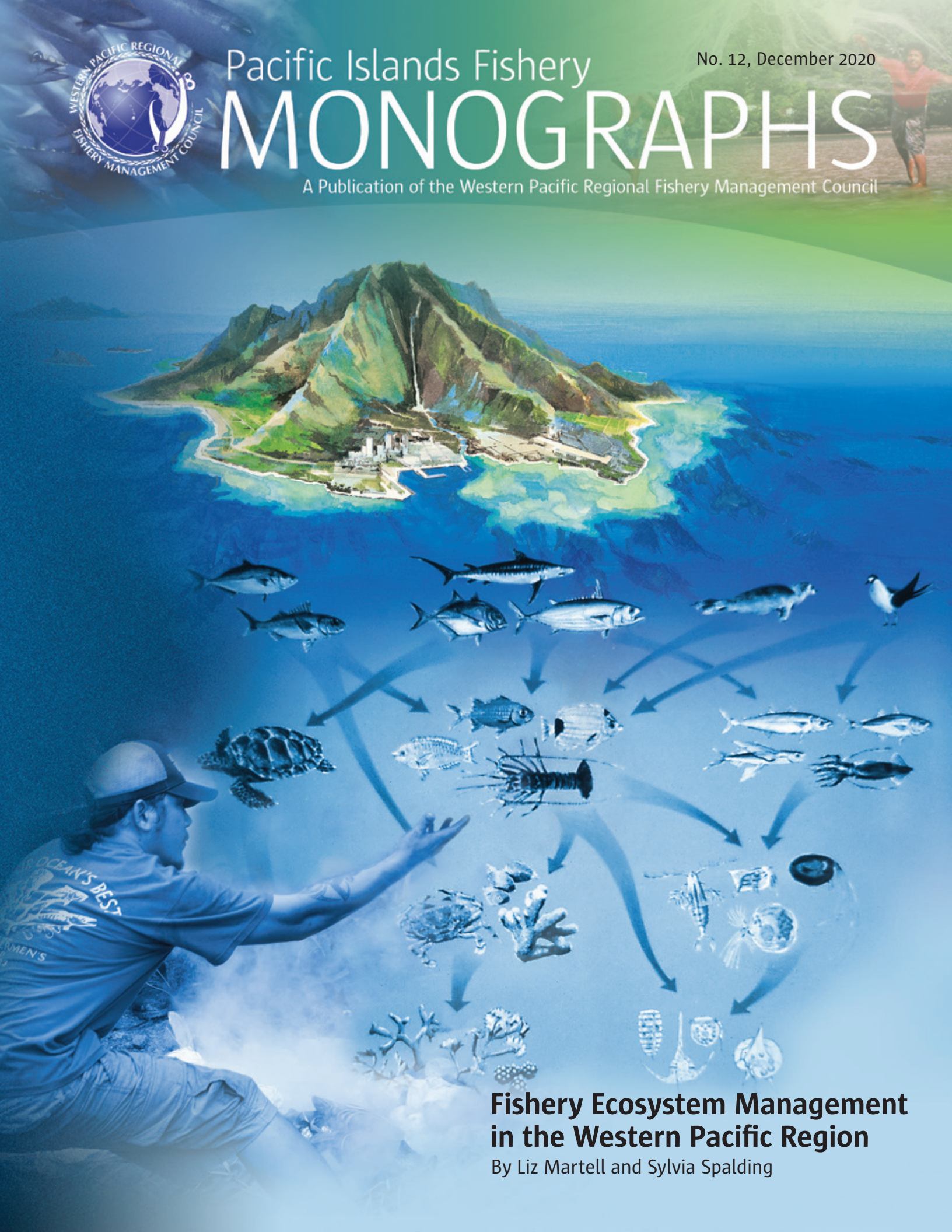
Pacific Islands Fishery
MONOGRAPHS
No. 12, December 2020
A Publication of the Western Pacific Regional Fishery Management Council



Fishery Ecosystem Management in the Western Pacific Region

By Liz Martell and Sylvia Spalding

ISBN: 978-1-944827-74-8

Front cover: Food web, courtesy of NOAA PIFSC; fisherman photo, courtesy of Eric Woo; island ecosystem illustration, courtesy of WPRFMC.

Back cover: Communal fishing in American Samoa, courtesy of National Park of American Samoa.

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List of Acronyms

AP	Advisory Panel
CDP	Community Development Program
CDPP	Community Demonstration Project Program
CNMI	Commonwealth of the Northern Mariana Islands
CRCP	Coral Reef Conservation Program
DAWR	Division of Aquatic and Wildlife Resources (Guam)
DFW	Division of Fish and Wildlife (Northern Mariana Islands)
EAFM	Ecosystem approach to fisheries management
EBFM	Ecosystem-based fisheries management
EEZ	exclusive economic zone
EPAP	Ecosystem Principles Advisory Panel
FDCRC	Fishery Data Collection and Research Committee
FEP	Fishery Ecosystem Plan
FISH	Fishery Information Survey and History
FMP	Fishery Management Plan
GBR	Great Barrier Reef
HARP	Hawai'i Archipelagic Ecosystem Research Plan
IATTC	Inter-American Tropical Tuna Commission
MCP	Marine Conservation Plans
MPA	Marine Protected Area
MPCC	Marine Planning and Climate Change
MSA	Magnuson Stevens Act
MSE	Management Strategy Evaluations
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NWHI	Northwestern Hawaiian Islands
PIFSC	Pacific Island Fisheries Science Center
PRIA	Pacific Remote Island Areas
PSAC	Protected Species Advisory Committee
REAC	Regional Ecosystem Advisory Committee
RFMO	regional fishery management organizations
SAFE	Stock Assessment and Fishery Evaluation
SEEM	Social, Economic, Ecological and Management
SPC	Secretariat of the Pacific Community
SSC	Science and Statistical Committee
TEK	Traditional ecological knowledge
WCPFC	Western and Central Pacific Fisheries Commission
WPacFIN	Western Pacific Fisheries Information Network
WPRFMC	Western Pacific Regional Fishery Management Council

PART I: Introduction

"It is unlikely that any significant improvements in the effectiveness of living marine resource management will be possible unless ecological concepts are explicitly incorporated into management approaches for living marine resources."

Nearly a quarter century has passed since William Evans (Assistant Administrator for Fisheries), James Douglas Jr. (Deputy Assistant Administrator for Fisheries) and Bill Powell (National Marine Fisheries Service (NMFS) executive director) made that statement in the *NMFS Program Development Plan for Ecosystems Monitoring and Fisheries Management* (Evans et al. 1987). The need to forecast ecosystem changes was the force behind NMFS's decision to reorient monitoring and management of the nation's fisheries from a single species/species complex perspective to a multi-species ecosystem approach.

The report noted that "a holistic approach to research, monitoring and management of living marine resources is now feasible because of advances in technology and systems modeling methods." It provided an annotated list of 14 program areas that needed enhancement, from pre-recruit surveys to habitat use resolution.

Redirecting management of the nation's fisheries from species-based to ecosystem-based has been a slow but steady process. Among the first to take up the call was the Western Pacific Regional Fishery Management (WPRFMC, or Council). One of eight councils established through the Magnuson-Stevens Fishery Conservation and Management Act (MSA) of 1976, the WRPFMC has authority over fisheries seaward of state waters around Hawai'i, American Samoa, Guam, the Commonwealth of the Northern Mariana Islands (CNMI) and eight isolated, essentially uninhabited islands and atolls known as the Pacific Remote Island Areas (PRIAs).[1] The Council's jurisdiction,[2] collectively known as the Western Pacific Region, encompasses 1.5 million square miles and accounts for nearly half of the entire U.S. exclusive economic zone (EEZ) (fig. 1).

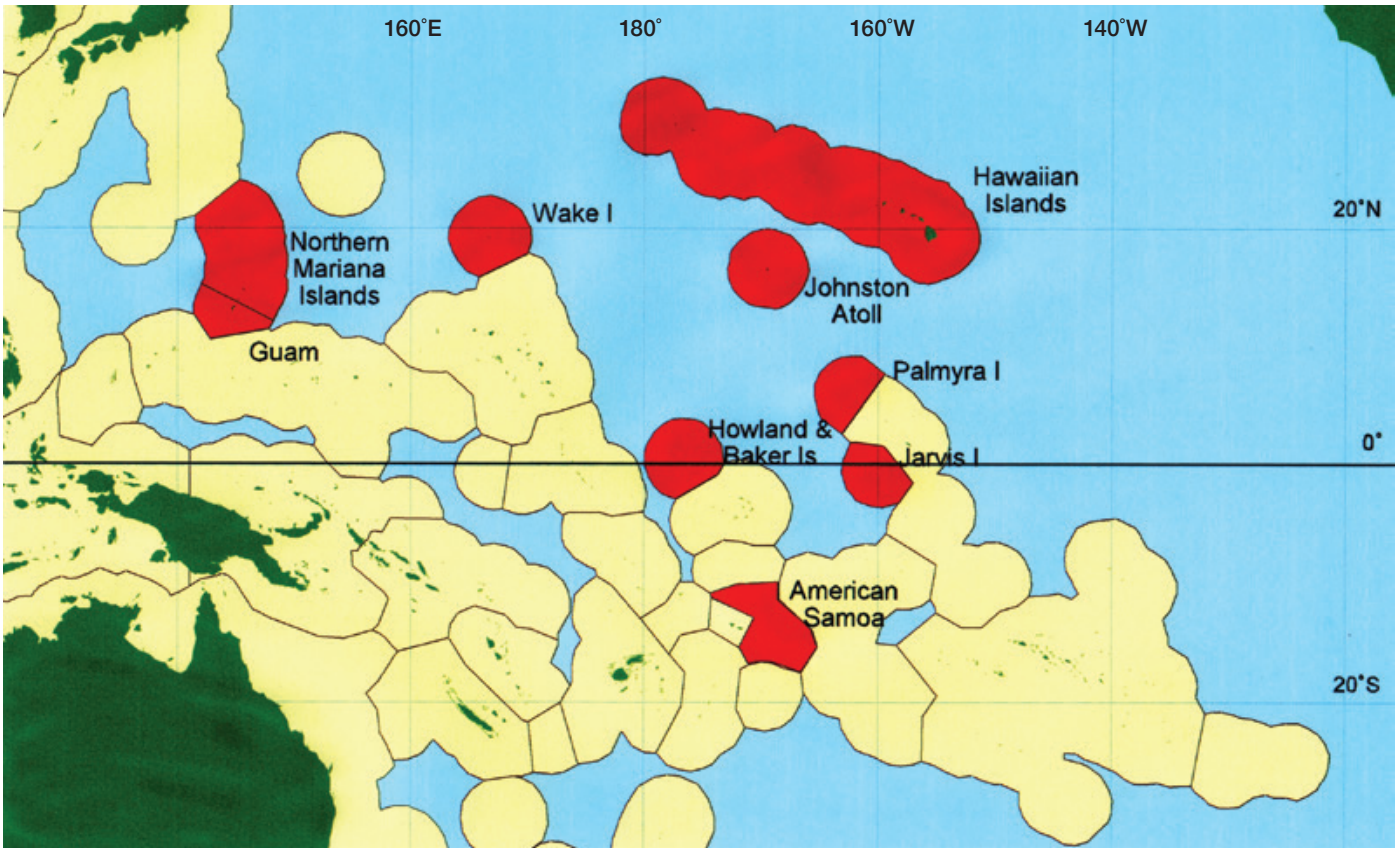


Fig. 1. The U.S. EEZ waters that comprise the Western Pacific Region are in red. The EEZ waters of nearby nations are in yellow. *Source: WPRFMC.*

1. The PRIAs are comprised of Johnston, Midway, Palmyra and Wake Atolls; Baker, Howland and Jarvis Islands; and Kingman Reef.

2. At the federal level, fishery management plans are developed, monitored and amended by the Council, approved by the Secretary of Commerce and implemented by NMFS. The U.S. Department of the Interior's Fish and Wildlife Service and the U.S. Coast Guard are also involved in fishery management issues and are non-voting members on the Council. Within state waters (generally 0 to 3 miles from shore), the principal fishery management agencies are the Hawai'i Division of Aquatic Resources, American Samoa Department of Marine and Wildlife Resources, Guam Division of Aquatic and Wildlife Resources (DAWR) and CNMI Division of Fish and Wildlife (DFW).

The ecosystem-approach to fisheries management (EAFM) meshes well with the traditional resource management methods that have been practiced in the U.S. Pacific Islands. The region's three archipelagos (Mariana, American Samoa and Hawai'i) each has its own distinct culture, communities and marine resources. However, they share a common history of sustaining themselves and their indigenous Chamorro, Carolinian, Samoan and Hawaiian communities on remote, land-limited islands and atolls for thousands of years prior to Western contact (Kirch 2000) through holistic management of the natural resources upon which they depended. These methods are adaptive and consider elements from the ocean to the mountain tops and beyond into the atmosphere, including recognition and respect for the spirit world.

An example is the *ahupua'a* system used in the Hawaiian Islands to manage natural resources, including deep-sea resources, in conjunction with human uses. The geologic configuration of the Hawaiian Islands contributed to the success of this approach. *Ahupua'a* boundaries followed the island's topography, typically a wedge shape, with the narrow point in the mountains expanding toward the coast (fig. 2). People living or working in the forested upland areas provided services and goods to coastal residents and vice versa. There was a hierarchy of leaders and knowledgeable people who made decisions about using and managing community resources. There was extensive interaction between commoners and leaders (*ali'i*) within and across each *ahupua'a*.

Considering that 12 of the 13 voting members of the Council are local marine users and local agency representatives (the exception being the NMFS Pacific Islands regional administrator), it is not surprising that the ecosystem mindset was reflected in the Fishery Management Plans (FMPs) developed by the Council. While the first four FMPs were species-based,[3] they included measures to safeguard the ecosystem, including several expansive marine protected areas (MPAs) and prohibitions against the use of numerous potentially destructive fishing gear and methods.[4]

Fig. 2. The ocean end of the *ahupua'a* of Halawa on Moloka'i. *Ed Glazier photo.*

The importance of being able to predict changes in the ecosystem in order to manage fisheries hit home for the Council in the 1980s. An unexpected North Pacific oceanic regime shift coincided with the development of a lucrative lobster fishery in the Northwestern Hawaiian Islands (NWHI). As catch per unit effort tumbled, environmentalists questioned the management of the fishery, which included bank-specific quotas set at very low (10%) risk of overfishing. Uncertainty in the NMFS models for the fishery coupled with an environmental lawsuit culminated in the annual quotas for the fishery being set at zero to this day.

NMFS convened its first EAFM workshop in 1986, which was attended by Council member Rufo Lujan of Guam and Council Executive Director Kitty M. Simonds. The next year, at the North Pacific Rim Fishermen's Conference in Marine Debris held Oct. 12-16, 1987, in Kailua-Kona, Hawai'i, the Council announced that it would be changing from species-based fisheries management to EAFM. The Council began by contracting studies to determine the management needs of coral reef resources in the region. Following the publication of these studies (Hunter 1995 and Green 1997), the Council started developing the Coral Reef Ecosystem FMP, which would become the nation's first FMP to be ecosystem based.[5]

The 1996 reauthorization of the MSA (also known as the Sustainable Fisheries Act) called for the creation of an Ecosystems Principles Advisory Panel (EPAP) to develop recommendations to implement ecosystem principles in fisheries management (Wilkinson and Abrams 2015). It also authorized the Secretary of Commerce to support regional pilot programs with the nation's eight regional fishery management councils to implement the EPAP recommendations.

3. Federal fisheries in the Western Pacific Region were managed under FMPs for crustaceans (implemented 1983), precious corals (1983), bottomfish and seamount groundfish (1986) and pelagic fisheries (1987).

4. The deep-water precious coral bed between Nihoa and Necker Islands in the Northwestern Hawaiian Islands (NWHI) was classified as a refugium in 1983. In 1986, waters 0 to 20 nautical miles (nm) around Laysan Island were established as spiny lobster refugia and waters landward of 10 fathoms in the remaining NWHI islands and atolls were set aside as a lobster fishery conservation zone. That same year, the Council prohibited the use of explosives, poisons, trawl nets and bottom-set gillnets to harvest fish throughout the region's entire 1.5 million square miles of U.S. EEZ waters. In 1987, it added drift gillnet fishing to the list of prohibited fishing methods in the region. In 1991, the Council created the Protected Species Zone, prohibiting longline fishing throughout the entire NWHI chain from 0 to 50 nm from shore and in the connecting corridors where the 50-nm-radius circles did not connect, an area of approximately 137,000 square nm.

Fig. 3. Fishery scientists and resource managers from more than two dozen Pacific Islands participated in the U.N. Food and Agriculture Organization, SPC and Council co-sponsored coastal fishery management workshop, which included EAFM as a major theme.

The EPAP's *Ecosystem Based Fishery Management* report to Congress was published in 1999. Its primary recommendation was for each Council (including NMFS in the case of Atlantic highly migratory species) to develop Fisheries Ecosystem Plans (FEPs) as the mechanism to meaningfully integrate ecosystem principles, goals and policies into species/species-complex based FMPs (EPAP 1999).

Shortly thereafter, the Council began work to restructure its five FMPs for the Western Pacific Region into place-based FEPs.

Developing an ecosystem-based approach to fisheries was one of three focuses at the second *Managing Our Nation's Fisheries* conference, held March 24–25, 2005, in Washington, DC (Wetherall 2005). At the conference, the WPRFMC reported on a pilot project underway in the Mariana Archipelago to lay the groundwork for implementing archipelagic-based FEPs for demersal fisheries. It also reported on activities to integrate ecosystem-based principles into the Council's existing multi-species Pelagic FMP in order to establish a Pelagic FEP that considers the full range of the highly migratory species. The Council also announced two workshops it would convene in April 2005. The first was a workshop for coastal fishery managers from the Pacific Islands, which included EAFM as one of its major themes (fig. 3). The co-hosts were the Council, the Secretariat of the Pacific Community (SPC) and the U.N. Food and Agriculture Organization.

The second workshop announced had the overarching objective of identifying the science requirements needed to support and develop EAFM in the Western Pacific Region. This workshop became the first of a three-part ecosystem workshop series that included a Biophysical Workshop (April 18–22, 2005), a Social Science Workshop (Jan. 17–20, 2006) and a Policy Workshop (Jan. 3–5, 2007).

The workshop series was held at the Council office in Honolulu and included a panel of experts in the fields related to marine ecosystems (fig. 4). The series Steering Committee was chaired by Sam Pooley, and the proceedings were produced by Ed Glazier of Impact Assessment, Inc.

This monograph, *Fishery Ecosystem Management in the Western Pacific Region*, highlights key elements from the proceedings of the ecosystem workshop series (Glazier 2008) and describes the Council's post-workshop accomplishments and ongoing projects to implement EAFM in the region.

Fig. 4. Ecosystem workshop series expert panel: (***front row l–r)***: Villy Christensen, Kitty M. Simonds (Council executive director), Neil Gribble, Steve Muawski; (***back row l-r***): Dave Fluharty, Samuel Pooley (Steering Committee chair), Jerald Ault, Carl Walters and Patrick Lehodey. Not pictured: Mike Fogarty. *WPRFMC photo.*

5. The Council completed the Coral Reef Ecosystem FMP in October 2001. On June 14, 2002, NMFS issued a Record of Decision that approved the FMP except for the portion regarding fishing in the NWHI west of 160°50' W because NMFS said 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 Feb. 24, 2004 (69 FR 8336).

PART II: Biophysical Workshop

The first workshop was in 2005 at the Council office in Honolulu. The workshop focused on the biophysical aspects of ecosystems that would support EAFM in the Western Pacific Region. The purpose of this workshop was to identify the biological information (such as data, models and indicators) that would be needed to support an ecosystem-based approach to marine resource management in Western Pacific Region.

Biophysical Workshop Goals and Objectives

The goal of the Biophysical Workshop was to identify the following tasks and objectives to support EAFM:

- Current ecosystem data and models
- Short-term ecosystem-based approaches using current data
- Ecosystem indicators and tradeoffs
- New data and models
- Policy or scientific changes needed to implement new data or models
- Management requirements

Data Sources and Needs

The workshop participants described the current biological and economic data for the Western Pacific Region and identified where data was still needed. The gaps in data included historic populations of commercial and recreational fish stocks, data and analytical needs and other key issues. Workshop participants agreed that they might need to find other data sources where existing data were insufficient.

Relationships among species and their environment are complex. In addition to managing the major fisheries, it's necessary to consider fisheries' impacts on nontarget species, habitats and predator-prey dynamics and their interactions with the biological and physical environments.

Fisheries Data: The NMFS Pacific Island Fisheries Science Center (PIFSC) monitors four fisheries in Hawai'i. These fisheries include pelagic longline, NWHI lobster, precious coral and bottomfish. Various fishery-dependent datasets are available for ecosystem modeling and EAFM. Because of the historical variability in data collection, quality varies and data use must be cautious. For example, data for longline and bottomfish fisheries comes from logbooks, the auction house, seafood dealer reports and the at-sea observer program. One important source of data is the public fish auction in Honolulu, which has recorded detailed size data since 1948 and provides the longest-running dataset in the Western Pacific Region.

The State of Hawai'i and the National Oceanographic and Atmospheric Administration (NOAA) have a data-sharing agreement that allows NMFS analysts to access all state datasets through the Western Pacific Fisheries Information Network (WPacFIN). NOAA created WPacFIN in 1981 to help agencies establish and maintain monitoring programs across the U.S. Pacific Islands. WPacFIN provided data collection design, data system design and development, data analysis, training in fisheries monitoring and offsite data storage and management.

Fig. 5. Biophysical Workshop participants, Honolulu, Hawai'i, April 2005. *WPRFMC photo.*

Habitat and Resources Data: Historical and recent data are available for habitat and resources that are associated with marine ecosystems in the Western Pacific Region. For example, NOAA's Coral Reef Conservation Program (CRCP) had a partnership among the NOAA Line Offices. The program provided funds to map and characterize shallow benthic habitats, fish and invertebrate communities around the U.S. Pacific Islands. The CRCP and affiliated programs aimed to provide baseline data for the region. Other research has relied on cruises, field camps, remote sensing, collaboration with other projects and archive data.

Monk seal studies have been conducted every year since 1984. Studies use research approaches that include visual surveys, tagging, identification of individuals and scat analyses.

Oceanographic Data: Scientists collect many types of large-scale oceanographic data in the Western Pacific Region: temperature; salinity; dissolved oxygen and other gases; concentrations of organic material such as chlorophyll pigment; flow dynamics of currents, tides, swells and waves; sea-surface height anomalies; air-sea flux related to global climate; and patterns of change in horizontal and vertical structures.

The appropriate level of resolution is critical to determine what types of data are needed. Workshop participants agreed that fine resolution oceanographic data are needed for an effective EAFM in the region.

Historic Catch Data: A lack of sufficient historic data has limited fisheries analysis in many regions of the world. Zeller et al. (2005) recommended using historic and contemporary information with clearly defined assumptions to conservatively estimate historic catch levels for various species of particular interest to fishery managers. This could help in understanding the historical status of fisheries and fish stocks in the Western Pacific Region.

Data Needs Working Group

The Data Needs Working Group recommended that the Council establish a post-workshop committee to guide research design and data collection for an EAFM in the Western Pacific Region. This proposed committee could gradually develop a centralized ecosystem database for the region that could become a comprehensive, centralized repository of information.

The Data Needs Working Group identified the following EAFM data needs:

- Catch and effort of commercial and noncommercial data
- Bycatch, byproduct and fishery interactions and tradeoffs
- Trophic interactions and diet
- Habitat–species associations and habitat–fishery interactions
- Stock identification and spatial distribution
- Environmental variability
- Traditional ecological knowledge
- Ontogeny and life history
- Spatially explicit processes
- Responses to climate change and oceanic regime shifts
- Eutrophication, habitat alterations and ecosystem productivity
- Social and economic dimensions
- Carrying capacity, lower trophic level and forage base interactions
- Spatial contrasts that reveal processes under differing use impacts

Ecosystem Models and Modeling

The Biophysical Workshop participants discussed models and modeling throughout the workshop. Data, models and management form a circular relationship among management questions, data and models. Management questions determine the data that scientists need to model processes, which then informs management decisions (Fig. 6).

The Biophysical Workshop participants agreed that the most important aspect of modeling is to identify the objectives of the models clearly. Ecosystem modeling in the region should achieve the following:

- Include adaptive management.
- Identify resource and resource management issues.

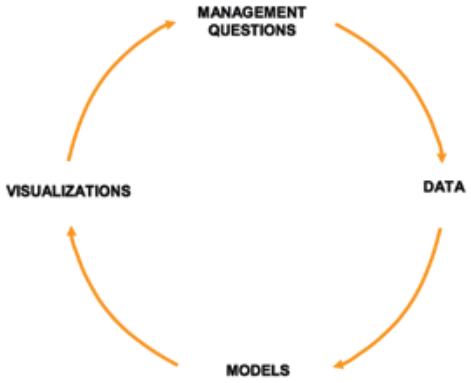


Fig. 6. A conceptual model of the circular relationship among management questions, data and models. *Source: Jeffrey Polovina.*

- Identify potential management policies and objectives.
- Match the model with management policies and options.
- Identify data needs for the model.
- Inventory and collect data for the model.
- Identify other biological processes required for analytical or experimental control.

EAFM should use data and predictive models that help assess the direction and magnitude of response in ecosystem dynamics. Data and models should avoid dogmatic and simplistic concepts about "natural" versus "human" systems, emphasize major interactions and dependencies and use details to capture relevant factors. Newer ecosystem models, such as Ecosim, attempt to represent interactions at all life stages, mortality rates, habitats and other factors that affect the recruitment component of system dynamics.

When transitioning to ecosystem-based management, the following ideas might be helpful when modeling isn't practical:

- Implement regulations on selective fishing, such as quotas that create incentives to avoid taking smaller fish.
- Use pulse rotation closures that are significant enough to prevent biodiversity loss.
- Formalize the use of territorial rights in fisheries to monitor and enforce regulations.
- Apply ecosystem-scale monitoring technologies.

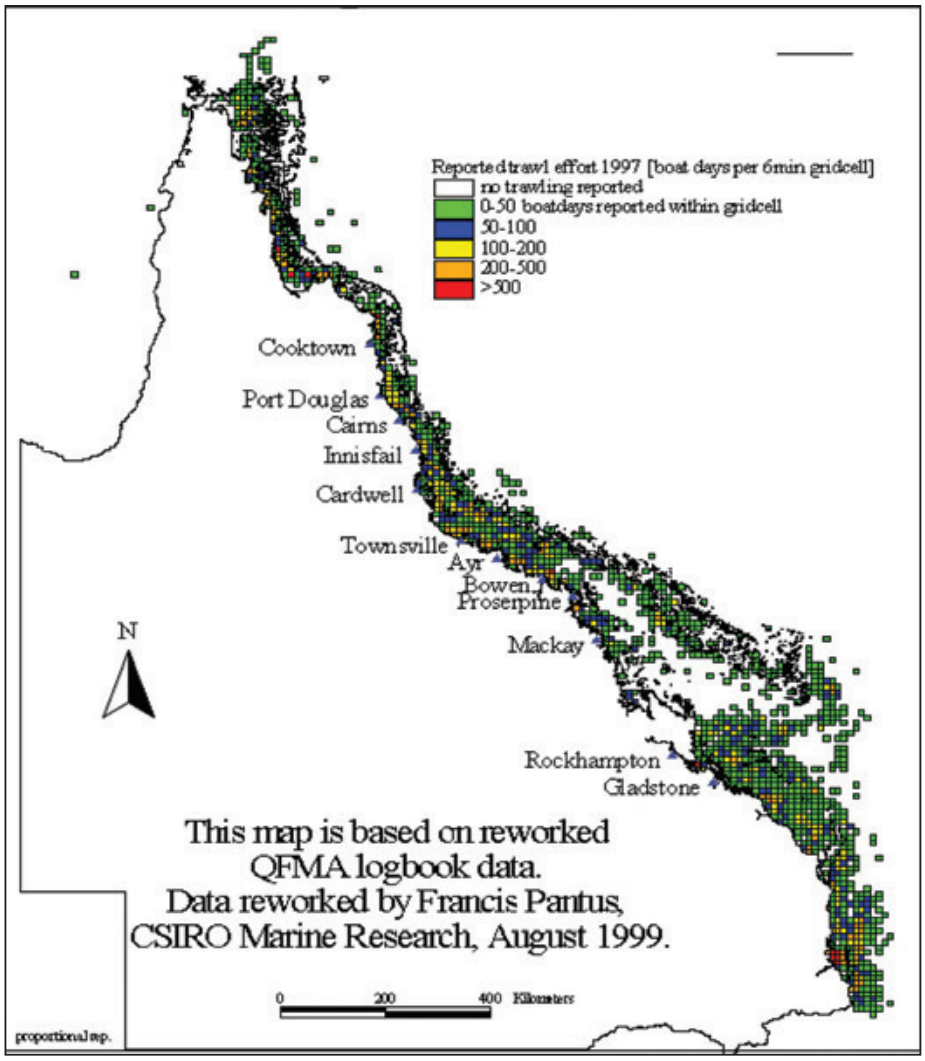


Fig. 7. An ecosystem model that shows the spatial distribution of effort for the prawn trawl fishery on Australia's Great Barrier Reef in 1997. *Source: Neil Gribble.*

Developing useful ecosystem models can be challenging to fishery managers. They must clearly identify policy changes that are needed to establish an ecosystem-based management program. Models also require real data for verification and testing.

Model results should not be considered prescriptive but rather be used to help managers visualize and clarify a question. Or the modeling process could lead to more questions and serve as an important feedback loop, consistent with experimental and adaptive approaches to ecosystem-based management.

Ecosystem Models from Other Regions

Ecosystem modeling incorporates, rather than excludes, assumptions, explanations and confounding factors. Workshops participants presented some of the modeling challenges encountered by those seeking to develop EAFM in coastal and island settings around the world.

Participants presented ecosystem models from other regions. Here, we describe models from Queensland (Australia) and from Florida and Hawai'i (USA).

Australia's Great Barrier Reef Fisheries *(Neil Gribble, Queensland Department of Primary Industries, Cairns, Australia)*

The Great Barrier Reef Marine Park was created in 1975 and became a World Heritage Area in 1981. The ecosystem-based management policy developed for the Great Barrier Reef (GBR) was based on state and federal laws and shared state-federal jurisdiction. It required that, by 2005, every fishery demonstrate ecological sustainability of all species, including bycatch species. Ecosystem-based fisheries management (EBFM) in the GBR relied on substantial spatial closures (approximately 30% of all habitat types are closed to extractive uses) and requirements that the region's fisheries were sustainable across all species captured.

The Northern GBR prawn trawl fishery was one of the principal fisheries in the GBR region. It provided jobs, seafood products and other benefits across a large region. An ecosystem model was developed to help understand the management problems that are associated with the GBR prawn trawl fishery (Fig. 7).

The Northern GBR prawn trawl fishery's ecosystem model was developed to help evaluate the management plans for the GBR World Heritage Area. There were many data sources, and researchers collaborated among several institutions, including the Queensland Department of Primary Industries, Commonwealth Scientific and Industrial Research Organization, Australian Institute of Marine Science (AIMS) and the Reef Cooperative Research Centre at James Cook University.

The ecosystem model considered five parameters for each of 1,000 species in 25 functional groups that included commercially important and bycatch species. The main goal of the modeling was to understand biomass dynamics and basic trends. Spatial simulations were conducted to examine the effectiveness of spatial closures. Researchers compared simulations to logbook data and fishermen interviews. Data that were obtained through the compulsory vessel monitoring system helped assess the extent that fishermen complied with closure regulations.

In summary, the GBR prawn trawl fishery model simulations suggested the following:

- Fishing effort was likely to concentrate along the borders of closed areas, which related to the closed area's size and the historic effort levels in the area.
- Vulnerable species (e.g., slow-growing, long-lived or rare) would benefit from MPAs.

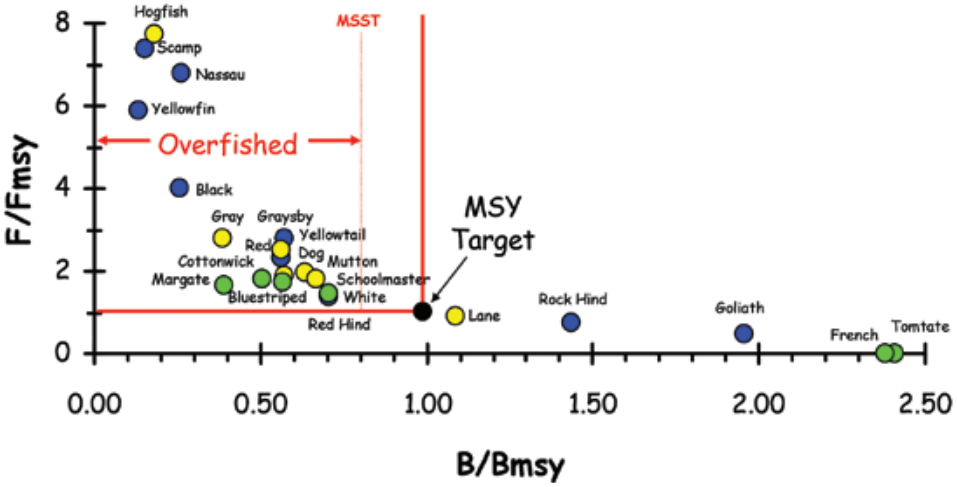


Fig. 8. South Florida and Florida Keys management benchmarks for coral reef ecosystems. *Source: Jerald Ault.*

- Opportunistic species might not benefit from reserve protection to the same degree as many species.
- MPAs are only effective to the extent that fishermen comply with the closures; this highlights the importance of stakeholder buy-in and thorough enforcement.

Florida's Coral Reef Fisheries
(Jerald Ault, University of Miami)

In 2001, coral reef ecosystems in South Florida generated $10 billion in economic activity and provided more than 70,000 jobs. Jurisdictional boundaries led to challenges in managing Florida's coral reef systems.

The University of Miami research program examined an EAFM for Florida, using fishery-dependent data and fishery-independent data. Between 1979 and 2005, the data included more than 300 species and spanned 12,500 km² of ocean. The management benchmarks suggested that overfishing was occurring for most coral reef species.

The EAFM approach in the South Florida coral reef ecosystem established a link between abundance and benthic habitats. This allowed researchers to find simple ecosystem-scale relationships, such as reef fish diversity and benthic habitat type. Around the time of the workshop, marine reserves were being designed in the South Florida coral reef ecosystem as part of the ecosystem-based management approach to fisheries (Fig. 8).

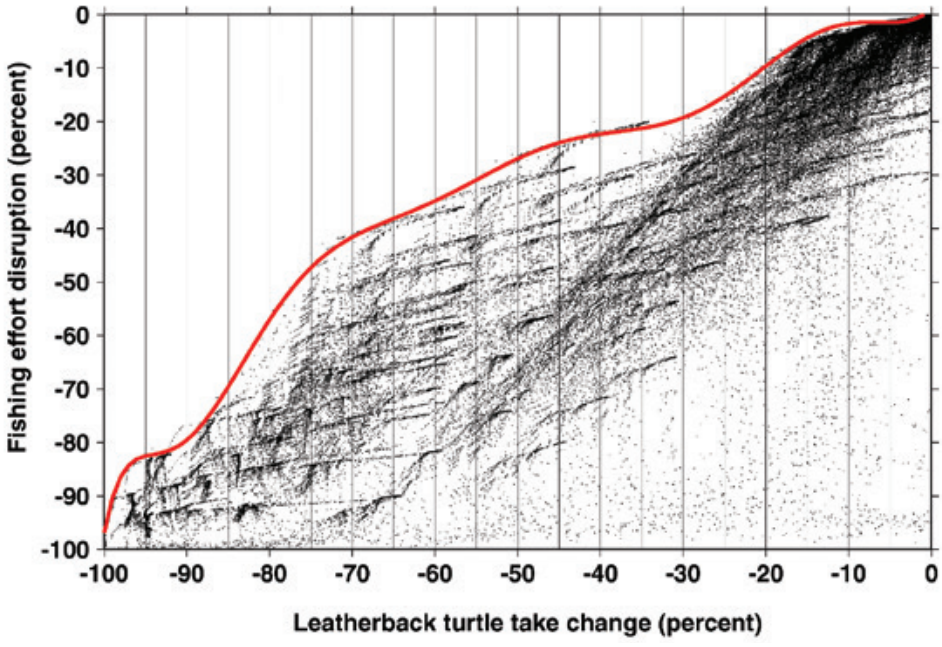


Fig. 9. A simulation of time/area closure scenarios against incidental take of endangered leatherback turtles. *Source: Jeffrey Polovina.*

Status of Hawai'i Ecosystem Models
(Jeffrey Polovina, NMFS Pacific Islands Fisheries Science Center)

At the time of the workshop, Hawai'i's ecosystem models included trophic models (Ecopath with Ecosim) for the NWHI and the Central North Pacific, and spatial models, such as a time–area–gear model, a passive movement model and an active movement model.

Three spatial models were being used or developed in the Western Pacific Region. One model examined the impact of the longline fishing fleet on the incidental take of sea turtles. It showed how the spatial and temporal changes to fishing effort could reduce the incidental take of sea turtles. Researchers used logbook and observer data to model the historical spatial distribution of fishing effort by the Hawai'i-based longline fleet.

The model simulated 350,000 time/area closures versus the inadvertent take of endangered leatherback turtles (Fig. 9). As a result, a time/area closure that reduced the leatherback take by 70% could require managers to reduce fishing effort by approximately 40%. The model was used to estimate the best time/area closure needed to reduce leatherback takes most effectively (per certain conservation targets). It also provided insight into evaluating management measures and their effects.

Another spatial ecosystem model simulated the movement of larvae in the NWHI (Polovina 1999). The model "released" simulated larvae into the environment, to understand the spatial and temporal population dynamics of larvae and their potential for dispersal and retention in the archipelago. It was thought that the model could lead to further hypotheses about the metapopulation dynamics of larvae and hypotheses about source and sink locations in the NWHI and Main Hawaiian Islands (MHI).

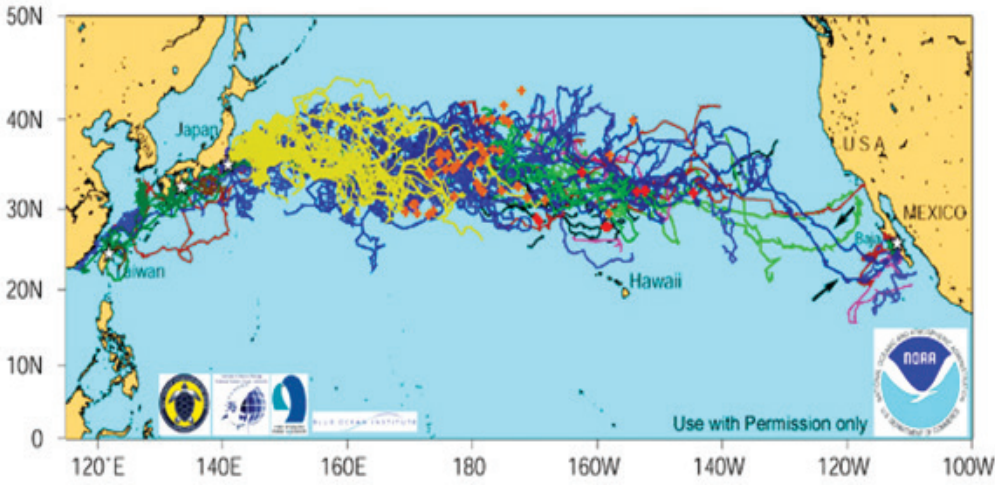


Fig. 10. Distribution and movement of loggerhead turtles in the North Pacific Ocean from 1990–92 high-seas drift-net fishery data and free-roaming turtles fitted with satellite-tracking transmitters 1997–2005. *Source: NOAA.*

A third model examined the distribution and movements of loggerhead turtles in the North Pacific Ocean (Fig, 10). The model used fisheries bycatch (from 1990 to 1992) and fishery independent tracking data (from 1997 to 2005) to observe movement patterns between East Asia, Hawai'i and Baja California. The model results suggested a range of loggerhead movements across the entire North Pacific Ocean. Researchers can use these results to understand loggerhead turtle population dynamics across space.

Ecosystem Models Working Group

The Ecosystem Models Working Group focused on a key question: "Can we develop a flexible, quantitative framework to address management issues and the range of policy and regulatory options required to sustain resources under an EAFM?"

The group agreed to the following priorities for EAFM: 1) clearly identify management issues by area and provide the Council and related decision-makers with potential policy options; 2) identify data needs and get new or already available data for the models chosen; and 3) improve current models by adding new data and modeling techniques, while adapting to changing ecosystems and fishing dynamics.

Workshop participants concluded the following about the role of ecosystem modeling in EAFM in the Western Pacific Region:

- Ecosystems are complex systems. More knowledge (data) might lead to complex models.
- Details that are difficult to model can have potentially significant effects on the outcome.
- Models can address great complexity but can produce false results or questionable precision.
- Complex models may explore strategic tradeoffs and risks even if they don't have precise results.
- Humans need straightforward models so they can make decisions based on understanding.
- Communication between science, management and policy must be clear and precise.
- Scientists should use plain language when describing the assumptions and limitations of data, indicators and models.

Ecosystem Indicators

Ecosystem indicators can help determine the state, or condition, of ecosystems. Ecosystem indicators characterize an ecosystem or one of its critical components (Jackson et al. 2000). In the biological workshop, there was consensus that no group of indicators would be appropriate to consider across all subregions of the Western Pacific Region. Participants stressed that it would be important to adapt and prioritize indicators for specific places and situations.

The International Commission for the Exploration of the Sea, the world's oldest intergovernmental science organization, described important characteristics of ecosystem indicators as:

- Easy to understand.
- Responsive to human activities.
- Linked to specific management actions.
- Easily and accurately measured.
- Unresponsive to other factors.
- Measurable over large areas.
- Based on existing data.

Indicators Working Group

The Ecosystem Indicators Working Group recommended the following actions for developing valid ecosystem indicators for the Western Pacific Region:

- Identify and evaluate feasible, trackable and useful indicators.
- Rank each priority according to how it applies to each archipelago or open pelagic zone.
- Assess the performance of specific indicators.
- Meet management needs and modeling requirements.
- Develop approaches to address the status and pressures of marine ecosystems and evaluate the feedback effects of management actions.

Workshop participants listed potential indicators as measures of ecosystem status in the Western Pacific Region. These included habitat quantity and quality, keystone or functional species, sentinel and protected species, assemblage structure, biodiversity, pathogens, harmful events and fishery measures. Any of these indicators could be linked to management objectives in the region.

Summary of the Biophysical Workshop

Biophysical Workshop participants provided policy recommendations to implement an EAFM in the Western Pacific Region:

- Industry should actively participate in research, monitoring, resource conservation and sustainability.
- Use a precautionary approach when implementing the ecosystem-based approach in the region (i.e., let science catch up to the management approach).

- Identify ways for scientists and managers to develop sufficient understanding of changing environmental conditions.
- Learn from other regions and their successes.
- Use incentives toward management goals.
- Consider fairness and equity for appropriate and ethical balance of social and economic benefits and liabilities.

Biophysical Workshop participants also gave other recommendations that apply to an EAFM in the Western Pacific Region. For example, scientists should work to reduce uncertainties associated with data, models and indicators. Managers should be able to use data and analyses to think through potential policy outcomes and effects for both biological and social aspects. Finally, when scientists know what policy options or potential outcomes to model, they should determine the data, indicators and approaches they will use to analyze the options (Fig. 11).

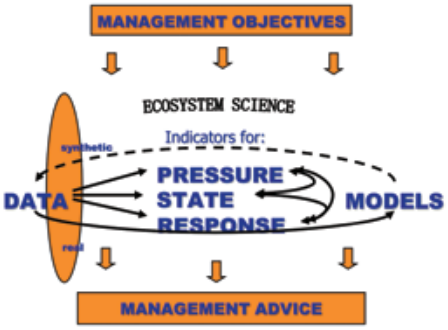


Fig. 11. A conceptual model of the role of ecosystem science in fisheries management. *Source: David Kirby.*

PART III: Social Science Workshop

The second workshop was in 2006 at the Council office in Honolulu. The Social Science Workshop focused on the human aspects of ecosystems that would support EAFM in the Western Pacific Region.

Fig. 12. Participants of the Northern Islands Community-Based Fishery Management Planning Workshop identify the general location of resources and their uses in the Northern Islands of the CNMI. *WPRFMC photo.*

For a long time, social scientists have realized that relationships between humans and the physical environment exist. NMFS and the fishery management councils have addressed the human dimensions of ecosystems in varying degrees since the beginning of the MSA in 1976. Over the years, the Western Pacific Council has clearly indicated that humans and societies are integral parts of fisheries and marine ecosystems.

Social science addresses complex issues by using sophisticated methods. Social science can help identify economic and social incentives to help communities benefit from conserving natural resources. It may also help identify key stakeholders and determine their support or opposition to new types of resource management. Finally, social science can help identify human threats and potential benefits to marine ecosystems.[6]

Community members often have ecological knowledge that can help scientists and managers involved in ecosystem planning and management (Fig. 12). Social science research methods can help reveal local ecological knowledge and adapt management strategies in context.

Fisheries social science is defined as "the study of human behavior associated with or affecting the pursuit, use, distribution and management of marine resources and the related environment" (Glazier 2008). The purpose of the Social Science Workshop was to examine social science requirements for an EAFM in the Western Pacific Region and provide recommendations for implementing it.

6. For more information about the history of social science and fisheries management in the region, refer to the Council's publication: *Managing Marine Fisheries of Hawai'i and the U.S. Pacific Islands—Past, Present, and Future* (WPRFMC *2003*).

Fig. 13. Social Science Workshop participants. *WPRFMC photo.*

Social Science Workshop Goals and Objectives

Participants considered two questions during the Social Science Workshop:

1. In what ways does EAFM differ from a single-species management approach?
2. When should new principles and approaches be implemented?

The workshop focused on three main topics, including: 1) opportunities for fishery ecosystem research and monitoring; 2) governance, institutional ecology and social connectivity within and across jurisdictions; and 3) traditional ecological knowledge (TEK). TEK issues included customary fishing practices and community participation in fishery management across the region. Participants considered several concepts and factors to guide their process and planning for EAFM (Fig 13).

Social Science Workshop participants established that the term ecosystem consists of three parts: 1) a distinct biological feature; 2) the people who are interested in, affect or are affected by that feature; and 3) people who manage or are otherwise responsible for developing and enforcing rules of human behavior related to the biological feature. Thus, people must be considered essential to ecosystem research and management.

For an effective EAFM in the Western Pacific Region, it's best to use a place-based approach centered on the islands and archipelagos. This approach emphasizes human ecological processes in the subregions (archipelagos) and addresses the connections between people and resources in those areas. This is a central principle of EAFM. It differs from the single-species management approach that tends to emphasize biological factors.

Workshop participants also discussed several concepts about ecosystem-based management.

In short, management is about managing people (not fish); incentives are a vital part of effective fisheries management; and context is everything. Adaptive and integrative approaches to management can integrate established fishing practices and concepts into the process. Traditions and knowledge based on experience vary widely in the Western Pacific Region and should be considered.

Further, management objectives should promote social science research and analysis. In other words, social scientists should perform research that is relevant to the needs of decision makers. Finally, social scientists should monitor human interactions within ecosystems by observing the flow of goods and services and by developing valid social and economic indicators. Social sciences should also consider indirect ecosystem relationships, such as tourism.

Before the workshop, the Council developed the following objectives for supporting EAFM with social science:

- Clearly identify social science research needs and related data and modeling.
- Set priorities for incorporating social science data and analyses into existing plans and programs.
- Adaptively respond to emerging challenges through social science research and data.
- Monitor and evaluate the outcomes of such work in terms of the degree to which efforts can better manage the fishery.

The Social Science Workshop explored a wide range of themes related to ecosystem-based management of marine resources in the Western Pacific Region. This included discussion and presentations on the following topics:

- Human and biological factors that relate to marine fisheries and fisheries management.
- Opportunities and constraints for including social science in ecosystem-based management.
- Data needs and collection methods.
- Indicators for assessing management strategies and the effects of regulations.
- Capacity and scope of social science efforts for ecosystem-based management.

Social Science Modeling and Approaches

It's important to examine the relationships of human systems and acknowledge humans as critically important parts of natural systems. To do this, different types of models and approaches can be used at various stages of the research process. Models allow social scientists to conceptualize and analyze relationships associated with human well-being. This can help highlight relationships that might otherwise go unnoticed. Models can also help further the understanding of relationships between multiple human and biological factors. Using models helps guide social scientists toward a better understanding of complex systems and related management decisions.

Different types of models are relevant and useful in social science: heuristic, causal and pattern-oriented models. Researchers use heuristic models

during initial research efforts. Using an iterative process, these models help develop theory and structure data collection processes. Causal models are useful for testing hypotheses, developing theory and making decisions. Social scientists often start with a heuristic model to collect quantitative data and then use that data to test hypotheses about causal relationships. Pattern-oriented models are used to develop theory about complex human systems.

Traditional Ecological Knowledge

TEK is of great interest for ecosystem-based management of marine fisheries. Much of the previous research on TEK has been anecdotal or qualitative, but TEK approaches have been increasingly systematic and quantitative. Modeling TEK may help compare different aspects of human knowledge and develop an ecosystem approach to management processes.

Bioeconomic Management Strategy Evaluations

Bioeconomic Management Strategy Evaluations (MSEs) could be useful to help determine which management strategies will most closely achieve specific objectives. These tools can simultaneously reveal a strategy's effect on future ecosystem properties, future patterns of ecosystem-related flow of goods and services and the distribution of gains and losses over time.

A bioeconomic MSE model for the Western Pacific Region could incorporate standard stock assessments and explore relationships between fishing effort, fishing mortality and participant well-being. It could help provide answers to questions about the effect of fishing mortality patterns on stock size, age class, distribution and spawning biomass.

To create an effective model, scientists need to understand participants' incentives and be ready to accommodate new variables, such as cultural aspects. Models will be useful only if they consider management objectives.

Adaptive Management

Adaptive management is "learning by doing." Implementing adaptive management programs involves an opportunity to test and improve the scientific process. While adaptive management may be useful, it's difficult to achieve in the policy arena. For example, when the Clean Water Act was enacted in the United States several decades ago, point source pollution was the first task to be considered. After initial adjustments and successes, a comprehensive policy began to develop. Many agencies are now implementing nonpoint source pollution programs around the nation.

It's a significant challenge to integrate multiple agencies in an ecosystem approach. To integrate agencies, ecosystems must be subdivided for management purposes into goals, programs, and projects. One challenge is to measure the goals to assess the overall progress toward achieving the broad goal of ecosystem health.

Social Science Data Sources

The following summaries describe some of the workshop presentations about agency and regional marine social science data, which included discussions about direct and indirect ecosystem relationships (Fig. 14). This section also provides descriptions of some of the regional or cultural aspects that relate to EAFM in the Western Pacific Region.

Agency Considerations

NMFS evaluates the extent of community involvement in fishing-related activities, including those associated with commercial, subsistence and recreational fishing. NMFS began

Fig. 14. Direct and indirect ecosystem relationships. *Source: Patrick Christie.*

Fig. 15. American Samoan villagers using a traditional *launiu* (coconut frond) weir to encircle and catch atule. *National Park of American Samoa photo.*

developing its Social Science Research Program in 1999, as a result of the National Standard 8 funding provided after the 1996 reauthorization of the MSA. The research program created regional and national databases, Community Profiles Databases and Indicators, to support community-level research and monitoring. These databases identified and profiled communities and ports where fishing-related activities occur. This provided researchers with a wide range of information relevant to fishing activities and local socioeconomic and demographic conditions, which is useful for developing EBFM plans.[7]

Based on recommendations from the NOAA Science Advisory Board, the National Ocean Service (NOS) created a Social Sciences Team to evaluate the status of social science in the agency. There were diverse and distinct NOS social science needs that included the following topics: characterizing sanctuary resource use, evaluating MPA use and impacts, socioeconomic monitoring and providing help with management planning and technical support.

The Coastal and Marine Resources Program, the Corals Program, the Ecosystem Research program and the Habitat Restoration Program used a "bottom-up" approach to management. Through its management processes, the Coastal and Marine Resources Program promoted healthy and productive ecosystems and incorporated socioeconomic and demographic factors. The Corals Program preserved and restored coral reef ecosystems. Ecosystem Research provided scientific information and decision support tools by integrating research from the biological and social sciences. Finally, the Habitat Restoration Program mostly used damage assessment to improve the quality and quantity of coastal habitat restoration.

Specifically, these programs developed a project called the "Regional Priorities for Research on MPAs" and the NWHI Reserve Commercial Bottomfish study. The Regional Priorities for Research on MPAs was established to detect social science research needs at a regional level, which resulted in several workshops with focus groups and targeted discussions and the identification of regional priority projects. The NWHI Reserve Commercial Bottomfish study began to develop the Environmental Impact Statement and management plan for the NWHI Reserve's Sanctuary Designation Process. The study analyzed existing information, including a survey of the fishermen and spatial analysis of logbook data.

Regional Considerations

Pacific Island societies have experienced significant, and sometimes negative, changes since the arrival of Europeans. As a result, locals' resistance to research by outsiders is not uncommon. Researchers can increase input from local community members by including them as paid participants and as interviewers on the research team. To enhance fisheries' social science capacity throughout the region, the researchers should view locals' perspectives as more than just a diplomatic gesture. Graduate and undergraduate programs and internships should represent this region's cultures and people.

American Samoa. Fishery-related industries in American Samoa are crucial to the economic and social livelihood of the local people. Commercial tuna fishing is particularly important to the local economy. At the time of the social science workshop, the tuna canneries provided the largest private-sector source of employment in the region. American Samoa tuna canneries employed about one-third of the country's approximately 15,000 employees. Another several hundred people supplied the fish.

Several issues have challenged fishermen in American Samoa: 1) unreliable airline service for exporting fresh fish;

7. NOAA line offices include NOS, NMFS, National Weather Service, National Environmental Satellite, Data and Information Services, Office of Oceanic and Atmospheric Research and the Office of Program Planning and Integration. NOS personnel manage coastal zones and ecosystems through the Office of Coastal Resource Management. Other NOS offices include the Office of Coast Survey, the Center for Oceanographic Products and Services, the Coastal Services Center and the Sanctuaries Program.

2) lack of a market for incidental catch landed by large vessels; and 3) unreliable results from the fish aggregating device program. Compared to neighboring Independent Samoa, fisheries-related development programs were insufficient. The potential departure of the tuna canneries was an immediate and significant issue.

Adequate enforcement, representation and jurisdictional authority challenged efforts to manage fishery resources in American Samoa effectively. Immigration laws made many Independent Samoan cannery workers ineligible to work, which resulted in a cannery worker shortage.

Understanding *Fa'a Samoa*—the Samoan way—is critical to understanding Samoan society, culture and environmental interactions. The chiefs, or *matai*, have great authority. Samoans' cultural identity shows respect for the *matai* system and follows customs and traditions. Fishing and fish are central aspects of local society and culture. Fisheries management occurs at the village level and local chiefs grant permission to fish in each reef area.

Subsistence-oriented fishing continues to be important for American Samoans' diet, culture and social practices. While there is a downward trend in fishing efforts because of access to cash income and the availability of food imports, Samoans continue to follow some traditional fishing practices (Fig. 15). Commercial fishermen are not required to provide portions of their catch to the chiefs and the community, but they will often donate their catch to family or community events. Fishermen still give some of their catch to relatives and friends waiting at landing sites in a traditional fishing practice called *tapuaiga*. Similarly, it's still common to provide and eat fish for Sunday brunch.

Entire villages are involved in the communal seining of the polychaete worm *palolo* (*Eunice viridis*) each year in October and November. Samoans still practice another traditional fishing method, *lau*, that also involves the entire village. Villagers gather on the inner reefs and drive fish (*atule*) toward a trap of coconut leaves. As with *palolo*, it was traditionally taboo to sell the *atule* catch, but roadside sales are now common.

Fishing-related stories and customs are an important part of Samoan culture. The Samoan language uses marine species' names, fishing gear and methods and has many familiar expressions originating from fishing experiences.

Mariana Archipelago: Commonwealth of the Northern Mariana Islands. In the Mariana Archipelago (CNMI and Guam), seafood consumption is an effective indicator of the potential for developing FEPs in the region. This indicator demonstrates how much seafood is consumed versus other food products, the rate of seafood consumption, the species consumed and the percent of locally landed food fish.

Seafood consumption in the CNMI has declined dramatically since the 1940s. At that time, islanders depended heavily on seafood. Declining local seafood consumption may reflect growth in the cash economy and a related decrease in fishing for subsistence and cooking at home.

Chamorros, a minority population in the CNMI, are politically dominant. Other ethnic groups in the subregion participate in fishing, including Filipinos, Micronesians and Carolinians. Seafood is socially and culturally important in the Mariana Archipelago, characterized by events such as festivities held in honor of the villages' patron saints (Fig. 16). Fresh fish is essential at these events.

Given the cultural variability in the CNMI, seafood consumption patterns vary extensively. Many nearshore species are pursued and consumed, including sea cucumbers, small crabs, mollusks and reef fish. The importance of seafood in the CNMI suggests a need to assess and monitor food security, local seafood production rates versus imports and general seafood consumption patterns.

The CNMI is comprised of 14 islands in the Mariana Archipelago, five of which are inhabited. Saipan is the largest island and most of the economic activity occurs there. Likewise, most of the approximately 70,000 residents of CNMI live on Saipan. The populations of Tinian and Rota form approximately five percent of the total population and there are a few families living on the northernmost islands. The population of CNMI is ethnically diverse and has an ethnically diverse labor force. Indigenous Chamorro and Carolinian ethnic groups, who total a quarter of the population, have traditionally maintained political power positions.

The northern islands have a controversial history of marine management. Some sanctuaries were designated by public law without holding public hearings or providing opportunities for public comment. Eight MPAs were designated around CNMI; some protected single species (e.g., sea cucumbers or trochus), while

Fig. 16. Fishermen preparing for Guam Lunar Festival. *Eric Woo photo.*

others protected important habitat. Bird Island and Forbidden Island were managed to protect a single species. Marine species diversity is extensive across the region, with 256 species of corals and more than 1,100 species of nearshore fishes.

Mariana Archipelago: Guam. Guam is a small island (35 miles long and approximately 9 miles wide) and has five MPAs. Historically, local villagers and people from neighboring islands have relied on its nearshore ecosystems. But marine ecosystem-related problems have resulted from changing social conditions, pressures and resource management policies.

For example, as the tourism industry grew, hotel owners developed strategies to attract more visitors. However, some efforts to improve their guests' experiences have had harmful effects on the marine resources and local users, such as removing algae and promoting jet skis.

The Fishery Information Survey and History (FISH) project was developed to characterize Guam fisheries and to contribute to a historical and cultural assessment of Guam's fishing and associated practices. Other local fisheries projects included a public awareness campaign to inform residents and visitors about traditionally important marine resources, biological cycles and existing regulations.

The FISH project also aimed to establish a common platform to increase cooperation between Guam's federal agencies, fishery participants, relevant businesses and other partners. The intent was to create initiatives that would improve marine resources and ecosystems, increase capacity for regulatory enforcement and encourage responsible fishing and shoreline management practices.

Hawai'i Archipelago. In the Hawai'i Archipelago, multiple cultures and social groups characterize life. Seafood is important throughout this subregion. There is a high demand for distinct seafood products at various times of the year; for example, from the *'ohana* setting to Japanese and Chinese New Year celebrations to the mixed commercial–recreational fishery sectors.

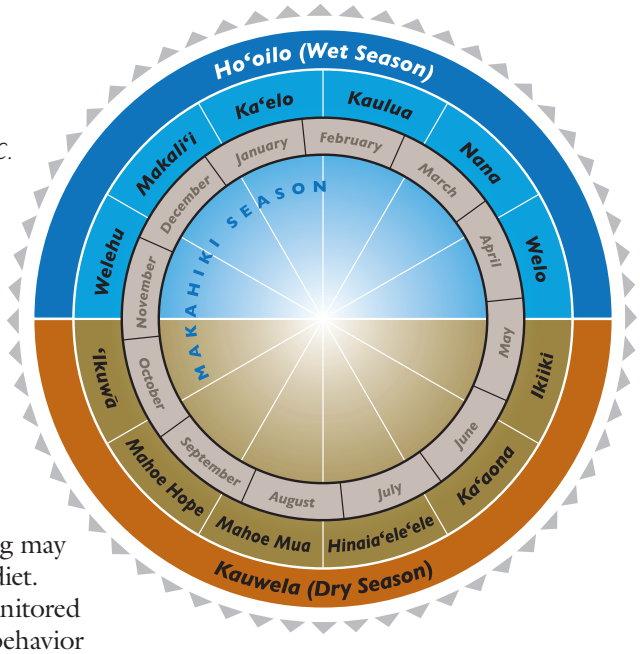


Fig. 17. Ancient Hawaiians used a lunar and seasonal calendar to regulate fishing.[8] *Source: WPRFMC.*

In Hawai'i, fisheries management's primary objective is to have sustainable marine resources to consume, share and celebrate. Consumptive or subsistence-based fishing is critically important in Hawai'i. In some rural locations, fishing may provide up to 30% of the local diet.

Hawaiians traditionally monitored seasonal changes in resource behavior and abundance and were familiar with the local habitat conditions (Fig. 17). These observation-based "models" determined how fishing pressure was regulated at certain times of the year and in specific locations.

Ancient Hawaiians developed their own "code of conduct" to regulate fishing. They associated *ko'a*, or favorable fishing areas, with specific land features and used these areas as dedicated fishing grounds. The Hawaiians monitored these areas and made decisions to open or close fishing based on environmental conditions. For example, they might take a management action if one *ko'a* seemed to have an unusually large proportion of spawning fish compared to other nearby *ko'a*.

The *ahupua'a* was once central to Native Hawaiian society. Its modern-day application has the potential to enhance conservation and the management of natural resources. Reintroducing these historic principles and social processes to existing county, state and federal agencies will require substantial efforts.

Socioecological Indicators

Marine biologists have advocated MPAs for protecting marine ecosystems and resources. Comparatively little is known about the human dimensions of MPAs, despite the human effort involved in managing them. In fact, MPAs can be biological "successes" and social "failures." As such, effective planning and public input can help avoid disagreement about the placement, nature or perceived effects of a protected area.

Through its work with MPAs in the Philippines, the Fish Project (from 2003 to 2010) outlined the following social indicators for evaluating and monitoring the success of MPAs:

1. Using ecological knowledge in the planning process.
2. Establishing an informational program about the MPA for user groups and the public.
3. Minimizing conflicts related to the cultural backgrounds of the involved parties.
4. Relocating fishing effort or finding other uses for resources.
5. Establishing mechanisms for enforcement.
6. Estimating fish biomass.
7. Improving threatened species' management.

Incorporating Social Science into an Ecosystem Approach to Fisheries Management

Each archipelago in the Western Pacific Region is distinct in terms of its sociocultural, socioeconomic and demographic conditions, its approach to governance, environmental conditions, fishing practices and other uses of marine resources. Social scientists

8. A copy of this circular version of the traditional lunar calendar developed by the Council has been on display at the Bishop Museum (Hawaiian Hall) in Honolulu.

recommended that the Council address these variations in their draft FEPs for each archipelago. The Council and NMFS representatives have recognized the potential for new challenges to archipelagic-based FEPs and are taking a measured approach to prospective policy changes.

Traditional knowledge can help people conceptualize and plan effective ecosystem-based management in the Western Pacific Region. Indigenous knowledge and marine resource use have political and policy implications for EAFM. The *ahupuaʻa* system, once widely used by Native Hawaiians, offers a model of resource management that focuses on ecological relationships within geopolitically specified boundaries.

A modern-day *ahupuaʻa* system, or a similar model, could be formally instituted in Hawaiʻi. Many of the management principles of current coastal zone and ocean management policies are inherent to the historic *ahupuaʻa* system. The main challenge to formalizing the system is addressing the historic boundaries and social processes of the Native Hawaiians, while navigating the modern, complex system of laws, policies and programs managed by federal, state and county agencies. Community-based management strategies and projects have already been designed to increase indigenous people's participation in managing marine resources. At the time of the workshops, the Council was already implementing a Community Development Program (CDP) and a Community Demonstration Project Program (CDPP), as mandated by the MSA.

The Social Science Workshop participants emphasized that it's important to identify and compile relevant, existing information about human aspects of ecosystem-based management. Further, social scientists should look for new, relevant data about core management issues and challenges and the related economic, sociocultural, political and demographic conditions across the Western Pacific Region. They stressed the evolving nature of ecosystem management and the need for a flexible and adaptable approach that could adjust to the changing social and biological dynamics of marine ecosystems.

The workshop participants recommended developing a comprehensive, long-term plan for ecosystem research and monitoring. Recommendations included the following objectives:

- Inventory existing biological, social science and traditional ecological data.
- Identify management objectives specific to an ecosystem approach across archipelagos.
- Identify funding sources for new research and monitoring that would complement existing programs.
- Define specific management objectives that relate to ongoing and new research, data analysis and management strategies.
- Develop methods for distributing information in a way that supports EBFM.

PART IV: Policy Workshop

The third and final workshop was in 2007 at the Council office in Honolulu. At the beginning of the workshop, Kitty M. Simonds, executive director of the Council, described how the Western Pacific Region and its respective islands and archipelagos provided an opportunity to pursue a place-based approach to ecosystem fisheries management. The ecosystem approach can empower local communities and ensure that traditional and local ecological knowledge is part of management. The ecosystem approach requires close working relationships with government and nongovernment agencies.

The Policy Workshop examined a wide range of issues related to EAFM. The participants (fig. 18) discussed cross-jurisdictional and cross-cultural government and policy options in the region. The group also considered how to address the needs and interests of indigenous fishermen and other resource user groups across the region. Finally, workshop participants discussed opportunities for fishery ecosystem research and monitoring in the Western Pacific Region.

While participants discussed new aspects of ecosystem-based management in the Western Pacific Region,

Fig. 18. Policy Workshop participants. *Source: WPRFMC.*

they noted that researchers have been using some of these principles for decades. The following existing challenges were noted:

- Convincing research institutions with established programs to try new, uncertain models.
- Administering new programs and their associated costs.
- Coordinating efforts to implement a new management system in a large, complex region with multiple jurisdictions.

The Policy Workshop participants addressed the challenges of implementing new marine resource management policies in the diverse region. They discussed policy issues as they related to EAFM, such as 1) including multiple agencies and jurisdictions, 2) involving indigenous people and groups and 3) implementing long-term research and monitoring.

Participants noted that fishery managers are well equipped to influence humans and the effects of their activities. They agreed that management agencies should focus more on humans and their relationship to marine ecosystems by applying social science methods to fishery management.

Policy Workshop participants also established that policymakers and managers need to consistently define ecosystem terminology across the biological and social sciences to help define management objectives. For successful ecosystem-based management, it's necessary to improve relationships and minimize conflicts between scientists, managers and fishermen.

Interactions between Scientists and Policymakers

The Policy Workshop participants considered the following question: "What is the appropriate role of scientists in the process of resource management and policymaking?" They agreed that science and research should be separate from the subjective process of making management decisions. However, participants acknowledged the need for ongoing dialogue between scientists and managers. Participants considered how to bridge biophysical science, social science and traditional knowledge with the management process as EAFM plans progress. Finally, they discussed the role of traditional knowledge and ways to integrate it into managing marine resources.

Policy for Indigenous Resource User Groups

The Policy Workshop participants considered how to effectively address the needs and interests of indigenous fishermen and other fishery participants in the subregions of the Western Pacific Region. They also recognized the need to understand cultural aspects of management and suggested that incentives might enhance the Council's efforts.

Participants made several recommendations to facilitate a streamlined approach to an EAFM across the archipelagos. For example, to address management problems in Guam and CNMI, a liaison could help initiate dialogue between these culturally distinct island areas. Other recommendations for the region included the following: 1) improve enforcement of nearshore fishing regulations on the populated islands; 2) integrate local knowledge with formal science-based approaches to management; and 3) increase local involvement in the management process.

Empowering island communities would enable meaningful local and regional participation in marine resource management. To successfully implement FEPs, local agencies and institutions would need to be supportive of the process, which could be challenging in the context of multiple interests and agendas.

Workshop participants shared fishery management and policy experiences from their region or islands. Here are a few examples.

Overview of Hawai'i Archipelagic Ecosystem Research Plan *(Frank Parrish, NOAA PIFSC)*

The Hawai'i Archipelagic Ecosystem Research Plan (HARP) is a long-term, multiagency research plan designed to address ecosystem-relevant information needs for the Hawaiian archipelago. HARP originated after a NWHI Symposium whose purpose was to define new and emerging research priorities and advance scientific inquiry to support an ecosystem approach to resource management. The HARP team highlighted the following themes:

- Ecosystem indicators and metrics, including physical, chemical, biological and remote sensing indices
- Native biodiversity and invasive species
- Connectivity, including hydrodynamics, movement studies, transport modeling and population genetic structure
- Monitoring human interactions and impacts on the marine ecosystem
- Sustainability, resilience and recovery
- Modeling and forecasting

The HARP drafting team anticipated a 10-year plan, but it hadn't started yet at the time of the workshop (Fig. 19).

Ecological Risk Assessment for Species Caught in Tuna Fisheries *(David Kirby, Senior Scientist, Secretariat of the Pacific Community)*

The Scientific Committee of the Western and Central Pacific Fisheries Commission (WCPFC) completed an ecological risk assessment for target, at-risk and incidental species caught in tuna fisheries. The assessment used a productivity–susceptibility model to learn about tuna fisheries-related interactions. Without precise catch or mortality estimates, the model was able to estimate how species interact with a given fishery by using data about the species' biological characteristics. The research provided an example relevant to EBFM in which models informed legislation decisions to address the incidental catch of fish species in various parts of the region.

Management and Policy Challenges in Commonwealth of Northern Mariana Islands *(John Gourley, Micronesian Environmental Services)*

To address critical fisheries issues in the CNMI, policymakers defined the following objectives:

- Improve enforcement of nearshore regulations for the populated islands.

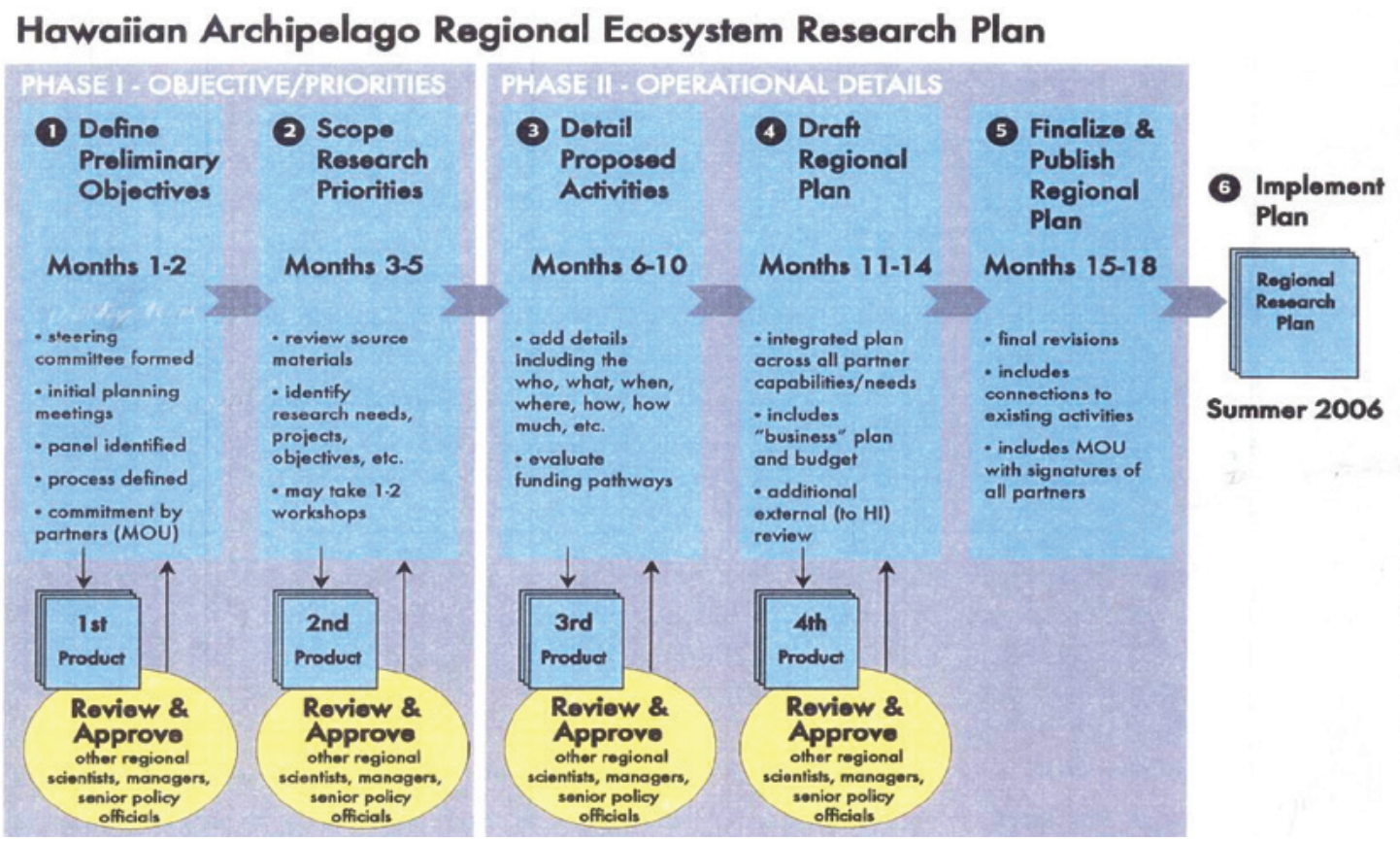


Fig. 19. Hawai'i Archipelagic Ecosystem Research Plan timeline. *Source: Frank Parrish.*

- Increase public involvement managing resources across the region.
- Improve science-based approaches to researching, monitoring and developing resource management programs.

Regulations affect how fisheries in the region are managed, but other factors indirectly influence fisheries. For example, weather conditions limit access to the Farallon de Medinilla region for about six months of the year. Further, fishermen must carry their own ice to the fishing grounds at Farallon de Medinilla. Local fishermen don't have the money to buy large ice makers, which would dramatically increase the local fleets' capacity to meet demands for fresh seafood.

Government officials of the CNMI considered options to establish marine reserves around the western seamounts, which are under WPFRMC jurisdiction. At the time of the workshops, there were two MPAs in the CNMI, the Managaha Marine Conservation Area and a protected area in Saipan. Managaha is an example of a success story for policy in ecosystem management. The DFW collaborated with local researchers to set up public outreach and education meetings, determine effective boundaries and conduct monitoring surveys.

The 2005 Micronesian Challenge required governments across Micronesia to conserve at least 30% of nearshore marine areas and 20% of forest land in each of the countries and territories across the archipelagos by 2020. Various nongovernmental groups also supported the Micronesian Challenge.

Management and Policy Challenges in Guam *(Judith Amesbury, Micronesian Archaeological Research Services)*

Chamorro residents living in the CNMI and in Guam have longstanding differences that are a political product of World War II. During the war, the Japanese hired Chamorros as scouts in the CNMI and as interpreters in Guam. The U.S. military recaptured Guam in 1944.

In 1969, an effort to unite the two regions into a single political entity was unsuccessful. Throughout the years, the relationship between Guam and the U.S. military has been alternately welcoming and negative. This presented a unique challenge for implementing an ecosystem approach across the region.

At the time of the workshop, military presence was expected to increase and expand Guam's population by 15%. With increased population, pressure on the infrastructure would be exacerbated, along with potential environmental effects associated with road expansion, construction of new sewage facilities and development of additional potable water sources.

The relationship between local fishermen and the government in Guam has also been turbulent. When marine preserves were set up, some fishermen believed that DAWR didn't fairly notify or represent them in the public hearing process. Some local fishermen thought it was unfair that areas closed to extractive uses could continue to allow other activities, such as jet skiing.

Regulating coastal resource planning was a specific management issue in Guam, increased by its dependence on tourism and the subsequent tendency

Fig. 20. The Guam Fishermen's Co-op combined conservation with business and empowered the local fishing community. Pictured are Michael Duenas from the co-op and Charles Ka'ai'ai, Council staff. *Eric Woo photo.*

toward overdevelopment. As a result, hotel properties could limit access to historically important fishing grounds and overlook the local residents' needs and values.

Empowering communities across the region could lead to a shared management process with potential benefits for the fisheries. A positive example of an empowered community in Guam is the Guam Fishermen's Co-op, the island's small boat commercial fishing cooperative (Fig. 20). The Co-op teaches pelagic fishing methods, using a vessel bought through the Council's CDPP, with the aim to reduce pressure on reef fish. The Co-op established policies that combined conservation with business and addressed safety and quality issues with seafood in Guam.

Management and Policy Challenges in American Samoa *(Fini Aitaoto, Council On-Site Coordinator for American Samoa)*

In American Samoa, the traditional *matai* system of governance presents challenges and opportunities. In the past, territorial government officials tried to restrict land use in areas where people from traditional village communities already claimed tenure or ownership through their own political or cultural processes. In some cases, this led to conflicts with modern-day management initiatives.

Managers should be culturally sensitive to American Samoans and their traditional form of governance as they work toward a complementary relationship with the *matai* system. Chiefs could use their authority to stop harmful activities or behaviors associated with the use of natural resources. Meanwhile, government agencies could only issue restrictions, which might not be as effective.

When the workshops occurred, management issues in American Samoa included disputes about maritime and fishing boundaries with Independent Samoa, reductions in seafood production (as indicated by imports) and refuge policies at Rose Atoll that could complicate research and data collection.

Report on the Puwalu Series *(Leimana DaMate, Association of Hawaiian Civic Clubs)*

In 2006, a series of three Puwalu conferences were held in Hawai'i to bring together Native Hawaiian cultural experts from each district on each island and other interested individuals and groups to address issues relevant to the current management of marine resources in the main Hawaiian Islands. The theme of the series–"truth"–was symbolized with an illustration of Ku'ula, the Hawaiian god of fishing and fish of the sea, rising from the ocean holding a *wana* (sea urchin) in his hand (Fig. 21).

The meetings aimed to promote the protection and restoration of ecosystem integrity with traditional resource and management practices. The Puwalu series helped with communication because all interested representatives had the information they needed to make the best possible decisions.

Participants of the third Puwalu worked to develop legislation that incorporated the concepts and objectives of *Aha Moku*, or regional councils, which represent the interests of Native Hawaiians. The purpose was to formally enable a community consultation process for each island, where participants selected each district's representatives. The *Aha Moku* process supported cross-generational knowledge and helped to ensure that the concerns of the *kupuna*, or revered elders, would be addressed. Future generations can get to know the history that developed over thousands of years.[9]

Fig. 21. Ku'ula rising from the ocean. *Source: WPRFMC.*

Options for Community and Agency Interaction

Policy Workshop participants agreed that expanding the scope of management considerations to include the public and specific interest groups was consistent with EAFM. The group discussed the Council's Regional Ecosystem Advisory Committee (REAC) process to increase public input and involvement in managing marine resources across the archipelagos. Workshop participants shared their experiences related to incorporating community and agencies in the fisheries management process. Here are two examples.

9. In 2007, the 24th Legislature of the State of Hawai'i passed House Bill 1948 H.D.2 S.D.1. The bill specified the *Aha Moku* system as "A system of best practices that is based upon the indigenous resource management practices of *moku* (regional) boundaries, the contours of the land, the specific resources located within those areas, and the methodology necessary to sustain resources and the community. The *Aha Moku* system will foster understanding and practical use of knowledge, including Native Hawaiian methodology and expertise, to assure responsible stewardship and awareness of the interconnectedness of the clouds, forests, valleys, lands, streams, fishponds and sea. This council system will include the use of community expertise and establish programs and projects to improve communication, education and provide training on stewardship issues throughout the region."

Regional Ecosystem Advisory Committees *(Paul Dalzell, Senior Scientist, Western Pacific Regional Fishery Management Council)*

The Council established REACs for each of the archipelagos. The committees included Council members and representatives from federal, state and local government agencies, businesses and nongovernmental organizations experienced with marine fisheries.

The REACs intended to share information about relevant programs and activities in the archipelagos and to coordinate management efforts. Moreover, they would allow the public to provide and collect information about local issues that affect fisheries and aspects related to their community and livelihoods. For example, the REAC would share information about a Marine Education and Training Program designed to integrate traditional knowledge and marine science into educational programs around the region.

Council staff visited the archipelagos in 2007 to discuss EAFM and FEPs with community representatives and to communicate the plan for an incremental, or gradual, shift to an ecosystem approach to management. During initial REAC meetings in the CNMI, Guam, American Samoa and Hawai'i, representatives expressed their concerns and hopes for the future of TEK and cultural practices that related directly and indirectly to marine resources and ecosystems. REAC representatives in the CNMI expressed concerns about the loss of traditional Chamorro life. In Guam, concerns focused on the loss of shoreline access from beachfront development and marine reserves. Hawaiian representatives expressed similar concerns but were optimistic about traditions related to fishing practices culture. Other themes for the region included enforcement problems, pollution and detrimental aspects of tourism.

Community Consultation and Interaction *(Jarad Makaiau, Habitat Coordinator, WPRFMC)*

The Council's main goals for the FEPs were to empower communities and provide them with tools to manage their fishery resources and marine ecosystems. The Council's CDP could provide communities with technical support to address problems such as pollution or habitat degradation. The CDPP could also help solve such problems.

Given that the Council can't assist each individual and group at once, they planned to prioritize resources to communities with the most critical and achievable goals. Communities would bring their issues to the REAC, which would ask the Council to address them. The Council would then provide resources to the community so they could work together on solutions. The Council planned to appoint a team to address REAC recommendations.

The Marine Education and Training Program authorized the Western Pacific Region and North Pacific Councils to provide funding and support that includes traditional knowledge in the management process. The nonregulatory part of the FEPs allows various resources to meet a range of fishery-related concerns and challenges in communities throughout the region.

Summary of the Policy Workshop

The Council planned to gradually and incrementally apply EAFM processes in the FEPs. Clear objectives that relate to the vision could evaluate the overall effectiveness of the approach. The regulatory part of the ecosystem approach would ideally involve a regular review process to identify lessons learned. The Council could revise the approach, as needed, for more effective implementation across the archipelagos.

Policy Workshop participants discussed opportunities for successful ecosystem management, given the complexities of multiple jurisdictions, agencies and island communities in the Western Pacific Region. The participants offered the following outcomes at the end of the Policy Workshop:

- Policy options that would empower local communities and allow local governments to develop place-based FMPs.
- Opportunities for effective long-term consultation with communities through the REAC process.
- Recommendations for supporting TEK through effective, culturally sensitive collaboration with indigenous communities.
- Funding opportunities that would enable long-term ecosystem research and monitoring across the region.

As described in the presentations, efforts to initiate the REACs, which were intended to improve the Council's understanding of the biological and human dimensions of the region's marine ecosystems, could introduce a more effective and empowering management process.

The REAC process would allow the Council to consider and address issues extending beyond those it has traditionally considered, such as terrestrially generated pollution and other factors affecting comprehensively envisioned marine ecosystems.

The Council staff reported that they would increase the attention given to the island communities' well-being, especially those that were dependent on marine ecosystems in the region. The problems and needs of communities would be communicated through the REACs, and with Council support, they could address specific issues with the Community Demonstration Projects Advisory Panel and Community Development Advisory Panel.

PART V: Workshop Series Conclusions

EAFM can improve our understanding of relationships between the marine environment and people, and it can provide user groups with opportunities for contributing to the management process. This would involve increased attention to social and political issues and improved relationships among the Council, fishery participants, communities and governments across the region.

Potential Benefits of an Ecosystem Approach to Fisheries Management

From a management perspective, the shift from a single-species approach to a place-based approach could reduce the administrative load of managing species and fisheries across these highly variable areas. Furthermore, FEPs could distinguish management requirements to address each archipelago and its marine resources as a distinct management unit.

Scientists and managers could benefit from traditional and local knowledge of marine resources, marine ecosystems and fishing and shoreline food-collecting practices. Each archipelago is home to indigenous people who have passed down centuries of experiences and knowledge about island ecosystems.

Improved connections with human communities may point out key issues such as the overuse of marine resources or potentially harmful fishing or food-collecting practices. Finally, EAFM may provide mechanisms for community development initiatives both related and unrelated to marine fisheries.

EAFM's goals for ecosystem research and monitoring are consistent with the objectives of the other fishery councils and NMFS. Moreover, potential opportunities for public participation in ecosystem research and monitoring programs around the region align with the Council's interest in empowering communities. The Council's CDPP and other program could facilitate these opportunities.

Biophysical Workshop's Policy Recommendations

The Biophysical Workshop participants provided the following recommendations for policy:

- Use a precautionary approach to understanding the status of marine resources and the people who depend on marine resources for food, cultural practices, employment and more.
- Encourage the fishing industry and managers to take an active, participatory role in research, monitoring, resource conservation and sustainability efforts.
- Develop opportunities for scientists and managers to understand changing environmental conditions.
- Find examples from other regions and use them adaptively in the Western Pacific Region.
- Use proper incentives to achieve management goals.
- Cultivate fairness and equity in the ecosystem approach to management in the region.

Social Science Workshop's Policy Recommendations

The Social Science Workshop participants provided the following recommendations for policy and incorporating social science in the region:

- Identify priority issues and objectives to address with social research and monitoring.
- Design social science research that meets the objectives and related information needs.
- Invest in social, economic and social-demographic research for the archipelagos.
- Develop and implement performance evaluation programs for ecosystem social science.
- Employ an incremental and adaptive strategy coupled with incentives.
- Identify valid social and economic indicators to assess and monitor direct and indirect interactions and to adjust resource use policies.
- Assess the potential for public input and community development programs and relate new research programs to ongoing programs.

Policy Workshop's Recommendations for Increasing Participation

One of the most important recommendations from the final workshop is to include communities and agencies in the Council's REAC process. The policy workshop participants provided the following recommendations for the REAC process:

- Determine the terms of reference and engagement before initiating formal relationships with agencies and individuals through the REAC process.
- Communicate to REAC participants the intent to enhance opportunities for empowering communities and solve fishery challenges rather than to expand its jurisdiction.
- Develop incentives for cooperation, such as identifying a common threat or need.
- Avoid potentially contentious issues, such as allocating marine resources.
- Convey that trial and error are fundamental to an adaptive approach to management.

By including fishery participants in the science and management process, the workshop participants agreed that the community would become more empowered and its residents would gain a sense of trust in the management process. Hawai'i's *Aha Moku* process might be a useful model that could guide community involvement in research, monitoring and management of marine resources in other areas of the Western Pacific Region. To evaluate the REAC process, indicators might

include: 1) sustained participation, 2) internal commitment of resources, 3) formal partnerships and 4) positive feedback from the community.

Policy Workshop's Recommendations for Identifying Funding and Resources

Workshop participants identified resource and funding options for expanding ecosystem research and monitoring programs across the region. One idea included expanding undergraduate internship programs for students to gain experience and exposure to traditional knowledge while contributing to scientific research and monitoring efforts.

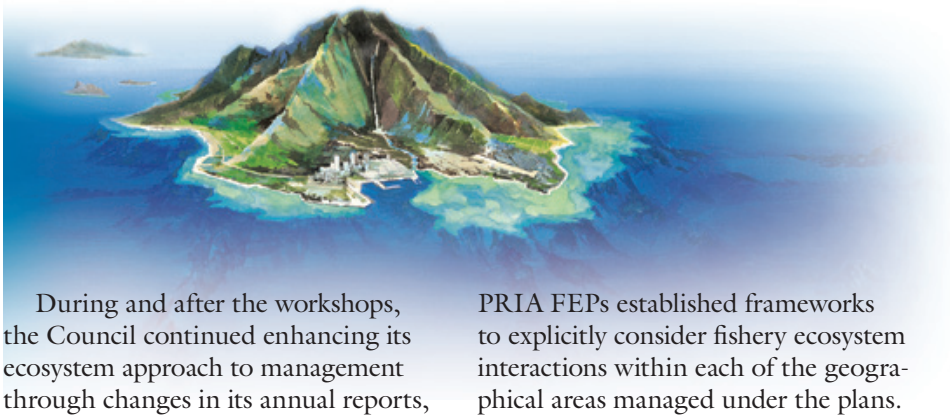
Research programs could make use of community efforts in formal scientific research and monitoring. The data collection process could occur with technical assistance and data management provided by dedicated staff from local agencies. This would facilitate ongoing interaction between those agencies and researchers studying marine fisheries and marine ecosystems in the region.

The Council's jurisdiction area in the Western Pacific Region is well suited to an ecosystem management approach. This approach must be responsive to the dynamics of large, open ocean marine ecosystems and the complex social and economic connections among islands, island communities, marine ecosystems, jurisdictions and associated marine resources.

The three workshops provided key insights, lessons and conclusions that will assist the Council as it incrementally and adaptively transitions to ecosystem-based management in the Western Pacific Region.

PART VI: Post-Workshop Accomplishments in the Western Pacific Region

During the time that the ecosystem workshops were held (2005 to 2007), the Council was restructuring its five species-based FMPs to place-based FEPs. In this effort, the Council had the advantage of not only the recommendations from the 1999 EPAP but also its prior experience developing and implementing its Coral Reef Ecosystem FMP, the nation's first ecosystem-based FMP for fisheries. In completing the FEPs, the Council also had the findings and recommendations from the workshops.



During and after the workshops, the Council continued enhancing its ecosystem approach to management through changes in its annual reports, advisory bodies and engagement with communities, agencies and organizations.

Fishery Ecosystem Plans

During its 2005 to 2009 Five-Year Program Plan, the Council began developing the FMPs into place-based FEPs. The American Samoa Archipelago, Mariana Archipelago, Hawai'i Archipelago, Pacific Remote Island Areas (PRIA) and Pelagic FEPs were completed in 2009 and codified in 2010 (75 FR 2198). The archipelagic and PRIA FEPs established frameworks to explicitly consider fishery ecosystem interactions within each of the geographical areas managed under the plans. The Pelagic FEPs alone retained a region-wide application because of the highly migratory nature of the species being managed. The Pelagic FEP includes a framework that allows explicit consideration to be given to ecosystem-level interactions.

Each FEP outlines 10 objectives to help the Council implement ecosystem approaches to fisheries management: 1) maintain biologically diverse and productive marine ecosystems that foster the long-term sustainable use of marine resources; 2) provide flexible and adaptive management systems; 3) improve public and government awareness and understanding of the marine environment; 4) encourage and provide for the sustained and substantive participation of local communities; 5) minimize bycatch; 6) manage and co-manage protected species, protected habitats and protected areas; 7) promote the safety of human life at sea; 8) encourage and support compliance and enforcement with all local and federal fishery regulations; 9) increase collaborating with domestic and foreign fishery management organizations (both governmental and nongovernmental) to successfully manage marine ecosystems; and 10) improve the quantity and quality of available information to support marine ecosystem management.

Since their implementation, the WPRFMC's FEPs have undergone several amendments. In 2010 the

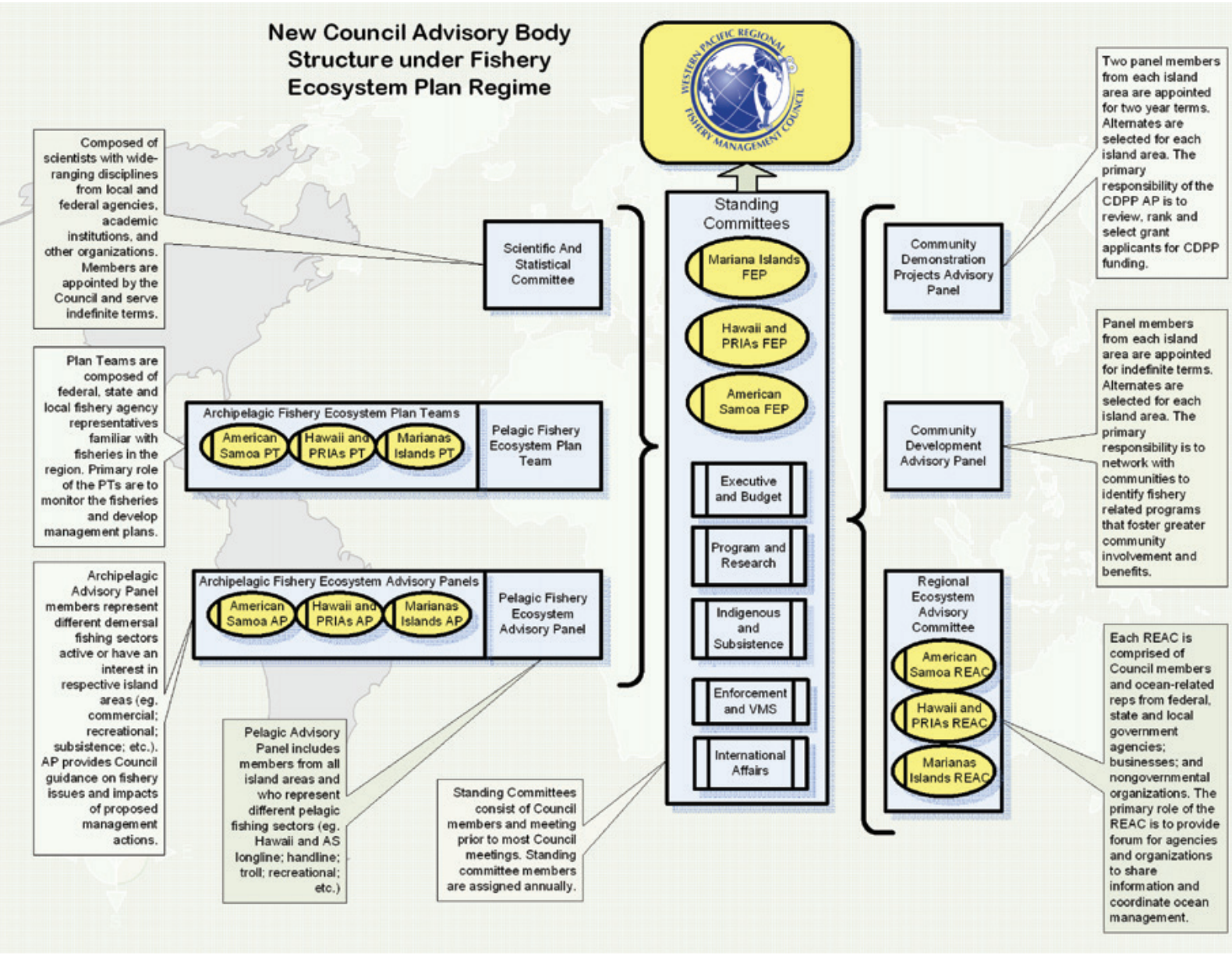


Fig. 22. New Council advisory body structure under the ecosystem-based fishery management regime. *Source: WPRFMC.*

American Samoa, Hawai'i, Mariana and Pelagic FEPs established 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 upon but may not have the capabilities to support continued and substantial participation. (See pages 15 and 19.)

In 2011, an omnibus amendment established a mechanism for specifying annual catch limits.

Another omnibus amendment in 2018 reclassified certain management unit species as ecosystem component species, largely because of the lack of data for these fisheries and the administrative constraints to meet the MSA requirements to set annual catch limits for each managed species. This reclassification reduced the managed species list from thousands to dozens.

In 2013, the establishment of the Pacific Remote Islands, Marianas Trench and Rose Atoll Marine National Monuments by presidential executive orders led to amendments to management measures for noncommercial and recreational fishing and prohibition of commercial fishing in all but the Hawai'i FEP.

Other area-based amendments included the establishment of the Hancock Seamount Ecosystem Management Area in the Hawaiian Islands (2011), a longline closed area in the CNMI (2011) and the removal of CNMI medium and large vessel prohibited areas (2016). Hawai'i FEP amendments also included refining the descriptions for essential fish habitat and habitat areas of particular concern for bottomfish and seamount groundfish.

Additionally, the Pelagic FEP was amended in 2011 and 2020 to address interactions between longline gear and sea turtles and to establish longline

bigeye-tuna catch and effort limits for the U.S. territories. The territories can transfer a portion of their limit to federally permitted U.S. vessels based in Hawai'i. As part of these U.S. Participating Territory Fishing Agreements, the territories receive support to implement their Marine Conservation Plans (MCPs).[10]

The Council conducted a five-year review of the five FEPs in 2014 and an external review of them in 2014 and 2015. Subsequently, efforts were directed to refine the objectives and to address and include emerging predictions on climate change impacts and regional marine planning initiatives. The Council will also include outcomes from its prior work on ecosystem drivers such as larval connectivity, population estimation of juvenile keystone species, environmental factors affecting catch-per-unit-effort, species home range, freshwater input effects on coral reef fisheries and patterns of reef fish activity using acoustic chorus. This information, along with improved life history understanding gained through targeted bio-sampling throughout the region, will also feed into the review of essential fish habitat and habitat areas of particular concern for all managed unit species.

The Council has been working with NMFS to finalize the revised plans.

Annual Reports

Another of the Council's primary roles is to produce annual reports that summarize the performance of federally managed fisheries, considering trends in catch, effort and catch rates. These annual stock assessment and fishery evaluation (SAFE) reports serve as a source document describing various projects and activities being undertaken at local and federal levels. With the incorporation of EBFM, the scope of the reports was expanded to also describe such ecosystem considerations as fish biomass estimates, biological indicators, protected species, habitat, climate change, human dimensions and marine spatial planning. The reports summarize annual catches relative to the annual catch limits established by the Council or national quotas developed through regional fishery management organizations (RFMOs). The reports describe the best scientific information available for each fishery and are developed by the Council's Plan Teams with contributions of data and analyses from local and federal agencies. These partners include NMFS PIFSC, NMFS Pacific Islands Regional Office, WPacFIN, American Samoa Department of Marine and Wildlife Resources, CNMI DFW Guam DAWR and Hawai'i Division of Aquatic Resources. Work continues for future reports to better address how dynamics described in the ecosystem section might have influenced the findings in the stock assessment and fishery evaluation sections of the reports. The annual SAFE reports are available at http://www.wpcouncil.org/annual-reports and the data are available at https://www.wpcouncildata.org/.

Advisory Bodies

To align with the new place-based FEPs, the Council's Plan Teams, Advisory Panels and Standing Committees were reshaped (Fig. 22). Other existing committees either remained intact but with additional ecosystem topics on their agenda or were renamed and changed to meet EAFM goals. In addition to the REACs, an Education Committee was created.

Plan Teams: The primary role of the Plan Teams is to develop the annual SAFE reports. The Archipelagic Plan Team was structured to work on the American Samoa, Hawai'i, Mariana (Guam and CNMI) and PRIA FEP annual reports while the Pelagic Plan Team remained fashioned to develop the Pelagic annual report.

Advisory Panels: As with the Plan Teams, the Council's Advisory Panels (APs) were reshaped to match the FEPs. The AP members represent various sectors of their islands' fisheries (Fig. 23). AP members formulate recommendations for Council consideration. For example, advisors provided recommendations regarding electronic reporting for vessels operating under Hawai'i and American Samoa longline limited entry permits under the Pelagic FEP. Electronic reporting allows for near real-time data streams to increase accuracy, reduce dataprocessing time and more rigorously monitor and forecast the attainment of international longline catch quotas. This also allows the possibility for near-real time adaptive management of pelagic longline fisheries based on ecosystem dynamics surmised by near-real time data streams.

Fig. 23. Members of the Guam Advisory Panel (circa 2015). *WPRFMC photo.*

10. For more on these MCP projects, see *Pacific Islands Fishery Monographs* No. 6 on *Fisheries Development Projects in American Samoa, Guam and the Northern Mariana Islands, 2010 to 2015*.

Standing Committees: Similar to the Plan Teams and APs, the Council's Standing Committees were revised to include place-based committees for American Samoa, Hawai'i and the Mariana Archipelagos. Issues regarding the Pelagic FEP are taken up by the International Standing Committee.

Scientific and Statistical Committee: While the Council's Scientific and Statistical Committee (SSC) continued as previously structured, its agenda includes additional ecosystem considerations, such as those presented in the draft annual reports for each of the five FEPs prepared by the Council's Plan Teams.

Community Demonstration Project Program Advisory Panel: The CDPP Advisory Panel was established to review proposed CDPP projects. The program was established under the MSA and was discussed during the Social Science and Policy Workshops (see pages 15 and 19).

Regional Ecosystem Advisory Committees: Council staff had also reported on the REACs during the 2007 Policy Workshop (see page 19). Established in each of the island areas under the Council's jurisdiction (Hawai'i, American Samoa, Guam and CNMI), the REACs bring together various entities that have not typically been engaged in traditional fisheries management but that could provide insight on the impacts of non-fishing activities on fisheries and vice versa. Members vary from island area based on the needs and resources of the state/territory. Among the members are local government offices such as coastal management, agriculture, parks and recreation, port authority, public works, environmental protection, planning, transportation, indigenous affairs and education and federal offices such as sanctuaries, agriculture, weather, Army Corps of Engineers and environmental protection. Fishery and environmental organization representatives are also members. From 2007 to 2019, each of the four REACs met annually except in 2015, when only the American Samoa REAC met. Over the years, they have reviewed and provided advice regarding resource management plans from the Navy, offshore aquaculture, coastal and marine spatial planning, access to resources and protected species. Among other activities, the REACs have helped promote fishermen participation in the stock assessment process, recommended including climate change indicators as part of the Council's annual reports and advocated for fisheries capacity building and development.

Fisheries Data Collection and Research Committee: The Fisheries Data Collection and Research Committee (FDCRC) was established to replace the Fisheries Data Coordinating Committee so as to better integrate fishery monitoring and research programs in the Western Pacific Region. Its impetus was the 2006 reauthorized MSA requirement for federal fisheries to be managed through annual catch limits. This requirement forced the Council, local fishery management agencies and NMFS to consider the state of the information being used by management to generate data. As a result of this review, the Council initiated changes in the committee structure and established partnerships among different agencies to achieve better data collection and coordination of fishery research. The FDCRC and its Technical Subcommittee produced the first regional strategic plan for fishery data collection and research in the Western Pacific Region. This regional strategic plan guides data improvement actions and coordinates the fishery research to meet management needs. The information generated by the data collection and the fishery research components is ultimately used in generating stock assessments and builds the foundation for ecosystem models. Among the projects implemented through the FDCRC were the investigation of catch and effort from the naval base in Guam that is not covered by the local creel surveys, development of targeted methods to capture rare events in territorial fisheries such as seasonal fishery runs and the use of electronic reporting for the noncommercial spear fisheries. All of these projects were funded through the Marine Recreational Information Program. The FDCRC also encouraged the Guam Bureau of Statistics and Plans to submit a Saltonstall-Kennedy Grant to develop an export-import database system for fisheries products. Lastly, the FDCRC agreed to develop the Catchit Logit electronic reporting system that would be deployed to the small boat fisheries in the territories to augment the current data collection system.

Social Science Planning Committee: The Council has had a committee in different forms to advise it on social science issues. The current Social Science Planning Committee incorporates the human dimensions of fishery management into the Council by coordinating research and identifying priorities, which in turn advances the EBFM approach to fisheries management.

Protected Species Advisory Committee: As a result of an expanding range of protected species or species of concern being emphasized through petitions, the Council restructured its Sea Turtle Advisory Committee to include experts from other fields including marine mammals, seabirds, corals, reef fish and sharks. Renamed the Protected Species Advisory Committee (PSAC) in 2013, the committee advised the Council on issues related to fisheries interaction with non-targeted species in the Pacific Islands and protected species conservation and management. The Council has made significant strides on these issues by supporting sea turtle projects across the Pacific, promoting information sharing and technology transfer and improving scientific and commercial information related to protected species as they relate to fishery management. Of note, the past five-year period experienced a stronger focus on marine mammal interactions and related scientific and management issues. The Committee was disbanded in 2019 and members of the PSAC were integrated into other advisory bodies (Plan Teams, APs and SSC) in 2019 to further integrate ecosystem focus throughout the Council's process.

The Council continues to improve scientific data and assessments of fishery impacts on protected species, develop and implement mitigation measures that reduce impacts on protected species and promote partnerships with government agencies, nongovernmental organizations, fishing communities and industry to conserve and manage protected species and their habitat. Recommendations from the PSAC led to a collaborative EBFM project supported by the Council, NMFS Pacific Islands Regional Office and PIFSC for protected species impact assessment.[11]

Marine Planning and Climate Change Committee: Keeping pace with the evolving national agenda, the Council's Marine Protected Area Committee became the Coastal and Marine Spatial Planning Committee and finally the marine planning and climate change (MPCC) Committee in 2003. The MPCC developed the Council's marine planning and climate change policy, annually reviewed the new climate change section of the Council's annual SAFE reports and developed products for outreach on climate change (Fig. 24). Assisted by NMFS and local fishery agencies, the Council held workshops on climate change for its Council and advisory body members in each of the archipelagos. Like the PSAC, the MPCC Committee disbanded in 2019 as key members became occupied with the Plan Teams and other Council committees.

Education Committee: In 2013, the Council began its Education Committee to explore ways to create more opportunities for college students from the U.S. Pacific Island territories to earn a degree in marine science. The intent was to build capacity in the territories for local fishery-related agencies to hire local people. A memorandum of understanding was signed by the Council, NMFS, the territorial fishery agencies and the major universities and colleges in the region that offered fisheries-related degrees, creating the Pacific Territories Fishery Capacity-Building Scholarship Program. To date, 15 students have been accepted into the program and five have graduated with degrees. Some are in the process of fulfilling their mandatory employment with a local fishery-related agency. The scholarship program works well with the Council's high school summer courses on marine resources and management, which have been held in each archipelago since 2006. Following a five-year review, a revised memorandum included the State of Hawai'i and expanded the objectives to include fishery lessons in K–12 classrooms and fishery-related vocational education.

Fig. 24. Outreach logo developed with input from the Council's Marine Planning and Climate Change Committee. *Source: WPRFMC.*

Communities

The MSA and the Council approach marine fishery management from an ecosystem perspective. Ecosystems were once considered only in terms of biological, ecological and geological dimensions, and their interconnectedness; more recently, scientists and managers have embraced the ecosystem-based approach to management, which explicitly recognizes the human dimension of ecosystems. People impact marine fisheries systems but also receive benefits from them. In some ways, this thinking is not new. For hundreds of years, many people have defined a fishery as a *social system* that includes fish, fishermen and the associated support infrastructure and industry. Even those who buy and eat fish on a regular basis could be considered part of a fishery.

The Council has supported programs aimed to provide tools and resources to the community, agencies and organizations and institutions to build that capacity in the region, particularly regarding the management of fishery ecosystems. Support for these programs can be in the form of education, outreach and provision of information. In Hawai'i, the implementation of *Aha Moku* councils on each island revitalized that archipelago's traditional natural resource management system and enhanced public participation in the Council process. An unexpected outcome of the Puwalu series was the development of a well-received fishermen's code of conduct, assembled from the traditional knowledge shared by the participants (Fig. 25).

In American Samoa, the Council supports the Territory's Village Marine Protected Areas program. In Guam, implementation of an exemption for traditional fish harvesting practices led to interest in community-based management of ocean resources. The Council collaborated with the Merizo (currently called Malesso) village community residents, local businesses,

Fig. 25. Participants of the 2014 Puwalu (conference) of native *lawai'a* (fishing) and *mahi'ai* (farming) practitioners held on the island of Maui. *WPRFMC photo.*

11. For details of this project, refer to Section 4.1 of the 2019 Pelagic Annual SAFE report at http://www.wpcouncil.org/wp-content/uploads/2020/09/Pelagic-FEP-SAFE-Report-2019-Final-v10.pdf.

Fig. 26. Participants of the Council-sponsored workshop on community-based resource management planning held in 2013 in Guam. *WPRFMC photo.*

local and federal agencies, the broader Guam public and other interested organizations to help identify the natural, cultural, historical, social and economic resources important to Malesso participants and then develop the community-based management plan for the marine and coastal resources for the village of Merizo (Fig. 26). In the CNMI, an exemption for traditional fishing practices is being implemented.

The Council provides additional support to fishing and indigenous communities through facilitated workshops, training sessions and feasibility studies. Regular meetings with communities, organizations and agencies support continued engagement with Council and often lead to identification and recognition of new stakeholders to participate in the Council process of federal fisheries management.

One example is the Community Training Workshop on Coastal and Marine Spatial Planning for the U.S. Pacific Islands presented to more than 125 fishing, indigenous and community members from Hawai‘i, Guam, CNMI and American Samoa. The purpose of the workshop was to prepare indigenous and fishing communities for such planning, as it was, one of nine strategic actions of the federal government’s new National Ocean Policy, established by President Obama through executive order. The training was led by Anne Walton of the NOAA National Marine Sanctuaries Program’s International Program, with the assistance of the Hawaiian Islands Humpback Whale National Marine Sanctuary and the State of Hawai‘i’s Division of Aquatic Resources (Fig. 27).

Another example is the Council-sponsored study comparing traditional fishing knowledge about fish distribution and abundance at a traditional *ko‘a* (fish aggregation area) with the results of modern scientific survey of the area.

Outreach and education are important aspects to engage communities in the federal fisheries management process. The Council has provided regular outreach in the form of publications and events. In 2006, it began producing traditional lunar calendars to announce the new FEPs. The overwhelming response prompted the Council to continue to produce the calendars, each year featuring different aspects of the local traditional fisheries and collaborating with local community groups and agencies. The Council also produces quarterly newsletters, abbreviated versions of its annual reports, a monograph series, topical brochures and more. A regular event tied to quarterly Council meetings is the Fishers Forum, featuring a topic of local interest and held in the evening for fishermen and other members of the public who cannot attend the Council meetings conducted during workday hours.

Regional, National and International Partnerships

The ecosystem approach acknowledges the importance of engaging with a wider array of players to address fisheries management. In this respect, the Council has spearheaded a variety of regional, national and international events and helped to initiate several key organizations.

Fig. 27. The 2011 Coastal and Marine Spatial Planning Community Workshop in Honolulu. *WPRFMC photo.*

Council staff was involved in the development of the NMFS Climate Science Strategy and its Pacific Islands Regional Action Plan. One of the outcomes of the regional plan was the annual Climate Change Collaborative Workshop, bringing together federal fishery managers and scientists to discuss environmental data and climate-related activities and needs.

The Council has helped to host a variety of ecosystem-related events, including the fifth national Scientific Coordination Subcommittee workshop, *Providing Scientific Advice in the Face of Uncertainty: from Data to Climate and Ecosystems*, held Feb. 23 to 25, 2015, in Honolulu (Sabater and Dalzell 2016). The Council also organized the Pacific Islands delegation to the 2012 First Stewards symposium, *Coastal Peoples and Climate Change*, and co-organized the 2014 First Stewards symposium, *United Indigenous Voices Address Sustainability: Climate Change and Traditional Places*, both held in Washington D.C., and involving Native Americans, Alaskan Natives and indigenous U.S. Pacific Islanders (Fig. 28).

The Council was instrumental in the formation of the National Marine Educators Association's Traditional Knowledge Committee in 2007 and organized the U.S. Pacific Islands delegation to the 2019 Ocean Obs conference, which resulted in the 2019 indigenous declaration, *Aha Honua*. The declaration calls on the ocean observation community to work in equal partnership with native communities during the upcoming United Nations Decade of Ocean Science for Sustainable Development (2021 to 2030).

Fig. 28. Council Executive Director Kitty M. Simonds (at podium) addresses the 2014 First Stewards symposium. *WPRFMC photo.*

The Council co-convened the International Fishers Forum in Hawai'i, Japan, Costa Rica and Taiwan to transfer technology of bycatch and protected species avoidance. It also convened the 2007 Honolulu conference of 100 marine educators from throughout the Pacific, which led to the formation of the International Pacific Marine Educators Network. This successful network has had biennial conferences in Australia, Fiji, Chile, Japan, Indonesia and Taiwan and has inspired the development of similar international marine education networks in Europe, Asia and Latin America.

An expert in organizing meetings, the Council has been called on to coordinate numerous international meetings in support of fisheries management, including the 2010 WCPFC seventh regular meeting in Honolulu, the 2014 workshop to address to disproportionate burden in Pacific Islands fisheries, the 2017 WCFPC Intersessional Meeting to advance a new tropical tuna measure and the 2020 virtual International Workshop on Area-Based Management of Blue Water Fisheries, to name just a few.

PART VII: Current and Future Ecosystem Projects in the Region

While the nation and the WPRFMC have made significant headway in reorienting toward EAFM, there is still much work to be done. In 2015, the NMFS Office of Sustainable Fisheries reviewed 10 FEPs that had been developed by four regional fishery management councils, comparing them against the eight recommendations made by the EPAP in 1999. It noted that the FEPs for the Western Pacific Region were "unique from those created by other Councils because they are also full FMPs" (Wilkinson and Abrams 2015).

The NMFS evaluation concluded that each of the 10 FEPs created by the four councils "reflected some, but not all of the EPAP recommendations." It suggested the 1999 EPAP report had not provided adequate guidance on how to implement some of its recommendations and that some of the EPAP recommendations were not relevant "given available information or other ongoing processes and analyses in FMP-related documents." For example, the EPAP report did not clearly articulate the steps between developing ecosystem indicators and using them in the context of management targets. It was also noted that Councils generally address uncertainty (one of the EPAP recommendations) during the process of establishing annual catch limits, which is a management approach that was developed after the EPAP recommendations were released. Similarly, the EPAP recommendations to develop conceptual food web models (fig. 29) and discuss all life stages of the animals within it were found to be not useful in informing FMP conservation and management measures. The NMFS review stressed that "future recommendations for FEPs should maintain the need for flexibility in fisheries management, while also promoting consistency in creation, implementation and use of FEPs between regions."

Fig. 29. Food web conceptual model. *Source: NOAA Pacific Islands Fisheries Science Center*

Progress made by the Western Pacific Council has included successfully identifying its ecosystems and reorganizing its FMPs into place-based FEPs. The next steps are to identify those ecosystem indicators that can help predict what will happen to a stock if that ecosystem indicator changes (up or down). Some of that work has been completed through the inclusion of the ecosystem consideration sections in the Council's Annual SAFE Reports and in NMFS stock assessments (for example, the effects of weather on fishery productivity). Until recently, there hasn't been a focus on modeling the effects of ecosystem elements like wind, sea surface temperature, moon phases, rainfall and so on.

The Council's future work is to determine ecosystem thresholds and reference points that determine the relationships between ecosystem indicators and human pressures (e.g., fishing) for the ecosystems in the Western Pacific Region. One such project is currently ongoing in Hawai'i through the Council's grant from the NOAA CRCP. It aims to identify data needs, screen for potential linear relationships and estimate threshold levels of pressures. The outcome of this project should provide a quantitative basis for ecosystem management and provide information needed to design targets and to measure and evaluate actions. The resulting model could, for example, provide a prediction on how fish stocks would be affected by a sea surface temperature increase

and what would happen if the sea surface temperature increase were compounded by increased storms and wave action. Improving the understanding of what would happen under different ecosystem conditions would help the Council evaluate the effects of its management options.

While the Council's ecosystem work was removed as a specific program in the Council's current 2020 to 2024 Program Plan, EBFM projects are incorporated within each of the Council's program areas (pelagic, insular, communities and protected species) (Appendix 2).

One of the primary reasons the Council transitioned its species-based FMPs to archipelagic FEPs was to increase support throughout its jurisdictions by consolidating the management regime and refocusing programmatic activities in each island area. The Council's 2020–2024 Program Plan will increase the Council's regular meetings from three to four times per year to ensure that the Council convenes in each of the three archipelagos under its jurisdiction at least once annually. The third quarterly meeting will focus on ecosystems and protected species. The Council will further support the Territories by having staff conduct quarterly trips to each of the Territories to implement and track Council actions, facilitate projects and program activities and support Council members, advisors and staff.

The 2020–2024 Plan also includes active participation in international scientific and management organizations and changes to the Council's advisory bodies and decision making process to better align with the Council's programs and improve support to all island areas.

Through these actions and others, the Council will continue to evolve its incorporation of ecosystem considerations in the management of fisheries in the Western Pacific Region.

Appendix 1: Workshop Invited Experts and Speakers

Susan Abbott-Jamieson, NOAA Fisheries/NMFS—Workshop 2

Tim Adams, Secretariat of the Pacific Community—Workshop 3

Fini Aitaoto, Western Pacific Council, American Samoa—Workshop 3

Stewart Allen, NOAA Fisheries Pacific Fishery Science Center—Workshop 3

Judith Amesbury, Micronesian Archaelogical Research Services—Workshop 3

Lee Anderson, University of Delaware—Workshop 2, 3

Bud Antonelis, NOAA-Honolulu—Workshop 1

Shankar Aswani, University of California at Santa Barbara—Workshop 2

Jerald Ault, University of Miami—Workshop 1

Paul Bartram, Akala Products, Inc.—Workshop 3

Russell Brainard, NOAA-Honolulu—Workshop 1

Leah Bunce, Conservation International—Workshop 2

Jim Burchfield, University of Montana—Workshop 2, 3

Villy Christensen, University of British Columbia, Fisheries Centre—Workshop 1

Patrick Christie, University of Washington—Workshop 2

Athline Clark, Hawai'i Division of Aquatic Resources—Workshop 3

Paul Dalzell, Western Pacific Council—Workshop 2,3

Leimana DaMate, Association of Hawaiian Civic Clubs—Workshop 3

Gerard DiNardo, NMFS-Honolulu—Workshop 1

Leanne Fernandes, Great Barrier Reef Marine Park Authority—Workshop 3

Tom Fish, NOAA/National Ocean Service—Workshop 2

David Fluharty, University of Washington—Workshop 1, 2, 3

Mike Fogarty, Northeast Fisheries Science Center—Workshop 1

Svein Fougner, Fisheries Consultant—Workshop 2, 3

Edward Glazier, Impact Assessment, Inc.—Workshop 3

John Gourley, Micronesian Environmental Services—Workshop 3

Neil Gribble, QDPI, Northern Fisheries Centre—Workshop 1

Michael Hamnett, Research Corporation of the University of Hawai'I—Workshop 3

Susan Hanna, Oregon State University—Workshop 2, 3

Tim Hennessey, University of Rhode Island—Workshop 2

Russell Ito, NMFS-Honolulu—Workshop 1

Jeff Johnson, East Carolina University—Workshop 2

Kurt Kawamoto, NMFS-Honolulu—Workshop 1

Colin Kippen, Native Hawaiian Education Council—Workshop 3

David Kirby, Ocean Fisheries Programme, SPC—Workshop 3

John Kirkpatrick, BeltCollins Hawai'I, Ltd.—Workshop 3

Patrick Lehody, SPC- New Caledonia—Workshop 1

Arielle Levin, Joint Institute for Marine and Atmospheric Research—Workshop 3

Jared Makaiau, Western Pacific Council—Workshop 3

Marc Miller, University of Washington—Workshop 2, 3

Russell Moffitt, NMFS-Honolulu—Workshop 1

Steve Murawski, NMFS Northeast Fisheries Science Center—Workshop 1

Bryan Oles, Marine Protected Area Institute—Workshop 2

Michael Orbach, Duke University Marine Lab—Workshop 2, 3

Minling Pan, NOAA Fisheries Pacific Fishery Science Center—Workshop 3

Frank Parrish, NOAA Fisheries Service, Honolulu Laboratory—Workshop 3

John Petterson, Impact Assessment, Inc.—Workshop 2, 3

Richard Pollnac, University of Rhode Island—Workshop 2

Jeffrey J. Polovina, NOAA Fisheries Pacific Islands Fisheries Science Center—Workshop 3

Samuel Pooley, NOAA Fisheries Pacific Islands Fisheries Science Center—Workshop 3

Lia Protopapadakis, Duke University—Workshop 2

Michael Quach, NMFS-Honolulu—Workshop 1

Jesse Rosario, University of Guam—Workshop 2

Craig Severance, University of Hawai'i at Hilo—Workshop 3

Janna Shackeroff, Duke University—Workshop 2, 3

Kitty Simonds, Western Pacific Council—Workshop 2, 3

Joeli Veitayaki, University of the South Pacific—Workshop 2

Robert Wakeford, MRAG-UK—Workshop 1

Carl Walters, University of British Columbia, Fisheries Centre—Workshop 1

Peter Wiley, National Ocean Services, Special Projects Division—Workshop 2

David Witherell, NPFMC-Anchorage—Workshop 1

Dirk Zeller, University of British Columbia, Fisheries Centre—Workshop 1

Appendix 2: Ecosystem-Related Projects in the WPRFMC 2020–2024 Program Plan

Pelagic Fisheries

Increase understanding of climate change impacts on pelagic and international fisheries management

Hawai'i and the U.S. Pacific Territories are a potential epicenter for climate change impacts and resulting species distributions shifts as ocean and climate conditions drive them further away from access to fisheries—or in some cases—closer to fishery access. Changes in productivity, whether adversely or positively affecting Hawai'i and the U.S. Pacific Islands, must be quantified. This can ensure sustainable harvests and help managers make informed decisions for future fishery action. PIFSC does not maintain a dedicated pelagic research program but does conduct periodic research on some of the research areas identified in the Council's pelagic research plan. Council staff, contractors and PIFSC will need to work together to address deficiencies and knowledge gaps, such as:

- Conduct research quantifying effects of climate change on the distribution of fishing effort in areas around the U.S. EEZ and how it may impact competition of U.S. Pacific fisheries with foreign fleets (with Global Fishing Watch).
- Research on simulations on the distribution of pelagic management unit species stocks as a result of changing oceanographic conditions (such as the Spatial Ecosystem and Population Dynamics Model, or SEAPODYM).
- Identify physical drivers that have near-term and time-lagged effects on availability and recruitment and carefully discern between the processes. This can be carried out with catch per unit effort and size composition data.

Account for socioeconomic risks and opportunity loss/gain due to climate change and ecosystem variability

Island communities in the Western Pacific Region rely on seasonal and localized productivity from the ocean. The ability to profitably fish and contribute to the local and international food supply is contingent on local productivity and access to fisheries. As climate change and ecosystem shifts persist, the ability for fishing communities to maintain the status quo in fishing operations is dynamic. Fishermen will possibly need to change operational characteristics, modify targeting seasonally or permanently, or find other means to contribute to fisheries. Managers need to be able to assist these communities by making informed decisions that consider ecosystem dynamics.

- Support research on human dimensions of pelagic fisheries including fishing communities, cultural knowledge, community resilience and risk perceptions with regard to climate change.
- Support research that projects future fishery targeting, market demand/supply and loss/gain of fishing capacity caused by climate and ecosystem shifts.

Increase participation in international fisheries data collection

International data collection is a critical component to fisheries management in the Pacific. Currently, the biggest issues in Pacific tuna management are stock structure and age/growth for pelagic species that have large spatial distributions but relatively unknown regional fidelity or source/sinks. Stock structure and regional demographic information is contingent on the collection of spatially explicit data including the following: 1) tagging information for movement; 2) demographic data (size/weight/sex identification, if possible) from catch composition; and 3) collected biological samples (stomachs, tissue samples for DNA analyses and otoliths for ageing).

The SPC has a Pacific Specimens Tissue Bank for the Western and Central Pacific. The Inter-American Tropical Tuna Commission (IATTC) recently recommended starting a similar program in the Eastern Pacific. U.S. fisheries have not provided a significant amount of data for biological sampling. U.S. Observer coverage for the Hawai'i shallow-set longline fishery is 100% and observer coverage exceeds 24% for the deep-set longline fishery, allowing for an opportunity to collect biological samples for RFMOs.

- Collect tissue samples of bigeye tuna and other pelagic species to collaborate with international scientists to best determine stock structure for fisheries management.
- Support research activities that can contribute to the SPC and IATTC biological data collection.
- Draft incentives at RFMO Commissions for international data collection to ensure all participating parties are contributing to biological sampling.
- Support international measures for fisheries data reporting and collection minimums and guidelines.

Island Fisheries

Streamline processes for ecosystem-based fishery management

To effectively use EBFM in managing the remaining stocks in the FEPs, the Council needs to develop harvest control rules and harvest control policies that support the annual catch limit specification process. Rules and policies would describe how harvest is intended to be controlled by management in relation to the state of some indicator of stock status. Policies could be implemented after an intensive analysis and simulation to determine the maximum and minimum harvest allowed depending on the productivity of the stock and the oceanic productivity levels. The P* (risk of overfishing) and Social, Economic, Ecological and Management (SEEM) processes quantify the scientific and management uncertainties for the acceptable biological catch and annual catch limit specification process. This must be aligned with the Harvest Control Rule and Harvest Control Policy. The following guidelines will streamline these

processes to simplify the harvest limit determination:

- Conduct simulation studies on fisheries management scenarios that would support development of harvest control rules and harvest control policies. A contracted fishery scientist and fishery policy analyst would develop a model that would generate recommendations of different harvest control rules and policies for the bottomfish and crustacean fisheries.
- Review and improve the P* and SEEM analysis. A regional workshop would be conducted to standardize and improve the criteria and scoring process in the P* and SEEM analysis.
- Draft amendments to incorporate Harvest Control Rule and Harvest Control Policy in the FEPs.
- Conduct Western Pacific Stock Assessment Review for the remaining management unit species. This covers the activities related to the Tier 1 review of the benchmark assessments for the bottomfish, crustacean, uku and precious coral fisheries.

Improve fishery data collection efforts to monitor ecosystem components

Ecosystem component species will be monitored using the existing fishery data collection that rely largely on creel intercept surveys and market reporting. These programs, however, need to be significantly improved by increasing spatial and temporal survey coverage. Environmental monitoring is also required to determine how the stock and fishery respond to the changes in environmental conditions. There is no reliable participation, catch and effort information for many species in the U.S. Pacific territories that can be used to produce stock assessments and determine and monitor annual catch limits. The following guidelines will improve ecosystem monitoring efforts:

- Increase survey coverage by funding additional survey teams to collect fishery data. A contracted team of surveyors would augment the existing local staff to increase survey coverage once the indicator species complex from representative fisheries are identified and the thresholds and ecosystem indicators are defined.
- Gather environmental information (via satellite derived imaging or in-situ loggers) that would generate data products that can be used to monitor environmental parameters that affect the fisheries. Once the environmental indicators for the key indicator species have been determined, the Council will work with NMFS and contractors to gather and improve on the environmental data products that would be monitored and used in the ecosystem models to provide management advice.
- Develop an effective monitoring strategy for the shoreline fisheries. Conduct a regional workshop to improve fishery data collection for the shoreline fisheries.

Develop ecological fishery indicators and ecosystem-level reference points

Fisheries need to be analyzed and managed in the context of the ecosystem. The Western Pacific Region lacks ecosystem fisheries indicators and ecosystem level reference points that would allow managers to make decisions in the context of the changes in the environment. The following guidelines will help with these efforts:

- Develop ecological fishery indicators. This contract work aims at evaluating all available ecological and fishery information to determine indicator species and the different ecological factors that drive population and fishery dynamics for those indicator species.
- Develop predictive ecosystem models that take changes in fishery productivity into account with changes in the ecological indicators. This contract work aims at utilizing the information above to develop a model that can simulate future scenarios and quantify the impacts to the fishery.
- Develop an ecosystem level reference point to determine fishery ecosystem health. This contract work would conduct a literature review of existing ecosystem level reference points used in other countries and regions, and to conduct analysis of existing information to determine what suits each jurisdiction in the Western Pacific.
- Develop a fishery decision tool that considers stock status and ecosystem considerations. This contract work would convert all of the above information into a fishery decision tool that can be used by the Council to achieve the objectives in the FEPs.

Understand and incorporate climate considerations into fisheries management

Fisheries management should be able to adapt and anticipate impacts from climate change. The management system should be able to accommodate climate considerations in its decision making, and improvements in the science used for fishery management must incorporate climate considerations to do so. The management structure should have the ability to monitor and incorporate climate indicators and thresholds in fishery decision making processes. The following guidelines will help incorporate climate into fisheries management:

- Develop harvest control rules and policies incorporating climate considerations. Once the harvest control rule and harvest control policies are in place, the second phase is to incorporate climate change considerations.
- Incorporate results of the predictive modeling in the annual SAFE reports through the Plan Teams.
- Revise the fishery decision tool to incorporate climate considerations.

Communities and Fisheries Development

Incorporate traditional ecological knowledge into the Council's current management

The Council's guiding principles recognize the importance of island cultures and traditional fishing practices in managing fishery resources. TEK is the knowledge, beliefs and practices passed down through generations regarding the relationship between humans and the environment. This knowledge can be used as baseline data in natural resource management to measure

changes over time. The Council has worked to increase TEK in the Western Pacific Region through lunar calendars and community-based management (e.g., *Aha Moku*, community-based FMPs), but little is known. There is a need to understand what TEK is available and how to integrate this information into the current management system. The following guidelines will help incorporate TEK into current management efforts:

- Support the use of community groups with TEK to determine protocols and appropriate collection mechanisms for fisheries in the region.
- Incorporate TEK into management through workshops with recognized TEK experts and community participants.
- Evaluate the performance of management strategies and research on rights-based management alternatives.

Integrate social, ecological and biophysical information into ecosystem-based fisheries management in the region.

Understanding and incorporating social science into fishery management is imperative to ensure that there are no adverse impacts to the human population, the environment or the target stock. Additionally, improved understanding of the dynamics of social and ecological effects may allow managers to be more proactive in ensuring sustainable fisheries. The following guidelines will help integrate social, ecological and biophysical information into EBFM:

- Develop integrated modeling of environmental and social parameters.
- Support studies to expand understanding of ecosystem service valuation (non-market values; non-economic considerations) and human well-being (seafood safety, security, equity) and other intangible benefits.
- Identify indicators to examine community resilience, risk perception and adaptive management.
- Improve understanding of attributes of island communities, including local knowledge and traditional practices.
- Improve understanding of cultural importance and community reliance on species vulnerable to climate change.
- Document fish-flow from fishery to consumer.
- Expand understanding of ecosystem service evaluation and human well-being.
- Explore dimensions of non-commercial fishing and determinants of participation, effort and catch.
- Improve understanding of social drivers of human behavior that affect compliance with fishery regulations and include best practices with applications to protected species.
- Peruse integrated social, ecological and biophysical research efforts to inform EBFM.

Understand the impacts of large-scale changes that result in an uncertain future (climate change) on fisheries and fishing communities

Understanding the impacts of large-scale changes that result in an uncertain future (climate change) on fisheries and fishing communities is lacking. The ability to qualify, and if possible, quantify such impacts could be used in adaptive management strategies. The following guidelines will help with understanding the impacts of large-scale changes on fisheries and fishing communities:

- Research is needed to identify robust indicators to examine community resilience, risk perception and adaptive management.
- Support studies to improve understanding the attributes of island communities, including local knowledge and traditional practices that could help community resiliency in the face of changes.
- Improve understanding of cultural importance of and community reliance on species vulnerable to effects of climate change.

Protected Species

Improve understanding of the overlap between climate change impacts and protected species interactions.

In the face of shifting productivity and distribution because of climate change, it is necessary to better understand how the changing environment may affect the rate of protected species interactions by fisheries in the Western Pacific Region. Similarly, improved information and analyses on protected species interactions' association with various habitat designations will assist management by verifying that Endangered Species Act Critical Habitat remains accurate. There are no concerns associated with protected species interactions and fishery habitat because pelagic habitat is generally the water column. The following guidelines will improve the understanding of the overlap between climate change impacts and protected species interactions:

- Conduct evaluations of environmental factors impacting protected species interaction patterns and trends in the Hawai'i longline fisheries, American Samoa longline fishery and other fisheries in the North Pacific.
- Analyze the overlap between protected species interactions and Endangered Species Act Critical Habitat for protected species.

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Traditional Fijian settlement. *Joeli Veitayaki photo*

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ISBN: 978-1-944827-74-8