CHAPTER 3

DESCRIPTION OF THE FISHERY AND FISHING COMMUNITIES

3.1 Introduction

Chapter 2 of this FMP outlined the biology and ecology of coral reefs. This chapter describes how people use and depend on those resources. The discussion is divided into two parts. The first part, Sections 3.2 through 3.5, describe various aspects of regional fisheries as they relate to coral reef resources. The next section provides an overview of the many uses of coral reefs in the region and identifies those uses—defined as "sectors"—that the management measures in this plan will directly affect. Section 3.3 summarizes the available data that can be used to characterize regional fisheries, and using these data briefly describes two important fisheries sectors. Section 3.4 reviews the ex-vessel value of regional fisheries under Council management and Section 3.5 describes bycatch by coral reef fisheries with special attention to the main gear types employed in these fisheries. The second part of this section, comprising Sections 3.6 and 3.7 describes fishing communities in the region and how they depend on coral reef resources. This discussion, in Section 3.6, provides a regional overview and descriptions specific to each of the jurisdictional areas in the Council region. Section 3.7 contains a brief statement about the definition of communities, as required by the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), and their dependence on coral reef resources.

3.2 Description of Coral Reef Uses

Ecosystem-based fisheries management—the principle that informs this FMP—recognizes that fisheries and other forms of resource harvest affect more than just the target species. Because of ecological linkages, other species and their habitats are affected too, and these effects may be felt in other reef-related fisheries. An ecosystem approach should also take into account value that accrues from not extracting resources, such as scenic or recreational use. In the summary that follows, current and potential uses of coral reef resources are called "sectors." Since the Council only manages fisheries, and this FMP covers the coral reef ecosystem, management measures in this FMP only apply to the fishery sectors summarized in the first category below. (These fisheries are defined as those that take coral reef MUS in depths between 0 and 50 fathoms. When coral reef fisheries are discussed in the remainder of this section this definition bounds the resources under consideration.) This includes coral reef MUS caught incidentally by other FMP-managed fisheries. The first two sectors, food and sport, are briefly described in the next section. (The remaining four coral reef fishery sectors—religious, ornamentals, natural products, and mariculture—have not yet developed in the EEZ.) Non-fishery sectors are described elsewhere, as indicated in the descriptions below.

Coral Reef Fishery Sectors[1]

Food	All commercial, subsistence, and recreational coral reef resource harvests generally for food production.
Sport	Fishing for coral reef resources mainly motivated by recreation.
Religious/ceremonial	Harvest of coral reef resources for use in traditional religious ceremonies by indigenous cultures.
Ornamentals	Harvest of coral reef resources, including fishes, invertebrates, and live rock for use as ornamentals, for home and local use and commercial trade.
Natural products	Harvest of coral reef resources for all other purposes, such as coral for bone grafts and production of pharmaceuticals.
Mariculture	At-sea mariculture of coral reef resources, and harvest of coral reef resource broodstock for land-based mariculture.

Non-coral Reef Fishery Sectors

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

Non-fishery Sectors

Tourism (non-fishing)	Visitors engaging in scuba diving, snorkeling, boating, swimming, viewing of coral reefs, and other coral reef-related activities, including eco-tourism. The economic value of tourism to different island areas is discussed in

[1] The Coral Reef Fishery Sectors listed here are categorized by the primary motivation of the fishery. Based on MSFCMA definitions, the natural products and mariculture fishery sectors as described above would be primarily commercial fisheries. The food, sport and ornamental sectors would encompass both recreational and commercial fisheries. The religious/ceremonial sector is unique in that the motivation is not for commerce, sport or pleasure, but for spiritual purposes including medicinal uses, social unity, and cultural perpetuation (self-identity).

	Section 3.6, which details fishery-related economic and social conditions in each of the Council's member jurisdictions.
Recreation (non-fishing)	Residents engaging in scuba diving, snorkeling, boating, swimming, viewing of coral reefs and other coral reef-related activities. Non-consumptive values and uses are discussed in Section 5.11 of the Environmental Impact Statement.
Mining	Extraction of fossil coral and sand from the coral reef ecosystem. The effects of dredging, mining and filling is discussed in Section 6.4 of the FMP.
Breakwater	Coral reef ecosystems functioning to protect shorelines from erosion and to provide shelter for navigation and mooring, and other activities. The value of coral reef ecosystems functioning to protect shorelines from erosion is not discussed in the FMP.
Ecological support	Coral reef ecosystems functioning as nursery areas, spawning areas, or otherwise in support of resources, protected species, essential fish habitat, fisheries, and ecological services in other ecosystems. Ecosystem effects on MUS are discussed in Sections 3.0 and 5.2 of the EIS.
Information	Coral reef ecosystems providing values associated with gaining and sharing information, or the non-extractive, "discovery" aspects of research and education, and the values associated with the consequential development and production of marine natural products.
Biodiversity	Coral reef ecosystems providing values associated with varied genetic resources. The biodiversity of coral reef ecosystems is discussed in section 3.1.2. of the EIS.

3.3 Summary of Data Describing Fisheries in the Council Region

3.3.1 Available Data

The ability to describe, assess, and manage fisheries depends on the amount and quality of available fisheries data. Local jurisdictions in the Council Region collect much of the data used for management. Most coral reef ecosystem resources in the EEZ are beyond the reach of the average recreational fisherman. Recreational fishing is limited and generally confined to shallow and deep-reef slope species which occur primarily in state or territorial waters. Data collection

systems employed by the various local jurisdictions are discussed below. Table 3.1 summarizes data availability for each area described.

The State of Hawaii requires fishermen who sell any portion of their catch to hold a commercial marine license and to complete and submit a monthly Division of Aquatic Resources' Fish Catch Report for every trip conducted during that period. The licensee must report the type of fishing gear used (e.g., trap, diving, net), number and/or weight of each species caught, and the area fished. In order to gather data on areas fished, the State of Hawaii employs a fisheries statistical grid chart which covers the Pacific Ocean from 10° to 32° North latitude and from 150° to 178° West longitude. Each grid is approximately 60 nautical miles^2 and is further divided into 20 x 20 nautical mile^2 blocks. Fishermen often sub- divide each block into smaller 10 mile^2 quadrants to report areas fished. However, this method of collection does not allow for precise separation between nearshore (0-3 nm) from offshore (3-12 nm) landings.

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

Table 3.1: Summary of data availability for major fishing sectors in the Western Pacific Region.

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

* Data collected through reporting forms but no separated from commercial information
** Some recreational information available from past creel surveys
***Data only available from boat-based fishing activity. Current survey program does not collect information from shore based fishers.

In American Samoa, the Offshore Creel Survey administered by the Department of Marine and Wildlife Resources (DMWR) collects fishery information from both commercial and recreational boat-based fishermen on the number and weight of each species, method of fishing, time fished, and area fished. In addition, the survey includes information on the disposition of the catch. Coral reef fishing in American Samoa is conducted on the plateaus and slopes of nearshore reefs within territorial waters (0-3 nmi from shore). Fishing for coral reef species in federal waters (3-200nm) is conducted at several well known banks and seamounts. Consequently, DMWR creel surveys can readily distinguish between nearshore and offshore landings. This is also true for reef fish landings in Guam and CNMI. DMWR applies a set of algorithms to estimate the commercial landings based on the estimate of total landings and catch disposition information derived from the survey. DMWR also directly monitors the commercial fishery by collecting "trip-ticket" receipts from fish sales to local fish markets, stores, hotels, and restaurants.

In Guam, the Division of Aquatic and Wildlife Resources (DAWR) administers both the Offshore and Inshore Creel Surveys. The surveyors interview fishermen to collect information on the length and weight of each species caught during fishing trips, method of fishing, number of gear used, time fished, area fished, and weather conditions. Nearly all of the available coral reef habitat around Guam is in the nearshore waters. There are however, a few areas in the EEZ containing coral reef habitat which are clearly beyond three nautical miles. This geographical separation allows surveyors to precisely distinguish between nearshore and offshore reef fish landings. The disposition of the catch is only recorded as part of the Offshore Creel Survey; therefore, differentiating commercial and recreational landings in the inshore fishery is almost impossible. Total landings are estimated from survey data by applying fairly complex stratum-based expansion factors, which are calculated by integrating data collected from participation surveys with the creel intercept and interview data. DAWR also collects information on commercial landings through a voluntary trip ticket receipt program with major fish dealers. Estimates of total commercial landings are calculated by applying expansion factors to the receipt book data.

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

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

The Council considers the current reporting systems collected by local governments in the region to be adequate in collecting data for all major coral reef fishery sectors in the region. However, there are areas where data collection can be improved. These include the collection of information from shore-based fishers, obtaining more accurate recreational/subsistence fishing catch and effort data, and more clearly defining areas fished.

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

3.3.2 Food Sector

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

In each of the island areas it is almost impossible to label the majority of these fishermen or fishing vessels as commercial or recreational as many "expense fishermen" often fish switch between commercial and pure recreational/subsistence. It is more appropriate to categorize the fish caught as commercial or recreational/subsistence during a particular trip. Most of the fish caught in 'recreational fisheries' are not released alive, but rather retained for home consumption.

Although some harvest occurs in the EEZ, existing fisheries for coral reef resources are concentrated in the nearshore waters (0-3 miles) around American Samoa, Guam, Hawaii and CNMI. However, the volume of trips made by recreational fishermen to fish for coral reef species in federal waters, or on reefs under local government jurisdiction is unknown. Hamilton and Huffman (1997) present data which shows in their survey of small boat fishing in Hawaii, about one quarter of trips by purely recreational fishermen were to catch coral reef fish. Hamilton and Huffman also noted that between 0.2 and 0.9% of fishing trips made by commercial fishermen in their survey were for recreational fishing on coral reefs.

Low levels of recreational and/or subsistence fishing occur at Palmyra and Johnston Atoll, Wake Island, and Midway Atoll. In all of these areas, inner boundary of the EEZ extends to the shoreline. Both shore-based and boat-based fishing for coral reef species occur at Palmyra and Johnston Atoll and Wake Island. Fishing at these locations is conducted primarily for food and recreation by temporary workers stationed there. Irons *et al.* (1990) reported that *Holocentridae, Acanthuridae, Carangidae Mullidae and Scaridae* comprised the majority of targeted coral reef taxa at Johnston Atoll. The gear types employed to harvest coral reef species varied with the targeted species and included hook-and-line fishing, spearfishing and thrownets. Although no

recent fishery statistics are available for the other areas, the species targeted and gear types used are probably similar to those at Johnston Atoll. The no-take zone MPAs proposed for the other Pacific Remote Island Areas (see Section 5.2.) will deter future tourism development as it prohibits extraction of all coral reef resource at these remote locations.

Recreational fishermen tend to harvest a greater variety of species than do commercial fishermen, so the diversity of the recreational catch is underestimated in commercial databases. For example, in a recent study conducted in nearshore state waters, the Hawaii DAR database contained only 28 commercial taxa for Hanalei Bay, whereas a creel survey of the area included 95 taxa, although the catches of many taxa were trivial (Friedlander 1996). Table 3.2a summarizes estimates of recreational/subsistence fishing for CRE management unit species in the Western Pacific Region. Currently, the proportion of the number recreational/subsistence vessels fishing for CRE management unit species in the EEZ is unquantifiable. However, most coral reefs in the EEZ are beyond the reach of the average recreational fishermen.

Table 3.2a: Summary of recreational/subsistence fishing for CRE management unit species in the Western Pacific Region (includes all landings from 0-3 nm and 3-200 nm)*

Area	Number of vessels	Total annual trips	CRE species targeted	Fishing location (miles from shore)	Total annual catch (pounds)
American Samoa	66	N/A	Jacks, surgeonfish, mullet, octopus, other mollusks and echinoderms	Shoreline	225,000
Guam	2,250**	N/A	Surgeons, jacks, emperors, snappers	Shoreline and banks	200,000
CNMI	142	N/A	Emperor, parrotfish, surgeonfish, rabbitfish	Shoreline and banks	16,500
Hawaii	14,000***	N/A	Jacks, goatfish, squirrelfish, octopus	Shoreline and banks	1,017,000
NWHI (Midway)	5	N/A	Jacks	Shoreline and banks	N/A
PRIAs	13	N/A	soldierfish, jacks, surgeonfish, parrotfish, bonefish	Shoreline	N/A

* Estimates of total non-commerical catches for Hawaii, Guam, American Samoa and CNMI are given in WPRFMC 2000a. The CRE-MUS component of the non-commercial catch is estimated from the product of the percentage of coral reef species in the total commercial landings data in 1999 for Hawaii, Guam, American Samoa and the CNMI (website: wpacfin.nmfs.hawaii.edu/), and the total non-commercial catch in the four island areas.
** Estimate based on vessels registered with the Guam Police Department and DAWR port surveys.
*** Estimate based on data from State of Hawaii Department of Boating and Ocean Recreation.

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

3.3.3 Sport Sector

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

Of the dozen or so charter vessels in the CNMI, several are targeting bottomfish. DFW reports that shallow-water charters generally last two hours and are conducted up to four times per day that could include occasional night trips. Charters generally fish outside the barrier reef in 80-200 feet of water from Chalan Kanoa in the south, up to areas off Nikko Hotel in the north. Given the distance to the nearest coral reef habitat in the EEZ and the frequency of trips, it is likely that charters remain well within CNMI territorial waters. In 2000 there were two vessels that strictly charter for shallow-water bottom/reef fish. With the re-implementation of the offshore creel survey, routine sampling of the charter fleet includes detailed interviews for bottomfish charters, including numerating and measuring all retained catch.

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

Catch and effort information from bottomfish charter operators are collected through the HDAR Commercial Marine Licenses or sales reporting forms (C-3 forms). However, because bottomfish chartering is relatively new in Hawaii, HDAR cannot tell whether reported bottomfish landings are taken during a charter trip or commercial trip. Fish sold from a bottomfish charter operation would be included on a C-3 form and probably credited toward a normal commercial

trip. The C-3 form does not require bottomfish charter operators to indicate if the fish was taken during a charter trip. Fish that are released or consumed may not be reported under the current system. A new form may need to be specifically developed to ensure catch and effort data is collected from the Hawaii bottomfish charter sector. HDAR has developed and will soon implement a new charter troll report form.

Sportfishing is a major attraction at Midway Atoll for ecotourists. Recreational charter fishing for coral reef species takes place primarily from the shoreline and within the boundaries of the Midway Atoll National Wildlife Refuge. Recreational fishing rules established by the U.S. Fish and Wildlife Service allow: catch and release pole and line fishing (unless world record setting); hand harvest of lobsters for on island consumption (1 lobster per person per day); and the taking of one fish per person on fishing boats per day. The recreational fishing rules prohibit the catch of bottomfish and other coral reef species (i.e. octopus, urchins, corals etc.) however, the U.S. Fish and Wildlife Service permits catch and release fishing for jacks (*Carnax spp.*) which are frequently caught in the shore-based recreational and boat-based charter fishing. As of 1998, there were 5 vessels used in the Midway charter fishery. The number of annual recreational and charter trips vary depending on the number of anglers visiting the atoll and seasonal weather conditions. Catch data for the recreational and charter fishery are collected by the U.S. Fish and Wildlife Service. Table 3.2b summarizes the estimates of charter fishing for coral reef management unit species in the Western Pacific Region.

Table 3.2b: Summary of charter fishing for CRE management unit species in the Western Pacific Region.

Area	Number of vessels	Total annual trips	CRE species targeted	Fishing location (miles from shore)	Total annual catch (pounds)
American Samoa	1	N/A	N/A	N/A	N/A
Guam	73	1700	wrasse, squirrel, trigger	<3	13,000 (all species combined)
CNMI	2	2000	N/A	<3	N/A
Hawaii	<12	N/A	N/A	Shoreline and banks	N/A
NWHI(Midway)	5	N/A	Jacks	Shoreline and banks	N/A
PRIAs	N/A	N/A	N/A	N/A	N/A

3.4 Ex-vessel Value of Coral Reef Resources

Tables 3.3 and 3.4a-3.4f summarize the recent approximate total annual ex-vessel value for each of the domestic marine fisheries of the Western Pacific Region's island groups. They focus on fisheries for coral reef resources. But rough estimates of the crustacean and precious coral

fisheries (categorized as deep-bottom), and pelagic fisheries, also appear. This allows these fisheries to be compared to coral reef fisheries. It also highlights the potential follow-on effects of the management measures in this FMP. Table 3.3 is a regional summary, while tables 3.4a-3.4f break down the information by island area. Monetary value is expressed in 1999 dollars. Ex-vessel values are the estimated total annual gross value of landings from each fishery, whether sold or not. The ex-vessel values for the sport sector represents charter fees. The landings value for these fisheries are included in the food sector. It should be noted that there is a variable, and in some cases quite high, level of uncertainty as to the accuracy of values in Tables 3.4a-3.4f.

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

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

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

Table 3.3: Summary of annual ex-vessel value for Western Pacific Region fisheries ($1,000/year).

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

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

Table 3.4a: American Samoa fisheries by area, annual volume, and ex-vessel value.

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

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

Table 3.4b: Northern Mariana Islands fisheries by area, annual volume and ex-vessel value.

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

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

Table 3.4c: Guam fisheries by area, annual volume and ex-vessel value.

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

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

Table 3.4d: Main Hawaiian Islands fisheries by area, annual volume and ex-vessel value.

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

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

Table 3.4e: Northwestern Hawaiian Islands fisheries by area, volume and ex-vessel value.

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

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

Table 3.4f: Other islands fisheries by area, annual volume and ex-vessel value.

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

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

3.5 Description of Fishing Gear Used and Associated Bycatch

3.5.1 Existing Bycatch Management Measures

Although the Council's existing FMPs do not specifically address coral reef fisheries, there are aspects of these plans and their amendments that may have an influence on coral reef fishery bycatch and on the potential for reporting bycatch. Measures in the Council's Bottomfish, Crustaceans, and Pelagic FMPs are summarized below.

The Bottomfish FMP prohibits certain destructive fishing techniques—including explosives, poisons, trawl nets, and bottom-set gillnets—all of which have the capacity to generate high levels of bycatch, especially the use of trawl nets. Bottomfishing, and hence the volume of resulting bycatch, is regulated by the Bottomfish FMP. The permit and reporting systems for bottomfish fisheries in the NWHI and Guam allow the reporting of catch and discards.

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

Fishing activity targeting highly migratory species rarely interacts with reef fishes. However, some of the provisions of the Pelagics FMP and amendments have tangentially influenced potential bycatch from coral reefs. Currently, the FMP management unit contains four shark families—Alopiidae, Lamnidae, Sphyrnidae, and Carcharhinidae—which include many inshore shark species found on and around coral reefs. The FMP contains a ban on the use of drift gillnets, which can take large numbers of sharks. Some of the species caught by drift gillnets—such as tiger sharks, Galapagos sharks, and hammerheads—are commonly found on and around coral reefs. The FMP also established a 50 nm longline closed area around the NWHI and a 50-75 nm closed area around the MHI, which also reduce the likelihood that longliners will catch sharks common to nearshore areas and coral reefs. Lastly, one of the measures in Amendment 9 to the FMP, although pending implementation, would ban bottom set longline fishing in federal waters which in the past has targeted coastal shark species. Many of these species are also part of the CRE-FMP management unit. Amendment 2 of the FMP implemented a logbook program, which includes a provision to record catch and discards, including shark species.

As part of CRE-FMP implementation, it is recommended that the Pelagics FMP be amended so that those coastal shark species belonging to the families Carcharhinidae and Sphyrnidae—currently classified as Pelagic MUS—be reclassified coral reef ecosystem MUS, managed under this FMP. Additionally, the Pelagic FMP will specifically list nine species of sharks as Pelagic MUS.

3.5.2 Coral Reef Fisheries Bycatch

All gears used to catch coral reef species are essentially artisanal in nature. Catch rates are minimal, usually only a few pounds per man-hour or other unit of effort. Large catches thus depend on fishing methods employing a lot of people, such as driven-in-net fishing or group spear fishing. Because of the characteristics of gear and methods, in most cases coral reef fishing generates very little bycatch. Bycatch is further reduced because almost all reef fish taken are eaten. For more detailed information consult Appendix A, which catalogs fishing gears and their impact on essential fish habitat.

In the Pacific Islands, discards, where they occur, are usually due to cultural or practical reasons. In some cultures customary taboos may still adhere. For example, people may avoid nearshore copraphageous scavengers, such as surf perches (Theraponidae) for this reason. Taboos may also stem from the association between a species and gender, as is the case with moorish idols (Zanclidae).

Reef fish preference is also strongly influenced by urbanization: many city dwellers eat a narrower range of reef fish than their brethren in traditional villages on the same island or of the same culture. For example, in Guam triggerfish, butterflyfish, angelfish, and damselfish are typically rejected because they are considered too boney and lacking sufficient meat, while in rural areas in Micronesia these species are readily consumed. Some reef fish in Hawaii state waters are also subject to minimum size and weight restrictions for sale or for capture by spearfishing. These include species of parrotfish, goatfish, jacks, surgeonfish, mullet, milkfish, and threadfins.

In other cases, fish may be avoided due to toxicity. Puffers, toad fish, and porcupine fish (Tetraodontidae, Diodontidae) carry ichthyotoxins, while ichthyosarcotoxicity due to ciguatoxins and related toxins cause people to avoid a wide range of species, including the snapper *Lutjanus bohar*, surgeon fish *Ctenochaetus* spp., moray eels (Muraenidae), groupers (Serranidae), amberjack (*Seriola dumerilli*), and barracuda (Sphyraenidae). Trianni (pers. comm.) suggests that in the Mariana Islands, the red snapper *Lutijanus bohar*, groupers of the genus *Variola* and *Cephalopholis*, jacks, and large barracuda are avoided due to ciguatera. More or less the same species are avoided for the same reason in American Samoa.

People in the Western Pacific Region consume a wide range of invertebrates. Titcomb (1972) catalogs an extensive list of invertebrates used by Native Hawaiians, including many types of crustaceans, sea cucumbers, sea urchins sponges, corals, and various marine worms. In the Samoan Islands, the annual appearance of the gonadal stage of the marine polychaete worm, or

palolo, is eagerly anticipated because it is regarded as a delicacy (Itano and Buckley 1988). Some traditionally-consumed marine invertebrates may be avoided by some people in the Western Pacific, particularly as dietary habits become more Westernized. Also, some religions, like the Seventh Day Adventist faith, follow dietary rules similar to the kosher dietary restrictions and avoid pork and shellfish. Inadvertent catches of shellfish would likely be discarded by Adventists and may be included as bycatch.

Three fishing gears predominate in Pacific Island coral reefs and lagoons: hook-and-line or handline, spearguns and gillnets. The bycatch characteristics of each of these gear types is summarized below.

Hook-and-Line Catches

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

The amberjack *Seriola dumerilii*, frequently a part of deep-slope bottomfish catches in the NWHI, are discarded because they are thought to carry worms and the ciguatera toxin which makes marketing this species difficult. This is reinforced by the selectivity of fish by the fish auction at Honolulu which do not accept these fish. However, small amount of amberjack may be retained for use as bait in crab pots. The other major discard in this fishery is the thick-lipped trevally or *butaguchi* (*Pseudocaranx dentex*), which has a fairly short shelf life and commands a low price in local markets. Therefore, it is often discarded in the early days of a trip to avoid losing room for more valuable fishes, but are retained in the later days to fill fish holds if necessary.

Spearfishing

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

Hawaiian spearfish catches are dominated by parrotfish, surgeonfish, octopus, and squirrelfish. In areas with greater reef fish diversity, such as Guam, spearfish catches are still mainly

dominated by surgeonfish, and parrotfish. Other common families—such as rabbitfish, emperors, snappers, and jacks—also contribute to catches.

Fish Traps

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

The main commercial trap fishery on Hawaii's coral reefs is in NWHI. It targets spiny lobster and slipper lobster, rather than reef fish. The fortunes of this fishery have waxed and waned over two decades, with catches in excess of a million lobsters annually in the 1980's, but with much more modest catches of between 100,000 and 300,000 lobsters in the late 1990's. The lobster traps also catch a wide range of other coral reef species, mainly reef fish and reef crustaceans. In the initial years of the fishery, many octopus were also caught and kept, but octopus catches dropped off to negligible amounts by the 1990's because of the use of escape vents. The lobster traps are two-piece plastic halves joined with pins that dissolve in seawater, preventing ghost-fishing by lost traps. They also have a series of small holes in the trap walls to allow undersized lobster and other small bycatch species to escape. Polovina (1993) reports that an estimated 2,000 traps are lost annually in the NWHI. Parrish and Kazama (1992) found that while lobsters may enter these traps, they were also able to exit and there were no observed mortalities associated with ghost fishing. These researchers concluded that lobsters utilized the traps as shelter.

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

Nets

In Hawaii, gillnets mostly catch the bigeye scad or *akule*. Other dominant species include surgeonfish, snappers, goatfish, and rudderfish. Goatfish, surgeonfish, parrotfish, and siganids are dominant features of gillnet catches in Guam. There are differences between night and day gillnet catches, with some nocturnally active species such as slipmouths composing part of night gillnet sets.

For smooth fusiform—or cigar-shaped—fish, gillnets tend to select a normally distributed size range, with the lower and upper size limits dependant on mesh size. Spiny fishes may be very vulnerable to gillnet catches, regardless of mesh size, because of tangling. Seasonality can also influence gillnet catches. Fish become more vulnerable during spawning season because gonad development increases their girth and spawning changes behavior (Ehrhardt and Die 1988). The selection effects of gillnets are further complicated by the type of material used, the hanging ratio or measure of meshes per unit of length, the way the net is deployed on a reef, the time of day set, and length of soak. If gillnets are not checked regularly, bycatch may increase. Entangled fish build up in the net; if they are not removed, they are either preyed on or rot and become unsaleable.

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

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

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

3.5.3 Bycatch Reduction

It is important to understand that virtually all coral reef fisheries production in the western Pacific comes from state waters and not from waters under federal control. Consequently, it might be argued that there is no bycatch problem for coral reef fisheries under federal control. However, under the MSFCMA there is no minimum acceptable threshold for bycatch. Whatever the bycatch, the Council must try to reduce it, where practicable. However, using the simple gears deployed on coral reefs in a way that catches only the target species is difficult, if not impossible. Specialized gears, such as kites and spider-web lures that catch garfish, are used in the Pacific Islands, but many of the other universally employed gears will invariably take species that people generally refuse to eat.

Incentives to reduce bycatch are limited. People will not eat suspected ciguatoxic fish and may regard any attempts to subvert taboos on other species as culturally insensitive. Coral reef fisheries are composed of many fishermen and small vessels without observer programs. This makes it difficult to enforce regulations mandating a "take-all fishery" to eliminate bycatch. Further, where fish are suspected of being ciguatoxic, prudence dictates that catches should continue to be discarded. Ciguatera test kits exist, but these are relatively expensive and are designed for amateur fishermen who want to test individual fish. It is not a test that can be applied wholesale on a cost-effective basis to even a modest commercial reef fish catch.

It probably makes the most sense to focus regulations and incentives on those gears that usually produce the most bycatch, especially on passive gears, such as traps and gillnets. Fish traps may be regulated by varying mesh size to exclude undersize fish and non-target species, or requiring escape vents for the same purpose. As mentioned earlier, some kind of degradable panel or fastening can be employed to open traps after a given amount of time, thus minimizing ghost-fishing by lost traps. The number of traps that a person is allowed to set could also be limited. Specifying the maximum soak time could also reduce the number of fish unnecessarily lost or killed due to a long set time. By the same token, not only could gillnet mesh size be regulated, but also the length of the net and the duration of soak time.

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

It is difficult, however, to conceive of ways in which speared fish can be safely released without trauma, although release has been successful in some reef fish tagging experiments. But the selection by fishermen of fish to spear should minimize most spearfishing bycatch. It is more difficult to release fish from gillnets and other seines in good condition if fish are gilled or tangled. Aside from the measures outlined above, there is very little direct regulatory action that will minimize bycatch. Instead, making fishermen more aware of the need to minimize discard volume and mortality might be more effective. Fortunately, traditional Pacific Island societies usually abide by this ethic already.

3.5.4 Reef Fish Bycatch Data

The WPacFIN program has recently begun to collect data on bycatch in American Samoa, Guam and the CNMI as part of the routine creel surveys carried out by local agencies. Members agreed at recent Council Plan Team meetings that the most critical and plausible information to collect on bycatch during creel surreys was the species name, the number of fish discarded, and whether they were discarded alive or dead/injured. The overall coverage rates of these surveys and the

experience of the personnel involved is sufficient to achieve good estimates of bycatch species and bycatch rates in most fisheries. Voluntary observer programs are also being discussed to obtain more reliable estimates from certain sectors, such as the charter bottomfish fishery.

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

3.6 Description of Island Areas in the Council Region: Economy, Fishing Communities, and Use of Reef Resources

This section describes fishery-related economic and cultural characteristics of each of the five jurisdictions in Council region. Section 3.6.1 provides a regional overview, describing the nature of contemporary island communities, how they depend on coral reef resources, and how they used these resources in the past and continue using them today. Section 3.6.2 generally repeats this format for each of the five jurisdictions in the Council Region: American Samoa, the CNMI, Guam, Hawaii, and the PRIAs.

The whole of Section 3.6, then, concerns the socio-cultural aspects of the fishery, which includes shared technology, customs, terminology, attitudes, and values. Fishermen may be the most direct beneficiaries of the fishing lifestyle, but the broader social context also needs to be considered. Those who participate in the marketing or consumption of fish, or in the provision of fishing supplies, may also share in the fishing culture. An integral part of this web of interactions is the broad network of interpersonal social and economic relations through which the cultural attributes of a fishery are transmitted and perpetuated. The relations that originate from a shared dependence on fishing and fishing-related activities to meet economic and social needs can have far-reaching effects in the daily lives of those involved.

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

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

3.6.1 Regional Overview

Island Communities in the U.S. Pacific

The Contemporary Socio-economic Context

The social and economic histories of the populated U.S. Pacific Islands differ considerably from that of the continental U.S. The Samoan, Hawaiian, and Mariana Islands were originally settled in ancient times by seafaring peoples. In most areas, the dearth of terrestrial resources led to great dependence on fishing for food security. This dependence, over thousands of years, have shaped the social organization, cultural values and spiritual beliefs of the indigenous populations.

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

World War II caused dramatic changes in all of the populated U.S. Pacific Island groups. It also caused an influx of Caucasians into Hawaii. New harbors, airports, and other infrastructure tied the islands closer to the U.S. mainstream. This increased the imports of goods, and exposure to American laws, education, media, and technology. The islands moved rapidly away from subsistence and toward cash economies.

For centuries, native cultures of the U.S. Pacific Island have relied on seafood as their principle source of protein. Archeological records indicate that reef and lagoon fisheries can and have supported long-term sustainable exploitation. With the shift from subsistence to cash economies, and limited terrestrial resources, native cultures are once again looking towards the ocean as a source of food and as means to support their island economies. However, the availability of many traditional seafood has been significantly diminished as a result of environmental degradation of the nearshore reefs areas since western contact. Localized overfishing is blamed for some of the adverse impacts, but coastal construction, industrial discharges, and poor watershed management and other impacts attributed to population growth are believed to contribute greatly to coral reef habitat damage near population centers.

Polunin and Roberts (1996) report that direct and indirect fishing impacts to fish and invertebrate populations are often reversible with time. Additionally, Dalzell and Adams (1997) also reported that while some gears such as gill nets and spearfishing under certain circumstances lead to rapid reduction in reef fish populations, these appear to recover rapidly if fishing effort is reduced.

Ultimately, the integration of a multi-disciplinary approach to coastal fisheries management on an ecosystem basis must be fortified in order to sustain long-term harvest of coral reef fisheries.

Table 3.5a: Major demographic and economic characteristics of American Samoa, Guam, Hawaii, and the CNMI.

	American Samoa	CNMI	Guam	Hawaii
Population	**57,291**	**69,221**	**154,805**	**1,193,001**
Indigenous Population (%)	**89%**	**29%**	**47%**	**19%**
Land Area (sq. mi.)	**77**	**179**	**212**	**6,423**
Reef Area (sq. mi.)	**296**	**579**	**179**	**(MHI) 2,535 (NWHI) 11,535**
GDP (U.S.$ million)	**253.00**	**664.60**	**3,065.80**	**35,146.40**
GDP Per Capita ($)	**4,295**	**8,367**	**18,766**	**29,164**
Major Income Sources	**Tuna canneries, government services, remittances from Samoans overseas.**	**Tourism, garment manufacturing, trade and services.**	**Tourism, military, trade and services.**	Tourism, services, trade, Government, military.
Political Status	**U.S. territory since 1899, Samoans are U.S. citizens but do not vote in U.S. national elections.**	**After WWI under Japanese Mandate. 1947-became part of UN TTPI (U.S. administered). 1978-Commonwealth. Islanders are U.S. citizens but do not vote in U.S. elections.**	**U.S. territory since 1898, 1950-Guam Organic Act conferred citizenship but no voting privileges in U.S. national elections. Organic Act never ratified by Guam referendum.**	**Kingdom overthrown by American businessmen,1893. Annexed in 1898 by "Newlands Resolution." Organic Act in 1900 creates U.S. Territory. 1959-Admissions Act creates State of Hawaii.**
Major Investment Sources	**U.S.**	**Japan, Korea, Hong Kong, U.S.**	**U.S., Japan, Korea**	**U.S., Japan, Australia**

Table 3.5b: Statute mile distances between population centers in the Region, and to Washington, D.C.

	Garapan, CNMI	Pago Pago, American Samoa	Honolulu, Hawaii	Washington, D.C.
Agana, Guam	136	3,598	3,812	7,396
Garapan, CNMI		3,604	3,717	7,802
Pago Pago, American Samoa			2,598	7,028
Honolulu, Hawaii				4,835

With the exception of American Samoa—and small enclaves in Guam, Hawaii, and the CNMI—the contemporary descendants of indigenous Pacific Islanders are dispersed as part of cosmopolitan populations. Island societies have become pluralistic, and many aspects of their economies and cultures have evolved in modern times. Yet, the vast majority of contemporary island inhabitants continue to depend on coral reef resources for consumptive and non-consumptive uses. Most are consumers of seafood and many are at least part-time fishermen. In addition to providing food and recreation, the harvest of coral reef resources is also important as a means of preserving and perpetuating indigenous cultural identities and values. Table 3.5a-b provide general socio-economic and geographic data for the four populated jurisdictions in the Council Region.

Fishing Communities in the U.S. Pacific

The U.S. Pacific Islands vary significantly in land area, population levels, and the size of their associated EEZs. They have had significantly different courses of political development and historical relationships with the U.S., but they share a common economic and social dependence on marine fisheries, especially coral reef resources. This dependence traces back thousands of years, when the islands were first settled by sea-faring peoples. Their dependence on fishing for food security shaped the social organization, cultural values and spiritual beliefs of the indigenous cultures. Contemporary island societies are pluralistic in population and culture and few people depend solely on fish catches for protein.

Contemporary communities result from webs of social interaction that people create by taking advantage of shared cultural understanding and identity. Fishing communities in the U.S. Pacific Islands are based on shared participation in fishing-related activities that occur over larger geographical scales than single villages or towns. At least one-third of the resident population of the U.S. Pacific Islands participates in some level of fishing, and all towns and villages include some proportion of residents who are part-time fishermen. Fishermen from one town travel to other parts of the island and between islands to visit family and friends. Fishing is one of the most common shared activities at such gatherings. Fishermen frequently trailer small boats from one side of an island to the other to take advantage of seasonal fish availability and weather

conditions. Fishing cooperatives in the U.S. Pacific Islands have island-wide memberships and seafood markets are supplied by widespread on-and off-island harvesters.

Community Participation in Coral Reef Fisheries

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

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

The harvest and consumption of coral reef resources has been a part of the way of life since the islands were first settled several thousand years ago. Pacific Islanders of old were considered masters in their knowledge of fish, their habits, and the means of capturing them. Through oral tradition, one generation taught the next about the dynamics of inshore marine resources and passed on the skills needed to harvest them. Based on their familiarity with specific places and through trial and error, the Pacific Islanders were able to devise social controls to foster, in modern terminology, "sustainable use" of marine resources in localized areas. Periods of scarcity brought about an early awareness that marine resources were limited. This reinforced a shared social obligation to exercise self-restraint in resource exploitation. Irresponsible resource use was tantamount to denying future generations their birthright and means of survival. Virtually every method utilized in modern fisheries management was in use in the Pacific Islands centuries ago. Many of the ancient fishing techniques survived into the twentieth century, but today these traditional management measures are rarely applied in the U.S. Pacific Islands.

The methods and patterns of coral reef fisheries that have evolved over the years in the U.S. Pacific Islands grew out of these traditions. Fishing for pelagic fish in offshore waters is constrained by the need for seaworthy vessels, distance to fishing grounds and weather. In contrast, nearshore coral reef resources can be harvested with low capital outlay, and less time and risk. Relative to other fisheries resources in theU.S.Pacific Islands, coral reefs are more accessible and are used by a larger and more diverse population of fishermen, which employs a wider variety of gear. Table 3.6 lists a broad spectrum of coral reef taxa, which are harvested for many purposes.

Table 3.6: Coral reef taxa harvested by indigenous and contemporary fishermen in the U.S. Pacific islands.

Taxa	Harvested by:	
	Indigenous People	Contemporary Fishermen
Acanthuridae (Surgeonfish)	F, C, M, (1)	F, A
Algae (Seaweeds)	C, F, M, B	F, A
Annelid (Seaworms)	M	B, A
Antipathes spp. (Black coral)	M	A
Apogonidae (Cardinal fishes)	F	F, A
Architeconicidae (Sundial shells, Sea hares)	F, C	A
Aulostomidae (Trumpetfish)	F	A
Balistidae (Triggerfish)	F	A
Blennidae (Blennies)	B	B, A
Carangidae (Jacks, Trevally)	F	F, A
Carcharhinidae (Sharks)	F, C, (1)	F, M, (1)
Cassididae (Helmet Shell)	F, T	F, A
Chaetodontidae (Butterflyfish)		A
Cheloniidae (Sea turtles)	F, M, T	F, A
Cirrhitidae (Hawkfish)	F	A
Clupeidae (Herrings)		B
Cnidara (Sea anemones)	F	A
Conidae (Cone shells)	F, A, T	A
Crustacea (Crabs, shrimps, lobsters)	B, F, M	B, F, A
Cypraeidae (Cowries)	F, A, T, M	A, T

(1) Skins of some species used for drums

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

Table 3.6 (cont.)

Taxa	Harvested by:	
	Indigenous People	Contemporary Fishermen
Dasyatididae		
Myliobatidae		F, A
Mobulidae (Rays)	F	
Decapterus/Selar spp (Scads)	B, F	B, F
Echinoderms (Sea cucmbers,sea Urchins)	B, F, T,	F, A
Engraulidae (Anchovies)		B
Fasciolariidae (Spindleshell)	T	A
Fistularidae (Cornetfish)		A
Gobiidae (Gobies)	B, F, C	B, A
Holocentridae (Soldierfish)	F	F
Kuhliidae (Flagtail)	C, F	F
Kyphosidae (Rudderfish)	F, M,	F
Labridae (Wrasses)	F, C	F
Lethrinidae (Emperor fish)	F	F
Littorinidae (Kukae kolea)	F	
Lutjanidae (Snappers)	F	F
Melampidae (Oe)	F	
Moringidae	F	
Muraenidae	F	B
Chlopsidae		

(1) Skins of some species used for drums

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

Table 3.6 (cont.)

Taxa	Harvested by	
	Indigenous Fishermen	Contemporary Fishermen
Congridae	F	F,B
Ophichthidae (Eels)	F	F, A, B
Mullidae (Goatfishes)	F	F
Neritidae (Snails)	F, A, T	F, A
Octopodidae (Octopus)	F	F
Patellids (Opihi)	F, M, C, T	F
Polynemidae (Threadfin)	F	F
Pomacanthidae spp (Angelfish)		A
Pomacentridae spp (damselfish)		A
Priacanthidae (Bigeye)	F	F
Pteridae (Oysters)	F, T	F, A
Scaridae (Parrotfish)	F	F
Scorpaenidae (Scorpion fishes)	F	F, A
Serranidae (Grouper, Sea bass)	F	F, A
Siganidae (Rabbitfish)	F	F
Sphyraenidae (Barracuda)	F	F
Terebridae (Auger shells)	T	
Verenidae (Clams)	F, T	F
Zanclidae (Moorish Idol)		A
Zooanthids (Soft Corals)	M	A

(1) Skins of some species used for drums

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

Historical and Contemporary Coral Reef Uses

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

In modern times, some reefs have been degraded by a range of human activities. Comprehensive lists of human threats to coral reefs in the U.S. Pacific Islands are provided by Maragos *et al.* (1996), Birkeland (1997b), Grigg (1997), Jokiel *et al.* (1999), and Clark and Gulko (1999). In general, reefs closest to human population centers are more heavily used and are in worse condition than those in remote locations (Green 1997). Table 3.7 summarize coral reef use in the various jurisdictions in the Council region.

Table 3.7: Summary of coral reef resource use levels in nearshore areas (0-3 nmi from shore) and offshore areas (3-200 nmi from shore) in sub-areas of the U.S. Pacific Islands (modified from Green, 1997).

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

3.6.2 Island Area Descriptions

American Samoa

Socio-economic Overview

American Samoa is an unincorporated territory of the U.S. comprising seven islands with a total land area of only 77 square miles. Because most of the islands are mountainous, there is very little area suitable for a agriculture. The Territory's population is about 60,000, and is growing rapidly, with a doubling time of only 20 years (Craig *et al.* in press). (Table 3.8 provides basic demographic data for the Territory.) Of all the U.S. Pacific Islands, American Samoa has the lowest gross domestic product and highest donor aid per capita (Adams *et al.* 1999).

Table 3.8: 2000 U.S. Bureau of Census Data for American Samoa.

	Population (n)	Population (%)	Land Area (sq. miles)	Land Area (%)
American Samoa Total	57,291	100.0	77.4	100.0
Tutuila Island and Aunu'u Island	55,876	97.5	54.8	70.8
(Eastern District)	23,441	40.9	25.9	33.5
(Western District)	32,435	56.6	28.9	37.4
Manu'a Islands	1378	2.4	21.9	28.3
(Ofu and Nu'u Islands)	289	0.5	2.8	3.6
(Olosega Island)	216	0.3	2	2.6
(Ta'u Island)	873	1.5	17.1	22.1
Rose Island	0	0	0.1	0.1
Swains Island	37	<0.06	0.6	0.8

American Samoa has a small developing economy, dependent mainly on two primary income sources: the American Samoa government, which receives income and capital subsidies from the federal government, and two tuna canneries on the island of Tutuila. These two 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 American Samoa government has compiled detailed labor force and employment data, the local government employed 4,355 people, or 32.2% of total employment, followed by the two canneries with 3,977 people (29.9%) and the rest of the services economy with 5,211 workers (38.4%). Altogether, the three segments employed 13,543 workers, while 2,718 people were registered as unemployed (that is, actively seeking employment). This gives a total labor force of 16,621 and an unemployment rate of 16.7%. A large proportion of the territory's workers are from Samoa, formerly Western Samoa. While Samoans working in the territory are legally alien workers under U.S. law, they share a common culture, history, and family ties.

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

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

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

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

Community Participation in Coral Reef Fisheries

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

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

Fishing has been interwoven with all aspects of Samoan community life and cultural identity since the islands were first settled 3,500 years ago. It shaped the traditional Samoan religion, diet, material culture, oral traditions and calendar (Severance and Franco 1989). Fishing and its products also played a fundamental role in the social structure. Ceremonial and cultural demands

involve exchange of food and other resources to support extended families and traditional leaders. Participation in commercial activities, wage labor, and a cash economy has not weakened this network of social obligations as much as provided new opportunities for customary exchange of goods and services within American Samoa's tightly held *aiga* (extended family) system.

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

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

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

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

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

Historical and Present Coral Reef Uses

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

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

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

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

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

Coral reefs around American Samoa are recovering from a series of natural disturbances that occurred over the past two decades: a crown-of-thorns invasion (1978), three hurricanes (1986, 1990, 1991), and mass coral bleaching (1994), as well as chronic human-induced impacts along

the populated coasts. Beaches, wetlands, and coral reefs have been extensively altered due to highway construction and urban expansion, particularly along the south shore of Tutuila. Coastal erosion is amplified by the removal of large quantities of beach sand and coral rubble from the shoreline for use around homes. Together, these shoreline alterations have largely eliminated the use of the central south coast by nesting sea turtles. Direct losses of coral reef habitats are related to dredging for harbors and filling to build the international airport runway.

Possible degradation of reefs has also occurred due to chronic water quality and sedimentation problems. Because of the main islands' steep terrain and high rainfall, hillside runoff causes heavy sedimentation in adjacent coastal waters. Landfills, sewage disposal, and—in Pago Pago Harbor—discharges from shoreside industries and spills from vessels in port have also had a major impact on the reef environment (Craig *et al.* in press). Remote Rose Atoll, protected as a National Wildlife Refuge (established through a cooperative agreement between the Territory of American Samoa and the U.S. Fish and Wildlife Service in 1973), was damaged in 1993 by a ship grounding and related oil spill.

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

Commonwealth of the Northern Mariana Islands

Socio-economic Overview

The Northern Mariana Islands was part of the former Trust Territory of the Pacific Islands, administered by the U.S., before becoming a commonwealth by plebiscite in 1998. It has a total land area of 179 square miles spread over 264,000 square miles of ocean and consists of three main islands, Saipan, Tinian, and Rota, and several small islands and atolls. The southernmost island, Rota, lies some 50 miles northeast of Guam and 430 miles south of CNMI's northernmost island, Uracus. The small islands of the northern part of the chain are lightly populated. In 1990, the population of the northern islands was 36, but has dwindled down to only 6 according to 2000 Census Bureau Data. The main islands are grouped together in the southern part of the chain. The Commonwealth's capital is Saipan, but no locality on that island is recognized specifically as the capital; several government offices are located in the CDP of Capital Hill, but the legislature meets in Susupe. Ninety percent of its of 69,221 residents live on the island of Saipan and almost al the rest on Tinian and Rota. (Table 3.9 provides basic demographic data for the Commonwealth). Chamorro is the most commonly spoken native language.

Table 3.9: 2000 Bureau of Census Data for the Northern Mariana Islands and Guam.

	Population (n)	Population (%)	Land Area (sq. Miles)	Land Area (%)
CNMI Total	69,221	100.0	179	100.0
Northern Islands	6	<0.01	59.8	33.4
Rota Island	3,283	4.8	33	18.4
Saipan Island	62,392	90.1	44.6	24.9
Tinian Island	3,540	5.1	41.7	23.3
Guam total	154,805	100	212	100

The Bureau of the Census estimates that the population of the Northern Mariana Islands grew by 25,867 persons between the 1990 census and 2000 to an estimated 69,221 persons. It is estimated that approximately 59% of this increase is a result from migration to the islands, principally from Asian countries. The Chamorro and Carolinan ethnic groups native to the islands represented some 29% of the CNMI's population (Bureau of Census, International Data Base, 12/29/99).

The early history of the Northern Mariana Islands parallels that of Guam. Spanish and other explorers first visited the islands in the sixteenth century, and they were colonized by Spain in the seventeenth century. Spain sold the islands in 1899 to Germany, following the end of the Spanish-American War. In 1914, Japan entered World War I on the side of the Allies and took possession of the islands. After the war, Japan retained the islands under a League of Nations Mandate. In 1944, the United States gained control of the islands from Japan and in 1947, along with other parts of U.S.-controlled Micronesia, these islands became a United Nations Trust Territory under U.S. administration. The islands were administered by the Defense Department until 1961. However, administrative authority was vested in the Department of the Interior in 1951. In 1978, a separate government for the Northern Mariana Islands was established and Commonwealth status was granted in 1986.

The main islands are each organized as a single municipality, with its own elected mayor and municipal council. Saipan's municipal council also serves the Northern Islands municipality. In 1990, there were 16 CDP's identified at the time of the Census. Each of these communities had locally recognized boundaries, a population of more than 300 people, and was enumerated in the decennial and economic censuses.

The aboriginal people of the CNMI include the indigenous Chamorros, original inhabitants of the islands, and the Carolinians, who are Micronesians that resettled on Saipan during the 1840s. Carolinians are a small minority of the population, but they are known for their seafaring and fishing skill. Their fishing activity largely centered on the harvest of lagoon and reef species, but small paddling canoes were sometimes used to fish a short distance outside the reef (Amesbury and Hunter-Anderson 1989). In the two decades since these islands achieved commonwealth status their demographic, economic, and social structure has changed dramatically. When the

CNMI opened to foreign capital and labor, it was transformed from a small economy supported largely by subsistence and government to a large regional tourist destination and a garment-manufacturing haven. Although tourism has been CNMI's largest income source, the Asian financial crisis of the late 1990s caused visitor arrivals from Japan and Korea to drop by one-third. At present, garment production is CNMI's fastest growing industry and is credited with preventing an economic depression following the decline of the tourist industry.

The development of tourist and garment industries based on foreign labor has had a dramatic impact on CNMI's population growth, which increased from 16,780 in 1980, to 79,429 in early 1999 (Bank of Hawaii 1997b). The majority of the current population are non-resident workers from the Philippines and other parts of Asia. There are also workers from Republic of Belau and the Federated States of Micronesia. Early 1999 data reveal that on Saipan only 28% of the population, and 22.6% of the labor force, are U.S. citizens. In addition to the garment industry, foreign workers hold most jobs in the construction, hotel, and retail sectors. The government provides approximately 12% of the jobs, and U.S. citizens make up most of this work force. They also make up 55% of the unemployed. The unemployment rate among Saipan's U.S. citizen labor force in early 1999 was 13.4%, compared to 3.2% among foreign workers (Bank of Hawaii 1997b). With the exception of a now defunct purse seine support base on the island of Tinian, CNMI has never had very much infrastructure dedicated to commercial fishing. Commercial domestic fisheries for reef fish and bottomfish make a minor contribution to the overall economy. The social and cultural importance of coral reef resources in the CNMI dwarfs their commercial value.

Community Participation in Coral Reef Fisheries

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

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

By 1980, several boats over 25 ft in length were actively engaged in commercial fishing for bottomfish and pelagic species (Orbach 1980). One vessel was operated by a Carolinian

company; one was owned and operated by the Tinian Fishing Cooperative, whose membership was Chamorro; and two other boats were skippered and crewed mainly by Japanese fishermen. In addition, some of the charter vessels that had been operating in the CNMI since 1978, catering to the Japanese tourists, were also being used to catch fish for sale to hotels and restaurants on Saipan (Orbach 1980).

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

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

The number of sometime food fishermen in the NMI may be from10,000 to as many as 30,000, depending on how actively the large population of non-resident Asian workers is engaged in fishing. Few depend on fishing for all of their income. The primary motivation for fishing is to provide food for home consumption and gifts to family and friends. According to Hamnett *et al.* (In press), each fishing trip had multiple purposes and the catch was used in a variety of ways, even though the primary reason for the fishing trip may have been associated with a specific event. Sixty-five percent of those surveyed contributed fish to a family or church fiesta. All of those who contributed fish to an event also took some of their catch home, gave fish to extended relatives, or sold some of their catch. Interviews with those surveyed revealed that fishermen who fished with the primary intent of making a contribution to an event, rarely sold part of their catch and usually took home fish for consumption.

Orbach (1980) notes that the fisheries in CNMI are inextricably involved with the lifestyles and plural-occupational patterns of the participants. Part-time fishing performed in conjunction with other activities has a prominent place in the socio-economic adaptations of local residents. People fish for bottomfish and pelagic species to supplement their family subsistence, which is gained by a combination of small-scale gardening and wage work (Amesbury and al 1989). Orbach suggests that the availability of economic activities like part-time fishing is among the

major reasons that CNMI has not experienced more of the problems of other island entities such as out-migration or high rates of crime and juvenile delinquency.

Because they are acculturated to fishing and seafood consumption practices in their home countries, Asians are likely to harvest a wider spectrum of coral reef resources for food and are less discouraged by declining catch rates. These attitudes are different from those of the indigenous islanders.

Fishing in Guam and the CNMI is still important, because it both contributes to the Chamorros' and Carolinians' subsistence needs and helps them to preserve their history and identity. Many aspects of traditional Chamorro and Carolinian culture have been lost. But fishing has helped Chamorros and Carolinians to keep alive what remains of their maritime tradition and maintain their connection to the sea and its resources.

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

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

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

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

Historical and Present Coral Reef Uses

Before World War II, the Japanese exploited sea cucumbers, trochus (topshell), precious corals and many other coral reef resources in the Japanese Mandated Islands, which included the

present Commonwealth of the Northern Mariana Islands. Commercial fisheries for trochus and sea cucumbers were re-opened during the mid-1990s for the first time in recent history. Over an 18-month period in 1995-1996, 268,000 sea cucumbers were collected (Green 1997).

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

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

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

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

Guam

Socio-economic Overview

Guam and the Mariana Islands were first settled about 3,000 years ago, but their present social and demographic structure is largely the result of colonial experiences of the last 300 years. Guam's total population is estimated to have reached 154,000 in 1999, nearly doubling the 1970 total of 85,000. Of the total reported labor force of 72,700 (June 1999), 61,460 were employed

and 11,060 were unemployed, for an official jobless rate of 15.2%. In September 1997, at the beginning of the current economic and employment downturn on Guam, the unemployment rate was only 9.2% (Bank of Hawaii 1997c).

Guam's economy has become so dependent on tourists from East Asia, particularly Japan, that any significant economic, financial and foreign exchange development in the region has had an immediate impact on the territory. During the mid- to late-1990's, as Japan experienced a period of economic stagnation and cautious consumer spending, visitor arrivals from Japan dropped, and the impact was felt as much on Guam as in Japan. The U.S. military presence on Guam has diminished to the lowest level in decades. Nevertheless, the military remains a vital stabilizing economic factor for Guam, particularly in times of regional economic crises. The Government of Guam currently supplies more than 20% of all civilian jobs in the territory. Recent deficits have resulted from a steady rise in government spending without a concomitant increase in tax revenues due to a stagnant tax base (Bank of Hawaii 1997c).

Guam's most significant commercial fishing attribute is its status as a regional tuna transshipment center and re-supply base for foreign tuna fleets (Hamnett and Pintz 1996). Guam is the fourth leading U.S. port in terms the dollar value of fish landings, which are mostly for transshipment to tuna markets in Japan. Commercial domestic fisheries for reef fish and bottomfish make a relatively minor contribution to the Guam economy. The social and cultural importance of coral reef resources in Guam dwarfs their commercial value. (Table 3.9 provides basic demographic data for Guam.)

Community Participation in Coral Reef Fisheries

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

After the U.S. acquired Guam in 1898, following the Spanish-American War, the U.S. colonial government held training programs to encourage local residents to participate in offshore commercial fishing (Amesbury and Hunter-Anderson 1989). However, because they lacked the capital necessary to purchase and maintain large enough boats, most couldn't participate. They were also largely unwilling to stay at sea for more than a day or so. Shortly after the end of World War II, the U.S. military assisted several villages in developing an inshore commercial

fishery using nets and traps. Post-World War II wage work enabled some fishermen to acquire small boats with outboard engines and other equipment for offshore fishing (Amesbury and Hunter-Anderson 1989). However, even as late as the 1970's, relatively few people in Guam fished offshore, even on the protected leeward side of the island, because boats and deep-sea fishing equipment were too expensive for most people (Jennison-Nolan 1979).

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

As Guam's tourism industry grew in the1980's, a fleet of marina-berthed charter vessels developed, which were used by tourists and residents for bottomfish fishing (Myers 1993). The charter boats made multiple two-hour to four-hour trips daily. Two types of charter bottomfish fishing trips were organized. The more typical charter boats involved three to six patrons, while the larger "party-boat" vessels carried as many as 30 patrons on a single trip. Most of these bottomfish charters operate out of the Agat Marina and primarily target the shallow-water bottomfish complex. Since most of the charter fishing trips are short, it is unlikely that many of these trips enter federal waters (WPRFMC 1999).

Participants in inshore reef fisheries are predominantly of indigenous Chamorro ancestry. Their harvest accounts for 79% of the non-commercial component of the inshore catch. One study concludes that "probably no one was supported full-time by this fishery, but probably a great many people added a useful income for themselves and their families through it" (Knudson 1987). In characterizing Guam's fisheries, Knudson (1987) concludes that "the commercial fishery on Guam is the product of many relatively small sales by a large number of 'semi-commercial' fishermen and that the non-commercial fishery is the product of a considerable pool of subsistence fishermen plus another sizeable pool of recreational fishermen," and that, "on the whole, catches in the Guam fishery are small, but that the number of participants is quite large." The number of sometime food-fishermen who harvest coral reef resources in Guam may be on the order of 20,000, with less than 1% engaged in commercial harvesting.

For the past two decades bottomfish fishing around Guam has been a highly seasonal small-scale commercial, subsistence, and recreational fishery. The majority of the participants in the bottomfish fishery operate vessels less than 25-ft long and primarily target the shallow-water bottomfish complex (WPRFMC 1999). The shallow-water component is the larger of the two in terms of participation because of the lower expenditure and relative ease of fishing close to shore (Myers 1993). Participants in the shallow-water component seldom sell their catch because they

fish mainly for recreational or subsistence purposes (WPRFMC 1999). The commercially-oriented highliner vessels tend to be longer than 25 ft, and their effort is usually concentrated on the deep-water bottomfish complex.

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

In the late 1880s, the Spanish governor of the Mariana Islands wrote of Guam that "inside the reef (indigenous people) catch different varieties (of fish) all year long." Whether the preference for reef fishing had anything to do with restrictions on the use of ocean-going canoes is not clear. The Governor also noted the importance of the seasonal arrival of rabbitfish (*manahak*) in inshore areas ("the populace then appears en masse to fish"), which is still an important event in Guam's reef fishery in modern times. Hensley and Sherwood (1993) note that the traditional practice of sharing the catch of *atulai* (*Selar crumenophtalmus*) from a surround net continues today, with equal portions given to the owner of the net, the village where the fish were caught, and the group that participated in the harvest.

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

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

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

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

Historical and Present Coral Reef Uses

Since World War II, Guam's coral reef fisheries have shifted from an exclusively subsistence focus to an artisanal fishery that blends subsistence, recreational, and commercial purposes (Hensley and Sherwood 1993). The more accessible reefs are considered overfished because of declining catch rates, declining size of target fish species, and greater prevalence of less desirable species (Birkeland 1997c; Green 1997; Katnik 1982).

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

Since the late 1970's, the percentage of live coral cover on Guam's reefs and the recruitment of small corals have decreased. This trend has been attributed to poor recruitment by coral larvae, increased sedimentation of reef habitat, and domination of reef habitat by fleshy algae. Corals have also been affected by natural disturbances (Birkeland 1997c). Pervasive events include starfish predation between 1968 and 1970 and exposure of corals due to extreme tides during El Niño events. Heavy wave action, associated with typhoons, has had more localized effects.

Shore-based fishing accounts for most of the fish and invertebrate harvest from coral reefs around Guam. In recent years, the estimated inshore harvest has ranged from 38 to 108 mt. This estimate excludes highly variable catches of juvenile rabbitfish and bigeye scad by traditional fisheries that are still practiced seasonally (Myers 1993). While spearfishing is the principal method of harvesting, it is highly seasonal because of weather conditions. In the fiscal years from 1985 to 1991, spearfishers mostly landed parrotfishes (36%), surgeonfishes (17%), and wrasses (7%) (Myers 1993).

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

muricatum), humphead wrasse (*Cheilinus undulatus*), stingrays, parrotfish, jacks, emperors, and groupers (Green 1997).

Many of the nearshore reefs around Guam appear to have been badly degraded by a combination of natural and human impacts, especially sedimentation, tourist overuse and overharvesting. In the last few years, there has been an increase in commercial spearfishing using scuba at night. Catch rates have increased because of improved technology (high capacity tanks, high tech lights, and bang sticks) that allows spearing in deeper water (30-42 m). As a result, many larger species that have already been heavily fished in shallow water—such as bumphead parrotfish, humphead wrasse, stingrays, and larger scarid species—are now reappearing in the fishery catch statistics (Green 1997).

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

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

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

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

Hawaii

Socio-economic Overview

Ocean resources are very important to Hawaii's economy. For example, tourism, the largest industry in Hawaii, is heavily dependent on oceanic resources. As important, both the indigenous and non-indigenous population depend upon the ocean and oceanic resources for recreation and social interactions. As a result, the State of Hawaii is broadly engaged in management of the ocean and ocean resources. However, Hawaii's economic situation changed dramatically in the 1990s. Several major economic sectors—such as plantation agriculture, tourism, and the military—suffered downturns. As a consequence, Hawaii never entered the period of economic prosperity that many U.S. mainland states experienced. Since 1998, Hawaii's tourism industry has recovered substantially, mainly because the strength of the national economy promoted growth in visitor arrivals from the continental US. Efforts to diversify the economy, and thereby render it less vulnerable to future economic downturns, have met with little success to date (Bank of Hawaii 1998). Commercial fishing has historically represented a small share of Hawaii's total economic activity. In contrast to the sharp decline in some industries of long-standing importance in Hawaii, however, the fishing industry has been fairly stable during the past decade. More importantly, fishery resources, especially coral reef resources, represent an important source of subsistence, providing food, income, opportunity for social interaction, and cultural exchange for Hawaii's residents during periods of economic recession. As a result of the rise in tourism-related ocean recreation in Hawaii, a premium has been placed on non-consumptive uses of nearshore marine resources (Pooley 1993b).

In 1998, Hawaii's ethnic makeup was 22% Caucasian, 21% Hawaiian or part Hawaiian, 18% Japanese, 13% Filipino, 7.3% Hispanic (1990), 3% Chinese, and 1% African-American; other ethnicities made up the balance (DBEDT 1999). (However, Office of Hawaiian Affairs data reveals that a significant part of the population lists their ethnicity as "other/unknown.") Hawaii's population has been growing at the rate of 7% during the past decade, and was estimated to be 1,193,001 in 1998. Table 3.10 provides additional demographic information.

By most statistical measures, people of Native Hawaiian ancestry have the lowest incomes and poorest health of any ethnic group in the State (OHA 1998). Federal, state, and private programs have been established to benefit Hawaiians. There is also an active cultural renaissance among Native Hawaiians, with efforts to restore the language, arts, and subsistence activities, including traditional fishing practices. As part of this renaissance, Native Hawaiians continue to assert their rights of access to oceanic resources. In Hawaii, all shoreline to the highwater mark and undeveloped areas *mauka* (inland, toward the mountains) are public areas that can be accessed for cultural and traditional practices, a holdover from the days of the kingdom. These Native Hawaiian gathering rights, including shoreline access, have been reaffirmed in court decisions.

The islands of the State of Hawaii were discovered and settled by Polynesians between the third and seventh centuries A.D. Captain James Cook, the first European to reach Hawaii, arrived in 1778. Europeans and Asians began to settle on the islands in the nineteenth century with the

development of pineapple and sugar plantations. In 1898 the islands were ceded to the United States and Hawaii became the fiftieth state in 1959.

Table 3.10: 1998 DBEDT estimates of population, employment and unemployment in Hawaii.

	Population	Population (%)	Civilian Labor Force	Unemployment (%)
State of Hawaii	1,193,001	100	597,800	6.2
City & County of Honolulu	872,478	73.13	427,650	5.4
Hawaii County	143,135	12.00	68,650	9.7
Maui County	120,785	10.12	71,650	6.6
Maui Island	105,336	8.83	66,850	n/a
Kauai County	56,603	4.74	28,700	9.8
Kauai Island	50,947	4.27	n/a	n/a
Molokai Island	6,838	0.57	3,050	n/a
Lanai Island	2,989	0.25	1,750	n/a
Niihau Island	230	0.02	n/a	n/a

Hawaii is a string of 137 islands extending in an arc across the Pacific Ocean from the northwest to the southeast. The eight largest islands—measured by size, population, and economic activity—are at the southeastern end of the arc, some 2,400 miles from the United States. They are divided into four municipal counties: Hawaii County, Maui County, City and County of Honolulu and Kauai County. The land area of the island chain is estimated to be 6,423 square miles.

Community Participation in Coral Reef Fisheries

Archaeological evidence reveals that seafood, particularly coral reef species, was part of the customary diet of the earliest human inhabitants of the Hawaiian Islands (Goto 1986). Fishing and related activities in traditional Hawaii were also often highly ritualized and important in religious beliefs and practices. The *Kumulipo*, or Hawaiian creation legend, says that fish were created after corals and mollusks, but before insects and birds (Beckwith 1951). Certain species of fish were venerated as personal, family or professional gods, called *aumakua*. Like the Native Hawaiians, nineteenth century Asian immigrants imbued fish with symbolic meaning, extending their cultural significance beyond their value as a dietary staple. Although no longer the only source of protein, seafood consumption in Hawaii is still at least twice as high as the U.S. national average (URS Corp., in prep).

The social and symbolic value of fish, reflected early Native Hawaiian traditions, is related to the sharing of fish in the extended family and community. This social responsibility remains an

important in the lives of many Native Hawaiians. It is regularly reenacted during weddings, communions, school graduations, funerals, or a child's first birthday (baby luau), where fish is considered an important customary food item (Glazier 1999). The importance of sharing fish is also found in other ethnic groups in Hawaii. For example, Japanese tradition dictates reciprocal exchanges of gifts according to an intricate pattern of established norms and procedures (Ogawa 1973). Those who neglect the obligation to reciprocate risk losing the trust of others, and eventually their support.

Commercial fishing has been part of Hawaii's economy for nearly two centuries and the socio-cultural context of fishing in Hawaii has been shaped by the multi-ethnicity of local fisheries. Although certain ethnic groups have predominated in Hawaii's fisheries in the past, and ethnic enclaves continue to exist in certain fisheries, the fishing tradition in Hawaii is generally characterized by a partial amalgamation of cultures. The remnants of the varied technology, customs, and values of Native Hawaiians and immigrant groups from Japan, China, Europe, America, the Philippines, and elsewhere appear in the methods used by contemporary Hawaii residents to harvest, distribute, and consume seafood.

A history of commercial fishing in Hawaii begins with the arrival of British and American whaling fleets during the early nineteenth century. Along with the introduction of a cash economy and the growth of the foreign—or non-Native Hawaiian—community, whalers fostered its development. Initially, commercial fishing in Hawaii was monopolized by Native Hawaiians, who supplied the local market with fish, using canoes, nets, traps, spears, and other traditional fishing devices (Cobb 1902; Jordan and Evermann 1902; Konishi 1930). However, the role that Native Hawaiians played in Hawaii's fishing industry gradually diminished through the latter half of the nineteenth century. During this period, successive waves of immigrants of various races and nationalities arrived in Hawaii, increasing the non-indigenous population from 5,366 in 1872 to 114,345 in 1900 (OHA 1998). The new arrivals included Americans, Chinese, Portuguese, and Filipinos.

The arrival of a large number of Japanese, in particular, had a long-term impact on the fishing industry. Like the majority of the early immigrants, they were contracted to work on Hawaii's sugar cane plantations. But many of these Japanese immigrants were also skilled commercial fishermen from the coastal areas of Wakayama, Shizuoka and Yamaguchi Prefectures in Japan. When their contract terms expired on the plantations, they turned to the sea for a living (Okahata 1971). Later, experienced Japanese fishermen came to Hawaii specifically to fish commercially. During much of the twentieth century Japanese immigrants to Hawaii and their descendants were preeminent in Hawaii's commercial fishing industry. Although these fishermen of Japanese ancestry became more Americanized, many Japanese fishing traditions persisted. As late as the 1970s, the full-time professional fishermen in Hawaii were predominately of Japanese descent (Garrod and Chong 1978). However, by then hundreds of local residents of various ethnicities were also participating in Hawaii's offshore fisheries as part-time commercial and recreational fishermen.

During the early years of the commercial bottomfish fishery, vessels restricted their effort to areas around the MHI. The fishing range of the sampan fleet increased substantially after the

introduction of motor powered vessels in 1905. Fishing activity around the NWHI began at least as early as 1913, when one commentator recorded: "Fishing for *ulua* and *kahala* is most popular, using bonito for bait, fishermen seek this (sic) species in a 500 mile range toward Tori-Jima (NWHI)" (Yamamoto 1970, p. 107). Within a few years, more than a dozen sampans were fishing for bottomfish around the NWHI (Konishi 1930). Fishing trips to the NWHI typically lasted 15 days or more, and the vessels carried seven to eight tons of ice to preserve their catch (Nakashima 1934). The number of sampans traveling to the more distant islands gradually declined due to the limited shelter the islands offered during rough weather, and the difficulty of maintaining the quality of the catch during extended trips (Konishi 1930). However, during the 1930's, at least five bottomfish fishing vessels, ranging in size from 65 to 70 ft, continued to operate in the waters around the NWHI (Hau 1984). These sampans harvested lobster, reef fish, turtles, and other marine animals in addition to bottomfish (Iverson et. al. 1989). During World War II the bottomfish fishery in Hawaii virtually ceased operations, but it recommenced shortly after the war ended (Haight *et al.* 1993). The late 1940s saw as many as nine vessels fishing around the NWHI, but by the mid-1950s, vessel losses and depressed fish prices, resulting from large catches, had reduced the number of fishery participants. But in 1948, the Pacific Ocean Fishery Investigation began researching potential commercial fisheries in the NWHI. In 1950, Leo Ohai, owner and captain of the Sea Queen, transported a small aircraft to French Frigate Shoals to support *akule* fishing and Buzzy Agard, using a DC3 cargo aircraft, flew catches of *akule* from French Frigate Shoals to Honolulu. He also captained the Koyo Maru to catch *akule* at Nihoa. During the 1960s, only one or two vessels were operating around the NWHI.

Commercial fisheries saw a rise and subsequent fall in both participation and landings during the first half of the twentieth century. There were 2,000 to 2,500 commercial fishermen in 1900 (Cobb 1902). In 1947, the number was about 3,500 (Hida and Skillman 1983), but by 1985 the number fell to about 2,600 (Shomura 1987). Thus, while Hawaii's motorized fleet grew remarkably during the twentieth century, participation in the commercial fisheries did not. Landings saw a similar rise and fall during this period. Hawaii's commercial catch statistics show an increase from about 6 million lbs. in 1900, to about 19 million lbs. in 1953, and a subsequent decrease to 11 million lbs. in 1986. Not surprisingly, most of the increase was in the pelagic fishery. The reported commercial catch of the "coastal" fishery—reef, bays, and nearshore habitats—in fact declined from about 3.6 million to 0.6 million lbs. from 1900 to 1986 (Shomura 1987).

There was renewed interest in harvesting the bottomfish resources of the NWHI in the late-1970s, following a collaborative study of the marine resources of the region by state and federal agencies (Haight *et al.* 1993). Several modern boats entered the NWHI fishery. As a result, the supply of high-valued bottomfish—such as *opakpaka* and *onaga*—increased. This regular and consistent supply of relatively fresh fish allowed the tourism-linked restaurant market to expand (Pooley 1993b). Markets for Hawaii bottomfish further expanded after wholesale seafood dealers began sending fish to the U.S. mainland. By 1987, 28 vessels were active in the NWHI bottomfish fishery, although only 12 were fishing for bottomfish full-time. Some of the part-time bottomfishing vessels also engaged in the pelagic or lobster fisheries (Iverson *et al.* 1989). In 1989, the WPRFMC developed regulations that divided the fishing grounds of the NWHI bottomfish fishery into the Ho'omalu Zone and Mau Zone. The Council established limited

entry programs for the Ho'omalu Zone and Mau Zone in 1989 and 1999, respectively, to avoid economic overfishing (Pooley 1993a). Since 1995, the number of vessels allowed to fish in the Ho'omalu Zone has been capped at seven. Currently, only ten vessels are allowed to bottomfish in the Mau zone (URS Corp. in press). The NWHI lobster fishery, centered around Necker Island, underwent a similar evolution. It developed in the late 1970s, reached a peak of 16 vessels in 1985 and 1986, and subsequently declined, with nine vessels active in 1997 (of 15 allowed under the limited access system) (Pooley and Kawamoto 1998).

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

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

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

Hawaii also has a large and apparently still growing recreational fishery, which overlaps considerably with the commercial and subsistence components. A 1996 national survey of recreational fishing (in which "recreation" included charter fishing) estimated that 244,000 recreational marine anglers, about half of them residents of Hawaii, made 2.3 million angler-trips (2.9 million angler-days) in Hawaii (U.S. Fish and Wildlife Service and Bureau of the Census 1998).
The cultural significance of this history of commercial development is underlined by its significance in the collective memory of some of Hawaii's major ethnic groups—the Japanese

and Native Hawaiians in particular. In 1999, for example, the Japanese Cultural Center of Honolulu organized an exhibition commemorating the past involvement of Japanese in Hawaii's commercial fishing industry. Some Hawaii fishermen feel a sense of continuity with previous generations of fishermen and want to perpetuate the fishing lifestyle. A 1993 survey of participants in the NWHI bottomfish fishery found that half of the respondents who fish in the Ho'omalu Zone were motivated to fish by a long-term family tradition (Hamilton 1994). This sense of continuity is also reflected in the importance placed on the process of learning about fishing from "old timers," and transmitting that knowledge to the next generation.

The importance of seafood, and the discriminating tastes of Hawaii's consumers, have made quality—and quantity and variety too—hallmarks of Hawaii's seafood markets. As a result, fish markets have became important institutions in Hawaii society. Long-established fishing-related infrastructure in Honolulu, such as the fish market and the Kewalo Basin mooring area, have helped define the character of the city. Consequently, even though much fish retailing now occurs through self-service supermarkets, Honolulu's fish market has endured and continues to be a center of social interaction for some island residents. The retail market is mainly composed of single proprietorship-family type operations. Close social connections have developed between retailers and consumers. This stems from the need for successful fish dealers to maintain good relations with their customers and thus keep a stable clientele (Garrod and Chong 1978). The large variety of seafood typically offered in Hawaii's seafood markets reflects Hawaii's ethnic diversity and each ethnic group's preferences, traditions, holidays, and celebrations (URS Corp. in prep).

Given the historical significance of commercial fishing in Hawaii, it is likely that some residents consider the fishing industry an important part of the cultural identity and heritage of the islands. Even people who have never fished, and do not intend to, may nonetheless wish that others continue to fish because of its contribution to Hawaii's social, cultural, and economic diversity. This existence value may be expressed in various ways. For example, some people may engage in vicarious fishing through the consumption of books, magazines, and television programs describing the fishing activities that others are pursuing in the waters around Hawaii.

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

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

The availability of seafood is also important to Hawaii's tourist industry, the mainstay of the state economy. Japanese tourists visiting Hawaii often want to enjoy the traditional foods and symbols of Japan while they vacation in Hawaii, including various types of high quality fresh fish

(Peterson 1973). Hawaii tourists from the U.S. mainland, and other areas where fish is not an integral part of the customary diet, typically want to eat seafood because it is part of the unique experience of a Hawaii vacation. Consuming fish that is actually caught in the waters around Hawaii further enhances that experience (WPRFMC 2000b).

Today, the people who participate in Hawaii's reef-related fisheries constitute an ethnically mixed and spatially dispersed community numbering thousands of individuals. A large percentage of the population harvests coral reef resources for subsistence and customary exchange of food with friends and family. Although it is hard to tell how many people this segment of the population represents, it has been estimated that some-time food fishermen range between 100,000 to 400,000 individuals.

There are a few rural villages in the state where most residents are at least partly dependent on fishing for their livelihood (Glazier 1999). But generally there are not particular towns or cities where the balance of the residents depend on or engage in fishing to make a living. Instead, fishing communities—in the sense of social groups whose members share similar lifestyles associated with fishing—are sub-populations within metropolitan areas or towns.

Today, Hawaii fishermen fish for a variety of reasons. In fact, the same person can cite a range of motivations (Glazier 1999). In the small boat fishery around the MHI the distinction between "recreational" and "commercial" fishermen is extremely tenuous (Pooley 1993b). Hawaii's seafood market is not as centralized and industrialized as U.S. mainland fisheries. Thus, it is has always been feasible for small-scale fishermen to sell any or all of their catch for a respectable price. Money earned from part-time commercial fishing is an important supplement to the basic incomes of many Hawaii families. Even full-time commercial fishermen cite other reasons, besides money, for why they fish. For example, a 1993 survey of owner-operators and hired captains who participate in the NWHI bottomfish fishery found that enjoyment of the lifestyle or work itself are important motivations for participants (Hamilton 1994).

Historical and Present Coral Reef Uses

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

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

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

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

Table 3.11: Mean actual catch (lbs) by gear type from Penguin Bank (2-200 nm), based on data from DAR reported commercial fishery catch statistics from 1991-1995 (modified from Friedlander 1996).

Gear Type	Catch (lbs/yr)
Offshore gear	
Aku pole & line	67,486
Trolling	26,607
Tuna handline	1,295
Subtotal	**95,388**
Inshore gear	
Deep handline	83,517
Net	14,191
Inshore handline	2,485
Other	573
Trap	493
Diving	22
Subtotal	**101,281**
Total	**196,670**

After two decades of minimal activity, the domestic fishery for pink, gold and bamboo precious corals in the EEZ of Hawaii resumed in December 1999. One company uses two one-man submersibles to survey and harvest the resource at depths between 400-500 m. These technologically advanced devices are capable of diving to 700 m, with a maximum bottom time of six hours. To date, they have only surveyed and begun harvesting in areas around two of the seven known beds between the islands of Oahu and Hawaii. The company has plans to search for additional beds in both the MHI and NWHI.

Table 3.12: Mean annual catch (lbs) of the most common reported inshore fish species from Penguin Bank (2-200 nm) based on reported DAR commercial fisheries catch statistics from 1991-1995 (modified from Friedlander 1996) and from 1996-2000 (D. Hamm, pers. comm.).

Species/Taxa	1991-1995	1996-2000
Bigeye scad *(Selar crumenophthalums)*	537	474
Goatfish (*Mulloidichthys vanicolensis*)	264	165
Surgeonfish (*Acanthurus xanthopterus*)	204	65
Scad (*Decapterus* spp.)	152	41
Wrasse *(Bodianus bilunulatus)*	149	62
Barracuda (*Sphyraena helleri*)	111	56
Wrasse (*Xyrichthys pavo*)	111	176
Sharks (misc.)	65	3,605
Other goatfish *(Parupeneus* spp.)	37	6
Big-eye-fish *(Priacanthus* spp.)	28	30
Parrotfish (*Scarid* spp.)	22	-
Trumpetfish (*Aulustoma chinensis*)	14	1
Soldierfish *(Myripristis* spp.)	12	31
Leatherback *(Scomberoides lysan)*	5	6
Surgeonfish (*Acanthurus dussumieri*)	4	1
Surgeonfish *(A. olivaceus)*	4	-
Goatfish (*Parupeneus porphyreus*)	2	1
Unicornfish (*Naso* spp.)	1	1
Threadfin (*Polydactylus sexfilis*)	1	-
Wrasse (*Coris* spp.)	1	3
Flyingfish (*Exocoetus* spp.)	-	1

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

Historically, Penguin Bank has also been one of the most important bottomfish fishing grounds in the MHI, because it is the most extensive shallow shelf area in the MHI, and it is within easy reach of major population centers. Penguin Bank is particularly important for the MHI catch of *uku* (Aprion virescens, or gray snapper), one of the few bottomfish species available in substantial quantities to Hawaii consumers during summer months. Table 3.13 compares bottomfish landings at Penguin Bank during two periods as a percentage of total MHI commercial landings, for five major bottomfish species. It shows that the bank has increased in importance over the years.

For the period 1991 to 1995, 8% of the licensed commercial fishermen who participated in the MHI bottomfish fishery reported catches from Penguin Bank (WPRFMC 1996). Penguin Bank has long been known to support a productive bottom "handline" fishery for snappers and groupers. It is also a popular bottomfish fishing ground for recreational anglers. However, the magnitude and value of the recreational landings, while significant, are poorly documented (Friedlander 1996). However, Holland (1985 in Friedlander 1996) noted that the Kewalo Basin charter fishing fleet uses Penguin Bank as one of its major fishing areas. Offshore and inshore fishing gear are used on Penguin Bank in about equal importance. Table 3.11 lists, in decreasing order of catch, offshore gear and inshore gear. Table 3.12 lists the most common reef/inshore fish species reported in commercial landings from Penguin Bank over the past decade, by five-year periods. Catches for most species are generally comparable for both periods with slightly less taken in the last period (1995-2000). Sharks appear to have been under-reported in the earlier period (1991-1995).

Table 3.13: Average percentage of total MHI commercial catch and average commercial catch of major bottomfish species harvested from Penguin Bank. Sources: WPRFMC (1996) and unpublished data from HDAR.

	Average annual percent of total MHI catch		Average annual catch (lbs)
	1980-1984	1991-1995	1997-1999
Opakapaka	9.63	16.11	20,609
Uku	12.06	44.04	28,785
Onaga	14.87	20.24	9,277
Ehu	12.15	17.60	3,380
Hapuupuu	4.31	6.64	905

Limited information is available on coral reef fish community structure at Penguin Bank. An investigation of deepwater artificial reefs on the bank, using manned submersibles, recorded 62 taxa (25 families), of which 32 were considered resident, 25 transient, and five incidental (Friedlander 1996). Estimates of mean biomass ranged from 3-290 mt/km^2 for resident species to 90-2,460 mt/km^2 for transient species. However, these estimates are considered high for the area, since several studies have shown that artificial reefs tend to support a higher biomass than natural reefs under similar circumstances.

An investigation of the deepwater macroalgal community, using a manned submersible, provides information on algae at Penguin Bank (Agegian and Abbott 1985). The bank consists of a broad carbonate platform (~60m deep) covered with loose carbonate rubble and coarse sediments from the calcareous green alga, *Halimeda.* The algal community, comprising 54 species, is characterized by two deepwater species and many species that occur in shallow water. The deeper areas of the bank (182 m) are dominated by crustose coralline algae.

When reef-associated species that are presently managed under other Council FMPs are excluded from the analysis, almost all of the coral reef fisheries in Hawaii take place in inshore (state) waters in the MHI (Friedlander 1996). For example, in Hawaii less than 12% of the inshore fishes are caught in federal waters, based on reported commercial catch from 1991-1995. Similarly, only 18% of molluscs, 1% of seaweeds, and no echinoderms are harvested in federal waters. Of the crustaceans, less than 50% of the reported commercial catch of kona crab—or 14,191 lbs. valued at $57,436—were taken in federal waters on Penguin Bank. Overall, only 1% of total catch, measured either by weight or value, comes from EEZ waters.

The top species by weight and value in the DAR inshore fish category were soldierfishes (*Myripristis* spp.), parrotfish (*Scarid* spp.), surgeonfishes (including *Acanthurus dussumieri, A. trostegus* and *Naso* spp.) and goatfishes (including *Mulloidichthys* spp.). Inshore fishermen target some of these species (especially the goatfishes *Parupeneus porphyreus* and *P. cyclostomus*), since they can fetch a high price in some seasons (Friedlander 1996). *Tilapia* spp. ranked high in terms of catch, but because it sells for a low price, it does not rank very high in terms of value. In the MHI, 89% of the catch of these species came from state waters.

Crabs are also an important group for commercial, recreational, and subsistence fishermen in Hawaii, with a mean annual commercial value of $182,182 (Friedlander 1996). The dominant species in the catch is kona crab (*Ranina ranina*) with more than 28,000 lbs. caught annually. By weight, 51% of kona crab are caught on Penguin Bank, which has long been an important location for kona crab net harvests of (Onizuka 1972). In contrast, almost all of the other crabs species were caught less than 2 nm from shore in the MHI.

Surveys of the NWHI demonstrate that coral reefs are in good condition with high standing stocks of many reef fish. Nearshore coral reefs receive little human use because of their remoteness, exposure to harsh seasonal ocean conditions, and their protected status as part of a national wildlife refuge. Most of the shallow reefs of the NWHI lie within the boundaries of the State of Hawaii, where access and resource use controlled by special permit.

There is a long history of fishing in the NWHI. Iverson *et al.* (1989) found ample evidence of fishing by the ancient Hawaiians as far northwest as Necker Island. Starting in the 1920's, a handful of commercial boats ventured into the NWHI to fish for shallow and deepwater bottomfish, spiny lobsters, and other reef and inshore species. Black-lipped pearl oysters at Pearl and Hermes Reef in the NWHI were overfished in the late 1920's and recent surveys indicate that stocks have still not recovered, perhaps due to a lack of suitable oyster shell habitat (Green 1997). Efforts to restock this species at this site are under consideration by the USFWS. As discussed in the previous section, from the late 1940s to the late 1950s, there was a fishery for *akule* and reef fish around French Frigate Shoals and Nihoa Island.

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

As discussed in the previous section, both the deep-slope bottomfish and lobster fisheries grew rapidly, beginning in the early 1980s. Both fisheries have declined from peaks late in that decade. They are now managed by the Council under limited access programs that fix the number of permits. The lobster trap fishery is also subject to a harvest quota, set annually at 13% of MSY, and it is one of the most intensively managed U.S. EEZ fisheries. Conservative management measures reduce the risk of overfishing and help prevent protected species interactions. The lobster fishery is managed for low fishing mortality, which is spread across a wide geographic region. However, the population structure of the lobster population in the region as a whole and the magnitude of oceanographic changes on the recruitment dynamics of the population are not fully understood. Spiny and slipper lobsters are harvested at many banks and on reefs deeper than 10 fathoms. The lobster trap fishery catches octopus and hermit crabs incidentally. But the incidental catch of reef fish is minimal because the lobster traps have escape vents. Bank-by-bank allocation of the 1999 harvest guideline caused permit holders in the lobster trap fishery to distribute effort into new trapping sites, including some areas where retrieval of trap lines may damage live coral.

Currently, there are no other major fisheries in the NWHI. Commercial trolling for *ono* occurs seasonally in some areas of the NWHI. For a short time in 1999, experimental fishing for coastal sharks was permitted. Many of the shallow reefs are in the NWHI are within the National Wildlife Refuge and will likely remain off limits to fishing. Chapter 5 of the EIS discusses documented and potential fisheries interactions with protected species in the NWHI. Occasional visitors, including federal government personnel and contract workers at Midway, sometimes fish recreationally in the NWHI. However, Midway is considered part of the PRIAs and recreational development is discussed in that section.

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

Pacific Remote Island Areas

Socio-economic Overview

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

Palmyra was claimed by the American Guano Company in 1859. It was annexed to the Kingdom of Hawaii in 1862, but became privately owned in 1911. In 1922, the Fullard-Leo family purchased it. It was later annexed to the United States, but specifically excluded from the Territory and State of Hawaii. In the late 1930's, in preparation for World War II, a seaplane base and other defense facilities were constructed on Palmyra. The U.S. Navy or other federal installations continuously occupied the atoll until 1949. It was also used for nuclear testing programs in 1962. The Navy's attempt to regain control of Palmyra after World War II ended with a U.S. Supreme Court decision to return the atoll to the private owners, the Fullard-Leo family, who also claim ownership of Kingman Reef. In January 2001, The Nature Conservancy negotiated exclusive purchasing rights to Palmyra Island with the Fullard-Leo family. They report that two-thirds of the island will eventually be designated a National Wildlife Refuge, run by the USFWS, and one-third will be used for ecotourism. On January 18, 2001, the Secretary of the Interior, through Secretarial Order 3223, declared Kingman Reef and the surrounding submerged lands and waters as a National Wildlife Refuge out to a distance of 12 nm. Secretarial Order 3224, issued the same day, declared the tidal waters and submerged lands and waters of Palmyra Atoll as a national wildlife refuge out to a distance of 12 nm. The MSFCMA establishes the Council's jurisdiction over EEZ waters surrounding Palmyra to the mean high water mark, including the waters of the lagoon and the area within the 12 nm refuge boundaries.

The written historical record provides no evidence of prehistoric populations on Wake Island, but Marshall Islanders occasionally visited Wake, giving it the name Enenkio. The island was annexed by the United States in 1899. Before the 1930's the only visitors were scientists and

survivors of shipwrecks. The 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. The U.S. re-occupied the atoll after the war, and administrative authority was held by the Federal Aviation Administration until 1962, when it was transferred to the Department of the Interior, which in turn assigned authority to the U.S. Air Force. Since 1994, the Department of the Army has maintained Administrative use of Wake Island.

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

A recently established eco-tourism operation in the Midway Atoll National Wildlife Refuge has improved public access to the NWHI. An agreement between Midway Phoenix Corporation and the USFWS allows up to 100 people to visit the atoll each week. These visitors normally get to Midway by air, on charter flights from Honolulu. Typical activities include charter fishing, diving, and wildlife observation. The company emphasizes this last activity in its promotional material, promoting wildlife tours that let visitors "gain first hand knowledge of the albatross, resident seabirds, migrant shorebirds, threatened green turtles and endangered Hawaiian monk seals." The Public Use Plan for the Refuge outlines other outdoor recreational activities—including shoreline fishing, lobstering, night diving, night fishing, kayaking tours, and glass-bottom boat excursions—that could be offered to visitors in the future (USFWS 1997). These activities should result in increased recreational use of NWHI marine resources. Because of their location and history, no genuine community participation in coral reef fisheries can be identified for the PRIAs. The next section discusses coral reef resource use by part-time residents on these islands and atolls.

Historical and Present Coral Reef Uses

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

Fishing is light in most areas. Hawaii-based vessels have been reported to make sporadic commercial fishing trips to Palmyra and Kingman Reef for bottom fishing, harvesting coastal sharks for finning,. The past extent of harvesting by passing yachts or poaching by foreign fishing vessels is unknown (Green 1997). Since May 2000, the Nature Conservancy has been conducting small scale experimental ecotourism activities, including, diving, snorkeling, kayaking, fishing, and wildlife photography. The Nature Conservancy has also proposed establishing an inshore/offshore sportfishing operation. It would include a catch-and-release

program for pelagic species, bonefish (*Albula* spp.), and other reef fish, particularly the giant trevally (*Caranx ignoblis*). The proposal also includes monitoring of fish stocks, and conducting biological investigations on the migratory, reproductive, and recruitment patterns of those stocks (Chuck Cook pers. comm. 2001). Data on catch and effort from the recreational fishing will also be recorded. In addition, pursuant to a license agreement with the Nature Conservancy, Palmyra Pacific Seafoods, LLC has established and is currently operating a commercial fishing operation on Palmyra Atoll. Palmyra Pacific Seafoods, LLC is operating under rights granted to it by the Fullard-Leo family, and its existing fishing areas and business interests include the resources in the vicinity of Kingman Reef (F. Sorba, pers. comm 2001).

There are no permanent residents on any of these islands, although on Wake and Johnston there are temporary work forces who have a long history of recreational fishing and shell collecting. The fishery at Johnston Atoll was described over a six-year period (1985–1990), based on the results of a creel census by Irons *et al.* (1990). They found that long-term 'residents' —almost all employees of the prime contractor for Johnston Atoll operations—did most of the fishing and thus produced a large proportion of the catch. These residents fished for enjoyment, to add fresh fish to their diet, and to accumulate fish to take home on leave. The remainder of the catch was harvested by 'transients,' military personnel and contractors stationed on the island for one or two years. However, through cooperative management between the USFWS and the military, the practice of shipping coolers of fish back to Hawaii by workers stationed on the atolls was stopped. Likewise, the collection and shipment of live corals by recreational divers were also stopped.

Irons *et al.* (1990) reported that the soldierfish (*Myrispristis amaenus*) composed the largest proportion of reef fish catch at Johnston (see Table 72 in Green 1997). Other important fish species included bigeyes (*Priacanthus cruentatus*), flagtails (*Kuhlia marginata*), mullet (*Chaenomugil leuciscus*), goatfishes (*Mulloides flavolineatus, Pseudupeneus bifasciatus, P. cyclostomus*, and *P. multifasciatus*), jacks (*Caranx melampygus* and *Carangoides orthogrammus*), parrotfish (*Scarus perspicillatus*), surgeonfishes (*Acanthurus triostegus* and *Ctenochaetus strigosus*), and bigeye scad (*Selar crumenophthalmus*). Gear types varied with the target species and included hook-and-line fishing, spearfishing and throw nets. All of the more heavily fished areas at Johnston are located in nearshore waters. Irons *et al.* (1990) also noted that recreational divers at Johnston collected pieces of coral for souvenirs. *Acropora cytherea* and the hydrocoral *Distichopora violacea* were the two main species collected, although smaller quantities of *Acropora valida, Millepora* and *Fungia* were also collected.

The original Johnston Atoll has been extensively modified by dredging and filling. An estimated 4 million square meters of coral were destroyed by construction, and an additional 25 million square meters were damaged by the resulting sedimentation. By 1964, dredge and fill operations had enlarged the original island by over tenfold and had added two manmade islands. Fishing regulations have changed at Johnston Atoll in recent years because of concerns that fish were being exported and that coral collecting had become excessive and was incompatible with the philosophy of the refuge (Green 1997). Current DOI policy prohibit coral collecting and the export of any reef fish or invertebrates from the island. However, collection of selected

organisms and shells is permitted in restricted areas by recreational divers. Since Johnston is a closed military base, only local residents engage in such activities. No recent fisheries statistics are available for the area.

National Wildlife Refuges have been established at Baker, Howland and Jarvis Islands, Palmyra Atoll Kingman Reef and Johnston Atoll. Natural resources are managed by the USFWS and access is by special use permit only. Wake Atoll is also a candidate for National Wildlife Refuge status.

3.7 Magnuson-Stevens Fishery Conservation and Management Act Definition of Communities

The MSFCMA requires that FMPs take into account the importance of fishery resources to fishing communities, in order to provide for the sustained participation of such communities and to the extent practicable, minimize adverse economic impacts on them. For the purposes of the Coral Reef Ecosystems FMP there are no communities substantially engaged in, or substantially dependent, on the harvesting and processing of coral reef resources from the EEZ, as defined by the MSFCMA.