about $1.6 million, the CNMI's about $1.3 million, and American Samoa's about $0.7 million.

Overall, it was very roughly estimated that 10 percent of the total ex-vessel value of harvested coral reef resources was taken in federal waters (or the "management zone" of the CNMI). The estimated percentages of total ex-vessel value caught in the proposed FMP area (federal waters between 0-50 fathoms) were 1 percent in American Samoa, 4 percent in the CNMI, 8 percent in Guam, and 11 percent in Hawaii.

1.6 Economic Analysis of Existing Coral Reef Ecosystem Resources and Processes

1.6.1 Analytical Approach

Fishery and Non-fishery Values:

The management measures of the FMP will, as recognized in the plan's ecosystem-based approach, affect not just the value of the federal coral reef fisheries directly being managed, but also adjacent coral reef fisheries (e.g., in state and territorial waters), other types of fisheries (e.g., pelagic and deep bottom), and reef-dependent non-fishery uses and values, such as tourism. A comprehensive benefit-cost analysis of the proposed measures would therefore require detailed determination of the physical processes connecting these aspects of the coral reef ecosystem and the effects of harvesting on these connections and processes, as well as assessments of the value of all these sectors and the changes that might be caused by harvesting and/or regulation. In concept that has been done here, but because of deficiencies in available data and methods, the assessment is only qualitative for many sectors, with specification of some quantitative ranges of plausible values derived from available data and studies in other parts of the world.

Notwithstanding the limitations of this assessment in providing accurate measures of the net value of the affected sectors, the valuation estimates should be useful in making comparisons among alternatives as well as between fishery and non-fishery uses of the coral reef ecosystem. Most importantly, they will give an idea of how much value is potentially "on the line" under the various management measures being discussed.

National Versus Foreign Benefits:

In this analysis, we are interested only in how the proposed management measures affect the national account, i.e., the value to the United States as a whole. If the catch is exported and consumed outside the US, the consumer surplus is not accruing to the national account and should be omitted from the assessment. Similarly, if foreign visitors in the US are enjoying producer surplus (e.g., as commercial fishermen) or consumer surplus (e.g., as visiting anglers), those components should be omitted from the assessment.

It should be kept in mind that while the generation of producer or consumer surplus outside the national account is not relevant in terms of assessing net economic value, it can be very important in terms of indirect economic impacts. The expenditures of foreign tourists that hire charter fishing services in Hawaii, for example, may bring great indirect economic benefits to the local economy, and the consumer surplus these anglers enjoy through fishing is, of course, an important motivation for them to visit the US and make those expenditures.

Net Present Value:
Impacts to net economic value are generally described in terms of how the total future stream of net benefits is affected. Net present value (NPV) is the measure of that stream of future net benefits (time-discounted benefits minus costs over time). It is the time-discounted (through use of a standard discount rate) sum of all future benefits less the discounted sum of all future costs. The alternative that yields the greatest NPV would be the preferred one, subject to other considerations such as indirect economic and social impacts and conflicting national standards (e.g., application of the Endangered Species Act). Estimates of NPV require projections of how the fishery and other harvesting activities will evolve. In most of the sectors affected by this FMP – and in particular for the non-fishery sectors, many of which are undeveloped or even unknown – this is difficult, requiring in a number of cases reasonable conjecture. The task is further confounded by the lack of information about even the current (annual) net value of some affected sectors, and by limitations in valuation methodologies. In short, it will not be possible to quantitatively estimate the NPV of most affected sectors under either the with- or without-action alternatives. Therefore, the analysis instead focuses on whether the impacts to the total NPV under a given alternative are likely to be positive or negative. The impacts of various alternatives will then be qualitatively compared in terms of direction and relative magnitude of impacts to provide a simple benefit-cost analysis of alternate management regimes.

In order to provide points of reference – for example, to roughly compare values among affected economic sectors, some measures of the possible bounds of net benefits will be made. Net economic benefit is the sum of producer surplus and consumer surplus, less any public inputs such as management costs. In the case of a commercial fishery, producer surplus is equal to net returns from the fishery: ex-vessel value less all input costs (all harvesting costs, including labor). Consumer surplus in a commercial fishery is the net benefit of the product to consumers, i.e., their demand for the product less the purchase cost, summed across all consumers. In the case of a recreational fishery, consumer surplus is the net benefit to anglers, i.e., their willingness-to-pay to fish less the costs incurred in angling, summed across all anglers. If the angler is hiring charter services, the fishery may also generate producer surplus, equal to net charter revenues: charter fees less the costs of operating the charter. There may also be consumer surplus in the charter boat case, i.e., the economic utility to the charter patron above the price he/she has to pay for the charter. In the case of subsistence fisheries, producer surplus and consumer surplus are one and the same, and they can be measured as willingness-to-pay less the cost of all fishery inputs.

In addition to these generally measurable benefits and costs, there are less direct and more difficult to measure values that should be accounted for. For example, just as purely recreational fishermen derive non-market values from fishing, many commercial fishermen do, as well. The social values of fisheries should also be accounted for in net value. Another important source of economic value is option value, which reflects the economic importance of keeping future options open – of not making irreversible commitments or changes to the resource. There is also what might be termed reverse-option value, the foreclosing of investment and other use opportunities in the near-term through overly-restrictive regulation. While options to engage in these types of activities may exist in the future (subject to natural changes in the environment, subsequent catastrophic natural or human events, etc.), the net present value of those options is reduced to the extent that they are pushed into the future.

Another type of value derived from fish populations, reef systems, etc. is existence value–the value derived by people who do not fish and do not consume fish, but who benefit from knowing that they have the opportunity to do so, or from the vicarious enjoyment of other peoples' fishing and consumption. For example, few people fish at the remote island of Midway, but many more anglers benefit from the fishery, as evidenced by the number of fishing magazines that feature articles on Midway. Existence value can clearly be affected by the management measures (e.g., negatively through direct closure of a fishery or positively through prevention of stock depletion that leads to the loss of harvesting opportunities). It should therefore be assessed as part of the net value of the fishery.

Furthermore, it is not just the value of traditional or developing fisheries that need to be assessed, but also other types of commercial exploitation of the coral reef ecosystem (e.g., aquarium fish collection, mariculture, and bio-prospecting), as well as reef-dependent non-fishery uses and values. Because this FMP addresses a range of effects on coral reef systems that have not been systematically analyzed in the fisheries literature or have only begun to be considered (either analytically or commercially), such as bio-prospecting, some of the discussion of economic impacts is hypothetical.

Finally, economic analysis usually requires a clear delineation of the physical and operational impact of an activity on the subsequent flow of economic resources from the affected natural resource asset (in this case, the coral reef ecosystem). Unfortunately the natural inter-relationships between particular components of the coral reef ecosystem are not well determined, at least quantitatively. As a result, it is frequently difficult or impossible to indicate to what extent the removal of a particular amount of a particular species will have on the surrounding ecosystem, and what effect, if any, that impact will affect economic values. It is relatively easy to identify the impact of regulation on the operation of existing harvesters, but less so on future operations. As a result, much of the regulatory impact review (and subsequent regulatory flexibility analysis) must take place at the level of principles, rather than quantities. This qualitative description of effects, or potential effects, nonetheless should provide decision-makers with insights into the economic effects of the proposed management measures and their alternatives.

Time Scales:
Some non-fishery values are highly dependent on coral reefs being alive, diverse, and/or productive, while others rely more on the reef's fundamental structure – the reef as a well-placed mass of

limestone. For example, in terms of protecting coastal property and providing calm waters for recreational water craft and shore-side activities, as long as the structure of the reef deflects waves and provides sandy beaches and lagoon bottoms, the values from these uses will remain high. A reef would have to be highly degraded before these values are affected – its physical structure would have to be substantially reduced. However, fishing-out a spawning aggregation of groupers or killing large areas of coral from cyanide can occur in just a year or two, and the consequent impacts to the value of scuba diving, for example, can be immediate and substantial. Thus, in terms of assessing the impacts of the fishery management measures proposed in the FMP, the time scales over which biological and ecological impacts are likely to occur are therefore very important.

Given that we as a society discount future benefits and costs substantially, any impacts that occur more than 20 to 50 years in the future are practically inconsequential in terms of present value. Society's annual discount rate is generally considered to be between 5 and 20 percent (this analysis has used a 7 percent rate). Even at a conservative discount rate of 5 percent, the difference in the present value of an activity over a 50 year time period versus a 100 year time period is only 9 percent. At a 10 percent discount rate, the difference is less than 1 percent. Clearly, assessments of NPV are sensitive to assumptions concerning the rates at which impacts occur.

Discount Rate, Time Horizon, and Inflation:
Where NPV is estimated, it is done by applying an annual discount rate of seven percent, following US government guidance (OMB 1992), and a time horizon of 25 years. Where there is reference in this analysis to NPV estimates from other studies, those estimates have been adjusted using seven percent and 25 years in order to facilitate comparison.

Except where otherwise noted, dollar figures have been inflation-adjusted to 1999 dollars using consumer price indices (CPI). Hawaii, American Samoa, and Pacific-wide values have been adjusted with the urban CPI for Honolulu (DBEDT, no date). Guam and the CNMI values have been adjusted with the Guam CPI (GDC, 1999). All others will be adjusted with the US city average CPI (BLS, 1999).

Measuring Producer and Consumer Surplus in Fisheries:
Pooley (1993b:93) notes that "...the distinction between 'commercial,' and 'recreational and subsistence' fishing in Hawaii is a weak [one]," and the same is true throughout the US Pacific Islands. The coastal fisheries of the region are dominated, at least in terms of numbers of fishermen, by small-scale, part-time fishermen that have variously mixed motivations to fish. They derive benefits as both producers and consumers–that is, consumers of both seafood and enjoyment. Even purely commercial fishermen may derive some enjoyment, or consumer surplus, from fishing, above and beyond that reflected in their net revenues. In fact, for the purposes of this analysis there is no need to categorize fisheries as being commercial, recreational, or subsistence, as long as all aspects of both producer and consumer surplus in each fishery are accounted for. Such comprehensive accounting is a difficult challenge in any fishery, let alone the fisheries of the US Pacific Islands. Data from the region on landings alone are often incomplete, unreliable, and/or not sufficiently dis-aggregated by species, area, or harvesting sector. Data on prices and gross revenues are available for many fisheries, but data on harvesting costs are rare, as are assessments of non-market values (e.g., willingness-to-pay to fish or to consume seafood).

For two reasons–the mixed and highly variable motivations among participants in the fishery and the lack of economic data–the net economic value of the affected fisheries is not rigorously assessed in here. Instead, quantified assessments have been done only on the elements of net economic value for which data are available–the ex-vessel value of the catch, and management costs. Both commercial and non-commercial catches are valued using prevailing ex-vessel prices. Charter fee revenues are considered the ex-vessel value of charter sport fisheries (the value of charter landings is assessed separately within the "food" fisheries).

Ex-vessel value can be viewed as the absolute upper bound to producer surplus. Producer surplus, however, is often less than zero. For example, the small-boat fishermen in Hawaii called "expense fishermen" by Hamilton and Huffman (1997) sell part of their catch to offset fishing expenses, but their expenses still outweigh their revenues. Their motivations are clearly a mix of recreation and commerce, and probably subsistence, as well. However, these fishermen are undoubtedly receiving enough consumer surplus (e.g., enjoyment) to offset that negative, and the net value of such a fishery can reasonably be assumed to be greater than zero.

The consumer surplus that accrues to fishermen is not estimated here, but because of the obvious problems with relying on ex-vessel value as an indicator of net value, the estimates of ex-vessel value will be supplemented with descriptions of possible ranges of fishermen's consumer surplus. Reviews of non-market valuations of consumer surplus from other fisheries are provided where possible, but extrapolation from one socio-economic and natural setting to another is in general not advised.

Allocation of Costs and Benefits:
A distinction must be made between the coral reef fisheries (resources) which would fall under this FMP's primary jurisdiction and those that would not–that is, those in territorial waters and those managed under other FMPs, including lobsters, precious corals, and most commercial bottomfish species. Most harvesting of coral reef resources takes place in territorial waters which would not be subject to the management measures, but the federal/state boundary (much less the 50 fathom contour line), is not a practical one for most fishermen nor for the various government agencies that monitor fisheries. Existing catch and effort data are therefore not easy to sort by federal versus state waters, and dividing the economic values of the fisheries between the two components is not easy. This analysis includes estimates of the total landings and value for each coral reef fishery sector and for the "FMP portion" of the total, the latter being that portion of the total coral reef resources that are derived from federal waters and that would be subject to the FMP.

1.6.2 Net Present Value of Coral Reef Fishery Sectors

Concepts and techniques for valuing coral reefs and other ecosystems have developed greatly in the last decade. The main application of valuation techniques has been for the purpose of measuring the actual (e.g., in the case of a vessel grounding) or projected (e.g., in the case of this FMP) impacts to the net value of a specific area of coral reef. Most approaches have involved identification of all the values associated with coral reefs, and to the extent possible, quantification of them. Direct uses that have markets, such as fisheries, can be assessed using market values. Indirect uses and values that have no markets can be assessed using contingent valuation techniques that measure consumer surplus–basically polling people to determine what they would be willing to pay to not lose a given resource. But the method is very dependent on which and how many people are polled, and what questions they are asked. It is also dependent on the information people have–if they do not have an understanding of the actual or potential values that can be derived from the genetic material of coral reefs, for example, they cannot be expected to place a reasonable value on those resources. The calculation of replacement cost is another method which can also be used to estimate the value of a particular product, function, or service provided by reefs.

Discussed below are the many products, functions, and services provided by coral reef ecosystems, including the extractive fisheries to be managed by this FMP. It should be kept in mind that some values of coral reefs are partially or wholly mutually exclusive, so the values identified below are not necessarily additive. Mining of corals, for example, is likely to detrimentally impact other values of the reef.

Over-valuation can also occur through double-counting particular values–once inside the "coral reef" sector and again, at least implicitly, outside the sector (Costanza *et al.* 1997). Spurgeon (1992), for example, suggested that the value of coral reefs includes the mineral and pelagic fisheries values associated with increased property rights to coastal states afforded by the UN Convention on the Law of the Sea. The convention allows coastal states to make certain claims to marine resources 200 miles not just from shore, but from exposed reefs up to 12 miles from shore. "By increasing the extent of coastal zones, these reefs can be responsible for significant economic benefits" (*ibid*:533). Clearly these provisions affect the distribution of benefits among countries, and they may in fact increase total available benefits if they lead to more effective management. But to attribute any such increase in benefits to the coral reefs themselves is a bit dangerous. It would be equally justifiable to attribute any increased value to the negotiators of the convention as to the reefs.

In an assessment of the world's natural capital and ecosystem services, Costanza *et al.* (1997) emphasized the interdependence of ecosystems and their services, and suggested that the next logical step in valuing ecosystem services would be the development of "general equilibrium" models to replace the typical approach of treating each ecosystem and each service independently and then summing their values. In other words, although this analysis is based on an ecosystem-based approach to valuation (as the entire FMP is based on an ecosystem-based approach to management), it may run into the same types of problems as a species-based approach, only at a more general level.

Another problem in valuing the total value of ecosystems is that ecological services tend to have much different supply and demand curves than products and services with markets. As described in Costanza *et al.* (1997), essential ecosystem services, such as clean air, are substitutable only up to a point. Demand will approach infinity as supply approaches zero, so consumer surplus and total value approach infinity, as well.

In sum, assessment of the values of coral reef ecosystems is complex and problematic. This analysis is mostly limited to a qualitative discussion of the various types of values associated with coral reefs, supplemented with examples of valuations made elsewhere. Certain reef-associated sectors, primarily the fishery and tourism sectors, are treated more thoroughly, with quantitative assessments based on market values and contingent valuation studies.

Producer and Consumer Surplus to Fishermen:

Meyer (1987a) examined in 1986 the motivations, revenues, costs, and non-market values associated with part-time resident boat fishermen of Hawaii (fishermen who did not make their primary living from commercial fishing). He estimated that the state-wide ex-vessel revenues from fish sales by this fleet of about $35 million (all values have been updated to 1999 dollars) were almost equal to estimated fishing inputs (about $38 million). But the non-market benefits that accrued to the boat fishermen in additional to their sale revenues were estimated through interviews with members of various fishing clubs to reach about $378 million. This estimate was based on the fishermen's assessment of the "fair" value, over costs, of an hour of fishing, and they were prompted to compare that value with the value of their time when working–their wage rate. The resulting average hourly non-market value of fishing ($31/hour) was about equal to the average wage rate of the fishermen ($32/hour). In other words, the fishermen were willing to pay to fish at a rate about equal to what they were received to work at their regular jobs. This figure may be unrealistically high, in part because of the small time scale over which it was assessed (one hour rather then one day, month, or year), and because of the prompting to compare it with the value of their labor.

These estimates are not equivalent to the willingness-to-pay (WTP) approach discussed earlier concerning the estimation of consumer surplus in non-market circumstances. It perhaps represents a "willingness-to-accept compensation" for the loss of their fishing opportunities, which for a variety of economic and psychological theoretical reasons might deviate rather considerably from the WTP approach. Still, it is clear that the ex-vessel reported commercial value of the catch–estimated in Meyer (1987a) to be equivalent to about 10 percent of the non-market value–is a poor indicator of the net economic value of the fishery–at least for Hawaii's "recreational" fleet.

Charter fisheries have also been assessed for the surplus values they generate for anglers. Samples and Schug (1985) estimated the consumer surplus of Hawaii's charter fishing patrons to be $95 per angler-trip (again, all values have been updated to 1999 dollars), equal to about half the charter fees paid. The study focused on the troll charter fishery that dominates the industry, and found that willingness-to-pay was strongly influenced by the probability of landing a blue marlin. It is doubtful the results are applicable to coral reef charter fisheries. Charter fisheries for coral reef species are generally of two types. In Guam and Saipan, the larger market is for generally inexperienced anglers making short trips on large party boats, fishing shallow bottoms with baited hooks. The still-developing charter fishery on Midway, in contrast, attracts experienced anglers that fish for several days with various methods, including spin-casting on the reef and sand flats and trolling for big game fish. Charter fees in the latter type of fishery are much greater than in the party boat fishery, and the potential for generating large consumer surpluses are probably also greater.

In order to generate a plausible range of fishermen's consumer surplus of the region's current coral reef fisheries, some simple assumptions have been applied. It should be emphasized that these assumptions are quite speculative, and when combined with the already tenuous assumptions used in estimating the volume of landings and charter trips, the results are useful for little more than illustrative purposes. The assumptions follow and the results are shown in Table 9.

Assumptions:
All coral reef food and ornamental fisheries generate some non-market value to fishermen–they all have a recreational aspect.

Recent average annual fisheries volumes are as estimated in Tables 2 through 9.

The average catch rate in the food fisheries is 5 pounds per hour fished (derived from data in Dalzell *et al.* 1996), and in the ornamental fisheries, 5 pieces per hour fished.

The non-market value to fishermen in the food and ornamental fisheries, measured as a surplus (i.e., willingness to pay above and beyond actual costs), is assessed under "low" and "high" scenarios, with fishermen's consumer surplus estimated as a percentage of the prevailing average wage rate:

1) in the low scenario, 20% of the wage rate;
2) in the high scenario, 100% of the wage rate.

The prevailing average private sector wage rates are $5/hr in American Samoa, $7/hr in the CNMI (citizens only), $9/hr in Guam (Bank of Hawaii 1997 a, b, and c), and $10/hr in Hawaii and the unincorporated islands (the recreational fishermen studied by Meyer (1987a) had much higher-than-average wage rates).

Angler's consumer surplus in the charter coral reef fisheries is assessed under low and high scenarios:

1) in the low scenario, $25/angler-trip in Hawaii (including Midway) and $5/angler-trip in the other islands (about 1/6 the charter fees);
2) in the high scenario, $100/angler-trip in Hawaii and $20/angler-trip in the other islands (about 2/3 the charter fees).

Table 9. Consumer Surplus to Coral Reef Fishermen ($1,000/year)

	Am. Samoa	CNMI	Guam	MHI	NWHI	Other islands	All islands
Food	68 to 342	139 to 693	149 to 743	2,000 to 10,000	106 to 530	4 to 21	**2,466 to 12,329**
Sport	min	8 to 32	51 to 204	10 to 50	8 to 38	0	**77 to 324**
Ornamentals	1 to 5	min	9 to 43	173 to 866	0	0	**183 to 914**
TOTAL	**69 to 347**	**147 to 725**	209 to 990	2,183 to 10,916	114 to 568	**4 to 21**	**2,726 to 13,567**

Based on the assumptions made above, a plausible range of the total consumer surplus that accrues to coral reef fishermen in the US Pacific Islands is $3 to $14 million per year. Assuming no change in the future, this implies a present value of $32 to $158 million (7% discount rate over 25 years).

Management Costs:

The annual management costs for the coral reef fisheries of each of the island groups are presented in Table 10. The estimates are based on data for the years 1997-1999. They include funds spent through the Sportfish Restoration Program administered by the US Fish and Wildlife Service, the Western Pacific Fishery Information Network, administered by the National Marine Fisheries Service, and funds administered by state and territorial fisheries agencies. The estimates are necessarily rough for several reasons. First, it was difficult to distinguish some management costs by fishery–that is, separating the coral reef, pelagic, deep bottom, and freshwater components of management costs. Second, it was difficult to obtain information on state and territorial spending. Third, it was difficult to distinguish spending on fisheries "management" from spending on fisheries "development." In general, funds spent on surveys and monitoring, research, rule-making, and enforcement, and a portion of funds spent on education and outreach, were considered management costs.

Table 10. Current Annual Coral Reef Fishery Management Costs ($1,000/year)

American Samoa	CNMI	Guam	MHI	NWHI	Other islands	All islands
500	330	500	1,520	230	0	**3,080**

Estimates are derived from 1997-1999 grant data from the US Fish and Wildlife Service (Sportfish Restoration Program), 1997-1999 grant and budget data from the National Marine Fisheries Service (Western Pacific Fisheries Information Network), and estimates of spending by local sources.
The division in costs between the Main and Northwestern Hawaiian islands is not an actual division in spending; it is simply the total costs in Hawaii divided according to the ex-vessel value of the fishery, as estimated above.

The estimated total of $3.1 million in management costs is conservative because there are additional federal funding sources for fisheries management that were not accounted for. Funds spent by coastal management and environmental agencies, some of which contribute to coral reef fisheries management, were not included. Funds spent by the US Fish and Wildlife Service in managing the Wildlife Refuges were not included. Funds spent by the WPRFMC on the crustacean, bottom fish, and precious coral fisheries were not included. Funds spent through other grant programs administered by the National Marine Fisheries Service (mostly for fisheries development) were not included.

Based on Table 10, more than half the spending on management was in or for Hawaii, and the rest fairly evenly distributed among American Samoa, the CNMI, and Guam. Using the ex-vessel value estimates from Table 2, management costs in Hawaii were equal to about 15 percent of the ex-vessel value of coral reef fisheries. In American Samoa, they were equal to about 73 percent of ex-vessel value, in Guam, about 32 percent, in the CNMI, about 25 percent, and overall, about 20 percent.

Net Present Value Given Current Conditions:
The annual ex-vessel value of the region's coral reef fisheries was estimated at $15 million. If these fisheries are like most, those revenues were almost, or more than, offset by fishing costs, which were not directly assessed here. A plausible range of the non-market value, or consumer surplus, that accrued to fishermen was estimated at $3 to $14 million per year. Public inputs into management were estimated to be about $3 million per year. If ex-vessel value is assumed to be completely offset by fishing costs, and the surplus to seafood consumers is assumed to be relatively small (e.g., $1 to $3 million per year), these figures suggest a net value of $0 to $15 million per year. If unchanged in the future, this would imply a net present value of $0 to $175 million (assuming a 7 percent discount rate over a 25 year horizon).

Net Present Value Given Likely Future Developments:
It is not possible to accurately project how the region's coral reef fisheries would develop in the no-action scenario. However, some general discussion about possible courses of fishery development is necessary in order to better characterize the no-action alternative and to compare the likely cost-effectiveness of the various management alternatives.

Most current harvesting of coral reef resources is for food; the biological yields and per-unit values of ornamentals, sport catches (which can be released), and marine natural products are less well known and more variable. More importantly, net value, not gross value, is generally the parameter of interest. One of the most important fishing cost items is travel to and from the fishing grounds. Fishing pressure is close to zero at many of the region's reefs because travel costs are prohibitive. Relatively high gross values would have to be available to justify travel to the more remote reefs. Lobster and deep bottom fishing in the Northwestern Hawaiian Islands and sportfishing at Midway are good examples of such high value (and high cost) fisheries. The per-unit gross values of lobster and deep bottom fish are relatively high. The relatively high angler surplus available from fishing the relatively pristine reefs of Midway, combined with the availability of a landing strip and shore-side support facilities, make the generation of net benefits from sportfishing feasible.

Government restrictions are also important determinants of where and what type of harvesting is likely to develop. Inshore sportfishing at Midway, for example, could not have developed without the US Fish and Wildlife Service relaxing its restrictions on harvesting in the wildlife refuge. Tighter restrictions in territorial waters, technological innovations that would reduce costs for long distance harvesting, or decreased productivity in territorial waters would also tend to increase the feasibility of harvesting in more distant federal waters.

Following are profiles of several possible scenarios of future developments. It is emphasized that the main purpose of the FMP is to anticipate and control such changes. The scenarios include development of a live reef fish fishery, which would most likely occur in the remote islands of the CNMI, expansion of the ornamentals fishery, most likely in the Northwestern Hawaiian Islands or the remote islands and reefs of the CNMI, and development of bioprospecting activities. Another possibility is development of coral reef sportfishing at Palmyra, Wake, or Kingston, where access by air is possible, as at Midway.

Distant Finfish and Live Finfish:
The remote northern islands of the CNMI have been intermittently exploited for reef fish and deep bottom fish. Growth in the CNMI's resident and tourism populations will influence the attractiveness of those fishing grounds to supply product for the local market. The high value Asian market for live reef fish may also drive development of fisheries into areas within reasonable reach by ship or with cost-effective air freight costs. Well-financed harvesting and transport operations based in Asia have conducted profitable harvesting in many remote areas of the Pacific, many of them apparently only cost-effective because they are able to move on to new and more productive fishing grounds at any time.

Ornamentals:
Ornamentals are currently being collected only on reefs within easy reach of ports and shorelines. The Northwestern Hawaiian Islands may have a relatively great abundance of high-value species, but so far their collection does not appear cost-effective relative to working in the main islands. Increases in prices of increasingly regulated species and products, such as live rock, could increase the motivation to fish in federal waters and on remote reefs.

Sportfishing:
Palmyra, Wake, and Kingston (via Palmyra) may have the potential for tourism development, including sportfishing similar to what is done at Midway (see Appendix II). After three years of opening to the public, Midway is attracting about 250 fishermen and divers per year. The potential for growth of these types of operations, either on Midway or other islands, is not known.

Natural Products:
Bioprospecting could develop almost anywhere that locally endemic species are found.

Given the 16,000 km^2 of coral reef in the region (Hunter 1995), the estimate of food fish landings made here (6.5 million pounds) implies a per-unit-area yield of about 430 lb/km^2-yr, or about 0.2 mt/km^2-yr. Yields were, of course, much higher in localized areas, and the 0-3 mile zone had higher yields than the reefs in federal waters. Dalzell and Adams (1997), for example, reported about the same level of annual landings for American Samoa (176mt) as estimated here (155mt), but identified the catch as coming from only 25 km^2, implying a yield of 7 mt/km^2-yr. When measured against the 270 km^2 of the whole of Tutuila (Hunter 1995), the yield would be only 0.7 mt/km^2-yr.

Munro and Williams (1985) suggested an average worldwide maximum sustainable yield of coral reef organisms of 15 mt/km^2-yr. This is in good agreement with a tentative estimate by Dalzell and Adams (1997), who applied what they emphasized to be an overly simple surplus production model. The model was fitted with yield estimates from various Pacific Islands (ranging from 0.3 to 64 mt/km^2-yr) and with human population per unit area of reef (ranging from 3 to 3,000 people/km^2) as a proxy for fishing effort. The model predicted a maximum sustainable yield of 16 mt/km^2-yr. The current yield from the US Pacific Island coral reefs is only about one percent of these estimates. Even in localized areas of relatively heavy fishing, such as around Guam and Tutuila, the yields appear to be well below these levels, consistent with the general belief that they are overfished (see body of FMP, and Green 1997). Dalzell and Adams (1997) reported recent yields from Guam and Tutuila to be 0.8 and 7.0 mt/km^2-yr, respectively, although a 1982 estimate from Tutuila that was based on only 3.6 km^2 of reef estimated a yield of 17.0 mt/km^2-yr (Wass 1982).

1.6.3 Net Present Value of Coral Reef Non-fishery Sectors

Tourism:

Coral reef-based tourism is very important in many countries. In the US Pacific Islands, it is especially important in Hawaii, Guam, and the CNMI. Scuba diving and snorkeling are two of the most obvious reef-dependent tourism activities. Others include underwater observatories, such as in Guam and glass-bottom boat tours. Activities that are partially dependent on the protected lagoons formed by reefs include swimming, jet skis, other small water craft activities, and all the beach and shoreline activities that coral reef ecosystems attract. The aesthetic qualities of coral reefs and lagoons as viewed from the shore are also important to tourists.

Some of these uses compete with and compromise other values. Scuba divers and snorkelers, for example can degrade reefs through physical contact. Jet skis have caused dramatic changes to localized areas of substrate in Guam.

There is a varying degree of dependence on coral reefs among these uses. The attraction of a reef to scuba divers and snorkelers, for example, depends on its aesthetic qualities, which are determined in large part by the complexity, diversity, vivacity, and density of its corals, fishes, and other organisms, as well as the degree of human congestion in the water. In general, the less degraded the reef, the higher the value, although proximity to tourist centers is critical. Other uses and values, such as personal water craft activities, shore-side tourism and recreation activities, and breakwater values, are much less dependent on the quality of the reef ecosystem per se (unless a degraded reef leads to increased siltage, intrusive sea grasses, etc.).

Net economic value from tourism includes the producer surplus that accrues to providers of tourism services -- e.g., dive boat operators-- and the consumer surplus that accrues to tourists. Some of what would otherwise be consumer surplus is often transferred to the public's producer surplus through the imposition of fees, such as entrance fees for parks.

An economic assessment of the value of Bonaire, in the Caribbean Sea, was done in 1991 (Dixon *et al.* 1994). The entire marine area surrounding Bonaire, to a depth of 60 meters, is a marine park, managed primarily for diving. The island economy is almost entirely dependent on tourism, which is centered around diving. A survey of visiting scuba divers revealed an average willingness-to-pay to visit the park of about \$33 (all values have been updated to 1999 dollars), above and beyond actual costs. Applying a per capita consumer surplus of \$33 to the approximately 17,000 divers visiting each year yields a total annual consumer surplus of about \$561,000 (in fact, \$207,000 was transferred to producer surplus through a visitor fee). Most diving, of course, takes place in a relatively small portion of the island's reefs. But an appropriate measure of value per unit area can be estimated by dividing the total consumer surplus by the island's total reef area. With roughly 100 km of coastline, and assuming an average reef width of 1 km, annual divers' consumer surplus totaled roughly \$5,600/km^2 of coral reef. Based again on a 7 percent discount rate over a 25 year time period, this yields a net present value of about \$0.07/m^2 .

In an assessment of a small developed coastal tourism area in Sri Lanka (with a fringing reef of about 0.25 km^2), the producer surplus from tourism was estimated at \$156,000/km^2-yr, and the consumer surplus of tourists at \$223,000/km^2-yr (1999\$) (Berg, *et al.*, 1998). Discounted at 7 percent over 25 years, this yields a net present value of \$4.40/m^2.

In a study of dive and snorkel-based tourism in West Lombok, Indonesia, Riopelle (1995) estimated the net present value (producer surplus only) of diving and snorkeling on the local reefs to total about \$33 million (adjusted from the author's 10 percent to a 7 percent discount rate), or about \$760,000 per km of coastline. Derived from the profits on expenditures by 19,000 visiting divers and 50,000 snorkelers, this is equivalent to a producer surplus of \$41 per visitor. West Lombok was described as having "major tourism potential," but still considerably less than other Indonesian locales, including Bali. It was suggested that a linear km of coastline is roughly equivalent to about one square km of coral reef, so the range of net present value from coral reef-related tourism in Indonesia, encompassing the "no tourism" and "major tourism" situations, was \$0 to \$1.40/m^2 (1999\$; adjusted from a discount rate of 10% to 7%; over a 25 year time period; derived from Cesar, 1996).

In the U.S. Pacific Islands, dive and snorkel-based tourism is a small percentage of overall tourism activity. As a result, the economic values given above should not be extrapolated to the reef coastlines adjacent to the major tourist areas (e.g., Waikiki on Oahu or Tumon Bay in Agana), and even less so should they be extrapolated to distant reef areas (e.g., the Northwestern Hawaiian Islands or the northern part of CNMI). Indeed, there are legitimate questions about the extent to which under-water tourism can be expanded in any of the heavily inhabited areas given already high levels of shoreline and near-shore recreation by residents. Unfortunately no adequate metric exists of the under-water tourism values in the Western Pacific region.

Turning to the US Pacific Islands specifically, Table 11 summarizes the tourism activity in each of the island groups.

Table 11. Marine Tourism and Scuba Diving: Annual Economic Activity by Island Group

	American Samoa	**CNMI**	**Guam**	**Hawai'i**	**Total**
Number of tourists	6,000	600,000	1,300,000	6,800,000	**8,800,000**
No. of tourists primarily "marine"	600	500,000	850,000	4,400,000	**5,750,000**
No. of tourists scuba divers	100	30,000	130,000	75,000	**235,000**
% of tourists American	80	12	5	54	**43**
Expenditures by tourists	$3m	$600m	$1,500m	$10,000m	**$12,100m**
Expenditures by "marine" tourists	$0.3m	$500m	$650m	$6,500m	**$7,650m**
Expenditures by scuba divers	$0.05m	$30m	$150m	$110m	**$290m**
Expenditures on marine recreation				$700m	
Expenditures on scuba diving		$16m		$28m	
Number of scuba dives	500	120,000	500,000	300,000	**920,000**
No. employed in tourism		8,000	20,000	170,000	**198,000**
No. employed. in marine recreation				6,200	
No. employed in scuba diving		150		650	
Gov't. revenues from tourism			60% of tot	30% of tot	
Tourism as % of gross local prod.				26	

Data sources and assumptions are given in Section 4.
"m" means million; for example, "$3m" means $3 million.
Expenditures by tourists, by "marine" tourists, and by scuba divers include all local vacation expenditures.

The US Pacific Islands receive almost 9 million tourists each year, most of whom visit for reasons related to marine recreation and the marine environment. However, overall only about three percent of tourists scuba dive, varying between 1 percent in Hawaii and 10 percent in Guam. It is not possible to assess the net economic value of this tourism accurately, but some simple assumptions can be used to provide a plausible range of its net value.

Assumptions:

Producer surplus is between $50 and $200 per visitor-trip (i.e., profits of roughly 5 to 20% on visitor expenditures).

Consumer surplus is between $50 and $200 per visitor-trip (i.e., on average, each visitor would have been willing to pay an additional $50 to $200 for his or her vacation experience).

In Tables 12 and 13 are these assessments for all “marine” tourists, and for scuba divers only. These represent projections based on hypothetical values but they are the best available comprehensive estimates of these economic values at this time and would appear to provide order-of-magnitude estimates.

Table 12. Net Annual Value of Marine-based Tourism

	American Samoa	**CNMI**	**Guam**	**Hawaii**	**Total**
No. “marine” tourists/year	600	500,000	850,000	4,400,000	**5,751,000**
No. Amer. marine tourists/yr	480	60,000	42,500	2,376,000	**2,479,000**
Total Am. tourists’ surplus ($1,000/year)	24 to 96	3,000 to 12,000	2,125 to 8,500	118,800 to 475,200	**123,949 to 495,796**
Total producer surplus ($1,000/year)	30 to 120	25,000 to 100,000	42,500 to 170,000	220,000 to 880,000	**287,530 to 1,150,120**
Net value ($1,000/year)	**54 to 216**	**28,000 to 112,000**	**44,625 to 178,500**	**338,800 to 1,355,200**	**411,479 to 1,645,916**

Table 13. Net Annual Value of Scuba Dive-based Tourism

	American Samoa	CNMI	Guam	Hawaii	Total
No. of scuba divers/year	100	30,000	130,000	75,000	**235,000**
No. of American divers/year	80	3,600	7,000	41,000	**51,600**
Total Am. divers' surplus ($1,000/year)	4 to 16	180 to 720	350 to 1,400	2,050 to 8,200	**2,584 to 10,336**
Total producer surplus ($1,000/year)	5 to 20	1,500 to 6,000	6,500 to 26,000	3,750 to 15,000	**11,755 to 47,020**
Net value ($1,000/year)	**9 to 36**	**1,680 to 6,720**	**6,850 to 27,400**	**5,800 to 23,200**	**14,339 to 57,356**

These rough assessments of the value of marine-based tourism suggest that the annual net value of marine-based tourism is $0.4 to $1.6 billion, and that scuba diving-based tourism contributes 3 to 4 percent of the total, i.e., $14-58 million. Assuming no change in the future, this implies a net present value of $5 to $19 billion for the discounted value of marine-related tourism in these islands, or $179,000 to $715,000 for scuba and diving-based tourism. Obviously the latter is the most relevant value for determining coral reef ecosystem-related net benefits, although some benefits accrue to the non-diving part of marine tourism.

Most tourism activities, including scuba diving, take place in territorial waters (or in the CNMI, in the "inshore management zone"). Exceptions are in Guam, where divers sometimes visit 11-Mile Bank, and at Midway, where all waters are federal waters. Between 100 and 150 scuba divers are estimated to have visited Midway in each of the last several years (Glover, pers. comm.).

Although tourism in federal waters is currently very limited, there appears to be some likelihood of growth. The tourism enterprise at Midway is only three years old, and will probably grow. Palmyra, Wake, and to a lesser extent, Kingman, may offer similar opportunities. The potential for tourism development in these remote islands, however, is very small compared to current and potential tourism use of the populated islands. Midway receives less than 1,000 visitors each year. However, such tourism can also lead to improved public awareness of these unique natural resources and consequently to improved protection of those resources.

Recreation:

"Recreation" as used here refers to uses by island residents rather than by tourists. The activities and values that bring recreation benefits are more or less the same as those in the tourism category. One difference, as defined here, is that recreation benefits to residents also include the quality of life, cultural, and heritage values associated with living near and in association with the coral reef ecosystem, and any values associated with having a tradition of doing so. Also, even when coral-reef activities are not directly undertaken, having the option to do so is an important value to many island residents.

In Hawaii in the early 1990s, it was estimated that on a typical busy day, at least 170,000 people (including tourists) were swimming or visiting beaches and shorelines, 23,000 were surfing, 25,000 were fishing, 3,000 were paddling, 18,000 were boating, and others were diving (Clark, 1991).

These activities are clearly very important in the US Pacific Island communities, and participation in reef-associated recreation must be close to 100 percent of resident populations.

It would be very difficult to accurately assess recreation values, and a rigorous assessment will not be made here. But the following scenarios can illustrate a way to think about the value of recreation. The resident population of the US Pacific Islands is about 1.5 million. If every person was willing to pay $10 per year to maintain their reef-related recreation opportunities (in addition to costs already incurred), it would imply a total consumer surplus of reef-associated recreation of $15 million per year. At $1,000 per person, it would be $1.5 billion.

Reef-associated recreation also generates producer surplus. MacDonald *et al.* (1996) estimated expenditures in Hawaii's ocean recreation industry (including expenditures by tourists–already accounted for above) to be $700 to $800 million per year. If profits were 10 percent of expenditures, for example, producer surplus would be $70 to $80 million per year.

However most reef-associated recreation occurs in territorial rather than federal waters. The economic value of off-shore coral reefs may depend on the "ecological services" provided by these components of the ecosystem, but this contribution is not well known. Exceptions to the off-shore element of this recreational activity include Johnston, Wake, and Midway, where there are small resident populations, and Rose atoll in American Samoa, the northern islands of the CNMI, and the Northwestern Islands of Hawaii, where some visitation by residents occurs. There is a modest potential for growth of recreation in these federal waters.

Because recreation values are likely to respond to a given management alternative in a similar way as tourism values, the two sectors will be grouped together in the discussion of impacts in Section 1.7.

Breakwater:

Coral reefs serve as natural breakwaters, deflecting the energy of waves and inhibiting shoreline erosion. Shoreline damage from typhoons has been observed to be less where reefs are broad (Birkeland 1997a). They also provide sheltered waters for navigation, mooring of vessels, and port facilities. They form calm embayments that are valuable for swimmers, snorkelers, and beach-goers, they make surf breaks, and they produce beach sand, all bringing tourism and recreation benefits (but these latter values should not be double-counted with the tourism and recreation values already addressed).

Some of these values can be quantified, such as in localities where reef degradation leads to shoreline erosion and the loss of property with known value. In an assessment of the value of

Indonesia's coral reefs, the protective net present value of coral reefs was estimated at $1,110 per km of sparsely population coastline (about $0.001/m^2$ of reef), $\$0.07/m^2$ along coastlines with some development (roads and houses), and $\$1.36/m^2$ along coastlines with major tourism infrastructure (in 1999 dollars, adjusted from 10% to 7% discount rate, over 25 years) (from Cesar, 1996). Using the same approach in Sri Lanka, the cost of coastal erosion was estimated to be between $\$0.002/m^2$ and $\$2.00/m^2$, depending on the land use (1999$, 7% discount rate applied over 25 years) (from Berg, *et al.*, 1998).

The cost of replacing the reef with an artificial breakwater could also be used to assess these values. In Sri Lanka, where coral mining has apparently led to coastal erosion, the costs of building preventative revetments, groynes, and other breakwaters was estimated to cost between $248,000 and $844,000 per kilometer of shoreline (1999$) (Berg, *et al.*, 1998). Assuming a reef width of one kilometer, these replacement costs would translate to coral reef net present values of $0.25 to $\$0.84/m^2$.

The reefs located in federal waters do not, generally, serve as breakwaters for coastlines that are highly developed. They are either on isolated banks or they surround generally undeveloped islands, including Palmyra, Kingman, Baker, Howland, and Jarvis, as well as the more developed islands of Johnston, Wake, and Midway. The value of these reefs as breakwaters, therefore, is derived more from protecting relatively pristine and valuable natural resources rather than protecting recreation areas and developed properties with easily assessed market values. Many of the remote atolls and emergent lands under federal jurisdiction, for example, are important as habitat for seabirds, sea turtles, and the Hawaiian monk seal. Assessing these aspects of the breakwater values of coral reefs would be more difficult than assessments based on market values of developed coastline properties, and it will not be attempted here.

While these breakwater values are clearly very high, it is not clear that any of the FMP management measures would have an impact on them. Impacts to the structure of the reef stemming from overfishing or damage from anchors, gears, and vessels may occur too slowly to be of any consequence in terms of impacts to NPV (see "time scales," above).

Wilkinson *et al.* (1999) assessed the economic impacts of the 1998 coral bleaching event in the Indian Ocean, using an "optimistic scenario" and a "pessimistic scenario." In the latter, damage was assumed to be severe and recovery slow or nonexistent. It was further estimated or assumed that the annual fisheries value would decline by 25 percent after 5 years, and the annual value of coastal protection, tourism, and other services would decline by 50 percent after 10 years. In other words, it was estimated that within 10 years of a near complete die-off of coral, without any direct physical disturbance, the reef would become susceptible to physical and bio-erosion and lose its ability to break waves to the point that half the value of the coastal lands that it protects would be lost.

In an assessment of the value of Sri Lanka's reefs, it was estimated or assumed that the breakwater value of the reef would decrease to zero and the fisheries value would decrease to one fifth after five years of coral mining (for lime production) (Berg *et al.* 1998).

On the scale of thousands of years, the balance between the rates of subsistence, accretion, erosion, and sea level change will determine whether the reef remains near sea level and serves to break waves. But on the scale of tens of years, subsistence is inconsequential and sea level change is perhaps marginally important. Although waves can cause erosion of a reef, they can also cause accretion; which effect will dominate when a reef dies depends on the orientation of the reef and its wave environment, and again, the time scale. In short, it is unclear how quickly the breakwater function of coral reefs can decline, especially for the types of impacts under the control of this FMP–overfishing and damage from vessels, fishing and other harvesting gear, and anchors. For the purposes of this analysis, the impacts of the FMP measures on breakwater values are assumed to be nil, and the breakwater sector is omitted from the discussion of economic impacts in Section 1.7.

Mining:

Many island communities, especially those lacking in terrestrial resources, such as atolls, are dependent on their reefs for construction materials, including blocks, aggregate, and sand. Even before the introduction of heavy machinery, island communities had been for thousands of years removing limestone and live and dead coral heads from their reefs to build jetties, breakwaters, building foundations, and paths. These are, of course, extractive uses, so they may compete with and compromise other values–both fishery and non-fishery. Several measures proposed in the FMP treat the coral reef substrate as either a non-renewable resource or too essential for other values to be worth harvesting or mining.

It is not known how much reef material is being mined from each of the US Pacific Islands.

None of the FMP management measures are projected to have any impact on the value of coral reefs for mining. This sector is therefore omitted from the discussion of economic impacts in Section 1.7.

Ecological Support:

As emphasized above, the coral reef ecosystem is not separable from other ecosystems in terms of function or value. For example, there are important physical and trophic connections between coral reef, mangrove, and pelagic ecosystems. The larvae of many coral reef organisms are pelagic and contribute to the diets of pelagic species like tunas. Many deep bottom fish, including snappers, emperors, and groupers, use coral reef habitat as juveniles.

Coral reefs also play important roles in the global balances of calcium and carbon (Spurgeon, 1992). The global climate affects coral reefs and coral reefs affect the global climate.

It would be very speculative to put a value on these types of roles of coral reefs, and as noted above, there is the problem of determining what portion of the value of, for example, the pelagic ecosystem, is attributable to coral reefs, rather than to the pelagic ecosystem itself, as well as vice versa.

No quantitative estimates of these values will be made here, but likely impacts to these roles of coral reefs is provided in the summary table of impacts.

Information:

This category refers to the benefits to be derived from discovering (research) and sharing (education) information gleaned from coral reefs. Some information leads to applications that are useful for managing the ecosystem itself, including fisheries management. Since those values must be subtracted as costs in the fishery sectors, the more important values to consider here are those that are beneficial beyond understanding and managing coral reefs themselves. The value of using coral reefs to monitor global climate change would be one example. Discoveries that lead to the development of marine natural products, such as pharmaceuticals, are perhaps the most valuable "information" use of coral reefs. Value in this category is largely a function of biodiversity–the greater the diversity, the greater the chance of discovering valuable information.

Most bioprospecting attention is being paid to those organisms that rely on chemical defense mechanisms, including sponges and ascidians, because they are more likely to have novel or complex chemistries. Several coral reef species have been found to have chemistries that led to the development of useful pharmaceutical products, including a gorgonian, a red alga, and an ascidian (Birkeland, 1997a).

The extent of current bioprospecting activities in the US Pacific Islands is not clear. It is difficult to monitor, in part because the people doing the collecting in the water are not bioprospecting, per se, but often doing basic biological research. Specimens or information derived from specimens can pass through several hands before the research has anything to do with the development of marine natural products, although increasingly universities and other research centers are developing entrepreneurial off-shoots to capitalize on their faculty's research efforts.

One example of a well-monitored bioprospecting operation is the one carried out by the US National Institutes of Health. The agency contracts researchers to collect a wide variety of coral reef and other marine species in order to screen their chemistries for possible activity against cancer and AIDS. The Coral Reef Research Foundation, based in Palau, is currently doing the collecting in many areas of the world, primarily in the Indo-Pacific, where marine biodiversity is highest. For any of these agreements, as with other agreements for developing conservation zones or establishing toxic waste dumps, a considerable valuation problem exists for deriving the economic value to the people of the "host" site, both in the present and in the long-term.

It is important to note that the costs associated with research, development, and production of marine natural products can be quite high, leaving relatively little left as net value. Mendohlson and Balick (1995), for example, estimated the potential net value of all yet-to-be discovered rainforest drugs to be $160 billion (1999$), far less than previous estimates that looked only at gross value.

The conventional approach to fisheries net valuation is to assess only the net benefits generated during first phase of the fishery–the harvest phase. All subsequent phases–such as processing–that add value to the product are considered indirect benefits. In the case of marine natural products, very little net value is associated with the harvest, or even research and development phases. Most comes in the ultimate phases–the profits stemming from product sales and consumer surplus. In a study of Korup National rainforest in Cameroun, it was determined that Cameroun–the owner and supplier of the forest-derived information–would stand to gain only $6,700 per patent for drugs derived from indigenous plants (1999$) (Ruitenbeck, 1989). Just what portion of the ultimate net benefits stemming from these types of products can be attributed to the information provided by coral reefs is an open question.

It is generally believed that the potential for coral reefs to provide valuable information has barely begun to be tapped. Both the current and potential information values of the coral reefs in the US Pacific Islands are difficult to assess and it will not be attempted here. The likely impacts of the FMP measures to those values, however, is provided in the summary table of impacts.

Biodiversity:

With their great number of species and their variety and complexity of habitats, coral reefs have a high diversity of chemistries and high evolutionary potentials. Rainforests have a greater number of species, but coral reefs have a greater diversity at higher taxonomic levels and a greater diversity of basic body plans and chemistry (Birkeland, 1997a).

Biodiversity on coral reefs is quite variable around the globe and there is a great range among the US Pacific Islands. Coral reef biodiversity among the island groups is compared in the FMP.

There are a range of benefits that are derived from the many forms and species that coral reef ecosystems support (e.g., the value of harvesting, which exploits many species). Even the aesthetic diversity of coral reefs is important, as it provides part of the appeal to divers. The "information" values addressed above include the benefits to made gained from discovering information that leads to the development of valuable products, and it was pointed out that the potential value of that information is a function of biodiversity. But all those values have already been addressed in the previous paragraphs. The concept of biodiversity, per se, as having value is really just the maintenance of future options that such diversity provides. These are options that might lead to new extractive fisheries, to the development of marine natural products, or to what are now inconceivable uses or values. The value of biodiversity itself is really just part of option value, discussed below, and will not be considered a separate sector in the analysis of impacts.

Existence Value:

Existence value and option value are very difficult to quantify, but they are undoubtedly important with regard to the impacts of the FMP. Existence value is the derived from the knowledge that a particular resource or opportunity to use that resource exists and is available to provide a range of benefits, regardless of whether it is actually used. Impacts to existence value are difficult to assess, in part because different groups are affected differently. For example, regulatory closure of a fishery could negatively impact the existence value enjoyed by anglers while positively impacting the existence value enjoyed by certain conservationists, researchers, or naturalists. While there is a literature on the measurement of existence values, we are aware of none for areas in the Western Pacific region.

Option Value:

Option value, is, according to Krutilla and Fisher (1995) is, "the value, in addition to consumer surplus, that arises from retaining an option to a good or service for which future demand is uncertain." Retention of that option is lost if a management action (or no action) results in irreversible changes–in this case, to the coral reef ecosystem. For example, if biodiversity on a reef decreases, option value is almost certain to decrease.

A type of value related to, or a subset of, option value is "quasi-option value." This refers to the "benefits of delaying a decision when one of the alternatives involves an irreversible choice and uncertainty exists about the benefits of the alternatives" (Dixon, *et al.*, 1994:109). It can be viewed as the expected value of the information that can be gained by delaying a decision (Conrad, 1980). Both option and quasi-option value are relevant in this analysis because they provide the means to recognize, if not quantify, the values associated with applying the precautionary approach to the management of coral reef fisheries. The rationale for using conservative biological reference points is reflected in option value. The rationale for conservatively controlling entry into a fishery until more information is gathered (e.g., through the permitting measures) is reflected in quasi-option value.

Existence value and option value do not necessarily track together. However, for the sake of simplicity, and because there is not enough information to accurately assess the impact on either one (as will be seen, virtually any management alternative could impact existence and option values either positively or negatively), the two values will be grouped together in the summary table of impacts. In both cases, because the future value of such options would be discounted by the net valuation process, and because the future value is both unknown, uncertainty, and likely distant into the future, the net present value of these options may be very small.

Holistic Valuations of Coral Reefs:

There have been numerous attempts to assess the total value associated with the many uses and functions that coral reefs provide, many of them done as a result of lawsuits claiming damages to reefs. CFMC (1999) reported that recent court settlements involving ship groundings on Florida's coral reefs averaged \$921 per square meter (m^2) of damaged or destroyed reef. One assessment of the damage from a ship grounding off the Florida Keys estimated a lost present value of \$4,363/m^2 (1999\$) (Mattson and DeFoor, 1985). A court case in Egypt led to a similar assessment–the government was paid \$2,083/m^2 (1999\$) of damaged coral reef (Spurgeon, 1992). In both cases, the damaged areas were small and in areas important for tourism, so the figures are not necessarily applicable to larger and different areas. Further, the assessments may have been based on potential gross value, so they may exceed net present value. On the other hand, the assessments assumed some degree of regeneration of the reefs and their value during the ensuing years, which would underestimate full present value.

An assessment on a much larger scale was carried out by Cesar (1996), and predictably, the estimated per-unit-area values were much smaller than those in the small-scale assessments described above. The assessment examined Indonesia's coral reefs as a whole, and focused on the values that could most easily be quantified–reef fisheries, coastal protection, and reef-associated tourism. The quantifiable net present values (actually the "net present loss to society due to destruction...") in those sectors ranged from about \$0.19 to \$1.57/m^2 (1999\$) of coral reef, depending on the level of tourism potential and the degree of coastal construction (i.e., the value of coastal property) (these figures have been adjusted from the study's 10 % discount rate to the 7 %

rate used throughout this analysis, over a 25 year time period). Fisheries value was assumed to be the same in both the low and high scenarios. At the low end of the range, fisheries contributed about 80 percent of the value. At the high end of the range, fisheries contributed only about 9 percent, while coastal protection and tourism contributed 47 and 43 percent, respectively (Cesar, 1996).

Costanza *et al.* (1997) assessed the value of all the earth's natural capital and ecosystem services. They identified and assessed the value of each of 17 ecosystem services for each of 16 biomes, of which coral reefs were one. The results were qualified as being tentative and conservative. The total annual value of world's coral reefs was estimated at $0.68 per m^2 per year (1999$). The present value would be $7.47/$m^2$ (1999$). Fully half the value was contributed by "recreation" (including tourism) services, followed closely by "disturbance regulation." "Food production" contributed about 4 percent of the total. Values in the authors' categories of "gas regulation," "climate regulation," "nutrient cycling," and "genetic resources" were not assessed or included because of a lack of information. Of 11 biomes for which total values were (tentatively) estimated, coral reefs ranked sixth in terms of per-unit-area value, and tenth in terms of total global value (ahead of cropland).

The range among the assessments described above, $0.19/$m^2$ for undeveloped areas of Indonesia to $4,363/$m^2$ for a small area in the Florida Keys, covers four orders of magnitude. For assessing the value of large areas, such as the entirety of the coral reefs under the jurisdiction of this FMP, the high end of the range is probably not applicable (at $4,363/$m^2$, the 16,000 km^2 of coral reefs in the US Pacific Islands would be worth $70 trillion). But for localized areas where the value of coastal property and tourism are high, such figures may be applicable, and may even underestimate NPV.

Summary:

In this analysis, the only quantitative valuations made of the coral reefs of the US Pacific Islands were for fisheries and tourism, and they were very tentative. A first-order estimate of the annual net value of the fisheries was $0 to $15 million, which, if unchanged in the future, would imply a net present value of $0 to $175 million. A first-order estimate of the annual net value of marine-based tourism was $400 to $1,600 million, which, if unchanged in the future, would imply a net present value of $5 to $19 billion.

Other reef-dependent sectors, including recreation, the value of reefs as breakwaters, ecological services and information, and existence value and option value, are clearly very important, but they are not quantifiable. These sectors are interconnected (e.g., the reef as a breakwater provides tourism and recreational opportunities) and coral reef ecosystems are interconnected with other ecosystems.

Tables 14 and 15 present a summary of the coral reef valuations of other studies described in the preceding sections, along with the fishery and tourism values assessed here. The findings are described in terms of value per-unit-area. The tables do not include all the types of coral reef values recognized here and in the cited studies. The terms used in the table for value types are not necessarily the same as those used in the cited studies, and the fits may not be exact (e.g., "breakwater" used for "coastline protection;" "fisheries" used for "food").

A high degree of variability in the assessments is apparent, much of which can be explained by the various scales on which the assessments were done. The smallest assessments had by far the highest values. The results of this study illustrate the correlation, as well. Both the fishery and tourism values were divided by the total area of coral reef in the US Pacific Islands (16,000 km^2), yielding relatively small NPVs of \$0 to \$0.01/m^2 for fisheries and \$0.30 to \$1.20/m^2 for tourism. The values of fisheries, tourism, and recreation are, of course, generated from only small portions of the total reef area of the US Pacific.

Table 14. Summary of Coral Reef Valuations: Net Present Value, in 1999 Dollars per Square Meter

Source	Fisheries	Tourism	Breakwater	Total value
Mattson and DeFoor (1985)				4,363.00
Spurgeon (1992)				2,083.00
CFMC (1999)				921.00
Berg *et al.* (1998)		4.40	0.002 to 2.00	
Dixon *et al.* (1994)		0.07		
This study	0 to 0.01	0.30 to 1.20		
Cesar (1996)	0.15	0 to 1.36	0.001 to 1.36	0.19 to 1.57
Costanza *et al.* (1997)	0.27	3.68		7.37

The values from this study are only very tentative figures used for illustrative purposes–see text for limitations.

The tourism and breakwater ranges of Cesar (1996) are his extreme ranges; the “total value” range is a more moderate range under “low” and “high” scenarios; thus the components do not sum to the “total value.”

The “tourism” value from Costanza *et al.* (1997) is actually called “recreation” by the authors, and presumably includes both tourism and recreation, as the terms are used here.

Table 15. Details of Valuation Studies

Source	Location	Scale	Methods
Mattson and DeFoor (1985)	Florida Keys	very small (ship grounding)	court case (unknown method)
Spurgeon (1992)	Egypt	very small (ship grounding)	court case (unknown method)
CFMC (1999)	Florida Keys	very small (ship groundings)	average of court cases (unknown methods)
Berg *et al.* (1998)	Sri Lanka	tourism: village specific (0.25 km^2) breakwater: country-wide	tourism: PS (profits), CS (WTP) breakwater: property values
Dixon *et al.* (1994)	Bonaire, Antilles	island-wide (100 km^2)	consumer surplus (WTP)
This study	US Pacific Islands	region-wide (16,000 km^2)	see text
Cesar (1996)	Indonesia	country-wide (75,000 km^2)	fisheries and tourism: PS (profits) breakwater: property values
Costanza *et al.* (1997)	World	global (620,000 km^2)	various

"PS" means producer surplus; "CS" means consumer surplus; "WTP" means willingness-to-pay.
It was here, not in the original study by Dixon *et al.*, that the net value was divided by the island's entire reef area.

1.7 Economic Analysis of FMP Alternatives

Alternatives:

The economic impacts of each of the four types of alternative measures (marine protected areas; permit and reporting requirements; allowable harvesting gear; and various miscellaneous requirements) are assessed relative to the no-action alternative. As explained in the preceding sections, the current value and future expected trajectory of the no-action alternative are not well known. A primary motivation of the FMP, in fact, is to address the largely unpredictable future course of fishery development and its potential problems.

Since the FMP considers a range of management (control) measures contained in four alternatives ranging from No Action through Maximum Additional Protection, the following analysis discusses the implications of each of the management measures in some detail. The section concludes with a summary of the overall implications of the suite of management measures in each of the four alternatives.

Factors Affecting Fishery Sector Values:

Projections of a harvesting sector's NPV under a given measure relative to the no-action NPV will be based primarily on the following four factors: 1) whether harvesting effort will increase or decrease relative to the no-action scenario, 2) whether the impact to harvesting effort will bring the fishery greater or fewer gross returns relative to the no-action scenario, 3) whether private costs will be greater than in the no-action scenario and whether they will outweigh any impact to gross returns, and 4) whether public costs will be greater than in the no-action scenario and whether they will outweigh any impact to net private returns.

An additional factor is whether the composition of the “fleet” will shift towards more efficient or less efficient participants. Measures that bring increased costs to fishermen, for example, will disproportionately reduce the participation or effort of those less willing or able to pay those costs. This choice depends on whether the costs are fixed or variable, the level of investment in the harvesting operation, the returns of the operation, and the underlying asset basis of the harvesting operation. For example, if the increased costs are on a fixed, flat rate basis (e.g., the cost of acquiring an annual permit), large full-time commercial food or sport operations are probably more likely to bear the costs than part-time recreational and mixed-motivation fishermen, assuming similar wealth levels, while wealthier participants (whatever their motivations) may have greater flexibility and willingness to absorb the costs than less wealthy participants. If a burdensome measure is not applied equally across the fleet, such as if subsistence fishermen are exempt, the fleet would shift accordingly.

Federal Versus State and Territorial Waters:

An important factor with respect to the economic and social impacts of these management measures is that they will apply only in federal waters.

The decision of where to fish (e.g., in territorial versus federal waters) is a function, among other things, of the costs and risks of getting to the fishing grounds or harvesting area (a function of distance and exposure), the costs of harvesting (including any restrictions that hinder harvesting efficiency and any costs associated with permitting and reporting), and expected returns (a function of fish abundance and related factors).

Some of the proposed management measures are restrictive and burdensome to fishermen. At least in the short term, they will reduce the incentive to fish in federal waters. Any resulting decrease in participation or harvesting effort in federal waters could result in shifts to other fisheries or other economic sectors. The impacts of shifts into other areas and fisheries will depend on the biological and economic state of those fisheries (e.g., whether they are already overfished). It is assumed in this analysis that:

1 fishing effort which shifts out of coral reef fisheries in the EEZs will result in greater effort in both territorial coral reef fisheries and non-coral reef fisheries (e.g., deep bottom and pelagic),

2 greater fishing and harvesting effort in territorial coral reef fisheries will, given the general assessment of their already being overfished in most nearshore areas (see Green 1997), result in smaller net returns relative to the no-action NPV, and

3 increased effort in pelagic fisheries will result in greater net returns for the pelagic sector relative to the no-action NPV, but not necessarily an increase in overall net returns, and

increased effort in non-coral reef fisheries (e.g., deep bottom fish) is likely to result in lesser net returns relative to the no-action NPV.

The “balance” between federal and territorial/state regulations is clearly an important consideration.

Increasing costs to fishermen could also push them out of fisheries altogether and into other economic sectors. It should be noted that these other sectors might include reef-dependent industries such as marine tourism, which, applying the concept of ecosystem management, could be considered part of the “fishery” being managed by this FMP.

Impacts to Non-fishery Sectors:

It is assumed that the value of each of the non-fishery sectors is purely a negative function of reef degradation, and that reef degradation is a positive function of harvesting effort and the degree of usage of destructive gears and practices. The extent of these relationships is of course the ultimate issue in the relationship between the management of harvesting sectors and the preservation of coral reef ecosystem values.

1.7. 1 General Effects of Management (Control) Measures

As indicated in the FMP, the potential for fishing and non-fishing activities to have fishery, environmental, and economic effects depends on how they are managed through one or more of the following management (control) measures:

- marine protected areas
- permit and reporting requirements
- allowable harvesting gear
- other (miscellaneous) requirements

Each of the four alternatives analyzed in the FMP contains these four management measures to a varying degree. In this section, the effects of each management measure under the Western Pacific coral reef FMP are described, focusing on how fishery participants and the fishery as a whole are likely to respond. Descriptions of compliance, management, fishery monitoring, and enforcement costs are also presented.

This is followed by a summary table of the likely effects outside the FMP regulated fishery itself, particularly in: 1) coral reef fisheries in territorial waters, 2) non-coral reef fisheries, and 3) non-fishery sectors. In addition, the impacts of each measure on net present value are assessed relative to the no-action alternative, with comparisons made among alternatives within a given type of management measure. The notations “zero,” “negative,” or “positive” in parentheses always refer to the impact relative to the No-Action alternative, not relative to any of the other alternatives.

Measure: Marine Protected Areas

The FMP includes two types of MPAs: "no take" and "low use". As with all natural resource harvesting restrictions, the economic issue is the extent to which these MPAs preserve the natural productivity of the ecosystem for social and/or economic values and to what extent they displace effort to open areas. The natural factors are not well known, nor is the recovery period (which in the case of snappers and groupers, for example, is likely to exceed the economic time-scale for value recovery). To the extent that MPAs are close to inhabited areas (e.g., in the EEZ of Guam) or accessible transportation (e.g., near Midway), then potential for use (and thus potential costs of restrictions) increases. To the extent that the areas are isolated (e.g., the Northwestern Hawaiian Islands except Midway), the costs of exploration and harvest increase. This reduces the profitability of harvest and reduces the social cost of regulation. Regarding insurance requirements for all vessels transiting no-take MPAs, several fishermen have indicated that pollution insurance is a standard part of their operations. As a result, although it would increase costs to existing fishermen who do not have such insurance, and to future fishermen and harvesters and similar operators (e.g., ecotourism purveyors), it would reduce asset risks to vessel operators and appear to provide substantial social value (as indicated by recent controversies concerning wreck removal).

The following summarizes the extent to which each alternative implements these management measures and the extent to which net economic values are affected:

No Action Alternative (Alternative 1):

In the absence of additional management measures, the bottomfish, lobster, and precious coral FMPs will still regulate those fisheries and through the Essential Fish Habitat portions of those FMPs, will serve to protect the general coral reef ecosystem. However, in the absence of the CRE MPAs, potential development of other fisheries (e.g., aquarium, live rock, bio-prospecting, etc.) will occur under open access conditions. While the lack of regulation usually fosters short-term investment and growth in nascent natural resource settings, in the long-term the lack of management controls tends to encourage over-exploitation and creates an unstable investment climate. The effect in high-cost coral reef fisheries, such as the NWHI, would be to preclude sustainable development and potentially harm the bottomfish, lobster, and precious coral fisheries as well.

Minimal Additional Protection (Alternative 2):

The restricted level of MPA protection identified in this alternative would be expected to offer extensive general ecosystem protection and preclude unsustainable development while allowing broad areas for exploratory development.

Substantial Additional Protection (Alternative 3, Preferred Alternative):

The broad levels of MPA protection identified in this alternative would be expected to offer extensive general ecosystem protection but would increase the costs of exploratory development. Low cost exploratory options would still be possible but high cost options might not. Where eco-tourism and other low-use activities would be possible, these should not be substantially affected by this alternative.

Maximum Additional Protection (Alternative 4):

The effect of these MPAs (100 fathoms) would be to preclude all development of marine resources from EEZ coral reef habitats except for research functions and high-cost deep-water exploration (perhaps in conjunction with the precious coral fishery). Whether eco-tourism and other low-use activities would be permitted would depend on the drafting of the management measures.

Measure: Harvesting Permits and Reporting Requirements

The impact on coral reef harvesting and on un-regulated fisheries (e.g., territorial) depends on a variety of factors including the degree of discretion given to NMFS concerning Special Permits in determining participation, effort, catch, compliance costs, and management costs. Outside the FMP fishery, such factors include the magnitude of the positive and negative impacts on habitat and ecosystem services and value caused by reduced participation in the FMP fishery and greater participation in other fisheries. The impact within the coral reef ecosystem fishery of various permit alternatives would be primarily determined by their severity and by the public costs of enforcement, permit processing, and data analysis (negative), the effects of compliance costs on individual net returns (negative), and the indirect effects of reduced participation on the FMP fishery's total private net returns (positive or negative). The impacts outside the fishery would be determined by any displacement of harvesting activity to (greater participation) territorial fisheries and in non-coral reef fisheries.

Participation in the fishery, and probably effort, would likely be least under the Special Permit requirements. Per-vessel compliance costs would be substantially greater under the Special Permit than under the General Permit, as would public permit processing and data analysis costs. Enforcement costs would likely be greatest for harvesting under the Special Permit and lower under both the General Permit and the No Action Alternative.

The subsistence harvesting exemption would likely result in greater net private returns in the fishery relative to any of the other permits, with the degree of the impact depending on how it is interpreted and applied. The benefits would be offset by enforcement being less effective and slightly more costly. The extent of these overall benefits is unknown.

The following summarizes the extent to which each alternative implements these management measures and the extent to which net economic values are affected:

No Action Alternative (Alternative 1):

In the absence of permitting and reporting requirements it is likely that information for future resource management decisions would be inadequate.

Minimal Additional Protection (Alternative 2):

The costs of permitting and reporting under this alternative are relatively minimal and therefore are likely to have a small effect on economic activity. To the extent that Alternative 2 encourages higher levels of development, however, it may increase the administrative burden to the government and subsequently the scientific research and analysis burden.

Substantial Additional Protection (Alternative 3, Preferred Alternative):

The costs of permitting and reporting under this alternative are limited to the low-use MPAs at this time and are likely to have a small effect on economic activity.

Maximum Additional Protection (Alternative 4):

Given the extensive nature of the MPAs in this alternative, and the requirement for permitting and reporting in most coral reef areas, reporting and permitting may have substantial costs to small-boat fishermen as well as to larger harvesters seeking permission to access more remote areas. Similar costs are likely to the government. With permits required for research and management activities, this may also have burdens on science.

Measure: Gear Restrictions

Gear restrictions are likely to have three primary effects: first, the reduction in efficiency in harvest; second, the (positive) biological effect of this reduced harvest; and third, the cost of enforcement. One alternative is to restrict gears consistent with rules in adjacent territorial waters. This would reduce enforcement problems significantly and would otherwise have the same effect of the current status quo (no action alternative) in terms of effect on participation and ecosystem. However, since the EEZ areas are more distant than the territorial areas, the costs of harvesting would be greater, as would the costs of compliance. It can also be anticipated that the density of participation would be lower.

The following summarizes the extent to which each alternative implements these management measures and the extent to which net economic values are affected:

No Action Alternative (Alternative 1):

In the absence of gear restrictions under the CRE FMP, protection of habitat from inappropriate gears would be limited to that provided by the bottomfish, lobster, and precious coral FMPs. This also suggests habitat dangers similar to those of over-fishing identified under Alternative 1 in the MPA category.

Minimal Additional Protection (Alternative 2):

This alternative is unlikely to impose substantial economic costs on any type of sustainable development and harvesting activities.

Substantial Additional Protection (Alternative 3, Preferred Alternative):

This alternative, through the prohibition of night-time spear-fishing with scuba or hookah may have some impact on recreational fishing but that effect is expected to be small. Otherwise its effects would be minimal (similar to those of Alternative 2).

Maximum Additional Protection (Alternative 4):

This alternative's prohibition of spear-fishing with scuba or hookah is likely to have a deleterious effect on recreational fishing.

Compliance Requirements and Costs

The permitting options are the only ones with direct costs of compliance. Although the details of the permitting measures have yet to be fully determined, the following assumptions regarding the measures will be made in order to estimate compliance costs, as shown in Table 16:

1. Permit applications are estimated to require 1 hour of labor for the General Permit and 2 hours for the Special Permit. These permits will be required to be renewed annually, however the renewal form should require no more than 0.5 hours of labor to complete.

2. A fee would be charged for each application, this fee would be calculated in accordance with the procedures of the NOAA Finance Handbook for determining the administrative costs of processing each application.

3. Reports on catch and effort would be required after every trip, requiring 0.5 hour per fishing day for fishing under the General Permit, and 1 hour per fishing day for the Special Permit.

4. If vessel observers are required, the public, and not the permit holder, would pay the entire cost, estimated at $5,000 per month.

5. No conditions beyond catch reporting requirements may be attached to a General Permit. Any conditions may be attached to a Special Permit.

Table 16. Compliance Costs of Permitting and Reporting Measure

	Fixed ($/permit-year)			Variable ($/vessel-day)		
	Cash	**Labor**	**Total**	**Cash**	**Labor**	**Total**
General Permit:						
Permit application	0	20	**20**			**0**

Reporting			**0**	0	10	**10**
General Permit total	**0**	**20**	**20**	**0**	**10**	**10**
Special Permit:						
Permit application	0	40	**40**			**0**
Reporting			**0**	0	20	**20**
Special Permit total	**0**	**40**	**40**	**0**	**20**	**20**

Costs are estimated on a per-vessel basis; multi-vessel operations would probably incur lower per-vessel costs.
The value of labor is assumed to be $20 per hour.
A Special Permit could include any number of additional conditions, with associated costs.

Management Costs

Plan Development:
It is estimated that the Western Pacific Regional Management Council will spend $500,000 to $700,000 on the development of this FMP. Costs include staff time, public scoping meetings and hearings, meetings of the Plan Team, Habitat and Ecosystem Advisory Panel, Scientific and Statistical Committee, and the Council itself, contractors that contributed to plan development, and administrative costs, including printing. The NMFS will also have made expenditures towards plan development in the form of staff time and administrative costs, estimated at $50,000 to $100,000.

Plan Review:
Monitoring and reviewing the plan, including routine meetings, data analysis and reporting by the Plan Team, making occasional adjustments such as framework measures and amendments, and implementing management actions that would require coordination among different plan teams, will bring running costs to both the WPRFMC and the NMFS. Staff time, administrative costs, meetings of the Council and relevant teams and committees, and public hearings can be expected to cost the WPRFMC $200,000 to $400,000 per year. Staff time and administrative costs can be expected to cost the NMFS $50,000 to $100,000 per year. These figures are based in part on estimates made in other Council documents for similar services (e.g., WPRFMC 1994).

Permits:
The General Permit would only require assessment of whether the applicant meets basic eligibility requirements (yet-to-be determined), and would be the least costly of the permits on a per-permit basis.

The Special Permit would require case-by-case scientific and administrative review of fairly sophisticated applications that include demonstration of how the proposed harvesting would be sustainable at the ecosystem level. The Regional Administrator of the NMFS would review applications in consultation with the WPRFMC.

The two-tiered permit systems also requires the additional task of maintaining the list of the two categories of target organisms–those subject to General Permits and those subject to Special Permits.

Given the Council's mandate under that option to determine needed biological reference points for species as information becomes available, the analytical requirements of the Council's and NMFS' staffs might be greater than under either the General Permit or the Special Permit options. The costs involved in creating and maintaining the two lists of species and determining the biological reference points are addressed under "fishery monitoring, analysis, and reporting."

The per-application processing costs of each of the three options are roughly estimated at:

General:	$50	to	$100	per application
Special:	$400	to	$2,000	per application

The total annual cost of each option would depend on the number of applicants. The Special Permit option, because of its costly application requirements and relative uncertainty of outcome, would probably yield the fewest applicants. Very rough estimates of the number of expected annual applicants, at least during the first few years, are:

General:	10	to	20	applicants
Special:	0	to	10	applicants

Under those assumptions, total annual permit processing costs would be:

General:	$500	to	$2,000 total cost	
Special:	$0	to	$20,000	total cost

Fishery Monitoring, Analysis, and Reporting:
The Western Pacific Fisheries Information Network is already monitoring components of the coral reef fisheries in the region. The system might be expected to be expanded or improved in response to the needs of the FMP. Roughly estimated additional costs of the network are $0 to $200,000 per year.

The FMP Special Permit would allow NMFS to require, at its discretion, vessel observers, at a cost of about $5,000 per vessel per month. Ten vessels harvesting half the year, for example, would cost $300,000, and that is treated here as the maximum possible cost (how the cost would be divided between the public and the harvesting participant has not been determined; in estimating compliance costs, above, it was assumed the public would pay, so the cost is included here).

The data reporting requirements of fishermen would be roughly the same under all permitting options, but less detailed reports would be required under General Permits than under Special Permits. The data in these reports would presumably be processed and analyzed by NMFS, which would report the results to the WPRFMC. The number of reports would depend on the number of permit holders, which would depend on the number of applicants (estimated for each permit system above) and the percent of applicants that are granted permits. Under the two-tiered permit system, NMFS would also have the task of devising and maintaining the two lists of species, and for Non-Target species, determining biological reference points. If vessel observers are used, analyzing their data would require additional costs. The total costs of these tasks are roughly estimated at $50,000 to $200,000 per year (based on estimates for similar services in WPRFMC 1994).

Enforcement:

Enforcement costs of NMFS and the Coast Guard for the region's federally managed pelagic fisheries were estimated in 1994 at $1.5 million per year (WPRFMC 1994). Enforcement costs are largely discretionary and are increased greatly by the proposed MPAs which would require some amount of distant patrolling by air and by sea. A large portion of the enforcement needs of the FMP could presumably be met through existing levels of patrolling and other services for other fisheries. Additional patrols would cost as much as $100,000 per air patrol and $250,000 per surface patrol from Honolulu to distant islands (not to all islands at once–just in one direction or another). Dock-side enforcement would require additional personnel, at a cost of about $100,000 per agent per year. Prosecution costs would increase according to the level of patrolling. In sum, the enforcement costs for the plan could run anywhere from about $0.3 million to as much as $3.0 million or more per year.

The estimated costs of implementing the FMP are summarized in Table 17.

Table 17. Summary of Expected Implementation Costs of FMP ($1,000/year)

	Low	**High**
Management plan	250	500
Permits	0	20
Fishery monitoring and analysis	50	700
Enforcement	300	3,000
TOTAL	**600**	**4220**

The one-time costs of developing the FMP, $0.55 to $0.80 million, are not included here.

Summary

The likely impacts of each management measures on the net present value of each of the fishery and non-fishery sectors are summarized in Table 18. For each sector and each measure, the likely impact is described as being either less than, the same as, or more than the likely no-action net present value. The coral reef resources under the jurisdiction of the FMP are termed "FMP fisheries." Coral reef fisheries not in federal waters are termed "local coral reef fisheries," and all other domestic fisheries are termed "non coral reef fisheries." The No Action Alternative is omitted from the table. Included are analyses of implementation of a framework procedure for future management actions, as well as a non-regulatory method for the integration of FMPs to allow for consideration of the ecosystem effects of the harvesting of coral reef resources which are primarily managed under the Bottomfish, Crustaceans, and Precious Corals FMPs.

Table 18. Impacts of FMP Management Measures to Net Present Value – Relative to the No Action Alternative

	FMP fisheries	Local coral reef fisheries	Non coral reef fisheries	Tourism and recrea-tion	Support for other ecosys-tems	Informa-tion	Existence and option values	Overall
Marine protected areas established								
Remote Areas	–	O	O	–	+	+	+	– +
Accessible Areas	– +	O	– +	O	+	+	+	– +
Guam's southern banks–no large harvesting vessel anchoring**	– +	O	– +	O	+	+	+	– +
Harvesting permit and reporting requirements								
General Permit	– +	– O	– +	– O	– +	– +	– +	– +
Special Permit	– +	– O	– +	– O	– +	– +	– +	– +
Permit exemption for subsistence harvesting	– +	– O	– +	– O	– +	– +	– +	– +
Gear restrictions								
Allow only certain gears	– +	O	O	O	O +	O +	O +	– +
Restrict gears consistent with rules in local waters	– +	O	O	O	O +	O +	O +	– +

" – +" means less than or greater than, i.e., indeterminate; " – O" means less than or the same as; and "O" means the same as the NPV under the no-action alternative. There are no strictly positive results.

As can be seen in Table 18, little can be said definitively about the likely impacts of the management measures on net value. The impact of most measures could be either positive or negative in most sectors, with the exception of the locally managed coral reef fisheries, in which positive impacts are relatively unlikely. The following summarizes the extent to which each alternative implements these management measures and the extent to which net economic values are affected:

No Action Alternative (Alternative 1):

Alternative 1 would implement no new management measures, leaving protection of the coral reef ecosystem to those measures implemented under the bottomfish, lobster, and precious coral FMPs and the essential fish habitat provisions of those FMPs. The absence of MPAs would open areas of the coral reef ecosystem to over-harvesting due to open access harvesting conditions; the absence of permitting and reporting requirements would mean that adequate information for scientific assessment of any such developments would be lacking; without gear restrictions it is possible that coral reef habitat itself could be harmed. Altogether the Council determined that the No Action alternative was not viable in an era of increased potential for harvesting pressure on the coral reef marine environment and increased concern worldwide for preserving coral reef ecosystems. Although there would be some costs in terms of economic developments potentially forestalled by the other three alternatives, the potential losses to the Western Pacific coral reef ecosystem of unfettered marine development and utilization would certainly offset any potential gains from such development.

Minimal Additional Protection (Alternative 2):

Alternative 2 would designate a range of precautionary management measures that would nonetheless allow for some controls on commercial and recreational use of the coral reef ecosystem in Federal waters in the Western Pacific. The implementation of low-take MPAs along with restrictions on taking live rock and coral and the prohibition of non-selective gear, as well as permitting and reporting requirements, should preclude any “mining” of the coral reef ecosystem by unfettered marine development. At the same time, the management measures under Alternative 2 impose minimal costs for marine development and utilization. However the Council believes that this alternative does not provide adequate protection for particularly sensitive coral reef ecosystem areas, particularly those in the shallow waters. As a result, although the measures in this alternative are precautionary, there is the potential for over-harvesting and habitat destruction in some circumstances. The potential costs of such activities would outweigh the potential benefits of harvesting in shallower waters and marine developers not being subject to stricter controls in sensitive areas.

Substantial Additional Protection (Alternative 3, Preferred Alternative):

Alternative 3 (which incorporates the management measures in Alternative 2) also provides a range of no-take MPAs in particularly sensitive regions of the Western Pacific coral reef ecosystem, requires additional permitting and reporting requirements, mandates the use of non-destructive gears, and implements some additional restrictions (vessel monitoring, anchoring controls, and night-time fishing regulations) which are intended to prevent not only unfettered marine development (as precluded by Alternative 2) but also to prevent or mitigate unintended harm to the coral reef ecosystem through reduction in vulnerability of certain coral reef fish to night-time fishing as well as providing insurance and mitigation systems for vessels operating within the coral reef ecosystem. The additional costs of the insurance and mitigation systems are expected to be low, relative to their potential benefits, while the lost opportunities concerning night-time fishing may be significant to recreational fishers but the prevalence of this activity outside of the 3 miles (i.e., in the EEZ) is thought to be low. As a result, the Council believed this alternative balanced the costs to current and future participants in the coral reef ecosystem with the benefits of increased protection.

Maximum Additional Protection (Alternative 4):

Finally, Alternative 4 provides much broader no-take MPAs (out to 100 fathoms) as well as incorporates the measures proposed in Alternatives 2 and 3. The result of the 100 fathom MPAs would be to effectively curtail any commercial and recreational use of the Western Pacific coral reef ecosystem within the EEZ. Although the benefits of such use in terms of aquarium fish collection, bio-prospecting, and other potential uses are not well known, it may be that some considerable value exists. The maximum protection provided by this alternative would impose future costs with unknown future benefits.

Summary of Impacts of the Preferred Alternative (Alternative 3):

The following is a further summary of impacts under the Preferred Alternative (Alternative 3). To the extent that Alternatives 2 and 4 (Minimal and Maximum Protection) mimic aspects of the Preferred Alternative, these impacts would accrue accordingly. To the extent that these other two alternatives contain lower degrees of management, e.g., smaller or larger MPAs, less or more restrictive gear rules, etc.)., then the impacts would be either smaller or greater, respectively.

1. The preferred management measures, primarily through the permitting and protected area measures, can be expected to result in a lower level of fishing and harvesting levels and participation on federal coral reefs than under the No-action alternative.

2. Because they would bring greater restrictions and greater harvesting costs in federal waters, the preferred measures would encourage harvesting effort outside federal waters, and they could thereby negatively impact values of both fishery (if the greater effort leads to or exacerbates overfishing) and non-fishery sectors (if the greater effort degrades habitat or other ecological services) of coral reefs under local jurisdiction.

3. Because of the flexible nature of the Special Permit system, as well as the uncertainty of how it would evolve relative to the General Permit system, the impacts of the permitting measure are difficult to assess. To the extent that the Special Permit system requires expert knowledge in formulating and defending the proposed activity, it will increase costs to participation and set a higher wealth threshold for participation.

4. The expected implementation costs of the FMP and the preferred measures are \$0.6 to \$4.6 million per year, not including the one-time costs of developing the plan (\$0.5 to 0.8 million), and not including the existing costs of managing coral reef fisheries in territorial

waters (about $3 million/year).

5. Management inputs needed for effective implementation of the preferred measures are likely to be relatively large compared to the net value of the existing and potential fisheries (especially since the basic operations of the bottomfish, lobster, and precious coral fisheries are covered by separate FMPs), but small relative to the net value of non-fishery sectors.

6. It is unlikely the preferred measures would result in a greater net value of coral reef fisheries–even just in federal waters–than under the no-action scenario. The preferred management are likely to result in prevention of losses to the net values of non-harvesting sectors, but only in federal waters. Those benefits could be offset by negative impacts to both harvesting and non-harvesting sectors in locally managed waters. Because coral reef harvesting activities have a limited capacity to affect non-harvesting values of reefs, the potential impact of the FMP measures on non-harvesting values – positive or negative – would likely be small relative to total non-fishery values.

7. It is not possible to determine whether the impact of the preferred measures on the overall net value of the region's coral reefs would be positive or negative but given the nature of open access fisheries historically, it is likely that they will be more positive than the No Action alternative.

8. The social and indirect economic impacts of the preferred measures would vary greatly from area to area. On remote reefs with little historical or current harvesting activity, few participants would be affected. One exception is Midway, where the preferred protected area measures would close the developing coral reef sportfishery. On nearshore reefs close to population centers, such as the federal reefs off Saipan and Tutuila, and Penguin and Ka'ula Banks in Hawaii, more participants would be affected, including commercial, recreational, and sport fishermen, most of whom only occasionally fish in federal waters. Fishing activity on the isolated offshore banks of Guam, American Samoa, CNMI, and Hawaii, and around Farallon de Medenilla in the CNMI would also be substantially affected by the permit requirements, and participation and effort can be expected to be substantially reduced.

9. The preferred permitting measure would be restrictive and costly enough that, where there are adjacent fishing grounds under local jurisdiction, many affected participants would probably choose to stop fishing in federal waters rather than bear the increased costs of compliance. Similarly, future growth in coral reef fishery participation and effort in locally managed waters is likely to be greater than it would have been in the no-action scenario.

10. Relatively few of the region's coral reef fishery participants would be affected by the preferred measures, and only some of those affected would be significantly affected. Consequently, with the exception of the community of Midway–which would be excluded from the coral reef fishery, the preferred measures are unlikely to hinder the "sustained participation" of fishing communities, consistent with part (A) of National Standard 8 of the Magnuson-Stevens Act.

11. Although the preferred measures do not include any explicit allocation of harvesting

privileges, the costs of complying with the preferred permitting measure would cause proportionately greater impacts to small-scale, part-time, recreational and mixed-motivation fishermen, with consequent shifts in the composition of participants.

12. The discretion in issuing Special Permits under the preferred permitting measure could result in preferences being given according to any number of criteria, some not intended, including time of application and the ability to express scientific ideas.

13. Implementation of the preferred measures on reefs in federal waters that are contiguous with reefs under local jurisdiction may be problematic and thus costly in terms of enforcement and effectiveness. The three-mile boundary is difficult for fishermen to know and comply with, and the measures, being quite restrictive relative to local rules, may not be readily accepted by local fishing communities. To the extent that straight-line enforcement boundaries are imposed, given the bottom topography of the western Pacific island areas, it is possible that the proposed management measures would have either a substantially greater or potentially smaller effect than anticipated.

14. The portion of new federal management inputs that are funneled through local economies would bring positive indirect economic impacts to those economies.

2.0 INITIAL REGULATORY FLEXIBILITY ANALYSIS

2.1 Introduction

The Regulatory Flexibility Act (5 U.S.C. 601 et seq.)(RFA) requires that agencies assess and present the impacts of their proposed actions on small business entities. In accordance with the RFA, the following is set forth: (1) The need for, and objective of, the measures are outlined in the draft FMP which accompanies this document; (2) The proposed measures would apply to all individuals who wish to harvest domestic coral reef resources in the federal waters of the western Pacific region; (3) All affected individuals are expected to be small business entities; (4) The proposed measures include new reporting requirements; and (5) No Federal rules are known to duplicate, overlap, or conflict with the proposed measures.

An IRFA is needed to determine if a regulatory action is expected to have a "significant economic impact" on a "substantial number" of "small entities."

A "small entity" in this case would be a commercial fishing or marine harvesting company, a wholesaler dependent on products harvested from the coral reef ecosystem, a non-profit organization that is independently owned and not dominant in its field, or a small government jurisdiction.

2.2 Basis for Rule and Description of Alternatives

The basis for the rule, description of alternatives, etc. are described in the preceding RIR. The following provides information specific to the needs of the RFA.

2.3 Description and Number of Affected Small Entities

Virtually no participants in the fisheries of the US Pacific Islands can be considered large entities. The challenge in identifying small entities in this case is first, distinguishing "businesses" from fishing participants that sell their catch only occasionally, and second, identifying which fishing entities participate in, or rely on, coral reef fisheries.

Tables in the Fishery Impact Statement of Appendix I, reproduced on the following page as Table 19, shows the number of participants in the fisheries of the US Pacific Islands.

Table 19. Harvesting Community Descriptors

	Am. Samoa	CNMI	Guam	Hawaii	Other islands	All islands
Resident population	64,000	65,000	160,000	1,187,000	350	**1,476,350**
Number of regular commercial food fishermen	50 to 100	50 to 100	50 to 500	2,000 to 3,000	0	**2,150 to 3,700**
Number of sometime commercial food fishermen	200 to 500	200 to 1,000	1,000 to 10,000	50,000 to 200,000	0 to 20	**51,400 to 216,020**
Number of sometime food fishermen	10,000 to 30,000	10,000 to 30,000	20,000 to 60,000	150,000 to 415,000	100 to 300	**190,100 to 535,300**
No. of commercial reef ornamentals collectors	1	0 to 1	2 to 4	170 to 220	0	**173 to 226**
No. of permitted non-comm. reef ornamentals collectors	na	na	35 to 45	190 to 300	na	**na**
Number employed in reef ornamentals industry	1 to 2	0 to 2	4 to 10	200 to 300	0	**205 to 314**
Number of regular commercial fishing boats	40 to 60	150 to 160	100 to 400	1,200 to 1,700	0	**1,490 to 2,320**
Number of boats that charter sportfish	1 to 2	30 to 40	20 to 25	150 to 250	2 to 4	**203 to 321**
Number of other boats that fish	20 to 30	250 to 350	300 to 1,500	8,000 to 12,000	5 to 20	**8,575 to 13,900**
Total number of boats that fish	70 to 80	430 to 550	420 to 1,925	9,400 to 13,900	7 to 24	**10,337 to 16,474**
Total annual production of seafood (1,000 lb)	770	1,050	1,120	32,000	15	**34,955**
Total annual production of reef seafood (1,000 lb)	340	500	410	5,300	10	**6,560**
Per-capita annual production of local seafood (lb)	12	16	7	27	43	**24**
Per-capita annual production of reef seafood (lb)	5	8	3	4	29	**4**
Per-capita annual consumption of seafood (lb)		56		56		
Per-capita annual consump. of local seafood (lb)	12	16	6	23	43	**20**
Per-capita annual consump. of local reef seafood (lb)	5	8	3	4	29	**5**
No. of wholesalers dealing local seafood/ornamentals	0	0	0 to 2	5 to 30	0	**5 to 32**
No. of retailers dealing local seafood/ornamentals	30 to 40	50 to 60	50 to 200	200 to 1,000	2 to 4	**332 to 1,304**

See Appendix I for data sources.

It is assumed that in terms of food fishing participants, only those identified as "regular commercial food fishermen" in Table 19 are members of "businesses," and all such businesses will be considered "small entities." All commercial ornamentals collecting participants and all charter sportfishing participants will also be considered members of "small entities."

In Table 20, numbers of fishery "participants" are converted to numbers of "entities," using the assumptions footnoted under the table. Research entities were not considered part of the "fishing communities" described in Table 19, but since they may be affected by the action, they are included here. Most research is undertaken by government organizations, such as universities. But universities and other governmental institutions contract research to small entities, and small entities may undertake independent research. With little information available on those small entities, the estimates here are rough.

In Table 21, the numbers of small entities in all fisheries are narrowed down to just those that would be subject to the regulatory action of the FMP–that is, to "affected entities."

As described throughout the RIR, the regulatory action will have economic impacts not just on participants in coral reef fisheries, but on participants in other fisheries and in non-fishery sectors, as well. This analysis, however, is limited to the impacts on "affected" small entities, where only those entities that are directly subject to the regulatory action are considered "affected." If the universe of affected small entities was expanded to include entities that are indirectly affected, or even just those that are *negatively* indirectly affected, the universe would be so large that none of the five IRFA triggering criteria would be met, and an IRFA would not be required. Use of the more restricted interpretation of "affected," as done here, leads to a more conservative analysis, with the triggering criteria more likely to be met.

The regulatory action would affect only fishermen, collectors, vessel operators, and vessel owners–that is, the harvesting sector. The processing, wholesaling, retailing, and exporting sectors would not be directly affected. Only entities that harvest coral reef ecosystem species in federal waters of the US Pacific Islands (or in the CNMI, in the offshore management zone) are affected entities, and all are "small" as defined by the RFA.

Table 20. Number of Small Entities in the Fisheries of the Us Pacific Islands

	Am. Samoa	CNMI	Guam	Hawaii	Other islands	All islands
Number of food fishing businesses	25 to 60	25 to 160	25 to 400	1,000 to 1,700	0	**1,075 to 2,320**
Number of charter sportfishing businesses	1 to 2	15 to 20	10 to 13	75 to 125	1	**102 to 161**
No. of reef ornamentals collecting businesses	1	1	1	5 to 13	0	**8 to 16**
Number of research entities	0	0 to 5	0 to 10	5 to 50	0	**5 to 65**
No. of wholesalers dealing local seafood/ornamentals	0	0	0 to 2	5 to 30	0	**5 to 32**
No. of retailers dealing local seafood/ornamentals retailers–local product	30 to 40	50 to 60	50 to 200	200 to 1,000	2 to 4	**332 to 1,304**
Total number of affected small entities	**57 to 103**	**91 to 246**	**86 to 626**	**1,290 to 2,918**	**3 to 5**	**1,527 to 3,898**

15. "No. of food fishing businesses" derived from Table 19 by assuming 2 fishermen per business, and setting the maximum equal to the maximum estimate of "number of regulator commercial fishing boats" from Table 19.
16. "Number of charter sportfishing businesses" estimated by assuming (with little basis) two charter boats per business, with the number of charter boats taken from Table 19 (the number is known for "other islands").
17. "No. of reef ornamentals collecting businesses" derived from Bartram (pers. comm.), Gourley (pers. comm.), Green (1997), and Miyasaka (1991 and 1997) for American Samoa, CNMI, Guam, and Hawaii, respectively.
18. "Number of research entities" roughly estimated with little basis.
19. Number of wholesalers and retailers taken directly from Table 19.

Table 21. Number of Affected Small Entities

	Am. Samoa	CNMI	Guam	Hawaii	Other islands	All islands
Number of food fishing businesses	1 to 3	2 to 16	2 to 40	100 to 170	0	**105 to 229**
Number of charter sportfishing businesses	0 to 1	3 to 4	1 to 2	7 to 13	1	**12 to 21**
No. of reef ornamentals collecting businesses	0	0	0	0	0	**0**
Number of research entities	0	0 to 5	0 to 10	5 to 50	0	**5 to 65**
Total number of affected small entities	**1 to 4**	**5 to 25**	**3 to 52**	**112 to 233**	**1**	**122 to 315**

1. It is estimated that in Am. Samoa, CNMI, Guam, and Hawaii, 5%, 10%, 10%, and 10%, respectively, of food fishing businesses fish for coral reef resources in federal waters (or in the CNMI, the offshore management zone).
2. In is estimated that in Am. Samoa, CNMI, Guam, and Hawaii, 20%, 20%, 10%, and 10%, respectively, and in the other islands, 100% (Midway), of charter sportfishing businesses catch coral reef species in federal waters.
3. It is believed that no reef ornamentals collecting businesses catch coral reef species in federal waters (there may be occasional commercial collecting of ornamentals on Palmyra, but it is assumed to be a rare activity).
4. It is assumed that all research entities in all island groups harvest coral reef species in federal waters.

2.4 Impacts on Affected Small Entities

The economic impacts of the management measures under the FMP alternatives are addressed in detail in both the RIR (in terms of the fishery as a whole) and in the FMP (in terms of fishing communities and participants). Those analyses are supplemented here with a discussion of how the action is likely to affect coral reef fishery participants as small entities.

There is some discussion of the possible differential impacts among entities–such as how smaller operations might bear relatively larger burdens than larger operations. It should be kept in mind, however, that all affected entities in the fishery are small entities, as defined by the RFA, so there will be no disproportionate effects between large and small entities–a central concern of the RFA.

It is difficult to determine the effects of the action on the risks, revenues, and costs of harvesting. It is also difficult to determine how entities will respond to a given change in risk, revenues, or costs. They may bear an increased burden by remaining in the fishery at the same level of harvesting effort, they may adjust to or mitigate the impact with innovations, they may shift to other areas or fisheries to avoid the impacts, they may put either less or more effort in the fishery in order to minimize the impacts (e.g., depending on whether they stem from changes in fixed or variable costs), or they may exit the fishery.

The most straightforward of the five IRFA-triggering mechanisms to examine is the second–the magnitude of compliance costs relative to total production costs.

The permitting requirements are the only part of the proposed action that would bring direct compliance costs. The requirement would apply to all entities that catch coral reef species (whether holders of permits issued under other FMPs would need a coral reef permit to catch coral reef species is not clear). The compliance requirements and costs of the proposed permit requirements were addressed in the RIR and for Special Permits were roughly estimated at a minimum of $600 per vessel per year (whether or not the permit is issued) plus $10 per trip. General Permits would cost about $50 per year plus $5 per trip, but since all harvesting would initially require Special Permits, the General Permit will be ignored in this analysis.

The threshold annual production costs, below which the (minimum) compliance costs would constitute more than 5 percent of total costs are about $14,000. Not all affected entities would necessarily bear the compliance costs. With the exception of the sportfishing operation based at Midway, all affected entities are based on islands that have adjacent territorial waters that would not be subject to the action. Many of the affected entities, especially the smaller ones, could be expected to shift their effort to territorial waters in order to avoid the costs of fishing federal waters. They could also shift to fishing for non-coral reef species. Although such shifts might result in fewer gross receipts or poorer efficiency, there would be no increase in compliance costs.

It is not possible to determine how many entities would bear the compliance costs and continue fishing for coral reef species in federal waters, how many would shift into other areas or species, or how many would exit the fishery. For the purposes of this analysis, it is determined that it is possible that 20 percent or more of the affected food, charter, and research fishing and harvesting entities would be significantly affected by the increase in compliance costs.

2.4.1 Compliance Requirements and Costs

The compliance requirements and costs of the permitting measure would be applicable to all affected small entities except lobster and bottomfish permit holders that target lobster and bottomfish.

The actual costs of compliance would vary among entities, depending on the number and sizes of vessels and the number of trips made. The compliance costs would include flat rate annual per-vessel annual costs (permits) and more or less flat rate per-vessel trip costs (data collection and reporting). Because most compliance costs are fixed costs, the smaller, less capital-intensive and less profitable operations would bear a greater burden than larger operations relative to total production costs.

The permit application and reporting requirements would require a certain level of scientific expertise, which would bring a certain level of costs. Issuance of Special Permits would require the applicant to demonstrate the proposed activity would be sustainable and not detrimental to the ecosystem. It would require a similar level of expertise and effort as applying for a research or exempted fishing permit. It was estimated in the RIR that such an application would require labor valued at about $20 per hour, and approximately 2 hours would be required to prepare the application the first year. The time required would presumably decrease considerably in subsequent years, with an average of perhaps 0.54 hours per year, valued at $40.

Another cost associated with the Special Permit requirement is that there is no guarantee that the permit would be issued. Even if issued, the permit may have restrictions or conditions that would make the enterprise cost-ineffective. In these cases, the permit application investment would be sunk and lost.

The Special Permit reporting requirements could be fulfilled with the expertise of a typical fisherman. It was estimated in the RIR that the labor requirements would be about one hour per fishing day, valued at $10. Because reporting costs are variable costs, the differential effects among entities would be small.

2.4.2 Other Economic Impacts

The restricted gears and methods provision could lead to decreased efficiency, less effort, and less return for some entities. Commercial fishing with tangle nets for Kona crab in the Main Hawaiian Islands, for example, would be allowed, but with yet-to-be-determined restrictions. Almost half the commercial catch of Kona crab is from federal waters, most of that from Penguin Bank (from Friedlander, 1996). If strongly affected, fishing effort for Kona crab could presumably shift to territorial waters. Spearfishing on compressed air at night, which would be prohibited, may have been done by one business in the northern islands of the CNMI, but not since 1995 (MES 1997). It may also currently be done by one or more small entities on the bank to the west of Saipan, in the offshore management zone.

The prohibition on the harvest of hard corals and wild live rock would not impact any small entities.

The Special Permit requirement–with its capacity to deny access and to attach any number of conditions on harvesting–may effectively exclude small entities from certain activities, areas, or the entire fishery. Because of the large degree of discretion given to NMFS in reviewing and issuing permits, it is not possible to estimate how many or to what degree small entities would be affected (this is in addition to the impacts of the compliance costs, addressed above).

The low degree of security, durability, and stability associated with the permits (e.g., their validity, conditions, and limitations may change at any time) provide permit holders with relatively little interest in the fishery and present a high level of risk associated with investment.

The substantial financial and technical requirements of the permit application process and the substantial costs needed to comply with permit conditions are likely to favor larger, full-time, capital intensive, high-profit operations, leading to effective allocation of fishing rights among different categories of entities. Those costs, along with the vague criteria for permit issuance, could also lead to allocation according to any number of other factors, as well, including vessel size, scientific expertise, or market (e.g., fishing for sport versus food).

The no-take zones in the NWHI would affect a number of small entities. The coral reef sportfishery at Midway takes place entirely in what would be a no-take zone. Without alternative fishing grounds, the single business would be limited to pelagic fishing. Most patrons participate in both coral reef and pelagic fishing. During the 1999 NEF sport fishing season there was an apparent large decline in CPUE of ulua. The loss of the opportunity to coral reef fish could cause the demand for sportfishing to decrease substantially and the business could be severely affected. There are no known businesses harvesting in the waters of the other unincorporated islands.

The no-anchoring restrictions for Guam's banks and other yet-to-be designated areas could reduce harvesting efficiency by vessels longer than 50 feet (of which there are apparently very few)–by how much is not known.

Whatever the impacts of the preferred measures, most affected entities do not rely totally on coral reef species in federal waters and have alternative activities and areas that they can fish.

2.5 Identification of Duplicating, Overlapping, and Conflicting Federal Rules

Two possibly duplicating, overlapping, or conflicting federal rules were identified:

1) The Special Permit system would be similar to the existing "exempted fishing permit" (EFP) system administered by the NMFS for otherwise closed fisheries (50CFR600.745). Like an EFP, a Special Permit may, at the discretion of NMFS, be conditioned with limits on catch, effort, periods, areas, gears and methods, and it would require reporting of catch and effort data. In both systems, the burden would be on the applicant to demonstrate the lack of detrimental effects, consistency with the objectives of the FMP, and to otherwise justify the need for a permit. The proposed Special Permit system could be viewed as closing the fishery, with exemptions provided through a permit system that is similar to the existing system for closed fisheries. The proposed system would use the same administrative infrastructure to provide what could be viewed as a second means, with slightly different requirements and conditions, of gaining access to the fishery. The substantive differences between the two systems are:

1. the EFP process requires publication in the *Federal Register* of receipt of any application determined by the NMFS Regional Administrator or Director to warrant consideration, as well as consideration of comments from the public and other agencies, including the USCG and local fishery agencies; the Special Permit process would not;

2. the fee for an EFP may be set as high as needed to cover the administrative expenses of issuance (currently set at zero); the fee for a Special Permit has not been determined;

3. the Special Permit system would give the WPRFMC discretion to review the application and consult with NMFS, while the EFP system gives NMFS the discretion to consult with the

WPRFMC over the application;

2) The proposed action would prohibit the harvest for hard corals and wild live rock, except for research or as aquaculture broodstock, subject to obtaining a Special Permit. The restriction would therefore apply to any dredging of reef material that contains coral or live rock. Dredging is governed by the Clean Water Act.

2.6 Alternatives to Minimize Impacts

The Draft Environmental Impact Statement for the FMP identifies a range of alternative regulatory measures and how each of them would meet the objectives of the FMP relative to the preferred set of actions. Those and other options are discussed here in terms of how they might reduce the impact on small entities while still accomplishing the objectives of the FMP. For reference to how the alternatives would meet statutory objectives, and how the objectives and proposed measures are consistent with the national standards of the Magnuson-Stevens Act, see Consistency with National Standard Guidelines and Sustainable Fisheries Act Provisions in the FMP.

Marine Protected Areas:

Using alternative MPA configurations would shift the impacts among affected small entities and could reduce the impacts on them. For example, not closing the waters around Midway would allow the existing sportfishing entity to continue coral reef fishing. Alternatively, an exemption could be provided for certain activities, such as catch-and-release fishing or fishing for local use (i.e., no export from the NWHI). However, based on recent suggestive declines in ulua CPUE at Midway Sportfishing, the efficacy of catch-and-release as it is now practiced for uluas in the NWHI should be seriously evaluted before such activities are given automatic exemptions. An exemption of the latter type could also reduce the possible future impact on potential sportfishing entities at islands such as Palmyra, Wake, or Kingman (at which a Special Permit would be required).

There is no alternative to the anchoring limitation on Guam's southern banks that would meet the stated objectives (FMP objective 4–minimize adverse human impacts), except possibly adjusting the affected vessel size (e.g., to larger than 50 feet). The relationships between vessel size, anchor damage, harvesting efficiency, and vessel safety are not known well enough to choose the optimal alternative.

The no-MPA option would bring smaller short term direct impacts to small entities, but it would not serve FMP objectives 1 (foster sustainable use ... through the use of the precautionary approach and ecosystem-based resource management) or 4 (minimize adverse human impacts).

Fishing Permit and Reporting Alternatives:

Reducing the compliance costs and uncertainty of the permitting system would reduce the impacts on small entities. The compliance costs and uncertainty of General Permits are much less than for

Special Permits. Classifying as many species as possible as Currently Harvested Coral Reef Taxa (General Permit) before implementation of the FMP could reduce impacts to some small entities.

Minimizing the degree of discretion in reviewing Special Permit applications, such as through the use of prescribed issuance guidelines, would improve the certainty of outcome and reduce the risk of small entities losing their investment in an application and in the fishery. The General Permit system would allow no discretion, but its utility would be limited to providing information (FMP objective 3), without any effective controls on harvesting effort that might be needed to "foster sustainable use ... through the use of the precautionary approach and ecosystem-based resource management" (objective 1) and to minimize adverse human impacts (objective 4).

Setting limitations on the types and degrees of conditions that may be placed on a permit would decrease likely compliance costs and provide more certainty of outcome of the application process. Set permit durations would also provide greater certainty and decrease the risk of losing an investment in the fishery. The disadvantage of these more prescriptive permit options is this that they would give fishery managers less flexibility and less ability to rapidly respond to changes in the environment, the fishery, and available information (FMP objective 2).

The no-permit, no-reporting option would result in no impact to small entities, but it would not contribute to FMP objectives 1, 2, 3, or 4, described above.

Less strict permit requirements (e.g., no permit requirement) might be appropriate on reefs that are contiguous with, or proximate to, locally-managed reefs, where permit requirements would be difficult to enforce in any case. The disadvantages to these alternatives are again, less control over harvesting effort (objectives 1 and 4), less flexibility and responsiveness afforded to managers (objective 2), and less ability to gather information (objective 3).

A final option would be to close the fishery entirely. This would be, in a sense, a permitting alternative, since exempted fishing permits (EFP) may be applied for when a fishery is otherwise closed. The likelihood of obtaining an EFP is probably not as great as obtaining a Special Permit, because although they have the common mandate of being consistent with the objectives of the FMP (e.g., "foster sustainable use . . . "), the EFP is designed to only allow harvesting for "exploratory," "data collection," or other limited purposes. The Special Permit, in contrast, has the less restrictive purpose of ensuring sustainable harvest. An EFP is unlikely to offer any greater certainty, stability, or durability than a Special Permit, but the costs of application would be no more than for a Special Permit.

Gear Restrictions:

Allowance of night spearfishing on compressed air would reduce the impacts to commercial spearfishermen operating in the offshore management zone of the CNMI (if such activity actually occurs). This gear does not degrade habitat or result in bycatch, so the effect of allowing it would be to increase potential harvesting efficiency, along with an increased risk of overfishing.

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4.0 SOURCES AND ASSUMPTIONS FOR TABLES

Data Sources and Assumptions

The ex-vessel values given in Tables E-1 through E-7 are the product of volume and per-unit value (e.g., price per pound or price per charter trip). The prices reported below for Tables E-2 through E-7 are nominal for the year(s) indicated; values shown in the tables have been inflation-adjusted to 1999 dollars using consumer price indices for Honolulu (for Hawaii and American Samoa data) and Guam (for Guam and CNMI data). All prices and values are ex-vessel unless otherwise noted.

Sources and Assumptions for Table 3 (Fisheries, American Samoa):

Coral Reef:

Food:

- Finfish landings are 1991-1995 average from Green (1997:Table 52); value used 1996 price of $1.80/lb from Hamm *et al.* (1998:Table II.1.1); % FMP roughly estimated from information in Green (1997), Saucerman (pers. comm.), and Kinsolving (pers. comm.).

- Crustacean landings are 1991-1995 average from Green (1997:Table 52); value estimated at $3.50/lb with little basis; % FMP from information in Green (1997), and excludes lobsters.

- Echinoderm landings are 1991-1995 average from Green (1997:Table 52); value estimated at $2/lb with little basis; % FMP from information in Green (1997).

- Mollusc landings are 1991-1995 average from Green (1997:Table 52); value estimated at $2/lb with little basis; % FMP from information in Green (1997).

- Other invertebrate landings are palolo worms, rough recent average from Green (1997:115); value of $10/lb taken from range of $7 to $10/lb from Saucerman (pers. comm.); % FMP from information in Green (1997).

- Seaweed landings from Green (1997:116); value unknown; % FMP from information in Green (1997).

Sport: There is a very small charter sportfishing industry, and most activity is trolling (Saucerman pers. comm. and Kinsolving pers. comm.), so assume minimal coral reef trips and value.

Ornamentals: Landings are rough estimates based on there being one commercial collector (Bartram pers. comm.) and assuming mostly fish and shells are the targets (Bartram pers. comm. and Kinsolving pers. comm.); value of $2/piece estimated with little basis; coral collecting is banned in depths shallower than 60 feet (Hunter 1995), no knowledge of any black coral or hermatypic coral, but some known collection of live rock, assume it is minimal; % FMP assumed zero from information in Green (1997)**.**

Marine natural products: No knowledge of any activity.

Mariculture: No knowledge of any activity except small giant clam farms (Kinsolving pers. comm.), so assume it is minimal.

Deep Bottom:

Food: Landings are 1993-97 average from WPRFMC (1998:1-3), multiplied by the 88% that were BMUS in 1997 (WPRFMC 1998:Table 1); value based on 1997 price of $2.35/lb from WPRFMC (1998:2).

Sport: There is a very small charter sportfishing industry, and most activity is trolling (Saucerman pers. comm. and Kinsolving pers. comm.), so assume minimal deep bottom trips and value.

Ornamentals: No knowledge of any activity.

Pelagic:

Food: Landings roughly estimated from Hamm *et al.* (1998:Figure II.3.1), which reported about 300,000 to 500,000 lb/year from 1994-1996 (not increase from 1991-1995 average of 180,800 lb/year reported in Green (1997:Table 52); value based on 1996 price, $1.10/lb, reported in Hamm *et al.* (1998:Table II.1.1) for albacore, which dominated landings in 1996.

Sport: There is a very small charter sportfishing industry, and most activity is trolling (Saucerman pers. comm. and Kinsolving pers. comm.); roughly estimated, with little basis, 2 active boats, each doing 20 trips/year and 3 anglers/trip; fees roughly estimated, with little basis, at $80/angler-trip.

Sources and Assumptions for Table 4 (Fisheries, CNMI):

Coral Reef:

Food:

- Finfish landings are rough 1983-1993 average from DFW (1994:Figure 3); note that Radtke and Davis (1995) reported only 307,500 lb for 1995, but may have been commercial only; value based on 1996 price of $2.40/lb from Hamm *et al.* (1998:Table .1.1), in agreement with Radtke and Davis (1995); % FMP roughly estimated based on information in MES (1997) and Green (1997), including the report in the former that 15 mt of reef fish were taken from the northern islands in 13 trips by one 110-ft vessel during 7 months of 1995.

- Lobster landings estimated from various sources in Green (1997:138); value based on 1996 price of $4.64/lb from Hamm *et al.* (1998:Table .1.1); % FMP excludes lobsters.

- Echinoderm landings are all sea cucumbers (wet weight), very roughly estimated from records of Oct 1995 to May 1997 landings as reported in Green (1997:137), of 168,235 lb, but qualified with evidence that such levels may not be sustainable; value based on $6,000/mt for Fiji, reported in Dalzell *et al.* (1996:App 1); % FMP estimated from information in MES (1997) and Green (1997).

- Mother-of-pearl mollusc landings are all trochus, very roughly estimated from information in MES (1997) about intermittent nature of fishery, potential harvests, and amount stockpiled by a local company; value based on 1996 price of $3.09/lb paid by one company for shell-with-meat (MES 1997); % FMP estimated from information in MES (1997) and Green (1997).

Sport: Miller (pers. comm.) reports 33 boats registered as charter in 1999; roughly estimated, with little basis, there were 2 active boats for reef fish, each taking 100 trips/year and 8 anglers/trip; fees roughly estimated, with little basis, at $50/angler-trip; % FMP estimated from information in MES (1997) and Green (1997), and the assumption that the bank off west coast of Saipan may be used for sportfishing.

Ornamentals: Finfishes, invertebrates, and live rock are taken, but rarely, for local use in homes and hotels, and shells and beach coral are taken for local use and by visitors (Gourley pers. comm.); corals are also taken to make lime, by permit; assume overall landings and value to be minimal; % FMP estimated from information in MES (1997) and Green (1997).

Marine Natural Products: No knowledge of any activity.

Mariculture: No knowledge of any activity.

Deep bottom:

Food: 1993-1997 average landings from WPRFMC (1998:4-6) was 33,494 lb (commercial only); Radtke and Davis (1995) reported about 72,000 lb in 1995; so roughly estimated 50,000 lb; value based on 1997 price of $3.32/lb from WPRFMC (1998:12).

Sport: Miller (pers. comm.) reports 33 boats registered as charter boats in 1999; roughly estimated, with little basis, there was 1 active boat for deep bottom, taking 100 trips/year and 3 anglers/trip; fees roughly estimated, with little basis, at $100/angler-trip.

Ornamentals: No knowledge of any activity.

Pelagic:

Food: Radtke and Davis (1995) reported about 360,000 lb in 1995; DFW (1994) implied about 700,000 lb/year, so roughly estimated 500,000 lb/year; value based on 1996 price of $1.90/lb, from Hamm *et al.* (1997:Table .1.1).

Sport: Miller (pers. comm.) reports 33 boats registered as charter boats in 1999; roughly estimated, with little basis, 20 active boats doing trolling, each taking 150 trips/year and 3 anglers/trip; fees roughly estimated, with little basis, at $100/angler-trip.

Sources and Assumptions for Table 5 (Fisheries, Guam):

Coral Reef:

Food:

- Finfish 1991-1994 average landings reported in Myers (1997:Table 5) as 250,271 lb, including shallow component of bottom fishing and *atulai*; but personnel of Department of Aquatic and Wildlife Resources are reported as believing annual value to be $1.5 to $2.0 million/yr (main body of this document), so made intermediate estimate of 400,000 lb; value based on 1996 price of $2.94/lb for "reef fish," from Hamm *et al.* (1998:Table IV.1.1); % FMP estimated from Myers (1997), which reports that "substantially less than 20%" of reef fish are taken in federal waters, so estimated 10%.

- Lobster landings are 1991-1994 average, derived from Myers (1997:Tables 3 and 5); value based on 1996 price of $3.66/lb, from Hamm *et al.* (1998:Table IV.1.1); % FMP excludes lobsters.

- Mother-of-pearl mollusc landings are trochus only, 1991-94 average, derived from Myers (1997:Tables 3 and 5); value based on $2.20/lb price for CNMI reported by Dalzell *et al.* (1996:App 1).

- Other mollusc landings are 1991-94 average, derived from Myers (1997:Tables 3 and 5), includes giant clam *(T. maxima*) and octopus; value based on 1996 price of $2.65/lb for octopus from Hamm *et al.* (1998:Table IV.1.1); % FMP estimated from information in Myers (1997).

- Other invertebrate landings are 1991-94 average, derived from Myers (1997:Tables 3 and 5); value estimated, with little basis, at $2.20/lb; % FMP estimated from information in Myers (1997).

- Seaweed landings discussed in Myers (1997) and Green (1997) but no indication of volume or value; % FMP estimated from information in Myers (1997).

Sport: Pitlik (pers. comm.) reported 1,733 “bottom fishing” boat-trips and 20,388 angler-trips; with little basis, estimated half were deep bottom and half coral reef fishing trips; value based on $30/pax for party boats (Pitlik, pers. comm.); % FMP estimated based on WPRFMC (1998:2-13), which reported charter boats made 23% of all bottom fishing trips in 1996, including some “reef fish”; but most trips were only 2-4 hours, so very few went to federal waters, and assumption that federal waters are visited proportionately less often by charter boats than by commercial and recreation boats.

Ornamentals: Green (1997) estimated landings of ornamental fishes at 1,000 to 2,000 fish per month/mo (most exported to US, 120 to 150 per month sold in local pet shop) and some local residents collect for both home use and sale to local pet shop; some invertebrates also collected, but not exported; value of $2 per fish estimated with little basis; % FMP estimated from information in Myers (1997).

Marine Natural Products: No knowledge of any activity.

Mariculture: No knowledge of any activity.

Deep Bottom:

Food: Landings are average annual landings of BMUS during 1993-1997 (WPRFMC 1998:Guam App:2-9); value based on 1996 price of $3.50/lb (WPRFMC 1998:7).

Sport: Pitlik (pers. comm.) reported estimated 1,733 “bottom fishing” boat-trips and 20,388 angler-trips; with little basis, estimated half were deep bottom and half coral reef fishing trips; WPRFMC (1998:2-13) reported that charter boats made 23% of all bottom fishing trips in 1996; value based on $30/pax for party boats (Pitlik, pers. comm.).

Ornamentals: No knowledge of any activity.

Pelagic:

Food: Landings derived from Myers (1993:Fig 1), which reported range of 168mt to 364mt from 1980 to 1991; so took 300 mt; historical commercial data in Hamm *et al.* (1998:Fig IV.3.1) indicate it is reasonable; value based on approximate 1996 price of $1.30/lb, from Hamm *et al.* (1998:Table IV.1.1).

Sport: Pitlik (pers. comm.) reported 3,537 troll boat-trips and 20,519 angler-trips; value based on $350/boat-trip (Pitlik pers. comm.).

Sources and Assumptions for Table 6 (Fisheries, Main Hawaiian Islands):

Coral Reef: DAR (no date) reported about 1.2 million lb of commercial coral reef species landings between 1993 and 1997; Friedlander (1996) reports that under-reporting of commercial is common and notes the large non-commercial component of the fishery. Meyer (1987a) reported 21m lbs landings just by recreational boaters, much of which must have been reef species; so very roughly estimate landings of coral reef species of 5 million lb/year.

Food:

- Finfish landings estimated as 5 million coral reef species total less all other species groups; value based on 1991-1995 average price, or $1.56/lb, from Friedlander (1996:Table 14); % FMP from % of commercial landings outside 2 mile statistical zone (Friedlander 1996:Table 14), less 10% to approximate the 3 mile federal boundary.

- Lobster landings roughly estimated as twice the reported commercial landings, from Friedlander (1996:Table 14); price of $11.74/lb was 1991-95 average, from Friedlander (1996:Table 14); % FMP excludes lobsters.

- Other crustaceans mostly kona crab, landings roughly estimated as twice reported commercial landings, from Friedlander (1996:Table 14); price of $3.83/lb was 1991-95 average, from Friedlander (1996:Table 14); although an MUS under the crustacean FMP, kona crabs included here under % FMP, which is from % of commercial landings outside 2 mile statistical zone (Friedlander 1996:Table 14), less 10% to approximate the 3 mile federal boundary.

- Echinoderms all sea cucumbers; landings estimated as average 1991-95 reported commercial landings (Friedlander 1996:Table 14) adjusted upwards proportionately with other species so that all coral reef species landings totaled 5 million lb; price of $7.16/lb was 1991-95 average, from Friedlander (1996:Table 14); % FMP from % of commercial landings outside 2 mile statistical zone (Friedlander 1996:Table 14), less 10% to approximate the 3 mile federal boundary.

- Mollusc landings estimated as average 1991-95 reported commercial landings (Friedlander 1996:Table 14) adjusted upwards proportionately with other species so that all coral reef species landings totaled 5 million lb; price of $2.30/lb was 1991-95 average, from Friedlander (1996:Table 14); % FMP from % of commercial landings outside 2 mile statistical zone (Friedlander 1996:Table 14), less 10% to approximate the 3 mile federal boundary.
- Seaweed landings estimated as average 1991-95 reported commercial landings (Friedlander 1996:Table 14) adjusted upwards proportionately with other species so that all coral reef species landings totaled 5 million lb; price of $3.84/lb was 1991-95 average, from Friedlander (1996:Table 14); % FMP from % of commercial landings outside 2 mile statistical zone (Friedlander 1996:Table 14), less 10% to approximate the 3 mile federal boundary.

Sport: Roughly estimated 500 angler-trips per year based on Hamilton (pers. comm.) estimating that less than 1% of charter trips are for reef fish, with 1-3 anglers/boat; value based on fee of $141/angler-trip estimated for pelagic charter fishery, as described below; % FMP estimated with little basis.

Ornamentals: Volume for fishes and other inverts is number of animals collected, 1991-95 average from Miyasaka (1997), fishes dominated but some inverts, particularly feather duster worm, note 99% are sold; value based on 1991-1995 average ex-collector prices from Miyasaka (1997); % FMP from information in Friedlander (1996). Volume and value for black coral are 1991-95 averages from Friedlander (1996:Table 14).

Marine Natural Products: No knowledge of any activity, but with Hawaii's large ocean research and development industry, it is possible.

Mariculture: No knowledge of any activity, but with Hawaii's large mariculture industry, it is possible.

Deep Bottom:
Food: Landings 1993-97 average from WPRFMC (1998:3-10); value based on 1993-96 average price of $3.48 from WPRFMC (1998:3-3).

Sport: Roughly estimated 5,000 angler-trips per year based on data in Hamilton (1998 and pers. comm.); value based on fee of $141/angler-trip estimated for pelagic charter fishery, as described below.

Ornamentals: No knowledge of any activity (see Grigg 1993).

Pelagic:

Food: First, assumed 32 million lb total food fish in Hawaii, derived from data in Pooley (1993a:Table 1) of 30.2 million lb for 1990, adjusted upwards by implied higher landings in Meyer (1987a), then subtracted 5 million lb of reef species and 1 million lb bottom fish species, leaving 26 million lb; then applied ratio of landings between main and northwestern islands of 85:15 (1991-95 average from Friedlander 1996:Table 13) to very roughly estimate pelagic landings in main islands; value based on 1991-95 average price of $2.01 from Friedlander (1996:Table 13) for all offshore gear.

Sport: Data in Hamilton (1998) on trips/boat and number of charter boats suggests about 33,000 charter boat trips/yr, assumed 3 anglers/trip; total revenues estimated from average annual fees per business in Hamilton (1998) of $73,195, multiplied by 200 boat fleet, estimated from data in Hamilton (1998).

Sources and Assumptions for Table 7 (Fisheries, Northwestern Hawaiian Islands):

Coral reef:

Food:

- Finfish volume and value from Friedlander (1996:Table 14), assume no additional non-commercial landings; note most of it is sharks, thus the low value; % FMP from % of commercial landings outside 2 mile statistical zone (Friedlander 1996:Table 14), less 10% to approximate the 3 mile federal boundary.

- Lobster volume and value are 1992-1997 averages from Pooley and Kawamoto (1998); note dramatic decrease since 1988-89, when 1.5 million lb landed; lobster excluded from % FMP.

- Other crustaceans volume and value from Friedlander (1996:Table 14), assume no additional non-commercial landings; % FMP from % of commercial landings outside 2 mile statistical zone (Friedlander 1996:Table 14), less 10% to approximate the 3 mile federal boundary.

- Other molluscs volume and value from Friedlander (1996:Table 14), assume no additional non-commercial landings; % FMP from % of commercial landings outside 2 mile statistical zone (Friedlander 1996:Table 14), less 10% to approximate the 3 mile federal boundary.

- No commercial sea cucumber, other invertebrate, or seaweed landings reported in Friedlander (1996).

Sport: About 150 anglers/yr recently visited Midway to fish (Glover pers. comm.); assumed 5 trips per angler (derived from MSF 1999), and half reef fishing (e.g., spin-casting) and half pelagic fishing (Glover (pers. comm.); value based on $2,125 per angler-visit (derived from MSF 1999); all Midway's waters federal, so 100% FMP fishery.

Ornamentals: No knowledge of any activity.

Marine Natural Products: No knowledge of any activity.

Mariculture: No knowledge of any activity.

Deep Bottom:

Food: Landings and value 1993-97 averages from WPRFMC (1998:3-10).

Sport: At Midway only pelagic and reef fishing noted by Glover (pers. comm.), but likely some minimal activity.

Ornamentals: No knowledge of any activity.

Pelagic: First, assumed 32 million lb total food fish in Hawaii, derived from data in Pooley (1993a:Table 1) of 30.2 million lb for 1990, adjusted upwards by implied higher landings in Meyer (1987a), then subtracted 5 million lb of reef species and 1 million lb bottom fish species, leaving 26 million lb; then applied ratio of landings between main and northwestern islands of 85:15 (1991-95 average from Friedlander 1996:Table 13) to very roughly estimate pelagic landings in northwestern islands; value based on 1991-95 average price of $2.01 from Friedlander (1996:Table 13) for all offshore gear.

Food: 1990 from Pooley (1993a:Table 1) for total for state, then used MHI:NWHI ratio of 85:15 to split it (Friedlander 1996:Table 13)

Sport: About 150 anglers/yr recently visited Midway to fish (Glover pers. comm.); assumed 5 trips per angler (derived from MSF 1999), and half reef fishing and half pelagic fishing (Glover (pers. comm.); value based on $2,125 per angler-visit (derived from MSF 1999).

Sources and assumptions for Table 8 (fisheries, other islands):

Coral Reef:

Food: Landings derived from Irons *et al.* (1990), who reported on harvest of reef species on Johnston in 1990; those figures were doubled to roughly account for the 110 people on Wake (Green 1997) presumably doing about the same amount of fishing as the 175 people on Johnston in 1990; per-unit values roughly estimated with little basis; lobsters excluded from % FMP.

Sport: No knowledge of any activity.

Ornamentals: Irons *et al.* (1990) noted that coral and shells were collected by residents of Johnston for personal use; some evidence of aquarium fish harvesting seen at Palmyra.

Marine Natural Products: No knowledge of any activity.

Mariculture: No knowledge of any activity.

Deep bottom:

Food: No knowledge of any activity.

Sport: No knowledge of any activity.

Ornamentals: No knowledge of any activity.

Pelagic:

Food: Estimated, with little basis, that about half as much pelagic landings were made as reef fish landings; value ($2/lb) roughly estimated with little basis.

Sport: No knowledge of any activity.

Sources and Assumptions for Table 10 (Tourism Activity):

American Samoa:

- Total number of tourists derived from NPS (1996) estimates for 1993: less than 5,000 tourists plus 5,000 cruise ship passengers, the latter of which spend only about 8 hours on land; these figures can be compared with the industry's peak of about 34,000 visitors in 1974.

- Percent of tourists American roughly estimated at 80 percent from data in Green (1997).

- Number of tourists "marine" and scuba divers from Kinsolving (pers. comm.) and Saucerman (pers. comm.).

- Expenditures by tourists, marine tourists, by scuba divers estimated by assuming expenditures of $500 per visitor.

- Number of scuba dives estimated by assuming five dives per visiting diver.

CNMI:

- Number of tourists and expenditures by tourists from MES (1997) and unpublished data of Marianas Visitors Authority.

- Percent of tourists American from Bank of Hawaii (1997b) and Miller (pers. comm.).

- Number of tourists "marine" roughly estimated from Green (1997) and Miller (pers. comm.).

- Number of scuba dives roughly estimated from DEQ (in prep.), which reported 84,000 or more dives in Lau Lau Bay alone.

- Number of scuba divers roughly estimated from the number of scuba dives (above), divided by a roughly estimated four dives per tourist (derived from the typical stay of Japanese tourists being 3 nights–Miller, pers. comm.).

- Expenditures by marine tourists and by scuba divers estimated by multiplying total tourist expenditures by the percentages of total tourists that were "marine" and scuba divers, respectively.

- Expenditures on scuba diving from DEQ (in prep.).

- Number employed in tourism roughly derived from 1995 census data, as reported by Miller (pers. comm.).

- Number employed in scuba diving roughly derived from Miller (pers. comm.).

Guam:

- Number of tourists, number of tourists "marine," percent of tourists American, number employed in tourism, and government revenues from tourism from GEDA (1999).

- Number of tourists scuba divers, expenditures per tourist, and number of scuba dives from Birkeland (1997b).

- Expenditures by marine tourists and by scuba divers estimated by multiplying total tourist expenditures by the percentages of total tourists that were "marine" and scuba divers, respectively.

Hawaii:

- Number of tourists, percent of tourists American, expenditures by tourists (1997-1998 averages) from Bank of Hawaii (1998).

- Number of tourists "marine" estimated at 65% of total, derived from an estimate of 85% by Clark (1991) for tourists that engage in some ocean recreation.

- Expenditures by marine tourists and by scuba divers estimated by multiplying total tourist expenditures by the percentages of total tourists that were "marine" and scuba divers, respectively.

- Expenditures on marine recreation from Grigg (1997), but includes expenditures by residents.

- Expenditures on scuba diving for 1992 and includes only tours and sales, from Clark (pers. comm.), cited in Friedlander (1996).

- Number of scuba dives (all paid dives, including by residents) from Tabata (pers. comm.) for 1986, adjusted upwards by 120%, the increase in visitation since 1986.

- Number of scuba divers estimated from number of scuba dives, assuming four dives per diver.

- Employment in tourism (1994-1997), government revenues from tourism (1992), and tourism as percent of gross state product (1992) from WTTC (1997), which treated the "travel and tourism industry."

- Employment in marine recreation from MacDonald *et al.* (1996).
- Employment in scuba industry (including part-time and contract workers) from Tabata (pers. comm.) for 1986, adjusted upwards by 120%, the increase in visitation since 1986.

Endnotes

1. "Natural products" as a fishery and "information" as a non-fishery are related but treated separately here. The former refers to the harvest side of gathering information and novel products from coral reefs, which is directly under the control of fisheries management agencies and this FMP. The latter, "information," refers to all the values of knowledge gleaned from the reef that do not rely on extraction and that are therefore not under the control of the FMP.

For example, a sponge might be harvested and examined by an academic researcher interested solely in taxonomy. The specimen might then be passed on to an academic or commercial researcher who learns about the chemistry of the sponge, including the discovery of some unique chemical activity with commercial application. This chemical information, either with or without the original specimen, might then be passed on to another party interested in producing commercial quantities of some derivative for pharmaceutical or other purposes. This might lead to synthesization of the chemical derivatives of the sponge and/or further harvest of the sponge, and ultimately to the production of saleable products. These last few steps in the process are well beyond the jurisdiction of the FMP. They are, however, important in terms of valuing the genetic and other "informational" resources of the sponge and the coral reef ecosystems in general.

It is assumed here that under even the most restrictive management alternatives being considered, extraction of small amounts of coral reef resources for primary research purposes–for the "discovery" of information–would be allowed, if governed by permits, and the measures would have no impact on this aspect of "information" value. If and when discovery of a valuable resource leads to the demand for more intensive extraction of an organism from the coral reef, the controls of the FMP could then conceivably restrict the extent of extraction and consequently the value of the research and development–for example by limiting the rate of extraction to the extent that it affects the production rate of a commercial product. Any such intensive extraction for commercial purposes, along with the value of the products that come from it, will be considered here as part of the "coral reef fishery natural products" sector. These are activities that are directly dependent on coral reef resources and directly under the control of the FMP. Harvesting of stony corals for use as bone graft material would be one example. In fact, it appears that no such activities are currently taking place in the US Pacific Islands. Any academically, educationally, or commercially motivated research that does not involve such intensive extraction, including research that leads to the development of commercial products, as well as any subsequent commercial production that does not rely on continued extraction from the reef, is treated under the "non-fishery information" sector.

Draft

Fishery Management Plan For Coral Reef Ecosystems of The Western Pacific Region:

Environmental Impact Statement

December 2000

Volume II

Western Pacific Regional Fishery Management Council

UNITED STATES DEPARTMENT OF COMMERCE
Office of the Under Secretary for Oceans and Atmosphere
Washington, D.C. 20230

JAN 5 2001

To All Interested Government Agencies and Public Groups

Pursuant to the National Environmental Policy Act, an environmental review has been performed on the following action.

TITLE: Draft Environmental Impact Statement (DEIS)/Draft Fishery Management Plan for Coral Reef Ecosystems of the Western Pacific Region (FMP)

LOCATION: Exclusive Economic Zone of the Western Pacific Region

SUMMARY: The FMP proposes to: (1) establish fishing permit and reporting requirements; (2) specify the use of selective, non-destructive gears and methods for harvesting management unit species; (3) designate marine protected areas, including no-take marine reserves and areas zoned for specific fishing activities allowed only with a special permit; and (4) establish a framework process to allow for future regulatory adjustments to the coral reef ecosystem management program. The FMP also would establish a formal process to allow the various fishery management plan teams, i.e., pelagics, crustaceans, bottomfish and seamount groundfish, precious coral, to coordinate their discussion of relevant fishery issues with the coral reef ecosystem plan team; facilitate consistent State and territorial level management of coral reef resources; create social, economic and political incentives for sustainable use and disincentives for non-sustainable use of coral reef resources; and foster education, public outreach and "coral reef management diplomacy." The FMP contains a definition of overfishing, designates management unit species divided into two groups: harvested coral reef taxa and non-targeted coral reef taxa; identifies essential fish habitat; describes fishing sectors; and addresses bycatch and other requirements of the Magnuson-Stevens Fishery Conservation and Management Act.

RESPONSIBLE OFFICIAL: Dr. Charles Karnella, Administrator
Pacific Islands Area Office, Southwest Region
National Marine Fisheries Service
1601 Kapiolani Blvd., Rm. 1110
Honolulu, Hawaii 96814
(808) 973-2937

A copy of the DEIS/FMP is enclosed for your information. Any written comments you may have should be submitted by February 26, 2001 to Kitty Simonds, Executive Director, Western Pacific Fishery Management Council, 1164 Bishop Street, Suite 1400, Honolulu, Hawaii 96814 (telephone number 808-522-8220). Also, one copy of your comments should be sent to me in Room 5805, OPSP, U.S. Department of Commerce, Washington, D.C. 20230.

Sincerely,

Susan Fruchter

Susan B. Fruchter
NEPA Coordinator

Enclosure

Draft Environmental Impact Statement
for the
Fishery Management Plan
Coral Reef Ecosystems in the Western Pacific Region

including amendments

Amendment 7 - Bottomfish and Seamount Groundfish Fisheries
Amendment 11 - Crustaceans Fisheries
Amendment 5 - Precious Corals Fisheries
Amendment 10 - Pelagics Fisheries

COVER SHEET

[x] Draft Environmental Impact Statement (Separate EIS)

Responsible Agencies (Contacts for further information)

Western Pacific Fishery Management Council
1164 Bishop St., #1400
Honolulu, HI 96813
Contact: Kitty M. Simonds
Executive Director
Telephone: (808) 522-8220

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Pacific Islands Area Office
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PROPOSED ACTION: Approval and implementation of the fishery management plan for Coral Reef Ecosystems in the Western Pacific Region

Abstract:

The proposed action is to implement a fishery management plan for Coral Reef Ecosystems in the western Pacific under the provisions of the Magnuson-Stevens Fishery Conservation and Management Act (MSFMCA). The plan proposes to 1) establish specific and comprehensive regulations -- fishing permit and reporting requirements, allowable fishing gear, "no-take" and "low-use" marine protected areas – for the EEZ to anticipate and avoid adverse impacts on coral reef resources and ecosystems from potentially damaging fishing activities; 2) create a framework procedure for timely regulatory action to adapt to new information and changes in fisheries; 3) encourage coherent and coordinated management, monitoring and enforcement across jurisdictional boundaries to address impacts such as illegal foreign fishing of coral reef resources in remote areas of the US Pacific Islands; degradation of essential fish habitat in nearshore (non-EEZ) coral reef areas; damage to reefs from derelict gear originating from outside of the western Pacific region; and 4) establish a procedure to assess and control possible ecosystem effects of fishing activities under the existing FMPs for bottomfish, crustacean and precious coral fisheries in the western Pacific, and 5) amendments through four existing FMPs to prohibit fishing (biological removal) in no-take MPAs.

COMMENTS

Comments must be received by: 26 February, 2001
Please send all comments to:
Western Pacific Regional Fishery Management Council
1164 Bishop Street, Suite 1400
Honolulu, HI 96813

Table of Contents

EXECUTIVE SUMMARY

This draft environmental impact statement (DEIS) was prepared to examine impacts of implementing the proposed Fishery Management Plan (FMP) for Coral Reef Ecosystems of the Western Pacific Region. An environmental impact statement is required under the National Environmental Policy Act (NEPA) for federal actions that may significantly affect the quality of the human environment. The DEIS also incorporates the relevant environmental impact analyses for FMP amendments for crustaceans, bottomfish and seamount groundfish, precious corals and pelagic fisheries.

The proposed Coral Reef Ecosystems FMP was developed by the Western Pacific Council, based on the ecosystem approach. A recent report to Congress by the Ecosystem Principals Advisory Panel recommends that FMPs be developed as "Fisheries Ecosystem Plans" covering the ecosystems under Council jurisdiction. This FMP represents the first fishery ecosystem plan developed in the United States.

The FMP has been proposed to address potential for problems due to interactions of humans and coral reefs in the Western Pacific exclusive economic zone (EEZ). Although local regulations control many of the impacts of resource exploitation on nearshore coral reefs in settled areas, exploitation of coral reef ecosystems remains relatively uncontrolled in federal waters of the EEZ. Although these areas have been minimally exploited to date, there has been interest expressed for fisheries to expand in these areas. These include expansion of current nearshore fisheries for coral reef species, new fisheries for the live fish markets in Southeast Asia, expanded fisheries for coral and "live rock" for the U.S. aquarium trade, and developing fisheries for pharmaceutical applications. In addition, the coral reef ecosystems FMP has been proposed to provide for better understanding of impacts due to natural environmental changes, other FMP managed fisheries, and non-fishing related impacts such as dredging.

To address these problems, four alternatives including the status quo, were examined. Alternatives 3 and 4 (substantial and maximum additional protection to coral reef resources) contains four primary management measures (marine protected areas, permits and reporting requirements, fishing gear and methods, and other ecosystem-based management measures), each with different components and options nested therein. The environmental effects of each of the alternatives, management measures, components, and options have been analyzed in this DEIS. In June 2000, the Council tentatively adopted a preferred alternative and management options. The alternatives and options considered are listed below.

Alternative 1: *No Action* - under this alternative no new MPAs of any type would be implemented.

Alternative 2: *Minimal Additional Protection to Coral Reef Resources* - under this alternative low-use MPAs would be established for EEZ waters from 0-50 fathoms around each of the Northwestern Hawaiian Islands (NWHI) and each of the Pacific Remote Island Areas (PRIA). In addition, no anchoring by large vessels would be allowed on Guam's offshore southern banks.

Midway island, which is physically located in the NWHI, would be exempted from these MPAs.

Alternative 3: *Substantial Additional Protection to Coral Reef Resources* **(preferred alternative)** - under this alternative no-take MPAs would be established for EEZ waters from 0-10 fathoms around all NWHI as well as EEZ waters from 0-50 fathoms around French Frigate Shoals, Laysan Island, and the northern half of Midway Island. No-take MPAs would also be established for EEZ waters from 0-50 fathoms around American Samoa's Rose Atoll, and Jarvis, Howland, Baker, Kingman, and Palmyra in the PRIA. In addition, low-use MPAs would be established in EEZ waters from 10-50 fathoms around the remaining NWHI (including the southern half of Midway Island), as well as EEZ waters from 0-50 fathoms around Johnston and Wake Islands. Sustainable utilization of coral reef resources for customary and traditional purposes shall be permitted in the low-use MPAs of the NWHI. No anchoring of large vessels would be allowed on Guam's offshore southern banks.

Alternative 4: *Maximum Additional Protection to Coral Reef Resources* - under this alternative no-take MPAs would be established for EEZ waters from 0-100 fathoms around all of the region's islands and atolls. Due to the broad extent of these areas, there would be no low-use MPAs under this alternative

Measure 1. Marine Protected Areas: MPAs are areas where some or all activities are prohibited. MPAs provide for holistic protection of ecosystems and multi-species resources that cannot be addressed by a species-by-species approach. Options considered were the location of these areas (off all the Pacific islands, or only in remote areas), how much of the MPAs would be no-take areas versus low-use areas for resource extraction, and what separate types of activities would be allowed or prohibited in these areas.

Measure 2. Permits and Reporting Requirements: Permits are used to identify participation in a fishery. They provide base data for fishery monitoring, catch reporting, and management. The options for permit requirements include type of permits, who is required to have a permit to harvest reef resources, prohibitions on harvest of certain reef resources, and other conditions of the permit.

Measure 3. Fishing Gear/Methods: Gear restrictions are used to prevent overfishing, protect habitat from direct impacts, and limit bycatch. Options considered include defining legal gear types so as to prohibit other gear types, and special restrictions for SCUBA spearfishing.

Measure 4. Other Ecosystem-Based Management Measures: The other measures proposed in the plan include a framework for adaptive management, a process to identify and address possible impacts of existing FMP fisheries on coral reef ecosystems, and other non-regulatory measures such as education. None of these constitute "action" in terms of NEPA.

Summary of Impacts of the Alternatives and Options

Environmental Impacts

- Because there is currently low fishing effort for coral reef taxa in remote areas of the EEZ, there are essentially no immediate impacts of implementing any alternative in these remote areas, except in bottomfish and lobster fisheries operating in NWHI under existing FMPs and low levels of recreational and subsistence fishing at Johnston, Wake, and Midway Atolls.

- For less remote areas, the preferred options under Alternatives 2, 3 and 4 would provide additional conservation than the status quo because gear types would be regulated, commercial harvest of live rock and corals would be prohibited, and resource removals would be monitored. If monitoring indicates that resource conditions warrant conservation action, these can more quickly be brought about through the framework process outlined under Alternative 2.

- Compared to the status quo and Alternative 2, Alternatives 3 and 4 reduce the potential for overfishing of reef resources in the future by implementing the preferred options for setting aside marine protected areas, establishing permit and reporting requirements for monitoring, and gear restrictions. Spawning adults of the more valuable food fishes would be better protected by prohibiting spearfishing with SCUBA gear at night, when they are most vulnerable.

- Compared with the status quo, Alternatives 3 and 4 provides for improved habitat protection and reduced discarding. Only specified gears would be allowed; unattended nets would be specifically prohibited for these reasons. In no-take MPA zones, all fishing gear including lobster traps and bottomfish hook and line fishing would be prohibited under Alternative 3 and 4. The option to prohibit harvest of coral and live rock under Alternative 3 and 4 would be expected to result in habitat conservation. Lastly, the FMP requires consultations for federal activities to minimize effects from fishing and non-fishing activities on essential fish habitat.

- Compared to the status quo, Alternative 3 and 4 could slow the introduction of exotic species through conditions on passage of all vessels in MPAs.

- Alternative 3 and 4, and the options to set aside some no-take MPA zones, would be expected to result in positive impacts for conserving reef ecosystems and marine diversity. No-take MPAs may conserve a large reservoir of spawning biomass and genetic material for multi-resource coral reef resources, including endemic and rare species.

- The MPAs proposed under Alternative 3 and 4 may reduce impacts of fishing on protected species. Existing no-take areas surrounding national wildlife islands would be expanded in sensitive areas. Vessel groundings, which pose some of the most serious human threat to these protected species habitats, would be expected to be reduced under Alternative 3 and 4 provisions for MPA designations and permit and vessel passage controls.

Social and Economic Impacts

- The status quo, Alternative 2 and the preferred alternative (3) do not restrict collection of coral reef resources for customary and traditional indigenous uses in the EEZ around the main inhabited island and provides incentives through preferential access to indigenous use sub-zones of MPAs. Alternative 4 would prohibit all types of fishing shallower than 100 fathoms throughout the EEZ

- The preferred alternative and options would mitigate most of the potential impacts on existing fisheries but existing fishing effort could be displaced or more costly to conduct around some of the NWHI, Johnston and Wake islands. Alternative 4 would displace all coral reef fisheries and other fisheries operating in the coral reef ecosystem.

- The preferred alternative and options for no-take zones would allow recreational fishing activities for tourists to continue at Midway, but it would deter future development of most PRIA as sportfishing destinations. Alternative 4 could displace recreational activities at Midway.

- The preferred alternative and options for locations of no-take MPAs are likely to cause some displacement from familiar grounds in the NWHI bottomfish fishery and, to a far lesser extent, NWHI lobster fishery. Alternative 4 would displace all fishing effort for these fisheries. For Alternative 3, fishing effort is likely to be redirected to other islands and banks in the NWHI. This could increase the cost of fishing and prevent the harvest of underutilized target resources but it is not expected to cause a major displacement of participants. For Alternative 4, fishing effort would likely be displaced to state and territorial waters. The number of permits in both fisheries is fixed under limited access plans so opportunities for new participants are already limited.

- Although NWHI bottomfish permit holders would lose access to a few familiar and productive fishing grounds as a result of the preferred alternative and options, closure of French Frigate Shoals and Laysan would likely have less effect than closure of more productive areas of the NWHI. The preferred option for no-take areas have accounted for 10 % of the recent total bottomfish harvest in the NWHI fishery. Applied to recent (1994-1998) landings data, this percentage represents about 36,047 lb. of bottomfish with an ex-vessel value of $115,350. Alternative 4 would cause a complete shutdown of this fishery.

- The preferred alternative and options for no-take zones would incur only minimal costs to lobster fishing activities in the waters around French Frigate Shoals and Laysan Island. These areas have historically accounted for about 1.2 % of the total lobster harvest in the NWHI fishery. Applied to recent (1996-1999) landings data, this percentage represents about 3,075 lb. of spiny and slipper lobsters with an ex-vessel value of $16,308. It is likely that fishery participants could recover this loss in revenue by moving to other fishing grounds. Alternative 4 would cause a complete shutdown of this fishery.

- Closure of some or all fishing grounds in the NWHI would also have a negative economic impact on local businesses that directly or indirectly support and are supported by the fishery.

- In addition to potential economic losses associated with closure of some fishing grounds in the NWHI, there would be the loss of lifestyle, assuming that displaced fishermen cannot find an equally satisfactory alternative way of life.

- Closure of some or all fishing grounds in the NWHI would also likely have a negative impact on those who value the continued existence of Hawaii's maritime tradition and culture.

- Closure of some or all NWHI bottomfish fishing grounds would have an impact on seafood consumers by reducing the amount of fresh bottomfish available for sale.

- Technically complex and customized permits to be issued under Alternative 3 would significantly increase cost of administration and enforcement

Justification for the Preferred Alternative

While a minimal amount of fishing pressure currently exists in the coral reef ecosystem management area for the proposed management unit species, this Fishery Management Plan has been developed as a framework upon which to address potential management needs. The plan has been drafted to immediately protect large portions of coral reef and associated resources, while allowing flexibility to adapt to a wide variety of potential management issues as resource utilization develops. Thus, this FMP should be viewed as a preemptive management regime as well as a work in progress. The preferred alternative is comprised of the following four management measures. The rationale for these measures is as follows:

No-Take Marine Protected Areas: No-take MPAs are delineated by the 10 fm isobath except for certain ecologically sensitive areas where the boundary is extended to the 50 fm isobath. These areas are French Frigate Shoals, Laysan Island, the north half of Midway Island and Jarvis, Howland and Baker Islands, Kingman Reef, and Palmyra and Rose Atolls. These no-take MPAs apply to the existing FMPs of the Council. The Council felt that no-take should apply for all activities save limited research and management which could not occur elsewhere.

The ecological significance of these areas as remote and near-pristine reefs were driving factors in choosing these areas as the initial MPAs for this FMP. Consideration of proximity to important monk seal colonies was a further rationale for these choices. Seaward boundaries are delineated by following the relevant depth contours around the indicated areas. Basing these seaward boundaries on either the closest State of Hawaii commercial catch reporting grid square inclusive of the relevant contours or on circles drawn around islands or banks that are inclusive of these areas was considered but rejected due to the significantly larger closed area that would result. Most of this additional closed area would be beyond the depth of coral reefs and would result in a major impact on existing fisheries.

Low-use Marine Protected Areas: The Council proposes a zone-based management approach to designate geographic areas for prescribed uses. Zone-based management allows for unique regulations for areas of varying ecological and socio-cultural importance, which has been successfully employed in other coral reef ecosystems and was preferred by the Council. All EEZ coral reefs around the Northwestern Hawaiian Islands not designated for no-take areas are designated as low-use MPAs. Other low-use MPAs are designated for coral reefs in the EEZ around Johnston and Wake atolls and on offshore banks south of the island of Guam. The seaward boundaries preferred for all low-use MPAs would extend to a uniform depth of 50 fm. These locations were chosen for similar reasons that the no-take MPAs were chosen, but allow for existing fisheries to continue as well as for closely monitored new fisheries in ecologically and socio-culturally important areas.

Permits and Reporting: Special permits and reporting are required for the harvest of coral reef resources in the low-use marine protected areas. Vessels regulated and targeting species managed by other FMPs would be exempt from this requirement. Special permits and reporting will also be required for potentially (but not previously) harvested coral reef taxa throughout the region's EEZ. Regional permit and reporting requirements for the remaining EEZ waters would continue for currently harvested coral reef taxa where reef resources are actively fished and managed under local laws and regulations. The Council preferred to retain regional reporting requirements for current practices in the populated regions, enacting general or special permit requirements under a framework provision at a later date if deemed necessary.

Due to their ecological vulnerability, the preferred alternative would prohibit the of collection live stony coral or live rock for commercial purposes, except small amounts to be collected under a special permit for use as seed stock for aquaculture, for bioprospecting, or for customary and traditional indigenous purposes.

Allowable Gears and Methods: The list of allowable gears is based primarily on these gear types potential for minimizing damage to essential fish habitat (EFH). Adverse impacts from fishing gear may include physical, chemical or biological alterations of the substrate and loss of, or injury to, benthic organisms, prey species and their habitat and other components of the ecosystem. A second criteria for allowable gear is its catch selectivity, allowing those gears which produce a minimum of bycatch.

Bottom line: The preferred alternative's combination of management measures is anticipated to provide enhanced levels of protection and increased opportunities for appropriate management of the region's coral reef ecosystem resources. Under this regime, the proposed Coral Reef Ecosystem FMP is expected to combine harvest controls with careful monitoring in a manner which allows for the controlled utilization of these vital resources in an ecologically sensitive manner.

Executive Summary Tables. Matrices showing management measures and options considered.

Marine Protected Areas:

Options	No-take MPAs	Low-use MPAs
Preferred	0-10 fathoms at all NWHI plus, 0-50 fathoms at FFS, Laysan, ½ Midway, Rose Atoll, Jarvis, Howland, Baker, Kingman, Palmyra. This will total 13% of the region's EEZ coral reefs.	10-50 fathoms all other NWHI, 0-50 fathoms around Johnston, Wake and the South ½ of Midway, and Guam's offshore southern banks (no anchoring allowed here by vessels>50 feet)
Rejected	No action.	0-100 fathoms in all MPA areas, including inhabited islands.
Rejected	Describe areas which will total 100% of the region's EEZ coral reefs.	Include all non no-take MPA management area as low-use MPAs (the whole EEZ would be either no-take or low-use MPA)
Rejected	No action	No action

Permit Requirements:

Options	CRE general permit	CRE special permit
Preferred	Option to require for take of specific CHCRT in specific sub-areas of the EEZ as determined by the Council through framework process. Unless specifically designated by Council, CHCRT will be managed by regional authorities in non-MPA areas of the EEZ. Required for transshipment of CRE MUS within EEZ of MHI, A. Samoa, Guam, CNMI.	Required for all take of CRE MUS within low-use MPAs, and for all PHCRT within the EEZ except for MUS fished under other FMPs (i.e. precious coral, crustacean, bottomfish and pelagic MUS) and anyone in an existing fishery for coral reef MUS (although requirement can be frameworked)
Rejected	Require general permit for any MUS take of CHCRT in all non-MPA areas in the EEZ.	Require special permit for any MUS take within the management unit area (the entire EEZ)
Rejected	No action	No action

Allowable gear types:

Option	
Preferred	Allow hand harvest, spear, slurp gun, hand/dip net, hoop net for kona crab, throw net, barrier net for aquarium fish, surround/purse set for targeted schools (e.g. akule, baitfish, weke) with a minimum of bycatch, hook-and-line (including powered and unpowered handlines, rod and reel, and trolling), traps (with conditions), and remote operating vehicles/submersibles. **Prohibit nighttime spearfishing with scuba/hookah in the EEZ of the NWHI and PRIA.**
Rejected	Allow hand harvest, spear, slurp gun, hand/dip net, hoop net for kona crab, throw net, barrier net for aquarium fish, surround/purse set for targeted schools (e.g. akule, baitfish, weke) with a minimum of bycatch, hook-and-line (including powered and unpowered handlines, rod and reel, and trolling), traps (with conditions), and remote operating vehicles/submersibles.
Rejected	Allow hand harvest, spear, slurp gun, hand/dip net, hoop net for kona crab, throw net, barrier net for aquarium fish, surround/purse set for targeted schools (e.g. akule, baitfish, weke) with a minimum of bycatch, hook-and-line (including powered and unpowered handlines, rod and reel, and trolling), traps (with conditions), and remote operating vehicles/submersibles. **Prohibit all spearfishing with scuba/hookah throughout the region's EEZ.**
Rejected	No action

Miscellaneous measures:

Preferred	No commercial take of live rock or live coral except for: 1) incidental take by other FMP permit holders; 2) take by indigenous people for traditional/ceremonial use; 3) use by aquaculture operations as seed stock; 4) science & management; 5) bioprospecting. All of these (except #1) would require a CRE special permit.	Establish a framework process for measures analyzed but not originally implemented (e.g., require VMS, designate anchoring areas, set aside a percentage of low-use MPAs for subsistence by indigenous users) Establish a formal process to coordinate ecosystem effects from other FMPs
Rejected	No commercial take of live rock, live coral, napoleon wrasse, humphead parrotfish, giant clams.	
Rejected	No action	No action

1.0 INTRODUCTION

PURPOSE AND NEED FOR ACTION

The National Environmental Policy Act (NEPA) is legislation signed into law in 1970 in response to an overwhelming national sentiment that federal agencies should take the lead in providing greater protection for the environment. It established environmental policy for the nation, provided an interdisciplinary framework for federal agencies, and established procedures and a public process to ensure that federal agency decision-makers take environmental factors into account. NEPA requires preparation of Environmental Impact Statements (EIS) for major federal actions significantly affecting the quality of the human environment. As stated in 40 CFR 1502.9(c): "Agencies shall prepare supplements to either draft or final environmental impact statements if: (i) The agency makes substantial changes in the proposed action that are relevant to environmental concerns and bearing on the proposed action or its impacts."

In accordance with the NEPA, an EIS is required because the implementation of the proposed Coral Reef Ecosystems Fishery Management Plan (CRE-FMP) is a "major federal action significantly affecting the quality of the human environment." Its purpose is to disclose to decision makers and the public alternative ways to manage coral reef resources in the U.S. Exclusive Economic Zone (EEZ) around the U.S. Pacific islands and to aid the decision makers in selecting a course of action. The Draft EIS (DEIS) describes four alternatives, including a proposed action, for the future management of coral reef resources in the EEZ. The DEIS describes the affected environment and the environmental consequences of implementing the proposed action and alternatives.

The DEIS also incorporates the environmental impact statement required for amending the existing FMPs for crustaceans, bottomfish, precious corals, and pelagic fisheries. Although these four fisheries are exempt from the regulations outlined in the CRE-FMP and will observe the management regime of their respective fisheries, the marine protected areas will be in effect for all Council managed fisheries. Each of the four FMPs will be amended to ensure the no-take status of these areas. The DEIS includes Amendment 7 to the Bottomfish and Seamount Groundfish FMP, Amendment 11 to the Crustaceans FMP, Amendment 10 to the Pelagics FMP and Amendment 5 to the Precious Corals FMP. These amendments specify where the no-take marine protected areas are located, and what management unit species are currently included in the existing FMPs. A summary description of the FMP fisheries and their FMPs are included in the DEIS. An analysis of the impacts of these area closures on the four existing FMPs is included in the section on environmental consequences of the DEIS.

The proposed Coral Reef Ecosystems FMP was developed by the Western Pacific Council, based on the ecosystem approach. A recent report to Congress by the Ecosystem Principals Advisory Panel (EPAP) recommends that FMPs be developed as "Fisheries Ecosystem Plans" covering the ecosystems under Council jurisdiction. This FMP represents the first fishery ecosystem plan developed in the United States.

In accordance with the policies recommended by EPAP in developing "Fisheries Ecosystems Plans", the Western Pacific Council established eight objectives for the FMP for Coral Reef Ecosystems of the western Pacific region. The objectives promote sustainable use of coral reef resources, especially by fishing communities and indigenous fishermen in the region, an adaptive management approach based on fishery-dependent and fishery-independent research, marine protected areas and habitat conservation, cooperative and coordinated management by the various agencies concerned with conservation of coral reef resources and education to foster public support for management.

The FMP has been proposed to address potential problems due to interactions between humans and coral reefs in the Western Pacific exclusive economic zone (EEZ). Although local regulations control many of the impacts of resource exploitation on nearshore coral reefs in settled areas, exploitation of coral reef ecosystems remains relatively uncontrolled in federal waters of the EEZ. Although these areas have been minimally exploited to date, there has been interest expressed for fisheries to expand in these areas. These include adverse impacts to habitat from expansion of current nearshore fisheries for coral reef species, new fisheries for the live fish markets in Southeast Asia, expanded fisheries for coral and "live rock" for the U.S. aquarium trade, and developing fisheries for pharmaceutical applications. In addition, the coral reef ecosystems FMP has been proposed to provide for better understanding of impacts due to natural environmental changes, other FMP managed fisheries, and non-fishing related impacts such as dredging.

Adverse impacts to habitat can occur due to certain gear types or the ways in which they are used. For instance, a new method of reef fishing with tangle nets was recently introduced to Hawaii. When retrieved by hydraulically-powered reels from depths of 10 to 100 m, the nets snag and damage the bottom. Lobster tangle nets used in nearshore areas around some of the main inhabited island groups have a similar impact of breaking coral when they are retrieved. The State of Hawaii has taken action to control destructive gillnetting in state waters around the Main Hawaiian Islands, and consistent measures are proposed for the EEZ by the Coral Reef Ecosystem FMP. The FMP proposes to control fishing gears and methods that will be allowed in the EEZ, and to exclude those which have the potential to significantly damage coral reef habitat. New underwater technologies (mixed gas SCUBA, rebreather, manned and unmanned submersibles) capable of greatly extending the depth at which reef habitats can be impacted are considered in determining allowable gear.

Destructive fisheries in Southeast Asia are known to target remote areas isolated from fishing communities and government patrols. Coral reefs in the Northwestern Hawaiian Islands generally lack the species most desired for the live reef fish trade and they are probably far enough from the major Asian markets that live transport by boat would be uneconomical. The remote US Pacific island possessions and the remote portions of the Commonwealth of the Northern Mariana Islands (CNMI) seem at the most risk from the live reef fish trade because some of the target species are present. The CNMI grounds are close enough to the Hong Kong live fish market that the catch could be transported economically. Island government regulations prohibit the use of poisons, explosives and breaking of coral in fishing nearshore areas but there are no comparable regulations that would protect EEZ reef habitats. Furthermore, long-range surveillance and enforcement capabilities are inadequate to police remote coral reef areas. Hence, this threat is not adequately controlled under existing management systems and the FMP proposes to control the use of destructive fishing methods in the EEZ around US Pacific Islands.

Few marine ornamental products are collected from reef areas in the EEZ around US Pacific islands. The aquarium trade is striving toward several plans of education and conservation to improve fish survivability. These plans include captive breeding of fishes, propagation of corals and education about advanced husbandry techniques, with the goal being to significantly lower the number of species harvested from the wild (Lowrie and Borneman, 1999). Nevertheless, the rapidly expanding reef ornamentals industry has the potential to expand into the EEZ in some areas of the US Pacific Islands. The marine ornamentals' trade involves numerous species of reef fish (especially angelfish, butterflyfish and damselfish), as well as a widening spectrum of invertebrates, including corals, anemones, crustaceans, molluscs, polychaetes, echinoderms and sponges. The removal of "live rock" substratum unavoidably includes an incidental harvest of commensal and infaunal organisms which are removed with the rock. Other coral reef resources that are highly endemic could be made locally extinct if heavily collected in their limited range of distribution. The FMP, therefore, proposes to manage this activity from an ecosystem perspective.

Coral reef ecosystems in the EEZ around US Pacific islands are likely targets for the emerging industries for pharmaceutical and natural products. These emerging "fisheries" have the potential to harvest organisms about which little or nothing is known, whether of their particular life cycle, their place in the food web or their abundance and distribution. The most interesting chemicals are usually species-specific, the species may be rare or patchily distributed and the natural production of the active chemical may vary in time and space (Birkeland, 1997a).

Pharmaceutical companies make their profit from synthesis of the active ingredients in their laboratories. Initial collections would involve small quantities of a broad spectrum of organisms for initial screening. Virtually any coral reef resource could become a target for bioprospecting, including species that are presently undescribed by science and for which there is no understanding of sustainable yield. Grants for millions of dollars have been given for medical bioprospecting of coral reef resources in the Pacific basin, although not yet in the US Pacific islands. Coral reef resources that have already attracted research interest include bryozoans, sponges, tunicates, coral and seaweeds.

Another type of bioprospecting is for ingredients that could be used in products advertised as totally organic. Most of this interest is from cosmetic companies who are seeking a regular supply of raw materials from wild harvest or aquaculture. Far greater quantities of target organisms would be collected in the "harvest model" than the "synthesis model" of bioprospecting.

The FMP anticipates that coral reef ecosystems in the EEZ around some of the US Pacific Islands will attract bioprospecting activities. Because coral reef ecosystems are comprised of multi-species resources which share a long co-evolutionary history, removal of some species can have undesirable secondary effects on others through predator-prey and other interactions.

In summary, the Coral Reef Ecosystems Fishery Management Plan is needed to:

- anticipate and avoid potential damage to essential and non-renewable coral reef habitat
- address the secondary effects of all reef-related fisheries on non-target coral reef resources, thereby encouraging ecosystem-scale management
- manage newly emerging coral reef fisheries ahead of best available information in a precautionary manner

- manage new underwater harvesting technologies that are extending the depth at which coral reef resources can be harvested

- encourage coherent and coordinated coral reef management, monitoring and enforcement across jurisdictional boundaries

- facilitate consensual management that considers all types of stakeholders and adaptive management that considers new data and unforseen impacts

- allow sustained use of coral reef resources that are important for the continuity of indigenous cultures in the US Pacific islands

Four alternatives including the status quo were examined to address these issues. Alternative 3 (the preliminary preferred alternative) contains four primary management measures (marine protected areas, permits and reporting requirements, fishing gear and methods, and other ecosystem-based management measures), each with different components and options nested therein. The environmental effects of each of the alternatives, management measures, components, and options have been analyzed in this DEIS. In June 2000, the Council tentatively adopted a preferred alternative and management options. The alternatives and options considered are listed below.

2.0 DESCRIPTION OF THE ALTERNATIVES

2.1 Introduction

Each of the alternatives analyzed in this EIS contains variations on four management (or control) measures. These four measures are: marine protected areas, permit and reporting requirements, allowable gear, and other (miscellaneous) requirements. Alternative 1 (No Action) would implement no new regulations while Alternative 2 (Minimal Additional Protection) would designate several low-use MPAs, and institute varying permit and gear requirements for the harvest of Coral Reef Ecosystem Management Unit Species (CRE MUS) throughout most of the region's EEZs. Alternative 2 would also prohibit most takes of live rock or live coral in low-use MPAs. In addition to the measures contained in Alternative 2, Alternative 3 (Substantial Additional Protection - the preferred alternative) would designate several no-take MPAs, require all fishing vessels transiting MPAs to carry wreck clean up and removal insurance, and prohibit the use of nighttime spearfishing for CRE MUS with SCUBA and/or hookah gear in the EEZs of the Northwestern Hawaiian Islands (NWHI) and the Pacific Remote Island Areas (PRIA - here used to designate Palmyra Atoll, Howland, Baker, Johnston, and Wake Islands, and Kingman Reef). Finally, Alternative 4 (Maximum Additional Protection) would additionally establish no-take MPAs out to 100 fathoms around all of the region's islands and atolls and extend Alternative 3's prohibition on spearfishing for CRE MUS with SCUBA and/or hookah gear to apply at all times and throughout most of the region's EEZs. Following some basic definitions of terms and a listing of the CRE MUS, these alternatives are summarized below and discussed in detail in the remainder of this chapter. Also discussed are several actions which are not part of the preferred alternative but which may be implemented through a framework process, if necessary, at a later date. The chapter concludes with a discussion of why Alternative 3 has been preliminarily selected as the preferred alternative.

2.2 Definitions

Coral reef ecosystem: those species, interactions, processes, habitats and resources of the water column and substrate located within any waters less than or equal to 50 fathoms in total depth.

Coral Reef Ecosystem Management Area (CRE management area, or management area): all Hawaii, Pacific Remote Island Areas (PRIA), American Samoa, Commonwealth of the Northern Mariana Islands (CNMI) and Guam Exclusive Economic Zone (EEZ) waters (from surface to ocean floor) which are outside of state or territorial waters and within 200 miles from shore. Because the EEZ of the Commonwealth of the Northern Mariana Islands currently extends to the shoreline, it is be separated into two zones; the inshore zone (0-3 miles from shore) and the offshore zone (3-200 miles from shore) with federal management of the coral reef ecosystem proposed for the offshore zone only and continuing management of the inshore zone left to local authorities. Daily management of these inshore waters remains with regional government authorities because (1) cooperation between the regional government and the Council relies on recognition of local management authority of the near-shore waters, (2) the CNMI-based small vessel fishers are best managed by a local regime with hands on interaction and knowledge of the issues, and (3) this regime retains consistency with the other areas under Council jurisdiction.

Coral Reef Ecosystem Management Unit Species (CRE MUS): these are the species to be managed by the Coral Reef Ecosystem Fishery Management Plan. Due to its ecosystem approach, this fishery management plan includes some species which are already managed under existing Fishery Management Plans (FMPs) for Pelagics, Bottomfish, Crustaceans and Precious Corals. The primary management for these cross-listed species would remain under their current FMPs while the ecosystem effects of those fisheries would be addressed via this plan. Coral reef ecosystem MUS are separated into two categories:
Currently Harvested Coral Reef Taxa (CHCRT) these are species that have appeared on catch reports and are relatively well understood. Due to ecosystem effects, overfishing limits and reference points will be established based on the coral reef ecosystem as a whole. Existing catch and effort data will be used to estimate these overfishing reference points, if insufficient data are available, data from similar species will be used as a proxy.
Potentially Harvested Coral Reef Taxa (PHCRT) are those species that have not been reported caught and for which there is little available information. As potential fisheries for these taxa develop, they will be moved into the Currently Harvested category and overfishing references points will be established.

No-take MPA: an area in which no harvest of coral reef ecosystem MUS would be allowed (with an exception for non-extractive monitoring, assessment, and research, to improve the understanding of resources and aid in determination of sustainable exploitation levels).

Low-use MPA: an area in which controlled harvests of coral reef ecosystem MUS would be allowed.

Coral reef ecosystem general permit (CRE general permit, or general permit): a permit which would be required under some alternatives to harvest Currently Harvested Coral Reef Taxa from all non-MPA coral reef management areas. This permit would involve simple application procedures and reporting requirements.

Coral reef ecosystem special permit (CRE special permit, or special permit): a permit which would be required under some alternatives to 1) fish for any coral reef MUS (both Currently Harvested and Potentially Harvested Taxa) within low-use MPAs (with some exceptions), and 2) fish for any Potentially Harvested Coral Reef Taxa outside of MPAs. This permit would be approved and issued on a case-by-case basis and would have more complex application procedures and reporting requirements.

Small vessel: a vessel < 50' length overall (exempt from alternatives for anchoring prohibition on Guam's southern banks)
Large vessel: a vessel =>50' length overall (prohibited from anchoring on Guam's southern banks)

Currently Harvested Coral Reef Taxa

Acanthuridae	Yelloweyed surgeonfish (*Ctenochaetus strigosus*) Orangespot surgeonfish (*Acanthurus olivaceus*) Yellowfin surgeonfish (*Acanthurus xanthopterus*) Convict tang (*Acanthurus triostegus*) Eye striped surgeon fish (*Acanthurus dussumieri*) Unicornfish (*Naso spp.*)
Balistidae	Triggerfish (*Xyrichthys pavo*)
Carcharhinidae	Gray reef shark (*Carcharhinus amblyrhynchos*)
Holocentridae	Soldierfish (*Myripristis spp.*)
Kuhliidae	Hawaiian flag-tail (*Kuhlia sandvicensis*)
Kyphosidae	Rudderfish (*Kyphosus spp*)
Labridae	Napoleon wrasse (*Cheilinus undulatus*) Saddleback hogfish (*Bodianus bilunulatus*) (*Xyricthys* spp.)
Lethrinidae	Smalltooth emperor)Lethrinus microdon)
Mullidae *	Goatfish (*Mulloidichthys spp.*) Striped mullet (*Mugil cephalus*) Yellowfin goatfish (*Mulloidichthys vanicolensis*) Goatfish (*Parupeneus porphyreus*) -Ku-mu Multi-barred goatfish (*Parupeneus multifaciatus*)
Octopodidae	Octopus (*Octopus cyanea, O. ornatus*)
Polynemidae	Threadfin (*Polydactylus sexfilis*) – Moi
Priacanthidae	Bigeye (*Priacanthus spp.*)
Scaridae	Bumphead parrotfish (*Bolbometopon muricatum*) Parrotfishes (*Scarid spp.*)
Serranidae	Groupers/Sea Bass (*Cephalopholis spp.*) Groupers/Sea Bass (*Epinephelus spp.*)
Sphyraenidae	Barracuda (*Sphyraena helleri*
Aquarium Taxa/Species	Yellow tang (*Zebrasoma flavescens*) Yellow-eyed surgeon fish (*Ctenochaetus strigosus*) Achilles tang (*Acanthurus achilles*) Morrish idol (*Zanclus cornutus*) Masked angel (*Genicanthus personatus*) Angelfish (*Centropyge shepardi* and *C. flavissimus*) Dragon eel (*Enchelycore pardalis*) Flame hawkfish (*Neocirrhitus armatus*) Butterflyfish (*Chaetodon auriga, C. lunula, C. melannotus* and *C. ephippium*) Damselfish (*Chromis viridis, Dascyllus aruanus* and *D. trimaculatus*) Turkeyfish (*Pterois sphex*) Featherduster worm (*Sabellidae*)

* Currently Harvested Coral Reef Taxa were identified by their presence on catch reports from fisheries in federal waters.

Potentially Harvested Coral Reef Taxa

Other Labridae spp. (wrasses)	Ephippidae (batfish)
Carcharhinidae, Sphyrnidae, *Triaenodon obesus* (sharks), except those managed under the Pelagics FMP	Monodactylidae (mono)
Dasyatididae, Myliobatidae, Mobulidae (rays)	Haemulidae (sweetlips)
Other Serranidae spp. (groupers) except those managed under the Bottomfish FMP	Echineididae (remoras)
Carangidae (jacks/trevallies), except those managed under Bottomfish FMP	Malacanthidae (tilefish)
Decapterus/Selar spp. (scads)	Acanthoclinidae (spiny basslets)
Other Holocentridae spp. (soldierfish/squirrelfish)	Pseudochromidae (dottybacks)
Other Mullidae spp. (goatfish)	Plesiopidae (prettyfins)
Other Acanthuridae spp. (surgeonfish/unicornfish)	Tetrarogidae (waspfish)
Other Lethrinidae spp. (emperors), except those managed under the Bottomfish FMP	Caracanthidae (coral crouchers)
Muraenidae, Chlopsidae, Congridae, Moringuidae, Ophichthidae (eels)	Grammistidae (soapfish)
Apogonidae (cardinalfish)	*Aulostomus chinensis* (trumpetfish)
Other Zanclidae spp. (moorish idols)	*Fistularia commersoni* (coronetfish)
Other Chaetodontidae spp. (butterflyfish)	Anomalopidae (flashlightfish)
Other Pomacanthidae spp. (angelfish)	Clupeidae (herrings)
Other Pomacentridae spp. (damselfish)	Engraulidae (anchovies)
Scorpaenidae (scorpionfish)	Gobiidae (gobies)
Blenniidae (blennies)	Lutjanids, except those managed under the Bottomfish FMP
Other Sphyraenidae spp. (barracudas)	Other Ballistidae/Monocanthidae spp.
Pinguipedidae (sandperches)	Siganidae
Gymnosarda unicolor	Other Kyphosidae spp.
Bothidae/Soleidae/Pleurnectidae (flounder/sole)	Caesionidae
Ostraciidae (trunkfish)	Cirrhitidae
Tetradontidae/Diodontidae (puffer/porcupinefish)	Antennariidae (frogfishes)
	Syngnathidae (pipefishes/seahorses)
Stony corals	Echinoderms (e.g., sea cucumbers, sea urchins)
Heliopora (blue)	Mollusca
Tubiphora (organpipe)	Sea Snails (gastropods)
Azooxanthellates (non-reefbuilders)	Trochus spp.

Fungiidae (mushroom corals)	Opistobranchs (sea slugs)
Sm/Lg Polyped Corals (endemic spp.)	*Pinctada margaritifera* (black lipped pearl oyster)
Millepora (firecorals)	Tridacnidae
Soft corals and Gorgonians	Other Bivalves
Anemones (non-epifaunal)	Cephalopods
Zooanthids,	Crustaceans, except those managed under the Crustaceans FMP
Sponges (non-epifaunal)	Lobsters (except those managed under the Crustaceans FMP)
Hydrozoans	Shrimp/Mantis
Stylasteridae (lace corals)	Crabs
Solanderidae (hydroid fans)	Annelids
Bryozoans	Algae
Tunicates (solitary/colonial)	Live rock
All other coral reef ecosystem marine plants, invertebrates and fishes not listed under existing FMPs.	

2.3 Summary of alternatives by management measure

Management Measure 1: Marine Protected Areas

Alternative	No-take MPAs (no harvest of coral reef ecosystem management unit species permitted)	Low-use MPAs (controlled harvest of coral reef ecosystem management unit species permitted)
Alternative 1 No Action	Under existing FMPs there is: no longline fishing within 50 miles of all NWHI; no lobster fishing within 0-10 fathoms around all NWHI and within 20 nm of Laysan Island; and no bottomfishing around Hancock seamount.	None
Alternative 2 Minimal Additional Protection	No new no-take MPAs.	0-50 fathoms around all NWHI and PRIA. No anchoring allowed on Guam's offshore southern banks by fishing vessels > 50 feet.
Alternative 3 Substantial Additional Protection (Preferred)	0-10 fathoms around all NWHI plus, 0-50 fathoms around FFS, Laysan, N. ½ Midway, Rose Atoll, Jarvis, Howland, Baker, Kingman, Palmyra. This will total 13% of the region's EEZ coral reefs.	10-50 fathoms around all other NWHI, 0-50 fathoms around Johnston, Wake and South ½ of Midway. 0-50 fathoms around the S. ½ of Midway. No anchoring allowed on Guam's offshore southern banks by fishing vessels > 50 feet.
Alternative 4 Maximum Additional Protection	0-100 fathoms around all islands and atolls throughout the region's EEZs This will total 100% of the region's EEZ coral reefs.	None

Management Measure 2: Permit Requirements

Alternative	CRE general permit (simple application and reporting requirements)	CRE special permit (more complex application and reporting requirements, approved and issued on a case-by-case basis)
Alternative 1 No Action	None	None
Alternative 2 Minimal Additional Protection	None	Required for all take of any CRE MUS within low-use MPAs, and for all take of PHCRT within the EEZ except by: 1) other FMP permit holders; 2); any take within 3 miles of CNMI.
Alternative 3 Substantial Additional Protection (Preferred)	None at this time but may be implemented at a later date via a framework process, in which case it would likely be required for all remaining take of CHCRT within the EEZ (outside of the no-take MPAs) except by: 1) other FMP permit holders; 2) any take with 3 miles of CNMI.	Required for all take of any CRE MUS within low-use MPAs, and for all take of PHCRT within the EEZ except by: 1) other FMP permit holders; 2); any take within 3 miles of CNMI.
Alternative 4 Maximum Additional Protection	Required for all remaining take of CHCRT within the EEZ (outside of the no-take MPAs) except by other FMP permit holders.	Required for all EEZ scientific research and management activities which could affect any CRE MUS. Required for all take of any PHCRT within the EEZ except by: 1) other FMP permit holders; 2) any take within 3 miles of CNMI.

Management measure 3: Allowable gear types and methods

Alternative	Listing of gears allowed for harvest of coral reef ecosystem management unit species
Alternative 1 No Action	All of the region's FMPs are regulated by a common list of allowable gears, which consist of: allowable chemical gear (e.g. awa/kava root), barrier net, dip net, gillnet, hand harvest, seine, slurp gun, trap, spear, rod and reel, and hook and line. Drift gillnets are specifically prohibited for use under the Pelagics FMP, and certain restrictions exist for traps used under the Crustaceans FMP. In addition, the Bottomfish FMP prohibits the use of bottom trawls, bottom set gillnets, poisons, explosives, and intoxicating substances for the harvest of bottomfish species. This alternative would not impose any new gear restrictions.
Alternative 2 Minimal Additional Protection	Allow the use of only the following gears throughout the regions EEZs for the harvest of any CRE MUS: hand harvest, spear, slurp gun, hand/dip net, hoop net for kona crab, throw net, barrier net for aquarium fish, surround/purse set for targeted schools (e.g. akule, baitfish, weke) with a minimum of bycatch, hook-and-line (including powered and unpowered handlines, rod and reel, and trolling), traps (with conditions), and remote operating vehicles/submersibles.
Alternative 3 Substantial Additional Protection (Preferred)	Allow the use of only the following gears throughout the regions EEZs for the harvest of any CRE MUS: hand harvest, spear, slurp gun, hand/dip net, hoop net for kona crab, throw net, barrier net for aquarium fish, surround/purse set for targeted schools (e.g. akule, baitfish, weke) with a minimum of bycatch, hook-and-line (including powered and unpowered handlines, rod and reel, and trolling), traps (with conditions), and remote operating vehicles/submersibles. **Prohibit nighttime spearfishing for CRE MUS with scuba/hookah in the EEZ of the NWHI and PRIA.**
Alternative 4 Maximum Additional Protection	Allow the use of only the following gears throughout the regions EEZs for the harvest of any CRE MUS: hand harvest, spear, slurp gun, hand/dip net, hoop net for kona crab, throw net, barrier net for aquarium fish, surround/purse set for targeted schools (e.g. akule, baitfish, weke) with a minimum of bycatch, hook-and-line (including powered and unpowered handlines, rod and reel, and trolling), traps (with conditions), and remote operating vehicles/submersibles. **Prohibit all spearfishing for CRE MUS with scuba/hookah throughout the region's EEZs.**

Management Measure 4: Miscellaneous measures

Alternative	Measures affecting the take of live rock and coral, and vessel insurance requirements
Alternative 1 No Action	None
Alternative 2 Minimal Additional Protection	No take of live rock or live coral in low-use MPAs except for: 1) incidental take by other FMP permit holders; 2) take by indigenous people for traditional/ceremonial use; 3) use by aquaculture operations as seed stock; 4) science & management; 5) bioprospecting. All of these (except #1) would require a CRE special permit.
Alternative 3 Substantial Additional Protection (Preferred)	No take of live rock or live coral throughout the region's EEZs except for: 1) incidental take by other FMP permit holders; 2) take by indigenous people for traditional/ceremonial use; 3) use by aquaculture operations as seed stock; 4) science & management; 5) bioprospecting. All of these (except #1) would require a CRE special permit. Require insurance for all fishing vessels transiting all MPAs.
Alternative 4 Maximum Additional Protection	No take of live rock or live coral throughout the region's EEZs. Require insurance for all fishing vessels transiting all MPAs.

2.4 Description of Alternatives by Management Measure

Each of the alternatives analyzed in this EIS would implement four management measures to varying degrees. The following description of alternatives describes each management measure, (marine protected areas, permits and reporting requirements, allowable gear, and other (miscellaneous) measures, and the degree to which it would be applied under the four alternatives.

Management Measure 1. Marine Protected Areas

Marine protected areas (MPAs) are an attractive option for ecosystem-based fisheries management because they do not require detailed knowledge of the management unit species but are nevertheless holistic in conserving multi-species resources and the functional attributes of marine ecosystems. They can also provide "insurance" against periods of poor recruitment of individual stocks.

MPAs can vary in scope and extent. They can be areas designated for seasonal or limited use (low-use), or areas that are completely restricted from consumptive use (no-take). Although completely restricted areas are thought to provide the highest degree of protection to marine ecosystems, less restrictive areas can provide some protection while balancing economic and social impacts.

The optimum size of an MPA depends on many factors, including the resources managed, management goals, enforcement capabilities and social and economic constraints. However, researchers do not yet fully understand the relationship between the area covered by an MPA and resulting benefits in the form of ecologically complete coral reef ecosystem protection. To be useful to fisheries and to promote the conservation of coral reef resources on a broader scale, MPAs should serve as sources of reproductive output to replenish larger surrounding or down-current areas. Small and/or isolated MPAs may be inadequate for this purpose.

Few, if any, studies have sought to verify whether MPAs established in the US Pacific islands do actually benefit nearby fisheries. It is clear that fish populations which build up in small areas temporarily closed to fishing are quickly reduced when fishing is resumed, as evidenced by studies in Hawaii and the Philippines. Existing marine protected areas in the US Pacific islands have been criticized for being either too small and fragmented or for not encompassing sufficient depth range and high quality habitat to provide broad coral reef ecosystem protection or recruitment benefits to fisheries.

It has been suggested that linking populations among MPAs over a broad area is necessary to assure long-term sustainability of coral reef fisheries. Some argue for complete protection from fishing, whereas others believe MPAs are more valuable when they can serve as natural laboratories for fishing experiments and testing of adaptive management strategies.

Alternative 1: No Action - under this alternative no new MPAs of any type would be implemented.

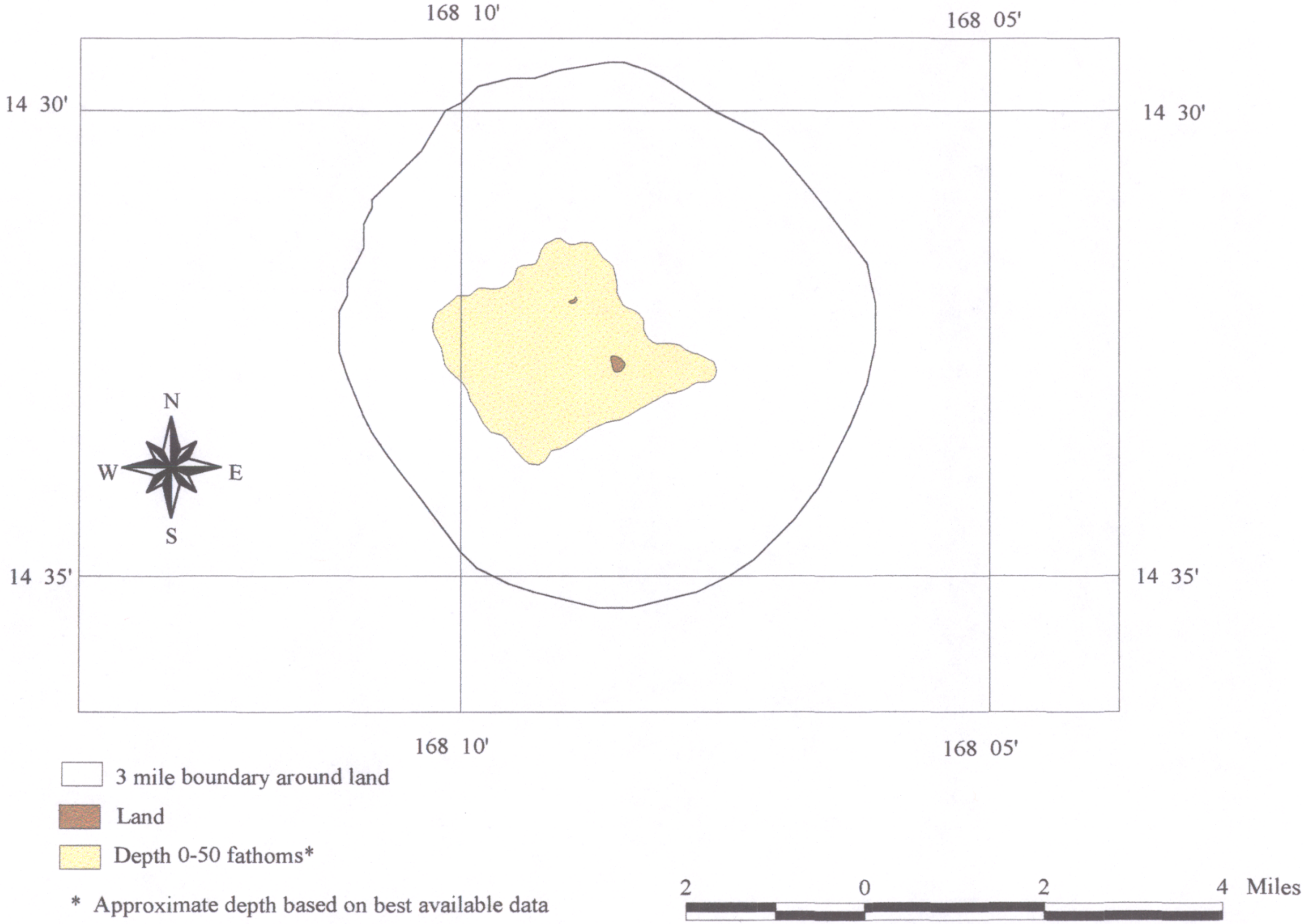
Alternative 2: Minimal Additional Protection to Coral Reef Resources - under this alternative low-use MPAs would be established for EEZ waters from 0-50 fathoms around each of the Northwestern Hawaiian Islands (NWHI) and each of the Pacific Remote Island Areas (PRIA). In addition, no anchoring by large vessels would be allowed on Guam's offshore southern banks. Midway island, which is physically located in the NWHI, would be exempted from these MPAs.

Alternative 3: Substantial Additional Protection to Coral Reef Resources (preferred alternative) - under this alternative no-take MPAs would be established for EEZ waters from 0-10 fathoms around all NWHI as well as EEZ waters from 0-50 fathoms around French Frigate Shoals, Laysan Island, and the northern half of Midway Island. No-take MPAs would also be established for EEZ waters from 0-50 fathoms around American Samoa's Rose Atoll, and Jarvis, Howland, Baker, Kingman, and Palmyra in the PRIA. In addition, low-use MPAs would be established in EEZ waters from 10-50 fathoms around the remaining NWHI (including 0-50 fathoms around the southern half of Midway Island), as well as EEZ waters from 0-50 fathoms around Johnston, and Wake Islands. Sustainable utilization of coral reef resources for customary and traditional purposes shall be permitted in the low-use MPAs of the NWHI. No anchoring of large fishing vessels would be allowed on Guam's offshore southern banks.

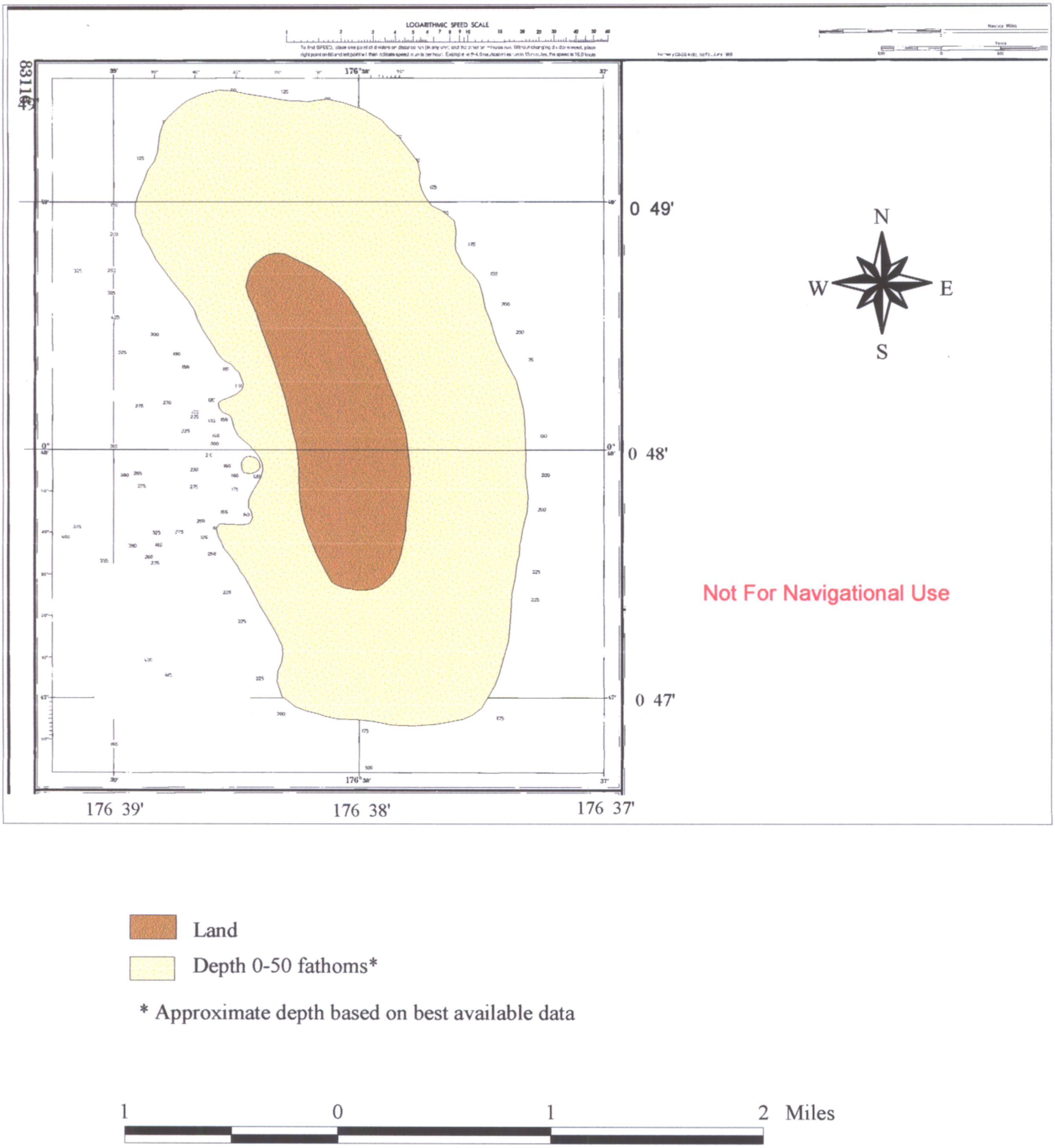
Alternative 4: Maximum Additional Protection to Coral Reef Resources - under this alternative no-take MPAs would be established for EEZ waters from 0-100 fathoms around all of the region's islands and atolls. Due to the broad extent of these areas, there would be no low-use MPAs under this alternative.

The following figures illustrate the depth contours around Marine Protected Areas which are referenced above.

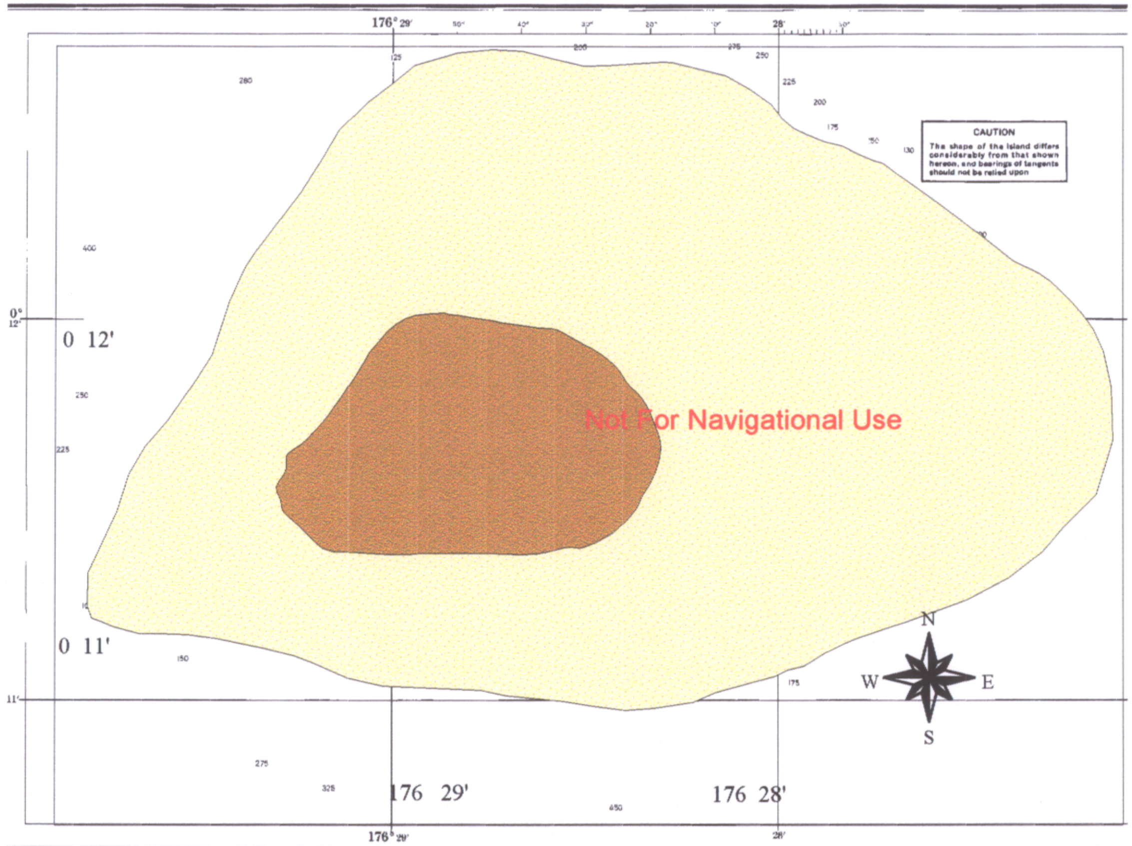
Rose Atoll
Proposed Marine Protected Area



Howland Island
Proposed Marine Protected Area



Baker Island
Proposed Marine Protected Area



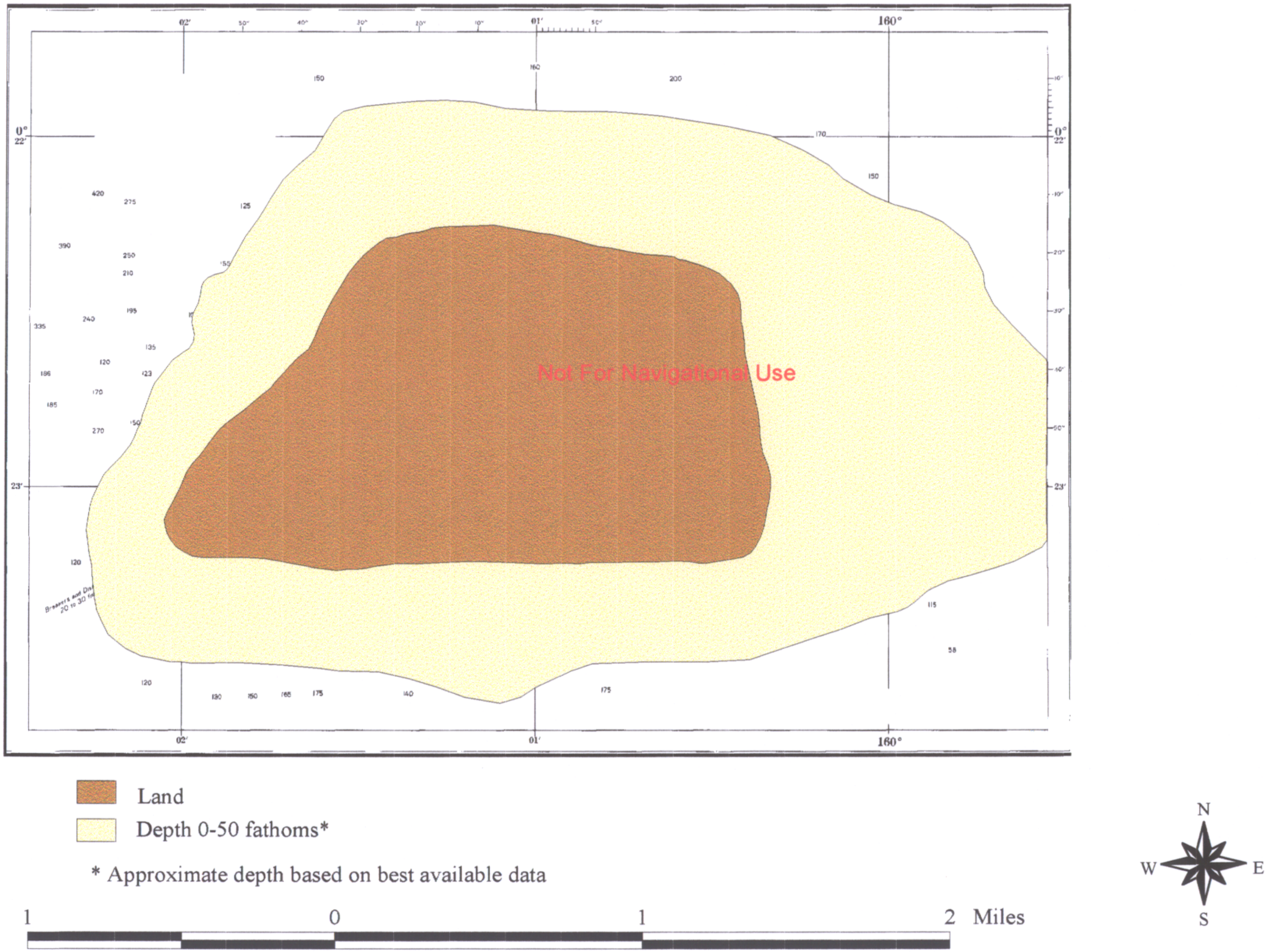
Land

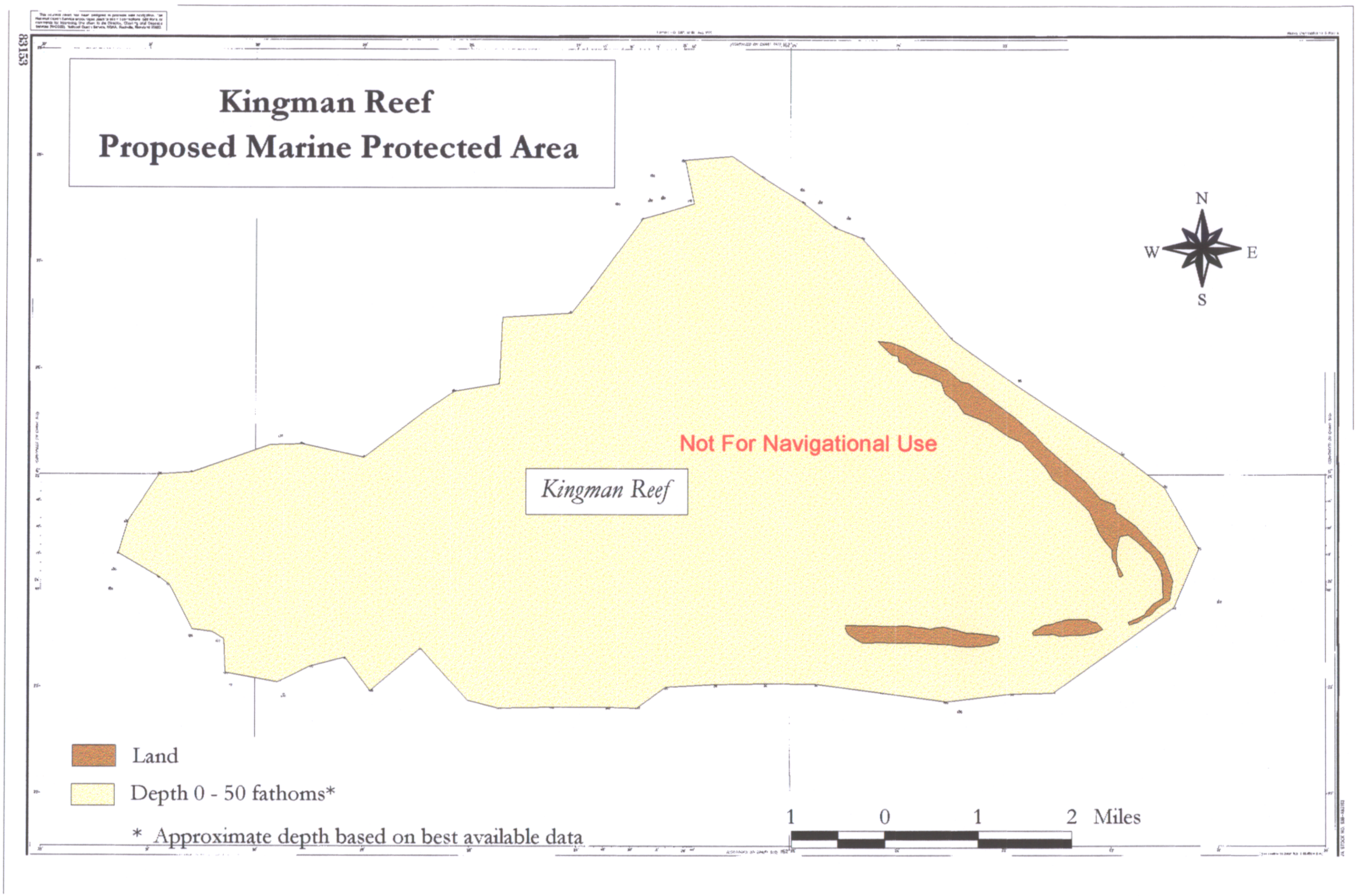
Depth 0 - 50 fathoms*

0.2 0 0.2 0.4 Miles

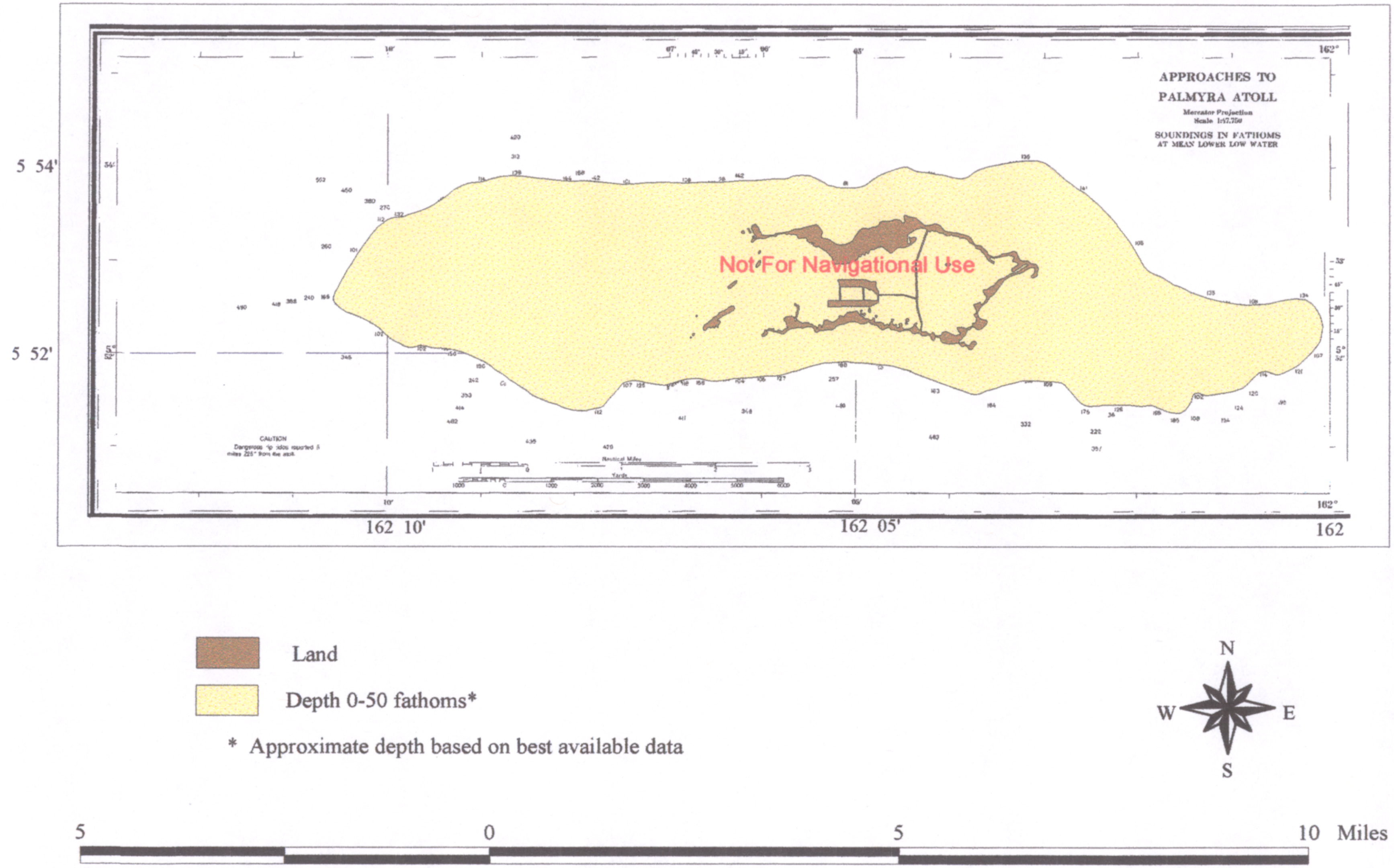
* Approximate depth based on best available data

Jarvis Island
Proposed Marine Protected Area

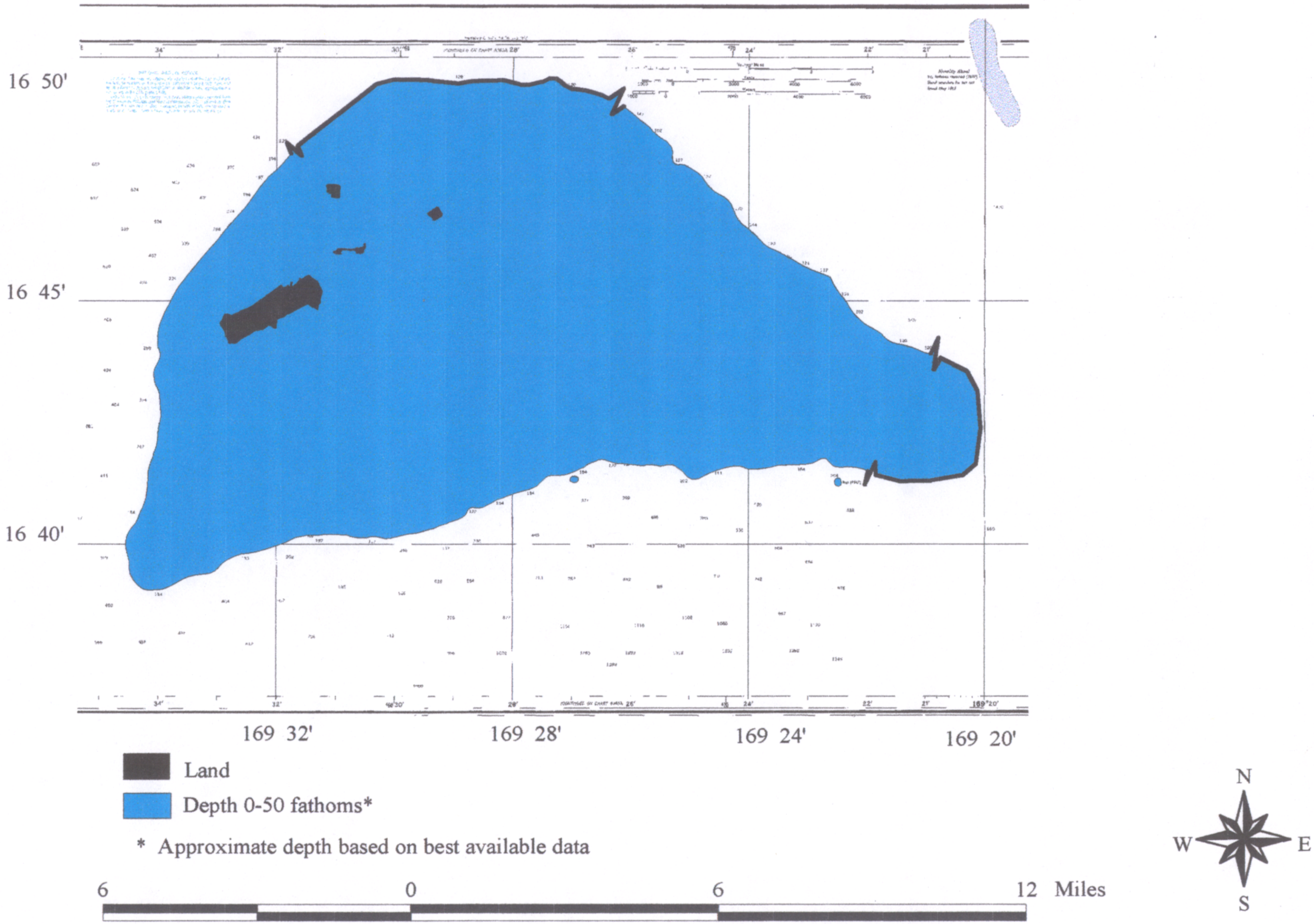


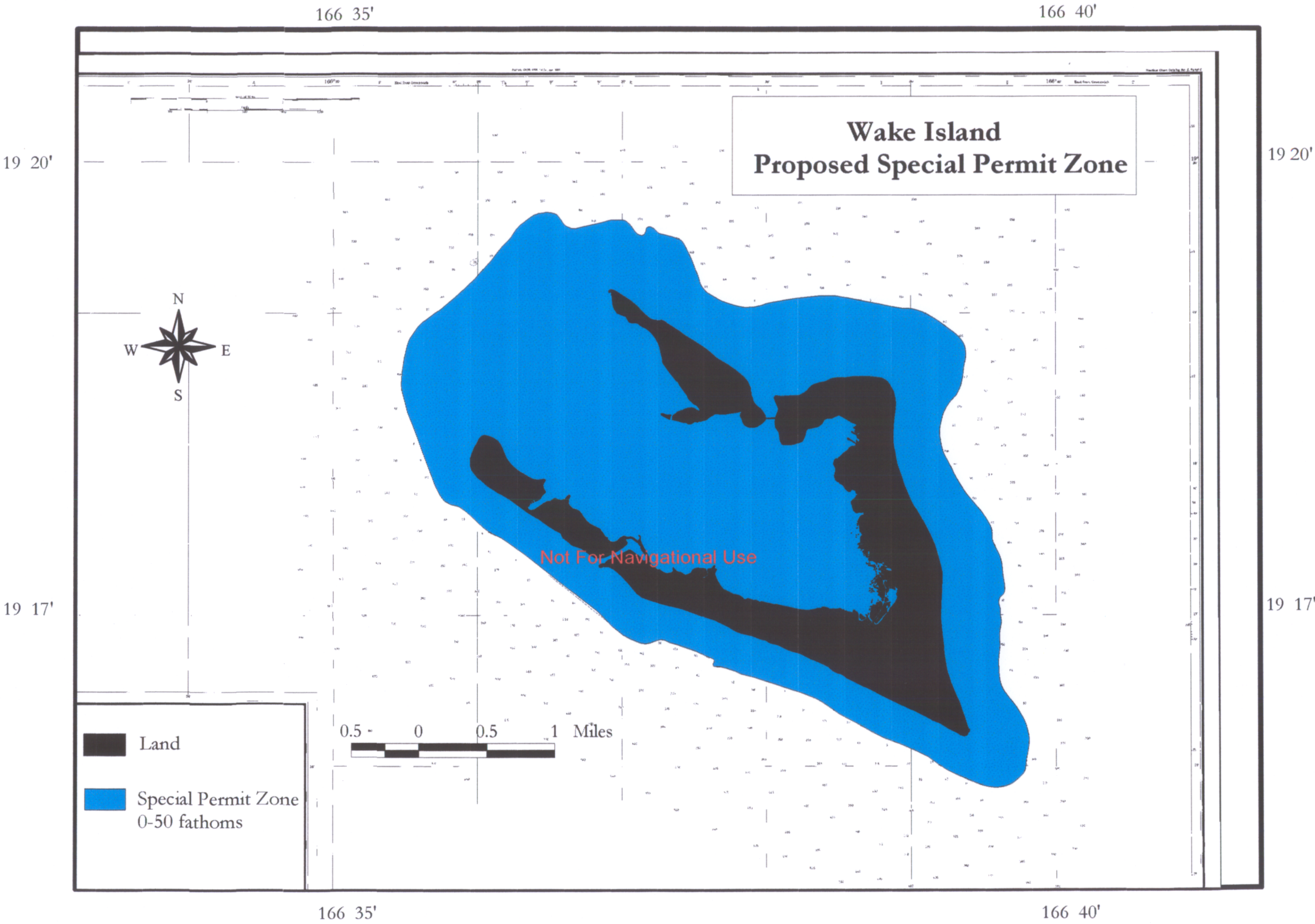

Kingman Reef
Proposed Marine Protected Area
N
W
E
S
Not For Navigational Use
Kingman Reef
Land
Depth 0 - 50 fathoms*
* Approximate depth based on best available data
1
0
1
2 Miles
83153

Palmyra Atoll
Proposed Marine Protected Area



Johnston Atoll
Proposed Special Permit Zone





166 35'
166 40'
19 20'
19 20'
Wake Island
Proposed Special Permit Zone
N
W
E
S
Not For Navigational Use
19 17'
19 17'
0.5
0
0.5
1
Miles
Land
Special Permit Zone
0-50 fathoms
166 35'
166 40'

Map Legend for the Northwestern Hawaiian Islands

Land

Current no-take zone for lobster/proposed coral reef resource no-take zone (0-10 fm)

Proposed coral reef resource low-use special permit zone (10-50 fm)

Current no-take lobster zone (20 mile radius)

Proposed no-take (kapu) zone (0-50 fm)

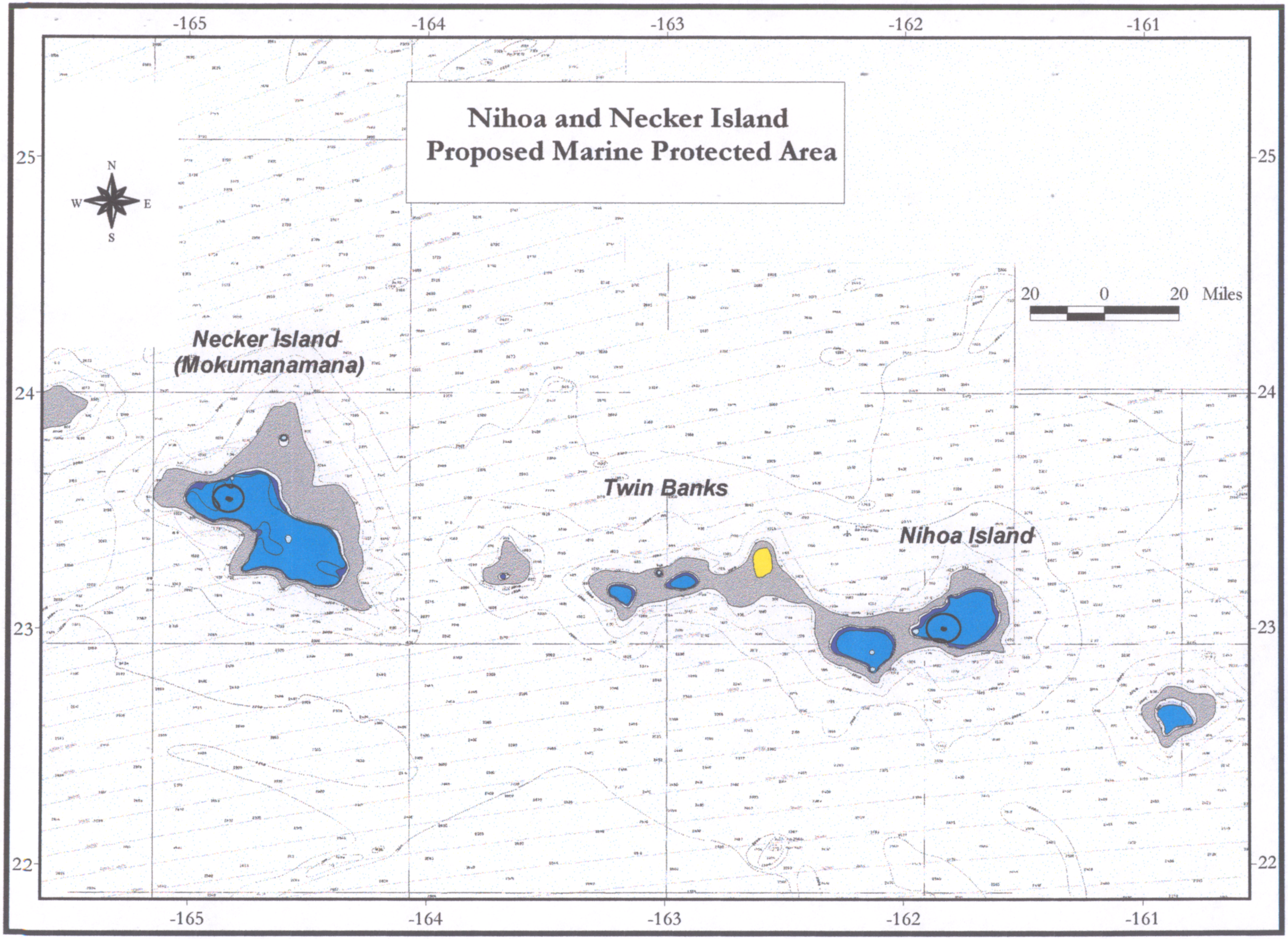
Deepwater precious coral permitted zones

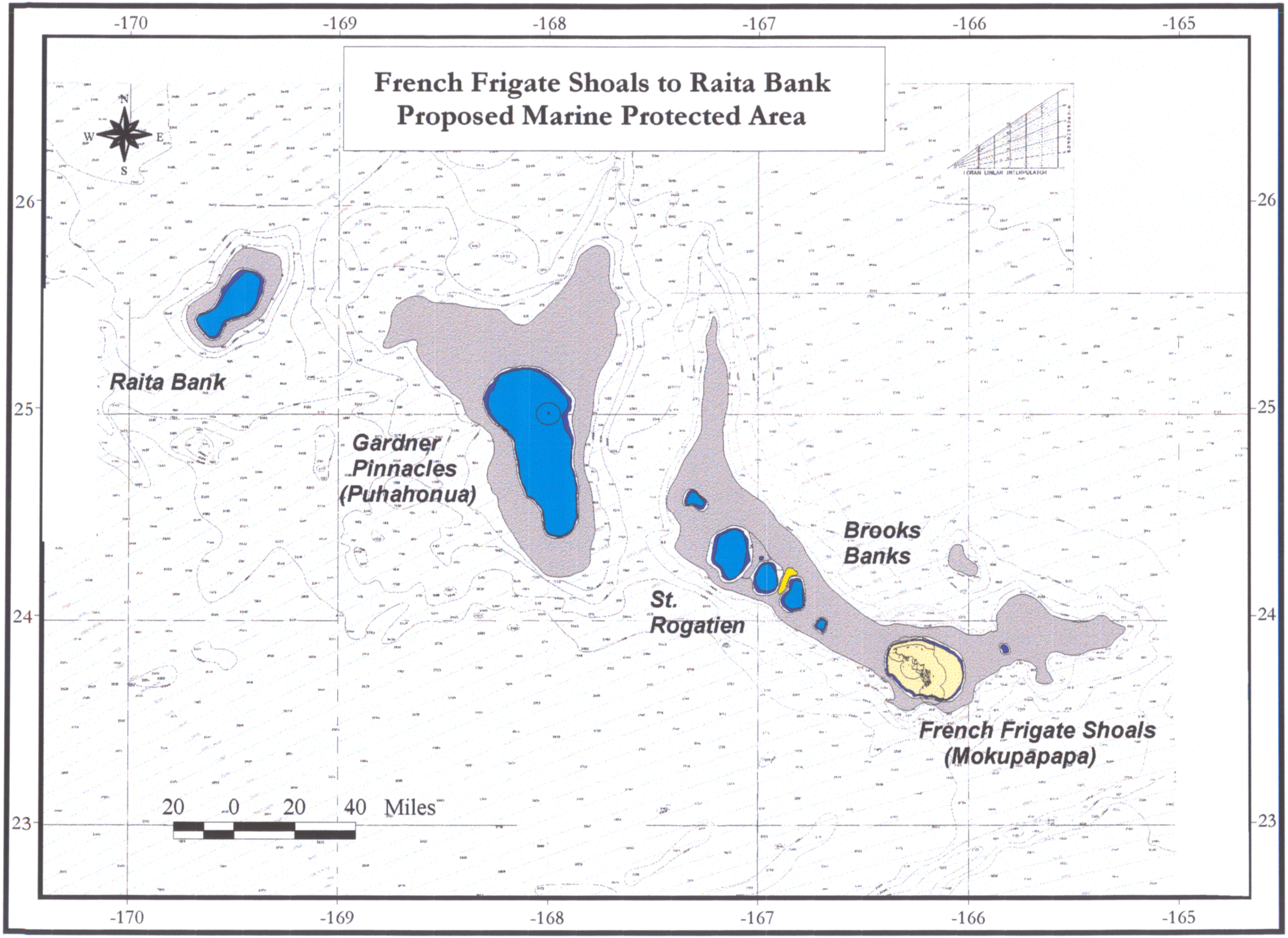
50-100 fm) bathymetric contour

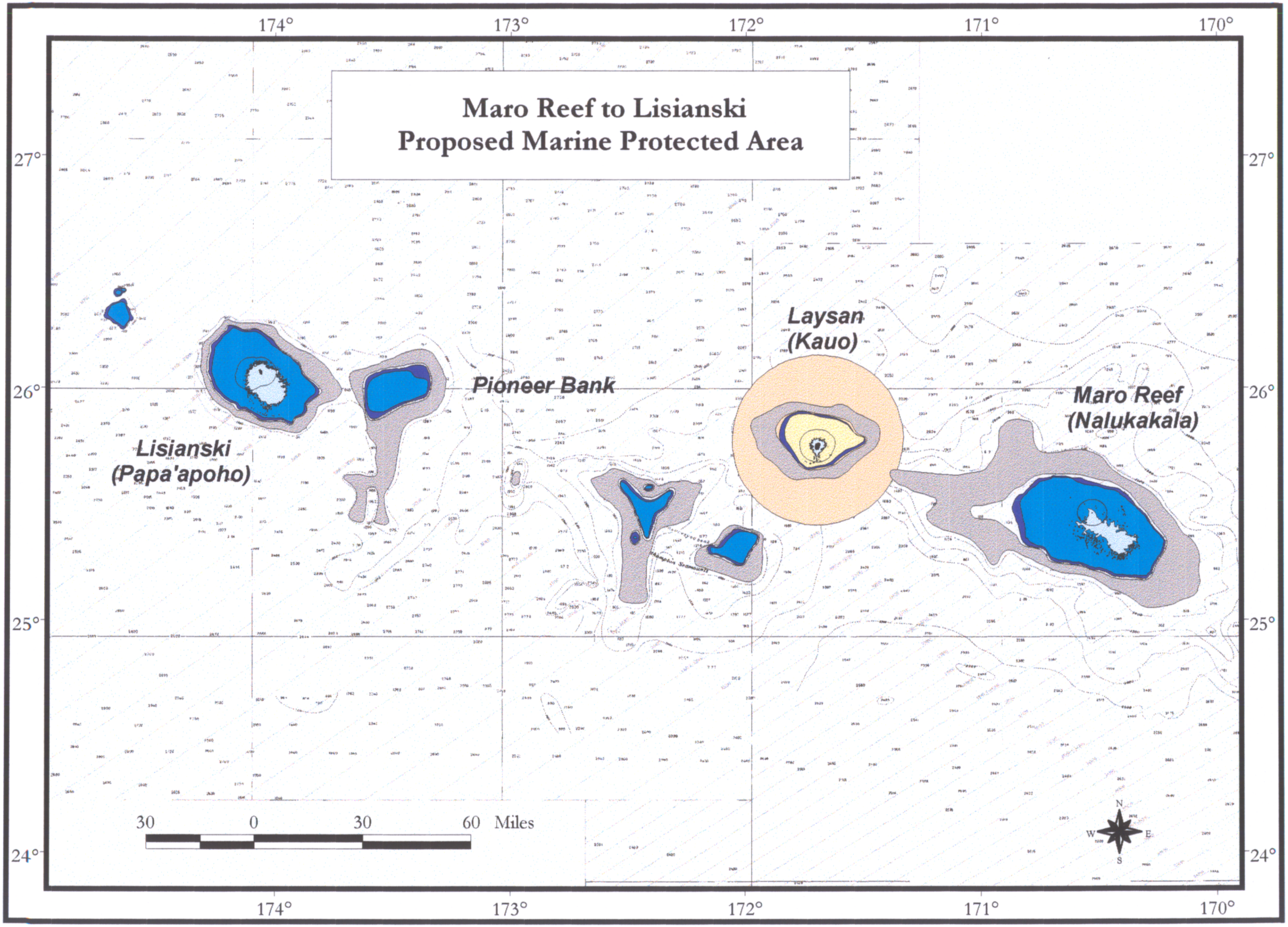
3 Miles boundary around land

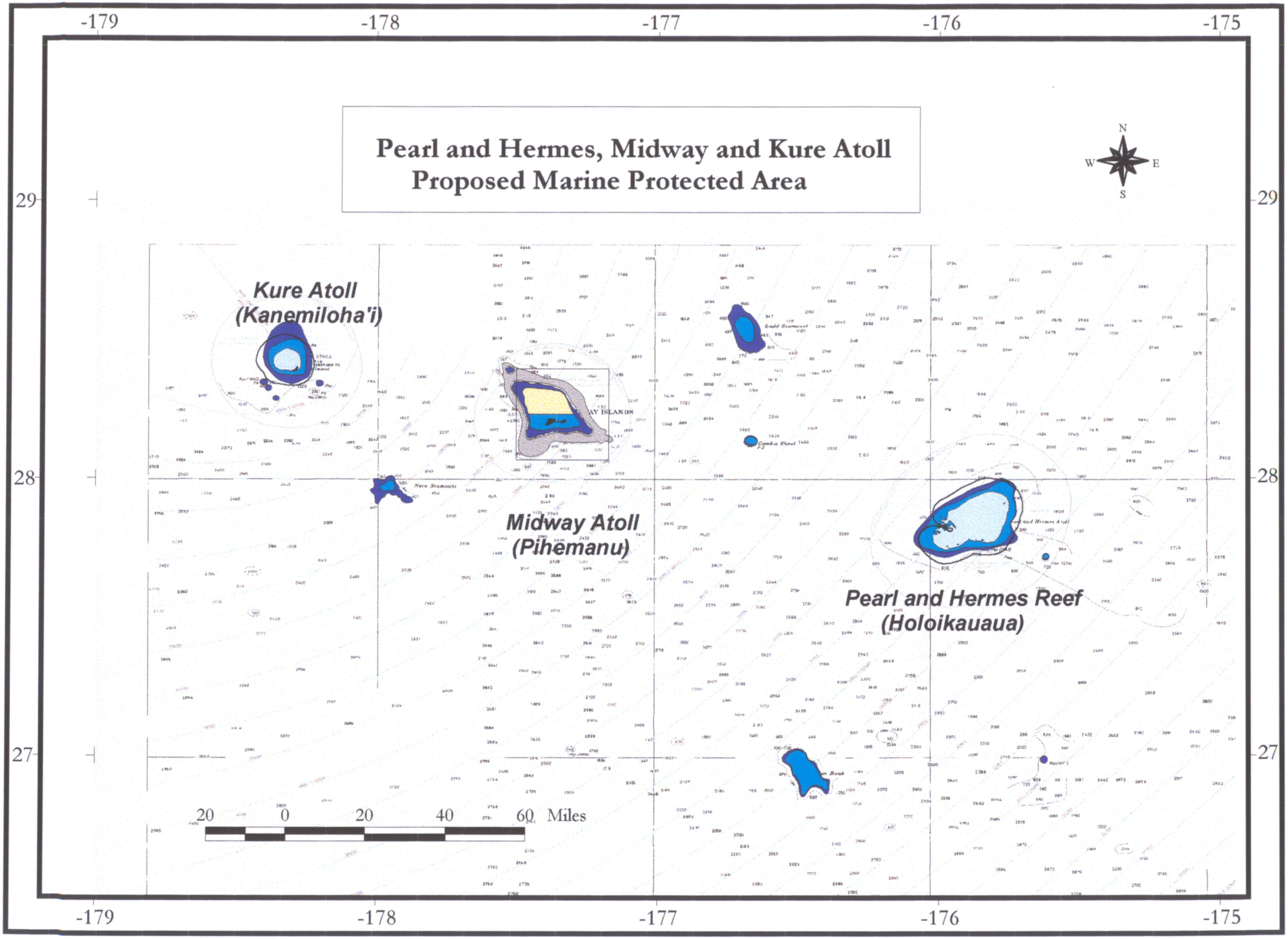
Potential deepwater coral habitat (150-750 fm)

* For Midway Atoll, the proposed coral reef resource low-use special permit zone encompasses all benthic substrates (0-50 fm)


Nihoa and Necker Island
Proposed Marine Protected Area
N
W
E
S
20 0 20 Miles
Necker Island
(Mokumanamana)
Twin Banks
Nihoa Island
-165
-164
-163
-162
-161
25
24
23
22


French Frigate Shoals to Raita Bank
Proposed Marine Protected Area
-170
-169
-168
-167
-166
-165
26
25
24
23
N
S
E
W
Raita Bank
Gardner
Pinnacles
(Puhahonua)
St.
Rogatien
Brooks
Banks
French Frigate Shoals
(Mokupapapa)
20
0
20
40
Miles


Maro Reef to Lisianski
Proposed Marine Protected Area
174°
173°
172°
171°
170°
27°
26°
25°
24°
Lisianski
(Papa'apoho)
Pioneer Bank
Laysan
(Kauo)
Maro Reef
(Nalukakala)
30
0
30
60
Miles
N
W
E
S



Pearl and Hermes, Midway and Kure Atoll
Proposed Marine Protected Area
N
W
E
S
-179
-178
-177
-176
-175
29
28
27
Kure Atoll
(Kanemiloha'i)
Midway Atoll
(Pihemanu)
Pearl and Hermes Reef
(Holoikauaua)
20
0
20
40
60
Miles

Management Measure 2.   Permits and Reporting Requirements

Permits are a fundamental management tool, and are used as a basis for participation in many fisheries. Permits establish the legal rights, privileges and obligations of fishermen while reporting requirements allow collection of data for fishery monitoring and management. In addition permit holders' records of compliance with permit requirements can be evaluated to maintain a register of those in good standing and standards of performance can be established as criteria for renewing permits.

A permit process that allows for monitoring of participation, effort and catch contributes to seven of the eight FMP objectives, particularly Objective 4, which calls for minimization of adverse human impacts. Permits focus management attention on details–the specific reef resources and areas to be exploited and the harvest methods to be used. Periodic analysis of catch and effort data collected through mandatory reporting facilitates adaptive management The case-by-case nature of the CRE special permits included in some alternatives would encourage applicants to more carefully consider their proposed activities and the potential impacts of those activities, and allow managers to carefully monitor emerging coral reef fisheries throughout the region's EEZs. Further details on the application and approval process for both the CRE special permit and the CRE general permit is available in the Draft Coral Reef Ecosystem Fishery Management Plan.

Alternative 1: No Action - under this alternative no permit or reporting requirements would be implemented.

Alternative 2: Minimal Additional Protection to Coral Reef Resources - under this alternative CRE special permits would be required for the harvest of both Currently Harvested and Potentially Harvested Coral Reef Taxa within low-use MPAs, with an exception for vessel operators holding permits and targeting species managed under other FMPs (Bottomfish, Crustaceans, Pelagics or Precious Corals).

Alternative 3: Substantial Additional Protection to Coral Reef Resources (preferred alternative) - under this alternative CRE special permits would be required for the harvest of both Currently Harvested and Potentially Harvested Coral Reef Taxa within low-use MPAs, with an exception for vessel operators holding permits and targeting species managed under other FMPs (Bottomfish, Crustaceans, Pelagics, or Precious Corals). In addition, CRE special permits would be required for all take of Potentially Harvested Coral Reef Taxa throughout the region's EEZs, with an exception for the inshore area of CNMI's EEZ. This alternative would also establish a framework process to allow future implementation of a CRE general permit requirement for the EEZ harvest of both Currently Harvested and Potentially Harvested Coral Reef Taxa outside of low-use MPAs (with exceptions for other FMP permit holders and harvests within CNMI's inshore area).

Alternative 4: Maximum Additional Protection to Coral Reef Resources - under this alternative CRE special permits would be required for all EEZ harvest of Potentially Harvested Coral Reef outside of the no-take MPAs (with exceptions for other FMP permit holders and harvests within CNMI's inshore area). This alternative would also implement a CRE general permit requirement for the EEZ harvest of Currently Harvested Coral Reef Taxa outside of the no-take MPAs (with exceptions for other FMP permit holders and harvests within CNMI's inshore area). Finally, this alternative would require a CRE special permit for any EEZ research or management activities which could affect any CRE MUS.

Management Measure 3. Allowable Gear Types and Methods

Pacific islanders have fished on coral reefs for several thousand years. Sustainability resulted in part from the inefficiency and selectivity of the gear that they used. Although many of the traditional methods are still used in contemporary fisheries, the introduction of manufactured gear and population growth have increased harvesters' impacts on coral reef resources. Today's fishermen employ a wide variety of gear and methods to harvest extremely diverse resources (hundreds of species). Although large scale and destructive fishing methods such as bottom trawls, all-terrain trawls, bottom dredges or industrial netting are prohibited in much of the region, threats to coral reef resources in the EEZ around US Pacific islands remain due to the potential use of several destructive fishing methods which remain unregulated.

Controls are needed to prevent the possession or use of destructive gear to harvest coral reef resources. These include poisons, explosives, intoxicating substances and unattended gill nets that damage coral reef ecosystems. Bioprospecters may also seek to harvest coral reef resources. Despite their potential benefits to society, these harvests must be carried out in a controlled manner. The collection of these organisms, many of which are still unknown, will utilize novel techniques that are difficult to anticipate. Unregulated live reef fish harvesters for food and ornamental markets, already a problem in Southeast Asia, could find their way to US EEZ waters, especially in remote, difficult to monitor areas.

Gear restrictions are also needed in order to address several other issues. Non-selective gears and methods often result in substantial incidental catch (non-targeted catches) or bycatch (discards). In addition, some highly selective methods, such as SCUBA assisted spearfishing, prevent fish from seeking refuge.

Placing limits on allowable gear types addresses FMP Objective 1: sustainable use of resources, and Objective 4: minimizing adverse human impacts.

Alternative 1: No Action - under this alternative no new gear requirements would be implemented.

Alternative 2: Minimal Additional Protection to Coral Reef Resources - under this alternative only the following gears would be allowed throughout the regions EEZs for the harvest of any CRE MUS: hand harvest, spear, slurp gun, hand/dip net, hoop net for kona crab, throw net, barrier net for aquarium fish, surround/purse set for targeted schools (e.g. akule, baitfish, weke) with a minimum of bycatch, hook-and-line (including powered and unpowered handlines, rod and reel, and trolling), traps (with conditions), and remote operating vehicles/submersibles. Other FMP permit holders would be required to comply with the gear restrictions of that FMP.

Alternative 3: Substantial Additional Protection to Coral Reef Resources (preferred alternative) - this alternative would include the same list of allowable gears as Alternative 2, but would also specifically prohibit nighttime spearfishing for CRE MUS with SCUBA or hookah gear in all EEZ waters surrounding the NWHI and the PRIA. Other FMP permit holders would be required to comply with the gear restrictions of that FMP.

Alternative 4: Maximum Additional Protection to Coral Reef Resources - this alternative would include the same list of allowable gears as Alternative 2, but would also specifically prohibit all spearfishing for CRE MUS with SCUBA or hookah gear in all EEZ waters throughout the region. Other FMP permit holders would be required to comply with the gear restrictions of that FMP.

Management Measure 4. Other (Miscellaneous) Measures

Two issues of concern specifically addressed by this FMP include the take of live rock and live coral, and the impacts of vessel wrecks on coral reef resources. Both have potential to significantly impact essential fish habitat.

Alternative 1: No Action - under this alternative no new restrictions on the harvest of live rock and live coral, or requirements for vessel insurance would be implemented.

Alternative 2: Minimal Additional Protection to Coral Reef Resources - under this alternative the take of live rock and live coral in low-use MPAs would be prohibited except for: 1) incidental take by other FMP permit holders; 2) take by indigenous people for traditional/ceremonial use; 3) use by aquaculture operations as seed stock; 4) science & management; 5) bioprospecting. All of these (except #1) would require a CRE special permit.

Alternative 3: Substantial Additional Protection to Coral Reef Resources (preferred alternative) - as in Alternative 2, this alternative would prohibit the take of live rock and live coral except for: 1) incidental take by other FMP permit holders; 2) take by indigenous people for traditional/ceremonial use; 3) use by aquaculture operations as seed stock; 4) science & management; 5) bioprospecting. All of these (except #1) would require a CRE special permit. In addition, this alternative would require all fishing vessels transiting MPAs to carry wreck and clean up insurance in case of an accident or fuel spill.

Alternative 4: Maximum Additional Protection to Coral Reef Resources - under this alternative all takes of live rock and live coral would be prohibited throughout the region's EEZs. In addition, this alternative would require all fishing vessels transiting MPAs to carry wreck and clean up insurance in case of an accident or fuel spill.

2.5 Future Measures Which Could be Implemented through Framework Actions

Since the status of coral resources and their exploitation can change, any management regime must be able to change in response. This is known as adaptive management and, depending on circumstances, rapid responses to natural or anthropogenic changes may be necessary. In comparison to amending the Coral Reef Ecosystem Fishery Management Plan, certain management changes can be implemented in an expedited manner using a framework process. Several measures are identified for possible later implementation using this procedure, including restrictions on anchoring in MPAs, and requiring vessels operating in MPAs to carry VMS. The framework procedure would also simplify reassignment of MUS between the "currently harvested taxa" and "potentially harvested taxa" categories. In general, other measures can be implemented through the framework process if their impacts have been previously evaluated (e.g. in this FMP or its amendments); otherwise an FMP amendment is required. The framework process is discussed in greater detail in the Draft FMP. Analyses of framework measures considered in the CRE- FMP are found below. The particular characteristics of the resource, and the desire to take an ecosystem approach to management, make the framework procedure a particularly appropriate component of the CRE-FMP. It should be noted that framework procedures are included in all other existing FMPs.

Discussion of Potential Framework Measures

This section describes changes to the FMP that may be made based on recommendations identified in the annual report, or at Council or other advisory body meetings. Current options being considered for future framework action are: (1) restrictions on mooring and anchoring in no-take MPAs except in emergencies, (2) requirements that fishing vessels operating in MPAs carry individual Vessel Monitoring Systems (if funded by NMFS), (3) designating sub-zones reserved for indigenous use within low-use MPAs, (4) changing permitting and reporting requirements for emerging fisheries for which sufficient information has been collected (movement of management unit species between potentially harvested taxa and currently harvested taxa lists), and (5) implementation of a general permit requirement for existing EEZ coral reef resource fisheries outside of MPAs if regional systems are found not to meet the needs of the FMP. These measures have not been included in the current management alternatives for one of two reasons. Details for the first three actions still need to worked out. Locations of mooring buoys have not yet been determined, although all agreed on their importance (#1). A closer look at the needs of vessels operating in MPAs and a better understanding of EFH and HAPC will be required before a preferred action on this issue can be identified. It is not yet determined whether the federal government will pay for the installation and operation of VMS in this fishery (#2). Size and location of indigenous sub-zones were not decided upon and legal issues were not fully explored (#3). Framework measures #4 and #5 are part of adaptive management and have been crafted to be enacted as new information on the fishery and its environment become available. Thus, the management aspects of these two framework measures have been explored, but proper action awaits necessary scientific data.

Framework Action 1. Designate zones in the EEZ where mooring buoys will be installed in order to protect EFH from anchor damage. In areas with approved mooring buoys, prohibit anchoring of fishing vessels within a radius indicated on the buoy.

Rationale: "No anchor zones" in specific habitat areas would protect coral reefs from devastating damage done by anchors. Mooring buoys have been used successfully in Hawaii and elsewhere in the Pacific as an alternative to anchoring, particularly in high use areas. The use of these buoys by fishers and others would reduce habitat damage caused by anchoring. The buoys would be used on a first-come-first-served basis and allowable time limits would be specified so that no one boat monopolizes a buoy. This process would ensure that the use of these buoys and the concomitant access to the resources would be fair and equitable to all fishers, consistent with National Standard 4. Only one boat would be allowed to moor at a time at each buoy. The prohibition of anchoring would limit the number of secured boats fishing an area to the number of mooring buoys at the site. While this may concentrate fishing effort around the buoys, it would also limit the number of vessels fishing at one time, increasing vessel safety and minimizing fishing pressure on coral reef resources.

Beneficial Impacts:

- prevents anchor damage to reef habitats
- allows anchoring for safety reasons in EFH and/or HAPC
- limits number of vessels fishing on the banks at one time, increasing vessel safety and minimizing fishing pressure on coral reef resources
- increases safety of fishers by making anchoring (and its hazards) unnecessary and reducing risk of anchor dragging

- is consistent with requirements of the Sustainable Fisheries Act by minimizing degradation of coral reef habitats

Adverse Impacts:

- limits number of vessels able to fish in a designated mooring zone at one time
- mooring buoy maintenance may be difficult
- may concentrate fishing effort in areas with buoys
- includes a cost for installation and maintenance of buoys
- may encourage "rafting" of vessels at each mooring buoy (even though it would be prohibited under the measure), which is a safety concern

Framework Action 2. Require fishing vessels to carry remote electronic vessel monitoring systems (VMS) as part of an effective monitoring and enforcement system for state, territorial, commonwealth and federal agencies. This requirement could be applied to coral reef fisheries in specific geographical areas (e.g., NWHI). This measure will only be enacted if the cost of such a system is fully subsidized with federal funding.

Rationale: VMS is an effective system for managing vessels operating in areas with different use zones, such as the MPAs, and with different licenses/permits, and for encouraging and documenting compliance with permit conditions. The vessel's precise location would be transmitted via satellite to a Land Earth Station (LES) and from there to a computerized monitoring station where the information would be kept in a secure and confidential database. If the vessel enters a designated buffer zone or MPA, an automatic signal is sent to both the ship's captain and the appropriate management agency. Such a system may prove to be a cost-effective compliance tool for real time and accurate positioning of vessels and instant recognition of a breach of permitted activities, as well as a tool to locate vessels in distress. VMS also has been shown to be an effective tool for monitoring of vessels and, when used in conjunction with automated buffer zones, for preventing vessel groundings.

Beneficial Impacts:

- protects coral reef resources by providing early warning of a vessel approaching too close to a reef slope, thereby protecting both the reef and the vessel from grounding damage
- protects coral reef resources by providing a tool that can dramatically improve compliance with FMPs
- is consistent with the requirements of the Sustainable Fisheries Act
- provides precise location information to assist in emergencies and rescues
- provides documentation on vessel movements, which can be used to clear up misunderstandings regarding liability or accusations of responsibility for environmental damage
- requires no input by captain or crew to run the automatic system
- can make enforcement easier and potentially much less costly

Adverse Impacts:

- cost of implementation may be burdensome to federal government
- implementation will require fiscal and personnel resources
- fishermen are concerned over the use of VMS information (security and confidentiality of data)

Framework Action 3. Designate a set percentage within low-use MPAs for sole use by indigenous peoples, with the percentage based upon percentage of indigenous population in the area around the low-use MPA

Rationale: Discussions during the planning process centered around access for native Hawaiians to the NWHI for traditional and ceremonial purposes. Tangentially, other island cultures were included with details to be worked out in the future as new MPAs were designated in those EEZs. Full details were not worked out for the NWHI as well. These include where these locations would be, the exact percentage of low-use MPA that would be set aside as well as legal issues surrounding the proposal. Nevertheless, the CRE plan team and other groups strongly believe in the premise.

The Samoa, Hawaii and Mariana islands were originally settled in ancient times by sea-faring peoples. The lack of terrestrial resources in most areas led to great dependence on fishing for food security. This dependence shaped the social organization, cultural values and spiritual beliefs of the indigenous populations. Repeated contacts with Europeans and North Americans eroded the stability of the social structures and subsistence economies created by indigenous people. Fishing not only provides food but cultivates intimacy and harmony with the ocean, reinforcing a sense of kinship with nature and relationships with places that perpetuate cultural identities and beliefs. Increasing restrictions on customary and traditional uses of marine resources are jeopardizing cultural continuity in many areas of the US Pacific. The designation of no-take zones in the NWHI could result in some negative impact on the Hawaii fishing community by causing a loss of earning potential, investment value and lifestyle some bottomfish and lobster fisheries participants.

A 1993 survey of participants in the NWHI bottomfish fishery found that half of the respondents who fish in the Ho'omalu Zone were motivated to fish by a long term family tradition (Hamilton, 1994). This sense of continuity is also reflected in the importance placed on the process of learning about fishing from "old timers" and transmitting that knowledge to the next generation. Hawaii's commercial fishing industry dates back nearly 200 years and closure of some fishing grounds in the NWHI would also likely have a negative impact on those who value the continued existence of Hawaii's maritime tradition and culture. In view of the historic and cultural importance of fishing over the last 2,000 years for Native Hawaiians, this deprivation of the right to make a living at *koa* (see Kahaulelio 1902, pp. 22, 24), which they have been accustomed to frequent in the NWHI, is an especially onerous penalty. This is exacerbated by the fact that annexation of Hawaii by the U.S. opened access to fishery resources to any U.S. citizen (Kosaki 1954), increasing fishing pressure on resources customarily used by Native Hawaiians and weakening cultural norms that controlled the proper conduct of fishing.

Beneficial Impacts

- helps preserve and reestablish island cultures and families whose history of traditional and ceremonial use of coral reef resources dates back thousands of years
- adds additional protection within low-use MPAs, by effectively limiting the amount of users in the area
- will make the permitting process for certain activities simpler as usage in these areas can be expected to be typical across these select user groups
- potential to support subsistence fishing

Adverse Impacts

- could be challenged legally on grounds of discrimination
- locations and size of the sub-zones could cause contention between user groups
- concerns have been expressed regarding what constitutes cultural take (e.g., modern gear and techniques could alter the purpose of the sub-zone)

Framework Action 4. Allow for movement of potentially-harvested MUS to the currently-harvested MUS list when sufficient information has been gathered for less restrictive management.

Rationale: If a market develops for a potentially-harvested species, fishers will request to fish that (those) species under the special permit. The special permit is designed to use the precautionary approach. Approval of the permit requires a thorough description and evaluation of all aspects of the fishing method for each applicant. Additionally, strict reporting requirements, including bycatch and discards, must be submitted. The data gathered from the vessels will help managers determine MSY, OY and potential for overfishing. When enough data has been gathered for a given species or species complex and its associated bycatch to understand cumulative impacts on the species and ecosystem, the Council can determine whether to lessen the stringent requirements. This reduces administrative and regulatory burdens at the appropriate time without causing risk to the resource.

Beneficial Impacts:

- relieves unnecessary administrative burdens on species for which management is understood
- reduces burden to the Council and the PIAO Administrator for permit approval
- eases burdens on fishermen who have complied with regulations, allowing for given species to be re-listed as currently-harvested MUS
- procedure to re-list MUS prompts fishery managers to better understand species and ecosystem to facilitate effective management

Adverse Impacts

- has the potential to put species at risk which could require more stringent management measures
- could facilitate additional fishing pressure for given species due to a simpler permitting process

Framework Action 5. Require general permits (with mandatory catch reporting) to fish for currently-harvested CRE MUS in non-MPAs in the EEZ, in the event that regional management is determined inadequate to protect the species and/or ecosystem.

Rationale: General permits will initially not be required for existing CRE fisheries. The general permit requirement enhances fishery managers' abilities to assess individual fishing effort and methods for given target species and associated bycatch. More effective and adaptive management through specific data collection (mandatory reporting) is the primary intent of this framework measure.

Where the Council determines that a regional system is inadequate to address the needs of the FMP for an existing fishery harvesting coral reef taxa and operating within the EEZ, this framework measure can be enacted to require a general permit for the take of currently-harvested CRE MUS.

This framework procedure can be instigated by a number of methods; (1) the Council will review the Coral Reef Ecosystem annual report for adequate data collection, overfishing or potential for overfishing, and other relevant scientific data which reflects the need for additional management measures, (2) the Council's Coral Reef Plan Team can issue a report outlining concerns to the Council to be addressed at the following scheduled Council meeting, (3) regional management authorities may bring concerns to the attention of the Council at any time.

Beneficial Impacts:

- requires specific data reporting of catch, effort, area and method of fishing
- allows for a thorough understanding of the total fishing effort for given areas and given target species
- provides information on bycatch and protected species
- allows for standardization of reporting, assisting fishery managers assessment of impacts
- makes fishers more aware of concerns of impacts from fishing through completing both permit form and logbooks
- assists adaptive management with crucial data on fishery harvests and status

Adverse Impacts:

- increases administrative burdens (time and costs) due to the permit process
- increases burdens to fishermen who may not be used to completing this type of paperwork
- removes management from regional authority which had traditionally managed these fisheries

Requiring general permits for a fishery in a given area is one example of a framework measure. Reef fisheries occur both in territorial and federal waters around American Samoa. The DAWR issues permits to fish for these species and collects data through both creel surveys and commercial purchases. These reef fisheries are small scale operations, with individuals catching a few to a couple hundred pounds of fish on a given day. If one or more large scale operations began efficiently targeting these species in the EEZ, increasing the total catch substantially, regional management might not be sufficient to address this development. The Council could then initiate the framework process to require a general permit for reef fisheries in the EEZ of American Samoa. While details as to who would be affected and how the measure would affect fishing are subject to a unique, unforeseeable situation, general procedures are consistent with 50 CFR 660.13. Permits would be valid only for the fishery management subarea specified on the permit and remain valid for the period specified unless transferred, revoked, suspended or modified. A permittee would first request an official Southwest Region Federal Fisheries application form. After filling out all required information and attaching necessary documents as outlined in the example form, the permittee would return the application along with any fees, as specified. The Pacific Islands Area Office (NMFS, Honolulu) must be allowed a minimum of 15 business days to review and process all completed applications. Permittees would be notified of incomplete or incorrect applications. If deficiencies are not corrected within 30 days following notification, the application would be considered abandoned. The Administrator of the Pacific Island Area Office would issue a CRE general permit to the applicant under the CRE-FMP or send a written notification of denial which would include the reasons for the denied application.

2.6 Procedures for Other New Measures (Amendments)

A more formal process is required for new management measures which are significant in scope (thus requiring public input and comment) as well as for lesser measures which have not been analyzed previously in the FMP or its amendments. These new measures would include, but are not limited to, catch limits, resource size limits, closures, and effort limitations.

In general a Federal Register notice will be published describing any proposed new management measure. This notice will solicit public comment on the proposed change. At the following Council meeting, the Council will formally address the specific measure, listen to public comments and recommendations from its advisory panels, and select a preliminarily preferred alternative. A Federal Register notice will be prepared summarizing the Council's decision, deliberations, and rationale for the preferred action, and include the time and place for any further Council meetings to consider the measure. At subsequent meetings, the Council will consider new public comments and other information received and will draft a document containing its recommendation to the NMFS Southwest Region's Regional Administrator (RA).

The Regional Administrator will propose regulations to carry out the action or offer a written explanation supporting the denial of the recommendation within two weeks of its decision. The Council may appeal a denial by writing to the NMFS Assistant Administrator. The Assistant Administrator must respond to the Council within 30 days. If the RA agrees with the recommendation, the RA and the Assistant Administrator will make their decision in accordance with the Magnuson Stevens Act and other applicable laws. Finally, NMFS may implement the Council's recommendation by rule making if approved by the Regional Administrator.

2.7 Measures to Address Ecosystem Impacts of Existing FMP Fisheries

It is recommended that a formal process be established (under the Council's Standard Operating Procedures and Practices) to ensure coordination of the CRE FMP with the already existing Pelagics, Bottomfish, Crustaceans, and Precious Corals FMPs. Under this process, the Coral Reef Ecosystem Plan Team (CRE-PT) would coordinate with the existing FMP Plan Teams to recommend methods for minimizing identified impacts to the coral reef ecosystem (e.g., lobster trap impacts to reef habitat). Details of the process are specified in the Draft CRE FMP.

2.8 Management Measures Considered But Not Analyzed Further

Catch Restrictions Including Harvest Quotas:
A harvest quota, which limits the amount of fish that may be landed within some time period (typically, a year) is the most common type of quantity control. Quotas can be set for all participants in a fishery or individual quotas can be assigned to fishermen or fishing groups. Bag or per-trip limits are a third type of catch restriction that limit individual catches during a narrowly defined time period such as a fishing trip. These controls can be applied to species groups or to individual species. The underlying concept of allowable catches has been applied widely and as a result managers have conducted a lot of research on its effects. However, this approach is most widely implemented in temperate zone single-species fisheries.

Some managers favor catch quotas based on the premise that other ecological factors and interdependent stocks can be controlled through careful application of catch restrictions. These require a lot of information about the status of stocks and they are complicated and expensive to enforce. These problems seriously limit their application to complexes such as coral reef ecosystems where fish assemblages are diverse and management agency budgets are often tight (Roberts and Polunin, 1991). The high diversity of coral reef species and the variable selectivity of fishing methods would require that catch quotas either be applied to the total catch from a given area or to selected species. Unless expensive biological surveys are conducted to set quotas, the average catch limit for a particular season or year is either reached within an unduly short time (after good recruitment) or it is never attained (after poor recruitment). Leaving aside limits on agency resources, the cost entailed in measuring all the relevant variables needed to calculate quotas for multi-resource, multi-gear and data-poor coral reef fisheries would exceed any realistic capabilities or budget. Furthermore, quotas based on equilibrium yield models of particular resources would not necessarily prevent ecosystem overfishing.

Seasonal/Time Closures:
A "rest period," when fishing for particular species is temporarily suspended, is a traditional resource management practice in Pacific island fishing communities. This period can range from hours (prohibiting night fishing when fish are particularly vulnerable to capture, for example) to several months (coinciding with peak spawning periods of protected species, for example). Seasonal closures are most effective for species that fishermen can avoid capturing out of season or for species that can survive capture and release. Rather than directly monitoring fishing, seasonal closures for particular species can be enforced at fish landing sites and markets. Despite these advantages, more information is needed on the biology of many coral reef species in order to determine both rest period duration and locality and the resulting benefits. Further, complementary nearshore regulations, which would have to be implemented by states, would be necessary for effective enforcement.

Harvest Size Restrictions:
Setting minimum or maximum sizes for landed organisms is another popular management tool. This approach is only enforceable when regulations apply to possession or sale, rather than harvesting itself. Minimum size restrictions discourage harvesting fish before they reach reproductive size. Maximum size restrictions, on the other hand, discourage taking the most fecund sizes, which contribute disproportionately to reproduction. Size limits may also postpone harvesting resident species that have a limited range. If a fish stock is depleted, increasing the spawning population has a clear benefit. If a stock is not depleted, the benefit of a minimum size limit is less predictable because the connection between spawning population size and future recruitment success is very tenuous. Size limits are enforced by monitoring landing sites. More information on life histories and other biological parameters (e.g., size at maturity) is needed before establishing proper size limits for most reef species. Setting minimum/maximum sizes is difficult due to the multispecies nature of most coral reef fisheries. This management tool is most appropriate for monospecific stocks and less applicable to the ecosystem management approach.

Harvest Moratorium all EEZ waters:
Because the FMP review, approval and implementation process is lengthy, there is some concern that in the interim there will be little control over harvesting of coral reef resources in the EEZ. A moratorium on harvesting would protect reef ecosystems until the FMP is implemented. The Secretary of Commerce has the authority to impose a moratorium but such an action would require as much (and possibly more) justification as a FMP. However, even if eventually approved, a

moratorium would be controversial and approval could take as long or longer than the FMP approval and implementation.

2.9 Discussion of the Preferred Alternative

The group of control measures proposed by Alternative 3 (Substantial Additional Protection) represent a combination of choices made by the Council based on a comparison of management options. At each decision step, options bracketing different solutions and potential environmental, social and economic impacts were considered and preferred options were selected. If approved by the Secretary of Commerce, implementation of Alternative 3 would result in four major regulatory actions: (a) designation of "no take" and "low use" marine protected areas (MPAs) in portions of the EEZ, (b) permit and reporting requirements for harvesting of some EEZ coral reef resources, (c) definition of allowable gear and methods of fishing for coral reef resources in the EEZ, and (d) limitations on the collection of live rock and coral as well a requirement that all fishing vessels transiting MPAs carry vessel insurance in case of a wreck or grounding. The Council also proposes that the CRE FMP include framework procedures to allow for timely, adaptive management based on new resource information, unforeseen effects or changes in fisheries. In addition, the Council recommends that a formal procedure be established for assessing and controlling the coral reef ecosystem effects of fisheries managed under separate FMPs for Pelagics, Bottomfish, Crustaceans and Precious Corals.

There is poor understanding of the basics, much less the intricacies, of coral reef ecosystems. Ecosystem-based management, therefore, can only be achieved over time as new information allows management to improve. It should be recognized that the technical data available for management decisions are almost always uncertain and incomplete. Hence, the proposed FMP applies the precautionary approach by designating and zoning marine protected areas (MPAs), requiring special permits and detailed reporting for low-use zones and for potentially-harvested resources for which no information has been generated by previous fishing, prohibiting the commercial collection of live rock and allowing only non-destructive, selective fishing methods. The proposed Coral Reef Ecosystem FMP would also establish a procedure for interface between other FMPs to monitor and resolve possible ecosystem effects of reef-related fisheries and a procedure which incorporates feedback from detailed fishery monitoring of special permit activities, fishery-independent research and unforeseen environmental impacts (e.g., coral bleaching, oceanographic climate shift, hurricane damage to living coral) into an adaptive management process. Through this process, informed and timely regulatory changes could be made in the future, including such possibilities as adding or reducing the number of special permits available, evaluating new and innovative methods of harvest or adjusting reef-related fisheries managed under other FMPs if undesirable ecosystem effects are detected.

The proposed FMP includes several types of "ecosystem insurance," as recommended by the Ecosystem Principles Advisory Panel (EPAP 1999). Requiring insurance for vessels operating in areas of particular concern to cover the cost of vessel removal and pollution liability, in the event of a grounding, can provide incentive for more responsible operations. Another form of "insurance" is provided by zoning of MPAs for alternative uses. For example, no-take MPAs prohibit consumptive uses in areas highly sensitive to impacts and in biogeographically diverse ecosystem types representing a substantial reservoir of spawning biomass and biodiversity. Low-use zones allow fishing but only under a special permit that tightly controls activity.

In selecting the preferred alternative (Alternative 3) and its management measures the Council considered trade-offs of costs and benefits to various resources. These trade-offs can be summarized as 1) between utilization of coral reef resources by controlled fishing versus preservation of coral reef ecosystems by minimal consumptive use, 2) between sustainable use of multi-resource coral reef ecosystems versus sustainable use of particular target resources, 3) between prevention of adverse fisheries impacts versus mitigation of damage, 4) between management actions now versus later, 5) between regulatory burdens on potential new coral reef fisheries versus burdens on existing fisheries. In general, the Council selected management measures which provide a balance between these often conflicting ideals in a manner that meets the objectives of the CRE FMP as outlined below.

Objective 1
To foster sustainable use of multi-species resources in an ecologically and culturally sensitive manner, through the use of the precautionary approach and ecosystem-based resource management.

Objective 2
To provide a flexible and responsive management system for coral reef resources, which can rapidly adapt to changes in resource abundance, new scientific information and changes in fishing patterns among user groups or by area.

Objective 3
To establish integrated resource data collection and permitting systems, a research and monitoring program to collect fishery and other ecological information and to develop scientific data necessary to make informed management decisions about coral reef ecosystems in the EEZ.

Objective 4
To minimize adverse human impacts on coral reef resources by establishing new and improving existing marine protected areas, managing fishing pressure, controlling wasteful harvest practices, reducing other anthropogenic stressors directly affecting them, and allowing the recovery of naturally-balanced reef systems. This objective includes the conservation and protection of essential fish habitats.

Objective 5
To improve public and government awareness and understanding of coral reef ecosystems and their vulnerability and resource potential in order to reduce adverse human impacts and foster support for management.

Objective 6
To collaborate with other agencies and organizations concerned with the conservation of coral reefs, in order to share in decision-making and to obtain and share data and resources needed to effectively monitor this vast and complex ecosystem.

Objective 7
To encourage and promote improved surveillance and enforcement of the plan.

Objective 8
To provide for sustainable participation of fishing communities in coral reef fisheries and, to the extent practicable, minimize the adverse economic impacts on such communities.

The following section provides details on the rationale for the four management measures which comprise the preferred alternative.

Marine Protected Areas

No-Take Marine Protected Areas

No-take marine protected areas are a powerful tool for ecosystem management because they do not require detailed knowledge of the management unit species in order to achieve conservation of multi-species resources, diverse habitats and the functional attributes of marine ecosystems. The designation of no-take marine protected areas (MPAs) proposed by the FMP combines preferences for (a) their location; (b) their extent; and (c) how seaward boundaries for no-take areas are best defined;

The no-take MPAs around the NWHI are estimated to comprise 14 percent of the coral reefs in the EEZ for that sub-region. If the State of Hawaii takes consistent action to designate adjacent nearshore reefs around the NWHI, the percent of no-take MPAs area in that sub-region would reach 24 percent

The total no-take MPAs that would be established around Kingman Reef, and Jarvis, Howland, Baker and Palmyra Islands would comprise 67 percent of total reef area in the PRIA.

The combination of the federal areas selected as no-take MPAs would represent 13% of the region's coral reefs and would represent an important step towards meeting the US Coral Reef Task Force's goal of restricting access to 20% of the region's coral reefs over the next 10 years.

Preliminary estimates of no-take MPAs as a percent of total area reefs

Area	Percent in Federal Waters	Percent in all waters (State and Federal)
NWHI	14%	24%
PRIA	67%	67%
All WP Region	13%	21%

The preferred alternative's no-take areas have been selected to provide protection to ecologically sensitive areas while at the same time allowing for the continued existence of carefully controlled commercial bottomfish and lobster fisheries in the NWHI, as well as recreational fishing by visitors to Midway Island. Consideration was also given to the desire for continued recreational fishing by residents of Johnston Atoll and Wake Island.

Under the preferred alternative, the seaward boundaries for no-take MPAs would be delineated by following the relevant isobath around the indicated areas (depth contours). Basing these seaward boundaries on either the closest State of Hawaii commercial catch reporting grid square inclusive of the relevant contours (for the NWHI) or on circles drawn around islands or banks that are inclusive of these areas was considered but was rejected due to the significantly larger closed area that would result, with a major impact on fisheries, and that most of this additional closed area would be beyond the depth of coral reefs.

Amendments to Existing FMPs for Compliance with No-take MPAs

The Coral Reef Ecosystem FMP has designated no-take marine protected areas within the Management Area. Commercial, recreational, subsistence or cultural take of any marine species within these areas is prohibited. No described or undescribed gear is exempt from this designation. While the four existing FMPs implemented by the WPRFMC (bottomfish and seamount groundfish, crustaceans, pelagics and precious corals) are exempt from the regulations outlined in the CRE FMP and will observe the management regime of their respective FMPs, the no-take marine protected areas will be in effect for all Council-managed fisheries. These fisheries and their FMPs are summarized in the section of the DEIS on description of the coral reef ecosystem. An analysis of the impacts of these area closures on the four existing FMPs is included in the section on environmental consequences of the DEIS. To ensure designated no-take MPAs are effective for all FMPs, each of the following FMPs will be amended to ensure the no-take status of these areas, as follows:

Amendment 7 to the Bottomfish and Seamount Groundfish FMP

Harvest of bottomfish management unit species, listed in table below, as well as all future additions to the bottomfish MUS list, is prohibited in the no-take marine protected areas defined below as well as for all future no-take marine protected area designations:

(1) federal waters shallower than 10 fathoms in the Northwestern Hawaiian Islands

(2) federal waters shallower than 50 fathoms around Jarvis Island (0°23' S, 160°01' W), Howland Island (0°48' N lat., 176° 38' W long.), Baker Island (0° 13' N lat., 176°38' W long.), Kingman Reef (6°23' N lat., 162°24' W long.), Palmyra Atoll (5°53' N lat., 162°05' W long.), Laysan Island (25° 45' N lat., 171°45' W long.), French Frigate Shoals (23° 45' N lat., 166°15' W long.), the North half of Midway Atoll (28° 45' N lat., 177°22' W long.), and Rose Atoll (14° 33' S lat., 168°09' W long.).

Bottomfish Management Unit Species List

Scientific Name	English Common Name
Aphareus rutilans	red snapper/silvermouth
Aprion virescens	gray snapper/jobfish
Caranx ignobilis	giant trevally/jack
C. lugubris	black trevally/jack
Epinephelus fasciatus	blacktip grouper
E. quernus	sea bass
Etelis carbunculus	red snapper
E. coruscans	red snapper
Lethrinus amboinensis	ambon emperor
L. rubrioperculatus	redgill emperor

Lutjanus kasmira	blueline snapper
Pristipomoides auricilla	yellowtail snapper
P. filamentosus	pink snapper
P. flavipinnis	yelloweye snapper
P. seiboldi	pink snapper
P. zonatus	snapper
Pseudocaranx dentex	thicklip trevally
Seriola dumerili	amberjack
Variola louti	lunartail grouper
Beryx splendens	alfonsin
Hyperoglyphe japonica	ratfish/butterfish
Pseudopentaceros richardsoni	armorhead

Amendment 11 to the Crustaceans FMP

Harvest of crustacean management unit species, listed in the table below, as well as all future additions to the crustacean MUS list, is prohibited in the no-take marine protected areas defined below as well as for all future no-take marine protected area designations:

(1) federal waters shallower than 10 fathoms in the Northwestern Hawaiian Islands

(2) federal waters shallower than 50 fathoms around Jarvis Island (0°23' S, 160°01' W), Howland Island (0°48' N lat., 176° 38' W long.), Baker Island (0° 13' N lat., 176°38' W long.), Kingman Reef (6°23' N lat., 162°24' W long.), Palmyra Atoll (5°53' N lat., 162°05' W long.), Laysan Island (25° 45' N lat., 171°45' W long.), French Frigate Shoals (23° 45' N lat., 166°15' W long.), the North half of Midway Atoll (28° 45' N lat., 177°22' W long.), and Rose Atoll (14° 33' S lat., 168°09' W long.).

Crustacean Management Unit Species List

Scientific Name	English Common Name
Panulirus marginatus	Spiny lobster
Panulirus penicillatus	Spiny lobster
Family Scyllaridae	Slipper lobster
Ranina ranina	Kona crab

Amendment 10 to the Pelagic FMP

Harvest of Pacific pelagic management unit species, listed in the table below, as well as all future additions to the bottomfish MUS list, is prohibited in the no-take marine protected areas defined below as well as for all future no-take marine protected area designations:

(1) federal waters shallower than 10 fathoms in the Northwestern Hawaiian Islands

(2) federal waters shallower than 50 fathoms around Jarvis Island (0°23' S, 160°01' W), Howland Island (0°48' N lat., 176° 38' W long.), Baker Island (0° 13' N lat., 176°38' W long.), Kingman Reef (6°23' N lat., 162°24' W long.), Palmyra Atoll (5°53' N lat., 162°05' W long.), Laysan Island (25° 45' N lat., 171°45' W long.), French Frigate Shoals (23° 45' N lat., 166°15' W long.), the North half of Midway Atoll (28° 45' N lat., 177°22' W long.), and Rose Atoll (14° 33' S lat., 168°09' W long.).

Pacific Pelagic Management Unit Species List

Scientific Name	English Common Name
Coryphaena spp.	Mahimahi (dolphinfishes)
Acanthocybium solandri	Wahoo
Makaira mazara: *M. indica*	Indo-Pacific blue marlin Black marlin
Tetrapturus audax	Striped marlin
T. angustirostris	Shortbill spearfish
Xiphias gladius	Swordfish
Istiophorus platypterus	Sailfish
Alopiidae, Carcharinidae, Lamnidae, Sphynidae	Oceanic sharks
Thunnus alalunga	Albacore
T. obesus	Bigeye tuna
T. albacares	Yellowfin tuna
T. thynnus	Northern bluefin tuna
Katsuwonus pelamis	Skipjack tuna
Euthynnus affinis	Kawakawa
Gymnosarda unicolor	Dogtooth tuna
Lampris spp	Moonfish
Gempylidae	Oilfish family
family Bramidae	Pomfret
Auxis spp, *Scomber* spp; *Allothunus* spp	Other tuna relatives

Amendment 5 to the Precious Corals FMP

Harvest of precious corals management unit species, listed in the table below, as well as all future additions to the bottomfish MUS list, is prohibited in the no-take marine protected areas defined below as well as for all future no-take marine protected area designations:

(1) federal waters shallower than 10 fathoms in the Northwestern Hawaiian Islands

(2) federal waters shallower than 50 fathoms around Jarvis Island (0°23' S, 160°01' W), Howland Island (0°48' N lat., 176° 38' W long.), Baker Island (0° 13' N lat., 176°38' W long.), Kingman Reef (6°23' N lat., 162°24' W long.), Palmyra Atoll (5°53' N lat., 162°05' W long.), Laysan Island (25° 45' N lat., 171°45' W long.), French Frigate Shoals (23° 45' N

lat., 166°15' W long.), the North half of Midway Atoll (28° 45' N lat., 177°22' W long.), and Rose Atoll (14° 33' S lat., 168°09' W long.).

Precious Corals Management Unit Species List

Scientific Name	English Common Name
Corallium secundum	Pink coral (also known as red coral)
Corallium regale	Pink coral (also known as red coral)
Corallium laauense	Pink coral (also known as red coral)
Gerardia spp.	Gold coral
Narella spp.	Gold coral
Calyptrophora spp.	Gold coral
Lepidisis olapa	Bamboo coral
Acanella spp.	Bamboo coral
Antipathes dichotoma	Black coral
Antipathes grandis	Black coral
Antipathes ulex	Black coral

Low-use Marine Protected Areas

One of the actions proposed by EPAP (1999) for ecosystem-based fishery management is for Councils to use a zone-based management approach to designate geographic areas for prescribed uses. This recommendation is incorporated in the FMP proposal to establish low-use marine protected areas. The designation of low-use marine protected areas combines preferences for (a) their location; (b) their extent; and (c) how seaward boundaries for low-use MPAs are best defined.

Under the preferred alternative, all EEZ coral reefs (e.g. those federal waters and substrate within the 50 fathom contour) around the Northwestern Hawaiian Islands not designated for no-take areas are designated as low-use MPAs. Other low-use MPAs are designated for coral reefs in the EEZ around Johnston and Wake atolls and on offshore banks south of the island of Guam.

The seaward boundaries preferred for all low-use MPAs would extend to a uniform depth of 50 fm. Those adjacent to no-take MPAs around French Frigate Shoals, Laysan Island would begin at 10 fathoms (the outer boundary of the no-take MPA) while all others (and anchoring restrictions for the offshore banks south of Guam) would begin at 0 fathoms (the southern half of Midway Island, Johnston and Wake). As for no-take MPAs, these boundaries would be delineated by following the relevant isobath around the indicated areas (depth contours).

Bottom Line on Marine Protected Areas:

Under the preferred alternative, all EEZ coral reefs in unpopulated areas would be designated MPAs (that is, in the NWHI and PRIA, and at Guam's Southern Banks and Rose Atoll in American

Samoa). The outer boundary for these MPAs is the 50 fm isobath. A zone-based management approach is applied to MPA design and designation. First, two types of MPAs are proposed: no-take and low-use. No fishing is allowed in no-take MPAs including that by existing FMP fisheries. No-take MPAs are delineated by the 10 fm isobath except for certain ecologically sensitive areas where the boundary is extended to the 50 fm isobath. These areas are French Frigate Shoals, Laysan Island, the north half of Midway Island and Jarvis, Howland Island and Baker Islands, Kingman Reef, and Palmyra and Rose Atolls. The remaining EEZ waters around the NWHI and PRIA (within the 50 fm isobath) would become low-use MPAs, which require a tightly controlled special permit and conditions for fishing.

All extractive activities would be prohibited in no-take MPAs, except for small harvests related to scientific research and resource management. In low-use MPAs existing fishing activities, including other FMP fisheries and recreational fisheries by residents on certain remote islands, would be allowed. The permit regime and its specific exemptions, outlined above, would regulate these activities as well as allowing for indigenous or cultural uses.

Using the framework process, vessel anchoring areas may be designated in MPAs at a future date. The only immediate restriction proposed in this FMP applies to large fishing vessels at Guam's southern banks, which would be prohibited from anchoring at that low-use MPA. Fishing vessels transiting MPAs would be required to carry insurance in order to pay for the costs of vessel removal and habitat damage mitigation in the event of a grounding. The Council felt that prohibiting large non-fishing vessels, and in particular cruise ships, from entering MPAs would be beneficial. However, the Council does not have the authority to regulate these vessels. Several longer term, cooperative efforts are proposed to manage the potential impacts of these vessels.

Permits and Reporting

The preferred alternative would implement permit requirements for the harvest of coral reef resources in the low-use marine protected areas (MPAs) proposed for designation in the EEZ around the Northwestern Hawaiian Islands (NWHI), Johnston Atoll and Wake Island. Vessels regulated and targeting species managed by other FMPs would be exempt from this requirement. Regional permit and reporting requirements for the region's remaining EEZ waters would continue for the harvest of currently harvested coral reef taxa in areas adjacent to inhabited islands where reef resources are actively fished and managed under local laws and regulations.

However, the preferred alternative would also require detailed permit and reporting for potentially (but not previously) harvested coral reef taxa throughout the region's EEZ. In this manner, the expanding marine ornamentals fishery and emerging bioprospecting industries, which target a broader spectrum of coral reef resources including species about which little is known, can be controlled and managed appropriately.

Due to their ecological vulnerability, the preferred alternative would prohibit the of collection live stony coral or live rock for commercial purposes, except small amounts to be collected under a special permit for use as seed stock for aquaculture, for bioprospecting, or for customary and traditional indigenous purposes.

Bottom Line on Permits and Reporting

In most populated areas existing local monitoring programs would remain unchanged, although under the preferred alternative's framework provisions, a general permit could be developed and implemented for all EEZ coral reef resources at a later date, if needed. In unpopulated areas where coral reefs would be designated as marine protected areas, special permits would regulate the harvest of these resources. In addition, the harvest of live rock and coral would be specifically prohibited. There are four exemptions to this permit regime. Permit holders in other FMP-managed fisheries would not have to obtain an additional permit for the incidental catch of coral reef taxa, and indigenous people, aquaculture operations, and scientific management activities could be exempted from the prohibition on the harvest of coral and live rock via the special permit process.

Allowable Gears and Methods

Adverse impacts from fishing gear may include physical, chemical or biological alterations of the substrate and loss of, or injury to, benthic organisms, prey species and their habitat and other components of the ecosystem. Controls on fishing gear and methods are an effective tool for mitigating such impacts.

The preferred alternative's list of allowable gears is based first on its potential for minimizing damage to essential fish habitat (EFH). Use of poisons, explosives and intoxicating substances, methods of choice for harvesting live reef fish in Southeast Asia, would not be allowed. Nets would be allowed only if they are tended and if their retrieval does not break coral and damage bottom habitat (e.g., certain methods of gillnetting, lobster tangle nets). Traps would be allowed in areas and under conditions where there is low potential for damage to EFH and gear loss, (the preference is that traps be permanently marked to identify their owners). Manned and remotely-operated submersibles have minimal adverse effects on EFH and they too are allowed.

A second criteria for allowable gear is its catch selectivity. Hand harvest, spear, slurp gun, hand net, dip net, hoop net (for Kona crab), throw net, barrier net (for aquarium fish) are selective types of gear that would be allowed. Manned and remotely-operated submersibles are also highly selective, producing negligible bycatch. Surround nets and seines can be used to target schooling fish species (e.g., akule, weke, ta'ape, baitfish) with a minimum of non-target catch and would be allowed for this purpose. The selectivity of traps varies with fishing techniques and species preferences by seafood consumers in the different island groups of the US Pacific. Non-targeted species of fish can be released alive if carefully handled. The selectivity of hook-and-line gear (including handlines, electrically and hydraulically retrieved lines, rod and reel and trolling) varies enormously, depending on the skill and knowledge of the individual fisherman. Amateur fishermen casting from shore will catch a variety of wanted and unwanted fish species. Bottomfishing vessels are often equipped with electronic navigational devices to relocate fishing areas, and sonar devices to target productive habitat and fish aggregations. This gear is relatively selective, with the ability to successfully target particular species groups dependent upon the skill of the vessel captain. Experienced vessel crew have the ability to catch the desired species with little non-target catch. It is, however, impossible to completely avoid non-target species with most hook and line fishing methods. Despite variations in selectivity, all types of hook-and-line methods are allowed because of their low impact.

Although spearfishing is a highly selective method of fishing that has little adverse impact on EFH, the preferred alternative would allow SCUBA assisted fishing in the EEZ around the NWHI and

PRIA only during daylight hours. This is because, when used at night this method allows no refuge for target species which are captured while sleeping.

Bottom Line on Allowable Gears and Methods

In order to minimize resource and habitat impacts, three conditions on gear use are incorporated into the preferred alternative. There is a list of allowable gear types, which includes the following: hand harvest, spear, slurp gun, hand/dip net, hoop net for kona crab, throw net, barrier net for aquarium fish, surround/purse set net for targeted schooling fish (e.g., akule, baitfish, weke) with a minimum of bycatch, hook-and-line (powered and unpowered handlines, rod and reel, and trolling) traps (with conditions), and remote operating vehicles/sumbersibles. There are several gears specifically prohibited for the harvest of coral reef ecosystem management unit species: gillnets, trawls, dredges, tanglenets, longlines, explosives, and poisons. And SCUBA assisted spear fishing is prohibited at night in EEZs of the Pacific Remote Island Areas and the Northwestern Hawaiian Islands.

Other (Miscellaneous) Management Measures

As discussed above, the preferred alternative would allow only small collections of coral reef organisms for aquaculture seed stock, scientific research, bioprospecting, and cultural or indigenous uses. A special permit would be required for these activities.

In addition, fishing vessels transiting through marine protected areas would be required to carry insurance to cover the cost of wreck removal and pollution liability in the event of grounding.

Summary

The preferred alternative's combination of management measures is anticipated to provide enhanced levels of protection and increased opportunities for appropriate management of the region's coral reef ecosystem resources. Under this regime, the proposed Coral Reef Ecosystem FMP is expected to combine harvest controls with careful monitoring in a manner which allows for the controlled utilization of these vital resources.

3.0 DESCRIPTION OF THE CORAL REEF ECOSYSTEM

3.1 Coral Reef Ecosystems

Coral reefs are carbonate rock structures at or near sea level which support viable populations of scleractinian or reef-building corals. Apart from a few exceptions coral reefs are confined to the warm tropical and sub-tropical waters lying between 30°N and 30°N . Coral reef ecosystems are arguably, the oldest and certainly the most diverse and complex ecosystems on earth. Their complexity is manifest on all conceptual dimensions, including geological history, growth and structure, biological adaptation, evolution and biogeography, community structure, organism and ecosystem metabolism, physical regimes, and anthropogenic interactions (see sources cited by Hatcher et al 1989). There is a voluminous and expanding literature on coral reefs and coral reef ecosystems (see Birkland 1997), beginning with Charles Darwin's 1842 volume; The Structure and Distribution of Coral Reefs, which remains the seminal volume on reef formation and structure, including reefs in the Western Pacific Region. A key feature of reef building corals is the symbiotic relationship of the animal coral polyps, which incorporate algal cells known as zooxanthellae into their tissue and which provide the coral with much of its nutritional needs, principally carbohydrates through photosynthesis. Most corals supplement this food source by actively feeding on zooplankton or dissolved organic nitrogen due to the low nitrogen content of the carbohydrates derived from photosynthesis.

The corals and coral reefs of the Pacific are described in Wells & Jenkins (1988) and Veron (1995), The number of species of coral declines in an easterly direction across the Western and Central Pacific in common with the distribution of fish and invertebrate species, with over 330 species contained in 70 genera on the Australian Barrier Reef compared with only 30 coral genera present in the Society Islands of French Polynesia and 10 genera in the Marquesa and Pitcairn Islands. Hawaii, by virtue of its isolated position in the Pacific, also has relatively few species of coral (about 50 species in 17 genera) and, more importantly, lacks most of the branching or "tabletop" *Acropora* species which form the majority of reefs elsewhere in the Pacific. The Acropora species provide a large amount of complex three dimensional structure and protected habitat for a wide variety of fishes and invertebrates. As a consequence, Hawaiian coral reefs provide limited 'protecting' three dimensional space and is thought to account for the exceptionally high amount of endemic Hawaiian marine species. Further it is believed by many to account for the reason certain species of fish and invertebrates look and act radically different than similar members of the same species found in other parts of the South Pacific (Gulko 1999)

Most forms of coral reef development can be found in the Western Pacific Region including barrier reefs in Guam and Saipan, fringing reefs in the Samoas and Hawaii, and patch and submerged reefs, banks and shoals throughout the region, but particularly abundant in the Northwestern Hawaiian Islands and with in the US EEZ of the Northern Mariana Islands. Other habitats commonly associated with coral reefs include mangrove forests, particularly in estuarine areas. The natural eastern limit of mangroves in the Pacific is American Samoa, although the Red Mangrove Rhizophora mangle was introduced into Hawaii in 1902 and has become the dominant plant within a number of large protected bays and coastlines on both Oahu and Molokai (Gulko 1999). Apart from the usefulness of the wood for building, charcoal and tannin, mangrove forests act to stabilize areas where physical sedimentation is occurring and, from a fisheries perspective, are important as nursery grounds for peneaeid shrimps and some inshore fish species, and form the habitat for some commercially valuable crustaceans.

Sea grasses are common in all marine ecosystems and are a regular feature of most of the inshore areas adjacent to coral reefs in the Pacific islands. According to Hatcher et al (1989), sea grasses stabilize sediments because leaves slow current flow, thus increasing sedimentation of particles. The roots and rhizomes form a complex matrix which binds sediments and stops erosion. Sea grass beds are the habitat of certain commercially valuable shrimps, and provide food for reef-associated species such as surgeonfishes (Acanthuridae) and rabbitfishes (Siganidae). Sea grasses are also important sources of nutrition for higher vertebrates such as dugongs and green turtles. A concise summary of the seagrass species found in the western tropical South Pacific is given by Coles and Kuo (1995). From the fisheries perspective, the fishes and other organisms harvested from the reef coral and associated habitats such as mangroves, seagrass beds, shallow lagoons, bays inlets and harbors, and the reef slope beyond the limit of coral reef growth contribute to the total yield from coral reef associated fisheries. Unlike other Council FMP's which are broadly species based, a key concept of this FMP is that it is ecosystem based, concerned not only with the health of target stocks, but also with the preservation of the coral reef ecosystems within the Western Pacific Region. To do this requires an understanding of the ecosystem components an ecosystem and how these various components interact.

Reef Productivity

Coral reefs are among the most biologically productive ecosystems in the world. The global potential for coral-reef fisheries has been estimated at 9 million tons per year, which is impressive given the small area of reefs compared to the extent of other marine ecosystems which collectively produce between 70 - 100 million tons/year (Smith 1978; Munro 1984). An apparent paradox of coral reefs, however, is their location in the nutrient deserts of the tropical oceans, i.e. water of high clarity and generally low gross primary productivity, generally ranging between 20 to 50 $gCm^{-2}yr^{-1}$. Coral reefs themselves are characterized by the highest gross primary production in the sea with reef flats and margins sustaining primary production rates of between 1,800-3700 $gCm^{-2}yr^{-1}$, and sand and rubble zones about 370 $gCm^{-2}yr^{-1}$. The main primary producers on reefs are the benthic microalgae, macroalgae, symbiotic microalgae of corals and other symbiont-bearing invertebrates. Zooxanthellae living in the tissues of hard corals make a substantial contribution to primary productivity in zones rich in corals due to their density (e.g. $>10^6$ cells cm^{-2} of live coral surface) and the high rugosity of the surfaces on which they live as well as their own photosynthetic potential. However, zones of high coral cover comprise only a small portion of entire coral reef ecosystems, and so their contribution to total reef gross primary productivity is small.

Although the ocean surface waters in the tropics generally have low productivity, these unproductive waters which bathe coral reefs are continually moving. Reefs therefore have access to substantial open-water productivity. Thus particularly in inshore continental waters, shallow benthic habitats such as reefs must not always be considered the dominant sources of carbon for fisheries. Outside sources may be important for reefs , and while this significance is rarely estimated, its input may be living (plankton) or dead (detrital) forms. In coastal waters detrital matter from land, the plankton and fringing marine plant communities is particularly abundant. There may be passive advection of particulate and dissolved detrital carbon onto reefs, and active transport on to reefs via fishes which shelter on reefs but feed in adjacent habitats. There is therefore greater potential for nourishment of inshore reefs than offshore reefs by external carbon sources and this inshore nourishment will be enhanced by large land masses.

For most of the Pacific islands rainfall typically ranges from 2,000 to 3,500 mm/yr. Low islands such as makateas and atolls tend to have less rainfall and may suffer prolonged droughts. Further, when rain does fall on coral islands and makateas where there is no major catchment area, there is little allochthonous nutrient input into surrounding coastal waters and lagoons. Lagoons and embayments around high islands in the South Pacific are therefore likely to be more productive than atoll lagoons. The productivity of high island coastal waters, particularly where there are lagoons and sheltered waters, is possibly reflected in the greater abundance of small pelagic fishes such as anchovies, sprats, sardines, scads, mackerels and fusiliers (Anon 1984). Furthermore, the range of different environments that can be found in the immediate vicinity of the coasts of high islands also contributes to the greater range of bio-diversity found in such locations.

Studies on coral reef fisheries are relatively recent, commencing with the major study by Munro & co-workers during the late 1960s in the Caribbean (Munro 1983) and even today, only relatively few examples are available of in-depth studies on reef fisheries. It was initially thought that the maximum sustainable yields for coral reef fisheries were in the range of 0.5 - 5 $t/km^{-2}yr^{-1}$, based on limited data (Stevenson & Marshall 1974, Marten & Polovina 1982). Much higher yields of around 20 $t/km^{-2}yr^{-1}$, for reefs in the Philippines (Alcala 1981; Alcala & Luchvez 1981) and American Samoa (Wass 1982) were thought to be unrepresentative (Marshall 1980), but high yields of this order have now been independently estimated for a number of sites in the South Pacific and Southeast Asia (Dalzell 1996; Dalzell & Adams 1997). These higher estimates are closer to the maximum levels of fish production predicted by trophic and other models of ecosystems (Polunin et al 1996). Dalzell & Adams (1997) suggest that the average MSY for Pacific reefs is in the region of 16 $t/km^{-2}yr^{-1}$ based on 43 yield estimates where the proxy for fishing effort was population density.

However, Birkeland (1997) has expressed some scepticism about the sustainability of the high yields reported for Pacific and SE Asian reefs. Among other examples, he notes that the high values for American Samoa reported by Wass (1982) during the early 1970s were followed by a 70% drop in coral reef fishery catch rates between 1979 and 1994. Saucerman (1995) ascribed much of this decline to a series of catastrophic events over the same period beginning with a crown of thorns infestation in 1978, followed by hurricanes in 1990 and 1991 which reduced the reefs to rubble and a coral bleaching event in 1994, probably associated with the El Nino phenomenon. These various factors reduced live coral cover in American Samoa from a mean of 60% in 1979, to between 3-13% in 1993.

Further, problems still remain in rigorously quantifying the effects of factors such as primary productivity, depth, sampling area or coral cover on yield estimates. Polunin et al (1996) noted that there was an inverse correlation between estimated reef fishery yield and the size of the reef area surveyed, based on a number of studies reported by Dalzell (1996). Arias-Gonzales et al (1994) have also examined this feature of reef fisheries yield estimates also noted that this was a problem when comparing reef fishery yields, noting that estimated yields are based on the perception of the investigator as to the maximum depth at which true reef fishes occur. Small pelagic fishes such as scads and fusiliers may comprise large fractions of the inshore catch from a particular reef and lagoon system and if included in the total catch can greatly inflate the yield estimate. The great variation in reef yield summarized by authors such as Arias-Gonzales et al (1994), Dalzell (1996) and Dalzell & Adams (1997) may also be due in part to the different size and trophic levels included in catches.

Another important aspect of the yield question is the resilience of reefs to fishing and recovery potential when overfishing or high levels of fishing effort have been conducted on coral reefs. Evidence from a Pacific atoll where reefs are regularly fished by community fishing methods such as leaf seeps and spearfishing indicated that depleted biomass levels may recover to pre-exploitation levels within 1-2 years. In the Philippines, abundances of several reef fishes have increased in small reserves within a few years of their establishment (White 1998; Russ & Alcala 1994), although recovery in numbers of fish is much faster than recovery of biomass, especially in larger species such as groupers. Other studies in the Caribbean and SE Asia (Polunin et al 1996) indicate that reef fish populations in relatively small areas have the potential to recover rapidly from depletion in the absence of further fishing. Conversely, Birkeland (1997) cites the example of a pinnacle reef off Guam fished down over a period of 6 months in 1967 and which has still not recovered 30 years later.

Estimating the recovery from and reversibility of fishing effects over large reef areas appears more difficult to determine. Where growth overfishing predominates, recovery following effort reduction may be rapid if th fish in question are fast growing, as in the case of goat fish (Garcia & Demetropolous 1986). However, recover may be slower if biomass reduction was due to recruitment overfishing as it takes time to rebuild adult spawning biomasses and high fecundities (Polunin & Morton 1992). However, many coral reef species have limited distributions, confined to a single island or a cluster of proximate islands. Widespread heavy fishing could cause global extinctions of some such species, particularly if there is also associated habitat damage. Ironically the majority of species with a limited range are also valuable. to the aquarium trade, and in the future restrictions on capture, possibly through CITES listing, may be appropriate to prevent overfishing.

<u>Extent and distribution of coral reefs</u>

Roughly 70 % of the world's coral reefs, or 420,000 km^2 are located in the Pacific Ocean (Bryant et al. 1998). Of all reefs under U.S. jurisdiction, 94 percent (Clark and Gulko 1999), or an estimated 15,852 km^2 of reef area, are associated with US Pacific islands (Hunter 1995). The table below shows their geographical distribution. Note that the much of this coral reef is located in areas where there is no human population (NWHI, remote US territories) or in island archipelagos where populations are concentrated on one or two islands (American Samoa, CNMI).

Coral reef area (in km^2 <100m deep) in nearshore waters (0-3 nmi from shore) and offshore waters (3-200 nmi from shore) in each location in the western Pacific region (Hunter 1995)

Location	0-3 mni	3-200 nmi	Total Coral Reef Area
American Samoa	271	25	296
Guam	69	110	179
Hawaii			
Main Hawaiian Islands	1,655	880	2,535
Northwestern Hawaiian Islands	2,227	9,104	11,331
Midway	203	20	223
Commonwealth of the Northern Marianas Islands	45	534	579
Remote US Pacific Island Areas	620	89	709
TOTAL	5,090	10,762	15,852

3.1.1 Coral Reef Ecological Characteristics and Resource Dynamics

Coral reefs and reef-building organisms are confined to the shallow upper photic zone and area normally restricted to depths less than 50-100 m (25-50 fm) (Maragos and Holthus 1995). Maximum reef growth and productivity occurs between 5-15 m (Hopley and Kinsey 1988) and maximum diversity of reef species occurs at 10-30 m (Huston 1985).

Available biological and fishery data are poor for all species and areas covered by the CRE-FMP and it is not possible to implement EPAP principle 4 (i.e., calculate total removals– including incidental mortality– and show how they relate to standing biomass, production, optimum yields, natural mortality, and trophic structure). Furthermore, high biological and environmental variability is a natural characteristic of coral reef ecosystems around the US Pacific islands, with or without fishing. Irregular pulses of new recruits (Walsh, 1987) cause cycles in the abundance and harvest potential of individual reef species. Environmental variability is both spatial, related to differences in the quality of habitat (Friedlander and Parrish, 1998a) and temporal, related to monthly moon phase, seasonal and longer-term environmental changes (Friedlander and Parrish, 1998b).

Polovina et al. (1994) examined a large-scale climatic shift that affected coral reef resources in the NWHI from the mid-1970s to the late 1980s. During this period, the central North Pacific experienced increased vertical mixing, with a deepening of the wind-stirred surface layer into nutrient-rich lower waters and probable increased injection of nutrients into the upper ocean.

Resulting increased primary productivity likely provided a larger food base for fish and animals at higher tropic levels. In the NWHI, changes of 60 to 100 percent over baseline levels in productivity for lobsters, sea birds, reef fish and monk seals were observed and attributed to deeper mixing during 1977-1988.

The highest quality habitat on a coral reef is often where abundant living coral has created high bottom relief. Natural disturbance cycles in areas exposed to large storm waves can dramatically alter habitat quality. For example, periodic storms in the Northwestern Hawaiian Islands (NWHI) reduce live coral cover to 10 percent in some areas. Coral cover eventually returns to 50 percent or more, depending on how protected the area is (R. Grigg, 104th Council meeting, June 2000).

Unlike pelagic ecosystems, which are driven primarily by oceanographic forces operating on a large scale, coral reef ecosystems are strongly influenced by biological processes, habitat utilization and environmental conditions at a relatively small scale. Innumerable animals and plants shelter, attach or burrow into the reef structure, creating some of the most biologically diverse and complex ecosystems on earth.

Ecological relationships

Coral reef ecosystems have existed in geological terms for nearly twice as long as flowering plants and some of the coral genera are more ancient than any grasslands. Therefore, the ecological relationships have had more time to develop complexity in coral reefs. A major portion of the primary production of the coral reef ecosystem comes from complex inter-kingdom relationships of animal/plant photo-symbioses hosted by animals of many taxa, most notably stony corals. Most of the geological structure of reefs and habitat is produced by these complex symbiotic relationships.

Complex symbiotic relationships for defense from predation, removal of parasites, building of domiciles and other functions are also prevalent. About 32 of the 33 animal phyla are represented on coral reefs (only 17 are represented in terrestrial environments) and this diversity produces complex patterns of competition. The diversity also produces a disproportionate representation of predators which have strong influences on lower levels of the food web in the coral reef ecosystem (Birkeland, 1997a). The Figure on adjacent page shows how a simplified diagram of how inter-relationship with other organisms and the surrounding environment can effect the population dynamic of reef species during different life phases.

Interrelationships Within Coral Reef Ecosystem

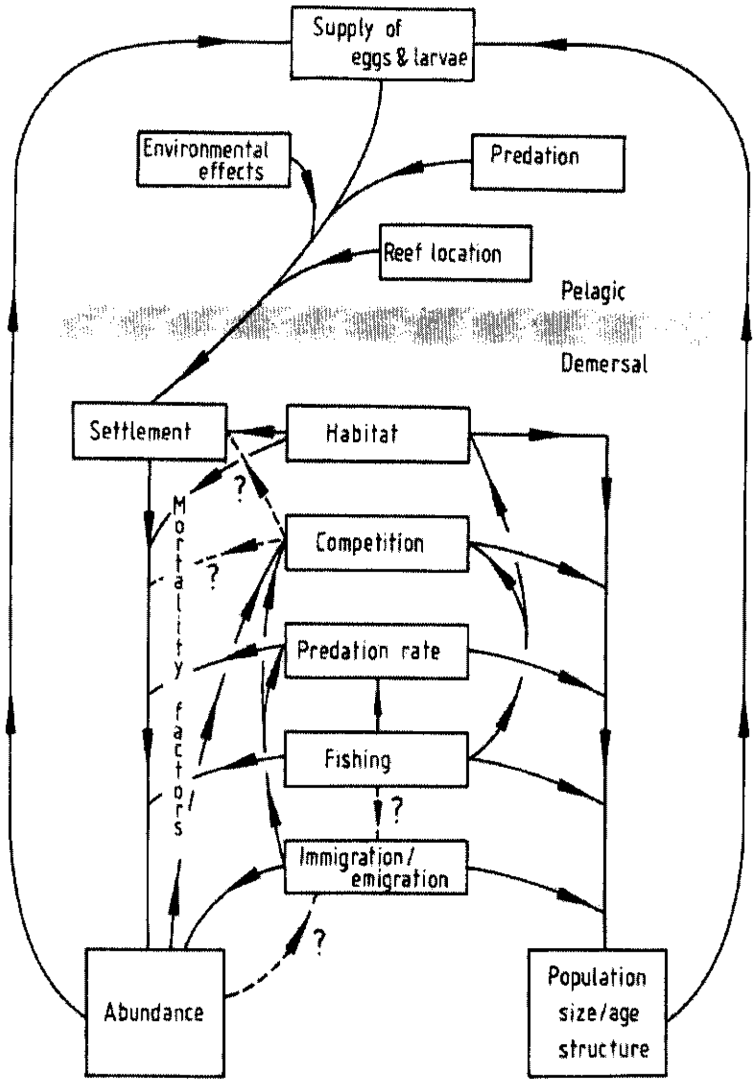


Fig. 3. Flow diagram illustrating factors determining the abundance and size/age structure of populations of reef fishes and their interrelationships. Arrows show the direction of effects, and solid links indicate those relationships supported by field evidence. Dashed links with question marks indicate expected relationships for which supporting evidence is as yet unavailable. Fishing mortality affects abundance and size/age structure of populations both directly and indirectly. Removal of fishing mortality may therefore be expected to result in pronounced changes in population structure.

Source: Roberts and Polunin, 1991.

In areas with high gross primary production but low net primary production or yield (e.g., rain forests and coral reefs), animals and plants tend to have a higher variety and concentration of natural chemicals as defenses against herbivores, carnivores, competitors and microbes. Because of this tendency and the greater number of phyla in the system, coral reefs are now a major focus for bioprospecting, especially in the southwest tropical Pacific (Birkeland, 1997a).

Coral reef habitat

Even within a thriving coral reef habitat, not all space is occupied by corals or coralline algae. Reefs are typically patchworks of hard and sediment bottoms. A reef provides a variety of environmental niches, or combination of resources. The wide variety of survival strategies of coral reef organisms allows different species to exploit some combination of resources better than their competitors. The ecosystem is dynamic, however. If conditions change, a very specialized species may not be able to survive the rigors of the new environment or may be forced out by another species more adept at using the available resources, including space, food, light, water motion and temperature.

Long-term Ecosystem Variability

Climate and ecosystem shifts may occur over decadal scale cycles or longer, meaning that resources management decisions need to consider changes in target level productivity over the long term as well as short term inter-annual variation.

For example the climatic shift that occurred in the central North Pacific in the late 1980s (see above) produced an ecosystem shift in the NWHI to a lower carrying capacity, with a 30-50% decline in productivity (Polovina et al. 1994) . This in turn had a concomitant negative effect on recruitment and survival of monk seals, reef fish, albatross and lobsters. Under the lower carrying capacity regime, fishing alters the age-structure of the population and may also lead to stock depletion.

At Laysan Island, where lobster fishing is prohibited, spawning biomass of lobsters was also depleted by natural mortality. This suggests that marine reserves may not guarantee the protection that is typically assumed (Polovina & Haight 1999). In response to this natural variability the Council adjusted its management measures (e.g., limited entry, annual quota) to reduce catch and effort to about 25% of its pervious level of the 1980s.

The destruction of coral reefs around the principal island in American Samoa, Tutuila, as described earlier, forced fishermen to move into predominantly pelagic fishing, initially trolling and latterly small scale longline fishing. Much of American Samoas reef fish now comes from Western Samoa. The reduction of fishing on coral reefs may also aid in the recovery of the live coral cover, but the long term recovery of the reefs around Tutuila is going to depend principally on a benign climate and marine environment over the next decade. Further, these destructive events occurred during a long-term shift in the physical environment of the equatorial Pacific Ocean which began in 1977 (Miller et al. 1994). Conditions included more clouds, more rainfall, warmer sea surface temperatures and weaker trade winds, similar to a weak decadal El Nino state. They were most pronounced in the central equatorial Pacific, so American Samoa was close to the center of this shift, which persisted until 1999, when conditions began to change. Whether 1999 marks another regime shift will not be known for several years (J. Polovina, pers. comm.).
The destruction of American Samoan coral reefs included a period of bleaching in 1994, which was also occurred to reefs in the Cook Islands and French Polynesia and was due to unseasonably high sea water temperatures. Coral bleaching occurs when corals lose or expel their zooxanthellae in large numbers, usually due to some trauma such as high or low temperatures or lower than usual salinities (Brown 1997). The corals that lose zooxanthellae also their color, becoming white and hence the term 'bleaching' Although first described in the 1900s, interest in this phenomenon was

heightened in the 1980s and 1990s after a series of major bleaching events in the Atlantic and Pacific Oceans. Some of these episodes were linked to the El-Nino Southern Oscillation or ENSO events (Gulko 1999).

When bleaching occurs, some corals are able to slowly re-infect themselves with zooxanthellae or through the reproduction of remaining zooxanthellae within the colony. Frequently, the loss of large amounts of symbiotic algae results in the colony becoming energy deficient, where it expend more energy than it is consuming, and if this occurs over the long term the colony dies (Gulko 1999, Brown 1997). Coral bleaching events require only a 1-2 °C change upwards of water temperature, and hence there are concerns that bleaching will become an increasing phenomenon due to global warming. Goreau et al (1997) note that corals in the Atlantic and the Indian Oceans also show that corals world wide are acclimated close to their upper temperature limits and are unable to adapt rapidly to an anomalous warming (Goreau et al 1997). consequently global warming represent a very serious threat to the survival of coral reefs.

Other physical phenomena that may bring long term change to coral reef systems include the impact of hurricanes and tectonic uplift. Bayliss-Smith describes the changes in reef islands at Ontong-Java Atoll over a 20 years period following severe hurricane. Most atoll islands are on reef flats in what are frequently high wave-energy locations near to seaward reef margins, and so would not be stable unless composed of coarse shingle and rubble. Hurricanes will destroy such small cays and scour motu beaches, and strip small or narrow islands of fine sediment during over-wash periods. Bayliss Smith notes that hurricanes tend to erode existing islands, but at the same time produces the material for their reconstruction. More frequent lower magnitude storms contribute to the process by transporting the rubble ramparts thrown up by hurricanes so as to reconstruct scoured beaches and eroded shore lines. Clearly such destruction and reconstruction activity on reef flats will have an effect on reef organisms including fish and invertebrates, particularly where large areas of reef are smothered by sand and silt following a hurricane.

A much slower but nonetheless profound influence on coral reef systems is the process of tectonic uplift, which although slow may create major change over the period of several centuries or millenia. A productive reef flat through time may be raised above the surface to become a terrace and thus reduce the amount of available reef area for fishing, as occurred at Niuatoputapu and in the Tonga archipelago (Kirch & Dye 1979). Tectonic uplift was also partially responsible for the change of the central lagoon of the island of Tongatapu from a marine to a brackish water environment, and the loss of an important reef mollusc resource *Anadara antiquata* which could not survive the reduced salinity. A similar event occurred at Tikopia in the Solomon Islands where a circular bay with a narrow entrance became a brackish coastal lake as the bay entrance was sealed through a combination of tectonic uplift, and increased sedimentation in the runoff from agriculture on neighboring slopes. Again this major habitat change wiped out a major food source in the form of reef and lagoon associated molluscs (see sources cited in Dalzell 1998).

3.1.2 Coral Reef Communities

Coral reef communities are among the most diverse and ecologically complex systems known. The structure of reef communities is usually defined in terms of the diversity and relative abundances of species characteristic of a habitat type. Commonly, only a few species compose over half the abundance, while hundreds of others are present in low numbers.

Life History

The literature on coral reef fish life histories is voluminous, but convenient entries into the literature are provided by Sale (1991); Polunin and Roberts (1996) and Birkeland (1997). The life of a coral reef fish includes several stages. Typically spawning occurs in the vicinity of the reef and is characterized by frequent repetition throughout a protracted season of the year, a diverse array of behavioral patterns, and extremely high fecundity. The eggs of many species are fertilized externally and dispersed directly into the pelagic environment as plankton. Other species have demersal eggs which upon hatching disperse larvae into the pelagic realm. Planktonic mortality is very high and unpredictable. Recruitment is the transition stage form the planktonic larval life to demersal existence on a coral reef. Recruitment is highly variable both spatially and temporally. This is when post-larval juveniles begin their residence on reefs where many remain for life. Highest predation mortality occurs within the first few days or weeks while growth out of the juvenile size is rapid.

The populations of terrestrial animals are usually dispersed by adults who deposit eggs or build nests in selected locations. In contrast, the most frequent pattern of coral reef organisms is dispersion of eggs and larvae in water currents which determine the final location of adults. The adults are often sedentary or territorial. The differences in factors which bring about success in these two phases of life histories complicate fisheries management (Birkeland, 1997a).

Species distribution and abundance

Species diversity declines eastwards across the Pacific from the locus of maximum species richness in Southeast Asia (Philippines/Indonesia) and is related in part to the position of land masses in relation to the Pacific Plate, the earth's largest lithospheric plate (Springer 1982). In general, the species richness is greatest along the plate margin and declines markedly on the plate itself. The net result is that islands in the Central Pacific have a lower reef organism diversity but also a high degree of endemism. For example, Guam has about 269 species of zooxanthellate Scleractinia, about 40 Alcyonacea and just under a thousand species of fishes, compared to far fewer in Hawaii. The proportion of endemic species increases in the opposite direction. For example, the Hawaiian Islands have about 18% endemic zooxanthellate corals, 60% endemic Alcyonacea and 25% endemic reef fishes, compared to the islands in the southwest portion of the Western Pacific Region. Likewise, the proportion of alien species in Hawaiian waters is greater and is increasing (Birkeland, 1997a).

Among the diverse array of species in each taxa on coral reefs, there are usually only a few that are consistently abundant, with the relative numbers of species within a taxa possibly approximating a log-normal distribution. The majority of species are relatively uncommon or only episodically abundant, following unusually successful recruitment (Birkeland, 1997a).

Individual sub-populations of larger stocks of reef species may increase, decrease or cease to exist locally without adversely affecting the overall population. The condition of the overall populations of particular species is linked to the variability among sub-populations: the ratio of sources and sinks, their degrees of recruitment connection, and the proportion of the sub-populations with high variability in reproductive capacity. Recruitment to populations of coral reef organisms depends largely on the pathways of larval dispersal and "downstream" links. Are the connections sufficient to actually restock distant sub-populations or only enough to maintain a homogenous genetic stock?

Reproduction and recruitment

The majority of coral reef animals are very fecund but temporal variations in recruitment success have been recorded for some species and locations. Many of the large, commercially targeted coral reef animals are long-lived and reproduce for a number of years. This is in contrast to the majority of commercially-targeted species in the tropical pelagic ecosystem. Long-lived species adapted to coral reef systems are often characterized by such complex reproductive patterns as sequential hermaphroditism, sexual maturity delayed by social hierarchy, multi-species mass spawnings and spawning aggregations in predictable locations (Birkeland, 1997a).

Growth and mortality rates

Recruitment of coral reef species is limited by high mortality of eggs and larvae, as well as by competition for space to settle out on coral reefs. Intensity of predation from a disproportionate number of predators limits the survival of juveniles (Birkeland 1997a).

Some fishes such as parrotfish and wrasses grow rapidly compared with most coral reef fishes, but they still grow relatively slowly compared to pelagic species. In addition, scarids and labrids may have complex haremic, in the case of parrotfish, territorial social structures that contribute to the overall affect of harvesting these resources. It appears that many tropical reef fishes grow rapidly to (near) adult size, and there often grow relatively little in length over a protracted adult life span, thus are relatively long–lived. In some groups of fishes, such as damselfish, individuals of the species are capable of rapid growth to adult size, but sexual maturity is still delayed by social pressures. This complex relationship between size and maturity makes resource management more difficult (Birkeland, 1997a).

Community Variability

High temporal and spatial variability is characteristic of reef communities. At large spatial scales, variation in species assemblages may be due to major differences in habitat types or biotopes (e.g., seagrass beds, reef flats, lagoonal patch refs, reef crests, seaward reef slopes).

Reef fish communities from the geographically isolated Hawaiian Islands are characterized by low species richness, high endemism, and exposure to large semiannual current gyres, which may help retain planktonic larvae. The NWHI is further characterized by 1) high latitude coral atolls, 2) a mild temperate to subtropical climate, where inshore water temperatures can reach below 18°C in late winter, 3) species which are common on shallow reefs and attain large sizes, which occur only rarely or in deep water to the southeast, and 4) inshore shallow reefs that are largely free of fishing pressure.

3.1.3 Ecosystem Models

Several approaches to model multi-species fisheries have been used by coral reef fisheries scientists with varying levels of success. The simplest approach has been to consider a community to be the sum of its species. Unfortunately, with highly diverse systems such as coral reefs, this leads to an extremely complex model with potentially hundreds of parameters. An alternative is to divide the assemblage into separate trophic levels and model the energy flow through the system to estimate potential yields (e.g., ECOPATH).

General multi-species models have also been applied by several researchers to estimate yields in coral reef fisheries. These models are based on simultaneous Lotka-Voltera equations which incorporate the impact of each species population size on every other species through use of shared resources. These models may be extended to incorporate predation and harvesting. These approaches are mentioned as possible avenues for future assessment methodologies, although at present the lack of data precludes their usage.

ECOPATH

ECOPATH is a simple mathematical model that estimates mean annual biomass, production and food consumption for major components (species groups) of a coral reef ecosystem (Polovina 1984). Species groups include tiger shark, monk seal, seabirds, reef sharks, sea turtle, small pelagics, jacks, reef fish (and octopus), lobsters and crabs, deepwater bottomfish, nearshore scombrids, zooplankton, phytoplankton, herterotrophic benthos and benthic algae. A box model illustrates a biomass budget schematic for major predator-prey pathways and lists annual production and annual biomass for each group. The model shows a high percent of internal predation which partially explains why fishery yields from coral reefs are generally low despite high primary productivity. A constraint of the ECOPATH approach is the allocation of species to trophic compartments, which imposes an artificial structure and may not coincide with actual community structure. This approach is also data intensive and requires information on each species' diet, mortality, and growth rates.

Extensive field work from French Frigate Shoals provided estimates of parameters used to validate the model. Application of ECOPATH to French Frigate Shoals found that the coral reef ecosystem is controlled mainly by predation from the top down and primary production is controlled mainly by nutrients, photosynthetic rate limits, and habitat space (Grigg et al. 1984). Fishery yields can be maximized by targeting lower trophic levels and cropping top predators to release pressure on prey. A fishery targeting tiger sharks at French Frigate Shoals should help ease predation pressure on endangered Hawaiian monk seals and threatened Hawaiian green turtles. Coral reef ecosystems are susceptible to overfishing due to high levels of natural mortality and low net annual production. A study of coral reef fish communities on patch reefs at Midway Atoll found a relative degree of resilience to several years of fishing pressure on top predators, while some control by predation was detected (Schroeder 1989).

ECOSIM

ECOSIM is a computer model that uses the output of the ECOPATH model. Input parameters, by species (or species group), include natural and fishing mortality, diet composition and production to biomass ratio. The vulnerability level of prey to predators can be adjusted. Gear selectivity levels can also be set. Predation levels are then determined. The model can be run for several decades to indicate qualitative changes in the structure of the resource community. Applying various levels of fishing pressure can indicate which target and non-target species increase and which decrease in abundance, considering predator-prey interactions (Kitchell et.al.1999). For example, a simulation run where most sharks were removed was found to produce little change on lower trophic-level species (i.e., sharks were not found to be important in stabilizing the ecosystem) (C. Boggs, pers. comm.).

3.1.4 Ecosystem Overfishing

The special vulnerability of targeted coral-reef resources comes from life-history traits of these economically valuable species that live in diverse communities with strong predatory and competitive forces. Coral-reef species are adapted for multiple reproduction because of improbable survival of progeny and therefore grow slowly, delay first reproduction, and are territorial compared with pelagic species. These life-history traits of coral-reef species make recovery from overfishing very uncertain. Some coral-reef ecosystem, driven by biological interactions, have not recovered for decades following intensive harvest and there are no indications that they will recover, while pelagic fisheries driven by oceanographic processes usually recover. For example, black-lipped pearl oysters at Pearl & Hermes Atoll in the NWHI were over-harvested to commercial extinction in the late 1920s, and recent surveys have demonstrated that the stocks have still not recovered after 70 years. Holothuroids or sea cucumbers were over-harvested in the late 1930s in Chuuk, Eastern Carolines, and recent surveys have shown the stocks have not recovered after 60 years. Dalzell et al (1996) cite several other examples of pearl oyster and sea-cucumber over-harvesting in the Pacific Islands where populations have failed to recover after several decades of no fishing.

Fishing activities that may degrade coral reef ecosystems, such as overfishing, can ultimately affect ecosystem processes (e.g., the removal of herbivorous fishes can lead to the overgrowth of coral by algae) and destroy the availability of coral reef resources (e.g., extraction of fishing aggregations of groupers). Munro (1983; 1999) has suggested that overfishing of reef predatory species may lead to a decline in the natural mortality of herbivores which will respond by increasing in biomass. When these in turn are overfished, there will be no control of algal production and biomasses of algae and sea-grasses will increase, with most production turning to detritus. However, there are few well documented examples of such effects cascading through ecosystems.

Munro (1999), cites the example of the north coast of Jamaica where reefs are almost entirely overgrown by macro-algae and the cover of live coral is extremely low. Although there is not full agreement between scientists, it appears that this can be attributed to the long term effects of overfishing. The island shelf is very narrow (<1km) and was covered by flourishing coral reefs until 1984. Then several events combined to change the situation. The herbivorous long-spined sea urchin, *Diadema antillarum* suffered a catastrophic epidemic that spread rapidly through the Caribbean and the north coast of Jamaica took a direct hit from a major hurricane. The reefs were pulverized by heavy seas and large corals were stripped of tissue. Macroalgae colonized all the newly exposed surfaced and in the absence of sea urchins and herbivorous fish have remained dominant up to the present (Hughes 1994). Other parts of the Caribbean with less heavily exploited fish stocks lost their urchin populations and suffered hurricanes but the reefs were not massively overgrown with algae. While it cannot be proven that overfishing was the cause of this catastrophe, the evidence points in that direction.

The Magnuson-Stevens Act requires fishery management units to be considered as individual species or taxonomic groups of species and Maximum Sustainable Yield (MSY) to be calculated for each species or group. There are thousands of potentially economically valuable species on coral reefs, a major portion of which have not been given scientific names and officially described. The major economic utilization of reef resources in the immediate future is bio-prospecting. The approach is to find as many species for pharmaceuticals as possible, whether officially described or not. If a species by species approach and a MSY for each resource are required, it will be many decades before a FMP can be completed and economic development can be initiated. The complex multispecies interactions on coral reefs requires an ecosystem-level approach as espoused by the NMFS Ecosystems Principles Advisory Panel.

Ecosystem overfishing occurs when fishing pressure causes changes to the species composition in a multispecies setting, often resulting in changes in ecosystem function (DeMartini et al., 1999). The concept of ecosystem overfishing may be most appropriate for the CRE-FMP, detected by shifts in species composition or trophic web dynamics, while simultaneously guarding against single stock recruitment overfishing where applicable. Because the coral reef ecosystem is a multispecies community removal of certain species may disrupt species diversity and possibly lead to the unwanted predominance of often less valuable generalist species. Changes in species dominance patterns in coral reefs experiencing fishing pressure have been reported for a number of tropical stocks from various areas around the world. It is also well known that the sensitivity of multispecies systems to environmental fluctuations increases as the level of exploitation increases.

3.2 Economic Environment

3.2.1 Overview

American Samoa

The Territory of American Samoa is a group of islands with a total land area of 76 square miles lying approximately 2,300 miles southwest of Hawai`i. The islands of the territory include Tutuila, the three islands of Ofu, Olosega, and Ta`u of the Manua`a group, Aunu`u, Rose Atoll and Swain`s Island. Formal annexation of Tutuila and Aunu`u by the U.S. occurred in 1900, Manu`a agreed to cede its authority to the U.S. in 1904. Swain`s Island was annexed in 1925. The islands remained under naval administration from 1900 to 1951, when the administration of American Samoa was transferred to the Secretary of the Interior. Ethnic divisions within the population of 56,000 include Samoans (89%), Caucasians (2%), Tongans (4%) and others (5%).

American Samoa has a small developing economy, dependent mainly on two primary income sources: the American Samoa Government (ASG), which receives income and capital subsidies from the United States, and two tuna canneries on the island of Tutuila. The two primary sources have given rise to a third: a services sector that derives from and complements the first two (Bank of Hawaii Economic Research Dept., 1997). American Samoa is lowest in gross domestic product and highest in donor air per capita among the US Pacific islands (Adams, et al., 1998).

Because of its tuna canneries, Pago Pago is the leading US port in terms of dollar value of fish landings. Star-Kist Samoa has become the largest tuna cannery in the world. Ancillary businesses associated with the tuna processing industry also contribute significantly to American Samoa's economy. Pago Pago Harbor supports mostly large fishing vessels, tankers and container ships. Shoreside infrastructure for small domestic fishing vessels is minimal. Commercial fisheries for bottomfish and reef fish make a minor contribution to the island's overall economy. The social and cultural importance of coral reef resources in American Samoa dwarfs their commercial value.

Guam

The Territory of Guam is an island of 212 square miles located at the southern end of the Mariana Islands Archipelago. It is 1,500 miles form Tokyo and 3,700 miles from Honolulu. The island was ceded to the United States following the Spanish American War of 1898 and has been an unincorporated territory of the U.S. since 1949. The estimated population of Guam is 163,373. The ethnic composition of the island is 43% Chamorro, 23% Filipino, 14% Caucasian, 5% other Pacific Islanders and 15% other ethnic groups.

Guam's economy has become so dependent on tourists from East Asia, particularly Japan, that any significant economic, financial and foreign exchange development in the region has had an immediate impact on the territory. During the mid- to late-1990s, as Japan experienced a period of economic stagnation and cautious consumer spending, visitor arrivals from Japan dropped and the impact was felt as much on Guam as in Japan. The US military presence on Guam has diminished to the lowest level in decades. Nevertheless, the military remains a vital stabilizing economic factor for Guam, particularly in times of regional economic crises. The Government of Guam currently supplies more than 20 percent of all civilian jobs in the territory. Recent deficits have resulted from a steady rise in government spending at the same time that tax bases have not kept up with spending demands (Bank of Hawaii Dept. of Economic Research, 1999).

With regard to commercial fishing, the most significant attribute of Guam is its status as a regional tuna transshipment center and re-supply base for foreign tuna fleets (Hamnett and Pintz, 1996). Guam is the fourth leading US port in terms the dollar value of fish landings, which are mostly for transhipment to tuna markets in Japan. Commercial domestic fisheries for reef fish and bottomfish make a relatively minor contribution to the Guam economy. The social and cultural importance of coral reef resources in Guam dwarfs their commercial value.

Commonwealth of the Northern Mariana Islands

The Commonwealth of the Northern Mariana Islands (CNMI)is the U.S.-affiliated island group closest to Asia. It is 1,500 miles from Japan, 1,400 miles from Taiwan and 2,000 miles from South Korea. The CNMI consists of 14 islands, five of which are inhabited, with a total land area of 176.5 square miles spread over about 264,000 square miles of ocean. The Northern Mariana Islands became part of the Pacific Trust Territory administered by the U.S. under a mandate granted in 1947. The Covenant that created the Commonwealth of the Northern Mariana Islands and attached it to the United States was fully implemented in 1986, pursuant to a Presidential Proclamation that terminated the Trust Territory of the Pacific Islands as it applied to the CNMI. The estimated population of the Commonwealth in 1999 was 79,129 about half of which are resident aliens mostly from the Phillipines, China and Korea. Approximately 75% of the native population is Chamorro and the rest are Carolinian.

Tourism has become CNMI's largest income source. In the late 1990s, however, the Asian financial crisis caused visitor arrivals from Japan and Korea to drop by one-third. At present, garment production is CNMI's fastest growing industry and is credited with preventing an economic depression following the decline of the tourist industry. The development of tourist and garment industries based on foreign labor has had a dramatic impact on CNMI's population growth, which increased from 16,780 in 1980 to 79,429 in early 1999 (Bank of Hawaii Economic Research Dept., 1999). With the exception of a purse seine support base (now defunct) on the island of Tinian, CNMI has never had a large infrastructure dedicated to commercial fishing. Commercial domestic fisheries for reef fish and bottomfish make a minor contribution to the overall economy. The social and cultural importance of coral reef resources in the CNMI dwarfs their commercial value.

Hawaii

The State of Hawai`i lies about 2,500 miles southwest of North America, the nearest continental land mass. The six main islands are part of a 128-island archipelago stretching 1,523 miles from Kure Atoll in the northwest to the Island of Hawai`i in the southeast. The total land area of the archipelago is 6,470 square miles. The main islands include O`ahu, Maui, Kaua`i, Ni`ihau, Hawai`i, Moloka`i and Lana`i. Hawai`i was established as a territory of the U.S. in 1900 and became the 50th state in 1959. In 1998, the ethnic composition of the 1,148,807 people residing in Hawai`i included Caucasians (22%), Japanese (18%), Hawaiian/part-Hawaiian (21%), Filipinos (13%), Chinese (4%) and other ethnic groups (22%).

The Office of Hawaiian Affairs (OHA) oversees Hawaiian affairs for the State of Hawai`i. The issue of the offshore extent of state jurisdiction affects potential native Hawaiian benefits. Between 1822 and 1886 the Hawaiian government formally annexed several of the NWHI, including Nihoa, Necker Island (Mokumanamana), French Frigate Shoals (Mokupapapa), Laysan Island (Kauo) and Kure Atoll (Kanemiloha`i) (Yamase, 1982). All submerged lands under state jurisdiction are also defined as "ceded lands." Twenty percent of the revenues that the Hawai`i Department of Land and Natural Resources (DLNR) receives from permitted uses of ceded lands, permitted by approval by DLNR of a conservation district use application, goes to OHA (Mcdonald and Mitsuyasu, 2000).

Hawaii's economic situation changed dramatically in the 1990s. Several major economic sectors, such as plantation agriculture, tourism and military, suffered downturns. As a consequence, Hawaii never entered the period of economic prosperity that many US mainland states are now experiencing. Since 1998, Hawaii's tourism industry has recovered substantially, mainly because the strength of the national economy promoted growth in visitor arrivals from the continental USA. Efforts to diversify the economy, and thereby render it less vulnerable to future economic downturns, have met with little success to date (Bank of Hawaii Economic Research Dept., 2000). Commercial fishing has historically represented a small share of Hawaii's total economic activity. In contrast to the sharp decline in some industries of long-standing importance in Hawaii, however, the fishing industry has been fairly stable during the past decade. More importantly, fisheries resources, especially coral reef resources, represent an important source of subsistence for Hawaii's residents during periods of economic recession. As a result of the rise in tourism-related ocean recreation in Hawaii, a premium has been placed on non-consumptive uses of nearshore marine resources (Pooley, 1993a). However, there is likely to be little ecotourism in the NWHI (excluding Midway) due to their extremely remote location.

Pacific Remote Island Areas

The PRIA include Baker, Howland, Jarvis, Johnston, Kingman, Midway, Palmyra and Wake. During the 19th century, the United States and Britain actively mined guano deposits on Howland, Jarvis and Baker islands. They became possessions of the US in 1936 and have been under the jurisdiction of he Department of the Interior since that time. From 1935 to 1942, the three islands were occupied by Hawaiians sent to consolidate US claims. They were used as weather stations an military outposts during World Was II years and debris from that period remains. The three atolls are presently national wildlife refuges administered by the US Fish and Wildlife Service. They are presently uninhabited but are visited periodically by scientists, researchers and, occasionally, expeditions of ham radio operators. Entry is controlled by special permit. The US Navy currently has jurisdiction over Kingman Reef.

Palmyra was claimed by the American Guano Company in 1859. It was annexed to the Kingdom of Hawaii in 1862 but in 1911 became privately owned and later was excluded from the territory an State of Hawaii. A seaplane base and other defense facilities were constructed on Palmyra in the late 1930s in preparation for World War II. The atoll was continuously occupied by the US Navy or other Federal installations after the war until 1949 and was also occupied during nuclear testing programs in 1962. The Navy attempt to regain control of Palmyra after World War II ended with a US Supreme Court decision to return the atoll to the present owners.

The written historical record provides no evidence of prehistoric populations on Wake atoll but Marshall islanders occasionally visited Wake, giving it the name Enenkio. The island was annexed by the United States in 1899. Prior to the 1930s the only visitors were scientists and survivors of shipwrecks. The Navy received administrative control of Wake in 1934 and an air base was established on the atoll in January 1941. Wake Island figured prominently in World War II. The US re-occupied the atoll after the war and administrative authority was held by the Federal Aviation Administration until 1962, when it was transferred to the Department of the Interior, which in turn assigned authority to the US Air Force.

Johnston Atoll was claimed by Hawaii and the United States in 1858. Guano deposits found on the island were exploited for a short period in the 19th century. Johnston and Wake atolls are still controlled by the US military. Starting in the late 1940s, Johnston atoll played an important role in the US nuclear testing program. In 1962, three rockets accidentally exploded on or above Johnston Island. Chemical munitions have been stockpiled on Johnston for storage and destruction by means of a specially deigned chemical munition incinerator.

Kingman Reef was annexed to the U.S. in 1922 and has been under the jurisdiction of the U.S. Navy since 1934. Baker Island, Jarvis Island, Howland Island, Kingman Reef, and Palmyra Atoll have been basically unoccupied in modern times. Wake Island and Johnston Atoll have had varying populations of military personnel during most of the 20th century.

3.2.2 Ex-vessel Value of Coral Reef Resources

The following tables provide a summary of the approximate, recent, total annual ex-vessel values for each of the domestic marine fisheries of the western Pacific region's island groups. The focus is on fisheries for coral reef resources (coral reef MUS taken from 0-50 fathoms), but rough estimates of the deep bottom and pelagic fisheries are also provided, both for comparison and because they may be affected by the management measures. Values presented are for the total value (in 1999 dollars) of landings from each area, as well as for the portion located in the proposed FMP management area. Ex-vessel values are the estimated total annual gross value of landings from each fishery, whether sold or not. The ex-vessel values for the sport sectors are the charter fees; the value of the landings in the sport fisheries are included in the food sector. The details behind these values, including the volume of landings on which they are based, are provided for each of the island groups in following tables. The uncertainty associated with these estimates is variable and in some cases quite high.

The total annual ex-vessel value of the region's fisheries for coral reef resources (coral reef MUS taken from 0-50 fathoms) in recent years was about $15 million, $14 million of which was in food fisheries (mostly bottomfish and lobsters) $1 million in ornamentals (from 0.5 million pieces), and $0.6 million in sport fisheries (from 12,000 angler-trips). The deep bottom fisheries (mostly bottomfish and lobsters harvested from greater than 50 fathoms) realized an approximate ex-vessel value of $4 million annually. The value of the natural products and mariculture sectors were assumed to be minimal, but more in-depth investigation might reveal otherwise.

Hawaii's share of total coral reef resource harvests was about 77 percent, or $12 million, of which 88 percent was in the main islands and 12 percent in the Northwestern Hawaiian Islands. The ex-vessel value of Guam's harvested coral reef resources was about $1.6 million, the CNMI's about $1.3 million, and American Samoa's about $0.7 million.

Overall, it was very roughly estimated that 10 percent of the total ex-vessel value of harvested coral reef resources was taken in federal waters (or the "management zone" of the CNMI). The estimated percentages of total ex-vessel value caught in the proposed FMP area (federal waters between 0-50 fathoms) were 1 percent in American Samoa, 4 percent in the CNMI, 8 percent in Guam, and 11 percent in Hawaii.

Summary of Fisheries Annual Ex-vessel Value ($1,000/year)

	Am. Samoa		CNMI		Guam		MHI		NWHI		Other islands		All islands	
	Total	FMP	Total	FMP	Total	FMP	Total	FMP	Total	FMP	Total	FMP	Total	FMP
Coral reef:														
Food	671	8	1,217	54	1,214	118	9,391	1,075	1,295	12	22	21	**13,809**	**1,287**
Sport	m	0	80	4	306	15	71	7	159	159	0	0	**616**	**186**
Ornamentals	10	0	m	0	48	0	1,004	0	0	0	m	m	**1,062**	**m**
Natural products	0	0	0	0	0	0	?	?	0	0	0	0	**?**	**?**
Mariculture	m	0	0	0	0	0	?	0	0	0	0	0	**m**	**0**
Total coral reef	**681**	**8**	**1,297**	**58**	**1,567**	**133**	**10,465**	**1,082**	**1,454**	**171**	**22**	**21**	**15,486**	**1,472**
Deep bottom:														
Food	64	0	166	0	158	0	1,455	0	1,161	0	0	0	**3,004**	
Sport	m	0	30	0	306	0	707	0	m	0	0	0	**1,043**	
Ornamentals	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
Total deep bottom	**64**	**0**	**196**	**0**	**463**	**0**	**2,162**	**0**	**1,161**	**0**	**0**	**0**	**4,047**	
Pelagic:														
Food	444	0	950	0	858	0	48,200	0	8,764	0	10	0	**59,226**	
Sport	10	0	900	0	1,238	0	14,000	0	159	0	0	0	**16,307**	
Total pelagic	**454**	**0**	**1,850**	**0**	**2,096**	**0**	**62,200**	**0**	**8,923**	**0**	**10**	**0**	**75,533**	
TOTAL	**1,199**	**8**	**3,343**	**58**	**4,127**	**133**	**74,827**	**1,082**	**11,538**	**171**	**32**	**21**	**95,066**	**1,472**

Values are approximate, recent, annual gross values of the production side of these fisheries, expressed in 1999 dollars (x 1,000).
"m" means minimal and unquantifiable.

American Samoa Fisheries by Area : Annual Volume and Ex-vessel Value

	Annual Total		% of harvest from proposed FMP area	FMP portion	
	Volume (lbs)	Value ($1,000)		Volume (lbs)	Value ($1,000)
Coral reef area harvests:					
Food					
Finfish:					
live	0	0	0	0	0
dead	216,000	393	2	4,000	8
Crustaceans:	7,000	26	0	0	0
lobster					
other crustaceans					
Echinoderms	43,000	87	0	0	0
Molluscs:	73,000	146	0	0	0
mother-of-pearl					
other molluscs					
Other invertebrates	2,000	20	0	0	0
Seaweeds	min	min	0	0	0
Sport	min	min	0	0	0
Ornamentals					
Fishes and other	5,000	10	0	0	0
Hermatypic coral/live	min	min	0	0	0
Black coral	0	0		0	0
Marine natural products	0	0		0	0
Mariculture	min	min	0	0	0
Total coral reef area		**681**			**8**

Deep bottom area harvests:					
Food	27,000	64	0	0	0
Sport	min	min	0	0	0
Ornamentals	0	0	0	0	0
Total deep bottom		**64**			**0**
Pelagic fisheries:					
Food	400,000	444	0	0	0
Sport	120	10	0	0	0
Total pelagic harvests		**454**			**0**
Total all fisheries		**1,199**			**8**

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.
"min" means minimal.

Northern Mariana Islands Fisheries by Area: Annual Volume and Ex-vessel Value

	Annual Total		% of harvest from proposed FMP area	FMP portion	
	Volume (lbs)	Value ($1,000)		Volume (lbs)	Value ($1,000)
Coral reef:					
Food					
Finfish:					
live	0	0		0	0
dead	446,000	1,070	5	22,000	54
Crustaceans:					
lobster	4,000	19	0	0	0
other crustaceans					
Echinoderms	25,000	68	0	0	0
Molluscs:					
mother-of-pearl	20,000	60	0	0	0
other molluscs					
Other invertebrates					
Seaweeds	min	min	0	0	0
Sport	1,600	80	5	80	4
Ornamentals					
Fishes and other inverts	min	min	0	0	0
Hermatypic coral/live	min	min	0	0	0
Black coral	0	0		0	0
Marine natural products	0	0		0	0
Mariculture	0	0		0	0
Total coral reef		**1,297**			**58**
Deep bottom:					
Food	50,000	166	0	0	0
Sport	300	30	0	0	0
Ornamentals	0	0		0	0
Total deep bottom		**196**			**0**
Pelagic:					
Food	500,000	950	0	0	0
Sport	9,000	900	0	0	0
Total pelagic		**1,850**			**0**
Total all fisheries		**3,343**			

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.

Guam Fisheries by Area: Annual Volume and Ex-vessel Value

	Annual Total		% of harvest from proposed FMP area	FMP portion	
	Volume (lbs)	Value ($1,000)		Volume (lbs)	Value ($1,000)
Coral reef:					
Food					
Finfish:					
live	0	0		0	0
dead	400,000	1,176	10	40,000	118
Crustaceans:					
lobster	5,000	19	0	0	0
other crustaceans					
Echinoderms					
Molluscs:					
mother-of-pearl	3,000	6	0	0	0
other molluscs	4,000	9	0	0	0
Other invertebrates	1,000	2	0	0	0
Seaweeds	some	unknown	0	0	0
Sport	10,000	306	5	510	15
Ornamentals					
Fishes and other inverts	24,000	48	0	0	0
Hermatypic coral/live	min	min	0	0	0
Black coral	0	0		0	0
Marine natural products	0	0		0	0
Mariculture	0	0		0	0
Total coral reef		**1,567**			**133**
Deep bottom:					
Food	45,000	158	0	0	0
Sport	10,000	306	0	0	0
Ornamentals	0	0			0
Total deep bottom		**463**			
Pelagic:					
Food	660,000	858	0	0	0
Sport	21,000	1,238	0	0	0
Total pelagic		**2,096**			**0**
Total all fisheries		**4,127**			**133**

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.

Main Hawaiian Islands Fisheries by Area: Annual Volume and Ex-vessel Value

	Annual Total		% of harvest from proposed FMP area	FMP portion	
	Volume (lbs)	Value ($1,000)		Volume (lbs)	Value ($1,000)
Coral reef:					
Food	1,004,900	9,391		540,001	1,076
Finfish:					
live					
dead	443,900	7,571	10	439,000	750
Crustaceans:					
lobster	10,000	128	0	0	0
other crustaceans	100,000	417	41	41,000	173
Echinoderms	1,000	11	3	0	0
Molluscs:					
mother-of-pearl					
other molluscs	369,000	925	16	60,000	150
Other invertebrates					
Seaweeds	81,000	339	1	1	3
Sport	500	71	10	50	7
Ornamentals					
Fishes and other	430,000	937	0	0	0
Hermatypic coral/live	min	min	0	0	0
Black coral	3,000	66	0	0	0
Marine natural products	unknown	unknown	unknown	unknown	unknown
Mariculture	unknown	unknown	0	0	0
Total coral reef		**10,465**			**1,082**
Deep bottom:					
Food	418,000	1,455	0	0	0
Sport	5,000	707	0	0	0
Ornamentals	0	0		0	0
Total deep bottom		**2,162**			**0**
Pelagic:					
Food	22,000,00	48,200	0	0	0
Sport	99,000	14,000	0	0	0
Total pelagic		**62,200**			**0**
Total all fisheries		**74,827**			**1,082**

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.

Northwestern Hawaiian Islands Fisheries by Area: Volume and Ex-vessel Value

	Annual Total		% of harvest from proposed FMP area	FMP portion	
	Volume (lbs)	Value ($1,000)		Volume (lbs)	Value ($1,000)
Food					
Finfish:					
live	0	0		0	0
dead	19,000	14	82	16,000	11
Crustaceans:					
lobster	246,000	1,280	0	0	0
other crustaceans	min	1	51	min	min
Echinoderms	0	0		0	0
Molluscs:					
mother-of-pearl					
other molluscs	0	0		0	0
Other invertebrates	0	0		0	0
Seaweeds	0	0		0	0
Sport	375	159	100	375	159
Ornamentals					
Fishes and other inverts	0	0		0	0
Hermatypic coral/live	0	0		0	0
Black coral	0	0		0	0
Marine natural products	0	0		0	0
Mariculture	0	0		0	0
Total coral reef		**1,454**			**171**
Deep bottom:					
Food	371,000	1,161	0	0	0
Sport	min	min	0	0	0
Ornamentals	0	0		0	0
Total deep bottom		**1,161**			**0**
Pelagic:					
Food	4,000,00	8,764	0	0	0
Sport	375	159	0	0	0
Total pelagic		**8,923**			**0**
Total all fisheries		**11,538**			**171**

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.

Other Islands Fisheries by Area: Annual Volume and Ex-vessel Value

	Annual Total		% of harvest from proposed FMP area	FMP portion	
	Volume (lbs)	Value ($1,000)		Volume (lbs)	Value ($1,000)
Coral reef:					
Food					
Finfish:					
live	0	0		0	0
dead	10,000	20	100	10,000	20
Crustaceans:					
lobster	200	1	0	0	0
other crustaceans	200	min	100	200	min
Echinoderms	0	0		0	0
Molluscs:					
mother-of-pearl					
other molluscs	100	min	100	100	min
Other invertebrates	0	0		0	0
Seaweeds	0	0		0	0
Sport	0	0		0	0
Ornamentals					
Fishes and other inverts	min	min	100	min	min
Hermatypic coral/live	min	min	100	min	min
Black coral	0	0		0	0
Marine natural products	0	0		0	0
Mariculture	0	0		0	0
Total coral reef		**22**			**21**
Deep bottom:					
Food	min	min	0	0	0
Sport	0	0		0	0
Ornamentals	0	0		0	0
Total deep bottom		**0**			**0**
Pelagic:					
Food	5,000	10	0	0	0
Sport	0	0		0	0
Total pelagic		**10**			**0**
Total all fisheries		**32**			**21**

All volume figures are in pounds per year, except the sportfishing sectors, which are in number of angler-trips per year, and ornamentals (except black coral), which are in number of pieces or organisms per year.

3.3 Historical and Present Use of Coral Reefs

Coral reef resources sustained indigenous populations in the US Pacific Islands for hundreds to thousands of years before European contact. More recently, coral reef resources have been harvested for recreational and commercial purposes as well. Reef species have been harvested for food, the aquarium trade, construction materials, curios, jewelry, pharmaceuticals and traditional medicines.

Summary of coral reef resource use levels in nearshore areas (0-3 nmi from shore) and offshore areas (3-200 nmi from shore) in sub-areas of the US Pacific Islands (modified from Green, 1997)

Location	0-3 nmi	3-200 nmi
American Samoa	Nil-Moderate	Nil-Light
CNMI	Nil-Heavy	Nil-Heavy
Guam	Light-Heavy	Nil-Heavy
Hawaii		
Main Hawaiian Islands	Light-Heavy	Nil-Heavy
Northwestern Hawaiian Islands	Mostly Nil	Nil-Moderate
Remote Islands	Nil-Light	Mostly Nil
Overall	Nil-Heavy	Nil-Moderate

American Samoa

Coral reef fishes and invertebrates are harvested in subsistence and small-scale commercial fisheries. In 1994, the only year when both components of this fishery were measured, catches were 86 mt and 76 mt, respectively, and consisted primarily of surgeonfish, parrotfish, groupers, octopus and sea urchins (Craig, et al., in press). Sixty-nine different taxa were harvested in 1991. The migratory *atule (Selar crumenophthalmus,* or bigeye scad) is an important catch component (Green, 1997).

As recently as 20 years ago, the harvest of reef fish and invertebrates from reef flats fronting the most densely populated section of coast on Tutuila was as high as 26.6 mt/km^2 per year (Wass, 1982). A decreasing trend in reef-related fish catches was observed in the early 1990s. At least one favored invertebrate (giant clams) has been overfished in most areas, except Rose Atoll (Craig, et al., in press). In general, the reefs adjacent to human population centers (Tutuila Island) appear to be in worse condition than those near less populated or unpopulated islands (Green, 1996).

Most of the coral reef fisheries in American Samoa occur in nearshore waters. Much of the bottom fishing activity by small boats is conducted in the EEZ and some of the shallow-water snappers and emperors taken can be considered reef fish species. At present, the catch from the latter fishery is minor (Green, 1997). Ornamental fish collection has occurred on a small scale in recent years. Live rock taken from shallow reef areas was exported during 1999, but this fishery has since been prohibited by the *fono* (American Samoa Legislature).

Fisheries statistics show that coral reef fisheries have accounted for 62% of the annual catch (154 mt) and 70% of the annual catch value ($619,000) in recent years. This estimate is low because it does not include the shoreline subsistence harvest, which is assumed to be substantial. Nor does the estimate include shallow-water species of bottom fish which are taken in a commercial small-boat fishery. The annual harvest of the latter fishery has been small (11 mt valued at $46,000) in recent years, so the contribution to the total reef fish harvest is insubstantial.

Most of the landings in the known reef-related fisheries in American Samoa are fish (98 mt/year), molluscs (33 mt/year) and echinoderms (19 mt/year), but small amounts of crustaceans (3 mt/year) are also reported (Green, 1997).

A much smaller commercial fishery, using 10-m boats, catches bottomfish (principally emperors and snappers) by hook and line around the islands and offshore banks. In 1997, this fishery harvested 12 mt (Craig, et al., 1999). Chambered nautilus has occasionally been taken by researchers and public aquaria at depths of about 200 m on offshore reef slopes (D. Itano, pers. comm.). Virtually nothing is known of the reefs on offshore banks because they are relatively inaccessible. It is assumed, however, that they are in better condition than the nearshore reefs because they are deep and remote from most human activities.

Coral reefs around American Samoa are recovering from a series of natural disturbances over the past two decades: a crown-of-thorns invasion (1978), three hurricanes (1986, 1990, 1991) and mass coral bleaching (1994), as well as chronic human-induced impacts along the populated coasts. There have been extensive alterations of coastal habitats (sandy beaches, wetlands, coral reefs) due to highway construction and urban expansion, particularly along the south shore of Tutuila. Coastal erosion is amplified by the removal of large quantities of beach sand and coral rubble from the shoreline for use around homes. Together, these shoreline alterations have largely eliminated the use of the central south coast by nesting sea turtles. Direct losses of coral reef habitats are related to dredging for harbors and filling to build the international airport runway.

Degradation of reefs has occurred due to chronic water quality and sedimentation problems. Because of the main islands' steep terrain and high rainfall, hillside runoff and erosion into adjacent coastal waters is heavy. Other activities that have had a major impact on the reef environment are landfills, sewage disposal and – in Pago Pago Harbor – discharges from shoreside industries and spills from vessels in port. (Craig, et al., in press). Remote Rose Atoll, protected as a National Wildlife Refuge, was damaged in 1993 by a ship grounding and related oil spill.

The condition of near shore reefs around American Samoa varies according to location. Reefs on the main island of Tutuila are in the worst condition because of a combination of natural and human effects (hurricanes, coral bleaching, pollution, sedimentation), whereas the reefs on the more remote and less populated islands tend to be in good condition (Green, 1997). There is evidence from recent fisheries statistics, scientific resource surveys and interviews with village elders and fishermen to suggest that the more accessible coral reefs are seriously overfished. A major contributor to this problem is SCUBA assisted fishing, especially at night (American Samoa Coral Reef Task Force, 1999). Green sea and hawksbill turtle populations have seriously declined due to harvesting of turtles and eggs and degradation of nesting and inshore habitats.

Guam

Since World War II, coral reef fisheries have shifted from an exclusively subsistence focus to an artisanal fishery which blends subsistence, recreational and commercial purposes (Hensley and Sherwood, 1993). The more accessible reefs are considered overfished because of declining catch rates, declining size of target fish species and greater prevalence of less desirable species (Katnik 1992; Birkeland, 1997c; Green, 1997).

Prior to World War II, trochus (top shell) was taken in large quantities for food and jewelry work. By the 1970s, the top shell population had recovered sufficiently to allow a limited fishery that is currently regulated with size restrictions. Stony and precious corals have been harvested in the past for ornamental use and jewelry work. Residents and visitors, including foreign fishing crews, collect stony corals and mollusks as curios. Coral harvesting is illegal on Guam without a permit and there have been several convictions of violators (Green, 1997).

Since the late 1970s, the percentage of live coral cover on Guam's reefs and the recruitment of small corals has decreased. Possible explanations for this trend are poor recruitment by coral larvae, increased sedimentation of reef habitat and domination of reef habitat by fleshy algae. Corals have also been impacted by natural disturbances (starfish predation in 1968-1970; emergence during El Nino events; and, in more localized areas, by heavy wave action associated with typhoons (Birkeland, 1997c).

Shore-based fishing accounts for most of the fish and invertebrate harvest from coral reefs around Guam. In recent years, the estimated inshore harvest has ranged from 38 to 108 mt. This estimate excludes highly variable catches of juvenile rabbitfish and bigeye scad by traditional fisheries that are still practiced seasonally (Myers, 1997). While spearfishing is the principal method of harvesting, it is highly seasonal because of weather conditions. During FY85 to FY91, parrotfishes (36%), surgeonfishes (17%) and wrasses (7%) were the primary species landed by spearfishing (Myers, 1997).

The coral reef fishery harvests more than 100 species of fish, including the families Acanthuridae, Carangidae, Gerreidae, Holocentridae, Kyphosidae, Labridae, Lethrinidae, Lutjanidae, Mugilidae, Mullidae, Scaridae and Siganidae (Hensley and Sherwood, 1993). Myers (1997) noted that seven families (Acanthuridae, Mullidae, Siganidae, Carangidae, Mugilidae, Lethrinidae and Scaridae) were consistently among the top 10 species in any given year from FY91 to FY95 and accounted for 45% of the annual fish harvest. Approximately 40 taxa of invertebrates are also harvested by the nearshore fishery, including 12 crustacean taxa, 24 mollusc taxa and 4 echinoderm taxa (Amesbury, et al., 1986 and 1991 in Hensley and Sherwood, 1993; Myers, 1997). Species that became rare on shallow reefs due to heavy fishing include bumphead parrotfish, humphead wrasse, stingrays, parrotfish, jacks, emperors and groupers (Green, 1997).

Many of the nearshore reefs around Guam appear to have been badly degraded by a combination of natural and human impacts, especially sedimentation, tourist overuse and overharvesting. In the last few years, there has been an increase in commercial spearfishing using SCUBA at night. Catch rates have increased because of improved technology (high capacity tanks, high tech lights and bang sticks) that allows spearing in deeper water (30–42 meters). As a result, many larger species that have already been heavily fished in shallow waters are now reappearing in the fishery catch statistics (e.g., *Bolbometopon muricatum, Cheilinus undulatus*, stingrays and larger scarid species) (DAWR personnel and M. Duenas pers. comm. in Green 1997).

Virtually no information exists on the condition of the reefs on offshore banks. On the basis of anecdotal information, most of the offshore banks are in good condition because of their isolation. Observations by divers suggest that anchor damage is having a major impact on branching coral formations on some of the offshore banks. Anchors dragged by small boats dig small furrows but anchors from large fishing vessels leave large craters in the surfaces of offshore banks.

According to Myers (1997), less than 20% of the total coral reef resources harvested in Guam are taken from the EEZ, primarily because they are associated with less accessible offshore banks. Finfish comprise most of the catch in the EEZ. Most offshore banks are deep, remote, shark infested and subject to strong currents. Generally, these banks are only accessible during calm weather in the summer months (May to August/September). Galvez Bank is the closest and most accessible and, consequently, fished most often. In contrast, the other banks (i.e., White Tuna, Santa Rose and Rota) are remote and can only be fished during exceptionally good weather conditions (M. Tenbata and J. Cruz pers. comm. in Green 1997). Local fishermen report that up to 10 commercial boats (2–3 people per boat) and some recreational boats use the banks when the weather is good (M. Duenas, pers. comm., in Green, 1997).

At present, the banks are fished using two methods: bottomfishing by hook and line and jigging at night for bigeye scad (Myers, 1997). In recent years, the estimated annual catch in these fisheries has ranged from 14 to 22 mt (shallow bottomfish) and 3 to 11 mt (atulai) (Green, 1997). The shallow-water component comprised almost 68% (35,002 to 65,162 lb) of the aggregate bottomfish landings in FY92–94 (Myers, 1997). Catch composition of the shallow-bottomfish complex (or coral reef species) is dominated by lethrinids, with one species (*Lethrinus rubrioperculatus*) alone accounting for 36% of the total catch. Other important components of the bottomfish catch include lujanids, carangids, serranids and sharks, while holocentrids, mullids, labrids, scombrids and balistids are minor components. It should be noted that at least two of these species (*Aprion virescens* and *Caranx lugubris*) also range into deeper water and some of the catch of these species occurs in the deepwater fishery.

The majority of bigeye scad (*Selar crumenophthalmus*) fishing occurs in territorial waters but also occasionally takes place in federal waters. Estimated annual offshore landings for this species since 1985 have ranged from 6,393 to 44,500 lb, with no apparent trend (Myers, 1997). It is unclear how much of this offshore *atulai* fishery has occurred in the EEZ.

Hawaii

In recent decades, there has been a notable decline in near shore fishery resources in the main Hawaiian Islands (Shomura, 1987). Overfishing is considered to be one of the major causes of this decline (Harman and Katekaru, 1988; Grigg, 1997) but coastal construction, sedimentation and other effects of urbanization have caused extensive damage to coral reefs and benthic habitat near the populated islands.

Fishing gear types that are primarily used to target inshore and coastal pelagic species accounted for about 10% (1.5 million lb) of the mean annual commercial fish catch in the State of Hawaii during the 1990-1995 period. The recreational and subsistence catches are not reported in Hawaii, but creel surveys at Kaneohe, Hanalei and Hilo Bays suggest that the total inshore catch from reef areas are at least equivalent and may be two or three times greater than the reported commercial catch (Friedlander, 1996).

The majority of the total commercial catch of inshore fishes, invertebrates and seaweed comes from nearshore reef areas around the main Hawaiian Islands. The exceptions are crustaceans, with over 90% of the spiny lobster landings from the NWHI and over 50% of Kona crab landings from the Penguin Bank. Nearshore reefs in the MHI are also the focus for commercial reef ornamentals harvesting and black coral collecting (Friedlander, 1996).

The collection of black coral from depths of 30 to 100 m by SCUBA divers has continued in Hawaii since black coral beds were discovered off Lahaina, Maui, in the late 1950s, although harvest levels have fluctuated with changes in demand. Since 1980, virtually all of the black coral harvested around the Hawaiian Islands has been taken from the bed located in the Auau Channel. Most of the harvest has come from State of Hawaii waters and no black coral diver has ever received a federal permit to harvest precious coral in the EEZ. However, a substantial portion of the black coral bed in the Auau Channel is located in the EEZ. Recently, the demand for small, immature black coral colonies has increased with the growing popularity of household marine aquaria. In 1999, concern about the potential for greater harvesting pressure on the black coral resources led the State of Hawaii to prohibit the take of black coral with a base diameter of less than 3/4 inches from state waters. The Council has recommended that a minimum size limit also be established for black coral harvested in the EEZ (WPRFMC 1999).

After two decades of minimal activity, the domestic fishery for pink, gold and bamboo precious corals in the EEZ of Hawaii resumed in December 1999. One company utilizes two one-manned submersibles to survey and harvest the resource at depths between 400-1,500 m. These technologically advanced devices are capable of diving to 2,000 feet with a maximum bottom time of six hours. To date, surveys and harvesting have only occurred around two of the seven known beds between the islands of Oahu and Hawaii. The company has plans to survey the NWHI as well as other locations in the MHI for additional beds.

The deep-slope bottomfish fishery in Hawaii concentrates on species of eteline snappers, carangids and a single species of grouper concentrated at depths of 30-150 fm. The fishery can be divided into two geographical areas: the inhabited main Hawaiian Islands (MHI) with their surrounding reefs and offshore banks; and the NWHI. In the MHI approximately 80% of the bottomfish habitat lies in state waters. Bottomfish fishing grounds within federal waters include Middle Bank, most of Penguin Bank and approximately 45 nm of 100-fathom bottomfish habitat in the Maui-Lanai-Molokai complex. For management purposes the NWHI fishery has been separated into the Mau Zone, closer to the MHI, and the Ho'omalu Zone.

Historically, Penguin Bank is also one of the most important bottomfish fishing grounds in the MHI, as it is the most extensive shallow shelf area in the MHI and within easy reach of major population centers. Penguin Bank is particularly important for the MHI catch of *uku*, one of the few bottomfish species available in substantial quantities to Hawaii consumers during summer months. A comparison of the percentage of the total commercial landings of five major bottomfish species in the MHI represented by Penguin Bank from 1980 to1984 and 1991 to 1995 shows that the bank has increased in importance over the years.

Average percentage of total MHI commercial catch and average commercial catch of major bottomfish species harvested from Penguin Bank.			
	Average annual percent of total MHI catch		Average annual catch (lbs.)
	1980-1984	1991-1995	1997-1999
Opakapaka	9.63	16.11	20,609
Uku	12.06	44.04	28,785
Onaga	14.87	20.24	9,277
Ehu	12.15	17.60	3,380
Hapuupuu	4.31	6.64	905
Sources: WPRFMC (1996); HDAR (2000)			

For the period 1991 to 1995, 8% of the licensed commercial fishermen who participated in the MHI bottomfish fishery reported catches from Penguin Bank (WPRFMC 1996). Penguin Bank is also a popular bottomfish fishing ground for recreational anglers (Friedlander, 1996). However, the magnitude of the recreational landings is unknown.

Surveys of the NWHI indicate that coral reefs are in good condition with high standing stocks of many reef fish. Nearshore coral reefs receive little human use because of their remoteness, exposure to harsh seasonal ocean conditions and their protected status as part of a national wildlife refuge. Most of the shallow reefs of the NWHI lie within the boundaries of the Hawaiian Islands National Wildlife Refuge, where access and resource use is controlled by special permit. Some recreational fishing is done by occasional visitors, including federal government personnel and contract workers at Midway (Graham, 1999). Public access to the NWHI has been improved by the establishment of an eco-tourism operation in the Midway Atoll National Wildlife Refuge.

Two domestic commercial fisheries (lobster trapping, bottomfish hook-and-line) have operated in the NWHI for several decades. Both fisheries are presently managed by the Council under limited access programs with fixed numbers of permits. The lobster trap fishery is also subject to a harvest quota that is set annually. The lobster fishery in the NWHI is one of the most intensively managed fisheries within the US EEZ. Conservative measures are in place to reduce the risk of overfishing, and to prevent interaction with protected species. The lobster fishery is managed with a low fishing mortality, which is spread across a wide geographic region. There is some uncertainty however, regarding the population structure of the lobster population in the region as a whole, and the magnitude of oceanographic changes on the recruitment dynamics of the population.

Spiny and slipper lobsters are harvested at many banks and on reefs deeper than 10 fathoms. The lobster trap fishery makes incidental catches of octopus and hermit crabs. The incidental catch of reef fish is minimal because the lobster traps have escape vents. Bank-by-bank allocation of the 1999 harvest guideline caused permit holders in the lobster trap fishery to distribute effort into new trapping sites, including some areas where retrieval of trap lines may damage live coral. Commercial trolling for *ono* occurs seasonally in some areas of the NWHI. For a short period in

1999, experimental fishing for coastal sharks was permitted. Many of the shallow reefs are in the NWHI are within the national wildlife refuge and will likely remain off limits to fishing. .5.

There is a long history of fishing in the NWHI. Iverson, et al. (1990) found ample evidence of a long history of fishing by the ancient Hawaiians as far northwest as Necker Island. Starting in the 1920s, a handful of commercial boats ventured into the NWHI to fish for shallow and deepwater bottomfish, spiny lobsters and other reef and inshore species (Iverson, et al., 1990). Black-lipped pearl oysters at Pearl and Hermes Reef in the NWHI were overfished in the late 1920s and recent surveys indicate that stocks have still not recovered due to lack of suitable habitat (i.e., oyster shells) (Green, 1997).

For about ten years, from the late 1940s to the late 1950s, there was a fishery for akule and reef fish around French Frigate Shoals and Nihoa Island, with the catch flown from the former to Honolulu. By the mid-1950s, vessel losses and depressed fish prices from large catches reduced the number of fishermen in the NWHI and by the 1960s, only one vessel remained in operation in the area (Iverson, et al., 1990).

During the 1960s and as recently as 1978, Asian fleets harvested tuna, billfish, precious corals and groundfish in and around the NWHI using longliners, pole-and-line vessels, draggers and trawlers. Foreign fleets were not excluded from the 200-mile zone surrounding the islands until after the Fishery Conservation and Management Act was signed into law in 1976 and the Council began developing management plans for domestic fisheries in 1978. Even so, over the two decades from 1965 to the late 1980s, dozens of foreign vessels intermittently and illegally harvested precious corals in the waters around the NWHI, causing major destruction of deepwater habitat by using tangle-net bottom dredges (Grigg, 1993)

There was renewed interest in the fisheries resources of the NWHI in the mid-1970s, when state and federal agencies collaborated in a study focusing on this region (Haight, et al., 1993). A fishery for deepslope bottomfish grew rapidly from the early 1980s until the late 1980s, with a peak of 27 vessels in 1987. It quickly declined after 1988, when the Council adopted a limited access system for areas northwest of Necker Island. In 1999, there were 12 vessels active in the NWHI bottomfish fishery (of 17 permitted) (Dames and Moore in prep.). The NWHI lobster fishery, centered around Necker Island, underwent a similar evolution. It developed in the late 1970s, reached a peak of 16 vessels in 1985-86 and subsequently declined, with 5 vessels active in 1999 (of 15 permitted under a limited access system adopted by the Council) (Dames and Moore in prep).

Commonwealth of the Northern Mariana Islands

Prior to World War II, the Japanese exploited many coral reef resources (sea cucumbers, top shells, precious corals) in the Japanese Mandated Islands, which included the present Commonwealth of the Northern Mariana Islands. Commercial fisheries for trochus and sea cucumbers were re-opened during the mid-1990s for the first time in recent history. Over an 18-month period in 1995-1996, 268,000 sea cucumbers were collected (Green, 1997). Sea turtles are a traditional food.

It is difficult to assess the total harvest of present-day coral reef fisheries in the CNMI because of shortcomings in fisheries statistics. Virtually no recent information is available for inshore subsistence and recreational catches of coral reef resources. This harvest is assumed to be substantial, especially in the more accessible areas like Saipan Lagoon. Coral reef fisheries in the CNMI are mostly limited to near shore areas, especially off the islands of Saipan, Rota and Tinian. Finfish and invertebrates are the primary targets but small quantities of seaweed are also taken. All of the recent data analyzed are only for commercial landings: 62 - 80mt/year of reef fish and 1 - 1.5 mt/year of spiny lobster. An unknown proportion of the bottomfish landings in the CNMI are shallow-water snappers, emperors and groupers which may be considered part of the coral reef fishery (Green, 1997).

Little is known of the coral reef fisheries in the northern islands of CNMI but the catch by domestic fishermen is believed to be minor. The exception was in 1995, when the near shore reefs around six of the northern islands (especially Anatahan and Sarigan) were fished commercially for several months. During that time, these areas yielded a harvest of 15 mt of reef fish and 380 pieces of spiny lobster. Poaching by foreign fishing boats may occur in some places (Green, 1997).

Coral reefs near some heavily populated areas in the southern islands of the CNMI have been degraded by heavy fishing, sedimentation and tourist recreation (Green, 1997). Limited information suggests that most of the nearshore reefs elsewhere in the CNMI are in good condition. Reefs off the southern islands experienced a massive starfish outbreak in late 1960s but corals recovered rapidly from this disturbance. Reefs around the northern islands are in good condition because of their isolation from human activities. Localized areas may have been damaged by storm waves, volcanic eruptions or military activities (e.g., Pagan, FDM) (Birkeland, 1997c; Green, 1997).

Virtually nothing is known about the condition of offshore reefs but they are assumed to be in good condition because of their isolation. Offshore reefs generally receive little fishing pressure because of the limited range of the small-boat fishery. The exceptions are banks that are relatively close to the main islands (e.g., Esmeralda) and the extensive bank off Farallon de Medinilla, where a fishery for shallow-water bottomfish is conducted by small boats.

Midway

Geographically Midway Atoll is part of the Hawaiian Island chain in the Northwestern Hawaiian Islands, however legally it is considered an unincorporated U.S. possession. Midway Atoll National Wildlife Refuge was established in 1988 as an overlay Refuge on military land. In 1996, the military transferred jurisdiction and control for Midway Atoll and its Naval Defense Seas to the Fish and Wildlife Service. The agency has a long term contract with Midway Phoenix Corporation, which maintains the airfield and operates an ecotourism business on the atoll.

Since 1996, there has been limited eco-tourism and public use within the Midway Atoll National Wildlife Refuge in the form of charter fishing, diving and wildlife observation. Midway Phoenix Corporation's agreement with the USFWS allows 100 visitors to enjoy the atoll per week. The most common way for visitors to access the Midway Atoll National Wildlife Refuge is by air service from Honolulu. The privately-owned company advertises wildlife tours that let visitors "gain first hand knowledge of the albatross, resident seabirds, migrant shorebirds, threatened green turtles and endangered Hawaiian monk seals" (Midway Phoenix Corporation, undated). Additional outdoor recreational activities for the public are suggested in the Public Use Plan for the Refuge and may be offered to visitors in the future (USFWS, 1997). Among these activities are shoreline fishing, lobstering, night diving, night fishing, kayaking tours and glass-bottom boat excursions.

The most serious problems in the NWHI at present are accumulation of marine debris and vessel groundings and oil spills. Most of the debris is derelict gear lost from North Pacific fisheries. In addition to the physical damage to coral reefs, the debris entangles protected species, ghost fishes and may introduce alien marine species (Green, 1997). Dredging, filling and contamination by the release of toxins from dumped transformers are significant impacts associated with prior military occupation at Kure Atoll, Midway Islands and French Frigate Shoals (Green, 1997).

Remote US Pacific Islands

Little is known about the present status of coral reefs in most of the remote US island possessions, although anecdotal reports suggest that they are mostly in good condition. Localized impacts on coral reefs have occurred due to coastal construction and pollution on some islands occupied by the US military. Hurricanes and starfish infestation have occasionally affected some areas.

Fishing is light in most areas. Hawaii-based vessels make sporadic commercial fishing trips to Palmyra and Kingman Reef for bottom fishing, harvesting coastal sharks for finning and possibly aquarium fish collecting. The past extent of harvesting by passing yachts or poaching by foreign fishing vessels in unknown (Green, 1997).

There are no permanent residents on any of these islands, although on Wake and Johnston, there are temporary work forces who have a long history of recreational fishing and shell collecting. The fishery at Johnston Atoll was described over a six-year period (1985–1990), based on the results of a creel census by Irons, et al. (1990). Irons, et al. (1990) found that the majority of fishing activity and a large proportion of the catch were generated by long-term 'residents' —almost all employees of the prime contractor for Johnston Atoll operations. These residents fished for enjoyment, to add fresh fish to their diet and to accumulate fish to take home on leave. The remainder of the catch was harvested by 'transients,' personnel (military and contractors) stationed on the island for one or two years.

Irons et al. (1990) reported that the soldierfish *Myrispristis amaenus* comprised the largest proportion of catch of reef fishes at Johnston (see Table 72 in Green, 1997). Other important fish species included bigeyes (*Priacanthus cruentatus*), flagtails (*Kuhlia marginata*), mullet (*Chaenomugil leuciscus*), goatfishes (*Mulloides flavolineatus, Pseudupeneus bifasciatus, P. cyclostomus* and *P. multifasciatus*), jacks (*Caranx melampygus* and *Carangoides orthogrammus*), parrotfish (*Scarus perspicillatus*), surgeonfishes (*Acanthurus triostegus* and *Ctenochaetus strigosus*) and bigeye scad (*Selar crumenophthalmus*). Gear types varied with the target species and included hook-and-line fishing, spearfishing and throw nets. All of the more heavily fished areas at Johnston are located in nearshore waters. Irons, et al. (1990) also noted that recreational divers at Johnston collected pieces of coral for souvenirs. *Acropora cytherea* and the red coral *Distichopora violacea* were the two main species collected, although smaller quantities of *Acropora valida*, *Millepora* and *Fungia* were also collected.

The original Johnston Atoll has been extensively modified by dredging and filling. An estimated 4 million square meters of coral were destroyed by construction and an additional 25 million square meters were damaged by the resulting sedimentation. By 1964, dredge and fill operations had enlarged the original island by over tenfold and had added two manmade islands.

Fishing regulations have changed at Johnston Atoll in recent years because of concerns that fish were being exported and that coral collecting had become excessive and was incompatible with the philosophy of the refuge (B. Flint, pers. comm., in Green 1997). Current DOI regulations prohibit coral collecting and the export of any reef fish or invertebrates from the island. However, collection of selective organisms and shells is permitted in restricted areas by recreational divers. Since Johnston is a closed military base, only local residents partake in such activities. No recent fisheries statistics are available for the area.

National wildlife refuges (NWR) have been established at Baker, Howland and Jarvis Islands and at Johnston Atoll. Natural resources are managed by the US Fish and Wildlife Service and access is by special permit only. Palmyra Atoll and Kingman Reef and Wake Atoll are candidates for NWR status.

3.4 Summary of Existing FMPs in the Western Pacific Region

Background information on other fisheries in the Western Pacific region is provided in this section.

3.4.1 Northwestern Hawaiian Islands Bottomfish Fishery

Prior to the implementation of the Bottomfish Fishery Management Plan, commercial bottomfish landings in the main Hawaiian Islands and Northwestern Hawaiian Islands were estimated at 1.4 million lb. During the 1960s bottomfish landings decreased to 400,000 lb, but consequently rose back to over 1.0 million pounds in the 1970s due to expanded local market and strong interest in the NWHI stocks. As a result of this expanding fishery, the Western Pacific Regional Fishery Management Council (WPRFMC) implemented the Bottomfish FMP for bottomfish and seamount groundfish fisheries in the western Pacific region in 1986 and has amended this plan six times. Currently, in the NWHI, a maximum of 17 total permits are assigned in two limited entry zones, the Hoomalu Zone, with seven permits, and the Mau Zone, with 10 permits of which two are designated for a Community Development Program. These 17 vessels fish an area approximately a quarter the size of the United States and provide the State of Hawaii with more than one-half of its fresh premium-quality bottomfish. The fishery currently harvests less than 55% of the maximum sustainable yield (MSY) and is valued at just under $1 million per year. Bottomfishing occurs year-round and each permit holder to the Hoomalu Zone must make a minimum of three trips and land 2,500 lb of fish (half bottomfish) to retain the permit. The most productive bottomfishing grounds include: Brooks Banks, Laysan Island, Maro Reef and Necker Island respectively, however, productivity varies at banks by year. The most productive bottomfish depths are found between 50 and 100 fathoms and between 50% and 90% of the total bottomfish in the NWHI are caught at these depths.

There are no known mortalities of monk seals attributed to the NWHI bottomfish fishery. Furthermore, data from a NMFS observer program in the early 1990's concluded that the NWHI bottomfish fishery is generally not taking fish that are considered prey for monk seals and that the bottomfish management unit species are healthy with none being overfished.

Interactions of the Bottomfish FMP fishery with coral reef resources/habitats where the major fishery occurs in the NWHI is very minimal. Most bottomfish fishing occurs between 50 and 100 fathoms, while coral reef substrate is defined to 50 fathoms. There may be some possible anchor damage less than 50 fm where there are steep drop-offs.

Summary of Regulations and Reporting

- The owner of any vessel used to fish for bottomfish management unit species in the NWHI must possess either a Mau Zone permit, or a Ho'omalu zone permit. A single vessel may not be registered in both zones concurrently.
- Possession and use of bottom trawls and bottom set gillnets is prohibited.
- Permits are non-transferrable.
- Establishes limited-entry into Ho'omalu and Mau Zones based prior qualified landings of BMUS
- Implements a use-it or lose-it requirement to permit renewal of vessels.
- The possession and use of any poisons, explosives, or intoxicating substances for the purpose of harvesting bottomfish managed unit species is prohibited.
- The fishery is subject to mandatory logbook reporting using the State of Hawaii NWHI bottomfish forms.
- Permitted vessels may not exceed 60 ft in length, unless approved by the Regional Administrator in consultation with the WPRFMC.
- Each permit holder must attend a NMFS protected species workshop
- Each permit holder must notify the Regional Director prior to any fishing within any protected species study zone in the NWHI.

In addition to those regulations stated above, participants in the NWHI fishery are required to complete the State of Hawaii Daily Bottomfish Catch Report. This form includes space for recording the number of Bottomfish MUS and other animals kept and discarded. This form includes the areas fished, weather conditions and the date and time the gear was deployed. There is also space for recording the numbers of monk seals, turtles, and other protected species observed in the area.

Habitat Impacts

Bottomfish gear has very limited impacts on habitat. Habitat damage may occur from deployment of anchors during deep water fishing activities. However, damage is highly localized as the total targeted fishing habitat is limited to 100 fathoms contours areas with high relief. Anchoring during fishing operations is generally conducted at depths from 40-60 fathoms, with depths ranging from 30 to 175 fathoms. Reef building corals are generally not found below 50 fathoms, the lower extent of light attenuation. It is estimated that suitable bottomfish habitat where vessel anchoring might occur represents approximately 1% of the total bank habitat. Shallow water bottomfish activities are conducted while drifting therefore minimizing the potential for anchor damage.

Target Resource

The domestic bottomfish fishery in the western Pacific region primarily targets deep-sea snappers and groupers. Generally, the following deep-water snapper and grouper species are sought after because of their high market values. These include the species: Kalekale- *(Prisipomoides seiboldi)*, Opakapaka- *(P. Coruscanus)*, Gindai- *(P. Zonatus)*, Ehu or red snapper- *(Etelis carbucnulus)*, and sea bass- *(Epinephelus quernus)*.

Gear Description and Use

The standard bottomfish gear primarily consists of a hydraulic or electric handline consisting of a 130 lb test mainline and terminal rigs, to which the hooks and lead weight are attached. Generally, the terminal line consists of 4-12 hooks spaced at 7-8 feet intervals with a 2-6 lb lead weight attached at the end of the line. A chum bag is attached just above the last hook and filled with finely chopped fish. Each hook is baited with fish or squid, and the gear is lowered into the water.

Depending on species targeted, the gear is lowered at depths ranging from 50-150 fathoms. Using years of acquired knowledge and advanced electronic equipment such as sonar fish finders and geographic positioning systems, target species are easily located and the gear can be accurately placed within a few meters above those substrates. Ideally, the gear is placed one fathom above the bottom in order to effectively attract target species. If the gear is set on the bottom, target species may not be enticed to take the bait, too high in the water column, it may deter target species wary of predation by larger predators. Once the gear is placed in its ideal location, it is jerked sharply to release the chum bag. The mainline is then hauled either by hand, hydraulic gurdy or electric reel. Vessels drift or anchor during gear deployment depending on weather conditions, ocean currents, species targeted, and other variables. Because most of the target species are found in areas with a steep slope, vessels usually deploy gear close to the minimum depth contour and drift out to deeper water.

Incidental Bycatch

Being a hook and line rig, this gear is relatively selective, with the ability to successfully target particular species groups dependant upon the skill of the fisher. Experienced vessel crews have the ability to catch the desired species with very little bycatch. Gear is deployed at specific depths and in areas of certain habitat characteristics (e.g., high relief). It is, however, impossible to completely avoid non-target species.

Logbook data and research programs conducted by the State of Hawaii and the NMFS indicate that bycatch accounts for approximately 8-19% of the total catch in bottomfish fisheries in the Hawaiian archipelago. Sharks, oilfish, snake mackerel, pufferfish, and moray eels are the most numerous discard species; they are not kept by vessels because of their unpalatability. With the recent increase in market demand for shark fins, more sharks are now "finned" before they are discarded. Some carangids (large jacks and amberjacks) are also discarded because of concerns of ciguatera poisoning. It should be noted that a large percentage of the snappers and the grouper are included as bycatch because of damage from sharks.

3.4.2 Northwestern Hawaiian Islands Lobster Fishery

Introduction

The Crustaceans Fishery Management Plan (FMP) establishes management measures for the spiny and slipper lobster fishery in the NWHI and is considered one of the most tightly regulated and conservative management plans for lobsters. The principal species targeted by this fishery are the spiny lobster *Panulirus marginatus* and the common slipper lobster *Scyllarides squammosus*. Other management unit species include the spiny lobster (*Panulirus penicillatus*), slipper lobster (family Scyllaridae) and Kona crab (*Ranina ranina*). It was not until the late 1970s that development of the lobster fishery in the NWHI was fully realized, following surveys by NMFS that underscored the commercial potential. The FMP for the lobster fishery was adopted in 1983. Landings reached a record high by 1988. However, in the early 1990s lobster catches fell dramatically, but not due to overfishing. This long-term cyclic change in abundance was produced by a broad climate-induced reduction in overall oceanic productivity which resulted in lower abundance of resources throughout the food web of the NWHI. The FMP was amended accordingly (e.g., limited entry, fleet-wide seasonal harvest quota). Major aspects of the NWHI lobster fishery include the following:

- The NWHI lobster fishery is a million-dollar industry in which commercial fishing vessels target red spiny and slipper lobsters.

- NWHI banks most important to the fishery include Necker, Maro, Gardner, Pearl and Hermes, Kure, Lisianski and Nihoa at depths between 10 to 35 fathoms.

- The fishery uses a "retain-all" strategy (where all lobsters caught are counted against the quota) since research suggested that more than 60% of lobsters that are released from the vessels die from predation or exposure.

- The annual harvest guideline for the NWHI fishery is determined based on 13% of the estimated exploitable lobster population (i.e., those lobsters taken in traps). This allows no more than a 10% risk of overfishing.

- Lobster populations in the NWHI are considered healthy. Maximum Sustainable Yield (MSY) for the NWHI is estimated to be about 220 mt (300,000 lobsters). The harvest guideline in recent years has been substantially less.

- NMFS closed the fishery in 2000 due to stated concerns regarding uncertainty in the population assessment model in response to litigation. A recent NMFS declaration proposes to keep the fishery closed for up to two years more, while allowing research at the major banks.

Summary of Regulations

- Lobsters may only be taken by lobster trap or by hand (use of nets, chemicals, explosives, hooks or spears is prohibited)

- Escape panels with specified opening size in traps are required
- Assembled traps limited to 1,100 per vessel (1,200 total traps)
- Traps may not be left unattended in the water except in the event of an emergency
- Closed areas include: 20-nmi (protected species zone) around Laysan Island and all federal waters shallower than 10 fathoms (federal waters 0-50 fm around French Frigate Shoals and the north half of Midway are also proposed under the draft Coral Reef Ecosystem FMP)
- Closed season for NWHI fishery (January–June; the fishery typically only lasts one to a few months a year)
- Mandatory logbook program and (if requested) data collectors/observers
- Limited entry program (15 maximum permits, of which only about half participate in a given year)
- Retain-all fishery due to low survival of released lobsters
- Fleet-wide harvest guidelines, with bank-specific quotas for Necker, Maro, Gardner and all other NWHI areas (known as Area 4)
- Recalculation of harvest quotas based on constant harvest rate and risk to overfishing (lowers risk)
- Lobster permitted vessels required to have operational vessel monitoring system (VMS) to transit through NWHI lobster grounds during closed season (voluntary VMS also facilitates enforcement)

<u>Habitat Impacts</u>

Typically traps are set in areas of relatively low structural relief, away from coral reef habitat. If traps are set too close to coral reef and other high relief habitats, lobsters cannot be enticed to enter the traps. Interactions of the lobster fishery with coral reef resources/habitats are limited and poorly known. Some coral pieces have recently been observed in trap-hauls, but is unquantified and additional research is needed. Potential for vessel groundings also exist in the NWHI fishery. In the past two decades only one permitted lobster vessel ran aground. A survey two years later found only limited damage. Existing management measures (e.g., gear restrictions, closed areas) of the FMP help mitigate potential adverse impacts to essential fish habitat (EFH).

<u>Gear Description and Use</u>

All vessels participating in the NWHI lobster fishery use traps manufactured by Fathoms Plus. The trap is dome-shaped and molded from black polyethylene. The trap dimensions are approximately 2.5' x 3.2' x 1'. To ensure traps deploy upright on the bottom, lead weights are secured inside the trap. Each trap has two entrance cones located on opposite sides of the traps. The traps also have two escape vents comprised of four circular holes at least 2½ inches in diameter, that allow for the escape of undersized lobsters and other incidental catch such as octopus. This gear restriction has resulted in significant reduction in the incidental take of non-target species. Trap opening sizes are specified by regulation. Traps are set in strings of several hundred (typically about 800 per day) and baited with chopped mackerel.

<u>Incidental Bycatch</u>

Bycatch, as determined by experimental traps without escape vents includes (in decreasing order of abundance) hermit crabs, reef fish, other crabs, moray eels, other lobsters, molluscs and small sharks. The amount of bycatch is much less in commercial traps with mandatory escape vents. Some lobster traps are lost each year. A NMFS 1992 report found that while lobsters may enter these traps they were also able to exit and there was no observed mortality associated as with ghost fishing. The study concluded that lobsters utilized the traps as shelter.

Reporting

Participants in the NWHI fishery are required to complete the NMFS Daily Lobster Catch Report after each set. The form includes space for recording the number of spiny lobsters, slipper lobsters, Kona crab, octopus and other animals kept and the number discarded. There is also space for recording the number of monk seals, turtles, and other protected species observed in the area. While lobster have been recorded in the diet of the endangered Hawaiian monk seal, no conclusive evidence exists regarding the importance of lobsters to seals. Also recorded are the areas fished, weather condition and date and time of gear set and haul. A Hawaii Division of Aquatic Resources Crustaceans Trip Report is also required, which summarizes the number and weight of lobsters caught and weight sold.

3.4.3 Precious Corals Fishery

Introduction

Prior to the passage of the Magnuson Act in 1976, precious corals had been fished in the US EEZ of the western Pacific region by foreign vessels. In 1975, Japanese vessels reportedly harvested about 100 Metric Tons of precious corals within 200 miles of Midway, Wake, Yap, and Saipan Islands. In 1977, a Taiwanese precious coral vessel entered Midway Island and reported that 30 vessels would dredge around Milwaukee bank, outside the US EEZ.

The Fishery Management Plan (FMP) for the precious corals fishery was implemented in 1983 and has been amended four times. In the FMP, precious coral beds are treated as distinct management units because of their widely separated and patchy distribution and the sessile nature of individual colonies. Beds are classified as Established, Conditional, Refugia or Exploratory. Established and Conditional beds have specific harvest quotas. Refugia Beds are areas set aside for baseline studies and possible reproductive reserves, with no commercial harvesting allowed. Exploratory areas comprise the remaining EEZ, where precious corals exist but have not been discovered. Each island area – Hawaii, American Samoa, Guam and the PRIA – have individual Exploratory areas with a 1,000 kg annual quota. An amendment has been drafted to include the CNMI under this same regime. The Hawaiian Exploratory area contains many times more precious coral habitat than the other Exploratory areas. Of the potential habitat in the Hawaiian EEZ, 99.7% is unexplored, with most of in the NWHI. The major potential banks are off Gardener Pinnacles, French Frigate Shoals and Maro Reef. The Council has proposed to increase the quota for the Hawaiian Exploratory area to 5,000 kg per year with various harvesting restrictions outlined in the regulations section below.

Interactions of the Precious Corals FMP with coral reef resources/habitats are non-existent for pink, red, gold and bamboo coral, as these fisheries occur much deeper than 50 fm. However, black coral is harvested from 30-50 fm. Harvesting black coral removes habitat itself, but it is unknown if this is a significant ecosystem effect, if harvested at sustainable levels. Black coral has been shown to correlate with higher abundances of bottomfish, but this may be confounded with long-term effects of fishing on the stocks. Additional research is needed.

Target Resources

The precious corals fishery in the western Pacific region has occurred exclusively in the EEZ (and state waters) surrounding Hawaii. Much of the black coral (*Antipathes dichotoma, A. grandis, and A. ulex*) is harvested in state waters. Most of the pink and red coral (*Corallium secundum, C. regale,* and *C. laauense)* and gold coral, (*Gerardia* spp., *Narella* spp., and *Calyptrophora* spp.) are harvested in deep waters (175 - 750 fathoms) of the EEZ. Bamboo coral (*Lepidisis olapa* and *Acanella* spp.) is also found at these depths, but is not currently exploited.

Gear Description and Use

Black coral harvesters use scuba with rebreathers and mixed gas to achieve greater depths, hatchets or sledges to harvest colonies, and float bags to send colonies to surface for retrieval. Red, pink, gold coral harvesters use one-man submersibles certified to dive 2000 ft (333 fm) equipped with manipulator arms and collecting baskets, on-board GIS, streaming video cameras, and computers with graphical software. While non-selective gear (tangle nets) is currently allowed, a proposed ban would allow only selective harvest methods. All harvesting methods are supported by a mothership. Black coral harvesters scuba dive from a small vessel located directly above the bed while deeper coral harvesters employs mothership and two submersibles. The first submersible is deployed for a maximum of four hours while batteries of second submersible are charging. This allows for round the clock harvesting operations.

Incidental Bycatch

Only organisms growing directly on the coral are potential bycatch. These include sponges, polychaetes and other lower invertebrates. Free-swimming fauna, inhabiting the corals, such as eels and bottomfish would invariably abandon their shelter as it is harvested.

Habitat Impacts

Selective harvest minimizes potential impacts on habitat. Precious corals are habitats for some species of animals, including juvenile bottomfish and arrowtooth eels. Monk seals are believed to forage for bottomfish and eels by breaking apart and knocking down precious coral colonies. Minimum size restrictions and a quota of 5% of the standing stock protect the habitat. While the largest colonies will be harvested, a twenty year age distribution will remain for all beds.

Reporting Requirements

Harvesters radio in daily harvest weight by species and position of the mothership. Harvesters fill out a NMFS daily precious coral harvest logbook which must be submitted within 72 hours of landing at port. Logbook requirements include harvest method, hours fished, depth and area fished and weight of coral by species. Additional data reporting has been proposed (see below).

As this fishery has recently emerged from a 20 year hiatus, many proposed measures are being considered to adapt to technology and other management concerns.

Current Regulations

- The five defined beds and the four Exploratory areas have area-specific permits
- No vessel can have more than one permit valid at any one time
- Permits are issued for one year, except for the Makapu'u bed (two year time span)
- Bed has a specific quota for each species, quotas apply only to live coral
- Exploratory areas have a 1,000 kg per year quota for all species combined
- 10" minimum size restriction to harvest pink coral
- Non-selective gear prohibited in MHI, allowed in all other areas of the EEZ

Proposed Regulations

- Only selective gear is allowed in all permit areas
- Size restrictions for pink corals applies to all permit areas, 48" minimum height, 1" minimum base size for black coral
- Harvest of gold coral suspended at Makapu'u bed, Brooks Bank bed and Gold Pinnacles bed until additional information is available on recruitment of these species
- New reporting requirements including submission of video tape logs, specific locations of all dives including dives where no harvest occurred, and report of damaged but not harvested coral
- Increase the quota for the Hawaiian Exploratory area to 5,000 kg per year with the following restrictions; (1) maximum of 1,000 kg harvested at any given site, (2) maximum of 1,000 of 5,000 kg total quota can be gold coral, (3) no take of gold coral in the Northwest Hawaiian Islands, (4) 5,000 kg quota is for one year, renewable upon approval, and (5) no more than 50% of the total legally harvestable stock of gold or pink coral at a given site within the exploratory area may be harvested.

3.4.4 Pacific Pelagic Fishery

The original Pelagic Fisheries Fishery Management Plan of the Western Pacific Region became effective on March 23, 1987. The plan addressed several immediate issues such as the regulation of foreign fishing vessels in US Pacific insular EEZ waters through fishing permits and area closures, the prohibition of drift gill net fishing except for experimental purposes, observer requirements and catch reporting definition of pelagic management unit species.

The plan also created a framework for the future management of pelagic fisheries within the EEZ of the Western Pacific Region. The Pelagic Fisheries Fishery Management Plan has been amended eight times and the following is a summary of each of the FMP amendments and Council activity related to each amendment.

Amendment 1 to the PFMP was added on 29 June 1991. It was drafted in response to the Secretary of Commerce Guidelines for the Magnuson Act National Standards requiring a measurable definition of recruitment overfishing for each species or species complex in a FMP. The overfishing index expressed the current spawning population as a percentage of the original un-fished spawning population in the virgin stock, or spawning potential ratio (SPR). For pelagic teleost fish the SPR was set at 20% of the original un-fished spawning population. For sharks, however, the Council recognized that these species were on the whole less resilient to fishing pressure and established a higher SPR of 35%. The optimum yield (OY) for pelagic management unit species was also defined as the amount of fish that can be harvested by domestic and foreign vessels in the EEZ without causing local overfishing or economic overfishing.

Amendment 2 to the PFMP was added on the 31 May 1991 and required domestic longline vessels to have federal permits, maintain federal fishing logbooks and the placement of observers on those vessels wishing to fish within 50 nmi of the Northwestern Hawaiian Islands. Amendment 2 also implemented the application of the PFMP to the Northern Mariana Islands.

Amendment 3 to the PFMP was added on the 18 October 1991 and established a 50 nmi longline exclusion zone around the Northwestern Hawaiian Islands (NWHI) to protect endangered Hawaiian monk seals. Amendment 2 abrogated Amendment 3 but contained framework provisions through which a mandatory observer program was implemented to collect information on turtle-longline interactions.

Amendment 4 to the PFMP was added on the 16 October 1991 established a three year moratorium on new entries into the Hawaii-based domestic longline fishery. The moratorium expired on 22 April 1994. The provision of imposing a mandatory vessel monitoring system (VMS) policy for domestic longline fisheries in the Western Pacific Region was implemented under the framework process of Amendment 4.

Amendment 5 to the PFMP was added on the 4 March 1992 and established a longline exclusion zone around the Main Hawaiian Islands (MHI) ranging from 50 to 75 nmi and a similar 50 nmi exclusion zone around Guam and its offshore banks. This zone was established to prevent gear conflicts and vessel safety issues arising form interactions between longliners and smaller fishing boats. A seasonal reduction in the size of the closure was implemented on the 6 October 1992. Between the months of October and January, longline fishing is prohibited within 25 nmi of the windward shores of all islands except Oahu, where longline fishing is prohibited within 50 nmi from the shore.

Amendment 6 to the PFMP was added on the 1 January 1992 and specified that all tuna species were now designated as fish under the United States management authority. Amendment 6 included tuna and related species of the genera *Allothunnus* spp, *Auxis* spp, *Euthynnus* spp, *Gymnosarda* spp, *Katsuwonus* spp, *Scomber* spp and *Thunnus* spp. Amendment 6 also proposed application of the longline exclusion zones of 50 nmi around the island of Guam and associated seamounts, and the 50/75 nmi zone around the MHI to foreign longliners, purse seiners and baitboats. Prior to this amendment the foreign longline exclusion zones around Guam and the MHI/NWHI extend to 150 nmi. The original foreign longline exclusion zones around American Samoa remained unchanged but applied equally to foreign purse seiners and baitboats.

Amendment 7 to the PFMP was added on the 14 January 1994 and instituted a limited entry program for the Hawaii-based domestic longline fishery. Amendment 7 limits the number of vessels in the fishery to 164 longline boats and these must not exceed 94 ft in length, the size of the largest vessel in the fleet prior to the moratorium period specified under Amendment 4.

This amendment was part of a collective document that besides the Pelagic FMP included amendments to other Council FMPs, and was drafted in 1998. This amendment was partially approved on April 19 1999. Sections on pelagic bycatch and overfishing were parts of the amendment not approved.

Proposed Amendment 9, still in draft form, implements an annual fleet-wide precautionary quota for sharks in the Hawaii-based longline fishery. Initially the quota will be set at 50,000 sharks, based on the average retained catch between 1996 and 1998. The amendment will also contain a framework by which the quota can be rapidly adjusted from year to year depending on blue shark stock assessments or other performance indices. The amendment will also ban demersal or bottom longline fishing in federal waters of the Hawaiian Islands targeting Pelagic Management Unit Species, and specifically sharks.

3.5 Status of Protected Species listed under the ESA

Several species listed as endangered or threatened under the Endangered Species Act (ESA) occur in the region in which the bottomfish fisheries operate. These include marine mammals, turtles and seabirds.

3.5.1 Endangered Marine Mammals

Marine mammals listed as endangered under the ESA, and that have been recorded from the region in which bottomfish vessels operate are: the Hawaiian monk seal (*Monachus schauinslandi*), humpback whale (*Megaptera novaeangliae*), sperm whale (*Physeter macrocephalus*), blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*), and the sei whale (*B. borealis*). With the exception of the Hawaiian monk seal, there have been no reported interactions with endangered marine mammals in the bottomfish fisheries of the region.

3.5.1.1 Hawaiian Monk Seal

The Hawaiian monk seal is the most endangered pinniped in U.S. waters and is second only to the northern right whale as the nation's most endangered marine mammal (Marine Mammal Commission 1999). It was designated depleted in 1976 under the Marine Mammal Protection Act, and was listed as endangered under the ESA following a 50% decline in beach counts from the late 1950s to the mid-1970s.

The Hawaiian monk seal breeds only in the Hawaiian Archipelago, with most monk seals inhabiting the remote, largely uninhabited atolls and surrounding waters of the NWHI. More than 90 percent of all pups are born at six major breeding colonies located at French Frigate Shoals, Laysan Island, Pearl and Hermes Reef, Lisianski Island, Kure Atoll and Midway Atoll. A few births also occur annually at Necker, Nihoa, and Ni'ihau Islands and in the main Hawaiian Islands. Although monk seals occasionally move between islands, females generally return to their natal colony to pup. Since 1990, there has been an apparent increase in the number of monk seal sightings and births in the main Hawaiian Islands (HMSRT 1999; Johanos 2000).

Little is known about Hawaiian monk seals or their population status before the 1950s. As a result of natural constraints, the species was probably never very abundant, presumably numbering, at most, in the thousands (as opposed to hundreds of thousands) (Ragen and Lavine 1999). The arrival of humans in the Hawaiian Islands may have reduced the range of the Hawaiian monk seal largely to the NWHI and contributed to its current endangered status. In historic times, human-related mortality appears to have caused two major declines of the Hawaiian monk seal (NMFS 1997; Marine Mammal Commission 2000). It generally is acknowledged that the species was heavily exploited in the 1800s during a short-lived sealing venture. Several island populations may have been completely eliminated during this period. The second major decline occurred after the late 1950s and appears to have been determined by the pattern of human disturbance from military activities at Kure Atoll, Midway Atoll and French Frigate Shoals. Such disturbance caused pregnant females to abandon prime pupping habitat and nursing females to abandon their pups. The result was a decrease in pup survival, which led to poor reproductive recruitment, low productivity and population decline (NMFS 1997; Marine Mammal Commission 2000).

The first attempt at estimating Hawaiian monk seal numbers was made in 1958, when a total of 1,206 seals was counted (Marine Mammal Commission 1999). Between then and the mid-1970s, the overall population size decreased by about 50 percent. The decline in monk seal numbers seemed to have slowed by the early 1980s, due primarily to a sevenfold increase in monk seal counts at French Frigate Shoals between the 1960s and mid-1980s. By 1985, the French Frigate Shoals colony had grown to a point where it included nearly half of the entire population (Marine Mammal Commission 2000). However, the overall population again began to decline in the late 1980s and early 1990s. The downward trend was driven primarily by a high mortality of juveniles at French Frigate Shoals, where the species' largest breeding colony resides (Marine Mammal Commission 2000). Since the mid-1990s total monk seal numbers appear to have stabilized at about 1,300 to 1,400 individuals. The first-year survival of pups at French Frigate Shoals increased significantly in 1998 (Marine Mammal Commission 2000).

Contributing to the species' decline over the past four decades have been human disturbance, reduced prey availability, shark predation, attacks by aggressive adult male monk seals on females and immature seals of both sexes (called "mobbing") and entanglement in derelict fishing gear (Marine Mammal Commission 1999). At each colony, differing combinations of these factors likely have contributed to local trends in abundance, with relative importance of individual factors changing over time (Marine Mammal Commission 2000). Factors contribution to the decline in monk seal abundance are described in greater detail in the following sections.

Human Disturbance

As noted above, human disturbance was probably the principal cause of monk seal population declines before the 1980s. Between 1958 and the mid-1970s, monk seal colonies at the western end of the archipelago between Kure Atoll and Laysan Island declined by at least 60 percent, and the colony at Midway Atoll all but disappeared (Marine Mammal Commission 1999). Most human activity was concentrated at the westernmost atolls of the chain during this period, suggesting that human disturbance contributed to the decline. The Navy undertook a major expansion of its air facility on Midway Atoll during the 1950s, and in 1960 the Coast Guard established a LORAN station at Kure Atoll that was occupied year-round. Ownership of Midway Atoll was transferred from the Navy to the U.S. Fish and Wildlife Service in 1996, and the atoll is now managed as the Midway Atoll National Wildlife Refuge. The Coast Guard closed the LORAN station at Kure Atoll in 1992 and removed most of the manmade structures by 1993.

The human population at Midway Atoll has decreased substantially in the last two decades, but year-round human habitation of the atoll has continued. Since 1996, there has been limited eco-tourism and public use within the Midway Atoll National Wildlife Refuge in the form of charter boat and shore fishing, diving and wildlife observation. A privately-owned business was awarded a concession to develop and manage the tourist facilities in the refuge. The number of visitors allowed on the atoll at any one time is limited to reduce impacts to wildlife. The HMSRT (2000) indicated that it supports the efforts of the U.S. Fish and Wildlife Service to provide compatible visitor opportunities and educational programs at the refuge. It is also important to note that the Midway Atoll monk seal population has increased since the atoll was transferred to the USFWS. However, some monk seal researchers have expressed concern about the possible long-term impacts of developing Midway Atoll as a tourist destination:

> *Such developments will of course yield benefits to the management bureaucracy, providing continued support for the Fish and Wildlife Service station on the island. It will also ease the logistical problems for scientists who wish to study the animals on the islands, and it will provide an opportunity for public education. But the conservation benefits of tourism for monk seals at Midway will not be measured by the numbers of visitors or their vacation experience, only its effects on the seals. Although these remain to be determined, one can only wonder what would happen if humans simply vacated Midway entirely* (Lavigne 1999:260).

Similarly, NMFS (1997) noted that as the tourism venture develops, so does a potential conflict of interest. The economic success of the venture may depend on the nature and variety of human activities permitted on the island. Importantly, those activities that are intended to enhance the Midway experience may be disruptive or detrimental to the refuge and its wildlife. It is clear from several documented cases in the MHI that the sport fish fishery occurring on Midway has the potential to interact with the monk seals. For instance, in 1994 a monk seal was found dead with a recreational hook lodged in its esophagus (Henderson 1998). In addition, at least seven other monk seals have been hooked by recreational fishermen in the MHI, with at least three of these fishermen targeting ulua (Henderson 1998).

During World War II, the Navy enlarged Tern Island, one of several small islets at French Frigate Shoals, from its original 4.5 hectares (11 acres) to about 16.2 hectares (40 acres) to accommodate a landing strip (Marine Mammal Commission 1999). To do so, the Navy constructed a sheet metal bulkhead around most of the island and backfilled behind the structure with dredged spoil and coral rubble from the surrounding lagoon. The Coast Guard took over the island from 1952 to 1979 to operate a LORAN station. Since then, it has been used by the U.S. Fish and Wildlife Service as a field station for the Hawaiian Islands National Wildlife Refuge.

The continued existence of the runway and field station at Tern Island – in fact, the integrity of the entire island – is in doubt because the sheet metal bulkhead, now more than 50 years old, is badly deteriorated (Marine Mammal Commission 1999). If the bulkhead fails, the airstrip would be lost, the field station would have to be abandoned, most of the island would erode away, buried debris would be exposed and create entanglement hazards to wildlife, and erosion pockets behind the rusted-out seawall would become serious entrapment hazards for monk seals and other wildlife. In 1991, a monk seal died after becoming trapped behind the eroding sea wall (NMFS 1997). In 1999, the U.S. Fish and Wildlife Service received $1 million as an initial investment for sea wall construction at Tern Island. The total cost of the project is estimated to be about $15 million (Marine Mammal Commission 1999).

Another legacy of past human use of the NWHI is environmental pollution from abandoned landfill areas and debris sites that could work its way into atoll food chains (Marine Mammal Commission 2000). Most notably, the presence of a point source of contaminants at Tern Island has been identified as a threat to monk seals and other components of the ecosystem at French Frigate Shoals. A recent analysis of risks to Hawaiian monk seals based on dietary exposure and contaminant concentrations in blubber and blood indicate that no contaminants are present at concentrations believed to present a risk to the seals (CH2M Hill 2000). However, due to the dynamic nature of the environment at the site, future risks associated with an episodic storm event indicate a potential risk should a portion or all of the contaminants in the landfill be redistributed into the lagoon.

Monk seal research activities can also inadvertently have a negative impact on monk seals. Since 1982, three seals have died from research efforts, and an additional 22 seals have died during translocation and rehabilitation efforts (G. Antonelis, pers. comm. 2000. NMFS-HL). However, a study by the NMFS Honolulu Laboratory indicates that research handling of monk seals causes no significant increase in mortality if the seals are released in a healthy condition (Baker and Johanos 2000). According to some researchers, it is also possible that continuous human habitation of research field camps in the NWHI could have an adverse effect on monk seals if not carefully controlled (Spalding 2000). However, many of the seals chosen for rehabilitation were in poor health before inclusion in the program, and therefore their risk of mortality from natural causes was already high (G. Antonelis pers. comm.).

Reduced Prey Availability

Since the early 1980s, steps have been taken to prevent human disturbance of monk seals, and the western colonies have begun to increase slowly (Marine Mammal Commission 2000). As noted earlier, however, the breeding colony of monk seals at French Frigate Shoals experienced a high juvenile mortality from 1989 to the mid-1990s. Whereas first-year survival rates for pups at the atoll in the early 1980s were between 80 and 90%, they dropped significantly between 1989 and the mid-199s. (Marine Mammal Commission 2000). One of the potential explanations of the poor juvenile survival at this site during this time period is limited prey availability and subsequent effects on both adults and juveniles. There are two factors related to food that influence weaned pup survival: 1) the amount of food (milk) pups acquire from their mothers prior to weaning and 2) the amount of food available to pups immediately after weaning (G. Antonelis, pers. comm. 2000. NMFS-HL). The first factor is related to the mother's condition and ability to forage successfully prior to parturition and may be viewed as an indicator of prey availability during gestation. The second factor is related to the pup's ability to forage successfully after weaning. Evidence of limited prey availability at French Frigate Shoals included small and, in some cases, emaciated pups, juveniles that were smaller and thinner than those at other colonies and delayed sexual maturity of adult females (Craig and Ragen 1999; Marine Mammal Commission 2000).

Further evidence of limited prey availability at French Frigate Shoals has been provided by satellite-linked, time-depth recorders that have been used to track movements and record diving patterns of Hawaiian monk seals at various locations. All but one of the animals tracked at Pearl and Hermes Reef foraged either within the fringing reef or just outside the reef (Stewart 1998). Most dives were to depths of 8 to 40 m, though there was a secondary mode at 100 to 120 m. Monk seals studied at French Frigate Shoals, where the population of seals is considerably larger, exhibited more variation in their habitat use (Abernathy and Siniff 1998). The most prevalent pattern, particularly among males, was utilization of the banks to the northwest (some of which are more than 200 km from haul-out sites), with daytime diving in the 50 to 80 m range and a nocturnal or crepuscular shift to the 110-190 m range. The next most common group included seals that did not leave the vicinity of French Frigate Shoals and rarely dived deeper that 80 m. Finally, a small number of seals made many dives greater than 300 m. Abernathy and Siniff (1998) suggested that reduced prey availability could account for the greater variety of foraging patterns at French Frigate Shoals as some individuals are forced to venture to new areas and alter their prey base.

The two leading hypotheses to explain the lack of prey at French Frigate Shoals are 1) the local population reached its carrying capacity during the mid-1980s, and essentially diminished its own food supply, and 2) carrying capacity was simultaneously reduced by large-scale natural perturbations in ecosystem productivity (NMFS 1997; Marine Mammal Commission 2000). Declines in Hawaiian monk seal, seabird and lobster reproductive success in the late 1980s appear to have been linked to a large-scale climatic event (Mundy undated; Polovina et al. 1994). From the mid-1970s to late 1980s, the central North Pacific experienced increased vertical mixing, with a deepening of the wind-stirred surface layer into nutrient-rich lower waters and probable increased injection of nutrients into the upper ocean. Resulting increased primary productivity likely provided a larger food base for fish and animals at higher trophic levels. In the NWHI changes of 60 to 100% over baseline levels in productivity for lobsters, sea birds, reef fish and monk seals were observed and attributed to deeper mixing during 1977-1988 (Polovina et al. 1994). The variation in the geographical position of this vertical mixing is in turn related to the position of the Aleutian low-pressure system.[1] As this system deviates from its long-term average position, productivity may be more or less affected in the waters around the NWHI.

Polovina et al. (1994) suggested that the average position of the Aleutian low-pressure system moved northward in the mid- to late-1980s. The "declines" in productivity observed at Midway and French Frigate Shoals after 1988 actually represented returns to more "normal," lower levels of productivity (Mundy undated). Productivity may have been most affected at French Frigate Shoals, the southernmost reproductive colony of Hawaiian monk seals (Craig and Ragan 1999).

1

There are also considerable biological data showing higher fish and zooplankton densities in the Gulf of Alaska during the 1970s and 1980s compared to earlier decades, as well as correlations between biological indices and an index of the strength of the Aleutian low-pressure system (Polovina et al. 1995).

Furthermore, the adverse impact of a return to less productive oceanographic conditions on monk seal reproduction and survival could presumably have been greater at French Frigate Shoals because that island's monk seal population was closer to carrying capacity (Ragen and Lavigne 1999).

The general decreases in reef fish abundance observed at Midway Atoll and French Frigate Shoals in 1992-1993 may also have been influenced by interdecadal changes in ecosystem productivity in the central Pacific, at and above the latitudes of the NWHI (DeMartini et al. 1996). In 1995, a dramatic increase in recruitment and availability of reef fish was detected at both French Frigate Shoals and Midway Atoll (DeMartini and Parrish 1996). No further increase in apparent abundance of reef fish since that time has been found (DeMartini and Parrish 1998), but from the mid- to late-1990s there was an improvement in the condition of monk seal pups at weaning and in local pup births at French Frigate Shoals and other major island populations (HMSRT 2000). Trends in pup girth measurements indicate that prey resources may have started to increase during the 1990s, most notably at Laysan Island, Lisianski Island and French Frigate Shoals (NMFS 1999).

Fisheries also have the potential of reducing the prey available to monk seals. Hawaiian monk seals have the capability to dive to depths at which many species targeted by the bottomfish fishery occur. In addition, monk seals are known to remove hooked bottomfish from handlines and consume them (Nitta 1999). Seals appear to prefer *'ōpakapaka* but will also steal and eat *onaga*, *butaguchi* and *kahala*. However, the results of dietary studies suggest that these species do not constitute a significant component of the natural diet of monk seals. An analysis of fecal and regurgitate samples from Hawaiian monk seals at five islands in the NWHI indicated that monk seals are opportunistic predators that feed on a wide variety of available prey as compared to the case of other seals in which the bulk of the diet is made up of only a few species (Goodman-Lowe 1998). The analysis revealed that teleosts (bony fish) were the most represented prey (78.6%) followed by cephalopods (15.7%) and crustaceans (5.7%). The most common teleost families found were marine eels (22.0%), Labridae (20.6%), Holocentridae (14.4%), Balistidae (13.1%) and Scaridae (10.5%). All teleosts found were common, shallow-water reef fishes, except for the beardfish family, Polymixiidae (1.0%), which is recognized to consist of deep-water benthic fish. The deep-water Polymixiidae are not caught in the bottomfish fishery either as target or non-target species. Evidence of target species such as snapper and grouper appeared infrequently in fecal and regurgitate samples.

A recent study contracted by NMFS used quantitative fatty acid signature analysis to identify which prey items are most important to the various age and sex components of the several island populations of monk seals (Iverson 2000). Initial estimates of diet suggest an array of prey species that are in some cases comparable to that found in the analysis of fecal and regurgitate samples. To date, the study has not focused on indetification of the fatty acids of the fish species most commonly targeted by the NWHI bottomfish fishery.

Shark Predation and Mobbing

Evidence suggests that during the mid- to late-1990s, shark predation and male monk seal aggression contributed significantly to the mortality of weaned and pre-weaned pups at French Frigate Shoals (HMSRT 1999). Predation by Galapagos sharks (*Carcharhinus galapagensis*) and perhaps tiger sharks (*Galeocerdo cuvieri*) of monk seal pups seems to be increasing in occurrence, as 17 (18%), 16 (15%) and 25 (27%) pup mortalities or disappearances were believed to be associated with shark attacks at French Frigate Shoals in 1997, 1998 and 1999, respectively (HMSRT 1999). In 1999, shark predation may have accounted for the deaths of 51% (23 of 45) of the pups born at Trig Island in French Frigate Shoals (G. Antonelis, pers. comm. 2000. NMFS-HL). According to the HMSRT (2000), a preliminary analysis of the impacts of shark predation on the recovery of the French Frigate Shoals population of monk seals indicates that the mitigation of this interaction is essential to the recovery of this population. The HMSRT has recommended that NMFS undertake a program to remove Galapagos and/or tiger sharks observed patrolling beaches where monk seal pups are present within the French Frigate Shoals atoll.

Aggressive behavior or mobbing of females and immature seals by adult males is a source of mortality at French Frigate Shoals, Laysan Island and Lisianski Island. The deaths can be a direct result of injuries inflicted by the aggressive males or as a result of later shark attacks on wounded seals or pups chased into the water by aggressive males. The primary cause of mobbing is thought to be an imbalance in the adult sex ratio, with males outnumbering females (NMFS 1998). Such imbalances are more likely to occur when populations are reduced. In 1997, 14 incidents of individual adult male aggression toward pups were documented at French Frigate Shoals, and eight pups subsequently died (Marine Mammal Commission 1999). In 1998, there were 13 documented cases of male aggression toward females, juveniles or pups that resulted in injury or death. Of these, three were at French Frigate Shoals, one of which resulted in a death; two were at Laysan Island, one of which resulted in a death; and eight were at Lisianski Island, one of which resulted in a known mortality. The subsequent removal and relocation of aggressive male monk seals has reduced or eliminated deaths caused by males at French Frigate Shoals and Laysan Island (HMSRT 1999).

Entanglement in Marine Debris

Marine debris, particularly derelict fishing nets, poses a serious risk of injury and death to Hawaiian monk seals. The inquisitive nature of seals, particularly pups and juveniles, tends to make them attracted to debris. Subsequent interactions can lead to entanglement and, unless they are able to free themselves quickly, entangled seals risk drowning or death through injuries caused by the entangling gear. In 1998, 18 seals were found entangled in debris (Marine Mammal Commission 1999). Of these, five were able to disentangle themselves, 12 were disentangled by field crews and one was found dead in a fishing net caught on the reef at Laysan Island. In 1999, a record 25 monk seals were reported to have been found entangled in marine debris (HMSRT 1999). Most of the net debris in the NWHI appears to be trawl webbing. Although its origin is unclear, no trawl or gillnet fishing occurs in the NWHI, and it is assumed that virtually all of the debris has been transported by ocean currents from distant fisheries around the rim of the North Pacific Ocean (Marine Mammal Commission 2000).

In 1998, NMFS organized a multi-agency cleanup effort to remove derelict fishing nets and other debris from the reefs surrounding French Frigate Shoals and Pearl and Hermes Reef. NMFS was able to remove only a small proportion of this debris and estimates that 38,000 pieces of netting remain in the waters surrounding each of these locations (Marine Mammal Commission 2000). NMFS continued the task of cleaning up this marine debris in 1999 and 2000.

In 1996, NMFS completed a Section 7 consultation Biological Opinion in association with Amendment 9 to the Fishery Management Plan for Crustaceans. This consultation considered impacts to protected species from the crustacean fishery. Species were considered that may occur in the management area, which included the Hawaiian monk seal, green sea turtle, leatherback turtle, and humpback whale. It concluded that Amendment 9 was not likely to jeopardize the continued existence of the listed species within the management areas or adversely affect any designated critical habitats. In addition, conservation recommendations were developed identifying those activities that NMFS and the Council could pursue to further reduce the adverse effects of fishing activities to listed species and their critical habitats.

In 1999, NMFS conducted an informal Section 7 Consultation regarding the establishment of a permanent lobster fishing areas and allocation of the 1999 Harvest guideline for the commercial lobster fishery in the Northwestern Hawaiian Islands (NWHI). This also concluded there was no evidence to suggest that the proposed 1999 harvest guideline for lobster, or establishment of permanent lobster fishing areas in the NWHI would likely adversely affect Hawaiian monk seals, and that the 1996 Biological Opinion remained valid.

3.5.1.2 Other Endangered Marine Mammals

Other marine mammals listed as endangered under the Endangered Species Act that have been recorded in waters in which bottomfish fishing vessels operate are the humpback whale (*Megaptera novaeangliae*), sperm whale (*Physeter macrocephalus*), blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*) and sei whale (*B. borealis*).

3.5.1.3 Non-Endangered Marine Mammals

Species of marine mammals that are protected under the Marine Mammal Protection Act (MMPA), but are not listed as threatened or endangered, and could occur in the areas where coral reef ecosystem fisheries operate are as follows:

- Pacific white-sided dolphin (Lagenorhynchus obliquidens)
- Rough-toothed dolphin (Steno bredanensis)
- Risso's dolphin (Grampus griseus)
- Spotted dolphin (Stenella attenuata)
- Spinner dolphin (Stenella longirostris)
- Striped dolphin (Stenella coeruleoalba)
- Melon-headed whale (Peponocephala electra)
- Pygmy killer whale (Feresa attenuata)
- False killer whale (Pseudorca crassidens)
- Killer whale (Orcinus orca)

3.5.2 Sea Turtles

All sea turtles are designated as either threatened or endangered under the Endangered Species Act. The five species of sea turtles recorded from the region in which bottomfish vessels operate are: the leatherback (*Dermochelys coriacea*), the olive ridley (*Lepidochelys olivacea*), the hawksbill (*Eretmochelys imbricata*), the loggerhead (*Caretta caretta*), and the green turtle (Chelonia mydas).

In Hawai'i, green turtles nested historically on beaches throughout the archipelago, but now nesting is restricted for the most part to beaches in the NWHI. More than 90% of the Hawaiian population of the green turtle nests at French Frigate Shoals. Satellite tagging of these animals indicates that most of them migrate to the MHI to feed and then return to breed. The four other species of sea turtles are seen in the waters of the NWHI only on rare occasions.

An issue of concern with the Hawaiian green sea turtle is the increased interactions between the sea turtles and monofilament fishing line, believed to come from the recreational fishery. Most of the sea turtles become entangled in the line with their front flipper, which severely strangulates the flipper and usually results in amputation. The turtles are eventually released back to the wild, where they are able to function reasonably well (NMFS HL Program Review 2000).

3.5.3 Seabirds

Although there are several seabird colonies in the MHI, the NWHI colonies harbor more than 90% of the total Hawaiian Archipelago seabird population. The NWHI provide most of the nesting habitat for more than 14 million Pacific seabirds. More than 99% of the world's Laysan albatross (*Phoebastria immutabilis*) and 98% of the world's black-footed albatross (*P. nigripes*) return to the NWHI to reproduce. Of the 18 species of seabirds recorded in the NWHI, only the short-tailed albatross (*P. albatrus*) is listed as endangered under the ESA. The short-tailed albatross population is the smallest of any of the albatross species occurring in the North Pacific. Land-based sighting records indicate that 15 short-tailed albatrosses have visited the NWHI over the past 60 years. Five of these visits were between 1994 and 1999 (NMFS 1999).

The fleet of fishing vessels holding 164 Hawaii longline limited access permits and operating with longline gear inadvertently hook and kill black-footed albatrosses and Laysan albatrosses that nest in the Northwestern Hawaiian Islands (NWHI). These seabirds follow the longline vessels and dive on the baited longline hooks as the vessels deploy or haul their fishing lines.

To mitigate the harmful effects of fishing by Hawaii-based longline vessels on seabirds the Council recommends that vessels registered for use under a Hawaii longline limited access permit operating with longline gear above 25° N. latitude be required to adhere to two or more of the following measures: 1) maintain adequate quantities of blue dye on board and use only completely thawed, blue-dyed bait; 2) discard offal while setting and hauling the line in a manner that distracts seabirds from hooks; 3) tow a NMFS-approved deterrent (such as a tori line or a buoy) while setting and hauling the line; 4) deploy line with line-setting machine so that the line is set faster than the vessel's speed and attach weights equal to or greater than 45 grams to branch lines within one meter of each hook; 5) attach weights equal to or greater than 45 grams to branch lines within one meter of each hook; 6) begin setting at least one hour after sunset and complete setting at least one hour before sunrise, using only the minimum vessel's lights necessary for safety. In addition, the Council recommends that 1) vessel operators be required to make every reasonable effort to ensure that birds brought onboard alive are released in a manner that ensures their long-term survival and 2) all vessel captains annually complete a protected species educational workshop conducted by the National Marine Fisheries Service.

3.6 Jurisdictional Issues

Introduction

This briefing is intended to provide an overview of the complexity of issues concerning marine boundaries in the Western Pacific Region. Delineation of current marine boundaries is included along with a summary of specific areas of contention between various federal and state authorities.

Exclusive Economic Zone

The Fishery Conservation and Management Act (FCMA or Magnuson Act[2]) of 1976 established U.S. jurisdiction from the seaward boundary of the territorial sea out to 200 miles for the purpose of managing fishery resources. Passage of the Magnuson Act was the first unilateral declaration of jurisdiction over a 200-mile zone by a major power. Presidential Proclamation 5030 of March 10, 1983, expanded Magnuson Act jurisdiction by establishing the U.S. exclusive economic zone (EEZ) which declared, "to the extent permitted by international law ... sovereign rights for the purpose of exploring, exploiting, conserving and managing natural resources, both living and non-living, of the seabed and subsoil and the superjacent waters"in the 200-mile zone. The assertion of jurisdiction over the EEZ of the United States provided a basis for economic exploration and exploitation, scientific research and protection of the environment under the exclusive control of the U.S. Government. Congress confirmed presidential designation of the EEZ in1986 amendments to the Magnuson Act. Under the Magnuson Act, fishery management authority in the EEZ off American Samoa, Guam, Hawaii, the Commonwealth of the Northern Mariana Islands, and other U.S. islands in the central and western Pacific is the responsibility of the Western Pacific Regional Fishery Management Council as established.

The EEZ is measured from the "baseline" of U.S. states and overseas territories and possessions out to 200 nautical miles. Under the Magnuson Act , the shoreward boundary of the EEZ is a line coterminous with the seaward boundary, baseline, of each "state." U.S. territories and possessions of the western Pacific fall within the definition of "state" under the Magnuson Act (16 U.S.C. 1802 M-S Act § 3 104-297). In the case of the Commonwealth of the Northern Mariana Islands (CNMI) and the Pacific Remote Island Areas (PRIAs[3]), the EEZ extends to the shoreline (Beuttler 1995).

2

The FCMA was initially referred to as the Magnuson Fishery Conservation and Management Act which was changed to the Magnuson-Stevens Fishery Conservation and Management Act by the 1996 amendment to the Act.

3

Pacific Remote Island Areas (PRIAs) Baker, Howland, Jarvis and Wake Islands, Kingman Reef, and Palmyra, Johnston and Midway Atolls.

Seaward boundaries (territorial seas) for "states" are recognized as extending out to a distance of three miles from the ordinary low-water mark, as established by the Submerged Lands Act (SLA) of 1953[4]. The Territorial Submerged Lands Act (TSLA) of 1960 was enacted to convey to the governments of American Samoa, Guam and Virgin Islands the submerged lands from the mean high-tide line out to three geographic miles from their coast lines (Beuttler 1995).

The CNMI was part of the U.S. Pacific Trust Territories until 1978 when it was given the status of Commonwealth by the United States. Although title of the emergent land was conveyed to the Commonwealth, the U.S. government withheld title to the submerged lands of the archipelago.[5] Submerged lands and underlying resources adjacent to CNMI remain owned by the Federal government and subject to its management authority (Beuttler 1995).

In the PRIAs, for which there are no sovereign entities similar to states or territories, various federal agencies have jurisdictional authority. Authority is often established through Statutes, Executive Orders and Presidential Proclamations and marine boundaries are often unclear. For this reason, the extent to which an agency exercises its jurisdictional authority is subject to legal interpretation.

Territorial Seas

State of Hawaii

The State of Hawaii consists of all islands, together with their appurtenant reefs and territorial waters, which were included in the Territory of Hawaii under the Organic Act of 1900. Under the Admissions Act of 1959, Congress granted to Hawaii the status of statehood and all amenities of a state which included the reversion of title and ownership of the lands beneath the navigable waters from the mean high-tide line seaward, out to a distance of 3 miles as stated by the SLA of 1953. Congress excluded Palmyra Atoll and Kingman Reef, Johnston Atoll, including Sand Island from the definition of the State of Hawaii in 1959. The U.S. government also retained 1,765 acres of emergent land in the Northwestern Hawaiian Islands (NWHI) which had been set aside by Executive Order 1019 in 1909, establishing the Hawaiian Islands Reservation (HIR). The HIR was later renamed the Hawaiian Islands National Wildlife Refuge (HINWR) after transference from the Department of Agriculture(DOA) to the Department of Interior (DOI) in 1939 (Yamase 1982).

Territories of Guam and American Samoa

Pursuant to the TSLA of 1960, the Territories of Guam and American Samoa own and have management responsibilities over the marine resources out to 3 "geographic" miles. In general, the

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Under the SLA, the term "boundaries" or the term "lands beneath navigable waters" is interpreted as extending from the coast line to three geographical miles into the Atlantic Ocean or the Pacific Ocean, or three marine leagues (9 miles) into the Gulf of Mexico.

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The Territorial Submerged Lands Act was enacted for CNMI on October 5, 1974 (Beuttler 1995). Congress approved the mutually negotiated "Covenant to Establish a Commonwealth of the Northern Marianas (CNMI in political union with the US)". However the Covenant was not fully implemented until 1986 pursuant to the Presidential Proclamation number 5564, which terminated the trusteeship agreement (Beuttler 1995).

authority of the Magnuson Act begins at 3 nautical miles from the shoreline at Guam and American Samoa. There are, however, exceptions to the management authority in the Territories, example for waters that are administered by the Federal government as national wildlife refuges (NWR) and naval defense sea areas (NDSA)(see below).

US Fish and Wildlife Refuges and Units

The U.S. Fish and Wildlife Service (USFWS) has been given authority to manage a number of NWRs in the Western Pacific Region. The USFWS asserts the authority to manage marine resources and activities, including fishing activities within Refuge boundaries pursuant to the National Wildlife Refuge System Administration Act (NWRSAA) of 1966, as amended by the National Wildlife Refuge System Improvement Act of 1997, and other authorities (Gillman 2000).[6] The USFWS asserts that NWRs are closed to all uses until they are specifically opened for such uses and that the USFWS is "solely" charged with making decisions whether to open NWRs for specific purposes for any use that is compatible with the refuge's primary purpose(s) and mission of the NWR (Smith 2000).

Executive Order 1019 reserved and set apart certain islets (i.e. Laysan Island, Lisianski Island) and reefs (i.e. Maro Reef, Pearl and Hermes Reef), excluding Midway, "as a preserve and breeding ground for native birds" to be administered by the Department of Agriculture. The HIR was transferred to the DOI in 1939 and later renamed the HINWR in 1040 through Presidential Proclamation 2466, with control transferred to the USFWS. Within the HINWR, the USFWS asserts management authority over coral reef resources to a depth of 10 fathoms around all islands with the exception of Necker Island where it asserts a 20 fathom boundary. The USFWS acknowledges that all HINWR islands are part of the State of Hawaii, but asserts that the islands are federally owned and administered as a NWR by the USFWS (U.S. Fish and Wildlife Service 1999, Smith 2000).

Kure Atoll was initially included in Executive Order 1019 in 1909, which establish the HIR. However, Kure Atoll was returned to the Territory of Hawaii in 1952 by Presidential Executive Order 10413. Kure Atoll is the only State Wildlife Refuge in the NWHI and extends only out 3 miles, to the State's seaward boundary (Feder Pers. Com.)

In the PRIAs, the USFWS based on interpretation of Executive Order 7358 asserts its refuge boundaries extend to the extent of the Naval Defensive Seas Area (NDSA) administered by the

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Legal opinion by Randolph Moss, U.S. Department of Justice, September 15, 2000, states that they are "unconvinced that the President has the authority to establish or expand a wildlife refuge within the U.S. territorial sea (12 miles) or the EEZ using presidential authority recognized in *Midwest Oil*." Because the NWRSAA does not itself contain a provision authorizing the President to withdraw land for a wildlife refuge, the DOI argues that the President could rely on the implied authority to reserve public lands recognized in *United States v. Midwest Oil Co.* 236, U.S. 459 (1915). The Federal Land Policy and Management Act (FLPMA) of 1976 repealed the Presidents authority, effective on and after approval of the Act, to make withdrawals and reservations resulting from acquiescence of Congress (*U.S. v. Midwest Oil Co.*). Moss continued by stating that they find "it likely that a court would find that §704(a) of the FLPMA prohibits the President from relying on the implied *Midwest Oil* authority to withdraw lands, regardless of where those lands are located." Also, that "they do not think history makes it clear that the President may continue make *Midwest Oil* withdrawals in the territorial sea or EEZ following the enactment of the FLPMA."

Department of Defense prior to the transfer of surplus land to the USFWS. At this time, the USFWS manages five wildlife refuges in the PRIAs, Jarvis, Baker and Howland Islands and Johnston and Midway Atolls (Smith 2000).

Midway Atoll NWR, established under Executive Order 13022 in 1996, is located in the NWHI and has a refuge boundary that is within a 22 by 22 mile quadrant surrounding the atoll (the exact boundary is disputed). Under the U.S. Navy, Midway was established as a Naval Air Facility in 1941. The USFWS established an overlay refuge in 1988 to manage the fish and wildlife on the Atoll. Through the Base Alignment Closure Act of 1990, as amended, the Naval Air Facility closed in 1993 and the property was transferred to the USFWS in 1996 (US Fish and Wildlife Service 1999). The mission of the refuge is to protect and restore biological diversity and historic resources of Midway Atoll, while providing opportunities for compatible recreational activities, education and scientific research (Shallenberger 2000). Through a long-term cooperative agreement with a private company (Midway Phoenix Corp.), the refuge has been open to the public for marine recreation and education (Shallenberger 2000).

Johnston Atoll NWR is managed cooperatively with the U.S. Navy. The atoll was first established as a federal bird refuge on June 29,1926, through Presidential Executive Order 4467 to be administered by the Department of Agriculture. In 1934, through Executive Order 6935, the atoll was placed under the jurisdiction of the U.S. Navy for administrative purposes and has been used as a military installation since 1939. In 1941, Executive Order 8682, designated Johnston and other Pacific atolls NDSAs. In 1976, the USFWS, under agreement with the military, assists in management of fish and wildlife resources on the Atoll. The USFWS manages a recreational fishing program in the NWR (Smith 2000).

Administration of Jarvis, Howland and Baker Islands were transferred from the Office of Territorial Affairs to the USFWS in 1936 to be run as NWRs. The USFWS asserts refuge boundaries out to 3 nautical miles where it prohibits fishing and any type of unauthorized entry (Smith 2000). The USFWS acknowledges fishery management authority under the WPRFMC in coordination with the NMFS within the "200-nautical mile EEZ" (Smith 2000).

Rose Atoll NWR, located in American Samoa, was established through a cooperative agreement between the Territory of American Samoa and the USFWS in 1973. Presidential Proclamation 4347 exempted Rose Atoll from a general conveyance of submerged lands around American Samoa to the Territorial Government. The boundary of the refuge extends out to 3 miles around the atoll and is under the joint jurisdiction of the Department of Commerce (DOC) and the DOI in cooperation of the Territory of American Samoa. The USFWS acknowledges fishery management authority of the WPRFMC in coordination with the NMFS within the "200-nautical mile EEZ"(Smith 2000).

In the Ritidian Unit of the Guam National Wildlife Refuge, USFWS has fee title which includes 371 acres of emergent land and 401 acres of submerged lands down to the 100 foot bathymetric contour (Smith 2000). The submerged lands adjacent to Ritidian were never transferred to the Territory of Guam pursuant to the TSLA by the Federal government (Smith 2000). In 1993, the USFWS acquired the emergent land of the Ritidian Unit and the surrounding submerged lands from the U.S. Navy at no cost in 1996 (Smith 2000).

Department of Defense Naval Defensive Sea Areas

A number of Executive Orders have given administrative authority over territories and possessions to the Army, Navy or the Air Force for use as military air fields and for weapons testing. In particular, Executive Order 8682 of 1941 authorizes the Secretary of the Navy to control entry into NDSAs around Palmyra, Johnston and Midway Atolls, Wake Island, and Kingman Reef. The NDSA includes "territorial waters between the extreme high-water marks and the three-mile marine boundaries surrounding" the areas noted above. The objectives of the NDSA controls over entry into naval defensive sea areas are to provide for the protection of military installations and to protect the physical security of, and ensure the full effectiveness of, bases, stations, facilities and other installations (32 CFR Part 761). In addition, the U.S. Navy has joint administrative authority with the USFWS of Johnston Atoll and sole administrative authority over Kingman Reef. More recently, the Midway Atoll NDSA was rescinded by Executive Order 13022 in 1996 and Wake Island NDSA has been suspended until further notice.

The U.S. Navy exerts jurisdiction over Farallon de Mendinilla in the CNMI and Ka'ula Rock in the main Hawaiian Islands, which are used as military bombing ranges. The Navy also exerts jurisdiction over a variety of waters offshore from military ports and air bases in Hawaii, PRIAs, Guam, and the CNMI.

Issues

Due to jurisdictional disputes between "state" and federal agencies regarding individual islands, reefs and atolls, points of contention have arisen between various management authorities in the Western Pacific Region.

State of Hawaii

Points of contention exist between the State of Hawaii and USFWS concerning refuge boundaries and submerged lands in the NWHI (US Fish and Wildlife Service 1986). The State of Hawaii asserts that the HINWR boundary never legally included more than the emergent lands of the NWHI, excluding Midway (US Fish and Wildlife Service 1986). The USFWS claims that the HINWR includes 252,000 acres of submerged lands as their interpretation of Executive Order 1019 based on the inclusion of the terms "reef and inlets" (US Fish and Wildlife Service 1986). However, following the Admissions Act of 1959, which required all federal agencies in Hawaii to inventory all lands for which there was a continual need, the USFWS in 1963 reported a continuing need of 1,765 acres of land in the NWHI. This area consisted of only the emergent land in the NWHI as was claimed by the Department of Agriculture as the original boundary of the HIR (Yamase 1982). This did not include the 252,000 acres of submerged lands that are now being claimed by the USFWS. Other jurisdictional disputes also involve East and Tern Islands in French Frigate Shoals.[7, 8]

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In 1940, Territorial Governor Poindexter, issued an Executive Order in concurrence with the President of the U.S. to set aside East Island, for the use and purpose of the United States as a radar station communication base under the DOC (Yamase, 1982). Prior to statehood, the DOC returned East Island to the Territory of Hawaii (Yamase, 1982). However, the DOI contends that East Island was part of the HIR as established by Executive Order 1019 in 1909 and later transferred to the DOI in 1939. Therefore, East Island remains included in the HINWR and under authority of

Contention exists between the USFWS and WPRFMC regarding primary fishery management responsibilities in EEZ waters within NWR boundaries. Since the late 1960's, citing USFWS interim administrative policy and interpretation of Executive Order 1019, the USFWS announced that they would enforce refuge regulations within the "de facto" boundaries of the HINWR that include all emergent land and their surrounding waters out to a depth of 10 fm for all islands and later 20 fm around Necker Island(*Smith R. P., 104th WPRFMC Meeting, Maui, June, 2000).* Under the authority of the Magnuson Act, the WPRFMC promulgated fishery regulations within Federal waters that correspond with USFWS refuge boundaries of 0-10 fathoms within NWHI federal waters, except at Necker where it is 20 fm (WPRFMC *1986*). The WPRFMC recognizes state waters in the NWHI from 0-3 miles and asserts management authority over fishery resources in all Federal waters (3-200 miles, except at Midway were it asserts authority from 0-200 miles)(Gillman 2000).

The State of Hawaii has on occasion claimed jurisdiction beyond its territorial seas of 0-3 nautical miles by claiming jurisdiction over channel waters between the main Hawaiian islands (MacDonald and Mitsuyasu, 2000). The authority of the Magnuson Act begins at 3 miles from the shoreline around all main Hawaiian islands in the State of Hawaii. The Federal Government does not recognize the State's claim of archipelagic jurisdiction, but interprets the State's seaward authority to stop at 3 nautical miles from the baseline (Feder 1997, MacDonald and Mitsuyasu 2000).

CNMI

Currently, the EEZ includes all waters surrounding CNMI from shore out to 200 miles. However, CNMI through the legal system is pursuing a claim for the U.S. to recognize Commonwealth authority out to 12 miles from the archipelagic baseline.

Guam

The Territory of Guam questions the legality of the transference of the Ritidian Unit to the USFWS. The U.S. Navy listed, in its property inventory to the General Services Administration, Ritidian Unit as excess lands, not of continual need and available for reversion to the Territory (Guthertz 2000). Therefore, the Territory asserts that the fee title should have been returned to the Territory and not the USFWS (Guthertz 2000).

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Tern Island was expanded from 11 to 37 acres in 1942 by military dredging (Yamase 1982). In 1948, the Navy conveyed Tern Island to the Territory of Hawaii which then permitted the US Coast Guard in 1952 to establish a navigational Loran station (Yamase 1982). In 1979, USCG operations were terminated and the Hawaii State Legislature adopted resolutions requesting the Governor to take immediate action to acquire and return Tern Island for use as a fishing base to support commercial activities (Yamase 1982). The Federal government asserts that it retains jurisdiction over Tern Island based on Executive Order 1019 and that the Navy did not have the authority to legally convey title to the Territory of Hawaii, therefore, the conveyance is void (Yamase 1982).

PRIAs

In the PRIAs, primary jurisdiction over fisheries is an ongoing issue between the USFWS and WPRFMC. Management authority is currently unresolved because no clear baseline boundary has been designated for which the seaward boundary of the PRIAs are measured. Seaward boundaries are not clearly defined because some islands in the PRIAs do not appear to have a seaward boundary as defined by U.S. law (i.e., Magnuson, SLA)(Beuttler 1995). For this reason, jurisdictional boundaries have been claimed by federal agencies in terms of fathoms, miles or territorial seas. Furthermore, it is recognized that various Executive Orders have given administrative authority of the PRIAs to either the DOD or DOI. However, Executive Orders themselves do not convey title of submerged lands unless specifically stated, as in the case of Ritidian Unit in Guam. In any case, based on interpretation by the National Ocean and Atmospheric Administration legal counsel, Magnuson Act authority applies to all marine waters around Federally owned possessions (i.e., PRIAs), including marine resources within bays, inlets, and other marine waters to the shoreline (Beuttler 1995).

Additionally, because the NWRSAA does not itself contain a provision authorizing the President to withdraw land for a wildlife refuge, the DOI agues that the President could rely on the implied authority to reserve public lands recognized in *United States v. Midwest Oil Co.* 236, U.S. 459 (1915).[5] However, since the Federal Land and Policy Act (FLPMA) of 1976 repealed the President's authority, effective on and after approval of the Act, to make withdrawals and reservations resulting from the acquiescence of Congress (*U.S. v. Midwest Oil Co.*), it appears that the President does not have the authority to establish or expand a wildlife refuge within the U.S. territorial sea (12 miles) or the EEZ using presidential authority recognized in *Midwest Oil* after 1976(Moss 2000). This could call into question asserted marine boundaries of any NWRs established after enactment of the FLPMA.

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Jurisdictional Marine Boundaries in the Western Pacific Region

28-Sep-00

Area	State/Territory	Commerce (WPRFMC)	Other Authorities	WPRFMC Coral Reef FMP Preferred Alternative (For Federal Waters Only) No-Take MPA	Low-Take MPA
Pacific Remote Islands Areas					
Howland Island		0-200 nmi	FWS 0-3 nmi	0-50 fm	
Baker Island		0-200 nmi	FWS 0-3 nmi	0-50 fm	
Jarvis Island		0-200 nmi	FWS 0-3 nmi	0-50 fm	
Johnston Island		0-200 nmi	FWS/Navy 0-3 nmi		0-50 fm*
Kingman Reef		0-200 nmi	Navy 0-3 nmi	0-50 fm	
Palmyra Atoll		0-200 nmi	FWS 0-3 nmi	0-50 fm	
Wake Island		0-200 nmi	Air Force 0-3 nmi		0-50 fm*
Midway Atoll		0-200 nmi	FWS 22x22 nmi quadrant	0-50 fm*	0-50 fm*
Hawaii					
Main Hawaiian Islands	Hawaii 0-3 nmi	3-200 nmi			
Nihoa	Hawaii 0-3 nmi	3-200 nmi	FWS 0-10 fm**	0-10 fm	10-50 fm
Necker	Hawaii 0-3 nmi	3-200 nmi	FWS 0-20 fm**	0-10 fm	10-50 fm
French Frigate Shoals	Hawaii 0-3 nmi	3-200 nmi	FWS 0-10 fm**	0-50 fm	
Gardner Pinnacles	Hawaii 0-3 nmi	3-200 nmi	FWS 0-10 fm**	0-10 fm	10-50 fm
Maro Reef	Hawaii 0-3 nmi	3-200 nmi	FWS 0-10 fm**	0-10 fm	10-50 fm
Laysan	Hawaii 0-3 nmi	3-200 nmi	FWS 0-10 fm**	0-50 fm	
Lisanski	Hawaii 0-3 nmi	3-200 nmi	FWS 0-10 fm**	0-10 fm	10-50 fm
Pearl and Hermes	Hawaii 0-3 nmi	3-200 nmi	FWS 0-10 fm**	0-10 fm	10-50 fm
Kure	Hawaii 0-3 nmi	3-200 nmi		0-10 fm	10-50 fm
Guam	Guam 0-3 nmi				
Ritidian Unit		0-200 nmi	FWS 100 ft. isobath		
Northern Mariana Islands	(CNMI 0-3 nmi***)	3-200 nmi			
American Samoa (A.S.)	A.S. 0-3 nmi	3-200 nmi			
Rose Atoll			FWS 0-3 nmi	0-50 fm	

* At Johnston, Wake and Midway, special permit fishing is only for recreational and on-island consumption. At Midway, the north half of the atoll would be a no-take MPA and the south half a low-take MPA.

** Fish and Wildlife Service (FWS) boundary begins at the shoreline; legally defined boundary is unresolved

*** The Coral Reef Ecosystem Fishery Management Plan proposes to designate jurisdiction over 0-3 nmi to the Commonwealth of the Northern Mariana Islands while retaining jurisdiction over 3-200 nmi in the EEZ.

4.0 DEIS PUBLIC SCOPING PROCESS AND POTENTIALLY SIGNIFICANT ENVIRONMENTAL, SOCIAL, AND ECONOMIC ISSUES

In addition to examining the environment impacts of proposed resources, the DEIS also addresses social and cultural impacts to fishery participants and to fishing communities. National Standard 8 of the Magnuson-Stevens Act requires that the management measures take into account the importance of fishing resources to fishing communities in order to provide for "sustained participation" by fishing communities and, to the extent practicable, minimize adverse economic impacts on fishing communities. The economic and social impacts of the proposed actions and their alternatives are analyzed and discussed in the other Appendices.

The Regulatory Impact Review (RIR) focuses on impacts to the net value of affected fisheries, as well as the non-fishery sectors that are dependent on coral reef ecosystems, including marine tourism, biodiversity, and other ecological services provided by coral reefs.

The Initial Regulatory Flexibility Analysis (IRFA) focuses on impacts to fishery participants as businesses, or as "small entities," as required by the Regulatory Flexibility Act. It focuses on the identification and minimization of increased burdens to small entities, such as commercial fishermen.

Scoping

The first step in the NEPA process in scoping. Scoping is designed to provide an opportunity for the public, agencies, and other interest groups to provide input on potential issues associated with the proposed project. Scoping is used to identify the scope of environment issues related to the proposed project and can also identify new alternatives to be considered int the DEIS. Scoping is generally accomplished through written communications, statements at public meetings, or formal and informal consultation with agency officials, interested individuals, organizations, and groups.

Draft EIS

After scoping is completed, a DEIS is prepared. The DEIS evaluates the important social, economic, and environmental impacts that may result from the proposed action. It focuses on cause and effect relationships, providing sufficient evidence and analysis for determining the magnitude of impacts and ways to minimize harm to the environment. The DEIS should include a full and fair discussion of significant environmental impacts and inform decision-makers and the public of the reasonable alternatives which would avoid or minimize adverse impacts, or which would enhance the quality of the human environment.

Public Comment and Final EIS

Following publication of the DEIS, a minimum 45-day public comment period ensues, and a public hearing is conducted to provide an opportunity for interested parties to provide oral comments on the DEIS. Verbal and written comments received are considered and the DEIS revised as appropriate. NMFS is required to specifically address each substantive comment received and include copies of the comments in the FEIS. Once the FEIS is completed, it is published and available for a minimum 30-day public comment period. Public comments received on the FEIS are collected and considered by the lead agency prior to making a final decision.

Record of Decision

Following the completion and submittal of the FEIS and the public comment period, a Record of Decision (ROD) is prepared by the lead agency. The ROD includes (1) a statement regarding what the decision is regarding the federal action; (2) an identification of alternatives considered in reaching the decision; and (3) a statement regarding the means to avoid or minimize environmental harm from the alternative selected.

DEIS Public Scoping Process

The scoping process began with a review of existing documentation and reports of advisory body meetings held during the FMP preparation process. The process included opportunities for the public to comment on the proposed actions and their environmental concerns stemming from these actions. The following public meetings were held:

Public scoping hearing - Honolulu (Council meeting)	16 June 1999
Public scoping hearing - Honolulu (Plan Team meeting)	15 July 1999
Public scoping hearing - Guam	28 July 1999
Public scoping hearing - CNMI	29 July 1999
Public scoping hearing - Honolulu (Ecosystem and Habitat Advisory Panel (EHAP) meeting)	5 August 1999
Public scoping hearing - American Samoa	19 August 1999
Public scoping hearing - Kona, HI	31 August 1999
Public hearing - Honolulu (Plan Team and EHAP meeting)	17 September 1999
Public Scoping Hearing - Honolulu (SSC meeting)	12 October 1999
Public Scoping Hearing - Honolulu (Council meeting)	18 October 1999
Public Meeting - American Samoa	20 December 1999
Public Meeting - Guam	28 December 1999
Public Meeting - Kona, Hawaii	28 December 1999
Public Meeting - Commonwealth of the Northern Mariana Islands	29 December 1999
Public Meeting - Hilo, Hawaii	29 December 1999
Public Meeting - Kahului, Maui	4 January 2000
Public Meeting - Haleiwa, Oahu	5 January 2000
Public Meeting - Lihue, Kauai	6 January 2000
Public Meeting - Waianae, Oahu	10 January 2000
Public Meeting - Lanai City, Lanai	11 January 2000
Public Meeting - Molokai	12 January 2000
Public Meeting - Honolulu	13 January 2000
Public Meeting - Honolulu (Hawaii Plan Team and Advisory Panel meeting)	26-28 January 2000

Public Meeting - Honolulu (Council meeting)	28 Feb - Mar 2 2000
Public Meeting - Honolulu (Plan Team meeting)	25 April 2000
Public Meeting - Honolulu (Joint Plan Team and Advisory Panel meeting)	26 April 2000
Public Meeting - Honolulu (SSC meeting)	16 - 18 May 2000
Public Meeting - Maui (Council meeting)	14 - 16 June 2000
Public Meeting - Honolulu (Council meeting)	10 - 12 July

The scoping process concluded with a review of issues arising from public meetings and documentation review to determine which were potentially significant.

Issues Raised During Public Scoping Process and Their Resolution Through the Draft FMP or Draft EIS

Interjurisdictional Boundaries and Consistency in Management.

Many of the existing problems and threats to coral reef resources occur in territorial waters, but the CRE-FMP would regulate 3-200 nmi from shore in most areas. Inconsistent management (e.g., regulations much stricter in EEZ than in territorial waters) could increase pressures on reefs under local jurisdiction. Jurisdiction is particularly troublesome in the CNMI, where both local and federal governments claim authority over the EEZ.

This issue has been addressed in the draft FMP. Proposed actions would only apply to offshore reef areas (3-200 nmi from shore).

Diverse Uses of and Impacts on Coral Reef Resources

The FMP can only regulate fisheries but numerous other ecological, aesthetic, economic and cultural benefits of coral reefs should be considered, as well as the impacts of non-fisheries uses.

Impacts on non-fishery coral reef values and uses have been considered in the DEIS.

Coral Reef Ecosystem, Bottomfish and Crustacean FMPs are Interdependent.

Species managed on the sustainable yield principle under other FMPs (bottomfish, spiny lobster) are part of coral reef ecosystems but they are explicitly excluded from the CRE-FMP. The FMPs are interdependent, yet there is no meaningful connection between Coral Reef, Crustacean, Bottomfish Plan Teams. How will plan teams incorporate each other's information and how will differing positions be resolved?

A non-regulatory action to improve FMP interface has been added as a proposed action of the draft FMP. In addition, environmental impact statements have been prepared for the FMPs for bottomfish, crustaceans and precious corals. The latter EISs are separate from this document.

The Process of Developing the FMP May Stimulate the Types of Unregulated Activities Which It Seeks to Prevent

It is not precautionary to leave coral reef resources exposed for a year before the FMP is in place.

A moratorium alternative was examined, as a possible action separate from the FMP process and as a measure within the draft FMP.

Small-scale, Sustainable Domestic Fisheries in the Us Pacific Islands Will Be Penalized for the Destructive, Illegal and Non-sustainable Harvesting Practices by Foreign and Large-scale Fisheries

Social and economic impacts on reef-related fisheries have been considered in the DEIS.

Designation and Jurisdiction Over Marine Protected Areas (MPAs)

MPAs are considered essential for coral reef ecosystem management but there is resistance to federal designation in many island areas. Fishermen in Hawaii have already been excluded from many areas. It is premature to designate MPA in the CNMI because of conflicting jurisdictional claims. Closure of EEZ banks off American Samoa and Guam is viewed as penalizing domestic fishermen. Existing national wildlife refuges in the NWHI and some of the remote U.S. island possessions already function as de facto MPAs, which could be reinforced by the FMP without changing jurisdictional authority over the areas. The total area of MPAs should be a large enough percentage of total area of EEZ reef to protect overall biodiversity and ecosystem structure and function.

Several options for strengthening existing MPAs and establishing new ones were considered in the draft CRE-FMP. Alternatives for different target levels of no-take MPAs were evaluated. Biological, social and economic impacts of all MPA alternatives were considered in the DEIS.

Stony Coral/Live Rock Harvest Restrictions

Some commentors see the need for an almost complete prohibition to conserve a non-renewable resource and to conform to national and international initiatives. Others describe scenarios in which harvest would not harm the resource (e.g., in areas to be filled or dredged, collection of broken pieces after typhoons, collection of fragments of faster-growing species). Wild stock will play an integral role in developing a coral and live rock aquiculture industry.

Options for regulating the collection of coral and live rock were considered in the draft FMP. Their biological, social and economic impacts have been evaluated in the DEIS.

Exploratory Fishing Permit Period and Conditions

A one-year permit is insufficient to allow for mobilization of a new fishing enterprise. Permit conditions and reporting requirements should be more reasonable. One commentor proposed a cap on cumulative harvest under the permit system and cautioned that the cumulative effects of subsistence fishing (exempted from permits) could be substantial.

Alternatives for coral reef ecosystem fishery permitting were considered in the draft CRE-FMP. Their biological, social and economic impacts have been evaluated in the DEIS.

Performance Standards for Controlling Fishing Gear; Add or Subtract Gear Types

According to one commentor, the problems with lists of prohibited gear is that they cannot anticipate new kinds of gear and the problem with lists of allowed gear is that they do not create incentives for innovative solutions. Another commentor suggested (a) adding manned submersibles and remotely operated vehicles to allowed gear types; and (b) reviewing the use of intoxicating substances case-by-case through the permitting process because some may be demonstrated to be harmless (e.g., clove oil). Consider allowing more selective methods of gill netting in which fish are herded rather than gilled.

Options for fishing gear controls were considered in the draft FMP. Their biological, social and economic impacts have been evaluated in the DEIS.

Impacts on Threatened or Endangered Species (NWHI, Remote Islands)

The Northwestern Hawaiian Islands National Wildlife Refuge provides critical habitat for a variety of threatened or endangered species, including the Hawaiian monk seal, migratory sea birds and green sea turtle. No action or action of the FMP might contribute (with cumulative factors) to loss of critical habitat, increased interactions with fishing gear, marine debris.

The DEIS has assessed the potential impacts on protected species for all of the alternatives considered in the draft FMP.

Degradation of Wilderness Resources (NWHI, Remote Islands).

The Northwestern Hawaiian Islands National Wildlife Refuge is the largest tract of relatively undisturbed coral reef in the USA. Smaller tracts of relatively pristine coral reef are located in the remote US Pacific island possessions. No action or action of the FMP might contribute (with cumulative factors) to undesirable changes in this ecosystem, including loss of rare species.

The DEIS has assessed the potential impacts on wilderness resources in the NWHI and remote islands for all of the alternatives considered in the draft FMP.

Degradation of Water Quality

Good water quality is crucial for coral reef habitats. No action or action without FMP might contribute (with cumulative factors) to increased sedimentation, turbidity, nutrient loading.

The DEIS has assessed the potential impacts on water quality as part of essential fish habitat and ecosystem impacts for all of the alternatives considered in the draft FMP.

Displacement of Traditional Fisheries

Harvesting of coral reef resources is a traditional and valued part of Pacific islanders' heritage. Actions taken under the FMP might contribute (with cumulative factors) to displacement of traditional fisheries.

The DEIS has assessed the potential impacts on sustainable participation by fishing communities for all of the alternatives considered in the draft FMP.

Reduction of Ocean Access

The FMP proposes designation of marine protected areas in the EEZ. This action may contribute (with cumulative factors) to reduced fishing access for the general public.

The DEIS has assessed the potential impacts on ocean access as part of impacts on sustained participation by fishing communities for all of the alternatives considered in the draft CRE-FMP.

Restrictions on Harvesting Underutilized Marine Resources.

The FMP proposes to regulate fishing for coral reef resources in the EEZ. This action may restrict fishing for resources that are underutilized (i.e., not at or above sustainable yield).

The DEIS has assessed the potential impacts on the opportunity to harvest underutilized species as part of sustainable participation by fishing communities for all of the alternatives considered in the draft CRE-FMP.

Inequity for Indigenous Fishermen

Indigenous Pacific islanders are under represented in commercial fisheries. The CRE-FMP proposes to limit fishing for coral reef resources in the EEZ and may provide further disincentives (with cumulative factors) to indigenous-owned fishing enterprises.

*The DEIS has assessed the potential impacts on opportunities for participation by indigenous fishermen as a part of environmental justice consideration (*E.O. 12898*) for all of the alternatives considered in the draft CRE-FMP*

Screening Process to Identify Potentially Significant Issues

This section identifies the potentially significant issues from a full array of environmental impact categories. Issues are considered potentially significant if they arose during the DEIS Public Scoping Process or if the comparison of FMP management alternatives predicted adverse effects for any category of the impacts considered. The following table summarizes the screening process. Any issue in the table that is definitely significant ("yes") or that "may be" significant due to implementation of the FMP is analyzed in later sections (a) to define baseline criteria for significance; and (b) to assess the environmental consequences of the alternative control measures considered in the proposed FMP. The screening indicates that the following topics are potentially significant issues:

Biological/Ecological Resources

- Target fishery resources
- Non-target fishery resources
- Protected species and wilderness resources
- Corals, live rock, essential fish habitat, reef ecosystems and biodiversity
- Exotic species

Physical Resources

- Coastal water quality

Cultural Resources

- Native cultures

Social and Economic Factors

- Sustained participation by fishing communities
- Fairness and equity to fishermen
- Search for promising new medicines
- Non-consumptive values and uses
- Administration and enforcement of regulations

Screening Process to Identify Potentially Significant Issues

General Topic	Potential Issue	Is Issue Significant Due to Implementation of FMP?	Is Issue Significant When Implementation of FMP is Considered With Cumulative Effects?
I. BIOLOGICAL/ECOLOGICAL RESOURCES			
Target resources	Will implementation of FMP affect the populations of target resources? Yes.	**Yes.** Coral reef resources already harvested in EEZ but not regulated under other FMPs would be managed to prevent overfishing. New and poorly understood resources not previously harvested would be managed with caution until sustainable yield can be assessed. Reservoirs of spawning bioass would be protected within no-take marine protected areas (MPAs).	**Yes.** Could add to (or reduce) spawning stocks of heavily fished species, provide "insurance" against (or increase risk of) recruitment failure. Could control (or not control) harvest of new, poorly understood resources at safe level s until sustainable yields are better known. Redirection of fishing effort to areas already heavily exploited could cause local overfishing.
Non-target resources	Will implementation of FMP affect the populations of non-target resources? Yes.	**Yes.** Coral reef resources already harvested incidentally in EEZ but not regulated under other FMPs would be managed to minimize bycatch. New and poorly understood resources not previously harvested would be managed with caution until level of bycatch can be assessed. Reservoirs of spawning bioass would be protected within no-take marine protected areas (MPAs).	**Yes.** Could add to (or reduce) spawning stocks of non-target species, provide "insurance" against (or increase risk of) recruitment failure, control (or not control) incidental harvest of new, poorly understood resources at safe levels until sustainable yields are better known.
Protected species and areas (e.g., wildlife refuges, wilderness resources)	Will implementation of FMP affect the populations of protected species or other wilderness resources? Yes. In NWHI, remote islands.	**Yes** (Issue 7.2.10). Could affect interactions with Hawaiian monk seal, green sea turtle populations, habitats. Controls proposed by FMP could extend protected areas, screen out potentially damaging fishing activities, reduce risk of vessel groundings, scrutinize potential impacts of non-fishing activities on EFH.	**Yes** (Issue 7.2.10). Could reduce (or add to) other pressures on Hawaiian monk seal, green sea turtle populations, habitats and other wilderness resources.

Corals, live rock, essential fish habitat (EFH), reef ecosystem, biodiversity	Will implementation of FMP affect corals, EFH, reef ecosystems, biodiversity? Yes.	**Yes**. A major purpose of FMP is to protect corals, reef ecosystems, biodiversity and EFH from degradation . Controls proposed by FMP could extend protected areas, screen out potentially damaging fishing activities, reduce risk of vessel groundings, scrutinize potential impacts of non-fishing activities on EFH.	**Yes**. Could reduce (or add to) local human stressors on coral reefs, ecosystems, biodiversity, EFH. Little affect on global stressors, however.
Exotic species, disease	Will implementation of FMP affect introduction of any new/noxious species or diseases? Yes.	**Yes**. Controls proposed by FMP could extend protected areas, screen out potentially damaging fishing activities, reduce risk of vessel groundings, scrutinize potential impacts of non-fishing activities on EFH. Inter-agency and inter-regional management to avoid problem (e.g., through marine debris) could improve.	**Yes**. Could affect sources of marine debris from outside US Pacific Islands.
II. PHYSICAL RESOURCES			
Air quality	Will implementation of FMP affect air quality. No.	No. No change from existing conditions.	No. No change from existing conditions.
Climate	Will implementation of FMP affect the climate. No.	No. No change from existing conditions.	No. No change from existing trends (globally, marine environment is becoming increasingly hostile to coral).
Geology, landscapes	Will implementation of FMP increase reef or coastal erosion or alter unique landscapes or oceanscapes? No.	No. No change from existing conditions.	No. No change from existing conditions.
Water quality	Will implementation of FMP affect coastal water quality? Maybe.	**Maybe** (Issue 7.2.12). Focus of regulation through FMP is the EEZ, not coastal waters. EFH consultation would encourage better scrutiny of potential impacts of non-fishing activities.	**Maybe** (Issue 7.2.12). EFH consultation could address sedimentation, nutrient loading impacts from non-fishing activities in inshore areas not directly regulated through FMP.
Flooding	Will implementation of FMP increase risk of flooding in coastal areas? No.	No. No change from existing conditions.	No. No change from existing conditions (globally, reef erosion may be reducing shore protection against storm waves).
Groundwater	Will implementation of FMP affect groundwater quality? No.	No. No change from existing conditions.	No. No change from existing conditions.

Noise	Will implementation of FMP increase noise levels? No.	No. No change from existing conditions.	No. No change from existing conditions.
III. CULTURAL RESOURCES			
Archaeological features, historic places, National Landmarks	Will implementation of FMP affect archaeological/historic sites? No.	No. No change from existing conditions.	No. No change from existing conditions.
Native cultures	Will implementation of FMP affect native cultures? Yes.	**Yes** (Issue 7.2.13). No-take MPAs are proposed for some submerged lands for which the claims of indigenous people are not yet resolved. Gear controls proposed by FMP could displace traditional fishing methods.	**Yes** (Issue 7.2.13). New restrictions on indigenous people could add to a series of previous displacements.
IV. HAZARDS			
Navigation and vessel safety	Will implementation of FMP interfere with vessel navigation and safe anchorage? Maybe in no anchoring zones.	No. Maritime law allows vessel anchoring in emergencies, even in no-anchoring zones proposed by FMP.	No. Minimal change from existing conditions.
V. INFRASTRUCTURE			
Harbors	Will implementation of FMP create demand for new harbor facilities? No.	No. No change from existing conditions.	No. No change from existing conditions.
Underwater cables, construction	Will implementation of FMP interfere with existing or proposed underwater communication cables? No.	No. No change from existing conditions.	No. No change from existing conditions.

VI. SOCIAL AND ECONOMIC FACTORS			
Land use	Will implementation of FMP affect present land use? No.	No. No change from existing conditions.	No. No change from existing conditions.
Sustained participation by fishing communities	Will implementation of FMP interfere with sustained participation by fishing communities? Yes.	**Yes** (Issues 7.2.13, 7.2.14, 7.2.15). Established fisheries could be displaced. MPAs that could totally or partially restrict access for fishing are proposed by FMP. Permits and other FMP controls could discourage harvesting of underutilized marine resources and new entry.	**Yes** (Issues 7.2.13, 7.2.14, 7.2.15). Could add new restrictions to previous closures in EEZ and nearshore areas. Permits and other FMP controls could add to existing restrictions on reef-related fisheries. Relocation to areas already heavily fished could cause a decline in catch rates
Fairness and equity to fishermen (including environmental justice E.O. 12898)	Will implementation of FMP have disproportionate impacts on low-income or indigenous populations? Yes.	**Yes** (Issue 7.2.13). Technically difficult and costly permit application and reporting requirements place unreasonable burdens on indigenous and other small-scale, poorly financed participants.	**Yes** (Issue 7.2.13). New restrictions on indigenous and other small-scale participants could add to a series of previous displacements.
Search for promising medicines	Will implementation of FMP interfere with the search for promising medicines? Yes.	**Yes** No-take MPAs are proposed by FMP.	**Yes** Would add to no-take coral reef areas worldwide.
Non-consumptive marine recreation	Will implementation of FMP affect non-consumptive marine recreation? Yes.	**Yes** (Issue 7.2.2). Controls on live coral take and MPAs proposed by FMP could improve (or degrade) non-consumptive recreational diving and underwater scenic opportunities..	**Yes** (Issue 7.2.2). Fishing controls proposed by FMP could improve (or degrade) environmental quality for non-fishery uses

Baseline: Evaluation Criteria for Potential Impacts

This section defines the baseline criteria for evaluating the significance of potential impacts for the major issues. The specified criteria are used to evaluate the potential severity of environmental consequences related to the proposed FMP alternatives.

Evaluation Criteria for Potential Impacts

Affected Resource	Potentially Significant If
I. BIOLOGICAL/ECOLOGICAL RESOURCES	
Target resources	Overfishing.
Non-target resources	Large bycatch.
Protected species, wilderness resources	Loss of rare species, critical habitat; increased interactions with fishing gear, vessel operations, marine debris.
Corals, live rock, essential fish habitat (EFH), reef ecosystem and biodiversity	Undesirable change in ecosystem structure or function, loss of rare species, live coral habitat, other EFH degradation.
Exotic species	Introduction of invasive species.
II. PHYSICAL RESOURCES	
Water quality	Increased sedimentation, turbidity, nutrient loading.
III. CULTURAL RESOURCES	
Native cultures	Displacement of indigenous claims to submerged lands Loss of existing/potential opportunities to collect coral reef resources for customary and traditional indigenous uses.
VI. SOCIAL AND ECONOMIC FACTORS	
Sustained participation by fishing communities	Displacement/relocation of established fisheries, with possible decline in catch rates Fishing is restricted for resources that are not at or above sustainable yield
Fairness and equity to fishermen	Unreasonable technical/cost burdens on indigenous and other small-scale, poorly financed fishermen for entry into fishery.
Search for promising new medicines	Loss of opportunity to make small collections for lab screening and future synthesis.
Non-consumptive uses of coral reefs	Loss of environmental quality.
Administration and enforcement of regulations	Multiple new and complex management responsibilities

5.0 ENVIRONMENTAL CONSEQUENCES

5.1 Introduction

Environmental consequences are the estimated physical, biological, ecological, social and economic effects that are likely to result from implementing each of the alternatives described previously. The analysis of these effects provides a basis for comparing the alternatives.

This section describes the projected direct, indirect and cumulative effects of the alternatives and summarizes the planned mitigation measures. It also describes the conflicts between the effects of the alternatives and other plans and policies. The environment can be directly changed by the activities promoted by an alternative. These changes may trigger indirect effects on other components of the environment. Cumulative effects are the combined effects of past, present and reasonably foreseeable future actions on coral reef ecosystems. Mitigation measures are activities planned to prevent, rectify or reduce projected adverse effects on the environment. Few of the effects can be measured in rigorous quantitative terms and many can only be described in qualitative terms.

The potential for fishing and non-fishing activities to have environmental effects depends on how they are managed through one or more of the following control measures; marine protected areas, permit and reporting requirements, allowable fishing gear, and other (miscellaneous) requirements.

Each of alternatives analyzed in this EIS contains these four control measures to a varying degree. Alternative 1 (No Action) would implement no new regulations while Alternative 2 (Minimal Additional Protection) would designate several low-use MPAs, require permits for some takes of Coral Reef Ecosystem Management Unit Species (CRE MUS, see management unit taxa section in introduction to FMP), limit takes of live rock and coral, and prohibit the use on non-selective gears to harvest CRE MUS throughout the EEZ. In addition to low use MPAs in remote areas, Alternative 3 (Substantial Additional Protection - the preferred alternative), would designate several no-take MPAs, require all fishing vessels transiting MPAs to carry wreck clean up and removal insurance, and prohibit the use of nighttime spearfishing for CRE MUS with SCUBA and/or hookah gear in the EEZs of the Northwestern Hawaiian Islands (NWHI) and the Pacific Remote Island Areas (PRIA - Palmyra Atoll, Howland, Baker, Johnston, Wake Islands, Kingman Reef and Midway). Finally, Alternative 4 (Maximum Additional Protection) would also establish no-take MPAs out to 100 fathoms around all of the region's islands and atolls. These alternatives are summarized in the following tables.

Summary of alternatives

Marine Protected Areas:

Alternative	No-take MPAs	Low-use MPAs
Alternative 1 No Action	Under existing FMPs there is: no longline fishing within 50 miles of all NWHI; no lobster fishing within 0-10 fathoms around all NWHI and within 20 nm of Laysan Island; and no bottomfishing around Hancock seamount.	None
Alternative 2 Minimal Additional Protection	No new no-take MPAs.	0-50 fathoms around all NWHI and PRIA. No anchoring allowed on Guam's offshore southern banks by vessels > 50 feet.
Alternative 3 Substantial Additional Protection (Preferred)	0-10 fathoms around all NWHI plus, 0-50 fathoms around FFS, Laysan, N ½ Midway, Rose Atoll, Jarvis, Howland, Baker, Kingman, Palmyra. This will total 13% of the region's EEZ coral reefs.	10-50 fathoms around all other NWHI and 0-50 fathoms around Johnston, Wake, and the Southern ½ of Midway. No anchoring allowed on Guam's offshore southern banks by vessels > 50 feet.
Alternative 4 Maximum Additional Protection	0-100 fathoms around all islands and atolls throughout the region's EEZs This will total 100% of the region's EEZ coral reefs.	None

Permit Requirements:

Alternative	CRE general permit	CRE special permit
Alternative 1 No Action	None	None
Alternative 2 Minimal Additional Protection	None	Required for all take of any CRE MUS within low-use MPAs, and for all take of PHCRT within the EEZ except by: 1) other FMP permit holders; 2) any take within 3 miles of CNMI.
Alternative 3 Substantial Additional Protection (Preferred)	None at this time but may be frameworked in which case it would likely be required for all take of CHCRT within the EEZ except by: 1) other FMP permit holders; 2) any take with 3 miles of CNMI.	Required for all take of any CRE MUS within low-use MPAs, and for all take of PHCRT within the EEZ except by: 1) other FMP permit holders; 2) any take within 3 miles of CNMI.
Alternative 4 Maximum Additional Protection	Required for all take of CHCRT within the EEZ except by other FMP permit holders.	Required for all EEZ scientific research and management activities which could affect any CRE MUS. Required for all take of any PHCRT within the EEZ except by: 1) other FMP permit holders; 2) any take within 3 miles of CNMI.

Allowable gear types:

Alternative	
Alternative 1 No Action	No specific gear restrictions, follow state/territory and existing FMPs
Alternative 2 Minimal Additional Protection	Allow the use of only the following gears throughout the regions EEZs for the harvest of any CRE MUS hand harvest, spear, slurp gun, hand/dip net, hoop net for kona crab, throw net, barrier net for aquarium fish, surround/purse set for targeted schools (e.g. akule, baitfish, weke) with a minimum of bycatch, hook-and-line (including powered and unpowered handlines, rod and reel, and trolling), traps (with conditions), and remote operating vehicles/submersibles.
Alternative 3 Substantial Additional Protection (Preferred)	Allow the use of only the following gears throughout the regions EEZs for the harvest of any CRE MUS hand harvest, spear, slurp gun, hand/dip net, hoop net for kona crab, throw net, barrier net for aquarium fish, surround/purse set for targeted schools (e.g. akule, baitfish, weke) with a minimum of bycatch, hook-and-line (including powered and unpowered handlines, rod and reel, and trolling), traps (with conditions), and remote operating vehicles/submersibles. Prohibit nighttime spearfishing for CRE MUS with scuba/hookah in the EEZ of the NWHI and PRIA.
Alternative 4 Maximum Additional Protection	Allow the use of only the following gears throughout the regions EEZs for the harvest of any CRE MUS hand harvest, spear, slurp gun, hand/dip net, hoop net for kona crab, throw net, barrier net for aquarium fish, surround/purse set for targeted schools (e.g. akule, baitfish, weke) with a minimum of bycatch, hook-and-line (including powered and unpowered handlines, rod and reel, and trolling), traps (with conditions), and remote operating vehicles/submersibles. Prohibit all spearfishing for CRE MUS with scuba/hookah throughout the region's EEZs.

Miscellaneous measures:

Alternative 1 No Action	None
Alternative 2 Minimal Additional Protection	No take of live rock or live coral in low-use MPAs except for: 1) incidental take by other FMP permit holders; 2) take by indigenous people for traditional/ceremonial use; 3) use by aquaculture operations as seed stock; 4) science & management; 5) bioprospecting. All of these (except #1) would require a CRE special permit.
Alternative 3 Substantial Additional Protection (Preferred)	No take of live rock or live coral throughout the region's EEZs except for: 1) incidental take by other FMP permit holders; 2) take by indigenous people for traditional/ceremonial use; 3) use by aquaculture operations as seed stock; 4) science & management; 5) bioprospecting. All of these (except #1) would require a CRE special permit. Require insurance for all vessels transiting all MPAs.
Alternative 4 Maximum Additional Protection	Require insurance for all vessels transiting all MPAs. No take of live rock or live coral throughout the region's EEZs.

The remainder of this section discusses the consequences of the four alternatives on specific components of the environment. These components are: target stocks; non-target stocks; coral reef habitat (live rock, coral, essential fish habitat and environmental quality); ecosystem biodiversity, structure and function; protected species; existing fisheries and communities; bioprospecting and other new fisheries; native cultures; non-consumptive values and uses; national wildlife refuge wilderness resources; administration and enforcement of regulations.

5.2 Environmental Consequences for Target Stocks (Management Unit Species)

To date, Alternative 1 (No Action) has prevented overfishing for currently-harvested coral reef taxa in the EEZ but it may not adequately protect coral reef resources from new harvest pressures. Due to jurisdictional constraints (this fishery management plan can only close federal or EEZ waters and thus cannot regulate the state or territorial areas immediately surrounding most inhabited areas), Alternatives 2 through 4 could redirect some fishing effort for currently-harvested resources away from no-take zones to fully exploited sub-populations. Nevertheless, these alternatives would all reduce the risk of overfishing for coral reef resources in EEZ waters.

Direct Effects on Target Stocks

Overfishing

Individual sub-populations of larger stocks of reef species may increase, decrease or cease to exist locally without adversely affecting the overall population. The condition of the overall populations of particular species is linked to the variability among sub-populations: the ratio of sources and sinks, their degrees of recruitment connection, and the proportion of the sub-populations with high variability in reproductive capacity.

Coral reefs in remote areas of the EEZ are not in danger of being overfished by existing fisheries for currently-harvested resources (Green 1997). Therefore, none of the alternatives to designate marine protected areas (MPAs) in remote areas of the EEZ are expected to have any effect on overfishing that is substantially different from that of Alternative 1 (No Action). However, MPAs provide a reservoir of unexploited spawning biomass as "insurance" against recruitment failure in nearby sub-populations, so the broader designation of MPAs in Alternative 4 to include EEZ waters around the main inhabited islands of American Samoa, Guam, Northern Mariana Islands and Hawaii, in addition to remote reefs, would likely have a greater beneficial impact to target stocks as compared to no action. This is because some stocks in nearshore reef areas under island government jurisdiction have been locally overfished (Green 1997) and adjacent MPAs could be beneficial in restocking these areas.

The largest existing reef-related fisheries are hook-and-line bottomfishing in the EEZ around American Samoa, Guam, Northern Mariana Islands, the Main Hawaiian Islands and the Northwestern Hawaiian Islands (NWHI), and lobster trapping around some of the NWHI. These fisheries are, and will continue to be, managed and closely monitored under separate state and federal fishery management plans (FMPs) to prevent overfishing, so none of the alternatives is likely to have significant direct effects on these stocks. Bottomfish and lobster fishing effort in the EEZ around the NWHI is controlled by limited entry permits and other measures, including boat size limits for bottomfishing vessels and annual harvest guidelines for lobster trapping. American Samoa, Guam and CNMI EEZ fisheries for bottomfish and lobsters are quite small at this time (<$0.2M). A summary of landings and value of the region's coral reef resources is in the section on description of the fishery of the FMP. The CRE-FMP includes a major section on specifications of MSY, OY, and overfishing, and domestic harvesting/processing capacity, as required by the Magnuson-Stevens Act.

New fisheries, such as bioprospecting, could target potentially-harvested coral reef taxa for which sustainable yields have not yet been determined. The detailed permit controls (i.e., special permits) in remote coral reef areas required under Alternatives 2-4 would be beneficial because proposals to take potentially-harvested resources would be carefully scrutinized before permits would be approved. The highly discretionary nature of special permit review would allow specific activities to be disapproved if they are likely to bring about ecosystem overfishing, as well guarding against target stock overfishing. Permits could be closely monitored to maintain harvests at safe levels while new resource information is acquired to estimate sustainable yields. An exemption for permit holders in other FMP-managed fisheries would not change the effect from that of No Action and the addition of a new permit requirement in FMP-managed fisheries for currently-harvested resources would only increase the regulatory burden, not further the objective of preventing overfishing.

The gear controls common to Alternatives 2-4 allow only selective methods of fishing and would also aid in preventing overfishing of both currently-harvested and potentially-harvested coral reef resources as compared to Alternative 1 (No Action). Restrictions on the use of spear fishing with SCUBA under Alternative 3 and 4 would also limit harvest rates. Most of the spawning adults of the more valuable food fish species are fully exploited in shallow waters near the major inhabited islands and the deep portion of the spawning biomass needs to be conserved to prevent recruitment overfishing. SCUBA-assisted fishing has the potential to harvest reproductive adults throughout their entire depth range. Because many of these species are especially vulnerable at night, prohibiting SCUBA-assisted fishing at night would provide significant benefit to the deep-water portion of spawning stocks compared to Alternative 1(No Action). Alternative 3's prohibition on this gear at night in the NWHI and PRIA EEZs would provide substantial refuge for target stocks, while Alternative 4's prohibition throughout the EEZ at all times would protect a wider area. However the additional prohibition on its use during the day is not expected to make a significant difference as it is the nighttime vulnerability of these species that is of highest concern.

Measures under Alternatives 2- 3 which would limit the commercial harvest of live rock and coral would relieve pressure on species that are slow growing and have low turnover rates, while Alternative 4's complete prohibition on all commercial take of live rock and coral would provide even greater protection to these species. Due to a lack of an FMP for these resources, their current EEZ harvest levels are unknown but believed to be low.

Indirect Effects on Target Stocks

Redirection of fishing effort

The designation of no-take MPAs in Alternatives 2-4 could displace existing fishing and redirect this effort to areas where the same stocks may be fully exploited, thereby increasing the risk of localized overfishing. The deeper seaward boundaries and broader designation of no-take MPAs under Alternative 4 could lead to the greatest redirection of fishing effort, while the inclusion of low-use MPAs (which allow limited fishing) in Alternatives 2 and 3 provide a lesser likelihood of significant redistribution of fishing effort and resultant indirect effects on target stocks.

The detailed permit requirement (i.e. special permit) in Alternatives 2-4 also has the potential to redirect effort if it proves too difficult to obtain permits for desirable resources. Given their ongoing regulation under other FMPs, the exemption for these other FMP permit holders would be expected to safely reduce the probability that these operations would move to new areas.

Alternatives prohibiting popular but non-selective fishing gear to harvest CRE MUS in the EEZ that is regularly used in nearshore coral reef fisheries is much more likely to redirect fishing effort to fully exploited nearshore stocks as they increase in scope from Alternative 1 (No Action) to Alternative 4. An objective of the FMP is to collaborate with other agencies and share in decision making and monitoring.

Alternatives 3 and 4 will restrict any new such fishing effort to nearshore areas where SCUBA fishing is permitted by island governments. If this gear is prohibited only in remote areas, where there is currently very little such fishing (Alternative 3), there would be no effort to redirect, so the impact would be similar to that of the No Action Alternative. Alternative 4 would be expected to have the greatest potential to redirect fishing effort into nearshore areas as it prohibits this gear at all times. By contrast, Alternative 1 (No Action) would allow this currently increasing effort to expand into the EEZ.

Recruitment

To be useful to fisheries and to promote the conservation of coral reef resources on a broad scale, MPAs should serve as sources of reproductive output to replenish larger surrounding areas. It has been suggested that linking populations among MPAs over a broad area is necessary to assure restocking. Recruitment to populations of coral reef organisms depends largely on the pathways of larval dispersal and "downstream" links. Are the connections sufficient to actually restock distant sub-populations or only enough to maintain a homogenous genetic stock? Existing information is insufficient to quantify the potential impacts of the various MPAs contained Alternatives 1- 4, on the recruitment of target resources. However, if there is a link between the size of MPAs and recruitment, the increasing areas set aside under Alternatives 2-4 should result in corresponding increases in recruitment of CRE MUS compared to Alternative 1 (No Action).

Cumulative Effects on Target Stocks

Cumulative effects on target stocks could occur if natural events, such as hurricanes and winter storms or increases or decreases in the nutrient flux into the coral reef system, are coupled with fishing pressures in the EEZ. A series of winter storms or an increase in sea surface temperature due to an el Nino event causes mortality of the coral reef. Living coral reef is believed to support a higher level of biomass than dead reef. The amount of nutrients flowing into the coral reef ecosystem is difficult to quantify, but is directly proportional to the amount of biomass the reef will support. Any of these events will likely cause stock depletion. When these occur in conjunction with fishing, stocks could become further depleted.

Alternative 1, no-action, does not take into account the synergistic effects of natural stressors with fishing pressure. No mechanism would be in place to diminish fishing pressure under a naturally stressed ecosystem. With the creation of low-use MPAs, alternative 2 would be able to better monitor fishing activity and react to a changing environment. Alternative 3 institutes some no-take MPAs which would allow some areas to be free from fishing pressure and could preserve some healthier stocks while the reef is less productive. Alternative 4, with 100% no-take for coral reefs throughout the region, removes all fishing pressure and only natural variations occur. Both alternative 3 and 4 will allow for the study of natural fluctuations in coral reef ecosystem populations, which could aid in a better understanding of the cumulative effects of fishing pressure and natural stressors.

Because this FMP can only regulate fishing activities in the EEZ, none of the alternatives would prevent overfishing of currently-harvested or potentially-harvested coral reef resources in nearshore areas regulated by island governments. Localized overfishing of high-value species is known to be occurring in the most accessible reef areas near island population centers. (Green 1997).

Perhaps the most important factor in the population dynamics of many coral reef species and ecosystems in the NWHI and likely elsewhere in the western Pacific region are cyclical oceanographic events which affect productivity over extensive areas and may account for large fluctuations in population abundance. In a study of recent climatic and oceanographic events and their effect on productivity in the NWHI, Polovina et al. (1994) found that declines of 30 to 50 percent in the abundance of a number of species representing various trophic levels, from the early 1980s to the present, could be explained by a shift in oceanographic conditions. Prior to this time period, oceanographic conditions that lasted from the late 1970s until the early 1980s moved nutrient-rich deep ocean water into the euphotic zone, resulting in higher survival of reef fish, crustaceans, monk seals and birds. Specific management measures to address such environmental changes are not directly incorporated in any alternative but the proposed CRE-FMP includes a non-regulatory framework procedure for timely and rapid adjustments based on feedback from the monitoring of fisheries and resource conditions which Alternatives 2-4 would provide. In addition, the requirement for special permits under these alternatives would easily allow for changes to the level of harvest allowed for most CRE MUS.

Consistency with Other Plans and Policies for Target Stocks

Alternatives likely to cause substantial displacement of existing bottomfish and lobster fishing activities in the EEZ would prevent sustainable use and optimum yield of those resources, which are the main objectives of the FMPs for Bottomfish and Crustaceans.

Mitigation Measures for Effects on Target Stocks

If environmental fluctuations or other natural or human factors change target resource conditions so that there is a greater risk of overfishing, timely preventive action can be taken under the framework adjustment procedures included in the established FMPs for Bottomfish, Crustaceans and Precious Corals and in the proposed CRE-FMP. Future adjustments could include such actions as changes in MPA boundaries, designation of new MPAs, in the number of special permits or their conditions of use or in the fishing gear that is allowed or not allowed.

Indirect Effects on Other Components of the Environment

Overfishing of target stocks could have indirect effects on protected species (5.6), ecosystem structure and function (5.7), existing fisheries and communities (5.8), native cultures (5.10) or non-consumptive values and uses (5.11).

5.3 Environmental Consequences for Non-Target Resources

Alternative 1 (no action) adequately minimizes bycatch in fisheries for currently-harvested coral reef resources in the EEZ but it does not consider the potential for indirect effects on non-target resources through food web relationships. Alternatives 2, 3, and 4 (CRE-FMP) could redirect some fishing effort from no-take zones to areas where non-target resources are more fully exploited, but it would address the potential food web effects of fishing through scientific review of applications to fish potentially-harvested resources.

Direct Effects on Non-Target Resources

Bycatch

Most of the fishing methods presently used to harvest coral reef resources around the U.S. Pacific islands are relatively selective and bycatch (i.e., discards) is negligible because almost all of the species taken can be eaten or sold. The principal exceptions are fish species which are considered high risk for ciguatera poisoning. The largest existing reef-related fisheries are hook-and-line bottomfishing in the EEZ around American Samoa, Guam, Northern Mariana Islands, Main Hawaiian Islands and Northwestern Hawaiian Islands (NWHI) and lobster trapping off some of the NWHI. These fisheries are already managed and closely monitored under separate FMPs to minimize bycatch, so none of the alternatives are likely to have direct effects significantly different from those of no action. Bottomfish and lobster fishing effort in the EEZ around the NWHI is controlled by limited entry permits and other measures, including boat size limits for bottomfishing vessels and annual harvest guidelines for lobster trapping. Indiscriminate gears, including bottom trawls, dredges and bottom-set nets are already prohibited by these FMPs. Lobster traps are required to have escape vents, which minimize bycatch. Bottomfishing vessels are often equipped with electronic navigational devices to relocate fishing areas, and sonar devices to target productive habitat and fish aggregations. This gear is relatively selective, with the ability to successfully target particular species groups dependant upon the skill of the vessel captain. Experienced vessel crew have the ability to catch the desired species with little non-target catch. It is, however, impossible to completely avoid non-target species with most hook and line fishing methods.

The greatest potential for large unintended catch or bycatch would come from live rock collection or potential new fisheries which harvest a broader spectrum of resources than existing fisheries. Alternatives 3 and 4 that designate no-take zones in remote reef areas of the EEZ provide a larger reservoir of unexploited spawning biomass than alternatives 1 and 2. These reservoirs act as "insurance" against recruitment failure in nearby sub-populations of non-target resources, but the potential for actual restocking of other areas through recruitment cannot be evaluated with available scientific information. Broader designation of MPAs around the main inhabited islands of American Samoa, Guam, Northern Mariana Islands and Hawaii, in addition to remote reefs, may have less unambiguous recruitment benefits than no action or MPAs only in remote areas. Alternatives 3 and 4 that zone a larger portion of MPAs as no take zones would enlarge the reservoir of unexploited spawning biomass more than alternatives 1 and 2, but the potential for actual restocking of other areas through recruitment cannot be evaluated with available scientific information.

Alternatives which require a special permit and detailed reporting requirements to take potentially-harvested coral reef resources in some areas of the EEZ would keep harvesting at low levels relative to natural environmental disturbance and mortality levels while data are collected to estimate biological reference points and determine sustainable yields for species about which little is known. Alternative 1 does not provide such safeguards against high levels of bycatch in new fisheries, such as bioprospecting, characterized by broad spectrum resource harvesting.

Alternatives that prohibit approval of permits for commercial collection of live rock and stony coral would reduce the incidental take of other organisms that is unavoidable when habitat is removed. Under Alternative 1, removal of live rock and stony corals is regulated by island governments only in state or territorial waters.

Alternatives that would only allow selective fishing gear in the EEZ or in portions of the EEZ are expected to keep bycatch at lower levels than Alternative 1. If selectivity is not a criterion in allowing gear, the impact would differ little from that of no action. SCUBA-assisted fishing is generally highly selective and has no bycatch, so none of the alternatives to control that practice would have any additional bycatch than those alternatives that do not control that practice.

Indirect Effects on Non-Target Resources

Food web effects

Coral reef ecosystems are comprised of multi-species resources that share a long co-evolutionary history. Removal of some species may cause undesirable changes in the abundance of other species through predator-prey relationships. Food web effects are poorly understood for coral reef ecosystems. Alternatives 3 and 4 that designate no-take MPAs can compensate for this lack of understanding by providing holistic conservation for the complete ecosystem. Existing levels of fishing of coral reef resources in the EEZ are relatively low, however. Whether alternatives to designate MPAs in remote reef areas only would have any detectable effects different from those of alternative 1 is difficult to assess against the background of high natural variability in coral reef ecosystems. Alternatives to designate MPAs in reef areas adjacent to major inhabited island groups where fishing is heavy are more likely to have detectable effects that differ from alternative 1. Other alternatives for MPA zoning and use would not change the risk any more than alternative 1. The removal of prey or alteration of prey assemblages by existing bottomfish and lobster fishing activities in the NWHI appears to be minimal (Dames and Morre in prep.), especially in comparison to the high levels of prey consumed by large jacks (Sudekum et al. 1993).

New fisheries, such as bioprospecting, could target potentially-harvested coral reef resources whose role in the food web is poorly understood. Alternatives which require a special permit and detailed reporting requirements in order to take potentially-harvested coral reef resources in some areas of the EEZ would allow proposals to be carefully scrutinized before permits are approved, and could keep harvesting at low levels relative to levels and frequency of natural environmental disturbance and mortality while data are collected to assess possible food web effects. The highly discretionary nature of the special permit review process would allow specific activities to be disapproved if there is a risk of adverse food web effects. No action does not provide such safeguards in new fisheries, such as bioprospecting, which may be characterized by broad spectrum resource harvesting.

Cumulative Effects on Non-Target Resources

Only fishing activities in the EEZ would be managed by the proposed CRE-FMP. None of the alternatives would prevent high fishing mortality of non-target coral reef resources that are currently-harvested or potentially-harvested in nearshore areas regulated by island governments. The most accessible reef areas near island population centers are heavily fished (Green 1997).

Perhaps the most important factor in the population dynamics of many coral reef species and ecosystems in the NWHI and possibly elsewhere in the western Pacific region are cyclical oceanographic events that affect productivity over large areas and which may account for large fluctuations in population abundance of some species. In a study of recent climatic and oceanographic events and their effect on productivity in the NWHI, Polovina et al. (1994) found that declines of 30 to 50 percent in the abundance of a number of species representing various trophic levels, from the early 1980s to the present, could be explained by a shift in oceanographic conditions. Prior to this time period, oceanographic conditions that lasted from the late 1970s until the early 1980s moved nutrient-rich deep ocean water into the euphotic zone, resulting in higher survival of reef fish, crustaceans, monk seals and birds. Allowances for such outside influences are not directly incorporated in any alternative but the proposed CRE-FMP includes a framework procedure for timely and rapid regulatory adjustments based on feedback from monitoring of changing fisheries and resource conditions.

Consistency with Other Plans and Policies for Non-Target Resources

Alternatives likely to cause substantial displacement of existing bottomfish and lobster fishing activities in the EEZ would reduce the data that is collected about incidental catches in these fisheries under the reporting requirements of the FMPs for Bottomfish and Crustaceans (i.e., no action). A special permit and reporting requirement for all coral reef fishing activities in the EEZ around Johnston and Wake Atolls and off the south half of Midway is consistent with special permits required by the U.S. Fish and Wildlife Service for entry and use of national wildlife refuge resources associated with those islands.

Mitigation Measures for Effects on Non-Target Resources

The current management regime (no action) under the FMP for Crustaceans includes mandatory trap escape vents which reduce incidental catch of non-target resources.

If environmental fluctuations or other natural or human factors change non-target resource conditions so that fishing mortality presents a higher risk to the system, timely preventive action can be taken under the framework adjustment procedures included in the established FMPs for Bottomfish, Crustaceans and Precious Corals and in the proposed CRE-FMP. Future adjustments could include such actions as changes in MPA boundaries, designation of new MPAs, in the number of special permits or their conditions of use or in the fishing gear that is allowed or not allowed.

Indirect Effects on Other Components of the Environment

High levels of non-target resource removal could have indirect effects on ecosystem structure and function (5.7), existing fisheries and communities (5.8), native cultures (5.9) or non-consumptive values and uses (5.11).

5.4 Environmental Consequences for Live Rock, Corals, Essential Fish Habitat and Environmental Quality

Alternative 1 (no action) adequately manages live rock and stony coral harvest in nearshore reefs under island government jurisdiction but not in the EEZ, however it does not prevent or mitigate on-going degradation of reef habitats under island government management. Alternative 2 would prohibit take of live rock or live coral in low-use MPAs except for incidental take by other FMP permit holders, and under a permit system it would allow take by indigenous people for traditional/ceremonial use, use by aquaculture operations as seed stock, for science & management purposes, and for bioprospecting. Alternative 3 (CRE-FMP) would extend conservation measures for live rock, coral and essential fish habitat into the EEZ and would extend no-take zones to a depth of 50 fm off two islands in the NWHI and off most of the PRIA. Alternative 4 would prohibit take of live rock and coral from all of the regions EEZ. Implementation of Alternatives 2, 3, and 4 would require consultations with NMFS and the Council for federal activities that have the potential for adverse effects on EFH.

Direct Effects on Coral Reef Habitat

Permit measures prohibiting commercial collection of live rock and stony coral would conserve non-renewable reef habitat on a broader scale than no action. Control of fishing gear that allow only non-destructive methods would also provide a higher level of habitat conservation in more areas of the EEZ than would no action.

The accidental grounding of fishing boats can have an adverse effect on coral reefs by physically destroying coral colonies in the immediate area of impact and possible break-up of the vessel and release of fuel and oil causing additional habitat degradation and mortality of reef life. Fishing vessel groundings in the NWHI are relatively rare events. Only two fishing boats have run aground during the past 15 years. In both cases there was localized mortality of corals crushed under the hulls but no reported effects on surrounding reef areas (Dames and Moore in prep.). Grounding of a foreign fishing vessel at Rose Atoll in 1983 caused more widespread damage (Green 1997).

Designation of extensive no-take zones and restrictions on how vessels operate in these zones would reinforce existing protection (i.e., no action) of shallow reef habitat adjacent to NWR in the NWHI and PRIA and extend it to broader areas of the EEZ than under the no action alternative. Particularly beneficial are alternatives that add protection to French Frigate Shoals (FFS), the southern-most atoll in the NWHI and the largest coral reef area in the Hawaiian Islands. It has one of the highest diversities of stony coral species in the Hawaiian Archipelago (Grigg 1983).

Anchor damage can occur to coral reefs and other types of bottom habitat from vessels attempting to maintain position over productive fishing areas. The dropping of handline weights on coral substrate and line entanglements during normal hook-and-line fishing operations could theoretically affect bottom habitat. These impacts have not yet been assessed for bottomfish fishing activities in the NWHI, but it is likely that they are minimal. Most bottomfish fishing in the NWHI occurs at depths (100-400m) deeper than the portion of the photic zone where coral reefs and reef building organisms are normally found (50-100m). When bottomfish fishing vessels fish in shallower waters for species such as *uku* they generally drift or slowly troll rather than anchor (Dames and Moore in prep.). In addition, given the large perturbations in coral reef habitat in the NWHI that result from the action of winter storms and associated storm surge and swell (Grigg 1983), the impact of fishing activities on this habitat is likely to be relatively small. Direct effects on reef habitat by bottomfishing vessels on reef habitat are minimal under no action but they would, nevertheless, be reduced in no-take zones around some of the NWHI under alternatives that would displace fishing effort.

NMFS observer logs from the 1999 NWHI lobster fishery and follow-up interviews with observers indicate that both pieces of live coral and entire coral heads were caught in some lobster traps and ground line and landed onboard the lobster vessel. One observer noted that "small broken pieces of coral were frequently (as many as one piece per five traps) wedged in the holes of the traps. Numerous softball-sized and a few basketball-sized whole coral heads came up stuck to the mainline." Only a portion of the damaged coral that reaches the vessel to be seen by observers. Some of the damaged corals that remains on the bottom may continue growing but others may be covered in sand or swept off the banks. The damage may vary from bank to bank. Trapping at atolls where lobster habitat is limited and coral reef density high may result in more coral damage than islands with large flat algal or sand bank areas. The bycatch of coral apparently came from habitats that would not usually be fished but where permit holders had been encouraged to trap experimentally during the 1999 season in an attempt to prevent fishing effort from concentrating solely on lobster populations off Necker Island. The long-term impact of lobster trapping on coral reef habitat is difficult to estimate because it is in the interest of the permit holders to avoid rugged, coral bottoms and to set gear in flat areas where lobster catches have been historically higher. Nevertheless, no-take zones the preferred alternative is likely to reduce impacts in sensitive areas from no-action levels in the EEZ around the NWHI and PRIA.

Indirect Effects on Coral Reef Habitat

Existing bottomfish and lobster fishing activities managed under other FMPs would be displaced from particularly sensitive reef areas in the NWHI under alternatives 3 and 4. These fisheries are already regulated to prohibit destructive gears and to conserve EFH for the target stocks. Their indirect effects on coral reef habitat are uncertain but they would, nevertheless, be reduced under alternatives 3 and 4 from the levels under the no action alternative.

Cumulative Effects on Coral Reef Habitat

Only fishing activities in the EEZ are managed by FMPs, which monitor for possible adverse effects on EFH and adjust management as necessary. The majority of reefs affected by the alternatives in the proposed CRE-FMP are in remote areas that are far removed from terrestrial activities and impacts. None of the alternatives considered by the proposed CRE-FMP would restore or prevent new degradation of EFH in nearshore reef areas managed by island governments. Nor does any alternative mitigate or prevent impacts on nearshore reef habitats resulting from coastal construction, watershed management, shoreline erosion or water pollution. The EFH consultation procedure required after implementation of the proposed CRE-FMP will help to mitigate the future potential for adverse effects resulting from proposed federal activities but will not address non-federal activities or the condition of nearshore fishery stocks.

Considering the large perturbations in NWHI and other coral reef habitats that result from large storms and associated wave action, the impact of fishing gear allowed under FMPs for Bottomfish, Crustaceans and Precious Corals and the proposed CRE-FMP would not be significant. Researchers have observed that periodic storms in the NWHI reduce live coral cover to 10 percent in some areas. Coral cover eventually returns to 50 percent or more in areas where the disturbance cycle is infrequent (R. Grigg, comm. at June 14 Council meeting).

Some of the activities that can degrade EFH are not controllable through unilateral management. One of the most serious problems in the NWHI is the accumulation of marine debris, largely derelict gear lost from North Pacific fisheries. Inter-regional and international management will be necessary to find solutions to this problem.

In 1998, global coral bleaching and die off was unprecedented in geographic extent, depth and severity (Pomerance, 1999). Several studies have related bleaching to the combination of increased ultraviolet radiation and ocean warming, phenomena that may be exacerbated by human activities. Projected long-term climatic changes are likely to expose stony corals to an increasingly hostile environment and could possibly lead to another episode of mass extinctions. Stony corals damaged by acute, local stresses (e.g., hurricanes, starfish predation) have often been able to recover as long as surrounding reefs remained healthy. Renewal of reef building following chronic, widespread stresses acting synergistically is likely to be much slower. Human uses of reefs have never been higher and there is growing concern about human impacts that could add to cumulative stresses on coral reefs in the western Pacific Region. Allowances for such outside influences are not directly incorporated in any alternative but the proposed CRE-FMP includes a framework procedure for timely and rapid regulatory adjustments based on feedback from monitoring of changing fisheries and resource conditions.

Consistency with Other Plans and Policies for Coral Reefs

The preferred alternative would address the MSFCMA requirement to avoid significant adverse effects on EFH more comprehensively than on action, under which EFH is more narrowly designated for other FMP-managed fisheries. The 10-year target established by the U.S. Coral Reef Task Force to designate 20 percent of reefs off US coasts as no-take zones will be easily met if the State of Hawaii takes consistent action for nearshore reefs adjacent to MPAs designated in the adjacent EEZ. The preferred alternative is also consistent with Presidential directives aimed at protecting coral reefs in the U.S. and specifically in the NWHI.

Mitigation Measures for Effects on Coral Reef Habitat

The current management regime (no action) under the FMPs for Bottomfish and Crustaceans include prohibitions on the use of nets, explosives and chemicals which reduce the potential degradation of coral reef habitat.

If environmental fluctuations or other natural or human factors change habitat conditions (e.g., hurricanes, coral bleaching episodes) so that fishing mortality presents a higher risk to the ecosystem, timely preventive action can be taken under the framework adjustment procedures included in the established FMPs for Bottomfish, Crustaceans and Precious Corals and in the proposed CRE-FMP. Future amendments could include such actions as changes in MPA boundaries, designation of new MPAs, in the number of special permits or their conditions of use or in the fishing gear that is allowed or not allowed.

None of the alternatives would directly mitigate adverse effects on coral reef habitats and environmental quality in nearshore areas under island government jurisdiction. However, designation of EFH and implementation of the CRE-FMP would mandate EFH consultations by NMFS and the Council for any proposed federal activity that has the potential for significant adverse effects.

Indirect Effects on Other Components of the Environment

Significant adverse effects on coral reef habitat could have indirect effects on almost all of the other environmental components addressed in Section 4.

5.5 Environmental Consequences for National Wildlife Refuge Wilderness Resources

Alternative 1 (no action) conserves National Wildlife Refuge wilderness resources. Alternative 2 provides some additional protection to these resources by creating a low-use MPA around the NWHI to a depth of 50 fm. Alternative 3 (CRE-FMP) reinforces the no-take status of NWR resources and provides a higher level of protection by enlarging no-take zones off two islands in the Hawaiian Islands NWR and off all NWR islands in the Pacific remote island areas. Alternative 4 would provide the most protection to National Wildlife Refuge wilderness resources by creating a no-take MPA throughout the regions EEZ in all areas shallower than 100 fm.

Direct Effects on NWR wilderness resources

The accidental grounding of fishing boats can have an adverse effect on coral reefs by physically destroying coral colonies in the immediate area of impact and possible break-up of the vessel and release of fuel and oil causing additional habitat degradation and mortality of reef life. A vessel grounding can lead to the introduction of alien species, such as rodents or insects, which can have an adverse impact on terrestrial native fauna and flora on NWR islands. Fishing vessel groundings in the NWHI are relatively rare events. Only two fishing boats have run aground during the past 15 years. In both cases there was localized mortality of corals crushed under the hulls but no reported effects on surrounding reef areas (Dames and Moore in prep.). Grounding of a foreign fishing vessel at Rose Atoll in 1983 caused more widespread damage (Green 1997).

Designation of extensive no-take zones, permit and vessel operation controls in MPAs would reinforce existing protection (i.e., no action) of shallow reef resources off National Wildlife Refuge islands and would extend no-take zones farther offshore in the EEZ than no action around particularly sensitive NWR in the NWHI and PRIA.

Indirect Effects on NWR wilderness resources

Existing bottomfish and lobster fishing activities managed under other FMPs would be displaced from particularly sensitive reef areas in the NWHI. These fisheries are already regulated to limit bycatch and to prohibit destructive and non-selective gears and conserve EFH for the target stocks. The indirect effects of displacement on NWR wilderness resources are uncertain but they would, nevertheless, be reduced in particularly sensitive areas of the NWHI from the levels under no action.

Cumulative effects on NWR wilderness resources

Alternatives 2, 3, and 4 reinforce the protected status of shallow reef resources adjacent to National Wildlife Refuge islands in the western Pacific region. Some of the activities that can degrade wilderness resources are not controllable through unilateral management. One of the most serious problems in the NWHI is the accumulation of marine debris, largely derelict gear lost from North Pacific fisheries. Inter-regional and international management will be necessary to find solutions to this problem.

Environmental fluctuations can bring about dramatic changes in coral reef ecosystem productivity and cause some resources to become more susceptible to overfishing. From the mid-1970s to late 1980s, the central North Pacific experienced increased vertical mixing, with a deepening of the wind-stirred surface layer into nutrient-rich lower waters and probable increased enrichment of the upper ocean. Resulting increased primary productivity likely provided a larger food base for fish and animals at higher trophic levels. In the NWHI, changes of 60-100 percent over baseline levels in productivity for lobsters, reef fish and other animals was observed and attributed to deeper mixing during the 1977-1988 period. Subsequent declines in reproductive success in the late 1980s appear to be linked to a shift back to a lower level of productivity. The variation in the geographical position of this vertical mixing is in turn related to the position of the Aleutian low-pressure system. As this system deviates from its long-term average position, productivity may increase or decline in the waters around the NWHI (Polovina et al. 1994). Allowances for such outside influences are not directly incorporated in any alternative but the proposed CRE-FMP includes a framework procedure for timely and rapid regulatory adjustments based on feedback from monitoring of changing fisheries and resource conditions.

Consistency with Other Plans and Policies for NWR Wilderness Resources

Designation of no-take zones adjacent to NWR islands would reinforce the protected status and limited access policies for refuge resources. A special permit and reporting requirement for all coral reef fishing activities in the EEZ around Johnston and Wake Atolls and off the south half of Midway is consistent with special permits required by the U.S. Fish and Wildlife Service for entry and use of national wildlife refuge resources associated with those islands.

Mitigation Measures for Effects on NWR Wilderness Resources

By reducing fishing effort in the NWHI, the limited access programs for FMP-managed bottomfish and lobster fisheries lowers the potential for vessel groundings or other accidents which could result in habitat degradation.

If environmental fluctuations or other natural or human factors change coral reef resource conditions so that fishing presents a higher risk, timely preventive action can be taken under the framework adjustment procedures included in the established FMPs for Bottomfish, Crustaceans and Precious Corals and in the proposed CRE-FMP. Future adjustments could include such actions as changes in MPA boundaries, designation of new MPAs, in the number of special permits or their conditions of use or in the fishing gear that is allowed or not allowed.

Indirect Effects on Other Components of the Environment

Significant adverse effects on NWR wilderness resources could have indirect effects on protected species (5.6), coral reef ecosystem biodiversity (5.7) and non-consumptive values (5.11).

5.6 Environmental Consequences for Protected Species and Non-Endangered Marine Mammals

Alternative 1 (no action) conserves protected species. Alternative 2 provides some additional protection by establishing low-use MPAs to a depth of 50 fm around all NWHI. Alternative 3 (CRE-FMP) reinforces existing protected species zones established under other FMPs and provides a higher level of protection by enlarging no-take zones off the two islands that are most important for breeding by the endangered Hawaiian monk seal in NWHI. French Frigate Shoals, which provides habitat for the largest colony of monk seals and where prey availability may be a factor limiting population recovery, is one of the areas where no-take zones would extend to a depth of 50 fm offshore under alternative 3. The second largest colony lives at Laysan, where the no-take zone would also be enlarged under alternative 3 compared to status quo (i.e., no action). Alternative 4 would provide the most protection to protected species and non-endangered marine mammals by creating a no-take MPA throughout the regions EEZ in all areas shallower than 100 fm.

Direct Effects on Protected Species, Non-Endangered Marine Mammals

Direct interactions of Hawaiian monk seals with existing fisheries in the NWHI are rare (Dames and Moore in prep.) and a low level of risk would remain under all alternatives, including no action. However, there have been three documented cases of monk seals hooked at Kure Atoll by recreational fishermen (Henderson 1998) and it is clear that the sport fishery at Midway Atoll has the potential to interact with monk seals. The alternative providing for detailed permit control and reporting of existing fishing in low-use zones of MPAs under alternatives 2 and 3, including recreational and subsistence activities at Midway, would provide more information about interactions than no action. Alternative 4 would prevent direct interactions with protected species and non-endangered marine mammals by creating a no-take MPA throughout the regions EEZ in all areas shallower than 100 fm that would prohibit all fishing activities.

Direct interactions between monk seals and bottomfish fisheries have occurred both in the NWHI and the MHI under the status quo (i.e., no action.) However, accidental hookings of monk seals or other marine mammals in these fisheries have been reported or observed only rarely (Nitta 1999). In 1982, a monk seal was photographed at French Frigate Shoals with a circle hook in its mouth. This type of hook is used in the bottomfish fishery as well as in other fisheries. The seal was later seen alive without the hook (Nitta 1999). In 1989, the hook from a slide-bait rig was observed in the mouth of a female monk seal near Kaua'i (Nitta 1999; K. Kawamoto, pers. comm. 2000, NMFS-HL). This type of fishing gear is typically used during shoreline fishing, and is not employed in the NWHI bottomfish fishery. The hook was removed from the seal with no apparent serious after-effects (Nitta and Henderson 1993). State of Hawai'i observers deployed on commercial bottomfish fishing vessels in 1981 and 1982 recorded no interactions with monk seals or other marine mammals (Nitta 1999). The NWHI bottomfish fishery was monitored by NMFS observers from October 1990 to December 1993 with about 13% vessel coverage (Nitta 1999). No Hawaiian monk seals were observed hooked or entangled in fishing gear.

In 1990, there were allegations that some fishermen were intentionally killing or injuring monk seals in order to stop them from stealing fish and bait from hooks (Wagner 1990; NMFS 1991). At that time a number of dead monk seals were observed by NMFS researchers with head injuries that could not have been inflicted by sharks or other natural predators. However, there was no evidence that the fatalities were caused by bottomfish fishermen. The only documented case of an illegal killing of a Hawaiian monk seal occurred when a resident of Kauai killed an adult female in 1989 (NMFS 1998). Since 1990, no additional monk seals have been sighted with injuries suspected of being intentionally inflicted by humans (G. Antonelis, pers.comm. 2000. NMFS-HL).

The NMFS observer program for the NWHI bottomfish fishery conducted from October 1990 to December 1993 reported no interactions between sea turtles and the bottomfish fishery (Nitta 1999). Continued bottomfish fishing in the NWHI is expected to have little effect on sea turtles in the region under all alternatives (Dames and Moore in prep.).

The NMFS observer program for the NWHI bottomfish fishery conducted from October 1990 to December 1993 reported a moderate level of interactions between seabirds and the bottomfish fishery (Nitta 1999). Interactions were characterized by attempted bait theft. Although there is a possibility of accidental hooking, circle hooks used in the bottomfish fishery do not lend easily to snagging. No seabird injuries or mortalities were reported while fishermen were fishing for bottomfish. One interaction involving a Laysan albatross occurred while a bottomfish fishing vessel was trolling for pelagic species. The bird became hooked but was subsequently released alive. This moderate level of direct interactions between seabirds and the bottomfish fishery would continue under this alternative. While continued bottomfish fishing may affect a limited number of individual seabirds, it is expected to have no effect on seabird distribution, survival or population structure. The NWHI lobster fishery does not use gear that is likely to cause any interactions with seabirds and none have been reported are expected under any of the alternatives (Dames and Moore in prep.).

Direct interactions of Hawaiian monk seals with the NWHI lobster fishery are rare. In 1986, a monk seal was entangled and drowned in the trap bridle and main lines of a string of lobster traps in the vicinity of Necker Island (Nitta and Henderson 1993). This is the only reported mortality of a monk seal associated with the lobster fishery. The low level of risk of such direct interactions would be reduced (in comparison to no action) under alternatives that extend no-take zones off French Frigate Shoals, which provides habitat for the largest colony of monk seals in the NWHI.

There have been no reported interactions by NWHI fisheries with species of whale listed as endangered under the Endangered Species Act but there is always a low level risk of behaviorial disturbance or vessel collision under any of the alternatives. Several species of marine mammals that are protected under the MMPA, but are not listed as threatened or endangered, occur in the areas where bottomfish fisheries operate. The NMFS observer program for the NWHI bottomfish fishery conducted from October 1990 to December 1993 reported interactions between bottlenose dolphins and the bottomfish fishery (Nitta 1999). No dolphins were observed hooked or entangled in fishing gear. Interactions were characterized by removal of fish catch from bottomfish fishing lines.

Dolphins interacting with fishing operations typically stayed with vessels as long as fish were being retrieved. Analysis of observer reports indicate a dolphin interaction rate of one event per 37.7 hours of fishing. This level of interaction between dolphins and the bottomfish fishery would continue under all alternatives. There have been no reported interactions of the NWHI lobster fishery with whales of dolphins and this is expected to continue for all alternatives (Dames and Moore in prep.).

Indirect Effects on Protected Species

However, there were interactions characterized by removal of fish catch from bottomfish fishing lines. Some seals showed no fear of vessels and exhibited an apparent familiarity with certain vessels. In those areas heavily targeted by bottomfish fishing vessels, conditioning of monk seals to associate vessels with easy meals may be occurring. Analysis of observer reports indicate a monk seal interaction rate of one event per 67.4 hours of fishing. During such interactions monk seals have been observed consuming discarded bottomfish which may contain high levels of ciguatoxin or other biotoxins (Nitta and Henderson 1993; Nitta 1999). In particular, *kāhala* are often discarded during bottomfish fishing operations because large specimens have a reputation for carrying ciguatoxin and, consequently, are not accepted for sale in the Honolulu fish auction. However, two studies in the NWHI found that *kāhala* tested positive for ciguatoxin much less frequently than shallow water species, such as wrasses, that are known to be significant monk seal prey items (Ito et al. 1983; Kimura et al.; Goodman-Lowe 1998).

Poisoning by ciguatoxin or related toxins was suspected as the primary cause of death of at least 50 monks seals at Laysan Island in 1978 and a contributing factor to the high mortality of juvenile seals translocated to Midway Atoll in 1992 and 1993 (NMFS 1997). However, evidence proving that marine toxins caused or contributed to these monk seal deaths is lacking (Work 1999). Moreover, there is no evidence that monk seals are susceptible to ciguatoxin poisoning. The fact that fish that are frequently highly ciguatoxic, such as moray eels and wrasses, comprise a substantial portion of the diet of the Hawaiian monk seal suggests that the seals are resistant to ciguatoxin.

Alternatives which would enlarge no-take zones around the NWHI would provide additional buffer zones but it is highly debatable whether this action would reduce food competition with monk seals any more than no action. The removal of prey or alteration of prey assemblages by existing bottomfish and lobster fishing activities in the NWHI appear to be minimal (Dames and Moore in prep.), especially in comparison to the high levels of prey consumed by large jacks (Sudekum et al. 1993). Research on the diet of monk seals indicates that the species commonly caught in the bottomfish fishery represent a small fraction of the total number of monk seal prey items. The NWHI lobster fishery has the potential of interacting with the Hawaiian monk seal indirectly by reducing prey availability. According to NMFS, however, there is insufficient data at this time to support statements that the fishery affects any important source of prey for any species of mammal, including the monk seal (Dames and Moore in prep.). The potential for indirect interaction with seabirds due to competition for prey is negligible, as seabirds do not prey upon bottomfish. In those areas heavily targeted by bottomfish fishing vessels, conditioning of dolphins to associate vessels with easy meals may be occurring. Such a food subsidy may be a positive direct impact, although consumption of fish with high concentrations of ciguatoxin could be a negative direct impact if these marine mammals are susceptible to the toxin.

The accidental grounding of fishing boats can also adversely affect coral reefs and other types of bottom habitat utilized by monk seals and sea turtles. The impact of a vessel striking the bottom can physically destroy coral colonies in the immediate area, and the possible subsequent break-up of the vessel and release of fuel and oil can result in pollution of habitat and mortality of marine life. A grounding can also lead to the introduction of alien species, such as rodents or insects, which can have an adverse impact on terrestrial native fauna and flora in the area. Fishing vessel groundings in the NWHI are relatively rare events. Only two fishing boats have run aground in the area during the past 15 years – one was a swordfish longline vessel and the other a lobster boat. In both cases there was localized mortality of corals crushed under the hull, but no reported effects on surrounding areas.

None of the alternatives are expected to have any indirect effects on protected seabirds or on whales and dolphins different from those of no action. Enlargement of the no-take zone off French Frigate Shoals, with conditions for vessel passage, would provide a higher level of protection for green sea turtle critical nesting habitat than no action.

Cumulative Effects on Protected Species

None of the alternatives is likely to add significantly to cumulative effects of reef-related (non-pelagic) fisheries on species of sea turtles or seabirds listed under the ESA. Nor would any alternative change cumulative effects on non-endangered species of whales and dolphins.

The overall status of the endangered Hawaiian monk seal may be grave. Contributing to the specie's decline in the NWHI over the past four decades have been human disturbance, reduced prey availability, shark predation, attacks by aggressive adult male monk seals on females and immature seals of both sexes and entanglement in derelict fishing gear originating in the North Pacific. At each colony, differing combinations of these factors likely have contributed to local trends in abundance, with relative importance of individual factors changing over times. A systematic assessment of the relative importance of various threats to the survival of the Hawaiian monk seal has not yet been conducted. However, the available information indicates that fisheries conducted in the NWHI under established FMPs or that could be conducted under the proposed CRE-FMP account for a very small proportion of the potential impacts to the Hawaiian monk seal. There is no information at this time to suggest that current levels of bottomfish and lobster fishing activities managed under other FMPS or expected levels of new fishing activities that could occur under the proposed CRE-FMP would inhibit the recovery of the Hawaiian monk seal (Dames and Moore in prep.).

Perhaps the most important factor in the population dynamics of many coral reef species and ecosystems in the NWHI and possibly elsewhere in the western Pacific region are cyclical oceanographic events which affect productivity over large areas and may account for large fluctuations in population abundance. In a study of recent climatic and oceanographic events and their effect on productivity in the NWHI, Polovina et al. (1994) found that declines of 30 to 50 percent in the abundance of a number of species representing various trophic levels, from the early 1980s to the present, could be explained by a shift in oceanographic conditions. Prior to this time period, oceanographic conditions that lasted from the late 1970s until the early 1980s moved nutrient-rich deep ocean water into the euphotic zone, resulting in higher survival of reef fish, crustaceans, monk seals and birds. Allowances for such outside influences are not directly incorporated in any alternative but the proposed CRE-FMP includes a framework procedure for timely and rapid regulatory adjustments based on feedback from monitoring of changing fisheries and resource conditions.

Consistency with Other Plans and Policies for Protected Species

The CRE-FMP is consistent with other plans and policies for recovery and conservation of the Hawaiian monk seals, including the Hawaiian Monk Seal Recovery Team (HMSRT), the Marine Mammal Recovery Team (MMRT), and the Marine Mammal Commission (MMC). The preferred alternative, applying the precautionary principle, proposes a no-take MPA in waters surrounding French Frigate Shoals to provide increased protection for areas with biological significance. For further discussion on monk seal recovery efforts see Section 3.5.

The CRE-FMP is consistent with the recovery efforts for sea turtles, marine mammals and seabirds.

Mitigation Measures for Effects on Protected Species

The FMP for Bottomfish contains management measures intended to monitor and mitigate interactions between the fishery and Hawaiian monk seals. The NMFS Regional Administrator has the authority to place federal observers on board bottomfish vessels to record interactions with monk seal or other protected species if this action is deemed necessary. In addition, before the NMFS Regional Administrator (RA) issues a Mau Zone or Ho`omalu Zone limited access permit to fish for bottomfish, the primary operator and relief operator named on the application must have completed a protected species workshop conducted by NMFS.

The FMP for Crustaceans contains management measures intended to mitigate and monitor interactions between the NWHI fishery and Hawaiian monk seals. The maximum size restriction for lobster trap openings help eliminate the potential for monk seal entrapments. Protected species zones mitigate direct and indirect interactions between monk seals and the lobster fishery by restricting fishing to areas removed from high monk seal densities. The NMFS RA is authorized to place an observer aboard a permitted vessel to determine if any interactions occur. The RA also has the authority to close the fishery if a report is received indicating a mortality of a monk seal due to the fishery. At present, vessels participating in the NWHI lobster fishery are not obligated to carry NMFS scientific data collectors. Since 1997, however, most vessel owners have allowed data collectors on board their boats during the fishing season. Not only do they gather catch and effort data but they record bycatch and any fishery interactions with protected species.

The current management regime (no action) also includes lobster harvest guidelines and mandatory trap escape vents which reduce impacts on monk seal prey distribution and abundance.

Prohibitions in both FMPs on the use of nets, explosives and chemicals reduce the potential for incidental harm to monk seals and help protect their habitat. By reducing fishing effort in the NWHI, the limited access programs for FMP-managed bottomfish and lobster fisheries lower the potential for direct interactions, as well as the risk of vessel groundings and other accidents which could result in monk seal mortality and habitat degradation. The current "retain-all" policy of lobster fishery management reduces the potential for direct impacts from monk seals approaching lobster fishing vessels and feeding on discarded lobster.

The HMSRT (1999) has suggested that direct interactions between monk seals and existing fisheries in the NWHI managed by other FMPs can best be mitigated by continuing to educate fishermen through briefing materials and workshops. Federal regulations require the primary vessel operator and relief operator named on the application for a bottomfishing or lobster fishing permit to complete a protected species workshop conducted by NMFS.

It is possible that colonies of gold coral at sub-photic depths near French Frigate Shoals (FFS) may provide foraging habitat for the endangered Hawaiian monk seal and the future harvest of live gold coral could have an adverse effect on the monk seal population at FFS by reducing the availability of prey species (Dames and Moore in prep.) The potential conflict has been addressed through a regulatory adjustment to the Precious Corals FMP that would suspend the harvest of gold coral throughout the EEZ around the NWHI while additional research is conducted on the relationship between monk seal foraging behavior and gold coral.

If environmental fluctuations or other natural or human factors change resource conditions so that fishing presents a higher risk, timely preventive action can be taken under the framework adjustment procedures included in the established FMPs for Bottomfish, Crustaceans and Precious Corals and in the proposed CRE-FMP. Future adjustments could include such actions as changes in MPA boundaries, designation of new MPAs, in the number of special permits or their conditions of use or in the fishing gear that is allowed or not allowed.

Indirect Effects on Other Components of the Environment

Significant adverse effects on protected species could have indirect effects on coral reef ecosystem biodiversity (5.7) and non-consumptive values (5.11).

5.7 Environmental Consequences for Reef Ecosystem Biodiversity, Structure and Function

Alternative 1 (no action) does not adequately conserve reef ecosystem biodiversity, structure or function. Alternative 2 would provide some additional protection over the no-action alternative by creating low-use MPAs, however this level of protection is not considered adequate to provide the desired long-term conservation of CRE biological resources. Alternative 3 (CRE-FMP) would immediately designate no-take zones and add others through amendments that will easily met the 20 percent target that the U.S. Coral Reef Task Force has set for the year 2010. Another way in which Alternative 3 provides a higher level of ecosystem conservation is through a procedure coordinating plan teams monitoring different FMPs and allowing joint analysis and evaluation of possible adverse effects of any fishery on coral reef ecosystems. If environmental fluctuations or other natural or human factors change resource conditions so that fishing presents a higher risk, timely preventive action can be taken under the framework adjustment procedures included in the established FMPs for Bottomfish, Crustaceans and Precious Corals and in the proposed CRE-FMP.

Future adjustments could include such actions as changes in MPA boundaries, designation of new MPAs, in the number of special permits or their conditions of use or in fishing that is allowed or not allowed.

Direct Effects on Reef Ecosystems

Alternatives designating no-take marine protected areas for reefs in remote areas of the EEZ would have a more positive impact than the no action alternative in conserving a large reservoir of spawning biomass and genetic material for multi-resource coral reef resources, including endemic and rare species. Restrictions on vessel operation in these areas would have the additional beneficial effect of reducing the potential for vessel grounding. The no action alternative does not lower this risk to the same extent. Broader designation of no-take areas in alternatives 3 and 4 could provide further benefits over those of alternatives 1 and 2, while increasing the diversity of biotypes included in MPAs. Unlike the no action alternative, the highly discretionary nature of the special permit process included in alternative 3 would allow harvesting at low levels not likely to have adverse effects while monitoring generates new resource information needed for adaptive management of this industry.

Alternatives that enlarge the no-take off French Frigate Shoals (FFS) provide significantly more benefit than no action. French Frigate Shoals is the largest coral reef area in the Hawaii and it has one of the high diversities of stony coral species in the Hawaiian Archipelago (Grigg 1983). Moreover, the expansive shallows enclosed by the barrier reef at FFS provides habitat for certain Indo-Pacific fish species that are rare or absent from other areas of the Hawaiian Islands (Hobson 1980). Added protection for Laysan Island is also more positive than no action because it is represents a reef ecosystem type characteristic of the middle of the NWHI and because there has been little previous human activity and disturbance of reefs.

Indirect Effects on Reef Ecosystems

Restrictions on vessel operation in MPAs and the highly discretionary nature of the permit process would allow careful scrutiny of the potential for new fishing activities to introduce invasive alien marine species throughout the EEZ before harvesting is permitted. These measures would prevent loss of biodiversity better than the no action alternative.

Cumulative Effects on Reef Ecosystems

Because the coral reef ecosystem is comprised of multiple species with a long co-evolutionary history, removal of certain species can result in loss of biodiversity, as well as undesirable changes in ecosystem structure or function, such as a predominance of less valuable generalist species. Possible secondary effects of fishing may be overlooked in conventional management of specific target stocks. Alternatives that would designate large no-take MPAs and allow for highly discretionary special permit review in adjacent low-use MPAs would guard against cumulative effects on reef ecosystem biodiversity, structure and function, while also guarding against overfishing of potentially-harvested species. In addition, alternative 3 (the proposed CRE-FMP) includes a consultation procedure among plan teams for different FMPs to monitor possible ecosystem effects of all reef-related fisheries in the EEZ and adjust management as necessary.

Only fishing activities in the EEZ would be managed by the proposed CRE-FMP. None of the alternatives would prevent adverse effects on reef ecosystem biodiversity, structure of function in nearshore areas regulated by island governments. Nor does any alternative mitigate or prevent impacts on nearshore reef ecosystems resulting from coastal construction, watershed management, shoreline erosion or water pollution. The EFH consultation procedure required after implementation of alternative 3 (the proposed CRE-FMP) will help to mitigate the future potential for adverse effects resulting from proposed federal activities but will not address non-federal activities or the condition of nearshore ecosystems.

Perhaps the most important factor in the population dynamics of many coral reef species and ecosystems in the NWHI and possibly elsewhere in the western Pacific region are cyclical oceanographic events which affect productivity over large areas and may account for large fluctuations in population abundance. In a study of recent climatic and oceanographic events and their effect on productivity in the NWHI, Polovina et al. (1994) found that declines of 30 to 50 percent in the abundance of a number of species representing various trophic levels, from the early 1980s to the present, could be explained by a shift in oceanographic conditions. Prior to this time period, oceanographic conditions that lasted from the late 1970s until the early 1980s moved nutrient-rich deep ocean water into the euphotic zone, resulting in higher survival of reef fish, crustaceans, monk seals and birds. Allowances for such outside influences are not directly incorporated in any alternative but the proposed CRE-FMP includes a framework procedure for timely and rapid regulatory adjustments based on feedback from monitoring of changing fisheries and resource conditions.

Consistency with Other Plans and Policies for Coral Reef Ecosystems

The preferred alternative is consistent with the 10-year target of the U.S. Coral Reef Task Force to designate 20 percent of reefs off U.S. coasts as no-take marine protected areas. It also adheres to ecosystem management principles and policies recommended to the U.S. Congress by the national Ecosystems Principles Advisory Panel (1999). The preferred alternative is also consistent with Presidential directives aimed at protecting coral reefs in the U.S. and specifically in the NWHI. No action would not be consistent with these policies.

Mitigation Measures for Effects on Reef Ecosystems

The preferred alternative establishes a procedure for coordination between plan teams monitoring different FMPs allowing joint analysis and evaluation of possible adverse effects of any fishery on coral reef ecosystems. If environmental fluctuations or other natural or human factors change resource conditions so that fishing presents a higher risk, timely preventive action can be taken under the framework adjustment procedures included in the established FMPs for Bottomfish, Crustaceans and Precious Corals and in the proposed CRE-FMP. Future amendments could include such actions as changes in MPA boundaries, designation of new MPAs, in the number of special permits or their conditions of use or in fishing that is allowed or not allowed.

None of the alternatives would directly mitigate adverse effects on coral reef habitats and environmental quality in nearshore areas under island government jurisdiction. However, designation of EFH and implementation of the CRE-FMP would mandate EFH consultations by NMFS and the Council for any proposed federal activity that has the potential for significant adverse effects.

Indirect Effects on Other Components of the Environment

Significant adverse effects on reef ecosystems could have indirect effects on almost all of the other environmental components addressed in Section 5.

5.8 Environmental Consequences for Existing Fisheries and Communities

Alternative 1 (no action) would continue the present effects. Alternative 2 would have very little impact on existing fisheries and fishing communities. Alternative 3 (CRE-FMP) would increase adverse impacts on existing fisheries and fishing communities by displacing existing bottomfish and lobster fishing effort around some NWHI where the seaward boundary of no-take zones would extend to a depth of 50 fm. Alternative 4 (CRE-FMP) would further increase adverse impacts on existing fisheries and fishing? communities by displacing existing bottomfish and lobster fishing effort around some NWHI where the seaward boundary of no-take zones would extend to a depth of 1000 fm. Irregular bottomfishing and shark fishing activities off Palmyra and Kingman Reef may also be adversely affected by no-take designations. Permit and reporting requirements would be imposed on participants in existing recreational and subsistence fisheries at Midway, Johnston and Wake Atolls. For these reasons, Alternative 3 has greater negative impacts than Alternatives 1 and 2, while alternative 4 would have the greatest impact of all the alternatives.

Direct Effects on Existing Fisheries and Communities

Designation of no-take zones in the NWHI could result in some negative impact on the Hawaii fishing community by causing a loss of earning potential, investment value and lifestyle some bottomfish and lobster fisheries participants. Relatively few persons would be negatively impacted and the State's economy would be relatively unaffected but this does not lessen the economic hardship that reduced earnings or loss of jobs would create form some fishermen and their families. Pooley and Kawamoto (1990) indicate that the net revenue of a bottomfish fishing vessel operating in the NWHI is most sensitive to the crew share percentage and to changes in total fixed costs. If closure of some NWHI bottomfishing grounds causes a reduction in net revenues, captain/owners may compensate by decreasing the pay of deckhands or laying them off. Suitable employment opportunities outside of fishing may be limited for affect deckhands.

Alternatives 3 and 4 that designate no-take zones in the EEZ are likely to displace existing fisheries to a varying extent. If no-take zones are limited in depth and are confined to remote areas of coral reefs, such as in alternative 3, the most significant displacement would be in the NWHI bottomfish fishery, with far less effects on the NWHI lobster fishery. Permit holders in these fisheries would lose access to a few familiar fishing grounds but the area closures are likely to have less adverse impact than closure of more productive areas of the NWHI. Data provided by the Council indicate that no-take zones with a boundary of 50 fm in the NWHI have accounted for about 10 percent of recent bottomfishing effort in the NWHI bottomfish fishery. Applied to recent (1994-1998) landings data (WPRFMC 1999), this percentage represents about 36,000 lb of bottomfish with an ex-vessel value of $115,000. The same areas have recently accounted for about 1.2 percent of the total lobster harvest in the NWHI fishery. Applied to recent (1996-1999) landings data (WPRFMC 2000), this percentage represents about 3,100 lb of spiny and slipper lobsters with an ex-vessel value of $16,000. It is likely that the displaced participants could recover this loss in revenue by moving to other fishing grounds. Recreational fishing activities for tourists could continue at Midway but future development of other PRIA as sportfishing destinations would be deterred.

Broader designation of no-take zones in alternative 4 with seaward boundaries extending to the 100 fm isobath throughout the EEZ would virtually eliminate existing bottomfish and crustacean fisheries in the NWHI, as well as small recreational fisheries at Midway, Johnston and Wake atolls. Immediate closure of the NWHI bottomfish fishery would impose an economic hardship on fishery participants. This alternative would immediately prohibit bottomfish fishing in the EEZ surrounding the NWHI. It is estimated that up to 45 fishermen would be displaced by this action based on the current number of vessels (17) eligible to fish in the area under the limited access programs for the Mau and Ho'omalu Zones and assuming that each Mau Zone vessel and Ho'omalu Zone vessel has a crew of two and three, respectively, and one-fourth of the vessels are not owner-operated. Based on recent (1994-1998) landings data, about 360,000 lbs. of bottomfish with an ex-vessel value of about $1,152,000 would no longer be harvested from the NWHI fishery (WPRFMC 1999a).

The termination of the NWHI bottomfish fishery would force displaced fishermen to relocate their fishing activities to bottomfish grounds that are still open, shift to different fisheries or tie up their vessels. It is likely that displaced fishermen would have difficulty relocating their operations to bottomfish fishing grounds around the MHI. Respondents in a 1993 survey of participants in the NWHI fishery generally indicated that it is not worth their time to fish around the MHI because it takes too long to catch a full load of fish (Hamilton 1994). Closure of the NWHI fishery is likely to have less of an impact on Mau Zone permit holders than Ho'omalu Zone permit holders, as most of the former tend to own smaller boats and currently utilize MHI bottomfish fishing grounds and/or participate in other fisheries (e.g., handlining or trolling for pelagic species). In contrast, Ho'omalu Zone vessels require larger catches to be profitable and have few, if any, viable alternative fisheries. For the owners of these vessels, closure of the fishery would represent a sunk cost of $150,000 to $250,000 per vessel. Broader designations of no-take zones in the NWHI would also displace five or six permit holders in the NWHI lobster fishery which annually harvests 211,000 - 330,000 lb of lobsters with an ex-vessel value of $1,043,000 to $1,896,000 (Dames and Moore in prep.). No such losses would be incurred under no action.

Fisheries for currently-harvested resources in low-use zones of MPAs and for potentially-harvested resources anywhere in the EEZ would face inefficiencies and higher costs as a result of special permit technical prerequisites and compliance costs. Such costs would not be incurred under no action. The difficulty and high cost of compliance with special permit requirements is likely to favor applicants who are well financed to research and express scientific information over small-scale, low-income fishermen. Measures that allow some types of fishing methods but not others (including alternatives to control SCUBA-assisted spear fishing) have disproportionate effects on fishermen who use one type of gear but not others. These impacts are not incurred with no action.

Indirect Effects on Existing Fisheries and Communities

Displaced fishermen who relocate to grounds that remain open may be forced to travel farther than previously, thereby making fishing more costly. In addition, competition for remaining open fishing locations would increase and catch rates might fall, generating less revenue for the same fishing effort. Enterprises with high operating costs would be the first to feel the cost-revenue squeeze (Samples and Sproul 1988).

Transfer of effort from the NWHI to the MHI could indirectly create economic hardship in the form of reduced profitability for fishermen already engaged in the MHI fishery. Bottomfish fishing grounds in the MHI are fully utilized with few, if any, unexploited areas. Recently implemented state regulations that close certain bottomfish fishing grounds have further increased competition for fishing locations around the MHI. If NWHI fishermen were to shift their effort to the MHI, catch per unit effort and individual harvest for both displaced and resident fishermen would likely decline substantially due to the intensified fishing pressure on bottomfish resources. Lower individual catches would mean a decrease in the incomes of part-time and full-time commercial fishermen and a reduction in the non-market value of the fishing experience to a number of recreational fishermen and charter fishing patrons. Total harvest in the MHI fishery would probably remain at current levels regardless of increased participation from displaced NWHI fishermen because nearly all MHI fishing grounds are fully utilized.

Those displaced fishermen who elect to target other species are likely to recover some portion of the revenue previously generated from bottomfish fishing in the NWHI, particularly if they pursue more widely distributed species like tuna. Many Mau Zone vessels are already outfitted to participate in fisheries on other stocks, but some boat owners may not be capable of shifting into other fisheries without significant additional capital outlays. Conversion to charter fishing may be a feasible option for some vessel owners. However, the charter fishing fleets in most of Hawai'i's ports are already over-capitalized (Hamilton 1998).

Given that opportunities for displaced fishermen to recover their lost harvest and income would be limited and the fishery is already characterized by limited profitability, it is likely that some displaced fishermen would be forced to sell out or retire. It is uncertain how active the Hawai'i or nationwide market is for the types of vessels, gear and other investment capital used in the NWHI bottomfish fishery. However, it is possible that the Hawai'i market for these assets could quickly be flooded. Closure of the NWHI bottomfish fishery would likely depress the immediate resale market for bottomfish fishing equipment and vessels as well as diminish the long-term investment value of the vessels owned by displaced fishermen who opt to continue fishing. This could create an economic hardship for those fishermen who are relying on money earned from selling their fishing assets to supplement their retirement funds (Dames and moore in prep.).

It is possible that closure of the NWHI fishing grounds could help rebuild stocks in the MHI and sustain or increase harvests, thereby mitigating the revenue reductions from fishing restrictions. However, the ability of closed areas to increase yields has not been demonstrated for bottomfish fisheries in Hawai'i. It should also be noted that, even if a closed area has the potential to have a positive effect on fish populations and fishery productivity, it may take several years after the closure of the NWHI fishery occurs for this effect to be realized because of the high age of first reproduction for most bottomfish species. Given this time lag, it is unlikely that the potential economic benefits of an area closure would accrue to the current generation of bottomfish fishermen. Moreover, if fishing effort is allowed to increase in the MHI, any economic gains from a closed area will be dissipated over the long-run (Dames and Moore in prep.).

Over the longer run, operations with higher fixed costs could be disadvantaged by the reduced margin of each fishing trip. Such effects could cause some fishermen to exit the NWHI fishery. For those enterprises that weather these negative effects, the long-term outlook could be brightened by a gradual increase in catch rates in response to initial effort reduction. It is possible that no-take zones could restock nearby fishing grounds and increase future harvest potential, thereby mitigating loss of revenue. However, the ability of closed areas to increase equilibrium yields has not been demonstrated for bottomfish fisheries in Hawaii (Dames and Moore in prep.).

Cumulative Effects on Existing Fisheries and Communities

It is likely that many families that depend on fishing and the seafood industry in the US Pacific islands are already economically, socially and psychologically stressed because of declining catch rates, increasing competition or unstable markets. Also contributing to this stress is the imposition of ever more restrictive state and federal regulations. In just two years, a limited access program was established for the Mau Zone of the NWHI bottomfish fishery, the State of Hawaii closed some areas around the MHI to bottomfishing, NMFS issued an emergency regulation that stopped the NWHI lobster season from opening in 2000 and recent litigation concerning possible impacts of the Hawaii-based longline fishery on sea turtles led a federal court to order NMFS to implement area closures, gear and effort restrictions and increased observer coverage for the fishery. Undoubtedly, many fishermen in Hawaii have the sense that government regulations are "boxing them in" and reducing their ability to maintain their characteristic highly flexible fishing strategy. This flexibility is important to the economic success of many smaller and medium-sized fishing vessels because of natural variations in the availability of various types of fish. Closure of some NWHI fishing grounds would further confine fishermen and could jeopardize the long-term economic viability of their fishing operations.

In addition to potential economic losses associated with the cumulative effects of various fishery closures, there would be a loss of lifestyle, assuming that displaced fishermen cannot find an equally satisfactory alternative way of life. Some Hawaii fishermen feel a sense of continuity with previous generations of fishermen and want to perpetuate the fishing life style. A 1993 survey of participants in the NWHI bottomfish fishery found that half of the respondents who fish in the Ho'omalu Zone were motivated to fish by a long term family tradition (Hamilton, 1994). This sense of continuity is also reflected in the importance placed on the process of learning about fishing from "old timers" and transmitting that knowledge to the next generation. Hawaii's commercial fishing industry dates back nearly 200 years and closure of some fishing grounds in the NWHI would also likely have a negative impact on those who value the continued existence of Hawaii's maritime tradition and culture.

Just as Hawaii's fishing tradition is an integral part of the islands' heritage and character, the image of Hawaii has become linked with the consumption of some types of locally-caught seafood. The availability of seafood is also important to Hawaii's tourist industry, the mainstay of the state economy. Japanese tourists visiting Hawaii often want to enjoy the traditional foods and symbols of Japan while they vacation in Hawaii, including various types of high quality fresh fish (Peterson 1973). Hawaii tourists from the U.S. mainland and other areas where fish is not an integral part of the customary diet typically want to eat seafood because it is part of the unique experience of a Hawaii vacation. Consuming fish that is actually caught in the waters around Hawaii further enhances that experience (Dames and Moore, in prep.).

Consistency with Other Plans and Policies for Existing Fisheries and Communities

The preferred alternative is consistent with the requirement of the MSFCMA to define affected fishing communities and to minimize, wherever practicable, adverse economic impacts on these communities.

Mitigation Measures for Effects on Existing Fisheries and Communities

Displacement of existing bottomfish and lobster fishing activity from no-take zones in the NWHI that would be created under alternatives 3 and 4 cannot be mitigated by transferring effort to other fisheries in Hawaii because those fisheries are becoming increasing restricted by state and federal regulations.

Indirect Effects on Other Environmental Components

Significant adverse effects on existing fisheries and communities could have indirect effects on native cultures (5.10).

5.9 Environmental Consequences for Bioprospecting and Other New fisheries

Alternative 1 (no action) does not recognize bioprospecting as an emerging fishery. Alternative 2 (CRE-FMP) would impose greater inefficiencies and higher costs than no action to comply with restrictions on vessel operation in MPAs and other permit conditions.

Direct Effects on Bioprospecting

Bioprospecting activities would not be prohibited by any of the alternatives. Even in no-take zones, bioprospecting may be conducted as "scientific research" if a permit is approved by the NMFS Regional Administrator after consultation with the Council. Restrictions on vessel operation in MPAs and imposing permit and reporting requirements could create inefficiencies and add to the cost of bioprospecting. Such enterprises are generally well financed, however. Even if novel techniques are employed to collect samples for laboratory screening, unevaluated collection methods using gear not currently on the allowable gear list could be approved after evaluation of the potential for adverse effects. The effects of alternatives 2, 3, and 4, therefore, differ little from those of no action.

Indirect Effects on Bioprospecting

Alternatives 3 and 4 that broadly designate no-take zones conserve a large reservoir of diverse genetic material of potential interest to bioprospecting operations seeking small samples of diverse organisms to screen for bioactive properties. Biodiversity may be reduced as a result of fishing activities under alternatives 1 and 2.

Cumulative Effects on Bioprospecting

Due to the high profile of bioprospecting enterprises, advocate groups have been active in controlling this industry and protecting the rights of indigenous populations throughout the world. It has become common practice for the industry to write detailed contracts with local and indigenous groups which strictly regulate harvest, negotiate up-front royalties for successful products, train local people to join the industry and offer assistance in environmental protection.

Consistency with Other Plans and Policies

The Convention on Biological Diversity, drafted at the Rio Earth Summit, recommends strong measures of protection against harmful bioprospecting.

Mitigation Measures for Effects on Bioprospecting

If environmental fluctuations or other natural or human factors change resource conditions so that harvesting presents a higher risk, timely preventive action can be taken under the framework adjustment procedures included in the established FMPs for Bottomfish, Crustaceans and Precious Corals and in alternatives 2, 3, and 4. Future amendments to the CRE FMP under alternatives 2 and 3 could include such actions as changes in MPA boundaries, designation of new MPAs, in the number of special permits or their conditions of use, or in allowable fishing gears and methods.

Indirect Effects on Other Environmental Components

Significant adverse effects on bioprospecting or other new fisheries are not likely to have indirect effects on the other environmental components considered in Section 5.

5.10 Environmental Consequences for Native Cultures

Alternative 3 (CRE-FMP) would designate no-take zones without addressing Native Hawaiian concerns regarding claims to the NWHI but it would provide for preferential access to indigenous zones in MPAs designated immediately and in the future in the EEZ around U.S. Pacific islands and it would also increase indigenous participation in the coral reef management process for the EEZ around the NWHI and elsewhere. Therefore, Alternative 3 has less negative effects on native cultures than alternative 1 (no action). Alternative 4 would prohibit all fishing activities in waters shallower than 100 fm and would decrease indigenous participation in coral reef fisheries conducted in the EEZ around the NWHI and elsewhere. Therefore, alternative 4 has greater negative effects on native cultures than alternatives 1 or 3.

Direct Effects on Native Cultures

Any alternative (including the existing protections included in the no action alternative) to designate no-take zones in the EEZ around the NWHI is potentially in conflict with the lingering sovereign claim by native Hawaiians. In 1993, the U.S. Congress passed the Apology Bill which states that "...the indigenous Hawaiian people never directly relinquished their claims to their inherent sovereignty as a people over their national lands to the United States, either through their monarchy or through a plebiscite or referendum." Murakami and Freitas (1987) argue that the legal claims of Native Hawaiians to the fishery in the main Hawaiian islands and Northwestern Hawaiian Islands have never been extinguished by the U.S. government, either (a) by condemning the fisheries granted to Hawaiian commoners and their successors and paying compensation for taking of their fishing grounds, or (b) by exercising its public trust duties to protect the aboriginal claims to the resources of the EEZ and determining the extent of participation by Hawaiians in the revenue from resource use and in resource conservation.

Broader designation of no-take zones in the NWHI that are included in alternatives 3 and 4 would adversely affect Native Hawaiians who are owners, captains or deckhands of fishing vessels presenting operating in that region, depriving them of a means of livelihood. In view of the historic and cultural importance of fishing over the last 2,000 years for Native Hawaiians, this deprivation of the right to make a living at *koa* (see Kahaulelio 1902, pp. 22, 24), which they have been accustomed to frequent in the NWHI, is an especially onerous penalty. This is exacerbated by the fact that annexation of Hawaii by the U.S. opened access to fishery resources to any U.S. citizen (Kosaki 1954), increasing fishing pressure on resources customarily used by Native Hawaiians and weakening cultural norms that controlled the proper conduct of fishing.

An alternative to reserve sub-zones of MPAs for indigenous use would be more beneficial than no action in compensating for the hardship to native cultures resulting from previous closures of fishing grounds without considering the claims of indigenous Pacific island populations.

Indirect Effects on Native Cultures

For centuries, native cultures in the U.S. Pacific islands relied on seafood as their principle source of protein. However, the availability of many traditional seafoods has been significantly diminished as a result of environmental degradation of nearshore reef areas under the jurisdiction of island governments. Localized overfishing is blamed for some of the adverse impacts, but coastal construction, industrial discharges and poor watershed management have damaged coral reef habitat on a massive scale near population centers. Shomura (1987) notes that between 1900 and 1986, commercial landings of coastal fish species in Hawaii declined by 80 percent. The drastic changes in diet that resulted from loss of access to marine fishery resources have contributed to the poor health of Native Hawaiians. Of all the racial groups living in Hawaii, Native Hawaiians are the group with the highest proportion of multiple risk factors leading to illness, disability and premature death (Look and Braun 1995). None of the alternatives would mitigate this situation, although reservation of MPA sub-zones for indigenous use would be more beneficial than no action.

Cumulative Effects on Native Cultures

The Samoa, Hawaii and Mariana islands were originally settled in ancient times by sea-faring peoples. The lack of terrestrial resources in most areas led to great dependence on fishing for food security. This dependence shaped the social organization, cultural values and spiritual beliefs of the indigenous populations. Repeated contacts with Europeans and North Americans eroded the stability of the social structures and subsistence economies created by indigenous people.

With the exception of American Samoa and small enclaves in Guam, Hawaii and the Commonwealth of the Northern Mariana Islands, the modern-day indigenous descendants are dispersed as part of cosmopolitan populations. Island societies have become pluralistic and many aspects of their economies and cultures have evolved in modern times. Yet, people descended from the original indigenous inhabitants have a particularly deep traditional, historical and contemporary involvement with coral reef resources. Fishing not only provides food but cultivates intimacy and harmony with the ocean, reinforcing a sense of kinship with nature and relationships with places that perpetuate cultural identities and beliefs. Increasing restrictions on customary and traditional uses of marine resources are jeopardizing cultural continuity in many areas of the US Pacific.

Consistency with Other Plans and Policies for Native Cultures

The preferred alternative is consistent with the Apology Bill in which the U.S. Congress expressed its commitment to acknowledge the ramifications of the overthrow of the Kingdom of Hawaii. In order to provide a proper foundation for reconciliation between the U.S. and the Native Hawaiian people. In December 1999, a series of reconciliation hearings attended by federal representatives, Native Hawaiians and the general public were conducted in Hawaii. In July 2000, Hawaii's congressional delegation introduced a bill to express the policy of the U.S. regarding its relationship with Native Hawaiians, to provide a process for the reorganization of a Native Hawaiian government and the recognition by the U.S. of a Native Hawaiian government.

Mitigation Measures for Effects on Native Cultures

Some of the alternatives could partially mitigate the cumulative effects resulting in this hardship by designating sub-zones in MPAs to provide indigenous populations with preferential access and resource use.

In addition, the MSFCMA provides for the establishment of a western Pacific community development program for any fishery under Council authority. This provision was added to the Act to address concerns that communities consisting of descendants of indigenous peoples in the Council's area of authority have not been appropriately sharing in the benefits from the area's fisheries. The Council and the Secretary of Commerce have discretion to develop and approve indigenous demonstration programs for eligible communities. Currently, the Council, in consultation with NMFS, is developing criteria for community eligibility. In 1999, the Council developed and the Secretary of Commerce approved an allocation of approximately one-fifth of the target number of Mau Zone permits to a community development program.

Indirect Effects on Other Environmental Components

Significant adverse effects on native cultures could have indirect affects on existing fisheries and communities (5.8).

5.11 Environmental Consequences for Non-Consumptive Values and Uses

Alternatives 3 and 4 may provide greater opportunities for research than alternatives 1 and 2 because they better conserve coral reef organisms. However, opportunities for marine recreation by the general public may be somewhat limited in the new no-take zones designated under Alternatives 3 and 4 because some of these zones are located in remote areas of the EEZ that are relatively inaccessible and, in some cases off limits, to the general public. However, the increased protection provided to the coral reef ecosystem in alternatives 3 and 4 would help maintain coral reef habitats in theirs natural state and allow for future ecotourism opportunities that may develop. None of the alternatives would restore or prevent new degradation of reef habitat and environmental quality in nearshore reef areas managed by island governments.

Direct Effects on Non-Consumptive Values and Uses

Alternatives 3 and 4 that designate no-take zones in remote areas of the EEZ would conserve a large reservoir of relatively undisturbed coral reef resources and habitats with high non-consumptive values. However, these areas are relatively inaccessible and are generally off limits to the public, except at Midway atoll, so there would be little change in impact from no action. Under alternatives 3 and 4 the opportunities for research of undisturbed coral reef baseline conditions would increase significantly above the level provided under alternative 1 (no action) or 2. Broader designation of no-take zones under alternatives 3 and 4 could emphasize underwater viewing and other non-consumptive activities in more accessible areas of the EEZ but deeper boundaries would be well below safe SCUBA diving depths. The resulting benefits for non-consumptive values and uses would be greater under alternatives 3 and 4 than those provided by alternatives 1 and 2

Indirect Effects on Non-Consumptive Values and Uses

None of the alternatives would directly mitigate adverse effects on coral reef habitats and environmental quality in nearshore areas under island government jurisdiction. However, designation of EFH and implementation of the CRE-FMP would mandate EFH consultations by NMFS and the Council for any proposed federal activity that has the potential for significant adverse effects. The consultation procedure produces greater benefits than no action.

Cumulative Effects on Non-Consumptive Values and Uses

Alternatives that would affect reefs only in remote and inaccessible areas of the EEZ would contribute less to cumulative effects than alternatives that affect reefs throughout the EEZ. Only fishing activities in the EEZ are managed by FMPs, which monitor for possible adverse effects on EFH and adjust management as necessary. The majority of reefs affected by the alternatives in the proposed CRE-FMP are in remote areas that are far removed from terrestrial activities and impacts.

Most areas are relatively inaccessible and access for non-consumptive recreation is restricted. By designating large no-take areas where coral reef surveys can be conducted, alternatives that designate no-take zones would be highly beneficial for research that allows comparison of undisturbed baseline conditions with coral reefs that are heavily exploited.

None of the alternatives considered by the proposed CRE-FMP would restore or prevent new degradation of EFH in nearshore reef areas managed by island governments. Nor does any alternative mitigate or prevent impacts on nearshore reef habitats resulting from coastal construction, watershed management, shoreline erosion or water pollution. The EFH consultation procedure required after implementation of the proposed CRE-FMP would help to mitigate the future potential for adverse effects resulting from proposed federal activities but would not address non-federal activities or the condition of nearshore fishery stocks.

Considering the large perturbations in NWHI and other coral reef habitats that result from large storms and associated wave action, the impact of fishing gear allowed under FMPs for Bottomfish, Crustaceans and Precious Corals and the proposed CRE-FMP under alternative 3 would not significantly effect non-consumptive values. Researchers have observed that periodic storms in the NWHI reduce live coral cover to 10 percent in some areas. Coral cover eventually returns to 50 percent or more in areas where the disturbance cycle is infrequent (R. Grigg, comm. at June 14, 2000 Council meeting).

Perhaps the most important factor in the population dynamics of many coral reef species and ecosystems in the NWHI and possibly elsewhere in the western Pacific region are cyclical oceanographic events which affect productivity over large areas and may account for large fluctuations in population abundance. In a study of recent climatic and oceanographic events and their effect on productivity in the NWHI, Polovina et al. (1994) found that declines of 30 to 50 percent in the abundance of a number of species representing various trophic levels, from the early 1980s to the present, could be explained by a shift in oceanographic conditions. Prior to this time period, oceanographic conditions that lasted from the late 1970s until the early 1980s moved nutrient-rich deep ocean water into the euphotic zone, resulting in higher survival of reef fish, crustaceans, monk seals and birds. Allowances for such outside influences are not directly incorporated in any of the alternatives but alternative 3 (the proposed CRE-FMP) includes a framework procedure for timely and rapid regulatory adjustments based on feedback from monitoring of changing fisheries and resource conditions.

Consistency with Other Plans and Policies for Non-Consumptive Values and Uses

Alternative 3 (the proposed CRE-FMP) is consistent with the 10-year target of the U.S. Coral Reef Task Force to designate 20 percent of reefs off U.S. coasts as no-take marine protected areas.

Mitigation Measures for Effects on Non-Consumptive Values and Uses

The preferred alternative establishes a procedure for coordination between plan teams monitoring different FMPs that allows joint analysis and evaluation of possible adverse effects of any fishery on coral reef ecosystems. If environmental fluctuations or other natural or human factors change resource conditions so that fishing presents a higher risk to coral reef ecosystem resources, timely preventive action can be taken under the framework adjustment procedures included in the established FMPs for Bottomfish, Crustaceans, and Precious Corals and in the proposed CRE-FMP. Future amendments could include such actions as changes in MPA boundaries, designation of new MPAs, in the number of special permits or their conditions of use, or in allowable fishing gears and methods.

Indirect Effects on Other Environmental Components

Significant adverse effects on non-consumptive values could indirectly affect native cultures (5.10).

5.12 Environmental Consequences for Administration and Enforcement of Regulations

Alternative 1 (no action) would not add new responsibilities or costs to existing administration and enforcement burdens. There would be continued low level of surveillance of remote coral reef areas of the EEZ and difficulty in prosecuting violators of island government regulations claiming illegal activities were conducted in the adjacent EEZ. Alternatives 2, 3, and 4 would significantly increase responsibilities and costs but with positive conservation benefits for coral reef ecosystems.

Direct Effects on Administration and Enforcement

Alternatives 2 and 3 that provide for special permits to fish in low-use MPA zones or for potentially-harvested coral reef resources would be technically complex. The cost of administration and enforcement under these alternatives would increase significantly above that of alternative 1 (no action) because each permit is customized to the proposed activity. Scientists and Council members would have to evaluate all applications before special permits are approved. A large number of applications could overwhelm and delay permit review and administration. Additional responsibilities and costs for permitting would not be incurred under alternative 1 (no action).

The enforcement of MPA boundaries would be simpler if the boundaries were delineated by grids or centroids rather than depth limits and if there were no take zones rather than zoning for a range of uses. Live rock harvest controls have similar enforcement issues. A prohibition on possession is simpler to enforce than a prohibition on commercial collection or exemptions for aquaculture brood stock and indigenous use. No new responsibilities or additional costs would be incurred under alternative 1 (no action).

At-sea enforcement of MPA zoning is likely to require additional air and sea patrols. Additional patrols would cost as much as $100,000 per air patrol and $25,000 per surface patrol (WPRFMC 1999). No additional costs would be incurred under alternative 1 (no action).

Indirect Effects on Administration and Enforcement

If substantial fishing activity is displaced from the NWHI as a result of broad designation of no-take MPAs under alternatives 3 and 4, administrative and enforcement costs associated with permitting, data collection, and observer coverage in the limited entry programs for FMP-managed bottomfish and lobster fisheries could be reduced below present levels (i.e., the no action alternative). Broad designations of no-take zones in the NWHI that displace existing fishing activities would remove any incentive for fishermen to self-monitor domestic fishing activity, and such designations would also preclude opportunities for fishermen to report illegal foreign and domestic fishing activity that may occur in the EEZ. These are both negative enforcement impacts of alternatives 3 and 4 compared to alternatives 1 (no action) and 2.

Essential fish habitat designations in the preferred alternative would be implemented through consultations by NMFS and the Council with agencies proposing or conducting activities with the potential for adverse impacts on EFH. Such consultations may help avoid or mitigate some of the adverse effects that are currently occurring in nearshore reef areas under alternative 1 (no action).

Cumulative Effects on Administration and Enforcement

The complexity of alternatives 2, 3, and 4 would add significantly to cumulative responsibilities and costs of fishery administration, surveillance, and enforcement for fisheries managed by FMPs. Separate jurisdictions and competing missions could hinder implementation of alternatives designating MPAs. It is likely that the process of developing inter-agency, inter-governmental and public-private relationships needed for ecosystem-scale management of coral reefs would be time consuming and costly.

Consistency with Other Plans and Policies for Administration and Enforcement

Permit alternatives that would exempt permit holders operating under established FMPs for Bottomfish, Crustaceans and Precious Corals avoid a duplication of administrative and enforcement costs resulting from implementation of alternative 3 (the proposed CRE-FMP).

In most areas of the NWHI where MPA would be designated, the State of Hawaii could take action to extend no-take zones from 3 nm offshore to the shoreline. The implementation of alternatives to designate MPAs within 3 nm of shore would require an unprecedented level of cooperation among agencies and levels of government that have different jurisdictions and missions.

Mitigation of Effects on Administration and Enforcement

High enforcement costs could be moderated through use of a vessel monitoring system (VMS). MPA boundaries based on depth will be extremely difficult to enforce unless VMS is required for all fishing vessels. A Honolulu-based VMS is presently operated by NMFS and the U.S. Coast Guard to monitor compliance in the pelagic longline and NWHI lobster fisheries. Additional costs would be incurred if the existing VMS were expanded to accommodate the additional vessel and area coverage associated with MPA designations.

The preferred alternative includes a framework procedure for adaptive management. This could be useful in streamlining the permit process, possibly by moving away from burdensome prerequisites and conditions toward performance standards that create positive incentives for innovation to minimize potential adverse fishery impacts. Such an approach would reduce the regulatory burden on fishermen and managers and law enforcement personnel.

FMPs for other western Pacific fisheries have often served as a catalyst for better coordinated fishery management across jurisdictional borders. An example is the deep-slope bottomfish fishery in Hawaii. A limited access program for EEZ around the NWHI was implemented under the Bottomfish FMP but no regulations were imposed on bottomfishing activity in the EEZ adjacent to the main Hawaiian Islands because the latter area has been traditionally managed by the State of Hawaii. After monitoring of the overall fishery documented localized overfishing of two deepwater snapper populations in the MHI, the State developed and implemented an ambitious plan for area closures to rebuild local bottomfish populations around the MHI.

The collection of data is a necessary part of the adaptive management procedure included in the proposed CRE-FMP. Some of the associated costs may be reduced by involvement of the fishing industry and other parties such as university researchers and volunteers but the costs will still exceed those of no action. The Council has established an education and public outreach program for all FMP-managed fisheries. The program is being expanded to raise public awareness of coral reef ecosystems and to improve compliance with regulations controlling the harvest of coral reef resources.

Indirect Effects on Other Environmental Components

Significant adverse effects on administration and enforcement could have indirect effects on target stocks (5.2), essential fish habitat (5.4), protected species (5.6) and existing fisheries and communities (5.8).

5.13 Summary of Impacts

Environmental Effects of the Alternatives

The 4 alternatives respond to resource issues and concerns differently, and as such, have different environmental effects. The impacts of each alternative on the environmental components likely to be affected by management activities are summarized for comparative purposes in Tables on the following pages.

Summary and Comparison of Effects of Alternatives

	Marine Protected Areas – Locations and Boundaries			
Environmental Component	Alternative 1 (No Action) Continuation of Current Management Regime	Alternative 2 (Minimal Additional Protection)	Alternative 3 (Substantial Additional Protection) (preferred) No-take: 0-10 fathoms around all NWHI plus, 0-50 fathoms around FFS, Laysan, N ½ Midway, Rose Atoll, Jarvis, Howland, Baker, Kingman, Palmyra. Low-use: 10-50 fathoms around all other NWHI, Johnston, and Wake. 0-50 fathoms around S ½ of Midway.	Alternative 4 (Maximum Additional Protection) No-take to 100 fm around all islands and atolls throughout the region's EEZ
Target stocks	All species currently harvested under established FMPs are above overfishing threshold. Changing conditions and environmental fluctuations are closely monitored and management is adapted as necessary. Does not prevent overfishing of potentially-harvested resources or of nearshore stocks managed by island governments.	All species currently harvested under established FMPs are above overfishing threshold. Changing conditions and environmental fluctuations are closely monitored and management is adapted as necessary. Does not prevent overfishing of potentially-harvested resources or of nearshore stocks managed by island governments.	Depending on zoning plan, some NWHI bottomfishing effort may be redirected from no-take areas to fully exploited stocks elsewhere. Spawning populations in MPAs might restock other areas connected through recruitment. Does not prevent overfishing of potentially-harvested resources or of nearshore stocks managed by island governments.	all bottomfishing lobster trapping effort in the EEZ would be prohibited. Spawning populations in MPAs could restock other areas connected through recruitment. Does not prevent overfishing of potentially-harvested resources or of nearshore stocks managed by island governments.

Non-target resources	Bycatch currently harvested is reported under established FMPs. Food web effects are unknown but overshadowed in NWHI by high level of predation by jacks. Changing conditions and environmental fluctuations are closely monitored and management is adapted as necessary. Fails to prevent overfishing of potentially-harvested resources or of nearshore stocks managed by island governments.	Bycatch currently harvested is reported under established FMPs. Food web effects are unknown but overshadowed in NWHI by high level of predation by jacks. Changing conditions and environmental fluctuations are closely monitored and management is adapted as necessary. Fails to prevent overfishing of potentially-harvested resources or of nearshore stocks managed by island governments.	Small reduction in fishing mortality may occur in some areas but impact may not be detectable against natural population fluctuations. Spawning populations in MPAs could restock other areas connected through recruitment. Does not prevent overfishing of potentially-harvested resources or of nearshore stocks managed by island governments.	Elimination of fishing mortality would occur in areas shallower than 100 fm. Spawning populations in MPAs could restock other areas connected through recruitment. Does not prevent overfishing of potentially-harvested resources or of nearshore stocks managed by island governments.

Live rock, coral, essential fish habitat (EFH) and environmental quality	Destructive gears are prohibited in existing FMP-managed fisheries. Effects on EFH are closely monitored and management is adapted as necessary. Low potential for damage to EFH or coral from existing fishing or anchoring methods. Island governments regulate live rock and stony coral collection in nearshore reef areas. Fails to prevent large-scale removal of live rock/stony coral in EEZ. Continues present level of risk of vessel grounding. Does not mitigate marine debris impacts caused by derelict fishing gear drifting into region from North Pacific fisheries. Fails to restore or prevent new degradation of nearshore reef habitat managed by island governments. Does not mitigate or prevent impacts from coastal construction, watershed management, shoreline erosion or water pollution.	Destructive gears are prohibited in existing FMP-managed fisheries. Effects on EFH are closely monitored and management is adapted as necessary. Low potential for damage to EFH or coral from existing fishing or anchoring methods. Island governments regulate live rock and stony coral collection in nearshore reef areas. Fails to prevent large-scale removal of live rock/stony coral in EEZ. Continues present level of risk of vessel grounding. Does not mitigate marine debris impacts caused by derelict fishing gear drifting into region from North Pacific fisheries. EFH consultation may help mitigate or prevent impacts from coastal construction, watershed management, shoreline erosion or water pollution..	Positive impact – MPAs would encompass large tracts of relatively undisturbed reef habitat in remote areas. Potential for vessel groundings or anchoring to degrade reef habitat is reduced in some areas. Fails to restore or prevent new degradation of nearshore reef habitat managed by island governments. EFH consultation may help mitigate or prevent impacts from coastal construction, watershed management, shoreline erosion or water pollution. Does not mitigate marine debris impacts caused by derelict fishing gear drifting into region from North Pacific fisheries.	Positive impact – MPAs would encompass large tracts of reef habitat around remote and main inhabited islands. Potential for vessel groundings or anchoring to degrade reef habitat is reduced in some areas. Fails to restore or prevent new degradation of nearshore reef habitat managed by island governments. EFH consultation may help mitigate or prevent impacts from coastal construction, watershed management, shoreline erosion or water pollution. Does not mitigate marine debris impacts caused by derelict fishing gear drifting into region from North Pacific fisheries.

National wildlife refuge wilderness resources	Shallow reefs adjacent to national wildlife refuge islands would continue to function as *de facto* MPAs. Continues present level of risk of vessel grounding. Does not mitigate marine debris impacts caused by derelict fishing gear drifting into region from North Pacific fisheries.	provides some additional protection to these resources by creating a low-use MPA around the NWHI to a depth of 50 fm.	Reinforces the no-take status of NWR resources and provides a higher level of protection by enlarging no-take zones off two islands in the Hawaiian Islands NWR and off all NWR islands in the Pacific remote island areas. Does not mitigate marine debris impacts caused by derelict fishing gear drifting into region from North Pacific fisheries.	Provide the most protection to National Wildlife Refuge wilderness resources by creating a no-take MPA throughout the regions EEZ in all areas shallower than 100 fm. Does not mitigate marine debris impacts caused by derelict fishing gear drifting into region from North Pacific fisheries.
Protected species – Hawaiian monk seal	Risk of direct impact from gear in FMP-managed fisheries and indirectly from food competition in NWHI is low but remains unchanged. Fails to mitigate marine debris impacts caused by derelict fishing gear drifting into region from North Pacific fisheries.	Risk of direct impact from gear in existing FMP-managed fisheries and indirectly from food competition in NWHI is reduced by establishing low-use MPAs to a depth of 50 fm around all NWHI.	Provides a higher level of protection by enlarging no-take zones off the two islands that are most important for breeding by the endangered Hawaiian monk seal in NWHI Potential direct impacts near breeding areas and indirect food competition in NWHI would be reduced. Depending on zoning plan, potential for vessel groundings to degrade critical habitat is reduced in some areas. Fails to mitigate marine debris impacts caused by derelict fishing gear drifting into region from North Pacific fisheries.	Provides the highest level of protection by enlarging no-take zones off the two islands that are most important for breeding by the endangered Hawaiian monk seal in NWHI Potential direct impacts near breeding areas and indirect food competition in NWHI would be greatly reduced. Depending on zoning plan, potential for vessel groundings to degrade critical habitat is reduced in some areas. Fails to mitigate marine debris impacts caused by derelict fishing gear drifting into region from North Pacific fisheries.

Protected species – sea turtles	No change in impact. Fails to mitigate large take of green sea turtles in main Hawaiian Islands' shoreline fishery or degradation of nesting habitat in American Samoa. Fails to mitigate marine debris impacts caused by derelict fishing gear drifting into region from North Pacific fisheries.	Risk of direct impact from gear in existing FMP-managed fisheries NWHI is reduced by establishing low-use MPAs to a depth of 50 fm around all NWHI. Depending on zoning plan, potential for vessel groundings to degrade nesting habitat is reduced.	Provides a higher level of protection from gear interactions by enlarging no-take zones Depending on zoning plan, potential for vessel groundings to degrade nesting habitat is reduced. Fails to mitigate large take of green sea turtles in main Hawaiian Islands' shoreline fishery or degradation of nesting habitat in American Samoa. Fails to mitigate marine debris impacts caused by derelict fishing gear drifting into region from North Pacific fisheries.	Provides the highest level of protection from gear interactions by enlarging no-take zones Depending on zoning plan, potential for vessel groundings to degrade nesting habitat is reduced in some areas. Fails to mitigate large take of green sea turtles in main Hawaiian Islands' shoreline fishery or degradation of nesting habitat in American Samoa. Fails to mitigate marine debris impacts caused by derelict fishing gear drifting into region from North Pacific fisheries.
Protected species – seabirds	Low risk of hooking in NWHI and PRIA continues at same level. Fails to mitigate marine debris impacts caused by derelict fishing gear drifting into region from North Pacific fisheries.	Low risk of hooking in NWHI and PRIA continues at same level. Fails to mitigate marine debris impacts caused by derelict fishing gear drifting into region from North Pacific fisheries.	Low risk of hooking in NWHI and PRIA continues at same level. Fails to mitigate marine debris impacts caused by derelict fishing gear drifting into region from North Pacific fisheries.	Low risk of hooking in NWHI and PRIA continues at same level. Fails to mitigate marine debris impacts caused by derelict fishing gear drifting into region from North Pacific fisheries.
Protected species – non-endangered marine mammals	Low impact but dolphin interaction rate in hook-and-line fisheries would continue at same level.	Low impact but dolphin interaction rate in hook-and-line fisheries would continue at same level.	Low impact but dolphin interaction rate in hook-and-line fisheries would be reduced in no-take MPAs.	Low impact but dolphin interaction rate in hook-and-line fisheries would be reduced in no-take MPAs.

Reef ecosystem biodiversity, structure and function	Fails to prevent loss of biodiversity, undesirable changes in species dominance or introduction of invasive exotic species.	Slight Positive Impact low-use MPAs would encompass areas of relatively undisturbed remote reef habitat. Fails to prevent the introduction of invasive alien species on derelict gear drifting into the region from the North Pacific. Fails to prevent loss of biodiversity or undesirable changes in species dominance in nearshore coral reef ecosystems managed by island governments.	Strong Positive impact – low-use and no-take MPAs would encompass large tracts of relatively undisturbed remote reef habitat. A large reservoir of unexploited genetic material would be conserved. Fails to prevent the introduction of invasive alien species on derelict gear drifting into the region from the North Pacific. Fails to prevent loss of biodiversity or undesirable changes in species dominance in nearshore coral reef ecosystems managed by island governments.	Strongest Positive Impact – No-take MPAs would encompass large tracts of relatively undisturbed remote reef habitat. A large reservoir of unexploited genetic material would be conserved. Fails to prevent the introduction of invasive alien species on derelict gear drifting into the region from the North Pacific. Fails to prevent loss of biodiversity or undesirable changes in species dominance in nearshore coral reef ecosystems managed by island governments.
Existing fisheries and communities	very little impact on existing fisheries and fishing communities	very little impact on existing fisheries and fishing communities	No-take and low-use MPAs would increase adverse impacts on existing fisheries and fishing communities by displacing existing bottomfish and lobster fishing effort around some NWHI where the seaward boundary of no-take zones would extend to a depth of 50 fm. Existing fisheries would be displaced in some areas and fishing costs would be increased.	No-take MPAs would greatly increase adverse impacts on existing fisheries and fishing communities by displacing existing bottomfish and lobster fishing effort around some NWHI where the seaward boundary of no-take zones would extend to a depth of 100 fm. Most existing bottomfish and crustacean fisheries would be closed
Bioprospecting and other new fisheries	No impact.	Very little impact	New fisheries would be prohibited in some areas within the EEZ.	New fisheries would be prohibited throughout the EEZ

Native cultures and environmental justice	Fails to prevent decline of customary and traditional uses in nearshore areas closed to traditional fishing by island governments. Green sea turtles cannot be harvested for customary and traditional uses.	Fails to prevent decline of customary and traditional uses in nearshore areas closed to traditional fishing by island governments. Green sea turtles cannot be harvested for customary and traditional uses	Would provide preferential access to indigenous zones in low-use MPAs designated immediately and in the future in the EEZ around U.S. Pacific islands. Would also increase indigenous participation in the coral reef management process for the EEZ around the NWHI and elsewhere. Therefore, less negative effects on native cultures than alternative 1 (no action) Financial institutions may view MPAs as creating too much risk and cost for new indigenous fishing enterprises.	Would prohibit all fishing activities in waters shallower than 100 fm and would decrease indigenous participation in coral reef fisheries conducted in the EEZ around No-use MPAs close to main inhabited islands and in waters shallower than 100 fm would displace most customary and traditional coral reef fisheries. Therefore, has greater negative effects on native cultures than alternatives 1, 2, or 3 Financial institutions are likely to view MPAs as creating too much risk and cost for new indigenous fishing enterprises.

Non-consumptive values and uses	No change in impacts. Island governments regulate live rock and stony coral collection in nearshore reef areas. Fails to prevent large-scale removal of live rock/stony coral in EEZ. Fails to restore or prevent new degradation of environmental quality in nearshore reef areas managed by island governments. Does not mitigate or prevent impacts from coastal construction, watershed management, shoreline erosion or water pollution.	Some positive impacts--low-use MPAs would encompass large tracts of relatively undisturbed reef habitat with high environmental quality Fails to restore or prevent new degradation of environmental quality in nearshore reef areas managed by island governments. Does not mitigate or prevent impacts from coastal construction, watershed management, shoreline erosion or water pollution.	Strong Positive impact – No-take and low-use MPAs would encompass large tracts of relatively undisturbed reef habitat with high environmental quality. Some areas may be accessible in the future for ocean recreation. Would provide undisturbed sites for surveying baseline characteristics of coral reefs. Fails to restore or prevent new degradation of environmental quality in nearshore reef areas managed by island governments. Does not mitigate or prevent impacts from coastal construction, watershed management, shoreline erosion or water pollution.	Strongest Positive impact – No-take MPAs would encompass large tracts of relatively undisturbed reef habitat with high environmental quality. Some areas may be accessible in the future for ocean recreation. .Would provide undisturbed sites for surveying baseline characteristics of coral reefs. Fails to restore or prevent new degradation of environmental quality in nearshore reef areas managed by island governments. Does not mitigate or prevent impacts from coastal construction, watershed management, shoreline erosion or water pollution.
Administration and enforcement of regulations	No added responsibilities and costs. Continued low level of surveillance of remote reefs and difficulties in presenting violations of island government regulations.	Definition of seaward boundaries following 50 fm isobath complicates enforcement more than grid or circle definitions.	Definition of seaward boundaries following 50 fm isobath complicates enforcement more than grid or circle definitions.	Definition of seaward boundaries following 100 fm isobath complicates enforcement more than grid or circle definitions.

5.14 Resource Tradeoffs

Short-Term Uses Versus Long-Term Productivity

Short-term uses are generally those that determine the present quality of life for the public. In coral reef ecosystems, short-term uses include fishing and ocean recreation. The quality of life for future generations depends on continued productivity of coral reef resources, and for Pacific island populations, the perpetuation of communities and cultures that are dependent on fishing and seafood. Long-term productivity refers to the capability of the ecosystem to provide resources on a sustainable basis. Management activities proposed by the CRE-FMP under alternative 3 could reduce the natural productivity of some coral reef areas in order to acquire new information and improve understanding and management of resources. The extent to which long-term productivity will be affected is not known because monitoring of these effects has only recently begun. However, it is known that coral reef management practices have the potential to reduce natural productivity if certain operating guidelines are not followed.

Control measures in all alternatives were specifically designed to meet the management standards of the MSFCMA and to prevent unacceptable degradation of coral reef resources. Monitoring will determine whether the control measures are effective and are being correctly applied. The alternatives emphasize marine protected areas, gear restrictions to prevent destructive and non-selective fishing methods and detailed permit control over new activities taking potentially-harvested resources about which little is known. The alternatives are less likely, therefore, to adversely affect long-term productivity than no action. The framework procedure in the proposed CRE-FMP allows for rapid and timely regulatory adjustments to be made in response to changing fisheries, resource conditions and environmental fluctuations.

Unavoidable Adverse Effects

Implementation of any alternative may result in some adverse environmental effects that cannot be avoided. Control measures in all alternatives are intended to keep the extent and duration of these effects within acceptable levels but adverse effects cannot be completely eliminated. The following adverse environmental consequences would be associated with some of the alternatives:

- Displacement of some existing fishing effort from within no-take MPAs to areas outside such MPAs, and possible redirection of this effort to fully exploited coral reef resources elsewhere.
- Increased costs to fishermen to travel further distances to fish in open areas, to comply with special permit, reporting, and insurance requirements for fishing vessel passage through MPAs.
- Increased government responsibilities and costs for administration, monitoring and enforcement of proposed new federal regulations.
- Continuing degradation of essential fish habitat and adverse effects on coral reef resources in non-EEZ areas and by non-fishing activities that cannot be directly managed under present MSFCMA authority.

Irreversible Resource Commitments

Irreversible commitments of resources are actions which disturb either a non-renewable resource (e.g. endangered species, cultural resources) or a renewable resource to the point that it can only be renewed over 100 years or more (e.g., slow-growing species of reef-building corals). Measures to protect resources that could be irreversibly affected by other resource uses were incorporated into alternative 3 (the proposed CRE-FMP). Following is a summary of the major irreversible commitments of resources and how they would be prevented.

Large-scale harvesting of live rock and stony corals directly removes major framework-building organisms that form coral reef habitat. Activities which damage reef habitat also cause irreversible losses because reef-building is very slow, often requiring eons to form a consolidated structure. Prohibitions on destructive fishing methods and on commercial collection of live rock and stony corals in alternatives 3 (the proposed CRE-FMP) and 4 are intended to prevent such irreversible losses.

Loss of biodiversity and undesirable changes in ecosystem structure or function induced by human activities may also constitute irreversible resource commitments. For example, extinction of an endangered species, such as the Hawaiian monk seal, would constitute an irreversible loss. Even management activities undertaken to promote the recovery of endangered species can result in irreversible commitments of other resources; e.g., if indigenous island populations who are dependent on fishing for cultural perpetuation are denied the opportunity.

Opportunities for research on undisturbed coral reef ecosystems to establish baselines are irreversibly lost once resources are harvested. Alternatives 1 and 2 which do not establish no-take zones would have the most irreversible commitment of coral reef resources to uses other than baseline research, whereas alternatives 3 and 4 that establish large no-take zones would have the least.

The use of fossil fuels for vessel operation and government surveillance and enforcement activities is an irreversible resource commitment. Alternatives with more activities and higher levels of surveillance and enforcement would cause higher consumption of fossil fuels.

Irretrievable Resource Commitments

An irretrievable commitment is the loss of opportunities for production or use of a renewable resource for a period of time. Almost all coral reef resource extraction activities produce varying degrees of irretrievable resource commitments. These commitments parallel the environmental impacts for each resource summarized earlier in this section. The difference between resource levels under a given alternative and potentially higher levels that could be otherwise produced also represents an irretrievable commitment of resources. The difference in output levels is the opportunity cost or lost production.

The major tradeoffs among resource output levels that may cause irretrievable commitments are: 1) between utilization of coral reef resources at sustainable levels versus complete conservation through "no take;" 2) between multi-resource and single resource management activities; 3) between preventive management versus mitigation after damage has occurred; 4) between management activities now or later; and 5) between economic effects on potential new fisheries versus effects on existing fisheries. These tradeoffs require commitments that are irretrievable because opportunities are foregone. The commitments are not irreversible, however, because they could be reversed by changing management direction. To allow for changes in management direction, alternative 3 (the proposed CRE-FMP) includes an adaptive procedure. Rapid and timely regulatory adjustments can be made based on changing fisheries, resource conditions or environmental fluctuations.

Environmental Justice

On November 23 1993 the 103rd Congress enacted the Public Law 103-150. It was an acknowledgment that the United States was involved in the illegal overthrow of the Hawaiian Kingdom. Section 1, (4) and (5), acknowledge the ramifications of the overthrow of the Kingdom and seek to establish a foundation for reconciliation between the Native Hawaiian people and the United States.

Under Executive Order 12898, dated February 11, 1994, federal agencies are required to address the potential for disproportionately high and adverse environmental effects of their actions on minority and low-income populations. Agencies are required to ensure that their programs and activities that affect human health or the environment do not directly or indirectly use criteria, methods, or practices that discriminate on the basis of race, color, or national origin. NEPA documents are specifically required to analyze effects of federal actions on minority and low-income populations and, whenever feasible, to develop mitigation measures to address significant and adverse effects on such communities. In addition, the Executive Order requires provision of opportunities for community input in the NEPA process. It states that the public, including minority and low-income communities, should have adequate access to public information relating to human health or environmental planning, regulation, and enforcement. Public Law 103-150 and Executive Order 12898 would bring close scrutiny upon any action that could be perceived to provide a negative impact onto the Native Hawaiian People. The Northwestern Hawaiian Islands, the bulk of the coral reef resources claimed by the United States, represents a cultural and economic value to the Native Hawaiian community. Claims of the Native Hawaiian community to ownership of the ceded lands have not been resolved. The dollar amount of the value has not been determined.

The Samoa, Hawai'i and Mariana islands were originally settled in ancient times by sea-faring peoples. The lack of terrestrial resources in most areas led to a great dependence on fishing for food security. This dependence shaped the social organization, cultural values and spiritual beliefs of the indigenous populations. Repeated contacts with Europeans and North Americans eroded the stability of the social structures and subsistence economies created by the indigenous people.

The Ceded Lands were former Government and Crown lands that, after the overthrow of the Kingdom of Hawai`i, were ceded to the United States by the Provisional government of Hawai`i. The provisional government was seeking annexation by the United States. In 1898, after passage of the "Newlands Resolution," Hawai`i was considered a territory of the United States. In 1899, the United States Attorney General, interpreting the language of the Newlands Resolution, consigned all the "public" lands, former Government and Crown lands, to a special trust limiting the revenue from or the proceeds of the lands to the uses of the inhabitants of the Hawaiian Islands for educational and other purposes (Mackenzie, 1991).

In 1900, the passage of Hawaii's Organic Act confirmed the cession of the ceded lands to the United States and provided specific laws for administering the public lands. The federal government recognized that, though they had received absolute title from the Republic of Hawaii, the beneficial title to the lands belonged to the inhabitants of Hawaii. The special relationship the federal government had with native Hawaiians was demonstrated with the passage of the Hawaiian Homes Commission Act of 1920. 188,000 acres were withdrawn from the Ceded Lands trust and placed under the authority of the Hawaiian Home Lands Commission (Murakami, 1991).

In 1959, Hawai`i became a State. It is apparent that the framers of the Admission Act were concerned with the survival and existence of Hawaiians. They were concerned with the unresolved issues surrounding land, land tenure and Hawaiian rights. Native Hawaiians had been displaced from their ancestral lands and their rights had not been adequately protected. The alienation from their lands and resources resulted in a dismal economic, social and physical conditions for native Hawaiians. The existence of the race and culture was in jeopardy. The former Government and Crown lands were conveyed to the State as trustee under section 5 of the Admission Act. Under Section 5f of the Admission Act are five stated purposes for the income and proceeds derived from these lands. One of the purposes of section 5f is "for the betterment of the conditions of Native Hawaiians as defined in the Hawaiian Homes commission Act of 1920." In 1978 the Hawaii Constitutional Convention created the Office of Hawaiian Affairs to receive a pro rata share of the proceeds and income from the Ceded lands trust. The State legislature set the share at 20%. The federal recognition of native Hawaiians and the special relationship between Hawaiians and the United States is exemplified in the actions regarding the former Government and Crown Lands, now referred to as the Ceded Lands. The 20% pro rata share of the proceeds and income from the ceded lands is the basis of the claims for 20% share of the resources of the State.

In 1953, an executive order by the President of the United States placed all submerged lands under the authority of the States. Submerged lands were defined in 1892, by the US Supreme Court, as all those lands under navigable waters of the State. The Supreme Court further recognized that this was a special class of land. Though States would hold title and authority over these lands they could not be treated as any other lands held by the States. Submerged lands were addressed in Section 5i of the Admission Act. Because of the position of the lands below navigable waters these lands could not be sold, leased or utilized unless it was by a special provision for the purpose of building piers or other structures that would benefit their use by the public.

The Northwestern Hawaiian Islands

In the late 19th century, King Kalākaua claimed all the islands to Kure (Kānemiloha`i) Atoll for the Kingdom of Hawai`i. The Northwestern Hawaiian Islands are part of the Government and Crown Lands that became the Ceded Lands Trust held by the State of Hawai`i (Yamase, 1982).

To enhance the revitalization of Native Hawaiian Culture and to correspond with the vision of the State and Federal government's view of native culture, management of the Northwestern Hawaiian

Islands must allow for the inclusion of the native voice in the decision-making process. Native access rights and cultural practices must be allowed. Reservation of rights to resources must be allowed. Additionally, the ability of the Hawaiian culture to perpetuate and accumulate cultural resources must be allowed. Culture must be practiced and allowed to grow to be viable, otherwise it is relegated as a museum piece, evidence of something that was. The renaissance of Native Hawaiian culture in the seventies and eighties was a rebirth of the arts. Now, the interest turns to mitigation of environmental impacts, restoration of the natural resources, traditional access and gathering rights.

Cultural and Spiritual Uses

Necker (Mokumanamana) Island has 33 identified shrines, *"heiau,"* and was undoubtedly a place of spiritual and religious importance. The number of shrines indicates that the purpose for visiting Necker Island was religious. This use should be allowed so that Hawaiian spiritual beliefs and practices can be continued (Cleghorn, 1988).

The American Indian Religious Freedom Act of 1978 was enacted to protect the religious rights of the Native American to access recognized sacred sites and burial sites. The Native American Graves Protection and Repatriation Act protects religious sites burial sites and funerary objects and establishes a process for the repatriation of the native remains and objects.

Nihoa Island has yielded burial sites. The burial sites, agricultural terracing and evidence of settlement indicates at least a semi-permanent settlement at Nihoa. Access to Nihoa must be allowed for cultural and spiritual purposes (Cleghorn, 1988).

Ka`ula Rock, Nihoa Island, and Necker (Mokumanamana) Island were known as the triplets in Hawaiian mythology and they marked the gateway to Hawaii. The Renaissance of Polynesian Voyaging makes access to the waters and terrestrial sites of these islands important to the future life of Hawaiian culture (source, date).

Access to the waters and terrestrial sites of Ka`ula, Nihoa and Necker is important for the education about and revitalization of Hawaiian culture. Gathering for customary and traditional practices shall be allowed in the Northwestern Hawaiian Islands. Resources for these materials have been greatly damaged by unregulated harvest in the Main Hawaiian Islands.

The loss of traditional fishing grounds in the Main Hawaiian Islands to public uses, resorts, harbors, airlines and other development have greatly damaged Kanaka Maoli culture. Native Hawaiian traditions and culture were based upon the understanding and appreciation of the ocean and marine resources. Cultural values and traditions are tied to an Oceanic perspective. If we are to maintain and revitalize Hawaiian culture, the host culture, then the oceanic perspective must be preserved and enhanced. The capability to utilize, understand and manage the NWHI resource will need to be developed in the community.

When King Kalākaua claimed all of the archipelago to Kure (Kānemiloha`i) Island for the Kingdom of Hawaii it was for the enhancement of the economy of the Kingdom. Internal political assaults upon the Kingdom of Hawaii had diminished the power of the sovereign. Military power was subject to the legislature. Executive powers were held by the cabinet, whose appointment needed legislative approval. There were property qualifications necessary for the right to vote which disenfranchised many native Hawaiians. The 75% of private property was owned by Westerners. The Native Hawaiian population was in serious decline. In 1891, the US government applied a tariff on sugar imported to the United States that increased the pressure to seek annexation by the Westerners. Through this difficult period Kalākaua worked to make Hawaii the hub of a wheel of commerce that united the Pacific Area. Through treaty he tried to ensure the independence of Hawaii. By immigration he tried to increase his people and level the economic playing field for the common citizen. Kalākaua died in 1891. The Kingdom of Hawaii ended with the invasion and overthrow on January 17, 1893 (Kuykendall, 1953).

Kalākaua claimed the archipelago to Kure Island for the Kingdom. Kalākaua battled for the economic life of the Kingdom. It is clear that he wished the economic resources of the entire archipelago to enhance the economy of the Kingdom and to benefit the people of Hawaii. He was clearly concerned with the Native Hawaiian people, his people, the kanaka maoli. The native trusts can be served by reserving 20% of all limited entry permits to all of the fisheries in the Northwestern Hawaiian Islands for the betterment of the native people of Hawaii. The disposition of such permits should be determined by the native people or their organizations. If quotas are established for the management of these fisheries then 20% of the quotas shall be reserved for the benefit of the Native Hawaiians. Any research pharmaceutical, cosmetic, extractive shall be allowed by contract, negotiated with the Kanaka Maoli or their agents reserving rights to the data, products or results of that research for the native people of Hawaii. In this manner the responsibilities and desires of the native Hawaiians, Kanaka Maoli, can be served.

The Apology Bill states that ". . . the indigenous Hawaiian people never directly relinquished their claims to their inherent sovereignty as a people over their national lands to the United States, either through their Monarchy or through a plebiscite or referendum. Murakami and Freitas argue that the legal claims of Native Hawaiians to the fishery in the main Hawaiian islands and Northwestern Hawaiian Islands have never been extinguished by the U.S. government, either (a) by condemning the fisheries granted to Hawaiian Commoners and their successors and paying compensation for taking of their fishing grounds, or (b) by exercising its public trust duties to protect the aboriginal claims to the resources of the EEZ and determining the extent of participation by Hawaiians in the revenue from resource use and in resource conservation. Until resolution of the claims by Native Hawaiians for their trust assets a 20% reservation of resources is a compromise that serves to preserve a portion of the trust resource in more or less untouched state. Resolution of these claims will define the extent of authority and responsibility that Native Hawaiians have for these assets. There is an understanding in the Native community that these assets fully belong to Native Hawaiians but there is an appreciation of the covetous nature of the United States and that a political compromise may need to be brokered in the interim.

5.15 Significant Cumulative Effects

Cumulative effects occur when effects of coral reef management activities combine with effects of other activities to produce a greater net effect than either would if considered separately. Cumulative effects will occur as a result of implementing any alternative. Actions taken under alternatives 3 (the proposed CRE-FMP) and 4 are expected to moderate the cumulative effects of fishery activities. In alternatives 1 and 2 the actions taken could increase the level of expected cumulative effects. In all alternatives, the management standards of the MSFCMA to prevent overfishing and prevent adverse effects on essential fish habitat will be met for currently-harvested resources by existing FMP-managed fisheries in the EEZ around U.S. Pacific islands. The cumulative effects on coral reef resources vary by alternative but they depend largely on four factors:

- The extent to which separate management activities in the EEZ can be integrated to avoid significant adverse effects on potentially-harvested resources and non-target coral reef resources, including protected species, ecosystem structure and function.

- The extent to which island governments in the US Pacific implement management standards for state and territorial waters to avoid significant adverse effects on currently-harvested, potentially-harvested and non-target coral reef resources.

- The extent to which non-fishing activities in the EEZ and in state and territorial waters can be managed according to standards that prevent further adverse effects on coral reef habitat.

- The extent to which adverse effects of fishing and non-fishing activities outside the western Pacific region (e.g., marine debris, introduction of invasive alien marine species) can be mitigated through inter-regional and international management.

Unpredictable and uncontrollable events, such as coral bleaching episodes, storm wave damage or ocean climatic shifts could occur in concert with planned management activities and result in significant cumulative effects on coral reef resources. Allowances for such outside influences are not directly incorporated in any alternative, however alternatives 3 (the proposed CRE-FMP) and 4 include a framework procedure for timely and rapid regulatory adjustments based on feedback from monitoring of changing fisheries and resource conditions. Future amendments could include such actions as changes in MPA boundaries, designation of new MPAs, elimination of MPAs, changes to or from no-use/low-use, or controls for vessel anchoring and passage. The number of special permits or their conditions of use might be adjusted. Based on performance of specific fishing gears, they may be added to or removed from the allowable gear list.

Significant Cumulative Effects on Target Stocks

Only fishing activities in the EEZ would be managed by the proposed CRE-FMP. None of the alternatives would prevent overfishing of currently-harvested or potentially-harvested coral reef resources in nearshore areas regulated by island governments. Localized overfishing of high-value species is known to be occurring in the most accessible reef areas near island population centers (Green 1997). The EFH consultation procedure required after implementation of the proposed CRE-FMP will help to mitigate the future potential for adverse effects resulting from proposed federal activities but would not address non-federal activities or the condition of nearshore fishery stocks.

Environmental fluctuations can bring about dramatic changes in coral reef ecosystem productivity and cause some resources to become more susceptible to overfishing. From the mid-1970s to late 1980s, the central North Pacific experienced increased vertical mixing, with a deepening of the wind-stirred surface layer into nutrient-rich lower waters and probable increased enrichment of the upper ocean. Resulting increased primary productivity likely provided a larger food base for fish and animals at higher trophic levels. In the NWHI, changes of 60-100 percent over baseline levels in productivity for lobsters, reef fish and other animals was observed and attributed to deeper mixing during the 1977-1988 period. Subsequent declines in reproductive success in the late 1980s appear to be linked to a shift back to a lower level of productivity. The variation in the geographical position of this vertical mixing is in turn related to the position of the Aleutian low-pressure system. As this system deviates from its long-term average position, productivity may increase or decline in the waters around the NWHI (Polovina et al. 1994). Allowances for such outside influences are not directly incorporated in any alternative but the proposed CRE-FMP includes a framework procedure for timely and rapid regulatory adjustments based on feedback from monitoring of changing fisheries and resource conditions. Future amendments could include such actions as changes in MPA boundaries, designation of new MPAs or in the number of special permits or their conditions of use.

Significant Cumulative Effects on Non-Target Resources

Only fishing activities in the EEZ would be managed by the proposed CRE-FMP. None of the alternatives would prevent high fishing mortality of non-target coral reef resources that are currently-harvested or potentially-harvested in nearshore areas regulated by island governments. The most accessible reef areas near island population centers are heavily fished (Green 1997).

Environmental fluctuations can bring about dramatic changes in coral reef ecosystem productivity and cause some non-target resources to become more susceptible to high fishing mortality. From the mid-1970s to late 1980s, the central North Pacific experienced increased vertical mixing, with a deepening of the wind-stirred surface layer into nutrient-rich lower waters and probable increased enrichment of the upper ocean. Resulting increased primary productivity likely provided a larger food base for fish and animals at higher trophic levels. In the NWHI, changes of 60-100 percent over baseline levels in productivity for lobsters, reef fish and other animals was observed and attributed to deeper mixing during the 1977-1988 period. Subsequent declines in reproductive success in the late 1980s appear to be linked to a shift back to a lower level of productivity. The variation in the geographical position of this vertical mixing is in turn related to the position of the Aleutian low-pressure system. As this system deviates from its long-term average position, productivity may increase or decline in the waters around the NWHI (Polovina et al. 1994). Allowances for such outside influences are not directly incorporated in any alternative, however, alternatives 3 (the proposed CRE-FMP) and 4 include a framework procedure for timely and rapid regulatory adjustments based on feedback from monitoring of changing fisheries and resource conditions. Future amendments could include such actions as changes in MPA boundaries, designation of new MPAs elimination of MPAs, changes to or from no-take/low-use, or in the number of special permits or their conditions of use.

Significant Cumulative Effects on Live Rock, Coral, Essential Fish Habitat (EFH) and Environmental Quality

Only fishing activities in the EEZ are managed by FMPs, which monitor for possible adverse effects on EFH and adjust management as necessary. The majority of reefs affected by the alternatives in the proposed CRE-FMP are in remote areas that are far removed from terrestrial activities and impacts.

None of the alternatives considered by the proposed CRE-FMP would restore or prevent new degradation of EFH in nearshore reef areas managed by island governments. Nor does any alternative mitigate or prevent impacts on nearshore reef habitats resulting from coastal construction, watershed management, shoreline erosion or water pollution. The EFH consultation procedure required after implementation of alternative 3 (the proposed CRE-FMP) or 4 would help to mitigate the future potential for adverse effects resulting from proposed federal activities but will not address non-federal activities or the condition of nearshore fishery stocks.

Considering the large perturbations in NWHI and other coral reef habitats that result from large storms and associated wave action, the impact of fishing gear allowed under FMPs for Bottomfish, Crustaceans and Precious Corals and the proposed CRE-FMP would not be significant. Researchers have observed that periodic storms in the NWHI reduce live coral cover to 10 percent in some areas. Coral cover eventually returns to 50 percent or more in areas where the disturbance cycle is infrequent (R. Grigg, comm. at June 14, 2000 Council meeting).

Some of the activities that can degrade EFH are not controllable through unilateral management. One of the most serious problems in the NWHI is the accumulation of marine debris, largely derelict gear lost from North Pacific fisheries. Inter-regional and international management will be necessary to find solutions to this problem.

In 1998, global coral bleaching and die off was unprecedented in geographic extent, depth and severity (Pomerance, 1999). Several studies have related bleaching to the combination of increased ultraviolet radiation and ocean warming, phenomena that may be exacerbated by human activities. Projected long-term climatic changes are likely to expose stony corals to an increasingly hostile environment and could possibly lead to another episode of mass extinctions. Stony corals damaged by acute, local stresses (e.g., hurricanes, starfish predation) have often been able to recover as long as surrounding reefs remained healthy. Renewal of reef building following chronic, widespread stresses acting synergistically is likely to be much slower. Human uses of reefs have never been higher and there is growing concern about human impacts that could add to cumulative stresses on coral reefs in the western Pacific Region. Allowances for such outside influences are not directly incorporated in any alternative but alternatives 3 (the proposed CRE-FMP) and 4 include a framework procedure for timely and rapid regulatory adjustments based on feedback from monitoring of changing fisheries and resource conditions. Future amendments could include such actions as changes in MPA boundaries, designation of new MPAs, elimination of MPAs, changes to or from no-take/low-use, changes in the number of special permits or their conditions of use, or in allowable fishing gear.

Significant Cumulative Effects on National Wildlife Refuge Wilderness Resources

All of the alternatives reinforce the protected status of shallow reef resources adjacent to National Wildlife Refuge islands in the western Pacific region. Some of the activities that can degrade wilderness resources are not controllable through unilateral management. One of the most serious problems in the NWHI is the accumulation of marine debris, largely derelict gear lost from North Pacific fisheries. Inter-regional and international management will be necessary to find solutions to this problem.

Environmental fluctuations can bring about dramatic changes in coral reef ecosystem productivity and cause some resources to become more susceptible to overfishing. From the mid-1970s to late 1980s, the central North Pacific experienced increased vertical mixing, with a deepening of the wind-stirred surface layer into nutrient-rich lower waters and probable increased enrichment of the upper ocean. Resulting increased primary productivity likely provided a larger food base for fish and animals at higher trophic levels. In the NWHI, changes of 60-100 percent over baseline levels in productivity for lobsters, reef fish and other animals was observed and attributed to deeper mixing during the 1977-1988 period. Subsequent declines in reproductive success in the late 1980s appear to be linked to a shift back to a lower level of productivity. The variation in the geographical position of this vertical mixing is in turn related to the position of the Aleutian low-pressure system. As this system deviates from its long-term average position, productivity may increase or decline in the waters around the NWHI (Polovina et al. 1994). Allowances for such outside influences are not directly incorporated in any alternative but the proposed CRE-FMP includes a framework procedure for timely and rapid regulatory adjustments based on feedback from monitoring of changing fisheries and resource conditions. Future amendments could include such actions as changes in MPA boundaries, designation of new MPAs, elimination of MPAs, changes to or from no-take/low-use, changes in the number of special permits or their conditions of use, or in allowable fishing gear.

Significant Cumulative Effects on Protected Species and Non-Endangered Marine Mammals

None of the alternatives is likely to add significantly to cumulative effects of reef-related (non-pelagic) fisheries on species of sea turtles or seabirds listed under the ESA. Nor would any alternative change cumulative effects on non-endangered species of whales and dolphins.

The overall status of the endangered Hawaiian monk seal may be grave. Contributing to the specie's decline in the NWHI over the past four decades have been human disturbance, reduced prey availability, shark predation, attacks by aggressive adult male monk seals on females and immature seals of both sexes and entanglement in derelict fishing gear originating in the North Pacific. At each colony, differing combinations of these factors likely have contributed to local trends in abundance, with relative importance of individual factors changing over times. A systematic assessment of the relative importance of various threats to the survival of the Hawaiian monk seal has not yet been conducted. However, the available information indicates that fisheries conducted in the NWHI under established FMPS or that could be conducted under the proposed CRE-FMP account for a very small proportion of the potential impacts to the Hawaiian monk seal. There is no information at this time to suggest that current levels of bottomfish and lobster fishing activities managed under other FMPS or expected levels of new fishing activities that could occur under the proposed CRE-FMP would inhibit the recovery of the Hawaiian monk seal.

Environmental fluctuations can bring about dramatic changes in coral reef ecosystem productivity and cause some resources to become more susceptible to overfishing. From the mid-1970s to late 1980s, the central North Pacific experienced increased vertical mixing, with a deepening of the wind-stirred surface layer into nutrient-rich lower waters and probable increased enrichment of the upper ocean. Resulting increased primary productivity likely provided a larger food base for fish and animals at higher trophic levels. In the NWHI, changes of 60-100 percent over baseline levels in productivity for lobsters, reef fish, sea birds and monk seals was observed and attributed to deeper mixing during the 1977-1988 period. Subsequent declines in reproductive success in the late 1980s appear to be linked to a shift back to a lower level of productivity. The variation in the geographical position of this vertical mixing is in turn related to the position of the Aleutian low-pressure system. As this system deviates from its long-term average position, productivity may increase or decline in the waters around the NWHI (Polovina et al. 1994). Allowances for such outside influences are not directly incorporated in any alternative but the proposed CRE-FMP includes a framework procedure for timely and rapid regulatory adjustments based on feedback from monitoring of changing fisheries and resource conditions. Future amendments could include such actions as changes in MPA boundaries, designation of new MPAs, in the number of special permits or their conditions of use or in the fishing gear that is allowed or not allowed.

Significant Cumulative Effects on Reef Ecosystem Biodiversity, Structure and Function

Because the coral reef ecosystem is comprised of multiple species with a long co-evolutionary history, removal of certain species can result in loss of biodiversity, as well as undesirable changes in ecosystem structure or function, such as a predominance of less valuable generalist species. Possible secondary effects of fishing may be overlooked in conventional management of specific target stocks. Alternatives 3 and 4 that would designate large no-take MPAs and allow for highly discretionary special permit review would guard against cumulative effects on reef ecosystem biodiversity, structure and function, while also guarding against overfishing of potentially-harvested species. In addition, alternative 3 includes a consultation procedure among plan teams for different FMPs to monitor possible ecosystem effects of all reef-related fisheries in the EEZ and adjust management as necessary.

Only fishing activities in the EEZ would be managed by the proposed CRE-FMP. None of the alternatives would prevent adverse effects on reef ecosystem biodiversity, structure of function in nearshore areas regulated by island governments. Nor does any alternative mitigate or prevent impacts on nearshore reef ecosystems resulting from coastal construction, watershed management, shoreline erosion or water pollution. The EFH consultation procedure required after implementation of alternative 3 (the proposed CRE-FMP) or 4 would help to mitigate the future potential for adverse effects resulting from proposed federal activities but will not address non-federal activities or the condition of nearshore ecosystems.

Environmental fluctuations can bring about dramatic changes in coral reef ecosystem productivity and cause some resources to become more susceptible to overfishing. From the mid-1970s to late 1980s, the central North Pacific experienced increased vertical mixing, with a deepening of the wind-stirred surface layer into nutrient-rich lower waters and probable increased enrichment of the upper ocean. Resulting increased primary productivity likely provided a larger food base for fish and animals at higher trophic levels. In the NWHI, changes of 60-100 percent over baseline levels in productivity for lobsters, reef fish and other animals was observed and attributed to deeper mixing during the 1977-1988 period. Subsequent declines in reproductive success in the late 1980s appear to be linked to a shift back to a lower level of productivity. The variation in the geographical position of this vertical mixing is in turn related to the position of the Aleutian low-pressure system. As this system deviates from its long-term average position, productivity may increase or decline in the waters around the NWHI (Polovina et al. 1994). Allowances for such outside influences are not directly incorporated in any alternative but alternative 3 (the proposed CRE-FMP) includes a framework procedure for timely and rapid regulatory adjustments based on feedback from monitoring of changing fisheries and resource conditions. Future amendments could include such actions as changes in MPA boundaries, designation of new MPAs, elimination of MPAs, changes to or from no-take/low-use, changes in the number of special permits or their conditions of use, or in allowable fishing gear.

Significant Cumulative Effects on Existing Fisheries and Communities

It is likely that many families that depend on fishing and the seafood industry in the US Pacific islands are already economically, socially and psychologically stressed because of declining catch rates, increasing competition or unstable markets. Also contributing to this stress is the imposition of ever more restrictive state and federal regulations. Undoubtedly, many fishermen in Hawaii have the sense that government regulations are "boxing them in" and reducing their ability to maintain their characteristic highly flexible fishing strategy. This flexibility is important to the economic success of many smaller and medium-sized fishing vessels because of natural variations in the availability of various types of fish. Closure of some NWHI fishing grounds under alternative 3 and especially closure of most NWHI fishing grounds under alternative 4 would further confine fishermen and would jeopardize the long-term economic viability of their fishing operations.

In addition to potential economic losses associated with the cumulative effects of various fishery closures, there would be a loss of lifestyle, assuming that displaced fishermen cannot find an equally satisfactory alternative way of life. Some Hawaii fishermen feel a sense of continuity with previous generations of fishermen and want to perpetuate the fishing life style. A 1993 survey of participants in the NWHI bottomfish fishery found that half of the respondents who fish in the Ho'omalu Zone were motivated to fish by a long term family tradition (Hamilton, 1994). This sense of continuity is also reflected in the importance placed on the process of learning about fishing from "old timers" and transmitting that knowledge to the next generation. Hawaii's commercial fishing industry dates back nearly 200 years and closure of some fishing grounds in the NWHI would also likely have a negative impact on those who value the continued existence of Hawaii's maritime tradition and culture.

Just as Hawaii's fishing tradition is an integral part of the islands' heritage and character, the image of Hawaii has become linked with the consumption of some types of locally-caught seafood. The availability of seafood is also important to Hawaii's tourist industry, the mainstay of the state economy. Japanese tourists visiting Hawaii often want to enjoy the traditional foods and symbols of Japan while they vacation in Hawaii, including various types of high quality fresh fish (Peterson 1973). Hawaii tourists from the U.S. mainland and other areas where fish is not an integral part of the customary diet typically want to eat seafood because it is part of the unique experience of a Hawaii vacation. Consuming fish that is actually caught in the waters around Hawaii further enhances that experience (Dames and Moore, in prep.).

Significant Cumulative Effects on Bioprospecting and Other New Fisheries

The search for promising new medicines provides strong incentives to explore coral reef ecosystems for potentially useful resources. This activity, known as "bioprospecting," is not presently managed in the EEZ and alternatives that provide for special permits and restrictions on vessel passage in MPAs would add to cumulative effects that increase the cost of this enterprise. The framework procedure for regulatory adjustments under alternative 3 could be useful for possible future streamlining of the permit process, moving away from burdensome prerequisites toward performance standards that create positive incentives for innovation to minimize adverse effects.

Significant Cumulative Effects on Native Cultures

The Samoa, Hawaii and Mariana islands were originally settled in ancient times by sea-faring peoples. The lack of terrestrial resources in most areas led to great dependence on fishing for food security. This dependence shaped the social organization, cultural values and spiritual beliefs of the indigenous populations. Repeated contacts with Europeans and North Americans eroded the stability of the social structures and subsistence economies created by indigenous people.

With the exception of American Samoa and small enclaves in Guam, Hawaii and the Commonwealth of the Northern Mariana Islands, the modern-day indigenous descendants are dispersed as part of cosmopolitan populations. Island societies have become pluralistic and many aspects of their economies and cultures have evolved in modern times. Yet, people descended from the original indigenous inhabitants have a particularly deep traditional, historical and contemporary involvement with coral reef resources. Fishing not only provides food but cultivates intimacy and harmony with the ocean, reinforcing a sense of kinship with nature and relationships with places that perpetuate cultural identities and beliefs. Increasing restrictions on customary and traditional uses of marine resources are jeopardizing cultural continuity in many areas of the US Pacific. Alternative 3 could partially mitigate the cumulative effects resulting in this hardship by designating sub-zones in MPAs to provide indigenous populations with preferential access and resource use to designated portions of those sub-zones.

Significant Cumulative Effects on Non-Consumptive values and Uses of Coral Reefs

Alternative 3 that would affect reefs only in remote and inaccessible areas of the EEZ would contribute less to cumulative effects than alternative 4 that affects all reefs throughout the EEZ. Only fishing activities in the EEZ are managed by FMPs, which monitor for possible adverse effects on EFH and adjust management as necessary. The majority of reefs affected by alternative 3 (the proposed CRE-FMP) are in remote areas that are far removed from most terrestrial activities and impacts. Most areas are relatively inaccessible and access for non-consumptive recreation is restricted. By designating large no-take areas where coral reef surveys can be conducted, alternatives 3 and 4 that designate no-take zones would be highly beneficial for research that allows comparison of undisturbed baseline conditions with coral reefs that are heavily exploited or impacted.

Alternatives 3 (the proposed CRE-FMP) and 4 would not restore or prevent new degradation of EFH in nearshore reef areas managed by island governments. Nor does any alternative mitigate or prevent impacts on nearshore reef habitats resulting from coastal construction, watershed management, shoreline erosion or water pollution. The EFH consultation procedure required after implementation of alternative 3 (the proposed CRE-FMP) or 4would help to mitigate the future potential for adverse effects resulting from proposed activities.

Considering the large perturbations in NWHI and other coral reef habitats that result from large storms and associated wave action, the impact of fishing gear allowed under FMPs for Bottomfish, Crustaceans and Precious Corals and the proposed CRE-FMP (alternative 3) would not significantly effect non-consumptive values. Researchers have observed that periodic storms in the NWHI reduce live coral cover to 10 percent in some areas. Coral cover eventually returns to 50 percent or more in areas where the disturbance cycle is infrequent (R. Grigg, comm. at June 14, 2000 Council meeting).

Environmental fluctuations can bring about dramatic changes in coral reef ecosystem productivity and cause some resources to become more susceptible to overfishing, with possible adverse effects on non-consumptive values. From the mid-1970s to late 1980s, the central North Pacific experienced increased vertical mixing, with a deepening of the wind-stirred surface layer into nutrient-rich lower waters and probable increased enrichment of the upper ocean. Resulting increased primary productivity likely provided a larger food base for fish and animals at higher trophic levels. In the NWHI, changes of 60-100 percent over baseline levels in productivity for lobsters, reef fish and other animals was observed and attributed to deeper mixing during the 1977-1988 period. Subsequent declines in reproductive success in the late 1980s appear to be linked to a shift back to a lower level of productivity. The variation in the geographical position of this vertical mixing is in turn related to the position of the Aleutian low-pressure system. As this system deviates from its long-term average position, productivity may increase or decline in the waters around the NWHI (Polovina et al. 1994). Allowances for such outside influences are not directly incorporated in any alternative but alternative 3 (the proposed CRE-FMP) includes a framework procedure for timely and rapid regulatory adjustments based on feedback from monitoring of changing fisheries and resource conditions. Future amendments could include such actions as changes in MPA boundaries, designation of new MPAs, elimination of MPAs, changes to or from no-take/low-use, changes in the number of special permits or their conditions of use, or in allowable fishing gear.

Significant Cumulative Effects on Administration and Enforcement of Regulations

Alternatives that would exempt permit holders operating under established FMPs for Bottomfish, Crustaceans and Precious Corals avoid a duplication of administrative and enforcement costs. The complexity of alternatives 3 and 4 would add significantly to cumulative responsibilities and costs of fishery administration, surveillance and enforcement.

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7.0 LIST OF AGENCIES AND PERSONS CONSULTED, AND RECIPIENTS

Federal Agencies

Members of the U.S. Coral Reef Task Force:

Governor	Commonwealth of the Northern Mariana Islands
Governor	Commonwealth of Puerto Rico
Governor	State of Florida
Governor	State of Hawaii
Governor	Territory of American Samoa
Governor	Territory of Guam
Governor	U.S. Virgin Islands
Secretary	U.S. Department of Commerce
Secretary	U.S. Department of Interior
Secretary	U.S. Department of State
Secretary	U.S. Department of Department of Defense
Secretary	U.S. Department of Agriculture
Attorney General	U.S. Department of Justice
Secretary	U.S. Department of Transportation
Director	Council for Environmental Quality, White House
Administrator	National Aeronautics and Space Administration
Director	National Science Foundation
Administrator	U.S. Agency for International Development
Administrator	U.S. Environmental Protection Agency, (Hdqrts. and Region IX)

Other:

Administrators	National Marine Fisheries Service Regional Offices
Directors	National Marine Fisheries Service (NFMS) Science Centers
Administrator	National Oceanic and Atmospheric Administration
Deputy Assistant Secretary	National Oceanic and Atmospheric Administration
Director	NMFS Honolulu Laboratory
Chief	NMFS Office of Law Enforcement, Long Beach & Hawaii
Administrator	NMFS Pacific Islands Area Office
Director	Office of Policy & Strategic Planning, NOAA
Executive Director	Science Advisory Board, NOAA
General Counsel	Southwest Region, NOAA
Director	U.S. Army Corps of Engineers
Admiral	U.S. Coast Guard (Hdqrts., 14th District & Public Affairs)
Administrator	U.S. Fish and Wildlife Service
Chairman	Marine and Fisheries Advisory Council

U.S. Congressional Delegation:

Representative	Commonwealth of the Northern Mariana Islands
Senators	State of Hawaii
Representatives	State of Hawaii
Representative	Territory of Guam
Representative	Territory of American Samoa

International Organizations

Director	Inter-American Tropical Tuna Commission
Director General	International Center for Living Aquatic Resource Management
Director	International Marine Life Alliance
Executive Director	Marine Aquarium Council
Director	Palau Coral Reef Center
Director General	Secretariate of the Pacific Community
Director	South Pacific Regional Environment Programme

State/Territory/Commonwealth Agencies/Organizations

Director	American Samoa Coastal Management Program
Director	American Samoa Department of Marine and Wildlife Resources
Director	American Samoa Department of Planning
Director	American Samoa Environmental Protection Agency
Director	CNMI Coastal Resources Management
Director	CNMI Department of Planning
Director	CNMI Division of Fish & Wildlife
Director	CNMI Division of Environmental Quality
Director	Division of Aquatic Resources, DLNR
Director	Division of Conservation & Resource Enforcement, DLNR
Director	Guam Bureau of Planning
Director	Guam Coastal Management Program
Director	Guam Division of Aquatic and Wildlife Resources
Director	Guam Environmental Protection Agency
Director	Hawaii Coastal Zone Management Program
Director	Hawaii Department of Health
Director	Hawaii Department of Land and Natural Resources
Director	Hawaii Office of Environmental Quality Control
Manager	Living Marine Resources, U.S. Coast Guard, Hawaii
Director	Office of Hawaiian Affairs

Other Organizations

President	American Samoa Community College
Director	Center for Marine Conservation
President	Coral Fish Hawaii
Director	Earth Justice Legal Defense Fund
Director	Environmental Defense Fund
Director	EnviroWatch, Inc
President	Guam Diving Industry Association
President	Guam's Fishermen's Cooperative Association
President	Hawaii Audubon Society
President	Hawaii Fishermen's Foundation
President	Hawaii Sport Fishing Club
President	Kawaihae Fishing Club
President	Keehi Sport Fishing Club
President	Kona Coast Divers
Director	Living Oceans Program, National Audubon Society
President	Maalaea Boat & Fishing Club
President	Mariana's Underwater Fishing Federation
Director	Natural Resources Defense Council
Director	Nature Conservancy, Hawaii
President	Northern Marianas College
Director	Ocean Wildlife Campaign
Director	Sierra Club, Hawaii
Director	United Fishing Agency, Hawaii
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Director	University of Guam Marine Laboratory
Director	University of Hawaii Institute of Marine Biology
Director	Western Pacific Fisheries Coalition
President	Windward Sport Fishing Club
Director	World Wildlife Fund

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Scott Moncrief	Fisherman, Hawaii
Leo Ohai	Fisherman, Hawaii
Joseph Pangelinan	Fisherman, CNMI
Tom Parker	Diver, Hawaii
Dave Raney	Sierra Club, Hawaii
Steve Smith	Naval Base, Pearl Harbor
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Mike Sur	Fisherman, Hawaii
Wallace Thompson	Swain's Island Representative, AS
Tim Timoney	F/V Laysan, Hawaii
Eric Wagenman	Commercial Fisherman, Hawaii

Council Groups

Executive Directors	Regional Fishery Management Council
Council Members	Western Pacific Regional Fishery Management Council
Members	WPRFMC Bottomfish Advisory Panel
Members	WPRFMC Bottomfish & Seamount Groundfish Plan Team
Members	WPRFMC Coral Reef Ecosystem Plan Team
Members	WPRFMC Crustaceans Advisory Panel
Members	WPRFMC Crustaceans Plan Team
Members	WPRFMC Demonstration Projects Advisory Panel
Members	WPRFMC Ecosystem & Habitat Advisory Panel
Members	WPRFMC Fishery Rights of Indigenous People Advisory Panel
Members	WPRFMC Pelagics Advisory Panel
Members	WPRFMC Pelagics Plan Team
Members	WPRFMC Precious Corals Advisory Panel
Members	WPRFMC Precious Corals Plan Team
Members	WPRFMC Scientific and Statistical Committee

Media

News Editor	Associated Press, Hawaii
Editor	Environment Hawaii
Editor	Hawaii Fishing News
Editor	Hawaii Tribune-Herald
Editor	Honolulu Advertiser (Oahu, Kauai and Maui offices)
Editor	Honolulu Star Bulletin (Oahu, Kauai and Maui offices)
Editor	Honolulu Weekly
Editor	Kauai Times
Editor	Marianas Variety
Editor	Maui News
Editor	Molokai Advertiser-News
Editor	Pacific Daily News, Guam
Director	Public Libraries (Am. Samoa, Guam, Hawaii, CNMI)
Editor	Samoa News
Editor	The Garden Island, Kauai

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9.0 RESPONSE TO PUBLIC COMMENTS

The following public meetings related to the Plan have been held to date around the western Pacific region. (Federal Register notices for these meetings follow.)

Public Scoping Hearing - Honolulu (Council Meeting)	16 June 1999
Public Scoping Hearing - Honolulu (Plan Team Meeting)	15 July 1999
Public Scoping Hearing - Guam	28 July 1999
Public Scoping Hearing - CNMI	29 July 1999
Public Scoping Hearing - Honolulu (Ecosystem and Habitat Advisory Panel (EHAP) Meeting)	5 August 1999
Public Scoping Hearing - American Samoa	19 August 1999
Public Scoping Hearing - Kona (Hawaii)	31 August 1999
Public Scoping Hearing - Honolulu (Plan Team and EHAP Meeting)	17 September 1999
Public Scoping Hearing - Honolulu (SSC Meeting)	12 October 1999
Public Scoping Hearing - Honolulu (Council Meeting)	18 October 1999
Public Meeting - American Samoa	20 December 1999
Public Meeting - Guam	28 December 1999
Public Meeting - Kona, Hawaii	28 December 1999
Public Meeting - Commonwealth of the Northern Mariana Islands	29 December 1999
Public Meeting - Hilo, Hawaii	29 December 19
Public Meeting - Kahului, Maui	4 January 2000
Public Meeting - Haleiwa, Oahu	5 January 2000
Public Meeting - Lihue, Kauai	6 January 2000
Public Meeting - Waianae	10 January 2000
Public Meeting - Lanai City, Lanai	11 January 2000
Public Meeting - Molokai	12 January 2000
Public Meeting - Honolulu	13 January 2000
Public Meeting - Honolulu (Hawaii Plan Teams and Advisory Panel Meetings)	
Public Meeting - Honolulu (Plan Team Meeting)	25 April 2000
Public Meeting - Honolulu (Joint Plan Teams and Advisory Panels Meeting)	26 April 2000
Public Comment - Honolulu (Council Meeting)	28 Feb - Mar 2 2000
Public Meeting - Honolulu (SSC Meeting)	16 - 18 May 2000
Public Comment - Maui (Council Meeting)	14 - 16 June 2000
Public Meeting - Honolulu (Council Meeting)	10 - 12 July 2000

Comments on Fishing Permit and Reporting Requirements:

1. Comment: Would like to add a management measure to the FMP that bans the possession or collection for commercial purposes of wild live rock and coral. The collection of live rock or live coral for scientific and research purposes could be allowed by permit, as well as the collection of small amounts of live coral as brood stock for captive breeding and aquaculture.

Response: The preferred alternative for the permit process specifies that no permits will be issued under these permit processes for the possession or collection for commercial purposes of wild "live rock" and live hexacorals (hard corals). The collection of wild live rock or live hexacoral for scientific and research purposes would be allowed by special permit. Collection of small amounts of live hexacoral as brood-stock for captive breeding/aquaculture would be allowed by special permit, except where it is not consistent with State and territorial laws regulating such collection in the adjoining State or territorial waters.

2. Comment: It is premature to ban the collection of live coral and live rock. The potential for commercial fisheries of these resources would help the local fishing communities.

Response: While prohibiting the commercial harvest of "wild" live rock and hard corals, the FMP will allow collection of small amounts for aquaculture broodstock and scientific research under a special permit, except where it is not consistent with State and territorial laws regulating such collection.. Further, the FMP will allow the commercial harvest of soft corals through a special permit provided such collection is sustainable. The harvest of other coral reef resources in Federal waters will be managed under a proposed special permit process or through collaboration with local resource agencies..

3. Comment: Concerned about standard conditions that would be attached to any permit issued for the fishery. Thinks conditions should be developed specifically for each particular fishery proposal on a case-by-case basis. Supports reporting requirements. Believes NOAA should not regulate the coral reef fishery out of business because the new fishery will provide data to the Federal government to assist in management decisions.

Response: For species/taxa that are currently harvested or that are believed to be subject to immediate harvest, a general permit will be considered as future framework option to harvest MUS outside MPAs in the EEZ, if existing local reporting systems are found to be in adequate. A special permit will be required to harvest MUS within low-use MPAs. A special permit will be required to harvest any non-targeted coral reef ecosystem taxa. Species that are less-well-known (non-targeted taxa) are managed more carefully, with a case-by-case analysis of the impact of each proposed fishing activity. This process allows for a precautionary approach for the collection of unknown or poorly understood species and for tightly controlled collection of harvested species within MPAs. For non-targeted species, appropriate levels of collection may be established once individual species or taxa are better understood. The permit process is designed to meet requirements of the Magnuson-Stevens Act (MSFCMA).

4. Comment: Will "outsiders" be able to get a permit to harvest coral reef resources in American Samoan waters?

Response: The MSFCMA prohibit discrimination against fishermen from any state or territory fishing in EEZ waters. The American Samoan government may have local rules that apply to waters under its management authority.

5. Comment: The FMP should address the issue of indigenous rights. Will indigenous people that want to fish be subject to permits and all the Federal regulations? Native Hawaiians should have a special right to fish and not need a special license.

Response: The preferred alternatives in the FMP provide for indigenous people to continue harvesting coral reef resources with minimal new regulatory burdens and costs. For fishing on currently harvested coral reef taxa, there will be no new permits required, a general permit for fishing will be developed under a framework process if needed. In addition, special exemptions are given to indigenous people to be able to collect small amounts of live rock/coral for customary and traditional uses, as well as fishing activities allowed in low-use MPAs for indigenous people by special permit. It is important for management purposes to be able to keep accurate data on fishery resources harvested.

6. Comment: Sportfishing is much more of a threat to the coral reef resources of Hawaii than commercial fishers, because the combined impact of recreational thrill craft and sportfishers far outweighs the few commercial fishers.

Response: The permit process established in the FMP will affect all types of fishing activities. It is beyond the scope of authority in the FMP under the MSFCMA, however, to manage non-fishing recreational activities.

7. Comment: Can some executive action be taken right away to adopt permit requirements to provide a safeguard against immediate, unregulated harvest of coral reef resources?

Response: A moratorium on harvesting in the interim while the FMP is being approved would protect coral reef resources in the EEZ. However, such an action would require as much justification as an FMP, and could be delayed as long or longer than the FMP itself.

8. Comment: Requiring a special permit to fish in MPAs turns most authority over to the RA. There is a concern about the NMFS and their permitting process, given that they are the permitting authority, the approving authority, all authorities.

Response: Permits will be issued by the RA in consultation with the Council. A detailed list of information will be required to be provided with the permit application. The RA will consult with the Council and the Director of the affected state fishery management agency; the Council will then recommend approval or disapproval of the application. The applicant can appear at the Council meeting to support his application with verbal testimony.

9. Comment: The FMP should address fishing for mollusks, recreational fishing, and the collection of shellfish and coral for the jewelry and ornamental trade.

Response: Mollusks and corals are addressed in the FMP as proposed MUS, with the FMP recognizing that MUS are utilized for a variety of purposes, including food, ornamental and bioprospecting. Recreational fishing is addressed in the section, Description of Commercial, Recreational and Charter Fishing Sectors.

10. Comment: Due to the unknown nature of "permitting" new fisheries or gears, a coral reef fishery permit applicant will not likely make any substantial investment in outfitting vessels that would be used under the permit. Therefore, a lag time will likely exist after permit issuance (if issued) and before fishing can realistically commence. The proposed one year timeframe for the exploratory permit should be extended three months to accommodate preparation by the fisher.

Response: At this time, no permit timeframes have been established in the FMP.

11. Comment: There should be some mechanism established to allow for the transfer of the permit.

Response: Permit transfer is irrelevant as no limited entry fishery is proposed. \

12. Comment: It might be wise to examine the extent of the impacts of small scale subsistence fishing prior to exempting it from the proposed permit process, since the cumulative impacts of such fishing might be substantial.

Response: Subsistence fishing in the EEZ is not exempt from permit process under the Council's preferred alternative. There will not be additional permits required for currently harvested MUS in the populated island areas, however this applies to everyone not simply subsistence fishermen.

13. Comment: The cumulative harvest represented by the permits should represent the minimum required to obtain the data necessary to determine allowable catch limits, in keeping with the strong emphasis on the precautionary approach in the FMP. An alternative harvest policy to MSY, perhaps an ecosystem overfishing threshold (cast in terms of species composition shifts) with a buffer (for uncertainty), is needed given the unsuitability of MSY to coral reef ecosystems and the paucity of knowledge available.

Response: Overfishing thresholds based on MSY definitions are required by the MSFCMA. These are described in the plan in the Section on "Overfishing". Refinement of ecosystems monitoring parameters is a priority of the plan.

14. Comment: Does not want to pay for permits to fish around Molokai. Would like to establish a Kapu system which the island would self-regulate, allowing people to fish in certain areas and not in others. A lot of overfishing for onaga and opakapaka is occurring around Molokai.

Response: There are no additional permits required for currently harvested taxa around Molokai, and reporting will continue to occur via local monitoring and coordination.

15. Comment: Bottomfishing should be exempted from the 50 fathom no-take rule.

Response: The 50 fathom no-take rule applies in federal waters to MPAs designated in French Frigate Shoals, Laysan, North half of Midway, Howland Island, Baker Island, Jarvis Island, Kingman Reef, Palmyra Atoll, and Rose Atoll. The preferred alternative for these areas is to remain closed to all fishing due to the sensitive nature of these ecosystems, for instance they contain significant monk seal pupping and breeding habitat, seabird nesting and feeding areas, as well as unique coral reef ecosystems.

16. Comment: Bottomfish boats already permitted do not have to be permitted under the new coral reef FMP?

Response: The existing FMP fisheries, bottomfish, crustacean and precious corals, follow the regulations in their existing FMPs not the coral reef FMP, but cannot fish in no-take MPAs.

17. Comment: Shell collectors do a lot of damage to the coral reefs, turning over the coral looking for certain species. They can do as much damage in an areas that is known to have a particular species of shell as an anchor from a boat can do. Outside of three miles in the NWHI is some of the finest shell collecting in the world.

Response: In the NWHI EEZ, no-take MPAs would extend to a depth of 10 fathoms offshore of all islands except French Frigate Shoals, Laysan and the north half of Midway which would extend to a depth of 50 fathoms. As these areas have been designated as no-take, harvesting of shells in these areas would be prohibited. In all other areas, a special permit would be required for all emerging fisheries, and the effects on the ecosystem would be explored at that time.

18. Comment: Does a "special permit" mean the fishermen needs to specify the type of fish he is catching, or a given amount of time, or the area being fished?

Response: With a special permit, the fishermen would be required to complete a detailed logbook documenting types and quantity of gear used, number and weights of species kept, number released alive, number released unknown, area fished, length of trip, specific effort information and other information required as a condition of holding the permit.

19. Comment: If Rose Atoll is a wildlife refuge in American Samoa, and its co-managed by the Department of Marine and Wildlife Resources and U.S. Fish and Wildlife Service, what are the laws on fishing in the area, and who needs a permit?

Response: Under the Councils preferred alternative, Rose Atoll would be designated a no-take MPA and no fishing of any kind would be allowed. The only exemption to this rule is the preferred alternative of allowing take of small collections of coral reef organisms for scientific research.

20. Comment: Who is going to benefit financially from the fees that are charged to the local fishermen?

Response: Generally, the fees that are charged to the local fishermen simply cover the administrative costs of the permitting system.

21. Comment: It seems as though the small local fishermen in Guam are being lumped in with the larger commercial industry with 180 foot vessels–most fishermen in Guam fish with 20 foot skiffs.

Response: The Magnuson Steven Act specifies that a fisherman is considered to be a commercial fisherman if he sells any portion of his catch, and the Coral Reef Ecosystem FMP must follow the guidelines of the Magnuson Stevens Act.

22. Comment: Thanks to WESPAC for coming and discussing the future regulations for fishing. However, the locals should be able to manage the fisheries themselves without regulations from the federal government. If a fishermen wants to go out one morning and fish when it is nice weather, he should not have to first go get a permit from NMFS. It is difficult to support the Federal Government when they cannot enforce the EEZ, when they cannot stop the Chinese and Taiwanese from overfishing the waters.

Response: The Council's preferred alternative specifies that there will be no new permits required for fishing for currently harvested coral reef taxa in the populated island areas. A general permit and reporting system will be developed at a later date if there is a need, i.e. if there is a gap in the system and data are not being accurately recorded.

23. Comment: Will the permit required for trapping be above and beyond what the state requires?

Response: The Councils Coral Reef Ecosystem FMP does not apply to State waters, so if the trapping occurs within 0 - 3 miles from shore there will be no additional requirements. Traps are listed as an allowable gear type in the FMP, however they will be allowed in appropriate areas and with appropriate conditions (e.g., negligible habitat impact, minimize potential for derelict traps) and traps must be permanently marked to identify the owner.

24. Comment: The same regulations could be passed for state waters within a short time. The state will be getting a lot of money for coral reef research and management.

Response: The state will certainly look at the regulations imposed by the Council's Coral Reef Ecosystem FMP, however there are no laws which compel the state to adopt the same measures.

25. Comment: Regarding reporting, filling forms is time consuming and fishermen do not have time to properly fill them out.

Response: It is imperative for proper management of fisheries to have accurate reporting of the resources that are removed from the ecosystem. NMFS has attempted to streamline the permitting process so it obtains the necessary information for proper fishery management, yet is not too much of a burden on the fishermen.

26. Comment: Instead of the permitting process where fishing activity inside MPAs would be permitted by NMFS, and outside MPAs anyone who meets basic safety and citizen requirements would be eligible for a permit, the Council should institute a two-tiered permitting approach where poorly understood species are managed on a case-by-case basis, and better known species are managed using a system with built in precaution and ecosystem considerations.

Response: The Council has instituted a permit process where better known species are managed by local data collection and monitoring, using built in precaution and ecosystem considerations. Species which are poorly understood are managed by special permit.

27. Comment: Concern with the overall effects and restrictions of this FMP that would apply to existing nearshore fisheries in Hawaii and to the substantial dive and fish trap fishery in the Auou Channel between Maui, Molokai and Lanai outside of three miles.

Response: The FMP does not apply to nearshore waters. The State of Hawaii, Department of Land and Natural Resources is responsible for managing fisheries from 0-3 nm. Fishing beyond 3 nm will be allowed for currently harvested coral reef species by the populated island areas, which will not require permits as of now. Depending on the species harvested and area fished, special permit may be required.

28. Comment: Does not support federal rules or FMPs that have provisions that are weaker than the adjacent State or territory, especially with respect to coral and live rock.

Response: The Council agrees. In fact, the regulations that will be implemented under this FMP are generally more stringent then any existing state or territorial regulations pertaining to coral reef management. Further, enforcement of federal fisheries regulation is generally more effective then state or territorial enforcement. Every effort has been made to ensure that the management measures proposed in the FMP are consistent with state/ territorial/ commonwealth laws and policies in order to simplify implementation and assist enforcement efforts.

Comments on Fishing Gear and Methods

1. Comment: Supports banning any kind of spearfishing using SCUBA. If this ban is implemented in Federal waters, would it be possible to have a similar ban in territorial waters?

Response: The FMP proposes banning the use of spear fishing with SCUBA at night in the EEZ around the NWHI and PRIA. The Council considered banning the use of SCUBA in the EEZ around the main inhabited island groups, however this was not supported. It is beyond the authority of the WPFMC to implement a ban on SCUBA in state and territorial waters. Such a ban would be under the purview of the state/ territorial/ commonwealth governments.

2. Comment: Does rod-and-line (under proposed listed gear) include motorized reels?

Response: Yes, motorized reels are included under the proposed listed gear (rod-and-line).

3. Comment: Trolling and purse seining should be banned under this Plan because they are extremely destructive to coral reef resources.

Response: Neither trolling nor purse seines interact with the bottom during normal deployment and retrieval procedures. Under the FMP only non-destructive, selective gear types will be allowed. The following allowable gears are proposed in the FMP: ROV/submersibles, hand harvest, handline, hook-and-line, rod and reel, spear, slurp gun, hand net/dip net, barrier net (aquarium), hoop net (for kona crab) and surround/purse net (for targeted schools such as akule, weke, and baitfish). Nets must be tended at all times. Traps will be allowed in appropriate areas and with appropriate conditions if permanently marked to identify the owner. The gear types specified in the plan were identified by the Council as the least destructive to coral reef resources and their habitats, while being effective at targeting desired species.

4. Comment: The list of allowable fishing gear types may be far too permissive if coral reef ecosystem protection is the goal of the FMP. Passive or active fishing gears that are detrimental to any coral reef ecosystem they come into contact with should not be allowed to remain on the list of allowable gear types.

Response: The gear types specified were identified by the Council as the least destructive to coral reef resources and their habitats, while being effective at targeting desired species.

5. Comment: Supports the addition of surround/purse net (for akule and aku bait fishing only) to the list of allowable gear.

Response: Surround/purse net, with conditions, has been included on the allowable gear list.

6. Comment: Concerned that fish traps are not listed as allowable gear because, in the years that the akule do not run in inshore waters, the fishers turn to fish trapping, which occurs in some places beyond three miles. Recommends WPRMFC incorporate a limited entry program for trap fishing for existing trap fishers.

Response: Traps will be allowed by permit in appropriate areas and with appropriate conditions if permanently marked to identify the owner.

7. Comment: Allowable gear listed and existing FMP fisheries should not be exempt in coral reef ecosystem areas.

Response: The Council considered this option but selected against it. Existing EEZ fisheries are considered to be sufficiently regulated under their respective FMP which must comply with all Magnuson-Stevens Act and Sustainable Fisheries Act requirements. The Council's preferred alternative also includes a formal coordination process among plan teams to consider possible fishery-ecosystem impacts.

8. Comment: Traps for Kona crab and other crabs should be allowed in the EEZ.

Response: Under the Council's preferred alternative traps are allowed only in appropriate areas/conditions if permanently marked with the owners ID. "Appropriate" implies using the gear in ways that are selective, do not incur large bycatch mortality and do not damage habitat.

9. Comment: The Council should consider using performance standards for controlling which kinds of gear can be used in coral reefs, rather than using a list of allowed and/or prohibited gear types.

Response: Federal regulations require that the FMP list allowable gear types. The allowable gear (as listed in the Section "Allowable gear ") has been included due to its selective nature and minimal impact to habitat.

10. Comment: On the North Shore of Molokai, they are seeing a lot of nets from foreign fishermen.

Response: The trawl nets are coming from North Pacific fisheries, not Hawaiian. In August 2000 Hawaii held a conference where all the countries that have those fleets fisheries discussed ways to reduce marine debris.

11. Comment: Fish traps and bait nets should not be on the list of allowable gear, as they result in bycatch and habitat damage. Recommends removing fish traps, surround/purse nets, and scuba with spear from the list of allowable gear types.

Response: Fish traps are only allowed under the CRE-FMP under the conditions that they shall be allowed in appropriate areas and with appropriate conditions, for instance the traps must produce negligible habitat impact. To minimize the potential for derelict traps, the traps must be permanently marked to identify the owner. The preferred alternative for scuba with spear is that this method be prohibited at night in the NWHI PRIA when the fish are the most vulnerable. In developing the Councils preferred alternatives, the Council considered trade-offs of benefits between utilization of coral reef resources by controlled fishing and preservation of coral reef ecosystems. It determined that the list of allowable gear would best meet this compromise.

12. Comment: Most of the coral reef and damage is being incurred well inside of three miles. Diving beyond three miles with scuba at night would be rare.

Response: The Councils CRE-FMP does not have jurisdiction 0 - 3 miles from shore surrounding the populated island areas, these areas are controlled by state/territorial laws.

13. Comment: How was it determined to prohibit the use of spear with scuba at night?

Response: It was determined to prohibit the use of spear with scuba at night in the NWHI and PRIA due to the vulnerability of target species. At night, this method allows no refuge because the target species are vulnerable to capture while sleeping in their holes, and there is a much greater likelihood of certain species becoming overharvested.

14. Comment: There is a concern that the state will follow the federal regulation to ban scuba spearfishing at night. This will leave Hawaii fishermen no way to feed their families.

Response: While the state will certainly be aware of the regulations imposed by the Council in federal waters, there is no guarantee that any of the regulations will be similarly adopted in state/territorial waters 0-3 miles from shore. State will allow opportunity for public comment if such a role is proposed.

15. Comment: Nets should be allowed for weke and other fish, not just akule bait fishing.

Response: The Council modified its preferred alternative regarding nets to allow harvesting of all species on the condition that the nets do not damage coral or bottom habitat, and also that they be tended at all times.

16. Comment: Fish traps and surround or purse nets can actually cause quite a bit of damage to the ecosystem, if not used responsibly. Traps and purse nets should only be permitted when their use has been screened to insure minimal bycatch mortality, negligible habitat impacts and provisions to minimize the possibility of ghost fishing.

Response: The Council agrees, and is required by the Magnuson Act to prevent, mitigate, or minimize any adverse effects from fishing gear if there is evidence that a fishing practice is having an identifiable adverse effect on essential fish habitat. Adverse fishing impacts may include physical, chemical, or biological alterations of the substrate and loss of, or injury to, benthic organisms, prey species, and their habitat and other components of the ecosystem. Controls on fishing gear are an effective tool for mitigating such impacts.

Comments on Marine Protected Areas:

1. Comment: Is fundamentally opposed to area closures and gear restrictions.

Response: Marine protected areas (MPA) are an attractive option for ecosystem-based fisheries management because they do not require detailed knowledge of the protected species while being holistic in conserving multi-species resources and the functional attributes of marine ecosystems. They can also provide "insurance" against periods of poor recruitment at individual populations.

MPAs can range in scope and extent. They can be areas designated for limited use, seasonal use or areas that are completely restricted from consumptive use. Although completely restricted areas are thought to provide the highest degree of protection to marine ecosystems, less restrictive areas also provide some protection and may be economically and socially more acceptable. The optimum size of a MPA depends on many factors: the resources managed, the management goals, the enforcement possible and social and economic constraints.

There is little understanding of what size of MPA would provide ecologically complete coral reef ecosystem protection. Even small MPA have been shown to be effective in increasing standing stocks and sizes of reef fish, especially of species that are exceptionally vulnerable to fishing and of older individuals which are critical components of spawning stock biomass. To be of utility to fisheries and to promote the conservation of coral reef resources on a broader scale, MPA should serve as sources of reproductive output to replenish larger surrounding or down current areas. The current approach of establishing small and isolated MPA is inadequate for this purpose.

2. Comment: It is premature to designate any MPAs in CNMI waters. The WPFMC needs to undertake a public participatory process to identify areas appropriate for designation.

Response: At this time, no MPAs are proposed in federal waters around CNMI. Any MPA designation in CNMI waters will be implemented under the FMPs amendment process. The Council is required to provide numerous opportunities for public comment and participation. The Council would seek the input and advice of local government officials, fishermen and other resource users as part of any effort to identify candidate areas as MPA in any of the areas under its jurisdiction.

3. Comment: It is premature and unnecessary to designate the Farallon de Medinilla (FDM) as a Habitat Area of Particular Concern (HAPC) because it does not meet any of the four qualifying criteria.

Response: The Council has endorsed the concept of designating Habitat Areas of Particular Concern (HAPC). The FMP lists *potential* areas within the Council's jurisdiction that meet one or more of the criteria for HAPC designation. Farallon de Medinilla has been included as one of these potential areas, since the Coral Reef Ecosystem Plan Team believes the ecological function provided by the habitat is important and that the area is susceptible to human impacts.

4. Comment: Does not support closed area in Hawaii (MHI or NWHI), especially when area is closed for fishing but not marine recreation.

Response: The Council does not have the authority to restrict activities other than U.S. fishing activities in areas within its jurisdiction. The state, which has management authority over waters 0 - 3 miles from shore, may restrict such activities. The state is aware of regulations being adopted by this FMP, and may choose to adopt similar regulations.

5. Comment: There seems to be a discrepancy between the definition of the EEZ (3-200 nm) and the proposed designation for Essential Fish Habitat of 0-200 nm. Will the Federal government be managing EFH in the territorial waters of American Samoa? How does the designation of 0-200 nm as EFH affect American Samoa management of its own territorial waters?

Response: Essential Fish Habitat (EFH) identifies important areas that the fishery management unit species use at some point during their life cycles. While NMFS does not have jurisdiction over the territorial waters between 0-3 nm, it can make recommendations to minimize impacts to EFH from proposed projects within these waters that are federally-funded or require a federal permit. The recommendations, however, are not legally binding.

6. Comment: Swain's Island and Rose Atoll should be deleted as candidate areas for MPA designation.

Response: At this time, Rose Atoll is targeted under the Councils preferred alternatives as a no-take MPA. The criteria considered for the selection of MPAs included: natural resource values, human use and historical values, impacts of human activities values, and management concerns values.

7. Comment: Who are the people that would benefit from closed areas (MPAs)?

Response: Fishermen and scientists are among those who benefit from no-take zones. Marine protected areas (MPA) are an attractive option for ecosystem-based fisheries management because they do not require detailed knowledge of the protected species while being holistic in conserving multi-species resources and the functional attributes of marine ecosystems. They can also provide "insurance" against periods of poor recruitment by individual populations.

MPAs can range in scope and extent. They can be areas designated for limited use, seasonal use or areas that are completely restricted from consumptive use. Although completely restricted areas are thought to provide the highest degree of protection to marine ecosystems, less restrictive areas also provide some protection and may be economically and socially more acceptable. The optimum size of a MPA depends on many factors: the resources managed, the management goals, the enforcement possible and social and economic constraints.

There is little understanding of what size of MPA would provide ecologically complete coral reef ecosystem protection. Even small MPA have been shown to be effective in increasing standing stocks and sizes of reef fish, especially of species that are exceptionally vulnerable to fishing and of older individuals which are critical components of spawning stock biomass. To be of utility to fisheries and to promote the conservation of coral reef resources on a broader scale, MPA should serve as sources of reproductive output to replenish larger surrounding or down current areas. The current approach of establishing small and isolated MPA is inadequate for this purpose.

Few, if any, studies have sought to verify whether marine protected areas established in the US Pacific islands do actually benefit nearby fisheries. It is clear that fish populations which build up in small areas (Hawaii, Philippines) temporarily closed to fishing are quickly reduced when fishing is resumed. Criticisms of the existing marine protected areas in the US Pacific islands are that they are either too small and fragmented or they do not encompass sufficient depth range and high quality habitat to provide broad coral reef ecosystem protection or recruitment benefits to fisheries.

It has been suggested that linking populations among MPAs over a broad area is necessary to assure long-term sustainability of coral reef fisheries. Some argue for complete protection from fishing, whereas others believe MPAs are more valuable when they can serve as natural laboratories for fishing experiments and testing of management strategies.

8. Comment: At least 30% of the management area under consideration by the Council should be considered for no fishing zones.

Response: Under the Councils preferred alternatives, 13% of all coral reef area under Council jurisdiction in the Western Pacific region will be closed to all fishing, and 14% of all coral reefs around the NWHI would be closed. If the state takes consistent action and designates adjacent reefs around the NWHI, the percent of "no-take" area would total 24%.

9. Comment: Twenty-five percent of the species in the coral reef areas of the Hawaiian Islands are known to be endemic. These need special consideration.

Response: In the Hawaiian Islands, the entire coral reef ecosystem in the EEZ of the NWHI will be designated as no-take or low-use MPAs. Endemics will be protected from overfishing under the requirements of the MSFCMA. For endemics that do not already have a history of harvest, a special permit will be required.

10. Comment: A "no-take" MPA to 50 fathoms in the NWHI will significantly and detrimentally affect existing fisheries managed under other FMPs.

Response: In the NWHI, federal waters shallower than 10 fathoms are designated as "no-take" for all fishing. The waters shallower than 50 fathoms are designated as "no-take" at French Frigate Shoals, Laysan, and the north half of Midway. In the other areas of the NWHI, fishermen would be required to obtain a special permit to fish for coral reef taxa. However, vessels already fishing for species regulated under another existing FMP would be exempt from the requirements of the CRE-FMP exception no-take zones.

11. Comment: Establishing a MPA to 50 fathoms in the NWHI where there are existing fisheries will create enforcement problems. In areas where the bottom is relatively flat, where will the 50 fathom contour be delineated? In areas where the bank drops off steeply at 50 fathoms, where will fishers anchor to fish in deeper waters?

Response: Vessels already fishing for species regulated under another existing FMP will be exempted from the permit requirements of this FMP. Most existing permitted vessels in NWHI have VMS, which facilitates enforcement. Vessels permitted under this FMP must comply with all regulations promulgated under the FMP.

12. Comment: Existing FMP fisheries should not be exempt from MPAs.

Response: The Council considered this option and choose to exempt existing FMPs, except form no-take MPAs. If not exempted the current designation of MPAs to 50 fm in the remote atolls and NWHI and associated restrictions would represent a significant impact to existing permitted FMP fisheries. Potential impacts of existing FMP fisheries on coral reef ecosystems will be considered through formal inter-plan team consultation.

13. Comment: EPA strongly supports the designation of MPAs; identification of Essential Fish Habitat, HAPC, and fishing and non-fishing threats; and clarification of allowable coral reef harvesting gear. Because information regarding the harvest of coral reef resources in the EEZ is largely unknown, EPA would like a clearly defined research component as part of the FMP.

Response: The designation of MPAs, identification of Essential Fish Habitat, HAPC, and fishing and non-fishing threats, and list of allowable harvest gear are primary aspects of the FMP. The FMP also includes a section on needs for research, monitoring and assessment. Specific research projects are identified and listed as high, medium or low priority. Research needs for EFH are also defined in the FMP. The Plan Team will continue to refine the identified research priorities of the FMP.

14. Comment: It would be useful to add up the areas that the proposed MPAs would comprise and compare it to the total area of reef under the Council's jurisdiction. The total area must be large enough to realize the intended benefits of MPA management.

Response: The Council did so, and determined that 13% of all coral reef areas in federal waters are designated as "no-take" MPAs.

15. Comment: It might be useful to integrate MPA management with traditional management systems that employed closed areas to protect fish stocks, to incorporate traditional knowledge, to respect tradition and culture, and to build confidence in the MPAs.

Response: There is increasing awareness about the value of traditional management techniques. While traditional management systems typically employed closed areas in nearshore waters, the Council may consider the possibility of working with local indigenous peoples to extend these systems into offshore waters.

16. Comment: No-take zones should be expanded to include the area up to three miles from shore.

Response: Generally, the area from the shoreline to three nautical miles offshore is managed by the State and territories and is not under the purview of the FMP. CNMI presents a special case. However, this plan proposed management regulations only for beyond 3 miles around CNMI. With a few exceptions, the nearshore areas of the NWHI are managed jointly by the State of Hawaii and Federal Department of Interior and the nearshore areas of the Pacific Remote Islands are managed jointly by WPRFMC and other Federal agencies. MPAs have been proposed for 0 - 50 fathoms in waters surrounding Wake Atoll, Johnston Atoll, Jarvis Island, Howland Island, Baker Island, Kingman Reef and Palmyra Atoll (Pacific Remote Islands); Rose Atoll in American Samoa; Guam's Southern Banks; up to10 fathoms in all the NWHI and up to 50 fathoms in French Frigate Shoals, Laysan and half of Midway. The Council will utilize the amendment process to modify existing MPAs and designate additional MPAs. In doing this, the Council will actively work with local island communities and appropriate local government agencies (Federal, state, territorial and/or commonwealth) to create additional MPAs of size, location, and management measures appropriate to that community and locale, and to the level of permitted fishing.

17. Comment: Want to propose a MPA for Molokai.

Response: The alternative to designate MPAs in the EEZ around the main inhabited island groups was discussed but was not preferred. In these areas, fishing activities are concentrated on adjacent nearshore reefs under state/territory government authority, and designation of no-take areas in the EEZ alone would have little impact on target resources.

18. Comment: If the coral reef plan covers zero to 50 fathoms, and all the protected areas are 0 to 50 fathoms also, then everything is a Marine Protected Area except for Guam?

Response: The CRE-FMP applies to all areas in the Western Pacific region under the Councils jurisdiction, which is generally from 3 - 200 miles from the shoreline in the EEZ. The preferred alternatives for MPAs are designated in the EEZ around the NWHI out to 10 fathoms, Rose Atoll in American Samoa and the PRIA would extend form the shoreline to 50 fathoms. In the NWHI, also extended to 50 fathoms in the EEZ would be French Frigate Shoals, Laysan and the north half of Midway.

19. Comment: Does the Council have a position on the relevance or importance of mangroves in the Main Hawaiian Islands coral reef ecosystem? In Hawaii the mangroves are an introduced species and many people want to eradicate the mangroves.

Response: Generally, mangroves do not occur in areas where the Council has jurisdiction (in Federal waters, which are usually 3-200 miles from shore).

20. Comment: MPA's should be strictly no-take.

Response: While strict no-take MPAs are thought to provide the highest degree of protection for the marine ecosystem, low-use MPAs also provide protection from harvesting and in some areas may be more economically and socially feasible. The Council feels the no-take MPAs that are designated under the preferred alternatives balances the competing needs of the resource users with strong ecosystem protection.

21. Comment: The Magnuson Act does not provide authority to prevent scientific research; scientific research is excluded from the definition of fishing.

Response: While the Council does not have authority to regulate scientific collecting under FMPs, (NMFS does so directly), the Council will advise on appropriate collecting methods, case-by-case, consistent with objectives of the plan.

22. Comment: MPAs should be designated by the island group where the MPAs would be located. The specific management strategy should balance the needs of the existing fishermen with resource conservation.

Response: The Council relies heavily on public input, and strives to work closely with the residents of the areas where any regulations will be implemented.

23. Comment: A broad based "no-take" zone for the NWHI which would result in the involuntary closure of existing fisheries is an unacceptable management strategy, as it is a precedent setting situation which closes an existing fishery. This would effect more than just Hawaii.

Response: Existing fisheries who are regulated by another FMP, such as the bottomfish, crustaceans or precious corals FMP, are exempt from the requirements of the CRE-FMP. However, in the zones designated "no-take" in the NWHI there is no fishing of any kind (including FMP fisheries) allowed except for small quantities for scientific research after a special permit is obtained. These areas were determined to be small enough to not severely effect existing fisheries. For example, the bottomfish fishery and precious coral fishery generally utilize areas deeper than the no-take zone within 10 fathoms. Some of the no-take areas were already designated as protected species zones under the crustacean fishery.

24. Comment: The NWHI MPAs should address the effects of coral harvesting on monk seal populations.

Response: An increasingly important issue in fishery management today is the impacts on protected species by fishing activities. The monk seal population was one of the main reasons for designating specific areas in the NWHI as MPAs. Specifically, coral harvesting is addressed in the Precious Corals FMP, and the effects of the coral harvesting on monk seal populations is explored in detail.

25. Comment: The FMP/EIS should indicate what measures will be taken to protect critical fish and wildlife habitat areas from potential adverse effects of proposed management actions. The feasibility of proposed mitigation measures should be full demonstrated.

Response: The FMP describes Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPCs). In addition, the FMP proposes a management measure to designate MPAs for important coral reef resource areas. The area where critical habitat occurs in the NWHI is largely designated as a MPA. The Council does not expect the proposed management measures to detrimentally affect habitat areas; however, if damage begins to occur, then additional protective measures can be taken by the Council through the framework or regulatory process.

26. Comment: The DEIS and proposed CRE FMP may be contrary to other existing applicable Federal statutes. The greatest concern is the lack of analysis given to the significance of national wildlife refuges (NWRs) with marine boundaries. NWRs are closed to all uses until they are specifically opened for such uses. The FWS is solely charged with making the decisions whether to open NWRs for specific uses.

Response: The FWS has expressed uncertainty as to the authority of its marine boundaries for the NWHI NWR. The Council has asked FWS to articulate its authority on a number of occasions, only to be told it is based on FWS policy. Council FMP-managed commercial fishing for lobsters and bottomfish, under the authority of the Magnuson-Stevens Act has occurred in the NWR of the NWHI since the FMPs were implemented in 1983 and 1986, respectively. In addition, critical habitat has been designated for the Hawaiian monk seal in the NWHI out to a depth of 20 fathoms around Kure, Midway, Pearl& Hermes, Laysan, Maro, Gardner, French Frigate Shoals, Necker and Nihoa. However, fishing still occurs in these areas.

27. Comment: The DEIS and proposed CRE FMP propose some level of fishing or other types of marine extraction within established NWR boundaries at Rose, Howland, Baker, Jarvis, Johnston, NWHI and Midway. It is not possible for those refuges or any NWR to be opened to a commercial or recreational use or be liberalized by action taken under the Magnuson-Stevens Act. The proposed

FMP seeks to close, open, or otherwise manage specific coral reef fisheries of the US flag Pacific Ocean.

Response: The CRE FMP would not encourage any level of fishing nor open any area to fishing, as the opportunity to fish most coral reef resources is currently open. In fact the FMP would only impose new restrictions on the allowable level of fishing, for example by closing the aforementioned areas altogether, through no-take MPAs (except recreational fishing and subsistence take on half of Midway and subsistence take at Johnston, both already allowed by FWS). The FMP would restrict fishing in other areas through special permit requirements and other regulatory restrictions. Currently, fishing for coral reef resources in the EEZ is nearly non-existent. Except perhaps for restrictions in NWRs of areas under DOD control, there are no other Federal regulations governing the taking of coral reef resources in the US EEZ of the Pacific islands. The CRE FMP is largely precautionary and proposes to prevent overfishing, and impacts to coral reef ecosystems, habitat and protected species that might occur should any possible reef-directed fisheries develop in the future. Therefore, the CRE FMP in fact substantially enhances the conservation goals of the NWRs.

28. Comment: No justification is given for the selection of the proposed 'no take' areas and depths by the Council. 'No take' areas should be selected based upon a set of sound biological criteria and include representation of all reef ecosystem types found in the NWHIs, as is recommended in the National Action Plan to Conserve Coral Reefs and the President's Executive Order for Marine Protected Areas. The proposed CREFMP does not select the proposed 'no take' areas based on a sound biological process.

Response: The Council's preferred alternative for no-take MPAs follows the SSC recommendation for French Frigate Shoals, Laysan and the north half of Midway to be no-take MPAs to 50 fm. These locations were selected to achieve representative habitat types characteristic of the south, middle and north subregions of the NWHI archipelago. Additionally, they balance ecological criteria with socioeconomic concerns and needs.

Further justification for the selection of no-take MPAs is described in the DEIS. For example, establishment of these no-take zones would provide a form of "insurance" against possible recruitment failure in some sub-populations of the NWHI. Closing these areas to all fishing may also provide additional protection to protected species (i.e., monk seals at FFS and Laysan).

The preferred alternatives for locations and depth ranges of no-take MPAs would conserve a large reservoir of spawning biomass and genetic material for multi-resource coral reef resources, including endemic and rare species.

Restrictions on how vessels operate in no-take areas would reduce the risk of groundings. Existing bottomfish and lobster fishing activities would be displaced from no-take areas around French Frigate Shoals and Laysan.

Further research is needed to improve understanding of ecosystem processes and to validate other criteria for establishment of MPAs. Such research is ongoing and planned by federal agencies. The

20% no-take MPA figure proposed by the National Action Plan itself needs further scientific validation to quantify actual benefits.

29. Comment: The majority of waters proposed as 'no take' areas under the CREFMP are already designated as 'no take' areas. The Council does not really need to give up much harvested area as the access to waters from 0-10 fathoms is already tightly managed under the Hawaiian Islands and Midway Wildlife Refuges. The Council claims that if the State and federal agencies comply with their recommendations, that 24% of the area will be set aside as 'no take'. However, the bulk of the 'no take' areas being proposed are within State waters and are not under Council jurisdiction. Without the State and federal Wildlife Refuge waters included, the Council is proposing only a minimal amount of 'no take' area, which is less than 14% of the harvestable resource area.

Response: As authorized by the Magnuson-Stevens Act, the Western Pacific Fishery Management Council has primary responsibility for conserving and managing fisheries in federal waters, which include waters up to the shoreline at Midway. The Council also has the responsibility for essential fish habitat.

Fishery management plans developed by the Council for crustaceans, bottomfish, precious coral and pelagic fisheries have been enforced in the NWHI since the 1980s. Currently, there are no areas in the NWHI designated as total no-take zones. There are 0-to-10 fathom no-take zones for lobsters throughout the NWHI islands except at Laysan, where the no-take for lobsters is 0 to 20 miles. There are also proposed and established no-take refugia for precious coral species in the NWHI.

The Council's preferred alternatives for its Coral Reef Ecosystem FMP includes a network of no-take zones in the NWHI. The extent of the no-take zones were based on the National Action Plan for Coral Reefs, which calls for 20% no-take MPAs to be established within 10 years. The Council has taken the lead by identifying 14% of the NWHI coral reef habitat as no-take zones. These waters are in federal waters and constitutes 70 percent of the no-take MPA recommended by the National Action Plan (hardly a "minimal amount"). If the State of Hawaii and US FWS agree to similar no-take areas in state waters (0 to 3 miles, except at Midway), the additional 30 percent of the National Action Plan would nearly be met for the NWHI.

Management in waters 0 to 10 fathoms in the Hawaiian Islands NWR by USFWS appears to center around regulating the take of certain marine species by NMFS, which is conducting prey research and shark eradication to help with recovery of the Hawaiian monk seal. At Midway Atoll NWR, critical habitat for monk seals has not been designated and USFWS has signed a long-term contract with Midway Phoenix Corp., which promotes recreational and charter fishing and allows subsistence fishing. While USFWS has developed a set of fishing regulations for residents and guests at Midway Atoll NWR, they are poorly enforced and recent surveys indicate an unusually low ulua population there.

30. Comment: Reefs deeper than 10 fathoms around Kure Atoll are given no protection and this is the most isolated atoll, least impacted by fishing and at the Darwin Point. It is amongst the most fragile, complex and unique resources in the NWHIs and is a State Wildlife Sanctuary. Additional protection for this resource area should be considered and was recommended by the plan team but not adopted by the Council.

Response: The SSC recommended half of Midway over Kure for a no-take MPA to 50 fm as both atolls have similar characteristics, and Kure is considered important to commercial fishermen, while Midway has already been closed to such fishing for decades. Half of Midway has been reserved as a low-use MPA to accommodate recreational fishing for ecotourism by the USFWS.

The State could provide protection to reefs around Kure from 0-3 miles from shore, where most reef habitat occurs, but has not done so.

31. Comment: The Council has designated all waters from 10-50 fathoms as Special Permit Zones and has indicated they are to be classified as 'low take' areas. However, any vessel that is issued a permit for access to harvest targeted species is allowed to take as many of that species as they want. The restrictions are for gear types or fishing methods not for limits on harvestable quotas.

Response: Issuance of a special permit requires numerous qualifying and operating conditions. Some will require a case-by-case evaluation.

The Council is mandated to prevent overfishing of any stock or species, and to restore stocks where overfishing has occurred.

Fishery-dependent data will facilitate research to determine what take levels are appropriate to achieve sustainability with ecosystem sensitivity.

Harvest quotas may be implemented in the future through the amendment process upon determination of the need.

Comments on Framework Actions:

1. Comment: VMS should be required on all vessels permitted to fish coral reef resources. VMS would provide a cost-effective increase in enforcement presence.

Response: Requiring VMS on vessels is a preferred alternative for future framwworking by the Council for vessels transiting MPAs, if the VMS system is federally funded by NMFS.

2. Comment: Vessels should be required to post bonds to cover removal of vessel and gear in the event of a grounding. This bonding process should be modeled after the oil spill version.

Response: Requiring permitted vessels to post bonds is one issue that was considered as a framework measure, but was rejected as infeasible. Instead, the Council developed the preferred alternative where fishing vessels transiting MPAs will be required to have insurance to cover the cost of vessel removal and pollution liability in the event of a grounding, depending on type of permit and fishing area. Also, non-fishing vessels transiting the MPA would be required under the Councils preferred alternative to have insurance to cover the cost of vessel removal and pollution liability in the event of a grounding. This, however, is beyond the Council's direct authority and will require coordination with other authorities.

3. Comment: How hard is it going to be to change a non-targeted taxa to harvested? Is it included as a framework provision?

Response: That particular item is included as a framework provision, so it would take 2 Council meetings.

4. Comment: Recommends that any designation of new MPAs should be done through the formal amendment process rather than under a framework process so that people have more time to comment on proposed changes.

Response: The Council concurs. Measures such as this, which are highly controversial for the entire fishery or a substantial sector are not suited to the framework process and must be addressed through the FMP amendment process to allow sufficient public comment.

Comments on Non-regulatory Actions:

1. Comment: Concern that comments of Coral Reef Ecosystem Plan Team members were not incorporated into subsequent drafts of the FMP.

Response: The recommendations of the Coral Reef Plan Team and Ecosystem and Habitat Advisory Panel were incorporated into a draft FMP and were reviewed by the Scientific and Statistical Committee (S.C.) and the Council. The current draft of the FMP describes the management measure alternatives that were endorsed including some proposed by the CRE-FMP and other alternatives considered by the Council.

2. Comment: There is a need to coordinate among agencies and educate decision-makers with respect to the management of coral reef resources.

Response: The FMP identifies non-regulatory measures to help with the effective management of coral reef resources, including: facilitating consistent state and territorial level management of coral reef resources; creating social, economic and political incentives for sustainable use and disincentives for unsustainable use of coral reef resources; and conducting education, public outreach, and "coral reef management diplomacy."

3. Comment: Would like every effort made to disseminate information through existing organizations and channels.

Response: Information about the FMP has been disseminated through WPRFMC's existing channels, and public meetings have been advertised in local newspapers and the *Federal Register* and notices distributed to WPRFMC's mailing list.

4. Comment: Would like WPRFMC to collaborate with the West Hawaii Fishery Council and other organizations concerned with the conservation of coral reefs to assist in gathering input from the community on the proposed FMP.

Response: The Council process provides numerous opportunities for public participation in the fishery management process. The Council endeavors to notify all interested parties of all pending council actions. One of the non-regulatory goals of the Council is the collaboration with public-private organizations concerned with reefs.

5. Comment: Concerned that rules that start in Federal waters may be adopted by the State in the future, affecting fishing in nearshore waters.

Response: This is a valid concern. The goal of the FMP, and numerous state/territory agencies is to achieve consistency in regulation, which facilitates efficiency.

6. Comment: Strongly supports objectives of the FMP, which is taking proactive action to protect Federal resources. Also supports the ecosystem-based approach and the implementation of the precautionary principle. Recognizes difficulty in fitting an innovative ecosystem-based plan into the more traditional requirements of the Magnuson-Stevens Act. The November U.S. Coral Reef Task Force meeting in the Virgin Islands provides an opportunity for WPRFMC to draw attention to these problems.

Response: Council Executive Director updated the task force in St. Croix regarding progress with the FMP.

7. Comment: The CRE Plan Team should have more management authority over existing FMPs/MUS and formal process for collaboration regarding ecosystem approach.

Response: The Council endorsed the formal process for inter-team collaboration. Existing FMPs sufficiently manage their respective MUS for fishery purposes.

8. Comment: Several commentary spoke in support of and encouraged the Council to accept the Plan Team's recommendations.

Response: The Council heard and carefully considered recommendations of the Plan Team; some recommendations were endorsed. Others lacked sufficient justification or were otherwise lacking in meeting the basic goals of the plan for balancing economic productivity and social acceptability with ecological integrity. Specific recommendations of the Plan Team were detailed in the 6 October 1999 and August drafts of the FMP reviewed by the Council.

9. Comment: Several commentary spoke in support of and encouraged the Council to accept the Advisory Panel's recommendations.

Response: The Council heard and carefully considered recommendations of the Advisory Panel; a number of these recommendations were endorsed. The Council preferred some adjustments to other recommendations to improve conformity with the goals of the plan. Specific recommendations of the Advisory Panel were detailed in the 6 October 1999 and August 2000 drafts of the FMP reviewed by the Council.

10. Comment: The ecosystem concept of management needs more work.

Response: This plan manages fisheries in coral reef ecosystems, and includes measures to protect ecosystems (gear/method restrictions, MPAs, EFH). Council advisory bodies will continue to meet to better understand and incorporate ecosystem principles in coral reef fishery management; the Plan will be amended in the future to refine the ecosystem management concept. The November draft of the FMP includes an expanded review of ecosystem management concepts.

11. Comment: Impacts of proposed regulations on existing fisheries would be significant (i.e., NWHI full time fishermen).

Response: The Council's preferred alternative intends to maintain a balance between ecosystem protection and economic and social impacts. Some of the regulations proposed would indeed have had highly significant economic impacts on NWHI commercial fishermen, which is why (in part) the Council selected against them.

12. Comment: NMFS should describe, evaluate, and highlight mechanisms for integrating coral reef management and conservation measures into non-federal and non-fishing actions.

Response: These issues are addressed in sections 2 on "Management Alternatives" and "Non-Fishing Impacts" of the FMP, respectively.

13. Comment: All other FMPs developed by the WPRFMC and implemented by NMFS should be modified as necessary to meet the requirements of the Coral Reef Ecosystem FMP for activities within the coral reef ecosystem boundaries or for activities outside the boundaries that might still result in impacts on MUS.

Response: The FMP describes a formal process for coordination among plan teams to identify and address impacts of other fisheries to coral reef ecosystems. Some MUS in the FMP are included under the Council's other four FMPs, under which their MSY/OY, EFH, and other fishery characteristics are identified. For these MUS, fishery-level effects and management should be the primary responsibility of the other FMP processes, while ecosystem effects should be the primary responsibility of the coral reef ecosystem FMP process.

14. Comment: FMP species managed under other FMPs should not be excluded from the Coral Reef Ecosystem FMP if they spend all or part of their life cycles on coral reefs.

Response: Although this FMP does not necessarily address managed species under other FMPs individually, many may be part of the coral reef ecosystem during at least a portion of their life cycles and may be key components of the system's health. Some MUS in the FMP are included under the Council's other four FMPs, under which their MSY/OY, EFH, and other fishery characteristics are identified. For these MUS, fishery-level effects and management should be the primary responsibility of the other FMP processes, while ecosystem effects should be the primary responsibility of the coral reef ecosystem FMP process. The section on non-regulatory measures describes a formal process for coordination among plan teams.

15. Comment: WPRFMC should institute a more formal process for future amendments to the draft FMP, wherein any changes must be approved by the recorded vote of Plan Team members.

Response: The Plan Team is one of several advisory bodies to the Council. While the Plan Team and others may recommend changes to the FMP, the Council is responsible for adopting which measures and amendments are appropriate to implement.

16. Comment: Lobster fishing should be prohibited in areas out to three miles from shore to protect lobsters and their role in the coral ecosystem and to prevent gear impacts to corals.

Response: Lobster fishing is managed under the Crustacean FMP. For these species, fishery-level effects and management should be the primary responsibility of the FMP processes, while ecosystem effects should be the primary responsibility of the coral reef ecosystem FMP process. The FMP describes a formal process for coordination among plan teams to identify and address impacts of other fisheries to coral reef ecosystems. In the NWHI, lobster fishery is prohibited from 0-10 fm.

17. Comment: Both the FMP and research component should include extensive public outreach and collaboration with the respective governments of the U.S. Pacific Islands, all potentially affected communities, and other interested private, local, State, and Federal entities.

Response: Under the management program for the Council's preferred alternative proposed management actions include facilitating consistent state/territory/commonwealth level management of coral reef resources and conducting education, public outreach and "coral reef management diplomacy". These actions are described in the FMP.

18. Comment: The DEIS should include a separate section describing specific actions and techniques which will be used to ensure coordination with U.S. Pacific Island governments, public participation, and inter-agency/intra-agency coordination throughout the FMP management and planning process.

Response: The FMP identifies non-regulatory measures to help with the effective management of coral reef resources, including: facilitating consistent state and territorial level management of coral reef resources; creating social, economic and political incentives for sustainable use and disincentives for unsustainable use of coral reef resources; and conducting education, public outreach, and "coral reef management diplomacy."

19. Comment: NMFS should continue to coordinate with the Hawaii Department of Land and Natural Resources, American Samoa Department of Marine and Wildlife Resources, Guam Division of Aquatic and Wildlife Resources, and the CNMI Division of Fish and Wildlife regarding impacts to all native species and habitats.

Response: NMFS will continue to coordinate with local resource agencies on issues that affect native species and habitats. Interagency coordination is a goal of the Plan.

20. Comment: A range of non-fishing impacts occur withing the complex coral reef ecosystems of the Northwestern Hawaiian Islands (NWHI). The Magnuson-Stevens Act only authorizes the Western Pacific Regional Fishery Management Council (WESTPAC) to manage fishing activities. Non-fishing interests do not have representation in the Council Plan development process. Given different user groups interested in obtaining access to the region, strong questions remain whether a Fishery Management Council is the best way to manage federal coral reef resources where multiple uses are occurring among multiple stakeholders, some who have no say in plan development.

Response: By Federal statute the Council is the authority to manage living marine resources in the EEZ. The draft Coral Reef Ecosystem Fishery Management Plan (CRE FMP) acknowledges its authority is limited to managing fishing vessels and fishing activities within Federal waters.

The Magnuson-Stevens Act also requires the Council to identify and describe non-fishing impacts to essential fish habitat (EFH) and recommend measures to mitigate any such impacts. The entire NWHI has been designated as EFH by the Council. The Council and NMFS are required to comment on any potential development activities, including non-fishing related activities, that may impact essential fish habitat within the NWHI.

The Council recognizes that comprehensive management of a region (e.g., the NWHI) requires interagency cooperation, considering the various agencies with respective jurisdictional authorities. The current draft of the FMP encourages such cooperation.

Amendments proposed for the re-authorization of the Magnuson-Stevens Act may expand the Council's authority beyond fishing activities.

The Council's advisory bodies include members with no direct connection to the fishing industry sector. The Coral Reef Ecosystem Plan Team is comprised largely of representatives from non-fishing interests, as are the Scientific and Statistical Committee (S.C.) and Ecosystem and Habitat Advisory Panel. Members of the public, including diverse stakeholders and NO representatives, also provide public comment at Council and related meetings.

In the process of developing the CRE FMP, the Council has worked with the Department of Interior, the Department of Commerce, the State of Hawaii, as well as numerous other agencies. The composition of the Council includes members from DO, DOC, and Hawaii. This is consistent with Executive Order 13158, where the President directed the Secretary of Interior and the Secretary of Commerce to work cooperatively with these agencies to develop recommendations for protection and sustainable use of the NWHI.

Comments on Research, Monitoring and Assessment:

1. Comment: There is a need for extensive mapping of the coral reef areas around American Samoa. Mapping of reefs is also a major focus of Task Force working group.

Response: Mapping of coral reef areas has been identified as a high priority research need.

2. Comment: A lot more research needs to be conducted on coral reef resources. In addition, research needs to be done on the effects of introduced species on coral reef resources.

Response: The FMP identifies recommended research, monitoring and assessment projects that will help obtain information necessary to more effectively manage coral reef resources.

3. Comment: The FMP should clearly state the baseline which will be used to evaluate the potential impacts of the various management alternatives. The baseline should be clearly defined, scientifically credible, local, and have general support from all stakeholders.

Response: Baseline is the current condition of the stocks and ecosystem. Research and monitoring are proposed to better define this. The referenced report by A. Green(1997) provides useful information on the current status of reef resources. The document on "MUS/EFH Descriptions". Also additional information is contained in the DEIS.

4. Comment: The FMP/EIS should discuss specific monitoring programs that will be implemented before and after proposed management actions to determine potential impacts on water quality and beneficial uses, and whether maintenance and protection of water quality can be guaranteed.

Response: The FMP is not expected to significantly affect water quality. The Plan Team will continue to evaluate and recommend improvements to the monitoring program after the proposed management actions are in place. An annual report will be produced that summarizes existing fishing activities and impacts.

5. Comment: There are currently fewer and fewer fish on the offshore reefs, only sharks. The fishers are not bringing in much fish on a consistent basis. Would like to see a study on the cause of these changes. Also, placing some FADs on the southern banks, where anchor damage has affected habitat, might help attract the fish back.

Response: The FMP identifies and prioritizes research, monitoring and assessment projects that should be undertaken to obtain information necessary to develop a sustainable coral reef fishery and effectively manage the coral reef ecosystem of the EEZ. One high priority project is to survey and assess biological resources in the EEZ, beginning with areas that are currently being fished. FADs are used to aggregate pelagic species of fish such as tunas, mahi mahi and billfish. The deployment of FADs would do little if anything to mitigate damage caused to bottom habitat caused by vessel anchoring or enhance coral reef/bottom dwelling species of fish.

6. Comment: There is a debate on the issue of overfishing in American Samoa waters. One study, using market data, concluded there was a decline in fishing resources, though it could have been an indication of market behavior at the time and not necessarily a decline in stock abundance. More research on this topic is needed.

Response: High priority research needs identified in the FMP include the survey and assessment of biological resources in the EEZ, beginning with areas that are currently being fished.
Comments on the Draft Environmental Impact Statement:

1. Comment: The draft Environmental Impact Statement (DEIS) should address water quality implications, if any, aquatic resources, threatened and endangered species, subsequent environmental reviews, environmental justice issues, and adequate binational collaboration. Full disclosure of direct, indirect, and cumulative impacts of all proposed actions is critical. The EIS should clearly describe other past, present, and reasonably foreseeable future planning and construction activities in the project area.

Response: These issues are addressed in the revised DEIS, as appropriate.

2. Comment: The DEIS should provide full disclosure of possible funding, implementation, enforcement, and monitoring commitments, assurances, and mechanisms for the proposed management actions. The reliability of these mechanisms and legal methods to ensure implementation of FMP commitments should be evaluated. The FMP/DEIS should describe potential options if funding and/or resources prove to be inadequate to ensure full implementation of the proposed management actions.

Response: The DEIS has been prepared following standard NEPA requirements. Alternatives (options) are also discussed and evaluated.

3. Comment: The DEIS should describe the measures taken by the Council and NMFS to fully analyze the environmental effects of the proposed action on minority communities (e.g., Pacific Islanders and low-income populations), and present opportunities for affected communities to provide input into the NEPA process.

Response: These issues are addressed in the DEIS. Also see, for a detailed synopsis of community social and economic impacts is included in the FMP and in the "Fishery Impact Statement" and Appendix III. "Regulatory Impact Review and Initial Regulatory Flexibility Analysis". Public hearings will be held in low income communities.

4. Comment: The DEIS should include a section on potential effects on local, State and Federal ordinances, regulations, legislation, and laws.

Response: Every effort has been made to ensure that the management measures proposed in the FMP are consistent with state and territorial laws and policies to the degree practicable in order to simplify implementation and assist enforcement efforts.

5. Comment: The DEIS should address fishery-related impacts to fish and wildlife resources and habitats associated with each proposed geographic fishery area. USFWS recommends that particular attention be given in the DEIS to addressing fishery-related impacts on endangered and threatened species, migratory birds, coral reefs, and rare, native species and habitats.

Response: These issues are addressed in the DEIS. 14% of the NWHI reef area is designated as "no-take" zones, and fishing is already restricted in many areas of the NWHI that serve as critical habitats for monk seals and green sea turtles.

6. Comment: With regard to federally-listed endangered and threatened species, a biological assessment that (1) evaluates the impacts of the proposed and existing fisheries on listed species and (2) determines whether any such species are likely to be adversely affected by the fisheries must be prepared in accordance with the interagency consultation regulations found at 50 CFR Part 402.

Response: Under the ESA, NMFS is required to prepare and provide an impact assessment, which may serve as the biological assessment for consultation under Section 7 of the ESA, on the impacts of the fishery, as it would operate under this FMP, upon endangered and threatened species and their critical habitats. The NMFS will conduct a consultation under ESA Section 7.

7. Comment: The DEIS should identify the federally-protected resource areas that exist either within or near EEZ waters, including their established administrative boundaries. The DEIS should discuss how the impacts to these protected resources from the fisheries activities and management measures will be avoided. The DEIS should discuss the cumulative effects of these impacts over time and propose potential measures to mitigate these impacts.

Response: Impact of fishing activities are addressed in the DEIS (see "Environmental Consequences of Alternatives").

8. Comment: The DEIS should discuss the potential for removal of indigenous coral species and establishment of marine alien species, assuming that harvesting platforms and gear could serve as vectors for the introduction of marine alien species. The DEIS should assess the potential for coral reef harvesting to open up substrate for colonization by marine alien species that already exist in the area or that might be introduced by some other vector (*e.g.*, fishing nets) and the potential for these species to become established and proliferate.

Response: The collection of live hard coral is prohibited for commercial purposes in the plan. Most permitted vessels could be expected to be locally based thus minimizing the threat of introductions. Additional research is needed to better quantify the significance of such proposed threats.

9. Comment: Since the FMP is ecosystem-based and there is species overlap among the Plan and other existing FMPs, the DEIS should discuss how and to what extent overlapping species would be managed under various plans. In addition, the DEIS should include a discussion of how the entire coral reef ecosystem would be managed effectively on a sustainable basis under the proposed FMP.

Response: The FMP describes a formal process for coordination among plan teams to identify and address impacts of other fisheries to coral reef ecosystems. Some MUS in the FMP are included under the Council's other four FMPs, under which their MSY/OY, EFH, and other fishery characteristics are identified. For these MUS, fishery-level effects and management should be the primary responsibility of the other FMP processes, while ecosystem effects should be the primary responsibility of the coral reef ecosystem FMP process. This is also discussed in the DEIS.

10. Comment: Because of the inter-relationships, the Coral Reef Ecosystem FMP and EIS should not be dealt with separately from the other existing FMPs.

Response: Although this FMP does not necessarily address managed species under other FMPs individually, many may be part of the coral reef ecosystem during at least a portion of their life cycles and may be key components of the system's health. Some MUS in the FMP are included under the Council's other four FMPs, under which their MSY/OY, EFH, and other fishery characteristics are identified. For these MUS, fishery-level effects and management should be the primary responsibility of the other FMP processes, while ecosystem effects should be the primary responsibility of the coral reef ecosystem FMP process. The section on non-regulatory measures describes a formal process for coordination among plan teams.

11. Comment: The FMP may be in violation of NEPA because the commentor believes it is impossible to hold scoping sessions on an EIS when the Council has not determined what actions will be included in the final document.

Response: The scoping meetings were intended to get public input about the issues, problems and range of alternative that should be addressed in the FMP and SEIS. Public hearings and public comment periods will be forthcoming to provide an opportunity for the public to review and comment on the draft FMP/EIS.

12. Comment: The DEIS and CRE FMP do not appear to adhere to standards of full disclosure when measured against the potential impacts of other draft FMPs which are now in preparation by the Council.

Response: The Council is not preparing any new FMPs aside from the CRE-FMP, and its accompanying DEIS does consider the impacts of existing fisheries. The Council is only preparing EISs for existing FMPs. These EISs are not associated with significant changes to the management of these fisheries.

Comments on Enforcement:

1. Comment: At night, the local fishermen see lights out on the water, other non-local boats fishing on the offshore banks. These are the boats that need to be regulated. There is a real need for enforcement with respect to coral reef fishing.

Response: Like all other FMPs implemented by the WPRFMC, the NMFS and the U.S. Coast Guard will be jointly responsible for the enforcement of the Coral Reef Ecosystem FMP. If applicable, cooperative agreements could be developed to deputize local enforcement officers to assist in the enforcement of regulations. Both the USCG and the NMFS agencies undertake surveillance of EEZ waters and have the authority to board vessels at sea and inspect vessels when they come into port.

2. Comment: Instead of closing down fishing areas, NMFS should conduct fish surveys to determine which species have been depleted over the last 20 years at FDM, Agrihan and Esmeralda.

Response: The FMP will not close any areas in the CNMI. High priority research needs identified in the FMP include the survey and assessment of biological resources in the EEZ, beginning with areas that are currently being fished.

3. Comment: The distinction between Federal and State waters was mentioned, which brings up the concern about enforcement. If the plan is not able to effectively enforce the rules, it is meaningless.

Response: The Coast Guard, NMFS will be conducting enforcement, and the State will be doing enforcement. One of the goals of the Council is to try to maintain consistency between the actions of the Council, the federal government and the state of Hawaii.

4. Comment: The proposed plan does not require automated vessel monitoring systems (VMS) installations. It also does not require that a bond be posted to cover the immediate costs of vessel removal due to groundings. Vessel insurance should also be required for all permit holders in any area in the NWHIs, and not be dependent on the type of permit held, category of vessel, etc. as is currently proposed in the CRE-FMP. Given that 3 Council permitted fishing vessels have run aground in State waters either in the NWHIs or in transit to the area in the past 20 months, the bonds and insurance should be mandatory.

Response: VMS, bonds and insurance were discussed at meetings of the advisory bodies with recommendations made to the Council.

Both fishing and non-fishing vessels operating in or transiting no-take MPAs would be required to have insurance through the CRE FMP so that in the event of a grounding they could pay for the cost of vessel removal and any legal liability for mitigation of habitat impacts.

VMS can be part of an effective monitoring and enforcement system for state and federal agencies, depending on category of vessel, type of permit and fishing area. A requirement for fishing vessels operating in MPAs to carry remote electronic vessel monitoring systems (VMS), if funded by NMFS, is included for future consideration, for implementation under the framework process.

Bonding was determined to be a socially and economically unfeasible alternative.

Other Comments:

1. Comment: How will this FMP affect existing, nearshore fisheries in Hawaii?

Response: Under the Magnuson-Stevens (M-S) Act, the Council has the authority to regulate fishing and other associated activities in federal waters. The management measures contained in the FMP apply only to fishing activities in federal waters. Management of living marine resources in state and territorial waters is the responsibility of the respective state resource management agencies; American Samoa, Department of Marine and Wildlife Resources; Guam, the Department of Aquatic and Wildlife Resources; Hawaii, the State Department of Land and Natural Resources; Northern Mariana Islands, Department of Lands and Natural Resources. The WPRFMC has designated essential fish habitat (EFH), as all bottom habitat and the adjacent water column, from the shoreline to the outer limits of the EEZ to a depth of 50 fm. The designation of EFH in and of itself will not have any biological impact. However, the proposed NMFS and Council consultation process should have an overall beneficial effect on habitats important to managed fisheries in the western Pacific region. A direct benefit of the FMP is the compilation of information on the habitats and life history characteristics of managed species. This information should facilitate the efforts of the Council and NMFS to assess cumulative impacts to EFH and propose measures to mitigate or avoid adverse impacts. Additionally, the review and compilation of the best available scientific data will serve to guide future research necessary to further describe and protect EFH. Second, EFH designation establishes a framework for NMFS and the Council to cooperatively comment on state and Federal agency actions affecting EFH. The comments of these agencies will, in turn, provide more specific guidance on how adverse impacts to EFH can be avoided or mitigated.

2. Comment: What do other countries, such as the French Territories and Fiji, do with regard to the management of their EEZ?

Response: French Territories have some closed areas. Fiji has a mixture of contemporary and traditional management, exercised through chiefly authority. The French government has given the Territorial legislature of French Polynesia full management and exploitation authority. The Ministry of Oceans, and in particular the Aquatic Resources Service (ARS) has the task of managing the total EEZ, from 0 - 200 nm, as well as lagoon and reef resources. In addition, the ARS is responsible for managing aquaculture. The Territorial legislature has the authority to negotiate bi- or multilateral fisheries arrangements, as long as the initiative, does not compromise France's international position, especially on defense. The Territorial government has the authority to establish reserves in lagoons or on reefs to protect fisheries resources. There is currently a professional lagoon fisher permit. In addition, the Ministry of the Environment sometimes gets involved when it comes to endangered species, such as sea turtles or endemic species such as the freshwater gobies in our rivers or even the "long-eared" eels. The Territorial government is in the process of establishing coastal or lagoon zone management for Moorea and Bora Bora, with appropriate legal language so that eventually some type of control and enforcement can be attached to it. In these plans there are provisions for zones of restricted activity, such as shark feeding only and no fishing. There have been efforts made to explore the possibility of same sort of reserve zone for stock replenishment in the Society Islands, (hopefully being able to overlap already established Kapu zones so as not to confound or duplicate enforcement) and the Tuamotus in an effort to sustain exploitable populations of things like giant clams, sea cucumbers, trochus, top and green snails. Fiji has reserve provision in their coastal/reef resources management plans. Fiji is an independent country within the Commonwealth of Nations and therefore has full authority of the 0-200 nm EEZ.

3. Comment: How does the management of the nearshore resources affect the offshore fisheries and vice versa?

Response: The movement and interaction between marine organisms found in shallow coastal waters and deeper offshore waters is highly species specific and dependent on a multitude of factors. Demersal species typically have a much more restrictive home range then do highly migratory pelagic species such as tuna and billfish. Therefore exchange between populations present in shallow coastal waters and those of deeper offshore waters is relatively limited. Conversely, most coral reef associated species of fish have a pelagic larval phase that may last up to several months. Tunas and other pelagic species of fish range freely throughout the ocean and are often found in shallow coastal waters. More research is needed to quantify the magnitude and importance of these relationships for most species. The Council has strived to develop and implement regulations consistent and complement existing state and territorial fishery management regulations where ever possible. Where state and federal fishery regulations are inconsistent undesirable consequences may occur. For instance, if nearshore fishery resources are mismanaged, overfishing is likely to occur. As overfishing occurs and populations of commercially important marine organisms decline in abundance, fishermen will be forced to move further offshore and in to new areas to fish. This can put unforseen pressure on the fishery resources found in federal waters and underscores the need for implementing a management regime for coral reef resources found in federal waters.

4. Comment: Would vessels from other island areas be able to fish in the EEZ waters of CNMI?

Response: Yes, the Magnuson-Stevens prohibits discrimination between fishermen or residents from different state or territories fishing in EEZ waters. The CNMI government has the authority to promulgate rules and regulations that apply to waters under its management authority.

5. Comment: In Hawaii, what is considered State versus Federal Waters?

Response: In Hawaii, State waters extend from the shoreline to 3 nautical miles offshore. Federal waters (the EEZ) extend from 3 to 200 nautical miles offshore.

6. Comment: What is the scope of management of the FMP?

Response: The FMP proposes active management, under Federal regulations, of the coral reef fisheries in the waters of the EEZ (3-200 nm) around American Samoa, CNMI, Guam, Hawaii, and the other unincorporated U.S. Pacific Islands.

7. Comment: The WPRFMC should be concerned about reef pollution because pollution will wipe out the coral reefs.

Response: The FMP identified pollution and contamination as non-fishing impacts to coral reef resources and recommends conservation measures to minimize these impacts. The MSFCMA does not provide councils authority to regulate sources of pollution or their impacts.

8. Comment: Is the intent of WPFMC to manage the coral reef ecosystem as a whole or simply to manage the fisheries within that ecosystem?

Response: The FMP is the first ecosystem-based plan developed by any of the eight regional Fishery Management Councils. The overall goal of the FMP is to manage coral reef ecosystem on an ecosystem basis to achieve a sustainable balance of economic productivity, ecological integrity and social acceptability. The FMP is consistent with the objectives of the Magnuson-Stevens Act, international *Code of Conduct for Responsible Fisheries*, the report by the NMFS Ecosystem Principles Advisory Panel, the President's Executive Order on coral reefs and the US Coral Reef Task Force efforts. An ecosystem approach to fishery management shifts the burden of proof from determining if proposed harvests will be detrimental to establishing prior to harvest that such activities will not jeopardize the health and sustainability of the ecosystem. A precautionary management approach (as presented in the *Technical Guidance on the Use of Precautionary Approaches to Implementing National Standard 1 of the Magnuson-Stevens Act* and the FAO Fisheries Department *Code of Conduct for Responsible Fisheries*) is employed and steps are taken to ensure against unforeseen impacts to the ecosystem. Fishery management under this FMP is adaptive and builds upon local and regional experiences. A coral reef ecosystem has ecological integrity if it retains its biological diversity, size structure and abundance over time and when all the elements in the ecosystem, along with the processes and functions that support these elements, are maintained. Solid scientific justification and the power of legal regulation must be coupled with the sincere belief by the resource users, especially those living in closest proximity to the resource, that the management policy is suitable. This suitability must take into account the culture, traditions and political perspectives of all resource users. Another goal of the FMP is to maintain consistency with state and territorial fishing regulations and landing laws, to the degree practicable.

9. Comment: Sportfishing needs to be discussed as a use of coral reef resources because it currently attracts many visitors to the management area.

Response: Charter fishing, which includes sportfishing, is discussed in the FMP.

10. Comment: How will the WPFMC handle differences between State and Federal rules?

Response: The Council intends to maintain consistence in state/territorial laws, to the degree practicable.

11. Comment: Definition of subsistence should include displacement of indigenous peoples. Indigenous peoples who fish on a subsistence basis should be allowed to sell a portion of their catch.

Response: The FMP must follow the MSFCMA definitions. The MSFCMA defines any catch that is sold as commercial.

12. Comment: Management efforts should be based on sound scientific rationale and equitable rationale.

Response: National Standard 2 of the Magnuson-Stevens Act requires that conservation and management measures be based on the best scientific information available. At the same time, the precautionary principle specifies that conservation measures should be implemented even in the absence of scientific certainty that fish stocks are being overexploited. The FMP is consistent with both National Standard 2 and the precautionary principle. In addition, the permit system and other conservation and management measures will not discriminate between residents of different states and territories, consistent with National Standard 4.

13. Comment: Plan should apply different regulations to different geographic units.

Response: It does. Some proposed regulations are general for the whole region. Others are more specific, such as MPAs with geographic subzones with special requirements.

14. Comment: It is difficult to estimate MSY for most coral reef species.

Response: The plan includes a section that addresses requirements to prevent overfishing. Harvested taxa with a history of exploitation have catch data that can be used to estimate MSY. Where this is insufficient data form other similar areas can be used. Where no information exists proxies can be used for MSY with stated assumptions.

15. Comment: Restrictions on nearshore fisheries would impact fishermen who are using resources in environmentally sensitive ways.

Response: This FMP will not restrict fishing in most nearshore areas. If the state/territories implement consistent or more stringent regulations in their inshore waters (generally 0-3 nmi) existing nearshore fishermen would be impacted; control of such is beyond the scope of this federal plan.

16. Comment: Ocean recreation uses and sportfishermen have greater cumulative impact than do the few commercial fishermen.

Response: This criticism has merit in terms of impacts to coral reef ecosystems, especially in nearshore state/territory waters. Management of ocean recreation users is not under the authority of the MSFCMA. Sport or recreational fishing in the EEZ will need to comply with the measures of the plan.

17. Comment: The process of developing the FMP may in itself stimulate the types of unregulated activities it seeks to prevent by describing the valuable coral reef resources currently unregulated.

Response: It may, but is assumed to be small. The fact that very little fishing for coral reef management unit species currently exist in the EEZ suggests that it is not economically attractive under present conditions. The plan is being developed as a high priority, following required timetables; regulations should be in effect by mid to late 2001.

18. Comment: The standard condition requiring the prohibition of ballast water discharge from fishing vessels should be deleted. It is the commentor's understanding that current USCG regulations fully address this issue and have required vessels to discharge ballast water in the open seas and not in static bay or lagoon environments. Prohibiting ballast discharge by fishing vessels in the EEZ is a rather extreme measure which cannot be enforced.

Response: This standard condition was proposed in an alternative measure that has since been rejected by the Council. Discharge of ballast water is regulated by the USCG, not the Magnuson-Stevens Act.

19. Comment: A full analysis of the present status of corals in the Western Pacific, including potential threats, present levels of harvesting, and areas needing protection, should be included in the FMP.

Response: Information about existing coral reef fishing is provided for each island area. Fishing and non-fishing impacts to Essential Fish Habitat (*i.e.*, coral reefs) are described in the FMP. The FMP also identifies EFH and Habitat Areas of Particular Concern (HAPCs).

20. Comment: A full analysis of how the FMP complies with the recent Presidential Executive Order to protect corals to the extent practicable should be included in the FMP.

Response: The FMP discusses the relationship between the FMP and Executive Order No. 13089.

21. Comment: Concern about where the FMP will be implemented, including limitations to the FMP to federally-controlled waters (3-200 miles). If this is the case, a large portion of the NWHI, FDM, and other areas of significant importance to indigenous communities will not be afforded protection under the Plan. Under Executive Order 13089 all coral reefs should be provided protection.

Response: Executive Order No. 13089 applies to the WPRFMC only in its areas of jurisdiction. Other coral reef areas are managed by other Federal, state, territorial, and commonwealth agencies. These other Federal agencies are also subject to the directive of the Executive Order.

22. Comment: Recommends revising the definition of "subsistence fishing" to read: "harvest of resources for non-commercial use, with the exception of indigenous residents who may sell their harvest; such subsistence sales are not to exceed $30,000 per person, per year."

Response: The MSFCMA, which councils are mandated to follow defines any catch that is sold as commercial.

23. Comment: What is the definition of sportfishing, recreational fishing, commercial fishing and charter fishing? Fishermen do not support the fact that if they sell one fish during the year, they are considered commercial rather than subsistence fishermen.

Response: The Council derives it authority to manage fishing activities in federal waters from the MSFCMA. The MSFCMA defines commercial fishing as follows: The term "commercial fishing" means fishing in which the fish harvested, either in whole or in part, are intended to enter commerce through sale, barter or trade. Therefore, if a fishermen sells any portion of his/her catch by definition he is a commercial fishermen under the MSFCMA. The Act defines recreational fishing as "....fishing for sport or pleasure."

24. Comment: Considering the FMP document is extremely long and technical, the time period for public comments is far too short.

Response: The Administrative Procedure Act requires a 45-day comment period for proposed rules that would implement a FMP. The proposed rules for this FMP will be published for public comment with the requisite comment period after NMFS receives the proposed FMP and regulations.

25. Comment: How can the mandate of the Magnuson act regarding essential fish habitat affect the plan for polluted runoff in Hawaii? When commentor read the mandate from congress, it only specifies that the NMFS has the power to advise states and their actions, but could this be extended to advise the states in their regulation of private actions that would affect the water? In other words, how far does essential fish habitat provisions reach?

Response: The Magnuson Act states that Councils are required to describe and identify essential fish habitat (EFH) based on all life stages of the managed species, with no limitations placed on the geographic location of EFH. EFH may be designated in state or federal waters depending on the biological requirements of the species. Regarding actions that occur in state waters that may adversely affect EFH, the Magnuson Act provides authority forNMFS and the Councils to provide EFH conservation recommendations. The Council has designated EFH and Habitat Areas of Particular Concern (HAPC) for its four existing FMP. The Coral Reef Ecosystem FMP proposes to designate additional areas as EFH and HAPC. Once EFH designations are approved by the Secretary of Commerce, NMFS is required to undertake consultation with federal and state agencies that authorize, fund or undertake actions that may adversely effect EFH. The MSFCMA Sections directs NMFS and the Councils to provide comments and EFH conservation recommendations to Federal or state agencies on actions that would adversely affect EFH. Such recommendations may include measures to avoid, minimize, mitigate, effects on EFH resulting from actions or proposed actions authorized, funded, or undertaken by that agency. The MSFCMA requires all Federal agencies to consult with NMFS on all actions, or proposed actions, authorized, funded, or undertaken by the agency, that may adversely affect EFH. Federal agencies are required to respond in writing to EFH comments. States are not required to respond to the NMFS or Council's recommendations for measures to avoid, minimize or mitigate adverse impacts to EFH, including non-point source pollution from run-off from upland areas in coastal water sheds.

26. Comment: Whatever can be done to encourage federal and state cooperation in maintaining essential fish habitat is going to be important in the future.

Response: The Council agrees. Coral reef ecosystems occur within all jurisdictional boundaries throughout the US EEZ in the western Pacific. Therefore, the implementation of this FMP will require federal, state, territorial, and other governmental agencies to work together to address mutual management concerns and collaborate on the needs for effective coral reef research and management. This inter-agency collaboration is consistent with the goals of the Coral Reef Task Force, to create a nationally coordinated, long-term coral reef protection program.

27. Comment: In CNMI, all federal waters go to the shoreline. However, the Council recommends no exception be granted for subsistence fishermen from permitting and reporting requirements. There is a group of truly subsistence fishermen in Saipan Lagoon who have practiced their own sort of community bases mechanisms of management. Therefore, it is important to address this jurisdictional issue clearly in the plan.

Response: The Fishery Rights of Indigenous Peoples Advisory Panel discussed the issue of permitting and reporting for subsistence fishermen in waters under the Council's jurisdiction. They understood the reasoning for exempting subsistence fishermen from a permitting process, but felt that the information produced from reporting was necessary for effective fishery management. Therefore, the panel recommended to the Council that true subsistence fishermen should be exempt from permitting requirements, however they would be required to report catch data. The FMP intends to apply to waters 3-200 miles from shore around CNMI

28. Comment: What Guam needs is a patrol boat, as many foreign fishing boats come to the islands and fish without the VMS on. They are able to fish in rougher water when the local fishermen cannot make it out.

Response: Foreign fishing is prohibited within the EEZ unless it is authorized by an international fishery agreement that existed prior to the passage of the Magnuson Act, or it is authorized by a Governing International Fishery Agreement. However, no such agreement exists in both the CNMI and Guam. None the less, the Council does not require fishing boats to carry electronic VMS with the exception of the Hawaii-based longline fishery. A framework measure is proposed in the FMP, certain types of fishing vessels (i.e. dependent on category of vessel, type of permit or fishing area) transiting through MPAs to carry remote electronic VMS, if funded by NMFS. Regarding enforcement, the US Coast Guard has 2 cutters which patrol the EEZ of Guam and the CNMI. In addition, aerial reconassaince are also conducted by Coast Guard aircraft around both EEZs.

29. Comment: Through the coral reef initiative from the President's executive order, perhaps there could be a way to approach the Coral Reef Plan Team management and maybe modify the Magnuson Act to allow a better approach

Response: The Coral Reef Ecosystem FMP embodies many of the goals set forth in the Presidential order. The Magnuson Act is up for re-authorization and a number of modifications to the Act are being considered to help further the goal of ecosystem management.

30. Comment: In the EIS, there should be a clarification of the relationship of the U.S. Federal jurisdiction and any authority of Guam of the 200 mile zone.

Response: In Guam, the relationship between Territory and Federal jurisdiction are clearly delineated. (0-3 miles for Territory; 3-200 miles for Federal).

31. Comment: Is there some mechanism to get the Coast Guard involved, and have their resources available for groundings? In Guam, ships bearing Chinese aliens ran aground on reefs, and the Coast Guard would take responsibility until the oil that was leaking out was gone. It would not take responsibility for the damage that was occurring from the ship up on the reef.

Response: The Coast Guard's mission is for marine safety and environmental protection. Their first duty is to protect America's interests on the seas. Their response to a mission is based upon priority determined by their command. Their highest priority is protection of human life and then the environment. A decision was made to limit the expenditure of their resources to mitigating the environmental damage caused by the spill. Comments can be made directly to the Coast Guard through their regional commands or the Department of Transportation by phone, fax , mail or electronically.

32. Comment: According to the Magnuson Act, it supports cultural sensitivity, so if there was no Hawaiian cultural member of the Plan Team then the process has been in error.

Response: The Magnuson Act recognizes that there are unique historical, cultural, legal, political and geographical circumstances in the Pacific Insular Areas. Individual Councils are responsible for establishing and administering plans for the management and stewardship of fisheries. The Councils are responsible for ensuring a wide participation in the process. It is a democratic process that calls for participation by the State, fishing industry, environmental organizations, consumer organizations, native representatives and other interested persons. The Council advisory panel on Native and Indigenous Rights have reviewed and comments on the plan. The Council may choose to agree with recommendations made by the participants or may not. It is the Council's decision. The Western Pacific Regional Fishery Management Council has been fair in balancing the needs of the industry with the concerns of the participants.

33. Comment: There may be an error in the statement regarding 94% of the coral reefs lies within U.S. jurisdiction. Under the Hawaiian Homes Commission Act 5F, in Hawaii some of these submerged lands exceed the three mile limit, so there is a problem with jurisdiction there.

Response: The Hawaiian Homes Commission Act was passed by the US Congress in 1920. Currently, the Hawaiian Homes Commission Act is administered by the State of Hawaii with oversight by the Department of Interior. Section 5f of the Admission Act, identifies five uses that proceeds from the ceded lands trust, the former Crown and Government lands of the Kingdom of Hawaii, can be used. Submerged lands are dealt with under section 5i of the Admission Act. Submerged lands are a special class of lands defined by the US Supreme Court. Submerged lands are those lands under navigable waters of the state that can be put to uses that benefit the public, e.g., piers, runways, etc. In Hawaii, it is argued that the submerged lands are part of the ceded lands trust. The 20% of the Ceded Lands trust is set aside for Native Hawaiians. Jurisdiction is an issue that remains unresolved.

34. Comment: There is a concern that the Council has intentionally excluded species listed under existing fishery management plans from coverage by the CRE-FMP. This decision is contrary to an ecosystem approach. The Presidential Executive Order 13089 provides that the Council must "ensure that any action authorized, funded, or carried out will not degrade the conditions of coral reef ecosystems." Therefore, the CRE-FMP should be developed in a manner that protects the marine ecosystems of the Western Pacific, and species listed under other FMPs must be included.

Response: Species were excluded because they were managed under another FMP. In an attempt to avoid overlapping jurisdictions they were excluded from the CRE-FMP. We will re-examine their exclusion and review the standards developed by the Ecosystems Principles Advisory Panel in their submission to Congress in April 1999. FMP's have been managed on a species basis. What we are finding is that there is very little research and data available for the large amount of species that are extant in the Coral Reef Ecosystem. Without sufficient data it is difficult to make recommendations for their management. The change from Management Unit Species to Ecosystem Based Management will be difficult transition. The EFH provisions of the MSFCMA requires Councils to move beyond traditional single-species and multi-species management and to begin to consider a broader, ecosystem-based approach to fishery management. The Councils are now required to begin to consider the ecological role (e.g., prey, competitors, trophic links within food webs etc) played by MUS. Further, Councils are now required to identify and minimize adverse impacts to EFH that result from both fishing and non-fishing activities. Throughout CRE-FMP ecosystem impacts of all FMP fisheries are consisted and addressed through a formal process of plan team coordination.

35. Comment: Would rather see money spent on stiffer regulations for longliners and tuna boats than studies on inshore fishing where mainly subsistence fishing occurs.

Response: The Longline Fishery is a managed fishery that occurs in the EEZ of the United States. The Magnuson Act mandates the Council to establish Fishery Management plans for the fisheries in the US EEZ - 3 to 200 miles offshore. Inshore fishing is an unregulated harvesting of the resource under the State's jurisdiction - 0 to 3 miles. We need data on shore fishing to determine the sustainable amount that can be taken from shore. What and how much is taken? How much is sold? Where is it taken?

36. Comment: It should be noted that the 200 mile zone is under protection of local Guam laws, what is the relationship of U.S. Federal jurisdiction?

Response: The Federal Government claims 3 miles to 200 miles as the US EEZ. Federal laws apply in that area and are enforced by the US in that area. Problems will arise where there might be conflict between federal laws and local laws governing those areas. The best way to avoid the conflicts would be to negotiate and amend those laws to reduce the conflict.

37. Comment: Providing fixed moorings is a good idea, especially in places like Palmyra and Kingman where anchor chain can damage pristine coral areas. The US navigational charts list an extensive shallow coral bank as a mooring area.

Response: Fixed moorings are a good idea. There are problems associated with fixed moorings but they will be examined for applicability and are considered in the FMP as a framework option.

38. Comment: The 50 fathom rule does not make sense, because the drop off is from seven fathoms to 200 in about 10 feet around Palmyra and Kingman Reef.

Response: The 50 fathom rule was adopted because it is the extreme of where algae and coral will grow and of course there will be exceptions and amendments needed to fully protect the Coral Reef Ecosystem.

39. Comment: Sudden storms may require anchoring in shallow areas.

Response: The prevention of loss of life is provided for in Maritime Law through exemption for emergency anchoring.

40. Comment: Satellites should have been put up to identify every boat that comes within our boundaries.

Response: Identifying boats by satellite would be very difficult. However, there is an effort to establish an international Vessel Monitoring System for all vessels. Every boat owner must agree to have a VMS installed on their boat for effective and efficient monitoring. VMS is included as a framework measure for possible future implementation.

41. Comment: The regulations coming down might not affect us right now, but will before long; the market demand is always going to be there.

Response: The effort of the Council is always to balance the interests of the stakeholders in the resource, including the general public. Rules and Regulations are established to allow the sustained use of the resource for the benefit of the people.

42. Comment: Need to work out jurisdictional issues before the Council can enforce regulations in the NWHI.

Response: The effort is to get the federal and other agencies to work together in the planning for and the management of the resource, possibly through MEAs.

43. Comment: Ulua should be included as a management unit species list.

Response: Ulua is included as a MUS under the bottomfish FMP.

44. Comment: The current version of the Coral Reef Ecosystem Management Plan (CREFMP) still exempts existing Fishery Management Plans (primarily bottomfish, crustaceans and precious corals) from inclusion in the management measures proposed under the CREFMP. All species of groupers, jacks, and snappers (which represent the majority of apex predators) were recently moved into inclusion in the bottomfish FMP. The organisms are clearly part of the coral reef ecosystem, and this type of fragmenting of reef organisms into separate management plans points to the inadequacies associated with the CREFMP in managing resources at an ecosystem level. Inclusion of other FMPs under the CREFMP is a necessity if the plan is to be considered as an ecosystem management plan.

Response: The current version of the FMP prohibits all fishing in no-take MPAs (i.e., no exemptions for existing FMP fisheries). Elsewhere, current fisheries are subject to management restrictions under their respective FMP, which include consideration of habitat impacts.

Prior to the establishment of the Coral Reef Ecosystem Plan Team the Council requested that all species of emperors, snappers, jacks and groupers be added to the BMUS list in the Bottomfish FMP. Most of these species are from CNMI, Guam and American Samoa and have been reported in the catch from these bottomfish fisheries for years. The required amendment has not yet been completed.

A formal process for Plan Team coordination, as recommended by the Coral Reef Ecosystem Plan Team, is included in the CRE FMP to address any potential ecosystem concerns from existing fisheries.

The CRE FMP was developed as a mechanism for incorporating ecosystem approaches into the present regulatory structure created through earlier FMPs for bottomfish, lobster and precious corals. The FMP is intended to serve as a demonstration "Fisheries Ecosystem Plan."

Aspects of the FMP that contribute to the ecosystem approach include: 1) measures to prevent overfishing and reef degradation, 2) prohibition on destructive and non-selective fishing methods, 3) characterization and protection of essential fish habitat, 4) no-take (i.e., no fishing) and low-use MPAs, 4) permit and reporting requirement to monitor changes in coral reef health, 5) insurance for vessels in MPAs, and 6) interagency collaboration for reef protection against other impacts.

There is poor understanding of the basics, much less the intricacies, of coral reef ecosystems. Ecosystem-based management, therefore, is a long-term goal that can only be achieved over time as new information allows for improved decision-making. Collection of new data and feedback for adaptive management are key elements of the proposed FMP. Comprehensive research is necessary to support ecosystem-based management; ongoing programs must continue and be expanded.

45. Comment: Existing impacts, such as the continuous dropping of lobster traps on coral reefs, have not been addressed under the proposed CRE-FMP nor are they considered under the existing Crustacean FMP. Observer data clearly show that some live coral is being brought up in the traps, yet the Council considers traps to be a non-destructive fishing gear in the CRE-FMP. Destruction of the coral reef habitat and substrate clearly has the potential to affect the overall integrity of the ecosystem, yet management measures to assess this impact are not addressed in either FMP. The plan also permits fishing with other types of non-selective gear such as gill nets, which and has few limitations on the types of fishing gear. Questions regarding what other impacts are not being addressed due to gaps in the plans, and the exempting the fishing specific plans from the CRE-FMP remain.

Response: The current draft of the CRE-FMP includes a "Fishing Gear Catalog", which discusses habitat impacts from lobster traps and other gear. Research is proposed to investigate such anecdotal observations.

Typically, lobster traps are set in areas of relatively low structural relief, away from coral reef habitat. If traps are set too close to coral reef and other high relief habitats, lobsters cannot be enticed to enter the traps. The occurrence of live coral in lobster traps is rare. Damage to the coral reef ecosystem is also not considered significant as the fishery typically includes less than 8 vessels and lasts only a few weeks per year.

The existing Crustaceans FMP includes a requirement to prevent significant impacts to essential fish habitat.

The allowable gear list in the FMP has been chosen based on selective non-destructive characteristics of gear and its usage.

Fishing for coral reef resources in the NWHI is practically non-existent outside of current FMP-regulated fisheries. Current State regulations also allow most of these gear types.

46. Comment: Coral reefs represent the most complex community of species on earth. There is a very tight inter-dependency of the organisms found on coral reefs. As such reef ecosystems are more susceptible to the impacts of any harvest than that seen with a single species. In addition, the significantly lower rates of coral growth found in the NWHIs makes the area more susceptible to all impacts as the corals are at the edge of their range of tolerances. It is important to recognize these factors and develop a fisheries management plan that is truly ecosystem based, without myriad other fisheries covered by separate management plans.

Response: Fishing has occurred in the NWHI for hundreds of years yet the area is still referred by many as "pristine." Coral reefs are in good-to-excellent condition there.

Commercial fishing activity is at an all-time low, due largely to regulations implemented by the Council, including limited entry. The NWHI lobster fishery is currently closed.

The coral reef ecosystem FMP was developed over a period of about six years through a collaborative effort of contractors, Council staff, Council advisory bodies and public input. Nine advisory bodies and the S.C. deliberated several times over the past two years over successive drafts of the CRE FMP to formulate recommendations to the Council. The Council's present preferred alternative for the FMP represents the best balance of concerns from its diverse constituency to manage coral reef ecosystems consistent with the goal of the plan to balance ecological integrity, economic productivity and social acceptability. (Further ecosystem aspects of the plan are introduced above.)

47. Comment: The CRE-FMP permits harvesting of live rock and coral, despite a State law prohibiting such activity.

Response: The CRE FMP prohibits the commercial take of live rock or live coral, including bulk harvesting or extractive activities, since it would result in the removal of habitat essential to fish and other benthic resources.

The Council also found it reasonable to allow take of small amounts of live rock/coral by indigenous peoples, under a special permit, for traditional and ceremonial use, and by aquaculture operators, under special permit, for use as seed stock. Limited collecting, under a special permit, would also be allowed for scientific research and management activities, including single harvest of a particular species (i.e., bioprospecting).

Draft

Fishery Management Plan For Coral Reef Ecosystems of The Western Pacific Region:

Essential Fish Habitat For Management Unit Species (Including Maps of Coral Reef Habitat in The Western Pacific Region)

December 2000

Volume III

Western Pacific Regional Fishery Management Council

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I. Description of Essential Fish Habitat for Harvested Coral Reef Species

EFH for Surgeonfish (Acanthuridae)

The surgeonfishes are one of the most prominent groups of reef-dwelling fishes in the tropical Indo-Pacific. They are important food fish on many Pacific islands, where they are typically caught by spearfishing or nets. In recent catch data (1991-1995) for Hawaii, 6 of the top 25 inshore species by weight were acanthurids (Friedlander 1996).[1] In American Samoa, Acanthuridae compose 28% of the reef fish catch (Dalzell et al. 1996), and over 40% of the catch composition by weight in the 1994 artisanal fishery was surgeonfishes (in Craig et al. 1995). Some species are also sought after for the aquarium trade; those are discussed further as part of a separate management unit species assemblage.

There are no species of surgeonfish endemic to any of the management areas considered in this plan, although *A. triostegus sandvicensis* in Hawaii is recognized as an endemic subspecies. Also, *Zebrasoma flavescens* has a distribution from the North Pacific to southern Japan, but it is abundant only in Hawaii. Twenty-three species of surgeonfish are found in Hawaii (Randall 1996), 39 species in Micronesia (Myers 1991), and 32 species in Samoa (Wass 1984).

Generally, acanthurids are diurnal herbivores or planktivores. All acanthurids shelter on the reef at night. *Acanthurus thompsoni, Naso annulatus, N. brevirostris, N. caesius, N. hexacanthus,* and *N. maculatus* feed primarily on zooplankton well above the bottom. *Naso lituratus* and *naso unicornis* browse mainly on leafy algae such as *Sargassum* (Randall 1996).

Surgeonfishes commonly defend territories that are primarily feeding territories; among three different species studied (*Acanthurus lineautus, A. leucosternon,* and *Zebrasoma scopas*), it was noted that each occupied characteristic depth zones and habitat types (Robertson et al. 1979).

Schooling behavior is common in acanthurids, particularly in association with spawning aggregations. Biologists have documented trains of surgeonfishes traveling along the reef to join thousands of other surgeonfish at spawning aggregation sites. Once there, the fish mingle near the substrate and slowly move upward as a group. Near dusk, small groups (6-15 individuals) of fish make spawning rushes to near the water surface and release gametes. Following spawning, fish return to the substrate, form trains, and return to their home reefs. Many species also form large single-species or mixed-species schools,

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[1] *A . dussumieri*-32,407 lbs, *A. triostegus*-11,705 lbs, *Naso* spp.-9969 lbs, *A. xanthopterus*-5,234 lbs, *A. olivaceous*-4,813 lbs, and *Ctenochaetus strigosus*-3,776 lbs .

apparently for overwhelming territorial reef fish to feed on the algal mats they are protecting. In *Acanthurus nigrofuscus*, for example, such schools may number in the thousands, and the fishes may migrate as much as 500 to 600 m daily to reach the feeding grounds (Fishelson et al. 1987).

Acanthurid eggs are pelagic, spherical, and small, 0.66-0.70 mm in diameter with a single oil droplet to 0.165 mm for *Acanthurus triostegus sandvicensis* (Randall 1961). For that species, hatching occurred in about 26 hours. Watson and Leis (1974) found an egg size of 0.575 to 0.625 mm in diameter for an unidentified acanthurid from Hawaii. Like other coral reef fishes, surgeonfish larvae are typically less abundant in samples taken from the water column near the reef than they are in samples from offshore (Miller 1973). Surgeonfish larvae are primarily found well offshore at depths from 0-100m.

Although surgeonfish generally settle at a larger size than most reef fish, acanthurids are one of the families with juveniles that settle with larval characters still present (Leis & Rennis 1983). Late phase larvae actively swim inshore at night, seek shelter in the reef, and begin the transformation to juveniles (Clavijo 1974). Juvenile surgeonfish have been reported to shelter in tide pools in Hawaii (Randall 1961).

Adult surgeonfish are found in many coral reef habitat types, including mid-water, sand patch, subsurged reef, and seaward or surge zone reef. The largest number of surgeonfish species are typically found in the subsurge reef habitat, which are defined by Jones (1968) to be areas of moderate to dense coral growth corresponding to the subsurge portions of fringing reefs, deepwater reef patches, reef filled bays, and coral-rich parts of lagoons inside of atolls. These species are typically found between 0-30m depth, although surgeonfish do live in depths from 0-150m. Some species of *Naso* have been seen below 200m (Chave & Mundy 1994).

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Acanthurid assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Appendix IV, Part 1.

Given the pelagic nature of the egg and larval phases of acanthurids, and their subsequent wide distribution, EFH for these life stages of this management unit is designated as extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fm. For juvenile and adult acanthurids, because of their varied habitat preferences, EFH is designated as all bottom habitat and the adjacent water column from 0 to 50 fm.

EFH for Triggerfish (Balistidae)

The triggerfishes are named for an ability to lock their large, thickened first dorsal spine in an upright position, which can be released only by pressing down on the second dorsal spine (the trigger). When alarmed, or at night, they wedge themselves into a hole in the reef or rocks by erecting the first dorsal spine and pelvic girdle. During the day, most are carnivores of a wide variety or benthic animals including crustaceans, mollusks, sea urchins, other echinoderms, coral, tunicates, and fishes. Some feed largely on benthic algae and zooplankton, including *M. niger* and *M. vidua*, while *Xanthichthys auromarginatus* and *X. mento* feed mainly on zooplankton. Triggerfishes are usually solitary except when they form pairs at spawning time, although the black durgon, *Melichthys niger* may form large aggregations. Eleven species are known from the Hawaiian islands. At least 20 species occur in Micronesia, and at least 16 species occur in Samoa. The range of the family is circumglobal, with some species (e.g., the clown triggerfish, *Balistoides conspicillum*) extending into temperate waters (to South Hokkaido, Japan [Myers 1991]).

The habitat preferences for the family are variable, and may include protected lagoons, high-energy surge zones, ledges and caves of steep dropoffs, sand bottoms, and rocky coral areas (Myers 1991). Preferences may vary from species to species, or may change within a given species depending on the life phase. Of the eleven known Hawaiian species, one (*Canthidermis maculatus*) is strictly pelagic (Randall 1996), rather than reef-associated (and is thus not considered as part of this management unit assemblage). Depth preferences are also variable. Some species frequent the shallow subtidal zone, while others are known only from fairly deep waters (e.g., *Xanthichthys caeruleolineatus*, 75-200 m; Myers 1991). Many species are collected for aquariums; the clown triggerfish *Balistoides conspicillum* is among the most highly prized aquarium fishes.

Balistids produce demersal eggs that may or may not be tended by a parent, usually the female. Unlike most other families of reef fishes, the balistids exhibit extensive maternal care of eggs. This could be related to a harem-based social structure that requires the male to vigorously defend his territory from other males. Balistid eggs are spherical, slightly over 0.5 mm in diameter, and translucent. Eggs are typically deposited in shallow pits excavated by the parents as an adhesive egg mass containing bits of sand and rubble. Triggerfish eggs hatch in as little as 12 hours and no more than 24 hours. The pelagic larval stage can last for quite a while, and some species reach a large size before settling to the bottom. Several species of *Melichthys* can reach as much as 144 mm before settling (Randall 1971, Randall & Klausewitz 1973). Prejuveniles are often associated with floating algae, and may be cryptically colored. Berry and Baldwin (1966) suggested that sexual maturity of *Sufflamen verres* and *Melichthys niger* occurs at approximately half maximum size, at an age of a year or more.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Balistidae assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Appendix IV, Part 1.

For the pelagic larvae of balistids, EFH is designated to include the shoreline to the outer boundary of the EEZ to a depth of 50 fm. For eggs, EFH is designated as the water column and all rocky or gravelly bottom areas from 0–50 fm. For adults and juveniles, EFH is designated as all bottom habitat and the adjacent water column from 0 to 50 fm.

EFH for Gray Reef Shark (*Carcharhinus amblyrhynchos*; Carcharhinidae)

The Carcharinidae are one of the largest and most important families of sharks, with many common and wide-ranging species found in all warm and temperate seas. They are the dominant sharks in tropical waters in variety, abundance, and biomass. Most species inhabit tropical continental coastal and offshore waters, but several species prefer coral reefs and oceanic islands.

The gray reef shark (*Carcharhinus amblyrhynchos*) is distributed in tropical waters across the Indo-Pacific from the Red Sea eastward as far as Hawaii. It is often associated with coral reefs, and is one of the species most likely to be encountered by scuba divers. As with other sharks, the eggs of the gray reef shark develop internally. Thus there are no planktonic egg or larval phases. The gestation period for *C. amblyrhynchos* is about 12 months, with from 1-6 pups being produced in a litter. DeCrosta et al. (1984) reported maximum ages from a sample of 30-65 specimens to be 10 years, but Myers (1991) states that sexual maturity is only reached at around 7 years of age, and that the species may live up to 25 years.

Juvenile sharks frequently inhabit inshore areas such as bays, seagrass beds, and lagoon flats before moving into deeper water as they mature. Adult sharks prefer steep outer reef slopes and dropoffs, and the species has been reported from shallow waters to depths of 274 meters (Myers 1991). Adults may move back into shallow inshore areas during mating or birthing events. Some species forage in these shallow areas as well. Reef-associated sharks range widely and are found in a variety of coral reef habitats. Adult female *C. amblyrhynchos* have been reported to aggregate seasonally over shallow reef areas in the Northwestern Hawaiian Islands.

EFH for adult and juvenile *Carcharhinus amblyrhynchos* is designated as all bottom habitat and the adjacent water column from 0 to 50 fathoms. Since eggs and developing young are carried internally, no separate EFH designation for eggs or larvae is applicable.

EFH for Soldierfish/Squirrelfish (Holocentridae)

Holocentrids are spiny, deep-bodied, usually red fishes with large eyes and mouth, small teeth, large coarse scales, and stout dorsal and anal fin spines. The soldierfish genera *Myripristis, Plectrypops, Pristelepis, Ostichthys*, and the squirrelfish genera, *Neoniphon* and *Sargocentron,* are represented throughout the Indo-Pacific. Soldierfishes and squirrelfishes are nocturnal predators; soldierfish predominantly feed on large zooplankton in the water column, while squirrelfish prey mainly on benthic crustaceans, worms, and small fishes. Most holocentrids prefer low-light environments, and during the day hover along dropoffs, in or near caves and crevices, under rocky or coral overhangs, or among branching corals.

Depth ranges for the various holocentrid species are reported from shallow water down to an average of approximately 40 m, but with some species occurring as deep as 235m. About 17 holocentrid species inhabit Hawaiian waters. At least 13 species of soldierfishes and 16 species of squirrelfishes occur in Micronesia. At least 31 holocentrid species are found in Samoan waters. *Myripristis amaena* is particularly important in the recreational fishery at Johnston Atoll where it is the species caught in greatest abundance (Irons et al. 1990). It is common in reef fish catches throughout the Hawaiian archipelago.

Little is known about embryonic development and larval cycles in this group. After fertilization, pelagic eggs are distributed in the water column for an indeterminate period of time. Both eggs and larvae are subject to advection by ocean currents. The larval stage is believed to last for several weeks, at the end of which the larvae settle down in refugia on the reef.

Holocentrids are slow growing, late maturing, and fairly long lived. A study (Dee and Parrish 1993) on the reproductive and trophic ecology of *Myripristis amaena* found that sexual maturity for both sexes was reached between 145 and 160 mm SL at about 6 yrs of age. Longevity was determined to be at least 14 years. Fecundity was relatively low, fewer than 70,000 eggs in the most fecund specimen, and increased sharply with body weight. Spawning peaked from early April to early May, with a secondary peak in September. The diet of *M. amaena* was mainly meroplankton, especially brachyuran crab megalops, hermit crab larvae, and shrimps, but also a variety of benthic invertebrates and fishes.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Holocentridae assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Appendix IV, Part 1.

In light of the uncertainties about distribution of eggs and larvae of the Holocentridae, EFH for these stages is designated under the Coral Reef Ecosystem FMP as the water column extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fm. EFH for holocentrids in the juvenile and adult stages is designated as all rocky and coral areas and the adjacent water column from 0 to 50 fm. Because caves, crevices and overhangs serve as the primary sheltering habitat for all species of the family Holocentridae, these areas are particularly important habitat.

EFH for Flag-tails (Kuhliidae)

The flagtail family is comprised of the single genus *Kuhlia*, distributed throughout the Indo-Pacific region. The flagtails are ordinary-looking silvery fishes, usually with banded tails. The Hawaiian flagtail, or 'aholehole (*Kuhlia sanvicensis*), is an endemic species that is much prized as a food fish. 'Aholehole form dense schools by day, often in areas of heavy surge, where they are safe from predators; at night the schools disperse to feed on plankton. Young 'aholehole are often found in tidepools. 'Aholehole may enter brackish and even fresh water areas (Hoover 1993).

Kuhlia marginata is found on Johnston Island and in Micronesia., while *K. mugil* has a wide Indo-Pacific distribution (Myers 1991). *K. rupestris* is a brackish-water species from Guam (Randall 1996).

No information on the egg and larval stages of this species is available so a conservative designation for EFH for these stages was made, from 0-50 fm from the shoreline to the limits of the EEZ. Because adult and juvenile flagtails are generally found in very shallow waters, EFH for this management unit is designated as all bottom habitat and the adjacent water column from 0 to 25 fm.

EFH for Rudderfishes (Kyphosidae)

Rudderfishes, or sea chubs, are shore fishes that occur over rocky bottoms or associated with coral reefs along exposed coasts. They are distributed throughout the tropical and sub-tropical Indo-Pacific from Easter Island westward to the Red Sea (Tinker 1978). Adults of species in the genus *Kyphosus* typically swim in schools several meters above the bottom, and are reported to feed on a variety of algae including filamentous Rhodophyta and coarse Phaeophyta such as *Sargassum* (Myers 1991). Three species occur in Hawaii, Micronesia, and Samoa: *Kyphosus bigibbus, K. cinerascens*, and *K. vaigiensis*. Another species, *Sectator ocyurus* has been reported in Hawaii, but is rare and may be a waif from the tropical eastern Pacific. *K. cinerascens* may occur at least to 24 m depth.

Very little is known about reproduction in the kyphosids. The eggs are spherical, pelagic, and 1.0-1.1 mm in diameter (Watson and Leis 1974). The larvae hatch at 2.4–2.9 mm. Eggs and larvae are both subject to advection by ocean currents. The largest pelagic specimen, a juvenile, examined by Leis and Rennis (1983) was 56 mm. Juvenile individuals may be carnivorous for a while before becoming herbivorous (Rimmer 1986). Juveniles often occur far out at sea beneath floating debris.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Kyphosidae assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Appendix IV, Part 1.

The scant information available for the developmental life history for eggs, larvae and juveniles for this family indicates that these stages usually occur in the upper layer of pelagic waters. EFH for these stages is designated to extend from the shoreline to the outer boundary of the EEZ to a depth of 50 fm. Because adults are almost always found in very shallow inshore waters, EFH is designated all rocky and coral bottom habitat and the adjacent water column from 0 to 15 fm.

EFH for Wrasses (Labridae; including Napoleon [*Cheilinus undulatus*])

The Labridae comprise a large family, second only to the Gobiidae for number of species in the Western Pacific. It is a very diverse family in size and body shape, with adult sizes ranging from less than 5 cm in *Wetmorella albofasciata* to greater than 229cm in the Napoleon, *Cheilinus undulatus*.

Labrids are shallow-water fishes closely associated with coral reefs or rocky substrate, though some species of *Bodianus* occur deeper than 200 m (Smith 1986, Chave & Mundy 1994), and the razorfishes, *Xyrichtys* and *Cymolutes* spp., occur on sand flats (though densities of these two genera tend to decline with distance from coral reefs;). Labrids are diurnal, and at night many bury themselves in the sand, seek refuge in holes and cracks of the reef, or lie motionless on the bottom. During the day, labrids keep close to coral or rocky cover, darting into refugia in the reef or burying themselves in the sand when danger approaches. Labrids can be found in virtually all coral reef habitats, including rubble, sand, algae, seaweeds, rocks, flats, tidepools, crevices, caves, fringing reefs, patch reefs, lagoons and reef slopes (Myers 1991, Randall 1993, Green 1996). Schooling behavior and excursions away from the reef into the water column are usually associated with reproduction (Thresher 1984). The degree of association with reef habitat varies for different species; many members of the family have large home ranges encompassing a wide variety of habitats (Green 1996). In general, many of the smaller species stay confined to very small areas of the reef, while larger species have bigger home ranges (Green 1996). However, even very large species such as *Cheilinus undulatus* return to favored holes or crevices to spend the night or to escape danger (Myers 1991).

The geographic range of the family as a whole includes shallow tropical and temperate seas of the Atlantic, Pacific, and Indian Oceans. Labrids are found throughout shallow areas in the Western Pacific, and include 96 known species in Micronesia (Myers 1991), and 43 species in Hawaii. Fourteen species of wrasses are endemic to Hawaii: *Anampses chrysocephalus*, *Anampses cuvier*, *Bodianus sanguineus*, *Cirrhilabrus jordani*, *Coris ballieui*, *Coris flavovittata*, *Coris venusta*, *Cymolutes lecluse*, *Labroides phthirophagus*, *Macropharyngodon geoffroy*, *Stethojulis balteata*, *Thalassoma ballieui*, *Thalassoma duperrey*, and *Xyrichtys umbrilatus* (Randall 1996). The Hawaiian population of another species, *Bodianus bilunulatus albotaeniatus*, is recognized as a subspecies (Randall 1996). No wrasse species are reported to be endemic to American Samoa (Wass 1984). There are no important species of introduced wrasses to the Western Pacific.

There is generally a dearth of information on the life history parameters of age, growth, and mortality of many coral reef fishes, including labrids, and what information exists for some species cannot realistically be applied to the whole family.

Many species migrate to prominent coral or rock outcrops for spawning, including species of *Thalassoma*, *Halichoeres*, *Choereodon*, *Bodianus*, and *Hemigymnus* (Thresher 1984). Sandy areas are necessary for the sand-dwelling labrids, *Xyrichtys spp.* and *Cymolutes spp.* Labrid eggs are pelagic, spherical, 0.45 to 1.2 mm in diameter, lightly pigmented if at all, and usually contain a single oil droplet (Leis & Rennis 1983, Thresher 1984, Colin & Bell 1991). Larvae hatch at 1.5-2.7 mm and have a large yolk sac, unformed mouth, and unpigmented eyes (Leis & Rennis 1983). Both eggs and larvae are dispersed by ocean currents. Victor (1986) measured the duration of the larval phase of twenty four species of wrasses in Hawaii and found a range of 29.5 days (*Anampses chrysocephalus*) to 89.2 days (*Thalassoma duperrey*), although he noted substantial variability within species, up to a standard deviation of 11 days for some wrasses. Victor (1986) and other authors (Miller 1973, Leis & Miller 1976) have noted that despite their abundance as adults in the nearshore fauna of coral reef habitats, labrid larvae are conspicuously absent from nearshore samples, and common in offshore samples. Some labrid larvae are routinely found in the open ocean (Leis & Rennis 1983).

Like adult wrasses, juvenile labrids inhabit a wide variety of habitats from shallow lagoon flats to deep reef slopes. Green (1996) reported that *Labroides dimidiatus* and *Thalassoma lunare* use deeper reef slope and reef base habitats as recruits, and shallower habitats as adults. Examples of ontogenetic shifts in habitat use are not widely reported for the family, although relatively few studies have examined the topic.

Labrids have some importance as a minor component of the catch of commercial fishermen in Hawaii, according to Division of Aquatic Resources catch statistics from 1991-1995. Two species are present in the top 25 inshore fish species by weight – 4159 lbs of *Bodianus bilunulatus* and 3955 lbs of *Xyrichthys pavo* (Table 15 in Friedlander 1996). Some wrasse species are caught for the aquarium trade, including *Pseudocheilinus octotaenia*, *Cirrhilabrus jordani*, *Thalassoma* spp., *Anampses chrysocephalus*, *Macropharyngodon geoffroy*, and *Novaculichthys taeniourus*, but wrasses are a small portion of the trade in numbers and value (Pyle, pers. comm). In American Samoa, labrids comprise less than 3% of the reef fish catch (Dalzell et al. 1996), while in Guam, Labridae made up 7.3 percent of total landings by weight of the small-boat based spearfishing landings between 1985-1991 (Table 63 in Green 1997). Other studies (Katnik 1982, Dalzell et al. 1996) reported that labrids composed approximately 4% of the reef fish catch in Guam. Data on labrids from other sites in the region are either too general to be useful, or lacking.

EFH for Napoleon (*Cheilinus undulatus*)

Within the Labridae, the Napoleon wrasse, *Cheilinus undulatus*, merits special consideration because of its importance as a target species and because its populations, under pressure through overfishing have been declining rapidly. Once an economically important species on Guam, *C. undulatus* is now rarely seen on the reefs, much less reported on the inshore survey catch results (Hensley and Sherwood 1993). Similar declines in the number of sightings are reported from Saipan (Green 1997). Spearfishing, particularly at night when wrasses are more exposed and vulnerable, has significantly decreased the numbers of this very large reef fish. They are sought after despite accounts of ciguatera poisoning (Myers 1991). A description for the species as it occurs in Micronesia follows (Myers 1991):

The humphead is among the largest of reef fishes. Adults develop a prominent bulbous hump on the forehead and amazingly thick fleshy lips. Adults occur along steep outer reef slopes, channel slopes, and occasionally on lagoon reefs, at depths of 2 to at least 60m. They often have a "home" cave or crevice within which they sleep or enter when pursued. Juveniles occur in coral-rich areas of lagoon reefs, particularly among thickets of staghorn *Acropora* corals. The Napoleon is usually solitary, but occasionally occurs in pairs. It feeds primarily on mollusks and a wide variety of other well-armored invertebrates including crustaceans, echinoids, brittle stars, and starfish, as well as on fishes. It is one of the few predators of toxic animals such as the crown-of-thorns starfish, boxfishes, and sea hares. The thick fleshy lips appear to absorb sea urchin spines, and the pharyngeal teeth easily crush heavy-shelled gastropods like *Trochus* and *Turbo*. Much of its prey comes from sand or rubble.

Cheilinus undulatus ranges across the Indo-Pacific from the Red Sea to the Tuamotus, as far north as the Ryukyus, and south to New Caledonia. Though rare, the species can be found throughout Micronesia, and also in American Samoa.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Labridae assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Appendix IV, Part 1.

As indicated above, eggs and larvae of labrids are subject to wide dispersal by ocean currents. Similarly, adult labrids may occur over and utilize a wide range of habitat types that extend beyond the physical boundaries of coral reefs. Thus, EFH for all life stages in the Labridae is designated as the water column and all bottom habitat extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.

In light of the continued extreme vulnerability of the Napoleon to overharvesting, it is critical that its preferred habitats are protected so that there may be some opportunity for populations of the species to recover to healthier levels. Thus, cave environments that are known (past or present) habitat for adult napoleon wrasse, and *Acropora* beds that may provide suitable habitat for juvenile napoleon wrasse, are particular valuable habitat for this species.

EFH for Emperors (Lethrinidae)

Lethrinids are a group of bottom-dwelling fishes found inhabiting coastal waters, including coral and rocky reefs, sandy bottoms, seagrass beds and mangrove swamps. They are of varying importance in commercial, recreational and artisanal fisheries throughout the tropical Pacific (Carpenter and Allen 1985). Emperors are taken primarily with handlines, droplines, longlines and traps. Lethrinids are important recreational target species in some countries, although some species of lethrinids are reported to be ciguatoxic (Carpenter and Allen 1989).

Lethrinids are relatively long-lived, with an average age range of 7 to 27 years. Lethrinid eggs are pelagic, spherical and colorless, possessing an oil globule and ranging in size from 0.68 to 0.83 mm in diameter. The eggs typically hatch within 21 to 40 hours after fertilization occurs. Newly hatched lethrinid larvae range in size from 1.3 to 1.7 mm.

Management requirements for two important commercially-fished lethrinid species, *Lethrinus amboinensis* and *L. rubrioperculatus*, are covered in the Bottomfish Management Plan. Both species are classes as belonging to the shallow- water bottomfish complex (0-100m). Among the other lethrinids that are closely associated with coral reefs are the mu, or Big-eye emperor (*Monotaxis grandoculis*), distributed throughout the Indo-Pacific, including Hawaii; *Lethrinus olivacèus,* the longnose emperor, found from the Red Sea to Samoa and throughout Micronesia; and the Smalltooth Emperor (*Lethrinus microdon*), found from the Red Sea to the Moluccas, and of limited distribution in Micronesia. Another species, *Lethrinus harak*, accounts for nearly 10 percent of the catch on lightly-fished reefs in Guam (Katnik 1982 in Green 1997).

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Lethrinid assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Appendix IV, Part 1.

EFH for lethrinid eggs and larvae is designated as waters from 0-50 fm from the shoreline to the limits of the EEZ. For adults and juveniles, EFH is designated as all bottom habitat and the adjacent water column from 0 to 50 fm.

EFH for Goatfish (Mullidae)

Goatfishes are important commercial fishes that are highly esteemed as food. All have a characteristic pair of long barbels at the front of the chin housing chemosensory organs, and the barbels are used to probe holes in the reef or nearby open sandy areas for benthic invertebrates or small fishes. Some species are primarily nocturnal, others are diurnal, and a few are active by day or night. Nocturnal species tend to hover in stationary aggregations or rest on coral ledges by day. In general, goatfishes are found in shallow waters, to depths of around 10m, but some species are reported from deeper waters (e.g., *Mulloides pfluegeri* at 110m [Myers 1991]; *P. porphyreus* at 140m [Randall 1996]).

There are 10 native species of goatfish known from Hawaiian waters, and one accidentally- introduced species from the Marquesas, *Upeneus vittatus*. Two species, *Parupeneus porphyreus* and *P. chrysonemus,* are endemic to Hawaii. Fifteen species are recorded from Micronesia. Thirteen species are recorded from Samoa.

Holland et al. (1993) conducted a study of the movements, distribution, and growth rates of *Mulloidichthys flavolineatus* by using tagging data. *M. flavolineatus* and *M. vanicolensis* were the most abundant mullids found in Hanalei Bay, Kauai (Friedlander et al. 1997). *M. flavolineatus* ranked second in overall mean biomass at 211g/100m^2, with an overall mean numerical density of 1.1 individuals/100m^2. *M. vanicolensis* had higher numbers in patch reef habitat, but the larger fish were present in reef slope habitat, indicating partitioning of habitat by size. *Parupeneus cyclostomus* was the rarest and most mobile of the mullids found in Hanalei Bay, with an overall mean density of 0.01 individuals/100m^2 or 2.02 g/100m^2. The largest individuals were seen in deeper reef slope habitat.

Schooling is common among the mullids, and group spawning and pair spawning have been documented for the family. An aggregation of 300 to 400 individuals was observed spawning at 21m depth off the coast of the U.S. Virgin Islands (Colin & Clavijo 1978). Groups of fish made spawning rushes about 2 meters above the bottom before releasing gametes.

Goatfish have pelagic eggs which are spherical, transparent, and non-adhesive with a single oil droplet. Egg diameters range from 0.63 to 0.93 mm and hatch within 3 days. Large size of larvae at settlement, and wide distribution, suggest that goatfish in general have a larval development period that lasts several weeks. Pelagic eggs and larvae are subject to advection by ocean currents. After settlement, juveniles take approximately one year to reach sexual maturity. Munro (1976) suggested that few live more than 3 years. In *P. porphyreus*, peak spawning occurs somewhere between December and July. Counts of nuclear rings on otoliths indicate a larval period of approximately 40-60 days. The juvenile phase involves rapid color changes, a lengthening of the gut, and an external change in shape. Fishes can mature sexually by about 1.25 years of age. Fecundity was estimated as 11,000 to 26,000 eggs per spawn. Adults in this species may live 6 years or longer (Moffitt 1979).

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Mullidae assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Appendix IV, Part 1.

EFH for the egg and larval stages of the mullids is designated as the water column extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fm. EFH for the juvenile and adult stages is designated as all rocky/coral and sand-bottom habitat and adjacent water column from 0 to 50 fm.

EFH for Mullets (Mugilidae)

The Mugilidae, or mullet family, includes silver-sided fishes that generally favor shallow nearshore waters. They can tolerate a wide range of salinities, are often found in brackish water, and occasionally even venture into fresh water. Traditionally, mullets have been an important food resource for people throughout the Western Pacific. Mullets generally feed over the reef or over sandy or mud bottoms. Three species of mullet occur in Hawaii: the common Striped mullet or 'ama'ama (*Mugil cephalus*), the Acute-jawed mullet or uouoa (*Neomyxus leuciscus*), and *Moolgarda engeli*, an introduced species that is proliferating at the expense of the more important striped mullet. At least 8 species in 5 genera are reported from Micronesia (Myers 1991). By weight, the striped mullet is ranked tenth among fish species caught inshore in Hawaii (DAR data in Green 1997), while acute-jawed mullet is the fourth most-important species caught at Johnston Atoll (1989-1990 data,Green1997).

Striped Mullet (*Mugil cephalus*): This species feeds over sandy or muddy bottoms in shallow water, filtering out fine algae and organic detritus material through the gills. Although reported to have circumglobal distribution in subtropical seas, there are no verifiable records in the literature of the occurrence of the species in Micronesia (Myers 1991), and it is possible that other species or subspecies may account for the reportedly wide distribution (Randall 1996).

Very little information is available concerning the distribution of eggs or larvae of mullets. (but presumably these stages are dispersed widely by ocean currents). Therefore EFH is designated as the water column from the shoreline to the outter limits of the EEZ to a depth of 50 fm. Because adult and juvenile mullets are reported to occur almost exclusively in very shallow nearshore waters, EFH for the species is designated as all sand and mud bottoms and the adjacent water column from 0 to 25 fm.

EFH for Octopuses (Octopodidae)

The octopods are mollusks of the class Cephalopoda. Several octopod species are found in the region, and at least two (*Octopus cyanea* and *O. ornatus*) are of some economic importance. While some octopods are known from at least 1,000 meters depth (FAO 1984), these deep-water species are not reef-associated. Reef-inhabiting octopods generally occur from the shallowest parts of the reef down to depths of around 50 m. They are bottom-dwelling species that usually occupy holes and crevices in rocks or coral areas; while they can swim rapidly if necessary (especially in escape swimming), octopuses usually avoid swimming in mid-water. In sandy areas, they may dig burrows or construct shelters built from scattered rocks. Octopods venture out of their dens in search of food, and may swim and crawl over the bottom to distances more than 100m from their holes. In Hawaii, *Octopus cyanea* forages during the day, and is known as "day squid", while *O. ornatus,* the "night squid", forages after dark (Kay 1979).

Octopods lay demersal eggs that are attached in clusters within rocky recesses on the reef. Some (e.g., large specimens of *Octopus cyanea*) may lay up to 700,000 eggs (Van Heukelem 1983). Embryonic development is considered "direct," that is, there is no larval phase. However, the degree of development at hatching may be related to the size of the egg. In those species with smaller eggs (<4mm), hatchlings are less-developed, and first go through a planktonic "paralarval" phase, before settling down to a benthic existence (Young and Harman 1989). Those species with larger eggs (around 17mm range) are typically more developed, and hatch immediately to a benthic stage. In *Octopus cyanea*, eggs are about 3mm in diameter. Newly-hatched juveniles are about 3mm long, and enter a planktonic stage, believed to last around 30-40 days. Similarly, *Octopus ornatus* has a juvenile, planktonic paralarval stage that measures less than 4mm in mantle length (Young and Harman 1989).

The following octopod species are known from Hawaiian waters: *Octopus cyanea, O. ornatus, Berrya hoylei* and *Scaeurgus patagiatus*. An additional three unnamed species are believed present (Young and Harman 1989). *Octopus hawiiensis,* an endemic species originally described in 1837, was only recently observed again in the islands (Hoover 1998). Octopus are a component of the incidental catch of the lobster-trap fishery in the Northwest Hawaiian Islands (WPRFMC 25 May 99). An unnamed species of octopus is known from Waianae, Oahu. It occupies burrows in sandy areas. The burrows have openings about the diameter of a thumb. It is not known whether the octopus digs the burrow, or simply occupies a burrow already dug by another animal (e.g., mantis shrimp). This octopus emerges from its burrow and mimics a flatfish (B. Carlson, pers. comm. 27 Aug 99).

On Tutuila Island, American Samoa, it was reported that octopus accounted for approximately five percent of the catch composition for the shoreline subsistence fishery (Craig et al. 1993). Octopus (*Octopus cyanea* and *O. ornatus*) are reef-associated species commonly taken as food in the Marianas (Myers 1997 in Green October 1997). *Octopus cyanea* was identified as a species found on the reef slope at Rota, and targeted for capture in the local fishery (Smith et al 1989). Octopus are considered a preferred catch item in Saipan (Micronesian Environmental Services, March 1997). Octopus, mainly *Octopus cyanea,* are considered the most sought-after unshelled mollusk.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Octopods assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS. See Appendix IV, Part 2.

Because some species of octopus have a pelagic paralarval phase that is subject to advection by ocean currents, EFH for this life phase is designated as the water column from the shoreline to the outer limits of the EEZ to a depth of 50 fm. The EFH for the adult and juvenile phase and for the demersal eggs of the octopods, is defined to include all coral, rocky and sand-bottom areas from 0 to 50 fm.

EFH for Threadfins (Polynemidae)

Threadfins are relatives of the mullets, named for their thread-like lower pectoral rays that are used as feelers which become relatively shorter with growth. Threadfins typically occur over shallow sandy to muddy bottoms, occasionally in fresh or brackish water. One species, *Polydactylus sexfilis,* or moi, occurs in Hawaii, where it is highly valued as a food fish. In Hawaii, it has become rare as a result of intense fishing pressure, and is currently being propagated in hatcheries for use in stock enhancement projects. The same species occurs in Micronesia. Two species occur in Samoa, *P. sexfilis* and *P. plebeius.* The family Polynemidae is distributed throughout the tropical waters of the Atlantic and Indo-Pacific Oceans.

P. sexfilis is a fast-growing species that inhabits turbid waters, and can be found in large schools in sandy holes along rocky shoals and high energy surf zones. In Kaneohe Bay, adults may be found on reef faces, in the depths of the inner bay and in shallow (2-4 m) areas with muddy sand bottoms (Lowell 1971). When moi were more abundant in Hawaii, airplane spotters used to locate large schools and direct net fishermen to the catch. Threadfins are also reported to prefer sandy and mud bottom habitats in Micronesia (Myers 1991).

Spawning takes place for 3-6 days per month and has been observed in Hawaii from June to September, with a peak in July and August (Ostrowski and Molnar 1997). Spawning may be year-round in very warm locations. Spawning occurs inshore and eggs hatch offshore within 14-24 hours depending on water temperature (May 1979). Eggs are small, averaging 0.75 mm in diameter with a large oil globule. Both eggs and larvae are subject to advection by ocean currents. Larvae are pelagic, but after metamorphosis they enter nearshore habitats such as surf zones, reefs, and stream mouths (Ostrowski and Molnar 1997). Young moi, from 150-250 mm long, are found from shoreline breakers to 100 m depth (Lowell 1971). Fishing for juvenile *P. sexfilis*, or moilii, has historically been an important recreational and subsistence seasonal fishery in Hawaii.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Polynemidae assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Appendix IV, Part 1.

EFH for the egg and larval stages of the polynemids is designated as the water column extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fm. EFH for the juvenile and adult stages is designated as all rocky/coral and sand-bottom habitat and the adjacent water column from 0 to 50 fm.

EFH for Bigeyes (Priacanthidae)

Priacanthids are nocturnal zooplanktivores that feed on larger zooplankton such as the larvae of crabs, fishes, polychaete worms and cephalopods. The family is distributed circumtropically and in temperate seas, but some species are limited to the Indo-Pacific or the Hawaiian islands. In Hawaiian waters, 4 species have been recorded: *Heteropriacanthus cruentatus*, the endemic *Priacanthus meeki*, and two deep-water species. In Micronesian waters, *H. cruentatus*, *P. hamrur*, and a deep species from over 200 m depth have been recorded. The shallow-water species are limited to 100 m or less. Five species are recorded from Samoan waters.

The glasseye, *H. cruentatus*, inhabits lagoon or seaward reefs from below the surge zone to a depth of at least 20m. During the day it is usually solitary or in small groups but may gather in large numbers at dusk prior to ascending into the water column for feeding.

Spawning by priacanthids has not been observed, but Colin and Clavijo (1978) reported seeing an aggregation of more than 200 individuals at a reef where many other species were spawning. The eggs of *Pristigenys niphonium* and *Priacanthus macracanthus* are pelagic, spherical, and 0.75 mm in diameter (Suzuki et al. 1980, Renzhai and Suifen 1982). The larvae hatch at 1.4 mm (Renzhai and Suifen 1982). The size of the largest examined pelagic larval specimen was 48 mm (Leis and Rennis 1983). Eggs and larvae are subject to advection by ocean currents. Caldwell (1962) reported a size at settlement for the deepwater subtropical species *Pristigenys alta* of 65mm.

Habits and habitat preferences for the family are similar to those of the holocentrids, in that these fishes prefer shaded overhangs, caves, and crevices on the reef during the daytime. At night, fishes may move out into the water column to feed, and some types are reported to feed over soft-bottom areas.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Priacanthid assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Appendix IV, Part 1.

Because the distribution of eggs and larvae of the Priacanthidae have not been thoroughly studied, a precautionary approach is required in establishing EFH for these stages. Therefore, EFH for priacanthid eggs and larvae is designated as the water column extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fm. EFH for priacanthids in the juvenile and adult stages is designated as all rocky/coral and sand-bottom habitat and the adjacent water column from 0 to 50 fm.

EFH for Parrotfishes (Scaridae, including Humphead Parrotfish (*Bulbometopon muricatum*)

Scarids inhabit a wide variety of coral reef habitats including seagrass beds, coral-rich areas, sand patches, rubble or pavement fields, lagoons, reef flats, and upper reef slopes (Myers 1991). They are prominent members in numbers and biomass of shallow reef environments. Scarids are chiefly distributed in tropical regions of the Indian, Atlantic, and Pacific Oceans.

Parrotfishes often occur in large, mixed-species schools which rove long distances while feeding on reefs. A few species are territorial, but the majority are roving herbivores, with the size of the home range increasing with the size of the fish. Choat and Robertson (1975) found that smaller, less mobile scarids are usually associated with cover such as *Acropora* growth. Open areas with large amounts of grazing surface harbor larger, more mobile, and school-forming scarids. Schooling behavior is common among the scarids, both for feeding and spawning.

Species endemic to Hawaii are: *Calotomus zonarchus*, *Chlorurus per spicillatus*, and *Scarus dubius*. Seven species of scarids can be found in Hawaii, 33 species in Micronesia, and 23 species in Samoa.

Scarids spawn in both pairs and groups. Group spawning frequently occurs on the outer slope of the reef in areas with high current speeds. Pair spawnings are frequently observed at the reef crest or reef slope at peak or falling tide. Scarids have been observed to undergo spawning migrations within lagoons and to the outer reef slope (Randall and

Randall 1963, Yogo et al. 1980, Johannes 1981, Choat and Randall 1986, Colin and Bell 1991). Some species are diandric, forming schools and spawning in groups often after migration to specific sites, while others are monandric, at times being strongly site-attached with haremic, pair spawning (Choat and Randall 1986). The pelagic eggs and larvae of scarids are subject to dispersal by ocean currents.

EFH for Bumphead Parrotfish (*Bolbometopon muricatum*)

The Bumphead parrotfish, *Bulbometopon muricatum*, merits special consideration because of its importance as a target species and because its populations, under pressure through overfishing, have been declining rapidly over much of its range. The Bumphead is a very large parrotfish (to 120cm and 75kg) that typically occurs in schools on clear outer lagoon and seaward reefs at depths from 1-30m. They are often located on reef crests and fronts. In unfished areas they may enter outer reef flats at low tide. The Bumphead is very wary in the daytime but sleeps in groups on the reef surface at night, making it an easy target for spearfishermen. As a result, it has nearly disappeared from most of Guam's reefs. Johannes (1981) cites an example of Bumpheads changing the location of their sleeping site away from the shallow reef flat to the deeper reef slope in Palau in response to increasing nighttime spearfishing. Their range is Indo-Pacific, although they are not found in the Hawaiian Islands. On the Great Barrier Reef, fish of less than 400mm are thought to have different habitat requirements from larger fish, since these smaller fishes are not seen on outer reefs (H. Choat, personal communication).

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Scarid assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Appendix IV, Part 1.

As indicated above, eggs and larvae of scarids are subject to dispersal by ocean currents. Similarly, adult scarids may occur over and utilize a wide range of coral and other shallow-water habitat types. Thus, EFH for all life stages in the Scaridae is designated as the water column and all bottom habitat from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.

In light of the continued extreme vulnerability of the Bumphead parrotfish to overharvesting, it is critical that its preferred habitats be protected so that there may be some opportunity for populations of the species to recover to healthier levels over time. At present, little information is available regarding the specific habitat requirements of this species. Further research is thus needed to better understand the habitat requirements of the Bumphead parrotfish so that appropriate Habitat Areas of Special Concern can be designated, and other management measures initiated, to better protect this species.

EFH for Groupers (Serranidae)

The Serranidae includes the groupers (Subfamily Epinephelinae), large-mouthed bottom-dwelling fishes that occupy a wide range of habitats from the shoreline to depths of 200m or more. In some species, individuals may attain weights of 100 kg or more. The larger species are highly vulnerable to depletion in overfished areas; due to sequential hermaphroditism in their life cycles, once larger individuals of a reef are harvested, only small or immature females may remain, requiring recruitment or in-migration of stocks from less exploited areas to revitalize depleted populations.

Larger groupers are much-prized for human consumption, and are the primary target species for the controversial live-fish trade supplying restaurants in the Orient. This industry has severely depleted stocks in the Philippines, and Indonesia, Palau, Papua New Guinea, and the Solomon Islands face similar threats (Johannes and Riepen 1995 in Green 1997). Large individuals may be much reduced in numbers, or totally absent, from overfished reefs. Sightings of large groupers in Guam are rare.

Grouper eggs are small (<1mm) and pelagic. The planktonic larval stage may last up to several weeks in widely-distributed species (Myers 1991). During the day, grouper larvae tend to avoid surface waters. At night they are more evenly distributed vertically in the surface water column. During the winter months larvae of most species are much less abundant. Very little is known about the food habits of serranid larvae. What is known is based on limited laboratory data. More research is needed on all aspects of the early life history of groupers, including feeding, growth and survival; ecology of early life history stages around oceanic islands; year-to-year variation in spatial and temporal patterns; and return of young stages to adult habitat from the pelagic larval habitat (WPRFMC 1988).

Reef-associated groupers typically are found hiding under ledges or in crevices on lagoon and seaward-facing reefs or along drop-offs, at depths ranging from 1 m to greater than 150 m. The prominent reef-associated species in Hawaii are *Seriola dumerili* and the hapu'u, or Hawaiian black grouper *Epinephelus quernus*. *E. quernus* is endemic to Hawaii and Johnston Island (Heemstra and Randall 1993). Both species are discussed in the WPRFMC Bottomfish FMP,[2] but are known to also be reef-associated (Friedlander 1996). Adults of the latter species occur in deeper waters in the MHI than in the NWHI. The Peacock grouper, *Cephalopholis argus* has been introduced to Hawaii from French

[2] Other grouper species treated in the Bottomfish FMP include *Epinephelus fasciatus* (Blacktip grouper) and *Variola louti* (Lunartail grouper).

Polynesia. Accounts of past captures of very large groupers (350 to 554 pounds) suggest that Giant groupers (*Epinephelus lanceolatus*) were, and possibly still are, present in the islands (Hoover 1993). At least 43 species in 9 genera of groupers occur in Micronesia (Myers 1991). Approximately 12 species are reported for American Samoa (Green 1996).

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for serranid assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Appendix IV, Part 1.

Because eggs and larvae are subject to advection by ocean currents, EFH for these stages is designated as the water column from the shoreline to the outer limit of the EEZ to a depth of 50 fm. For adults and juveniles, EFH is designated as all bottom habitat and the adjacent water column from 0 to 50 fm Additional EFH for selected species is designated under the Bottomfish FMP.

EFH for Baracudas (Sphyraenidae)

The barracudas, all in the single genus *Sphyraena*, are top-level carnivorous fishes that feed mainly on other fishes. Some species are primarily diurnal, while others are nocturnal. Species such as *Sphyraena helleri* school in large groups during the day, but disperse at night to feed. *Sphyraena barracuda* is typically a solitary diurnal predator. In Hawaiian waters, these are the only two species positively recorded. In Micronesian waters, at least 6 species occur. In Samoan waters, at least five species occur.

Juvenile *S. barracuda* occur among mangroves and in shallow sheltered inner reef areas. Adults occur in a wide range of habitats ranging from murky inner harbors to the open sea. *S. forsteri, S. acutipinnis, S. novaehollandiae*, and *S. obtusata* are all schooling barracudas that occur over lagoon and seaward reefs. *S. forsteri* is reported to occur on outer reef slopes to a depth of 300m (Myers 1991). *S. genie* is a larger schooling barracuda that frequently schools within defined territories on submarine terraces and is most often caught at night by trollers in Micronesia. In general, barracudas may be found in almost any tropical marine habitat, including within lagoons and mangrove areas, over coral reefs or sand or mud bottoms, or off of deep outer reef slopes.

Barracudas migrate to specific spawning areas, often in very large numbers at reef edges or in deeper water. The eggs are pelagic, spherical, and range in diameter from 0.7-1.5 mm with a single clear or yellow oil droplet. Eggs hatch within 24-30 hours. Both eggs and larvae may be carried for long distances by ocean currents. Larvae begin to feed within 3 days on small copepods. Larger larvae voraciously feed on zooplankton and other fish larvae. Settlement typically occurs at a length of 18 mm, but *S. barracuda* larvae occasionally drift in the ocean for an indefinite period of time, usually associated with floating debris or algae, developing all the characteristics of juveniles and sometimes attaining large sizes before being delivered inshore. Newly settled juveniles are piscivorous.

Because eggs and larvae of barracudas are subject to wide dispersal by currents, and since the adults may occur over virtually any bottom type, EFH for all life stages in the Sphyraenidae is designated to extend from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.

Aquarium Taxa/Species Habitat

Within the jurisdictional waters of the WPRFMC, Hawaii is the main site where commercial collection and sale of coral reef fishes and invertebrates for the aquarium trade is occurring. On Guam, commercial collection at present is quite limited (only one commercial operation is involved in the export of live aquarium fish). On American Samoa, commercial collection of aquarium fishes is allowed by permit, but presently there are no commercial aquarium fish operators. In CNMI, the commercial export of live aquarium fishes is prohibited. No aquarium fish collecting occurs on other U.S. Pacific islands, since these islands are either National Wildlife Refuges or are in use by the military (Green 1997).

Because Hawaii is the area where most commercial harvesting of aquarium species occurs, the aquarium MUS complex is based primarily on those species known from Hawaiian waters. While the descriptions that follow give general information about the distribution of aquarium taxa across the region, EFH is defined primarily on the basis of the occurrence of taxa in Hawaii.

The "Aquarium Species/Taxa"grouping, does not represent a taxonomically related cluster of species. Nonetheless, the species contained in this MUS form a natural assemblage from the ecological standpoint, since most are found in similar habitat, primarily being closely associated with shallow coral areas.[3]

A. Surgeonfishes (Acanthuridae)

[3] One exception is the feather-duster worm, a sessile benthic invertebrate that occupies sandy or rubble bottom areas. The species is nonetheless included as part of the aquarium assemblage because of its commercial importance as a harvested aquarium species.

Surgeonfishes are among the most common families found on Indo-Pacific coral reefs. They are primarily herbivores and planktivores. The larval period is long, up to around 2.5 months (Randall 1961). Surgeonfish larvae are primarily found well offshore at depths from 0-100m. Like other common adult members of the coral reef fish community, surgeonfish larvae are typically less abundant in samples of the water column near the reef than they are in samples from offshore (Miller 1973). Presumably, the prolonged pelagic larval period contributes to the wide distribution of species in this family. Although surgeonfish larvae generally settle at a larger size than most other reef fish, acanthurids are one of the families wherein juveniles settle with larval characters still present (Leis & Rennis 1983). Late-phase larvae actively swim inshore at night, and seek shelter on the reef. Surgeonfishes have relatively long life spans, up to as much as 40 years (Dalzell et al. 1996).

Yellow tang (*Zebrasoma flavescens*): Although widely distributed in the Indo-Pacific, this species is only abundant in Hawaii. The yellow tang is a popular aquarium fish that represents more than 75% of all aquarium animals caught statewide (Clark and Gulko 1999). They occur singly or in loose groups on coral-rich areas of lagoon and seaward reefs from below the surge zone to at least 46 m depth. Juveniles tend to hide among branches of finger coral, while adults graze near the shore in calm areas.

Z. flavescens tends to prefer the leeward sides of islands (Brock 1954), particularly areas of dense coral growth of *Pocillopora damicornis* and *Porites compressa*. It feeds on algae growing exposed on basalt and dead coral heads, as well as in crevices and interstices of the reef that it can reach with its long, thin snout (Jones 1968).

Yellow-eyed surgeon fish (*Ctenochaetus strigosus*): Like the yellow tang, the yellow-eyed surgeon is distributed across the tropical Indo-Pacific, but is only common in Hawaii. Individuals are observed in coral-rich areas of deep lagoon and seaward reefs. In addition to its importance as an aquarium species, it is also a popular food fish.

Achilles tang (*Acanthurus achilles*): This fish is distributed only in the Pacific Islands. It is common in Hawaii and Polynesia, but rare in Micronesia. It is a territorial species that feeds on filamentous and fleshy algae. The Achilles tang is primarily found in the surge zone to a depth of 4 m.

B. Moorish idol (*Zanclus cornutus;* Zancildae)

The Moorish idol, sole member of this monotypic family, is ubiquitous in areas of hard substrate, from waters less than 1 m deep in turbid inner harbors and reef flats, to clear seaward reefs as deep as 182 m. It is often found in small groups but may sometimes occur in schools of as many as 100 or more individuals. The species has a long larval stage and settles at a large size, >6cm SL for some individuals. As a result, they are ubiquitous wherever hard substrate is found, from turbid inner harbors to clear seaward reefs. They feed mainly on sponges, but will also take other invertebrates and algae. Their range is the Indo-Pacific and tropical eastern Pacific, and they are found throughout the jurisdiction. They are a popular aquarium fish.

C. Angelfishes (Pomacanthidae)

Angelfishes are indisputably among the most beautiful and popular of all aquarium fishes, in many cases commanding very high prices. Six species are found in Hawaiian waters, and four of them are endemic: *Centropyge fisheri, Centropyge potteri, Desmoholacanthus arcuatus,* and *Genicanthus personatus*. At least 26 species occur in Micronesia, and at least 11 species occur in Samoa.

Pomacanthid eggs are small, spherical, nearly transparent, and contain from one to several oil droplets. Hatching occurs within 24 hours after release (Thresher 1984). Feeding by the larvae begins within 2-3 days and settlement to the bottom occurs between 17-39 days (Moe 1977, Allen et al. 1998).

Adult angelfishes require suitable shelter in the form of boulders, caves, and coral crevices. Most species occur from 2 to 30 m depth, but a few such as *Centropyge narcosis* are found in waters over 100m deep. Angelfishes are territorial, and males frequently maintain a harem of 2-5 females and defend a territory ranging from a few square meters for some smaller species (e.g., *Centropyge*) to well over 1 sq km for some larger species (e.g, *Pomacanthus*).

Masked Angel (*Genicanthus personatus*): This Hawaiian endemic is more commonly found in the NWHI; it is rare in the main islands. Usually the species can be found feeding on plankton off of dropoffs at depths of at least 27.5 m and deeper (to around 65 m).

Angelfish (*Centropyge shepardi and C. flavissimus*): These are two of the prime target species for the aquarium trade, and are found on Guam. Shepard's angelfish (*C. shepardi*) is usually observed on outer reef slopes at depths between 18-56 m. The lemonpeel angelfish (*C. flavissumus*) inhabits areas of rich coral growth in shallow lagoons or on exposed seaward reefs to depths of 25 m or more.

D. Dragon Moray (*Enchelycore pardalis*; Muraenidae)

Morays, in the family Muraenidae, occur mostly in waters less than 30 m deep. There are 38 species of morays in Hawaii, second only to the wrasses for number of species.

Gymnothorax steindachneri is endemic to Hawaii. At least 53 species are known from Micronesia. At least 47 species are known from Samoa.

Eel eggs are pelagic, spherical, and relatively large, ranging from 1.8 to 4.0mm. Watson and Leis (1974) collected 145 eels eggs off Hawaii which ranged from 2.4 to 3.8mm. Brock (1972) found 200,000 to 300,000 ripe eggs in each of four 5.0 to 6.8kg *Gymnothorax javanicus*. Hatching of an unidentified 1.8mm muraenid egg took approximately 100 hours (Bensam 1966).

Eels have a characteristic leptocephalus larval stage: a long, transparent, feather-shaped larva that starts out at 5-10 mm and grows up to 200mm before settlement and metamorphosis. The duration of the planktonic stage is on the order of 6-10 months for muraenids (Eldred 1969, Castle 1965).

Both juvenile and adult eels inhabit cryptic locations in the framework of the reef, or in sand plains for some species. Some species remain so hidden within the reef that they have never been seen alive; their existence is known only from samples taken with the use of poisons. Many species emerge to feed and some may even slither over rocks and enter shallow tidepools. *Enchelycore pardalis*, the dragon moray, is a striking fish that is popular with aquarists, and may attain a length of around 1 m. It is distributed throughout the Indo-Pacific. Known in Hawaii as puhi kauila, it is more common in the NWHI than in the MHI.

E. Hawkfishes (Cirrhitidae)

Hawkfishes are small grouper-like fishes in the family Cirrhitidae. In Hawaii, there are 6 species recorded. At least 10 species occur in Micronesia, and at least 8 species occur in Samoa. The colorful species are popular aquarium fishes.

Eggs are pelagic, spherical, and approximately 0.5 mm in diameter. The development at hatching is unknown. A lengthy pelagic larval stage, probably lasting a few to several weeks (Randall 1963) is suggested by the widespread distribution and limited geographic variation of some species.

Adults typically inhabit rock, coral, or rubble of the surge zone, seaward reefs, lagoons, channels, rocky shorelines, and submarine terraces. Some are typically found on heads of small branching corals.

Longnose hawkfish (*Oxycirrhites typus*): The longnose hawkfish, *Oxycirrhites typus*, is a popular aquarium species that feeds mainly on zooplankton, and is usually seen perched on black coral or gorgonians at depths greater than 30 m. The fish is distributed throughout the Indo-Pacific from East Africa to the Americas. The fish is found and collected in Hawaii.

Flame hawkfish (*Neocirrhitus armatus*): This spectacular hawkfish is commonly found along surge-swept reef fronts and marine terraces to a depth of about 11m. It inhabits coral heads of various species, including *Stylophora mordax*, *Pocillopora elegans*, *P. edouxi*, and *P. verrucosa*. The species is distributed in the islands and coastlines of the Pacific plate, and is collected in Guam.

F. Butterflyfishes (Chaetodontidae)

Butterflyfishes are among the most colorful and conspicuous fishes on the coral reef. Many species are corallivores that feed on polyps of corals and other coelenterates. The corallivores tend to be territorial and limited to the shallower depth ranges of the corals that they feed upon (e.g., *Pocillopora meandrina*). Others feed heavily on benthic algae and small benthic invertebrates. Some species, including those of *Hemitaurichthys*, are primarily zooplanktivores which often occur in mid-water aggregations and range into relatively deep water.

Butterflyfish eggs are planktonic and hatch within two days. The duration of the planktonic stage is not well studied, but Burgess (1978) suggested it is likely to be at least several months. Settlement occurs at night and juveniles tend to occupy shallower, more sheltered habitats than adults. The family is represented in Hawaiian waters by 24 species; *Chaetodon fremblii, C. miliaris,* and *C multicinctus* are endemic to Hawaii, and *C. tinkeri* is found only in Hawaii and the Marshall Islands. The family is represented in Micronesian waters by at least 40 species, and in Samoan waters by 30 species. The yellow-crowned butterflyfish *C. flavocoronatus* is listed as a vulnerable species in Guam on the 1996 IUCN Red List.

Threadfin butterflyfish (*Chaetodon auriga*): This species is one of the most common butterflyfishes of areas of mixed sand, rubble, and coral, and typically occurs in shallow waters to a depth of 30m. It is distributed from the Red Sea eastward to Hawaii, and is taken as an aquarium fish in Hawaii and Guam.

Raccoon butterflyfish (*Chaetodon lunula*): This is a nocturnal species (possibly the only nocturnal butterflyfish) that inhabits lagoon and seaward reefs to depths in excess of 30m. It prefers rocky areas with high relief. Juveniles occur in shallows and tidepools. The species is distributed from East Africa to Hawaii, and is captured for use as an aquarium fish in Hawaii and Guam.

Black-backed butterflyfish (*Chaetodon melannotus*): This species occurs in areas where corals grow luxuriantly, and can be found in shallow waters to depths of over 15 m. The black-backed butterflyfish is found from the Red Sea to American Samoa; it is absent in Hawaii. It has some importance as an aquarium species in Guam.

Saddled butterflyfish (*Chaetodon ephippium*): The saddled butterflyfish is a relatively common inhabitant of lagoon and seaward reefs to a depth oaf around 30m. It prefers areas of rich coral growth and clear water. The species is distributed throughout the Central and Western Pacific, but is uncommon in Hawaii. It is captured for aquarium use in Hawaii and Guam.

G. Damselfishes (Pomacentridae)

The damselfishes are among the most abundant fishes on coral reefs. Most damselfishes occur in shallow water on coral or rock substrata, wherever there is shelter. The species of *Chromis, Dascyllus, Lepidozygus, Amblyglyphidodon, Neopomacentrus*, and *Pomachromis* are aggregating planktivores that often form large schools in the water column. Most members of *Abudefduf, Chrysiptera*, and *Pomacentrus* are omnivores that feed on benthic algae, small invertebrates, or zooplankton. *Plectroglyphidodon johnstonianus* feeds on coral polyps. Other members of *Plectroglyphidodon*, as well as members of *Stegastes*, are aggressively territorial herbivores. Algal feeders frequently cultivate algal mats which they weed of undesirable algae and aggressively defend from other reef inhabitants. The anemonefishes, subfamily *Amphiprioninae*, live in a symbiotic relationship with large sea anemones. No anemonefish are found in Hawaii both because of the absence of host anemones, and the short larval duration, which has apparently prevented distribution of viable larvae to such an isolated location.

Pomacentrid eggs are demersal, elliptical, and adhesive by means of a cluster of fine threads at one end of the egg. Eggs are kept in nests and aggressively guarded by the males. Egg diameters range from 0.49 - 2.3mm. Hatching occurs in 2-4 days for most species, but up to 2 weeks for anemonefish eggs. The planktonic larval stage typically lasts 2-3 weeks but may be longer. Thresher, Colin and Bell (1989) found larval durations for the following genera: *Amphiprion* and *Premnas*: 7-14 days, *Chromis* and *Dascyllus*: 17-47 days with most between 20-30 days, and genera in the subfamily *Pomacentrinae*: 13-42 days. Size at settlement ranges from 7 to 15mm, and several studies suggest that settlement occurs mainly at dusk and at night (Williams 1980, Nolan 1975).

Many damselfishes are suitable for use in aquaria. Three of the species taken in the greatest numbers on Guam are further described below.

Blue-green chromis (*Chromis viridis*): Huge aggregations of this brightly colored chromis may be seen above thickets of branching corals in protected areas. They occur on subtidal reef flats and in lagoons to depths of around 12 m. The species has a wide distribution throughout the Indo-Pacific, from the Red Sea to Line Islands and throughout Micronesia.

Humbug dascyllus (*Dascyllus aruanus*): This damselfish occurs in large aggregations in shallow water, above branching *Acropora* heads. The fishes are strongly associated with their home coral heads. They are a shallow-water species, and are distributed from the Red Sea to the Line Islands, Lord Howe Island, and Micronesia.

Three-spot dascyllus (*Dascyllus trimaculatus*): This popular aquarium species occurs in waters from 1-55m depth. Juveniles shelter among sea anemone tentacles, and adults are found around prominent coral mounds or large rocks. The species has an Indo-Pacific distribution from the Red Sea to the Line Islands, Lord Howe Island, and Micronesia.

H. Turkeyfishes (Scorpaenidae)

The Scorpaenidae, variously known as lionfishes, turkeyfishes, or scorpionfishes, possess venomous dorsal, anal, and pelvic fins in many species. They are stout-bodied, benthic carnivores that typically have fleshy flaps, a mottled coloring, and small tentacles on the head and body. These camouflage features help them to hide and effectively ambush small fishes and crustaceans. Lionfishes and turkeyfishes may swim well above the bottom, whereas small cryptic species of the subfamily Scorpaeninae tend to remain on the bottom and may be quite common in shallow rubbly areas. Fishes in the family are often observed by divers in shallow waters (around 10 m) but may also occur deeper (to at least 50m). In Hawaiian waters, around 25 species in the family are known (Hoover 1993) and 3 are endemic: *Dendrochirus barberi, Pterois sphex*, and *Scorpaenopsis cacopsis*. At least 30 species are known from Micronesia, and at least 22 species are recorded from Samoa.

Most reef scorpaenids (*Scorpaena, Pterois, Dendrochirus*) have 0.7-1.2mm spherical to slightly ovoid eggs embedded in a large, pelagic, sac-like gelatinous matrix (Leis & Rennis 1983). Eggs hatch in 58-72 hours. The duration of the planktonic larval stage is not known.

Hawaiian turkeyfish (*Pterois sphex*): The endemic Hawaiian turkeyfish, *Pterois sphex,* is found resting in caves or under ledges by day, usually stationed upside-down on the ceiling. At night they emerge to feed on small crustaceans. Several biologists and aquarium collectors have noted reduced numbers of the endemic Hawaiian turkeyfish, *Pterois sphex*. Sightings of this previously more abundant species have become very infrequent. It is thought that its numbers have been reduced by collecting efforts driven by its popularity as an aquarium fish. Randall et al. (1993) listed it as occasional in caves or ledges inside and outside the lagoon at Midway Atoll, but it is now very rare in the Main Hawaiian Islands.

I. Feather-duster worms (Sabellidae)

Feather-duster worms are attached benthic invertebrates in the Phylum Annelida, Class Polychaeta. The most conspicuous part of these animals is the large fan, or crown. The body is enclosed in a leathery tube that is mostly embedded in the substrate of the reef, often in sandy or rubble-bottom areas. Feather-duster worms generally prefer shallow, turbid waters, and can be found inhabiting harbors, bays, and similar sheltered areas. Occasionally, they are also found in clearer waters, down to depths of 30m or more.

Collectively, the aquarium fish unit comprises a diverse array of organisms that favor a wide variety of substrates, depths, and habitats. However, in general the group is characterized by a close association with the shallow coral reef environment, and most collecting of the species in the group occurs within a narrowly-defined range, i.e., from near-surface waters to depths usually no greater than about 50 m. The EFH for the juvenile and adult phase of this management unit is therefore designated as all coral, rubble, or other hard-bottom features and the adjacent water column from 0-50 fm. EFH for eggs and larvae of the group (though some eggs are demersal, e.g. in damselfishes) is described to include waters from 0-50 fm from the shoreline to the limits of the EEZ.

II. Descriptions of EFH for Management Unit Species

Introduction

This report presents a compilation of information that will be used to help to define essential fish habitat (EFH) as part of a Coral Reef Ecosystem (CRE) Fisheries Management Plan (FMP) for the Western Pacific Region pursuant to Sections 303(a) and (b) of the Magnuson-Stevens Act. The development of a CRE FMP is also in keeping with the spirit and intent of Executive Order No. 13089 on Coral Reef Protection, issued by the President on June 11, 1998.

The report presents data for selected fish, invertebrate, and sessile taxa, termed Management Units Species (MUS), occurring within the geographical fishery management units (FMUs) under the jurisdiction of the Western Pacific Regional Fishery Management Council (WPRFMC). Information was gathered through review of available literature, and communication with authorities in the field. For each taxon, an effort was made to locate those data that will be helpful in defining EFHs, including descriptions of the habitat and ecological requirements for each life phase of the organisms under consideration.

For the purpose of this investigation, the taxa included were limited to those known or believed to occur on or in association with coral reefs, at least during some phase of the life cycle. In general therefore, pelagic taxa are excluded from this report. Similarly, those species occurring exclusively in zones deeper than the typical depth for coral reefs (as defined by the lower limits of the photic zone, i.e., 100 m depth), are not included.

A. Descriptions for Management Unit Species- Fish

Management Unit Species: **Carcharhinidae, Sphyrnidae, *Triaenodon obesus* (sharks)**

Carcharinidae is one of the largest and most important families of sharks, with many common and wide-ranging species found in all warm and temperate seas. They are the dominant sharks in tropical waters in variety, abundance and biomass. Most species inhabit tropical continental coastal and offshore waters, but several species prefer coral reefs and oceanic islands. All members of *Carcharhinidae* have a circular eye, nictitating eyelids, a first dorsal fin positioned well ahead of the pelvic fins, precaudal pits and well developed lower caudal lobe.

Sharks differ from bony fishes in their cartilagenous skeleton, 5 to 7 gill openings on each side of the head, the frequent presence of a spiracle behind or below the eye, a rough skin composed of small, close-set dermal denticles, the absence of a swimbladder and the presence of a very large liver with large amounts of oil. Many sharks are apex predators in the food chain, feeding on bony fishes, octopuses, squids, shrimps, sea birds, other sharks and rays, sea turtles and marine mammals. Many sharks, including members of *Carcharhinidae* and *Sphyrnidae*, make seasonal migrations to warmer waters in the winter and cooler waters in the summer.

DeCrosta et al. (1984) reported on age determination, growth and energetics of the gray reef shark, the Galapagos shark and the tiger shark in the Northwestern Hawaiian Islands (NWHI). They found maximum ages from a sample of 30–65 specimens of each species to be 10, 15 and 22 years, respectively. The gray reef shark was the most highly piscivorous species with 51% of its diet composed of perciform fish, as well as >12% eels and >22% cephalopods. The Galapagos shark ate primarily cephalopods (43%), tetraodontiform fish (21%), eels (14%) and parrotfish (7 %). The tiger shark was a very opportunistic feeder, with seabirds in 75% of the specimen stomachs, but also sea turtles (33%), lobsters (30%), cephalopods (22%) and tetraodontiform fish (15%).

Sphyrnidae is a small but common family of wide-ranging, warm-temperate and tropical sharks found in continental and insular waters. Depths range from the surface to at least 275 m depth. Hammerheads are very active swimmers, ranging from the surface to the bottom. They are versatile feeders on bony fishes, elasmobranchs, cephalopods, crustaceans and other prey, although some may specialize on other elasmobranchs (Compagno 1984). Sphyrnids are similar to carcharhinids with one obvious exception, a blade-like lateral extension of the head. The head shape serves to spread the eyes and olfactory organs farther apart and may increase electroreception, vision and smell; increases lift and maneuverability; and may be used to pin prey such as rays to the bottom.

Sharks reproduce by internal fertilization. Male sharks can be identified by the presence of a pair of claspers along the medial edge of the pelvic fin. The tiger shark, *Galeocerdo cuvier*, and most sharks are ovoviviparous, developing eggs within the uterus. The sharks of *Sphyrnidae* and *Carcharinidae* except the tiger shark, are viviparous, nourishing embryos by a placenta-like organ in the female. Some species such as *Nebrius concolor* and *Sphyrna lewini* move into shallow water to give birth. Calm, protected bays such as Kaneohe Bay are important nursery areas for sharks such as *S. lewini*.

Forty species of sharks are known from Hawaiian waters, but 20 of them occur only in deep water. Sharks likely to be associated with coral reefs in Hawaii include the gray reef shark *Carcharhinus amblyrhynchos*, the Galapagos shark *C. galapagensis*, the tiger shark *Galeocordo cuvier*, the blacktip reef shark *Carcharhinus melanopterus*, the sandbar shark *C. plumbeus*, the whitetip reef shark *Triaenodon obesus* and the scalloped hammerhead *S. lewini*. Ten species of carcharhinid sharks and two sphyrnid species, *S. lewini* and *S.*

mokorran, are described for Micronesia in Myers (1991). Twelve carcharhinid and two sphyrnids are recorded for American Samoa.

Schooling is well documented for many shark species, especially the hammerheads. These species make long migrations in large groups for the purpose of spawning.

Trophic ecology: Sharks are apex predators on many coral reefs, where their presence may be a good indication of large stocks of fishes upon which they feed. All sharks are carnivorous, feeding on a wide variety of fishes, elasmobranchs and invertebrates including eagle rays, other sharks, reef fish, cephalopods, crustaceans, tuna, baitfishes and mahimahi. Larger species such as tiger sharks and great white sharks feed on those animals as well as porpoises, whales, sea turtles, sea birds, domestic animals, humans occasionally and marine debris, such as tin cans and plastic cups. Many sharks are nocturnal feeders, as sensory organs such as ampullae of Lorenzini are used to detect electomagnetic fields of prey fishes. The same sensory systems, including exceptional smell and a highly developed lateralis system, allow sharks to detect injured prey from considerable distance and lead to opportunistic feeding during the day as well.

Reproductive ecology: Egg and larval distribution are not applicable to sharks because they develop eggs internally. Sharks typically have a gestation period within the female of about 12 months. The gestation period and number of offspring per litter of common Western Pacific Region reef-associated sharks are *Triaenodon obesus* - 13 mths, 1–5 pups; *Carcharhinus albimarginatus* - 12 mths, 1–11 pups; *C. amblyrhynchos* - about 12 mths, 1–6 pups; *C. falciformis* - 2–14 pups; *C. galapagensis* - 6–16 pups; *C. melanopterus* - 8–9 mths, 2–4 pups; *Galeocerdo cuvier* - 12–13 mths, 10–82 pups; *C. plumbeus* - 8–12 mths, 1–14 pups, *Negaprion acutidens* - 1–11 pups; *Sphyrna lewini* - 15–31 pups; and *S. mokorran* - 13–42 pups.

Juvenile sharks frequently inhabit inshore areas such as bays, seagrass beds and lagoon flats before moving into deeper water as they mature. For example, *S. lewini* has well-documented nursery areas in shallow, turbid coastal areas such as Guam's inner Apra Harbor and Kaneohe Bay and Keehi lagoon on Oahu in Hawaii. The southern part of Kaneohe Bay is a major breeding and pupping ground for this species. Pups tend to avoid light, preferring more turbid water. They school in a core refuge area during the day and then disperse at night, foraging along the base of patch reefs (Clarke 1971, Holland et al. 1993). Schools of young hammerheads forage near the bottom within these bays before moving to deeper outer reef waters as adults.

Size at maturity for reef-associated sharks within the management area are *T. obesus* - 101 cm for females and 82 cm for males, *C. galapagensis* - 205–239 cm for males and 215–245 cm for females, *C. melanopterus* - 131–178 cm for males and 144–183 cm for females, *G. cuvier* - 226–290 cm for males and 250–350 cm for females, C. plumbeus - 131–178 cm for males and 144–183 cm for females, *S. lewini* - 140–165 cm for males and about 212 cm for females, and *S. zygaena* - about 210–240 cm for males and females.

Adult sharks can be found in shallow inshore areas during mating or birthing events. Some species forage in these shallow areas as well. Reef-associated sharks are found in a wide variety of coral reef habitats, and because of their wide-ranging nature, no particular coral reef habitat except the inshore areas important for mating and birthing holds significantly higher numbers of sharks than other habitats. The larger species, such as *Galeocerdo cuvier*, are more often found on outer reef slopes near deep dropoffs. Randall et al. (1993) noted the presence of tiger sharks in lagoon waters of Midway Island during June–August when they prey upon fledgling Laysan albatross. Adult female gray reef sharks *C. amblyrhynchos* aggregate seasonally over shallow reef areas in the NHWI.

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Management Unit Species: Carcharhinidae, Sphyrnidae (sharks)

	Gestation	Juvenile	Adult
Duration	about 12 months	to 5–10 years or more	to 20 years or more
Diet	N/A	carnivorous - fish, elasmobranchs, squid, crustaceans, molluscs, may feed more intensively on crustaceans in inshore nursery areas	carnivorous - fish, elasmobranchs, squid, crustaceans, molluscs
Distribution, general and seasonal	Sphyrnids and some Carcharhinids have inshore nursery grounds	variable among species, *S. lewini* and *Negaprion acutidens* inhabit inshore nursery grounds	Carcharinidae: variable among the family from Indo-Pacific, circumglobal, and circumtropical Sphyrnidae: circumtropical
Location	variable	highly variable, *S. lewini* and *Negaprion acutidens* inhabit inshore nursery grounds	Carcharinidae: highly variable among the family Sphyrnidae: primarily pelagic but use inshore areas for reproduction
Water column	N/A	inshore benthic, neritic to epipelagic, 1–275 m	inshore benthic, neritic to epipelagic, mesopelagic. 1–275 m
Bottom type	N/A	highly variable due to wide-ranging nature of most species	highly variable due to wide-ranging nature of most species
Oceanic features	N/A	unknown	unknown

Management Unit Species: **Dasyatididae, Myliobatidae, Mobulidae (rays)**

The rays are characterized by a flattened form, a lack of dorsal fins, a distinct tail which has one or more venomous barbs in some families and a small mouth with close-set pavement-like teeth. Water is taken in through a spiracle behind the eye and expelled through gill slits on the underside of the ray. Rays often bury into the sand with only the eyes and spiracle showing. Most rays are carnivorous on shellfish, worms and small burrowing fishes, except the members of Mobulidae that feed on zooplankton in the water column. Rays are ovoviviparous, giving birth to fully developed young that are nourished from vascular filaments within the uterus during gestation.

Dasyatidae - There are 3 species in Hawaii - *Dasyatis violacea, D. brevis* and *D. latus*; 4 species in Micronesia - *D. kuhlii, Hymantura uarnak, Taeniura melanospilos* and *Urogymnus asperrimus*; and 2 species in Samoa - *D. kuhlii* and *Hymantura fai*. Sting rays feed on sand-dwelling and reef-dwelling invertebrates and fishes, often excavating large burrows in sand bottoms to capture subsurface mollusks and worms.

Myliobatidae - One species, the spotted eagle ray *Aetobatis narinari*, represents the family in Hawaiian, Micronesian and Samoan waters. Eagle rays feed mainly on hard-shelled mollusks and crustaceans, using their snout to probe through sand and powerful jaws to crush the shells. An average of 4 pups are born per litter after a gestation period of about 12 months. They have a depth range from the intertidal to 24 m. Groups move from reef channels and the reef face during flood tide to feed. Schools of up to 200 individuals have been observed.

Mobulidae - One species of manta ray, *Manta birostris* (which recently has come to include other synonyms, including *M. alfredi*) represents the family in Hawaiian and Micronesian waters. Mantas are the largest of all rays and may attain a width of 6.7 m and a weight of 1,400 kg. They occur singly or in small groups in surface or mid-waters of lagoons and seaward reefs, particularly near channels. They strain zooplankton from the water using cephalic flaps to direct the plankton into the mouth. They occur in all tropical and subtropical seas. Mating and birthing occur in shallow water, and juveniles often remain in these areas before heading into deeper water as adults. During winter, mantas may migrate to warmer areas, or deeper water or disperse offshore.

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Management Unit Species: Dasyatididae, Myliobatidae, Mobulidae (rays)

	Gestation	Juvenile	Adult
Duration	about 12 months for Myliobatidae, avg of 4 pups	little information	little information on longevity
Diet	N/A	small fish, crustaceans, mollusks, worms, zooplankton for Mobulidae, may be a greater emphasis on shellfish for juveniles in shallow water habitats	fish, crustaceans, mollusks, worms, zooplankton for Mobulidae
Distribution, general and seasonal	N/A	*Dasyatis latus* range includes Hawaii and Taiwan, *D. kuhlii* and *Hymantura uarnak* range through the Indo-west-Pacific, *Taeniura melanospilos* and *Urogymnus asperrimus* range the Indo-Pacific, the spotted eagle ray and manta ray are circumtropical	*Dasyatis latus* range includes Hawaii and Taiwan, *D. kuhlii* and *Hymantura uarnak* range through the Indo-west-Pacific, *Taeniura melanospilos* and *Urogymnus asperrimus* range the Indo-Pacific, the spotted eagle ray and manta ray are circumtropical

Location	variable	wide variety of habitats from shallow lagoons to outer reef slopes, nursery areas in seagrass beds, mangroves, and shallow flats are important for many species	wide variety of habitats from shallow lagoons to outer reef slopes, generally located from 0-100m but have been found much deeper
Water column	N/A	demersal and in the water column	demersal and in the water column
Bottom type	N/A	soft (sand and mud), coral reef, pavement	soft (sand and mud), coral reef, pavement
Oceanic features	N/A	unknown	unknown

Management Unit Species: **Muraenidae, Chlopsidae, Congridae, Moringuidae, Ophichthidae (eels)**

There are 15 families of true eels, and these are some of the important ones on Western Pacific Region coral reefs. The eels are characterized by very elongate bodies, lack of pelvic fins, very small gill openings and a caudal fin that, if present, is joined with the dorsal and anal fins.

Members of Muraenidae, the morays, lack pectoral fins and scales and have a large mouth. Most species have long, fang-like teeth, but some do not. Species with long canines feed mainly on reef fishes, occasionally on crustaceans and octopuses. Species of *Echidna* and *Gymnomuraena* with mainly nodular or molariform teeth feed more on crustaceans, especially crabs. Morays have a lengthy pelagic leptocephalus larval stage that has resulted in a very wide distribution. Morays are hunted for food in many locations, even though large individuals may be ciguatoxic. Morays typically remain hidden within the framework of the reef, and many are more active at night than during the day. There are 38 species of morays in Hawaii, second only to the wrasses for number of species. *Gymnothorax steindachneri* is endemic to Hawaii. At least 53 species are known from Micronesia. At least 47 species are known from Samoa.

Members of Chlopsidae, the false morays, resemble morays but have pectoral fins and posterior nostrils open to the margin of the upper lip. Males are typically smaller with larger teeth, which may be used for grasping females during courtship. They probably migrate off the reef to spawn but otherwise stay well hidden within the reef framework. Five species are recorded from Samoa.

Members of Congridae include the conger eels and garden eels. Conger eels have well-developed pectoral fins. Garden eels are smaller, extremely elongate burrowing forms with reduced or absent pectoral fins. They occur in large colonies on sand plains or slopes at depths of 7–53 m with strong currents. They are diurnal planktivores that extend from their burrows to feed on plankton in the current. The large-eye conger, *Ariosoma marginatum*, and the Hawaiian garden eel, *Gorgasia hawaiiensis,* are endemic to Hawaii. Five species are recorded in Samoan waters.

Members of Moringuidae, the spaghetti eels, have extremely elongate bodies with the anus located about two thirds of the way back. They change morphology radically as they mature. Immature spaghetti eels are orange-brown with small eyes and reduced fins. Mature eels have large eyes and a distinct caudal fin and are dark above and silvery below. Females burrow in shallow sandy areas but migrate to the surface to spawn with males, which are pelagic. Six species are recorded from Samoan waters.

Members of Ophichthidae, the snake eels, have elongate, nearly cylindrical bodies with median fins and small pectoral fins. Most species of snake eels are indwellers that stay buried in the sand but a few will occasionally come out and swim across sand, rubble or seagrass habitats. They appear to be nocturnal, and some species, if not all, come to the surface to spawn at night. Sixteen species are reported from the Hawaiian Islands. The freckled snake eel, *Callechelys lutea*, is endemic to Hawaii, and the magnificent snake eel, *Myrichthys magnificus,* is endemic to the Hawaiian Islands and Johnston Island. At least 26 species are known from Micronesia. Five species are recorded from Samoan waters.

Sexual characteristics of eels vary widely among the different families. Spawning migrations are a general, though not universal, characteristic of eel reproduction. Eel species that migrate for spawning, including members of the congrids, moringuids and ophichthids, tend to be sexually dimorphic, with moringuids displaying the greatest morphological difference between males and females. Nonmigratory eels such as morays and garden eels typically have no definitive external sexual dimorphism. Hermaphroditism has been documented for some species, including some morays, but is not a widespread characteristic of eels. Group spawning of eels has been documented, with large numbers of adults congregating at the water surface at night.

Eel eggs are pelagic and spherical with a wide periviteline space, usually no oil droplets and in some species a densely reticulated yolk. The eggs are relatively large, ranging from 1.8 to 4.0 mm. Watson and Leis (1974) collected 145 eels eggs off Hawaii that ranged from 2.4 to 3.8 mm. Brock (1972) found 200,000 to 300,000 ripe eggs in each of four 5.0 to 6.8 kg *Gymnothorax javanicus*. Hatching of an unidentified 1.8 mm muraenid egg took approximately 100 hours (Bensam 1966).

Eels have a characteristic leptocephalus larval stage: a long, transparent, feather-shaped larva that starts out at 5-10 mm and grows up to 200 mm before settlement and metamorphosis. The duration of the planktonic stage is on the order of 3–5 months for moringuids (Castle 1979), 6–10 months for muraenids (Eldred 1969, Castle 1965) and about 10 months for some congrids (Castle and Robertson 1974).

Both juvenile and adult eels inhabit cryptic locations in the framework of the reef or in sand plains for some species. Some species remain so hidden within the reef that they have never been seen alive; their existence is known only from samples taken with the use of poisons.

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Management Unit Species: Muraenidae, Chlopsidae, Congridae, Moringuidae, Ophichthidae (eels)

	Egg	Larvae	Juvenile	Adult
Duration	100 hours or more	3–10 months		
Diet	N/A	zooplankton	most are benthic carnivores on fish, octopus, crustaceans; frequently nocturnal garden eels are diurnal planktivores	most are nocturnal benthic carnivores on fish, octopus, crustaceans; the morays of Gymnomuraena, Enchelycore and Sideria feed mainly on crustaceans; garden eels are diurnal planktivores
Distribution, general and seasonal	eggs frequently released near the surface; some are pelagic spawners, others spawn on reefs	predominantly offshore	worldwide in tropical and temperate seas; *Callechelys lutea*, *Ariosoma marginatum*, *Gorgasia hawaiiensis* and *Gymnothorax steindachneri* are endemic to the Hawaiian islands; *Myrichthys magnificus* is endemic to the Hawaiian Islands and Johnston Island	worldwide in tropical and temperate seas; *Callechelys lutea*, *Ariosoma marginatum*, *Gorgasia hawaiiensis* and *Gymnothorax steindachneri* are endemic to the Hawaiian islands; *Myrichthys magnificus* is endemic to the Hawaiian Islands and Johnston Island
Location	near reefs and offshore	predominantly offshore	coral reefs and soft-bottom habitats	coral reefs and soft-bottom habitats
Water column	pelagic	pelagic	demersal	demersal
Bottom type	N/A	N/A	coral reef crevices, holes; sand, mud, rubble	coral reef crevices, holes; sand, mud, rubble
Oceanic features				

Management Unit Species: **Engraulidae (anchovies)**

The anchovies are a large family of small, silvery schooling fishes that are common baitfish for pole-and-line tuna fisheries. They share many of the characteristics of the clupeids but can be distinguished by their rounded overhanging snout and slender lower jaw. Most species also have a brilliant silver mid-lateral band. Anchovies typically inhabit estuaries and turbid coastal waters. However, but some occur over inner protected reefs, and, at least one, *Encrasicholina punctifer*, is found in the open sea. Anchovies occur in dense schools and feed by opening their mouths to strain plankton from the water with their numerous gill rakers. Two species are known from Hawaiian waters: the endemic Hawaiian anchovy *Encrasicholina purpurea* and the offshore species *E. punctifer*. Seven species are known from Micronesian waters. Four species are known from Samoan waters.

Anchovy eggs are pelagic. In *Coilia, Setipinna* and *Thryssa* they are spherical and of small to moderate size (0.8–1.6 mm). Eggs of *Encrasicholina, Engraulis* and *Stolephorus* are ovate to elliptical and vary from small to large (0.8–2.3 x 0.5–0.8 mm) (Zhang et al 1982, Fukuhara 1983, McGowan and Berry 1984, Ikeda and Mito 1988). Larvae hatch at 2.5–3.7 mm. The size of the largest pelagic specimen examined by Leis and Trnski (1989) was 23–27 mm.

Thryssa baelama occurs in large schools in turbid waters of river mouths and inner bays. The oceanic or buccaneer anchovy *E. punctifer* is mostly pelagic, but it can be found in large atoll lagoons or deep, clear bays. The blue anchovy *E. heterolobus* occurs primarily in deep bays under oceanic influence. Other anchovies occur in estuaries and coastal bays.

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Management Unit Species: Engraulidae (anchovies)

	Egg	Larvae	Juvenile	Adult
Duration				
Diet	N/A	plankton	plankton	plankton
Distribution, general and seasonal			same as adults	Two species in Hawaiian waters: the endemic Hawaiian anchovy *Encrasicholina purpurea* and the offshore species *E. punctifer*. Seven Micronesian species. Four Samoan species.
Location			schools in inshore waters	estuaries and turbid coastal waters but some occur over inner protected reefs and at least one, *Encrasicholina punctifer*, is found in the open sea
Water column	pelagic	pelagic	frequently near the surface	frequently near the surface
Bottom type	N/A	N/A	same as adults	sand, coral reef, rock, mud
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Clupeidae (herrings)**

Herrings, sardines and sprats are small planktivorous silvery fishes with a single short dorsal fin near the middle of the body, no spines, no lateral line and a forked caudal tail. They are schooling fishes that are important for food and bait. Round herrings include several species that inhabit coral reefs as well as coastal waters. Sardines typically inhabit coastal waters of large land masses or high islands. In Hawaiian waters, 4 species occur. Two were introduced: the goldspot sardine *Herklotsichthys quadrimaculatus* unintentionally from the Marshall Islands in 1972 and the Marquesan sardine *Sardinella marquensis* intentionally from the Marquesas between 1955 and 1959, but it never became abundant. The other two Hawaiian species are the delicate roundherrring *Spratelloides delicatulus*, which is an inshore species that occurs in small schools over coral reefs, and the red-eye roundherring *Etrumeus teres*, although it is rare. In Micronesian waters, there are at least 6 species of Clupeidae. In Samoan waters, 9 species have been recorded.

Clupeid eggs are spherical and vary among species from small to large (0.8–2.1 mm). They are thought to be pelagic in all tropical taxa except *Spratelloides*, which has demersal eggs (McGowan and Berry 1984, Jiang and Lim 1986). Clupeid larvae range from 1.6 to 4.7 mm long at the time of hatching. The size of the largest pelagic specimens examined by Leis and Trnski (1989) ranged from 21 to 33 mm.

The gold spot sardine, or herring, is an important food fish in many areas. It schools near mangroves and above sandy shallows of coastal bays and lagoons during the day and moves into deeper water at night to feed. In Belau, it migrates to tidal creeks to spawn from November to April (Myers 1991). The blue sprat *Spratelloides delicatulus* generally schools near the surface of clear coastal waters, lagoons and reef margins where it feeds on plankton.

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Management Unit Species: Clupeidae (herrings, sprats and sardines)

	Egg	Larvae	Juvenile	Adult
Duration				
Diet	N/A	plankton	plankton	plankton
Distribution, general and seasonal			same as adults	Four species in Hawaiian waters; two introduced: *Herklotsichthys quadrimaculatus* and *Sardinella marquensis*, and two others: *Spratelloides delicatulus* and *Etrumeus teres*. At least 6 species occur in Micronesian waters, and at least 9 species occur in Samoa.
Location			schools in inshore waters	estuaries and turbid coastal waters but some occur over inner protected reefs
Water column	pelagic	pelagic	frequently near the surface	frequently near the surface; 0–20 m
Bottom type	N/A	N/A	same as adults	sand, coral reef, rock, mud
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		most species tend to accumulate in relatively clear coastal, lagoon, and seaward reef waters

Management Unit Species: **Antennariidae (Frogfishes)**

Frogfishes have bulbous bodies, jointed elbow-like pectoral fins that are used like arms, small holes behind the pectorals for gill openings and large upturned mouths. The first dorsal spine is modified to a lure consisting of the slender ilicium tipped with the esca (bait), which is used to attract prey. The frogfishes are very well camouflaged piscivores with cryptically colored prickly skin and fleshy or filamentous appendages. They are able to lure prey by waving the esca above their head, then striking quickly with a large mouth. They are able to swallow prey longer than themselves because of a highly distensible body. At intervals of 3 to 4 days, reproductive females lay thousands of tiny eggs embedded in a large, sometimes scroll-shaped gelatinous mass. Habitats where frogfish are found include bottoms of seagrass, algae, sponge, rock or corals from tidepools to lagoon and seaward reefs. In Hawaiian waters, 6 species are found, with one endemic: the Hawaiian freckled frogfish *Antennarius drombus*. At least 12 species occur in Micronesia, and at least 7 species in Samoa. Frogfishes are rare on most coral reefs and are present only in low numbers if at all.

Spawning by anglerfishes involves the production of a large, jelly-like egg mass. Frogfishes appear to be sexually monomorphic, with the only difference between sexes being the expanded size of the female prior to releasing eggs. For those species that have been observed spawning—*Histrio histrio* (Mosher 1954, Fujita and Uchida 1959), *Antennarius nummifer* (Ray 1961) and *A. zebrinus* (Burgess 1976)—spawning occurred in pairs after a quick spawning rush to the surface. Egg masses, or "rafts," or "scrolls," vary in size from species to species but are usually quite large. That of *H. histrio* is about 9 cm long (Mosher 1954, Fujita and Uchida 1959); that of *A. multiocellatus, A. tigrinus* and *A. zebrinus* is slightly larger (Mosher 1954, Burgess 1976); and that of *A. nummifer* is about 5 cm across and about 7 cm high (Ray 1961). Some species have immense egg rafts, including a raft produced by *A. hispidus* in an aquarium that was 2.9 m by 15.9 cm (Hornell 1922). Since rafts can be produced at 3-to 4-day intervals for many species, fecundity is extremely high for the frogfishes. Eggs hatch within 2–5 days. For *H. histrio*, growth and development is extremely fast, and an entire generation can take as little as 21 days (Adams 1960). Other species likely have much longer development and life spans.

A different spawning mode has been documented for members of at least two genera, *Lophiocharon* and *Histiophryne*, which brood eggs attached to the body of the male. The eggs are much larger (3.2–4.2mm) and more advanced at hatching than for pelagic spawners (Pietsch and Grobecker 1987).

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Management Unit Species: Antennariidae (frogfishes)

	Egg	Larvae	Juvenile	Adult
Duration	2–5 days	days for *H. histrio*, but likely weeks for other species		*H. histrio* may only live a month or so; little information on others but likely to live much longer
Diet	N/A	likely zooplankton	similar to adult	ambush small fish which they lure close by waving an esca that resembles food
Distribution, general and seasonal				shallow tropical and temperate seas worldwide; 6 species in Hawaii with one endemic: the Hawaiian freckled frogfish *Antennarius drombus*. At least 12 species in Micronesia, and at least 7 species in Samoa.
Location	large egg “raft” released at the surface after a fast spawning rush			from tidepools to lagoon and seaward reefs
Water column	pelagic	pelagic	demersal	demersal; 1–130 m, but most at less than 30 m
Bottom type	N/A	N/A	seagrass, algae, sponge, rock or corals	seagrass, algae, sponge, rock or corals
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Anomalopidae (flashlightfish)**

Flashlightfish are small, dark fishes with luminous organs under each eye, blunt snouts, large mouths and a forked tail. The lime-green light is produced biochemically by bacteria within the light organ. The light may be used to attract zooplankton prey, to communicate to other flashlightfish or to confuse predators. They are usually at depths from 30 to 400 m but may be found much shallower in some locations. They remain hidden during the day and venture out at night to feed, tending to occur shallower on dark, moonless nights. Flashlightfish do not occur in the Hawaiian Islands, but two species occur in Micronesian waters: *Anomalops katoptron* and *Photoblepheron palpebratus*. *A. katoptron* also occurs in Samoan waters.

The eggs of *A. katoptron* and *P. palpebratus* are of moderate size (1.0–1.3 mm) with a mucous sheath. They are positively buoyant (Meyer-Rochow 1976). The larvae of *A. katoptron* hatch at 2.6–3.3 mm.

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Management Unit Species: Anomalopidae (flashlightfishes)

	Egg	Larvae	Juvenile	Adult
Duration		hatch at a size of 2.6–3.3 mm		
Diet	N/A	zooplankton	zooplankton	zooplankton
Distribution, general and seasonal				none found in Hawaiian Islands; 2 species in Micronesia, *Anomalops katoptron* and *Photoblepheron palpebratus*
Location			same as adult	hidden in caves or crevices by day; active in the water column by night
Water column	pelagic	pelagic	same as adult	demersal by day, and in the water column by night; 5–400 m
Bottom type	N/A	N/A	coral reef	coral reef
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Holocentridae (soldierfishes/squirrelfishes)**

Holocentrids are spiny, deep bodied, usually red fishes with large eyes and mouth, small teeth, large coarse scales and stout dorsal and anal fin spines. The family is divided into two subfamilies: the Myripristinae (soldierfishes of the genus *Myripristis, Plectrypops, Pristelepis* and *Ostichthys* are found in the Indo-Pacific; the latter two occur in deep water) and the Holocentrinae (squirrelfishes of the genus *Neoniphon* and *Sargocentron*). Soldierfishes lack a well-developed preopercular spine and a pointed snout, both of which are present in squirelfishes. The spine on the preopercle of squirrelfish may be venomous. Soldierfishes and squirrelfishes are both nocturnal predators, but soldierfish predominantly feed on large zooplankton in the water column while squirrelfish prey mainly on benthic crustaceans, worms and small fishes. During the day, most holocentrids hover in or near caves and crevices or among branching corals.

About 17 holocentrid species inhabit Hawaiian waters, some of them in very deep water. At least 13 species of soldierfishes and 16 species of squirrelfishes occur in Micronesia. At least 31 holocentrid species are found in Samoan waters.

Holocentrids are slow growing, late maturing and fairly long lived. A study (Dee and Parrish 1993) on the reproductive and trophic ecology of *Myripristis amaena* found that sexual maturity for both sexes was reached between 145 and 160 mm SL at about 6 years of age. Longevity was determined to be at least 14 years. Fecundity was relatively low, fewer than 70,000 eggs in the most fecund specimen, and increased sharply with body weight. Spawning peaked from early April to early May, with a secondary peak in September. The diet of *M. amaena* was mainly meroplankton, especially brachyuran crab megalops, hermit crab larvae and shrimps but also a variety of benthic invertebrates and fishes.

M. amaena is particularly important in the recreational fishery at Johnston Atoll where it is the species caught in greatest abundance (Irons et al. 1990). It is common in reef fish catches throughout the Hawaiian archipelago.

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Management Unit Species: Holocentridae (soldierfishes/squirrelfishes)

	Egg	Larvae	Juvenile	Adult
Duration		probably several weeks, settle at large size (up to 30 mm or more)	6 years for *M. amaena*	at least 14 years (Dee and Radtke 1989)
Diet	N/A	zooplankton	diet similar to adults	Myropristis spp.: mostly meroplankton, especially brachyuran crab megalops, hermit crab larvae and shrimps, but also a variety of benthic invertebrates and fishes, Holocentrinae: feed mainly on benthic crustaceans
Distribution, general and seasonal	spawning peak in April–May and another in Sept. for *M. amaena* at Johnston Atoll	generally, a recruitment peak in June-July and another in Feb.–March, but a lot of variation	tropical Atlantic, Indian, and Pacific Oceans	tropical Atlantic, Indian, and Pacific Oceans
Location				
Water column	pelagic	pelagic	demersal in caves and crevices during the day; demersal and in the water column at night	demersal in caves and crevices during the day ; demersal and in the water column at night
Bottom type	N/A	settle in refugia on the reef	coral reef caves and crevices, also within the branches of branching corals	coral reef caves and crevices, also within the branches of branching corals
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Aulostomidae (trumpetfishes)**

Trumpetfishes are very elongate with a compressed body, a small mouth, a long tubular snout, small teeth and a small barbel on the chin. The one Indo-Pacific species occurs in three color patterns: uniformly brown to green, mottled brown to green and uniformly yellow. They feed on fishes and shrimps by slowly moving close to the prey, often in a vertical stance, and then darting forward to suck the prey in through its snout. Trumpetfishes inhabit rocky and coral habitats of protected and seaward reefs from below the surge zone to a depth of 122 m. They have an ability to blend in with a background of coral branches or seagrasses by hanging vertically in order to sneak up on unwary prey. They also camouflage themselves by traveling with schools of surgeonfishes or large individual fish to sneak up on prey. There are three species in the world, but only one in the Indo-Pacific, *Aulostomus chinensis*. It is found in Hawaii, Micronesia and Samoa.

Spawning by *A. chinensis* has been observed off One Tree Island, Great Barrier Reef. At dusk, a male and female made a spawning ascent of 5–8 m to release gametes before returning to the bottom (in Thresher 1984). The pelagic eggs of *A. chinensis* are spherical, smooth and 1.3 to 1.4 mm in diameter. Larvae are approximately 4.8 mm at hatching (Watson and Leis 1974).

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Management Unit Species: Aulostomidae (trumpetfish)

	Egg	Larvae	Juvenile	Adult
Duration	approximately 4 days	4.8 mm at hatching		
Diet	N/A	likely small zooplankton	similar to adults	ambush predators of small fishes and crustaceans
Distribution, general and seasonal			similar to adults	one Indo-Pacific species, *Aulostomus chinensis*
Location	pelagic	pelagic	similar to adults	protected and seaward reefs from below the surge zone to 122 m
Water column	pelagic	pelagic	similar to adults	reef-associated; 1–122 m
Bottom type	N/A	N/A	similar to adults	coral reef and rock
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Fistularidae (cornetfish)**

Cornetfishes have a very elongate body like the trumpetfish but differ in the body being vertically flattened rather than laterally compressed and by having a forked caudal fin with a long median filament. Like the trumpetfish, cornetfish feed by sucking small fishes and crustaceans into their long tubular snout. They are seen in virtually all reef habitats except areas of heavy surge. They are usually seen in open sandy areas and may occur in schools of similarly sized individuals. One species, *Fistularia commersonii*, is seen on Hawaiian, Micronesian and Samoan coral reefs, and another species is seen only in deep water.

Fistularid eggs are pelagic and large, with a diameter of 1.5–2.1 mm (Mito 1961). The larvae hatch at 6–7 mm (Mito 1961). Hatching occured in about 7 days for *Fistularia petimba* (Mito 1966). The size of the largest examined pelagic fistularid specimen examined by Leis and Rennis (1983) was 145 mm.

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Management Unit Species: Fistularidae (cornetfish)

	Egg	Larvae	Juvenile	Adult
Duration	4 –7 days	6 mm at hatching		
Diet	N/A	likely small zooplankton	similar to adults	ambush predators of small fishes and crustaceans
Distribution, general and seasonal			similar to adults	two Indo-Pacific species: *Fistularia commersonii* and one deepwater species
Location	pelagic	pelagic	similar to adults	virtually all coral reef habitats except areas of high surge; most common in sandy areas where it may form schools of similarly sized fish
Water column	pelagic	pelagic	similar to adults	reef-associated; 1–128 m
Bottom type	N/A	N/A	similar to adults	sand, coral reef, rock
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Syngnathidae (pipefishes/seahorses)**

Pipefishes and seahorses have a long tubular snout with a very small mouth, which they use to feed in a pipette-like manner on small free-living crustaceans such as copepods. Some species clean other fishes. Many species are small and generally inconspicuous bottom dwellers that feed on minute benthic and planktonic animals. The syngnathids have very unique parental care in which the female deposits eggs into a ventral pouch on the male, which carries the eggs until hatching. Most species are rarely seen on reefs in the management area, partly because of their small size and inconspicuous nature. They occur in a wide variety of shallow habitats from estuaries and shallow sheltered reefs to seaward reef slopes, though they are generally limited to water shallower than 50 m. There are 8 species reported from Hawaiian waters, where the redstripe pipefish *Dunckerocampus baldwini* is endemic. At least 37 species occur in Micronesian waters, and at least 17 species occur in Samoa.

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Management Unit Species: Syngnathidae (pipefishes/seahorses)

	Egg	Larvae	Juvenile	Adult
Duration		likely weeks to months		
Diet	N/A		similar to adults	small free-living crustaceans such as copepods; minute benthic and planktonic invertebrates
Distribution, general and seasonal				circumtropical and temperate; 8 spp. reported from Hawaiian waters, where the redstripe pipefish *Dunckerocampus baldwini* is endemic. At least 37 species in Micronesian waters, and at least 17 in Samoa
Location	male carries eggs in a ventral pouch	offshore waters	occasionally found in the open sea in association with floating debris	wide variety of shallow habitats from estuaries and shallow sheltered reefs to seaward reef slopes
Water column	male carries eggs in a ventral pouch	pelagic	similar to adults	benthic and free-swimming
Bottom type	N/A	N/A	similar to adults	coral, rock, mud, seagrass, algae
Oceanic features		subject to advection by ocean currents		

Management Unit Species: **Caracanthidae (coral crouchers)**

The coral crouchers consist of one genus, *Caracanthus*, and 4 small species. They are small, deep-bodied, ovoid fishes with venomous dorsal spines and small tubercles covering the body. They are found exclusively among the branches of certain *Stylophora, Pocillopora* and *Acropora* corals, where they feed on alpheid shrimps and other small crustaceans. The name coral crouchers comes from their tendency to tightly wedge themselves into the coral branches when threatened. One species, the Hawaiian orbicular velvetfish *Caracanthus typicus*, is found in Hawaiian waters and is endemic. Two species are found in Micronesian and Samoan waters: the spotted coral croucher *C. maculatus* and the pigmy coral croucher *C. unipinna*. *C. maculatus* is common among the long branches of large pocilloporid corals such as *Pocillopora eydouxi*, *Stylophora mordax* and ramose species of *Acropora*. *C. unipinna* is found in *S. mordax* and ramose species of *Acropora*.

The spawning mode and development at hatching of coral crouchers is not known. Caracanthid larvae are very similar to Scorpaenid larvae. The size of the largest examined pelagic specimen was 16.5 mm (Leis and Trnski 1989).

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Management Unit Species: Caracanthidae (coral crouchers)

	Egg	Larvae	Juvenile	Adult
Duration				
Diet	N/A	zooplankton		alpheid shrimps and other small crustaceans
Distribution, general and seasonal			same as adults	Indian and Pacific Ocean; one endemic species in Hawaii - *Caracanthus typicus*, two species in Micronesia
Location			same as adults	exclusively among the branches of certain *Stylophora, Pocillopora*, and *Acropora* corals
Water column	probably pelagic; gelatinous egg masses float	pelagic; 0–100m depth	demersal	demersal
Bottom type	N/A	N/A	*Stylophora, Pocillopora*, and *Acropora* corals	*Stylophora, Pocillopora* and *Acropora* corals
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Tetrarogidae (waspfish)**

Waspfishes are closely related to scorpionfishes but have dorsal fins that originate over or in front of the eyes, typically do not have scales and tend to be more compressed. They have extremely venomous spines. They feed on small fishes and crustaceans. No species are found in Hawaiian waters, and only one species is found in Micronesia: the mangrove waspfish *Tetraroge barbata*, which inhabits muddy inshore waters of mangrove swamps and may also move into freshwater rivers.

There is little information on waspfish reproduction, but it is likely to be very similar to that for Scorpaenidae. They likely produce small to medium eggs embedded in a large, pelagic, sac-like gelatinous matrix.

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Management Unit Species: Tetrarogidae (waspfishes)

	Egg	Larvae	Juvenile	Adult
Duration				
Diet	N/A	zooplankton	ambush small fishes and crustaceanss	ambush small fishes and crustaceans
Distribution, general and seasonal	no information on spawning in the wild			Indo-West Pacific; little seasonal difference in distribution
Location				estuarine or freshwater habitats; mangroves or rivers
Water column	probably pelagic; gelatinous egg masses float	pelagic; 0–100m depth	demersal	demersal
Bottom type	N/A	N/A		mangroves, rock, rubble, mud
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Scorpaenidae (scorpionfishes)**

Scorpionfishes are so named for the venomous dorsal, anal and pelvic fins of many species. They are stout-bodied, benthic carnivores that typically have fleshy flaps, a mottled coloring and small tentacles on the head and body. These camouflage features help them to ambush small fishes and crustaceans. Scorpionfish lie on the reef and wait for unwary prey to come near, when they pounce on the prey with a large mouth full of small viliform teeth. Many feed mainly at dusk or during the night. Lionfishes and turkeyfishes of the subfamily Pteroinae have greatly enlarged pectoral fins, elongate dorsal fin spines and bright colorations. The lionfish and turkeyfish species may swim well above the bottom, whereas small cryptic species of the subfamily Scorpaeninae tend to remain on the bottom and may be quite common in shallow rubbly areas. In Hawaiian waters, 13 species are known and 3 are endemic: *Dendrochirus barberi, Pterois sphex* and *Scorpaenopsis cacopsis*. At least 30 species are known from Micronesia. At least 22 species are recorded from Samoa.

Most reef scorpaenids (*Scorpaena, Pterois, Dendrochirus*) have 0.7–1.2 m spherical to slightly ovoid eggs embedded in a large, pelagic, sac-like gelatinous matrix (Leis and Rennis 1983). Eggs hatch in 58–72 hours. The duration of the planktonic larval stage is not known. Older larval stages are described by Miller, Watson and Leis (1979).

Harmelin-Vivien and Bouchon (1976), analyzing the stomach contents of 17 species of scorpionfish from Tuléar, Madagascar, find that crustaceans generally were a dominant component of their diet. Only one species, *S. gibbosa,* fed exclusively upon fishes, while others fed on a mixture of fish and crustaceans. Seven species fed mainly on crustaceans such as brachyurans, shrimps and polychaetes. Their diets were supplemented with small amounts of galatheids and amphipods. Feeding tended to be heavier at night than during the day, but feeding was apparent for both night and day for all species.

Several biologists and aquarium collectors have noted reduced numbers of the endemic Hawaiian turkeyfish, *Pterois sphex*. Sightings of this previously more abundant species have become very infrequent. Its numbers may have been reduced by collecting efforts driven by its popularity as an aquarium fish. Randall et al. (1993) lists it as occasional in caves or ledges inside and outside the lagoon at Midway Atoll, but it is now very rare in the main Hawaiian Islands.

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Management Unit Species: Scorpaenidae (scorpionfishes)

	Egg	Larvae	Juvenile	Adult
Duration	little information, but 58–72 hrs for *Scorpaena guttata* (David 1939)		2–3 yrs for 2 Mediterranean species	
Diet	N/A	zooplankton	ambush small fishes and invertebrates	ambush fish and invertebrates; *Scorpaenopsis diabolus* feeds exclusively on fishes (Harmelin-Vivien et al. 1976)
Distribution, general and seasonal	little information on spawning in the wild		worldwide in tropical and temperate seas; little seasonal information, but probably recruitment peak in summer or fall	worldwide in tropical and temperate seas; small home ranges; little seasonal difference in distribution
Location			reef and hard-bottom associated	reef and hard-bottom associated
Water column	pelagic; gelatinous egg masses float	pelagic; 0–100m depth	demersal	demersal
Bottom type	N/A	N/A	coral reef, rock, rubble	coral reef, rock, rubble
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Serranidae (Groupers)**

Egg and Larvae

Serranid fertilized eggs are spherical, transparent and range in size from 0.70 to 1.20 mm in diameter. Each egg contains a single oil globule 0.13 to 0.22 mm in diameter. Based on the available data, the length of the pelagic larval stage of groupers is 25-60 days (Kendall 1984, Leis 1987). The wide geographic distribution of serranids is thought to be due to this relatively long pelagic larval phase. Serranid larvae are distinguishable by their kite-shaped bodies and highly developed head spination (Heemstra and Randall 1993).

Juvenile

Very little is known about the distribution and habitat utilization patterns of juvenile serranids. Research has found that transformation of pelagic serranids into benthic larvae takes place between 25 mm to 31 mm TL (Heemstra and Randall, 1993). The juveniles of some species of serranids are known to inhabit sea-grass beds and tide pools.

Adult

Serranids inhabit coral reefs and rocky bottom substrate from the shore to a depths of at least 400 m. Serranids typically are long-lived and have relatively slow growth rates. Based on the available data, groupers appear to be protogynous hermaphrodites. After spawning for one or more years the female undergoes sexual transformation, becoming male. Some species of serranids spawn in large aggregations, others in pairs. Individual males may spawn several times during the breeding season. Some species of groupers are known to undergo small, localized migrations, of several km to spawn. Except for occasional spawning aggregations, most species of groupers are solitary fishes with a limited home range (Heemstra and Randall, 1993). Based on the results of tagging studies, it has been found that serranids are resident to specific sites, often residing on a particular reef for years .

Groupers are typically ambush predators, hiding in crevices and among coral and rocks in wait for prey (Heemstra and Randall 1993). Adults reportedly feed during both the day and night. The diet of adult serranids includes brachyuran crabs, fishes, shrimps, galatheid crabs, octopus, stomatopods, fishes and ophiurids (Heemstra and Randall, 1993, Morgan 1982, Randall and Ben-Tuvia 1983, Harmelin-Vivien and Bouchon 1976)

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Management Unit: Serranidae (Groupers)

	Egg	**Larvae**	**Juvenile**	Adult
Duration	Incubate in 20-35 days	Pelagic duration : 25-60 days	Metamorphosis to demersal habitat at ~25-31 mm TL	Long-lived, slow growing
Diet	N/A	No information available	No information available	Primarily feed in demersal habitat. Diet includes crabs, shrimp, octopus and fish.
Distribution	Serranid eggs have a relatively long pelagic phase that results in wide distribution	Serranid larvae have a relatively long pelagic phase that results in wide distribution	Throughout Indo-Pacific. Juveniles of some species Inhabit shallow reef areas (sea-grass beds and tide pools).	Throughout Indo-Pacific. Inhabit shallow coastal coral reef areas to deep slope rocky habitats (0-400 m)
Water Column	Pelagic	Pelagic	Demersal	Demersal
Bottom Type	N/A	N/A	Wide variety of shallow-water reef and estuarine habitats	Primary forage habitat is shallow to deep reef and rocky substrate.
Oceanic Features	Subject to advection by prevailing currents	Subject to advection by prevailing currents	N/A	N/A

Management Unit Species: **Grammistidae (Soapfish)**

The soapfishes are small, grouper-like fishes that emit a toxic slime to deter predation by larger fishes. They are secretive fish that occur on reef flats, shallow lagoon and seaward reefs, often in small caves, under ledges or in holes at depths up to 150 m. They are nocturnal predators on fishes, crustaceans and a variety of invertebrates. They are represented in Hawaii by three species of the genus *Liopropoma* and two species of *Pseudogramma*. At least one species, *L. aurora*, is endemic. There are 6 species of soapfishes in Micronesia and 4 species in Samoan waters. The taxonomy of the soapfish is frequently under debate, and it has been placed in at least 4 other families. Randall (1996) treats Grammistinae as a subfamily of the Serranidae.

The grammistids, like the serranids, are generally hermaphroditic, although Smith (1971) reported that members of *Liopropoma* appeared to be secondary gonochorists, with separate sexes but clearly derived from hermaphroditic ancestors. Smith and Atz (1966) reports that members of *Pseudogramma* are hermaphroditic. All are typically solitary and territorial. *Diploprion* and *Liopropoma* appear to have pelagic eggs, while P*seudogramma* has large, bright red eggs that are probably demersal. The duration of the planktonic phase is not known, but the size of the largest examined pelagic specimen was 12.6–14.5 mm (Leis and Rennis 1983).

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Management Unit Species: Grammistidae (soapfishes)

	Egg	Larvae	Juvenile	Adult
Duration				
Diet	N/A	zooplankton	similar to adult	small fishes, crustaceans and other invertebrates
Distribution, general and seasonal			similar to adult	Atlantic, Pacific, and Indian Oceans; 5 species in Hawaii with at least one endemic; at least 6 species in Micronesia
Location	pelagic; possibly demersal for *Pseudogramma* spp.	predominantly offshore		outer reef slopes, reef flats, lagoons, wave-washed seaward reefs
Water column	pelagic; possibly demersal for *Pseudogramma* spp.	pelagic	demersal; 1-150 m	demersal; 1–150 m
Bottom type		N/A	similar to adults	secretive inhabitants of caves, crevices on coral reefs and rocky substrate
Oceanic features		subject to advection by ocean currents		

Management Unit Species: **Plesiopidae (prettyfins)**

Prettyfins, or longfins, are characterized by a disjunct lateral line, preopercle with a double border and long pelvic fins. They are nocturnal predators on small crustaceans, fishes and gastropods. They are secretive during the day. No species are recorded for the Hawaiian islands, and 3 species are recorded for Micronesian waters. Three species are recorded in Samoan waters. The comet *Calloplesiops altivelis* is a popular aquarium fish that is relatively uncommon in Micronesia. The red-tipped longfin *Plesiops caeruleolineatus* is a common, but seldom seen, fish on exposed outer reef flats and outer reef slopes to a depth of 23 m. The bluegill longfin *P. corallicola* is relatively common on reef flats under rocks or in crevices.

Prettyfin reproduction is similar to the closely related dottybacks. They are demersal spawners in which the male tends the egg mass. Mito (1955) reported that *P. semeion* eggs are 0.9 by 0.6 mm, and are deposited in a single layer on the underside of a rock.

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Management Unit Species: Plesiopidae (prettyfins)

	Egg	Larvae	Juvenile	Adult
Duration	15 days by a mouth-brooding species in an aquarium (Debelius and Baensch 1994)	3 months for a related basslet	3 years for a related basslet	
Diet	N/A	zooplankton	probably similar to adult	small crustaceans, fishes, and gastropods
Distribution, general and seasonal				3 species recorded for Micronesian waters; none in Hawaiian waters
Location	near adult territory; often in caves or crevices	primarily offshore	similar to adults	outer reef slopes and flats
Water column	demersal; or carried in the mouth of the male	pelagic	demersal; 3-45 m	demersal; 3–45 m
Bottom type	cleared patch of rock or coral	N/A	same as adults	holes and crevices on coral reefs; also sand and rock
Oceanic features		subject to advection by ocean currents		

Management Unit Species: **Pseudochromidae (dottybacks)**

Dottybacks are small (<65mm) elongate fishes with a long continuous dorsal fin. Two genera are present in Micronesian waters: *Pseudochromis* has a disjunct lateral line, whereas *Pseudoplesiops* lacks one. Members of *Pseudoplesiops* typically remain hidden within the reef framework and are rarely seen except when an ichthyocide is used. Some members of *Pseudochromis* are brightly colored and are sought after for the aquarium trade. The dottybacks are carnivores of small crustaceans, polychaete worms and zooplankton. The dottybacks are demersal spawners, and some may brood eggs in the mouth of the male. Females of *Pseudochromis* produce a spherical mass of eggs that is guarded by the male. Dottybacks are not present in Hawaiian waters, while 10 species are present in Micronesian waters. Five species are recorded for Samoan waters.

Dottybacks are hermaphrodites. Males are typically larger than females. Some species are obviously sexually dichromatic, while others are not. Pseudochromoid egg balls range in diameter from 7 mm with about 60 eggs in *Assessor macneilli* (Thresher 1984) to 5–8 cm with 8,200 to 17, 500 eggs for *Acanthoclinus quadridactylus* (Jillet 1968). Individual *Pseudochromis fuscus* eggs are 1.25 mm in diameter, slightly elongate spheroids attached by several adhesive threads. Incubation periods range from 3 to 5 days at approximately 29°C. Hatching typically occurs at night, shortly after sunset. Newly hatched larvae of *P. fuscus* are 2.5 mm, and feeding typically begins on the first day after hatching (Lubbock 1975). Jillett (1968) estimates a planktonic larval stage of 3 months for *A. quadridactylus*, which reaches sexual maturity in approximately 3 years.

Pseudochromis cyanotaenia is sexually dichromatic, relatively common near holes and crevices of exposed outer reef flats and reef margins to a depth of 4 m, often occurs in pairs and feeds on small crabs, isopods and copepods. *P. fuscus* is common near small patches of branching corals on shallow sandy subtidal reef flats and lagoons.

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Management Unit Species: Pseudochromidae (dottybacks)

	Egg	Larvae	Juvenile	Adult
Duration	3–5 days for *Pseudochromis fuscus* (Thresher 1984)	3 months	3 years for an Australian species *Acanthoclinus quadridactylus*	
Diet	N/A	zooplankton	probably similar to adult	small crustaceans, polychaete worms, and zooplankton
Distribution, general and seasonal				10 species recorded for Micronesian waters; none in Hawaiian waters
Location	near adult territory; often in caves or crevices	primarily offshore	similar to adults	exposed outer reef flats and reef margins; also near small patches of branching corals on shallow sandy subtidal reef flats and lagoons
Water column	demersal; or carried in the mouth of the male	pelagic	demersal; 0–100m	demersal; 0–100m
Bottom type	cleared patch of rock or coral	N/A	same as adults	holes and crevices on coral reefs; also sand
Oceanic features		subject to advection by ocean currents		

Management Unit Species: **Acanthoclinidae (spiny basslets)**

Acanthoclinids are closely related to the pseudochromids but differ in having more dorsal and anal fin spines and 1or 2 instead of 3 to 5 pelvic rays. Basslets in general produce demersal eggs and have a tendency towards oral incubation. Eggs are typically tended by the male or brooded by them in the case of brooders. Other basslets have eggs that hatch within 3–16 days and larvae that have a planktonic stage of up to 3 months. The basslets are fairly secretive inhabitants of coral reefs, but some species are conspicuous as they hover near shelter. They are often collected for aquariums. There are 10 known species, but only 3 occur in the Indo-Pacific, with none in Hawaii and one species in Micronesia. Hiatt's basslet *Acanthoplesiops hiatti* is a tiny species (to 21 mm) that has been collected from shallow-washed seaward reefs in Micronesia.

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Management Unit Species: Acanthoclinidae (spiny basslets)

	Egg	Larvae	Juvenile	Adult
Duration	3–16 days	months		
Diet	N/A		similar to adults	small crustaceans, polychaete worms, and zooplankton
Distribution, general and seasonal				West-central Pacific; one species *Acanthopesiops hiatti* found in Micronesia
Location		offshore waters	shallow wave-washed seaward reefs	shallow wave-washed seaward reefs
Water column	demersal	pelagic	reef-associated; 1–65 m	reef-associated; 1–65 m
Bottom type			coral or rock shelter	coral or rock shelter
Oceanic features		subject to advection by ocean currents		

Management Unit Species: **Cirrhitidae (hawkfish)**

Hawkfishes are small grouper-like fishes characterized by projecting cirri on the tips of the dorsal spines. The common name comes from their tendency to perch themselves on the outermost branches of coral heads or other prominences. They use enlarged lower pectoral rays to support their body or to wedge themselves in place. All are carnivores of small benthic crustaceans and fishes. The species thus far studied are protogynous hermaphrodites, and the males are territorial and defend a harem of females. Courtship and spawning occur at dusk or early night throughout the year in the tropics. Spawning occurs at the apex of a short, rapid paired ascent. The pelagic larval stage probably lasts a few to several weeks (Randall 1963). In Hawaii, there are 6 species recorded. At least 10 species occur in Micronesia, and at least 8 species occur in Samoa. The colorful species are popular aquarium fishes.

Hawkfishes range in size at maturity from less than 10 cm to almost a meter. Most species are sexually monomorphic. Pair spawning occurs with the male making quick ascents with each of the members of his harem in rapid succession. Eggs are pelagic, spherical and approximately 0.5 mm in diameter. The development at hatching is unknown. A lengthy pelagic stage is suggested by the widespread distribution and limited geographic variation of some species. The smallest specimen examined by Leis and Rennis (1983) was 2.7 mm, and the largest pelagic specimen examined was 33.0–37.9 mm. Juveniles of most species resemble the adults.

Adults typically inhabit rock, coral or rubble of the surge zone, seaward reefs, lagoons, channels, rocky shorelines and submarine terraces. Some are typically found on heads of small branching corals. The longnose hawkfish *Oxycirrhites typus* is a popular aquarium fish that feeds mainly on zooplankton and is usually seen perched on black coral or gorgonians at depths greater than 30 m.

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Management Unit Species: Cirrhitidae (hawkfishes)

	Egg	Larvae	Juvenile	Adult
Duration		weeks to months		
Diet	N/A		similar to adults	carnivores of small benthic crustaceans and fishes; the longnose hawkfish *Oxycirrhites typus* feeds heavily on zooplankton
Distribution, general and seasonal				most are Indo-West Pacific; 6 species in Hawaii, at least 10 species in Micronesia, and at least 8 species in Samoa
Location	near adult territory	generally offshore	similar to adults	the surge zone, seaward reefs, lagoons, channels, rocky shorelines and submarine terraces. Some are typically found on heads of small branching corals
Water column	pelagic	pelagic	demersal	demersal
Bottom type	N/A	N/A	rock, coral, or rubble	rock, coral, or rubble
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Apogonidae (cardinalfishes)**

The cardinalfishes are named for the red color of some of the species, although most are fairly drab and many are striped. They are characterized by two dorsal fins, large eyes, a large mouth and double-edged preopercles. Most species are small, less than 12 cm. They are typically nocturnal, remaining hidden under ledges or in holes in the reef during the day. Most prey mainly on large zooplankton, but some feed primarily on small benthic crustaceans. A few species form dense aggregations immediately above mounds of branching corals. As far as is known, all species are brood spawners in which the male carries the eggs in his mouth until they hatch. Ten species occur in Hawaii, and at least 58 species occur in Micronesia. *Apogon erythrinus*, *A. maculiferus*, and *A. menesemus* are endemic to the Hawaiian Islands. At least 36 species occur in Samoa.

External sexual dimorphism is slight or nonexistent in the cardinalfishes, except for females that are noticeably swollen with eggs prior to spawning. Temporary color differences during courtship and spawning occur in a few species. Apogonid species display a variety of different seasonal spawning patterns, from year-round spawning to spring and fall peaks. Spawning may also be tied to the phases of the moon.

Schooling behavior is important in some species of cardinalfishes. The fragile cardinalfish *A. fragilis* occurs in large aggregations above branching corals. Despite these aggregations, courtship and spawning in cardinalfishes are always paired rather than group activities. The female often initiates courtship, which involves prolonged tight side-by-side swimming until spawning occurs and the female releases a ball of eggs which the male quickly circles back to and inhales. The male broods the eggs in the mouth for anywhere from 2 to 8 days. The eggs, up to 22,000 of them, are bound together by threads that originate from one pole of the egg and, in some species, a fine mucous membrane. Upon hatching, the eggs become planktonic larvae ranging in size from 1.0–3.3 mm. The planktonic larval stage lasts approximately 60 days, until larvae settle out at a size ranging from 10 to 25 mm.

Cardinalfish are found in water depths from 1 to 80 m. Members of the genera *Apogonichthys, Foa* and *Fowleria* are typically secretive, cryptic inhabitants of seagrasses, algal beds or rubble of sheltered reefs and reef flats. The bay cardinalfish *Foa brachygramma* is usually found around dead coral, sponge or heavy plant growth in shallow bays such as Kaneohe Bay, Oahu, and Tumon Bay, Guam.

Chave (1978) detailed the ecology of 6 species of Hawaiian cardinalfishes, all of which remain in holes and caves in the daytime and emerge at night to feed on zooplankton and benthic invertebrates. The habitat requirements of each species was distinct. Some species remain near the substrate at night (*A. snyderi* and *A. erythrinus*), while others occur in midwater (*A. menesemus*, *A. maculiferus* and *A. waikiki*), and *Foa brachygramma* occurs in both locations. *A. snyderi* eats mostly sand dwelling invertebrates in sandy, bright, flat substrate, *A. maculiferous* eats mostly midwater zooplankton near dawn, and *A. erythrinus* eats crustaceans only (Chave 1978).

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Management Unit Species: Apogonidae (Cardinalfishes)

	Egg	Larvae	Juvenile	Adult
Duration	2–8 days	approximately 60 days		
Diet	N/A	zooplankton; tintinnids (Watson 1974)	feed on plankton at night; some species eat primarily small benthic crustaceans	feed on plankton at night; some species eat primarily small benthic crustaceans
Distribution, general and seasonal	throughout the year, spring and fall peaks for some species	throughout the year, spring and fall peaks for some species	Atlantic, Pacific, and Indian Ocean	Atlantic, Pacific, and Indian Ocean
Location	within the father's mouth	predominantly offshore	coral reefs	coral reefs
Water column	within the father's mouth	pelagic	demersal and mid-water at night for feeding on zooplankton; 1-80m depth	demersal and mid-water at night for feeding on zooplankton; 1–80 m depth
Bottom type	N/A	N/A	coral reef ledges, holes, flats, rubble, within the branches of branching corals	coral reef ledges, holes, flats, rubble, within the branches of branching corals
Oceanic features				

Management Unit Species: **Priacanthidae (Bigeyes)**

Priacanthids have very large eyes, moderately deep compressed bodies, oblique mouths with a projecting lower jaw, small conical teeth in a narrow band in each jaw, an opercle with 2 flat spines and a serrate preopercle with a broad spine at the corner. They are usually red but are able to change quickly to silver or blotches of silver and red. They are nocturnal zooplanktivores on larger zooplankton, such as the larvae of crabs, fishes, polychaete worms and cephalopods. The family is distributed circumtropically and in temperate seas, but some species are limited to the Indo-Pacific or the Hawaiian Islands. In Hawaiian waters, 4 species have been recorded: *Heteropriacanthus cruentatus*, the endemic *Priacanthus meeki* and two deep-water species. In Micronesian waters, *H. cruentatus*, *P. hamrur* and a deep species from below 200 m depth have been recorded. The shallow-water species are limited to 100 m or less. Five species are recorded from Samoan waters.

The glasseye *H. cruentatus* inhabits lagoon or seaward reefs from below the surge zone to a depth of at least 20 m. During the day it is usually solitary or in small groups but may gather in large numbers at dusk prior to ascending into the water column for feeding.

Spawning by priacanthids has not been observed, but Colin and Clavijo (1978) reports seeing an aggregation of more than 200 individuals at a reef where many other species were spawning. The eggs of *Pristigenys niphonium* and *Priacanthus macracanthus* are pelagic, spherical and 0.75 mm in diameter (Suzuki et al. 1980, Renzhai and Suifen 1982). The larvae hatch at 1.4 mm (Renzhai and Suifen 1982). The size of the largest examined pelagic larval specimen was 48 mm (Leis and Rennis 1983). Caldwell (1962) reports a size at settlement for the deep-water subtropical species *Pristigenys alta* of 65 mm.

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Management Unit Species: Priacanthidae (bigeyes)

	Egg	Larvae	Juvenile	Adult
Duration		from 10 mm to about 60 mm		
Diet	N/A	various zooplankton	similar to adults	larger zooplankton such as the larvae of crabs, fishes, polychaete worms and cephalopods; also crustaceans and soft-bodied invertebrates
Distribution, general and seasonal				worldwide in tropical and temperate seas, but 3 Indo-Pacific genera, 1 Hawaiian endemic
Location				lagoon or seaward reefs from below the surge zone to a depth of at least 80 m
Water column	pelagic	pelagic	demersal and mid-water column	demersal and mid-water column; some species very deep
Bottom type	N/A	N/A		coral reef crevices or overhangs during the day; may feed over soft substrate at night
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Malacanthidae (tilefishes)**

The tilefishes have elongate bodies with one sharp opercular spine and a long continuous dorsal fin. They have viliform and canine teeth for taking a variety of benthic animals along with substantial amounts of plankton. They usually occur in pairs on sandy and rubbly areas of outer reef slopes. They frequently build a burrow into which they retreat when threatened, often piling rubble on top. They can be found in depths from 6 to 115 m in mud, sand, rubble or talus areas of barren seaward slopes. The family is distributed worldwide in tropical and temperate seas. The family is represented in Hawaiian waters by a single species, *Malacanthus brevirostris*, and in Micronesian waters by the same species plus four more: *Hoplolatilus cuniculus, H. fronticinctus, H. starcki* and *M. latovittatus*. Two species are present in Samoan waters: *M. brevirostris* and *M. latovittatus*.

Accounts of spawning are few, but pairs typically make a short spawning ascent to release pelagic, spheroid eggs, about 0.7 mm in diameter with a single oil globule. After a larval phase of undetermined duration, *Malacanthus* settle to the bottom at a size of about 6 cm and immediately construct burrows under rocks in shallow water (Araga 1969).

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Management Unit Species: Malacanthidae (Tilefishes)

	Egg	Larvae	Juvenile	Adult
Duration		weeks or months	settlement at a size of about 6 cm	
Diet	N/A		benthic invertebrates and plankton	benthic invertebrates and plankton
Distribution, general and seasonal				3 Indo-Pacific genera
Location			shallow sheltered habitats	outer reef slopes
Water column	pelagic	pelagic	demersal	demersal
Bottom type	N/A	N/A	sand, mud, rubble	sandy and rubbly areas
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Echineididae (remoras)**

Remoras have a broad flat head uniquely modified for suction that allows them to attach to other marine animals. Some species are host specific while others use a variety of hosts such as sharks, rays, large bony fishes, sea turtles or marine mammals. Some species are free swimming. The two species of *Echeneis* are not host-specific and are free-living part of the time. Remoras are circumglobal in their distribution. In Hawaii and in Micronesia, the sharksucker *E. naucrates* is the most common, although *Remora remora* may be found on large sharks and *Remorina albescens* on mantas. Five species are recorded from Samoan waters, including *E. naucrates, R. remora,* and *Phtheirichthys lineatus*, which was attached to a hawksbill turtle. *Remoropsis pallidus* and *Rhombochirus osteochir* were found attached to marlin.

Johnson (1984) reports that eggs of *E. naucrates* and *R. remora* are large (1.4–2.6 mm), pelagic and spherical, although Nakajima et al. (1987) reports *E. naucrates* eggs are negatively buoyant. Newly hatched eggs are 4.7–7.5 mm long. The size of the largest examined pelagic larval stage was 14.5–22 mm (Leis and Trnski 1989).

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Management Unit Species: Echineididae (remoras)

	Egg	Larvae	Juvenile	Adult
Duration		size at hatching ranges from 3.7 to 7.5 mm		
Diet	N/A	zooplankton	similar to adults	zooplankton such as copepods and isopods; zoobenthos such as small crustaceans; detritus, and small fishes (Randall 1967)
Distribution, general and seasonal	little information on seasonal patterns		circumglobal	circumglobal
Location			coastal and pelagic waters	coastal and pelagic waters; often attached to sharks, rays, large bony fishes, sea turtles, or marine mammals
Water column	pelagic	pelagic	same as adults	pelagic; either free swimming or attached to large reef-associated inhabitants
Bottom type	N/A	N/A	N/A	N/A
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: ***Carangidae (Jacks, papio,ulua)***

Eggs and larvae

There are few extant studies of the distribution of carangid eggs and larvae. Carangid eggs are planktonic, spherical and 0.70-1.3mm in diameter (Laroche et al. 1984, Miller et al. 1979). The eggs usually contain one to several oil globules. The eggs hatch 24-48 hours after spawning in water temperatures from 18 to 30 C° (Laroche et al. 1984). The larvae are relatively small (1 - 2 mm) at hatching and contain a relatively large yolk sac. The larvae are moderately deep bodied and large headed with well developed preopercular spines (Miller et al. 1979). According to Miller et al. (1979) carangid larvae are common in nearshore waters surrounding the Hawaiian Archipelago.

Juvenile

Juvenile carangids are often found in nearshore and estuarine waters and may form small schools over sandy inshore reef flats (Lewis et al. 1983, Meyers 1991). Available diet studies suggest that juvenile carangids are planktivorous and feed on fish larvae and planktonic crustaceans

Adult

The carangids are distributed throughout tropical and subtropical waters in the Indo-Pacific. They are widely distributed in shallow coastal waters, estuaries, shallow reefs, deep reef slope, banks and seamounts (Sudekum et al. 1991). Juvenile and adult carangids are an important component of shallow reef and lagoon fish catches throughout the management area. Adult carangids are large highly-mobile predators that range widely through the reef and deep slope habitat from depths of 0- 250m. A single species (*Seriola dumerili*) has been documented to forage at depths of up to 355 m (Myers 1991, Ralston et al. 1986). Although most of the large jacks utilize the complete water column in their habitat range they are associated primarily with demersal habitat.

In general adult carangids are piscivourous, they also prey on crustaceans, gastropods, and cephalopods. *Caranx ignobilis*, one of the most abundant species of jacks found in Hawaii is primarily piscivourous, preying primarily on reef-associated fish. The most recent study of the feeding habits of *C. ignobilis* concludes that the predominance of reef fishes in its diet indicates that shallow-water reef areas are important foraging habitat for these fish. The occurrence of small pelagic fish and squid in the diet of C. ignobilis indicates that part of its foraging also occurs in the water-column (Sudekum at al. 1991).

Reproductive information is sparse for most species. In Hawaii the sex ratio for *C. ignobilis* is slightly skewed toward females 1:1.39 (Sudekum et al. 1991). Peak spawning occurs between May and August, although gravid fish are present in the Northwestern Hawaiian Islands (NWHI) between April and November. Spawning occurs in pairs within larger aggregations during the new and full moon (Johannes 1981), on offshore banks and shallow nearshore reefs (Myers 1991).

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Management Unit: Carangidae (jacks)

	Egg	Larvae	Juvenile	Adult
Duration	24 - 48 hours after spawning	Poorly known, larvae thought to be more common offshore than inshore	Sexual maturity attained at 1-3.5 years depending on species	One species (*C. ignobilis*) life span exceeds 15 years
Diet	N/A	No information available	Generally switch from planktivory to piscivory with increase in age	Predominantly piscivorous utilizing shallow-water reefs. The water-column is also utilized .
Distribution	Pelagic	Pelagic, more common in summer	Near-shore and estuarine waters	Throughout Indo-Pacific. Inhabit shallow coastal areas to deep slope (0-350m)
Water Column	Pelagic	Pelagic	Bentho-pelagic	Bentho-pelagic, utilize entire water-column but primarily associated with demersal habitat
Bottom Type	N/A	N/A	Wide variety of shallow-water reef and estuarine	Primary forage habitat is shallow to deep reef
Oceanic Features	Subject to advection by prevailing currents	Subject to advection by prevailing currents	N/A	N/A

Management Unit Species: **Decapterus/Selar** ***(Scads, opelu, akule)***

Egg and Larvae

The spawning of scads occurs in the pelagic environment. Depending on the species the ovaries of the female may contain from 30,000 to 200,000 eggs. The spawned eggs are spherical with a single oil globule, non-adhesive, and free floating (Yamaguchi 1953).

Juvenile

After hatching the larvae and juvenile fish remain in the pelagic environment where they frequently form large aggregating schools. Reports from fishermen have identified aggregations of juvenile scads as far as 80 nmi. offshore (Yamaguchi 1953). Juveniles enter the nearshore coastal waters in late fall and winter, where they grow rapidly over the next few months, usually attaining sexual maturity during the first year of life.

Larval and juvenile fish remain in offshore pelagic waters for the first several months of their life, after which they migrate to the nearshore adult habitat (0-100m).

Adults

Adults spawn in pelagic waters usually in proximity to their coastal habitat. Spawning appears to be seasonal from March through August, reaching a peak from May to July. These species feed in the water column and are mainly planktivorous, preying on zooplankton. Their diet consists of amphipods, crab megalops, fish larvae, pteropods, and copepods, however some species also feed on small fishes such as anchovies and holocentrids (Yamaguchi 1953). Adult opelu and akule inhabit nearshore waters around islands from shoreline depths to 100m.

Management Unit: Decapturus/Selar

	Egg	Larvae	Juvenile	Adult
Duration	No information	No information	migrate to nearshore waters ~ Six months after hatching	Relatively fast growing and short lived. Sexual maturity usually in first year of life
Diet	N/A	planktivorous	zooplanktivorous	primarily zooplanktivorous, with some piscivory
Distribution	circumtropical pelagic	circumtropical pelagic	circumtropical nearshore	circumtropical nearshore
Water Column	pelagic	pelagic	pelagic and nearshore reef in water column	nearshore reef in water column (neritic)
Bottom Type	N/A	N/A	N/A	N/A
Oceanic Features	Subject to advection by prevailing currents	Subject to advection by prevailing currents	offshore pelagic, migrate to nearshore waters in first year	nearshore waters

Management Unit Species: **Caesionidae (fusiliers)**

Fusiliers are planktivorous, schooling fishes. They have an elongate, fusiform body, a small terminal mouth with a very protrusible upper jaw, small conical teeth and a deeply forked tail. During the day, fusiliers swim actively in midwater around or near reefs in synchronomous formation, changing the formation to feed on zooplankton. They are particularly abundant along steep outer reef slopes and around deep lagoon pinnacles. They are often observed around cleaner stations, where some members of the aggregations pause to be cleaned by cleaner wrasses. They are not found in Hawaii. At least 10 species occur in Micronesia, and at least 5 species occur in Samoa.

The reproductive biology of caesionids has been examined in only a few species. They appear to be typified by early sexual maturity and high fecundity. They have a prolonged spawning season, but recruitment peaks once or twice a year. Fusiliers are dioecious and gonochoristic, with no significant difference in sex ratio. Spawning has been observed for *Caesio teres* (Bell and Colin 1986) and *Pterocaesio digramma* (Thresher 1984). These caesionids spawn in large groups around the full moon. They migrate to select areas on the reef at dusk and initiate spawning during slack water. In *C. teres*, spawning is preceded by periodic mass vertical ascents and descents to within about 1 m of the surface. During spawning they stay near the surface and subgroups within the mass swirl rapidly in circles and release gametes (Carpenter 1988).

During initial recruitment to a reef, juvenile caesionids generally remain close to the substrate and dart around coral heads and rocks to escape. At night, fusiliers shelter in crevices and under coral heads. Fusiliers often school in mixed species aggregations. They are primarily reef inhabitants, although they often range over soft bottoms in between reefs.

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Management Unit Species: Caesionidae (fusiliers)

	Egg	Larvae	Juvenile	Adult
Duration		weeks to months	reach maturity early	
Diet	N/A	various plankton	planktivores	planktivores
Distribution, general and seasonal	prolonged spawning season but tends to peak once or twice a year			tropical Indo-Pacific; None in Hawaii, at least 10 spp. in Micronesia, and 5 in Samoa
Location	spawning occurs at specific sites on a reef (Bell and Colin 1986)	offshore	similar to adults	abundant along steep outer reef slopes and around deep lagoon pinnacles
Water column	pelagic	pelagic	reef-associated; typically remain close to shelter	pelagic
Bottom type	N/A	N/A	coral or rock	coral, rock, but range over sand in travels from reef to reef
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Haemulidae (sweetlips)**

Haemulids are very similar to lutjanids but differ by having smaller mouths a bit lower on the head with small conical teeth and thickened lips, by having pharyngeal teeth and by lacking canine and palatine teeth. Some members of the sweetlip family are commonly called grunts because of the sound they can make by grinding the pharyngeal teeth and amplifying the noise with their gas bladder. Haemulids are primarily nocturnal feeders on benthic invertebrates. During the day they typically school under or near overhangs or tabular corals. Their general lethargy during the day and their schooling tendencies makes them easy targets for spearfishers. As a result, they have become scarce in waters near population centers such as Guam. Most species of *Plectorhinchus* change color dramatically with group. The striped juveniles of many species are similar and difficult to distinguish from other haemulid juveniles. Eleven species are recorded from Micronesian waters. None are recorded for the Hawaiian Islands. Three species are recorded from Samoan waters.

There is little information on haemulid reproduction, particularly in Indo-Pacific locations. Given their similarity to other roving benthic predators, such as groupers or snappers, the haemulids probably migrate to spawning sites on the outer reef slope for group spawning at dusk. Eggs are pelagic with a single oil droplet, and hatching time is approximately 24 hours. Duration of the planktonic stage for *Haemulon flavolineatum* is approximately 15 days, when the larvae settle to the bottom at a length of approximately 6 mm (McFarland 1980, Brothers and McFarland 1981). Juvenile grunts are commonly found in small groups on grass flats, near mangroves and in other inshore areas. Cummings et al. (1966) report sexual maturity of *H. album* at approximately 37.5 cm. Gaut and Munro (1983) found mean lengths at maturity for the Caribbean species *H. plumieri, H. flavolineatum, H. sciurus* and *H. album* of 22 cm FL, 12 cm FL or less, 15.5 cm FL 22 cm FL and 24 cm FL respectively.

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Management Unit Species: Haemulidae (sweetlips and grunts)

	Egg	Larvae	Juvenile	Adult
Duration	approximately 24 hrs	15 days to months	from 6 mm until 12–24 mm FL	
Diet	N/A	copepods, nauplii (Houde and Lovdal 1984)	similar to adult	nocturnal predators on benthic invertebrates, including crustaceans, mollusks, and fishes
Distribution, general and seasonal	likely spring spawning peak		similar to adult	no species recorded for Hawaii; tropical and temperate seas in marine and brackish waters worldwide; 11 Micronesian species
Location	probably outcroppings on outer reef slopes	offshore	sheltered inshore areas in lagoons, estuaries, mangroves as well as adult locations	close to patch reefs, lagoons,inshore and seaward reefs, channels, outer reef slopes
Water column	pelagic	pelagic	demersal and reef or mangrove-associated	demersal and reef-associated; 1–100m
Bottom type	N/A	N/A	sandy to muddy bottoms, coral, rocky ledges or table corals	sandy to muddy bottoms, coral, rocky ledges or table corals
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Lethrinidae (Emperors)**

Egg and Larvae

Lethrinid eggs are pelagic, spherical ,colorless, and range in size from 0.63 to 0.83 mm. The eggs hatch within 21 to 40 hours after fertilization (Carpenter and Allen 1989). The larvae when hatched range in size from 1.3 to 1.7mm. Larval characteristics include unpigmented eyes, large yolk sac, variable body pigmentation and extensively developed head spination.

Juveniles and Adults

Juvenile and adult lethridids are found throughout the Indo-Pacific in tropical and sub-tropical waters. They are fairly long-lived ranging 7-27 years (Carpenter and Allen 1989). Although little is known of the biology of these species, they are known to inhabit the deeper waters of coral reefs and adjacent sandy areas. Some species also occur in shallow water habitats around coral reefs, sand flats, sea-grass beds and mangrove swamps (Carpenter and Allen 1985). Lethrinids appear to be carnivorous bottom-feeders. Their diet includes: crabs, sea-urchins, bivalves, gastropods, and fish (Walker 1978).

Based on the available data, lethrinids appear to be protogynous hermaphrodites (Young and Martin 1982). Spawning occurs throughout the year, and is preceded by localized migrations during crepuscular periods. Peak spawning occurs on or near the new moon. Spawning may occur at near the surface as well as near the bottom of reef slopes. Lethrinids may reach a maximum length of 70 cm. Males tend to attain a larger size than females.

Management Unit: Lethrinidae (Emperors)

	Egg	Larvae	Juvenile	Adult
Duration	hatch 21 - 40 hours after spawning	No information	No information	7-27 Years
Diet	N/A	No information	No information	Carnivorous bottom-feeders
Distribution	Pelagic	Pelagic	Nearshore areas and shallow seamounts	Throughout Indo-Pacific. Inhabit shallow coastal areas to deep slope (0-350m)
Water Column	Pelagic	Pelagic	Benthic	Benthic
Bottom Type	N/A	N/A	Demersal Reef	Primary forage habitat shallow to deep reef feeding on the bottom
Oceanic Features	Subject to advection by prevailing currents	Subject to advection by prevailing currents	N/A	N/A

Management Unit Species: **Lutjanidae (Snappers)**

Egg and Larvae

Lutjanid eggs are pelagic, spherical and 0.65-1.02 mm in diameter. Each egg contains a single oil globule which provides buoyancy during the pelagic phase. Incubation is between 17-27 hours depending on species and temperature. Newly hatched larvae of lutjanids in general are typical of those from fish with small pelagic eggs; the larvae have a large yolk sac, unpigmented eyes and no mouth. The yolk sac typically lasts 3-4 days, after which the mouth is fully formed and the eyes become pigmented (Leis 1987). The larvae are absent from surface waters during the day and migrate upward at night. Snapper larvae are thought to be planktonic and subject to advection by ocean current systems until benthic habitat suitable for metamorphosis is encountered (Munro 1987). The duration of the pelagic phase is thought to be at least 25 days (Leis 1987) and may be as long as 45 days.

Juveniles

Little information currently exists on larval development, settlement or early juvenile life history of deepwater snappers in Hawaii (Haight et al. 1993a). Little is known about the ecology of juveniles from time of settlement to their appearance in the adult fishery. Age at entry to the fishery for the principle fishery species in Hawaii is thought to be 2 to 3 years after settlement (Moffitt and Parrish 1996). In a three year study of fish settlement on artificial reefs adjacent to adult snapper habitat in Hawaii, no recruitment of juvenile snappers to the reefs was observed, although adults aggregated at times around the reef structures (Moffitt et al. 1989).

Studies on juveniles of one snapper species in Hawaii indicated juvenile *Pristipomoides filamentosus* first appear in the relatively shallow (60 - 100 m) nearshore areas at about 10 months of age (7 - 10 cm FL) during the fall and early winter months. The young fish remain in this habitat for the next 7 months until they reach 18 - 24 cm FL (Moffitt and Parrish 1996, Ellis et al 1992). *In situ* scuba observations of the juvenile habitat found it to be a relatively flat, soft sediment substrate devoid of relief (Parrish 1989).

Adults

Tropical snappers in general are slow growing, long lived and have low rates of natural mortality. Maximum ages exceed 10 years and von Bertalanffy growth coefficients (K) are usually in the range of 0.10 to 0.25 per year (Manooch 1987). Most ageing studies of tropical snappers have depended on the enumeration of regularly formed marks on calcareous structures. In Hawaii, Ralston and Miyamoto (1983) used daily growth increments deposited on the otoliths of immature *P. filamentosus* to determine its growth rate. The estimated growth coefficient of opakapaka is 0.145 per year, and asymptotic upper boundary on growth ($L\infty$) was 78 cm FL, which occurred at over 18 years of age.

Ralston (1987), in a comprehensive review of published reports on snapper growth and natural mortality, determined that for the 10 species studied, mortality and growth rates were highly correlated, with a mean M/K ratio of 2.0. Thus, if a value of K is available for a given species, its natural mortality rate can be estimated. Using an age-length probability matrix for opakapaka applied to length frequency samples, Ralston (1981) estimated the natural mortality rate for opakapaka in Hawaii to be 0.25, which when compared to the estimated K value for this species (0.145) is close to the value predicted by the M/K relationship derived for snappers in general.

Size at sexual maturity for lutjanids on average occurs at about 43 to 51% of L_∞ (Allen 1985). Size at maturity has been estimated for only two species in the MHI and two species in the NWHI. In the MHI, uku reaches sexual maturity at 47 cm fork length (FL), which is 46% of maximum size (L_∞). Onaga reaches sexual maturity at 61 cm FL (62% L_∞) (Everson et al. 1989). In the NWHI, ehu reaches maturity at about 30 cm FL (46% L_∞) and opakapaka reaches maturity at around 43 cm FL (48% L_∞) (Everson 1984, Kikkawa 1984, Grimes 1987).

Gonadal studies on four of the species in Hawaii indicate that spawning may occur serially over a protracted period but is at a maximum during the summer months, and peaks from July to September (Everson et al. 1989, Uchida and Uchiyama 1986). Estimated annual fecundity is 0.5 to 1.5 million eggs. The eggs are released into the water column.

Although snappers throughout the world are generally thought of as top level carnivores, several snapper species in the Pacific are known to incorporate significant amounts of zooplankton, often gelatinous urochordates, in their diets (Parrish 1987). Haight et al. (1993b) found zooplankton to be an important prey item in four of the commercially important snappers in Hawaii. The same study found that the six snapper species studied were either primarily zooplanktivorous or primarily piscivorous, with little overlap in diet composition between trophic guilds. A contributing factor in the distribution pattern of zooplanktivores may be that currents striking deepwater areas of high relief form localized zones of turbulent vertical water movement, increasing the availability of planktonic prey items (e.g. Brock and Chamberlain 1968). In an ecological study of the bottomfish resources of Johnston Atoll, Ralston et al. (1986) found *P. filamentosus* in much higher densities on the upcurrent versus downcurrent side of the atoll, and postulated that this was related to increased availability of allochthonous planktonic prey in the neritic upcurrent areas due to oceanic currents impacting the atoll.

Management Unit Lutjanidae (Snappers)

	Egg	**Larvae**	**Juvenile**	**Adult**
Duration	Incubate 17-36 hours	Pelagic duration : 25-47 days	Reach sexual maturity in 2-3 years	Long-lived, slow growing. Age at entry to fishery at 2-3 years
Diet	N/A	No information available	Diet of one species includes crustaceans, cephalopods and small fish	Primarily demersal carnivores although some species are zooplanktivorous
Distribution	Widely distributed throughout management area	Widely distributed throughout management area	Throughout Indo-Pacific. Juveniles of some species Inhabit shallow reef areas not utilized by adults	Throughout Indo-Pacific. Inhabit shallow coastal coral reef areas to deep slope rocky habitats (0-400 m)
Water Column	Pelagic	Pelagic	Demersal	Demersal
Bottom Type	N/A	N/A	Wide variety of shallow-water reef and estuarine habitats	Primary forage habitat is shallow to deep reef and rocky substrate.
Oceanic Features	Subject to advection by prevailing currents	Subject to advection by prevailing currents	N/A	N/A

Management Unit Species: **Mullidae (goatfishes)**

Goatfish are important commercial fish that are highly esteemed as food. All have a characteristic pair of long barbels at the front of the chin, a moderately elongate body, two well-separated dorsal fins, a small mouth with a slightly protruding upper jaw and a forked tail. Goatfish use the barbels, which contain chemosensory organs, to probe sand or holes in the reef for benthic invertebrates or small fishes. The barbels are tucked between the lower portion of the gill covers when not in use. Some species are primarily nocturnal, others are diurnal and a few are active by day or night. Nocturnal species tend to hover in stationary aggregations or rest on coral ledges by day.

There are 10 native species of goatfish known from Hawaiian waters, and one accidental introduced species from the Marquesas, *Upeneus vittatus*. Two species, *Parupeneus porphyreus* and *P. chrysonemus,* are endemic to Hawaii. Fifteen species are recorded from Micronesia. Thirteen species are recorded from Samoa.

Goatfish have pelagic eggs, which are spherical, transparent and non-adhesive with a single oil droplet. Egg diameters range from 0.63 to 0.93 mm and hatch within 3 days. Goatfish in general have a long larval development. After settlement, juveniles take approximately 1 year to reach sexual maturity. Munro (1976) suggests that few live more than 3 years.

Schooling is common among the mullids. Group spawning and pair spawning have been documented for goatfishes. An aggregation of 300 to 400 individuals was observed spawning at 21 m depth off the coast of the US Virgin Islands (Colin and Clavijo 1978). Groups of fish made spawning rushes about 2 meters above the bottom before releasing gametes.

Holland et al. (1993) conducted a study of the movements, distribution and growth rates of *Mulloidichthys flavolineatus*by using tagging data. *M. flavolineatus* and *M. vanicolensis* were the most abundant mullids found in Hanalei Bay (Friedlander et al. 1997). *M. flavolineatus* ranked second in overall mean biomass at 211g/100m^2, with an overall mean numerical density of 1.1 individuals/100m^2. *M. vanicolensis* had higher numbers in patch reef habitat, but the larger fish were present in reef slope habitat, indicating partitioning of habitat by size. *Parupeneus cyclostomus* was the rarest and most mobile of the mullids found in Hanalei Bay, with an overall mean density of 0.01 individuals/100m^2 or 2.02 g/100m^2. The largest individuals were seen in deeper reef slope habitat. *P. cyclostomus* has a diet strongly dominated by fish, particularly fish that are diurnally active over reef and other hard substrata. It also eats lesser quantities of crabs, shrimps and stomatopods and trace amounts of other invertebrates. It typically probes sand or reef crevices to flush out small fish with its barbels. *P. cyclostomus* is inactive at night.

The diet of the Hawaiian endemic *P. porphyreus* encompasses a wide variety of benthic invertebrates such as crabs, shrimps, isopods, amphipods, ostracods, stomatopods, planktonic crab megalops larvae and copepods, gastropods, foraminiferans and fish in order of decreasing importance. *P. porphyreus* shelters in areas of high relief and feeds over hard substrate and sandy areas nearby (Friedlander et al. 1997).

The breeding season for *P. porphyreus* shows peak spawning somewhere between December and July. Counts of nuclear rings on otoliths indicate a larval period of approximately 40–60 days. The juvenile phase involves rapid color changes, a lengthening of the gut and an external change in shape. Juveniles can sexually mature as early as 1.25 years. Fecundity was estimated as 11,000 to 26,00 eggs per spawn. Adults live 6 years or longer (Moffitt 1979).

Five goatfish species at Midway Island were generalized feeders, eating mostly small crustaceans, polychaetes and bivalve and opisthobranch molluscs (Sorden 1982). Sorden (1982) discusses similarities and differences among feeding preferences of the goatfish fauna at Midway.

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Management Unit Species: Mullidae (goatfishes)

	Egg	Larvae	Juvenile	Adult
Duration	3 days	relatively long, months?	approximately one year	3 years (Munro 1976)
Diet	N/A	planktivorous	benthic invertebrates such as crabs, shrimps, isopods, amphipods, ostracods, stomatopods, planktonic crab megalops larvae and copepods, gastropods, and foraminiferans; some species eat small fish	benthic invertebrates such as crabs, shrimps, isopods, amphipods, ostracods, stomatopods, planktonic crab megalops larvae and copepods, gastropods, and foraminiferans; some species eat small fish
Distribution, general and seasonal	spawning peaks in late spring and fall	most abundant in the open ocean, though still <25km from reefs	Atlantic, Indian and Pacific oceans, rarely in brackish waters	Atlantic, Indian and Pacific oceans, rarely in brackish waters; may have seasonal spawning aggregations at prominent reef features
Location	released several meters from the bottom	most abundant in the open ocean, though still <25km from reefs	pelagic for some species (Caldwell 1962), but coral reef and sand flat otherwise	coral reef or soft-bottom habitat
Water column	pelagic	pelagic	demersal	demersal
Bottom type	N/A	N/A	coral reef, rock, sand, mud, crevices, ledges	coral reef, rock, sand, mud, crevices, ledges
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents	unknown	spawning aggregations near channels with heavy tidal flow

Management Unit Species: **Kyphosidae (rudderfishes)**

Rudderfishes, or sea chubs, are shore fishes of rocky bottoms or coral reefs of exposed coasts. They have deep oval bodies, a continuous dorsal fin, a forked caudal fin and a small mouth with close-set incisiform teeth. They are benthic herbivores and the species of *Kyphosus* often occur in large groups that may overwhelm the defenses of territorial herbivorous fish, such as damselfishes and surgeonfishes. Juveniles often occur far out at sea beneath floating debris. Adults typically swim in schools several meters above the bottom, where they may feed on planktonic algae. Three species occur in Hawaii, Micronesia and Samoa: *Kyphosus bigibbus, K. cinerascens* and *K. vaigiensis*. Another species *Sectator ocyurus* has been reported in Hawaii but is rare and may be a waif from the tropical eastern Pacific.

Very little is known about reproduction in the kyphosids. The eggs are spherical, pelagic and 1.0–1.1 mm in diameter (Watson and Leis 1974). The larvae hatch at 2.4–2.9 mm. The largest pelagic specimen, a juvenile, examined by Leis and Rennis (1983) was 56 mm. Juvenile individuals may be carnivorous for a while before becoming herbivorous (Rimmer 1986).

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Management Unit Species: Kyphosidae (rudderfishes)

	Egg	Larvae	Juvenile	Adult
Duration		prejuveniles commonly collected far out at sea under floating debris		
Diet	N/A	zooplankton	may be carnivorous for a while, such as *Kyphosus cornelii* (Rimmer 1986)	herbivorous on benthic and planktonic algae
Distribution, general and seasonal				circumtropical; 3 species in Hawaii, Micronesia, and Samoa: *Kyphosus bigibbus, K. cinerascens,* and *K. vaigiensis*
Location			exposed seaward reefs	exposed seaward reefs
Water column	pelagic	pelagic	same as adults	benthic and pelagic, may school in the water column
Bottom type	N/A	N/A	rocky bottoms or coral reefs	rocky bottoms or coral reefs
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Monodactylidae (Monos)**

Monos are a small family of highly compressed silvery fishes with small oblique mouths, brush-like teeth in the jaws, viliform teeth on the vomer and palatines, vestigial pelvic fins and a continuous unnotched dorsal fin. They occur primarily in estuarine habitats and can live in freshwater. No monos are recorded for the Hawaiian Islands. The family occurs off West Africa and in the Indo-Pacific, and one species, *Monadactylus argenteus*, occurs in Micronesia and Samoa. It is an active schooling fish that occurs primarily in estuaries but may venture over silty coastal reefs. It is valued as an aquarium fish.

M. argenteus spawns demersal, adhesive eggs, at least in freshwater (Breder and Rosen 1966). The eggs of *Psettus sebae*, a tropical Atlantic species, are small (0.6–0.7 mm), spherical and pelagic in seawater but demersal in freshwater (Akatsu et al. 1977). Larvae of *P. sebae* hatch at 1.8 mm. The largest size of a pelagic larval specimen of *M. argenteus* was 14.5 mm (Leis and Trnski 1989).

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Management Unit Species: Monodactylidae (Monos)

	Egg	Larvae	Juvenile	Adult
Duration		from <1 mm to 14.5 mm		
Diet	N/A		probably similar to adults	small benthic and planktonic invertebrates
Distribution, general and seasonal	spring or summer spawning peak likely		similar to adults	West Africa and Indo-Pacific; not in Hawaii, *Monadactylus argenteus* only species in Micronesia
Location			similar to adults	primarily in estuaries, but may venture over silty coastal reefs
Water column	pelagic in seawater, demersal in freshwater	pelagic in seawater, demersal in freshwater	pelagic	pelagic
Bottom type			silt, mud, sand, coral	silt, mud, sand, coral
Oceanic features	pelagic larvae subject to dispersal by ocean currents	pelagic larvae subject to dispersal by ocean currents		

Management Unit Species: **Ephippidae (Batfishes, Spadefishes)**

Batfishes have deep, highly compressed bodies, a small terminal mouth with brushlike teeth, a continuous dorsal fin and small ctenoid scales extending to the basal portions of the median fins. They are schooling, semi-pelagic fishes often associated with reefs. Juveniles have very deep bodies and greatly elevated dorsal, anal and pelvic fins that shorten with age. Juveniles occur singly or in small groups among mangroves and in inner sheltered lagoons or reefs. Adults migrate to deeper channels and lagoons where they aggregate in small schools, although larger adults may be solitary. They are omnivores that feed on algae, invertebrates and small fishes. In Micronesian waters, 3 species occur: *Platax orbicularis, P. pinnatus* and *P. teira*. In Samoan waters, 2 species have been recorded.

There is little information on the spawning or egg characteristics of Indo-Pacific ephippidids, but there is some information for the Atlantic genus *Chaetodipterus*, which has pelagic eggs of about 1 mm diameter (Johnson 1984). Spawning for *C. faber* was observed near floating objects about 40 m offshore. Two small schools were present, but spawning occured between pairs (Chapman 1978). This observation suggests that ephippids migrate offshore to spawn. Spadefish larvae hatch in 24 hours and are about 2.5 mm long. By a length of 10 mm, the larvae are recognizable as spadefish and are ready to settle.

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Management Unit Species: Ephippidae (Batfishes, Spadefishes)

	Egg	Larvae	Juvenile	Adult
Duration	24 hrs	hatch at 2.5 mm, ready to settle at 10 mm		
Diet	N/A		similar to adults	algae, invertebrates, small fishes
Distribution, general and seasonal	spring or summer spawning (Munro et al. 1973)		similar to adults	the family is found in tropical and temperate seas worldwide; the genus *Platax* is found in Micronesia, not in Hawaii
Location	offshore	offshore	mangroves, sheltered lagoons and reefs	deeper channels, lagoons, seaward reefs
Water column	pelagic	pelagic	semi-pelagic	semi-pelagic
Bottom type	N/A	N/A	sand, mud, silt, and coral reefs	reef-associated, but also mud and sand bottoms in mangroves and lagoons
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Chaetodontidae (butterflyfishes)**

Butterflyfishes are colorful, conspicuous fishes with deep, highly compressed, ovate bodies, small mouths and a band of brush-like teeth in the jaws. They have a single continuous dorsal fin with anterior interspinous membranes deeply incised and a caudal fin varying from slightly rounded to slightly emarginate. They are diurnal predators with diets that vary significantly between species. Many specialize on polyps of corals and other coelenterates. The corallivores tend to be territorial and limited to the shallower depth ranges of the corals, such as *Pocillopora meandrina,* upon which they feed. Others feed heavily on benthic algae and small benthic invertebrates. Some species, including those of *Hemitaurichthys*, are primarily zooplanktivores. The zooplankton feeders often occur in mid-water aggregations and range into relatively deep water. Most butterflyfishes are solitary or occur in pairs, but a few form aggregations. Butterflyfishes appear to be gonochorists, with sex remaining the same throughout life, and often form heterosexual pairs that stay together for many years and possibly their whole life.

Spawning generally occurs in pairs at the top of an ascent in which the male nudges the abdomen of the female. Eggs are planktonic and hatch within 2 days. The larval stage lasts from several weeks to a few months, with a distinctive late larval stage called the tholichthys larva when large bony plates cover the head and front of the body. Settlement occurs at night, and juveniles tend to occur in shallower, more sheltered habitats than adults. Coloration typically changes little with growth, although butterflyfish do exhibit slightly different, more subdued color patterns at night when they shelter in the reef. Because of their specialized feeding habits, butterflyfishes do not tend to do well in aquariums, although some of the generalists and planktivores are collected for the aquarium trade. The family is represented in Hawaiian waters by 24 species; *Chaetodon fremblii, C. miliaris,* and *C multicinctus* are endemic to Hawaii; and *C. tinkeri* is found only in Hawaii and the Marshall Islands. The family is represented in Micronesian waters by at least 40 species. It is represented in Samoan waters by 30 species. The yellow-crowned butterflyfish *C. flavocoronatus* is listed as a vulnerable species in Guam on the 1996 IUCN Red List.

Chaetodontid eggs are buoyant, transparent and spherical. They typically range from 0.6 to 0.74 mm in diameter and contain a single oil droplet. The eggs hatch in 1–2 days. The larvae typically have a preopercular spine and a bony sheath around the head. The tholichthys stage of development is unique to the butterflyfishes and is characterized by a series of thin transparent bony plates that completely encase the head of the larva and extend dorsally and ventrally to form bony spines. The plates remain until after the fish have settled on the bottom. The duration of the planktonic stage is not well studied, but Burgess (1978) suggests it is likely to be at least several months.

The Hawaiian endemic *C. miliaris* reaches reproductive maturity at a size of about 90 mm SL, or about 1 year old (Ralston 1976). Spawning occurs between December and April but peaks around the end of February or the beginning of March.

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Management Unit Species: Chaetodontidae (butterflyfishes)

	Egg	Larvae	Juvenile	Adult
Duration	2 days	several weeks to a few months	1–2 yrs; approximately one year for *C. miliaris* (Ralston 1976), two years for *C. rainfordi* (Fowler 1991); size at settlement for *Hemitaurichthys polylepis* is 60 mm (Burgess 1978)	10–25 yrs in captivity (Allen et al. 1998)
Diet	N/A	zooplankton	some are obligate corallivores (*C. trifascialis* and *C. trifasciatus*); some are planktivores; others consumea variety of benthic algae, small benthic invertebrates, fish eggs, coelenterate tentacles or polyps	some are obligate corallivores (*C. trifascialis* and *C. trifasciatus*); some are planktivores; others consumea variety of benthic algae, small benthic invertebrates, fish eggs, coelenterate tentacles or polyps
Distribution, general and seasonal	spawning peaks in late winter through early summer —January to March for *C. miliaris* in Hawaii (Ralston 1981), with another smaller peak in early fall for some species	typically more abundant in offshore waters in the summer months in Hawaii	primarily Indo-West-Pacific, but also tropical to temperate Atlantic, Pacific, and Indian Oceans; settlement of juvenile *C. lunula* and *C. multicinctus* peaked in Hawaii in May-July (Walsh 1987)	primarily Indo-West-Pacific, but also tropical to temperate Atlantic, Pacific, and Indian Oceans
Location	waters above coral reefs and nearshore waters	offshore waters	coral reef ecosystems	coral reef ecosystems
Water column	eggs released at the height of spawning rushes	pelagic	demersal and mid-water column; 1–100 m, as deep as 172 m	demersal and mid-water column; 1–100 m, as deep as 172 m
Bottom type	N/A	N/A	coral reef; obligate corallivores may be restricted to distributions of corals they feed upon- *C. trifascialis* and *Acropora* for example (Reese 1981)	coral reef; obligate corallivores may be restricted to distributions of corals they feed upon–*C. trifascialis* and *Acropora*, for example (Reese 1981)
Oceanic features	subject to dispersal by currents	subject to dispersal by currents		

Management Unit Species: **Pomacanthidae (angelfishes)**

Angelfishes are similar to butterflyfishes and at one time were grouped in the same family. They differ mainly in having a strong spine on the cheek at the corner of the preopercle, in the presence of strongly ctenoid scales and in lacking the distinctive chaetodontid tholichthys larval stage. They are diurnal, spectacularly colored and territorial. Many of the large species, including those of *Pomacanthus,* are primarily spongivores with a small amount of feeding on other soft-bodied invertebrates, algae and fish eggs. Smaller species such as those of *Centropyge* feed on benthic algae and detritus. Species of *Genicanthus* feed primarily on zooplankton but also a little on benthic invertebrates and algae. Juveniles of some species are cleaners of external parasites from larger fishes. Most, and possibly all, of the angelfishes are protogynous hermaphrodites that change from male to female and frequently have different color patterns depending on their sexual development. Males frequently maintain a harem of 2–5 females and defend a territory ranging from a few square meters for some species of *Centropyge* to well over 1 km for some *Pomacanthus* species. Angelfish spawn in pairs, typically near dusk, at the apex of a spawning rush after courtship and nuzzling by the male. Eggs hatch within 24 hours and undergo a pelagic larval stage of 3–4 weeks. They are popular aquarium fish. Six species are found in Hawaiian waters, and 4 of them are endemic: *Centropyge fisheri, C. potteri, Desmoholacanthus arcuatus* and *Genicanthus personatus* At least 26 species occur in Micronesia. At least 11 species occur in Samoa.

Pomacanthid eggs are small, spherical and nearly transparent and contain from one to several oil droplets. Egg diameter ranges from 0.6 to 1.05 mm depending on the species. Hatching occurs from 15 to 23 hours after release (Thresher 1984). Feeding by the larva begins within 2–3 days and settlement to the bottom occurs between 17 and days (Moe 1977, Allen et al. 1998). Juveniles seek shelter in reef crevices. Juveniles frequently exhibit dramatically different color patterns from adults and may inhabit shallower habitats. Juveniles of *Pomacanthus* may maintain cleaning stations on or near the reef (Brockmann and Hailman 1976). There is little information on the age at sexual maturity, but most angelfishes probably become mature at between 1 and 2 years of age (Allen et al. 1998).

Adult angelfishes require suitable shelter in the form of boulders, caves and coral crevices. Most species occur from 2 to 30 m depth, but a few, such as *C. narcosis*, are found over 100 m deep. Adults forage throughout territories that vary in size with the size of the species. Generally *Pomacanthus* are spongivores; *Genicanthus* are zooplanktivores, especially on pelagic tunicates; and *Centropyge* are herbivores. Small amounts of zoantharians, tunicates, gorgonians, fish and invertebrate eggs, hydroids and seagrasses may supplement the diet of any of the angelfish species. Hybridization is common amongst the angelfish species (Pyle and Randall 1994).

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Management Unit Species: Pomacanthidae (angelfishes)

	Egg	Larvae	Juvenile	Adult
Duration	12–24 hrs	17–39 days	1–2 yrs	10–26 yrs in captivity
Diet	N/A	plankton	diet similar to adults, although some species may be cleaners as juveniles	*Pomacanthus*-sponges; *Genicanthus* - zooplankton, especially pelagic tunicates; *Centropyge* - benthic algae; all may take small amounts of zoantharians, tunicates, gorgonians, fish and invertebrate eggs, hydroids, algae and seagrasses
Distribution, general and seasonal	spawning peak for *C. miliaris* in Hawaii from Jan. to Mar. (Ralston 1981)	more abundant in offshore samples	circumtropical, with greatest number of species in Indo-Pacific; seasonal peak of recruitment for Hawaii in the summer (Walsh 1987)	circumtropical, with greatest number of species in Indo-Pacific
Location	eggs released at apex of spawning rush of 3–9 m above the bottom	more abuundant in offshore samples	coral reef ecosystems	coral reef ecosystems
Water column	pelagic	pelagic	demersal and mid-water column, mostly 2–30 m but some species over 100 m deep	demersal and mid-water column, mostly 2–30 m but some species over 100 m deep
Bottom type	N/A	N/A	refugia on the reef such as cracks, crevices, boulders	home ranges encompass a wide variety of bottom types on coral reefs and flats; rubble/coral
Oceanic features	subject to advection by currents	subject to advection by currents		

Management Unit Species: ***Genicanthus personatus* (masked angelfish)**

The masked angelfish is endemic to the Hawaiian islands and is highly valued for the aquarium trade, despite doing very poorly in captivity. They are typically found on seaward reef slopes below 23 m deep. In the main Hawaiian Islands, they are seldom seen within safe diving depth limits, but, in the Northwestern Hawaiian Islands, they are more common in shallower water. The population starts at Necker Island and increases in density toward Midway, where it is common at diveable depths and probably extends into undiveable depths (Pyle, pers. comm.). They are often found near ledges and dropoffs and on bottoms or walls of coral reef, rock or sand and rubble.

First collected in 1972, the females of the species were described in Randall (1975) from 3 specimens collected off Oahu and one off the Kona coast of Hawaii. Almost all the specimens from the main Hawaiian Islands have been females, including individuals seen from submersibles greater than 100 m deep (Chave and Mundy 1994). Soon after the original description, 2 males were trawled from a depth of 51 m near Nihoa Island and described by Randall (1976). The stomach of one of the males was full of the green alga *Codium*, as well as planktonic organisms and fish eggs. Though members of *Genicanthus* are generally zooplanktivores, the guts of several *G. personatus* contained a majority of algae but also copepods, diatoms, fish eggs and sponge spicules (Howe 1993). Howe (1193) notes that the presence of oesophageal papillae may allow for a different feeding mode from other pomacanthids.

Like other members of the genus, *G. personatus* is sexually dichromatic. It most likely forms harems and is hermaphroditic. If like other angelfish species, it releases pelagic eggs at the end of a short spawning ascent, with eggs hatching within 12–24 hours and larvae remaining adrift for 17–39 days before settlement (Allen et al. 1998). In a study of the reproductive behaviour of another endemic Hawaiian angelfish, *Centropyge potteri*, Lobel (1978) found a peak in spawning from January to April and a peak in juvenile recruitment from May to July. Juvenile and adult angelfishes are highly dependent on the availability of shelter in the form of boulders, caves and coral crevices.

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Management Unit Species: *Genicanthus personatus* (masked angelfish)

	Egg	Larvae	Juvenile	Adult
Duration	angelfish in general: 12–24 hrs (Allen et al. 1998)	angelfish in general: 17–39 days (Allen et al. 1998)	angelfish in general: likely 1–2 yrs (Allen et al. 1998)	
Diet	N/A	likely small zooplankton	no information that it is different from adult	the genus is considered zooplanktivorous, but gut samples of *G. personatus* show a majority of algae, with some copepods, diatoms, fish eggs, and sponge spicules (Howe 1993, Randall 1976)
Distribution, general and seasonal	Lobel (1978) found a spawning peak from Jan to April for another endemic Hawaiian angelfish, *Centropyge potteri*		Lobel (1978) found a recruitment peak from May through July for another endemic Hawaiian angelfish, *Centropyge potteri*	endemic to Hawaii; rare in main Hawaiian Islands within diving depths, but more common shallower in Northwestern Hawaiian Islands
Location	typically released 3–9 m from the bottom after a spawning ascent	offshore waters	no information that it is different from adult	seaward reef slope, often near vertical discontinuities
Water column	pelagic	pelagic	demersal	demersal
Bottom type	N/A	N/A	coral reef, rock, sand and rubble	coral reef, rock, sand and rubble
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents	N/A	N/A

Management Unit Species: **Pomacentridae (damselfishes)**

The damselfishes are one of the most abundant fishes on coral reefs. They are seldom larger than 10–15 cm and are moderately deep-bodied, with a small mouth and conical or incisiform teeth. They have a continuous dorsal fin and a caudal fin that varies from truncate to lunate but is usually forked. Juveniles frequently have very different and brighter colors than adults. Males tend to have a distinct, darker color pattern during spawning times. Most damselfishes occur in shallow water on coral reefs or rocky substrata, wherever there is shelter. The species of *Chromis, Dascyllus, Lepidozygus, Amblyglyphidodon, Neopomacentrus* and *Pomachromis* are aggregating planktivores, which often form large schools in the water column. Most members of *Abudefduf, Chrysiptera* and *Pomacentrus* are omnivores that feed on benthic algae, small invertebrates or zooplankton. *Plectroglyphidodon johnstonianus* feeds on coral polyps. Other members of *Plectroglyphidodon*, as well as members of *Stegastes*, are aggressively territorial herbivores. Algal feeders frequently cultivate algal mats, which they weed of undesirable algae and aggressively defend from other reef inhabitants. Spawning for damselfishes usually occurs in the morning. The eggs, are elliptical and demersal and are guarded by the male until hatching. Predators on the eggs such as wrasses and butterflyfishes, quickly consume the eggs if the male is removed from the nest. In Hawaiian waters, there are 17 species of pomacentrids; 6 are endemic: *Abudefduf abdominalis, Chromis hanui, C. ovalis, C. verater, Dascyllus albisella* and *Plectroglyphidodon sindonis*. At least 89 species occur in Micronesian waters. At least 47 species occur in Samoan waters.

The anemonefishes, subfamily Amphiprioninae, live in a symbiotic relationship with large sea anemones. They are protandrous hermaphrodites; all females start out as males before sex reversal. *Amphiprion* and *Premnas* are unique among the damselfishes in forming permanent pair bonds (Fautin and Allen 1992). Spawning typically occurs near the time of a full moon most often during morning hours and involves the laying of several hundred adhesive eggs on a hard surface near the base of the anemone. Within the tropics, spawning occurs throughout the year although there may be seasonal peaks of activity. The male guards the eggs until hatching after about a week. A short planktonic larval stage lasts from 8 to16 days before settlement. New recruits must locate a suitable anemone, as anemonefish do not survive without a host. No anemonefish are found in Hawaii because of both the absence of host anemones and the short larval duration. Anemonefishes feed primarily on copepods, larval tunicates and filamentous algae. They have been recorded to live at least 6–10 years in nature (Fautin and Allen 1992).

Pomacentrid eggs are demersal, elliptical and adhesive by means of a cluster of fine threads at one end of the egg. Egg diameters range from 0.49 to 2.3 mm. Hatching occurs in 2–4 days for most species but up to 2 weeks for anemonefish eggs. The planktonic larval stage typically lasts 2–3 weeks but may be longer. Thresher, Colin and Bell (1989) found larval durations for the following families: *Amphiprion* and *Premnas*: 7–14 days; *Chromis* and *Dascyllus*: 17–47 days with most between 20 and 30 days; and genera in the subfamily Pomacentrinae: 13–42 days. Size at settlement ranges from 7 to 15 mm, and several studies suggest that settlement occurs mainly at dusk and at night (Williams 1980, Nolan 1975).

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Management Unit Species: Pomacentridae (damselfishes)

	Egg	Larvae	Juvenile	Adult
Duration	2–4 days for most species, but up to 14 days for anemonefish	2–3 weeks for most species, but ranging from 7-47 days	1–2 years	6–8 years, but up to 10 years or more
Diet	N/A	zooplankton	planktivores: *Chromis, Dascyllus, Lepidozygus, Amblyglyphidodon, Neopomacentrus* and *Pomachromis*; omnivores: *Abudefduf, Chrysiptera* and *Pomacentrus*; herbivores: *Stegastes* and *Plectroglyphidodon*, except *P. johnstonianus* that feeds on corals	planktivores: *Chromis, Dascyllus, Lepidozygus, Amblyglyphidodon, Neopomacentrus* and *Pomachromis*; omnivores: *Abudefduf, Chrysiptera* and *Pomacentrus*; herbivores: *Stegastes* and *Plectroglyphidodon*, except *P. johnstonianus* that feeds on corals
Distribution, general and seasonal	peak spawning in Mar./Ap. and another in Sept./Oct. (Watson and Leis 1974)	more abundant in offshore waters	circumtropical and warm temperate with 84% of species in the Indo-West Pacific; peak in recruitment in spring or summer (Walsh 1987)	circumtropical and warm temperate with 84% of species in the Indo-West Pacific
Location	on hard substrate cleared and protected by the male	more abundant in offshore waters	coral reef-associated	coral reef-associated
Water column	demersal	pelagic	demersal and mid-water column, most within 0–20 m, but some deeper than 100 m	demersal and mid-water column, most within 0–20 m, but some deeper than 100 m
Bottom type	cleared surface of rock or coral	N/A	all hard substrate in coral reef habitats	all hard substrate in coral reef habitats
Oceanic features	N/A	subject to advection by ocean currents		

Management Unit Species: **Labridae (wrasses)**

Labridae is a large family, second only to Gobiidae for number of species in the Western Pacific. It is a very diverse family in size and body shape, with adult sizes ranging from less than 5 cm in *Wetmorella albofasciata* to greater than 229 cm in the humphead wrasse, *Cheilinus undulatus* (this species is rare and heavily fished in Guam and is treated as a separate management unit). Labrid body shapes vary from elongate and cigar-shaped in many species to deep and compressed in others (Myers 1991). Most wrasses are brilliantly and complexly colored, with juveniles frequently having a different color pattern from adults. Color changes may also be associated with protogynous hermaphroditism, sex reversal from female to male that has been described for many labrids and may be true for all species in the family (Randall 1996). Wrasses swim mainly with their pectoral fins, using their tail only when quick bursts are necessary. They have a terminal mouth usually with thick lips, protruding front canine teeth and nodular to molariform pharyngeal teeth. Scales are cycloid. Important summary documents are Randall (1996) and Myers (1991).

The wide variety of color phases in the labrids has created significant taxonomic confusion. Some new species have proven to be a different color phase of an existing species, resulting in a general shrinking of the number of species listed in the family. Still, the family has over 600 species (Hoover 1993). There are 96 known species of labrids in Micronesia (Myers 1991), 43 species in Hawaii (Randall 1996) and 68 species in American Samoa (Wass 1984).

Labrids are shallow-water fishes closely associated with coral reefs or rocky substrate, though some species of *Bodianus* occur deeper than 200 m (Smith 1986, Chave and Mundy 1994), and the razorfishes *Xyrichtys* and *Cymolutes* spp. occur on sand flats. Labrids are diurnal, and at night many bury into the sand, seek refuge in holes and cracks of the reef or lie motionless on the bottom. During the day, labrids keep close to coral or rocky cover, darting into refugia in the reef or burying themselves in the sand when danger approaches. Labrids can be found in virtually all coral reef habitats from inner lagoons and subtidal reef flats to deep seaward reefs (Myers 1991, Green 1996). Schooling behavior and excursions away from the reef into the water column are usually associated with reproduction (Thresher 1984). Many labrid species are solitary inhabitants of the reef, though many members of the family have large home ranges encompassing a wide variety of habitats (Green 1996). The geographic range of *Labridae* as a family are shallow, tropical and temperate seas of the Atlantic, Pacific and Indian Oceans. Labrids are found throughout shallow areas in the Western Pacific Region, including 96 known species in Micronesia (Myers 1991), and 43 species in Hawaii, 14 of them endemic (Randall 1996).

There is generally a dearth of information on the life history parameters of age, growth and mortality of many coral reef fishes, including labrids, and what information exists cannot realistically be applied to the whole family. Reef fish guides for Pacific coral reef fishes (Myers 1991, Hoover 1993, Randall 1996) include maximum sizes in the species description. Few correlations have been made between size and age for wrasses.

Sexual dimorphism is a characteristic of all labrids. Every species studied thus far has proven to be a protogynous hermaphrodite (Myers 1991, Randall 1996). Most species have a drab initial phase consisting of all females or a combination of females and non-sex-reversing males and a gaudier terminal phase consisting of males that were formerly females. Species vary as to the ratio of initial phase and terminal phase fishes (Thresher 1984). Spawning usually occurs along the outer edge of a patch reef or along the outer slope of more extensive reefs. Two types of spawning are characteristics of the labrids: aggregate spawning of large groups of a dozen to several hundred initial-phase males and females and pair spawning of a terminal-phase male and an initial-phase female (Thresher 1984). Both types of spawning involve a sudden upward rush of the participants 0.1 to 2 m into the water column, where milt and eggs are released before the fish return to the bottom. The entire sequence often takes less than a second (Thresher 1984). Colin and Bell (1991) described polygonous haremic, lek-like and promiscuous mating systems for labrids in the Marshall Islands. Spawning season for many tropical wrasses is year-round, and some species perform spawning rituals daily. In Hawaii, the saddle wrasse *Thalassoma duperrey* had a peak in spawning from November to February (Ross 1983) and a peak in juvenile recruitment from January to March (Walsh 1987). Many species migrate to prominent coral or rock outcrops for spawning, including species of *Thalassoma*, *Halichoeres*, *Choereodon*, *Bodianus* and *Hemigymnus* (various references in Thresher 1984).

Fourteen species of wrasses are endemic to Hawaii: *Anampses chrysocephalus*, *A. cuvier*, *Bodianus sanguineus*, *Cirrhilabrus jordani*, *Coris ballieui*, *Coris flavovittata*, *Coris venusta*, *Cymolutes lecluse*, *Labroides phthirophagus*, *Macropharyngodon geoffroy*, *Stethojulis balteata*, *Thalassoma ballieui*, *T. duperrey* and *Xyrichtys umbrilatus* (Randall 1996). The Hawaiian population of another species, *Bodianus bilunulatus albotaeniatus*, is recognized as a subspecies (Randall 1996). No wrasse species are reported to be endemic to American Samoa (Wass 1984). There are no important species of introduced wrasses to the Western Pacific Region.

Schooling behavior is common among the wrasses, particularly group spawning aggregations and haremic systems of certain wrasse species. Aggregations of spawning labrids sampled by Robertson and Choat (1974) consisted of mostly males, although initial-phase females typically outnumber initial-phase males in the general population (Thresher 1984).

The majority of labrids are benthic carnivores, feeding on a wide variety of invertebrates or fishes, although some are planktivores, corallivores or cleaners.

The following carnivores feed on benthic invertebrates, including molluscs, crustaceans, polychaetes, sea urchins, brittle stars, tunicates and foraminiferans. Many species also feed on fishes or fish eggs.

Bodianus spp.	*Choerodon anchorago*
Pseudodax moluccanus	*Cheilinus spp.*
Wetmorella spp.	*Epibulis insidiator*
Cymolutes spp.	*Novaculichthys spp.*
Xyrichtys spp.	*Pseudocheilinus spp.*
Pterogogus spp.	*Anampses spp.*
Cheilio inermis	*Coris spp.*
Gomphosus varius	*Halichoeres spp.*
Hemigymnus spp.	*Hologymnosus spp.*
Macropharyngdon spp.	*Pseudojuloides spp.*
Stethojulis spp.	*Thalassoma spp.* (except *T. amblycephalum*)

The following small planktivore (usually < 100 mm) feed on zooplankton such as copepods, fish eggs, and larval fish and invertebrates in the water column.

Cirrhilabrus spp.	*Paracheilinus spp.*
Pseudocoris yamashiroi	*Thalassoma amblycephalum*

The following corallivores feed on live coral polyps.

Labropsis xanthonata (adults)	*Labrichthys unilineatus*
Diproctacanthus xanthurus (plus cleaning)	

The following cleaners feed on external parasites or damaged tissue of other fishes. They are frequently territorial around a cleaning station, although some species roam larger areas to find fishes to clean. Larger fishes often travel long distances seeking the services of a cleaner, and removal of cleaners has led to abandonment of the area by larger fishes.

Labroides spp.	*Labropsis micronesica*
Labropsis xanthonata (juvenile)	*Diproctacanthus xanthurus*

Labrids are found in large numbers in a wide variety of habitats associated with reefs in the Western Pacific Region. Green (1996) measured the density of the 10 most abundant fish families in each of 5 coral reef habitat types in American Samoa. Labridae were the third most abundant fish family in the reef flat, shallow lagoon, reef crest and reef front at 20 m depth, with densities ranging from 719 to 1,123 fish per hectare. Wrasses were the fourth most abundant family on the reef front at 10 m depth with 858 fish per hectare (Table 11 in Green 1997). The great majority of Labridae are found in depths from 1 to 100 m of water, in close association with coral or rocky substrate, although species of *Bodianus*, *Polylepion* and *Suezichthys* were seen well below 150 m during submersible cruises on seamounts near Hawaii (Chave and Mundy 1994). Prominent outcroppings of rock or coral are important as sites for spawning aggregation in some species (Thresher 1984). Sandy areas are necessary for the sand-dwelling labrids, *Xyrichtys* spp. and *Cymolutes* spp.

Migration patterns have not been documented for the labrids. Many of the smaller species stay confined to very small areas of the reef, while larger species have bigger home ranges (Green 1996). Even very large species, such as *Cheilinus undulatus,* return to a favored hole or crevice to spend the night or to escape danger (Myers 1991).

In the main Hawaiian Islands, wrasses are a minor portion of the commercial catch, according to Division of Aquatic Resources catch statistics from 1991 to 1995. Two species are present in the top 25 inshore fish species by weight—4,159 lbs of *Bodianus bilunulatus* and 3,955 lbs of *Xyrichthys pavo* (Table 15 in Friedlander 1996). Some wrasse species are caught for the aquarium trade, including *Pseudocheilinus octotaenia*, *Cirrhilabrus jordani*, *Thalassoma* spp., *Anampses chrysocephalus*, *Macropharyngodon geoffroy* and *Novaculichthys taeniourus*, but wrasses are a small portion of the trade in numbers and value (Pyle, pers. comm). A report on commercial collection of aquarium fish by Forum Fisheries Agency countries— which did not include Hawaii, Guam or the Philippines but did include exporters from Belau, Christmas Island, Fiji, Kwajalein, Majuro, Pohnpei, Rarotonga, Tarawa and Australia—indicate that wrasses made up 7% of the catch by number of fish and 12% by value of catch, with an approximate selling price between US $3 and $15 per fish (Pyle 1993).

No fisheries target wrasses in the Northwestern Hawaiian Islands. Labrids do form a substantial component of coral reef systems in these areas (Hobson 1983, Parrish 1989, Randall et al. 1993, Demartini et al. 1994).

The coral reef fishery in American Samoa has two components: the shoreline subsistence and the boat-based artisanal fishery (Green 1997). Labrids comprise less than 3% of the reef fish catch throughout American Samoa (Dalzell et al. 1996) and were not listed in the catch composition of the shoreline fishery on Tutuila Island in 1991 (from Craig et al. 1993 in Green 1997). Green (1997) reports no commercial aquarium trade in American Samoa.

There is little information on the biological resources of the coral reefs in the federal waters surrounding Guam. Fisheries data is limited to unprocessed catch reports and anecdotal collection data (Myers 1996). Inshore, Labridae made up 7.3% of total landings by weight of the small-boat based spearfishing landings on Guam between 1985 and 1991 (Table 63 in Green 1997). In a study by Katnik (1982), wrasses composed 4.4% of the total catch weight on heavily fished reefs and 4.0% of total catch weight on lightly fished reefs. Similarly, Dalzell et al. (1996) reported that labrids composed 4.31% of the reef fish catch in Guam. Studies detailing overfishing of reefs near Guam are discussed in Green (1997).

There is very little information on the catch of wrasses in the Northern Marianas. For example, data collection in Saipan from 1992 to 1994 assigned 87–91% of annual landings to an unidentified reef fish category (Gourley 1997). Hamm et al. (1994, 1995, 1996) reported catches of 44, 346 and 206 lbs of wrasses in NMI reef-associated commercial fisheries in 1992, 1993 and 1994, respectively. As of 1997, NMI Division of Fish and Wildlife regulations prohibited the commercial export of live fish for the aquarium trade (Gourley 1997).

Labrid eggs are pelagic, spherical, 0.45 to 1.2 mm in diameter and lightly pigmented if at all and usually contain a single oil droplet (Leis and Rennis 1983, Thresher 1984, Colin and Bell 1991). Colin and Bell (1991) measured oil globule diameter for 21 species of labrids in Enewetak Atoll and found a range of 0.10 to 0.24 mm. Colin and Bell documented spawning mostly on a reef bisecting a main channel with strong tidal currents but also on lagoon reefs and in *Halimeda* beds. Most labrids spawned at or slightly after high tide (Colins and Bell 1991), which is in agreement with similar findings for Indo-Pacific labrids (Ross 1983).

Larvae hatch at 1.5–2.7 mm and have a large yolk sac, unformed mouth and unpigmented eyes (Leis and Rennis 1983). Victor (1986) measured the duration of the larval phase of 24 species of wrasses in Hawaii and found a range of 29.5 days (*Anampses chrysocephalus*) to 89.2 days (*Thalassoma duperrey*), although he noted substantial variability within species, up to a standard deviation of 11 days for some wrasses. Victor (1986) and other authors (Miller 1973, Leis and Miller 1976) have noted that despite their abundance as adults in the nearshore fauna of coral reef habitats, labrid larvae are conspicuosly absent from nearshore samples and common in offshore samples. Some labrid larvae are routinely found in the open ocean (Leis and Rennis 1983).

Like adult wrasses, juvenile labrids inhabit a wide variety of habitats from shallow lagoon flats to deep reef slopes. Green (1996) reported that *Labroides dimidiatus* and *Thalassoma lunare* use deeper reef slope and reef base habitats as recruits and shallower habitats as adults. Examples of ontogenetic shifts in habitat use are not widely reported for the family, although relatively few studies have examined the topic.

Labrids are found in most any habitat associated with a coral reef, including rubble, sand, algae, seaweeds, rocks, flats, tidepools, crevices, caves, fringing reefs, patch reefs, lagoons and reef slopes (Myers 1991, Randall 1993). Most species of Labridae show similar patterns of habitat use as adults and recruits, aside from 2 species reported by Green (1996). Spatial and temporal patterns of habitat use by labrids, including descriptions of labrid assemblages distinct to each depth zone, are further reported in Green (1996).

A study of the fish population of Hanalei Bay, Kauai, found *Thalassoma duperrey* was the most numerous species in all habitat types except the deep slope (Friedlander et al. 1997). In the same study, 3 labrid species, *Bodianus biulunulatus*, *Coris flavovittata* and *Thalassoma ballieui,* were present in a creel survey of fishers in the bay. Sand-dwelling species, such as the razorfish *Xyrichtys pavo*, live in and forage over open sandy areas on crabs, shrimp and benthic molluscs (Friedlander et al. 1997). Their densities tend to decline with distance from the reef (Friedlander et al. 1997).

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Management Unit Species: Labridae (wrasses)

	Egg	Larvae	Juvenile	Adult
Duration	approximately 24 hours	29.5 to 89.2 days for 24 species in Hawaii (Victor 1986)		
Diet	N/A	likely small zooplankton	some species have ontogenetic shifts —*Labropsis xanthonata* from cleaner to corallivore, for example—but most have similar diets as adults	1) most are carnivores of benthic invertebrates and fishes; some are 2)corallivores, 3)planktivores, and 4)cleaners—see text for species list
Distribution, general and seasonal	year-round spawning common, although Miller (1973) and others have documented spring and fall peaks in spawning; *Thalassoma duperrey* has a winter spawning peak (Ross 1983)	more abundant in offshore samples	coral reef habitats throughout the Western Pacific; seasonal peak in recruitment for *T. duperrey* from January to May (Walsh 1987)	coral reef habitats throughout the Western Pacific
Location	released from <1 up to 5 m from the bottom	more abundant in offshore samples (Miller 1973, Leis and Miller 1976)	closely associated with reef substrate or sand flats; 1-200m	closely associated with reef substrate or sand flats; 1–200 m
Water column	pelagic	pelagic	demersal	demersal
Bottom type	N/A	N/A	wide variety from shallow lagoon sand flats to deep reef slopes (Green 1996)	wide variety from shallow lagoon sand flats to deep reef slopes (Green 1996)
Oceanic features	subject to ocean currents	subject to ocean currents		prominent points or outcroppings are important for spawning aggregations; gyres associated with these points may serve to take larvae temporarily away from reef predators (Johannes 1978)

Management Unit Species: **Cheilinus undulatus (humphead wrasse)**

Cheilinus undulatus is treated as a separate management unit because spear fishing has brought the species to very low population levels, particularly around Guam (Dalzell et al. 1996). Because the species is not present in Hawaii, a description follows from Micronesia (Myers 1991).

The humphead wrasse is among the largest of reef fishes. Adults develop a prominent bulbous hump on the forehead and amazingly thick fleshy lips. Adults occur along steep outer reef slopes, channel slopes, and occasionally on lagoon reefs, at depths of 2 to at least 60 m. They often have a home cave or crevice within which they sleep or enter when pursued. Juveniles occur in coral-rich areas of lagoon reefs, particularly among thickets of staghorn *Acropora* corals. The humphead wrasse is usually solitary, but occasionally occurs in pairs. It feeds primarily on mollusks and a wide variety of other well-armored invertebrates including crustaceans, echinoids, brittle stars, and starfish, as well as on fishes. It is one of the few predators of toxic animals such as the crown-of-thorns starfish, boxfishes, and sea hares. The thick fleshy lips appear to absorb sea urchin spines, and the pharyngeal teeth easily crush heavy-shelled gastropods like *Trochus* and *Turbo*. Much of its prey comes from sand or rubble.

The range of *Cheilinus undulatus* is Indo-Pacific: Red Sea to the Tuamotus, north to the Ryukyus, south to New Caledonia. Though rare, they can be found throughout Micronesia and also in American Samoa.

Humphead, or Napoleon, wrasse reach sizes of 229 cm TL and weights of 191 kg. Kitalong and Dalzell (1994) estimate growth and mortality parameters from length frequency data for humpheads in Belau. Studies of humphead wrasse otoliths from the Great Barrier Reef indicate an expected life span of about 25 years (in Dalzell et al. 1996). New research on the life history of *C. undulatus* indicates that it may grow and mature much faster than previously thought (C. Birkeland, pers. comm.).

Once an economically important species in Guam, *C. undulatus* is now rarely seen on the reefs, much less reported on the inshore survey catch results (Hensley and Sherwood 1993). Similar declines in the number of sightings are reported from Saipan (Green 1997). Spearfishing, particularly at night when wrasses are inactive near the reef surface or in caves, has significantly decreased the numbers of this very large reef fish. They are sought after despite accounts of ciguaterra poisoning (Myers 1991).

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Management Unit Species: *Cheilinus undulatus* (humphead wrasse)

	Egg	Larvae	Juvenile	Adult
Duration			research underway by Dr. Howard Choat	at least 25 years (in Dalzell et al. 1996)
Diet	N/A		likely to be similar to adult	carnivore; primarily on mollusks and a wide variety of well-armored invertebrates including crustaceans, echinoids, brittle stars, and starfish, as well as on fishes; also eats toxic animals such as crown-of-thorns starfish, boxfishes, and sea hares
Distribution, general and seasonal				Indo-Pacific, though not found in Hawaii
Location			coral-rich areas of lagoon reefs; among thickets of staghorn *Acropora* corals	steep outer reef slopes, channel slopes, and occasionally on lagoon reefs
Water column	pelagic	pelagic	demersal	demersal; 2 to at least 60 m depth
Bottom type	N/A	N/A	coral, sand, rubble	coral, sand, rubble
Oceanic features	subject to ocean currents	subject to ocean currents		

Management Unit Species: **Scaridae (parrotfishes)**

Parrotfishes get their name from the beak-like dentition and brightly colored appearance of mature adults. Like the wrasses from which they evolved, scarids are protogynous hermaphrodites that change color in relation to changes in growth and sex. Unlike wrasses, parrotfishes have a characteristic pharyngeal dentition, a digestive system lacking a true stomach but with a very long intestine, and a diet of mostly algae with some ingestion of live coral. Most scarids feed by scraping algae and bits of coral from the surface of coral rock, grinding the material with their pharyngeal mill into a slurry of calcium carbonate and algae, digesting the slurry and excreting grains of calcium carbonate "sand" that make up a large portion of the sediment on most coral reefs. A few species feed heavily on live coral, on large leafy algae or seagrasses or on sand to extract algae from between the grains. Parrotfishes are diurnal, sleeping under ledges or wedged against coral or rock at night, often surrounded by a mucus cocoon that may serve to mask their scent from detection by nocturnal predators. Small juveniles are frequently drab with white stripes. Some species are diandric, with both male and female juveniles, while others are monandric, with only females in the initial phase. Terminal males, usually formed from sex-reversal of a female, frequently maintain a harem of females, though they perform pair-spawning with each female individually. Initial phase males spawn in groups. Parrotfishes often occur in large, mixed-species schools which rove long distances while feeding on reefs. Some species are territorial and occur in small groups. Important summary documents are Myers (1991) and Randall (1996).

Scarids inhabit a wide variety of coral reef habitats including seagrass beds, coral-rich areas, sand patches, rubble or pavement fields, lagoons, reef flats and upper reef slopes (Myers 1991). They are prominent members in numbers and biomass of shallow reef environments. Scarids are chiefly distributed in tropical regions of the Indian, Atlantic and Pacific Oceans.

Among scarid species, adult sizes range from 110 to 1,000 mm SL, but most are between 200 to 500 mm. Warner and Downs (1977) suggested a maximum age of 6 years for *Scarus iserti*. Choat et al. (1996) found life spans ranging from 5 years (*S. psittacus*) to 20 years (*S. frenatus*). Coutures (1994) used annular marks on scales to age *Bolbometopon muricatum* and found a life span of about 25 years.

Parrotfishes generally have complex socio-sexual systems based on protogynous hermaphroditism, drab initial phase coloration, gaudy terminal phase color patterns and dualistic reproduction. Males can either be primary, in which they are born male, or secondarily derived from females. Most species of *Scarus* are diandric. The relative proportion of primary males, terminal males and females vary widely between and within species.

Scarids spawn in both pairs and groups. Group spawning frequently occurs on the outer slope of the reef in areas with high current speeds. Pair spawnings are frequently observed at the reef crest or reef slope at peak or falling tide. Scarids have been observed to undergo spawning migrations within lagoons and to the outer reef slope (Randall and Randall 1963, Yogo et al. 1980, Johannes 1981, Choat and Randall 1986, Colin and Bell 1991). Some species are diandric, forming schools and spawning in groups often after migration to specific sites, while others are monandric, at times being strongly site-attached with haremic, pair-spawning (Choat and Randall 1986).

A few species are territorial, but the majority are roving herbivores, with the size of the home range increasing with the size of the fish. Choat and Robertson (1975) found that smaller, less mobile scarids are usually associated with cover such as *Acropora* growth. Open areas with large amounts of grazing surface harbour larger, more mobile and school-forming scarids. Schooling behavior is common among the scarids, both for feeding and spawning.

Species endemic to Hawaii are *Calotomus zonarchus*, *Chlorurus perspicillatus*, *Scarus dubius*. Seven species of scarids can typically be found in Hawaii, 33 species in Micronesia, and 23 species in Samoa.

Most scarids are herbivores, although a few feed on live coral (most notably *Bolbometopon muricatum*) and a few have been reported to feed on newly exposed cryptic sponges (Bakus 1964, Dunlap and Pawlik 1996). The majority graze turf algae from hard substrata, some ingest algal filaments with sand grains, and some feed on seagrasses and leafy algae, such as *Padina*. Friedlander et al. (1997) found high counts of scarids in back reef and reef slope habitats of Hanalei Bay.

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Management Unit Species: Scaridae (parrotfishes)

	Egg	Larvae	Juvenile	Adult
Duration	25 hours	30–50 days	3–5 years (Sale 1991)	average as a family is 8–12 years, medium size-6–9 years, large size-20–25+years
Diet	N/A	copepods, nauplii, bivalve larvae (Houde and Lovdal 1984)	carniverous for 1 month, gradually becoming herbivorous (Horn 1989, Bellwood 1988)	algae—usually thin algal film on coral or rock, but some feed on seagrasses, macroalgae, or graze over sand; a few species feed on live coral
Distribution, general and seasonal	year round, but peak spawning may occur in the summer	higher concentrations in offshore water samples	abundant year round in many coral reef systems	abundant year round in many coral reef systems
Location	spawning aggregation sites frequently on the outer edge of the reef	0–100 m; peak density between 40–80 m in the Caribbean (Hess et al. 1986)	all coral reef habitats, plus seagrass beds, mangroves, lagoons	all coral reef habitats, plus seagrass beds, mangroves, lagoons
Water column	pelagic	pelagic	demersal	demersal
Bottom type	N/A	N/A	coral reef, sand patches, rubble, pavement	coral reef, sand patches, rubble, pavement
Oceanic features	advection by ocean currents	advection by ocean currents	seagrass beds and mangroves may be important nursery areas	channels with high relief habitat nearby are important spawning aggregation sites

Management Unit Species: **Bolbometopon muricatum (bumphead parrotfish)**

The bumphead is a very large parrotfish (to 120 cm and 75 kg) with a vertical head profile, a uniform dark green color except for the front of the head which is often light green to pink and a nodular outer surface to its beak. It typically occurs in schools on clear outer lagoon and seaward reefs at depths from 1 to 30 m. They are often located on reef crests and fronts. In unfished areas it may enter outer reef flats at low tide. In addition to algae, it feeds substantially on live coral, using its large foreheads to ram coral and break it into smaller pieces for ingestion. It is very wary in the daytime but sleeps in groups on the reef surface at night, making it an easy target for spearfishers. As a result, it has nearly disappeared from most of Guam's reefs and is rapidly declining in Belau. Johannes (1981) cites an example of bumpheads changing the location of their sleeping site away from the shallow reef flat to the deeper reef slope in Belau in response to increasing nighttime spearfishing. Its range is Indo-Pacific, although it is not found in the Hawaiian Islands.

B. muricatum on the Great Barrier Reef exhibits a gradual approach to the asymptotic length. On the Northern Great Barrier Reef, most schools are composed of fish 12–20 years old. The oldest bumphead *maximum age* identified is a 3- year-old fish with a standard length of 770 mm (Howard Choat, pers. comm.). Younger fishes appear to have different habitat requirements, as fish of SL less than 400 mm are not seen on outer reefs.

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Management Unit Species: Bolbometopon muricatum (bumphead parrotfish)

	Egg	Larvae	Juvenile	Adult
Duration	25 hours	30–50 days		20–25+years, up to 34 years
Diet	N/A		herbivore/coralivore	herbivore/ coralivore; eats a substantial amount of live coral; in Palau, stomachs were often full of sea urchins (Johannes 1981)
Distribution, general and seasonal	Spawning aggregations reported in barrier reef channels of Palau on the 8th and 9th days of the lunar month (Johannes 1981)			Indo-Pacific; not found in Hawaii
Location			fish < 400 mm not seen on outer reefs of the Great Barrier Reef	typically occurs in schools on clear outer lagoon and seaward reefs at depths of 1 to at least 30 m; may enter outer reef flats at low tide in unfished areas
Water column	pelagic	pelagic	demersal	demersal
Bottom type	N/A	N/A	coral reef, rubble, pavement	coral reef, rubble, pavement
Oceanic features	advection by ocean currents	advection by ocean currents		

Management Unit Species: **Polynemidae (threadfins)**

Threadfins are relatives of the mullets with silvery bodies, an inferior mouth with villiform teeth, two widely-spaced dorsal fins, a deeply forked caudal fin and moderately large scales. Thread-like lower pectoral rays are used as feelers and become relatively shorter with growth. Threadfins typically occur over shallow sandy to muddy bottoms, occasionally in fresh or brackish water. One species, *Polydactylus sexfilis,* occurs in Hawaii where it is highly valued as a food fish. The species, called *moi* in Hawaii, was historically reserved for royal people, or *alii.* It has become rare as a result of intense fishing pressure, and is currently being propagated in hatcheries for use in stock enhancement projects. The same species occurs in Micronesia. Two species occur in Samoa, *P. sexfilis* and *P. plebeius.* The family Polynemidae is distributed throughout the tropical Atlantic and Indo-Pacific Ocean.

P. sexfilis is a fast-growing species that inhabits turbid waters and can be found in large schools in sandy holes along rocky shoals and high energy surf zones. Spawning takes place for 3–6 days per month and has been observed in Hawaii from June to September, with a peak in July and August (Ostrowski and Molnar 1997). Spawning may be year-round in very warm locations. Spawning occurs inshore and eggs hatch offshore within 14–24 hours depending on water temperature (May 1979). Eggs are small, averaging 0.75 mm in diameter with a large oil globule.

Larvae are pelagic, but after metamorphosis they enter nearshore habitats such as surf zones, reefs and stream entrances (Ostrowski and Molnar 1997). Larvae and pre-settlement juveniles feed on zooplankton in the water column, mainly mysids, euphausiids, crab zoeae and amphipods.

Inshore juveniles have distinct dark vertical bars and feed on benthic crustaceans, mostly penaeid and caridean shrimps, as well as zooplankton. Young moi, from 150 to 250 mm long, are found from shoreline breakers to 100 m depth (Lowell 1971). Fishing for juvenile *P. sexfilis*, or *moilii,* has historically been an important recreational and subsistence seasonal fishery in Hawaii.

*P. sexfilis*is a protandrous hermaphrodite, with individuals first maturing as males within 5–7 months at a fork length of 20–29 cm. After mating at least once as a male, fish have a hermaphroditic stage of about 8 months when they have both male and female characteristics. By an age of about 1.5 years and a fork length of 30–40 cm, fish become mature females. The sexes are monomorphic.

Adults feed throughout the day on benthic crustaceans as well as fish. In Kaneohe Bay, adults could be found on reef faces, in the depths of the inner bay and in shallow (2–4 m) areas with muddy sand bottoms (Lowell 1971). When *moi* were more abundant in Hawaii, airplane spotters used to locate large schools and direct net fishers to the catch.

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Management Unit Species: Polynemidae (threadfins)

	Egg	Larvae	Juvenile	Adult
Duration	14–24 hours depending on the temperature	weeks to months	5–7 months	
Diet	N/A	zooplankton, mainly mysids, uphausiids, crab zoeae, and amphipods	benthic crustaceans (mainly penaeid and caridean shrimps) and zooplankton	benthic crustaceans (mainly penaeid and caridean shrimps) and fish
Distribution, general and seasonal	spawning 3–6 days per month from June to September in Hawaii, with a peak in July/August; may be year-round in very warm locations	largest numbers in late summer	largest numbers in late summer and fall in Hawaii	*Polydactylus sexfilis* only species in Hawaii, also found in Micronesia and Samoa; *P. plebeius* recorded in Samoa
Location	inshore	offshore	from shoreline breakers to offshore reefs; also near stream entrances in sheltered bays	sandy holes along rocky shoals and high energy surf zones
Water column	pelagic	pelagic	0–100 m depth	0–100 m depth
Bottom type	N/A	N/A	sand, mud, rock, coral reef	sand, mud, rock, coral reef
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Sphyraenidae (barracudas)**

The barracudas are a single genus of top-level carnivorous fishes that feed mainly on other fishes. They have a very elongate body, a large mouth with protruding pointed lower jaw, very large compressed teeth and two widely separated dorsal fins. They have small cycloid scales and a well-developed lateral line. Some species are primarily diurnal, while others are nocturnal. Species such as *Sphyraena helleri* school in large groups during the day but disperse at night to feed. *S. barracuda* is typically a solitary diurnal predator. In Hawaiian waters, these are the only 2 species positively recorded. In Micronesian waters, at least 6 species occur. In Samoan waters, at least 5 species occur.

Juvenile *S. barracuda* occur among mangroves and in shallow sheltered inner reef areas. Adults occur in a wide range of habitats ranging from murky inner harbors to the open sea. Ciguaterra is widely reported for large *S. barracuda*, and has caused deaths in the West Indies where it is now banned from sale. *S. forsteri, S. acutipinnis, S. novaehollandiae* and *S. obtusata* are all schooling barracudas that occur over lagoon and seaward reefs. *S. genie* is a larger schooling barracuda that frequently schools at the same sites on submarine terraces and is most often caught at night by trollers in Micronesia.

There is no evident external sexual dimorphism among sphyraenids, although males reach sexual maturity at a smaller size than females. Male *S. barracuda* reach maturity in 2 years, but females take about 4 years. Barracudas migrate to specific spawning areas, often in very large numbers at reef edges or in deeper water. Spawning typically takes place in warmer months, and may last extended periods of time in which individual females spawn repeatedly.

The eggs are pelagic, spherical, and range in diameter from 0.7–1.5 mm with a single clear or yellow oil droplet. Eggs hatch within 24–30 hours. Larvae begin to feed within 3 days on small copepods. Larger larvae voraciously feed on zooplankton and other fish larvae. Settlement typically occurs at a length of 18 mm but may be larger. *S. barracuda* larvae occasionally drift in the ocean for an indefinite period of time, usually associated with floating debris or algae, developing all the characteristics of juveniles and sometimes attaining large sizes before being delivered inshore. Newly settled juveniles are piscivorous.

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Management Unit Species: Sphyraenidae (barracudas)

	Egg	Larvae	Juvenile	Adult
Duration	24–30 hours for *S. pinguis*	the time it takes to grow from 1–2 mm to 18 mm	2 years for male *S. barracuda*, 4 years for females	
Diet	N/A	zooplankton, copepods, fish eggs	mostly fish	mostly fish
Distribution, general and seasonal	spring spawning aggregation sites may be important for some species	typically more abundant in offshore waters	circumtropical and subtropical	circumtropical and subtropical; seasonal spawning aggregations may be important for some species
Location	reef edge or interface of pelagic and coastal currents	coastal offshore waters	mangroves, shallow lagoons, estuaries	from shallow turbid inner harbors to reefs, as well as coastal offshore waters
Water column	pelagic	pelagic; within 0–100 m depth	from reef-associated to surface	from reef-associated to surface
Bottom type	N/A	N/A	mud, sand, reef	all bottom types
Oceanic features	subject to advection by currents	subject to advection by currents		

Management Unit Species: **Pinguipedidae (sandperches)**

The sandperches are represented in the Indo-Pacific by only one genus, *Parapercis*. The genus is characterized by an elongate, nearly cylindrical body, eyes on the top of the head and oriented upwards and a terminal protractile mouth. All are benthic carnivores of small invertebrates and fishes. They are usually found on rubble or sand bottoms near reefs, where they typically rest on the bottom by propping on well-separated pectoral fins. Adults are typically found in depths from 1 to 50 m, but some occur deeper. Most species are sexually dichromatic. Hermaphroditism has been demonstrated for some species and may be true for all. Males are territorial and haremic. Spawning occurs year round in the tropics, typically just before sunset. Eggs are pelagic and the larval period lasts for 1–2 months. In Hawaiian waters, 2 species occur. In Micronesia, 4 shallow water species occur. In Samoan waters, 3 species are recorded.

P. cylindrica males defend an area that includes 2–5 females who are defending smaller territories from each other. The male initiates courtship with one of the females about 40 minutes prior to sunset, and eventually the pair makes a short spawning ascent of 60–70 cm before releasing gametes. The eggs are spherical and pelagic, with a diameter ranging from 0.63 to 0.99 mm. Hatching occurs in 22–24 hours. Duration of the planktonic larval stage is estimated to be 1–2 months (Stroud 1981).

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Management Unit Species: Pinguipedidae (sandperches)

	Egg	Larvae	Juvenile	Adult
Duration	22–24 hours	1–2 months		
Diet	N/A	zooplankton	small invertebrates and fishes	small invertebrates and fishes
Distribution, general and seasonal	year-round spawning, but late spring/summer peak	year-round, with summer peak	one Indo-Pacific genus *Parapercis*	one Indo-Pacific genus *Parapercis*
Location	released near parents home; no evidence of spawning migrations	offshore of reefs and soft-bottom habitats	coral reefs and associated soft-bottom communities	coral reefs and associated soft-bottom communities
Water column	pelagic	pelagic, although Leis (1989) found them concentrated in the epibenthos over soft bottoms on the GBR	demersal; most within 1–50 m, but some deeper	demersal; most within 1–50 m, but some deeper
Bottom type	N/A	N/A	sand, mud, rubble and occasionally coral	sand, mud, rubble and occasionally coral
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

Management Unit Species: **Blenniidae (blennies)**

Blennies are small, elongate, agile, scaleless fishes with blunt heads and a long continuous dorsal fin. They are a large family of more than 300 species, most of which are bottom-dwelling territorial fishes that lay adhesive demersal eggs that are guarded by the male. The family may be divided into two subfamilies primarily based on dentition and diet. The sabretooth blennies, subfamily Salariinae, typically have small mouths and large fangs. They are carnivores and some feed on the scales, skin or mucus of larger fishes. Some species are mimics of cleaner wrasses or other blennies. They are active swimmers that rapidly approach larger fish, while other members of Salariinae are sedentary. The combtooth blennies, subfamily Blenniinae, typically have wide mouths, feeble teeth and feed on benthic algae. An exception is the leopard blenny *Exalias brevis*, which feeds primarily on coral polyps of *Acropora, Pocillopora, Seriatopora, Porites* and *Millepora*. Most combtooth blennies are sedentary inhabitants of rocky shorelines, reef flats or shallow seaward reefs. In Hawaiian waters, 14 species of blennies have been recorded; 7 are endemic: *Cirripectes obscurus, C. vanderbilti, Entomacrodus marmoratus, E. strasburgi, Istiblennius zebra, Plagiotremus ewaensis* and *P. goslinei*. The mangrove blenny *Omobranchus rotundiceps obliquus* was introduced to the Hawaiian and Line Islands, and the tasseled blenny *Pablennius thysanius* was probably introduced to Hawaii by ballast water. At least 59 species occur in Micronesia. At least 47 species occur in Samoa.

The blennies have very complex color patterns and are often well camouflaged to the surrounding habitat. Blennies tend to shelter in small holes in the reef or sand by backing into them tail-first. Some blennies, including those of the genera *Istiblennius* and *Entomacrodus*, live inshore on rocky bottom exposed to surge. They are called rockskippers for their ability to leap from pool to pool.

In addition to their unique feeding strategy, *Exalias brevis* has unusual reproductive characteristics. Males prepare a nesting site by clearing a patch of coral near a crevice. Females make the rounds of up to 10 different male's nests, depositing bright yellow eggs in each of them. Nests may contain more than one females eggs, and both males and females occasionally cannibalize eggs. Spawning occurs throughout the year with a peak from January to April.

The reproductive biology of blennies has been studied extensively. There are many variations, but all appear to produce relatively large demersal eggs which are deposited in or near a shelter hole and defended by the male. Eggs are characteristically flattened ovals, usually brightly colored, and about 1.0 mm in the longest dimension. Hatching typically occurs in 9–11 days. In the Red Sea species *M. nigrolineatus*, the larvae develop juvenile colors in 20 days and settle to the bottom by 30 days.

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Management Unit Species: Blenniidae (blennies)

	Egg	Larvae	Juvenile	Adult
Duration	9–11 days	20–30 days		
Diet	N/A	copepods, nauplii, bivalve larvae (Watson 1974, Houde and Lovdal 1984)	most graze on benthic algae; some feed on zooplankton; some prey on minute invertebrates such as foraminiferans, ostracods, copepods and gastropods; fangblennies of *Plagiotremus* eat mucus and skin tissue from fishes; at least one species, *Exallias brevis*, feeds on coral polyps	most graze on benthic algae; some feed on zooplankton; some prey on minute invertebrates such as foraminiferans, ostracods, copepods and gastropods; fangblennies of *Plagiotremus* eat mucus and skin tissue from fishes; at least one species, *Exallias brevis*, feeds on coral polyps
Distribution, general and seasonal			worldwide in tropical and temperate seas	worldwide in tropical and temperate seas
Location	near the adults shelter hole		rocky shorelines, coral reefs, reef flats, shallow seaward reefs, sand flats, lagoons	rocky shorelines, coral reefs, reef flats, shallow seaward reefs, sand flats, lagoons
Water column	demersal	pelagic	demersal; a few feed on zooplankton in the water column, and many of the fangtooths are active swimmers that pursue larger fish; many found in very shallow depths, and some rockskippers found above sealevel	demersal; a few feed on zooplankton in the water column, and many of the fangtooths are active swimmers that pursue larger fish; many found in very shallow depths, and some rockskippers found above sealevel
Bottom type	coral or rock	N/A	rock, coral reef, sand	rock, coral reef, sand
Oceanic features		subject to advection by ocean currents		

Management Unit Species: **Gobiidae (gobies)**

The gobies are the largest family of marine fishes, with about 1000 Indo-Pacific species and at least 1900 marine and freshwater species worldwide. They are typically small, elongate, blunt-headed fishes with a relatively large mouth with conical teeth, pelvic fins close together and usually fused to form a sucking disk, and two dorsal fins. Gobies are primarily shallow-water species. All are carnivorous and bottom-dwelling, although a few swim a short distance above the bottom to feed on plankton (*Ioglossus*, *Nemateleotris*). They inhabit a variety of habitats such as coral reef, sand, mud, rubble or seagrass. The majority of gobies occur on coral reefs, where they typically have unsurpassed diversity and abundance, but many occur in adjacent coastal and estuarine waters. Many live in close association with other animals such as sponges, gorgonians, and snapping shrimps. Several species have a symbiotic relationship with one or more species of Alpheid snapping shrimp in which the gobies share a burrow. The shrimp digs the burrow while one or more gobies keeps watch for predators. Nearly all gobies are gonochorists that lay a small mass of demersal eggs which are guarded by the male. A few have been shown to be protogynous hermaphrodites. There are 31 marine species of gobies in Hawaiian waters. Five of them are endemic to Hawaii: the noble goby *Priolepis eugenius*, the rimmed-scale goby *Priolepis limbatosquamis*, the Hawaiian shrimp goby *Psilogobius mainlandi*, plus two new species described recently in *Copeia*. In Micronesian waters, at least 159 species occur. At least 100 species are recorded for Samoan waters.

Most reef-associated gobies are sexually monomorphic, although gobies in other habitats do have color and size differences between the sexes. Protogynous hermaphroditism was documented for gobies of the genus *Paragobiodon*, in which the largest individual present was always male, the second largest was the functional female, and the smaller individuals were non-spawning females (Lassig 1977). In most cases gobies appear to spawn promiscuously with many individuals loosely organized into a social hierarchy or with individuals maintaining small contiguous territories, although pairing and apparent monogamy have been documented for a number of gobies, including Ioglossus spp. (Colin 1972), Gobodion spp. (Tyler 1971), and Valencienna spp. (Hiatt & Strasburg 1960), among others.

Gobies lay demersal adhesive eggs in a burrow, on the underside of a rock or shell, or in cavities within the body of a sponge. Males tend and guard the eggs, which are attached to the substrate by a tuft of adhesive filaments at one end. Most goby eggs are elongate, smoothly round-ended and range in length from 1.1 to 3.3 mm and in diameter from 0.5 to 1.0 mm, although the eggs of fresh water and anadramous species may be as large as 8 mm. Some species, such as those of *Elacatinus*, have distinctive protuberances from the eggs. Incubation typically lasts 5-6 days depending on temperature. The size at hatching ranges from less than 2 mm to 4mm. The majority of the gobies leave the plankton at a size less than 10 mm. The planktonic larval duration is known for a few species. Lassig (1976) estimated a duration of about 6 weeks for *Paragobiodon spp.* at Heron Island. Moe (1975) reported a planktonic larval duration of from 18-40 days for *Gobiosoma oceanops*. Colin (1975) reported metamorphosis at 26 days for neon gobies, which grew quickly to subadult size in 3 months and spawned as soon as 5 months. He suggested neon gobies were "annual" fishes that mature quickly and may only live one or two years.

Species of *Amblyeleotris, Cryptocentroides, Cryptocentrus, Ctenogobiops, Vanderhorstia, Lotilia,* and *Mahidolia* live in burrows constructed by alpheid prawns. At least 20 species of gobies share burrows with at least 7 species of prawns in Micronesia. The gobies, either singly or in pairs, act as sentinels for the alpheid shrimps who maintain the burrows. The gobies benefit from the use of the burrow, and also from feeding on the invertebrates excavated by the shrimp. The shrimps benefit from having a wary sentinel with better eyesight to warn them of approaching danger.

Some gobies have specific habitat requirements. The gorgonian goby *Bryaninops amplus* is usually found on gorgonians. The whip coral goby *Bryaninops yongei* is usually found on the antipatharian seawhip *Cirrhipathes anguina*. The Hawaiian shrimp goby *Psilogobius mainlandi* lives in burrows built and maintained by the snapping shrimp *Alpheus rapax*. The translucent coral goby *Bryaninops erythrops* lives on certain branching forms of fire corals *Millepora* spp. and other branching or massive corals such as *Porites cylindrica* and *P. lutea*. The hovering goby *Bryaninops natans* occurs in groups that hover just above or within the branches of *Acropora* corals. Members of *Paragobiodon* and *Gobiodon* are obligate coral-dwellers. Mudskippers of the genus *Periophthalmus* are essentially amphibious and are typically found resting on mud, rocks, or mangrove roots.

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Management Unit Species: Gobiidae (gobies)

	Egg	Larvae	Juvenile	Adult
Duration	5-6 days	18-42 days	as soon as 5 months for neon gobies (Colin 1975)	smaller gobies may only live 1-2 years; others much longer
Diet	N/A	copepods, nauplii, tintinnids, mollusc larvae (Watson 1974, Houde and Lovdal 1984)	similar to adults	most are carnivorous on a wide variety of benthic invertebrates (copepods, amphipods, ostracods, nematodes, foraminiferans), fishes, and fish eggs; some semi-pelagic species are planktivorous
Distribution, general and seasonal				worldwide in tropical and temperate seas; 28 marine species of gobies in Hawaiian waters, with 3 endemic; at least 159 Micronesian species and at least 100 species in Samoa
Location			rocky shorelines, coral reefs, reef flats, shallow seaward reefs, sand flats, lagoons	rocky shorelines, coral reefs, reef flats, shallow seaward reefs, sand flats, lagoons
Water column	demersal	pelagic	same as adults	demersal; species of *Ioglossus* and *Nemateleotris* are semi-pelagic, hovering a short distance above the reef
Bottom type	coral, rock, sponge	N/A	coral reef, sand, mud, rubble or seagrass	coral reef, sand, mud, rubble or seagrass
Oceanic features		subject to advection by ocean currents		

Management Unit Species: **Acanthuridae (Surgeonfishes)**

The acanthurids typically have ovate to elongate compressed bodies, a small terminal mouth with a single row of close-set teeth, eyes high on the head, continuous unnotched dorsal and anal fins, and a tough skin with very small ctenoid scales. The common name surgeonfish stems from the presence of one or more pairs of sharp spines on the caudal peduncle which may be used to slash other fish or unwary human handlers. In species of the genera *Acanthurus*, *Ctenochaetus*, and *Zebrasoma*, the single lancet-like spine folds into a groove, while species of *Naso* have 2 fixed, keel-like spines. Some *Naso* species have a horn-like projection on the forehead, and as a result all members of the genus are commonly called unicornfishes. Generally, acanthurids are diurnal herbivores or planktivores. Species of *Ctenochaetus* and some of *Acanthurus* have a thick-walled gizzard-like stomach and often ingest sand with their diet of benthic algae. Some species of *Acanthurus* and many *Naso* spp. feed mainly on zooplankton in the water column. All acanthurids shelter on the reef at night. Reproduction typically occurs on a lunar cycle with greater activity in winter or early spring, but with some activity throughout the year. Spawning events are more frequent at dusk and involve groups, pairs, or both. The larval stage is long by reef fish standards, and size at settlement is larger than most. Surgeonfishes are important foodfishes on most Pacific islands. This description was composed from Myers (1991) and Randall (1996).

Habitat utilization - Jones (1968) divided the acanthurids from Hawaii and Johnston Island into 4 major habitat types: mid-water (*Acanthurus thompsoni*, *Naso hexacanthus)*, sand patch (*A. dussumieri, A. mata, A. olivaceous, A. xanthopterus*), subsurge reef (*A. nigrofuscus, A. nigroris, A. sandvicensis, Ctenochaetus hawaiiensis, C. strigosus, Naso brevirostris, N. lituratus, N. unicornis, Zebrasoma flavescens, Z. veliferum*), and seaward reef or surge zone (*A. achilles, A. glaucopareius, A. guttatus, A. leucopareius*) dwellers. The same paper gives extensive descriptions of feeding habits and each species use of the habitat features.

Life history - The biology and life history of surgeonfish have been studied in a number of Western Pacific locations, including *Acanthurus triostegus* in Hawaii (Randall 1961), *Naso brevirostris* in French Polynesia (Caillart 1988), and *Acanthurus nigricauda* and *A. xanthopterus* in Papua New Guinea (Dalzell 1989). Age and growth has been described by a combination of oberving captive specimens, otolith microstructure, length frequency data, and tagging. Lou and Moltschanowskyj (1992) validated daily growth increment formation on otoliths of several juvenile surgeonfish species, and Lou (1993) plotted growth curves for juvenile *Ctenochaetus binotatus* by measuring lapillus growth increments. Surgeonfishes have relatively long life spans. Randall (1961) reported *Naso unicornis* and *Acanthurus xanthopterus* living 15-20 years in captivity. Surgeonfish on the Great Barrier reef have shown an average maximum life span of over 20 years, and 40 years in one instance (Dalzell et al. 1996). Both of these situations involve no mortality from fishing. Hart & Russ (1996) measured *A. nigrofuscus* ages and found a mean age at different reefs on the Great Barrier reef ranging from 5.4 to 9.5 years, with the oldest specimen being 25 years old. Choat and Axe (1996) aged 10 species of acanthurids from the Great Barrier Reef through the use of otoliths and found life spans of 30-45 years in which growth was very rapid in the first 3-4 years of life. In American Samoa, Craig et al. (1997) found *A. lineatus* to grow very rapidly during the first year, 70-80% of total growth, followed by slower growth and a long life, up to 18 years.

Permanent sexual dimorphism is uncommon in the family. There are usually few differences between males and females, though in some species there are size differences, usually larger males. Males of the genus *Naso* frequently have a larger horn than females. Sexual dichromatism only exists during times of spawning, the rest of the time the sexes are similarly colored. Spawning is frequently timed with the lunar cycle, either during a new moon, a full moon, or both. Many surgeonfishes spawn in large aggregations, and others spawn strictly in pairs. Pair spawners may spawn throughout the lunar month (Robertson et al. 1979). The act of reproduction for all surgeonfishes involves a quick upward rush of the participants and a release of gametes into the water column. Spawning rushes typically occur in low light conditions, usually at or near dusk. Detailed descriptions of spawning behavior and spawning cycles of eight Indo-Pacific surgeonfish species are given in Robertson (1983).

Acanthurids appear to have a peak in spawning activity in late winter and early spring. Spawning of *Acanthurus triostegus* in Hawaii occurs primarily from December to June (Thresher 1984). Watson and Leis (1974) identified peak spawning from March to May, and another peak in October, for many reef fish in Hawaii, including acanthurids. There are instances of year-round spawning, and Randall (1961) suggested that seasonal variations in spawning may be less obvious in the deep tropics where variations in seawater temperature are less pronounced. Large aggregations of acanthurids do occur during spawning events, often near the mouths of channels in the reef and in areas with strong offshore currents (Randall 1961, Johannes 1981).

There are no species of surgeonfish endemic to any of the management areas in this plan, although *A. triostegus sandvicensis* in Hawaii is recognized as a subspecies. Also, *Zebrasoma flavescens* has a distribution from the North Pacific to southern Japan, but it is abundant only in Hawaii. Twenty three species of surgeonfish are found in Hawaii (Randall 1996), 39 species in Micronesia (Myers 1991), and 32 species in Samoa (Wass 1984).

Schooling behavior is common in acanthurids, particularly in association with spawning aggregations. Biologists have documented trains of surgeonfishes traveling along the reef to join thousands of other surgeonfish at spawning aggregation sites. Once there, the fish mingle near the substrate and slowly move upward as a group. Near dusk, small groups (6-15 individuals) of fish make spawning rushes to near the water surface and release gametes. Following spawning, fish return to the substrate, form trains, and return to their home reefs. Many species also form large single-species or mixed-species schools, apparently for overwhelming territorial reef fish to feed on the algal mats they are protecting.

Trophic ecology

Although acanthurids are predominantly herbivores, they are diverse and delicate feeders harvesting a variety of plants and organic materials which are processed in a gut environment characterized by a complex microflora (Choat 1991). Species of *Ctenochaetus*feed on detritus and algal fragments by whisking them from the substrate with comb-like teeth. *Acanthurus thompsoni*, *Naso annulatus, N. brevirostris, N. caesius, N. hexacanthus,* and *N. maculatus* feed primarily on zooplankton well above the bottom. *Naso lituratus* and *naso unicornis* browse mainly on leafy algae such as *Sargassum* (Randall 1996).

Surgeonfishes commonly defend territories that are primarily feeding territories (Robertson et al. 1979). In a study of the behavioral ecology of *Acanthurus lineautus, A. leucosternon,*and *Zebrasoma scopas*, Robertson et al. (1979) described the morphology, feeding strategies, and social and mating systems of three territorial species that occupied characteristic depth zones and habitat types.

Jones (1968) identified *Acanthurus thompsoni* and *Naso hexacanthus* as zooplankton feeders on copepods, crustacean larvae, and pelagic eggs; *A. dussumieri, A. mata, A. olivaceus, Ctenochaetus hawaiiensis,* and *C. strigosus* as grazers on a calcareus substratum rich in diatoms and detritus; and *A. achilles, A. glaucopareius, A. guttatus, A. leucopareius, A. nigrofuscus, A. nigroris, A. sandvicensis, Zebrasoma flavescens, Z. veliferum, Naso brevirostris, N. lituratus,* and *N. unicornis* as browsers on multicellular benthic algae.

Pacific fisheries

Surgeonfishes are important food fish on many Pacific islands, where they are typically caught by spearfishing or nets. Some species are also sought after for the aquarium trade.

Main Hawaiian Islands - Less than 12% of the catch of inshore fishes reported in DAR commercial statistics from 1991-1995 came from federal waters (Friedlander 1996). For catches reported to DAR between 0-200nm, six of the top 25 inshore species by weight are acanthurids: *A. dussumieri*-32,407 lbs, *A. triostegus*-11,705 lbs, *Naso* spp.-9969 lbs, *A. xanthopterus*-5,234 lbs, *A. olivaceous*-4,813 lbs, and *Ctenochaetus strigosus*-3,776 lbs (Friedlander 1996).

Northwestern Hawaiian Islands - No data is available on catches of surgeonfish in this area, where inshore fisheries are fairly unexploited (see Green 1997).

American Samoa - Craig et al. (1993) reported that no major commercial fishery operates in federal waters in American Samoa. Closer to shore, *Acanthuridae* compose 28% of the reef fish catch (Dalzell et al. 1996). Over 40% of the catch composition by weight in the 1994 artisanal fishery was surgeonfishes (in Craig et al. 1995). In 1994, *A. lineatus* ranked second among all species harvested in both the artisanal and substience fisheries, accounting for 10 % of the total catch of 295 metric tons (Craig et al. 1997). The artisanal fishery captured 28 t of *A. lineatus* by spearfishing. A much smaller amount of that species, only 1-3% of the catch, was taken in the subsistence fishery by use of gill nets, throw nets, rod-and-reels, and handlines.

Guam - At this time, much less than 20% of the total coral reef resources harvested in Guam are taken from federal waters (Myers 1997). Acanthuridae composed 9.12 % of the reef fish catch in Guam (Dalzell et al. 1996). Small-boat based spearfish landings from FY85-91 were 19.0% surgeonfishes by weight (Myers 1996). Further discussion of reef fish catches in Guam can be found in Green (1997).

CNMI - Most reef fish landed in the Northern Mariana Islands are reported as mixed reef fish. Only 1.11% of the catch was assigned to surgeonfishes (Dalzell et al. 1996).

Egg and larval distribution

Acanthurid eggs are pelagic, spherical, and small - 0.66-0.70 mm in diameter with a single oil droplet to 0.165 mm for *Acanthurus triostegus sandvicensis* (Randall 1961). For that species, hatching occured in about 26 hours. Watson and Leis (1974) found an egg size of 0.575 to 0.625 mm in diameter for an unidentified acanthurid from Hawaii.

Acanthurid larvae are typically diamond-shaped and strongly laterally compressed, with a prominent serrated dorsal spine, two large and serrated pelvic fin spines, and a single smoother spine near the anal fin (Thresher 1984). Late larval stages, roughly 20-25 mm, are orbicular, transparent except for a silvery abdomen and gut, with small scales in narrow vertical ridges on the body (Randall 1996). Spines on the larvae serve to enhance protection from predation, and may be venomous. Lou (1993) reported that *Ctaenochaetus binotatus* larvae fed on various zooplankton for a larval period ranging from 47-74 days. Similarly, Randall (1961) reported a zooplankton diet and a larval duration of 2.5 months for *Acanthurus triostegus sandvicensis*.

Surgeonfish larvae are primarily found well offshore at depths from 0-100m. Like other common adult members of the coral reef fish community, surgeonfish larvae are typically less abundant in samples of the water column near the reef than they are in samples from offshore (Miller 1973).

Although surgeonfish generally settle at a larger size than most reef fish, acanthurids are one of the families with juveniles that settle with larval characters still present (Leis & Rennis 1983). Late phase larvae actively swim inshore at night, seek shelter in the reef, and begin growing scales and intestines to complete the transformation to juveniles (Clavijo 1974). Lengthening of the alimentary track to accommodate an herbivorous diet happens fairly quickly. Juvenile surgeonfish have been reported to shelter in tide pools in Hawaii (Randall 1961). Hart and Russ (1996) found an age-at-maturity for *Acanthurus nigrofuscus* of 2 years. Choat (1991) reported a range of 12-18 months to maturity for acanthurids. Juveniles frequently differ in coloration and behavior from adults.

Adult surgeonfish are found in many coral reef habitat types, including mid-water, sand patch, subsurge reef, and seaward or surge zone reef. The largest number of surgeonfish species are typically found in the subsurge reef habitat, which are defined by Jones (1968) to be areas of moderate to dense coral growth corresponding to the subsurge portions of fringing reefs, deepwater reef patches, reef filled bays, and coral-rich parts of lagoons inside of atolls. These species are typically found between 0-30m depth, although surgeonfish do live in depths from 0-150m. Some species of *Naso* have been seen below 200m (Chave & Mundy 1994).

Acanthurids were the dominant family of fishes in Hanalei Bay in both numbers and biomass (Friedlander 1997). There were high numbers of surgeonfish in shallow, complex backreef habitat. Biomass for the depth stratum 4.3-7.2m was dominated by three surgeonfish species, *A. Tristegus, A. leucopareis,* and *Ctenochaetus strigosus*. *C. strigosus* and *A. nigrofuscus* were common in the shallow complex backreef as well as in the deep slope and spur and groove habitat types (Friedlander and Parrish 1998).

As an example for the family, *Acanthurus nigrofuscus* form schools that migrate 500 to 600m daily to intertidal feeding areas of algal turf communities. In the summer, the main food items are brown and red algae, while in the winter, it is green algae. Spawning occurs in large schools of 2000 to 2500 fish on selected sites at dusk (Fishelson et al. 1987).

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Management Unit Species: Acanthuridae (surgeonfishes)

	Egg	Larvae	Juvenile	Adult
Duration	26 hours for *A. triostegus sandvicensis*	47-74 days for *C. Binotatus*, 2.5 months for *A. triostegus sandvicensis*	1-2 years	25 yrs for *A. Nigrofuscus* (Hart & Russ 1996), over 40 yrs for *Naso* spp. (Choat & Axe 1996)
Diet	N/A	various zooplankters (Randall 1961)	mostly herbivorous although some may feed on zooplankton	*Acanthurus & Zebrasoma* - algal turfs, *Ctenochaetus* - detritus and sediment, *Naso & Paracanthurus* - mostly zooplankton
Distribution, general and seasonal	some species spawn year-round, but generally there appears to be a peak in spring and early summer; many species show lunar spawning periodicity	year-round distribution, with perhaps more settlement in late summer or fall	coral reef habitats throughout the Western Pacific	coral reef habitats throughout the Western Pacific, spawning aggregations at prominent outcroppings, some species are fairly stationary and territorial while others travel long distances for feeding
Location	water column from the surface to 100m	0-100m, larvae typically are more common in offshore waters than in water over reefs	tide pools, refugia on the reef	bottom and water-column; most between 0-100m but some deeper than 200m
Water column	N/A	pelagic	demersal and mid-water	demersal and mid-water
Bottom type	N/A	N/A	coral, rock, sand, mud, rubble, pavement	coral, rock, sand, rubble, pavement
Oceanic features	subject to ocean currents	subject to ocean currents		spawning aggregations may occur at channels just before or during outgoing tides

Management Unit Species: **Zebrasoma flavescens (yellow tang)**

The yellow tang is a popular aquarium fish that is the top marine fish export from Hawaii, representing more than 75% of all animals caught statewide (Clark and Gulko 1999). They occur singly or in loose groups on coral-rich areas of lagoon and seaward reefs from below the surge zone to at least 46 m. Juveniles tend to hide among branches of finger coral, while adults graze near the shore in calm areas. They are diurnal herbivores of filamentous algae from hard surfaces. The genus is characterized by an unusually deep body with tall dorsal and anal fins and an elongate tubular snout. The yellow tang is moderately common at some locations in the Marianas, but is most abundant in Hawaii.

Group spawning (Lobel 1978) as well as pair spawning by territorial males that court passing females (in Thresher 1984) has been observed. Spawning occurs a few meters above the bottom or the depth of the spawning aggregation, usually at dusk. Pelagic eggs likely hatch within 1 to 2 days, and a pelagic larval stage lasts for up to a few months.

Z. flavescens tends to prefer the leeward sides of islands (Brock 1954), particularly areas of dense coral growth of *Pocillopora damicornis* and *Porites compressa.* It feeds on algae growing exposed on basalt and dead coral heads, as well as in crevices and interstices of the reef that it can reach with its long, thin snout (Jones 1968). The majority of yellow tang in Hawaii are collected off West Hawai'i, Kawaihae, Kona and Miloli'i (Clark and Gulko 1999).

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Management Unit Species: Zebrasoma flavescens (yellow tang)

	Egg	Larvae	Juvenile	Adult
Duration	approximately 24 hours	up to a few months		
Diet	N/A	various zooplankters	similar to adults	herbivores on filamentous algae
Distribution, general and seasonal	late winter, spring peak in spawning		highest recruitment in the summer, May to August, in Hawaii (Walsh 1987)	Pacific Plate; abundant only in Hawaii, found uncommonly at some locations in the Marianas; not recorded from Samoa
Location	eggs released after short spawning ascent from the bottom or the depth of a spawning aggregation	0-100m, larvae typically are more common in offshore waters than in water over reefs	often hide within the branches of finger coral	coral-rich areas of lagoon and seaward reefs from below the surge zone to at least 46 m; adults may feed very near the shore in calm areas
Water column	pelagic	pelagic	demersal and mid-water	demersal and mid-water
Bottom type	N/A	N/A	coral, rock, rubble, pavement	coral, rock, rubble, pavement
Oceanic features	subject to ocean currents	subject to ocean currents		

Management Unit Species: **Zanclidae (Moorish idol)**

This family consist of one species, *Zanclus cornutus*. It has a strongly compressed discoid body, tubular snout with a small mouth and many bristle-like teeth, and dorsal spines elongated into a whip-like filament. Moorish idols have a long larval stage and settle at a large size, >6cm SL for some individuals. As a result, they are ubiquitous in areas of hard substrate from turbid inner harbors to clear seaward reefs. They feed mainly on sponges, but will also take other invertebrates and algae. They usually are found in small groups of 2-5 individuals but may occur in large schools of well over 100 individuals. Their range is Indo-Pacific and tropical eastern Pacific, and they are found throughout the management area. They are a popular aquarium fish.

There is little information on Moorish idol reproduction, but they have been observed to spawn in pairs at dusk on outer reef slopes, producing pelagic eggs that are capable of long planktonic existence. Their wide distribution and length at settlement as large as 7.5cm are good indicators of long larval stages. The larval phase is similar to acunthurid larval phases.

Moorish idols inhabit all types of hard substrate in the tropical Pacific. They are present in very shallow habitats < 1m deep and have also been sighted as deep as 180m. They are diurnal predators that feed mainly on sponges, but also on small benthic crustaceans and algal film on rocks and coral.

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Management Unit Species: Zanclidae (Moorish idol)

	Egg	Larvae	Juvenile	Adult
Duration	unknown	relatively long; several months, ranging in size from a few millimeters to 7.5 cm		
Diet	N/A	zooplankton	mostly sponges, some small benthic crustaceans and algae	mostly sponges, some small benthic crustaceans and algae
Distribution, general and seasonal	little known	predominantly offshore	Indo-Pacific and tropical Eastern Pacific	Indo-Pacific and tropical Eastern Pacific
Location	released near the surface on outer reef slope	predominantly offshore	from turbid inshore harbors to clear outer reef slopes	from turbid inshore harbors to clear outer reef slopes
Water column	pelagic	pelagic	demersal	demersal
Bottom type	N/A	N/A	all hard substrates, including coral reef, rocks, rubble, reef flats, wrecks	all hard substrates including coral reef, rocks, rubble, reef flats, wrecks
Oceanic features				

Management Unit Species: **Siganidae (Rabbitfishes)**

Siganids are small (from 20 -50 cm), essentially marine tropical Indo-West Pacific fishes. They have venomous dorsal, anal and pelvic spines. With a single row of flattened, close-set teeth, rabbitfishes feed primarily on algae and seagrasses, although some may occasionally feed on tunicates or sponges. Because of their herbivorous diet, most species live at depths less than 15 m, but some are trawled from as deep as 50m. Half the species live as pairs on coral reefs, the others usually gather in small schools. One species, *Siganus vermiculatus*, is almost exclusively estuarine; the rest move between estuaries, coral reefs, rocky shores, and other habitats. Rabbitfishes generally spawn on a lunar cycle with peak activity during the spring and early summer. Spawning occurs in pairs or groups on outgoing tides either at night or early in the morning. Juveniles of some species are estuarine. Rabbitfishes are highly esteemed foodfishes. Some of the colorful ones are popular aquarium fishes. None are found in Hawaii. Approximately 16 species are found in Micronesia, and at least 4 species in Samoa.

Spawning by rabbitfishes is typically preceded by a migration to specific and traditional spawning sites. The location varies from near mangrove stands (*S. lineatus*, Drew 1971), to shallow reef flats (*S. canaliculatus*, Manacop 1937, Johannes 1981), the outer reef crest (several spp. at Palau, Mcvey 1972; Johannes 1978), and even the deeper reef (*S. lineatus*, Johannes 1981). Sites are usually characterized by easy access to the ocean via channels, and large areas of sea grass flats nearby.

Reproduction in the schooling species has been studied in some detail, and in general the eggs are adhesive and demersal (with a few exceptions such as the pelagic eggs of *S. argenteus*); hatching occurs within 1-3 days and yolk sac absorption is completed in about 3 or 4 days (Lam 1974). Fecundity is high: 250,000-500,000 eggs per spawning season (Lam 1974, Gunderman et al. 1983). Larvae are pelagic and feed on phytoplankton and zooplankton. The duration of the larval stage is about 3 weeks in *S. fuscescens* (Hasse et al. 1977) and 3-4 weeks in *S. vermiculatus* (Gunderman et al. 1983). Popper et al. (1976) reported that siganid larvae follow a lunar rhythm in appearing on the reef, typically arriving inshore 3-5 days after a new moon. Fish are 15-20 cm long and sexually mature after one year. Judging by maximum size, some species survive from 2-4 years. *S. argenteus* is unique amongst the Siganidae in having a prejuvenile stage which is distinct from the larval and juvenile stages and is specially adapted for a pelagic life (Hubbs 1958). They can reach sizes of 6-8 cm SL before settling. Not surprisingly, *S. argenteus* has the widest distribution of all rabbitfishes.

The rabbitfishes vary widely in their habitat uses. The schooling species typically move between a wide range of habitats, whereas the pairing species tend to lead a sedentary existence among the branches of hard corals. Rabbitfishes are common on reef flats, around scattered small coral heads, and near grass flats. Gundermann et al. (1983) divided the siganids into two groups on the basis of habitat, behavioral characteristics and coloraton. One group includes species (*S. corallinus, S. puellus*, and *Lo vulpinnus*) that live in pairs, have limited home-ranges on reefs and are brightly colored. The remaining group, including *S. rivulatus* and *S. canaliculatus*, form schools at some stage of their life cycle, may undertake substantial migrations, and assume a coloration similar to their preferred habitat.

Schools of juvenile *S. rostratus* and *S. spinus* swarm on the reef flats of Guam each year during April and May, and occasionally during June and October. Tsuda et al. (1976) studied the feeding and habitat requirements for these fish to determine the likelihood of mariculture of the rabbitfishes, which are highly esteemed for gastronomic and cultural reasons in Guam.

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Management Unit Species: Siganidae (rabbitfishes)

	Egg	Larvae	Juvenile	Adult
Duration	1-3 days	3-4 weeks	1 year	2-4 years
Diet	N/A	phytoplankton and zooplankton	herbivores	herbivores, though some may feed on tunicates and sponges; they will assume a carnivorous diet in captivity
Distribution, general and seasonal	spawning in Guam in April and May, and occasionally in June and October		some species estuarine as juveniles before moving offshore	throughout the shelf waters of the Indo-West Pacific, except for the Hawaiian and Easter Island provinces
Location	mangrove stands (*S. lineatus*, Drew 1971), to shallow reef flats (*S. canaliculatus*, Manacop 1937, Johannes 1981), the outer reef crest (several spp. at Palau, Mcvey 1972; Johannes 1978), and even the deeper reef (*S. lineatus*, Johannes 1981). Sites are usually characterized by easy access to the ocean via channels, and large areas of sea grass flats nearby	more abundant offshore	estuaries for some species	most wide-ranging over many habitats. *Siganus vermiculatus*, is almost exclusively estuarine; the rest tend to move between estuaries, seagrass beds, coral reefs, rocky shores
Water column	pelagic	pelagic	demersal or reef-associated	demersal or reef associated
Bottom type	N/A	N/A	silt, sand, and mud for estuarine species	some pair-forming species are sedentary in the branches of Acropora corals; most range over many bottom types
Oceanic features	ocean currents	ocean currents		

Management Unit Species: **Gymnosarda unicolor (dogtooth tuna)**

Very little is known about the biology of the dogtooth tuna (*Gymnosarda unicolor*), although it is widely distributed throughout much of the Indo-Pacific faunal region, from the Red Sea eastward to French Polynesia (Collette and Nauen 1983). This species is not found in the Hawaiian islands, although fishermen do refer to catches of the meso-pelagic snake mackerel (Gempylidae) as "dogtooths".

G. unicolor is an epipelagic species, usually found individually or in small schools of 6 or less (Lewis et al. 1983). Dogtooth tuna are found in deep lagoons and passes, shallow pinnacles and off outer reef slopes (Collette and Nauen 1983). It occurs in mid-water, from the surface to depths of approximately 100m, and has a preference for water temperatures ranging from 20-28 degrees Celsius.

G. unicolor is one of the few tuna species found primarily in association with coral reefs (Amesbury and Myers 1982) and probably occupies a niche similar to other reef-associated pelagic predators such as Spanish mackerel (*Scomberomorus* spp.) and queenfish (*Scomberoides* spp). Like the Spanish mackerels, large dogtooths can become ciguatoxic from preying on coral reef herbivores, which themselves have become toxic through ingestion of the dinoflagellate, *Gambierdiscus toxicus* (Myers 1991).

A positive correlation between size and depth has been observed in the distribution of this species based on limited information from Tuvalu, with larger individuals being found at greater depths (Haight 1998). This species reportedly reaches a maximum size of 150cm FL and 80kg (Lewis et al. 1983).

Observations from Fiji suggest that dogtooth tuna obtain sexual maturity at approximately 65 cm (Lewis et al. 1983), while Silas (1963) reported a partially spent 68.5 cm male dogtooth tuna from the Andaman Islands. Females outnumbered males by nearly 2:1 in Fiji, and all fish larger than 100cm were females, suggesting sexual dimorphism in this species (Lewis et al. 1983). Lewis et al. (1983) suggest that the vulenrability of female dogtooth tuna to trolling declines as the fish approach spawning condition.

In Fiji, spawning reportedly occurs during the summer months - between October and March (Lewis et al. 1983). Dunstan (1961) observed spawning dogtooth tuna in Papua New Guinea during March, August and December, and various other authors (Silas 1963) have provided some evidence of summer spawning for this species. Okiyama and Ueyangi (1977) note that the larvae of dogtooth tuna occur over a wide area of the tropical and subtropical Pacific Ocean, between 10°N and 20°S, with concentrations along the shallow coastal waters of islands, such as the Caroline Islands, Solomon Islands and Vanuatu. Dogtooth larvae were collected in surface and subsurface tows, with greater numbers in the sub-surface tows at depths between 20-30m. Older larvae appear to make diurnal vertical migrations, rising to the surface during the night. On the basis of larval occurrence throughout the year, Okiyama and Ueyangi (1977) postulate year round spawning in tropical areas.

There are no fisheries specifically directed at dogtooth tuna in the western Pacific region. The primary means of capture include pole and line, handlines and surface trolling (Severance 1998, pers. comm; Collette and Nauen 1983). Dogtooth tuna have been sold in local markets in American Samoa and the Northern Mariana Islands, but currently have little market value (Severance 1998, pers. comm.).

Dogtooth tuna are voracious predators, feeding on a variety of squids, reef herbivores such as tangs and unicorn fish (Acanthuridae), and small schooling pelagic species including fusiliers (*Caesio* spp) and roundscads (*Decapterus*) (Myers 1989).

Dogtooth tuna are unique among the family Scombridae in having such a close association with coral reefs, although they are also found around rocky reefs in higher latitudes such as in Korea and Japan (Myers 1989). Within the western Pacific region, waters on and adjacent to coral reefs down to a depth of about 100m should be designated EFH for this specis.

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Management Unit Species: Gymnosarda unicolor (dogtooth tuna)

	Egg	Larvae	Juvenile	Adult
Duration			sexually mature at approximately 65cm	unknown
Diet	N/A	unknown	unlikely to be different from adult	a variety of squids, reef herbivores such as tangs and unicornfish (Acanthuridae), and small schooling pelagic species such as fusiliers (*Caesio* spp)and roundscads (*Decapterus*)
Distribution, general and seasonal	unknown	tropical and subtropical Pacific Ocean between 10°N and 20°S, with greater concentrations along shallow coastal waters of islands such as the Caroline Isl., Solomon Isl. and Vanuatu	unlikely to be different from adult	widely distributed throughout much of Indo-Pacific, from the Red Sea eastward to French Polynesia. Not found in the Hawaiian islands
Location			unlikely to be different from adults	deep lagoons and passes, shallow pinnacles and off outer reef slopes
Water column	epipelagic	epipelagic; greater numbers in subsurface tows at depths between 20-30m	epipelagic	epipelagic; occurs in mid-water, from the surface to approximately 100m
Bottom type	N/A	N/A	N/A	N/A
Oceanic features	subject to advection by prevailing currents	subject to advection by prevailing currents	unknown	unknown

Management Unit Species: **Bothidae/Soleidae/Pleuronectidae (flounder and soles)**

Flatfishes have both eyes on one side of the body and a greatly compressed body suited for lying flat on the bottom. The eyes are situated on both sides of the head in the larvae, but migrate to one side as the larvae transforms into a benthic juvenile. The eyes migrate onto the left side for members of the family Bothidae, and onto the right side for members of the family Pleurnectidae and Soleidae. The side with no eyes settles on the bottom and remains unpigmented, while the top side can change color patterns to match the surrounding bottom. They are ambush carnivores of small fishes and crustaceans that live on silt, sand or gravel bottoms. They are important foodfishes worldwide, where they inhabit continental shelves of tropical and temperate seas. A few species are found on shallow coral reefs: in Hawaiian waters, there are 13 species of Bothidae but only 2 common shallow species, 2 species of the genus *Samariscus* that formerly were considered a part of Pleuronectidae but now are in their own family Samaridae, and 2 species of Soleidae. In Micronesian waters, there are at least 3 species of Bothidae, one species of Pleuronectidae, and at least 5 species of Soleidae found on shallow reefs. Two sole species, *Aseraggodes borehami* and *Aseraggodes theres*, are recently described species found only in the Hawaiian islands. Three species are recorded from Samoan waters.

Bothid eggs are pelagic, spherical, and small, with a diameter of 0.6-0.9mm. The larvae hatch at 1.6-2.6mm. Soleid eggs are pelagic, spherical and moderate in size, with a diameter of 0.9-18mm. The larvae range from 1.7 to 4.1mm at hatching. Larval pleuronectiform fish have symmetrical eyes, but many remain pelagic for some time after the eyes migrate. Some become quite large before settling, and often possess highly ornamented spines, elongate fin rays, or protruding guts as larval specializations (Leis & Trnski 1989). Larvae are found in the upper 100m of the water column.

Habitat for most flatfishes is soft bottoms such as sand, mud, or silt that are often found in association with coral reef habitats. Some species are found directly on the reef or within the reef framework. Many species are found in water deeper than 100m, but some are common in shallow habitats.

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Management Unit Species: Bothidae/Soleidae/Pleurnectidae (flounder and soles)

	Egg	Larvae	Juvenile	Adult
Duration		1.6 to 4.1mm at hatching		
Diet	N/A	the sole *Achirus lineatus* eats copepods, mollusc larvae, rotifers, dinoflagellates (Houde & Lovdal 1984); other species eat larvaceans, chaetognaths and copepods (Liew 1983)	similar to adult	ambush carnivores of fishes and invertebrates
Distribution, general and seasonal			similar to adult	tropical and temperate continental shelves worldwide; some species associated with coral reefs in the Indo-Pacific
Location	spawning aggregations not recorded	offshore waters	lagoons, caves, flats, reefs	lagoons, caves, flats, reefs
Water column	pelagic	pelagic; from 0-100m depth	demersal	demersal
Bottom type	N/A	N/A	similar to adult	soft bottoms such as sand, gravel, mud, and silt; some species found on reef surface or within reef framework
Oceanic features				

Management Unit Species: **Balistidae/Monocanthidae (triggerfishes/filefishes)**

The triggerfishes are named for an ability to lock their large, thickened first dorsal spine in an upright position, which can be released only by pressing down on the second dorsal spine (the trigger). They are deep-bodied fish with eyes high on the head, a long snout, a small terminal mouth, and tough skin with armor-like non-overlapping scales. Triggerfishes are usually solitary except when they form pairs at spawning time, although the black durgon *Melichthys niger* may form large aggregations. When alarmed, or at night, they wedge themselves into a hole in the reef or rocks by erecting the first dorsal spine and pelvic girdle. During the day, most are carnivores of a wide variety or benthic animals including crustaceans, mollusks, sea urchins, other echinoderms, coral, tunicates, and fishes. Some feed largely on benthic algae and zooplankton, including *M. niger* and *M. vidua*, while *Xanthichthys auromarginatus* and *X. mento* feed mainly on zooplankton. Eleven species are known from the Hawaiian islands. At least 20 species occur in Micronesia. At least 16 species occur in Samoa. Many species are collected for aquariums. The clown triggerfish *Balistoides conspicillum* is among the most highly prized aquarium fishes, although like most triggerfishes it is very aggressive to other fish in a tank and tends to eat all the invertebrates.

The filefishes are closely related to the triggerfishes, differing by having more compressed bodies, a longer and thinner first dorsal spine, a more pointed snout, a very small or absent second dorsal spine, and no third dorsal spine. Unlike the triggerfishes, many filefish are able to change their coloration to match their surroundings, and are frequently secretive. Some filefishes are sexually dimorphic, not in coloration so much as the size of the spines or setae posteriorly on the body. Filefishes are mostly omnivorous, feeding on a wide variety of benthic plant and animal life. Some species eat noxious sponges and stinging coelenterates that most fish avoid. Eight species occur in Hawaii, at least 17 in Micronesia, and at least 7 species occur in Samoa. Three species are endemic to Hawaii: the squaretail filefish *Cantherhines sandwichiensis*, the shy filefish *C. verecundus*, and the fantail filefish *Pervagor spilosoma*.

Sexual dimorphism is widespread, though not universal, in the triggerfishes. The male is typically more brightly colored and larger, as in *X. auromarginatus, X. mento, B. undulatus, B. vetula, Odonus niger, Pseudobalistes fuscus, Hemibalistes chrysopterus*, and *M. niger* (Berry & Baldwin 1966, Randall et al. 1978, Matsuura 1976, Breder & Rosen 1966, Aiken 1975, Fricke 1980). Sexual dimorphism is less common in the filefishes, in which males and females tend to be more drab. There is some evidence of lunar spawning periodicity for balistids. At Belau, the yellowmargin triggerfish *Pseudobalistes flavimarginatus* spawns in nests in sand-bottom channels within a few days before both new and full moons during the months of November, December, March, April, and May, if not throughout the year (Myers 1989). Balistids produce demersal eggs that may or may not be tended by a parent, usually the female. They are one of the, if not the only, reef fish families that have extensive maternal care. This could be related to a harem-based social structure that requires the male to vigorously defend his territory from other males. Balistid eggs are spherical, slightly over 0.5 mm in diameter, and translucent. Eggs are typically deposited in shallow pits excavated by the parents as an adhesive egg mass containing bits of sand and rubble. Triggerfish eggs hatch in as little as 12 hours and no more than 24 hours. Filefish eggs may take longer to hatch, up to 58 hours. The pelagic larval stage can last for quite a while, and some species reach a large size before settling to the bottom. Several species of Melichthys can reach as much as 144 mm before settling (Randall 1971, Randall & Klausewitz 1973). Prejuveniles are often associated with floating algae, and may be cryptically colored. Berry and Baldwin (1966) suggested that sexual maturity of *Sufflamen verres* and *Melichthys niger* occurs at approximately half maximum size, at an age of a year or more. Smaller filefishes may mature within a few months after hatching.

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Management Unit Species: Balistidae/Monacanthidae (triggerfishes/filefishes)

	Egg	Larvae	Juvenile	Adult
Duration	12-24 hours for triggerfish, up to 58 hours for filefish	several months, can grow up to 144 mm before settling (Randall & Klausewitz 1973)	one or more years	
Diet	N/A	various plankton	similar to adult	carnivores of a wide variety or benthic animals including crustaceans, mollusks, sea urchins, other echinoderms, coral, tunicates, and fishes. Some feed largely on benthic algae and zooplankton
Distribution, general and seasonal	At Belau, the yellowmargin triggerfish *Pseudobalistes flavimarginatus* spawns within a few days before both new and full moons during the months of November, December, March, April, and May, if not throughout the year (Myers 1989)		similar to adult	tropical and temperate seas worldwide; 11 species are known from the Hawaiian islands. At least 20 species occur in Micronesia. At least 16 species occur in Samoa.
Location	many spawn on sand or other soft-bottom habitats		Juvenile *B. conspicillum* usually occur in or near ledges and caves of steep dropoffs below 20m (Myers 1989)	lagoon and seaward reefs; many prefer steeply sloping areas with high coral cover and a lot of caves and crevices; zooplanktivores spend day in the water column
Water column	demersal	pelagic	demersal and pelagic	some species in very shallow water, 2-20m while others as deeper than 100m
Bottom type	sand, mud, rubble	N/A	similar to adults	coral reef, rock, sand
Oceanic features		subject to advection by ocean currents		

Management Unit Species: **Ostraciidae (trunkfish)**

The trunkfishes, or boxfishes, possess a bony carapace of polygonal plates that encase the head and body. The bony shell may be triangular, quadrangular, pentagonal, hexagonal, or nearly round in cross-section. Some species have stout spines projecting from the rough surface of the plates. The mouth is small and low with thick lips and a row of conical to incisiform teeth with rounded tips. Trunkfishes are slow swimming diurnal predators that feed on a wide variety of small sessile invertebrates, especially tunicates and sponges, and algae. Some species, and perhaps all, secrete a skin toxin when under stress. Some species, and perhaps all, are protogynous hermaphrodites. Sexual dichromatism is common in the family. The species studied thus far are haremic with males defending a large territory with non-territorial females and subordinate males. Spawning in pairs occurs at dusk, usually above a conspicuous outcrop. In Hawaiian waters, 6 species are recorded and the spotted boxfish *Ostracion meleagris camurum* is recognized as a subspecies. In Micronesian waters, 6 species are recorded. In Samoan waters, 3 species are recorded.

Leis (1978) described the eggs of Hawaiian ostraciids as slightly oblong, with less than 10 oil droplets, and a patch of "bumps" at one end. However, Mito (1962) described eggs from Japanese waters as 1.62-1.96mm in diameter with a single oil droplet. A western Atlantic species *Acanthostracion quadricornis* had spherical eggs, 1.4 to 1.6mm in diameter, that hatched in about 48 hours at 27.5°C. About 114 hours after hatching, it reaches a distinctive square armor-plated postlarval stage. Postlarvae and juveniles are commonly collected in grassbeds and other shallow areas and are rarely seen on the reef (Thresher 1984). Juveniles of *Ostracion*, on the other hand, are commonly seen on shallow reefs, especially in late summer.

The longhorn cowfish, *Lactoria cornuta*, occurs over sand and rubble bottoms of subtidal reef flats, lagoons, and bays to a depth of 50m. It feeds on polychaetes and other benthic invertebrates, often "blowing" sand off the bottom to expose the prey. The thornback cowfish *Lactoria fornasini* inhabits sandy areas with rubble, algae, or corals of clear outer lagoon and seaward reefs. The spotted trunkfish *Ostracion meleagris* occurs on clear lagoon and seaward reefs from the lower surge zone to 30m, where it feeds on didemnid tunicates as well as smaller amounts of polychaetes, algae, sponges, mollusks, and copepods. They are sexually dimorphic, with males taking a bright blue and yellow form upon sex-reversal from a female to male.

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Management Unit Species: Ostraciidae (trunkfishes)

	Egg	Larvae	Juvenile	Adult
Duration	48 hrs for A. quadricornis (Thresher 1984)	fairly short in general; 114 hrs in A. quadricornis in the Caribbean (Thresher 1984), but Moyer (1980) reported much older pelagic larvae, up to 90mm long		
Diet	N/A		similar to adults	small sessile invertebrates, especially didemnid tunicates and sponges, but also polychaetes, algae, sponges, mollusks, and copepods; also algae
Distribution, general and seasonal				
Location		offshore	grassbeds and other shallow areas	coral reefs, lagoon and seaward reefs
Water column	pelagic	pelagic	demersal and mid-water column	demersal and mid-water column, well defended from predators
Bottom type	N/A	N/A	similar to adults;	sandy areas with rubble, algae, or corals
Oceanic features	subject to advection by prevailing currents	subject to advection by prevailing currents		

Management Unit Species: **Tetradontidae/Diodontidae (puffers/porcupinefishes)**

Puffers are named for their ability to enlarge their bodies by drawing water into a highly distensible ventral diverticulum of the stomach. That feature, prickly skin, and a powerful toxin concentrated in their viscera, gonads, and skin helps them deter predators. Toxicity varies greatly with species, area, and season. Puffers have the teeth in their jaws fused to beak-like dental plates with a median suture. Most are slow swimmers that feed on a wide variety of algae and benthic invertebrates, including fleshy, calcareous or coralline algae and detritus, sponges, mollusks, tunicates, corals, zoanthid anemones, crabs, hermit crabs, tube worms, sea urchins, brittle stars, starfishes, hydroids, bryozoans and foraminifera. All species known to date lay demersal eggs. At least one species of Canthigaster, *C. valentini*, is haremic with males controlling a territory containing 1-7 females. The males spawn at mid-morning with a different female each day, and the eggs are deposited in a tuft of algae. Most puffers are solitary but a few form small aggregations. In Hawaiian waters, there are 14 species recorded, with 2 endemics: *Canthigaster jactator* and *Torquigener randalli*. In Micronesian waters, there are at least 17 species. In Samoan waters, 18 species are recorded.

Much of the information on puffer reproduction has been completed in temperate locations, but some reasonable assumptions can made about tropical species. Puffers lay demersal adhesive eggs, although courtship is often observed near the surface. The eggs are typically on their own after being deposited, and take approximately 4 days to hatch in *C. valentini* (Gladstone 1985). Newly hatched larvae range in size from 1.9 to 2.4mm. Settlement to the bottom can occur in a little over 30 days, but some species have a much longer pelagic existence.

Porcupinefishes are similar to puffers in many ways, but differ primarily in having prominent spines on the head and body. They also have larger eyes, broader pectoral fins, and lack a median suture on the dental plates. Hard, beak-like jaws allow them to crush the hard shells of mollusks or crustaceans, or tests of sea urchins. They appear to be nocturnal. Spawning has been observed in *Diodon holacanthus*, which spawns at the surface at dawn or dusk as pairs or groups of males with a single female. In Hawaiian waters, 3 species have been recorded. In Micronesian waters, 3 species are known, although one, *Diodon eydouxii*, is entirely pelagic. The juveniles of *D. hystrix* and *D. liturosus* are pelagic as well.

Porcupinefish in Hawaii have a peak in spawning in the late spring, with some spawning from January to September (Leis 1978). Courtship and spawning by *Diodon holacanthus* has been observed in a large public aquarium (Sakamoto & Suzuki 1978) and in the Gulf of California (Thresher 1984). Diodontid eggs are spherical, 1.62 to 2.1 mm in diameter, and may be demersal or pelagic. Hatching occurs in 4-5 days. Leis (1987) reported metamorphosis at a length of 3 mm and an age of 3 weeks to a postlarval stage similar in appearance to the adult. The duration of the larval stage may be several months. Very large prejuveniles (up to 86 mm for *D. holacanthus* and 180 mm for *D. hystrix*) are common in plankton tows.

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Management Unit Species: *Tetradontidae/Diodontidae* (Puffers/Porcupinefishes)

	Egg	Larvae	Juvenile	Adult
Duration	4-5 days	several months or longer	size at settlement of 180-191mm (Leis 1987)	
Diet	N/A	various zooplankton	similar to adult	wide variety of algae and benthic invertebrates, including fleshy, calcareous or coralline algae and detritus, sponges, mollusks, tunicates, corals, zoanthid anemones, crabs, hermit crabs, tube worms, sea urchins, brittle stars, starfishes, hydroids, bryozoans and foraminifera
Distribution, general and seasonal			same as adults	worldwide throughout tropical and temperate seas
Location	pelagic or demersal depending on species	pelagic	estuaries, mangroves, lagoons, coral reefs	estuaries, mangroves, lagoons, coral reefs
Water column	puffers are demersal spawners, porcupinefish may spawn pelagic or demersal eggs	pelagic; 0-100m	reef-associated and pelagic	reef-associated and pelagic
Bottom type	reef, sand, or algae tufts	N/A	sand, silt, coral, rock	sand, silt, coral, rock
Oceanic features		subject to advection by ocean currents		

B. EFH for Management Unit Species- Invertebrates

Management Unit Species: **Cephalopods**

General Description of the Taxon[1]

The cephalopods (Class Cephalopoda of the Phylum Mollusca) comprise a relatively small group of organisms that includes squid, octopods, cuttlefish, and nautilus. Although certain members of the class (e.g., the octopods) are for the most part bottom-dwellers, the majority are adapted for a free-swimming lifestyle. The head projects into a circle of large prehensile tentacles or arms, which are homologous to the anterior of the foot of other mollusks. The tentacles are used for various functions, including seizing prey, grasping the substrate, and for copulation and fertilization. Most cephalopods swim by jet propulsion, rapidly expelling water from the mantle cavity through a ventral tubular funnel. The funnel is highly mobile and can be directed either anteriorly or posteriorly. The force of water leaving the funnel propels the animal in the opposite direction, enabling both backward and forward swimming. Certain species of squid have attained the highest speed of movement through water observed for any marine invertebrate (up to 40 km per hour). (Barnes 1987; Nesis 1987). Within the class, only members of the genus *Nautilus* (in Subclass Nautiloidea) have a true external shell. All other cephalopods belong to the subclass Coleoidea, in which the shell is reduced and internal, or lacking altogether. In squids, for example, the shell is reduced to a long, flattened chitinous "pen" or gladius, while in cuttlefish the internal shell, the sepion, is thicker and calcareous. In certain genera—*Nautilus, Spirula,* and *Sepia*—the gas-filled chambers of the animals' shells allow for maintenance of neutral buoyancy within the water column. Many species exhibit diurnal vertical migration, moving upward to feed during the night and into deeper water during the day (Barnes 1987; Nesis 1987).

Reproduction and Life History

Cephalopods are dioecious, with a single gonad positioned at the posterior end of the body. Sperm are conducted through the vas deferens to a ciliated seminal vesicle, where the sperm are rolled together and encased in spermatophores. The spermatophores are then transported to a storage sac which opens into the mantle cavity. In females, the oviduct terminates in an oviductal gland. Octopods and some squid may have two oviducts.

Fertilization may occur within the mantle cavity or outside. One of the arms of the male is highly modified into a copulatory organ, the hectocotylus. During copulation, while the male grasps the female with the regular arms, the hectocotylus receives spermatophores from the funnel (opening of the vas deferens), or plucks them from the storage sac. The hectocotylus may be inserted into the mantle cavity, and spermatophores are deposited on the mantle wall of the female, near the openings of the oviducts. In *Octopus*, the hectocotylus is inserted into the genital duct. In some squid, the hectocotylus may be inserted into a seminal receptacle located in a fold beneath the mouth for deposition of spermatophores.

Eggs are discharged from the oviduct, then surrounded by a paired membrane or capsule. In some genera eggs may be surrounded by a gelatinous mass. In most cases, eggs are either attached by the female to a stable substrate, or shed into the seawater. Sepioids may attach the single eggs by means of a flexible threadlike stalk, which the female wraps around the blades of seagrasses or seaweeds (Pearse et al. 1987).

Embryonic development is considered "direct," that is, there is no trochophore or larval phase. However, newly-hatched cephalopods may remain planktonic for a time. In the octopods, those species in which hatchlings are less-developed may first go through a planktonic phase and then settle down to a benthic existence, while those species in which the newly-hatched offspring are well-developed may immediately take up a benthic lifestyle (Pearse et al. 1987). The degree of development at hatching may be related to the size of the egg, since Young and Harman (1989) noted that species with small eggs include a paralarval (planktonic) phase, while those with larger eggs, do not.

Most cephalopods are relatively short-lived (typically one- to two-year lifespan), dying after a single spawning, while certain members such as *Nautilus*, may live longer (up to twenty years; Barnes 1987).

Habitat and Ecological Requirements for Various Life History Stages

Substrate and Depth Preferences

Nautilus occur in waters down to 500 m depth, but generally occur at depths from 200-300m. The few observations made of nautiluses in the ocean suggest that they spend the day resting in coral crevices on deep reefs, attached by their tentacles, and swim out at night to feed (Pearse et al. 1987). They may rise to within 60-100m during nighttime (B. Carlson, Waikiki Aquarium, pers. comm., 27 Aug 99).

Cuttlefishes are generally found in shallow waters of seagrass beds and nearby reefs. Some species may bury themselves in the sand during the day, and emerge at night to hunt for the small fishes and crustaceans that are their preferred prey.

Octopods generally inhabit crevices in rocks or coral areas. In sandy areas, they may dig burrows or construct shelters built from scattered rocks.

Substrates utilized for the deposition of eggs may vary for different taxa, but it appears that there is some correlation with the habitats utilized for shelter by the species in question. Thus octopods may attach egg clusters within rocky recesses on the reef, while cuttlefish may attach their eggs to seaweeds or seagrasses.

The reef squid, *Sepioteuthis lessoniana*, uses corals and rocks of reef areas for egg-laying, and swims over the reef in shallow areas to feed. The reef cuttlefish, *Sepia latimanus,* deposits its eggs deep among the branches of heads of finger coral (B. Carlson, pers. comm. 27 Aug 99).

Feeding

Within the cephalopod group are found a range of feeding habits and food preferences. Free-swimming squids typically hunt for fish, crustaceans, and other squids in open water. Cuttlefish swim near the bottom in shallow water, stir up sand with jets from their siphons, and feed on benthic and infaunal invertebrates, including crustaceans such as shrimps and crabs. Octopods venture out of their dens in search of food, and may swim and crawl more than 100m from their holes. Octopods often hunt by jumping to ambush their prey, which include principally crabs and shrimps. In Hawaii, one of the most common species, *Octopus cyanea*, forages during the day (hence the name "day squid"), while another *O. ornatus* (the "night squid"), forages after dark (Kay 1979). Squid bite and tear prey organisms with their jaws; cuttlefish first immobilize prey by injecting salivary toxins, and then chew their prey; while octopods, which also first paralyze their prey with salivary toxins, release enzymes that start to digest the tissue of the target prey prior to ingestion. It is thought that nautiluses scavenge on such food items as crab and lobster molts; it is not known whether they also prey on live organisms (B. Carlson, pers. comm. 27 Aug 99).

Economic Importance and Utilization of the Resource

Within the region, cephalopods, especially squid, cuttlefish, and octopus, have some economic importance as food items in the subsistence fishery. Octopus are a component of the incidental catch of the lobster-trap fishery in the Northwest Hawaiian Islands (NWHI; WPRFMC 25 May 99). In addition, shells of *Nautilus* may be used for ornamental purposes on a small scale, either by utilizing the whole or cut shell, or processing for production of mother-of-pearl. The meat is also occasionally sold in markets (Roper et al. 1984). The internal shells (cuttlebones) of sepioids may also have limited commercial value for use in the pet supply industry.

Occurrence of the Taxon Within WPRFMC Fishery Management Units (FMUs)

The following is an account of those cephalopod species reported in the literature that may occur on reef areas within the jurisdictional waters of WPRFMC.

American Samoa

On Tutuila Island, it was reported that octopus accounted for approximately five percent of the catch composition for the shoreline subsistence fishery (Craig et al. 1993).

Nautilus pompilius is known to occur in American Samoa. This may represent the easternmost extension of its range (B. Carlson, pers. comm. 27 Aug 99).

Commonwealth of Northern Mariana Islands (CNMI)

Octopus (*Octopus cyanea* and *O. ornatus*), squid (*Sepioteuthis lessoniana*), and cuttlefish (*Sepia latimanus*) are reef-associated species[1] commonly taken as food in the Marianas (Myers 1997 in Green October 1997). *Octopus cyanea* was identified as a species found on the reef slope at Rota, and targeted for capture in the local fishery (Smith et al 1989).

Guam

It is reported that on Guam, the octopus is the most sought-after unshelled mollusk, while squid and cuttlefish form a part of the incidental catch of the inshore fisheries (Hensley and Sherwood 1993). Octopus and squid are reported to contribute to the importance of mollusks as a food source (Amesbury et al. 1986 in Green October 1997). *Sepia latimanus* is reported from Guam (B. Carlson, pers. comm. 27 Aug 99). Presumably, other cephalopod species reported in the Northern Marianas (i.e., *Octopus cyanea, O. ornatus*, *Sepioteuthis lessoniana*) would be expected to occur in Guam, as well.

Hawaii (MHI and NWHI)

The following octopod species are known from Hawaiian waters: *Octopus cyanea, O. ornatus, Berrya hoylei* and *Scaeurgus patagiatus*. An additional three unnamed species

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[1] The octopods are well-known reef-dwellers. The common names for *Sepioteuthis lessoniana* and *Sepia latimanus*, bigfin reef squid and reef cuttlefish, respectively, reflect their assocation with reef areas (Allen and Steene 1996).

are believed present (Young and Harman 1989). Octopus are a component of the incidental catch of the lobster-trap fishery in the Northwest Hawaiian Islands (WPRFMC 25 May 99). An unnamed species of octopus is known from Waianae, Oahu. It occupies burrows in sandy areas. The burrows have openings about the diameter of a thumb. It is not known whether the octopus digs the burrow, or simply occupies a burrow already dug by another animal (e.g., mantis shrimp). This octopus emerges from its burrow and mimics a flatfish (B. Carlson, pers. comm. 27 Aug 99).

While more than a dozen species of squids and cuttlefishes are recorded from Hawaiian waters (Matsumoto and Suzuki October 1988), most of these are pelagic. *Euprymna scolopes*, an endemic cuttlefish, is typically associated with a benthic existence in shallow-water areas. The species is common in the sand and mud flats of Kaneohe Bay, where it forages to feed on shrimp (*Leander debilis*) at depths of less than 0.5m (Kay 1979).

In Hawaii, *Sepioteuthis lessoniana,* the bigfin reef squid, was previously common, but may now be nearly extirpated. It had been known from Waianae, Oahu. A recent sighting of the species was made on Molokini Island, Maui (B. Carlson, pers. comm. 27 Aug 99).

Other Sites

No reports.

Management Unit Species: **Tunicates**

General Description of the Taxon

The tunicates, or sea squirts, are an unusual group of sessile marine organisms within the Phylum Chordata. While vertebrates make up the most conspicuous and well-known species in the phylum, species in two subphyla, the Urochordata and Cephalochordata, lack backbones. Nonetheless, they possess the three traits diagnostic for chordates--presence of a notochord, a dorsal hollow nerve cord, and pharyngeal clefts at some point in the life cycle. The Urochordata, which comprise the tunicates, are further divided into three classes, the Ascidiacea, the Larvacea, and the Thaliacea, the latter two being specialized planktonic forms (Abbott et al. 1977). The discussion in this section therefore refers to members of the Class Ascidiacea.

The ascidians are common marine invertebrates worldwide. Most inhabit shallow waters, where they attach to rocks, shells, pilings, or ship bottoms, or grow epizoically on other sessile organisms. Some forms anchor in sand or mud, though the species inhabiting sediments occur more generally in deeper waters.

The tunicate animal is sheathed in an outer covering, the tunic, that is distinctive for the group. The tunic in most cases contains cellulose, a rare instance of the substance being produced by an animal. Calcareous spicules may also be present. The consistency of the tunic varies from soft and gelatinous to fleshy, tough, leathery, cartilaginous, or fibrous. Tunicates are attached to the substrate at their proximal end, and have two openings at the opposite pole, the buccal and atrial siphons. The organisms filter plankton by drawing water into a pharyngeal "basket" through the buccal siphon (ICLARM 1998). The pharyngeal basket is the most prominent internal organ in most tunicates. Rows of perforations in the basket, the stigmata, are fringed with beating cilia that circulate water through the basket, with plankton filtered out in the process. A single tunicate a few centimeters long can filter about 173 liters of seawater in a 24-hour period (Barnes 1987). The filtered water is ultimately discharged through the atrial siphon. In addition to obtaining nutrition through filter-feeding, some tunicates possess within their tissues (in the tunic or cloacal region) endosymbiotic algae of the genus *Prochloron.* In certain ascidians, another algal endosymbiont, *Synechocystis,* occurs. This alga imparts a pink or red color to the appearance of the tunicate Monniot et al. 1991). Presumably, excess photosynthate produced by *Prochloron* or *Synechocystis* cells provides an accessory food source for the tunicate host.

While some of the largest species are solitary (or simple) ascidians, many are colonial. Colonies may be organized along several different lines. In the simplest colonies (e.g., *Perophora*), the bodies of individual zooids are almost completely separated but are connected by a stolon. In other types, the stolons are short, and the individuals form tuftlike groups (e.g., *Clavelina*). In the most specialized colonial types (e.g., *Botryllus*), individual animals are minute, and completely embedded in a common tunic. The buccal siphons of each zooid open separately to the environment. The atrial siphons may also, but in many cases the apertures of the atrial siphons open into a common cloacal chamber, which has one large opening in the middle of the colony (Barnes 1987; Abbott et al. 1977).

Reproduction and Life History

Patterns of sexual reproduction vary from one family to another, and sometimes from one genus to another, within the class. For the most part, solitary and colonial ascidians are simultaneous hermaphrodites (Abbott et al. 1977). The degree to which self-fertilization occurs is not well known. Typically, solitary ascidians release both eggs and sperm into open water, where fertilization occurs. The embryo develops into a non-feeding, swimming larva, or "tadpole." It is in the tadpole phase (which superficially resemble a typical frog tadpole) that the notochord and dorsal nerve cord, which characterize these organisms as chordates, are present. However, these features are lost during metamorphosis, and are absent in the adult phase. Colonial forms are ovoviviparous: sperm are shed to the sea, but not eggs. Fertilization in these types occurs within the oviduct or peribranchial cavity of the female parent, and the tadpole larvae emerge swimming, following development inside the parent body (Monniot et al. 1991). The larvae are completely encased in a tunic, and the buccal and atrial siphons are not functional. Thus the larvae are unable to feed; their prime function is to quickly find a suitable substrate to settle on. Therefore, tadpole larvae may only swim for a few minutes to a few days (Pearse et al. 1987). Following settlement, metamorphosis to the adult phase generally entails resorption of the tail and other larval structures, 180-degree rotation of the body to its adult posture, opening of the siphons, development of the brancial sac, and formation of the adult nervous system (Monniot et al. 1991).

In addition to sexual reproduction, the tunicates can reproduce asexually by budding. Budding individuals, or blastozooids, originate in different parts of the ascidian body, depending on the species. Individuals produced by primary buds are eventually freed from the parent colony (Barnes 1987). In addition to budding, colonial forms may undergo continuous divisions into smaller units termed cormomeres. The division entails rapid and dynamic movement of the colonies over the substrate. In addition to accomplishing the actual physical separation of the colony fragments, it is thought that this form of division may serve some other purposes as well, including maximizing periphery to area (which may improve efficiency of feeding or growth), excluding competitors by the dynamic movement involved; and mingling clones to facilitate cross-fertilzation (Ryland et al., 1984).

Typically, tunicates may live for 1-3 years, but some colonies may have a somewhat longer life span (Barnes 1987).

Habitat and Ecological Factors

Finding a stable substrate is critical for the survival of settling tunicates. Thus, inert surfaces of rocks, corals or pilings may be preferable to the less durable surfaces of seaweeds, mangrove roots, or other sessile invertebrates (soft corals, sponges, other tunicates), though all of these may provide surfaces for tunicates to grow on. Many tunicates (especially the more delicate soft-bodied forms) also show a marked preference for growth in protected pockets or crevices, as opposed to exposed areas of the reef crest or face, where they would be subject to extreme variations in water movement, and possibly, greater predation by grazing animals. When they do occur in such places, tunicates are often covered by epibionts that may afford some camouflage and physical protection (Monniot et al. 1991).

Light and color of the substrate may be physical cues that influence larval settling, with darker, less illuminated surfaces being the preferred substrates. However, some forms, especially didemnids containing the endosymbiotic alga, *Prochloron,* can grow as high up as the intertidal zone, where light is most intense (Ryland et al. 1984). In addition, it is believed that certain chemicals may trigger initiation of various processes, including spawning, metamorphosis, larval attraction, and repulsion of predators or epibionts. For example, chemicals exuded by parent zooids may cause larvae to settle nearby, increasing the likelihood that larvae will find a suitable settlement substrate (Monniot et al. 1991).

As filter-feeders, tunicates are dependent upon the availability of adequate suspended food particles in the water column. Tunicate growth on outer reef slopes may be relatively more limited than within enclosed bays or lagoons, since phytoplankton may be less abundant there. Ovoviviparous colonial types are better suited to growth on outer slopes than are solitary forms, since larvae are protected during development and the free-swimming stage is very brief. By contrast, within lagoons, both solitary and colonial types are fairly abundant. Solitary forms seem to dominate in colonizing newly-available surfaces in disturbed areas (for example, in harbors), but typically species diversity in such settings is low (Monniot et al. 1991). Dominance of the solitary forms may be due to the fact that their larvae are released in greater numbers, and spend a longer time in the free-swimming phase, than larvae of colonial types.

Tunicates are not selective about the types of particles that are ingested in filter-feeding, and in waters with a high sediment load, silt and other mineral particles may accumulate in the pharyngeal basket and the digestive tract. If excessive, the silt may clog the pharynx and suffocate the animal.

Economic Importance

With minor exceptions,[2] ascidians are not presently utilized for any economic purposes. However, over the last twenty years or so, considerable research efforts have been directed at isolating and identifying compounds from tunicates that may have some cytotoxic activity, and thus some future medical value. For example, didemnines extracted from *Trididemnum solidum* are effective anti-cancer agents and may also have anti-viral properties (Monniot et al. 1991). Alkaloids and peptides, derivatives of amino acids, have also been isolated from tunicates. Some of these have antimicrobial

[2] In some countries, certain larger species are consumed as a food item.

properties (Lee et al., 1997; Zhao et al., 1997). Other proteinaceous compounds derived from tunicates may play a role in mediating responses in the immune system (Pancer et al., 1997; Pancer et al., 1993). *Lissoclinum bistratum*, a tunicate from New Caledonia that contains within its tissues endosymbiotic *Prochloron* algae, has been the source of polyethers that have strong effects on the nervous system. It remains to be determined whether the embedded *Prochloron* algal cells, rather than the tissues of the tunicate animal itself, are the source of these compounds (Monniot et al., 1991). It is speculated that in life, tunicates may utilize cytotoxic compounds to ward off predators or repel epibionts (Muller et al., 1994).

The ascidians are important members of the community of marine fouling organisms. The solitary tunicates seem to be especially opportunistic in colonizing freshly-exposed surfaces of pilings, docks, other harbor structures, and boat hulls. Ascidians and other fouling organisms interfere with boat operations and normal function such equipment as cooling water intakes. On hulls, fouling organisms cause additional drag of vessels as they move through the water. Significant effort and money are spent in developing effective means for deterring the growth of fouling organisms, and for eliminating them from boat hulls and other structures. Recently, great concern has developed about the transoceanic transport of tunicate species to areas where they are not indigenous, typically by attachment to boat hulls or being carried in bilge water. Introduction of exotic species transported in this manner can be disruptive of the balance of species in natural communities.[3] Among the Hawaiian species discussed by Abbott (1977), many are potential fouling organisms, with *Polyclinum constellatum, Diplosoma listerianum, Ciona intestinalis, Corella minuta, Ascidia sydneiensis Phallusia nigra, Symplegma oceania, Polyandrocarpa zorritensis, Styela canopus, Herdmania momus* being the most prevalent.

While ascidians typically will settle only on dead parts of coral, once established they may overgrow and smother adjacent living coral tissue (Monniot et al. 1991). The encrusting colonial tunicate, *Diplosoma similis,* has an extremely wide range in the tropical Western Pacific, and is known to overgrow large areas of living *Acropora* coral and the coralline alga, *Hydrolithon* (Littler and Littler 1995). This can cause indirect economic consequences, since such overgrowth of living coral areas can reduce the productivity of the reef, reducing the potential for fisheries.

Occurrence of the Taxon Within WPRFMC Fishery Management Units (FMUs)

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[3] Biological Resources Division, US Geological Service, Nonindigenous Tunicate Information Website.

Little information is available on occurrence of ascidians in the Pacific Islands. Data from the few citations located are presented here.

American Samoa

No reports.

Commonwealth of Northern Mariana Islands (CNMI)

Abbott et al. (1977) mention that *Polyclinum vasculosum*, has been reported widely in the Pacific, including from the Marianas.

Guam

The ascidian fauna of Guam is not well-known. As the result of some recent surveys, work is in progress to more accurately assess and describe the fauna (pers. comm. Gretchen Lambert, California State University, Fullerton 19 Aug 99).

Hawaii (MHI and NWHI)

Eldredge and Miller (1995) report a total of 45 species from Hawaii, but give no firm indications about how many might be endemic or introduced species. Abbott et al. (1977) report species from Hawaii in the following families: Polyclinidae (4 species); Polycitoridae (4); Didemnidae (11); Cionidae (1); Perophoridae (4); Corellidae (1); Ascidiidae (6); Styelidae (10); Pyuridae (3). All the growth forms discussed above are represented, and these taxa occupy a corresponding range of substrates. *Diplosoma similis,* the species that overgrows live reefs, is among the tunicates reported from Hawaii.

Other Sites

No reports.

Management Unit Species: **Bryozoans**

General Description of the Taxon

The Phylum Bryozoa is a taxonomically problematic group. While authorities have variously regarded them as including (Ehrenberg [1831]) or excluding (Hyman [1959]) the Entoprocta (a group of sessile organisms that superficially resemble hydroids), the Bryozoa as considered here refer only to the Ectoprocta. This group is comprised of colonial, sessile animals, with the vast majority occurring in marine environments. They have formed an important component of the fossil record since the Ordovician period. Though widespread on tropical reefs, bryozoans are often not recognized because they occur in mixed associations with algae, hydroids, sponges, and tunicates, especially on older portions of coral reefs (Soule et al. 1987).

The Bryozoa comprise the largest of four phyla of invertebrates that possess a lophophore. The lophophore is a fold of the body wall that encircles the mouth and bears numerous ciliated tentacles. Through the movement of the cilia, a water current is generated that drives plankton into the mouth of the bryozoan animal. The individual animals of the colony, or zooids, have a large coelom and a "U"-shaped digestive tract, with the anus opening to the outside of the lophophore tentacle circle (hence, "Ectoprocta"). Organs for gas exchange, circulation, and excretion are absent, probably owing mostly to the small size of the animals, which would allow for direct exchange of nutrients and wastes.

The phylum is divided into three classes, with Class Gymnolaemata containing most of the living marine species. Other marine types are contained within the order Cyclostomata in Class Stenolaemata (Ryland 1970). While some Bryozoa occur at great depths, the majority are found in shallower coastal waters, where they grow attached to rocks, corals, shells, other animals, wood (e.g., mangrove roots), or algae. Growth habit may be stoloniferous, foliose, branching, or encrusting. Large colonies may consist of more than two million individual zooids, and may reach up to 24 cm in height for erect species, and up to 50 cm diameter for encrusting forms (Barnes 1987). While various species are recognized on a gross level by their growth habit, to some degree, growth form is mediated by environmental conditions, so that within any given taxon, a range of variation in the form of the colony may occur (Soule et al. 1987).

The Gymnolaemata are divided into two distinct orders. The Ctenostomata, or ctenostomes, contain stoloniferous or compact colonies in which the exoskeleton is membranous, chitinous, or gelatinous. Usually, the terminal aperture of the zooid is open (i.e., lacks an operculum). In contrast, the Cheilostomata, or cheilostomes, have boxlike calcareous walls. A hinged, moveable operculum covers the aperture of the zooid in most cheilostome species. The operculum opens when the lophophore is extended for feeding, and shuts when the animal withdraws into the calcareous chamber of the zooecium (the colonial skeleton). Specially modified zooids are the avicularia, with movable jaw-like parts that serve to repel predators, and vibracula, with setae or bristles that are used to prevent accumulations of silt. The marine Stenolaemata, the cyclostomes, are considered more primitive in organization than the Gymnolaemata (Ryland 1970). In the cyclostomes, the zooids are tubular and calcified, and the orifice is distally or anteriorly located, without an operculum (Barnes 1987).

Reproduction and Life History

The reproductive process in the Gymnolaemata is representative for the majority of marine species. Most marine bryozoans are hermaphroditic. However, the details of this arrangement may vary, with individual bryozoans being sequentially or simultaneously hermaphroditic, or unisexual. In some cases, permanently unisexual colonies may form (Soule et al. 1987). Sperm are shed through terminal pores of two or more tentacles of the lophophore, and released into seawater. Sperm are captured in the currents generated by the action of the lophophores of other nearby zooids. Fertilization between zooids of the same colony is probably common, but sufficient cross-fertilization likely occurs between colonies to assure outbreeding. In certain non-brooding species, fertilized eggs are shed directly into the seawater. Eggs of other species may be brooded in the coelomic cavity, or outside it. One specialized structure for brooding is a hood-like outgrowth of the body wall and coelom called the ovicell. In many species, the developing embryo receives its nutrition from a contained yolk, but in others, placenta-like connections to the ovicell from the mother zooid may provide food material.

For the Cyclostomata, specialized individuals, the gonozooids, may be modified for reproduction, or the colony may form a centralized chamber as a brooding structure (Soule 1987).

Bilateral cleavage leads to the development of a larva that has a locomotory ciliated girdle, or corona, an anterior tuft of long cilia, and a posterior adhesive sac. In certain genera of non-brooding bryozoans (e.g., *Membranipora*) a specialized feeding larva, the cyphonautes larva, develops. These are the only larvae that possess a functional digestive tract, and feed during the larval stage, a phase which may last several months. In brooding species, larvae are non-feeding, and the larval phase lasts only for a brief period before settlement.

During settling, the vibratile plume, a sensory tuft of cilia, is used in selecting a suitable site for attachment. The adhesive sac is everted and attaches the larva to the selected site. After settlement, the larva undergoes a marked metamorposis to form the ancestrula, the first zooid. Subsequent zooids in the colony are formed by asexual budding. The zooids formed by budding can themselves bud in various arrangements, giving rise to the form that characterizes each species (Meglitsch and Schram 1991).

Habitat and Ecological Requirements for Various Life History Stages

Substrate Preferences and Other Physical Parameters

Rather than being a primary structural reef-builder, bryozoans generally function as "hidden encrusters" that grow on the undersides of coral heads, rock ledges, and rubble, and may also partially fill cavities deep within the reef (Cuffey 1972). In this capacity, to a limited degree, bryozoans may reinforce the structural strength and stability of the reef.

A correlation has been noted between growth form and the depth at which various types occur (Ryland 1970). Generally, encrusting forms may be associated with intertidal areas or other sites subject to strong waves. Such forms would also be more resistant to grazing by predators. Less sturdy types, including erect branching and foliose forms, are found in areas not subject to strong surge or heavy pressure from grazing predators. For example, reticulate to fenestrate reteporids are typically confined to deeper, more stable marine habitats (Dade and Honkalehto 1986).

On modern tropical reefs, encrusting cheilostomes are the most abundant and diversified bryozoans. Encrusting cheilostomes comprise from 50 to 70 percent of the colonies observed in various reef environments in Kaneohe Bay (Dade and Honkalehto 1986). It appears that in depths below 5 to 7 m, bryozoans become more abundant and more diverse than in shallower areas (Cuffey 1972). In surveys conducted to depths of approximately 20 m in Kaneohe Bay (Dade and Honkalehto 1986), a similar trend was observed toward conditions that appear to favor more abundant and diverse growth in deeper water. Among the possible contributing factors cited were environmental stability (e.g., less water movement, fewer grazers); availability of substrate (as competition with corals and encrusting algae decreases); and decrease in ambient light.

It is known that bryozoan larvae actively search for suitable substrates for settlement. It has been observed that bryozoan larvae are able to persist in the plankton for many days longer than expected when conditions are not favorable for settling (Soule et al. 1987). Different species settle variously on rocks, shells, corals, or algae. The length of time over which larvae settle for a given species within a given area is thought to be dependent on a number of environmental factors, including day length and temperature. Day length may be both a direct influencing factor, and an indirect influence, since phytoplankton, presumed to be the preferred food source for many bryozoans, would be available in larger quantities during days with longer daylight hours. In Hawaii, larvae of *Bugula neritina* settled almost year-round (March to December). This also may indicate that *B. neritina* has an extended spawning season in Hawaii (Ryland 1970).

In many species, larvae first exhibit a positive phototropic reaction, but then become negatively phototropic before metamorphosis, eventually settling in dark places on the reef, such as the undersides of stones or flat coral plates (Soule et al. 1987). Generally, high light intensity environments do not support the growth of bryozoans (Soule et al. 1987). Empirical observation suggests that heavily-silted environments generally deter successful settlement; few bryozoans are found growing in areas where rapid deposition of fine sediments occurs, or where water is frequently muddy or turbid (Soule et al. 1987).

Strong correlations were observed between various growth form groups and their position on the reef. So-called lagoon reef areas (fringing and patch reefs, 1-8m depth) were dominated by encrusting cheilostomes (*Celleporaria vagens*, *Rynchozoon* sp., *Coscinopsis fusca, Cleidochasma* sp.) and mat-like, tuft-like, and disk-like cheilostomes, as well as lichenoporid and tubuliporid cyclostomes. The barrier reef coral-algal flat breaker zone (1-2.5m depth) portion of the study site was dominated by the encrusting cheilostomes, *Thallamoporella stapifera* and *Rhynchozoon* sp. The ocean slope bench (15-20m depth) provided habitat for a wider variety of species, including encrusting cheilostomes (especially *Steginoporella magnilabris, Parasmittina parsevaliformis,* and *Schizoporella decorata*), as well as an assortment of reteporid cheilostomes, tuft-like cheilostomes, and lichenoporid and tubuliporid cyclostomes.

Idmidronea, a genus of highly-branched cyclostomatous bryozoans, is reported to occur on the surface of living corals and sponges in Hawaii (Gossliner et al. 1996).

Reteporellina and *Reteporella* sp. occur in areas with fairly strong currents at 10-20m depth (Gossliner et al. 1996).

Another interesting occurrence is the association of bryozoans with black corals (*Antipathes dichotoma*) growing at around 50m depth in the Auau Channel off Maui. About thirty species were found attached to the bases of the corals, and to mollusks attached to the lower coral branches. *Haloporella vaganas* and *Reteporellina denticulata* were the most common members of these assemblages (Soule et al. 1986).

In another study, encrusting and erect cheilostome bryozoans were found to grow on an artificial reef positioned in 20m of water in Kaneohe Bay, Oahu. Bryozoans grew rapidly on introduced substrates after two months. Two encrusting species, *Celloporaria vagans* and *Thalamoporella* spp., competed vigorously for space on an artificial substrate (Bailey-Brock 1987). In a similar manner, fouling organisms also appear to opportunistically colonize available surfaces. Thirteen species[4] were found to occur

[4] *Aetea recta, Bowerbankia gracilis, B. imbricata, Bugula stolonifera, B. neritina, Hippopodina feegeensis, Savignyella lafonti, Schizoporella unicornis, Zoobotryon verticillatum, Scrupocellaria*

regularly on harbor and bay structures and boat hulls around Oahu (Soule et al. 1987).

Feeding

Bryozoans are suspension-feeders that capture plankton from the water. Gut contents show the presence of diatoms, detritus, bacteria, silicoflagellates, peridinians, coccolithophores, algal cysts, and flagellates. Unicellular algal cultures (*Dunaliella tertiolecta* and *Gymnodinium simplex)* have been used to successfully rear bryozoans in the laboratory (Soule et al. 1987).

While not an obvious food source for other animals, bryozoans are utilized by a variety of grazers, including echinoids, labrid fishes, and nudibranchs (Soule et al. 1987).

Economic Significance

Despite their widespread occurrence, bryozoans are generally not directly utilized for any applied purposes. However, they are being thoroughly investigated for the presence of biochemically active compounds that may ultimately prove useful for treatment of disease. Bryostatin 1, a compound isolated from a common marine bryozoan, is currently being tested as an anti-cancer drug.[5] Bryozoans are recognized for producing a range of other compounds, particularly alkaloids, that may ultimately be shown to have pharmaceutical applications (Van Alstyne and Paul 1988).

Many bryozoan species also have economic importance because of their action as fouling organisms. Bryozoa, along with other common sessile invertebrates and algae, attach to boat hulls, making their movement in the water less efficient. Among the common bryozoan fouling species in warm-water areas are *Bugula neritina, Schizoporella errata, Watersipora subovoidea,* and *Zoobotryon verticillatum* (Ryland 1970). These and other species can also clog industrial water intakes and conduits. Significant effort and money are spent in developing effective means for deterring the growth of fouling organisms, and for eliminating them from boat hulls and other structures. The growth of fouling organisms, besides being of economic significance, also has ecological implications--species growing on ship hulls are readily transported great distances beyond their natural range, and may be introduced into new areas, thus having an impact on the natural balance of species in established ecosystems.

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sinuosa, Cryptosula pallasiana, Tryptostega venusta, and *Watersipora edmondsoni.*

[5] U. of California, Berkeley: Bryozoan Internet website.

Occurrence of the Taxon Within WPRFMC Fishery Management Units (FMUs)

American Samoa

No reports.

Commonwealth of Northern Mariana Islands (CNMI)

No reports.

Guam

No reports.

Hawaii (MHI and NWHI)

Surveys in Kaneohe Bay (Dade and Honkalehto 1986) yielded a total of 57 species of ectoproct bryozoans, including 45 cheilostomes, 13 cyclostomes, and 1 ctenostome. Many of these are cosmopolitan, capable of being dispersed over great distances, often by rafting on algae, logs, or artificial substrates. However, owing to the isolation of the archipelago, significant speciation has occurred, with the result that of the species recorded in Kaneohe Bay, 23 percent were believed to be endemic to Hawaii. It is estimated that over 150 species of bryozoans occur in Hawaii, however the total number of endemic species for Hawaii is not known (Eldredge and Miller 1985).

Other Sites

With the exception of Hawaii, little published information is available for the other U.S. Pacific Islands. Because the shallow sublittoral bryozoan fauna for the Indo-Pacific is not well known, it is difficult at present to establish with any certainty the degree of endemism of specific taxa within any given island or archipelago (Soule et al. 1987).

Management Unit Species: **Crustaceans**

Introduction

The arthropod subphylum Crustacea is one of the most diverse and widespread groups of invertebrates. Within the subphylum, the Class Malacostraca contains such familiar types as mantis shrimps, lobsters, crabs, and shrimp, as well as less conspicuous, but ecologically important organisms, the isopods and amphipods.

Crustaceans cannot grow as many other animals do, because the hard exoskeleton does not stretch. Therefore, they periodically shed the outer skeleton, grow rapidly for a period of time, then re-grow a new exoskelteton. The molting process involves many complex physiological changes, including reduction of the lime content in the exoskeleton to weaken it prior to molting; rapid absorption of water after molting to expand the body size; and redeposition of lime to again strengthen the exoskeleton (Tinker 1965). During molting, the animal is in a weakened and vulnerable condition, and must seek shelter to avoid being preyed upon by other animals. Thus the molting process strongly influences the habitat requirements of these animals.

The malacostracan body is typically composed of 14 segments, plus the telson, with the first 8 segments forming the thorax and the last 6, the abdomen. The thorax may or may not be covered by a carapace. All segments bear appendages, with the first antennae usually being biramous, the exopodite (outer branch) of the second antennae often in the form of a flattened scale, and the mandibles usually bearing palps. In the primitive condition, the thoracic appendages are similar, with the endopodite (inner branch) being more developed for use in crawling or grasping. In most species, the first one, two, or three pairs of thoracic legs have been turned forward and modified to form maxillipeds. The anterior abdominal legs are similar, and are called pleopods. They are used for swimming, burrowing, ventilating, gas exchange, and carrying eggs in females. In males, the first one or two pleopods are modified to form copulatory organs. The sixth abdominal appendages, or uropods, are flattened, and together with the telson, form a tail fan used in escape swimming.

The present discussion is confined to those larger forms that are of concern from a management standpoint. These belong to the order Stomatopoda (mantis shrimps), and order Decapoda (shrimps, lobsters, and crabs). As part of Amendment 10 to the *Crustacean Fisheries Management Plan,* (WPRFMC September 1998) background information has been presented, and EFH has already been defined, for certain economically-important decapod taxa (i.e., spiny lobsters, *Panulirus marginatus* and *P. penicillatus*, and kona crab, *Ranina ranina*). The present discussion will provide further information on other decapod taxa, and summarize the information contained in Amendment 10 on lobsters and Kona crab.

Stomatopoda (Mantis Shrimps)

Description

Several hundred marine species constitute the order Stomatopoda, the mantis shrimps. These organisms live in rock or coral crevices or in burrows excavated in sand. They are dorsoventrally flattened with a small, shield-like carapace and a large segmented abdomen that widens toward the posterior end. Characteristic of the group is the possession of a highly developed, powerful pair of second-segment raptorial appendages that are used either for spearing or smashing prey.

Reproduction and Life History

In stomatopods, as many as 50,000 eggs (e.g., genus *Squilla*) are joined together by an adhesive secretion to form a globular mass. The mass is held by the female in small subchelate appendages and constantly turned and cleaned. The female does not feed while brooding. Depending on the species, the egg mass may be left in the burrow, or the female may carry the egg mass with the thoracic legs (Meglitsch and Schram 1991). The eggs hatch into zoea larvae that have carapaces that are much larger than in the adult, relative to total body size. The larvae may appear in very large numbers in the plankton community in tropical waters. Two types of larvae are recognized, an erichthus and an alima. The larvae pass through a prolonged phase during which the last three thoracic somites have no appendages, a feature also observed in zoea larvae of decapods (Meglitsch and Schram 1991). The planktonic larval phase lasts for up to three months (Barnes 1987).

Habitat and Ecological Requirements for Various Life History Stages

Most stomatopods live in pockets or crevices on the reef, or in burrows in sand. They may dig their own burrows or occupy burrows excavated by other animals. A variety of mechanisms are used to close the burrow entrance for protection; the animal may plug the hole with its telson, or gather shells and other debris to close the entrance at night, and block it during the day with the raptorial appendages.

Mantis shrimps may leave the burrows to feed, either crawling or swimming over the bottom. Some types ("spearers," e.g., *Lysiosquilla maculata*) are equipped with raptorial appendages that have sharp barbs that pierce soft-bodied prey animals, such as shrimps or fishes. In others ("smashers" such as *Gonodactylus* spp.) the raptorial appendages have a sharp, heavy heel that can crack the shells of crabs, snails, and clams.

Economic Importance

Mantis shrimps are part of the incidental catch of subsistence fisheries, and may be captured in crab nets that are placed near their burrows (Tinker 1965). Their use as a food source is generally limited. Some species, especially brightly-colored ones (e.g., *Gonodactylus* sp.), may have some minor value in the aquarium trade (?-confirm). Limited use is made of the ivory-like raptorial appendages of some species in the small-scale manufacture of jewelry (Tinker 1965).

Occurrence of the Taxon Within WPRFMC Fishery Management Units

American Samoa

No reports.

Commonwealth of Northern Mariana Islands (CNMI)

Two stomatopods found in the Northern Marianas, *Mesacturus dicrurus* and *Gonodactylus* sp., were reported by Hamano (1994). Both species, in the Gonodactylidae, occur in rocky intertidal areas.

Guam

Lysiosquilla spp. (Green October 1997) and *Mesacturus dicrurus* (Gonodactylidae; Hamano 1994) are known from Guam. *Mesacturus dicrurus* is associated with rocky intertidal environments (Hamano 1994).

Gossliner et al. (1996) report on the following species:

Gonodactylellus affinis (Stomatopodidae), a species that is highly polymorphic in color, occurs here, usually below 20m depth. By contrast, *Gonodactylus chiragra* is an inhabitant of shallow intertidal reef flats and rocky outcrops, and forages in low tide in a few centimeters of water. *Gonodactylaceus mutatus* occurs on reef flats to 5m depth, and also forages at extreme low tide. *Mesacturoides spinosocarinatus* may be found at depths ranging from 5 to 50 m. The animals stay close to their burrows, but dart about nearby. *Pseudosquilla ciliata* burrows in sand and gravel on reefs and sand flats, to 30m depth.

Hawaii (MHI and NWHI)

Eldredge and Miller (1995) list a total of approximately 17 stomatopods from Hawaii. Of these, 11 are considered endemic.

Lysiosquilla maculata and *Squilla (Oratosquilla) oratoria* are reported to occur in Hawaii. Both are found in mud-bottom areas suitable for burrows (Tinker 1965).

Gossliner et al. (1996) report the occurrence of the following Hawaiian species:

Odontodactylus brevirostris is found in burrows of small rubble pieces at 10-50m depth. *O. scyallarus* is a night-feeding carnivore that preys on crustaceans, worms, mollusks, fish. It is found on sand and rubble bottoms to 70m. *Oratosquilla oratoria,* another nocturnal species, is reported in muddy estuaries and on reefs, in U-shaped burrows up to 1m long. *Pseudosquilla ciliata* burrows in sand and gravel on reefs and sand flats, and is found to 30m depth.

Other Sites

A single specimen of *Pseudosquilla ciliata* was encountered at Palmyra Island (Edmondson 1923).

Decapoda: Shrimps, Lobsters, and Crabs

Introduction

With approximately 10,000 species, decapods represent about one fourth of all known crustaceans (Barnes 1987). They are among the most diverse and successful crustacean groups, having exploited virtually all available niches in the marine habitat, as well as having developed specialized strategies for nutrition and reproduction.

The generalized decapod life cycle is characterized by the nauplius and protozoea stages being passed inside the egg. However, some primitive forms (e.g., penaeids) pass the earlier developmental stages outside of the egg. Transition from protozoea to the next stage (zoea) involves the addition of thoracic limbs and dependence on the thoracic appendages for locomotion. The carapace fuses to the thorax, and pleopods and stalked eyes appear. The zoea is typically the stage at which the larva emerges from the egg. From the zoea phase, further transformations occur, making the postlarval or juvenile phase more closely resemble the adult (Meglitsch and Schram 1991).

In the adult phase, decapods are distinguished by having the first three pairs of thoracic appendages modified into maxillipeds. The remaining five pairs are the legs. The first or second pair of legs may be chelipeds (pincer-like claws) that are used for seizing prey or for defense (Barnes 1987).

Decapods exhibit a wide range of feeding behaviors, but most combine predation with scavenging, with large invertebrates being typical prey items (Barnes 1987). Others may be detritus or filter feeders. The form of the body, especially the appendages, is often modified for more effective functioning in acquiring food. Thus, box crabs such as *Calappa calappa* have powerful chelae used to crush mollusks; sand-burrowing mole crabs (e.g., *Emerita pacifica*) use long fringed antennae to filter plankton and detritus; and banded coral shrimp (*Stenopus hispidus*) use thin pincers to delicately pick ectoparasites from the scales of fishes' bodies (Gossliner et al. 1996).

Shrimps: Infraorders Penaeidea, Stenopodidea, Caridea

General Description and Morpohology

The shrimps are found in several different decapod infraorders, and this taxonomic disunity reflects the wide range of forms and lifestyles that are represented in this large but artificial grouping. The penaeids are considered the most primitive decapods, while other types, such as the alpheids and palaemonids, represent more advanced forms. The features that generally characterize shrimps are bodies that are laterally compressed or more or less cylindrical, with well-developed abdomens, and a cephalothorax that often has a keel-shaped, serrated rostrum. Legs are usually slender, and chelipeds may be present or absent. The exoskeleton is usually relatively thin and flexible (Barnes 1987).

Reproduction and Life History

In most shrimps, copulation takes place with the adults pair oriented at right angles to each other. The male uses the modified first and second pair of pleopods to transfer a spermatophore to a median receptacle between the thoracic legs of the female. The penaeids are the only decapod group in which eggs are shed directly into the water and hatch as naupliar or metanaupliar larvae. In all other decapods, females carry the eggs on the pleopods, and hatching takes place at the protozoea or zoea stage (Barnes 1987). The various larval schemes in decapods are summarized in Table A.

Habitat and Ecological Requirements for Various Life History Stages

Most shrimps are bottom-dwellers. Thoracic appendages are used for crawling, while pleopods are used for swimming, and also to fan sediments during excavation of burrows. Many penaeids construct burrows in sand or other soft-bottom material, or simply bury themselves in sediment during daytime, emerging at night to feed (Gossliner et al. 1996). Other types, such as snapping or pistol shrimp (Alpheidae), live in holes and crevices beneath rocks and coral rubble, or may construct burrows. Certain alpheids are also closely associated with corals, especially in the genus *Pocillopora* (Hayashi et al. 1994; see notes in section IV.C.4.e, below) Other genera also may live inside or in close association with a variety of other living organisms, including sponges, tunicates, mollusks, corals, echinoderms, or anemones.

Many of the commensal associations between shrimps and other organisms are quite specialized. The "cleaner shrimps," an artificial grouping of species distributed among several families, play an important role in reef ecology by reducing ectoparasites on reef fishes. Through complex behavioral cues and signals, the fishes approach well-defined "cleaning stations" on the reef and allow the shrimps to climb over their bodies and even insert their chelipeds into the gill region to pick off parasites. Anemone shrimps in the genus *Periclimenes* may also clean fish, and spend most of their time living among the stinging tentacles of sea anemones. Many snapping shrimps of the family Alpheidae typically share their burrows in a close relationship with fish of the family Gobiidae, presumably to the mutual benefit of both partners.

Occurrence of the Taxon Within WPRFMC Fishery Management Units

American Samoa

No reports.

Commonwealth of Northern Mariana Islands (CNMI)

Hayashi et al (1994) surveyed the crustacean fauna on Anatahan, Sarigan, Guguan, Alamagan, Pagan, Agrihan, Asuncion, Maug (East, West and North), and Uracas. Their collections were made at depths ranging from 3-14 meters. The findings included reports of the following species of shrimps:

Stenopodidae:

Stenopus hispidus (found in the rocky subtidal zone; known from a wide geographic range where it occurs from the intertidal to depths of 210m); Rhyncocinetidae: *Rhyncocinetes* sp.; Palaemonidae: *Brachycarpus biunguiculatus, Harpiliopsis beaupresii* (on coral), *H.depressa, Ichnopontonia lophos, Jocaste japonica, Onycocaris* *quadratophthalma* (on *Pocillopora* coral), *Palaemonella spinulata*; Alpheidae: *Alpheopsis* sp., *Alpheus bidens, A.* cf. *crinitus, A. frontalis* (under boulders), *A. lottini* (in somewhat deeper water [14 m]on *Pocillopora*), *A. obesomanus, A. pacificus, A. pearcyi, Athanas areteformis* (on *Pocillopora*), *Automate dolicognatha, Metalpheus rostratipes* (on *Pocillopora*), *Racilius compressus, Syalpheus charon* (on *Pocillopora*), *S. paraneomeris* (on *Pocillopora*), *S. tumidomanus* (on *Pocillopora*); Hippolytidae: *Hippolyte edmondsoni* (on algae; known otherwise only from Oahu, Hawaii)

Guam

Several species of snapping shrimp (Alpheidae) were found in Guam. One species, *Alpheus obesomanus*, occupied extensive tunnels in *Millepora platyphylla* colonies; up to 95 percent of the colonies surveyed had shrimp tunnels. Another species, *A. idiocheles*, occupied sub-hemispherical pockets, called "galleries," in an intertidal erosion bench. Each gallery typically was inhabited by a male-female pair (Kropp 1987).

Hawaii (MHI and NWHI)

Eldredge and Miller (1995) indicate that there are approximately 200 species of marine shrimps in Hawaii; of these, 4 stenopodids are believed to be endemic. Endemism of other types has not been established with certainty.

Tinker (1965) reports the following species of interest: *Stenopus hispidus* (Stenopodidae), the banded cleaner shrimp, is or pan-tropical distribution. It is typically found in holes in the reef. The harlequin shrimp, *Hymenocera picta* (Gnathophyllidae), is found from Hawaii eastward to the Red Sea. This species, relatively uncommon in Hawaii, is occasionally found in quiet inshore waters on the reef.

Gossliner et al. (1996) report the following shrimps from Hawaii:

Stenopodidae:
Stenopus hispidus, *S. pyrosonotus* (cleaner shrimp found in crevices to 15 m depth; eggs are light blue color); Pontoniidae: *Periclimenes soror* (on sea stars), *P. imperator* (on nudibranch [*Hexabranchus*], holothurians [*Stichopus, Bohadschia, Synapta*], and sea star [*Gomophia*]), *Pontonides unciger* (mimics polyps of black coral [*Cirripathes*] on which it lives), *Stegopontonia commensalis* (on sea urchin spines); *Lysmata amboinensis* (cleaner shrimp); Hippolytidae: *Parhippolyte uveae* (in anchialine ponds), *Saron marmoratus* (nocturnal in protected lagoons); Gnathophyllidae: *Gnathophylloides mineri* (on sea urchins), *Gnathophyllum americanum* (associated with echinoderms), *Hymenocera picta* (preys on sea stars); Rhinchocinetidae:*Rhinchocinetes rugulosus.*

Hayashi et al (1994) indicate that the following species are known from Hawaii:

Palaemonidae:
Brachycarpus biunguiculatus; Alpheidae: *Alpheus pearcyi, Metalpheus rostratipes, Syalpheus paraneomeris*; Hippolytidae: *Hippolyte edmondsoni* (on algae; known only from, Oahu, Hawaii and CNMI).

Other Sites

For each of the following families of shrimps, Edmondson (1923) lists the following number of species (in parentheses) represented at Palmyra Atoll and/or Fanning Island:[6] Alpheidae (10); Hippolytidae (1); Gnathophyllidae (2); Palaemonidae (5); Stenopodidae (1); Sergestidae (1).

Lobsters, Spiny Lobsters, Slipper Lobsters: Infraorders Astacidea, Palinura

General Description and Morpohology

Lobsters are heavy-bodied decapods that generally inhabit holes and crevices of rocky and coralline bottoms. They have extended abdomens that bear a full complement of appendages, and the carapace is always longer than it is broad. The infraorder Astacidea includes large-clawed lobsters, while the Palinura include the spiny lobsters (Palinuridae), slipper lobsters (Scyllaridae), and coral lobsters (Synaxidae)(Barnes 1987; Pitcher 1993). Spiny lobsters are non-clawed, decapod crustaceans with slender walking legs of roughly equal size (Uchida 1986, FAO 1991). In spiny lobsters, the carapace is large and spiny. Two horns and antennae project forward of the eyes and the abdomen terminates in a flexible tailfan (FAO 1991). The slipper lobster, while in many respects quite similar to the spiny lobster, has its second antennae modified into broad, platelike structures (Pearse et al.1987). The body is more flattened dorsiventally than the body of spiny lobsters. Large-clawed, or true lobsters are more widespread and abundant in temperate areas, but of limited occurrence in the tropical and sub-tropical Western Pacific. They differ from palinurids in having large, heavy chelipeds.

Reproduction and Life History

The developmental history of the spiny lobster is covered at length in Amendment 10 of the *Crustacean Fisheries Management Plan,* (WPRFMC September 1998). Key points

[6] Family name nomenclature is updated.

are excerpted here.

Spiny lobsters (*Panulirus* sp.) are dioecious (Uchida 1986). Generally, the different species within the genus have the same reproductive behavior and life cycle (Pitcher 1993). The male spiny lobster deposits a spermatophore or sperm packet on the female's abdomen (WPRFMC 1983, Uchida 1986). The fertilization of the eggs occurs externally (Uchida 1986a). The female lobster scratches and breaks the mass, releasing the spermatozoa (WPRFMC 1983). Simultaneously, ova are released from the female's oviduct and are then fertilized and attached to the setae of the female's pleopods (WPRFMC 1983, Pitcher 1993). At this point the female lobster is ovigerous, or "berried" (WPRFMC 1983).

The fertilized eggs hatch into leaf-like zoea larvae (the phyllosoma larvae) after 30–40 days (MacDonald 1986, Uchida 1986), and enter a planktonic phase (WPRFMC 1983). The duration of this planktonic phase varies, depending on the species and geographic region, and may last from 6 months to 1 year from the time of hatching (WPRFMC 1983, MacDonald 1986). There are 11 dissimilar morphological stages of development that the phyllosoma larvae pass through before they transform into the postlarval puelurus phase (Johnson 1986, MacDonald 1986). The relatively long pelagic phase for palinurid larvae results in very wide dispersal; palinurid larvae are transported up to 2,000 miles by prevailing ocean currents (Johnston 1973, MacDonald 1986).

There is a lack of published data pertaining to the preferred depth distribution of phyllosoma larvae in Hawaii. However, the depth distribution of phyllosoma larvae of other species of *Panulirus* common in the Indo-Pacific region has been documented. Newly hatched larvae of the western rock lobster (*P. cygnus*) are typically found within 60 m of the surface. Later stages of the phyllosoma larvae are found at depths between 80–120 m. *P. cygnus* undergoes a diurnal vertical migration, ascending to the surface at night, descending to lower depths during the day, the authors add. Research has shown that early phyllosoma larvae display a photopositive reaction to dim light. In the Gulf of Mexico, the depth to which *Panulirus* larvae descend is restricted by the depth of the thermocline (Phillips and Sastry 1980).

The puelurus stage for spiny lobster lasts 6 months or less (WPRFMC 1983). The pueruli are free-swimming and actively return to shallow, nearshore waters in preparation for settlement (WPRFMC 1983, MacDonald 1986). MacDonald and Stimson (1980) found pueruli settlement to occur at approximately 1 cm in length.

MacDonald (1986) states that after settlement the pueruli molt and transform into post-pueruli, a transitional phase between the pelagic phyllosoma phase and the juvenile stage.

Pitcher (1993) states that the post-pueruli of *Panulirus penicillatus* have been observed inhabiting the same "high-energy reef-front habitat" as adults of the species. Yoshimura and Yamakawa (1988) conclude that small holes in rocks, boulders and algae provide important habitat for the newly settled pueruli and juvenile lobsters.

The other palinuroids (coral and slipper lobsters) also have the unique phyllasoma larval phase (Pitcher 1993). Johnston (1973) reports that the phyllosoma phase of some species of slipper lobster (genus *Scyllarides)* is somewhat shorter than that of the spiny lobster.

Habitat and Ecological Requirements

Adult spiny lobsters are typically found on rocky substrate in well-protected areas, in crevices and under rocks (Pitcher 1993, FAO 1991), down to a depth of around 110m (Brock 1973). Unlike many other species of *Panulirus*, the juveniles and adults of *P. marginatus* are not found in separate habitat apart from one another (MacDonald and Stimson 1980, Pitcher 1993, Parrish and Polovina 1994). Juvenile *P. marginatus* recruit directly to adult habitat; they do not utilize separate shallow water nursery habitat apart from the adults as do many Palinurid lobsters (MacDonald and Stimson 1980, Parrish and Polovina 1994). Juvenile and adult *P. marginatus* do utilize shelter differently from one another (MacDonald and Stimson 1980). Similarly, juvenile and adult *P. pencillatus* also share the same habitat (Pitcher 1993).

In the NWHI, *P. marginatus* is found seaward of the reefs and within the lagoons and atolls of the islands (WPRFMC 1983). Uchida (1986) reports that *P. penicillatus* rarely occur in the commercial catches of the NWHI lobster fishery. In the NWHI, *P. pencillatus* is found inhabiting shallow waters (<18 m) (Uchida and Tagami 1984).

In the NWHI, the relative proportion of slipper lobsters to spiny lobsters varies between banks; several banks produce relatively higher catch rates of slipper lobster than total spiny lobster (Uchida 1986; Clarke et al. 1987, WPRFMC 1986). The slipper lobster is taken in deeper waters than the spiny lobster (Clarke et al., 1987, WPRFMC 1986). Uchida (1986) reports that the highest catch rates for slipper lobster in the NWHI occur between the depths of 20–55 m.

Pitcher (1993) observes that, in the southwestern Pacific, spiny lobsters are typically found in association with coral reefs. Coral reefs provide shelter as well as a diverse and abundant supply of food items, he notes. Pitcher also states that in this region, *P. pencillatus* inhabits the rocky shelters in the windward surf zones of oceanic reefs, an observation also noted by Kanciruk (1980). Other species of *Panulirus* show more general patterns of habitat utilization, Pitcher continues. At night, *P. penicillatus* moves on to reef flat to forage, Pitcher continues. Spiny lobsters are nocturnal predators (FAO 1991).

P. marginatus is typically found on rocky substrate in well-protected areas such as crevices and under rocks (FAO 1991). During the day, spiny lobsters are found in dens or crevices in the company of one or more other lobsters (WPRFMC 1983). MacDonald and Stimson (1980), studying the population biology of spiny lobsters at Kure Atoll in the NWHI, found that 57% of the dens examined were inhabited by solitary lobsters. The remaining 43% were occupied by more than one lobster, with adult and juvenile lobsters of both sexes often found sharing the same dens. However, the authors note, adult and juvenile spiny lobsters exhibit distinctly different den occupancy patterns, with juveniles (less than 6 cm in carapace length) typically in multiple occupancy dens with other lobsters. Adult and juvenile spiny lobsters are not segregated by geographic area or habitat type at Kure Atoll, MacDonald and Stimson observe. They found that juvenile spiny lobsters do not utilize separate nursery habitats apart from the adult lobsters. The larval spiny lobster puerulus recruits directly to the adult habitat (Parrish and Polovina 1994). This is in contrast to the juveniles of other species of spiny lobsters that tend to reside in shallow water and migrate to deeper, offshore waters as they mature (MacDonald and Stimson 1980).

There are limited data available concerning growth rates, reproductive potentials and natural mortality rates at the various life history stages (WPRFMC 1983). The relationships between egg production, larval settlement, and stock recruitment are poorly understood (WPRFMC 1983).

Occurrence of the Taxon Within WPRFMC Fishery Management Units

American Samoa

The only species of *Panulirus* reported from American Samoa is *P. penicillatus* (Pitcher 1993).

Commonwealth of Northern Mariana Islands (CNMI)

P. penicillatus is the most common species of the genus encountered in the CNMI. *P. longipes* and *P. versicolor* are also found in significant numbers. Regulations prohibit capture of individuals less than 76 mm carapace length and of egg-bearing females (Pitcher 1993).

Guam

P. penicillatus is the most common species of spiny lobster on Guam, and is caught by islanders spearfishing at night. *P. longipes* and *P. ornatus* are also caught occasionally. Regulations are in effect that protect small (<0.45 kg) lobsters (Pitcher 1993).

Of the several hundred species of crustaceans that likely occur on Guam, lobsters of various types are among the most sought-after by local fishermen. They include spiny lobsters (*Panulirus longipes, P. ornatus, P. penicillatus,* and *P. versicolor*); a homarid; and a slipper lobster (*Scyllarus squamosus*)(Green October 1997).

Hawaii (MHI and NWHI)

Eldredge and Miller (1995) state that 13 palinurids occur in Hawaii, with 2 endemic species.

Tinker (1965) indicates that *Justitia longimanus* and *Enoplometapus occidentalis* are seldom found in Hawaii. They usually occur in depths greater than 30 m. He characterizes *Panulirus penicillatus* as an omnivorous species that eats algae and animal prey. It is nocturnal and hides during the day.

Scillarus timidus is a rare species of slipper lobster that has been found in Hawaii at a depth below 30m. *Scillarides squammosus* inhabits rocky areas of the reef. It is another nocturnal species that hides during the day ad feeds on the reef at night. This species is much prized by fishermen and divers. According to Tinker (1965), the body of *Parribacus antarcticus* is too small and flat to be of much interest as a food item.

Two species of slipper lobster, the ridgeback slipper lobster (*Scyllarides haanii*) and the Chinese slipper lobster (*Parribacus antarcticus*) are caught in low numbers incidental to the targeted fishery for *Panulirus marginatus* and *Scyllarides squamosus* in the NWHI . The traps are typically set at depths of 20-70m (Polovina 1993).

Gossliner et al. (1996) report the following lobster species from Hawaii:

Palinuridae:
Enoplometopus debelius (in caves and crevices of reef faces), *E. occidentalis* (in caves and crevices of reef faces), *Hoplometopus holthuisi* (in caves and crevices of reef faces); *Justitia longimanus* (found in caves at outer reef edge, to 35 m depth; feeds at night), *Palinurellus wieneckii* (of interest for the aquarium trade), *Panulirus marginatus* (endemic species), *P. penicillatus*; Scyllaridae: *Arctides regalis* (endemic species occurring in caves), *Parribacus antarcticus, Scyllarides haanii.*

Other Sites

Panulirus marginatus has been reported from Wake Island (pers. comm., Mark Minten), and Johnston Atoll (Brock 1973). *Parribacus antarcticus* was record at Palmyra Atoll in the 19th century (Edmondson 1923).

Crabs (True Crabs and Hermit Crabs): Infraorders Brachyura and Anomura

Description

The Brachyura, the so-called true crabs, are one of the largest and most successful groups of decapods. The body form is short and wide, and the abdomen is flexed to fit tightly beneath the cephalothorax. Uropods are generally lacking. Pleopods are retained in females for brooding of eggs, and in males only the anterior two pairs of copulatory pleopods are present. The carapace is typically wider than long. The broad body form, while allowing for crawling in the forward direction, is better suited for sideways movement. Most crabs are poor swimmers, but in the Portunidae (swimming crabs), the last pair of legs are modified into broad paddles, enabling them to swim rapidly (Barnes 1987).

The Anomura contain the hermit crabs and several other interesting groups, such as the Porcellanidae (porcelain crabs). In the Anomura, the fifth pair of legs is reduced. However, the abdomen is not reduced (as in brachyurans) and uropods are generally present. The anomuran superfamily Pagurolidea, the hermit crabs, have adapted to living the majority of their adult life with their abdomens protected in abandoned shells of gastropods. In these types, the abdomen is modified to fit inside the spiral chamber of the gastrpopod shell. The porcelain crabs, often found in commensal relationships with sea anemones, resemble true crabs in having symmetrical, flexed abdomens, but the abdomens are longer than in typical brachyurans (Barnes 1987).

Reproduction and Life History

When brachyurans copulate, the female lies under the male facing in the same position, or with ventral surfaces opposed. The male inserts the first pair of pleopods into the openings on the female's abdomen. Fertilization is internal. The abdomen, which is normally in a tightly flexed position, is lifted to a considerable degree to permit brooding. The egg mass, often orange in color is called a sponge. Eggs hatch out into a zoea larval stage, easily recognized by the presence of a long rostral spine, and sometimes a pair of lateral spines that project from the posterior of the carapace. The postlarval megalops is also quite distinctive, already possessing the flexed abdomen and the full complement of appendages found in the adult (Barnes 1987).

Hermit crabs partially emerge from their gastropod shell shelters to mate. The mating pair appress their ventral surfaces, and eggs and spermatophores are released simultaneously. Eggs hatch into a zoea larval phase, and metamorphose into glaucothoë postlarvae (Barnes 1987).

The kona crab, *Ranina ranina*, is one brachyuran species for which EFH has already been established under Amendment 10 of the *Crustacean Fisheries Management Plan,* (WPRFMC September 1998). A summary of the basic life history is presented here.

Ranina ranina, the kona crab, has a wide range, being found from the Hawaiian Islands south to Polynesia and westward across the tropical Pacific through Micronesia and Melanesia, as far north as Japan and Taiwan, and reaching across the Indian Ocean as far east as the coast of Africa (Tinker). In the NWHI, it occurs from Kure Atoll to Nihoa at depths of 24 to 115 m (Uchida, 1986; Edmonson, 1946). *R. ranina* is also found in the main Hawaiian Islands (MHI).

It is believed that female kona crabs reach sexual maturity somewhere between 54.3 and 63 mm CL. Uchida (1986) reports that 60% of male kona crabs ≥60 mm were sexually mature. Kona crabs are dioecious and display sexual dimorphism. The males tend to grow to a larger size (Uchida, 1986). The sex ratio of males to females has been found to be skewed in favor of males (Fielding and Haley, 1976; Onizuka, 1972).

This species spawns at least twice during the spawning season (Uchida, 1986). The female kona crab usually spawns a second time approximately nine days after the first batch of eggs hatch. Fertilization of the eggs occurs externally. The fertilized eggs adhere to the females' numerous setae (Uchida, 1986). In the MHI, ovigerous females have been found to occur only from May to September (Uchida, 1986; Fielding and Haley, 1976). There are insufficient data available to define the exact spawning season in the NWHI (Uchida, 1986).

A small, directed fishery for kona crabs exists in the MHI. While there is no directed fishery for kona crabs in the NWHI, it is taken incidentally in the spiny lobster fishery. The principal gear used in the fishery is the kona crab net. *R. ranaina* is also taken in lobster traps. In the MHI from 1961 to 1979 the average total landings for kona crab averaged 13,519 kg.

Kona crab eggs are spherical and orange. They hatch at approximately 29 days after fertilization (Uchida, 1986). About 5 days prior to hatching the eggs change from an orange to brown color at the onset of the eyed stage (Uchida, 1986).

Little is known about the plankton larval stage of kona crabs. The first molt occurs at 7-8 days after hatching, the second molt about seven days later (Uchida, 1986).

There is no information available concerning the distribution or habitat utilization patterns of juvenile kona crabs.

Adult kona crabs are found inhabiting sandy bottom habitat at depths between 24 to 115 m. Kona crabs are opportunistic carnivores that feed throughout the day. The species buries itself in the sand where it lies in waits for prey or food particles (Uchida, 1986).

The WPRFC has designated EFH for the juvenile and adult life stages of *Ranina ranina* as the shoreline to a depth of 100 m. EFH for this species larval stage is designated as the water column from the shoreline to the outer limit of the EEZ down to 150 m.

Habitat and Ecological Requirements

Crabs exhibit an astonishing array of structural and behavioral adaptations that enable them to occupy a wide range of niches within the coral reef habitat and associated environs. They may bury themselves in high littoral sands, occupy crevices or burrows among subtidal rocks and coral heads, or live on the surfaces of marine plants or other invertebrates. Their commensal associations include living in the mantle cavities of bivalves (pea crabs, Pinnotheridae); living among the tentacles of sea cucumbers (sea cucumber crab, Portunidae), attaching varied invertebrates to their carapaces for camouflage (sponge crabs, Dromiidae; decorator crabs, Majidae); or holding anemones in their chelipeds for defense (boxer crabs, genus *Lybia*). Additional ecological and habitat notes, where available, are provided in Section IV.C.4.e., below.

Occurrence of the Taxon Within WPRFMC Fishery Management Units

American Samoa

A number of crabs that cause gall formation in corals are reported from Samoa. For example, Eldredge and Kropp (1981) discuss the occurrence of the crab, *Cymo* sp., that causes galls in *Acropora hyacinthus* growing at 1-5m depth. *Calcinus herbstii*, a coral-inhabiting hermit crab, is also known from Samoa (Edmondson 1923).

Gossliner et al. (1996) report several species of crabs from American Samoa, including *Emerita pacifica,* the mole crab (Hippidae); *Cryptodromia* cf. *coronata* (Dromiidae), a sponge decorator that places live sponge on its carapace; and a coral crab, *Trapezia wardi* (Xanthidae).

Commonwealth of Northern Mariana Islands (CNMI)

Asakura et al. (1994) collected 27 species of anomurans in the Northern Marianas. Among these was the coconut crab, *Birgus latro* (Coenobitidae). Its distribution includes most islands of the Marianas, including Guam, Saipan and Tinian.

Takeda et al. (1994) reported on the results of collections of crustaceans made during a survey of the remote islands of the Northern Marianas in 1992. The majority of the collections were from the rocky intertidal and high subtidal zones. Subtidal collections were from the 3m depth zone, usually on coral. The following families and genera of crabs, and number of species (in parentheses) were recorded:

Dromiidae: Cryptodromia (1); Dynomenidae: Dynomene (1); Majidae: Menaethius (1), Perinea (1), Tiarinia (1); Parthenopidae: Daira (1); Atelecyclidae: Kraussia (1); Portunidae: Charybdis (1), Thalamita (2); Xanthidae: Chlorodiaella (1), Forestia (1), Lachnopus (1), Leptodius (1), Liomera (1), Lophozozymus (1), Lybia (1), Macromedaeus (1), Paraxanthias (1), Phymodius (1), Pilodius (2), Pseudoliomera (4), Xanthias (2); Menippidae: Dacryopilumnus (1), Epixanthus (1), Eriphia (1), Lydia (1), Ozius (1), Pseudozius (1); Pilumnidae: Nanopilumnus (1), Parapilumnus (1); Trapeziidae: Domecia (2), Tetralia (2), Trapezia (9); Ocypodidae: Ocypode (2); Grapsidae: Grapsus (2), Geograpsus (3), Pachygrapsus (2), Cyclograpsus (1), Plagusia (1), Percnon (1); Gecarcinidae: Cardisoma (1).

Guam

Several crabs (*Carpilius maculatus, Etisus dentatus, E. utilis, Calappa calappa* and *C. hepatica*) are among the species of shellfish sought by local fishermen (Green October 1997).

Hawaii (MHI and NWHI)

Eldredge and Miller (1995) state that nearly 200 species of crabs occur in Hawaii. Data concerning endemism is limited.

In a partial listing, Gossliner et al. (1996) indicate the following species found in Hawaii:

Anomura: *Aniculus maximus* (occurring in water up to 35m deep), *Dardanus gemmatus* (in waters to 15 m deep), *D. megistos;* Hippidae: *Emerita pacifica* (mole crab; sits submerged in sand and filter-feeds in intertidal wave zone); Calappidae: *Calappa calappa* (mollusks are principal diet), *C. hepatica* (mollusks are principal diet); Raninidae: *Ranina ranina* (found in sandy substrates); Dromiidae: *Dromia dormia* (carries sponge held over carapace by rear legs for camouflage); Majidae: *Huenia heraldica* (in 30m-deep waters with gorgonians), *Schizophrys aspera* (to 15m depth); Portunidae (swimming crabs): *Charybdis erythrodactyla* (feeds at night in waters 5-10m deep), *C. hawaiiensis* (on reef face at 10-20m depth), *Lissocarcinus laevis* (on anemones and soft corals; Xanthidae: *Carpilius maculatus* (in rocky areas 3-35m deep), *Etisus dentatus* (molluscivore found in waters to 15m deep), *Lybia edmondsoni* (endemic species; holds anemones in chelipeds), *Lophozozymus incisus* (occupies crevices on reef slopes), *Polydectus cupulifer* (camouflages with yellow anemones), *Trapezia wardi, Zosymus aeneas* (with poisonous flesh); Grapsidae: *Plagusia depressa, Percnon planissimum* (intertidal to subtidal)

Calcinus herbstii, a coral-inhabiting hermit crab, is the most common hermit crab on Oahu reefs (Edmondson 1923).

Other Sites

Edmondson (1923) reported 9 brachyuran families and 5 anomuran families from Palmyra Atoll and Fanning Island. Among the notable taxa reported are the following: *Carpilius maculatus* (dark-finger coral crab); 5 species of *Trapezia*; *Lissocarcinus orbicularis,* a swimming portunid crab; *Calappa spinosissima,* a box crab; *Petrolisthes speciosa,* a porcellanid crab; *Calcinus herbstii*, a coral-inhabiting hermit crab also found at Wake Island, Samoa, and Hawaii.

Calappa hepatica (Calappidae) and *Brachycarpus biunguiculatus* (Palaemonidae) are among the species found at Wake Island (Gossliner et al. 1996; Hayashi et al. 1994).

Table 1. Summary of Postembryonic Development and Larval Types in Decapoda[7]

Group	Postembryonic Development	Larvae
Suborder Dendrobranchiata		
Family Penaeidae	slightly metamorphic	nauplius > protozoea > mysis (zoea) > mastigopus (postlarva)
Family Sergestidae	metamorphic	nauplius > elaphocaris (protozoea) > acanthosoma (zoea) >mastigopus (postlarva)
Suborder Pleocyemata		
Infraorder Caridea	metamorphic	protozoea > zoea > parva (postlarva)
Infraorder Stenopodidea	metamorphic	protozoea > zoea > parva (postlarva)
Infraorder Palinura	metamorphic	phyllosoma (zoea) > puerulus, nisto, or pseudibaccus (postlarva)
Infraorder Astacidea	slightly metamorphic	mysis (zoea) > postlarva
Infraorder Anomura	metamorphic	zoea > glaucothoë [in pagurids], or grimothea (postlarva)
Infraorder Brachyura	metamorphic	zoea > megalopa (postlarva)

[7] After Waterman and Chace (T. H. Waterman [ed.]: Physiology of Crustacea, Vol. 1) *in* Barnes 1987.

Table 2. Habitat Description for Cephalopods (Class Cephalopoda)

Life Cycle Stage	Egg	Larvae	Juvenile	Adult
Duration		N/A (no larval phase)	unknown	in many cases, cephalopods die shortly after spawning; 1-2 year life span is typical (e.g., 12-15 months after settling from planktonic juvenile phase in *Octopus cyanea*); *Nautilus* may live up to 10 years
Diet	yolk	N/A	in *Nautilus,* eggs hatch directly to juvenile phase; juveniles believed to start immediately scavenging and grazing	generally predators on fishes, shrimps, crabs and mollusks; *Nautilus* may scavenge upon crab and lobster molts
Distribution	•*Nautilus* may have a single annual egg laying season, peaking around October; a few (10-15) large (mean 29mm) eggs are produced by each female •*Euprymna scolopes* may have two reproductive periods per year •in other taxa (e.g., *Octopus cyanea*) no seasonality noted	N/A	*Euprymna scolopes* goes through a short (<1 week) planktonic juvenile phase	nautiloids may migrate into deeper waters in daytime, rise to shallower reef flats at night to feed
Location	octopods attach eggs to rocky recesses on the reef reef cuttlefish deposits eggs among branches of finger coral; other cuttlefish may attach eggs to seagrasses; *Euprymna scolopes* attaches eggs to dead coral reef squid attach eggs to rocks and coral *Nautilus* attaches egg capsules to hard substrate	N/A		*Octopus* spp. in American Samoa, CNMI, Guam, NWHI, MHI *Nautilus pompilius* is found in American Samoa, perhaps the easternmnost extension of its range reef squid and cuttlefish in CNMI, Guam *Euprymna scolopes* cuttlefish endemic to Hawaii *Sepioteuthis lessoniana* believed nearly extirpated in Hawaii
Water Column		N/A	in octopod species with smaller, less developed eggs, juveniles may be planktonic and then settle to benthic existence; other octopod species may not have planktonic phase juveniles of other cephalopods generally have a planktonic phase	interidal, high subtidal (e.g., octopods, *Euprymna*); mesopelagic (squids, cuttlefishes); 60-500m (nautiloids) nautiloids may migrate into deeper waters in daytime, rise to shallower reef flats at night to feed
Bottom Type		N/A		octopods mostly in holes and crevices in rocky or coral areas, but some types in burrows in sand; squid and cuttlefish over reefs or seagrass areas; *Euprymna scolopes* burrows in sand on shallow sand and mud flats
Oceanic Features	N/A	N/A		some reef-associated squids semi-pelagic

Table 3. Habitat Description for Tunicates (Class Ascideacea)

Life Cycle Stage	Egg	Larvae	Juvenile	Adult
Duration	solitary forms release eggs to the water; in colonial forms, fertilization is internal and larvae, not eggs are released	"tadpole" larvae are non-feeding, and thus short-lived; larval phase may last from several minutes to a few days	rapid transition from larval to adult zooid phase, with no marked juvenile phase	typically 1-3 year life span
Diet	N/A	nutrition derived from yolk sac; some forms have endosymbionts that may contribute photosynthate product to the ascidian host as a food source	N/A	adults filter-feed non-selectively on phytoplankton and other suspended food particles and nutrients
Distribution	egg production occurs year-round	in some species studied (e.g., *Diplosoma similis*), larvae are released year-round		wide range of species known from most locations in the region; many species dispersed as fouling organisms transported on boat hulls
Location	eggs may be found in peribranchial cavity during embryonic development; in solitary forms, fertilization and subsequent development occurs outside the parent body	in colonial forms, larvae are typically held in the peribranchial cavity, or may be in a brood pouch or the basal test	N/A	range from high-light and high-energy environments (especially those forms with photosynthetic endosymbionts), to protected deeper-water areas
Water Column	N/A	larvae generally in same depth range as adults, approx. 0-100 m (or deeper); larvae in *Diplosoma similis* first swim up to enter layers with faster current, then swim down to settle on substrate	N/A	intertidal to 120 m depth or greater
Bottom Type	N/A	attach to dead corals, seaweeds, mangrove roots, other sessile invertebrates; favor attachment to darker surfaces with lower illumination	N/A	dead corals, seaweeds, mangrove roots, other sessile invertebrates; may also overgrow live coral
Oceanic Features	N/A	larvae in *Diplosoma similis* first swim up to enter layers with faster current, then swim down to settle on substrate	N/A	N/A (sessile attached organisms)

Table 4. Habitat Description for Bryozoans (Phylum Bryozoa or Ectoprocta)

Life Cycle Stage	Egg	Larvae	Juvenile	Adult
Duration	approximately two weeks from fertilization to development and release of larva	two types: ●non-feeding coronate larvae: planktonic for a few hours ●feeding (cyphonautes) larvae develop in those forms that shed eggs directly to the sea (e.g., in *Membranipora*): cyphonautes may last several months	no distinct juvenile phase; following adhesion of larva to substrate, all larval organs undergo histolysis within approx. one hour from the onset of metamorphosis, forming ancestrula (first zooid of colony)	large colonies may add 2-4 cm growth annually and believed to live for ten years or more
Diet	in some species, developing embryo receives its nutrition from a contained yolk, but in others, placenta-like connections to the ovicell from the mother zooid may provide food material	cyphonautes larvae are planktotrophic; "non-feeding" types may take up dissolved organic nutrients (e.g., amino acids)		selective suspension-feeders that consume diatoms, bacteria, flagellates, and phytoplankton
Distribution				adult colonies may be transported as fouling organisms on ships' hulls; various species found throughout all sites in the region
Location	eggs may variously be: ●small sized, fertilized at the time of discharge into seawater (e.g., *Membranipora*); ●larger, brooded internally in coelomic cavity during embryonic development; ●brooded in specialized ovicells	may develop internal or external to parent zooid		usually found on shaded surfaces (e.g., undersides of coral tables)
Water Column		larvae are initially positively phototropic, and move upward in water column; later become negatively phototropic and move toward shaded areas (e.g., under stones or coral plates) prior to settlement		benthic sessile organisms occurring from intertidal to abyssal depths, but majority associated with substrates at 20-80m depth; preference for clear water free of suspended silt and sediment
Bottom Type		larvae highly selective in choosing attachment site; usually settle on rock, dead coral, seaweeds or wood		adults attached to rock, dead coral, seaweeds or wood
Oceanic Features		January thermal boundaries (e.g. 27 degree C isotherm may act as filtering mechanisms that determine larval distribution		steady water currents essential for successful filter-feeding function; however, waves may be destructive of delicate erect, branching or foliose colonies

Table 5. Habitat Description for Crustaceans (Class Malacostraca [in part])[8]

Life Cycle Stage	Egg	Larvae	Juvenile	Adult
Duration	30-40 days in lobster; 29 days in kona crab	●zoea larvae last up to 3 months in stomatopods ●in penaeids, eggs hatch to the nauplius or metanauplius stage, last for a few weeks ●in spiny lobster phyllosomae may last approx. 6 months to 1 year (shorter in other lobsters), metamorphose into pueruli which last 6 months, and after settling, post pueruli ●brachyurans and anomurans hatch to zoea phase, develop into megalops and glaucothöe postlarvae, respectively	up to six years (in coconut crab)	most species several years; up to 50 years in coconut crab
Diet	N/A	generally planktivorous		various, but typically carnivorous or omnivorous predators or scavengers, with preferred food items being mollusks, other crustaceans, and small fish; some taxa are specialized cleaners that feed on ectoparasites, while others are filter feeders
Distribution	in spiny lobster spawning continuous throughout the year, with individual females spawning up to 4 times each year, producing up to 0.5 million eggs each spawning; other species may have more defined spawning seasons			all major groups known or assumed to be well-represented at all locations in the region (e.g., around 2,000 species of crabs are known from the region)
Location	in penaeid shrimps, eggs are shed directly to the water; in other decapod groups and in stomatopods eggs carried on the pleopods of the female			
Water Column		in lobsters, newly-hatched larvae may occur in upper 60m, but later larval stages may occur in deeper water (80-120m)		●stomatopods are generally subtidal from 5-70m depth ●coral associated shrimps generally found in depths from 3-15m but may be found much deeper ●lobsters generally occur in depths between 20-55m, but may occur to at least 110m ●crabs may be terrestrial, intertidal, or subtidal to depths of at least 115m

[8] The MUS as defined here includes mantis shrimp (Order Stomatopoda), as well as shrimps, lobsters, and crabs (various taxa within the Order Decapoda). The taxa not already addressed under Amendment 10 of the *Crustacean Fisheries Management Plan* (which covers spiny lobsters and kona crab) are the primary emphasis here.

Life Cycle Stage	Egg	Larvae	Juvenile	Adult
Bottom Type			juvenile spiny lobsters occupy habitat similar to that of adults	●stomatopods typically in burrows, either in sand or rubble ●shrimp may stay buried in sand or live in pockets in coral or among rubble ●lobsters typically in subtidal holes or crevices on reefs ●crabs may occupy mud or sand bottom, corals, or rocky areas
Oceanic Features		palinurid larvae may be transported up to 2,000 miles by prevailing ocean currents		while some taxa are pelagic, these are generally not reef-associated

FMU	Economic Importance				Distribution					
	Food	Ornamental	Bio-prospecting	Fouling Organism	AS	CNMI	GU	MHI	NWHI	Other
CEPHALOPODS:										
octopus	●	L			●	●	●	● R	● R	A
squid and cuttlefish	●				A	●	●	●	A	A
nautilus	L	●			●					
TUNICATES			●	●	A	●	●	●	●	●
BRYOZOANS			●	●	A	A	A	●	A	A
CRUSTACEANS:										
stomatopods	L	L			A	● R[9]	●	●	A	●
shrimps	●	●			A	● R[1]	●	●	●	●
lobsters	●	L			●	● R	●R	●R	●R	●
crabs	●	L			●	● R[1]	● R[10]	● R[11]	● R	●

L = Limited Use

A = Assumed to be Present; R = Regulated

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[9] all invertebrates regulated (for export)

[10] coconut crab

[11] blue crab, Samoan crab

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C. EFH for Management Unit Species- Sessile Benthos

The concept of essential fish habitat (EFH) is of obvious value when used as a tool to protect individual fisheries. It is defined as that habitat necessary for their various stages of managed species life histories to perpetuate. To consider the sessile benthos (SB) as required by the Interim Final Rule (IFR) for EFH, the concept must be qualified. This is because it is applied to broad groups of organisms, many of which form the habitat upon which all other species depend. Due to the large numbers of species of coral, algae and other sessile benthos (450 spp algae; 99 Scleractinia and 150 spp. of the other groups considered in Hawaii (Eldredge and Miller, 1995) and a total of approximately 1200 spp of the combined groups in the total AFPI), the concept loses definition and becomes too generalized to be of value. The vast numbers of SB do not represent a managed fishery. This is particularly the case when considering the benthos of coral and algae.

The fauna and flora, generally, lack mobility in the adult stages with the intermediate stages are transported in the water column until settlement. Once they have settled they largely become habitat. They are instrumental in the ecosystems primary production and are largely responsible for supporting the higher trophic levels, many with predator-prey relationships. The high degree of symbiosis begins with the zooxanthellate associations and encompasses a wide degree of associations involving all groups of the fauna and flora. Much of the physical relief of the reef is the result of the living environment as is the deposition of the coral reef itself. An overly simplistic assessment of the habitat requirements for the sessile benthos are suitable substrate, water quality and light. This, however, negates the history of the substrate development and the myriad of biological interactions, which qualify as a coral reef. Due to these considerations, the species and their fundamental roles in the ecosystem define the EFH as the coral reefs themselves. As such, all coral reefs in the AFPI should be designated EFH for the sessile benthos. This is because all of the coral reef associated fisheries for which the Magnuson-Stevens Fisheries Conservation and Management Act was designed to protect and conserve depend on the coral reef ecosystem.

As there is no fisheries extraction of the sessile benthos in the AFPI, the objective of the concept discussion shifts to the life history characteristics of the fauna and flora of the coral reef environment. It is the life history stages of the selected benthic groups that comprise the discussion of their importance in the EFH description. It is important in the consideration of the management unit species (MUS).

Life histories and habitat requirements rely on an understanding that the coral reef is a variable and dynamic entity. The composition of the reefs responds to environmental parameters such as temperature, dilution and sedimentation. Regionally, their composition varies in response to temperature by virtue of latitude, current regimes and events brought on by unique climatic events such as El Nino hot spots. Such major discontinuities in taxa occurrence such as the absence of the genus *Acropora* in Hawaii or reef cementing coralline alga in extra-tropical areas, require that we consider reefs on a regional basis, as well as, locally. The history of a particular area is as important as short-term community cycles and is often seen to be decadal in time frame, and most probably represents longer cycles. The fossil record of reefs shows a process of progressive change in the nature of reefs. Current concern for global warming and the effects of some of the hotspots may require this to be added to the equation, when human induced impacts are considered.

The interconnectivity of the coral reef, in terms of potential recruitment, provide us with an understanding of the reef environment that is at once very robust and able to restore itself after the most destructive natural events. The coral reef is fragile, in that, if the composition of a reef is changed then the effect is likely to be manifest down current as well. A chronic change in the environmental parameters of an area is likely to result in a permanent change in the community composition. In summary, EFHs are not a useful concept for the numerous sessile benthos at the species level but rather a conformation of the importance of the many non-commercial species that comprise the coral reef ecosystem. In developing this as an operational framework, Conservation of these broad groups may be accomplished in two ways. 1) It may be appropriate to establish criteria for the amount of reef that is allowed to be affected by development, fishing practices or tourism. This quantity would be established in relation to the amount of area of unaffected reef, within the range of the ocean currents that would allow restoration or maintenance of this area through recruitment. 2) Equally useful is the concept of the *management unit species (MUS)* in making the description of the ecosystem more manageable with better resolution in its definition. Here generic assemblages or their interactions are considered entities, which allow a more categorical method of management.

The Management Unit Species (MUS): an ecosystem approach

The concept of the management unit species (MUS) is a useful concept when considering a resource composed of species or higher taxa who share the same habitat, have the same trophic ecology or respond to changing environmental variables in a predictable way. Coral reef zonation, as the result of an environmental regime, reflects a natural MUS organization. Whether through tolerance or requirement, benthos is sorted into a zonation with respect to the proximity to land, depth or wave action. Impacts which add nutrients, as the result of some human activity, to a naturally low-nutrient coral reef and the community changes from being micro-algal and coral dominated, to being macro-algal and with a great reduction in the hard coral component. In the case of increases in sediments and freshwater, there is a reduction in species numbers in both groups to those which are resistant to such effects. Tidal influences of periodic exposure, ponded waters or exposure to wave action have a dramatic effect in conditioning species compliments.

The MUS may be defined in relation to the environmental variables, be it natural or induced. With respect to this, taxonomic classification does not conform to groupings by environmental tolerances. As a result, a wide range of taxonomic groups is considered depending on the type of organism. This section describes these groups as general taxonomic entities. Depending on the availability of information or scale of consideration, in an operational sense, the appropriate taxonomic level should be used. As an example, *Porites/Favid* assemblages are characteristic of areas of periodic flooding. *Acropora* assemblages and a micro-algal assemblage are characteristic of normal seawater salinity with clear, flowing aerated water. Add wave action to this and the coral assemblages become reduced in diversity and morphology characterized by robust or encrusting forms. Coralline alga dominated. The dynamic potential inherent in coral reef communities becomes apparent with a change in the environment as the result of some change in a natural parameter resulting from development or terrestrial activity.

In conforming to the MUS approach, using the general taxonomic groupings of sessile benthos was considered for designations of the MUS. Within these groups species can be clumped based on selection by environmental parameters. Suggested divisions are the hard and soft coral and the micro and macro-alga. Other benthic groups of reef associated organisms (*Porifera, Actinaria, Hydroidea, Gorgonacea and Zooanthidea*), generally, are less dominate in reef communities and more liable to conform, in terms of abundance, to the dominance exhibited by the primary groupings. In terms of the reef community composition, these more minor groups are largely coral or algal associated with the type and abundance of coral or alga conditioning their occurrence. It is useful to consider the light limited environments of depth or caves where the groups such as the *Gorgonacea* and *Porifera* may be dominant.

It would be in error not to emphasize considering the regionality of such a framework. The Caribbean and Florida seaboard are very different than the Indo-Pacific. Within the Indo-Pacific, species occurrence, generally, winnows from west to east and is limited when approaching the temperate boundaries. As a result, geographic locations may vary in terms of their species complements. This gives rise to variability in dominance but does not change the relationship within the four major groupings. The species within the groupings become less consequential, varying in dominance depending on the region.

Habitat Areas of Particular Concern (HAPC)

Habitat areas of particular concern for the benthos of coral reefs may include a variety of situations. These may be the same as those which give rise to marine protected areas or where a conservation area has been set aside to protect organisms which may have been depleted through fishery harvest. Particular concern may be for an area where coastal development has adversely impacted near shore areas. With respect to this, it may be that areas within ocean current range should be protected to conserve areas which are unprotectable due to a requirement for subsistence fishing, recreational usage, damage done by circumstances of coastal development or activities inland such as agriculture. It may be that an area is of concern due to the long history of research at a particular site or area and the encroachment of development (e.g. Pago Pago Harbor, American Samoa). Reserves, national parks, wildlife refuges and other protected areas are existing operational areas of particular concern.

Algal life cycles

Both sexual and asexual reproduction are widespread in algae, and the predominance of one or the other is mainly linked to the class of algae in question (Cyanobacteria, Chlorophyta, Phaeophyta or Rhodophyta) and the predominant geographical and environmental conditions affecting the algal populations (Bold and Wynne, 1985). Unicellular algae reproduce mainly asexually, while multicellular algae have asexual or sexual life cycles of varying complexity. Sexual life cycles are classified into four basic types, according to the site of meiosis or reduction-division of the algal genome (table I). By far the most common type is the sporic life cycle, in which a usually diploid sporophyte stage alternates with a usually haploid gametophyte stage. The recurring sequence of these two stages is called alternation of generations, which can be either isomorphic (when both generations are morphologically similar) or heteromorphic (where one generation can differ markedly in morphology from the other).

Table I. Classification of sexual algal life cycles (after South and Whittick, 1987)

Life cycle type	Site of meiosis	Main algal groups concerned
Zygotic	zygote	Unicellular algae (Chrysophyceae)
Sporic	sporangia	Rhodophyta, Phaeophyta, Chlorophyta
Gametic	gametangia	Chlorophyta
Somatic	thallus cells	Chlorophyta, Rhodophyta

Cyanophyta

In the Cyanophyta, reproduction is primarily by the production of asexual spores, which are released into the environment and grow into new individuals. These spores can be produced by budding from the free ends of the filaments, or by the fission of large vegetative cells within the thallus.

Phaeophyta

In most members of the Phaeophyta, sexual reproduction is sporic, with the alternation of a haploid gametophyte generation with a diploid sporophyte generation; both generations may or may not be morphologically similar. Spores are usually numerous and motile, being produced in unilocular sporangia.

Chlorophyta

The Chlorophyta life cycle is variable, but a typical case can be demonstrated in the common genera *Ulva*, where zoospores are produced in the thallus which are released and fuse to produce a new individual.

Rhodophyta

Most members of the Rhodophyta exhibit a sporic life cycle, a majority of which are of the triphasic *Polysiphonia*-type. The gametophytes and the tetrasporophyte are often isomorphic (although in some algae the tetrasporophyte can be crustose and alternate with large fleshy gametophytes). The Carposporophyte is reduced, and attached to the female gametophyte. The gametes are non-motile.

Distribution patterns of algae amongst the American Flag Pacific Islands (AFPI)(with nomenclature updated (following taxonomy in Silva *et al.* 1996), from available literature; excludes varietal status of species). The attached AFPI algae distribution table lists 815 taxa of marine algae, statistically broken down as follows:

Table 2: Algae distribution within the American Affiliated Pacific Islands (AFPI)

AFPI locality	Cyanophyta	Chlorophyta	Phaeophyta	Rhodophyta	Total
American Samoa	15	31	14	68	128
Baker Is.	1	6	3	6	16
Howland Is.	0	5	1	3	9
Jarvis Is. [1]	-	-	-	-	-
Palmyra Is.	19	39	11	64	133
Kingman Reef [1]	-	-	-	-	-
Johnston Atoll	19	24	9	40	92
Hawaii [2]	3	48	29	343	423
North West Hawaiian Islands	0	43	32	121	196
Wake Island	2	8	10	3	23
Commonwealth of the Northern Marianas	5	55	20	57	137
Guam	16	58	29	98	201
Total	52	142	70	333	

[1] no data available at this time

[2] Abbott (1995) estimates the total Hawaiian flora at about 400 species

Comments:
Because the reported distribution is related to the sampling effort in each particular locality, the comparisons are largely artificial at this stage. For instance, the Guam and North West Hawaiian floras are fairly well-known, while the Jarvis Is., Kingman Reef, Wake Is, Baker and Howland Islands floras are seriously under-collected or unknown. For the Hawaiian flora, there is a large amount of as yet unpublished material which will drastically increase the number of known species in the near future (Abbott 1995).

The most comparable groups of algae are the Phaeophyta and Chlorophyta, because they are mostly intertidal in habitat and thus most easily collected and inventoried, and there is a relatively constant number of common species across the AFPI islands for the better investigated localities.

Distribution among islands
From an examination of the species distribution table, the most commonly reported species (those which occur in 50% or more of the localities under study) for the islands of the AFPI are as follows, according to class:

Table 3: Most commonly reported species for the islands of the AFPI

Class	Most common species	Typical reef habitat
Cyanophyta	*Lyngbya majuscula*	inner reef flat
	Schizothrix calcicola	inner reef flat
Chlorophyta	*Boodlea spp.*	inner / outer reef flat
	Bryopsis pennata	inner reef flat / lagoon
	Caulerpa racemosa	inner / outer reef flat
	Caulerpa serrulata	inner reef flat / lagoon
	Dictyosphaeria spp.	inner reef flat / lagoon
	Halimeda discoidea	inner reef flat
	Halimeda opuntia	inner reef flat
	Neomeris annulata	inner reef flat
	Ventricaria ventricosa	reef flat / outer reef slope
Phaeophyta	*Dictyota friabilis*	reef flat
	Feldmannia indica	reef flat
	Hincksia breviarticulata	reef crest / exposed shoreline
	Lobophora variegata	reef flat / lagoon
	Sphacelaria spp.	reef flat / epiphytic
	Turbinaria ornata	reef flat / bommies in lagoon

Rhodophyta	*Amphiroa fragilissima*	inner reef flat
	Asparagopsis taxiformis	reef crest / outer reef slope
	Centroceras clavulatum	reef flat / epiphytic
	Gelidiopsis intricata	inner reef flat / lagoon
	Gelidium pusillum	inner reef flat
	Hydrolithon reinboldii	reef crest
	Hypnea esperi	inner reef flat
	Jania capillacea	reef flat
	Martensia fragilis	outer reef slope
	Neogoniolithon brassica-florida	reef crest
	Polysiphonia spp.	reef flat
	Porolithon onkodes	reef crest
	Portieria hornemanni	outer reef slope

Habitat distribution of the common algal species in the AFPI (After N' Yeurt, 1999)

The Flora of Fringing Reefs

In shallow, calm fringing areas where sediment accumulations are predominant, green and brown algae are most abundant with the most characteristic species being *Caulerpa spp.*, *Chlorodesmis fastigiata*, *Halimeda spp.*, *Neomeris spp.*, *Ventricaria ventricosa* and *Boodlea spp.* for the greens, and *Padina spp.* and *Dictyota spp.* for the browns. Common red algae include *Galaxaura* spp. and *Laurencia* spp. When water depth and movement are more important, hard substrata (coral colonies and rubble) are more numerous and ubiquitous species such as *Turbinaria spp.* and *Sargassum spp.* thrive. In very exposed places, the marine scenery is generally rocky or limited to small shelves below the border road. The violent wave action increases sea spray and enables the rise of certain species notably the two brown algae *Chnoospora minima* and *Hincksia breviarticulata*. On this type of shelf we generally find the flora of external reef shelves described later, confined to a few square meters owing to the intensity of the hydrodynamic factors such as wave action.

The Flora of the Barrier Reef

On barrier reefs, coral bommies are generally dominant, between which are spread out well sorted-out sediments. The pavement of the lagoon floor is visible in areas of strong hydrodynamism. Water level rarely exceeds 2.5 m. The flora is essentially one of hard substrata, and species exist in close link with the coral colonies, resulting in a mosaic pattern of species distribution. The summit of coral bommies skimming the water surface are generally colonised by the large brown algae *Turbinaria ornata* and *Sargassum spp.*, that form an elevated layer under which grow species such as *Amansia sp.*, and coralline algae. In areas where grazing by herbivores is more important, the bommies are covered by a fine tuft where a great number of discrete species belonging to the Ceramiaceae and Rhodomelaceae intermingle. In areas where hydrodynamism is more important, the encrusting coralline algae form pinkish, yellowish and bluish blotches on the upper parts of the substratum.

At the base of bommies, it is common to see large bunches of brown algae such as *Dictyota bartayresiana*, intermingled to the spread-out thalli of *Halimeda opuntia* and tufts of the red algae *Galaxaura fasciculata* and *G. filamentosa*. Most crevices are colonised by *Ventricaria ventricosa*, *Valonia fastigiata*, and *Dictyosphaeria spp*. Finally, where direct sunlight does not reach, live a range of encrusting coralline algae whose pink, violet and purple hues mingle with the soft green colours of *Halimeda spp.* and *Caulerpa spp.*

The Flora of the Outer Reef Flats

It is probably the richest and most diversified flora of the reef complex. On high islands, it is represented by a belt of the brown algae *Turbinaria ornata* and *Sargassum spp.*. We find in particular the erect and stiff tufts of *Laurencia spp. and Gelidiella spp.*, to which are attached the little bright green balls of *Chlorodesmis fastigiata*, or the light pink hemispherical cushions of the articulated Corallinaceae *Amphiroa spp.* and the opportunistic *Jania spp*. It is here that the encrusting calcified algae form the most important growths, with notably *Hydrolithon* spp. However, it is on the reef flats of atolls that Corallinaceae formations are the most exuberant. They form a compact pad of a beautiful brick-red colour, and in very exposed places even construct spectacular corbellings several tens of centimetres thick. The dominant species is *Hydrolithon onkodes* with a rather smooth texture. On atolls, large brown algae are absent and the fleshy species are limited to yellowish-brown rosettes of *Lobophora variegata* and *Turbinaria spp.*

The Flora of the Lagoons of Atolls

The sandy bottoms of the lagoons are often in deeper parts, covered with a mucous film rich in bacteria or of a carpet of Cyanobacteria where mingle tufts of filamentous red algae such as *Polysiphonia*, *Ceramium*. The hard substrata are always much richer in various green algae such as *Caulerpa* and *Halimeda*. Bommies in the lagoon offer a habitat for green genera such as *Cladophoropsis spp.* and very large varieties of *Dictyosphaeria cavernosa*.

The Flora of the Outer Reef Slope

It extends beyond 10 meters depth. The red algae are most abundant and diversified. It is the main area of encrusting coralline algae (mainly in the atolls), but also of elegant and fleshy forms such as *Gibsmithia hawaiiensis* and *Asparagopsis taxiformis*. As one goes deeper, coralline algae become the dominant species, although occasionally species of the green algal genus *Halimeda* and the brown algal genus *Lobophora* have been found up to depths of 130 metres (Littler *et al.* 1985) while the green alga *Caulerpa bikinensis* has been reported beyond depths of 70 metres (Meinesz *et al.* 1981).

The Ecological Role of Algae in the Coral Reef Ecosystem

Benthic algae are a very important, yet often overlooked component of any reef biome. Marine plants are responsible for the primary productivity of the reef ecosystem, owing to their photosynthetic ability which inputs solar-derived energy into the reef community. This energy is made available to other reef organisms in a variety of forms, ranging from direct input (grazing by hervibores; symbiotic relationships with invertebrates and fungi) or indirectly by the breaking down of plant products and detrital residues after death.

Algae play an important role in organic and inorganic material cycles within the reef community, by being able to retain and uptake key elements such as nitrogen and carbon. The primary role of marine algae in the carbon and nutrient cycles of coral reef ecosystems cannot be underestimated and has been the focus of much research (Dahl 1974; Wanders 1976; Hillis-Colinvaux 1980; Payri 1988; Charpy and Charpy-Roubaud 1990; Charpy-Roubaud and Sournia 1990; Charpy-Roubaud *et al.* 1990, Charpy *et al.* 1992; Gattuso *et al.* 1996).

Calcified (*Halimeda* and *Amphiroa spp.*) and crustose coralline algae play a major but easily overlooked role in coral reef construction and consolidation, and contribute a major part of reef carbonate sediments (Payri 1988). These organisms lay down calcium carbonate as calcite, which is much stronger than the brittle aragonite produced by corals, thus cementing and consolidating the reef structure. In particular, coralline algae are of primary importance in constructing the algal ridge that is characteristic of exposed Indo-Pacific reefs, which prevent oceanic waves from striking and eroding coastal areas (Nunn 1993; Keats 1996). At the other extreme, penetrating or boring algae such as Cyanophyta are important contributors to bioerosion and breakdown of dead reef structures (Littler and Littler 1994).

Marine macroalgae contribute significantly to organism interrelationships in reef ecosystems, either by the production of chemical or structural by-products on which other organisms depend, the providing of protective micro-habitats for other species of algae or marine invertebrates, or by offering surfaces promoting the settlement and growth of other algal species or the larvae of some herbivorous invertebrates such as abalone (Dahl 1974; Keats 1996). Symbiosis is also an important aspect of algal interrelationships in reef communities, with hermatypic corals relying on photosynthetic zooxanthellae for food. Marine plants thus offer a remarkable potential as experimenting organisms in the elucidation of the complex chemical and biological interactions that make up the fragile, closed ecosystems of tropical coral reefs (Littler and Littler 1994).

The Effects of Human Activities on Coral Reefs, in Relation to Algae

The impact of human habitation, and activities linked to industries and waste processing and disposal have proven negative impacts on coral reef ecology. An "healthy ecosystem" is a self-regulating unit where ecological productivity and capacity is maintained, with a diversity of flora and fauna present (Federal Register 1997: 66551). Some reef organisms are very sensitive to disruptions, and can act as timely indicators of changes in the natural balance of the ecosystem. For instance, the absence of *Acropora* coral on the backreef areas could indicate polluted waters with high levels of siltation, a situation reported from the stressed Aua Reef on Tutuila Island, American Samoa (Dahl and Lamberts 1977). The green algae *Enteromorpha* spp. and *Ulva* spp. thrive in high-nutrient areas, acting as bio-indicators of organic pollution linked to sewage outfalls, and also accumulate heavy metals present in industrial effluents (Tabudravu 1996). Dredging and increasing reclamation of coastal mangrove for industrial and urban use further contribute to siltation of the lagoon and the destruction of algal habitats and marine nursery areas. In this respect, algae can be classified as essential fish habitats (EFH) as they are direct contributors to the well-being and protection of fish species, both as a source of food and offering protection to larvae and small fish species. Overfishing in the lagoon reduces the number of herbivorous fishes, destroying the fragile equilibrium between reef organisms, while the input of excess nutrients via sewage and domestic effluents into the lagoon contributes to algal blooms. This can lead to the ecosystem shifting from coral dominance to algal dominance, and abnormal blooms of turf algae have been known to overgrow and kill healthy coral (Dahl 1974; Littler and Littler 1994) while >red tide= dinoflagellate blooms lead to anoxic conditions killing a wide range of marine organisms (Horiguchi and Sotto 1994). Increased chemical pollution of the lagoon could also lead to a bloom of reef-destroying organisms such as the crown-of-thorn starfish (Randall 1972).

Coral reefs have been known to recover relatively well if the stressing factors are removed soon enough before permanent damage is done (Dahl and Lamberts 1977). A strong and healthy barrier reef, in particular the *Porolithon* algal ridge of atolls, acts as a natural breakwater offering protection to coastal areas in the event of cyclones and such natural disasters, which are frequent in the region (Nunn 1993). However, the coral structure can be severely damaged and weakened as a result of siltation, eutrophication and the overgrowing of coral colonies by opportunistic filamentous algae (such as for instance happened in Kaneohe Bay, Hawaii; see Smith 1981), necessitating the construction of artificial barriers.

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Table 4. Algal species occurrence in the AFPI.

AS: American Samoa; PA: Palmyra Atoll; JA: Johnston Atoll; MHI: Main Hawaiian Islands; NWHI: Northwestern Hawaiian Islands; WA: Wake Atoll; CNMI: Commonwealth of Northern Mariana Islands; GU: Guam

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Division Cyanophyta (Blue-green)												
Anacystis dimidiata							X					
Aphanocapsa grevillei	X											
Arthrospira brevis												X
Arthrospira laxissima	X											
Calothrix aeruginosa					X							
Calothrix confervicola												X
Calothrix crustacea							X				X	X
Calothrix pilosa												X
Calothrix scopulorum							X					
Chroococcus turgidus					X							
Entophysalis conferta					X							X
Entophysalis deusta							X					X
Hormothamnion enteromorphoides							X	X				X

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Hormothamnion solutum					X							X
Hydrocoleum lyngbyaceum							X					
Hyella caespitosa	X											
Isactis plana							X					
Lyngbya aestuarii					X		X					
Lyngbya confervoides					X		X					
Lyngbya gracilis					X							
Lyngbya infixa					X							
Lyngbya lutea							X					
Lyngbya majuscula	X				X		X	X		X	X	
Lyngbya pygmaea	X											
Lyngbya rivulariarum					X							
Lyngbya semiplana					X							
Lyngbya sordida					X							
Microchaete vitiensis	X											
Microcoleus chthonoplastes					X		X					
Microcoleus lyngbyaceus	X										X	X
Microcoleus tenerrimus							X					

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Microcoleus vaginatus							X					
Oscillatoria bonnemaisonii					X							
Oscillatoria lutea												X
Oscillatoria nigro-viridis							X					
Oscillatoria submembranacea												X
Phormidium corium					X							
Phormidium crosbyanum										X		
Phormidium penicillatum					X							
Phormidium submembranaceum					X		X					
Porphyrosiphon notarisii												X
Radaisea sp.	X											
Schizothrix calcicola	X	X					X				X	X
Schizothrix mexicana	X										X	X
Scytonema figuratum	X											
Scytonema hofmannii	X											X
Scytonema stuposum	X											
Spirulina major					X							
Spirulina subsalsa												X

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Spirulina tenerrima							X					
Symploca atlantica							X					
Symploca hydnoides	X				X			X				
Symploca muscorum	X											
Division Chlorophyta (Green)												
Acetabularia clavata							X	X				
Acetabularia exigua											X	
Acetabularia moebii							X	X	X		X	
Acetabularia tsengiana							X					
Acetabularia sp.							X					
Anadyomene wrightii					X						X	X
Avrainvillea erecta												X
Avrainvillea lacerata					X							
Avrainvillea obscura											X	X
Avrainvillea pacifica												X
Boergesenia forbesii											X	X

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Boodlea coacta											X	X
Boodlea composita					X		X	X	X			X
Boodlea vanbosseae	X				X				X		X	X
Bornetella oligospora											X	
Bornetella sphaerica								X	X			
Bryopsis harveyana	X											
Bryopsis hypnoides									X			
Bryopsis pennata	X				X		X	X	X		X	X
Bryopsis plumosa											X	X
Bryopsis pottsii	X											
Bryopsis sp.								X				
Caulerpa ambigua					X		X	X	X		X	
Caulerpa cupressoides										X	X	X
Caulerpa elongata											X	
Caulerpa fastigiata											X	
Caulerpa filicoides											X	X
Caulerpa lentillifera								X				X
Caulerpa lessonii												X

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Caulerpa okamurai											X	X
Caulerpa peltata	X								X	X	X	X
Caulerpa plumaris												X
Caulerpa racemosa	X						X	X	X		X	X
Caulerpa serrulata			X		X			X	X	X	X	X
Caulerpa sertularioides								X			X	X
Caulerpa taxifolia								X	X		X	X
Caulerpa urvilliana					X		X				X	X
Caulerpa vickersiae					X						X	
Caulerpa verticillata								X				X
Caulerpa webbiana								X	X		X	X
Chaetomorpha antennina	X							X	X			
Chaetomorpha indica								X				X
Chaetomorpha restricta	X											
Chamaedoris orientalis												X
Chlorodesmis fastigiata	X											X
Chlorodesmis hildebrandtii					X			X	X		X	X
Cladophora crystallina					X		X					

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Cladophora fascicularis								X				
Cladophora glomerata	X											
Cladophora inserta					X							
Cladophora patentiramea					X							X
Cladophora patula								X				
Cladophora pinniger	X											
Cladophora socialis					X				X			
Cladophora vagabunda									X			
Cladophora sp.		X			X			X	X	X		
Cladophoropsis fascicularis											X	
Cladophoropsis gracillima		X	X		X							
Cladophoropsis infestans	X											
Cladophoropsis limicola	X											
Cladophoropsis luxurians								X				
Cladophoropsis membranacea								X			X	X
Cladophoropsis sundanensis					X			X				
Cladophoropsis sp.							X					
Codium arabicum							X	X	X			

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Codium dichotomum								X				
Codium edule								X	X		X	
Codium geppiorum	X				X							
Codium mamillosum								X	X			
Codium ovale												
Codium phasmaticum								X				
Codium reediae								X	X			
Codium spongiosum								X				
Codium tomentosa												X
Codium sp.							X		X			
Derbesia attenuata					X							
Derbesia marina					X		X					
Derbesia ryukiuensis					X							
Derbesia sp.							X					
Dictyosphaeria cavernosa		X	X		X			X	X	X	X	
Dictyosphaeria versluysii	X	X			X		X	X	X		X	X
Enteromorpha clathrata	X				X							X
Enteromorpha compressa												X

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Enteromorpha flexuosa	X											
Enteromorpha intestinalis	X				X			X	X			
Enteromorpha kylinii		X			X		X					
Enteromorpha prolifera	X											
Enteromorpha tubulosa					X				X			
Enteromorpha sp. 1									X			
Enteromorpha sp. 2									X			
Enteromorpha sp. 3									X			
Enteromorpha sp.								X				
Halimeda copiosa									X		X	
Halimeda cuneata											X	X
Halimeda cylindracea											X	
Halimeda discoidea	X				X		X	X	X		X	X
Halimeda fragilis					X							
Halimeda gigas												X
Halimeda gracilis					X						X	X
Halimeda incrassata	X										X	X
Halimeda lacunalis											X	

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Halimeda macroloba	X										X	X
Halimeda macrophysa											X	
Halimeda opuntia	X				X				X	X	X	X
Halimeda tuna							X		X		X	X
Halimeda velasquezii									X			
Halimeda spp.			X									
Microdictyon japonicum								X	X			
Microdictyon pseudohaptera					X						X	X
Microdictyon setchellianum							X	X	X			
Neomeris annulata	X							X	X	X	X	X
Neomeris bilimbata					X							
Neomeris dumetosa											X	X
Neomeris vanbosseae								X				
Ostreobium quekettii	X						X					X
Palmogloea protuberans							X					
Phaeophila dendroides					X							
Phaeophila engleri					X							
Phyllodictyon anastomosans								X	X			X

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Pseudobryopsis oahuensis								X				
Pseudochlorodesmis furcellata											X	X
Pseudochlorodesmis parva							X					
Rhipidosiphon javensis								X	X		X	
Rhipilia geppii					X							
Rhipilia orientalis										X		
Rhipilia sinuosa												X
Rhizoclonium hieroglyphicum	X											
Rhizoclonium implexum	X				X							
Rhizoclonium samoense	X											
Rhizoclonium tortuosum												X
Siphonocladus tropicus								X				
Spongocladia vaucheriaeformis											X	X
Struvea delicatula											X	
Struvea tenuis											X	X
Tydemannia expeditionis	X										X	X
Udotea argentea											X	X
Udotea indica											X	

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Ulva fasciata		X	X					X	X			
Ulva reticulata								X				
Ulva rigida									X			
Ulva sp.									X			
Valonia aegagropila								X	X		X	X
Valonia fastigiata	X											X
Valonia trabeculata								X				
Valonia utricularis					X						X	X
Ventricaria ventricosa	X						X	X	X		X	X
Zygomitis sp.					X							
Division Phaeophyta (Brown)												
Chnoospora implexa								X				X
Chnoospora minima	X							X	X			X
Colpomenia sinuosa								X	X			X
Dictyopteris australis								X	X			
Dictyopteris plagiogramma								X	X	X		

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Dictyopteris repens	X								X	X	X	X
Dictyota acutiloba								X	X			
Dictyota bartayresiana								X			X	X
Dictyota cervicornis												X
Dictyota crenulata									X			
Dictyota divaricata					X			X	X	X	X	X
Dictyota friabilis	X		X		X			X	X			
Dictyota hamifera											X	
Dictyota lata	X											
Dictyota patens											X	X
Dictyota sandvicensis								X				
Dictyota sp.							X		X			
Dictyota sp. 1										X		
Dictyota sp. 2										X		
Dilophus radicans												X
Ectocarpus vanbosseae	X											
Ectocarpus sp.					X		X					
Endarachne binghamiae								X				

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Feldmannia indica	X	X			X		X		X		X	X
Feldmannia irregularis					X		X					
Hapalospongidion pangoense	X							X				X
Hincksia breviarticulata	X						X	X	X	X	X	
Hincksia conifera									X			
Hincksia mitchelliae									X			
Homoeostrichus flabellatus											X	
Hormophysa triquetra											X	
Hydroclathrus clathratus								X	X		X	X
Lobophora papenfussii					X							
Lobophora variegata					X		X	X	X	X	X	X
Nemacystus decipiens									X			
Padina australis								X				
Padina boergesenii									X			
Padina crassa									X			
Padina gymnospora												X
Padina japonica								X	X			
Padina jonesii											X	X

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Padina pavonia								X		X		X
Padina tenuis											X	X
Padina thivyi								X				
Padina sp.										X		
Ralfsia occidentalis								X				
Rosenvingea intricata								X			X	X
Sargassum anapense	X											
Sargassum crassifolium												X
Sargassum cristaefolium											X	X
Sargassum echinocarpum								X	X			
Sargassum fonanonense	X											
Sargassum hawaiiensis									X			
Sargassum microphyllum											X	
Sargassum obtusifolium								X	X			
Sargassum piluliferum									X			
Sargassum polycystum												X
Sargassum polyphyllum								X	X			
Sargassum tenerrimum												X

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Sargassum sp.									X			
Spatoglossum solierii								X				
Sphacelaria ceylanica	X											
Sphacelaria cornuta	X											
Sphacelaria furcigera	X				X		X	X				X
Sphacelaria novae-hollandiae					X		X	X	X			X
Sphacelaria rigidula									X			
Sphacelaria tribuloides							X		X			X
Sphacelaria sp.		X			X						X	
Sporochnus dotyi									X			
Stypopodium hawaiiensis								X	X		X	
Turbinaria condensata												X
Turbinaria ornata	X	X						X	X	X	X	X
Turbinaria trialata					X						X	X
Zonaria hawaiiensis												X

Division Rhodophyta (Red)

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Acanthophora pacifica								X				
Acanthophora spicifera								X			X	X
Acrochaetium actinocladium								X				
Acrochaetium barbadense								X				
Acrochaetium butleriae								X				
Acrochaetium corymbifera								X				
Acrochaetium dotyi								X				
Acrochaetium gracile					X							
Acrochaetium imitator								X				
Acrochaetium liagorae								X				
Acrochaetium microscopicum								X				
Acrochaetium nemalionis								X				
Acrochaetium robustum					X			X				
Acrochaetium seriatum								X				
Acrochaetium trichogloeae								X				
Acrochaetium sp.									X			
Acrosymphyton taylorii								X				
Actinotrichia fragilis	X							X			X	X

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Actinotrichia robusta											X	
Aglaothamnion boergesenii								X		X		
Aglaothamnion cordatum								X	X			
Ahnfeltiopsis concinna								X				
Ahnfeltiopsis divaricata												
Ahnfeltiopsis flabelliformis												
Ahnfeltiopsis pygmaea												
Alsidium cymatophilum								X				
Alsidium pacificum					X							
Amansia glomerata									X			X
Amphiroa anceps	X											
Amphiroa beauvoisii								X	X			
Amphiroa crassa	X											
Amphiroa foliacea	X							X				X
Amphiroa fragilissima	X							X	X		X	X
Amphiroa rigida								X				
Amphiroa valonioides								X				
Amphiroa sp.							X					

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Anotrichum secundum	X							X				
Anotrichum tenue								X				
Antithamnion antillanum					X		X	X				
Antithamnion decipiens								X	X			
Antithamnion erucacladellum								X				
Antithamnion nipponicum								X				
Antithamnion palmyrense					X							
Antithamnion percurrens								X				
Antithamnion sp.									X			
Antithamnionella breviramosa								X	X			
Antithamnionella graeffei								X				
Apoglossum gregarium								X				
Ardreanema seriospora								X				
Arthrocardia sp.								X				
Asparagopsis taxiformis	X				X			X	X		X	X
Asterocystis ornata					X		X					
Balliella repens								X				
Bangia atropurpurea								X	X			

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Bostrychia tenella	X											
Botryocladia skottsbergii								X			X	
Botryocladia tenuissima								X				
Branchioglossum prostratum								X				
Callidictyon abyssorum								X				
Callithamniella pacifica								X				
Callithamnion marshallensis							X					
Callithamnion sp.							X		X			
Calloglossa leprieurii					X		X					
Calloglossa viellardii	X											
Caulacanthus ustulatus								X				
Carpopeltis bushiae												
Centroceras clavulatum	X				X		X	X	X		X	X
Centroceras corallophilloides								X				
Centroceras minutum					X			X				X
Ceramium aduncum								X				
Ceramium affine							X		X			
Ceramium borneense								X				

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Ceramium byssoideum	X											
Ceramium cingulum								X				
Ceramium clarionense					X			X	X			
Ceramium codii					X			X				
Ceramium dumosertum								X				
Ceramium fimbriatum							X	X				
Ceramium flaccidum								X	X			
Ceramium gracillimum		X			X		X					
Ceramium hamatispinum								X	X			
Ceramium hanaense								X				
Ceramium jolyi								X				
Ceramium masonii					X							
Ceramium maryae							X					
Ceramium mazatlanense	X							X	X		X	
Ceramium paniculatum								X				
Ceramium punctiforme	X							X				
Ceramium serpens					X			X				
Ceramium taylori					X							

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Ceramium tenuissimum								X				
Ceramium tranquillum								X				
Ceramium vagans					X		X	X				X
Ceramium womersleyi								X				
Ceramium zacae							X					
Ceramium sp.		X			X		X		X			
Ceratodictyon spongiosum											X	
Chamaebotrys boergesenii								X				
Champia compressa	X											X
Champia parvula							X	X	X			X
Champia vieillardii								X				
Cheilosporum acutilobum	X											
Cheilosporum spectabile	X											
Chondracanthus acicularis								X				
Chondracanthus tenellus								X				
Chondria arcuata								X				
Chondria dangeardii								X				
Chondria minutula								X				

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Chondria polyrhiza								X				
Chondria simpliciuscula								X				
Chondria repens					X		X		X			
Chondria sp.									X			
Chondria sp. 1									X			
Chondria sp. 2									X			
Chondrus ocellatus								X				
Chroodactylon ornatum								X				
Chrysymenia kairnbachii								X				
Chrysymenia okamurae								X				
Chrysymenia procumbens								X				
Coelarthrum albertisii									X			
Coelarthrum boergesenii									X			
Coelothrix irregularis								X				
Corallina elongata								X				
Corallophila apiculata					X		X	X	X			
Corallophila huysmansii							X	X				X
Corallophila itonoi								X				

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Corallophila ptilocladioides								X				
Crouania mageshimensis								X	X			
Crouania minutissima							X	X	X			
Crouania sp.								X				
Cruoriella dubyi					X							
Cruoriopsis mexicana					X							
Cryptonemia decumbens	X											
Cryptonemia umbraticola					X			X				
Cryptonemia yendoi												
Cryptopleura corallinara								X				
Cubiculosporum koronicarpus								X				
Dasya adhaerens							X					
Dasya bailouvianna									X			
Dasya corymbifera									X			
Dasya kristeniae								X				
Dasya murrayana								X				
Dasya pilosa								X				
Dasya sinicola							X					

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Dasya villosa									X			
Dasya sp.							X	X				
Dasyopsis sp.								X				
Dasyphila plumarioides												X
Delesseriopsis elegans								X				
Dermocorynus occidentalis								X				
Dermonema virens											X	
Dermonema pulvinatum								X				
Diplothamnion jolyi								X				
Ditria reptans								X	X			
Dotyophycus pacificum								X				
Dotyophycus yamadae								X				
Dotyella hawaiiensis								X	X			
Dotyella irregularis								X				
Dudresnaya hawaiiensis								X				
Dudresnaya littleri								X				
Dudresnaya sp.									X			
Erythrocladia irregularis					X							

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Erythrocolon podagricum								X				
Erythrotrichia carnea					X			X				
Erythrotrichia parietalis					X							
Erythrotrichia sp.							X					
Eucheuma denticulatum							X					
Eupogodon sp.									X			
Euptilocladia magruderi								X				
Exophyllum wentii								X				
Fernandosiphonia ecorticata								X				
Fernandosiphonia nana								X				
Fosliella farinosa												X
Galaxaura elongata											X	
Galaxaura fasciculata								X				
Galaxaura fastigiata								X				
Galaxaura filamentosa	X							X			X	X
Galaxaura glabriuscula												X
Galaxaura marginata	X							X			X	X
Galaxaura obtusata								X			X	

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Galaxaura pacifica									X		X	
Galaxaura rugosa	X							X	X		X	
Galaxaura subfructiculosa											X	
Galaxaura subverticillata								X				
Galaxaura sp.									X			
Ganonema farinosum								X				
Gelidiella acerosa								X				X
Gelidiella antipai								X				
Gelidiella bornetii					X							
Gelidiella machrisiana								X				
Gelidiella myrioclada								X				X
Gelidiella stichidiospora					X							
Gelidiella womersleyana												
Gelidiella sp.	X											
Gelidiocolax mammillata								X				
Gelidiopsis acrocarpa												X
Gelidiopsis intricata	X				X			X	X		X	X
Gelidiopsis pannosa											X	X

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Gelidiopsis repens	X											
Gelidiopsis rigida												X
Gelidiopsis scoparia								X				
Gelidiopsis variabilis								X				
Gelidiopsis sp.			X									
Gelidium abbotiorum	X											
Gelidium crinale					X		X	X				
Gelidium delicatulum	X											
Gelidium pluma								X				
Gelidium pusillum	X				X		X	X	X		X	X
Gelidium reediae								X				
Gelidium samoense	X											
Gibsmithia dotyi								X				
Gibsmithia hawaiiensis	X							X				
Gloiocladia iyoensis								X				
Goniolithon frutescens					X							
Goniotrichum alsidii							X					
Goniotrichum elegans					X							

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Gracilaria abbottiana								X				
Gracilaria arcuata												X
Gracilaria bursapastoris								X				
Gracilaria cacalia												X
Gracilaria coronopifolia								X	X			
Gracilaria dawsonii								X				
Gracilaria dotyi								X				
Gracilaria edulis											X	
Gracilaria epihippisora								X				
Gracilaria filiformis								X				
Gracilaria lemaneiformis								X				
Gracilaria lichenoides								X				X
Gracilaria minor											X	X
Gracilaria radicans												X
Gracilaria parvispora								X				
Gracilaria salicornia								X				X
Gracilaria tikvahiae								X				
Gracilaria verrucosa												X

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Grateloupia filicina								X				
Grateloupia hawaiiana								X				
Grateloupia phuquocensis								X				
Griffithsia heteromorpha								X				
Griffithsia metcalfii							X	X				
Griffithsia ovalis							X					
Griffithsia schousboei								X				
Griffithsia subcylindrica								X				
Griffithsia tenuis							X					X
Griffithsia sp.					X		X					
Gymnogongrus sp.								X				
Gymnothamnion elegans								X				
Halarachnion calcareum												X
Halichrysis coalescens								X				
Haliptilon subulatum								X	X			
Haloplegma duperreyi	X							X	X			
Halymenia actinophysa								X				
Halymenia chiangiana								X				

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Halymenia cromwellii								X				
Halymenia durvillaei												X
Halymenia formosa								X				
Halymenia lacerata											X	X
Halymenia stipitata								X				
Hawaiia trichia								X				
Helminthocladia rhizoidea								X				
Helminthocladia simplex								X				
Herposiphonia arcuata								X				X
Herposiphonia crassa								X				
Herposiphonia delicatula								X	X			
Herposiphonia dendroidea									X			X
Herposiphonia dubia								X	X			
Herposiphonia nuda								X	X			
Herposiphonia obscura								X				X
Herposiphonia pacifica								X	X			X
Herposiphonia parca								X	X			
Herposiphonia secunda	X				X			X	X			X

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Herposiphonia variabilis								X				X
Herposiphonia sp.							X		X			
Heterosiphonia crispella					X		X	X	X			
Heteroderma subtilissima					X							
Heteroderma sp.					X							
Hydrolithon breviclavium								X				
Hydrolithon reinboldii	X							X	X			X
Hypnea cervicornis								X	X			
Hypnea chloroides								X				
Hypnea chordacea								X				
Hypnea esperi					X		X		X		X	X
Hypnea musciformis								X				
Hypnea nidulans	X				X							
Hypnea pannosa	X							X	X			X
Hypnea rugulosa								X				
Hypnea spinella					X			X	X			
Hypnea valentiae								X				
Hypnea sp.		X										

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Hypnea sp. 1									X			
Hypnea sp. 2									X			
Hypneocolax stellaris								X				
Hypoglossum attenuatum	X										X	
Hypoglossum barbatum								X				
Hypoglossum caloglossoides								X				
Hypoglossum minimum								X				
Hypoglossum rhizophorum								X				
Hypoglossum simulans								X				
Hypoglossum sp.									X			
Janczewskia hawaiiana								X				
Jania adhaerens	X							X				
Jania capillacea	X	X			X		X		X		X	X
Jania decussato-dichotoma					X		X		X		X	
Jania mexicana									X			
Jania microarthrodia			X					X	X	X		
Jania natalensis									X			
Jania pumila								X				

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Jania radiata												X
Jania tenella					X						X	X
Jania ungulata									X			
Jania verrucosa								X				
Jania sp.								X				
Kallymenia sessilis								X				
Kappaphycus alvarezii								X				
Kappaphycus striatum								X				
Laurencia brachyclados								X				
Laurencia cartilaginea								X				
Laurencia ceylanica	X										X	X
Laurencia corymbosa									X			
Laurencia crustiformans								X				
Laurencia decumbens								X				
Laurencia dotyi								X				
Laurencia forsteri								X				
Laurencia galtsoffii								X	X			
Laurencia glandulifera								X				

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Laurencia intricata											X	X
Laurencia majuscula								X	X			X
Laurencia mariannensis								X				
Laurencia mcdermidiae								X				
Laurencia nana		X	X									
Laurencia nidifica	X							X	X			
Laurencia obtusa								X	X		X	X
Laurencia papillosa	X											
Laurencia parvipapillata								X	X			
Laurencia perforata									X		X	
Laurencia pygmaea									X			
Laurencia rigida											X	X
Laurencia succisa								X			X	
Laurencia surculigera											X	
Laurencia tenera								X				
Laurencia tropica											X	
Laurencia undulata								X				
Laurencia yamadana								X				

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Laurencia sp.					X		X		X			X
Laurencia sp. 1									X			
Laurencia sp. 2									X			
Laurencia sp. 3									X			
Laurencia sp. 4									X			
Laurencia sp. 5									X			
Lejolisia colombiana					X							
Lejolisea pacifica								X				
Leveillea jungermannioides								X			X	X
Liagora albicans								X				
Liagora boergesenii								X				
Liagora ceranoides								X	X			
Liagora coarctata									X			
Liagora divaricata								X				
Liagora farinosa									X			
Liagora hawaiiana								X	X			
Liagora hirta	X											
Liagora kahukuana									X			

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Liagora orientalis								X	X			
Liagora papenfussii								X	X			
Liagora perennis												
Liagora pinnata								X				
Liagora samaensis								X				
Liagora robusta									X			
Liagora setchellii								X	X			
Liagora tetrasporifera								X				
Liagora valida								X	X			
Liagora sp.	X									X	X	
Liagorophyla endophytica								X				
Lithophyllum kaiserii	X											
Lithophyllum kotschyanum								X			X	X
Lithophyllum moluccense	X										X	X
Lithophyllum sp.								X				
Lithoporella melobesioides											X	X
Lithoporella pacifica												X
Lithoporella sp.	X											

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Lithothamnion asperulum												X
Lithothamnion byssoides								X				
Lithothamnion funafutiense												X
Lithothamnion philippii												X
Lithothamnion spp.					X				X			
Lomentaria hakodatensis					X		X	X				
Lomentaria sp.		X										
Lophocladia kipukaia								X				
Lophocladia trichoclados									X			
Lophosiphonia bermudensis					X							
Lophosiphonia cristata								X	X			
Lophosiphonia obscura	X											
Lophosiphonia prostrata								X				
Lophosiphonia scopulorum					X							
Lophosiphonia sp.					X							
Martensia fragilis	X							X	X		X	X
Mastophora lamourouxii												X
Mastophora macrocarpa												X

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Mastophora melobesoides	X											
Mastophora plana												X
Mastophora rosea												X
Mazzaella volans								X				
Malaconema minimum								X				
Melanamansia daemelii								X				
Melanamansia fimbrifolia								X				
Melanamansia glomerata								X				
Mesophyllum erubescens	X											X
Mesophyllum mesomorphum	X							X				X
Mesophyllum simulans	X											X
Micropeuce setosus								X				
Monosporus indicus								X				
Murrayella periclados												X
Myriogramme bombayensis								X				
Naccaria hawaiiana								X				
Neogoniolithon brasica-florida	X				X			X			X	X
Neogoniolithon fosliei												X

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Neogoniolithon medioramus												
Neogoniolithon pacificum												X
Neogoniolithon reinboldii											X	
Neomartensia flabelliformis								X				
Nitophyllum adhaerens								X				
Osmundaria obtusiloba								X				
Ossiella pacifica								X				
Peleophycus multiprocarpium								X				
Peyssonelia conchicola								X				
Peyssonelia corallis											X	X
Peyssonelia delicata	X											
Peyssonelia foveolata	X											
Peyssonelia inamoena								X				
Peyssonelia mariti	X											
Peyssonelia rubra	X				X			X				
Peyssonelia sp.									X			
Phaeocolax kajimurai								X				
Platoma ardreanum								X				

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Pleonosporium caribaeum								X				
Peonosporium intricatum								X				
Plocamium sandwicense								X	X			
Polyopes hakalauensis								X				
Polysiphonia anomala								X				
Polysiphonia apiculata								X				X
Polysiphonia beaudettei								X				
Polysiphonia delicatula								X				X
Polysiphonia exilis								X	X			
Polysiphonia flaccidissima								X				X
Polysiphonia hancockii								X				
Polysiphonia hawaiiensis								X				
Polysiphonia herpa								X				X
Polysiphonia homoia								X				
Polysiphonia howei								X				
Polysiphonia pentamera								X				
Polysiphonia poko								X				X
Polysiphonia polyphysa									X			

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Polysiphonia poko								X				
Polysiphonia profunda								X				
Polysiphonia pseudovillum								X				
Polysiphonia rubrorhiza								X	X			
Polysiphonia saccorhiza								X	X		X	
Polysiphonia savatieri								X	X			X
Polysiphonia scopulorum	X				X			X	X			X
Polysiphonia setacea								X				X
Polysiphonia simplex								X	X			
Polysiphonia sparsa								X				X
Polysiphonia sphaerocarpa								X	X			X
Polysiphonia subtilissima								X				
Polysiphonia tepida								X				
Polysiphonia tongatensis	X							X				
Polysiphonia triton								X				
Polysiphonia tsudana								X				
Polysiphonia tuberosa												
Polysiphonia upolensis								X	X			X

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Polysiphonia sp.	X				X		X		X		X	X
Polystrata dura	X											
Porolithon craspedium					X						X	X
Porolithon gardineri					X			X				
Porolithon marshallense					X							
Porolithon onkodes	X				X			X			X	X
Porolithon sp.									X			
Porphyra vietnamensis								X				
Portieria hornemanni	X							X	X		X	X
Predaea laciniosa								X				
Predaea weldii								X				
Prionitis corymbifera								X				
Prionitis obtusa	X											
Pterocladia capillacea								X				
Pterocladia musiformis					X							
Pterocladia parva									X			X
Pterocladia tropica					X							
Pterocladia sp.					X							

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Pterocladiella bulbosa								X				
Pterocladiella caerulescens								X				
Pterocladiella caloglossoides								X				
Pterocladiella capillacea								X				
Pterosiphonia pennata								X				
Ptilocladia yuenii								X				
Ptilothamnion cladophorae								X				
Pugetia sp.									X			
Reticulocaulis mucosissimus								X				
Rhodolachne decussata								X				
Rhodymenia sp.	X											
Rhodymenia leptophylla								X				
Scinaia furcata								X				
Scinaia hormoides								X				
Spermothamnion sp.					X				X			
Spirocladia barodensis								X				
Spirocladia hodgsoniae								X				
Sporolithon erythraeum	X							X			X	

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Sporolithon schmidtii												X
Sporolithon sibogae	X											
Spyridia filamentosa	X							X	X			X
Stenopeltis gracilis								X			X	
Stenopeltis liagoroides								X				
Stenopeltis setchelliae								X				
Stictosiphonia kelanensis												X
Stylonema alsidii	X							X				
Stylonema cornu-cervi								X				
Symphyocladia marchantioides								X			X	
Taenioma macrourum							X					
Taenioma perpusillum								X	X			
Tayloriella dictyurus								X				
Tenarea tessellatum								X				
Tiffaniella codicola									X			
Tiffaniella saccorhiza								X	X			
Titanophora marianensis												X
Titanophora pikeana								X				

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Tolypiocladia glomerulata	X							X			X	X
Trichogloea lubrica								X				
Trichogloea requienii								X	X			
Trichogloeopsis hawaiiana								X	X			
Irichogloeopsis mucosissima								X				
Tricleocarpa cylindrica								X	X			
Tricleocarpa fragilis								X	X		X	X
Ululania stellata								X				
Vanvoorstia coccinea								X				
Vanvoorstia spectabilis								X				
Womersleyella pacifica								X				
Wrangelia anastomosans											X	
Wrangelia dumontii								X				
Wrangelia elegantissima								X				
Wrangelia penicillata								X				
Wrangelia tenuis									X			
Wurdemannia miniata					X			X			X	X
Wurdemannia sp.							X					

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Yamadaella coenomyce								X				

***References Used:** Birkland *et al.* 1994; Setchell 1924; Tsuda and Trono 1968; Dawson 1959; Dawson *et al.* 1955; Hillis- Colinvaux 1959; Buggeln and Tsuda 1969; Vernon *et al.* 1966; Abbott 1988; 1999; Bailey and Harvey 1862; Egerod 1952; Eldredge and Paulay 1996; Magruder and Hunt 1979; Abbott 1989; Anon 1999; Bailey and Harvey 1862; Eldredge *et al.* 1977; Tsuda 1981; Tsuda and Wray 1977; Eldredge and Paulay 1996; Gilbert 1978; Gordon 1976; Itono and Tsuda 1980; King and Puttock 1989; Nam and Saito 1991; Tsuda 1981; Tsuda and Wray 1977

Management Unit Profiles: **Porifera (sponges)**

Important summary documents
Moore (1955) described the paleosponges and their dominance in ancient reefs. Early records of Pacific sponges Bowerbank (1873) and Agassiz (1906). Bergquist (1965,1967, and 1977) catalogued sponges in Micronesia and Hawaii. Kelly-Borges and Valentine (1995) have reviewed the status of the sponges of Hawaii.

Taxonomic issues
No overall classification of the *Porifera* exists. Calcarea: Burton (1963); Vacelet (1970). Demospongiae Levi (1973) and Bergquist (1978). Sclerospongiae: Hartman & Goreau (1970, 1975) Hexactinellida: Ijima (1927). De Laubenfels (1950a,b 1951, 1954; 1957) recorded the sponges from Hawaii. Species numbers: 84 species in Hawaii Berquist (1977); Chave and Jones (1991); 5000-9000 spp. (Colin and Arneson, 1991) and 10,000 spp. George and George (1979) world-wide.

Habitat utilization
Use of chemical agents in competing for substrate. Often found at depth, in caves, and vertical areas where not colonized by hard coral. Rutzler and Rieger (1973) described the burrowing sponge *Cliona* into a calcareous substrate.

Life History

Adult: appearance and physical characteristic
Vary greatly in size. The majority are irregular and exhibit massive, erect, encrusting, or branching growth pattern. Many are brightly colored. The body of the sponge is a system of water canals, where with incurrent pores allow water to flow into the atrium and out through the osculum (asconoid, syconoid, and leuconoid plans). The skeleton may be composed of calcareous and silaceous spicules, protein spongin fibers. The spicules exist in a variety of forms and are important in the identification and classification of species.

Of pharmaceutical interest due to the biologically active compounds, most probably used in defense. Some compounds affective against certain tumors and potential effective in treating other diseases.

Reproductive strategies
Sexual (viviparous and oviparous), asexual and hermaphroditic. Synchronous release of gametes triggered by lunar or daily cycles. Eggs develop into larvae which swim or creep along the bottom. Asexual reproduction is through budding, fragmentation and

gemmules (Barnes, 1987, Fromont, 1994). Recruitment may occur by fragmentation from predation (Kelly-Borges and Berguist, 1988).

Distribution

Table 5 shows the distribution of the sponges in some of the AFPI. In Guam and Mariana Islands Bryan(1973). Briggs (1974) provided information on broad distributions as did Hooper and Levi, 1994. In Hawaii, biological interactions affect the occurrence of the sponge *Damiriana hawaiiana* Casper (1981). Encrusting sponges may kill corals (Plucer-Rosario, 1987).

Feeding and food

Partical feeding and ingestion of plankton and bacteria (Reiswig 1971,1975a) Utilization of DOM, directly or indirectly, by symbiotic cyanobacteria (Barnes 1987; Wilkinson, 1979, 1983).

Behaviour

Symbiosis common which includes shrimps, crabs, barnacles, worms, brittlestars, holothurians, and other sponges (Colin and Arneson, 1991). *Tethya sp.* produces filamentous extensions for mobility. *Placospongia* rapidly closes its plate-like surface when touched. *Tedania* (fire sponge) causes burning due to spicules and chemicals. *Hippospongia* and *Spongia* are used as bath sponges.

Diurnal rhythm in the active flow of water (Reiswig, 1971)

Spawning : spatial and temporal distribution

Lunar and diurnal periodicity

Appearance and physical characteristics of eggs (size, shape, color, etc) and duration of phase

During mass spawning events (Reiswig, 1971), sperm appears as clouds of smoke. In some cases, release of eggs causes appearance of opaque mucous covering sponge (Colin and Arneson, 1995).

Larvae: appearance and physical characteristics of larvae

The larval metamorphosis is described by Simpson (1986).

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Table 5: Distribution of sponges within the American Affiliated Pacific Islands (AFPI) (after Kelly-Borges and Valentine, 1995)

AS: American Samoa; HI: Hawaiian Islands; NMI: Commonwealth of Northern Mariana Islands; GU: Guam

Taxonomy/occurrence	AS	HI	CNMI	GU
DEMOSPONGIAE				
Homosclerophorida				
Oscarella tenuis		X		
Plakina monolopha		X		
Plakortis simplex		X		
Astrophorida				
Ancorina acervus			X	
Asteropus kaena		X		
Dorypleres splendens			X	
Erylus caliculatus		X		
Erylus proximus		X		
Erylus rotundus		X		
Erylus sollasi		X		
Geodia gibberella		X		
Jaspis stellifera			X	
Melophlus sarasinorum				X
Rhabdastrella pleopora		X		
Stelletta debilis		X		
Zaplethes digonoxea		X		
Lithistida				
Aciculites papillata			X	
Leidermatium sp		X		
Spirophorida				

Taxonomy/occurrence	AS	HI	CNMI	GU
Cinachyra porosa			X	
Paratetilla bacca			X	
Hadromerida				
Anthosigmella valentis		X		
Chondrosia chucalla		X		
Chondrosia corticata			X	
Chondrosia sp		X		
Cliona vastifica		X		
Diplastrella spiniglobata		X		
Kotimea tethya		X		
Placospongia carinata			X	
Prosuberites oleteira		X		
Spheciospongia aurivilla			X	
Spheciospongia purpurea			X	
Spheciospongia vagabunda		X	X	
Spirastrella coccinea		X		
Spirastrella keaukaha		X		
Terpios aploos				X
Terpios granulosa		X		
Terpios hoshinoto				X
Terpios sp				X
Terpios zeteki		X		
Tethya coccinea			X	
Tethya diploderma		X		
Tethya robusta			X	
Timea xena		X		
Halichondrida				

Taxonomy/occurrence	**AS**	**HI**	**CNMI**	**GU**
Axechina lissa		X		
Axinella solenoides		X		
Axinyssa aplysinoides				X
Axinyssa pitys			X	
Axinyssa terpnis			X	
Axinyssa xutha			X	
Ciocalypta pencillus		X		
Cymbastella cantherella			X	
Densa mollis			X	
Eurypon distincta		X		
Eurypon nigra		X		
Halichondria coerulea		X		
Halichondria dura		X		
Halichondria melanadocia		X		
Higginsia anfractuosa			X	
Higginsia mixta			X	
Homaxinella anamesa		X		
Hymeniacidon chloris		X		
Myrmekioderma granulata			X	
Myrmekioderma sp.				X
Phycopsis aculeata		X		
Pseudaxinella australis			X	
Raphisia myxa		X		
Rhabderemia sorokinae			X	
Stylotella aldis			X	
Stylotella aurantium			X	X
Ulosa rhoda		X		

Taxonomy/occurrence	AS	HI	CNMI	GU
Haplosclerida				
Adocia gellindra		X		
Adocia turquosia			X	
Adocia viola				X
Aka mucosa			X	
Amphimedon sp				X
Callyspongia aerizusa			X	
Callyspongia diffusa		X		X
Callyspongia parva			X	
Gellius gracilis			X	
Haliclona acoroides			X	
Haliclona aquaeducta		X		
Haliclona flabellodigitata		X		
Haliclona koremella			X	
Haliclona lingulata				X
Haliclona pellasarca			X	
Haliclona permollis		X		
Haliclona streble			X	
Haliclona viridis			X	
Niphates cavernosa			X	
Niphates spinosella			X	
Sigmadocia amboinensis			X	
Sigmadocia symbiotica			X	
Toxadocia violacea		X		
Petrosida				
Pellina eusiphonia		X	X	
Pellina pulvilla				X

Taxonomy/occurrence	AS	HI	CNMI	GU
Pellina sitiens		X		
Petrosia puna		X		
Xestospongia sp				X
Poecilosclerida				
Acamas caledoniensis			X	
Amphinomia sulphurea			X	
Axociella kilauea		X		
Biemna fortis			X	
Clathria frondifera				X
Clathria procera		X		
Clathria vulpina			X	
Coelocartaria singaporense			X	
Crella spinulata			X	
Damiriana hawaiiana		X		
Desmacella lampra			X	
Echinodictyum antrodes				X
Esperiopsis anomala		X		
Iotrochota baculifera			X	
Iotrochota protea		X		
Kaneohea poni		X		
Lissodendoryx calypta		X		
Lissodendoryx oxytes			X	
Microciona eurypa			X	
Microciona cecile			X	
Microciona haematodes		X		
Microciona maunaloa		X		
Mycale cecilia		X		

Taxonomy/occurrence	AS	HI	CNMI	GU
Mycale contarenii		X		
Mycale maunakea		X		
Myxilla rosacea		X		
Naniupi ula		X		
Prianos phlox			X	
Strongylacidon sp.		X		
Tedania ignis		X		
Tedania macrodactyla		X		
Xytopsiphum kaneohe		X		
Xytopsiphum meganese		X	X	
Xytopsues zukerani		X		
Zygomycale parishii		X		
Dictyoceratida				
Coscinoderma denticulatum		X		
Fasciospongia chondrodes			X	
Hippospongia densa		X		
Hippospongia metachromia			X	
Hyrtios erecta				X
Lendenfeldia dendyi			X	
Lufferiella sp		X		
Lufferiella variabilis				X
Spongia irregularis dura		X		
Spongia irregularis lutea		X		
Spongia irregularis mollior		X		
Spongia irregularis tenuis		X		
Spongia denticulata		X		
Spongia oceania		X		

Taxonomy/occurrence	AS	HI	CNMI	GU
Stelospongia lordii		X		
Strepsichordaia lendenfeldi			X	
Verongida				
Aplysinella strongylata			X	
Aplysinella tyroeis			X	
Ianthella basta				X
Psammaplysilla purpurea		X		
Psammaplysilla verongiformis			X	
Dendroceratida				
Aplysilla rosea		X		X
Aplysilla sulphurea		X		
Aplysilla violacea		X		
Dendrilla cactus		X		
Dendrilla nigra			X	
Dysidea avara		X	X	X
Dysidea fragilis			X	
Dysidea herbacea		X		
Dysidea sp		X		X
Euryspongia lobata			X	
Pleraplysilla hyalina		X		
Slerosponges				
Acanthochaetetes wellsi			X	
Astrosclera willeyana			X	X
Stromatospongia micronesica			X	X
CALCAREA				
Clathrina sp		X		
Leucetta avacado				X

Taxonomy/occurrence	AS	HI	CNMI	GU
Leucetta solida		X		
Leuconia kaiana		X		
Leucosolenia eleanor		X		
Leucosolenia vesicula		X		
Murrayona phanolepis			X	
Sycandra coronata		X		
Sycandra parvula		X		
Sycandra staurifera		X		
HEXACTINELLIDA				
Euplectella sp		X		
Stylocalyx elegans		X		

Management Unit: **Millepora sp. (Linnaeus, 1758) (Stinging or Fire coral)**

Important summary documents

Lewis (1989) discussed the ecology of Millepora. Growth and age were investigated (Lewis, 1991).

Taxonomic issues

Class Hydrozoa: Order Milleporina (Hydroidea): Family Milleporidae: 48 species
The history of *Millepora* taxonomy has been the opposite of scleractinian taxonomy where each minor growth form was often described as a new species (Veron, 1986).

Habitat utilization

Found on projecting parts of the reef where tidal currents are strong. They are also abundant on upper reef slopes and in lagoons and may be a dominant component of some coral communities (Veron, 1986).

Life History

Adult: appearance and physical characteristic

Colonial and hermatypic. Arborescent, plate-like, columnar or encrusting with a smooth surface perforated by near-microscopic pores. These are of two sizes: the larger are the gastropores, with each surrounded by five to seven smaller dactylopores. Fine straight hairs, visible under water, project from the colony surface. The growth variation is often based on environmental influences. Colors are green, cream or yellow. May be tan-coloured antler-like sheets with branch ends whitish.

Distribution

Globally, the genus is distributed from as far south as South Africa and southern Western Australia to the Kyushu Islands. From the African coast of western Indian Ocean and the Red Sea to Hawaii and the Marquesas in the east. The genus occurs in the Caribbean Sea.

Following is a summary of some Indo-Pacific species (adapted from Lewis 1989): their morphology, depth and reef zone and water circulation requirements.

Table 6. Species Summary of the genus *Millepora* (Lewis 1989)

Species	Form	Location on reef	Habitat type
Millepora dichotoma	Fan, branches, vertical sheets and walls	0-5m, reef edge	Turbulent, area of the surf

M. exaesa	Robust branches or solid and round	0-10m, reef edge, outer reef slope	Moderate to turbulent
M. platyphylla	Sheets, leaves fans branches	0-10m, reef edge, reef flat	Strong to powerful, turbulent
M. tenella	Fans, branches, sheets	0-10m, reef edge, outer reef slope	medium to strong

Feeding and food

Gastrozoiids consume food and are the colony polyps have tentacles and a gastrovascular cavity. The dactylozoiids are used for prey capture and have numerous tentacles, which convey a fuzzy appearance. They have a potent sting. Autotrophic due to zooxanthellae but may rely on small plankton and dissolved nutrients.

Reproductive strategies

Alternation of generations: a sessile, asexual polyp stage and a free-living, sexual medusa stage. Medusa are reproduced by asexual division or budding. The medusa has separate sexes and produce eggs or sperm, which unite and develop into free-swimming planula larvae. Planula larvae are able to swim freely, though largely planktonic.

References

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Veron J. E. N. 1986: *Coral of Australia and the Indo-Pacific.* Angus and Robertson. ISBN 0 207 15116 4.

Management Unit: **Stylasteridae (Gray, 1847) (Stylasterines; Lace Corals)**

Important summary documents

Veron (1986) Colin and Arneson (1995) and Fossa and Nilsen (1998) provide description of the family.

Taxonomic issues

Class Hydrozoa; Class Stylasterina; Family Stylasteridae
Approximately 15 genera. Two are common reef genera: *Stylaster* Gray 1831 (48 species); *Distichopora* Lamarck 1816 (34 species) (Veron, 1986).
Taxonomy at the species level poorly known.

Habitat utilization

With in the reef, sciaphilic or low light, often abundant under overhangs or on the roof of caves. Also found in deep reef conditions particularly if swept by tidal currents (Colin and Arneson, 1995)

Life History

Adult: appearance and physical characteristic

Colonial, ahermatypic, usually arborescent, with tubular gastropores surrounded by smaller dactylopores and usually forming cyclosystems (Veron, 1986). Colour is bright and may be red, pink, orange, purple or white.

Stylaster spp.: Colonies are arborescent with fine branches, growing in one plane, which seldom anastomose. Cyclosystems alternate left and right side of branches.

Distichopora spp.: Colonies are arborescent with flattened, blunt-ended, non-anastomosing branches of uniform width, growing in one plane. There are no cyclosystems: gastropores are aligned along the lateral margins of branches with rows of dactylopores on either side (Veron, 1986; Sheer and Obrist, 1986).

Distribution

Stylaster spp.: Worldwide, extending to the Arctic and Antarctic.
Distichopora spp.: Circum-Australia and the Indo-Pacific.

Feeding and food

No zooxanthellae so heterotrophic, feeding presumably on small plankton. Dissolved nutrient absorption must be important.

Reproductive strategies

Sexual individuals, the gonophores, develop in ampullae between the gastropores and release planula larvae.

References

Colin, P. L., and C. Arneson. 1995. Tropical Pacific Invertebrates. San Diego: Coral Reef Press, California, USA.

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Veron J. E. N. 1986. *Coral of Australia and the Indo-Pacific.* Angus and Robertson. ISBN 0 207 15116 4.

Management Unit: **Solanderidae; Gray (Hydroid fans)**

Important summary documents
Cooke (1977) described Hawaiian fauna all, of which, have a wider distribution.

Taxonomic issues
Class Hydrozoa; Order Hydroida; Suborder Athecata (=Anthomedusa; Gymnoblastea); Family Solanderiidae (George and George, 1977; Barnes, 1987).

Habitat utilization
Shallow water to 100 metres (Colin and Arneson, 1995).
Often found in deeper water ore cave or overhang environment (Cooke, 1977).

Life History

Adult: appearance and physical characteristic
Similar in appearance to gorgonians and other sea fans. May be branching, ramose or encrusting. Branching in one plane, perpendicular to the current or wave action. Commonly found in exposed areas on wave swept shallow outer reefs (Colin and Arneson, 1995). *Solanderia spp.* is branching and may be 30cm high. Family is characterized by the presence of a perisarc composed of anastomosing chitinous fibers with scattered capitate tentacles (Cooke, 1977).

Defense is accomplished by the specialized tentacle the dactylozooids.
Colour species dependent: dark brown to yellow brown, red with white tentacle.

Distribution
Occur from western Africa through the central Indo-Pacific. Northerly limit Japan and Hawaii.

From Cooke (1977):
Solanderia minima: Zanzibar, Africa; *Hawaii.*
S. secunda: Central Pacific
S. misakinensis: Japan; Hawaii
S. sp.: New Guinea (Colin and Arneson 1995)

Feeding and food
Gastrozooids capture and ingest zooplankton that is small enough to be handled. Extra-cellular digestion takes place in the gastrozooid. The partially digested broth the passes into the common gastrovascular cavity where intracellular digestion occurs.

Reproductive strategies
Reproduction is by means of fixed gonophores or gonozooids. Applying generalized hydroid reproduction, the gonophores bud off both male and female, mobile medusae, which develop gonads and reproduce. The fertilized egg divides and develops into free-swimming larvae that attach to substrate to form a new hydroid.

References

Barnes, R. D. 1987. Invertebrate zoology. Saunders College, Philadelphia.

Colin, P. L., and C. Arneson. 1995. Tropical Pacific Invertebrates. San Diego: Coral Reef Press.

Cooke, J. 1977. Order Hydroida. In Devany D. M. & L. G. Eldredge (eds.) 1977. Reef and Shore Fauna of Hawaii. Bernice P. Bishop Museum Special Publication **64** (1).

George, D. & J. George, 1979. An Illustrated Encyclopedia of Invertebrates in the Sea *Marine Life.*

Management Unit: **Scleractinia (stony corals)**

Important summary documents

Veron (1986) provides a popular taxonomic guide for stony corals and their biology. Birkeland (1997) is a modern synthesis of coral reef dynamics.
Fadlallah, (1983), Harrison and Wallace (1990) reviewed coral reproduction. Richmond and Hunter (1990) compared coral reproduction geographically.

Taxonomic issues

Veron and Pichon (1976); Veron, Pichon and Wijsman-Best (1977); Veron and Pichon (1979); Veron and Pichon (1982); Veron and Wallace (1984) have revised the taxonomy of the order Scleractinia in the AIMS Monograph series. Many of the earlier checklists require revision for comparison. References for description and checklists of the AFPI are: Hawaii -Maragos (1977, 1992,1995); Guam - Jones and Randall (1973); CNMI - Randall (1995); American Samoa - Birkeland,, Randall and Amesbury (1994); Lamberts (1980); Wake I. - Anon. (1999); Midway Atoll, Northern Hawaiian Islands - DeFelice, Coles, Muir, Eldredge (1998); Johnston Atoll - Maragos and Jokiel (1986); Jokiel and Tyler (1992); Palmyra Atoll B Maragos (1979, 1988)

Habitat utilization

Stony coral attach to the reef substrate creating a variety of biological habitats on which many other groups rely for shelter and symbiosis. Coral skeletons with the aid of coralline algae create the reef structure.

The distribution of hard coral over the reef is the result of fortuitous settlement and environmental sorting. The history of disturbance in an area plays a large role in the nature of the coral assemblage. Generally, there is a near shore assemblage which is dominated by genera resistant to the influence of the terrestrial factors and tidal variation. (eg. siltation, flooding, and variation in temperature). The genus *Porites, Montipora* and the *favids* tend to dominate this area. In permanently sub-tidal areas and further offshore the *Acropora* dominate but often in association by substantial growths of a variety of other species. In Hawaii, this dominance is replaced by Montipora and Pocillopora. Stony coral are limited by light (depth), wave action and disturbance.

The AFPI span a broad biogeographic realm from Guam (144^0 45=E long.) to Hawaii (155^0 W. Long) and from American Samoa (15^0 S latitude) to the northern Hawaii Islands (28^0 40= N. Lat). In terms of coral development, the tropical/temperature gradient gives rise to a range of reef types and species assemblages. The luxuriance of the high island reefs of American Samoan, Guam are in contrast to the variety of reefs which occur in Hawaii. The Jarvis, Baker, Howland, Palmyra Johnston and Wake reefs are atolls as are some of the reefs northern Hawaiian Islands. For most of these areas, varying degrees of information is available, though being generally scant.

Life History

Adult: appearance and physical characteristic

Corals are similar to anemones in having a polyp form which may be colonial or solitary. They are characterized by a hard skeleton of aragonite (calcium carbonate). The colonial form may manifest a variety of forms: branching, tabulate, massive or encrusting. Some forms are species specific while some species respond to environmental influences which condition the colonial morphology. Polyps have tentacle though these are absent in some genera. They are often a crown, in multiples of six, (Hexacorallia) encircling the mouth though these may be manifest in furrows or over the surface as in the solitary *Fungia.* They possess nematocysts. Internally, the mouth opens into a gastrovascular cavity with mensentaries and mesentarial filaments. The mesentaries extend from the scleroseptum. The skeleton has a thecal wall, sclosepta and a basal plate (Barnes, 1987).

The colony expands by budding of new polyps from the bases of old polyps or from the oral discs of old polyps through intra-tentacular or extra-tentacular budding. Polyps of meandroid colonies share a common oral disc bearing many mouths (Barnes, 1987).

Age, growth, longevity

Corals can be very long lived for massive species. An estimated 1000 years has been estimated for some massive *Porites,* colonial sizes representing 300 is reasonably common. Growth rates have been recorded by Buddemeir and Kinzie (1976).
Corals as a group have a wide range of growth rates. The rate variable between 0.4 and 22.5 cm per year. The massive corals grow more slowly with a range of 0.4 to 1.8cm. (DeVantier, 1993). Growth also includes fusion of colonies.

Table 7. Growth rates among some scleractinian coral

Species	Growth (cm/yr)
Faviidae	0-1.38
Favia, Favites	Mean range
Goniastrea,	0.07-1.25
Montastrea	
Platygyra	
Poritidae	0-1.88
Porites	Mean range
Goniopora	0.13-0.97

<u>*Mussidae*</u> *Lobophyllia* *Symphyllia* *Acanthastrea*	0-1.65 Mean range 0.38-0.94
<u>*Oculinidae*</u> *Galaxea*	0.67-1.18 Mean range 0.54-0.93
<u>*Merulinidae*</u> *Hydnophora*	.56-1.15 Mean 0.86
<u>*Caryophylliidae*</u> *Physogyra* *Euphyllia* *Plerogyra*	0.5-0.75 Mean range 0.5-0.75
<u>*Acroporiidae*</u> *Acropora*	10.17-22.58
<u>*Pocilloporiidae*</u> *Pocillopora*	0.4-3.59

Reproductive strategies

Corals reproduce by both sexual (external fertilization and development and brooded planulae) and asexual development (brooded planulae, polyp-balls, polyp bail-out, fission, fragmentation and re-cementation). May be bisexual or hermaphroditic (protandric, protogynous or synchronous) (Chorneski and Peters, 1987). Self fertilisation occurs (Heyward and Babcock, 1986).

<u>Asexual modes of reproduction:</u>
brooded planulae
polyp-balls: *Goniopora spp.* (Sammarco 1986)
polyp bail-out: *Seriatopora spp.* (Sammarco 1981,1982)
reversible metamorphosis: *Pocillopora damicornis* (Richmond 1985)
fission: *Fungiidae*
fragmentation and re-cementation: *Acropora spp* and others (Tunnicliffe, 1981)
Corals may be free spawners or brooders depending on their geographic distribution. In Hawaii , *Tubastrea* is a brooder but in Australia is a brooder and free spawner.(Harrison and Wallace, 1990)

Sexual maturity depends, on growth as well as colony age (Kojis and Quinn, 1985) Brooders reach maturity a few years earlier than free spawners. Ahermatypic corals reach sexual maturity earlier than hermatypic corals (Harriot, 1983). Fecundity increases with age. (Soong and Lang, 1992). Availability of light influences fecundity whether through depth or an increase in suspended particles in the water (Kojis and Quinn, 1984) or the reduction of UV light (Jokiel and York, 1982).

Distribution
Table 6 details the occurrence of Scleractinia in the AFPI. Veron (1993b) detailed the global distribution of coral genera and regionally with species. Regional variation in generic occurrence has been documented with latitudinal gradients (Wells 1956).

Zonation within reefs due to environmental influences is well known.(In American Samoa: Birkeland et al. 1994, 1996; In Hawaii: Palmyra Atoll: Maragos 1977, 1988, 1992; In Guam: Jones and Randall).

Discrete coral populations may result from asexual reproduction and possess the same genotype (Hunter, 1985; Willis and Ayre, 1985; Ayre and Resing, 1986) though many appear heterogenous.

Feeding and food
Stony coral s feed on planktonic organisms or dissolved organic matter (DOM). Capture of prey is by tentacles, suspension feeding occurs and some use mesenterial filaments. Most prey capture at night though some feed during the day.

The presence of symbiotic zooxanthellae make some corals functional autotrophs (Muscatine et al. 1981) and contribute to all hermatypes nutrition. Muscatine and Porter (1977) determined plankton comprise approx. 20% of coral required nutrition. Franzisket (1970) showed coral could live without plankton, but additional nutrition was required from this source (Johannes et al. 1970). The relative dependance on heterotrophy varies with species and with environment. Sorokin (1973, 1995) described the relative dependence on predation, bacteria and DOM. The zooxanthellae receive elements from predation (i.e. nitrogen, iron, and vitamine B_{12}). Recycling of nutrients between corals and zooxanthellae is well known (Johannes 1974; Muscatine 1973; Porter, 1976).

Behaviour
Competition for space is achieved by direct tentacular competition ; mesenterial filaments, sweeper tentacles, allopathy, over-growth, shading.

Spawning: Spatial and temporal distribution
Mass spawning has been described by Babcock et al. (1986) and follows a lunar periodicity (Richmond and Hunter , 1990). Geographic variation introduces the effects of temperature and other climatic factors. In Australia, (GBR), *A .palifera* spawns only once per year at 23^0S latitude and through out the year at 14^0S lat.(Kojis and Quinn, 1984, 1986a).

Appearance and physical characteristics of eggs (size, shape, color, etc) and duration of phase

Eggs are round and may pink, orange, blue, purple or white. Pigmentation may be UV protection. White eggs are non-fertile in *Galaxea fascicularis.* Maturation of eggs and ejection may be controlled by the hormone Estradiol-17*b* (Atkinson and Atkinson, 1992). Form into egg sperm bundles. Some eggs contain zooxanthellae. Eggs range in size from 1.5 x 1.00mm *(Flabellum rubrum)* to Acorporidae and Mussidae 0.4-0.8mm; Faviidae and Pectiniidae 0.3- 0.5mm, Portitidae, Agariciidae, Fungiidae and Pocilloporidae 0.05-0.25mm. The total length of sperm is <0.005mm. Eggs and sperm production is cyclic and maturity is reached at the same time for most corals. For *Stylophora pistillata* (Rinkevich and Loya, 1979), the time is different for different colonies. *Acropora palifera* spawning may take place in several stages in synchrony with moon phases with six reproductive cycles per year (Kojis, 1986a, b). Free spawners have a 12 month maturation cycle but brooders have several cycles per year.

Spawning is in synchrony with the lunar cycle begin on the 15th to the 24th night of the lunar cycle. Spawning starts at dusk and continues until midnight. It may vary geographically. A slick is often observed as the gammetes are brought together by currents. Likelihood of fertilization is increased and the abundance of material means predation is decreased through satiation.

Duration of gamete development after spawning is 30 minutes until the ability to fertilise, first cell division 1-2 hours, to planula stage 6-24 hours (Szmant-Froelich et al. 1980; Kojis and Quinn 1982, Bull 1986, Heyward 1986)

Larvae: appearance and physical characteristics of larvae

It is covered with cilia which provides locomotion. In *Porites porites,* 200 planula may be released from a section of colony (2cm^2) (Fadallah, 1983). They are ciliated, spherical initially and oval or pear-like when mobile.

Age, growth and duration of larval phase

Initially, they move to the surface of the water and drift as a ciliated ball. In 3-7 days they elongate into a conical shape. They have a cavity and mouth and are 1.5mm long with mesenteries developed. They then move to deeper water and seek substrate (Babcock and Heyward, 1986).

Coral with long lived larvae are: *Galaxea aspera* 49 days; Cyphastrea ocellina (Hawaii) 60 days; Acropora spp. 91 days; Pocillopora damicornis (Hawaii) 103 days (Gulko,1999).

Larval feeding and food

Nutrition in planulae is achieved as the result of energy reserves transferred from the embryonic cells. Zooxanthellae, most probably, provide nutrition through nutrient translocation. Some planula feed actively.

Habitat utilization
Some planula have zooxanthallae and may exist for longer in the plankton and disperse further. Most settle with the proximity of the parent <1km. Discussion of factors in dispersal have been reviewed by Harrison and Wallace (1990). Currents must play a major role in the transport of the larvae. Longevity in the plankton will determine the potential distance of dispersal (Richmond, 1987).

Settlement sites are often cryptic. Clumping of planula may give rise to fusion into a single colony.

Habitat features affecting the abundance and density of eggs and larvae
Currents affect the abundance of eggs and larvae, often concentrating them into a dense mass and dispersing them with the flow. Rain storms may cause mass mortality at this stage as does grounding of the slick at low tide or along the shore. After settlement, the planulae develop primary polyps. The settlement site is important. If inshore, large amounts of organic particular matter and sediment will increase mortality. Wave action may destroy the primary polyps. Young polyps may abandon primary calyx, and relocate planktonically (Richmond, 1985) or through bailout responses.

There is the potential for rafting of coral polyps on driftwood or other current borne objects which would allow for the settlement by larvae and polyp growth (Jokiel, 1984).

Abundance and distribution of coral planulae was investigated in Kaneohe Bay, Oahu (Hodgson, 1985) and Bull (1986) for Australia.

Settlement occurs by finding a suitable location. The size of the new polyp is <2mm. Mortality at this stage is high. Both the environmental and biological environment affect the potential for coral development (Goreau, et al. 1981).

In Western Australia, large numbers of fish and coral died as the result of a coral spawn slick being embayed and using up the oxygen and then decaying (Simson 1993).

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Managment Unit: **Fungiidae (Dana, 1846) (mushroom corals)**

Important summary documents

Veron (1986) provides a species summary of the systematics, anatomy and distribution in Australia and the Indo-Pacific. Veron (1993b) the family Fungiidae is discussed with respect to its global distribution.

Taxonomic issues

Veron & Pichon (1979) revised the taxonomy of the family Fungiidae.

Has 11 extant genera: Cycloseris (7 spp.), *Diaseris* (4 nominal spp.), *Heliofungia, Fungia* (25 spp.), *Herpolitha* (2 spp.), *Polyphyllia* (3 spp.), *Halomitra* (1 spp.), *Sandalolitha* (2 spp.), *Lithophyllon (2 spp.), Podabacia (*1 spp.) and *Zoopilus* (1 spp.).

Habitat utilization

Begin life as anthocauli attached to a hard substrate. Detach to continue life as a free-living colony inhabiting reef areas unsuitable for permanently attached corals such as sand or rubble.

Life History

Adult: appearance and physical characteristic

All shallow water with the exception of the *Fungiacyathus (not occur AFPI).* The majority are hermatypic, solitary, and free living (not *Lithophyllum or Podabacia)* with attached juvenile stage. They may be individual with one mouth or colonial with many mouths and other anatomy characteristic of a colonial form.

From Veron (1986):

Cycloseris (Edwards & Haime, 1849): Solitary, free-living, flat or dome-shaped, circular or slightly oval in outline with a central mouth. Fine tentacles cover the upper surface of the disc. Pale brown to cream with a darker margin.

Diaseris (Edwards & Haime, 1849): Circular though with an irregular margin and segments. Colour is brown to green.

Heliofungia (Wells, 1966): Solitary, free-living, flat with central mouth. Septa have large lobed teeth. Polyps are extended day and night, and as a single polyp are the largest of all corals. Tentacles are longest of the stony corals and dark purple or green tentacle with pale tips. The oral disc is striped and the single mouth is 30mm wide.

Fungia (Lamarck, 1801): Free-living, circular or elongate

Herpolitha (Eschscholtz, 1825)*:* Free-living, elongate with and axial furrow that may extend to the corallum ends. Several centers or mouths occur in the furrow. Colonies may be heavily calcified and >1m in length. Tentacles are short and widely spaced.

Polyphyllia (Quoy and Gaimard, 1833): Free-living, elongate with many mouths and tentacles over the upper surface. Larger mouths are down the axial furrow. Long tentacles, which are always extended.

Halomitra (Dana, 1846): Colonies are large and free-living, circular and dome or bell shaped, thin and delicate and without an axial furrow. Corallites widely spaced. Tentacles are small and widely spaced and extended at night.

Sandalolitha (Quelch, 1884): Colonies are large, free-living, and circular to oval, dome-shaped, heavily constructed and without an axial furrow. Corallites are compacted. Pale or darks brown, sometimes with purple margins and white centers.

Lithophyllon *(*Rehberg, 1892): Colonies are attached, encrusting or laminar, unifacial. Colonies may be large, up to several metres. Polyps extended at night. Dull green, grey or brown with white margins or white centers.

Podabacia (Edwards and Haime, 1849): Colonies are attached, encrusting or laminar, unifacial and up to 1.5m in diameter.

Their coloration may be frown, green, red or pink. They may have contrasting stripped design.

Distribution
Cycloseris: Extends from southern Africa to the Red Sea and Arabian Gulf through the Indo- Pacific ranging from south Western Australia, Lord Howe I. and Easter I. in the south to southern Japan in the north. It occurs in the Hawaiian Islands, though not in Midway. It is present in the eastern Pacific from Baja California, northern Mexico to Columbia. The recorded occurrence in the AFPI is Johnston Atoll, Hawaii and Guam

Diaseris: Similar to *Cycloseris* though narrower, extending from southern Madagascar and the Red Sea. Across the Pacific at varying latitude in the north to include Japan and in the south of New Caledonia and the Tuamotus Is. The recorded occurrence in the AFPI is Hawaii.

Heliofungia: Indonesia, Australia, Philippines, Ryukyu Is. east to the Caroline and Solomon Is and south to New Caledonia. The genus does not occur in the AFPI.

Fungia: South of Madagascar, to the Red Sea, Northern Australia, the Great Barrier Reef, south to Lord Howe I. and across to Pitcairn I. Its northerly extent is southern India, Southeast Asia, southern Japan, Midway I., Hawaiian Is. Its easterly extent is the Marquesas Is. The recorded occurrence by virtue of *Fungia scutaria* is present in all AFPI where checklists have been made. Considering the other species of the genus, occurrence is limited to American Samoa, Palmyra Atoll, and Guam.

Herpolitha: South of Madagascar to the Red Sea, Northern Australia, the Great Barrier Reef, south to New Caledonia and across to Pitcairn I. Its northerly extent is southern India, Philippines, and Ryukyu Is., Japan. Its easterly extent is the Tuamotus Is. The AFPI that this species is found in is American Samoa, Palmyra Atoll and Guam.

Polyphyllia: Central Indo-Pacific: Northern Madagascar and the Seychelles Is in the west. Northern Australia, New Caledonia and Tonga in the south. American Samoa (only AFPI occurrence) in the east and Ryukyu Is, Japan in the north.

Halomitra: West Africa Madagascar in the west through Indonesia to the Line Is in the east. South to New Caledonia and Tonga and north to the Ryukyu I in the north. Present in the AFPI in American Samoa and Palmyra.

Sandalolitha: Occurs in Indonesia and Southeast Asia in the west to the Kyushu Is. in the north. Extends to Northern Australia and New Caledonia and Tubuai Is in the south. Also extends to the Tubuai Is and Line Is in the east. AFPI occurrence limited to American Samoa and Palmyra Atoll.

Lithophyllon: Similar to Sandalolitha, occurring to Indonesia in the west and the Malay Peninsula. Its southerly extent is northern Australia, New Caledonia, and Fiji to the east. It is confined to the western Pacific to include the Philippines and north to southern Japan. There are no occurrences in the AFPI.

Podobacia: Indo-Pacific: Occurs from west Africa and the Red Sea south to Madagascar, Northern Australia, New Caledonia to Tahiti. Range extends to the Fiji in the east. In the north, it extends along Southeast Asia to Japan. There are no occurrences in the AFPI.

Feeding and food

Heterotrophic: prominent tentacles indicate prey capture. Autotrophic: abundant zooxanthellae.

Behavior

Are partially mobile. May free themselves if buried and some are capable of lateral movement, ability to right themselves, and able to climb over obstacles by using their tentacles and inflating their body cavities.

Mobility in *Cycloseris* by ciliary hairs, by inflation of the body cavity or use of tentacles. Tentacle extended at night.
Fungia and Herpolitha: Polyps are extended only at night.

Reproductive strategies

Asexual: Fragmentation or natural regeneration through fracture. Many develop attached daughter polyps (acanthocauli) from the parent colony.

Sexual: Dioecious or hermaphroditic. Planula larvae settle to form the attached acanthocauli, which may grow to several centimeters before detaching due to degeneration of the stalk. *Heliofungia* has been reported as hermaphroditic while *Fungia* has separate sexes. It is likely the family has separate sexes, the females either brood planulae or release gametes (Veron, 1986).

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Table 8: Distribution of Scleractinia (hard coral) within the American Flag Pacific Islands (AFPI).

AS: American Samoa; PA: Palmyra Atoll; JA: Johnston Atoll; MHI: Main Hawaiian Islands; NWHI: Northwestern Hawaiian Islands; WA: Wake Atoll; CNMI: Commonwealth of Northern Mariana Islands; GU: Guam

Coral Order, Family and Species	AS	PA	JA	MHI	NWHI	WA	NMI	GU	Site Record
Order SCLERACTINIA									
Family ASTROCOENIIDAE									
Stylocoeniella armata (Ehrenberg, 1834)	X						X	X	3
Stylocoeniella guentheri (Bassett-Smith, 1890)							X	X	2
Family THAMNASTERIIDAE									
Psammocora contigua (Esper, 1797)	X							X	2
Psammocora digitata Edward & Haime, 1851							X	X	2
Psammocora explanulata van der Horst, 1922				X					1
Psammocora folium (Syn)	X								1
Psammocora (P.) haimeana Edwards and Haime, 1851	X	X						X	3
Psammocora nierstraszi van der Horst,1921	X		X	X			X	X	5
Psammocora profundacella Gardiner,1898		X						X	2
Psammocora stellata (Verril,1866)		X	X	X	X			X	5
Psammocora superficiales Gardiner,1898	X								1
Psammocora (V.) tutuilensis (Syn)	X								1

Coral Order, Family and Species	AS	PA	JA	MHI	NWHI	WA	NMI	GU	Site Record
Psammocora verrilli Vaughan				X				X	2
Family POCILLOPORIDAE									
Pocillopora ankeli Sheer & Pillai, 1974	X								1
Pocillopora damicornis (Linnaeus,1758)	X	X	X	X	X			X	6
Pocillopora eydouxi *Edwards & Haime,1860*	X	X	X	X		X		X	6
Pocillopora ligulata Dana, 1846	X			X				X	3
Pocillopora molokensis Vaughan, 1907				X					1
Pocillopora setchelli Hoffmeister,1929	X						X	X	3
Pocillopora verrucosa (Ellis & Solander, 1786)	X	X	X	X	X	X	X	X	8
Pocillopora woodjonesi Vaughan,1918	X							X	2
Seriatopora crassa Quelch, 1886	X								1
Seriatopora hystrix Dana, 1846	X							X	2
Stylophora pistillata Esper, 1797	X	X					X	X	4
Family ACROPORIDAE									
Acropora (A.) aculeus (Dana, 1846)	X					X			2
Acropora (A.) acuminata (Verrill, 1864)	X	X						X	3
Acropora (A.) aspera (Dana, 1846)	X	X						X	3
Acropora (A.) azurea Veron & Wallace, 1984	X								1

Coral Order, Family and Species	AS	PA	JA	MHI	NWHI	WA	NMI	GU	Site Record
Acropora (A.) bushyensis Veron & Wallace, 1984								X	1
Acropora (A.) carduus (Dana, 1846)		X						X	2
Acropora (A.) cerealis (Dana, 1846)	X	X	X				X	X	5
Acropora (A.) clathrata (Brook, 1891)	X								1
Acropora (A.) cuspidata Dana	X								1
Acropora (A.) cytherea (Dana,1846)	X	X	X	X				X	5
Acropora (A.) danai (Milne-Edwards & Haime, 1860)	X	X					X	X	4
Acropora (A.) digitifera (Dana, 1846)	X	X					X	X	4
Acropora (A.) divaricata (Dana, 1846)	X								1
Acropora (A.) echinata (Dana, 1846)								X	1
Acropora (A.) elseyi (Brook, 1892)		X	X						2
Acropora (A.) florida (Dana, 1846)		X							1
Acropora (A.) formosa (Dana, 1846)	X	X						X	3
Acropora (A.) gemmifera *(Brook, 1892)*	X	X							2
Acropora (A.) granulosa (Edwards & Haime, 1860)	X						X	X	3
Acropora (A.) horrida *(Dana, 1846)*	X								1
Acropora (A.) humilis (Dana, 1846)	X	X	X	X			X	X	6

Coral Order, Family and Species	AS	PA	JA	MHI	NWHI	WA	NMI	GU	Site Record
Acropora (A.) hyacinthus (Dana, 1846)	X	X					X	X	4
Acropora (A.) latistella (Brook, 1892)	X								1
Acropora (A.) listeri (Brook, 1893)	X								1
Acropora (A.) longicyathus (Edwards & Haime, 1860)	X								1
Acropora (A.) millepora (Ehrenberg, 1834)	X							X	2
Acropora (A.) monticulosa (Bruggemanni, 1879)	X	X						X	3
Acropora (A.) multiacuta Nemenzo,1967		X							1
Acropora (A.) loripes (Brook, 1892)	X	X					X	X	4
Acropora (A.) nana (Studer, 1878)	X	X						X	3
Acropora (A.) nasuta (Dana, 1846)	X	X				X	X	X	5
Acropora (A.) nobilis (Dana, 1846)	X	X						X	3
Acropora (A.) ocellata (Klunzinger, 1897)	X							X	2
Acropora (A.) pagoensis Hoffmeister	X								1
Acropora (A.) palmerae Wells, 1954	X							X	2
Acropora (A.) paniculata Verrill,1902	X		X	X					3
Acropora (A.) paxilligera *(Dana, 1846)*	X								1

Coral Order, Family and Species	AS	PA	JA	MHI	NWHI	WA	NMI	GU	Site Record
Acropora (A.) polystoma ***(Brook, 1891)***	X	X							2
Acropora (A.) pulchra (Brook, 1891)	X								1
Acropora (A.) rambleri (Bassett-Smith, 1890)	X							X	2
Acropora (A.) robusta (Dana, 1846)	X							X	2
Acropora (A.) samoensis (Brook, 1891)	X	X							2
Acropora (A.) schmitti	X								1
Acropora (A.) secale (Studer, 1878)	X								1
Acropora (A.) selago (Studer, 1878)	X	X	X					X	4
Acropora (A.) studeri (Brook, 1893)								X	1
Acropora (A.) tenuis (Dana, 1846)	X						X	X	3
Acropora (A.) teres (Verrill, 1866)	X							X	2
Acropora (A.) valenciennesi (Edwards & Haime, 1860)	X								1
Acropora (A.) valida (Dana, 1846)	X	X	X	X		X		X	6
Acropora (A.) vaughani Wells, 1954		X							1
Acropora (A.) yongei Veron & Wallace, 1984	X		X						2
Acropora (A.) sp.1	X				X			X	3
Acropora (A.) sp.2	X								1

Coral Order, Family and Species	AS	PA	JA	MHI	NWHI	WA	NMI	GU	Site Record
Acropora (A.) sp.3	X								1
Acropora (I.) brueggemanni ***(Brook, 1893)***	X	X						X	3
Acropora (I.) cuneata (Dana, 1846)	X	X							2
Acropora (I.) palifera (Lamarck, 1816)	X	X					X	X	4
Astreopora cucullata Lamberts, 1980	X								1
Astreopora explanata		X							1
Astreopora gracilis Bernard, 1896		X						X	2
Astreopora listeri ***Bernard, 1896***	X							X	2
Astreopora myriophthalma (Lamarck, 1816)	X	X				X	X	X	5
Astreopora randalli Lamberts,1890	X								1
Astreopora sp. 1	X						X		2
Montipora aequituberculata Bernard, 1897	X			X				X	3
Montipora berryi Hoffmeister, 1925	X								1
Montipora bilaminata	X								1
Montipora caliculata (Dana, 1846)	X								1
Montipora conicula Wells								X	1
Montipora danae Edwards & Haime, 1851						X		X	2

Coral Order, Family and Species	AS	PA	JA	MHI	NWHI	WA	NMI	GU	Site Record
Montipora dilatata Struder, 1901				X					1
Montipora efflorescens Bernard, 1897	X								1
Montipora ehrenbergii Verrill, 1875	X							X	2
Montipora elschneri Vaughan, 1918	X							X	2
Montipora eydouxi	X								1
Montipora flabellata Struder, 1901				X					1
Montipora floweri Wells, 1954								X	1
Montipora foliosa (Pallas, 1766)	X	X						X	3
Montipora foveolata (Dana, 1846)	X	X				X		X	4
Montipora granulosa Bernard, 1897	X							X	2
Montipora hispida ***(Dana, 1846)***	X	X	X						3
Montipora hoffmeisteri Wells, 1954	X	X				X		X	4
Montipora incrassata Dana, 1846			X	X					2
Montipora informis *Bernard, 1897*	X					X			2
Montipora lobulata *Bernard, 1897*	X							X	2
Montipora marshallensis	X								1
Montipora millepora Crossland, 1952								X	1

Coral Order, Family and Species	AS	PA	JA	MHI	NWHI	WA	NMI	GU	Site Record
Montipora monasteriata (Forskal, 1775)		X	X	X	X	X		X	6
Montipora peltiformis Bernard, 1897				X				X	2
Montipora spumosa (Lamarck, 1816)	X								1
Montipora tubercubsa		X							1
Montipora tuberculosa (Lamarck, 1816)	X		X	X				X	4
Montipora turgescens Bernard, 1897					X				1
Montipora undata Bernard, 1897	X								1
Montipora venosa (Ehrenberg, 1834)	X								1
Montipora verrucosa (Lamarck, 1816)				X		X		X	3
Montipora sp.1 (green spine)	X				X		X	X	4
Montipora sp.2 (ramose tuber.)	X						X	X	3
Montipora sp.3 (Pago)	X						X	X	3
Montipora sp.4 (Ramose pap.)							X	X	2
Montipora sp.5 (thick branch)							X	X	2
Family AGARICIIDAE									
Gardineroseris planulata (Dana, 1846)	X			X				X	3
Leptoseris hawaiiensis Vaughan, 1907			X	X				X	3
Leptoseris incrustans (Quelch, 1886)	X		X	X				X	4

Coral Order, Family and Species	AS	PA	JA	MHI	NWHI	WA	NMI	GU	Site Record
Leptoseris mycetoseroides Wells, 1954	X	X		X		X		X	5
Leptoseris papyracea ***(Dana, 1846)***				X					1
Leptoseris scabra Vaughan, 1907			X	X					2
Pachyseris levicollis	X								1
Pachyseris speciosa (Dana, 1846)	X							X	2
Pachyseris rugosa (Lamarck, 1801)	X								1
Pavona clavus (Dana, 1846)	X	X	X	X	X		X	X	7
Pavona decussata (Dana, 1846)	X							X	2
Pavona diffluens (Lamarck, 1816)	X								1
Pavona divaricata (Lamarck, 1816)	X							X	2
Pavona explanulata (Lamarck, 1816)	X	X							2
Pavona frondifera (Lamarck, 1816)	X							X	2
Pavona gigantea	X								1
Pavona maldivensis (Gardiner, 1905)	X	X	X	X			X	X	6
Pavona minuta Wells, 1954	X							X	2
Pavona qardineri van der Horst								X	1

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
Pavona varians Verrill, 1864	X	X	X	X		X	X	X	7
Pavona (P.) venosa (Ehrenberg, 1834)	X							X	2
Family BALANOPHYLLIDAE									
Balanophyllia sp.cf. *affinis* (Semper, 1872)				X					1
Balanophyllia hawaiiensis Vaughan, 1907				X					1
Family SIDERASTREIDAE									
Coscinaraea columna (Dana, 1846)	X							X	2
Coscinaraea wellsi Veron & Pichon, 1879				X					1
Family FUNGIIDAE									
Cycloseris hexagonalis ***Edwards & Haime, 1848***				X					1
Cycloseris patelliformis Boschma, 1923	X								1
Cycloseris tenuis Dana, 1846				X					1
Cycloseris vaughani (Boschma, 1923)			X	X					2
Diaseris distorta Michelin, 1842				X					1
Fungia (D.) danai Edwards & Haime, 1851	X	X							2
Fungia (D.) valida Verrill, 1864		X							1
Fungia (C.) echinata (Pallas,1766)	X								1

Coral Order, Family and Species	AS	PA	JA	MHI	NWHI	WA	NMI	GU	Site Record
Fungia (F.) fungites (Linnaeus, 1758)	X	X						X	3
Fungia (P.) paumotensis Stutchbury, 1833	X	X						X	3
Fungia (P.) scutaria Lamarck, 1801	X	X	X	X	X	X	X	X	8
Fungia (V.) concinna Verrill, 1864	X	X						X	3
Fungia (V.) granulosa Klunzinger, 1879	X								1
Fungia (V.) repanda Dana, 1846	X	X							2
Fungia (C.) simplex ***(Gardiner, 1905)***	X								1
Halomitra pileus (Linnaeus, 1758)	X	X							2
Herpolitha limax ***(Houttuyn, 1772)***	X	X						X	2
Polyphyllia talpina (Lamarck, 1801)	X								1
Sandalolitha robusta (Quelch,1886)	X	X							2
Family PORITIDAE									
Alveopora allingi ***Hoffmeister, 1925***	X								1
Alveopora japonica								X	1
Alveopora superficialis Sheer & Pillai, 1976	X								1
Alveopora verrilliana Dana, 1846	X	X						X	3

Coral Order, Family and Species	AS	PA	JA	MHI	NWHI	WA	NMI	GU	Site Record
Alveopora viridis Quoy & Gaimard, 1833	X								1
Goniopora arbuscula Umbgrove								X	1
Goniopora columna Dana, 1846	X							X	2
Goniopora parvistella Ortmann, 1888	X								1
Goniopora somaliensis Vaughan, 1907	X								1
Goniopora sp.1	X						X	X	3
Goniopora sp.2							X	X	2
Porites (P.) annae ***Crossland, 1952***	X							X	2
Porites (P.) australiensis Vaughan, 1918		X						X	2
Porites (P.) cocosensis Wells								X	1
Porites (P.) compressa Vaughan				X				X	2
Porites (P.) cylindrica Dana, 1846	X							X	2
Porites (P.) duerdeni Vaughan				X				X	2
Porites (P.) cf. *Evermanni* Vaughan, 1907				X					1
Porites (P.) latistella	X								1
Porites (P.) lichen ***Dana, 1846***	X			X				X	3
Porites (P.) lobata Dana, 1846	X	X	X	X	X		X	X	7

Coral Order, Family and Species	AS	PA	JA	MHI	NWHI	WA	NMI	GU	Site Record
Porites (P.) lutea Edwards & Haime, 1860	X	X	X			X	X	X	6
Porites (P.) matthaii Wells	X							X	2
Porites (P.) murrayensis Vaughan, 1918	X			X				X	3
Porites (P.) pukoensis Vaughan, 1907	X			X					2
Porites (P.) queenslandi septima	X								1
Porites (P.) solida (Forskal, 1775)						X			1
Porites (P.) stephensoni Crossland, 1952	X								1
Porites (P.) studeri Vaughan, 1907				X					1
Porites (P.) sp.1(nodular)	X				X			X	3
Porites (S.) horizontalata Hoffmeister, 1925	X							X	2
Porites (S.) rus (Forskal, 1775)	X			X				X	3
Porites (N.) vaughani **Crossland, 1952**		X							1
Stylaraea punctata ***(Linnaeus, 1758)***								X	1
Synaraea horizontalata	X								1
Family FAVIIDAE									

Coral Order, Family and Species	AS	PA	JA	MHI	NWHI	WA	NMI	GU	Site Record
Caulastrea furcata Dana, 1846	X								1
Cyphastrea chalcidicum (Forskal, 1775)			X	X	X			X	4
Cyphastrea microphthalma (Lamarck, 1816)	X					X			2
Cyphastrea serailia (Forskal, 1775)	*X*					*X*		*X*	3
Diploastrea heliopora ***(Lamarck, 1816)***	X						X	X	3
Echinopora hirsuitissima ***(Edwards & Haime, 1849)***	X								1
Echinopora lamellosa (Esper, 1795)	X					X	X	X	4
Favia favus (Forskal, 1775)	X					X		X	3
Favia helianthoides Wells, 1954	X								1
Favia laxa (Klunzinger, 1879)	X								1
Favia matthaii Vaughan, 1918	X							X	2
Favia pallida (Dana, 1846)	X	X				X	X	X	5
Favia rotumana (Gardiner, 1899)	X							X	2
Favia russelli (Wells)								X	1
Favia speciosa (Dana)	X	X					X	X	4
Favia stelligera (Dana, 1846)	X	X				X		X	4

Coral Order, Family and Species	AS	PA	JA	MHI	NWHI	WA	NMI	GU	Site Record
Favia sp.1 (small calice)	X	X					X		3
Favia sp.2							X		1
Favites abdita (Ellis & Solander, 1786)	X	X				X		X	4
Favites chinensis (Verrill, 1866)	X								1
Favites complanata (Ehrenberg, 1834)	X							X	2
Favites favosa (Ellis & Solander)								X	1
Favites flexuosa (Dana, 1846)	X	X				X		X	4
Favites halicora (Ehrenberg, 1834)	X	X				X			3
Favites pentagona (Esper, 1794)		X							1
Favites russelli (Wells, 1954)	X								1
Goniastrea australensis (Edwards & Haime, 1857)	X								1
Goniastrea edwardsi Chevalier, 1971	X							X	2
Goniastrea favulus (Dana, 1846)	X					X			2
Goniastrea palauensis (Yabe,Sugiyama & Eguchi, 1936)	X								1
Goniastrea pectinata (Ehrenberg, 1834)	X	X				X		X	4
Goniastrea retiformis (Lamarck, 1816)	X					X	X	X	4
Hydnophora exesa (Pallas, 1766)	X	X						X	3

Coral Order, Family and Species	AS	PA	JA	MHI	NWHI	WA	NMI	GU	Site Record
Hydnophora microconos ***(Lamarck, 1816)***	X	X						X	3
Hydnophora rigida ***(Dana, 1846)***	X								1
Leptastrea bottae ***(Edwards & Haime, 1849)***				X				X	2
Leptastrea cf. *Immersa* Klunzinger, 1879	X								1
Leptastrea purpurea (Dana, 1846)	X	X	X	X	X	X	X	X	8
Leptastrea transversa Klunzinger, 1979	X	X						X	2
Leptoria phrygia (Ellis & Solander, 1786)	X					X	X	X	4
Montastrea annuligera ***(Edwards & Haime, 1849)***	X								1
Montastrea curta (Dana, 1846)	X	X				X	X		4
Montastrea valenciennesi (Edwards & Haime, 1848)						X			1
Oulangia bradleyi (Verrill, 1866)			X						1
Oulophyllia crispa (Lamarck, 1816)	X							X	2
Platygyra daedalea (Ellis & Solander, 1786)	X	X				X		X	4
Platygyra lamellina (Ehrenberg, 1834)	X	X					X	X	4
Platygyra pini Chevalier, 1975	X						X	X	3

Coral Order, Family and Species	AS	PA	JA	MHI	NWHI	WA	NMI	GU	Site Record
Platygyra sinensis (Edwards & Haime, 1849)						X		X	2
Plesiastrea versipora ***(Lamarck, 1816)***	X	X						X	3
Family RHIZANGIIDAE									
Culicia rubeola (Quoy & Gaimard)							X		1
Culicia sp.cf. *tenella* Dana, 1846				X					1
Family OCULINIDAE									
Acrhelia horrescens ***(Dana, 1846)***	X							X	2
Galaxea cf. astreata ***(Lamarck, 1816)***	X							X	2
Galaxea fascicularis ***(Linnaeus, 1767)***	X						X	X	3
Family MERULINIDAE									
Clavarina triangularis Veron & Pichon, 1979	X								1
Merulina ampliata (Ellis & Solander, 1786)	X	X				X		X	4
Family MUSSIDAE									
Acanthastrea echinata (Dana, 1846)	X					X	X	X	4
Acanthastrea sp.1								X	1
Lobophyllia corymbosa (Forskal, 1775)	X	X						X	3

Coral Order, Family and Species	AS	PA	JA	MHI	NWHI	WA	NMI	GU	Site Record
Lobophyllia hemprichii (Ehrenberg, 1834)	X							X	2
Symphyllia radians *(Edwards & Haime, 1849)*						X			1
Symphyllia recta *(Dana, 1846)*	X					X			2
Symphyllia valenciennesii *Edwards & Haime, 1849*	X								1
Family PECTINIIDAE									
Echinophyllia aspera *(Ellis & Solander, 1786)*	X							X	2
Mycedium elephantotos (Pallas, 1766)	X								1
Oxypora lacera (Verrill, 1864)	X								1
Family CARYOPHYLLIIDAE									
Euphyllia (E.) glabrescens (Chamisso & Eysenhardt, 1821)	X						X	X	3
Plerogyra simplex ***Rehberg, 1892***	X								1
Plerogyra sinuosa ***(Dana, 1846)***							X	X	2
Polycyathus verrilli ***Duncan***								X	1

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
Family DENDROPHYLLIIDAE									
Tubastrea aurea ***(Quoy & Gaimard)***	X						X		2
Tubastraea coccinea Lesson, 1831	X	X		X	X				4
Turbinaria frondens ***(Dana, 1846)***	X								1
Turbinaria peltata (Esper, 1794)	X								1
Turbinaria reniformis Bernard, 1896	X								1
Order COENOTHECALIA									1
Family HELIOPORIDAE									
Heliopora coerulea (Pallas, 1766)	X						X	X	3
Order STOLONIFERA									
Family TUBIPORIDAE									
Tubipora musica ***Linnaeus, 1758***								X	1
Order MILLEPORINA									
Family MILLEPORIDAE									
Millepora dichotoma Forskal, 1775	X						X	X	3
Millepora exaesa Forskal, 1775						X	X	X	3
Millepora platyphyllia Hemprich & Ehrenberg, 1834	X						X	X	3

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
Millepora tenera Boschma, 1949	X		X						2
Millepora tuberosa Boschma, 1966	X								1
Millepora sp.1	X								1
Family STYLASTERIDAE									
Distochopora gracilis Dana, 1846	X								1
Distochopora violacea (Pallas, 1776)			X					X	2
Distochopora sp.1								X	1
Stylaster gracilis Dana, 1846	X								1
Stylaster sp.			X						1
Order ALCYONACEA									
Family ALCYONIIDAE									
Lobophytum sp.1		X							1
Sinularia abrupta Tixier-Durivault, 1970				X					1
Sinularia sp.1		X							1
Corallimorpharia spp.	X								1
Palythoa sp.	X								1
Tethya sp.	X								1

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
Zoanthus sp.	X								1
Number of: Scleractinians	222	82	29	51	13	39	53	159	
Acyonarians	4	1		1					
Hydrozoans	7	1	3			1	3	5	
Coelothecalia	1							1	

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Comment: *Oulangia bradleyi (Verrill, 1866): Johnston Atoll.* This record does not conform to the current taxonomy though is included subject to further clarification.

Table 9: Zooxanthellate Corals Likely to be Found in the American Flag Pacific Islands (Adapted from Veron 1995)

Family and genus	Extant species {no.}	Present distribution	General abundance
Astrocoeniidae Stylocoeniella	At least 3	Red Sea to central Pacific	Uncommon, cryptic
Pocilloporidae Pocillopora	Approx. 10	Red Sea and western Indian Ocean to far eastern Pacific	Very common, very conspicuous
Stylophora	Approx. 5	Red Sea and western Indian Ocean to southern Pacific	Very common, very conspicuous
Seriatopora	Approx. 5	Red Sea and western Indian Ocean to southern Pacific	Very common, conspicuous
Acroporidae	At least 80	Red Sea and western	Extremely
Acropora	At least 150	Cosmopolitan in Indo-Pacific reefs	Extremely common, very conspicuous, usually dominant
Astreopora	Approx. 15	Red Sea and western Indian Ocean to southern Pacific	Generally common, conspicuous
Poritidae Porites	Approx. 80	Cosmopolitan	Extremely common, conspicuous at generic level
Stylaraea	1	Red Sea and western Indian Ocean to westernPacific	Rare, occurs only in shallow,wave-washed biotopes
Goniopora	Approx. 30	Red Sea and western Indian Ocean to southern Pacific	Generally common, very conspicuous
Alveopora	Approx. 15	Red Sea and western Indian Ocean to southern Pacific	Sometimes common, very conspicuous

Family and genus	Extant species {no.}	Present distribution	General abundance
Siderastreidae Psammocora	Approx. 15	Red Sea and western Indian Ocean to far eastern Pacific	Generally common, sometimes cryptic
Coscinaraea	Approx. 12	Red Sea and western Indian Ocean to southern Pacific	Generally common, conspicuous
Agariciidae Pavona	Approx. 22	Red Sea and western Indian Ocean to far eastern Pacific	Very common, conspicuous
Leptoseris	Approx. 14	Red Sea and western Indian Ocean to far eastern Pacific and Caribbean and Gulf of Mexico	Sometimes common, mostly conspicuous
Gardineroseris	At least 2	Red Sea and western	Generally
Pachyseris	Approx. 4	Red Sea and western	Very common,
Fungiidae Cycloseris	Approx. 16	Red Sea and western Indian Ocean to far eastern Pacific	Generally uncommon, non-reefal
Diaseris	At least 3	Red Sea and western Indian Ocean to far eastern Pacific	Generally uncommon, non-reefal
Fungin	Approx. 33	Red Sea and western Indian Ocean to southern Pacific	Very common, very conspicuous
Herpolitha	2	Red Sea and western Indian Ocean to western Pacific	Generally common, very conspicuous
Sandalolitha	2	Central Indian Ocean to southern Pacific	Sometimes common, very conspicuous
Halomitra	2	Western Indian Ocean to southern Pacific	Generally uncommon, very conspicuous

Family and genus	Extant species {no.}	Present distribution	General abundance
Oculinldae Ga]axea	Approx. 5	Red Sea and western Indian Ocean to southern Pacific	Very common, very conspicuous
Acrhelia	1	Eastern Indian Ocean to southern Pacific	Generally uncommon, conspicuous
Pectiniidae Echinophyllia	Approx. 8	Red Sea and western Indian Ocean to southern Pacific	Very common, conspicuous
Oxypora	At least 3	Western Indian Ocean to southern Pacific	Generally common, conspicuous
Mycediurn	At least 2	Red Sea and western Indian Ocean to southern Pacific	Generally common, conspicuous
Mussidae Acanthastrea	Approx. 6	Red Sea and western Indian Ocean to southern Pacific	Generally uncommon, Favites-like
Lobophyllia	Approx. 9	Red Sea and western Indian Ocean to southern Pacific	Very common, very conspicuous
Symphyllia	Approx. 6	Red Sea and western Indian Ocean to southern Pacific	Generally common, very conspicuous
Merulinidae Hydnophora	Approx. 7	Red Sea and western Indian Ocean to southern Pacific	Generally common, very conspicuous
Merulina	3	Red Sea and western Indian Ocean to southern Pacific	Sometimes common, conspicuous
Scapophyllia	1	Eastern Indian Ocean to	Generally
Faviidae	Approx. 4	Red Sea and western	Generally common,
Favia	At least thirty	Cosmopolitan	Extremely common, conspicuous
Favites	Approx. 15	Red Sea and western	Very common,

Family and genus	Extant species {no.}	Present distribution	General abundance
Goniastrea	Approx. 12	Red Sea and western Indian Ocean to southern Pacific	Very common, generally conspicuous
Platygyra	Approx. 12	Red Sea and western Indian Ocean to southern Pacific	Extremely common, conspicuous but may be confused with Goniastrea
Leptoria	2	Red Sea and western	Sometimes
Oulophyllia	Approx. 3	Red Sea and western Indian Ocean to western Pacific	Sometimes common, conspicuous
Montastrea	Approx. 13	Cosmopolitan	Generally common, conspicuous
Plesiastrea	At least 2	Red Sea and western Indian Ocean to far eastern Pacific	Sometimes common
Diploastrea	1	Red Sea and western Indian Ocean to southern Pacific	Generally common, very conspicuous
Leptastrea	Approx. 8	Red Sea and western Indian Ocean to southern Pacific	Generally common, conspicuous
Cyphastrea	Approx. 9	Red Sea and western Indian Ocean to southern Pacific	Very common, conspicuous
Echinopora	Approx. 7	Red Sea and western Indian Ocean to southern Pacific	Very common, conspicuous
Caryophylliidae Euphyllia	9	Red Sea and western Indian Ocean to southern Pacific	Generally common, very conspicuous
Plerogyra	3	Red Sea and western Indian Ocean to southern Pacific	Generally uncommon, very conspicuous

Family and genus	Extant species {no.}	Present distribution	General abundance
Dendrophylliidae Turbinaria	Approx. 15	Red Sea and western Indian Ocean to southern Pacific	Very common, very conspicuous
Duncanopsammia	1	Central Indo-Pacific	Uncommon, very conspicuous

Management Unit: **Ahermatypic Corals (Azooxanthellate)**

Important Summary Documents

Veron (1986) describes the three genera with photos of living and skeletal examples.

Taxonomic Issues

Order Scleractinia; Family Dendrophylliidae; Genera *Dendrophyllia* (de Blainville, 1830), *Tubastraea (*Lesson. 1829), *Balanophyllia spp*. (Wood, 1844). *Duncanopsammia axifuga* is of the same family and has a skeletal structure and growth form intermediate between hermatypic and ahermatypic forms. As it is zooxanthellate, it is not described here. Other zooxanthellate corals such as *Heteropsammia* and *Psammoseris* (both Dendrophyllidae), *and Heterocyathus* (Caryophylliidae) are they small, single polyp forms and appear as partial ahermatypes (Veron, 1986). Their contribution to reef growth is minor and they occur on sand and rubble substrates. Heteropsammia spp. doesn't occur in the AFPI.

Other genera occur in deep water or deep inter-reef areas and are listed with their recorded depth range (after Veron, 1986): Letepsammia (165-457m); Fungiacyathus (190-600m); Madrepora (55-450m); Cyathelia (40m); Culicia and Astrangia (inter-tidal to 128m, largely temperate); Flabellum (10-824m); Placotrochus (to 188m); Monomyces (3-40m); Gardineria (55m); Anthemiphyllia (to 210m); Caryophyllia (119-1006m); Tethocyathus; Premocyathus (20-230m); Cythoceras (86-766m); Trochocyathus (86-531m); Deltocyathus (16-531m); Boureotrochus (210-531m); Sphenotrochus; Polycyathus (>40m); Aulocyathus (163-190m); Conotrochus (210-365); Stephanocyathus (366-1006m); Oryzotrochus (9-15m); Conocyathus (8-22m); Trematrochus (>27m); Dunocyathus (100-531m); Paracyathus(>20m); Patytrochus (28-183m); Cylindrophyllia; Peponocyathus (339-365); Holcotrochus (11-183m); Desmophyllum; Solenosmilia (860m); Stenocyathus (455-531m); Septosammia (8-86m); Endopachys; Notophyllia (36-457m); Thecopsammia (270m).

Habitat Utilization

Not dependent on light so able to colonizes overhangs and caves. Competes best in areas of low scleractinian coral or algal occurrence. *T. micrantha* competes best due to its erect arborescent nature and may be dominant below 15m in areas of exposed currents.

Life History

Adult: Appearance and Physical Characteristic

Dendrophyllidae :

Solitary and colonial corals with more than two rings of tentacles on the polyps. Numerous skeletal element of the ridges form an almost continuous sheet and rods connect adjacent ridges. *Dendrophyllia* and *Tubastrea spp.* may appear similar superficially but are separated by differences in septal plans.

Dendrophyllia spp.: Often brightly colored (yellow or orange) resulting from the corals own pigment, as no zooxanthellae are present. Colonies are dendroid and proliferate through extra-tentacular budding. Generally nocturnal but also diurnal extension.

Tubastraea spp.: Tubular corallites forming hemispherical colonies. *Tubastrea aurea* forms domed clumps up to 10cm dia. Polyps protrude for a common encrusting base. Usually found in low-light conditions in caves and beneath rocky overhangs. Common species *T. faulkneri, T. coccinea, T. diphana and T. micrantha.*

Tubastrea micrantha forms tree-like branching colonies to 1m in height. Colour dark brown and green. Occurs in deeper reef environments.

Balanophyllia spp.: Solitary corals which bud to form closely packed clumps. Clumps may be 50cm diam. Thick walls. Polyps are oval and tapering towards the base, and the septa are fuse. Color black, bright-orange or yellow polyps.

Feeding and Food
Heterotrophic with dependence on the capture of zooplankton. Nocturnal and diurnal feeding.

Reproductive Strategies
Dioecious. Fertilization is internal and larvae are brooded. Asexual larval reported (Richmond and Hunter, 1990). The larvae are 1mm long and crawl or swim after release before settling. They may also be free-spawners (Harrison and Wallace, 1990). Planula takes four to seven days before they settle and form a primary polyp.

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Table 10. Deep Water Ahermatypes from Hawaii (From Maragos 1977)

Anisopsammia amphelioides (Alcock) B 40 ftm
Anthemiphyllia pacifica Vaughan B 92 ftm
Balanophyllia desmophyllioides Vaughan B 78 ftm
Balanophyllia diomeseae Vaughan B 148 ftm
Balanophyllia hawaiiensis Vaughan B 190 ftm
Balanophyllia laysanensis Vaughan B 130 ftm
Bathyactis hawaiiensis Vaughan B 963 ftm
Caryophyllia alcocki Vaughan B 876 ftm
Caryophyllia hawaiiensis Vaughan B 92 ftm
Caryophyllia octopali Vaughan B 28 ftm
Ceratotrochus laxus Vaughan B 319 ftm
Cyathoceras diomedeae Vaughan B 169 ftm
Deltosyathus andamanicus Alcock B 147 ftm
Dendrophyllia oahensis Vaughan B 154 ftm
Dendrophyllia serpentina Vaughan B 147 ftm
Desmophyllum cristagalli Milne- Edwards & Haine B 220 ftm
Endopachys oahense Vaughan B 53 ftm
Flabellum deludens v. Marenzeller B 670 ftm
Flabellum parvoninum Lesson B 127 ftm
Gardineria hawaiiensis Vaughan B 272 ftm
Madracis kauaiensis Vaughan B 24 ftm
Madrepora kauaiensis Vaughan B 294 ftm
Paracyathus gardineri Vaughan
Paracyathus mauiensis Vaughan B 95 ftm
Paracyathus molokensisx Vaughan B 88 ftm
Paracyathus tenuicalyx Vaughan B 252 ftm
Placotrochus fuscus Vaughan B 148 ftm
Stephanophyllia formosissima Moseley B 66 ftm
Trochocyathus oahensis Vaughan B 252 ftm
Depths(ftm) represent shallowest collection record.
Data Vaughan (1907).

Management Unit: **Actiniaria: (Anemones)**

Important summary documents
Symbiosis between anemones and fish was first noted by Collingwood (1868). Fishelson (1970, 1971) speculated on the ecological role of this association. The taxonomy of symbiotic anemones was revised by Dunn (1981). The taxonomy of the Hawaiian anemones were described in Eldredge and Devaney (1977). Chia (1976) has described reproduction in terms of patterns and adaptive radiation. Fautin and Allen (1992) describe the biology of anemonefish and their host anemones.

Taxonomic issues
Ecotypes are common (e.g. *Entacmaea quadricolor)* which has given rise to taxonomic confusion Allen (1975) described the deeper water as *Radianthus gelam* and the smaller individuals a *Physobranchia douglasi.* Their ability to adopt a varied coloration both in terms of background color and geographic variation has made taxonomy difficult.

Habitat Utilization
Anemones attach to hard substrate by their basal disc, burrow into soft substrate or attach as symbionts to sessile and mobile reef creatures.

Life History

Adult: Appearance and Physical Characteristic
Anemones have a body column and oral disc with tentacles with nematocysts and a central mouth. They are attached by a basal or pedal disc to the substrate (Barnes, 1980). They are often associated with symbiotic relationships such as with fish or shrimps (Fautin and Allen, 1992). *Heteractis magnifica* reaches a diameter of 30-50cm though may reach 1m.

Ten species are recognized as symbiotic anemones (Actiidae; Thalassianthidae; Stichodactylidae).

Both *Actinodendron plumosum* and *Phyllodiscus semoni* have severe stings if touched.

Some species of anemones can exhibit mimicry appearing like their background or other reef entities like hard coral or algae.

Age, Growth, Longevity
The growth of tropical anemones is variable being largely dependent on nutrition. Longevity among tropical anemones is poorly known. Anemones approaching a meter in diameter may exceed 100 years old (Fautin and Allen, 1992). *Actinia tenebrosa* requires

8 to 66 years to reach a column diameter of 40mm and has an average longevity of 50 years (Ottaway, 1980).

Reproductive Strategies

Asexual: Common: Pedal laceration and longitudinal or transverse fission
Asexual reproduction has been observed as budding (Vine, 1986). Devaney & Eldredge (1977) describe *Boloceroides mcmurrichi* as reproducing sexually in spring and asexually in fall when the asexually young arise as buds on the outer tentacles and are shed when they have developed 10 to 30 tentacles.

Eggs and sperm are produced and host anemones appear to be characterised by separate sexes.

Absence of small individuals is indicative of low fertilization, larval survival or larval settlement or young have high mortality (Fautin and Allen, 1992).

Most are hermaphroditic but reproduce only one type of gamete per reproductive period. Groups of clones evident.

Distribution

Anemones are often widely distributed. The common anemone *Entacmaea quadricolor* is found from Samoa to East Africa and the Red Sea and from the surface down to 40 metres. Of nearly 1000 species, only 10 species are host to anemone fishes. In Hawaii, There is only one host species recorded from Hawaii though without commensal fish (Fautin and Allen, 1992).

Feeding and Food

Anemones are polyphagous opportunists (Ayre 1984). Prey is caught by the tentacles, paralyzed by nematocysts and carried to the mouth. The food consists of plankton borne crustacea but fish worms, and algal fragments are includes Sand dwelling anemones such as *Heteractis malu* ingest gastropods (Shick, 1990) as does *Catalophyllia sp.* Some anemones are suspension feeders (Barnes , 1980).

Specialized corallimorpharians such as *Rhodactis, Actinodiscus, Discosoma, Amplexidiscus* can capture large prey by enveloping them with the entire disk (Hamna and Dunn, 1980; Elliott and Cook, 1989).

Anemones which contain symbiotic zooxanthelle but also capture plankton and other detrital or water borne food. Those without zooxanthella are dependent on plankton and may capture pother food such as crustaceans or smaller fish.

Absorption of dissolved organic material (DOM) by anemones occurs Schlichter (1980) and Schlichter et al. (1987). DOM is important in times of no solid food. (Shick, 1975)

Extracellular digestion is achieved by mesenterial filaments (Nicol, 1959)

Some species of anemones extend their tentacles at night and diminutive during the day (*Alicia sp)*. Others feed during daylight hours.

Behaviour

The family Boloceriodidae contains anemones capable of swimming by beating their tentacles. The Hawaiian species *Boloceroides mcmurrichi* has a large crown of tentacles compared to a relatively small body. They become capable of swimming at the 10 to 30 tentacle stage (Devaney and Eldredge, 1977).

Edwardsia spp. are found on sandy bottoms and dig themselves into the substrate.

Anemones are basically sedentary but are able to move over the substrate slowly, some can swim for short distances.

There commensal behavior with fish where it gains protection and food and in turn protects the anemone from some predators and removes sediment and other material by its swimming motion (Barnes, 1987).

Spawning: Spatial and temporal distribution

Spawning is synchronised with the full moon or low tide (Fautin and Allen, 1992).

Eggs are fertilized in the gastrovascular cavity or occurs outside in the seawater (Fautin and Allen, 1992).

Free swimming planula

Larval feeding and food

Ingest copepods, chaetognaths, or larvae of other cnidarians. Unicellullar algae and dinoflagellates has been observed Widersten, 1968; Siebert, 1974)

The planula may be planktotrophic or lecithotrophic and has a variable larval life span. The young sea anemone lives as a ciliate ball, unattached and free swimming. The larvae settles, attaches and forms tentacles.

Habitat utilization

Asexual of reproduction give rise to many individuals in close proximity, often forming a continuous surface by adjacent oral discs. Like other sessile benthos, settlement of larval stages colonizes available substrate.

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Table 11. <u>ACTINIARIA FROM HAWAII</u>
<u>(Cutress, 1977)</u>

Order ACTINIARIA

Family BOLOCEROIDIDAE
Boloceroides memurrichi (Kwietniewski 1898)
Bunodeopsis medusoides (Fowler 1888)

Family ALICIIDAE
Triactis producta Klunzinger 1877

Family ACTINIIDAE
Anemonia mutabilis Verrill 1928
Anthopleura nidrescens (Verrill 1928)
Anthopleura sp. *a*
Anthopleura sp. *b*
Actiniogeton sesere (Haddon & Shackleton 1893)
Cladactella manni (Verrill 1899)

Family STOICHACTINIDAE
Antheopsis papillosa (Kwietniewski 1898)
Stoichactis sp.

Family PHYMANTHIDAE
Heteranthus verruculatus Klunzinger 1877

Family ISOPHELLIDAE
Telmatactis decora (Hemprich and Ehrenberg 1834)
Epiphellia pusilla (Verrill 1928)
Epiphellia humilis (Verrill 1928)

Family HORMATHIIDAE
Calliactis polypus (Forskal 1775)

Family SAGARTIIDAE
Anthothoe sp.

Family AIPTASIIDAE
Aiptasia pulchella Carlgren 1943

Family DIADUMENIDAE
Diadumene leucolena (Verrill 1866)

Family EDWARDSIDAE
Edwardsia sp. *a.*
Edwardsia sp. *b.*

Management Unit: **Zoanthidae (colonial anemones)**

Important summary documents

Hyman (1940) details systematics and anatomy. Mather and Bennett (1993) discuss the order Zoanthidae. Burnett et al. (1997) a good summary of systematics for some central Indo-Pacific species. Walsh (1967) produced an annotated bibliography for the family.

Taxonomic issues

Class Anthozoa; subclass Zoantharia (=Hexacorallia); order Zoanthiniaria (=Zoanthidea); suborder Brachcnemina; family Zoanthidae; genera Acrozoanthus; *Zoanthus; Isaurus; Protopalythoa; Palythoa; Sphenopus. s*uborder Macrocnemina; family Epizoanthidae; genera *Epizoanthus; family* Epizoanthidae, *Thoracactis*; genus *Parazoanthus, Gerardia, Isozoanthus* (Barnes, 1987; Muirhead and Ryland, 1985).

Poorly known due to reliance on preserved specimens and a high degree of inter-population variability. Nominal species 300.

Differentiated from the Actinaria by the presence of a fifth cycle of mesenteries.

Zoanthiniarian systematics is discussed by Herberts (1972a; 1987) and Mather and Bennett (1993).

Habitat utilization

Often distinct zonation: back reef flats, lagoon floors, reef crests and shallow sublitoral zone.

Palythoa spp.: Growth in large numbers on reef flats immediately behind the reef crest, also found on lagoon floors and the spur and groove channels of reef slopes. Tide pools in Hawaii.

Parazoanthus ssp., Epizoanthus ssp. , Acrozoanthus spp.: May colonize worm tubes, hydroids, sponges and gorgonian skeletons. May be epizootic on sponges, or ascideans as ATuff Balls or providing as protection (Colin and Arneson, 1995).

Protopalythoa spp.: Shallow fore reefs, reef crests or outer reef flat areas. Shallow reef zones may be dominated by this genus and cover may be >90%. May occur as small assemblages of polyps or separate individuals.

Zoanthus spp.: They are found in back reef areas and the shallow sub-littoral zone.

Life History

Adult: appearance and physical characteristic

Zoanthid anemones are solitary or colonial, zooxanthellate (except *Sphenopus*). Principal tropical genera are *Palythoa, Protopalythoa* and *Zoanthus.* Generally, discs are 1-2cm in diameter with tentacles 3-5mm long but may extend to 2-3cm. Coloration varies from red, orange, yellow, turquoise, green or brown. The stem (scapus), disc (capitulum), tentacles or coenenchyma vary in coloration. Zooanthids differ from other Zoantharia in that they don't produce skeleton but incorporate sediment into the body wall. As well, they don't have a pedal disc and a differing septal arrangement (this forms the basis for the two suborders).

Isaurus spp.: Loosely connected colonies without connecting stolons. Height varies 15-160cm. Colonies with < 50 individuals. Taxonomically best known (Muirhead and Ryland, 1985). Often inconspicuous. Nocturnal tentacular extension.

Palythoa spp.: Growth in massive colonies. Sand particles are encrusted into the coenenchyme. Colonies are convex and 30cm. Coenenchyme is light brown to yellow. Often buried in the sand to the level of the disc.

Protopalythoa spp.: Generally in loosely connected colonies. Often the polyps lack contact or have contact at the base through a stolon. Polyp height is 15-25 mm high and 7-11mm in diameter. Expanded discs may attain a diameter of 2-3cm. May occur as large areas of colonization, small assemblages or individual polyps. Polyps are encrusted with sand particles. For some, full retraction is not possible due to the size of the disc. Colour is uniform on the stem and disc; brown or green. It may be variable due to the intensity of light.

Zoanthus spp.: Sediments are not incorporated in their tissues but are tolerant of sediment environments. Most species are brightly coloured, often contrasting disc, tentacles and stem.

Growth

Growth morphology may depend on the environment. *Z. pacificus* has a lamellar coenenchyme with crowded polyps and separate bases. In surge pools, the bases are joined and crowding less. In wave washed area the coenenchyme can be lamellar or stoloniforous with single polyps or groups of two or three (Walsh and Bowers, 1971).

In *Palythoa,* growth is by the spreading of the thickened coenenchyme. Yamazato et al. (1973), found 0.18 new polyps per day increase in *Palythoa tubercles.* Density of colonies may be 671 polyps/0.1m^2 (*Zoanthus sociatus*) and 302 polyps/ 0.1m^2 for *Z.*

solanderi. (Karlson, 1981). 12,000/m^2 of *Palythoa vestitus* where found in Kaneohe Bay.

Distribution

Isaurus spp: Widespread in all tropical seas; present in Hawaii.

Palythoa spp.: Pan-tropical; present in Hawaii.

Protopalythoa spp.: Pan tropical; occurs in Hawaii, American Samoa and Tahiti.

Zoanthus spp.: Pan-tropical; occurs in Hawaii, American Samoa and Tahiti.

Feeding and food

Heterotrophic (zooplankton); autotrophic (zooxanthellae) (Reimer 1971b).

Muscatine et al. (1983) determined zooxanthellae could provide 48% of the carbon requirement for *Zoanthus sociatus.*

Palythoa, Protopalythoa and Zoanthus are diurnal in expansion. Others are nocturnal Isaurus and Sphenopus. Able to ingest a variety of live and dead crustacea and fish portions (Reimer, 1971a). Crustacean and detrital fragments were found in *Zoanthus Sociatus*, though few contained food items with only a greater frequency at night (Sebens, 1977). Azooxanthellate genera (*Epizoanthus and Parazoanthus)* rely greatly on feeding to obtain sufficient nutrition.

The uptake of dissolved organic matter may contribute to nutrition (Reimer, 1971; Trench, 1974). The common presence of *Zoanthus* spp and *Protopalythoa* in shore may be due to the higher organic levels. With the reduction in sewage contamination in Kaneohe Bay, zoanthid population declined.

Isaurus spp: Autotrophic nutrition from the zooxanthellae but also feeds on plankton nocturnally. Polyps never open in the day.

Palythoa spp.: Generally autotrophic but tentacles and diurnal expansion indicate reliance on zooplankton.

Protopalythoa spp.: Heterotrophic; autotrophic

Zoanthus spp.: Heterotrophic; autotrophic

Reproductive strategies
Asexual by the arising of new polyps from a spreading sheet of coenenchyma or stolons or budding from the parent polyp. Extensive monoclonal colonies occur. Fragmentation is common.

Sexual reproduction: Both dioecious (gonochoristic) and sequential and simultaneous hermaphrodites.

Isaurus spp: Unknown.
Palythoa spp.: Readily reproduces asexually. Yamazoto et al. (1973) studied the reproductive cycle of *Palythoa tuberculosa* in Okinawa. The oocytes grow from March/April, to a peak in the middle of the year, which followed by a second peak in October indicative of two spawnings per year. Mature eggs are rather large with a length of 300-500um.

Protopalythoa spp.: Asexual and sexual. Babcock and Ryland (1990) and Ryland and Babcock (1991) describe reproduction and larval development.

Zoanthus spp.: Asexual and sexual. Cooke (1976) describes reproduction for *Zoanthus pacificus* and for *Z. solanderi and Z. sociatus* by Fadlallah et al. (1989).

Spawning: Spatial and temporal distribution
Ovaries develop initially in the cycle along the margin of the mesenteries with the testis later in the cycle. Seasonal free spawning. Report of spawning synchronous with the mass spawning of the stony coral, on the 4th to 6th nights after full moon in November (Ryland and Babcock, 1991). In Hawaii, *P. versitis* was only active May to September while *Z. pacificus* was bound to be sexually active all year but greatest during the summer (Cooke, 1976).

Eggs and Larvae
Egg diameter range from 75um to 280 um. Sperm are bell shaped and 50 um long. Egg counts range from 800 to 2400 (Ryland and Babcock, 1991). Larvae settle in areas of coralline algae and crawl to find a site. Suitable sites are often shaded. Fecundity is high and settlement rates are low. Sexual reproduction is therefore thought to allow for dispersal and colonization over large distances (Karlson, 1981).

The larvae are oval in shape and have a girdle of cilia near the oral end. The Larvae of *Protopalythoa spp.* are referred to as zoanthella and are elongate with a ventral band of long cilia (Hyman, 1940).

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Table 12. Zoanthiniaria from Hawaii

Order ZOANTHINIARIA

Family ZOANTHIDAE
Isaurus elongatus Verrill 1928
Palythoa vestitus (Verrill 1928)
Palythoa tuberculosa (Esper 1791)
Palythoa psammophilia Walsh and Bowers 1971
Palythoa toxica Walsh and Bowers 1971
Zoanthus pacificus Walsh and Bowers 1971
Zoanthus kealakekuaensis Walsh and Bowers 1971

From Walsh and Bowers (1977)

Subclass Alcyonaria (=Octocorallia); Order Alcyonacea; Suborder Alcyoniina: soft corals

Important Summary Documents

Bayer et al. (1983) and Bayer (1981) details anatomical terminology and taxonomy. Hyman, (1940) describes the anatomy.

Taxonomic issues

Subclass Alcyonaria (=Octocorallia); order Alcyonacea; suborder Alcyoniina: families: Paralcyoniidae; Alcyoniidae; Asterospiculariidae; Nephtheidae; Nidaliidae; Xeniidae

The taxonomy of common intertidal and lagoon genera *Sarcophyton* and *Sinularia* are revised in Verseveldt (1980, 1982).

Habitat Utilization

Colonies characteristic of large size grow in shallow water areas in high light intensity and intertidally. Generally colonies are smaller on roofs of caves.

Life History

Adult: appearance and physical characteristic

Alcyonaria: Colonial, tentacles and mesenteries 8 with tentacles pinnate attached. Alcyonacea: Alcyoniina (Soft corals): Fleshy, stolon, membranous, encrusting or erect with tree-like branching. Monomorphic polyps (autozooids: function in food intake, water movement and bear the gonads). Some genera have dimorphic polyps (autozooids and tentacle-less siphonozooids) e.g. *Lobophytum spp.* and *Sarcophyton spp.* Dimorphism attributed to need for transport of water (Bayer, 1973). Skeleton has calcite spicules (sclerites). Coenechyme is the general colonial mass filled with solenia that connect with the polyps and their anthocodium. Tentacular contraction possible in some and only partial in others.

Zooxanthellate with resulting colour of greens to brown or bright coloration in the sclerites.

Paralcyoniidae: Lobed to arborescent upper portions and are able to retract this region into the lower stalk. Rigidly reinforced with large sclerites.

Alcyoniidae: Large, lobed colonial forms with considerable amounts of scleritic coenenchyme.

Nephtheridae: The coenenchyme between polyps is thin, arboresent with polyps grouped at the ends of branches. Hydrostatic pressure important to provide support.

Nidalidae: Rigid, brittle, arborescent colonies with narrow stems and branches. Densely covered with spindle shaped sclerites. Similar in appearance to gorgonians Xeniidae: Fleshy with sclerite mass reduced. Characterized by tentacular oscillation.

Age, Growth, Longevity
Two main growth forms massive and arborescent.

Growth by vegetative budding from the system of solenial canals between confluent coenenchyme. Mucus production high in some and effective in cleaning of the surface of the colony. Colonies are often prolific with numerous colonies covering large areas. In Guam population density of up to 24 colonies per square meter of *Asterspicularia randalli* (Gawel, 1976).

Distribution
Occurring in all oceans at all latitudes, they are most abundant in the tropics.

Paralcyoniidae: *Studeiroides spp.: Indo-Pacific*

Alcyoniidae: *Sarcophyton spp./ Lobophytum spp.: Cladiella spp.:* Very common in the Indo-Pacific. *Sinularia spp.:* Indo-Pacific Philippines, Malayan Archipelago Great barrier Reef- Australia, Vietnam, Palau, New Caledonia and the Ryukyu Island, Japan.

Asterospiculariidae: *Asterospicularia sp.:* Guam

Nephtheidae: *Capnella spp. / Nepthea spp. / Dendroneptha spp.:* Very common in the Indo-Pacific.

Nidaliidae: *Chironephthya spp./ Nephthyigorgia spp/ Siphonogorgia spp.*: Very common in the Indo-Pacific.

Xeniidae: *Xenia spp./ Cespitularia spp.:* Indo-Pacific

Feeding and Food
Heterotrophic through zooplankton capture. Autotrophic through nutrient exchange with zooxanthellae, digestion of zooxanthellae and absorption of dissolved organic matter in the seawater (Fabricius, et al. 1995a,b).

Food is taken in through the mouth. Prey are immobilized by nematocysts and conveyed to the mouth by tentacles.

Behavior
Defensive

Chemical substances provide advantage over other organisms for protection by preventing feeding or securing space on the reef. Majority of species of soft corals contain toxic terpene compounds which they release in to their surroundings (Coll et al. 1982; and Coll and Sammarco 1983; 1986; Sammarco et al. 1983; Webb and Coll 1983). These may influence the reproductive capability or survivorship of scleractinian corals (Aceret et al. 1995a,b).

Physical defenses involve the use of sweeper tentacles, sclerites, overtopping,

Reproductive strategies
Asexual: Almost all increase colonial numbers through mechanisms such as fragmentation, budding, transverse fission and pedal laceration.

Fragmentation: Takes place in *Dendronephthya* in 5-10 days (Fabricius, 1995). Fragmentation can occur through constriction or though parting of the stolons.

Sexual: Dioecious and hermaphroditic. Gonads occur on the mesenteries and reproduction involves the release of gametes into the surrounding water. Fertilization may occur externally through broadcast spawning or within the polyp cavity. Internal fertilization gives rise to an internal brooded planula. Also internal fertilization may give rise to an externally brooded planulae. (Benayahu, and Loya 1983, 1984a, 1984b; Yamazato et al. 1981).

Alcyonium, Heteroxenia, Lobophytum, Parerythropodium, Sarcophyton and Xenia planulae were released between 11 and 13 days after the full moon in November. Egg size range from 625um (*Lobophytum*) to 810um (*Sarcophytum)* (Alino and Coll, 1989). Some are may be dioecious, external surface planula brooders (Benayahu, and Loya, 1983; 1984b; 1986). Presence of zooxanthellae is likely in planulae.

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Subclass Alcyonaria (=Octocorallia); Order Alcyonacea; Suborder Scleraxonia; Holoaxonia: Gorgonians Corals; Sea Fans and Sea Whips

Important Summary Documents
Bayer (1956, 1973, and 1981) summarizes taxonomy and anatomy.

Taxonomic Issues
Subclass Alcyonaria (=Octocorallia); Order Alcyonacea; Suborder Scleraxonia; Families: Briareidae; Anthothelidae; Subergorgiidae; Coralliidae; Melithaeidae; Parisididae; Holoaxonia; Families: Acanthogorgidae; Plexuridae; Gorgoniidae; Ellisellidae; Ifalukellidae: Chrysogorgiidae; Primnidae; Isididae.

Habitat Utilization
Strong current location; low light conditions such as depths and overhangs.

Life History

Adult: Appearance and Physical Characteristic
Generally arborescent in nature, some unbranched. Skeletal support by stiff axis utilizing the flexible gorgonin. Divided taxonomically on basis of a central supporting axis (gorgonin and fused sclerites) or core (cortex around chambered gorgonin). Polyps have pinnate tentacles, anthocodia sit in coenenchymal calyx and sheath is formed around the central axis.

The main stem is attached by to a plate or branchlets to the surface. Stem contains a central strengthening rod. The rod may be calcareous but is commonly of horny gorgonin. Short polyps occur all over the branches of the colony but not on the main stem. Colonies are often brightly colored and may reach 3m in height. Epizoic life common (George and George, 1979).

From (George and George, 1979):

Suborder Scleraxonia

Briareidae: Erect, finger-like processes of spongy texture (20cm height) or massive and encrusting. Zooxanthellate. Polyps monomorphic

Anthothelidae: Thinly branched sea-fan. Fragments easily. Polyps monomorphic.

Subergorgiidae: Sea-fan with anastomosing branches (1m height), strong and flexible, polyps monomorphic.

Coralliidae: Calcareous skeleton with color from pink to red. Retractile white feathery polyps and branch in any plane. Polyps dimorphic.

Melithaeidae: Sea-fan with jointed axis and brittle (50cm height).

Suborder Holoaxonia

Plexuridae: Dichotomously branched species.

Gorgoniidae: Sea-fan with anastomosing box-section branches, flattened, bushy or feathery branches (1m height).

Ellisellidae: Whip-like (1m long).

Primnidae: Stems stiff and heavily calcified. Polyp bases composed of spicules are arranged in whorls around the stem.

Isididae: Parallel with upright branches

Age, Growth, Longevity
Photosynthetic gorgonians grow rapidly 15 cm (*Gorgonia ventalin*); 2.5 cm/mon./branch *Pseudoplexaura spp and Pseudopterogorgia acerosa* (Sprung and Delbeek 1997)

0.8-4.5cm/yr. found in Puerto Rico. (Yoshioka and Buchanan-Yoshioka 1991)
Small colonies grow vertically faster but not necessarily in area.

Distribution
Cosmopolitan though most abundant in warmer waters.

Indo-Pacific occurrence:
Suborder Scleraxonia
Briareidae: *Solenopodium spp.; Briareum spp.*
Anthothelidae: *Erythropodium spp*
Subergorgiidae: *Subergorgia spp*
Melithaeidae: *Melithaea spp.; Mopsella spp.*
Ellisellidae: *Ellisella spp. / Junceella spp.*

Suborder: Holoaxonia
Acanthogorgidae: *Acanthogorgia spp.; Muricella spp.*
Plexuridae: *Bebryce spp.*
Gorgoniidae: *Lophogorgia spp.*
Chrysogorgiidae: *Stephanogorgia sp.*
Isididae: *Isis spp.*

Feeding and Food
Heterotrophic by the capture of zooplankton. Autotrophic through nutrient translocation from zooxanthellae. Relative few holoaxonic zooxanthellate genera in the Indo-Pacific. Particulate feeding described (Lasker, 1981)

Require strong current situations for effective feeding by fan-like colonies.

Behavior
Periodic shedding of the waxy cuticle as a means of surface cleaning.

Reproductive Strategies
Parthenogenetic planulae production possible with planulae internal brooders (Brazeau and Lasker, 1989) though most where produced through broadcast spawning (Lasker and Kim, 1996).

Clonal propagation occurs (Lasker 1990).

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Heliopora coerulea

(DeBlainville, 1830) (Alcyonaria, Coenothecalia): Blue Coral

Important Summary Documents

Zann and Boulton (1985) detail the distribution, abundance and ecology in the Pacific. Hyman (1940) and Bayer (1973, 1981) describe the anatomy and taxonomy.

Taxonomic issues

Subclass Alcyonaria (=Octocorallia): Order Coenothecalia (=Helioporacea); monotypic, family Helioporidae with a single species. It is a soft coral with a hard, >stony coral-like= skeleton.

Habitat Utilization

High abundance of *Heliopora* is attributed to a reduction in competition from *Acropora, Pocillopora* and faviids in areas where theses are mutually exclusive. *Heliopora* frequently co-existed with *Porites* and *Montipora.* In terms of interspecific aggression, Heliopora is a good competitor as both *Acropora* and *Pocillopora* are considered aggressive (Lang, 1973).

It is a warm-water generalist with a wide habitat range.

Life History

Adult: appearance and physical characteristic

Zooxanthellate and colonial with a blue calcium carbonate skeleton which is the result of iron salts (Hill, 1960). Bouillon and Houvenaghel-Crevecoeur (1970) conclude the blue pigmentation is composed primarily of biliverdin IX and secondary oxidation products. (Hyman, 1940) describes the skeleton as composed of crystalline slivers of aragonite fused into a layer. There are no sclero-proteinaceous structures as in the rest of the Octocorallia. The skeleton contains strontium but in smaller amounts in comparison to hermatypic scleractinia.

Colour and growth form is highly variable: corallum pale to deep blue; living coral is light brown-grey with extended polyps grey-white. Growth forms: encrusting, columnar and branching (coalescent compressed, flabellate fronds, fine branching). May form massive micro-atolls (Zann and Boulton, 1985). Appears like a species of *Millepora.* There is a clear correlation between colony shape and environmental conditions (Veron 1986).

Skeleton with blind tubes internally one for the polyps and one for the solenia (Hyman, 1940).

Reproductive Strategies

Dioecious with fertilization taking place internally and the eggs are brooded externally (Babcock, 1990). External brooding is where they fertilized eggs are shed from the polyp and adhere to the side in mucus pouches were they the developed until they are released. Weingarten (1992) describes a synchronous annual of oocytic development following the general octocorallian reproductive strategy. The gametes are typically released in January, after the full moon, at the summer thermal maximum. Where its distribution is geographically marginal, it takes more than one year for the gametes to mature. It broods its larvae, which settle immediately after release.

Zann and Boulton (1985) suggest the limitation to its distribution to more isolated areas due to a relatively short larval life span. The short larval stage may be nutrient limited as the planula is azooxanthellate.

Distribution

Duration of larval life span, prevailing currents, and the geological and climatic history of isolated archipelagoes determine its distribution. Though widely distributed since the Cretaceous, now more abundant in the equatorial Central Pacific than in the Western Pacific. Comprises 16% of beach sediment in Tuvalu and 40% of substrate between 6m and 10m on Tarawa Atoll, Kirribati. Competition with Acroporidae and Faviidae influence its occurrence (Zann and Boulton, 1985). Globally, it occurs along West Africa, Red Sea, Indonesia and the Maldives, where it may be the dominant coral fauna. It occurs as far south as Madagascar and north to the Ryukyu Islands in Japan (Veron, 1986).

With regard to the AFPI, it is only present in Guam (Randall, 1977), Commonwealth of the Northern Marianas and American Samoa (rare) (U.S. Army Corps Engineers 1980).

Its habitat distribution is inter-tidal reef flats, reef front reef slope in Guam from < 1m to >30m. It is uncommon or rare (e.g. GBR; American Samoa) while it is abundant elsewhere. Heliopora zones have been described in the Marshall Islands and where it is considered as the most common coral (Emory et al. 1954; Wells, 1954a).

Feeding and Food

Heterotrophic and autotrophic by virtue of its zooxanthellae symbiosis. Prey capture is tentacular using nematocysts. Other sources of nutrition may be dissolved organic material and suspension feeding.

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Management Unit Species: **Tubipora Musica (Linnaeus, 1758) (Organ-pipe Coral or Star Polyps)**

Important Summary Documents
Veron (1986) describe the species.

Taxonomic Issues
Subclass Alcyonaria (=Octocorallia); Order Stolonifera; Family Tubiporidae; Genus Tubipora with one species *Tubipora musica*

Four nominal species, probably one true species (Veron, 1986).

Order Stolonifera may be considered a sub-order, with the Order Alcyonacea. Two genera present, *Tubipora* and *Pachyclavularia,* often confused with *Clavularia spp.* One form has tentacles which look like *Alveopora* though eight tentacles.

Habitat Utilization
Requires high illumination and strong circulation through wave action or currents. Abundant in shallow lagoons in turbid water. Also found on reef slopes and in deep water with clear or turbid water. In back reef locations, large heads form in sand or coral rubble. On the reef flat the colonies are smaller and encrusting (Sprung and Delbeek, 1997).

Life History

Adult: Appearance and Physical Characteristic
Colonies are massive, formed by long, parallel, calcareous tubes (stolons) of fused spicules connected by horizontal platforms. The tubes contain the polyps (zooids), each of which has eight pinnate or feather-like tentacles. The skeleton is a permanent dark-red colour. Polyp colour greenish-brown or grey polyps (Veron, 1986; Barnes 1987).

Age, Growth, Longevity
Asexual growth by budding from the solenial canals. Linking of polyps by outward growth from the body wall. The secondary stolon are platform-like and the scerites fuse producing hard massive colonies.

Distribution
Extends from the Red Sea and west Africa, east to Fiji and the Marshall Is. Southerly distribution from south of Madagascar and south Western Australia, north to the Kyushu Is., Japan. Not present in Hawaii, though in Guam and the CNMI.

Feeding and Food
Heterotrophic, autotroph with zooxanthellae

Reproductive Strategies
Sexual and asexual. Sexual reproduction is unknown in *Tubipora musica.* An example of other genera within the family may provide an analogous understanding. Morphologically similar, *Briareum stechei, Pachyclavularia violacea* was found to be dioecious external brooder with the developing planulae residing just beside the mouth. The reddish-brown planulae were released between 11 and 13 days after the full moon in November (Alino and Coll, 1989). The colour of the planulae suggests the presence of zooxanthellae.

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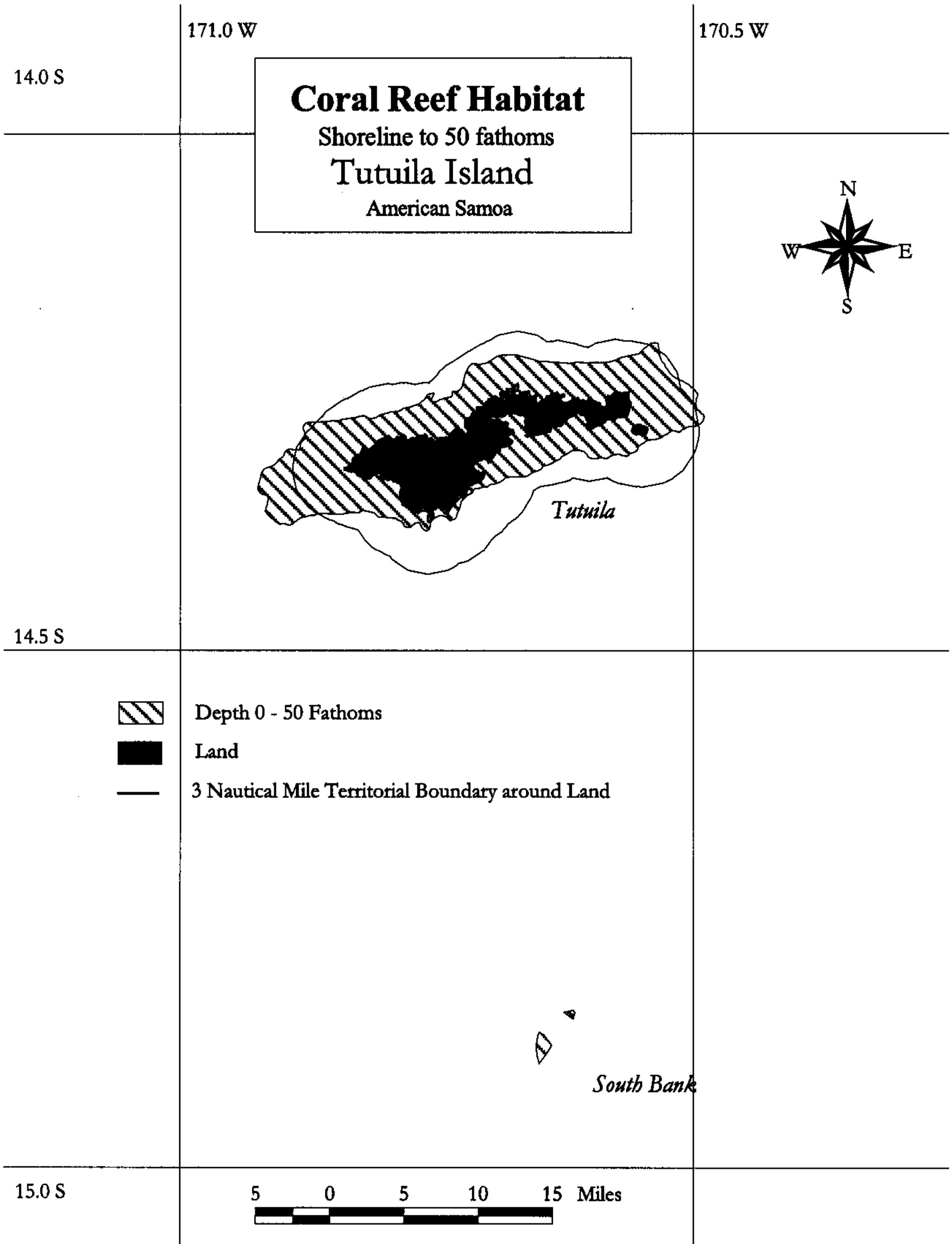
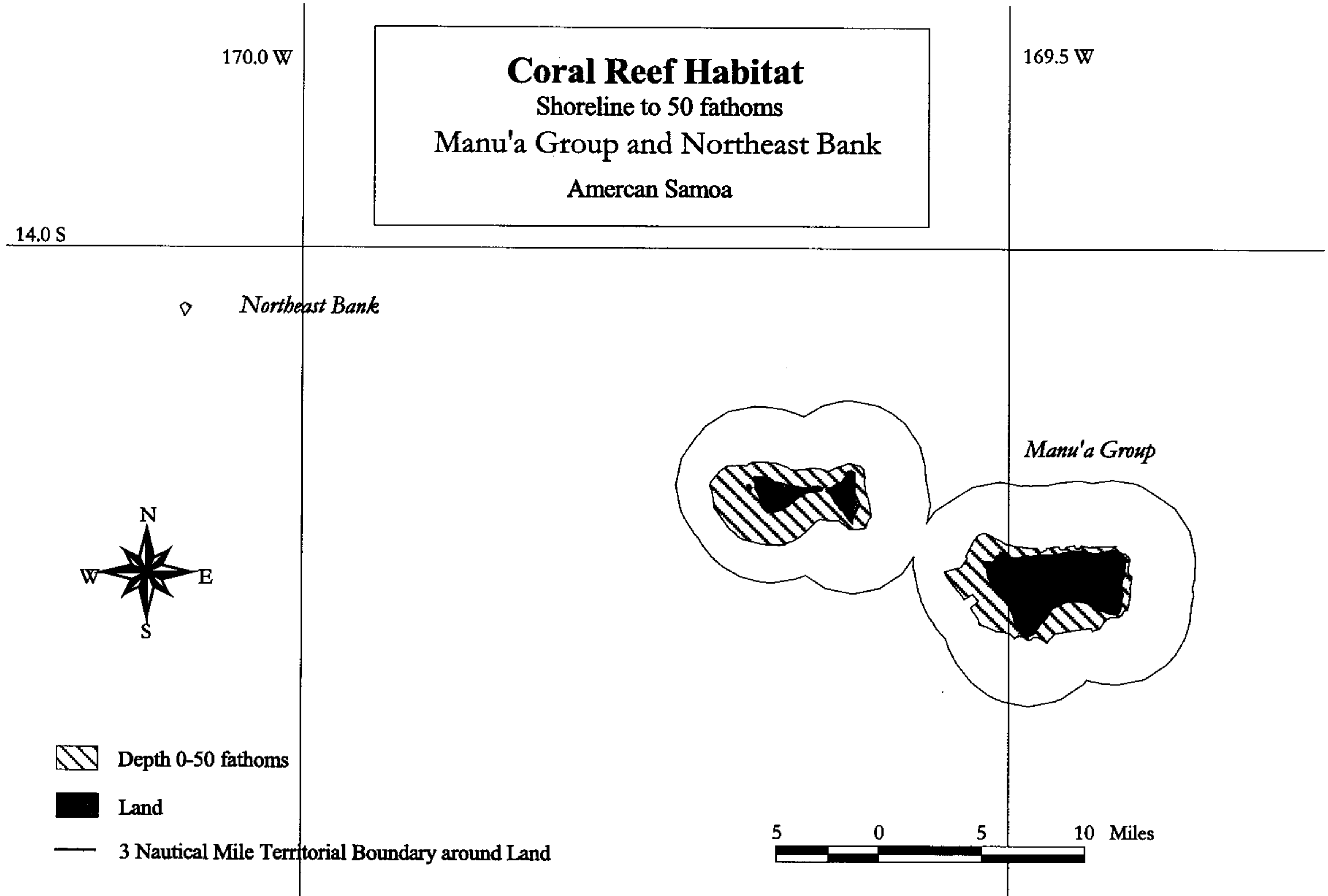
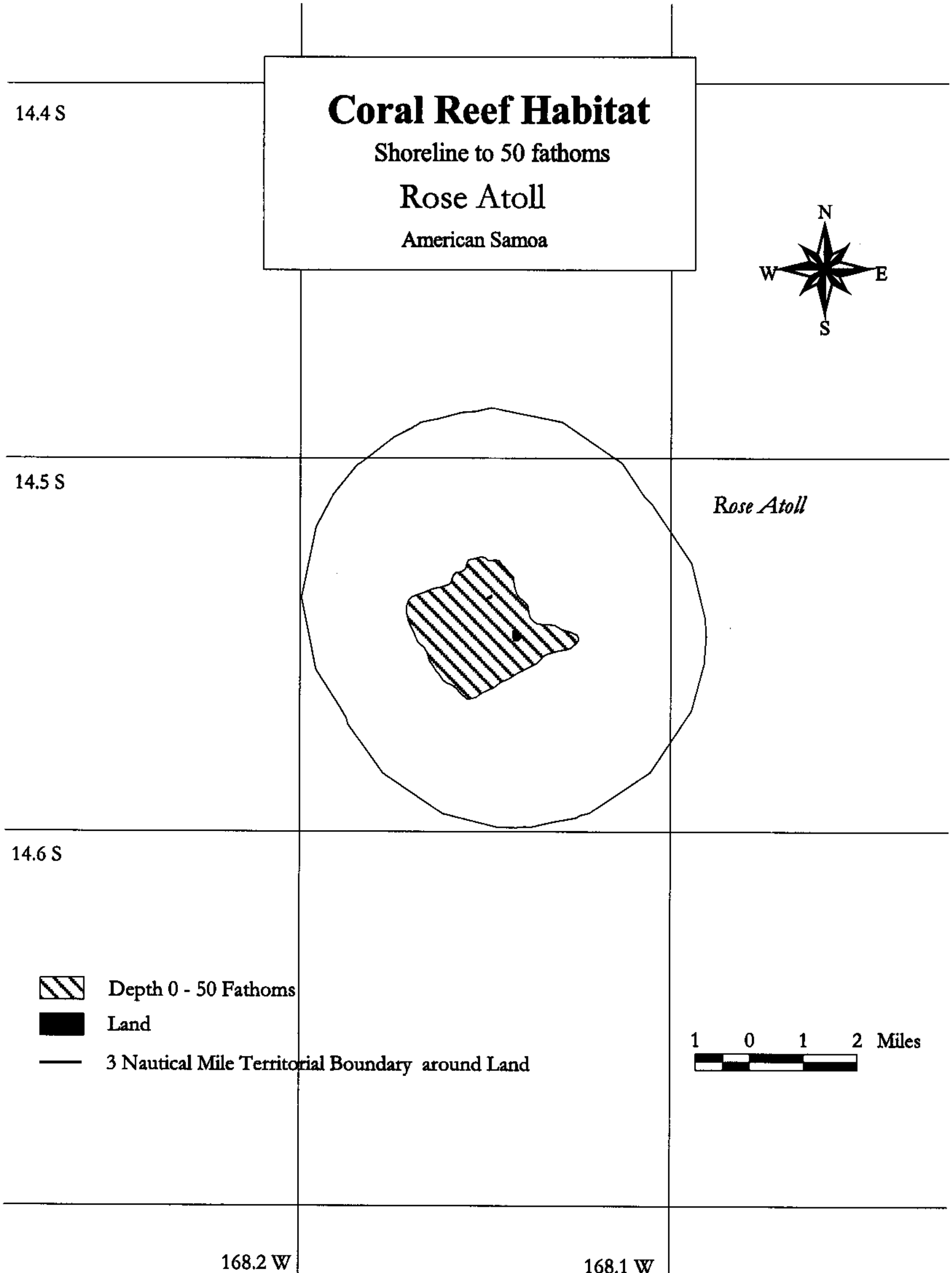
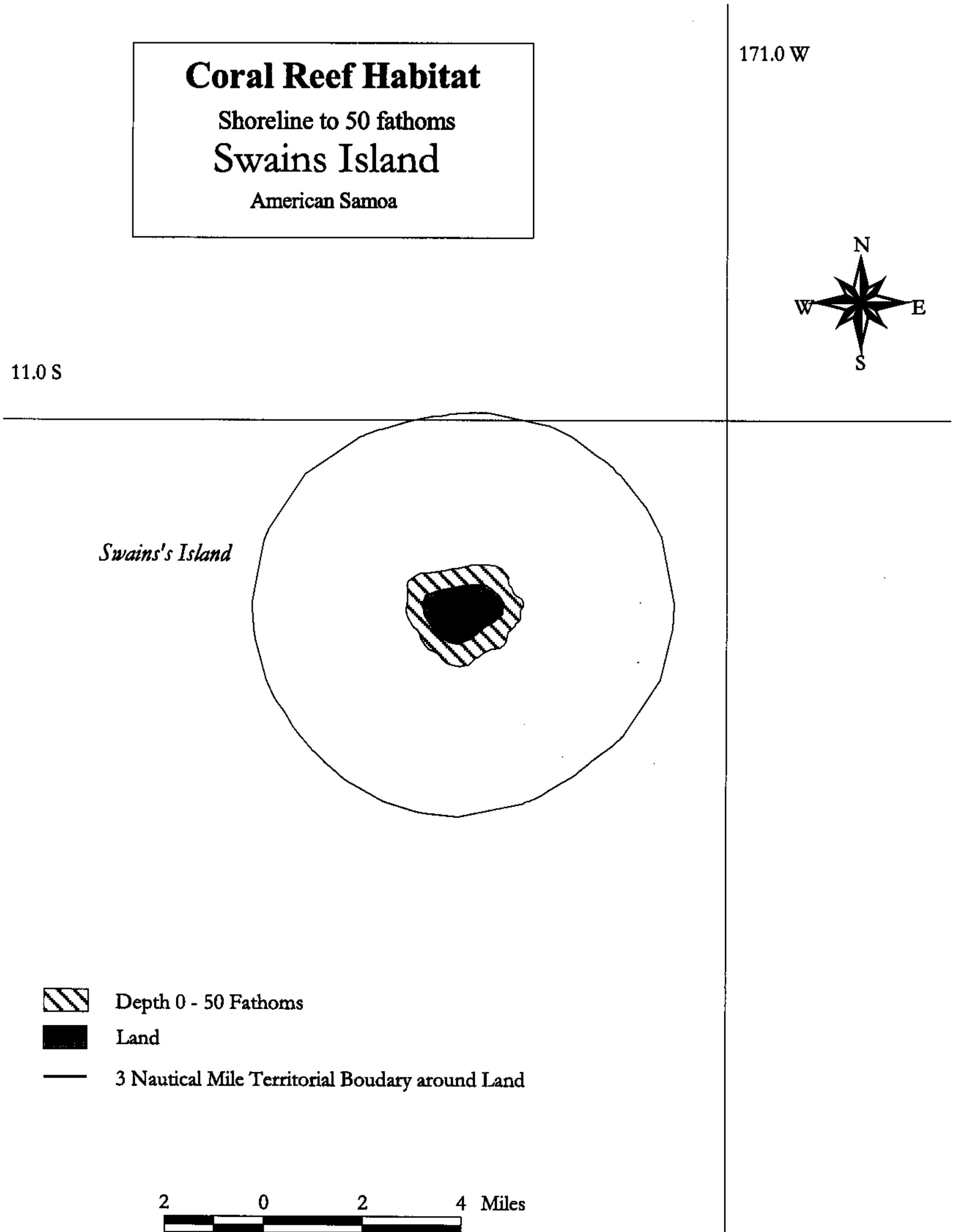

171.0 W
170.5 W
14.0 S
Coral Reef Habitat
Shoreline to 50 fathoms
Tutuila Island
American Samoa
N
W
E
S
Tutuila
14.5 S
Depth 0 - 50 Fathoms
Land
3 Nautical Mile Territorial Boundary around Land
South Bank
15.0 S
5 0 5 10 15 Miles

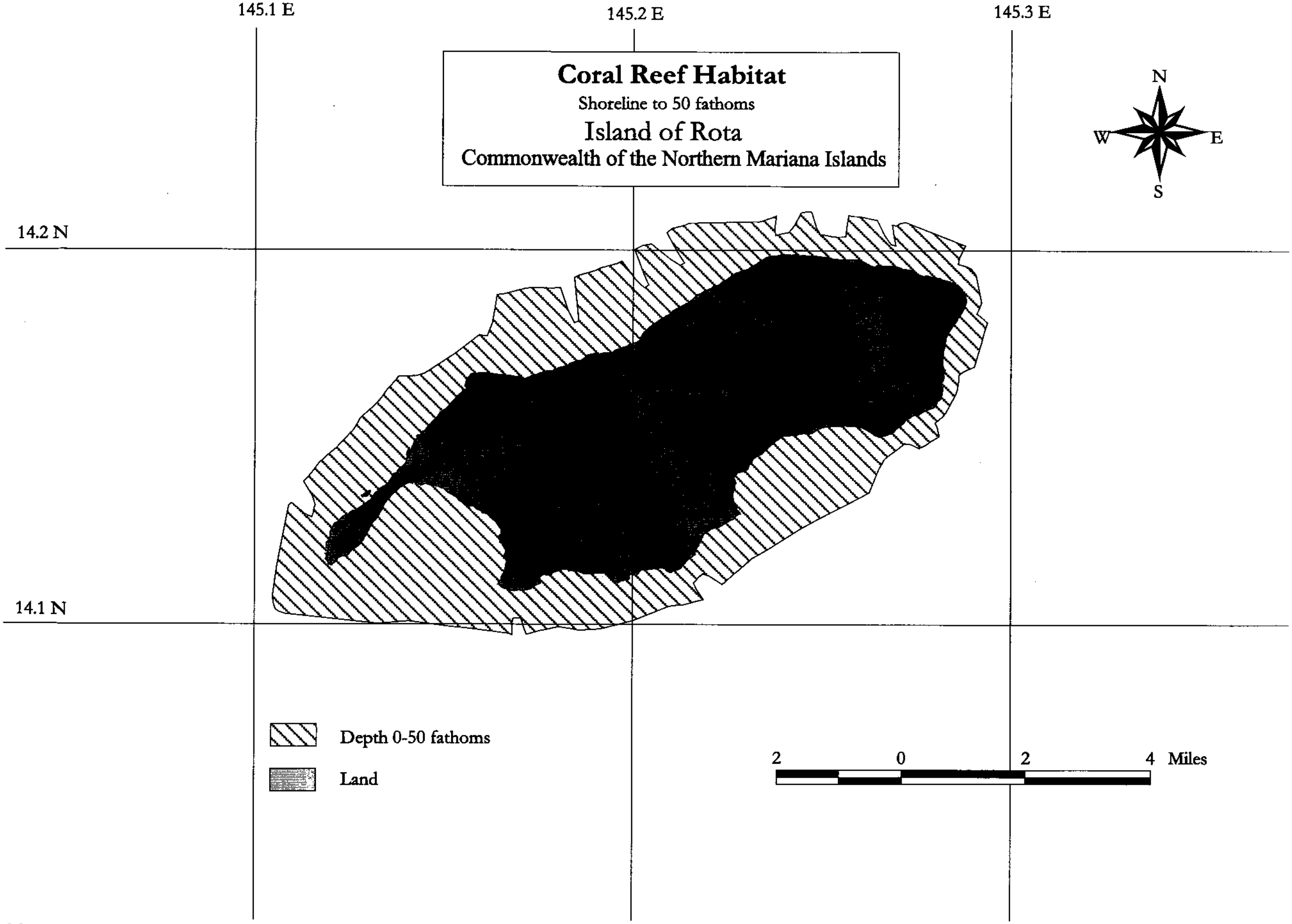

Coral Reef Habitat
Shoreline to 50 fathoms
Manu'a Group and Northeast Bank
Amercan Samoa
170.0 W
169.5 W
14.0 S
Northeast Bank
Manu'a Group
N
W
E
S
Depth 0-50 fathoms
Land
3 Nautical Mile Territorial Boundary around Land
5
0
5
10
Miles



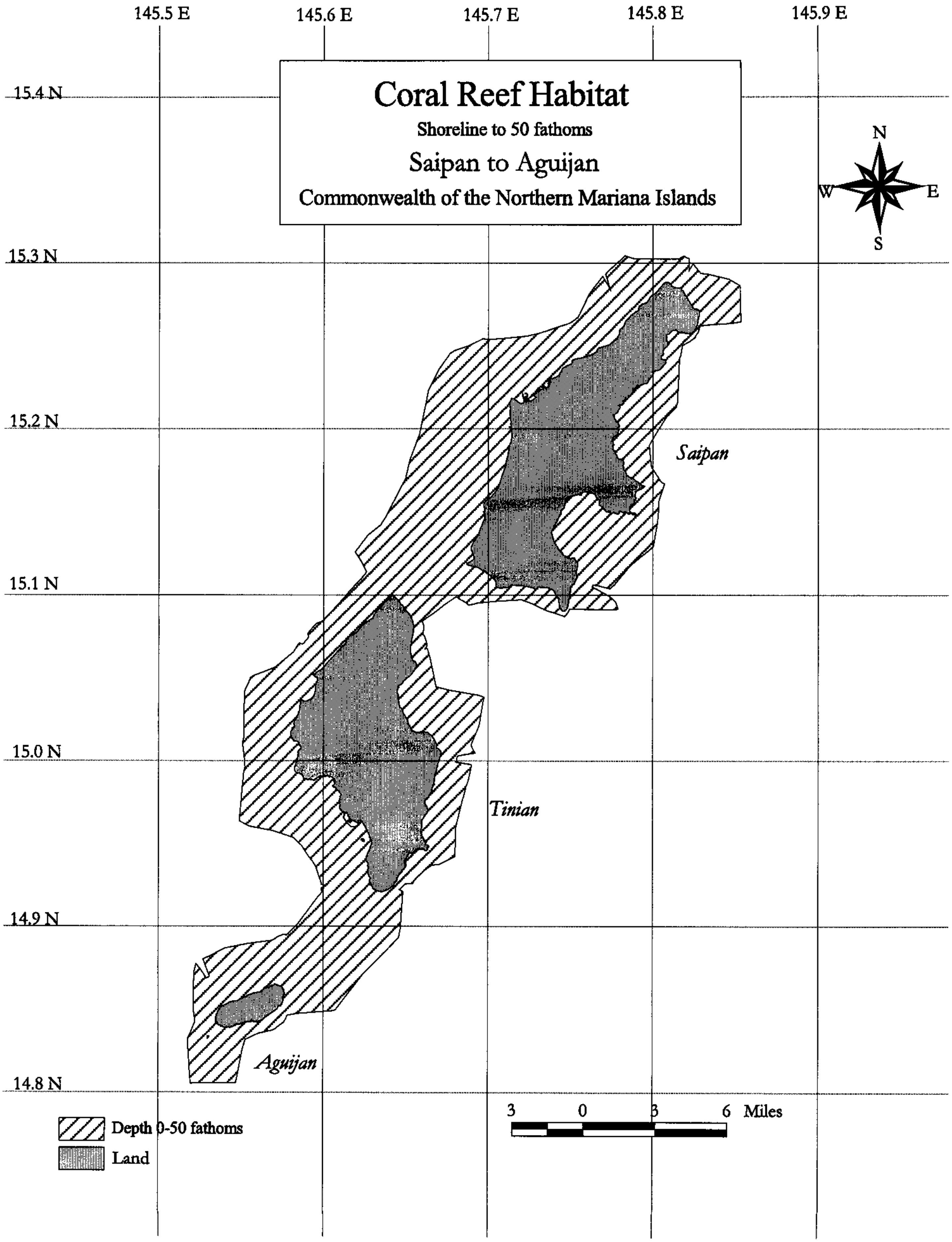
Coral Reef Habitat
Shoreline to 50 fathoms
Rose Atoll
American Samoa
14.4 S
14.5 S
14.6 S
N
W
E
S
Rose Atoll
Depth 0 - 50 Fathoms
Land
3 Nautical Mile Territorial Boundary around Land
1 0 1 2 Miles
168.2 W
168.1 W



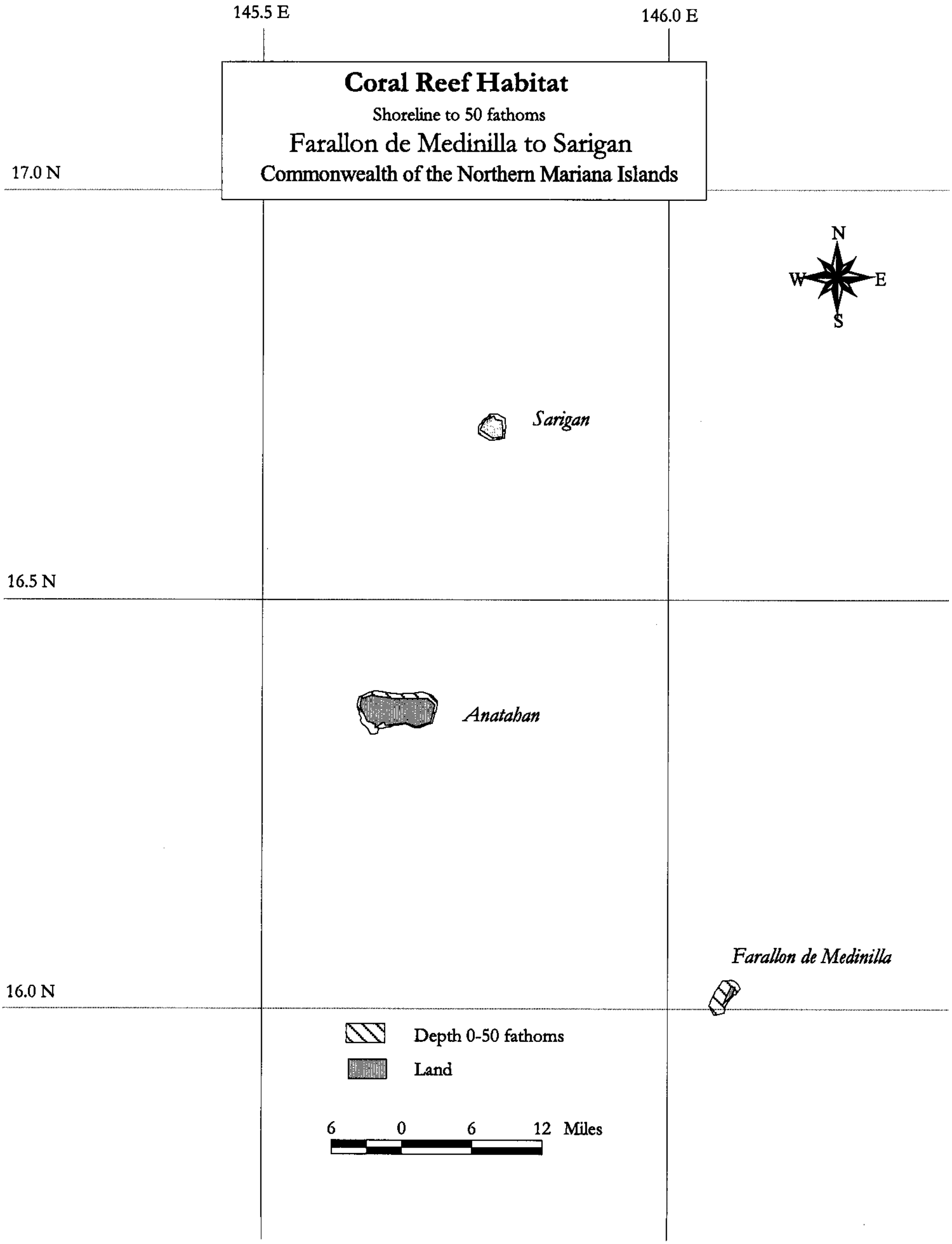
Coral Reef Habitat
Shoreline to 50 fathoms
Swains Island
American Samoa
171.0 W
N
W
E
S
11.0 S
Swains's Island
Depth 0 - 50 Fathoms
Land
3 Nautical Mile Territorial Boudary around Land
2
0
2
4
Miles

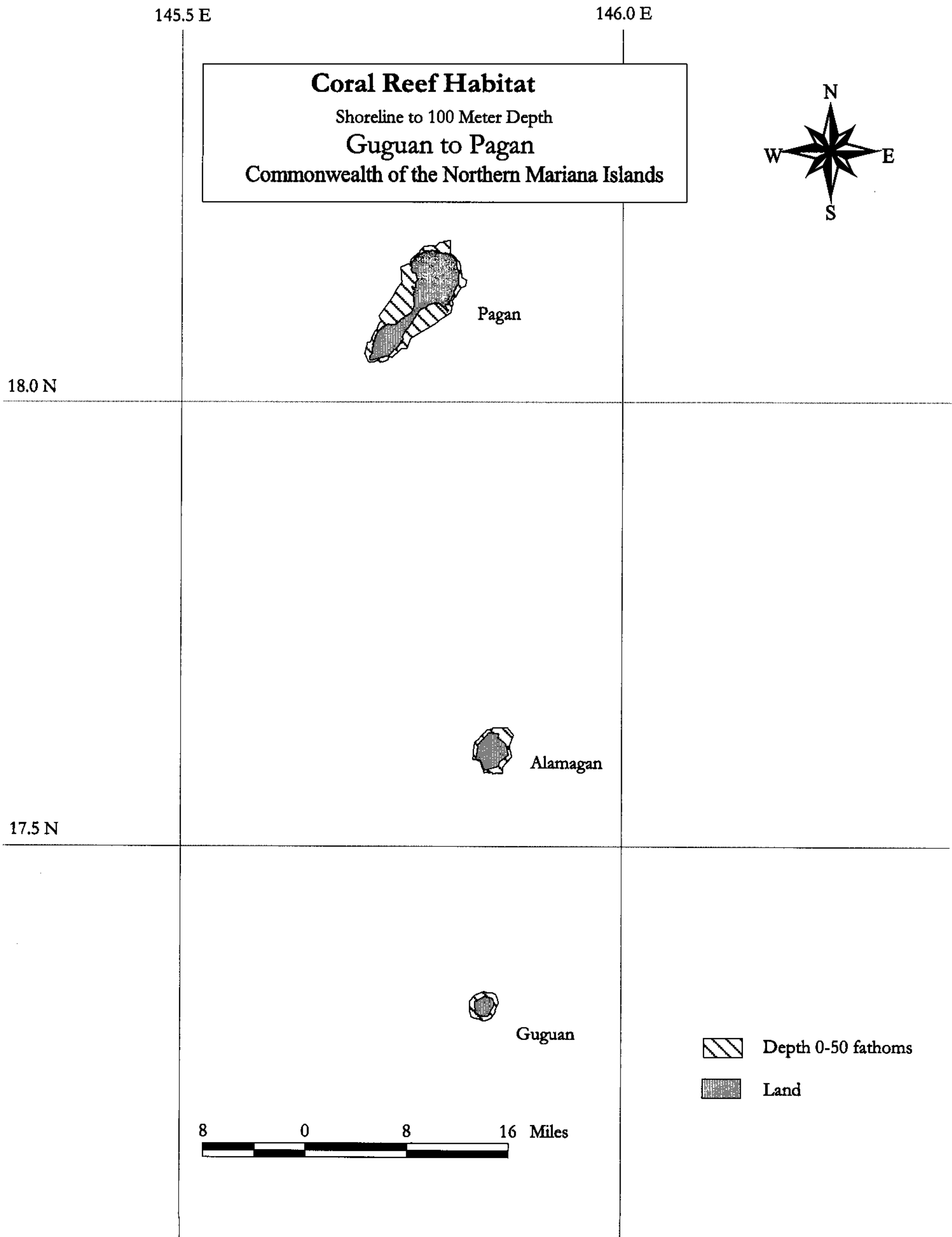


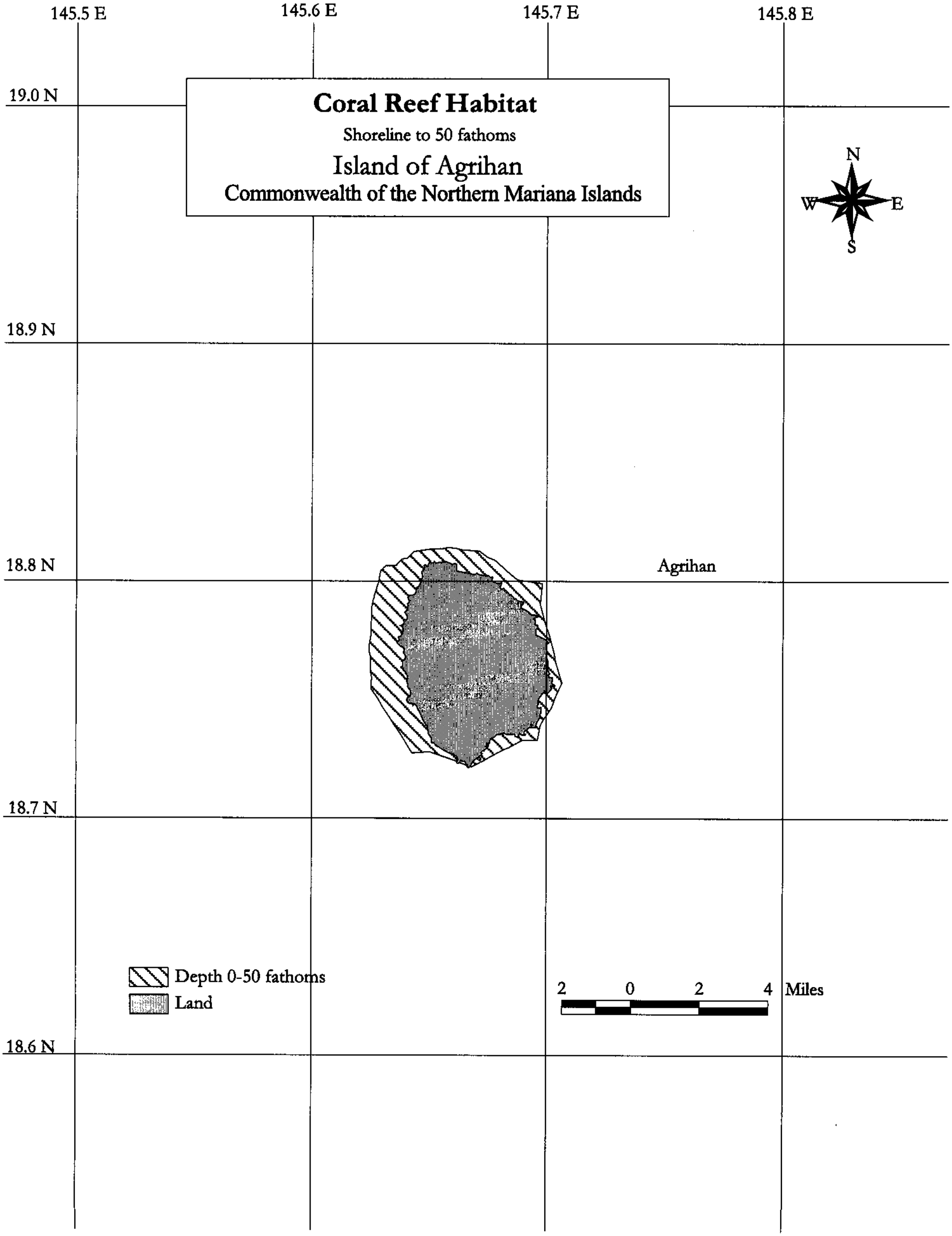
145.1 E
145.2 E
145.3 E
Coral Reef Habitat
Shoreline to 50 fathoms
Island of Rota
Commonwealth of the Northern Mariana Islands
N
W
E
S
14.2 N
14.1 N
Depth 0-50 fathoms
Land
2
0
2
4
Miles

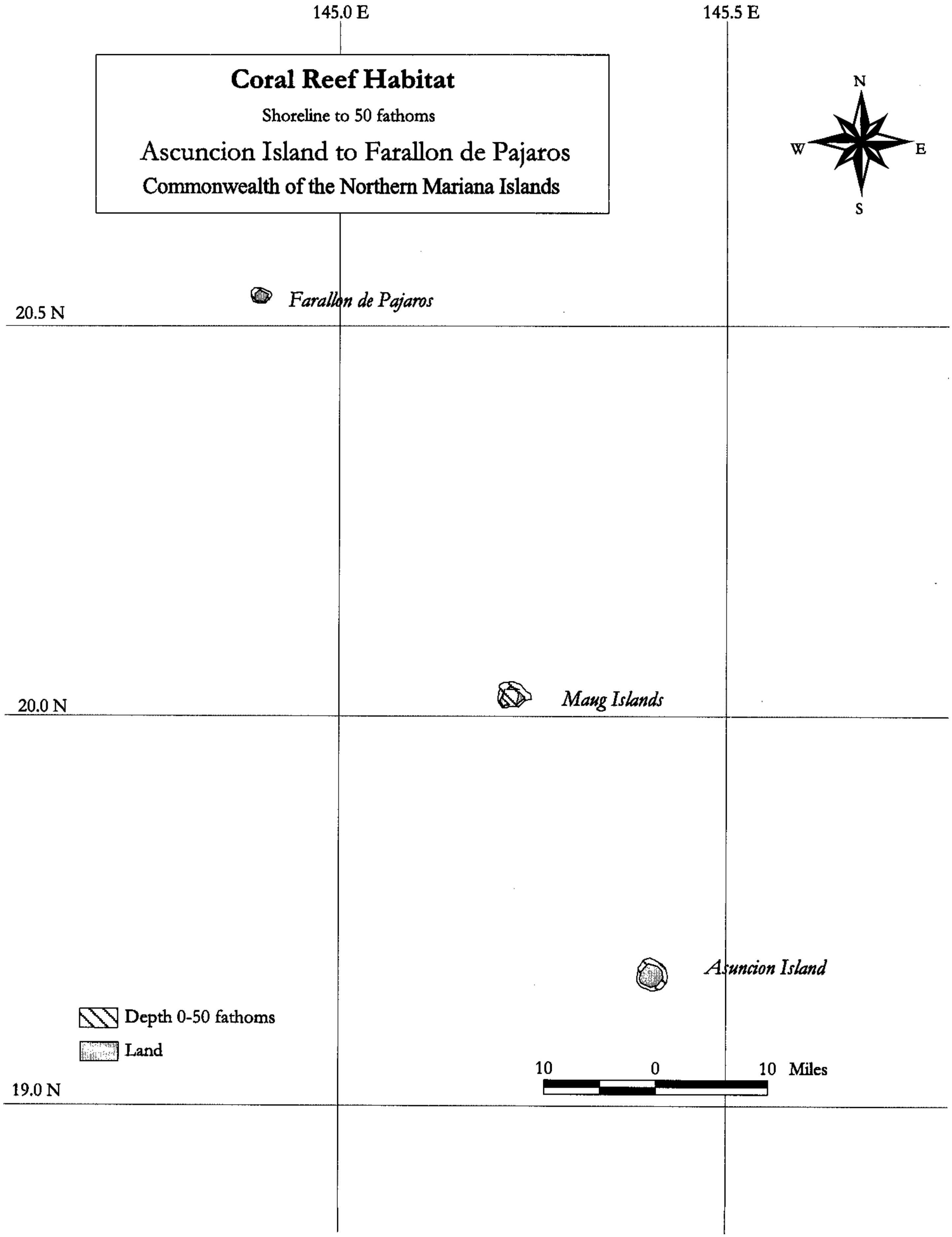


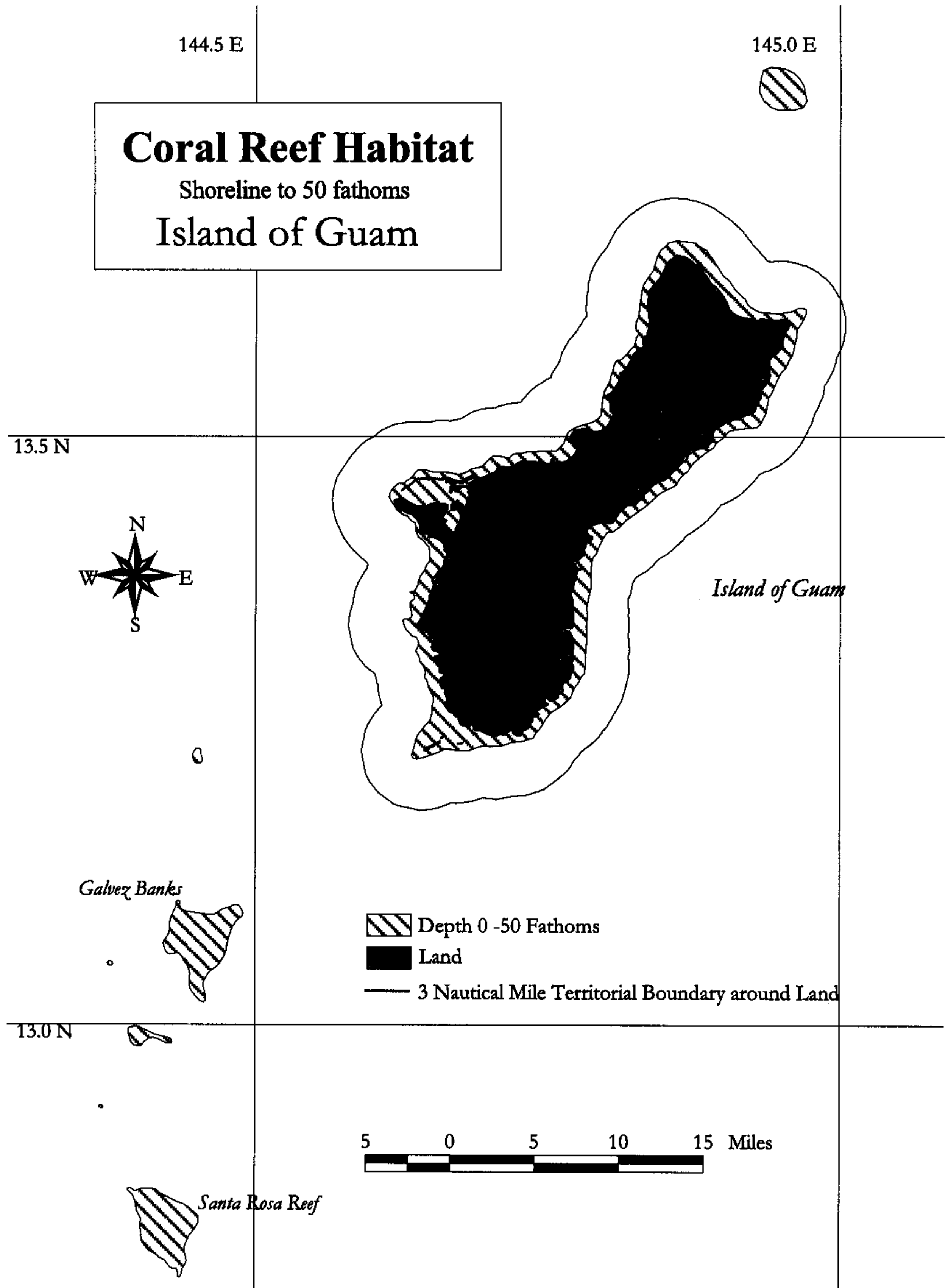
Coral Reef Habitat
Shoreline to 50 fathoms
Saipan to Aguijan
Commonwealth of the Northern Mariana Islands
145.5 E
145.6 E
145.7 E
145.8 E
145.9 E
15.4 N
15.3 N
15.2 N
15.1 N
15.0 N
14.9 N
14.8 N
N
E
S
W
Saipan
Tinian
Aguijan
Depth 0-50 fathoms
Land
3 0 3 6 Miles

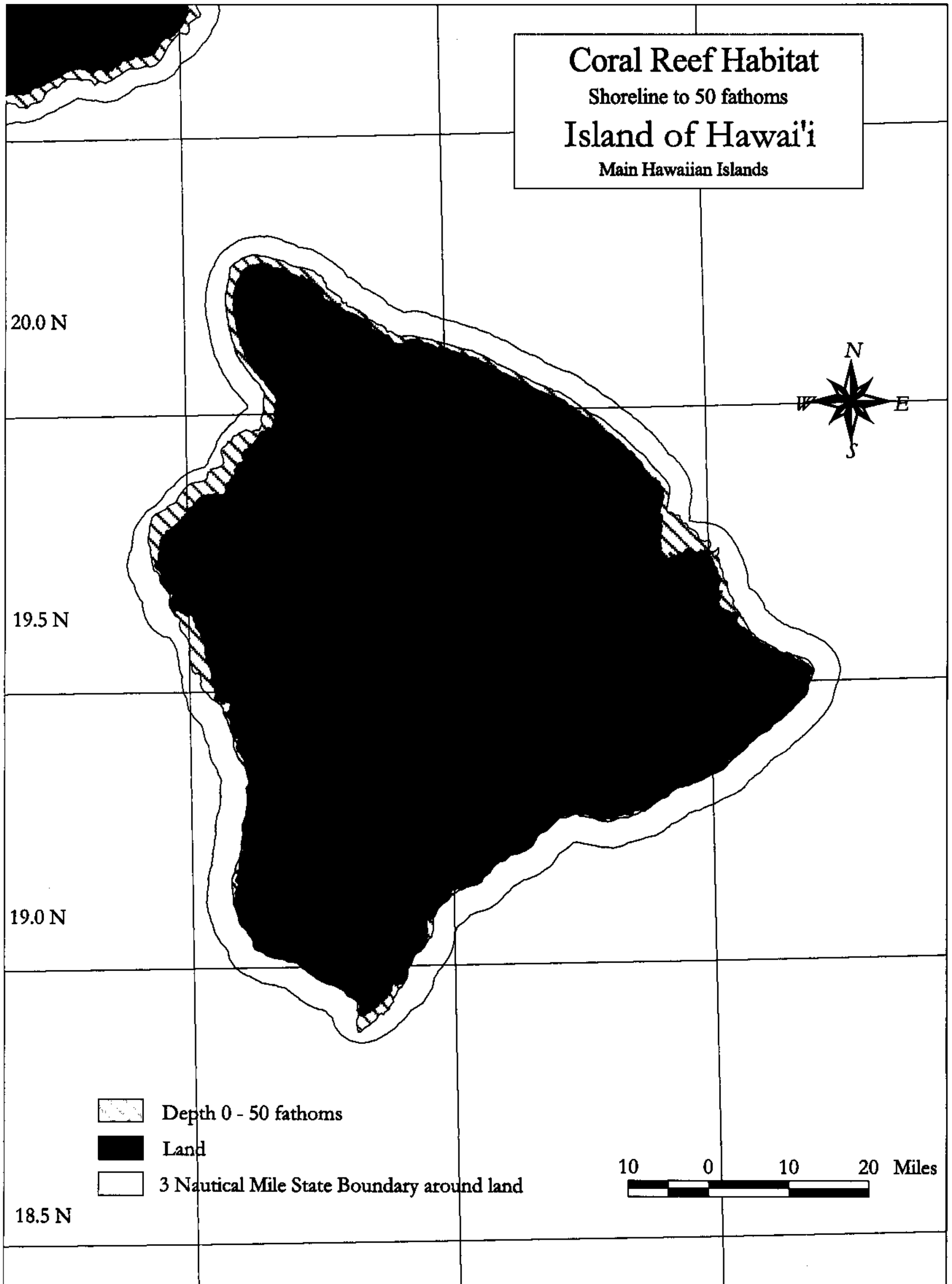

145.5 E
146.0 E
Coral Reef Habitat
Shoreline to 50 fathoms
Farallon de Medinilla to Sarigan
Commonwealth of the Northern Mariana Islands
17.0 N
N
W
E
S
Sarigan
16.5 N
Anatahan
Farallon de Medinilla
16.0 N
Depth 0-50 fathoms
Land
6
0
6
12
Miles

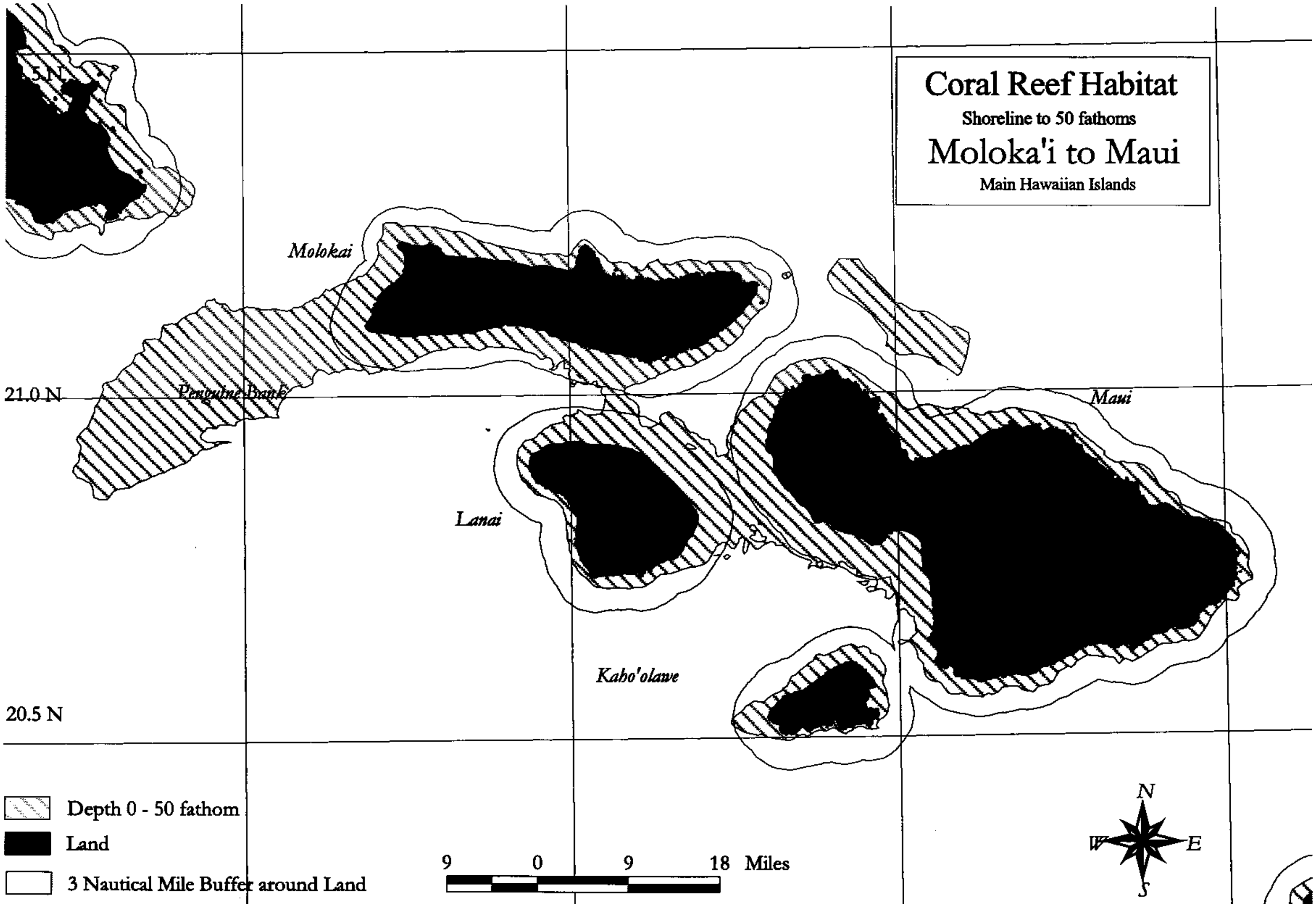

145.5 E
146.0 E
Coral Reef Habitat
Shoreline to 100 Meter Depth
Guguan to Pagan
Commonwealth of the Northern Mariana Islands
N
W
E
S
Pagan
18.0 N
Alamagan
17.5 N
Guguan
Depth 0-50 fathoms
Land
8
0
8
16
Miles


145.5 E
145.6 E
145.7 E
145.8 E
19.0 N
18.9 N
18.8 N
18.7 N
18.6 N
Coral Reef Habitat
Shoreline to 50 fathoms
Island of Agrihan
Commonwealth of the Northern Mariana Islands
N
W
E
S
Agrihan
Depth 0-50 fathoms
Land
2
0
2
4
Miles

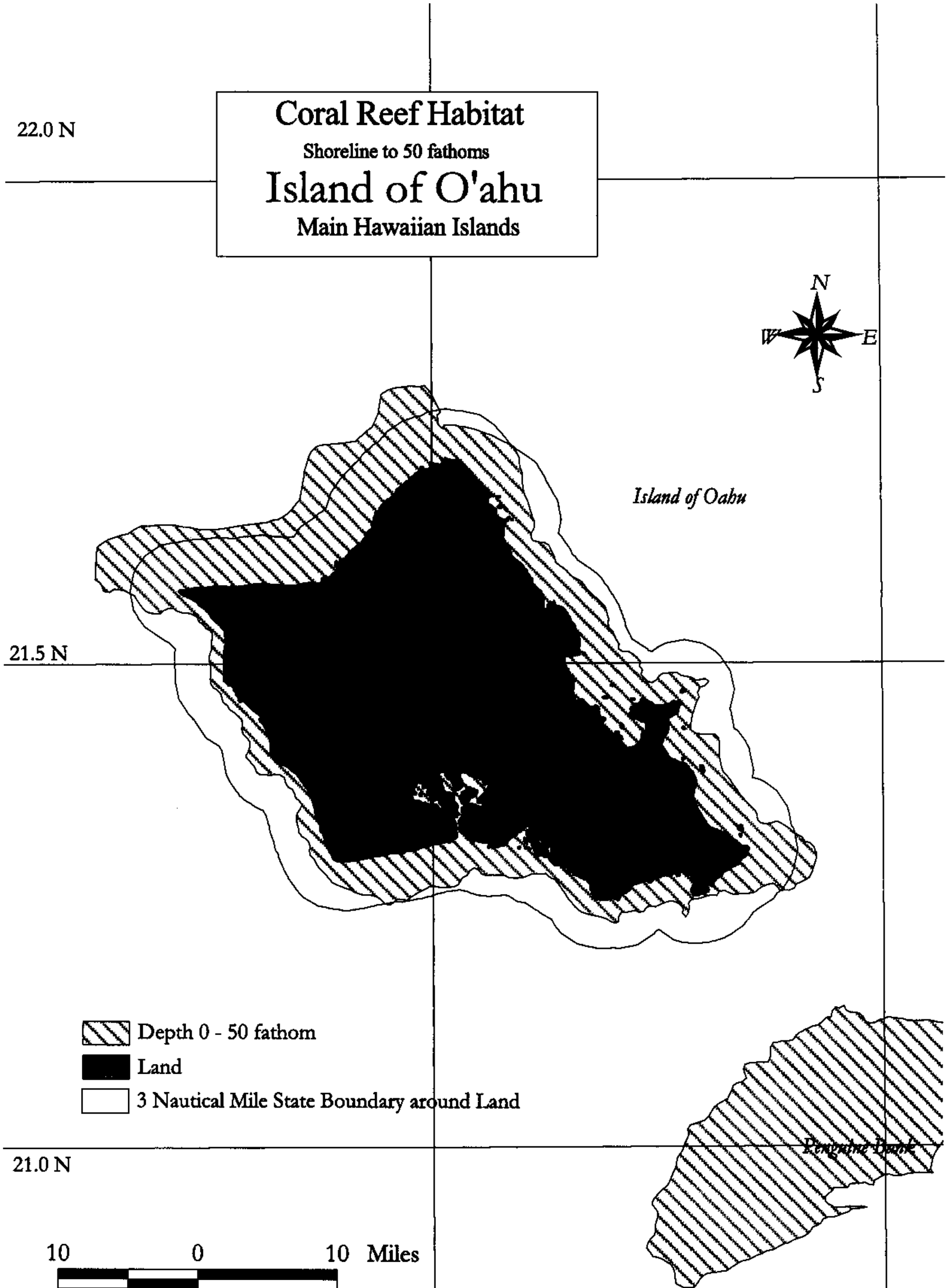

145.0 E
145.5 E
Coral Reef Habitat
Shoreline to 50 fathoms
Ascuncion Island to Farallon de Pajaros
Commonwealth of the Northern Mariana Islands
N
W
E
S
Farallon de Pajaros
20.5 N
Maug Islands
20.0 N
Asuncion Island
Depth 0-50 fathoms
Land
10
0
10
Miles
19.0 N


144.5 E
145.0 E
Coral Reef Habitat
Shoreline to 50 fathoms
Island of Guam
13.5 N
N
W
E
S
Island of Guam
Galvez Banks
Depth 0 -50 Fathoms
Land
3 Nautical Mile Territorial Boundary around Land
13.0 N
5 0 5 10 15 Miles
Santa Rosa Reef

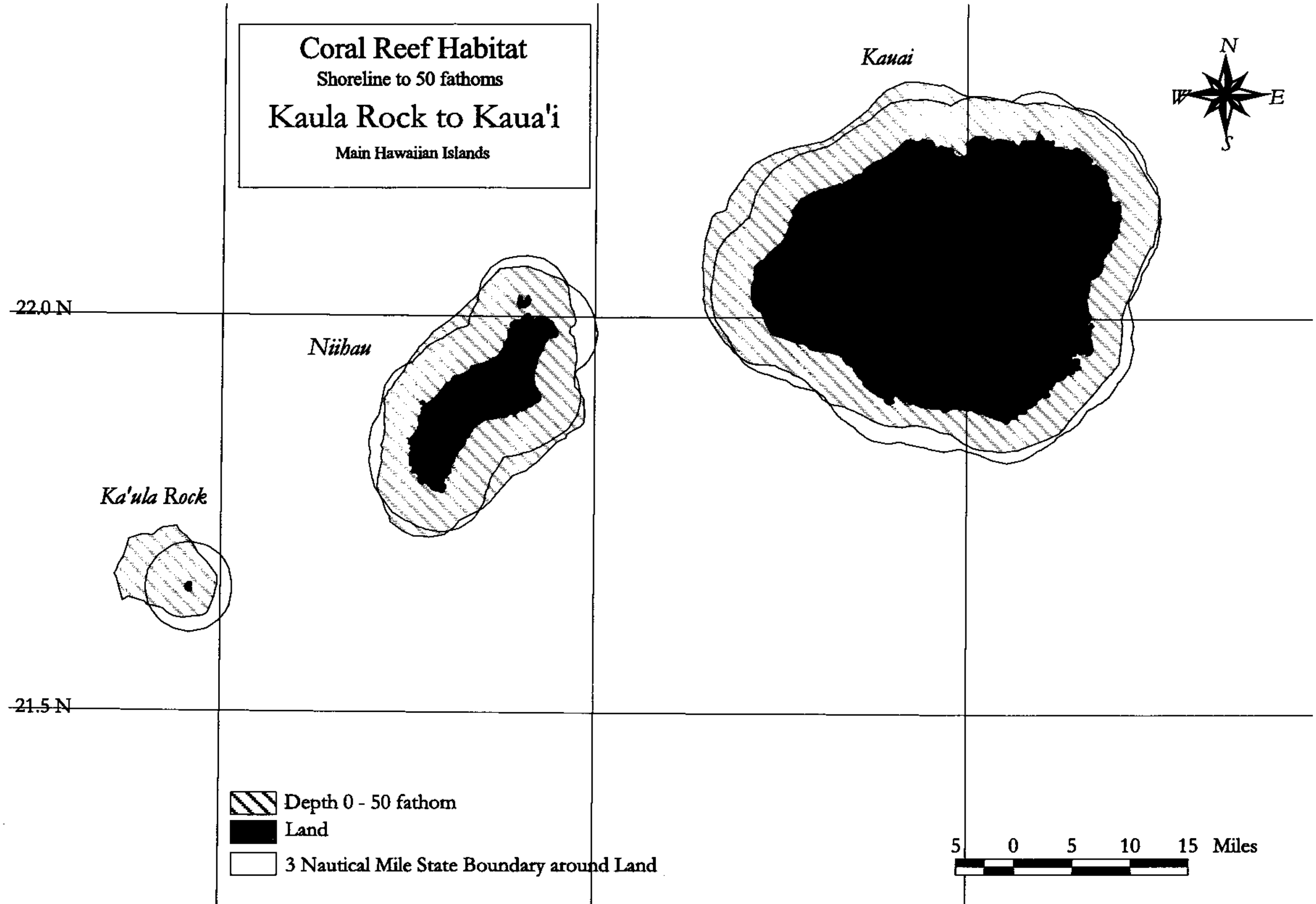

Coral Reef Habitat
Shoreline to 50 fathoms
Island of Hawai'i
Main Hawaiian Islands
20.0 N
19.5 N
19.0 N
18.5 N
N
W
E
S
Depth 0 - 50 fathoms
Land
3 Nautical Mile State Boundary around land
10 0 10 20 Miles



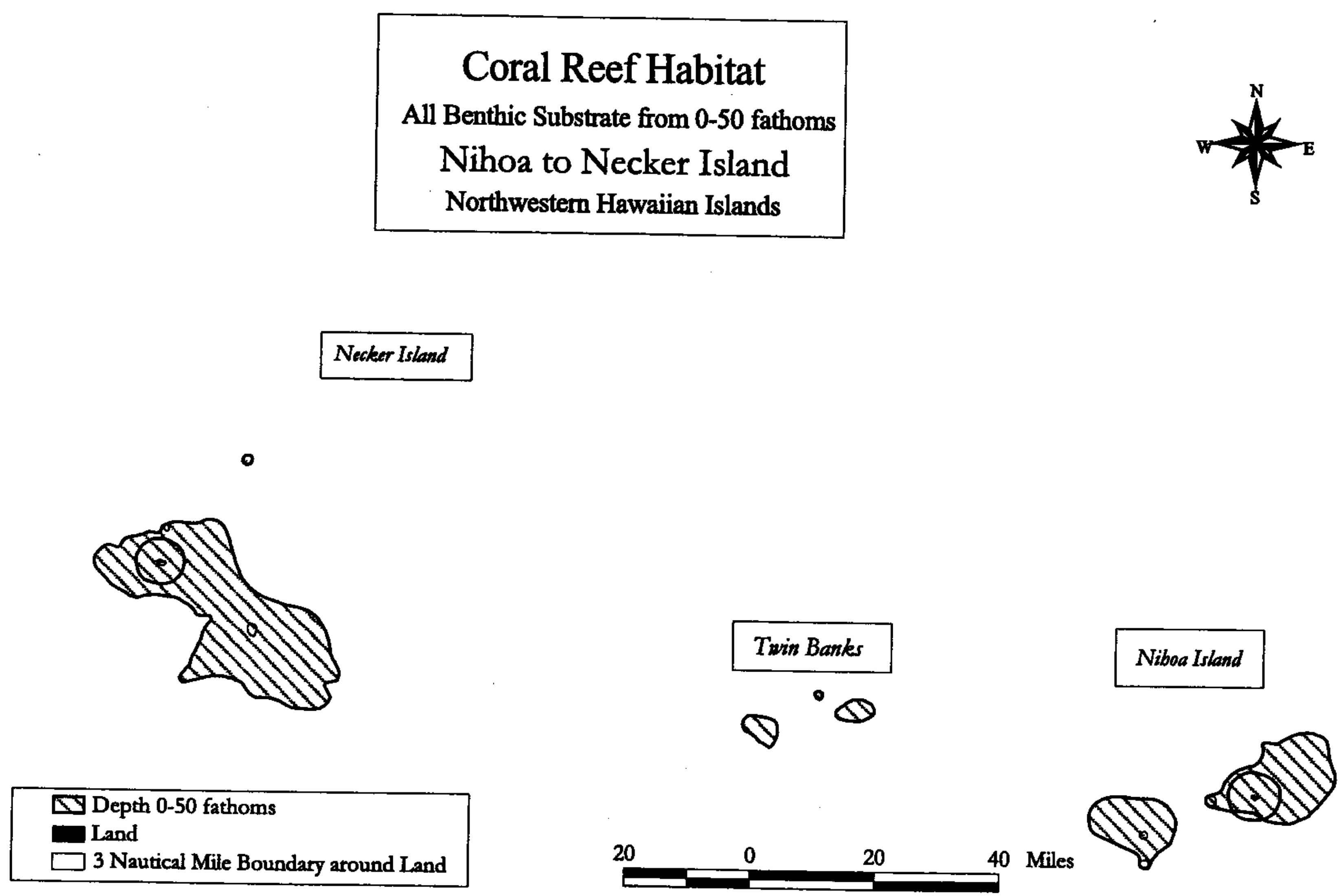
Coral Reef Habitat
Shoreline to 50 fathoms
Moloka'i to Maui
Main Hawaiian Islands
Molokai
Penguine Bank
21.0 N
20.5 N
Lanai
Maui
Kaho'olawe
Depth 0 - 50 fathom
Land
3 Nautical Mile Buffer around Land
9 0 9 18 Miles
N
W
E
S

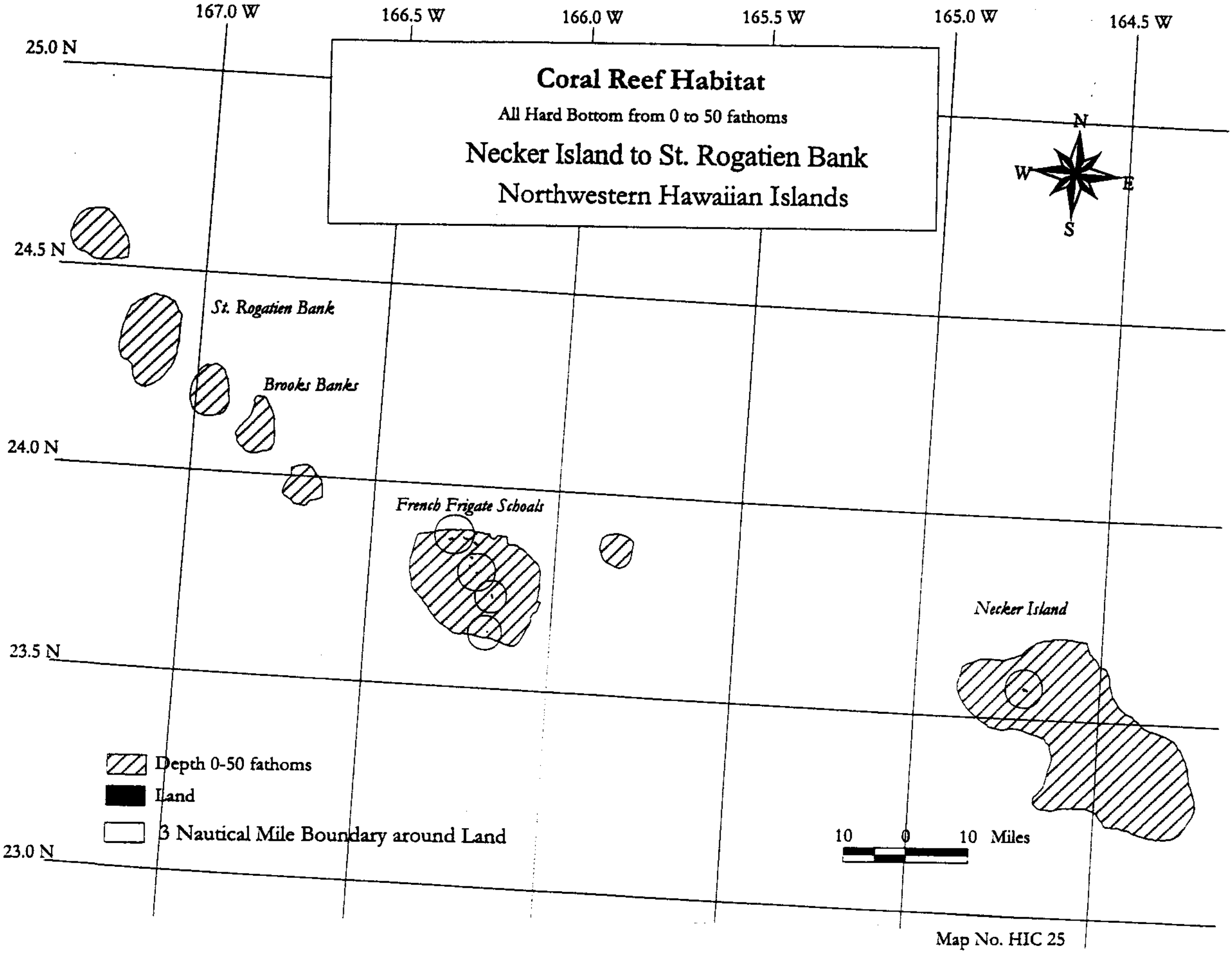


Coral Reef Habitat
Shoreline to 50 fathoms
Island of O'ahu
Main Hawaiian Islands
22.0 N
21.5 N
21.0 N
N
W
E
S
Island of Oahu
Depth 0 - 50 fathom
Land
3 Nautical Mile State Boundary around Land
10
0
10
Miles

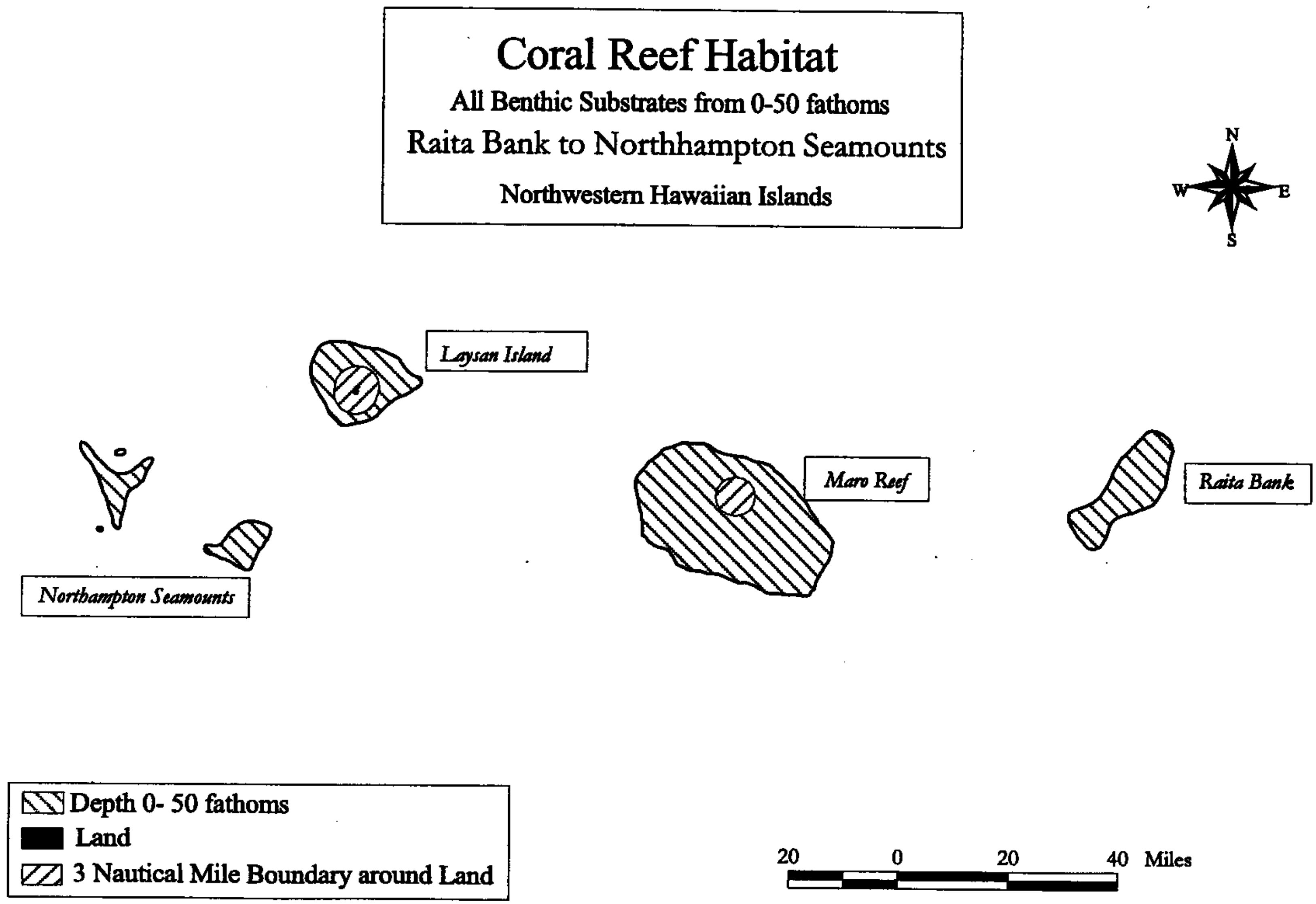


Coral Reef Habitat
Shoreline to 50 fathoms
Kaula Rock to Kaua'i
Main Hawaiian Islands
Kauai
N
W
E
S
22.0 N
Niihau
Ka'ula Rock
21.5 N
Depth 0 - 50 fathom
Land
3 Nautical Mile State Boundary around Land
5 0 5 10 15 Miles

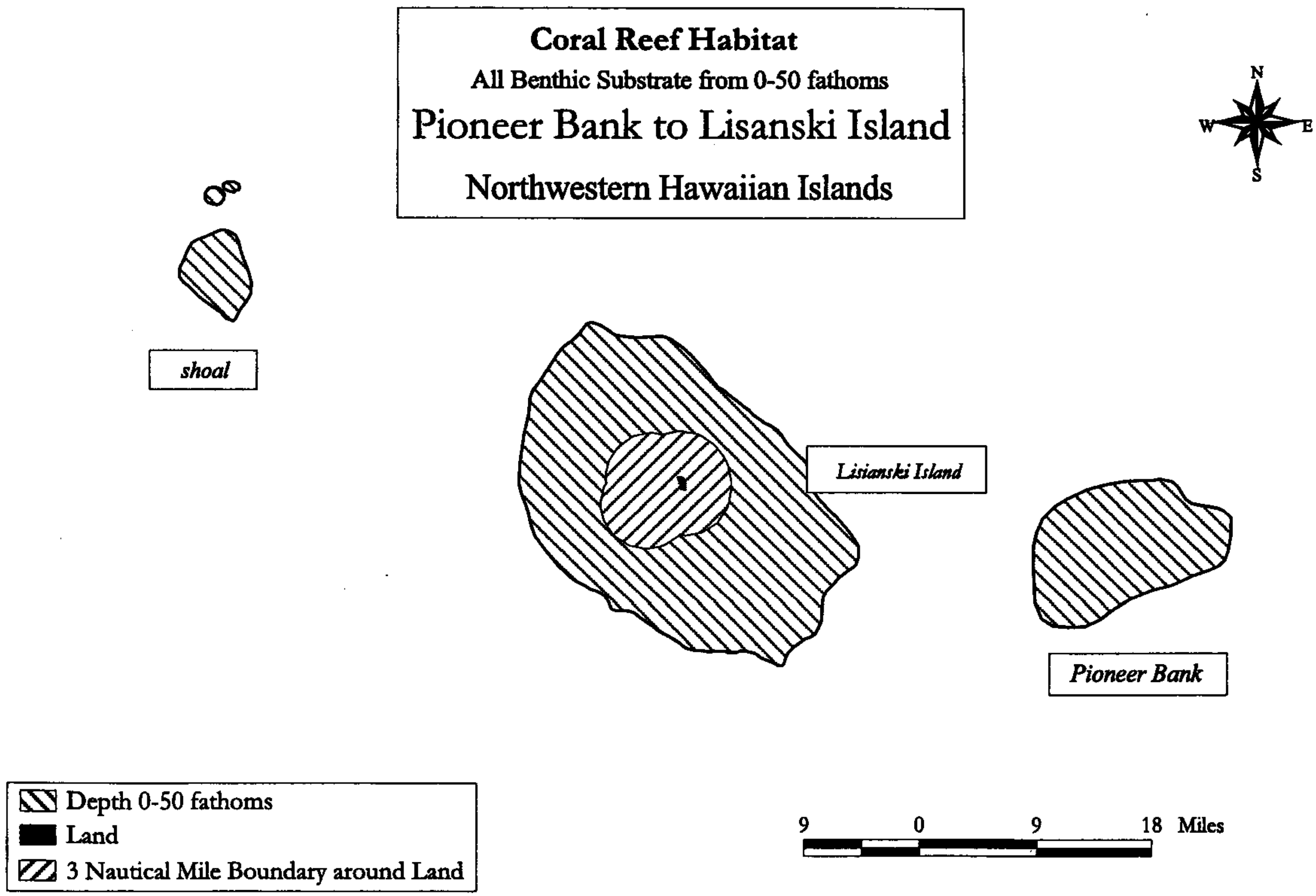

Coral Reef Habitat
All Benthic Substrate from 0-50 fathoms
Nihoa to Necker Island
Northwestern Hawaiian Islands
N
W
E
S
Necker Island
Twin Banks
Nihoa Island
Depth 0-50 fathoms
Land
3 Nautical Mile Boundary around Land
20
0
20
40
Miles

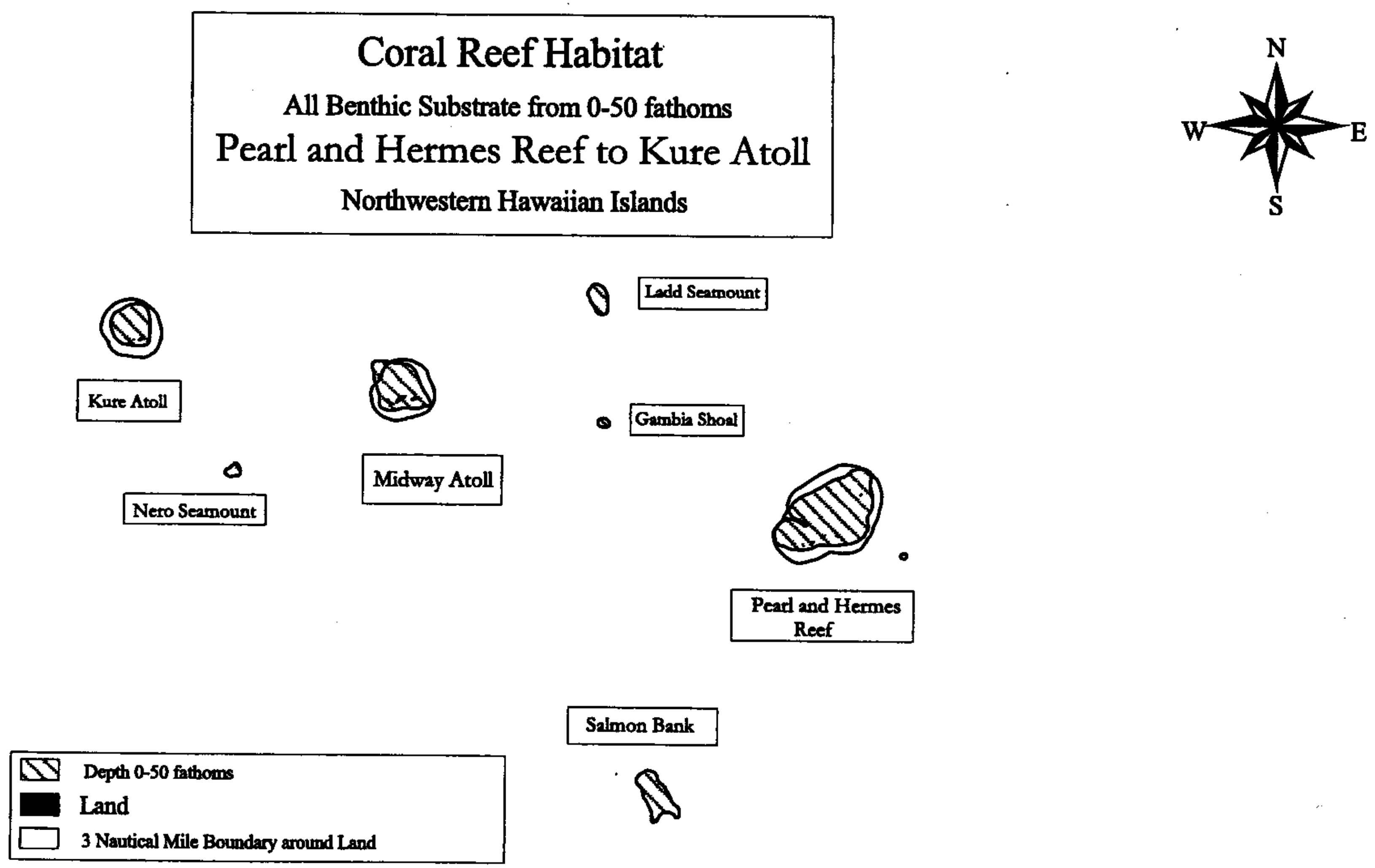


Coral Reef Habitat
All Hard Bottom from 0 to 50 fathoms
Necker Island to St. Rogatien Bank
Northwestern Hawaiian Islands
167.0 W
166.5 W
166.0 W
165.5 W
165.0 W
164.5 W
25.0 N
24.5 N
24.0 N
23.5 N
23.0 N
N
S
E
W
St. Rogatien Bank
Brooks Banks
French Frigate Schoals
Necker Island
Depth 0-50 fathoms
Land
3 Nautical Mile Boundary around Land
10
0
10
Miles
Map No. HIC 25



Coral Reef Habitat
All Benthic Substrates from 0-50 fathoms
Raita Bank to Northhampton Seamounts
Northwestern Hawaiian Islands
N
W
E
S
Laysan Island
Maro Reef
Raita Bank
Northampton Seamounts
Depth 0- 50 fathoms
Land
3 Nautical Mile Boundary around Land
20
0
20
40
Miles

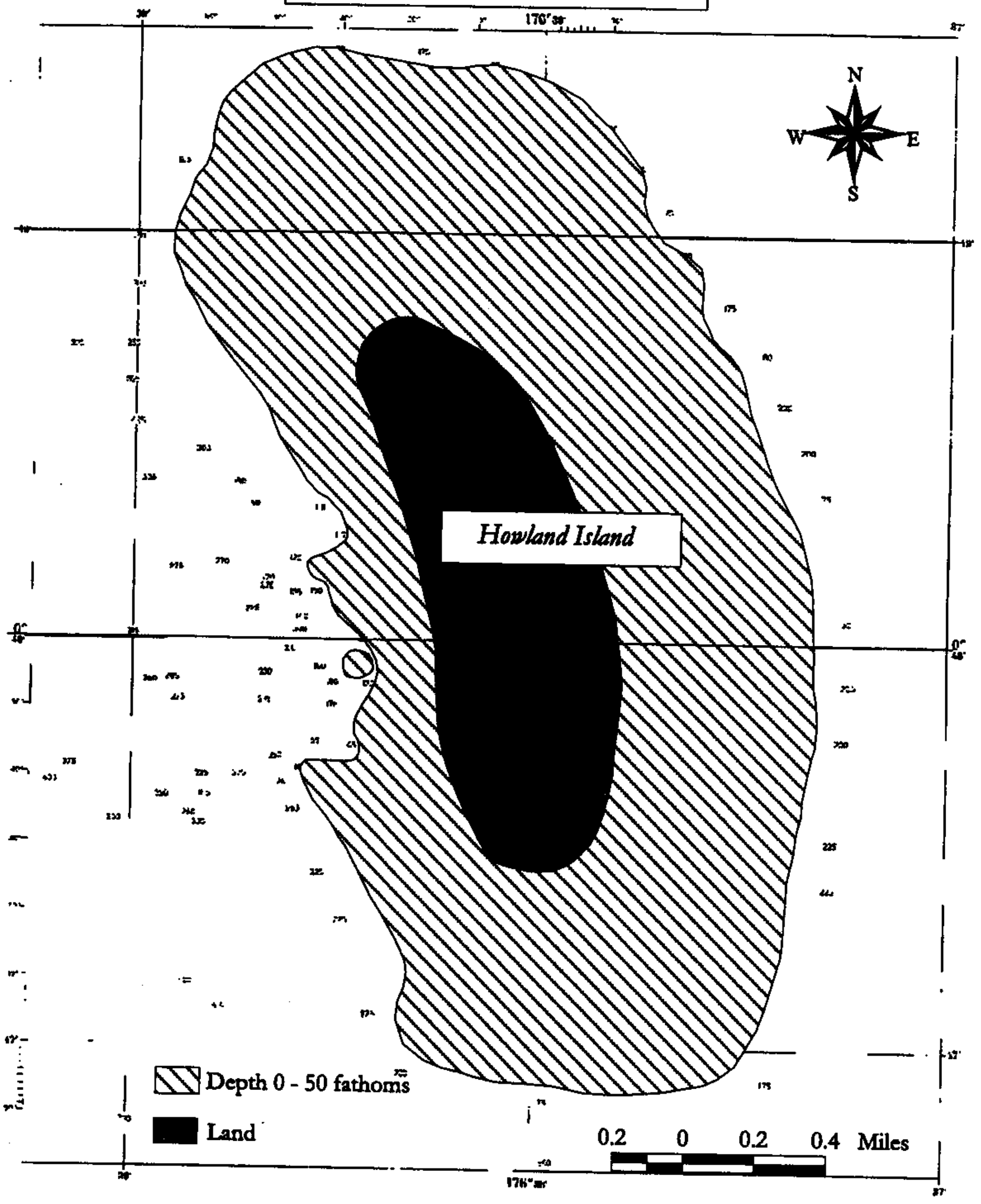

Coral Reef Habitat
All Benthic Substrate from 0-50 fathoms
Pioneer Bank to Lisanski Island
Northwestern Hawaiian Islands
N
W
E
S
shoal
Lisianski Island
Pioneer Bank
Depth 0-50 fathoms
Land
3 Nautical Mile Boundary around Land
9 0 9 18 Miles

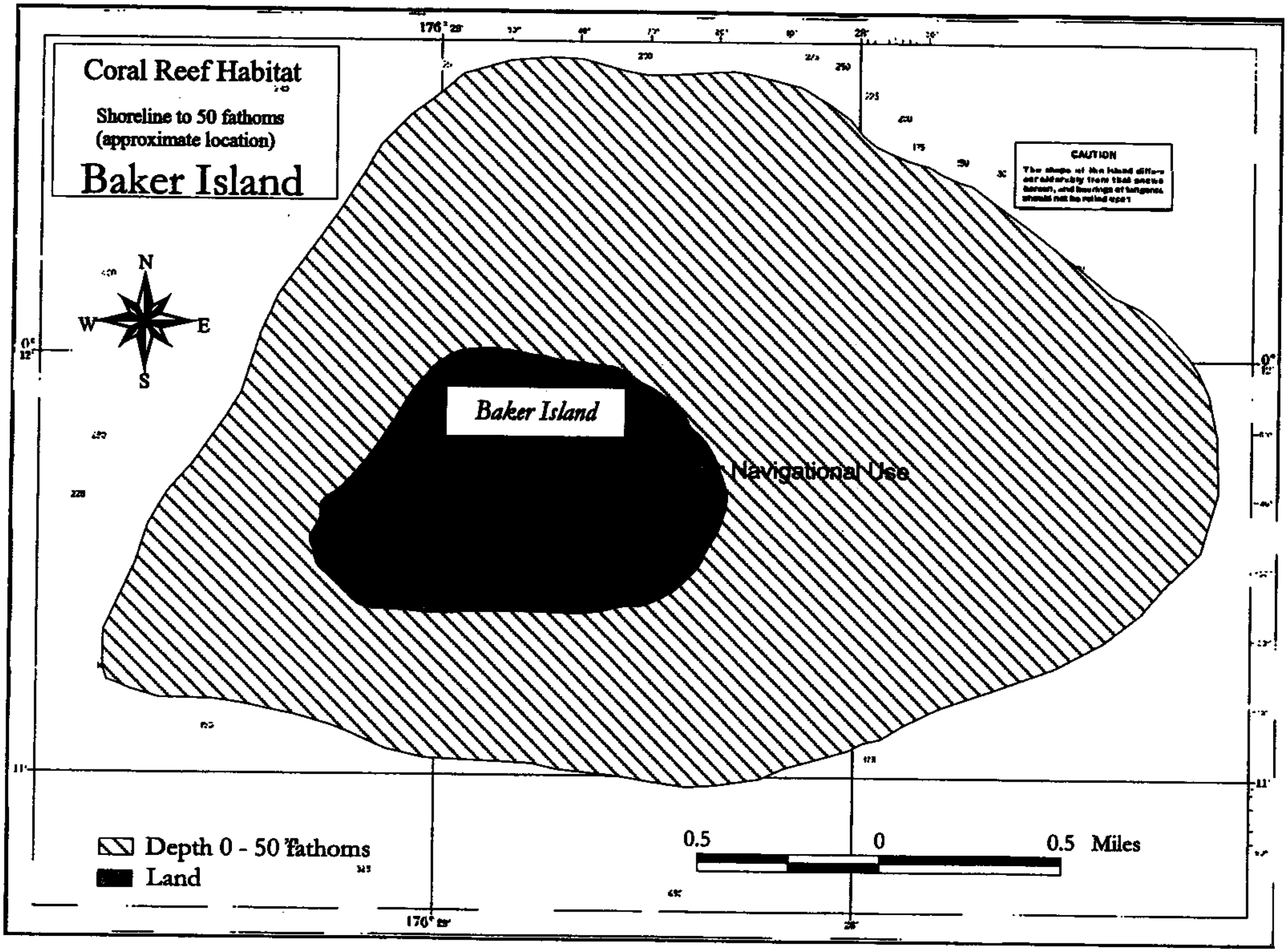

Coral Reef Habitat
All Benthic Substrate from 0-50 fathoms
Pearl and Hermes Reef to Kure Atoll
Northwestern Hawaiian Islands
N
W
E
S
Ladd Seamount
Kure Atoll
Gambia Shoal
Midway Atoll
Nero Seamount
Pearl and Hermes Reef
Salmon Bank
Depth 0-50 fathoms
Land
3 Nautical Mile Boundary around Land

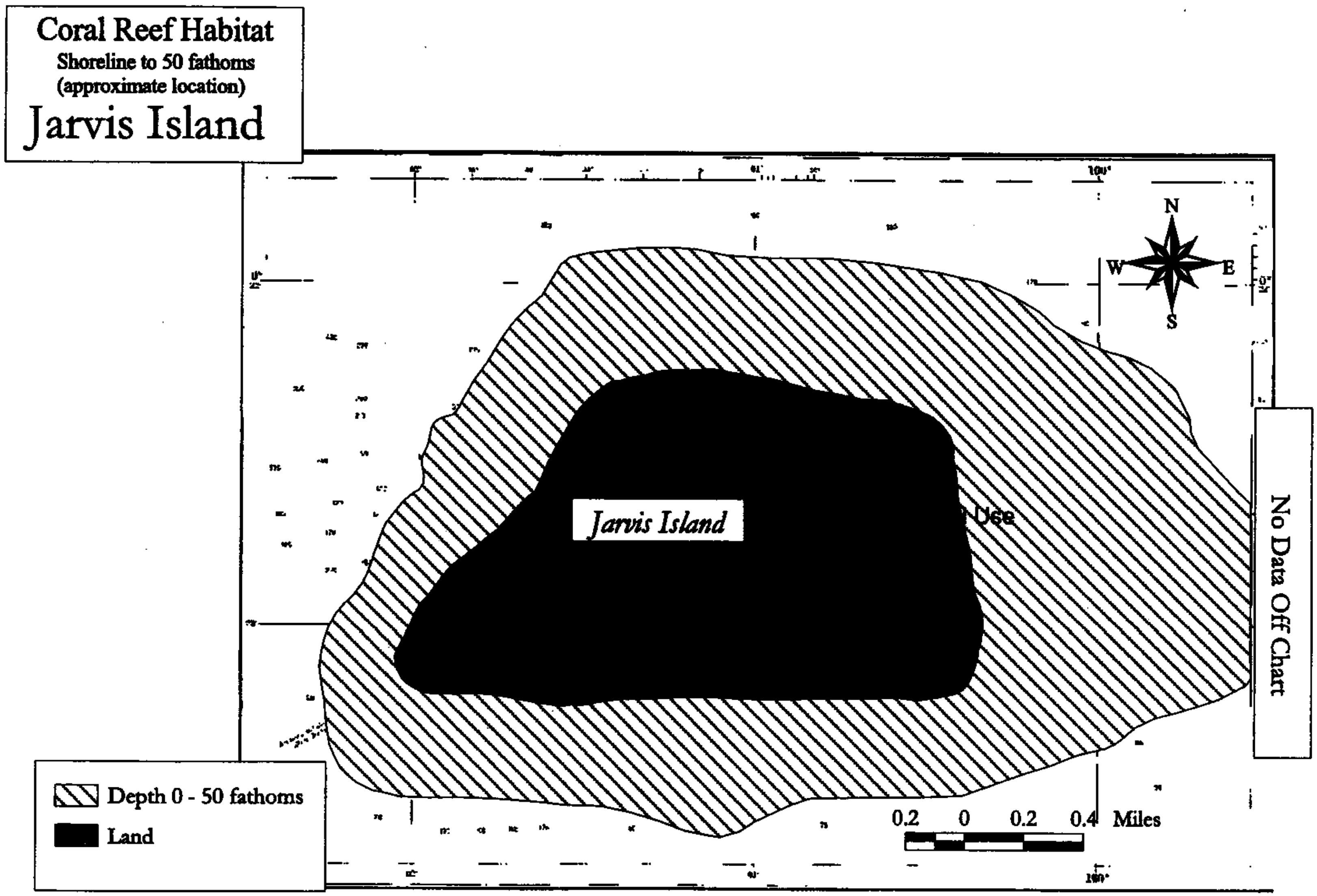
Coral Reef Habitat

Shoreline to 50 fathoms
(approximate location)

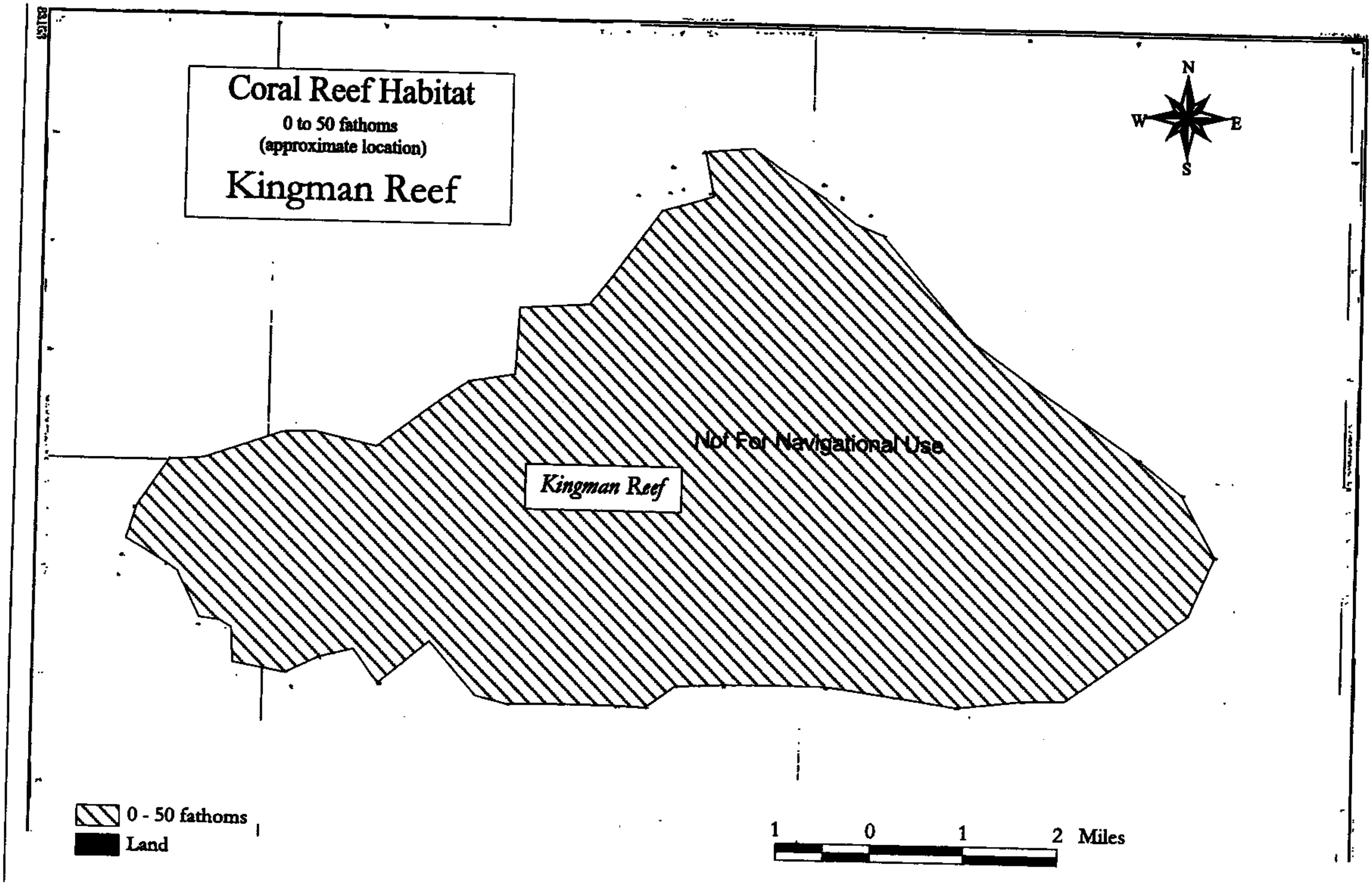
Howland Island

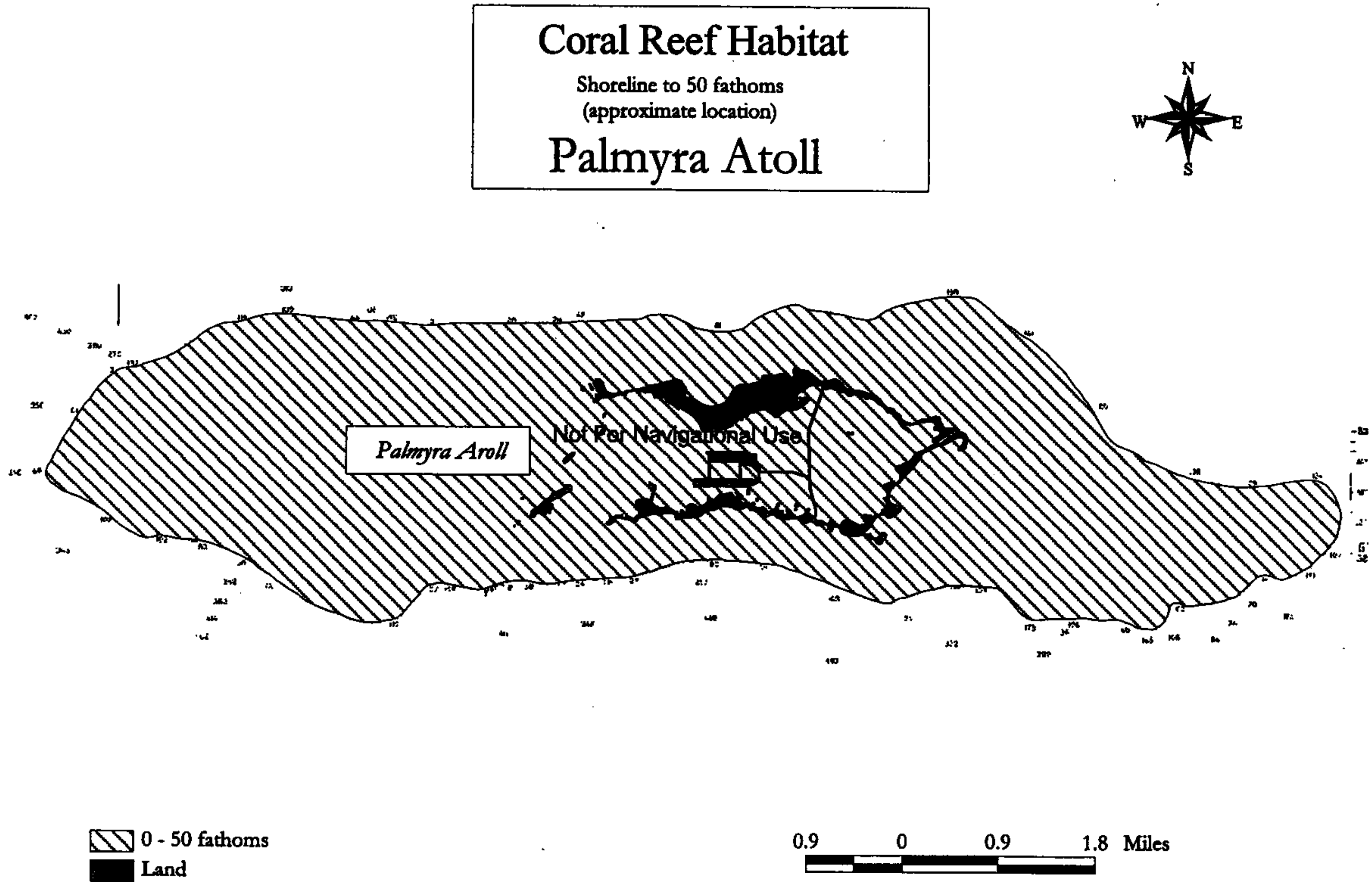


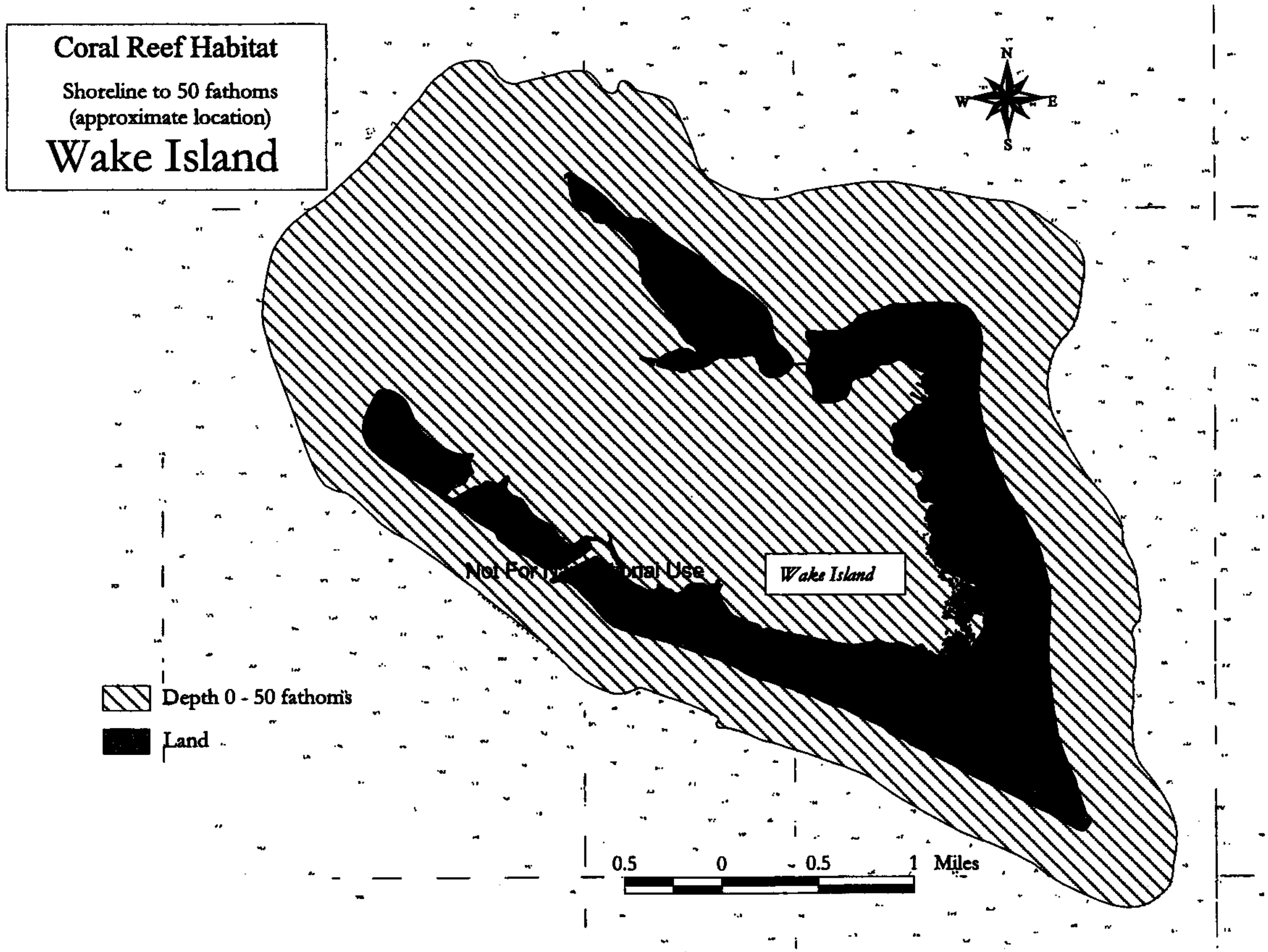

Coral Reef Habitat
Shoreline to 50 fathoms
(approximate location)
Baker Island
N
W
E
S
Baker Island
Navigational Use
CAUTION
Depth 0 - 50 fathoms
Land
0.5
0
0.5 Miles



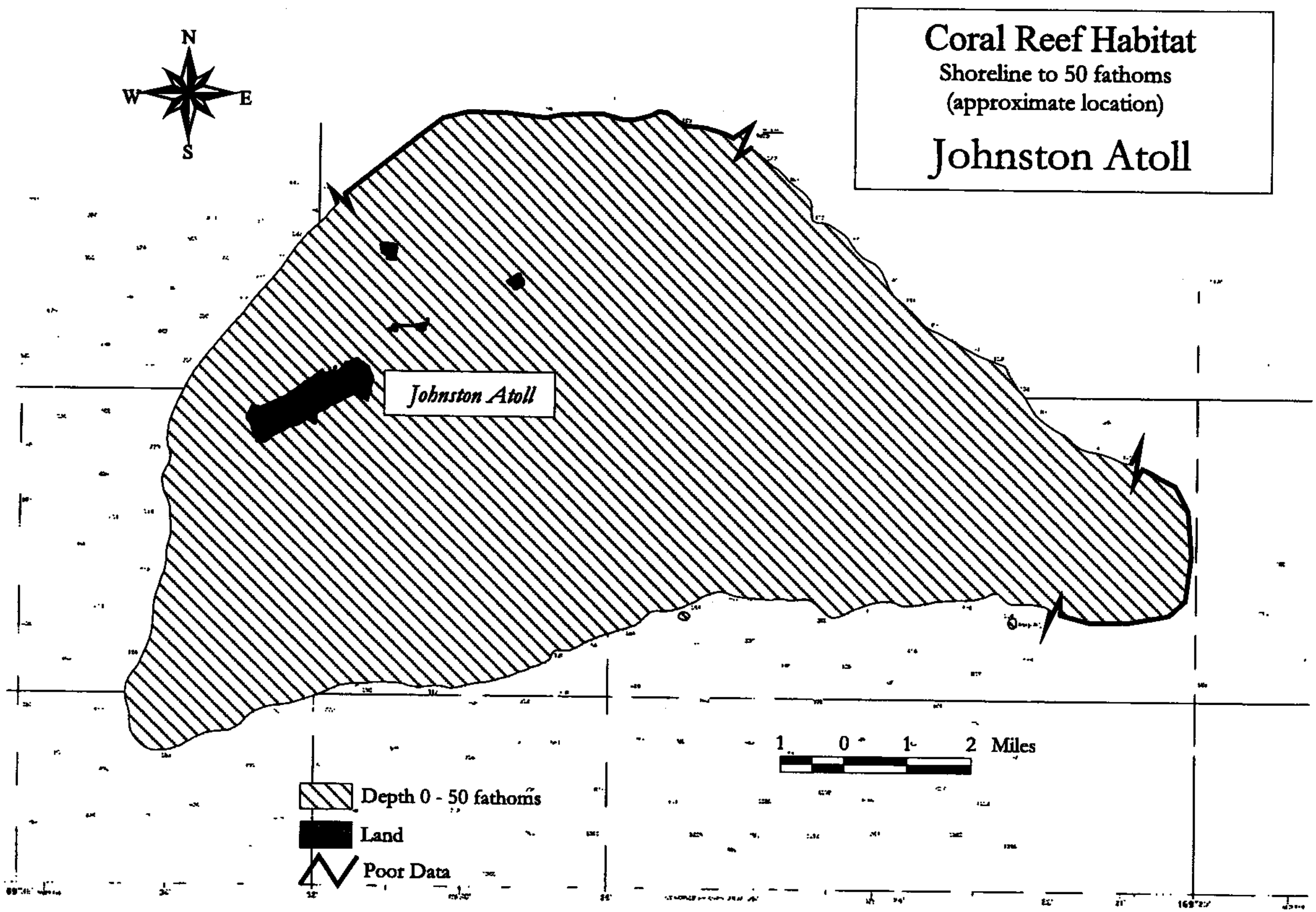
Coral Reef Habitat
Shoreline to 50 fathoms
(approximate location)
Jarvis Island
Jarvis Island
No Data Off Chart
N
W
E
S
Depth 0 - 50 fathoms
Land
0.2
0
0.2
0.4
Miles


Coral Reef Habitat
0 to 50 fathoms
(approximate location)
Kingman Reef
N
W
E
S
Not For Navigational Use
Kingman Reef
0 - 50 fathoms
Land
1 0 1 2 Miles


Coral Reef Habitat
Shoreline to 50 fathoms
(approximate location)
Palmyra Atoll
N
W
E
S
Palmyra Aroll
Not For Navigational Use
0 - 50 fathoms
Land
0.9 0 0.9 1.8 Miles



Coral Reef Habitat
Shoreline to 50 fathoms
(approximate location)
Wake Island
N
W
E
S
Wake Island
Depth 0 - 50 fathoms
Land
0.5
0
0.5
1
Miles



Coral Reef Habitat
Shoreline to 50 fathoms
(approximate location)
Johnston Atoll
N
W
E
S
Johnston Atoll
1 0 1 2 Miles
Depth 0 - 50 fathoms
Land
Poor Data

IV. Habitat Areas of Particular Concern

Habitat Area of Particular Concern

In addition to EFH, the Council also identified potential areas for designation as habitat areas of particular concern (HPAC). HAPCs are those areas that are essential to the life cycle of important coral reef species. In determining whether a type or area of EFH should be designated as a HAPC, one or more of the following criteria must be met: (1) ecological function provided by the habitat is important; (2) habitat is sensitive to human-induced environmental degradation; (3) development activities are, or will be, stressing the habitat type; or (4) the habitat type is rare. Although an area meets one of the HAPC criteria, does not mean that it must be designated an HAPC.

The Council, in consultation with its Coral Reef Ecosystem Plan team and NMFS PIAO staff, refined HAPC designation for the Coral Reef Ecosystem under its jurisdiction. All of the following areas identified as HAPC under this FMP have met at least one of the criteria listed above however, a great deal of life history work needs to be done in order to adequately identify HAPCs.

The Following Areas Have Been Identified as HAPC under the CRE FMP:

Northwestern Hawaiian Islands	All substrate less than 10 fathom All substrate 0-50 fm at French Frigate Shoals All substrate 0-50 fm at Laysan All substrate 0-50 fm at Midway
Main Hawaiian Islands	
Kaula Rock	Entire Bank
Niihau	Lehua
Kauai	Kaliu Point

Oahu	1. Hanauma Bay (MLCD)
	2. Pupukea (MLCD)
	3. Makapuu Head/Tide Pool Reef Area
	4. Kanehoe Bay
	• Sharks Cove (MLCD)
	• Kaena Point
	• Kahe Reef
	• Waikiki (MLCD) - Diamond Head
	• Offshore Islets, Windward side
	    • Mokumanu
	    • Mokulua Islands
	    • Manana Island
	    • Kaohikapu

Molokai	• South Shore Reefs
Lanai	• Halope Bay • Manele Bay • Five Needles
Maui	• Molokini • Oalowalo Reef Area • Honolua-Mokuleia Bay (MLCD) • Ahihi Kinau Natural Area Reserve
Hawaii	• Lapakahi State Park (MLCD) • Puako Bay and Reef (MLCD) • Kealakekua • Lapakahi Bay (MLCD) • Waialea Bay (MLCD) • Kawaihae Harbor-Old Kona Airport (MLCD)
Additional	• All long-term research sites • All CRAMP sites

American Samoa	• Fagatele Bay • Larsen Bay • Steps Point • National Park of American Samoa, Pago Pago (North Coast Tutuila) • Aunuu Island • Rose Atoll • South coast Ofu, (underwater portion of the national park) • Aua Transect – Pago Pago harbor, oldest coral reef transect • Tau Island
Guam	• Cocos Lagoon • Orote Point Ecological Reserve Area • Haputo Point Ecological Reserve Area • Ritidian Point • Jade Shoals
Northern Mariana Islands	
Saipan	• Saipan Lagoon
US Pacific Remote Islands	• Wake Atoll • Johnston Atoll • Palmyra Atoll • Kingman Reef • Howland Island • Baker Island • Jarvis Island

The Following Is a List of Potential Areas Within the Council's Jurisdiction That Meet the Criteria for Designation as HAPC Used by the Council to Identify HAPC

	Rarity	Ecological Function	Susceptibility to Human Impacts	Likelihood of developmental Impacts
<u>Guam</u>				
Offshore banks and nearshore fringing reef	x	x	x	x
Cocos Lagoon	x	x	x	x
Mangrove areas	x	x	x	x

	Rarity	Ecological Function	Susceptibility to Human Impacts	Likelihood of developmental Impacts
Brackish waters (rivers/streams)	x	x	x	x
Apra Harbor, including Arote area	x	x	x	x
Merizo Lagoon	x	x	x	x
Western Shoals	x		x	x
North coast		x		
Southwest coast	x	x	x	x
<u>American Samoa</u>				
Offshore banks	x	x	x	x
Nearshore fringing reefs	x	x	x	x
Leone Lagoon	x	x	x	x
Pala Lagoon	x	x	x	x
South Tutuila		x	x	x
Nafanua and Tiema	x	x	x	
South Aunuu	x	x		
Southwest Ofu	x	x	x	x
West Olosega	x	x		
Rose Atoll	x	x	x	x
Swain's Atoll	x	x	x	x
North Ta`u	x	x		
<u>CNMI</u>				
Marpi Reef		x	x	x
Farallon de Medinilla		x	x	x
Tourist Reef		x	x	x
Saipan Lagoon	x	x	x	x
Saipan nearshore reefs		x	x	x
Tinian nearshore reefs		x	x	x

	Rarity	Ecological Function	Susceptibility to Human Impacts	Likelihood of developmental Impacts
Rota nearshore reefs		x	x	x
Offshore banks	x	x	x	x
NWHI				
French Frigate Shoals	x	x	x	x
Laysan	x	x		
Lisianski (Neves Shoals)	x	x	x	x
Pearl and Hermes	x	x		x
Maro Reef	x	x		x
Midway	x	x	x	
Kure	x	x	x	x
Submerged banks and shoals	x	x	x	x
Main Hawaiian Islands				
Niihau (west coast, Lehua)	x	x		
Kaula Rock (5-fathom pinnacle)	x	x	x	x
Hawaii (west coast)	x	x	x	x
Kahoolawe (whole island)	x	x		
Maui (south and west coast) and Molokini islet		x	x	x
Molokai (south coast)	x	x	x	x
Lanai (NW coast and south coast)	x	x		
Oahu (entire island and associated islets)	x	x	x	x
Kauai (north and south coasts; Lehua islet)	x	x	x	x
Penguin Banks	x		x	x
Pacific Remote Islands				
Wake Atoll	x	x		
Johnston Atoll	x	x		x

	Rarity	Ecological Function	Susceptibility to Human Impacts	Likelihood of developmental Impacts
Jarvis Island	x	x		
Palmyra Atoll	x	x	x	
Kingman Reef	x	x	x	
Howland Island	x	x		
Baker Island	x	x		