APPENDIX B

REGULATORY IMPACT REVIEW (RIR)
AND
INITIAL REGULATORY FLEXIBILITY ANALYSIS
(IRFA)

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION: ECONOMIC ANALYSIS OF REGULATORY ALTERNATIVES

Executive Order 12866 (E.O. 12866) requires that a Regulatory Impact Review be prepared for all regulatory actions that are of public interest. This review provides an overview of the problem, policy objectives, and anticipated impacts of the action, and ensures that management alternatives are systematically and comprehensively evaluated such that the public welfare can be enhanced in the most efficient and cost-effective way. In accordance with E.O. 12866, the following is set forth: (1) This rule is not likely to have an annual effect on the economy of more than $100 million or to adversely affect in a material way the economy, a sector of the economy, productivity, jobs, the environment, public health or safety, or state, local, or tribal governments or communities; (2) This rule is not likely to create any serious inconsistencies or otherwise interfere with any action taken or planned by another agency; (3) This rule is not likely to materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights or obligations of recipients thereof; (4) This rule is not likely to raise novel or policy issues arising out of legal mandates, or the principles set forth in the Executive Order. Based on these findings, this rule is determined not to be significant under E.O. 12866.

The Regulatory Flexibility Act (5 U.S.C. 601 et seq.)(RFA) requires that agencies assess and present the impacts of their proposed actions on small business entities. In accordance with the RFA, the following is set forth: (1) Details on the need for, and objective of, the measures that are outlined in the FMP which accompanies this document; (2) The proposed measures would apply to individuals who wish to harvest coral reef resources in the federal waters of the Western Pacific Region; (3) All affected individuals are expected to be small business entities; (4) The proposed measures include new reporting requirements; and (5) Some federal rules are known to duplicate, overlap, or conflict with the proposed measures.

The general intent of the RIR and RFA analytical and procedural requirements is to make the decision process open and transparent so that all can understand the what, where, and why of regulatory decision-making and can agree that the required steps of the process were followed. The economic analyses provide decision-makers and the public with the agency's best estimates of the impacts of proposed actions and their alternatives. "In deciding whether and how to regulate, agencies should assess all costs and benefits of available regulatory measures, including the alternative of not regulating" (EO 12866, Section 1). Further, "agencies should select those approaches that maximize net benefits...." The emphasis of the analysis is therefore on the changes in the stream of net benefits that will occur as a result of each of the alternative management measures. The RIR also requires analysis of distributive impacts and the costs of government administration and private compliance with the proposed measures.

1.0 REGULATORY IMPACT REVIEW

1.1 Management Objectives

The objectives of the proposed regulatory actions are reflected in the objectives of the Fishery Management Plan for Coral Reef Ecosystems (FMP), described in Section 1 of the FMP. These are:

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

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

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

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

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

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

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

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

1.2 Statutory Basis

These management actions are proposed under the Magnuson-Stevens Fishery Conservation and Management Act (as amended in 1996), 50 CFR Part 660. Particular attention has been paid to requirements concerning essential fish habitat as defined in the Sustainable Fisheries Act of 1996. The relationship between the proposed measures and other national laws and policies is described in the Other Applicable Laws and Policies section of the FMP. A summary of existing laws and management measures in the state and territorial waters adjacent to those controlled by the proposed measures is provided in the FMP (Section 9.2.3).

1.3 Problem to be Resolved and Summary Economic Information

The rationale for the proposed management measures is described in detail in the FMP. In summary, many types of human activities have impacted, or have the potential to impact, coral reef resources around the US Pacific islands. The scale of different impacts can range from ocean wide to specific islands and watersheds, to specific reefs.

Stony corals are among the principal reef framework building organisms in the US Pacific Islands. In 1998, global coral bleaching and die off was unprecedented in geographic extent, depth and severity. Several studies have related bleaching to the combination of increased ultraviolet radiation and ocean warming, phenomena that may be exacerbated by human activities. Projected long-term climatic changes are likely to expose stony corals to an increasingly hostile environment and could possibly lead to mass extinctions. Of foremost concern is the degradation and destruction of habitats essential for the reproduction and recruitment of many coral reef species. Much of the previous damage to coral reef habitats in the US Pacific Islands has occurred as a result of non-harvesting activities such as coastal and harbor development, watershed land use practices and runoff, industrial discharges and military use. Harvesting and non-harvesting vessels have the potential to degrade habitat by grounding, anchoring, introduction of invasive species, derelict gear, and other marine debris. The removal of live rock and the use of destructive harvesting techniques, such as explosives and poisons, can also directly affect coral reef habitats. Because many resources that contribute to coral reef habitat are essentially non-renewable (in human time dimension), prevention is a far more effective strategy than mitigation of damage after it has occurred.

The current regulatory regime in the western Pacific allows for open access with uncontrolled and unregulated harvesting of coral reef resources from many of the domestic coral reef ecosystems in the western Pacific. Although deep water bottom fisheries for bottomfish (snappers, groupers and jacks), trap fishing for crustaceans (primarily spiny and slipper lobster), and selected harvest of precious corals (which generally inhabit deeper depths than the coral reef ecosystem) are regulated by their own Western Pacific Regional Fishery Management Council FMPs (which include limited

entry and other regulatory measures to control access and harvest levels), these FMPs fail to fully integrate an ecosystem approach to coral reef management. While fishing and other marine harvesting activities of domestic coral reef ecosystems are at present relatively quite limited, (particularly if excluding the bottomfish, crustacean, and precious coral fisheries), there are a number of possibilities for rapid and relatively unanticipated development of marine resource harvesting potential in this region. Particular opportunities exist for the marine ornamental products trade (including aquarium species and live rock), mariculture, bioprospecting and bio-harvesting (e.g., algae), and ecotourism activities including snorkeling and diving. Although there are some State and/or Territorial/Commonwealth licensing requirements for some of these activities, there are few requirements for the unincorporated US Pacific Islands (PRIAs) and little if any controls on access or total harvest. As a result, coral reef fisheries or other types of marine product harvesting could develop relatively unchecked.

Most of the problems addressed by this FMP are anticipated to derive from future developments rather than from current practices. This means the FMP is largely precautionary, which suggests a risk of unnecessarily precluding activities (which might have lower ecological impacts than anticipated), and thus foregoing the income and human welfare that a renewable natural resource can be expected to generate. The task of economic analysis in this FMP is to provide information to decision-makers and the public that will allow an informal calculus of the trade-offs between future risks and returns (information does not exist for a detailed quantitative cost-benefit analysis).

The following is a brief summary of what is known about the value of coral reef resources in the US Pacific Islands. The information sources for this information appears subsequently in this RIR.

1. The annual ex-vessel value of harvests from coral reef fisheries in the US Pacific Islands is about $15 million of a total ex-vessel value of all domestic marine fisheries in the region of roughly $95 million. In general, the coral reef resources component is much greater than the deep bottom component but much smaller than the pelagic component. The relative ex-vessel value of coral reef fisheries compared to other fisheries varies greatly among island groups, being greatest in American Samoa and least in Hawaii.

2. About 10 percent of the coral reef resource ex-vessel value is from reef areas under federal jurisdiction (or in the case of the CNMI, from the "offshore management zone").

3. At least $3 million per year is spent on managing the coral reef fisheries of the region. In American Samoa, management costs are equal to about 75 percent of the fishery's ex-vessel value. In Hawaii, the relative inputs into management are much lower–roughly 15 percent of ex-vessel value, and in the CNMI and Guam, the relative costs of management are intermediate–in the range of 25 to 35 percent of ex-vessel value.

4. The net value of the region's coral reef fisheries is difficult to estimate because of the lack of information on harvesting costs and consumer surplus, including the non-market values that accrue to both seafood consumers and fishermen, including recreational, subsistence,

and commercial fishermen. Based on tentative assumptions about the non-market benefits that accrue to fishermen, a plausible range of net value is $0 to $15 million per year, or assuming no change in the future trajectory of coral reef utilization, a net present value (NPV) of $0 to $175 million. That is, if the fisheries are operating at the open access equilibrium represented by minimal fisheries management, they may be generating no net value (profits) at all, or they may be generating net values of as much as the total ex-vessel value if there is considerable consumer and producer surplus, as well as non-market value.

5. In terms of the potential net value of coral reef fisheries in the region, the "nearshore" reefs–those within easy access of populated areas and ports–have the advantages of lower harvesting costs but potentially greater harvesting pressure and dangers of over-fishing. Given the higher population levels, management costs may be substantial. Remote reefs may have the advantages of less degraded habitat and higher productivity.

6. The region's coral reefs generate economic value (both market and non-market values) in a number of non-fishery "sectors," including tourism and recreation, the reef as a breakwater, support for other ecosystems, etc. These values accrue to varying degrees to both local communities and to the nation and the world as a whole and their long-term value and utilization depends on their resilience to human, including fishing and other types of harvesting, and other non-human natural processes. Although accurate assessment of the value of all these reef-dependent sectors and sources of value is not possible in the context of this FMP (and has barely been attempted in a few marine park and polluted marine settings), it is apparent that the value of coral reef fisheries are, in general, smaller than the non-fishery values of coral reef ecosystems. For example, a tentative assessment of the annual net value of marine-based tourism in the US Pacific Islands is $400 million to $1.6 billion, or assuming no change in the future, a net present value of $5 to $19 billion. The extent to which this tourism relies on the coral reef ecosystem, and the marginal value of "units" of the coral reef ecosystem to those tourism values, has not been determined.

7. While coral reef fisheries and other forms of harvesting, through extraction of fish and degradation of habitat, have some capacity to degrade the non-fishery values of coral reef ecosystems, compared to impacts from other sources, such as oceanographic conditions and land-based disturbances – including shoreline development – the potential impacts from coral reef fisheries appear small if properly managed.

8. Although the actual and potential net values of the region's coral reef fisheries are modest, especially in comparison with the non-fishery values of the reefs, coral reef fisheries are very important in terms of the indirect economic benefits and social benefits that they generate. The fishing communities and economies of the US Pacific Islands have a high degree of dependence on these fisheries and derive great benefits through the production of food, income, recreation, and values associated with culture and tradition.

9. Indirect economic benefits derived from local coral reefs include local spending by resident consumers, fishermen, and dealers, employment of fishermen and dealers and their suppliers, and expenditures by visiting anglers, divers, and other tourists. Federal funds applied to the management and development of local coral reef fisheries also generate substantial indirect benefits to local economies.

10. The dependence of fishing communities on coral reef fisheries is mostly limited to nearshore reefs close to populated areas. Only small portions of these reefs are under federal jurisdiction.

1.4 Proposed Actions

This FMP proposes management, under federal regulation, of the coral reef resources in the waters of the EEZ around American Samoa, Guam, Hawaii, Northern Mariana Islands and the unincorporated U.S. Pacific islands. The Fishery Management Unit is the entire region from the boundary of territorial waters (generally 3 miles offshore) to the limit of the EEZ (200 miles offshore) with special attention to waters within 50 fathoms. The proposed regulatory and non-regulatory measures are fully described in the FMP.

For the purposes of this FMP, the coral reef ecosystem is defined as substrate from 0-50 fm deep. In most areas, a large portion of these ecosystems fall within state or territorial waters (generally 3 miles from shore). The FMP proposes to regulate those portions that are outside of state or territorial waters and within 200 miles from shore (with an exception made for the Commonwealth of the Northern Mariana Islands where federal waters extend to the shoreline but management activities under this FMP will nevertheless begin at 3 miles from shore). Species to be managed under this FMP are termed management unit species (MUS) and are divided into two groups; Currently Harvested Coral Reef Taxa, which are relatively well understood; and Potentially Harvested Coral Reef Taxa, which have not been historically harvested or are not well understood. Some species already managed under existing FMPs are included as MUS under this FMP as well. These overlapping species would continue to be managed primarily under their current FMPs (Bottomfish, Crustaceans, Precious Corals), however broader ecosystem effects of these harvesting activities would now be addressed via this Coral Reef Ecosystem FMP.

The FMP proposes four (4) alternatives for managing the western Pacific coral reef ecosystem:

> Alternative 1 (No Action) would implement no new regulations, i.e., only the existing Bottomfish, Crustacean, and Precious Coral FMPs would regulate activity in the western Pacific coral reef ecosystem;
>
> Alternative 2 (Minimal Additional Protection) would designate several low-use MPAs, require permits for some takes of Coral Reef Ecosystem Management Unit Species (CRE MUS), limit takes of live rock and coral, and prohibit the use on non-selective gears to harvest CRE MUS throughout the EEZ;

Alternative 3 (Substantial Additional Protection - the Preferred Alternative) would encompass regulations in Alternative 2 and in addition designate several no-take MPAs, require all fishing vessels operating or transiting MPAs to carry wreck clean up and removal insurance, and prohibit the use of nighttime spearfishing for CRE MUS with SCUBA and/or hookah gear in the EEZs of the Northwestern Hawaiian Islands (NWHI) and the Pacific Remote Island Areas.

Alternative 4 (Maximum Additional Protection) would incorporate regulations in Alternatives 2 and 3 and in addition establish no-take MPAs out to 100 fathoms around all of the region's islands and atolls.

The Preferred Alternative for the Coral Reef Ecosystem FMP, i.e., Alternative 3, as approved by the Western Pacific Regional Fishery Management Council (Council) at a meeting in June 2000, would result in three major regulatory actions: (a) designation of marine protected areas; (b) harvesting permit and reporting requirements for harvesting of coral reef resources; and (c) definition of allowable gear and methods of harvesting for coral reef resources. The Council also proposes that the regulations include framework procedures to allow for timely, adaptive management based on new resource information, unforeseen effects, or changes in fisheries. In addition, the Council recommends that a formal procedure be established (under Standard Operating Procedures and Practices) for assessing and controlling ecosystem effects of reef-related fisheries which are managed under the existing FMPs for Bottomfish, Crustaceans and Precious Corals.

Alternative 1 (the No Action alternative) is essentially the existing baseline on which analysis of the action alternatives is based. The difference between the Preferred Alternative (Alternative 3) and the other two action alternatives (Alternatives 2 and 4) is essentially the extent of no-take MPAs designated by the FMP. These differences are delineated in detail in the text of the FMP.

Regarding marine protected areas (MPAs), the Council proposes to designate a series of areas as MPAs, which would be grouped into two types. The first is no-take MPAs in which no fishing or other harvest of coral reef resources would be permitted. The second is low-use MPAs in which controlled harvests of coral reef resources would be permitted. Under the Preferred Alternative, waters out to 50 fathoms surrounding the NWHI islands of Laysan, French Frigate Shoals, and the northern half of Midway would be designated as no-take MPAs. Proposed as no-take MPAs are the waters out to 50 fathoms surrounding Rose Atoll (American Samoa), Jarvis, Howland, Baker and Kingman Reef. Finally, waters out to 10 fathoms surrounding all other NWHI would also be designated as no-take MPAs under the Preferred Alternative. Low-use MPAs would consist of all remaining coral reef management areas (waters 0-50 fathoms) surrounding the NWHI and Palmyra, Johnston and Wake Atolls. Anchoring by harvesting vessels more than 50 feet in length would be prohibited on Guam's southern banks, and could be prohibited elsewhere at a later date under the FMP's framework process.

Regarding harvesting permits and reporting requirements, the Council's Preferred Alternative includes two types of permits, each with its own reporting requirements. The Special permit would

be instituted immediately upon final ruling of the FMP. The Special permit would be required to harvest any coral reef resources from low-use MPAs, as well as for the harvest of any Potentially Harvested Coral Reef Taxa from any coral reef management area. This permit would be issued on a case-by-case basis pending NMFS review and approval of the proposed activity. Accompanying this permit would be a mandatory detailed catch report form. Harvest of Currently Harvested Coral Reef taxa from all non-MPA coral reef management areas would not require a permit initially. Local monitoring systems, familiar to the fishers in each region, currently collect the data which would be required under a General Permit. The quality of the local monitoring systems and the need to institute a General permit will be analyzed in each annual report. While the General permit application and reporting process has been analyzed as a potential framework measure in the FMP, further analysis through the annual reports may alter the final appearance of the General permit. Exceptions to permit requirements would be made for NWHI bottomfish, lobster, or precious corals fishery permit holders who are targeting species managed under their respective FMPs. These individuals would be prohibited from any harvesting within no-take MPAs, but would be allowed to fish within low-use MPAs under their current permit and reporting requirements. No permits would be issued for the collection of live stony coral or live rock for commercial purposes. Preferences would be given for the granting of Special Permits for indigenous harvesting activities in low-use MPAs, with a portion of each such area set aside for such activities.

A detailed list of proposed allowable gears is available in the FMP. In general, the Council proposes to prohibit the use of gears which would destroy coral reef habitat or have the potential for non-selective use. These include poisons, explosives, and intoxicating substances. Certain nets would be allowed if they are tended, and fish traps would be allowed in some areas. The use of manned and remotely operated submersibles would be permitted, as would hook and line fishing, and spear fishing. However, night spear fishing with SCUBA in coral reef areas around the NWHI, and the PRIA would be prohibited. These gear restrictions would apply only in low-use MPAs, such that harvesting in coral reef areas around the Main Hawaiian Islands, the Commonwealth of the Northern Mariana Islands, and most of American Samoa and Guam, would continue as currently allowed under state and local rules.

Finally, the Council's Preferred Alternative includes a requirement that all fishing vessels passing through MPAs would be subjected to insurance requirements to cover wreck removal and pollution clean up in the event of a grounding.

1.5 Description of Coral Reef Sectors

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

from federal waters between 0-50 fathoms) including those currently managed under the Bottomfish, Crustaceans, and Precious Corals FMPs.

Types of Activities[1]

Coral Reef Fishery Sectors:

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

Non-coral Reef Fishery Sectors:

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

Non-fishery Sectors:

Tourism (non-fishing)	Visitors engaging in scuba diving, snorkeling, boating, swimming, viewing of coral reefs, and other coral reef-related activities, including eco-tourism.
Recreation (non-fishing)	Residents engaging in scuba diving, snorkeling, boating, swimming, viewing of coral reefs, and other coral reef-related activities.

Mining	Extraction of fossil coral and sand from the coral reef ecosystem.
Breakwater	Coral reef ecosystems functioning to protect shorelines from erosion and to provide shelter for navigation and mooring, and other activities.
Ecological support	Coral reef ecosystems functioning as nursery areas, spawning areas, or otherwise in support of resources, fisheries, and ecological services in other ecosystems.
Information	Coral reef ecosystems providing values associated with gaining and sharing information–that is, the non-extractive, "discovery," aspects of research and education, and the values associated with the consequential development and production of marine natural products.
Biodiversity	Coral reef ecosystems providing values associated with varied genetic resources.

Location of Activities

Table 1 presents the size and locations of western Pacific domestic coral reef ecosystems (coral reefs located in waters between 0 and 50 fathoms in depth), as well as the portions which would be included within the proposed FMP management area (those coral reefs located between 0 and 50 fathoms in depth and between 3 and 200 miles from shore).

Table 1. Domestic Coral Reef Areas of the Western Pacific Region

Location	Total coral reef area (km^2)	Coral reef area between 0-3 miles from shore (percent of total)	Coral reef area between 3-200 miles from shore (percent of total)
American Samoa	296	271 (92%)	25 (8%)
Guam	179	69 (39%)	110 (61%)
Hawaii			
Main Hawaiian Islands	2,535	1,655 (65%)	880 (35%)
Northwestern Hawaiian Islands	11,554	2,430 (21%)	9,124 (79%)
Commonwealth of the Northern Marina Islands	579	45 (8%)	534 (92%)
Remote US Pacific Islands	709	620 (87%)	89 (13%)
TOTAL	15,852	5,090 (32%)	10,762 (68%)

Source: Hunter, 1995.

Overall, 68 % of domestic western Pacific coral reefs would be managed under this FMP, however the distribution of reefs between local and federal authorities varies dramatically by area.

Volume II of the FMP provides a summary of the known historical and present uses of domestic coral reefs. Table 2 is a summary of the approximate, recent, total annual ex-vessel values for each of the domestic marine fisheries of the Western Pacific Region's island groups. The focus is on fisheries for coral reef resources (coral reef MUS taken from 0-50 fathoms), but rough estimates of the deep bottom and pelagic fisheries are also provided, both for comparison and because they may be affected by the management measures. Values presented are for the total value (in 1999 dollars) of landings from each area, as well as for the portion located in the proposed FMP management area. Ex-vessel values are the estimated total annual gross value of landings from each fishery, whether sold or not. The ex-vessel values for the sport sectors are the charter fees; the value of the landings in the sport fisheries are included in the food sector. The details behind these values, including the volume of landings on which they are based, are provided for each of the island groups in Tables 3 through 8. The uncertainty associated with these estimates is variable and in some cases quite high; refer to Section 4 for data sources, assumptions, qualifiers, and the periods upon which the estimates are based.

Table 2. Summary of Fisheries Annual Ex-vessel Value ($1,000/year)

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

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

Table 3. American Samoa Fisheries by Area : Annual Volume and Ex-vessel Value

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

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

Table 4. Northern Mariana Islands Fisheries by Area: Annual Volume and Ex-vessel Value

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

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

Table 5. Guam Fisheries by Area: Annual Volume and Ex-vessel Value

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

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

Table 6. Main Hawaiian Islands Fisheries by Area: Annual Volume and Ex-vessel Value

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

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

Table 7. Northwestern Hawaiian Islands Fisheries by Area: Volume and Ex-vessel Value

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

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

Table 8. Other Islands Fisheries by Area: Annual Volume and Ex-vessel Value

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

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

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

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

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

1.6 Economic Analysis of Existing Coral Reef Ecosystem Resources and Processes

1.6.1 Analytical Approach

Fishery and Non-fishery Values:

The management measures of the FMP will, as recognized in the plan's ecosystem-based approach, affect not just the value of the federal coral reef fisheries directly being managed, but also adjacent coral reef fisheries (e.g., in state and territorial waters), other types of fisheries (e.g., pelagic and deep bottom), and reef-dependent non-fishery uses and values, such as tourism. A comprehensive benefit-cost analysis of the proposed measures would therefore require detailed determination of the physical processes connecting these aspects of the coral reef ecosystem and the effects of harvesting on these connections and processes, as well as assessments of the value of all these sectors and the changes that might be caused by harvesting and/or regulation. In concept that has been done here, but because of deficiencies in available data and methods, the assessment is only qualitative for many sectors, with specification of some quantitative ranges of plausible values derived from available data and studies in other parts of the world.

Notwithstanding the limitations of this assessment in providing accurate measures of the net value of the affected sectors, the valuation estimates should be useful in making comparisons among alternatives as well as between fishery and non-fishery uses of the coral reef ecosystem. Most importantly, they will give an idea of how much value is potentially "on the line" under the various management measures being discussed.

National Versus Foreign Benefits:

In this analysis, we are interested only in how the proposed management measures affect the national account, i.e., the value to the United States as a whole. If the catch is exported and consumed outside the US, the consumer surplus is not accruing to the national account and should be omitted from the assessment. Similarly, if foreign visitors in the US are enjoying producer surplus (e.g., as commercial fishermen) or consumer surplus (e.g., as visiting anglers), those components should be omitted from the assessment.

It should be kept in mind that while the generation of producer or consumer surplus outside the national account is not relevant in terms of assessing net economic value, it can be very important in terms of indirect economic impacts. The expenditures of foreign tourists that hire charter fishing services in Hawaii, for example, may bring great indirect economic benefits to the local economy, and the consumer surplus these anglers enjoy through fishing is, of course, an important motivation for them to visit the US and make those expenditures.

Net Present Value:

Impacts to net economic value are generally described in terms of how the total future stream of net benefits is affected. Net present value (NPV) is the measure of that stream of future net benefits (time-discounted benefits minus costs over time). It is the time-discounted (through use of a standard discount rate) sum of all future benefits less the discounted sum of all future costs. The alternative that yields the greatest NPV would be the preferred one, subject to other considerations such as indirect economic and social impacts and conflicting national standards (e.g., application of the Endangered Species Act). Estimates of NPV require projections of how the fishery and other harvesting activities will evolve. In most of the sectors affected by this FMP – and in particular for the non-fishery sectors, many of which are undeveloped or even unknown – this is difficult, requiring in a number of cases reasonable conjecture. The task is further confounded by the lack of information about even the current (annual) net value of some affected sectors, and by limitations in valuation methodologies. In short, it will not be possible to quantitatively estimate the NPV of most affected sectors under either the with- or without-action alternatives. Therefore, the analysis instead focuses on whether the impacts to the total NPV under a given alternative are likely to be positive or negative. The impacts of various alternatives will then be qualitatively compared in terms of direction and relative magnitude of impacts to provide a simple benefit-cost analysis of alternate management regimes.

In order to provide points of reference – for example, to roughly compare values among affected economic sectors, some measures of the possible bounds of net benefits will be made. Net economic benefit is the sum of producer surplus and consumer surplus, less any public inputs such as management costs. In the case of a commercial fishery, producer surplus is equal to net returns from the fishery: ex-vessel value less all input costs (all harvesting costs, including labor). Consumer surplus in a commercial fishery is the net benefit of the product to consumers, i.e., their demand for the product less the purchase cost, summed across all consumers. In the case of a recreational fishery, consumer surplus is the net benefit to anglers, i.e., their willingness-to-pay to fish less the costs incurred in angling, summed across all anglers. If the angler is hiring charter services, the fishery may also generate producer surplus, equal to net charter revenues: charter fees less the costs

of operating the charter. There may also be consumer surplus in the charter boat case, i.e., the economic utility to the charter patron above the price he/she has to pay for the charter. In the case of subsistence fisheries, producer surplus and consumer surplus are one and the same, and they can be measured as willingness-to-pay less the cost of all fishery inputs.

In addition to these generally measurable benefits and costs, there are less direct and more difficult to measure values that should be accounted for. For example, just as purely recreational fishermen derive non-market values from fishing, many commercial fishermen do, as well. The social values of fisheries should also be accounted for in net value. Another important source of economic value is option value, which reflects the economic importance of keeping future options open – of not making irreversible commitments or changes to the resource. There is also what might be termed reverse-option value, the foreclosing of investment and other use opportunities in the near-term through overly-restrictive regulation. While options to engage in these types of activities may exist in the future (subject to natural changes in the environment, subsequent catastrophic natural or human events, etc.), the net present value of those options is reduced to the extent that they are pushed into the future.

Another type of value derived from fish populations, reef systems, etc. is existence value–the value derived by people who do not fish and do not consume fish, but who benefit from knowing that they have the opportunity to do so, or from the vicarious enjoyment of other peoples' fishing and consumption. For example, few people fish at the remote island of Midway, but many more anglers benefit from the fishery, as evidenced by the number of fishing magazines that feature articles on Midway. Existence value can clearly be affected by the management measures (e.g., negatively through direct closure of a fishery or positively through prevention of stock depletion that leads to the loss of harvesting opportunities). It should therefore be assessed as part of the net value of the fishery.

Furthermore, it is not just the value of traditional or developing fisheries that need to be assessed, but also other types of commercial exploitation of the coral reef ecosystem (e.g., aquarium fish collection, mariculture, and bio-prospecting), as well as reef-dependent non-fishery uses and values. Because this FMP addresses a range of effects on coral reef systems that have not been systematically analyzed in the fisheries literature or have only begun to be considered (either analytically or commercially), such as bio-prospecting, some of the discussion of economic impacts is hypothetical.

Finally, economic analysis usually requires a clear delineation of the physical and operational impact of an activity on the subsequent flow of economic resources from the affected natural resource asset (in this case, the coral reef ecosystem). Unfortunately the natural inter-relationships between particular components of the coral reef ecosystem are not well determined, at least quantitatively. As a result, it is frequently difficult or impossible to indicate to what extent the removal of a particular amount of a particular species will have on the surrounding ecosystem, and what effect, if any, that impact will have on economic values. It is relatively easy to identify the impact of regulation on the operation of existing harvesters, but less so on future operations. As a result, much of the regulatory impact review (and subsequent regulatory flexibility analysis) must take place at the level of principles, rather than quantities. This qualitative description of effects, or potential

effects, nonetheless should provide decision-makers with insights into the economic effects of the proposed management measures and their alternatives.

Time Scales:

Some non-fishery values are highly dependent on coral reefs being alive, diverse, and/or productive, while others rely more on the reef's fundamental structure – the reef as a well-placed mass of limestone. For example, in terms of protecting coastal property and providing calm waters for recreational water craft and shore-side activities, as long as the structure of the reef deflects waves and provides sandy beaches and lagoon bottoms, the values from these uses will remain high. A reef would have to be highly degraded before these values are affected – its physical structure would have to be substantially reduced. However, fishing-out a spawning aggregation of groupers or killing large areas of coral with cyanide can occur in just a year or two, and the consequent impacts to the value of scuba diving, for example, can be immediate and substantial. Thus, in terms of assessing the impacts of the fishery management measures proposed in the FMP, the time scales over which biological and ecological impacts are likely to occur are therefore very important.

Given that we as a society discount future benefits and costs substantially, any impacts that occur more than 20 to 50 years in the future are practically inconsequential in terms of present value. Society's annual discount rate is generally considered to be between 5 and 20 percent (this analysis has used a 7 percent rate). Even at a conservative discount rate of 5 percent, the difference in the present value of an activity over a 50 year time period versus a 100 year time period is only 9 percent. At a 10 percent discount rate, the difference is less than 1 percent. Clearly, assessments of NPV are sensitive to assumptions concerning the rates at which impacts occur.

Discount Rate, Time Horizon, and Inflation:

Where NPV is estimated, it is done by applying an annual discount rate of seven percent, following US government guidance (OMB 1992), and a time horizon of 25 years. Where there is reference in this analysis to NPV estimates from other studies, those estimates have been adjusted using seven percent and 25 years in order to facilitate comparison.

Except where otherwise noted, dollar figures have been inflation-adjusted to 1999 dollars using consumer price indices (CPI). Hawaii, American Samoa, and Pacific-wide values have been adjusted with the urban CPI for Honolulu (DBEDT, no date). Guam and the CNMI values have been adjusted with the Guam CPI (GDC, 1999). All others will be adjusted with the US city average CPI (BLS, 1999).

Measuring Producer and Consumer Surplus in Fisheries:

Pooley (1993b:93) notes that "...the distinction between 'commercial,' and 'recreational and subsistence' fishing in Hawaii is a weak [one]," and the same is true throughout the US Pacific Islands. The coastal fisheries of the region are dominated, at least in terms of numbers of fishermen, by small-scale, part-time fishermen that have variously mixed motivations to fish. They derive benefits as both producers and consumers–that is, consumers of both seafood and enjoyment. Even purely commercial fishermen may derive some enjoyment, or consumer surplus, from fishing, above

and beyond that reflected in their net revenues. In fact, for the purposes of this analysis there is no need to categorize fisheries as being commercial, recreational, or subsistence, as long as all aspects of both producer and consumer surplus in each fishery are accounted for. Such comprehensive accounting is a difficult challenge in any fishery, let alone the fisheries of the US Pacific Islands. Data from the region on landings alone are often incomplete, unreliable, and/or not sufficiently disaggregated by species, area, or harvesting sector. Data on prices and gross revenues are available for many fisheries, but data on harvesting costs are rare, as are assessments of non-market values (e.g., willingness-to-pay to fish or to consume seafood).

For two reasons–the mixed and highly variable motivations among participants in the fishery and the lack of economic data–the net economic value of the affected fisheries is not rigorously assessed here. Instead, quantified assessments have been done only on the elements of net economic value for which data are available–the ex-vessel value of the catch, and management costs. Both commercial and non-commercial catches are valued using prevailing ex-vessel prices. Charter fee revenues are considered the ex-vessel value of charter sport fisheries (the value of charter landings is assessed separately within the "food" fisheries).

Ex-vessel value can be viewed as the absolute upper bound to producer surplus. Producer surplus, however, is often less than zero. For example, the small-boat fishermen in Hawaii called "expense fishermen" by Hamilton and Huffman (1997) sell part of their catch to offset fishing expenses, but their expenses still outweigh their revenues. Their motivations are clearly a mix of recreation and commerce, and probably subsistence, as well. However, these fishermen are undoubtedly receiving enough consumer surplus (e.g., enjoyment) to offset that negative, and the net value of such a fishery can reasonably be assumed to be greater than zero.

The consumer surplus that accrues to fishermen is not estimated here, but because of the obvious problems with relying on ex-vessel value as an indicator of net value, the estimates of ex-vessel value will be supplemented with descriptions of possible ranges of fishermen's consumer surplus. Reviews of non-market valuations of consumer surplus from other fisheries are provided where possible, but extrapolation from one socio-economic and natural setting to another is in general not advised.

Allocation of Costs and Benefits:

A distinction must be made between the coral reef fisheries (resources) that would fall under this FMP's primary jurisdiction and those that would not–that is, those in territorial waters and those managed under other FMPs, including lobsters, precious corals, and most commercial bottomfish species. Most harvesting of coral reef resources takes place in territorial waters which would not be subject to the management measures, but the federal/state boundary (much less the 50 fathom contour line), is not a practical one for most fishermen nor for the various government agencies that monitor fisheries. Existing catch and effort data are therefore not easy to sort by federal versus state waters, and dividing the economic values of the fisheries between the two components is not easy. This analysis includes estimates of the total landings and value for each coral reef fishery sector and for the "FMP portion" of the total, the latter being that portion of the total coral reef resources that are derived from federal waters and that would be subject to the FMP.

1.6.2 Net Present Value of Coral Reef Fishery Sectors

Concepts and techniques for valuing coral reefs and other ecosystems have developed greatly in the last decade. The main application of valuation techniques has been for the purpose of measuring the actual (e.g., in the case of a vessel grounding) or projected (e.g., in the case of this FMP) impacts to the net value of a specific area of coral reef. Most approaches have involved identification of all the values associated with coral reefs, and to the extent possible, quantification of them. Direct uses that have markets, such as fisheries, can be assessed using market values. Indirect uses and values that have no markets can be assessed using contingent valuation techniques that measure consumer surplus–basically polling people to determine what they would be willing to pay to not lose a given resource. This method is very dependent on which and how many people are polled, and what questions they are asked. It is also dependent on the information people have–if they do not have an understanding of the actual or potential values that can be derived from the genetic material of coral reefs, for example, they cannot be expected to place a reasonable value on those resources. The calculation of replacement cost is another method which can also be used to estimate the value of a particular product, function, or service provided by reefs.

Discussed below are the many products, functions, and services provided by coral reef ecosystems, including the extractive fisheries to be managed by this FMP. It should be kept in mind that some values of coral reefs are partially or wholly mutually exclusive, so the values identified below are not necessarily additive. Mining of corals, for example, is likely to detrimentally impact other values of the reef.

Over-valuation can also occur through double-counting particular values–once inside the "coral reef" sector and again, at least implicitly, outside the sector (Costanza *et al.* 1997). Spurgeon (1992), for example, suggested that the value of coral reefs includes the mineral and pelagic fisheries values associated with increased property rights to coastal states afforded by the UN Convention on the Law of the Sea. The convention allows coastal states to make certain claims to marine resources 200 miles not just from shore, but from exposed reefs up to 12 miles from shore. "By increasing the extent of coastal zones, these reefs can be responsible for significant economic benefits" (*ibid*:533). Clearly these provisions affect the distribution of benefits among countries, and they may in fact increase total available benefits if they lead to more effective management. To attribute any such increase in benefits to the coral reefs themselves is a bit dangerous. It would be equally justifiable to attribute any increased value to the negotiators of the convention as to the reefs.

In an assessment of the world's natural capital and ecosystem services, Costanza *et al.* (1997) emphasized the interdependence of ecosystems and their services, and suggested that the next logical step in valuing ecosystem services would be the development of "general equilibrium" models to replace the typical approach of treating each ecosystem and each service independently and then summing their values. In other words, although this analysis is based on an ecosystem-based approach to valuation (as the entire FMP is based on an ecosystem-based approach to management), it may run into the same types of problems as a species-based approach, only at a more general level.

Another problem in valuing the total value of ecosystems is that ecological services tend to have much different supply and demand curves than products and services with markets. As described in Costanza *et al.* (1997), essential ecosystem services, such as clean air, are substitutable only up

to a point. Demand will approach infinity as supply approaches zero, so consumer surplus and total value approach infinity, as well.

In sum, assessment of the values of coral reef ecosystems is complex and problematic. This analysis is mostly limited to a qualitative discussion of the various types of values associated with coral reefs, supplemented with examples of valuations made elsewhere. Certain reef-associated sectors, primarily the fishery and tourism sectors, are treated more thoroughly, with quantitative assessments based on market values and contingent valuation studies.

Producer and Consumer Surplus to Fishermen:

Meyer (1987) examined in 1986 the motivations, revenues, costs, and non-market values associated with part-time resident boat fishermen of Hawaii (fishermen who did not make their primary living from commercial fishing). He estimated that the state-wide ex-vessel revenues from fish sales by this fleet of about $35 million (all values have been updated to 1999 dollars) were almost equal to estimated fishing inputs (about $38 million). The non-market benefits that accrued to the boat fishermen in addition to their sale revenues, however, were estimated through interviews with members of various fishing clubs to reach about $378 million. This estimate was based on the fishermen's assessment of the "fair" value, over costs, of an hour of fishing, and they were prompted to compare that value with the value of their time when working–their wage rate. The resulting average hourly non-market value of fishing ($31/hour) was about equal to the average wage rate of the fishermen ($32/hour). In other words, the fishermen were willing to pay to fish at a rate about equal to what they received to work at their regular jobs. This figure may be unrealistically high, in part because of the small time scale over which it was assessed (one hour rather than one day, month, or year), and because of the prompting to compare it with the value of their labor.

These estimates are not equivalent to the willingness-to-pay (WTP) approach discussed earlier concerning the estimation of consumer surplus in non-market circumstances. It perhaps represents a "willingness-to-accept compensation" for the loss of their fishing opportunities, which for a variety of economic and theoretical psychological reasons might deviate rather considerably from the WTP approach. Still, it is clear that the ex-vessel reported commercial value of the catch–estimated in Meyer (1987) to be equivalent to about 10 percent of the non-market value–is a poor indicator of the net economic value of the fishery–at least for Hawaii's "recreational" fleet.

Charter fisheries have also been assessed for the surplus values they generate for anglers. Samples and Schug (1985) estimated the consumer surplus of Hawaii's charter fishing patrons to be $95 per angler-trip (again, all values have been updated to 1999 dollars), equal to about half the charter fees paid. The study focused on the troll charter fishery that dominates the industry, and found that willingness-to-pay was strongly influenced by the probability of landing a blue marlin. It is doubtful the results are applicable to coral reef charter fisheries. Charter fisheries for coral reef species are generally of two types. In Guam and Saipan, the larger market is for generally inexperienced anglers making short trips on large party boats, fishing shallow bottoms with baited hooks. The still-developing charter fishery on Midway, in contrast, attracts experienced anglers that fish for several days with various methods, including spin-casting on the reef and sand flats and trolling for big game fish. Charter fees in the latter type of fishery are much greater than in the party boat fishery, and the potential for generating large consumer surpluses is probably also greater.

In order to generate a plausible range of fishermen's consumer surplus of the region's current coral reef fisheries, some simple assumptions have been applied. It should be emphasized that these assumptions are quite speculative, and when combined with the already tenuous assumptions used in estimating the volume of landings and charter trips, the results are useful for little more than illustrative purposes. The assumptions follow and the results are shown in Table 9.

Assumptions:

All coral reef food and ornamental fisheries generate some non-market value to fishermen–they all have a recreational aspect.

Recent average annual fisheries volumes are as estimated in Tables 2 through 9.

The average catch rate in the food fisheries is five pounds per hour fished (derived from data in Dalzell *et al.* 1996), and in the ornamental fisheries, five pieces per hour fished.

The non-market value to fishermen in the food and ornamental fisheries, measured as a surplus (i.e., willingness to pay above and beyond actual costs), is assessed under "low" and "high" scenarios, with fishermen's consumer surplus estimated as a percentage of the prevailing average wage rate:

1) in the low scenario, 20% of the wage rate;
2) in the high scenario, 100% of the wage rate.

The prevailing average private sector wage rates are $5/hr in American Samoa, $7/hr in the CNMI (citizens only), $9/hr in Guam (Bank of Hawaii 1997 a, b, and c), and $10/hr in Hawaii and the unincorporated islands (the recreational fishermen studied by Meyer (1987) had much higher-than-average wage rates).

Angler's consumer surplus in the charter coral reef fisheries is assessed under low and high scenarios:

1) in the low scenario, $25/angler-trip in Hawaii (including Midway) and $5/angler-trip in the other islands (about 1/6 the charter fees);
2) in the high scenario, $100/angler-trip in Hawaii and $20/angler-trip in the other islands (about 2/3 the charter fees).

Table 9. Consumer Surplus to Coral Reef Fishermen ($1,000/year)

	Am. Samoa	CNMI	Guam	MHI	NWHI	Other islands	All islands
Food	68 to 342	139 to 693	149 to 743	2,000 to 10,000	106 to 530	4 to 21	**2,466 to 12,329**
Sport	min	8 to 32	51 to 204	10 to 50	8 to 38	0	**77 to 324**
Ornamentals	1 to 5	min	9 to 43	173 to 866	0	0	**183 to 914**
TOTAL	**69 to 347**	**147 to 725**	**209 to 990**	**2,183 to 10,916**	**114 to 568**	**4 to 21**	**2,726 to 13,567**

Based on the assumptions made above, a plausible range of the total consumer surplus that accrues to coral reef fishermen in the US Pacific Islands is $3 to $14 million per year. Assuming no change in the future, this implies a present value of $32 to $158 million (7% discount rate over 25 years).

Management Costs:

The annual management costs for the coral reef fisheries of each of the island groups are presented in Table 10. The estimates are based on data for the years 1997-1999. They include funds spent through the Sportfish Restoration Program administered by the US Fish and Wildlife Service, the Western Pacific Fishery Information Network, administered by the National Marine Fisheries Service, and funds administered by state and territorial fisheries agencies. The estimates are necessarily rough for several reasons. First, it was difficult to distinguish some management costs by fishery–that is, separating the coral reef, pelagic, deep bottom, and freshwater components of management costs. Second, it was difficult to obtain information on state and territorial spending. Third, it was difficult to distinguish spending on fisheries "management" from spending on fisheries "development." In general, funds spent on surveys and monitoring, research, rule-making, and enforcement, and a portion of funds spent on education and outreach, were considered management costs.

Table 10. Current Annual Coral Reef Fishery Management Costs ($1,000/year)

American Samoa	CNMI	Guam	MHI	NWHI	Other islands	All islands
500	330	500	1,520	230	0	**3,080**

Estimates are derived from 1997-1999 grant data from the US Fish and Wildlife Service (Sportfish Restoration Program), 1997-1999 grant and budget data from the National Marine Fisheries Service (Western Pacific Fisheries Information Network), and estimates of spending by local sources. The division in costs between the Main and Northwestern Hawaiian islands is not an actual division in spending; it is simply the total costs in Hawaii divided according to the ex-vessel value of the fishery, as estimated above.

The estimated total of $3.1 million in management costs is conservative because there are additional federal funding sources for fisheries management that were not accounted for. Funds spent by coastal management and environmental agencies, some of which contribute to coral reef fisheries management, were not included. Funds spent by the US Fish and Wildlife Service in managing the Wildlife Refuges were not included. Funds spent by the WPRFMC on the crustacean, bottom fish, and precious coral fisheries were not included. Funds spent through other grant programs administered by the National Marine Fisheries Service (mostly for fisheries development) were not included.

Based on Table 10, more than half the spending on management was in or for Hawaii, and the rest fairly evenly distributed among American Samoa, the CNMI, and Guam. Using the ex-vessel value estimates from Table 2, management costs in Hawaii were equal to about 15 percent of the ex-vessel value of coral reef fisheries. In American Samoa, they were equal to about 73 percent of ex-vessel value, in Guam, about 32 percent, in the CNMI, about 25 percent, and overall, about 20 percent.

Net Present Value Given Current Conditions:

The annual ex-vessel value of the region's coral reef fisheries was estimated at $15 million. If these fisheries are like most, those revenues were almost, or more than, offset by fishing costs, which were not directly assessed here. A plausible range of the non-market value, or consumer surplus, that accrued to fishermen was estimated at $3 to $14 million per year. Public inputs into management were estimated to be about $3 million per year. If ex-vessel value is assumed to be completely offset by fishing costs, and the surplus to seafood consumers is assumed to be relatively small (e.g., $1 to $3 million per year), these figures suggest a net value of $0 to $15 million per year. If unchanged in the future, this would imply a net present value of $0 to $175 million (assuming a 7 percent discount rate over a 25 year horizon).

Net Present Value Given Likely Future Developments:

It is not possible to accurately project how the region's coral reef fisheries would develop in the no-action scenario. However, some general discussion about possible courses of fishery development is necessary in order to better characterize the no-action alternative and to compare the likely cost-effectiveness of the various management alternatives.

Most current harvesting of coral reef resources is for food; the biological yields and per-unit values of ornamentals, sport catches (which can be released), and marine natural products are less well known and more variable. More importantly, net value, not gross value, is generally the parameter of interest. One of the most important fishing cost items is travel to and from the fishing grounds. Fishing pressure is close to zero at many of the region's reefs because travel costs are prohibitive. Relatively high gross values would have to be available to justify travel to the more remote reefs. Lobster and deep bottom fishing in the

Northwestern Hawaiian Islands and sportfishing at Midway are good examples of such high value (and high cost) fisheries. The per-unit gross values of lobster and deep bottom fish are relatively high. The relatively high angler surplus available from fishing the relatively pristine reefs of Midway, combined with the availability of a landing strip and shore-side support facilities, make the generation of net benefits from sportfishing feasible.

Government restrictions are also important determinants of where and what type of harvesting is likely to develop. Inshore sportfishing at Midway, for example, could not have developed without the US Fish and Wildlife Service relaxing its restrictions on harvesting in the wildlife refuge. Tighter restrictions in territorial waters, technological innovations that would reduce costs for long distance harvesting, or decreased productivity in territorial waters would also tend to increase the feasibility of harvesting in more distant federal waters.

Following are profiles of several possible scenarios of future developments. It is emphasized that the main purpose of the FMP is to anticipate and control such changes. The scenarios include development of a live reef fish fishery, which would most likely occur in the remote islands of the CNMI, expansion of the ornamentals fishery, most likely in the Northwestern Hawaiian Islands or the remote islands and reefs of the CNMI, and development of bioprospecting activities. Another possibility is development of coral reef sportfishing at Palmyra, Wake, or Kingman, where access by air is possible, as at Midway.

Distant Finfish and Live Finfish:

The remote northern islands of the CNMI have been intermittently exploited for reef fish and deep bottom fish. Growth in the CNMI's resident and tourism populations will influence the attractiveness of those fishing grounds to supply product for the local market. The high value Asian market for live reef fish may also drive development of fisheries into areas within reasonable reach by ship or with cost-effective air freight costs. Well-financed harvesting and transport operations based in Asia have conducted profitable harvesting in many remote areas of the Pacific, many of them apparently only cost-effective because they are able to move on to new and more productive fishing grounds at any time.

Ornamentals:

Ornamentals are currently being collected only on reefs within easy reach of ports and shorelines. The Northwestern Hawaiian Islands may have a relatively great abundance of high-value species, but so far their collection does not appear cost-effective relative to working in the main islands. Increases in prices of increasingly regulated species and products, such as live rock, could increase the motivation to fish in federal waters and on remote reefs.

Sportfishing:

Palmyra, Wake, and Kingman (via Palmyra) may have the potential for tourism development, including sportfishing similar to what is done at Midway (see EIS). After three years of opening to the public, Midway is attracting about 250 fishermen and divers per year. The potential for growth of these types of operations, either on Midway or other islands, is not known.

Natural Products:

Bioprospecting could develop almost anywhere that locally endemic species are found. Given the 16,000 km^2 of coral reef in the region (Hunter 1995), the estimate of food fish landings made here (6.5 million pounds) implies a per-unit-area yield of about 430 lb/km^2-yr, or about 0.2 mt/km^2-yr. Yields were, of course, much higher in localized areas, and the 0-3 mile zone had higher yields than the reefs in federal waters. Dalzell and Adams (1997), for example, reported about the same level of annual landings for American Samoa (176mt) as estimated here (155mt), but identified the catch as coming from only 25 km^2, implying a yield of 7 mt/km^2-yr. When measured against the 270 km^2 of the whole of Tutuila (Hunter 1995), the yield would be only 0.7 mt/km^2-yr.

Munro and Williams (1985) suggested an average worldwide maximum sustainable yield of coral reef organisms of 15 mt/km^2-yr. This is in good agreement with a tentative estimate by Dalzell and Adams (1997), who applied what they emphasized to be an overly simple surplus production model. The model was fitted with yield estimates from various Pacific Islands (ranging from 0.3 to 64 mt/km^2-yr) and with human population per unit area of reef (ranging from 3 to 3,000 $people/km^2$) as a proxy for fishing effort. The model predicted a maximum sustainable yield of 16 mt/km^2-yr. The current yield from the US Pacific Island coral reefs is only about one percent of these estimates. Even in localized areas of relatively heavy fishing, such as around Guam and Tutuila, the yields appear to be well below these levels, consistent with the general belief that they are overfished (see body of FMP, and Green 1997). Dalzell and Adams (1997) reported recent yields from Guam and Tutuila to be 0.8 and 7.0 mt/km^2-yr, respectively, although a 1982 estimate from Tutuila that was based on only 3.6 km^2 of reef estimated a yield of 17.0 mt/km^2-yr (Wass 1982).

1.6.3 Net Present Value of Coral Reef Non-fishery Sectors

Tourism:

Coral reef-based tourism is very important in many countries. In the US Pacific Islands, it is especially important in Hawaii, Guam, and the CNMI. Scuba diving and snorkeling are two of the most obvious reef-dependent tourism activities. Others include underwater observatories, such as in Guam and glass-bottom boat tours. Activities that are partially

dependent on the protected lagoons formed by reefs include swimming, jet skiing, other small water craft activities, and all the beach and shoreline activities that coral reef ecosystems attract. The aesthetic qualities of coral reefs and lagoons as viewed from the shore are also important to tourists.

Some of these uses compete with and compromise other values. Scuba divers and snorkelers, for example can degrade reefs through physical contact. Jet skis have caused dramatic changes to localized areas of substrate in Guam.

There is a varying degree of dependence on coral reefs among these uses. The attraction of a reef to scuba divers and snorkelers, for example, depends on its aesthetic qualities, which are determined in large part by the complexity, diversity, vivacity, and density of its corals, fishes, and other organisms, as well as the degree of human congestion in the water. In general, the less degraded the reef, the higher the value, although proximity to tourist centers is critical. Other uses and values, such as personal water craft activities, shore-side tourism and recreation activities, and breakwater values, are much less dependent on the quality of the reef ecosystem per se (unless a degraded reef leads to increased siltage, intrusive sea grasses, etc.).

Net economic value from tourism includes the producer surplus that accrues to providers of tourism services (e.g., dive boat operators) and the consumer surplus that accrues to tourists. Some of what would otherwise be consumer surplus is often transferred to the public's producer surplus through the imposition of fees, such as entrance fees for parks.

An economic assessment of the value of Bonaire, in the Caribbean Sea, was done in 1991 (Dixon *et al.* 1994). The entire marine area surrounding Bonaire, to a depth of 60 meters, is a marine park, managed primarily for diving. The island economy is almost entirely dependent on tourism, which is centered around diving. A survey of visiting scuba divers revealed an average willingness-to-pay to visit the park of about $33 (all values have been updated to 1999 dollars), above and beyond actual costs. Applying a per capita consumer surplus of $33 to the approximately 17,000 divers visiting each year yields a total annual consumer surplus of about $561,000 (in fact, $207,000 was transferred to producer surplus through a visitor fee). Most diving, of course, takes place in a relatively small portion of the island's reefs. But an appropriate measure of value per unit area can be estimated by dividing the total consumer surplus by the island's total reef area. With roughly 100 km of coastline, and assuming an average reef width of 1 km, annual divers' consumer surplus totaled roughly $5,600/km^2 of coral reef. Based again on a 7 percent discount rate over a 25 year time period, this yields a net present value of about $0.07/m^2 .

In an assessment of a small developed coastal tourism area in Sri Lanka (with a fringing reef of about 0.25 km^2), the producer surplus from tourism was estimated at $156,000/km^2-yr, and

the consumer surplus of tourists at $223,000/km^2-yr (1999$) (Berg, *et al.,* 1998). Discounted at 7 percent over 25 years, this yields a net present value of $4.40/m^2.

In a study of dive and snorkel-based tourism in West Lombok, Indonesia, Riopelle (1995) estimated the net present value (producer surplus only) of diving and snorkeling on the local reefs to total about $33 million (adjusted from the author's 10 percent to a 7 percent discount rate), or about $760,000 per km of coastline. Derived from the profits on expenditures by 19,000 visiting divers and 50,000 snorkelers, this is equivalent to a producer surplus of $41 per visitor. West Lombok was described as having "major tourism potential," but still considerably less than other Indonesian locales, including Bali. It was suggested that a linear km of coastline is roughly equivalent to about one square km of coral reef, so the range of net present value from coral reef-related tourism in Indonesia, encompassing the "no tourism" and "major tourism" situations, was $0 to $1.40/m^2 (1999$; adjusted from a discount rate of 10% to 7%; over a 25 year time period; derived from Cesar, 1996).

In the U.S. Pacific Islands, dive and snorkel-based tourism is a small percentage of overall tourism activity. As a result, the economic values given above should not be extrapolated to the reef coastlines adjacent to the major tourist areas (e.g., Waikiki on Oahu or Tumon Bay in Agana), and even less so should they be extrapolated to distant reef areas (e.g., the Northwestern Hawaiian Islands or the northern part of CNMI). Indeed, there are legitimate questions about the extent to which under-water tourism can be expanded in any of the heavily inhabited areas given already high levels of shoreline and near-shore recreation by residents. Unfortunately no adequate metric exists of the under-water tourism values in the Western Pacific Region.

Turning to the US Pacific Islands specifically, Table 11 summarizes the tourism activity in each of the island groups.

Table 11. Marine Tourism and Scuba Diving: Annual Economic Activity by Island Group

	American Samoa	CNMI	Guam	Hawai'i	Total
Number of tourists	6,000	600,000	1,300,000	6,800,000	**8,800,000**
No. of tourists primarily "marine"	600	500,000	850,000	4,400,000	**5,750,000**
No. of tourists scuba divers	100	30,000	130,000	75,000	**235,000**
% of tourists American	80	12	5	54	**43**
Expenditures by tourists	$3m	$600m	$1,500m	$10,000m	**$12,100m**
Expenditures by "marine" tourists	$0.3m	$500m	$650m	$6,500m	**$7,650m**
Expenditures by scuba divers	$0.05m	$30m	$150m	$110m	**$290m**
Expenditures on marine recreation				$700m	
Expenditures on scuba diving		$16m		$28m	
Number of scuba dives	500	120,000	500,000	300,000	**920,000**
No. employed in tourism		8,000	20,000	170,000	**198,000**
No. employed in marine recreation				6,200	
No. employed in scuba diving		150		650	
Gov't. revenues from tourism			60% of tot	30% of tot	
Tourism as % of gross local prod.				26	

Data sources and assumptions are given in Section 4.
"m" means million; for example, "$3m" means $3 million.
Expenditures by tourists, by "marine" tourists, and by scuba divers include all local vacation expenditures.

The US Pacific Islands receive almost 9 million tourists each year, most of whom visit for reasons related to marine recreation and the marine environment. However, overall only about three percent of tourists scuba dive, varying between 1 percent in Hawaii and 10 percent in Guam. It is not possible to assess the net economic value of this tourism accurately, but some simple assumptions can be used to provide a plausible range of its net value.

Assumptions:

Producer surplus is between $50 and $200 per visitor-trip (i.e., profits of roughly 5 to 20% on visitor expenditures).

Consumer surplus is between $50 and $200 per visitor-trip (i.e., on average, each visitor would have been willing to pay an additional $50 to $200 for his or her vacation experience).

In Tables 12 and 13 are these assessments for all "marine" tourists, and for scuba divers only. These represent projections based on hypothetical values but they are the best available comprehensive estimates of these economic values at this time and would appear to provide order-of-magnitude estimates.

Table 12. Net Annual Value of Marine-based Tourism

	American Samoa	CNMI	Guam	Hawaii	Total
No. "marine" tourists/year	600	500,000	850,000	4,400,000	**5,751,000**
No. Amer. marine tourists/yr	480	60,000	42,500	2,376,000	**2,479,000**
Total Am. tourists' surplus ($1,000/year)	24 to 96	3,000 to 12,000	2,125 to 8,500	118,800 to 475,200	**123,949 to 495,796**
Total producer surplus ($1,000/year)	30 to 120	25,000 to 100,000	42,500 to 170,000	220,000 to 880,000	**287,530 to 1,150,120**
Net value ($1,000/year)	**54 to 216**	**28,000 to 112,000**	**44,625 to 178,500**	**338,800 to 1,355,200**	**411,479 to 1,645,916**

Table 13. Net Annual Value of Scuba Dive-based Tourism

	American Samoa	CNMI	Guam	Hawaii	Total
No. of scuba divers/year	100	30,000	130,000	75,000	**235,000**
No. of American divers/year	80	3,600	7,000	41,000	**51,600**
Total Am. divers' surplus ($1,000/year)	4 to 16	180 to 720	350 to 1,400	2,050 to 8,200	**2,584 to 10,336**
Total producer surplus ($1,000/year)	5 to 20	1,500 to 6,000	6,500 to 26,000	3,750 to 15,000	**11,755 to 47,020**
Net value ($1,000/year)	**9 to 36**	**1,680 to 6,720**	**6,850 to 27,400**	**5,800 to 23,200**	**14,339 to 57,356**

These rough assessments of the value of marine-based tourism suggest that the annual net value of marine-based tourism is $0.4 to $1.6 billion, and that scuba diving-based tourism contributes 3 to 4 percent of the total, i.e., $14-58 million. Assuming no change in the future, this implies a net present value of $5 to $19 billion for the discounted value of marine-related tourism in these islands, or $179,000 to $715,000 for scuba and diving-based tourism. Obviously the latter is the most relevant value for determining coral reef ecosystem-related net benefits, although some benefits accrue to the non-diving part of marine tourism.

Most tourism activities, including scuba diving, take place in territorial waters (or in the CNMI, in the "inshore management zone"). Exceptions are in Guam, where divers sometimes visit 11-Mile Bank, and at Midway, where all waters are federal waters. Between 100 and 150 scuba divers are estimated to have visited Midway in each of the last several years (Glover, pers. comm.).

Although tourism in federal waters is currently very limited, there appears to be some likelihood of growth. The tourism enterprise at Midway is only three years old, and will probably grow. Palmyra, Wake, and to a lesser extent, Kingman, may offer similar opportunities. The potential for tourism development in these remote islands, however, is very small compared to current and potential tourism use of the populated islands. Midway receives less than 1,000 visitors each year. However, such tourism can also lead to improved public awareness of these unique natural resources and consequently to improved protection of those resources.

Recreation:

"Recreation" as used here refers to uses by island residents rather than by tourists. The activities and values that bring recreation benefits are more or less the same as those in the tourism category. One difference, as defined here, is that recreation benefits to residents also include the quality of life, cultural, and heritage values associated with living near and in association with the coral reef ecosystem, and any values associated with having a tradition of doing so. Also, even when coral-reef

activities are not directly undertaken, having the option to do so is an important value to many island residents.

In Hawaii in the early 1990s, it was estimated that on a typical busy day, at least 170,000 people (including tourists) were swimming or visiting beaches and shorelines, 23,000 were surfing, 25,000 were fishing, 3,000 were paddling, 18,000 were boating, and others were diving (Clark, 1991).

These activities are clearly very important in the US Pacific Island communities, and participation in reef-associated recreation must be close to 100 percent of resident populations.

It would be very difficult to accurately assess recreation values, and a rigorous assessment will not be made here. But the following scenarios can illustrate a way to think about the value of recreation. The resident population of the US Pacific Islands is about 1.5 million. If every person was willing to pay $10 per year to maintain their reef-related recreation opportunities (in addition to costs already incurred), it would imply a total consumer surplus of reef-associated recreation of $15 million per year. At $1,000 per person, it would be $1.5 billion.

Reef-associated recreation also generates producer surplus. MacDonald *et al.* (1996) estimated expenditures in Hawaii's ocean recreation industry (including expenditures by tourists–already accounted for above) to be $700 to $800 million per year. If profits were 10 percent of expenditures, for example, producer surplus would be $70 to $80 million per year.

However, most reef-associated recreation occurs in territorial rather than federal waters. The economic value of off-shore coral reefs may depend on the "ecological services" provided by these components of the ecosystem, but this contribution is not well known. Exceptions to the off-shore element of this recreational activity include Johnston, Wake, and Midway, where there are small resident populations, and Rose atoll in American Samoa, the northern islands of the CNMI, and the Northwestern Islands of Hawaii, where some visitation by residents occurs. Recreational fishing for tourists is also being developed at Palmyra. There is a modest potential for growth of recreation in these federal waters.

Because recreation values are likely to respond to a given management alternative in a similar way as tourism values, the two sectors will be grouped together in the discussion of impacts in Section 1.7.

Breakwater:

Coral reefs serve as natural breakwaters, deflecting the energy of waves and inhibiting shoreline erosion. Shoreline damage from typhoons has been observed to be less where reefs are broad (Birkeland 1997a). They also provide sheltered waters for navigation, mooring of vessels, and port facilities. They form calm embayments that are valuable for swimmers, snorkelers, and beach-goers, they make surf breaks, and they produce beach sand, all bringing tourism and recreation benefits (but these latter values should not be double-counted with the tourism and recreation values already addressed).

Some of these values can be quantified, such as in localities where reef degradation leads to shoreline erosion and the loss of property with known value. In an assessment of the value of Indonesia's coral reefs, the protective net present value of coral reefs was estimated at $1,110 per km of sparsely populated coastline (about 0.001/m^2 of reef), $0.07/$m^2$ along coastlines with some development (roads and houses), and $1.36/$m^2$ along coastlines with major tourism infrastructure (in 1999 dollars, adjusted from 10% to 7% discount rate, over 25 years) (from Cesar, 1996). Using the same approach in Sri Lanka, the cost of coastal erosion was estimated to be between $0.002/$m^2$ and $2.00/$m^2$, depending on the land use (1999$, 7% discount rate applied over 25 years) (from Berg, *et al.,* 1998).

The cost of replacing the reef with an artificial breakwater could also be used to assess these values. In Sri Lanka, where coral mining has apparently led to coastal erosion, the costs of building preventative revetments, groins, and other breakwaters was estimated to cost between $248,000 and $844,000 per kilometer of shoreline (1999$) (Berg, *et al.*, 1998). Assuming a reef width of one kilometer, these replacement costs would translate to coral reef net present values of $0.25 to $0.84/$m^2$.

The reefs located in federal waters do not, generally, serve as breakwaters for coastlines that are highly developed. They are either on isolated banks or they surround generally undeveloped islands, including Palmyra, Kingman, Baker, Howland, and Jarvis, as well as the more developed islands of Johnston, Wake, and Midway. The value of these reefs as breakwaters, therefore, is derived more from protecting relatively pristine and valuable natural resources rather than protecting recreation areas and developed properties with easily assessed market values. Many of the remote atolls and emergent lands under federal jurisdiction, for example, are important as habitat for seabirds, sea turtles, and the Hawaiian monk seal. Assessing these aspects of the breakwater values of coral reefs would be more difficult than assessments based on market values of developed coastline properties, and it will not be attempted here.

While these breakwater values are clearly very high, it is not clear that any of the FMP management measures would have an impact on them. Impacts to the structure of the reef stemming from overfishing or damage from anchors, gears, and vessels may occur too slowly to be of any consequence in terms of impacts to NPV (see "time scales," above).

Wilkinson *et al.* (1999) assessed the economic impacts of the 1998 coral bleaching event in the Indian Ocean, using an "optimistic scenario" and a "pessimistic scenario." In the latter, damage was assumed to be severe and recovery slow or nonexistent. It was further estimated or assumed that the annual fisheries value would decline by 25 percent after 5 years, and the annual value of coastal protection, tourism, and other services would decline by 50 percent after 10 years. In other words, it was estimated that within 10 years of a near complete die-off of coral, without any direct physical disturbance, the reef would become susceptible to physical and bio-erosion and lose its ability to break waves to the point that half the value of the coastal lands that it protects would be lost.

In an assessment of the value of Sri Lanka's reefs, it was estimated or assumed that the breakwater value of the reef would decrease to zero and the fisheries value would decrease to one fifth after five years of coral mining (for lime production) (Berg *et al.* 1998).

On the scale of thousands of years, the balance between the rates of subsidence, accretion, erosion, and sea level change will determine whether the reef remains near sea level and serves to break waves. But on the scale of tens of years, subsidence is inconsequential and sea level change is perhaps marginally important. Although waves can cause erosion of a reef, they can also cause accretion; which effect will dominate when a reef dies depends on the orientation of the reef and its wave environment, and again, the time scale. In short, it is unclear how quickly the breakwater function of coral reefs can decline, especially for the types of impacts under the control of this FMP–overfishing and damage from vessels, fishing and other harvesting gear, and anchors. For the purposes of this analysis, the impacts of the FMP measures on breakwater values are assumed to be nil, and the breakwater sector is omitted from the discussion of economic impacts in Section 1.7.

Mining:

Many island communities, especially those lacking in terrestrial resources, such as atolls, are dependent on their reefs for construction materials, including blocks, aggregate, and sand. Even before the introduction of heavy machinery, island communities had been for thousands of years removing limestone and live and dead coral heads from their reefs to build jetties, breakwaters, building foundations, and paths. These are, of course, extractive uses, so they may compete with and compromise other values–both fishery and non-fishery. Several measures proposed in the FMP treat the coral reef substrate as either a non-renewable resource or too essential for other values to be worth harvesting or mining.

It is not known how much reef material is being mined from each of the US Pacific Islands.

None of the FMP management measures are projected to have any impact on the value of coral reefs for mining. This sector is therefore omitted from the discussion of economic impacts in Section 1.7.

Ecological Support:

As emphasized above, the coral reef ecosystem is not separable from other ecosystems in terms of function or value. For example, there are important physical and trophic connections between coral reef, mangrove, and pelagic ecosystems. The larvae of many coral reef organisms are pelagic and contribute to the diets of pelagic species like tunas. Many deep bottom fish, including snappers, emperors, and groupers, use coral reef habitat as juveniles.

Coral reefs also play important roles in the global balances of calcium and carbon (Spurgeon, 1992). The global climate affects coral reefs and coral reefs affect the global climate.

It would be very speculative to put a value on these types of roles of coral reefs, and as noted above, there is the problem of determining what portion of the value of, for example, the pelagic ecosystem, is attributable to coral reefs, rather than to the pelagic ecosystem itself, as well as vice versa.

No quantitative estimates of these values will be made here, but likely impacts to these roles of coral reefs are provided in the summary table of impacts.

Information:

This category refers to the benefits to be derived from discovering (research) and sharing (education) information gleaned from coral reefs. Some information leads to applications that are useful for managing the ecosystem itself, including fisheries management. Since those values must be subtracted as costs in the fishery sectors, the more important values to consider here are those that are beneficial beyond understanding and managing coral reefs themselves. The value of using coral reefs to monitor global climate change would be one example. Discoveries that lead to the development of marine natural products, such as pharmaceuticals, are perhaps the most valuable "information" use of coral reefs. Value in this category is largely a function of biodiversity–the greater the diversity, the greater the chance of discovering valuable information.

Most bioprospecting attention is being paid to those organisms that rely on chemical defense mechanisms, including sponges and ascidians, because they are more likely to have novel or complex chemistries. Several coral reef species have been found to have chemistries that led to the development of useful pharmaceutical products, including a gorgonian, a red alga, and an ascidian (Birkeland, 1997a).

The extent of current bioprospecting activities in the US Pacific Islands is not clear. It is difficult to monitor, in part because the people doing the collecting in the water are not bioprospecting, per se, but often doing basic biological research. Specimens or information derived from specimens can pass through several hands before the research has anything to do with the development of marine natural products, although increasingly universities and other research centers are developing entrepreneurial off-shoots to capitalize on their faculty's research efforts.

One example of a well-monitored bioprospecting operation is the one carried out by the US National Institutes of Health. The agency contracts researchers to collect a wide variety of coral reef and other marine species in order to screen their chemistries for possible activity against cancer and AIDS. The Coral Reef Research Foundation, based in Palau, is currently doing the collecting in many areas of the world, primarily in the Indo-Pacific, where marine biodiversity is highest. For any of these agreements, as with other agreements for developing conservation zones or establishing toxic waste dumps, a considerable valuation problem exists for deriving the economic value to the people of the "host" site, both in the present and in the long-term.

It is important to note that the costs associated with research, development, and production of marine natural products can be quite high, leaving relatively little left as net value. Mendohlson and Balick (1995), for example, estimated the potential net value of all yet-to-be discovered rainforest drugs to be $160 billion (1999$), far less than previous estimates that looked only at gross value.

The conventional approach to fisheries net valuation is to assess only the net benefits generated during first phase of the fishery–the harvest phase. All subsequent phases–such as processing–that add value to the product are considered indirect benefits. In the case of marine natural products, very little net value is associated with the harvest, or even research and development phases. Most comes in the ultimate phases–the profits stemming from product sales and consumer surplus. In a study of Korup National Rainforest in Cameroon, it was determined that Cameroon–the owner and supplier of the forest-derived information–would stand to gain only $6,700 per patent for drugs derived from

indigenous plants (1999 dollars) (Ruitenbeck, 1989). Just what portion of the ultimate net benefits stemming from these types of products can be attributed to the information provided by coral reefs is an open question.

It is generally believed that the potential for coral reefs to provide valuable information has barely begun to be tapped. Both the current and potential information values of the coral reefs in the US Pacific Islands are difficult to assess and it will not be attempted here. The likely impacts of the FMP measures to those values, however, are provided in the summary table of impacts.

Biodiversity:

With their great number of species and their variety and complexity of habitats, coral reefs have a high diversity of chemistries and high evolutionary potentials. Rainforests have a greater number of species, but coral reefs have a greater diversity at higher taxonomic levels and a greater diversity of basic body plans and chemistry (Birkeland, 1997a).

Biodiversity on coral reefs is quite variable around the globe and there is a great range among the US Pacific Islands. Coral reef biodiversity among the island groups is compared in the FMP.

There are a range of benefits that are derived from the many forms and species that coral reef ecosystems support (e.g., the value of harvesting, which exploits many species). Even the aesthetic diversity of coral reefs is important, as it provides part of the appeal to divers. The "information" values addressed above include the benefits to be gained from discovering information that leads to the development of valuable products, and it was pointed out that the potential value of that information is a function of biodiversity. All of those values have been addressed in the previous paragraphs. The concept of biodiversity, per se, as having value is really just the maintenance of future options that such diversity provides. These are options that might lead to new extractive fisheries, to the development of marine natural products, or to what are now inconceivable uses or values. The value of biodiversity itself is really just part of option value, discussed below, and will not be considered a separate sector in the analysis of impacts.

Existence Value:

Existence value and option value are very difficult to quantify, but they are undoubtedly important with regard to the impacts of the FMP. Existence value is derived from the knowledge that a particular resource or opportunity to use that resource exists and is available to provide a range of benefits, regardless of whether it is actually used. Impacts to existence value are difficult to assess, in part because different groups are affected differently. For example, regulatory closure of a fishery could negatively impact the existence value enjoyed by anglers while positively impacting the existence value enjoyed by certain conservationists, researchers, or naturalists. While there is a literature on the measurement of existence values, we are aware of none for areas in the Western Pacific Region.

Option Value:

Option value, is, according to Krutilla and Fisher (1995) is, "the value, in addition to consumer surplus, that arises from retaining an option to a good or service for which future demand is uncertain." Retention of that option is lost if a management action (or no action) results in irreversible changes–in this case, to the coral reef ecosystem. For example, if biodiversity on a reef decreases, option value is almost certain to decrease.

A type of value related to, or a subset of, option value is "quasi-option value." This refers to the "benefits of delaying a decision when one of the alternatives involves an irreversible choice and uncertainty exists about the benefits of the alternatives" (Dixon, *et al.*, 1994:109). It can be viewed as the expected value of the information that can be gained by delaying a decision (Conrad, 1980). Both option and quasi-option value are relevant in this analysis because they provide the means to recognize, if not quantify, the values associated with applying the precautionary approach to the management of coral reef fisheries. The rationale for using conservative biological reference points is reflected in option value. The rationale for conservatively controlling entry into a fishery until more information is gathered (e.g., through the permitting measures) is reflected in quasi-option value.

Existence value and option value do not necessarily track together. However, for the sake of simplicity, and because there is not enough information to accurately assess the impact on either one (as will be seen, virtually any management alternative could impact existence and option values either positively or negatively), the two values will be grouped together in the summary table of impacts. In both cases, because the future value of such options would be discounted by the net valuation process, and because the future value is unknown, uncertain, and likely distant into the future, the net present value of these options may be very small.

Holistic Valuations of Coral Reefs:

There have been numerous attempts to assess the total value associated with the many uses and functions that coral reefs provide, many of them done as a result of lawsuits claiming damages to reefs. CFMC (1999) reported that recent court settlements involving ship groundings on Florida's coral reefs averaged $921 per square meter ($m^2$) of damaged or destroyed reef. One assessment of the damage from a ship grounding off the Florida Keys estimated a lost present value of $4,363/$m^2$ (1999$) (Mattson and DeFoor, 1985). A court case in Egypt led to a similar assessment–the government was paid $2,083/$m^2$ (1999$) of damaged coral reef (Spurgeon, 1992). In both cases, the damaged areas were small and in areas important for tourism, so the figures are not necessarily applicable to larger and different areas. Further, the assessments may have been based on potential gross value, so they may exceed net present value. On the other hand, the assessments assumed some degree of regeneration of the reefs and their value during the ensuing years, which would underestimate full present value.

An assessment on a much larger scale was carried out by Cesar (1996), and predictably, the estimated per-unit-area values were much smaller than those in the small-scale assessments described above. The assessment examined Indonesia's coral reefs as a whole, and focused on the values that could most easily be quantified–reef fisheries, coastal protection, and reef-associated

tourism. The quantifiable net present values (actually the "net present loss to society due to destruction...") in those sectors ranged from about \$0.19 to \$1.57/m^2 (1999\$) of coral reef, depending on the level of tourism potential and the degree of coastal construction (i.e., the value of coastal property) (these figures have been adjusted from the study's 10 % discount rate to the 7 % rate used throughout this analysis, over a 25 year time period). Fisheries value was assumed to be the same in both the low and high scenarios. At the low end of the range, fisheries contributed about 80 percent of the value. At the high end of the range, fisheries contributed only about 9 percent, while coastal protection and tourism contributed 47 and 43 percent, respectively (Cesar, 1996).

Costanza *et al.* (1997) assessed the value of all the earth's natural capital and ecosystem services. They identified and assessed the value of each of 17 ecosystem services for each of 16 biomes, of which coral reefs were one. The results were qualified as being tentative and conservative. The total annual value of world's coral reefs was estimated at \$0.68 per m^2 per year (1999\$). The present value would be \$7.47/m^2 (1999\$). Fully half the value was contributed by "recreation" (including tourism) services, followed closely by "disturbance regulation." "Food production" contributed about 4 percent of the total. Values in the authors' categories of "gas regulation," "climate regulation," "nutrient cycling," and "genetic resources" were not assessed or included because of a lack of information. Of eleven biomes for which total values were (tentatively) estimated, coral reefs ranked sixth in terms of per-unit-area value, and tenth in terms of total global value (ahead of cropland).

The range among the assessments described above, \$0.19/m^2 for undeveloped areas of Indonesia to \$4,363/m^2 for a small area in the Florida Keys, covers four orders of magnitude. For assessing the value of large areas, such as the entirety of the coral reefs under the jurisdiction of this FMP, the high end of the range is probably not applicable (at \$4,363/m^2, the 16,000 km^2 of coral reefs in the US Pacific Islands would be worth \$70 trillion). For localized areas where the value of coastal property and tourism are high, however, such figures may be applicable, and may even underestimate NPV.

Summary:

In this analysis, the only quantitative valuations made of the coral reefs of the US Pacific Islands were for fisheries and tourism, and they were very tentative. A first-order estimate of the annual net value of the fisheries was \$0 to \$15 million, which, if unchanged in the future, would imply a net present value of \$0 to \$175 million. A first-order estimate of the annual net value of marine-based tourism was \$400 to \$1,600 million, which, if unchanged in the future, would imply a net present value of \$5 to \$19 billion.

Other reef-dependent sectors, including recreation, the value of reefs as breakwaters, ecological services and information, and existence value and option value, are clearly very important, but they are not quantifiable. These sectors are interconnected (e.g., the reef as a breakwater provides tourism and recreational opportunities) and coral reef ecosystems are interconnected with other ecosystems.

Tables 14 and 15 present a summary of the coral reef valuations of other studies described in the preceding sections, along with the fishery and tourism values assessed here. The findings are described in terms of value per-unit-area. The tables do not include all the types of coral reef values recognized here and in the cited studies. The terms used in the table for value types are not

necessarily the same as those used in the cited studies, and the fits may not be exact (e.g., "breakwater" used for "coastline protection;" "fisheries" used for "food").

A high degree of variability in the assessments is apparent, much of which can be explained by the various scales on which the assessments were done. The smallest assessments had by far the highest values. The results of this study illustrate the correlation, as well. Both the fishery and tourism values were divided by the total area of coral reef in the US Pacific Islands (16,000 km^2), yielding relatively small NPVs of \$0 to \$0.01/m^2 for fisheries and \$0.30 to \$1.20/m^2 for tourism. The values of fisheries, tourism, and recreation are, of course, generated from only small portions of the total reef area of the US Pacific.

Table 14. Summary of Coral Reef Valuations: Net Present Value, in 1999 Dollars per Square Meter

Source	Fisheries	Tourism	Breakwater	Total value
Mattson and DeFoor (1985)				4,363.00
Spurgeon (1992)				2,083.00
CFMC (1999)				921.00
Berg *et al.* (1998)		4.40	0.002 to 2.00	
Dixon *et al.* (1994)		0.07		
This study	0 to 0.01	0.30 to 1.20		
Cesar (1996)	0.15	0 to 1.36	0.001 to 1.36	0.19 to 1.57
Costanza *et al.* (1997)	0.27	3.68		7.37

The values from this study are only very tentative figures used for illustrative purposes–see text for limitations.

The tourism and breakwater ranges of Cesar (1996) are his extreme ranges; the "total value" range is a more moderate range under "low" and "high" scenarios; thus the components do not sum to the "total value."

The "tourism" value from Costanza *et al.* (1997) is actually called "recreation" by the authors, and presumably includes both tourism and recreation, as the terms are used here.

Table 15. Details of Valuation Studies

Source	Location	Scale	Methods
Mattson and DeFoor (1985)	Florida Keys	very small (ship grounding)	court case (unknown method)
Spurgeon (1992)	Egypt	very small (ship grounding)	court case (unknown method)
CFMC (1999)	Florida Keys	very small (ship groundings)	average of court cases (unknown methods)
Berg *et al.* (1998)	Sri Lanka	tourism: village specific (0.25 km^2) breakwater: country-wide	tourism: PS (profits), CS (WTP) breakwater: property values
Dixon *et al.* (1994)	Bonaire, Antilles	island-wide (100 km^2)	consumer surplus (WTP)
This study	US Pacific Islands	region-wide (16,000 km^2)	see text
Cesar (1996)	Indonesia	country-wide (75,000 km^2)	fisheries and tourism: PS (profits) breakwater: property values
Costanza *et al.* (1997)	World	global (620,000 km^2)	various

"PS" means producer surplus; "CS" means consumer surplus; "WTP" means willingness-to-pay.
It was here, not in the original study by Dixon *et al.*, that the net value was divided by the island's entire reef area.

1.7 Economic Analysis of FMP Alternatives

Alternatives:

The economic impacts of each of the four types of alternative measures (marine protected areas; permit and reporting requirements; allowable harvesting gear; and various miscellaneous requirements) are assessed relative to the no-action alternative. As explained in the preceding sections, the current value and future expected trajectory of the no-action alternative are not well known. A primary motivation of the FMP, in fact, is to address the largely unpredictable future course of fishery development and its potential problems.

Since the FMP considers a range of management (control) measures contained in four alternatives ranging from No Action through Maximum Additional Protection, the following analysis discusses the implications of each of the management measures in some detail. The section concludes with a summary of the overall implications of the suite of management measures in each of the four alternatives.

Factors Affecting Fishery Sector Values:

Projections of a harvesting sector's NPV under a given measure relative to the no-action NPV will be based primarily on the following four factors: 1) whether harvesting effort will increase or decrease relative to the no-action scenario, 2) whether the impact to harvesting effort will bring the fishery greater or fewer gross returns relative to the no-action scenario, 3) whether private costs will be greater than in the no-action scenario and whether they will outweigh any impact to gross returns,

and 4) whether public costs will be greater than in the no-action scenario and whether they will outweigh any impact to net private returns.

An additional factor is whether the composition of the "fleet" will shift towards more efficient or less efficient participants. Measures that bring increased costs to fishermen, for example, will disproportionately reduce the participation or effort of those less willing or able to pay those costs. This choice depends on whether the costs are fixed or variable, the level of investment in the harvesting operation, the returns of the operation, and the underlying asset basis of the harvesting operation. For example, if the increased costs are on a fixed, flat rate basis (e.g., the cost of acquiring an annual permit), large full-time commercial food or sport operations are probably more likely to bear the costs than part-time recreational and mixed-motivation fishermen, assuming similar wealth levels, while wealthier participants (whatever their motivations) may have greater flexibility and willingness to absorb the costs than less wealthy participants. If a burdensome measure is not applied equally across the fleet, such as if subsistence fishermen are exempt, the fleet would shift accordingly.

Federal Versus State and Territorial Waters:

An important factor with respect to the economic and social impacts of these management measures is that they will apply only in federal waters.

The decision of where to fish (e.g., in territorial versus federal waters) is a function, among other things, of the costs and risks of getting to the fishing grounds or harvesting area (a function of distance and exposure), the costs of harvesting (including any restrictions that hinder harvesting efficiency and any costs associated with permitting and reporting), and expected returns (a function of fish abundance and related factors).

Some of the proposed management measures are restrictive and burdensome to fishermen. At least in the short term, they will reduce the incentive to fish in federal waters. Any resulting decrease in participation or harvesting effort in federal waters could result in shifts to other fisheries or other economic sectors. The impacts of shifts into other areas and fisheries will depend on the biological and economic state of those fisheries (e.g., whether they are already overfished). It is assumed in this analysis that:

1. Fishing effort which shifts out of coral reef fisheries in the EEZs will result in greater effort in both territorial coral reef fisheries and non-coral reef fisheries (e.g., deep bottom and pelagic),

2. Greater fishing and harvesting effort in territorial coral reef fisheries will, given the general assessment of their already being overfished in most nearshore areas (see Green 1997), result in smaller net returns relative to the no-action NPV, and

3. Increased effort in pelagic fisheries will result in greater net returns for the pelagic sector relative to the no-action NPV, but not necessarily an increase in overall net returns, and increased effort in non-coral reef fisheries (e.g., deep bottom fish) is likely to result in lesser net returns relative to the no-action NPV.

The "balance" between federal and territorial/state regulations is clearly an important consideration. Increasing costs to fishermen could also push them out of fisheries altogether and into other economic sectors. It should be noted that these other sectors might include reef-dependent industries such as marine tourism, which, applying the concept of ecosystem management, could be considered part of the "fishery" being managed by this FMP.

Impacts to Non-fishery Sectors:

It is assumed that the value of each of the non-fishery sectors is purely a negative function of reef degradation, and that reef degradation is a positive function of harvesting effort and the degree of usage of destructive gears and practices. The extent of these relationships is of course the ultimate issue in the relationship between the management of harvesting sectors and the preservation of coral reef ecosystem values.

1.7. 1 General Effects of Management (Control) Measures

As indicated in the FMP, the potential for fishing and non-fishing activities to have fishery, environmental, and economic effects depends on how they are managed through one or more of the following management (control) measures:

- marine protected areas
- permit and reporting requirements
- allowable harvesting gear
- other (miscellaneous) requirements

Each of the four alternatives analyzed in the FMP contains these four management measures to a varying degree. In this section, the effects of each management measure under the Western Pacific Coral Reef Ecosystem FMP are described, focusing on how fishery participants and the fishery as a whole are likely to respond. Descriptions of compliance, management, fishery monitoring, and enforcement costs are also presented.

This is followed by a summary table of the likely effects outside the FMP regulated fishery itself, particularly in: 1) coral reef fisheries in territorial waters, 2) non-coral reef fisheries, and 3) non-fishery sectors. In addition, the impacts of each measure on net present value are assessed relative to the no-action alternative, with comparisons made among alternatives within a given type of management measure. The notations "zero," "negative," or "positive" in parentheses always refer to the impact relative to the No-Action alternative, not relative to any of the other alternatives.

Measure: Marine Protected Areas

The FMP includes two types of MPAs: "no take" and "low use." As with all natural resource harvesting restrictions, the economic issue is the extent to which these MPAs preserve the natural productivity of the ecosystem for social and/or economic values and to what extent they displace effort to open areas. The natural factors are not well known, nor is the recovery period (which in the case of snappers and groupers, for example, is likely to exceed the economic time-scale for value recovery). To the extent that MPAs are close to inhabited areas (e.g., in the EEZ of Guam) or

accessible transportation (e.g., near Midway), then potential for use (and thus potential costs of restrictions) increases. To the extent that the areas are isolated (e.g., the Northwestern Hawaiian Islands except Midway), the costs of exploration and harvest increase. This reduces the profitability of harvest and reduces the social cost of regulation. Regarding insurance requirements for all fishing vessels operating in or transiting MPAs, several fishermen have indicated that pollution insurance is a standard part of their operations. As a result, although it would increase costs to existing fishermen who do not have such insurance, and to future fishermen and harvesters and similar operators (e.g., ecotourism purveyors), it would reduce asset risks to vessel operators and appear to provide substantial social value (as indicated by recent controversies concerning wreck removal).

The following summarizes the extent to which each alternative implements these management measures and the extent to which net economic values are affected:

No Action Alternative (Alternative 1):

In the absence of additional management measures, the bottomfish, lobster, and precious corals FMPs will still regulate those fisheries and through the Essential Fish Habitat portions of those FMPs, will serve to protect the general coral reef ecosystem. However, in the absence of the CRE MPAs, potential development of other fisheries (e.g., aquarium, live rock, bio-prospecting, etc.) will occur under open access conditions. While the lack of regulation usually fosters short-term investment and growth in nascent natural resource settings, in the long-term the lack of management controls tends to encourage over-exploitation and creates an unstable investment climate. The effect in high-cost coral reef fisheries, such as the NWHI, would be to preclude sustainable development and potentially harm the bottomfish, lobster, and precious coral fisheries as well.

Minimal Additional Protection (Alternative 2):

The restricted level of MPA protection identified in this alternative would be expected to offer extensive general ecosystem protection and preclude unsustainable development while allowing broad areas for exploratory development.

Substantial Additional Protection (Alternative 3, Preferred Alternative):

The broad levels of MPA protection identified in this alternative would be expected to offer extensive general ecosystem protection but would increase the costs of exploratory development. Low cost exploratory options would still be possible but high cost options might not. Where eco-tourism and other low-use activities would be possible, these should not be substantially affected by this alternative.

Maximum Additional Protection (Alternative 4):

The effect of these MPAs (to 100 fathoms) would be to preclude all development of marine resources from EEZ coral reef habitats except for research functions and high-cost deep-water exploration (perhaps in conjunction with the precious corals fishery). Whether eco-tourism and other low-use activities would be permitted would depend on the drafting of the management measures.

Measure: Harvesting Permits and Reporting Requirements

The impact on coral reef harvesting and on less regulated fisheries (e.g., territorial) depends on a variety of factors including the degree of discretion given to NMFS concerning Special Permits in determining participation, effort, catch, compliance costs, and management costs. Outside the FMP fishery, such factors include the magnitude of the positive and negative impacts on habitat and ecosystem services and value caused by reduced participation in the FMP fishery and greater participation in other fisheries. The impact within the coral reef ecosystem fishery of various permit alternatives would be primarily determined by their severity and by the public costs of enforcement, permit processing, and data analysis (negative), the effects of compliance costs on individual net returns (negative), and the indirect effects of reduced participation on the FMP fishery's total private net returns (positive or negative). The impacts outside the fishery would be determined by any displacement of harvesting activity to (greater participation) territorial fisheries and in non-coral reef fisheries.

Participation in the fishery, and probably effort, would likely be least under the Special Permit requirements. Per-vessel compliance costs would be substantially greater under the Special Permit than under the General Permit, as would public permit processing and data analysis costs. Reliance on local data collection systems may instill greater trust and compliance by fishers. As these systems have a long history in the islands, the cost of continuing these programs would likely be of much lower cost than a new system. For this reason, the Council and NMFS continue to provide support and guidance to these programs. Enforcement costs would likely be greatest for harvesting under the Special Permit and lower under both the General Permit and the No Action Alternative.

The subsistence harvesting exemption would likely result in greater net private returns in the fishery relative to any of the other permits, with the degree of the impact depending on how it is interpreted and applied. The benefits would be offset by enforcement being less effective and slightly more costly. The extent of these overall benefits is unknown.

The following summarizes the extent to which each alternative implements these management measures and the extent to which net economic values are affected:

No Action Alternative (Alternative 1):

The reliance on local data collection systems may lead to gaps in information for future resource management decisions, although compliance to a locally-run and familiar system is likely higher. Nevertheless, inadequate data collection over time may cause drastic management measures to occur in the face of a real or perceived future problem.

Minimal Additional Protection (Alternative 2):

The costs of permitting and reporting under this alternative are relatively minimal and therefore are likely to have a small effect on economic activity. To the extent that Alternative 2 encourages higher levels of development, however, it may increase the administrative burden to the government and subsequently the scientific research and analysis burden.

Substantial Additional Protection (Alternative 3, Preferred Alternative):

The costs of permitting and reporting under this alternative are limited to the low-use MPAs at this time and are likely to have a small effect on economic activity.

Maximum Additional Protection (Alternative 4):

Given the extensive nature of the MPAs in this alternative, and the requirement for permitting and reporting in most coral reef areas, reporting and permitting may have substantial costs to small-boat fishermen as well as to larger harvesters seeking permission to access more remote areas. Similar costs are likely to the government. With permits required for research and management activities, this may also place burdens on science.

Measure: Gear Restrictions

Gear restrictions are likely to have three primary effects: first, the reduction in efficiency in harvest; second, the (positive) biological effect of this reduced harvest; and third, the cost of enforcement. One alternative is to restrict gears consistent with rules in adjacent territorial waters. This would reduce enforcement problems significantly and would otherwise have the same effect of the current status quo (no action alternative) in terms of effect on participation and ecosystem. However, since the EEZ areas are more distant than the territorial areas, the costs of harvesting would be greater, as would the costs of compliance. It can also be anticipated that the density of participation would be lower.

The following summarizes the extent to which each alternative implements these management measures and the extent to which net economic values are affected:

No Action Alternative (Alternative 1):

In the absence of gear restrictions under the CRE FMP, protection of habitat from inappropriate gears would be limited to that provided by the bottomfish, lobster, and precious coral FMPs. This also suggests habitat dangers similar to those of over-fishing identified under Alternative 1 in the MPA category.

Minimal Additional Protection (Alternative 2):

This alternative is unlikely to impose substantial economic costs on any type of sustainable development and harvesting activities.

Substantial Additional Protection (Alternative 3, Preferred Alternative):

This alternative, through the prohibition of night-time spear-fishing with scuba or hookah may have some impact on recreational fishing but that effect is expected to be small. Otherwise its effects would be minimal (similar to those of Alternative 2).

Maximum Additional Protection (Alternative 4):

This alternative's prohibition of spear-fishing with scuba or hookah is likely to have a deleterious effect on recreational fishing.

Compliance Requirements and Costs

The permitting options are the only ones with direct costs of compliance. Although the details of the permitting measures have yet to be fully determined, the following assumptions regarding the measures will be made in order to estimate compliance costs, as shown in Table 16:

1. Permit applications are estimated to require 1 hour of labor for the General Permit and 2 hours for the Special Permit. These permits will be required to be renewed annually, however the renewal form should require no more than 0.5 hours of labor to complete.

2. A fee would be charged for each application, this fee would be calculated in accordance with the procedures of the NOAA Finance Handbook for determining the administrative costs of processing each application.

3. Reports on catch and effort would be required after every trip, requiring 0.5 hour per fishing day for fishing under the General Permit, and 1 hour per fishing day for the Special Permit.

4. If vessel observers are required, the public, and not the permit holder, would pay the entire cost, estimated at $5,000 per month.

5. No conditions beyond catch reporting requirements may be attached to a General Permit. Any conditions may be attached to a Special Permit.

Table 16. Compliance Costs of Permitting and Reporting Measure

	Fixed ($/permit-year)			Variable ($/vessel-day)		
	Cash	**Labor**	**Total**	**Cash**	**Labor**	**Total**
General Permit:						
Permit application	0	20	**20**			**0**
Reporting			**0**	0	10	**10**
General Permit total	**0**	**20**	**20**	**0**	**10**	**10**
Special Permit:						
Permit application	0	40	**40**			**0**
Reporting			**0**	0	20	**20**
Special Permit total	**0**	**40**	**40**	**0**	**20**	**20**

Costs are estimated on a per-vessel basis; multi-vessel operations would probably incur lower per-vessel costs.
The value of labor is assumed to be $20 per hour.
A Special Permit could include any number of additional conditions, with associated costs.

Management Costs

Plan Development:

It is estimated that the Western Pacific Regional Management Council will spend $500,000 to $700,000 on the development of this FMP. Costs include staff time, public scoping meetings and hearings, meetings of the Plan Team, Habitat and Ecosystem Advisory Panel, Scientific and Statistical Committee, and the Council itself, contractors that contributed to plan development, and administrative costs, including printing. The NMFS will also have made expenditures towards plan development in the form of staff time and administrative costs, estimated at $50,000 to $100,000.

Plan Review:

Monitoring and reviewing the plan, including routine meetings, data analysis and reporting by the Plan Team, making occasional adjustments such as framework measures and amendments, and implementing management actions that would require coordination among different plan teams, will bring running costs to both the WPRFMC and the NMFS. Staff time, administrative costs, meetings of the Council and relevant teams and committees, and public hearings can be expected to cost the WPRFMC $200,000 to $400,000 per year. Staff time and administrative costs can be expected to cost the NMFS $50,000 to $100,000 per year. These figures are based in part on estimates made in other Council documents for similar services (e.g., WPRFMC 1994).

Permits:

The General permit would only require assessment of whether the applicant meets basic eligibility requirements, and would be the least costly of the permits on a per-permit basis.

The Special permit would require case-by-case scientific and administrative review of fairly sophisticated applications that include demonstration of how the proposed harvesting would be sustainable at the ecosystem level. The Regional Administrator of the NMFS would review applications in consultation with the WPRFMC.

The two-tiered permit systems also requires the additional task of maintaining the list of the two categories of target organisms–those subject to General Permits and those subject to Special Permits. Given the Council's mandate under that option to determine needed biological reference points for species as information becomes available, the analytical requirements of the Council's and NMFS' staffs might be greater than under either the General Permit or the Special Permit options. The costs involved in creating and maintaining the two lists of species and determining the biological reference points are addressed under "fishery monitoring, analysis, and reporting."

The per-application processing costs of each of the three options are roughly estimated at:

General:	$50	to	$100	per application
Special:	$400	to	$2,000	per application

The total annual cost of each option would depend on the number of applicants. The Special Permit option, because of its costly application requirements and relative uncertainty of outcome, would probably yield the fewest applicants. Very rough estimates of the number of expected annual applicants, at least during the first few years, are:

General:	10	to	20	applicants
Special:	0	to	10	applicants

Under those assumptions, total annual permit processing costs would be:

General:	$500	to	$2,000 total cost
Special:	$0	to	$20,000 total cost

Fishery Monitoring, Analysis, and Reporting:

The Western Pacific Fisheries Information Network is already monitoring components of the coral reef fisheries in the region. The system might be expected to be expanded or improved in response to the needs of the FMP. Roughly estimated additional costs of the network are $0 to $200,000 per year.

The FMP Special Permit would allow NMFS to require, at its discretion, vessel observers, at a cost of about $5,000 per vessel per month. Ten vessels harvesting half the year, for example, would cost $300,000, and that is treated here as the maximum possible cost (how the cost would be divided between the public and the harvesting participant has not been determined; in estimating compliance costs, above, it was assumed the public would pay, so the cost is included here).

The data reporting requirements of fishermen would be roughly the same under all permitting options, but less detailed reports would be required under General Permits than under Special Permits. The data in these reports would presumably be processed and analyzed by NMFS, which would report the results to the WPRFMC. The number of reports would depend on the number of permit holders, which would depend on the number of applicants (estimated for each permit system above) and the percent of applicants that are granted permits. Under the two-tiered permit system, NMFS would also have the task of devising and maintaining the two lists of species, and for Non-Target species, determining biological reference points. If vessel observers are used, analyzing their data would require additional costs. The total costs of these tasks are roughly estimated at $50,000 to $200,000 per year (based on estimates for similar services in WPRFMC 1994).

Enforcement:

Enforcement costs of NMFS and the Coast Guard for the region's federally managed pelagic fisheries were estimated in 1994 at $1.5 million per year (WPRFMC 1994). Enforcement costs are largely discretionary and are increased greatly by the proposed MPAs which would require some amount of distant patrolling by air and by sea. A large portion of the enforcement needs of the FMP could presumably be met through existing levels of patrolling and other services for other fisheries. Additional patrols would cost as much as $100,000 per air patrol and $250,000 per surface patrol from Honolulu to distant islands (not to all islands at once–just in one direction or another). Dock-

side enforcement would require additional personnel, at a cost of about $100,000 per agent per year. Prosecution costs would increase according to the level of patrolling. In sum, the enforcement costs for the plan could run anywhere from about $0.3 million to as much as $3.0 million or more per year.

The estimated costs of implementing the FMP are summarized in Table 17.

Table 17. Summary of Expected Implementation Costs of FMP ($1,000/year)

	Low	High
Management plan	250	500
Permits	0	20
Fishery monitoring and analysis	50	700
Enforcement	300	3,000
TOTAL	**600**	**4220**

The one-time costs of developing the FMP, $0.55 to $0.80 million, are not included here.

Summary

The likely impacts of each management measure on the net present value of each of the fishery and non-fishery sectors are summarized in Table 18. For each sector and each measure, the likely impact is described as being either less than, the same as, or more than the likely no-action net present value. The coral reef resources under the jurisdiction of the FMP are termed "FMP fisheries." Coral reef fisheries not in federal waters are termed "local coral reef fisheries," and all other domestic fisheries are termed "non coral reef fisheries." The No Action Alternative is omitted from the table. Included are analyses of implementation of a framework procedure for future management actions, as well as a non-regulatory method for the integration of FMPs to allow for consideration of the ecosystem effects of the harvesting of coral reef resources which are primarily managed under the Bottomfish, Crustaceans, and Precious Corals FMPs.

Table 18. Impacts of FMP Management Measures to Net Present Value – Relative to the No Action Alternative

	FMP fisheries	Local coral reef fisheries	Non coral reef fisheries	Tourism and recrea-tion	Support for other ecosys-tems	Informa-tion	Existence and option values	Overall
Marine protected areas established								
Remote Areas	–	O	O	–	+	+	+	– +
Accessible Areas	– +	O	– +	O	+	+	+	– +
Guam's southern banks–no large harvesting vessel anchoring	– +	O	– +	O	+	+	+	– +
Harvesting permit and reporting requirements								
General Permit	– +	– O	– +	– O	– +	– +	– +	– +
Special Permit	– +	– O	– +	– O	– +	– +	– +	– +
Permit exemption for subsistence harvesting	– +	– O	– +	– O	– +	– +	– +	– +
Gear restrictions								
Allow only certain gears	– +	O	O	O	O +	O +	O +	– +
Restrict gears to be consistent with rules in local waters	– +	O	O	O	O +	O +	O +	– +

"– +" means less than or greater than, i.e., indeterminate; "– O" means less than or the same as; and "O" means the same as the NPV under the no-action alternative.

As can be seen in Table 18, little can be said definitively about the likely impacts of the management measures on net value. The impact of most measures could be either positive or negative in most sectors, with the exception of the locally managed coral reef fisheries, in which positive impacts are relatively unlikely. The following summarizes the extent to which each alternative implements these management measures and the extent to which net economic values are affected:

No Action Alternative (Alternative 1):

Alternative 1 would implement no new management measures, leaving protection of the coral reef ecosystem to those measures implemented under the bottomfish, lobster, and precious corals FMPs and the essential fish habitat provisions of those FMPs. The absence of MPAs would open areas of the coral reef ecosystem to over-harvesting due to open access harvesting conditions. The absence of permitting and reporting requirements would mean that adequate information for scientific assessment of any such developments would be lacking. Without gear restrictions it is possible that coral reef habitat itself could be harmed. Altogether the Council determined that the No Action alternative was not viable in an era of increased potential for harvesting pressure on the coral reef marine environment and increased concern worldwide for preserving coral reef ecosystems. Although there would be some costs in terms of economic developments potentially forestalled by the other three alternatives, the potential losses to the Western Pacific coral reef ecosystem of unfettered marine development and utilization would certainly offset any potential gains from such development.

Minimal Additional Protection (Alternative 2):

Alternative 2 would designate a range of precautionary management measures that would impose some controls on commercial and recreational use of the coral reef ecosystem in Federal waters in the Western Pacific. The implementation of low-take MPAs along with restrictions on taking live rock and coral and the prohibition of non-selective gear, as well as permitting and reporting requirements, should preclude any "mining" of the coral reef ecosystem by unfettered marine development. At the same time, the management measures under Alternative 2 impose minimal costs for marine development and utilization. However, the Council believes that this alternative does not provide adequate protection for particularly sensitive coral reef ecosystem areas, particularly those in shallow waters. As a result, although the measures in this alternative are precautionary, there is the potential for over-harvesting and habitat destruction in some circumstances. The potential costs of such activities would outweigh the potential benefits of harvesting in shallower waters and marine developers not being subject to stricter controls in sensitive areas.

Substantial Additional Protection (Alternative 3, Preferred Alternative):

Alternative 3 (which incorporates the management measures in Alternative 2) also provides a range of no-take MPAs in particularly sensitive regions of the Western Pacific coral reef ecosystem, requires additional permitting and reporting requirements, mandates the use of non-destructive gears, and implements some additional restrictions (vessel monitoring, anchoring controls, and night-time fishing regulations) which are intended to prevent not only unfettered marine development (as precluded by Alternative 2) but also to prevent or mitigate unintended harm to the coral reef ecosystem through reduction in vulnerability of certain coral reef fish to night-time fishing as well

as providing insurance and mitigation systems for fishing vessels operating in or transiting through areas designated as no-take or low-use MPAs. The additional costs of the insurance and mitigation systems are expected to be low, relative to their potential benefits, while the lost opportunities concerning night-time fishing may be significant to recreational fishers but the prevalence of this activity outside of three miles (i.e., in the EEZ) is thought to be low. As a result, the Council believed this alternative balanced the costs to current and future participants in the coral reef ecosystem with the benefits of increased protection.

Maximum Additional Protection (Alternative 4):

Finally, Alternative 4 provides much broader no-take MPAs (out to 100 fathoms) as well as incorporates the measures proposed in Alternatives 2 and 3. The result of the 100 fathom MPAs would be to effectively curtail any commercial and recreational use of the Western Pacific coral reef ecosystem within the EEZ. Although the benefits of such use in terms of aquarium fish collection, bio-prospecting, and other potential uses are not well known, it may be that some considerable value exists. The maximum protection provided by this alternative would impose future costs with unknown future benefits.

Summary of Impacts of the Preferred Alternative (Alternative 3):

The following is a further summary of impacts under the Preferred Alternative (Alternative 3). To the extent that Alternatives 2 and 4 (Minimal and Maximum Protection) mimic aspects of the Preferred Alternative, these impacts would accrue accordingly. To the extent that these other two alternatives contain different degrees of management (e.g., smaller or larger MPAs, less or more restrictive gear rules), then the impacts would be either smaller or greater, respectively.

1. The preferred management measures, primarily through the permitting and protected area measures, can be expected to result in a lower level of fishing, harvesting levels and participation on federal coral reefs than under the No-action Alternative.

2. Because they would bring greater restrictions and greater harvesting costs in federal waters, the preferred measures would encourage harvesting effort outside federal waters, and they could thereby negatively impact values of both fishery (if the greater effort leads to or exacerbates overfishing) and non-fishery sectors (if the greater effort degrades habitat or other ecological services) of coral reefs under local jurisdiction.

3. Because of the flexible nature of the Special Permit system, as well as the uncertainty of how it would evolve relative to the General Permit system, the impacts of the permitting measure are difficult to assess. To the extent that the Special Permit system requires expert knowledge in formulating and defending the proposed activity, it will increase costs to participation and set a higher wealth threshold for participation.

4. The expected implementation costs of the FMP and the preferred measures are $0.6 to $4.6 million per year, not including the one-time costs of developing the plan ($0.5 to 0.8 million), and not including the existing costs of managing coral reef fisheries in territorial waters (about $3 million/year).

5. Management inputs needed for effective implementation of the preferred measures are likely to be relatively large compared to the net value of the existing and potential fisheries (especially since the basic operations of the bottomfish, lobster, and precious coral fisheries are covered by separate FMPs), but small relative to the net value of non-fishery sectors.

6. It is unlikely the preferred measures would result in a greater net value of coral reef fisheries–even just in federal waters–than under the no-action scenario. The preferred management measures are likely to result in prevention of losses to the net values of non-harvesting sectors, but only in federal waters. Those benefits could be offset by negative impacts to both harvesting and non-harvesting sectors in locally managed waters. Because coral reef harvesting activities have a limited capacity to affect non-harvesting values of reefs, the potential impact of the FMP measures on non-harvesting values – positive or negative – would likely be small relative to total non-fishery values.

7. It is not possible to determine whether the impact of the preferred measures on the overall net value of the region's coral reefs would be positive or negative but given the nature of open access fisheries historically, it is likely that they will be more positive than the No-action Alternative.

8. The social and indirect economic impacts of the preferred measures would vary greatly from area to area. On remote reefs with little historical or current harvesting activity, few participants would be affected. One exception is Midway, where the preferred protected area measures would reduce the area the coral reef sportfishery could develop. On nearshore reefs close to population centers, such as the federal reefs off Saipan and Tutuila, and Penguin and Ka'ula Banks in Hawaii, more participants would be affected, including commercial, recreational, and sport fishermen, most of whom only occasionally fish in federal waters. Fishing activity on the isolated offshore banks of Guam, American Samoa, CNMI, and Hawaii, and around Farallon de Medinilla in the CNMI would also be substantially affected by the permit requirements, and participation and effort can be expected to be substantially reduced.

9. The preferred permitting measure would be restrictive and costly enough that, where there are adjacent fishing grounds under local jurisdiction, many affected participants would probably choose to stop fishing in federal waters rather than bear the increased costs of compliance. Similarly, future growth in coral reef fishery participation and effort in locally managed waters is likely to be greater than it would have been in the no-action scenario.

10. Relatively few of the region's coral reef fishery participants would be affected by the preferred measures, and only some of those affected would be significantly affected. Consequently, the preferred measures are unlikely to hinder the "sustained participation" of fishing communities, consistent with part (A) of National Standard 8 of the Magnuson-Stevens Act.

11. Although the preferred measures do not include any explicit allocation of harvesting privileges, the costs of complying with the preferred permitting measure would cause proportionately greater impacts to small-scale, part-time, recreational and mixed-motivation fishermen, with consequent shifts in the composition of participants.

12. The discretion in issuing Special Permits under the preferred permitting measure could result in preferences being given according to any number of criteria, some not intended, including time of application and the ability to express scientific ideas.

13. Implementation of the preferred measures on reefs in federal waters that are contiguous with reefs under local jurisdiction may be problematic and thus costly in terms of enforcement and effectiveness. The three-mile boundary is difficult for fishermen to determine and comply with, and the measures, being quite restrictive relative to local rules, may not be readily accepted by local fishing communities. To the extent that straight-line enforcement boundaries are imposed, given the bottom topography of the western Pacific island areas, it is possible that the proposed management measures would have either a substantially greater or potentially smaller effect than anticipated.

14. The portion of new federal management inputs that are funneled through local economies would bring positive indirect economic impacts to those economies.

2.0 INITIAL REGULATORY FLEXIBILITY ANALYSIS

2.1 Introduction

The Regulatory Flexibility Act (5 U.S.C. 601 et seq.)(RFA) requires that agencies assess and present the impacts of their proposed actions on small business entities. In accordance with the RFA, the following is set forth: (1) The need for, and objective of, the measures are outlined in the ~~draft~~ FMP which accompanies this document; (2) The proposed measures would apply to all individuals who wish to harvest domestic coral reef resources in the federal waters of the Western Pacific Region; (3) All affected individuals are expected to be small business entities; (4) The proposed measures include new reporting requirements; and (5) No Federal rules are known to duplicate, overlap, or conflict with the proposed measures.

An IRFA is needed to determine if a regulatory action is expected to have a "significant economic impact" on a "substantial number" of "small entities."

A "small entity" in this case would be a commercial fishing or marine harvesting company, a wholesaler dependent on products harvested from the coral reef ecosystem, a non-profit organization that is independently owned and not dominant in its field, or a small government jurisdiction.

2.2 Basis for Rule and Description of Alternatives

The basis for the rule, description of alternatives, etc. are described in the preceding RIR. The following provides information specific to the needs of the RFA.

2.3 Description and Number of Affected Small Entities

Virtually no participants in the fisheries of the US Pacific Islands can be considered large entities. The challenge in identifying small entities in this case is first, distinguishing "businesses" from fishing participants that sell their catch only occasionally, and second, identifying which fishing entities participate in, or rely on, coral reef fisheries.

Tables in the Fishery Impact Statement, reproduced on the following page as Table 19, shows the number of participants in the fisheries of the US Pacific Islands.

Table 19. Harvesting Community Descriptors

	Am. Samoa	CNMI	Guam	Hawaii	Other islands	All islands
Resident population	64,000	65,000	160,000	1,187,000	350	**1,476,350**
Number of regular commercial food fishermen	50 to 100	50 to 100	50 to 500	2,000 to 3,000	0	**2,150 to 3,700**
Number of sometime commercial food fishermen	200 to 500	200 to 1,000	1,000 to 10,000	50,000 to 200,000	0 to 20	**51,400 to 216,020**
Number of sometime food fishermen	10,000 to 30,000	10,000 to 30,000	20,000 to 60,000	150,000 to 415,000	100 to 300	**190,100 to 535,300**
No. of commercial reef ornamentals collectors	1	0 to 1	2 to 4	170 to 220	0	**173 to 226**
No. of permitted non-comm. reef ornamentals collectors	na	na	35 to 45	190 to 300	na	**na**
Number employed in reef ornamentals industry	1 to 2	0 to 2	4 to 10	200 to 300	0	**205 to 314**
Number of regular commercial fishing boats	40 to 60	150 to 160	100 to 400	1,200 to 1,700	0	**1,490 to 2,320**
Number of boats that charter sportfish	1 to 2	30 to 40	20 to 25	150 to 250	2 to 4	**203 to 321**
Number of other boats that fish	20 to 30	250 to 350	300 to 1,500	8,000 to 12,000	5 to 20	**8,575 to 13,900**
Total number of boats that fish	70 to 80	430 to 550	420 to 1,925	9,400 to 13,900	7 to 24	**10,337 to 16,474**
Total annual production of seafood (1,000 lb)	770	1,050	1,120	32,000	15	**34,955**
Total annual production of reef seafood (1,000 lb)	340	500	410	5,300	10	**6,560**
Per-capita annual production of local seafood (lb)	12	16	7	27	43	**24**
Per-capita annual production of reef seafood (lb)	5	8	3	4	29	**4**
Per-capita annual consumption of seafood (lb)		56		56		
Per-capita annual consump. of local seafood (lb)	12	16	6	23	43	**20**
Per-capita annual consump. of local reef seafood (lb)	5	8	3	4	29	**5**
No. of wholesalers dealing local seafood/ornamentals	0	0	0 to 2	5 to 30	0	**5 to 32**
No. of retailers dealing local seafood/ornamentals	30 to 40	50 to 60	50 to 200	200 to 1,000	2 to 4	**332 to 1,304**

See section 3 of FMP for additional details.

It is assumed that in terms of food fishing participants, only those identified as "regular commercial food fishermen" in Table 19 are members of "businesses," and all such businesses will be considered "small entities." All commercial ornamentals collecting participants and all charter sportfishing participants will also be considered members of "small entities."

In Table 20, numbers of fishery "participants" are converted to numbers of "entities," using the assumptions footnoted under the table. Research entities were not considered part of the "fishing communities" described in Table 19, but since they may be affected by the action, they are included here. Most research is undertaken by government organizations, such as universities, but universities and other governmental institutions contract research to small entities, and small entities may undertake independent research. With little information available on those small entities, the estimates here are rough.

In Table 21, the numbers of small entities in all fisheries are narrowed down to just those that would be subject to the regulatory action of the FMP–that is, to "affected entities."

As described throughout the RIR, the regulatory action will have economic impacts not just on participants in coral reef fisheries, but on participants in other fisheries and in non-fishery sectors, as well. This analysis, however, is limited to the impacts on "affected" small entities, where only those entities that are directly subject to the regulatory action are considered "affected." If the universe of affected small entities was expanded to include entities that are indirectly affected, or even just those that are *negatively* indirectly affected, the universe would be so large that none of the five IRFA triggering criteria would be met, and an IRFA would not be required. Use of the more restricted interpretation of "affected," as done here, leads to a more conservative analysis, with the triggering criteria more likely to be met.

The regulatory action would affect only fishermen, collectors, vessel operators, and vessel owners–that is, the harvesting sector. The processing, wholesaling, retailing, and exporting sectors would not be directly affected. Only entities that harvest coral reef ecosystem species in federal waters of the US Pacific Islands (or in the CNMI, in the offshore management zone) are affected entities, and all are "small" as defined by the RFA.

Table 20. Number of Small Entities in the Fisheries of the US Pacific Islands

	Am. Samoa	CNMI	Guam	Hawaii	Other islands	All islands
Number of food fishing businesses	25 to 60	25 to 160	25 to 400	1,000 to 1,700	0	**1,075 to 2,320**
Number of charter sportfishing businesses	1 to 2	15 to 20	10 to 13	75 to 125	1	**102 to 161**
No. of reef ornamentals collecting businesses	1	1	1	5 to 13	0	**8 to 16**
Number of research entities	0	0 to 5	0 to 10	5 to 50	0	**5 to 65**
No. of wholesalers dealing local seafood/ornamentals	0	0	0 to 2	5 to 30	0	**5 to 32**
No. of retailers dealing local seafood/ornamentals retailers–local product	30 to 40	50 to 60	50 to 200	200 to 1,000	2 to 4	**332 to 1,304**
Total number of affected small entities	**57 to 103**	**91 to 246**	**86 to 626**	**1,290 to 2,918**	**3 to 5**	**1,527 to 3,898**

"No. of food fishing businesses" derived from Table 19 by assuming 2 fishermen per business, and setting the maximum equal to the maximum estimate of "number of regulator commercial fishing boats" from Table
"Number of charter sportfishing businesses" estimated by assuming (with little basis) two charter boats per business, with the number of charter boats taken from Table 19 (the number is known for "other islands").
"No. of reef ornamentals collecting businesses" derived from Bartram (pers. comm.), Gourley (pers. comm.), Green (1997), and Miyasaka (1991 and 1997) for American Samoa, CNMI, Guam, and Hawaii, respectively.
"Number of research entities" roughly estimated with little basis.
Number of wholesalers and retailers taken directly from Table 19.

Table 21. Number of Affected Small Entities

	Am. Samoa	CNMI	Guam	Hawaii	Other islands	All islands
Number of food fishing businesses	1 to 3	2 to 16	2 to 40	100 to 170	0	**105 to 229**
Number of charter sportfishing businesses	0 to 1	3 to 4	1 to 2	7 to 13	1	**12 to 21**
No. of reef ornamentals collecting businesses	0	0	0	0	0	**0**
Number of research entities	0	0 to 5	0 to 10	5 to 50	0	**5 to 65**
Total number of affected small entities	**1 to 4**	**5 to 25**	**3 to 52**	**112 to 233**	**1**	**122 to 315**

It is estimated that in Am. Samoa, CNMI, Guam, and Hawaii, 5%, 10%, 10%, and 10%, respectively, of food fishing businesses fish for coral reef resources in federal waters (CNMI, the offshore management zone).
In is estimated that in Am. Samoa, CNMI, Guam, and Hawaii, 20%, 20%, 10%, and 10%, respectively, and on Midway, 100%, of charter sportfishing businesses catch coral reef species in federal waters.
It is believed that no reef ornamentals collecting businesses catch coral reef species in federal waters (there may be occasional commercial collecting of ornamentals on Palmyra, but it is assumed to be a rare activity).
It is assumed that all research entities in all island groups harvest coral reef species in federal waters.

2.4 Impacts on Affected Small Entities

The economic impacts of the management measures under the FMP alternatives are addressed in detail in both the RIR (in terms of the fishery as a whole) and in the FMP (in terms of fishing communities and participants). Those analyses are supplemented here with a discussion of how the action is likely to affect coral reef fishery participants as small entities.

There is some discussion of the possible differential impacts among entities–such as how smaller operations might bear relatively larger burdens than larger operations. It should be kept in mind, however, that all affected entities in the fishery are small entities, as defined by the RFA, so there will be no disproportionate effects between large and small entities–a central concern of the RFA.

It is difficult to determine the effects of the action on the risks, revenues, and costs of harvesting. It is also difficult to determine how entities will respond to a given change in risk, revenues, or costs. They may bear an increased burden by remaining in the fishery at the same level of harvesting effort, they may adjust to or mitigate the impact with innovations, they may shift to other areas or fisheries to avoid the impacts, they may put either less or more effort in the fishery in order to minimize the impacts (e.g., depending on whether they stem from changes in fixed or variable costs), or they may exit the fishery.

The most straightforward of the five IRFA-triggering mechanisms to examine is the second–the magnitude of compliance costs relative to total production costs.

The permitting requirements are the only part of the proposed action that would bring direct compliance costs. The requirement would apply to all entities that catch coral reef. The compliance requirements and costs of the proposed permit requirements were addressed in the RIR and for Special Permits were roughly estimated at a minimum of $600 per vessel per year (whether or not the permit is issued) plus $10 per trip. General Permits, if needed, would cost about $50 per year plus $5 per trip, but since all harvesting would initially require Special Permits, the General Permit will be ignored in this analysis.

The threshold annual production costs, below which the (minimum) compliance costs would constitute more than 5 percent of total costs are about $14,000. Not all affected entities would necessarily bear the compliance costs. With the exception of the sportfishing operation based at Midway, all affected entities are based on islands that have adjacent territorial waters that would not be subject to the action. Many of the affected entities, especially the smaller ones, could be expected to shift their effort to territorial waters in order to avoid the costs of fishing federal waters. They could also shift to fishing for non-coral reef species. Although such shifts might result in fewer gross receipts or poorer efficiency, there would be no increase in compliance costs.

It is not possible to determine how many entities would bear the compliance costs and continue fishing for coral reef species in federal waters, how many would shift into other areas or species, or how many would exit the fishery. For the purposes of this analysis, it is determined that it is possible that 20 percent or more of the affected food, charter, and research fishing and harvesting entities would be significantly affected by the increase in compliance costs.

2.4.1 Compliance Requirements and Costs

The compliance requirements and costs of the permitting measure would be applicable to all affected small entities except lobster and bottomfish permit holders that target lobster and bottomfish.

The actual costs of compliance would vary among entities, depending on the number and sizes of vessels and the number of trips made. The compliance costs would include flat rate annual per-vessel annual costs (permits) and more or less flat rate per-vessel trip costs (data collection and reporting). Because most compliance costs are fixed costs, the smaller, less capital-intensive and less profitable operations would bear a greater burden than larger operations relative to total production costs.

The permit application and reporting requirements would require a certain level of scientific expertise, which would bring a certain level of costs. Issuance of Special Permits would require the applicant to demonstrate the proposed activity would be sustainable and not detrimental to the ecosystem. It would require a similar level of expertise and effort as applying for a research or exempted fishing permit. It was estimated in the RIR that such an application would require labor valued at about $20 per hour, and approximately two hours would be required to prepare the application the first year. The time required would presumably decrease considerably in subsequent years, with an average of perhaps 0.5 hours per year, valued at $10.

Another cost associated with the Special Permit requirement is that there is no guarantee that the permit would be issued. Even if issued, the permit may have restrictions or conditions that would make the enterprise cost-ineffective. In these cases, the permit application investment would be sunk and lost.

The Special Permit reporting requirements could be fulfilled with the expertise of a typical fisherman. It was estimated in the RIR that the labor requirements would be about one hour per fishing day, valued at $20. Because reporting costs are variable costs, the differential effects among entities would be small.

2.4.2 Other Economic Impacts

The restricted gears and methods provision could lead to decreased efficiency, less effort, and less return for some entities. Commercial fishing with tangle nets for Kona crab in the Main Hawaiian Islands, for example, would be allowed, but with yet-to-be-determined restrictions. Almost half the commercial catch of Kona crab is from federal waters, most of that from Penguin Bank (from Friedlander, 1996). If strongly affected, fishing effort for Kona crab could presumably shift to territorial waters. Spearfishing on compressed air at night, which would be prohibited, may have been done by one business in the northern islands of the CNMI, but not since 1995 (MES 1997). It may also currently be done by one or more small entities on the bank to the west of Saipan, in the offshore management zone.

The requirement for fishing vessels operating in or transiting through MPAs to carry varying amounts of insurance to cover the cost of vessel removal and pollution liability in the event of a grounding represents a potential additional cost to vessel owners. The amount and cost of this required insurance is expected to vary with vessel category, size, permit type and fishing area and has yet to be determined. However, it is not anticipated that large numbers of individuals or small business entities will be affected by this measure as most of the MPAs are far from inhabited areas.

The prohibition on the harvest of hard corals and wild live rock would not impact any small entities.

The Special Permit requirement–with its capacity to deny access and to attach any number of conditions on harvesting–may effectively exclude small entities from certain activities, areas, or the entire fishery. Because of the large degree of discretion given to NMFS in reviewing and issuing permits, it is not possible to estimate how many or to what degree small entities would be affected (this is in addition to the impacts of the compliance costs, addressed above).

The low degree of security, durability, and stability associated with the permits (e.g., their validity, conditions, and limitations may change at any time) provide permit holders with relatively little interest in the fishery and present a high level of risk associated with investment.

The substantial financial and technical requirements of the permit application process and the substantial costs needed to comply with permit conditions are likely to favor larger, full-time, capital intensive, high-profit operations, leading to effective allocation of fishing rights among different

categories of entities. Those costs, along with the vague criteria for permit issuance, could also lead to allocation according to any number of other factors, as well, including vessel size, scientific expertise, or market (e.g., fishing for sport versus food).

The no-take zones would affect a few small business entities. Existing fisheries operating in the NWHI would be prohibited from fishing at all depths 0-10 fm and 0-50 fm around Laysan, French Frigate Shoals the northern half of Midway. However, the small business entities are not likely to be significantly affected by restriction of these areas, as no-take zones represent approximately 14% of the available fishing grounds in federal waters in the NWHI. Similarly, the sportfisheries operating out of the Midway Atoll National Wildlife Refuge would not be significantly affected by the no-take MPAs. Shore-based fishing would be allowed to continue under special permits while pelagic fishing will be allowed to continue in the 0-50 fathoms in the southern half of Midway Atoll and with a special permit beyond 50 fm in both the southern and northern half of the Refuge. The developing ecotourism and sportfishing business at Palmyra will be able to develop under the Special permit regime. Permitting costs, as a percentage of total costs, would be minimal for this operation.

The no-anchoring restrictions for Guam's banks and other yet-to-be designated areas could reduce harvesting efficiency by vessels longer than 50 feet (of which there are apparently very few)–by how much is not known.

Whatever the impacts of the preferred measures, most affected entities do not rely totally on coral reef species in federal waters and have alternative activities and areas that they can fish.

2.5 Identification of Duplicating, Overlapping, and Conflicting Federal Rules

Two possibly duplicating, overlapping, or conflicting federal rules were identified:

1) The Special Permit system would be similar to the existing "exempted fishing permit" (EFP) system administered by the NMFS for otherwise closed fisheries (50CFR600.745). Like an EFP, a Special Permit may, at the discretion of NMFS, be conditioned with limits on catch, effort, periods, areas, gears and methods, and it would require reporting of catch and effort data. In both systems, the burden would be on the applicant to demonstrate the lack of detrimental effects, consistency with the objectives of the FMP, and to otherwise justify the need for a permit. The proposed Special Permit system could be viewed as closing the fishery, with exemptions provided through a permit system that is similar to the existing system for closed fisheries. The proposed system would use the same administrative infrastructure to provide what could be viewed as a second means, with slightly different requirements and conditions, of gaining access to the fishery. The substantive differences between the two systems are:

1. The EFP process requires publication in the *Federal Register* of receipt of any application determined by the NMFS Regional Administrator or Director to warrant consideration, as well as consideration of comments from the public and other agencies, including the USCG and local fishery agencies; the Special Permit process would not;

2. The fee for an EFP may be set as high as needed to cover the administrative expenses of issuance (currently set at zero); the fee for a Special Permit has not been determined; and

3. The Special Permit system would give the WPRFMC discretion to review the application and consult with NMFS, while the EFP system gives NMFS the discretion to consult with the WPRFMC over the application.

2) The proposed action would prohibit the harvest of hard corals and wild live rock, except for research or as aquaculture broodstock, subject to obtaining a Special Permit. The restriction would therefore apply to any dredging of reef material that contains coral or live rock. Dredging is governed by the Clean Water Act.

2.6 Alternatives to Minimize Impacts

The Environmental Impact Statement for the FMP identifies a range of alternative regulatory measures and how each of them would meet the objectives of the FMP relative to the preferred set of actions. Those and other options are discussed here in terms of how they might reduce the impact on small entities while still accomplishing the objectives of the FMP. For reference to how the alternatives would meet statutory objectives, and how the objectives and proposed measures are consistent with the national standards of the Magnuson-Stevens Act, see Consistency with National Standard Guidelines and Sustainable Fisheries Act Provisions in the FMP.

Marine Protected Areas:

Using alternative MPA configurations would shift the impacts among affected small entities and could reduce the impacts on them. For example, not closing the waters around Midway would allow the existing sportfishing entity to continue coral reef fishing. Alternatively, an exemption could be provided for certain activities, such as catch-and-release fishing or fishing for local use (i.e., no export from the NWHI). However, based on recent suggestive declines in *ulua* CPUE at Midway Sportfishing, the efficacy of catch-and-release as it is now practiced for *uluas* in the NWHI should be seriously evaluted before such activities are given automatic exemptions. An exemption of the latter type could also reduce the possible future impact on potential sportfishing entities at islands such as Palmyra, Wake, or Kingman (at which a Special Permit would be required).

There is no alternative to the anchoring limitation on Guam's southern banks that would meet the stated objectives (FMP Objective 4–minimize adverse human impacts), except possibly adjusting the affected vessel size (e.g., to larger than 50 feet). The relationships between vessel size, anchor damage, harvesting efficiency, and vessel safety are not known well enough to choose the optimal alternative.

The no-MPA option would bring smaller short-term direct impacts to small entities, but it would not serve FMP Objective 1 (foster sustainable use ... through the use of the precautionary approach and ecosystem-based resource management) or 4 (minimize adverse human impacts).

Fishing Permit and Reporting Alternatives:

Reducing the compliance costs and uncertainty of the permitting system would reduce the impacts on small entities. The compliance costs and uncertainty of General Permits are much less than for Special Permits. Classifying as many species as possible as Currently Harvested Coral Reef Taxa (General Permit) before implementation of the FMP could reduce impacts to some small entities.

Minimizing the degree of discretion in reviewing Special Permit applications, such as through the use of prescribed issuance guidelines, would improve the certainty of outcome and reduce the risk of small entities losing their investment in an application and in the fishery. The General Permit system would allow no discretion, but its utility would be limited to providing information (FMP Objective 3), without any effective controls on harvesting effort that might be needed to "foster sustainable use ... through the use of the precautionary approach and ecosystem-based resource management" (Objective 1) and to minimize adverse human impacts (Objective 4).

Setting limitations on the types and degrees of conditions that may be placed on a permit would decrease likely compliance costs and provide more certainty of outcome of the application process. Set permit durations would also provide greater certainty and decrease the risk of losing an investment in the fishery. The disadvantage of these more prescriptive permit options is that they would give fishery managers less flexibility and less ability to rapidly respond to changes in the environment, the fishery, and available information (FMP Objective 2).

The no-permit, no-reporting option would result in no impact to small entities, but it would not contribute to FMP Objectives 1, 2, 3, or 4, described above.

Less strict permit requirements (e.g., no permit requirement) might be appropriate on reefs that are contiguous with, or proximate to, locally-managed reefs, where permit requirements would be difficult to enforce in any case. The disadvantages to these alternatives are again, less control over harvesting effort (Objectives 1 and 4), less flexibility and responsiveness afforded to managers (Objective 2), and less ability to gather information (Objective 3).

A final option would be to close the fishery entirely. This would be, in a sense, a permitting alternative, since exempted fishing permits (EFP) may be applied for when a fishery is otherwise closed. The likelihood of obtaining an EFP is probably not as great as obtaining a Special Permit, because although they have the common mandate of being consistent with the objectives of the FMP (e.g., "foster sustainable use . . . "), the EFP is designed to only allow harvesting for "exploratory," "data collection," or other limited purposes. The Special Permit, in contrast, has the less restrictive purpose of ensuring sustainable harvest. An EFP is unlikely to offer any greater certainty, stability, or durability than a Special Permit, but the costs of application would be no more than for a Special Permit.

Gear Restrictions:

Allowance of night spearfishing on compressed air would reduce the impacts to commercial spearfishermen operating in the offshore management zone of the CNMI (if such activity actually occurs). This gear does not degrade habitat or result in bycatch, so the effect of allowing it would be to increase potential harvesting efficiency, along with an increased risk of overfishing.

3.0 REFERENCES

ASA (no date). The Economic Importance of Sport Fishing. American Sportfishing Association.

Bank of Hawaii (1997a). American Samoa Economic Report April 1997. Bank of Hawaii.

Bank of Hawaii (1997b). Commonwealth of the Northern Mariana Islands Economic Report September 1997. Bank of Hawaii.

Bank of Hawaii (1997c). Guam Economic Report September 1997. Bank of Hawaii.

Bank of Hawaii (1998). Hawaii 1998 Annual Economic Report, Vol. 47. Bank of Hawaii.

Bartram, P. (pers. comm.). Contractor to the Western Pacific Regional Fishery Management Council, Honolulu.

Berg, H., M.C. Ohman, S. Troeng, and O. Linden (1998). Environmental economics of coral reef destruction in Sri Lanka. *Ambio* 27(8):627-634.

Birkeland, C. (1997a). Introduction. In: C. Birkeland (ed.), Life and Death of Coral Reefs. Chapman & Hall, pp1-12.

Birkeland, C. (1997b). Status of coral reefs in the Marianas. In: R.W. Grigg and C. Birkeland (eds.), The Status and Health of Coral Reefs in the Pacific - 1997, the International Year of the Reef. University of Hawaii Sea Grant College Program, Honolulu, pp91-100.

BLS (1999). Consumer Price Index. Bureau of Labor Statistics, Department of Commerce, US Government.

Cesar, H. (1996). Economic Analysis of Indonesian Coral Reefs. The World Bank.

CFMC (1999). Amendment Number 1 to the Fishery Management Plan for Corals and Reef Associated Plants and Invertebrates of Puerto Rico and the United States Virgin Islands for Establishing a Marine Conservation District including Regulatory Flexibility Analysis and a Final Supplemental Environmental Impact Statement. Caribbean Fishery Management Council, Puerto Rico.

Clark, A.M. (1991). Ocean recreation. In: Hawaii Ocean Resources Management Plan; Technical Supplement. A report prepared by Hawaii Ocean and Marine Resources Council, pp16-28.

Conrad, J. (1980). Quasi-option value and the expected value of information. *Quarterly Journal of Economics*, 92:813-819.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V.O. O'Neil, J. Paruelo, R.G. Raskin, P. Sutton, and M. van den Belt (1997). The value of the world's ecosystem services and natural capital. *Nature* 387:253-260.

Dalzell, P. and T.J.H. Adams (1997). Sustainability and management of reef fisheries in the Pacific Islands. Proceedings of the 8th International Coral Reef Symposium, 2:2027-2032.

Dalzell, P., T.J.H. Adams, and N.V.C. Polunin (1996). Coast fisheries in the Pacific Islands. *Oceanography and Marine Biology: an Annual Review* 34:395-531.

DAR (no date). Commercial Marine Landings Summary Trend Report, Calendar Year 1997. Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii.

DBEDT (no date). The State of Hawaii Data Book. The Department of Business, Economic Development & Tourism, State of Hawaii, Honolulu.

DEQ (in prep.). Lau Lau Bay Watershed Nonpoint Source Pollution Project. Ecological and Economic Value Study. Department of Environmental Quality, Commonwealth of the Northern Mariana Islands.

DFW (1994). Reef Fish Resources of the CNMI: A Review of the Fisheries, Research and Management. DFW Technical Report 94-03, Division of Fish and Wildlife, Commonwealth of the Northern Mariana Islands.

Dixon, J.A., L.F. Scura, R.A. Carpenter, and P.B. Sherman (1994). Economic Analysis of Environmental Impacts. Second edition. Asian Development Bank, The World Bank, and Earthscan Publications Ltd., London.

Friedlander, A.M. (1996). Assessment of the Coral Reef Resources of Hawaii with Emphasis on Waters of Federal Jurisdiction. Final report prepared for The Western Pacific Regional Fishery Management Council, Honolulu.

GDC (1999). Price Indicators. Department of Commerce, Government of Guam, www.admin.gov.gu/commerce/guam_price_indicators.htm.

GEDA (1999). Guam Economic Development Authority, Government of Guam, www.investguam.com/thd/visitor.html.

Glover, D. (pers. comm.). Midway Sport Fishing, Inc., and Midway Diving, Inc.

Gourley, J. (pers. comm.). Principal, Micronesian Environmental Services, Saipan, Commonwealth of the Northern Mariana Islands.

Green, A. (1997). An Assessment of the Status of the Coral Reef Resources, and their Patterns of Use, in the U.S. Pacific Islands, Draft. Prepared for Western Pacific Regional Fisheries Management Council, Honolulu.

Grigg, R.W. (1997). Coral reefs in Hawaii: status and health in 1997. *Makai. Toward the Sea* 19(3):1. University of

Hawaii Sea Grant College Program publication, University of Hawaii, Honolulu.
Grigg, R.W. (1993). Precious coral fisheries of Hawaii and the U.S. Pacific Islands. *Marine Fisheries Review* 55(2):50-60.
Hamilton, M.S. (pers. comm.). Fisheries Economist, National Marine Fisheries Service, Honolulu.
Hamilton, M.S. (1998). Cost-Earnings Study of Hawaii's Charter Fishing Industry 1996-1997. SOEST 98-08, JIMAR Contribution 98-322. University of Hawaii, Joint Institute for Marine and Atmospheric Research, Honolulu.
Hamilton, M.S. and S.W. Huffman (1997). Cost-Earnings Study of Hawaii's Small Boat Fishery, 1995-1996. SOEST 97-06, JIMAR Contribution 97-314. University of Hawaii, Joint Institute for Marine and Atmospheric Research, Honolulu.
Hamm, D.C., N.T.S. Chan, and M.M.C. Quach (compilers) (1998). Fishery Statistics of the Western Pacific, Volume X, Territory of American Samoa (1996), Commonwealth of the Northern Mariana Islands (1996), Territory of Guam (1996), State of Hawaii (1996). Southwest Fisheries Center Administrative Report H-98-04. National Marine Fisheries Service, Honolulu Laboratory, Honolulu.
Hunter, C.L. (1995). Review of Status of Coral Reefs around American Flag Pacific Islands and Assessment of Need, Value, and Feasibility of Establishing a Coral Reef Fishery Management Plan for the Western Pacific Region. Prepared for Western Pacific Regional Fishery Management Council, Honolulu.
Irons, D.K., R.K. Kosaki, J.D. Parrish (1990). Johnston Atoll Resource Survey Final Report - Phase Six (21 Jul 89 - 20 Jul 90). Report submitted to Dept. of the Army, U.S. Army Engineer District, Honolulu, Fort Shafter, Hawaii.
Kinsolving, A. (pers. comm.). Former Fisheries Biologist, Department of Marine and Wildlife Resources, American Samoa.
Krutilla, J.V. and A.C. Fisher (1985). The Economics of Natural Environments (revised edition). Johns Hopkins University Press for Resources for the Future, Baltimore.
MacDonald, C.D., E. Corbin, H.E. Deese, and A.M. Clark (1996). A Synopsis of Hawaii's Strategy for Ocean Industry Development. State of Hawaii Department of Business, Economic Development and Tourism, Ocean Resources Branch, Honolulu.
MacDonald, C.D, A.L. LaBarge, and E. Corbin (1997). Changing Markets and Emerging Performers in Hawaii's Ocean R&D Industry. State of Hawaii Department of Business, Economic Development and Tourism, Ocean Resources Branch, Honolulu.
MacDonald, C.D. (1998). Ocean Economic Potential. State of Hawaii Department of Business, Economic Development and Tourism, Ocean Resources Branch, Honolulu.
Mattson, J.S. and J.A. DeFoor, II (1985). Natural resource damages: restitution as a mechanism to slow destruction of Florida's natural resources. *J. Land Use and Env. Law*, 1(3):295-319.
Mendohlson, R. and M. Balick (1995). The value of undiscovered pharmaceuticals in tropical forests. *Economic Botany*, 49(2):223-28.
MES (1997). The Commonwealth of the Northern Mariana Islands: An Assessment of the Coral Reef Resources under Local and Federal Jurisdiction. Final report prepared for Western Pacific Regional Fishery Management Council by Micronesian Environmental Services, Saipan.
Meyer (1987). A Report on Resident Fishing in the Hawaiian Islands. Prepared by Meyer Resources, Inc. for Southwest Fisheries Center Administrative Report H-87-8C, National Marine Fisheries Service, Honolulu Laboratory, Honolulu.
MSF (1999). Midway Island 1999 Price List. Midway Sport Fishing, www.midwaydive.com/rates.htm.
Miller, K. (pers. comm.). Natural Resources Planner, Division of Fish and Wildlife, Commonwealth of the Northern Mariana Islands.
Miyasaka, A. (1997). Status Report Aquarium Fish Collections Fiscal Year 1994-95. Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii, Honolulu.
Miyasaka, A. (1991). Hawaii's Aquarium Fish Industry; a Business Profile. Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii, Honolulu.
Munro, J.L. and D.M. Williams (1985). Assessment and management of coral reef fisheries: biological, environmental and socio-economic aspects. Proceedings of the Fifth International Coral Reef Congress, 4:643-687.
Myers, R.F. (1997). Assessment of Coral Reef Resources of Guam with Emphasis on Waters of Federal Jurisdiction. Draft report prepared for the Western Pacific Regional Fisheries Management Council, Honolulu.
Myers, R.F. (1993). Guam's small-boat-based fisheries. *Marine Fisheries Review* 55(2):117-128.
NPS (1996). Draft General Management Plan / Environmental Impact Statement. National Park of American Samoa,

US Department of the Interior, National Park Service.
OMB (1992). Circular No. A-94 Revised. US Office of Management and Budget, Washington DC.
Pitlik, T. (pers. comm.). Fishery Biologist, Division of Aquatic and Wildlife Resources, Guam.
Pooley, S.G. (1993a). Hawaii's marine fisheries: some history, long-term trends, and recent developments. *Marine Fisheries Review* 55(2):7-19.
Pooley, S.G. (1993b). Economics and Hawaii's marine fisheries. *Marine Fisheries Review* 55(2):93-101.
Pooley, S.G. and K.E. Kawamoto (1998). Annual Report of the 1995-97 Western Pacific Lobster Fishery. Southwest Fisheries Science Center Administrative Report H-98-09, National Marine Fisheries Service, Honolulu Laboratory, Honolulu.
Radtke, H. and S. Davis (1995). Analysis of Saipan's Seafood Markets, Final Report. Prepared for Division of Fish and Wildlife, Commonwealth of the Northern Mariana Islands.
Riopelle, J.M. (1995). The Economic Valuation of Coral Reefs: A Case Study of West Lombok, Indonesia. Thesis, Dalhousie University, Halifax.
Ruitenbeck, H.J. (1989). Social Cost-Benefit Analysis of the Korup Project, Cameroun. World Wide Fund for Nature.
Samples, K.C., J.N. Kusakabe, and J.T. Sproul (1984). A Description and Economic Appraisal of Charter Boat Fishing in Hawaii. Southwest Fisheries Center Administrative Report H-84-6C, National Marine Fisheries Service, Honolulu Laboratory.
Samples, K.C. and D.M. Schug (1985). Charter Fishing Patrons in Hawaii: A Study of their Demographics, Motivations, Expenditures and Fishing Values. Southwest Fisheries Center Administrative Report H-85-8C, National Marine Fisheries Service, Honolulu Laboratory.
Saucerman, S. (pers. comm.). Former Fisheries Biologist, Department of Marine and Wildlife Resources, American Samoa.
Spurgeon, J.P.G. (1992). The economic valuation of coral reefs. *Marine Pollution Bulletin* 24(11):529-536.
Tabata, R.S. (pers. comm.). Associate Extension Agent, Sea Grant Hawaii, University of Hawaii, Honolulu.
USFWS and BC (1998). 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. US Fish and Wildlife Service, Department of the Interior, and Bureau of the Census, Department of Commerce.
van Poolen, H.W. and A.M. Obara (1984). Hawaii's Marine Aquarium Fish Industry Profile. Studies on Marine Economics No. 3, University of Hawaii Sea Grant College Program and Ocean Resources Office, State of Hawaii, Honolulu.
Wass, R.C. (1982). The shoreline fishery of American Samoa: past and present. In: Munro, J.L. (ed.), Marine and Coastal Processes in the Pacific: Ecological Aspects of Coastal Zone Management, pp51-83. UNESCO, Jakarta.
Wilkinson, C., O. Linden, H. Cesar, G. Hodgson, J. Rubens, and A.E. Strong (1999). Ecological and socioeconomic impacts of 1998 coral mortality in the Indian Ocean: an ENSO impact and a warning of future change? *Ambio* 28(2):188-196.
WTTC (1997). Travel & Tourism and Hawaii's Economy. World Travel and Tourism Council.
WPRFMC (1998). Bottomfish and Seamount Groundfish Fisheries of the Western Pacific Region, 1997 Annual Report. Western Pacific Regional Fishery Management Council, Honolulu.
WPRFMC (1994). Amendment 7 to the Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region; Proposed Limited Entry Program for the Hawaii Longline Fishery (Measures to Replace the 1991-94 Moratorium on New Entrants to the Fishery). Western Pacific Regional Fishery Management Council, Honolulu.

4.0 SOURCES AND ASSUMPTIONS FOR TABLES

Data Sources and Assumptions

The ex-vessel values given in Tables 1 through 7 are the product of volume and per-unit value (e.g., price per pound or price per charter trip). The prices reported below for Tables 2 through 7 are nominal for the year(s) indicated; values shown in the tables have been inflation-adjusted to 1999 dollars using consumer price indices for Honolulu (for Hawaii and American Samoa data) and Guam (for Guam and CNMI data). All prices and values are ex-vessel unless otherwise noted.

Sources and Assumptions for Table 3 (Fisheries, American Samoa):

Coral Reef:

Food:

- Finfish landings are 1991-1995 average from Green (1997:Table 52); value used 1996 price of $1.80/lb from Hamm *et al.* (1998:Table II.1.1); % FMP roughly estimated from information in Green (1997), Saucerman (pers. comm.), and Kinsolving (pers. comm.).
- Crustacean landings are 1991-1995 average from Green (1997:Table 52); value estimated at $3.50/lb with little basis; % FMP from information in Green (1997), and excludes lobsters.
- Echinoderm landings are 1991-1995 average from Green (1997:Table 52); value estimated at $2/lb with little basis; % FMP from information in Green (1997).
- Mollusc landings are 1991-1995 average from Green (1997:Table 52); value estimated at $2/lb with little basis; % FMP from information in Green (1997).
- Other invertebrate landings are palolo worms, rough recent average from Green (1997:115); value of $10/lb taken from range of $7 to $10/lb from Saucerman (pers. comm.); % FMP from information in Green (1997).
- Seaweed landings from Green (1997:116); value unknown; % FMP from information in Green (1997).

Sport: There is a very small charter sportfishing industry, and most activity is trolling (Saucerman pers. comm. and Kinsolving pers. comm.), so assume minimal coral reef trips and value.

Ornamentals: Landings are rough estimates based on there being one commercial collector (Bartram pers. comm.) and assuming mostly fish and shells are the targets (Bartram pers. comm. and Kinsolving pers. comm.); value of $2/piece estimated with little basis; coral collecting is banned in depths shallower than 60 feet (Hunter 1995), no knowledge of any black coral or hermatypic coral, but some known collection of live rock, assume it is minimal; % FMP assumed zero from information in Green (1997).

Marine natural products: No knowledge of any activity.

Mariculture: No knowledge of any activity except small giant clam farms (Kinsolving pers. comm.), so assume it is minimal.

Deep Bottom:

Food: Landings are 1993-97 average from WPRFMC (1998:1-3), multiplied by the 88% that were BMUS in 1997 (WPRFMC 1998:Table 1); value based on 1997 price of $2.35/lb from WPRFMC (1998:2).

Sport: There is a very small charter sportfishing industry, and most activity is trolling (Saucerman pers. comm. and Kinsolving pers. comm.), so assume minimal deep bottom trips and value.

Ornamentals: No knowledge of any activity.

Pelagic:

Food: Landings roughly estimated from Hamm *et al.* (1998:Figure II.3.1), which reported about 300,000 to 500,000 lb/year from 1994-1996 (note increase from 1991-1995 average of 180,800 lb/year reported in Green (1997:Table 52); value based on 1996 price, $1.10/lb, reported in Hamm *et al.* (1998:Table II.1.1) for albacore, which dominated landings in 1996.

Sport: There is a very small charter sportfishing industry, and most activity is trolling (Saucerman pers. comm. and Kinsolving pers. comm.); roughly estimated, with little basis, 2 active boats, each doing 20 trips/year and 3 anglers/trip; fees roughly estimated, with little basis, at $80/angler-trip.

Sources and Assumptions for Table 4 (Fisheries, CNMI):

Coral Reef:

Food:

- Finfish landings are rough 1983-1993 average from DFW (1994:Figure 3); note that Radtke and Davis (1995) reported only 307,500 lb for 1995, but may have been commercial only; value based on 1996 price of $2.40/lb from Hamm *et al.* (1998:Table .1.1), in agreement with Radtke and Davis (1995); % FMP roughly estimated based on information in MES (1997) and Green (1997), including the report in the former that 15 mt of reef fish were taken from the northern islands in 13 trips by one 110-ft vessel during 7 months of 1995.
- Lobster landings estimated from various sources in Green (1997:138); value based on 1996 price of $4.64/lb from Hamm *et al.* (1998:Table .1.1); % FMP excludes lobsters.
- Echinoderm landings are all sea cucumbers (wet weight), very roughly estimated from records of Oct 1995 to May 1997 landings as reported in Green (1997:137), of 168,235 lb, but qualified with evidence that such levels may not be sustainable; value based on $6,000/mt for Fiji, reported in Dalzell *et al.* (1996:App 1); % FMP estimated from information in MES (1997) and Green (1997).
- Mother-of-pearl mollusc landings are all trochus, very roughly estimated from information in MES (1997) about intermittent nature of fishery, potential harvests, and amount stockpiled by a local company; value based on 1996 price of $3.09/lb paid by one company for shell-with-meat (MES 1997); % FMP estimated from data in MES (1997) and Green (1997).

Sport: Miller (pers. comm.) reports 33 boats registered as charter in 1999; roughly estimated, with little basis, there were 2 active boats for reef fish, each taking 100 trips/year and 8 anglers/trip; fees roughly estimated, with little basis, at $50/angler-trip; % FMP estimated from information in MES (1997) and Green (1997), and the assumption that the bank off west coast of Saipan may be used for sportfishing.

Ornamentals: Finfishes, invertebrates, and live rock are taken, but rarely, for local use in homes and hotels, and shells and beach coral are taken for local use and by visitors (Gourley pers. comm.); corals are also taken to make lime, by permit; assume overall landings and value to be minimal; % FMP estimated from information in MES (1997) and Green (1997).

Marine Natural Products: No knowledge of any activity.

Mariculture: No knowledge of any activity.

Deep bottom:

Food: 1993-1997 average landings from WPRFMC (1998:4-6) was 33,494 lb (commercial only); Radtke and Davis (1995) reported about 72,000 lb in 1995; so roughly estimated 50,000 lb; value based on 1997 price of $3.32/lb from WPRFMC (1998:12).

Sport: Miller (pers. comm.) reports 33 boats registered as charter boats in 1999; roughly estimated, with little basis, there was 1 active boat for deep bottom, taking 100 trips/year and 3 anglers/trip; fees roughly estimated, with little basis, at $100/angler-trip.

Ornamentals: No knowledge of any activity.

Pelagic:

Food: Radtke and Davis (1995) reported about 360,000 lb in 1995; DFW (1994) implied about 700,000 lb/year, so roughly estimated 500,000 lb/year; value based on 1996 price of $1.90/lb, from Hamm *et al.* (1997:Table .1.1).

Sport: Miller (pers. comm.) reports 33 boats registered as charter boats in 1999; roughly estimated, with little basis, 20 active boats doing trolling, each taking 150 trips/year and 3 anglers/trip; fees roughly estimated, with little basis, at $100/angler-trip.

Sources and Assumptions for Table 5 (Fisheries, Guam):

Coral Reef:

Food:

- Finfish 1991-1994 average landings reported in Myers (1997:Table 5) as 250,271 lb, including shallow component of bottom fishing and *atulai*; but personnel of Department of Aquatic and Wildlife Resources are reported as believing annual value to be $1.5 to $2.0 million/yr (main body of this document), so made intermediate estimate of 400,000 lb; value based on 1996 price of $2.94/lb for "reef fish," from Hamm *et al.* (1998:Table IV.1.1); % FMP estimated from Myers (1997), which reports that "substantially less than 20%" of reef fish are taken in federal waters, so estimated 10%.
- Lobster landings are 1991-1994 average, derived from Myers (1997:Tables 3 and 5); value based on 1996 price of $3.66/lb, from Hamm *et al.* (1998:Table IV.1.1); % FMP excludes lobsters.
- Mother-of-pearl mollusc landings are trochus only, 1991-94 average, derived from Myers (1997:Tables 3 and 5); value based on $2.20/lb price for CNMI reported by Dalzell *et al.* (1996:App 1).
- Other mollusc landings are 1991-94 average, derived from Myers (1997:Tables 3 and 5), includes giant clam *(T. maxima)* and octopus; value based on 1996 price of $2.65/lb for octopus from Hamm *etal.* (1998:Table IV.1.1); % FMP estimated from data in Myers (1997).
- Other invertebrate landings are 1991-94 average, derived from Myers (1997:Tables 3 and 5); value estimated, with little basis, at $2.20/lb; % FMP estimated from data in Myers (1997).
- Seaweed landings discussed in Myers (1997) and Green (1997) but no indication of volume or value; % FMP estimated from information in Myers (1997).

Sport: Pitlik (pers. comm.) reported 1,733 "bottom fishing" boat-trips and 20,388 angler-trips; with little basis, estimated half were deep bottom and half coral reef fishing trips; value based on $30/pax for party boats (Pitlik, pers. comm.); % FMP estimated based on WPRFMC (1998:2-13), which reported charter boats made 23% of all bottom fishing trips in 1996, including some "reef fish"; but most trips were only 2-4 hours, so very few went to federal waters, and assumption that federal waters are visited proportionately less often by charter boats than by commercial and recreation boats.

Ornamentals: Green (1997) estimated landings of ornamental fishes at 1,000 to 2,000 fish per month/mo (most exported to US, 120 to 150 per month sold in local pet shop) and some local residents collect for both home use and sale to local pet shop; some invertebrates also collected, but not exported; value of $2 per fish estimated with little basis; % FMP estimated from information in Myers (1997).

Marine Natural Products: No knowledge of any activity.

Mariculture: No knowledge of any activity.

Deep Bottom:

Food: Landings are average annual landings of BMUS during 1993-1997 (WPRFMC 1998:Guam App:2-9); value based on 1996 price of $3.50/lb (WPRFMC 1998:7).

Sport: Pitlik (pers. comm.) reported estimated 1,733 "bottom fishing" boat-trips and 20,388 angler-trips; with little basis, estimated half were deep bottom and half coral reef fishing trips; WPRFMC (1998:2-13) reported that charter boats made 23% of all bottom fishing trips in 1996; value based on $30/pax for party boats (Pitlik, pers. comm.).

Ornamentals: No knowledge of any activity.

Pelagic:

Food: Landings derived from Myers (1993:Fig 1), which reported range of 168mt to 364mt from 1980 to 1991; so took 300 mt; historical commercial data in Hamm *et al.* (1998:Fig IV.3.1) indicate it is reasonable; value based on approximate 1996 price of $1.30/lb, from Hamm *et al.* (1998:Table IV.1.1).

Sport: Pitlik (pers. comm.) reported 3,537 troll boat-trips and 20,519 angler-trips; value based on $350/boat-trip (Pitlik pers. comm.).

Sources and Assumptions for Table 6 (Fisheries, Main Hawaiian Islands):

Coral Reef: DAR (no date) reported about 1.2 million lb of commercial coral reef species landings between 1993 and 1997; Friedlander (1996) reports that under-reporting of commercial is common and notes the large non-commercial component of the fishery. Meyer (1987a) reported 21m lbs landings just by recreational boaters, much of which must have been reef species; so very roughly estimate landings of coral reef species of 5 million lb/year.

Food:

- Finfish landings estimated as 5 million coral reef species total less all other species groups; value based on 1991-1995 average price, or $1.56/lb, from Friedlander (1996:Table 14); % FMP from % of commercial landings outside 2 mile statistical zone (Friedlander 1996:Table 14), less 10% to approximate the 3 mile federal boundary.
- Lobster landings roughly estimated as twice the reported commercial landings, from Friedlander (1996:Table 14); price of $11.74/lb was 1991-95 average, from Friedlander (1996:Table 14); % FMP excludes lobsters.
- Other crustaceans mostly kona crab, landings roughly estimated as twice reported commercial landings, from Friedlander (1996:Table 14); price of $3.83/lb was 1991-95 average, from Friedlander (1996:Table 14); although an MUS under the crustacean FMP, kona crabs included here under % FMP, which is from % of commercial landings outside 2 mile statistical zone (Friedlander 1996:Table 14), less 10% to approximate the 3 mile federal boundary.

- Echinoderms all sea cucumbers; landings estimated as average 1991-95 reported commercial landings (Friedlander 1996:Table 14) adjusted upwards proportionately with other species so that all coral reef species landings totaled 5 million lb; price of $7.16/lb was 1991-95 average, from Friedlander (1996:Table 14); % FMP from % of commercial landings outside 2 mile statistical zone (Friedlander 1996:Table 14), less 10% to approximate the 3 mile federal boundary.
- Mollusc landings estimated as average 1991-95 reported commercial landings (Friedlander 1996:Table 14) adjusted upwards proportionately with other species so that all coral reef species landings totaled 5 million lb; price of $2.30/lb was 1991-95 average, from Friedlander (1996:Table 14); % FMP from % of commercial landings outside 2 mile statistical zone (Friedlander 1996:Table 14), less 10% to approximate the 3 mile federal boundary.
- Seaweed landings estimated as average 1991-95 reported commercial landings (Friedlander 1996:Table 14) adjusted upwards proportionately with other species so that all coral reef species landings totaled 5 million lb; price of $3.84/lb was 1991-95 average, from Friedlander (1996:Table 14); % FMP from % of commercial landings outside 2 mile statistical zone (Friedlander 1996:Table 14), less 10% to approximate the 3 mile federal boundary.

Sport: Roughly estimated 500 angler-trips per year based on Hamilton (pers. comm.) estimating that less than 1% of charter trips are for reef fish, with 1-3 anglers/boat; value based on fee of $141/angler-trip estimated for pelagic charter fishery, as described below; % FMP estimated with little basis.

Ornamentals: Volume for fishes and other inverts is number of animals collected, 1991-95 average from Miyasaka (1997), fishes dominated but some inverts, particularly feather duster worm, note 99% are sold; value based on 1991-1995 average ex-collector prices from Miyasaka (1997); % FMP from information in Friedlander (1996). Volume and value for black coral are 1991-95 averages from Friedlander (1996:Table 14).

Marine Natural Products: No knowledge of any activity, but with Hawaii's large ocean research and development industry, it is possible.

Mariculture: No knowledge of any activity, but with Hawaii's large mariculture industry, it is possible.

Deep Bottom:

Food: Landings 1993-97 average from WPRFMC (1998:3-10); value based on 1993-96 average price of $3.48 from WPRFMC (1998:3-3).

Sport: Roughly estimated 5,000 angler-trips per year based on data in Hamilton (1998 and pers. comm.); value based on fee of $141/angler-trip estimated for pelagic charter fishery, as described below.

Ornamentals: No knowledge of any activity (see Grigg 1993).

Pelagic:

Food: First, assumed 32 million lb total food fish in Hawaii, derived from data in Pooley (1993a:Table 1) of 30.2 million lb for 1990, adjusted upwards by implied higher landings in Meyer (1987a), then subtracted 5 million lb of reef species and 1 million lb bottom fish species, leaving 26 million lb; then applied ratio of landings between main and northwestern islands of 85:15 (1991-95 average from Friedlander 1996:Table 13) to very roughly estimate pelagic landings in main islands; value based on 1991-95 average price of $2.01 from Friedlander (1996:Table 13) for all offshore gear.

Sport: Data in Hamilton (1998) on trips/boat and number of charter boats suggests about 33,000 charter boat trips/yr, assumed 3 anglers/trip; total revenues estimated from average annual fees per business in Hamilton (1998) of $73,195, multiplied by 200 boat fleet, estimated from data in Hamilton (1998).

Sources and Assumptions for Table 7 (Fisheries, Northwestern Hawaiian Islands):

Coral reef:

Food:

- Finfish volume and value from Friedlander (1996:Table 14), assume no additional non-commercial landings; note most of it is sharks, thus the low value; % FMP from % of commercial landings outside 2 mile statistical zone (Friedlander 1996:Table 14), less 10% to approximate the 3 mile federal boundary.
- Lobster volume and value are 1992-1997 averages from Pooley and Kawamoto (1998); note dramatic decrease since 1988-89, when 1.5 million lb landed; lobster excluded from % FMP.
- Other crustaceans volume and value from Friedlander (1996:Table 14), assume no additional non-commercial landings; % FMP from % of commercial landings outside 2 mile statistical zone (Friedlander 1996:Table 14), less 10% to approximate the 3 mile federal boundary.
- Other molluscs volume and value from Friedlander (1996:Table 14), assume no additional non-commercial landings; % FMP from % of commercial landings outside 2 mile statistical zone (Friedlander 1996:Table 14), less 10% to approximate the 3 mile federal boundary.
- No commercial sea cucumber, other invertebrate, or seaweed landings reported in Friedlander (1996).

Sport: About 150 anglers/yr recently visited Midway to fish (Glover pers. comm.); assumed 5 trips per angler (derived from MSF 1999), and half reef fishing (e.g., spin-casting) and half pelagic fishing (Glover (pers. comm.); value based on $2,125 per angler-visit (derived from MSF 1999); all Midway's waters federal, so 100% FMP fishery.

Ornamentals: No knowledge of any activity.

Marine Natural Products: No knowledge of any activity.

Mariculture: No knowledge of any activity.

Deep Bottom:

Food: Landings and value 1993-97 averages from WPRFMC (1998:3-10).

Sport: At Midway only pelagic and reef fishing noted by Glover (pers. comm.), but likely some minimal activity.

Ornamentals: No knowledge of any activity.

Pelagic: First, assumed 32 million lb total food fish in Hawaii, derived from data in Pooley (1993a:Table 1) of 30.2 million lb for 1990, adjusted upwards by implied higher landings in Meyer (1987a), then subtracted 5 million lb of reef species and 1 million lb bottom fish species, leaving 26 million lb; then applied ratio of landings between main and northwestern islands of 85:15 (1991-95 average from Friedlander 1996:Table 13) to very roughly estimate pelagic landings in northwestern islands; value based on 1991-95 average price of $2.01 from Friedlander (1996:Table 13) for all offshore gear.

Food: 1990 from Pooley (1993a:Table 1) for total for state, then used MHI:NWHI ratio of 85:15 to split it (Friedlander 1996:Table 13)

Sport: About 150 anglers/yr recently visited Midway to fish (Glover pers. comm.); assumed 5 trips per angler (derived from MSF 1999), and half reef fishing and half pelagic fishing (Glover (pers. comm.); value based on $2,125 per angler-visit (derived from MSF 1999).

Sources and assumptions for Table 8 (fisheries, other islands):

Coral Reef:

Food: Landings derived from Irons *et al.* (1990), who reported on harvest of reef species on Johnston in 1990; those figures were doubled to roughly account for the 110 people on Wake (Green 1997) presumably doing about the same amount of fishing as the 175 people on Johnston in 1990; per-unit values roughly estimated with little basis; lobsters excluded from % FMP.

Sport: No knowledge of any activity.

Ornamentals: Irons *et al.* (1990) noted that coral and shells were collected by residents of Johnston for personal use; some evidence of aquarium fish harvesting seen at Palmyra.

Marine Natural Products: No knowledge of any activity.

Mariculture: No knowledge of any activity.

Deep bottom:

Food: No knowledge of any activity.

Sport: No knowledge of any activity.

Ornamentals: No knowledge of any activity.

Pelagic:

Food: Estimated, with little basis, that about half as much pelagic landings were made as reef fish landings; value ($2/lb) roughly estimated with little basis.

Sport: No knowledge of any activity.

Sources and Assumptions for Table 10 (Tourism Activity):

American Samoa:

- Total number of tourists derived from NPS (1996) estimates for 1993: less than 5,000 tourists plus 5,000 cruise ship passengers, the latter of which spend only about 8 hours on land; these figures can be compared with industry's peak of about 34,000 visitors in 1974.
- Percent of tourists American roughly estimated at 80 percent from data in Green (1997).
- Number of tourists "marine" and scuba divers from Kinsolving (pers. comm.) and Saucerman (pers. comm.).
- Expenditures by tourists, marine tourists, by scuba divers estimated by assuming expenditures of $500 per visitor.
- Number of scuba dives estimated by assuming five dives per visiting diver.

CNMI:

- Number of tourists and expenditures by tourists from MES (1997) and unpublished data of Marianas Visitors Authority.
- Percent of tourists American from Bank of Hawaii (1997b) and Miller (pers. comm.).
- Number of tourists "marine" roughly estimated from Green (1997) and Miller (pers. comm.).
- Number of scuba dives roughly estimated from DEQ (in prep.), which reported 84,000 or more dives in Lau Lau Bay alone.
- Number of scuba divers roughly estimated from the number of scuba dives (above), divided by a roughly estimated four dives per tourist (derived from the typical stay of Japanese tourists being 3 nights–Miller, pers. comm.).

- Expenditures by marine tourists and by scuba divers estimated by multiplying total tourist expenditures by the percentages of total tourists that were "marine" and scuba divers, respectively.
- Expenditures on scuba diving from DEQ (in prep.).
- Number employed in tourism roughly derived from 1995 census data, as reported by Miller (pers. comm.).
- Number employed in scuba diving roughly derived from Miller (pers. comm.).

Guam:

- Number of tourists, number of tourists "marine," percent of tourists American, number employed in tourism, and government revenues from tourism from GEDA (1999).
- Number of tourists scuba divers, expenditures per tourist, and number of scuba dives from Birkeland (1997b).
- Expenditures by marine tourists and by scuba divers estimated by multiplying total tourist expenditures by the percentages of total tourists that were "marine" and scuba divers, respectively.

Hawaii:

- Number of tourists, percent of tourists American, expenditures by tourists (1997-1998 averages) from Bank of Hawaii (1998).
- Number of tourists "marine" estimated at 65% of total, derived from an estimate of 85% by Clark (1991) for tourists that engage in some ocean recreation.
- Expenditures by marine tourists and by scuba divers estimated by multiplying total tourist expenditures by the percentages of total tourists that were "marine" and scuba divers, respectively.
- Expenditures on marine recreation from Grigg (1997), but includes expenditures by residents.
- Expenditures on scuba diving for 1992 and includes only tours and sales, from Clark (pers. comm.), cited in Friedlander (1996).
- Number of scuba dives (all paid dives, including by residents) from Tabata (pers. comm.) for 1986, adjusted upwards by 120%, the increase in visitation since 1986.
- Number of scuba divers estimated from number of scuba dives, assuming four dives per diver.
- Employment in tourism (1994-1997), government revenues from tourism (1992), and tourism as percent of gross state product (1992) from WTTC (1997), which treated the "travel and tourism industry."
- Employment in marine recreation from MacDonald *et al.* (1996).
- Employment in scuba industry (including part-time and contract workers) from Tabata (pers. comm.) for 1986, adjusted upwards by 120%, the increase in visitation since 1986.

Endnotes

1. "Natural products" as a fishery and "information" as a non-fishery are related but treated separately here. The former refers to the harvest side of gathering information and novel products from coral reefs, which is directly under the control of fisheries management agencies and this FMP. The latter, "information," refers to all the values of knowledge gleaned from the reef that do not rely on extraction and that are therefore not under the control of the FMP.

For example, a sponge might be harvested and examined by an academic researcher interested solely in taxonomy. The specimen might then be passed on to an academic or commercial researcher who learns about the chemistry of the sponge, including the discovery of some unique chemical activity with commercial application. This chemical information, either with or without the original specimen, might then be passed on to another party interested in producing commercial quantities of some derivative for pharmaceutical or other purposes. This might lead to synthesization of the chemical derivatives of the sponge and/or further harvest of the sponge, and ultimately to the production of saleable products. These last few steps in the process are well beyond the jurisdiction of the FMP. They are, however, important in terms of valuing the genetic and other "informational" resources of the sponge and the coral reef ecosystems in general.

It is assumed here that under even the most restrictive management alternatives being considered, extraction of small amounts of coral reef resources for primary research purposes–for the "discovery" of information–would be allowed, if governed by permits, and the measures would have no impact on this aspect of "information" value. If and when discovery of a valuable resource leads to the demand for more intensive extraction of an organism from the coral reef, the controls of the FMP could then conceivably restrict the extent of extraction and consequently the value of the research and development–for example by limiting the rate of extraction to the extent that it affects the production rate of a commercial product. Any such intensive extraction for commercial purposes, along with the value of the products that come from it, will be considered here as part of the "coral reef fishery natural products" sector. These are activities that are directly dependent on coral reef resources and directly under the control of the FMP. Harvesting of stony corals for use as bone graft material would be one example. In fact, it appears that no such activities are currently taking place in the US Pacific Islands. Any academically, educationally, or commercially motivated research that does not involve such intensive extraction, including research that leads to the development of commercial products, as well as any subsequent commercial production that does not rely on continued extraction from the reef, is treated under the "non-fishery information" sector.