FISHERY ECOSYSTEM PLAN
for the
AMERICAN SAMOAN ARCHIPELAGO

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PREFACE

In 2005, the Council recommended to establish and implement fishery ecosystem plans for archipelagic, pelagic, and remote island areas in the Western Pacific Region. In order to accomplish this directive, Council staff conducted a series of ecosystem-based fishery management (EBFM) workshop between 2005 and 2007: Ecosystem Science (2005); Social Science (2006); and Management Policy (2007). Previously, the Council managed fisheries in these areas using the single-species management paradigm. Ecosystem-based fishery management addresses a geographically-specified system of fishery-associated organisms (including humans), and the environment and the processes that control its dynamics. It includes noncommercial and commercial fisheries, and recognizes the physical, biological, economic and social interactions among the affected components of the ecosystem. Perhaps most importantly, EBFM seeks to manage for a spectrum of goals society has for fishery ecosystems – some of which may be in competition.

The Council's first fishery ecosystem plans were approved by the Secretary of Commerce in September 2009. However, ecosystem-based fishery management thinking has an extended history in our region. For example, the Council's Executive Director, Kitty Simonds, was an active participant in one of the National Oceanic and Atmospheric Administration's (NOAA) first ecosystem management workshops, in 1986. In 2001, the Council took final action to recommend the first fishery ecosystem management plan in the nation. The Coral Reef Ecosystem Fishery Management Plan encompassed Council-associated coral reef fishery ecosystems in the U.S. Pacific Islands. Among other things, the plan established a process to assess and control ecosystem effects of bottomfish, precious coral, and crustacean fisheries operating federal waters under then-existing fishery management.

The Fishery Ecosystem Plan for the American Samoan Archipelago (FEP) is the framework under which the Council will manage place-based fishery ecosystem resources, including the integration of important ecosystem elements important to decision-making. These elements include social, cultural, and economic dimensions, protected species, habitat considerations, climate change effects, and the implications to fisheries from various spatial uses of the marine environment. Successful ecosystem-based fisheries management requires an increased understanding of a range of social and scientific issues, including the societal goals society appropriate management objectives, biological and trophic relationships, ecosystem indicators and models, and the ecological effects of non-fishing activities on the marine environment. Future fishery management actions are anticipated to utilize this information as it becomes available, and adaptive management will be used to further advance the implementation of ecosystem science and principles. In this regard, the success of the EBFM approach relies heavily on the data collection and synthesis process established by the pelagic and archipelago annual fishery ecosystem reports (SAFE Reports). In 2015, the Council, in partnership with the National Marine Fisheries (NMFS) Pacific Islands Fishery Science Center, local fishery resource management agencies, and the NMFS Pacific Islands Regional Office revised and expanded the contents of these reports to include the range a ecosystem elements described above.

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EXECUTIVE SUMMARY

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) is the primary domestic legislation governing management of the nation's marine fisheries. The United States Congress has amended and reauthorized the MSA several times since 1976. The 1996 reauthorization included, among other things, a new emphasis on the precautionary approach. In 2006, an annual catch limit requirement was written in. The MSA contains ten national standards, with which all fishery management plans and plan amendments must conform. The MSA also requires U.S. fisheries management be consistent with the requirements of other regulations including the National Environmental Policy Act, Marine Mammal Protection Act, the Endangered Species Act, the Migratory Bird Treaty Act, and several other Federal laws and Executive Orders.

Under the Magnuson-Stevens Act, the Western Pacific Regional Fishery Management Council (Council) is authorized to prepare and submit to the Secretary of Commerce for approval, disapproval or partial approval, a Fishery Management Plan (FMP) and any necessary amendments, for fisheries that are under its authority and that require conservation and management. The Council transitioned to Fishery Ecosystem Plans (FEPs) from FMPs in 2009. The Council conducts public hearings so that all interested persons may have opportunities to participate in the development of FEPs and amendments.

This Fishery Ecosystem Plan (FEP) governs federal fisheries of the American Samoa archipelago. The management area is the United States (U.S.) Exclusive Economic Zone (EEZ) of archipelago. The Plan covers bottomfish, coral reef fish, crustacean, and precious coral stocks and fisheries. The FEP was implemented on September 24, 2009. It replaced a set of species-based FMPs that covered the Western Pacific Region. This version of the FEP was implemented on ____. It strengthens the ecosystem-based fishery management approach, provides the public with additional information regarding the management process, conforms with new information requirements, and is a framework for a clearer understanding of fishery and conservation and management measures promulgated by the FEP and subsequent amendments to it.

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1.1 Mission

The Western Pacific Regional Fishery Management Council (Council) is a federal instrumentality established and authorized by Congress in 1976. Its mission is to “plan, coordinate and realize all responsibilities as delegated under the MSA for effective conservation and prudent development of the region’s fishery resources for the benefit of the region and the nation.” To meet this mission, the Council established the following Guiding Principles:

1. Support quality research and obtain the most complete scientific information available to assess and manage fisheries;
2. Promote an ecosystem approach in fisheries management, including reducing waste in fisheries and minimizing impacts on marine habitat and impacts on protected species;
3. Conduct education and outreach to foster good stewardship principles and broad and direct public participation in the Council’s decision making process;
4. Recognize the importance of island cultures and traditional fishing practices in managing fishery resources and foster opportunities for participation;
5. Promote environmentally responsible fishing and the utilization of sustainable fisheries that provide long term economic growth and stability;
6. Promote regional cooperation to manage domestic and international fisheries; and
7. Encourage development of technologies and methods to achieve the most effective level of monitoring, control and surveillance and to ensure safety at sea.

The Council is responsible for developing fishery management policies for the western Pacific region, which includes the State of Hawaii, Territories of American Samoa and Guam, the Commonwealth of the Northern Mariana Islands and other U.S. Pacific remote island areas (Figure 1). All management plans, amendments to them, and regulations implementing them, must comply with the MSA and all other applicable laws – such as the National Environmental Policy Act (NEPA). The Council’s primary responsibility is to develop and recommend fishery management measures for any federal managed fishery, stock, or stock complex, as well as measure to protect important ecosystem components, such as protected species and fish habitat.

Our region’s archipelagos have distinct cultures, communities, and marine resources. For thousands of years, the indigenous people of these islands relied on healthy marine ecosystems to sustain themselves, their families, and their island communities. Although the past century has brought enormous advancements in transportation and diet, these islanders continue to depend on healthy marine ecosystems, owing to the remoteness of the islands, and their intact cultural practices. Even in the modern period, much ecological, economic, and social benefit is realized from sustainably managing island resources.

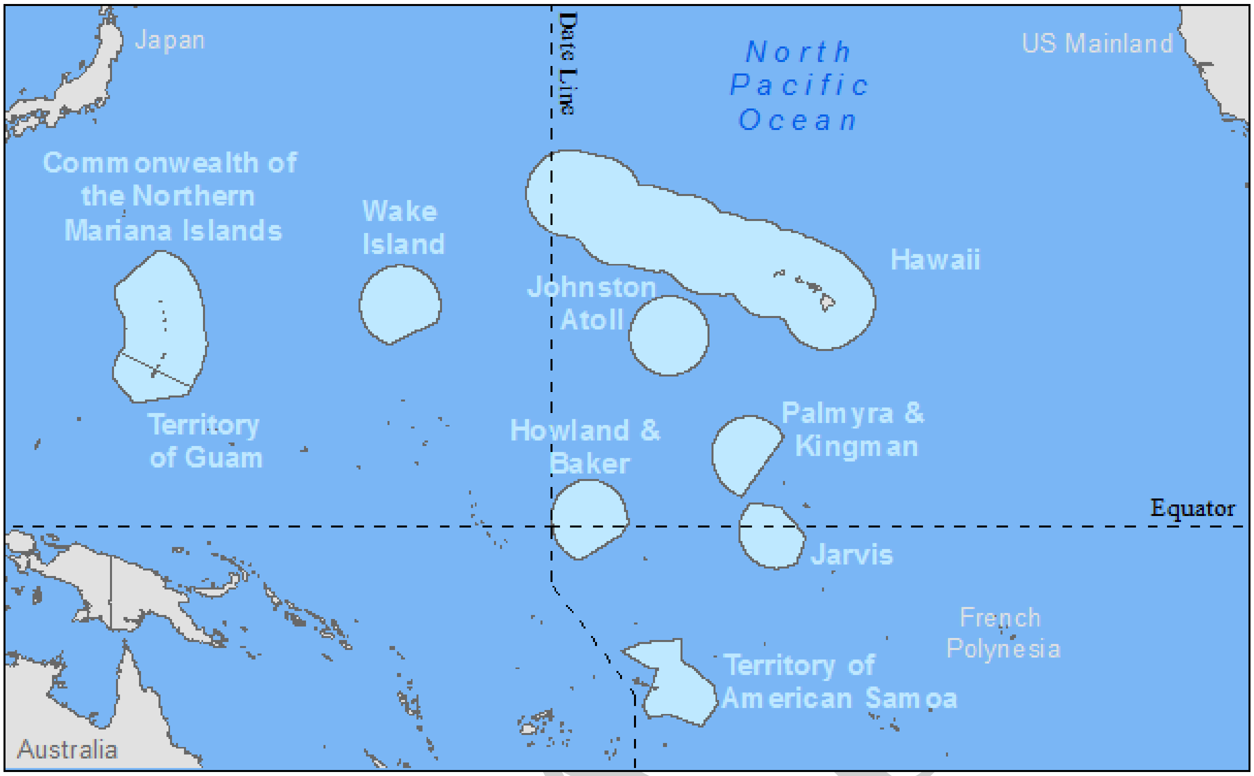

Figure 1. Western Pacific Region

1.2 Authorities and Primary Management and Process Drivers

1.2.1 MSA

In 1976, the United States Congress passed the Fishery Conservation and Management Act to promote domestic fisheries and establish management authority over fishery and related resources within the 200 mile federal Exclusive Economic Zone (EEZ). The statute has been subsequently amended and reauthorized over the ensuing years and is now known as the Magnuson-Stevens Fishery Conservation and Management Act (MSA).[2] It is the primary law governing federal management of United States fisheries.

Under the MSA, the United States (U.S.) has exclusive fishery management authority over all fishery resources found within its Exclusive Economic Zone (EEZ). For purposes of the MSA, the inner boundary of the U.S. EEZ extends from the seaward boundary of each coastal state to a distance of 200 nautical miles from the baseline from which the breadth of the territorial sea is measured. The Western Pacific Regional Fishery Management Council (Council) has authority over the fisheries based in, and surrounding, the Territory of American Samoa.

The management system created by the MSA is unique in U.S. natural resource management. In

[2] The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended through 2006, is available at: http://www.nmfs.noaa.gov/sfa/magact/MSA_Amended_2007%20.pdf

order to reduce top-down, centralized fishery resource management decision-making, Congress established eight regional fishery management councils and provided them with responsibility for developing fishery management plans and recommending amendments to those plans on an ongoing basis, as well as regulatory language for implementation. As such, the Councils have a unique relationship with their primary partner federal agency, the National Marine Fisheries Service (NMFS). Councils are composed of federal, state, and territorial fishery management officials, participants in commercial and recreational fisheries, and other individuals with experience, scientific expertise, or training that give them knowledge about fishery conservation and management or commercial or recreational harvest. In addition, the MSA mandates certain advisory bodies (and authorized the Councils to creates others) so as to provide the Councils with technical advice and guidance in fishery policy decision making. The MSA mandates an open, public process for the development of fishery management measures and actions through the Council system.

As in other regions, responsibility for the management of marine resources in the Western Pacific is shared by a number of federal and local government agencies. At the federal level are the Council, the NMFS (also known as the NOAA Fisheries Service), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Fish and Wildlife Service (U.S. Department of the Interior) and the U.S. Department of State. The U.S Coast Guard, in the U.S. Department of Homeland Security, as well as the Department of Defense, through the Air Force, Army, Navy and Marine Corps, also controls access, enforcement, and use of various marine waters throughout the region.

Sixteen members of the Council include the following:

- Regional Administrator, Pacific Islands Regional Office, National Marine Fisheries Service
- Director, Department of Marine and Wildlife Resources, Territory of American Samoa
- Secretary, Department of Land and Natural Resources, Commonwealth of the Northern Mariana Islands
- Director, Department of Agriculture, Territory of Guam
- Chair, Department of Land and Natural Resources, State of Hawaii
- One obligatory member from each of the four island areas nominated by their respected governors and appointed by the Secretary of Commerce
- Four at-large members nominated by the region's Governors and appointed by the Secretary of Commerce.
- District Commander, US Coast Guard 14th District (non-voting member)
- Director, Office of Marine Conservation, US State Department (non-voting member)
- Director, US Fish and Wildlife Service (non-voting member)

The basic functions of the Council as required by the MSA are diverse. For fisheries under its authority that require conservation and management the Council has the following responsibilities:

1. Prepares and transmits to the Secretary fishery ecosystem plans (FEPs) and amendments to such plans as necessary to address changing needs in conservation and management;
2. Prepares comments on any application for foreign fishing transmitted to the Council, and any fishery management plan or amendment transmitted to the Council;

3. Conducts public scoping, meetings and hearings at appropriate times and in appropriate locations in its geographic area[3] so as to allow all interested persons an opportunity to be heard in the development of FEPs and amendments to such plans, and other matters with respect to the administration and implementation of the provisions of the Magnuson-Stevens Act and other Statutory requirements;
4. Submits to the Secretary such periodic reports as the Council deems appropriate and any other relevant report that may be requested by the Secretary;
5. Reviews on a continuing basis, and revises as appropriate, the following for each fishery within its geographical area of authority: assessments and related specifications with respect to the optimum yield (OY); the capacity and extent to which US fish processors will process US harvested fish; and the total allowable level of foreign fishing;
6. Develops annual catch limits (ACLs) for managed fisheries that may not exceed the fishing level recommendations of its Scientific and Statistical Committee (SSC) or similar peer-review process;
7. Develops, in conjunction with its SSC, five-year research priorities for fisheries, fisheries interactions, habitats and other areas of research that are necessary for management purposes; update them as necessary; and submit them to the Secretary of Commerce (Secretary) and the Pacific Islands Fisheries Science Center (PIFSC) of the National Marine Fisheries Service (NMFS) for their consideration in developing research priorities and budgets for the Pacific Islands/Western Pacific Region;
8. May review and provide comments on any federal or state action that may affect fishery habitat under the Council's jurisdiction; and
9. Conducts any other activities that are required by, or provided for in, the MSA or which are necessary and appropriate to the foregoing functions.

1.2.1.1 National Standards

To carry out the above functions, the Council pays particular attention to 10 National Standards (NS) described in the MSA, against which the Council's recommendations to the Secretary are measured:

1. Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the OY from each fishery for the United States fishing industry.
2. Conservation and management measures shall be based upon the best scientific information available.
3. 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.

[3] "Geographic area" may include an area under the authority of another Council if the fish in the fishery concerned migrate into, or occur in, that area or if the matters being heard affect fishermen of that area.

4. 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 fair and equitable to all such fishermen; reasonably calculated to promote conservation; and carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.
5. 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.
6. Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources and catches.
7. Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.
8. Conservation and management measures shall, consistent with the conservation requirements of the MSA (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities by utilizing economic and social data that meet the requirements of NS 2 in order to provide for the sustained participation of such communities, and, to the extent practicable, minimize adverse economic impacts on such communities.
9. Conservation and management measures shall, to the extent practicable, minimize bycatch and, to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.
10. Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea.

1.2.1.2 Essential Fish Habitat

In 1996, Congress passed the Sustainable Fisheries Act, which amended the MSA and added several new FMP provisions. From an ecosystem management perspective, the identification and description of EFH for all federally managed species were among the most important of these additions.

According to the MSA, EFH is defined as “those waters and substrate necessary to fish for spawning, breeding or growth to maturity.” This new mandate represented a significant shift in fishery management. Because the provision required councils to consider a MUS’s ecological role and habitat requirements in managing fisheries, it allowed Councils to move beyond the traditional single-species or multispecies management to a broader ecosystem-based approach. In 1999, NMFS issued guidelines intended to assist Councils in implementing the EFH provision of the MSA, and set forth the following four broad tasks:

1. Identify and describe EFH for all species managed under an FMP.
2. Describe adverse impacts to EFH from fishing activities.
3. Describe adverse impacts to EFH from non-fishing activities.
4. Recommend conservation and enhancement measures to minimize and mitigate the adverse impacts to EFH resulting from fishing and non–fishing related activities.

The guidelines recommended that each Council prepare a preliminary inventory of available environmental and fisheries information on each managed species. Such an inventory is useful in describing and identifying EFH, as it also helps to identify missing information about the habitat utilization patterns of particular species. The guidelines note that a wide range of basic information is needed to identify EFH. This includes 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. Because EFH has to be identified for each major life history stage, information about a species' distribution, density, growth, mortality, and production within all of the habitats it occupies, or formerly occupied, is also necessary.

The guidelines also state that the quality of available data used to identify EFH should be rated using the following four-level system:

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 utilized by a species could be identified, allowing a more precise designation of EFH. Habitats of lesser value to a species may also 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.

The EFH provisions are especially important because of the procedural requirements they impose on both Councils and federal agencies. First, for each FMP, Councils must identify adverse impacts to EFH resulting from both fishing and non-fishing activities, and describe measures to minimize these impacts. Under § 305(b)(2) of the MSA, federal agencies are required to consult with NMFS on any action authorized, funded, or undertaken by the agency that may adversely affect EFH identified by the Council. Councils are not required to provide conservation and enhancement recommendations except for anadromous species. In 2002, NMFS revised the guidelines by providing additional clarifications and guidance to ease implementation of the EFH provisions by Councils.

Based on the best available information on habitats in waters of American Samoa and the existing fisheries, the Council has determined that the fisheries operating in American Samoa are not expected to have adverse impacts on EFH or HAPC for managed species. Continued and future operations of fisheries under the American Samoa FEP are not likely to lead to substantial physical, chemical, or biological alterations to the habitat, or result in loss of or injury to, these species or their prey.

The description and identification of EFH and HAPC for fisheries managed under this FEP can be found in section 3.1, Management Regime. Life history and habitat information on managed species, on which the EFH descriptions are based, may be found in Appendix F. Information related to activities that may adversely affect EFH and EFH maps can be found in Appendices G and H.

1.2.2 National Marine Fisheries Service Guidance

Primary authority for implementing and enforcing management action developed under the MSA rests with the U.S. Secretary of Commerce (Secretary), who has delegated this responsibility to the National Marine Fisheries Service (NMFS). The NMFS develops guidance to aid the Councils, fishermen and others to develop, implement and comply with fishery regulations. In addition, the Council and NMFS have established operating agreements to help define specific roles and responsibilities for developing, approving, and implementing fishery management plans and other actions under the auspices of the MSA.

1.2.3 National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to assess and consider the effects of major federal actions on the quality of the human environment by considering the environmental impacts of proposed actions and reasonable alternatives to those actions. The Act also requires that the public be provided the opportunity to help identify, review and comment on such effects, particularly in cases where an environmental impact statement (EIS) is being prepared.

NEPA requires an environmental impact statement (EIS) for major federal actions that significantly affect the quality of the human environment. Agencies may conduct an environmental assessment to determine whether an EIS is necessary or whether a Finding of No Significant Impact (FONSI) or a Categorical Exclusion (CE) is warranted.

At the time of the final decision (and in the case of an EIS, at least 30 days after the Final EIS is noticed and at least 90 days after the Draft EIS is noticed), agencies must have prepared a record of decision (ROD), FONSI, or determined that a CE applies. It is important to be aware of the interaction of NEPA and MSA timing requirements. For example, the deadline for the Secretary to approve, disapprove, or partially approve a Council-submitted FMP or Amendment (i.e., 30 days after the close of the comment period on the FMP or Amendment and often referred to as "Day 95") should not occur prior to signing the ROD or the FONSI. If it is an FEIS, the ROD may not be signed sooner than 30 days after noticing the availability of the FEIS.

1.2.4 ESA

The Endangered Species Act (ESA) provides for the conservation of species that are endangered or threatened, and the conservation of the ecosystems on which they depend. Section 7(a)(2) of the ESA requires each federal agency to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat of such species. To "jeopardize" means to reduce appreciably the likelihood of survival and recovery of a species in the wild by reducing its numbers, reproduction, or distribution. As described in the NMFS policy for Integration of Endangered Species Act Section 7 with the Magnuson-Stevens Act Processes (PD 01-117), the Council plays an integral role in these consultations.

When a federal agency's action "may affect" an ESA-listed species, that agency is required to consult formally with NMFS (for marine species, some anadromous species, and their designated critical habitats) or the U.S. Fish and Wildlife Service (USFWS; for terrestrial and freshwater species or their designated critical habitat). The product of formal consultation is the agency's biological opinion (BiOp). Federal agencies are exempt from this formal consultation requirement if they have concluded that an action "may affect, but is not likely to adversely affect" ESA-listed species or their designated critical habitat, and NMFS or USFWS concur with that conclusion (see 50 CFR § 402.14(b)).

The ESA also prohibits the taking[4] of listed species except under limited circumstances. Western Pacific regional fisheries are operated in accordance with terms of ESA consultations that consider the potential interactions of fisheries with listed species, the impacts of interactions on the survival and recovery of listed species, and the protection of any designated critical habitat.

As provided in 50 CFR § 402.16, NMFS is required to reinitiate formal consultation if:

(1) the amount or extent of the incidental take is exceeded;
(2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in an opinion;
(3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in the opinion; or
(4) a new species is listed or critical habitat designated that may be affected by the action.

Fisheries operating under this FEP have the potential to interact with a range of protected species. A current list of ESA listed species applicable to the American Samoa FEP is included in the Annual Archipelagic Fishery Ecosystem Report (SAFE Report) and additional information regarding protected species interactions in this FEP is included in Section 3.2 (Other Considerations Important for Implementation – Protected Species Information).

1.2.5 MMPA

The Marine Mammal Protection Act (MMPA) prohibits, with certain exceptions, the take of marine mammals in the U.S. EEZ and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the United States. The MMPA gives the Secretary authority and duties for the protection and conservation of all cetaceans (whales, dolphins, and porpoises) and pinnipeds (seals and sea lions, except walruses). The MMPA requires NMFS to prepare and periodically review marine mammal stock assessments (see 16 U.S.C. § 1361, *et seq*.).

[4] The definition of "take" includes to harass, harm, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct.

Pursuant to the MMPA, NMFS has promulgated specific regulations that govern the incidental take of marine mammals during fishing operations (50 CFR 229). Under section 118 of the MMPA, NMFS must publish, at least annually, a List of Fisheries that classifies U.S. commercial fisheries into three categories, based on relative frequency of incidental mortality and serious injury to marine mammals in each fishery:

- Category I designates fisheries with frequent serious injuries and mortalities incidental to commercial fishing. Annual mortality and serious injury of a stock in a given fishery is by itself responsible for the annual removal of greater than or equal to 50 percent or more of any stock's potential biological removal (PBR) level.

- Category II designates fisheries with occasional serious injuries and mortalities incidental to commercial fishing. Annual mortality and serious injury of a stock in a given fishery is, collectively with other fisheries, responsible for the annual removal of greater than 10 percent of any stock's PBR level, and is by itself responsible for the annual removal of between 1 and less than 50 percent, exclusive, of any stock's PBR level.

- Category III designates fisheries with a remote likelihood or no known serious injuries or mortalities. A Category III fishery is, collectively with other fisheries, responsible for the annual removal of 10 percent or less of any stock's PBR level; or collectively with other fisheries, more than 10 percent of any stock's PBR level, but is by itself responsible for the annual removal of 1 percent or less of PBR level.

Owners of vessels or gear engaging in a Category I or II fishery are required under 50 CFR 229.4 to obtain authorization to lawfully incidentally take non-ESA listed marine mammals by registering with NMFS' marine mammal authorization program. Fishermen participating in Category I or II fisheries are also required to accommodate an observer onboard upon request by NMFS, and are required to comply with any applicable take reduction plans. Current List of Fisheries classifications for fisheries operating under the American Samoan Archipelago FEP are included in the Archipelagic Fishery Annual Report (SAFE Report).

Section 101 (a)(5)(E) of the MMPA requires the Secretary of Commerce to allow the incidental, but not intentional, taking of individuals from marine mammal stocks that are designated as depleted because of listing as threatened or endangered under the ESA in the course of commercial fishing operations if it is determined that three criteria are met:

1. Incidental mortality and serious injury will have a negligible impact on the affected species or stock;
2. A recovery plan has been developed or is being developed; and
3. Where required under section 118 of the MMPA, a monitoring program has been established, vessels engaged in such fisheries are registered in accordance with section 118 of the MMPA, and a take reduction plan (TRP) has been developed or is being developed for such species or stock.

1.3 Samoan Archipelago

1.3.1 Geography

The Samoan Archipelago is an island chain in the central South Pacific Ocean running roughly east-west at approximately 14° south latitude. Today, the archipelago is divided into two political jurisdictions – the independent country of Samoa in west and the U.S. territory of American Samoa to the east. The strait between the two jurisdictions is about 70 miles wide.

The two large islands, Upolu and Savai'i, are in Independent Samoa and are among the largest islands in all of Polynesia. Only the two main islands of Fiji and the Hawaiian islands of Hawaii and Maui are larger. The next largest island in the chain is Tutuila, where the American Samoa government and a deep, large harbor are located. The islands are approximately 2,500 miles from Hawaii and 1,800 miles from New Zealand.

In American Samoa, the five volcanic islands of Tutuila, Aunu'u, Ofu, Olosega and Ta'u are the major inhabited islands. Tutuila, the largest island of these, is the center of government and business. Aunu'u lies approximately one mile off the southeast coast of Tutuila. The three islands of Ofu, Olosega and Ta'u, collectively referred to as the Manu'a Islands, lie 70 miles east of Tutuila. Swains Island, with a population of approximately 30, lies 240 miles north of Tutuila, and the uninhabited Muliava (Rose) Atoll is 180 miles to the east.

At 14° south latitude, the Samoan Islands have a tropical marine. The rainy season runs from November to April. Due to its position, the islands are periodically impacted by hurricanes – typically between December and March.

1.3.2 People

The Samoan Islands have been inhabited for several thousand years and are one of the most ethically-intact island groups in all of Polynesia. Samoans (Tagata Māoʻi) have long held their ancestors were birthed by special creation in Samoa. However, linguistic commonalities and the archaeological record, including the presence of Lapita pottery, have led some scholars to believe that seafaring migrants from Southeast Asia arrived in the islands approximately 3,500 years ago. It is possible however that the former hypothesis is true. Support for this possibility includes the fact that the Samoan language, culture, and social practice are divergent from the other groups associated with Lapita pottery and the term "Austronesia." Most American Samoans are bilingual and speak fluent English and Samoan.

1.3.2.1 Indigenous Culture

The primary social unit in the Samoan Islands is the family. Society runs largely on the basis of *Faʻ aSamoa*, or the Samoa Way [of Life], a bundle of language and traditional customs of relationships and culture that is understood by all Samoans and provides support and direction. The most important aspects of the *Fa'aSamoa* include the way people comport themselves in terms of standing, walking, and speaking. Church activities play an important role in daily life. Many villages maintain a short dusk-time curfew (called *Sa*), when families gather to sing hymns and pray and during which most activity in the village should cease. Public meetings, including those in the legislative and executive branches of government all begin and end in prayer.

The Deeds of Cession that underpin the present union between the United States and American Samoa preserved certain traditional land tenure. Consequently, approximately 95% of the landmass in American Samoa is held under the under the direct authority of a category of Samoan chiefs known as *matai*. Under the Matai System, traditional land cannot be purchased or sold and the current family chief has final say over the disposition of a family's holdings.

1.3.2.2 Current Demographics

The 2010 U.S. Census estimated the total population of American Samoa to be 57,291 people. Males comprised 50.7% of the population. The racial composition of American Samoa was: Samoan 88.9%, Tongan 2.9%, Filipino 2.2%, white 1.1%, and mixed 5.1%. Nearly all American Samoans are Christian. The largest religious denomination is the Congregational Christian Church, but the Roman Catholic Church, the Church of Jesus Christ of Latter-day Saints, Methodists, Seventh-Day Adventists and the Baha'i Faith also have healthy numbers of participants.

1.3.2.3 Socio-political Boundaries

Contact with Europeans occurred in the mid-1700s and led to a greatly-altered socio-political landscape over the next 150 years. By the late 1800s, the U.S., Germany, and the United Kingdom were vying for influence and presence in the Samoan Islands, in part of because the deep harbor at Pago Pago on Tutuila. The Tripartite Convention of 1899 settled much of this dispute but partitioned the archipelago into a German colony (German Samoa) and a United States territory – American Samoa. New Zealand occupied the German colony through 1920 and then formally governed those islands until independence in 1962 following the pro-independence Mau Movement across the islands. American Samoa remains a political territory of the United States. The Demarcation between Samoa and American Samoa is political. Cultural and commercial exchange continues, with families living and commuting between both Samoas.

American Samoa is divided politically into three districts (Eastern, Western, Manu‘a) and two unorganized atolls. There are five counties per district. There are 74 villages in the Territory and most have a mayor (*pulenu‘u*).

1.3.2.4 Fishing Communities

The MSA defines a 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.

American Samoa is like other island communities in the Western Pacific, where the surrounding ocean and its resources have long provided residents with a source of food and opportunities for maritime commerce and recreation. Because participants in American Samoa's various marine fisheries are not concentrated in specific locales but rather reside in villages and small towns across the islands, and because fishing, seafood, and fishing-related businesses assume extensive social and economic importance throughout the region, the Council recommended in 1999 that the Secretary of Commerce designate all of the island of American Samoa as one fishing community under the MSA[5]. The NMFS Pacific Islands Fisheries Science Center has since

[5] Federal Register Vol. 64, No. 74 April 19, 1999, 19067

developed a general profile of the American Samoa fishing community[6].

The social and economic interplay between American Samoa residents and the surrounding ocean environment is central to an understanding of community life in the archipelago. The islands are relatively small and most towns and villages are located along the coastal zone. As such, the ocean is an ongoing visual presence in the lives of all residents. American Samoa is the only U.S. territory in the southern hemisphere and goods must be transshipped on or over thousands of miles of ocean. This has led to a relatively high cost of living and limited availability of certain goods and services. The tourism economy is closely related to recreation and leisure opportunities along the coastal zone, and it too is conditioned by distance of travel to the islands. Fishing activities are important across American Samoa, and living marine resources are used for commercial sale, household consumption, and as a source of recreation. Various aspects of local and indigenous history, culture, and society are closely related to the surrounding ocean and use of its resources.

[6] Grace-McCaskey, C.A. 2015. American Samoa Fishing Community Profile: 2013 Update. Pacific Islands Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96818-5007. Pacific Islands Fish. Sci. Cent. Admin. Rep. H-15-04,30 p.

2 MANAGEMENT POLICY, GOALS, AND OBJECTIVES

2.1 Council Management Policy

The Council's management policy is to apply responsible and proactive management practices, based on sound scientific data and analysis and inclusive of fishing community members, to conserve and manage fisheries and their associated ecosystems of the American Samoan archipelago.

2.2 American Samoa FEP Purpose and Need

The American Samoan archipelago contains various stocks and stock complexes that are found in federal waters and which provide important benefits to the people of American Samoa and by extension, the Nation. Since these resources are in need of management, the Council is required under the MSA to develop management plans to accomplish this. In addition, the habitats for these fish, as well as other elements of the marine ecosystem, such as sea turtles, cetaceans, and corals, are also locally and nationally important. Since all of these are interconnected, the Council opted in the mid-2000s[7] to take an archipelagic ecosystem-based approach to fisheries managed and spent the next several years revising its species/complex-based fishery management plans (FMPs) to place-based fishery ecosystem plans (FEPs).

The Council's decision to transition to ecosystem-based fishery management (EBFM) followed Congressional direction in 1998 to the NMFS to establish an Ecosystem Principles Advisory Panel (Panel; EPAP). The Panel was tasked with assessing the extent to which ecosystem principles were being or could be used in fisheries management and recommending how to further ecosystem principle use to improve the status and management of marine resources. The Panel was composed of members of academia, fishery and conservation organizations, and fishery management agencies (see below).

Since all of these are interconnected, the Council opted in the mid-2000s to take an archipelagic ecosystem-based approach to fisheries managed and spent the next several years revising its five species/complex-based fishery management plans (FMPs) (Precious Corals FMP became effective in September 1983; Crustaceans FMP (March 1983); Bottomfish and Seamount Groundfish (August 1986); Pelagics FMP (March 1987); Coral Reef Ecosystems FMP (February 2004)) to place-based fishery ecosystem plans (FEPs). The five FEPs approved by the Council in 2007 and implemented in 2009 include the American Samoa Archipelago FEP, Mariana Islands Archipelago FEP, Hawaii Archipelago FEP, Pacific Remote Island Area FEP, and Pacific Pelagic FEP.

[7] At its 130th meeting held December 20, 2005, the Council took final action to recommend implementation of place-based FEPs for the Western Pacific Region.

2.3 American Samoan Archipelago Fishery Ecosystem Plan Goals

The American Samoan Archipelago FEP establishes a framework under which the Council can recommend management measures required by federal law and best available scientific information. The NMFS Ecosystem Principles Advisory Panel described above reached consensus that the Councils and NMFS should develop and implement Fishery Ecosystem Plans in order to manage U.S. fisheries and marine resources in a more comprehensive and integrated manner (NMFS 1999).

The National Oceanic and Atmospheric Administration (NOAA) defines an ecosystem approach as “management that is adaptive, specified geographically, takes account of ecosystem knowledge and uncertainties, considers multiple external influences, and strives to balance diverse social objectives” In addition, because of the wide-ranging nature of ecosystems, successful implementation of ecosystem approaches will need to be incremental and collaborative (NOAA 2004).

On international, national, and local levels, institutions and agencies tasked with managing marine resources are moving toward an ecosystem approach to fisheries management. One reason for this shift is a growing awareness that many of Earth’s marine resources are stressed and the ecosystems that support them are degraded. In addition, increased concern regarding the potential impacts of fishing and non-fishing activities on the marine environment, and a greater understanding of the relationships between ecosystem changes and population dynamics, have all fostered support for a holistic approach to fisheries management that is science based and forward thinking (Pikitch et al. 2004).

In order to achieve EBFM, this plan: 1. identifies the management objectives of the American Samoan Archipelago FEP; 2. delineates the boundaries of the American Samoan Archipelago FEP; 3. designates the management unit species included in the American Samoan Archipelago FEP; 4. details the federal fishery regulations applicable under the American Samoan Archipelago FEP; and 5. establishes appropriate Council structures and advisory bodies to provide scientific and management advice to the Council regarding the American Samoan Archipelago FEP. In addition, this plan provides the information and rationale for these measures; discusses the key components of the American Samoan archipelago ecosystem, including an overview of the region’s non-pelagic fisheries; and explains how the measures contained here are consistent with the MSA and other applicable laws.

This FEP has four goals:

- Goal 1. Conserve and manage target and non-target stocks;
- Goal 2. Protect species and habitats of special concern;
- Goal 3. Understand and account for important ecosystem parameters and their linkages, and;
- Goal 4. Meet the needs of fishermen, their families, and communities in the American Samoan archipelago.

2.4 American Samoa FEP Objectives

To achieve the policy and goals of the American Samoan Archipelago FEP, the Council has adopted the following objectives:

OBJECTIVE 1. Support Fishing Communities

a. Identify the various social and economic groups within the region's fishing communities and their interconnections.
b. Ensure that regulations designed to meet conservation objectives are written to be as minimally-constraining as possible.
c. Select alternatives that minimize adverse economic impacts to fishing communities when possible.
d. Eliminate regulations that are no longer necessary (i.e., eliminate access barriers).
e. Increase communication between fishery sectors.
f. Support fishery development, training and processing opportunities.
g. Support projects, programs and policies that increase sustainable fishing opportunities.

OBJECTIVE 2: Prevent Overfishing on Council-managed Stocks

a. Develop status determination criteria for all stocks and stock complexes in the fisheries.
b. Monitor fisheries to understand when overfishing may be close to occurring.

OBJECTIVE 3. Improve Fishery Monitoring and Data Collection

a. Increase the number of fishery ecosystem elements being monitored.
b. Improve the timeliness of data availability.
c. Improve the quantity and quality of relevant fishery data.
d. Encourage research to improve precision of data regarding protected species populations and distributions.
e. Increase research coordination between the Council, the state, and federal agencies.
f. Increase the quality and quantity of monitoring and enforcement data through improved technology.

OBJECTIVE 4. Promote Compliance

a. Understand factors that may result in non-compliance.
b. Consider ways to develop or increase buy-in from affected parties.
c. Ensure that regulations are written and implemented so as to be easy to follow and enforce.
d. Develop codes of conduct specific to individual fisheries.

OBJECTIVE 5. Reduce Bycatch and Minimize Interactions and Impacts to Protected Species to the Extent Practicable

a. Maintain minimal impacts to protected species and other bycatch species while maintaining the viability of fisheries.

b. Encourage non-regulatory approaches to reducing protected species and bycatch impacts where necessary and appropriate.
c. Increase fishermen's knowledge about protected species issues and regulations and ways to minimize interactions.
d. Continue to work with federal and state agencies to protect relevant threatened and endangered species.
e. Improve assessment of protected species and bycatch species impacts through improvements in data collection, research and monitoring.
f. Encourage research that examines whether and to what extent bycatch is an issue in the fisheries covered by this management plan.

OBJECTIVE 6. Refine and Minimize Impacts to Essential Fish Habitat

a. Review and update EFH and HAPC designations on regular schedule (5-years) based on the best available scientific information of a higher EFH level than was used for the original designation.
b. Identify and prioritize research to: assess adverse impacts to EFH and HAPC from fishing and non-fishing activities, including, but not limited to, activities that introduce land-based pollution into the marine environment.

OBJECTIVE 7. Increase Traditional and Local Knowledge in Decision-making

a. Identify relevant Samoan practices and knowledge that may improve scientific inquiry regarding Council-managed fisheries.
b. Utilize cultural practitioners, concepts, and bodies in the analysis of management alternatives.
c. Utilize fishermen knowledge in the analysis of management alternatives.

OBJECTIVE 8. Consider the Implications of Spatial Management Arrangements in Council Decision-making

a. Identify and prioritize research that examines the positive and negative consequences of current no-take fishing areas to fisheries, fishery ecosystems, and fishermen, such as military installations, Monuments, and Marine Conservation Areas.
b. Consider whether the goals of any spatial-based fishing restrictions proposed in federal waters appear to be achievable.
c. Establish effective spatially-based fishing
d. Remove spatial-based fishing restrictions that are no longer necessary.

OBJECTIVE 9. Consider the Implications of Climate Change in Council Decision-making

a. Identify and prioritize research that examines the effects of climate change on Council-managed fisheries and fishing communities.
b. Ensure climate change considerations are incorporated into the analysis of management alternatives.
c. Monitor climate-change related variables via the Council's Annual Reports.

d. Engage in climate change outreach with US Pacific islands communities.

3 MANAGEMENT REGIME AND FISHERY INFORMATION

3.1 Management Regime

Management unit species (MUS) are those species that are managed under a fishery management or ecosystem plan and typically include those species that are caught in quantities sufficient to warrant management or monitoring by NMFS and the Council. The primary impact of inclusion of species in an MUS list is that the fishery targeting that species can be directlymanaged. National Standard 3 of the MSA requires that 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. Under the American Samoan Archipelago FEP, MUS include bottomfish and seamount species, crustaceans, precious corals, and coral reef ecosystem species that are known to be present within EEZ waters around the American Samoan archipelago. Certain pelagic species also occur within the boundary of the American Samoa FEP, but they are managed under the Council's Pacific Pelagic FEP.

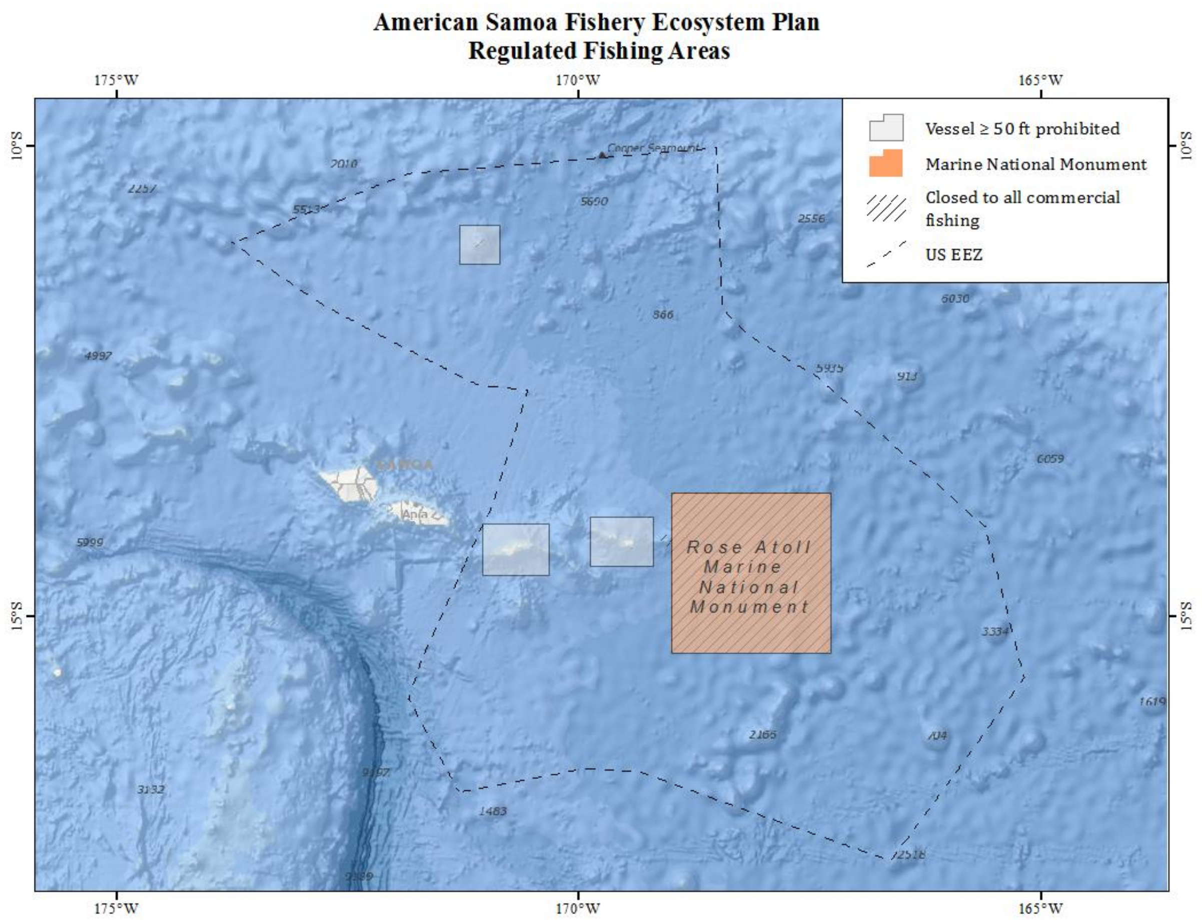

Figure 2. American Samoa Fishery Ecosystem Plan Regulated Fishing Areas.

3.1.1 Bottomfish Fishery

The commercial and non-commercial bottomfish fisheries of the American Samoan archipelago harvest a complex of 17 species that includes both shallow and deep-water snappers, and several species of groupers, emperors and jacks. The main species targeted is the redgill emperor (*Lethrinus rubrioperculatus*). The local names of bottomfish management unit species (BMUS) are provided in Gagana fa`a Sāmoa (Table 1), the native language of American Samoa.

Table 1. American Samoan Archipelago Bottomfish Management Unit Species.

Scientific Name	English Common Name	Samoan Name
Aphareus rutilans	red snapper/silvermouth	palu-gutusiliva
Aprion virescens	gray snapper/jobfish	asoama
Caranx ignobilis	giant trevally/jack	sapoanae
C. lugubris	black trevally/jack	tafauli
Epinephelus fasciatus	blacktip grouper	Fausi
Variola louti	lunartail grouper	papa, velo
Etelis carbunculus	red snapper	palu malau
E. coruscans	red snapper	palu-loa
Lethrinus amboinensis	ambon emperor	filoa-gutumumu
L. rubrioperculatus	redgill emperor	filoa-paomumu
Lutjanus kasmira	blueline snapper	savane
Pristipomoides auricilla	yellowtail snapper	palu-i'usama
P. filamentosus	pink snapper	palu-'ena'ena
P. flavipinnis	yelloweye snapper	palu-sina
P. seiboldii	pink snapper	palu
P. zonatus	snapper	palu-ula, palu-sega

Scientific Name	English Common Name	Samoan Name
Seriola dumerili	amberjack	malauli

3.1.1.1 Type and Quantity of Fishing Gear

The bottomfish fishery of American Samoa consists of part-time vessels that typically jig overnight using skipjack tuna as bait (WPRFMC 2004a). The fishing technology employed by the fleet is relatively unsophisticated. Most vessels are aluminum alia catamarans less than 30 feet in length and many of the boats are outfitted with wooden hand reels that are used for both trolling and bottomfish fishing. In 1999, less than 10 percent of the boats carried a depth recorder, electronic fish finder, or global positioning system (Severance et al. 1999). Because few boats carry ice, they typically fish within 20 miles of shore. In recent years, however, a growing number of fishermen in American Samoa have been acquiring larger (> 35 ft) vessels with capacity for chilling or freezing fish and a much greater fishing range. To date there are no Federal permitting or reporting requirements for this fishery in Federal waters around American Samoa. Available fishery information is not spatially specific and cannot be clearly separated by jurisdiction (i.e., Federal vs. territorial waters); however, at least some fishing for bottomfish MUS occurs in Federal waters. Many trips are not exclusively conducted for bottomfishing but rather are mixed trips, and include trolling and mid-reef fishing. Similarly, fishing trips are often motivated by both commercial and noncommercial interests

In the early 1980s, the 28-foot *alia* catamaran, designed by the Food and Agriculture Organization of the United Nations, was introduced into American Samoa, and local boat builders began constructing these inexpensive but seaworthy fishing vessels. A recovery in the size of the fishing fleet, together with a government-subsidized development project aimed at exporting deep-water snapper to Hawaii, caused another notable increase in bottomfish landings (Itano 1996). Between 1982 and 1988, the bottomfish fishery made up as much as half of the total catch of the local commercial fishery. However, since 1988, the nature of American Samoa's fisheries have changed dramatically, with a shift in importance from bottomfish fishing to trolling and longlining for pelagic species (WPRFMC 1999b). Landings trends in the bottomfish fishery have also been periodically adversely impacted by hurricanes. The 1987 hurricane, in particular, damaged or destroyed a large segment of American Samoa's small-boat fishing fleet.

3.1.1.2 Catch in Numbers or Weight

Between 2004-2014, American Samoa BMUS catch averaged 20,906 lbs., with a high of 34,844 lbs. (2009) and a low of 9,727 lbs. (2010). During the same period, the average amount of BMUS catch that was sold was 87%. For the most recent catch amounts, refer to the most current Annual Archipelagic Fishery Ecosystem Report (SAFE Report).

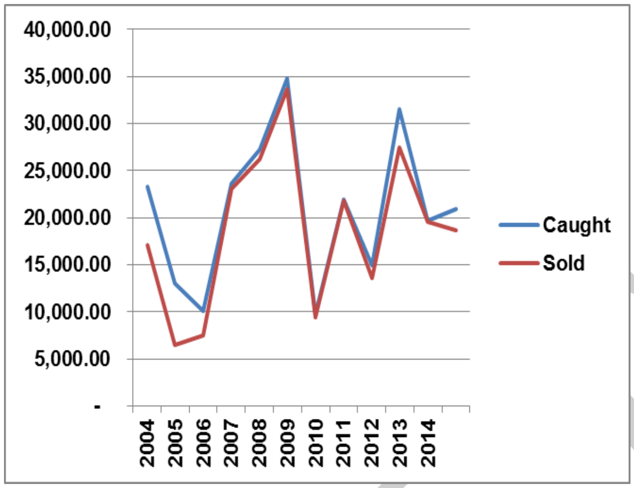

Figure 3. American Samoa bottomfish catch trends 2004-2014 (SOURCE: WPacFIN website - http://www.pifsc.noaa.gov/wpacfin/as/Pages/as_data_8.php. Accessed June 26, 2015).

3.1.1.3 Fishing Areas

Traditionally, villages retain ownership and responsibility of nearshore marine areas adjacent to their villages and use is administered through the village matai system. In general, marine resources in a village's nearshore marine area is restricted for use by the village residents. The American Samoa Government has implemented a village marine protected area VMPA system. The VMPA system enhances government support for enforcing the village rules and regulations.

3.1.1.4 Time of Fishing

Fishing is often conducted during daylight hours, with vessels presumed to return before or soon after sunset, although larger vessels have made multi-day trips.

3.1.1.5 Number of Hauls

The American Samoa bottomfish fishery does not use hauls; it is mostly a pole and reel fishery.

3.1.1.6 Economics

The ten-year average (2003-2013) for revenue across the fishery was $79,378, with a high of $211,166 (2009) and a low of $19,975 (2006). For the same time period, price per pound in the fishery averaged $3.11/lb., with a high of $3.42 (2005) and a low of $2.89 (2004). For current information regarding revenue of the fishery, price per pound, total direct employment, and fisheries-dependent services or industries, refer to the most current WPFMC Archipelagic Fishery Ecosystem Report (SAFE Report).

3.1.1.7 Estimated and Actual Processing Capacity Utilized by U.S. Processors

Bottomfish in American Samoa is sold fresh and whole, there are no processing or value added products from this fishery.

3.1.1.8 Present and Probable Future Condition of the Fishery

The constant 2-year catch projection scenarios for American Samoa bottomfish from 2016-2017 resulted in projected probabilities of overfishing, relative biomasses, and probabilities of being overfished. The 2016 catch level corresponding to a 50% risk of overfishing in 2016 (i.e., H>HMSY) was 137,000 pounds, which is over 5 times higher than recent average catch of 21,000 pounds from the past three years. For comparison, the 2016 catch that would lead to a risk of overfishing in 2016 was 108,000 pounds. If the recent average catch of 21,000 pounds was harvested in 2016 and 2017, the 2016 risk of overfishing is <1% and the 2017 risk of being overfished is <1% (Yau et. al, 2015).

3.1.1.9 Maximum Sustainable Yield

The MSY for the bottomfish fishery is estimated through stock assessments generated by the Pacific Island Fisheries Science Center. The assessments determine the status of the stock following the MSY control rule (described in Appendix E, which also specifies the relationship of F to B or other indicator of productive capacity under an MSY harvest policy.) The assessments are updated every three years (maximum) and benchmark assessment every six years (maximum) following the assessment schedule described in the Western Pacific Stock Assessment Review Policy.

For more information regarding the MSY reference points, refer to the current Annual Archipelagic Fishery Ecosystem Report (SAFE Report).

3.1.1.10 Optimum Yield

3.1.1.10.1 Optimum yield for American Samoa’s bottomfish fishery is defined as the amount of fish that will be caught by fishermen fishing in accordance with applicable fishery regulations in this plan, in the EEZ and adjacent waters around the archipelago. *Extent to Which Fishing Vessels will Harvest OY*

Domestic vessels do not have sufficient harvesting capacity to take the entire OY. Therefore, the domestic processing capacity and domestic processing levels will not equal or exceed the OY for the foreseeable future.

3.1.1.10.2 Extent to Which U.S. Fish Processors will Process OY

Bottomfish harvested in American Samoa are marketed as fresh whole product. Processing of bottomfish does not occur at sea or at the market level. Therefore, U.S. fish processors will not process bottomfish beyond OY.

3.1.1.11 Annual Catch Limit

3.1.1.11.1 Specification Mechanism

For the bottomfish fishery, specification of the acceptable biological catch and annual catch limits are required by the MSA and follows the mechanism described in Appendix E. The specification will be done on an annual basis by NMFS based on recommendations from the

Council.

3.1.1.11.2 Limit

For the most recent Annual Catch Limits, refer to the current Annual Archipelagic Fishery Ecosystem Report (SAFE Report).

3.1.1.11.3 Accountability Measures

Accountability measures are specified on an annual basis by NMFS based on recommendations by the Council. There currently is no near-real-time monitoring for bottomfish fisheries in the American Samoa. The specification of accountability measures will follow the process described in Appendix E.

3.1.1.12 Criteria for Determining Overfishing

Biological and other fishery data are poor for all bottomfish species in the American Samoa Archipelago. Generally, data are only available on commercial landings by species and catch-per-unit-effort (CPUE) for the multi-species complexes as a whole. At this time it is not possible to partition these effort measures among the various bottomfish MUS

Overfishing criteria and control rules are specified and applied to individual species within the multi-species stock whenever possible. When this is not possible, they are based on an indicator species for the multi-species stock. It is important to recognize that individual species would be affected differently based on this type of control rule, and it is important that for any given species fishing, mortality does not currently exceed a level that would result in excessive depletion of that species.

The MSY control rule is used as the maximum fishing mortality threshold (MFMT). The MFMT and minimum stock size threshold (MSST) are specified based on recommendations in Restrepo et al. (1998) and both are dependent on the natural mortality rate (M). The value of M used to determine the reference point values are not specified in this document. The latest estimate, published annually in the SAFE report, is used and the value is occasionally re-estimated using the best available information. The range of M among species within a stock complex is taken into consideration when estimating and choosing the M to be used for the purpose of computing the reference point values.

The American Samoa bottomfish fishery is not overfished and overfishing is not occurring.

3.1.1.13 MSA Conservation and Management Measures

This section describes the conservation and management measures to prevent overfishing and protect and promote the long-term health and sustainability of bottomfish resources of American Samoa. Appendix C contains the Code of Federal Regulations, Title 50, Part 665, Subpart G.

3.1.1.13.1 Management Areas, Sub-areas and Seasons

The American Samoa bottomfish fishery management area includes all U.S. EEZ waters seaward of the Territory of American Samoa. There are no bottomfish management sub-areas. The fishing year for American Samoa bottomfish begins on January 1 and ends December 31.

3.1.1.13.2 Permit and Reporting Requirements

[Reserved]. There is no Federal permit or reporting requirements for bottomfish fisheries in American Samoa at this time.

3.1.1.13.3 Annual Catch Limits and Accountability Measures

For the most recent Annual Catch Limits, refer to the current Annual Archipelagic Fishery Ecosystem Report (SAFE Report).

Accountability measures are specified on an annual basis by NMFS based on recommendations by the Council. There currently is no near-real-time monitoring for bottomfish fisheries in the American Samoa. The specification of accountability measures will follow the process described in Appendix E.

3.1.1.13.4 Gear Restrictions and Identification Requirements

The American Samoan bottomfish fishery is a hook and line fishery. The shallow and deepwater bottomfish fishing gear is essentially a hook and line where one or several hooks are attached to a mainline weighted with a sinker and lowered to a desired depth to target one or several species of grouper, snappers and emperors.

Fishing for bottomfish by means of bottom trawls and bottom set gillnets is prohibited. Possession or use of any poisons, explosives or intoxicating substances to harvest bottomfish is also prohibited.

3.1.1.13.5 At-Sea Observer Coverage

[Reserved]. Because there is no Federal permit requirement for bottomfish fisheries in American Samoa, there is no associated requirement to carry at-sea-observers at this time.

3.1.1.13.6 Marine Protected Areas

Rose Atoll in American Samoa is a designated marine protected area (MPA) with an outer boundary at the 50-fm isobath. It is a no-take MPA in which all extractive activities are prohibited except for small harvests related to scientific research and related resource management. Additionally, Rose Atoll and adjacent marine waters out to a distance of approximately 50 nm are also designated as a Marine National Monument jointly managed by the U.S. Fish and Wildlife Service.

3.1.1.13.7 Temporary Adjustments to Fishery Access

Due to the nature of the bottomfish fishery and associated regulations, the Council has not established temporary adjustments to existing FEP conservation and management measures that facilitate access to the fishery to vessels that otherwise would be preventing from harvesting because of weather or other ocean conditions affecting the safe conduct of the fishery. To the extent that temporary adjustments may be necessary in the future, the Council will consult with the US Coast Guard, fishery participants and the public in the development of temporary adjustments and will ensure that such measures will not adversely affect conservation efforts in other fisheries or discriminate among participants in the affected fishery.

3.1.1.13.8 Fishing Moratorium

[Reserved]. There is no fishing moratorium for any bottomfish management unit species in American Samoa at this time.

3.1.1.13.9 Bycatch Mitigation Measures

A variety of operational and management measures are used to minimize bycatch and bycatch mortality in the bottomfish fishery around American Samoa. Gear types and fishing strategies used tend to be relatively selective for desired species and sizes. Measures that serve to further reduce bycatch in the bottomfish fishery include prohibitions on the use of bottom trawls, bottom gillnets, explosives, and poisons.

Five types of non-regulatory measures aimed at reducing bycatch and bycatch mortality, and improving bycatch reporting are being implemented. They include: 1) outreach to fishermen and engagement of fishermen in management, including research and monitoring activities, to increase awareness of bycatch issues and to aid in development of bycatch reduction methods; 2) research into fishing gear and method modifications to reduce bycatch quantity and mortality; 3) research into the development of markets for discard species; and 4) improvement of data collection and analysis systems to better quantify bycatch, and 5) outreach and training of fishermen in methods to reduce baraotrauma in fish that are to be released.

3.1.1.14 Regulations implementing International Recommendations and other Applicable Laws

The South Pacific Regional Fisheries Management Organization (SPRFMO) is an inter-governmental organization committed to the long-term conservation and sustainable use of the fishery resources of the South Pacific Ocean, safeguarding marine ecosystems in which the resources occur. The SPRFMO Convention applies to the high seas of the South Pacific. The main commercial resources managed by the SPRFMO are jack mackerel and jumbo flying squid in the Southwest Pacific and, to a lesser degree, deep-sea species associated with seamounts in the Southeast Pacific. SPRFMO is negotiating to regulate deep-sea fisheries; a temporary prohibition on the expansion of bottom fishing in the South Pacific into new high seas areas; the closure of some 40% of the area previously bottom trawled by New Zealand's orange roughy fleets on the high seas; and a ban on bottom gillnet fishing.

3.1.1.15 Bycatch Amount and Type

Bottomfishing bycatch is obtained directly from bottomfishing interviews where bycatch was voluntarily reported. It is an unexpanded number. In general, bottomfishing results in minimal bycatch. Interactions with protected species are also believed to be minimal. To date, there have been no reported or observed interactions between protected species and bottomfish fisheries in Federal waters around the American Samoa and the potential for interactions is believed to be low due to the gear types and fishing methods.

Not applicable, information on the amount and types of bycatch or interactions with protected species anecdotal. For the most bycatch numbers, see the most current Annual Archipelagic Fishery Ecosystem Report (SAFE Report).

3.1.1.16 Bottomfish Essential Fish Habitat

Except for several of the major commercial species, very little is known about the life histories, habitat utilization patterns, food habits, or spawning behavior of most adult bottomfish and seamount groundfish species. Furthermore, very little is known about the distribution and habitat requirements of juvenile bottomfish.

Generally, the distribution of adult bottomfish in the Samoan Archipelago is closely linked to suitable physical habitat. Unlike the U.S. mainland with its continental shelf ecosystems, Pacific islands are primarily volcanic peaks with steep drop-offs and limited shelf ecosystems. The BMUS under the Council's jurisdiction are found concentrated on the steep slopes of deepwater banks. The 100-fathom isobath is commonly used as an index of bottomfish habitat. Adult bottomfish are usually found in habitats characterized by a hard substrate of high structural complexity. The total extent and geographic distribution of the preferred habitat of bottomfish is not well known. Bottomfish populations are not evenly distributed within their natural habitat; instead, they are found dispersed in a non-random, patchy fashion. Deepwater snappers tend to aggregate in association with prominent underwater features, such as headlands and promontories.

There is regional variation in species composition, as well as a relative abundance of the MUS of the deepwater bottomfish complex in the Western Pacific Region. In American Samoa, the bottomfish fishery can be divided into two distinct fisheries: a shallow- and a deep-water bottomfish fishery, based on species and depth. The shallow-water (0–100 m) bottomfish complex comprises groupers, snappers, and jacks in the genera *Lethrinus*, *Lutjanus*, *Epinephelus*, *Aprion*, *Caranx*, *Variola*, and *Cephalopholis*. The deep-water (100–400 m) bottomfish complex comprises primarily snappers and groupers in the genera *Pristipomoides*, *Etelis*, *Aphareus*, *Epinephelus*, and *Cephalopholis*.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for bottomfish assemblages pursuant to Section 600.805(b) of 62 FR 66551. The species complex designations include deep-slope bottomfish (shallow water and deep water). The designation of these complexes is based on the ecological relationships among species and their preferred habitat. These species complexes are grouped by the known depth distributions of individual BMUS throughout the Western Pacific Region.

3.1.1.17 Description and Identification of EFH

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 data. Given the uncertainty concerning the life histories and habitat requirements of many BMUS, the Council designated EFH for adult and juvenile bottomfish as the water column and all bottom habitat extending from the shoreline to a depth of 400 meters (200 fathoms) encompassing the steep drop-offs and high-relief habitats that are important for bottomfish throughout the Western Pacific Region.

The eggs and larvae of all BMUS are pelagic, floating at the surface until hatching and subject thereafter to advection by the prevailing ocean currents. There have been few taxonomic studies of these life stages of snappers (lutjanids) and groupers (epinepheline serranids). Presently, few larvae can be identified to species. As snapper and grouper larvae are rarely collected in plankton surveys, it is extremely difficult to study their distribution. Because of the existing scientific uncertainty about the distribution of the eggs and larvae of bottomfish, the Council designated the water column extending from the shoreline to the outer boundary of the EEZ to a depth of 400 meters as EFH for bottomfish eggs and larvae throughout the Western Pacific Region.

3.1.1.17.1 Identification of Habitat Areas of Particular Concern

On the basis of the known distribution and habitat requirements of adult bottomfish, the Council designated all escarpments/slopes between 40–280 meters as HAPC. The basis for this designation is the ecological function that these areas provide, the rarity of the habitat, and the susceptibility of these areas to human-induced environmental degradation.
The discovery of concentrations of juvenile snappers in relatively shallow water and featureless bottom habitat in Hawai‘i indicates the need for more research to help identify, map, and study nursery habitat for juvenile snapper in the Samoan Archipelago.

3.1.2 Coral Reef Fishery

Table 2: American Samoan Archipelago Coral Reef Ecosystem Management Unit Species, (Currently Harvested Coral Reef Taxa)[8]

[8] Samoan names provided by F. Aitoato. The extensive use of the hyphen mark in Samoan names reflects the general use of descriptive names where the word after the hyphen is usually a description of the color(s) or other characteristics. A single species/group sometimes has more than one Samoan name depending on the color(s) and size (pers. comm. Chief Mauala P. Seiuli). In several cases, one Samoan name has been traditionally used for several species/groups. Different islands of the Samoa group sometimes have different

Family Name	Scientific Name	English Common Name	Samoan Name
Acanthuridae (Surgeonfishes) [pone = general name for *Acanthurus spp*]	*Acanthurus olivaceus*	orange-spot surgeonfish	Afinamea
	Acanthurus xanthopterus	yellowfin surgeonfish	**
	Acanthurus triostegus	convict tang	Aanini
	Acanthurus dussumieri	eye-striped surgeonfish	**
	Acanthurus nigroris	blue-lined surgeon	Ponepone, gaitolama
	Acanthurus lineatus	blue-banded surgeonfish	Alogo
	Acanthurus nigricauda	blackstreak surgeonfish	pone-i'usama
	Acanthurus nigricans	whitecheek surgeonfish	laulama,
	Acanthurus guttatus	white-spotted surgeonfish	Maogo
	Acanthurus blochii	ringtail surgeonfish	**
	Acanthurus nigrofuscus	brown surgeonfish	Ponepone
	Acanthurus mata	elongate surgeonfish	**
	Acanthurus pyroferus	mimic surgeonfish	**
	Ctenochaetus strigosus [Pone=genral name for Ctenochaetus]	yellow-eyed surgeonfish	Pone
	Ctenochaetus striatus	striped bristletooth	pone, pala'ia, logoulia
	Ctenochaetus binotatus	twospot bristletooth	**
	Naso unicornus [ume = general name for *Naso spp.]*	bluespine unicornfish	ume-isu
	Naso lituratus	orangespine unicornfish	ili'ilia, umelei
	Naso hexacanthus	black tongue unicornfish	**
	Naso vlamingii	bignose unicornfish	ume-masimasi
	Naso annulatus	whitemargin unicornfish	**
	Naso brevirostris	spotted unicornfish	ume-ulutao
	Naso thynnoides	barred unincornfish	**
Balistidae (Triggerfishes) [sumu = general name for triggerfishes**]**	*Balistoides viridescens*	titan triggerfish	sumu, sumu-laulau
	Balistapus undulatus	orangstriped triggerfish	**
	Melichthys vidua	pinktail triggerfish	sumu-'apa'apasina, sumu-si'umumu
	Melichthys niger	black triggerfish	sumu-uli
	Pseudobalistes fuscus	blue Triggerfish	sumu-laulau

names for a single local species/groups, hence the attempt to include all known Samoan names from all the islands of the Samoa group.

Family Name	Scientific Name	English Common Name	Samoan Name
	Rhinecanthus aculeatus	Picassofish	sumu-uo’uo, sumu-aloalo
	Sufflamen fraenatum	bridled triggerfish	sumu-gase’ele’ele
	Selar crumenophthalmus	bigeye scad	Atule
	Decapterus macarellus	mackerel scad	atuleau, namuauli
Carcharhinidae (Sharks) [malie = general name for sharks]	*Carcharhinus amblyrhynchos*	grey reef shark	malie-aloalo
	Carcharhinus albimarginatus	silvertip shark	aso
	Carcharhinus galapagensis	galapagos shark	malie
	Carcharhinus melanopterus	blacktip reef shark	apeape, malie-alamata
	Triaenodon obesus	whitetip reef shark	malu
Holocentridae (Soldierfish/Squir-relfish [malau = general name for squirrelfishes]	*Myripristis berndti*	bigscale soldierfish	malau-ugatele, malau-va’ava’a
	Myripristis adusta	bronze soldierfish	malau-tui
	Myripristis murdjan	blotcheye soldierfish	**
	Myripristis amaena	brick soldierfish	**
	Myripristis pralinia	scarlet soldierfish	malau-mamo, malau-va’ava’a.
	Myripristis violacea	violet soldierfish	malau-tuauli
	Myripristis vittata	whitetip soldierfish	**
	Myripristis chryseres	yellowfin soldierfish	**
	Myripristis kuntee	pearly soldierfish	malau-pu’u
	Myripristis hexagona	double tooth squirrelfish	**
	Sargocentron melanospilos	blackspot squirrelfish	**
	Sargocentron microstoma	file-lined squirrelfish	malau-tianiu
	Sargocentron tiereoides	pink squirrelfish	**
Holocentridae (Soldierfish/Squirrelfish [malau = general name for squirrelfishes]	*Sargocentron diadema*	crown squirrelfish	malau-tui, malau-talapu’u, malau-tusitusi, malau-pauli.
	Sargocentron punctatissimum	peppered squirrelfish	**
	Sargocentron tiere	blue-lined squirrelfish	**
	Sargocentron spiniferum	Saber or Long jaw squirrelfish	tamalu, mu-malau, malau-toa
	Neoniphon spp.	spotfin squirrelfish	**
Kuhliidae (Flagtails)	*Kuhlia mugil*	barred flag-tail	safole, inato
Kyphosidae	*Kyphosus cinerascens*	Rudderfish	nanue, mata-mutu,

Family Name	**Scientific Name**	**English Common Name**	**Samoan Name**
(Rudderfish)	*Kyphosus biggibus*		mutumutu.
	Kyphosus vaigienses	Rudderfish	nanue
Labridae (Wrasses) [sugale = general name for wrasses]	*Cheilinus undulatus*	napoleon wrasse	lalafi, tagafa. malakea
	Cheilinus trilobatus	triple-tail wrasse	lalafi-matamumu
	Cheilinus chlorourus	floral wrasse	lalafi-matapua'a
	Cheilinus fasciatus	harlequin tuskfish	lalafi-pulepule
	Oxycheilinus diagrammus	bandcheek wrasse	sugale
	Oxycheilinus arenatus	arenatus wrasse	sugale
	Xyrichtys aneitensis	whitepatch wrasse	sugale-tatanu
	Cheilio inermis	cigar wrasse	sugale-mo'o
	Hemigymnus melapterus	blackeye thicklip	sugale-laugutu, sugale-uli, sugale-aloa, sugale-lupe.
	Hemigymnus fasciatus	barred thicklip	sugale-gutumafia
	Halichoeres trimaculatus	three-spot wrasse	lape, sugale-pagota
	Halichoeres hortulanus	checkerboard wrasse	sugale-a'au, sugale-pagota, ifigi
Labridae (Wrasses) [sugale = general name for wrasses]	*Halichoeres margaritaceus*	weedy surge wrasse	sugale-uluvela
	Thalassoma purpureum	surge wrasse	uloulo-gatala, patagaloa
	Thalassoma quinquevittatum	red ribbon wrasse	lape-moana
	Thalassoma lutescens	sunset wrasse	sugale-samasama
	Novaculichthys taeniourus	rockmover wrasse	sugale-la'o, sugale-taili, sugale-gasufi.
Mullidae (Goatfishes)	*Mulloidichthys spp.*	yellow goatfish	i'asina, vete, afulu
	Mulloidichthys vanicolensis	yellowfin goatfish	Vete
	Mulloidichthys flaviolineatus	yellowstripe goatfish	afolu, afulu
	Parupeneus spp	banded goatfish	afoul, afulu
	Parupeneus barberinus	dash-dot goatfish	tusia, tulausaena, ta'uleia
	Parupeneus bifasciatus	doublebar goatfish	matulau-moana
	Parupeneus heptacanthus	redspot goatfish	moana-ula
	Parupeneus cyclostomas	yellowsaddle goatfish	i'asina, vete, afulu, moana
	Parupeneus pleurostigma	side-spot goatfish	matulau-ilamutu
	Parupeneus multifaciatus	multi-barred goatfish	i'asina, vete, afulu

Family Name	**Scientific Name**	**English Common Name**	**Samoan Name**
Mugilidae (Mullets) [anae = general name for mullets]	*Crenimugil crenilabis*	fringelip mullet	anae, aua. Fuafua
	Neomyxus leuciscus	false mullet	moi, poi
Muraenidae (Moray eels)	*Gymnothorax flavimarginatus*	yellowmargin moray eel	Pusi
	Gymnothorax javanicus	giant moray eel	maoa'e
	Gymnothorax undulatus	undulated moray eel	pusi-pulepule
Octopodidae (Octopus)	*Octopus cyanea*	Octopus	fe'e
	Octopus ornatus	Octopus	fe'e
Polynemidae	*Polydactylus sexfilis*	Threadfin	umiumia, i'ausi
Pricanthidae (Bigeye) [matapula = general name for Priacanthus]	*Heteropriacanthus cruentatus*	Glasseye	matapula
	Priacanthus hamrur	Bigeye	matapula
Scaridae (Parrotfishes) [fuga = general name for parrotfishes]	*Calotomus carolinus*	stareye parrotfish	fuga
	Scarus spp.	Parrotfish	fuga, galo-uluto'I, fuga-valea, laea-mamanu
	Hipposcarus longiceps	pacific longnose parrotfish	ulapokea, laea-ulapokea
Scombridae	*Gymnosarda unicolor*	dogtooth tuna	tagi
Siganidae (Rabbitfish)	*Siganus aregenteus*	forktail rabbitfish	loloa, lo
Sphyraenidae (Barracuda)	*Sphyraena helleri*	heller's barracuda	sapatu
	Sphyraena barracuda	great Barracuda	saosao
Turbinidae (turban shells/green snails	*Turbo spp.*	green snails	alili

3.1.2.1 Description (commercial, charter, recreational)

Coral reef species harvest methods in American Samoa involve gleaning, spearfishing (snorkel or free dive from shore or using boat), rod and reel using nylon lines and metal hooks, bamboo pole, throw nets and gillnets. SCUBA spearfishing was introduced in 1994 and resulted in a sharp increase is the take of certain species. Consequently, the use of SCUBA while spearfishing was restricted to indigenous American Samoans in the late 1990s. It was banned altogether in

2002 following a recommendation from the Department of Marine and Wildlife Resources and local scientists. A majority of coral reef MUS catch is believed to come from Territorial waters. There are some reef areas in federal waters that are fished, though current reporting systems do not allow managers to parse out catch by federal vs. Territorial waters. However, the ecosystem-based fishery management approach suggests the consideration of inshore fisheries and stocks as they interrelate with those in Federal waters. Tourism-based charter fishery is very limited in American Samoa and is often focused on pelagic species. Recreational fishing is also limited and is not characteristic of Pacific Island practices. Non-commercial fisheries involve subsistence (personal consumption), traditional/cultural (communal fishing to share with communities), weekend sportfishing some of which the catch are shared with the community or taken home to families.

There are traditional fisheries associated with seasonal run of certain species like atule (Selar crumenophthalmus – big eye scad), juvenile surgeonfish and goatfish, and notably *palolo* worms. Palolo usually appear in American Samoa waters in October. They are also known to appear in November, as well as during both months. Swarming occurs for two or three consecutive nights with the second night usually having the strongest showing. Samoans eagerly await this night and scoop up large amounts of this local delicacy along the shoreline with hand nets

3.1.2.2 Type and Quantity of Fishing Gear

In American Samoa, coral reef fishes and invertebrates are harvested in subsistence and small-scale commercial fisheries by various gear types, including hook and line, spear gun, gillnets, as well as gleaning, cast nets, bamboo poles, scoop nets.

3.1.2.3 Catch in Numbers or Weight

The reef fish catch composition in American Samoa is dominated (90% of total catch) by eleven families based on average catch data from 2004 to 2014: Acanthuridae (15%), Lutjanidae (13%), miscellaneous bottomfish (11%), Scaridae (9%), mollusk (9%), Lethrinidae (9%), Carangidae (6 percent), Selar crumenophthalmus (6 %), Serranidae (5 %), other coral reef MUS (4%), and coral reef crustacean (4%) (WPRFMC unpublished report).

Between 2004 and 2014, the mean annual total coral reef fisheries landing in American Samoa was 81,286 pounds (WPRFMC unpublished report). In general, majority of the coral reef MUS landings are below the long term average due to a variety of reasons: fishing effort decreased (Sabater and Carroll 2008), pollution, sedimentation, habitat degradation (cite the state of the reef reports), possible underreporting (Zeller et al. 2007) etc. The mean commercial landing was 41,369 pounds between 2004 and 2014 (cite WPacFIN data page) indicating that less than half of the total landings are non-commercial There is little to no recreational fisheries in American Samoa.

3.1.2.4 Fishing Areas

Most coral reef species and habitat in American Samoa occur within 3 nm (Figure 4), with some exceptions. The coral reef habitat for most of the islands in the American Samoan archipelago are characterized with a narrow reef flat and a steep reef slope continuing to the continental shelf. There are deep off shore banks but most are still within 3 nm.

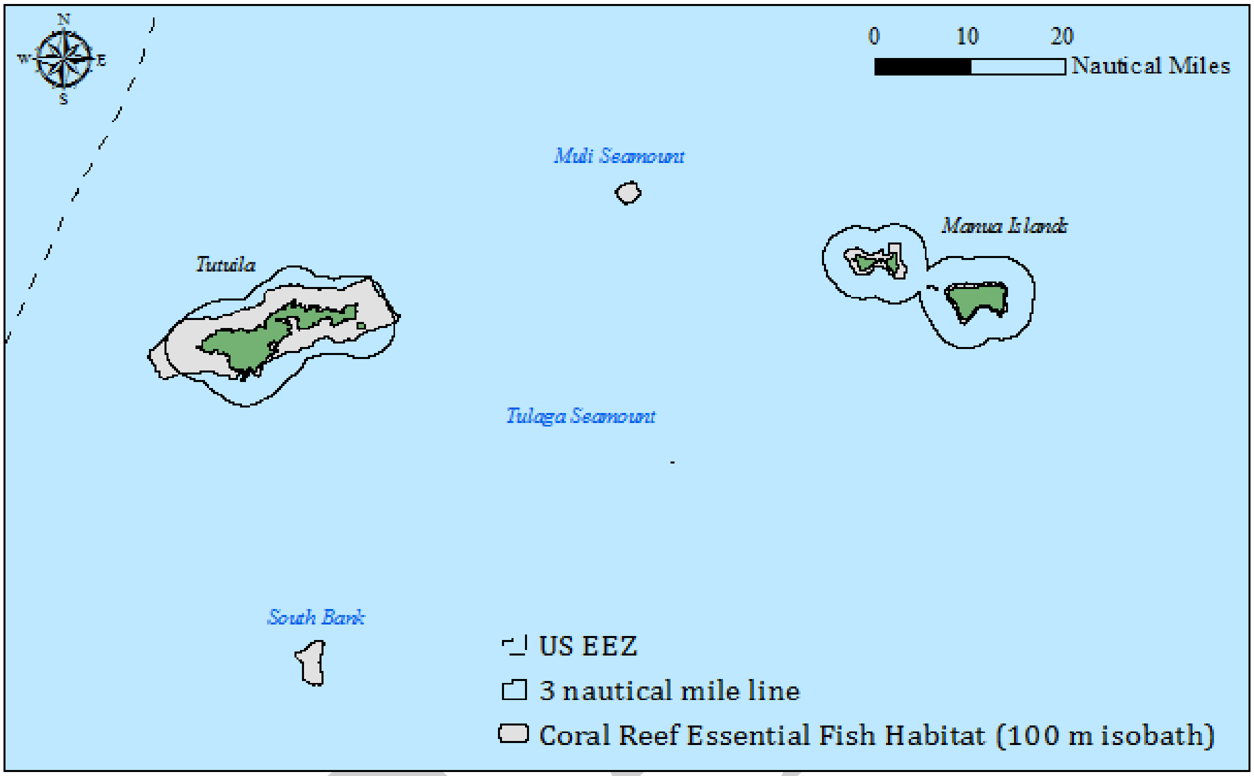

Figure 4. Occurrence of Coral Reef Habitat within Federal Waters.

3.1.2.5 Time of Fishing

The majority of the coral reef fishing in American Samoa is conducted during the day time – particularly the hook-and-line and net fishery. Boat-based spearfishing is commonly a night fishery but shore-based spearfishing can occur both at day and night. Trolling occurs mostly during daytime. Gleaning for invertebrates and hunting for octopus occurs during daytime and only at low tide.

3.1.2.6 Economics

The 2004-2014 average for revenue across the fishery (families: Acanthuridae; Balistidae; Carangidae; Holocentridae; Kyphosidae; Labridae; Lethrinidae; Lutjanidae; Mollusk; Muglidae; Mullidae; Scaridae; Serranidae; Siganidae) was $38,740, with a high of $74,683 (2014) and a low of $14,305 (2004). For current information regarding revenue of the fishery, price per pound, total direct employment, and fisheries-dependent services or industries, refer to the current WPFMC Archipelagic Fishery Ecosystem Report (SAFE Report).

3.1.2.7 Estimated and Actual Processing Capacity Utilized by U.S. Processors

There is no processing of coral reef fish products in American Samoa. Products are sold as whole fresh fish on small fish retail outlets or through fish trailer vans along the roadside.

3.1.2.8 Present and Probable Future Condition of the Fishery

Currently the fishery is experiencing low participation and most fish retailers rely on imports from the neighboring Samoa to fill in the demand for fish (Sabater and Carroll 2008). Several attempts to revitalize the fishery through fishery development programs are underway but have yet to show any progress. Catches are low relative to the established catch limits, which indicate there is room for increase in fishing participation.

3.1.2.9 Maximum Sustainable Yield

The Maximum Sustainable Yield for the fishery is estimated through stock assessments generated by the Pacific Island Fisheries Science Center. The assessments determine the status of the stock following the MSY control rule (described in Appendix E, which also specifies the relationship of F to B or other indicator of productive capacity under an MSY harvest policy.) The assessments are updated every three years (maximum) and benchmark assessment every six years (maximum) following the assessment schedule described in the Western Pacific Stock Assessment Review Policy. However, due to the data-limited nature of the coral reef fishery, the current MSY control rules and reference point proxies described in Section 3.1.2.1.13 below cannot be applied to the hundreds of species in the coral reef management unit species list.

For ACL specification purposes, Maximum Sustainable Yield in the coral reef fisheries are determined by using the Biomass-Augmented Catch-MSY approach (Sabater and Kleiber 2014). This method estimates MSY using plausible combination rates of population increase (denoted by r) and carrying capacity (denoted by k) assumed from the catch time series, resilience characteristics (from FishBase), and biomass from existing underwater census surveys done by the Pacific Island Fisheries Science Center. This method was applied to species complexes grouped by taxonomic families. For more information regarding the MSY reference points, refer to the current Annual Archipelagic Fishery Ecosystem Report (SAFE Report).

3.1.2.10 Optimum Yield

3.1.2.10.1 The MSA defines OY as "the amount of fish that 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 as prescribed on the basis of the MSY from the fishery, as reduced by any relevant economic, social, or ecological factor." National Standard 1 guidelines define OY as "is a long-term average amount of desired yield from a stock, stock complex, or fishery after economic, social or ecological factors are considered." OY for coral reef ecosystem associated species is defined as 75 percent of their MSY.Extent to Which Fishing Vessels will Harvest OY

Fishing participation is monitored through the Annual Archipelagic Fishery Ecosystem Report (SAFE Report). Once OY has been calculated, the total number of fishing participants is extrapolated to determine the extent that fishing participants can potentially harvest OY.

3.1.2.10.2 Extent to Which U.S. Fish Processors will Process OY

Coral reef fishes are not typically processed (filleted, etc.). Reef fish are sold fresh whole by retailers or directly to consumers by fishermen in person-to-person transactions or along the roadside.

3.1.2.11 Annual Catch Limit

3.1.2.11.1 Specification Mechanism

For the coral reef fishery, specification of the acceptable biological catch and annual catch limits are required by the MSA and follows the mechanism described in Appendix E. The specification is conducted on an annual basis by NMFS based on recommendations from the Council.

3.1.2.11.2 Limit

For the most recent coral reef fishery taxonomic family Annual Catch Limits, refer to the most current Annual Archipelagic Fishery Ecosystem Report (SAFE Report)

3.1.2.11.3 Accountability Measures

Accountability measures are specified on an annual basis by NMFS based on recommendations by the Council. There currently is no near-real-time monitoring for coral reef fisheries in American Samoa. The specification of accountability measures will follow the process described in Appendix E.

3.1.2.12 Criteria for Determining Overfishing

<u>MSY Control Rule and Stock Status Determination</u>
Available biological and fishery data are poor for all coral reef ecosystem management unit species in the Mariana Islands. There is scant information on the life histories, ecosystem dynamics, fishery impact, community structure changes, yield potential, and management reference points for many coral reef ecosystem species. Additionally, total fishing effort cannot be adequately partitioned between the various management unit species (MUS) for any fishery or area. Biomass, maximum sustainable yield, and fishing mortality estimates are not available for any single MUS. Once these data are available, fishery managers can establish limits and reference points based on the multi-species coral reef ecosystem as a whole.

When possible, the MSY control rule is applied to the individual species in a multi-species stock. When this is not possible, MSY may be specified for one or more species; these values can then be used as indicators for the multi-species stock's MSY.

Clearly, any given species that is part of a multi-species complex will respond differently to an OY-determined level of fishing effort (F_{OY}). Thus, for a species complex that is fished at F_{OY}, managers still must track individual species' mortality rates in order to prevent species-specific population declines that would lead to their becoming depleted.

Individual species that are part of a multi-species complex will respond differently to an OY-determined level of fishing effort (F_{OY}). Thus, for a species complex that is fished at F_{OY}, managers still must track individual species' mortality rates in order to prevent species-specific population declines that would lead to depletion.

For the coral reef fishery, the multi-species complex as a whole is used to establish limits and reference points for each area. When possible, available data for a particular species are used to evaluate the status of individual MUS stocks in order to prevent recruitment overfishing. When better data and the appropriate multi-species stock assessment methodologies become available, all stocks will be evaluated independently, without proxy.

Establishing Reference Point Values

Standardized values of catch per unit effort (CPUE) and effort (E) are used to establish limit and reference point values, which act as proxies for relative biomass and fishing mortality, respectively. Limits and reference points are calculated in terms of $CPUE_{MSY}$ and E_{MSY} included in Table 3.

Table 3. CPUE-based Overfishing Limits and Reference Points for Coral Reef Species.

Value	**Proxy**	**Explanation**
MaxFMT (F_{MSY})	E_{MSY}	0.91 $CPUE_{MSY}$
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)
MinSST	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*

When estimates of E_{MSY} and $CPUE_{MSY}$ are not reliable, they are generated from time series of catch and effort values, standardized for all identifiable biases using the best available analytical tools. $CPUE_{MSY}$ is calculated as one-half a multi-year moving average reference CPUE ($CPUE_{REF}$).

3.1.2.13 MSA Conservation and Management Measures

Below are several important conservation and management measures for this fishery. Federal regulations governing this fishery can be found in the Code of Federal Regulations, Title 50, Part 665, Subpart G and Appendix C. Contact the Council or the National Marine Fisheries Service Pacific Islands Regional Office for and the fishery compliance guides (www.pir.noaa.gov).

Marine Protected Areas (MPAs)

Rose Atoll in American Samoa is a designated MPA with an outer boundary at the 50-fm isobath. In addition, it is a no-take MPA 0 to 12 miles, in which all extractive activities are prohibited except for small harvests related to scientific research and related resource management.

Permits and Reporting Requirements
Any person who harvests coral reef ecosystem MUS in a low-use MPA is required to have a Federal special permit issued by NMFS. Issuance of special permits is on a case-by-case basis and based upon several factors including the potential for bycatch, the sensitivity of the area to the type of fishing proposed, and the level of fishing occurring in relation to the level considered sustainable in a low-use MPA. A person permitted and targeting non-CRE MUS under other fishery management plans is not required to obtain a special permit to fish in low-use MPAs. In addition to the permit requirement for low-use MPAs, special permits are required for any directed fisheries on potentially harvested coral reef taxa (PHCRT) within the regulatory area or to fish for any CRE MUS in the coral reef regulatory area with any gear not normally permitted. Those issued a Federal permit to fish for non-CRE MUS, but who incidentally catch CRE MUS are exempt from the CRE permit requirement. Those fishing for currently harvested coral reef taxa (CHCRT) outside of an MPA and who do not retain any incidentally-caught PHCRT, or any person collecting marine organisms for scientific research are also exempt from the CRE permit requirement. Permits are only valid for fishing in the fishery management subarea specified on the permit.

The harvest of live rock and living corals is prohibited throughout the federally managed U.S. EEZ waters of the region; however, under special permits with conditions specified by NMFS following consultation with the Council, indigenous people could be allowed to harvest live rock or coral for traditional uses, and aquaculture operations could be permitted to harvest seed stock. Resource monitoring systems administered by state, territorial, and commonwealth agencies continue to collect fishery data on the existing coral reef fisheries that do not require special permits. Fishery participants have the option of using NMFS approved electronic logbooks in lieu of paper logbooks.

Notification
Any special permit holder must contact the appropriate NMFS enforcement agent in American Samoa at least 24 hours before landing any CRE MUS harvested under a special permit, and report the port and the approximate date and time at which the catch will be landed.

Gear Restrictions
Allowable gear types include: (1) Hand harvest; (2) spear; (3) slurp gun; (4) hand/dip net; (5) hoop net; (6) throw net; (7) barrier net; (8) surround/purse net that is attended at all times; (9) hook-and-line (powered and unpowered handlines, rod and reel, and trolling); (10) crab and fish traps with vessel ID number affixed; and (11) remote operating vehicles/submersibles. New fishing gears that are not included in the allowable gear list may be allowed under the special permit provision. CRE MUS may not be taken by means of poisons, explosives, or intoxicating substances. Possession and use of these materials is prohibited. All fish and crab trap gear used

by permit holders must be identified with the vessel number. Unmarked traps and unattended surround nets or bait seine nets found deployed will be considered unclaimed property and may be disposed of by NMFS or other authorized officers.

Framework Procedures
A framework process, providing for an administratively simplified procedure to facilitate adjustments to management measures previously analyzed in the CRE FMP, is an important component of the FEP. These framework measures include designating “no-anchoring” zones and establishing mooring buoys, requiring vessel monitoring systems on board fishing vessels, designating areas for the sole use of indigenous peoples, and moving species from the PHCRT to the CHCRT list when sufficient data has been collected. A general fishing permit program could also be established for all U.S. EEZ coral reef ecosystem fisheries under the framework process.

Other Actions
There are other non-regulatory measures consistent with plan objectives that are being undertaken by the Council outside of the regulatory regime. These include a process and criteria for EFH consultations; formal plan team coordination to identify and to address coral reef ecosystem impacts from existing fisheries; a system to facilitate consistent state and territorial level management; and research and education efforts.

No bycatch measures or actions are necessary at this time

3.1.2.14 Bycatch

Almost all coral reef fishes caught in American Samoa are considered food fishes and are kept, regardless of size or species. There is no specific information available on bycatch from coral reef fisheries, particularly inshore fisheries. Bycatch measures include a series of no-take marine protected areas established in the CRE FMP and carried forward in this FEP (see Section 5.6.1) that apply to all Council managed fisheries. In addition CRE MUS may not be taken by means of poisons, explosives, or intoxicating substances, and further, possession and use of these materials is prohibited. These restrictions further reduce the potential for bycatch in this fishery. In addition, any fishing vessel (commercial or non-commercial) operating in the territorial seas or EEZ of the U.S. in a fishery identified through NMFS’ annual determination process must carry an observer when directed to do so.

3.1.2.15 Coral Reef Essential Fish Habitat

In designating EFH for Coral Reef Ecosystem MUS, MUS are linked to specific habitat “composites” (e.g., sand, live coral, seagrass beds, mangrove, open ocean) for each life history stage, consistent with the depth of the ecosystem to 50 fathoms and to the limit of the EEZ.

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, through the CRE-FMP, designated EFH using a two-tiered approach based on the division of MUS into the Currently Harvested Coral Reef Taxa

(CHCRT) and Potentially Harvested Coral Reef Taxa (PHCRT) categories. This is also consistent with the use of habitat composites.

3.1.2.15.1 Description and Identification of EFH for Currently Harvested Coral Reef Taxa

In the first tier, EFH has been identified for species that (a) are currently being harvested in state and federal waters and for which some fishery information is available and (b) are likely to be targeted in the near future based on historical catch data.

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 50 CFR 600.815 (a)(2)(ii)(E). The designation of these complexes is based on the ecological relationships among species and their preferred habitat. These species complexes are grouped by the known depth distributions of individual MUS. The textual EFH designations for CHCRT throughout the Western Pacific Region are found in Table 4.

3.1.2.15.2 Description and Identification of EFH for Potentially Harvested Coral Reef Taxa

EFH has also been designated for the second tier, PHCRT. These taxa include literally thousands of species encompassing almost all coral reef fauna and flora. However, there is very little scientific knowledge about the life histories and habitat requirements of the thousands of species of organisms that compose these taxa. In fact, a large percentage of these biota have not been described by science. Therefore, the Council has used the precautionary approach in designating EFH for PHCRT so that enough habitat is protected to sustain managed species.

EFH for all life stages of Potentially Harvested Coral Reef Taxa is designated as the water column and bottom habitat from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms (Table 4). As with CHCRT, the Council has designated EFH for species assemblages pursuant to the federal regulations cited above.

Table 4. EFH Designations for Coral Reef Taxa.

Species Assemblage/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.
Carangidae	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.
Carcharhinidae	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.
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.	
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.

Species Assemblage/Complex	**EFH (Egg and Larvae)**	**EFH (Adult and Juvenile)**
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.
Muraenidae	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.
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
Siganidae	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.
Scombridae	EFH for all life stages of dogtooth tuna is designated as the water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.	
Sphyraenidae	EFH for all life stages in the family Sphyraenidae is designated as the water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.	
Turbinidae	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.

Species Assemblage/Complex	**EFH (Egg and Larvae)**	**EFH (Adult and Juvenile)**
All Potentially Harvested Coral Reef Taxa	EFH for all life stages of Potentially Harvested Coral Reef Taxa is designated as the water column and bottom habitat from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.	

3.1.2.15.3 Identification of Habitat Areas of Particular Concern

Because of the already-noted lack of scientific data, the Council considered locations that are known to support populations of Coral Reef Ecosystem MUS and meet NMFS criteria for HAPC. Although not one of the criteria established by NMFS, the Council considered designating areas that are already protected—for example, wildlife refuges—as HAPC because such areas have been singled out for their ecological values during their designation as a protected area, and therefore would likely meet the HAPC criteria as well. The Coral Reef Ecosystem MUS HAPCs identified in Table 5 have met at least one of the four criteria listed above, or the fifth criterion just identified (i.e., protected areas). However, a great deal of life history work needs to be done in order to adequately identify the extent of HAPCs and link them to particular species or life stages. Nine coral reef ecosystem HAPCs have been designated in American Samoa (Table 5).

Table 5. American Samoa Coral Reef Ecosystem HAPC.

	Rarity of Habitat	Ecological function	Susceptibility to Human Impact	Likelihood of Developmental Impacts	Existing Protective Status
American Samoa					
Fagatele Bay	x	x			x
Larsen Bay		x	X	x	
Steps Point		x	X		
Pago Pago (North Coast of Tutuila), National Park of American Samoa	x	x	X		x
Aunuu Island	x	x	X	x	
Rose Atoll	x	x			x
South coast Ofu (marine areas)	x	x	X	x	
Aua Transect-Pago Pago harbor, oldest coral reef transect	x	x	X	x	
Tau Island	x	x	X		

3.1.3 Crustacean Fishery

Table 6: American Samoan Archipelago Crustacean Management Unit Species[8]

Scientific Name	English Common Name	Samoan Name
Panulirus penicillatus, Panulirus marginatus	spiny lobster	ula-sami
Family *Scyllaridae*	slipper lobster	Papata
Ranina ranina	kona crab	pa'a
Heterocarpus species	Ama ebi	NA

3.1.3.1 Description (commercial, charter, recreational)

In American Samoa, lobsters are the primary crustacean fishery. Lobsters are more expensive than finfish and are often present in important occasions, such as weddings, funerals, Christmas, and New Year's Day. Formerly, lobsters were provided at the level of the village/family, whereas nowadays they are mainly caught by commercial fishermen and are bought at the market. Spiny lobster (*Panulirus penicillatus*) is the main lobster species and is generally harvested at night near the outer slope by free divers while diving for finfish by hand or by spear.

No fishing for deepwater shrimp has been reported around American Samoa. In 1987 PIFSC fishery scientists conducted sampling at 10 shrimp trapping stations at depths ranging between 200 and 510 fathoms around American Samoa. Large pyramid single set traps were used and at least some Heterocarpus were present in every trap haul. Unpublished results from the cruise showed that deepwater shrimp may be more abundant in some places than others, but they were found at every trapping station (PIFSC unpublished).

3.1.3.2 Type and Quantity of Fishing Gear

Crustaceans are caught by hand and/or spear in American Samoa by fishermen utilizing boats or by swimming from shore. For the most recent crustacean fishery gear quantities, refer to the current Annual Archipelagic Fishery Ecosystem Report (SAFE Report).

3.1.3.3 Catch in Numbers or Weight

The average catch between 2004-2013 catch for spiny lobster in American Samoa was 2,371 lbs., with high of 5,388 lbs. (2006) and a low of 532 lbs. (2004). For the most recent crustacean fishery catch amounts, refer to the current Annual Archipelagic Fishery Ecosystem Report (SAFE Report).

[8] Samoan names provided by F. Aitaoto. Pa'a = general name for crabs.

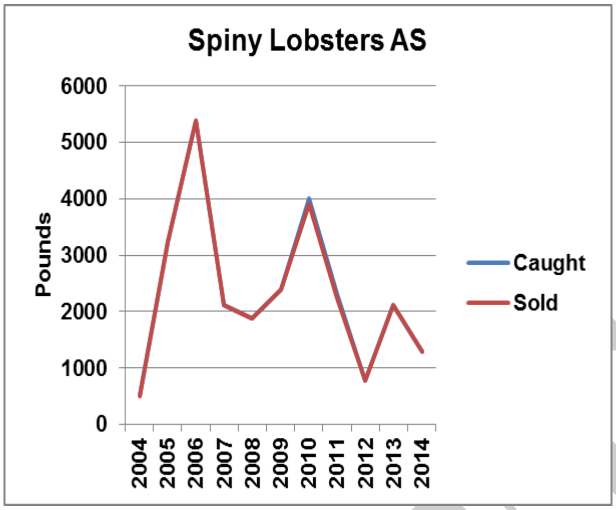

Figure 5. Spiny lobster catch trend 2004-2013. (SOURCE: WPacFIN website - http://www.pifsc.noaa.gov/wpacfin/as/Pages/as_data_8.php. Accessed June 26, 2015).

3.1.3.4 Fishing Areas

Lobster harvest is conducted on the outer reef slopes.

3.1.3.5 Time of Fishing

Lobster fishing occurs at night by free divers on the outer reef slope.

3.1.3.6 Number of Hauls

There is no data on the frequency of lobster harvest.

3.1.3.7 Economics

The primary crustacean fishery in American Samoa is the spiny lobster fishery. The 2004-2014 average for revenue across the spiny lobster fishery was $9,997.16, with a high of $22,765.50 (2005) and a low of $2,046.90 (2004). For the same time period, price per pound in the fishery averaged $4.26/lb., with a high of $4.95 (2008) and a low of $3.85 (2014). For current information regarding revenue of the fishery, price per pound, total direct employment, and fisheries-dependent services or industries, refer to the current WPFMC Archipelagic Fishery Ecosystem Report (SAFE Report).

3.1.3.8 Estimated and Actual Processing Capacity Utilized by U.S. Processors

Lobsters are sold locally, fresh and whole, with minimal processing.

3.1.3.9 Present and Probable Future Condition of the Fishery

Currently the fishery is experiencing low fishing participation and most fish retailers rely on imports from the neighboring Samoa to fill in the demand for fish (Sabater and Carroll 2008). Several attempts to revitalize the fishery through fishery development programs are underway but have yet to show any progress. Catches are low relative to the established catch limits which indicate there is room for increase in fishing participation.

3.1.3.10 Maximum Sustainable Yield

The Maximum Sustainable Yield for the fishery is estimated through stock assessments generated by the Pacific Island Fisheries Science Center. The assessments determine the status of the stock following the MSY control rule (described in Appendix E, which also specifies the relationship of F to B or other indicator of productive capacity under an MSY harvest policy.) The assessments are updated every three years (maximum) and benchmark assessment every six years (maximum) following the assessment schedule described in the Western Pacific Stock Assessment Review Policy. However, due to the data-limited nature of the coral reef fishery, the current MSY control rules and reference point proxies described in Appendix E cannot be applied to the species in the crustacean management unit species list.

For ACL specification purposes, Maximum Sustainable Yield in the crustacean fishery are determined by using the Biomass-Augmented Catch-MSY approach (Sabater and Kleiber 2014). This method estimates MSY using plausible combination rates of population increase (denoted by r) and carrying capacity (denoted by k) assumed from the catch time series, resilience characteristics (from FishBase), and biomass from existing underwater census surveys done by the Pacific Island Fisheries Science Center. This method was applied to spiny lobster complex . For more information regarding the MSY reference points, refer to the current Annual Archipelagic Fishery Ecosystem Report (SAFE Report).

There are no MSY estimates for deepwater shrimp, slipper lobster and Kona crabs in American Samoa.

3.1.3.11 Optimum Yield

No values for OY are available for crustaceans in American Samoa.

3.1.3.11.1 Extent to Which Fishing Vessels will Harvest OY

Crustaceans harvested in the American Samoa are marketed as fresh product or as frozen lobster tails, with each vessel processing its catch at sea. Therefore the domestic processing capacity and domestic processing levels will equal or exceed the harvest for the foreseeable future. Domestic vessels have the sufficient harvesting capacity to take the entire OY. Therefore the TALFF appears to be zero.

3.1.3.11.2 Extent to Which U.S. Fish Processors will Process OY

There is no processing of crustacean products in American Samoa. Products are sold as whole lobsters through fish retailers and along the roadside.

3.1.3.12 Annual Catch Limit

3.1.3.12.1 Specification Mechanism

For the crustacean fishery, specification of the acceptable biological catch and annual catch limits are required by the MSA and follows the mechanism described in Appendix E. The specification will be done on an annual basis by NMFS based on recommendations from the

Council.

3.1.3.12.2 Limit

For the most recent crustacean fishery Annual Catch Limits, refer to the current Annual Archipelagic Fishery Ecosystem Report (SAFE Report).

3.1.3.12.3 Accountability Measures

Accountability measures are specified on an annual basis by NMFS based on recommendations by the Council. There currently is no near-real-time monitoring for crustacean fisheries in the American Samoa. The specification of accountability measures will follow the process described in Appendix E.

3.1.3.13 Criteria for Determining Overfishing

No stock assessments have been conducted for the American Samoa lobster fishery and no status determination criteria were specified for the crustacean fishery.

3.1.3.14 MSA Conservation and Management Measures

Below are several important conservation and management measures for this fishery. Federal regulations governing this fishery can be found in the Code of Federal Regulations, Title 50, Part 665, Subpart G and Appendix C. Contact the Council or the National Marine Fisheries Service Pacific Islands Regional Office for and the fishery compliance guides (www.pir.noaa.gov).

Permit Area 3 includes the EEZ around the Territory of American Samoa. Federal permit and logbook reporting is required when fishing for Crustacean MUS in the U.S. EEZ waters around American Samoa. A permit must be obtained from the Regional Administrator and will be issued to the owner of the vessel that is used to fish for Crustacean MUS. Fishery participants have the option of using NMFS approved electronic logbooks in lieu of paper logbooks. In Permit Area 3, it is unlawful for any person to fish for, take or retain lobsters with explosives, poisons, or electrical shocking devices.

Vessel operators must report not less than 24 hours, but not more than 36 hours, before landing, the port, the approximate date and the approximate time at which spiny and slipper lobsters will be landed. They must also report not less than six hours, and not more than twelve hours, before offloading, the location and time that offloading spiny and slipper lobsters will begin. The Regional Administrator will notify permit holders of any change in the reporting method and schedule required at least 30 days prior to the opening of the fishing season. All fishing vessels must carry an observer when requested to do so by the NMFS Regional Administrator.

New management measures may be added through rulemaking if new information demonstrates that there are biological, social, or economic concerns in Permit Areas 1, 2 or 3. By June 30 of each year, the Council-appointed Plan Team will prepare an annual report on the fisheries in the management area. The report shall contain, among other things, recommendations for Council action and an assessment of the urgency and effects of such action(s).

Established measures are management measures that, at some time, have been included in regulations implementing the FEP, and for which the impacts have been evaluated in

Council/NMFS documents in the context of current conditions. Following the framework procedures of Amendment 9 to the former Crustaceans FMP, the Council may recommend to the NMFS 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 rulemaking if approved by the Regional Administrator.

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. Following the framework procedures of Amendment 9 to the former Crustaceans FMP, the Council will publicize, including by a Federal Register document, 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 document 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 rulemaking if approved by the Regional Administrator.

3.1.3.15 Bycatch

No bycatch measures or actions are necessary at this time. Lobsters taken by hand harvest and spear occurs primarily in territorial waters, 0-3 miles. There is no known bycatch associated with this fishery.

3.1.3.16 Identification and Description of EFH and HAPC

3.1.3.16.1 Spiny and Slipper Lobster and Kona Crab Essential Fish Habitat

Spiny lobsters are found through the Indo-Pacific region. All spiny lobsters in the Western Pacific Region belong to the family Palinuridae. The slipper lobsters belong to the closely related family, Scyllaridae. There are 13 species of the genus *Panulirus* distributed in the tropical and subtropical Pacific between 35° N and 35° S. *P. penicillatus* is the most widely distributed, and the other three species are absent from the waters of many island nations of the region. Spiny lobsters are typically found on rocky substrate in well-protected areas, in crevices, and under rocks. Similarly, juvenile and adult *P. penicillatus* also share the same habitat.

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. *P. penicillatus* inhabits the rocky shelters in the windward surf zones of oceanic reefs and moves on to the reef flat at night to forage.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for crustacean species assemblages. The species complex designations are spiny and slipper lobsters and Kona crab. The designation of these complexes is based on the ecological relationships among species and their preferred habitat.

At present, there are not enough data on the relative productivity of different habitats of CMUS to develop EFH designations based on Level 3 or Level 4 data. There are little data concerning growth rates, reproductive potentials, and natural mortality rates at the various life history stages. The relationship between egg production, larval settlement, and stock recruitment is also poorly understood. Although there is a paucity of data on the preferred depth distribution of phyllosoma larvae in Hawaii, the depth distribution of phyllosoma larvae of other species of *Panulirus* common in the Indo-Pacific region has been documented. Later stages of panulirid phyllosoma larvae have been found at depths between 80 and 120 meters.

3.1.3.16.1.1Description and Identification of EFH for Spiny and Slipper Lobster and Kona Crab

For these reasons, the Council designated EFH for spiny and slipper lobster and Kona crab eggs and larvae as the water column from the shoreline to the outer limit of the EEZ down to a depth of 150 meters throughout the Western Pacific Region. The EFH for juvenile and adult spiny and slipper lobster and Kona crab is designated as the bottom habitat from the shoreline to a depth of 100 meters throughout the Western Pacific Region.

3.1.3.16.1.2Identification of Habitat Areas of Particular Concern

Research from the Northwestern Hawaiian Islands indicates that banks with summits less than 30 meters support successful recruitment of juvenile spiny lobster while those with summit deeper than 30 meters do not. For this reason, the Council has designated all banks with summits less than 30 meters as HAPC. The basis for designating these areas as HAPC is the ecological function these areas provided, the rarity of the habitat type, and the susceptibility of these areas to human-induced environmental degradation. The complex relationship between recruitment sources and sinks of spiny lobsters is poorly understood, so the spiny lobster in the NWHI was used as a proxy for American Samoa crustaceans stocks. The Council believes that in the absence of a better understanding of these relationships, the adoption of a precautionary approach to protect and conserve habitat is warranted.

The relatively long pelagic larval phase for palinurids results in very wide dispersal of spiny lobster larvae. Panulirid larvae are transported up to 2,000 nautical miles by prevailing ocean currents. Because phyllosoma larvae are transported by the prevailing ocean currents outside of EEZ waters, the Council has identified habitat in these areas as “important habitat.”

3.1.3.16.2 Deepwater Shrimp Essential Fish Habitat

The basis of deep water shrimp essential fish habitat in American Samoa are the results Moffitt and Polovina’s (1987) study conducted at 22 islands and banks between 1982 and 1984 in the the Mariana Archipelago. Trapping surveys reported the presence of all eight species of *Heterocarpus: Heterocarpus ensifer, H. laevigatus* and *H. longirostris* comprised 99 percent of the catch while *H. tricarinatus, H. gibbosus* and *H. sibogae* were rare (). Maximum depths according to Moffitt and Polovina are *H. ensifer* 366 m, *H. laevigatus* 777 m, and *H. longirostris* 1052 m. Similar depth ranges were reported for *H. ensifer* and *H. laevigatus* in Guam (Wilder

1977). Absent localized research, this study has been used as a proxy for the Western Pacific Region.

The species complex designations include all eight species of deepwater shrimp extant in the Western Pacific Region (*Heterocarpus ensifer, H. laevigatus, H. sibogae, H. gibbosus, H. Lepidus, H. dorsalis, H. tricarinatus and H. longirostris*). This designation is consistent with the Code of Federal Regulations (CFR) §600.815 (a)(1)(iv)(E).

3.1.3.16.2.1Description and Identification of EFH for Deepwater Shrimp

To reduce the complexity and the number of EFH identifications required for each individual species and life stages of the genus *Heterocarpus* in the Western Pacific Region, and based upon the above information, the Council has recommended EFH for the complete assemblage of adult and juvenile *Heterocarpus* spp. as the outer reef slopes between 300 and 700 meters surrounding every island and submerged banks in the Western Pacific Region.

At present, there are not enough data on the relative productivity of different habitats of *Heterocarpus* to develop EFH designations based on Level 3 (growth, reproduction and survival rates by habitat area) or Level 4 (production rates by habitat) data. In fact, there are little to no data available concerning growth rates, reproductive potentials and natural mortality rates at each life history stage.

The relationship between egg production, larval settlement and stock recruitment is also poorly understood and only available for a few specific sites (Wilder 1977; Clarke 1972; Moffitt and Polovina 1987). Mature shrimps may undergo a depth related seasonal migration in synchrony with reproduction and a shift into deeper waters from depths of about 550 meters to 700 meters. For these reasons the Council has designated EFH for *Heterocarpus* spp. eggs and larvae as the water column and outer reef slopes between 550 and 700 meters in the Western Pacific Region.

3.1.3.16.2.2 Identification of Habitat Areas of Particular Concern

To date HAPC has not been identified or designated for deepwater shrimp.

3.1.4 Precious Corals

A Federal permit is required to harvest Precious Coral MUS in Federal waters around American Samoa and permit holders are required to maintain Federal logbooks of their catch and effort. There are currently no defined precious coral beds or active precious coral fisheries in either Federal or Territorial waters around American Samoa. However, because precious coral MUS are known to be in the waters around American Samoa it is possible a future fishery may develop. If one were to develop a fishery in the future it would be subject to the existing annual harvest quota 1,000 kg of all species combined (except black corals) which applies to the Federal waters around American Samoa. The fishery is also subject to a five-year moratorium on fishing for, taking, or retaining any gold coral in any precious coral permit area. This moratorium includes all waters of the U.S. Exclusive Economic Zone of the Western Pacific Region and is in effect through June 30, 2018 (78 FR 18302, March 26, 2013)

Table 7. American Samoan Archipelago Precious Coral Management Unit Species.[9]

Scientific Name	**English Common Name**	**Samoan Name**
Corallium secundum [amu = general name for corals]	pink coral (also known as red coral)	amu piniki-mumu
Corallium regale	pink coral (also known as red coral)	amu piniki-mumu
Corallium laauense	pink coral (also known as red coral)	amu piniki-mumu
Gerardia spp.	gold coral	amu auro
Narella spp.	gold coral	amu auro
Calyptrophora spp.	gold coral	amu auro
Lepidisis olapa	bamboo coral	amu ofe
Acanella spp.	bamboo coral	amu ofe
Antipathes dichotoma	black coral	amu uliuli
Antipathes grandis	black coral	amu uliuli
Antipathes ulex	black coral	amu uliuli

3.1.4.1 Description and Pattern of Use

There are currently no known precious coral beds or precious coral fisheries in waters around American Samoa; however, because precious coral MUS are known to be in the waters around American Samoa it is possible a future fishery may develop. Should a fishery develop, the provisions of this FEP would allow harvest only by selective gear (i.e., with submersibles or by hand).

3.1.4.2 Economics

There are no existing or recent fisheries for precious corals in American Samoa.

3.1.4.3 Maximum Sustainable Yield

No MSY estimates are available for the American Samoa Exploratory Area which consists of EEZ waters around American Samoa.

[9] Samoan names provide by F. Aitaoto

3.1.4.4 Optimum Yield

OY for this area is estimated at 1,000 kg per year of all species combined, except black coral.

3.1.4.4.1 Extent to Which Fishing Vessels will Harvest OY

Since there is no fishery, it is unlikely that OY will be met by fishing vessels.

3.1.4.4.2 Extent to Which U.S. Fish Processors will Process OY

Since there is no fishery, it is unlikely that OY will be met by fish processors.

3.1.4.5 Annual Catch Limit

3.1.4.5.1 Limit

For the most recent precious coral Annual Catch Limits, please refer to the most current Annual Archipelagic Fishery Ecosystem Report (SAFE Report).

3.1.4.5.2 Specification Mechanism

The American Samoa precious coral stocks are considered data-limited stock according to the ABC Control Rules (see ACL Process section). MSY has not been estimated for American Samoa precious corals resources. Currently, there are no existing fisheries for precious corals in American Samoa. No catch time series can be applied to the ABC control rules hence the Council used an *ad hoc* approach justified by the SSC, at its 108th meeting, as a proxy to the Tier 5 control rule.

American Samoa black corals: the MSY proxy was based on comparing available black coral habitat in Auau Channel of the MHI (in nmi^2) and Hawaii's coastline length (in nmi) to the coastline length of American Samoa (in nmi). Using this ratio comparison provides a potential available area for black coral habitat in CNMI (in nmi^2).

American Samoa black coral habitat proxy equation:

$$\frac{Auau\ channel\ habitat\ area}{HI\ coastline} \times AS\ coastline = AS\ habitat\ area$$

The ratio of Hawaii black coral MSY and habitat area in Hawaii was then multiplied to potential habitat area in AS, resulting in a potential MSY proxy.

American Samoa black coral MSY proxy equation:

$$\frac{HI\ black\ coral\ MSY}{Auau\ channel\ habitat\ area} \times AS\ habitat\ area = AS\ black\ coral\ MSY$$

This estimation is rough, and it does not take into account differences in available shelf habitat. For example, American Samoa does not have the shelf area afforded by Penguin Banks in Hawaii, which includes the Auau Channel. Thus, this MSY is likely an overestimation. The SSC then determined that the black coral fishery in American Samoa can be regarded as Tier 4 because MSY/MSY proxy is known, but there is no harvest. Therefore, consistent with the Tier 4 control rule described in the American Samoa FEP which requires the ABC be set equal to 0.91*MSY.

The ACL was set equal to ABC since there are currently no active fisheries for precious corals in American Samoa.

Pink, Gold, and Bamboo Coral in the American Samoa Exploratory Area: At its 152nd meeting held October 17-19, 2011, the Council considered the SSC-recommended ABC and recommended maintaining the current harvest quota of 1,000 kg/yr for pink and bamboo corals in the Exploratory Area around American Samoa. Gold coral would continue to be subject to a fishing moratorium until June 30, 2018.

3.1.4.5.3 Accountability Measures

If fisheries existed in the American Samoa archipelago for precious corals, there would be no near-real-time monitoring. Therefore, overage adjustments are applied to subsequent ACLs. Such reduction would be equivalent to the amount of overage in the previous fishing year. If the ACLs are exceeded in two consecutive years, the Council will revisit the ACL specification.

3.1.4.6 Criteria for Determining Overfishing

Due to the paucity of information on the existence and distribution of precious corals and the absence of a precious coral fishery in the American Samoa Archipelago, specification of MSY, OY and overfishing have not been individually determined for precious coral management unit species. However, OY values have been defined for precious corals in the exploratory areas around American Samoa. Should a precious coral fishery develop in the American Samoa Archipelago, the Council may develop specifications for specific coral species or beds depending on the information and stock assessment tools available. Spatial assessments will initially be done separately for EEZ waters around American Samoa but may be integrated as stock bounds and ecosystem structure become better understood.

3.1.4.7 MSA Conservation and Management Measures

Below are several important conservation and management measures for this fishery. Federal regulations governing this fishery can be found in the Code of Federal Regulations, Title 50, Part 665, Subpart G and Appendix C. Contact the Council or the National Marine Fisheries Service Pacific Islands Regional Office for and the fishery compliance guides (www.pir.noaa.gov).

This is an open access fishery. However, a Federal permit is required to harvest Precious Coral MUS in Federal waters around American Samoa and permit holders are required to maintain Federal logbooks of their catch and effort.

If a fishery were to develop a fishery in the future it would be subject to annual harvest quota and would also be subject to a moratorium on fishing for, taking, or retaining any gold coral in any precious coral permit area. This moratorium includes all waters of the U.S. Exclusive Economic Zone of the Western Pacific Region.

For a detailed description of the current regulations that would affect an American Samoan Archipelago Precious Coral Fishery, contact the Council, the National Marine Fisheries Service Pacific Islands Regional Office, or see the Code of Federal Regulations 50 CFR part 665. The Code of Federal Regulations can be accessed via www.regulations.gov.

As a signatory to the Convention on International Trade in Endangered Species (CITES), the United States is required to abide by regulations include in this international agreement. CITES includes regulations on international trade of endangered species through import and export permits. Currently, Black Coral is listed as an Appendix II species, which requires an export permit for international commercial trade. Corallium (Red/Pink corals) continues to be proposed as an Appendix II species and may end up on the list in the near future.

3.1.4.8 Precious Corals Essential Fish Habitat

Precious corals may be divided into deep- and shallow-water species. Deep-water precious corals are generally found between 350 and 1,500 meters and include pink coral (*Corallium secundum*), gold coral (*Gerardia* sp. and *Parazoanthus* sp.), and bamboo coral (*Lepidistis olapa*). Shallow-water species occur between 30 and 100 meters and consist primarily of three species of black coral: *Antipathes dichotoma*, *Antipathes grandis*, and *Antipathes ulex*.

Precious corals are non–reef building and inhabit depth zones below the euphotic zone. They are found on solid substrate in areas that are swept relatively clean by moderate-to-strong (> 25 cm/sec) bottom currents. Strong currents help prevent the accumulation of sediments, which would smother young coral colonies and prevent settlement of new larvae. Precious coral yields tend to be higher in areas of shell sandstone, limestone, and basaltic or metamorphic rock with a limestone veneer.

Black corals are most frequently found under vertical drop-offs. Pink, bamboo, and gold corals all have planktonic larval stages and sessile adult stages. Larvae settle on solid substrate where they form colonial branching colonies. The length of the larval stage of all species of precious corals is unknown.

The habitat sustaining precious corals is generally in pristine condition. There are no known areas in the Marinas Archipelago that have sustained damage due to resource exploitation.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council designated EFH for precious coral assemblages. The species complex designations are deep- and shallow-water complexes. The designation of these complexes is based on the ecological relationships among the individual species and their preferred habitat.

3.1.4.8.1 Description and Identification of EFH

The Council considered using the known depth range of individual precious coral MUS to designate EFH, but rejected this alternative because of the rarity of the occurrence of suitable habitat conditions. Instead, the Council designated the six known beds of precious corals as EFH. The Council believes that the narrow EFH designation will facilitate the consultation process.

3.1.4.8.2 Identification of Habitat Areas of Particular Concern

There are no designated HAPC for the precious corals fishery in the American Samoan archipelago.

3.1.5 Small Boat Pelagic Fisheries

Small boat pelagic fisheries are an important component of the American Samoa fishing community and the harvest of pelagic fish has been a part of the way of life in the Samoan archipelago since the islands were first settled some 3,500 years ago. Subsistence fishing continues to the present, but the importance of pelagic fisheries as a source of income and employment is decreasing. Below we present summary information on small boat pelagic fishing in American Samoa. However, because they are regulated under the Council's Pelagics Fishery Ecosystem Plan, detailed information about them can be found in that FEP or the Pelagic Fishery Ecosystem Annual Report (SAFE Report).

The primary small boat pelagic fishery in American Samoa is trolling and small-scale longlining. However, since 2001, the number of American Samoa troll vessels actively landing pelagic species and participants in the small-scale *alia* domestic longline fishery have declined substantially. As of 2014, only one alia longline vessel was operating in the Territory. American Samoa's commercial fishermen moved from troll or handline gear to longline gear in the mid-1990s. This switch was motivated by the fishing success of alia catamarans (generally less than 30' in length) engaged in longline fishing in the EEZ around Independent Samoa. This type of fishing involves short monofilament longline, with an average of 350 hooks per, set deployed from a hand-powered reel. An estimated 90 percent of the crews that were working in the American Samoa small-scale alia longline fleet were believed to be from Independent Samoa. The predominant catch was albacore tuna (~76% of landings). Yellowfin, skipjack, and bigeye tuna; and wahoo contribute the bulk of the non-albacore landings.

Recreational fishing purely for sport or pleasure is uncommon in American Samoa. Most fishermen normally harvest pelagic species for subsistence or commercial sale.

3.2 Other Consideration Important for FEP Implementation

3.2.1 Sociocultural Data

The MSA states the "Pacific Insular Areas contain unique historical, cultural, legal, political, and geographical circumstances which make fisheries resources important in sustaining their economic growth." In addition, ecosystem-based fishery management recognizes and attempts to manage for the interconnectedness of biological, ecological, geological, and social management dimensions. For many in islands communities, a fishery is *social system* that includes fish as well as fishermen, their families and friends, and, in the case of more commercialized fisheries, the associated support infrastructure and industry. Even those who buy and eat fish on a regular basis might be thought of as being part of a fishery.

Because of the importance of managing fishery resources as public trust, and because of the cultural uniqueness of the Pacific Islands, the Council has established several elements in its management process to incorporate science-based social data and traditional ecological knowledge. In fact, the Council from its inception has been very sensitive to traditional and indigenous fishing issues and considerations, and the Council's Guiding Principle #4 is to "recognize the importance of island cultures and traditional fishing practices in managing fishery resources and foster opportunities for participation." These issues include ensuring fishermen participation in setting ACLs, preserving indigenous way of life, navigating the relationship between federal processes and requirements and local custom and norms, and the dependence, on nearshore and pelagic resource, even in the modern era.

These process elements include formal social science input science the late 1980s via social science recommendations to the newly-established Pelagic Fisheries Research Program, and SSC subcommittee on social science, and a Council Cultural and Social Science Research Plan. In 1988, the Council spearheaded a request for proposals focused on native fishery rights issues and was instrumental in getting a Western Pacific Community Development Program and Plan included in 1996 reauthorization of the MSA. Following and in response to that, the Council established a Community Development Planning Committee. This committee is utilized under this FEP to assist with addressing American Samoan Archipelago FEP Objective: Increase Traditional and Local Knowledge in Decision-making.

Between 1999-2002, the Council worked to have the Secretary of Commerce formally designate fishing communities in American Samoa, the CNMI, Guam, and Hawaii under the MSA’s fishing communities provision (National Standard 8). To date, ours is the only region that has done so. In 2002, the Council established a formal Social Science Research and Planning Committee (known now as the Social Science Committee). Among other things, this Committee vets social science information needs as part of the Council’s identification of fishery research priorities. During the mid-2000s, as it worked to transition to ecosystem-based fishery management planning, the Council conducted a series of ecosystem planning workshops, including one dedicated to sociocultural considerations. The Council has used the recommendations from this workshop to improve the incorporation of social science in the management process.

Finally, the Council works to address sociocultural considerations via its “SEEM” process and its annual fishery (SAFE) reports. The SEEM assessment quantifies social, economic, and ecological factors, as well as management uncertainty dimensions and SEEM working groups thus recommend whether the ACL is set equal or lower than the ABC based on these considerations. The Council’s annual/SAFE report contents were overhauled in 2015 to monitor a host of social variables.

The Western Pacific Regional Fishery Management Council is the only regional fishery management council that employs both an Indigenous Coordinator and a Social Scientist.

3.2.2 Protected Species Information

Bottomfish, precious coral, coral reef and crustacean fisheries managed under this FEP have limited impacts to protected species, and no specific regulations are in place to mitigate protected species interactions. Destructive gear such as bottom trawls, bottom gillnets, explosives and poisons are prohibited under this FEP, and these provide benefit to protected species by preventing potential interactions with non-selective fishing gear.

NMFS has determined that the fisheries operating under the American Samoa FEP are not likely to adversely affect ESA-listed sea turtles, marine mammals, reef-building corals, and scalloped hammerhead shark. The current list of ESA Section 7 consultations applicable to this FEP are listed in the Annual Archipelagic Fishery Ecosystem Report (SAFE Report). NMFS will reinitiate consultation if a new species is listed or critical habitat is designated that may be affected by American Samoa FEP fisheries. These fisheries are not known to interact with non-ESA listed marine mammals or seabirds.

Fisheries operating under the American Samoa FEP currently do not have federal observers on board. The Council monitors protected species interactions in these fisheries in the WPFCM Annual Archipelagic Fishery Ecosystem Report (SAFE Report) using other proxy indicators such as fishing effort and changes in gear types.

3.2.3 Climate Change

Changing climate is already adversely impacting island communities, ecosystems, resources, cultures and economies. Increasing pressures on valuable marine and coastal habitats and resources due to changing demands for food, energy, economic growth and community sustainability make climate change an issue of community, national and regional security. In addition to economic considerations such as commercial fisheries, Pacific Island communities must address threats to culturally important species and places as well as community health and food security. Ultimately, for many low-lying coral atoll nations, climate change is a direct threat to national security as rising sea level and changes in the availability of freshwater may make at least some of those nations uninhabitable. To escape these impacts, human migration is anticipated.

The *Executive Summary of the 2012 Pacific Islands Regional Climate Assessment* (PIRCA) notes that the indicators of climate change suggest multiple concerns for human and natural communities in the Pacific Islands region: decreased freshwater supplies, especially on atolls and low-lying islands; increased coastal flooding and erosion; increased coral bleaching; unknown, negative consequences for the entire marine ecosystem; declines in open-ocean fisheries; increased risk of species extinctions; threats to the traditional lifestyles of indigenous communities making it difficult for Pacific Island communities to sustain their connection with a defined place and their unique set of customs, beliefs, and languages; and human migration from low islands to high islands and continental sites.

At its 157th meeting in June 2013, the Council restructured its Coastal and Marine Spatial Planning (CMSP) Committee into a Marine Planning and Climate Change (MPCC) Committee. The MPCC Committee advises the Council on new and developing research and happenings related to marine planning and climate change as it relates to Western Pacific fisheries, provides input on Council actions and associated analyses and documents as it relates to marine planning and climate change, and recommends research and program priorities, including outreach and education, to address marine planning and impacts of climate change in fisheries and fishing communities. The Committee includes up to 20 members, including at least three representatives each from Hawaii, American Samoa, Guam and the Commonwealth of the Northern Mariana Islands (one of the three is a community representative), three members representing the federal government and an ecosystem modeler. The basic criteria for Committee membership is expertise and interest in marine planning and climate change, with a focus on fisheries and fishing communities. Members of the Committee are selected by the Council and serve three-year terms.

In 2015, the Council adopted the MPCC Policy and action plan drafted by the MPCC Committee. The definition of climate change included in the MPCC Policy is the one used by the Intergovernmental Panel on Climate Change, which includes natural climate variability such as El Nino Southern Oscillation and other patterns of natural variability as well as long-term changes in climate associated with anthropogenic (human) influence on greenhouse gases and other aspects of the Earth's climate system. The definition of climate change in the Council's MPCC policy also includes ocean acidification. The MPCC policy notes that, in the Pacific Ocean, anticipated climate change impacts include ocean acidification; changing migratory patterns of tuna, other commercially valuable stocks and protected species, among other species; changes in coastal and marine habitats with associated changes in socially, culturally and economically valuable coastal fisheries and other sources of ocean economy; changing patterns of El Niño and other patterns of climate variability; changes in water level including, but not limited to sea level change, increased severity of extreme weather, coral reef changes; and human migration, among others. The MPCC policy recognizes a set of overarching and specific principles and specific policy points for the Council, its advisory bodies and its staff to consider and incorporate in the American Samoan Archipelago FEP as well as in Council programs and other actions. The policy can be found on the Council's website.

The Council's MPCC Action Plan prioritizes and provides guidance on implementing climate change measures adopted by the Council, including items related to climate change research and data needs. A working group of the MPCC Committee, with additional support from PIFSC, tentatively identified climate indicators to monitor initially for the annual reports on the Council's FEPs.

This work was completed by the Council's 2015 restructured Plan Team. The Plan Team members responsible for the climate change modules determined that each 2015 annual report would include 10 preliminary climate change indicators. Preliminary Climate Indicators for 2015 Archipelagic Annual Reports include a) atmospheric Concentration of CO_2; b) ocean pH; c) Oceanic Nino Index; d) Pacific Decadal Oscillation (PDO); e) Sea Surface Temperature and anomaly; f) Sea Surface Height and anomaly; g) ocean pH; h) bad/extreme weather (including lulls); i) wave data; and j) near-surface wind velocity. The Plan Team members discussed including additional climate change indicators in future annual reports such as sea level pressure for the Archipelagic Annual Report.

The WPRFMC is working with its MPCC Committee to hold community meetings to garner feedback on the annual reports and other public input related to the region's climate change needs, knowledge and impacts, including potential climate change impact indicators, such as socioeconomic indicators.

To identify the climate change impact indicators and potential climate change impact indicators to be monitored in the American Samoan Archipelago, the Council intends to work with the American Samoa Department of Marine and Wildlife Resources and American Samoa Coastal Management Program, as well as community members, schools and policymakers in the Territory.

In addition to the FEPs, themselves, climate change issues are incorporated, by process, into annual catch limit specifications, amendments to the FEPs and elements in the plans, such as the threatened status of the green sea turtle.

3.2.3 Marine Planning

In the American Samoan archipelago, fisheries compete with other activities for fishing grounds and access to them. These activities include, but are not limited to, commercial shipping, marine protected areas, recreational activities and pollution.

Marine planning is a tool utilized regionally, nationally and globally to identify and address issues of multiple human uses, ecosystem health and cumulative impacts and is a component of the National Ocean Policy. Since 2010, CMSP has been the focus of several of the Council's advisory body meetings and outreach activities. During this time, the Council also began transforming its Marine Protected Area Committee first into a CMSP Committee and then into the current Marine Planning and Climate Change Committee (see above for details on the Committee).

In 2015, the Western Pacific Regional Fishery Management Council adopted its MPCC Policy, which was drafted by the Council's MPCC Committee. The policy uses the definition of marine planning as defined in the National Ocean Policy Implementation Plan. The MPCC policy recognizes a set of overarching and specific principles and specific policy points for the Council, its advisory bodies and its staff to consider and incorporate in the American Samoan Archipelago FEP as well as in Council programs and other actions. The policy notes that marine planning can be used to determine ocean management priorities across jurisdictions and identify common objectives. The MPCC Policy recognizes that traditional resource management systems, such as Fa`a Samoa, can provide an appropriate context for marine planning. A key component of the policy is collaboration with existing organizations in data and information collection, dissemination and outreach. Organizations with whom the Council intends to work include, but are not limited to, the American Samoa Department of Marine and Wildlife Resources, the American Samoa Coastal Management Program and the Pacific Islands Regional Planning Body as well as community members, the private-sector, schools and policymakers in the Territory. The MPCC Policy can be found on the Council's website.

A working group of the MPCC Committee, with additional support from PIFSC, tentatively identified climate indicators to monitor initially for the annual reports on the Council's FEPs.

This work was taken over by the Council's 2015 restructured Plan Team. The Plan Team members responsible for the climate change modules determined that each 2015 annual report would include 10 preliminary climate change indicators. Preliminary Climate Indicators for 2015 Archipelagic Annual Reports include a) atmospheric Concentration of CO_2; b) ocean pH; c) Oceanic Nino Index; d) Pacific Decadal Oscillation (PDO); e) Sea Surface Temperature and anomaly; f) Sea Surface Height and anomaly; g) ocean pH; h) bad/extreme weather (including lulls); i) wave data; and j) near-surface wind velocity. The Plan Team members discussed including additional climate change indicators in future annual reports such as sea level pressure for the Archipelagic Annual Report.

The WPRFMC is working with its MPCC Committee to hold community meetings to garner feedback on the annual reports and other public input related to the region's climate change needs, knowledge and impacts, including potential climate change impact indicators, such as socioeconomic indicators.

To identify the climate change indicators and potential climate change impact indicators to be monitored in the American Samoan Archipelago, the Council intends to work with the American Samoa Department of Marine and Wildlife Resources and American Samoa Coastal Management Program, as well as community members, schools and policymakers in the Territory.

In addition to the FEPs, themselves, climate change issues are incorporated, by process, into annual catch limit specifications, amendments to the FEPs and elements in the plans, such as the threatened status of the green sea turtle.

The Council's Plan Team (restructured in 2015) includes a marine planning expert, and a section on marine planning will be included in the American Samoan Archipelago FEP annual reports.

3.2.4 Western Pacific Community Development Program

Section 305(i)(2) of the MSA authorizes the Council and the Secretary of Commerce, through NMFS, to establish a Western Pacific Community Development Program for any fishery under the authority of the Council and NMFS. The intent of the program is to provide Western Pacific communities access to fisheries that they have traditionally depended upon, but may not have the capabilities to support continued and substantial participation in, possibly due to economic, regulatory, or other barriers.

The Western Pacific Community Development Program includes two components: (1) Development Plan Program; and (2) Demonstration Projects Program. Under the Western Pacific Community Development Program (CDP), the Council provides support for fishery projects of Western Pacific communities and indigenous communities through administrative processes. The Western Pacific Community Demonstration Project Program (CDPP) is a grant program that provides funds to Western Pacific indigenous communities for the demonstration of traditional, cultural fishery, fishery management and fishery conservation projects

To be eligible to participate in the western Pacific community development program, a community must meet the following criteria:

1. Be located in American Samoa, Guam, Hawaii, or the Northern Mariana Islands (collectively, the Western Pacific);
2. Consist of community residents descended from aboriginal people indigenous to the Western Pacific who conducted commercial or subsistence fishing using traditional fishing practices in the waters of the Western Pacific;
3. Consist of individuals who reside in their ancestral homeland
4. Have knowledge of customary practices relevant to fisheries of the Western Pacific;
5. Have a traditional dependence on fisheries of the Western Pacific;
6. Are currently experiencing economic or other constraints that have prevented full participation in the Western Pacific fisheries and, in recent years, have not had

harvesting, processing or marketing capability sufficient to support substantial participation in fisheries in the area; and

7. Develop and submit a community development plan to the Council and the NMFS.

Development Plan Program

An eligible community seeking access to a fishery under the authority of the Council and NMFS must submit to the Council a community development plan that includes the following information[10]:

1. A statement of the purposes and goals of the plan.
2. A description and justification for the specific fishing activity being proposed, including:
   - Name, address, and telephone number of the vessel owner(s) and operator(s). Location of the proposed fishing activity.
   - Management unit species to be harvested, and any potential bycatch.
   - Gear type(s) to be used.
   - Frequency and duration of the proposed fishing activity.
3. A statement describing the degree of involvement by the indigenous community members, including the name, address, telephone and other contact information of each individual conducting the proposed fishing activity.
4. A description of how the community and or its members meet each of the eligibility criteria in paragraph (b) of this section.
5. If a vessel is to be used by the community to conduct fishing activities, for each vessel:
   - Vessel name and official number (USCG documentation, state, territory, or other registration number).
   - Vessel length overall, displacement, and fish holding capacity.
   - Any valid federal fishing permit number(s).

3.2.5 Aquaculture

Aquaculture is a growing industry in the U.S. producing an ever-increasing proportion of marine consumer products once solely harvested from the wild. NMFS defines aquaculture as the as the propagation and rearing of aquatic organisms for any commercial, recreational, or public purpose. In the Pacific it has evolved into a multi-million dollar industry producing a range of marine products including algae, pearls, and fish. In the twentieth century, most aquaculture in the U.S. was conducted at land-based facilities and was focused on freshwater species.

[10] The description must be in sufficient detail for NMFS and the Council to determine consistency with the Council's fishery ecosystem plans, the Magnuson-Stevens Act, and other applicable laws.

Technical innovations, declines in wild marine stocks, and greater demand for seafood have led to a recent expansion of the industry into marine environments.

NMFS is responsible for managing fisheries in federal water and NOAA General Council determined that aquaculture is included in the definition of "fishing" under the Magnuson-Stevens Fishery Conservation and Management Act (MSA)[11]. This designation provides the statutory authority for NMFS and the regional fishery management councils (FMCs) to regulate aquaculture projects in federal waters. NMFS and the FMCs are just beginning to establish management plans for aquaculture activities. In 2009, The Gulf of Mexico FMC established the first fishery management plan for offshore aquaculture. That same year, the Council voted to consider including management measures for offshore aquaculture in the FEPs at its 146th Meeting in October 2009.

The WPRFMC defines aquaculture as the raising and cultivation of plants or animals, both freshwater and marine, for food or other purposes. Aquaculture, as defined by the Council, includes fish farming, fish culturing, ocean ranching, and mariculture. The Western Pacific Regional Fishery Management Council recognizes that aquaculture is a rapidly developing industry in the Western Pacific Region as well as the rest of the world, and that aquaculture presents both potential benefits and potential negative impacts to the environment and society. The Council's Aquaculture Policy can be found at the Council's website, www.wpcouncil.org.

[11] A 1993 legal opinion issued by NOAA's General Counsel supports the agency's position that the MSA confers authority on the Council and NMFS to manage aquaculture activities (NOAA Aquaculture Policy Statement June 2011).

4 MANAGEMENT PROCESS

4.1 Council Process

4.1.1 Overview of Council Process

The Council process to develop or change regulations involves many stages and includes many steps and opportunities for public input and comment. The Council considers proposals, options papers, draft amendment documents, National Environmental Policy Act analysis documents, and eventually votes on preferred alternatives, which may result in regulations at the end of the process.

The Council generally follows this process:

- An issue is brought to the Council's attention – presented from the public, an advisory body, or other avenue;
- The Council reviews the issue and decides whether to initiate an analysis of alternatives;
- If such an analysis is initiated, then:
    - Council staff develops alternatives, analysis and other needed documents for review;
    - There is a review by the Council, its advisory bodies and the public; and
    - The Council may select a preferred alternative, initiate further analysis or decide on no further action.
- After a preferred alternative is selected, the Council decision is forwarded to the Secretary of Commerce in the form of a plan or amendment for review and approval; The Secretary of Commerce may do either of the following:
    - Reject the plan/amendment;
    - Approve the plan/amendment;
    - Partially approve the plan/amendment.
- If the plan/amendment is approved, draft rules are published for public comment;
- After the rules are noticed and comments are addressed, a final decision is made by the Secretary of Commerce; and
- If approved, the rules and regulations from the plan/amendment are implemented through the Code of Federal Regulations.
- If the plan/amendment is rejected or partially approved, it is returned to the Council, with rationale for rejection/partial approval, for the Council's consideration.

4.1.1.1 Development and Approval Process for Management Actions

The process to develop and approve fishery management actions is governed by the MSA with further guidance provided through the Operational Guidelines (OG), Regional Operating Agreements (ROA) and other applicable laws (OALs). While most actions are focused specifically on the Council-initiated fishery management actions, OALs and other rulemaking authorities provide information relevant to fisheries managed by the Secretary under the "Highly Migratory Species" (HMS) provisions of the MSA.

As described in the OG, the fishery management process for Council-managed fisheries consists of five basic phases. Section C of Appendix 2 to the OG provides detailed information about these phases. In general, they are as follow:

1. Planning
2. Document Drafting
3. Public Review and Council Action to Recommend a Measure
4. Post Council Action to Recommend a Measure
    (a) Preparation for Transmittal
    (b) Secretarial Review and Implementation
5. Ongoing Management (additional regulatory activity, monitoring, need identification, and response – feeds back into phase1).

While the ROA outlines NMFS/Council cooperation and sharing of workloads, it is important to note that the MSA and other applicable laws assign different responsibilities to each entity. Therefore, both NMFS and the Councils must ensure they fulfill their required roles.

4.1.1.2 Specific Elements and their Relationship to Decision-making

The MSA and OALs set forth specific analytical and procedural requirements that interact with NMFS' and Councils decision-making processes under the MSA. Mandates placed on NMFS, as the federal action agency, are distinct from the requirements pertaining to the activities of the Council, in their role as an advisory body. The Council is not precluded from developing analyses and documentation to support compliance with the OALs; in fact, this practice is recommended. However, legal responsibility for most requirements lies with the NMFS. The Council desires to have as complete analysis and documentation as possible available during its deliberations.

a. MSA Role of the Councils

As set forth in sections 302(h), 303, and 304 of the MSA, Councils are responsible for:

- Conducting public hearings to allow for public input into the development of FMPs and amendments,
- Reviewing pertinent information,
- Preparing fishery management plans and amendments for fisheries requiring conservation and management
- Drafting or deeming regulations to implement the plans or amendments
- Developing ACLs,
- Identifying research priorities, and
- Transmitting complete packages containing documentation necessary for NMFS to initiate a review of compliance with all applicable laws including NEPA.

b. MSA Role of NMFS

As set forth in section 304(a) of the MSA, the role of NMFS with respect to fishery management plans and plan amendments developed by the Council is to review– and approve, disapprove, or partially approve –those plans and amendments in accordance with specified procedures, including:

- Immediately upon transmittal of the FMP or FMP amendment: publish a plan or amendment in the Federal Register for a 60-day comment period.

- Approve, disapprove, or partially approve a plan or amendment within 30 days of the end of the comment period on the plan or amendment. Disapproval must be based on inconsistency with the MSA or other applicable law. In addition, disapprovals must provide guidance on what was inconsistent and how to remedy the situation, if possible (see MSA section 304(a)(3)(A)-(C)).

In addition, as set forth in section 304(b) the role of NMFS with respect to Council-recommended draft regulations is to:

- Immediately upon transmittal of the proposed regulations: initiate an evaluation of whether they are consistent with the fishery management plan, plan amendment, the MSA, and other applicable law.

- Within 15 days make a determination of consistency, and—

    - if that determination is affirmative: publish the regulations for a public comment period of 15 to 60 days; or,

    - if that determination is negative: notify the Council in writing of the inconsistencies and provide recommendations on revisions that would make the proposed regulations consistent.

- Consult with the Council before making any revisions to the proposed regulations,

- Promulgate final regulations within 30 days after the end of the comment period and publish in the Federal Register an explanation of any differences between the proposed and final regulations.

The MSA, at section 304(c), also authorizes NMFS to prepare a fishery management plan or amendment if:

(a) the Council fails to develop and submit to NMFS, after a reasonable period of time, a fishery management plan for such fishery, or any necessary amendment to such a plan, if such fishery requires conservation and management;

(b) the NMFS disapproves or partially disapproves any such plan or amendment, or disapproves a revised plan or amendment, and the Council involved fails to submit a revised or further revised plan or amendment; or

(c) the NMFS is given authority to prepare such plan or amendment under the MSA.
NMFS may also develop regulations to implement Secretarial plans and amendments. (MSA section 304(c)(6), (7)).

c. Other Applicable Laws Roles for NMFS and Councils

As described in section D in Appendix 2 of the OG, the OALs set forth a variety of requirements for analysis, documentation, determinations, and procedures. Because of the close relationship between NMFS' actions and the Council's recommendations, compliance with the OALs will be most effective if NMFS and the Councils coordinate closely. The ROAs explain how these relationships work for each Council/Region pair. Council staff can often be responsible for drafting supporting analyses and documentation; however, it is the NMFS' responsibility to ensure the final documents are legally sufficient.

4.1.1.3 Specific Elements and their Relationship to Decision-making

The MSA and OALs set forth specific analytical and procedural requirements that interact with NMFS's and the Councils' decision-making processes under the MSA. The mandates on NMFS, as the federal action agency, are distinct from the requirements pertaining to the activities of the Councils, in their role as advisory bodies. Nothing precludes a Council's development of analyses and documentation to support compliance with the OALs, and in fact this practice is recommended. However, ultimate legal responsibility for most requirements lies with NMFS. It is the goal to have as complete analysis and documentation as possible available during Council deliberations.

b. MSA Role of the Councils

As set forth in sections 302(h), 303, and 304 of the MSA, Councils are responsible for:

- Conducting public hearings to allow for public input into the development of FMPs and amendments,
- Reviewing pertinent information,
- Preparing fishery management plans and amendments for fisheries requiring conservation and management
- Drafting or deeming regulations to implement the plans or amendments
- Developing ACLs,
- Identifying research priorities, and
- Transmitting complete packages containing documentation necessary for NMFS to initiate a review of compliance with all applicable laws including NEPA.

b. MSA Role of NMFS

As set forth in section 304(a) of the MSA, the role of NMFS with respect to fishery management plans and plan amendments developed by the Council is to review – and approve, disapprove, or partially approve –those plans and amendments in accordance with specified procedures, including:

- Immediately upon transmittal of the FMP or FMP amendment publish a plan or amendment in the Federal Register for a 60-day comment period.
- Approve, disapprove, or partially approve a plan or amendment within 30 days of the end of the comment period on the plan or amendment. Disapproval must be based on inconsistency with the MSA or other applicable law. In addition, disapprovals must

provide guidance on what was inconsistent and how to remedy the situation, if possible (see MSA section 304(a)(3)(A)-(C)).

In addition, as set forth in section 304(b) the role of NMFS with respect to Council-recommended draft regulations is to:

- Immediately upon transmittal of the proposed regulations initiate an evaluation of whether they are consistent with the fishery management plan, plan amendment, the MSA, and other applicable law.
- Within 15 days make a determination of consistency, and—
  - if that determination is affirmative, publish the regulations for a public comment period of 15 to 60 days; or,
  - if that determination is negative, notify the Council in writing of the inconsistencies and provide recommendations on revisions that would make the proposed regulations consistent.
- Consult with the Council before making any revisions to the proposed regulations,
- Promulgate final regulations within 30 days after the end of the comment period and publish in the Federal Register an explanation of any differences between the proposed and final regulations.

The MSA, at section 304(c), also authorizes NMFS to prepare a fishery management plan or amendment if:

(a) the appropriate Council fails to develop and submit to NMFS, after a reasonable period of time, a fishery management plan for such fishery, or any necessary amendment to such a plan, if such fishery requires conservation and management;

(b) NMFS disapproves or partially disapproves any such plan or amendment, or disapproves a revised plan or amendment, and the Council involved fails to submit a revised or further revised plan or amendment; or

(c) NMFS is given authority to prepare such plan or amendment under the MSA.

NMFS may also develop regulations to implement Secretarial plans and amendments. (MSA section 304(c)(6), (7)).

c. Other Applicable Laws Roles for NMFS and Councils

As described in section D in Appendix 2 of the OG, the OALs set forth a variety of requirements for analysis, documentation, determinations, and procedures. Because of the close relationship between NMFS's actions and the Council's recommendations, compliance with the OALs will be most effective if NMFS and the Councils coordinate closely. The ROAs explain how these relationships work for each Council/Region pair. Council staff can often be responsible for drafting supporting analyses and documentation; however, it is NMFS's responsibility to ensure the resulting documents fully comply with all law.

4.1.1.3.1 Advisory Panels

Advisory Panels are established as necessary to assist in carrying out the functions of the Council under the MSA. Section 302(g)(4) of the MSA establishes Advisory Panels to "assist in the evaluation of information relevant to the development of any fishery management plan or plan amendment for a fishery." The Western Pacific Regional Fishery Management Council's Advisory Panel includes representation from various sectors of the fisheries. Members of the Subpanels are selected by the Council and serve four-year terms with an overall Advisory Panel Chair and a Vice-Chair, with a Chair for each Advisory Panel sub-panel. Sub-panels are designated by the Archipelago FEPs and have representation from user groups and interests concerned with management of the fishery including fair representation of commercial fishing interests in the Council's geographical area of authority. The Advisory Panel provides advice on the content and effects of management plans, amendments and pre-season and in-season management measures, as well as issues to be discussed at Council Meetings.

The Hawaii Archipelago FEP Sub-Panel includes 8 members, not including alternates, and meets prior to Council Meetings to discuss action items and provide comments and recommendations on issues of concern to the Council. Recommendations from the Advisory Panel and its Sub-Panels are provided to the Council for its consideration at Council Meetings.

4.1.1.3.2 Plan Teams

Plan teams are a form of advisory panel authorized under Section 302(g) of the MSA. FEP Plan Teams are comprised of Federal, State and non-government specialists that are appointed by the Council and serve indefinite terms. The Council created an Archipelagic FEP Plan Team to oversee the ongoing development and implementation of the American Samoa, Hawaii, Mariana, and PRIA FEPs. The Team is also responsible for reviewing information pertaining to the performance of all the fisheries, the status of all the stocks managed under the four Archipelagic FEPs, monitoring the performance of the FEP through the production of an annual stock assessment and fishery evaluation (SAFE) report , providing information on the status of the fish stocks and other components of the ecosystem, and recommending conservation and management adjustments under framework procedures to better achieve management objectives. The Archipelagic Plan Team's findings and recommendations are reported to the Council at its regular meetings. The Archipelagic Plan Team meets at least once annually and its chair is appointed by the Council Chair after consultation with the Council's Executive Standing Committee.

4.1.1.3.3 Science and Statistical Committee

The Scientific and Statistical Committee (SSC) is mandated under MSA 302(g) to "assist the Council in the development, collection, evaluation, and peer review of such statistical, biological, economic, social, and other scientific information as is relevant to such Council's development and amendment of any fishery management plan." The Western Pacific Regional Fishery Management Council's SSC is composed of experts with scientific or technical credentials and experience from State and Federal agencies, academic institutions, and other sources. SSC Members represent a wide range of disciplines required for preparation and review of Fishery Ecosystem Plans.

The SSC typically meetings several days prior to a Council meeting to identify scientific resources required for the development of management plans and amendments and recommend resources for Plan Teams; Identify scientific resources required for the development of management plans and amendments and recommend resources for Plan Teams; Provide ongoing multi-disciplinary review of management plans or amendments and advise the Council on their scientific content, including recommendations for acceptable biological catch, preventing overfishing, maximum sustainable yield and achieving rebuilding targets, and reports on stock status and health, bycatch, habitat status, social and economic impacts of management measures and sustainability of fishing practices; Assist the Council in the development, collection, evaluation and peer review of such statistical, biological, economic, social, and other scientific information as is relevant to the Council's activities, and recommend methods and means for the development and collection of such information; Recommend to the Council the composition of Plan Teams; and provide scientific advice to the Council through recommendations on issues and action items.

4.1.1.3.4 Fishing Industry Advisory Committee

Section 302(g) of the MSA requires the Council to establish a Fishing Industry Advisory Committee (FIAC). It includes representation from various fishing sectors of the Western Pacific region. Members of the committee are selected by the Council and serve four year terms, with representation from each of the island jurisdictions. The FIAC reports to the Council and has representation from industry user groups concerned with the management of the fishery for which a plan is being prepared or reviewed, with fair representation of the fishing industry interests in the Council's geographical area of authority. The functions of the FIAC are to advise the Council on fishery management problems; to provide input to the fishery management planning efforts; and to advise the Council on the content and effects of management plans, amendments, and pre-season and in-season management measures. The FIAC includes members from each Archipelagic FEP (with the PRIA FEP included with the Hawaii FEP).

4.1.1.3.5 REAC and other Council Committees

The Regional Ecosystem Advisory Committee (REAC)'s primary role is to provide a forum for government agencies, organizations and other entities to share information to better integrate and coordinate ocean and coastal management. Sub-committees for each area are created with members that include representation from the Council, various Federal, State and local agencies, non-government specialists and private business from each respective area. Members of the REAC are appointed by the Council with the Chair of each area sub-committee appointed by the Council Chair after consultation with the Executive and Budget Committee.

Other Council Committees created to assist the Council in carrying out its statutory functions, as provided under section 302(g)(2) of the MSA include:

- Protected Species Advisory Committee
- Social Science Planning Committee
- Community Demonstration Projects Advisory Panel
- Community Development Program Advisory Panel
- Fishery Data Collection and Research Committee
- Marine Planning and Climate Change Committee
- Education Committee
- Non-Commercial Fisheries Advisory Committee

4.1.1.3.6 Ad-hoc Committees and Working Groups

The Council develops different ad-hoc committees and working groups to deal with specific issues relevant to the FEP and to assist in carrying out its statutory function.

4.1.1.3.7 Federal Agencies

4.1.1.3.7.1 National Marine Fisheries Service

The NMFS implements Council recommendations and is a primary federal enforcement agency for fisheries and other marine resource regulations. Recommendations from the Council, including transmitted amendments and plans, are provided to the NMFS and the Department of Commerce for approval. The Secretary of Commerce may approve, partially-approve, or reject any amendment or plan, in which case the Council will revisit or revise any partially-approved or rejected amendment or plan.

Regionally, the Council works in conjunction with the NMFS Pacific Islands Regional Office (PIRO) and the Pacific Islands Fisheries Science Center (PIFSC).

4.1.1.3.7.2 US Fish and Wildlife Service

The US Fish and Wildlife Service is a non-voting member of the Council and provide information as needed. Rose Atoll National Wildlife Refuge, 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 three miles around the atoll and is under the joint jurisdiction of the Departments of Commerce and Interior, in cooperation of the Territory of American Samoa. Here the USFWS acknowledges fishery management authority of the Council, in coordination with the NMFS, within the “200-nautical mile EEZ” (Smith 2000b).

However the USFWS also asserts the authority to manage marine resources and all 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).

USFWS regulations governing access and uses within National Wildlife Refuges can be found in 50 CFR Part 32.

4.1.1.3.7.3 U.S. Coast Guard

The United States Coast Guard, District 14, is responsible for fishery regulation enforcement in the American Samoan archipelago, including enforcing regulations listed in the FEP. The Fourteenth District’s boundaries of responsibility stretch from the Hawaiian Islands and across most of the Central and Western Pacific. The District Commander oversees 25 operational units ashore and afloat throughout the Pacific, which regularly perform missions in maritime safety, protection of natural resources, maritime security, homeland security, and national defense.

4.1.1.3.8 Rose Atoll Marine National Monument

The Rose Atoll Monument was designated in 2009. Rose Atoll is in the American Samoa EEZ, approximately 130 nautical miles east-southeast of Pago Pago Harbor. It consists of 13,436 square miles. The outer boundary is approximately fifty miles from the mean low water line of Rose Atoll. Commercial fishing is prohibited in the Rose Atoll Monument. All fishing is prohibited within 12 nm of Rose Atoll. The Council and NMFS may review the Rose Atoll regulations after three years to assess the closure's impacts. Both the owner and operator of a vessel used to fish in the Monument must hold either a non-commercial fishing permit or a recreational charter fishing permit. NMFS may issue a permit only to a community resident of American Samoa or a charter business established legally under the laws of American Samoa. Fishermen who harvest fishery resources under a non-commercial fishing permit may engage in customary exchange, which helps to preserve traditional, indigenous, and cultural fishing practices, on a sustainable basis. However, customary exchange by fishermen fishing under a recreational charter permit is not allowed.

4.1.1.3.9 National Marine Sanctuary of American Samoa

The Fagatele Bay National Marine Sanctuary in 1986. At the time, it was the smallest and most remote of the National Marine Sanctuaries. The Sanctuary protects 163 acres of tropical marine habitat on the southwest coast of Tutuila Island, American Samoa. Sanctuary regulations prohibit taking invertebrates and sea turtles, as well as any historical artifacts found in the bay. Only traditional fishing methods are permitted in the inner bay. Line fishing is permitted in the outer bay only.

4.1.1.3.10 Local Agencies

American Samoa's Department of Marine and Wildlife Resources (DMWR) functions for the protection and management or the Territory's marine and wildlife resources to the extent intended to best benefit the people of American Samoa while ensuring the integrity of such resources for posterity. The various projects undertaken by the department are designed to:

Generate information for the formulation of policies and guidelines for

1. conservation and management of the resources;
2. Provide direct services and technical assistance for the development of
3. community and government programs compatible with the wise utilization of natural resources; and
4. Prevent or minimize abusive or exploitative use of resources through conservation education and implementation of applicable federal and local regulations.

Regulations governing fishing activities and harvest of marine resources can be found in the American Samoa Administrative Code, Title 24, Chapter 9.

4.1.1.3.11 Regional Entities

There are no current regional entities involved in fisheries management in the American Samoan archipelago. However, there are regional fishery management organizations that are responsible for pelagic fisheries and one for seamount groundfish that American Samoa is not a part of.

4.1.1.3.12 Fishery Impact Statement

The Magnuson-Stevens Act requires that fishery management plan and plan amendments submitted to the Secretary after October 1, 1990 assesses the likely biological and socioeconomic effects of the conservation and management measures on fishery participants and their communities; participants in the fisheries conducted in adjacent areas under the authority of another Council; and the safety of human life at sea. This is typically referred to as a Fishery Impact Statement (FIS). Appendix D contains a list of all relevant amendments that predate this FEP, as well as amendments that were approved subsequent to its adoption. The elements of a FIS are integrated into the environmental impact analyses prepared for these amendment documents, as required. To find a FIS for a specific management measure contained in this FEP, see Appendix D.

4.1.1.3.13 Public Consultation Process

The public is provided opportunity to comment on provide testimony at all meetings noticed through the Federal Register. The Council also accepts comments and testimony by phone, email and fax.

4.1.1.4 The Role of Agreements, Statement of Organization Practices and Procedures, etc.

International coordination is an important component of marine resource management within the island areas of the Western Pacific Region. For example, fish stocks and other marine resources that found within the American Samoan archipelago may be part of populations that occur on larger geographic scales. Also, the US EEZ around the islands areas within the Western Pacific Region are adjacent to other EEZs of foreign countries. Marine debris from foreign sources also wash ashore on American Samoa. To support international coordination, American Samoa is a member of the Secretariat of the Pacific Community and South Pacific Regional Environmental Programme. American Samoa is also recognized as a Participating Territory within the Western and Central Pacific Fisheries Commission. The Territory also has formal observer status within the Pacific Islands Forum Fisheries Agency.

4.1.1.5 Communication Plan

The Communication is an essential component of the Council's bottom-up approach to fisheries management and is one of the Council's seven Guiding Principles: "Conduct education and outreach to foster good stewardship principles and broad and direct public participation in the Council's decision making process."

The Council's Public Involvement and Outreach Plan was prepared in 1995 and serves as the basis for the Council's ongoing communication efforts. The plan identifies training sessions, programs, information sessions, special events and product development (audio-visual, printed materials and displays) for three targeted audiences: fishing communities, regulatory/policy setting agencies and the general public.

In 2010 and 2011, fishermen focus groups were conducted in Hawaii to assess the effectiveness of the Council's outreach efforts and elicit suggestions for improving it. This research was conducted by an independent research firm, which also conducted interviews to gauge the effectiveness of particular Council outreach projects in the Territories and the Commonwealth. The results indicated that fishermen were aware of the Council; however, their understanding of what the Council does could be improved. In 2011, in response to these comments, the Council developed a Communications Framework among other activities.

The Council publishes meeting notices in local publications in English and, in American Samoa, also in the Samoan language. Other regular Council outreach materials include a quarterly newsletter, a monograph series, brochures, displays, magazine articles and press releases and occasional videos, public serve announcements, proceedings and books.

The Council's regularly scheduled outreach and education activities, some of which have been conducted annually for more than a decade, include Fishers Forums, student art contests with teacher resources on various themes of fishery importance, traditional lunar calendars highlighting student art and traditional fishery information, and high school summer courses. The Council also occasionally conducts International Fishers Forums, teacher workshops, student symposiums, community workshops, fishermen workshops and other special events locally, regionally, nationally and internationally.

In 2013, the Council established an Education Committee, which spearheaded a memorandum of understanding signed by federal and local governments and higher education institutions in the Western Pacific Region. The aspiration of the MOU is to improve the capacities of the US Pacific Island territories to manage their fisheries and to enhance tertiary education in fisheries science and management offered in Hawai`i. In 2015, the first outcomes of the MOU included the implementation of the US Pacific Territories Fishery Capacity-Building scholarship and internship program.

The Council has increased its outreach through social media, including the Council website, Facebook, Twitter and Constant Contact distribution. It also works with the education and outreach staff of the other seven Reginal Fishery Management Councils on the fisherycouncils.org website, Managing Our Nation's Fisheries conferences and occasional publications, displays and events.

4.1.1.6 Council Five Year Research Priorities

The reauthorized Magnuson-Stevens Fishery Conservation and Management Act (MSRA), created new responsibilities and authorities for domestic regional fishery management councils and their advisory bodies. Following is the relevant MSRA text regarding the development and implementation of five-year regional research priorities by Councils. Section 302 (h) Each Council shall develop, in conjunction with the scientific and statistical committee, multi-year research priorities for fisheries, fishery interactions, habitats, and other areas of research that are necessary for management purposes that shall –

> (A) establish priorities for 5-year periods;
> (B) be updated as necessary; and
> (C) be submitted to the Secretary and the regional science centers of the National Marine Fisheries Service for their consideration in developing research priorities and budgets for the region of the Council.

The research priority document is vetted through the Council advisory groups and submitted to the Secretary of Commerce and NMFS on an annual basis for their consideration. These priorities are also the basis for Federal funding opportunities such as the Saltonstall Kennedy Grant Program. A process of addressing and monitoring these research priorities is yet to be developed by the Council and NMFS PIFSC.

Stock assessments for Council managed fisheries remains the highest research priority. Another priority is to understand the fishery dynamics as affected by fish imports (and exports) which is particularly critical for small island communities. For current research priorities, see the Council's website at www.wpcouncil.org.

4.1.1.7 Annual Fishery Reports and their Use

The Council's annual fishery reports serve as Stock Assessment and Fishery Evaluation (SAFE) reports for the Western Pacific region and contain information beyond the SAFE report requirements found in National Standard 2. Because they contain the most recent information about the fisheries, they serve as the basis for developing management measures and evaluating management alternatives as well as tracking the performance of this FEP.

The reports are generated by members of the Council's Plan Team and contain information about the MUS and their associated ecosystems derived from fishery dependent and fishery independent data collection systems. The SAFE Reports will typically contain information related to describing the fisheries, the ecosystem elements the fisheries influence and are in turn influenced by, and integrated characterizations of the fisheries. The specific elements of SAFE Reports may change due to availability of information or other factors. The current contents of the SAFE Reports can be obtained by contacting the Council or reviewing the most recent reports.

A comprehensive report will be created every 3 years, while a shorter report that describes more dynamic data elements will be generated during the interim years.

4.1.1.8 Other Applicable Laws and their Role

Section 303(a)(1)(C) of the MSA requires federal fishery management plans to be consistent with other applicable laws. These other laws impose additional procedural, substantive, and timing requirements on the decision process and their applicability must be assessed on a case-by-case basis. This FEP is consistent with the Magnuson-Stevens Act (16 USC 1851), including the ten National Standards, and other applicable law. These laws typically include the following:

- Administrative Procedure Act
- Coastal Zone Management Act
- Endangered Species Act
- Executive Orders 12630, 12866, 12898, 13089, 13132, 13158, 13175, 13272
- Information Quality Act
- Marine Mammal Protection Act
- National Environmental Policy Act
- National Marine Sanctuaries Act
- Paperwork Reduction Act
- Regulatory Flexibility Act

Specific information regarding the implications of each of these can be in the Operational Guidelines for the Fishery Management Process developed by NMFS in consultation with the Council Coordinating Committee at http://www.nmfs.noaa.gov/sfa/laws_policies/operational_guidelines/index.html. The statutes themselves, along with their guidance language, regulations, and associated case law are controlling in the instance of any discrepancy between them and this document.

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Appendix A: List of Acronyms

APA: Administrative Procedure Act

B: Stock biomass

B_{FLAG}: Minimum Biomass Flag

B_{MSY}: Biomass Maximum Sustainable Yield

B_{OY}: Biomass Optimum Yield

BMUS: Bottomfish Management Unit Species

CFR: Code of Federal Regulations

CITES: Council on International Trade and Endangered Species

CNMI: Commonwealth of the Northern Mariana Islands

CPUE: Catch per unit effort at the reference point

$CPUE_{MSY}$: Catch per unit effort Maximum Sustainable Yield

$CPUE_{REF}$: Catch per unit effort at the Reference Point

CRAMP: Coral Reef Assessment and Monitoring Program

CRE: Coral Reef Ecosystem

CRE-FMP: Coral Reef Ecosystem Fishery Management Plan

CRTF: Coral Reef Task Force

DAR: Division of Aquatic Resources, State of Hawaii

DOC: United States Department of Commerce

DOD: United States Department of Defense

DOI: United States Department of the Interior

EEZ: Exclusive Economic Zone

EFH: Essential Fish Habitat

EIS: Environmental Impact Statement

E_{MSY}: Effort Maximum Sustainable Yield

ENSO: El Niño Southern Oscillation

EO: Executive Order

EPAP: Ecosystem Principals Advisory Panel

ESA: Endangered Species Act

F: Fishing mortality

F_{MSY}: Fishing mortality Maximum Sustainable Yield

F_{OY}: Fishing mortality Optimum Yield

FEP: Fishery Ecosystem Plan

FLPMA: Federal Land Policy and Management Act

fm: fathoms

FMP: Fishery Management Plan

FR: Federal Register

FRFA: Final Regulatory Flexibility Analysis

ft: feet

FWCA: Fish and Wildlife Coordination Act

GIS: Geographic information systems

GPS: Global Positioning System

HAPC: Habitat Areas of Particular Concern

IQA: Information Quality Act

IRFA Initial Regulatory Flexibility Analysis

kg: kilograms

km: kilometers

lb: pounds

LOF List of Fisheries

m:	meters
mt:	metric tons
MFMT:	maximum fishing mortality threshold
MHI:	Main Hawaiian Islands
min SST:	minimum spawning stock threshold
mm:	millimeters
MMPA:	Marine Mammal Protection Act
MPA:	Marine Protected Area
MSA:	Magnuson-Stevens Fishery Conservation and Management Act
MSST:	Minimum Stock Size Threshold
MSY:	Maximum Sustainable Yield
MUS:	Management Unit Species
NDSA:	Naval Defense Sea Areas
NEPA:	National Environmental Policy Act
nm or nmi:	nautical miles
NMFS:	National Marine Fisheries Service (also known as NOAA Fisheries Service)
NOAA:	National Oceanic and Atmospheric Administration
NWHI:	Northwestern Hawaiian Islands
NWR:	National Wildlife Refuge
NWRSAA:	National Wildlife Refuge System Administration Act
OMB:	Office of Management and Budget
OY:	Optimum Yield
PBR:	Potential Biological Removal
PIFSC:	Pacific Islands Fisheries Science Center, NMFS
PIRO:	Pacific Islands Regional Office, NMFS

PRA:	Paperwork Reduction Act
PRIA:	Pacific Remote Island Areas
RFA:	Regulatory Flexibility Act
RIR:	Regulatory Impact Review
SFA:	Sustainable Fisheries Act
SLA:	Submerged Lands Act
SPR:	Spawning Potential Ratio
SSC:	Scientific and Statistical Committee
TALFF:	Total Allowable Level of Foreign Fishing
TSLA:	Territorial Submerged Lands Act
USCG:	United States Coast Guard
USFWS:	United States Fish and Wildlife Service
VMS:	Vessel Monitoring System
WPacFIN:	Western Pacific Fisheries Information Network, NMFS
WPRFMC:	Western Pacific Regional Fishery Management Council

Appendix B: List of Definitions

Adaptive Management: A program that adjusts regulations based on changing conditions of the fisheries and stocks.

Bycatch: Any fish harvested in a fishery 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 resources in plants, animals and microorganisms for use in food production, the development of new drugs and other biotechnology applications.

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 recreational 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 Ecosystem Plan, commercial fishing includes the commercial extraction of biocompounds.

Consensual Management: Decision making process where stakeholders meet and reach consensus on management measures and recommendations.

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.

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 Endangered Species Act (ESA), and which may require special management considerations or protection. These areas are designated pursuant to the ESA as having physical or biological features essential to the conservation of listed species.

Dealer: Any person who (1) Obtains, with the intention to resell management unit species, or portions thereof, that were harvested or received by a vessel that holds a permit or is otherwise regulated under this FEP; or (2) Provides recordkeeping, purchase, or sales assistance in obtaining or selling such management unit species (such as the services provided by a wholesale auction facility).

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 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 ecological changes.

Economic Discards: Fishery 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: A geographically specified system of organisms (including humans), the environment, and the processes that control its dynamics.

Ecosystem-Based Fishery Management: Fishery management actions aimed at conserving the structure and function of marine ecosystems in addition to conserving fishery resources.

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 (NEPA) to assess alternatives and analyze the impact on the environment of proposed major Federal actions significantly affecting the human environment.

Essential Fish Habitat (EFH): Those waters and substrate necessary to a species or species group or complex, 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 the Magnuson Act, 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.

Exporter: One who sends species in the fishery management unit to other countries for sale, barter or any other form of exchange (also applies to shipment to other states, territories or islands).

Fish: Finfish, mollusks, crustaceans and all other forms of marine animal and plant life other than 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 Ecosystem Plan: A fishery ecosystem management plan that contains conservation and management measures necessary and appropriate for fisheries within a given ecosystem to prevent overfishing and rebuild overfished stocks, and to protect, restore, and promote the long-term health and stability of the fishery.

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.

Food Web: Inter-relationships among species that depend on each other for food (predator-prey pathways).

Framework Measure: Management measure listed in an FEP for future consideration. Implementation can occur through an administratively simpler process than a full FEP amendment.

Ghost Fishing: The chronic and/or inadvertent capture and/or loss of fish or other marine organisms by lost or discarded fishing gear.

Habitat: Living place of an organism or community, characterized by its physical and biotic properties.

Habitat Area of Particular Concern (HAPC): Those areas of EFH identified pursuant to Section 600.815(a)(8). In determining whether a type or area of EFH should be designated as a HAPC, one or more of the following criteria should 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.

Harvest: The catching or taking of a marine organism or fishery MUS by any means.

Hook-and-line: Fishing gear that consists of one or more hooks attached to one or more lines.

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: A Marine Protected Area zoned to allow limited fishing activities.

Main Hawaiian Islands (MHI): The islands of the Hawaiian Islands archipelago consisting of Niihau, Kauai, Oahu, Molokai, Lanai, Maui, Kahoolawe, Hawaii and all of the smaller associated islets lying east of 161° W longitude.

Marine Protected Area (MPA): An area designated to allow or prohibit certain fishing activities.

Marine National Monument (MNM):

Maximum Sustainable Yield (MSY): The largest long-term average catch or yield that can be taken, from a stock or stock complex under prevailing ecological and environmental conditions and fishery technological characteristics (e.g., gear selectivity), and the distribution of catch among fleets.

National Marine Fisheries Service (NMFS): The component of the National Oceanic and Atmospheric Administration (NOAA), Department of Commerce, responsible for the conservation and management of living marine resources. Also known as NOAA Fisheries Service.

No-Take MPA: A Marine Protected Area where no fishing or removal of living marine resources is authorized.

Northwestern Hawaiian Islands (NWHI): the islands of the Hawaiian Islands archipelago lying to the west of 161°W longitude.

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.

Overfished: A stock or stock complex is considered "overfished" when its biomass has declined below a level that jeopardizes the capacity of the stock or stock complex to produce maximum sustainable yield on a continuing basis.

Overfishing: (to overfish) occurs whenever a stock or stock complex is subjected to a level of fishing mortality or total annual catch that jeopardizes the capacity of a stock or stock complex to produce maximum sustainable yield on a continuing basis.

Pacific Remote Island Areas (PRIA): Baker Island, Howland Island, Jarvis Island, Johnston Atoll, Kingman Reef, Midway Atoll, Wake Island and Palmyra Atoll.

Passive Fishing Gear: Gear left unattended for a period of time prior to retrieval (e.g., traps, gill nets).

Precautionary Approach: The implementation of conservation measures even in the absence of scientific certainty that fish stocks are being overexploited.

Recreational Fishing: Fishing for sport or pleasure.

Recruitment: A measure of 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 fishermen are required by regulation to discard whenever caught, or are required to retain but not sell.

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.

Social Acceptability: The acceptance of the suitability of management measures 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.

Adaptive Management: A program that adjusts regulations based on changing conditions of the fisheries and stocks.

Bycatch: Any fish harvested in a fishery 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 resources in plants, animals and microorganisms for use in food production, the development of new drugs and other biotechnology applications.

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 recreational 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 Ecosystem Plan, commercial fishing includes the commercial extraction of biocompounds.

Consensual Management: Decision making process where stakeholders meet and reach consensus on management measures and recommendations.

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.

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 Endangered Species Act (ESA), and which may require special management considerations or protection. These areas are designated pursuant to the ESA as having physical or biological features essential to the conservation of listed species.

Dealer: Any person who (1) Obtains, with the intention to resell management unit species, or portions thereof, that were harvested or received by a vessel that holds a permit or is otherwise regulated under this FEP; or (2) Provides recordkeeping, purchase, or sales assistance in obtaining or selling such management unit species (such as the services provided by a wholesale auction facility).

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 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 ecological changes.

Economic Discards: Fishery 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: A geographically specified system of organisms (including humans), the environment, and the processes that control its dynamics.

Ecosystem-Based Fishery Management: Fishery management actions aimed at conserving the structure and function of marine ecosystems in addition to conserving fishery resources.

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 (NEPA) to assess alternatives and analyze the impact on the environment of proposed major Federal actions significantly affecting the human environment.

Essential Fish Habitat (EFH): Those waters and substrate necessary to a species or species group or complex, 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 the Magnuson Act, 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.

Exporter: One who sends species in the fishery management unit to other countries for sale, barter or any other form of exchange (also applies to shipment to other states, territories or islands).

Fish: Finfish, mollusks, crustaceans and all other forms of marine animal and plant life other than 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 Ecosystem Plan: A fishery ecosystem management plan that contains conservation and management measures necessary and appropriate for fisheries within a given ecosystem to prevent overfishing and rebuild overfished stocks, and to protect, restore, and promote the long-term health and stability of the fishery.

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.

Food Web: Inter-relationships among species that depend on each other for food (predator-prey pathways).

Framework Measure: Management measure listed in an FEP for future consideration. Implementation can occur through an administratively simpler process than a full FEP amendment.

Ghost Fishing: The chronic and/or inadvertent capture and/or loss of fish or other marine organisms by lost or discarded fishing gear.

Habitat: Living place of an organism or community, characterized by its physical and biotic properties.

Habitat Area of Particular Concern (HAPC): Those areas of EFH identified pursuant to Section 600.815(a)(8). In determining whether a type or area of EFH should be designated as a HAPC, one or more of the following criteria should 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.

Harvest: The catching or taking of a marine organism or fishery MUS by any means.

Hook-and-line: Fishing gear that consists of one or more hooks attached to one or more lines.

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: A Marine Protected Area zoned to allow limited fishing activities.

Main Hawaiian Islands (MHI): The islands of the Hawaiian Islands archipelago consisting of Niihau, Kauai, Oahu, Molokai, Lanai, Maui, Kahoolawe, Hawaii and all of the smaller associated islets lying east of 161° W longitude.

Marine Protected Area (MPA): An area designated to allow or prohibit certain fishing activities.

Marine National Monument (MNM):Marine protected area designated by Presidential Proclamation, via the Antiquities Act of 1906.

Maximum Sustainable Yield (MSY): The largest long-term average catch or yield that can be taken, from a stock or stock complex under prevailing ecological and environmental conditions and fishery technological characteristics (e.g., gear selectivity), and the distribution of catch among fleets.

National Marine Fisheries Service (NMFS): The component of the National Oceanic and Atmospheric Administration (NOAA), Department of Commerce, responsible for the conservation and management of living marine resources. Also known as NOAA Fisheries Service.

No-Take MPA: A Marine Protected Area where no fishing or removal of living marine resources is authorized.

Northwestern Hawaiian Islands (NWHI): the islands of the Hawaiian Islands archipelago lying to the west of 161°W longitude.

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.

Overfished: A stock or stock complex is considered "overfished" when its biomass has declined below a level that jeopardizes the capacity of the stock or stock complex to produce maximum sustainable yield on a continuing basis.

Overfishing: (to overfish) occurs whenever a stock or stock complex is subjected to a level of fishing mortality or total annual catch that jeopardizes the capacity of a stock or stock complex to produce maximum sustainable yield on a continuing basis.

Pacific Remote Island Areas (PRIA): Baker Island, Howland Island, Jarvis Island, Johnston Atoll, Kingman Reef, Midway Atoll, Wake Island and Palmyra Atoll.

Passive Fishing Gear: Gear left unattended for a period of time prior to retrieval (e.g., traps, gill nets).

Precautionary Approach: The implementation of conservation measures even in the absence of scientific certainty that fish stocks are being overexploited.

Recreational Fishing: Fishing for sport or pleasure.

Recruitment: A measure of 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 fishermen are required by regulation to discard whenever caught, or are required to retain but not sell.

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.

Social Acceptability: The acceptance of the suitability of management measures 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.

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 to obtain food for personal and/or community use rather than for profit sales or recreation.

Target Resources: Species or taxa sought after in a directed fishery.

Trophic Web: A 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.

Western Pacific Regional Fishery Management Council (WPRFMC or Council): A Regional Fishery Management Council established under the MSA, consisting of the State of Hawaii, the Territory of American Samoa, the Territory of Guam, and the Commonwealth of the Northern Mariana Islands which has authority over the fisheries in the Pacific Ocean seaward of such States, Territories, Commonwealths, and Possessions of the United States in the Pacific Ocean Area. The Council has 13 voting members including eight appointed by the Secretary of Commerce at least one of whom is appointed from each of the following States: Hawaii, the Territories of American Samoa and Guam, and the Commonwealth of the Northern Mariana Islands.

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Appendix C: Regulations Implementing the American Samoa Fishery Ecosystem Plan and Rose Atoll Marine National Monument

PART 665—FISHERIES IN THE WESTERN PACIFIC

Contents

AUTHORITY: 16 U.S.C. 1801 *et seq.*

SOURCE: 75 FR 2205, Jan. 14, 2010, unless otherwise noted.

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Subpart A—General

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§665.1 Purpose and scope.

(a) The regulations in this part govern fishing for western Pacific fishery ecosystem MUS by vessels of the United States that operate or are based inside the outer boundary of the U.S. EEZ around American Samoa, Hawaii, Guam, the Northern Mariana Islands, Palmyra Atoll, Kingman Reef, Jarvis Island, Baker Island, Howland Island, Johnston Atoll, and Wake Island.

(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 50 CFR part 600.

(c) Regulations governing the harvest, possession, landing, purchase, and sale of shark fins are found in 50 CFR part 600 subpart N.

(d) This subpart contains regulations that are common to all western Pacific fisheries managed under Fishery Ecosystem Plans (FEPs) prepared by the Western Pacific Fishery Management Council under the Magnuson-Stevens Act.

(e) Regulations specific to individual areas and fisheries are included in subparts B through F of this part.

(f) Nothing in subparts B through F of this part is intended to supersede any valid state or Federal regulations that are more restrictive than those published here.

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§665.2 Relation to other laws.

NMFS recognizes that any state law pertaining to vessels registered under the laws of that state while operating in the fisheries regulated under this part, that is consistent with this part and the FEPs implemented by this part, shall continue in effect with respect to fishing activities regulated under this part.

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§665.3 Licensing and registration.

Any person who is required to do so by applicable state law or regulation must comply with licensing and registration requirements in the exact manner required by applicable state law or regulation.

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§665.4 Annual catch limits.

(a) *General.* For each fishing year, the Regional Administrator shall specify an annual catch limit, including any overage adjustments, for each stock or stock complex of management unit species defined in subparts B through F of this part, as recommended by the Council, and considering the best available scientific, commercial, and other information about the fishery for that stock or stock complex. The annual catch limit shall serve as the basis for invoking accountability measures in paragraph (f) of this section.

(b) *Overage adjustments.* If landings of a stock or stock complex exceed the specified annual catch limit in a fishing year, the Council will take action in accordance with 50 CFR 600.310(g), which may include recommending that the Regional Administrator reduce the annual catch limit for the subsequent year by the amount of the overage or other measures, as appropriate.

(c) *Exceptions.* The Regional Administrator is not required to specify an annual catch limit for a management unit species that is statutorily excepted from the requirement pursuant to 50 CFR 600.310(h)(2), or that the Council has identified as an ecosystem component species. The Regional Administrator will publish in the FEDERAL REGISTER the list of ecosystem component species, and will publish any changes to the list, as necessary.

(d) *Annual catch target.* For each fishing year, the Regional Administrator may also specify an annual catch target that is below the annual catch limit of a stock or stock complex, as recommended by the Council. When used, the annual catch target shall serve as the basis for invoking accountability measures in paragraph (f) of this section.

(e) *Procedures and timing.* (1) No later than 60 days before the start of a fishing year, the Council shall recommend to the Regional Administrator an annual catch limit, including any overage adjustment, for each stock or stock complex. The recommended limit should be based on a recommendation of the SSC of the acceptable biological catch for each stock or stock complex. The Council may not recommend an annual catch limit that exceeds the acceptable biological catch recommended by the SSC. The Council may also recommend an annual catch target below the annual catch limit.

(2) No later than 30 days before the start of a fishing year, the Regional Administrator shall publish in the FEDERAL REGISTER a notice of the proposed annual catch limit specification and any associated annual catch target, and request public comment.

(3) No later than the start of a fishing year, the Regional Administrator shall publish in the FEDERAL REGISTER and use other methods to notify permit holders of the final annual catch limit specification and any associated annual catch target.

(f) *Accountability measures.* When any annual catch limit or annual catch target is projected to be reached, based on available information, the Regional Administrator shall publish notification to that effect in the FEDERAL REGISTER and shall use other means to notify permit holders.

(1) The notice will include an advisement that fishing for that stock or stock complex will be restricted beginning on a specified date, which shall not be earlier than 7 days after the date of filing the notice for public inspection at the Office of the Federal Register. The restriction may include, but is not limited to, closure of the fishery, closure of specific areas, changes to bag limits, or restrictions in effort. The restriction will remain in effect until the end of the fishing year, except that the Regional Administrator may, based on a recommendation from the Council, remove or modify the restriction before the end of the fishing year.

(2) It is unlawful for any person to conduct fishing in violation of the restrictions specified in the notification issued pursuant to paragraph (f)(1) of this section.

[76 FR 37286, June 27, 2011]

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§§665.5-665.11 [Reserved]

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§665.12 Definitions.

In addition to the definitions in the Magnuson-Stevens Act, §600.10 of this chapter, and subparts B through F of this part, general definitions for western Pacific fisheries have the following meanings:

American Samoa FEP means the Fishery Ecosystem Plan for American Samoa.

Bottomfish FMP means the Fishery Management Plan for Bottomfish and Seamount Groundfish of the Western Pacific Region established in 1986 and replaced by FEPs.

Carapace length means a measurement in a straight line from the ridge between the two largest spines above the eyes, back to the rear edge of the carapace of a spiny lobster (see Figure 1 to this part).

Circle hook means a fishing hook with the point turned perpendicularly back towards the shank.

Commercial fishing means 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. All lobster fishing in Crustacean Permit Area 1 is considered commercial fishing.

Commonwealth of the Northern Mariana Islands (CNMI) means the Northern Mariana Islands.

Coral Reef Ecosystems FMP means the Fishery Management Plan for Coral Reef Ecosystems of the Western Pacific Region established in 2004 and replaced by FEPs.

Council means the Western Pacific Fishery Management Council.

Crustacean receiving vessel means a vessel of the United States to which lobsters taken in a crustacean management area are transferred from another vessel.

Crustaceans FMP means the Fishery Management Plan for Crustacean Fisheries of the Western Pacific Region established in 1982 and replaced by FEPs.

Currently harvested coral reef taxa (CHCRT) means coral reef associated species, families, or subfamilies, as defined in §§665.121, 665.221, 665.421, and 665.621, that have annual landings greater than 454.54 kg (1,000 lb) as reported on individual state, commonwealth, or territory catch reports or through creel surveys. Fisheries and research data from many of these species have been analyzed by regional management agencies.

Customary exchange means the non-market exchange of marine resources between fishermen and community residents, including family and friends of community residents, for goods, and/or services for cultural, social, or religious reasons. Customary exchange may include cost recovery through monetary reimbursements and other means for actual trip expenses, including but not limited to ice, bait, fuel, or food, that may be necessary to participate in fisheries in the western Pacific. Actual trip expenses do not include expenses that a fisherman would incur without making a fishing trip, including expenses relating to dock space, vessel mortgage payments, routine vessel maintenance, vessel registration fees, safety equipment required by U.S. Coast Guard, and other incidental costs and expenses normally associated with ownership of a vessel.

Dead coral means any precious coral that no longer has any live coral polyps or tissue.

Ecosystem component species means any western Pacific MUS that the Council has identified to be, generally, a non-target species, not determined to be subject to overfishing, approaching overfished, or overfished, not likely to become subject to overfishing or overfished, and generally not retained for sale or personal use.

EFP means an experimental fishing permit.

First level buyer means:

(1) The first person who purchases, with the intention to resell, management unit species, or portions thereof, that were harvested by a vessel that holds a permit or is otherwise regulated under crustacean fisheries in subparts B through E of this part; or

(2) A person who provides recordkeeping, purchase, or sales assistance in the first transaction involving MUS (such as the services provided by a wholesale auction facility).

Fishing gear, as used in regulations for the American Samoa, CNMI, Hawaii, and PRIA bottomfish fisheries in subparts B through E of this part, includes:

(1) Bottom trawl, which means a trawl in which the otter boards or the footrope of the net are in contact with the sea bed;

(2) Gillnet, (see §600.10);

(3) Hook-and-line, which means one or more hooks attached to one or more lines;

(4) Set net, which means a stationary, buoyed, and anchored gill net; and

(5) Trawl, (see §600.10).

Fishing trip means a period of time during which fishing is conducted, beginning when the vessel leaves port and ending when the vessel lands fish.

Fishing year means the year beginning at 0001 local time on January 1 and ending at 2400 local time on December 31, with the exception of fishing for Hawaii Restricted Bottomfish Species and any precious coral MUS.

Freeboard means the straight line vertical distance between a vessel's working deck and the sea surface. If the vessel does not have gunwale door or stern door that exposes the working deck, freeboard means the straight line vertical distance between the top of a vessel's railing and the sea surface.

Harvest guideline means a specified numerical harvest objective.

Hawaiian Archipelago means the Main and Northwestern Hawaiian Islands, including Midway Atoll.

Hawaii FEP means the Fishery Ecosystem Plan for the Hawaiian Archipelago.

Hookah breather means a tethered underwater breathing device that pumps air from the surface through one or more hoses to divers at depth.

Incidental catch or incidental species means species caught while fishing for the primary purpose of catching a different species.

Land or landing means offloading fish from a fishing vessel, arriving in port to begin offloading fish, or causing fish to be offloaded from a fishing vessel.

Large vessel means, as used in this part, any vessel equal to or greater than 50 ft (15.2 m) in length overall.

Length overall (LOA) or length of a vessel as used in this part, means the horizontal distance, rounded to the nearest foot (with any 0.5 foot or 0.15 meter fraction rounded upward), between the foremost part of the stem and the aftermost part of the stern, excluding bowsprits, rudders, outboard motor brackets, and similar fittings or attachments (see Figure 2 to this part). “Stem” is the foremost part of the vessel, consisting of a section of timber or fiberglass, or cast forged or rolled metal, to which the sides of the vessel are united at the fore end, with the lower end united to the keel, and with the bowsprit, if one is present, resting on the upper end. “Stern” is the aftermost part of the vessel.

Live coral means any precious coral that has live coral polyps or tissue.

Live rock means 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.

Low-use marine protected area (MPA) means an area of the U.S. EEZ where fishing operations have specific restrictions in order to protect the coral reef ecosystem, as specified under area restrictions in subparts B through F of this part.

Main Hawaiian Islands (MHI) means the islands of the Hawaii Archipelago lying to the east of 161° W. long.

Mariana Archipelago means Guam and the Northern Mariana Islands.

Mariana FEP means the Fishery Ecosystem Plan for the Mariana Archipelago.

Medium vessel, as used in this part, means any vessel equal to or more than 40 ft (12.2 m) and less than 50 ft (15.2 m) LOA.

Non-commercial fishing means fishing that does not meet the definition of commercial fishing in the Magnuson-Stevens Fishery Conservation and Management Act, and includes, but is not limited to, sustenance, subsistence, traditional indigenous, and recreational fishing.

Non-precious coral means any species of coral other than those listed under the definitions for precious coral in §§665.161, 665.261, 665.461, and 665.661.

Non-selective gear means any gear used for harvesting coral that cannot discriminate or differentiate between types, size, quality, or characteristics of living or dead coral.

Northwestern Hawaiian Islands (NWHI) means the islands of the Hawaiian Archipelago lying to the west of 161° W. long.

No-take MPA means an area of the U.S. EEZ that is closed to fishing for or harvesting of any MUS, as defined in subparts B through F of this part.

Offload means to remove MUS from a vessel.

Offset circle hook means a circle hook in which the barbed end of the hook is displaced relative to the parallel plane of the eyed end, or shank, of the hook when laid on its side.

Owner, as used in the regulations for the crustacean fisheries in subparts B through E of this part and §665.203(i) and (j), means a person who is identified as the current owner of the vessel as described in the Certificate of Documentation (Form CG-1270) issued by the United States Coast Guard (USCG) for a documented vessel, or in a registration certificate issued by a state, a territory, or the USCG for an undocumented vessel. As used in the regulations for the precious coral fisheries in subparts B through E of this part and §665.203(c) through (h), the definition of “owner” in §600.10 of this chapter continues to apply.

Pacific Islands Regional Office (PIRO) means the headquarters of the Pacific Islands Region, NMFS, located at 1845 Wasp Blvd., Bldg. 176, Honolulu, HI 96818; telephone number: 808-725-5000.

Pacific remote island areas (PRIA, or U.S. island possessions in the Pacific Ocean) means Palmyra Atoll, Kingman Reef, Jarvis Island, Baker Island, Howland Island, Johnston Atoll, Wake Island, and Midway Atoll.

Pelagics FEP means the Fishery Ecosystem Plan for Pacific Pelagic Fisheries of the Western Pacific Region.

Pelagics FMP means the Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region that was established in 1987 and replaced by the western Pacific pelagic FEP.

Potentially harvested coral reef taxa (PHCRT) means coral reef associated species, families, or subfamilies, as defined in §§665.121, 665.221, 665.421, and 665.621, for which little or no information is available beyond general taxonomic and distribution descriptions. These species have either not been caught in the past or have been harvested annually in amounts less than 454.54 kg (1,000 lb).

Precious Corals FMP means the Fishery Management Plan for Precious Corals of the Western Pacific Region established in 1983 and replaced by fishery ecosystem plans (FEPs).

PRIA FEP means the Fishery Ecosystem Plan for the Pacific Remote Island Areas of Palmyra Atoll, Kingman Reef, Jarvis Island, Baker Island, Howland Island, Johnston Atoll, and Wake Island.

Protected species means an animal protected under the MMPA, as amended, listed under the ESA, as amended, or subject to the Migratory Bird Treaty Act, as amended.

Receiving vessel means a vessel that receives fish or fish products from a fishing vessel, and with regard to a vessel holding a permit under §665.801(e), that also lands western Pacific pelagic MUS taken by other vessels using longline gear.

Recreational fishing means fishing conducted for sport or pleasure, including charter fishing.

Regional Administrator means Regional Administrator, Pacific Islands Region, NMFS (see Table 1 of §600.502 of this chapter for address).

Selective gear means any gear used for harvesting coral that can discriminate or differentiate between type, size, quality, or characteristics of living or dead coral.

Special Agent-In-Charge (SAC) means the Special Agent-In-Charge, NMFS, Pacific Islands Enforcement Division, located at 1845 Wasp Blvd., Bldg. 176, Honolulu, HI 96818; telephone number: 808-725-6100, or a designee.

Special permit means a permit issued to allow fishing for coral reef ecosystem MUS in low-use MPAs or to fish for any PHCRT.

SSC means the Scientific and Statistical Committee of the Western Pacific Fishery Management Council.

State of Hawaii commercial marine license means the license required by the State of Hawaii for anyone to take marine life for commercial purposes (also known as the commercial fishing license).

Transship means to offload or otherwise transfer MUS or products thereof to a receiving vessel.

Trap means a box-like device used for catching and holding lobsters or fish.

U.S. harvested coral means coral caught, taken, or harvested by vessels of the United States within any fishery for which an FMP or FEP has been implemented under the Magnuson-Stevens Act.

Vessel monitoring system unit (VMS unit) means the hardware and software owned by NMFS, installed on vessels by NMFS, and required to track and transmit the positions of certain vessels.

Western Pacific fishery management area means those waters shoreward of the outer boundary of the EEZ around American Samoa, Guam, Hawaii, CNMI, Midway, Johnston and Palmyra Atolls, Kingman Reef, and Wake, Jarvis, Baker, and Howland Islands.

[75 FR 2205, Jan. 14, 2010, as amended at 76 FR 37286, June 27, 2011; 78 FR 33003, June 3, 2013; 79 FR 64111, Oct. 28, 2014]

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§665.13 Permits and fees.

(a) *Applicability.* The requirements for permits for specific western Pacific fisheries are set forth in subparts B through I of this part.

(b) *Validity.* Each permit is valid for fishing only in the specific fishery management areas identified on the permit.

(c) *Application.* (1) An application for a permit to operate in a Federal western Pacific fishery that requires a permit and is regulated under subparts B through I of this part may be obtained from NMFS PIRO. The completed application must be submitted to PIRO for consideration. In no case shall PIRO accept an application that is not on a Federal western Pacific fisheries permit application form.

(2) A minimum of 15 days after the day PIRO receives a complete application should be allowed for processing the application for fisheries under subparts B through I of this part. If an incomplete or improperly completed application is filed, NMFS will notify the applicant of the deficiency. If the applicant fails to correct the deficiency within 30 days following the date of the letter of notification of deficiency, the application will be administratively closed.

(d) *Change in application information.* Any change in the permit application information or vessel documentation, submitted under paragraph (c) of this section, must be reported to PIRO in writing within 15 days of the change to avoid a delay in processing the permit application. A minimum of 10 days from the day the information is received by PIRO should be given for PIRO to record any change in information from the permit application submitted under paragraph (c) of this section. Failure to report such changes may result in a delay in processing an application, permit holders failing to receive important notifications, or sanctions pursuant to the Magnuson-Stevens Act at 16 U.S.C. 1858(g) or 15 CFR part 904, subpart D.

(e) *Issuance.* After receiving a complete application submitted under paragraph (c) of this section, the Regional Administrator will issue a permit to an applicant who is eligible under this part, as appropriate.

(f) *Fees.* (1) PIRO will not charge a fee for a permit issued under §§665.142, 665.162, 665.242, 665.262, 665.442, 665.462, 665.642, or 665.662 of this part, for a Ho'omalu limited access permit issued under §665.203, or for a Guam bottomfish permit issued under §665.404.

(2) PIRO will charge a non-refundable processing fee for each application (including transfer and renewal) for each permit listed in paragraphs (f)(2)(i) through (f)(2)(xiii) of this section. The amount of the fee is calculated in accordance with the procedures of the NOAA Finance Handbook for determining the administrative costs incurred in processing the permit. The fee may not exceed such costs. The appropriate fee is specified with each application form and must accompany each application. Failure to pay the fee will preclude the issuance, transfer, or renewal of any of the following permits:

(i) Hawaii longline limited access permit.

(ii) Mau Zone limited access permit.

(iii) Coral reef ecosystem special permit.

(iv) American Samoa longline limited access permit.

(v) MHI non-commercial bottomfish permit.

(vi) Western Pacific squid jig permit.

(vii) Crustacean permit.

(viii) CNMI commercial bottomfish permit.

(ix) Marianas Trench Monument non-commercial permit.

(x) Marianas Trench Monument recreational charter permit.

(xi) Pacific Remote Islands Monument recreational charter permit.

(xii) Rose Atoll Monument non-commercial permit.

(xiii) Rose Atoll Monument recreational charter permit.

(g) *Expiration.* A permit issued under subparts B through I of this part is valid for the period specified on the permit unless revoked, suspended, transferred, or modified under 15 CFR part 904.

(h) *Replacement.* Replacement permits may be issued, without charge, to replace lost or mutilated permits. An application for a replacement permit is not considered a new application.

(i) *Transfer.* An application for a permit transfer under §§665.203(d), 665.242(e), or 665.801(k), or for registration of a permit for use with a replacement vessel under §665.203(i), must be submitted to PIRO as described in paragraph (c) of this section.

(j) *Alteration.* Any permit that has been altered, erased, or mutilated is invalid.

(k) *Display.* Any permit issued under this subpart, or a facsimile of such permit, must be on board the vessel at all times while the vessel is fishing for, taking, retaining, possessing, or landing MUS shoreward of the outer boundary of the fishery management area. Any permit issued under this section must be displayed for inspection upon request of an authorized officer.

(l) *Sanctions.* Procedures governing sanctions and denials are found at subpart D of 15 CFR part 904.

(m) *Permit appeals.* Procedures for appeals of permitting and administrative actions are specified in the relevant subparts of this part.

[75 FR 2205, Jan. 14, 2010, as amended at 78 FR 33003, June 3, 2013; 78 FR 39583, July 2, 2013]

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§665.14 Reporting and recordkeeping.

(a) Except for precious coral and crustacean fisheries, any person who is required to do so by applicable state law or regulation must make and/or file all reports of MUS landings containing all data and in the exact manner required by applicable state law or regulation.

(b) *Fishing record forms*—(1) *Applicability.* (i) The operator of a fishing vessel subject to the requirements of §§665.124, 665.142, 665.162, 665.203(a)(2), 665.224, 665.242, 665.262, 665.404, 665.424, 665.442, 665.462, 665.603, 665.624, 665.642, 665.662, 665.801, 665.905, 665.935, or 665.965 must maintain on board the vessel an accurate and complete record of catch, effort, and other data on paper report forms provided by the Regional Administrator, or electronically as specified and approved by the Regional Administrator, except as allowed in paragraph (b)(1)(iii) of this section.

(ii) All information specified by the Regional Administrator must be recorded on paper or electronically within 24 hours after the completion of each fishing day. The logbook information, reported on paper or electronically, for each day of the fishing trip must be signed and dated or otherwise authenticated by the vessel operator in the manner determined by the Regional Administrator, and be submitted or transmitted via an approved method as specified by the Regional Administrator, and as required by this paragraph (b).

(iii) In lieu of the requirements in paragraph (a)(1)(i) of this section, the operator of a fishing vessel registered for use under a Western Pacific squid jig permit pursuant to the requirements of §665.801(g) may participate in a state reporting system. If participating in a state reporting system, all required information must be recorded and submitted in the exact manner required by applicable state law or regulation.

(2) *Timeliness of submission.* (i) If fishing was authorized under a permit pursuant to §§665.142, 665.242, 665.442, 665.404, 665.162, 665.262, 665.462, 665.662, or 665.801, the vessel operator must submit the original logbook information for each day of the fishing trip to the Regional Administrator within 72 hours of the end of each fishing trip, except as allowed in paragraph (iii) of this section.

(ii) If fishing was authorized under a permit pursuant to §665.203(a)(2), the vessel operator or vessel owner must submit the original logbook form for each day of the fishing trip to the Regional Administrator within 72 hours of the end of each fishing trip.

(iii) If fishing was authorized under a PRIA bottomfish permit pursuant to §665.603(a), PRIA pelagic troll and handline permit pursuant to §665.801(f), crustacean fishing permit for the PRIA (Permit Area 4) pursuant to §665.642(a), or a precious coral fishing permit for Permit Area X-P-PI pursuant to §665.662, the original logbook form for each day of fishing within EEZ waters around the PRIA must be submitted to the Regional Administrator within 30 days of the end of each fishing trip.

(iv) If fishing was authorized under a permit pursuant to §§665.124, 665.224, 665.424, 665.624, 665.905, 665.935, or 665.965, the original logbook information for each day of fishing must be submitted to the Regional Administrator within 30 days of the end of each fishing trip.

(c) *Transshipment logbooks.* Any person subject to the requirements of §§665.124(a)(2), 665.224(a)(2), 665.424(a)(2), 665.624(a)(2), or 665.801(e) 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. Each form must be signed and dated by the receiving vessel operator. The original logbook for each day of transshipment activity must be submitted to the Regional Administrator within 72 hours of each landing of western Pacific pelagic MUS. The original logbook for each day of transshipment activity must be submitted to the Regional Administrator within 7 days of each landing of coral reef ecosystem MUS.

(d) *Sales report.* The operator of any fishing vessel subject to the requirements of §§665.142, 665.242, 665.442, or 665.642, or the owner of a medium or large fishing vessel subject to the requirements of §665.404(a)(2) must submit to the Regional Administrator, within 72 hours of offloading of crustacean MUS, an accurate and complete sales report on a form provided by the Regional Administrator. The form must be signed and dated by the fishing vessel operator.

(e) *Packing or weigh-out slips.* The operator of any fishing vessel subject to the requirements of §§665.142, 665.242, 665.442, or 665.642 must attach packing or weighout slips provided to the operator by the first-level buyer(s), unless the packing or weighout slips have not been provided in time by the buyer(s).

(f) *Modification of reporting and recordkeeping requirements.* The Regional Administrator may, after consultation with the Council, initiate rulemaking to modify the information to be provided on the fishing record forms, transshipment logbook, and sales report forms and timeliness by which the information is to be provided, including the submission of packing or weighout slips.

(g) *Availability of records for inspection.* (1) Western Pacific pelagic MUS. Upon request, any fish dealer must immediately provide an authorized officer access to inspect and copy all records of purchases, sales, or other transactions involving western Pacific pelagic MUS taken or handled by longline vessels that have permits issued under this subpart or that are otherwise subject to subpart F of this part, including, but not limited to, information concerning:

(i) The name of the vessel involved in each transaction and the owner and operator of the vessel.

(ii) The weight, number, and size of each species of fish involved in each transaction.

(iii) Prices paid by the buyer and proceeds to the seller in each transaction.

(2) *Crustacean MUS.* Upon request, any first-level buyer must immediately allow an authorized officer and any employee of NMFS designated by the Regional Administrator, to access, inspect, and copy all records relating to the harvest, sale, or transfer of crustacean MUS taken by vessels that have permits issued under this subpart or §§665.140 through 665.145, 665.240 through 665.252, 665.440 through 665.445, or 665.640 through 665.645 of this part. This requirement may be met by furnishing the information on a worksheet provided by the Regional Administrator. The information must include, but is not limited to:

(i) The name of the vessel involved in each transaction and the owner or operator of the vessel.

(ii) The amount, number, and size of each MUS involved in each transaction.

(iii) Prices paid by the buyer and proceeds to the seller in each transaction.

(3) Bottomfish and seamount groundfish MUS. Any person who is required by state laws and regulations to maintain records of landings and sales for vessels regulated by this subpart and by §§665.100 through 665.105, 665.200 through 665.212, 665.400 through 665.407, and 665.600 through 665.606 of this part must make those records immediately available for Federal inspection and copying upon request by an authorized officer.

(4) *Coral reef ecosystem MUS.* Any person who has a special 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 MUS by this subpart and §§665.120 through 665.128, 665.220 through 665.228, 665.420 through 665.428, or 665.620 through 665.628 of this part must make those records immediately available for Federal inspection and copying upon request by an authorized officer as defined in §600.10 of this chapter.

(h) *State reporting.* Any person who has a permit under §§665.124, 665.203, 665.224, 665.404, 665.424, 665.603, or 665.624 and who is regulated by state laws and regulations to maintain and submit records of catch and effort, landings and sales for vessels regulated by subparts B through F of this part must maintain and submit those records in the exact manner required by state laws and regulations.

[75 FR 2205, Jan. 14, 2010, as amended at 78 FR 33003, June 3, 2013; 78 FR 39583, July 2, 2013]

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§665.15 Prohibitions.

In addition to the prohibitions in §600.725 of this chapter, it is unlawful for any person to:

(a) 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 §§665.13 or 665.17, unless the vessel was at sea when the permit was issued under §665.13, in which case the permit must be on board the vessel before its next trip.

(b) File false information on any application for a fishing permit under §665.13 or an EFP under §665.17.

(c) Fail to file reports in the exact manner required by any state law or regulation, as required in §665.14.

(d) Falsify or fail to make, keep, maintain, or submit any logbook or logbook form or other record or report required under §§665.14 and 665.17.

(e) Refuse to make available to an authorized officer or a designee of the Regional Administrator for inspection or copying, any records that must be made available in accordance with §665.14.

(f) Fail to affix or maintain vessel or gear markings, as required by §§665.16, 665.128, 665.228, 665.246, 665.428, 665.628, or 665.804.

(g) Violate a term or condition of an EFP issued under §665.17.

(h) Fail to report any take of or interaction with protected species as required by §665.17(k).

(i) Fish without an observer on board the vessel after the owner or agent of the owner has been directed by NMFS to make accommodations available for an observer under §§665.17, 665.105, 665.145, 665.207, 665.247, 665.407, 665.445, 665.606, 665.645, or 665.808.

(j) Refuse to make accommodations available for an observer when so directed by the Regional Administrator under §§665.105, 665.145, 665.207, 665.247, 665.407, 665.445, 665.606, 665.645, or 665.808, or under any provision in an EFP issued under §665.17.

(k) Fail to notify officials as required in §§665.126, 665.144, 665.205, 665.226, 665.244, 665.426, 665.444, 665.626, 665.644, 665.803, or 665.808.

(l) Fish for, take or retain within a no-take MPA, defined in §§665.99, 665.199, 665.399, or 665.599, any bottomfish MUS, crustacean MUS, western Pacific pelagic MUS, precious coral, seamount groundfish or coral reef ecosystem MUS.

(m) Fail to comply with a term or condition governing the vessel monitoring system in violation of §665.19.

(n) Fish for, catch, or harvest MUS without an operational VMS unit on board the vessel after installation of the VMS unit by NMFS, in violation of §665.19(e)(2).

(o) Possess MUS, that were harvested after NMFS has installed the VMS unit on the vessel, on board that vessel without an operational VMS unit, in violation of §665.19(e)(2).

(p) Interfere with, tamper with, alter, damage, disable, or impede the operation of a VMS unit or attempt any of the same; or move or remove a VMS unit without the prior permission of the SAC in violation of §665.19(e)(3).

(q) Make a false statement, oral or written, to an authorized officer, regarding the use, operation, or maintenance of a VMS unit, in violation of §665.19(e).

(r) Interfere with, impede, delay, or prevent the installation, maintenance, repair, inspection, or removal of a VMS unit, in violation of §665.19(e).

(s) Interfere with, impede, delay, or prevent access to a VMS unit by a NMFS observer, in violation of §665.808(f)(4).

(t) Connect or leave connected additional equipment to a VMS unit without the prior approval of the SAC, in violation of §665.19(f).

(u) Fail to comply with the restrictions specified in the notification issued pursuant to §665.4(f)(1), in violation of §665.15(f)(2).

[75 FR 2205, Jan. 14, 2010, as amended at 76 FR 37287, June 27, 2011]

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§665.16 Vessel identification.

(a) Applicability. Each fishing vessel subject to this part, except those identified in paragraph (e) of this section, must be marked for identification purposes, as follows:

(1) A vessel that is registered for use with a valid permit issued under §665.801 and used to fish on the high seas within the Convention Area as defined in §300.211 of this title must be marked in accordance with the requirements at §§300.14 and 300.217 of this title.

(2) A vessel that is registered for use with a valid permit issued under §665.801 of this part and not used to fish on the high seas within the Convention Area must be marked in accordance with either:

(i) Sections 300.14 and 300.217 of this title, or

(ii) Paragraph (b) of this section.

(3) A vessel that is registered for use with a valid permit issued under subparts B through E and subparts G through I of this part must be marked in accordance with paragraph (b) of this section.

(b) Identification. Each vessel subject to this section must be marked as follows:

(1) The vessel's official number must be affixed to 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. Marking must be legible and of a color that contrasts with the background.

(2) For fishing and receiving vessels of 65 ft (19.8 m) LOA or longer, the official number must be displayed in block Arabic numerals at least 18 inches (45.7 cm) in height, except that vessels in precious coral fisheries that are 65 ft (19.8 m) LOA or longer must be marked in block Arabic numerals at least 14 inches (35.6 cm) in height.

(3) For all other vessels, the official number must be displayed in block Arabic numerals at least 10 inches (25.4 cm) in height.

(c) The vessel operator must ensure that the official number is clearly legible and in good repair.

(d) The vessel operator must 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.

(e) The following fishing vessels are exempt from the vessel identification requirements in this section:

(1) A vessel registered for use under a MHI non-commercial bottomfish permit that is in compliance with State of Hawaii bottomfish vessel registration and marking requirements.

(2) A vessel less than 40 ft (12.2 m) LOA registered for use under a CNMI commercial bottomfish permit that is in compliance with CNMI bottomfish vessel registration and marking requirements.

[75 FR 2205, Jan. 14, 2010, as amended at 75 FR 3417, Jan. 21, 2010; 78 FR 33003, June 3, 2013; 78 FR 39583, July 2, 2013]

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§665.17 Experimental fishing.

(a) *General.* The Regional Administrator may authorize, for limited purposes, the direct or incidental harvest of MUS that would otherwise be prohibited by this part. No experimental fishing may be conducted unless authorized by an EFP issued by the Regional Administrator in accordance with the criteria and procedures specified in this section. EFPs will be issued without charge.

(b) *Observers.* No experimental fishing for crustacean MUS may be conducted unless a NMFS observer is aboard the vessel.

(c) *Application.* An applicant for an EFP must submit to the Regional Administrator at least 60 days before the desired date of the EFP a written application including, but not limited to, the following information:

(1) The date of the application.

(2) The applicant's name, mailing address, and telephone number.

(3) A statement of the purposes and goals of the experiment for which an EFP is needed, including a general description of the arrangements for disposition of all species harvested under the EFP.

(4) A statement of whether the proposed experimental fishing has broader significance than the applicant's individual goals.

(5) For each vessel to be covered by the EFP:

(i) Vessel name.

(ii) Name, address, and telephone number of owner and operator.

(iii) USCG documentation, state license, or registration number.

(iv) Home port.

(v) Length of vessel.

(vi) Net tonnage.

(vii) Gross tonnage.

(6) A description of the species (directed and incidental) to be harvested under the EFP and the amount of such harvest necessary to conduct the experiment.

(7) For each vessel covered by the EFP, the approximate times and places fishing will take place, and the type, size, and amount of gear to be used.

(8) The signature of the applicant.

(d) *Incomplete applications.* The Regional 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.

(e) *Issuance.* (1) If an application contains all of the required information, NMFS will publish a notice of receipt of the application in the FEDERAL REGISTER with a brief description of the proposal and will give interested persons an opportunity to comment. The Regional Administrator will also forward copies of the application to the Council, the USCG, and the fishery management agency of the affected state, accompanied by the following information:

(i) The current utilization of domestic annual harvesting and processing capacity (including existing experimental harvesting, if any) of the directed and incidental species for which an EFP is being requested.

(ii) A citation of the regulation or regulations that, without the EFP, would prohibit the proposed activity.

(iii) Biological information relevant to the proposal.

(2) At a Council meeting following receipt of a complete application, the Regional Administrator will consult with the Council and the Director of the affected state fishery management agency concerning the permit 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.

(3) Within 5 working days after the consultation in paragraph (e)(2) of this section, or as soon as practicable thereafter, NMFS will notify the applicant in writing of the decision to grant or deny the EFP and, if denied, the reasons for the denial. Grounds for denial of an EFP include, but are not limited to, the following:

(i) 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.

(ii) According to the best scientific information available, the harvest to be conducted under the permit would detrimentally affect any species of fish in a significant way.

(iii) Issuance of the EFP would inequitably allocate fishing privileges among domestic fishermen or would have economic allocation as its sole purpose.

(iv) Activities to be conducted under the EFP would be inconsistent with the intent of this section or the management objectives of the FEP.

(v) The applicant has failed to demonstrate a valid justification for the permit.

(vi) The activity proposed under the EFP would create a significant enforcement problem.

(4) The decision to grant or deny an EFP is final and unappealable. If the permit is granted, NMFS will publish a notice in the FEDERAL REGISTER describing the experimental fishing to be conducted under the EFP. The Regional Administrator may attach terms and conditions to the EFP consistent with the purpose of the experiment including, but not limited to:

(i) The maximum amount of each species that can be harvested and landed during the term of the EFP, including trip limits, where appropriate.

(ii) The number, sizes, names, and identification numbers of the vessels authorized to conduct fishing activities under the EFP.

(iii) The times and places where experimental fishing may be conducted.

(iv) The type, size, and amount of gear which may be used by each vessel operated under the EFP.

(v) The condition that observers be carried aboard vessels operating under an EFP.

(vi) Data reporting requirements.

(vii) Such other conditions as may be necessary to assure compliance with the purposes of the EFP consistent with the objectives of the FEP.

(f) *Duration.* Unless otherwise specified in the EFP or a superseding notice or regulation, an EFP is effective for no longer than one (1) year from the date of issuance, unless revoked, suspended, or modified. EFPs may be renewed following the application procedures in this section.

(g) *Alteration.* Any EFP that has been altered, erased, or mutilated is invalid.

(h) *Transfer.* EFPs issued under subparts B through F of this part are not transferable or assignable. An EFP is valid only for the vessel(s) for which it is issued.

(i) *Inspection.* Any EFP issued under subparts B through F of this part must be carried aboard the vessel(s) for which it was issued. The EFP must be presented for inspection upon request of any authorized officer.

(j) *Sanctions.* Failure of the holder of an EFP to comply with the terms and conditions of an EFP, the provisions of subparts A through F of this part, any other applicable provision of this part, the Magnuson-Stevens Act, or any other regulation promulgated thereunder, is grounds for revocation, suspension, or modification of the EFP with respect to all persons and vessels conducting activities under the EFP. Any action taken to revoke, suspend, or modify an EFP will be governed by 15 CFR part 904 subpart D. Other sanctions available under the statute will be applicable.

(k) *Protected species.* Persons fishing under an EFP must report any incidental take or fisheries interaction with protected species on a form provided for that purpose. Reports must be submitted to the Regional Administrator within 3 days of arriving in port.

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§665.18 Framework adjustments to management measures.

Framework measures described below for each specific fishery are valid for all management areas, except where specifically noted in this section.

(a) *Pelagic measures*—(1) *Introduction.* Adjustments in management measures may be made through rulemaking if new information demonstrates that there are biological, social, or economic concerns in the fishery. The following framework process authorizes the implementation of measures that may affect the operation of the fisheries, gear, harvest guidelines, or changes in catch and/or effort.

(2) *Annual report.* By June 30 of each year, the Council-appointed pelagics monitoring team will prepare an annual report on the fisheries in the management area. The report shall contain, among other things, recommendations for Council action and an assessment of the urgency and effects of such action(s).

(3) *Procedure for established measures.* (i) Established measures are regulations for which the impacts have been evaluated in Council or NMFS documents in the context of current conditions.

(ii) The Council may recommend to the Regional Administrator that established measures be modified, removed, or reinstituted. 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 rulemaking if approved by the Regional Administrator.

(4) *Procedure for new measures.* (i) New measures are regulations for which the impacts have not been evaluated in Council or NMFS documents in the context of current conditions.

(ii) 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 rulemaking if approved by the Regional Administrator.

(b) *Crustacean measures*—(1) *Introduction.* New management measures may be added through rulemaking if new information demonstrates that there are biological, social, or economic concerns in Permit Areas 1, 2, or 3. The following framework process authorizes the implementation of measures that may affect the operation of the fisheries, gear, harvest guidelines, or changes in catch and/or effort.

(2) *Annual report.* By June 30 of each year, the Council-appointed team will prepare an annual report on the fisheries in the management area. The report shall contain, among other things, recommendations for Council action and an assessment of the urgency and effects of such action(s).

(3) *Procedure for established measures.* (i) Established measures are regulations for which the impacts have been evaluated in Council or NMFS documents in the context of current conditions.

(ii) The Council may recommend to the Regional Administrator that established measures be modified, removed, or reinstituted. 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 rulemaking if approved by the Regional Administrator.

(4) *Procedure for new measures.* (i) New measures are regulations for which the impacts have not been evaluated in Council or NMFS documents in the context of current conditions.

(ii) The Council will publicize, including by a FEDERAL REGISTER document, 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 document 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 rulemaking if approved by the Regional Administrator.

(c) *Bottomfish measures*—(1) *Annual reports.* By June 30 of each year, a Council-appointed bottomfish monitoring team will prepare an annual report on the fishery by area covering the following topics:

(i) Fishery performance data.

(ii) Summary of recent research and survey results.

(iii) Habitat conditions and recent alterations.

(iv) Enforcement activities and problems.

(v) Administrative actions (*e.g.,* data collection and reporting, permits).

(vi) State and territorial management actions.

(vii) Assessment of need for Council action (including biological, economic, social, enforcement, administrative, and state/Federal needs, problems, and trends). Indications of potential problems warranting further investigation may be signaled by the following indicator criteria:

(A) Mean size of the catch of any species in any area is a pre-reproductive size.

(B) Ratio of fishing mortality to natural mortality for any species.

(C) Harvest capacity of the existing fleet and/or annual landings exceed best estimate of MSY in any area.

(D) Significant decline (50 percent or more) in bottomfish catch per unit of effort from baseline levels.

(E) Substantial decline in ex-vessel revenue relative to baseline levels.

(F) Significant shift in the relative proportions of gear in any one area.

(G) Significant change in the frozen/fresh components of the bottomfish catch.

(H) Entry/exit of fishermen in any area.

(I) Per-trip costs for bottomfish fishing exceed per-trip revenues for a significant percentage of trips.

(J) Significant decline or increase in total bottomfish landings in any area.

(K) Change in species composition of the bottomfish catch in any area.

(L) Research results.

(M) Habitat degradation or environmental problems.

(N) Reported interactions between bottomfish fishing operations and protected species in the NWHI.

(viii) Recommendations for Council action.

(ix) Estimated impacts of recommended action.

(2) *Recommendation of management action.* (i) The team may present management recommendations to the Council at any time. Recommendations may cover actions suggested for Federal regulations, state/territorial action, enforcement or administrative elements, and research and data collection. Recommendations will include an assessment of urgency and the effects of not taking action.

(ii) The Council will evaluate the team's reports and recommendations, and the indicators of concern. The Council will assess the need for one or more of the following types of management action: Catch limits, size limits, closures, effort limitations, access limitations, or other measures.

(iii) The Council may recommend management action by either the state/territorial governments or by Federal regulation.

(3) *Federal management action.* (i) 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 Bottomfish Advisory Panel and obtaining public comments at a public hearing.

(ii) The Regional Administrator will consider the Council's recommendation and accompanying data, 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 2 weeks of the decision.

(iii) The Council may appeal a denial by writing to the Assistant Administrator, who must respond in writing within 30 days.

(iv) The Regional Administrator and the Assistant Administrator will make their decisions in accord with the Magnuson-Stevens Act, other applicable law, and the bottomfish measures of the FEPs.

(v) To minimize conflicts between the Federal and state management systems, the Council will use the procedures in paragraph (c)(2) of this section to respond to state/territorial management actions.

Council consideration of action would normally begin with a representative of the state or territorial government bringing a potential or actual management conflict or need to the Council's attention.

(4) *Access limitation procedures.* (i) Access limitation may be adopted under this paragraph (c)(4) only for the NWHI, American Samoa, and Guam.

(ii) If access limitation is proposed for adoption or subsequent modification through the process described in this paragraph (c)(4), the following requirements must be met:

(A) The bottomfish monitoring team must consider and report to the Council on present participation in the fishery; historical fishing practices in, and dependence on, the fishery; economics of the fishery; capability of fishing vessels used in the fishery to engage in other fisheries; cultural and social framework relevant to the fishery; and any other relevant considerations.

(B) Public hearings must be held specifically addressing the limited access proposals.

(C) A specific advisory subpanel of persons experienced in the fishing industry will be created to advise the Council and the Regional Administrator on administrative decisions.

(D) The Council's recommendation to the Regional Administrator must be approved by a two-thirds majority of the voting members.

(5) *Five-year review.* The Council will conduct a comprehensive review on the effectiveness of the Mau Zone limited access program 5 years following implementation of the program. The Council will consider the extent to which the FEP objectives have been met and verify that the target number of vessels established for the fishery is appropriate for current fishing activity levels, catch rates, and biological condition of the stocks. The Council may establish a new target number based on the 5-year review.

(d) *Precious coral measures*—(1) *Introduction.* Established management measures may be revised and new management measures may be established and/or revised through rulemaking if new information demonstrates that there are biological, social, or economic concerns in a precious coral permit area. The following framework process authorizes the implementation of measures that may affect the operation of the fisheries, gear, quotas, season, or levels of catch and/or in effort.

(2) *Annual report.* By June 30 of each year, the Council-appointed precious coral team will prepare an annual report on the fisheries in the management area. The report will contain, among other things, recommendations for Council action and an assessment of the urgency and effects of such action(s).

(3) *Procedure for established measures.* (i) Established measures are regulations for which the impacts have been evaluated in Council or NMFS documents in the context of current conditions.

(ii) The Council may recommend to the Regional Administrator that established measures be modified, removed, or reinstituted. Such recommendation will include supporting rationale and analysis and will be made after advance public notice, public discussion, and consideration of public comment. NMFS may implement the Council's recommendation by rulemaking if approved by the Regional Administrator.

(4) *Procedure for new measures.* (i) New measures are regulations for which the impacts have not been evaluated in Council or NMFS documents in the context of current conditions.

(ii) The Council will publicize, including by a FEDERAL REGISTER document, 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 document 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 a subsequent public meeting, the Council will consider public comments and other information received before making a recommendation to the Regional Administrator about any new measure. If approved by the Regional Administrator, NMFS may implement the Council's recommendation by rulemaking.

(e) *Coral reef ecosystem measures*—(1) *Procedure for established measures.* (i) Established measures are regulations for which the impacts have been evaluated in Council or NMFS documents in the context of current conditions.

(ii) The Council may recommend to the Regional Administrator that established measures be modified, removed, or reinstituted. 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 rulemaking if approved by the Regional Administrator.

(2) *Procedure for new measures.* (i) New measures are regulations for which the impacts have not been evaluated in Council or NMFS documents in the context of current conditions. New measures include, but are not limited to, catch limits, resource size limits, closures, effort limitations, reporting and recordkeeping requirements.

(ii) The Regional Administrator 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 document 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 rulemaking if approved by the Regional Administrator.

(A) The Regional Administrator will consider the Council's recommendation and supporting rationale and analysis, and, if the Regional Administrator concurs with the Council's recommendation, will propose regulations to carry out the action. If the Regional Administrator rejects the Council's proposed action, the Regional Administrator will provide a written explanation for the denial within 2 weeks of the decision.

(B) The Council may appeal a denial by writing to the Assistant Administrator, who must respond in writing within 30 days.

(C) The Regional Administrator and the Assistant Administrator will make their decisions in accordance with the Magnuson-Stevens Act, other applicable laws, and the FEPs.

(D) To minimize conflicts between the Federal and state/territorial/commonwealth management systems, the Council will use the procedures in this paragraph (e)(2)(ii) to respond to state/territorial/commonwealth management actions. The Council's 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.

(3) *Annual report.* By July 31 of each year, a Council-appointed coral reef ecosystem monitoring team will prepare an annual report on coral reef fisheries of the western Pacific region. The report will contain, among other things:

(i) Fishery performance data, summaries of new information and assessments of need for Council action.

(ii) Recommendation for Council action. The Council will evaluate the annual report and advisory body recommendations and may recommend management action by either the state/territorial/commonwealth governments or by Federal regulation.

(iii) If the Council believes that management action should be considered, it will make specific recommendations to the Regional Administrator after considering the views of its advisory bodies.

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§665.19 Vessel monitoring system.

(a) *Applicability.* The holder of any of the following permits is subject to the vessel monitoring system requirements in this part:

(1) Hawaii longline limited access permit issued pursuant to §665.801(b);

(2) American Samoa longline limited entry permit, for vessel size Class C or D, issued pursuant to §665.801(c);

(3) Vessels permitted to fish in Crustacean Permit Area 1 VMS Subarea; or

(4) CNMI commercial bottomfish permit, if the vessel is a medium or large bottomfish vessel, issued pursuant to §665.404(a)(2).

(b) *VMS unit.* Only a VMS unit owned by NMFS and installed by NMFS complies with the requirement of this subpart.

(c) *Notification.* After a permit holder subject to §665.19(a) has been notified by the SAC of a specific date for installation of a VMS unit on the permit holder's vessel, the vessel must carry and operate the VMS unit after the date scheduled for installation.

(d) *Fees and charges.* During the experimental VMS program, the holder of a permit subject to §665.19(a) shall not be assessed any fee or other charges to obtain and use a VMS unit, including the communication charges related directed to requirements under this section. Communication charges related to any additional equipment attached to the VMS unit by the owner or operator shall be the responsibility of the owner or operator and not NMFS.

(e) *Permit holder duties.* The holder of a permit subject to §665.19(a) and master of the vessel must:

(1) Provide opportunity for the SAC to install and make operational a VMS unit after notification.

(2) Carry and continuously operate the VMS unit on board whenever the vessel is at sea.

(3) Not remove, relocate, or make non-operational the VMS unit without prior approval from the SAC.

(f) *Authorization by the SAC.* The SAC has authority over the installation and operation of the VMS unit. The SAC may authorize the connection or order the disconnection of additional equipment, including a computer, to any VMS unit when deemed appropriate by the SAC.

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§665.20 Western Pacific Community Development Program.

(a) *General.* In accordance with the criteria and procedures specified in this section, the Regional Administrator may authorize the direct or incidental harvest of management unit species that would otherwise be prohibited by this part.

(b) *Eligibility.* To be eligible to participate in the western Pacific community development program, a community must meet the following criteria:

(1) Be located in American Samoa, Guam, Hawaii, or the Northern Mariana Islands (collectively, the western Pacific);

(2) Consist of community residents descended from aboriginal people indigenous to the western Pacific who conducted commercial or subsistence fishing using traditional fishing practices in the waters of the western Pacific;

(3) Consist of individuals who reside in their ancestral homeland;

(4) Have knowledge of customary practices relevant to fisheries of the western Pacific;

(5) Have a traditional dependence on fisheries of the western Pacific;

(6) Are currently experiencing economic or other constraints that have prevented full participation in the western Pacific fisheries and, in recent years, have not had harvesting, processing or marketing capability sufficient to support substantial participation in fisheries in the area; and

(7) Develop and submit a community development plan to the Council and the NMFS that meets the requirements in paragraph (c) of this section.

(c) *Community development plan.* An eligible community seeking access to a fishery under the authority of the Council and NMFS must submit to the Council a community development plan that includes, but is not limited to, the following information:

(1) A statement of the purposes and goals of the plan.

(2) A description and justification for the specific fishing activity being proposed, including:

(i) Location of the proposed fishing activity.

(ii) Management unit species to be harvested, and any potential bycatch.

(iii) Gear type(s) to be used.

(iv) Frequency and duration of the proposed fishing activity.

(3) A statement describing the degree of involvement by the indigenous community members, including the name, address, telephone and other contact information of each individual conducting the proposed fishing activity.

(4) A description of how the community and or its members meet each of the eligibility criteria in paragraph (b) of this section.

(5) If a vessel is to be used by the community to conduct fishing activities, for each vessel:

(i) Vessel name and official number (USCG documentation, state, territory, or other registration number).

(ii) Vessel length overall, displacement, and fish holding capacity.

(iii) Any valid federal fishing permit number(s).

(iv) Name, address, and telephone number of the vessel owner(s) and operator(s).

(d) *Council review.* The Council will review each community development plan to ensure that it meets the intent of the Magnuson-Stevens Act and contains all required information. The Council may consider advice of its advisory panels in conducting this review. If the Council finds the community development plan is complete, it will transmit the plan to the Regional Administrator for review.

(e) *Agency review and approval.* (1) Upon receipt of a community development plan from the Council, the Regional Administrator will review the plan for consistency with paragraphs (b), (c), and (d) of this section, and other applicable laws. The Regional Administrator may request from the applicant additional information necessary to make the determinations pursuant to this section and other applicable laws before proceeding with the review pursuant to paragraph (e)(2) of this section.

(2) If the Regional Administrator determines that a plan contains the required information and is consistent with paragraphs (b), (c), and (d) of this section, and other applicable laws, NMFS will publish a notice in the FEDERAL REGISTER to solicit public comment on the proposed plan and any associated environmental review documents. The notice will include the following:

(i) A description of the fishing activity to be conducted.

(ii) The current utilization of domestic annual harvesting and processing capacity (including existing experimental harvesting, if any) of the target, incidental, and bycatch species.

(iii) A summary of any regulations that would otherwise prohibit the proposed fishing activity.

(iv) Biological and environmental information relevant to the plan, including appropriate statements of environmental impacts on target and non-target stocks, marine mammals, and threatened or endangered species.

(3) Within 90 days from the end of the comment period on the plan, the Regional Administrator will notify the applicant in writing of the decision to approve or disapprove the plan.

(4) If disapproved, the Regional Administrator will provide the reasons for the plan's disapproval and provide the community with the opportunity to modify the plan and resubmit it for review. Reasons for disapproval may include, but are not limited to, the following:

(i) The applicant failed to disclose material information or made false statements related to the plan.

(ii) The harvest would contribute to overfishing or would hinder the recovery of an overfished stock, according to the best scientific information available.

(iii) The activity would be inconsistent with an applicable law.

(iv) The activity would create a significant enforcement, monitoring, or administrative problem, as determined by the Regional Administrator.

(5) If approved, the Regional Administrator will publish a notice of the authorization in the FEDERAL REGISTER, and may attach limiting terms and conditions to the authorization including, but not limited to, the following:

(i) The maximum amount of each management unit species and potential bycatch species that may be harvested and landed during the term of the authorization.

(ii) The number, sizes, names, identification numbers, and federal permit numbers of the vessels authorized to conduct fishing activities.

(iii) Type, size, and amount of gear used by each vessel, including trip limits.

(iv) The times and places where fishing may or may not be conducted.

(v) Notification, observer, vessel monitoring, and reporting requirements.

(f) *Duration.* Unless otherwise specified, and unless revoked, suspended, or modified, a plan may be effective for no longer than five years.

(g) *Transfer.* Plans authorized under this section are not transferable or assignable.

(h) *Sanctions.* The Regional Administrator may revoke, suspend or modify a community development plan in the case of failure to comply with the terms and conditions of the plan, any other applicable provision of this part, the Magnuson-Stevens Act, or other applicable laws.

(i) *Program review.* NMFS and the Council will periodically review and assess each plan. If fishery, environmental, or other conditions have changed such that the plan's goals or requirements are not being met, or the fishery has become in an overfished state or overfishing is occurring, the Regional Administrator may revoke, suspend, or modify the plan.

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§665.98 Management area.

The American Samoa fishery management area is the EEZ seaward of the Territory of American Samoa with the inner boundary coterminous with the seaward boundaries of the Territory of American Samoa and the outer boundary designated as a line drawn in such a manner that each point on it is 200 nautical miles from the baseline from which the territorial sea is measured, or is coterminous with adjacent international maritime boundaries.

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§665.99 Area restrictions.

Fishing is prohibited in all no-take MPAs. The following U.S. EEZ waters around American Samoa are no-take MPAs: Landward of the 50 fm (91.5 m) curve around Rose Atoll, as depicted on National Ocean Survey Chart Number 83484.

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§665.100 American Samoa bottomfish fisheries. [Reserved]

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§665.101 Definitions.

As used in §§665.100 through 665.119:

American Samoa bottomfish management unit species (American Samoa bottomfish MUS) means the following fish:

Samoan name	English common name	Scientific name
palu-gutusiliva	red snapper, silvermouth	*Aphareus rutilans.*
asoama	gray snapper, jobfish	*Aprion virescens.*
sapoanae	giant trevally, jack	*Caranx ignobilis.*
tafauli	black trevally, jack	*Caranx lugubris.*
fausi	blacktip grouper	*Epinephelus fasciatus.*
papa, velo	lunartail grouper	*Variola louti.*
palu malau	red snapper	*Etelis carbunculus.*
palu-loa	red snapper	*Etelis coruscans.*
filoa-gutumumu	Ambon emperor	*Lethrinus amboinensis.*
filoa-paomumu	redgill emperor	*Lethrinus rubrioperculatus.*
savane	blueline snapper	*Lutjanus kasmira.*
palu-i'usama	yellowtail snapper	*Pristipomoides auricilla.*
palu-`ena`ena	pink snapper	*Pristipomoides filamentosus.*
palu-sina	yelloweye snapper	*Pristipomoides flavipinnis.*
palu	pink snapper	*Pristipomoides seiboldii.*
palu-ula, palu-sega	snapper	*Pristipomoides zonatus.*
malauli	amberjack	*Seriola dumerili.*

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§665.102 [Reserved]

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§665.103 Prohibitions.

In addition to the general prohibitions specified in §600.725 of this chapter and §665.15, it is unlawful for any person to fish for American Samoa bottomfish MUS using gear prohibited under §665.104.

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§665.104 Gear restrictions.

(a) *Bottom trawls and bottom set gillnets.* Fishing for American Samoa bottomfish MUS with bottom trawls and bottom set gillnets is prohibited.

(b) *Possession of gear.* The possession of a bottom trawl or bottom set gillnet within the American Samoa fishery management area is prohibited.

(c) *Poisons and explosives.* The possession or use of any poisons, explosives, or intoxicating substances for the purpose of harvesting bottomfish is prohibited.

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§665.105 At-sea observer coverage.

All fishing vessels subject to §§665.100 through 665.105 must carry an observer when directed to do so by the Regional Administrator.

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§§665.106-665.119 [Reserved]

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§665.120 American Samoa coral reef ecosystem fisheries. [Reserved]

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§665.121 Definitions.

As used in §§665.120 through 665.139:

*American Samoa coral reef ecosystem management unit species (American Samoa coral reef ecosystem MUS)*means all of the Currently Harvested Coral Reef Taxa and Potentially Harvested Coral Reef Taxa listed in this section and which spend the majority of their non-pelagic (post-settlement) life stages within waters less than or equal to 50 fathoms in total depth.

American Samoa Currently Harvested Coral Reef Taxa:

Family name	Samoan name	English common name	Scientific name
Acanthuridae (Surgeonfishes)	afinamea	orange-spot surgeonfish	*Acanthurus olivaceus.*
		yellowfin surgeonfish	*Acanthurus xanthopterus.*
	Aanini	convict tang	*Acanthurus triostegus.*
		eye-striped surgeonfish	*Acanthurus dussumieri.*
	ponepone, gaitolama	blue-lined surgeon	*Acanthurus nigroris.*
	Alogo	blue-banded surgeonfish	*Acanthurus lineatus.*
	pone-i'usama	blackstreak surgeonfish	*Acanthurus nigricauda.*
	laulama,	whitecheek surgeonfish	*Acanthurus nigricans.*
	Maogo	white-spotted surgeonfish	*Acanthurus guttatus.*
		ringtail surgeonfish	*Acanthurus blochii.*
	ponepone	brown surgeonfish	*Acanthurus nigrofuscus.*
		elongate surgeonfish	*Acanthurus mata.*
		mimic surgeonfish	*Acanthurus pyroferus.*
	Pone	yellow-eyed surgeonfish	*Ctenochaetus strigosus.*
	pone, pala'ia, logoulia	striped bristletooth	*Ctenochaetus striatus.*
		two-spot bristletooth	*Ctenochaetus binotatus.*
	ume-isu	bluespine unicornfish	*Naso unicornus.*
	ili'ilia, umelei	orangespine unicornfish	*Naso lituratus.*
		black tongue unicornfish	*Naso hexacanthus.*

	ume-masimasi	bignose unicornfish	*Naso vlamingii.*
		whitemargin unicornfish	*Naso annulatus.*
	ume-ulutao	spotted unicornfish	*Naso brevirostris.*
		barred unicornfish	*Naso thynnoides.*
Balistidae (Triggerfishes)	sumu, sumu-laulau	titan triggerfish	*Balistoides viridescens.*
		orangestriped triggerfish	*Balistapus undulatus.*
	sumu-\`apa\`apasina, sumu-si'umumu	pinktail triggerfish	*Melichthys vidua.*
	sumu-uli	black triggerfish	*Melichthys niger.*
	sumu-laulau	blue triggerfish	*Pseudobalistes fuscus.*
	sumu-uo'uo, sumu-aloalo	picassofish	*Rhinecanthus aculeatus.*
	sumu-gase'ele'ele	bridled triggerfish	*Sufflamen fraenatum.*
	Atule	bigeye scad	*Selar crumenophthalmus.*
	atuleau, namuauli	mackerel scad	*Decapterus macarellus.*
Carcharhinidae (Sharks)	malie-aloalo	grey reef shark	*Carcharhinus amblyrhynchos.*
	Aso	silvertip shark	*Carcharhinus albimarginatus.*
	Malie	Galapagos shark	*Carcharhinus galapagensis.*
	apeape, malie-alamata	blacktip reef shark	*Carcharhinus melanopterus.*
	Malu	whitetip reef shark	*Triaenodon obesus.*
Holocentridae (Soldierfish, squirrelfish	malau-ugatele, malau-va'ava'a	bigscale soldierfish	*Myripristis berndti.*
	malau-tui	bronze soldierfish	*Myripristis adusta.*
		blotcheye soldierfish	*Myripristis murdjan.*
		brick soldierfish	*Myripristis amaena.*

	malau-mamo, malau-va'ava'a	scarlet soldierfish	*Myripristis pralinia.*
	malau-tuauli	violet soldierfish	*Myripristis violacea.*
		whitetip soldierfish	*Myripristis vittata.*
		yellowfin soldierfish	*Myripristis chryseres.*
	malau-pu'u	pearly soldierfish	*Myripristis kuntee.*
		double tooth squirrelfish	*Myripristis hexagona.*
		blackspot squirrelfish	*Sargocentron melanospilos.*
	malau-tianiu	file-lined squirrelfish	*Sargocentron microstoma.*
		pink squirrelfish	*Sargocentron tiereoides.*
	malau-tui, malau-talapu'u, malau-tusitusi, malau-pauli	crown squirrelfish	*Sargocentron diadema.*
		peppered squirrelfish	*Sargocentron punctatissimum.*
		blue-lined squirrelfish	*Sargocentron tiere.*
	tamalu, mu-malau, malau-toa	saber or long jaw squirrelfish	*Sargocentron spiniferum.*
		spotfin squirrelfish	*Neoniphon* spp.
Kuhliidae (Flagtails)	Safole, inato	barred flag-tail	*Kuhlia mugil.*
Kyphosidae (Rudderfish)	nanue, mata-mutu, mutumutu	rudderfish	*Kyphosus cinerascens Kyphosus biggibus.*
	Nanue	rudderfish	*Kyphosus vaigienses.*
Labridae (Wrasses)	lalafi, tagafa malakea	napoleon wrasse	*Cheilinus undulatus.*
	Lalafi-matamumu	triple-tail wrasse	*Cheilinus trilobatus.*
	lalafi-matapua'a	floral wrasse	*Cheilinus chlorourus.*
	lalafi-pulepule	harlequin tuskfish	*Cheilinus fasciatus.*
	sugale	bandcheek wrasse	*Oxycheilinus diagrammus.*

	sugale	arenatus wrasse	*Oxycheilinus arenatus.*
	sugale-tatanu	whitepatch wrasse	*Xyrichtys aneitensis.*
	sugale-mo'o	cigar wrasse	*Cheilio inermis.*
	sugale-laugutu, sugale-uli, sugale-aloa, sugale-lupe	blackeye thicklip	*Hemigymnus melapterus*
	sugale-gutumafia	barred thicklip	*Hemigymnus fasciatus.*
	lape, sugale-pagota	three-spot wrasse	*Halichoeres trimaculatus.*
	sugale-a'au, sugale-pagota, ifigi	checkerboard wrasse	*Halichoeres hortulanus.*
	sugale-uluvela	weedy surge wrasse	*Halichoeres margaritaceus.*
	uloulo-gatala, patagaloa	surge wrasse	*Thalassoma purpureum.*
	lape-moana	red ribbon wrasse	*Thalassoma quinquevittatum.*
	sugale-samasama	sunset wrasse	*Thalassoma lutescens.*
	sugale-la'o, sugale-taili, sugale-gasufi	rockmover wrasse	*Novaculichthys taeniourus.*
Mullidae (Goatfishes)	i'asina, vete, afulu	yellow goatfish	*Mulloidichthys* spp.
	Vete	yellowfin goatfish	*Mulloidichthys vanicolensis.*
	afolu, afulu	yellowstripe goatfish	*Mulloidichthys flavolineatus.*
	afoul, afulu	banded goatfish	*Parupeneus* spp.
	tusia, tulausaena, ta'uleia	dash-dot goatfish	*Parupeneus barberinus.*
	matulau-moana	doublebar goatfish	*Parupeneus bifasciatus.*
	moana-ula	redspot goatfish	*Parupeneus heptacanthus.*
	i'asina, vete, afulu, moana	yellowsaddle goatfish	*Parupeneus cyclostomas.*
	matulau-ilamutu	side-spot goatfish	*Parupeneus pleurostigma.*
	i'asina, vete, afulu	multi-barred goatfish	*Parupeneus multifaciatus.*
Mugilidae (Mullets)	anae, aua. fuafua	fringelip mullet	*Crenimugil crenilabis.*
	moi, poi	false mullet	*Neomyxus leuciscus.*

Muraenidae (Moray eels)	Pusi	yellowmargin moray eel	*Gymnothorax flavimarginatus.*
	maoa'e	giant moray eel	*Gymnothorax javanicus.*
	pusi-pulepule	undulated moray eel	*Gymnothorax undulatus.*
Octopodidae (Octopus)	fe'e fe'e	octopus octopus	*Octopus cyanea, Octopus ornatus.*
Polynemidae	umiumia, i'ausi	threadfin	*Polydactylus sexfilis.*
Pricanthidae (Bigeye)	matapula	glasseye	*Heteropriacanthus cruentatus.*
	matapula	bigeye	*Priacanthus hamrur.*
Scaridae (Parrotfishes)	Fuga	stareye parrotfish	*Calotomus carolinus.*
	fuga, galo-uluto'i, fuga-valea, laea-mamanu	parrotfish	*Scarus* spp.
	ulapokea, laea-ulapokea	Pacific longnose parrotfish	*Hipposcarus longiceps.*
Scombridae	Tagi	dogtooth tuna	*Gymnosarda unicolor.*
Siganidae (Rabbitfish)	loloa, lo	forktail rabbitfish	*Siganus aregenteus.*
Sphyraenidae (Barracuda)	Sapatu	heller's barracuda	*Sphyraena helleri.*
	Saosao	great barracuda	*Sphyraena barracuda.*
Turbinidae (turban shells, green snails	Alili	green snails	*Turbo* spp.

American Samoa Potentially Harvested Coral Reef Taxa:

Samoan name	English common name	Scientific name
sugale, sugale-vaolo, sugale-a'a, lalafi, lape-a'au, la'ofia	wrasses (Those species not listed as CHCRT)	Labrida.
malie, apoapo, moemoeao	sharks (Those species not listed as CHCRT)	Carcharhinidae, Sphyrnidae.
Fai	rays and skates	Dasyatididae, Myliobatidae.
pe'ape'a	batfishes	Ephippidae.
mutumutu, misimisi, ava'ava-moana	sweetlips	Haemulidae.

talitaliuli	remoras	Echeneidae.
mo'o, mo'otai	tilefishes	Malacanthidae.
Tiva	dottybacks	Pseudochromidae.
aneanea, tafuti	prettyfins	Plesiopidae.
Tapua	coral crouchers	Caracanthidae.
	flashlightfishes	Anomalopidae.
gatala, ataata, vaolo, gatala-uli, gatala-sega, gatala-aleva, ateate, apoua, susami, gatala-sina, gatala-mumu	groupers (Those species not listed as CHCRT or BMUS)	Serrandiae.
lupo, lupota, mamalusi, ulua, sapoanae, taupapa, nato, filu, atuleau, malauli-apamoana, malauli-sinasama, malauli-matalapo'a, lai	jacks and scads (Those species not listed as CHCRT or BMUS)	Carangidae.
Malau	soldierfishes and squirrelfishes (Those species not listed as CHCRT)	Holocentridae.
i'asina, vete, afulu, afoul, ulula'oa	goatfishes (Those species not listed as CHCRT)	Mullidae.
pone, palagi	surgeonfishes (Those species not listed as CHCRT)	Acanthuridae.
pelupelu, nefu	herrings	Clupeidae.
nefu, file	anchovies	Engraulidae.
mano'o, mano'o-popo, mano'o-fugafuga, mano'o-apofusami, mano'o-a'au	gobies	Gobiidae.
mu, mu-taiva, tamala, malai, feloitega, mu-mafalaugutu, savane-ulusama, matala'oa	snappers (Those species not listed as CHCRT or BMUS)	Lutjanidae.
sumu, sumu-papa, sumu-taulau	trigger fishes (Those species not listed as CHCRT)	Balistidae.
Lo	rabbitfishes (Those species not listed as CHCRT)	Siganidae.
nanue, matamutu, mutumutu	rudderfishes (Those species not listed as CHCRT)	Kyphosidae.
ulisega, atule-toto	fusiliers	Caesionidae.

filoa, mata'ele'ele, ulamalosi	emperors (Those species not listed as CHCRT or BMUS)	Lethrinidae.
pusi, maoa'e, atapanoa, u'aulu, apeape, fafa, gatamea, pusi-solasulu	eels (Those species not listed as CHCRT)	Muraenidae, Chlopsidae, Congridae, Moringuidae, Ophichthidae.
fo, fo-tusiloloa, fo-si'umu, fo-loloa, fo-tala, fo-manifi, fo-aialo, fo-tuauli	cardinalfishes	Apogonidae.
pe'ape'a, laulaufau	moorish idols	Zanclidae.
tifitifi, si'u, i'usamasama, tifitifi-segaula, laulafau-laumea, alosina	butterfly fishes	Chaetodontidae.
tu'u'u, tu'u'u-sama, tu'u'u-lega, tu'u'u-ulavapua, tu'u'u-matamalu, tu'u'u-alomu, tu'u'u-uluvela, tu'u'u-atugauli, tu'u'u-tusiuli, tu'u'u-manini	angelfishes	Pomacanthidae.
tu'u'u, mutu, mamo, tu'u'u-lumane	damselfishes	Pomacentridae.
i'atala, la'otele, nofu	scorpionfishes	Scorpaenidae.
mano'o, mano'o-mo'o, mano'o-palea, mano'o-la'o	blennies	Blenniidae.
sapatu	barracudas (Those species not listed as CHCRT)	Sphyraenidae.
la'o, ulutu'i, lausiva	hawkfishes (Those species not listed as CHCRT)	Cirrhitidae.
la'otale, nofu	frogfishes	Antennariidae.
	pipefishes and seahorses	Syngnathidae.
ta'oto	sandperches	Pinguipedidae.
tagi	dog tooth tuna	*Gymnosarda unicolor.*
taoto-ena, taoto-sama, \`au\`aulauti, taotito	trumpetfish	*Aulostomus chinensis.*
taotao, taoto-ama	cornetfish	*Fistularia commersoni.*
sue, sue-vaolo, sue-va'a, sue-lega, sue-mu, sue-uli, sue-lape, sue-afa, sue-sugale	puffer fishes and porcupine fishes	Tetradontidae.
ali	flounders and soles	Bothidae, Soleidae.
moamoa	trunkfishes	Ostraciidae.
fugafuga, tuitui, sava'e	sea cucumbers and sea urchins	Echinoderms.

amu	blue corals	Heliopora.
amu	organpipe corals	Tubipora.
	ahermatypic corals	Azooxanthellates.
amu	mushroom corals	Fungiidae.
amu	small and large coral polyps	
amu	fire corals	Millepora.
amu	soft corals and gorgonians.	
lumane, matalelei	anemones	Actinaria.
	soft zoanthid corals (Those species not listed as CHCRT)	Zoanthinaria. Mollusca.
sisi-sami	sea snails	Gastropoda.
aliao, alili		*Trochus* spp.
sea	sea slugs	Opistobranches.
	black lipped pearl oyster	*Pinctada margaritifera.*
faisua	giant clam	Tridacnidae.
pipi, asi, fatuaua, tio, pae, fole	other clams	Other Bivalves.
ula, pa'a, kuku, papata	lobsters, shrimps, mantis shrimps, true crabs and hermit crabs (Those species not listed as Crustacean MUS)	Crustaceans.
	sea squirts	Tunicates.
	sponges	Porifera.
amu	lace corals	Stylasteridae.
amu	hydroid corals	Solanderidae.
	segmented worms (Those species not listed as CHCRT)	Annelids.
limu	seaweed	Algae.
	Live rock.	
All other American Samoa coral reef ecosystem MUS that are marine plants, invertebrates, and fishes that are not listed in the American Samoa CHCRT table or are not American Samoa bottomfish, crustacean, precious coral, or western Pacific pelagic MUS.		

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§665.122 [Reserved]

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§665.123 Relation to other laws.

To ensure consistency between the management regimes of different Federal agencies with shared management responsibilities of fishery resources within the American Samoa fishery management area, fishing for American Samoa coral reef ecosystem MUS is not allowed within the boundary of a National Wildlife Refuge unless specifically authorized by the USFWS, regardless of whether that refuge was established by action of the President or the Secretary of the Interior.

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§665.124 Permits and fees.

(a) *Applicability.* Unless otherwise specified in this subpart, §665.13 applies to coral reef ecosystem permits.

(1) *Special permit.* Any person of the United States fishing for, taking or retaining American Samoa coral reef ecosystem MUS must have a special permit if they, or a vessel which they operate, is used to fish for any:

(i) American Samoa coral reef ecosystem MUS in low-use MPAs as defined in §665.99;

(ii) American Samoa Potentially Harvested Coral Reef Taxa in the coral reef ecosystem management area; or

(iii) American Samoa coral reef ecosystem MUS in the coral reef ecosystem management area with any gear not specifically allowed in this subpart.

(2) *Transshipment permit.* A receiving vessel must be registered for use with a transshipment permit if that vessel is used in the American Samoa coral reef ecosystem management area to land or transship PHCRT, or any American Samoa coral reef ecosystem MUS harvested within low-use MPAs.

(3) *Exceptions.* The following persons are not required to have a permit under this section:

(i) Any person issued a permit to fish under any FEP who incidentally catches American Samoa coral reef ecosystem MUS while fishing for bottomfish MUS, crustacean MUS, western Pacific pelagic MUS, precious coral, or seamount groundfish.

(ii) Any person fishing for American Samoa CHCRT outside of an MPA, who does not retain any incidentally caught American Samoa PHCRT; and

(iii) Any person collecting marine organisms for scientific research as described in §665.17, or §600.745 of this chapter.

(b) *Validity.* Each permit will be valid for fishing only in the fishery management area 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 §665.13.

(d) *Special permit.* The Regional Administrator shall issue a special permit in accordance with the criteria and procedures specified in this section.

(1) *Application.* An applicant for a special or transshipment permit issued under this section must complete and submit to the Regional Administrator, a Special Coral Reef Ecosystem Fishing Permit Application Form issued by NMFS. Information in the application form must include, but is not limited to, a statement describing the objectives of the fishing activity for which a special permit is needed, including a general description of the expected disposition of the resources harvested under the permit (*i.e.,* stored live, fresh, frozen, preserved; sold for food, ornamental, research, or other use; and a description of the planned fishing operation, including location of fishing and gear operation, amount and species (directed and incidental) expected to be harvested and estimated habitat and protected species impacts).

(2) *Incomplete applications.* The Regional 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 and completed in writing.

(3) *Issuance.* (i) If an application contains all of the required information, the Regional Administrator will forward copies of the application within 30 days to the Council, the USCG, the fishery management agency of the affected state, and other interested parties who have identified themselves to the Council, and the USFWS.

(ii) Within 60 days following receipt of a complete application, the Regional Administrator will consult with the Council through its Executive Director, USFWS, and the Director of the affected state fishery management agency concerning the permit application and will receive their recommendations for approval or disapproval of the application based on:

(A) Information provided by the applicant;

(B) The current domestic annual harvesting and processing capacity of the directed and incidental species for which a special permit is being requested;

(C) The current status of resources to be harvested in relation to the overfishing definition in the FEP;

(D) Estimated ecosystem, habitat, and protected species impacts of the proposed activity; and

(E) Other biological and ecological information relevant to the proposal. The applicant will be provided with an opportunity to appear in support of the application.

(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 FEP, the national standards, the Endangered Species Act, and other applicable laws, approve or deny 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) If the Regional Administrator does not receive a recommendation from the Council within 60 days of Council receipt of the permit application, the Regional Administrator can make a determination of approval or denial independently.

(v) Within 30 working days after the consultation in paragraph (d)(3)(ii) of this section, or as soon as practicable thereafter, NMFS will notify the applicant in writing of 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 directed or incidental catch in the season or location specified under the permit would detrimentally affect any coral reef resource or coral reef ecosystem in a significant way, including, but not limited to issues related to, spawning grounds or seasons, protected species interactions, EFH, and habitat areas of particular concern (HAPC).

(C) Issuance of the special permit would inequitably allocate fishing privileges among domestic fishermen or would have economic allocation as its sole purpose.

(D) The method or amount of harvest in the season and/or location stated on the permit is considered inappropriate based on previous human or natural impacts in the given area.

(E) NMFS has determined that the maximum number of permits for a given area in a given season has been reached and allocating additional permits in the same area would be detrimental to the resource.

(F) The activity proposed under the special permit would create a significant enforcement problem.

(vi) The Regional Administrator may attach conditions to the special permit, if it is granted, consistent with the management objectives of the FEP, 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 times and places where fishing may be conducted.

(C) The type, size, and amount of gear which may be used by each vessel operated under the special permit.

(D) Data reporting requirements.

(E) Such other conditions as may be necessary to ensure compliance with the purposes of the special permit consistent with the objectives of the FEP.

(4) *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 rule on the appeal in accordance with the permit eligibility criteria set forth in this section and the FEP, 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 therefore, 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 parties, may appear personally and/or be represented by counsel at the hearing and may 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 constitutes final action for the agency for the purposes of the Administrative Procedure Act.

(5) The Regional Administrator may, for good cause, extend any time limit prescribed in this section for a period not to exceed 30 days either upon his or her own motion or upon written request from the Council, appellant or applicant stating the reason(s) therefore.

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§665.125 Prohibitions.

In addition to the general prohibitions specified in §600.725 of this chapter and §665.15 of this part, it is unlawful for any person to do any of the following:

(a) Fish for, take, retain, possess or land any American Samoa coral reef ecosystem MUS in any low-use MPA as defined in §665.99 unless:

(1) A valid permit has been issued for the hand harvester or the fishing vessel operator that specifies the applicable area of harvest;

(2) A permit is not required, as outlined in §665.124; or

(3) The American Samoa coral reef ecosystem MUS 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 American Samoa coral reef ecosystem MUS species:

(1) That is determined overfished with subsequent rulemaking by the Regional Administrator;

(2) By means of gear or methods prohibited under §665.127;

(3) In a low-use MPA without a valid special permit; or

(4) In violation of any permit issued under §§665.13, 665.123, or 665.124.

(c) Fish for, take, or retain any wild live rock or live hard coral except under a valid special permit for scientific research, aquaculture seed stock collection or traditional and ceremonial purposes by indigenous people.

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§665.126 Notifications.

Any special permit holder subject to the requirements of this subpart must contact the appropriate NMFS enforcement agent in American Samoa, Guam, or Hawaii at least 24 hours before landing any coral reef ecosystem MUS unit species harvested under a special permit, and report the port and the approximate date and time at which the catch will be landed.

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§665.127 Allowable gear and gear restrictions.

(a) American Samoa coral reef ecosystem MUS may be taken only with the following allowable gear and methods:

(1) Hand harvest;

(2) Spear;

(3) Slurp gun;

(4) Hand net/dip net;

(5) Hoop net for Kona crab;

(6) Throw net;

(7) Barrier net;

(8) Surround/purse net that is attended at all times;

(9) Hook-and-line (includes handline (powered or not), rod-and-reel, and trolling);

(10) Crab and fish traps with vessel ID number affixed; and (11) Remote-operating vehicles/submersibles.

(b) American Samoa coral reef ecosystem MUS may not be taken by means of poisons, explosives, or intoxicating substances. Possession or use of these materials by any permit holder under this subpart who is established to be fishing for coral reef ecosystem MUS in the management area is prohibited.

(c) Existing FEP fisheries shall follow the allowable gear and methods outlined in their respective plans.

(d) Any person who intends to fish with new gear not included in this section must describe the new gear and its method of deployment in the special permit application. A decision on the permissibility of this gear type will be made by the Regional Administrator after consultation with the Council and the director of the affected state fishery management agency.

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§665.128 Gear identification.

(a) The vessel number must be affixed to all fish and crab traps on board the vessel or deployed in the water by any vessel or person holding a permit under §§665.13 or 665.124 or that is otherwise established to be fishing for American Samoa coral reef ecosystem MUS in the management area.

(b) *Enforcement action.* (1) Traps not marked in compliance with paragraph (a) of this section and found deployed in the coral reef ecosystem management area 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 coral reef ecosystem management area will be considered unclaimed or abandoned property, and may be disposed of in any manner considered appropriate by NMFS or an authorized officer.

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§§665.129-665.139 [Reserved]

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§665.140 American Samoa Crustacean Fisheries. [Reserved]

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§665.141 Definitions.

As used in §§665.140 through 665.159:

American Samoa crustacean management unit species means the following crustaceans:

Samoan name	English common name	Scientific name
Ula	spiny lobster	*Panulirus marginatus, Panulirus penicillatus.*
Papata	slipper lobster	Scyllaridae.
pa'a	Kona crab	*Ranina ranina.*
	deepwater shrimp	*Heterocarpus* spp.

Crustacean Permit Area 3 (Permit Area 3) includes the EEZ around American Samoa.

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§665.142 Permits.

(a) *Applicability.* (1) The owner of any vessel used to fish for lobster in Permit Area 3 must have a permit issued for that vessel.

(2) The owner of any vessel used to fish for deepwater shrimp in Crustacean Permit Area 3 must have a permit issued for that vessel.

(b) *General requirements.* General requirements governing application information, issuance, fees, expiration, replacement, transfer, alteration, display, sanctions, and appeals for permits issued under this section, as applicable, are contained in §665.13.

(c) *Application.* An application for a permit required under this section will be submitted to PIRO as described in §665.13. If the application for a limited access permit is submitted on behalf of a partnership or corporation, the application must be accompanied by a supplementary information sheet obtained from PIRO and contain the names and mailing addresses of all partners or shareholders and their respective percentage of ownership in the partnership or corporation.

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§665.143 Prohibitions.

In addition to the general prohibitions specified in §600.725 of this chapter and §665.15, in Crustacean Permit Area 3, it is unlawful for any person to fish for, take, or retain deepwater shrimp without a permit issued under §665.142.

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§665.144 Notifications.

(a) The operator of any vessel fishing subject to the requirements of this subpart must:

(1) Report, not less than 24 hours, but not more than 36 hours, before landing, the port, the approximate date and the approximate time at which spiny and slipper lobsters will be landed.

(2) Report, not less than 6 hours and not more than 12 hours before offloading, the location and time that offloading of spiny and slipper lobsters will begin.

(b) The Regional Administrator will notify permit holders of any change in the reporting method and schedule required in paragraphs (a)(1) and (a)(2) of this section at least 30 days prior to the opening of the fishing season.

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§665.145 At-sea observer coverage.

All fishing vessels subject to §§665.140 through 665.145 and subpart A of this part must carry an observer when requested to do so by the Regional Administrator.

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§§665.146-665.159 [Reserved]

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§665.160 American Samoa precious coral fisheries. [Reserved]

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§665.161 Definitions.

As used in §§665.160 through 665.169:

American Samoa precious coral management unit species (American Samoa precious coral MUS) means any coral of the genus *Corallium* in addition to the following species of corals:

Local name	English common name	Scientific name
Amu piniki-mumu	Pink coral (also known as red coral)	*Corallium secundum*, *Corallium regale*, *Corallium laauense.*
Amu auro	Gold coral	*Gerardia* spp., *Callogorgia gilberti*, *Narella* spp., *Calyptrophora* spp.
Amu ofe	Bamboo coral	*Lepidisis olapa*, *Acanella* spp.
Amu ofe	Black coral	*Antipathes dichotoma*, *Antipathes grandis*, *Antipathes ulex.*

American Samoa precious coral permit area means the area encompassing the precious coral beds within the U.S. EEZ around American Samoa. Each bed is designated by a permit area code and assigned to one of the following four categories:

(1) Established beds. [*Reserved*]

(2) Conditional beds. [*Reserved*]

(3) Refugia. [*Reserved*]

(4) Exploratory Area. Permit Area X-P-AS includes all coral beds, other than established beds, conditional beds, or refugia, in the EEZ seaward of American Samoa.

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§665.162 Permits.

(a) Any vessel of the United States fishing for, taking, or retaining American Samoa precious coral MUS in any American Samoa precious coral permit area must have a permit issued under §665.13.

(b) Each permit will be valid for fishing only in the permit area specified on the permit. Precious Coral Permit Areas are defined in §665.161.

(c) No more than one permit will be valid for any one vessel at any one time.

(d) No more than one permit will be valid for any one person at any one time.

(e) The holder of a valid permit to fish one permit area may obtain a permit to fish another permit area only upon surrendering to the Regional Administrator any current permit for the precious coral fishery issued under §665.13.

(f) General requirements governing application information, issuance, fees, expiration, replacement, transfer, alteration, display, sanctions, and appeals for permits for the precious coral fishery are contained in §665.13.

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§665.163 Prohibitions.

In addition to the general prohibitions specified in §600.725 of this chapter and in §665.15, it is unlawful for any person to:

(a) Use any vessel to fish for, take, retain, possess or land precious coral in any precious coral permit area, unless a permit has been issued for that vessel and area as specified in §665.13 and that permit is on board the vessel.

(b) Fish for, take, or retain any species of American Samoa precious coral MUS in any precious coral permit area:

(1) By means of gear or methods prohibited by §665.164.

(2) In refugia specified in §665.161.

(3) In a bed for which the quota specified in §665.167 has been attained.

(4) In violation of any permit issued under §665.13 or §665.17.

(5) In a bed that has been closed pursuant to §§665.166 or 665.169.

(c) Take and retain, possess, or land any live pink coral or live black coral from any precious coral permit area that is less than the minimum height specified in §665.165 unless:

(1) A valid EFP was issued under §665.17 for the vessel and the vessel was operating under the terms of the permit; or

(2) The coral originated outside coral beds listed in this paragraph, and this can be demonstrated through receipts of purchase, invoices, or other documentation.

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§665.164 Gear restrictions.

Only selective gear may be used to harvest coral from any precious coral permit area.

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§665.165 Size restrictions.

The height of a live coral specimen shall be determined by a straight line measurement taken from its base to its most distal extremity. The stem diameter of a living coral specimen shall be determined by measuring the greatest diameter of the stem at a point no less than 1 inch (2.54 cm) from the top surface of the living holdfast.

(a) Live pink coral harvested from any precious coral permit area must have attained a minimum height of 10 inches (25.4 cm).

(b) *Black coral.* Live black coral harvested from any precious coral permit area must have attained either a minimum stem diameter of 1 inch (2.54 cm), or a minimum height of 48 inches (122 cm).

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§665.166 Closures.

(a) If the Regional Administrator determines that the harvest quota for any coral bed will be reached prior to the end of the fishing year, NMFS shall publish a notice to that effect in the FEDERAL REGISTER and shall use other means to notify permit holders. Any such notice must indicate the reason for the closure, the bed being closed, and the effective date of the closure.

(b) A closure is also effective for a permit holder upon the permit holder's actual harvest of the applicable quota.

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§665.167 Quotas.

(a) General. The quotas limiting the amount of precious coral that may be taken in any precious coral permit area during the fishing year are listed in §665.167(d). Only live coral is counted toward the quota. The accounting period for all quotas begins July 1, 1983.

(b) *Conditional bed closure.* A conditional bed will be closed to all nonselective coral harvesting after the quota for one species of coral has been taken.

(c) *Reserves and reserve release.* The quotas for exploratory area X-P-AS will be held in reserve for harvest by vessels of the United States in the following manner:

(1) At the start of the fishing year, the reserve for the American Samoa exploratory area will equal the quota minus the estimated domestic annual harvest for that year.

(2) As soon as practicable after December 31 each year, the Regional Administrator will determine the amount harvested by vessels of the United States between July 1 and December 31 of the year that just ended on December 31.

(3) NMFS will release to TALFF an amount of precious coral for each exploratory area equal to the quota minus two times the amount harvested by vessels of the United States in that July 1-December 31 period.

(4) NMFS will publish in the FEDERAL REGISTER a notification of the Regional Administrator's determination and a summary of the information on which it is based as soon as practicable after the determination is made.

(d) The American Samoa exploratory permit area X-P-AS has an annual quota of 1,000 kg for all American Samoa precious coral MUS combined with the exception of black corals.

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§665.168 Seasons.

The fishing year for precious coral begins on July 1 and ends on June 30 the following year.

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§665.169 Gold coral harvest moratorium.

Fishing for, taking, or retaining any gold coral in any precious coral permit area is prohibited through June 30, 2018.

[78 FR 32182, May 29, 2013]

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Subpart I—Rose Atoll Marine National Monument

SOURCE: 78 FR 33003, June 3, 2013, unless otherwise noted.

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§665.960 Scope and purpose.

The regulations in this subpart codify certain provisions of the Proclamation, and govern the administration of fishing within the Monument. Nothing in this subpart shall be deemed to diminish or enlarge the jurisdiction of the Territory of American Samoa.

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§665.961 Boundaries.

The Monument consists of emergent and submerged lands and waters extending seaward approximately 50 nm from Rose Atoll. The boundary is defined by straight lines connecting the following coordinates in the order listed:

ID	W. long.	S. lat.
1	169°0′42″	13°41′54″
2	167°17′0″	13°41′54″

3	167°17′0″	15°23′10″
4	169°0′42″	15°23′10″
1	169°0′42″	13°41′54″

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§665.962 Definitions.

The following definitions are used in this subpart:

Management Unit Species or MUS means the American Samoa management unit species as defined in §§665.401, 665.421, 665.441, and 665.461, and the pelagic management unit species as defined in §665.800.

Monument means the waters and emergent and submerged lands of the Rose Atoll Marine National Monument, as defined in §665.961.

Proclamation means Presidential Proclamation 8337 of January 6, 2009, “Establishment of the Rose Atoll Marine National Monument.”

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§665.963 Prohibitions.

In addition to the general prohibitions specified in §600.725 of this chapter, and §665.15 and subpart B of this part, the following activities are prohibited in the Monument and, thus, unlawful for a person to conduct or cause to be conducted.

(a) Commercial fishing in the Monument.

(b) Non-commercial fishing in the Monument, except as authorized under permit and pursuant to the procedures and criteria established in §665.965.

(c) Transferring a permit in violation of §665.965(d).

(d) Commercial fishing outside the Monument and non-commercial fishing within the Monument on the same trip in violation of §665.964(c).

(e) Fishing within 12 nm of emergent land within the Monument in violation of §665.964(d).

[78 FR 33003, June 3, 2013, as amended at 78 FR 39583, July 2, 2013]

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§665.964 Regulated activities.

(a) Commercial fishing is prohibited in the Monument.

(b) Non-commercial fishing is prohibited in the Monument, except as authorized under permit and pursuant to the procedures and criteria established in §665.965.

(c) Commercial fishing outside the Monument and non-commercial fishing within the Monument during the same trip is prohibited.

(d) All fishing is prohibited within 12 nm of emergent land within the Monument.

[78 FR 33003, June 3, 2013, as amended at 78 FR 39583, July 2, 2013]

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§665.965 Fishing permit procedures and criteria.

(a) *Rose Atoll Monument non-commercial fishing permit*—(1) *Applicability.* Both the owner and operator of a vessel used to non-commercially fish for, take, retain, or possess MUS in the Monument must have a permit issued under this section, and the permit must be registered for use with that vessel.

(2) *Eligibility criteria.* A permit issued under this section may be issued only to a community resident of American Samoa.

(3) *Terms and conditions.* (i) Customary exchange of fish harvested under a non-commercial permit within the Monument is allowed, except that customary exchange by fishermen engaged in recreational fishing is prohibited.

(ii) Monetary reimbursement under customary exchange shall not exceed actual fishing trip expenses, including but not limited to ice, bait, fuel, or food.

(b) *Rose Atoll Monument recreational charter permit* — (1) *Applicability.* Both the owner and operator of a vessel that is chartered to fish recreationally for, take, retain, or possess MUS in the Monument must have a permit issued under this section, and the permit must be registered for use with that vessel. Charter boat customers are not required to obtain a permit.

(2) *Permit eligibility criteria.* To be eligible for a permit issued under this section, a charter business must be established legally under the laws of American Samoa.

(3) *Terms and conditions.* (i) The sale or exchange through barter or trade of fish caught by a charter boat fishing in the Monument is prohibited.

(ii) No MUS harvested under a recreational charter fishing permit may be used for the purposes of customary exchange.

(c) *Application.* An application for a permit required under this section must be submitted to PIRO as described in §665.13.

(d) *Transfer.* A permit issued under this section is not transferrable.

(e) *Reporting and recordkeeping.* The operator of a vessel subject to the requirements of this section must comply with the terms and conditions described in §665.14.

[78 FR 33003, June 3, 2013, as amended at 78 FR 39583, July 2, 2013]

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§665.966 International law.

The regulations in this subpart shall be applied in accordance with international law. No restrictions shall apply to or be enforced against a person who is not a citizen, national, or resident alien of the United States (including foreign flag vessels) unless in accordance with international law.

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Figure 1 to Part 665—Carapace Length of Lobsters

FIGURE 1 TO PART 665. CARAPACE LENGTH OF LOBSTERS

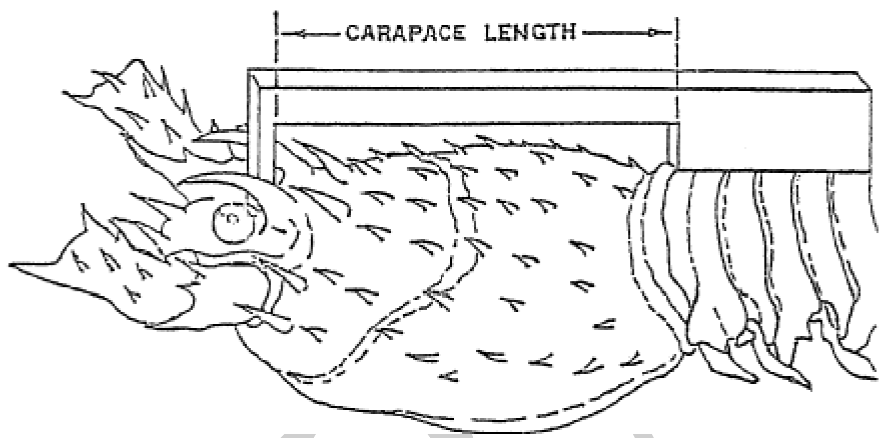

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Figure 2 to Part 665—Length of Fishing Vessels

FIGURE 2 TO PART 665. LENGTH OF FISHING VESSELS

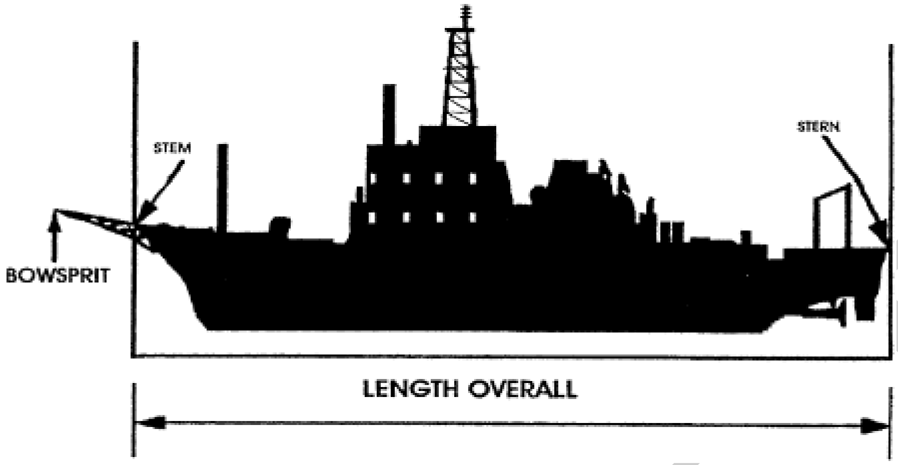

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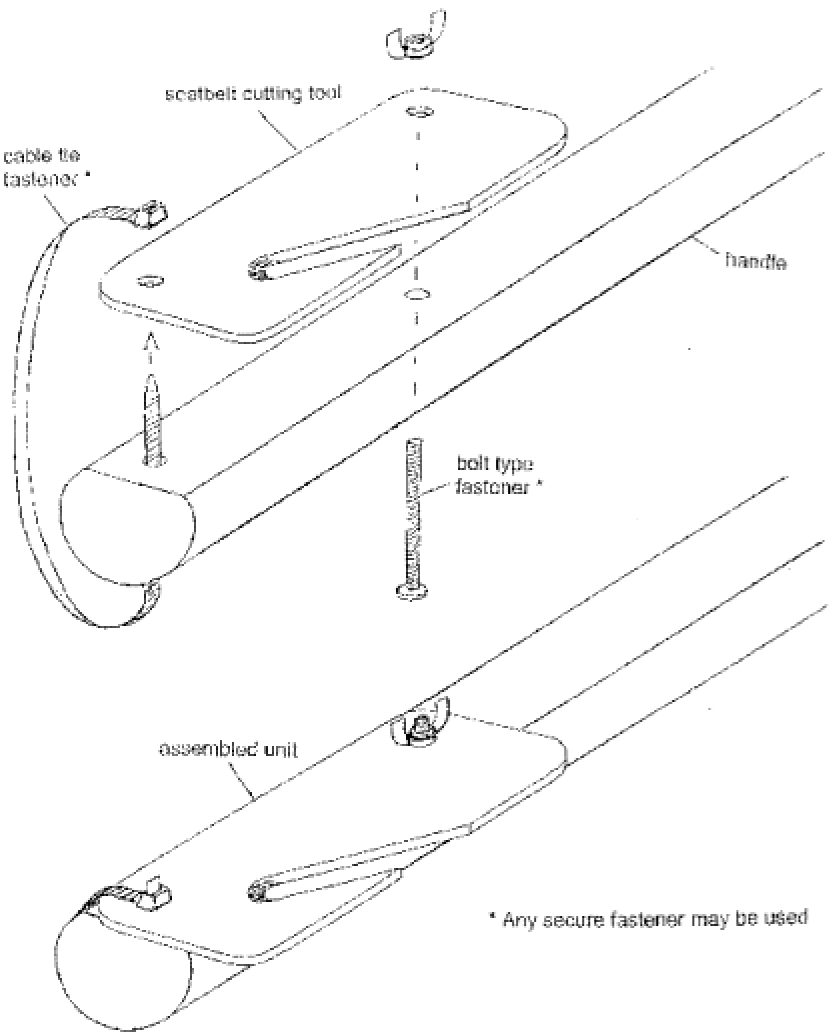
Figure 3 to Part 665—Sample Fabricated Arceneaux Line Clipper

FIGURE 3 TO PART 665. SAMPLE FABRICATED ARCENEAUX LINE CLIPPER



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Appendix D: Summary of Fishery Management Plan and Fishery Ecosystem Plan Amendments

1. Fishery Management Plan Amendments

FMP for Precious Corals of the Western Pacific Region

The fishery management plan (FMP) for Precious Coral Fisheries of the Western Pacific Region was implemented in September 1983 (48 FR 39229, September 29, 1983) and established the plan's management unit species, management areas and classified several known precious coral beds. Since 1983, the FMP has been amended seven times with each amendment summarized in **Table** 1.

Table 1. Amendments to the Precious Coral FMP

No.	Effective Date/Federal Register Notice	Action
7	8/13/08 73 FR 47098	Designated the Auau Channel bed as an established bed with a harvest quota for black coral of 5,000 kg every two years for Federal and state waters combined. Implemented a five year gold harvest moratorium for the entire region.
6	9/12/06 71 FR 53605	Included Federal waters around CNMI and the Pacific Remote Island Areas within the FMP's management area. Extended existing requirements for Federal permits and logbooks to include all harvests of precious corals in EEZ waters in these areas.
5	2/24/04 69 FR 8336	Prepared in parallel with the Coral Reef FMP. Prohibits the harvest of Precious Coral Management Unit Species in the no-take marine protected areas established under the Coral Reef FMP, including areas around Rose Atoll in American Samoa, Kingman Reef, Jarvis Island, Howland Island, and Baker Island.
4	4/19/99 64 FR 19067 8/5/03 56 FR 14866	Addressed new requirements under the 1996 Sustainable Fisheries Act (SFA). Portions of the amendment that were immediately approved included designations of essential fish habitat, definitions of overfishing and descriptions of bycatch and of some fishing communities. Those provisions became effective on February 3, 1999. Remaining provisions regarding Hawaii fishing communities became effective August 5, 2003.
3	10/19/98 63 FR 55809	Established a framework procedure for adjusting management measures in the fishery.
2	1/28/91 56 FR 3072	Defined overfishing for Established beds as: an Established bed shall be deemed overfished with respect to recruitment when the total spawning biomass (all species combined) has been reduced to 20% of its unfished condition. This definition applies to all species of precious corals and is based on cohort analysis of the pink coral, *Corallium secundum*.

No.	Effective Date/Federal Register Notice	Action
1	7/21/88 50 FR 27519	Applied the management measures of the FMP to the Pacific Remote Island Areas by incorporating them into a single Exploratory Permit Area, expanded the management unit species to include all species of the genus *Corallium*, and outlined provisions for the issuance of experimental fishing permits designed to stimulate the domestic fishery

In addition to FMP amendments, the management program for precious coral fisheries has been modified through several regulatory amendments and framework actions as described below.

Regulatory Amendment 1: Removed an exemption allowing fishermen who reported black coral harvest to the State of Hawaii within five years prior to April 17, 2002 to harvest black coral at a minimum base diameter of 3/4 inch. All harvest of black corals must be done at a minimum of 1 inch base diameter or 48 inch minimum height (72 FR 59259, October 15, 2007).

Framework Action 1: Revised the definitions of "live coral" and "dead coral," suspended the harvest of gold coral at Makapu'u Bed, applied minimum size restrictions only to live precious corals, prohibited the harvest of black coral with a stem diameter of less than one inch or a height of less than 48 inches (with certain exceptions), prohibited the use of non-selective fishing gear to harvest precious corals, and applied the minimum size restrictions for pink coral to all permit areas (67 FR 11941, April 17, 2002).

FMP for Crustacean Fisheries of the Western Pacific Region

The FMP for Crustacean Fisheries of the Western Pacific Region was approved in 1983. Initial provisions of the FMP, which was initially named "Spiny Lobster Fisheries of the Western Pacific Region," went into effect March 9, 1983 (48 FR 5560, 7 February 1983). The FMP implemented the following management measures for the Northwestern Hawaiian Islands (NWHI) management area: federal permit requirements, a minimum size limit for spiny lobsters, gear restrictions, a ban on the harvest of egg-bearing female spiny lobsters, the closure of waters within 20 nm of Laysan Island, all NWHI waters shallower than 10 fm, and all NWHI lagoons, to fishing for spiny lobsters, a mandatory logbook program, and a requirement to carry a fishery observer if directed by the National Marine Fisheries Service. The FMP also implemented permit, data reporting, and observer requirements within EEZ waters around the Main Hawaiian Islands (MHI), American Samoa, and Guam. Since 1983, the Crustacean FMP has been amended 13 times with each amendment summarized in **Table** 2.

Table 2. Amendments to the Crustaceans FMP

No.	Effective Date/Federal Register Notice	Action
13	11/21/08 73 FR 70603	Included the deepwater shrimp genus *Heterocarpus* as Management Unit Species (MUS) within the Crustaceans FMP. Required Federal permits and reporting for deepwater shrimp fishing in all Federal

No.	Effective Date/Federal Register Notice	Action
		waters of the Western Pacific Region.
12	10/26/06 71 FR 53605	Included federal waters around CNMI and the Pacific Remote Island Areas in the Crustaceans FMP and implemented federal permit and reporting requirements (71 FR 231) for vessels targeting crustacean MUS in these areas.
11	2/24/04 69 FR 8336	Prepared in parallel with the Coral Reef Ecosystems FMP. This amendment prohibits the harvest of Crustacean MUS in the no-take marine protected areas established under the Coral Reef Ecosystems FMP, including Rose Atoll in American Samoa, Kingman Reef, Jarvis Island, Howland Island, and Baker Island. The final rule implementing the Coral Reef Ecosystem FMP (including Amendment 11 to the Crustaceans FMP) became effective 3/25/04.
10	4/19/99 64 FR 19067 8/5/03 68 FR 46112	Addressed new requirements under the 1996 Sustainable Fisheries Act. Portions of the amendment that were immediately approved included designations of essential fish habitat, and descriptions of bycatch and of some fishing communities. Those provisions became effective on February 3, 1999. Remaining portions approved on August 5, 2003, included provisions regarding Hawaii fishing communities, overfishing definitions, and bycatch.
9	7/5/96 61 FR 35145	Established a system by which the annual harvest guideline would be set based on a constant percent of the population (i.e., proportional to the estimated exploitable population size) based on a specified acceptable risk of overfishing. Amendment 9 set this risk level at 10% and specified that annual harvest guidelines be published by NMFS no later than February 28 of each year. Earlier in-season adjustment procedures were eliminated. Earlier minimum size limits and prohibitions on harvesting of egg bearing females were eliminated and a mechanism was provided for certain regulatory adjustments to be made through framework procedures of the FMP.
8	11/10/94 59 FR 56004	Eliminated the NWHI minimum landings requirements for permit renewal, allowed the catch per unit effort target that is used to set the harvest guideline to be changed through the framework process, and modified reporting requirements
7	3/26/92 57 FR 10437	Established a NWHI limited access program, an adjustable fleet-wide NWHI annual harvest guideline, and a closed season (January through June) in the NWHI fishery. Participation was limited to 15 permits (and vessels). Other measures include a maximum limit on the number of traps per vessel (1,100), revisions to reporting requirements, and other provisions
6	1/28/91 56 FR 3071	Defined recruitment overfishing for lobster stocks in terms of reference points expressed in terms of the spawning potential ratio (SPR). The minimum SPR threshold, below which the stock would

No.	Effective Date/Federal Register Notice	Action
		be considered recruitment overfished, is 20%.
5	1987	Implemented a minimum size for slipper lobster (5.6 cm tail width), required the release of egg-bearing female slipper lobsters, required escape vents in all lobster traps, and revised some of the permit application and reporting requirements. It also changed the name of the FMP from “Spiny Lobster Fisheries” to “Crustaceans Fisheries.”
4	1986	Applied existing NWHI closed areas to slipper lobsters.
3	1985	Revised the minimum spiny lobster size specifications for the NWHI management area to a limit on tail width (5.0 cm).
2	1983	Modified the allowable trap opening dimensions with the intent of minimizing the risk of harm to the Hawaiian monk seal while allowing sufficient flexibility in trap design.
1	1983	Adopted the State of Hawaii’s lobster fishing regulations for the federal waters around the MHI.

In addition to FMP amendments, the management program for crustacean fisheries has been modified through several regulatory amendments described below.

Regulatory Amendment 1: Implemented VMS for the crustacean fishery in the NWHI (64 FR 36820, July 8, 1999).

Regulatory Amendment 2: Allocated 1998 NWHI lobster harvest among three individual banks and a fourth combined area (63 FR 40337, June 29, 1998).

Regulatory Amendment 3: Divided the NWHI into four fishing grounds across which harvest is allocated and allowed fishing vessels with NMFS-certified VMS to transit through fishing grounds during a closure (64 FR 36820, July 8, 1999).

FMP for Bottomfish and Seamount Groundfish of the Western Pacific Region

The FMP for Bottomfish and Seamount Groundfish Fisheries of the Western Pacific Region became effective on August 27, 1986 (51 FR 27413). Initial bottomfish fishery management measures prohibited certain destructive fishing techniques, including explosives, poisons, trawl nets, and bottom-set gillnets; established a moratorium on the commercial harvest of seamount groundfish stocks at the Hancock Seamounts, and implemented a permit system for fishing for bottomfish in the waters of the Exclusive Economic Zone (EEZ) around the Northwestern Hawaiian Islands (NWHI). The plan also established a management framework that provided for regulatory adjustments to be made, such as catch limits, size limits, area or seasonal closures, fishing effort limitations, fishing gear restrictions, access limitations, permit and/or catch reporting requirements, as well as a rules-related notice system. Since 1986, the Bottomfish and Seamount Groudfish FMP has been amended multiple times with each amendment summarized in **Tabl**e 3.

Table 3. Amendments to the Bottomfish and Seamount Groundfish FMP.

No.	Effective Date/Federal Register Notice	Action
14	4/04/08 73 FR 18450	Addressed bottomfish overfishing in the Hawaiian Archipelago by implementing a total allowable catch limit (TAC), federal non-commercial permits and reporting requirements, non-commercial bag limits and a closed season for fishing for Deep 7 species in the Main Hawaiian Islands. It also defined the Main Hawaiian Islands bottomfish fishing year as September 1-August 31, and became effective April 1, 2008 (73 FR 18450) with the permit and reporting requirements effective as of August 18, 2008 (73 FR 41296).
11-13		Amendments 11-13 were intended to address various issues which have now become moot due to changing circumstances.
10	12/12/08 73 FR 75615	Prohibited commercial fishing for bottomfish from vessels greater than 40' long in waters 0-10 miles around the Southern Islands of CNMI and 0-10 miles around the Northern Island of Alamagan. Commercial bottomfishing vessels over 40' long must carry active VMS units owned, installed, and maintained by NMFS. Also, the operators of all vessels commercially fishing for bottomfish in EEZ waters around CNMI must obtain federal permits and complete federal logbooks.
9	11/02/06 71 FR 67774	Prohibited vessels greater than 50' long from targeting Bottomfish species within 50 miles of Guam and required these vessels to obtain federal permits and to submit federal logbooks effective December 4, 2006 (71 FR 69496).
8	9/12/06 71 FR 53605	Included federal waters around CNMI and the Pacific Remote Island Areas in the Bottomfish FMP. Implemented federal permitting and reporting requirements for bottomfish fishing in the PRIA effective 1/2/07 (71 FR 69496).
7	2/24/04 69 FR 8336	Developed in parallel with the Coral Reef Ecosystems FMP. Prohibited harvest of Bottomfish and Seamount Groundfish Management Unit Species (MUS) in the no-take marine protected areas established under the Coral Reef Ecosystems FMP. The Coral Reef Ecosystems established such areas around Rose Atoll in American Samoa, Kingman Reef, Jarvis Island, Howland Island, and Baker Island. The final rule implementing the Coral Reef Ecosystem FMP (including Amendment 7 to the Bottomfish FMP) became effective 3/25/04.
6	4/19/99 64 FR19067 8/5/03 68 FR 46112	Addressed new requirements under the 1996 Sustainable Fisheries Act. Portions of the amendment that were immediately approved included designations of essential fish habitat, and descriptions of bycatch and of some fishing communities. Those provisions became effective on 2/3/99. Remaining portions approved on 8/5/03, included provisions regarding Hawaii fishing communities, overfishing definitions, and bycatch.
5	4/28/99	Established a limited entry program for the Mau Zone in the NWHI

No.	Effective Date/Federal Register Notice	Action
	64 FR 22810	with non-transferable permits and landing requirements for permit renewal. Included in requirements was attendance by the primary vessel operator at a protected species workshop. Also reserved 20% of Mau Zone permits a Western Pacific Community Development Program (CDP), as well as instituting a maximum vessel length of 60' for replacement vessels in the Hoomalu or Mau Zones
4	5/30/91 56 FR 24351	Implemented a requirement for vessel owners or operators to notify NMFS at least 72 hours before leaving port if they intend to fish in a “protected species study zone” that extends 50 nautical miles (nm) around the NWHI to allow federal observers to be placed on board bottomfish vessels to record interactions with protected species if this action is deemed necessary
3	1/16/91 56 FR 2503	Defined recruitment overfishing as a condition in which the ratio of the spawning stock biomass per recruit at the current level of fishing to the spawning stock biomass per recruit that would occur in the absence of fishing is equal to or less than 20%. Amendment 3 also delineated a process by which overfishing would be monitored and evaluated.
2	9/6/88 53 FR 29907	Divided the EEZ around the NWHI into the Hoomalu and Mau zones. A vessel limited access system was established for the Ho’omalu Zone, with non-transferable permits and landing requirements for permit renewal and for new entry into the fishery. Access to the Mau Zone was left unrestricted, except for vessels permitted to fish in the Hoomalu Zone.
1	11/11/87 52 FR 38102	Established a system to allow implementation of limited access systems for bottomfish fisheries in EEZ waters around American Samoa and Guam within the framework measures of the FMP.

FMP for Pelagic Fisheries of the Western Pacific Region

The FMP for Pelagic Fisheries of the Western Pacific Region became effective on March 23, 1987 (52 FR 5987). The Pelagic Management Unit Species (PMUS) at that time were billfish, wahoo, mahimahi, and oceanic sharks. The FMP’s first measures prohibited drift gillnet fishing within the region’s waters of the U.S. EEZ and prohibited foreign longline fishing within certain areas of the EEZ. Since 1987, the Pelagic FMP has been amended multiple times with each amendment summarized in **Table** 4.

Table 4. Amendments to the Pelagic FMP.

No.	Effective Date/Federal Register Notice	Action

No.	Effective Date/Federal Register Notice	Action
18	12/10/09 74 FR 65460	Removed 2,120 set limit for Hawaii-based shallow-set longline fishery. Implemented a new loggerhead sea turtle hard cap of 46 annual interactions.
16-17		Was intended to address issues which have now become moot due to changing circumstances.
15	11/21/08 73 FR 70600	Added the following pelagic squid species to the FMP: *Ommastrephes bartramii*, *Thysanoteuthis rhombus*, and *Sthenoteuthis oualaniensis*. Also, required owners of U.S. vessels greater than 50 ft in length overall that fish for pelagic squid in U.S. EEZ of the western Pacific to obtain Federal permits under the Pelagics Fishery Management Plan, to carry Federal observers if requested by NMFS, and to report any Pacific pelagic squid catch and effort either in Federal logbooks or via existing local reporting systems.
14	6/18/07 72 FR 33442	Partially approved by NMFS. This amendment contained recommendations regarding international and domestic management, including a mechanism by which the Council could participate in international negotiations regarding these stocks. Amendment 14 contained measures to implement control dates for Hawaii's non-longline commercial pelagic vessels (70 FR 47781) and purse seine and longline vessels (70 FR 47782), as well as requirements for federal permits and reporting for Hawaii-based non-longline commercial pelagic vessels. NMFS disapproved the Amendment's international measures as premature. NMFS disapproved the domestic permit and reporting requirements as duplicative of existing State requirements. NMFS noted that Amendment 14 met the requirements of the Magnuson-Act regarding overfishing.
12-13		Was intended to address issues which have now become moot due to changing circumstances.
11	5/24/05 70 FR 29646	Effective August 1, 2005, Amendment 11 established a limited access system for pelagic longlining in EEZ waters around American Samoa. Longline vessel operators were required to obtain federal permits, to complete federal logbooks, to carry and use vessel monitoring systems installed, owned and operated by NFMS on vessels greater than 40 ft in length, to carry federal observers if requested by NMFS, and to follow sea turtle handling and resuscitation requirements.
10	2/24/04 69 FR 8336	Amendment 10 prohibits the harvest of Pelagic Management Unit Species in the no-take marine protected areas established under the Coral Reef Ecosystems FMP. The Coral Reef FMP establishes such areas around Rose Atoll in American Samoa, Kingman Reef, Jarvis Island, Howland Island, and Baker Island. The final rule implementing the Coral Reef Ecosystem FMP includes Amendment

No.	Effective Date/Federal Register Notice	Action
		10 to the Pelagics FMP.
9		Was intended to address issues which have now become moot due to changing circumstances.
8	4/19/99 64 FR 19067 8/5/03 68 FR 46112	Addressed new requirements under the 1996 Sustainable Fisheries Act. Portions of the amendment that were immediately approved (4/19/99) included designations of essential fish habitat and descriptions of some fishing communities. Remaining portions were provisions regarding Hawaii fishing communities, overfishing definitions, and bycatch (approved 8/5/03).
7	5/24/94 59 FR 26979	Replaced Amendment 4 moratorium with a limited entry program for Hawaii-based domestic longline fishery with transferable permits, a limit of 164 vessels, and a maximum vessel size of 101' in length overall. It also established a framework procedure for use with implementation of certain new regulations.
6	11/2/92 57 FR 36637	Specified that all tuna species are designated as fish under U.S. management authority and included tunas and related species as Pelagic Management Unit Species under the FMP. It also applied the longline exclusion zones of 50 nm around the island of Guam and the 25-75 nm zone around the MHI to foreign vessels.
5	3/2/92 57 FR 7661	Created a domestic longline vessel exclusion zone around the Main Hawaiian Islands (MHI) ranging from 50 to 75 nm, and a similar 50 nm exclusion zone around Guam and its offshore banks. A seasonal reduction in the size of the closure was implemented in October 1992; between October and January longline fishing is prohibited within 25 nm of the windward shores of all Main Hawaiian Islands except Oahu, where it is prohibited within 50 nm from the shore.
4	10/14/91 56 FR 52214	Created a 50 nm longline exclusion zone around the NWHI to protect endangered Hawaiian monk seals. It also implemented framework provisions for establishing a mandatory observer program to collect information on interactions between longline fishing and sea turtles.
3	10/14/91 56 FR 52214	Created a 50 nm longline exclusion zone around the NWHI to protect endangered Hawaiian monk seals. It also implemented framework provisions for establishing a mandatory observer program to collect information on interactions between longline fishing and sea turtles.
2	5/26/91 56 FR 24731	Implemented requirements for domestic pelagic longline fishing and transhipment vessel operators to have Federal permits, maintain Federal fishing logbooks, and, if fishing within 50 nm of the Northwestern Hawaiian Islands, to have observers on board if directed by NMFS. It required longline gear to be marked with the official number of the permitted vessel, and incorporated waters of the EEZ around CNMI into the area managed under the FMP.

No.	Effective Date/Federal Register Notice	Action
1	3/1/91 56 FR 9686	Defined recruitment overfishing for each PMUS. Defined the optimum yield for PMUS.

In addition to FMP amendments, the management program for pelagic fisheries has been modified through several regulatory amendments and framework actions described below.

Regulatory Amendment 1: Incorporated reasonable and prudent alternative of the March 2001 Biological Opinion issued by NMFS. This amendment prohibited shallow set pelagic longlining north of the equator and closed waters between 0° and 15° N from April-May annually to longline fishing. It instituted sea turtle handling requirements for all vessels using hooks to target pelagic species in the region's EEZ waters and extended the protected species workshop requirement to include the operators of vessels registered to longline general permits (67 FR 40232, July 12, 2002**)**.

Regulatory Amendment 2: Established Federal permit and reporting requirements for any vessel using troll or handline gear to catch PMUS in EEZ waters around the Pacific Remote Island Areas of Kingman Reef, Howland, Baker, Jarvis, Johnston and Wake Islands, and Palmyra and Midway Atolls (67 FR 59813, October 24, 2002- comment period end)

Regulatory Amendment 3: Implemented measures for the longline fisheries to achieve optimum yield while not jeopardizing the long term existence of sea turtles and other listed species. The amendment established a limited Hawaii-based shallow-set swordfish fishery using circle hooks with mackerel bait. Fishing effort in the shallow-set swordfish fishery was limited to 50% of the 1994-1999 annual average number of sets (just over 2,100 sets) allocated between fishermen applying to participate in the fishery. A 'hard' limit on the number of leatherback (16) and loggerhead (17) turtle interactions that could occur in the swordfish fishery was implemented; the fishery closed for the remainder of the calendar year if either limit was reached. The amendment re-implemented earlier sea turtle handling and resuscitation requirements and included conservation projects to protect sea turtles in their nesting and coastal habitats. This rule implemented the requirement for night setting imposed by the USFWS Biological Opinion on Hawaii-based longline vessels targeting swordfish north of 23 degrees north latitude (69 FR 17329, April 2, 2004**)**.

Regulatory Amendment 4: Included measures to minimize turtle interactions by non-Hawaii based domestic longline vessels operating in the Western Pacific under general longline permits. Vessels with longline general permits making shallow sets north of the equator were required to use 18/0 circle hooks with mackerel-type bait and dehookers to release any accidentally caught turtles. The amendment required vessel operators and owners with general longline permits to annually attend protected species training workshops. Operators of vessels with general longline permits were required to carry and use specific mitigation gear to aid release of sea turtles accidentally hooked or entangled by longlines. This amendment required operators of non-longline pelagic vessels (e.g. trollers and handliners) to follow handling guidelines and remove trailing gear wherever they fish (70 FR 69282, December 15, 2005).

Regulatory Amendment 5: Allowed operators of Hawaii-based longline vessels fishing north of 23 degrees north latitude, as well as those targeting swordfish south of 23 degrees north, to utilize side-setting to reduce seabird interactions in lieu of the seabird mitigation measures required by Framework Measure 1 (70 FR 75075, January 18, 2006).

Regulatory Amendment 6: Removed the seven day delay in effectiveness when closing the Hawaii based shallow-set longline fishery as a result of reaching interaction limits for sea turtles, allowing instead for an immediate closure of the fishery (72 FR 8289, February 26, 2007).

Regulatory Amendment 7: Provided pelagic fishery participants the option of using NMFS approved electronic logbooks in lieu of paper logbooks (72 FR 19123, April 16, 2007)

Framework Amendment 1: Prohibited fishing for pelagic species by vessels greater than 50 ft in length overall within EEZ waters 0-50 nm around the islands of American Samoa. Exception: vessels that landed PMUS in American Samoa under a Federal longline general permit prior to November 13, 1997 (67 FR 4369, January 30, 2002)

Framework Amendment 2: Incorporated terms and conditions developed by the Council and contained in the November 28, 2000 USFWS seabird Biological Opinion requiring Hawaii-based pelagic longline vessel operators to use blue-dyed bait, strategic offal discards, and line shooters with weighted branch lines when fishing north of 23° N. Also included requirement that all Hawaii-based longline vessel owners and operators annually attend a protected species workshop conducted by NMFS (67 FR 34408, June 13, 2002)

FMP for Coral Reef Ecosystem Fisheries of the Western Pacific Region

The FMP for Coral Reef Ecosystems of the Western Pacific Region was partially approved on June 14, 2002. NMFS disapproved a portion of the plan that governs fishing in the Northwestern Hawaiian Islands (NWHI) west of 160°50' W. long. because it would be inconsistent with or duplicate certain provisions of Executive Orders 13178 and 13196, which together established the NWHI Coral Reef Ecosystem Reserve. A final rule implementing the Coral Reef Ecosystem FMP was published on February 24, 2004 (69 FR 8336). The FMP is the nation's first ecosystem-based plan for fisheries and includes specific measures to promote sustainable fisheries while providing for substantial protection of coral reef ecosystem resources and habitats throughout the Council's jurisdiction. The management measures of the Coral Reef Ecosystems FMP:

- Established a network of marine protected areas (MPA) in the Pacific Remote Island Areas (PRIA). Howland, Baker, Jarvis Islands, Rose Atoll, and Kingman Reef have been designated as no-take MPAs. Palmyra and Johnston Atolls, and Wake Islands are designated as low-use MPAs where fishing is allowed under special fishing permits. Both no-take and low-use MPAs were proposed for the NWHI in the FMP, but were disapproved by NMFS;
- Requires a special permit and federal reporting system for controlling and monitoring the harvest of certain coral reef ecosystem management unit species (MUS) for which there is little or no information. Special permits are also required to fish in all areas designated as low-use MPAs. The FMP also uses data collected under existing local reporting systems to monitor the harvest of currently fished coral reef ecosystem MUS;

- Prohibits the use of destructive and non-selective fishing gears;
- Prohibits harvesting of coral and live rock, but allow limited take under the special permit system for collection of seed stock by aquaculture operations, and religious/cultural use by indigenous peoples;
- Incorporates an adaptive management approach using a framework process for rapid regulatory modifications in the event of major changes within coral reef ecosystems or coral reef fisheries;
- Considers and take into account in management, the historical and cultural dependence of coral reef resources by indigenous people and;
- Identifies and prioritize coral reef related research needs for each island area, including socio-economic and cultural research for future potential allocation of resources.

Since its implementation in 2004, the Coral Reef FMP has not been amended.

2. Fishery Ecosystem Plan Amendments

Omnibus Amendment: Community Development Program Process, 9/3/10

The Council amended all FEPs to establish eligibility requirements and procedures for reviewing and approving community development plans. The intent is to promote participation of island communities in fisheries that they traditionally depend on, but may not have the capabilities to support continued and substantial participation. A second final rule was published 11/05/10 in which OMB approved the collection-of-information requirements (75 FR 68199).

Omnibus Amendment: Establish a Western Pacific Region Process for Specifying Annual Catch Limits and Accountability Measures, 6/27/11

The Council amended all FEPs to establish the mechanism the Council will use to specify ACLs and AMs for each FEP fishery. Specifically, the proposed action described in this document consists of three components that would: 1) in each FEP, establish a mechanism the Council will use to determine ACLs and AMs , including a process for setting acceptable biological catch limits (ABCs); 2) adopt the ecosystem component (EC) species classification described in the NMFS advisory guidelines for National Standard 1 (NS1) so the Council can develop specific criteria for identifying EC species in subsequent amendments to the FEPs; and 3) identify pelagic management unit species that have statutory exceptions to the ACL and AM requirements.

Amendment to the Pacific Pelagic, American Samoa, Mariana, and Pacific Remote Island Area FEPs: Fishery Management in the Marianas Trench, Pacific Remote Islands, and Rose Atoll Marine National Monuments,

The Council amended the Pacific Pelagics, American Samoa, Pacific Remote Island Areas, and the Mariana Islands FEPs, to establish certain provisions relating to non-commercial fishing practices. Consistent with the monument Proclamations, the amendments:

- Codified the boundaries of the Monuments and their various management units.

- Implemented the prohibition on commercial fishing at Rose Atoll and PRI Monuments, and in the Islands Unit of the Marianas Trench Monument.
- Established management measures for non-commercial and recreational fishing in the Monuments including, but not limited to:
  - Requiring Federal permits and reporting for non-commercial and recreational charter fishing to aid in the monitoring of fishing activities.
  - Limiting fishing permit eligibility to residents and businesses of local fishing communities in the Rose Atoll Monument and Marianas Trench Monument, Islands Unit.
  - Allowing customary exchange in non-commercial fishing in the Marianas Trench Islands Unit and Rose Atoll Monuments to help preserve traditional indigenous and cultural fishing practices.
  - Defining customary exchange as the non-market exchange of marine resources between fishermen and community residents for goods, services, and/or social support for cultural, social or religious reasons, and may include cost recovery through monetary reimbursements and other means for actual trip expenses (ice, bait, food, or fuel) that may be necessary to participate in fisheries in the western Pacific. Customary exchange of fish harvested in the Monuments includes family and friends of residents of the fishing communities.
  - Prohibiting all fishing within 12 nautical miles (nm) of the Pacific Remote Islands, subject to USFWS's authority to allow non-commercial fishing, in consultation with NMFS and the Council.
  - Prohibit all fishing within 12 nm around Rose Atoll.
- Prohibited the conduct of commercial fishing outside of a monument, and noncommercial fishing within a monument, on the same trip.

Amendment 2 to the Pacific Pelagic FEP: Establishment of Longline Prohibited Areas in the Mariana Archipelago, 3/4/2011

The Council amended the Pacific Pelagic FEP to establish a 30 mile longline fishing prohibited areas in the CNMI to promote sustained participation in fishing by Guam and CNMI fishing communities.

Amendment 5 to the Pacific Pelagic FEP: Measures to Reduce Interactions between the American Samoa Longline Fishery and Green Sea Turtles, 8/24/11

The American Samoa longline fishery has been observed to interact with (hook or entangle) with green sea turtles (Chelonia mydas) which are listed as threatened under the Endangered Species Act. To address this issue, the Council amended the Pelagics FEP to provide for the longterm survival, recovery, and sustainability of the sea turtles by reducing the number of sea turtle interactions with the fishery.

Amendment 7 to the Pacific Pelagic FEP: Use and Assignment of Catch and Effort Limits of Pelagic Management Unit Species by the U.S. Pacific Island Territories. 3/28/14

Amendment 7 establishes a management framework and process for specifying fishing catch and effort limits and accountability measures for pelagic fisheries in the U.S. Pacific territories (American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands). The framework authorizes the government of each territory to allocate a portion of its specified catch or effort limit to a U.S. fishing vessel or vessels through a specified fishing agreement, and establish criteria, which a specified fishing agreement must satisfy. The framework also includes measures to ensure accountability for adhering to fishing catch and effort limits.

Table 5. Amendments to the Fishery Ecosystem Plans (post-2009).

FEP	No.	Effective Date/Federal Register Notice	Action
AS	1	6/27/11 76 FR 37285	Omnibus amendment. Establishes eligibility requirements and procedures for reviewing and approving community development plans. The intent is to promote participation of island communities in fisheries that they traditionally depend on, but may not have the capabilities to support continued and substantial participation. . A second final rule was published 11/05/10 in which OMB approved the collection-of-information requirements (75 FR 68199).
AS	2	09/03/10 75 FR 54044	Omnibus amendment that establishes a mechanism for specifying annual catch limits.
HI	1	09/03/10 75 FR 54044	Omnibus amendment. Establishes eligibility requirements and procedures for reviewing and approving community development plans. The intent is to promote participation of island communities in fisheries that they traditionally depend on, but may not have the capabilities to support continued and substantial participation. A second final rule was published 11/05/10 in which OMB approved the collection-of-information requirements (75 FR 68199).
HI	2	11/10/10 75 FR 69015	Establishes the Hancock Seamounts Ecosystem Management Area as well as continues the moratorium on armorhead and other seamount groundfish until the armorhead stock is rebuilt.
HI	3	6/27/11 76 FR 37285	Omnibus amendment that establishes a mechanism for specifying annual catch limits
MA	1	09/03/10 75 FR 54044	Omnibus amendment. Establishes eligibility requirements and procedures for reviewing and approving community development plans. The intent is to promote participation of island communities in fisheries that they traditionally depend on, but may not have the capabilities to support continued and substantial participation. A second final rule was published 11/05/10 in which OMB approved the collection-

FEP	No.	Effective Date/Federal Register Notice	Action
			of-information requirements (75 FR 68199).
MA	2	6/27/11 76 FR 37285	Omnibus amendment that establishes a mechanism for specifying Annual Catch Limits.
PRIA	1	6/27/11 76 FR 37285	Omnibus amendment that establishes a mechanism for specifying annual catch limits.
PRIA	2	6/03/13 78 FR 32996	Establishes management measures for non-commercial and recreational fishing within the Pacific Remote Islands Marine National Monument; prohibits commercial fishing within monument
PEL	1	09/03/10 75 FR 54044	Eligibility requirements and procedures for reviewing and approving community development plans. The intent is to promote participation of island communities in fisheries that they traditionally depend on, but may not have the capabilities to support continued and substantial participation.
PEL	2	Disapproval: 7/11/11 76 FR 40764	Establishes a purse seine area closure in American Samoa. The purse seine area closure was disapproved.
PEL	3	6/27/11 76 FR 37287	Establishes a purse seine area closure and longline area closure in CNMI. The final rule only approved the longline closure.
PEL	4	6/27/11 76 FR 37285	Omnibus amendment that establishes a mechanism for specifying annual catch limits.
PEL	5	8/24/11 76 FR 52888	American Samoa longline gear configuration modifications to reduce sea turtle interactions.
PEL	6		
PEL	7		Catch and effort limits for the US Participating Territories; Specification of annual bigeye tuna catch limits for the US Participating Territories.

Appendix E: MSY Control Rule & Stock Status Determination Criteria and Process for Specifying Annual Catch Limits and Accountability Measures

MSY Control Rule and Stock Status Determination Criteria

A MSY control rule is a control rule that specifies the relationship of F to B or other indicator of productive capacity under an MSY harvest policy. Because fisheries must be managed to achieve optimum yield, not MSY, the MSY control rule is a benchmark control rule rather than an operational one. However, the MSY control rule is useful for specifying the "objective and measurable criteria for identifying when the fishery to which the plan applies is overfished" that are required under the MSA. The National Standard Guidelines (74 FR 3178) refer to these criteria as "status determination criteria" and state that they must include two limit reference points, or thresholds: one for F that identifies when overfishing is occurring and a second for B or its proxy that indicates when the stock is overfished.

The status determination criterion for F is the maximum fishing mortality threshold (MFMT). Minimum stock size threshold (MSST) is the criterion for B. If fishing mortality exceeds the MFMT for a period of one year or more, overfishing is occurring. A stock or stock complex is considered overfished when its biomass has declined below a level that jeopardizes the capacity of the stock to produce MSY on a continuing basis (i.e., the biomass falls below MSST). A Council must take remedial action in the form of a new FMP, an FMP amendment, or proposed regulations within two years following notification by the Secretary of Commerce that overfishing is occurring, a stock or stock complex is overfished or approaching an overfished condition[1] or existing remedial action to end previously identified overfishing or to rebuild an overfished stock has not resulted in adequate progress.

The National Standard Guidelines state that the MFMT may be expressed as a single number or as a function of some measure of the stock's productive capacity. Guidance in Restrepo et al. (1998:17) regarding specification of the MFMT is based on the premise that the MSY control rule constitutes the MFMT. In the example in Figure 1 the MSY control rule sets the MFMT constant at F_{MSY} for values of B greater than the MSST and decreases the MFMT linearly with biomass for values of B less than the MSST. This is the default MSY control rule recommended in Restrepo et al. (1998). Again, if F is greater than the MFMT for a period of one year or more, overfishing is occurring.

The National Standard Guidelines state that to the extent possible, the MSST should equal whichever of the following is greater: One-half the MSY stock size, or the minimum stock size at which rebuilding to the MSY level would be expected to occur within 10 years if the stock or stock complex were exploited at the MFMT. The MSST is indicated in Figure 1 by a vertical line at a biomass level somewhat less than B_{MSY}. A specification of MSST below B_{MSY} would allow

[1] A stock or stock complex is approaching an overfished condition when it is projected that there is more than a 50 percent chance that the biomass of the stock or stock complex will decline below MSST within two years (74 FR 3178).

for some natural fluctuation of biomass above and below B_{MSY}, which would be expected under, for example, an MSY harvest policy. Again, if B falls below MSST the stock is overfished.

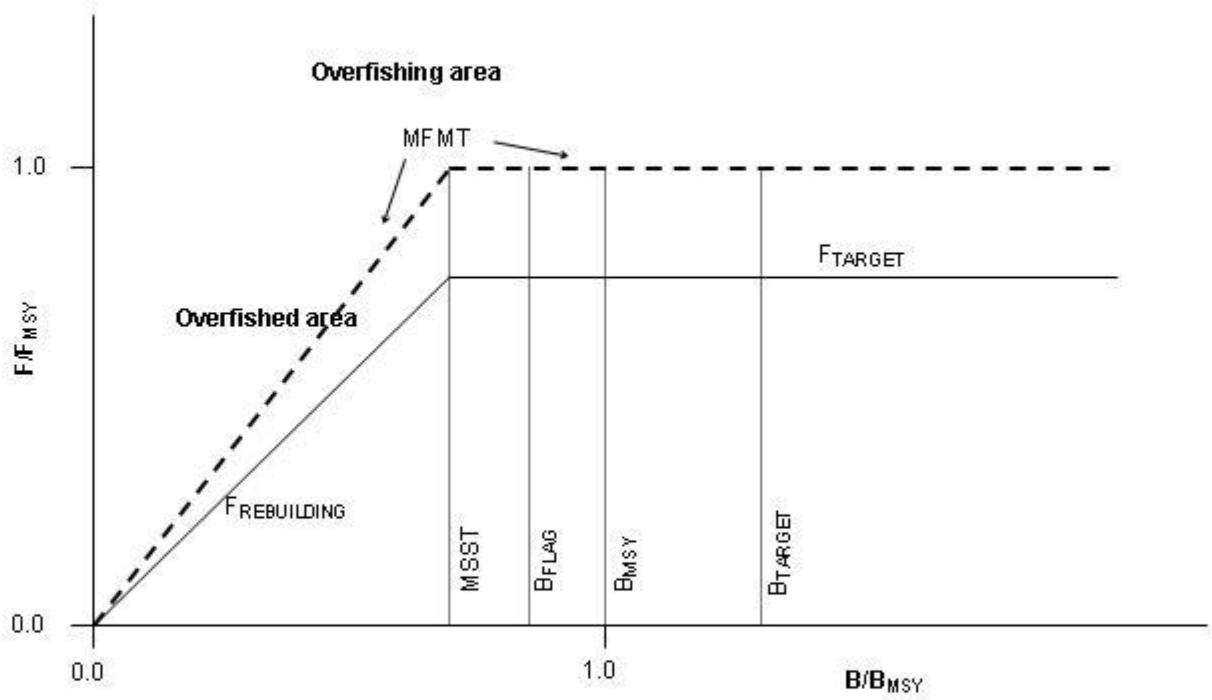

Figure 1. Example of MSY, Target and Rebuilding Control Rules

Source: Restrepo et al. 1998

Warning reference points comprise a category of reference points that will be considered in this FEP together with the required thresholds. Although not required under the MSA, warning reference points could be specified in order to provide warning in advance of B or F approaching or reaching their respective thresholds. Considered in this FEP is a stock biomass flag (B_{FLAG}) that would be specified at some point above MSST, as indicated in Figure 1. The control rule would not call for any change in F as a result of breaching B_{FLAG} – it would merely serve as a trigger for consideration of action or perhaps preparatory steps towards such action. Intermediate reference points set above the thresholds could also be specified in order to trigger changes in F – in other words, the MFMT could have additional inflection points.

Target Control Rule and Reference Points (For Crustacean Management Unit Species only)

A target control rule specifies the relationship of F to B for a harvest policy aimed at achieving a given target. Optimum yield (OY) is one such target, and National Standard 1 requires that conservation and management measures both prevent overfishing and achieve OY on a continuing basis. Optimum yield is the yield that will provide the greatest overall benefits to the nation, and is prescribed on the basis of MSY, as reduced by any relevant economic, social, or ecological factor. MSY is therefore an upper limit for OY.

A target control rule can be specified using reference points similar to those used in the MSY control rule, such as F_{TARGET} and B_{TARGET}. For example, the recommended default in Restrepo et al. (1998) for the target fishing mortality rate for certain situations (ignoring all economic, social, and ecological factors except the need to be cautious with respect to the thresholds) is 75 percent of the MFMT, as indicated in Figure 1. Simulation results using a deterministic model have shown that fishing at 0.75 F_{MSY} would tend to result in equilibrium biomass levels between 1.25 and 1.31 B_{MSY} and equilibrium yields of 0.94 MSY or higher (Mace 1994).

It is emphasized that while MSST and MFMT are limits, the target reference points are merely targets. They are guidelines for management action, not constraints. For example Restrepo et al. (1998) state that target reference points should not be exceeded more than 50% of the time, nor on average.

Rebuilding Control Rule and Reference Points (For Crustacean Management Unit Species only)

If it has been determined that overfishing is occurring, a stock or stock complex is overfished or approaching an overfished condition, or existing remedial action to end previously identified overfishing or to rebuild an overfished stock has not resulted in adequate progress, the Council must take remedial action within two years. In the case that a stock or stock complex is overfished (i.e., biomass falls below MSST in a given year), the action must be taken through a stock rebuilding plan (which is essentially a rebuilding control rule as supported by various analyses) with the purpose of rebuilding the stock or stock complex to the MSY level (B_{MSY}) within an appropriate time frame, as required by MSA §304(e)(4). The details of such a plan, including specification of the time period for rebuilding, would take into account the best available information regarding a number of biological, social, and economic factors, as required by the MSA and National Standard Guidelines.

If B falls below MSST, management of the fishery would shift from using the target control rule to the rebuilding control rule. Under the rebuilding control rule in the example in Figure 1, F would be controlled as a linear function of B until B recovers to MSST (see $F_{REBUILDING}$), then held constant at F_{TARGET} until B recovers to B_{MSY}. At that point, rebuilding would have been achieved and management would shift back to using the target control rule (F set at F_{TARGET}). The target and rebuilding control rules “overlap” for values of B between MSST and the rebuilding target (B_{MSY}). In that range of B, the rebuilding control rule is used only in the case that B is recovering from having fallen below MSST. In the example in Figure 1 the two rules are identical in that range of B (but they do not need to be), so the two rules can be considered a single, integrated, target control rule for all values of B.

Measures to Prevent Overfishing and Overfished Stocks

The control rules specify how fishing mortality will be controlled in response to observed changes in stock biomass or its proxies. Implicitly associated with those control rules are management actions that would be taken in order to manipulate fishing mortality according to the rules. In the case of a fishery which has been determined to be “approaching an overfished condition or is overfished," MSA §303(a)(10) requires that the FMP "contain conservation and management measures to prevent overfishing or end overfishing and rebuild the fishery."

Use of National Standard 1 Guidelines in FEPs

This FEP carries forward the provisions pertaining to compliance with the Sustainable Fisheries Act which were recommended by the Council and subsequently approved by NMFS (68 FR 16754, April 7, 2003). Because biological and fishery data are limited for all species managed by this FEP, MSY-based control rules and overfishing thresholds are specified for multi-species stock complexes.

Process for Specifying Annual Catch Limits (ACLs) and Accountability Measures (AMs)

In 2012, a mechanism for specifying ACLs was established in the FEPs for American Samoa, Hawaii, the Mariana Archipelago, the Pacific Remote Island Areas, and western Pacific Pelagic fisheries. The ACL mechanism included a tiered system of ABC control rules that the SSC applies to calculate ABC. Included in this is a qualitative method the Council employed to determine an appropriate P* (P* denotes risk of overfishing) value for each fishery. The ACL mechanism also includes methods for determining ACLs and AMs for stocks and stock complexes in the fishery. ACLs and AMs developed by the Council are specified by the agency prior to the start of each fishing year. Figure 2 illustrates the method for specifying ACLs, including the procedures for calculating ABC and setting ACL and AMs that are all described in this section.

Calculation of the Acceptable Biological Catch

This section describes how the ABC is calculated and set compared to the OFL using ABC control rules that account for the level of scientific knowledge about the stock or stock complex, scientific uncertainty in the estimate of OFL, and other scientific information. This section also discusses how the acceptable risk of overfishing (P*) is factored into the ABC control rule and how P* is determined.

Tiered System of ABC Control Rules

For stocks and stock complexes required to have an ABC, the Council utilizes a five-tiered system of ABC control rules that allows for different levels of scientific information to be considered when calculating ABC. The control rules are organized from data rich down to data poor, with Tier 1 being the highest (data rich) and Tier 5 being the lowest (data poor). Tiers 1-2 involve data rich to data moderate situations and include levels of uncertainty derived from model-based stock assessments. Tiers 3-5 involve data poor situations and include levels of uncertainty derived from ad-hoc procedures including simulation models or expert opinion.

When calculating an ABC for a stock or stock complex, the SSC first evaluate the information available for the stock and assign the stock or stock complex into one of the five tiers. The SSC then applies the control rule assigned to that tier to determine the ABC. The SSC may recommend an ABC that differs from the result of the control rule calculation based on factors such as data uncertainty, recruitment variability, declining trends in population variables, and other factors determined relevant by the SSC, but must explain their rationale. The tiered system of ABC control rules are described below.

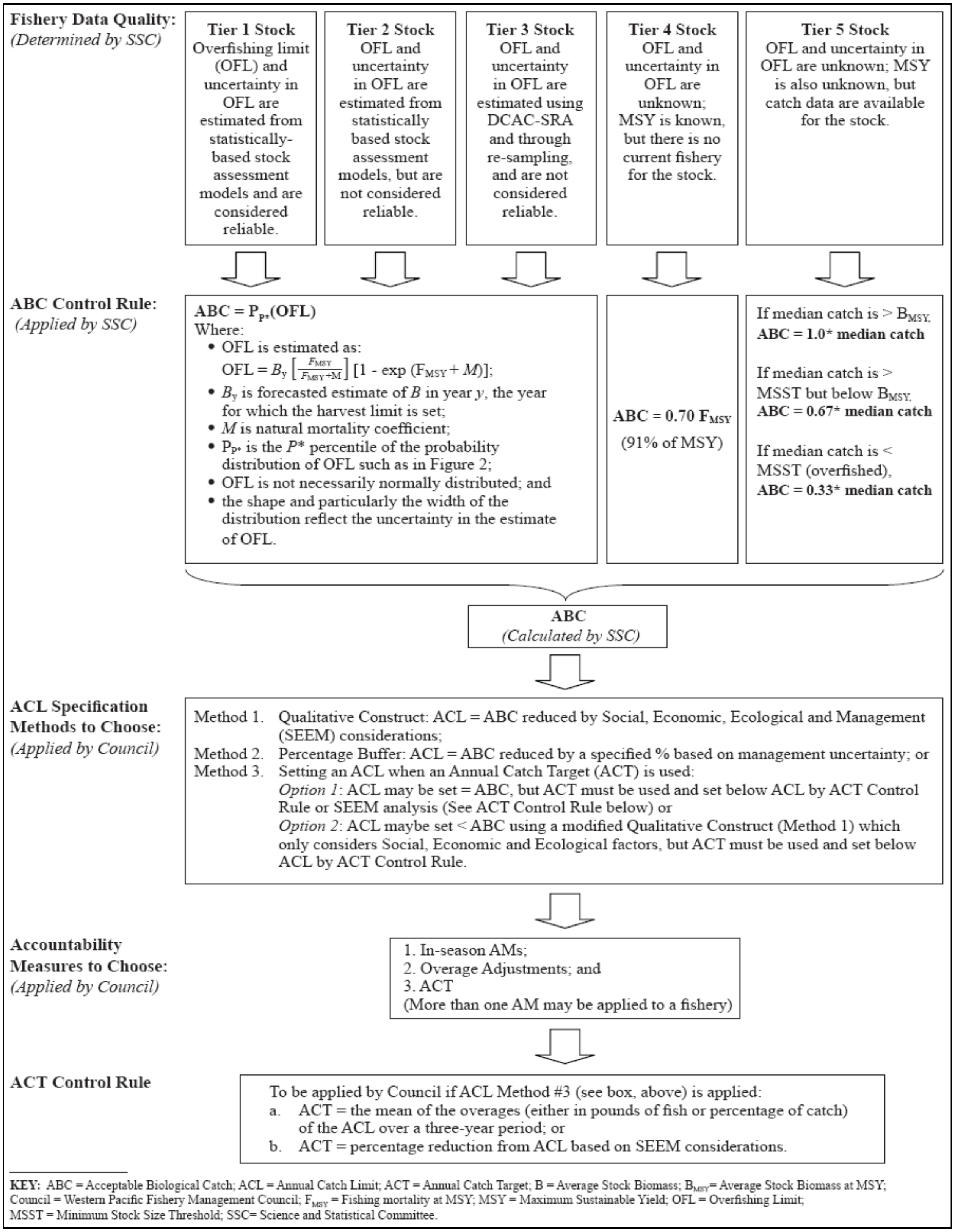

Figure 2. Schematic of method for specifying ABC, ACL and AMs, including ACTs.

Tier 1. Model-Based Probabilistic Approach to Estimating ABCs

In this tier, the data used are reliable and complete enough to be able to utilize statistical-based stock assessment models (e.g., Stock Synthesis 2 (or 3), Multifan-CL (MFCL), C++ Algorithmic Stock Assessment Laboratory (CASAL), and Bayesian production models). From these stock assessments, reliable estimates of MSY, F_{MSY}, B_{MSY}, and B_t are available. Of special relevance to being included in this tier, measures of the uncertainty of F_{MSY}, B_t and B_{t+k} and OFL_{t+k} must be available directly.

In plain English:

> ABC is the maximum value for which the probability "p" of exceeding OFL is less than P*.

Or, in conceptual mathematical terms:

> ABC = max (x | p(x > OFL) < P*)

Or, as commonly estimated:

> ABC = P_{P*}(OFL)
>
> Where:

- OFL is estimated as $\mathrm{OFL} = B_y \left[\frac{F_{\mathrm{MSY}}}{F_{\mathrm{MSY}}+M}\right] \left[1 - \exp(F_{\mathrm{MSY}} + M)\right]$;
- B_y is forecasted estimate of B in year y, the year for which the harvest limit is set;
- M is natural mortality coefficient;
- P_{P*} is the P* percentile of the probability distribution of OFL such as in Figure 2;
- OFL is not necessarily normally distributed; and
- the shape and particularly the width of the distribution reflect the uncertainty in the estimate of OFL.

The Council must advise the SSC on the acceptable P* to use prior to calculating and recommending the ABC. If the SSC determines that the uncertainty of OFL is underestimated (due to underestimating the uncertainty of F_{MSY} and/or the forecasted estimated B_t), the SSC could appropriately rescale the width of the OFL distribution.

Tier 2. Quasi-Probabilistic Approach to Estimating ABCs

The key difference between assessments in Tier 1 and Tier 2 is that in Tier 2, measures of uncertainty of OFL are not as reliable or are not available from a single, integrated stock assessment model. Reliable data must still be available to be in included in this tier, but those used are obtained through some separate analysis or analyses. The methods often involve re-sampling or ad hoc methods. While the statistical-based model characteristic of Tier 1 can occur here, the common assessments are Yield-per-Recruit (Y/R) and Spawning-per-Recruit (SPR). Such assessments involve the use of F_{MSY} proxies, usually $F_{30\%}$ and $F_{60\%}$. The data in Tier 2 may not be as reliable or complete as in Tier 1, though still of sufficient quality to provide fully usable stock assessments.

$F_{30\%}$ = Fishing at the rate that reduces spawning biomass per recruit to 30% of the unfished value. Used as a substitute for F_{MSY} when using Y/R and SPR stock assessments. $F_{60\%}$, as well as others, has also commonly been used.

ABC is estimated using the equation in Tier 1 above, with the uncertainty estimates coming from re-sampling (i.e. method for estimating and re-estimating probability distributions such as bootstrapping). The Council must advise the SSC on the acceptable P* to use prior to calculating and recommending the ABC.

Tier 3. Data-poor Probabilistic Approach to Setting ABCs
In this tier, the available data are not sufficient for the use of model-based assessment tools. Data are sufficient to apply the data limited approaches such as (but not limited to) Depletion-Corrected Average Catch (DCAC) (MacCall 2009), Stock Reduction Analysis (DCAC-SRA) (Dick and MacCall 2011), Catch-MSY (Martell and Froese 2012), Biomass-augmented catch-MSY (Sabater and Kleiber 2014) with information on the biology of the stock, or DCAC, in which there is some estimate of natural mortality (M), but other life history information is lacking. For a comprehensive list of data limited approaches see Carruthers et al 2014. In these circumstances, the uncertainty of OFL (the probability distribution of OFL) can be estimated using the Monte Carlo simulation (i.e. a technique that uses algorithms that rely on repeated random sampling to compute results). These tools are to be applied to long-lived species where the natural mortality coefficient M should be less than 0.20 and recruitment should not be highly episodic.

ABC is estimated using the equation in Tier 1 above, with the uncertainty estimates established by the Monte Carlo simulation. Again, the Council must advise the SSC on the acceptable P* to use prior to calculating and recommending the ABC.

Tier 4. ABC Control Rule for Species without Current Harvest
This ABC control rule is for species or species assemblages with stock assessments and/or MSY estimates, but no current harvest, such as deepwater shrimp (*Heterocarpus*). The ABC is set at 0.70 F_{MSY} (= yield 91% OFL = 91% MSY = ABC; see Walters et al. 2005) as a precautionary measure to maximize yield while minimizing biomass impacts and accounting for scientific uncertainty. An alternative target fishing mortality value may be specified if additional data or modeling is available to support it, or the Council chooses to be more precautionary.

Walters et al. (2005) provided an example through the modeling tool, ECOSIM, in which k = 0.7 represents a precautionary factor in setting the target fishing mortality (F_{MSY}), which is predicted to have little impact on yield. When k = 0.7, the ECOSIM simulations implied a sustainable yield of around 0.9 MSY. "k" is a factor that a fishery modeler can vary to represent varying levels of precaution for F_{MSY} within the ECOSIM model. Similarly, NMFS Technical Guidance on implementing NS1 by Restrepo et al. (1998) recommended a default fishing mortality target of 25% below MFMT, or 0.75 F_{MSY}, which results in an equilibrium yield of 94% MSY or higher. This Tier 4 control rule adopted by the WPFMC is more precautionary than the control rule recommended by Restrepo et al. (1998) and in line with the results of Walters et al. (2005). As Tier 4 involves a fishery with no current harvest, this ABC control rule does not include consideration of P*; however if harvest occurs, the fishery may be moved into higher tier where P* would be need to be considered.

Tier 5. Data-poor Ad-hoc Approach to Setting ABCs
In this tier, catches may be small and/or the catch history may contain gaps or be too variable. Catch history may also be lacking in consistently stable periods or periods with consistent trends for using DCAC-SRA or DCAC. Hence, there is no basis for estimating a reliable MSY or OFL.

For these data poor fisheries, a multiplier of the long-term median catch history will be used. The multiplier will be determined by the biological knowledge of the stock or stock complex, in light of the guidance provided by Restrepo et al. *(Section 2.2.2: Data Poor Situations*). The guidance recommends that the default control rule be implemented by multiplying the average catch from a time period where there is no quantitative or qualitative evidence of declining abundance ("Recent Catch") by a factor based on a qualitative estimate of relative stock size. The following guidelines were provided:

Above B_{MSY}	Limit catch = 1.00*Recent Catch
Above MSST but below B_{MSY}	Limit catch = 0.67*Recent Catch
Below MSST (i.e. overfished)	Limit catch = 0.33*Recent Catch

However, Restrepo et al. (1998) advises that because it will probably not be possible to analytically determine stock status relative to B_{MSY} for data poor stocks, an approach based on informed judgment will be necessary. The authors further state that "in cases of severe data limitations, qualitative approaches may be necessary, including expert opinion and consensus-building methods." As Tier 5 involves data poor situations, this ABC control rule does not include consideration of P*.

Determining the Acceptable Probability of Overfishing used in the ABC Control Rule
The ABC control rule for Tier 1-3 fisheries requires the Council to advise the SSC on the acceptable probability of overfishing (P*) in order for the SSC to calculate and recommend the ABC. As discussed above, P* refers to the acceptable probability or risk that actual catch equal to the ABC would exceed the OFL and thus, result in overfishing. NS1 guidelines require that the probability that overfishing will occur cannot exceed 50% and should be a lower value. Consequently, the Council adopted a maximum P* value of 50%; however, where adequate scientific information is available on the stock or stock complex, the Council will utilize a qualitative method for determining an appropriate P* that is lower than the maximum of 50%. This qualitative approach is described below.

<u>Qualitative Analysis for Determining P*</u>
The Council developed a process by which the risk of overfishing can be reduced from the 50% maximum P*. This approach, based on the approach developed by the South Atlantic FMC, is a qualitative method of determining P* that considers the amount of information available on the stock or stock complex, including scientific uncertainty, for the following dimensions: 1) assessment information, 2) assessment uncertainty, 3) stock status, and 4) productivity and susceptibility. Information on the four dimensions will be complied and analyzed by a team that may include Council and SSC members, Council staff, and other individuals knowledgeable in

the fishery, including stock assessment experts. Team members will use their knowledge and expertise to assign a single score for each dimension based on the criteria below. The maximum value for each dimension is 12.5 and the sum of the four dimensions has a maximum value of 50. The scores for each dimension will be added together for a final score, then be reduced from the maximum risk of overfishing ($P*_{MAX}$) of 50. The team's analysis will be vetted through the Council process with the Council ultimately deciding the final P* value. The Council-approved P* would then be utilized in the calculation of the recommended ABC. An example of the qualitative analysis is provided below, but the exact criteria and scoring values used may change as deemed appropriate by the team for each assessed stock.

1) Assessment Information

Criteria	Score	
Quantitative assessment provides estimates of exploitation and B; includes MSY-derived benchmarks	0.0	
Reliable measures of exploitation or B, no MSY benchmarks, proxy reference points	2.5	X
Relative measures of exploitation or B, absolute measures of stock unavailable, proxy reference points	5.0	
Reliable catch history	7.5	
Scarce or unreliable catch records	12.5	

2) Assessment Uncertainty

Criteria	Score	
Complete. Key determinant – uncertainty in both assessment inputs and environmental conditions included	0.0	
High. Key determinant – reflects more than just uncertainty in future recruitment	2.5	
Medium. Uncertainties are addressed using statistical techniques and sensitivities, but full uncertainty is not carried forward in projections	5.0	X
Low. Distributions of F_{MSY} and MSY are lacking	7.5	
None. Only single point estimates; no sensitivities or uncertainty evaluations	12.5	

3) Stock Status

Criteria	Score	
Neither overfished nor overfishing. Stock is at high B and low exploitation relative to benchmark values	0.0	
Neither overfished nor overfishing. Stock may be in close proximity to benchmark values	2.5	X
Stock is either overfished or overfishing is occurring	5.0	
Stock is overfished and overfishing is occuring	7.5	
Either status criterion is unknown	12.5	

4) Productivity and Susceptibility

Criteria	Score	
Low risk. High productivity, low vulnerability, low susceptibility	0.0	
Medium risk. Moderate productivity, vulnerability, and susceptibility	5.0	X
High risk. Low productivity, high vulnerability, high susceptibility	12.5	

SCORE SUMMARY

Dimensions	Score
Assessment information	2.5
Assessment uncertainty	5.0
Stock status	2.5
PSA	5.0
Total Score	**15.0**
Risk of overfishing: **(P*=50 minus Total Score, where 50 equals P^*_{MAX})**	**35**

In the example above, the resulting P* of 35 could then be used in the ABC control rule equations available for stocks in any of the tiers 1 through 3. Benefits of this include the following: 1) it brings together multiple experts to determine the risk of overfishing based on their diverse knowledge; 2) it can be applied in both data rich and data poor situations, i.e. whether formal stock assessments can be conducted or not; and 3) it need not be repeated annually unless information suggests that circumstances have changed significantly.

Setting the Annual Catch Limit

NS1 guidelines require the Council to determine an ACL that may not exceed the SSC-recommended ABC; however, NS1 does not provide guidance on how to set an ACL below the SSC-recommended ABC. This section describes the methods the Council will use to set ACLs starting in 2011.

ACL will be set by the Council after considering the ABC provided by the SSC, as well as social and economic factors, pertinent ecological considerations, and management uncertainty. Management uncertainty stems from insufficient information about true catch (e.g. late reporting, underreporting and misreporting of landings), lack of management precision, and/or the ability to close a fishery before a catch limit is exceeded. NS1 guidelines suggest management uncertainty be accounted for during the establishment of AMs for a fishery, including ACTs; however, nothing precludes the Council from accounting for management uncertainty at the ACL step.

Method 1: Qualitative Construct for Setting an ACL

The ACL qualitative construct uses an approach similar to the P* qualitative construct. While the P* qualitative construct considers the amount of biological information (scientific uncertainty) available on the stock or stock complex, the ACL qualitative construct considers the amount of socio-economic information (management uncertainty) on the fishery that targets the stock or stock complex. Specifically, the dimensions that will be used for the ACL qualitative construct would include the following factors: 1) Social; 2) Economic; 3) Ecological; and 4) Management uncertainty (SEEM). Aspects of the SEEM dimensions could include the importance of the fishery both socially and economically; consideration of the ecological importance of the stock or stock complex targeted by the fishery (e.g., is the stock a key indicator species of ecological health of the ocean), and whether managers can effectively constrain catch to planned levels.

Information on the SEEM dimensions will be compiled and analyzed by a team that may include Council and SSC members, Council staff, and other individuals knowledgeable in the fishery. This team will also be responsible for developing the criteria and scoring values regarding the quality and completeness of the information for each dimension. Like the P* qualitative construct, the scores for each dimension will be added together so that the total score is subtracted from a default value of 100% ABC (i.e., 100). Because SEEM analyses will be unique for each fishery, there are no specifics given at this time for the criteria or scoring values within the dimensions.

Method 2: Percentage Buffer for Setting an ACL

Under this method, the ACL would be set as a percentage of the ABC (e.g., ACL = 10% to 100% of the ABC) with the actual percentage dependent upon the amount of management uncertainty that exists in the fishery. For example, if management uncertainty is low, the ACL would be set close to 100% of the ABC. Alternatively, if management uncertainty is high, ACL would be set as a lower percentage. Factors that the Council will consider when selecting the percentage include late reporting, underreporting, and misreporting of landings in the fishery, as these factors contribute to the possibility that the true catch may actually exceed the ABC and ultimately the OFL of a fishery, thus resulting in overfishing. The justification for using this method over method 1 would need to be clearly identified by the Council when setting the ACL, as it is not a quantitative decision. However, it is useful to note that the ACL is a management decision for the Council to make, not necessarily a numerically-derived limit.

Method 3: Setting an ACL when an ACT will be Utilized

An ACT is an amount of annual catch of a stock or stock complex that is the management target of the fishery, and accounts for management uncertainty in controlling the actual catch at or below the ACL. When an ACT is used, it should be set lower than the ACL with a large enough buffer between the two reference points such that risk of exceeding the ACL is low. NS1 guidelines recommend ACTs in the system of accountability measures so that ACL is not exceeded. See Section 0 for a description of setting the ACT.

If the Council decides to use an ACT as a means to ensure an ACL is not exceeded, there are two options the Council may use in setting an ACL. Under the first option, the Council could simply set the ACL equal to the ABC. If this option is taken, management uncertainty will be accounted for at the ACT level using the ACT control rule. Under this option, in addition to management uncertainty, the Council could also consider social, economic and ecological factors to set the ACT and thus could apply the entire SEEM analysis described under Method 1 to set the ACT below the ACL. While NS1 guidelines do not require social, economic or ecological factors to be considered in setting the ACT, nothing precludes the Council from doing so, although the resulting ACT would be more precautionary than NS1 intends.

Under the second option, the Council would set the ACL less than the ABC using a modified Method 1 (Qualitative construct for setting ACLs) described above whereby the analysis for setting the ACL will only consider sociological, economic, and/or ecological factors. Under this option, management uncertainty will be accounted for at the ACT level using the ACT control rule (3-year running average).

As a performance measure for all ACL managed fisheries, if landings exceed the ACL for any stock or stock complex more than once in a four year period, the Council will re-evaluate the system of ACLs and AMs for the fishery and modify the system as necessary to improve its performance and effectiveness.

Suite of Accountability Measures

In addition to ACLs, the MSA also requires NMFS and the Councils to implement AMs (MSA §303(a)(15)). NS1 guidelines (74 FR 3178; January 16, 2009) explain that AMs are management controls to prevent ACLs from being exceeded and to correct or mitigate overages of the ACLs if they occur. The guidelines recommend FMPs describe AMs and how those measures are triggered. NS1 guidelines also suggest that management uncertainty be accounted for in establishing the AMs for a fishery, including uncertainty in the ability of managers to constrain catch and uncertainty in quantifying the true catch amounts. Since the purpose of ACLs and other harvest controls is to prevent overfishing, AMs are triggered at the ACL level to ensure the ABC and OFL are not exceeded and overfishing does not occur.

In fisheries for which in-season monitoring of catch is possible (i.e. fisheries with federal logbook reporting and State of Hawaii commercial fisheries, including MHI bottomfish), tracking of catch landings towards the ACL would be initiated at the start of each fishing year. When the ACL is projected to be reached, the commercial and non-commercial fishery sectors will be closed in federal waters for the remainder of the fishing year. For fisheries that rely on non-federal creel survey programs conducted by local marine resource management agencies, in-season tracking of catch landings may not be fully possible because availability of catch data is dependent upon local agencies workload and priorities. For these fisheries, the Council may employ overage adjustments as an accountability measure. If the Council determines at the end of a fishing year that total catch has exceeded the specified ACL for any fishery, the Council may reduce the ACL for the subsequent fishing year by the percentage or absolute value of the overage. However, one crucial aspect of this is that overages are typically factored into the subsequent year's stock assessment, as are any underages. For this reason, the Council will need to decide whether to include an overage adjustment if the overage has already been considered in a stock assessment, although stock assessments are typically not performed annually. However, as a performance measure for all ACL managed fisheries, if landings exceed the ACL for any stock or stock complex more than once in a four year period, the Council will re-evaluate the system of ACLs and AMs for the fishery and may modify the system as necessary to improve its performance and effectiveness.

In Method 3 of ACL specification options, ACTs may also be utilized as an accountability measure to ensure a fishery does not exceed its ACL.

The first approach utilizes an ACT control rule based on a 3-year running average of overages of a specified catch limit (e.g. TAC, quota, ACL, or ACT). The percentage or absolute value of the overage of a catch limit over a three year period will be reduced from the ACL in the following year. With this approach, if an ACL is not exceeded, a zero (0) percentage or absolute value will be attributed for that year. For example, assuming a static ACL of 100,000 pounds has been set annually for three consecutive years, and total catch exceeded the ACL in year 1 by 2,000 pounds (or 2%), year 2 by 6000 pounds (6%), and in the third year was 3000 pounds short (or 97,000 pounds), the ACT reduction would be calculated as a percentage as follows (2% + 6% + 0%)÷3 = 2.67%. In this example, ACT will be reduced by 2.67% (or 2,667 pounds) from the next 100,000 ACL, resulting in an ACT of 97,330 pounds in that following year. Alternatively, absolute values instead of a percentage could also be utilized. For example, using the same 100,000 pound ACL, the ACT would be calculated as follows: (2000 pounds + 6000 pounds + 0 pounds) ÷ 3 = 2,667 pounds, which results in that amount being reduced from the 100,000 pound ACL in the following year, or an ACT of 97,330 pounds. It is important to note, however, that assuming a static ACL for a number of years sequentially is unrealistic. More likely the ACL will vary annually due to fishery dynamics; therefore, using the percentage approach would likely be employed in these situations because this method allows the value of any overages to be standardized.

The second approach for setting an ACT is based on a percentage reduction from ACL using the SEEM analysis. This approach could be used regardless of whether an ACL is set equal to or less than the ABC. Under this approach, instead of applying the 3-year running average approach, the Council could apply the full SEEM analysis described under Method 1 to set the ACT below the ACL when the ACL equals the ABC. If ACL is set lower than the ABC because the social, ecological, and economic factors have already been taken into account, then the ACT can be set by using the 3-year running average approach described above or based on factors related to management uncertainty (i.e. the M part of the SEEM analysis).

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Appendix F: EFH Species Descriptions

WESTERN
PACIFIC
REGIONAL
FISHERY
MANAGEMENT
COUNCIL

Essential Fish Habitat Species Descriptions for Western Pacific Archipelagic and Remote Island Areas Fishery Ecosystem Plan Management Unit Species

(Bottomfish, Precious Coral, Crustacean, Coral Reef Ecosystem Species)

Western Pacific Regional Fishery Management Council

1164 Bishop Street, Suite 1400

Honolulu, Hawaii 96813

December 21, 2015

Essential Fish Habitat Source Document for Western Pacific Archipelagic, Remote Island Areas, and Pelagic Fishery Ecosystem Plan Management Unit Species

(Bottomfish, Precious Coral, Crustacean, Coral Reef Ecosystem Species)

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1 BOTTOMFISH SPECIES

1.1 Introduction

As noted in Amendment 3 of the Bottomfish Fishery Management Plan (FMP, bottom-associated fish resources of the western Pacific region can be divided into three broad classes relative to their vertical distribution on the islands' shelves and slopes: 1) the reef fish complex, inhabiting shallow reefs, bays and lagoons; 2) the bottomfish complex, inhabiting the outer shelves and deep slopes; and 3) the groundfish complex, inhabiting or associating with seamount summits. The bottomfish complex includes at least 65 species of four different families: jacks (Carangidae), emperor fishes (Lethrinidae), snappers (Lutjanidae), and groupers (Serranidae). These species are primarily caught by hook-and-line fishing gear, of which 19 are landed in quantities substantial enough to be classified as bottomfish management unit species (BMUS, Table 1).

BMUS in the western Pacific vary regionally with respect to species composition and relative abundance. For example, neither of the two lethrinid BMUS are found in Hawaii, nor are two of the three species of serranids. The third species, *Epinephelus quernus*, is an endemic to Johnston Atoll and Hawaii and is not found in American Samoa, Guam or the Commonwealth of the Northern Marianas Islands (CNMI). Table 2 provides the proportion of the total catch that each of the four families of bottomfish comprises in the different management areas (WPFMC, 2004, 2005). Lethrinids dominate the catch in the (CNMI) while snappers are the dominate component in the other three areas. Within the snapper group, Polovina et al. (1985) found that in Guam/CNMI, *Pristipomoides zonatus* made up 51.2% of the total catch followed by *Pristipomoides auricilla* and *Etelis carbunculus* that together accounted for 27.9%. More recent data (WPFMC, 2004, 2005) indicates that *Etelis coruscans* is now the dominant snapper in the catch from all 4 areas. The second and third most abundant species varied between areas and included *Aprion virescens, E. carbunculus, Pristipomoides filamentosus, P. zonatus,* and *P. auricilla*. *E. coruscans* may have been under-represented in the 1985 survey as a result of the fishing technique used. The three species that comprised over 79% of the catch in that survey are benthic whereas *E. coruscans* is primarily benthopelagic. Commercial fishers targeting the latter typically suspend their weights and hooks up to 40m above the bottom, which may not have been done in the earlier study.

Bottomfish production off western Pacific islands is inherently limited because only a narrow portion of the ocean bottom satisfies the depth requirements of most species. Since bottomfish are typically found concentrated in the steep drop-off zones at approximately 100-fathoms (183m), the length of the 100-fathom isobath has been used as an index of bottomfish habitat (Polovina, 1985). Polovina (1985) estimated the maximum sustainable yield (MSY) of bottomfish per year per nautical mile of 100-fathom isobath in the western Pacific to be 403 lb. This value was then used to estimate an annual MSY for American Samoa and Guam (Table 3). The results were then compared to similar calculations made for the Hawaiian archipelago, suggesting that MSY for Hawaii is 11-fold and 16-fold higher than that for American Samoa and CNMI, respectively.

Table 1: Bottomfish Managemnet Unit Species (BMUS)

Fishery	Family	Scientific Name	Common Name	American Samoa	Guam/ NMI	Hawaii
Bottomfish	Carangidae	*Caranx ignobilis*	giant trevally	sapoanae	tarakito	white ulua/pauu
		Caranx lugubris	black trevally	tafauli	trankiton attilong	black ulua
		Pseudocaranx cheilio	thicklip trevally		terakito	butaguchi/pig ulua
		Seriola dumerili	greater amberjack		guihan tatdong	kahala
	Lethrinidae	*Lethrinus amboinensis*	ambon emperor		mafuti/lililok	
		Lethrinus rubrioperculatus	redgill emperor	filoa-paoomumu	mafuti tatdong	
	Lutjanidae	*Aphareus rutilans*	silvermouth snapper	palu-gutusiliva	maraap tatoong	lehi
		Aprion virescens	gray snapper	asoama	Tosan	uku
		Etelis carbunculus	ruby snapper	palu-malau	guihan boninas	ehu
		Etelis coruscans	flame snapper	palu-loa	onaga	onaga
		Lutjanus kasmira	blue-line snapper	savane	sas/funai	taape
		Pristipomoides auricilla	yellowtail snapper	palu-iusama	guihan boninas	yellowtail kalekale
		Pristipomoides filamentosus	pink snapper	palu-enaena	guihan boninas	opakapaka
		Pristipomoides flavipinnis	yelloweye snapper	palu-sina	guihan boninas	yelloweye opakapaka
		Pristipomoides sieboldii	lavender snapper		guihan boninas	kalekale
		Pristipomoides zonatus	oblique banded snapper	palu-sega	guihan boninas/gindai	gindai

Serranidae	*Epinephelus fasciatus*	blacktip grouper	fausi	gadao matai	
	Epinephelus quernus	Hawaiian grouper			hapuupuu
	Variola louti	lunartail grouper	papa	Bueli	

Table 2: Percent of the total catch that each of the four families of bottomfish comprises in the four management areas (Source: WPRFMC Seamount Groundfish and Bottomfish Annual Reports for 2004 and 2005)

Family	Common name	CNMI	AM Sam	Guam	Hawaii
Lethrinidae	emperors	52	18	6	0
Carangidae	jacks	7	7	3	5
Serranidae	groupers	7	9	11	9
Lutjanidae	snappers	34	69	80	86
	Total	100	100	100	100

Table 3: Index of bottomfish habitat and yield for three of the four management areas. (Source: Amendment 1 of bottomfish FMP)

Management Area	Length of 100-fathom Isobath (nm)	Estimated MSY (403 lbs x length)
American Samoa	196	78,988
Guam	138	55,614
Hawaii (MHI)	997	401,791
Hawaii (NWHI)	1,231	496,093

The current bottomfish MSY values derived by Brodziak et al (2009) are 1,588,000 lbs and 1,964,000 lbs for the Main Hawaiian Islands (MHI) and Northwestern Hawaiian Islands (NWHI), respectively. These are approximately 4 times those estimated by Polovina (1985).

Multibeam sonar mapping has since provided a more precise estimate of the actual area of bottomfish habitat in the MHI (Table 4). Based on these data, the 0-400m MHI bottomfish Essential Fish Habitat (EFH) occupies a total of 10,614 square kilometers of seafloor from the big island of Hawaii to Middle Bank. This area divided into the estimate from Brodziak et al (2009) provides an average bottomfish MSY of 150 lbs per square kilometer of EFH for the MHI. EFH area can also be used as the basis to derive an estimated MSY for each bank/island (Table 4).

Table 4: The planimetric areas of bottomfish EFH (0-400m depths) and estimated MSY based on those areas for each "bank" in the MHI

Bank	EFH Area (km2)	MSY (lbs)
Hawaii	2,207	330,197
Maui	5,555	831,104
Oahu	1,430	213,948
Kauai	711	106,375

Niihau	427	63,885
Kaula	88	13,166
Middle	196	29,324
Total	**10,614**	**1,588,000**

These estimates assume no significant difference between banks in the proportion of actual preferred habitat (e.g. rocky with high relief) within the EFH areas. Maui County has the largest area of bottomfish EFH and consequently the largest MSY (831,104 lbs) while Kaula Rock has the smallest (88 km^2 and 13,166 lbs). In general, EFH area in the northwestern portion of the MHI is significantly smaller than in the southeastern portion.

Table 5 provides the EFH area in the MHI for each of the three proposed complexes listed in the current amendment: shallow (0-240m), intermediate (40-320m) and deep (80-400m). As a result of the depth overlap between these complex EFH definitions, their areas sum to approximately double the size of the 0-400m EFH for the entire fishery and deriving MSY for each complex is not possible. In general, the deep complex has the smallest amount of habitat in the MHI while the shallow complex has the largest. One noteworthy exception is the island of Hawaii. Maui has the largest amount of habitat available for all three complexes while Kaula Rock has the smallest, particularly for the deep species where there is only 40 km^2 available.

Table 5: The planimetric areas per MHI bank of the 3 proposed complex EFH definitions

Bank	**Shallow Complex EFH Area (km2)**	**Intermediate Complex EFH Area (km2)**	**Deep Complex EFH Area (km2)**
Hawaii	1,188	1,203	1,725
Maui	4,155	4,166	3,392
Oahu	988	691	756
Kauai	578	329	280
Niihau	315	220	184
Kaula	72	75	40
Middle	133	157	97
Total	**7429**	**6841**	**6474**

1.2 General Life History

Bottomfish spawn pelagic eggs and once the pelagic larval stage is completed, settlement generally occurs below SCUBA depths. Obtaining field observations as well as collecting live individuals for captive studies is consequently quite difficult and expensive. Therefore the life histories of most species are not well known. For the purpose of EFH descriptions, their development from egg to sexually mature adult can be segregated into four general stages: egg, larval, juvenile and adult. In past EFH descriptions, the egg and larval stages were combined into one phase while juveniles and adults were combined into another. EFH descriptions were therefore only specific to two very broad life history phases: the pre-settlement pelagic phase and post-settlement benthic and/or benthopelagic phase. While the decision to do this was based on the lack of knowledge regarding bottomfish development, it yielded overly generalized descriptions that lost utility. For example, while the egg stages of all bottomfish species are presumed to be no longer than 36 hrs their larval stages through settlement can range from 30-180 days. Eggs are completely passive whereas larvae, of almost all species of fishes, are active swimmers and undoubtedly exhibit both positive and negative taxis that include rheotaxis and phototaxis, respectively (See Fishery Science: the unique contributions of early life stages, 2002). Similar larval behaviors are to be expected for the species evaluated here. The egg/larvae EFH is currently defined out to the 200 mile boundary of the Exclusive Economic Zone (EEZ), which larvae may reach but certainly not eggs. Nursery grounds that are completely isolated from adult habitat have been documented in at least one species of bottomfish (Parrish, 1989). The juveniles of onaga are benthic in comparison to their benthopelagic adults (Ikehara, 2006; Kelley, unpub. data). These are important differences that should be accommodated in EFH descriptions. For this reason, the pre-settlement and post-settlement phases have been separated back to egg, larval, juvenile, and adult stages.

1.2.1 Eggs

There have been very few taxonomic studies of the egg and larval stages of bottomfish and as a result, many species cannot be identified until after metamorphosis. Lutjanid and serranid eggs have a similar appearance to the eggs of many other fish species, leading Leis (1987) to conclude that their identification "from plankton samples is not likely to be possible in the foreseeable future". However, recent advances in shipboard genetic identification have been made that may provide unprecedented opportunities to identify eggs and early stage larvae in the near future (Hyde et al 2005). All three families of bottomfish: serranids, carangids and lutjanids, are known to spawn spherical pelagic eggs with a single oil droplet (Heemstra & Randall, 1993; Leis, 1987; Leis & Trnski, 1989). Table 6 provides general information on egg diameter and time from fertilization to hatching.

Table 6: Ranges of egg diameters and incubation times for the three families of bottomfish.

Family	Egg Diameter (mm)	Incubation	Source

Serranidae	0.70-1.20	20-45 hrs	Heemstra & Randall 1993, Leis 1987
Carangidae	0.70-1.50	18-48 hrs	Leis & Trnski 1989, Honebrink 2000
Lutjanidae	0.65-1.02	17-36 hrs	Leis 1987

1.2.2 Larvae

Leis (1987) conducted a detailed review of the early life history of tropical groupers and snappers and found that eteline snapper larvae are generally more abundant in slope and oceanic waters than over the continental shelf. He also found evidence of a vertical migration pattern in which the larvae of both families avoided surface waters during the day. During the winter months larvae of most species are much less abundant. Very little is known about the natural food habits of serranid and lutjanid larvae and what little is known is based on limited laboratory data. More research is needed on all aspects of the early life history of snappers and 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. Table 7 provides general information on the size of the larvae at hatching, the duration of the yolk-sac phase and the age at “metamorphosis”, here defined as the age at which a transition occurs from either pelagic larva or pelagic juvenile to a benthic or benthopelagic juvenile at the time of “settlement”.

Table 7: Newly hatched larval length, completion of yolk sac absorption, and age at metamorphosis for the three families of bottomfish (Laroche et al., 1984; Leis & Trnski, 1989; Leis, 1987)

Family	Post-hatch (mm)	Yolk-sac (hrs)	Metamorphosis (days)
Serranidae	1.6-2.5	48-120	25-70
Carangidae	1.0-4.3	72	Unknown
Lutjanidae	1.8-2.3	72-96	25-120

1.2.3 Juveniles

The juvenile stage in fishes begins at the completion of the larval stage. Even though similar in appearance, juveniles differ from adults by being physiologically underdeveloped and reproductively immature. Some authors consider the end of the juvenile stage to be sexual maturity when the fish becomes a fully functional adult. Others insert a “sub-adult” stage between juveniles and reproductive adults based in part on observed behavioral changes, such as migration from nursery habitat to adult habitat and the onset of interaction with adult con-specifics. These behaviors likely occur in at least two bottomfish species, *E. coruscans* and *P. filamentosus*, but may not in others such as *E. carbunculus* and *P. zonatus*. Sub-adults occupy the same habitat as adults and therefore, from a habitat prospective, are indistinguishable from functional adults. For that reason, a separate sub-adult stage is not included in this review. The duration of the juvenile phase for the various species in this fishery ranges (as far as is presently known) from 1 year for *Lutjanus kasmira* to 6 years for *E. coruscans*. All of the eteline lutjanids require at least 2.4 years to reach sexual maturity based on present estimates of size-at-age and size-at-maturity.

Size at metamorphosis from larva to juvenile and whether settlement occurs as a post-flexion larva or a pelagic juvenile are generally unknown for most species of bottomfishes; although most eteline lutjanids probably settle as juveniles, After settlement, the juveniles of most bottomfish species are benthic, utilizing hard substrate features as shelter from predation. One exception to this pattern is *P. filamentosus*, whose juveniles have been observed in schools swimming up in the water column over soft substrate flats (Parrish, 1989). The juveniles of at least two other species, *P. sieboldii*, and *E. coruscans*, have also been observed in schools but the individuals swam much closer to the bottom. The adults of these three species are best considered benthopelagic. Juvenile *E. carbunculus* and *P. zonatus* have only been observed as solitary individuals. Juvenile behavior is therefore species specific and cannot be generalized for the fishery as a whole.

Juvenile diets are generally unknown for most bottomfish, *P. filamentosus* again being the one exception. Parrish (1989) and DeMartini et al. (1996) reported the diet of juvenile *P. filamentosus* off Kaneohe Bay, Oahu consisted of small crustaceans (crabs, shrimps and stomatopods), other juvenile fish, mollusks (octopods, squids, and micro-gastropods) gelatinous plankton (salps and heteropods) and echinoids. More recently, the stomachs of juveniles caught from a shallower location off the south shore of Oahu were found to contain pelagic crustaceans and salps (B. Schumacher, unpub data). These reports are consistent with juvenile *P. filamentosus* being observed in the water column where they are presumed to be feeding. It therefore follows that the more benthic juveniles of other bottomfish species may feed primarily on benthic prey. As was noted with juvenile behavior, the diets of juvenile bottomfish cannot be generalized for the fishery as a whole except to say that they are most likely carnivorous, feeding at multiple trophic levels.

1.2.4 Adults

Adult bottomfish share the fact that, by definition, they are all sexually mature individuals. However, aside from that, considerable differences exist between species in their size and age at sexual maturity, maximum size, behavior, reproductive biology and diet. Table 8 summarizes currently available information on sexual maturity and maximum size.

Bottomfish reach sexual maturity as soon as 1.3 years of age for *Seriola dumerili* to as late as 6 years of age for *E. coruscans* and *P. sieboldii*. *S. dumerili* also reaches maturity at the largest size of any species, which coupled with the age, is indicative of an extremely fast growth rate.

L. kasmira is the smallest species in the fishery and it is not surprising that it also reaches maturity at the smallest size. The maximum sizes of the various species ranged between 164 cm and 87 kg for *C. ignobilis* down to 32 cm and 0.9 kg for *L. kasmira*. With *E. quernus* being the only exception, the larger sized species are all generally found higher in the water column possibly due in part to their lower vulnerable to predation in comparison to the smaller species. Water column preferences permits the various species to be partitioned into either benthic or benthopelagic categories. There are also clear differences in social systems with some species forming large schools (e.g., *E. coruscans* and *P. filamentosus*) while others forming only small aggregations of a few individuals (e.g., *E. carbunculus* and *P. zonatus*). Schooling species are typically benthopelagic while non-schooling species are typically benthic. These relatively common patterns have also been observed in many other fish species.

Table 8: Summary of bottomfish age and size at sexual maturity and maximum sizes in Hawaii based on Hawaii state records obtained. Species are ordered from largest to smallest by weight. Maximum size data are from Randall (2007) and Hawaii state fishing records from the Hawaii Fishing News website (http://www.hawaiifishingnews.com/records.cfm). Most length data were in forklengths but in some cases, it wasn't clear and therefore is listed below as simply length. Various sources were used for the data on sexual maturity and are provided in the species accounts below.

Species	Sexual Maturity		Maximum Size	
	Years	Length (cm)	Length (cm)	Hawaii (kg)
Caranx ignobilis	3.5	55-60	164	87.0
Seriola dumerili	1.3	64-73	145	66.0
Epinephelus quernus	6*	58	106	22.7
Pseudocaranx cheilio	-	28-30	82	18.0
Aprion virescens	4-5	43-48	110	17.9
Aphareus rutilans	-	-	80	14.7
Etelis coruscans	5-6	66	81	12.7
Pristipomoides filamentosus	3-5	43	80	8.4
Caranx lugubris	-	-	80	7.6
Etelis carbunculus	2.8	24-30	90	5.2
Pristipomoides zonatus	3.3	-	45	1.9
Pristipomoides sieboldii	3-6	29	60	1.4
Pristipomoides auricilla	2.4	-	45	1.3
Lutjanus kasmira	-	12-25	32	0.9

* Age and length at 50% female maturity is for *E. quernus* in the NWHI only (DeMartini et al. 2010). Length-at-sex change (from adult female to adult male) in *E. quernus* is about 90 cm in the NWHI (DeMartini et al. (2010); fish of 90 cm are a poorly estimable 20-something years old (Nichols and DeMartini 2008).

1.2.4.1 Reproductive biology

Thirteen of the 14 species of bottomfish in Hawaii are either confirmed or believed to be gonochoristic. *E. quernus* is the only sex changing species, having recently been confirmed as a protogynous hermaphrodite (DeMartini et al. 2010). All 14 species are broadcast spawners that release pelagic eggs into the water column. Twelve of the species exhibit peak spawning activity during the summer or early fall with the other two, *E. quernus* and *S. dumerili* peaking during the spring (Table 9). Reproductive seasonality is a particularly important life history characteristic to understand for fisheries management since it has direct bearing on the potential success of seasonal closures that are currently part of bottomfish fishery management in Hawaii. During the last 4 years, the bottomfish closed fishing seasons have been:

May 15 to October 1, 2007	139 days
April 16 to September 1, 2008	138 days
July 6 to August 31, 2009	57 days
April 20 to August 31, 2010	134 days

An annual total allowable catch limit (TAC) has been implemented for this fishery and the point at which this is reached each year has been used to determine the lengths and dates of the closed seasons. Table 10 provides a graphical summary of the bottomfish seasonal closures in Hawaii for direct comparison to Table 9. Annually varying seasonal closures undoubtedly result in annually varying numbers of reproductive adults in the catch. Of potential concern is the fact that due to their offset spring reproductive season, *E. quernus* spawning adults received almost no protection from this management measure.

Grimes (1987) provided a detailed review of the reproductive biology of the Lutjanidae. In the lutjanids, spawning takes place at night, and may be timed to coincide with spring tides at new and full moons. Spawning likely takes place at night in both the serranids and carangids as well. As with many marine fish species, courtship behavior is believed to culminate in an upward spiral swim, with gametes released at the apex. Similarly, many features of the reproductive biology of lutjanids (e.g. spawning site preference, spawning seasonality, lunar periodicity and spawning behavior) appear to be a strategy to introduce gametes into an environment where predation is relatively less intense and that young juveniles are returned to suitable, but patchy habitat for settlement.

Table 9: Summary of bottomfish reproductive seasons. The question marks represent data obtained from non-Hawaii locations. Lighter shading is from questionable or incidental records. This table was created from the following sources: Sudekum et al 1991; Munro et al. 1973; Alfonso et al. 2008; Uchiyama & Tagami 1984; Kikkawa & Everson 1984; Current Line Fish Facts for Bottom Fishes of Hawaii; Allen 1985; Morales-Nin & Ralston, 1990; DeMartini & Lau 1999; Ralston & Williams 1988a, Harris et al., 2007.

Species	J	F	M	A	M	J	J	A	S	O	N	D
E. quernus												
C. ignobilis												
C. lugubris		?	?	?	?	?	?	?	?			
P. cheilio								?	?			
S. dumerili												
A. rutilans	?	?							?	?	?	?
A. virescens												
E. carbunculus												
E. coruscans												
L. kasmira												
P. auricilla												
P. filamentosus												
P. sieboldii												
P. zonatus				?	?	?	?		?			

Table 10: Summary of bottomfish seasonal closures from 2007 to 2010. Lightly hatched cells indicate the closure did not encompass the entire month. This table was created for comparison to table 9 above

Year	J	F	M	A	M	J	J	A	S	O	N	D
2007												
2008												
2009												
2010												

1.2.4.2 Feeding Habits and Prey

The feeding habits and prey preferences of all larval and most juvenile bottomfish are completely unknown at the present time. For adults, there have been very few studies of groupers and snappers that have documented the time and depth at which feeding occurs. Based on the review of the available literature, Parrish (1987) concluded that snappers engage in widespread, nocturnal foraging while groupers feed at all times of day, but particularly near dusk and dawn. Anecdotal information from fishers indicates that some species are caught more easily at night, while others are caught during the day or near sunrise and sunset. However, more recent unpublished fishing survey data collected by UH and NOAA researchers indicate that snappers will take bait at any time of the day (UH data, 2010, Parrish, unpub data), which is consistent with the belief that these fish are opportunistic carnivores. Both *P. filamentosus* and *E. carbunculus* will feed at any time of the day when held in captivity (Moriwake et al, unpub data). Both fishing and captivity provide unnatural feeding opportunities for these fish and therefore should generally not be used to draw conclusions regarding their natural feeding behavior. However, these observations do suggest that the time of day "natural" feeding occurs may be closely related to prey availability. Snappers that feed in the water column on either the shallow or deep backscatter layers may have well defined feeding periods that coincide with the vertical migration of these layers. Benthic feeders may have either poorly defined feeding periods or forage primarily during the day or night depending on prey preference and availability.

Depth of foraging is also hard to evaluate in deep-water snappers and groupers. Our only source of information is fishing data however bait produces an unnatural odor plume that can draw these fish from a considerable distance. Along most island or bank slopes, the current will disperse a bait plume horizontally rather than vertically. However, caution should be exercised when using depths derived from catch data to draw conclusions about natural feeding depths. Without precise data on feeding times and depths it is difficult to identify a species feeding habitat. Feeding is a major daily activity for most species of fish and therefore it is assumed for now that the depth a species is caught or observed at is within its feeding depth range.

The adults of larger snapper species such as *E. coruscans, Aphareus rutilans, and P. filamentosus*, have been observed in schools relatively high in the water column while the adults of smaller species such as *E. carbunculus* and *P. zonatus* have only been observed as solitary individuals or in small groups close to the bottom. With one exception, juvenile snappers appear to stay, and presumably feed, close to the bottom. Smaller fish, whether they are adults or juveniles, are at greater risk of predation and the carbonate substrate where snappers are often found have ledges and cavities that offer shelter from attacks. Juvenile *P. filamentosus* are the exception, having been observed feeding in the water column, although generally not as high as adults. This is the only snapper species that has been found to have a distinctly different nursery area (sediment flats) and depth range (40-80 m) than adults. Larger predators have not been observed in these areas, which has led to the hypothesis that *P. filamentosus* juveniles may be "hiding in plain sight" (Parrish, 1989). Parrish (1987) reported that most species of groupers take their prey at, or very close to, the bottom. *E. quernus* is no exception and, regardless of size, is most often observed close to the substrate. This may be a shark avoidance strategy, but is more likely due to their reproductive strategy and social structure, which is described in more detail later.

Diet studies of deepwater snappers and groupers are difficult to conduct because gut contents are frequently lost from regurgitation when specimens are bought to the surface. The few found in the literature indicate that both groupers and snappers are omnivorous, opportunistic carnivores whose diets include a wide range of food items dominated by fish, crabs, shrimp and other benthic crustaceans, especially stomatopods and lobsters (Haight et al, 1993a, Parrish et al, 2000). However, some diet preferences are evident among the species and are consistent with behavioral observations mentioned above. Some off-bottom schooling species consume large planktonic prey including pelagic urochordates (Pyrosomida, Salpidae, and Dolioda) and pelagic gastropods (pteropods and heteropods) while others principally consume pelagic fishes (Haight et al 1993a). Opportunistic collection of non-regurgitated prey from these same species during other surveys have yielded a pelagic salp as well as fishes, crustaceans and cephalopods typically found in backscatter layers (Kelley, unpub). Planktonic animals have not been reported in the diets of groupers which is consistent with their benthic lifestyle. Benthic species of snappers have been found to have diets consisting of benthic crustaceans and benthic fishes including eels and octopuses (Kelley, unpub).

1.3 General Habitat

Bottomfish Essential Fish Habitat (EFH) is presently defined as the 0-400m depth range on the slopes of each island, bank or seamount around Hawaii and other Pacific Islands. For benthic or benthopelagic juveniles and adults, the geographic extent of their habitat ends with the 400 m contour around each of these features because these stages are associated with the bottom. However, egg and larval stages are pelagic and therefore the geographic boundaries of their habitats are believed to extend well beyond 400m contours as a result of current flow.

1.3.1 Egg Habitat

While bottomfish egg habitat is presently unknown, several logical assumptions can be made based on available data. First, eggs are spawned no deeper than the lower extent of the adult ranges. Adults of pelagic spawning fish species typically spawn at the same depth as their feeding habitat or move into shallower waters. Secondly, bottomfish eggs hatch no more than 48 hrs after spawning and are completely passive with regard to their dispersal. The maximum distance bottomfish egg habitat can extend from shore can therefore be estimated using HYCOM, a hydrodynamic ocean circulation model of the flow around the Hawaiian Islands. Vaz (unpub data) obtained the 2008 output from HYCOM at www.hycom.org, and coupled it offline with the BOLTS biological model (Paris et al. 2007) depicting adult spawning strategy, larval development, displacement and mortality. Bottomfish spawning was assumed to take place no further than 10 km from each island. Therefore, the 10 km (i.e., 6 mi) buffer regions around the islands were subdivided in 183 polygons each representing a separate egg release area. Every 5 days 300 "eggs" were released from each of the polygons at a simulated depth of 50m and were then tracked for 1, 2 and 6 days. The mortality coefficient used in the model was 0.03 day^{-1}.

Figure 1 provides the results from this trial. Eggs reached a maximum of 30 km (i.e. 19 mi) from shore one day after release, which increased to only 50 km (i.e. 31 mi) from shore by day 2. At this point, the eggs of all bottomfish species should have hatched. Based on these results, the recommendation was made to define bottomfish egg habitat as the 0-400m depth range extending no more than 30 mi from the 400m contour around each island and bank. In the MHI, this area is generally within the first 50 mi from shore in the EEZ. It is reasonable to assume the eggs of bottomfish species are no deeper than the maximum depth of adult habitat because of their positive buoyancy. Therefore, in this review, it was recommended that egg habitat definitions for the three complexes as well as the "deep seven" species in the MHI have the same lower depth limit as the adults. For example, the proposed shallow complex egg habitat definition is 0-240 m extending out 50 miles from each island and bank.

1.3.2 Larval Habitat

Bottomfish larvae are pelagic, but unlike eggs, are active swimmers during most of this stage which can last from 25 to 180 days post hatch. Their swimming proficiency improves dramatically from hatching to metamorphosis. In addition to diel vertical movements (Leis 1987), bottomfish larvae acquire the ability to move effectively in the horizontal plane in response to current flow, prey detection, and possibly to sound and magnetic fields, which have been documented in other species (See Fishery Science: the unique contributions of early life stages, 2002; Stobutzki & Bellwood 1997, Cowen et al 2006). These variable 3-dimensional movements are overlaying complex water circulation patterns, making it extremely difficult to precisely define their habitat extent. Using the same model described above, Vaz (unpub data) determined that, in the absence of any swimming activity, water circulation around the MHI could carry larvae spawned at either 50 or 100m depth out past the 200mi EEZ 4 in 6 days, or 4 days post-hatch. During the first 3 days post-hatch, the larvae are still within their yolk-sac absorption phase, during which their swimming ability is extremely limited. It is therefore likely that bottomfish larvae are being dispersed as far out as the EEZ boundary.

Relatively few bottomfish larvae have been collected in plankton tows (Leis 1987; Clarke, 1991) and therefore the depth range of their habitat is presently unknown. All of the species of bottomfish are physoclists, however the mechanism and timing of swim bladder inflation is unknown. Many, but not all, physoclists initially inflate their swim bladders by gulping air at the surface (Swartz, 1971). Assuming at least some bottomfish species need to do this, then the upper depth limit should conservatively be left at 0 m. It is also assumed that the larval habitat does not extend below the lower limit of the adult habitat. Coupled with the modeled trajectories, it is recommended that the bottomfish larval habitat definition remain the same at 0-400m depth extending out to the EEZ. Complex and species habitat definitions will only vary with regard to their lower depth limit, which is recommended to match that of the adults.

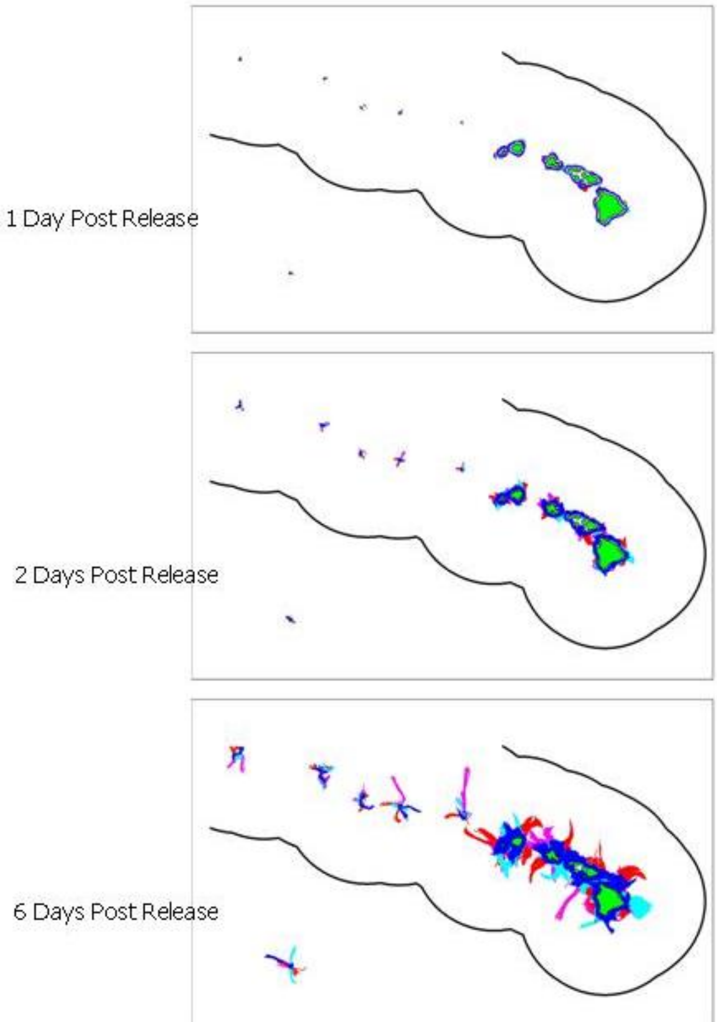

Figure 3: Simulated bottomfish egg trajectories released from 50m depth around the MHI and lower NWHI (Vaz, unpub data). The 200 mile boundary of the US EEZ is shown as a black boundary line. The colors of the trajectories in the plots represent the season of spawning as follows: a) magenta: January-March; b) red: April-June, c) light blue: July-September, d) blue: October-December.

1.3.3 Juvenile Habitat

Progress in identifying juvenile bottomfish habitat has clearly been made during the last 5-10 years. However, only *P. filamentosus* juveniles have been systematically studied and there are still a number of species whose juveniles have never been observed. Even with its importance for understanding recruitment patterns, identification of bottomfish juvenile habitat is one of the major gaps in our basic knowledge of this fishery.

In 1988, the NOAA Fisheries Honolulu Laboratory initiated an investigation to identify the habitat requirements of juvenile snappers in the Hawaiian Islands. This effort found a significant number of *P. filamentosus* juveniles and a modest number of *A. virescens*, and *A. rutilans* juveniles occupying a habitat quite different than their adults (Parrish, 1989; Haight, 1989; Moffitt & Parrish, 1996; Parrish et al., 1997). The “nursery areas” for these shallow and intermediate species were primarily flat, open soft substrate in depths ranging from 40 to 73 m, whereas adult habitat is typically steep rocky carbonate slopes in deeper water. Subsequent surveys have found additional *P. filamentosus* nursery areas of this same kind (UH data, 2010) but also one quite different off the Big Island that consisted of highly rugose volcanic basalt (Drazen, unpub). Juvenile carangids also seem to settle out in habitats shallower than those of adults (Longenecker & Langston, 2008). The presence of juvenile *S. dumerili* on one of the *P. filamentosus* nursery areas has been documented using a baited drop camera (Merritt, unpub). Major (1978) and Smith & Parrish (2002) found that back reefs, lagoons, and particularly estuaries were important nursery areas for carangids such as *Caranx ignobilis* and *Pseudocaranx cheilio*.

This pattern however, does not appear to be consistent for all of the species in this fishery. Juveniles of two deep species, *E. coruscans* and *E. carbunculus*, have been documented in habitat more similar and in closer proximity to that of their adults (Kelley et al, 1997, Ikehara, 2006). These deeper “nurseries” consisted of low sloping rocky carbonate terraces and ledges that were clearly providing the juveniles with shelter. A solitary juvenile *P. zonatus* swimming very close to the bottom has also been observed from the Pisces submersible at the same depth and habitat where adults were observed (Kelley, unpub data).

The various species in this fishery appear to be using one of two different strategies for avoiding predation after settlement: either settling in shallower areas that predators don’t frequent (Parrish, 1989) or settling in or near adult habitat but close to the bottom. In the latter case, risk of predation is directly related to height off the bottom and inversely related to body size. The substrate in these areas has cavities that provide shelter, thereby reducing that risk. Table 11 summarizes what is presently known about juvenile habitat for bottomfish.

Within the snapper component of the bottomfish fishery, the adults of larger species are found higher off the bottom than the adults of smaller species as well as the juveniles of any species including their own. Behavioral observations recorded by submersibles and drop cameras indicate that large *S. dumerili* pose the most significant predation risk to small bottomfish species and juveniles (Kelley and Drazen in prep). *S. dumerili* are aggressive predators that often form large aggregations, making them a threat to many different species of fish and invertebrates. Unlike sharks, this species must swallow its prey whole. Thus there is a maximum size of prey that *S. dumerili* can consume and once potential prey exceed that size, their risk of predation drops significantly. Based on behavioral observations, *S. dumerili* are a risk to all juvenile bottomfish as well as adult *E. carbunculus*, *P. zonatus*, *P. sieboldii*, and *P. auricilla*. This species does not pose a threat to adult *E. coruscans*, *P. filamentosus*, *A. rutilans*, and *E. quernus* due to their size.

Table 11: Summary of juvenile bottomfish habitats

Complex	Species	Juvenile habitat	Reference
Shallow	*Aprion virescens*	shallow sediment flats	Parrish 1989
(0 - 240m)	*Lutjanus kasmira*	sediment flats, fringe rubble piles	Friedlander et al 2002
	Caranx ignobilis	lagoons, estuaries, back reefs	Longenecker & Langston 2008
Intermediate	*Aphareus rutilans*	shallow sediment flats	Parrish 1989
(40 - 320m)	*Pristipomoides filamentosus*	shallow sediment flats, basalt	Parrish 1989, Drazen unpub data
	Epinephelus quernus	shallow bank flats	Moffitt 2003
	Caranx lugubris		
	Pseudocaranx cheilio	lagoons, estuaries, back reefs	Longenecker & Langston 2008
	Seriola dumerili	shallow sediment flats	Merritt, unpub data
	Seriola rivoliana		
Deep	*Etelis carbunculus*	deep carbonate terraces	Kelley et al 1997
(80 - 400m)	*Etelis coruscans*	deep carbonate terraces	Kelley, unpub data
	Pristipomoides auricilla		
	Pristipomoides sieboldii	deep carbonate terraces, sediment flats	Kelley et al 1997
	Pristipomoides zonatus	deep carbonate terraces	Kelley (pers comm)

1.3.4 Adult Habitat

As part of this review, adult Hawaiian bottomfish depth data were obtained from recent University of Hawaii (UH) scientific fishing surveys, baited drop cameras, submersible transects and the Hawaii Undersea Research Laboratory's (HURL) database. A total of 18,125 records were extracted for 9 snappers, 1 grouper, and 5 jacks (Table 12). The number of records per species varied considerably, due to differences in abundance but also to non-uniform sampling across geographic areas as well as depth range. For example, the depth range for *P. auricilla* and *Caranx lugubris* was very well sampled in this analysis however these species are simply not as common in Hawaii as they are around other Pacific Islands. *A. virescens* is common in shallower waters around Hawaii, however, very few submersible and drop camera records were available for this depth range. Nevertheless, this dataset hereafter referenced as "UH data (2010)", combined with depth data found in the literature, provided the most up-to-date and thorough compilation of bottomfish depth ranges currently available. Table 13 provides the upper and lower depth limits for each species to the nearest 40 m interval.

Adult depth ranges for these 15 bottomfish species clearly overlap to one extent or another but depth record frequency distributions (Fig. 2) indicate the existence of depth preferences or potentially distinct species assemblages, or both. Two snappers and one jack (*L. kasmira, A. virescens*, and *C. ignobil*is) were rarely observed below 160 m whereas four species of snappers (*P. auricilla*, *P. zonatus*, *E. coruscans*, and *E. carbunculus*) were rarely observed above that depth. With one exception, none of the shallow species were recorded together at the same time with any of the deeper species. The other 9 bottomfish species were recorded together at separate times with either shallow or deep species, although *P. sieboldii* was for the most part observed together with the deeper species. Based on these distributions, bottomfish species were classified as being either shallow (0-240m, 3 species), intermediate (40-320m, 7 species), or deep (80-400m, 5 species). Table 14 provides these classifications as proposed revisions to the currently accepted species complex definitions.

Table 12: The number of depth records obtained for each of 15 species of bottomfish in the main Hawaiian Islands from fishing surveys, baited drop cameras, submersible transects and the HURL database.

Family	Species	# Records
Lutjanidae (snappers)	*Aprion virescens*	81
	Lutjanus kasmira	1136
	Aphareus rutilans	93
	Etelis carbunculus	3007
	Etelis coruscans	2540
	Pristipomoides auricilla	63
	Pristipomoides filamentosus	1714
	Pristipomoides sieboldii	4809
	Pristipomoides zonatus	719
Serranidae (groupers)	*Epinephelus quernus*	859
Carangidae (jacks)	*Caranx ignobilis*	25
	Caranx lugubris	43
	Pseudocaranx cheilio	166
	Seriola dumerili	2512
	Seriola rivoliana	358
Total		18, 125

Table 13: Depth ranges for Hawaiian bottomfish rounded to the nearest 40m interval

Family	Species	Depth range (m)
Lutjanidae (snappers)	*Aprion virescens*	0 – 240
	Lutjanus kasmira	0 – 280
	Aphareus rutilans	40 – 360
	Etelis carbunculus	80 – 520
	Etelis coruscans	80 – 480
	Pristipomoides auricilla	80 – 360
	Pristipomoides filamentosus	40 – 400
	Pristipomoides sieboldii	40 – 360
	Pristipomoides zonatus	40 – 360
Serranidae (groupers)	*Epinephelus quernus*	0 – 360

Carangidae (jacks)	*Caranx ignobilis*	0 – 200
	Caranx lugubris	0 – 400
	Pseudocaranx cheilio	40 – 360
	Seriola dumerili	0 – 560
	Seriola rivoliana	0 – 320

Depth (m)	taap	ului	uku	paka	lehi	kahr	buta	ulul	hapu	kahd	ykale	kale	gind	onag	ehu
0-40	0.4							2.3							
40-80	15.5	40.0	9.9	3.6	1.1			2.3	0.5	0.7					
80-120	37.2	40.0	45.7	20.1	14.1	12.0	2.4	4.7	1.0	7.3		0.3	0.3		0.2
120-160	46.0	12.0	33.3	39.0	37.0	26.8	35.9	39.5	15.3	18.0	6.3	51.9	7.9	0.1	1.1
160-200	0.8	8.0	4.9	25.0	30.4	26.3	26.3	20.9	28.5	14.1	28.6	12.1	27.1	2.4	6.3
200-240	0.1		6.2	9.0	14.1	19.0	31.1	11.6	33.8	29.2	46.0	26.4	42.1	43.5	17.4
240-280				3.2	2.2	13.4	3.6	16.3	16.4	16.5	14.3	7.9	21.3	32.2	33.4
280-320				0.1	1.1	2.5			3.6	8.4	3.2	1.4	1.1	17.5	25.4
320-360				0.1			0.6		1.0	3.3	1.6	0.1	0.1	3.0	13.0
360-400								2.3		1.0				0.9	1.8
400-440										1.0				0.2	1.1
440-480										0.2				0.1	0.2
480-520										0.2					0.1
520-560										0.0					
560-600															

Figure 4: Forty meter binned depth frequency distributions for 15 species of bottomfish (red to blue colored bins with numbers) derived from the records shown in table 1. Frequencies greater than 20 are red, 15-20 dark orange, 10-15, beige 5-10, and light blue 0-5. Green bins represent extensions, or filling of gaps, in these depth ranges derived from the literature. Species abbreviations are the following: taap= Lutjanus kasmira, ului= Caranx ignobilis, uku= Aprion virescens, paka= Pristipomoides filamentosus, lehi= Aphareus rutilans, kahr= Seriola rivoliana, buta= Pseudocaranx cheilio, ulul= Caranx lugubris, hapu= Epinephelus quernus, kahd= Seriola dumerili, ykale= Pristipomoides auricilla, kale= Pristipomoides sieboldii, gind= Pristipomoides zonatus, onag= Etelis coruscans, ehu= Etelis carbunculus.blue

A study of the hooking depth of the six most important bottomfish species in the Northwestern Hawaiian Islands (NWHI) supports the existence of overlapping depth ranges as well as the fact that certain species are more common at shallow depths while others are more common at deeper depths. As noted in Amendment 2 of the bottomfish FMP, adult bottomfish in the NWHI are caught at depths of 40 to 145 fathoms (73-265m, Table 15). Hooking depth ranges for individual species show no overlap between the shallow *A. virescens* and the deeper *E. coruscans* and *E. carbunculus*, while the other three species fell into an intermediate group. These findings are the same as those from the analysis above.

In a five-year study of the bottomfish fishery resource of the Northern Mariana Islands and Guam, Polovina et al. (1985) found bottomfish species to be stratified by depth with three broad distributions located throughout the archipelago. Between 164 and 183 m, *C. lugubris*, *P. flavipinnis*, *P. filamentosus* and *A. rutilans* are common; between 183 to 201 m, *P. auricilla*, *S. dumerili* and *P. zonatus* are most abundant; and at depths of greater than 201 m, *P. sieboldii*, *E. coruscans*, *E. carbunculus* and *Epinephelus sp* were the most abundant (Table 16). Even though these findings were from a different region of the Pacific, the depth ranges are consistent with the data from Hawaii. The seven species that ranged between 164 and 201 m would fall into an intermediate complex while the 4 species caught below 201m would fall into a deep complex. No shallow complex species were caught during this particular study while the groupers (*Epinephelus sp*) were all caught in deeper water.

Table 14: Recommended adult bottomfish complexes based on observed depth preferences and species assemblages.

Fishery	Complex	Family	Species
Bottomfish	Shallow (0 – 240m)	snapper	*Aprion virescens*
		snapper	*Lutjanus kasmira*
		jack	*Caranx ignobilis*
	Intermediate (40 – 320m)	snapper	*Aphareus rutilans*
		snapper	*Pristipomoides filamentosus*
		grouper	*Epinephelus quernus*
		jack	*Caranx lugubris*
		jack	*Pseudocaranx cheilio*
		jack	*Seriola dumerili*
		jack	*Seriola rivoliana*
	Deep (80 – 400m)	snapper	*Etelis carbunculus*
		snapper	*Etelis coruscans*
		snapper	*Pristipomoides auricilla*
		snapper	*Pristipomoides sieboldii*
		snapper	*Pristipomoides zonatus*

Table 15: Hooking depth range for dominant Northwestern Hawaiian Islands Bottomfish. Source: (Amendment 2 of bottomfish FMP)

Species	Hooking Depth Range (m)	Average (m)
Aprion virescens	37-110	73
Pristipomoides filamentosus	54-201	128
Pseudocaranx cheilio	73-183	128
Epinephelus quernus	91-274	183
Etelis coruscans	183-274	229
Etelis carbunculus	201-329	265

Depth alone does not provide an adequate description of adult bottomfish habitat. As noted in Amendment 2 of the bottomfish FMP, variations in catch rates along the same depth contour indicate that the quantity and quality of benthic habitat are also both important. Within their depth ranges, bottomfish populations are found in non-random clumped distributions. Both topography and substrate type appear to be responsible for this pattern as well as the schooling behavior of some species. Unlike the US mainland with its continental shelf ecosystems, the Pacific islands are primarily volcanic seamounts with steep drop-offs and limited shelf ecosystems (Ralston 1979). Adult bottomfish in the NWHI are found in habitats characterized by a hard substrate of high structural complexity. Pinnacles, drop-offs and other high relief rocky substrate are prime fishing grounds (Ralston 1979). In the main Hawaiian Islands, bottomfish are generally concentrated on or above old carbonate terraces, which are remnants of coral reefs that developed on the slopes of these islands and subsequently drowned thousands of years ago. The top of the largest and most prominent drowned reef terrace above 400m is located between 110-150m (60-82 fathoms) around every island or bank. Off the Big Island, this reef is believed to have drowned approximately 14,000 yrs ago during the late Pleistocene in association with a major glacial melt water pulse (Webster et al. 2007). The tops and slopes of this, and similar smaller drowned reef structures, have ledges, promontories, canyons, ridges and pinnacles where upwelling, turbulence or other alterations to the vertical flow field that is likely to concentrate benthopelagic prey. This process has has been documented on seamounts and banks elsewhere (Genin et al 1986, Genin 2004, Porteiro & Sutton 2007).

Table 16: Hooking depth range of various snappers, jacks and groupers caught off the Northern Marianas and Guam from Polovina et al, 1985.

Scientific Name (common name)	**Mean Depth**		
Depth range	M	Fathoms	N
164 - 183 m			
Caranx lugubris (black ulua)	166	91	270
Pristipomoides flavipinnis (yelloweye opakapaka)	170	93	499
Pristipomoides filamentosus (pink opakapaka)	170	93	191
Aphareus rutilans (lehi)	174	95	81
183 - 201 m			
Pristipomoides auricilla (yellowtail kalekale)	188	102	1,166
Seriola dumerili (kahala)	196	107	47
Pristipomoides zonatus (gindai)	199	109	3,890
>201 m			
Epinephelus sp	214	117	38
Pristipomoides sieboldii (pink kalekale)	214	117	200
Etelis coruscans (onaga)	218	119	200
Etelis carbunculus (ehu)	225	123	950

These sites also have cavities that provide shelter to benthic prey as well as smaller species of bottomfish. In his study of Penguin Bank in the Hawaiian Islands, Haight (1989) observed aggregations of up to 100 *P. filamentosus* and *A. rutilans* 2-10 m above high-relief coral bench substrate and in the vicinity of underwater headlands and promontories. These and other observations suggest that the distribution of at least some species of deepwater snappers appears to be closely related to current flow. Ralston et al (1986) found that the up-current side versus the down-current side of Johnston Atoll supported higher densities of *P. filamentosus*. It has been hypothesized that water flow may enhance food supplies (Haight 1989; Parrish et al. 1997). High relief forms localized zones of turbulent vertical water movement, which may increase the availability of prey (Haight et al. 1993a).

More recent submersible and ROV surveys in Hawaii indicate that large-scale topographic features (i.e. pinnacles, canyons, large outcrops and terraces) that potentially increase water flow are important to some species while substrate type and macro-scale characteristics, particularly hard substrate with cavities, are important to others (Kelley et al, 2006). Exposed basalt, not buried under old carbonate reef terraces is uncommon at depths above 400m. However this type of substrate is present off the big island of Hawaii where active volcanism is still occurring and as far west as Niihau, where it was recently found up as shallow as 200m (Kelley & Drazen, unpub data). Bottomfish and their prey were observed in these habitats indicating that the type of rock is less important than the vertical relief and cavities hard substrate of any type provides. This is furthermore supported by observations of juvenile and benthic species of bottomfish on or near man made metal wreckage that had holes where they and their prey could hide. (Kelley, unpub.data).

High slope hard substrate is attractive to many different species of bottomfish that, according to Ralston & Polovina (1982), co-exist with apparent negligible inter-specific interaction. Polovina (1987) found a weak predator-prey relationship among the species of the NWHI bottomfish complex. As noted in Amendment 2, the establishment of territorial strongholds by individual species may account for the low multi-species interaction. Amendment 2 also notes that variations are known to occur in the way different bottomfish utilize habitat. For example *P. filamentosus* are believed to migrate into shallower depths during the night hours; *E. coruscans* are caught in considerably deeper water than other species of snappers and in association with abrupt relief zones, such as outcroppings, pinnacles and drop-offs; and groupers are generally more benthic than these species of snappers. Haight (1989) found that niche overlap between species of deep-slope snappers on Penguin Bank, in terms of forage habitat and forage period, was reduced by the different depth and dietary preferences of individual species.

Ambient light bait stations, conducted from submersibles (Kelley & Ikehara, 2006) or using a remote drop camera (Drazen et al, in prep), clearly show differences in swimming height off the bottom between different species that are likely to contribute to minimizing interspecific interactions. Adult *E. coruscans*, *P. filamentosus*, *A. virescens* and *A. rutilans* are “high-column” benthopelagic, typically swimming from a few meters to over 50m above the bottom. Adult *P. sieboldii, P. auricilla, L. kasmira, P. cheilio, C. ignobilis, C. lugubris* and the two species of *Seriola* are generally “low or mid column” benthopelagic species that typically swim from a few to no more than 20 meters off the bottom. *E. carbunculus, P. zonatus* and *E. quernus* are benthic species typically found near the bottom, often in cavities or under ledges. Predation is at least one of the variables that may be responsible for this observed pattern while social structure and reproductive strategy are others, at least for *E. quernus*.

E. quernus are protogynous hermaphrodites (DeMartini et al. 2010) and like most fishes having this type of reproductive strategy, may have a haremic social structure that requires territoriality. Since the sexes cannot be identified by external appearance, this contention will likely remain unproven for many years. However, assuming this is correct harem maintenance (i.e., control and competition for females) may be a more important factor than the risk of predation that is causing large adults to remain close to the bottom.

1.4 Life History and Habitat Descriptions for Each Species

1.4.1 Groupers (family Serranidae)

The groupers (family Serranidae) consist of at least 511 species in 68 genera organized into 3 subfamilies (Fishbase.org). All three species presently classified as BMUS in the Pacific are in the subfamily Epinephelinae and only one of these, *Epinephelus quernus*, is found in Hawaii. Most if not all epinepheline groupers are believed to be benthic protogynous hermaphrodites that according to Heemstra & Randall (1993) spawn small (0.70-1.20 mm) pelagic eggs that contain a single oil globule. The incubation period varies between 20-45 hrs after spawning with newly hatched larvae ranging between 1.6-2.5 mm (Leis, 1987). Yolk sac absorption is completed 48-120 hrs after hatching. Early stage serranid larvae are described as having "kite-shaped" bodies and highly developed head spination. The length of the pelagic larval stage is believed to range from 25-70 days, with settlement taking place when the fish reach 25-31 mm total length (TL). The juveniles of some species of serranids are known to inhabit sea-grass beds and tide pools while the adults of one species (*Epinephelus nigritus*) range in depth down to 525m (Heemstra & Randall 1993).

1.4.1.1 *Epinephelus quernus* (Hawaiian grouper, hapuupuu)

<u>Life History</u>

The Hawaiian grouper, *Epinephelus quernus*, is a member of the subfamily Epinephelinae and has recently been renamed to *Hyporthodus quernus*. In Hawaii adults of this species are known as hapu while juveniles are referred to as hapuupuu. According to Heemstra & Randall (1993) *E. quernus* is endemic to the Hawaiian Islands and Johnston Atoll and is the only grouper species native to the Hawaiian Islands. In the NWHI, this species reaches 50% sexual maturity at a length of 58 cm (Everson 1992; DeMartini et al. 2010) and at an age of about 6 years (Nichols & DeMartini 2008). Most individuals attain at least 80 cm total length and reach a weight of 10 kg or 22 lbs (Randall, 2007). In the NWHI, the species changes sex from adult female to adult male at a length of about 90 cm (DeMartini et al. 2010) and at an imprecisely estimable age of between 20 and 30 years (Nichols & DeMartini 2008). Its maximum length has been reported to be 106 cm or 41.7 in (Randall, 2007) and the Hawaii state record weight for this species is 22.7 kg (50 lbs) (http://www.hawaiifishingnews.com/records.cfm).

A recent histological study of their gonads has confirmed that this species is a protogynous hermaphrodite, similar to most other epinepheline groupers (DeMartini et al. 2010). *E. quernus* is often observed in small groups of 3-5 individuals during submersible dives (Kelley, unpub data). In the NWHI, the adult sex ratio is about 6 females to 1 male (DeMartini et al. 2010). Protogyny is commonly associated with monandric, haremic social systems and in these cases the sex ratio is typically skewed 2:1 to 5:1 females to males. Specimens captured during fishing surveys in the MHI were predominantly females (Kelley, unpub data) suggesting the possibility that *E. quernus* could have a haremic social system.

Seki (1984a) reported the diet of *E. quernus* consists primarily of fish and to a lesser extent of cephalopods (mostly octopuses) and other invertebrates. Three of the 22 families of fish identified to be most important in the diet were Lutjanidae, Emmelichthyidae, and Congridae. Shrimp from the family Pandalidae accounted for 79% of all crustaceans. Prey regurgitated by *E. quernus* specimens after they were boated included two species of fish, *Symphysanodon maunaloae,* and *Bembradeum roseum*, as well as an unidentified octopus (Kelley, unpub data). These data are summarized in Table 17 and coupled with behavioral observations, suggests that *E. quernus* feeds primarily on benthic fish and invertebrates over a wide range of depths both day and night.

Table 17: *Epinephelus quernus* prey species combined from 67 stomachs (Seki, 1984a) and regurgitated specimens (Kelley, unpub data) [1]

Group	Category/Family	Subcategory/Species
Mollusks	Cephalopoda	unidentified
	Cephalopoda – octopods	*Octopus* sp.[1]
	Cephalopoda – octopods	unidentified
Crustaceans	Amphipoda	*Phronima sedentaria*
	Decapoda - crabs	Galatheidae
	Decapoda - crabs	Homolidae
	Decapoda - crabs	*Munida* sp.
	Decapoda - crabs	Raninidae
	Decapoda - shrimps	Caridae
	Decapoda - shrimps	Pandalidae
	Decapoda - shrimps	*Plesionika longirostris*
	Decapoda - shrimps	unidentified
	Isopoda	unidentified
	Stomatopoda	*Odontodactylus brevirostris*
Echinoderms	Echinoidea	unidentified
Urochordates	Pyrosomatidae	*Pyrosoma* sp.
Fishes	Anguilliformes	unidentified
	Apogonidae	unidentified
	Argentinidae	unidentified
	Brembridae	*Bembradium roseum*[1]
	Carangidae	*Decapterus* sp.
	Carangidae	*Seriola* sp.
	Congridae	unidentified
	Echeneidae	unidentified
	Emmelichthylidae	unidentified
	Gempylidae	unidentified
	Gonorhynchidae	*Gonorhynchus gonorhynchus*
	Holocentridae	unidentified

	Lutjanidae	*Etelis carbunculus*
	Monacanthidae	*Pervagor spilosoma*
	Monacanthidae	unidentified
	Mullidae	*Parupeneus* sp.
	Muraenidae	unidentified
	Myctophidae	unidentified
	Ophidiidae	*Brotula multibarbata*

Group	**Category/Family**	**Subcategory/Species**
Fishes cont.	Polymixiidae	*Polymixia berndti*
	Polymixiidae	unidentified
	Pomacentridae	unidentified
	Priacanthidae	*Priacanthus* sp.
	Scorpaenidae	unidentified
	Serranidae	unidentified
	Symphysanodantidae	*Symphysanondon maunaloae*[1]
	Symphysanodantidae	*Symphysanondon* sp.
	Tetraodontidae	unidentified
	Trachichthyidae	*Paratrachichthys* sp.
	Trachichthyidae	unidentified
	unidentified	unidentified

Egg and Larval Habitat

E. quernus eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 380m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

Newly settled (i.e., 25mm long) *E. quernus*, still having pelagic coloration, have been found in NWHI lobster traps in early summer (Moffitt 2003). Age of settlement from these fish was estimated from otolith examination to be about 50 days (R. Nichols, NMFS, PIFSC, unpubl. data) The traps were set on bank flats at depths of 30–50 m, but with limited information, generalizations as to the bottom type these fish naturally settle on can not be made. *E. quernus* is generally more abundant and found in shallower water in the NWHI than in the MHI. Small juveniles (i.e., <4 in FL) have been collected off the west shore of Oahu in depths of 14 and 55m (Culp, pers comm.). The one shallow specimen was found in a discarded refrigerator while at least 5 deeper specimens were found hiding in an aggregation of *Diadema sp* urchins. Larger juveniles (i.e., 9-11 in FL) have been caught by hook and line off Oahu and depths between 73-121m (UH data, 2010). While both juveniles and adults have been observed relatively close to shore, it is believed that settlement generally occurs at depths greater than 30 m. The lower limit of juvenile *E. quernus* habitat is not known and in the absence of additional information, is considered to be the same depth as that of adult habitat.

Adult Habitat

Adult *E. quernus* have been documented as shallow as 5 m at Midway and Kure (Hobson, 1980) and as deep as 350 m in the MHI (UH data, 2010). Heemstra & Randall (1993) listed its overall depth range at 20-380 m. Seki (1984a) trapped adult *E. quernus* at 18 m in the NWHI. With only one exception, adults caught during fishing surveys in the MHI were all below 100 m while > 90% of those observed in BotCam deployments ranged from 119 to 229 m (UH data, 2010). Adults were observed on carbonate or mixed carbonate/sediment substrate during submersible transects (Kelley unpub data). In some cases, the fish were clearly associating with ledges and other large cavities while in other cases they appeared on more open terrain. A habitat summary is provided in Table 18.

Table 18: Habitat summary for *Epinephelus quernus* (Hawaiian grouper, hapuupuu)

	Egg	Larvae	Juvenile	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown <380m	Unknown <380m	14-121m	5-380m
Water Column Zone	Pelagic	Pelagic	Benthic	Benthic
Water Quality	Unknown	Unknown	Unknown	15-24 °C
Substrate Type	N/A	N/A	Unknown	Rocky bottom substrate.
Prey	N/A	Unknown	Unknown	Fishes, shrimps, octopods, and other invertebrates

Bottomfish Complex: Intermediate (40-320 m depth range)

Species EFH Descriptions:

Egg: pelagic zone, 0-320 m depth range from shoreline out 50 mi

Post Hatch Pelagic: pelagic zone, 0-320 m depth range from shoreline to EEZ

Post Settlement and Sub Adult: benthic zone, 40-320 m depth range

Adult: benthic zone, 40-320 m depth range

1.4.2 Jacks (family Carangidae)

Large carangids, or jacks, form an important component of shallow water reef and lagoon fish catches throughout the Pacific Islands. The species are found distributed throughout tropical and subtropical waters of the Indo-Pacific region in shallow coastal areas in estuaries and on reefs, on the deep reef slope and banks and seamounts (Sudekum et al., 1991). Despite their importance to fisheries, little is known about the basic biology and habitat requirements of these fish. Generally speaking, jacks are highly mobile, wide-ranging predators that travel throughout the water column from the surface to depths greater than 250 m, although they are more closely affiliated with demersal habitats and feeding on benthos (Seki 1986b, Sudekum et al. 1991).

Carangid eggs are planktonic, spherical (0.70-1.5 mm in diameter), and have one to several oil globules (Laroche et al., 1984; Leis & Trnski, 1989; Honebrink, 2000). Incubation generally takes 18 to 48 hours with newly hatched larvae ranging from 1.0 to 2.0 mm according to Laroche et al. (1984) and 2.0 to 4.3 mm according to Leis & Trnski (1989). Carangid larvae have a relatively large yolk sac and an oil globule at the anterior end of the sac (Laroche et al., 1984). Yolk sac absorption is completed in 72 hrs. Leis & Trnski (1989) provide a detailed description of larvae in the genus *Caranx*. According to Miller et al. (1979), carangid larvae are common in the near-shore waters of Hawaii. However, the identification of either eggs or larvae to even the level of family is frequently impossible because of their similarity in size and appearance to many other marine fishes (Laroche et al., 1984). No general information could be found on settlement and metamorphosis in this family.

1.4.2.1 *Caranx ignobilis* (giant trevally/white ulua)

<u>Life History</u>

Caranx ignobilis or white ulua is one of the most abundant species of jacks found in Hawaii. This species is the largest jack found in the Indo-Pacific region, obtaining a weight over 50 kg and living in excess of 15 years (Lewis et al. 1983). The Hawaii state record is 191 lbs or 87 kg (http://www.hawaiifishingnews.com/records.cfm). The sex ratio of males to females in Hawaii was reported to be 1:1.39 (Sudekum et al. 1991) in contrast to Fiji where it was reported to be 2:1 (Lewis et al. 1983). This species reaches sexual maturity in 3.5 years at a size of 60 cm (Sudekum et al. 1991).

Gravid fish are found between April and November in the NWHI while in general, peak spawning in Hawaii occurs between May and August (Sudekum et al. 1991). Johannes (1981) reported that *C. ignobilis* spawns in pairs within larger aggregations during new and full moon events. Myers (1991) reports that *C. ignobilis* gather to spawn on offshore banks and shallow seaward reefs. No description of either eggs or larvae currently exists for this species.

C. ignobilis in the NWHI is predominantly piscivorous with fish comprising > 90% of its diet (Sudekum et al. 1991, Parrish et al. 1980). Stomach contents included parrotfish (Scaridae), mackerel scads (Carangidae), wrasses (Labridae), bigeyes (Priacanthidae) eels (Muraenidae and Congridae), and invertebrates including cephalopods, gastropods and crustaceans (crabs, shrimp and lobsters). The number of reef fishes in their diet suggests that shallow-water benthic habitats are important foraging areas, however, the occurrence of small pelagic fish and squids in their stomachs indicates that time is also spent foraging in the water column (Sudekum et al. 1991). In Kaneohe Bay in the MHI, Meyer et al. (2001) examined the stomach contents of 19 *C. ignobilis* and found only about 7.3% of the prey items were fish. Crustaceans, particular crabs (*Portunus sanguinolentus, Portunus japonicus,* and *Pachygrapsus* sp.), were the most abundant items, accounting for 90% of the prey volume. Table 19 summarizes the known types of prey for this species.

Smith (1992) found that juvenile *C. ignobilis* consumed primarily fish. Smith & Parrish (2002) subsequently examined the stomach contents of 106 juveniles collected from an estuary on Kauai and found that fish, including kuhliids, bothids, mugilids and gobioids, accounted for 95.1% of the total volume. Crustaceans, including amphipods, tanaids, isopods, shrimp, stomatopods, copepods and crabs, were also found in the majority of the stomachs but did not account for a high percentage of the volume. Based on both prey species found in their stomachs and tracking studies, *C. ignobilis* appears to be primarily a nocturnal feeder (Longenecker & Langston, 2008; Sudekum et al. 1991; Okamoto & Kawamoto 1980).

Egg and Larval Habitat

C. ignobilis eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 190m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

Juvenile *C. ignobilis* are often found in near-shore and estuarine waters (Lewis et al. 1983; Smith, 1992) and in small schools over sandy inshore reef flats (Myers 1991). Smith & Parrish (2002) collected over 100 juveniles in an estuary on the island of Kauai. This species therefore appears to have near-shore nursery areas however, their presence in less surveyed deeper habitats, cannot be ruled out. The lower limit of juvenile *C. ignobilis* habitat is not known and in the absence of additional information, is considered to be the same depth as that of adult habitat.

Adult Habitat

In the NWHI, diver towboard surveys conducted among reefs, among habitats within atolls (fore reef, back reef, channel and lagoon), and banks (insular and exposed), found *C. ignobilis* in greater abundance on fore reef habitats within atolls and in similar abundance on exposed and insular reefs within banks (Holzwarth et al., 2006). The deepest record of *C. ignobilis* in Hawaii is 190m (UH data, 2010). A habitat summary is provided in Table 20.

Table 19: *Caranx ignobilis* prey species combined from 81 stomachs (Sudekum et al. 1991) and 19 stomachs (Meyer et al., 2001).

Group	Category/Family	Subcategory/Species
Mollusks	Cephalopoda	unidentified
	Cephalopoda – octopus	unidentified
	Cephalopoda - squids	unidentified
	Gastropoda	*Bittium parcum*
Crustaceans	Decapoda - crabs	*Pachygrapsus* sp.
	Decapoda - crabs	Portunidae
	Decapoda - crabs	*Portunus japonicas*
	Decapoda - crabs	*Portunus sanguinolentus*
	Decapoda - lobsters	Palinuridae
	Decapoda - shrimps	unidentified
	Stomatopoda	unidentified
	unidentified	unidentified
Fishes	Acanthuridae	unidentified
	Anguilliformes	unidentified
	Blennidae	unidentified
	Carangidae	*Decapterus macarellus*
	Carangidae	unidentified
	Congridae	unidentified
	Holocentridae	unidentified
	Labridae	unidentified
	Monacanthidae	unidentified
	Mullidae	*Parupeneus cyclostomus*
	Mullidae	unidentified
	Muraenidae	unidentified
	Ophidiidae	*Brotula multiberbata*
	Ostraciidae	unidentified
	Pomacentridae	unidentified
	Priacanthidae	unidentified
	Scaridae	unidentified
	unidentified	unidentified

Table 20: Habitat summary for *Caranx ignobilis* (giant trevally, white ulua)

	Egg	**Larvae**	**Juvenile**	**Adult**
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	unknown < 190m	unknown < 190m	0-10m	10-190m
Water Column Zone	Pelagic	Pelagic	Benthic or benthopelagic	Benthopelagic
Water Quality	18-30°C	18-30°C	Unknown	21-24 °C
Substrate Type	N/A	N/A	Often found in near-shore and estuarine waters and in small schools over sandy inshore reef flats	Wide variety of substrates
Prey	N/A	Unknown	Predominantly fish, including kuhliids, bothids, mugilids, and gobioids. Also preys on crustaceans, including amphipods, tanaids, isopods, shrimp, stomatopods, copepods and crabs.	Habitat dependent. Predominantly fish in areas in the NWHI while predominantly crustaceans in Kaneohe Bay. Also preys on gastropods and cephalopods.

<u>Bottomfish Complex</u>: Shallow (0-240 m depth range)

<u>Species EFH Descriptions</u>:

Egg: pelagic zone, 0-200 m depth range from shoreline out 50 mi

Post Hatch Pelagic: pelagic zone, 0-200 m depth range from shoreline to EEZ

Post Settlement and Sub Adult: benthic or benthopelagic zone, 0-200 m depth range

Adult: benthic or benthopelagic zone, 0-200 m depth range

1.4.2.2 *Caranx lugubris* (black trevally/black ulua)

Life History

Caranx lugubris, known in Hawaii as the black ulua, has a world wide distribution although it is not particularly common in the Hawaiian Islands (Randall, 2007). *C. lugubris* is the most common carangid taken from offshore banks in the Marianas, despite concerns about ciguatera, which is a form of food poisoning caused by bioaccumulation of dinoflagellate toxins in the flesh. (Myers, 1991). This species is not a major component of the bottomfish catch in Hawaii, accounting for 0.2% of the annual catch and ranking 13th in importance (WPRFMC, 2005). *C. lugubris* reach lengths of up to 80 cm or 31.5 in, with the world angling record being 17.9 kg or 28.4 lbs (Randall, 2007). In Hawaii, the state record weight for this species is 16.75 lbs or 7.6 kg (http://www.hawaiifishingnews.com/records.cfm). No information was available regarding its spawning season in Hawaii. However, in the Caribbean it reportedly spawns from February to September (Munro et al., 1973). This species has been reported to feed primarily on other fishes and, as a result, has been implicated in ciguatera poisoning (Randall, 2007).

Egg and Larval Habitat

The early life history of *C. lugubris* is poorly known. *C. lugubris* eggs and larvae are pelagic however their depth and geographic ranges are unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 367 m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

There is presently no information available on the juveniles of this species in Hawaii. However, it is assumed that juvenile habitat will be found at either the same or shallower depths as the adults.

Adult Habitat

Very little is known about the adult habitat of this species in Hawaii. Smith-Vaniz (1986) stated that this species appears to be confined to clear, offshore waters at depths of 25 to 65 m. Myers (1991) however, found these fish occurring singularly or in small groups on offshore banks and along the steep outer reef slopes at depths of 12 to 354 m. *C. lugubris* has been recorded to a depth of 367 m during submersible dives (UH data, 2010). A habitat summary is provided in Table 21.

Table 21: Habitat summary for *Caranx lugubris* (black trevally/black ulua)

	Egg	Larvae	Juvenile	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown <367m	Unknown <367m	Unknown <367m	12-367m
Water Column Zone	Pelagic	Pelagic	Benthic or benthopelagic	Benthopelagic
Water Quality	18-30°C	18-30°C	Unknown	Unknown
Substrate Type	N/A	N/A	Unknown	Shallow coastal areas and in estuaries and on reefs, the deep reef slope, banks and seamounts
Prey	N/A	Unknown	Unknown	Predominantly piscivorous, fish comprising >90% of its diets. Also preys on crustaceans, gastropods and cephalopods, eels. Shallow-water reef habitats are of prime importance as foraging habitat for large jacks. Time is also spent foraging in the water column.

Bottomfish Complex: Intermediate (0-320 m depth range)

Species EFH Descriptions:

Egg: pelagic zone, 0-320 m depth range depth range from shoreline out 50 mi

Post Hatch Pelagic: pelagic zone, 0-320 m depth range depth range from shoreline to EEZ

Post Settlement and Sub Adult: benthic or benthopelagic zone, 40-320 m depth range

Adult: benthic or benthopelagic zone, 40-320 m depth range

1.4.2.3 *Pseudocaranx cheilio* (thick-lipped trevally, butaguchi)

Life History

Pseudocaranx cheilio has been recently renamed from *Pseudocaranx dentex*, and is called butaguchi in Hawaii. Its taxonomy is still uncertain and as a result, its current distribution is considered to be only in the Hawaiian Islands (Randall, 2007). This species has accounted for roughly 15% of the annual bottomfish catch in the NWHI (WPRFMC 1997) and 10.4% of the annual catch throughout the archipelago since 1948 (WPRFMC, 2005). On that basis, it is ranked 5th in importance to the fishery in Hawaii. However, the number caught has been in decline for over 10 years and in 2004, the most recent year of data, it accounted for only 4.3% of the catch. Its maximum size has been reported to be 82 cm or 32 in (Randall, 2007), while the Hawaii state record is 40 lbs or 18 kg (http://www.hawaiifishingnews.com/records.cfm).

Based on the von Bertalanffy growth curves from Williams & Lowe (1997), this species can reach 80 cm FL in 4-6 years, depending on the method used.

In the Azores, *P. dentex* spawns from June to September (Afonso et al., 2008), however, in Hawaii, spawning has only been reported from June to July (Uchiyama & Tagami 1984).

Seki (1984b) examined the content of 64 *P. cheilio* stomachs and found them to be opportunistic carnivores (Table 22). Their diet was primarily piscivorous, but also included cephalopods and crustaceans. The types of prey and the observation of rubble in 31% of the stomachs suggest *P. cheilio* are bottom feeders. During submersible bait stations, adult *P. cheilio* appeared to "vacuum" bait right off the bottom with their large mouths.

Egg and Larval Habitat

P. cheilio eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 321m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

Very little information is currently available on the juveniles of this species. Seki (1984b) reported trapping hundreds of *P. cheilio* juveniles in the NWHI at depths of 60-64m which is at the upper end of the adult depth range. As mentioned earlier, Major (1978) and Smith & Parrish (2002) found that back reefs, lagoons and particularly estuaries were important nursery areas for carangids such as *C. ignobilis* and *P. cheilio*. While no juveniles of this species have ever been recorded on deeper submersible dives and drop camera deployments their presence in deeper water cannot be ruled out.

Table 22: *Pseudocaranx cheilio* prey species collected from 64 stomachs (Seki, 1984b).

Group	Category/Family	Subcategory/Species
Mollusks	Bivalvia	*Nemocardium thaaumi*
	Bivalvia	*Pinna muricata*
	Cephalopoda	unidentified
	Cephalopoda – octopods	unidentified
	Gastropoda	unidentified
Annelids	Polychaeta	unidentified
Crustaceans	Amphipoda	unidentified
	Decapoda - crabs	Brachyura
	Decapoda - crabs	*Munida* sp.
	Decapoda - crabs	Paguridae
	Decapoda - lobsters	*Panulirus* sp.
	Decapoda - shrimps	Caridae
	Decapoda - shrimps	Crangonidae
	Decapoda - shrimps	Pandalidae
	Decapoda - shrimps	“shrimp remains”
	Decapoda - shrimps	unidentified
	Stomatopoda	*Lysiosquilla* sp.
	Stomatopoda	*Odontodactylus* sp.
	Stomatopoda	*Pseudosquilla* sp.
	Stomatopoda	unidentified
	unidentified	unidentified
Echinoderms	Cidaridae	*Prionocidaris hawaiiensis*
	Ophiuroidea	unidentified
Fishes	Ammodytidae	*Embolichthys* sp.
	Anguilliformes	unidentified
	Bothidae	*Bothus thompsoni*
	Bothidae	unidentified
	Callionymidae	unidentified
	Chlorophthalmidae	unidentified
	Congridae	*Congrina aequoria*
	Congridae	unidentified
	Dactyloperidae	*Dactyloptera orientalis*
	Lutjanidae	unidentified
	Monacanthidae	unidentified
	Moridae	unidentified
	Myctophidae	unidentified
	Ogocephalidae	*Halieutaea retifera*
	Ogocephalidae	*Malthopsis* sp.

	Ogocephalidae	unidentified
	Ophichthidae	“Leptocephalus larvae”
	Ophichthidae	*Muraenichthys cookei*
	Ophichthidae	unidentified
	Ophidiidae	unidentified
	Ostheichthyes	unidentified
	Pegasidae	*Pegasus papilio*
	Percophidae	unidentified
	Priacanthidae	*Priacanthus* sp.
	Scorpaenidae	unidentified

Group	**Category/Family**	**Subcategory/Species**
Fishes cont.	Serranidae	*Anthias* sp.
	Serranidae	unidentified
	Symphysanodontidae	*Symphysanondon* sp.
	Synodontidae	unidentified
	Tetraodontidae	unidentified

<u>Adult Habitat</u>

Seki (1986a) noted that *P. cheilio* is rarely caught in the MHI, but is abundant in the NWHI where it is found at depths of 18-183 m. In addition to living on deeper reef slopes and banks, *P. cheilio* can also be found in near-shore areas in large schools of 200-300 fish. Adults of this species have been recorded to a maximum depth of 321 m on submersible dives (UH data, 2010). These fish were observed swimming closely and synchronously in small aggregations over carbonate or mixed carbonate/sediment substrate. Based on these observations, this species likely has a relatively large home range. Table 23 provides a habitat summary for this species.

Table 23: Habitat description for *Pseudocaranx cheilio* (thick-lipped trevally, butaguchi)

	Egg	Larvae	Juvenile	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown <321m	Unknown <321m	0-64m	18-321m
Water Column Zone	Pelagic	Pelagic	Benthic or benthopelagic	Benthopelagic
Water Quality			Unknown	Unknown
Substrate Type	N/A	N/A		Carbonate and mixed carbonate/sediment
Prey	N/A	Unknown	Unknown	Fish, cephalopods, and crustaceans

<u>Bottomfish Complex</u>: Intermediate (0-320 m depth range)

<u>Species EFH Descriptions</u>:

Egg: pelagic zone, 0-280 m depth range from shoreline out 50 mi

Post Hatch Pelagic: pelagic zone, 0-280 m depth range from shoreline to EEZ

Post Settlement and Sub Adult: benthic or benthopelagic zone, 40-280 m depth range

Adult: benthic or benthopelagic zone, 40-280 m depth range

1.4.2.4 *Seriola dumerili* (greater amberjack, kahala)

Life History

Seriola dumerili is found throughout the Atlantic, Indian, and Pacific oceans occupying a wide range of habitats including shallow estuaries, reefs, the deep reef slope, banks and seamounts (Harris et al., 2007; Sudekum et al., 1991). This species was previously an important component of the commercial bottomfish fishery in Hawaii. For the last couple of decades, however, its landings have been insignificant due principally to its association with ciguatera and a resulting ban on commercial sales (Uchida & Uchiyama 1986). *S. dumerili* is a key member of the bottomfish community being both a predator and competitor to other bottomfish species. Attacks and consumption of juveniles and smaller snapper species have been recorded during Pisces submersible and ROV dives (Kelley, unpub data).

Despite their importance to the fishery, very little is known about their basic biology in Hawaii. *S. dumerili* reaches sexual maturity between 1 and 2 years of age at an approximate length of 54 cm (Kikkawa & Everson 1984, Uchida & Uchiyama 1986). The Hawaii state record for this species is 145.5 lbs or 66 kg (http://www.hawaiifishingnews.com/records.cfm). Humphreys (1986a) reported that in the NWHI, *S. dumerili* spawn throughout the year with peak activity occurring in April. Elsewhere, Harris et al. (2007) conducted a comprehensive study on their life history off the Southeast Atlantic coast. From over 2,700 specimens, the maximum age was 13 years and maximum FL was 145 cm. Females reached 50% sexual maturity at 1.3 years at an average FL of 73 cm. Males attained sexual maturity at 64 cm. Spawning took place from February to May at 24-26 degrees of latitude with April and May being the peak months. Annual fecundity estimates ranged up to 59 million eggs. In the Canary Islands, *S. dumerili* underwent natural spawning in captivity from the month of April through October (Jerez et al, 2006). Thirty-eight spawns produced on average 368,431 pelagic eggs with mean diameter 1.121 ± 0.032 mm. The eggs hatched between 34-45 hrs, with newly hatched larvae averaging 3.639 ± 0.012 mm. Miller et al. (1979) described *Seriola* sp. larvae as moderately deep-bodied, large-headed and possessing well-developed pre-opercular spines. The length of the pelagic larval phase and age of settlement and metamorphosis are presently unknown.

S. dumerili is an opportunistic bottom feeder, with primary prey items comprising fishes such as eels, groupers, bigeyes, crustaceans (crabs and shrimps) and octopus (Seki, 1986b; Humphreys, 1980; Kelley, unpub data). Humphreys (1986a) found that their diet in the NWHI included bottom-associated prey and octopus while in the MHI the primary prey items are pelagic species, such as round scads. There is a significant shift in the diet of *S. dumerili* from cephalopods to fish as it increases in weight (Humphreys 1980). Humphreys & Kramer (1984) examined the stomach contents of 268 *S. dumerili* in the Hawaiian Islands and concluded that *S. dumerili* is primarily piscivorous, but also feeds on cephalopods and crustaceans. Known prey items are listed below in Table 24.

Table 24: *Seriola dumerili* prey species combined from 268 stomachs (Humphreys & Kramer, 1984) and regurgitated specimens (Kelley, unpub data[1]).

Group	Category/Family	Subcategory/Species
Mollusks	Cephalopoda	unidentified
	Cephalopoda – octopods	unidentified
	Cephalopoda – squids	Teuthoidea
Crustaceans	Amphipoda	unidentified
	Decapoda - crabs	*Munida* sp.
	Decapoda - crabs	Paguridae
	Decapoda - crabs	Portunidae
	Decapoda – lobsters and crabs	unidentified
	Decapoda - shrimps	Caridae
	Decapoda - shrimps	*Heterocarpus ensifer*
	Decapoda - shrimps	Penaeidea
	Decapoda - shrimps	*Plesionika edwardsii*
	Decapoda - shrimps	*Plesionika* sp.
	Decapoda - shrimps	unidentified
	Euphausiacea	unidentified
	Stomatopoda	*Squilla* sp.
	unidentified	unidentified
Fishes	Acanthuridae	unidentified
	Ammodytidae	*Ammodytoides pylei*
	Ammodytidae	*Lepidammodytes macropthalmus*
	Ammodytidae	unidentified
	Anguilliformes	unidentified
	Argentinidae	unidentified
	Ariommatidae	*Ariomma* sp.
	Balistidae	unidentified
	Balistidae	*Xanthichthys mento*
	Bothidae	unidentified
	Bramidae	unidentified
	Callanthiidae	*Grammatonoyus* sp.
	Caproidae	*Antigonia capros*
	Caproidae	unidentified
	Carangidae	*Decapterus macrosoma*
	Carangidae	*Decapterus* spp.
	Carangidae	*Decapterus tabl*
	Carangidae	*Selar crumenophthalus*
	Carangidae	unidentified
	Chaetodontidae	unidentified
	Congridae	unidentified
	Dactylopteridae	unidentified
	Emmelichthyidae	unidentified

	Engraulidae	unidentified
	Exocoetidae	unidentified
	Fistulariidae	unidentified
	Gobiidae	unidentified
	Gonostomatidae	unidentified
	Labridae	unidentified

Group	Category/Family	Subcategory/Species
Fishes cont.	Lutjanidae	*Etelis carbunculus*[1]
	Lutjanidae	*Etelis coruscans*
	Lutjanidae	*Lutjanus* sp.
	Lutjanidae	*Pristipomoides filamentosus*[1]
	Lutjanidae	*Pristipomoides sieboldii*
	Lutjanidae	*Pristipomoides* sp.
	Lutjanidae	unidentified
	Monacanthidae	*Thamnaconus garretti*
	Moridae	unidentified
	Mullidae	unidentified
	Muraenidae	unidentified
	Myctophidae	unidentified
	Nomeidae	*Psenes* sp.
	Nomeidae	unidentified
	Ostraciidae	*Kentrocarpros aculeatus*
	Ostraciidae	unidentified
	Paralepididae	unidentified
	Pegasidae	unidentified
	Percophidae	unidentified
	Pleuronectiformes	unidentified
	Polymixiidae	unidentified
	Pomacentridae	unidentified
	Priacanthidae	unidentified
	Scombridae	*Auxis rochei*
	Scombridae	*Auxis* sp.
	Scombridae	*Auxis thazard*
	Scombridae	*Scomber japonicus*
	Scombridae	unidentified
	Scorpaenidae	*Pontinus macrocephalus*
	Scorpaenidae	*Scorpaenopsis* sp.
	Scorpaenidae	unidentified
	Serranidae	*Anthias* sp.
	Serranidae	unidentified
	Sphyraenidae	unidentified
	Symphysanodontidae	*Symphysanodon typus*
	Symphysanodontidae	*Symphysanodon maunaloae*

Synodontidae	unidentified
Tetraodontidae	unidentified
Triglidae	unidentified
unidentified	unidentified
Zeidae	unidentified

Egg and Larval Habitat

S. dumerili eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 555m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ, while the larval habitat extends all the way out to the 200 mi EEZ boundary.

In a survey of larval distribution in near-shore waters off Hawaii, *Seriola* sp. larvae were found to be relatively uncommon (Miller et al, 1979). Slightly more *Seriola* sp. larvae were taken in summer than in winter, although this was not significant. They also found that *Seriola* sp. larvae were more common in offshore, as opposed to near-shore, tows.

Juvenile Habitat

Juvenile *S. dumerili* have been documented at approximately 80 m on flat sediment outside of Kaneohe Bay, Oahu (Figure 6a, Merritt, unpub data) and swimming at the surface under a dead albatross (http://www.hawaiianatolls.org/research/June2006/underwater_village.php, Fig. 6b). Juveniles have been reported to associate with floating plants and debris (Fishbase.org).

Adult Habitat

In the NWHI, diver towboard surveys among reefs, among habitats within atolls (fore reef, back reef, channel, and lagoon) and banks (insular and exposed), found *S. dumerili* in greater abundance on fore reef habitats within atolls and similar in abundance on exposed and insular reefs within banks (Holzwarth et al., 2006). *S. dumerili* is commonly found inhabiting the inner reefs and outer slopes of island shelves to depths of 335 m (Humphreys 1986a; Myers 1991; Ralston et al. 1986). This species has been frequently recorded on submersible dives and drop camera deployments to a maximum depth of 555 m (UH data, 2010). These records include observations of solitary individuals, pairs, small aggregations and schools swimming very close to the bottom or very high in the water column over hard carbonate and or basalt substrates, mixed hard and sediment substrates and sediment flats. *S. dumerili* appears to be a widely ranging, versatile, opportunistic carnivore. Table 25 provides a habitat summary for this species.

Figure 6: a) Juvenile *S. dumerili* off Kaneohe Bay, Oahu (Merritt unpub data), and b) under a dead albatross in the NWHI (photo by E. Tong).

Table 25: Habitat description for *Seriola dumerili* (greater amberjack, kahala)

	Egg	Larvae	Juvenile	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown <555m	Unknown <555m	0-80m	1-555m
Water Column Zone	Pelagic	Pelagic	Benthic or benthopelagic	Benthopelagic
Water Quality	18-30 °C	Unknown	Unknown	13-24 °C
Substrate Type	N/A	N/A	often found in near-shore and estuarine waters and in small schools over sandy inshore reef flats	shallow coastal areas and in estuaries and on reefs, the deep reef slope, banks and seamounts
Prey	N/A	Unknown	Unknown	Mostly piscivorous, with fish comprising >90% of its diets. Also preys on crustaceans, gastropods and cephalopods, eels. Shallow-water reef habitats are of prime importance as foraging habitat for large jacks. Time is also spent foraging in the water column.

<u>Bottomfish Complex</u>: Intermediate (0-320 m depth range)

<u>Species EFH Descriptions</u>:

Egg: pelagic zone, 0-320 m depth range from shoreline out 50 mi

Post Hatch Pelagic: pelagic zone, 0-320 m depth range from shoreline to EEZ

Post Settlement and Sub Adult: benthic or benthopelagic zone, 40-320 m depth range

Adult: benthic or benthopelagic zone, 40-320 m depth range

1.4.3 Snappers (family Lutjanidae)

The snappers (family Lutjanidae) consist of at least 103 species in 17 genera (Fishbase.org). Ten species are presently classified as BMUS in the Pacific, nine of which are found in Hawaii. All but one of these (e.g. *Lutjanus kasmira*) are in the subfamily Etelinae. *L. kasmira* is the only one of the nine that is non-native, having been introduced to Hawaii in the later half of the last century.

Lutjanids are reported to have life spans of 4-21 years, with larger species generally ranging from 15 to 20 years. Lutjanids reach sexual maturity at 43-51% of their maximum total length and dioecious (separate sexes), displaying little or no sexual dimorphism (Allen 1985). Females are batch spawners, producing several clutches of pelagic eggs over the course of the spawning season. According to Leis (1987), lutjanids eggs are typically less than 0.85mm in size and hatch in 17-36 h depending on water temperature. Newly hatched lutjanids are similar in appearance to the pelagic larvae of many other species and have a large yolk sac, no mouth, un-pigmented eyes and limited swimming capabilities. The duration of the pelagic phase has been estimated to range from 25 to 47 days for snappers of the subfamily Lutjaninae, with the larger members of the subfamily Etelinae (e.g. *A. rutilans*) taking longer to settle at a larger size of 50 mm or greater (Leis 1987). Leis (1987) also proposed that size may be a more important factor than age in determining when larval settlement occurs. However, the relatively low abundance of lutjanid larvae in plankton samples makes ecological studies difficult.

Ralston et al. (1986) found that the distribution of the larger deepwater snappers is non-random, with aggregations forming near areas of prominent relief features such as headlands and promontories. The adults of both large and small species clearly show a preference for habitats with hard substrates.

1.4.3.1 *Aphareus rutilans* (silvermouth snapper, lehi)

Life History

Aphareus rutilans is a member of the subfamily Etelinae and is one of two species in the genus *Aphareus* found in Hawaii. *A. rutilans* is widespread throughout the subtropical and tropical Pacific and Indian Oceans (Allen, 1985). This species has distinctive silver pigment lining the inside of its mouth which is responsible for its English common name of silvermouth snapper. *A. rutilans* is reported to reach a maximum length of 80 cm (Allen, 1985) with the Hawaii state record being 32.5 lbs (14.7 kg, http://www.hawaiifishingnews.com/records.cfm). This is an important commercial species in the island areas of the Indo-Pacific region and has been one of the principal target species in the Hawaiian bottomfish fishery, although it presently accounts for only 1% of the total bottomfish catch (WPRFMC, 2005). According to "Current Line Fish Facts: Bottomfishes of Hawaii" published by the state of Hawaii's DLNR Division of Aquatic Resources, *A. rutilans* prey include pelagic tunicates, fish, squid and crustaceans.

Egg and Larval Habitat

A. rutilans eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 350 m (White & Sumpton 2002). The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

There is almost no information available concerning the life history and habitat requirements of the juveniles. Parrish (1989) reported the collection of a single juvenile at 40 m off Kaneohe Bay, Oahu.

Adult Habitat

Adult *A. rutilans* aggregate near areas of high bottom relief (Parrish 1987). Of the 28 records of *A. rutilans* found in the HURL database, 24 were over hard substrate of basalt or carbonate. This species was observed as either solitary individuals or small groups but not in large schools typical of *E. coruscans* or *P. filamentosus*. *A. rutilans* has been recorded at submersible bait stations with other species of snappers, but is generally seen moving only with conspecifics (Kelley, unpub data). *A. rutilans* adults are benthopelagic and may be feeding primarily on pelagic organisms similar to other large schooling snappers. White (2002) reported its depth range as 100-350 m. Submersible, drop camera, and fishing records from Hawaii range from 61 to 310m (UH data, 2010). Table 26 provides a habitat summary for this species.

Table 26: Habitat Summary for *Aphareus rutilans* (silvermouth snapper, lehi)

	Egg	Larvae	Juvenile	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown <350m	Unknown <350m	40m	61-350m
Water Column Zone	Pelagic	Pelagic	Benthic or benthopelagic	Benthopelagic
Water Quality	Unknown	Unknown	Unknown	14-23 °C
Substrate Type	N/A	N/A	Unknown	Hard rocky bottoms, areas of high relief
Prey	N/A	Unknown	Unknown	Fish, squid, and crustaceans

<u>Bottomfish Complex</u>: Intermediate (0-320 m depth range)

<u>Species EFH Descriptions</u>:

Egg: pelagic zone, 0-280 m depth range from shoreline out 50 mi

Post Hatch Pelagic: pelagic zone, 0-280 m depth range from shoreline to EEZ

Post Settlement and Sub Adult: benthic or benthopelagic zone, 40-280 m depth range

Adult: benthopelagic zone, 40-280 m depth range

1.4.3.2 *Aprion virescens* (gray snapper, uku)

Life History

Aprion virescens is in the subfamily Etelinae and is the only species in its genus. This species is widely distributed throughout the Indian and Pacific oceans from East Africa to Hawaii, where it is known as the uku (Druzhinin 1970, Tinker, 1978). *A. virescens* has been an important member of the bottomfish fishery in American Samoa, Guam, and Hawaii (*1996 Annual Report Bottomfish and Seamount Groundfish Fisheries of the Western Pacific Region)* but much less so in the Northern Mariana Islands (Polovina 1987). In the latest available annual report (WPRFMC, 2005), this species is second only to *E. coruscans* in number of pounds caught in Hawaii in 2004. This is one of only 3 species that include *E. coruscans* and *P. zonatus* caught in 2004 in significantly higher numbers than their annual average since 1948.

In the NWHI, Kramer (1986) reported that *A. virescens* were caught only at Nihoa Island, Brooks Banks, St. Rogatien Bank and Midway Islands. However, in a survey of the near shore fishery resources of the NWHI, uku were also observed at Necker Island, French Frigate Shoals and Pearl and Hermes Atolls (Okamoto & Kanenaka 1983). In addition to these sites, *A. virescens* has been caught and tagged on Maro Reef (Meyer et al. 2007) and during research cruises transiting across the top of Raita Bank (Kelley, pers comm). This species is likely present on the tops of most or all banks in the NWHI. In the MHI, *A. virescens* has been recorded at depths of 54-227 m (UH data, 2010). However, it is also known to frequent waters just below the surface. In this respect, *A. virescens* is quite different from the other species of bottomfish and consequently is caught on surface trolling lures (Haight et al. 1993a, b; Kelley & Ikehara 2006; Meyer et al. 2007). Landings are seasonal, the majority of which are made between June and December (Ralston 1979, Haight 1989, Haight et al.1993a). *A. virescens* reach sexual maturity at an age of 4-5 years and approximately 42.5-47.5cm SL (Everson et al, 1989; Grimes, 1987) in Hawaii. Ralston (1979) reported it spawns during the summer months while its spawning season has been reported elsewhere as being from May to October (Everson et al, 1989). The maximum length is 110 cm (Randall, 2007) and the Hawaii state record is 39.5 lbs or 17.9 kg (http://www.hawaiifishingnews.com/records.cfm).

Egg and larval development in this species is poorly known. Leis & Lee (1994) described identifying characteristics of their larvae which appear to be more similar to *Etelis* than *Aphareus* or *Pristipomoides* larvae. This species lacks a melanophore cluster on the dorsal side of the tail but has a distal melanophore or several in series on the second dorsal spine. Larvae are confirmed to be pelagic to at least 18 mm NL and may in fact settle before it reaches 20 mm Leis & Lee (1994).

Haight (1989) reported that *A. virescens* feed during daytime hours and found the diet of specimens collected from Penguin Bank in the MHI to include fish (89%), larval fish (6%), planktonic crustaceans (1%), shrimp (3%) and crabs (1%). Talbot (1960) reported the diet of *A. virescens* on the coast of East Africa to consist of fish (49%), plankton (17%), cephalopods (14%), non-planktonic crustaceans (12%) and others (8%). Unlike the benthic species of deepwater lutjanids, *A. virescens* has feeding habits that do not seem to be constrained by substrate association (Parrish 1987). This species forages throughout the water column (Ralston 1979, Parrish 1987), from the surface down to almost 200 m. Table 27 summarizes the known prey of this species.

Table 27: Food items in 42 stomachs of *Aprion virescens* (Haight et al., 1993b).

Group	Category/Family	Subcategory/Species
Mollusks	Cephalopoda	unidentified
	Cephalopoda – octopods	unidentified
	Gastropoda - Pteropods	*Diacra* sp.
Crustaceans	Decapoda - crabs	megalopa larvae
	Decapoda - crabs	unidentified adults
	Decapoda - shrimps	unidentified
	Isopoda	unidentified
	Stomatopoda	*Odontodactylus henseni*
	unidentified	unidentified
Urochordates	Salpidae	unidentified
	Thaliacea	unidentified
Fishes	Acanthuridae	*Naso hexacanthus*
	Acanthuridae	*Naso* sp.
	Antennaridae	*Antennarius pictus*
	Balistidae	unidentified
	Dactylopteridae	*Dactyloptena orientalis*
	Larvae	unidentified
	Monacanthidae	unidentified
	Mullidae	*Parupeneus* sp.
	Pegasidae	*Pegasus papilio*
	Sphyraenidae	unidentified
	Synodontidae	larvae
	Tetraodontiformes	unidentified
	unidentified	unidentified

Eggs and Larval Habitat

A. virescens eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 194 m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

There is very little information available concerning the distribution and habitat requirements of the juvenile stage of this species. Parrish (1989) caught 5 juveniles off Kaneohe Bay in 40m of water where there the substrate was coarse sediment covered by a bed of *Halimeda spp* algae. They also caught one juvenile over a sediment bottom off West Oahu at a depth greater than 61 m. Parrish et al. (1997) suggested that this type of habitat is not attractive to many species which could provide the advantage of reduced predation pressure and lessened interspecific competition.

Adult Habitat

In the Hawaiian Archipelago, Ralston & Polovina (1982) reported that most bottomfish species are caught along the steep drop-offs and slopes that surround the islands and banks. *A. virescens*, however, is different in that it is primarily caught on the tops, not the sides or slopes, of these banks. Furthermore *A. virescens* is the only bottomfish species that is regularly caught at or near the surface with a lure (Kramer 1986). Its adult habitat has been described as the open waters of deep lagoons, channels, or seaward reefs at depths of 0–180 m, where individuals or small aggregations are most often observed (Haight et al. 1993b; Lieske & Myers 1994). At several banks in the NWHI, *A. virescens* were tracked moving both along the slope as well as across the flat tops Meyer et al. (2007). In Guam, *A. virescens* are found along the outer reef slopes, in deep channels and in shallow lagoons at depths of 3-180 m (Amesbury and Myers 1982). Druzhinin (1970) reported *A. virescens* as deep as 150 fathoms (i.e., 274m). Talbot (1960) reported that *A. virescens* was more abundant in shallow water over coral reefs along the coast of East Africa. The deepest record found for Hawaiian waters was 227 m (UH data, 2010). Table 28 provides a habitat summary for this species.

Table 28: Habitat Description for *Aprons virescens* (gray snapper, uku)

	Egg	**Larvae**	**Juvenile**	**Adult**
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown <227m	Unknown <227m	40-61m	0-227m
Water Column Zone	Pelagic	Pelagic	Benthic	Benthopelagic
Water Quality	Unknown	Unknown	Unknown	20-24 °C
Substrate Type	N/A	N/A	Hard, flat, course sand bottom	Top of banks, mixed sediment and rocks
Prey	N/A	Unknown	Unknown	Fish (89%), larval fish (6%), Planktonic crustaceans (1%), shrimp (3%) and crab (1%), (Haight 1989).

Bottomfish Complex: Shallow (0-240m depth range)

Species EFH descriptions:

Egg: pelagic zone, 0-240 m depth range from shoreline out 50 mi

Post Hatch Pelagic: pelagic zone, 0-240 m depth range from shoreline to EEZ

Post Settlement and Sub Adult: benthic or benthopelagic zone, 0-240 m depth range

Adult: benthopelagic zone, 0-240 m depth range

1.4.3.3 *Etelis carbunculus* (ruby snapper, ehu)

Life History

Etelis carbunculus is in the subfamily Etelinae and is known in Hawaii as ehu. It is widely distributed throughout the Indo-Pacific region from East Africa to the Hawaiian Islands and from southern Japan to Australia (Allen 1985; Everson 1984). Like most bottomfish species, *E. carbunculus* is important in western Pacific fisheries but its life history is not well known (Ralston 1979). *E. carbunculus* is an important commercial species throughout its range and is taken primarily with deep-sea hand lines. This species ranks 7th in Hawaii in terms of average percent of the annual bottomfish catch since 1948 (WPRFMC, 2005).

In American Samoa, *E. carbunculus* is one of the most valuable species landed and comprised almost 9% of the total reported bottomfish landings in 1996 (WPRFMC 1997). However, a genetic analysis of this species found evidence for two genotypes in those islands, which indicates the presence of either two subspecies or completely separate species (Moriwake et al., 2000). These appear to have separate phenotypes as well, one growing to a much larger size than the other. This same study found only the smaller genotype present in Hawaii.

Polovina & Ralston (1986) reported that this species reaches sexual maturity in 2.75 yrs while Everson (1986a) reported it reached sexual maturity at approximately 30 cm FL in the NWHI. DeMartini & Lau (1999) more precisely identified the L50, or length at which 50% of the fish are mature, to be 27.9 cm FL for this species in the NWHI. More recent surveys in the MHI found one sexually mature female as small as 20.3 cm SL; however, with that exception aside, mature gonads were not observed in fish below 24 cm SL (UH data, 2010). Both Everson (1984) and DeMartini & Lau (1999) found that this species has a relatively short, well-defined spawning season of July to September in the NWHI. Closer to the equator at Vanuatu, spawning reportedly occurs throughout most of the year (Allen 1985). Both Everson (1984) and DeMartini & Lau (1999) orted that *E. carbunculus* are serial spawners, with females producing multiple batches of eggs during the spawning season. Everson (1984) reported that the sex ratio was skewed 2:1 in favor of females over males in the NWHI.

There have been very few taxonomic studies of the eggs and larval stages of lutjanids and as a result, very few larvae can be identified to species (Leis, 1987). Leis & Lee (1994) subsequently reported being able to distinguish differences between *E. carbunculus* and *E. coruscans* larvae larger than 13.7 mm. In 1999-2000, two *E. carbunculus* females were captured alive, one of which had completed final maturation at capture while the other was hormonally induced to undergo final maturation in a hatchery tank (Kelley et al., 2000, Kelley, 2004). The first female naturally completed ovulation and was “strip spawned” with several captured mature males to produce 129,000 eggs, 73% of which were fertilized. The eggs hatched 27 hrs after fertilization and the larvae survived for 10 days on no food since their larval diet was completely unknown. These were the first ever eggs and early larvae observed for this species. Figure 7 provides images of the larval development through day 4. Images of 5-10 day old larvae were not included here since they appeared emaciated and therefore did not adequately represent natural development. Newly hatched larvae (D0) were characterized by an ellipsoidal yolk sac containing an oil droplet located at the anterior end.

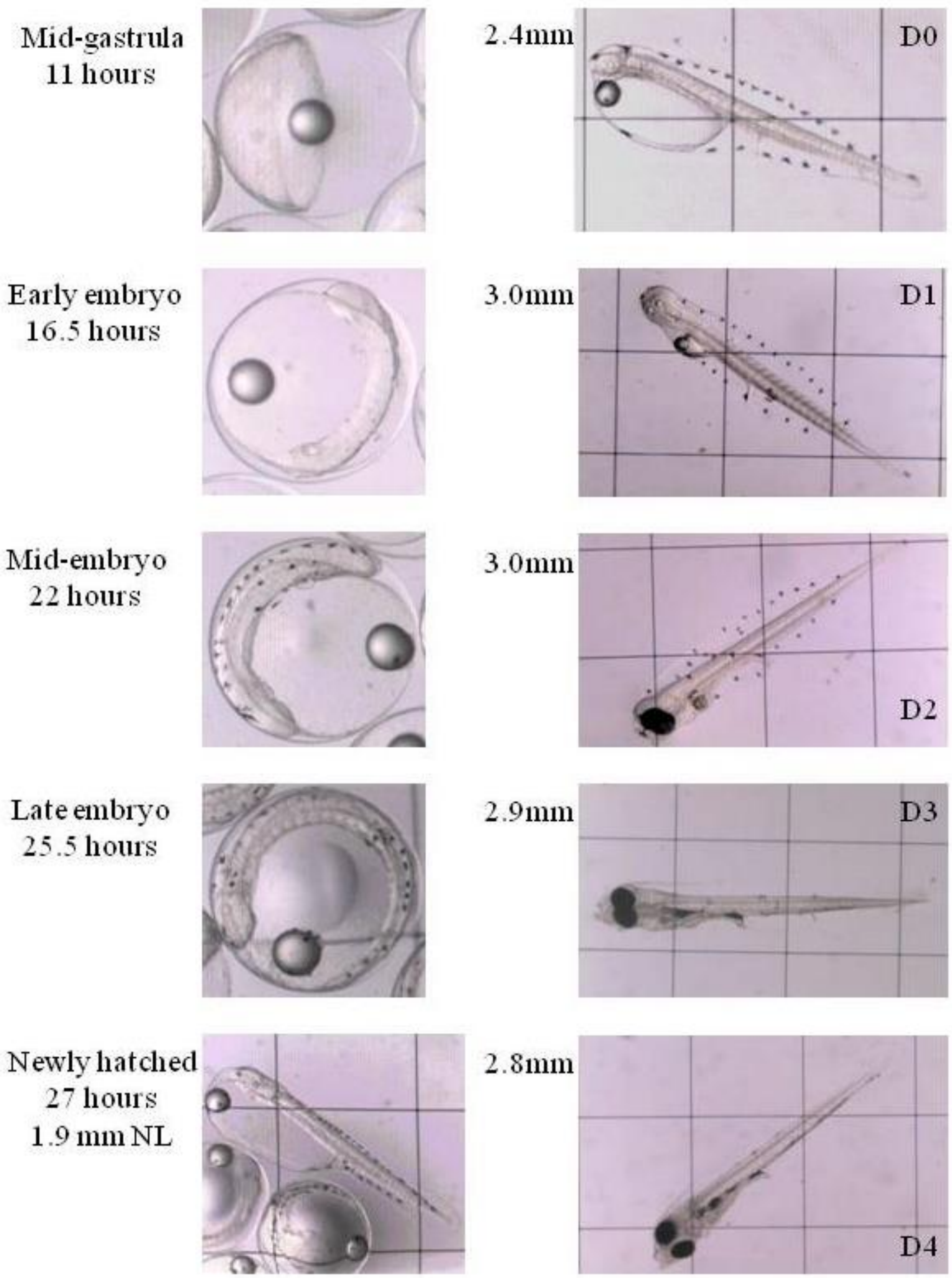

Figure 7: *Etelis carbunculus* egg and larval development at 25-27 °C. Spawned eggs were spherical and contained a single oil droplet. Gastrulation was well underway by 11 hours after fertilization (HAF) with

embryogenesis beginning 3 hours later. Hatching took place approximately 27 HAF. Yolk absorption was completed by day 2 post-hatch (PH). By days 3 and 4, the eyes were pigmented, pectoral fins were present, the mouth had opened and the larvae appeared to be able to ingest food if appropriate prey had been available (Kelley et al, unpub data).

The lenses in the eyes were present as were melanophores extending along the outer edges of the dorsal and ventral finfolds. By day 1 (D1) post-hatch, the yolk sac was greatly reduced, and by Day 2 (D2), was for the most part completely consumed. Melanophores were still present along the finfold edges and pigment was now visible in the eyes. Day 3 (D3) larvae had fully pigmented eyes, the mouth had opened and the finfold melanophores were almost completely absent. Day 4 (D4) larvae were similar in appearance to D3 larvae, perhaps due to the lack of feeding.

The second female was strip spawned, five days after capture and hormone injection, producing over 400,000 eggs, 80% of which were fertilized. The eggs from these two trials were used to conduct an incubation temperature experiment, the results from which suggest *E. carbunculus* eggs must reach shallow water in order to complete embryogenesis and hatching (Kelley et al., 2000, Kelley et al., unpub data). In both trials, eggs incubated in ambient surface temperatures (24 to 28ºC) hatched, whereas eggs incubated at colder temperatures similar to what's found on adult habitats (15.0-19ºC) arrested at the late multi-cell stage. Perhaps eggs spawned at adult depths, being buoyant, can reach the relatively warm mixed layer above 80 m before the late multi-cell stage.

Additional data obtained from studies on captive fish support the conclusion of Everson (1984) and DeMartini & Lau (1999) that this species spawns serially. One captive *E. carbunculus* female naturally spawned three times within a three week period, producing approximately 775,000 eggs (Kelley, 2004). In this and other cases, spawning took place at night.

E. carbunculus reportedly reach a maximum length of 90 cm (Randall, 2007). The Hawaii state record is 11.5 lbs or 5.2 kg (http://www.hawaiifishingnews.com/records.cfm). Parrish (1987) stated that, like most species of deepwater snappers, very little is known about the food habits of this species. In the Mariana Islands important prey items have been reported to include fish, benthic crustaceans and pelagic urochordates (Pyrosomida, Salpidae, and Dolioda). In Hawaii, Haight (1989) found that *E. carbunculus* mostly fed between 6:00pm and 8:00pm, with fish comprising almost 98% of the prey items followed by copepods, shrimp, crabs and octopuses. More recent submersible and fishing surveys (UH data, 2010) did not find any preference in feeding time for this species. *E. carbunculus* is a benthic species and the presence of pelagic prey in their stomach contents could be indicative of nocturnal feeding. Pelagic invertebrates and fishes such as pyrosomes and myctophids regularly come in close proximity to the substrate at night. Haight et al. (1993a) suggested that the composition of the diet may be influenced by opportunistic feeding on temporarily abundant prey items. For example, the monacanthid, *Pervagor* sp., which accounted for 28.5% of the volume of gut contents, was one of the most abundant species seen in submersible observations of Penguin Bank during the time of the diet study. Table 29 provides a list of known prey for *E. carbunculus* showing the presence of both benthic and pelagic species in their diet.

Table 29: Combined *Etelis carbunculus* prey records: 33 stomachs (Haight et al., 1993b), 42 stomachs (Parrish et al., 2000), and regurgitated prey (Kelley, unpub data[1]).

Group	Category/Family	Subcategory/Species
Mollusks	Bivalvia	unidentified
	Cephalopoda	unidentified
	Cephalopoda – octopods	unidentified
	Cephalopoda – squids	*Abralia trionura*
	Cephalopoda – squids	*Chiroteuthis* sp.
	Cephalopoda – squids	*Nototodarus hawaiiensis*
	Cephalopoda – squids	unidentified
	Gastropoda	unidentified
	Gastropoda - Heteropods	unidentified
	unidentified	unidentified
Annelids	Polychaeta	unidentified
Crustaceans	Benthic	unidentified
	Copepoda	Cyclopoida
	Copepoda	unidentified
	Decapoda - crabs	Anomura
	Decapoda - crabs	Brachyura
	Decapoda - crabs	*Munida plexaura*[1]
	Decapoda –crabs	unidentified
	Decapoda –crabs	xanthid crab
	Decapoda - shrimps	*Heterocarpus ensifer*
	Decapoda - shrimps	*Plesionika* sp?[1]
	Decapoda - shrimps	unidentified
	Ostracoda	unidentified
	Planktonic	unidentified
	unidentified	unidentified
Urochordates	Salpida	unidentified

	Thaliacea	unidentified
Fishes	Callanthiidae	*Grammatonotus laysanus*
	Engraulidae?	*Encrasicholina punctifer*?[1]
	Epigonidae	*Epigonus occidentalis*
	Nettastomatidae	unidentified
	Serranidae	*Pseudanthias fucinus*
	Monacanthidae	*Pervagor* sp.
	Monacanthidae	unidentified
	Myctophidae	*Benthosema fibulatum*
	Ogcocephalida	*Malthopsis* sp.[1]
	Sternoptychidae	*Argyripnus brocki*
	Symphysanodontidae	*Symphysanodon maunaloae*
	unidentified	unidentified

Egg and Larval Habitat

E. carbunculus eggs and larvae are pelagic, the latter to at least 51 mm SL (Leis & Lee, 1994), however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 515m. Based on the incubation experiments described above, the eggs of this species need to reach a minimum of 120-180 m depth prior to hatching (note: depth range based on submersible temperature and depth data from bottomfish habitats in the MHI and NWHI).

The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

There is very little information available concerning the preferred juvenile habitat for this species. Parrish (1989) reported that the habitat requirements of the juveniles of several species of deepwater snappers are markedly different than those of adults. However, juvenile *E. carbunculus* have been observed from a submersible at the same depth and rocky habitat preferred by adults (Kelley et al., 1997). Immature ehu, less than 22 cm SL and presumed to be juveniles, were caught during fishing surveys in depths between 183-313 m while juveniles with 6 in (15 cm) FL were observed during submersible dives off North Oahu (Figure 8) and East Oahu at depths of 274-290 m and 300 m, respectively (UH data, 2010). Juvenile behavior is very similar to adults in that both stages have been observed as solitary individuals or in very small groups that associate very closely with the bottom. Cavities that provide shelter appear to be particularly important to this species in comparison to other species of bottomfish (Kelley et al., 2006).

Figure 8: *E. carbunculus* juvenile 6 in FL observed during dive P5-323 off north Oahu at a depth of 284 m.

<u>Adult Habitat</u>

E. carbunculus are found on the deepwater slopes of Pacific Islands in habitats having hard substrate of high structural complexity. Individuals are found solitarily or in small groups at depths of 90 to 350 m (Allen 1985, Everson 1984, Ralston & Polovina 1982). Haight (1989) found the catch rate for *E. carbunculus* was highest between 200-250 m on Penguin Bank in the MHI. *E. carbunculus* were recorded during 90 BotCam drop camera deployments in the MHI at depths of 192 to 325 m and in temperatures ranging from 10.70 ^{o}C to 19.11 ^{o}C and averaging 14.58 ^{o}C (Drazen, unpub data). This species has been recorded as deep as 515 m from the Pisces submersible (UH data, 2010). *E. carbunculus* is a benthic species in Hawaii, always being observed in very close association with natural hard bottom features such as ledges and holes as well as man made features such as shipwrecks and discarded large metal objects (Figure 9). This is one of the smallest species of bottomfish and even as adults, appears to be vulnerable to predation from other species of fish. Successful predatory attacks on this species by kahala (*S. dumerili*) have been recorded during submersible dives (Kelley unpub data). *E. carbunculus* has also been found in the stomach contents of *E. quernus* (Seki, 1984a). Unlike most other species of bottomfish, the adults of *E. carbunculus* require shelter and therefore are rarely observed venturing up into the water column. Table 30 provides a habitat summary for this species.

Figure 9: Adult *E. carbunculus* off east Oahu at 300m depth. This photo was taken during dive P5-433 (R. Moffitt, PI).

Table 30: Habitat Description for *Etelis carbunculus* (ruby snapper, ehu)

	Egg	Larvae	Juvenile	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown <515m	Unknown <515m	183-313m	89-515m
Water Column Zone	Pelagic	Pelagic	Benthic	Benthic
Water Quality	>20 °C?	>20 °C?	10-15 °C	10.2-19.1 °C
Substrate Type	N/A	N/A	Hard substrate that has cavities for shelter and may include carbonate, basalt, or manmade objects. Slope and relief are of secondary importance.	Hard substrate that has cavities for shelter and may include carbonate, basalt, or manmade objects. Slope and relief are of secondary importance.
Prey	N/A	Unknown	Unknown	Include fish, benthic crustaceans and pelagic urochordates

Bottomfish Complex: Deep (0-400 m depth range)

Species EFH Descriptions:

Egg: pelagic zone, 0-400 m depth range from shoreline out 50 mi

Post Hatch Pelagic: pelagic zone, 0-400 m depth range from shoreline to EEZ

Post Settlement and Sub Adult: benthic zone, 80-400 m depth range

Adult: benthic zone, 80-400 m depth range

1.4.3.4 *Etelis coruscans* (flame snapper, onaga)

Life History

Etelis coruscans is in the subfamily Etelinae and has numerous common names around the world. In Hawaii it's known as the long-tailed red snapper (English) or by its more often used local name onaga. This species is widely distributed throughout the Indian and Pacific oceans from Hawaii to the east to Samoa, the Mariana Islands, the Cook Islands, Tuvalu and Vanuatu (Ralston, 1979). *E. coruscans* is the most highly prized of the bottomfish species and is one of only 3 species, including *A. virescens* and *P. zonatus*, caught in 2004 in significantly higher numbers than their annual average since 1948 (WPRFMC, 2005). It commands the highest price per pound of any bottomfish species landed in Hawaii (WPRFMC, 1997 and is presently the most important species in terms of the number of pounds caught and percentage of the total catch (WPRFMC, 2005). *E. coruscans* also accounted for 11% of the total reported BMUS landings in American Samoa and commanded the second highest price per lb of any species landed in the territory (WPRFMC, 1997. In the Northern Mariana Islands, *E. coruscans* was the single most abundant bottomfish species landed in 1996, accounting for almost 29% of the total catch, and commanded the highest price per pound of any bottomfish species. In Guam, this species comprised only about 3% of the total reported bottomfish landings yet is still considered a highly prized species. In the MHI, landings of *E. coruscans* are seasonal, increasing in or around the month of December when prices are highest, and decreasing during the early summer months.

Ralston (1979) reported the maximum size *E. coruscans* attains is 80 lb (36 kg) while Amesbury and Myers (1982) reported this species can reach 81 cm FL and weights of up to 20 kg. Most of those landed in Hawaii weigh less than 15 lbs (6.8 kg), with the mean in the NWHI being 4.28 and 5.45 kg for males and females, respectively (Everson, 1986b). The state record for this species is 28 lbs or 12.7 kg (http://www.hawaiifishingnews.com/records.cfm).

While little is known about the reproduction of *E. coruscans*, Everson (1986b) speculated that it is probably similar to its congener *E. carbunculus*. Polovina & Ralston (1986) estimated sexual maturity was reached at two years of age however, it has since been determined to take a minimum of 5-6 years when they reach 66.3 cm (Everson et al., 1989). In the NWHI, ripe ovaries were collected from *E. coruscans* in August and September however the study only took place during the summer months (Everson 1986b). Hydrating females have been caught August-October around the full moon (Holzman, pers comm) while vitellogenic females have been caught as early as April (UH data, 2010). In general, *E. coruscans* does appear to be a summer spawner similar to *E. carbunculus*.

As with other bottomfish species, there are almost no ecological or taxonomic studies of the eggs and larvae of *E. coruscans*. Recently a commercial bottomfisher (Greg Holzman) obtained the first and only fertilized eggs of this species ever collected. In 2001, Mr. Holzman was trained in "strip spawning techniques and in September of that year, caught a ripe, adult *E. coruscans* female and two males that he was able to successfully strip and fertilize on his boat. This took place at 5 pm and the following day he sent 59,000 eggs to the Hawaii Institute of Marine Biology (HIMB) where they hatched at approximately 4:40 pm. Mr. Holzman again succeeded in strip-spawning *E. coruscans* in October, 2003, this time sending hatched larvae to HIMB. As a result of his efforts, detailed in Hawaii Fishing News, the first 46 days of *E. coruscans* larval development were documented and are summarized in Figures 10a-c (Kelley et al, unpub data). *E. coruscans* eggs and larvae were clearly shown to be pelagic. Furthermore, it was established that the larvae can be differentiated from *P. filamentosus* larvae as early as day 15 post-hatch.

Similar to *E. carbunculus* and *P. filamentosus*, embryonic development in *E. coruscans* occurs rapidly with hatching taking place approximately 24 hrs after fertilization (Figure 10a) at ambient surface temperatures. The large, ellipsoidal yolk sac of newly-hatched day 0 (D0) larvae containing an anterior oil droplet extended slightly beyond the head. The lenses in the eyes were present as were melanophores extending along the outer edges of the dorsal and ventral finfolds. By day 1 (D1) post-hatch, the yolk sac was greatly reduced. Developing pectoral fins and pigment in the eyes were visible and by day 3 (D3), the larvae had fully pigmented eyes, open mouths, and actively fed on copepods. Melanophores were fewer and were now located along the base of the finfolds, having for the most part disappeared from the edges.

Figure 10a: Early development of *E. coruscans* from un-hatched late embryo (left) to three days (D3) post hatching (Kelley et al, unpub data).

Dorsal and pelvic fin spines were present in D15 larvae (Figure 10b). Melanophores were concentrated along the entire length of these spines in contrast to *P. filamentosus*, where they appeared only at the distal ends. This observation is consistent with Leis & Lee (1994) who reported for the genus *Etelis* the presence of "many dash-like closely-spaced melanophores in chevron groove of Dsp2 and P_2sp" which were not present in *Pristipomoides* or *Aphareus*, and only present in Dsp2 of *Aprion*. This difference in fin spine pigmentation appears to be the first easily observed character useful in differentiating the larvae of this species. Day 20 larvae showed continued dorsal fin development with spines both longer and in greater numbers. Melanophores were absent on the dorsal side of the tail in both D15 and D20 larvae, which is consistent with Leis & Lee (1994).

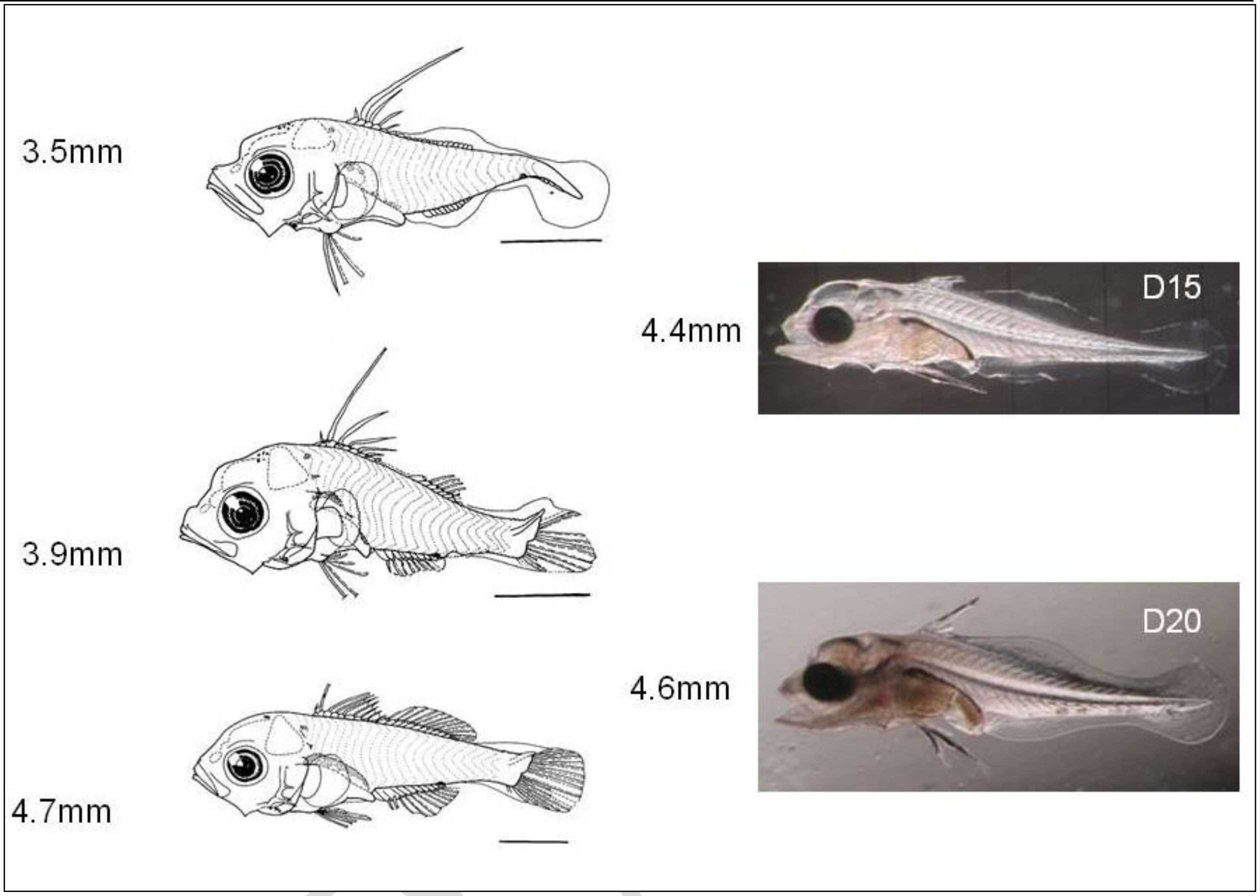

Figure 10b: Drawings of trawled wild *E. coruscans* larvae (left) ranging between 3.5-4.7 mm NL (notochord length) reproduced with permission from Leis & Lee (1994) adjacent to photographs of day 15 and day 20 hatchery reared *E. coruscans* larvae of roughly the same size (right, Kelley et al, unpub data).

Fins were relatively well developed and transparent scales were present by day 38 (Figure 10c). The melanophore series in P_2sp and Dsp2 were still present however, the latter but not the former had spread out to other dorsal fin spines as was reported to occur in individuals larger than 8.7 mm NL by Leis & Lee (1994). Not noted in the previous study was the presence of red chromatophores, particularly along the base of the dorsal and anal fins extending down to the caudal peduncle. Red chromatophores were also present in a cluster over the urostyle as well as along the dorsal edge of the caudal fin where at the tip, a small number of melanophores were observed. This same pigmentation pattern was present in the day 46 larvae that had reached 14.0 mm SL.

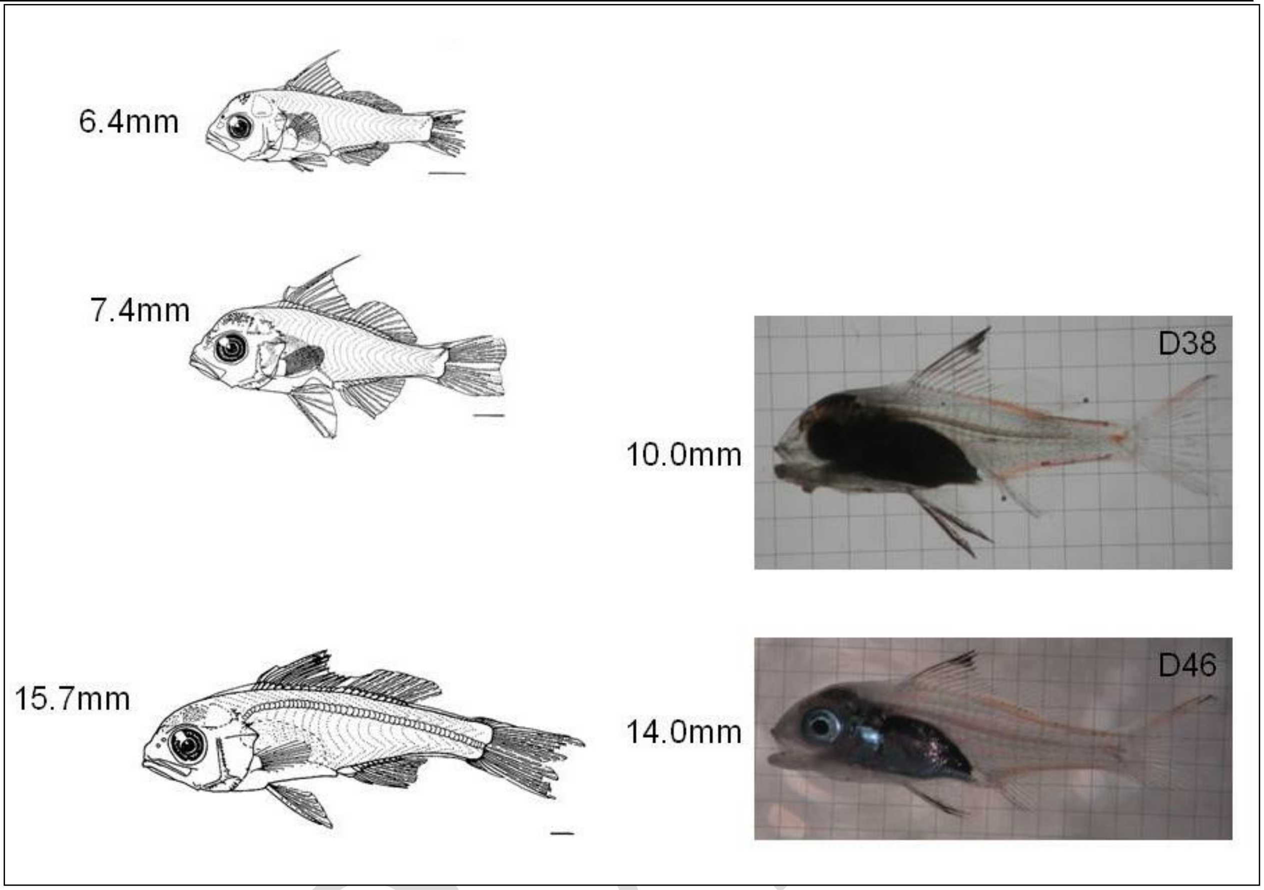

Figure 10c: Drawings of trawled wild *E. coruscans* larvae (left) ranging between 6.4-15.7 mm NL (notochord length) reproduced with permission from Leis & Lee (1994) adjacent to photographs of cultured *E. coruscans* larvae measuring 10.4 and 14.0 mm SL (Kelley et al, unpub data).

Haight (1989) found that peak feeding times for adult *E. coruscans* occurred during daylight hours, with the highest catch rates between 0600-0800 hours. Their diet included fish (76.4%), shrimp (16.4%), planktonic crustaceans (3.4%), cephalopods (2%), urochordates (1.5%) and crabs (.2%). Haight et al. (1993b) noted that some prey fish species have diel migration patterns, which depending on the time of feeding could be consumed near the bottom or in the water column. More recently, opportunistic collection of regurgitated prey yielded mostly pelagic prey species that included fish, shrimp, squids, the pelagic phase of an octopus and salps (Kelley et al., unpub data). Additionally, Kubodera et al (2009) reported a new species of bobtail squid, *Heteroteuthis ryukyuensis n. sp*. regurgitated by *E. coruscans* off Japan. A summary of all known *E. coruscans* prey from Hawaiian waters is provided in Table 31.

Table 31: Combined records of Etelis coruscans: 24 stomachs (Haight et al., 1993b), 9 stomachs (Parrish et al., 2000) and regurgitated prey (Kelley, unpub data[1]).

Group	Category/Family	Subcategory/Species
Mollusks	Bivalvia	unidentified
	Cephalopoda – octopods	*Octopus* sp. [1]
	Cephalopoda – squids	*Abralia trigonura*[1]
	Cephalopoda – squids	*Abraliopsis* sp. [1]
	Cephalopoda – squids	*Enoploteuthis* sp.[1]
	Cephalopoda – squids	*Nototodarus hawaiiensis*
	Cephalopoda – squids	unidentified
	Cephalopoda	unidentified
	Gastropoda - Pteropods	*Diacra* sp.
	unidentified	unidentified
Crustaceans	Amphipoda	unidentified
	Benthic	unidentified
	Copepoda	Cyclopoida
	Decapoda - crabs	Brachyura
	Decapoda - crabs	Hippoidea
	Decapoda - crabs	Megalops larvae
	Decapoda - lobsters	slipper lobster parts[1]
	Decapoda - shrimps	*Heterocarpus ensifer*
	Decapoda - shrimps	*Oplophorus* sp.[1]
	Decapoda - shrimps	unidentified
	Euphausiacea	unidentified
	Ostracoda	Myodocopa
	Ostracoda	unidentified
	Stomatopoda	*Pseudosquilla oculata*[1]
	Planktonic	unidentified
	unidentified	unidentified
Urochordates	Larvacea	unidentified
	Pyrosomatidae	*Pyrosoma* sp.
	Salpida	unidentified
Fishes	Acanthuridae	*Naso sp.* ? pelagic phase[1]
	Bramidae	*Pterycombus petersii*[1]
	Epigonidae	*Epigonus* sp.
	Idiacanthidae	*Idiacanthus fasciola*[1]
	Myctophidae	*Diaphus* sp.
	Myctophidae	*Benthosema fibulatum*[1]
	Myctophidae	*Lampadena urophaos*[1]
	Myctophidae	*Lampanyctus* sp. [1]
	Pomacanthidae	unidentified pelagic phase[1]
	Priacanthidae	unidentified[1]
	Stomiidae	*Astronesthes spendidus*[1]

	Trichiuridae	*Aphanopus* sp. [1]
	Trichiuridae	*Benthodesmus* sp. [1]
	unidentified	unidentified
Other	Algae	unidentified

Eggs and Larval Habitat

E. coruscans eggs and larvae are pelagic, the latter to at least 51 mm SL (Leis & Lee 1994). However, their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 457 m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

Juvenile *E. coruscans* have been recorded during submersible dives at 222 m south of Lanai and 282-300 m off Oahu (Kelley et al, 1997; Ikehara, 2006; Figures 11a,b). In both cases, the substrate was hard carbonate. The juveniles were stationary and close to the bottom or hiding in cavities, and their locations were close to or part of known adult habitats. Additional observations of juveniles have been made on manmade wreckage at 350 m off the south coast of Oahu (Kelley, unpub data). Based on these observations, it appears that juvenile habitat for *E. coruscans* is natural or manmade hard substrate that provides shelter. Unlike *P. filamentosus*, juvenile habitat appears to be located at the same depth as adult habitat. In contrast to adults, juveniles are found in very close association with the bottom near cavities, presumably due to their greater vulnerability to predation.

Adult Habitat

Similar to its congener, *E. carbunculus*, *E. coruscans* is typically found at the deeper portion of the bottomfish depth range in association with areas of abrupt relief, such as steep drop-offs, ledges, outcrops and pinnacles (Everson 1986b, Moffitt 1993). A cluster analysis of bank catch composition in the Mariana archipelago determined that the banks can be grouped into three catch profiles: southern, northern and seamount clusters. The seamount cluster was characterized throughout the resource assessment by its higher proportion of *Etelis* species (*Etelis coruscans* and *E. carbunculus*), almost twice the amount of the other clusters (Polovina, 1985). In Hawaii, adults have been recorded on seamounts, pinnacles, canyons and promontories (UH data, 2010). In almost all cases, the fish have been swimming in schools from a few to tens of meters off the bottom. Unlike the benthic juveniles, adults are benthopelagic, which is consistent with the high proportion of pelagic prey in their diets.

Analyzing the overall CPUE distribution in Hawaii by depth intervals for all species landed, Haight (1989) found that *E. coruscans* are caught at the highest rate between depths of 250 and 300 m. The average hooking depth is slightly shallower than the 229 m found for the NWHI, and 218 m in the Northern Mariana Islands (Polovina et al., 1985). *E. coruscans* has been recorded on sixty-six BotCam deployments in Hawaii at depths of 208 to 308 m and in temperatures ranging from 11.65 ^{o}C to 18.98 ^{o}C (Drazen, unpublished data). This species has been recorded down to a depth of 457 m on Pisces submersible dives (UH data, 2010). Table 32 provides a habitat summary for this species.

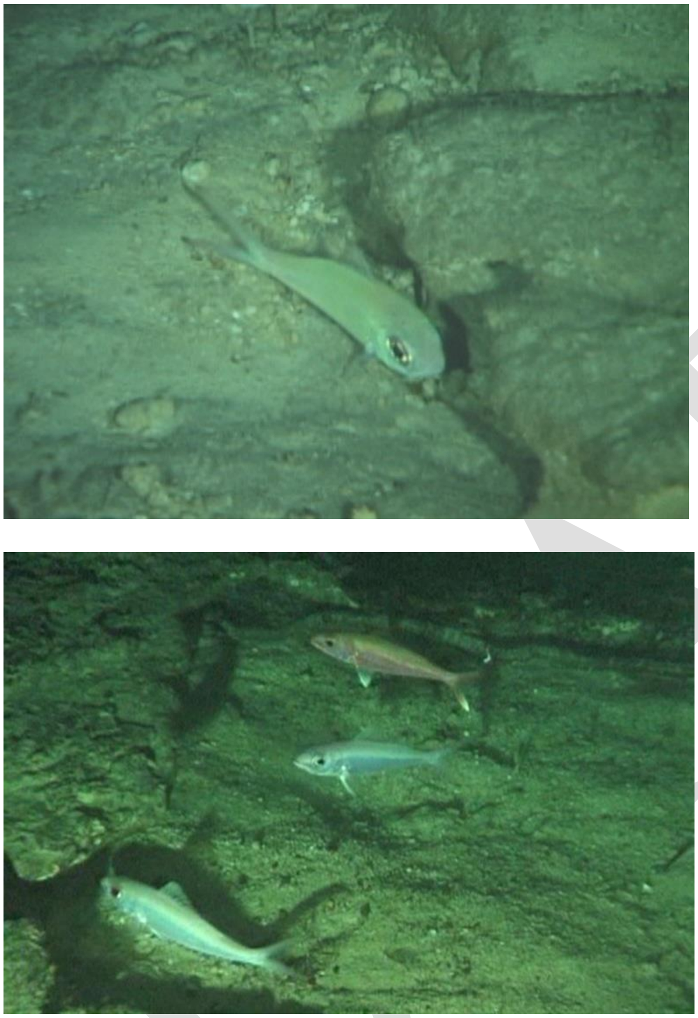

Figure 11: a) *E. coruscans* juvenile 6 in FL observed on dive P5-323 off north Oahu at 282 m (Kelley et al, 1997). b) *E. coruscans* juveniles 6-8 in FL (bottom and middle fishes) observed during a Pisces submersible dive 373 at 300 m depth off east Oahu (Ikehara, 2006). The fish on top is a small *E. carbunculus*.

Table 32: Habitat Description for *Etelis coruscans* (flame snapper, onaga)

	Egg	Larvae	Juvenile	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	unknown <410m	unknown <410m	known between 222-350m	90-457m
Water Column Zone	Pelagic	Pelagic	Benthic	Benthopelagic
Water Quality	Unknown	Unknown	Unknown	11.65-18.98 °C
Substrate Type	N/A	N/A	Hard natural or manmade substrate with cavities	Areas of high relief, (e.g., steep slopes, pinnacles, headlands, rocky outcrops)
Prey	N/A	Unknown	Unknown	Fish (76.4%), shrimp (16.4%), planktonic crustaceans (3.4%), cephalopods (2%), urochordates (1.5%), crabs (0.2%) (Haight 1989).

Bottomfish Complex: Deep (0-400 m depth range)

Species EFH descriptions:

Egg: pelagic zone, 0-400 m depth range from shoreline out 50 mi

Post Hatch Pelagic: pelagic zone, 0-400 m depth range from shoreline to EEZ

Post Settlement and Sub Adult: benthic zone, 80-400 m depth range

Adult: benthic zone, 80-400 m depth range

1.4.3.5 *Lutjanus kasmira* (blue-lined snapper, taape)

Life History

Lutjanus kasmira is in the subfamily Lutjaninae and is the only non-eteline lutjanid in the bottomfish fishery. The native range of this species covers nearly the entire tropical and subtropical Indo-Pacific region; it is found from East Africa to the Line and Marquesas Islands and from Australia to Japan (Allen 1985, Druzhinin 1970). It also occurs in waters around Hawaii where it was introduced between 1955 and 1961 by the Hawaii Department of Land and Natural Resources (Oda & Parrish 1981). There are concerns among fishermen that *L. kasmira* may compete with commercially important native fish such as bottomfish, but available data from multiple studies do not support this claim (Oda & Parrish 1981; Parrish et al. 2000; DeFelice & Parrish 2003; Schumacher 2011). *L. kasmira* is one of the shallow members of the bottomfish fishery and most are landed in state waters (Ralston 1979) by hand lines, gill nets and traps (Allen 1985).

Very little is known about this species' life history in Hawaii, and currently most information comes from general reports (e.g. Allen 1985) or those from other locations (e.g. Rangjaran 1979). As with other lutjanids, *L. kasmira* is dioecious (Allen 1985). It generally reaches sexual maturity at 20-25 cm (Rangjaran 1979; Allen 1985). In an aquarium study in Japan, Suzuki & Hioka (1979) reported group spawning taking place in the evening and at night. Mizenko (1984) found in Samoa that spawning events occur with a lunar periodicity coinciding with the full and new moon over an extended spawning period during autumn and winter months. Rangjaran (1979) reported a peak spawning period from November to March in the Andaman Sea. Suzuki & Hioka (1979) describe fertilized eggs as being spherical and 0.78-0.85 mm in diameter. They also note that that these eggs contain a single oil droplet and are buoyant. Hatching occurs approximately 18 hours after fertilization at 22 to 25°C under controlled conditions. Newly hatched *L. kasmira* larvae measure 1.83 mm in total length, possess a large ellipsoid yolk sac and are otherwise typical of the pelagic larvae of other fish species. The Hawaii state record for this species is just under 2 lbs or 0.9 kg (http://www.hawaiifishingnews.com/records.cfm), making it the smallest of all the species in this fishery. This species can attain a length of 32 cm (Randall 2007).

While some pelagic prey are found in their diets, *L. kasmira* would best be described as an opportunistic benthic carnivore. Studies in shallow water indicate this species is a nocturnal predator that preys primarily on small benthic fish and crustaceans such as portunid crabs, megalops and alpheid shrimp (Oda & Parrish 1981, Parrish 1987; DeFelice & Parrish 2003; Schumacher 2011). Similarly, a study of deepwater native eteline snappers and *L. kasmira* in the MHI found that benthic invertebrates were the predominant prey of *L. kasmira* (Parrish et al. 2000). In general existing data do not indicate that there are dramatic difference in the diets of young and adult fish of this species in Hawaii or elsewhere (Rangaran 1972; Oda & Parrish 1981; Schumacher 2011), though more focused study would be needed to fully understand ontogenetic patterns in diets. Table 33 provides a summary of prey items identified in at least one fish by Parrish et al. (2000). Note that some fish identifications were listed as tentative by the authors.

Table 33: Food items in 180 stomachs of *Lutjanus kasmira* (Parrish et al., 2000).

Group	Category/Family	Subcategory/Species
Cnidarians/Ctenophores	unidentified	unidentified
Mollusks	Bivalvia	unidentified
	Cephalopoda	unidentified
	Cephalopoda – octopods	*Haliphron atlanticus*
	Cephalopoda – squids	*Abralia trigonura*
	Cephalopoda – squids	*Heteroteuthis hawaiiensis*
	Gastropoda	unidentified
	Gastropoda - Heteropods	unidentified
	Gastropoda - Pteropods	*Cavolinia* sp.
	Gastropoda - Pteropods	*Clio* sp.
	Gastropoda - Pteropods	*Creseis* sp.
	Gastropoda - Pteropods	*Diacra* sp.
	unidentified	unidentified
Annelids	Polychaeta	unidentified
Crustaceans	Amphipoda	Caprellidea
	Benthic	unidentified
	Copepoda	Calanoida
	Copepoda	Cyclopoida
	Copepoda	unidentified
	Decapoda - crabs	Anomura
	Decapoda - crabs	Brachyura
	Decapoda - crabs	Galitheidae
	Decapoda - crabs	Megalops larvae
	Decapoda - crabs	Portunidae
	Decapoda - shrimps	unidentified
	Euphausiacea	unidentified
	Ostracoda	Myodocopa
	Ostracoda	unidentified
	Planktonic	unidentified
	Stomatopoda	unidentified
	unidentified	unidentified
Urochordates	Larvacea	unidentified
	Salpida	unidentified
Fishes	Apogonidae	*Apogon kallopterus*
	Apogonidae	*Apogon maculiferus*
	Callanthiidae	*Grammatonotus laysanus*
	Carangidae	*Gnathanodon speciosus*
	Elopidae	*Elops hawaiiensis*
	Emmelichthyidae	*Emmelichthys struhsakeri*

Group	Category/Family	Subcategory/Species
	Gempylidae	Species 2
	Lutjanidae	*Aphareus furca*
	Lutjanidae	*Aphareus rutilans*
	Lutjanidae	*Lutjanus kasmira*
	Lutjanidae	*Pristipomoides filamentosus*
	Moridae	*Physiculus jordani*
	Mullidae	*Parupeneus cyclostomus*
	Myctophidae	Species 2
Group	**Category/Family**	**Subcategory/Species**
Fishes cont.	Myctophidae	Species 3
	Serranidae	*Luzonichthys* sp.
	Serranidae	*Plectranthisa helenae*
	Serranidae	*Pseudanthias fucinus*
	Soleidae	*Aseraggodes* sp.
	unidentified	unidentified
Other	Algae	unidentified

<u>Egg and Larval Habitat</u>
Leis (1987) estimated the pelagic larval phase of lutjanids in general to be 25-47 days, with species in the genus *Lutjanus* being shorter than that of the etelines. The depth and geographic ranges of their eggs and larvae are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 265 m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

<u>Juvenile Habitat</u>
Juveniles of this species are known to utilize shallow water habitats such as seaward reefs and small patch reefs as nursery habitat (Myers 1991; Amesbury & Myers 1982; Frederick 1997). Friedlander et al. (2002) found most of the juveniles on their surveys “hiding in the interstitial spaces in small rubble piles on the talus slope below the reef slope”.

<u>Adult Habitat</u>
L. kasmira is found in a variety of habitat types and depths. *L. kasmira* is found from shallow inshore waters and lagoons to outer reef slopes down to a maximum depth of 265 m (Amesbury & Myers 1982; Myers 1991; Parrish et al. 2000; Friedlander et al 2002). Mizenko (1984) found in Samoa that except during spawning events *L. kasmira* was segregated by sex, with males dominating the deeper part of its range. It is not known whether this pattern occurs in Hawaii, though there are some indications that larger fish are found in deeper water (Morales-Nin & Ralston 1990). During the day, *L. kasmira* commonly forms large

aggregations near high relief bottom features such as prominent coral heads, ledges, caves, wrecks and patch reefs, and disperses at dusk to forage on benthic organisms—primarily crustaceans and fish—over surrounding sand or rubble (Myers 1991; Friedlander et al. 2002; DeFelice & Parrish 2003; Schumacher 2011). Schumacher (2011) found that in shallow waters (< 70 m) some fish move up to several hundred meters during these nocturnal feeding migrations, though Friedlander et al. (2002) found that larger fish may forage closer to daytime habitat. The extent of daily feeding migrations is not known for *L. kasmira* in deeper waters. This species has been recorded in the shallower extent of *P. filamentosus* depth range (UH data 2010; Parrish et al. 2000), but does not appear to co-occur frequently with other species of deepwater lutjanids in Hawaii. *L. kasmira* has been recorded during recent drop-camera deployments, submersible dives, and fishing surveys to a maximum depth of 200 m (UH data 2010). This species has been reported to reach a depth of 265 m (Randall 2007), though it is found at these depths relatively rarely. It is most common in water less than 150 m deep (Parrish et al 2000). Table 34 provides a habitat summary for this species.

Table 34: Habitat Description for *Lutjanus kasmira* (blue-lined snapper, taape)

	Egg	**Larvae**	**Juvenile**	**Adult**
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown < 265m	Unknown < 265m	0-20m	3-265m
Water Column Zone	Pelagic	Pelagic	Benthic	Benthopelagic
Water Quality	Unknown	Unknown	Unknown	20.8-24.1 °C
Substrate Type	N/A	N/A	Unknown	Mixed rock and sediment
Prey	N/A	Unknown	Unknown	Primarily fish and crustaceans

<ins>Bottomfish Complex</ins>: Shallow (0-240m depth range)

<ins>Species EFH Descriptions</ins>:

Egg: pelagic zone, 0-240 m depth range from shoreline out 50 mi

Post Hatch Pelagic: pelagic zone, 0-240 m depth range from shoreline to EEZ

Post Settlement and Sub Adult: benthic zone, 0-240 m depth range

Adult: benthic zone, 0-240 m depth range

1.4.3.6 *Pristipomoides auricilla* (yellowtail snapper, yellowtail kalekale)

Life History

Pristipomoides auricilla is in the subfamily Etelinae and is called yellowtail kalekale in Hawaii. This species is found in both the Indian and Pacific oceans, from Mauritius and Maldive Islands to the Hawaiian Islands and from New Caledonia to Japan (Randall, 2007). This species accounts for approximately 20% of commercial bottomfish catches in Guam, and was the second most common fish caught on a survey in the Mariana Islands (Randall, 2007). However, it comprises the smallest fraction of the bottomfish catch in Hawaii. On average, only 22 lbs have been reported per year since 1996, the first year it showed up in the catch (WPRFMC, 2005). In 2004, the annual reported catch was 54 lbs. *P. auricilla* attains a length of about 45 cm (Randall, 2007) with the Hawaii state record for this species being 2.9 lbs or 1.3 kg (http://www.hawaiifishingnews.com/records.cfm). *P. auricilla* has been reported to reach sexual maturity in 2.4 yrs (Polovina & Ralston, 1986). However, its spawning season in Hawaii is presently unknown.

Seki & Callahan (1988) found *P. auricilla* in the Mariana Archipelago feed primarily on large pelagic plankton. Table 35 provides a summary of the prey species found in their study.

Table 35: Food items in 72 stomachs of *Pristipomoides auricilla* in the Mariana Archipelago (Seki & Callahan, 1988).

Group	Category/Family	Subcategory/Species
Mollusks	Cephalopoda	unidentified
	Cephalopoda – squids	Teuthoidea
	Gastropoda	unidentified
	Gastropoda - Heteropods	Atlantidae
	Gastropoda - Pteropods	Cavolinidae
Annelids	Polychaeta	unidentified
Crustaceans	Decapoda - crabs	Brachyura
	Decapoda - lobsters	Palinura
	Decapoda - shrimps	Caridea
	Euphausiidae	unidentified
	Stomatopoda	unidentified
	unidentified	unidentified
Urochordates	Pyrosomatidae	*Pyrosoma* sp.
Fishes	Gempylidae	unidentified
	Myctophiformes	unidentified
	unidentified	unidentified

Egg and Larval Habitat

P. auricilla eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 360 m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

Nothing is known about the juvenile habitat for this species in Hawaii.

Adult Habitat

P. auricilla adult habitat has been described as rocky bottom between the depths of 90-360 m (Allen, 1985). This species has also been observed on rocky substrate in Hawaii between 124 and 352 m (UH data, 2010). Table 36 provides a habitat summary for this species. Only 63 records were found in a recent analysis of submersible, drop camera and fishing survey data (UH data, 2010). From these few observations, this species appears to be benthopelagic forming small to medium sized schools that swim relatively close to the bottom. This is a similar life style as that of the more common *P. sieboldii*.

Table 36: Habitat description for *Pristipomoides auricilla* (yellowtail snapper, yellowtail kalekale)

	Egg	**Larvae**	**Juvenile**	**Adult**
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown, ≤360m	Unknown, ≤360m	Unknown, ≤360m	90-360m
Water Column Zone	Pelagic	Pelagic	Unknown but probably benthic	Benthopelagic
Water Quality	Unknown	Unknown	Unknown	18.5-22.3 °C
Substrate Type	N/A	N/A	Unknown	Rocky bottoms
Prey	N/A	Unknown	Unknown	Fish, crab, shrimp, polychaetes, pelagic urochordates and cephalopods

<u>Bottomfish Complex</u>: Deep (80-400 m depth range)

<u>Species EFH Descriptions</u>:

Egg: pelagic zone, 0-400 m depth range from shoreline out 50 mi

Post Hatch Pelagic: pelagic zone, 0-400 m depth range from shoreline to EEZ

Post Settlement and Sub Adult: benthic zone, 80-400 m depth range

Adult: benthic zone, 80-400 m depth range

1.4.3.7 *Pristipomoides filamentosus* (pink snapper, opakapaka)

Life History

Pristipomoides filamentosus is in the subfamily Etelinae and is known in Hawaii as the opakapaka. This species is widely distributed from the Red Sea and East Africa to the Hawaiian Islands (Randall, 2007) and is common throughout the Indo-west Pacific region (Mees 1993, Druzhinin 1970). In Hawaii, *P. filamentosus* is the top ranked bottomfish species in terms of the average number of pounds caught per years since 1948 (WPRFMC, 2005). It has accounted for an average of 26.6% of the annual bottomfish catch, which is almost twice (i.e., 13.9%) that of the second ranked *A. virescens*. *P. filamentosus* comprises a smaller proportion of the catches (i.e., 1-10%) in American Samoa, Guam and the Northern Mariana Islands but is still considered one of the more important bottomfish species in these areas (WPRFMC, 1997.

P. filamentosus is a long-lived species capable of reaching an age of at least 40 years (A. Andrews, PIFSC, unpublished data). Previous research on the age and growth of opakapaka estimated a maximum age of 18 years (Ralston and Miyamoto, 1983). However, recent ageing research based on bomb radiocarbon and lead radium decay dating of archival otolith samples indicate that this species has a life span on the order of 40 years. (A. Andrews, PIFSC, unpublished data, in Brodziak et al., in prep). This suggests that the adult natural mortality rate of opakapaka, the most abundant and key Deep 7 bottomfish species, is on the order of M=0.1 (Brodziak et al. in prep). Growth rates for wild *P. filamentosus* have been estimated to range from 0.03 to 0.05 cm FL/day using the von Bertalanffy growth function (Ralston & Miyamoto, 1983, DeMartini et. al, 1994, Ralston & Williams, 1988b, and Hardman-Mountford et. al, 1997). Captive juveniles maintained in floating net pens in Hawaii have grown an average of 0.06 to 0.07 cm FL/day (Kelley et al, in prep). The latter however, should be considered a potential growth rate for this species since neither the temperature nor the feed were natural. This species can attain at least 80 cm in length (Randall, 2007) and the Hawaii state record is currently 18.5 lbs or 8.4 kg (http://www.hawaiifishingnews.com/records.cfm).

Females of this species reach sexual maturity at a length of 42.7 cm (Kikkawa, 1984) which, based on the growth curve from DeMartini et al. (1994) is reached at just over 5 years of age (Figure 12). In captivity, *P. filamentosus* juveniles attained sexual maturity after two years when their age was estimated to be just over 3 years (Kelley et al., in prep). The results should be interpreted cautiously and with the understanding that the captive conditions did not mimic their natural environment. These fish were caught off Kaneohe Bay, Oahu, in 1999 and 2001 and held in floating net pens at the Hawaii Institute of Marine Biology (HIMB) under ambient surface seawater conditions. The “higher than natural” temperature and light conditions did not appear to negatively impact their reproductive cycles. Once the fish reached sexual maturity, they began spawning in the pens (Kelley et al., in prep). From 2001 though 2005, 568 natural spawns were documented from which approximately sixty million fertilized eggs were collected. In the first year, spawning occurred over a period of 5 months from June to October which is 2 months shorter than the 7 month, June to December spawning season reported from the wild (Kikkawa 1984). However, by 2005 the captive spawning season had expanded to 11 months (February to December) perhaps as a result of increased age or continued adaptation to warmer temperatures. Spawning took place during all lunar phases and up to 25 times in a single month. Individual *P. filamentosus* females spawned up to 31 times in a single year, releasing more than 3 million fertilized eggs (Moriwake et al 2004), which is an underestimate since an unknown number were loss out the sides of the pens.

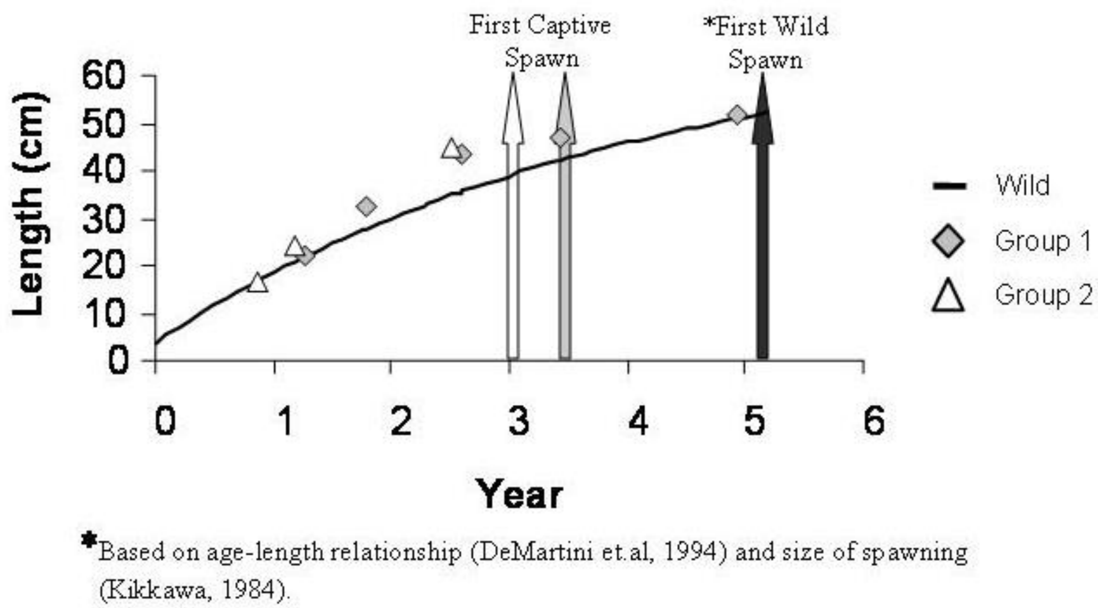

Figure 12: Growth of *P. filamentosus* juveniles under captive conditions (Kelley et al., in prep) in comparison their published age-length curve from DeMartini et al. (1994). Also shown is their estimated age at first spawning in comparison to the predicted age of first spawning in the wild from Kikkawa (1984).

Captive *P. filamentosus* always spawned at night and the eggs were collected between 0730 and noon in mid-gastrula to mid-embryo stage. Spawning took place exactly between 9-10 pm on the one occasion the collector was monitored throughout the evening. Night time spawning has been reported in other lutjanids (Suzuki & Hioki, 1979, Hamamoto et al., 1992, Grimes, 1987). However, the only purported observation of wild *P. filamentosus* spawning was in the mid-morning (Haight et al., 1993a). This was an anecdotal observation from a commercial fisherman in the NWHI and included a description of egg masses adhering to his fishing gear. Fertilized eggs of this and many other pelagic spawning species do not form masses and therefore this observation is suspect.

Little was known about embryonic development in *P. filamentosus* until captive spawning began in 2001. In the bottomfish hatchery at HIMB, the egg stage was documented from fertilization through hatching, which occurred 27 hours later in incubation temperatures between 24 and 26 °C (Figure 13a). Newly spawned eggs were spherical, ranged in size from 0.77 to 0.85 mm in diameter and typically contained a single, small (0.13 mm) oil droplet. Cell division began about an hour after fertilization and progressed to the 128 cell stage by 3 hours after fertilization (HAF). Blastulation was considered complete at the germ ring stage at 8 HAF. Gastrulation was well underway by 10.5 HAF and the embryo clearly began to form by 15.5 HAF. The mid-embryo stage was reached by 19 HAF when the embryo had optic vesicles and 15-17 somites. At this point, melanophores began to appear along the embryo’s dorsal surface. Close to hatching (26 HAF) muscular contractions (i.e., embryonic twitching) began, their hearts had started beating and their tails detached from the yolk. One hour later the larvae hatched.

Newly hatched larvae measured 2.0 to 2.1 mm from the end of the head to the end of the notochord, which is referred to as the notochord length (NL). The large ellipsoidal yolk sac contained an oil droplet at the anterior end and extended slightly beyond the head (Figure 13a). The lenses in the eyes were present and rows of melanophores were visible along the dorsal and ventral finfolds, as well as a few scattered along the body and the yolk sac. One day later, the larvae had elongated to between 2.8 and 3.2 mm NL and had consumed the majority of the yolk. By two days post-hatch (D2), the mouth had opened, the eyes had pigmented, pectoral fins were present and very little remained of the yolk sac. At this point, the larvae began actively searching for food and those that had not fed by D5 did not survive. Similar to *E. coruscans* and *E. carbunculus*, the melanophores in D2-3 *P. filamentosus* larvae were fewer and were now located along the base of the finfolds, particularly on the ventral side.

Leis & Lee (1994) provided the best information available on post yolk sac larval stages of this and other eteline snappers, detailing the characteristics of variously sized trawled larvae that they had identified to species. Drawings of their *P. filamentosus* larvae are reproduced here in Figures 13b and 13c. To the right of these, are photos of similarly sized cultured larvae from rearing trials at the HIMB hatchery (Kelley et al. in prep). In cultured larvae, the swim bladder began to develop at D4 and the pelvic fins appeared at D10-14. The dorsal fin began forming shortly thereafter as the pelvic fins were elongating. Teeth and pre-opercular spines also appeared at this point.

Cultured *P. filamentosus* larvae developed at different rates within the same tanks, between tanks within the same trial and between trials. This variation was due to factors which are still largely unknown but undoubtedly included differences in temperature and feeding behavior (Kelley et al. in prep). Figure 13b shows two D15 larvae from two separate trials as an example. Larvae of this age ranged from 4.8 to 5.7 mm NL and some had completed flexion while others had not. Twenty day-old larvae, however, were generally all post-flexion and had clearly formed dorsal, anal and caudal fins. The ratio of pelvic fin length to body length reached its maximum between D15-20. At this point, the tip of the fins, when folded back, extended back to the ventral melanophore cluster before drawing back anteriorly after the larvae reached 30 days of age.

As mentioned earlier, the pigmentation patterns of *P. filamentosus* larvae were clearly different than those for *E. coruscans*, which was first apparent at D15. Melanophores were restricted to the tips of the dorsal and pectoral fin spines in *P. filamentosus* as opposed to extending along the extent of the spines in *E. coruscans*. A melanophore cluster also appeared at the base of the anal fin or at the bases of both the anal and dorsal fins in D15 larvae, which were not present in *E. coruscans* larvae. These pigmentation patterns were also shown in the 4.9bmm larvae provided by Leis & Lee (1994). A red chromatophore cluster was present over the urostyle in D15 larvae, as well as a modest row extending along the base of the anal fin and onto the caudal peduncle.

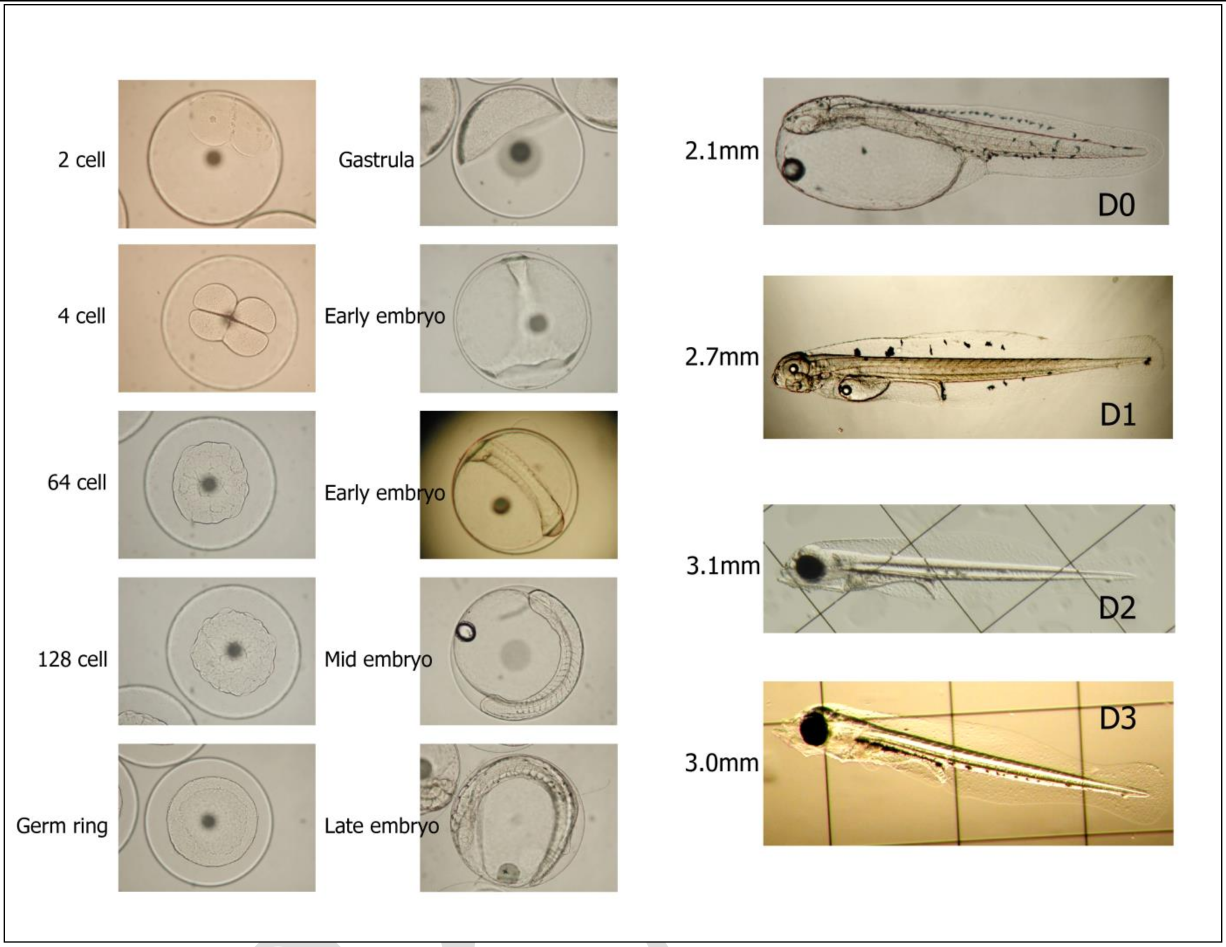

Figure 13a: Development of *P. filamentosus* eggs and larvae from 2 cell stage until three days after hatching.

By D27 (6.6mm NL), red chromatophores had also appeared at the base of the dorsal fin rays and were quite apparent over the urostyle (Figure 13c). Transparent scales had formed and the caudal fin had begun to fork by D30. By D33 the silvery lining of the abdominal cavity was obscuring the internal organs and a small number of red chromatophores had appeared on the front of the head. Melanophores persisted on the tips of the dorsal and pelvic fins spines through D39 but had disappeared from the caudal peduncle and the base of the anal and dorsal fins in the D39 larva shown in Figure 13c. The fork in the caudal fin became more pronounced and is mentioned here primarily because the caudal fins had been damaged in the specimens collected by Leis & Lee (1994). Also by D39, the pelvic fins appear noticeably shorter in relation to body length.

Figure 13d shows photos of cultured D52-120 larvae (right) next to a graph showing the growth rates of *P. filamentosus* larvae during hatchery rearing trials (left). At D52, the melanophores persisted at the tips of the dorsal and pelvic fins but had disappeared along the anal fin and over the urostyle. Red chromatophores persisted over the urostyle and along the dorsal and anal fin posterior bases and the scales were still transparent. Moriwake (pers comm) that observed larvae around this age appeared to "settle" (i.e., began swimming much closer to the bottom) in the rearing tanks. In general, larvae of this size had not yet acquired scale pigmentation. Scale pigmentation generally appeared by D80, but this was variable and transparent larvae over 90 days old were sometimes observed (Figure 13d). By D120 metamorphosis was complete.

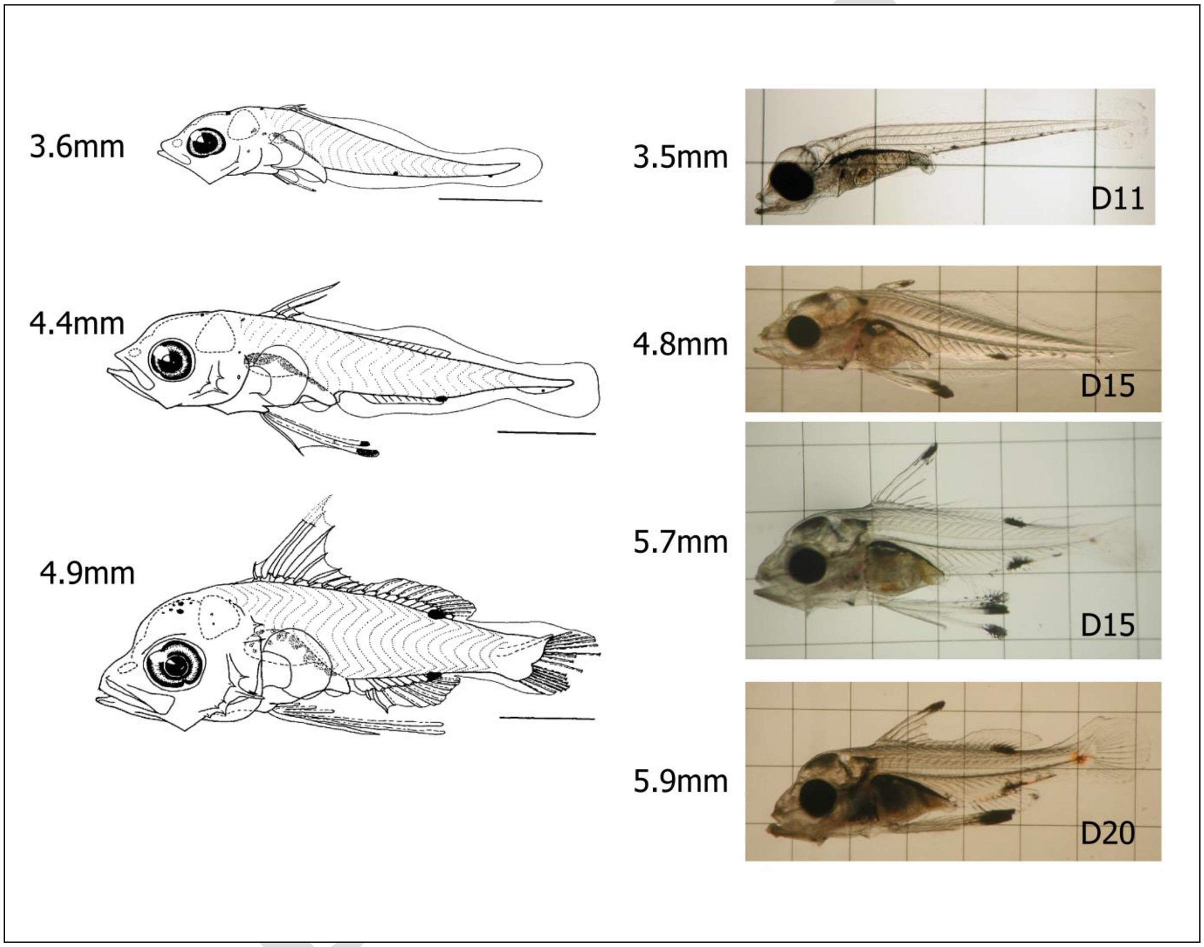

Figure 13b: Drawings of wild-caught larvae between 3.6-4.9mm NL reproduced with permission from Leis & Lee (1994) adjacent to photographs of cultured 11-20 day old *P. filamentosus* larvae from Kelley et al. (in prep).

The data on growth rates (Figure 13d on left) in captivity shows relatively low variability in lengths from D0 through D40. From D40 to D120, the variability increases significantly to the point where D120 larvae ranged in length from 40-110mm SL. This degree of variability is most likely a reflection of our current ability to rear this species rather than the degree of variability that is occurring in the wild.

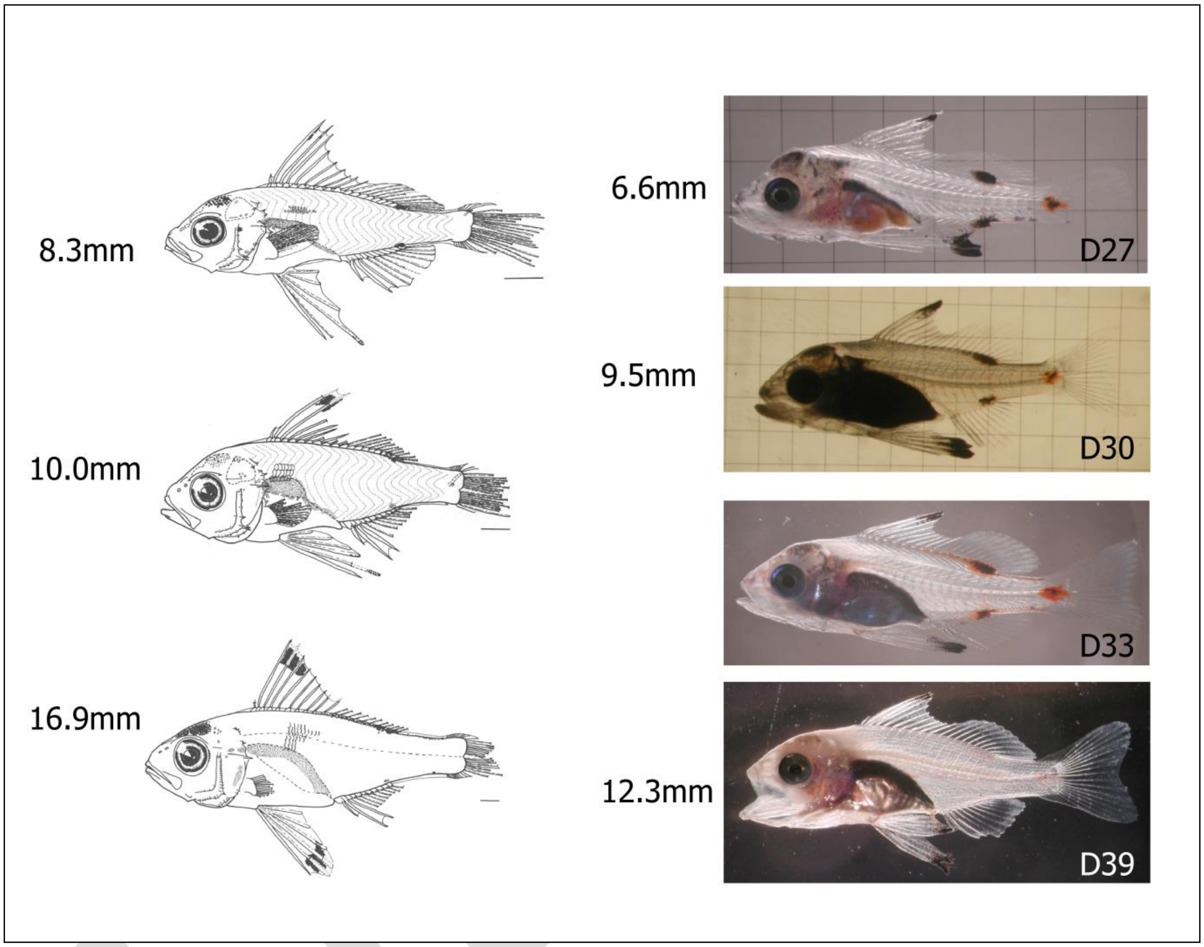

Figure 13c: Drawings of 8.3-16.9mm SL wild-caught *P. filamentosus* larvae reproduced with permission from Leis & Lee (1994) adjacent to cultured 27-39 day old *P. filamentosus* larvae measuring 6.6-12.3mm SL from Kelley et al. (in prep).

The natural diet of juvenile *P. filamentosus* off Kaneohe Bay, Oahu, comprises small crustaceans (crabs, shrimps and stomatopods), other juvenile fish, mollusks (octopods, squids, and micro gastropods) gelatinous plankton (salps and heteropods) and echinoids (Parrish, 1989, DeMartini et al., 1996). The diet of juveniles from a shallower location off the south shore of Oahu was pelagic crustaceans and salps (B. Schumacher, unpub data). Haight et al. (1993b) and Parrish (1987) included pelagic tunicates, fish, shrimp, cephalopods, gastropods, planktonic urochordates and crabs as prey items for this species in general.

It is of interest to note that in Malaysia, *P. filamentosus* are primarily piscivorous, feeding on ponyfish, *Leiognathus* spp. and purple-spot big-eye, *Priacanthus tayenus*, in addition to rabbitfish, *Siganus spp*., squids and crabs (Bachok et al, 2004).

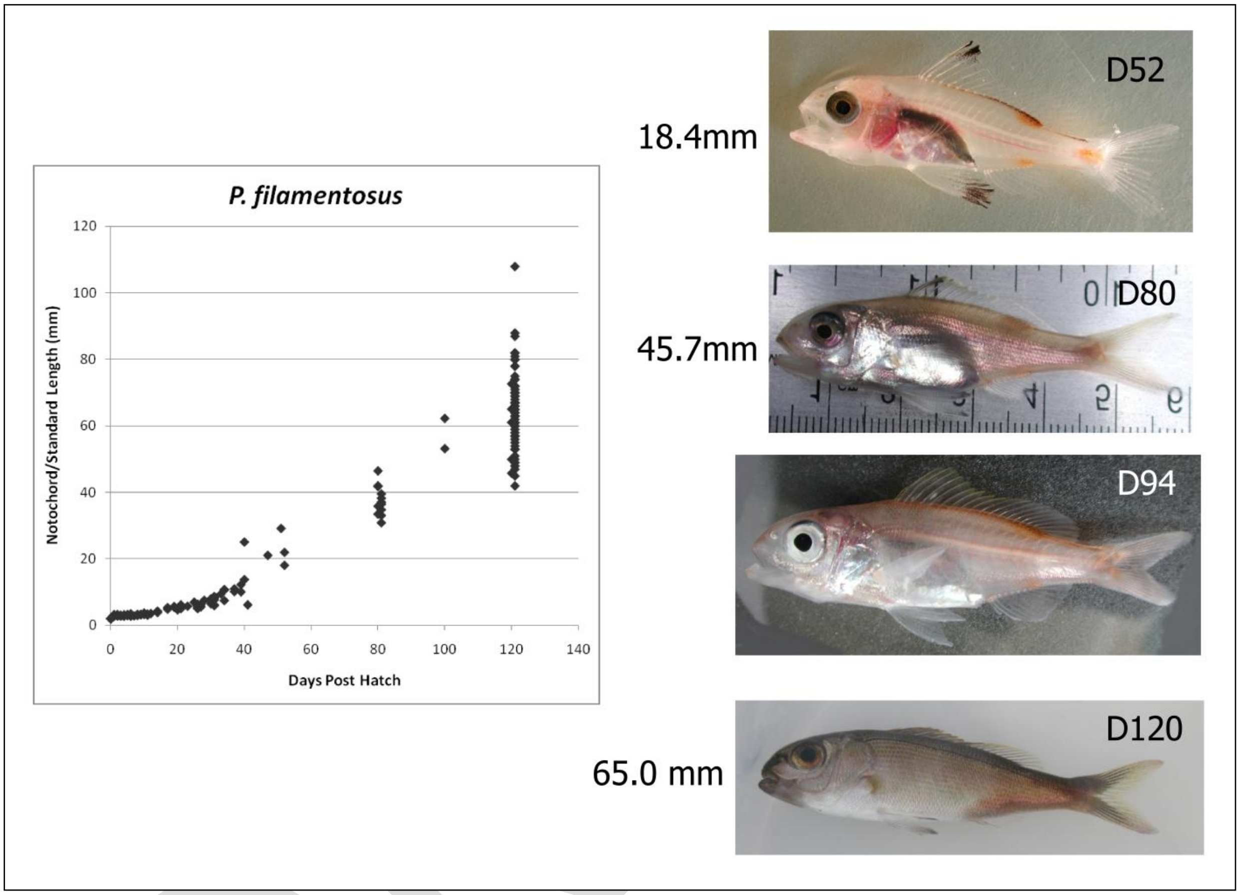

Figure 13d: Cultured 52-120 day old *P. filamentosus* larvae measuring 18.4-65mm SL (right) and left, a graph showing the growth rate of the larvae during hatchery rearing trials (Kelley et al., in prep.)

Parrish (1987) reported that this species forages over a wide area mostly at night while Haight (1989) characterized *P. filamentosus* as a crepuscular feeder, displaying two peak foraging periods, shortly before dawn and shortly after sunset. He also found this species to display a seasonal variation in its diet and later (Haight et al., 1993b) showed a diel variation in diet, feeding primarily on bioluminescent salps at night when they are easier to see. According to Parrish (1987), *P. filamentosus* feed primarily below 100 m and stay within several meters of the bottom, however its now known that this species comes up above 100 m at night (Ziemann & Kelley, 2004) where it appears to be foraging over sediment flats. Table 37 provides a summary of prey identified for this species.

Table 37: Combined records of *Pristipomoides filamentosus*: 54 stomachs (Haight et al., 1993b), 67 stomachs (Parrish et al., 2000), and regurgitated prey (Kelley, unpub data[1]).

Group	Category/Family	Subcategory/Species
Cnidarians	Siphonophora	Diphyidae
	unidentified	unidentified
Cnidarians/Ctenophores	unidentified	unidentified
Mollusks	Bivalvia	unidentified
	Cephalopoda	unidentified
	Cephalopoda – squids	*Abralia trigonura*
	Cephalopoda – squids	*Sepioteuthis lessoniana*
	Gastropoda	unidentified
	Gastropoda - Heteropods	unidentified
	Gastropoda - Pteropods	*Cavolinia* sp.
	Gastropoda - Pteropods	*Clio* sp.
	Gastropoda - Pteropods	*Creseis* sp.
	Gastropoda - Pteropods	*Cuvierina* sp.
	Gastropoda - Pteropods	*Diacra* sp.
	Gastropoda - Pteropods	unidentified
	Micromollusks	unidentified
	unidentified	unidentified
Annelids	Polychaeta	unidentified
Crustaceans	Amphipoda	Caprellidea
	Amphipoda	Gammaridea
	Amphipoda	Hyperiidea
	Amphipoda	unidentified
	Benthic	unidentified
	Copepoda	Calanoida
	Copepoda	Cyclopoida
	Copepoda	unidentified
	Decapoda - crabs	Anomura
	Decapoda - crabs	Brachyura
	Decapoda - crabs	Megalops larvae
	Decapoda - shrimps	Pandalidae
	Decapoda - shrimps	unidentified
	Decapoda - Zoea	unidentified
	Euphausiacea	unidentified
	Isopoda	unidentified
	Mysidacea	unidentified
	Ostracoda	Myodocopa
	Ostracoda	unidentified
	Planktonic	unidentified

Group	Category/Family	Subcategory/Species
	Stomatopoda	*Lysiosquilla* sp. larvae
	Stomatopoda	*Odontodactylus* sp. larvae
	Stomatopoda	*Squilla* sp. larvae
	Stomatopoda	unidentified
	Stomatopoda	unidentified larvae
	unidentified	unidentified
Urochordates	Larvacea	unidentified
	Pyrosomatidae	*Pyrosoma* sp.
Urochordates cont.	Salpida	unidentified
	Thaliacea	unidentified
Fishes	Acanthuridae	*Zebrasoma* sp. pelagic phase[1]
	Gempylidae	Species 1
	Gempylidae	Species 2
	larvae	unidentified
	Malacosteidae	unidentified
	Melamphaidae	unidentified
	Monocanthidae	unidentified
	Myctophidae	Species 1
	Ostaciidae	unidentified
	unidentified	unidentified

<u>Egg and Larval Habitat</u>

Efforts are currently underway to model egg and larval dispersion patterns for this species in the main Hawaiian Islands. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 400 m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

<u>Juvenile Habitat</u>

Juvenile *P. filamentosus* were first observed and documented in a featureless sediment flat (Figure 14) located offshore of Kaneohe Bay, Oahu at depths of 65-100 m (Parrish, 1989). This type of habitat is very different from the high relief rocky areas preferred by adults of the species. The Kaneohe site is now considered to be a nursery ground for this species based on repeated observations of juveniles over many years within its relatively narrow depth range and geographic extent. No juveniles were caught there in surveys below 100 m (Moffitt & Parrish, 1996). However, there have been unsubstantiated reports of catches by fishers at depths as shallow as 37 m (Kelley, pers comm). Parrish et al. (1997) found a significant correlation between the abundance of juvenile *P. filamentosus* and the presence of clay-silt sediment suggesting this type of substrate is an important nursery habitat feature for this species. In contrast, significantly fewer juveniles were found in areas surrounded by small escarpments and exposed carbonate. Parrish (1989) posited the hypothesis that the lack of relief and hard substrate in this nursery ground made this area unattractive to predators thereby allowing the juveniles to "hide in plain sight". The paucity of other species furthermore lessened inter-specific competition. The size range of juvenile *P. filamentosus* in the Kaneohe nursery ground was found to be approximately 7-20cm FL (Moffitt & Parrish 1996). DeMartini et al. (1994) conducted an age-length study and determined that 1 year old fish would be approximately 18 cm in FL. Parrish et al. (1997) concluded from these studies that juveniles remain in the nursery ground for less than a year before moving into deeper waters (e.g., 150-190m) where they presumably merge into schools of adult *P. filamentosus*.

Since 1989, other potential nursery grounds for *P. filamentosus* have been located in the MHI. From 1989 to 1994, Henry Okamoto of the state's Division of Aquatic Resources (DAR) captured, tagged and released approximately 4,000 subadult/juveniles at locations off Oahu and in Maui County (Current Line, 2001). These fish were captured from 3 sites off Oahu and 8 sites from Maui County, specifically off Maui, Molokai and Lanai. Potential nursery grounds, where many juveniles were caught over time include both South Oahu and West Molokai. This study also provided clear evidence that this species was traversing channels between the islands which had previously been unknown. Parrish et al. (1997) found another nursery ground in 1993 off the southwest coast of Molokai. However, juvenile abundance at this site was not correlated with substrate type but rather sources of coastal drainage. Off Kaneohe, an internal, semi-diurnal tide was identified that provides an influx of cold water during high tide (Moffitt & Parrish 1996). Nutrients provided either by terrigenous material associated with outgoing tides or material carried from deeper water during incoming tides could be an important element of *P. filamentosus* nursery grounds. Parrish et al. (1997) suggested that the distribution of juvenile snappers within the nursery grounds may be more closely related to water flow and its enhancement of food supplies in these areas than sediment particle size. Finally, unpublished fishing surveys conducted for DAR between 1998 and 2007 identified more potential nursery grounds off the east and north coasts of Oahu outside Kailua, Kahana Bay and Haleiwa (UH data, 2010).

Figure 14: *P. filamentosus* juveniles recorded by the BotCam on the Kaneohe nursery ground (Merritt, unpub data).

All of these sites are shallow and have soft substrates similar to the Kaneohe nursery ground, which has led researchers to believe that juvenile *P. filamentosus* habitat is well understood. However, that is not the case. Recent BotCam deployments recorded juveniles at several locations off Hilo, Hawaii over very hard, rugose volcanic substrate (Figure 15, Drazen et al., unpub. data). These fish were at the larger end of the “juvenile size range” and therefore may have recently migrated from a more typical juvenile habitat. However, the possibility that settlement is occurring on hard substrate at some locations cannot be discounted.

Areas of flat featureless bottom have typically been thought of as providing low value fishery habitat. The discovery of dense juvenile snapper aggregations in areas of very low relief provides substantial evidence to the contrary. This fact has important management implications for the conservation and protection of this critical and limited habitat type. More research is clearly needed to identify and map nursery habitat for this particularly important species of bottomfish.

Figure 15: *P. filamentosus* juveniles recorded by the BotCam remote drop camera system over volcanic pillow lava formations off Hilo, Hawaii (Drazen et al., unpub data).

Adult Habitat

Adult *P. filamentosus* are typically found on the steep slopes and deepwater banks of Pacific Islands, aggregating near areas of high bottom relief (Parrish, 1987). Areas of high relief form localized zones of turbulent vertical water movement that increase the availability of prey items (Haight et al. 1993b). Ralston et al. (1986) found higher densities of *P. filamentosus* on the up-current side versus the down-current side of Johnston Atoll. Large mixed schools of snappers (50-100), including *P. filamentosus*, have been observed aggregating 2-10 m above high relief structures on Penguin Bank (Haight, 1989). However, more recent submersible surveys suggest that behaviorally these are not actual mixed schools but rather overlapping mono-specific schools (Kelley, pers comm) feeding in a common area. The presence of bait is an adequate stimulus to causes this type of overlap.

Moffitt (1993) reported that *P. filamentosus* adults are not restricted to high relief, deep-slope habitat. During the day, individuals are found in areas of high relief at depths of 100-200 m, however at night, they migrate into shallower flat, shelf areas, where they are found at depths of 30-80 m. This diel migration pattern is further supported by recent tracking studies conducted off the island of Kahoolawe (Ziemann & Kelley, 2004). Adults were tracked via surgically implanted VR2 transmitters that broadcast a signal detected by moored receivers.

Off Kahoolawe, adults repeatedly moved up into shallow sediment flats at night and returned to the rocky shelf drop-off during the day.

Haight (1989) found the greatest catch per unit effort (CPUE) for *P. filamentosus* on Penguin Bank at depths of between 100 and 150 m, but did not specify whether fishing took place during the day or night. Juvenile and adult *P. filamentosus* have recently been recorded during fishing, drop camera and submersible surveys between depths of 40-350 (UH data, 2010). Temperature data recorded from 127 BotCam deployments between 40-275 m, where this species was recorded, ranged from 11.74 ^{o}C to 24.37 ^{o}C (Drazen et al., unpub data). Finally, adult *P. filamentosus* occurs in progressively shallower waters (103 m) in the more northern reaches of the NWHI (Humphreys 1986b). Table 38 provides a habitat summary for this species.

Table 38: Habitat Description for *Pristipomoides filamentosus* (pink snapper, opakapaka)

	Egg	Larvae	Juvenile	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown, ≤400m	Unknown, ≤400m	40-100m	55-400m
Water Column Zone	Pelagic	Pelagic	Benthopelagic	Benthopelagic
Water Quality	Unknown	Unknown	20.5 ^{o}C to 22.5 ^{o}C	11.7 ^{o}C to 24.4 ^{o}C
Substrate Type	N/A	N/A	Low relief, sediment, low slope	Generally high relief, rocky with steep slope
Prey	N/A	Unknown	Small crustaceans, juvenile fish, cephalopods gelatinous plankton, fish scale	Pelagic tunicates, fish, shrimp, cephalopods gastropods, planktonic urochordates, crabs

Bottomfish Complex: Intermediate (0-320 m depth range)

Species EFH Descriptions:

Egg: pelagic zone, 0-280 m depth range from shoreline out 50 mi

Post Hatch Pelagic: pelagic zone, 0-280 m depth range from shoreline to EEZ

Post Settlement and Sub Adult: benthic or benthopelagic zone, 40-100 m depth range

Adult: benthic or benthopelagic zone, 40-280 m depth range

:

1.4.3.8 *Pristipomoides sieboldii* (lavender snapper, kalekale)

Life History

The lavender snapper, *Pristipomoides sieboldii*, is a member of the subfamily Etelinae. This species ranged from East Africa to Hawaii and as far north as Japan (Randall, 2007). In Hawaii it is known as kalekale while in Guam and the Northern Mariana Islands it is called guihan boninas. *P. sieboldii* is common throughout the Hawaiian archipelago however, because of its relative small adult size it is not typically targeted by commercial fishers. This species is ranked 10th in terms of the average number of pounds landed per year in Hawaii since 1948 (WPRFMC, 2005). Based on the available landing data, *P. sieboldii* is also not a major contributor to the total catch in American Samoa, Guam and the Northern Mariana Islands. The maximum size of this species has been reported to be 60 cm or 24 in (Randall, 2007) although it doesn't often get larger than 40 cm (Allen 1985). The Hawaii state record for this species is 3.1 lbs or 1.4 kg (http://www.hawaiifishingnews.com/records.cfm).

DeMartini & Lau (1999) reported that *P. sieboldii* attained sexual maturity at a length of 29 cm FL, which based on estimated von Bertalanffy growth curves from Williams & Lowe (1997) is reached between 3-6 years of age depending on the method used. They found mature ovaries in females collected from June through September. Uchiyama & Tagami (1984) also reported that their spawning season ran from June through September, peaking in the last two months. Based on the presence of hydrated oocytes found in their ovaries, *P. sieboldii* eggs are pelagic and similar to the eggs of other eteline snappers. However, spawned eggs have not been documented to date. Leis & Lee (1994) provided descriptions of *P. sieboldii* larvae collected in Hawaii, noting that this species can possibly be distinguished from other eteline snappers by the presence of 69-72 lateral line scales and 17 pectoral rays. Its closest congener, *P. auricilla*, has a similar number of lateral line scales but generally only 15-16 pectoral fin rays. These two morphological characters are likely not present or distinguishable in larvae of either species younger than 20 days post hatch (PH).

Allen (1985) stated that *P. sieboldii* feeds primarily on fish, crab, shrimp, polychaetes, pelagic urochordates and cephalopods. Based on an examination of guts contents from 60 specimens, Haight et al. (1993b) described *P. sieboldii* as being primarily planktivorous. Table 39 provides a summary of known prey for this species.

Table 39: Combined prey records for *Pristipomoides sieboldii* from 60 stomachs (Haight et al., 1993b), and 32 stomachs (Parrish et al., 2000).

Group	Category/Family	Subcategory/Species
Cnidarians	Siphonophorae	Abylidae
	Siphonophorae	Diphyidae
Cnidarians/Ctenophores	unidentified	unidentified
Mollusks	Bivalvia	unidentified
	Cephalopoda	unidentified
	Cephalopoda - octopods	unidentified
	Cephalopoda – squids	*Onychoteuthis* sp.
	Cephalopoda – squids	*Pterygioteuthis giardi*
	Cephalopoda – squids	unidentified
	Gastropoda	*Cymatium/Bursa*
	Gastropoda	unidentified
	Gastropoda - Heteropods	unidentified
	Gastropoda - Pteropods	*Cavolinia* sp.
	Gastropoda - Pteropods	*Clio* sp.
	Gastropoda - Pteropods	*Creseis* sp.
	Gastropoda - Pteropods	*Cuvierina* sp.
	Gastropoda - Pteropods	*Diacra* sp.
	Gastropoda - Pteropods	unidentified
	Micromollusks	unidentified
	unidentified	unidentified
Annelids	Polychaeta	unidentified
Crustaceans	Amphipoda	Caprellidea
	Amphipoda	Gammaridea
	Amphipoda	Gammaroidea
	Amphipoda	Hyperiidea
	Amphipoda	unidentified
	Benthic	unidentified
	Copepoda	Calanoida
	Copepoda	Cyclopoida
	Copepoda	unidentified
	Decapoda - crabs	Anomura
	Decapoda - crabs	Brachyura
	Decapoda - crabs	Megalops larvae
	Decapoda - crabs	unidentified
	Decapoda - lobsters	Palinuridae larvae
	Decapoda - shrimps	Alpheidae larvae
	Decapoda - shrimps	unidentified
	Decapoda - Zoea	unidentified
	Euphausiacea	unidentified
	Isopoda	unidentified

	Mysidacea	unidentified
	Ostracoda	Myodocopa
	Ostracoda	unidentified
	Planktonic	unidentified
	Stomatopoda	*Lysiosquilla* sp. larvae
	Stomatopoda	*Squilla* sp. larvae
	Stomatopoda	unidentified
	Stomatopoda	unidentified larvae

Group	**Category/Family**	**Subcategory/Species**
Crustaceans cont.	unidentified	unidentified
Chaetognaths	unidentified	unidentified
Urochordates	Doliolidea	*Doliolum* sp.
	Larvacea	unidentified
	Pyrosomatidae	*Pyrosoma* sp.
	Salpida	unidentified
	Thaliacea	unidentified
Fishes	Bothidae	*Engyprosopon* sp.
	Eel	unidentified[1]
	Larvae	unidentified
	Malacanthidae	*Malacanthus brevirostris*
	Melamphaidae	unidentified
	Monocanthidae	unidentified
	Myctophidae	*Diaphus* sp.
	Myctophidae	*Hygophum* sp.
	Myctophidae	unidentified
	Unidentified	unidentified

<u>Egg and Larval Habitat</u>

P. sieboldii eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 360 m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

<u>Juvenile Habitat</u>

Juvenile *P. sieboldii* have been documented on two Pisces submersible dives, one in the MHI (Kelley et al., 1997) and the other in the NWHI (Kelley et al., unpub data). The first took place during dive P5-322 off the North shore of Oahu. A school of juveniles was encountered swimming very close to a bottom of low relief carbonate at a depth of 187 m (Figure 16). The second took place on dive P5-462 off Raita Bank. Juveniles along with subadults and adults were observed at 145 m over hard carbonate substrate. The former remained very close to the bottom and attempted to hide in holes as the submersible passed. A small number of juvenile

P. sieboldii have also been caught at 80 m on the *P. filamentosus* nursery ground off Kaneohe Bay, Oahu (UH data, 2010). Juvenile habitat for this species is therefore somewhat enigmatic, however, appears to be primarily on rocky substrate between 145-187m in the upper half of the adult depth range.

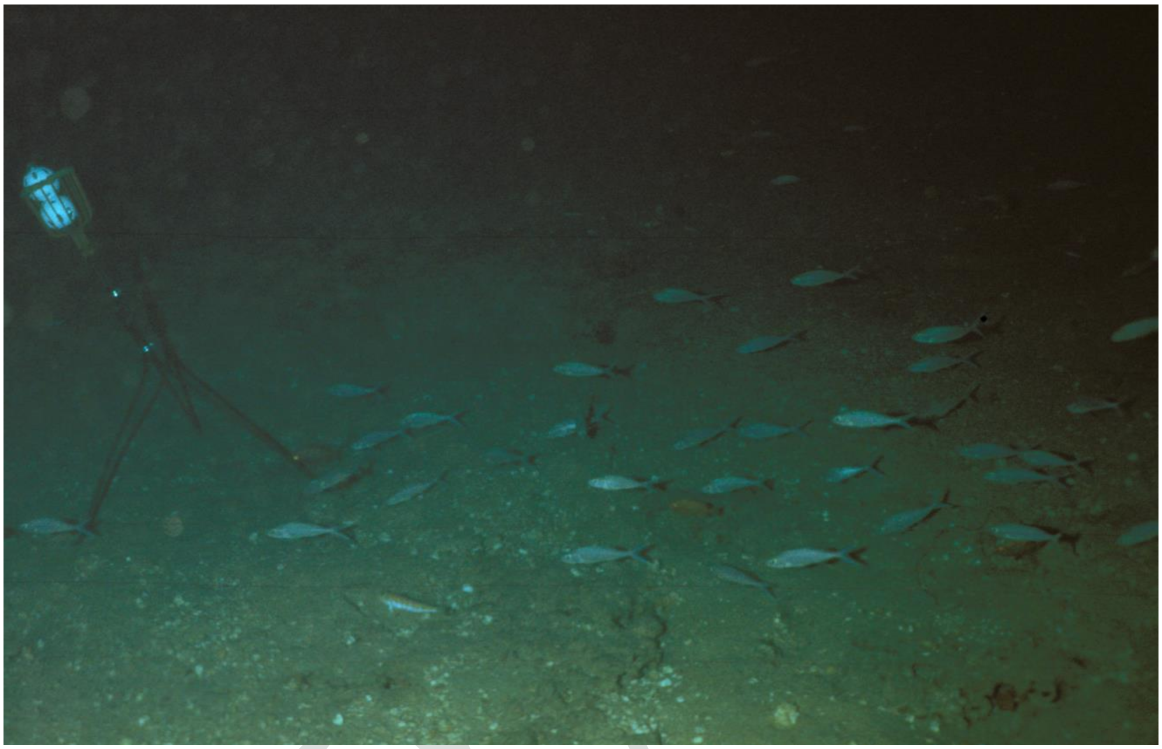

Fig. 16: Juvenile *P. sieboldii* recorded on Pisces dive P5-322 off the north shore of Oahu.

Adult Habitat
P. sieboldii adult habitat was previously described as rocky bottoms throughout the tropical Indo-Pacific region. More recent data supports their preference for hard substrate (UH data, 2010). Previous studies have reported their depth range as being 65-360 m (DeMartini & Lau, 1999; Randall, 2007). In Hawaii the majority of the observations have been made from 145-280 m (UH data, 2010) in temperatures typically ranging from 11.72 ^{o}C to 22.28 ^{o}C (Drazen et al., unpub data). This species is benthopelagic, forming schools that while coming up into the water column swim closer to the bottom than those of *P. filamentosus* and *E. coruscans*. Adults are smaller than either of those two species, and attacks by *S. dumerili* have been documented during submersible dives (Kelley et al., unpub data). Observations of their behavior are consistent with this species feeding primarily on planktonic prey. Based on its depth range, this species could be placed in either the intermediate or deep complexes. However, the adults are more often observed in the same area as *E. coruscans* and *E. carbunculus*. On that basis is considered to be part of the deep complex. Table 40 provides a habitat summary for this species.

Table 40: Habitat description for *Pristipomoides sieboldii* (lavender snapper, kalekale)

	Egg	**Larvae**	**Juvenile**	**Adult**
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown, ≤360	Unknown, ≤360	80-187m	65-360m
Water Column Zone	Pelagic	Pelagic	Benthic	Benthopelagic
Water Quality	Unknown	Unknown	Unknown	11.72 ^{o}C to 22.28 ^{o}C
Substrate Type	N/A	N/A	Primarily rocky	rocky bottom substrate
Prey	N/A	Unknown	Unknown	fish, crab, shrimp, polychaetes, pelagic urochordates and cephalopods

<u>Bottomfish Complex</u>: Deep (80-400 m depth range)

<u>Species EFH descriptions</u>:

Egg: pelagic zone, 0-400 m depth range from shoreline out 50 mi

Post Hatch Pelagic: pelagic zone, 0-400 m depth range from shoreline to EEZ

Post Settlement and Sub Adult: benthic zone, 80-400 m depth range

Adult: benthic zone, 80-400 m depth range

1.4.3.9 *Pristipomoides zonatus* (oblique-banded snapper, gindai)

Life History and General Description

The oblique-banded snapper, *Pristipomoides zonatus*, is the final member of the subfamily Etelinae in Hawaii. This species is found from East Africa to Hawaii and is common in the IndoPacific from Japan to New Caledonia (Randall, 2007). Its local name in Hawaii is gindai. *P. zonatus* accounts for about 6% of the commercial bottomfish catch in Guam. However, it does not comprise a major fraction of the catch in Hawaii, ranking 12th in terms of the average number of pounds landed per year since 1948 (WPRFMC, 2005). Its maximum size has been reported to 45 cm or 18 in (Randall, 2007). The Hawaii state record for this species is 4.2 lbs or 1.9 kg (http://www.hawaiifishingnews.com/records.cfm). *P. zonatus* has been reported to reach sexual maturity in 3.25 yrs (Polovina & Ralston, 1986). Its spawning season in the Marianas was reported to be April-September (Ralston & Williams 1988a), but is probably late summer in Hawaii, ("Current Line Fish Facts for Bottom Fishes of Hawaii"). In the NWHI, ripe ovaries have been collected in August (Uchiyama & Tagami 1984).

Haight et al. (1993b) reported that *P. zonatus* appeared to have a diet intermediate to the piscivorous (*Etelis sp.* and *Aprion virescens*) and the planktivorous (*P. filamentosus* and *P. sieboldii*) snappers. Seki & Callahan (1988) describe *P. zonatus* in the Mariana Archipelago as demersal carnivores. Prey specimens regurgitated by this species at capture in Hawaii were all benthic fish and invertebrates (Kelley, unpub data). The combined data from these sources and from Parrish et al. (2000) suggest that this species is primarily a benthic or demersal carnivore (Table 41). This is consistent with observations that *P. zonatus* is a benthic species, living either as solitary individuals or in small aggregations. Similar to *E. carbunculus*, this species has not been observed in schools.

Table 41: Combined prey records of *Pristipomoides zonatus*: 6 stomachs (Haight et al., 1993b), 23 stomachs (Parrish et al., 2000), 106 stomachs from the Mariana Archipelago (Seki & Callahan, 1988), and regurgitated prey (Kelley, unpub data[1]).

Group	**Category/Family**	**Subcategory/Species**
Cnidarians/Ctenophores	unidentified	unidentified
Ctenophores	Ctenophora	unidentified
Mollusks	Cephalopoda	unidentified
	Cephalopoda - octopods	Octopoda
	Gastropoda	unidentified
	Gastropoda - Heteropods	unidentified
	Gastropoda - Pteropods	*Cavolinia* sp.
	Gastropoda - Pteropods	Cavolinidae
	Gastropoda - Pteropods	*Diacra* sp.

Group	Category/Family	Subcategory/Species
	unidentified	unidentified
Annelids	Polychaeta	unidentified
Crustaceans	Benthic	unidentified
	Copepoda	Cyclopoida
	Copepoda	unidentified
	Decapoda - crabs	Brachyura
	Decapoda - crabs	Galatheidae
	Decapoda - crabs	Megalops larvae
	Decapoda - crabs	*Munida* sp.
	Decapoda - crabs	Galatheidae[1]
	Decapoda - crabs	unidentified
	Decapoda - lobsters	*Scylanus* sp. [1]
	Decapoda - shrimps	Caridea
	Decapoda - shrimps	Pandalidae
	Decapoda - shrimps	unidentified
	Ostracoda	unidentified
	Planktonic	unidentified
	Stomatopoda	unidentified
	unidentified	unidentified
Echinoderms	Ophiuroidea	unidentified
Urochordates	Larvacea	unidentified
	Pyrosomatidae	*Pyrosoma* sp.
	Salpida	unidentified
	Thaliacea	unidentified
Fishes	Anguillformes	unidentified
	Ballistidae	unidentified
	Chaetodontidae	unidentified
	Congridae	unidentified
	Monocanthidae	*Pervagor* sp.
	Moridae	unidentified[1]
	Myctophidae	Species 2
	Ophichthidae	unidentified
	Ophidiidae	*Ophidion muraenolepis*[1]
	Ophidiidae	unidentified
	Serranidae	*Luzonichthys* sp.
	Serranidae	*Odontanthias elisabethae*[1]
	Serranidae	Anthiiae[1]
Fishes cont.	Serranidae	unidentified
	Symphysanodontidae	*Symphysanodon maualoae*[1]
	Symphysanodontidae	unidentified
	unidentified	unidentified

Egg and Larval Habitat

P. zonatus eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 352m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

Very little is known about the distribution and habitat requirements for juveniles of this species. There have been only two observations of *P. zonatus* juveniles, both of which occurred during Pisces submersible dive P4-045 off the south coast of Kahoolawe in the MHI (Kelley, unpub data). Both juveniles were observed swimming very close to the bottom which was hard carbonate at a depth of 200m. One juvenile was accompanied by an adult (Fig. 17). The depth, substrate, and behavior of the juveniles were very similar to that of adults.

Fig. 17: Juvenile *P. zonatus* (right, top) with an adult (right, bottom) recorded during Pisces dive P4-045 at 200m off Kahoolawe. The juvenile was estimated to be 4 in SL.

Adult Habitat

P. zonatus adults are found in depths ranging from 70 to 352 m, and in Hawaii, it is most abundant from 160-280m in temperatures ranging from 13.65 ^{o}C to 19.75 ^{o}C (UH data, 2010). This species is benthic, found close to the bottom on rocky substrate as either solitary individuals or in small aggregations. It is often seen near ledges or other cavities that may serve as shelter. Attacks on this species from *S. dumerili* have been documented from the

Pisces submersible (Kelley, unpub data). Table 42 provides a habitat summary for this species.

Table 42: Habitat Description for *Pristipomoides zonatus* (oblique-banded snapper, gindai)

	Egg	Larvae	Juvenile	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown, ≤352m	Unknown, ≤352m	200m	70-352m
Water Column Zone	Pelagic	Pelagic	Benthic	Benthic
Water Quality	Unknown	Unknown	Unknown	13.7-19.8 ^{o}C
Substrate Type	N/A	N/A	rocky bottom	Rocky bottom
Prey	N/A	Unknown	Unknown	Benthic fish, crab, shrimp, polychaetes, pelagic urochordates and cephalopods

<u>Bottomfish Complex</u>: Deep (80-400 m depth range)

<u>Species EFH description</u>:

Egg: pelagic zone, 0-400 m depth range from shoreline out 50 mi

Post Hatch Pelagic: pelagic zone, 0-400 m depth range from shoreline to EEZ

Post Settlement and Sub Adult: benthic zone, 80-400 m depth range

Adult: benthic zone, 80-400 m depth range

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2 Hawai'i Seamount Groundfish

2.1 Introduction

2.2 General Life History

2.3 General Habitat

2.4 Life History and Habitat Descriptions for Each Species

2.4.1 Habitat description for *Beryx splendens* (alfonsin)

Management Plan and Area:

American Samoa, Guam, Main Hawaiian Islands (MHI), Northwestern Hawaiian Islands (NWHI), Commonwealth of the Northern Mariana Islands (NMI), Johnston Atoll, Kingman Reef, Palmyra Atoll, Jarvis Island, Midway Island, Howland and Baker Islands and Wake Islands.

Life History and General Description

The alfonsins (Berycidae), typically bright red in coloration, are fairly large fish. The family consists of two genera, *Beryx and Centroberyx* (Mundy, 1990).

Alfonsin inhabit rocky bottom habitats at depths of several hundred meters (Seki and Tagami, 1986; Masuda et al., 1975). The distribution of the alfonsin is widespread in the tropical and subtropical waters of the Pacific, Indian and Atlantic oceans (Busakhin, 1982). In the Pacific northern hemisphere, alfonsin are found primarily in two areas, over the southern Emperor and Northern Hawaiian Ridge (SE-NHR) seamounts in the central Pacific and from Japan to Palau in the western Pacific. In the central Pacific, alfonsin are found over seamounts while in the western Pacific region they are also found over continental shelf areas (Humphreys et al., 1984). Over the SE-NHR seamounts their distribution overlaps with that of the pelagic armorhead (*Pseudopentaceros wheeleri*). Most of the available information about the biology and life history of alfonsin come from studies done in the South Pacific and a few Russian studies from the Atlantic. Alfonsin occupies a wide depth range from 10 to 1240 m (Lehodey and Grandperrin, 1995; Massey and Horn, 1990).

Based on examination of otoliths, Lehodey and Grandperrin (1996) calculated a maximum age of 16.8 years for a female of 56.7 cm (FL). The average size of alfonsin captured at the Hancock seamounts in the SE-NHR region ranges from 15.3 to 35.3 cm (FL) (Uchida, 1986).

In the South Pacific, females reportedly grow faster than males, the difference increasing with age (Lehodey and Grandperrin, 1994). At the Hancock seamounts, the sex ratio is nearly equal (Humphreys et al., 1983). In the South Pacific, Alfonsin reaches sexual maturity at 6 years of age for females and at 7 to 8 years for males; approximately 33 to 34 cm respectively for females and males (Lehodey and Grandperrin, 1996; Mundy, 1990). In the western Pacific, alfonsin reportedly reach sexual maturity by age three (Ikenuye, 1969). Alfonsin spawns between August and October in the Hancock seamount region (Mundy, 1990). The pelagic eggs hatch approximately 1 day after spawning (Uchida, 1986)

Tagging studies conducted by Japanese researchers indicate that alfonsins migrate form coastal to offshore waters as they mature. Alfonsins become demersal at one year of age or less (Uchida, 1986)

In the past, a large-scale foreign seamount groundfish fishery extended throughout the southeastern reaches of the northern Hawaiian Ridge. A collapse of the seamount groundfish stocks has resulted in a greatly reduced yield in recent years. Alfonsin are taken primarily by means of bottom trawls. While it is the second most abundant species taken in the seamount groundfish fishery it comprises only a small portion of the total catch (Seki and Tagami, 1986). Much of the demersal habitat on the southern Emperor and Northern Hawaiian Ridge (SE-NHR) seamounts is too steep and rough for bottom trawling. In the past, the principal gear used in the harvest of alfonsin by the Japanese was bottom longlines and handlines (Seki and Tagami, 1986).

Although a moratorium on the harvest of the seamount groundfish within the EEZ has been in place since 1986, no substantial recovery of the stocks has been observed. Historically, there has been no domestic seamount groundfish fishery.

<u>Egg and larval distribution</u>

Although alfonsin are commercially important species little is known about their early life history. As previously mentioned, the eggs of the alfonsin are pelagic and hatch in about 1 day after spawning. The larvae are planktonic for the first 2 to 3 days of existence after which time they begin to swim (Uchida, 1986). The dispersal of eggs and larvae is determined by the prevailing currents (Humphreys et al., 1983).

<u>Larvae</u>

At the Hancock seamount *Beryx* larvae have been found almost exclusively in the upper 50 m of the water column. Larvae are nearly twice as abundant in the upper 25 m than between the 25 to 50 m (Mundy, 1990).

<u>Juvenile distribution</u>

Juveniles undergo a pelagic development phase that lasts several; months. Recruitment to benthic habitat takes place at approximately 1.5 years of age. (Lehodey and Grandperrin, 1994). Juveniles inhabit shallower water than do adults, moving into progressively deeper waters as they grow and mature (Seki and Tagami, 1986).

Galaktionov (1984) studied the schooling behavior of juvenile alfonsin. He found that during midday juveniles were concentarted on the bottom. Between 1700 and 1800 hours school formation occurs relatively rapidly. The schooled juveniles move into shallower water at depths as shallow as 75 m around sunset.

<u>Adult distribution</u>

The alfonsin is a bentho-pelagic species, migrating to the surface at night to feed returning to the bottom during the day (Lehodey and Grandperrin, 1994). Galaktionov (1984) reports that adult alfonsin form dense schools from 1000 to 1100 hours and from 1600 to 1700 to hours. The fish school while at or near the bottom and slowly migrate upward through the water column.

Food habit studies indicates that small fish dominate this species diet. Other prey items include small crustaceans including decapods, euphausiids, krill and mysids (Uchida, 1986). Alfonsin are believed to prey primarily on bathypelagic organisms with benthic prey

contributing little to its diet (Lehodey and Grandperrin, 1994). In turn, alfonsin are preyed upon by large pelagic predators, including tuna.

In the western Pacific region, the abundance and distribution of alfonsin is dependent on the prevailing currents, particularly the Kuroshio (Uchida, 1986). Size increases with depth and latitude (Uchida, 1986). Sekli and Tagami (1986) report an optimum temperature range for this species of 6° to 18° C.

Essential Fish Habitat: Seamount groundfish complex

The EFH designation for the adult life stage of the seamount groundfish complex is all EEZ waters and bottom habitat bounded by latitude 29°-35°N and longitude 171°E-179°W between 80 to 600 m. EFH for eggs, larvae and juveniles is the epipelagic zone (~ 200 m) of all EEZ waters bounded by latitude 29°-35°N and Longitude 171°E-179°W.

Habitat description for *Beryx splendens* (alfonsin)

	Egg	**Larvae**	**Juvenile**	**Adult**
Duration	Eggs hatch approximately 1 day after spawning	The larvae are planktonic for the first 2 to 3 days of existence after which time they begin to swim.	Alfonsin reaches sexual maturity at 6 years of age for females and at 7 to 8 years for males; approximately 33 to 34 cm respectively for females and males	16.8 years for a female of 56.7 cm
Diet	N/A	No information available	No information available	Small fish dominate this species diet. Other prey items include small crustaceans including decapods, euphausiids, krill and mysids
Distribution: General and Seasonal	No information available	No information available	Alfonsins migrate form coastal to offshore waters as they mature	The distribution of the alfonsin is widespread in the tropical and subtropical waters of the Pacific. In the Pacific northern hemisphere, alfonsin are found

				primarily in two areas, over the southern Emperor and Northern Hawaiian Ridge (SE-NHR) seamounts in the central Pacific and from Japan to Palau in the western Pacific.
Water Column	Pelagic	Pelagic, At the Hancock seamount *Beryx* larvae have been found almost exclusively in the upper 50 m of the water column. Larvae are nearly twice as abundant in the upper 25 m than between the 25 to 50 m	Pelagic, Juveniles undergo a pelagic development phase that lasts several; months. Recruitment to benthic habitat takes place at approximately 1.5 years of age. Juveniles inhabit shallower water than do adults, moving into progressively deeper waters as they grow and mature	Demersal, Alfonsin occupies a wide depth range from 10 to 1240 m
Bottom Type	N/A	N/A	N/A	Alfonsin inhabit rocky bottom habitats at depths of several hundred meters. In the central Pacific, alfonsin are found over seamounts while in the western Pacific region they are also found over continental shelf areas

Oceanic Features	The dispersal of eggs is determined by the prevailing currents	The dispersal of larvae is determined by the prevailing currents	The abundance and distribution of alfonsin is dependent on the prevailing currents, particularly the Kuroshio	The abundance and distribution of alfonsin is dependent on the prevailing currents, particularly the Kuroshio

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2.4.2 Habitat description for *Hyperoglyphe japonica* (ratfish, butterfish)

Management Plan and Area

American Samoa, Guam, Main Hawaiian Islands (MHI), Northwestern Hawaiian Islands (NWHI), Commonwealth of the Northern Mariana Islands (NMI), Johnston Atoll, Kingman Reef, Palmyra Atoll, Jarvis Island, Midway Island, Howland and Baker Islands and Wake Islands.

Life History and General Description

There is no information available concerning the life history and basic biology of the ratfish. This species is infrequently taken as an incidental species in conjunction with the seamount groundfish fishery.

2.4.3 Habitat description for *Pseudopentaceros wheeleri* (armorhead)

Management Plan and Area

American Samoa, Guam, Main Hawaiian Islands (MHI), Northwestern Hawaiian Islands (NWHI), Commonwealth of the Northern Mariana Islands (NMI), Johnston Atoll, Kingman Reef, Palmyra Atoll, Jarvis Island, Midway Island, Howland and Baker Islands and Wake Islands.

Life History and General Description

Boehlert and Sasaki (1988) and Humphreys et al. (1983) were the primary sources used in the preparation of this species profile.

The pelagic armorhead (*Pseudopentaceros wheeleri*) is widely distributed throughout the North Pacific Ocean (Boehlert and Sasaki, 1988). Electrophoretic and meristic work suggests that a single stock of pelagic armorhead exists (Humphreys et al., 1983). Oceanographic conditions seem to be the primary factor regulating the armorhead's distribution. Zones of upwelling, produced by the prevailing currents, result in high biological productivity over the Southern

Emperor-Northern Hawaiian Ridge (SE-NHR) seamounts (Pontekorvo, 1974 in Humphreys et al.,1983). The life histories and distributional patterns of the armorhead are poorly understood as is the effects of oceanographic variability on migration and recruitment of the armorhead.

The pelagic armorhead has two distinct life history phases that includes a pelagic juvenile phase and a demersal adult phase (Somerton and Kikkawa, 1992). Between 1.5 and 2.5 years of age, the pelagic armorhead inhabits the epipelagic zone of the subarctic-transitional waters of the North Pacific during a lengthy pre-recruit phase (Humphreys, 1995; Somerton and Kikkawa, 1992). During this time the fish remain nonreproductive. Subsequently, these fish recruit to demersal habitat on the SE-NHR seamounts. Humphreys et al. (1983) report that adults are found on the slopes of seamounts down to depths of 800 to 900 m. The commercial fishery for pelagic armorhead targets fish on the summits of seamounts at the 200 to 490 m depth range (Humphreys et al., 1983; Takahashi and Sasaki, 1977)

The smallest reported sizes for pelagic armorhead range from 5 to 20 mm and typically occurred south of 33 N° (Humphreys et al., 1984). Research indicates an age estimate of 3 years for 22 cm fork length (FL) and 6 years for 32 cm fork length (Humphreys et al., 1983). Based on length frequency data, it is believed that fish taken by the trawl fishery are typically 5 to 7 years of age (Chikuni, 1970 in Humphreys et al., 1983). Females are slightly larger than males.

Adult pelagic armorhead have three distinct morphological types: "lean type", "intermediate type" and "fat type". While all three types are found over the SE-NHR seamounts, the lean and intermediate types predominate. The epipelagic phase of the armorhead life history is characterized by the accumulation of fat reserves and continuous somatic growth (Humphreys et al., 1989). The bluish mottled coloration of the open ocean fat type is indicative of its epipelagic existence. The open ocean fat type is nonreproductive. After recruitment to the summits of the SE-NWR seamounts, newly settled adults rapidly lose their mottled bluish coloration, ultimately assuming a brownish coloration. This transformation is fairly rapid and explains the relatively low abundance of fat type on the seamounts. Somatic growth ceases and the fat reserves are depleted as the fish become reproductively active. These physiological changes result in the intermediate morphological type and ultimately the lean type as the fat reserves are further depleted (Humphreys et al., 1989). The existence of these distinct morphological types are absent in juveniles. (Humphreys et al., 1983).

The main reproductive population is found on SE-NHR seamounts between latitude 29° and 35° N. (Boehlert and Sasaki, 1988). Spawning activity is benthic and is restricted to December to February at the SE-NHR seamounts.(Humphreys, 1995). Peak spawning activity occurs between January and February (Humphreys et al., 1983). Research indicates that armorhead reach sexual maturity at 1.5 to 2.5 years in age, ranging in size from 23.0 to 28.5 standard length (Boehlert and Sasaki, 1988). Spawning occurs at depths ranging from 200 to 500 m (Boehlert and Sasaki, 1988). It is thought that *P. wheeleri* is semelparous, spawning only once before dying.

Eggs, larvae and juveniles are pelagic and are found widely distributed in the North Pacific Ocean (Boehlert and Sasaki, 1988). Initially the larvae are found in the epipealgic waters in the vicinity of the SE-NHR seamounts (Humprheys et al., 1993). The larvae are transported by prevailing ocean currents to the subarctic waters of the North Pacific Ocean (Humphreys et al., 1993). Boehlert and Sasaki (1973) report a 1.5 to 2.5 year time period between spawning and recruitment to the seamounts. The process by which these fish return and recruit to the seamounts is poorly understood (Humphreys et al., 1993). It is thought that recruitment occurs only during the late spring to midsummer months. The long pelagic phase combined with the variability of oceanic conditions play an important role in determining the strength of year-classes in this species (Boehlert and Sasaki, 1988). The size of individuals at recruitment is generally uniform, ranging from 25 to 33 cm (Humphreys et al., 1989).

In the past, a large-scale foreign seamount groundfish fishery extended throughout the southeastern reaches of the northern Hawaiian Ridge. The seamount groundfish complex consists of three species (pelagic armorhead's, alfonsins, and ratfish). These species dwell at 200 to 600 m on the submarine slopes and summits of seamounts. A collapse of the seamount groundfish stocks has resulted in a greatly reduced yield in recent years. Although a moratorium on the harvest of the seamount groundfish within the EEZ has been in place since 1986, no substantial recovery of the stocks has been observed. Historically, there has been no domestic seamount groundfish fishery.

<u>Egg and larval distribution</u>
The egg, larval and juvenile stages of the pelagic armorhead all occur in the surface layers where they are subject to advection by the prevailing currents (Humphrey et al., 1984; Borets, 1979).

Larval and juvenile stages prey on zooplankton. Interannual variability in environment conditions affecting the abundance and availability of zooplankton may play an important role in the survival of these early life stages and thus year class strength (Boehlert and Sasaki, 1988).

Larvae of *P. wheeleri* are neustonic and are carried eastward by the prevailing wind driven surface flow in the SE-NHR seamount region (Boehlert and Sasaki, 1988). Through some unknown mechanism, fish move northeastward ultimately entering the subarctic waters of the Alaska gyre (Boehlert and Sasaki, 1988). The two available studies of larval distribution of armorhead conflict but suggest that the distribution of larvae varies from year to year (Boehlert and Sasaki, 1988).

<u>Juvenile distribution</u>
As stated, during the first 1.5 to 2.5 years of life, juveniles lead a pelagic existence., inhabiting the epipelagic zone of the subarctic-transitional waters of the North Pacific Ocean (Somerton and Kikkawa, 1992). Subsequently, a shift occurs from pelagic to demersal habitat. During the

pelagic juvenile phase, armorhead acquire large reserves of fat before recruiting to SE-NHR seamounts. The largest influx of juvenile recruits to the Juveniles recruit to the SE-NHR seamounts occurs during spring between April and June (Humphreys, 1995). Recruits are characterized by their bluish to grey coloration and their fat reserves. After recruitment, the fish gradually assume a brownish coloration. The diet of juveniles is comprised primarily of small plankktonic prey items, particularly copepods (Borets, 1979).

Adult distribution

As stated, adults are found on the slopes of seamounts. *P. wheeleri* display crespuscular migrations through the water column. During daylight hours, they are found in the upper water column at depths between 80 to 100 m. As dusk approaches they descend to the summits of the seamounts. It is thought that these movements are related to foraging activity (Humphreys et al., 1983). At night, dense aggregations of armorhead are found on the summits of the seamounts (Somerton and Kikkawa, 1992).

The pelagic armorhead feeds during daylight hours, especially between the hours of 0800 and 1000. (Humphreys et al., 1983; Sakiura, 1972). Prey items include epipelagic crustaceans, copepods, amphipods, tunicates,eupausiids, pteropods, sergestids, myctophids, macrura and mesopelagic fish. Organisms of the deep scattering layer also comprise a portion of this species diet (Humphreys et al., 1983; Sakiura, 1972).

It is believed that the horizontal and vertical distribution of *P. wheeleri* is controlled by water temperature. The lower tolerance limit is approximately 5 C° while the upper limit is roughly 20 C°. It is thought that the preferred temperature range of this species is 8 to 15 C° (Humphreys et al., 1983; Chikuni, 1971). Pelagic armorhead are found year-round on the southern Emperor-Northern Hawaiian Ridge seamounts.

The life expectancy of the armorhead once it has recruited to demersal habitat ranges from 4 to 5 years.

Essential Fish Habitat: Seamount groundfish complex

The EFH designation for the adult life stage of the seamount groundfish complex is all EEZ waters and bottom habitat bounded by latitude 29°-35°N and longitude 171°E-179°W between 80 to 600 m. EFH for eggs, larvae and juveniles is the epipelagic zone (~ 200 m) of all EEZ waters bounded by latitude 29°-35°N and Longitude 171°E-179°W.

Habitat description for *Pseudopentaceros wheeleri* (armorhead)

	Egg	**Larvae**	**Juvenile**	**Adult**
Duration	No information available	No information available	Fish recruit to demersal habitat Between 1.5 and 2.5 years of age	The life expectancy of the armorhead once it has recruited to demersal habitat ranges from 4 to 5 years
Diet	N/A	Larval stages prey on zooplankton	Juvenile stages prey on zooplankton	Prey items include epipelagic crustaceans, copepods, amphipods, tunicates,eupausiids, pteropods, sergestids, myctophids, macrura and mesopelagic fish.
Distribution: General and Seasonal	Eggs are found in the epipealgic waters in the vicinity of the SE-NHR seamounts	Initially the larvae are found in the epipealgic waters in the vicinity of the SE-NHR seamounts	The pelagic armorhead inhabits the epipelagic zone of the subarctic-transitional waters of the North Pacific during a lengthy	The pelagic armorhead (*Pseudopentaceros wheeleri*) is widely distributed throughout the North Pacific Ocean

			pre-recruit phase	
Water Column	pelagic	pelagic	pelagic	Demersal, During daylight hours, they are found in the upper water column at depths between 80 to 100 m. At night, dense aggregations of armorhead are found on the summits of the seamounts
Bottom Type	N/A	N/A	N/A	Adults are found on the slopes of seamounts down to depths of 800 to 900 m
Oceanic Features	The eggs are transported by prevailing ocean currents to the subarctic waters of the North Pacific Ocean	The larvae are transported by prevailing ocean currents to the subarctic waters of the North Pacific Ocean	Oceanographic conditions seem to be the primary factor regulating the armorhead's distribution.	Oceanographic conditions seem to be the primary factor regulating the armorhead's distribution.

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3 PRECIOUS CORALS SPECIES

3.1 General Distribution of Precious Corals

Besides the references noted, the Council's 1979 environmental impact statement and FMP for the precious corals fisheries in the western Pacific region as well as Amendments 1 and 2 to the FMP and their accompanying environmental assessments were sources for the following sections.

Precious corals are known to exist in American Samoa, Guam, Hawaii and the Northern Mariana Islands, as well as other US possessions in the Pacific (Tables 1 and 2). However, very little is known about their distribution and abundance. A summary of the known distribution and abundance of precious corals in the western Pacific region follows.

American Samoa

There is little information available for the deepwater species of precious corals in American Samoa. Much of the information available comes from the personal accounts of fishermen. All known commercial quantities of *Corallium* sp. occur north of 19^{o}N (Grigg 1984). In the South Pacific there are no known commercial beds of pink coral (Carleton and Philipson 1987). Survey work begun in 1975 by the Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas (CCOP/SOPAC) has identified three areas of *Corralium* off Western Samoa: off eastern Upolu, off Falealupo and at Tupuola Bank (Carleton and Philipson 1987). Pink coral has been reported off Cape Taputapu, but no information concerning the quality or quantity of these corals or the depths where they occur is available. Unidentified precious corals have also been reported in the past off Fanuatapu at depths of around 90 m. Precious corals are known to occur at an uncharted seamount, about three-fourths of a mile off the northwest tip of Falealupo Bank at depths of around 300 m.

Commercial quantities of one or more species of black coral are known to exist at depths of 40 m and deeper. However, these are found in the territorial waters of American Samoa and, therefore, are not subject to the Council's authority.

Guam and the Commonwealth of the Northern Marianas

There are no known commercial quantities of precious corals in the Northern Mariana Islands archipelago (Grigg and Eldredge 1975). In the past, Japanese fishermen claimed to have taken some *Corralium* north of Pagan Island and off Rota and Saipan.

Hawaii

In the Hawaiian Islands there are six known beds of pink, gold and bamboo corals (Grigg 1974). These six locations are as follows:

- In the MHI, precious coral beds have been found only in the deep inter-island channels and off promontories such as Keahole Point on the Big Island of Hawaii.

Species	**Common name**
Corallium secundum	Pink coral
Corallium regale	Red coral
Corallium laauense(sp)	Red coral
Gerardia sp.	Gold coral
Narella sp.	Gold coral
Calyptrophora sp.	Gold coral
Callogorgia gilberti	Gold coral
Lepidisis olapa	Bamboo coral
Acanella sp.	Bamboo coral
Antipathes dichotoma	Black coral
Antipathes grandis	Black coral

Species	**Common name**
Antipathes ulex	Black coral

Table 1: Precious corals covered under the FMP.

- Also in the MHI, the Makapuu bed is located off Makapuu, Oahu, at depths of between 350 and 450 m. Discovered in 1966, it the only precious coral bed that has been accurately surveyed in the Hawaiian chain. Its total area is about 4.5 km^2. Its substrate consists largely of hard limestone (Grigg 1988). Careful examination during numerous dives with a submersible has determined that about 20% of the total area of the Makapuu bed is comprised of irregular lenses of thin sand, sediments and barren patches (WPRFMC 1979). These sediment deposits are found primarily in low lying areas and depressions (Grigg 1988). Thus, the total area used for extrapolating coral density is 3.6 km^2, or 80% of 4.5 km^2 (WPRFMC 1979). The preliminary results of a recent resurvey of the Makupuu bed show that the bed may actually be as much as 15% larger then previously thought (Grigg 1998, pers. comm.).

- Also in the MHI is a bed off Kaena Point, Oahu.

- In the NWHI, a very small bed of deepwater precious corals have been found on WesPac bed, between Nihoa and Necker Islands and east of French Frigate Shoals. This bed is not large enough to sustain commercial harvests. However, large areas of potential habitat exist in the NWHI on seamounts and banks near 400 m depth. Based on the abundance of potential habitat it is thought that stocks of precious corals may be more abundant in the northwestern end of the island chain.

- A small precious coral bed has also been discovered at Brooks Banks, located near Cross Seamount southwest of the island of Hawaii. This bed is no large enough to sustain commercial harvests

- Precious corals have also been discovered at the 180 Fathom Bank, north of Kue Island, in EEZ waters surrounding Palmyra Island, a US possession in the western Pacific. The extent of this bed is not known. While little is known about the distribution and abundance of precious corals in the western Pacific region, it is almost certain that undiscovered beds of precious corals exist in the EEZ waters of the region covered by the Council.

Description	**Lat. N**	**Long. W.**	**Area in km^2**
Off Keahole Point, Hawaii	19^{o}46.0'	156^{o}06.0'	0.24
Off Makapuu, Oahu	21^{o}18.0'	157^{o}35.5'	4.2
Off Kaena Point, Oahu	21^{o}35.4'	158^{o}22.9'	0.24
WesPac Bed, between Nihoa and Necker Islands	23^{o}18'	162^{o}35'	0.8
Brooks Banks	24^{o}06.0'	166^{o}48'	1.6
180 Fathom Bank, north of Kue Island	28^{o}50.2'	178^{o}53.4'	0.8

Table 2: Location of known precious coral beds. Source: WPRFMC 1979

3.2 Systematics of the Deepwater Coral Species

Precious corals have a global distribution (Grigg 1993). The richest beds are found on seamounts in the western North Pacific Ocean and the western Mediterranean Sea. Precious corals are found principally in three orders of the class Anthozoa: Gorgonacea, Antipatharia, and Zoanthiae (Grigg 1984). In the western Pacific region, pink coral (*Corallium secundum*), gold coral (*Gerardia sp*. and *Parazoanthus sp*.), black coral (*Antipathes* sp.) and bamboo coral (*Lepidistis olapa*) are the primary species/genera of commercial importance. Of these, the most valuable precious corals are species of the genus *Corallium*, the pink and red corals (Grigg 1984). Pink coral (*Corallium secundum*) and Midway deep-sea coral (*Corallium* sp. nov) are two of the principal species of commercial importance in the Hawaiian and Emperor Seamount chain's (Grigg 1984). *C. secundum*, is found in the Hawaiian archipelago from Milwaukee Banks in the Emperor Seamounts (36^{o}N) to the Island of Hawaii (18^{o}N); *Corallium* sp nov. is found between 28^{o}–36^{o}N, from Midway to the Emperor Seamounts (Grigg 1984). In addition to the pink corals, the bamboo corals, *Lepidistis olapa* and *Acanella* sp., are commercially important precious corals in the western Pacific region (Grigg 1984). Pink coral and bamboo coral are found in the order Gorgonacea in the subclass Octocorallia of the class Anthozoa, in the Phylum Coelenterata (Grigg, 1984). The final two major groups of commercially important precious corals, gold coral and black coral, are found in separate orders, Zoanthidea and Antipatharia, in the subclass Hexacorallia in the class Anthozoa and the phylum Coelenterata. The gold coral, *Gerardia* sp., is endemic to the Hawaiian and Emperor Seamount chain (Grigg 1984). It inhabits depths ranging from 300–400 m (Grigg 1974, 1984). In Hawaii, gold coral, *Gerardii* sp., grows in association with *Acanella* as a parasitic overgrowth (Brown 1976, Grigg 1984). Gold coral is, therefore, only found growing in areas that were previously inhabited by colonies of *Acanella* (Grigg 1993).

Grigg (1984) classifies black corals in the order *Antipatharia*. Grigg says there are 200 known species of black coral that occur in the oceans of the world, and of this total, only about 10 species are of commercial importance, almost all of which are found in the genus *Antipathes*.

Many species of gorgonian corals are known to occur within the habitat of pink, gold and bamboo corals in the Hawaiian Islands. At least 37 species of precious corals in the order Gorgonacea have been identified from the Makapuu bed (Grigg and Bayer 1976). In addition, 14 species of black coral (order Antipatharia) have been reported to occur in Hawaiian waters (Grigg and Opresko 1977, Oishi 1990).

3.3 Biology and Life History

Precious corals may be divided into two groups of species based on the depths that they inhabit, the deepwater species and the shallow water species. In the EEZ waters of the western Pacific region, precious corals are found in two principal depth zones: 350–450 m and 1,000–1,500 m. In the Hawaiian Islands, these two zones comprise 1,700 nm^2 and 5,900 nm^2 of potential habitat, respectively, and range from 18^{o} N to 35^{o} S.

The deepwater precious coral species include pink coral (*Corallium secundum*), gold coral (*Gerardia sp*., and *Parazoanthus sp*.) and bamboo coral (*Lepidistis olapa*). As previously discussed, the most valuable precious corals are in the genus *Corallium* (Grigg 1984). There are seven varieties of pink and red precious corals in the western Pacific region, six of which are recognized as distinct species of *Corallium* (Grigg 1981). As mentioned, the two species of *Corallium* of commercial importance in the EEZ around the Hawaiian Islands are *C. secundum* (pink coral) and *Corallium* sp. Nov. (Midway deep-sea). The Midway deep-sea coral (*Corallium* sp. Nov), a previously undescribed species of *Corallium*, was discovered in 1980–1981 by Japanese vessels fishing for precious corals on the Emperor Seamounts northwest of Midway Island. The discovery of this rich, unexploited deepwater precious coral species resource underscores the potential of the coral fishery in the NWHI.

The second group of species is found in shallow water between 30 and 100 m (Grigg 1993). The shallow water fishery is comprised of three species of black coral, *Antipathes dichotoma*, *A. grandis* and *A. ulex*, which have historically been harvested in Hawaii (Oishi 1990). In Hawaii, *A. dichotoma* accounts for around 90% of the commercial harvest of black coral (Oishi 1990). *A. grandis* accounts for 9% and *A. ulex* 1% of the total black corals harvested. In Hawaii, roughly 85% of all black coral harvested are taken from within state waters. Black corals are managed jointly by the State of Hawaii and the Coucnil. Within state waters (0–3 nmi), black corals are managed by the State of Hawaii (Grigg 1993).

Species and Common Name	**Depth Range (m)**
Corallium secundum Angle skin coral	350–475
Corallium sp nov. Midway deepsea coral	1,000–1,500
Gerardia sp. Hawaiian gold coral	300–400
Lepidisis olapa bamboo coral	350–400

Species and Common Name	Depth Range (m)
Antipathes dichotoma, black coral	30–100
Antipathes grandis, pine black coral	45–100
Antipathes ulex, fern black coral	40–100
Antipathes anguina, wire black coral	20–60

Table 3: Depth zonation of all species of precious coral in the Western Pacific. (Source: Grigg 1993)

While different species of precious corals inhabit distinct depth zones, their habitat requirements are strikingly similar. Grigg (1984) notes that these corals are non-reef building and inhabit depth zones below the euphotic zone. In an earlier study, Grigg (1974) determined that precious corals are found in deep water on solid substrate in areas that are swept relatively clean by moderate to strong bottom currents (>25 cm/sec). Strong currents help prevent the accumulation of sediments, which would smother young coral colonies and prevent settlement of new larvae. Grigg (1984) notes that, in Hawaii, large stands of *Corralium* are only found in areas where sediments almost never accumulate. He also notes that 1971–75, surveys of all potential sites for precious corals in the MHI conducted using a manned submersible show that most shelf areas in the MHI near 400 m are periodically covered with a thin layer of silt and sand. Grigg (1988) concludes that the concurrence of oceanographic features (strong currents, hard substrate, low sediments) necessary to create suitable precious coral habitat are rare in the MHI.

The habitat sustaining precious corals is generally in pristine condition. There are no known areas that have sustained damage due to resource exploitation, notwithstanding the alleged heavy foreign fishing for corals in the Hancock Seamounts area. Although unlikely, if future development projects are planned in the proximity of precious coral beds, care should be taken to prevent damage to the beds. Projects of particular concern would be those that suspend sediments or modify water-movement patterns.

There is a correlation between the location and abundance of *Corallium* beds and the Kuroshio Current in the western Pacific region (Grigg 1984). This relationship further illustrates the importance of suitable current regimes in determining suitable precious coral habitat. Currents also play an important ecological role in transporting food to and carrying wastes away from corals.

There has been very little research conducted concerning the food habits of precious corals. Precious corals are filter feeders (Grigg 1984, 1993). The sparse research available suggests that particulate organic matter and microzooplankton are important in the diets of pink and bamboo coral (Grigg 1970). Many species of pink coral (*Corallium*), gold coral (*Gerardia*) and black coral (*Antipathes*) form fan shaped colonies (Grigg 1984, 1993). This type of morphological adaption maximizes the total area of water that is filtered by the polyps (Grigg 1984, 1993). Bamboo coral (*Lepidisis olapa*), unlike other species of precious corals, is unbranched (Grigg 1984). Long coils that trail in the prevailing currents maximize the total amount of seawater that is filtered by the polyps (Grigg 1984). While clearly, the presence of strong currents is a vital factor determining habitat suitability for precious coral colonies, their role to date is not fully understood.

Precious corals are known to grow on a variety of bottom substrate types. Precious coral yields, however, tend to be higher in areas of shell sandstone, limestone and basaltic or metamorphic rock with a limestone veneer.

Light is one of the most important determining factors of the upper depth limit of many species of precious corals (Grigg 1984).The larvae of two species of black coral, *Antipathes grandis* and *A. dichotoma*, are negatively phototaxic**.**

Grigg (1984) states that temperature does not appear to be a significant factor in delimiting suitable habitat for precious corals. In the Pacific Ocean, species of *Corallium* are found in temperature ranges of 8^{o} to 20^{o}C, he observes. Temperature may determine the lower depth limits of some species of precious coral, including two species of black corals in the MHI, he suggests. In the MHI, the lower depth range of two species of black corals (*Antipathes dichotoma* and *A. grandis*) coincides with the top of the thermocline (about 100 m), Grigg observes.

In pink coral (*Corallium secundum*), the sexes are separate (Grigg 1993). Based on the best available data, it is believed that *C. secundum* becomes sexually mature at a height of approximately 12 cm (13 years) (Grigg 1976). Pink coral reproduce annually, with spawning occurring during the summer, during the months of June and July. Coral polyps produce eggs and sperm. Fertilization of the oocytes is completed externally in the water column (Grigg 1976, 1993). The resulting larvae, called planulae, drift with the prevailing currents until finding a suitable site for settlement.

Pink, bamboo and gold corals all have planktonic larval stages and sessile adult stages. Larvae settle on solid substrate where they form colonial branching colonies. Grigg (1993) notes that the length of the larval stage of all deepwater species of precious corals is not known. Clean swept areas exposed to strong currents provide important sites for settlement of the larvae, Grigg adds. The larvae of several species of black coral (*Antipathes*) are negatively photoactic, he notes. They are most abundant in dimly lit areas, such as beneath overhangs in waters deeper than 30 m, he observes. In an earlier study, Grigg (1976) found that “[w]ithin their depth ranges, both species are highly aggregated and are most frequently found under vertical dropoffs. Such features are commonly associated with terraces and undercut notches relict of ancient sea level still stands. Such features are common off Kauai and Maui in the MHI. Both species are particularly abundant off of Maui and Kauai, suggesting that their abundance is related to suitable habitat.” Off of Oahu, many submarine terraces that otherwise would be suitable habitat for black corals are covered with sediments, Grigg (1976) adds.

Grigg (1993) observes that precious corals have low recruitment and mortality. They are slow growing and long lived, believed to reach the age of 75 years and older, he notes. Common causes of mortality include smothering by sediments and toppling of colonies due to erosion of the substrate, he concludes. (Another cause is worms boring into the colony, weakening it and causing it to collapse**.**)

A variety of invertebrates and fish are known to utilize the same habitat as precious corals. These species of fish include onaga (*Etelis coruscans*), kahala (*Seriola dumerallii*) and the shrimp (*Heterocarpus ensifer*). These species do not seem to depend on the coral for shelter or food.

Densities of pink, gold and bamboo coral have been determined for an unexploited section of the Makapuu bed (Grigg, 1976). As noted in the FMP for precious corals, the average density of pink coral in the Makapuu bed is 0.022 colonies/m^2. This figure was extrapolated to the entire bed (3.6 million m^2), giving an estimated standing crop of 79,200 colonies. At the 95% confidence limit, the standing crop is 47,500 to 111,700 colonies. The standing crop of colonies was converted to biomass ($3N_iW_i$), resulting in an estimate of 43,500 kg of pink coral in the Makapuu bed.

In addition to coral densities, Grigg (1976) determined the age-frequency distribution of pink coral colonies in Makapuu bed. He applied annual growth rates to the size frequency to calculate the age structure of pink coral at Makapuu Bed (Table 4).

Age Group (years)	**Number of Colonies**
0–10	44
10–20	73

Age Group (years)	**Number of Colonies**
20–30	22
30–40	12
40–50	7
50–60	0

Table 4: Age-Frequency Distribution of *Corallium secundum* (Source: Grigg 1973)

Estimates of density were also made for bamboo (*Lepidisis olapa*) and gold coral (*Gerardia* sp.) for Makapuu bed. The distributions of both these species are patchy. As noted in the FMP, the area where they occur comprises only half of that occupied by pink coral (1.8 km^2). Estimates of the unexploited abundance of bamboo and gold coral were 18,000 and 5,400 colonies, respectively. Estimates of density for the unexploited bamboo coral and gold coral in the Makapuu bed are 0.01 colonies/m^2 and 0.003 colonies/m^2. Using a rough estimate for the mean weights of gold and bamboo coral colonies (2.2 kg and 0.6 kg), a standing crop of about 11,880 kg of gold coral and 10,800 kg for bamboo for Makapuu bed was obtained.

Growth rates for several species of precious corals found in the western Pacific region have been calculated.

Grigg (1976) determines that the height of pink coral (*C. secundum*) colonies increases about 0.9 cm/yr up to about 30 years of age. As noted in the FMP for precious corals, the height of the largest colonies of *Corallium secundum* at Makapuu bed rarely exceed 60 cm. Colonies of gold coral are known to grow up to 250 cm tall while bamboo corals may reach 300 cm. The natural mortality rate of pink coral at Makapuu bed is believed to be 0.066, equivalent to an annual survival rate of about 93%.

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4 CRUSTACEAN SPECIES

This section is divided up between spiny lobster, slipper lobster, and Kona crab in Hawaii and spiny lobster in the other islands of the Western Pacific Region. This is because the only significant fisheries for crustaceans, primarily spiny lobsters and slipper lobsters, are found in Hawaii. Moreover, these fisheries use traps, which are not used extensively for crustaceans outside of Hawaii, and which are used in Hawaii to target other crustaceans such as Kona crab and white crabs. Moreover, while other spiny lobsters are widespread in the Pacific Islands and the US Western Pacific Region, the target of the lobster fishery in Hawaii, *Panulirus marginatus*, is found only in Hawaii, Johnson Island and Wake Island. Further, a major component of the Hawaii lobster fishery is the slipper lobster *Scyllarides squammosus.* Slipper lobsters, which are not targeted to any extent by other fisheries in the Western Pacific, may be taken opportunistically by divers.

Throughout the other Pacific Islands, including American Samoa, Mariana Islands and the Pacific Remote Islands, the most common spiny lobster found on rocky and coral reefs, apart from Hawaii, is *Panulirus penicillatus*, while other species such as *P. versicolor*, *P.ornatus* and *P.longipes* have also been observed, but are much less common.

4.1 Hawaiian Spiny Lobster

4.1.1 Habitat

Adult spiny lobsters are typically found on rocky substrate in well protected areas, in crevices and under rocks (Pitcher 1993, FAO 1991). Spiny lobsters found in Hawaii include both *Panulirus marginatus* and *P. penicillatus.* However, most fishing for lobsters in Hawaii is targeted at *P. marginatus* and the slipper lobster *Scyllarides squammosus, and these species are the focus of this review.* An extensive review of the EFH for *P. penicillatus* is included in the FEPs for Mariana Islands, American Samoa and the PRIAs.

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 occurs 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).

4.1.2 Morphology

Spiny lobsters are non-clawed, decapod crustaceans with slender walking legs of roughly equal size (Uchida 1986, FAO 1991). Spiny lobster have a large spiny carapace with two horns and antennae projecting forward of their eyes and a large abdomen terminating in a flexible tailfan (FAO 1991).

Uchida (1986) provides a detailed description of the morphology of the slipper lobster *Scyllarides squammosus* and *S. haanii*. He notes that the two species are very similar in appearance and are easily confused (Uchida 1986). The appearance of the slipper lobster is notably different than that of the spiny lobster.

4.1.3 Reproduction

Spiny lobsters (*Panulirus* sp.) are dioecious (Uchida 1986). Generally, the different species of the genus *Panulirus* 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). In *Panulirus* sp., 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 for the female's oviduct and are then fertilized and attach to the setae of the female's pleopod (WPRFMC 1983, Pitcher 1993). At this point the female lobster is ovigerous, or berried (WPRFMC 1983). The fertilized eggs hatch into phyllosoma larvae after 30-40 days (MacDonald 1986, Uchida 1986). Spiny lobsters are very fecund (WPRFMC 1983). The release of the phyllosoma larvae appears to be timed to coincide with the full moon and dawn in some species (Pitcher 1993). In *Scyllarides* sp. fertilization is internal (Uchida 1986b).

4.1.4 Larval Stage

Very little is known about the planktonic phase of the phyllosoma larvae of *Panulirus marginatus* (Uchida et al. 1980). After hatching, the leaf-like larvae (or phyllosoma) enter a planktonic phase (WPRFMC 1983). The duration of this planktonic phase varies depending on the species and geographic region (WPRFMC 1983). The planktonic larval stage may last from 6 months to 1 year from the time of the hatching of the eggs (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 pelagic phyllosoma stage of development is followed by the puerulus stage. The puelurus stage lasts 6 months or less (WPRFMC 1983). Spiny lobster pueruli are free-swimming and actively return to shallow, nearshore waters in preparation for settlement (WPRFMC 1983, MacDonald 1986). Johnston (1973) reports that the phyllosoma phase of some species of the genera *Scyllarides* is somewhat shorter. MacDonald and Stimson (1980) found pelagic, puerulus larvae settlement to occur at approximately 1 cm in length. MacDonald (1986) found puerulus settlement occurred primarily at the new moon and first quarter lunar phase in Hawaii. The settlement of puerulus is higher in the central portion of the Hawaiian Island chain than what, and it is higher in the NWHI than around the MHI (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. Phillips and Sastry (1980) reports that the newly hatched larvae of the western rock lobster (*P. cygnus*) is 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. The authors also note that 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 note.

MacDonald (1986) state that after settlement the pueluri molt and transform into post-pueruli, a transitional phase between the pelagic phyllosama phase and the juvenile stage. Yoshimura and Yamakawa (1988) note that very little is known about the habitat requirements of Palinurid pueruli after settlement occurs. However, Pitcher (1993) states that the post-pueruli of *Panulirus penicillatus* has been observed inhabiting the same high-energy reef-front habitat as adults of the species. Studying the benthic ecology and habitat utilization of newly settled pueruli and juveniles of the Japanese spiny lobster (*P.*

japonicus), Yoshimura and Yamakawa (1988) conclude that microhabitats, such as small holes in rocks and boulders and algae, provide important habitat for the newly settled pueruli and juvenile lobsters. The Japanese spiny lobster is found inhabiting shallow waters at depths of 1-15 m on rocky bottom (FAO 1991).

The oceanographic and physiographic features that result in the retention of lobster larvae within the Hawaiian archipelago are not understood (WPRFMC 1983). Johnston (1968) suggests that fine-scale oceanographic features, such as eddies and currents, serve to retain phyllosoma larvae within the Hawaiian Island chain. In the NWHI, puerulus settlement appears to be linked to the north and southward shifts of the North Pacific Central Water (NPCW) type (MacDonald 1986). The relatively long pelagic larval phase for palinurids results in very wide dispersal of spiny lobster larvae; palinurid larvae are transported up to 2,000 miles by prevailing ocean currents (Johnston 1973, MacDonald 1986).

4.1.5 Habitat Description for Hawaiian Spiny Lobster (*Panulirus marginatus and Scyllarides squammosus*)

Management Plan and Area:
American Samoa, Guam, MHI, NWHI, Northern Mariana Islands, Johnston Atoll, Kingman Reef, Palmyra Atoll, Jarvis Island, Midway Island, Howland and Baker Islands and Wake Islands.

The Hawaiian spiny lobster, within the Council's jurisdiction is managed under the FEP for the Hawaiian Archipelago.

General Description and Life History
The Hawaiian spiny lobster (*Panuliris marginatus*) is endemic to the Hawaiian Islands and Johnston Atoll (Brock 1973, FAO 1991). The relative abundance of *P. marginatus* at Johnston Atoll is very low (Brock 1973). The spiny lobster is distributed throughout the entire NWHI, from Kure Atoll to Nihoa (Uchida 1986a). *P. marginatus* is the principal species landed in the NWHI spiny lobster fishery (WPRFMC.1983).The reported depth distribution of this species in the NWHI is 5-100 fm (WPRFMC 1983). While this species is found down to depths of 100 fm it usually inhabits shallower waters (FAO 1991). Uchida and Tagami (1984) report that *P. marginatus* is most abundant in waters of 90 m or less. Moffitt (1998, pers. comm.) states that spiny lobster are found in greatest abundance between the depths of 10-50 fm. At Maro Reef, in the NWHI, large adult spiny lobsters have been captured at depths as shallow as 10 feet (Moffitt 1998, pers comm.).

Uchida and Tagami (1984) note that within the NWHI, there is a dramatic shift between depth and relative abundance. They report that in the vicinity of the northern most islands and banks relative abundance of spiny lobsters was highest at depths of 19-54 m and that at the lower end of the chain the highest abundance of spiny lobsters were observed between 55-73 m. North of Maro Reef the highest relative abundance of spiny lobsters is found at shallower depths, they continue. They suggest that this variability may be due to differences in the temperature regime in the NWHI.

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 relationship between egg production, larval settlement, and stock recruitment are poorly understood (WPRFMC 1983).

<u>Egg and larval distribution</u>
The Hawaiian spiny lobster (*P. marginatus*) is dioecious (Uchida 1986a). The male spiny lobster deposits a spermatophore or sperm packet on the female's abdomen (WPRFMC 1983, Uchida 1986a). In *P. marginatus*, 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 for the female's oviduct, where they are then fertilized and attach to the setae of the female's pleopod (WPRFMC 1983). At this point the female lobster is ovigerous, or berried (WPRFMC 1983). The fertilized eggs hatch into phyllosoma larvae after 30-40 days (MacDonald 1986, Uchida 1986a).

The spawning season for *P. marginatus* varies throughout the Hawaiian Island chain (Uchida 1986a). In the northwestern end of the NWHI spawning occurs primarily during the early summer months (Uchida et al. 1980, Uchida, 1986a). MacDonald and Stimson (1980) found ovigerous females at Kure Atoll between the months of May to September. Uchida et al (1980) found the peak abundance of ovigerous female lobsters at Nihoa, French Frigate Shoals between late summer and early winter. It is believed that reproduction is nearly continuous in the warmer waters south of Maro Reef in the NWHI (WPRFMC 1983). Around the island of Oahu spawning occurs year-round (Uchida 1986a). In the MHI, peak spawning activity occurs between the months of May and August with a minimal amount of activity from November to January (Uchida 1986a). Egg-bearing females are found year-round in the MHI (WPRFMC 1983).

Spiny lobsters are very fecund (WPRFMC 1983). Honda (1980) found that fecundity increased with size. Most female spiny lobsters reach sexually maturity at 2 years of age (WPRFMC 1983). Estimating size at maturity for male and female spiny lobsters at Necker Island and Oahu, Prescott (19 *) concludes the Necker Island females reach sexual maturity at 60.7 mm, males at 59.2 mm, while Oahu females reach sexual maturity at 58.6 mm, males at 63.6 mm. At Necker Island the smallest mated lobster observed was 48.3 mm; it is not conclusive that the ovaries of females are mature at this size (Uchida and Tagami 1984). Growth rates for male spiny lobsters at Necker Island have been calculated as follows: 3.7 cm CL at 1 year, 5.7 cm at 2 years, 7.3 cm at 3 years, 8.5 cm at 4 years, 9.4 cm at 5 years and 10.1 cm in 6 years (Uchida 1986a). Due to insufficient data the growth of females has not been calculated (Uchida 1986a).

Larvae

After hatching, the larvae (or phyllosoma) enter a planktonic phase (WPRFMC 1983). The duration of this planktonic phase varies depending on the species and geographic region (WPRFMC 1983).Very little is known about the planktonic phase of the phyllosoma larvae of *P. marginatus* (Uchida et al.1980). The planktonic larval stage may last from 6 months to 1 year from the time of the hatching of the eggs (WPRFMC 1983, MacDonald 1986). There are 11 dissimilar stages of development that the phyllosoma larvae pass through before they transform into the postlarval puelurus phase (Johnson 1968, MacDonald 1986).

The pelagic phyllosoma stage of development is followed by the puerulus stage. Spiny lobster pueruli are free-swimming and actively migrate into shallow, near-shore waters in preparation for settlement (WPRFMC 1983, MacDonald 1986). The puelurus stage lasts 6 months or less (WPRFMC 1983). MacDonald and Stimson (1980) found pelagic, puerulus larvae settlement to occur at approximately 1 cm in length. After settlement the pueluri molt and transform into postpueruli, a transitional phase between the pelagic phyllosama phase and the juvenile stage (MacDonald 1986).

It is believed, that because of the endemic nature of *P. marginatus* in the Hawaiian archipelago, the resident population is the source of larval recruits (Uchida et al. 1983). Shaklee (1962) found no genetic variation within the various spiny lobster populations at the different islands and banks in the NWHI chain. These data suggest that a single stock of spiny lobster exists in the NWHI (WPRFMC 1983). Recruitment of puerulus lobster larvae occurred at Kure Atoll beginning in the spring and lasting to October; no recruitment occurred from October to March (MacDonald and Stimson 1980). The distribution of lobster larvae in the waters surrounding the banks and islands of the NWHI is patchy (Parrish and Polovina 1994). Settlement of palinurid larvae tends to be higher in the middle of the Hawaiian Island chain and higher in the NWHI than in the MHI (MacDonald, 1986).

There is evidence that the recruitment of puelerus lobster larvae is tied to the lunar phase with maximum recruitment occurring during the new moon and first quarter phases (MacDonald and Stimson 1980).

<u>Juvenile distribution</u>

Parrish and Polovina (1994) found that banks with summits deeper than 30 m had consistently lower catches of spiny lobster; six of eight banks surveyed with summits at depths greater then 30 m did not provide commercial quantities of spiny lobster. They suggest a depth threshold may prevent the successful settlement and/or survival of pueruli of the spiny lobster in commercial quantities at these banks.

Parrish and Polovina (1994) studied the production rates of three banks in the NWHI; two commercially productive banks, Maro Reef and Necker Island, and one commercially unproductive bank, Lisianski. In this study the percent coverage of the different substrate types were measured and classified into four habitat types. The intermediate relief habitat (5-30 cm) was found to support the highest abundance of juvenile lobsters. Based on the results of their analysis, Parrish and Polovina conclude that the intermediate relief habitat provides optimal habitat for juvenile spiny lobster.This intermediate relief habitat rarely exceeded 10 cm in height and was comprised of macroalgaes including *Dictopterus* sp., *Sargassum* sp. and *Padina* sp. Parrish and Polovina determined that a much greater proportion of intermediate substrate exists at the two productive banks studied, Maro Reef and Necker Island, than at the unproductive bank, Lisianski Island. They conclude that the amount of suitable habitat may be a factor limiting the total abundance of adult lobster production. The intermediate relief habitat provides suitable habitat for the settlement, survival and growth of *P. marginatus* pueruli and post pueruli. It does not provide enough structural relief to support a community of predatory reef fish, Parrish and Polovina note. Furthermore, they add, the lack of structural relief provides little shelter or protection for fish that forage on juvenile lobster from large piscovores such as sharks and jacks.

Parrish and Polovina (1994) describe the substrate of Necker Island and Maro Reef as predominantly comprised of intermediate relief algal communities. However, prolonged changes in water temperature could greatly modify the algal abundance, they note. The effects of such changes might include increased predation, reduced recruitment and reduced availability of food, they conclude.

Annual exploratory trapping surveys at Maro Reef in the NWHI have been conducted by NMFS since 1994. Haight (1998) explains that the survey was designed to identify juvenile spiny lobster habitat and determine abundance. Preliminary results of this survey indicate that the northwestern portion of Maro Reef supports higher concentrations of juvenile *P. marginatus* than are found at other sample stations within the reef. The northwest portion of the reef extends outward from the lagoon and as a result is exposed to greater wave action and currents than other areas of Maro Reef, Haight observes. The benthic habitat at the northwestern site (site 1) is distinctly different from that of other sites sampled within Maro Reef, he continues. Of particular note was the predominance of live coral colonies of *Acropora* and *Pocillopora* corals, he observes. However, colonies of *Acropora* sp. coral were not found at any of the stations sampled within the reef and are rarely found outside the reef (F. Parrish, unpub. data. in Haight 1998). Three other sites comprised of coral heads interspersed with barren sand patches and coral rubble were sampled during the survey, and the majority of spiny lobsters found at them were adults (Haight 1998). The specific ecological and physical mechanisms that are responsible for higher abundance of juvenile spiny lobster at the northwestern portion of Maro Reef need further study.

MacDonald and Stimson (1980) found juvenile spiny lobsters to exhibit a restricted home range, while adult spiny lobsters displayed a much wider home. Uchida and Tagami (1984) observed that 90 percent of recaptured adult spiny lobsters showed movement of 5 nmi or less, while MacDonald and Stimson (1980) found spiny lobsters had a dispersal rate that rarely exceeded several hundred m.

<u>Adult distribution</u>
Spiny lobsters are distributed throughout the NWHI, from Nihoa to Kure Atoll (WPRFMC 1983). The distribution of adult spiny lobsters is uneven throughout the NWHI chain. Research conducted prior to advent of commercial exploitation of spiny lobsters found the greatest abundance of lobsters at Necker and Maro Reef in the NWHI (Uchida et al. 1980, WPRFMC 1983). Surprisingly, the benthic habitat of Maro Reef differs markedly from bottom conditions found at Necker Island (Uchida et al 1980, WPRFMC 1983). The substrate at Necker Island is largely composed of coral interspersed with sandy areas and sandstone outcroppings. The bottom at Maro Reef is primarily

composed of coral rubble and sand, lacking the type of habitat features normally thought to be lobster habitat (WPRFMC 1983).

Uchida et al (1980) found significant differences in the average sizes among spiny lobsters populations at the various banks and islands they sampled. MacDonald and Stimson (1980) found there to be a seasonal variation in the size distribution of the spiny lobster population at Kure Atoll in the NWHI. Small lobsters were more abundant in the months of June to September while larger lobsters were found to be more abundant in January. These researchers found males to be more abundant than females throughout the year. Male spiny lobsters were also found to comprise the majority of individuals in the larger-sized class.

Spiny lobsters are nocturnal predators (FAO 1991). Spiny lobsters are regarded as omnivorous, opportunistic scavengers (Pitcher 1993). Food items reported from the diets of *Panulirus* sp. include echinoderms, crustaceans, molluscs (primarily gastropods) algae and seagrass (Pitcher 1993). The habitat description for *P. marginatus* is summarized in Table 1.

Table 17. Habitat Description for Hawaiian Spiny Lobster (*Panulirus marginatus*)

	Egg	Larvae	Juvenile	Adult
Duration	30B40 days.	Planktonic Phyllosoma stage (6B12 months), free-swimming pueruli stage (up to 6 months).	Not known	Not known
Diet	N/A	No information available	No information available	Diet of *Panulirus* sp. includes echinoderms, crustaceans, molluscs (primarily gastropods) algae and seagrass
Distribution	Release of phyllosoma larvae appears to be timed to coincide with the full moon and dawn (Pitcher 1993). In NWHI spawning takes place during summer months, in MHI spawning takes place year round.	In Hawaii, puerulus settlement occurrs primarily at the new moon and first quarter lunar phase (MacDonald 1986)	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.	
Location	female spiny lobster broods the eggs until they hatch	Puerulus larvae seem to have a low rate of settlement success and survival if summit of bank is deeper than 30 m.	Banks with summits deeper than 30 m support lower abundance of juvenile lobsters. The NW portion of Maro supports higher concentrations of juvenile lobsters.	NWHI, MHI, Johnston Atoll
Water Column	N/A	Pelagic - Palinurid larvae are transported great distances by the prevailing water currents, up to 2,000 miles	Benthic	Benthic

Bottom Type	N/A	N/A	Areas of intermediate relief habitat (5B30 cm) seems to provide optimal habitat for juveniles	Adults are typically found on rocky substrates in well protected areas, in crevices and under rocks.
Oceanic Features	female spiny lobster may move to areas of strong currents to release newly hatched larvae into the oceanic environment.	In the NWHI, settlement appears to be linked to the north and southward shifts of the North Pacific Central Water (NPCW) type.	No information available	No information available

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4.2 Life Histories and Habitat Descriptions for Other Crustacean Species

4.2.1 Habitat Description for Kona Crab (*Ranina ranina*)

<u>Management Plan and Area</u>

American Samoa, Guam, Main Hawaiian Islands (MHI), Northwestern Hawaiian Islands (NWHI), Commonwealth of the Northern Mariana Islands (NMI), Johnston Atoll, Kingman Reef, Palmyra Atoll, Jarvis Island, Howland and Baker Islands and Wake Islands.

Very little is known about the life history of *Ranina ranina*. The kona crab is found in the northwestern Hawaiian Islands (NWHI) 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 obtain 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 bacth of eggs hatch. Fertilization of the eggs occurs externally. The fertilized eggs adhere to the females numerous seatae (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. There is no directed fishery for kona crabs in the NWHI however 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.

<u>Egg and larval distribution</u>
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).

<u>Larvae</u>
Little is known about the plankton larval stage of kona crabs. The first molt occurs at 7-8 after hatching, the second molt about seven days later (Uchida, 1986).

<u>Juvenile distribution</u>
There is no information available concerning the distribution or habitat utilization patterns of juvenile kona crabs.

<u>Adult distribution</u>
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. It buries itself in the sand where it lies in waits for prey or food particles (Uchida, 1986).

The Council 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 Description for Kona Crab (*Ranina ranina*)

	Egg	**Larvae**	**Juvenile**	**Adult**
Duration	Approximately 29 days after fertilization	Little is known about the duration of the plankton larval stage of kona crabs. The first molt occurs at 7-8 after hatching, the second molt about seven days later.	Not known	No inforamtion available
Diet	N/A	Not known	Not known	Kona crabs are opportunistic carnivores that feed throughout the day. It buries itself in the sand where it lies in waits for prey or food particles
Distribution: General	Fertilization of the eggs	Little is known about	There is no information	Adult kona crabs are

and Seasonal	occurs externally. The fertilized eggs adhere to the females numerous seatae.	the plankton larval stage of kona crabs	available concerning the distribution or habitat utilization patterns of juvenile kona crabs	found inhabiting sandy bottom habitat at depths between 24 to 115 m.
Water Column	demersal	pelagic?	Demersal	demersal
Bottom Type	N/A	N/A	N/A	sandy bottom
Oceanic Features	N/A	Larvae are subject to advection by prevailing currents.	N/A	N/A

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4.2.2 Habitat description for *Panulirus penicillatus, P. versicolor, P.ornatus* and *P.longipes* in the Western Pacific Region

Management Plan and Area:
American Samoa, Guam, MHI, NWHI, Northern Mariana Islands, Johnston Atoll, Kingman Reef, Palmyra Atoll, Jarvis Island, Midway Island, Howland and Baker Islands and Wake Islands. The spiny lobsters, within the Council's jurisdiction are managed under the FMP for the Crustaceans of the Western Pacific Region. Some information is also provided on the slipper lobsters of the genus Parribacus, which was also observed in recent surveys in Americasn Samoa.

General Description and Life History
Scyllarids and palinurids are commonly considered to be opportunistic omnivorous i.e. they are able to feed on a wide range of food (Phillips et al., 1980). Chambers and Nunes (1975) indicated that the diet of *P. penicillatus* in American Samoa was "primarily, if not solely, algae". However, other studies showed that this species also feeds on Annelids Polychaetes, Mollusks (Gastropods and Bivalve), Crustaceans, and Echinoderms (George, 1972; Prescott in Pitcher, 1993). Whereas only a few studies have dealt with the slipper lobster diet, they showed similar patterns to that for spiny lobsters (Lau, 1987; Spanier, 1987). These organisms are are able to select their food according to availability and density. Thus, individuals of the same species but which are living in different areas can have different diets implying important differences in growth rates (Morgan, 1980; McKoy & Esterman, 1981; Edgar, 1990).

Lobsters, as other Crustaceans, increase in size by molting, while the growth of tissues (and thus the weight) is continuous. The growth rate decreases with age, and the inter-molt duration increases. During the molt, most of the calcified components are replaced. *P. penicillatus* is sexually dimorphic for size, with males reaching larger sizes than females. The largest males can weight 3 kg (6.5 Lb) for 16 cm (6 ¼ in) of Cephalothoracic (or Carapace) Length (CL: measured from the basis of the supraorbital spines to the end of the cephalothorax) (Richer de Forges & Laboute, 1995).

Reproduction

For crustaceans, the reproductive season is determined by photoperiod and luminosity (Lipcius & Cobb, 1994). As a result, lobsters from temperate and sub-tropical waters have only one spawning period (Chubb, 1994; Kittaka & MacDiarmid, 1994) whereas numerous tropical species are able to spawn nearly year-round, and some individuals are able to spawn several times in the same year (Berry, 1971; Moore & MacFarlane, 1984; Juinio, 1987). In Hawaii, 40 % of the *P. penicillatus* females are berried (with eggs under the abdomen) (McDonald, 1971, 1979) at any time, and some females spawn 2 or 3 times a year (Juinio, 1987; Plaut, 1993).

Fertilization is external (Lyons, 1970; Morgan, 1980); the male deposits a spermatophore, via paired penile projections at the base of the fifth walking legs, onto the female sternum. This spermatophoric mass becomes black and is butterfly-shaped for spiny lobsters and covers the two first pairs of pleopods in *Parribacus* spp. The female is then called 'tarred'. After a few days, the female spawns several thousands of oocytes from the paired gonopores situated at the base of the third walking legs, into a 'chamber' formed by curving the abdomen under the sternum. The female scrapes the spermatophore with special chelae (claws or pincher) on the dactyl (last segment) of the fifth walking legs, to release the sperm which fertilizes the oocytes during the transit (Berry, 1970; Lipcius & Herrnkind, 1987; Pitcher, 1993). The fertilized eggs adhere to the ovigerous setae of the internal part of the biramous pleopods (Berry, 1970) (see Appendix I). In the literature, the smallest *P. penicillatus* berried females measured from 4.08 cm of CL (1.6 inches) in Philippines (Juinio, 1987) to 6.20 cm (2.45 inches) in the Marshall Islands (Ebert & Ford, 1986). No information on any *Parribacus spp*. reproduction is available in the literature.

Eggs

Following courtship, several hundred thousand eggs are extruded from the paired gonopores at the base of the third walking legs into a chamber formed by curving the abdomenover the sternum. The eggs are carried under the tail of females for about a month before the phyllosoma larvae are released.

Larvae

After 1 to 9 weeks of incubation [20 to 35 days for *P. penicillatus* (Juinio, 1987; Plaut, 1993)], larvae are released in the field (George, 1958; Chittleborough, 1974, 1976; Nair et al., 1981; Pitcher, 1993). Among spiny lobsters, hatching always occurs in an area allowing the larvae to quickly drift offshore (Phillips & Sastry, 1980; Coutures, 2000b), which implies that sometimes there is migration from coastal to oceanic areas (Moore & MacFarlane, 1984; MacFarlane & Moore, 1986; Coutures, 2000b).

The larvae of Palinuroidea (spiny lobster or Palinuridae, slipper lobster or Scyllaridae, and Synaxidae or coral lobsters) is called phyllosoma (from Greek "phyllo" leaf, and "soma" body), a flat, transparent, leaf-like larva, which corresponds to the Crustacean zoea stage.

The outstanding feature in the life history of the Palinuroidea is the exceptional duration of their larval phase, which varies among spiny lobsters from 6 to 12 months according to the species (Phillips & Sastry, 1980; Booth & Phillips, 1994) and even 24 months for *Jasus edwardsii* (Lesser, 1978), a species occurring in New Zealand and South Australia, and from 1 to 9 months for slipper lobsters (Sims, 1965; Robertson, 1968a,b, 1969a,b; Takahashi & Saisho, 1978; Ito & Lucas, 1990; Marinovic et al., 1994; Mikami & Greenwood, 1997). During the larval phase, phyllosomata can travel great distances, e.g. Johnson (1974) caught one *Panulirus penicillatus* phyllosoma in the Pacific Ocean 3,700 km from the Galapagos Archipelago, which was the closest hatching site. Mechanisms allowing phyllosomata to come back to the coast have been shown only for a few species, especially for *Panulirus cygnus* in the southwest of Australia (see Pearce & Phillips, 1980; Phillips et al., 1991; Pearce et al., 1992). However, for species with a wide geographic distribution such as *P. penicillatus* and *P. parribacus*, the larval dispersion implies that recruits can come from adults living at great distances (Lyons, 1980, 1981; Menzies & Kerrigan, 1980). Oceanic currents and gyres seem important in the transport, and the dispersion, and thus, in the "oceanic routes" used by phyllosomata (Yeung & McGowan, 1991; Booth & Phillips, 1994).

During their larval development, phyllosomata increase in size and general shape through numerous molts. For the species studied, systematicians have described 7 to 12 larval stages which characterize the growth by appearance of anatomic features (e.g.: Stage I, 3 pairs of pereiopods, stage II: bud of the fourth one), and characteristic measurements (Phillips & Sastry, 1980).

The different larval stages of *P. penicillatus* have been described by Johnson (1968) and Michel (1969, 1971). The duration of the larval species has been estimated to be 7 - 8 months for this species (Johnson, 1971).

For *P. caledonicus*, stage I is the only stage to have been described so far with certainty (Coutures, 2001b). It must be noted that in the Pacific, Parribacus species form a complex including a widely distributed species – *P. antarcticus* – and 5 allopatric species (without overlap of their adult distributions). Larvae of this complex are very similar (Coutures, 2001b), and sometimes impossible to separate (Prasad & Tampi, 1960; Michel, 1971; Berry, 1974). Furthermore, some giant larvae – from 6.5 to 8 cm (2.55 to 3.14 inches) of total length, without pereiopods - have been caught in the Pacific, Indian, and Atlantic Oceans, that would correspond to the late-stage of *P. antarcticus* (Johnson, 1951; Robertson, 1968c).

When phyllosomata have reached the last larval stage, have enough body reserves, and may be after stimulation from a coastal signal (Booth, 1986; Phillips & McWilliam, 1986a; Booth & Phillips, 1994; McWilliam & Phillips, 1997), they metamorphose into post-larvae called nisto for slipper lobsters and puerulus for spiny lobsters (Lyons, 1970).

Juvenile distribution

Puerulus and nistos differ from juveniles by the absence of calcification and lack of pigmentation, except for the eyes and a few streaks and points on the antennas (Phillips & Sastry, 1980) (Figure 6). The carapace is smoother, pleopods bear long setae (Phillips & Penrose, 1985), the body is longer, antennas are longer (only for spiny lobsters), and sometimes they terminate in a spatula (Serfling & Ford, 1975; Briones-Fourzan) (Fig. 5). According to numerous authors (Serfling & Ford, 1975 ; Sweat, 1968; Witham et al., 1968; Phillips, 1972; Phillips & Olsen, 1975; Serfling & Ford, 1975; Phillips et al, 1978; Lyons, 1980; Calinski & Lyons, 1983; McDonald, 1986; Hayakawa et al., 1990; Coutures, 2000a, 2001a; Coutures & Chauvet, 2002), the behavior of pueruli and nistos would be to actively swim to benthic coastal habitats (with the aid of their pleopods) before settling onto the benthos. For example, the puerulus of *Panulirus cygnus* can swim from 20 to 60 km (12.5 to 37.5 miles) (Phillips & Penrose, 1985), in 5 to 15 days (Lemmens, 1994).

The post-larvae begins to be colored as soon as it settles on the bottom. The first molt occurs 8 to 10 days after settlement (Phillips & Sastry, 1980). Although it is not the case for all species, *Panulirus penicillatus* and *Parribacus caledonicus* settle in the same habitat as the adults (McDonald, 1971; Nunes & Chambers, 1975; Pitcher, 1992, 1993; Coutures, 2000a; Coutures et al., 2002), i.e. just in front of the breakers.

The puerulus of *Panulirus penicillatus* has been described by Michel (1971): it measures about 1 cm (0.4 inch) of CL. The nisto of *Parribacus caledonicus* has not been described yet but it is likely to be similar to congeners which reach sizes varying from 5 to 5.82 cm (2-2.3 inches) (Rathbun, 1903; Coutures et al., 2002).

Small juvenile *P. pencillatus* of this species have not been observed but it is assumed that they occupy the same habitat as the adults on the windward exposures of fringing rock or coarl reefs. *P. versicolor* juveniles inhabit inshore areas as well as the more typical adult reef. Post larvae are often seen under floating moorings and rafts. It is not known whether these lobster move to the reef successfully or whether they die.

Adult distribution

Virtually all shallow water habitats in the tropical western Pacific are occupied by one or more species of spiny lobster. Each species has a preferred habitat, however, there is a

Great deal of overlap and it is not uncommon to find 2-4 species cohabiting on a single reef in locations such as the south coast of Papua new Guinea. Certain species are more specific in their habitat requirements than others. The greatest constrats is perhaps between *P. ornatus* and *P.penicillatus*. *P ornatus* has been found from a depth of 100 fathoms on the outer slope of the Great Barrier Reef to areas with extremely high sediment load and reduced salinity near the mouth of the Fly River in Papua New Guinea. *P. penicillatus* is found across nearly a 60 degree range in latitude, from rocky shores to coral reefs, but with the common feature of clear oceanic waters and high energy wave action typical of windward exposures. This habitat is remarkably similar in terms of salinity, dissolved oxygen, and turbidity and the variability of these factors despite latitudinal changes.

The preferred habitat of *P. pencillatus* as discussed above is the windward exposures of fringing rock or coarl reefs. It shelters in deep recesses during the day at depths to ten meters and frequently much shallower than that. At night it forages over the reef face, crest and flats, thus exploiting a much larger habitat than where it shelters during the day. It is also common on leeward barrier reefs and in reef passages when there is sufficient water movement. The larvae likely settle in the adult habitat, settling in deep caves and crevices used by the adults to shelter in the day.

P. longipes is generally found in the lower energy zones behind the reef crest and at the lower boundary of the the distribution of *P. peniciullatus*, i.e. away from areas of intense wave action. *P. versicolor* dominates in still lower energy areas, frequently among live acroprora and other reef building coral. It is less cryptic than either *P. penicillatus* or *P. longipes* and can frequently be seen during the day in coral bommies or under plate corals. *P. versicolor* appears to be more tolerant of terrestrial influences than either *P. longipes* or *P. penicillatus* and can be found on reefs exposed ro high turbidity and reduced salinity.

P. ornatus is the most common in areas with a strong terrestrial influence. It is frequently found on lagoon bottoms and deep channels emanating from mangrove communities. In Papua New Guinea it makes a 500 km breeding migration, passing through a variety of habitats in its life cycle, but elsewhere in its distribution large scale migrations have not been noted, and it is likely more resident in one habitat. Some larval settlement is known to take place in its reef habitat.

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4.2.3 Habitat Description for *Heterocarpus* spp.

Deepwater caridean shrimp species of the genus *Heterocarpus* have been reported throughout tropical waters of the Pacific including, Hawaii (Clark 1972, Struhsaker and Aasted; 1974, Daley and Ralston 1986; Gooding et al. 1988; Tagami and Barrows 1988; Moffit and Parrish 1992; Ralston and Tagami 1992;), Guam (Wilder 1977), Western Samoa (King 1980), and the Northern Mariana Islands (Moffit 1983, Ralston 1986).

Eight species of *Hetercarpus* (*Heterocarpus ensiver, H. laevigatus, H. sibogae, H. gibbosus, H. Lepidus, H. dorsalis, H. tricarinatus and H. longirostris*) have been reported from U.S. Pacific Islands although two species – *Hetercarpus ensifer* and *H. laevigatus* – have been the predominate focus of commercial harvesting operations and scientific research surveys to date.

<u>Adult and Juvenile</u>

Adult *Heterocarpus* are generally found in benthic deepwater habitats between 200-900 meters in depth, primarily on steep outer reef slopes surrounding islands and deepwater banks. Their distribution tends to be stratified by depth with each species occupying different but often overlapping depth ranges (King and Moffit, 1984; Ralston 1986). However, because *Heterocarpus* are found at such deep depths, accurate description and characterization of preferred habitat types are difficult to obtain and virtually non-existent for all but a few select locations in Hawaii.

Hawaii

Around Hawaii, *Heterocarpus laevigatus* and *H. ensifer* have been reported from both the Main Hawaiian Islands and the Northwestern Hawaiian Islands (Gooding 1984; Daley and Ralston 1986; Ralston and Tagami 1992; Moffit and Parrish 1992). Submersible surveys of shrimp densities on different habitats in the Main Hawaiian Islands reported *Heterocarpus* *ensifer* tended to group around large anemones and other benthic relief over an otherwise flat, sandy bottom (Gooding et. al., 1988; Moffitt and Parrish, 1992). Conversely, *Heterocarpus laevigatus* were observed as solitary individuals and had greater densities on volcanic substrata compared to coralline substrata (Moffitt and Parrish, 1992). However, Moffit and Parrish (1992) also suggest bottom slope, substrate complexity, stability, current patterns and other aspects may be of considerable importance to both *Hetercarpus ensiver* and *H. laevigatus.*

In terms of habitat related abundance, trapping surveys in the Main Hawaiian Islands report that the exploitable biomass of *H. laevigatus* was greatest at 460- 640 meters and negligible amounts occurred shallower than 350 meters or deeper than 830 meters (Ralston and Tagami, 1992). In the NWHI, highest catch rates for *H. laevigatus* were made between 500 and 800 meters while the highest catch rates for *H. ensifer* occurred between 350 and 600 meters (Gooding 1984).

Mariana Archipelago

In the Mariana Archipelago, shrimp trapping surveys conducted at 22 islands and banks between 1982 and 1984 reported the presence of all eight species of *Heterocarpus*. During these surveys, *Heterocarpus ensifer, H. laevigatus* and *H. longirostris* accounted for 99 percent of the catch while *H. tricarinatus, H. gibbosus* and *H. sibogae* were reportedly rare (Moffit and Polovina 1987). Maximum catch rates for *H. ensifer* occurred at a depth of 366 meters, *H. laevigatus* – between 549 and 777 meters and H. longirostris at 777 meters. Wilder (1977) reported similar findings for *H. ensifer* and *H. laevigatus* in Guam. Specific descriptions on habitat types were not reported in these surveys.

American Samoa

Currently, there is no information on *Hetercarpus* for American Samoa. However, King (1980) reported that trapping surveys on steep slopes between 250 and 700 m in Western Samoa yielded six species of carid shrimp with *Hetercarpus ensifer* and *Heterocarpus laevigatus* possessing the greatest commercial potential. Because American Samoa and Western Samoa are distinct only by their political status, it can be inferred that *Heterocarpus* are present and distributed at similar depths on steep slopes surrounding the islands and banks of American Samoa.

U.S. Pacific Remote Island Areas

There have been no surveys of deepwater caridean shrimps conducted in any of the U.S. Pacific Remote Island Areas of Howland, Baker, and Jarvis Islands, Johnston and Palmyra Atoll or Kingman Reef. However, *Hetercarpus ensifer, H. laevigatus* and *H. gibbosus* have been reported from the Northern Gilbert Islands, Kiribati, which is at the same latitude and roughly 800 miles west of Howland and Jarvis Islands (Crutz and Preston 1987). Due to their distribution throughout the tropical pacific islands, it may be inferred that *Heterocarpus* resources are likely to be present at similar depth ranges throughout the U.S. Pacific Remote Island Areas.

Eggs and Larvae

The relationship between habitat and egg production, larval settlement and stock recruitment for *Hetercarpus* is extremely limited. Studies by King and Moffit (1984) and Moffit and Polovina (1987) have reported that deepwater caridean shrimps have separate sexes which can be determined by examining the shapes of the first endopods of the first pleopods or swimming legs. In the male sex, the endopod is broader and more leaf shape than in females. Additionally, on the second pleopod, males posses both an appendix interna and an appendix masculine whereas, the latter is absent in females. Like most shrimps, eggs of caridean deepwater shrimps are carried externally on the pleopods of ovigerous females. King (1983) estimates larger species of *Hetercarpus* may carry over 30,000 eggs.

In Hawaii, there is some evidence to suggest that mature male and female of *Hetercarpus laevigatus* move to deeper waters (between 550-700 meters) when females are ovigerous, indicating that deeper depths are of some importance during this life stage (Daley and Ralston, 1986). It is not known if eggs have a pelagic or epipelagic life cycle although, Daley and Ralston (1986) conclude that females apparently settle in deep water and migrate gradually to shallower depths as they grow.

Reproduction, Growth and Mortality (by island area if possible)

The available literature on the reproductive biology, growth and mortality of deepwater caridean shrimps in the Western Pacific Region is limited, and primarily restricted to *H. ensifer* and *H. laevigatus* and to an even lesser degree, *H. longirostris.*

Heterocarpus Laevigatus

Female *H. laevigatus* reaches sexual maturity between 40 and 43 cm (King, 1983; Daley and Ralston, 1986; Moffit and Polovina, 1987). In Hawaii, over 50% of *H. laevigatus* bear eggs from October to January suggesting that reproduction of this species occurs during the fall and winter seasons (Daley and Ralsoton, 1986). Moffit and Polovina (1987) reported the corresponding time periods in the Northern Mariana Islands was November – February, while similar, but more narrowly defined breeding seasons were reported by Wilder (1977) in Guam. King (1983) reports that in Fiji, egg bearing females were observed in the months of April, June and July. Based on this information, spawning season of *H. laevigatus* appears to be during the winter season of each hemisphere.

<u>*Heterocarpus ensifer*</u>

In Hawaii, H. ensifer is recruited into the fishery at 23 cm

In Mariana H. ensifer lenth at maturity is 20.2 mm (Moffit and Polovina, 1987)

For H. ensifer, Moffit and Polovina (1987) found that peak breeding season occur in both December and May

(Moffit and Polovina, 1987) found that

- length at maturity is 20.2 mm
- females become sexually mature at 40 mm
- believe males become sexually mature at age 3 when they are 37-38 mm CL
- suggest spatial heterogeneity between sexes, with female abundance diminish as depth increases
- H. longirostris become sexually mature at 34 cm

<u>Length at recruitment (info from all areas)</u>

- Growth parameters
  - Size/length species is recruited into the fishery
  - Size at maturity

H. ensifer is recruited into the fishery at 23 cm (Moffitt and Polovina, 1987)

For female HL, length at recruitment into the fishery at 29 cm (Moffitt and Polovina, 1987) or 2 years of age

H. longirostris is recruited into the fishery at 34 cm (Moffitt and Polovina, 1987)

Length at maturity for H. ensifer is 20.2 mm (Moffitt and Polovina, 1987)

Length at mortality is 23.9 mm

Length at maturity for male H. laevigatus is 35.7; female 40 mm (Moffitt and Polovina, 1987)

Length at mortality 42.7mm

Length at maturity for H. longstrosis is 31 mm (Moffitt and Polovina, 1987)

Length at mortality is 37.4

Unlike shallow-water penaeid shrimps, pandalid shrimps have lifespans in excess of a year, and some species such as *H. laevigatus*, may have life spans of up to 8 years. King (1993) suggests that the natural mortality rates of *H. laevigatus* is about 50% per year. King (1993) reports that *H. laevigatus* matures at about 75% of its maximum size or between 4-5 years old.

Sub-artic pandalid shrimps have been suggested to be protandrous hermaphradites (Butler 1964), which means being male for the first few years of life and then changing to female for the last year or two of life. However, measuring the length of male appendage of several species of *Heterocarpus* in the Mariana Archipelago, Moffit and Polovina (1987) found that length of the male appendage increased with carapace length, which suggests that tropical deep water shrimp may not be protandrous hermaphradites. Observations by Dailey & Ralston (1986) suggest that *Heterocarpus.* shrimps may be semelparous, i.e. reproducing only once in their lifetime then dying thereafter. In the Mariana Archipelago, the length at maturity for *H. ensifer* was calculated at 22.2 mm, 35.7 mm for *H. laevigatus*, and 31 mm for *H. longirostris* (Moffit and Polovina 1987).

<u>Description of male and female physiology</u>
Studies on male and female caridean shimps have shown that tropical deepwater species have separate sexes (King and Moffit 1984; Moffit and Polovina 1987). The sexes can be differentiated by the shape of the endopods and its first pleopods. Males have a broader endopod than females, and have an appendix masculine situated between the appendix interna nad the endopod of the second pleopod. Females carry their eggs externally on their pleopods and the number of eggs that they carry can be greater than 30,000 in *Heterocarpus* species (King and Butler 1985).

Males grow faster while experiencing a grater total mortality and smaller size than females (Dailey and Ralston 1986). Young females may move from deep to shallow water as they mature. Mature *H. laevigatus* in Hawaii may migrate seasonally (Dailey and Ralston 1986).

<u>Spawning seasons if known</u>
In Hawaii, *Heterocarpus spp.* reproduce in the fall and winter months October to January, which is the opposite of other crustaceans in Hawaii that reproduce in the spring and summer seasons (Dailey and Ralston 1986). Similarly, *H. laevigatus* in Guam has an ovigerous peak in the winter months of November to February (Wilder 1977; Moffit and Polovina 1987). Incidences of ovigerous females have been reported in Fiji from April to July, concluding that there appears to be a spawning season coinciding with the winter season of each hemisphere (King 1983).

Estimates of natural mortality rates

In the Marianas archipelago, the natural mortality of *Heterocarpus* is estimated to be 0.75 yr^{-1} (Moffit and Polovina 1987).

Trophic Relationships

King (1983) reported heterocarpus found in stomachs of tuna in Fiji, indicating some vertical migration.

[Add information from sources listed on pink reference paper]

In summary, available evidence suggests that H. ensifer is not a major prey item for either tuna or commercial bottomfish. Tuna feed in the surface and midwater zones and would encounter *Hetercarpus ensifer* only during its pelagic stage. Upon settlement, H. ensifer inhabits depths <300m while commercial bottomfish tends to occur >300 m.

Diet and trophic relationships.

King (1993) notes that *H. sibogae* feeds on other demersal crustaceans, fish, foraminiferans, and even small, midwater squid. Little is known of the trophic relationships of deepwater shrimps. Pandalid shrimps have been observed in fishes as diverse as obligate demersal deepslope snappers and even open ocean pelagic tunas, however available evidence suggests that *Heterocarpus ensifer* is not a major prey item for either tunas or commercial bottomfish. Research conducted on the stomach contents of the Hapuupuu, Seale's grouper, (*Epinephelus uernus*) and Butaguchi, or pig ulua, (*Pseudocarnax dentex*) found that pandalid shrimps may be of major importance to hapuupuu, but only *Plesionika longirostris* was identified to species (Seki 1984). A study by Kami (1973) lists shrimp as being present in the stomach contents of *Pristipomoides sieboldii* (Von sieboldi's snapper or Kalekale), though it was not identified to the family level. This study also found that shrimps were not present in the stomachs of *P. auricilla* (goldflag jobfish), *P. filamentosus* (pink snapper or Opakapaka) or *P. flavipinnis* (golden eye jobfish). A study on Kahala (*Seriola dumerili*) by Humpreys and Kramer (1984) found that crustaceans formed only 1-4% of the stomach contents, with only *Plesionika longirostris* and *Heterocarpus ensifer* identified. Pandalid shrimps have not been identified in yellowfin, bigeye, or albacore tuna in any of the studies, while only one individual pandalid (*Heterocarpus ensifer*) was identified in the stomach contents of a skipjack tuna out of 707 fish studied.

5 Coral Reef Ecosystem Management Unit Species

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.

5.1 EFH for Management Unit Species - Fish

5.1.1 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.

<u>Trophic ecology</u>

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.

<u>Pacific fisheries</u>
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 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.

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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Table 18. 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 tide

5.1.2 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 30B65 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.

<u>Trophic ecology</u>
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.

<u>Reproductive ecology</u>
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, 1B5 pups; *Carcharhinus albimarginatus* - 12 mths, 1B11 pups; *C. amblyrhynchos* - about 12 mths, 1B6 pups; *C. falciformis* - 2B14 pups; *C. galapagensis* - 6B16 pups; *C. melanopterus* - 8B9 mths, 2B4 pups; *Galeocerdo cuvier* - 12B13 mths, 10B82 pups; *C. plumbeus* - 8B12 mths, 1B14 pups, *Negaprion acutidens* - 1B11 pups; *Sphyrna lewini* - 15B31 pups; and *S. mokorran* - 13B42 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* - 205B239 cm for males and 215B245 cm for females, *C. melanopterus* - 131B178 cm for males and 144B183 cm for females, *G. cuvier* - 226B290 cm for males and 250B350 cm for females, C. plumbeus - 131B178 cm for males and 144B183 cm for females, *S. lewini* - 140B165 cm for males and about 212 cm for females, and *S. zygaena* - about 210B240 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 JuneBAugust 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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Table 19. Management Unit Species: Carcharhinidae, Sphyrnidae (sharks)

	Gestation	Juvenile	Adult
Duration	about 12 months	to 5B10 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, 1B275 m	inshore benthic, neritic to epipelagic, mesopelagic. 1B275 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

5.1.3 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.

<u>Dasyatidae</u>

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.

<u>Myliobatidae</u>

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 is 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.

<u>Mobulidae</u>

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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Table 20. 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

5.1.4 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 7B53 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 3B5 months for moringuids (Castle 1979), 6B10 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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Table 21. Muraenidae, Chlopsidae, Congridae, Moringuidae, Ophichthidae (eels)

	Egg	**Larvae**	**Juvenile**	**Adult**
Duration	100 hours or more	3B10 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				

5.1.5 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 (0.8B1.6 mm). Eggs of *Encrasicholina, Engraulis* and *Stolephorus* are ovate to elliptical and vary from small to large (0.8B2.3 x 0.5B0.8 mm) (Zhang et al 1982, Fukuhara 1983, McGowan and Berry 1984, Ikeda and Mito 1988). Larvae hatch at 2.5B3.7 mm. The size of the largest pelagic specimen examined by Leis and Trnski (1989) was 23B27 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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Table 22. 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		

5.1.6 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 (0.8B2.1 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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Table 23. 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; 0B20 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

5.1.7 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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Table 24. 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; 1B130 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	subject to advection		

	by ocean currents	by ocean currents	

5.1.8 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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Table 25. Management Unit Species: Anomalopidae (flashlightfishes)

	Egg	Larvae	Juvenile	Adult
Duration		hatch at a size of 2.6B3.3 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; 5B400 m
Bottom type		N/A	coral reef	coral reef
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

5.1.9 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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Table 26. 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 AprilBMay and another in Sept. for *M. amaena* at Johnston Atoll	generally, a recruitment peak in June-July and another in Feb.BMarch, 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		

5.1.10 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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Table 27. 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; 1B122 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		

5.1.11 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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Table 28. Management Unit Species: Fistularidae (cornetfish)

	Egg	Larvae	Juvenile	Adult
Duration	4 B7 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; 1B128 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		

5.1.12 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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Table 29. 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		

5.1.13 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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Table 30. 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; 0B100m 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		

5.1.14 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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Table 31. 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		

5.1.15 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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Table 32. Management Unit Species: Scorpaenidae (scorpionfishes)

	Egg	Larvae	Juvenile	Adult
Duration	little information, but 58-72 hrs for *Scorpaena guttata* (David 1939)		2B3 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; 0B100m 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		

5.1.16 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 substrates from the shore to 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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Table 33.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

5.1.17 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 12.6B14.5 mm (Leis and Rennis 1983).

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Table 34. 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; 1B150 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		

5.1.18 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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Table 35. 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; 3B45 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		

5.1.19 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 5B8 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 29EC. 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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Table 36. Management Unit Species: Pseudochromidae (dottybacks)

	Egg	**Larvae**	**Juvenile**	**Adult**
Duration	3B5 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; 0B100m	demersal; 0B100m
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		

5.1.20 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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Table 37. Management Unit Species: Acanthoclinidae (spiny basslets)

	Egg	**Larvae**	**Juvenile**	**Adult**
Duration	3B16 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; 1B65 m	reef-associated; 1B65 m
Bottom type			coral or rock shelter	coral or rock shelter
Oceanic features		subject to advection by ocean currents		

5.1.21 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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Table 38. 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		

5.1.22 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 were 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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Table 39. Management Unit Species: Apogonidae (Cardinalfishes)

	Egg	**Larvae**	**Juvenile**	**Adult**
Duration	2B8 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; 1B80 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				

5.1.23 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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Table 40. 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		

5.1.24 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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Table 41. 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		

5.1.25 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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Table 42. 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	subject to advection by		

	Egg	Larvae	Juvenile	Adult
	by ocean currents	ocean currents		

5.1.26 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 CE (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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Table 43. 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

5.1.27 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.

Table 44. Management Unit: Decapturus/Selar (scads)

	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

5.1.28 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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Table 45. 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	subject to advection		

	Egg	**Larvae**	**Juvenile**	**Adult**
	ocean currents	by ocean currents		

5.1.29 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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Table 46. Management Unit Species: Haemulidae (sweetlips and grunts)

	Egg	**Larvae**	**Juvenile**	**Adult**
Duration	approximately 24 hrs	15 days to months	from 6 mm until 12B24 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; 1B100m
Bottom type	N/A	N/A	sandy to muddy bottoms, coral, rocky ledges or	sandy to muddy bottoms, coral, rocky ledges or table corals

	Egg	Larvae	Juvenile	Adult
Duration	approximately 24 hrs	15 days to months	from 6 mm until 12B24 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
			table corals	
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents		

5.1.30 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.

Table 47. 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

5.1.31 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 (L4) 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_4 (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_4). Onaga reaches sexual maturity at 61 cm FL (62% L_4) (Everson et al. 1989). In the NWHI, ehu reaches maturity at about 30 cm FL (46% L_4) and opakapaka reaches maturity at around 43 cm FL (48% L_4) (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.

Table 48. 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

5.1.32 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 40B60 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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Table 49. 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

	Egg	Larvae	Juvenile	Adult
Oceanic features	subject to advection by ocean currents	subject to advection by ocean currents	unknown	spawning aggregations near channels with heavy tidal flow

5.1.33 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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Table 50. 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		

5.1.34 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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Table 51. 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		

5.1.35 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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Table 52. 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		

5.1.36 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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Table 53. Management Unit Species: Chaetodontidae (butterflyfishes)

	Egg	**Larvae**	**Juvenile**	**Adult**
Duration	2 days	several weeks to a few months	1B2 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)	10B25 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 CJanuary 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; 1B100 m, as deep as 172 m	demersal and mid-water column; 1B100 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 uponB*C. trifascialis* and *Acropora*, for example (Reese 1981)
Oceanic features	subject to dispersal by currents	subject to dispersal by currents		

5.1.37 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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Table 54. Management Unit Species: Pomacanthidae (angelfishes)

	Egg	**Larvae**	**Juvenile**	**Adult**
Duration	12B24 hrs	17B39 days	1B2 yrs	10B26 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 3B9 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 2B30 m but some species over 100 m deep	demersal and mid-water column, mostly 2B30 m but some species over 100 m deep

	Egg	**Larvae**	**Juvenile**	**Adult**
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		

5.1.38 *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. 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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Table 55. 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

	Egg	**Larvae**	**Juvenile**	**Adult**
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

5.1.39 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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Table 56. Management Unit Species: Pomacentridae (damselfishes)

	Egg	Larvae	Juvenile	Adult
Duration	2B4 days for most species, but up to 14 days for anemonefish	2B3 weeks for most species, but ranging from 7-47 days	1B2 years	6B8 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 0B20 m, but some deeper than	demersal and mid-water column, most within 0B20 m, but some

	Egg	**Larvae**	**Juvenile**	**Adult**
Duration	2B4 days for most species, but up to 14 days for anemonefish	2B3 weeks for most species, but ranging from 7-47 days	1B2 years	6B8 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
			100 m	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		

5.1.40 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 is 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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Table 57. 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)cleanersCsee 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; 1B200 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)

5.1.41 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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Table 58. 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		

5.1.42 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 most 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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Table 59. 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 8B12 years, medium size-6B9 years, large size-20B25+years
Diet	N/A	copepods, nauplii, bivalve larvae (Houde and Lovdal 1984)	carniverous for 1 month, gradually becoming herbivorous (Horn 1989, Bellwood 1988)	algaeCusually 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,

	Egg	Larvae	Juvenile	Adult
				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

5.1.43 *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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Table 60. Management Unit Species: *Bolbometopon muricatum* (bumphead parrotfish)

	Egg	**Larvae**	**Juvenile**	**Adult**
Duration	25 hours	30B50 days		20B25+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

	Egg	Larvae	Juvenile	Adult
Oceanic features	advection by ocean currents	advection by ocean currents		

5.1.44 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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Table 61. 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	0B100 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		

5.1.45 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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Table 62. 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		

5.1.46 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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Table 63. 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 1B50 m, but some deeper	demersal; most within 1B50 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		

5.1.47 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 female’s 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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Table 64. 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	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

	Egg	Larvae	Juvenile	Adult
			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		

5.1.48 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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Table 65. 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
			coral reef, sand,	

	Egg	Larvae	Juvenile	Adult
Bottom type	coral, rock, sponge	N/A	mud, rubble or seagrass	coral reef, sand, mud, rubble or seagrass
Oceanic features		subject to advection by ocean currents		

5.1.49 *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 Hawaii, Kawaihae, Kona and Milolii (Clark and Gulko 1999).

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Table 66. 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		

	Egg	Larvae	Juvenile	Adult
		currents		

5.1.50 Zanclidae (Moorish idol)

This family consists 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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Table 67. 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				

5.1.51 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 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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Table 68. 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	some pair-forming species are sedentary in the branches

	Egg	**Larvae**	**Juvenile**	**Adult**
			estuarine species	of Acropora corals; most range over many bottom types
Oceanic features	ocean currents	ocean currents		

5.1.52 *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 vulnerrability 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 10EN and 20ES, 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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Table 69. 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 10EN and 20ES, 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

	Egg	Larvae	Juvenile	Adult
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

5.1.53 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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Table 70. 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				

5.1.54 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 drabber. 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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Table 71. 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

	Egg	**Larvae**	**Juvenile**	**Adult**
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		

5.1.55 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 27.5EC. 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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Table 72. 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

	Egg	Larvae	Juvenile	Adult
Oceanic features	subject to advection by prevailing currents	subject to advection by prevailing currents		

5.1.56 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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Table 73. 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

	Egg	**Larvae**	**Juvenile**	**Adult**
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		

5.2 EFH for Management Unit Species - Invertebrates

5.2.1 Cephalopods

General Description of the Taxon[i]

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 Apen@ or gladius, while in cuttlefish the internal shell, the sepion, is thicker and calcareous. In certain generaC*Nautilus, Spirula,* and *Sepia*Cthe gas-filled chambers of their 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[2] 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 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

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).

No reports.

5.2.2 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 comprise 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 resembles 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,[3] 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 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.[4] 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

[3] In some countries, certain larger species are consumed as a food item.

[4] Biological Resources Division, US Geological Service, Nonindigenous Tunicate Information Website.

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)
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.

5.2.3 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

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[5] were found to occur 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).

[5] *Aetea recta, Bowerbankia gracilis, B. imbricata, Bugula stolonifera, B. neritina, Hippopodina feegeensis, Savignyella lafonti, Schizoporella unicornis, Zoobotryon verticillatum, Scrupocellaria sinuosa, Cryptosula pallasiana*, *Tryptostega venusta*, and *Watersipora edmondsoni*.

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.[6] 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.

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

[6] U. of California, Berkeley: Bryozoan Internet website.

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).

5.2.4 Crustaceans

5.2.4.1 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*) (Table 88). The present discussion will provide further information on other decapod taxa, and summarize the information contained in Amendment 10 on lobsters and Kona crab.

5.2.4.2 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).

5.2.4.3 Decapoda: Shrimps, Lobsters, and Crabs

<u>Introduction</u>

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 83.

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 (Tables 84-87).

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 Agalleries,@ 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:[7] 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 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

[7] Family name nomenclature is updated.

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).

<u>Crabs (True Crabs and Hermit Crabs): Infraorders Brachyura and Anomura</u>

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).

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

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).

Table 74. Summary of post-embryonic development and larval types in Decapoda.[8]

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)

[8] After Waterman and Chace (T. H. Waterman [ed.]: Physiology of Crustacea, Vol. 1) *in* Barnes 1987.

Infraorder Brachyura	metamorphic	zoea > megalopa (postlarva)

Table 75. Habitat description for Cephalopods (Class Cephalopoda).

	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	interidal, high subtidal (e.g., octopods, *Euprymna*); mesopelagic (squids, cuttlefishes);

	Egg	Larvae	Juvenile	Adult
			existence; other octopod species may not have planktonic phase juveniles of other cephalopods generally have a planktonic phase	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 76. Habitat description for Tunicates (Class Ascideacea).

	Egg	Larvae	Juvenile	Adult
Duration	solitary forms release eggs to the water; in colonial forms, fertilization is internal and larvae, not eggs are released	Atadpole@ 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	N/A	adults filter-feed non-selectively on phytoplankton and other suspended food particles and nutrients

	Egg	Larvae	Juvenile	Adult
		food source		
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 77. Habitat description for Bryozoans (Phylum Bryozoa or Ectoprocta).

	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; Anon-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 78. Habitat description for Crustaceans (Class Malacostraca [in part]).[9]

	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	up to six years (in coconut crab)	most species several years; up to 50 years in coconut crab

	Egg	Larvae	Juvenile	Adult
		phase, develop into megalops and glaucothöe postlarvae, respectively		
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

	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

[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.

Table 79. Economic importance of invertebrates.

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[10]	!	!	A	!

[10] all invertebrates regulated (for export)

shrimps	!	!			A	! R[1]	!	!	!	!
lobsters	!	L			!	! R	! R	! R	! R	!
crabs	!	L			!	! R[1]	! R[11]	! R[12]	! R	!

L = Limited Use

A = Assumed to be Present; R = Regulated

[11] coconut crab

[12] blue crab, Samoan crab

5.2.5 Bibliography

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5.3 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. Tables 89 to 92 summarize the various aspects of EFH for algae in the Western Pacific Region.

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 includes 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.

<u>The Management Unit Species (MUS): An Ecosystem Approach</u>

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.

5.3.1 Algae

5.3.1.1 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 80. 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.

5.3.1.2 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 81. Algae distribution in 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
NWHI	0	43	32	121	196
Wake Island	2	8	10	3	23
CNMI	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

<u>Comments</u>
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 82. Most commonly reported algal 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

Class	Most common species	Typical reef habitat
	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).

5.3.1.3 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).

5.3.1.4 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.

5.3.1.5 Bibliography

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Table 83. 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

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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
Hormothamnion solutum					X							X
Hydrocoleum lyngbyaceum							X					
Hyella caespitosa	X											
Isactis plana							X					
Lyngbya aestuarii					X		X					

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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					

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Microcoleus lyngbyaceus	X										X	X
Microcoleus tenerrimus							X					
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

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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
Spirulina tenerrima							X					
Symploca atlantica							X					
Symploca hydnoides	X				X			X				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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							

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Avrainvillea obscura											X	X
Avrainvillea pacifica												X
Boergesenia forbesii											X	X
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

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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
Caulerpa okamurai											X	X
Caulerpa peltata	X								X	X	X	X

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
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

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Chaetomorpha restricta	X											
Chamaedoris orientalis												X
Chlorodesmis fastigiata	X											X
Chlorodesmis hildebrandtii					X			X	X		X	X
Cladophora crystallina					X		X					
Cladophora fascicularis								X				
Cladophora glomerata	X											
Cladophora inserta					X							
Cladophora patentiramea					X							X
Cladophora patula								X				
Cladophora pinniger	X											
Cladophora socialis					X				X			

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
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					

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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
Enteromorpha flexuosa	X											
Enteromorpha intestinalis	X				X			X	X			
Enteromorpha kylinii		X			X		X					
Enteromorpha prolifera	X											
Enteromorpha tubulosa					X				X			

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Halimeda lacunalis											X	
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

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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
Pseudobryopsis oahuensis								X				
Pseudochlorodesmis furcellata											X	X
Pseudochlorodesmis parva							X					
Rhipidosiphon javensis								X	X		X	

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
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

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Tydemannia expeditionis	X										X	X
Udotea argentea											X	X
Udotea indica											X	
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

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
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		
Dictyopteris repens	X								X	X	X	X
Dictyota acutiloba								X	X			

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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		

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Dilophus radicans												X
Ectocarpus vanbosseae	X											
Ectocarpus sp.					X		X					
Endarachne binghamiae								X				
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	

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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
Padina pavonia								X		X		X

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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			

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Sargassum microphyllum											X	
Sargassum obtusifolium								X	X			
Sargassum piluliferum									X			
Sargassum polycystum												X
Sargassum polyphyllum								X	X			
Sargassum tenerrimum												X
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

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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
Actinotrichia robusta											X	
Aglaothamnion boergesenii								X		X		
Aglaothamnion cordatum								X	X			
Ahnfeltiopsis concinna								X				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Amphiroa valonioides								X				
Amphiroa sp.							X					
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			

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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			
Bostrychia tenella	X											
Botryocladia skottsbergii								X			X	
Botryocladia tenuissima								X				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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				

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Centroceras minutum					X			X				X
Ceramium aduncum								X				
Ceramium affine							X		X			
Ceramium borneense								X				
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					

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
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							
Ceramium tenuissimum								X				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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											

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Chondracanthus acicularis								X				
Chondracanthus tenellus								X				
Chondria arcuata								X				
Chondria dangeardii								X				
Chondria minutula								X				
Chondria polyrhiza								X				
Chondria simpliciuscula								X				
Chondria repens					X		X		X			
Chondria sp.									X			
Chondria sp. 1									X			
Chondria sp. 2									X			

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Dasya adhaerens							X					
Dasya bailouvianna									X			
Dasya corymbifera									X			
Dasya kristeniae								X				
Dasya murrayana								X				
Dasya pilosa								X				
Dasya sinicola							X					
Dasya villosa									X			
Dasya sp.							X	X				
Dasyopsis sp.								X				
Dasyphila plumarioides												X
Delesseriopsis elegans								X				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Dudresnaya sp.									X			
Erythrocladia irregularis					X							
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				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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	
Galaxaura pacifica									X		X	
Galaxaura rugosa	X							X	X		X	
Galaxaura subfructiculosa											X	

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Gelidiopsis acrocarpa												X
Gelidiopsis intricata	X				X			X	X		X	X
Gelidiopsis pannosa											X	X
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											

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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							
Gracilaria abbottiana								X				
Gracilaria arcuata												X

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Gracilaria radicans												X
Gracilaria parvispora								X				
Gracilaria salicornia								X				X
Gracilaria tikvahiae								X				
Gracilaria verrucosa												X
Grateloupia filicina								X				
Grateloupia hawaiiana								X				
Grateloupia phuquocensis								X				
Griffithsia heteromorpha								X				
Griffithsia metcalfii							X	X				
Griffithsia ovalis							X					
Griffithsia schousboei								X				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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
Herposiphonia variabilis								X				X
Herposiphonia sp.							X		X			
Heterosiphonia crispella					X		X	X	X			
Heteroderma subtilissima					X							
Heteroderma sp.					X							

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Hypnea sp.		X										
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			

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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				
Jania radiata												X
Jania tenella					X						X	X
Jania ungulata									X			
Jania verrucosa								X				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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				

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Laurencia forsteri								X				
Laurencia galtsoffii								X	X			
Laurencia glandulifera								X				
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			

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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				
Laurencia sp.					X		X		X			X
Laurencia sp. 1									X			

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Liagora farinosa									X			
Liagora hawaiiana								X	X			
Liagora hirta	X											
Liagora kahukuana									X			
Liagora orientalis								X	X			
Liagora papenfussii								X	X			
Liagora perennis												
Liagora pinnata								X				
Liagora samaensis								X				
Liagora robusta									X			
Liagora setchellii								X	X			

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
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											
Lithothamnion asperulum												X

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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											

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Lophosiphonia prostrata								X				
Lophosiphonia scopulorum					X							
Lophosiphonia sp.					X							
Martensia fragilis	X							X	X		X	X
Mastophora lamourouxii												X
Mastophora macrocarpa												X
Mastophora melobesoides	X											
Mastophora plana												X
Mastophora rosea												X
Mazzaella volans								X				
Malaconema minimum								X				
Melanamansia daemelii								X				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Neogoniolithon fosliei												X
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											

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Peyssonelia foveolata	X											
Peyssonelia inamoena								X				
Peyssonelia mariti	X											
Peyssonelia rubra	X				X			X				
Peyssonelia sp.									X			
Phaeocolax kajimurai								X				
Platoma ardreanum								X				
Pleonosporium caribaeum								X				
Peonosporium intricatum								X				
Plocamium sandwicense								X	X			
Polyopes hakalauensis								X				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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				

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
Polysiphonia poko								X				X
Polysiphonia polyphysa									X			
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			

Algae species	AS	BK	HL	JV	PY	KG	JS	HI	NWHI	WK	MR	GU
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
Polysiphonia sp.	X				X		X		X		X	X
Polystrata dura	X											
Porolithon craspedium					X						X	X

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Pterocladia musiformis					X							
Pterocladia parva									X			X
Pterocladia tropica					X							
Pterocladia sp.					X							
Pterocladiella bulbosa								X				
Pterocladiella caerulescens								X				
Pterocladiella caloglossoides								X				
Pterocladiella capillacea								X				
Pterosiphonia pennata								X				
Ptilocladia yuenii								X				
Ptilothamnion cladophorae								X				
Pugetia sp.									X			

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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	
Sporolithon schmidtii												X

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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				

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
Tenarea tessellatum								X				
Tiffaniella codicola									X			
Tiffaniella saccorhiza								X	X			
Titanophora marianensis												X
Titanophora pikeana								X				
Tolypiocladia glomerulata	X							X			X	X
Trichogloea lubrica								X				
Trichogloea requienii								X	X			
Trichogloeopsis hawaiiana								X	X			
Irichogloeopsis mucosissima								X				
Tricleocarpa cylindrica								X	X			

Algae species	**AS**	**BK**	**HL**	**JV**	**PY**	**KG**	**JS**	**HI**	**NWHI**	**WK**	**MR**	**GU**
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

5.3.2 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 Characteristics

Vary greatly in size. Most 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 93 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

Particle feeding and ingestion of plankton and bacteria (Reiswig 1971,1975a)

Utilization of DOM, directly or indirectly, by symbiotic cyanobacteria (Barnes 1987; Wilkinson, 1979, 1983).

Behavior

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 84. 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		

Taxonomy/occurrence	**AS**	**HI**	**CNMI**	**GU**
Jaspis stellifera			X	
Melophlus sarasinorum				X
Rhabdastrella pleopora		X		
Stelletta debilis		X		
Zaplethes digonoxea		X		
Lithistida				
Aciculites papillata			X	
Leidermatium sp		X		
Spirophorida				
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		

Taxonomy/occurrence	**AS**	**HI**	**CNMI**	**GU**
Kotimea tethva		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		

Taxonomy/occurrence	**AS**	**HI**	**CNMI**	**GU**
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		
[illegible]				
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	

Taxonomy/occurrence	AS	HI	CNMI	GU
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	

Taxonomy/occurrence	**AS**	**HI**	**CNMI**	**GU**
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		
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		

Taxonomy/occurrence	**AS**	**HI**	**CNMI**	**GU**
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

Taxonomy/occurrence	**AS**	**HI**	**CNMI**	**GU**
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
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				

Taxonomy/occurrence	AS	HI	CNMI	GU
Euplectella sp		X		
Stylocalyx elegans		X		

5.3.3 *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 Characteristics

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 and the Marquesas in the east. The genus also occurs in the Central and Eastern Pacific and the Caribbean Sea.

Table 94 summarizes some Indo-Pacific species (adapted from Lewis 1989): their morphology, depth and reef zone and water circulation requirements.

Table 85. 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.

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Veron J. E. N. 1986: *Coral of Australia and the Indo-Pacific.* Angus and Robertson. ISBN 0 207 15116 4.

5.3.4 Stylasteridae (Gray, 1847) (Stylasterines; lace corals)

<u>Important Summary Documents</u>

Veron (1986) Colin and Arneson (1995) and Fossa and Nilsen (1998) provide description of the family.

<u>Taxonomic Issues</u>

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.

<u>Habitat Utilization</u>

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)

<u>Life History</u>

Adult: Appearance and Physical Characteristics

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, Central 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.

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Veron J. E. N. 1986. *Coral of Australia and the Indo-Pacific.* Angus and Robertson. ISBN 0 207 15116 4.

5.3.5 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 Characteristics

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.

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5.3.5.1 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. Table 96 summarizes the Scleractinia in the US Flag Pacific Islands, while Table 97 includes a summary of the likely zooxaznthellate corals to be found in the Western Pacific Region. .

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 - Maragos (1979, 1988, in prep.)

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 *Pavona, in that order* to dominate the reef seleractinians in Hawaii. In Hawaii, the predominantly branching coral genus *Acropora* is rare and generally confined to several areas in the NWHI. Elsewhere in the region, *Acropora, faviids* and *Millepora* are dominant or very common along with the other genera mentioned above. 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 Characteristics

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 95).

Table 86. 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
Mussidae	0-1.65
Lobophyllia	Mean range
Symphyllia	0.38-0.94
Acanthastrea	
Oculinidae	0.67-1.18
Galaxea	Mean range
	0.54-0.93
Merulinidae	.56-1.15
Hydnophora	Mean 0.86
Caryophylliidae	0.5-0.75
Physogyra	Mean range
Euphyllia	0.5-0.75

Species	**Growth (cm/yr)**
Plerogyra	
<u>*Acroporiidae*</u>	10.17-22.58
Acropora	
<u>*Pocilloporiidae*</u>	0.4-3.59
Pocillopora	

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 96 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 makes 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).

Behavior

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 be 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 beginning 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 provide 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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5.3.6 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 Characteristics

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 87. Distribution of Scleractinia (hard coral) in 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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
Acropora (A.) azurea Veron & Wallace, 1984	X								1
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
Acropora (A.) paxilligera *(Dana, 1846)*	X								1
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
Montipora conicula Wells								X	1
Montipora danae Edwards & Haime, 1851						X		X	2
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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
Montipora monasteriata (Forskal, 1775)		X	X	X	X	X		X	6
Montipora peltiformis Bernard, 1897				X				X	2
Montipora spumosa (Lamarck, 1816)	X								1

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
Montipora tuberculosa (Lamarck, 1816)	X	X	X	X				X	5
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
Leptoseris hawaiiensis Vaughan, 1907			X	X				X	3
Leptoseris incrustans (Quelch, 1886)	X		X	X				X	4
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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
Pavona varians Verrill, 1864	X	X	X	X		X	X	X	7
Pavona (P.) venosa (Ehrenberg, 1834)	X							X	2

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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
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			X					1
Fungia (V.) repanda Dana, 1846	X	X							2
Fungia (C.) simplex ***(Gardiner, 1905)***	X								1

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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
Alveopora viridis Quoy & Gaimard, 1833	X								1

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
Family FAVIIDAE									
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
Hydnophora exesa (Pallas, 1766)	X	X						X	3
Hydnophora microconos ***(Lamarck, 1816)***	X	X						X	3
Hydnophora rigida ***(Dana, 1846)***	X								1
Leptastrea bottae ***(Edwards & Haime, 1849)***				X				X	2
Leptastrea cf. I*mmersa* 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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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
Platygyra sinensis (Edwards & Haime, 1849)						X		X	2
Plesiastrea versipora ***(Lamarck, 1816)***	X	X						X	3
Family RHIZANGIIDAE									
Culicia rubeola (Quoy & Gaimard)							X		1

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
Acanthastrea sp.1								X	1
Lobophyllia corymbosa (Forskal, 1775)	X	X						X	3
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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
Family DENDROPHYLLIIDAE									
Tubastrea aurea ***(Quoy & Gaimard)***	X						X		2
Tubastraea coccinea Lesson, 1831	X	X		X	X				4

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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									

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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
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

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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	X	X	X					4
Tethya sp.	X								1
Zoanthus sp.	X			X					2
Number of: Scleractinians	222	82	29	51	13	39	53	159	

Coral Order, Family and Species	**AS**	**PA**	**JA**	**MHI**	**NWHI**	**WA**	**NMI**	**GU**	**Site Record**
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 88. 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 Indian	Extremely common
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- washe d biotopes
Goniopora	Approx. 30	Red Sea and western Indian Ocean to southern Pacific	Generally common, very conspicuous

Family and genus	Extant species {no.}	Present distribution	General abundance
Alveopora	Approx. 15	Red Sea and western Indian Ocean to southern Pacific	Sometimes common, very conspicuous
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 Indian	Generally
Pachyseris	Approx. 4	Red Sea and western Indian	Very common, very
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
Fungia	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

Family and genus	Extant species {no.}	Present distribution	General abundance
Halomitra	2	Western Indian Ocean to southern Pacific	Generally uncommon, very conspicuous
Oculinldae Galaxea	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

Family and genus	Extant species {no.}	Present distribution	General abundance
Scapophyllia	1	Eastern Indian Ocean to	Generally
Faviidae	Approx. 4	Red Sea and western Indian	Generally common
Favia	At least thirty	Cosmopolitan	Extremely common, conspicuous
Favites	Approx. 15	Red Sea and western Indian	Very common
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 Indian	Sometimes common
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

Family and genus	Extant species {no.}	Present distribution	General abundance
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
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

5.3.7 Ahermatypic Corals (Azooxanthellate)

Important Summary Documents

Veron (1986) describes the three genera with photos of living and skeletal examples. Table 98 summarizes the ahermatypic corals from Hawaii.

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 Characteristics

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 89. Deep-water Ahermatypes from Hawaii. (From Maragos 1977; data Vaughan (1907)).

Species	Shallowest Collection Record
Anisopsammia amphelioides (Alcock)	40 fm
Anthemiphyllia pacifica Vaughan	92 fm
Balanophyllia desmophyllioides Vaughan	78 fm
Balanophyllia diomeseae Vaughan	148 fm
Balanophyllia hawaiiensis Vaughan	190 fm
Balanophyllia laysanensis Vaughan	130 fm
Bathyactis hawaiiensis Vaughan	963 fm
Caryophyllia alcocki Vaughan	876 fm
Caryophyllia hawaiiensis Vaughan	92 fm
Caryophyllia octopali Vaughan	28 fm
Ceratotrochus laxus Vaughan	319 fm
Cyathoceras diomedeae Vaughan	169 fm
Deltosyathus andamanicus Alcock	147 fm
Dendrophyllia oahensis Vaughan	154 fm
Dendrophyllia serpentina Vaughan	147 fm
Desmophyllum cristagalli Milne- Edwards & Haine	
Endopachys oahense Vaughan	53 fm
Flabellum deludens v. Marenzeller	670 fm

Species	**Shallowest Collection Record**
Flabellum parvoninum Lesson	127 fm
Gardineria hawaiiensis Vaughan	272 fm
Madracis kauaiensis Vaughan	24 fm
Madrepora kauaiensis Vaughan	294 fm
Paracyathus gardineri Vaughan	
Paracyathus mauiensis Vaughan	95 fm
Paracyathus molokensisx Vaughan	88 fm
Paracyathus tenuicalyx Vaughan	252 fm
Placotrochus fuscus Vaughan	148 fm
Stephanophyllia formosissima Moseley	66 fm
Trochocyathus oahensis Vaughan	252 fm

5.3.8 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 was 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. Table 99 summarizes the Actinaria from Hawaii.

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 (Actiiidae; 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.

Behavior

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 occur 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 90. Actinaria from Hawaii (Cutress, 1977).

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.*

5.3.9 Zoanthidae (colonial anemones)

<u>Important Summary Documents</u>

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. Table 100 summarizes Zoanthiniaria from Hawaii.

<u>Taxonomic Issues</u>

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).

<u>Habitat Utilization</u>

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 Characteristics

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 91. Zoanthiniaria from Hawaii: (Walsh and Bowers 1971).

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

5.3.10 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 Characteristics

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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5.3.11 Subclass Alcyonaria (=Octocorallia); Order Alcyonacea; Suborder Scleraxonia; Holoaxonia (gorgonian 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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5.3.12 *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 Characteristics

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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5.3.13 *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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Appendix G: EFH Impacts Provisions

The EFH provisions of the Magnuson Stevens Act impose procedural requirements on both Councils and federal agencies related to marine planning. First, for each FMP, Councils must identify adverse impacts to EFH resulting from both fishing and non-fishing activities, and describe measures to minimize these impacts. Second, the provisions allow Councils to provide comments and make recommendations to federal or state agencies that propose actions that may affect the habitat, including EFH, of a managed species. NMFS is required to consult with federal agencies on actions that may adversely affect EFH, which usually occurs concurrently with the NEPA planning process.

None of the fisheries operating under the American Samoan Archipelago FEP are expected to have adverse impacts on EFH or HAPC for species managed under the different fisheries. Continued and future operations of fisheries under the American Samoan Archipelago FEP are not likely to lead to substantial physical, chemical, or biological alterations to the habitat, or result in loss of, or injury to, these species or their prey.

1. MSA and non-MSA fishing activities that may adversely affect EFH

The Council is required to act to prevent, mitigate, or minimize adverse effects from fishing on evidence that a fishing practice has identifiable adverse effects on EFH for any MUS covered by an FMP. 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 or other components of the ecosystem.

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 utilized by coral reef species, bottomfish, crustaceans, or 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 is prohibited and only selective and non-destructive gear may be allowed to fish for Coral Reef Ecosystem MUS. Although lobster traps have a potential impact on the benthic habitat, the tropical lobster *Panulirus penicillatus* does not enter lobster traps. In the limited areas where harvesting does occur in the Hawaii Archipelago, lobsters are caught by hand. This technique causes limited damage or no fishing-related impacts to the benthic habitat, and its continued use is likely.

The Council has determined that current management measures to protect fishery habitat are adequate and that 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.

- Remotely operated vehicle (ROV) tether damage to precious coral during harvesting operations.

Trash and discarded and lost gear (leaders, hooks, weights) by fishing vessels operating in the EEZ, are a Council concern. A report on the first phase of a submersible-supported research project conducted in Hawaii in 2001 preliminarily determined that bottomfish gear exhibited minimal to no impact on the coral reef habitat (C. Kelley, personal communication). A November 2001 cruise in the Main Hawaiian Islands determined that precious corals harvesting has "negligible" impact on the habitat (R. Grigg, personal communication). The Council is concerned with habitat impacts of marine debris originating from fishing operations outside the Western Pacific Region. NMFS is currently investigating the source and impacts of this debris. International cooperation will be necessary to find solutions to this broader problem.
Because the habitat of pelagic species is the open ocean, 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 it 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. There is also a concern that invasive marine and terrestrial species may be introduced into sensitive environments by fishing vessels transiting from populated islands and grounding on shallow reef areas. Of most concern is the potential for unintentional introduction of rats (*Rattus* spp.) to the remote islands in the NWHI and PRIA that harbor endemic land birds. Although there are no restrictions that prohibit fishing vessels from transiting near these remote island areas, no invasive species introductions due to this activity have been documented. However, the Council is concerned that this could occur as fisheries expand and emerging fisheries develop in the future.

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.

In modern times, some reefs have been degraded by a range of human activities. Comprehensive lists of human threats to coral reefs in the U.S. Pacific Islands are provided by Maragos et al. (1996), Birkeland (1997a), Grigg 2002, and Clark and Gulko (1999). (These findings are summarized in Table 27.) More recently, the U.S. Coral Reef Task Force identified six key threats to coral reefs: (1) landbased sources of pollutions, (2) overfishing, (3) recreational overuse, (4) lack of awarness, (5) climate change, and (6) coral bleaching and disease. In general, reefs closest to human population centers are more heavily used and are in worse condition than those in remote locations (Green 1997). Nonetheless, it is difficult to generalize about the present condition of coral reefs in the U.S. 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 U.S. 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 the remote NWHI, PRIAs, and northern islands of the CNMI. Reefs near the inhabited islands are heavily used for small-scale artisanal, recreational, and subsistence fisheries, and those in Hawaii, CNMI and Guam are also the focus for extensive non-consumptive marine recreation. Rather than a relatively few large-scale mechanized operations, many fishermen each deploy more limited gear. The more accessible banks in the main Hawaiian Islands (Penguin Bank, Kaula Rock), Guam (southern banks), and the CNMI (Esmeralda Bank, 300 Reef, Marpi Reef, Dump Coke and Malakis Reef are the most heavily fished offshore reefs in the Western Pacific Region management area.

The vast majority of the reefs in the Western Pacific Region are remote and, in some areas, they have protected status. Most of these are believed to be in good condition. Existing fisheries are limited. Poaching by foreign fishing fleets is suspected at Guam's southern banks, in the PRIA, and possibly in other areas. Poachers usually target high-value and often rare or overfished coral reef resources. These activities are already illegal but difficult to detect.

2. Non-fishing related activities that may adversely affect EFH

On the basis of the guidelines established by the Secretary under Section 305 (b)(1)(A) of the MSA, NMFS has developed a set of guidelines to assist councils meet the requirement to describe adverse impacts to EFH from non-fishing activities in their FMPs (67 FR 2376). A wide range of non-fishing activities throughout the U.S. Pacific Islands contribute to EFH degradation. FEP implementation will not directly mitigate these activities. However, as already noted, it will allow NMFS and the Council to make recommendations to any federal or state agency about actions that may impact EFH. Not only could this be a mechanism to minimize the environmental impacts of agency action, it will help them focus their conservation and management efforts.

The Council is required to identify non-fishing activities that have the potential to adversely affect EFH quality 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 used 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. These activities and impacts, along with mitigation measures, are detailed in the next section.

Table 92: Threats to Coral Reefs in the Hawaiian Archipelago

Activity	**MHI**	**NWHI**
Coastal construction	x	
Destructive fishing	x	
Flooding	x	
Industrial pollution		
Overuse/over harvesting	x	
Nutrient loading (sewage/eutrophication)	x	
Soil erosion/sedimentation	x	

Vessel groundings/oil spills		x
Military activity	x	x
Hazardous waste		x
Tourist impacts	x	
Urbanization	x	
Thermal pollution	x	
Marine debris	x	x
Introduced species	x	

Sources: Birkeland 1997a; Clark and Gulko 1999; Grigg 2002; Jokiel 1999; Maragos et al. 1996

3. Cumulative Impacts Assessment

A cumulative impacts analysis (CIA) is required by the NMFS EFH Final Rule (2002) to the extent feasible and practicable. The CIA "should analyze how the cumulative impacts of fishing and non-fishing activities influence the function of EFH on an ecosystem or watershed scale" (67 FR 2378, January 17, 2002). The assessment should include multiple threats, including natural stresses.

There are a variety of past, present, and future activities that have the potential to affect EFH in the Hawaiian Archipelago. In the Main Hawaiian Islands, there has been interest in aquaculture, inter-island electricity cables, and offshore energy development as the state moves toward self-sufficiency in energy and food production. Since many water column impacts are temporary in nature, benthic alteration associated with laying cables and anchoring are most likely to have an adverse impact and pose the greatest threat to EFH for juvenile and adult life stages. Nearshore impacts associated with development have the potential to impact shallow water species. Large-scale impacts such as global climate change that affect ocean temperatures, currents, and potentially food chain dynamics are most likely to threaten EFH for egg and larval pelagic stages.

The Northwestern Hawaiian Islands are very remote. All commercial fishing for bottomfish and seamount groundfish species is under moratorium in the Hancock Seamount Ecosystem Management Area; commercial fishing is banned within the Papahānaumokuākea Marine National Monument. Activity within the Monument is generally limited to scientific research. Similar to larval and egg life stages, global environmental problems pose the largest threat to EFH in the NWHI.

Future analyses will seek to analyze cumulative impact of habitat conversion and the impacts of discharges in order to evaluate the cumulative impacts on EFH. Information and techniques that are developed for this process will be used to supplement future revisions of these EFH provisions as the information becomes available.

4. Conservation and Enhancement Recommendations

According to NMFS guidelines, Councils should describe ways to avoid, minimize, or compensate for the adverse effects to EFH and promote the conservation and enhancement of EFH. Generally, non-water dependent actions that may have adverse impacts should not be located in EFH. Activities that may result in significant adverse effects 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. FEPs 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. Councils should describe a variety of options to conserve or enhance EFH, which may include, but are not limited to the following:

Enhancement of rivers, streams, and coastal areas through new federal, state, or local government planning efforts to restore river, stream, or coastal area watersheds.

Improve water quality and quantity through the use of the best land management practices to ensure that water-quality standards at state and federal levels are met. The practices include improved sewage treatment, disposing of waste materials properly, and maintaining sufficient in-stream flow to prevent adverse effects to estuarine areas.

Restore or create habitat, or convert non-EFH to EFH, to replace lost or degraded EFH, if conditions merit such activities. However, habitat conversion at the expense of other naturally functioning systems must be justified within an ecosystem context.

Established policies and procedures of the Council 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 MSA will be met through appropriate application of these policies and principles. In assessing the potential impacts of proposed projects, the Council 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.
- The extent to which mitigation may be used to offset unavoidable loss of habitat functions and values.

Seven non-fishing activities have been identified that directly or indirectly affect habitat used by MUS. Impacts and conservation measures are summarized below for each of these activities.

Although not all inclusive, what follows is a good example of the kinds of measures that can help to minimize or avoid the adverse effects of identified non-fishing activities on EFH.

o Habitat Loss and Degradation

Impacts:

- Changes in abundance of 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

Conservation Measures:

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 should 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 that 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.

o Pollution and Contamination

Impacts:

- Introduction of chemicals
- Introduction of animal wastes
- Increased sedimentation
- Wastewater effluent with high contaminant levels
- High nutrient levels downcurrent of outfalls
- Biocides to prevent biofouling
- Thermal effects
- Turbidity plumes
- Affected submerged aquatic vegetation sites
- Stormwater runoff
- Direct physical contact
- Indirect exposure
- Cleanup

Conservation Measures:

1. Outfall structures should be placed sufficiently far 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 environments 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.

o Dredging

Impacts:

- Changes in abundance of infaunal and bottom-dwelling organisms
- Turbidity plumes
- Bioavailability of toxic substances

- Damage to sensitive habitats
- Water circulation modification

Conservation Measures:

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 deep-water 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 that 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 the EPA and U.S. 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 should be 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.

o Marine Mining

Impacts:

- Loss of habitat function
- Turbidity plumes
- Resuspension of fine-grained mineral particles
- Composition of the substrate altered

Conservation Measures:

1. Mining in areas identified as a 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.

o Water Intake Structures

Impacts:

- Entrapment, impingement, and entrainment
- Loss of prey species

Conservation Measures:

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 MUS larvae 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.

o Aquaculture Facilities

Impacts:

- Discharge of organic waste from the farms
- Impacts to the seafloor below the cages or pens

Conservation Measures:

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.

o Introduction of Exotic Species

Impacts:

- Habitat alteration
- Trophic alteration

- Gene pool alteration
- Spatial alteration
- Introduction of disease

Conservation Measures:

1. Vessels should discharge ballast water far enough out to sea to prevent introduction of nonnative species to bays and estuaries.
2. Vessels should conduct routine inspections for presence of exotic species in crew quarters and hull of the vessel prior to embarking to remote islands (PRIAs, NWHI, and northern islands of the CNMI).
3. Exotic species should not be introduced for aquaculture purposes unless a thorough scientific evaluation and risk assessment are performed (see section on aquaculture).
4. Effluent from public aquaria display laboratories and educational institutes using exotic species should be treated prior to discharge.

5. Essential Fish Habitat Research Needs

The Council conducted an initial inventory of available environmental and fisheries data sources relevant to the EFH of each managed fishery. Based on this inventory, a series of tables were created that indicated the existing level of data for individual MUS in each fishery. These tables are available in Supplements to Amendment 4, 6, and 10 to the Precious Corals, Bottomfish and Seamount Groundfish, and Crustaceans FMPs respectively (WPRFMC 2002), and the Coral Reef Ecosystems FMP (WPRFMC 2001) and are summarized below.
Additional research is needed to make available sufficient information to support a higher level of description and identification of EFH and HAPC. 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, climate change, and climate shifts. The following scientific data are needed to more effectively address EFH provisions:

All Species

- 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 MUS life history stages
- Habitat utilization patterns for different life history stages and species for BMUS
- Growth, reproduction, and survival rates for MUS within habitats

Bottomfish Species

- Inventory of marine habitats in the EEZ of the Western Pacific Region
- Data to obtain a better SPR estimate for American Samoa's bottomfish complex
- Baseline (virgin stock) parameters (CPUE, percent immature) for the Guam/NMI deep- and shallow-water bottomfish complexes
- High-resolution maps of bottom topography/currents/water masses/primary productivity

Crustaceans Species

- Identification of postlarval settlement habitat of all CMUS
- Identification of source–sink relationships in the NWHI and other regions (i.e., relationships between spawning sites settlement using circulation models, and genetic techniques)
- Establish baseline parameters (CPUE) for the Guam/Northern Marinas crustacean populations
- Research to determine habitat related densities for all CMUS life history stages in American Samoa, Guam, Hawaii, and NMI
- High-resolution mapping of bottom topography, bathymetry, currents, substrate types, algal beds, and habitat relief

Precious Corals Species

- Distribution, abundance, and status of precious corals in the Western Pacific Region

Coral Reef Ecosystem Species

- The distribution of early life history stages (eggs and larvae) of MUS by habitat
- Description of 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 MUS life history stages
- Habitat utilization patterns for different life history stages and species
- Growth, reproduction, and survival rates for MUS within habitats.
- Inventory of coral reef ecosystem habitats in the EEZ of the Western Pacific Region
- Location of important spawning sites
- Identification of postlarval settlement habitat
- Establishment of baseline parameters for coral reef ecosystem resources
- High-resolution mapping of bottom topography, bathymetry, currents, substrate types, algal beds, and habitat relief

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 and SAFE reports by the Plan Teams, in accordance with the National Standards guidelines. EFH designations may be changed under the FEP amendment process if information presented in an annual review indicates that modifications are justified.

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Appendix H: Essential Fish Habitat and Habitat Areas of Particular Concern Maps

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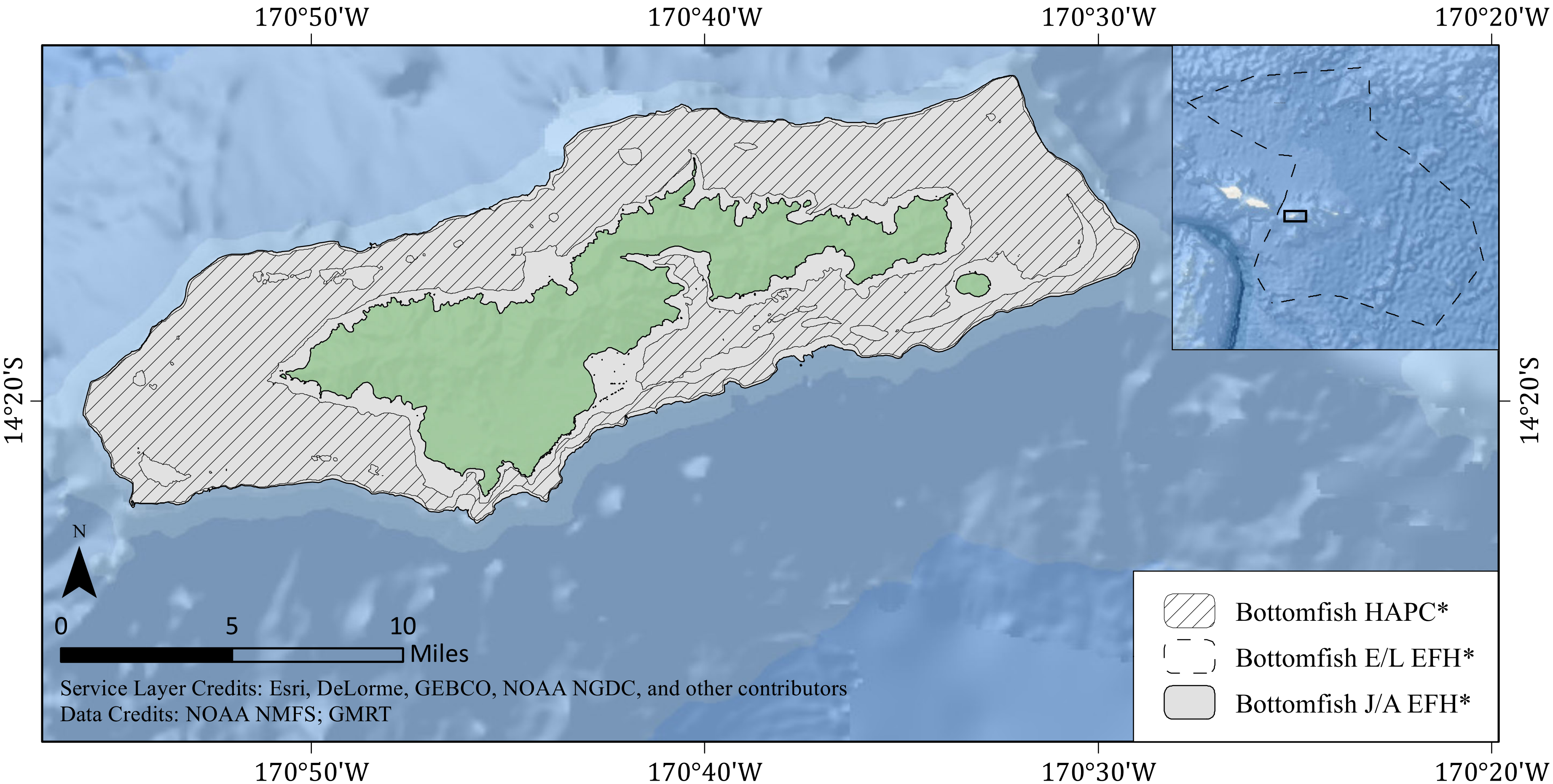
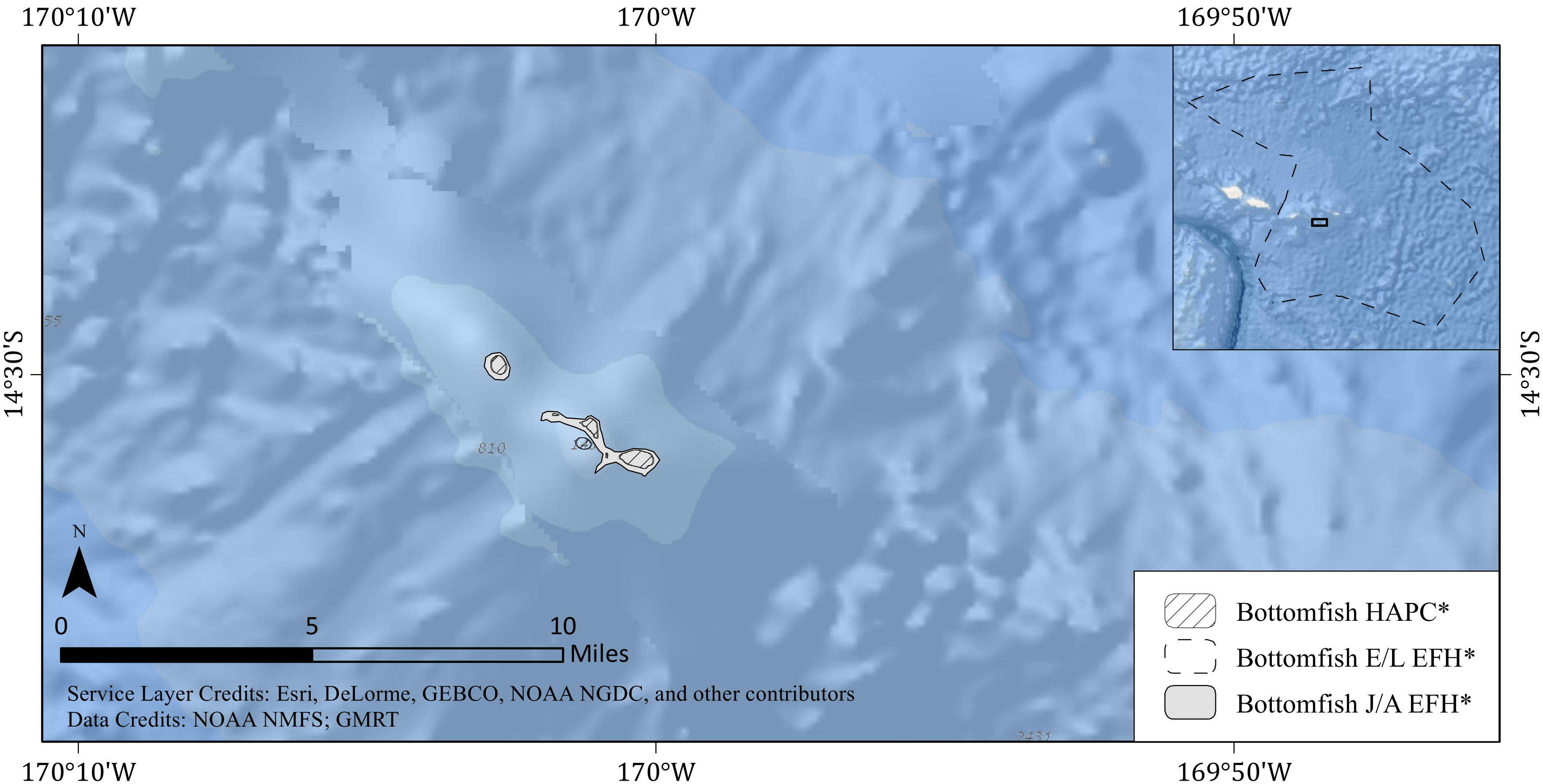
American Samoan Archipelago Fishery Ecosystem Plan
Bottomfish EFH/HAPC: Tutuila



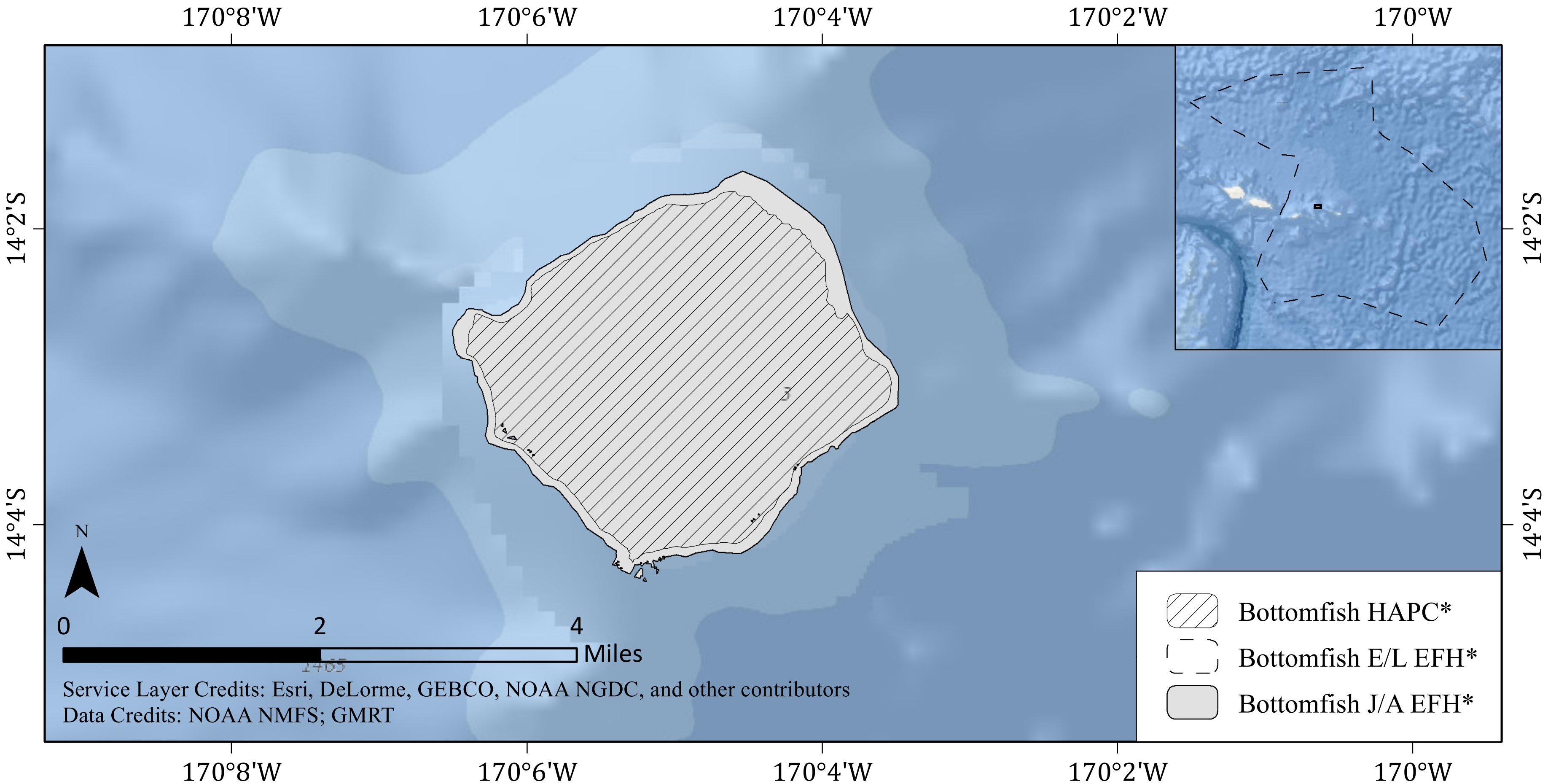
**The geographic extent of EFH and HAPC are shown. EFH for eggs and larvae (E/L) is the water column to a depth of 400 m from the shoreline to the outer boundary of the EEZ, while juvenile/adult (J/A) EFH is the water column and all bottom habitat to a depth of 400 m to the extent shown. HAPC is all escarpments/slopes between 40–280 meters to the extent shown.*

American Samoan Archipelago Fishery Ecosystem Plan
Bottomfish EFH/HAPC: Tulaga Seamount/Two % Bank



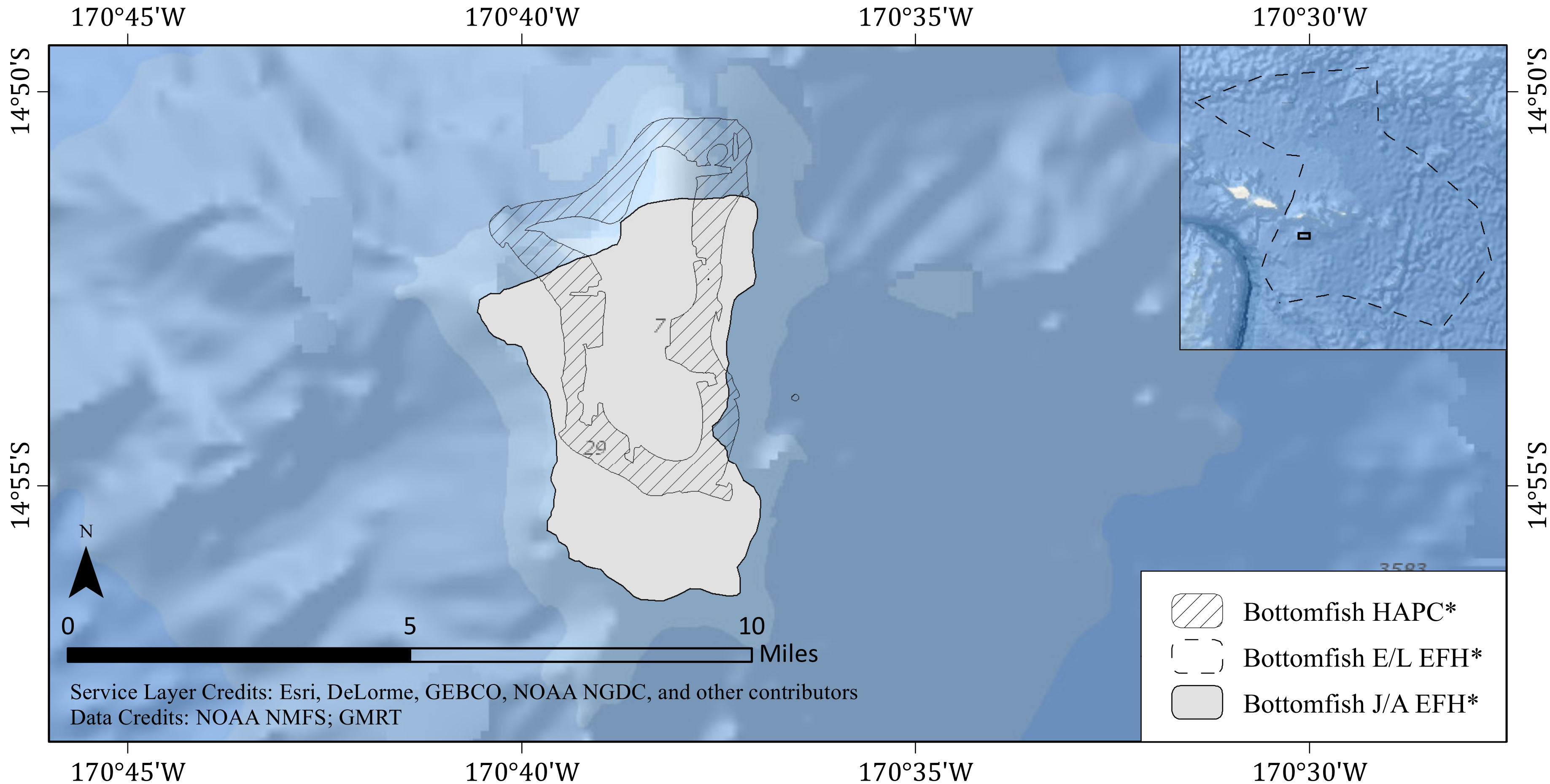
**The geographic extent of EFH and HAPC are shown. EFH for eggs and larvae (E/L) is the water column to a depth of 400 m from the shoreline to the outer boundary of the EEZ, while juvenile/adult (J/A) EFH is the water column and all bottom habitat to a depth of 400 m to the extent shown. HAPC is all escarpments/slopes between 40–280 meters to the extent shown.*

American Samoan Archipelago Fishery Ecosystem Plan
Bottomfish EFH/HAPC: Muli Seamount



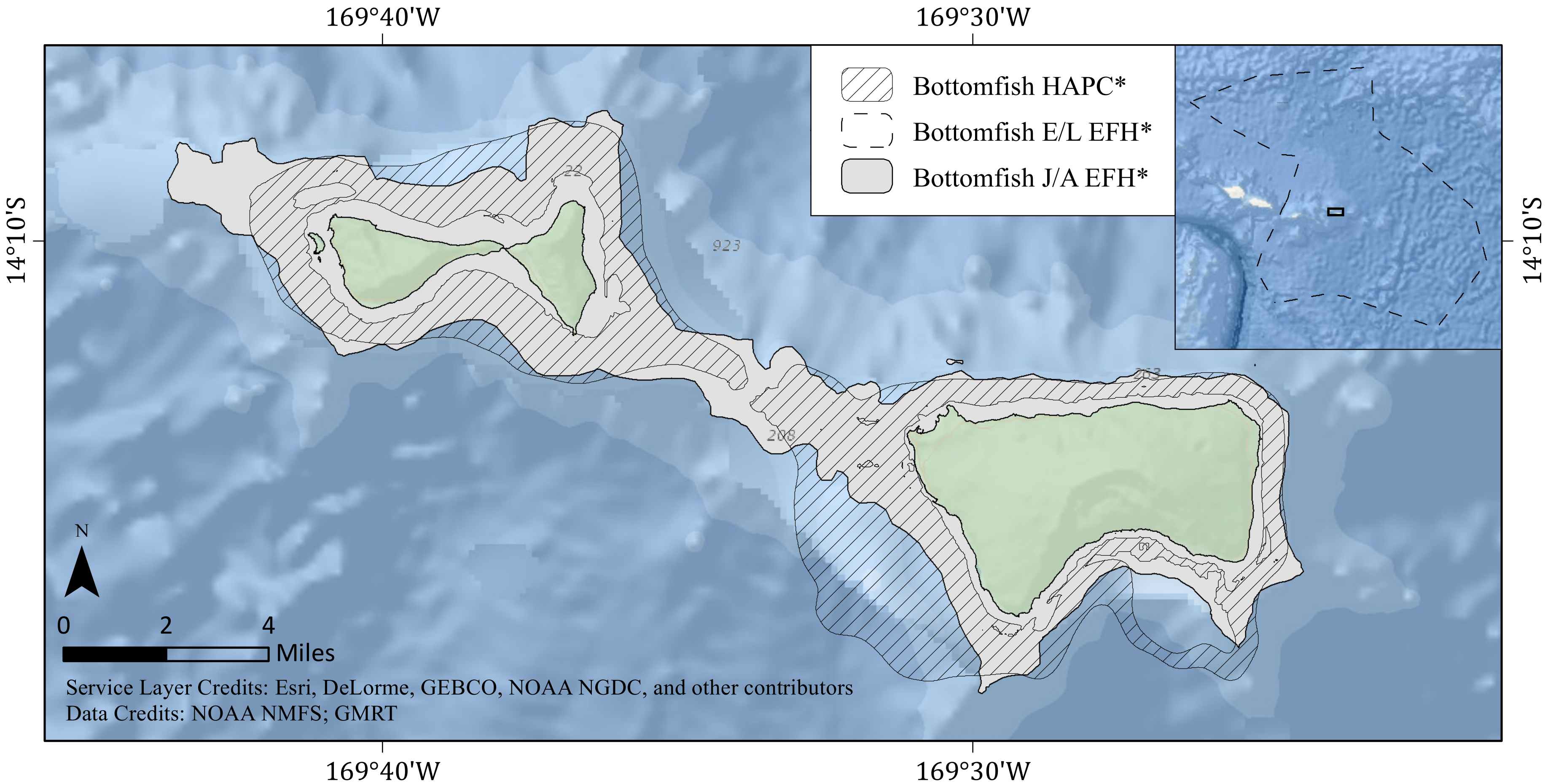
**The geographic extent of EFH and HAPC are shown. EFH for eggs and larvae (E/L) is the water column to a depth of 400 m from the shoreline to the outer boundary of the EEZ, while juvenile/adult (J/A) EFH is the water column and all bottom habitat to a depth of 400 m to the extent shown. HAPC is all escarpments/slopes between 40–280 meters to the extent shown.*

American Samoan Archipelago Fishery Ecosystem Plan
Bottomfish EFH/HAPC: South Bank



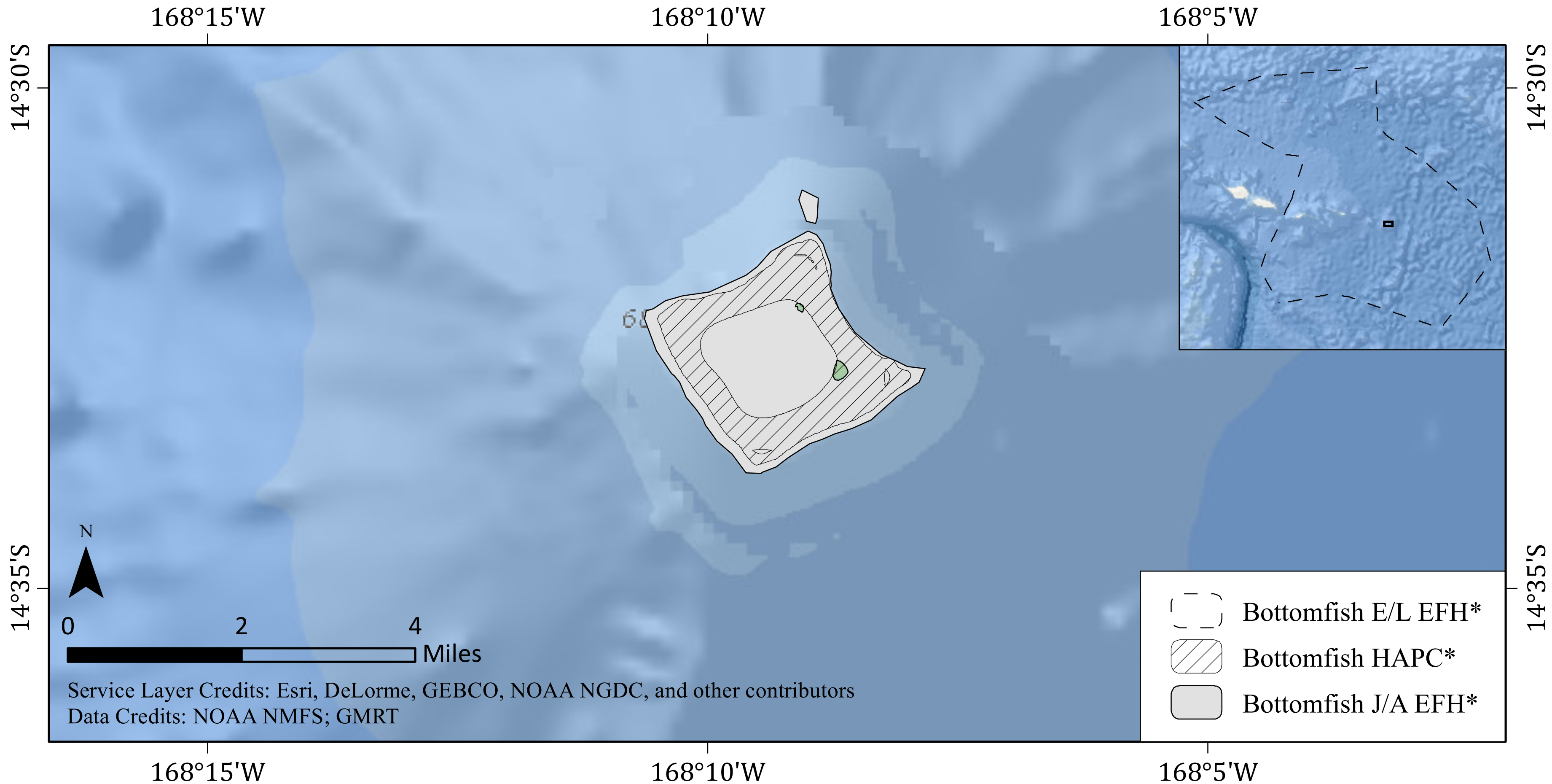
**The geographic extent of EFH and HAPC are shown. EFH for eggs and larvae (E/L) is the water column to a depth of 400 m from the shoreline to the outer boundary of the EEZ, while juvenile/adult (J/A) EFH is the water column and all bottom habitat to a depth of 400 m to the extent shown. HAPC is all escarpments/slopes between 40–280 meters to the extent shown.*

American Samoan Archipelago Fishery Ecosystem Plan
Bottomfish EFH/HAPC: Manu'a Islands



**The geographic extent of EFH and HAPC are shown. EFH for eggs and larvae (E/L) is the water column to a depth of 400 m from the shoreline to the outer boundary of the EEZ, while juvenile/adult (J/A) EFH is the water column and all bottom habitat to a depth of 400 m to the extent shown. HAPC is all escarpments/slopes between 40–280 meters to the extent shown.*

American Samoan Archipelago Fishery Ecosystem Plan
Bottomfish EFH/HAPC: Rose Atoll



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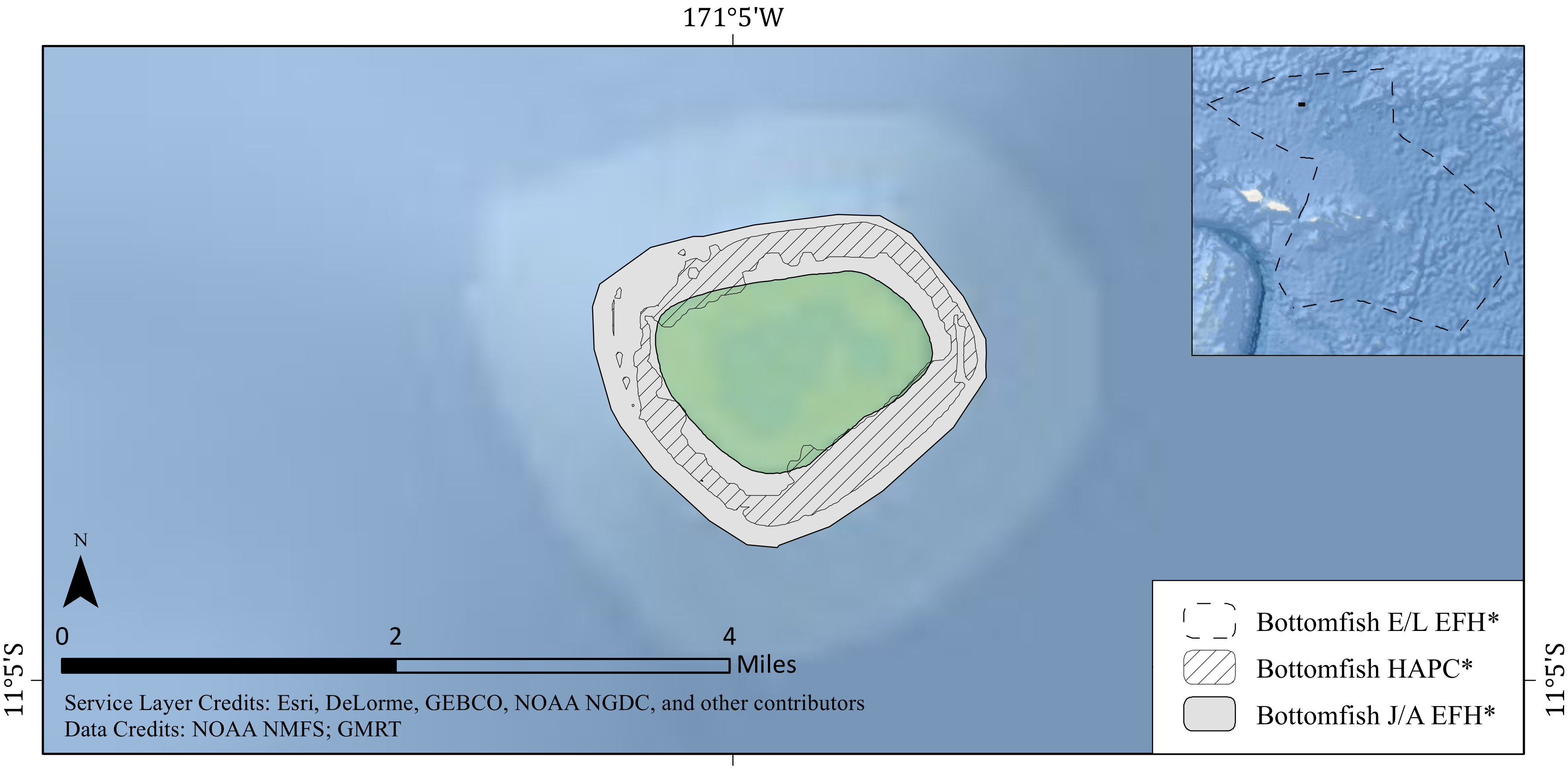
American Samoan Archipelago Fishery Ecosystem Plan
Bottomfish EFH/HAPC: Swains Island



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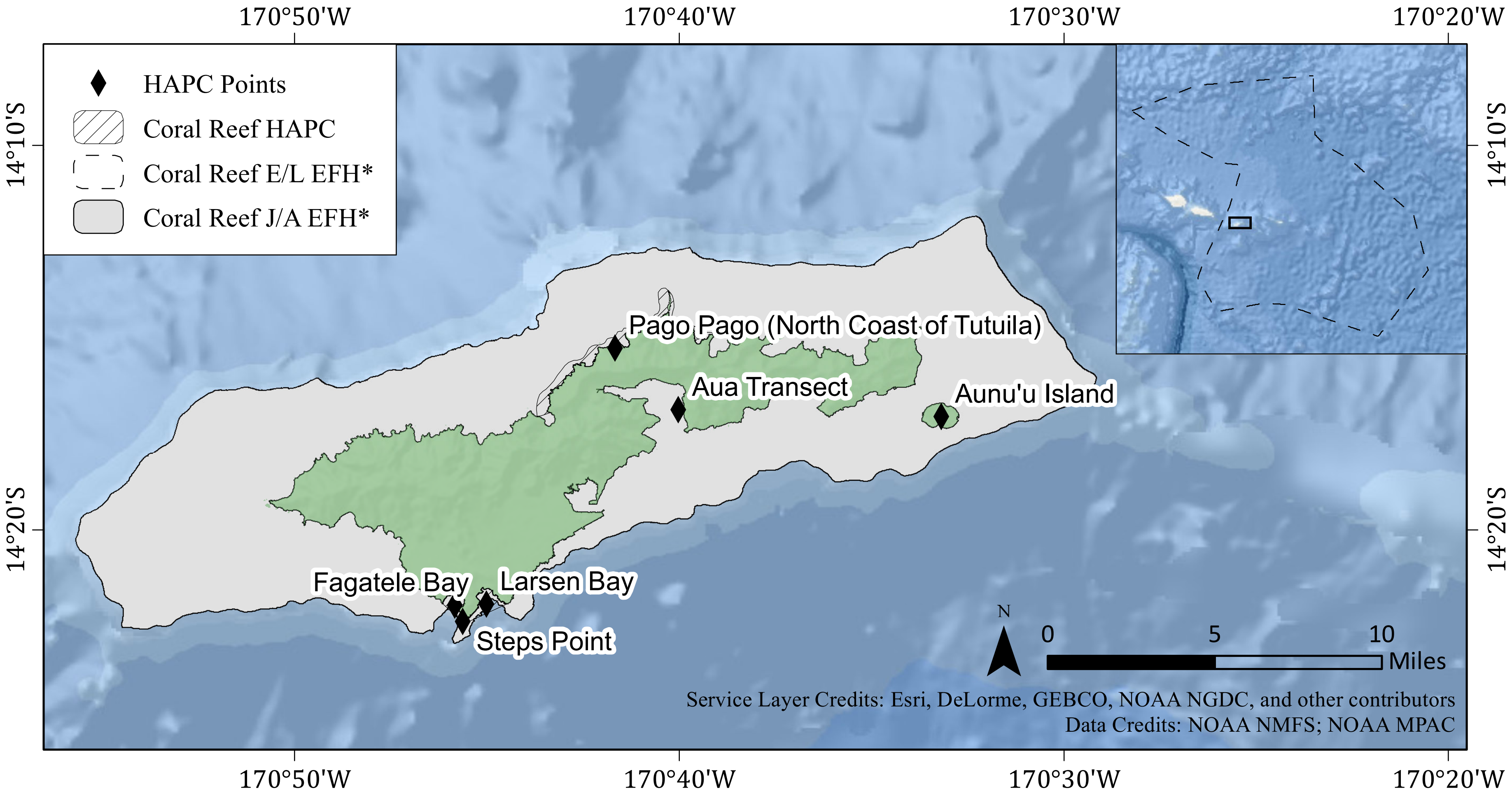
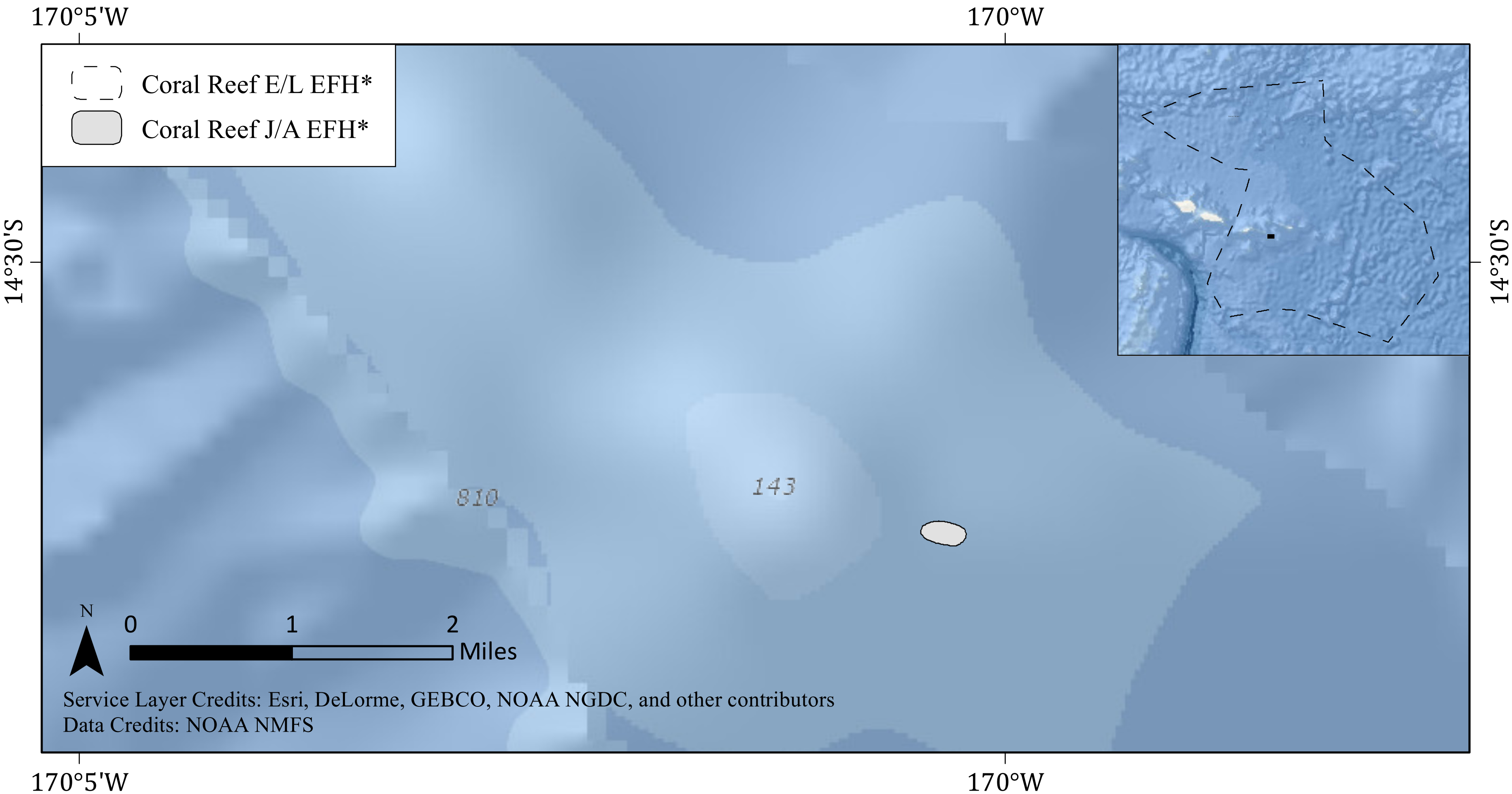
American Samoan Archipelago Fishery Ecosystem Plan
Coral Reef EFH/HAPC: Tutuila



**The geographic extent of juvenile/adult (J/A) EFH is shown. EFH for eggs and larvae is the water column to a depth of 100 m from the shoreline to the outer boundary of the EEZ, while J/A EFH is all bottom habitat and the adjacent water column to a depth of 100 m to the extent shown. The type of bottom habitat varies by family.*

American Samoan Archipelago Fishery Ecosystem Plan
Coral Reef EFH/HAPC: Tulaga Seamount/Two % Bank



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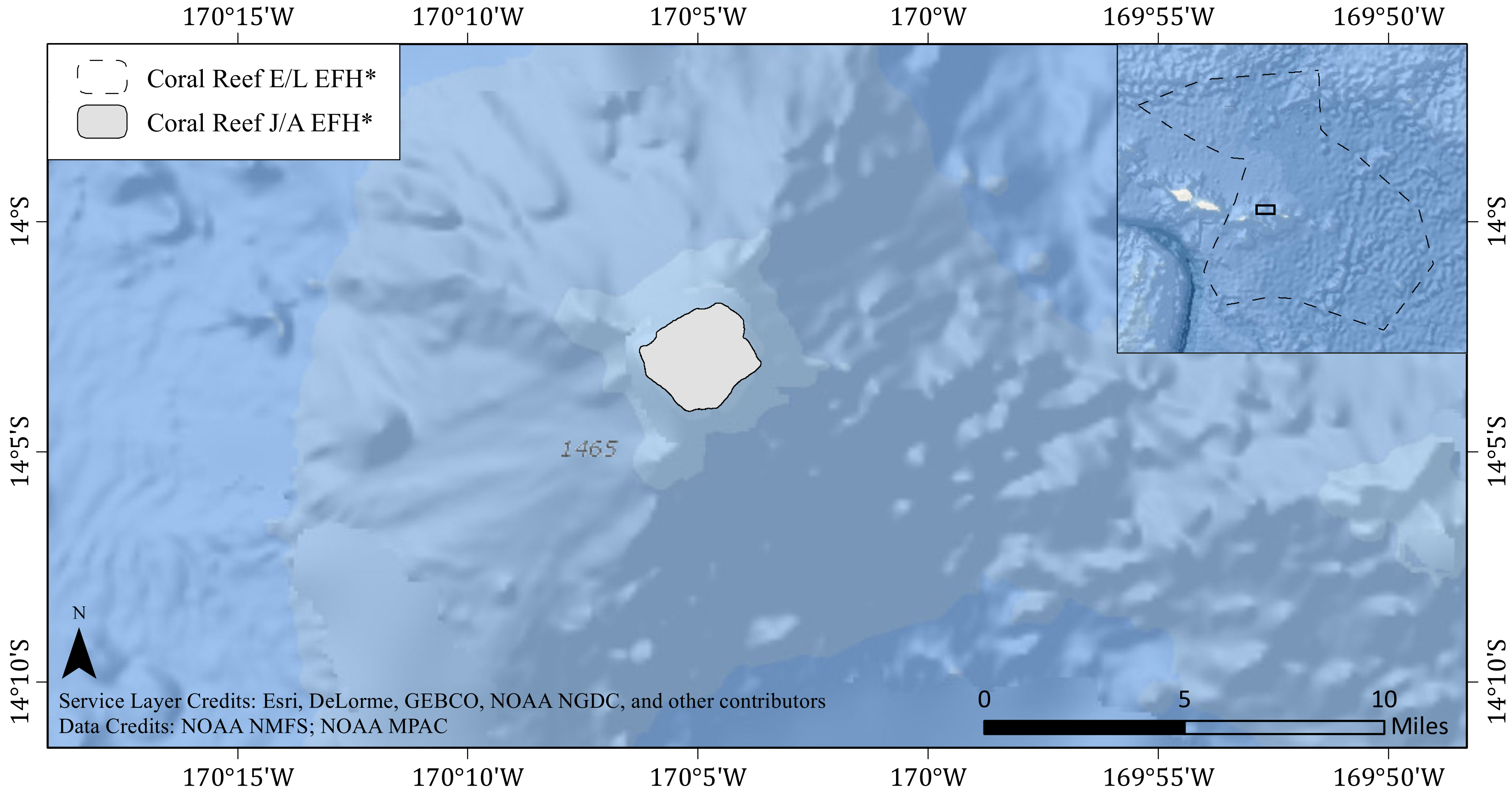
American Samoan Archipelago Fishery Ecosystem Plan
Coral Reef EFH/HAPC: Muli Seamount



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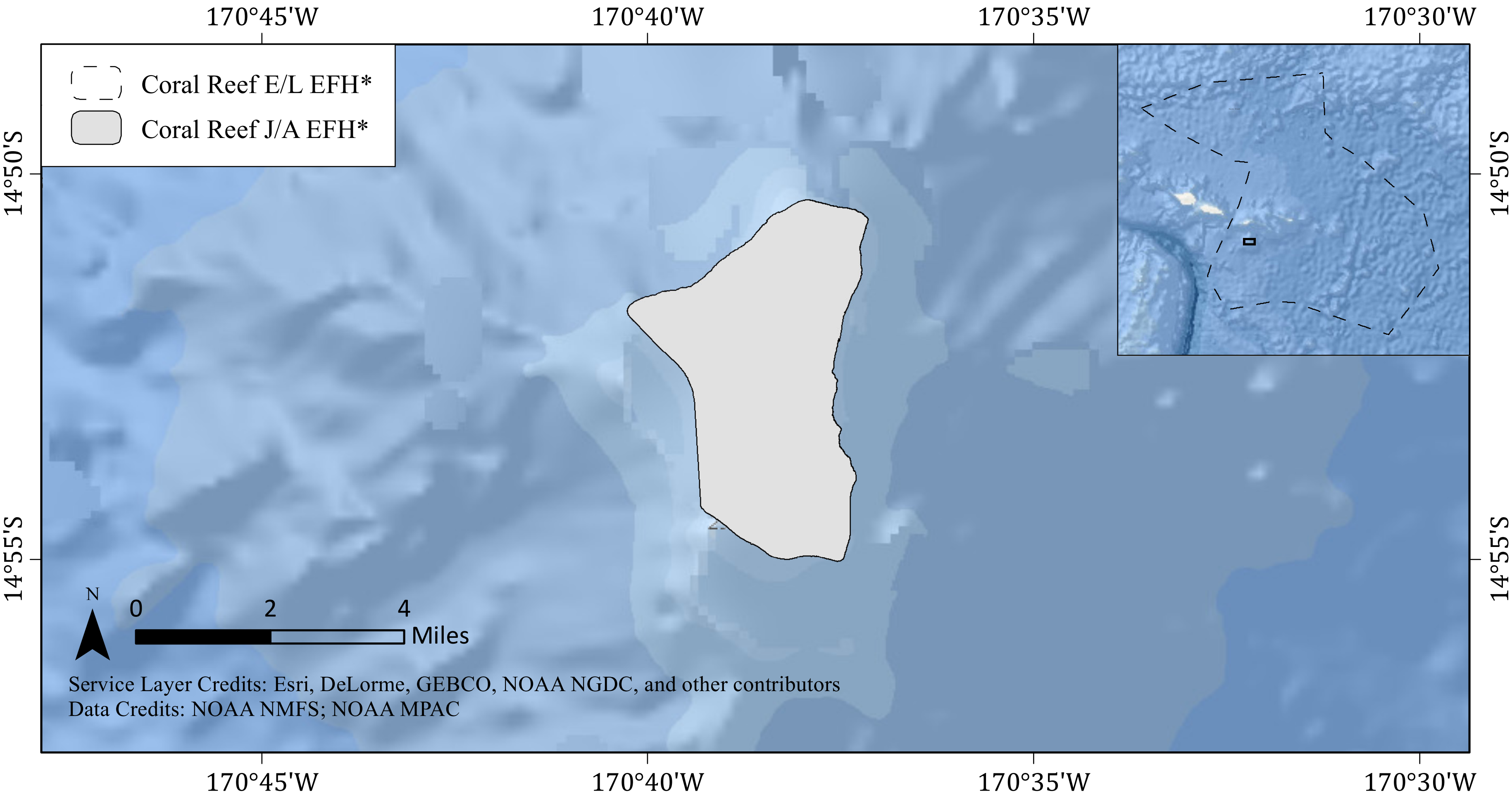
American Samoan Archipelago Fishery Ecosystem Plan
Coral Reef EFH/HAPC: South Bank



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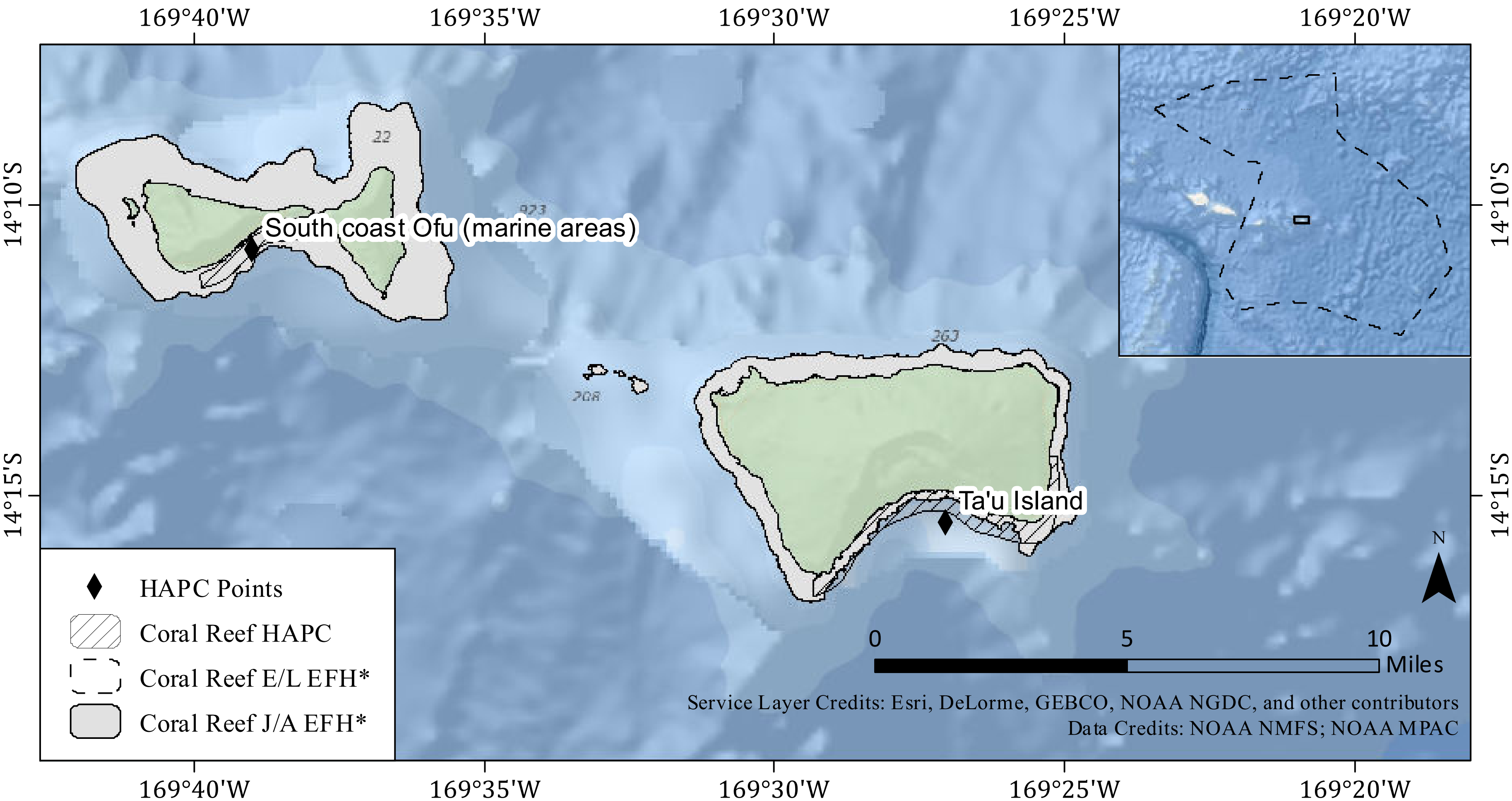
American Samoan Archipelago Fishery Ecosystem Plan
Coral Reef EFH/HAPC: Manu'a Islands



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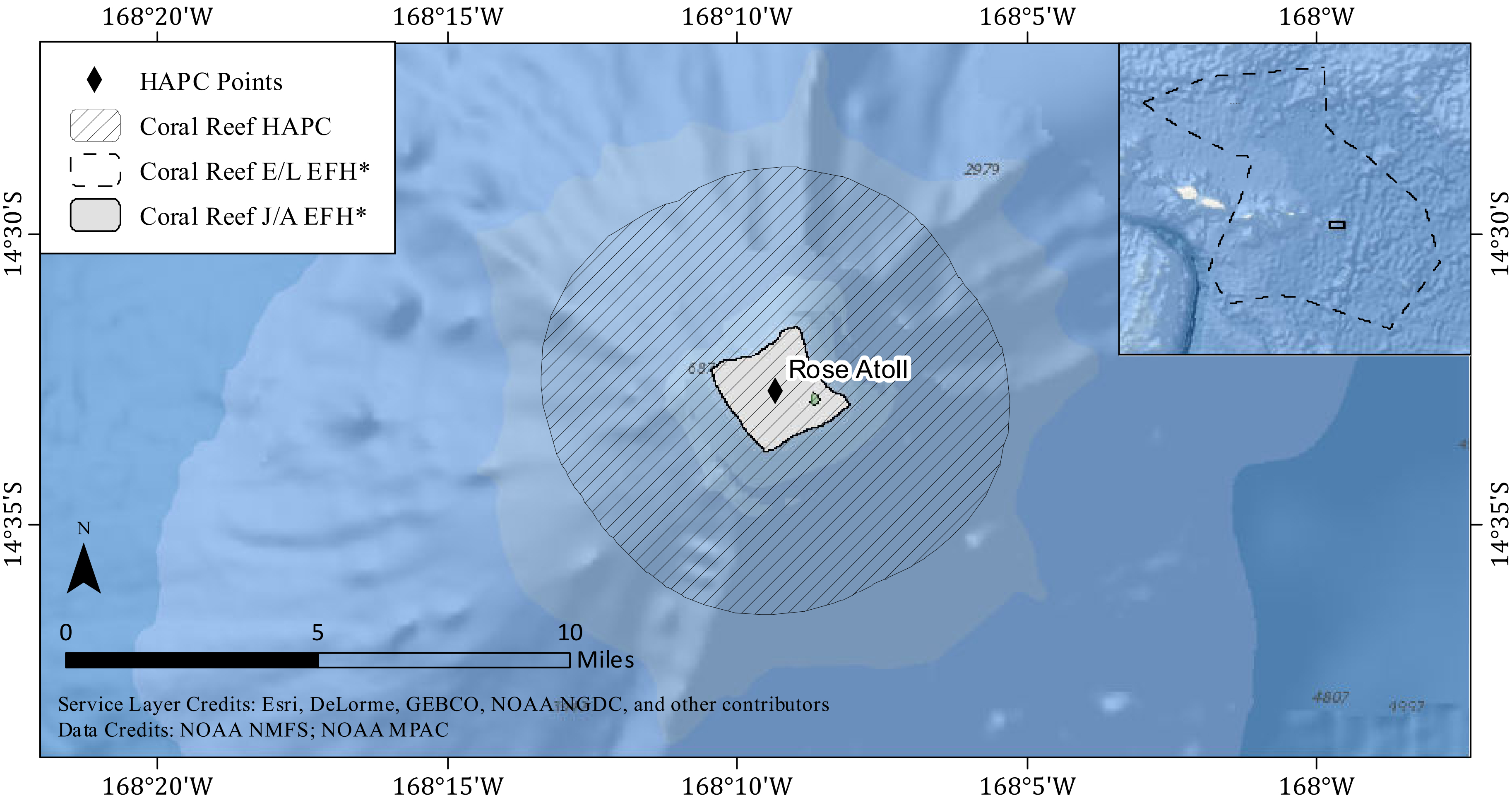
American Samoan Archipelago Fishery Ecosystem Plan
Coral Reef EFH/HAPC: Rose Atoll



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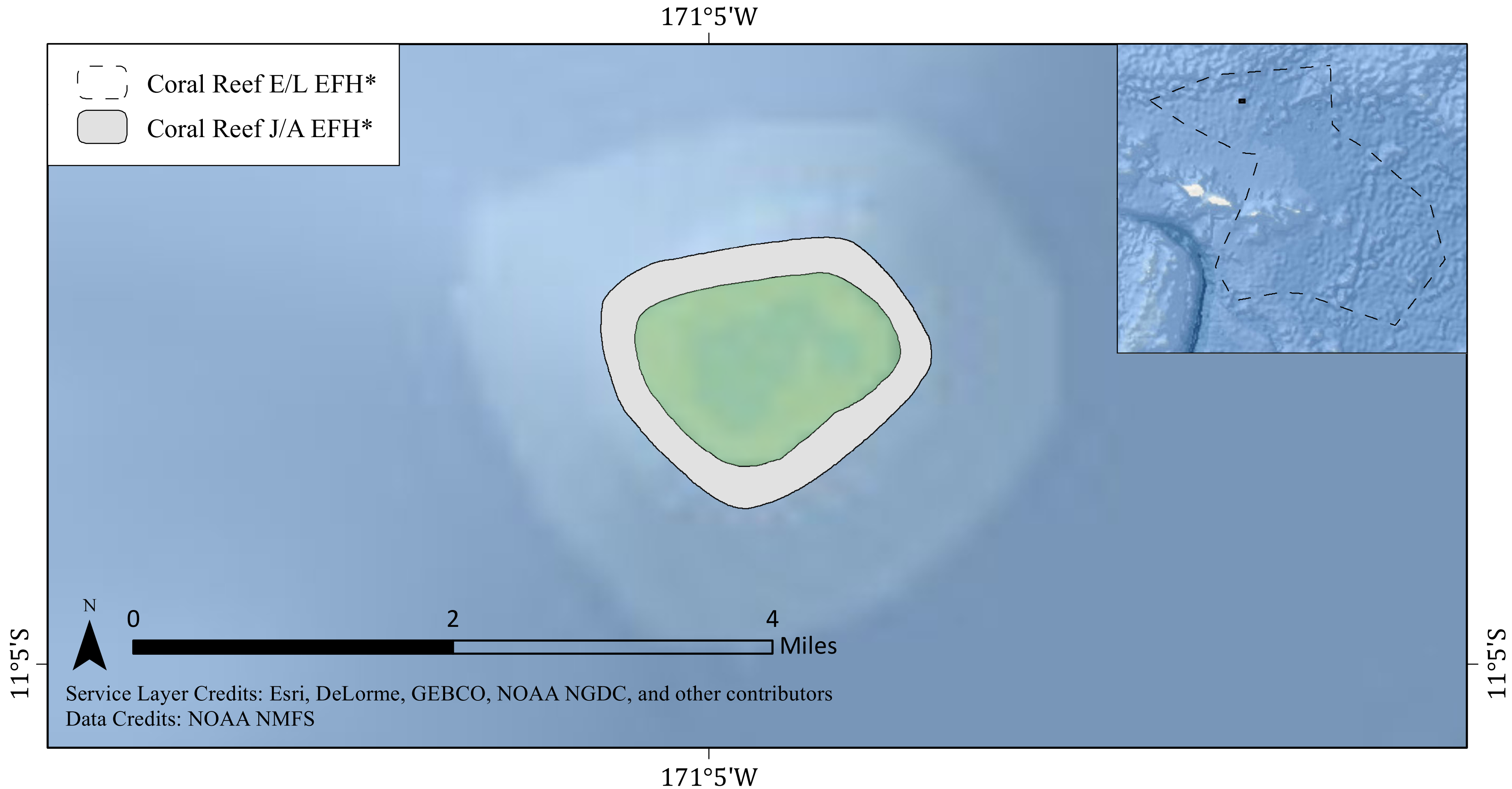
American Samoan Archipelago Fishery Ecosystem Plan
Coral Reef EFH/HAPC: Swains Island



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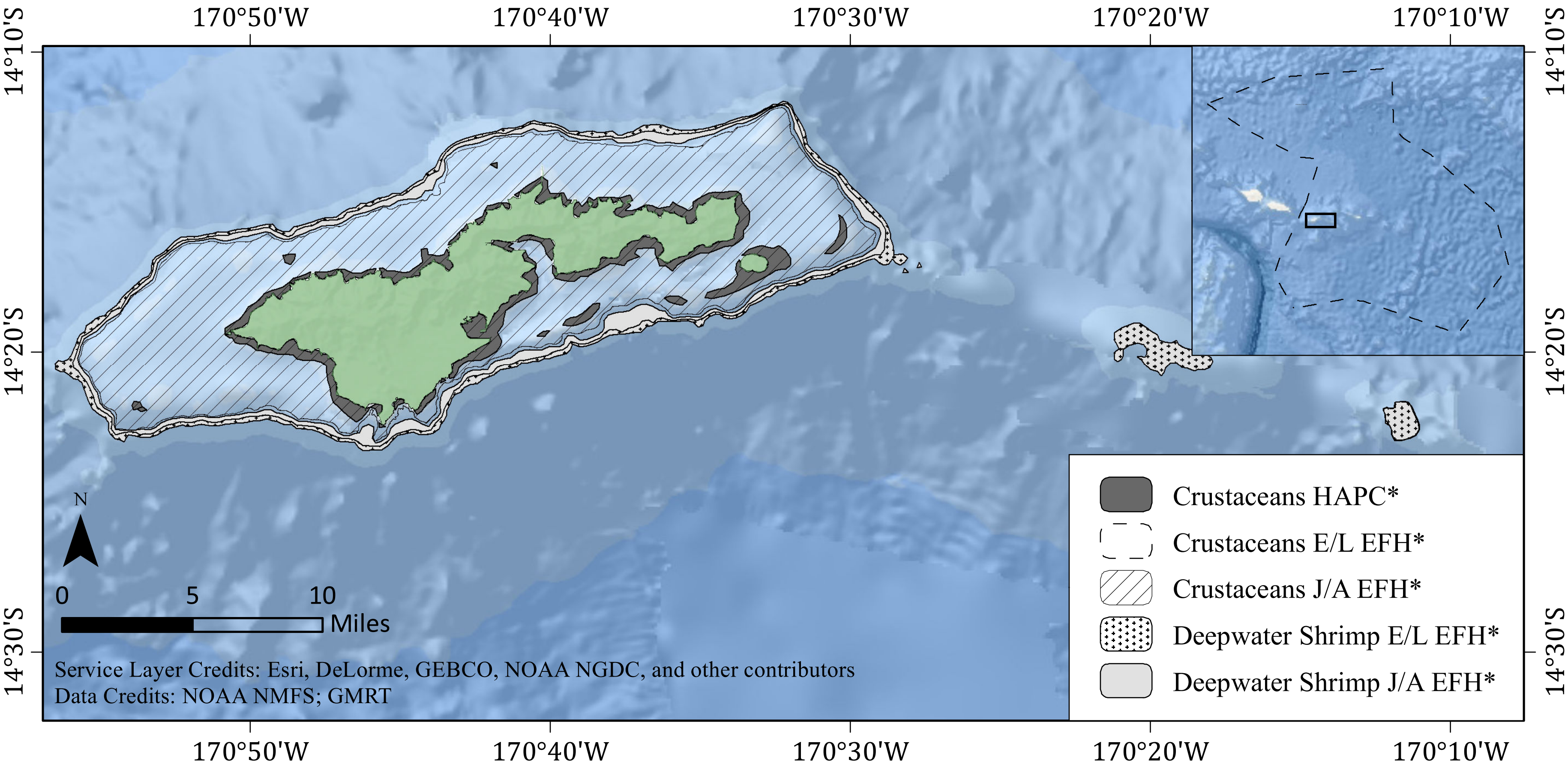
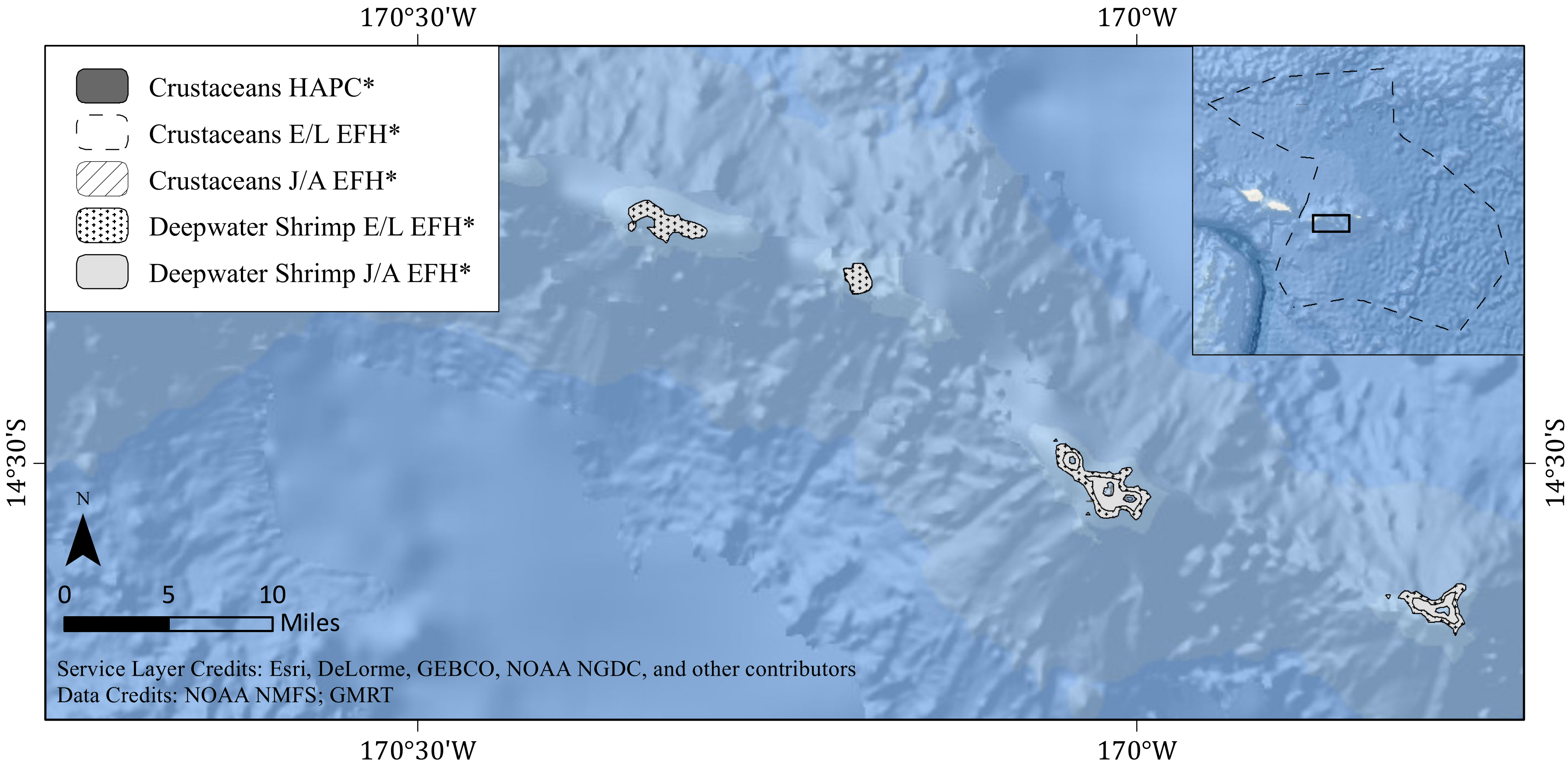
American Samoan Archipelago Fishery Ecosystem Plan
Crustaceans EFH/HAPC: Tutuila



**The geographic extent of EFH is shown. EFH for crustaceans eggs and larvae (E/L) is the water column to a depth of 150 m from the shoreline to the outer boundary of the EEZ, while juvenile/adult (J/A) EFH is all bottom habitat to a depth of 100 m to the extent shown.. HAPC is all banks with summits shallower than 30 m. Deepwater shrimp E/L EFH is the water column and outer reef slopes between 550 m and 700 m to the extent shown, while deepwater shrimp J/A EFH is the outer reef slopes between 300 and 700 meters to the extent shown.*

American Samoan Archipelago Fishery Ecosystem Plan
Crustaceans EFH/HAPC: Tulaga Seamount/Two % Bank



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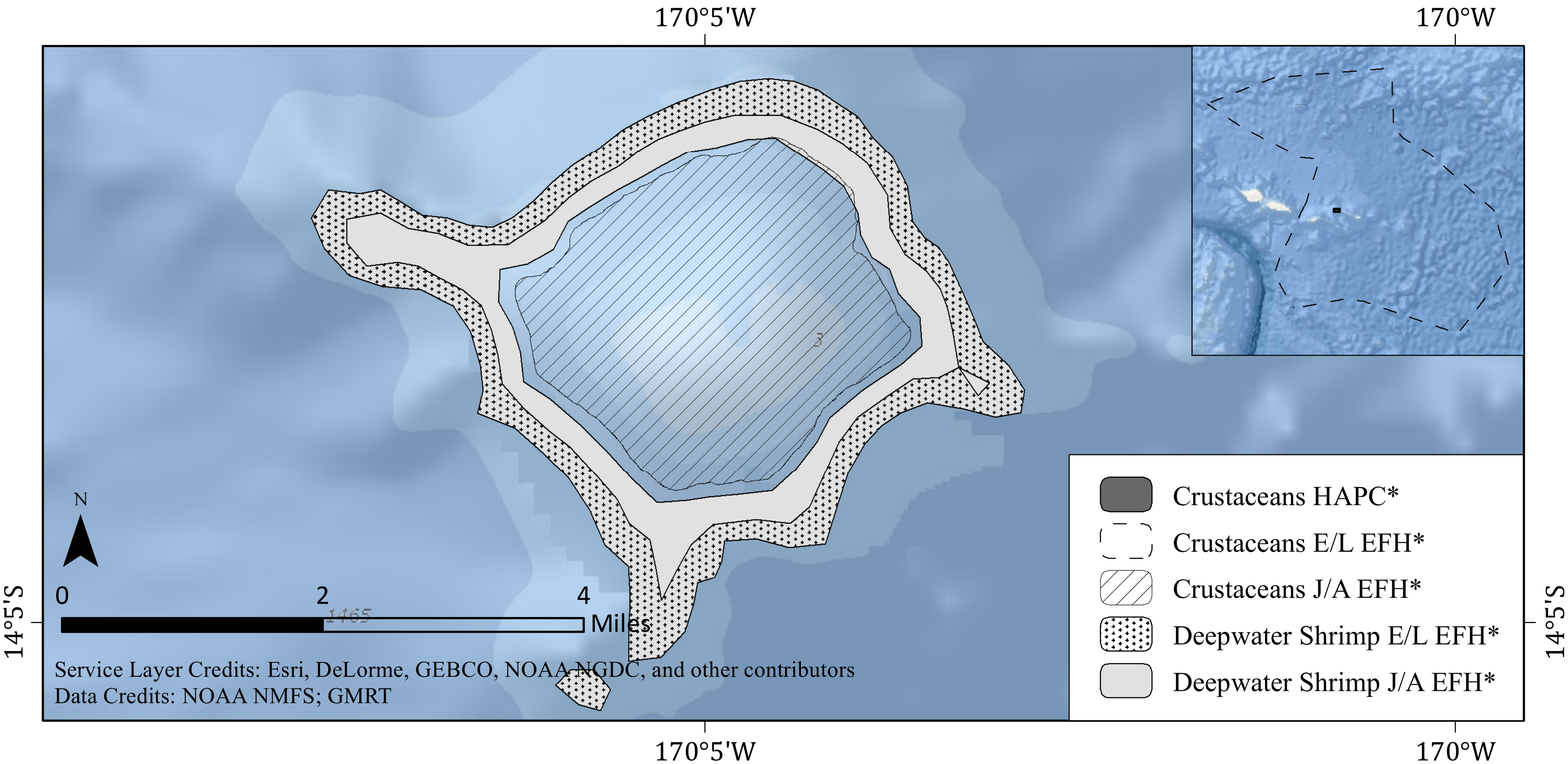
American Samoan Archipelago Fishery Ecosystem Plan
Crustaceans EFH/HAPC: Muli Seamount



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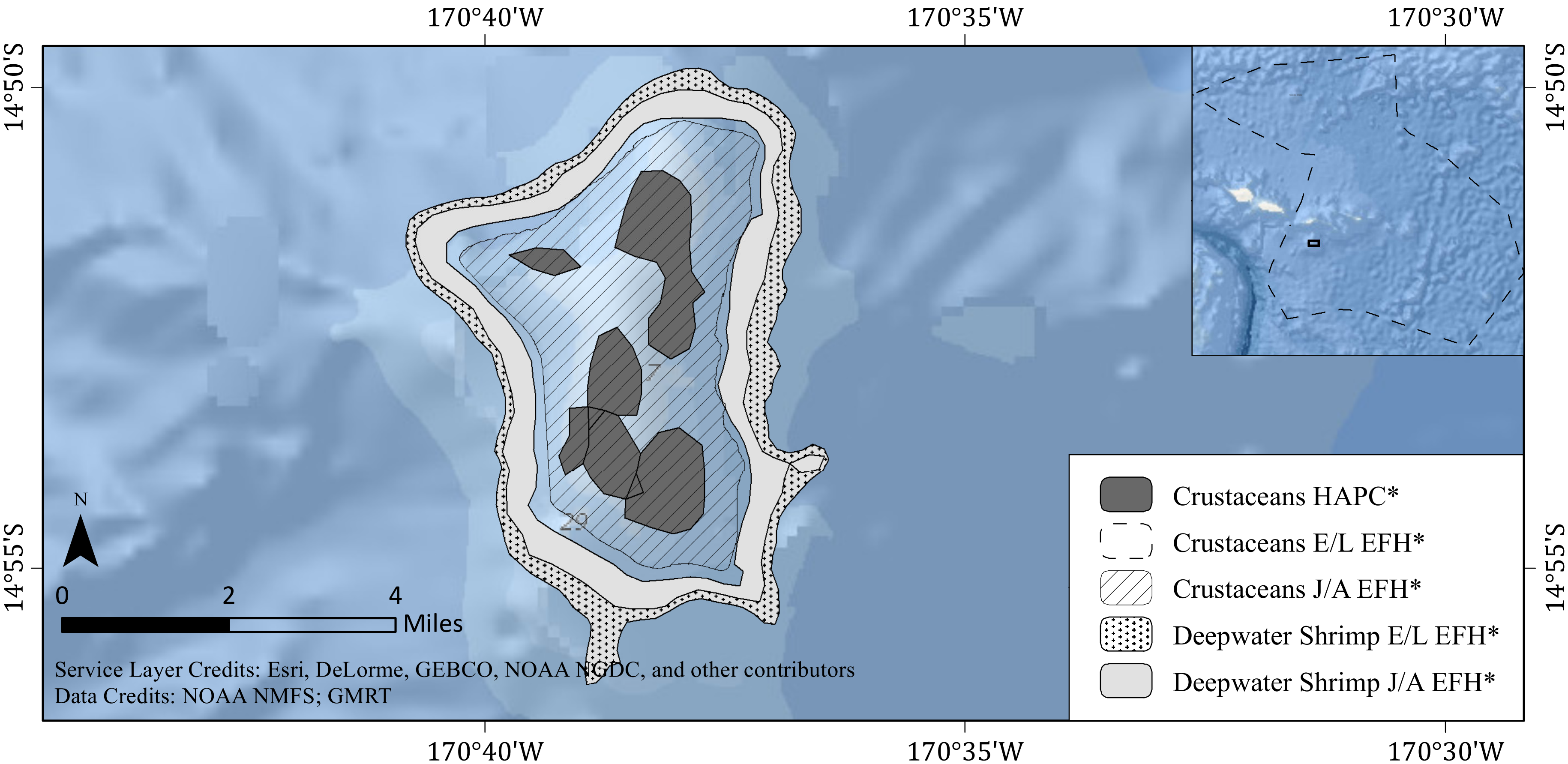
American Samoan Archipelago Fishery Ecosystem Plan
Crustaceans EFH/HAPC: South Bank



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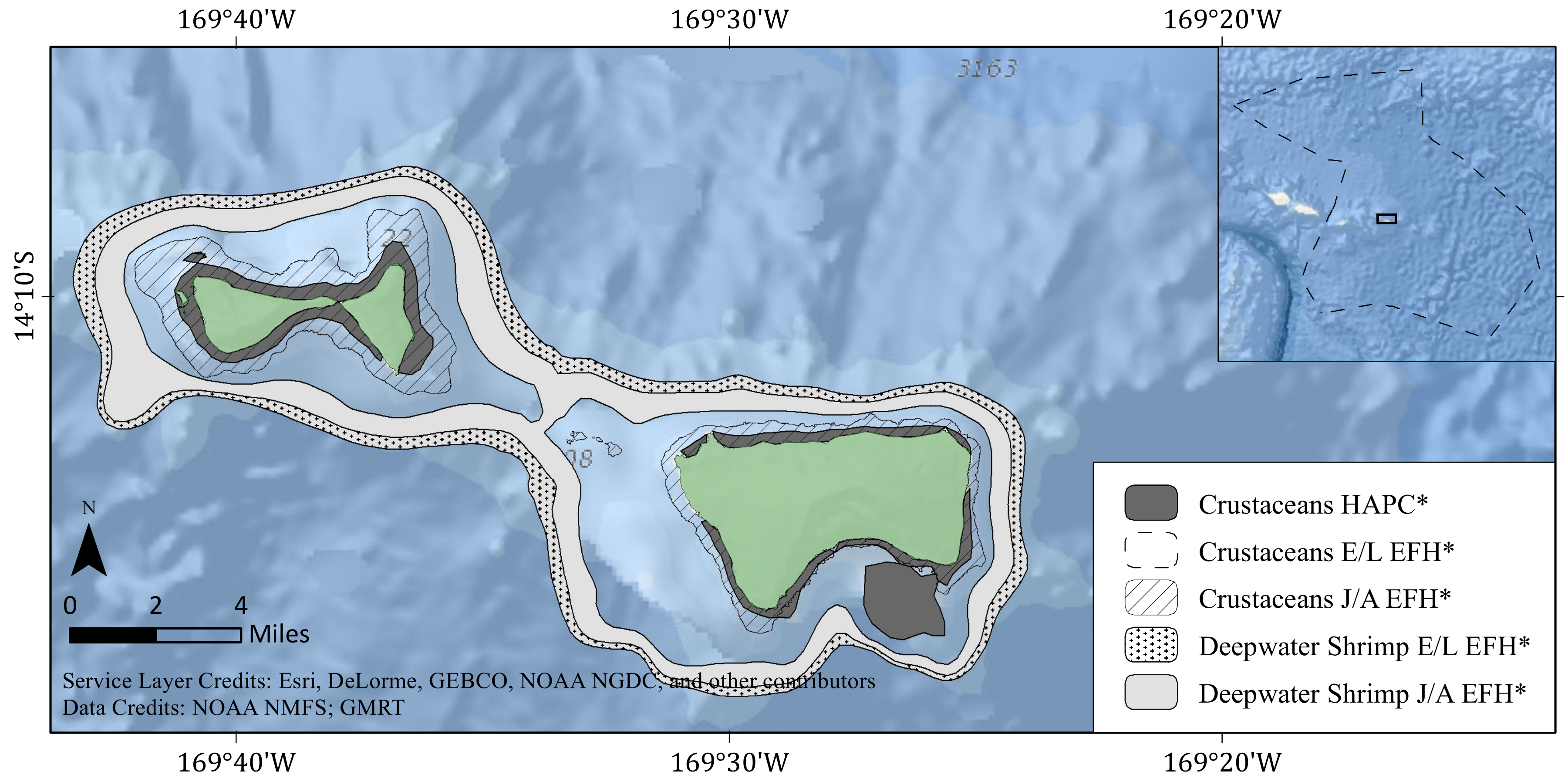
American Samoan Archipelago Fishery Ecosystem Plan
Crustaceans EFH/HAPC: Manu'a Islands



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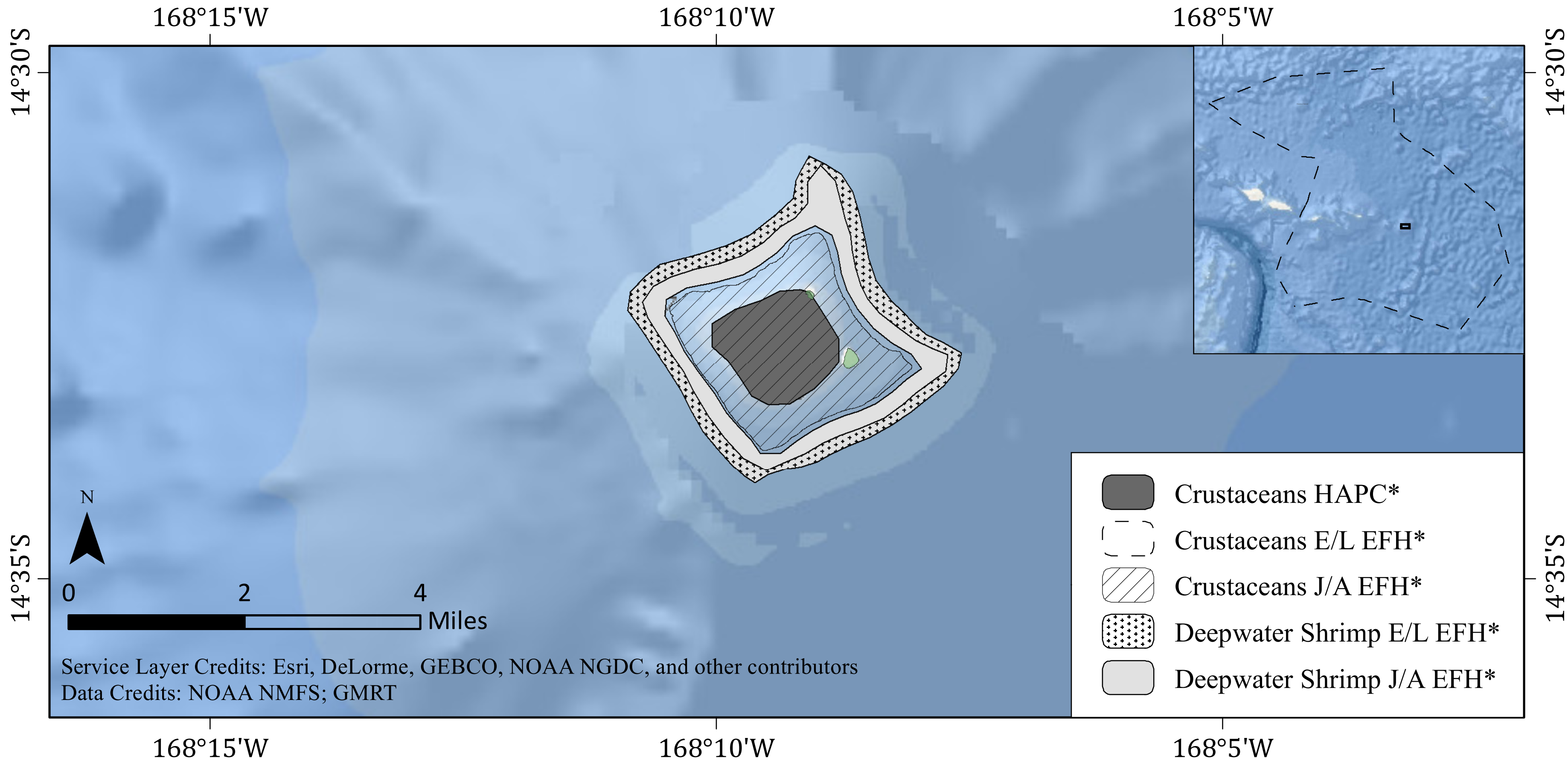
American Samoan Archipelago Fishery Ecosystem Plan
Crustaceans EFH/HAPC: Rose Atoll



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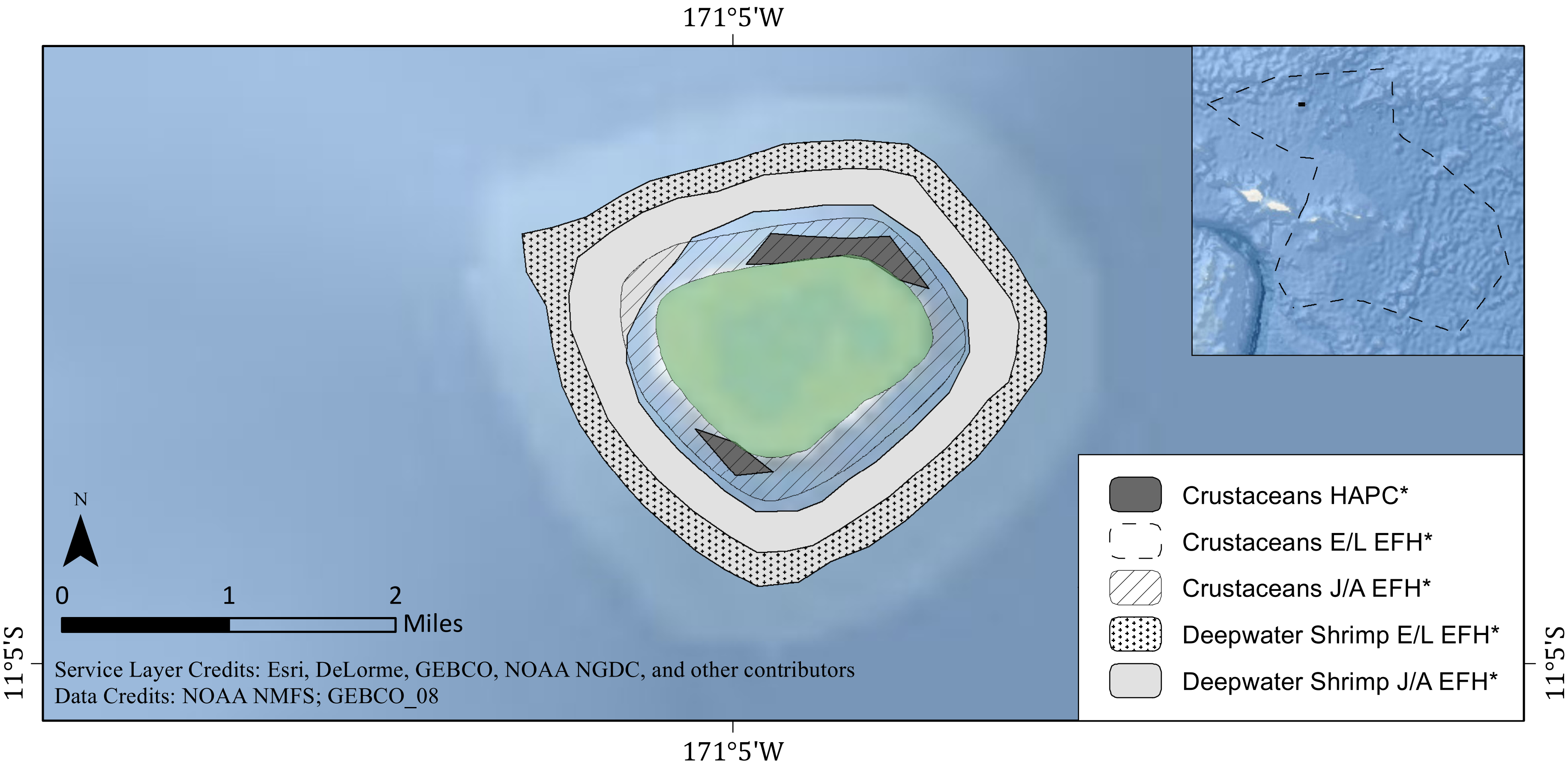
American Samoan Archipelago Fishery Ecosystem Plan
Crustaceans EFH/HAPC: Swains Island



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