WESTERN
PACIFIC
REGIONAL
FISHERY
MANAGEMENT
COUNCIL

Fishery Ecosystem Plan for Pacific Pelagic Fisheries of the Western Pacific Region

Western Pacific Regional Fishery Management Council
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September 24, 2009

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EXECUTIVE SUMMARY

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) authorizes fishery management councils to create fishery management plans (FMP). The Western Pacific Regional Fishery Management Council (Council) developed this Fishery Ecosystem Plan (FEP) as an FMP, consistent with the MSA and the national standards for fishery conservation and management. The FEP represents the first step in an incremental and collaborative approach to implement ecosystem approaches to fishery management for western Pacific pelagic species.

Since the 1980s, the Council has managed fisheries throughout the Western Pacific Region through separate species-based fishery management plans (FMP) – the Bottomfish and Seamount Groundfish FMP (WPRFMC 1986a), the Crustaceans FMP (WPRFMC 1981), the Precious Corals FMP (WPRFMC 1979), the Coral Reef Ecosystems FMP (WPRFMC 2001) and the Pelagic FMP (WPRFMC 1986b). However, the Council is now moving towards an ecosystem-based approach to fisheries management and is restructuring its management framework from species-based FMPs to place-based FEPs. Recognizing that a comprehensive ecosystem approach to fisheries management must be initiated through an incremental, collaborative, and adaptive management process, a multi-step approach is being used to develop and implement the FEPs. To be successful, this will require increased understanding of a range of issues including, biological and trophic relationships, ecosystem indicators and models, and the ecological effects of non-fishing activities on the marine environment. This FEP, in conjunction with the Council's American Samoa Archipelago, Hawaii Archipelago, Mariana Archipelago, and Pacific Remote Island Areas FEPs, replaces the Council's existing Bottomfish and Seamount Groundfish, Coral Reef Ecosystems, Crustaceans, Precious Corals and Pelagic Fishery Management Plans and reorganizes their associated regulations into a place-based structure aligned with the FEPs.

The Pacific Pelagic FEP establishes the framework under which the Council will manage fishery resources, and begin the integration and implementation of ecosystem approaches to management of Pacific pelagic species. This FEP does not establish any new fishery management regulations at this time but rather creates the organizational structure for developing and implementing Fishery Ecosystem Plans that explicitly incorporate community input and local knowledge into the management process. This FEP also identifies topics in ecosystem approaches to management and identifies ten overarching objectives to guide the Council in further implementing ecosystem approaches to management.

Future fishery management actions are anticipated to incorporate additional information as it becomes available. An adaptive management approach will be used to further advance the implementation of ecosystem science and principles. Such actions would be taken in accordance with the Magnuson-Stevens Fishery Conservation and Management Act, the National Environmental Policy Act, the Endangered Species Act, the Marine Mammal Protection Act, and other applicable laws and statutes.

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ACRONYMS

APA:	Administrative Procedure Act
ASG:	American Samoa Government
B:	Stock biomass
B_{FLAG}:	Minimum Biomass Flag
B_{MSY}:	Biomass at Maximum Sustainable Yield
B_{OY}:	Biomass Optimum Yield
CFR:	Code of Federal Regulations
CITES:	Council on International Trade and Endangered Species
CNMI:	Commonwealth of the Northern Mariana Islands
CPUE:	Catch per Unit Effort
$CPUE_{MSY}$:	Catch per unit effort at Maximum Sustainable Yield
$CPUE_{REF}$:	Catch per unit effort at the Reference Point
CRE:	Coral Reef Ecosystem
CZMA:	Coastal Zone Management Act
DAR:	Division of Aquatic Resources, Government of Hawaii
DAWR:	Division of Aquatic and Wildlife Resources, Government of Guam
DBEDT:	Department of Business, Economic Development and Tourism, State of Hawaii
DFW:	Division of Fish and Wildlife, Government of CNMI
DLNR:	Department of Land and Natural Resources, State of Hawaii
DMWR:	Department of Marine and Wildlife Resources, Government of American Samoa
DOC:	United States Department of Commerce
DOD:	United States Department of Defense
DOI:	United States Department of the Interior
EEZ:	Exclusive Economic Zone
EFH:	Essential Fish Habitat
EIS:	Environmental Impact Statement
E_{MSY}:	Effort at Maximum Sustainable Yield
ENSO:	El Niño Southern Oscillation
EO:	Executive Order
EPAP:	Ecosystem Principals Advisory Panel
ESA:	Endangered Species Act
F:	Fishing mortality
F_{MSY}:	Fishing mortality at Maximum Sustainable Yield
F_{OY}:	Fishing mortality at Optimum Yield
FEP:	Fishery Ecosystem Plan
FDM:	Farallon de Medinilla, CNMI
FEP:	Fishery Ecosystem Plan
FFS:	French Frigate Shoals
FLPMA:	Federal Land Policy and Management Act
fm:	Fathoms
FMP:	Fishery Management Plan
FR:	Federal Register
FRFA:	Final Regulatory Flexibility Analysis

FWCA:	Fish and Wildlife Coordination Act
GIS:	Geographic information systems
GPS:	Global Positioning System
HAPC:	Habitat Areas of Particular Concern
HINWR:	Hawaiian Islands National Wildlife Refuge
HIR:	Hawaiian Islands Reservation
IRFA	Initial Regulatory Flexibility Analysis
kg:	Kilograms
km:	Kilometers
LOF	List of Fisheries
LORAN	Long Range Aid to Navigation
m:	Meters
mt:	Metric tons
MFMT:	Maximum Fishing Mortality Threshold
MHI:	Main Hawaiian Islands
mm:	millimeters
MMPA:	Marine Mammal Protection Act
MPA:	Marine Protected Area
MSA:	Magnuson-Stevens Fisheries Conservation and Management Act
MSST:	Minimum Stock Size Threshold
MSY:	Maximum Sustainable Yield
MUS:	Management Unit Species
NDSA:	Naval Defense Sea Areas
NEPA:	National Environmental Policy Act
nm or nmi:	Nautical Miles
NMFS:	National Marine Fisheries Service (also known as NOAA Fisheries Service)
NOAA:	National Oceanic and Atmospheric Administration
NWHI:	Northwestern Hawaiian Islands
NWR:	National Wildlife Refuge
NWRSAA:	National Wildlife Refuge System Administration Act
OMB:	Office of Management and Budget
OY:	Optimum Yield
PIFSC:	Pacific Islands Fisheries Science Center, NMFS
PBR:	Potential Biological Removal
PIRO:	Pacific Islands Regional Office, NMFS
PMUS:	Pelagic Management Unit Species
PRA:	Paperwork Reduction Act
PRIA:	Pacific Remote Island Areas
RFA:	Regulatory Flexibility Act
RFMO:	Regional Fishery Management Organization
RIR:	Regulatory Impact Review
SAC:	Special Agent in Charge
SFA:	Sustainable Fisheries Act
SLA:	Submerged Lands Act
SPR:	Spawning Potential Ratio
SWR:	State Wildlife Refuge

SSC:	Scientific and Statistical Committee
TALFF:	Total Allowable Level of Foreign Fishing
TSLA:	Territorial Submerged Lands Act
TPC:	Territorial Planning Commission
USCG:	United States Coast Guard
USFWS:	United States Fish and Wildlife Service
VMS:	Vessel Monitoring System
WCPFC:	Western and Central Pacific Fisheries Planning Commission
WPacFIN:	Western Pacific Fisheries Information Network, NMFS
WPRFMC	Western Pacific Regional Fishery Management Council

DEFINITIONS

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

Bycatch: Any fish harvested in a fishery which are not sold or kept for personal use, and includes economic discards and regulatory discards.

Barrier Net: A small-mesh net used to capture coral reef or coastal pelagic fishes.

Bioprospecting: The search for commercially valuable biochemical and genetic resources in plants, animals and microorganisms for use in food production, the development of new drugs and other biotechnology applications.

Charter Fishing: Fishing from a vessel carrying a passenger for hire (as defined in section 2101(21a) of Title 46, United States Code) who is engaged in recreational fishing.

Commercial Fishing: Fishing in which the fish harvested, either in whole or in part, are intended to enter commerce or enter commerce through sale, barter or trade. For the purposes of this Fishery Ecosystem Plan, commercial fishing includes the commercial extraction of biocompounds.

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

Coral Reef Ecosystem (CRE): Those species, interactions, processes, habitats and resources of the water column and substrate located within any waters less than or equal to 50 fathoms in total depth.

Critical Habitat: Those geographical areas that are essential for bringing an endangered or threatened species to the point where it no longer needs the legal protections of the Endangered Species Act (ESA), and which may require special management considerations or protection. These areas are designated pursuant to the ESA as having physical or biological features essential to the conservation of listed species.

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

Dip Net: A hand-held net consisting of a mesh bag suspended from a circular, oval, square or rectangular frame attached to a handle. A portion of the bag may be constructed of material, such as clear plastic, other than mesh.

Ecology: The study of interactions between an organism (or organisms) and its (their) environment (biotic and abiotic).

Ecological Integrity: Maintenance of the standing stock of resources at a level that allows ecosystem processes to continue. Ecosystem processes include replenishment of resources, maintenance of interactions essential for self-perpetuation and, in the case of coral reefs, rates of accretion that are equal to or exceed rates of erosion. Ecological integrity cannot be directly measured but can be inferred from observed ecological changes.

Economic Discards: Fishery resources that are the target of a fishery but which are not retained because they are of an undesirable size, sex or quality or for other economic reasons.

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

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

Ecotourism: Observing and experiencing, first hand, natural environments and ecosystems in a manner intended to be sensitive to their conservation.

Environmental Impact Statement (EIS): A document required under the National Environmental Policy Act (NEPA) to assess alternatives and analyze the impacts of proposed major Federal actions significantly affecting the human environment.

Essential Fish Habitat (EFH): Those waters and substrate necessary to a species or species group or complex, for spawning, breeding, feeding or growth to maturity.

Exclusive Economic Zone (EEZ): The zone established by Proclamation numbered 5030, dated March 10, 1983. For purposes of the Magnuson Act, the inner boundary of that zone is a line coterminous with the seaward boundary of each of the coastal states, commonwealths, territories or possessions of the United States.

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

Fish: Finfish, mollusks, crustaceans and all other forms of marine animal and plant life other than marine mammals and birds.

Fishery: One or more stocks of fish that can be treated as a unit for purposes of conservation and management and that are identified on the basis of geographical, scientific, technical, recreational and economic characteristics; and any fishing for such stocks.

Fishery Ecosystem Plan: A fishery ecosystem management plan that contains conservation and management measures necessary and appropriate for fisheries within a given ecosystem to prevent overfishing and rebuild overfished stocks, and to protect, restore, and promote the long-term health and stability of the fishery.

Fishing: The catching, taking or harvesting of fish; the attempted catching, taking or harvesting of fish; any other activity that can reasonably be expected to result in the catching, taking or harvesting of fish; or any operations at sea in support of, or in preparation for, any activity described in this definition. Such term does not include any scientific research activity that is conducted by a scientific research vessel.

Fishing Community: A community that is substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs and includes fishing vessel owners, operators and crews and United States fish processors that are based in such community.

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

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

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

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

Habitat Area of Particular Concern (HAPC): Those areas of EFH identified pursuant to Section 600.815(a)(8). In determining whether a type or area of EFH should be designated as a HAPC, one or more of the following criteria should be met: (1) ecological function provided by the habitat is important; (2) habitat is sensitive to human-induced environmental degradation; (3) development activities are, or will be, stressing the habitat type; or (4) the habitat type is rare.

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

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

Live Rock: Any natural, hard substrate (including dead coral or rock) to which is attached, or which supports, any living marine life-form associated with coral reefs.

Longline: A type of fishing gear consisting of a main line which is deployed horizontally from which branched or dropper lines with hooks are attached.

Low-Use MPA: A Marine Protected Area zoned to allow limited fishing activities.

Magnuson-Stevens Fisheries Conservation and Management Act (Magnuson-Stevens Act): Federal legislation establishing the eight regional fishery management councils and the mandatory and discretionary guidelines for federal fishery management plans.

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

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

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

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

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

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

Optimum Yield (OY): With respect to the yield from a fishery "optimum" means the amount of fish that: (a) will provide the greatest overall benefit to the nation, particularly with respect to food production and recreational opportunities and taking into account the protection of marine ecosystems; (b) is prescribed as such on the basis of the MSY from the fishery, as reduced by any relevant economic, social or ecological factor; and (c) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the MSY in such fishery.

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

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

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

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

Pelagic: Inhabiting the water column as opposed to being associated with the sea floor, generally occurring anywhere from the surface to 1,000 meters.

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

Recreational Fishing: Fishing for sport or pleasure.

Recruitment: A measure of the weight or number of fish which enter a defined portion of the stock such as fishable stock (those fish above the minimum legal size) or spawning stock (those fish which are sexually mature).

Reef: A ridgelike or moundlike structure built by sedentary calcareous organisms and consisting mostly of their remains. It is wave-resistant and stands above the surrounding sediment. It is characteristically colonized by communities of encrusting and colonial invertebrates and calcareous algae.

Regulatory Discards: Any species caught that fishermen are required by regulation to discard whenever caught, or are required to retain but not sell.

Resilience: The ability of a population or ecosystem to withstand change and to recover from stress (natural or anthropogenic).

Restoration: The transplanting of live organisms from their natural habitat in one area to another area where losses of, or damage to, those organisms has occurred with the purpose of restoring the damaged or otherwise compromised area to its original, or a substantially improved, condition; additionally, the altering of the physical characteristics (e.g., substrate, water quality) of an area that has been changed through human activities to return it as close as possible to its natural state in order to restore habitat for organisms.

Rock: Any consolidated or coherent and relatively hard, naturally formed, mass of mineral matter.

Rod-and-Reel: A hand-held fishing rod with a manually or electrically operated reel attached.

Scuba-assisted Fishing: Fishing, typically by spear or by hand collection, using assisted breathing apparatus.

Secretary: The Secretary of Commerce or a designee.

Sessile: Attached to a substrate; non-motile for all or part of the life cycle.

Slurp Gun: A self-contained, typically hand-held, tube–shaped suction device that captures organisms by rapidly drawing seawater containing the organisms into a closed chamber.

Social Acceptability: The acceptance of the suitability of management measures by stakeholders, taking cultural, traditional, political and individual benefits into account.

Spear: A sharp, pointed, or barbed instrument on a shaft, operated manually or shot from a gun or sling.

Stock Assessment: An evaluation of a stock in terms of abundance and fishing mortality levels and trends, and relative to fishery management objectives and constraints if they have been specified.

Stock of Fish: A species, subspecies, geographical grouping or other category of fish capable of management as a unit.

Submersible: A manned or unmanned device that functions or operates primarily underwater and is used to harvest fish.

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

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

Trophic Web: A network that represents the predator/prey interactions of an ecosystem.

Trap: A portable, enclosed, box-like device with one or more entrances used for catching and holding fish or marine organism.

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

CHAPTER 1: INTRODUCTION

1.1 Introduction

In 1976, the United States Congress passed the Magnuson Fishery Conservation and Management Act which was subsequently twice reauthorized as the Magnuson–Stevens Fishery Conservation and Management Act (MSA). Under the MSA, the United States (U.S.) has exclusive fishery management authority over all fishery resources found within its Exclusive Economic Zone (EEZ). For purposes of the MSA, the inner boundary of the U.S. EEZ extends from the seaward boundary of each coastal state to a distance of 200 nautical miles from the baseline from which the breadth of the territorial sea is measured. The Western Pacific Regional Fishery Management Council (Council) has authority over the fisheries based in, and seaward of the State of Hawaii, the Territory of American Samoa, the Territory of Guam, the Commonwealth of the Northern Mariana Islands, and the U.S. Pacific Remote Island Areas (PRIA) of the Western Pacific Region.[1]

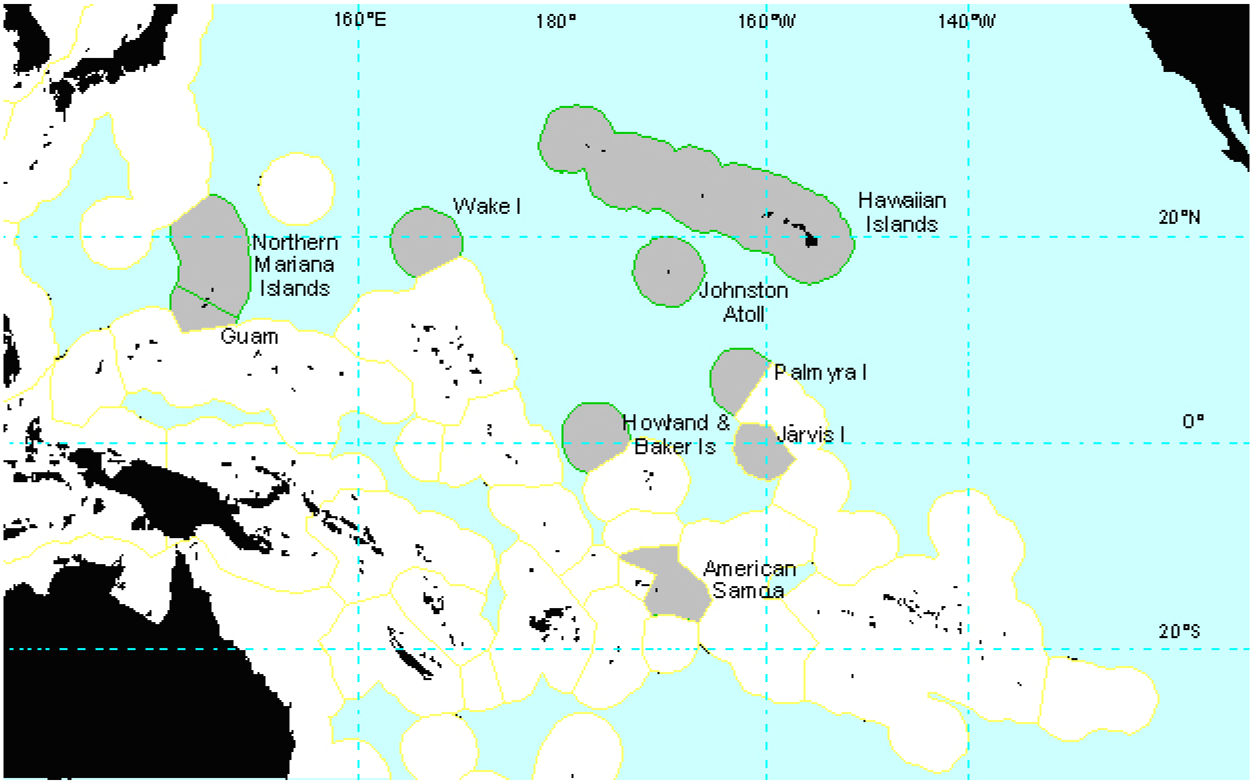

Figure 1: The Western Pacific Region

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[1] The Pacific Remote Island Areas comprise Baker Island, Howland Island, Jarvis Island, Johnston Atoll, Kingman Reef, Wake Island, Palmyra Atoll, and Midway Atoll. Although physically located in the Hawaiian Archipelago, administratively, Midway is considered part of the PRIA because it is not a part of the State of Hawaii. However, because Midway is located in the Hawaii Archipelago, it is included in the Hawaii Archipelago FEP. As used in the remainder of this document, "Pacific Remote Island Areas" and "PRIA" do not include Midway Atoll.

In the Western Pacific Region, responsibility for the management of marine resources is shared by a number of federal and local government agencies. At the federal level, the Council, the National Marine Fisheries Service (NMFS, also known as NOAA Fisheries Service), the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of Commerce develop and implement fishery management measures. Additionally, NOAA's Ocean Service co-manages (with the State of Hawaii) the Hawaiian Islands Humpback Whale National Marine Sanctuary, manages the Fagatele Bay National Marine Sanctuary in American Samoa, and administers the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve.

On June 15, 2006, President George W. Bush signed Presidential Proclamation No. 8031 establishing the Northwestern Hawaiian Islands Marine National Monument (NWHI monument, an approximately 100 mile corridor around the NWHI). Proclamation No. 8031 allows the Secretary of Commerce and the Secretary of Interior (Secretaries) to issue permits for the following activities: (1) research activities; (2) educational activities; (3) conservation and management activities; (4) Native Hawaiian practices: (5) special ocean uses; and (6) recreational activities. With the exception of limited fishing by nine federally permitted bottomfish vessels, commercial and recreational fishing is prohibited in the monument. Bottomfishing will be prohibited effective June 2011. The prohibitions for Monument access do not apply to activities and exercises of the Armed Forces (including those carried out by the United States Coast Guard) or for emergencies threatening life, property, or the environment, or to activities necessary for law enforcement purposes.

The U.S. Department of the Interior, through the U.S. Fish and Wildlife Service, manages ten National Wildlife Refuges throughout the Western Pacific Region. Some refuges are co-managed with other federal and state agencies, while others are not. The U.S. Department of Defense, through the Air Force, Army, Navy, and Marine Corps, controls access and use of various marine waters throughout the region.

The Territory of American Samoa, the Territory of Guam, and the State of Hawaii manage all marine resources within waters 0–3 miles from their shorelines.

In the case of the CNMI and the PRIA, the EEZ extends to the shoreline (Beuttler 1995). State waters generally extend out to three miles from the ordinary low-water mark, as established by the Submerged Lands Act (SLA) of 1953[2]. The Territorial Submerged Lands Act (TSLA) of 1960 was enacted to convey to the governments of American Samoa, Guam and U.S. Virgin Islands the submerged lands from the mean high-tide line out to three miles from their coast lines[3] (Beuttler 1995).

The CNMI was part of the United Nations Trust Territory of the Pacific Islands (administered by the United States) until 1978 when its citizens chose to become a U.S. commonwealth by

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[2] Under the SLA, the term boundaries or the term lands beneath navigable waters is interpreted as extending from the coastline to three geographical miles into the Atlantic Ocean or the Pacific Ocean, or three marine leagues (9 miles) into the Gulf of Mexico for the states of Texas and Florida.

[3] The Territorial Submerged Lands Act was enacted on October 5, 1974 (Beuttler 1995). Congress approved the mutually negotiated Covenant to Establish a Commonwealth of the Northern Marianas (CNMI in political union with the U.S.). However, the Covenant was not fully implemented until 1986, pursuant to Presidential Proclamation number 5564, which terminated the trusteeship agreement.

plebiscite and it was agreed to by Congress. Although title of the emergent land was conveyed to the Commonwealth, the U.S. government has not transferred to the CNMI government the submerged lands around the archipelago. Submerged lands and underlying resources adjacent to CNMI are still owned by the Federal government and subject to its management authority (Beuttler 1995).

In 1997, CNMI initiated civil action against the Federal Government in the U.S. District Court for the Northern Mariana Islands (CNMI v. United States, CA 97-0086) claiming jurisdiction over a 12-mile territorial sea. Subsequently, the District Court (1999) and U.S. Court of Appeals for the Ninth Circuit (2005) ruled against the CNMI government. In March 2006, the U.S. Supreme Court denied CNMI's petition for review and reversal of the appellate court's ruling, thus affirming the Federal Government's jurisdiction over all submerged lands and marine resources from the shoreline out to 200 nm around the Northern Mariana Islands.

1.2 Purpose and Need for Action

The Western Pacific Region includes a series of archipelagos with distinct cultures, communities, and marine resources. For thousands of years, the indigenous people of these Pacific islands relied on healthy marine ecosystems to sustain themselves, their families, and their island communities. This remains true in today's modern period, in which Pacific island communities continue to depend on the ecological, economic, and social benefits of healthy marine ecosystems.

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

In 1998, the U.S. Congress charged the NMFS with the establishment of an Ecosystem Principles Advisory Panel (EPAP) responsible for assessing the extent that ecosystem principles were being used in fisheries management and research, and recommending how to further their use to improve the status and management of marine resources. The EPAP was composed of members of academia, fishery and conservation organizations, and fishery management agencies.

The EPAP reached consensus that Fishery Ecosystem Plans (FEPs) should be developed and implemented to manage U.S. fisheries and marine resources (EPAP 1999). According to the EPAP, an FEP should contain and implement a management framework to control harvests of marine resources on the basis of available information regarding the structure and function of the ecosystem in which such harvests occur. The EPAP constructed eight ecosystem principles that it believes to be important to the successful management of marine ecosystems which were recognized and used as a guide by the Council in developing this FEP. These principles are as follows:

- The ability to predict ecosystem behavior is limited.
- Ecosystems have real thresholds and limits that, when exceeded, can affect major system restructuring.
- Once thresholds and limits have been exceeded, changes can be irreversible.
- Diversity is important to ecosystem functioning.
- Multiple scales interact within and among ecosystems.
- Components of ecosystems are linked.
- Ecosystem boundaries are open.
- Ecosystems change with time.

The Food and Agriculture Organization of the United Nations provides that the purpose of an ecosystem approach to fisheries "is to plan, develop and manage fisheries in a manner that addresses the multiple needs and desires of societies, without jeopardizing the options for future generations to benefit from a full range of goods and services provided by marine ecosystems" (Garcia et al. 2003).

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

Given the above, on December 20, 2005 the Council recommended the establishment and implementation of this FEP for Federally managed pelagic fisheries of the Western Pacific Region. In particular, this FEP:
1. Identifies the management objectives of the Pacific Pelagic FEP;
2. Delineates the boundaries of the Pelagic FEP;
3. Designates the management unit species included in the Pacific Pelagic FEP;
4. Details the federal fishery regulations applicable under the Pacific Pelagic FEP; and
5. Establishes appropriate Council structures and advisory bodies to provide scientific and management advice to the Council regarding the Pacific Pelagic FEP.

In addition, this document provides the information and rationale for these measures; discusses the key components of the Western Pacific Region's pelagic ecosystem, including an overview of the region's pelagic fisheries; and explains how the measures contained here are consistent with the MSA and other applicable laws. This FEP, in conjunction with the Council's Hawaii Archipelago, Mariana Archipelago, American Samoa Archipelago, and Pacific Remote Island Areas FEPs, incorporates by reference and replaces the Council's existing Fishery Management Plans (FMPs) for Bottomfish and Seamount Groundfish, Coral Reef Ecosystems, Crustaceans, Precious Corals and Pelagics (and their amendments) and reorganizes their associated regulations into a place-based structure aligned with the FEPs.

1.3 Incremental Approach to Ecosystem-based Management

As discussed above, fishery scientists and managers have recognized that a comprehensive ecosystem approach to fisheries management must be implemented through an incremental and collaborative process (Jennings 2004; NOAA 2004; Sissenwine and Murawski 2004). The goal of the measures contained in this document is to begin this process by establishing a Pacific Pelagic FEP with appropriate boundaries, management unit species, and advisory structures. This FEP does not establish any new fishery management regulations at this time but rather incorporates all of the management regulations of the Pacific Pelagic fishery management plan under this one umbrella document.

Successful ecosystem-based fisheries management will require an increased understanding of a range of social and scientific issues including appropriate management objectives, biological and trophic relationships, ecosystem indicators and models, and the ecological effects of non-fishing activities on the marine environment. Future fishery management actions are anticipated to utilize this information as it becomes available and adaptive management will be used to further advance the implementation of ecosystem science and principles.

1.4 Pacific Pelagic FEP Boundaries

NOAA defines an ecosystem as a geographically specified system of organisms (including humans), the environment, and the processes that control its dynamics (NOAA 2004). Ecosystems can be considered at various geographic scales—from a coral reef ecosystem with its diverse species and benthic habitats to a large marine ecosystem such as the Pacific Ocean.

From a marine ecosystem management perspective, the boundary of an ecosystem cannot be readily defined and depends on many factors, including life history characteristics, habitat requirements, and geographic ranges of fish and other marine resources including the interdependence among species and their environment. Additionally, processes that affect and influence abundance and distribution of natural resources, such as environmental cycles, extreme natural events and acute or chronic anthropogenic impacts must also be considered. Serious considerations must also be given to social, economic and/or political constraints. The Pelagic FEP is subject to multinational political constraints due to the highly migratory nature of pelagic species, such as tunas, whose stocks cross many international borders [EEZs] and are extensively targeted on the high seas. Highly migratory stocks in the Pacific are also divided between Regional Fisheries Management Organizations (RFMOs) such as the eastern Pacific Ocean (EPO) and the western and central Pacific Ocean (WCPO) management units which will add complexity to including ecosystem considerations when managing these stocks.

For the purposes of this document, ecosystems are defined as a geographically specified system of organisms, the environment, and the processes that control its dynamics. Humans and their society are considered to be an integral part of these ecosystems and the measures considered here are cognizant of the human jurisdictional boundaries and varying management authorities that are present in the Western Pacific Region. This is also consistent with NMFS's EPAP's 1999 report to Congress recommending that Councils should develop FEPs for the ecosystems under their jurisdiction and delineate the extent of those ecosystems.

Taking these factors into account, the Council has determined that at this time, the Pacific Pelagic FEP encompasses all areas of pelagic fishing operations in the EEZ or on the high seas, for any domestic vessels that:

1. Fish for, possess, or transship Pacific Pelagic Management Unit Species (PMUS; see Section 1.6) within the EEZ waters of the Western Pacific Region; or
2. Land Pacific Pelagic MUS within the states, territories, commonwealths, or unincorporated U.S. island possessions of the Western Pacific Region.

Although this overlaps with the boundaries of the Council's archipelagic FEPs for demersal fisheries which include the American Samoa Archipelago FEP, the Mariana Archipelago FEP, the Hawaii Archipelago FEP, and the Pacific Remote Island Areas or PRIA FEP, the Pacific Pelagic FEP specifically manages those resources and habitats associated with the pelagic ecosystem.

Under the approach described in this document, continuing adaptive management could include subsequent actions to refine these boundaries if and when supported by scientific data and/or management requirements. Such actions would be taken in accordance with the MSA, the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), and other applicable laws and statutes.

1.5 Pacific Pelagic FEP Management Objectives

The MSA mandates that fishery management measures achieve long-term sustainable yields from domestic fisheries while preventing overfishing. In 1999, the EPAP submitted a report to Congress arguing for management that—while not abandoning optimum yield and overfishing principles—takes an ecosystem-based approach (EPAP 1999).

Heeding the basic principles, goals, and policies for ecosystem-based management outlined by the EPAP, the Council initiated the development of FEPs for each major ecosystem under its jurisdiction beginning with the Coral Reef Ecosystems FMP, which was implemented in March 2004. This Pacific Pelagic FEP represents —along with the American Samoa Archipelago FEP, the Mariana Archipelago FEP, the Hawaii Archipelago FEP, and the PRIA FEP — the next step in the establishment and successful implementation of place-based FEPs for fisheries within the Council's jurisdiction, which it will manage using an ecosystem-based approach.

The overall goal of the Pacific Pelagic FEP is to establish a framework under which the Council will improve its abilities to realize the goals of the MSA through the incorporation of ecosystem science and principles.

To achieve this goal, the Council has adopted the following ten objectives for the Pacific Pelagic FEP:

Objective 1: To maintain biologically diverse and productive marine ecosystems and foster the long-term sustainable use of marine resources in an ecologically and culturally sensitive manner through the use of a science-based ecosystem approach to resource management.

Objective 2: To provide flexible and adaptive management systems that can rapidly address new scientific information and changes in environmental conditions or human use patterns.

Objective 3: To improve public and government awareness and understanding of the marine environment in order to reduce unsustainable human impacts and foster support for responsible stewardship.

Objective 4: To encourage and provide for the sustained and substantive participation of local communities in the exploration, development, conservation, and management of marine resources.

Objective 5: To minimize fishery bycatch and waste to the extent practicable.

Objective 6: To manage and comanage protected species, protected habitats, and protected areas.

Objective 7: To promote the safety of human life at sea.

Objective 8: To encourage and support appropriate compliance and enforcement with all applicable local and federal fishery regulations.

Objective 9: To increase collaboration with domestic and foreign regional fishery management and other governmental and nongovernmental organizations, communities, and the public at large to successfully manage marine ecosystems.

Objective 10: To improve the quantity and quality of available information to support marine ecosystem management.

1.6 Pacific Pelagic FEP Management Unit Species

Management unit species (MUS) are those species that are managed under each FMP or FEP. In fisheries management, MUS typically include those species that are caught in quantities sufficient to warrant management or specific monitoring by NMFS and the Council. The primary impact of inclusion of species in an MUS list is that the species (i.e., the fishery targeting that species) can be directly managed. National Standard 3 of the MSA requires that to the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination. The MUS of the Pacific Pelagic FEP are the same (identical) to the current MUS managed under the Pelagic FMP (see Table 1).

Those species for which maximum sustainable yields (MSYs) have been estimated are indicated with an asterisk and their MSY values can be found in Section 5.6, Table 13. Some of the species included as MUS are not subject to significant fishing pressure and there are no estimates of

MSY or minimum stock size threshold (MSST, the level of biomass beneath which a stock or stock complex is considered overfished) or maximum fishing mortality threshold (MFMT, the level of fishing mortality, on an annual basis, above which overfishing in occurring) available for these species at this time. However, these species are important components of the ecosystem and for that reason are included in this FEP. Permitting and data collection measures established under the existing FMPs will be continued under this FEP. Including these species as MUS in the FEP is consistent with MSA National Standard 3 which states that "To the extent practicable, an individual stock of fish shall be managed as a stock throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination." (50 CFR 600.320). This section further provides that "A management unit may contain, in addition to regulated species, stocks of fish for which there is not enough information available to specify MSY and optimum yield (OY) or to establish management measures, so that data on these species may be collected under the FMP". Under the adaptive approach that utilizes the best available scientific information, the Council, in coordination with NMFS, will continue to develop and refine estimates or proxies of MSY for these species when sufficient data are available. The establishment of MSY proxies is consistent with 50 CFR 600.310 text regarding MSA National Standard 1 which states that "When data are insufficient to estimate MSY directly, Councils should adopt other measures of productive capacity that can serve as reasonable proxies of MSY to the extent possible." Future management measures that would directly affect the harvest of any MUS contained in this FEP will be subject to the requirements of the MSA and other applicable laws.

Table 1. Pacific Pelagic Management Unit Species (PMUS)

Scientific Name	English Common Name	Scientific Name	English Common Name
TUNAS		**BILLFISHES**	
*Thunnus alalunga**	albacore	*Tetrapturus audax**	striped marlin
*T. obesus**	bigeye tuna	*T. angustirostris*	shortbill spearfish
*T. albacares**	yellowfin tuna	*Xiphias gladius**	swordfish
T. thynnus	northern bluefin tuna	*Istiophorus platypterus*	sailfish
*Katsuwonus pelamis**	skipjack tuna	*Makaira mazara**	blue marlin
Euthynnus affinis	kawakawa	*M. indica*	black marlin
Auxis spp. *Scomber* spp. *Allothunus* spp.	other tuna relatives		
SHARKS		**OTHER PELAGICS**	
Alopias pelagicus	pelagic thresher shark	*Coryphaena* spp.	mahimahi (dolphinfish)
A. superciliousus	bigeye thresher shark	*Lampris* spp.	moonfish
A. vulpinus	common thresher shark	*Acanthocybium solandri*	wahoo
Carcharhinus falciformis	silky shark	*Gempylidae*	oilfish family
C. longimanus	oceanic whitetip shark	*Bramidae*	pomfret family

Scientific Name	English Common Name	Scientific Name	English Common Name
TUNAS		**BILLFISHES**	
*Prionace glauca**	blue shark	*Ommastrephes bartamii*	neon flying squid
Isurus oxyrinchus	shortfin mako shark	*Thysanoteuthis rhombus*	diamondback squid
I. paucus	longfin mako shark	*Sthenoteuthis oualaniensis*	purple flying squid
Lamna ditropis	salmon shark		

*** Indicates a species for which there is an estimated MSY value.**

1.7 Regional Coordination

In the Western Pacific Region, the management of ocean and coastal activities is conducted by a number of agencies and organizations at the federal, state, county, and even village levels. These groups administer programs and initiatives that address often overlapping and sometimes conflicting ocean and coastal issues.

To be successful, ecosystem approaches to management must be designed to foster intra and inter-agency cooperation and communication (Schrope 2002). Increased coordination with state and local governments and community involvement will be especially important to the improved management of near-shore resources that are heavily used. To increase collaboration with domestic and international management bodies, as well as other governmental and nongovernmental organizations, communities, and the public, the Council has adopted the multilevel approach described below.

1.7.1 Council Panels and Committees

The Council has approved the establishment and roles of its panels and committees described below.

FEP Advisory Panel

The FEP Advisory Panel advises the Council on fishery management issues, provides input to the Council regarding fishery management planning efforts, and advises the Council on the content and likely effects of management plans, amendments, and management measures.

The Advisory Panel consists of four sub-panels. In general, each Advisory Sub-panel includes two representatives from the area’s commercial, recreational, and subsistence fisheries, as well as two additional members (fishermen or other interested parties) who are knowledgeable about the area’s ecosystems and habitat. The exception is the Mariana FEP Sub-panel, which has four representatives from each group to represent the combined areas of Guam and the Northern Mariana Islands. The Hawaii FEP Sub-panel addresses issues pertaining to demersal fishing in the PRIA due to the lack of a permanent population and because such PRIA fishing has primarily originated in Hawaii. The FEP Advisory Panel meets at the direction of the Council to provide continuing and detailed participation by members representing various fishery sectors and the general public. FEP Advisory Panel members are representatives from various fishery sectors that are selected by the Council and serve two-year terms.

Pelagic FEP Plan Team

The Pelagic FEP Plan Team oversees the ongoing development and implementation of the Pacific Pelagic Fishery Ecosystem Plan and is responsible for reviewing information pertaining to the performance of all the fisheries and the status of all the stocks managed under the Pelagic FEP. Similarly, the Archipelagic FEP Plan Team oversees the ongoing development and implementation of the American Samoa, Hawaii, Mariana, and PRIA FEPs. These teams monitor the performance of the FEP through production of an annual stock assessment and fishery evaluation (SAFE) Report and provide information on the status of the fish stocks and other components of the ecosystem. The FEP Plan Team also makes recommendations for conservation and management adjustments under framework procedures to better achieve management objectives.

The Pelagic Plan Team meets at least once annually and comprises individuals from local and federal marine resource management agencies and non-governmental organizations. It is led by a Chair who is appointed by the Council Chair after consultation with the Council’s Executive Standing Committee. The Pelagic Plan Team’s findings and recommendations are reported to the Council at its regular meetings. Plan teams are a form of advisory panel authorized under Section 302(g) of the MSA. FEP Plan Team members comprise Federal, State and non-government specialists that are appointed by the Council and serve indefinite terms.

Science and Statistical Committee

The Scientific and Statistical Committee (SSC) is composed of scientists from local and federal agencies, academic institutions, and other organizations. These scientists represent a range of disciplines required for the scientific oversight of fishery management in the Western Pacific Region. The role of the SSC is to (a) identify scientific resources required for the development of FEPs and amendments, and recommend resources for Plan Teams; (b) provide multi-disciplinary review of management plans or amendments, and advise the Council on their scientific content; (c) assist the Council in the evaluation of such statistical, biological, economic, social, and other scientific information as is relevant to the Council's activities, and recommend methods and means for the development and collection of such information; and (d) advise the Council on the composition of both the Pelagic and Archipelagic Plan Teams. Members of the SSC are selected by the Council and serve indefinite terms.

FEP Standing Committees

The Council’s four FEP Standing Committees are composed of Council members who, prior to Council action, review all relevant information and data including the recommendations of the FEP Advisory Panels, the Archipelagic and Pelagic Plan Teams, and the SSC. The Standing Committees are the American Samoa FEP Standing Committee, the Hawaii FEP Standing

Committee (as in the Advisory Panels, the Hawaii Standing Committee will also consider demersal issues in the PRIA), the Mariana FEP Standing Committee, and the Pelagic FEP Standing Committee. The recommendations of the FEP Standing Committees, along with the recommendations from all of the other advisory bodies described above, are presented to the full Council for their consideration prior to taking action on specific measures or recommendations.

Regional Ecosystem Advisory Committees

Regional Ecosystem Advisory Committees for each inhabited area (American Samoa, Hawaii, and the Mariana archipelago) comprise Council members and Council selected representatives from federal, state, and local government agencies; businesses; and non-governmental organizations that have responsibility or interest in land-based and non-fishing activities that potentially affect the area's marine environment. Committee membership is by invitation and provides a mechanism for the Council and member agencies to share information on programs and activities, as well as to coordinate management efforts or resources to address non-fishing related issues that could affect ocean and coastal resources within and beyond the jurisdiction of the Council. Committee meetings coincide with regularly scheduled Council meetings, and recommendations made by the Committees to the Council are advisory as are recommendations made by the Council to member agencies. Regional Ecosystem Advisory Committees are a form of advisory panel authorized under Section 302(g) of the MSA.

1.7.2 Community Groups and Projects

As described above, communities and community members are involved in the Council's management process in explicit advisory roles, as sources of fishery data and as stakeholders invited to participate in public meetings, hearings, and comment periods. In addition, cooperative research initiatives have resulted in joint research projects in which scientists and fishermen work together to increase both groups' understanding of the interplay of humans and the marine environment, and both the Council's Community Development Program and the Community Demonstration Projects Program foster increased fishery participation by indigenous residents of the Western Pacific Region.

The Council is sponsoring the Hoohanohano I Na Kupuna (Honoring our Ancestors) conference series in partnership with the Association of Hawaiian Civic Clubs and in consultation with the native Hawaiian community. The conference has received the support of the Kamehameha Schools/Bishop Estate, Office of Hawaiian Affairs, various departments of the State of Hawaii, the Hawaii Tourism Authority and numerous community organizations and projects throughout the State of Hawaii. Fishery ecosystem management provides the Council with the opportunity to utilize the manao (thoughts) and ike (knowledge) of our kupuna (elders) – ideas and practices that have sustained na kanaka maoli (native Hawaiian) culture for millennia.

The conference series was initiated by the Council to engage the Kanaka Maoli community in the development of the Hawaii Archipelago FEP and to increase their participation in the management of fisheries under the FEP's authority. A series of workshops with the Kanaka Maoli community to promote the concept of ahupuaa (traditional natural resource unit) management began in 2003 through the AOHCC. This endeavor was continued by the Council in order to take the ahupuaa concept to the next level, the development of a process to implement traditional resource management practices into today's management measures.

Conference attendees, many of them native practitioners who continue traditional practices and relationships with the natural environment taught to them by their kupuna, requested that traditional resource management be incorporated into contemporary resource management and that education play a major role in this effort. A motivation for the series was the often heard manao that "we want to teach our keiki (children) a practice, not a memory."

The first conference (Puwalu I) was held in August 2006 and included over 100 ahupuaa practitioners who discussed the development of aha moku (traditional councils which governed one or more ahupuaa) that would manage natural resources for the aha moku through the implementation of culturally based, site-specific conservation and utilization practices.

The second conference (Puwalu II) was held in November 2006. At this conference cultural practitioners and educators met and developed a declaration regarding the education of Hawaii's children, the development of appropriate consultation protocols, the customary and traditional rights of na kanaka maoli, and a commitment to further action as follows:

Having met to deliberate on how to incorporate traditional Hawaiian practices and knowledge, into the daily education of Hawai'i's children;

Believing that na kanaka maoli have the right of self-determination and that the natural resources of ka pae 'aina Hawai'i and associated traditional knowledge are by birthright the kuleana and intellectual property of na kanaka maoli, and, as such, the hana pono for sustaining, developing, managing, utilizing and educating about 'aina, kai, and wai, and shall be utilized to sustain these natural resources and promote the culture of na kanaka maoli;

Emphasizing that it is the kuleana of na kanaka maoli to perpetuate their culture and knowledge, which if maintained, can sustain Hawai'i's natural resources for the benefit of future generations;

Recognizing that the vast cumulative knowledge of kanaka maoli kupuna, practitioners and experts on Hawai'i's marine and terrestrial environments represents hundreds of years of knowledge gained by hands on observation and experimentation integral to Native Hawaiian culture and values;

Agreeing that educating Hawai'i's kamali'i and opio on Native Hawaiian culture, values, practices, requiring learning through oli, mo'olelo, place names, and ecosystem observations held by na kanaka maoli kupuna;

Recognizing that there are examples of existing programs and schools that are attempting to integrate traditional Native Hawaiian knowledge and practices into curriculum; however, the effort lacks coordination and adequate funding as well as is being hindered by school policies on liability issues;

Recognizing that this ‘ike is imparted through mo’olelo and place names and not from books, requires the skill of patient listening and observing and teaches from the na’au and not just the po’o;

Agreeing that while the details of a practice may evolve, the relationship to a particular place, to a practice, to a resource remains, and that this relationship is important to the identity of na kanaka maoli, imparting values such as malama ‘aina, aloha ‘aina, and sharing;

Believing that we must teach this ‘ike to people of all ages, all nationalities, be they ohana, neighbors or visitors;

We customary and traditional practitioners of the second Hoohanohano I Na Kupuna Puwalu, building on the resolution of the first Ho’ohanohano I Na Kupuna Puwalu, which called upon na kanaka maoli to begin the process to uphold and continue traditional land and ocean practices in the governance and education of the Hawaii Archipelago,

Affirm that na hana kupono (righteous procedures) shall be acknowledged as encompassing na mea Hawai’i (all things Hawaiian) and that the sharing of knowledge between cultural informants and others shall include the following nah ana kupono:

Kekipa ana e kahui ana (visiting and meeting procedures)

1. *Hoomakaukau ana (preparing for the call and interview)*
2. *Ke kahea (proper introduction or call to the informant)*
3. *Ka hookupu (appropriate gift presented to the informant*
4. *Ke kukakuka ana e kahuiana (discussion and negotiation)*
5. *kapanina e hookupu (closure)*

Ke ike (sharing knowledge and understanding procedures)

1. *Ka hoomakaumakau ana (preparation for sharing)*
2. *Ke a`o mai ana (sharing knowledge with the informant)*
3. *Ka malama ana (agreement on how the knowledge will be used and protecting the knowledge)*
4. *Ke a`o aku ana (instruction to the guest and sharing of `ike)*

Furthermore we declare that Native Hawaiians today are entitled to all customary and traditional subsistence, cultural and religious rights that were possessed by ahupuaa tenants prior to 1778, and

We further recommend, and will act to establish the following:

- *An Aha Moku on each island*
- *Laws that prohibit the introduction of alien invasive species that would negatively impact on native, endemic and indigenous species,*
- *Provisions to remove such species as noted above to make the land pono,*
- *The inventory and monitoring of our natural resources,*
- *Recommendations to be made based on the results of the above,*

- *A State holiday (e.g., January 17 or July 31) to celebrate the Kanaka Maoli during which we shall walk our aina, and*
- *Recognition and establishment by the State and county governments of a means for community-based self enforcement (such as Native Hawaiian rangers) of the rules and practices of each ahupuaa.*

The third conference (Puwalu III) brought together practitioners, educators, government agencies and policy makers to discuss the implementation of a community and cultural consultation process through the development of na aha moku for each island.

Under the Hawaii Archipelago FEP, this conference series will continue in Hawaii and will subsequently be extended to the other areas of the Western Pacific Region. Although the specific format will be tailored to each area's cultures and communities, in all cases the Council will seek to increase the participation of indigenous communities in the harvest, research, conservation and management of marine resources as called for in Section 305 of the MSA.

1.8 International Management and Research

The Council is an active participant in the development and implementation of international agreements regarding marine resources. These include agreements made by the Inter-American Tropical Tuna Commission (IATTC), of which the U.S. is a member, and the Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Central and Western Pacific Region (Convention). On September 4, 2000, the United States voted for the adoption of and signed the Convention along with 19 other participants in the Conference on the Conservation and Management of Highly Migratory Fish Stocks of the Central and Western Pacific (or MHLC, for Multilateral High-Level Conference). The Convention established the Central and Western Pacific Fisheries Commission (WCPFC) to conserve and manage highly migratory species in the vast area of the western and central Pacific west of 150° meridian of west longitude. As of December 8, 2006, with passage of the amended MSA, the WCPFC was ratified and the U.S. will be a member of the Convention upon depositing the articles of association with the repository nation (New Zealand).

The Council is serving as a role model to other member nations with regards to ecosystem based-management through its participation in these and other international organizations. The Council's comprehensive and interdisciplinary approach to pelagics fisheries management is an example of advances in conservation through improved gear technology; community participation through the public meeting process; sustainable fishing through limited entry programs and adherence to quota management; and using the best available science through cooperative research, improved stock assessments, and sharing knowledge within the regional fishery management organization (RFMO) process.

The Council also participates in and promotes the formation of regional and international arrangements for assessing and conserving all marine resources throughout their range, including the ecosystems and habitats that they depend on (e.g., the Forum Fisheries Agency, the Secretariat of the Pacific Community's Oceanic Fisheries Programme, the Food and Agriculture Organization of the U.N. , the Intergovernmental Oceanographic Commission of UNESCO, the

Inter-American Convention for the Protection and Conservation of Sea Turtles, the International Scientific Council, and the North Pacific Marine Science Organization). The Council is also developing similar linkages with the Southeast Asian Fisheries Development Center and its turtle conservation program. Of increasing importance are bilateral agreements regarding demersal resources that are shared with adjacent countries (e.g., Samoa).

CHAPTER 2: TOPICS IN ECOSYSTEM APPROACHES TO MANAGEMENT

2.1 Introduction

An overarching goal of an ecosystem approach to fisheries management is to maintain and conserve the structure and function of marine ecosystems by managing fisheries in a holistic manner that considers the ecological linkages and relationships between a species and its environment, including its human uses and societal values (Garcia et al. 2003; Laffoley et al. 2004; Pikitch et al. 2004). Although the literature on the objectives and principles of ecosystem approaches to management is extensive, there remains a lack of consensus and much uncertainty among scientists and policy makers on how to best apply these often theoretical objectives and principles in a real-world regulatory environment (Garcia et al. 2003; Hilborn 2004). In many cases, it is a lack of scientific information that hinders their implementation (e.g., ecosystem indicators); in other cases, there are jurisdictional and institutional barriers that need to be overcome before the necessary changes can be accomplished to ensure healthy marine fisheries and ecosystems (e.g., ocean zoning). These and other topics are briefly discussed below to provide a context for the Council's increasing focus on ecosystem approaches to management.

2.2 Ecosystem Boundaries

It is widely recognized that ecosystems are not static, but that their structure and functions vary over time due to various dynamic processes (Christensen et al. 1996; Kay and Schneider 1994; EPAP 1999. The term *ecosystem* was coined in 1935 by A. G. Tansley, who defined it as "an ecological community together with its environment, considered as a unit" (Tansley 1935). The U.S. Fish and Wildlife Service has defined an ecosystem as "a system containing complex interactions among organisms and their non-living, physical environment" (USFWS 1994), while NOAA defines an ecosystem as "a geographically specified system of organisms (including humans), the environment, and the processes that control its dynamics" (NOAA 2004).

Although these definitions are more or less consistent (only NOAA explicitly includes humans as part of ecosystems), the identification of ecosystems is often difficult and dependent on the scale of observation or application. Ecosystems can be reasonably identified (e.g., for an intertidal zone on Maui, Hawaii, as well as the entire North Pacific Ocean). For this reason, hierarchical classification systems are often used in mapping ecosystem linkages between habitat types (Allen and Hoekstra 1992; Holthus and Maragos 1994). NOAA's Ecosystem Advisory Panel found that although marine ecosystems are generally open systems, bathymetric and oceanographic features allow their identification on a variety of bases. In order to be used as functional management units, however, ecosystem boundaries need to be geographically based and aligned with ecologically meaningful boundaries (FAO 2002). Furthermore, if used as a basis for management measures, an ecosystem must be defined in a manner that is both scientifically and administratively defensible (Gonsalez 1996). Similarly, Sissenwine and Murawski (2004) found that delineating ecosystem boundaries is necessary to an ecosystem approach, but that the scale of delineation must be based on the spatial extent of the system that is to be studied or influenced by management. Thus, the identification of ecosystem boundaries for management purposes may differ from those resulting from purely scientific assessments, but in all cases ecosystems are geographically defined, or in other words, place- based.

2.3 Precautionary Approach, Burden of Proof, and Adaptive Management

There is general consensus that a key component of ecosystem approaches to resource management is the use of precautionary approaches and adaptive management (EPAP 1999). The FAO Code of Conduct for Responsible Fisheries states that under a precautionary approach:

> …in the absence of adequate scientific information, cautious conservation management measures such as catch limits and effort limits should be implemented and remain in force until there is sufficient data to allow assessment of the impacts of an activity on the long-term sustainability of the stocks, whereupon conservation and management measures based on that assessment should be implemented. (FAO 1995)

This approach allows appropriate levels of resource utilization through increased buffers and other precautions where necessary to account for environmental fluctuations and uncertain impacts of fishing and other activities on the ecology of the marine environment (Pikitch et al. 2004).

A notion often linked with the precautionary approach is shifting the "burden of proof" from resource scientists and managers to those who are proposing to utilize those resources. Under this approach, individuals would be required to prove that their proposed activity would not adversely affect the marine environment, as compared with the current situation that, in general, allows uses unless managers can demonstrate such impacts (Hildreth et al. 2005). Proponents of this approach believe it would appropriately shift the responsibility for the projection and analysis of environmental impacts to potential resource users and fill information gaps, thus shortening the time period between management decisions (Hildreth et al. 2005). Others believe that it is unrealistic to expect fishery participants and other resource users to have access to the necessary information and analytical skills to make such assessments.

The precautionary approach is linked to adaptive management through continued research and monitoring of approved activities (Hildreth et al. 2005). As increased information and an improved understanding of the managed ecosystem become available, adaptive management requires resource managers to operate within a flexible and timely decision structure that allows for quick management responses to new information or to changes in ecosystem conditions, fishing operations, or community structures.

2.4 Ecological Effects of Fishing and Non-fishing Activities

Fisheries may affect marine ecosystems in numerous ways, and vice versa. Populations of fish and other ecosystem components can be affected by the selectivity, magnitude, timing, location, and methods of fish removals. Fisheries can also affect marine ecosystems through vessel disturbance, bycatch or discards, impacts on nutrient cycling, or introduction of exotic species, pollution, and habitat disturbance. Historically, federal fishery management focused primarily on ensuring long-term sustainability by preventing overfishing and by rebuilding overfished stocks. However, the reauthorization of the MSA in 1996 placed additional priority on reducing non-target or incidental catches, minimizing fishing impacts to habitat, and eliminating interactions with protected species. While fisheries management has significantly improved in these areas in recent years, there is now an increasing emphasis on the need to account for and minimize the unintended and indirect consequences of fishing activities on other components of the marine environment such as predator–prey relationships, trophic guilds, and biodiversity (Browman and Stergiou 2004; Dayton et al. 2002).

For example, fishing for a particular species at a level below its maximum sustainable yield can nevertheless limit its availability to predators, which, in turn, may impact the abundance of the predator species. Similarly, removal of top-level predators can potentially increase populations of lower level trophic species, thus causing an imbalance or change in the community structure of an ecosystem (Pauly et al. 1998). Successful ecosystem management will require significant increases in our understanding of the impacts of these changes and the formulation of appropriate responses to adverse changes.

Marine resources are also affected by non-fishing aquatic and land-based activities. For example, according to NOAA’s (2005b) *State of Coral Reefs Ecosystems of the United States and Pacific Freely Associated States*, anthropogenic stressors that are potentially detrimental to coral reef resources include the following:

- Coastal development and runoff
- Coastal pollution
- Tourism and recreation
- Ships, boats, and groundings
- Anchoring
- Marine debris
- Aquatic invasive species
- Security training activities

Non-anthropogenic impacts arise from events such as weather cycles, hurricanes, and environmental regime changes. While managers cannot regulate or otherwise control such events, their occurrence can often be predicted and appropriate management responses can lessen their adverse impacts.

Understanding the complex inter-relationships between marine organisms and their physical environment is a fundamental component of successful ecosystem approaches to management.

Obtaining the necessary information to comprehensively assess, interpret, and manage these inter-relationships will require in-depth and long-term research on specific ecosystems.

2.5 Data and Information Needs

Numerous research and data collection projects and programs have been undertaken in the Western Pacific Region and have resulted in the collection of huge volumes of potentially valuable detailed bathymetric, biological, and other data. Some of this information has been processed and analyzed by fishery scientists and managers; however, much has proven difficult to utilize and integrate due to differences in collection methodologies coupled with a lack of meta-data or documentation of how the data were collected and coded. This has resulted in incompatible datasets as well as data that are virtually inaccessible to anyone except the primary researchers. The rehabilitation and integration of existing datasets, as well as the establishment of shared standards for the collection and documentation of new data, will be an essential part of successful and efficient ecosystem management in the Western Pacific Region.

Of particular importance to successful implementation of this FEP is the continued participation of the local communities in providing information on the importance of fishing, participation levels, and concerns regarding community development. Other information that may be useful includes ecosystem data (trophic level studies, indicator species, food web data), stock assessments including those on less important commercial species, and information on the ecological effects of fishing and non-fishing activities.

2.6 Use of Indicators and Models

Clearly, ecosystem-based management is enhanced by the ability to understand and predict environmental changes, as well as the development of measurable characteristics (e.g., indices) related to the structure, composition, or function of an ecological system (de Young et al. 2004; EPAP 1999; MAFAC 2003).

Indicators

The development and use of indicators are an integral part of an ecosystem approach to management as they provide a relatively simple mechanism to track complex trends in ecosystems or ecosystem components. Indicators can be used to help answer questions about whether ecosystem changes are occurring, and the extent (state variables; e.g., coral reef biomass) to which causes of changes (pressure variables; e.g., bleaching) and the impacts of changes influence ecosystem patterns and processes. This information may be used to develop appropriate response measures in terms of management action. This pressure–state–response framework provides an intuitive mechanism for causal change analyses of complex phenomena in the marine environment and can clarify the presentation and communication of such analyses to a wide variety of stakeholders (Wakeford 2005).

Monitoring and the use of indicator species as a means to track changes in ecological health (i.e., as an identifier of stresses) have been studied in various marine ecosystems including Indo-Pacific coral reefs using butterflyfishes (Crosby and Reese 1996) and boreal marine ecosystems in the Gulf of Alaska using pandalid shrimp, a major prey of many fish species (Anderson 2000). Some researchers have examined the use of spatial patterns and processes as indicators of management performance (Babcock et al. 2005), and others have used population structure parameters, such as mean length of target species, as an indicator of biomass depletion (Francis and Smith 1995). Much has been written on marine ecosystem indicators (FAO 1999; ICES 2000, 2005). There are, however, no established reference points for optimal ecosystem structures, composition, or functions. Due to the subjective nature of describing or defining the desirable ecosystems that would be associated with such reference points (e.g., a return to some set of prehistoric conditions vs. an ecosystem capable of sustainable harvests), this remains a topic of much discussion.

Models

The ecosystem approach is regarded by some as endlessly complicated as it is assumed that managers need to completely understand the detailed structure and function of an entire ecosystem in order to implement effective ecosystem-based management measures (Browman and Stergiou 2004). Although true in the ideal, interim approaches to ecosystem management need not be overly complex to achieve meaningful improvements.

Increasing interest in ecosystem approaches to management has led to significant increases in the modeling of marine ecosystems using various degrees of parameter and spatial resolution. Ecosystem modeling of the Western Pacific Region has progressed from simple mathematical models to dynamically parameterized simulation models (Polovina 1984; Polovina et al. 1994; Polovina et al. 2004).

While physical oceanographic models are well developed, modeling of trophic ecosystem components has lagged primarily because of the lack of reliable, detailed long-term data. Consequently, there is no single, fully integrated model that can simulate all of the ecological linkages between species and the environment (de Young et al. 2004). In fact, there may not ever by a single fully integrated model that can fully accomplish this.

De Young et al. (2004) examined the challenges of ecosystem modeling and presented several approaches to incorporating uncertainty into such models. However, Walters (2005) cautioned against becoming overly reliant on models to assess the relative risks of various management alternatives and suggested that modeling exercises should be used as aids in experimental design rather than as precise prescriptive tools.

2.7 Single-species Management versus Multi-species Management

A major theme in ecosystem approaches to fisheries management is the movement from conventional single-species management to multi-species management (Mace 2004; Sherman 1986). Multi-species management is generally defined as management based on the consideration of all fishery impacts on all marine species rather than focusing on the maximum sustainable yield for any one species. The fact that many of the ocean’s fish stocks are believed to be overexploited (FAO 2002) has been used by some as evidence that single-species models and single-species management have failed (Hilborn 2004; Mace 2004). Hilborn (2004) noted that some of the species that were historically overexploited (e.g., whales, bluefin tuna) were not subject to any management measures, single- species or otherwise. In other cases (e.g., northern cod), it was not the models that failed but the political processes surrounding them (Hilborn 2004). Thus, a distinction must be made between the use of single-species or multi-species models and the application of their resultant management recommendations. Clearly, ecosystem management requires that all fishery impacts be considered when formulating management measures, and that both single-species and multi-species models are valuable tools in this analysis. In addition, fishery science and management must remain open and transparent, and must not be subjected to distorting political perspectives, whether public or private. However, it also appears clear that fishery regulations must continue to be written on a species-specific basis (e.g., allowing participants to land no more than two bigeye tuna and two fish of any other species per day), as to do otherwise would lead to species highgrading (e.g., allowing participants to land no more than four fish [all species combined] per day could result in each participant landing four bigeye tuna per day) and likely to lead to overexploitation of the most desirable species.

Although successful ecosystem management will require the holistic analysis and consideration of marine organisms and their environment, the use of single-species models and management measures will remain an important part of fishery management (Mace 2004). If applied to all significant fisheries within an ecosystem, conservative single-species management has the potential to address many ecosystem management issues (ICES 2000; Murawski 2005; Witherell et al. 2000).

Recognizing the lack of a concise blueprint to implement the use of ecosystem indicators and models, there is growing support for building upon traditional single-species management to incrementally integrate and operationalize ecosystem principles through the use of geographically parameterized indicators and models (Browman and Stergiou 2004; Sissenwine and Murawski 2004).

2.8 Ocean Zoning

The use of ocean zoning to regulate fishing and non-fishing activities has been a second major theme in the development of marine ecosystem management theory (Browman and Stergiou 2004). In general, these zones are termed *Marine Protected Areas* (MPAs) and are implemented for a wide variety of objectives ranging from establishing wilderness areas to protecting economically important spawning stocks (Lubchenco et al. 2003). In 2000, Executive Order 13158 was issued for the purpose of expanding the Nation's existing system of MPAs to "enhance the conservation of our Nation's natural and cultural marine heritage and the ecologically and economically sustainable use of the marine environment for future generations." The Executive Order also established an MPA Federal Advisory Committee charged with providing expert advice and recommendations on the development of a national system of MPAs. In June 2005, this Committee released its first report, which includes a range of objectives and findings including the need for measurable goals, objectives, and assessments for all MPAs (NOAA 2005). Today, MPAs can be found throughout the Western Pacific Region and are considered to be an essential part of marine management. Ongoing research and outreach is anticipated to result in the implementation of additional MPAs as ecosystem research provides additional insights regarding appropriate MPA locations and structures to achieve specific objectives.

2.9 Intra-agency and Inter-agency Cooperation

To be successful, ecosystem approaches to management must be designed to foster intra- and inter-agency cooperation and communication (Schrope 2002). As discussed in Chapter 1, the Western Pacific Region includes an array of federal, state, commonwealth, territory, and local government agencies with marine management authority. Given that these many agencies either share or each has jurisdiction over certain areas or activities, reaching consensus on how best to balance resource use with resource protection is essential to resolving currently fragmented policies and conflicting objectives. Coordination with state and local governments will be especially important to the improved management of near-shore resources as these are not under federal authority. The recently released U.S. Ocean Action Plan (issued in response to the report of the U.S. Ocean Commission on Policy) recognized this need and established a new cabinet level Committee on Ocean Policy (U.S. Ocean Action Plan 2004) to examine and resolve these issues. One alternative would be to centralize virtually all domestic marine management authority within one agency; however, this would fail to utilize the local expertise and experience contained in existing agencies and offices, and would likely lead to poor decision making and increased social and political conflict.

2.10 Community-based Management

Communities are created when people live or work together long enough to generate local societies. Community members associate to meet common needs and express common interests, and relationships built over many generations lead to common cultural values and understandings through which people relate to each other and to their environment. At this point, collective action may be taken to protect local resources if they appear threatened, scarce, or subject to overexploitation. This is one example of community-based resource management.
As ecosystem principles shift the focus of fishery management from species to places, increased participation from the primary stakeholders (i.e., community members) can enhance marine management by (a) incorporating local knowledge regarding specific locations and ecosystem conditions; (b) encouraging the participation of stakeholders in the management process, which has been shown to lead to improved data collection and compliance; and (c) improving relationships between communities and often centralized government agencies (Dyer and McGoodwin 1994).

Top-down management tends to center on policy positions that polarize different interest groups and prevent consensus (Yaffee 1999). In contrast, “place”—a distinct locality imbued with meaning—has value and identity for all partners and can serve to organize collaborative partnerships. Despite often diverse backgrounds and frequently opposing perspectives, partners are inspired to take collective on-the-ground actions organized around their connections and affiliations with a particular place (Cheng et al. 2003).

In August 2004, President Bush issued Executive Order 13352 to promote partnerships between federal agencies and states, local governments, tribes, and individuals that will facilitate cooperative conservation and appropriate inclusion of local participation in federal decision making regarding the Nation's natural resources. Similarly, the U.S. Ocean Action Plan (2004) found that "local involvement by those closest to the resource and their communities is critical to ensuring successful, effective, and long-lasting conservation results."

Successful resource management will need to incorporate the perspectives of both local and national stakeholder groups in a transparent process that explicitly addresses issues of values, fairness, and identity (Hampshire et al. 2004). Given their long histories of sustainable use of marine resources, indigenous residents of the Western Pacific Region have not universally embraced increasingly prohibitive management necessitated by the modern influx of foreign colonizers and immigrants. In addition, some recent campaigns by non-governmental organizations representing often far-off groups vigorously opposed to virtually all use of marine resources have increased what many see as the separation of local residents from the natural environment that surrounds them. As humans are increasingly removed and alienated from the natural environment, feelings of local ownership and stewardship are likely to decline, and subsequent management and enforcement actions will become increasingly difficult (Hampshire et al. 2004). This is especially relevant in the Western Pacific Region, which comprises a collection of remote and far-flung island areas, most of which have poorly funded monitoring and enforcement capabilities.

2.10.1 Community Participation

The Council's community program developed out of the need for an indigenous program to address barriers to the participation of indigenous communities in fisheries managed by the Council. An objective of the indigenous program is to arrive at a point of collaboration, reconciliation and consensus between the native indigenous community and the larger immigrant communities in CNMI, Guam and Hawaii. The community in American Samoa is 80 – 90 percent native but the objective is the same—to arrive at a point of collaboration, reconciliation and consensus with the larger U.S.

The Council's community program is consistent with the need for the development of Fishery Ecosystem Plans. Fishery Ecosystem Plans are place-based fishery management plans that allow the Council to incorporate ecosystem principles into fishery management. Human communities are important elements for consideration in ecosystem-based resource management plans. Resources are managed for people, communities. NOAA has recognized that communities are part of the ecosystem.

Any community-based initiative is about empowering the community. The Council's efforts to develop fishery ecosystem plans (FEP) are focused on community collaboration, participation and partnership. The efforts result in the development of strong community projects such as community-led data collection and monitoring programs and revitalization of traditional and cultural fishing practices. Finding and partnering with communities and organizations is time-consuming and resource depleting. Outreach to communities in the form of presentations and participation in school and community activities and other fora is ongoing to find projects that the Council can support.

Community-Based Resource Management (CBRM) is a way for communities to gain control of and manage their resources in ways that allow them to harvest and cultivate products in a sustainable manner. CBRM is based on the principle of empowering people to manage the natural and material resources that are critical to their community and regional success. This FEP increases the community's capacity and expertise in natural resource management, and provides viable alternatives to uncontrolled resource depletion.

Because of the Council's role in fishery conservation and management, many resources and skills are available within the Council. These assets form the base for the application of Asset Based Community Development (ABCD) – Community assets connected to organization assets produces strong community-based projects.

Community assets include, but are not limited to, cultural knowledge, resource areas, habitats, sites, organizations, schools, individuals, families, community diversity and all of the attributes that bring value to and define a community.

The community program of the Council is the application of Council assets to community assets to produce community-based projects that strengthen the community's ability to conserve and manage their marine resources.

2.10.2 Community Development

In recent years, attention has been given to the potential impact of growth and development on communities. In general, growth has been viewed as healthy and desirable for communities because it leads to additional jobs; increased economic opportunities; a broader tax base; increased access to public services and the enhancement of cultural amenities. Growth is also accompanied by changes in social structure, increased fiscal expenditures for necessary public services and infrastructure, increased traffic, increased and changed utilization and consumption of local natural resources and loss of open space and unique cultural attributes. Development decisions are often made without a sufficient understanding of the consequences of those decisions on overall community well-being. Changes induced by growth in a community are not always positive. Fishery ecosystem planning requires the participation of communities. Careful, planned decision-making is necessary for ensuring that growth and development is consistent with the long-range goals of the community.

CHAPTER 3: DESCRIPTION OF THE ENVIRONMENT

3.1 Introduction

Chapter 3 describes the physical, chemical, geological and biological environments of the pelagic ecosystem which influence management decisions under an ecosystem approach. This chapter also includes descriptions of the living resources found within the geographic boundaries of the Pacific Pelagic FEP. For more information please see the Council's Pelagic FMP and FMP amendments[4]. Additional information on Pacific Pelagic fisheries is available in the Council's annual reports, in a 2001 Comprehensive Pelagic EIS (NMFS 2001), a 2004 EIS (WPRFMC 2004a), a 2005 EIS (NMFS 2005), 2004 and 2009 Supplemental EISs (WPRFMC 2004 and 2009 respectively) as well as in environmental assessments completed in 2004 (WPRFMC 2004b), 2005 (WPRFMC 2005a) and 2006 (WPRFMC 2006), all of which are incorporated here by reference. Although this FEP will not directly manage the Western Pacific Region's demersal resources, successful ecosystem-based management requires considerations of interactions between the pelagic and demersal environments and thus both are discussed here.

3.2 Physical Environment

The following discussion presents a broad summary of the physical environment of the Pacific Ocean. The dynamics of the Pacific Ocean's physical environment have direct and indirect effects on the occurrence and distribution of life in marine ecosystems.

3.2.1 The Pacific Ocean

The Pacific Ocean is world's largest body of water. Named by Ferdinand Magellan as *Mare Pacificum* (Latin for "peaceful sea"), the Pacific Ocean covers more than one third of Earth's surface (~64 million square miles). From north to south, it's more than 9,000 miles long; from east to west, the Pacific Ocean is nearly 12,000 miles wide (on the Equator). The Pacific Ocean contains several large seas along its western margin including the South China Sea, Celebes Sea, Coral Sea, and Tasman Sea.

3.2.2 Geology and Topography

Pacific islands have been formed by geologic processes associated with plate tectonics, volcanism, and reef accretion. The theory of plate tectonics provides that Earth's outer shell, the "lithosphere", is constructed of more than a dozen large solid "plates" that migrate across the planet surface over time and interact at their edges. The plates sit above a solid rocky mantle that is hot, and capable of flow. Figure 2 is a schematic diagram of Earth's lithospheric plates. These are made of various kinds of rock with different densities and can be thought of as pieces of a giant jigsaw puzzle–where the movement of one plate affects the position of others. Generally, the oceanic portion of plates is composed of basalt enriched with iron and magnesium which is

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[4] Available from the Council at www.wpcouncil.org or at 1164 Bishop St. Ste 1400, Honolulu, HI 96813

denser than the continental portion composed of granite which is enriched with silica.[5] Tectonic processes and plate movements define the contours of the Pacific Ocean. The abyssal plain or seafloor of the central Pacific basin is relatively uniform, with a mean depth of about 4270 m (14,000 ft).[6] Within the Pacific basin, however, are underwater plate boundaries that define long mountainous chains, submerged volcanoes, islands and archipelagos, and various other bathymetric features that influence the movement of water and the occurrence and distribution of marine organisms.

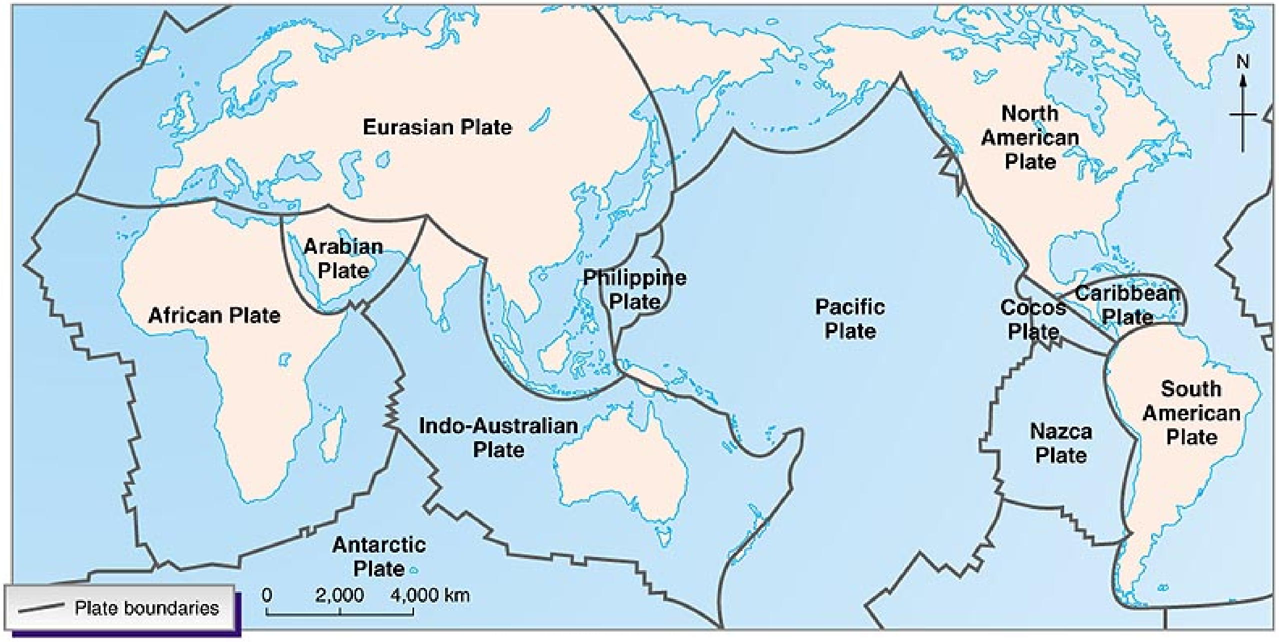

Figure 2: Schematic Diagram of Earth's Lithospheric Plates
Source: Dr. C.H. Fletcher III, UH Dept. of Geology and Geophysics, personal communication

Divergent plate boundaries —locations where lithospheric plates separate from each other—form "spreading centers" where new seafloor is constructed atop high mid-ocean ridges. These ridges stretch for thousands of kilometers[7] and are characterized by active submarine volcanism and earthquakes. At these ridges, magma is generated at the top of the mantle immediately underlying an opening, or rift, in the lithosphere. As magma pushes up under the spreading lithosphere it inflates the ridges until a fissure is created and lava erupts onto the sea floor (Fryer and Fryer 1999). The erupted lava, and its subsequent cooling, forms new seafloor on the edges of the separating plates. This process is responsible for the phenomenon known as "seafloor spreading", where new ocean floor is constantly forming and sliding away from either side of the ridge.[8]

Convergent plate boundaries are locations where two plates move together and one plate, usually composed of denser basalt, subducts or slides beneath the other which is composed of less dense

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[5] http://www.soest.hawaii.edu/coasts/chip/ch02/ch_2_7.asp
[6] http://www.physicalgeography.net/fundamentals/8o.html
[7] http://www.washington.edu/burkemuseum/geo_history_wa/The Restless Earth v.2.0.htm
[8] http://www.washington.edu/burkemuseum/geo_history_wa/The Restless Earth v.2.0.htm

rock, and is recycled into the mantle. When two plates of equivalent density converge, the rock at the boundary fractures and shears like the front ends of two colliding cars, and forms a large mountain range. The Himalayan Range has this origin. There are three different types of plate convergence: 1) ocean-continent convergence, 2) ocean-ocean convergence, and 3) continent-continent convergence (Fryer and Fryer 1999). A well known example of ocean-ocean convergence is observed in the western Pacific, where the older and denser Pacific Plate subducts under the younger and less dense Philippine Plate at a very steep angle. This results in the formation of the Marianas Trench which at nearly 11 km (~36,000 ft) is the deepest point of the seafloor.[9] Ocean-ocean convergent boundary movements may result in the formation of island arcs, where the denser (generally older) plate subducts under the less dense plate. Melting in the upper mantle above the subducting plate generates magma that rises into the overlying lithosphere and may lead to the formation of a chain of volcanoes known as an island arc.[10] The Indonesian Archipelago has this geologic origin, as does the Aleutian Island chain.

Transform boundaries, a third type of plate boundary, occur when lithospheric plates neither converge nor diverge, but shear past one another horizontally, like two ships at sea that rub sides. The result is the formation of very hazardous seismic zones of faulted rock, of which California's San Andreas Fault is an example (Fryer and Fryer 1999).

In addition to the formation of island arcs from ocean-ocean convergence, dozens of linear island chains across the Pacific Ocean are formed from the movement of the Pacific Plate over stationary sources of molten rock known as hot spots (Fryer and Fryer 1999). A well known example of hot spot island formation is the Hawaiian Ridge-Emperor Seamounts chain that extends some 6,000 km from the "Big Island" of Hawaii (located astride the hotspot) to the Aleutian Trench off Alaska where ancient islands are recycled into the mantle.[11] Although less common, hot spots can also be found at mid-ocean ridges, exemplified by the Galapagos Islands in the Pacific Ocean.[12]

The Pacific Ocean contains nearly 25,000 islands which can be simply classified as high islands or low islands. High islands, like their name suggests, extend higher above sea level, and often support a larger number of flora and fauna and generally have fertile soil. Low islands are generally atolls built by layers of calcium carbonate secreted by reef building corals and calcareous algae on a volcanic core of a former high island that has submerged below sea level. Over geologic time, the rock of these low islands has eroded or subsided to where all that is remaining near the ocean surface is a broad reef platform surrounding a usually deep central lagoon (Nunn 2003).

3.2.3 Ocean Water Characteristics

Over geologic time, the Pacific Ocean basin has been filled in by water produced by physical and biological processes. A water molecule is the combination of two hydrogen atoms bonded with one oxygen atom. Water molecules have asymmetric charges, exhibiting a positive charge on the

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[9] http://www.soest.hawaii.edu/coasts/chip/ch02/ch_2_7.asp
[10] http://www.soest.hawaii.edu/coasts/chip/ch02/ch_2_7.asp
[11] http://pubs.usgs.gov/publications/text/Hawaiian.html
[12] http://pubs.usgs.gov/publications/text/hotspots.html#anchor19620979

hydrogen sides and a negative charge on the oxygen side of the molecule. This charge asymmetry allows water to be an effective solvent, thus the ocean contains a diverse array of dissolved substances. Relative to other molecules, water takes a great deal of heat to change temperature, and thus the oceans have the ability to store large amounts of heat. When water evaporation occurs, large amounts of heat are absorbed by the ocean (Tomzack and Godfrey 2003). The overall heat flux observed in the ocean is related to the dynamics of four processes: (a) incoming solar radiation, (b) outgoing back radiation,(c) evaporation, and (d) mechanical heat transfer between ocean and atmosphere (Bigg 2003).

The major elements (> 100 ppm) present in ocean water include chlorine, sodium, magnesium, calcium, and potassium, with chlorine and sodium being the most prominent, and their residue (sea salt–NaCL) is left behind when seawater evaporates. Minor elements (1–100 ppm) include bromine, carbon, strontium, boron, silicon, and fluorine. Trace elements (< 1 ppm) include nitrogen, phosphorus, and iron (Levington 1995).

Oxygen is added to seawater by two processes: (a) atmospheric mixing with surface water, and (b) photosynthesis. Oxygen is subtracted from water through respiration and bacterial decomposition of organic matter (Tomzack and Godfrey 2003).

3.2.4 Ocean Layers

On the basis of the effects of temperature and salinity on the density of water (as well as other factors such as wind stress on water), the ocean can be separated into three layers: the surface layer or mixed layer, the thermocline or middle layer, and the deep layer. The surface layer generally occurs from the surface of the ocean to a depth of around 400 meters (or less depending on location) and is the area where the water is mixed by currents, waves, and weather. The thermocline is generally from 400 meters –to 800 meters and where water temperatures significantly differ from the surface layer, forming a temperature gradient that inhibits mixing with the surface layer. More than 90 percent of the ocean by volume occurs in the deep layer, which is generally below 800 meters and consists of water temperatures around 0–4° C. The deep zone is void of sunlight and experiences high water pressure (Levington 1995).

The temperature of ocean water is important to oceanographic systems. For example, the temperature of the mixed layer has an affect on the evaporation rate of water into the atmosphere, which in turn is linked to the formation of weather. The temperature of water also produces density gradients within the ocean, which prevents mixing of the ocean layers (Bigg 2003). See Figure 3 for a generalized representation of water temperatures and depth profiles

The amount of dissolved salt or salinity varies between ocean zones, as well as across oceans. For example, the Atlantic Ocean has higher salinity levels than the Pacific Ocean due to input from the Mediterranean Sea (several large rivers flow into the Mediterranean). The average salt content of the ocean is 35 ppt, but it can vary at different latitudes depending on evaporation and precipitation rates. Salinity is lower near the equator than at middle latitudes due to higher rainfall amounts. Salinity also varies with depth creating vertical salinity gradients often observed in the oceans (Bigg 2003). See Figure 3 for a generalized representations of a salinity and a temperature cline at various ocean depths.

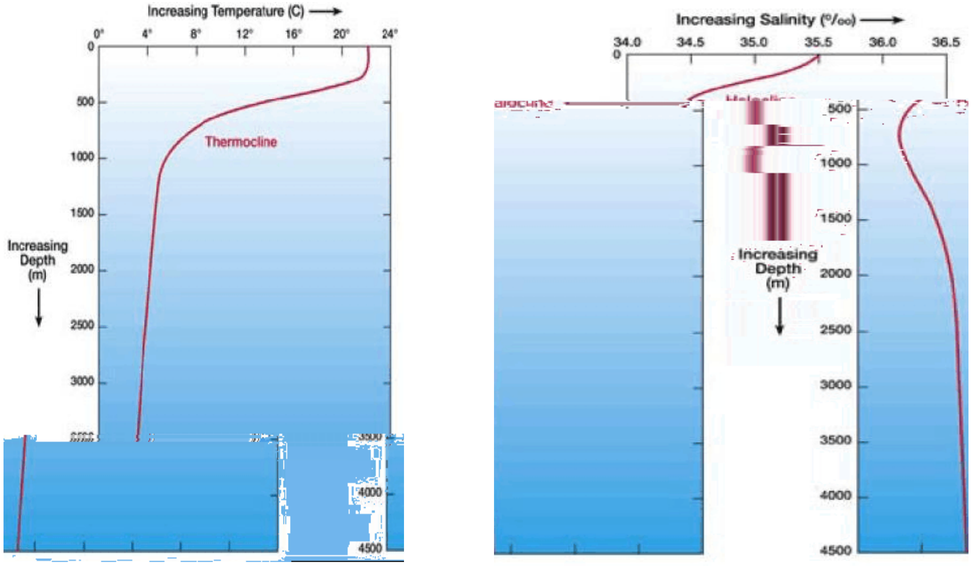

Figure 3: Temperature and Salinity Profile of the Ocean

Sources: http://www.windows.ucar.edu/tour/link=/earth/Water/temp.html&edu=high
http://www.windows.ucar.edu/tour/link=/earth/Water/salinity_depth.html&edu=high (both accessed July 2005).

3.2.5 Ocean Zones

The ocean can be separated into the following five zones (see Figure 4) relative to the amount of sunlight that penetrates through seawater: (a) epipelagic, (b) mesopelagic, (c) bathypelagic, (d) abyssopelagic, and (e) hadalpelagic. Sunlight is the principle factor of primary production (phytoplankton) in marine ecosystems, and because sunlight diminishes with ocean depth, the amount of sunlight penetrating seawater and its affect on the occurrence and distribution of marine organisms are important. The epipelagic zone extends to nearly 200 meters and is the near extent of visible light in the ocean. The mesopelagic zone occurs between 200 meters and 1,000 meters and is sometimes referred to as the "twilight zone." Although the light that penetrates to the mesopelagic zone is extremely faint, this zone is home to wide variety of marine species. The bathypelagic zone occurs from 1,000 feet to 4,000 meters, and the only visible light seen is the product of marine organisms producing their own light, which is called "bioluminescence." The next zone is the abyssopelagic zone (4,000 m–6,000 m), where there is extreme pressure and the water temperature is near freezing. This zone does not provide habitat for very many creatures except small invertebrates such as squid and basket stars. The last zone is the hadalpelagic (6,000 m and below) and occurs in trenches and canyons. Surprisingly, marine life such as tubeworms and starfish are found is this zone, often near hydrothermal vents.

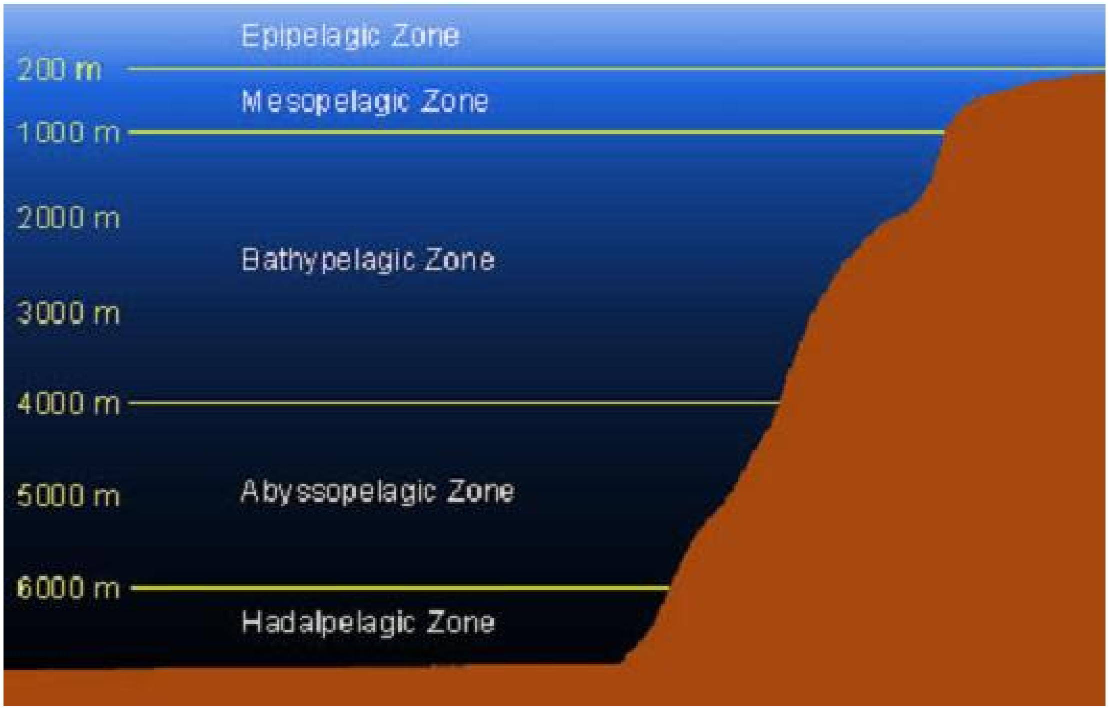

Figure 4. Depth Profile of Ocean Zones
Source: Image produced by WPRFMC. Concept from http://www.seasky.org/monsters/sea7a4.html

3.2.6 Ocean Water Circulation

The circulation of ocean water is a complex system involving the interaction between the oceans and atmosphere. The system is primarily driven by solar radiation that results in wind being produced from the heating and cooling of ocean water, and the evaporation and precipitation of atmospheric water. Except for the equatorial region, which receives a nearly constant amount of solar radiation, the latitude and seasons affect how much solar radiation is received in a particular region of the ocean. This, in turn, has an affect on sea–surface temperatures and the production of wind through the heating and cooling of the system (Tomzack and Godfrey 2003).

3.2.7 Surface Currents

Ocean currents can be thought of as organized flows of water that exist over a geographic scale and time period in which water is transported from one part of the ocean to another part of the ocean (Levington 1995). In addition to water, ocean currents also transport plankton, fish, heat, momentum, salts, oxygen, and carbon dioxide. Wind is the primary force that drives ocean surface currents; however, Earth’s rotation and wind determine the direction of current flow. The sun and moon also influence ocean water movements by creating tidal flow, which is more readily observed in coastal areas rather than in open-ocean environments (Tomzack and Godfrey 2003). Figure 5 shows the major surface currents of the Pacific Ocean.

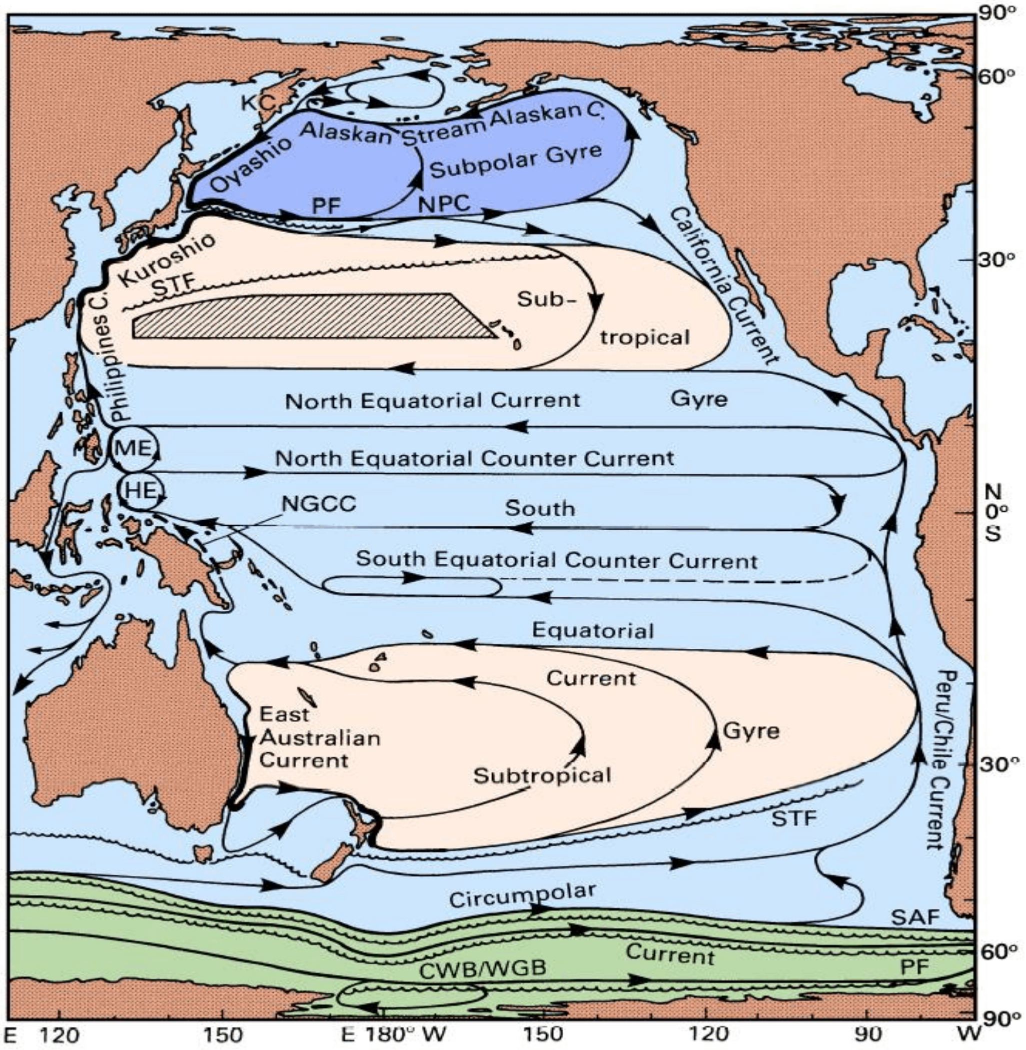

Figure 5. Major Surface Currents of the Pacific Ocean
Source: Tomzack and Godfrey 2003

Surface currents of the Pacific Ocean. Abbreviations are used for the Mindanao Eddy (ME), the Halmahera Eddy (HE), the New Guinea Coastal (NGCC), the North Pacific (NPC), and the Kamchatka Current (KC). Other abbreviations refer to fronts: NPC (North Pacific Current), STF (Subtropical Front), SAF (Subantarctic Front), PF (Polar Front), and CWB/WGB (Continental Water Boundary/Weddell Gyre Boundary). The shaded region indicates banded structure (Subtropical Countercurrents). In the western South Pacific Ocean, the currents are shown for April–November when the dominant winds are the Trades. During December–March, the region is under the influence of the northwest monsoon, flow along the Australian coast north of 18° S and along New Guinea reverses, the Halmahera Eddy changes its sense of rotation, and the South Equatorial Current joins the North Equatorial Countercurrent east of the eddy (Tomzack and Godfrey 2003).

3.2.8 Transition Zones

Transition zones are areas of ocean water bounded to the north and south by large-scale surface currents originating from subartic and subtropical locations (Polovina et al. 2001). Located generally between 32° N and 42° N, the North Pacific Transition Zone is an area between the southern boundary of the Subartic Frontal Zone (SAFZ) and the northern boundary of the Subtropical Frontal Zone (STFZ; see Figure 6). Individual temperature and salinity gradients are observed within each front, but generally the SAFZ is colder (~8° C) and less salty (~33.0 ppm) than the STFZ (18° C, ~35.0 ppm, respectively). The North Pacific Transition Zone (NPTZ) supports a marine food chain that experiences variation in productivity in localized areas due to changes in nutrient levels brought on, for example, by storms or eddies. A common characteristic among some of the most abundant animals found in the Transition Zone such as flying squid, blue sharks, Pacific pomfret, and Pacific saury is that they undergo seasonal migrations from summer feeding grounds in subartic waters to winter spawning grounds in the subtropical waters. Other animals found in the NPTZ include swordfish, tuna, albatross, whales, and sea turtles (Polovina et al. 2001).

3.2.9 Eddies

Eddies are generally short to medium term water movements that spin off of surface currents and can play important roles in regional climate (e.g., heat exchange) as well as the distribution of marine organisms. Large-scale eddies spun off of the major surface currents often blend cold water with warm water, the nutrient rich with the nutrient poor, and the salt laden with fresher waters (Bigg 2003). The edges of eddies, where the mixing is greatest, are often targeted by fishermen as these are areas of high biological productivity.

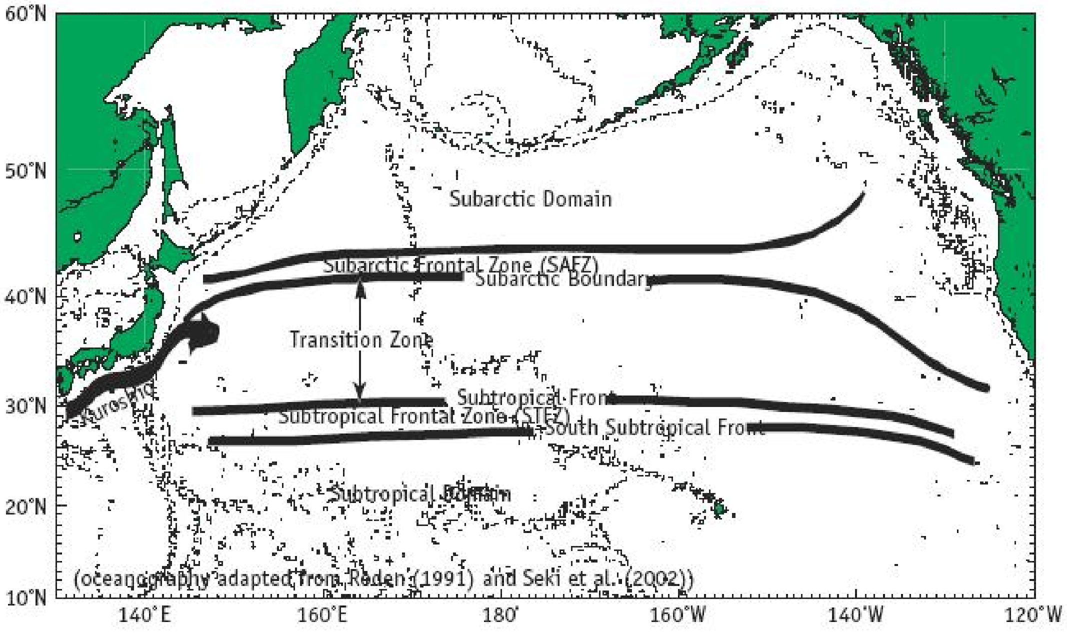

Figure 6: North Pacific Transition Zone

Source: http://www.pices.int/publications/special_publications/NPESR/2005/File_12_pp_201_210.pdf

3.2.10 Deep-Ocean Currents

Deep-ocean currents, or thermohaline movements, are a result of density differences in the ocean from the effects of salinity and temperature on seawater (Tomzack and Godfrey 2003). In the Southern Ocean, for example, water exuded from sea ice is extremely dense due to its high salt content and, therefore, sinks to the bottom and flows downhill filling up the deep polar ocean basins. The system delivers water to deep portions of the polar basins as the dense water spills out into oceanic abyssal plains. The movement of the dense water is influenced by bathymetry. For example, the Arctic Ocean does not contribute much of its dense water to the Pacific Ocean due to the narrow shallows of the Bering Strait. Generally, the deep-water currents flow through the Atlantic Basin, around South Africa, into the Indian Ocean, past Australia, and into the Pacific Ocean. This process has been labeled the "ocean conveyor belt"—taking nearly 1,200 years to complete one cycle. The movement of the thermohaline conveyor can affect global weather patterns, and has been the subject of much research as it relates to global climate variability. This deep circulation is important as it mixes the water, keeps chemistry more or less uniform and carries oxygen from the atmosphere into the deeper layers, making life there possible. See Figure 7 for a simplified schematic diagram of the deep-ocean conveyor belt system.

Upwellings are highly productive areas along the edges of continents or continental shelves where waters are drawn up from the ocean depths to the surface. Rich in nutrients, these waters nourish algae, which in turn support an abundance of fish and other aquatic life. In order for upwellings to occur, there must be deep currents flowing close to the continental margin. There must also be prevailing winds that push the surface waters away from the coast—as the surface waters move offshore, the cold, nutrient-rich bottom waters move up to replace them.

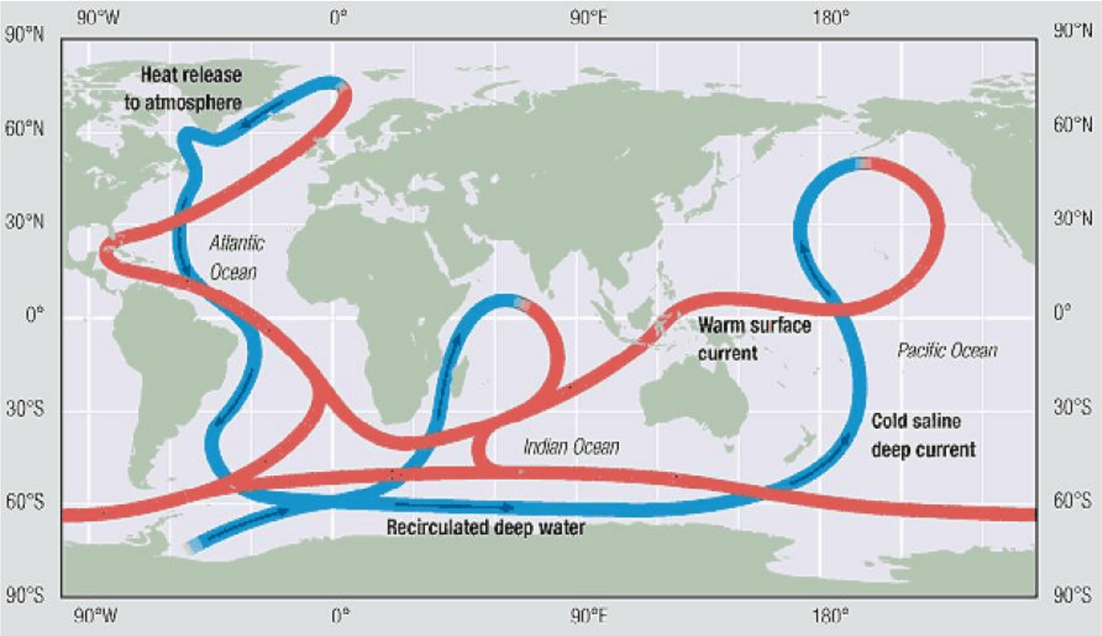

Figure 7: Deep-Ocean Water Movement

Source: U.N. GEO Yearbook 2004

3.2.11 Prominent Pacific Ocean Meteorological Features

The air–sea interface is a dynamic relationship in which the ocean and atmosphere exchange energy and matter. This relationship is the basic driver for the circulation of surface water (through wind stress) as well as for atmospheric circulation (through evaporation). The formation of weather systems and atmospheric pressure gradients are linked to exchange of energy (e.g., heat) and water between air and sea (Bigg 2003).

Near the equator, intense solar heating causes air to rise and water to evaporate, thus resulting in areas of low pressure. Air flowing from higher trade wind pressure areas move to the low pressure areas such as the Intertropical Convergence Zone (ITCZ) and the South Pacific Convergence Zone (SPCZ), which are located around 5° N and 30° S, respectively. Converging trade winds in these areas do not produce high winds, but instead often form areas that lack significant wind speeds. These areas of low winds are known as the “doldrums.” The convergence zones are associated near ridges of high sea–surface temperatures, with temperatures of 28° C and above, and are areas of cloud accumulation and high rainfall amounts. The high rainfall amounts reduce ocean water salinity levels in these areas (Sturman and McGowan 2003).

The air that has risen in equatorial region fans out into the higher troposphere layer of the atmosphere and settles back toward Earth at middle latitudes. As air settles toward Earth, it creates areas of high pressure known as subtropical high-pressure belts. One of these high-pressure areas in the Pacific is called the “Hawaiian High Pressure Belt,” which is responsible for the prevailing trade wind pattern observed in the Hawaiian Islands (Sturman and McGowan 2003).

The Aleutian Low Pressure System is another prominent weather feature in the Pacific Ocean and is caused by dense polar air converging with air from the subtropical high-pressure belt. As these air masses converge around 60° N, air is uplifted, creating an area of low pressure. When the relatively warm surface currents (Figure 7) meet the colder air temperatures of subpolar regions, latent heat is released, which causes precipitation. The Aleutian Low is an area where large storms with high winds are produced. Such large storms and wind speeds have the ability to affect the amount of mixing and upwelling between ocean layers (e.g., mixed layer and thermocline in Polovina et al. 1994).

The dynamics of the air–sea interface do not produce steady states of atmospheric pressure gradients and ocean circulation. As discussed in the previous sections, there are consistent weather patterns (e.g., ITCZ) and surface currents (e.g., north equatorial current); however, variability within the ocean–atmosphere system results in changes in winds, rainfall, currents, water column mixing, and sea-level heights, which can have profound effects on regional climates as well as on the abundance and distribution of marine organisms.

One example of a shift in ocean–atmospheric conditions in the Pacific Ocean is El Niño–Southern Oscillation (ENSO). ENSO is linked to climatic changes in normal prominent weather features of the Pacific and Indian Oceans, such as the location of the ITCZ. ENSO, which can occur every 2–10 years, results in the reduction of normal trade winds, which reduces the intensity of the westward flowing equatorial surface current (Sturman and McGowan 2003). In turn, the eastward flowing countercurrent tends to dominate circulation, bringing warm, low-salinity low-nutrient water to the eastern margins of the Pacific Ocean. As the easterly trade winds are reduced, the normal nutrient-rich upwelling system does not occur, leaving warm surface water pooled in the eastern Pacific Ocean.

The impacts of ENSO events are strongest in the Pacific through disruption of the atmospheric circulation, generalized weather patterns, and fisheries. ENSO affects the ecosystem dynamics in the equatorial and subtropical Pacific by considerable warming of the upper ocean layer, rising of the thermocline in the western Pacific and lowering in the east, strong variations in the intensity of ocean currents, low trade winds with frequent westerlies, high precipitation at the dateline, and drought in the western Pacific (Sturman and McGowan 2003). ENSO events have the ability to significantly influence the abundance and distribution of organisms within marine ecosystems. Human communities also experience a wide range of socioeconomic impacts from ENSO such as changes in weather patterns resulting in catastrophic events (e.g., mudslides in California due to high rainfall amounts) as well as reductions in fisheries harvests (e.g., collapse of anchovy fishery off Peru and Chile in Levington 1995; Polovina 2005).

Changes in the Aleutian Low Pressure System are another example of interannual variation in a prominent Pacific Ocean weather feature profoundly affecting the abundance and distribution of marine organisms. Polovina et al. (1994) found that between 1977 and 1988 the intensification of the Aleutian Low Pressure System in the North Pacific resulted in a deeper mixed-layer depth, which led to higher nutrients levels in the top layer of the euphotic zone. This, in turn, led to an increase in phytoplankton production, which resulted in higher productivity levels (higher abundance levels for some organisms) in the Northwestern Hawaiian Islands. Changes in the Aleutian Low Pressure System and its resulting effects on phytoplankton productivity are thought to occur generally every ten years. The phenomenon is often referred to as the Pacific Decadal Oscillation (PDO) (Polovina 2005; Polovina et al. 1994).

3.2.12 Pacific Island Geography

The Pacific islands can be generally grouped into three major areas: (a) Micronesia, (b) Melanesia, and (c) Polynesia. However, the islands of Japan and the Aleutian Islands in the North Pacific are generally not included in these three areas, and they are not discussed here as this analysis focuses on the Western Pacific Region and its ecosystems. Information used in this section was obtained from the online version of the U.S.Central Intelligence Agency's World Fact Book.[13]

3.2.12.1 Micronesia

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[13] http://www.cia.gov/cia/publications/factbook/index.html

Micronesia, which is primarily located in the western Pacific Ocean, is made up of hundreds of high and low islands within six archipelagos including the: (a) Caroline Islands, (b) Marshall Islands, (c) Mariana Islands, (d) Gilbert Islands, (e) Line Islands, and (f) Phoenix Islands.

The Caroline Islands (~850 square miles) are composed of many low coral atolls, with a few high islands. Politically, the Caroline Islands are separated into two countries: Palau and the Federated States of Micronesia.

The Marshall Islands (~180 square miles) are made up of 34 low-lying coral atolls separated into two chains: the southeastern Ratak Chain and the northwestern Ralik Chain. Wake Island is geologically a part of the Marshall Islands archipelago.

The Mariana Islands (~396 square miles) are composed of 15 volcanic islands that are part of a submerged mountain chain that stretches nearly 1,500 miles from Guam to Japan. Politically, the Mariana Islands are split into the Territory of Guam and the Commonwealth of Northern Mariana Islands, both of which are U.S. possessions.

Nauru (~21 square miles), located southeast of the Marshall Islands, is a raised coral reef atoll rich in phosphate. The island is governed by the Republic of Nauru, which is the smallest independent nation in the world.

The Gilbert Islands are located south of the Marshall Islands and are made up of 16 low-lying coral atolls.

The Line Islands, located in the central South Pacific, are made up of ten coral atolls, of which Kirimati is the largest in the world (~609 square miles). The U.S. possessions of Kingman Reef, Palmyra Atoll, and Jarvis Island are located within the Line Islands. Most of the islands and atolls in these three chains, however, are part of the Republic of Kiribati (~ 811 square miles), which has an EEZ of nearly one million square miles.

The Phoenix Islands, located to the southwest of the Gilbert Islands, are composed of eight coral atolls. Howland and Baker Islands (U.S. possessions) are located within the Phoenix archipelago.

3.2.12.2 Melanesia

Melanesia is composed of several archipelagos that include: (a) Fiji Islands, (b) New Caledonia, (c) Solomon Islands, (d) New Guinea, (e), Vanuatu Islands, and (f), Maluku Islands.

Located approximately 3,500 miles northeast of Sydney, Australia, the Fiji archipelago (~18,700 square miles) is composed of nearly 800 islands: the largest islands are volcanic in origin and the smallest islands are coral atolls. The two largest islands, Viti Levu and Vanua Levu, make up nearly 85 percent of the total land area of the Republic of Fiji Islands.

Located nearly 750 miles east–northeast of Australia, is the volcanic island of Grande Terre or New Caledonia (~6,300 square miles). New Caledonia is French Territory and includes the nearby Loyalty Islands and the Chesterfield Islands, which are groups of small coral atolls.

The Solomon Islands (~27,500 square miles) are located northwest of New Caledonia and east of Papua New Guinea. Thirty volcanic islands and several small coral atolls make up this former British colony, which is now a member of the Commonwealth of Nations. The Solomon Islands are made up of smaller groups of islands such as the New Georgia Islands, the Florida Islands, the Russell Islands, and the Santa Cruz Islands. Approximately 1,500 miles separate the western and eastern island groups of the Solomon Islands.

New Guinea is the world's second largest island and is thought to have separated from Australia around 5000 BC. New Guinea is split between two nations: Indonesia (west) and Papua New Guinea (east). Papua New Guinea (~178,700 square miles) is an independent nation that also governs several hundred small islands within several groups. These groups include the Bismarck Archipelago and the Louisiade Islands, which are located north of New Guinea, and Tobriand Islands, which are southeast of New Guinea. Most of the islands within the Bismarck and Lousiade groups are volcanic in origin, whereas the Tobriand Islands are primarily coral atolls.

The Vanuatu Islands (~4,700 square miles) make up an archipelago that is located to the southeast of the Solomon Islands. There are 83 islands in the approximately 500-mile long Vanuatu chain, most of which are volcanic in origin. Before becoming an independent nation in 1980 (Republic of Vanuatu), the Vanuatu Islands were colonies of both France and Great Britain, and known as New Hebrides.

The Maluku Islands (east of New Guinea) and the Torres Strait Islands (between Australia and New Guinea) are also classified as part of Melanesia. Both of these island groups are volcanic in origin. The Maluku Islands are under Indonesia's governance, while the Torres Strait Islands are governed by Australia.

3.2.12.3 Polynesia

Polynesia is composed of several archipelagos and island groups including (a) New Zealand and associated islands, (b) Tonga, (c) Samoa Islands, (d) Cook Islands, (e) Tuvalu, (f) Tokelau , (g) the Territory of French Polynesia, (h) Pitcairn Islands, (i) Easter Island (Rapa Nui), and (j) Hawaii.

New Zealand (~103,470 square miles) is composed of two large islands, North Island and South Island, and several small island groups and islands. North Island (~44,035 square miles) and South Island (~58,200 square miles) extend for nearly 1,000 miles on a northeast–southwest axis and have a maximum width of 450 miles. The other small island groups within the former British colony include the Chatham Islands and the Kermadec Islands. The Chatham Islands are a group of ten volcanic islands located 800 kilometers east of South Island. The four emergent islands of the Kermadec Islands are located 1,000 kilometers northeast of North Island and are part of a larger island arc with numerous subsurface volcanoes. The Kermadec Islands are known to be an active volcanic area where the Pacific Plate subducts under the Indo-Australian Plate.

The islands of Tonga (~290 square miles) are located 450 miles east of Fiji and consist of 169 islands of volcanic and raised limestone origin. The largest island, Tongatapu (~260 square miles), is home to two thirds of Tonga's population (~106,000). The people of Tonga are governed under a hereditary constitutional monarchy.

The Samoa archipelago is located northeast of Tonga and consists of seven major volcanic islands, several small islets, and two coral atolls. The largest islands in this chain are Upolu (~436 square miles) and Savai`i (~660 square miles). Upolu and Savai`i and its surrounding islets and small islands are governed by the Independent State of Samoa with a population of approximately 178,000 people. Tutuila (~55 square miles), the Manua Islands (a group of three volcanic islands with a total land area of less than 20 square miles), and two coral atolls (Rose Atoll and Swains Island) are governed by the U.S. Territory of American Samoa. More than 90 percent of American Samoa's population (~68,000 people) live on Tutuila. The total land mass of American Samoa is about 200 square kilometers, surrounded by an EEZ of approximately 390,000 square kilometers.

To the east of the Samoa archipelago are the Cook Islands (~90 square miles), which are separated into the Northern Group and Southern Group. The Northern Group consists of six sparsely populated coral atolls, and the Southern Group consists of seven volcanic islands and two coral atolls. Rorotonga (~26 square miles), located in the Southern Group, is the largest island in the Cook Islands and also serves as the capitol of this independent island nation. From north to south, the Cook Islands spread nearly 900 miles, and the width between the most distant islands is nearly 450 miles. The Cook Islands EEZ is approximately 850,000 square miles.

Approximately 600 miles northwest of the Samoa Islands is Tuvalu (~10 square miles), an independent nation made up of nine low-lying coral atolls. None of the islands have elevation higher than 14 feet, and the total population of the country is around 11,000 people. Tuvalu's coral island chain extends for nearly 360 miles, and the country has an EEZ of 350,000 square miles.

East of Tuvalu and north of Samoa are the Tokelau Islands (~4 square miles). Three coral atolls make up this territory of New Zealand, and a fourth atoll (Swains Island) is of the same group, but is controlled by the U.S Territory of American Samoa.

The 32 volcanic islands and 180 coral atolls of the Territory of French Polynesia (~ 1,622 square miles) are made up of the following six groups: the Austral Islands, Bass Islands, Gambier Islands, Marquesas Islands, Society Islands, and the Tuamotu Islands. The Austral Islands are a group of six volcanic islands in the southern portion of the territory. The Bass Islands are a group of two islands in the southern-most part of the territory, with their volcanism appearing to be much more recent than that of the Austral Islands. The Gambier Islands are a small group of volcanic islands in a southeastern portion of the Territory and are often associated with the Tuamotu Islands because of their relative proximity; however, they are a distinct group because they are of volcanic origin rather than being coral atolls. The Tuamotu Islands, of which there are 78, are located in the central portion of the Territory and are the world's largest chain of coral atolls. The Society Islands are group of several volcanic islands that include the island of Tahiti. The island of Tahiti is home to nearly 70 percent of French Polynesia's population of approximately 170,000 people. The Marquesa Islands are an isolated group of islands located in the northeast portion of the territory, and are approximately 1,000 miles northeast of Tahiti. All but one of the 17 Marquesas Islands are volcanic in origin. French Polynesia has one of the largest EEZs in the Pacific Ocean at nearly two million square miles.

The Pitcairn Islands are a group of five islands thought to be an extension of the Tuamotu Archipelago. Pitcairn Island is the only volcanic island, with the others being coral atolls or uplifted limestone. Henderson Island is the largest in the group; however, Pitcairn Island is the only one that is inhabited.

Easter Island, a volcanic high island located approximately 2,185 miles west of Chile, is thought to be the eastern extent of the Polynesian expansion. Easter Island, which is governed by Chile, has a total land area of 63 square miles and a population of approximately 3,790 people.
The northern extent of the Polynesian expansion is the Hawaiian Islands, which are made up of 137 islands, islets, and coral atolls. The exposed islands are part of a great undersea mountain range known as the Hawaiian-Emperor Seamount Chain, which was formed by a hot spot within the Pacific Plate. The Hawaiian Islands extend for nearly 1,500 miles from Kure Atoll in the northwest to the Island of Hawaii in the southeast. The Hawaiian Islands are often grouped into the Northwestern Hawaiian Islands (Nihoa to Kure) and the Main Hawaiian Islands (Hawaii to Niihau). The total land area of the 19 primary islands and atolls is approximately 6,423 square miles, and the over 75 percent of the 1.2 million population lives on the island of Oahu.

3.3 Biological Environment

This section contains general descriptions of marine trophic levels, food chains, and food webs, as well as a description of two general marine environments: benthic or demersal (associated with the seafloor) and pelagic (the water column and open ocean). A broad description of the types of marine organisms found within these environments is provided, as well as a description of organisms important to fisheries. Protected species are also described in this section. This section is intended to provide background information on the ecosystems which will be given consideration in managing the pelagic fisheries through this FEP.

3.3.1 Marine Food Chains, Trophic Levels, and Food Webs

Food chains are often thought of as a linear representation of the basic flow of organic matter and energy through a series of organisms. Food chains in marine environments may be segmented into six trophic levels: primary producers, primary consumers, secondary consumers, tertiary consumers, quaternary consumers, and decomposers.

Generally, primary producers in the marine ecosystems are organisms that fix inorganic carbon into organic carbon compounds using external sources of energy (i.e., sunlight). Such organisms include single-celled phytoplankton, bottom-dwelling algae, macroalgae (e.g., sea weeds), and vascular plants (e.g., kelp). All of these organisms share common cellular structures called “chloroplasts,” which contain chlorophyll. Chlorophyll is a pigment that absorbs the energy of light to drive the biochemical process of photosynthesis. Photosynthesis results in the transformation of inorganic carbon into organic carbon such as carbohydrates, which are used for cellular growth.

Primary consumers in the marine environment are organisms that feed on primary producers, and depending on the environment (i.e., pelagic vs. benthic) include zooplankton, corals, sponges, many fish, sea turtles, and other herbivorous organisms. Secondary, tertiary, and quaternary consumers in the marine environment are organisms that feed on primary or higher level consumers and include fish, mollusks, crustaceans, mammals, and other carnivorous and omnivorous organisms. Decomposers live off dead plants and animals, and are essential in food chains as they break down organic matter and make it available for primary producers (Valiela 2003).

Marine food webs are representations of overall patterns of feeding among organisms, but generally they are unable to reflect the true complexity of the relationships between organisms, so they must be thought of as simplified representations. An example of a marine food web applicable to the Western Pacific is presented in Figure 8. The openness of marine ecosystems, lack of specialists, long life spans, ontogenetic changes in size and food preference across the life histories of many marine species make marine food webs more complex than their terrestrial and freshwater counterparts (Link 2002). Nevertheless, food webs are an important tool in understanding ecological relationships among organisms.

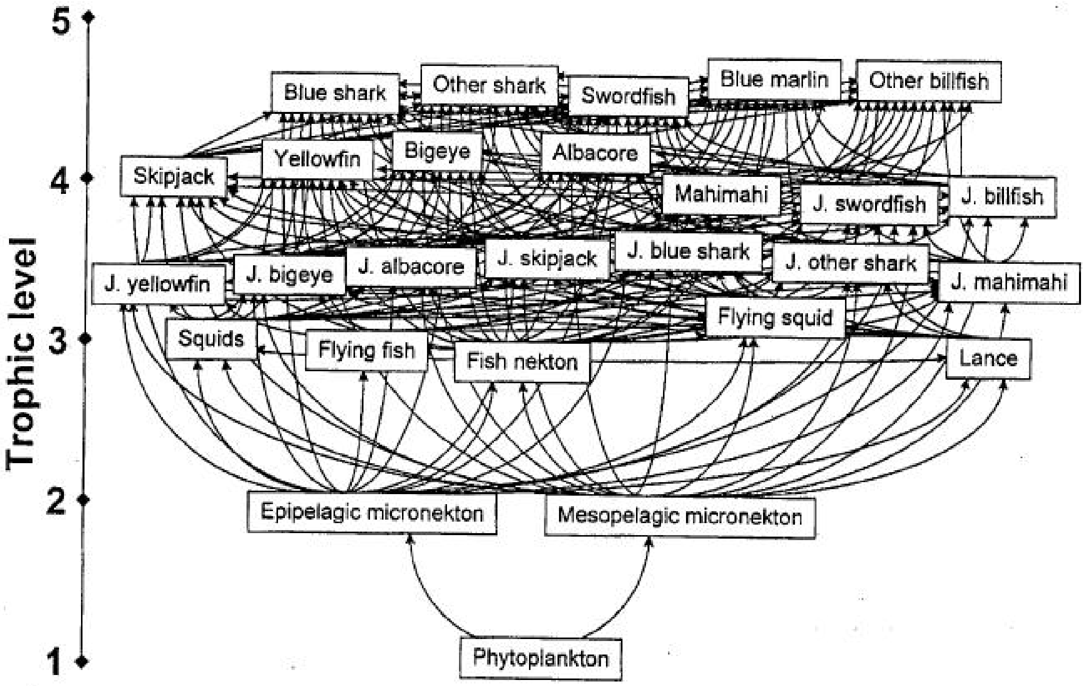

Figure 8: Central Pacific Pelagic Food Web
Source: Kitchell et al. 1999

This tangled "bird's nest" represents interactions at the approximate trophic level of each pelagic species, with increasing trophic level toward the top of the web.

3.3.2 Pelagic Environment

Pelagic species are closely associated with their physical and chemical environments. Suitable physical environment for these species depends on gradients in temperature, oxygen, or salinity, all of which are influenced by oceanic conditions on various scales. In the pelagic environment, physical conditions such as isotherm and isohaline boundaries often determine whether the surrounding water mass is suitable for pelagic fish, and many of the species are associated with specific isothermic regions. Additionally, fronts and eddies which become areas of congregation for different trophic levels are important habitat for foraging, migration, and reproduction for many species (Bakun 1996).

The pelagic marine ecosystem is the largest ecosystem on earth. Biological productivity in the pelagic zone is highly dynamic, for example, in the equatorial Pacific Ocean, upwelling extends westward along the equator in a cold tongue of water from the coast of South America, eventually encountering a large pool of warmer water in the western Pacific (the cold tongue-warm pool system). The eastern cold-tongue system is characterized by high levels of primary production, and the western warm pool by lower levels of primary production. The largest proportion of the tuna catch in the Pacific Ocean originates from the warm pool, even though paradoxically this is a region of low primary productivity. Tuna movement to upwelling zones at the fringe of the warm pool may be key in resolving this apparent discrepancy between algal and tuna production. Testing how regional variations in primary productivity relate to production of tunas in the cold tongue-warm pool system is the subject of a research project by scientists at the Pelagic Fisheries Research Program at the University of Hawaii at Manoa[14].

Phytoplankton comprise more than 95 percent of primary productivity in the marine environment (Valiela 1995) representing several different types of microscopic organisms. Requiring sunlight for photosynthesis, phytoplankto primarily live in the upper 100 meters of the euphotic zone of the water column and include organisms such as diatoms, dinoflagellates, coccolithophores, silicoflagellates, and cyanobacteria. Although some phytoplankton have structures (e.g., flagella) that allow them some movement, their general distribution is primarily controlled by current movements and water turbulence.

Diatoms can be either single celled or form chains with other diatoms. They are mostly found in areas with high nutrient levels such as coastal temperate and Polar regions. Diatoms are one of the major contributors to primary production in coastal waters, and occur everywhere in the ocean. Dinoflagellates are unicellular (one-celled) organisms that are often observed in high abundance in subtropical and tropical regions. Coccolithophores, which are also unicellular, are mostly observed in tropical pelagic regions (Levington 1995). Cyanobacteria, or blue-green algae, are often found in warm nutrient-poor waters of tropical ocean regions.

Oceanic pelagic fish including skipjack, yellowfin tuna and blue marlin prefer warm surface layers, where the water is well mixed by surface winds and is relatively uniform in temperature and salinity. Other pelagic species, albacore, bigeye tuna, striped marlin, and swordfish, prefer cooler, more temperate waters, often meaning higher latitudes or greater depths. Preferred water temperature often varies with the size and maturity of pelagic fish, and adults usually have a wider temperature tolerance than subadults. Thus, during spawning, adults of many pelagic species usually move to warmer waters, the preferred habitat of their larval and juvenile stages.

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[14] http://www.spc.int/oceanfish/Html/TEB/EcoSystem/foodisotope.htm Accessed March, 2007.

Large-scale oceanographic events (such as El Niño) change the characteristics of water temperature and productivity across the Pacific, and these events have a significant effect on the habitat range and movements of pelagic species. Tuna are commonly most concentrated near islands and seamounts that create divergences and convergences, which concentrate forage species, and also near upwelling zones along ocean current boundaries and along gradients in temperature, oxygen, and salinity. Swordfish and numerous other pelagic species tend to concentrate along food-rich temperature fronts between cold upwelled water and warmer oceanic water masses (NMFS 2001). These frontal zones also function as migratory pathways across the Pacific for loggerhead turtles (Polovina et al. 2000). Loggerhead turtles are opportunistic omnivores that feed on floating prey such as the pelagic cnidarian, *Vellela vellela* ("by the wind sailor") and the pelagic gastropod *Janthina* spp., both of which are likely to be concentrated by the weak downwelling associated with frontal zones (Polovina et al. 2000). Data from on-board observers in the Hawaii-based longline fishery indicate that incidental catch of loggerheads occurs along the 17° C front during the first quarter of the year, and along the 20° C front in the second quarter of the year. The interaction rate, however, is substantially greater along the 17° C front (Polovina et al. 2000).

3.3.3 Pelagic Species of Economic Importance

The most commonly harvested pelagic species in the Western Pacific Region are as follows: tunas (*Thunnus obesus, Thunnus albacares, Thunnus alalunga, Katsuwonus pelamis*), billfish (*Tetrapturus auda, Makaira mazara, Xiphias gladius*), dolphinfish (*Coryphaena hippurus, C. equiselas*), and wahoo (*Acanthocybium solandri*). Many species of oceanic pelagic fish live in tropical and temperate waters throughout the world's oceans and are capable of long migrations which reflect complex relationships to oceanic environmental conditions. These relationships differ for larval, juvenile, and adult life history stages. The larvae and juveniles of most species are more abundant in tropical waters, whereas adults are more widely distributed. Geographic distribution varies with seasonal changes in ocean temperature. In both the Northern and Southern Hemispheres, there is seasonal movement of tuna and related species toward the pole in the warmer seasons and a return toward the equator in the colder seasons. In the western Pacific, pelagic adult fish range from as far north as Japan to as far south as New Zealand. Albacore, striped marlin, and swordfish can be found in even cooler waters at latitudes as far north as 50° N, and as far south as 50° S. As a result, fishing for these species is conducted year-round in tropical waters, and seasonally in temperate waters (NMFS 2001).

Migration patterns of pelagic fish stocks in the Pacific Ocean are not easily understood or categorized, despite extensive tag-and-release projects for many of the species. This is particularly evident for the more tropical tuna species (e.g., yellowfin, skipjack, bigeye) that appear to roam extensively within a broad expanse of the Pacific centered on the equator. Although tagging and genetic studies have shown that some interchange does occur, it appears that short life spans and rapid growth rates restrict large-scale interchange and genetic mixing of eastern, central, and far-western Pacific stocks of yellowfin and skipjack tuna. Morphometric studies of yellowfin tuna also support the hypothesis that populations from the eastern and western Pacific derive from relatively distinct substocks in the Pacific. The stock structure of bigeye in the Pacific is poorly understood, but a single Pacific-wide population is assumed. The movement of the cooler water tuna (e.g., bluefin, albacore) is more predictable and defined, with tagging studies documenting regular, well-defined seasonal movement patterns relating to specific feeding and spawning grounds. The oceanic migrations of billfish are poorly understood, but the results of limited tagging work conclude that most billfish species are capable of transoceanic movement, and some seasonal regularity has been noted (NMFS 2001).

In the ocean, light and temperature diminish rapidly with increasing depth, especially in the region of the thermocline. Many pelagic fish make vertical migrations through the water column. They tend to inhabit surface waters at night and deeper waters during the day, but several species make extensive vertical migrations between surface and deeper waters throughout the day. Certain species, such as swordfish and bigeye tuna, are more vulnerable to fishing when they are concentrated near the surface at night. Bigeye tuna may visit the surface during the night, but generally, longline catches of this fish are highest when hooks are set in deeper, cooler waters just above the thermocline (275–550 m or 150-300 fm). Surface concentrations of juvenile albacore are largely concentrated where the warm mixed layer of the ocean is shallow (above 90 m or 50 fm), but adults are caught mostly in deeper water (90–275 m or 50–150 fm). Swordfish are usually caught near the ocean surface but are known to venture into deeper waters. Swordfish demonstrate an affinity for thermal oceanic frontal systems that may act to aggregate their prey and enhance migration by providing an energetic gain through moving the fish along with favorable currents (Olson et al. 1994).

3.3.3.1 Bigeye Tuna

Life History and Distribution

Bigeye tuna (BET) are believed to have recently evolved from a common parent stock of yellowfin tuna (YFT) (*Thunnus albacares*), remaining in a close phylogenetic position to yellowfin with similar larval form and development. Although the species shares a similar latitudinal distribution worldwide, BET have evolved to exploit cooler, deeper and more oxygen poor waters when compared to YFT in a classic example of adaptive niche partitioning. Several investigators have demonstrated that this has been accomplished through a combination of physiological and behavioral thermoregulation and other anatomical adaptations for foraging at depth, e.g., respiratory adaptations, eye and brain heaters (Lowe et al. 2000; Fritsches and Warrant 2001). In this way, the species is considered to be intermediate between a tropical tuna (e.g., yellowfin, blackfin (*T. atlanticus*), longtail tuna (*T. tonggol)*) and the temperate water tunas (e.g., albacore (*T. alalunga*), the bluefin tunas). This combination of traits can be characterized by rapid growth during the juvenile stage, movements between temperate and tropical waters to feed and spawn, equatorial spawning with high fecundity -- combined with a preference for cool water foraging and a protracted maturity schedule, an extended life span and the potential for broad spatial movements. It is believed that BET are relatively long lived in comparison to YFT but not as long lived as the three bluefin tuna species.

Feeding is opportunistic at all life stages, with prey items consisting of crustaceans, cephalopods and fish (Calkins 1980). There is significant evidence that BET feed at greater depths than YFT, utilizing higher proportions of cephalopods, and mesopelagic fish and crustaceans in their diet thus reducing niche competition (Whitelaw and Unnithan 1997).

Spawning spans broad areas of the Pacific and occurs throughout the year in tropical waters and seasonally at higher latitudes with water temperatures above 24°C (Kume 1967; Miyabe 1994). Hisada (1979) reported that BET require a mixed layer depth of at least 50 m with a sea surface temperature (SST) of at least 24°C. While spawning of bigeye tuna occurs across the Pacific, the highest reproductive potential was considered to be in the EPO based on size frequencies and catch per unit of effort inferred abundance (Kikawa 1966).

Basic environmental conditions favorable for survival include clean, clear oceanic waters between 13°C and 29°C. However, recent evidence from archival tags indicates that bigeye can make short excursions to depths in excess of 1000 m and to ambient sea temperatures of less than 3°C (Schaefer and Fuller 2002). Juvenile BET in the smaller length classes occupy surface mixed layer waters with similar sized juvenile YFT. Larger bigeye frequent greater depths, cooler waters and areas of lower dissolved oxygen compared to skipjack and yellowfin. Hanamoto (1987) estimated optimum bigeye habitat to exist in water temperatures between 10° to 15°C at salinities ranging between 34.5‰ to 35.5‰ where dissolved oxygen concentrations remain above 1 ml/l. Recent data from archival tagging has largely corroborated these earlier findings while extending the actual habitat range of the species.

Age, growth and maturity schedules for BET are only now becoming better defined. BET are considerably longer lived, slower growing and, therefore, more vulnerable than the YFT. It is now considered that bigeye mature at three to four years of age after which growth slows considerably with fish capable of living well past ten years. Critical to the understanding of bigeye biology and management are better estimates of maturity schedules by area which are just now beginning to become available. Preliminary results indicate that earlier assessments may have been utilized unrealistically low estimates of size at “maturity” for the species.

Juvenile Stage

Juvenile BET are regularly taken as an incidental in surface fisheries, and occasionally as targeted catch, such as in the seamount and FAD-associated offshore handline fishery of Hawaii (Adam et al. 2003). Juvenile BET of very small sizes are taken in the equatorial Philippine ringnet and small purse seine fishery, but are poorly documented due to mixing in the statistical database with YFT and other tuna species (Lawson 2004). These fisheries are based on anchored FADs, taking advantage of the strong tendency of juvenile tuna to aggregate to floating objects.

Juvenile BET are regularly taken as an incidental in pole-and-line fisheries, especially when floating objects or FADs are utilized. BET as small as 32 cm are also taken in the Japanese coastal pole-and-line fishery (Honma et al. 1973). BET have also been recorded from a seamount-associated handline fishery and FAD-based pole-and-line and handline fisheries in Hawaii as small as approximately 40 cm FL (Boggs and Ito 1993, Itano 1998). Smaller sized fish are apparently available but not retained due to marketing preferences. The smallest BET of 7,957 tag releases achieved during the Hawaii Tuna Tagging Project was 29.0 cm captured by handline gear (Itano and Holland 2000).

Both juvenile and sub-adult BET are taken as an incidental catch in floating object sets in western Pacific purse seine fisheries. In the EPO, purse seine catches of sub-adult BET have been quite high in some years and should be considered as a retained component of the catch in the skipjack floating object fishery. Schaefer and Fuller (2002) from archival tag data noted that BET less than 110 cm spent a greater percentage of their time in association with drifting FADs in the EPO but that the larger bigeye still had an affinity for aggregating to floating objects. Very small BET are also taken in equatorial purse seine fisheries though may be discarded or poorly enumerated due to market demands and mixed reporting with juvenile YFT.

Juvenile and sub-adult BET of increasing size appear in higher latitude fisheries, suggesting portions of the population move away from equatorial spawning/nursery grounds to feed and grow, only to return later to spawn. The distribution of these juvenile and sub-adult tuna becomes better understood as they begin to enter catch statistics of temperate water fisheries. The sub-adult size BET figure significantly in several handline and longline fisheries including the HBLLF which takes primarily sub-adult BET. During the 16 year period from 1987-2002, annual average size of BET ranged from 111 – 120 cm (WPRFMC 2005b).

Adult Stage

Adult BET are distributed across the tropical and temperate waters of the Pacific, between northern Japan and the North Island of New Zealand in the western Pacific, and from 40°N to 30°S in the eastern Pacific (Calkins 1980). There is some consensus that the primary determinants of adult BET distribution are water temperature and dissolved oxygen (DO) levels. Salinity does not appear to play an important role in tuna distribution in comparison to water temperature, DO levels and water clarity. Hanamoto (1987) reasons that optimum salinity for BET ranges from 34.5‰ to 35.5‰ given the existence of a 1:1 relationship between temperature and salinity within the optimum temperature range for the species. Alverson and Peterson (1963) stated that BET are found within SST ranges of 13° to 29°C with an optimum temperature range of 17° to 22°C. However, the distribution of BET cannot be accurately described by SST data since the fish spend a great deal of time at depth in cooler waters. Hanamoto (1987) analyzed longline catch and gear configurations in relation to vertical water temperature profiles to estimate preferred BET habitat. He noted that bigeye are taken by longline gear at ambient temperatures ranging from 9° to 28°C and concluded from relative catch rates within this range that the optimum temperature for large BET lies between 10° and 15°C if available DO levels remain above 1ml/l.

The IATTC is in the process of concluding and publishing results of a two-year investigation on the reproductive biology of BET from the EPO that evaluated 1,869 gonad samples from male and female bigeye ranging between 80 and 163 cm FL to determine spawning habitat, maturity, fecundity and sex ratios. Histological methods were used to evaluate sexual maturity, spawning periodicity and spawning time. The smallest female BET histologically classified as mature was 120 cm FL and only 4 per cent of fish 120.0-124.0 cm FL (n=70) were mature (IATTC 2004). Approximately 54 percent of samples 140.0-144.9 and 78 per cent of fish 150.9-154.9 were classified as sexually mature.

These initial findings suggest considerably larger sizes at maturity for BET in the EPO in comparison to observations made in the central and western Pacific. However, it should be noted that spawning of bigeye has been linked with sea surface temperatures above 24°C. It has been suggested that sexual maturity, or more accurately, the development into active spawning condition appears to be linked to mixed layer water temperatures above 26° C (Mohri 1998). Kume (1967) noted a correlation between mature but sexually inactive BET at SSTs below 23° to 24°C, which appears to represent a lower limit to spawning activity. SSTs are considerably lower in the equatorial EPO compared to the WCPO which could depress and lengthen maturity schedules of BET in the EPO if they remained in that area for extended periods. In other words, bigeye maturity schedules and spawning patterns need to be examined on a regional basis. In general, BET are believed to spawn throughout the year in tropical regions (10°N - 10°S) and during summer months at higher latitudes (Collette and Nauen 1983).

The Hawaii Tuna Tagging Project (HTTP) conventionally tagged and released 7,440 YFT and 7,957 BET throughout the Hawaiian archipelago, primarily from 1996 – 1999. Most of the BET releases were juvenile fish (mean 59.8 cm) tagged and released near a large seamount feature in the Hawaii EEZ or on offshore buoys that were acting as FADs (Itano and Holland 2000). BET recaptures reached 15 percent overall, which were primarily short-term recaptures at or near their point of release, reinforcing the importance of aggregation and schooling to juvenile BET behavior. Recaptured BET appeared to remain within the Hawaii zone for at least two or three years, repeatedly aggregating to the same seamount or FADs where recaptures continued to be reported. Adam et al. (2003) supported some degree of regional fidelity or island association of these juvenile and sub-adult phase BET with a low level of mixing with the broader WCPO. These results shared similarities to those reported by Hampton and Gunn (1998) for BET in the Australian Coral Sea.

Recent studies by scientists at PIFSC describe the fishing grounds near 30°N and the abundance of BET at this location during the summer months (Polovina et al. 2006). They integrated fishery, biological, and oceanographic data to describe the area and used pop-up archival tags to determine BET movements. The tuna showed an apparent site fidelity to this area in the summer months. This area around 30°N is very stratified with no apparent nutrient inputs to the surface layers yet often has large phytoplankton blooms visible by satellites.

Sibert et al. (2003) applied a Kalman filter statistical model to refine horizontal movement data from geolocating archival tags recovered from Hawaiian BET. Juvenile and sub-adult BET recoveries showed little real movement and a strong tendency to remain at the seamount and FADs where they had been tagged. The only large BET (131 cm) apparently remained associated with the coastal features and nearshore bathymetry of the island of Hawaii during 84 days at liberty. The authors suggest that large features, such as islands, may act as points of attraction and aggregation for BET. This is a commonly held belief of traditional handline fishermen in Polynesia who target deep swimming tunas at specific locations close to atolls and high islands. There are several of these traditional handline areas along the south shore of the island of Hawaii that are known to hold BET and YFT (Rizutto 1983).

Increasing numbers of HTTP recaptures have been reported radiating out from the Hawaiian Islands in all directions, but primarily to the south of Hawaii toward Johnston and Palmyra

Atolls. This recapture pattern may reflect different life stages of BET, with semi-resident juveniles and sub-adults strongly aggregated to island and seamount features, expanding out into oceanic environments and tropical spawning grounds with their development to maturity. Higher recapture rates to the south of Hawaii are likely influenced by differential fishing effort, but effort and abundance are often closely related.

Horizontal movements of BET in relation to FADs and other drifting objects are not well described, although a great deal of anecdotal information is available from the fishing industry. Schaefer and Fuller (2005) noted that BET tended to remain tightly aggregated and upcurrent of anchored FADs and downcurrent from the drifting research vessel during the day. At night, the BET aggregations became more diffuse when it was presumed that individuals were foraging on organisms of the sea surface layer. They returned to their daytime positions at dawn, often forming monospecific schools at the surface, usually termed a “breezer”.

BET can move freely throughout broad regions of favorable water temperature and dissolved oxygen values; and are capable of large, basin-scale movements as documented by tag recoveries. However, most recaptures have occurred within 200 miles of their point of release. These results may, however, be confounded by the preponderance of juvenile fish in tag release cohorts, a protracted time to reach adult stages, reporting problems for recaptures of large fish from high seas fleets and a small sample size of tag release data.

If the majority of spawning takes place in equatorial waters, then this infers mass movements of juvenile and sub-adult fish to higher latitudes, and presumably some return movements of mature or maturing fish to spawn. However, the extent of BET directed movement between the western, central and eastern Pacific remains unclear. An increase in tag releases of medium and large BET throughout their range, incorporating fishery independent technologies where possible is needed.

BET Stock Structure

The geographic distribution of BET is pan-Pacific with no physical or oceanographic barriers to movement within temperature extremes. Analyses of genetic variation in mitochondrial DNA and nuclear microsatellite loci have been conducted on BET otoliths from nine geographically scattered regions of the Pacific (Grewe and Hampton 1998). Their study noted some evidence for restricted gene-flow between the most geographically distinct samples (Ecuador and the Philippines), however, the data otherwise failed to reject the null hypothesis of a single Pacific-wide population of BET. In other words, the study supported the possibility of some degree of population mixing throughout the basin. Grewe et al. (2000), however, found no evidence to suggest that BET samples from the Indian Ocean were genetically different from the Pacific Ocean samples examined in the earlier study. This suggests that the methodology currently used may be an inappropriate tool for determining the issue of stock structure.

Miyabe and Bayliff (1998) suggested that there is insufficient information currently available to definitively determine the stock structure of BET in the Pacific, and therefore, a single stock hypothesis is usually adopted for Pacific BET. However, consistent areas of low catch separate principal fishing grounds in the eastern and central/western regions (around 165 - 170°W) and there appears to be little mixing of tagged populations although the tagging data are quite limited. Due to these considerations and the existence of two major, geographically separated, fishing grounds and fisheries coupled with the possibility of ocean basin movements of Pacific BET, stock assessments have been carried out on both a Pacific-wide basis and a two-stock hypothesis separating the central and western Pacific from the EPO.

The results of the genetic analyses are broadly consistent with tagging experiments done by the South Pacific Commission on BET whereby most stay close but some show extensive movement. BET tagged in locations throughout the western tropical Pacific have displayed eastward movements of up to 4,000 nm over periods of one to several years. The widespread distribution of BET spawning throughout the tropical Pacific and the greater longevity of BET relative to other tropical tunas, such as YFT (Hampton et al. 1998), are also consistent with a high potential for basin-scale gene flow. However, large-scale movements of BET > 1,000 nmi have accounted for only a small percentage of returns, with most recaptures occurring within 200 nmi of release. In addition, a significant degree of site fidelity of BET in some locations has been suggested, such as near large land masses, island-rich archipelagos, and possibly areas of high FAD densities.

Sibert and Hampton (2003) estimated median lifetime displacements of skipjack and yellowfin tuna in the order of some hundreds of nautical miles, rejecting the notion that these tropical tuna species are widely ranging by nature and “highly migratory”. These findings are consistent with the concept of “semi-discrete stocks” of YFT in the Pacific as proposed by Suzuki et al. (1978). BET, representing a unique blend of traits between a tropical and temperate tuna species with a protracted life span, may be expected to remain in a general area for extended periods of time and to also range further and have a higher potential for broader displacements throughout their extended life span.

3.3.3.2 Yellowfin Tuna

Yellowfin tuna (YFT) are in the subgenera *Neothunnus* with the Atlantic blackfin tuna (*Thunnus atlanticus*) and Indo-Pacific longtail tuna (*T. tonggol*) based on various morphological adaptations to endothermy, e.g., heat exchanger and liver morphology (Collette and Nauen 1983). This separation characterizes yellowfin tuna as “tropical” tuna vs. the “cold-water” subgenera *Thunnus* that consists of the bluefins, albacore and to some extent the bigeye tuna. However, YFT and BET share important morphological characters and BET appears to cluster weakly with the tropical tunas based on some genetic evidence (Chow and Kishino 1995; Alvarado Bremer et al. 1996).

While these observations suggest the BET is somehow intermediate between the tropical and “cold water” tunas, the YFT is clearly a tropical species, occupying the surface waters of all warm oceans. Yellowfin and bigeye tuna share a great deal of latitudinal distribution across the world oceans with yellowfin tending to occupy shallower and warmer depth strata within the upper mixed layer, i.e., the epipelagic zone.

Within the Pacific, YFT are widely distributed from around 35°N - 33°S in the EPO and 40°N - 35°S in the WCPO (Blackburn 1965). Basic environmental conditions favorable for survival include clean oceanic waters between 18°C and 31°C within salinity ranges normal for the pelagic environment with DO concentrations greater than 1.4 to 2.0 ml/l; higher than those required by BET (Blackburn 1965; Sund et al. 1981). Larval and juvenile YFT occupy surface waters with adults increasingly utilizing greater depth strata while remaining within the mixed layer, i.e., generally above the thermocline (Suzuki et al. 1978). However, these habitat preferences are not strict or exclusive as juveniles of both species occupy surface waters, and recent evidence suggests adults may spend some time at significant depths below the thermocline.

Feeding is opportunistic at all life stages, with prey items consisting of crustaceans, cephalopods and fish (Reintjes and King 1953; Cole 1980). A large number of age and growth studies have been carried out for Pacific yellowfin tuna as reviewed by Suzuki (1994). Studies have examined length or weight frequencies, tagging data, scales, otoliths or other hard parts such as dorsal spines. Results have been inconsistent with some suggestion that the examination of hard parts yields superior results to length or weight frequency analyses or tagging data in growth determination studies. Growth is considered very rapid, with individuals reaching approximately 55 cm in fork length at age one and over 90 cm at age two. YFT are not considered long-lived in comparison to the bluefin tunas or albacore with tagging data suggesting a maximum age of around 6 - 7 years.

Spawning occurs over broad areas of the Pacific, occurring throughout the year in tropical waters and seasonally at higher latitudes at water temperatures above 24°C (Suzuki 1994; Schaefer 1998; Itano 2000). Yellowfin are serial spawners, capable of repeated spawning at near daily intervals with batch fecundities of millions of ova per spawning event (June 1953; McPherson 1991; Schaefer 1996, Itano 2000). It is believed maturity is reached very quickly at around two years of age with some regional variability.

Yellowfin tuna appear to move freely within broad regions of favorable water temperature and are known to make annual excursions to higher latitudes as water temperatures increase with season. However, the extent to which these are directed movements is unknown and the nature or existence of yellowfin “migration” in the central and western Pacific remains unclear (Suzuki 1994). Yellowfin are clearly capable of large-scale movements which have been documented by tag and recapture programs, but many tag recaptures occur within a relatively short distance of release.

Yellowfin tuna are known to aggregate to drifting flotsam, large marine animals and in regions of elevated productivity, such as near seamounts and regions of localized upwelling (Blackburn 1969; Wild 1994; Suzuki 1994). Aggregation to floating objects is particularly pronounced for juvenile stages. Major surface fisheries for YFT exploit these behaviors either by utilizing artificial FADs or by targeting productive areas with vulnerable concentrations of tuna (Sharp 1978; Hampton and Bailey 1993).

The combination of these biological and behavioral traits identify YFT as a classic “tropical” tuna species with rapid growth and maturity, high fecundity, relatively short life span and inhabiting broad expanses of warm, surface waters. In a simplified way, yellowfin and bigeye tuna may be considered as shallow and deeper-dwelling cousins with similar worldwide (horizontal) distributions but adapted to exploit different, vertically stratified food sources.

Larval and Juvenile Stage

Yellowfin larvae are trans-Pacific in distribution and found throughout the year in tropical waters but are restricted to summer months in sub-tropical regions. For example, peak larval abundance occurs in the Kuroshio Current during May and June and in the East Australian Current during the austral fall and summer (November to December). Yellowfin larvae have been reported close to the main Hawaiian Islands in June and September but were not found in December and April (Beohlert and Mundy 1994).

The basic environment of yellowfin larvae can be characterized by warm, oceanic surface waters with a preference toward the upper range of temperatures utilized by the species, which may be a reflection of preferred spawning habitat. YFT larvae are common at SSTs above 26°C (Ueyanagi 1969) but may occur in some regions with SSTs of approximately 24°C and above to coincide with what is known of yellowfin spawning distributions. Harada et al. (1980) found the highest occurrence of normally hatched larvae at water temperatures between 26.4°C to 27.8°C with no normal larvae found in water less than 18.7°C or greater than 31.9°C from laboratory observations. Yellowfin larvae appear to be restricted to surface waters of the mixed layer well above the thermocline and at depths less than 50 to 60 meters, with no clear consensus on diurnal preference by depth or patterns of vertical migration (Matsumoto 1958; Strasburg 1960; Ueyanagi 1969). Prey species inhabit this zone, consisting of crustacean zooplankton at early stages with some fish larvae at the end of the larval phase.

The distribution of yellowfin larvae has been linked to areas of high productivity and islands, but how essential these areas are to the life history of the species is not known. Grimes and Lang (1992) noted high concentrations of yellowfin larvae in productive waters on the edge of the Mississippi River discharge plume and *Thunnus* larvae (most likely yellowfin due to spawning distributions) have been noted to be relatively abundant near the Hawaiian Islands compared to offshore areas (Miller 1979; Boehlert and Mundy 1994).

Juvenile yellowfin feed primarily during the day and are opportunistic feeders on a wide variety of forage organisms, including various species of crustaceans, cephalopods and fish (Reintjes and King 1953; Watanabe 1958). Prey items include epipelagic or mesopelagic members of the oceanic community or pelagic post-larval or pre-juvenile stages of island, reef or benthic associated organisms. Significant differences in the composition of prey species of FAD and non-FAD associated yellowfin have been noted in Hawaii (Brock 1985), American Samoa (Buckley and Miller 1994) and the southern Philippines (Yesaki 1983).

Recent work in Hawaiian waters found that juvenile yellowfin and bigeye tuna in a size range of 40 – 80 cm exploited similar broad groups of prey but significantly different species (Grubbs et al. 2002). Yellowfin were noted to feed almost exclusively on epipelagic crustaceans and fish or mesopelagic species that vertically migrate into the shallow mixed layer at night. Bigeye tuna of the same size and in the same aggregations fed primarily on a deeper dwelling complex of mesopelagic crustaceans, cephalopods and fish.

Adult Stage

The habitat of adult yellowfin can be characterized as warm oceanic waters of low turbidity with a chemical and saline composition typical of tropical and sub-tropical oceanic environments. Adult yellowfin are clearly trans-Pacific in distribution and range to higher latitudes compared to juvenile fish. Sea surface temperatures play a primary role in the horizontal and vertical distribution of yellowfin, particularly at higher latitudes. Blackburn (1965) suggested the range of yellowfin distribution was bounded water temperatures between 18°C and 31°C with commercial concentrations occurring between 20°C and 30°C. Salinity does not appear to play as important a role in yellowfin tuna distribution in comparison to water temperature and clarity.

Adult yellowfin tuna opportunistic feeders, relying primarily on crustaceans, cephalopods and fish as has been described for juvenile fish. However, the larger size of adult fish allows the exploitation of larger prey items, with large squid and fish species becoming more important diet items. Yesaki (1983) noted a high degree of cannibalism of large FAD-associated YFT on juvenile tunas in the southern Philippines. The baiting of longlines with saury, mackerel and large squid also implies that mature fish will take large prey items if available. YFT are also known to aggregate to large near surface concentrations of forage, such as the spawning aggregations of lanternfish (*Diaphus* spp.) that occur seasonally in the Australian Coral Sea (Hisada 1973; McPherson 1991b).

Juvenile and adult YFT aggregate to drifting flotsam, anchored buoys and large marine animals, while adult yellowfin are known to associate with herds of porpoises (Hampton and Bailey 1993). Adults also aggregate in regions of elevated productivity and high zooplankton density, such as near seamounts and regions of upwelling and convergence of surface waters of different densities, presumably to capitalize on the elevated forage available (Blackburn 1969; Cole 1980; Wild 1994; Suzuki 1994).

The use of sonic and archival tagging technologies has greatly expanded our knowledge of tuna behavior and habitat selection. Electronic evidence supports the belief that YFT spend most of their time in the mixed layer above 100 m depth, above or just below the thermocline.

Age and growth of yellowfin larvae has been investigated under a variety of laboratory conditions and from field collections. Observations from both laboratory-raised and wild specimens indicate highly variable growth rates, with wild fish consistently exhibiting higher growth rates compared to laboratory reared specimens (IATTC 1997). It was suggested the differences in growth rates and size at age were due to less than optimal growth conditions in the laboratory environment. Two critical periods of larval mortality have been identified at 4 - 5 days and another at about 11 days after hatching which corresponds to the time period when the diet of yellowfin larvae is proposed to shift from crustaceans to fish larvae (FSFRL 1973).

Yellowfin tuna spawn in sea surface temperatures above 24 - 25°C in pelagic environments across the Pacific with some evidence suggesting some preference for leeward coasts of oceanic islands and archipelagos. Spawning of yellowfin takes place at night, peaking between 2200 – 0300 and is believed to take place close to the surface although wild spawning has not been witnessed (Schaefer 1998; Itano 2001).

YFT are serial spawners, releasing millions of eggs during each spawning event and capable of repeated spawning at daily or near daily intervals during extended spawning.

An examination of spawning frequencies in an area with a definite seasonal spawning period is illustrative. Mature yellowfin in Hawaii were sampled during the spawning season (April – September) and the non-spawning season (October – March) and analyzed for spawning frequency and fecundity (Itano 2001). During the Hawaii spawning season, the spawning rates were very high from all surface fisheries, ranging from 1.02 d to 1.07 d indicating a near-daily spawning pattern. Yellowfin taken by deep-set longline gear during this time indicated a lower average spawning frequency resulting from a higher percentage of mature, non spawning fish. Spawning activity ceased completely in the fall season, resuming in early spring.

YFT are highly fecund, releasing hundreds of thousands to some millions of eggs during each spawning event. Batch fecundity increases significantly with weight but can be highly variable between fish of similar sizes (Schaefer 1998). Spawning occurs throughout the year in tropical waters at least within 10 degrees of the equator and seasonally at higher latitudes when sea surface temperatures rise above 24°C (Suzuki 1994). Several different areas and seasons of peak spawning for yellowfin have been proposed for the central and western equatorial Pacific.

The total catch of yellowfin tuna has increased steadily since 1980 in the Pacific Ocean, driven for the most part by increases in purse seine landings (Williams and Reid 2005). Pole-and-line catches have remained relatively stable during this time period in the WCPO while declining significantly in the EPO in recent years. Longline catches in both areas have been generally stable, while there have been significant increases in yellowfin landings in the WCPO by mixed gear types that primarily consist of unclassified gear types of Indonesia and Philippine handline catches (WCPFC 2005).

Juvenile YFT form a major component of surface landings in the WCPO and form an economically and socially important component of domestic, artisanal and subsistence fisheries in the Pacific, particularly in small island and coastal states. In particular, small scale troll and surface handline fisheries generally take juveniles less than 100 cm. Juvenile YFT are also regularly taken as an incidental byproduct in skipjack pole and line fisheries, especially when floating objects or FADs are utilized. Juveniles of very small sizes are taken in the Philippine ringnet, gillnet and small purse seine fisheries or by a mixture of hook and line gears. These fisheries are based on anchored FADs, taking advantage of the strong tendency of juvenile tuna to aggregate to floating objects

Large, mature-sized YFT are caught by higher value sub-surface fisheries, primarily longline fleets landing sashimi grade product. Adult YFT aggregate to drifting flotsam and anchored buoys, though to a lesser degree than juvenile fish. Large fish also aggregate over deep seamount and ridge features where they are targeted by some longline and handline fisheries.

A general perception suggests that adult YFT are taken by longline gear and in unassociated purse seine sets while juvenile yellowfin are taken during purse seine sets on floating objects, i.e., logs, and anchored or drifting FADs. In reality, considerable overlap exists in longline and purse seine fisheries. It appears that juvenile YFT recruit to and are potentially vulnerable to longline gear from around 55 cm and may be retained or discarded depending on the market characteristics of the fishery. Purse seine sets on floating objects definitely harvest mainly juvenile-sized YFT but a small proportion of mature tuna are also taken. Examples of fishing gears or methods that really concentrate on mature-sized YFT include dolphin-associated purse seine fishing in the EPO and deep handline fisheries of the Philippines and Indonesia.

The Hawaii Tuna Tagging Project (1998 – 2000) conventionally tagged and released 7,440 yellowfin and 7,957 bigeye tuna throughout the Hawaiian archipelago, primarily to examine within-zone movement and fishery interaction issues (Adam et al. 2003). More than half of the YFT releases were caught in association with a shallow seamount or deep-water FADs in the outer Hawaii EEZ. However, 11 percent of yellowfin releases were made around FADs anchored close to the main Hawaiian Islands (MHI) and 29 percent of releases were made in the Northwestern Hawaiian Islands (NWHI). YFT were recaptured at a rate of 10.8 percent (807 fish) (Itano and Holland 2000). Most of the fish were recaptured within a short time and distance of release.

An observation relates to the difference between YFT tagged within the MHI group (5,264 fish) vs. those tagged in the NWHI (2,176 fish). Virtually all of the recaptures resulting from YFT tagged in the MHI area were caught within the MHI areas. Only one recapture was reported from outside the zone for the only recapture reported from the EPO. However, YFT tagged and released in the NWHI recorded long-distance movements in all directions; into the MHI, south to Johnston Atoll or west to Japan. Ten YFT recaptures have been reported west of the Date Line from NWHI releases all the way to the coastal waters of Japan and Okinawa. None of the releases made near the MHI were recaptured at any distance westward (University of Hawaii Pelagic Fisheries Research Program unpublished data). This behavior suggests an island-associated tendency for YFT, particularly in a situation of isolated high islands such as the MHI, but further research is needed. Kleiber and Hampton (1994) have modeled tagging data and suggested that the retention and residency rates of skipjack can be positively influenced by the presence of island archipelagos and anchored FADs, these findings may also apply toYFT.

Very few studies have examined the fine scale behavior of adult YFT. Brill et al. (1999) used sonic tracking to record horizontal and vertical behavior of five adult yellowfin tuna (148 – 167 cm) near the island of Hawaii. The fish tended to move parallel to the coastline, often very close to shore and were tracked to associations with FADs, drifting objects and the tracking vessel itself. The adult YFT moved repeatedly and directly between FADs up to 18 km apart but without the repeated daily pattern noted for juveniles by previous authors.

YFT Stock Structure

YFT is an epipelagic species with worldwide distribution and there appear to be no physical or physiological barriers that prevent YFT from mixing throughout the Pacific basin. However, the question of stock structure of yellowfin in the Pacific continues to confront management and several theories on stock heterogeneity exist.

Wild (1994) and Suzuki (1994) review the body of research on the stock structure of YFT in the EPO and WCPO. Several indirect stock identification procedures or methodologies have been employed that include morphometric and meristic variability, length frequency and catch-and-effort analyses, analyses of tagging data and spawning/reproductive studies (Cole 1980). Recently, genetic studies and the analyses of microconstituents in hard parts have attempted to develop more direct methods to discriminate yellowfin subpopulations. Results from indirect and direct methods have not always been complementary and the existence of sub-populations of YFT in the Pacific has yet to be proven (Wild 1994).

Tagging data suggest that YFT move throughout the western and central Pacific Ocean, at least within the equatorial latitudes, but generally do not move more than a few hundred miles (Sibert and Hampton 2003). Movement to higher latitudes may be more restricted in nature, but further research and tagging is needed. However, tagging data strongly suggest that movement between the EPO and the WCPO is fairly restricted for the species. Morphometric studies also support the possibility of restricted gene flow between the EPO and WCPO and even between northern and southern groups of YFT within the EPO (Schaefer 1989, 1991).

3.3.3.3 Albacore Tuna

Separate northern and southern stocks of albacore (*Thunnus alalunga*), with separate spawning areas and seasons, are believed to exist in the Pacific. In the North Pacific there may be two sub-stocks, separated due to the influence of bathymetric features on water masses (Laurs and Lynn 1991). Growth rates and migration patterns differ between populations north and south of 40° N. (Laurs and Wetherall 1981; Laurs and Lynn 1991).

In the North Pacific, albacore are distributed in a swath centered on 35° N. and range as far as 50° N. at the western end of their range. In the central South Pacific (150° E. to 120° W.) they are concentrated between 10° S. and 30° S.; in the west they may be found as far as 50º S. They are absent from the equatorial eastern Pacific. Hawaii appears to be at the southern edge of their range.

Temperature is recognized as the major determinant of albacore distribution. Albacore are both surface dwelling and deep-swimming. Deep-swimming albacore tuna are generally more concentrated in the western Pacific but with eastward extensions along 30° N. and 10° S. (Foreman 1980). The 15.6° to 19.4° C SST isotherms mark the limits of abundant distribution although deep-swimming albacore tuna have been found in waters between 13.5° and 25.2° C (Saito 1973). Laurs and Lynn (1991) describe North Pacific albacore tuna distribution in terms of the North Pacific Transition Zone, which lies between the cold, low salinity waters north of the sub-arctic front and the warm, high salinity waters south of the sub-tropical front. This band of water, roughly between 40° and 30-35° N. (the Transition Zone is not a stable feature) also helps to determine migration routes.

Telemetry experiments demonstrate that albacore will enter water as cold as 9.5° C for short periods of time. Laurs and Lynn (1991) argue that acoustic tracking demonstrates that albacore tuna have a wider temperature range than stated previously and that their normal habitat is 10°-20° C with a dissolved oxygen saturation level greater than 60 percent.

The overall thermal structure of water masses, rather than just SST, has to be taken into account in describing total range because depth distribution is governed by vertical thermal structure. Albacore are found to a depth of at least 380 m and will move into water as cold as 9° C at depths of 200 m. They can move through temperature gradients of up to 10° C within 20 minutes. This reflects the many advanced adaptations of this fish; it is a thermoregulating endotherm with a high metabolic rate and advanced cardiovascular system. Generally, albacore have different temperature preferences according to size, with larger fish preferring cooler water, although the opposite is true in the northeast Pacific. They are considered epi- and mesopelagic in depth range.

The main albacore fisheries in the Pacific may be distinguished as either surface or deep water. The surface fisheries are trolling operations off the American coast from Baja to Canada, baitboat operations south of Japan at the Kuroshio Front and a fishery in New Zealand waters. A troll fishery has also developed south of Tahiti. Purse seine fishing is also considered a surface method but is currently of minor importance in the albacore fishery. Albacore are occasionally taken as bycatch in other tuna fisheries. Elsewhere, mainly in the northwest and South Pacific, longline gear is used to capture deep-swimming fish. Taiwanese and Japanese high seas drift gillnetters rapidly expanded effort in the South Pacific after 1988, targeting albacore tuna. A number of regional and international initiatives were put forward to limit or ban this fishery, and by 1990 operations had ceased (Wright and Doulman 1991). Generally, surface fisheries occur in cooler waters and target immature fish; the longline fishery, targeting deep-swimming fish, occurs closer to the equator.

Larval and Juvenile Stage

Davis et al. (1990) studied diel distribution of tuna larvae, including albacore tuna in the Indian Ocean off of northwest Australia. They found that albacore tuna migrate to the surface in the day and are deeper at night. This diel pattern was much more marked in albacore tuna than southern bluefin tuna (*Thunnus maccoyii*) larvae. Total vertical range was limited by pycnocline depth, which was 16-22 m in the study area. They concluded that the pycnocline acts as a physical barrier to movement. Albacore tuna may forage during daylight hours and simply sink to neutral depth at night when they cease swimming. Other studies indicate that the top boundary of the pycnocline can be an area of concentration for larvae.

Young and Davis (1990) report on larval feeding of albacore tuna in the Indian Ocean. They found *Corycaeus* spp., *Farranula gibbula* (Cyclopoida) and *Calanoid nauplii* to be major prey items. Diet breadth was greatest for larvae less than 5.5 mm. Leis et al. (1991) found high concentrations of tuna larvae, including albacore tuna, at sample sites near coral reefs on three islands in French Polynesia. They note that tuna larvae are sparsely distributed in the open ocean, possibly because they congregate near islands. Their findings are similar to those of Miller's (1979) study around Oahu, Hawaii.

Small juvenile albacore tuna range from 12 to 300 mm in length and have been found in coastal waters from a number of areas in the western Pacific including the Mariana Islands, Japanese coastal waters, Fiji, waters east of Australia, and Tuvalu. They have also been reported from Hawaiian waters. Albacore tuna are not mature until about five years old.

Off the West coast of North America, young albacore congregate in large, loosely aggregated schools. Larger fish are observed to form more compact schools, but the dense schools common to yellowfin tuna and skipjack tuna are not true of albacore.

Adult Stage

Albacore are heterosexual with no external characters to distinguish males from females. Immature fish generally have an even sex ratio but, for mature fish, male-female ratios range from 1.63:1 to 2.66:1 (Foreman 1980). Ramon and Bailey (1996) report sexual size dimorphism in South Pacific stocks, confirming findings by Otsu and Sumida (1968) with the males being larger. Fecundity is estimated at 0.8-2.6 million eggs per spawning.

Albacore spawn in the summer in subtropical waters. There is also some evidence of multiple spawning (Otsu and Uchida 1959). Foreman (1980) provides a map showing distribution of spawning areas. In the North Pacific the area centers on 25° N. and 160° E. and does not extend east of about 150° W. The same map in Foreman shows larval distribution, which is more restricted in extent than estimates of total spawning area. Based on age groups it is believed that maximum longevity is around ten years. Female albacore tuna reach maturity by about 90 cm, while mature males are somewhat larger. Ueyanagi (1957) postulated that males reach maturity at 97 cm. This length would accord with ages between five and seven years, based on length-at-age estimates.

Albacore are noted for their tendency to concentrate along thermal fronts, particularly the Kuroshio front east of Japan and the North Pacific Transition Zone. Laurs and Lynn (1991) note that they tend to aggregate on the warm side of upwelling fronts. Near continental areas they prefer warm, clear oceanic waters adjacent to fronts with cool turbid coastal water masses. It is not understood why they do not cross these fronts, especially given that they are able to thermoregulate, but it may be because of water clarity since they are sight-dependent foragers. Further offshore, fishing success correlates with biological productivity.

Albacore have a complex migration pattern with the north and south Pacific stocks having their own patterns. Most migration is undertaken by pre-adults, two to five years old. A further sub-division of the northern stock, each with separate migration, is also suggested. The model suggested by Otsu and Uchida (1963) shows trans-Pacific migration by year class. Generally speaking, a given year class migrates east to west and then east again in a band between 30° N. and 45° N., leaving the northeast Pacific in September-October, reaching waters off Japan the following summer and returning to the east in the summer of the following year. Four- to six-year old albacore enter sub-tropical waters south of 30° N., and west of Hawai‘i (Kimura *et al.* 1997) where they spawn. Migration may also be influenced by large-scale climate events that affect the Kuroshio Current regime (Kimura *et al.* 1997). Albacore may migrate to the eastern Pacific when the Kuroshio takes a large meander path. This also affects the southward extension of the Oyashio Current and may reduce the availability of forage, primarily saury, in the western Pacific.

The aforementioned sub-stocks apparently divide along 40° N. Albacore tagged off the U.S. West coast north of 40º N. apparently undertake more westward migration (58 percent of tag returns come from the western Pacific west of 180°) versus those tagged to the south (only ten percent were recovered in the western Pacific, 78 percent from the tagging area) (Laurs and Lynn 1991).

The U.S. accounted for approximately 20 percent of the North Pacific albacore catch in 2003, with 78 percent of the landings caught with troll gear followed by 15 percent recreational catch and 6 percent taken by longliners (Stocker 2005). The Hawaii-based longline fleet incidentally landed 521 mt of North Pacific albacore in 2003, while California-based vessels landed 2 mt. They do not target them but catch them while targeting swordfish, bigeye, or yellowfin tuna. The U.S. troll fleet caught over 17,000 mt during 2003, however, this is almost exclusively landed by vessels from U.S. West coast ports (Stocker 2005).

3.3.3.4 Skipjack Tuna

Morphological and genetic research indicates that skipjack tuna (*Katsuwonis pelamis)* is one worldwide species, and no subspecies are recognized. Serological and genetic analysis of Pacific populations has not conclusively determined the sub-population structure. The species is genetically heterogeneous across the Pacific. Skipjack tuna are found in large schools across the tropical Pacific. They prefer warm, well-mixed surface waters. Barkley (1969) and Barkley *et al.* (1978) described the hypothetical habitat for skipjack tuna as areas where a shallow salinity maximum occurs seasonally or permanently. Matsumoto *et al.* (1984) described the habitat in terms of temperature and salinity: "(1) a lower temperature limit around 18° C; (2) a lower dissolved O_2 level of around 3.5 ppm; and (3) a speculative upper temperature limit, ranging from 33° C for the smallest skipjack tuna caught in the fishery to 20° C or less for the largest." These limits represent constraints on activity based on available DO and water temperature. Wild and Hampton (1991) suggest a minimum oxygen level of 2.45 ml/l in order to maintain basal swimming speed. Since skipjack tuna lack a swim bladder Sharp (1978) calculated that a 50 cm skipjack tuna must swim 60.5 km/d just to maintain hydrodynamic stability and respiration. A maximum range is proposed as an area bounded by the 15° C or roughly between 45° N. and S. in the western Pacific and 30º N. and S. in the east. This range is more restricted in the eastern Pacific due to the basin-wide current regime, which brings cooler water close to the equator in the east.

Wild and Hampton (1994) note a variety of other oceanographic and biological features influence distribution, including thermocline structure, bottom topography, water transparency, current systems, water masses and biological productivity. In the tropics these factors may be more important in determining distribution than temperature. Temperature change in sub-tropical regions affects seasonal abundance and large-scale climatic features, of which *El Niño*/*La Niña* is the most well known, also affect distribution. Vertical distribution is generally limited by the depth profile of the temperature and oxygen concentrations given as minimums above. Dizon et al. (1978), found that skipjack tuna move between the surface and 263 m during the day but remain within 75 m of the surface at night.

Historically, bait boats (pole-and-line) were the main gear used in catching skipjack tuna but since the 1950s, purse seiners have come to dominate the fishery. Some skipjack tuna are also caught incidentally by longliners, particularly those using shallow gear.

There are two major fisheries in the eastern Pacific. The most important is located east of 100° W. off Central and South America. The northern fishery, separated by a region of low abundance (described above) occurs near Baja California, the Revillagigedo Islands and Clipperton Island.

In the western Pacific, the fishery is diverse, occurring in the waters of a number of island nations and carried out by both small domestic fleets and distant water fleets from developed nations, primarily Japan and the United States. Fishing effort is concentrated in the waters around Micronesia and northern Melanesia.

Skipjack tuna spawn year-round in tropical waters so it would be expected that in tropical waters eggs and larvae would be present much of the time. The distribution of larvae has been documented by Japanese research vessel net tows (Ueyanagi 1969; Nishikawa *et al.* 1985). Like adults, larvae have a wider latitudinal distribution in the western Pacific than in the east. Kawasaki (1965) suggests that the center of abundance of skipjack tuna larvae in the Pacific Ocean lies between 5° N. and 4° S. and 160° E. and 140° W. Matsumoto (1975) later reported the center of abundance between 160° E. and 140° W., but moderate between 100° W. and 140° W. and 120° E. and 160° E. Areas above 20° N. with relatively high larval abundance include the Hawaiian islands. Klawe (1963) did not find any larvae below the mixed layer. Larvae apparently migrate to the surface at night while staying deeper during the day (Wild and Hampton 1994).

Wild and Hampton (1994) stated that skipjack tuna larval distribution is strongly influenced by temperature. Forsbergh (1989) demonstrated that the concentration of larvae in the Pacific approximately doubles with each 1° C increase in SST between 24°-29° C and then begins to decrease above 30° C. Matsumoto et al. (1984) present a limit for larval distribution based on the 25° C isotherm. As noted above, larvae remain in the mixed layer. Leis *et al.* (1991) found particularly high concentrations of skipjack tuna larvae near coral reefs of islands in French Polynesia. It may be that the more productive waters around oceanic islands and reefs provide preferred habitat for larval development.

Mori (1972) defines juveniles as smaller than 15 cm (but above 12-15 mm as the upper limit for larvae as defined by Matsumoto et al. 1984), and the young 15-35 cm. Skipjack tuna first spawn at about 40 cm length. Relatively little is known about the juvenile phase (especially the adolescent or pre-adult stage) since they do not turn up in plankton tows and are too small to enter any fishery. Most have been collected from the stomachs of larger tunas and billfish (Wild and Hampton 1994).

Adult Stage

Matsumoto et al. (1984), reviewing a variety of sources, argue that the minimum size for female skipjack tuna at maturity is 40 cm and initial spawning occurs between 40-45 cm. Based on growth estimates, skipjack tuna are about one year old at this size.

Skipjack tuna are opportunistic foragers, and an extensive range of species have been found in their stomachs. Matsumoto et al. (1984) document taxonomic groups found in various studies analyzing stomach contents; eleven invertebrate orders and 80 or more fish families are listed. In the western and central Pacific fish are the most important prey, followed by molluscs and crustaceans. Scombrids are the most important group of fish consumed by skipjack tuna.

Although skipjack tuna form large schools, these are not stable and often break up at night. Tagging data indicate that school membership is not stable over time (Bayliff 1988; Hilborn 1991). From analysis of parasite fauna, Lester et al. (1985) determined that school half-life is likely to be only a few weeks.

Pre-recruits disperse from the central Pacific, arriving in the eastern Pacific at 1-1.5 years old and return to the central Pacific at 2-2.5 years old (Wild and Hampton 1994). Migrants to the eastern Pacific split between a northern and southern group off Mexico and Central and South America respectively. Ianelli (1993) reviews three possible migration models that might account for this north-south distribution. These models are based on large-scale current patterns in the region.

3.3.3.5 Swordfish

Numerous studies on the taxonomy, biology, diet, stock structure and exploitation of swordfish (*Xiphias gladius*) have been conducted. Information on billfish, including swordfish is summarized in Nakamura et al. (1968) and Nakamura (1985). Palko et al. (1981) and Joseph et al. (1994) provide a detailed synopsis of the biology of swordfish. An extensive review of the biology of swordfish and the status of swordfish fisheries around the world was published by Ward and Elscot (2000).

Broadbill swordfish are worldwide in distribution in all tropical, subtropical and temperate seas, ranging from around 50° N. to 50° S. (Nakamura 1985; Bartoo and Coan 1989). The adults can tolerate a wide range of water temperature, from 5°-27° C, but are normally found in areas with SSTs above 13° C (Nakamura 1985). Larvae and juveniles occur in warmer tropical and subtropical regions where spawning also occurs. Swordfish occur throughout the entire region of the Council's jurisdiction and in all neighboring states, territories and adjacent high seas zones.

Swordfish have separate sexes with no apparent sexual dimorphism, although females attain a larger size. Fertilization is external and the fish are believed to spawn close to the surface. There is some evidence for the pairing of spawning adults as the fish apparently do not school (Palko et al. 1981).

Swordfish are voracious feeders at all life stages. Adults feed opportunistically on a wide range of squids, fish and crustaceans. Sex ratio appears to vary with fish size and spatial distribution. Most large sized fish are females and females appear to be more common in cooler waters. Beckett (1974) noted that few males were found in waters below 18° C, but make up the majority of warm water landings. Details of growth, maturity, fecundity and spawning are given later in this report.

Little is known about migration in Pacific swordfish although limited tagging data support a general west to east movement from Hawaii toward North America. There is some evidence that there may be several semi-independent stocks in the Pacific (a northern stock, a southwest stock and two or three eastern stocks).

Swordfish are targeted by a Hawaii-based longline fishery that occurs primarily to the north of the EEZ around Hawai‘i. Incidental or targeted catches within the EEZ around Hawaii are made by longline and handline vessels fishing primarily for tuna species.

Adult swordfish are the most widely distributed of all billfish species, ranging from approximately 50° N. to 50° S. in the Pacific as indicated by catch records of commercial longline vessels. Adult swordfish are able to occupy a very broad range of water temperatures, from 5°-27° C with a preferred temperature range of 18°-22° C (Nakamura 1985). Individuals can exceed 500 kg in weight with females growing larger than males. The larger fish occupy cooler waters, with few fish less than 90 kg and few males found in waters less than 18° C (Palko 1981).

Wilson and Dean (1983) estimated a maximum age of nine years for males and 15 years for females from otolith analysis. Radtke and Hurley (1983), using otoliths, estimated a maximum age of 14 years for males and 32 years for females. Research on the reproductive biology and size at maturity of swordfish is reviewed by DeMartini (1996). Yabe *et al.* (1959) estimated that swordfish reach maturity between five and six years of age at a size of 150-170 cm (eye to fork length). Sosa-Nishizaki (1990) estimated that female swordfish in the Pacific mature at 140-180 cm based on gonad indices. Length at first maturity has been observed in females as small as 101-110 cm (Nakano and Bayliff 1992). Spawning occurs in the upper mixed layer of the water column from the surface to 75 m (Nakamura 1985).

Swordfish are found in waters with a wide range of SSTs and sonic tracking experiments indicate that they spend prolonged periods in deep, cooler water and can therefore tolerate water temperatures that are considerably cooler than at the surface. Swordfish can forage at great depths and have been photographed at a depth of 1,000 m by deep diving submersible (Mather 1976). Carey (1982) and other researchers have suggested that specialized tissues warm the brain and eyes, allowing swordfish to successfully forage at great depths in frigid waters. Holts et al. (1994) used acoustic telemetry to monitor an adult swordfish and notes that the fish spent about 75 percent of its time in or just below the upper mixed layer at depths of 10 to 50 m in water temperatures about 14° C and made excursions to approximately 300 m where the water was close to 8° C.

The horizontal and vertical movements of several swordfish tracked by acoustic telemetry in the Atlantic and Pacific are documented by Carey and Robison (1981). Studies have noted a general pattern of remaining at depth, sometimes near the bottom, during the day and rising to near the surface during the night in what is believed to be a foraging strategy. They further proposed that differences in preferred diving depths between different areas were due to an avoidance of depth strata with low dissolved oxygen.

Adult swordfish are opportunistic feeders, preying heavily on squid and various fish species. Oceanographic features such as frontal boundaries that tend to concentrate forage species (especially cephalopods) apparently have a significant influence on adult swordfish distributions in the North Pacific. Swordfish are relatively abundant near boundary zones where sharp gradients of temperature and salinity exist (Palko 1981). Sakagawa (1989) notes that swordfish are found in areas of high productivity where forage species are abundant near current boundaries and frontal zones.

3.3.3.6 Black Marlin

Fish of the genus *Makaira* are teleost fish of the order Perciformes (suborder Xiphiidae) and family Istiophoroidae. Two other *Makaira* species are recognized: the Indo-Pacific blue marlin *(M. mazara*) and the Atlantic blue marlin (*M. nigricans*). However, the separation of these populations into distinct species has recently been questioned based on genetic analysis (Graves and McDowell 1995).

Based on their widely separated centers of relatively high abundance in the peripheral eastern and western Pacific and their comparatively sparse distribution across the mid-oceanic Pacific, Howard and Ueyanagi (1965) argued that there are two separate stocks of Pacific black marlin (*M. indica*) in the Pacific. However, recaptures of tagged marlin that have crossed from the eastern Pacific to Australia and from north of the equator to the south, indicate that a pan-Pacific stock must be considered possible (Pepperell and Davis 1999).

Nakamura (1985) gives the range for black marlin as 35°-40° N. to 45° S. in the western Pacific and 30° N.-35° S. in the eastern Pacific. Specifically mentioned areas of concentration are along continental margins and in Indo-Pacific archipelagic waters from Southeast Asia to Australia. Based on longline catch per unit of effort (CPUE) data alone, the area of greatest abundance would be in the waters north of Australia to New Guinea and the Indonesian archipelago. A second center of abundance lies off Central America, centered on Panama. Based on data from the western Indian Ocean, Merrett (1971) reported that the highest catch rate is in water depths between 250-500 fathoms (457.2-914.4 m). No fish are reported landed in waters deeper than 2,000 fathoms (3,657.6 m). The reported range in SST for this species is relatively wide, 15°-30° C. Squire and Nielsen (1983) reported an optimal temperature, based on longline CPUE off northeast Australia, as 26.7° C. In terms of movement, Howard and Ueyanagi (1965) noted a seasonal movement away from the equator during summer months in the respective hemispheres.

Koto and Kodama (1962, *in* Nakamura 1975) estimated growth rates at 50 cm per year for black marlin of length 150-200 cm, 30 cm for lengths 200-230 cm and 20 cm for lengths 230-250 cm. Estimates could not be made for sizes above and below this range.

Reported spawning grounds are in the South China Sea in May or June and the Coral Sea between October and November. Given their sparse distribution in the oceanic Pacific, it may be that spawning is confined to western Pacific continental margin/shelf areas. Major fishing grounds are on the western Pacific continental margin around Taiwan, the East China Sea, the Coral Sea and northwest Australian waters. In these areas black marlin are caught by harpooners and trollers. A major charter-boat sports-fishery captures black marlin in northeast Australian waters. Black marlin are also caught as bycatch by tuna longliners in these and other areas of the Pacific.

3.3.3.7 Blue Marlin

The blue marlin (*Makaira nigricans*) is the most tropical of all marlins. It has been variously described as a single pan-tropical species (Rivas 1974) or two distinct species, *Makaira nigricans* in the Atlantic and *Makaira mazara* in the Pacific (Nakamura 1983). Using mitochondrial DNA (mtDNA) techniques, Graves and McDowell (1995) found that "[t]he lack of significant genetic differentiation between Atlantic and Indo-Pacific samples of blue marlin [and sailfish] does not support…recognition of distinct Atlantic and Indo-Pacific species." The current assumption is that there is a single Pacific-wide stock. This conclusion is supported by genetic studies that suggest a single Pacific-wide cytochrome b DNA haplotype (Finnerty and Block 1992).

Important fishing grounds for blue marlin include the northwest Pacific where the majority are caught in the longline fishery. Blue marlins are also extremely important to the sport fishing sectors within the management plan area. In Hawaii, Guam and the Northern Mariana Islands, blue marlins are caught by recreational small-boat trollers and charter boats.

Based on a long-term study of reproductive condition of blue marlin caught in Hawaii billfish tournaments, Hopper (1990) contends they congregate around the Hawaiian Islands during summer months in order to spawn and that they migrate from more southerly latitudes. Hawaii may be a focus for blue marlin spawning in the northern central Pacific because oceanographic conditions are favorable to survival of marlin larvae and juveniles (Hopper 1990). Other researchers (Nishikawa et al. 1985) note that areas where larvae occur more frequently correspond to the best summer fishing grounds. It has also been suggested that marlin spawn year-round in tropical waters.

Tracking experiments (Holland et al. 1990; Block et al. 1992a) show that blue marlin in Hawaiian waters spend virtually all of their time within the mixed layer, frequently moving between the surface and the top of the thermocline which, in Hawaii, is usually at a depth of between 80 and 100 meters. Dives through the thermocline are uncommon and are usually to relatively shallow depths; Block et al. (1992b) recorded a maximum dive depth of 209 meters in one tracked marlin. There is a north-south seasonal migration of fish that corresponds to warmer waters. These migrations may be more northwesterly and southeasterly so that northward moving groups pass the equator around 150° E.-180° and southward migrants pass the equator between 160° E.-180° (Au 1991). If there is a single Pacific-wide stock, these data suggest that there may be a seasonal clockwise gyral pattern of migration.

3.3.3.8 Striped Marlin

In the Pacific, the striped marlin (*Tetrapturus audax*) is distributed in two supra-equatorial bands that join at the eastern tropical margin. This has led some researchers to divide the population into two separate stocks, at least for management purposes. This interpretation is supported by genetic analysis (mitochondrial DNA) that suggests a corresponding spatial partitioning in genotypes (Graves and McDowell 1995). The authors suggest that this differentiation may be due to spawning site fidelity.

In contrast to the blue marlin, there is no significant sexual size dimorphism in this species. Region-wide major catches of striped marlin are made by Japan and Korea. Important fishing areas include FAO Fishing Area 61 (northwest Pacific) where about 50 percent of the catch is made. Most of the catch is made by surface longlining that targets tunas (Nakamura 1985).

Distribution of eggs is unknown. Larvae are reportedly found between 10°-30° N. and 10°-30° S. Peak abundance is in May-June in the northwestern Pacific (Ueyanagi and Wares 1974). This corresponds to the spawning ground described by Squire and Suzuki (1990). Thus, spawning is probably seasonal and confined to the early summer months in both hemispheres, and there is probably a separate spawning ground in the southwest Pacific. Like other billfish, striped marlins are generally confined to pelagic surface waters; the larvae may make diurnal vertical migrations in the top 50 m of the water column. Little is known about time of first feeding or food preferences. Females are reported to reach first maturity at 50-80 lb; it is not possible to determine onset of sexual maturity in males because change in the size of testes is slight.

Acoustic tracking of adult striped marlin in Hawaiian waters and off California (Brill et al. 1993; Holts and Bedford 1990) demonstrated that they spent virtually all their time in the mixed layer. The authors conclude that depth preference is governed by temperature stratification; the fish they tracked spent the vast majority of time in waters within 2° C of the mixed layer temperature and never ventured into waters 8° C colder than the mixed layer temperature. Squire and Suzuki (1990) argued that striped marlin make long-term migrations between spawning and feeding areas. The spawning areas are in the northwest and to a lesser extent the southwest Pacific. Young fish migrate eastward to feeding areas off the Central American coast and subsequently return westward as adults.

3.3.3.9 Shortbill Spearfish

The shortbill spearfish (*Tetrapturus angustirostris*) is an Istiophorid billfish and shares the genus with five other species. Kikawa (1975), summarizing various works, describes the total distribution as sporadic between 10° N. and 10° S. with possible range extent to 30° N. and 30° S., based on longline catch data. Nakamura (1985) gave a range of 40° N. to 35° S. for the Pacific with a low density throughout its range. Nakamura further stated that the shortbill spearfish "is an oceanic pelagic fish which does not generally occur in coastal or enclosed waters but is found well offshore. Boggs (1992), conducting research in 1989 on longline capture depth, obtained the highest catch rates at 120-360 m with a few fish caught as deep as 280-360 m. This distribution is described as "the middle of the thermocline" that begins at 120 m and 20° C. In another survey in 1990, the highest catch rates were shallower (40-80 m) with no catch below 200 m.

Nakano et al. (1997), analyzing catch depth data from research cruises in the mid-Pacific, classes shortbill spearfish among fish for which catch rate declines with depth. The hypothetical habitat for this fish may be described as open ocean epipelagic and mesopelagic waters from the surface to 1,000 meters in the tropics and subtropics.

Spearfish are heterosexual and no sexual dimorphism is reported. Shortbill spearfish apparently spawn in winter months in tropical and subtropical waters between 25° N. and 25° S. Kikawa (1975) noted that unlike other billfish spawning does not occur in large groups over a very short period of time, but probably is continuous over a long period and over broad areas of the sea. There is no special fishery for spearfish; they are caught incidentally by longliners and occasionally by surface troll.

3.3.3.10 Sailfish

The sailfish (*Istiophorus platypterus*) is an Istiophorid billfish, sharing the genus with the Atlantic sailfish (*I. albicans*). Based on mtDNA analysis, Graves and McDowell (1995) have called for a re-evaluation of the taxonomic separation of these two species. They also note considerable intra-oceanic genetic diversity that suggests the existence of finer population structure, but no information was found concerning possible sub-populations in the Pacific.

Howard and Ueyanagi (1965) emphasized that sailfish are more common near land masses. In the western Pacific they identify areas of high density near the land masses of Papua New Guinea, Caroline Islands and Solomon Islands, as well as in the Banda Sea, Timor Sea, East China Sea and the waters east of Taiwan to southwestern Japan. They note that both adults and young are associated with the Kuroshio Current, migrating to the coastal waters of southern Japan in this current. Beardsley et al. (1975) describe the Pacific distribution as more extensive in the western half than eastern and note that catch data show a distribution from 27° S. to 40° N. in the west and 5° S. to 25º N. in the east. In describing habitat parameters, they state the vertical zone of the community in which the sailfish lives is characterized by good illumination and is likely to be delimited below by temperature at the main thermocline (from 10-20 m to 200-250 m, depending on area) and that temperature is likely important and salinity may also have an effect in the latitudinal distribution of the species. They suggest the 28° C isotherm as optimal. Kuwahara et al. (1982) note a negative correlation between catch and salinity for landings at Kyoto Prefecture in Japan. Nakamura (1985) notes that maximum abundance in the Indian Ocean is correlated with a maximum temperature of the East African Coastal Current of 29°-30° C and low salinity of 32.2-33.3 ppt. He also notes that sailfish share habitat with the black marlin (*Makaira indica*), another managed species. The only habitat feature consistently mentioned in the literature that affects abundance and density of population (indicating preferred habitat) is the sailfish's preference for continental coasts.

As with other billfish, the age of individual sailfish is difficult to determine by analysis of hard parts. They apparently grow rapidly; Beardsley et al. (1975) give the following lengths at age: one year – 183 cm, two years – 216 cm and three years – 233.7 cm. Prince et al. (1986) suggest a revision of the maximum age of sailfish based on a tag recapture. They estimate a maximum age of 13-15 years or more in contrast to earlier estimates in the range of seven years.

3.3.3.11 Interactions between Pelagic and Other Oceanic Environments

The pelagic or open ocean environment is where PMUS spend their lives and are caught, however, other oceanic communities are vitally important to these species in part because of the food-poor nature of much of the pelagic environment. For example, the mesopelagic boundary area described as being between 200 and 1,000 m depth and bordered by the photic zone above, and the aphotic zone below, provides habitat for a unique community of fish, crustaceans, mollusks and other invertebrates which become prey for tunas and other pelagic species. The biomass of available forage is likely a key factor controlling abundance and distribution of tropical tunas because of their high energy demands and the low productivity of the pelagic environment (Rogers 1994 *in* Benoit-Bird et al. 2001). Diel vertical migrations of mesopelagic boundary organisms are well documented (Roe 1974 *in* Benoit-Bird et al. 2001, Sassa et al. 2002). Acoustic sampling techniques off the coasts of Oahu and Kona were implemented by Benoit-Bird et al. (2001) to assess the spatial heterogeneity, horizontal and vertical migration patterns, relative abundances, and temporal patterns of the mesopelagic community as well as the linkages among this community, the influence of the coastlines, and oceanographic parameters. The Benoit-Bird et al study showed that the horizontal component of the mesopelagic community migration indicates a clear link between the nearshore and oceanic ecosystems in the Hawaiian Islands, which in turn affects the presence and abundance of the pelagic predator species.

Studies near the Hawaiian Islands indicate that concentrations of spawning tuna near the islands may be due to increased forage in these areas associated with elevated primary productivity (Itano 2001). Spawning in yellowfin tuna has been correlated to sea surface temperatures (SSTs), mainly above 24 - 26°C and may also be correlated with frontal areas such as the edge of Western Pacific Warm Pool (WPWP). The WPWP is the largest oceanic body of warm water with surface temperatures consistently above 28°C (Yan et al. 1992 *in* Itano 2001). The edge zones of this warm area are convergence zones which bring up nutrient rich waters and create high productivity areas resulting in high densities of tuna forage (i.e., baitfish such as anchovy) and thus large numbers of tuna. This has been translated into high CPUE of skipjack by the western Pacific purse seine fishery (Lehodey et al. 1997 *in* Itano 2001). Offshore areas of high catch rates and spawning frequencies were found around several productive seamounts which also exhibit high productivity due to interactions of submarine topography, current gyres and being located in the lee of the main Hawaiian Islands (Itano 2001). Trophic linkages such as those evident in tunas whereby ocean anchovy are a primary forage species [of tuna] which themselves feed primarily on copepods provide a critical link between zooplankton and larger pelagic fish (Ozawa and Tsukahara 1973 *in* Itano 2001). Understanding these linkages is an essential component of successful ecosystem based fishery management.

3.3.3.12 Geographic Distribution of Managed Species as Related to the Pelagic Environment

Species of oceanic pelagic fish live in tropical and temperate waters throughout the world's oceans. They are capable of long migrations that reflect complex relationships to oceanic environmental conditions. These relationships are different for larval, juvenile and adult stages of life. The larvae and juveniles of most species are more abundant in tropical waters, whereas the adults are more widely distributed. Geographic distribution varies with seasonal changes in ocean temperature. In both the Northern and Southern Hemispheres, there is seasonal movement of tunas and related species toward the pole in the warmer seasons and a return toward the equator in the colder seasons. In the western Pacific, pelagic adult fish range from as far north as

Japan to as far south as New Zealand. Albacore, striped marlin and swordfish can be found in even cooler waters at latitudes as far north as latitude 50° N. and as far south as latitude 50° S. As a result, fishing for these species is conducted year-round in tropical waters and seasonally in temperate waters.

Migration patterns of pelagic fish stocks in the Pacific Ocean are not easily understood or categorized, despite extensive tag-and-release projects for many of the species. This is particularly evident for the more tropical tuna species (e.g., yellowfin, skipjack, bigeye) which appear to roam extensively within a broad expanse of the Pacific centered on the equator. Although tagging and genetic studies have shown that some interchange does occur, it appears that short life spans and rapid growth rates restrict large-scale interchange and genetic mixing of eastern, central and far-western Pacific stocks of yellowfin and skipjack tuna. Morphometric studies of yellowfin tuna also support the hypothesis that populations from the eastern and western Pacific derive from relatively distinct sub-stocks in the Pacific. The stock structure of bigeye in the Pacific is poorly understood, but a single, Pacific-wide population is assumed. The movement of the cooler-water tuna (e.g., bluefin, albacore) is more predictable and defined, with tagging studies documenting regular and well-defined seasonal movement patterns relating to specific feeding and spawning grounds. The oceanic migrations of billfish are poorly understood, but the results of limited tagging work conclude that most billfish species are capable of transoceanic movement, and some seasonal regularity has been noted.

In the ocean, light and temperature diminish rapidly with increasing depth, especially in the region of the thermocline. Many pelagic fish make vertical migrations through the water column. They tend to inhabit surface waters at night and deeper waters during the day, but several species make extensive vertical migrations between surface and deeper waters throughout the day. Certain species, such as swordfish and bigeye tuna, are more vulnerable to fishing when they are concentrated near the surface at night. Bigeye tuna may visit the surface during the night, but generally, longline catches of this fish are highest when hooks are set in deeper, cooler waters just above the thermocline (275-550 meters or 150-300 fathoms). Surface concentrations of juvenile albacore are largely concentrated where the warm mixed layer of the ocean is shallow (above 90 m or 50 fm), but adults are caught mostly in deeper water (90-275 m or 50-150 fm). Swordfish are usually caught near the ocean surface but are known to venture into deeper waters. Swordfish demonstrate an affinity for thermal oceanic frontal systems which may act to aggregate their prey (Seki et al. 2002) and enhance migration by providing an energetic gain by moving the fish along with favorable currents (Olsen et al. 1994).

3.3.4 Benthic Environment

The word *benthic* comes from the Greek work *benthos* or “depths of the sea.” The definition of the benthic (or demersal) environment is quite general in that it is regarded as extending from the high-tide mark to the deepest depths of the ocean floor. Benthic habitats are home to a wide range of marine organisms forming complex community structures. This section presents a simple description of the following benthic zones: (a) intertidal, (b) subtidal (e.g., coral reefs), (c) banks and seamounts, (d) deep-reef slope, and (e) deep-ocean bottom (see Figure 9).

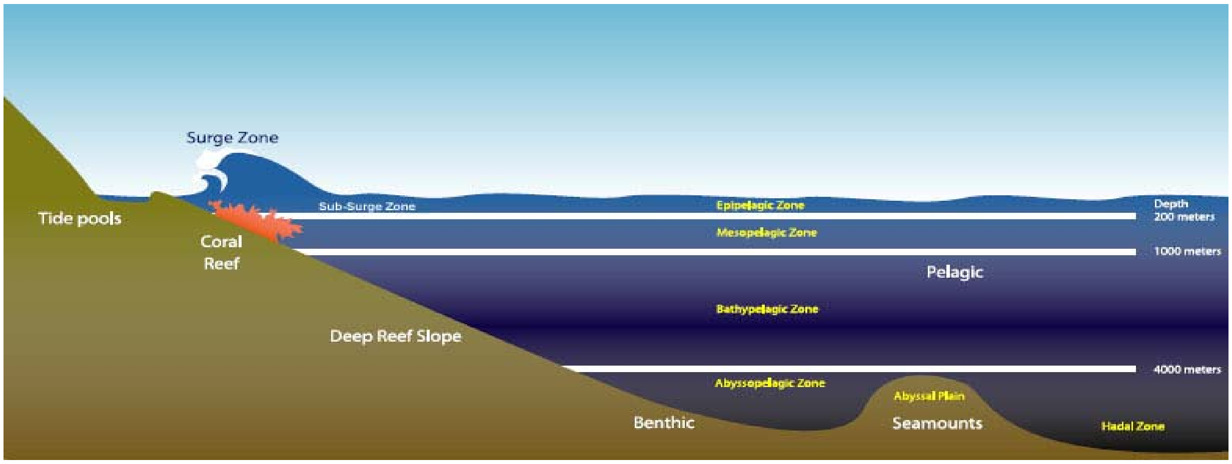

Figure 9: Benthic Environment
Source: Produced by WPRFMC

3.3.4.1 Intertidal Zone

The intertidal zone is a relatively small margin of seabed that exists between the highest and lowest extent of the tides. Because of wave action on unprotected coastlines, the intertidal zone can sometimes extend beyond tidal limits due to the splashing effect of waves. Vertical zonation among organisms is often observed in intertidal zones, where the lower limits of some organisms are determined by the presence of predators or competing species, whereas the upper limit is often controlled by physiological limits and species' tolerance to temperature and drying (Levington 1995). Organisms that inhabit the intertidal zone include algae, seaweeds, mollusks, crustaceans, worms, echinoderms (starfish), and cnidarians (e.g., anemones).

Many organisms in the intertidal zone have adapted strategies to combat the effects of temperature, salinity, and desiccation due to the wide-ranging tides of various locations. Secondary and tertiary consumers in intertidal zones include starfish, anemones, and seabirds. Marine algae are the primary produces in most intertidal areas. Many species' primary consumers such as snails graze on algae growing on rocky substrates in the intertidal zone. Due to the proximity of the intertidal zone to the shoreline, intertidal organisms are important food items to many human communities. In Hawaii, for example, intertidal limpet species (snails) such as opihi (*Cellana exarata*) were eaten by early Hawaiian communities and are still a popular food item in Hawaii today. In addition to mollusks, intertidal seaweeds are also important food items for Pacific islanders.

3.3.4.2 Seagrass Beds

Seagrasses are common in all marine ecosystems and are a regular feature of most of the inshore areas adjacent to coral reefs in the Pacific Islands. According to Hatcher et al. (1989), seagrasses stabilize sediments because leaves slow current flow, thus increasing sedimentation of particles. The roots and rhizomes form a complex matrix that binds sediments and stops erosion. Seagrass beds are the habitat of certain commercially valuable shrimps, and provide food for reef-associated species such as surgeonfishes (*Acanthuridae*) and rabbitfishes (*Siganidae*). Seagrasses are also important sources of nutrition for higher vertebrates such as dugongs and green turtles. A concise summary of the seagrass species found in the western tropical South Pacific is given by Coles and Kuo (1995). From the fisheries perspective, the fishes and other organisms harvested from the coral reef and associated habitats, such as mangroves, seagrass beds, shallow lagoons, bays, inlets and harbors, and the reef slope beyond the limit of coral reef growth, contribute to the total yield from coral reef-associated fisheries.

3.3.4.3 Mangrove Forests

Mangroves are terrestrial shrubs and trees that are able to live in the salty environment of the intertidal zone. Their prop roots form important substrate on which sessile organisms can grow, and they provide shelter for fishes. Mangroves are believed to also provide important nursery habitat for many juvenile reef fishes. The natural eastern limit of mangroves in the Pacific is American Samoa, although the red mangrove (*Rhizophora mangle*) was introduced into Hawaii in 1902, and has become the dominant plant within a number of large protected bays and coastlines on both Oahu and Molokai (Gulko 1998). Apart from the usefulness of the wood for building, charcoal, and tannin, mangrove forests stabilize areas where sedimentation is occurring and are important as nursery grounds for peneaeid shrimps and some inshore fish species. They also provide a habitat for some commercially valuable crustaceans.

3.3.4.4 Coral Reefs

Coral reefs are carbonate rock structures at or near sea level that support viable populations of scleractinian or reef-building corals. Apart from a few exceptions in the Pacific Ocean, coral reefs are confined to the warm tropical and subtropical waters lying between 30° N and 30° S. Coral reef ecosystems are some of the most diverse and complex ecosystems on Earth. Their complexity is manifest on all conceptual dimensions, including geological history, growth and structure, biological adaptation, evolution and biogeography, community structure, organism and ecosystem metabolism, physical regimes, and anthropogenic interactions (Hatcher et al. 1989).

Coral reefs and reef-building organisms are confined to the shallow upper euphotic zone. Maximum reef growth and productivity occur between 5 and 15 meters (Hopley and Kinsey 1988), and maximum diversity of reef species occurs at 10–30 meters (Huston 1985). Thirty meters has been described as a critical depth below which rates of growth (accretion) of coral reefs are often too slow to keep up with changes in sea level. This was true during the Holocene transgression over the past 10,000 years, and many reefs below this depth drowned during this period. Coral reef habitat does extend deeper than 30 meters, but few well-developed reefs are found below 50 meters. Many coral reefs are bordered by broad areas of shelf habitat (reef slope) between 50 and 100 meters that were formed by wave erosion during periods of lower sea levels. These reef slope habitats consist primarily of carbonate rubble, algae, and microinvertebrate communities, some of which may be important nursery grounds for some coral reef fish, as well as a habitat for several species of lobster. However, the ecology of this habitat is poorly known, and much more research is needed to define the lower depth limits of coral reefs, which by inclusion of shelf habitat could be viewed as extending to 100 meters.

The symbiotic relationship between the animal coral polyps and algal cells (dinoflagellates) known as zooxanthellae is a key feature of reef-building corals. Incorporated into the coral tissue, these photosynthesizing zooxanthellae provide much of the polyp's nutritional needs, primarily in the form of carbohydrates. Most corals supplement this food source by actively feeding on zooplankton or dissolved organic nitrogen, because of the low nitrogen content of the carbohydrates derived from photosynthesis. Due to reef-building coral's symbiotic relationship with photosynthetic zooxanthellae, reef-building corals do not generally occur at depths greater than 100 meters (~328 feet)(Hunter 1995).

Primary production on coral reefs is associated with phytoplankton, algae, seagrasses, and zooxanthellae. Primary consumers include many different species of corals, mollusks, crustaceans, echinoderms, gastropods, sea turtles, and fish (e.g., parrot fish). Secondary consumers include anemones, urchins, crustaceans, and fish. Tertiary consumers include eels, octopus, barracudas, and sharks.

The corals and coral reefs of the Pacific are described in Wells and Jenkins (1988) and Veron (1995). The number of coral species declines in an easterly direction across the western and central Pacific, which is in common with the distribution of fish and invertebrate species. More than 330 species are contained in 70 genera on the Australian Barrier Reef, compared with only 30 coral genera present in the Society Islands of French Polynesia and 10 genera in the Marquesas and Pitcairn Islands. Hawaii, by virtue of its isolated position in the Pacific, also has relatively few species of coral (about 50 species in 17 genera) and, more important, lacks most of the branching or "tabletop" *Acropora* species that form the majority of reefs elsewhere in the Pacific. The *Acropora* species provide a large amount of complex three-dimensional structure and protected habitat for a wide variety of fishes and invertebrates. As a consequence, Hawaiian coral reefs provide limited "protecting" three-dimensional space. This is thought to account for the exceptionally high rate of endemism among Hawaiian marine species. Furthermore, many believe that this is the reason certain fish and invertebrate species look and act very differently from similar members of the same species found in other parts of the South Pacific (Gulko 1998).

Coral Reef Productivity

Coral reefs are among the most biologically productive environments in the world. The global potential for coral reef fisheries has been estimated at nine million metric tons per year, which is impressive given the small area of reefs compared with the extent of other marine ecosystems, which collectively produce between 70 and 100 million metric tons per year (Munro 1984; Smith 1978). An apparent paradox of coral reefs, however, is their location in the low-nutrient areas of the tropical oceans. Coral reefs themselves are characterized by the highest gross primary production in the sea, with sand, rubble fields, reef flats, and margins adding to primary production rates. The main primary producers on coral reefs are the benthic microalgae, macroalgae, symbiotic microalgae of corals, and other symbiont-bearing invertebrates (Levington 1995). Zooxanthellae living in the tissues of hard corals make a substantial contribution to primary productivity in zones rich in corals due to their density—greater than 10^6 cells cm^{-2} of live coral surface—and the high rugosity of the surfaces on which they live, as well as their own photosynthetic potential. However, zones of high coral cover make up only a small part of entire coral reef ecosystems, so their contribution to total coral reef primary productivity is small (WPRFMC 2001).

Although the ocean's surface waters in the tropics generally have low productivity, these waters are continually moving. Coral reefs, therefore, have access to open-water productivity and thus, particularly in inshore continental waters, shallow benthic habitats such as reefs are not always the dominant sources of nutrients for fisheries. In coastal waters, detrital matter from land, plankton, and fringing marine plant communities are particularly abundant. There may be passive advection of particulate and dissolved detrital carbon onto reefs, as well as active transport onto reefs via fishes that shelter on reefs but that feed in adjacent habitats. There is, therefore, greater potential for nourishment of inshore reefs than offshore reefs by external sources, and this inshore nourishment is enhanced by large land masses (Birkeland 1997).

For most of the Pacific Islands, rainfall typically ranges from 2,000 to 3,500 millimeters per year. Low islands, such as atolls, tend to have less rainfall and may suffer prolonged droughts. Furthermore, when rain does fall on coral islands that have no major catchment area, there is little nutrient input into surrounding coastal waters and lagoons. Lagoons and embayments around high islands in the South Pacific are, therefore likely to be more productive than atoll lagoons. There are, however, some exceptions such as Palmyra Atoll and Rose Atoll which receive up to 4,300 millimeters of rain per year. The productivity of high-island coastal waters, particularly where there are lagoons and sheltered waters, is possibly reflected in the greater abundance of small pelagic fishes such as anchovies, sprats, sardines, scads, mackerels, and fusiliers. In addition, the range of different environments that can be found in the immediate vicinity of the coasts of high islands also contributes to the greater range of biodiversity found in such locations.

Coral Reef Communities

A major portion of the primary production of the coral reef ecosystem comes from complex interkingdom relationships of animal/plant photosymbioses hosted by animals of many taxa, most notably stony corals. Most of the geological structure of reefs and habitat are produced by these complex symbiotic relationships. Complex symbiotic relationships for defense from predation, removal of parasites, building of domiciles, and other functions are also prevalent. About 32 of the 33 animal phyla are represented on coral reefs (only 17 are represented in terrestrial environments), and this diversity produces complex patterns of competition. The diversity also produces a disproportionate representation of predators, which have strong influences on lower levels of the food web in the coral reef ecosystem (Birkeland 1997).

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

Typically, spawning of coral reef fish occurs in the vicinity of the reef and is characterized by frequent repetition throughout a protracted time of the year, a diverse array of behavioral patterns, and an extremely high fecundity. Coral reef species exhibit a wide range of strategies related to larval dispersal and ultimately recruitment into the same or new areas. Some larvae are dispersed as short-lived, yolk-dependent (lecithotrophic) organisms, but the majority of coral reef invertebrate species disperse their larvae (planktotrophic) into the pelagic environment to feed on various types of plankton (Levington 1995). For example, larvae of the coral *Pocillopora damicornis*, which is widespread throughout the Pacific, has been found in the plankton of the open ocean exhibiting a larval life span of more than 100 days (Levington 1995). Because many coral reefs are space limited for settlement, therefore, planktotrophic larvae are a likely strategy to increase survival in other areas (Levington 1995). Coral reef fish experience their highest predation mortality in their first few days or weeks, thus rapid growth out of the juvenile stage is a common strategy.

The condition of the overall populations of particular species is linked to the variability among subpopulations: the ratio of sources and sinks, their degrees of recruitment connection, and the proportion of the subpopulations with high variability in reproductive capacity. Recruitment to populations of coral reef organisms depends largely on the pathways of larval dispersal and "downstream" links.

Reproduction and Recruitment

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

Growth and Mortality Rates

Recruitment of coral reef species is limited by high mortality of eggs and larvae, and also by competition for space to settle out on coral reefs. Predation intensity is due to a disproportionate number of predators, which limits juvenile survival (Birkeland 1997). In response, some fishes—such as scarids (parrotfish) and labrids (wrasses)—grow rapidly compared with other coral reef fishes. But they still grow relatively slowly compared with pelagic species. In addition, scarids and labrids may have complex haremic territorial social structures that contribute to the overall effect of harvesting these resources. It appears that many tropical reef fishes grow rapidly to near-adult size, and then often grow relatively little over a protracted adult life span; they are thus relatively long lived. In some groups of fishes, such as damselfish, individuals of the species are capable of rapid growth to adult size, but sexual maturity is still delayed by social pressure. This complex relationship between size and maturity makes resource management more difficult (Birkeland 1997).

Community Variability

High temporal and spatial variability is characteristic of reef communities. At large spatial scales, variation in species assemblages may be due to major differences in habitat types or biotopes. Seagrass beds, reef flats, lagoonal patch reefs, reef crests, and seaward reef slopes may occur in relatively close proximity, but represent notably different habitats. For example, reef fish communities from the geographically isolated Hawaiian Islands are characterized by low species richness, high endemism, and exposure to large semiannual current gyres, which may help retain planktonic larvae. The Northwestern Hawaiian Islands (NWHI) are further characterized by (a) high-latitude coral atolls; (b) a mild temperate to subtropical climate, where inshore water temperatures can drop below 18° C in late winter; (c) species that are common on shallow reefs and attain large sizes, which to the southeast occur only rarely or in deep water; and (d) inshore shallow reefs that are largely free of fishing pressure (Maragos and Gulko 2002).

3.3.4.5 Deep Reef Slopes

As most Pacific islands are oceanic islands versus continental islands, they generally lack an extensive shelf area of relatively shallow water extending beyond the shoreline. For example, the average global continental shelf extends 40 miles, with a depth of around 200 feet (Postma and Zijlstra 1988). While lacking a shelf, many oceanic islands have a deep reef slope, which is often angled between 45° and 90° toward the ocean floor. The deep reef slope is home to a wide variety of marine of organisms that are important fisheries target species such as snappers and groupers. Biological zonation does occur on the reef slope, and is related to the limit of light penetration beyond 100 meters. For example, reef-building corals can be observed at depths less than 100 meters, but at greater depths gorgonian and black corals are more readily observed (Colin et al. 1986).

3.3.4.6 Banks and Seamounts

Banks are generally volcanic structures of various sizes and occur both on the continental shelf and in oceanic waters. Coralline structures tend to be associated with shallower parts of the banks as reef-building corals are generally restricted to a maximum depth of 30 meters. Deeper parts of banks may be composed of rock, coral rubble, sand, or shell deposits. Banks thus support a variety of habitats that in turn support a variety of fish species (Levington 1995).

Fish distribution on banks is affected by substrate types and composition. Those suitable for lutjanids, serranids, and lethrinids tend to be patchy, leading to isolated groups of fish with little lateral exchange or adult migration except when patches are close together. These types of assemblages may be regarded as consisting of metapopulations that are associated with specific features or habitats and are interconnected through larval dispersal.

From a genetic perspective, individual patch assemblages may be considered as the same population; however, not enough is known about exchange rates to distinguish discrete populations.

Seamounts are undersea mountains, mostly of volcanic origin, which rise steeply from the sea bottom to below sea level (Rogers 1994). On seamounts and surrounding banks, species composition is closely related to depth. Deep-slope fisheries typically occur in the 100–500 meter depth range. A rapid decrease in species richness typically occurs between 200 and 400 meters deep, and most fishes observed there are associated with hard substrates, holes, ledges, or caves (Chave and Mundy 1994). Territoriality is considered to be less important for deep-water species of serranids, and lutjanids tend to form loose aggregations. Adult deep-water species are believed to not normally migrate between isolated seamounts.

Seamounts have complex effects on ocean circulation. One effect, known as the Taylor column, relates to eddies trapped over seamounts to form quasi-closed circulations. It is hypothesized that this helps retain pelagic larvae around seamounts and maintain the local fish population. Although evidence for retention of larvae over seamounts is sparse (Boehlert and Mundy 1993), endemism has been reported for a number of fish and invertebrate species at seamounts (Rogers 1994). Wilson and Kaufman (1987) concluded that seamount species are dominated by those on nearby shelf areas, and that seamounts act as stepping stones for transoceanic dispersal. Snappers and groupers both produce pelagic eggs and larvae, which tend to be most abundant over deep reef slope waters, while larvae of Etelis snappers are generally found in oceanic waters. It appears that populations of snappers and groupers on seamounts rely on inputs of larvae from external sources.

3.3.4.7 Deep Ocean Floor

At the end of reef slopes lies the dark and cold world of the deep ocean floor. Composed of mostly mud and sand, the deep ocean floor is home to deposit feeders and suspension feeders, as well as fish and marine mammals. Compared with shallower benthic areas (e.g., coral reefs), benthic deep-slope areas are lower in productivity and biomass. Due to the lack of sunlight, primary productivity is low, and many organisms rely on deposition of organic matter that sinks to the bottom. The occurrence of secondary and tertiary consumers decreases the deeper one goes due to the lack of available prey. With increasing depth, suspension feeders become less abundant and deposit feeders become the dominant feeding type (Levington 1995).

Although most of the deep seabed is homogenous and low in productivity, there are hot spots teeming with life. In areas of volcanic activity such as the mid-oceanic ridge, thermal vents exist that spew hot water loaded with various metals and dissolved sulfide. Bacteria found in these areas are able to make energy from the sulfide (thus considered primary producers) on which a variety of organisms either feed or contain in their bodies within special organs called “trophosomes.” Types of organisms found near these thermal vents include crabs, limpets, tubeworms, and bivalves (Levington 1995).

3.3.4.8 Benthic Species of Economic Importance

Coral Reef Associated Species

The most commonly harvested species of coral reef associated organisms include the following: surgeonfishes (Acanthuridae), triggerfishes (Balistidae), jacks (Carangidae), parrotfishes

(Scaridae), soldierfishes/squirrelfishes (Holocentridae), wrasses (Labridae), octopus (*Octopus cyanea, O. ornatus*), goatfishes (Mullidae), and giant clams (Tridacnidae). Studies on coral reef fisheries are relatively recent, commencing with the major study by Munro and his co-workers during the late 1960s in the Caribbean (Munro 1983). Even today, only a relatively few examples are available of in-depth studies on reef fisheries.

It was initially thought that the maximum sustainable yields for coral reef fisheries were in the range of 0.5–5 t km^{-2} yr^{-1}, based on limited data (Marten and Polovina 1982; Stevenson and Marshall 1974). Much higher yields of around 20 t km^{-2} yr^{-1}, for reefs in the Philippines (Alcala 1981; Alcala and Luchavez 1981) and American Samoa (Wass 1982), were thought to be unrepresentative (Marshall 1980), but high yields of this order have now been independently estimated for a number of sites in the South Pacific and Southeast Asia (Dalzell and Adams 1997; Dalzell et al. 1996). These higher estimates are closer to the maximum levels of fish production predicted by trophic and other models of ecosystems (Polunin and Roberts 1996). Dalzell and Adams (1997) suggested that the average maximum stainable yield (MSY) for Pacific reefs is in the region of 16 t km^{-2} yr^{-1} based on 43 yield estimates where the proxy for fishing effort was population density.

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

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

Another important aspect of the yield question is the resilience of reefs to fishing, and recovery potential when overfishing or high levels of fishing effort have been conducted on coral reefs. Evidence from a Pacific atoll where reefs are regularly fished by community fishing methods, such as leaf sweeps and spearfishing, indicates that depleted biomass levels may recover to preexploitation levels within one to two years. In the Philippines, abundances of several reef fishes have increased in small reserves within a few years of their establishment (Russ and Alcala 1994; White 1988), although recovery in numbers of fish is much faster than recovery of biomass, especially in larger species such as groupers. Other studies in the Caribbean and Southeast Asia (Polunin and Roberts 1996) indicate that reef fish populations in relatively small areas have the potential to recover rapidly from depletion in the absence of further fishing. Conversely, Birkeland (1997) cited the example of a pinnacle reef off Guam fished down over a period of six months in 1967 that has still not recovered 30 years later.

Estimating the recovery from, and reversibility of, fishing effects over large reef areas appears more difficult to determine. Where growth overfishing predominates, recovery following effort reduction may be rapid if the fish in question are fast growing, as in the case of goatfish (Garcia and Demetropolous 1986). However, recovery may be slower if biomass reduction is due to recruitment overfishing because it takes time to rebuild adult spawning biomasses and high fecundities (Polunin and Morton 1992). Furthermore, many coral reef species have limited distributions; they may be confined to a single island or a cluster of proximate islands. Widespread heavy fishing could cause global extinctions of some such species, particularly if there is also associated habitat damage.

Crustaceans

Crustaceans are harvested on small scales throughout the inhabited islands of the Western Pacific Region. The most common harvests include lobster species of the taxonomic groups *Palinuridae* (spiny lobsters) and *Scyllaridae* (slipper lobsters). Adult spiny lobsters are typically found on rocky substrate in well-protected areas, in crevices, and under rocks. Unlike many other species of *Panulirus*, the juveniles and adults of *P. marginatus* are not found in separate habitats apart from one another (MacDonald and Stimson 1980; Parrish and Polovina 1994). Juvenile *P. marginatus* recruit directly to adult habitat; they do not utilize separate shallow-water nursery habitat apart from the adults as do many Palinurid lobsters (MacDonald and Stimson 1980; Parrish and Polovina 1994). Juvenile and adult *P. penicillatus* also share the same habitat (Pitcher 1993).

In the southwestern Pacific, spiny lobsters are typically found in association with coral reefs which provide shelter as well as a diverse and abundant supply of food items. Kanciruk (1980) and Pitcher (1993) found that *P. penicillatus* inhabits the rocky shelters in the windward surf zones of oceanic reefs while other species of *Panulirus* show more general patterns of habitat utilization. As nocturnal predators, *P. penicillatus* moves onto reef flat at night to forage.

Spiny lobsters are non-clawed decapod crustaceans with slender walking legs of roughly equal size. Spiny lobster have a large spiny carapace with two horns and antennae projecting forward of their eyes and a large abdomen terminating in a flexible tailfan (Uchida et al.1980). Uchida and Uchiyama (1986) provided a detailed description of the morphology of slipper lobsters (*S. squammosus* and *S. haanii)* and noted that the two species are very similar in appearance and are easily confused (Uchida and Uchiyama 1986). The appearance of the slipper lobster is notably different than that of the spiny lobster.

Spiny lobsters (*Panulirus* spp.) are dioecious, i.e., have separate male and femail individuals (Uchida and Uchiyama 1986). The male spiny lobster deposits a spermatophore or sperm packet on the female's abdomen and fertilization of the eggs occurs externally (Uchida et al. 1980). The female lobster scratches and breaks the mass, releasing the spermatozoa while simultaneously ova are released from the female's oviduct, are fertilized and attach to the setae of the female's pleopods. At this point, the female lobster is ovigerous, or "berried" (WPRFMC 1983). The fertilized eggs hatch into phyllosoma larvae after 30–40 days (MacDonald 1986; Uchida and Uchiyama 1986). Spiny lobsters have very high fecundity (WPRFMC 1983). The release of the phyllosoma larvae appears to be timed to coincide with the full moon and in some species at dawn (Pitcher 1993). In *Scyllarides* spp. fertilization is internal (Uchida and Uchiyama 1986).

Very little is known about the planktonic phase of the phyllosoma larvae of *Panulirus marginatus* (Uchida et al. 1980). After hatching, the "leaf-like" larvae (or phyllosoma) enter a planktonic phase, the duration of which varies depending on the species and geographic region.

Johnson (1968) suggested that fine-scale oceanographic features, such as eddies and currents, serve to retain lobster larvae within island areas. In the NWHI, for example, lobster's larvae settlement appears to be linked to the north and southward shifts of the North Pacific Central Water type (MacDonald 1986). The relatively long pelagic larval phase for palinurids results in very wide dispersal of spiny lobster larvae; palinurid larvae are transported up to 2,000 miles by prevailing ocean currents (MacDonald 1986).

Reef Slope, Bank, and Seamount Associated Species

Bottomfish

The families of bottomfish and seamount fish that are often targeted by fishermen include snappers (*Lutjanidae*), groupers (*Serranidae*), jacks (*Carangidae*), and emperors (*Lethrinidae*). Distinct depth associations are reported for certain species of emperors, snappers, and groupers. Many snappers and some groupers are restricted to feeding in deep water (Parrish 1987). The emperor family contains bottom-feeding carnivorous fishes frequently found in shallow coastal waters on or near reefs, with some species observed at greater depths (e.g., *L. rubrioperculatus*). Lethrinids are not reported to be territorial, but may be solitary or form schools. The snapper family is largely confined to continental shelves and slopes, as well as corresponding depths around islands. Adults are usually associated with the bottom. The genus *Lutjanus* is the largest of this family, consisting primarily of inhabitants of shallow reefs. Species of the genus *Pristipomoides* occur at intermediate depths, often schooling around rocky outcrops and promontories (Ralston et al. 1986), while *Eteline* snappers are deep-water species. Groupers are relatively larger and mostly occur in shallow areas, although some occupy deep-slope habitats. Groupers in general are more sedentary and territorial than snappers or emperors, and are more dependent on hard substrata. In general, groupers may be less dependent on hard-bottom substrates at depth (Parrish 1987). For each family, schooling behavior is reported more frequently for juveniles than for adults. Spawning aggregations may, however, occur even for the solitary species at certain times of the year, especially among groupers.

A commonly reported trend is that juveniles occur in shallow water and adults are found in deeper water (Parrish 1989). Juveniles also tend to feed in different habitats than adults, possibly reflecting a way to reduce predation pressures. Not much is known about the location and characteristics of nursery grounds for juvenile deep-slope snappers and groupers. In Hawaii, juvenile opakapaka (*P. filamentosus)* have been found on flat, featureless shallow banks, as opposed to high-relief areas where the adults occur. Similarly, juveniles of the deep-slope grouper, Hāpu`upu`u (*Epinephelus quernus*), are found in shallow water (Moffitt 1993). Ralston and Williams (1988), however, found that for deep-slope species, size is poorly correlated with depth.

The distribution of adult bottomfish is correlated with suitable physical habitat. Because of the volcanic nature of the islands within the region, most bottomfish habitat consists of steep-slope areas on the margins of the islands and banks. The habitat of the major bottomfish species tend to overlap to some degree, as indicated by the depth range where they are caught. Within the overall depth range, however, individual species are more common at specific depth intervals.

Depth alone does not assure satisfactory habitat. Both the quantity and quality of habitat at depth are important. Bottomfish are typically distributed in a non-random patchy pattern, reflecting bottom habitat and oceanographic conditions. Much of the habitat within the depths of occurrence of bottomfish is a mosaic of sandy low-relief areas and rocky high-relief areas. An important component of the habitat for many bottomfish species appears to be the association of high-relief areas with water movement. In the Hawaiian Islands and at Johnston Atoll, bottomfish density is correlated with areas of high relief and current flow (Haight 1989; Haight et al. 1993a; Ralston et al. 1986).

Although the water depths utilized by bottomfish may overlap somewhat, the available resources may be partitioned by species-specific behavioral differences. In a study of the feeding habitats of the commercial bottomfish in the Hawaii archipelago, Haight et al. (1993b) found that ecological competition between bottomfish species appears to be minimized through species-specific habitat utilization. Species may partition the resource through both the depth and time of feeding activity, as well as through different prey preferences.

Precious Corals

Currently, there are minimal harvests of precious corals in the Western Pacific Region. However, in the 1970s to early 1990s both deep- and shallow-water precious corals were targeted in EEZ waters around Hawaii. The commonly harvested precious corals include pink coral (*Corallium secundum, Corallium regale, Corallium laauense*), gold coral (*Narella* spp., *Gerardia* spp., *Calyptrophora* spp.), bamboo coral (*Lepidisis olapa, Acanella* spp.), and black coral (*Antipathes dichotoma*, *Antipathes grandis*, *Antipathes ulex*).

In general, western Pacific precious corals share several ecological characteristics: they lack symbiotic algae in tissues (they are ahermatypic), and most are found in deep water below the euphotic zone; they are filter feeders; and many are fan shaped to maximize contact surfaces with particles or microplankton in the water column. Because precious corals are filter feeders, most species thrive in areas swept by strong-to-moderate currents (Grigg 1993). Although precious corals are known to grow on a variety of hard substrate, they are most abundant on substrates of shell sandstone, limestone, or basaltic rock with a limestone veneer.

All precious corals are slow growing and are characterized by low rates of mortality and recruitment. Natural populations are relatively stable, and a wide range of age classes is generally present. This life history pattern (longevity and many year classes) has two important consequences with respect to exploitation. First, the response of the population to exploitation is drawn out over many years. Second, because of the great longevity of individuals and the associated slow rates of turnover in the populations, a long period of reduced fishing effort is required to restore the ability of the stock to produce at the MSY if a stock has been over exploited for several years.

Because of the great depths at which they live, precious corals may be insulated from some short-term changes in the physical environment; however, not much is known regarding the long-term effects of changes in environmental conditions, such as water temperature or current velocity, on the reproduction, growth, or other life history characteristics of the precious corals (Grigg 1993).

3.3.5 Protected Species

To varying degrees, protected species in the Western Pacific Region face various natural and anthropogenic threats to their continued existence. These threats include regime shifts, habitat degradation, poaching, fisheries interactions, vessel strikes, disease, and behavioral alterations from various disturbances associated with human activities. This section presents available information on the current status of protected species (generally identified as sea turtles, marine mammals, and seabirds) known to occur (perhaps only occasionally) in waters within the boundaries of this FEP.

3.3.5.1 Sea Turtles

All Pacific sea turtles are designated under the Endangered Species Act as either threatened or endangered. The breeding populations of Mexico's olive ridley sea turtles (*Lepidochelys olivacea*) are currently listed as endangered, while all other ridley populations are listed as threatened. Leatherback sea turtles (*Dermochelys coriacea*) and hawksbill turtles (*Eretmochelys imbricata*) are also classified as endangered. Loggerhead (*Caretta caretta*) and green sea turtles (*Chelonia mydas*) are listed as threatened (the green sea turtle is listed as threatened throughout its Pacific range, except for the endangered population nesting on the Pacific coast of Mexico). These five species of sea turtles are highly migratory, or have a highly migratory phase in their life history (NMFS 2001).

Leatherback Sea Turtles

Leatherback turtles (*Dermochelys coriacea*) are widely distributed throughout the oceans of the world, and are found in waters of the Atlantic, Pacific, and Indian Oceans; the Caribbean Sea; and the Gulf of Mexico (Dutton et al. 1999). Increases in the number of nesting females have been noted at some sites in the Atlantic (Dutton et al. 1999), but these are far outweighed by local extinctions, especially of island populations, and the demise of once-large populations throughout the Pacific, such as in Malaysia (Chan and Liew 1996) and Mexico (Sarti et al. 1996; Spotila et al. 1996). In other leatherback nesting areas, such as Papua New Guinea, Indonesia, and the Solomon Islands, there have been no systematic, consistent nesting surveys, so it is difficult to assess the status and trends of leatherback turtles at these beaches. In all areas where leatherback nesting has been documented, current nesting populations are reported by scientists, government officials, and local observers to be well below abundance levels of several decades ago. The collapse of these nesting populations was most likely precipitated by a tremendous overharvest of eggs coupled with incidental mortality from fishing (Sarti et al. 1996).

Leatherback turtles are the largest of the marine turtles, with a shell length often exceeding 150 centimeters and front flippers that are proportionately larger than in other sea turtles and that may span 270 centimeters in an adult (NMFS and USFWS1998). The leatherback is morphologically and physiologically distinct from other sea turtles, and it is thought that its streamlined body, with a smooth dermis-sheathed carapace and dorso-longitudinal ridges may improve laminar flow.

Leatherback turtles lead a completely pelagic existence, foraging widely in temperate waters, except during the nesting season when gravid females return to tropical beaches to lay eggs. Males are rarely observed near nesting areas, and it has been proposed that mating most likely takes place outside of tropical waters, before females move to their nesting beaches (Eckert and Eckert 1988). Leatherbacks are highly migratory, exploiting convergence zones and upwelling areas in the open ocean, along continental margins, and in archipelagic waters (Eckert 1998). In a single year, a leatherback may swim more than 10,000 kilometers (Eckert 1998).

Satellite telemetry studies indicate that adult leatherback turtles follow bathymetric contours over their long pelagic migrations and typically feed on cnidarians (jellyfish and siphonophores) and tunicates (pyrosomas and salps), and their commensals, parasites, and prey (NMFS 1998). Because of the low nutrition value of jellyfish and tunicates, it has been estimated that an adult leatherback would need to eat about 50 large jellyfish (equivalent to approximately 200 liters) per day to maintain its nutritional needs (Duron 1978). Compared with greens and loggerheads, which consume approximately 3–5 percent of their body weight per day, leatherback turtles may consume 20–30 percent of their body weight per day (Davenport and Balazs 1991).

Females are believed to migrate long distances between foraging and breeding grounds, at intervals of typically two or four years (Spotila et al. 2000). The mean renesting interval of females on Playa Grande, Costa Rica to be 3.7 years, while in Mexico, 3 years was the typical reported interval (L. Sarti, Universidad Naçional Autonoma de Mexico [UNAM], personal communication, 2000 in NMFS 2004). In Mexico, the nesting season generally extends from November to February, although some females arrive as early as August (Sarti et al. 1996). Most of the nesting on Las Baulas takes place from the beginning of October to the end of February (Reina et al. 2002). In the western Pacific, nesting peaks on Jamursba-Medi Beach (Papua, Indonesia) from May to August, on War-Mon Beach (Papua) from November to January (Starbird and Suarez 1994), in peninsular Malaysia during June and July (Chan and Liew 1989), and in Queensland, Australia in December and January (Limpus and Reimer1994).

Migratory routes of leatherback turtles originating from eastern and western Pacific nesting beaches are not entirely known. However, satellite tracking of postnesting females and genetic analyses of leatherback turtles caught in U.S. Pacific fisheries or stranded on the west coast of the U.S. presents some strong insights into at least a portion of their routes and the importance of particular foraging areas. Current data from genetic research suggest that Pacific leatherback stock structure (natal origins) may vary by region. Due to the fact that leatherback turtles are highly migratory and that stocks mix in high-seas foraging areas, and based on genetic analyses of samples collected by both Hawaii-based and west-coast-based longline observers, leatherback turtles inhabiting the northern and central Pacific Ocean comprise individuals originating from nesting assemblages located south of the equator in the western Pacific (e.g., Indonesia, Solomon Islands) and in the eastern Pacific along the Americas (e.g., Mexico, Costa Rica; Dutton et al. 2000).

Recent information on leatherbacks tagged off the west coast of the United States has also revealed an important migratory corridor from central California to south of the Hawaiian Islands, leading to western Pacific nesting beaches. Leatherback turtles originating from western Pacific beaches have also been found along the U.S. mainland. There, leatherback turtles have been sighted and reported stranded as far north as Alaska (60° N) and as far south as San Diego, California (NMFS 1998). Of the stranded leatherback turtles that have been sampled to date from the U.S. mainland, all have been of western Pacific nesting stock origin (P. Dutton NMFS, personal communication 2000 in NMFS 2004).

Loggerhead Sea Turtles

The loggerhead sea turtle (*Caretta caretta*) is characterized by a reddish brown, bony carapace, with a comparatively large head, up to 25 centimeters wide in some adults. Adults typically weigh between 80 and 150 kilograms, with average curved carapace length (CCL) measurements for adult females worldwide between 95—100 centimeters CCL (Dodd 1988) and adult males in Australia averaging around 97 centimeters CCL (Limpus 1985, in Eckert 1993). Juveniles found off California and Mexico measured between 20 and 80 centimeters (average 60 cm) in length (Bartlett 1989, in Eckert 1993). Skeletochronological age estimates and growth rates were derived from small loggerheads caught in the Pacific high-seas driftnet fishery. Loggerheads less than 20 centimeters were estimated to be 3 years old or less, while those greater than 36 centimeters were estimated to be 6 years old or more. Age-specific growth rates for the first 10 years were estimated to be 4.2 cm/year (Zug et al. 1995).

For their first years of life, loggerheads forage in open-ocean pelagic habitats. Both juvenile and subadult loggerheads feed on pelagic crustaceans, mollusks, fish, and algae. The large aggregations of juveniles off Baja California have been observed foraging on dense concentrations of the pelagic red crab *Pleuronocodes planipes* (Nichols et al. 2000). Data collected from stomach samples of turtles captured in North Pacific driftnets indicate a diet of gastropods (*Janthina* spp.), heteropods (*Carinaria* spp.), gooseneck barnacles (*Lepas* spp.), pelagic purple snails (*Janthina* spp.), medusae (*Vellela* spp.), and pyrosomas (tunicate zooids). Other common components include fish eggs, amphipods, and plastics (Parker et al. 2002).

Loggerheads in the North Pacific are opportunistic feeders that target items floating at or near the surface, and if high densities of prey are present, they will actively forage at depth (Parker et al. 2002). As they age, loggerheads begin to move into shallower waters, where, as adults, they forage over a variety of benthic hard- and soft-bottom habitats (reviewed in Dodd, 1988). Subadults and adults are found in nearshore benthic habitats around southern Japan, as well as in the East China Sea and the South China Sea (e.g., Philippines, Taiwan, Vietnam).

The loggerhead sea turtle is listed as threatened under the ESA throughout its range, primarily due to direct take, incidental capture in various fisheries, and the alteration and destruction of its habitat. In general, during the last 50 years, North Pacific loggerhead nesting populations have declined 50–90 percent (Kamezaki et al. 2003). From nesting data collected by the Sea Turtle Association of Japan since 1990, the latest estimates of the number of nesting females in almost all of the rookeries are as follows: 1998 –2,479 nests, 1999 –2,255 nests, and 2000 –2,589 nests.[15]

In the South Pacific, Limpus (1982) reported an estimated 3,000 loggerheads nesting annually in Queensland, Australia during the late 1970s. However, long-term trend data from Queensland indicate a 50 percent decline in nesting by 1988–89 due to incidental mortality of turtles in the coastal trawl fishery. This decline is corroborated by studies of breeding females at adjacent feeding grounds (Limpus and Reimer 1994). Currently, approximately 300 females nest annually in Queensland, mainly on offshore islands (Capricorn-Bunker Islands, Sandy Cape, Swains Head; Dobbs 2001). In southern Great Barrier Reef waters, nesting loggerheads have declined approximately 8 percent per year since the mid-1980s (Heron Island), while the foraging ground population has declined 3 percent and comprised less than 40 adults by 1992. Researchers attribute the declines to recruitment failure due to fox predation of eggs in the 1960s and mortality of pelagic juveniles from incidental capture in longline fisheries since the 1970s (Chaloupka and Limpus 2001).

Green Sea Turtles

Green turtles (*Chelonia mydas*) are distinguished from other sea turtles by their smooth carapace with four pairs of lateral “scutes,” a single pair of prefrontal scutes, and a lower jaw edge that is coarsely serrated. Adult green turtles have a light to dark brown carapace, sometimes shaded with olive, and can exceed 1 meter in carapace length and 100 kilograms in body mass. Females nesting in Hawaii averaged 92 centimeters in straight carapace length (SCL), while at Olimarao Atoll in Yap, females averaged 104 centimeters in curved carapace length and approximately 140 kilograms in body mass. In the rookeries of Michoacán, Mexico, females averaged 82 centimeters in CCL, while males averaged 77 centimeters in CCL (NMFS1998). Based on growth rates observed in wild green turtles, skeletochronological studies, and capture–recapture studies, all in Hawaii, it is estimated that an average of at least 25 years would be needed to achieve sexual maturity (Eckert 1993).

Although most adult green turtles appear to have a nearly exclusively herbivorous diet, consisting primarily of seagrass and algae (Wetherall 1993), those along the east Pacific coast

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[15] In the 2001, 2002, and 2003 nesting seasons, a total of 3,122, 4,035 and 4,519 loggerhead nests, respectively, were recorded on Japanese beaches (Matsuzawa, March 2005, final report to the WPRFMC).

seem to have a more carnivorous diet. Analysis of stomach contents of green turtles found off Peru revealed a large percentage of mollusks and polychaetes, while fish and fish eggs, jellyfish, and commensal amphipods made up a lesser percentage (Bjorndal 1997). Seminoff et al. (2000) found that 5.8 percent of gastric samples and 29.3 percent of the fecal samples of east Pacific green turtles foraging in the northern Sea of Cortéz, Mexico, contained the remains of the fleshy sea pen (*Ptilosarcus undulatus*).

Green sea turtles are a circumglobal and highly migratory species, nesting and feeding in tropical/subtropical regions. Their range can be defined by a general preference for water temperature above 20° C. Green sea turtles are known to live in pelagic habitats as posthatchlings/juveniles, feeding at or near the ocean surface. The non-breeding range of this species can lead a pelagic existence many miles from shore while the breeding population lives primarily in bays and estuaries, and are rarely found in the open ocean. Most migration from rookeries to feeding grounds is via coastal waters, with females migrating to breed only once every two years or more (Bjorndal 1997).

Tag returns of eastern Pacific green turtles (often reported as black turtles) establish that these turtles travel long distances between foraging and nesting grounds. In fact, 75 percent of tag recoveries from 1982–1990 were from turtles that had traveled more than 1,000 kilometers from Michoacán, Mexico. Even though these turtles were found in coastal waters, the species is not confined to these areas, as indicated by sightings recorded in 1990 from a NOAA research ship. Observers documented green turtles 1,000–2,000 statute miles from shore (Eckert 1993). The east Pacific green is also the second-most sighted turtle in the east Pacific during tuna cruises; they frequent a north–south band from 15° N to 5° S along 90° W and an area between the Galapagos Islands and the Central American Coast (NMFS 1998).

In a review of sea turtle sighting records from northern Baja California to Alaska, Stinson (1984, in NMFS 1998) determined that the green turtle was the most commonly observed sea turtle on the U.S. Pacific coast, with 62 percent reported in a band from southern California and southward. The northernmost (reported) year-round resident population of green turtles occurs in San Diego Bay, where about 30–60 mature and immature turtles concentrate in the warm water effluent discharged by a power plant. These turtles appear to have originated from east Pacific nesting beaches, on the basis of morphology and preliminary genetic analysis (NMFS 1998). California stranding reports from 1990–1999 indicate that the green turtle is the second most commonly found stranded sea turtle (48 total, averaging 4.8 annually; J. Cordaro, NMFS, personal communication, April 2000, NMFS 2004).

Stinson (1984) found that green turtles will appear most frequently in U.S. coastal waters when temperatures exceed 18° C. An east Pacific green turtle was tracked along the California coast by a satellite transmitter that was equipped to report thermal preferences of the turtle. This turtle showed a distinct preference for waters that were above 20° (S. Eckert, unpublished data). Subadult green turtles routinely dive to 20 meters for 9–23 minutes, with a maximum recorded dive of 66 minutes (Lutcavage et al. 1997).

The non-breeding range of green turtles is generally tropical, and can extend approximately 500–800 miles from shore in certain regions (Eckert 1993). The underwater resting sites include coral recesses, undersides of ledges, and sand bottom areas that are relatively free of strong currents and disturbance from natural predators and humans. In the Pacific, the only major (> 2,000 nesting females) populations of green turtles occur in Australia and Malaysia. Smaller colonies occur in the insular Pacific islands of Polynesia, Micronesia, and Melanesia (Wetherall 1993) and on six small sand islands at French Frigate Shoals (FFS), a long atoll situated in the middle of the Hawaii archipelago (Balazs et al. 1994).

Green turtles were listed as threatened under the ESA on July 28, 1978, except for breeding populations found in Florida and the Pacific coast of Mexico, which were listed as endangered. Using a precautionary estimate, the number of nesting female green turtles has declined by 48 percent to 67 percent over the last three generations (~150 years; Troeng and Rankin 2005). Causes for this decline include harvest of eggs, subadults, and adults; incidental capture by fisheries; loss of habitat; and disease. The degree of population change is not consistent among all index nesting beaches or among all regions. Some nesting populations are stable or increasing (Balazs and Chaloupka 2004; Chaloupka and Limpus 2001; Troeng and Rankin 2005). However, other populations or nesting stocks have markedly declined. Because many of the threats that have led to these declines have not yet ceased, it is evident that green turtles face a measurable risk of extinction (Troeng and Rankin 2005).

Green turtles in Hawaii are considered genetically distinct and geographically isolated, although a nesting population at Islas Revillagigedos in Mexico appears to share the mtDNA haplotype that commonly occurs in Hawaii. In Hawaii, green turtles nest on six small sand islands at French Frigate Shoals, a crescent-shaped atoll situated in the middle of the Hawaii archipelago (Northwestern Hawaiian Islands; Balazs et al. 1995). Ninety to 95 percent of the nesting and breeding activity occurs at the French Frigate Shoals, and at least 50 percent of that nesting takes place on East Island, a 12-acre island. Long-term monitoring of the population shows that there is strong island fidelity within the regional rookery. Low-level nesting also occurs at Laysan Island, Lisianski Island, and on Pearl and Hermes Reef (NMFS and USFWS 1998a).

Since the establishment of the ESA in 1973, and following years of exploitation, the nesting population of Hawaiian green turtles has shown a gradual but definite increase (Balazs 1996; Balazs and Chaloupka 2004). In three decades, the number of nesting females at East Island FFS increased from 67 nesting females in 1973 to 467 nesting females in 2002. Nester abundance increased rapidly at this rookery during the early 1980s, leveled off during the early 1990s, and again increased rapidly during the late 1990s to the present. This trend is very similar to the underlying trend in the recovery of the much larger green turtle population that nests at Tortuguero Costa Rica (Bjorndal et al. 1999). The stepwise increase of the long-term nester trend since the mid-1980s is suggestive, but not conclusive, of a density-dependent adjustment process affecting sea turtle abundance at the foraging grounds (Balazs and Chaloupka 2004; Bjorndal et al. 2000). Balazs and Chaloupka (2004) concluded that the Hawaiian green sea turtle stock is well on the way to recovery following 25 years of protection. This increase is attributed to increased female survivorship since the harvesting of turtles was prohibited in addition to the cessation of habitat damage at the nesting beaches since the early 1950s (Balazs and Chaloupka 2004).

Hawksbill Sea Turtles

Hawksbill sea turtles (*Eretmochelys imbricata*) are circumtropical in distribution, generally occurring from latitudes 30° N to 30° S within the Atlantic, Pacific, and Indian Oceans and associated bodies of water (NMFS 1998). While data are somewhat limited on their diet in the Pacific, it is well documented that in the Caribbean hawksbill turtles are selective spongivores, preferring particular sponge species over others (Dam and Diez 1997b). Foraging dive durations are often a function of turtle size, with larger turtles diving deeper and longer. At a study site also in the northern Caribbean, foraging dives were made only during the day and dive durations ranged from 19 to 26 minutes at depths of 8–10 meters. At night, resting dives ranged from 35 to 47 minutes in duration (Dam and Diez 1997a).

As a hawksbill turtle grows from a juvenile to an adult, data suggest that the turtle switches foraging behaviors from pelagic surface feeding to benthic reef feeding (Limpus 1992). Within the Great Barrier Reef of Australia, hawksbills move from a pelagic existence to a “neritic” life on the reef at a minimum CCL of 35 centimeters. The maturing turtle establishes foraging territory and will remain in this territory until it is displaced (Limpus 1992). As with other sea turtles, hawksbills will make long reproductive migrations between foraging and nesting areas (Meylan 1999), but otherwise they remain within coastal reef habitats. In Australia, juvenile turtles outnumber adults 100:1. These populations are also sex biased, with females outnumbering males 2.57:1 (Limpus 1992).

Along the far western and southeastern Pacific, hawksbill turtles nest on the islands and mainland of southeast Asia, from China to Japan, and throughout the Philippines, Malaysia, Indonesia, Papua New Guinea, the Solomon Islands (McKeown 1977), and Australia (Limpus 1982).

The hawksbill turtle is listed as endangered throughout its range. In the Pacific, this species is threatened by the harvesting of the species for its meat, eggs, and shell, as well as the destruction of nesting habitat by human occupation and disruption. Along the eastern Pacific Rim, hawksbill turtles were common to abundant in the 1930s (Cliffton et al. 1982). By the 1990s, the hawksbill turtle was rare to absent in most localities where it was once abundant (Cliffton et al. 1982).

Olive Ridley Sea Turtles

Olive ridley turtles (*Lepidochelys olivacea*) are olive or grayish green above, with a greenish white underpart, and adults are moderately sexually dimorphic (NMFS and USFWS1998d). Olive ridleys lead a highly pelagic existence (Plotkin 1994). These sea turtles appear to forage throughout the eastern tropical Pacific Ocean, often in large groups, or flotillas. In a 3-year study of communities associated with floating objects in the eastern tropical Pacific, Arenas et al. (1992) found that 75 percent of sea turtles encountered were olive ridleys and were present in 15 percent of the observations, thus implying that flotsam may provide the turtles with food, shelter, and/or orientation cues in an otherwise featureless landscape. It is possible that young turtles move offshore and occupy areas of surface-current convergences to find food and shelter among aggregated floating objects until they are large enough to recruit to the nearshore benthic feeding grounds of the adults, similar to the juvenile loggerheads mentioned previously.

While it is true that olive ridleys generally have a tropical range, individuals do occasionally venture north, some as far as the Gulf of Alaska (Hodge and Wing 2000). The postnesting migration routes of olive ridleys, tracked via satellite from Costa Rica, traversed thousands of kilometers of deep oceanic waters ranging from Mexico to Peru and more than 3,000 kilometers out into the central Pacific (Plotkin 1994). Stranding records from 1990–1999 indicate that olive ridleys are rarely found off the coast of California, averaging 1.3 strandings annually (J. Cordaro, NMFS, personal communication, NMFS 2004).

The olive ridley turtle is omnivorous, and identified prey include a variety of benthic and pelagic prey items such as shrimp, jellyfish, crabs, snails, and fish, as well as algae and seagrass (Marquez, 1990). It is also not unusual for olive ridley turtles in reasonably good health to be found entangled in scraps of net or other floating synthetic debris. Small crabs, barnacles, and other marine life often reside on debris and are likely to attract the turtles. Olive ridley turtles also forage at great depths, as a turtle was sighted foraging for crabs at a depth of 300 meters (Landis 1965, in Eckert et al. 1986). The average dive lengths for adult females and males are reported to be 54.3 and 28.5 minutes, respectively (Plotkin 1994, in Lutcavage and Lutz 1997).

Declines in olive ridley populations have been documented in Playa Nancite, Costa Rica; however, other nesting populations along the Pacific coast of Mexico and Costa Rica appear to be stable or increasing, after an initial large decline due to harvesting of adults. Historically, an estimated 10-million olive ridleys inhabited the waters in the eastern Pacific off Mexico (Cliffton et al. 1982, in NMFS and USFWS 1998b). However, human-induced mortality led to declines in this population. Beginning in the 1960s, and lasting over the next 15 years, several million adult olive ridleys were harvested by Mexico for commercial trade with Europe and Japan (NMFS and USFWS 1998b). Although olive ridley meat is palatable, it is not widely sought; eggs, however, are considered a delicacy, and egg harvest is considered one of the major causes for its decline. Fisheries for olive ridley turtles were also established in Ecuador during the 1960s and 1970s to supply Europe with leather (Green and Ortiz-Crespo 1982). In the Indian Ocean, Gahirmatha supports perhaps the largest nesting population; however, this population continues to be threatened by nearshore trawl fisheries. Direct harvest of adults and eggs, incidental capture in commercial fisheries, and loss of nesting habits are the main threats to the olive ridley's recovery.

3.3.5.2 Marine Mammals

Cetaceans listed as endangered under the ESA and that have been observed in the Western Pacific Region include the humpback whale (*Megaptera novaeangliae*), sperm whale (*Physeter macrocephalus*), blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*), and sei whale (*B. borealis*). In addition, one endangered pinniped, the Hawaiian monk seal (*Monachus schauinslandi*), occurs in the region.

Humpback Whales

Humpback whales (*Megaptera novaeangliae*) can attain lengths of 16 meters. Humpback whales winter in shallow nearshore waters, usually 100 fathoms or less. Mature females are believed to conceive on the breeding grounds one winter and give birth the following winter. Genetic and photo identification studies indicate that within the U.S. EEZ in the North Pacific, there are at least three relatively separate populations of humpback whales that migrate between their respective summer/fall feeding areas to winter/spring calving and mating areas (Hill and DeMaster 1999). The Central North Pacific stock of humpback whales winters in the waters of the Main Hawaiian Islands (Hill et al. 1997). At least six well-defined breeding stocks of humpback whales occur in the Southern Hemisphere.

There is no precise estimate of the worldwide humpback whale population. The humpback whale population in the North Pacific Ocean basin is estimated to contain 6,000–8,000 individuals (Calambokidis et al. 1997). The Central North Pacific stock appears to have increased in abundance between the early 1980s and early 1990s; however, the status of this stock relative to its optimum sustainable population size is unknown (Hill and DeMaster 1999).

Sperm Whales

The sperm whale (*Physeter macrocephalus*) is the most easily recognizable whale with a darkish gray-brown body and a wrinkled appearance. The head of the sperm whale is very large, making up to 40 percent of its total body length. The current average size for male sperm whales is about 15 meters, with females reaching up to 12 meters.

Sperm whales are found in tropical to polar waters throughout the world (Rice 1989). They are among the most abundant large cetaceans in the region. Sperm whales have been sighted around several of the Northwestern Hawaiian Islands (Rice 1960) and off the main islands of Hawaii (Lee 1993). The sounds of sperm whales have been recorded throughout the year off Oahu (Thompson and Friedl 1982). Sightings of sperm whales were made during May–July in the 1980s around Guam, and in recent years strandings have been reported on Guam (Reeves et al. 1999). Historical observations of sperm whales around Samoa occurred in all months except February and March (Reeves et al. 1999). Sperm whales are occasionally seen in the Fagatele Bay Sanctuary as well.

According to NOAA (www.nmfs.noaa.gov/pr/species/mammals/cetaceans/spermwhale.htm, accessed April 17, 2009) the world's population of sperm whales is estimated to be between 200,000 and 1,500,000 individuals. However, the methods used to make this estimate are in dispute, and there is considerable uncertainty over the remaining number of sperm whales. The world population is at least in the hundreds of thousands, if not millions. The status of sperm whales in Hawaii waters relative to the optimum sustainable population is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

Blue Whales

The blue whale (*Balaenoptera musculus*) is the largest living animal. Blue whales can reach lengths of 30 meters and weights of 160 tons (320,000 lbs), with females usually being larger than males of the same age. They occur in all oceans, usually along continental shelves, but can also be found in the shallow inshore waters and on the high seas. No sightings or strandings of blue whales have been reported in Hawaii, but acoustic recordings made off Oahu and Midway

Islands have reported blue whales somewhere within the EEZ around Hawaii (Thompson and Friedl 1982). The stock structure of blue whales in the North Pacific is uncertain (Forney et al. 2000). The status of this species in Hawaii waters relative to the optimum sustainable population is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

Prior to whaling, the worldwide population of blue whales is believed to have been about 200,000 animals. Only 8,000-12,000 are estimated to be alive today. Blue whales have always been more abundant in the Antarctic than in the northern hemisphere. An estimated 4,900 to 6,000 blue whales are believed to have inhabited the north Pacific prior to whaling. The north Pacific population is now estimated at 1,200 to 1,700 animals.

Fin Whales

Fin whales (*Balaenoptera physalus*) are found throughout all oceans and seas of the world from tropical to polar latitudes (Forney et al. 2000). Although it is generally believed that fin whales make poleward feeding migrations in summer and move toward the equator in winter, few actual observations of fin whales in tropical and subtropical waters have been documented, particularly in the Pacific Ocean away from continental coasts (Reeves et al. 1999). There have only been a few sightings of fin whales in Hawaii waters.

There is insufficient information to accurately determine the population structure of fin whales in the North Pacific, but there is evidence of multiple stocks (Forney et al. 2000). The status of fin whales in Hawaii waters relative to the optimum sustainable population is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

Sei Whales

Sei whales (*Balaenoptera borealis*) have a worldwide distribution but are found mainly in cold temperate to subpolar latitudes rather than in the tropics or near the poles (Horwood 1987). They are distributed far out to sea and do not appear to be associated with coastal features. Two sei whales were tagged in the vicinity of the Northern Mariana Islands (Reeves et al. 1999). Sei whales are rare in Hawaii waters. The International Whaling Commission only considers one stock of sei whales in the North Pacific, but some evidence exists for multiple populations (Forney et al. 2000). In the southern Pacific most observations have been south of 30°(Reeves et al. 1999).

There are no data on trends in sei whale abundance in the North Pacific (Forney et al. 2000). It is especially difficult to estimate their numbers because they are easily confused with Bryde's whales, which have an overlapping, but more subtropical, distribution (Reeves et al. 1999).

Hawaiian Monk Seals

The Hawaiian monk seal (*Monachus schauinslandi*) is a tropical seal endemic to the Hawaiian Islands. Today, the entire population of Hawaiian monk seals is about 1,300 to1,400 and occurs mainly in the NWHI. The six major reproductive sites are French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, and Kure Atoll. Small populations at

Necker Island and Nihoa Island are maintained by immigration, and an increasing number of seals are distributed throughout the MHI.

The subpopulation of monk seals on French Frigate Shoals has shown the most change in population, increasing dramatically in the 1960s–70s and declining in the late 1980s–90s. In the 1960s–70s, the other five subpopulations experienced declines. However, during the past decade, the number of monk seals increased at Kure Atoll, Midway Atoll, and Pearl and Hermes Reef while the subpopulations at Laysan Island and Lisianski Island remained relatively stable. The recent subpopulation decline at French Frigate Shoals is thought to have been caused by male aggression, shark attack, entanglement in marine debris, loss of habitat, and decreased prey availability. The Hawaiian monk seal is assumed to be well below its optimum sustainable population, and, since 1985, the overall population has declined approximately 3 percent per year (Forney et al. 2000). Aggressive male monk seals in the NWHI are known to mob females and sometimes kill pups. Mobbing behavior is thought to occur due to a skewed sex ratio, and 22 subadult males were translocated from Laysan Island in the NWHI to the Big Island in the MHI in 1994. In 1998, two males were identified as aggressive at French Frigate Shoals. They were translocated to Johnston Atoll in 1999 and were resighted at that location for a few months, although they have not been resighted recently.

The 2004 U.S. Pacific Marine Mammal Stock Assessment estimates that there are 1,304 monk seals in the Hawaiian Islands, with at least 52 of those occurring in the Main Hawaiian Islands (NOAA 2005). The latest Hawaiian monk seal assessment, based on the 2006 field season, showed a continuation in the downward population trend (NMFS PSD 2007) with overall abundance estimated at 1,016 seals in the NWHI. The number of pups born at the six main subpopulations in 2006 remained about the same as 2005 with 165 and 163, respectively, however, certain sites, most notably French Frigate Shoals, had the lowest level ever recorded at 39 and of those only 22 survived to weaning. Most pup deaths were attributed to shark predation. In the MHI the minimum abundance estimate has been raised to 77 seals.

Other Marine Mammals

Table 2 lists known non-ESA listed marine mammals that occur in the Western Pacific Region.

Table 2 : Non-ESA Listed Marine Mammals of the Western Pacific

Common Name	Scientific Name	Common Name	Scientific Name
Blainsville beaked whale	*Mesoplodon densirostris*	pygmy sperm whale	*Kogia breviceps*
bottlenose dolphin	*Tursiops truncatus*	Risso’s dolphin	*Grampus griseus*
Bryde’s whale	*Balaenoptera edeni*	rough-toothed dolphin	*Steno bredanensis*
Cuvier’s beaked whale	*Ziphius cavirostris*	short-finned pilot whale	*Globicephala macrorhynchus*
dwarf sperm whale	*Kogia simus*	spinner dolphin	*Stenella longirostris*

Common Name	Scientific Name	Common Name	Scientific Name
false killer whale	*Pseudorca crassidens*	spotted dolphin	*Stenella attenuata*
killer whale	*Orcinus orca*	striped dolphin	*Stenella coeruleoalba*
melon-headed whale	*Peponocephala electra*	Pacific white-sided dolphin	*Lagenorhynchus obliquidens*
pygmy killer whale	*Feresa attenuata*	minke whale	*Balaenoptera acutorostrata*
Fraser's dolphin	*Lagenodelphis hosei*	Dall's porpoise	*Phocoenoides dalli*
Longman's beaked whale	*Indopacetus pacificus*		

3.3.5.3 Seabirds

Short-tailed Albatross

The short-tailed albatross (*Phoebastria immutabilis*) is the largest seabird in the North Pacific, with a wingspan of more than 3 meters (9 ft) in length. It is characterized by a bright-pink bill with a light-blue tip and defining black line extending around the base. The plumage of a young fledgling (i.e., a chick that has successfully flown from the colony for the first time) is brown, and at this stage, except for the bird's pink bill and feet, the seabird can easily be mistaken for a black-footed albatross. As the juvenile short-tailed albatross matures, the face and underbody become white and the seabird begins to resemble a Laysan albatross. In flight, however, the short-tailed albatross is distinguished from the Laysan albatross by a white back and by white patches on the wings. As the short-tailed albatross continues to mature the white plumage on the crown and nape changes to a golden yellow color.

Before the 1880s, the short-tailed albatross population was estimated to be in the millions, and it was considered the most common albatross species ranging over the continental shelf of the U.S. (DeGange 1981). Between 1885 and 1903, an estimated five million short-tailed albatrosses were harvested from the Japanese breeding colonies for the feather, fertilizer, and egg trade, and by 1949 the species was thought to be extinct (Austin 1949). In 1950, ten short-tailed albatrosses were observed nesting on Torishima (Tickell 1973).

The short-tailed albatross is known to breed only in the western North Pacific Ocean, south of the main islands of Japan. Although at one time there may have been more than ten breeding locations (Hasegawa 1979), today there are only two known active breeding colonies: Minami Tori Shima Island and Minami-Kojima Island. On December 14, 2000, one short-tailed albatross was discovered incubating an egg on Yomejima Island of the Ogasawara Islands (southernmost island among the Mukojima Islands). A few short-tailed albatrosses have also been observed attempting to breed, although unsuccessful, at Midway Atoll in the NWHI.

Historically, the short-tailed albatross ranged along the coasts of the entire North Pacific Ocean from China, including the Japan Sea and the Okhotsk Sea (Sherburne 1993) to the west coast of North America. Prior to the harvesting of the short-tailed albatross at their breeding colonies by Japanese feather hunters, this albatross was considered common year-round off the western coast of North America (Robertson 1980). In 2000, the breeding population of the short-tailed albatross was estimated at approximately 600 breeding age birds, with an additional 600 immature birds, yielding a total population estimate of 1,200 individuals (65 FR 46643, July 31, 2000). At that time, short-tailed albatrosses were estimated to have an overall annual survival rate of 96 percent and a population growth rate of 7.8 percent (65 FR 46643, July 31, 2000). More recently, NMFS estimated the global population to consist of approximately 1,900 individuals (P. Sievert, personal communication; in NMFS 2005), and the Torishima population was estimated to have increased by 9 percent between the 2003–04 and 2004–05 seasons (Harrison 2005).

The short-tailed albatross was first listed under the Endangered Foreign Wildlife Act in June 1970. On July 31, 2000, the United States Fish and Wildlife Service extended the endangered status of the short-tailed albatross to include the species' range in the United States. The primary threats to the species are destruction of breeding habitat by volcanic eruption or mud- and landslides, reduced genetic variability, limited breeding distribution, plastics ingestion, contaminants, airplane strikes, and incidental capture in longline fisheries.

The short-tailed albatross population is growing annually, likely the result of effective habitat protection and management. Active breeding colonies are found on Torishima, south of Honshu Island, Japan and Minami-kojima in the Senkaku islands north of Taiwan. An estimated 80-85 percent of the breeding short-tailed albatrosses occur in a single colony on Torishima. The current worldwide population is estimate at 2,771 individuals (G. Blogh, USFWS pers comm. to L. Van Fossen, NMFS, 2008). Based on breeding pair counts, the short-tailed albatross population appears to be increasing by seven percent annually (Naughton et al. 2008). In 2006, there were 341 breeding pairs counted at Torishima (Hasegawa 2007a), and 382 breeding pairs were counted there in 2007 (Hasegawa 2007b). No critical habitat has been established for the short-tailed albatross and none of the fisheries evaluated in this FEP are likely to interact with the endangered short-tailed albatross.

Newell's Shearwater

The Newell's shearwater (*Puffinus auricularis newelli*) is listed as threatened under the ESA. Generally, the at-sea distribution of the Newell's shearwater is restricted to the waters surrounding the Hawaii archipelago, with preference given to the area east and south of the main Hawaiian Islands. The Newell's shearwater has been listed as threatened because of its small population, approximately 14,600 breeding pairs, its isolated breeding colonies, and the numerous hazards affecting them at their breeding colonies (Ainley et al. 1997). The Newell's shearwater breeds only in colonies on the main Hawaiian Islands (Ainley et al. 1997), where it is threatened by urban development and introduced predators like rats, cats, dogs, and mongooses (Ainley et al. 1997).

Shearwaters are most active in the day and skim the ocean surface while foraging. During the breeding season, shearwaters tend to forage within 50–62 miles (80–100 km) of their nesting burrows (Harrison 1990). Shearwaters also tend to be gregarious at sea, and the Newell's shearwater is known to occasionally follow ships (Harrison 1990. Shearwaters feed by surface seizing and pursuit plunging (Warham 1990). Often shearwaters will dip their heads under the water to sight their prey before submerging (Warham 1990).

Shearwaters are extremely difficult to identify at sea, as the species is characterized by mostly dark plumage, long and thin wings, a slender bill with a pair of flat and wide nasal tubes at the base, and dark legs and feet. Like the albatross, the nasal tubes at the base of the bill enhance the bird's sense of smell, assisting them to locate food while foraging (Ainley et al. 1997).

Other Seabirds

Other seabirds found in the region include the black-footed albatross (*Phoebastria nigripes*), Laysan albatross (*Phoebastria immutabilis*), masked booby (*Sula dactylatra*), brown booby (*Sula leucogaster*), red-footed booby (*Sula sula*), wedge-tailed shearwater (*Puffinus pacificus*), Christmas shearwater (*Puffinus nativitatis*), petrels (*Pseudobulweria* spp., *Pterodroma* spp.), tropicbirds (*Phaethon* spp.), frigatebirds (*Fregata* spp.), and noddies (*Anous* spp.). The world's largest Laysan albatross colony is located on Hawaii's Midway Atoll where lead paint is reported to be flaking off of deteriorating buildings. Paint chips are consumed by albatross chicks as they wait for their parents to return with food and the American Bird Conservancy has stated that these chicks have shockingly high lead concentrations. The organization estimates that 10,000 chicks die each year as a result. The USFWS has stated that they plan to clean up as many buildings as possible over the next two to four years and will also excavate chip-contaminated soil from around the buildings and six inches down. The soil will be replaced with clean beach sand (TenBruggencate 2006).

3.4 Social Environment

This section contains general descriptions of social and economic characteristics of inhabited islands of the Western Pacific Region (American Samoa, the Commonwealth of the Northern Mariana Islands, Guam, and Hawaii). A broad overview of their populations, economies, political histories, and fisheries is provided. Additional information is available in the Council's Pelagic FMP and FMP amendments as well as in the 2001 Comprehensive Pelagic EIS, 2002 environmental assessment, 2004 Supplemental EIS and the 2005 Squid and Seabird EIS.

3.4.1 American Samoa

American Samoa has been a U.S. territory since 1899, in part because of U.S. interests in the harbor at PagoPago. New Zealand occupied Western in 1914, and in 1962 Western Samoa gained independence. In 1997, Western Samoa changed its name to Samoa (it is also referred to as Independent Samoa). The demarcation between Independent Samoa and American Samoa is political. Cultural and commercial exchange continues with families living and commuting between the two.

American Samoa is more than 89 percent native Samoan. This population is descended from the aboriginal people who, prior to discovery by Europeans, occupied and exercised sovereignty in Samoa. There is approximately 199 sq km (~ 77 sq mi) of land divided between five islands and two coral atolls (Rose and Swains Islands). EEZ waters around American Samoa are truncated due to the nearby presence of other island nations, and comprise 390,000 square kilometers.

Approximately 95 percent of the landmass in American Samoa is held under the traditional land tenure system and under the direct authority of the Samoan chiefs known as "matais." Under this system, traditional land cannot be purchased or sold and the current reigning chief from within the family unit has final say over the disposition of a family's holdings. This system ensures the passage of assets to future generations and serves as the catalyst in the preservation of the Samoan culture.

Under the MSA, the islands of American Samoa are recognized as a fishing community. However, American Samoa's history, culture, geography, and relationship with the U.S. are vastly different from those of the typical community in the continental U.S. and are closely related to the heritage, traditions, and culture of neighboring independent Samoa. The seven islands that make up American Samoa were ceded in 1900 and 1904 to the U.S. and governed by the U.S. Navy until 1951, when administration was passed to the U.S. Department of the Interior, which continues to provide technical assistance, represent territorial views to the federal government, and oversee federal expenditures and operations. American Samoa elected its first governor in 1978, and is represented by a non-voting member of Congress.

The Samoan Constitution, the Convention of 1899, and subsequent amendments and authority recognize the primacy of Samoan custom over all sources of traditional law. Article 1, Section 3 of the Bill of Rights of the Constitution of American Samoa states: "It shall be the policy of the government of American Samoa to protect persons of Samoan Ancestry against alienation of their lands and the destruction of the Samoan way of life and language, contrary to their best interests. Such legislation as may be necessary may be enacted to protect the lands, customs, culture and traditional Samoan family organization of persons of Samoan ancestry, and to encourage business enterprises by such persons. No change in the law respecting the alienation or transfer of land or any interest therein, shall be effective unless the same be approved by two successive legislatures by a two-thirds vote of the entire membership of each house and by the Governor."

Tutuila, American Samoa's largest island, is the center of government and business, and is home to 90 percent of the estimated 63,000 total population of the territory. American Samoan natives born in the Territory are classified as U.S. nationals and categorized as Native Americans by the U.S. government (TPC/Dept. of Commerce 2000). Population density is about 320 people/km^2, and the annual population growth rate is nearly three percent, with projected population doubling in only 24 years (SPC 2000). The net migration rate from American Samoa was estimated as 3.75 migrants/1,000 population in the year 2000 (CIA World Factbook).

The only U.S. territory south of the equator, American Samoa is considered "unincorporated" because the U.S. Constitution does not apply in full, even though it is under U.S. sovereignty (TPC/DOC 2000). American Samoa's vision for the future is not fundamentally different from that of any other people in the U.S., but American Samoa has additional objectives that are related to its covenant with the U.S., its own constitution, and its distinctive culture (TPC/DOC 2000). A central premise of ceding eastern Samoa to the U.S. was to preserve the rights and property of the islands' inhabitants. American Samoa's constitution makes it government policy to protect persons of American Samoan ancestry from the alienation of their lands and the destruction of the Samoan way of life and language. It provides for such protective legislation and encourages business enterprise among persons of American Samoan ancestry (TPC/DOC 2000).

American Samoa has a small developing economy, dependent mainly on two primary income sources: the American Samoa Government (ASG), which receives income and capital subsidies from the federal government, and the two fish canneries on Tutuila (BOH 1997). These two primary income sources have given rise to a third: a services sector that derives from and complements the first two. In 1993, the latest year for which the ASG has compiled detailed labor force and employment data, the ASG employed 4,355 persons (32.2 percent of total employment), followed by the two canneries with 3,977 persons (29.4 percent) and the rest of the services economy with 5,211 persons (38.4 percent). As of 2000, there were 17,644 people 16 years and older in the labor force, of which 16,718, or 95 percent, were employed (U.S. DOC 2000).

A large proportion of the territory's work force is from Western Samoa (now officially called Samoa; BOH 1997). While it would be true that Western Samoans working in the territory are alien workers by law, in fact they are the same people, by culture, history, and family ties.

Statistics on household income indicate that the majority of American Samoans live in poverty according to U.S. income standards. American Samoa has the lowest gross domestic product and highest donor aid per capita among the U.S.-flag Pacific islands (Adams et al. 1999). However, by some regional measures, American Samoa is not a poor economy. It's estimated per capita income of $4,357 (U.S. DOC 2000) is almost twice the average for all Pacific island economies, although it is less than half of the per capita income in Guam, where proximity to Asia has led to development of a large tourism sector. Sixty-one percent of the population in 1999 was at or below poverty level (U.S. DOC 2000).

From the time of the Deeds of Cession to the present, despite increasing Western influences on American Samoa, native American Samoans have expressed a very strong preference for and commitment to the preservation of their traditional matai (chief), `aiga (extended family), and communal land system, which provides for social continuity, structure, and order. The traditional system is ancient and complex, containing nuances that are not well understood by outsiders (TPC/DOC 2000).

American Samoan dependence on fishing undoubtedly goes back as far as the peopled history of the islands of the Samoan archipelago, which is about 3,500 years ago (Severance and Franco 1989). Many aspects of the culture have changed in contemporary times, but American Samoans have retained a traditional social system that continues to strongly influence and depend on the culture of fishing. Centered around `aiga and allegiance to matai, this system is rooted in the economics and politics of communally held village land. It has effectively resisted Euro-

American colonial influence and has contributed to a contemporary cultural resiliency unique in the Pacific islands region (Severance et al. 1999).

Traditional American Samoan values still exert a strong influence on when and why people fish, how they distribute their catch, and the meaning of fish within the society. When distributed, fish and other resources move through a complex and culturally embedded exchange system that supports the food needs of `aiga, as well as the status of both matai and village ministers (Severance et al. 1999).

The excellent harbor at PagoPago and certain special provisions of U.S. law form the basis of American Samoa's largest private industry, fish processing, which is now more than 40 years old (BOH 1997). The territory is exempt from the Nicholson Act, which prohibits foreign ships from landing their catches in U.S. ports. American Samoan products with less than 50 percent market value from foreign sources enter the United States duty free (Headnote 3(a) of the U.S. Tariff Schedule). The parent companies of American Samoa's fish processing plants enjoy special tax benefits, and wages in the territory are set not by federal law but by recommendation of a special U.S. Department of Labor committee that reviews economic conditions every two years and establishes minimum wages by industry.

The ASG has estimated that the tuna processing industry directly and indirectly generates about 15 percent of current money wages, 10 to 12 percent of aggregate household income and 7 percent of government receipts in the territory (BOH 1997). On the other hand, both tuna canneries in American Samoa are tied to multinational corporations that supply virtually everything but unskilled labor, shipping services, and infrastructure facilities (Schug and Galeai 1987). Even a substantial portion of the raw tuna processed by StarKist Samoa is landed by vessels owned by the parent company. The result is that few backward linkages have developed, and the fish-processing facilities exist essentially as industrial enclaves. Furthermore, most of the unskilled labor of the canneries is imported. Up to 90 percent of cannery jobs are filled by foreign nationals from Western Samoa and Tonga. The result is that much of the payroll of the canneries "leaks" out of the territory in the form of overseas remittances.

Harsh working conditions, low wages, and long fishing trips have discouraged American Samoans from working on foreign longline vessels delivering tuna to the canneries. American Samoans prefer employment on the U.S. purse seine vessels, but the capital-intensive nature of purse seine operations limits the number of job opportunities for locals in that sector as well. However, the presence of the industrial tuna fishing fleet has had a positive economic effect on the local economy as a whole. Ancillary businesses involved in reprovisioning the fishing fleet generate a significant number of jobs and amount of income for local residents. Fleet expenditures for fuel, provisions, and repairs in 1994 were estimated to be between $45 million and $92 million (Hamnett and Pintz 1996).

The tuna processing industry has had a mixed effect on the commercial fishing activities undertaken by American Samoans. The canneries often buy fish from the small-scale domestic longline fleet based in American Samoa, although the quantity of this fish is insignificant compared with cannery deliveries by the U.S. purse seine, U.S. albacore, and foreign longline fleets. The ready market provided by the canneries is attractive to the small-boat fleet, and virtually all of the albacore caught by the domestic longline fishery is sold to the canneries. Nevertheless, local fishermen have long complained that a portion of the frozen fish landed by foreign longline vessels enters the American Samoa restaurant and home-consumption market, creating an oversupply and depressing the prices for fresh fish sold by local fishermen.

Local fishermen have indicated an interest in participating in the far more lucrative overseas market for fresh fish. To date, however, inadequate shoreside ice and cold-storage facilities in American Samoa and infrequent and expensive air transportation links have been restrictive factors.

Using information obtained from industry sources for a presentation to the American Samoa Legislature (Faleomavaega 2002), canning the 3,100 metric tons of albacore landed in American Samoa by the domestic longline fishery in 2001 is estimated to have generated 75 jobs, $420,000 in wages, $5 million in processing revenue, and $1.4 million in direct cannery spending in the local economy. Ancillary businesses associated with the tuna canning industry also contribute significantly to American Samoa's economy. In 2004, thirty-four percent of the territory's population was employed by the ASG, twenty-seven percent by the canneries, and thirty-nine percent by private industry or other sectors (ASG 2006). The canneries and the supporting pelagic fisheries are vitally important to the economy and livelihood of the people of American Samoa. American Samoa's position in the industry is being eroded by forces in the world economy and in the tuna canning industry itself. Whereas wage levels in American Samoa are well below those of the U.S., they are considerably higher than in other canned tuna production centers around the world. To remain competitive, U.S. tuna producers are purchasing more raw materials, especially precooked loins, from foreign manufacturers. Tax benefits to U.S. canneries operating in American Samoa have also been tempered in recent years by the removal of a provision in the U.S. tax code that previously permitted the tax-free repatriation of corporate income in U.S. territories. Trends in world trade, specifically reductions in tariffs, are reducing the competitive advantage of American Samoa's duty-free access to the U.S. canned tuna market (TPC/DOC 2000).

Despite the long history of the tuna canning industry in American Samoa, processing and marketing of pelagic fish by local enterprises have not yet developed beyond a few short-term pilot projects. However, the government's comprehensive economic development strategy (TPC/DOC 2000) places a high priority on establishing a private sector fish processing and export operation proposed to be located at the Tafuna Industrial Park.

3.4.2 Commonwealth of the Northern Mariana Islands

The CNMI consists of 14 islands, five of which are inhabited, with a total land area of 176.5 square miles spread over about 264,000 square miles of ocean. The Northern Mariana Islands became part of the Pacific Trust Territory administered by the U.S. under a mandate granted in 1947. The covenant that created the commonwealth and attached it to the U.S. was fully implemented in 1986, pursuant to a Presidential Proclamation that terminated the Trust Territory of the Pacific Islands as it applied to the Northern Mariana Islands.

Fishery resources have played a central role in shaping the social, cultural and economic fabric of the CNMI. The aboriginal peoples indigenous to these islands relied on seafood as their principal source of protein and developed exceptional fishing skills. Later immigrants to the islands from East and Southeast Asia also possessed a strong fishing tradition. Under the MSA, the CNMI is defined as a fishing community.

The population (July 2006 estimate) of the CNMI is 82,459 individual and is comprised of 56 percent Asians, 36 percent Pacific Islanders, 2 percent Caucasians and the remaining 6 percent reported mixed ethnicities (U.S. DOC 2000). Per capita income in the CNMI in 1999 was $9,151. The median household income for the CNMI as whole was $22,898. For Saipan, the median household income was $19,698 in the first quarter of 1999, as compared with $21,457 in 1990. The Commonwealth had an unemployment rate in 1999 of 5.5 percent. Forty-six percent of the CNMI population was at or below poverty in 1999 (U.S. DOC 2000).

In 2000, CNMI had 20,378 men ages 16 and over in the labor force, of whom 96 percent or 19,458 were employed. There were 24,093 women ages 16 and over in the labor force, of whom 97 percent were employed (U.S. DOC 2000). The economy of the CNMI has historically benefited substantially from financial assistance from the United States, but in recent years this assistance has declined as locally generated government revenues have grown. Between 1988 and 1996, tourism was the commonwealth's largest income source. During that period tourist traffic to the CNMI tripled from 245,505 to 736,117 (BOH 1999c). Total tourist expenditures in the CNMI were estimated to be a record $587 million in 1996. In 1997 and 1998, however, the loss of air service between the CNMI and Korea, together with the impact of the Asian financial crisis on both Korean and Japanese travelers, caused tourist arrivals in the CNMI to drop by one third (BOH 1999c).

More recently garment production has been an important industry, with shipments of $1 billion to the U.S. under duty and quota exemptions during 1999 (BOH 1999c). The garment industry is credited with preventing an economic depression in the Commonwealth following the decline of its tourist industry, but the future of the CNMI's garment manufacturers is uncertain. When the commonwealth was created it was granted an exemption from certain U.S. immigration, naturalization, and labor laws. These economic advantages are now a matter of national political debate centered on what some regard as unfair labor practices in the CNMI's garment industry. The two main advantages for manufacturing garments in the CNMI are low-cost foreign labor and duty-free sale in the U.S. The controversy over labor practices in the CNMI may cause the commonwealth to lose these unique advantages, forcing garment makers to seek alternative low-cost production sites. The end of the quota on foreign textiles in 2005 may cause garment manufacturers to move to China, which has some competitive advantages.

In the early 1980s, U.S. purse seine vessels established a transshipment operation at Tinian Harbor. The CNMI is exempt from the Jones Act, which requires the use of U.S.-flag and U.S built vessels to carry cargo between U.S. ports. The U.S. purse seiners took advantage of this exemption by offloading their catch at Tinian onto foreign vessels for shipment to tuna canneries in American Samoa. In 1991, a second type of tuna transshipment operation was established on Saipan (Hamnett and Pintz 1996).This operation transships fresh tuna caught in the Federated States of Micronesia from air freighters to wide-body jets bound for Japan. The volume of fish flown into and out of Saipan is substantial, but the contribution of this operation to the local economy is minimal (Hamnett and Pintz 1996).

With the exception of the purse seine support base on Tinian (now defunct), the CNMI has never had a large infrastructure dedicated to commercial fishing. The majority of boats in the local fishing fleet are small, outboard engine-powered vessels. Between 1994–1998, the annual ex-vessel value of commercial landings of bottomfish and pelagic species has averaged about $473,900, which bottomfish accounts for about 28 percent of the total revenues (WPRFMC 1999). Existing planning data for the CNMI are not suited to examining the direct and indirect contributions attributed to various inter-industry linkages in the economy. It is apparent, however, that fishing by the local small-boat fleet represents only a small fraction of the economic activity in the Commonwealth.

3.4.3 Guam

The island of Guam was ceded to the U.S. following the Spanish–American War of 1898 and has been an unincorporated territory since 1949. The land mass of Guam's two islands is approximately 541 sq km (209 sq mi). Guam's population (July 2006 estimate) is 171,019 individuals and is comprised of 37 percent Chamorros, 26 percent Filipinos, 11 percent other Pacific Islanders, 11 percent Caucasians, 6 percent other Asian ethnicities and the remaining 33 percent reported mixed ethnicities. The main income sources on Guam include tourism, national defense, and trade and services. Per capita income in Guam was $12,722 in 1999, up from $10,152 in 1991. Median household income was $39,317 in 1999, up from $31,118 in 1991. Twenty-three percent of the population in 1999 was at or below poverty level (U.S. DOC 2000).

The Guam Department of Labor estimated the number of employees on payroll to be 64,230 in 1998, a decrease of 3.8 percent from the 1997 figure. Of the 64,230 employees, 44,780 were in the private sector and 19,450 were in the public sector. The Federal government employs 7.6 percent of the total work force, while the Government of Guam employs 22.7 percent. Guam had an unemployment rate of 15.2 percent in 1999. As of 2000, Guam had 39,143 men age 16 and over in the labor force, of whom 81 percent were employed and 29,751 women age 16 and over in the labor force, of which 86 percent were employed (U.S. DOC 2000).

The major economic factor in Guam for most of the latter part of the twentieth century was the large-scale presence of the U.S. military (BOH 1999b). In the 1990s, however, the military's contribution to Guam's economy has waned and been largely replaced by Asian tourism. Guam's macroeconomic situation exhibited considerable growth between 1988 and 1993 as a result of rapid expansion of the tourist industry. In fact, Guam's economy has become so dependent on tourists from Asia, particularly Japan, that any significant economic, financial and foreign exchange development in the region has had an immediate impact on the territory (BOH 1999b). During the mid- to late-1990s, as Japan experienced a period of economic stagnation and cautious consumer spending, the impact was felt just as much in Guam as in Japan. Visitor arrivals in Guam dropped 17.7 percent in 1998. Despite recent efforts to expand the tourist market, Guam's economy remains dependent on Japanese tourists.

The Government of Guam has been a major employer on Guam for many years. However, recent deficits have resulted from a steady rise in government spending at the same time that tax bases have not kept up with spending demands. Many senior government workers have been offered and have accepted early retirement to reduce the payroll burden.

In the 1990s, after three decades of troop reductions, the military presence on the island diminished to the lowest level in decades, but with the post–9/11 emphasis on homeland security, the war in Iraq, and repositioning of military assets from Asia and the mainland U.S., military spending on Guam has rebounded significantly, and the effects have been felt throughout the economy including in employment and housing prices (Los Angeles Times, July 25, 2004).

Over the centuries of acculturation beginning with the Spanish conquest in the late seventeenth century, many elements of traditional Chamorro culture in Guam were lost. But certain traditional values, attitudes and customs were retained to become a part of contemporary life. Amesbury and Hunter-Anderson et al. (1989, p. 48) noted that the practice of sharing one's fish catch with relatives and friends during Christian holidays is rooted in traditional Chamorro culture:

> *A strongly enduring cultural dimension related to offshore fishing is the high value placed on sharing of the catch, and the importance of gifts of fish to relatives and friends.*

Based on creel surveys of fishermen, only about one quarter to one third of the inshore catch is sold. The remainder enters noncommercial channels (Knudson 1987). Reef and bottomfish continue to be important for social obligations, such as fiestas and food exchange with friends and families. One study found a preference for inshore fish species in noncommercial exchanges of food (Amesbury and Hunter-Anderson 1989).

The social obligation to share one's fish catch extends to part-time and full-time commercial fishermen. Such gifts are often reef fish or shallow-water bottomfish (Amesbury and Hunter-Anderson 1989). Even when fish are purchased informally by friends, neighbors or relatives of the fisherman, the very personal marketing tends to restrain the price asked (WPRFMC 2003).

Domestic fishing on Guam supplements family subsistence, which is gained by a combination of small scale gardening, ranching and wage work (Amesbury and Hunter-Anderson 1989). The availability of economic activities such as part-time fishing is among the major reasons that Guam has not experienced more social problems during times of economic hardship and increasing unemployment. The subsistence component of the local economy has gained significance in recent years with the downturn in Guam's major industries and increasing unemployment.

Fishing in Guam continues to be important not only in terms of contributing to the subsistence needs of the Chamorro people but also in terms of preserving their history and identity. Fishing assists in perpetuating traditional knowledge of marine resources and maritime heritage of the Chamorro culture.

The importance of commercial fishing in Guam lies mainly in the territory's status as a major regional fish transshipment center and resupply base for domestic and foreign tuna fishing fleets. Among Guam's advantages as a home port are well-developed and highly efficient port facilities in Apra Harbor, an availability of relatively low-cost vessel fuel, a well-established marine supply/repair industry, and recreational amenities for crew shore leave (Hamnett and Pintz 1996). In addition, the territory is exempt from the Nicholson Act, which prohibits foreign ships from landing their catches in U.S. ports. Initially, the majority of vessels calling in Apra Harbor to discharge frozen tuna for transshipment were Japanese purse seine boats and carrier vessels. Later, a fleet of U.S. purse seine vessels relocated to Guam, and since the late 1980s, Guam has become an important port for Japanese and Taiwanese longline fleets. The presence of the longline and purse seine vessels has created a demand for a range of provisioning, vessel maintenance and gear repair services.

By the early 1990s, an air transshipment operation was also established on Guam. Fresh tuna is flown into Guam from the FSM and elsewhere on air cargo planes and out of Guam to the Japanese market on wide-body passenger planes (Hamnett and Pintz 1996). A second air transshipment operation that began in the mid-1990s is transporting to Europe fish that do not meet Japanese sashimi market standards.

Guam is an important resupply and transshipment center for the international tuna longline fleet in the Pacific. However, the future of home port and transshipment operations in Guam depends on the island's ability to compete with neighboring countries that are seeking to attract the highly mobile longline fleet to their own ports. Trends in the number of port calls made in Guam by various fishing fleets reflect the volatility of the industry. The number of vessels operating out of Guam decreased by almost half from 1996 to 1997, and further declined in 1998 (Hamnett and Anderson 2000).

The Guam Department of Commerce reported that fleet expenditures in Guam in1998 were about $68 million, and a 1994 study estimated that the home port and transshipment industry employed about 130 people (Hamnett and Pintz 1996). This industry constitutes an insignificant percentage of the gross island product, which was about $2.99 billion in 1996, and is of minor economic importance in comparison to the tourist or defense industries (Hamnett and Anderson 2000). Nevertheless, home port and transshipment operations make an important contribution to the diversification of Guam's economy (Hamnett and Pintz 1996). As a result of fluctuations in the tourism industry and cuts in military expenditures in Guam, the importance of economic diversification has increased.

3.4.4 Hawaii[16]

The State of Hawaii is comprised of eight major islands in the main Hawaiian Islands and at least 33 main islands in the northwestern island chain. The MHI's seven inhabited islands contain 6,419 sq. miles of land while the NWHI contain only 4.9 sq. miles of land[17]. Within the

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[16] Unless otherwise noted, all data in this section are taken from the 2005 STATE OF HAWAII DATA BOOK, on-line edition, hereafter referenced DBEDT, 2005. [http://www.hawaii.gov/dbedt/ accessed April 7, 2007.]

[17] www.hawaii.gov/dbedt

200-mile EEZ of the Hawaiian Archipelago is approximately 833,198 sq.miles (or 629,171 sq. nautical mi.) of water area.

Hawaii's economy is dominated by tourism and defense, with tourism by far the leading industry in terms of employment and expenditures. The two represent approximately one quarter of Gross State Product without consideration of ancillary services and also comprise the largest shares of "export" earnings (Tables 3 and 4).

Table 3. Hawaii's Gross State Product

Year	Gross State Product (million $)	Per Capita State Product	Resident Population
2005	53,710	$42,119	1,275,194

Source: DBEDT 2005. Table 13.02

Table 4. Hawaii's "Export" Industries

Year	Sugar (million $)	Pineapple (million $)	U.S. Military (million $)	Tourism (million $)
2004[18]	94	123	4,772	10,862

Source: DBEDT 2006

Natural resource production remains important in Hawaii, although nothing compared to the period of the sugar and pineapple plantations from throughout the first 60 or 70 years of the 20th century. Crop and livestock sales were $516.1 million in 2004, with the primary diversified agriculture crops being flower and nursery products, $94.5 million; macadamia nuts, $40.1 million; coffee, $19.8 million; cattle, $22.1 million; milk, $20.2 million (DBEDT 2006). Aquaculture production was $28.1 million in 2004 (DBEDT 206), although much of aquaculture's value to Hawaii comes from development of technology. Commercial fishing ex-vessel value was $57.5 million, not including value added by the seafood processing sector (WPacFIN 2007), lower than some earlier years due to the closure of the longline fishery for swordfish from 2000-2004.

Hawaii's commercial economy has been particularly vibrant over the past five years, with a 7.5 percent growth in Gross State Product in 2005 and an average of 5.8 percent annual growth rate since 2000. Figure 11 indicates the long-term trend in Gross State Product (1970-2005), with the inflation-adjusted figures clearly showing the downturns in the early 1980s and the mid-1990s, followed by sustained growth recently.

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[18] 2004 is the most recent year when complete industry statistics are available.

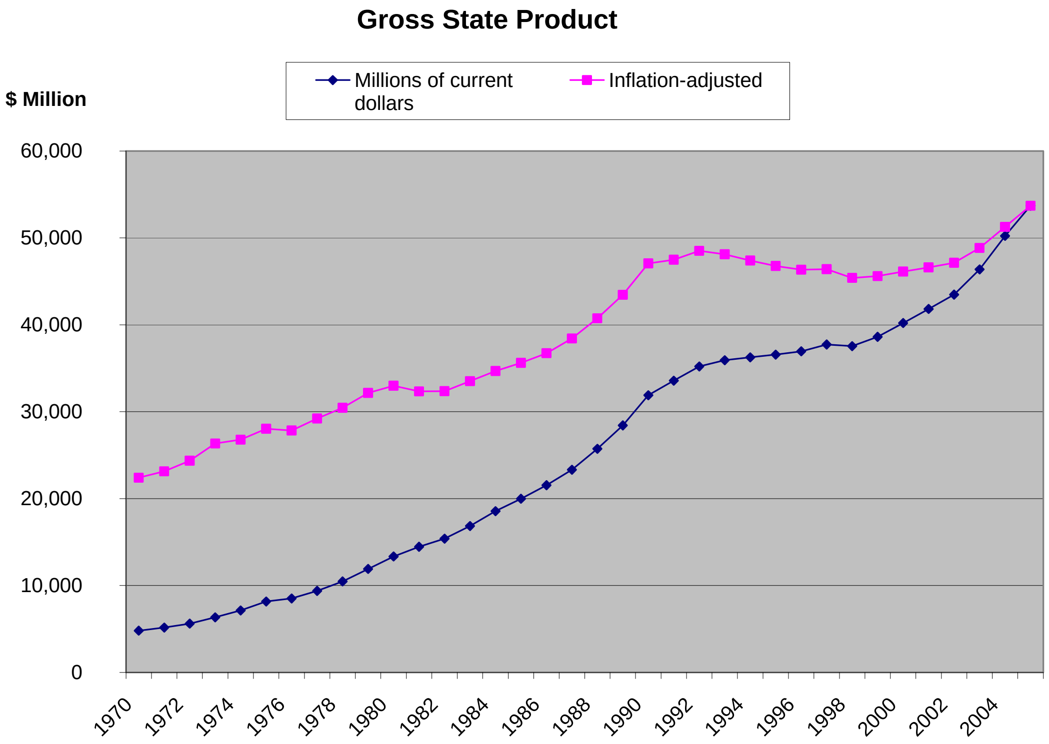

Figure 10. Hawaii Gross State Product

The current unemployment rate (2006, see Table 5) of 2.6 percent (DBEDT 2007) is the lowest in the United States by far, and less than half the U.S. average rate. This marks a major turn-around from the 1990s when Asian economies declined, the U.S. military down-sized due to the end of the Cold War, and Hawaii plantation agriculture was battered by the cost effects of global trade. Construction, manufacturing and agriculture account for only 9 percent of wage and salary jobs. About 30 percent of civilian workers are professional or managerial. Federal, state and local government accounts for 20 percent of wage and salary jobs (DBEDT 2006).

Table 5. Hawaii Employment Statistics

	2006
Civilian labor force	651,850
Employed	635,100
Unemployment rate	2.6%
Payroll jobs	624,650
Real personal income ($ million)	46,766

Tourism arrivals increased almost monotonically from 1970-1990, but growth was slower in the 1990s until the past three years. There were 7.4 million tourists in Hawaii in 2005. This represents a daily rate of 185,445 tourists, 13 percent of the "de facto" population (resident, tourist, and military combined), indicating the weight of tourism in many sectors of Hawaii's economy and society (DBEDT 2005). Tourism arrivals have become more evenly distributed across source locations, with the continental U.S. and Japan being the mainstays, but with arrivals increasing from Europe and China. Nonetheless, Hawaii's economy remains subject to national and international economic factors.

Total federal expenditures were $12.2 billion in 2004, with 85,900 military personnel and dependents and 31,300 federal civilian workers (not all of whom work on military bases, DBEDT 2006). Research and development spending by the federal government (2003) was $349.6 million representing the importance of the University of Hawaii and a number of other public and private research entities in particular.

Despite these successes, at some individual and community levels, Hawaii's commercial economy has been less successful. For example, per capita disposable income in Hawaii ($29,174) has fallen to below the national average despite a cost of living nearly double the national average (Table 6).

Table 6. Hawaii Cost of Living Comparison

Cost of Living Analysis: Ratio of Honolulu living costs compared to U.S. Average at four income levels				
	Income level 1	Income level 2	Income level 3	Income level 4
Honolulu cost of living indexed to U.S. average	192.9	171.6	161.9	155.1
Rent, utilities	241.4	235.4	230.3	229.0

Source: DBEDT 2005. Table 14.11

Indeed, per capita Gross State Product is the same today as it was in 1990. Hawaii per capita income has fallen from 122.5 percent of the U.S. average in 1970 to 99 percent in 2005 (Figure 11). Much of this is attributable to housing costs, with the average single family house selling for $744,174 in 2005, with the median being $590,000, the latter discrepancy also indicating the uneven nature of the housing industry in Hawaii over the past several years.

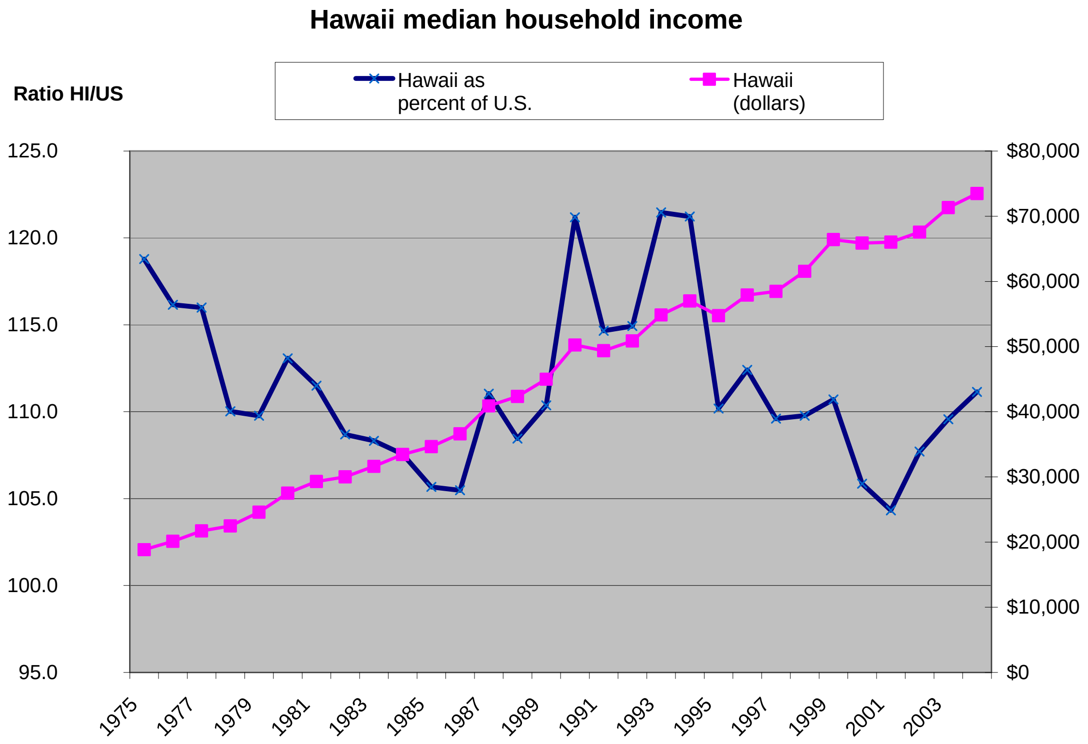

Figure 11: Hawaii Median Household Income, 1975-2005

Tourism is a service industry, and as such, tends to have lower wage levels than manufacturing, for example. So the dominance of tourism means that many workers in Hawaii holds more than one job, with 16 percent of the workforce reporting they work 49 or more hours per week (DBEDT 2005. Table 12.38). Similarly, the benefits of the commercial economy are not spread evenly across either islands or ethnic groups in Hawaii. In 2004, 8.4 percent of Hawaii's population was below the poverty line (DBEDT 2005. Table 13.23). The effect of these conditions is that the value of common use resources, such as shorelines, forests, and the ocean, is important for both subsistence and recreational reasons.

The State of Hawaii has been attempting to diversify its economy for many years. Industries encouraged are science and technology, film and television production, sports, ocean research and development, health and education tourism, diversified agriculture and floral and specialty food products. (DBEDT, 2006) However these remain small percentage of the Hawaii commercial economy.

The most recent estimate of the ex-vessel value of fish sold by the fisheries regulated by the FEP is $ 70.9 million. This amounts to a small percentage of Gross State Product, in fact, less than 1 percent. On the other hand, the seafood industry is an important component of local and tourist consumption, and recreational and subsistence fishing represents a substantial proportion of the local population (estimated at 109,000 participants, 8.6 percent of Hawaii's population).[19] And

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[19] DBEDT, 2005. Table 7.56.

additional 41,000 tourists are also reported to go fishing while in Hawaii, and total fishing expenditures (resident and tourist combined) were estimated at $125 million.

The Bank of Hawaii summarized the recent general trends as of August, 2008. At midyear, 2008, Hawaii's economic growth had slowed to a crawl due to higher oil prices, falling tourism, and falling residential investment. The decrease in tourism is fueled by both decreased domestic demand and a reduction in the number of trans-Pacific flights resulting from the shutdown of Aloha Airlines and ATA, which previously represented 15-20 percent of the available seats to Hawaii. Hawaii's unemployment rate rose to 3.5 percent in June 2008 on a seasonally-adjusted basis, while job growth slowed to a few tenths of one percent, well below the rate necessary to generate enough labor force absorption to prevent the unemployment rate from rising. Since then, Hawaii's unemployment rate has continued to rise and as of September 2008, hit 4.5 percent. Honolulu's inflation rate was 4.9 percent in first half 2008, up slightly from the 4.8 percent for all of 2007. While shelter costs began to moderate, energy costs rose significantly. Household fuels and utilities costs rose 36.4 percent, year-over-year.

The most recent estimate of the total economic contribution of the commercial, charter, and recreational fishing sectors to the state economy indicated that in 1992, these sectors contributed $118.79 million of output (production) and $34.29 million of household income, employing 1,469 people (Sharma et al. 1999. These contributions accounted for 0.25 percent of total state output ($47.4 billion), 0.17 percent of household income ($20.2 billion), and 0.19 percent of employment (757,132 jobs). Recreational, subsistence and sport (e.g., charter) fisheries provide additional but unquantified economic benefits in terms of angler satisfaction, protein sources, and tourism revenues.

Hawaii's pelagic fisheries are responsible for the largest share of annual commercial landings and ex-vessel revenue, with 28.2 million pounds of pelagic fish landed in 2005 at an ex-vessel value of $66.7 million. The domestic longline fishery for tuna, swordfish, and other pelagic species is the largest component of the fishery, landing 23 million pounds in 2005 with an ex-vessel value of $58 million. Among the demersal fisheries, commercial harvests of CRE MUS dominate, with MHI and NWHI bottomfish relatively close behind. The remainder of Hawaii's commercial fisheries are relatively small, with annual fishery ex-vessel revenues of less than $150,000. See Chapter 4 for more information on Hawaii's pelagic fisheries.

As is the case for most Pacific islands, fishing has been an essential part of Hawaii's culture and society since its first inhabitants settled in the archipelago. As waves of immigrants have arrived, Hawaii has been changed from a self-sufficient subsistence economy to a multi-ethnic cash and wage society largely dependent on imports, tourism and federal spending. As described in Section 3.4, commercial fishing comprises a small part of Hawaii's total economy. Nevertheless fishing, in all its myriad forms, continues to play a significant role in Hawaii's society and culture. These forms vary by place and individual, ranging from subsistence activities by residents to non-consumptive recreational tag and release fishing and snorkeling by tourists, to commercial harvests of the "red fish" that are culturally important and much anticipated for Christmas and New Year's holiday celebrations. The longest human use of Hawaii's marine resources has obviously been that of subsistence use. The continuing importance of subsistence activities to today's Native Hawaiians has been recently described by Davianna McGregor

(McGregor 2007) as follows below. Although McGregor wrote primarily about Native Hawaiians, her words are also relevant for many other groups and individuals in Hawaii.

> *Through subsistence, families attain essential resources to compensate for low incomes. They can also obtain food items, especially seafood that might be prohibitively expensive in a strict cash economy. If families on fixed incomes were required to purchase these items, they would probably opt for cheaper, less healthy food that would predispose them to health problems. In this respect, subsistence not only provides food, but also ensures a healthy diet.*
>
> *Subsistence generally requires a great amount of physical exertion e.g., fishing, diving, hunting), which is a valuable form of exercise and stress reduction and contributes to good physical and mental health. It is also a form of recreation that the whole family can share in. Family members of all ages contribute to different phases of subsistence, be it active hunting, fishing, gathering, or cleaning and preparing the food for eating. Older family members teach younger ones how to engage in subsistence and prepare the food, thus passing on ancestral knowledge, experience, and skill.*
>
> *Another benefit of subsistence is sharing and gift giving within the community. Families and neighbors exchange resources when they are abundant and available, and the elderly are often the beneficiaries of resources shared by younger, more able-bodied practitioners. Most ku'aina believe that generosity is rewarded with better luck in the future.*
>
> *Resources obtained through subsistence are also used for a variety of special life cycle occasions that bond families and communities. Resources such as fish, limu, opihi, wild venison, and so on are foods served at luau for baby birthdays, graduations, weddings, and funerals. Ohana and community residents participate in these gatherings, which cultivate and reinforce a sense of family and community identity. If ohana members had to purchase such resources rather than acquire through subsistence, the cost would be prohibitive, and the number of ohana gatherings would decrease. Subsistence activities therefore enable ohana to gather frequently and reinforce important relationships and support networks.*

The author goes on to provide case studies of five cultural kipuka or areas in which Native Hawaiian traditions and lifestyles have persisted most strongly. In each area, subsistence fishing, hunting and gathering continues to play an essential role in allowing Hawaiians (and surely some non-Hawaiians as well) to interact with the natural environment and to continue their family and cultural traditions on a daily basis.

Few studies have attempted to quantify the importance of subsistence activities to Hawaii's residents. One study that did so was conducted by the University of Hawaii and focused on Molokai. A random survey of Molokai families found that 28 percent of their food came from subsistence activities, and for Native Hawaiian families 38 percent of their food came from subsistence activities. The authors also noted that virtually every family interviewed stated that subsistence was important (not just a necessary component but a desirable one) to the lifestyle of Molokai. (Matsuoka et al. *in* McGregor 2007). Molokai is likely to represent the high end of the scale of subsistence activities among the islands due to its relative isolation, lack of employment opportunities, rural character and continued availability of natural resources. However subsistence fishing, hunting and gathering are important and respected aspects of life for many Hawaii residents.

Fishing plays many roles in the lives of Hawaii residents and tourists, in addition to providing subsistence resources. A myriad of books, television shows and magazines highlight various aspects of Hawaii's fisheries and fishery resources and local newspapers provide lively commentary on fishery issues. Hawaii's image as a marine wonderland is a major tourism draw and many tourists are likely to either view fish (e.g., go snorkeling visit an aquarium or buy attire, souvenirs or art with a fish motif), catch fish (e.g., go fishing) or eat fish during their visit. Indeed locally caught fish comprise many of Hawaii's "signature dishes" which are a tourism draw in themselves.

Shoreline fishing is an important social and competitive activity in Hawaii. Shoreline fishing tournaments are extremely popular and both young and old fishermen can be seen along Hawaii's shores every weekend (HDAR 2000). Many of these will be targeting ulua but pulses of weke, akule and opelu will also draw crowds of fishermen to certain areas, including Honolulu's shoreline and major harbors. Smaller groups gather regularly at harbors, beaches, cliffs and breakwalls in the early morning and evening hours to fish and talk story with their friends and neighbors.

Fishing clubs provide another avenue for social interaction, support, and service. Schultz et al. (2006) provide a list of 25 fishing clubs that were active in 2003. Many of Hawaii's fishing clubs focus on pelagic fishing, however the majority of club members are also likely to target non-pelagic species over the course of a year. Fishing clubs usually meet at least one time per month and often engage in community services such as providing fishing opportunities for young, disabled or senior citizens who would otherwise be unable to participate. Not only do fishing clubs allow for social interaction between old friends, they also bring together people from many disparate social and economic groups that may not otherwise interact on a regular basis (Schultz et al. 2006).

As described in Chapter 4, landings by commercial fishermen (those who sell at least one fish during the year) are captured through the State's reporting system. The volume and ex-vessel value of these landings are described in Chapter 4. Due to the lack of either State or Federal reporting requirements for recreational (i.e., non-commercial, including subsistence) fishermen, available estimates of their landings are based primarily on data collected through intermittent creel and phone surveys. Estimates of recreational catches have varied widely over the past decade, perhaps due to differences in survey definitions and/or wording, or perhaps due to differences in sample design and subsequent data extrapolation. In several recent cases, no definition of the term "recreational" was provided to survey respondents, which is believed to have resulted in double-counting of catches by fishermen who consider their motivation for fishing to be recreational, but who nevertheless sell some of their catch. Assuming that these respondents followed State laws, their catches are categorized as, and included with, other commercial catches and to count them again as recreational catches inappropriately inflates total Hawaii landings.

Reported commercial landings alone convey to some degree the importance of fishing to Hawaii's society. These landings and their sales (and related jobs and shoreside support industries) are a significant part of Hawaii's dwindling primary production industries.

In order to have the most complete understanding of the importance of fishing to Hawaii's society, fishing and fishery related data need to be obtained and disaggregated based on both fishing motivation (e.g., subsistence, family and cultural traditions, fun, camaraderie, competition, non-consumptive uses, income, or profit) and fish disposition (e.g., consumed by family, used for ohana or community events, bartered, displayed, or sold). Such information would provide a clearer picture of the many roles that fish and fishing play in Hawaii's contemporary society. This is becoming increasingly important as non-fishermen have become interested and active in the management of Hawaii's fisheries and have sought to have their voices heard. One major initiative has been a movement to establish marine protected areas in which no fishing is allowed. Several such areas have been implemented, some with the agreement of the majority of affected fishermen, others against their wishes. Other recent concerns include the potential impacts of fishing on protected species such as the Hawaiian monk seal and green sea turtle, as well as questions regarding the appropriate levels of scientific analysis needed for decision making in a social and political environment of conflicting values and priorities.

3.4.5 Pacific Remote Island Areas

The Pacific Remote Islands of Howland, Baker, Jarvis, Kingman Reef, and Palmyra have been basically unoccupied for all of modern times, while Midway Atoll, Johnston Atoll, and Wake Island have had varying levels of military populations for most of the twentieth century.

Baker Island

Baker Island, which is part of the Phoenix Islands archipelago, is located 13 miles north of the equator at 0° 13' N and 176° 38' W and approximately 1,600 nautical miles to the southwest of Honolulu. It is a coral-topped seamount surrounded by a narrow-fringing reef that drops steeply very close to the shore. The total amount of emergent land area of Baker Island is 1.4 square kilometers (CIA World Fact Book 2005).

In 1924, Bishop Museum archaeologist Kenneth Emory discovered several Polynesian structures as well as stone paths and pits, and concluded that Baker Island was known to early Polynesians.[20] In the early nineteenth century, several whaling ships landed on the island, including the *Gideon Howard* for whose captain, Michael Baker, the island is named. Captain Baker later sold his rights to the island to the American Guano Company, which extensively mined the island's phosphate deposits from 1859 to 1878. In 1935, American colonists attempted to settle the island and built dwellings, a lighthouse, and planted trees and shrubs.[21] The settlement was abandoned due to World War II. Baker Island was designated a National

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[20] Source: Bishop Museum, Honolulu, Hawaii, past exhibits (1995) and at ; http://www.bishopmuseum.org/exhibits/pastExhibits/1995/hawaiilo/hawbaker.html

[21] http://www.janeresture.com/baker/

Wildlife Refuge in 1974 and is administered by the USFWS. Currently, Baker Island is uninhabited. The Coral Reef Ecosystems FMP (69 FR 8336) established a no-take MPA from 0 to 50 fathoms around Baker Island and this FEP maintains that regulation.

Howland Island

Howland Island, which is also part of Phoenix Islands archipelago, is located 48 miles north of the equator at 0° 48' N and 176° 38' W, and 36 nautical miles north of Baker Island. The island, which is the emergent top of a seamount, is fringed by a relatively flat coral reef that drops off sharply. Howland Island is approximately 1.5 miles long and 0.5 miles wide. The island is flat and supports some grasses and small shrubs. The total land area is 1.6 square kilometers (CIA World Fact Book).

Throughout the whaling era of the early nineteenth century, several ships are believed to have landed at Howland Island. In 1857, Howland Island was claimed by the American Guano Company, which mined several hundred thousand tons of guano between 1857 and 1878. American colonists landed on the island in 1935 and later built a runway that was planned to be used by Ameila Earhart on her circumnavigation flight in 1937. Earhart was supposed to land on Howland on July 2, 1937, as a stopover during her flight from Lau, New Guinea, to Oahu, Hawaii, however, Earhart never arrived nor was she heard from again. The lighthouse at Howland Island is called Amelia Earhart light.[22] In 1942, following attacks on the island by Japanese forces, the American colonists were removed. Since that time, the island has remained uninhabited. In 1974, management authority of the refuge was transferred to the USFWS. The Coral Reef Ecosystems FMP (69 FR 8336) established a no-take MPA from 0 to 50 fm around Howland Island and this FEP maintains that provision.

Jarvis Island

Jarvis Island, which is part of the Line Island archipelago, is located at 0° 23' S, 160° 01' W and approximately 1,300 miles south of Honolulu and 1,000 miles east of Baker Island. Jarvis Island is a relatively flat (15–20-ft beach rise), sandy coral island with a total land area of 4.5 square kilometers. It experiences a very dry climate with limited rainfall (CIA World Fact Book).

Between 1859 and 1878, Jarvis Island was extensively mined for its rich guano deposits by the American Guano Company. In 1889, Great Britain annexed the island and leased to a British mining company, which did not extract large amounts of guano. In 1935, American colonists reclaimed Jarvis as an American possession and built a group of buildings that they named Millerstown. Jarvis was abandoned by the colonists due to attacks from Japanese forces during World War II, and since 1974 it has been a National Wildlife Refuge administered by the USFWS. The Coral Reef Ecosystems FMP (69 FR 8336) established a no-take MPA from 0 to 50 fathoms around Jarvis Island, and this FEP maintains that provision.

Palmyra Atoll

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[22] http://www.janeresture.com/howland/

Palmyra Atoll comprises approximately 52 islets surrounding three central lagoons. This low-lying coral atoll system is approximately 1,056 nm south of Honolulu and is located at 5° 53' N latitude and 162° 05' W longitude. Palmyra Atoll and Kingman Reef occur at the northern end of the Line Island archipelago, situated halfway between Hawaii and American Samoa. Palmyra Atoll is located in the ITCZ, an area of high rainfall (see Chapter 3)

Palmyra has had an interesting history involving shipwrecks, pirates, and buried treasure, and a double murder in the mid-1970s. Palmyra first became an American possession when it was claimed by the American Guano Company in 1859. In 1862, King Kamehameha IV claimed Palmyra for the kingdom of Hawaii. In 1898, when the U.S. annexed the Territory of Hawaii, President McKinley also included Palmyra Atoll. In 1912, a judge from Honolulu bought all of Palmyra Atoll, which he later sold to the Fullard-Leo family. From 1940–1946, the U.S. Navy took control of Palmyra and used it as a naval aviation facility. In 1947, the U.S. Supreme Court returned ownership of Palmyra to the Fullard-Leo family from the U.S. Navy. In 1961, President Kennedy assigned the U.S. Department of Interior to have civil administration over Palmyra. In 2000, the Nature Conservancy bought Palmyra Atoll from the Fullard-Leo family and in July 2004 established the Palmyra Atoll Research Consortium (PARC). Palmyra Atoll is managed cooperatively by the USFWS and the Nature Conservancy, which owns Cooper Island and currently manages it as which it manages as a nature preserve with limited recreational fishing (e.g., flyfishing for bonefish). The USFWS administers the island atoll as a National Wildlife Refuge. The Coral Reef Ecosystems FMP (69 FR 8336) established a low-use MPA from 0 to 50 fathoms around Palmyra Atoll and this FEP maintains that provision.

Kingman Reef

Kingman Reef, which is located 33 nautical miles northwest of Palmyra Atoll at 6° 23' N and 162° 24' W, is a series of fringing reefs around a central lagoon. Kingman Reef does not have any emergent islets that support vegetation. The USFWS administers the reef area as a National Wildlife Refuge. The Coral Reef Ecosystems FMP (69 FR 8336) established a no-take MPA from 0 to 50 fathoms around Kingman Reef and this FEP maintains that provision.

In 2001, management authority of Kingman Reef was transferred to the U.S. Fish and Wildlife Service. The USFWS administers the island as a National Wildlife Refuge. The Coral Reef Ecosystem FMP (69 FR 8336) established a no-take MPA from 0-50 fathoms around Kingman Reef.

Wake Island

Wake Island is located at 19° 18' N latitude and 166° 35' E longitude, and is the northernmost atoll of the Marshall Islands archipelago, located approximately 2,100 miles west of Hawaii. Wake Island has a total land area of 6.5 square kilometers and comprises three islets: Wake, Peale, and Wilkes.

The written historical record provides no evidence of permanent prehistoric populations on Wake Island, however, for 2,000 years Marshall Islanders occasionally visited Wake, giving it the name *Eneen-kio*.[23] The island was annexed by the U.S. in 1899. Before the 1930s, the only visitors were scientists and survivors of shipwrecks. The U.S. Navy received administrative control of Wake in 1934, and established an air base on the atoll in January 1941.Wake Island figured prominently in World War II, and the Japanese overtook U.S. forces on Wake in 1941. The U.S. reoccupied the atoll after the war, and administrative authority was held by the Federal Aviation Administration until 1962, when it was transferred to the Department of the Interior, which in turn assigned authority to the U.S. Air Force. Since 1994, the Department of the Army has maintained administrative use of Wake Island. This area is closed to the public and permission is needed to enter the area. The USFWS is currently considering incorporating Wake Island as part of the National Wildlife Refuge system. The Coral Reef Ecosystems FMP (69 FR 8336) established a low-use MPA from 0 to 50 fathoms around Wake Island, and this FEP maintains that provision.

Johnston Atoll

Johnston Atoll is located at 16° 44' N latitude and 169° 31' W longitude and is approximately 720 nautical miles southwest of Honolulu. French Frigate Shoals in the NWHI is the nearest land mass (~ 450 nm to the northwest), and due to its proximity to the Hawaiian Islands there is believed to be genetic and larval connectivity between Johnston Atoll and the Hawaiian Islands. Johnston Atoll is an egg-shaped coral reef and lagoon complex residing on a relatively flat, shallow platform approximately 21 miles in circumference (205 square kilometers). Johnston Atoll comprises four small islands totaling 2.8 square kilometers. Johnston Island, the largest and main island, is natural in origin, but has been enlarged by dredge and fill operations. Sand Island is composed of a naturally formed island (eastern portion) connected by a narrow, man-made causeway to a dredged coral island (western portion). The remaining two islands, North Island and East Island, are completely man-made from dredged coral (USAF 2004).

Although both the U.S. and Great Britain annexed Johnston Atoll in the mid-1850s, only the U.S. (American Guano Company) mined phosphates from the island (CIA World Fact Book). President Theodore Roosevelt designated Johnston Atoll as a wildlife refuge in 1926, and in 1934, the U.S. Navy administered the area. In 1948, Johnston Atoll was managed by the U.S. Air Force, which in the 1950s - 1960s used the area for high-altitude nuclear tests. Until 2000, Johnston Atoll was managed by the U.S. Department of Defense as a storage and disposal site for chemical weapons. In 2004, cleanup and closure of the storage and disposal facilities was completed. Now the USFWS manages Johnston Atoll as a National Wildlife Refuge. Recreational fishing occurs within the refuge. The Coral Reef Ecosystems FMP (69 FR 8336) established a low-use MPA from 0 to 50 fathoms around Johnston Atoll, and this FEP maintains that provision.

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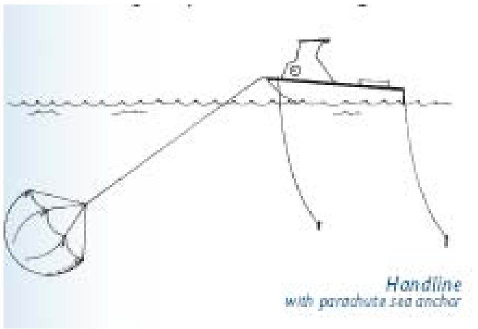
[23] http://www.enenkio.org/history_main.htm

CHAPTER 4: DESCRIPTION OF PACIFIC PELAGIC FISHERIES

4.1 Introduction

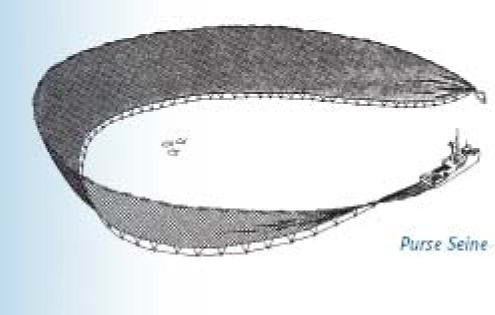
Chapter 4 describes the domestic pelagic fisheries of the Western Pacific Region and provides background on the history of fishing by the residents of the area, including information on catches, landings and bycatch. At this time there is no authorized fishing by foreign vessels in the Region's EEZ; however the MSA provide mechanisms by which this could take place in the future, including the use of Pacific Island Area Fishing Agreements and International Fishery Agreements. A description of the Pelagics FMP and its amendments may be found in Section 5.2 of this document. Detailed information on annual landings, effort, CPUE, and revenues may be found in the Council's annual reports. Additional information on Pacific Pelagic fisheries is available in the Council's annual reports, in a 2001 Comprehensive Pelagic EIS (NMFS 2001), a 2004 EIS (WPRFMC 2004a), a 2005 EIS (NMFS 2005), 2004 and 2009 Supplemental EISs (WPRFMC 2004 and 2009 respectively) as well as in environmental assessments completed in 2004 (WPRFMC 2004b), 2005 (WPRFMC 2005a) and 2006 (WPRFMC 2006).

4.1.1 Overview of Pelagic Gear Types and Fisheries of the Western Pacific Region



U.S. pelagic fisheries in the Western Pacific Region, with the exception of purse seining, primarily utilize variations of hook-and-line fishing. These include longlining, trolling, handlining and pole-and-line fishing.

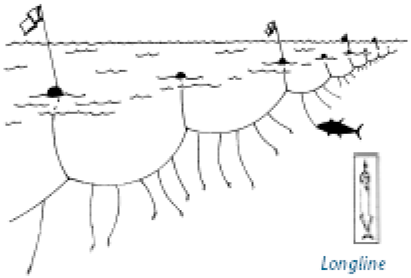
The 2004 total reported commercial catches of albacore, bigeye, skipjack and yellowfin tunas from the entire Pacific were approximately 2.6 million tons (Lawson 2005). The majority of these landings (60 percent) were skipjack followed by yellowfin (26 percent), bigeye (9 percent) and albacore with 5 percent.



Although the U.S. fleet has been decreasing in size from a peak in 1984 of 61 vessels to 14 vessels in 2004, it remains the largest domestic Pacific fishery in terms of tonnage of fish landed.

The U.S. fleet of albacore trollers, based at West Coast ports, comprises about 500 vessels, fishing primarily in the temperate waters of the North Pacific and landing in 2003 about 17,000 mt of fish. Some vessels from this fleet also fish seasonally for albacore in the South Pacific, catching on average between 1,000 and 2,500 mt of albacore with marlins and other billfish constituting a negligible fraction of the catch.

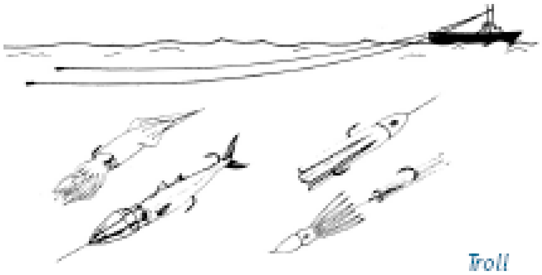
Bigeye tuna catches by commercial fisheries under the Council's jurisdiction in 2004 amounted to 5,163 tons, or 2.3 percent of the 2004 total Pacific-wide bigeye catch. Similarly, 2004 yellowfin tuna catches by commercial fisheries under the Council's jurisdiction amounted to 2,383 t or about 0.35 percent of the 2004 total Pacific-wide yellowfin catches.



U.S. longline vessels in the Western Pacific Region are based primarily in Hawaii and American Samoa, although Hawaii-based vessels targeting swordfish have also fished seasonally out of California. The Hawaii fishery, with about 125 active vessels targets a range of species, with vessels either setting shallow to catch swordfish or setting deep to maximize catches of bigeye tuna.

Catches by the Hawaii fleet also include yellowfin tuna, mahimahi (dorado), wahoo, blue and striped marlins, opah (moonfish) and monchong (pomfret). The Hawaii fishery does not freeze its catch, which is sold for the fresh fish and sashimi market in Hawaii, Japan and the U.S. mainland.

The American Samoa fleet of about 50 vessels fishes almost exclusively for albacore tuna, which is landed at two tuna canneries in American Samoa. The combined landings from the two fisheries in 2003 amounted to 14,743 mt, with about two-thirds of landings coming from the Hawaii fishery.



Small boat trolling and, to a lesser extent, handline fishing for pelagics is the Region's largest commercial fishery in terms of participation, although it catches a relativly modest volume of fish amounting to about 3,000 mt annually. Part of this catch is made by charter or for-hire fishing vessels. There are 1,494 commercial troll vessels and 156 handline vessels in Hawaii, 73 troll vessels in the Northern Mariana Islands, 343 troll vessels in Guam, and 20 troll vessels in American Samoa. Troll and handline catches are dominated by yellowfin and bigeye tuna in Hawaii and by skipjack in Guam, the Northern Mariana Islands and American Samoa. Other commonly caught troll catches include mahimahi, wahoo and blue marlin. About 85 percent of the Region's domestic commercial small boat troll landings are made by Hawaii vessels. In 2003, the combined catches of blue and striped marlins by these fisheries amounted to 207 and 28 mt respectively.

Troll fishing for pelagics is the most common recreational fishery in the islands of the Western Pacific Region. The definition of recreational fishing, however, continues to be problematic in a region where many fishermen who are fishing primarily for recreation may sell their fish to cover their expenses.

The probable future of Council-managed pelagic fisheries in the Western Pacific Region is dependent on many factors including: the size of the fleets operating inside and outside the EEZ; fuel costs; catch limits such as the EPO and WCPO bigeye quotas, and other international agreements pursuant to the RFMOs. Fisheries could also be impacted due to environmental variables affecting the abundance, location, and condition of pelagic fish stocks. Oceanographic and climactic cycles, described in Sections 3.2 and 3.3.2, can have profound effects on the spatial and temporal characteristics of pelagic species and in turn may affect catches of target species and presence of bycatch species.

4.2 American Samoa-based Pelagic Fisheries

The harvest of pelagic fish has been a part of the way of life in the Samoan archipelago since the islands were first settled some 3,500 years ago (Severance and Franco 1989). In 1995, small-scale longline fishing began in American Samoa following training initiated by the Secretariat of the Pacific Community (Chapman 1998). Both the American Samoa and Samoa fisheries are based on supplying fresh or frozen albacore directly to the two large tuna canneries in PagoPago. Subsistence fishing continues to the present, but the importance of pelagic fisheries as a source of income and employment is increasing. Commercial ventures are diverse, ranging from small-scale vessels having very limited range, to large-scale vessels catching tuna in the EEZ and distant waters, and delivering their catches to canneries based in American Samoa. Since 1982, the number of vessels landing pelagic species in American Samoa has ranged between 22 and 68 each year, with 46 active in 2005.

Tuna PMUS landings by American Samoa-based longline, troll, and handline vessels have declined since a 2002 peak; however, non-tuna PMUS catches are on an increasing trend (Figure 12). The 2005 tuna landings were 8.2 million lbs while the non-tuna landings were over 600,000 pounds. Total pelagic landings were approximately 8.8 million pounds in 2005, with longline landings making up the majority of this total (WPRFMC 2006). During 2005, nearly 90 percent of these longline landings were albacore, with yellowfin, skipjack, and bigeye tuna making up the majority of the remainder (WPRFMC 2006).

In 2005 inflation-adjusted revenues from pelagic species caught by longline gear decreased by approximately one-million dollars to approximately $8.1 million, continuing a trend that began in 2003. The decrease and trend are primarily due to decreased albacore landings. Adjusted non-tuna PMUS revenues increased four percent to approximately $469,000 continuing their 15-year increasing trend. Troll-caught or other non-longline gear caught pelagics accounted for approximately $18,000 in revenue.

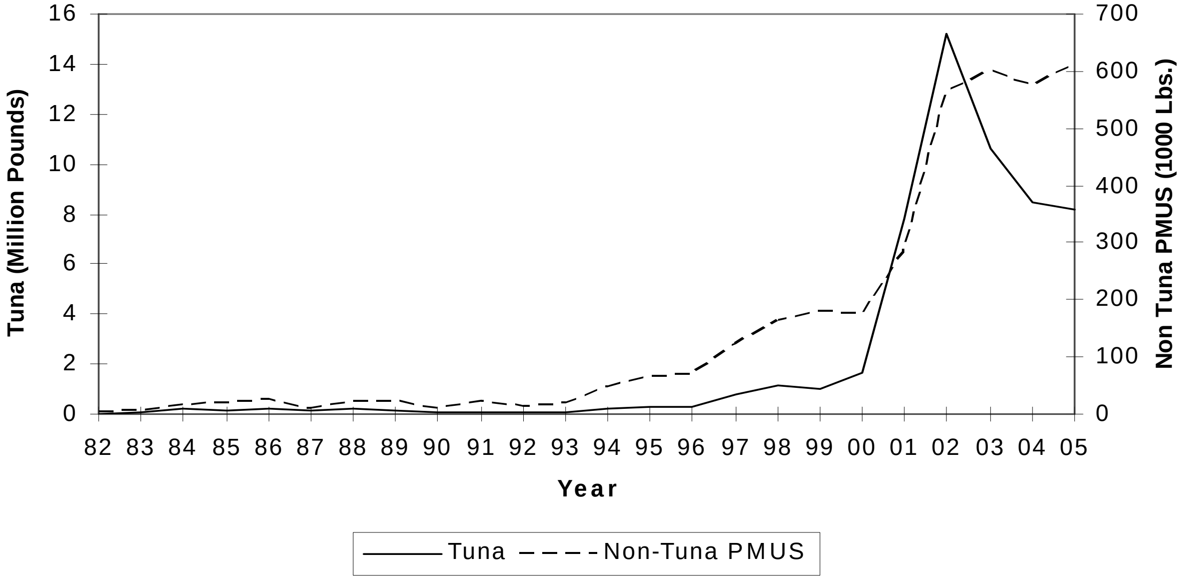


Figure 12: Tuna and Non-Tuna PMUS Landings in American Samoa 1982–2005
Source: WPRFMC 2006

Small-Scale Longline

Most participants in the small-scale domestic longline fishery are indigenous American Samoans with vessels under 50 feet in length. The stimulus for American Samoa's commercial fishermen to shift from troll or handline gear to longline gear in the mid-1990s (see Figure 12) was the fishing success of 28-foot alia catamarans that engaged in longline fishing in the EEZ around Independent Samoa. Horizontal longlining was introduced to the Territory by Independent Samoa fishermen in 1995. Local fishers found longlining a worthwhile venture as they could land more pounds with less effort and use less gasoline for trips. Almost all of the vessels used are "alias" which are locally built, twin-hulled (wood with fiberglass or aluminum) boats about 30 feet long, powered by 40HP gasoline outboard engines. Navigation on the alias is visual, using landmarks with the exception of a few modernized alias that have global positioning systems (GPS). Gear is stored on deck attached to a hand-crank reel that can hold as much as 10 miles (25 miles for the jig-boat) of monofilament mainline. The gear is set by spooling the mainline off the reel and retrieved by handpulling and cranking the mainline back onto the reel. Trips are typically one day long (about 8 hours) with setting beginning in the early morning. Haulback is generally in the mid-day to afternoon. The catch is stored in containers secured to the deck, or in the hulls. As with the large longliners, albacore is the primary species caught, and is generally stored in personal freezers until a sufficient amount accumulates to take to the canneries. Some of the catch is sold to stores, restaurants and local residents or is donated for family functions.

In mid-1995 five alias began longlining. The number of alias grew to 12 in 1996. In 1997, 33 vessels had permits to longline of which 21 were actively fishing on a monthly basis. However, increased fuel costs, maintenance costs and other factors caused the fleet to shrink so that by 2005 there were only seven active alias.

Large-Scale Longline

In 1997 the first longline vessel over 60 feet in length (and thus capable of making multi-day trips) began operating in American Samoa and in 1998, 25 vessels longlined. The fishery expanded rapidly in 2001. Much of the growth was due to the entry of monohull vessels larger than 50 feet in length. The number of permitted longline vessels in this sector increased from three in 2000 to 30 by March 21, 2002 (DMWR, unpublished data). Of these, five permits (33 percent of the vessel size class) for vessels between 50.1 feet–70 feet and five permits (33 percent of the vessel size class) for vessels larger than 70 feet were believed to be held by indigenous American Samoans as of March 21, 2002 (T. Beeching, DMWR, personal communication to P. Bartram, March 2002). Economic barriers have prevented more substantial indigenous participation in the large-scale sector of the longline fishery. To date, lack of capital appears to be the primary constraint to substantial indigenous participation in this sector (DMWR, 2001). In 2002, there were 60 active large-scale longline vessels but only 29 were active in 2005.

While the smallest (less than or equal to 40 ft) vessels average 350 hooks per set, a vessel over 50 feet can set five to six times more hooks and has a greater fishing range and capacity for storing fish (8–40 metric tons as compared with 0.5–2 metric tons on a small-scale vessel). Larger vessels are also outfitted with hydraulically powered reels to set and haul mainline, and with modern electronic equipment for navigation, communications, and fish finding. Most are presently being operated to freeze albacore onboard, rather than to land chilled fish. Three vessels that left Hawaii after the swordfish longline fishery closure are operating in the American Samoa tuna longline fishery under new ownership. It does not appear that large numbers of longliners from Hawaii are relocated in American Samoa (O’Malley and Pooley, 2002).

Distant-Water Purse Seine Fishery

The U.S. purse seine fleet operating in the central and western Pacific uses large nets to capture skipjack, yellowfin, and bigeye tuna near the ocean surface, in free-swimming schools, around fish aggregation devices (FADs) deployed by the fleet, or by setting on logs or other floating objects. These vessels often land their catches at canneries based in American Samoa. These large vessels (200–250 ft length) could not be economically operated for longline fishing, but some former participants in the U.S. purse seine fishery have acquired more suitable vessels and participated in the American Samoa-based longline fishery.

Distant-Water Jig Albacore Fishery

Domestic albacore jig vessels also supply tuna to the canneries in American Samoa. Since 1985, approximately 50–60 U.S. vessels have participated in the high-seas troll fishery for albacore. This fishery occurs seasonally (December through April) in international waters at 35°–40° S latitude. The vessels range in length from 50 to 120 feet, with the average length about 75 feet

(Heikkila, 2001). They operate with crews of three to five and are capable of freezing 45–90 tons of fish (WPRFMC 2000).

Troll and Handline Fishery

From October 1985 to the present, catch-and-effort data in American Samoa fisheries have been collected through a creel survey that includes subsistence and recreational fishing, as well as commercial fishing. However, differentiating commercial troll fishing activity from noncommercial activity can be difficult.

Recreational fishing purely for sport or pleasure is uncommon in American Samoa. Most fishermen normally harvest pelagic species for subsistence or commercial sale. However, tournament fishing for pelagic species began in American Samoa in the 1980s, and between 1974 and 1998, a total of 64 fishing tournaments were held in American Samoa (Tulafono, 2001). Most of the boats that participated were alia catamarans and small skiffs. Catches from tournaments are often sold, as most of the entrants are local small-scale commercial fishermen. In 1996, three days of tournament fishing contributed about 1 percent of the total domestic landings. Typically, 7 to 14 local boats carrying 55 to 70 fishermen participated in each tournament, which were held two to five times per year (Craig et al. 1993).

The majority of tournament participants have operated 28-foot alia, the same vessels that engage in the small-scale longline fishery. With more emphasis on commercial longline fishing since 1996, interest in the tournaments has waned (Tulafono, 2001) and pelagic fishing effort has shifted markedly from trolling to longline (see Figure 13). Catch-and-release recreational fishing is virtually unknown in American Samoa. Landing fish to meet cultural obligations is so important that releasing fish would generally be considered a failure to meet these obligations (Tulafono 2001). Nevertheless, some pelagic fishermen who fish for subsistence release fish that are surplus to their subsistence needs (S. Steffany, personal communication to P. Bartram, September 15, 2001).

Total 2005 commercial pelagic landings by the nine active American Samoa-based troll vessels were estimated to be 13,094 lb with 7,600 lb of skipjack tuna and 4,500 lb of yellowfin tuna.

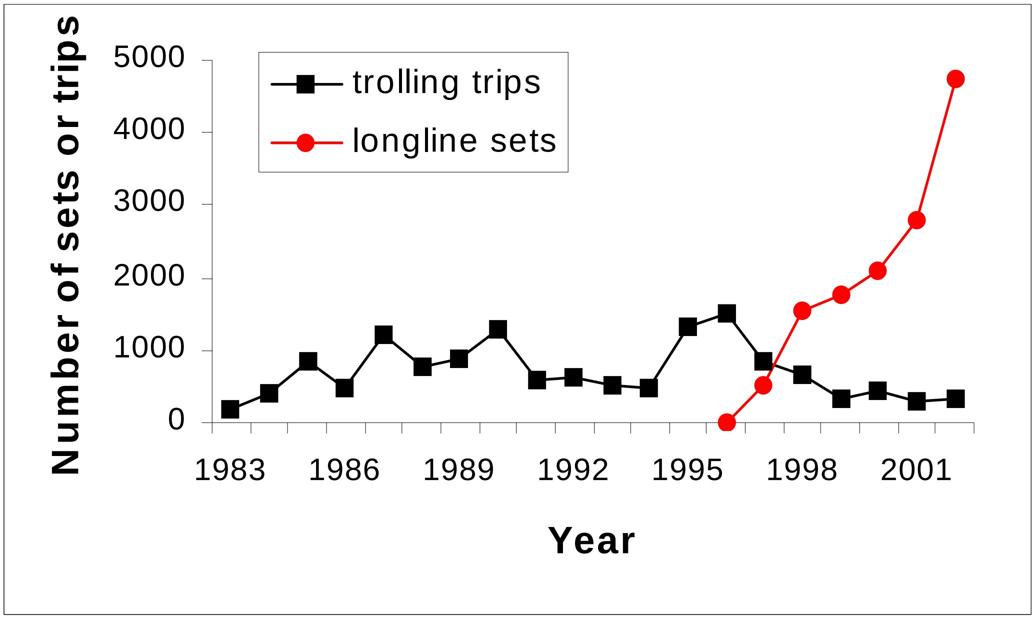


Figure 13: Distribution of Pelagic Trolling and Longlining Effort in American Samoa
Source: WPRFMC 2005

American Samoa has been unable to develop a significant tourist industry that could support charter fishing (TPC/DOC 2000), nor is American Samoa known for producing large game fish. Few, if any, charter boats are in operation (Tulafono 2001), so no data are collected specifically for the charter fishing sector.

4.3 CNMI-based Pelagic Fisheries

CNMI's pelagic fisheries occur primarily from the island of Farallon de Medinilla (FDN) south to the island of Rota. Trolling is the primary fishing method utilized in the pelagic fishery. The pelagic fishing fleet consists primarily of vessels less than 24 feet in length, which usually have a limited 20-mile travel radius from Saipan. The current Commercial Purchase Database system documents commercial sales on Saipan only; however, data collection systems for Rota and Tinian islands are being established. The existing database lacks information on fishing method, gear, location, and effort. There is currently no logbook system in effect and information on charter vessel catches is mostly lacking because these vessels are rare sell their catches. There is also a small subsistence fishery on Saipan in which a portion of the landings are sold to cover trip expenses.

The primary target and most marketable species for the pelagic fleet is skipjack tuna (67 percent of 2004 commercial landings). Yellowfin tuna and mahimahi are also easily marketable species, but are seasonal. During their runs, these fish are usually found close to shore and provide easy targets for the local fishermen. In addition to the economic advantages of being near shore and their relative ease of capture, these species are widely accepted by all ethnic groups, which has kept market demand fairly high. Figure 14 presents historical data on pelagic landings in CNMI.

It is estimated that in 2004, 68 fishery participants made 235,382 pounds of commercial landings of pelagic species with a total ex-vessel value of $466,490 (WPRFMC 2005b).

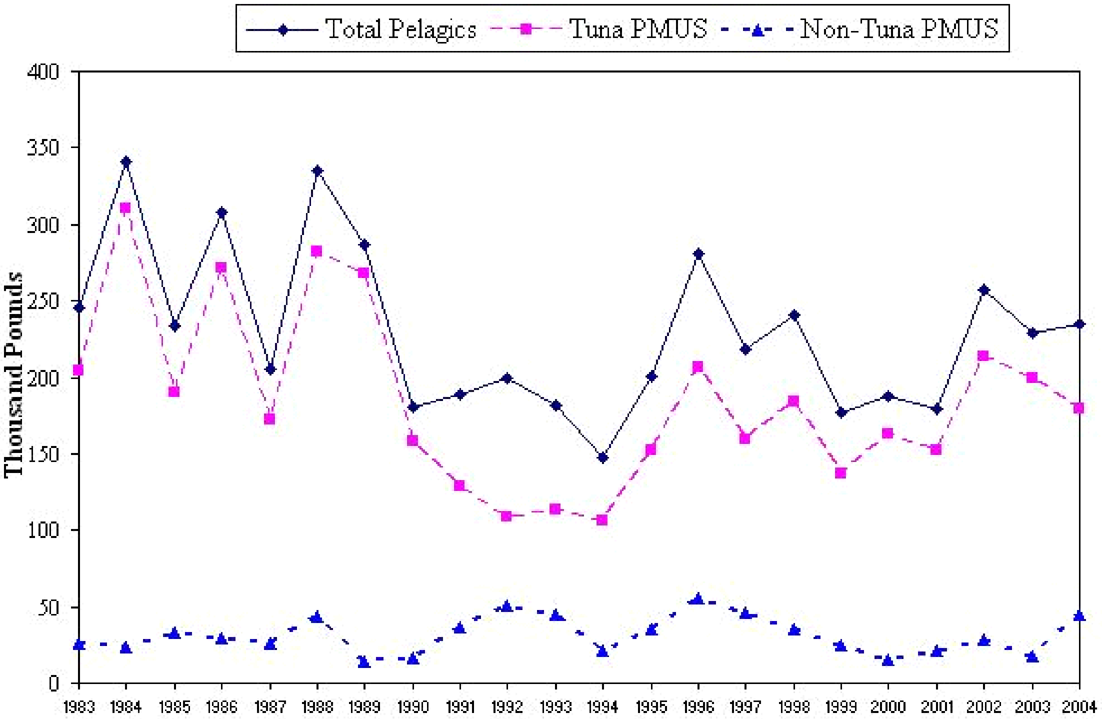


Figure 14: Pelagic Landings in CNMI 1983–2004
Source: CNMI DLNR-DFW

4.4 Guam-based Pelagic Fisheries

Guam hosts a number of distant-water purse seine and longline fleets, but does not currently engage in any large-scale pelagic fisheries. Guam's pelagic fisheries consist of primarily small, recreational, trolling boats that are either towed to boat launch sites or berthed in marinas. They fish only within local waters, either within EEZ waters around Guam or on some occasions in the adjacent EEZ waters around CNMI . In 2006 the first Guam-based longline vessel became active. This vessel employs deep-set gear targeting tuna. The vessel is 60' in length with a 5 ton capacity and does not have a refrigeration system; it uses ice to keep fish fresh. This vessel normally makes 5-day trips relatively close to shore (although outside the longline area closure described in Chapter 5).

Domestic annual pelagic landings in Guam have varied widely, ranging between 322,000 and 937,000 pounds in the 23-year time series. The 2004 total pelagic landings were approximately 691,366 pounds, an increase of 36 percent compared with 2003. Of this total, it is estimated that 285,545 pounds were sold for an ex-vessel revenue of $433,911 (WPRFMC 2005b).

Landings consisted primarily of five major species: mahimahi (*Coryphaena hippurus*), wahoo (*Acanthocybium solandri*), bonita or skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), and Pacific blue marlin (*Makaira mazara*). Other minor pelagic species caught include rainbow runner (*Elagatis bipinnulatus*), great barracuda (*Sphyraena barracuda*), kawakawa (*Euthynnus affinis*), dogtooth tuna (*Gymnosarda unicolor*), double-lined mackerel *(Grammatorcynus bilineatus*), oilfish (*Ruvettus pretiosus*), and three less common species of barracuda. Sailfish and sharks were also known to be caught during 2004 but these species were not encountered during offshore creel surveys.

There are wide year-to-year fluctuations in the estimated landings of the five major species. 2004 mahimahi catch increased more than 134 percent from 2003, and reached the highest level since 1998. Wahoo catch totals increased 83 percent from 2003, and were the sixth highest total during the 23-year recording period. Pacific blue marlin landings decreased 28percent from 2003, and were 24 percent below the 23-year average. Super typhoon Pongsona's direct hit on Guam in December 2002 and subsequent negative impact on fishing during the first quarter of 2003 probably account for the low numbers of mahimahi caught during 2003. Participation and effort generally increased in 2004 with the number of trolling boats up by 8 percent (WPRFMC 2005b).

The number of boats involved in Guam's pelagic or open ocean fishery gradually increased from 193 in 1983 to 469 in 1998. This number decreased until 2001, but then began increasing, and has been increasing since. There were 401 boats active in Guam's domestic pelagic fishery in 2004. A majority of the fishing boats are less than 10 meters (33 ft) in length and are usually owner operated by fishermen who earn a living outside of fishing. Most fishermen sell a portion of their catch at one time or another, and it is difficult to make a distinction between recreational, subsistence, and commercial fishers. A small, but significant, segment of Guam's pelagic fishery is made up of marina-berthed charter boats that are operated primarily by full-time captains and crews. These operations were responsible for 22 percent of all domestic pelagic fishing trips from Guam in 2004 (WPRFMC 2005b). Figure 15 provides the estimated annual total domestic pelagics catch in Guam.

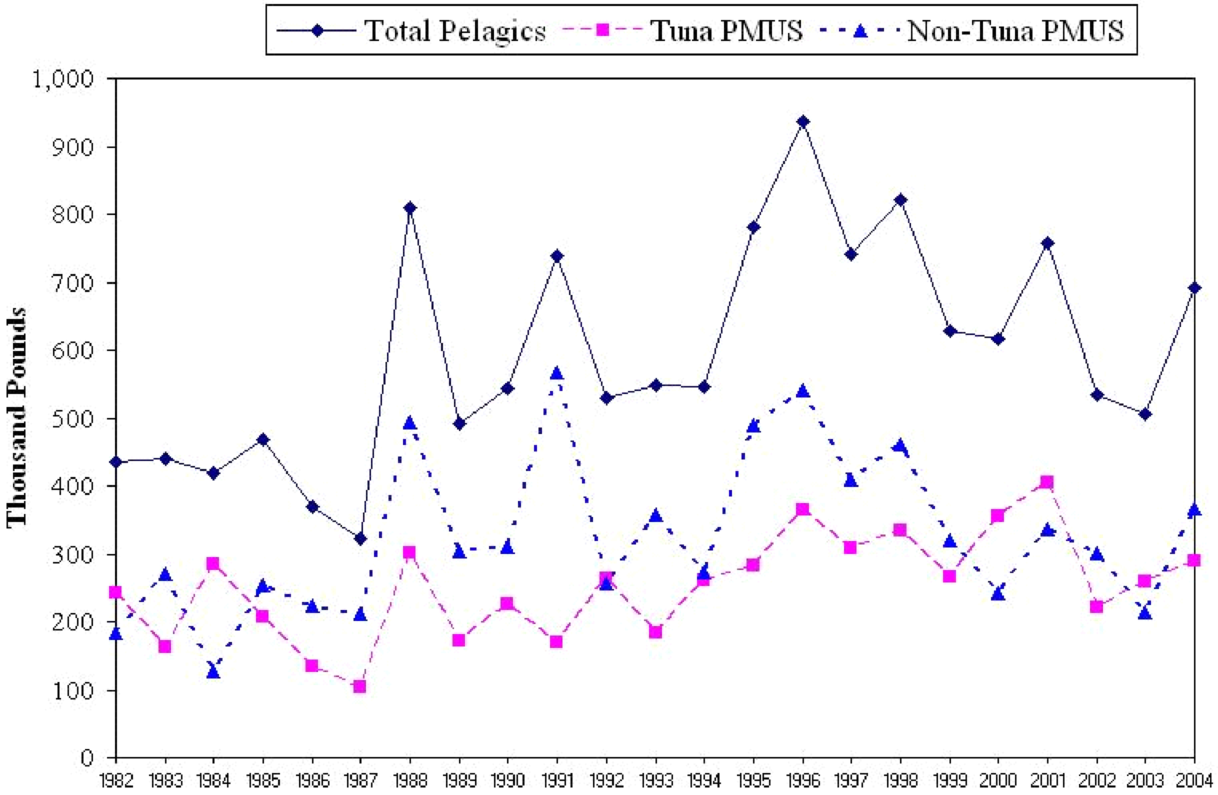


Figure 15: Estimated Annual Total Domestic Pelagics Catch in Guam 1982–2004
Source: WPRFMC 2005

4.5 Hawaii-based Pelagic Fisheries

Hawaii's pelagic fisheries are small in comparison with other Pacific Ocean pelagic fisheries such as distant-water purse seine fisheries and other foreign pelagic longline fisheries, but they comprise the largest fishery sector in the State of Hawaii. Tuna, billfish and other tropical pelagic species supply most of the fresh pelagic fish consumed by Hawaii residents and support popular recreational fisheries. Hawaii-based longline vessels are capable of traveling long distances to high-seas fishing grounds, while the smaller handline, troll, charter and pole-and-line fisheries—which may be commercial, recreational or subsistence —generally occur within 25 miles of land, with trips lasting only one day.

Hawaii’s pelagic fisheries—which include the longline, Main Hawaiian Islands troll and handline, offshore handline, and the aku boat (pole and line) fisheries—are the state’s largest and most valuable fishery sector. The majority of the commercial landings and revenue come from the longline fishery although the majority of State Commercial Licenses (CMLs) required to report are for fishermen on small vessels using trolling gear.

Primary Fishing Method	Number of licensees required to report 2004	 2005
Trolling	1,378	1,406
Longline	390	489
Ika Shibi & Palu Ahi	172	147
Aku Boat (Pole and Line)	25	27
Total Pelagic	1,965	2,069
Total All Methods	3,083	3,136

The target species are tunas and billfishes, but a variety of other species are also important including mahimahi, ono (wahoo), opah (moonfish), and monchong (pomfret) among others. Table 7 presents an overview of Hawaii's commercial pelagic landings, and their values, for the years 2004 and 2005. Collectively, these pelagic catches amounted to approximately 28 million pounds of commercial landings with an estimated ex-vessel value of nearly $67 million in 2005 (WPRFMC 2005b).

The largest component of pelagic catch in recent years is bigeye tuna. Swordfish was the largest component of the billfish catch from 1990 through 2000, but was replaced by blue marlin in the next two years, and followed by striped marlin in 2005. Mahimahi was the largest component of the non-tuna and non-billfish catch, though ono and opah catches are also substantial.

Table 7. Hawaii Commercial Pelagic Catch Information 2004-2005

	2004			2005		
Species	**Pounds caught (1000 lbs)**	**Ex-vessel revenue ($1000)**	**Average price ($/lb)**	**Pounds caught (1000 lbs)**	**Ex-vessel revenue ($1000)**	**Average price ($/lb)**
Tuna PMUS						
Albacore	1,141	$1,549	$ 1.38	1,063	$1,492	$ 1.45
Bigeye Tuna	10,258	$29,840	$ 3.04	11,424	$36,059	$ 3.29
Bluefin Tuna	4	$2	$10.69	12	$1	$ 2.81
Skipjack Tuna	1,158	$1,174	$ 1.36	1,145	$1,123	$ 1.17
Yellowfin Tuna	3,108	$7,308	$ 2.35	3,249	$7,285	$ 2.24
Tuna PMUS subtotal	**15,668**	**$39,873**	**$2.67**	**16,894**	**$45,959**	**$2.84**
Billfish PMUS						
Swordfish	573	$1,270	$ 2.44	3,491	$7,780	$ 2.26
Blue Marlin	970	$1,153	$ 1.29	1,061	$968	$ 1.03
Striped Marlin	934	$1,399	$ 1.50	1,192	$1,535	$ 1.29
Other Billfish	491	$469	$ 1.02	506	$431	$ 0.91
Billfish PMUS subtotal	**2,968**	**$4,290**	**$1.53**	**6,250**	**$10,715**	**$3.82**
Other PMUS						
Mahimahi	2,272	$5,096	$ 2.30	1,603	$3,583	$ 2.41
Ono (wahoo)	881	$2,271	$ 2.68	840	$2,229	$ 2.75
Opah (moonfish)	785	$1,391	$ 1.77	1,091	$1,895	$ 1.75
Sharks (whole weight)	418	$77	$ 0.33	392	$101	$ 0.37
Other Pelagics	1,209	$1,990	$ 1.73	1,110	$2,171	$ 2.04
Other PMUS subtotal	**5,565**	**$10,826**	**$2.07**	**5,037**	**$9,978**	**$2.11**
Total Pelagics	**24,201**	**$54,989**	**$2.40**	**28,181**	**$66,652**	**$2.47**

Though somewhat dated, Boggs and Ito (1993) provide an excellent overview of the development and status of Hawaii's pelagic fisheries circa 1990. Generally, the aku boat fishery has contracted steadily to where it now exists as minor remnant of former times while the longline fishery has expanded steadily and is by far the leading producer of pelagic landings and bigeye tuna in Hawaii. The fishery is based upon and targets sub-adult and adult sized bigeye tuna. The MHI troll and handline fisheries take a variety of pelagic species of which bigeye tuna is a relatively minor component. The inshore *ika shibi* handline fishery for large tunas, which did at one time take significant quantities of bigeye tuna, has contracted steadily over the last decade for a variety of reasons. In its place, the "offshore handline fishery" has evolved steadily and undergone a number of changes. This fishery originally centered on handline and troll fishing on tuna found in aggregations around the Cross Seamount and four offshore moored NOAA weather buoys. Although the FADs moored around the coast of Hawaii by the State government have not been used extensively by the offshore handline fishery, the fishery has, in recent years, expanded to include fishing operations on privately set FADs, some of which are very close to the MHI thus blurring the distinction between "offshore handline" and "MHI handline" fisheries. The private FAD fishery is included here with the offshore handline fishery due to similar fishing techniques, operational and catch characteristics. The offshore handline fishery targets juvenile and sub-adult bigeye tuna with a considerable catch of juvenile, sub-adult and adult size yellowfin. Each of these fisheries is discussed in turn below.

Hawaii-based longline fishery

Hawaii's longline fishery began around 1917 and was based on fishing techniques brought to Hawaii by Japanese immigrants. The early Hawaiian sampan-style flagline boats targeted large yellowfin and bigeye tuna using traditional basket gear with tarred rope mainline. This early phase of Hawaii longline fishing declined steadily into the 1970s due to low profitability and lack of investment in an ageing fleet (Boggs and Ito 1993). During the 1980s, tuna longline effort began to expand to supply developing domestic and export markets for high quality fresh and sashimi grade tuna. In the late 1980s and early 1990s, the nature of the fishery changed completely with the arrival of swordfish and tuna targeting fishermen from longline fisheries of the Atlantic and Gulf States. Longline effort increased rapidly from 37 vessels in 1987 to 138 vessels in 1990 (Ito and Machado 2001). An emergency moratorium was placed on the rapidly expanding fishery in 1991. In 1985, the longline fishery surpassed landings of the skipjack pole-and-line fleet and has remained the largest Hawaii-based fishery to date. Swordfish landings rose rapidly from 600,000 lbs in 1989 to 13.1 million pounds in 1993 (WPRFMC 2005b). The influx of large, modern longline vessels promoted a revitalization of the fishery, and the fleet quickly adopted new technology to better target bigeye tuna at depth. The near-full adoption of monofilament mainline longline reels further modernized the fleet and improved profitability.

The Hawaii-based limited access longline fishery is the largest of all the pelagics fisheries under Council jurisdiction. This fishery accounted for the majority of Hawaii's commercial pelagic landings with an average of 9,672 t or 19.3 million lb for the years 2000 - 2005 (Table 8). The longline fleet is composed mostly of steel-hulled vessels and a few wood and fiberglass vessels. The longline fleet has historically operated in two distinct modes based on gear deployment: deep-set longline to target primarily tuna and shallow-set longline used to target swordfish or mixed species including bigeye, albacore and yellowfin tuna. Swordfish and mixed target sets are buoyed to the surface, have few hooks between floats, and are relatively shallow. These sets use a large number of lightsticks since swordfish are primarily targeted at night. Tuna sets use a different type of float placed much further apart, have more hooks per foot between the floats and the hooks are set much deeper in the water column. Hawaii-based tuna longline vessels typically deploy about 34 horizontal miles of mainline in the water and use a line shooter. The line shooter increases the speed at which the mainline is set, which causes the mainline to sag in the middle (more line between floats), allowing the middle hooks to fish deeper. The average speed of the shooter is nine knots with an average vessel speed of about 6.8 knots. No light sticks are used and float line lengths average 22 m (72 feet) with branch line lengths averaging 13 m (43 feet). The average number of hooks deployed is 1,690 hooks per set with an average of 27 hooks set between floats. There are approximately 66 floats used during each set. The average target depth is 167 m, and gear is allowed to soak during the day, with total fishing time typically lasting about 19 hours, including the setting and hauling of gear.

To manage the rapidly expanding fishery, longline fishing was prohibited around the main Hawaiian Islands to reduce gear conflicts between small troll and handline boats and longline vessels. Another area closure was established prohibiting longline fishing within a 50 nmi radius of the Northwest Hawaiian Islands to prevent interactions with the endangered Hawaiian monk seals. A limited access program was established in 1994 allowing for a maximum of 164 transferable longline permits for vessels ≤101 feet in overall length. During the same year, the Hawaii Longline Observer Program was initiated, primarily to monitor interactions with protected species.

The relative importance of swordfish to the fishery declined during the mid 1990s following a 47 percent decrease in landings in 1994. The latter part of 1994 saw a stabilization of swordfish landings at close to 6.5 million pounds/year, a significant increase in shark take, primarily blue shark fins, and a gradual increase in tuna fishing effort and landings. Effort continued to shift away from swordfish and back to tuna targeted trips throughout the latter 1990s (WPRFMC 2005b). In fact, most of the fishery always simply continued to fish tuna and bigeye remains a primary target species and mainstay of the fishery.

During this period, the fishery was often described as consisting of three components; a core tuna group, a swordfish targeting sector and vessels that were classified as “mixed”; switching between swordfish and tuna throughout the year or even within a single trip. Generally speaking, tuna vessels set deep gear with more than 15 hooks between floats in the morning, began hauling gear in the late afternoon or dusk, usually used a line shooter to deepen the set, preferred saury or sardine bait and made relatively short trips within 500 miles of home port. Swordfish boats were generally larger than tuna boats, set shallow gear at dusk with an average of 4 hooks between floats, used chemical light sticks, hauled gear at dawn, never used a line shooter, preferred large squid bait and made much longer trips beyond 700 miles from port. The primary swordfish grounds lie far to the north of the Hawaiian Islands.

Regulations imposed in 2001 temporarily prohibited swordfish targeted longline fishing for Hawaii-based vessels due to concerns of interactions with sea turtles. Subsequently a suite of regulations were adopted to minimize interactions and facilitate the safe release of accidentally hooked sea turtles and seabirds (see sections 5.2 and 5.5 for more information).

As a result of restrictions on swordfish-targeted longline fishing by Hawaii-based boats, a number of vessels left Hawaii to exploit the same swordfish stocks from bases in California. Other swordfish boats converted gear to remain in Hawaii and target bigeye tuna. In April 2005, the Hawaii-based swordfishery re-opened in Hawaii under a quota system for both the number of swordfish sets and the maximum number of sea turtle interactions allowed. Integral to this program has been the requirement for 100 percent observer coverage. Additional operational requirements also apply including the use of large circle hooks and mackerel-type bait instead of squid. Most of the swordfish boats that had moved to California have now returned, but tuna directed effort remains high.

All longline vessels carry mandatory VMS monitored by the NMFS and must submit mandatory logsheet data at the completion of every trip. VMS are satellite-based vessel monitoring systems whereby each unit transmits a signal (typically once-per-hour) identifying the exact latitude and longitude of a vessel.

The limited access program allows for 164 vessels in the fishery, but active vessel participation has been closer to 115 during the past decade. In 2005, 124 vessels actively participated in the fishery (Table 8). Vessel sizes range up to nearly the maximum 100 foot limit, but the average size is closer to 65 – 70 ft. Most of the vessels are of steel construction and use flake ice to hold catch in fresh/chilled condition. A few older wooden boats persist in the fishery. Some of the boats have mechanical refrigeration that is used to conserve ice, but catch is not frozen in this fishery.

The physical and operational characteristics of Hawaii-based longliners were summarized from interviews and NMFS data by O'Malley and Pooley (2003) during the 2000 season. Based on their interviews, swordfish vessels were newer than tuna boats on average (14 vs. 23 years), were slightly larger (average 74 vs. 65 feet), had larger fish hold capacities (mean 37,765 vs. 33,967 pounds), carried more fuel and had more powerful engines compared to tuna targeting vessels. Swordfish vessels made fewer, longer trips, set more times per trip and traveled much further than tuna vessels. Tuna targeting vessels averaged 11 trips per year, made 11 sets per trip, set gear that averaged 29 hooks per basket and set an average of 2,069 hooks per set on 33 miles of monofilament mainline. Swordfish targeting boats set only 4 or 5 hooks per basket at night. Based on interview data, Hamilton et al. (1996) found that tuna vessels operated with an average of 3.7 – 4 crewmen, while swordfish vessels required a larger crew of 4 – 5 persons (both figures excluding the captain).

Tuna vessels may range out to 1,000 nmi but generally make trips within 500 nmi from the home port of Honolulu. Prime tuna fishing grounds lie to the south of the main Hawaiian Islands and towards Johnston Atoll. The swordfish grounds center around the sub-tropical convergence zone that forms north of the Hawaiian archipelago near 35°N.

Almost all of the Hawaii-based longline catch is sold at the United Fishing Agency auction in Honolulu. It is believed that very little of the longline catch is directly marketed to retailers or exported by the fishermen. For detailed information and annual landings data see the Council's Annual Reports.

Table 8. Hawaii-based Longline Fishery Information 2000-2005

Item	2000	2001	2002	2003	2004	2005
Area Fished	EEZ and high seas	EEZ and high seas	EEZ and high seas	EEZ and high seas	EEZ and high seas	EEZ and high seas
Total Landings (t)	11,900	7,800	8,750	8,700	9,266	11,617
Percent Catch Composition*						
Tuna	41	52	52	65	48	43
Swordfish	9	1	1	2	1	5
Miscellaneous**	32	36	37	31	50	50
Sharks	18	11	10	2	0.7	0.6
Active Vessels	125	101	100	110	125	124
Total Permits	164	164	164	164	164	164
Total Trips	1,103	1,034	1,165	1,215	1,338	1,492
Hooks Set in All Areas (millions)	20.3	22.4	27.0	29.8	32.0	35.0
Total Ex-vessel Value (adjusted) ($millions)	$52.5	$34.1	$38.4	$38.6	$44.2	$57.9

* Based on number of fish kept from longline logbook summary data
** Billfishes and other PMUS
Source: WPRFMC 2005b

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Hawaii-based non-longline pelagic fisheries

Hawaii’s smaller pelagic fisheries can be classified by gear type as the aku boat (pole and line), troll, handline, and the offshore handline fisheries (WPRFMC 2005b). All fishery participants who fish, or land at least one fish with an intent to sell, within 3 miles of the shoreline (i.e., within State waters) are required by the State to have an annually renewable CML, and vessel operators are required to file state catch reports reporting the fishing effort, catch, discards, and landings of all those onboard during each fishing trip. In 2003 there were 3,219 licensed commercial pelagic fishermen in Hawaii. Of these licensed fishermen most indicated that their primary interest was to catch pelagic fish (67 percent). Most of these pelagic targeting fishermen indicated that their primary fishing method was trolling (73 percent) or longline fishing (17 percent). Mixed handline fishing gears (8 percent) and skipjack pole and line fishing (2 percent) accounted for the rest of the licensed fishermen (WPRFMC 2005b).

Hawaii's seafood dealers are required to report to the State the provenance (i.e., the CML number of the seller), weight and price of each fish that they buy. This provides a means to verify reported catches, to detect unreported catches, and to collect additional information regarding the weight and price of each fish. This relatively new requirement has yet to be fully implemented; however it is believed that Hawaii's major fish dealers are now in compliance.

Pole-and-line fishery

The Hawaii-based skipjack tuna, or aku (skipjack tuna) fishery, is also known as the pole-and-line fishery or the bait boat fishery because of its use of live bait. The aku fishery is a labor-intensive and highly selective operation. Live bait is broadcast to entice the primary targets of skipjack and juvenile yellowfin tuna to bite on lures made from barbless hooks with feather skirts. During the fast and furious catching activity, tuna are hooked on lines and in one motion swung onto the boat deck by crew members. In 2005 the three active vessels landed 931,000 lb of pelagic species in Hawaii.

The Hawaiian pole and line fishery has had a long development from traditional Hawaiian canoes in the 1800s to the unique "Hawaiian sampan" still in use today. These vessels evolved from designs introduced to Hawaii by Japanese immigrants and employed live bait assisted poling techniques from Okinawa. Boggs and Kikkawa (1991) provide a summary of the development and status if the fishery.

The skipjack (or aku boat) fishery was formerly the most important domestic Hawaiian pelagic fishery, supplying fresh and dried skipjack to domestic markets and a locally-based cannery. The fleet size peaked in 1948 at 32 vessels while maximum production reached 7,400 t in 1965. The fishery has been in steady decline since the mid-1970s reflecting a decline in total effort as well as declining CPUE (Boggs and Kikkawa 1991). Constraints to the fishery have included limitations on live baitfish supplies, increased competition and reduced profitability due to the developing skipjack purse seine fisheries, the closure of the local cannery in 1984, increased fixed costs and general ageing of the fleet. There has also been a significant and ongoing decline in the CPUE of large sized skipjack by the fishery that have a higher value and marketability compared to the smaller fish.

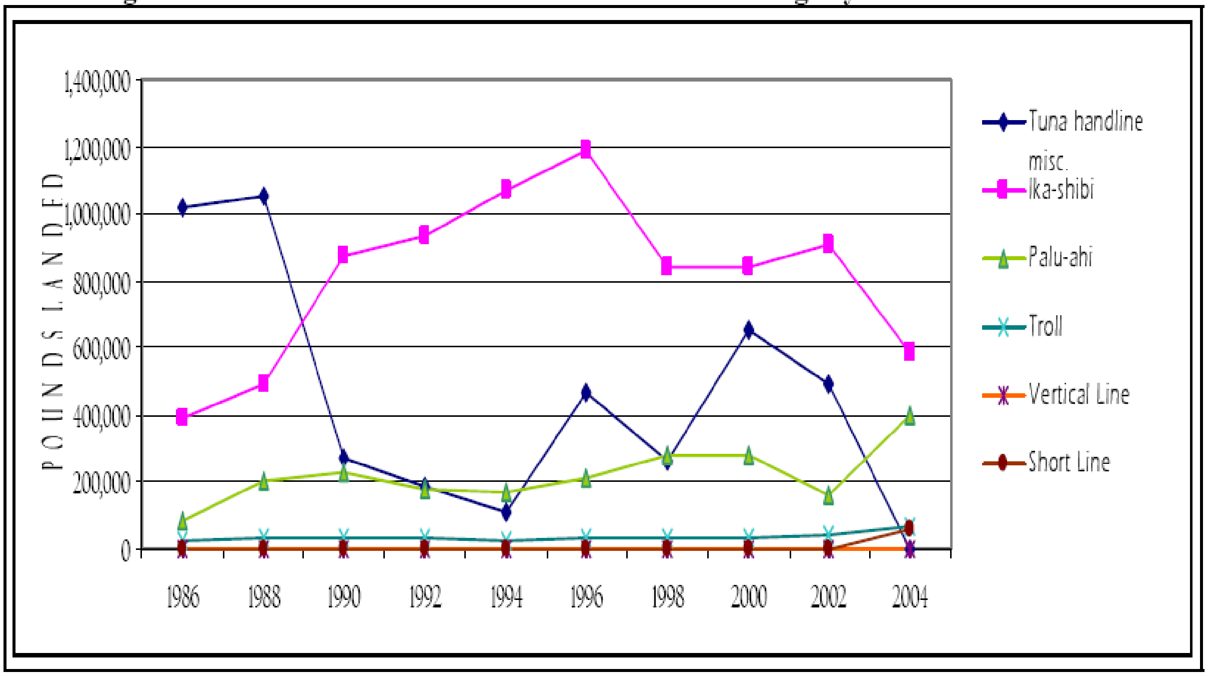
Landings have declined from around 1000 – 2,000 t/year during the 1980s and 1990s, to 466 t in 2005. During the history of the fishery, the catch has been predominantly skipjack with small quantities of juvenile yellowfin and bigeye tuna. Catches of juvenile yellowfin and bigeye tuna occur primarily during times of low skipjack abundance when the boats operate on anchored FADs. Generally, landings of juvenile bigeye are considered insignificant by this fishery and do not appear in published sources. However, it is known that some juvenile bigeye tuna are taken by the fishery, particularly when operating on FADs. During tagging cruises of the Hawaii Tuna Tagging Project on a Hawaii-based pole and line vessel Itano and Holland (2000) recorded 81 bigeye tuna tagged and released on Hawaii State FADs. These fish were all of juvenile size (40 – 64 cm) averaging 47 cm FL and are believed to be representative of the size range typically encountered by the fishery. In 2005 this fishery reported landing 390 t of skipjack and 75 t of yellowfin tuna.

Handline fisheries

Handline fishing is an ancient technique used to catch yellowfin and bigeye tunas with simple gear and small boats. Handline gear is set below the surface to catch relatively small quantities of large, deep-swimming tuna that are suitable for sashimi markets. This fishery continues in isolated areas of the Pacific and is the basis of an important commercial fishery in Hawaii. Three methods of pelagic handline fishing are practiced in Hawaii, the ika-shibi (nighttime) method, the palu-ahi (daytime) method and seamount fishing (which combines both handline and troll methods). These fishing methods are described in detail by Yuen (1979) and Rizzuto (1983). *Palu ahi* fishing is a modern evolution of the traditional Polynesian *drop stone* technique to target chum and a baited, single hook handline on sub-surface concentrations of tuna. The method usually concentrates on medium-sized tuna found in natural aggregations near the main islands or near FADs. The *ika shibi* fishery targets medium and large sized tuna attracted to drifting vessels using underwater bait-attracting lights and additional chum supplied by the fishermen.

Compared to longline operations, the handline fishery is relatively small. In 2004, Hawaii-based MHI and offshore handline fishers reported landing about 1.4 million lb of pelagic fishes or about 6 percent of Hawaii's total commercial pelagic catch. However small, this fishery is undeniably significant to Hawaii's small boat operators and as sources of fresh seafood which is so highly valued in both economic and sociocultural terms (Impact Assessment, Inc. 2007). Historic and recent trends in the handline fishery show that the majority of participation and production is on the Hilo and Kona coasts of the Big Island and show a decline in landings by most handline gear types except palu-ahi and short line as shown in the figure below from Impact Assessment, Inc. (2007).

Figure 3-7 MHI Commercial Small-Boat Annual Landings by Method: 1986-2004



Source: Hawaii Division of Aquatic Resources

The long term average tuna catch by the MHI handline fishery (1982 – 2003) was 745 t with 529 t of tunas reported in 2003. The reported MHI handline catch consists primarily of yellowfin tuna, followed by bigeye and albacore. However, bigeye tuna were once an important component of the *ika shibi* handline fishery, accounting for the highest proportion of catch and value landed by the fishery in 1973 – 1974 (Yuen 1979). During the same time period, catch records of HDAR recorded only minor landings of bigeye tuna by the fishery (Boggs and Ito 1993), highlighting a reporting problem that exists to this day. Significant mixing of bigeye with yellowfin catch statistics has apparently plagued handline and troll catches for decades. Reported 2003 MHI handline catches were 343.5 t, 90 t and 89.5 t respectively (WPRFMC 2005b).

Landings by the MHI handline fisheries peaked in 1986 followed by a decline in catches apparently led by a general decline in effort by the *ika shibi* fishery. The increase in reported bigeye catch in recent years may reflect better species specific reporting by the fisheries and recording by HDAR. However, further investigation is required to clarify these issues.

Offshore handline fishery

Larger handline vessels operate offshore to exploit tuna aggregations found on an offshore submarine feature (Cross Seamount) and anchored weather buoys 100 – 200 nmi from the main Hawaiian Islands (Boggs and Ito 1993). This fishery is considered to be distinct from the MHI handline fisheries due to significant differences in fishing grounds, trip characteristics, fishing methods, and landings. Separate catch and effort statistics have been reported by HDAR and NMFS since 1990.

The development and fishery characteristics of the offshore handline fishery are described in detail by Itano (1998). Hamilton and Huffman (1997) provide economic and some operational details on the fishery. Offshore handline boats are generally larger and better equipped than typical MHI handline boats that use a variety of handline and troll methods. Crew sizes range from 2 – 5 persons taking part in multiple day trips that were reported to average 4.9 days (Hamilton and Huffman 1997).

The fishery targets juvenile and sub-adult bigeye and yellowfin tuna in structure-associated aggregations that are highly vulnerable to simple hook and line gear types (Itano and Holland 2000). The WPRFMC initiated the Hawaii Handline Project to examine catch and effort data on the fishery. A control date of July 2, 1992 for participation in the fishery was established by the Council and later updated to July 15, 2000, but has not been applied to date. Data from the Hawaii Handline Project, NMFS dock sampling, and the Hawaii Tuna Tagging Project determined that the fishery targets bigeye tuna in the size range of 6.8 – 18 kg, although larger fish to 30+ kgs contribute significantly to the value of landings. Yellowfin tuna make up a smaller proportion of the catch. The same sources of data indicate that total tuna landings from the fishery consist of 75 – 80 percent bigeye and ~20 percent juvenile yellowfin (Itano 1998). Smaller quantities of dolphinfish, wahoo and billfish are also taken.

Reported landings by the fishery peaked in 1994 at 533 t with a long term average (1990 – 2003) of 383 t/year. HDAR catch statistics reported ~ 75 - 80 percent yellowfin in the catch during the pre-1995 period after which the proportion of reported bigeye has gradually increased. This situation is likely due to the standard practice of HDAR to record any catches reported under the Hawaiian name of "*ahi*" as yellowfin tuna despite the fact that the fishery takes mainly bigeye tuna. Therefore, species specific landing data for the earlier years should be viewed with caution. In recent years, species specific catch report forms and efforts by HDAR to educate fishermen on the importance of correct species identification and reporting procedures may have improved the situation significantly. In 2003, total landings of 148 t were recorded of which 122 t was bigeye and 18 t yellowfin (WPRFMC 2005b).

Although current information is difficult to obtain, it appears that total effort and catch by the offshore handline fishery has declined in recent years. At the same time, there has been increasing effort by Hawaii handline fishermen directed to the setting of privately funded FADs. The so called "Private FAD" fishery (PFAD) is centered off the east coast of the island of Hawaii, but PFADs currently surround the island at distances of approximately 15 – 50 nmi (HDAR pers.comm.). These buoys appear to aggregate juvenile and sub-adult bigeye and yellowfin tuna in a similar manner to which they aggregate to the weather buoys fished by the offshore handline fishery. Fishing methods, gears and catch composition are believed to be very similar to the offshore handline fishery. However, there is a marked lack of documented information on the PFAD fishery. The Pelagic Fisheries Research Program (PFRP) is currently funding a study on Hawaii handline fisheries that may provide additional information on the current status of PFADs and related fisheries[24]

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[24] Human Dimensions Analysis of Hawaii's *Ika-Shibi* Fishery, E. Glazier and J. Petterson

Another recent development in Hawaii pelagic fisheries has been the adoption of short longline-type gear less than one nmi in length on the Cross Seamount to target bigeye tuna and the lustrous pomfret (*Eumegistus illustris*). This type of gear has been referred to as “short-line gear” in Council documents though it is not yet defined as a separate gear type within the Pelagics FMP. The gear type lands bigeye tuna of a larger size and higher value than handline vessels operating in the time/area strata. The use of and catch characteristics short-line gear on the Cross Seamount has been documented by Beverly et al. (2004) and Itano (2005). The method improves targeting of baited branchlines at depth and has been proposed as a means to reduce shallow-water bycatch within the upper mixed-layer.

Troll fishery

Troll fishing is conducted by towing lures or baited hooks from a moving vessel, using big-game-type rods and reels as well as hydraulic haulers, outriggers and other gear. Up to six lines rigged with artificial lures or live bait may be trolled when outrigger poles are used to keep gear from tangling. When using live bait, trollers move at slower speeds to permit the bait to swim “naturally.” The majority of Hawaii-based troll fishing is largely non-commercial; however, some full-time commercial trollers do exist.

The long term average reported commercial tuna catch by MHI troll gear (1982 – 2003) was 552 t, with 566 t reported in 2003 (WPRFMC 2005b). The most important species by weight in the fishery (1982 - 2003 means) in declining order were yellowfin, blue marlin, dolphinfish, wahoo and skipjack. Bigeye tuna make up a very minor proportion of total reported troll catch, ranking eighth in importance (by weight) behind albacore and striped marlin (WPRFMC 2005b).

Recreational fishery

There are no State or Federal permit or reporting requirements for recreational participants (those who do not sell a single fish during the year), therefore, catch rates and effort data are unknown. However in 2001, NMFS in conjunction with HDAR resumed its voluntary Marine Recreational Fishing Statistics Survey (MRFSS) program in Hawaii. This is a random phone survey of all Hawaii households to determine statewide fishing participation rates. Also newly instituted are associated voluntary creel surveys (the Hawaii Marine Recreational Fishing Survey or HMRFS) conducted by HDAR personnel to determine catch rates and species composition. The results from these two surveys are then combined to yield estimates of recreational catch and effort by both shore and land based fishermen. Limited final species specific estimates of recreational fishing have been informally released, although there is still some question as to whether or not these fishers are purely recreational (fishing for sport or pleasure with no sales), “subsistence” (fishing primarily for food) or “expense” (selling just enough to cover trip costs). Some interim MRFSS reports have indicated an extremely low number of interviews with recreational fishermen who caught bigeye tuna. This may well be because such landings are indeed extremely rare by recreational fishermen, as Table 7 illustrates bigeye tuna are not commonly caught on (commercial) trolling gear which is also the most popular pelagic recreational fishing gear. In 2006 NMFS commissioned the National Research Council to provide an external review of the MRFSS system. That review found fundamental errors in the program’s sampling and extrapolation methodologies, and in response the Council recommended at their 133rd meeting that that current MRFSS catch estimates should not be used as a basis for management or allocation decisions.

The total number of recreational fishers in Hawaii is unknown but there are about 14,300 small vessels in Hawaii, of which about 90 percent are registered as ”pleasure craft”. McConnell and Haab (2001) estimated that 6,600 of these vessels might be used for recreational fishing. Out of a sample of 1008 respondents from these 6,600 vessel owners in a phone survey, 17 percent indicated that their vessel was either not being used or was not used for fishing. Based on these data it is estimated that Hawaii’s recreational small boat fleet numbers about 5,500 vessels. As mentioned above, HMRFS has been sampling recreational catches since 2003. The data indicate that little to no bigeye tuna is caught by recreational fishers, while yellowfin landings have been estimated to range between 2,270 and 5,050 t, with a three year mean of 3,295 t. However, caution must be exercised in interpreting the figures from the HMFRS program, which are generated through the product of catch per trip from intercept surveys at landing sites, and a random digit dialing phone survey to estimate effort in trips. The National Research Council review of the entire NMFS MRFSS program has been highly critical of the sampling methods and statistical algorithms employed to develop recreational catch totals. As such this Council has recommended that HMRFS catch estimates should not be used for management purposes until these problems have been resolved.

Hawaii’s charter fisheries primarily troll for billfish. Big game sportfishing rods and reels are used, with four to six lines trolled at any time with outriggers. Both artificial and natural baits are used. In addition to lures, trollers occasionally use freshly caught skipjack tuna and small yellowfin tuna as live bait to attract marlin, the favored landings for charter vessels, as well as yellowfin tuna.

The recreational fleet also primarily employs troll gear to target pelagic species. As described above, although their motivation for fishing is recreational, some of these vessel operators sell a portion of their landings to cover fishing expenses and have been termed “expense” fishermen (Hamilton 1999). While some of the fishing methods and other characteristics of this fleet are similar to those described for the commercial troll fleet, a survey of recreational and expense fishermen showed substantial differences in avidity and catch rates compared to commercial operations. Table 9 summarizes the 2004 - 2005 catches from each of these fisheries.

Table 9. Hawaii-based Commercial Pelagic Landings and Revenues 2004-2005

Fishery	2004 Pounds caught (1000 lbs)	Ex-vessel revenue ($1000)	Average price ($/lb)	2005 Pounds caught (1000 lbs)	Ex-vessel revenue ($1000)	Average price ($/lb)
Longline	18,532	$44,233	$2.52	23,234	$57,939	$2.61
MHI trolling	3,053	$6,427	$2.24	2,416	$4,999	$2.18
MHI Handline	1,318	$2,355	$1.84	1,272	$2,132	$1.70
Offshore Handline	465	$769	$1.82	155	$196	$2.05
Aku boat	648	$886	$1.37	940	$1,074	$1.14
Other Gear	185	$320	$1.81	164	$313	$1.95
Total	**24,201**	**$54,989**	**$2.40**	**28,181**	**$66,652**	**$2.47**

Source: WPRFMC 2005b

Domestic High Seas Squid Jigging Fishery

This fishery has recently been conducted by a single operation which uses four catcher vessels and one large mothership (NMFS 2005). These vessels operate under HSFCA permits and visit ports at Honolulu, Hawaii and in Alaska. Each vessel carries 21-38 jigging machines and fishes primarily to the north of the Hawaiian Archipelago targeting neon flying squids (*Ommastrephes bartrami*) seasonally during the summer months. Please see the FEIS written for Amendment 12 to the Pelagic Fishery Plan for a detailed description of these squid and the fishery (NMFS 2005).

4.6 PRIA-based Pelagic Fisheries

There are no known pelagic fisheries based in the PRIA at this time. However, longline fishermen from Hawaii have reported catch landings from the EEZ waters surrounding the PRIA.

4.7 Purse Seine Tuna Fishery

Purse seiners catch tuna by setting a net vertically in the water with floats attached to the top for flotation and weight on the lower edge which is deployed by smaller skiffs which encircle the school of target tuna. The fish are then confined in the net as it is closed off from the bottom. Purse seiners typically set their nets on a variety of school types including schools associated with floating objects, such as logs or other debris, with other species such as whales or dolphins, or with FADs; or those that are free swimming or unassociated. The Secretariat of the Pacific Community (SPC) lists 18 countries that have participated in this fishery in the WCPO in the last 15 years; however, more than 70 percent of the total catch may be attributed to four distant-water fishing nations (DWFNs), Japan, Korea, Taiwan, and the U.S. (NMFS 2006).

Currently the U.S. purse seine fleet in the Pacific is managed as part of international agreements with the aforementioned Pacific Ocean RFMOs and is regulated by NMFS through the High Seas Fishing Compliance Act; however, the Council has developed and NMFS implemented management measures applicable to the purse seine fishery in the Western Pacific Region. For example, in EEZ waters around American Samoa, vessels over 50 ft in length are prohibited from fishing within 50 nm of shore (see Chapter 5). The U.S. tropical tuna purse seine fleet has fished the central-western Pacific Ocean under the South Pacific Tuna Treaty since 1988.

In the WCPO, the number of vessels active in the U.S. purse seine fleet has been declining since 2001, decreasing from 32 active vessels to only 15 in 2005. Catches have followed suit with an approximate decline of 40 percent from 2001 (115,858 mt) to 2005 (74,287 mt) despite a slight increase from 2004 landings (67,419 mt). These purse seine vessels are usually based in American Samoa and offload catches to canneries in PagoPago.

In the EPO, the purse seine fishery is being restricted through time/area closures pursuant to the IATTC Resolution C-04-09, whereby the fishery for tunas by purse-seine vessels in the EPO shall be closed from either (1) August 1 to September 11; or (2) November 20 to December 31. This resolution also prohibits "landings, transshipments and commercial transactions in tuna or tuna products ... originating from fishing activities that contravene this resolution." To assist in the implementation of this provision, the Commission staff will attempt to obtain information on any tuna caught in contravention of the Resolution.

A study conducted in 1996 on the U.S. purse seine fishery in the WCPO by Coan et al. (1997) found that about 75 percent of the trips reported bycatch information. The data were tabulated using species and species groups reported in the logbooks. For convenience, the species were grouped under four large categories: Tunas, Billfishes, Sharks, and Others. Under this scheme, tunas, by far, made up the largest share (92 percent by weight) of reported bycatch with skipjack tuna the dominant species. This bycatch represented 1.1 percent of the retained tuna catch and was rejected largely because the fish were too small for the targeted market. Sharks, at 5 percent of the reported bycatch, were next in importance, followed by others with 2 percent, and billfishes with less than 1 percent.

Recent observer data, summarized in OFP (2007), for purse seine vessels fishing under the U.S. Multilateral Treaty and FSM Arrangement Programs also indicates that most bycatch are tunas considered too small, which are discarded because of small size, gear damage or due to the vessel reaching capacity. The most common large-size bycatch species are rainbow runner, silky shark, oceanic white-tip shark, wahoo, mahimahi and barracuda. The most common small fishes are mackerel scad and oceanic triggerfish. And the most common billfishes are blue marlin and black marlin.

4.8 Fishing Communities

Each of the inhabited Hawaiian Islands (Niihau, Kauai, Oahu, Maui, Molokai, Lanai, and Hawaii) has been defined as a fishing community under the MSA. Also defined as fishing communities are American Samoa, Guam, and the CNMI. For further information on these areas and communities, please see the Council’s FEPs for the American Samoa Archipelago, the Hawaii Archipelago, and the Mariana Archipelago.

4.9 Status of Fisheries

4.9.1 Overfishing determinations

Stock status for most PMUS is unknown at this time; however, where possible stock status is reported annually in SAFE reports on Pacific-wide or sub-basin scales., e.g., Pacific bigeye tuna, EPO and WCPO yellowfin tuna.

The Council was notified by letter on December, 15, 2004, and a notice was published in the Federal Register on December 30, 2004, (69 FR 78397) stating that the Secretary of Commerce (Secretary) had determined that overfishing of bigeye tuna (*Thunnus obesus*) was occurring Pacific-wide[25]. Pacific bigeye tuna (bigeye) are caught by a suite of domestic and foreign purse seiners and longliners, with small amounts also taken by handline and troll vessels. Until recently, the majority of the bigeye catch was taken by longliners, primarily for the Japanese sashimi market. However, during the past 10 years catches of bigeye by purse seiners have increased considerably. This is not due to deliberate targeting of bigeye tuna by purse seiners, but as an incidental catch when purse seiners are targeting skipjack (*Katsuwonus pelamis*) and juvenile yellowfin tuna (*Thunnus albacares*) around fish aggregating devices (FADs) with larger and deeper purse seine nets. Not surprisingly, the stock of bigeye tuna in the Pacific has shown signs of over-exploitation, with declining biomass, and fishing mortalities at unsustainably high levels. Stock assessments for bigeye tuna in the Eastern and Western Pacific, conducted in 2003 and 2004, showed that the level of fishing mortality had exceeded the fishing mortality associated with maximum sustainable yields (F_{msy}). This level of fishing mortality is one of the limit reference points of the Council's overfishing control rule for bigeye tuna and other pelagic fishes. The Pacific-wide stock itself is not yet overfished, but could become so if levels of fishing mortality are not reduced.

In August 2005, the Scientific Committee of the Western and Central Pacific Fisheries Commission reviewed stock assessments for both the Eastern and Western-Central Pacific that indicated that yellowfin tuna across the Pacific also appeared to be subject to overfishing (Hoyle and Maunder 2005; Hampton et al. 2005). A notice was published by NMFS in the Federal Register on March 24, 2006, (71 FR 14837) stating that NMFS, on behalf of the Secretary of Commerce, had determined that overfishing was occurring on the yellowfin tuna (*Thunnus albacares*) stock in the western and central Pacific Ocean (WCPO) requiring the Council take action to address this situation. Yellowfin tuna are caught primarily by purse seine and ring nets in the Western and Central Pacific, and by purse seines in the Eastern Pacific Ocean. Substantial volumes of yellowfin tuna are also caught by pole-and-line fleets in Indonesia and by handliners in the Philippines. Yellowfin catches by longlines comprise a significant catch of yellowfin tuna, but longlining is a much smaller component of the fishing mortality on this species compared to bigeye tuna. Recent landings of yellowfin in the Western and Central Pacific have ranged from 400,000 to 450,000 mt, while the MSY estimates for this stock range from about 209,200 t to

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[25] A stock is considered to be subject to overfishing whenever it is subjected to a rate of fishing mortality that jeopardizes its capacity to produce MSY on a continuing basis (50 CFR 600.310(d)(ii)). See Section 5.4 of this document for further information.

313,400 t per year (Hampton et al. 2005). Yield estimates are substantially lower than recent catches indicating catches have been sustained by the removal of the accumulated biomass.

The Council completed Amendment 14 to the Pelagics FMP to address overfishing of bigeye and yellowfin tuna on August 23, 2006 and a proposed rule to implement its recommendations was published on March 29, 2007 (72 FR 14761). The rule contained recommendations regarding both international and domestic management, including a mechanism by which the Council could participate in international negotiations regarding these stocks. Amendment 14 also contained measures to implement control dates for Hawaii's non-longline commercial pelagic vessels (70 FR 47781) and purse seine and longline vessels (70 FR 47782) as well as requirements for federal permits and reporting for Hawaii-based non-longline commercial pelagic vessels. NMFS disapproved the Amendment's international measures as premature given ongoing international negotiations as well as the development of a memorandum of understanding by the Councils and the Secretary of Commerce, in consultation with the Secretary of State, regarding participation in U.S. delegations and other issues. NMFS disapproved Amendment 14's domestic permit and reporting requirements as duplicative of existing requirements imposed by the State of Hawaii and stated that they were working with the State to improve their data collection and processing system. NMFS also noted that Amendment 14 met the requirements of the Magnuson-Act regarding overfishing of fisheries that have been determined to be subject to overfishing due to excessive international fishing pressure. In October 2007 NMFS determined that WCPO yellowfin tuna was no longer subject to overfishing.

CHAPTER 5: PACIFIC PELAGIC FEP MANAGEMENT PROGRAM

5.1 Introduction

This chapter describes the Council's management program for pelagic fisheries of the Western Pacific Region, as well as the criteria used to assess the status of managed stocks.

The Council has taken a series of management actions to conserve pelagic species caught by fisheries in the Western Pacific Region. The Pelagics FMP when published in 1986 banned the use of drift gill nets in the U.S. EEZ waters of the U.S. Flag Pacific Islands. Although this gear was primarily used to catch albacore, the ban eliminated the potential for this gear to incidentally catch other tunas which make diurnal feeding migrations between the epilimnion and the deeper waters of the epipelagic zone. Subsequent management actions to manage pelagic species and to comply with amendments to the MSA are briefly described below, with specific regulations provided in Section 5.5. These measures will be a part of the Pacific Pelagic FEP as it replaces the Pelagics FMP.

The 2003 administrative and enforcement costs of conserving and managing the domestic fisheries of the Western Pacific Region were estimated by NMFS and the Council to total $37 million, with future annual costs predicted to be $74 million (NOAA and WPRFMC 2004).

5.2 Amendments to the Pelagics FMP

Amendment 1 became effective on March 1, 1991 (56 FR 9686, March 7, 1991) and defined recruitment overfishing for each Pelagic MUS (PMUS). It also defined the optimum yield for PMUS as the amount of fish, including bigeye and yellowfin tunas that can be harvested by domestic and foreign vessels in the EEZ without causing local overfishing or economic overfishing.

Amendment 2, effective on May 26, 1991, (56 FR 24731, May 31, 1991) laid the groundwork to limit growth of the number of participants in the Hawaii-based longline fishery by requiring fishery participants to obtain Federal permits and maintain logbooks. It implemented requirements for domestic pelagic longline fishing and transshipment vessel operators to have Federal permits, to maintain Federal fishing logbooks, and, if fishing within 50 nm of the Northwestern Hawaiian Islands (NWHI), to have observers placed on board if directed by NMFS. The logbook program, in conjunction with the observer program, has permitted the accurate reporting of pelagic catches by longline fisheries under the Council's jurisdiction. Amendment 2 also required longline gear to be marked with the official number of the permitted vessel, and incorporated the waters of the EEZ around the Commonwealth of the Northern Mariana Islands into the area managed under the FMP.

Amendment 3, which became effective on October 14, 1991 (56 FR 52214, October 18, 1991) created a 50 nm longline exclusion zone around the NWHI to protect endangered Hawaiian monk seals. This is a contiguous area extending 50 nm from named features in the NWHI and connected by corridors between those areas where the 50-nm-radius circles do not intersect. Both longline exclusion zones have a conservation benefit for bigeye tuna by placing them beyond the reach of Hawaii-based longliners operating in the U.S. EEZ around Hawaii. Amendment 3 also implemented framework provisions for establishing a mandatory observer program to collect information on interactions between longline fishing and sea turtles. This area closure has a conservation effect by placing those fish within the 50 nm zone out of the reach of longline gear.

Amendment 4 was effective October 10, 1991 through April 22, 1994 (56 FR 14866, October 16, 1991). It established a three-year moratorium on new entry into the Hawaii-based domestic longline fishery. The amendment also included provisions for establishing a mandatory vessel monitoring system for domestic longline vessels fishing in the Western Pacific Region. This amendment, through limiting vessel numbers, limited catches of pelagic species by the Hawaii-based longline fleet. A final rule effective December 15, 1994 (59 FR 58789, November 15, 1994) under Amendment 4 required Hawaii-based longline vessels to carry and use a NMFS-owned vessel monitoring system (VMS) transmitter to ensure that they do not fish within prohibited areas.

Amendment 5 became effective on March 2, 1992 (57 FR 7661, March 4, 1992) and created a domestic longline vessel exclusion zone around the Main Hawaiian Islands ranging from 50 to 75 nm, and a similar 50 nm exclusion zone around Guam and its offshore banks. The zones were designed primarily to prevent gear conflicts and vessel safety issues arising from interactions between longline vessels and smaller fishing boats which had arisen with the rapid growth of the Hawaii-based longline fleet early on the fishery. A seasonal reduction in the size of the closure was implemented in October 1992; between October and January longline fishing is prohibited within 25 nm of the windward shores of all Main Hawaiian Islands except Oahu, where it is prohibited within 50 nm from the shore.

Amendment 6, which became effective on November 27, 1992 (57 FR 48564, October 27, 1992) specified that all tuna species are designated as fish under U.S. management authority and included tunas and related species as PMUS under the FMP. This amendment allowed tuna species to be subject to specific management and conservation measures developed by the Council. It also applied the longline exclusion zones of 50 nm around the island of Guam and the 25-75 nm zone around the MHI to foreign vessels.

Amendment 7 which became effective on June 24, 1994 (59 FR 26979, May 25, 1994) established a limited entry permit program, supplanting the moratorium established under Amendment 4. This capped the number of permits at 164 but made them transferable, allowing potential fishery entrants to purchase an available permit from someone exiting the fishery. It also made vessels longer than 101 ft ineligible for permits. This was the size of the largest vessel prior to the moratorium. These restrictions were intended to limit fleet fishing capacity, thereby helping to reach optimum yield and limiting impacts such as localized depletion, gear conflicts, and protected species interactions.

Amendment 8 addressed new requirements under the 1996 Sustainable Fisheries Act (SFA). This amendment implemented new definitions for overfishing stemming from the 1996 reauthorization of the MSA, based on the biomass at MSY and the fishing mortality that generates MSY (see Section 5.6). Portions of the amendment that were immediately approved included designations of essential fish habitat (see Chapter 6) and the designations and descriptions of American Samoa, Guam and CNMI as individual fishing communities. Those provisions became effective on February 3, 1999 (64 FR 19067, April 19, 1999). Remaining portions that were approved in 2003 were provisions designating each of the inhabited Hawaiian islands as a separate fishing community, additional overfishing definitions (see Section 5.6), and methods to collect standardized bycatch data (68 FR 46112, August 5, 2003). Amendment 8 did not impose any new regulatory requirements on fisheries managed under the Pelagics FMP.

Amendment 9 was to address the management of sharks in the Western Pacific Region, however, passage of the Shark Finning Prohibition Act of 2000 and reauthorization of the MSA in 2006 rendered the issues to be addressed in this amendment moot and therefore it was discontinued.

Amendment 10 (prepared and transmitted to NMFS for approval in parallel with the FMP for Coral Reef Ecosystems of the Western Pacific Region) clarified the PMUS by moving all but truly oceanic sharks to the Coral Reef Ecosystems FMP along with dogtooth tuna.

Amendment 11, issued on May 24, 2005 (70 FR 29646), established a limited entry system for pelagic longline vessels fishing in waters of the U.S. EEZ around American Samoa. This was intended to: (1) Avoid a “boom and bust” cycle of fishery development that could disrupt community participation in the American Samoa small-scale pelagic fishery; (2) establish a framework to adjust regulations for the American Samoa-based longline fishery; (3) reduce the potential for fishing gear conflict in waters of the EEZ around American Samoa; (4) maintain local catch rates of albacore tuna at economically viable levels; and (5) provide an opportunity for substantial participation by indigenous islanders in the large vessel sector of the fishery. It applied to the owners and operators of vessels that fish for pelagic management species under Hawaii limited access longline permits or western Pacific general longline permits within the EEZ and high seas around the Western Pacific Region (American Samoa, the Commonwealth of the Northern Mariana Islands, Guam, Hawaii, Midway, Johnston, and Palmyra Atolls, Kingman Reef, and Wake, Jarvis, Baker, and Howland Islands).

Amendment 14 addressed overfishing of bigeye (BET) and yellowfin tuna (YFT) in the Western Central Pacific Ocean (WCPO) and was partially approved by NMFS on May 16, 2007 (72 FR 33442). This amendment made recommendations based on the best available science including the most recent stock assessments (July 2004 and August 2005 for BET and YFT, respectively), and in light of the fact that any unilateral management action on U.S.-based vessels can only have minimal direct impacts on stocks due to our fleet harvesting only 2.3 percent of the total BET catch and less than 1 percent of the total Pacific-wide YFT catch. Therefore, multilateral internationally coordinated management is needed to ensure overfishing for these two tuna species is achieved and this approach is recommended in this amendment. The Council also set a control date for entry into the Hawaii-based small boat pelagic fisheries of June 2, 2005, should future decisions include limiting entry into the domestic tuna fishery. Amendment 14 also recommended that data collection for U.S. Hawaii-based small boat fishing be enhanced through mandatory Federal permits and data-collection programs (logbooks) for commercial pelagic fisheries, and improved surveys and voluntary reporting for recreational pelagic fisheries; however this recommendation was not approved by NMFS.

Amendment 15 was implemented in December 2008 (73 FR 70600) and included pelagic squid in the Council's existing Pelagics Fishery Management Plan to ensure monitoring of these species, and to establish mechanisms for their management should it become necessary.

Framework Measure 1, effective March 1, 2002, closed waters within 3-50 nm around American Samoa to pelagic fishing by vessels greater than 50ft in length (67 FR 4369, January 30, 2002). Although not specifically aimed at bigeye and yellowfin tuna, the area closure may have a conservation effect by placing those fish out of the reach of large scale American Samoa based-longline vessels as well domestic purse seiners. This action was taken to prevent potential gear conflicts and catch competition between large fishing vessels and locally-based small vessels.

Framework Measure 2**,** effective June 13, 2002, required Hawaii-based pelagic longline vessel operators to use blue-dyed bait, strategic offal discards and line shooters with weighted branch lines to mitigate seabird interactions when fishing north of 23° N. (67 FR 34408; May 14, 2002). Also included was a requirement that all Hawaii-based longline vessel owners and operators annually attend a protected species workshop conducted by NMFS. These measures were primarily intended to prevent potential interactions with the endangered short-tailed albatross, as well as to reduce interactions with other seabird species.

Regulatory Amendment 1**,** effective June 9, 2002, prohibited shallow-set swordfish longlining north of the equator by vessels managed under the FMP and closed waters between 0° and 15°N from April through May of each year to longline fishing to reduce interactions with threatened and endangered sea turtles. It also instituted sea turtle handling requirements for all vessels using hooks to target pelagic species in the region's EEZ waters.

Regulatory Amendment 2, effective October 4, 2002, required vessel operators using troll or handline gear to target PMUS around the PRIA to obtain Federal permits and to submit Federal logbooks documenting their catch and effort (67 FR 56500, September 4, 2004). Although not specifically developed for bigeye tuna, this regulatory amendment to the FMP provides information on all pelagic catches (including bigeye and yellowfin tunas) from these vessels. This measure is intended to monitor participation in the pelagic troll and handline fishery, collect catch and effort data, and obtain information on interactions between fishing gear and protected species.

Regulatory Amendment 3, effective April 2, 2004, re-opened the shallow-set swordfish fishery by allowing 2,120 shallow-sets to be made annually by the Hawaii-based longline line fleet (69 FR 17329, April 2, 2004). In order to prevent and mitigate interactions with sea turtles, circle hooks and mackerel-type bait were required, along with other mitigation measures and a maximum annual limit on the number of interactions with sea turtles is set at 16 leatherbacks and 17 loggerheads.

Regulatory Amendment 4, effective December 15, 2005 further reduced and mitigated interactions between turtles and longline gear by requiring that: (1) owners and operators of vessels registered for use under longline general permits attend protected species workshops annually, (2) owners and operators of vessels registered for use under longline general permits carry and use dip nets, line clippers, and bolt cutters, and follow handling, resuscitation, and release requirements for incidentally hooked or entangled sea turtles, and (3) operators of non-longline vessels using hooks to target pelagic management unit species follow sea turtle handling, resuscitation, and release requirements, as well as remove the maximum amount of gear possible from incidentally hooked or entangled sea turtles (70 FR 69282). In addition this rule extended the requirement to use circle hooks, mackerel-type bait and dehookers when shallow-setting north of the equator to include all longline vessels managed under the Pelagics FMP.

Regulatory Amendment 5, effective January 18, 2006, implemented measures to further reduce the incidental catch of seabirds in the Hawaii-based longline fishery (70 FR 75075). Depending on the fishing method and area where the vessels operate, owners and operators of Hawaii-based longline fishing vessels must either side-set (deploy longline gear from the side of the vessel rather than from the stern) or one or more other specific seabird mitigation measures shown to prevent seabirds from being accidentally hooked, entangled, or killed during fishing operations.

Regulatory Amendment 7, effective May 17, 2007, allowed the optional use of electronic logbook (e-logs) forms in fisheries with federal reporting requirements as an alternative to the currently required paper logbook forms (72 FR19123). This rule was implemented in recognition that the availability and capability of personal computers had increased to the point where their use in recording fisheries dependent information could improve data accuracy and result in significant time savings for both fishermen and NMFS.

At the request of the Council NMFS issued a control date of June 19, 2008 (73 FR 42540) to notify persons who entered the Hawaii-based pelagic charter fishery after that date that they would not necessarily be assured of continuing participation if a limited entry program was subsequently implemented for their fishery. The control date was issued in response to concerns regarding significant expansion of the charter vessel fleet and its potential to impact billfishes and other pelagic species.

At the request of the Council NMFS issued a control date of June 19, 2008 (73 FR 42769) to notify persons who entered the CNMI longline fishery after that date that they would not necessarily be assured of continuing participation if a limited entry program was subsequently implemented for their fishery. The control date was issued in response to concerns regarding the potentially uncontrolled expansion of the CNMI-based pelagic longline fishery and the potential resultant interactions with, and impacts on, small-boat pelagic fisheries and localized depletion of pelagic fish stocks.

5.3 International Management Measures

Management of pelagic fisheries is complicated by the nature of the targeted “highly migratory species” whose life histories span the arbitrary jurisdictional boundaries used in management, such as EEZs, of many nations. The Hawaii-based longline fleet does much of its fishing on the high seas outside the EEZ waters of the United States and other nations. Management includes trans-boundary issues, both because fish stocks may straddle EEZs and because fishing may occur in international waters where no nation has comprehensive jurisdiction. For this reason, fishery managers and their governments have sought to establish stable multilateral arrangements through regional fishery management organizations (RFMOs). The United States is a member of at least five that cover the region and target species relevant to pelagic fisheries. Two RFMOs, the Inter-American Tropical Tuna Commission (IATTC) and the Western and Central Pacific Fisheries Commission (WCPFC) currently set harvest limits for bigeye tuna (BET) as described below.

5.3.1 Tuna Limit Allocation

Limits on the catches of BET for longline vessels operating in the Eastern Pacific Ocean (EPO - west of 150 deg W) and in the Western and Central Pacific Ocean (WCPO west of 150 deg W) have been adopted by the respective RFMOs, the IATTC and the WCPFC.

5.3.1.1 The EPO Limit

IATTC Resolution (Resolution C-06-02) on the Conservation of Tuna in the eastern Pacific Ocean in 2006 required that China, Japan, Korea, and Chinese Taipei take the measures necessary to ensure that their total annual longline catch of BET in the EPO during 2007 did not exceed the following catch levels:

China	2,639 t
Japan	34,076 t
Korea	12,576 t
Chinese Taipei	7,953 t

The Resolution for 2007 called for other IATTC Parties cooperating non-parties, fishing entities or regional economic integration organizations (CPCs) which includes the U.S. to take measures to ensure their total catch did not exceed either 500 mt or their 2001 catch level. No agreement was reached on quotas for 2008 and to date no agreement is in place for 2009.

5.3.1.2 The WCPO Limit

With respect to the WCPO, the WCPFC developed a resolution for the conservation of BET and YFT in December 2008 with the following key provisions for longliners as follows:

- Longline fisheries were required to begin a phased-in reduction of BET catches by 30 percent by 2011. Catches are to be reduced in 10 percent annual increments starting in 2009.

- The baseline for the reductions is the average of the 2001-2004 BET catches for all countries except the U.S. and China, which use 2004 as the baseline year.

- A 2,000 mt/yr limit was established for Commission Members and Cooperating Non-Members (CCMs) that caught less than 2,000 mt in 2004.

- Those fleets that land exclusively fresh fish shall have a 10 percent BET reduction in 2009, but no further reductions thereafter provided that catches do not exceed 500 mt.

- The limits do not apply to small island developing State members or to Participating Territories (e.g., American Samoa, Guam and CNMI) that are undertaking responsible development of their domestic fisheries.

- The WCPFC also adopted a CMM that will cap catch and effort for South Pacific swordfish. However, this measure will not affect U.S. longline vessels operating from American Samoa which may target swordfish as the measure contained language which indicated that this CMM would not prejudice the legitimate rights and obligations under international law of small island developing State and participating Territory CCMs, in the Convention Area who may wish to pursue a responsible level of development of their own fisheries in the Convention Area south of 20°S.

5.4 Description of National Standard 1 Guidelines on Overfishing

Overfishing occurs when fishing mortality (F) is higher than the level at which fishing produces maximum sustainable yield (MSY). MSY is the maximum long-term average yield that can be produced by a stock on a continuing basis. A stock is overfished when stock biomass (B) has fallen to a level substantially below what is necessary to produce MSY. So there are two aspects that managers must monitor to determine the status of a fishery: the level of F in relation to F at MSY (F_{MSY}), and the level of B in relation to B at MSY (B_{MSY}).

The National Standard Guidelines for National Standard 1 call for rules identifying "good" versus "bad" fishing conditions in the fishery and the stock and describing how a variable such as F will be controlled as a function of some stock size variable such as B in order to achieve good fishing conditions. The technical guidance for implementing National Standard 1 (Restrepo et al. 1998) provides a number of recommended default control rules that may be appropriate, depending on such things as the richness of data available. For the purpose of illustrating the following discussion of approaches for fulfilling the overfishing-related requirements of the MSA, a generic model that includes example MSY, target, and rebuilding control rules is shown in Figure 14. The y-axis, F/F_{MSY}, indicates the variable which managers must control as a function of B/B_{MSY} on the x-axis.

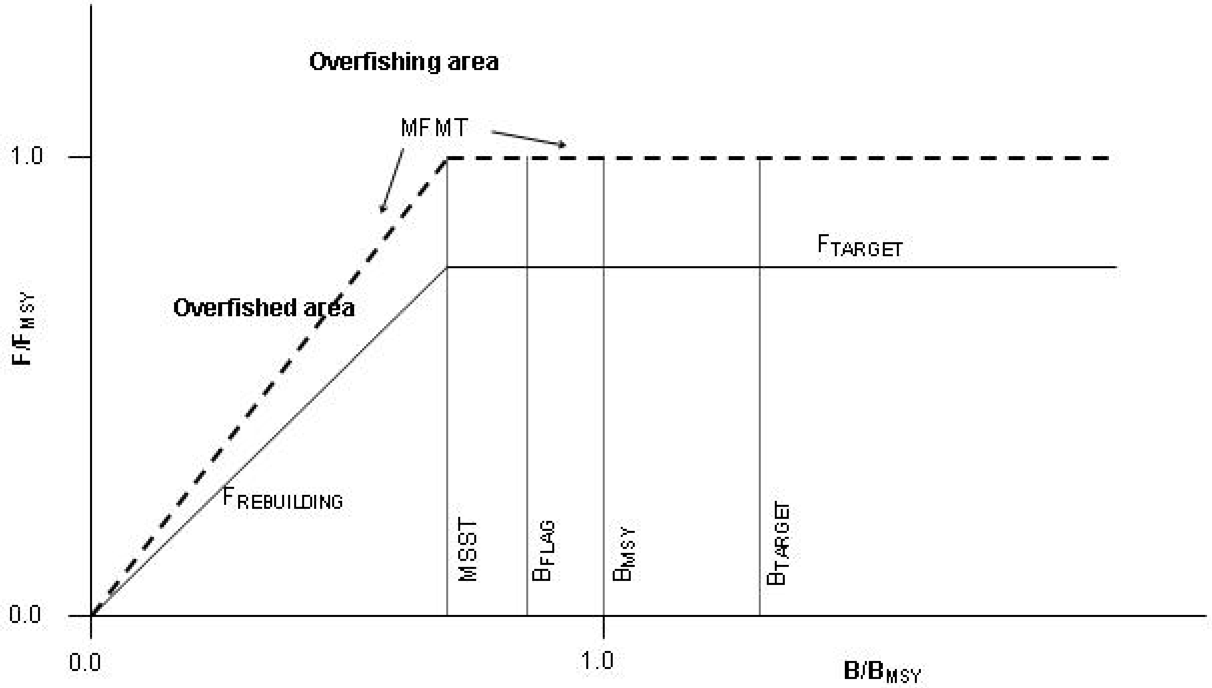

Figure 16: Example MSY, Target, and Rebuilding Control Rules

The dashed horizontal and diagonal line represents a model MSY control rule that is used as the MFMT; the solid horizontal and diagonal line represents a model integrated target (F_{TARGET}) and rebuilding ($F_{REBUILDING}$) control rule.

Source: Restrepo et al. 1998

The Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 (MSRA) amended the MSA to include new requirements for annual catch limits (ACLs) and accountability measures (AMs) and other provisions regarding preventing and ending overfishing and rebuilding fisheries as follows:

SEC. 302. *REGIONAL FISHERY MANAGEMENT COUNCILS*
(h) FUNCTIONS.--Each Council shall, in accordance with the provisions of this Act--
(6) develop annual catch limits for each of its managed fisheries that may not exceed the fishing level recommendations of its scientific and statistical committee or the peer review process established under subsection g;

SEC. 303. *CONTENTS OF FISHERY MANAGEMENT PLANS*
(a) REQUIRED PROVISIONS – Any fishery management plan which is prepared by any Council, or by the Secretary, with respect to any fishery, shall -
(10) specify objective and measurable criteria for identifying when the fishery to which the plan applies is overfished (with an analysis of how the criteria were determined and the relationship of the criteria to the reproductive potential of stocks of fish in that fishery) and, in the case of a fishery which the Council or the Secretary has determined is approaching an overfished condition or is overfished, contain conservation and management measures to prevent overfishing or end overfishing and rebuild the fishery;
(15) establish a mechanism for specifying annual catch limits in the plan (including a multiyear plan), implementing regulations, or annual specifications, at a level such that overfishing does not occur in the fishery, including measures to ensure accountability.

EFFECTIVE DATES; APPLICATION TO CERTAIN SPECIES.—The amendment made by subsection (a)(10) [and 303((a)(15) above]—
(1) shall, unless otherwise provided for under an international agreement in which the United States participates, take effect—
(A) in fishing year 2010 for fisheries determined by the Secretary to be subject to overfishing; and
(B) in fishing year 2011 for all other fisheries; and
(2) shall not apply to a fishery for species that have a life cycle of approximately 1 year unless the Secretary has determined the fishery is subject to overfishing of that species; and
(3) shall not limit or otherwise affect the requirements of section 301(a)(1) or 304(e) of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1851(a)(1) or 1854(e), respectively).

The Council will continue the development of a mechanism(s) to meet the new requirements for specifying ACLs including measures to ensure accountability and this FEP will undergo future amendments as necessary to meet the new MSRA requirements. For additional information on NMFS' guidance regarding National Standard 1, see 74 FR 3178.

5.4.1 MSY Control Rule and Stock Status Determination Criteria

An MSY control rule is a control rule that specifies the relationship of F to B or other indicator of productive capacity under an MSY harvest policy. Because fisheries must be managed to achieve optimum yield, not MSY, the MSY control rule is a benchmark control rule rather than an operational one. However, the MSY control rule is useful for specifying the "objective and measurable criteria for identifying when the fishery to which the plan applies is overfished" that are required under the MSA. The National Standard Guidelines (74 FR 3178) refer to these criteria as "status determination criteria" and state that they must include two limit reference points, or thresholds: one for F that identifies when overfishing is occurring and a second for B or its proxy that indicates when the stock is overfished.

The status determination criterion for F is the maximum fishing mortality threshold (MFMT). Minimum stock size threshold (MSST) is the criterion for B. If fishing mortality exceeds the MFMT for a period of one year or more, overfishing is occurring. A stock or stock complex is considered overfished if its stock biomass has declined below a level that jeopardizes the capacity of the stock to produce MSY on a continuing basis (i.e., the biomass falls below MSST). A Council must take remedial action in the form of a new FMP, an FMP amendment, or proposed regulations within two years following notification when it has been determined by the Secretary of Commerce that overfishing is occurring, a stock or stock complex is overfished or, either of the two thresholds is being approaching an overfished condition,[26] or existing remedial action to end previously identified overfishing or to rebuild an overfished stock has not resulted in adequate progress. The Secretary reports annually to the Congress and the Councils on the status of fisheries according to the above overfishing criteria. A Council must take remedial action in the form of a new FMP, an FMP amendment, or proposed regulations within two years following notification by the Secretary of Commerce that overfishing is occurring, a stock or stock complex is overfished or approaching an overfished condition ,[27] or existing remedial action to end previously identified overfishing or to rebuild an overfished stock has not resulted in adequate progress. The Secretary reports annually to the Congress and the Councils on the status of fisheries according to the above overfishing criteria.

The National Standard Guidelines state that the MFMT may be expressed as a single number or as a function of some measure of the stock's productive capacity. Guidance in Restrepo et al. (1998:17) regarding specification of the MFMT is based on the premise that the MSY control rule constitutes the MFMT. In the example in Figure 14 the MSY control rule sets the MFMT constant at F_{MSY} for values of B greater than the MSST and decreases the MFMT linearly with biomass for values of B less than the MSST. This is the default MSY control rule recommended in Restrepo et al. (1998). Again, if F is greater than the MFMT for a period of one year or more, overfishing is occurring.

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[26] A stock or stock complex is approaching an overfished condition when it is projected that there is more than a 50 percent chance that the biomass of the stock or stock complex will decline below MSST within two years (74 FR 3178).

[27] A threshold is being "approached" when it is projected that it will be reached within two years (50 CFR 600.310 (e)(1)).

The National Standard Guidelines state that to the extent possible, the stock size threshold [MSST] should equal whichever of the following is greater: One-half the MSY stock size, or the minimum stock size at which rebuilding to the MSY level would be expected to occur within 10 years if the stock or stock complex were exploited at the MFMT. The MSST is indicated in Figure 14 by a vertical line at a biomass level somewhat less than B_{MSY}. A specification of MSST below B_{MSY} would allow for some natural fluctuation of biomass above and below B_{MSY}, which would be expected under, for example, an MSY harvest policy. Again, if B falls below MSST the stock is overfished.

Warning reference points comprise a category of reference points that will be considered in these amendments together with the required thresholds. Although not required under the MSA, warning reference points could be specified in order to provide warning in advance of B or F approaching or reaching their respective thresholds. Considered in these amendments is a stock biomass flag (B_{FLAG}) that would be specified at some point above MSST, as indicated in Figure 14. The control rule would not call for any change in F as a result of breaching B_{FLAG} – it would merely serve as a trigger for consideration of action or perhaps preparatory steps towards such action. Intermediate reference points set above the thresholds could also be specified in order to trigger changes in F – in other words, the MFMT could have additional inflection points.

One of the principles of ecosystem-based management is the need to consider the precautionary approach, the burden of proof, and adaptive management. The Pelagic FEP will continue to give consideration to these principles and to be adaptively managed under the MSA using a precautionary approach which rejects a lack of information as a basis for inaction.

5.4.2 Target Control Rule and Reference Points

A target control rule specifies the relationship of F to B for a harvest policy aimed at achieving a given target. Optimum yield (OY) is one such target, and National Standard 1 requires that conservation and management measures both prevent overfishing and achieve OY on a continuing basis. Optimum yield is the yield that will provide the greatest overall benefits to the nation, and is prescribed on the basis of MSY, as reduced by any relevant economic, social, or ecological factor. MSY is therefore an upper limit for OY.

A target control rule can be specified using reference points similar to those used in the MSY control rule, such as F_{TARGET} and B_{TARGET}. For example, the recommended default in Restrepo et al. (1998) for the target fishing mortality rate for certain situations (ignoring all economic, social, and ecological factors except the need to be cautious with respect to the thresholds) is 75 percent of the MFMT, as indicated in Figure 14. Simulation results using a deterministic model have shown that fishing at 0.75 F_{MSY} would tend to result in equilibrium biomass levels between 1.25 and 1.31 B_{MSY} and equilibrium yields of 0.94 MSY or higher (Mace 1994).

It is emphasized that while MSST and MFMT are limits, the target reference points are merely targets. They are guidelines for management action, not constraints. For example, Restrepo et al. 1998 state that "Target reference points should not be exceeded more than 50 percent of the time, nor on average".

5.4.3 Rebuilding Control Rule and Reference Points

If it has been determined that overfishing is occurring, a stock or stock complex is overfished or approaching an overfished condition, or existing remedial action to end previously identified overfishing or to rebuild an overfished stock has not resulted in adequate progress, the Council must take remedial action within two years. In the case that a stock or stock complex is overfished (i.e., biomass falls below MSST in a given year), the action must be taken through a stock rebuilding plan (which is essentially a rebuilding control rule as supported by various analyses) with the purpose of rebuilding the stock or stock complex to the MSY level (B_{MSY}) within an appropriate time frame, as required by MSA §304(e)(4). The details of such a plan, including specification of the time period for rebuilding, would take into account the best available information regarding a number of biological, social, and economic factors, as required by the MSRA and National Standard Guidelines.

If B falls below MSST, management of the fishery would shift from using the target control rule to the rebuilding control rule. Under the rebuilding control rule in the example in Figure 14, F would be controlled as a linear function of B until B recovers to MSST (see $F_{REBUILDING}$), then held constant at F_{TARGET} until B recovers to B_{MSY}. At that point, rebuilding would have been achieved and management would shift back to using the target control rule (F set at F_{TARGET}). The target and rebuilding control rules “overlap” for values of B between MSST and the rebuilding target (B_{MSY}). In that range of B, the rebuilding control rule is used only in the case that B is recovering from having fallen below MSST. In the example in Figure 14 the two rules are identical in that range of B (but they do not need to be), so the two rules can be considered a single, integrated, target control rule for all values of B.

5.4.4 Measures to Prevent Overfishing and Overfished Stocks

The control rules are used as a basis for determining if the conservation and management measures in place are having the desired effects in terms of keeping stock biomass at or above minimum stock size levels or keeping fishing mortality at or below maximum fishing mortality rates or levels. These determinations than lead to consideration of the need for more (or perhaps even fewer) conservation and management measures which in turn control fishing effort and presumably mortality. In the case of a fishery which has been determined to be “approaching an overfished condition or is overfished,” MSA §303(a)(10) requires that the FMP “contain conservation and management measures to prevent overfishing or end overfishing and rebuild the fishery.”

5.4.5 Use of National Standard 1 Guidelines in FEPs

This FEP carries forward the provisions pertaining to compliance with the Sustainable Fisheries Act which were recommended by the Council and subsequently approved by NMFS (68 FR 16754, April 7, 2003). Because biological and fishery data are limited for all species managed by this FEP, MSY-based control rules and overfishing thresholds are specified for multi-species stock complexes.

5.5 Management Program for Pelagic Fisheries

Management programs for pelagic fisheries of the western Pacific are codified in subpart A and F of Federal Register at 50 CFR Part 665. Programs include limited entry permits, fishing reports (logbooks and sales), gear and vessel identification, vessel monitoring systems, area management, at-sea observer coverage, sea turtle and sea bird mitigation measures, and other bycatch measures. These programs are intended to sustainably harvest area resources, provide economic opportunity, and conserve non target species.

5.6 Application of National Standard 1

MSY Control Rule and Stock Status Determination

Although the Pelagics FEP will seek to manage pelagic resources on an ecosystem basis, the stock status with respect to biomass and fishing mortality of individual PMUS stocks will continue to be reported annually in the Pelagics FEP SAFE report, as required by the MSA. Despite the existence of stock assessments for several of the key species, none of the PMUS stocks in the western and central Pacific can be considered data-rich. Many can be considered data-moderate and the rest are considered data-poor, as indicated in Table 10. Species for which there are insufficient data to determine status, such as those in the "other MUS" category, are managed as part of a mixed stock complex.[28]

Table 10. Quality of Data for Pelagic Stocks

Stock	Data richness
Bigeye tuna	moderate
Northern Pacific albacore	moderate
Southern Pacific albacore	moderate
Eastern Pacific yellowfin tuna	moderate
Western Pacific yellowfin tuna	moderate
Eastern Pacific skipjack tuna	moderate
Western Pacific skipjack tuna	moderate
Other tunas	poor
Northern Pacific swordfish	moderate
Blue marlin	moderate
Other billfishes	poor
Pelagic sharks	poor
Other MUS	poor

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[28] The National Standards Guidelines allow overfishing of "other" components in a mixed stock complex if (1) long-term benefits to the nation are obtained, (2) similar benefits cannot be obtained by modification of the fishery to prevent the overfishing, and (3) the results will not necessitate ESA protection of any stock component or ecologically significant unit.

The defaults recommended in the technical guidance for National Standard 1 (Restrepo et al. 1998) for data-moderate species have been used to specify control rules and reference points, as described below. The specifications apply to those stocks for which assessments against the criteria can be performed with available data. Efforts are being made to improve the quality of data on the data-poor stocks so that stock assessments against the specified criteria can be performed.

The MSY control rule is used as the MFMT. The MFMT and MSST are specified based on the recommendations of Restrepo et al. (1998) and both are dependent on the natural mortality rate (M). The values of M to be used to determine the reference point values are not specified in this document as the latest estimate for each stock, published annually in the SAFE report, is used and the value is periodically re-estimated using the best available information.

Also specified is a warning reference point, B_{FLAG}, to provide a trigger for consideration of management action prior to B reaching the threshold. MFMT, MSST, and B_{FLAG} are specified as indicated in Table 11.

Table 11. Overfishing Threshold Specifications for Pelagic Stocks

MFMT	**MSST**	**B_{FLAG}**
$F(B) = \frac{F_{MSY} B}{c\, B_{MSY}}$ for $B \leq c\, B_{MSY}$ $F(B) = F_{MSY}$ for $B > c\, B_{MSY}$	$c\, B_{MSY}$	B_{MSY}
where $c = \max(1-M, 0.5)$		

To illustrate these specifications of the MSST, for species with natural mortality rates greater than 0.5 (e.g., yellowfin tuna and skipjack tuna) the MSST is 0.5 B_{MSY}. Similarly, the MSST for a species with a natural mortality rate of 0.2 would be 0.8 B_{MSY}.

Where F_{MSY} cannot be reliably estimated, the technical guidance for implementing National Standard 1 (Restrepo et al. 1998) recommends a default specification of $F_{MSY} = 0.8$ M. That specification has been adopted for all stocks for which F_{MSY} cannot be directly estimated.

As with F_{MSY}, some B_{MSY} values can be derived from published or unpublished sources. For other stocks, B_{MSY} is specified as follows:

$B_{MSY} = MSY/0.8M$

For some stocks with relatively high fecundity B_{MSY} is specified as suggested in the technical guidance for data-poor stocks:

$B_{MSY} = 0.4\, B_0$, where B_0 is the initial biomass, or carrying capacity

For these stocks, $CPUE_{YEAR}/CPUE_0$ is used as a proxy for B_{YEAR}/B_0, as suggested in the technical guidance for data-poor stocks. In these cases, standardized CPUE time series extending back to the earliest years of the fishery ($CPUE_0$) is used to estimate B_{YEAR}/B_{MSY}:

$B_{YEAR}/B_{MSY} = (CPUE_{YEAR}/CPUE_0)\,(B_0/B_{MSY})$

Such estimates based on CPUE time series are periodically recalculated (i.e., re-standardized) to take into account changes in technology or fishing strategy.

Target Control Rule and Reference Points

While there is an established OY for the Pacific pelagic fisheries managed under this FEP, it is not quantified or in the form of a control rule. No reference points are currently specified.

Rebuilding Control Rule and Reference Points

While there is an established OY for the Pacific pelagic fisheries managed under this FEP, it is not quantified or in the form of a control rule. No reference points are currently specified.

Measures to Address Overfishing and Overfished Stocks

In 2005, it was determined that Pacific-wide overfishing of bigeye tuna was occurring and that overfishing of yellowfin tuna may be occurring (69 FR 78397, December 30, 2004). Amendment 14 to the Pelagic FMP contained recommendations regarding both international and domestic management, including a mechanism by which the Council could participate in international negotiations regarding these stocks. Because the Western Pacific Region's pelagic fisheries (those managed by the Council) account for only approximately 2 percent of Pacific-wide bigeye tuna landings and 5 percent of yellowfin tuna landings, the Council has increased its participation in international management fora that are essential to addressing this problem on an international scale. As described in Section 5.3, the Council's pelagic longline fishery is complying with the quotas for bigeye and yellowfin tuna as a participating member in the IATTC and the WCPFC, international fora managing tuna stocks in the Pacific. Amendment 14 also contained measures to implement control dates for Hawaii's non-longline commercial pelagic vessels (70 FR 47781, see above) and purse seine and longline vessels (70 FR 47782, see above), as well as requirements for federal permits and reporting for Hawaii-based non-longline commercial pelagic vessels. NMFS disapproved the Amendment's international measures as premature given ongoing international negotiations as well as the development of a memorandum of understanding by the Councils and the Secretary of Commerce, in consultation with the Secretary of State, regarding participation in U.S. delegations and other issues. NMFS disapproved Amendment 14's domestic permit and reporting requirements as duplicative of existing requirements imposed by the State of Hawaii and stated that they were working with the State to improve their data collection and processing system. NMFS also noted that Amendment 14 met the requirements of the Magnuson-Act regarding overfishing of fisheries that have been determined to be subject to overfishing due to excessive international fishing pressure. As of October 2007, NMFS no longer considered WCPO yellowfin to be subject to overfishing.

If in the future it is determined that overfishing is occurring for other stocks managed under this FEP, or that a stock is overfished, (or approaching either of these conditions), the Council will consider similar or other remedial management actions.

At the same time, the Council will continue to sustainably manage the fisheries within its jurisdiction to achieve OY. In the case that it is determined that localized depletion is occurring, the Council may consider additional management measures using the FEP amendment process. Measures that may be considered include area closures, seasonal closures, reductions in the number of available limited entry permits, establishment of limited access systems in other fisheries, trip limits, effort limits, and fleet-wide limits on catch or effort.

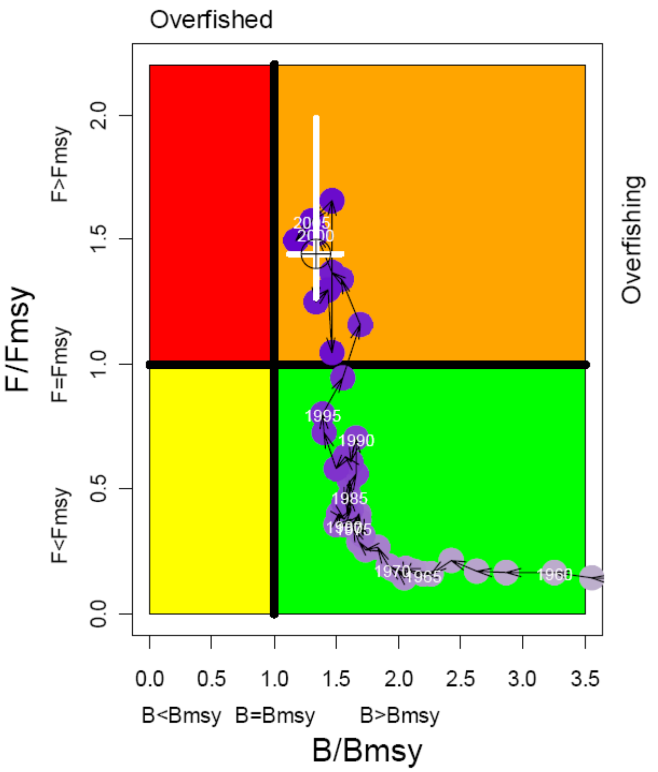

Figure 17. Phase Plot of the Time Series of Estimates for Stock Size and Fishing Mortality of Bigeye Tuna in the WCPO Relative to MSY
Source: Langley et al. 2008

In the most recent stock assessment for bigeye in the WCPO (Langley et al. 2008) the estimate of current fishing mortality to fishing mortality at MSY ($F_{current}/F_{MSY}$) indicates that overfishing of bigeye tuna is occurring (Figure 17). While the ratio of current total biomass to biomass at MSY ($B_{current}/B_{MSY}$) is greater than 1, the situation is less optimistic when adult biomass is considered in isolation. A number of plausible model options indicate that adult biomass has been below the equilibrium adult biomass level at MSY (SB_{MSY}) for a considerable period ($SB_{current}/SB_{MSY} < 1$). Further, both the adult and total biomass are predicted to fall below B_{MSY} at 2003-2006 average fishing mortality levels and long-term average recruitment levels. This is consistent with a recent decline in biomass under increasing fishing mortality levels, resulting in an increase in the probability of the stock becoming overfished over time. Recent catches are high relative to the estimated MSY, both because of high recent fishing mortality and because the stock has benefited from above-average recruitment over the past 15 years. Under the MSA, bigeye tuna is considered to be subject to overfishing in the WCPO but is not considered to be overfished.

The most recent yellowfin stock assessment in the WCPO was conducted in 2007 and found that B_t/B_{MSY} was greater than 1 and F_t/F_{MSY} was less than 1 (Langley et al. 2007). As such, under the MSA, the WCPO yellowfin stock is not overfished nor being subject to overfishing.

Table 12 shows the recent estimates of stock status of PMUS in relation to reference points for PMUS adopted by the Western Pacific Council in Amendment 8 to the Pelagics Fishery Management Plan. Table 13 gives the most recent MSY estimates for many of the major PMUS and the corresponding reference.

Table 12. Estimates of Stock Status of PMUS in Relation to PMUS Reference Points

Stock	Overfishing reference point	Is overfishing occurring?	Approaching Overfishing (2 yr)	Overfished reference point	Is the stock overfished?	Approaching Overfished (2 yr)	Assessment results	Natural mortality[1]	MSST
Skipjack Tuna (WCPO)	$F/F_{MSY}=0.17$	No	No	$B/B_{MSY}=3.0$	No	No	Langley et al. 2005	$>0.5\ yr^{-1}$	$0.5\ B_{MSY}$
Yellowfin Tuna (WCPO)	$F/F_{MSY}=1.22$	Yes	Not applicable	$B/B_{MSY}=1.32$	No	No	Hampton et al. 2005a	$0.8\text{-}1.6\ yr^{-1}$	$0.5\ B_{MSY}$
Albacore Tuna (S. Pacific)	$F/F_{MSY}=0.05$	No	No	$B/B_{MSY}=1.69$	No	No	Langley & Hampton 2005	$0.3\ yr^{-1}$	$0.7\ B_{MSY}$
Albacore Tuna (N. Pacific)	Unknown			Unknown				$0.3\ yr^{-1}$	$0.7\ B_{MSY}$
Bigeye Tuna (WCPO)[2]	$F/F_{MSY}=1.23$	Yes	Not applicable	$B/B_{MSY}=1.25$	No	No	Hampton et al. 2005b	$0.4\ yr^{-1}$	$0.6\ B_{MSY}$
Blue Marlin (Pacific)	$F/F_{MSY}=0.50$	No	Unknown	$B/B_{MSY}=1.4$	No	Unknown	Kleiber et al. 2002	$0.2\ yr^{-1}$	$0.8\ B_{MSY}$
Swordfish (N. Pacific)[3]	$F/F_{MSY}=0.33$	No	Unknown	$B/B_{MSY}=1.75$	No	Unknown	Kleiber & Yokawa 2004	$0.3\ yr^{-1}$	$0.7\ B_{MSY}$
Blue Shark (N. Pacific)	$F/F_{MSY}=0.01$	No	Unknown	$B/B_{MSY}=1.9$	No	Unknown	Kleiber et al. 2001	Unknown	
Other Billfishes	Unknown			Unknown				Unknown	
Other Pelagic Sharks	Unknown			Unknown				Unknown	
Other PMUS	Unknown			Unknown				Unknown	
[1] Estimates based on Boggs et al. 2000									
[2] Assessment results based on natural mortality fixed at $0.2\ yr^{-1}$									

Table 13. Recent Estimates of MSY values for PMUS Stocks

Stock	MSY mt	Reference
WCPO Bigeye	64,600-91,400	Hampton et al (2005)
EPO Bigeye	102,263	Maunder & Hoyle (2006)
WCPO Yellowfin	329,680-388,120	Hampton et al (2006)
EPO Yellowfin	287,377	Hoyle & Maunder (2006)
WCPO Skipjack	1,304,000-2,656,000	Langley et al (2005)
EPO Skipjack	NA	Maunder & Harley (2004)
SP Albacore	90,080-180,800	Langley & Hampton (2006)
NP Albacore	NA	Stocker (2005)
Southwest Pacific Swordfish	NA	Kolody et al (2006)
Southwest Pacific Striped Marlin	2,555-3,003	Langley et al (2006)
North Pacific Swordfish	22,284	Kleiber and Yokawa (2004)
Pacific Blue-marlin	13,056	Kleiber, Hinton and Uozumi (2003)
North Pacific blue shark	318,500	Kleiber, Takeuchi & Nakano (2001)

CHAPTER 6: IDENTIFICATION AND DESCRIPTION OF ESSENTIAL FISH HABITAT

6.1 Introduction

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

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

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

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

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

Level 1:	All that is known is where a species occurs based on distribution data for all or part of the geographic range of the species.
Level 2:	Data on habitat-related densities or relative abundance of the species are available.
Level 3:	Data on growth, reproduction, or survival rates within habitats are available.
Level 4:	Production rates by habitat are available.

With higher quality data, those habitats most highly valued by a species can be identified, allowing a more precise designation of EFH. Habitats of intermediate and low value may also be essential, depending on the health of the fish population and the ecosystem. For example, if a species is overfished, and habitat loss or degradation is thought to contribute to its overfished condition, all habitats currently used by the species may be essential.

The EFH provisions are especially important because of the procedural requirements they impose on both Councils and federal agencies. First, for each FMP, Councils must identify adverse impacts to EFH resulting from both fishing and non-fishing activities, and describe measures to minimize these impacts. Second, the provisions allowed Councils to provide comments and make recommendations to federal or state agencies that propose actions that may affect the habitat, including EFH, of a managed species. In 2002, NMFS revised the guidelines by providing additional clarifications and guidance to ease implementation of the EFH provision by Councils.

None of the fisheries operating under the Pelagic FEP are expected to have adverse impacts on EFH or HAPC for species managed under the Western Pacific Fishery Ecosystem Plans. Continued and future operations of fisheries under the Pelagic FEP are not likely to lead to substantial physical, chemical, or biological alterations to the habitat, or result in loss of, or injury to, these species or their prey. Implementation of the Pelagic FEP will not result in any changes in fishing gear or strategy that will impact EFH, it will maintain the same level of protection to EFH as the Pelagics FMP.

6.2 EFH Designations for PMUS

The following EFH designations were developed by the Council and approved by the Secretary of Commerce on February 3, 1999 (64 FR 19068).

In describing and identifying EFH for PMUS, four alternatives were considered: (1) designate EFH based on the best available scientific information (preferred alternative), (2) designate all waters EFH, (3) designate a minimal area as EFH, and (4) no action. Ultimately, the Council selected Alternative 1 designate EFH based on observed habitat utilization patterns in localized areas as the preferred alternative.

This alternative was preferred by the Council for three reasons. First, it adhered to the intent of the MSA provisions and to the guidelines that have been set out through regulations and expanded on by NMFS because the best available scientific data were used to make carefully considered designations. Second, it resulted in more precise designations of EFH at the species complex level than would be the case if Alternative 2 were chosen. At the same time, it did not run the risk of being arbitrary and capricious as would be the case if Alternative 3 were chosen. Finally, it recognized that EFH designation is an ongoing process and set out a procedure for reviewing and refining EFH designations as more information on species' habitat requirements becomes available.

The Council has used the best available scientific information to describe EFH in text and tables that provide information on the biological requirements for each life stage (egg, larvae, juvenile, adult) of all MUS. Careful judgment was used in determining the extent of the essential fish habitat that should be designated to ensure that sufficient habitat in good condition is available to maintain a sustainable fishery and the managed species' contribution to a healthy ecosystem. Because there are large gaps in scientific knowledge about the life histories and habitat requirements of many MUS in the Western Pacific Region, the Council adopted a precautionary approach in designating EFH to ensure that enough habitats are protected to sustain managed species.

PMUS under the Council's jurisdiction are found in tropical and temperate waters throughout the Pacific Ocean. Variations in the distribution and abundance of PMUS are affected by ever changing oceanic environmental conditions including water temperature, current patterns, and the availability of food. There are large gaps in the scientific knowledge about basic life histories and habitat requirements of many PMUS. The migration patterns of PMUS stocks in the Pacific Ocean are poorly understood and difficult to categorize despite extensive tagging studies for many species. Little is known about the distribution and habitat requirements of the juvenile life stages of tuna and billfish after they leave the plankton until they recruit to fisheries. Since spawning and larvae occur only in tropical temperatures (including temperate summer), the pre-recruit sizes are likely more tropically distributed than recruits, and juvenile tunas of this size (1–15 cm) are only caught in large numbers around tropical archipelagoes. Very little is known about the habitat of different life history stages of PMUS that are not targeted by fisheries (i.e., sharks, Gempylids).

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for pelagic species assemblages pursuant to Section 600.805(b) of 62 FR 66551. The species complex designations for the PMUS are temperate species, tropical species, and sharks (Table 14). The designation of these complexes is based on the ecological relationships among species and their preferred habitat. The marketable species complex has been subdivided into tropical and temperate assemblages. The temperate species complex includes those PMUS that are found in greater abundance in higher latitudes such as swordfish and bigeye, bluefin, and albacore tuna. In reality, all PMUS are tropical.

Because of the uncertainty about the life histories and habitat utilization patterns of many PMUS, the Council has taken a precautionary approach by adopting a 1,000 meters depth as the lower bound of EFH for PMUS. Although many of the PMUS are epipelagic, bigeye tuna are abundant at depths in excess of 400 meters and swordfish have been tracked to depths of 800 meters. One thousand meters is the lower bound of the mesopelagic zone. The vertically migrating mesopelagic fishes and squids associated with the deep scattering layer are important prey organisms for PMUS and are seldom abundant below 1,000 meters. This designation is also based on anecdotal reports of fishermen that PMUS aggregate over raised bottom topographical features as deep as 2,000 meters (1,000 fm) or more. This belief is supported by research that indicates seabed features such as seamounts exert a strong influence over the superadjacent water column. For example, studies by Polzin et al. (1997) in the Atlantic and Kunze and Toole (1997) in the Northwest Pacific show that mixing occurs mostly at oceanic boundaries: along continental slopes, above seamounts and mid-ocean ridges, at fronts, and in the mixed layer at the sea surface. Mixing results in areas of high primary productivity which in turn become foraging ‘hotspots’ for pelagic species including sea turtles (Polovina et al. 2006) and tunas (Gunn et al. 2005).

The eggs and larvae of all teleost PMUS are pelagic. They are slightly buoyant when first spawned, are spread throughout the mixed layer and are subject to advection by the prevailing ocean currents. Because the eggs and larvae of the PMUS are found distributed throughout the tropical (and in summer, the subtropical) epipelagic zone, EFH for these life stages has been designated as the epipelagic zone (~200 m) from the shoreline to the outer limit of the EEZ. The only generic variation in this distribution pattern occurs in the northern latitudes of the Hawaii EEZ, which extends farther into the temperate zone than any other EEZ covered by the plan. In these higher latitudes, eggs and larvae are rarely found during the winter months (November–February).

For additional details on the life history and habitat utilization patterns of individual PMUS, please see the EFH descriptions and maps contained in Amendment 8 to the Pelagic FMP (WPRFMC 2002).

6.3 HAPC Designations for PMUS

The Council designated the water column down to 1,000 meters that lie above all seamounts and banks within the EEZ shallower than 2,000 meters (1,000 fm) as habitat areas of particular concern (HAPC) for PMUS (Table 14). In determining whether a type or area of EFH should be designated as an HAPC, one or more of the following criteria established by NMFS must be met: (a) the ecological function provided by the habitat is important; (b) the habitat is sensitive to human-induced environmental degradation; (c) development activities are, or will be, stressing the habitat type; or (c) the habitat type is rare. However, it is important to note that if an area meets only one of the HAPC criteria, it will not necessarily be designated an HAPC.

The EFH relevance of topographic features deeper than 1,000 meters is due to the influence they have on the overlying mesopelagic zone. These deeper features themselves do not constitute EFH, but the waters from the surface to 1,000 meters deep superadjacent to these features are designated as HAPC within the EFH. The 2,000-meter depth contour captures the summits of most seamounts mentioned by fishermen, and all banks within the EEZ waters under the Council’s jurisdiction. The basis for designating these areas as HAPC is the ecological function provided, the rarity of the habitat type, the susceptibility of these areas to human-induced environmental degradation, and proposed activities that may stress the habitat type.

As noted above, localized areas of increased biological productivity are associated with seamounts, and many seamounts are important grounds for commercial fishing in the Western Pacific Region. There have been proposals to mine the manganese rich summits of the off-axis seamounts in the EEZ around Hawaii. The possible adverse impacts of this proposed activity on fishery resources are of concern to the Council.

Because the PMUS are highly migratory, the areas outside the EEZ in the Western Pacific Region are designated by the Council as “important habitat” because they provide essential spawning, breeding, and foraging habitat.

Table 14. Summary of EFH and HAPC Designations for PMUS

Species Complex	EFH	HAPC
Temperate species Striped Marlin (*Tetrapurus audax*), Bluefin Tuna (*Thunnus thynnus*), Swordfish (*Xiphias gladius*), Albacore (*Thunnus alalunga*), Mackerel (*Scomber* spp.), Bigeye (*Thunnus obesus*), Pomfret (family Bramidae)	**Eggs and larvae:** the (epipelagic zone) water column down to a depth of 200 m (100 fm) from the shoreline to the outer limit of the EEZ **Juvenile/adults:** the water column down to a depth of 1,000 m (500 fm) from the shoreline to the outer limit of the EEZ	The water column from the surface down to a depth of 1,000 m (500 fm) above all seamounts and banks with summits shallower than 2,000 m (1,000 fm) within the EEZ
Tropical species Yellowfin (*Thunnus albacares*), Kawakawa (*Euthynnus affinis*), Skipjack (*Katsuwonus pelamis*), Frigate and bullet tunas (*Auxis thazard*, *A. rochei*), Blue marlin (*Makaira nigricans*), Slender tunas (*Allothunnus fallai*), Black marlin (*Makaira indica*), Dogtooth tuna (*Gymnosarda unicolor*), Spearfish (*Tetrapturus* spp.), Sailfish (*Istiophorus platypterus*), Mahimahi (*Coryphaena hippurus, C. equiselas*), Ono (*Acanthocybium solandri*), Opah (*Lampris* spp.)		
Sharks Pelagic thresher shark (*Alapias pelagicus*), Bigeye thresher shark (*Alopias*), Common thresher shark (*Alopias vulpinus*), Silky shark (*Carcharhinus falciformis*), Oceanic whitetip shark (*Carcharhinus longimanus*), Blue shark (*Prionace glauca*), Shortfin mako shark (*Isurus oxyrinchus*), Longfin mako shark (*Isurus paucus*), Salmon shark (*Lamna ditropis)*		
Squid Neon flying squid *(Ommastrephes bartamii),* Diamondback squid *(Thysanoteuthis rhombus),* Purple flying squid *(Sthenoteuthis oualaniensis)*		

6.4 Fishing Related Impacts That May Adversely Affect EFH

The Council is required to act to prevent, mitigate, or minimize adverse effects from fishing on evidence that a fishing practice has identifiable adverse effects on EFH for any MUS covered by an FMP. Adverse fishing impacts may include physical, chemical, or biological alterations of the substrate and loss of, or injury to, benthic organisms, prey species, and their habitat or other components of the ecosystem. Adverse fishing impacts may include physical, chemical, or biological alterations of the substrate and loss of, or injury to, benthic organisms, prey species, and their habitat or other components of the ecosystem

The predominant fishing gear types—hook and line, longline, troll—used in the pelagic fisheries managed by the Council cause few fishing-related impacts to the benthic habitat. However, the Council has identified the following potential sources of fishery-related impacts to benthic habitat that may occur during normal fishing operations:

- Anchor damage from vessels attempting to maintain position over productive fishing habitat.
- Heavy weights and line entanglement occurring during normal hook-and-line fishing operations.

Because the habitat of pelagic species is the open ocean, and managed fisheries employ variants of hook-and-line gear, there are no direct impacts to EFH. Lost gear may be a hazard to some species due to entanglement and may eventually cause harm to reef habitat if it becomes entangled on coral reefs after drifting close to shore as marine debris. While the Council has determined that current management measures to protect fishery habitat are adequate, should future research demonstrate a need, the Council will act accordingly to protect habitat necessary to maintain a sustainable and productive fishery in the Western Pacific Region.

6.5 Non-Fishing Related Impacts That May Adversely Affect EFH

On the basis of the guidelines established by the Secretary under Section 305 (b)(1)(A) of the MSA, NMFS has developed a set of guidelines to assist councils meet the requirement to describe adverse impacts to EFH from non-fishing activities in their FMPs. A wide range of non-fishing activities throughout the U.S. Pacific Islands contribute to EFH degradation. FEP implementation will not directly mitigate these activities. However, as already noted, it will allow NMFS and the Council to make recommendations to any federal or state agency about actions that may impact EFH. Not only could this be a mechanism to minimize the environmental impacts of agency action, it will help them focus their conservation and management efforts.

The Council is required to identify nonfishing activities that have the potential to adversely affect EFH quality and, for each activity, describe its known potential adverse impacts and the EFH most likely to be adversely affected. The descriptions should explain the mechanisms or processes that may cause the adverse effects and how these may affect habitat function. The Council has considered a wide range of nonfishing activities that may threaten important properties of the habitat used by managed species and their prey, including mineral exploration, aquaculture, offshore wastewater discharge, oil and hazardous substance discharge or spills, construction of fish enhancement structures, and introduction of exotic species. These activities and impacts, along with mitigation measures, are detailed in the next section.

6.5.1 Habitat Conservation and Enhancement Recommendations

According to NMFS guidelines, Councils must describe ways to avoid, minimize, or compensate for the adverse effects to EFH and promote the conservation and enhancement of EFH.

Generally, non-water dependent actions that may have adverse impacts should not be located in EFH. Activities that may result in significant adverse effects on EFH should be avoided where less environmentally harmful alternatives are available. If there are no alternatives, the impacts of these actions should be minimized. Environmentally sound engineering and management practices should be employed for all actions that may adversely affect EFH. Disposal or spillage of any material (dredge material, sludge, industrial waste, or other potentially harmful materials) that would destroy or degrade EFH should be avoided. If avoidance or minimization is not possible, or will not adequately protect EFH, compensatory mitigation to conserve and enhance EFH should be recommended. FEPs may recommend proactive measures to conserve or enhance EFH. When developing proactive measures, Councils may develop a priority ranking of the recommendations to assist federal and state agencies undertaking such measures. Councils should describe a variety of options to conserve or enhance EFH, which may include, but are not limited to the following:

Enhancement of rivers, streams, and coastal areas through new federal, state, or local government planning efforts to restore river, stream, or coastal area watersheds.

Improve water quality and quantity through the use of the best land management practices to ensure that water-quality standards at state and federal levels are met. The practices include improved sewage treatment, disposing of waste materials properly, and maintaining sufficient in-stream flow to prevent adverse effects to estuarine areas.

Restore or create habitat, or convert non-EFH to EFH, to replace lost or degraded EFH, if conditions merit such activities. However, habitat conversion at the expense of other naturally functioning systems must be justified within an ecosystem context.

6.5.2 Description of Mitigation Measures for Identified Activities and Impacts

Established policies and procedures of the Council and NMFS provide the framework for conserving and enhancing EFH. Components of this framework include adverse impact avoidance and minimization, provision of compensatory mitigation whenever the impact is significant and unavoidable, and incorporation of enhancement. New and expanded responsibilities contained in the MSA will be met through appropriate application of these policies and principles. In assessing the potential impacts of proposed projects, the Council and the NMFS are guided by the following general considerations:

- The extent to which the activity would directly and indirectly affect the occurrence, abundance, health, and continued existence of fishery resources.
- The extent to which the potential for cumulative impacts exists.
- The extent to which adverse impacts can be avoided through project modification, alternative site selection, or other safeguards.
- The extent to which the activity is water dependent if loss or degradation of EFH is involved.
- The extent to which mitigation may be used to offset unavoidable loss of habitat functions and values.

Seven nonfishing activities have been identified that directly or indirectly affect habitat used by MUS. Impacts and conservation measures are summarized below for each of these activities. Although not all inclusive, what follows is a good example of the kinds of measures that can help to minimize or avoid the adverse effects of identified nonfishing activities on EFH.

Habitat Loss and Degradation

Impacts

- Infaunal and bottom-dwelling organisms
- Turbidity plumes
- Biological availability of toxic substances
- Damage to sensitive habitats
- Current patterns/water circulation modification
- Loss of habitat function
- Contaminant runoff
- Sediment runoff
- Shoreline stabilization projects

Land-based Conservation Measures

1. To the extent possible, fill materials resulting from dredging operations should be placed on an upland site. Fills should not be allowed in areas with subaquatic vegetation, coral reefs, or other areas of high productivity.

2. The cumulative impacts of past and current fill operations on EFH should be addressed by federal, state, and local resource management and permitting agencies and should considered in the permitting process.

3. The disposal of contaminated dredge material should not be allowed in EFH.

4. When reviewing open-water disposal permits for dredged material, state and federal agencies should identify the direct and indirect impacts such projects may have on EFH. When practicable, benthic productivity should be determined by sampling prior to any discharge of fill material. Sampling design should be developed with input from state and federal resource agencies.

5. The areal extent of the disposal site should be minimized. However, in some cases, thin layer disposal may be less deleterious. All non-avoidable impacts should be mitigated.

6. All spoil disposal permits should reference latitude–longitude coordinates of the site so that information can be incorporated into GIS systems. Inclusion of aerial photos may also be required to help geo-reference the site and evaluate impacts over time.

7. Further fills in estuaries and bays for development of commercial enterprises should be curtailed.

8. Prior to installation of any piers or docks, the presence or absence of coral reefs and submerged aquatic vegetation should be determined. These areas should be avoided. Benthic productivity should also be determined, and areas with high productivity avoided. Sampling design should be developed with input from state and federal resource agencies.

9. The use of dry stack storage is preferable to wet mooring of boats. If that method is not feasible, construction of piers, docks, and marinas should be designed to minimize impacts to the coral reef substrate and subaquatic vegetation.

10. Bioengineering should be used to protect altered shorelines. The alteration of natural, stable shorelines should be avoided.

Pollution and Contamination

Impacts

- Introduction of chemicals
- Introduction of animal wastes
- Increased sedimentation
- Wastewater effluent with high contaminant levels
- High nutrient levels downcurrent of outfalls
- Biocides to prevent biofouling
- Thermal effects
- Turbidity plumes
- Affected submerged aquatic vegetation sites
- Stormwater runoff
- Direct physical contact
- Indirect exposure
- Cleanup

Conservation Measures

1. Outfall structures should be placed sufficiently far offshore to prevent discharge water from affecting areas designated as EFH. Discharges should be treated using the best available technology, including implementation of up-to-date methodologies for reducing discharges of biocides (e.g., chlorine) and other toxic substances.

2. Benthic productivity should be determined by sampling prior to any construction activity. Areas of high productivity should be avoided to the maximum extent possible. Sampling design should be developed with input from state and federal resource agencies.

3. Mitigation should be provided for the degradation or loss of habitat from placement of the outfall structure and pipeline as well as the treated water plume.

4. Containment equipment and sufficient supplies to combat spills should be on-site at all facilities that handle oil or hazardous substances.

5. Each facility should have a Spill Contingency Plan, and all employees should be trained in how to respond to a spill.

6. To the maximum extent practicable, storage of oil and hazardous substances should be located in an area that would prevent spills from reaching the aquatic environment.

7. Construction of roads and facilities adjacent to aquatic environments should include a storm-water treatment component that would filter out oils and other petroleum products.

8. The use of pesticides, herbicides, and fertilizers in areas that would allow for their entry into the aquatic environment should be avoided.

9. The best land management practices should be used to control topsoil erosion and sedimentation.

Dredging

Impacts

- Infaunal and bottom-dwelling organisms
- Turbidity plumes
- Bioavailability of toxic substances
- Damage to sensitive habitats
- Water circulation modification

Conservation Measures

1. To the maximum extent practicable, dredging should be avoided. Activities that require dredging (such as placement of piers, docks, marinas, etc.) should be sited in deep-water areas or designed in such a way as to alleviate the need for maintenance dredging. Projects should be permitted only for water-dependent purposes, when no feasible alternatives are available.

2. Dredging in coastal and estuarine waters should be performed during the time frame when MUS and prey species are least likely to be entrained. Dredging should be avoided in areas with submerged aquatic vegetation and coral reefs.

3. All dredging permits should reference latitude–longitude coordinates of the site so that information can be incorporated into Geographic Information Systems (GIS). Inclusion of aerial photos may also be required to help geo-reference the site and evaluate impacts over time.

4. Sediments should be tested for contaminants as per the EPA and U.S. Army Corps of Engineers requirements.

5. The cumulative impacts of past and current dredging operations on EFH should be addressed by federal, state, and local resource management and permitting agencies and should be considered in the permitting process.

6. If dredging needs are caused by excessive sedimentation in the watershed, those causes should be identified and appropriate management agencies contacted to assure action is done to curtail those causes; i.e., stop it at the source.

7. Pipelines and accessory equipment used in conjunction with dredging operations should, to the maximum extent possible, avoid coral reefs, seagrass beds, estuarine habitats, and areas of subaquatic vegetation.

Marine Mining

Impacts

- Loss of habitat function
- Turbidity plumes
- Resuspension of fine-grained mineral particles
- Composition of the substrate altered

Conservation Measures

1. Mining in areas identified as a coral reef ecosystem should be avoided.

2. Mining in areas of high biological productivity should be avoided.

3. Mitigation should be provided for loss of habitat due to mining.

Water Intake Structures

Impacts

- Entrapment, impingement, and entrainment
- Loss of prey species

Conservation Measures

1. New facilities that rely on surface waters for cooling should not be located in areas where coral reef or other marine organisms are concentrated. Discharge points should incorporate cooling towers that employ sufficient safeguards to ensure against release of blow-down pollutants and thermal pollution into the aquatic environment.

2. Intake structures should be designed to prevent entrainment or impingement of MUS larvae and eggs.

3. Discharge temperatures (both heated and cooled effluent) should not exceed the thermal tolerance of the plant and animal species in the receiving body of water.

4. Mitigation should be provided for the loss of EFH from placement of the intake structure and delivery pipeline.

Aquaculture Facilities

Impacts

- Discharge of organic waste from the farms
- Impacts to the seafloor below the cages or pens (including moorings or anchors)
- Introduction of disease through transmission from cultured organisms to wild stocks.

Conservation Measures

1. Facilities should be located out of the maritime zone of influence to the maximum extent possible. Tidally influenced wetlands should not be enclosed or altered for mariculture purposes including hatchery and grow-out operations. Siting of facilities should also take into account the size of the facility, the presence or absence of submerged aquatic vegetation and coral reef ecosystems, proximity of wild fish stocks, migratory patterns, competing uses, hydrographic conditions, and upstream uses. Benthic and nearshore productivity should be determined by sampling prior to any operations. Areas of high productivity should be avoided to the maximum extent possible. Sampling design should be developed with input from state and federal resource agencies.

2. To the extent practicable, water intakes should be designed to avoid entrainment and impingement of native fauna.

3. Water discharge should be treated to avoid contamination of the receiving water and should be located only in areas having good mixing characteristics.

4. Where cage mariculture operations are undertaken, water depths and circulation patterns should be investigated and should be adequate to preclude the buildup of waste products, excess feed, and chemical agents.

5. Non-native, ecologically undesirable species that are reared may pose a risk of escape or accidental release, which could adversely affect the ecological balance of an area. A thorough scientific review and risk assessment should be undertaken before any non-native species are allowed to be introduced.

6. Any net pen structure should have small enough webbing to prevent entanglement by prey species and escape by cultured organisms.

7. Mitigation should be provided for the EFH areas impacted by the facility.

Introduction of Exotic Species

Impacts

- Habitat alteration
- Trophic alteration
- Gene pool alteration
- Spatial alteration
- Introduction of disease

Conservation Measures

1. Vessels should discharge ballast water far enough out to sea to prevent introduction of non-native species to bays and estuaries.

2. Vessels should conduct routine inspections for presence of exotic species in crew quarters and hull of the vessel prior to embarking to remote islands (PRIAs, NWHI, and northern islands of the CNMI).

3. Exotic species should not be introduced for aquaculture purposes unless a thorough scientific evaluation and risk assessment are performed (see section on aquaculture).

4. Effluent from public aquaria display laboratories and educational institutes using exotic species should be treated prior to discharge.

5. Intentional release or introduction of non-native species should be avoided.

6.6 EFH Research Needs

The Council conducted an initial inventory of available environmental and fisheries data sources relevant to the EFH of each managed fishery. Based on this inventory, a series of tables were created that indicated the existing level of data for individual MUS in each fishery. These tables are available in Amendment 8 to the Pelagic FMP (WPRFMC 2002).

Additional research is needed to make available sufficient information to support a higher level of description and identification of EFH and HAPC. Additional research may also be necessary to identify and evaluate actual and potential adverse effects on EFH, including, but not limited to, direct physical alteration; impaired habitat quality/functions; cumulative impacts from fishing; or indirect adverse effects, such as sea level rise, global warming, and climate shifts.

The following scientific data are needed to more effectively address EFH provisions:

All Species

- Distribution of early life history stages (eggs and larvae) of MUS by habitat
- Juvenile habitat (including physical, chemical, and biological features that determine suitable juvenile habitat)
- Food habits (feeding depth, major prey species, etc.)
- Habitat-related densities for all MUS life history stages
- Habitat utilization patterns for different life history stages and species for MUS
- Growth, reproduction, and survival rates for MUS within habitats

NMFS guidelines suggest that the Council and NMFS periodically review and update the EFH components of FMPs as new data become available. The Council recommends that new information be reviewed, as necessary, during preparation of the annual reports by the Plan

Teams. EFH designations may be changed under the FEP framework processes if information presented in an annual review indicates that modifications are justified.

CHAPTER 7: COORDINATION OF ECOSYSTEM APPROACHES TO FISHERIES MANAGEMENT IN THE PACIFIC PELAGIC FEP

7.1 Introduction

In the Western Pacific Region, the management of ocean and coastal activities is conducted by a number of agencies and organizations at the federal, state, county, and even village levels. These groups administer programs and initiatives that address often overlapping and sometimes conflicting ocean and coastal issues.

To be successful, ecosystem approaches to management must be designed to foster intra and inter-agency cooperation and communication (Schrope 2002). Increased coordination with state and local governments and community involvement will be especially important to the improved management of near-shore resources that are heavily used. To increase collaboration with domestic and international management bodies, as well as other governmental and nongovernmental organizations, communities, and the public, the Council has adopted the multilevel approach described below. This process is depicted in Figure 16.

7.2 Council Panels and Committees

FEP Advisory Panel

The FEP Advisory Panel advises the Council on fishery management issues, provides input to the Council regarding fishery management planning efforts, and advises the Council on the content and likely effects of management plans, amendments, and management measures.

The Advisory Panel consists of four sub-panels. In general, each Advisory Sub-panel includes two representatives from the area’s commercial, recreational, and subsistence fisheries, as well as two additional members (fishermen or other interested parties) who are knowledgeable about the area’s ecosystems and habitat. The exception is the Mariana FEP Sub-panel, which has four representatives from each group to represent the combined areas of Guam and the Northern Mariana Islands (see Table 15). The Hawaii FEP Sub-panel addresses issues pertaining to demersal fishing in the PRIA due to the lack of a permanent population and because such PRIA fishing has primarily originated in Hawaii. The FEP Advisory Panel meets at the direction of the Council to provide continuing and detailed participation by members representing various fishery sectors and the general public.

Table 15. FEP Advisory Panel and Sub-panel Structure

Representative	**American Samoa FEP Sub-panel**	**Hawaii FEP Sub-panel**	**Mariana FEP Sub-panel**	**Pelagic FEP Sub-panel**
Commercial representatives	Two members	Two members	Four members	Two members
Recreational representatives	Two members	Two members	Four members	Two members
Subsistence representatives	Two members	Two members	Four members	Two members
Ecosystems and habitat representatives	Two members	Two members	Four members	Two members

Pelagic FEP Plan Team

The Pelagic FEP Plan Team oversees the ongoing development and implementation of the Pacific Pelagic Fishery Ecosystem Plan and is responsible for reviewing information pertaining to the performance of all the fisheries and the status of all the stocks managed under the Pelagic FEP. Similarly, the Archipelagic FEP Plan Team oversees the ongoing development and implementation of the American Samoa, Hawaii, Mariana, and PRIA FEPs.

The Pelagic Plan Team meets at least once annually and comprises individuals from local and federal marine resource management agencies and non-governmental organizations. It is led by a Chair who is appointed by the Council Chair after consultation with the Council's Executive Standing Committee. The Pelagic Plan Team's findings and recommendations are reported to the Council at its regular meetings. Plan teams are a form of advisory panel authorized under Section 302(g) of the MSA.

Science and Statistical Committee

The Scientific and Statistical Committee (SSC) is composed of scientists from local and federal agencies, academic institutions, and other organizations. These scientists represent a range of disciplines required for the scientific oversight of fishery management in the Western Pacific Region. The role of the SSC is to (a) identify scientific resources required for the development of FEPs and amendments, and recommend resources for Plan Teams; (b) provide multi-disciplinary review of management plans or amendments, and advise the Council on their scientific content; (c) assist the Council in the evaluation of such statistical, biological, economic, social, and other scientific information as is relevant to the Council's activities, and recommend methods and means for the development and collection of such information; and (d) advise the Council on the composition of both the Pelagic and Archipelagic Plan Teams.

FEP Standing Committees

The Council's four FEP Standing Committees are composed of Council members who, prior to Council action, review all relevant information and data including the recommendations of the FEP Advisory Panels, the Archipelagic and Pelagic Plan Teams, and the SSC. The Standing

Committees are the American Samoa FEP Standing Committee, the Hawaii FEP Standing Committee (as in the Advisory Panels, the Hawaii Standing Committee will also consider demersal issues in the PRIA), the Mariana FEP Standing Committee, and the Pelagic FEP Standing Committee. The recommendations of the FEP Standing Committees, along with the recommendations from all of the other advisory bodies described above, are presented to the full Council for their consideration prior to taking action on specific measures or recommendations.

Regional Ecosystem Advisory Committees

Regional Ecosystem Advisory Committees (REACs) for each inhabited area (American Samoa, Hawaii, and the Mariana archipelago) comprise Council members and representatives from federal, state, and local government agencies; businesses; and non-governmental organizations that have responsibility or interest in land-based and non-fishing activities that potentially affect the area's marine environment. Committee membership is by invitation and provides a mechanism for the Council and member agencies to share information on programs and activities, as well as to coordinate management efforts or resources to address non-fishing related issues that could affect ocean and coastal resources within and beyond the jurisdiction of the Council. Committee meetings coincide with regularly scheduled Council meetings, and recommendations made by the Committees to the Council are advisory as are recommendations made by the Council to member agencies. REACs are a form of advisory panel authorized under Section 302(g) of the MSA.

Advisory Body Coordination and Recommendations to Council

Recommendations from each Council advisory body are reviewed separately by the Council, although there may be comments from one advisory body on the recommendations arising in another team or panel. This is partially dependant on timing and typically, the SSC reviews those recommendations arising from the Plan Teams, Advisory Panels and other bodies that have met prior to a Council meeting, and either concurring with these recommendations or suggesting an alternative. The same would be true of any recommendations arising from the Regional Ecosystem Advisory Committees, where the Council would look to the SSC for any comments on recommendations arising from the REACs. Finally, the Pelagics Plan Team coordinates with the archipelagic Plan Teams on small boat issues, since the same fishing platform used for pelagic trolling and handlining, can be used for a variety of other fishing methods, e.g., bottomfish and coral reef fishes, and may involve cross cutting issues that have arisen in the past, such as shark depredation of fish catches.

Community Groups and Projects

As described above, communities and community members are involved in the Council's management process in explicit advisory roles, as sources of fishery data and as stakeholders invited to participate in public meetings, hearings, and comment periods. In addition, cooperative research initiatives have resulted in joint research projects in which scientists and fishermen work together to increase both groups' understanding of the interplay of humans and the marine environment, and both the Council's Community Development Program and the Community

Demonstration Projects Program, described below, foster increased fishery participation by indigenous residents of the Western Pacific Region.

7.3 Indigenous Program

The Council's indigenous program addresses the economic and social consequences of militarization, colonization and immigration on the aboriginal people in the Council's area of responsibility and authority. The resultant cultural hegemony is manifested in the poverty, unemployment, social disruption, poor education, poor housing, loss of traditional, cultural practices and health problems for indigenous communities. These social disorders affect island society. Rapid changes in the patterns of environmental utilization are disruptive to ecological systems that developed over millennia into a state of equilibrium with traditional native cultural practices. The environmental degradation and social disorder impacts the larger community by reducing the quality of life for all island residents. The result is stratification along social and economic lines and conflict within the greater community.

The primary process for the indigenous community to participate in the Council process is through their participation in the Subsistence and Indigenous Advisory Panel discussions. Grant workshops and other Council public fora provide additional opportunity for the indigenous community to participate in the Council process. As described in Chapter 1, the Council is sponsoring the Hoohanohano I Na Kupuna (Honoring our Ancestors) conference series in partnership with the Association of Hawaiian Civic Clubs (AOHCC) and in consultation with the native Hawaiian community. The conference has received the support of the Kamehameha Schools/Bishop Estate, Office of Hawaiian Affairs, various departments of the State of Hawaii, the Hawaii Tourism Authority and numerous community organizations and projects throughout the State of Hawaii. Fishery ecosystem management provides the Council with the opportunity to utilize the manao (thoughts) and ike (knowledge) of our kupuna (elders) – ideas and practices that have sustained na kanaka maoli (native Hawaiian) culture for millennia.

The conference series was initiated by the Council to engage the Kanaka Maoli community in the development of the Hawaii Archipelago FEP and to increase their participation in the management of fisheries under the FEP's authority. A series of workshops with the Kanaka Maoli community to promote the concept of ahupuaa (traditional natural resource unit) management began in 2003 through the AOHCC. This endeavor was continued by the Council in order to take the ahupuaa concept to the next level, the development of a process to implement traditional resource management practices into today's management measures.

Under the Pelagic FEP, this conference series will continue in Hawaii and will subsequently be extended to the other areas of the Western Pacific Region. Although the specific format will be tailored to each area's cultures and communities, in all cases the Council will seek to increase the participation of indigenous communities in the harvest, research, conservation and management of marine resources as called for in Section 305 of the MSA.

There are two programs mandated by the MSA for these communities to participate in the Council process: The Western Pacific Community Development Program and the Western Pacific Community Demonstration Project Program. With inception of the FEPs these programs will continue, however, ecosystem considerations will be included in analysis of the proposals and their potential impacts.

7.3.1 Western Pacific Community Development Program (CDP)

The CDP establishes a process to increase participation of the indigenous community in fisheries managed by the Council through FMP amendments, program development or other administrative procedures to manage fisheries.

The Council will put into service a Community Development Program Advisory Panel (CDP AP). The advisory panel will review recommendations made by a community and report to the Council. The AP will be one of the vehicles for communities to bring their concerns to the Council for consideration in the further development and implementation of the fishery ecosystem plans.

Two projects have been developed under the CDP. The first project would have reserved 20 percent of the federal NWHI Mau Zone bottomfish permits for indigenous communities of the Hawaiian Archipelago (two of 10 permits), however before this project could be implemented the majority of the NWHI was established as a marine national monument in which fishing is to be prohibited. The second project called the Guam Volunteer Fishery Data Collection Project uses community participation to enhance and complement creel survey and market data collection in Guam.

7.3.2 Western Pacific Community Demonstration Project Program (CDPP)

The Community Demonstration Project Program is a grant program. The Council develops the funding priorities. The Council has an advisory panel which reviews and ranks proposals and forwards to the Council for approval and transmittal to the Secretary of Commerce.

The purpose of the Western Pacific Demonstration Project Program is to promote the involvement of western Pacific communities in fisheries by demonstrating the application and/or adaptation of methods and concepts derived from traditional indigenous practices. Projects may demonstrate the applicability and feasibility of traditional indigenous marine conservation and fishing practices; develop or enhance community-based opportunities to participate in fisheries; involve research, community education, or the acquisition of materials and equipment necessary to carry out a demonstration project. Under the FEPs, projects will also be evaluated in terms of value to the ecosystem.

To support this program, region wide grant application trainings and workshops are conducted by the Council. These workshops also provide a forum for the community to make recommendations and participate in the Council process.

Figure 18. Illustration of Institutional Linkages in the Council Process

Please see Section 1.8 for a description of the Council’s international management and research program.

CHAPTER 8: CONSISTENCY WITH APPLICABLE LAWS

8.1 Introduction

This chapter provides the basis for the Council's belief that the measures contained in this document are consistent with MSA's National Standards and other applicable laws.

8.2 Magnuson-Stevens Fisheries Conservation and Management Act

8.2.1 Required Provisions

8.2.1.1 Fishery Description

Pelagic management unit species are caught in the pelagic fisheries by longline, troll, handline, pole-and-line, and purse seine. The Hawaii-based longline fishery is the most significant pelagic fishery under Council jurisdiction in terms of landings and value. The number of longline vessels based in Hawaii is restricted by a limited access program to 164. Fishery participants in the pelagic fishery of the Western Pacific Region utilize several different fishing methods and gear types; fish for different pelagic species during different seasons; are restricted by different limited entry programs, gear requirements, set limitations, quotas, and threatened and endangered species protective measures; and share the resource within the international arena of the Pacific Ocean. For complete descriptions of the fishery see Chapter 4 and for descriptions of the pelagic fishery management measures, see Chapter 5 of this document. And for the most up-to-date information and data please refer to the Council's annual report(s).

8.2.1.2 MSY and OY

For further information on determination of MSY, see the Council's Amendment 8 (Supplement) to the Pelagic FMP (WPRFMC 2002) and Sections 5.4 and 5.6 of this document.

Optimum yield or OY for the PMUS is defined in the original Pelagics FMP as "the amount of each species in the management unit that will be caught by domestic and foreign fishing vessels in the FCZ in accordance with the measures contained in this plan." This definition was amended in 1992 to also apply to tunas. In addition, in 1994 Amendment 7 revised the definition of OY to recognize that it should encompass the fishery beyond the EEZ. In Amendment 7 define OY as "the amount of each management unit species or species complex that can be harvested by domestic and foreign fishing vessels in the EEZ and adjacent waters to the extent regulated by the FMP without causing "local overfishing" or "economic overfishing" within the EEZ of each island area, and without causing or significantly contributing to "growth overfishing" or "recruitment overfishing" on a stock-wide basis".

8.2.1.3 Domestic Capacity to Harvest and Process OY

Given the non-numeric definition of OY for the Pelagics FMP, it is difficult to quantify the domestic capacity to harvest OY or that portion of OY that can be made available for foreign fishing and to date no TALFF has been specified for this fishery. With the exception of the American Samoa longline fishery, harvests by pelagic fisheries of the Western Pacific Region supply fresh fish markets with little to no processing beyond heading and gutting of swordfish which is done onboard the vessels. The majority of harvests by the American Samoa longline fishery are sold to the two American tuna canneries located on Tutuila. The remaining portion of this fishery's harvests is sold in American Samoa as fresh fish. Thus domestic processors appear fully capable of processing 100 percent of domestic pelagic fish harvests in the Western Pacific Region.

8.2.1.4 Fishery Data Requirements

The Pelagic FEP will continue to collect and submit the pertinent fishery data including information on the type and quantity of gear used, catch data, areas where fishing occurs, time of fishing, amount of fishing, i.e., fishing effort, and data on processors. This information is reviewed annually before being presented in the Council's annual report. Pertinent information on the status of the pelagic fisheries is also provided to the Secretary on an annual basis to be inserted into NOAA's annual report on the Status of the Stocks.

8.2.1.5 Description of EFH

For a description of the pelagic fishery essential fish habitat (EFH), please see Chapter 6 of this document.

8.2.1.6 Fishery Impact Statement

For detailed information on the economic and social impacts of the Pelagic FEP please see the Council's Programmatic EIS on the Fishery Ecosystem Plans.

8.2.1.7 Overfishing Criteria

For further information on overfishing criteria, see the Council's Amendment 8 (Supplement) to the Pelagics FMP (December 20, 2002), and Section 5.4 of this document.

8.2.1.8 Bycatch Reporting

Bycatch and protected species interactions are assessed and reported in the Hawaii-based longline fishery through a logbook program and a recently expanded vessel observer program. Bycatch in the American Samoa fishery is measured through creel surveys and a Federal logbook program, and is further assessed through a vessel observer program. Bycatch in the other Council-managed pelagic fisheries is monitored through local catch reports and creel surveys with federal oversight. In addition, any fishing vessel (commercial or non-commercial) operating in the territorial seas or EEZ of the U.S. in a fishery identified through NMFS' annual determination process must carry an observer when directed to do so. For additional information on bycatch provisions including reporting please refer to the Council's Amendment 8 (Supplement) to the Pelagics FMP (December 20, 2002). Additional information on bycatch reduction measures may be found in Section 5.5.14 of this document.

Bycatch data sources in the U.S. pelagic fisheries in the WCPO are listed in Table 16 below. Indicated for each program or survey instrument is the main agency responsible for implementing the data collection program and the years for which data are available. Additional agencies may be involved in collecting, managing, interpreting, and disseminating the data. Not included in the table are fishery-independent sources of bycatch data and sources of fisheries data that do not generally provide information on bycatch, such as programs that monitor fish sales. The bycatch-related forms used in each of these data collection programs are included in Appendix 1 of Amendment 8 to the Pelagics FMP.

Table 16: Bycatch Reporting Methodology for Pacific Pelagic Fisheries

	Observer programs[29]	Logbook programs	Creel surveys
Hawaii-based Longline	NMFS: 1994-present	NMFS W. Pacific Daily Longline Fishing Log	None
America Samoa-based Longline	NMFS: 2006-present	NMFS W. Pacific Daily Longline Fishing Log	DMWR Offshore Survey
Hawaii-based Small Boats	None	HDAR Fish Catch Report (commercial only)	HI Marine Recreational Fishing Survey
American Samoa-based Small Boats	None	None	DMWR Offshore Survey
CNMI-based Small Boats	None	None	DFW Offshore Creel Census
Guam-based Small Boats	None	None	DAWR Offshore Creel Census
PRIA Small Boats	None	NMFS PRIA Troll/Handline Logbook HDAR Fish Catch Report (commercial only, if landed in Hawaii); USFWS Midway Sports Fishing Boat Trip Log (if based on Midway);	HI Marine Recreational Fishing Survey (if landed in Hawaii)
U.S. Albacore Boats	None	NMFS HSFCA Logbook (EEZ waters) HDAR Albacore Trip Report (if landed in Hawaii)	None
U.S. Purse Seine Boats	SPC: 1988-present	SPC Regional Purse Seine Logsheet	None
U.S. Squid Jig Boats	NMFS : 2008-present	NMFS HFSCA logbook NMFS Squid Jig logbook HDAR Fish Catch Report (commercial only, if landed in Hawaii)	None

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[29] Pursuant to the Endangered Species Act NMFS may require fishing vessels in fisheries identified through an annual determination process to carry Federal observers (72 FR 43176, August 3, 2007).

8.2.1.9 Recreational Catch and Release

Chapter 4 of this document describes the recreational pelagic fisheries in the Western Pacific Region. Additional information may be found in the Council's annual reports on the pelagic fishery. There are no MSA recognized catch and release fishery management programs in the WPR.

8.2.1.10 Description of Fishery Sectors

Chapter 4 of this document describes the different pelagic fishery sectors in the Western Pacific Region. Additional information including landings data and trends may be found in the Council's annual reports on the pelagic fishery.

8.2.2 National Standards for Fishery Conservation and Management

National Standard 1 states that conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry.

The management measures in the pelagic fisheries managed through this FEP are consistent with National Standard 1 because they emphasize managing pelagic fisheries in a sustainable manner to best obtain optimum yield. Currently Pacific-wide bigeye tuna has been determined by NMFS to be experiencing overfishing. Dmoestic measures have been proposed and implemented to end this overfishing to the maximum extent practicable for these highly migratory, pan-Pacific stocks which straddle the jurisdiction of numerous nations and the high seas. Because the fisheries managed under this FEP catch only a small percentage of the total Pacific catch of these stocks, multilateral international efforts are necessary to end the overfishing, and these are being developed and implemented through U.S. participation in several RFMOs.

National Standard 2 states that conservation and management measures shall be based upon the best scientific information available.

The management measures in the pelagic fisheries managed through this FEP are consistent with National Standard 2 because the best scientific information available on a national and international level is being accessed and utilized to determine appropriate management to conserve the PMUS stocks, protect the pelagic ecosystem, and coordinate with international management entities to most effectively manage the fisheries. Stock assessments on a Pacific-wide, EPO, and WCPO basis are utilized and research is conducted and shared on a regional and international level.

National Standard 3 states that, to the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.

The management measures in the pelagic fisheries managed through this FEP are consistent with National Standard 3 because they promote the coordinated management of Pacific pelagic species across their full range to the maximum extent possible considering the highly migratory nature of pelagic species in the Pacific. To maximize best management across the range(s) of these species this FEP includes international coordination and participation in several regional fisheries management organizations including adherence to international tuna quotas.

National Standard 4 states that conservation and management measures shall not discriminate between residents of different States. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be (A) fair and equitable to all such fishermen; (B) reasonably calculated to promote conservation; and (C) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.

The management measures in the pelagic fisheries managed through this FEP are consistent with National Standard 4 because they do not discriminate between residents of different States or allocate fishing privileges among fishery participants. Hawaii and American Samoa's pelagic longline fisheries are managed under limited entry systems, therefore, participation in these fisheries has been limited through prior rulemaking. The limited entry system decision-making processes were based on prior participation and catch history and did not discriminate between residents of different States.

National Standard 5 states that conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose.

The management measures in the pelagic fisheries managed through this FEP are consistent with National Standard 5 because they do not require or promote inefficient fishing practices. Rather, they promote sustainable harvest through use of gear and technology which maximizes efficiency and ecosystem sustainability while minimizing protected species interactions and bycatch.

National Standard 6 states that conservation and management action shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.

The management measures in the pelagic fisheries managed through this FEP are consistent with National Standard 6 because they establish a management structure that allows consideration of the local factors affecting fisheries, fishery resources, and catches.

National Standard 7 states that conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.

The management measures in the pelagic fisheries managed through this FEP are consistent with National Standard 7 because they encourage the development of management measures that are tailored for the specific circumstances affecting various Pacific pelagic fisheries and do not unnecessarily duplicate any other existing regulations or data collection programs.

National Standard 8 states that conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities.

The management measures in the pelagic fisheries managed through this FEP are consistent with National Standard 8 because they include explicit mechanisms to promote the participation of fishing communities in the development and implementation of further management measures for Pacific pelagic fisheries and include consideration of conservation measures on an international scale as may be necessary for sustainable harvest of highly migratory pelagic species.

National Standard 9 states that conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided minimize the mortality of such bycatch.

The management measures in the pelagic fisheries managed through this FEP are consistent with National Standard 9 because the bycatch provisions contained within the Pelagic FMP which were previously determined to be consistent with National Standard 9 are maintained in this FEP without change, and no new measures have been added that would increase bycatch or bycatch mortality.

National Standard 10 states that conservation and management measures shall, to the extent practicable, promote the safety of human life at sea.

The management measures in the pelagic fisheries managed through this FEP are consistent with National Standard 10 because they do not require or promote any changes to current fishing practices and they continue to promote the safety of human life at sea. Such measures already in place which promote safety at sea include the use of limited access programs which reduce the tendency for a “race to the fish”; workshops to educate fishery participants on sea turtle release methods and safety issues; and changes in proposed longline gear requirements in response to fishermen’s concerns about the use of 60 g. weighted swivels in association with side-setting.

8.3 Essential Fish Habitat

None of the measures in this FEP are expected to cause adverse impacts to EFH or HAPC for species managed under the Fishery Ecosystem Plans for Pacific Pelagics, the American Samoa Archipelago, the Hawaii Archipelago, the Mariana Archipelago, or the PRIA (Table 17). Implementation of this FEP is not expected to significantly affect the fishing operations or catches of any fisheries, rather it would simply amend and reorganize the Pelagic FMP into a geographically defined ecosystem plan. Furthermore, this FEP is not likely to lead to substantial physical, chemical, or biological alterations to the oceanic and coastal habitat, or result in any alteration to waters and substrate necessary for spawning, breeding, feeding, and growth of harvested species or their prey.

The predominant fishing gear types (hook-and-line, troll) used in the western Pacific fisheries included in this FEP cause few fishing-related impacts to the benthic habitat of bottomfish, crustaceans, coral reefs, and precious corals. None of the measures in this FEP will result in a change in fishing gear or strategy, therefore, EFH and HAPC maintain the same level of protection.

Table 17. EFH and HAPC for Management Unit Species of the Western Pacific Region
All areas are bounded by the shoreline, and the seaward boundary of the EEZ, unless otherwise indicated.

MUS	EFH (Juveniles and Adults)	EFH (Eggs and Larvae)	HAPC
Pelagic	Water column down to 1,000 m	Water column down to 200 m	Water column down to 1,000 m that lies above seamounts and banks
Bottomfish	Water column and bottom habitat down to 400 m	Water column down to 400 m	All escarpments and slopes between 40–280 m and three known areas of juvenile opakapaka habitat
Seamount Groundfish	Water column and bottom from 80 to 600 m, bounded by 29° °–35° ° N and 171 ° E –179° ° W (adults only)	Epipelagic zone (0–200 nm) bounded by 29° °–35° ° N and 171° ° E -179° ° W (includes juveniles)	Not identified
Precious Corals	Keahole, Makapuu, Kaena, Wespac, Brooks, and 180 Fathom gold/red coral beds, and Milolii, S. Kauai, and Auau Channel black coral beds	Not applicable	Makapuu, Wespac, and Brooks Bank beds, and the Auau Channel
Crustaceans	**Lobsters** Bottom habitat from shoreline to a depth of 100 m **Deepwater shrimp** The outer reef slopes at depths between 300-700 m	Water column down to 150 m Water column and associated outer reef slopes between 550 and 700 m	All banks with summits less than 30 m No HAPC designated for deepwater shrimp.

MUS	EFH (Juveniles and Adults)	EFH (Eggs and Larvae)	HAPC
Coral reef ecosystem	Water column and benthic substrate to a depth of 100 m	Water column and benthic substrate to a depth of 100 m	All MPAs identified in the FMP, all PRIAs, many specific areas of coral reef habitat (see Chapter 6)

8.4 Coastal Zone Management Act

The Coastal Zone Management Act requires a determination that a recommended management measure has no effect on the land or water uses or natural resources of the coastal zone or is consistent to the maximum extent practicable with the enforceable policies of an affected state's approved coastal zone management program.

8.5 Endangered Species Act (ESA)

The ESA requires that any action authorized, funded, or carried out by a Federal agency ensure its implementation would not jeopardize the continued existence of listed species or adversely modify their critical habitat. Species listed as endangered or threatened under the ESA that have been observed, or may occur, in the Western Pacific Region are listed below (and are described in more detail in Chapter 3):

- All Pacific sea turtles including the following: olive ridley sea turtles (*Lepidochelys olivacea*), leatherback sea turtles (*Dermochelys coriacea*), hawksbill turtles (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*), and green sea turtles (*Chelonia mydas*).

- The humpback whale (*Megaptera novaeangliae*), sperm whale (*Physeter macrocephalus*), blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*), and sei whale (*B. borealis*). In addition, one endangered pinniped, the Hawaiian monk seal (*Monachus schauinslandi*).

- The short tailed albatross (*Phoebastria albatus*).

ESA consultations were conducted by NMFS and the U.S. Fish and Wildlife Service (for species under their jurisdiction) to ensure ongoing pelagic fishery operations are not jeopardizing the continued existence of any listed species or adversely modifying critical habitat. The results of these consultations, conducted under section 7 of the ESA are briefly described below. Implementation of this FEP would not result in any additional measures not previously analyzed. Therefore, the Council believes that there would be no additional impacts to any listed species or habitat.

Section 7 Consultations

NMFS issued a biological opinion on February 23, 2004 on the ongoing operation of the Western Pacific Region's pelagic fisheries as managed under the Pelagic FMP. The opinion concluded that the fisheries were not likely to jeopardize the continued existence of any threatened or endangered species under NMFS's jurisdiction or destroy or adversely modify critical habitat that has been designated for them. Although not considered in NMFS' biological opinion, the Council has undertaken five off-site sea turtle conservation projects. These projects are aimed at protecting affected sea turtle populations on their nesting beaches and in their nearshore foraging grounds at sites in Southeast Asia, Mexico, and Japan.

On October 4, 2005 NMFS issued a biological opinion on the ongoing operations of the deep-set sector of the Hawaii-based longline fishery. The opinion concluded that the deep-set sector was not likely to jeopardize the continued existence of any humpback whales, or green, leatherback, loggerhead, or olive ridley sea turtles.

On November 18, 2002, the U.S. Fish and Wildlife Service issued a biological opinion on the potential impacts of the entire Hawaii-based domestic longline fishery on the short-tailed albatross. The opinion concluded that the fishery is not likely to jeopardize the continued existence of the short-tailed albatross.

On October 8, 2004, the U.S. Fish and Wildlife Service issued a biological opinion on the potential impacts of the shallow-set sector of the Hawaii-based pelagic longline fishery on the short-tailed albatross. The opinion concluded that the shallow-set sector is not likely to jeopardize the continued existence of the short-tailed albatross.

On August 21, 2008 NMFS completed an informal consultation on the potential impacts of the Hawaii pole-and-line fishery which concluded that the fishery is not likely to adversely impact any ESA-listed species or critical habitat in the Western Pacific Region.

On October 15, 2008 NMFS issued a biological opinion on the ongoing operations of the shallow-set sector of the Hawaii-based longline fishery. The opinion concluded that the deep-set sector was not likely to jeopardize the continued existence of any humpback whales, or green, leatherback, loggerhead, or olive ridley sea turtles.

Because the management and conservation measures contained in this FEP for vessels targeting pelagic species are identical to those in the Pelagic FMP, the Council believes that their activities under this FEP are not likely to jeopardize the continued existence of any threatened or endangered species under the jurisdiction of NMFS or the USFWS or destroy or adversely modify critical habitat that has been designated for them.

8.6 Marine Mammal Protection Act (MMPA)

Under section 118 of the Marine Mammal Protection Act (MMPA), NMFS must publish, at least annually, a List of Fisheries (LOF) that classifies U.S. commercial fisheries into one of three categories. These categories are based on the level of serious injury and mortality of marine mammals that occurs incidental to each fishery. Specifically, the MMPA mandates that each fishery be classified according to whether it has frequent, occasional, remote, or no likelihood of incidental mortality or serious injury of marine mammals.

NMFS uses fishery classification criteria, which consist of a two-tiered, stock-specific approach. This two-tiered approach first addresses the total impact of all fisheries on each marine mammal stock and then addresses the impact of individual fisheries on each stock. This approach is based on the rate, in numbers of animals per year, of incidental mortalities and serious injuries of marine mammals due to commercial fishing operations relative to a stock's Potential Biological Removal (PBR) level. The PBR level is defined in 50 CFR 229.2 as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population.

Tier 1:
If the total annual mortality and serious injury across all fisheries that interact with a stock is less than or equal to 10 percent of the PBR level of this stock, all fisheries interacting with this stock would be placed in Category III. Otherwise, these fisheries are subject to the next tier of analysis to determine their classification.

Tier 2:
Category I: Annual mortality and serious injury of a stock in a given fishery is greater than or equal to 50 percent of the PBR level.
Category II: Annual mortality and serious injury of a stock in a given fishery is greater than 1 percent and less than 50 percent of the PBR level.
Category III: Annual mortality and serious injury of a stock in a given fishery is less than or equal to 1 percent of the PBR level.

In 2004, NMFS reclassified the Hawaii Swordfish, Tuna, Billfish, Mahi Mahi, Wahoo, Oceanic Sharks Longline/Set Line Fishery (Hawaii longline fishery) from Category III to Category I under the MMPA primarily because of the level of incidental mortality and serious injury that occurs between this fishery and the Hawaiian stock of false killer whales (*Pseudorca crassidens*).

In 2008, NMFS separated the Hawaii longline fishery into two sectors: shallow-set (generally targeting swordfish) and deep-set (generally targeting tunas and other pelagic species). The deep-set sector was retained its Category I classification, while the shallow-set sector was reclassified as Category II.

Under existing regulations, all fishers participating in Category I or II fisheries must register under the MMPA, obtain an Authorization Certificate, and pay a fee of $25. Additionally, fishers may be subject to a take reduction plan and requested to carry an observer. The Authorization Certificate authorizes the taking of marine mammals incidental to commercial fishing operations. Because the pelagic fisheries managed under this FEP are not expected to change fishing operations or patterns, implementation of this FEP is not anticipated to have any increased impacts on marine mammals that occur in the Western Pacific Region. The regulations governing Category III fisheries (found at 50.CFR 229.5) are listed below:

§ 229.5 Requirements for Category III fisheries.

- (a) *General.* Vessel owners and crew members of such vessels engaged only in Category III fisheries may incidentally take marine mammals without registering for or receiving an Authorization Certificate.
- (b) *Reporting.* Vessel owners engaged in a Category III fishery must comply with the reporting requirements specified in §229.6.
- (c) *Disposition of marine mammals.* Any marine mammal incidentally taken must be immediately returned to the sea with a minimum of further injury unless directed otherwise by NMFS personnel, a designated contractor, or an official observer, or authorized otherwise by a scientific research permit in the possession of the operator.
- (d) *Monitoring.* Vessel owners engaged in a Category III fishery must comply with the observer requirements specified under §229.7(d).
- (e) *Deterrence.* When necessary to deter a marine mammal from damaging fishing gear, catch, or other private property, or from endangering personal safety, vessel owners and crew members engaged in commercial fishing operations must comply with all deterrence provisions set forth in the MMPA and any other applicable guidelines and prohibitions.
- (f) *Self-defense.* When imminently necessary in self-defense or to save the life of a person in immediate danger, a marine mammal may be lethally taken if such taking is reported to NMFS in accordance with the requirements of §229.6.
- (g) *Emergency regulations.* Vessel owners engaged in a Category III fishery must comply with any applicable emergency regulations.

NMFS has concluded that the Western Pacific Region's pelagic commercial fisheries will not affect marine mammals in any manner not considered or authorized under the Marine Mammal Protection Act.

8.7 National Environmental Policy Act (NEPA)

To comply with the National Environmental Policy Act, a Programmatic Environmental Impact Statement (PEIS) has been prepared to analyze the proposed action to implement this FEP. A Draft PEIS (dated October 27, 2005) was circulated for public review from November 10, 2005 to December 26, 2005 (70 FR 68443).

Subsequent to the circulation of the 2005 Draft PEIS for public review, it was decided to expand the document to contain analyses of impacts related specifically to the approval and implementation of fishery ecosystems plans in the Western Pacific Region. As a result, NMFS' Pacific Islands Regional Office, NMFS' General Counsel and Council staff revised the Draft PEIS that was released in October 2005 and published a notice of availability of a new Draft PEIS in the Federal Register on April 13, 2007 (72 FR 18644). The public comment period for the revised Draft PEIS ended on May 29, 2007, and responses to the comments received have been incorporated into a Final PEIS and this document where applicable.

8.8 Paperwork Reduction Act (PRA)

The purpose of the Paperwork Reduction Act (PRA) is to minimize the burden on the public by ensuring that any information requirements are needed and are carried out in an efficient manner (44 U.S.C. 350191(1)). This FEP contains no new reporting requirements and all existing requirements were lawfully approved and have been issued the appropriate OMB control numbers.

8.9 Regulatory Flexibility Act (RFA)

In order to meet the requirements of the Regulatory Flexibility Act (RFA), 5 U.S.C. 601 et seq. requires government agencies to assess the impact of their regulatory actions on small businesses and other small entities via the preparation of regulatory flexibility analyses. The RFA requires government agencies to assess the impact of significant regulatory actions on small businesses and other small organizations. The basis and purpose of the measures contained in this FEP are described in Chapter 1, and the alternatives considered are discussed in the EIS prepared for this action. Because none of the alternatives contain any regulatory compliance or paperwork requirements, the Council believes that this action is not significant (i.e., it will not have a significant impact on a substantial number of small entities) for the purposes of the RFA, and no Regulatory Flexibility Analysis has been prepared.

8.10 Executive Order 12866

In order to meet the requirements of Executive Order 12866 (E.O. 12866), NMFS requires that a Regulatory Impact Review be prepared for all regulatory actions that are of public interest. This review provides an overview of the problem, policy objectives, and anticipated impacts of the proposed action, and ensures that management alternatives are systematically and comprehensively evaluated such that the public welfare can be enhanced in the most efficient and cost effective way. In accordance with E.O. 12866, the following is set forth by the Council: (1) This rule is not likely to have an annual effect on the economy of more than $100 million or to adversely affect in a material way the economy, a sector of the economy, productivity, jobs, the environment, public health or safety, or state, local, or tribal governments or communities; (2) This rule is not likely to create any serious inconsistencies or otherwise interfere with any action taken or planned by another agency; (3) This rule is not likely to materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights or obligations of recipients thereof; (4) This rule is not likely to raise novel or policy issues arising out of legal mandates, or the principles set forth in the Executive Order; (5) This rule is not controversial.

The measures contained in this FEP are anticipated to yield net economic benefits to the nation by improving our ability to maintain healthy and productive marine ecosystems, and foster the long-term sustainable use of marine resources in an ecologically and culturally sensitive manner that relies on the use of a science-based ecosystem approach to resource conservation and management.

8.11 Information Quality Act

The information in this document complies with the Information Quality Act and NOAA standards (NOAA Information Quality Guidelines, September 30, 2002) that recognize information quality is composed of three elements: utility, integrity, and objectivity. Central to the preparation of this regulatory amendment is objectivity that consists of two distinct elements: presentation and substance. The presentation element includes whether disseminated information is presented in an accurate, clear, complete, and unbiased manner and in a proper context. The substance element involves a focus on ensuring accurate, reliable, and unbiased information. In a scientific, financial, or statistical context, the original and supporting data shall be generated, and the analytic results shall be developed, using sound statistical and research methods.

At the same time, however, the Federal government has recognized that “information quality comes at a cost.” In this context, agencies are required to weigh the costs and the benefits of higher information quality in the development of information, and the level of quality to which the information disseminated will be held” (OMB Guidelines, pp. 8452–8453).

One of the important potential costs in acquiring "perfect" information (which is never available), is the cost of delay in decision- making. While the precautionary principle suggests that decisions should be made in favor of the environmental amenity at risk (in this case, marine ecosystems), this does not suggest that perfect information is required for management and conservation measures to proceed. In brief, it does suggest that caution be taken but that it not lead to paralysis until perfect information is available. This document has used the best available information and made a broad presentation of it. The process of public review of this document provides an opportunity for comment and challenge to this information, as well as for the provision of additional information. A draft of this FEP was distributed for public review along with a revised draft of the Final Programatic EIS.

8.12 Executive Order 13112

Executive Order 13112 requires agencies to use authorities to prevent introduction of invasive species, respond to, and control invasions in a cost effective and environmentally sound manner, and to provide for restoration of native species and habitat conditions in ecosystems that have been invaded. Executive Order 13112 also provides that agencies shall not authorize, fund, or carry out actions that are likely to cause or promote the introduction or spread of invasive species in the U.S. or elsewhere unless a determination is made that the benefits of such actions clearly outweigh the potential harm, and that all feasible and prudent measures to minimize the risk of harm will be taken in conjunction with the actions. The Council has adopted several recommendations to increase the knowledge base of issues surrounding potential introductions of invasive species into waters included in this FEP. The first recommendation is to conduct invasive species risk assessments by characterizing the shipping industry, including fishing, cargo, military, and cruise ships for each FEP’s geographic area. This assessment will include a comparative analysis of the risk posed by U.S. fishing vessels in the western Pacific with other vectors of marine invasive species.

The second recommendation is to develop a component in the Council's existing education program to educate fishermen on invasive species issues and inform the fishing industry of methods to minimize and mitigate the potential for inadvertent introduction of alien species to island ecosystems.

Fishing operations are not expected to change under this FEP and therefore are not expected to have increased risks of introducing alien species to U.S.waters or elsewhere.

8.13 Executive Order 13089

In June 1998 the President signed an Executive Order for Coral Reef Protection, which established the Coral Reef Task Force (CRTF) and directed all federal agencies with coral reef-related responsibilities to develop a strategy for coral reef protection. Federal agencies were directed to work cooperatively with state, territorial, commonwealth, and local agencies; non-governmental organizations; the scientific community; and commercial interests to develop the plan. The Task Force was directed to develop and implement a comprehensive program of research and mapping to inventory, monitor, and address the major causes and consequences of degradation of coral reef ecosystems. The Order directs federal agencies to use their authorities to protect coral reef ecosystems and, to the extent permitted by law, prohibits them from authorizing, funding, or carrying out any actions that will degrade these ecosystems.

Of particular interest to the Council is the implementation of measures to address: (1) fishing activities that may degrade coral reef ecosystems, such as overfishing, which could affect ecosystem processes (e.g., the removal of herbivorous fishes leading to the overgrowth of corals by algae) and destroy the availability of coral reef resources (e.g., extraction of spawning aggregations of groupers); (2) destructive fishing techniques, which can degrade EFH and are thereby counter to the Magnuson-Stevens Act; (3) removal of reef substrata; and (4) discarded and/or derelict fishing gear, which can degrade EFH and cause "ghost fishing."

To meet the requirements of Executive Order 13089, the Coral Reef Task Force issued the National Action Plan to Conserve Coral Reefs in March 2000. In response to the recommendations outlined in the Action Plan, the President announced Executive Order 13158, in May 2002 which is designed to strengthen and expand Marine Protected Areas

CHAPTER 9: STATE AND LOCAL APPLICABLE LAWS

9.1 Introduction

This chapter provides information on the state, local and other fishery management authorities for the inhabited islands of the Western Pacific Region (American Samoa, Hawaii, the Commonwealth of the Northern Mariana Islands, and Guam). For more information please see the Council's Fishery Ecosystem Plans for the American Samoa Archipelago, the Hawaii Archipelago, the Mariana Archipelago and the Pacific Remote Island Areas.

9.2 American Samoa

Department of Marine and Wildlife Management

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

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

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

U.S. Fish and Wildlife Refuges and Units

Rose Atoll National Wildlife Refuge, located in American Samoa, was established through a cooperative agreement between the Territory of American Samoa and the USFWS in 1973. Presidential Proclamation 4347 exempted Rose Atoll from a general conveyance of submerged lands around American Samoa to the Territorial Government. The boundary of the refuge extends out to three miles around the atoll and is under the joint jurisdiction of the Departments of Commerce and Interior, in cooperation of the Territory of American Samoa. Here the USFWS acknowledges fishery management authority of the Council, in coordination with the NMFS, within the "200-nautical mile EEZ" (Smith 2000b).

Fagatele Bay National Marine Sanctuary

Fagatele Bay National Marine Sanctuary was designated in 1986 in response to a proposal from the American Samoa Government to the National Marine Sanctuary Program. The sanctuary comprises a fringing coral reef ecosystem nestled within an eroded volcanic crater on the island of Tutuila, American Samoa. This smallest and most remote of all the National Marine Sanctuaries is the only true tropical reef in the Program. Fagatele Bay provides a home to a wide variety of animals and plants, that thrive in the protected waters of the bay. The coral reef ecosystem found in the Sanctuary contains many of the species native to this part of the Indo-Pacific biogeographic region. Fishing is prohibited in this sanctuary.

Regulations governing access and uses within the Fagatele Bay National Marine Sanctuary can be found in 15 CFR Part 922.100 Subpart J.

Rose Atoll Marine National Monument

On January 6, 2009, then President George W. Bush also established the Rose Atoll Marine National Monument, through Presidential Proclamation 8337. The Secretary of the Interior has management responsibility for the monument, including Rose Atoll National Wildlife Refuge in consultation with the Secretary of Commerce. The Secretary of Commerce, through the National Oceanic and Atmospheric Administration, has the primary management responsibility regarding management of marine areas of the monument with respect to fishery-related activities. Proclamation 8337 directs the Secretaries to prohibit commercial fishing within the monument but allows noncommercial and sustenance fishing, or, after consultation with the Government of American Samoa, traditional indigenous fishing within the monument. It also directs the Secretaries, in consultation with the Government of American Samoa, to provide a process to ensure that recreational fishing is managed as a sustainable activity. In addition Proclamation 8337 directs the Secretary of Commerce to initatiate the process to add the Rose Atoll monument to the Fagatele Bay National Marine Sanctuary.

9.3 Hawaii

Department of Land and Natural Resources, Division of Aquatic Resources

The management responsibility of marine resources in the State of Hawaii is vested to the Department of Land of Natural Resources through the Division of Aquatic Resources (DAR).

The mission of the DAR is to manage, conserve and restore the state's unique aquatic resources and ecosystems for present and future generations. The DAR manages the State's aquatic resources and ecosystems through programs in commercial fisheries and resource enhancement; aquatic resources protection, habitat enhancement and education; and recreational fisheries. Major program areas include projects to manage or enhance fisheries for long-term sustainability of the resources, protect and restore the aquatic environment, protecting native and resident aquatic species and their habitat, and providing facilities and opportunities for recreational fishing.

The DAR utilizes a range of fishery management tools to conserve and manage the state's marine resources and ecosystem including gear restrictions, size and bag limits, closed seasons, permit and reporting requirements, and an array of marine managed areas (i.e., Regulated Fishing Areas, Public Fishing Areas, Marine Life Conservation Districts, and Marine Refuges) among other measures. Regulations governing fishing activities and harvest of marine resources can be found in the Hawaii Revised Statutes, Title 13, Subtitle 4, Fisheries.

U.S. Fish and Wildlife Refuges and Units

The USFWS has been given authority to manage a number of National Wildlife Refuges (NWR) within the Hawaii Archipelago.Executive Order 1019 reserved and set apart the islands reefs and atolls from Nihoa to Kure Atoll, excluding Midway, "as a preserve and breeding ground for native birds" to be administered by the Department of Agriculture. The Hawaiian Islands Reservation (HIR) was transferred to the Department of the Interior in 1939 and in 1940 renamed the Hawaiian Islands National Wildlife Refuge (HINWR) through Presidential Proclamation 2466, with control transferred to the USFWS.

Midway Atoll NWR, established under Executive Order 13022 in 1996, is located in the NWHI and has a refuge boundary of 12 miles seaward from the shoreline (the exact boundary is disputed). The Navy established a Naval Air Facility at Midway in 1941. The USFWS established an overlay refuge in 1988 to manage the fish and wildlife on the Atoll. Through the Base Alignment Closure Act of 1990, as amended, the Naval Air Facility closed in 1993 and the property was transferred to the USFWS in 1996 (USFWS 1999a). The mission of the refuge is to protect and restore biological diversity and historic resources of Midway Atoll, while providing opportunities for compatible recreational activities, education and scientific research (Shallenberger 2000).

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

Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve

In May 2000, then President Clinton issued a Memorandum to implement a U.S. Coral Reef Task Force recommendation and comprehensively protect the coral reef ecosystem of the NWHI.[6] The Memorandum directed the Secretaries of Interior and Commerce, in cooperation with the State of Hawaii, and in consultation with the WPRFMC, to develop recommendations for a new, coordinated management regime to increase protection for the NWHI coral reef ecosystem and provide for sustainable use. After considering their recommendations and comments received during the public visioning process on this initiative, President Clinton

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[6] The President's directive coincided with Executive Order 13158, which requires federal agencies to establish a comprehensive national network of marine protected areas throughout U.S. marine waters. The Executive Order calls for expansion of the nation's MPA system to include examples of all types of marine ecosystems. According to the executive order, a MPA means any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or has regulations to provide lasting protection for part or all of the natural and cultural resources therein.

issued Executive Order 13178 on December 4, 2000, establishing the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve, pursuant to the National Marine Sanctuaries Amendments Act of 2000 (NMSA). The Executive Order was revised and finalized by Executive Order 13196, issued January 18, 2001. Pursuant to Executive Order 13178 and the NMSA, NOAA is initiating the process to designate the Reserve as a national marine sanctuary (66 FR 5509, January 19, 2001).

NWHI Marine National Monument

On June 15, 2006, President George W. Bush signed Presidential Proclamation No. 8031 establishing the Northwestern Hawaiian Islands Marine National Monument (NWHI monument). The proclamation set apart and reserved the Northwestern Hawaiian Islands for the purpose of protecting the historic objects, landmarks, prehistoric structures and other objects of historic or scientific interest that are situated upon lands owned and controlled by the federal Government of the United States. Proclamation No. 8031 directs the Secretary of Commerce and the Secretary of the Interior (the Secretaries) to prohibit access into the NWHI monument unless authorized, and limit or regulate virtually all activities in the area through a permit and zoning system among other measures.

In establishing the NWHI monument, Proclamation No. 8031 assigns primary management responsibility of marine areas to the Secretary of Commerce, through the National Oceanic and Atmospheric Administration (NOAA) in consultation with the Secretary of the Interior. The proclamation assigns the Secretary of the Interior, through the U.S. Fish and Wildlife Service (USFWS) with sole responsibility for management of the areas of the monument that overlay the Midway Atoll National Wildlife Refuge, the Battle of Midway National Memorial and the Hawaiian Islands National Wildlife Refuge, in consultation with the Secretary of Commerce. Proclamation No. 8031 also requires the Secretary of Commerce to manage the NWHI monument in consultation with the Secretary of the Interior and the State of Hawaii and directs the Secretaries to promulgate any additional regulations needed for the proper care and management of the monument objects identified above, to the extent authorized by law.

Proclamation No. 8031 allows the Secretary of Commerce and the Secretary of Interior (Secretaries) to issue permits for the following activities: (1) research activities; (2) educational activities; (3) conservation and management activities; (4) Native Hawaiian practices: (5) revenue generating special ocean uses; and (6) recreational activities. Proclamation No. 8031 directs the Secretaries to allow all permitted vessels to conduct subsistence fishing while in the monument and, directs the Secretaries to prohibit commercial fishing in the monument 5 years from the date of the monument designation.

Hawaiian Islands Humpback Whale National Marine Sanctuary

The Hawaiian Islands Humpback Whale National Marine Sanctuary is located within waters from the shoreline to the 100 fathom isobath around the islands of Hawaii, Maui, Molokai, Lanai, and parts of Oahu and Kauai. The primary purpose of the sanctuary is to protect humpback whales and their habitat. This sanctuary’s designation document does not provide for the management of fishing operations at this time (NOAA 1997).

9.4 Commonwealth of the Northern Mariana Islands

Department of Land and Natural Resources, Division of Fish and Wildlife

Although the ownership of submerged lands and underlying resources adjacent to CNMI remain owned by the federal government, the CNMI, the Department of Land and Natural Resources, Division of Fish and Wildlife provides for the conservation of fish and game. They accomplish this through research and regulations governing hunting, fishing and conservation areas (i.e., fish reserves, marine conservation areas and marine sanctuaries) in the CNMI. The goal is to manage and conserve resources so that future generations can enjoy them. Regulations governing fishing activities and harvest of marine resources in the CNMI can be found in the Commonwealth Register Volumes 22, 23 and 25.

Mariana Trench Marine National Monuments

On January 6, 2009, then President George W. Bush also established the Mariana Trench Marine National Monument, through Presidential Proclamation 8335. The Secretaries of Commerce, through the National Oceanic and Atmospheric Administration, and the Interior, will manage the monument pursuant to applicable legal authorities and in consultation with the Secretary of Defense. The Secretary of Commerce has primary management responsibility, in consultation with the Secretary of the Interior, with respect to fishery related activities. Proclamation 8335 directs the Secretary of Commerce to prohibit commercial fishing within the Islands Unit of the monument (i.e., within 50 nm of the islands of Maug, Farallon de Pajaros and Asuncion) but allow sustenance fishing, recreational and traditional indigenous fishing after consultation with the Government of CNMI. It also directs the Secretaries, to establish the Mariana Monument Advisory Council to provide advice and recommendations on the development of management plans and management of the monument.

9.5 Guam

Department of Agriculture, Department of Aquatic and Wildlife Resources

The management responsibility of marine resources in the Territory of Guam is vested to the Department of Agriculture through the Division of Aquatic and Wildlife Resource (DAWR). The mission of the Fisheries Section of the DAWR is to restore, conserve, manage, and enhance the aquatic resources in and about Guam and to provide for the public use of and benefits from these resources. The DAWR manages the fisheries through education and conservation initiatives to foster health of the reefs on which the fish depend, including placing shallow water moorings to prevent reef damage and setting aside marine protected areas to help restock the fishing areas. Regulations governing fishing activities and harvest of marine resources in Guam can be found in the Organic Act of Guam, Guam Code, Title 5, Division 6, Chapter 63.

U.S. Fish and Wildlife Refuges and Units

In Guam, the USFWS manages the Ritidian Unit National Wildlife Refuge and has fee title, which includes 371 acres of emergent land and 401 acres of submerged lands down to the 100-foot bathymetric contour. The submerged lands adjacent to Ritidian were never transferred to the Territory of Guam pursuant to the TSLA by the Federal government. In 1993, the USFWS acquired the emergent land of the Ritidian Unit and the surrounding submerged lands from the Navy at no cost (Smith 2000b).

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

9.6 PRIA

PRIA Marine National Monuments

On January 6, 2009, then President George W. Bush established the Pacific Remote Islands Marine National Monument through Presidential Proclamation 8336. The Secretary of Interior, in consultation with the Secretary of Commerce, was given authority for the management of the monument. The Secretary of Commerce was given primary authority for the management of the monument with respect to fisheries seaward of the 12 nm areas above. The Secretary of Defense shall continue to manage Wake Island. Proclamation 8336 states that the Secretary of Commerce may permit noncommercial fishing at specific (unspecified) locations upon request and that noncommercial fishing currently allowed by the U.S.FWS at Palmyra Atoll may continue unless the Secretary of Interior determines that this would be incompatible with the purposes of the the Palymra Atoll National Wildlife Refuge. It goes on to state that the Secretary shall provide a process to ensure that recreational fishing is managed as a sustainable activity in certain (unspecified) areas of the monument. It also directs the Secretaries to prepare management plans within their respective authorites for the proper care and management of monument objects.

CHAPTER 10: PROPOSED REGULATIONS

In preparation.

CHAPTER 11: REFERENCES

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