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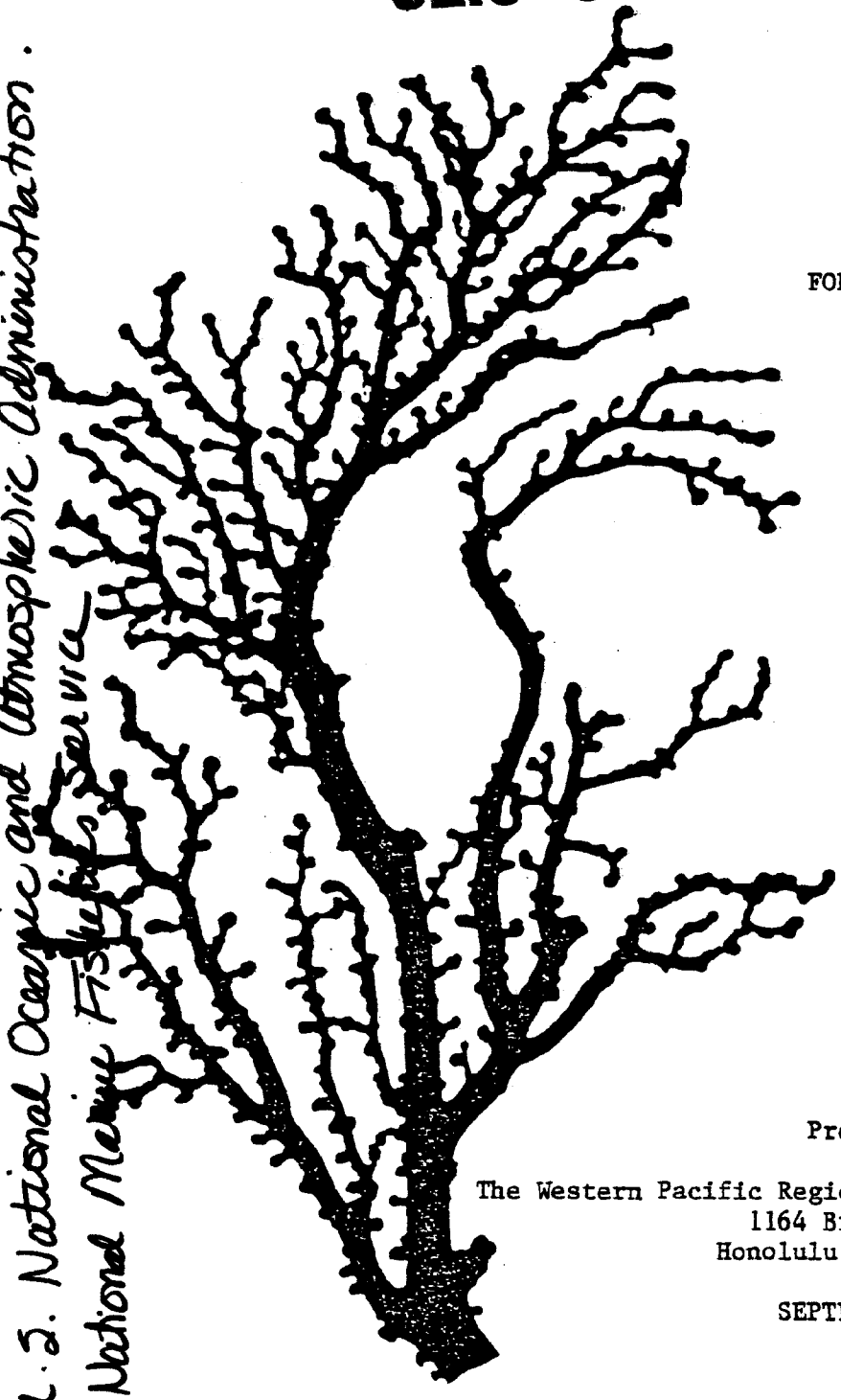

FOR THE PRECIOUS CORAL FISHERIES

OF THE

WESTERN PACIFIC REGION

Prepared by

The Western Pacific Regional Fishery Management Council
1164 Bishop Street
Honolulu, Hawaii 96813

SEPTEMBER 1979

U.S. National Oceanic and Atmospheric Administration.
National Marine Fisheries Service

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ENVIRONMENTAL IMPACT STATEMENT

on the

FISHERY MANAGEMENT PLAN

for the

PRECIOUS CORAL FISHERIES (and ASSOCIATED NON-PRECIOUS CORALS)

of the

WESTERN PACIFIC REGION

CZIC COLLECTION

Prepared by

The Western Pacific Fishery Management Council
1164 Bishop Street
Honolulu, Hawaii 96813

SEPTEMBER 1979

U.S. National Oceanic and Atmospheric Administration
National Marine Fisheries Service
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#6433306
AUG 6 1997

SUMMARY SHEET

Precious coral resources in the U. S. fishery conservation zones off the Hawaiian Islands, Guam and American Samoa

( ) Draft (X) Final Environmental Statement

Responsible Agencies:

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1. Name of Action (X) administrative ( ) legislative

2. Description of Action:

The proposed action is to adopt and implement a Fishery Management plan for the fisheries for all species of precious corals and other corals in the FCZ under the provisions of the Fishery Conservation and Management Act of 1976 (P. L. 94-265). This Act extends jurisdiction over fishery resources and establishes a program for their management.

The objective of the management plan is to permit and regulate fishing for precious corals within the U.S. fishery conservation zone so that the optimum yield of the coral resources will be harvested on a continuing basis. Implicit in this objective is the protection and conservation of precious coral stocks. Various management measures are considered including catch quotas, size limits, gear and seasonal restrictions, limited entry, permit and reporting requirements, and area closures. Of those considered, the management measures selected for implementation are: catch quotas, a minimum size for pink coral colonies, gear restrictions, establishment of closed beds or refugia, requirement that all coral harvesting be done under permit, and the requirement of extensive reporting of operations by permit holders. Three classes of coral beds are defined: Established Beds, which have a history of exploitation and have been studied sufficiently for the productivity of their coral populations to be specifically determined; Conditional Beds, which have been located and measured as to their approximate areas but otherwise uninvestigated; and all other beds referred to as Exploratory Areas. See figures 1 - 5 of the FMP for maps of the FCZ and precious coral beds. There is a single Established Bed, off Makapuu Point, Oahu, and biennial harvesting quotas are prescribed for each of the three types of precious coral that occur there.

For the five Conditional Beds, all in the Hawaiian Islands, annual quotas of the three corals are set for each bed. No quotas are set for non-precious coral for Established or Conditional Beds. For Exploratory Areas catch quotas of all precious corals combined are prescribed collectively for all beds that may be found in each such Area. Domestic fishing would be permitted to harvest up to 500 Kg per Exploratory Area, all species combined, from a permanent "reserve". Foreign vessels would be permitted to harvest up to 500 Kg per Exploratory Area per year.

The Exploratory Areas comprise those areas of the Fishery Conservation Zone around Hawaii, Guam, American Samoa, the Northern Marianas and the combined FCZ's of such island possessions as Wake, Johnston, Baker and Kingman Reef. WesPac Bed in the Northwestern Hawaiian Islands is designated as a refuge area closed to fishing for precious corals, in order to provide a reserve for possible reproductive replenishment of other beds and as a baseline for monitoring the effect of harvesting on coral populations. For the Makapuu Established Bed, the biennial species quotas are optimum yields which are only slightly reduced below the level of the estimated maximum sustainable yields of the populations. Only selective harvesting methods are permitted on this bed, as this permits taking the full optimum yield without risk of overfishing, and the history of the fishery shows that full exploitation of this bed by such means is economically feasible. Catch quotas for the Conditional Beds are determined by extrapolating, as far as possible, the known characteristics of the Makapuu populations to these areas. Non-selective harvesting (dredging) is permitted on the Conditional Beds (except Conditional Beds south and east of Niihau Island in the NWHI) and Exploratory Areas, for reasons of technical and economic feasibility. When such methods are used on Conditional Beds as permitted, the harvesting quotas are reduced by 80%, to compensate for losses due to harvesting undersized colonies and to incomplete recovery of the colonies which are knocked down. For the Makapuu Established Bed, and the Conditional Beds off Ke-ahole Point, Hawaii and Kaena Point, Oahu, a minimum size of pink coral colonies to be harvested will be enforced, corresponding approximately to the size at which natural mortality overtakes growth. No size limit will be applied to gold or bamboo coral, because of a lack of biological information on which to base such a requirement, nor on pink coral in areas where the permitted use of non-selective harvesting gear makes it impracticable. The plan calls for full reporting of all precious coral catch and effort data, continuing monitoring of the fisheries, and periodic review of the management measures. Foreign fishing will be permitted only in the Exploratory Areas, subject to approval of foreign permits by NMFS.

3. Summary:

(a) Environmental Impacts:

Regulation of precious coral fishing in accordance with the fishery management plan will give assurance that the long-term productivity of the resources will not be lowered by overexploitation, and that data be collected on distribution and abundance of precious corals. The

amount of coral that will be permitted to be removed from the beds in each harvesting period will be approximately commensurate with the new growth of the coral populations during that period. The accuracy of the approximation will vary depending on the degree to which research has made available firm data on the population dynamics and stock size in each case, but the information that will be generated by the reporting requirements of the management plan and by observer coverage of coral fishing operations, should steadily improve the reliability of the optimum yield estimates. The amount of coral that may be removed from each bed (using either selective or non-selective methods) in each harvesting period should be only about 2 percent of the standing crop. The risk of overfishing is believed to be slight because the quantities of corals which may be harvested are low.

There is no information to indicate that removal of the prescribed quantities of coral will significantly affect the environment of any other species. The management measures will allow continuation of the present domestic fishery at a slightly reduced level of production and will permit, although they will not particularly facilitate or encourage, expansion of the fishery to new areas. The effect on foreign fisheries cannot be clearly estimated, because the extent of foreign coral harvesting in the fishery conservation zone hitherto is not known; in any case, the potential harvest made available to foreign fishers is minimal. No particular impact of the fishery under this management system on coastal areas or land use patterns is foreseen, as the corals to be managed occur at depths averaging about 400 meters, several miles from shore at the nearest, and the product is of small bulk and innocuous character. There will be no impact on recreational activities.

(b) Adverse Environmental Impacts:

Permitting the use of dredges for harvesting precious corals in the areas other than the Makapuu Bed and two Conditional Beds in the Major Islands will have adverse environmental impacts to the extent that the quantity of pink coral that can be allowed to be taken will be only about 20% of the optimum yield that could be harvested with selective gear, such as manned submersibles, because of the loss of growth by harvesting undersized colonies and the wastage that results from failure of the dredge to recover all of the colonies that are killed. In addition, the dredge will damage or destroy a proportionately small quantity of other sessile organisms. There may also be some small adverse indirect effects on other organisms through alteration of the environment by dredging. It is unlikely that the dredges, which are tangles of netting dragged at low speed, will have a significant effect on any very mobile organisms that may inhabit the coral beds. Lastly, the catch quotas for the Conditional Beds and the Exploratory Beds are, at this initial stage of management, based on rough estimates and broad assumptions. If they are seriously in error, adverse impacts to the coral stocks of those areas could result, however, they should not be of a magnitude to cause serious long-term losses of productivity.

4. Alternatives:

Alternatives for each of the management measures were proposed and are discussed in this statement and in the FMP. The general alternative of taking no action or of postponing action would not be in accord with the letter or the spirit of the Fishery Conservation and Management Act. This would continue to leave the responsibility for management in the hands of the State of Hawaii and other local governments, which have dubious jurisdiction and enforcement capability, and the Bureau of Land Management of the Department of the Interior, which has a regulation requiring permits for activities which impinge on viable coral communities but no comprehensive program for management of coral fisheries. Failure to take action would be a dereliction of duty both to the resources and to the fishers.

5. Comments Requested:
U. S. Department of State
U. S. Coast Guard
U. S. Environmental Protection Agency
Hawaii Division of Fish and Game
Hawaii Office of Environmental Quality Control
Government of Guam
Government of American Samoa
Government of the Northern Mariana Islands
Fishing Firms
Processors
Environmental and Conservation Organizations
U. S. Department of the Interior
Other Federal Agencies

6. Hearings:

City	Time and Date 1979	Location
Chalan Kanoa Village	4:30 p.m. March 14	Grand Hotel Saipan, Northern Mariana Islands
Agana	4:30 p.m. March 15	Guam Reef Hotel Agana, Guam
Honolulu	7:00 p.m. March 21	Pagoda Hotel Honolulu, Hawaii
Lahaina	7:00 p.m. March 23	Lahaina Civic Center Lahaina, Maui, Hawaii
Pago Pago	5:00 p.m. March 27	Conference Center Pago Pago, American Samoa

7. Comments received during the public hearing process and responses to comments are given in Section XII of the EIS.

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I. INTRODUCTION

This final environmental impact statement (FEIS) for the fishery management plan (FMP) for the precious coral fisheries of the Western Pacific Region describes and discusses the potential impacts of implementing conservation and management measures for the management of fisheries for three species of precious corals, within the U. S. fishery conservation zone (FCZ) around the islands of the State of Hawaii and the Territories of Guam and American Samoa. This FMP also contains recommendations for the Secretary of Commerce for coral management in the FCZ of the Northern Mariana Islands. This FMP has been prepared by the Western Pacific Fishery Management Council under the authority of the Fishery Conservation and Management Act of 1976 (the FCMA) and the DEIS has been prepared in accordance with the National Environmental Policy Act of the 1969 (the NEPA).

In the NEPA, the Congress prescribed a strategy for achieving coordination of Federal activities and environmental considerations. The Act's basic purpose is to ensure that Federal officials weigh and give due consideration to unquantified environmental values, in addition to technical and economic considerations, in policy formulation, decision-making and administrative actions. Section 102(2)(C) of the NEPA requires preparation of a detailed environmental impact statement in the case of major Federal actions that may significantly affect the quality of the human environment.

The Fishery Conservation and Management Act of 1976 (P.L. 94-265) provides for the conservation of fishery resources and the management of fisheries, except for highly migratory species, defined in the Act as tunas, by establishing exclusive United States management authority within a fishery conservation zone of 200 nautical miles and on the continental shelf within and beyond that zone. The act calls for the preparation and implementation of a management plan for each fishery, through which the objectives of a National Fishery Management Program may be accomplished.

The fishery management plans provide the basis for determination of the appropriate limits for harvests from the fisheries, predicated on scientific information and taking into consideration the needs of the States, the fishing industry, recreational groups, consumers, environmentalist organizations and any other interested parties. In essence, the plans will prescribe the allowable catch of any fishery resource on the basis of the optimum yield from that resource.

The fishery management unit in this case is a number of widely separated known beds (See Sec. II-A of the FMP for a listing of known beds) of three species of deep-water corals, and other suspected but as yet unlocated beds of the same species, in the 200-mile FCZ around United States islands in the region or on banks and seamounts of appropriate depths within the FCZ or on the continental shelf. The pink coral *(Corallium secundum)*, the gold coral *(Gerardia sp.)* and the bamboo coral *(Lepidisis olapa)*, are commonly called "precious corals" as distinguished from the reef-building stony corals. In the context of fishery management

under the FCMA, the precious corals, because of the great depths at which they occur (average about 400 meters), are mostly within the fishery conservation zone and therefore under Federal jurisdiction, while stony corals inhabit mainly shallower inshore waters under the State or Territorial jurisdiction. Other species of precious coral, such as black corals will be included in the plan on a sequential basis. At the present time, black corals are harvested in waters of the Hawaiian Islands, but approximately 85% of the catch is taken within three miles of island coastlines. The remaining catch is taken within channel waters outside of three miles between the islands of Maui and Lanai. Jurisdiction over this area is currently a subject of dispute between the State of Hawaii and the Federal Government. The Council is in favor of including black corals in the FMP for precious corals, but also favors managing the resource as a single unit. This will require developing a joint plan with the state. The state has informally agreed with this position but in testimony provided during the public hearings, it has made it clear that this action would in no way jeopardize their claim of sovereignty over channel waters. Hence, black corals are covered by the plan but will be included on a sequential basis. Other species of precious coral in the FCZ for which there is likelihood of future harvest are also covered by the plan but will be incorporated into the plan on a sequential basis.

The location and extent of precious coral resources, both within United States jurisdiction in the Western Pacific Region and in the intervening areas outside that jurisdiction, are very imperfectly known to the United States fishery scientists and administrators. One bed, located off Makapuu Point on the island of Oahu, Hawaii, has been under commercial exploitation on a small scale for the past 10 years and has been the subject of biological study, so that its dimensions and stock density are fairly well established. Five other areas in the FCZ Seaward of the Hawaii Islands have been identified as precious coral beds by exploratory dredging and their approximate areal limits have been established (See Figures 1 - 5 of the FMP). Fishermen of Japan and Taiwan are known to have ranged widely throughout the tropical and sub-tropical Pacific Ocean dredging for precious coral, and they undoubtedly have a good deal of practical knowledge of the distribution and abundance of the coral resources; this has not, however, been published or otherwise made generally available. Some of the information on foreign fishing is little more than rumor, and some exploratory dredging by American researchers in areas said to have been formerly exploited by foreign fishermen has failed to turn up signs of precious coral. The general picture that emerges from the available information, documented and undocumented, is one of relatively small, widely separated areas inhabited by precious corals. This picture may be a fact, related to special habitat requirements of the species, or it may be in large part an artifact related to the difficulty of discovering and mapping a resource of this nature. There is no reason to doubt that additional beds of precious corals will be discovered in the FCZ of the Western Pacific Region, if there is sufficient commercial and scientific interest to support the necessary prospecting.

Given the limited present knowledge of the reproduction and recruitment of precious corals and the geographical distribution of the known beds, it seems reasonable to proceed on the assumption that each bed represents a discrete, self-renewing population and to manage each bed as a unit. Ideally, each bed should be managed on the basis of its particular biological requirements and production potential. However, at the present time there is specific information on these parameters for only one coral bed, that located off Makapuu Point, Oahu. Until comparably detailed data are available for other beds, the fishery management plan proposes to manage them as if their population dynamics were analogous to the Makapuu population of precious corals.

The only use for the precious corals is for jewelry and ornaments. Domestic exploitation of the resource in the Western Pacific Region has been virtually limited to the Makapuu bed and has a history of only a little more than a decade. Early in this period, the bed was fished with dredges, which evidently proved uneconomical. In recent years the bed has been exploited only by a submersible craft operated by a Honolulu-based firm, Maui Divers of Hawaii Ltd. Of the three species for which the fishery management plan prescribes specific management measures, pink coral has been the main object of the fishery. Gold coral has been exploited to a much lesser degree, and bamboo coral has not yet been developed into a commercial product. There has been extensive and intensive exploitation of precious coral resources in the central and western tropical and sub-tropical Pacific Ocean for many years by foreign, mainly Japanese, dredgers. As mentioned earlier, this foreign fishing has not been well documented. It is known that in the 1960's Japanese fishermen carried on an intensive fishery for pink coral on the Milwaukee Banks, northwest of Midway Islands, and there are undocumented reports that they have harvested precious corals in more recent years within 200 miles of islands under United States administration, such as Midway, Wake, Yap and Saipan. Since the Fishery Conservation and Management Act took effect, Japanese dredgers have been sighted by patrol aircraft in the vicinity of the Northwest Hawaiian Islands, and a Taiwanese dredger has put in at Midway Islands for emergency repairs, so it can be assumed that the foreign fishery continués to be carried on as it has in the past, by small vessels operating singly with simple dredges and without supervision or control by their flag governments. This foreign fishing would appear to be comparable in its style to the operations of primitive placer-mining prospectors, inefficiently gathering what they can from such pockets of the resource as they may chance upon.

Because of the great depths inhabited by the precious corals and the isolated locations of a number of the known beds, there is no recreational or artisanal utilization of the resource, nor does any appear likely.

II. DESCRIPTION OF THE PROPOSED ACTION

II.1 Management Objectives

The proposed action is to implement a fishery management plan for the populations of precious corals inside the U.S. 200-mile fishery conservation zone in the Western Pacific Region, that is, around the islands of Hawaii, American Samoa and Guam. The specific objectives to be achieved by management measures adopted under this fishery management plan are as follows:

1. To allow a fishery for precious coral in the fishery conservation zone in the Western Pacific but to limit the fishery so as to achieve the Optimum Yield on a continuing basis.

2. To prevent overfishing and wastage of the resource.

3. To encourage the use of selective harvesting methods.

4. To minimize the harvest of colonies of coral which are immature.

5. To minimize the harvest of colonies of coral which have not reached their full potential for growth

6. To preserve an opportunity for low-investment equipment in the fishery (dredges).

7. To encourage the discovery and exploration of new beds.

8. To provide for the establishment of refugia, i.e., beds completely protected from exploitation.

9. To encourage the development of new information concerning the distribution, abundance and ecology of precious corals.

II.2 Optimum Yield

II.2.1 Optimum Yield Considerations

The Fishery Conservation and Management Act of 1976 establishes the optimum yield concept as the basis of fishery management, defining the optimum yield of a fishery as the quantity of fish which equals the maximum sustainable yield as modified by relevant social, economic or ecological considerations so as to provide the greatest benefit to the nation.

For the pink coral population of the Makapuu bed, the maximum sustainable yield (MSY) has been estimated to be 1,185 kg per year. This estimate is derived from the assumption of a stable annual recruitment of 5,227 colonies, the observed density of colonies per unit of area and the known area of the bed, an estimated annual

instantaneous mortality rate of 0.066, and an estimated maximum yield per recruit of 237 gm at an age of 31.4 years. This level of yield can be sustained only if a minimum limit for harvestable colony size is enforced at a size approximating that at which yield per recruit is greatest, which is of course possible only when selective harvesting methods are used. For the pink coral, the minimum size limit is set at a colony height of 10 inches. When a bed is exploited by non-selective methods, such as dredging, the sustainable yield is reduced by approximately 80%, because of the loss of potential growth of the undersized colonies that are harvested and failure of the gear to recover all of the coral colonies that it knocks down.

The optimum yield prescribed for the pink coral fishery on the Makapuu bed represents a modification of the MSY by reference to economic considerations affecting the coral harvesting industry. The 10-inch minimum colony height limit is approximately 1 inch smaller than the minimum size which would produce the theoretically highest yield per recruit. This departure from the ideal size limit is made to accommodate current practice in the fishery, where it is considered that a colony height of about 10 inches is the minimum below which harvest of the small, lower valued colonies is not an economically efficient use of the harvesting equipment. The lowered size limit will slightly improve catch rates, and the analyses presented in the fishery management plan indicate that the effect on the MSY will be negligible. To compensate for this relaxation of the theoretically most productive limit, and to provide a conservative buffer against the possibility of any errors of over-estimation in the production analyses, the optimum yield is obtained by rounding the MSY figure downward to 1,000 kg.

The major difference between the MSY of 1,000 kg of pink coral per annum and the optimum yield is that the latter is established as 2,000 kg to be taken during any part of a 2-year period rather than 1,000 kg to be harvested each year. The reason for this biennial quota rule is that it is, according to industry sources, economically infeasible to tie up the expensive specialized equipment required for selective harvesting of precious coral for only a part of each year on one coral bed, whereas the more flexible biennial schedule would permit productive employment of the submersible craft during a greater part of the available time by making it easier to deploy it in other areas after the quota for the Makapuu bed is taken. The analyses presented in the fishery management plan indicate that any lowering of the long-term MSY by this strategy would be negligible.

Optimum yields for the gold coral, based on an MSY of 300 kg per year, and for bamboo coral, based on an MSY of 250 kg per year, on the Makapuu bed have been determined by analogy with the case of pink coral and on the same rationale, although information on the size composition, growth rates and consequently the natural mortality is lacking for these species. Similarly, optimum yields of pink, gold and bamboo stocks on beds other than Makapuu, concerning which there is no information available other than in cases the approximate gross area of the bed, are calculated by considering them to bear the same relation

to the optimum yields of the Makapuu stocks that the areas of the beds bear to the area of the Makapuu bed.

The full optimum yield will be made available from the Makapuu precious coral populations by requiring that only selective harvesting methods be used there, as the history of exploitation of that bed shows that full harvesting by such methods is technically and economically feasible. On Conditional Beds, in which non-selective methods are permitted for the present, the optimum yields will most likely be only 20% of the full potential. The high cost and technological requirements of submersible craft or remote-controlled selective harvesting devices will limit their use by foreign fishermen or by the inhabitants of United States island territories of the region. Therefore, the reduced harvests that can be permitted with the simpler non-selective gear are accepted as the price of allowing the development of a domestic harvesting industry in the parts of the region where selective harvesting devices cannot at present be economically used. Any foreign fishing which may be permitted in the FCZ would improve the circumstances for development of a domestic fishery by providing information on the locations and characteristics of coral resources which are not known at present to domestic fishermen or government authorities.

Aside from the several economic considerations noted above as having affected the derivation of optimum yield from the MSY, no other social, economic or ecological factors were found to be either relevant or well enough known to cause further modification of the optimum yield.

II.2.2 Total Allowable Level of Foreign Fishing (TALFF)

In accordance with provisions of the Fishery Conservation and Management Act of 1976, foreign fishers will generally be allowed to harvest precious corals in the U.S. fishery conservation zone and from the Continental Shelf areas under U.S. jurisdiction at a level corresponding to the difference between the optimum yield established for a given coral bed and the domestic harvest from that bed. In the case of the Makapuu bed, which is the only one currently under exploitation in the FCZ of the region, the present level of harvesting effort is more than sufficient to take the entire optimum yield of 2,000 kg of pink coral within a part of the 2-year period for which this catch quota is made available, and therefore there will be no TALFF from that resource. No foreign country is known at present to be able to deploy selective harvesting gear in the Makapuu bed, where that is the only type of harvesting method to be permitted. Domestic harvesting capacity is also deemed adequate to take the entire optimum yields of gold and bamboo corals from the Makapuu bed and of all three kinds of precious corals from the five Conditional Beds which have been located and surveyed in the FCZ Seaward of the Hawaiian Islands, so no TALFF's will be provided from those resources. An optimum yield of 1,000 kg annually is established for the total of all newly discovered beds that may come under exploitation in each of the major areas of the region; the Hawaiian Islands, American Samoa, Guam, the Northern Mariana Islands (recommended for Secretarial Action, but not a part of the Council's FMP) and the various

island possessions jointly. One half of this amount is reserved for the potential development of domestic fisheries in those areas. This measure will provide the possibility of a TALFF of 500 kg of all three kinds of precious coral combined in each such exploratory area.

Given the longlived nature of precious corals, the low rate of natural mortality, and the small quantity of corals involved, there is little "waste" inherent in not taking the Optimum Yield in a single year. Therefore, none of the reserve is intended to be released to foreign fishing even if domestic vessels fail to harvest the reserve in a single year. The Council will reconsider this measure after three years of implementation to determine if the reserve approach is effective in promoting domestic fishing without a conservation risk. Thus, there is a 500 kg/year TALFF for the first three years of the FMP in Exploratory Areas. Foreign research fishing may be permitted.

II.2.3 Management Measures Adopted

After consideration of various alternative management measures, as described in section IV.F.1 of the fishery management plan, the following set of management measures is adopted for the precious coral fisheries under United States jurisdiction in the Western Pacific Region.

(a) Fishing Permits

Harvesting of precious corals will be permitted from all coral beds under U.S. jurisdiction in the Western Pacific Region, except such beds as may be designated as reserves or refugia. All persons engaged in coral harvesting will be required to have annual, area specific permits to which appropriate conditions will apply.

(b) Classification of Coral Beds

Coral beds are specific known sites in which corals are found and are classified in three categories. Beds which have been subjected to harvesting and have been sufficiently studied to determine their specific maximum sustainable yields are designated Established Beds. At present the only such bed in the Region is the one located approximately 6 miles off Makapuu Point, Oahu. Beds which have been definitely located by survey and for which the approximate total area is known but where the density, size composition and other specific characteristics have not been studied sufficiently to determine their maximum sustainable yields are designated as Conditional Beds. There are five such beds known at present, all in the Hawaiian Islands. One such bed will be designated a Refugium. All other precious coral beds still to be discovered in areas under U.S. jurisdiction in the Region are designated collectively as forming an Exploratory Permit Area in each of the five major geographical divisions of the Region -- Hawaii, American Samoa, Guam, the Northern Marianas and the combined FCZ's around the remaining minor U.S. islands in the central and western Pacific Ocean.

(c) Catch Quotas

The optimum yields determined as described in section II.2.1 are applied as limits to the harvest permitted from each bed or exploratory area. For the Established Bed at Makapuu, Oahu, the quotas are 2,000 kg of pink coral, 600 kg of gold coral and 500 kg of bamboo coral per biennial quota period. For the Conditional Beds, the catch quotas are annual and are determined by reducing or increasing it by a factor corresponding to the relation which the area of the Conditional Bed bears to the area of the Makapuu Bed. In two Conditional Beds, off Kea-hole Point, Hawaii and Kaena Point, Oahu, dredging is prohibited. In Conditional Beds where non-selective methods such as dredges are allowed, the quota is to be reduced by 80% In order to prevent over-harvesting, a Conditional Bed is closed to further non-selective harvesting whenever the catch of any one of the three kinds of precious coral reaches the annual quota. For each Exploratory Area, the annual catch quota is 1,000 kg of all three precious coral varieties in total, half of which is reserved for domestic fishing. Up to 500 kg/year of all three species may be made available for foreign fishing in each Exploratory Area.

(d) Closed Areas

Provision is made for the designation of coral beds as reserves or refugia in which no harvesting of precious corals is permitted, and for the present one such refugium is established at the WesPac Bed, between Nihoa and Necker Islands of the Northwestern or Leeward Hawaiian Islands. The purpose of this measure is to provide a reproductive reserve for replenishment for beds which could be inadvertently overexploited and a baseline study area for evaluating the effects of exploitation on other coral beds.

(e) Seasons

Permitted coral harvesting may be carried on at any time of the year, no biological, technical or economic reason having been found for limiting fishing to any particular season. A harvesting season for purposes of permit validity and quota enforcement extends from July 1 through June 30 of the next year, in the case of Conditional Beds or Exploratory Permit Areas, or of the second year following, in the case of the Makapuu Established Bed. These dates were selected for congruence with the established management system of the State of Hawaii, which is based on such a fiscal year.

(f) Harvesting Methods

Only selective harvesting gear is permitted on the Makapuu Established Bed, because the history of that fishery has demonstrated that it is technically and economically feasible to take the entire optimum yield of precious corals at that location by selective methods and because the harvesting quota that can be permitted when such methods are used is five times that which can be allowed, without exceeding the

the MSY, when non-selective methods are employed. Dredging is also prohibited in the Kea-hole and Kaena Point Beds because it is judged that their small area would not produce a return sufficient to offset the biological risks associated with dredging. On all other coral beds and in Exploratory Permit Areas, dredging is permitted, with a reduction of the harvesting quotas to 20% of the nominal optimum yield, because of the losses of broken coral colonies from the dredges and the harvesting of colonies which have not reached their optimum growth. Harvesting of precious coral, under a quota limitation, by the biologically less efficient dredging method is only permitted because under the present circumstances there is judged to be no possibility of achieving anything approaching the full potential production of the coral resources or involving the people of the islands of the region in the precious coral fishery or identifying presently unknown coral beds if the use of only selective gear throughout is required. The capital investment, high operating and maintenance costs and technological expertise required for submersible craft to operate in the coral fisheries would place such harvesting methods beyond the reach of island fishers and result in a defacto monopoly of the coral resources of the region for the one firm which is now conducting selective harvesting operations. This firm's single harvesting vessel would be unlikely to be able to utilize the potential harvest from the widely separated known beds and also to carry out the exploratory fishing needed to locate other beds in the various areas of the Hawaiian Islands, American Samoa, the Marianas and the scattered island possessions intervening. Coral dredging, on the other hand, does not require a specialized vessel nor expensive or complex equipment and thus, could be readily taken up by island inhabitants who, in most areas of the region, face a need for additional economic development. The methods used for coral dredging are described in section II-C-2 of the FMP.

(g) Size Limit

For pink coral in the Makapuu Established Bed, and the Conditioned Beds off Kea-hole and Kaena Points, a 10-inch colony height is set as the minimum size limit for coral to be harvested. This limit is feasible because of the required use of selective gear and is essential to achieve the optimum yield. Biological information is inadequate to support a minimum size limit for gold or bamboo coral on the Makapuu Bed and elsewhere the permitted use on some beds of dredging, which is non-selective for colony size, precludes the imposition of a size limit.

(h) Incidental Catches

Any precious coral taken from a bed under U.S. jurisdiction in the region by fishing gear intended to catch other species, such as in trawling for finfish or shellfish, is required to be reported to the regulatory authorities and to be returned to the sea. It has been reported that trawlers fishing for deep-dwelling bottomfish species do occasionally bring up coral, but there is no documentation

of the frequency or volume of such incidental catches. The only foreign fishery now permitted in the areas of the FCZ covered by this plan is for Seamount groundfish, and that plan prohibits retention of any corals taken incidental to groundfish. The management measure will furnish quantitative data on the problem and, by ruling out retention of incidental catches will prevent their being used as a subterfuge for unlicensed coral harvesting. If incidental catches in any area are revealed to be more than 50 kg per vessel per year, more restrictive measures will be considered.

(i) Permit Conditions

Permit holders will be required to maintain and submit to the NMFS a detailed and accurate logbook covering all significant particulars of their coral harvesting operations and sales of their catches and to identify their vessels by conspicuously exhibiting their permit number on its superstructure.

II.3 Description of Environment

II.3.1 Marine Environment

The precious corals to which the above-described management measures occur at depths of 300 to 475 meters, on hard substrates which are believed to be swept clear by relatively strong currents. Several of the known beds are located off promontories of islands or in inter-island channels. The coral polyps form colonies resembling small trees, and these colonies form aggregations called beds. Within the 200-mile fishery conservation zones around islands under U.S. jurisdiction in the Western Pacific Region, six beds of precious coral have been located definitely, all in the Hawaiian Islands area, and their approximate areas have been determined. These beds are small; only two of them have an area greater than 1 square kilometer, and the largest is 3.6 km^2. There are undocumented and unconfirmed reports that precious corals have been observed or exploited in widely scattered locations in the region: off American Samoa, Guam, the Northern Marianas, Yap Island and Wake Island, but no details are available. In some cases attempts at scientific surveys in areas referred to in such reports have failed to turn up any evidence of precious corals. Undocumented reports of large past commercial production by Japanese vessels on the Milwaukee Banks, some 500 miles beyond the northwestern extreme of the Leeward Hawaiian Islands, and the large physical area of those banks lead to conjecture that precious corals may at some locations occur in much larger aggregations than have as yet been demonstrated by scientific surveys. Asian coral fishers, who have roamed the western and central Pacific for decades, undoubtedly have undocumented and unorganized information on precious coral beds that is unavailable to U.S. researchers and administrators. It must be said that in general the available information on precious coral occurrence and distribution is fragmentary and

very incomplete, and there is a high probability that further surveying and prospecting will reveal significant additional precious coral resources in the areas under U.S. jurisdiction.

Likewise, little information is available on the ecological associations of the precious corals or their significance to the lives of other organisms. Microzooplankton and particulate organic matter are important in the diet of related gorgonians, and like other anthozoan species they are associated with numerous kinds of commensal invertebrates. They are also associated with many species of other anthozoans. They have not been observed to be consistently associated with any kind of finfish or free-swimming invertebrate. There are no known predators on precious corals.

Estimates of the densitites of occurrence of precious coral colonies in their habitat based on in site observations have been made only for the Makapuu Bed, and indicate a sparse, widely separated habit of growth, which is confirmed by photographs taken from T.V. cameras and submersible craft. The estimated average densities are 0.022 colony per square meter for pink coral, 0.003 col/m^2 for gold coral and 0.01 col/m^2 for bamboo coral.

Because of the great depths at which they live, the precious corals would be expected to be insulated from some short-term drastic changes in the physical environment. For the same reason it is difficult to imagine circumstances in which man-made pollution would affect their environment, except in the unlikely event that large quantities of heavy material such as waste from manganese nodule refining, were dumped directly on a bed. Nothing is known of the effects of long-term changes in environmental conditions, such as water temperature or current velocity, on the reproduction, growth or other life activities of the precious corals. In the fishery management plan, stability of these parameters is based on the stable nature of the age frequency distribution.

As far as is known at present, the precious corals of the region have no ecological relationship with any threatened or endangered species or any marine mammal.

II.3.2 Human Environment

The precious corals do not, in the living state, form an overt part of the human environment in the region, because of the great depths which they inhabit and the isolated locations of most of the known beds. They are not within the range of observation of recreational or commercial free divers, and are seen in vivo only by the operators of the submersible vessel employed to harvest them in Hawaii, or occasionally by research scientists. It should be noted, however, that precious corals, like any species of wildlife, have scientific values apart from socio-economical considerations.

The handling and processing of the product, which is a small volume of an inert mineral skeletal material, does not obtrude itself on the public notice as the analogous operations in other fisheries often do, through cannery odors or localized pollution of harbor waters. Probably the majority of the inhabitants of the Hawaiian Islands and elsewhere in the region are unaware that there are precious coral resources in the surrounding waters, except as that fact is brought to their attention by the advertisement and display of coral jewelry on the local market.

Precious corals are rarely, if ever, harvested accidentally by any type of domestic commercial or recreational fishery practiced in the region nor has there been any indication that any group of fishermen of the region consider the precious corals in any way related to the success of their fishing operations. It is probable that foreign fishers, who from time to time carry on deep trawling for finfish in some areas of the fishery conservation zone, occasionally encounter incidentally harvested precious coral in their trawls.

The element of the human population of the region which is aware of and concerned about the precious coral resources, aside from a few scientists and administrators, primarily comprises the persons employed in the precious coral fishery and the associated processing industry and members of environmental groups. The largest firm in the Hawaiian precious coral industry employs about 308 persons, including 35 involved directly in fishing and/or processing of locally harvested coral. It is reported that there are about 15 other firms in Hawaii engaged in making jewelry from imported coral and it is estimated that as many as 500 retail outlets in the State handle coral jewelry, among other types, of which an unknown portion is made of locally harvested coral. In total, around 800 to 1,000 persons, from fishermen to retail sales clerks are employed in the coral industry in Hawaii. In other island groups of the region the involvement of the local population is much less, although most curio shops and airport terminal duty-free stores sell coral jewelry.

In considering the human environment of the precious coral fishery in the Western Pacific Region, attention must be paid to the possibility that people of islands other than those of Hawaii may become involved in the future in precious coral harvesting and perhaps in the processing of precious coral into jewelry. There is no such involvement at present, although a basis for its development may exist in that small quantities of black corals *(Antipathes spp.)* are reported to be collected by local divers at some of the islands from time to time. It is generally agreed that the people of American Samoa, Guam and the Northern Marianas, like those of the Trust Territory of the Pacific Islands, need the development of a variety of new economic activities, in order to become self-supporting, and that they must look to ocean resources as a major basis for such

development, because of the general paucity of land and terrestrial natural resources. Coral harvesting by simple methods such as dredging would be relatively easy for the island people to take up, if organized surveys by government agencies or private prospecting should reveal the existence of significant beds of coral in locations accessible to them. On the other hand, dredging as practiced on the Makapuu Bed in Hawaii in the 1960's was apparently not efficient enough to be profitable, and there is some question whether it could be made to pay in American Samoa or in the Marianas. Other simple but labor-intensive and low paying activities, such as copra making and commercial fishing, do not seem to have much appeal under the prevailing socio-economic conditions in the U.S. Territories.

The foreign coral fishermen are a part of the human environment which must be taken into account. At present, and until a management plan for precious corals is put into effect, there is no legal way for them to participate in coral fishing in areas under U.S. jurisdiction in the region. There has been no direct approach by any foreign government seeking U.S. permits for its fishermen to take precious coral in the fishery conservation zone of the region, although as mentioned above there have been sightings of Japanese boats engaged in unlicensed dredging off the Northwestern Hawaiian Islands. Given the extremely low intensity of surveillance in the region, there could be considerable undetected illegal coral fishing by foreigners. It is difficult to tell whether the failure of any foreign government to show an interest in U.S. precious coral stocks is due to their judgment that those stocks are of negligible importance compared with other resources known to them in areas outside the FCZ, or to a belief that coral can be harvested with impunity from the FCZ without getting involved with possibly onerous U.S. conservation rules and reporting requirements. Most likely the operations are of such a small scale and value, compared with other fisheries which Japanese and Taiwan fishermen engage in within the fishery conservation zone, that they have not attracted the attention of the flag governments. Observations of a Taiwanese coral dredger which put in at Midway Island in 1977 would indicate that the fishery is carried on, at least in part, by very small vessels which show no signs that the operation is a very lucrative one. In any case, available information indicates that in recent years at least 90 Japanese boats and at least 30 Taiwanese boats have engaged in precious coral harvesting in the central and western Pacific Ocean. There are no data available on the number of fishermen employed in the foreign fleets. However, it is reported that the larger dredge boats carry crews as large as 20 men. Implementation of the measures prescribed in the fishery management plan would open up the possibility for the Japanese and Taiwanese coral dredgers to engage in legal fishing for stocks of precious corals under U.S. jurisdiction, under permit, to the limited extent of 500 kg total harvest of all three types of coral combined annually in each of five major Exploratory Areas. There would be no change in the conditions governing incidental catches of coral by foreign fishermen engaged in the Seamount groundfish fisheries of

the central North Pacific, as the Federal regulations for those fisheries already require full reporting of such incidental catches and the return of the broken coral to the sea.

III. RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE PLANS, POLICIES AND CONTROLS FOR THE AFFECTED AREA

Implementation of the fishery management plan for precious corals would change the present situation of the precious coral fisheries, actual and potential, in the region by opening up the possibility for a limited legal fishery by foreign fishermen at the present time, which as noted earlier, is not possible under the provisions of the Fishery Conservation and Management Act except through the promulgation of a Fishery Management Plan or a Preliminary Fishery Management Plan. On the other hand, this action would apply a number of new controls and limitations to any harvesting of precious corals by domestic fishermen. This change in the situation of domestic fishermen is, at the present time, more theoretical than real, as the only existing domestic fishery, the Maui Divers operation off Makapuu Point, Hawaii, is being regulated by the State of Hawaii through a set of management measures similar to those established by the fishery management plan. This fishery is also subject to regulation under a permit system established by the Secretary of the Interior and administered by the Bureau of Land Management of the Department of the Interior.

According to a draft memorandum of understanding between the Departments of Commerce and the Interior, implementation of coral fishery management measures by the Secretary of Commerce, under a fishery management plan developed by the cognizant Regional Fishery Management Council, will cause the Bureau of Land Management to withdraw from managing any fishing for the coral resources concerned. The real effect of this change of administering authority is difficult to evaluate, as the BLM does not have an overall management strategy but attaches conditions to its permits on a case by case basis. In the case of the Makapuu fishery, the main changes in the management system would appear to be the change from an annual to a biennial catch quota and the possibility that the harvesters will not be required to pay royalties to the Federal Government. Appendix II of the FMP contains the BLM regulations.

The effect of implementation of the fishery management plan on the regulatory system of the State of Hawaii is more difficult to predict. It appears to be a policy of the State administration to claim jurisdiction over resources in the channels between the main islands which make up the State, on the analogy of claims to jurisdiction over "archipelagic waters" that have been advanced by certain nations in the international forum. Following this policy, the State has promulgated regulations for fishing of pink and gold coral "in waters subject to the jurisdiction of the State". With no further definition and assuming that State jurisdiction were limited to the waters within 3 nautical miles of shore, there would be no conflict with Federal policy as

expressed, for example, in the Fishery Conservation and Management Act, and probably little real effect, assuming that there is in fact little or no precious coral growing within 3 miles of the islands. However, the State regulations refer specifically to the Makapuu coral bed, which is about 6 miles off shore. The State's regulation sets a biennial quota only for pink coral from the Makapuu bed, equal to the 2,000 kg prescribed in the fishery management plan. Unless the State recedes from its claim to jurisdiction or loses a test of that claim in the courts, it appears likely that anyone harvesting coral from the Makapuu bed will have to hold permits from and make reports to both the Department of Commerce and the State of Hawaii. The same could be true of any harvesting operations that might be initiated on the bed off the northwestern point of Oahu. Potentially more troublesome to future coral fishery development are the provisions of the State regulations that any pink or gold coral landed in the State must be taken in accordance with the regulations, whether or not taken in waters subject to the State's jurisdiction, and that no dredges or other non-selective means can lawfully be used to harvest these types of coral. Depending on how the State defines the geographical boundaries of its jurisdictional claim, and the locations of any beds that may be found in future, this could bring the State and Federal authorities into conflict and jeopardize the development of a Hawaii-based fishery on beds beyond the present reach of selective harvesting gear. It should be noted that the plan will prohibit dredging in the main Hawaiian Islands, thus preventing conflicts in that area.

Guam is the only other local government of the areas covered by the fishery management plan that has specific regulations or policies relating to the precious coral fisheries. The government of Guam has established in the Guam Comprehensive Development Plan an interest in research aimed at developing fishery resources out to the legal 3 mile boundary in the FCZ. A representative of the Government of the Northern Marianas, in the status of official observer at a meeting of the Western Pacific Fishery Management Council, asked that a recommendation not be made to establish a 500 kg allowable level of foreign fishing for exploratory operations in the Fishery Conservation Zone around the Northern Marianas, apparently on the basis of the belief that foreign fishermen are well acquainted with the locations of precious coral beds in that area, so that such fishing would not be truly exploratory in nature, and also because the Northern Marianas has no voting membership on the Council. Implementation of measures for this area of the FCZ is the responsibility of the Secretary of Commerce. It is recommended in the FMP that foreign fishing be allowed in the NMI but limited to 500 kg/year for all species of precious coral combined.

The precious coral fisheries covered by the proposed action have no direct relationship, nor any demonstrable indirect relationship, to any land use plan, in the region, because the harvesting covered, by definition, occurs beyond 3 nautical miles from shore and at great depths, and the product is of small volume, non-noxious in character and is processed in workshops in general light industry areas. Harvesting vessels use

established mooring facilities and it is not forseen that they will ever require any additional or specialized harbor facilities. The objectives of the FMP are consistent with those of the Coastal Zone Managememt Plan of the State of Hawaii.

IV. PROBABLE IMPACTS OF THE PROPOSED ACTION ON THE ENVIRONMENT

IV.1. Biological Impact

The biological impacts of the management measures for precious corals are considered on four levels. First is the impact on the particular populations of pink, gold and bamboo corals that are to be harvested under the prescribed management measures. Second is the incidental direct impact on other organisms inhabiting the coral beds by the gear used for coral harvesting. Third is the impact on precious corals of incidental catches resulting from operations in other fisheries, such as deep trawling for Seamount groundfish. Fourth in the indirect ecological effect of the removal of precious corals on other organisms and the bottom terrain.

Harvesting of precious corals in the quantities and by the methods permitted by the proposed management measures should result in conservation of the coral stocks and their maintenance at levels that will sustain a maximum yield over long periods of time, provided that there are no drastic changes in natural environmental conditions and provided that the estimates of the main parameters of the dynamics of the coral populations are approximately correct. Admittedly, little is known of the influence of environmental factors on the corals. However, the evidence available from such studies as have been made of the age structure of the Makapuu stock indicates long-term stability. Also admittedly, the harvest quotas provided for the known but as yet unstudied Conditional Beds and for the as yet undiscovered beds in the Exploratory Areas are based on arbitrary extrapolations and may be in error. However, they are considered conservative enough to preclude serious damage to the productivity of the beds pending acquisition of more specific and precise data, and without such estimates of MSY there would be no possibility, within the terms of the FCMA, of permitting the development of fisheries which in turn should be a source of better data on which to base improved management measures. In this connection, it is pointed out that the fishery management plan calls for a periodic review of all management measures and their revision as needed.

At the second level of concern, harvesting by a manned submersible, with visual selection of the coral colonies to be removed from the substrate, as practiced at present on the Makapuu bed, should have a minimal effect on associated non-commercial anthozoan species and other organisms inhabiting the coral beds. Other "selective" methods which have been suggested may be less innocuous in this respect. For example, coral fisheries have worked on designs for a tracked vehicle which would traverse the coral beds under remote control, picking up coral colonies selected through the medium of closed-circuit television. Presumably

such a harvesting method, if it should come to be employed, would have more physical impact on the sessile organisms inhabiting the bed than does the submersible, and this added impact could fall on undersized colonies of the target species as well as on other species. If this impact proved great enough, it might be necessary to classify such gear as "semi-selective" and adjust harvesting quotas appropriately where it is used.

The greatest impact on associated organisms undoubtedly comes from the dredge, which is the harvesting device used in most precious coral fisheries in the world. Dredges, as used by Asian fishers in the Pacific, consist of a number of large stone weights which are dragged over the bottom to break off the coral colonies from the substrate and pieces of netting to entangle the broken pieces of coral so that it can be recovered. It is probable that this process does considerable damage to other sessile organisms on the beds, especially those which, like the precious corals, form colonies which rise some distance off the bottom. Little quantitative data are available on the miscellaneous incidental catches of coral dredges. On the basis of a field simulations and a theoretical analysis of the effect of non-selective harvesting on a pink coral population, the fishery management plan calls for reduction of harvesting quotas by 80% from the potential MSY to account for loss resulting from harvesting under-site colonies and imperfect recovery of colonies knocked down by the dredge. With respect to the other species commonly occurring on the beds, many are tough and flexible, unlike pink coral, which is brittle, and thus may have a certain degree of resistance to being broken off by the dredge. Field observations by Dr. Richard Grigg, HIMB, U.H., suggest that impacts on related corals are no greater than the impact on pink coral, i.e., no more than 2% of the standing crop should be affected during the harvesting period. No effects of dredging on bottom terrain are anticipated. In considering dredging more generally, it may be appropriate to point out that the standard fishing methods used in a number of fisheries, such as bottom trawling for finfishes and shrimp and dredging for clams, scallops, oysters and crabs, similarly impinge on many species other than the target species.

There is no evidence that incidental taking of precious corals by other fisheries is of a magnitude likely to have a serious effect on the coral resources, although admittedly there are few relevant observations on record. The only fishery at present in the region that would seem capable of having such an effect is the deep trawl fishery carried on by Japanese and Russians on the Seamounts of the central North Pacific. Only a small part of that fishery takes place within the fishery conservation zone under U.S. jurisdiction. The proposed action would not affect the current prohibition on retention of incidentally caught coral and requirement for detailed reporting of all incidental catches. These requirements are already included in the U.S. regulations for the foreign Seamount groundfish fisheries. The proposed coral fishery management measures also call for a close monitoring of the incidental catch problem

and for timely revision of the regulations if incidental catches in any area amount to as much as 50 kg annually.

Little can be said at the present time about the indirect ecological effects of precious coral harvesting, as there have been no quantitative studies of the eco-system on a coral bed before and after harvesting. However, insofar as only about 2 percent of the standing crop of pink coral will be subject to harvest in each harvesting period, it is reasonable that no more than this proportion of any other associated (obligate or not) species will be similarly affected.

The National Marine Fisheries Service has issued a biological opinion indicating that the plan is unlikely to jeopardize the continued existence of any endangered species (Appendix IV).

There may be some dredging around the Northwestern or Leeward Hawaiian Islands, which some individuals believe should be designated as a sanctuary due to its unique character and the presence of the Hawaiian monk seal, an endangered species. The U.S. Fish and Wildlife Service restricts access to the islands in the Hawaiian Islands National Wildlife Refuge, and the U.S. Navy restricts access to Midway Island. It appears that the Leeward Islands will be amply protected from disturbance. A limited amount of dredging around the Leeward Islands would not pose a significant risk to the islands' resources, especially since the location of the known Conditional Beds in this area are more than 25 miles offshore.

IV.2 Socio-Economic Impact

The socio-economic effects of the proposed action will probably not be great. The existing small domestic fishery will be permitted to continue on a scale approximating that of its operations in recent years, although there will have to be a minor reduction in the pink coral harvest from the Makapuu bed. However, the industry will be permitted to extend its operations to the known Conditional Beds, under quota limitations, or to operate in the Exploratory Areas to discover and develop new beds. The biennial quota system will facilitate the redeployment of harvesting equipment to these new areas during the anticipated extended lay-off period of the Makapuu bed. Thus the industry should continue to enjoy whatever impetus the availability of Hawaiian raw coral gives to the sale of coral products in general, and it may be able to develop additional domestic sources of raw material as a hedge against a possible future interruption of imported supplies. Maintenance of the productivity of the known beds at the MSY level should also be source of strength to the industry in the long term. It is impossible to predict whether there will actually be any domestic development of a dredge fishery within the limitations prescribed in the management plan; that will be determined by the economics of the industry. There was no prohibition on coral dredging anywhere in the region until the recent promulgation of the State of Hawaii's coral regulations, and yet there was no domestic dredge fishery since the operations on the Makapuu bed were abandoned,

apparently having been found to be unprofitable, in the 1960's. The provision permitting limited dredging, except on the Established Bed at Makapuu and other Conditional Beds in the main Hawaiian Islands, will at least leave open the possibility for island fishers to take up coral fishing with a simple technology that is within their abilities to finance and operate. There may be a feeling that the requirement that only selective fishing gear be used on the Makapuu bed confers a de facto monopoly of that bed on the only firm which is at present in a position to operate in that mode. However, the proposed management measures do leave open the opportunity for entry into the Makapuu bed by any operator who may acquire a selective harvesting craft, and the restriction appears justified by the fact that the bed has actually been under full exploitation for a number of years by selective fishing and by the consideration that this strategy allows for five times the potential production that would be permitted for non-selective fishing. Finally, the proposed action should contribute to stability of the industry and enhanced interest in investing in its expansion by clarifying the jurisdictional situation; that is, by substituting a cohesive and predictable management system for the ad hoc and ill-defined permit requirement of the Bureau of Land Management. It is not possible to predict clearly at this time how the conflicting claims to jurisdiction of the Secretary of Commerce and the State of Hawaii will be reconciled. Implementation of the fishery management plan should promote a clarification of that question as regards the resources of the Hawaiian area, and it will of course provide for the conservation of coral resources and the management of coral fisheries in other parts of the region where similar conflicts do not exist.

Even less can be said about the socio-economic impacts on foreign coral fisheries, because practically nothing is known of the past or present fishing operations by foreigners in the U.S. fishery conservation zone. Certainly the quotas prescribed for foreign fishing under permit -- 500 kg of all species combined annually in each of five major Exploratory Areas and nothing on the Established and Conditional Beds -- are minimal and cannot be critical to the economic viability of the foreign coral fleets. It is hoped that they will be sufficient to stimulate some fishing which, when reported as required, may provide the information on which inhabitants of the region can base a decision on whether to enter the coral fishery in their areas.

In considering the socio-economic impact it is pointed out that the total domestic fishery for pink and gold coral at present involves about 47 persons directly and that most of the personnel engaged in manufacturing and selling precious coral products are predominantly working with black coral and other imported raw material. The ex-vessel value of pink and gold coral landed in Hawaii in 1977 is estimated in the management plan at $262,000, and it is stated that this value is doubled when the coral is processed to the polished but unset state. In 1976, the value of retail sales of coral jewelry, both locally produced and imported, in Hawaii was estimated at $16 million, and the total of State and Federal taxes of all kinds paid by the industry was estimated at about $2 million.

V. ALTERNATIVES TO THE PROPOSED ACTION

A number of options were considered in the process of deciding to adopt the management measures described in section II.2.3. They are discussed, with the rationale for their adoption or rejection, in section IV.F.1 of the fishery management plan. The principal options considered but not adopted were as follows:

(a) Prohibition of Non-Selective Fishing Methods in All Areas

It was thought that such a prohibition would seriously inhibit the development of domestic fisheries, particularly in those areas of the region where fishery development is most needed, and it was considered that an appropriate reduction of the optimum yield when dredging is employed will prevent overfishing of the resources.

(b) Retention of Incidental Catches Permitted to Domestic Fishers

It was considered that this would be unreasonably discriminatory against foreign fishers and perhaps conducive to abuse in the form of deliberate unauthorized taking of coral under the guise of incidental catches. In fact, there is at present no domestic fishery in the region which takes coral incidentally.

(c) Prohibition of Any Incidental Taking of Coral

This would presumably amount to a prohibition of trawling for finfish in any area where precious coral is likely to be broken off by the trawl. This was deemed an unreasonable inhibition on the development of finfish fisheries, since there is no evidence that incidental taking of coral is a serious problem in such fisheries.

(d) Closed Season

Consideration was given to closing fishing during the reproductive season, which is June and July for pink coral in Hawaii. It was deemed unwarranted to close the fishery during the time of year when operating conditions (sea conditions) are optimum, in view of the long reproductive life of the organism.

(e) Royalties

A requirement that harvesters pay a royalty on their catch was discussed, since such a requirement is a feature of the management regime established for coral fisheries by the Bureau of Land Management. However, the Fishery Conservation and Management Act provides that regulations promulgated to implement fishery management plans may not require fees for domestic fishermen beyond the cost of administering the permit system. No royalty requirement is proposed. Whether royalties may be imposed under the FCMA is not clear.

(f) Limited Entry

The FCMA allows the inclusion of limited entry provisions in management plans under certain conditions, However, it was judged that the domestic fisheries for precious coral in the region are at a stage where stimulation of development is a greater need than a limitation of participation.

In general, it might have been considered that no action would be a reasonable alternative, since two management systems covering some of the same ground were already in place -- those of the State of Hawaii and the Bureau of Land Management (Department of the Interior). This would have been contrary to the spirit of the Fishery Conservation and Management Act, under which a Regional Fishery Management Council shall prepare a fishery management plan for each fishery in the fishery conservation zone of its region and submit such plan to the Secretary of Commerce for implementation. Furthermore, the regulations of the State of Hawaii can apply to only a small part of the region at best, and the regulation of the Bureau of Land Management is skeletal and does not provide a clear and comprehensive management system. The other local governments of the region have not, as Hawaii has, claimed jurisdiction over the waters where the precious corals occur, and their ability to enforce any management system for the coral fisheries beyond the territorial sea is doubtful in any case. Finally, it would not be feasible to leave the regulation of foreign fishing activities beyond the territorial sea to local government authorites.

VI. PROBABLE UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

Assuming that the proposed management measures will succeed in their objective of conserving the precious coral populations at an appropriate level of productivity, the only avoidable adverse environmental effects that will probably ensue from their implementation are the impacts of dredge operations on non-target sessile organisms inhabiting the coral beds. At present there is very little basis for estimating the amount of such destruction that will result or its ecological significance. It may be comparable to analogous side-effects of other commercial fishing methods, such as coral dredging is reportedly done at slow speeds while drifting, and the catching part of the gear is a tangle of netting, its impact on any mobile organism will probably be less than that of any sort of trawl. The most probable adverse impact is the knocking down or tearing up of sessile colonial species for which the fishers have no use. The management plan concedes that dredging will waste potential precious coral production by knocking down colonies which have not reached their full growth and by failing to entangle and recover some percentage of the coral colonies that are knocked down and killed. The deleterious effect of this on conservation is compensated for by reducing catch quotas by 80% when dredging is employed. The loss in productive efficiency is considered an unavoidable trade-off for the opportunity to develop domestic precious coral fisheries where the considerable capital and advanced technology required for selective harvesting equipment

cannot be brought to bear. The risk of serious adverse impacts due to taking action without full information on the biology, and ecology of the coral beds is slight because the harvest quotas are so low. Even in a "worst case", one or two small beds might be severely damaged but not irreversibly.

Whatever changes may be wrought on the precious coral beds by the impacts of fishing under the proposed management measures, they can hardly be seen as directly affecting the human environment, because of the great depths at which the corals occur. As for any indirect adverse effects, there is no basis of data by which to identify them or evaluate them, if they exist.

VII. RELATIONSHIPS BETWEEN LOCAL SHORT-TERM USES AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

A basic objective of the fishery management plan is to achieve precious coral harvesting at a level of an optimum yield which will ensure sustained maximum productivity of the coral populations over the long-term. The assurance that this objective will be achieved is strongest in the case of the established pink coral bed at Makapuu, Oahu, because the firmest data on population parameters are available for that stock. In that case, the only departures from an ideal management strategy for the stock to accomodate local short-term use are the use of a biennial catch quota period, rather than an annual harvesting quota, and a reduction of the minimum colony size limit from approximately 11 inches to 10 inches. The results of a careful analysis of the available data, as presented in the FMP, indicate that the effects of these provisions on the maintenance of long-term productivity would be slight. On the other hand, economic considerations indicate that the fishery might not remain viable if the optimum yield had to be taken annually, because of the high overhead costs of maintaining the selective harvesting equipment and the constraints which annual seasons would place on its redeployment to other areas to develop new fisheries. The setting of the minimum size limit at 10 inches is a minor concession to current industry practice, and "rounding off" of MSY downward to 1,000 kg/year compensates for this concession.

The harvesting quotas established for the Conditional Beds and the Exploratory Areas, and the sanctioning of the use of non-selective harvesting methods in some of these areas, mean the acceptance of an apparently higher but unquantifiable degree of risk to the long-term productivity of the resources in the interest of making it possible to develop new fisheries in the short-term. The quotas for the Conditional Beds are set by extrapolating the density of coral colonies on the Makapuu bed, as well as their growth and mortality rates, to beds where their parameters have not been determined. If their values are significantly lower than for the Makapuu stock, there is a possibility that the prescribed quotas could result in overfishing that would affect the long-term productivity of the affected beds. In the

Exploratory Areas, the prescribed catch quotas are area-wide rather than bed-specific. Thus, in a given area the whole annual quota could conceivably be taken from a single bed, and if the bed were smaller or otherwise less productive than the Makapuu bed, localized overfishing could result. The management plan attempts to mitigate these risks by setting all quotas at conservative levels, prohibiting dredging in the major Hawaiian Islands including two small Conditional Beds, reducing the quotas by 80% where non-selective harvesting methods are used, and requiring constant monitoring of the results of management and periodic review of the management measures.

VIII. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

No irretrievable and irreversible commitments of marine resources are expected as a result of the implementation of this fishery management plan for precious corals although admittedly there is a remote but finite biological risk. The long-term productivity of the single established fishing area, the Makapuu coral bed, should be well protected and it should not suffer even short-term reduction of productivity, since the biological characteristics of the coral populations there are reasonably well known and have been made the scientific basis of the whole management system. For the coral stocks of the Conditional Beds and the Exploratory Areas, there will be, as noted above, some degree of risk of temporary overfishing, pending the carrying out of surveys and biological studies that will permit a more accurate evaluation of their productivity. It seems highly unlikely that any exploitation of these beds would become economically infeasible before the populations were reduced below a level from which they could never recover. Careful monitoring of fishing results, including observer coverage and provisions for timely modification of management measures, as called for in the management plan, should eliminate any remaining risk of irreversible damage to resources. It must be borne in mind, however, that recovery of a severely overexploited bed of this slow growing colonial organism is believed to require a very long time, as much as 50 years according to some estimates quoted in the management plan. On the other hand, if permission to exploit any coral stock other than the Makapuu bed in the U.S. fishery conservation zone of the central and western Pacific Ocean were to be denied until research has defined the dynamics of each population and its specific productivity, any development of domestic coral fisheries in the region could also be very greatly delayed, especially in the less developed island communities where new economic alternatives are most needed and where resource surveys are prohibitively expensive.

IX. OTHER INTERESTS AND CONSIDERATIONS OF FEDERAL POLICY OFFSETTING ADVERSE ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTION

In addition to the policy considerations of generally promoting the expansion of domestic fishery industries and of fostering the economic development of U.S. island territories in the Pacific, so

that they may be more nearly self-supporting, the proposed action would contribute to realizing the policy expressed in the FCMA of promoting domestic full utilization of the fishery resources of the fishery conservation zone. Expansion of the domestic coral fisheries could also make a modest contribution to the balance of payments problem, by reducing the dependence of the coral jewelry manufacturing industry on imports of raw or semi-processed material, which at present is the bulk of their supply. More speculatively, a management strategy which encourages further development of deep submersibles and their use to explore new areas should produce incidental benefits to national ocean science and perhaps to national defense interests. The plan also provides a more consistent and uniform basis for management in the FCZ than current regulations.

X. CONSULTATION AND COORDINATION WITH OTHERS

The team which developed the fishery management plan consulted informally, as opportune, with members of the precious coral industry, and formally with an Advisory Sub-Panel of the Western Pacific Fishery Management Council's Federally chartered Advisory Panel. The Sub-Panel includes representatives of the precious coral industry and the public at large. The planning team's work was frequently reviewed and evaluated by the Council's Scientific and Statistical Committee, which includes biologists and economists from academic and government research institutions in the region, among them the fishery administration agencies of Hawaii, American Samoa and Guam. Representatives of the Outer Continental Shelf Office of the Bureau of Land Management participated in committee and panel meetings on occasion and were kept apprised of the development of the management plan throughout the process. The Western Pacific Program Office of NMFS and the 14th Coast Guard District staff, both in Honolulu, were constantly consulted in the course of development of the plan, particularly regarding mechanisms for implementation and enforcement.

XI. REFERENCES

In general this EIS is abstracted from the FMP, and references are made at several points to pertinent sections of the plan. A list of references to literature relevant to the plan, and copies of several related documents, are given in sections VI and VII of the FMP.

XII. COMMENTS RECEIVED THROUGH THE PUBLIC HEARING PROCESS AND RESPONSES

The EIS/FMP for precious corals in the Western Pacific was subjected to a 45 day public review. This review began March 9, 1979 and ended April 23, 1979. During this period, five public hearings were held as follows: in Saipan on March 14, in Agana, Guam on March 15, in Honolulu on March 21, in Lahaina, Maui on March 22, and in Pago Pago, Samoa on March 27.

A large number of comments were received during the public hearing process. A list of individuals, groups or government agencies from which oral or written testimony was received is given in the Table 1. Directly following the table is a summarized list of all substantive comments received with corresponding responses. The source(s) of the comment are indicated in parenthesis following each comment. In many instances the same or very similar comment was received by two or more sources. In such cases a single response is given but all sources of the comment are listed. In most cases the comments have been abbreviated in the interest of clarity and space. However, in all cases, care was exercised to preserve the intent and meaning of the comment.

Table I - Individuals, organizations and government agencies providing oral or written testimony on the DEIS/FMP

Individuals

Nolan Chock
Native Hawaiian Legal Corporation

Edward Henry

George Kent
Professer of Urban & Regional Planning & Political Science, University of Hawaii

James E. Maragos
Coral Ecologist

Clifford D. Slater
President, Maui Divers of Hawaii, Ltd.

Richard C. Wass
Fishery Biologist, Government of American Samoa

Organizations

Greenpeace

Life of the Land (LOL)

Sierra Club

Citizens Forum of Hawaii Costal Zone Management Program

Government Agencies

Hawaii

Office of Environmental Quality Control - Office of the Governor (OEQC)
Department of Health (SDOH)
County of Hawaii - Planning Department
Environmental Center - University of Hawaii (EC-UH)
Department of Land and Natural Resources (DLNR)
Department of Planning and Economic Development (DPED)

Federal

Department of the Army - Army Corps of Engineers (ACOE)
Department of Interior - Bureau of Land Management (BLM)
Department of Interior - Office of the Secretary (DOI)
Government of Guam

1. Comment: To expand statement on objectives to include protection and conservation of precious coral stocks. (ACOE, James Maragos)

   Response: Under Section IV-B-2 of the plan, Specific Management Objectives, items 2, 4, 5 and 8 deal directly with protecting and conserving precious coral stocks. The language of this section has been incorporated in the EIS.

2. Comment: Consider clarifying whether the plan provides for revised catch quotas for Conditional and Exploratory Beds once adequate information on coral population dynamics and site is obtained for each bed. (ACOE, Government of Guam)

   Response: If adequate information becomes available Conditional or Exploratory Beds would be upgraded to Established Beds and specific quotas would be set. This would require revision of the plan.

3. Comment: Justify why no size limits are given for gold or bamboo coral. (ACOE, Greenpeace, James Maragos, George Kent)

   Response: Estimates of growth rates, mortality rates and size at reproductive maturity are necessary before a size limit can be reliably set. These data are lacking for gold and bamboo coral.

4. Comment: Expand section on environmental impact of harvesting precious corals on other species which occupy the same habitat. Include in the discussion, other corals, crustaceans and fishes which might be impacted. (Ed Henry, ACOE, James Maragos, DOI, BLM, OEQC, LOL, Sierra Club)

   Response: Section IV-1 of the EIS and Section V-C have been revised to address more fully the impacts of dredging.

5. Comment: It is not clear how the plan will relate to the Northern Mariana Islands. (N.M.I.) (ACOE, James Maragos)

   Response: The Council has requested information from NMFS as to the procedure the Secretary will use to implement the Councils recommendations for the N.M.I. The FMP, however, proposes the same approach for the N.M.I. as for other parts of the FCZ.

6. Comment: Clarify whether weight quotas in the plan refer to only live precious coral or live and dead precious coral. (ACOE, James Maragos)

Response: Weight quotas in the plan refer to the total dry weight (at least 24 hours air dry) of live precious coral harvested. The mathematics on which the modeling efforts were based involve growth and mortality rates of live corals and by definition cannot be applied to dead corals. Further, the inclusion of dead coral in the quotas may remove any incentive for their being harvested since they are less valuable than live coral. From the standpoint of conservation, it is more desirable to harvest dead than live coral.

7. Comment: An appraisal of the error involved in estimating MSY would help determine confidence limits. (ACOE, DOI, Greenpeace, James Maragos)

Response: For estimates of growth and natural mortality mean values were used since they are considered to be the best scientific information available. For density, 95% confidence limits are given in Section III-B of the plan. The upper and lower 95% confidence limits are plus or minus 40% of the mean for pink coral. Mean values of density were also used in all estimates of MSY.

8. Comment: Suggest that a section on plan enforcement provisions be added to the EIS including an evaluation of penalties, fines, size limits, field surveillance and inspections, if applicable. (ACOE, LOL, Sierra Club, James Maragos)

Response: This is addressed in the Plan, but in general, the magnitude of enforcement will depend on the number of vessels which apply for permits to harvest coral in the FCZ. Penalties and fines would be levied under the terms of FMCA. Size limits and weight quotas would be enforced by dockside inspections. Field surveillance would be conducted through aerial and surface patrols.

9. Comment: Are there provisions in the plan to improve information on Conditional Beds and Exploratory Areas so as to insure against overharvesting of stocks? Are there specific information requirements and timetables? (ACOE, James Maragos, Ed Henry)

Response: Section IV-K of the FMP deals with future research needs. One is to upgrade Exploratory and Conditional Beds. No specific timetables are given for this.

10. Comment: Resolve conflicting statements on royalties in EIS and FMP; discuss pros and cons. (ACOE, NMFS, Ed Henry, BLM)

Response: The statements have been revised for consistency; pros and cons do not seem relevant since no fees can be collected in excess of costs to administer the Act. If the FCMA is amended to allow for royalities, an argument in favor of royalties would be that it is a common property resource. Arguments against are (1) that royalties are not currently imposed on any other fisheries

in the United States, and (2) that taxes and jobs generated by the fishery represent a fair return to the public for use of the resource. For these reasons, the Council elected not to propose a royalty on harvested coral.

11. Comment: Indicate rationale for designating only one known precious coral bed as a refuge. (ACOE, James Maragos)

Response: One out of six beds in the Hawaiian Archipelago was deemed to be reasonable to the Council. In three of the remaining known beds, non-selective methods of harvest are prohibited.

12. Comment: Provide more details on the simulation studies to estimate the efficiency of coral dredges. Is there a possibility that the estimate of 40% is too high, too low? (ACOE, LOL, DOI, Greenpeace, James Maragos, Ed Henry)

Response: More details on the simulation have been provided in Section II-C-II of the FMP. The variability of the efficiency of coral nets during actual fishing is probably greater than that indicated by simulation trials. This would be expected because of the variability in operating conditions due to weather and sea floor topography.

13. Comment: Quotas given in the plan for non-selective harvesting should be further reduced to account for the inefficiency of coral dredges. A figure of 20% of the quota using selective methods is recommended. (ACOE, DOI, EC-UH, James Maragos, Greenpeace, NMFS, LOL)

Response: The quota associated with dredging in Conditional Beds has been reduced to account for this factor. See Sections IV-C and IV-F-2.

14. Comment: The plan addresses only 3 species of precious corals in the Western Pacific. Other potential species of precious coral are not treated including black coral. This creates an administrative problem for DOI and could lead to duplication of effort since DOI would be responsible for regulating species not covered in the plan. (DOI, OEQC, BLM, Ed Henry)

Response: The plan has been revised to include all known and potential species of precious corals in the Western Pacific. (Sections II-A) Regulations regarding species not presently subject to harvest will be developed as needed on a sequential basis. Commercial species of black coral in Hawaii occur primarily inside of 3 miles. Regulations will be developed in cooperation with the state. Regulations for black corals will be incorporated into the plan on a sequential basis.

15. Comment: The use of dredging is contrary to the policy of the Department of Interior to "maintain the integrity of viable coral communities and their surrounding OCS environment". (DOI)

Response: In areas where coral dredges are allowed, weight quotas have been reduced by 80% of quotas using selective methods. The impact of taking 20% of selective quotas using non-selective gear is considered to be equivalent to the impact of using only selective gear. Hence, the quota reduction for non-selective gear serves to maintain the integrity of viable coral communities to the same extent as quotas using selective gear.

16. Comment: The allowance of dredging in the major Hawaiian Islands is contrary to State law. (DOI, DLNR - State of Hawaii, Ed Henry)

Response: The plan has been revised and is now consistent with State law. See Section IV-F.1-B.

17. Comment: The impacts of dredging on the environment have been too easily dismissed in both the FMP and the EIS. (DOI, Ed Henry, Greenpeace, James Maragos)

Response: Section IV-1 of the EIS and Section V-C of the FMP have been expanded to address more fully the impacts of dredging. Also, see response to Comments 15 and 32.

18. Comment: The research on which the plan is based is inadequate to justify the conclusions reached in the draft EIS/FMP. (DOI, Ed Henry)

Response: The plan is based on the best scientific information available. FCMA requires that estimates of MSY and OY be determined using the best scientific information available. The plan allows the placing of observers on fishing vessels that will insure more complete and accurate reporting of catch, effort, species composition, location of beds, and other important data. The plan also includes a section on topics in need of future research.

19. Comment: A bed should be closed to further fishing as soon as the quota for one species has been reached. (DOI, EC-UH, Greenpeace, Richard Wass, NMFS)

Response: Section IV-F-2 has been revised to require closing a Conditional Bed when the quota for any one species has been reached using non-selective methods.

20. Comment: The confidence limits on the standing crop of pink coral are not used to determine MSY or OY. (DOI)

Response: For estimates of growth and natural mortality mean values were used since they are considered to be the best scientific information available. For density, 95% confidence limits are given in Section III-B of the plan. The upper and lower 95% confidence limits are plus or minus 40% of the mean for pink coral. Mean values of density were also used in all estimates of MSY.

21. Comment: More concrete evidence is needed to support the assumption that growth rings in pink coral are annual. (DOI, James Maragos)

Response: More research is needed on this question. Annual growth rings have been found in shallow water gorgonians in California and the Caribbean. In Hawaii, annual growth rings are present in the black coral *(Antipathes dichotoma)*. The assumption that growth rings are annual in pink coral *(Corallium secundum)* is based on zoological similarity to other species which do have growth rings and the observation that the growth rate obtained by making this assumption is very close to estimates of growth by long-time commercial coral fishermen. A linear growth rate was used in the model of MSY because the width of the growth rings in pink coral *(Corallium secundum)* did not decrease with colony size.

22. Comment: Actual data on recruitment should be obtained since if it drops below present estimates,the plan should be revised. (DOI)

Response: It is economically infeasible to directly measure recruitment. Over the long-term, catch per unit effort data can be used to determine if the resource is being conserved. The plan requires that these data be reported.

23. Comment: There should be a discussion in the plan regarding environmental impact of harvesting precious coral on the Leeward Hawaiian Islands. (OEQC, Greenpeace)

Response: Only two Conditional Beds in the Leeward Hawaiian Islands have been designated. Both are about 25 miles from the nearest land in the Archipelago. No negative impacts of harvesting on Leeward Hawaiian Islands ecosystems are anticipated.

24. Comment: Harvesting should be prohibited for any species until growth rates and MSY levels have been determined. (OEQC)

Response: MSY levels have been estimated for those species on established and conditional beds. Information is not available to extend MSY's for other areas. The Council has judged that allowing limited dredging in exploratory areas is more likely to result in acquisition of data to estimate MSY's than is waiting for results of governmental surveys or research.

25. Comment: Other corals beside pink and gold coral are harvested from the Makapuu Bed. (OEQC, Ed Henry)

Response: The only species of precious coral harvested commercially from the Makapuu Bed are pink coral *(Corallium secundum)* and gold coral *(Gerardia sp.)*. Other species of precious and non-precious corals have been collected for scientific purposes from the Makapuu Bed.

26. Comment: The EIS lacks maps to indicate location of the coral beds. (OEQC)

Response: Maps are provided in the FMP and are referenced in Section I of the EIS.

27. Comment: What is the ecological role of precious coral? (OEQC)

Response: Sections IV-1 and V-C of the EIS have been revised to address more fully the ecological role of precious coral.

28. Comment: What is the rationale for allocating 500 kg quotas for TALFF and the domestic fishery in Exploratory Areas. (OEQC)

Response: Section IV-E has been revised to include a description of the rationale for selecting a 500 kg quota for TALFF and domestic fisheries in Exploratory Areas. The quota is for all species combined. Briefly, the rationale is to provide an economic incentive with minimum biological risk.

29. Comment: How will the plan be enforced? (OEQC)

Response: Both domestic and foreign fishers must obtain coral harvesting permits with provisions for observers and data reporting requirements. Dockside inspection and air and surface patrols will be among the enforcement activities undertaken.

30. Comment: The amount of pink, gold and bamboo coral harvested from each bed should be given in the plan. (OEQC, Ed Henry, DPED, LOL)

Response: Section II-B of the FMP has been revised to include data for beds other than the Makapuu Bed.

31. Comment: Requirements of the Bureau of Land Management, DOI for coral harvesting should be summarized in the plan. (OEQC, Ed Henry)

Response: BLM regulations are given in Appendix III of the FMP. Reference in the plan to these regulations can be found in Section III.

32. Comment: In terms of the impacts associated with dredging a "worst case" should be considered. (OEQC)

Response: Where coral dredging is allowed a "worst case" would probably result in no more than 4% of the populations of all species being destroyed in any one harvesting period. Also see response to comment 17.

33. Comment: What is the environmental impact of silt or sedimentation caused by dredging. (OEQC)

Response: The impact of siltation or sedimentation caused by dredging is unknown. However, since precious corals occur on clearly swept hard substrates, it is not likely that this factor is of significance.

34. Comment: The quotas set for gold and bamboo coral are not considered conservative since they are based on too little information. (OEQC)

Reponse: The plan includes a section on future research needs in which the need for better data on growth, mortality and recruitment is treated. Present quotas are based on the best scientific information available. An absolute prohibition on harvesting for lack of information is considered by the Council to be arbitrary and counter to producing more information.

35. Comment: It should be noted that the State of Hawaii is currently assessing whether a State EIS is required. (OEQC)

Response: The FMP contains a Federal EIS which is intended to serve the same purpose.

36. Comment: The method of dredging should be described in the EIS. (OEQC)

Response: A reference has been added to Section II-2-3-f of the EIS indicating that Section II-C-2 of the FMP discusses dredging gear and techniques.

37. Comment: It should be noted that the submersible vessel used to harvest pink and gold coral is owned by the University of Hawaii. (OEQC)

Response: Ownership of the vessel is not considered a relevant factor in the management of the fishery, although costs of operations are consistent in the section on economics.

38. Comment: Black corals should be covered by the plan. (OEQC)

Response: The plan has been revised to include all known and potential species of precious corals in the Western Pacific. (Sections II-A) Regulations regarding species not presently subject to harvest will be developed as needed on a sequential basis. Commercial species of black coral in Hawaii occur primarily inside of 3 miles. Regulations for black corals will be incorporated into the plan on a sequential basis.

39. Comment: What is the basis for the annual harvest of 3,200 kg for the fishery? (OEQC)

Response: The figure of 3,200 kg given in Section II-D-2 of the FMP refers to annual harvest capacity of the fishery, not values of actual harvest given in Table II of the FMP.

40. Comment: The figures relating to the tax base of the industry are taken from an article in the Honolulu Advertiser (9-7-77). Tax figures should be based on data in the FMP. (OEQC, NMFS)

Response: Tax figures in the FMP are based on information provided by Clifford Slater, President of Maui Divers of Hawaii, Ltd. and represent his best estimate for the industry in 1976. The Council judges this to be the best information available.

41. Comment: In the FMP, the Hawaii State Regulation 41 is described as providing a quota and permit system for pink and gold coral. This is misleading since a quota is only specified for pink coral. (OEQC)

Response: Section II-G of the FMP has been revised to more accurately portray Regulation 41.

42. Comment: Unless growth rates are known for gold and bamboo corals, how can mature colonies be identified? (OEQC)

Response: Maturity can be based on size but the relationship between maturity and size and age is unknown for gold and bamboo coral. For this reason size or age limits for gold and bamboo corals are not recommended in the plan.

43. Comment: How will the plan be enforced? (OEQC)

Response: Both domestic and foreign fishers must obtain coral harvesting permits with provisions for observers and data reporting requirements. Dockside inspection and air and surface patrols will be among the enforcement activities undertaken.

44. Comment: Why are only 3 species of precious coral covered by the plan? (OEQC)

Response: The plan has been revised to include all known and potential species of precious corals in the Western Pacific. (Sections II-A) Regulations regarding species not presently subject to harvest will be developed as needed on a sequential basis. Commercial species of black coral in Hawaii occur primarily inside of 3 miles. Regulations will be developed in cooperation with the state. Regulations for black corals will be incorporated into the plan on a sequential basis.

45. Comment: The FMP/EIS should discuss any proposed discharges or solid waste disposal facilities necessary to implement the plan. (State of Hawaii, Department of Health)

Response: No proposed discharges or solid waste disposal facilities are necessary to implement the plan.

46. Comment: The plan incorrectly states that the relationship of the proposed action to coastal zone management cannot be determined because CZM plans for the region have not been completed. (Hawaii County-Planning Dept., DLNR- State of Hawaii, James Maragos, LOL, Sierra Club, NMFS, Ed Henry)

Response: When the draft was prepared no CZM plans were completed for the Western Pacific region. A Hawaii CZM plan is now available. A determination of Federal consistency with the Hawaii CZM plan has been made and included in Section V-B of the FMP. It is concluded that the objectives of the Hawaii CZM plan and the precious coral FMP for the Western Pacific are in no way contradictory.

47. Comment: The plan should describe mitigating measures in support of developing both a precious coral industry and a manganese mining industry. (Hawaii County-Planning Dept.)

Response: The Council or NOAA/NMFS have no authority to control or manage manganese mining.

48. Comment: The FMP should provide for an ongoing study to determine the ecological effect of coral harvesting, i.e. monitoring. (Hawaii County-Planning Dept., George Kent, Greenpeace, NMFS)

Response: The need for research on this topic is mentioned in Section IV-k of the plan. However, FMP's cannot "provide" for research.

49. Comment: A more definitive evaluation of the destruction caused by dredging should be made including an assessment of alternative harvesting technologies such as unmanned systems. (DPED-State of Hawaii, Ed Henry)

Response: The first point has been partially addressed in comment 4. No destruction of the bottom substrata is anticipated from dredging. Observations from the submersible Star II of areas previously dredged support this conclusion. An assessment of alternative technologies is beyond the scope of the FMP, although research needs have been recognized in Section IV-k.

50. Comment: The plan should specifically address the ecological role played by deep water coral communities. (DPED-State of Hawaii, Ed Henry, James Maragos)

Response: Section III-A has been expanded to more fully address the ecological role of deep water precious corals. See response to comment 4.

51. Comment: The plan should address possible adverse environmental and economic impacts of managing Conditional Beds on the basis of analagous information from the Makapuu Bed. (DPED-State of Hawaii)

Response: The impacts of dredging and the risks associated with management based on limited data are discussed in Section IV of the EIS.

52. Comment: Would not restricting a portion of each coral bed be better than establishing refugia? (DPED-State of Hawaii)

Response: This may be true in theory but would be virtually impossible in practice. Enforcement would also be cumbersome.

53. Comment: The plan should include black coral. (DPED)

Response: The plan has been revised to include all known and potential species of precious corals in the Western Pacific. (Sections II-A) Regulations regarding species not presently subject to harvest will be developed as needed on a sequential basis. Commercial species of black coral in Hawaii occur primarily inside of 3 miles. Regulations will be developed in cooperation with the state. Regulations for black corals will be incorporated into the plan on a sequential basis.

54. Comment: The plan should document and evaluate past research on precious corals in the Hawaiian Islands. (DPED)

Response: All pertinent available data on precious corals have been used in developing the plan. Also see response to comment 30.

55. Comment: A size limit should be set for all species of precious corals which are subject to harvest. (DPED)

Response: Biological information is inadequate for gold and bamboo coral to set a size limit. Also see response to comment 3.

56. Comment: The plan should be compared to the State CZM plan for consistency. (DPED)

Response: When the draft was prepared no CZM plans were completed for the Western Pacific region. A Hawaii CZM plan is now available. A determination of Federal consistency with the Hawaii CZM plan has been made and included in Section V-B of the FMP. It is concluded that the objectives of the Hawaii CZM plan and the precious coral FMP for the Western Pacific are in no way contradictory.

57. Comment: the plan should assess the State of Hawaii's Archipelagic claim with regard to precious coral management. (DPED)

Response: The conflict between the State of Hawaii and the Federal Government over jurisdiction of interisland waters beyond 3 miles is addressed in the Section on CEM in the FMP (Section 5-B).

58. Comment: Precious corals should be considered as part of an entire ocean community in terms of management. (DPED)

Response: The WPRFMC recognizes that fishery management must be viewed within the context of overall ocean resource management.

59. Comment: Extrapolation of the Makapuu data to Conditional Beds is subject to an extreme high degree of uncertainty, especially since beds are considered separate units. (EC-UH, Ed Henry, Sierra Club)

Response: The uncertainty associated with extrapolation of Makapuu Bed data is recognized in the EIS/FMP.

60. Comment: Quotas for Conditional Beds where non-selective methods are allowed should be reduced by 60%. (EC-UH)

Response: The quota associated with dredging in Conditional Beds has been reduced. See Sections IV-C and IV-F-2.

61. Comment: In a Conditional Bed where non-selective methods are allowed, the bed should be closed when the quota of any one species is reached. (EC-UH)

Response: Section IV-F-2 has been revised to require closing a Conditional Bed when the quota for any one species has been reached using non-selective methods.

62. Comment: If Conditional Beds are opened to fishing the plan should mandate that an assessment of their standing stock be made. (EC-UH)

Response: Such a mandate is not legally possible. However, catch records provided by fishermen would assist in such an assessment.

63. Comment: Have methods other than dredging and submersibles been considered in the plan? (EC-UH, Ed Henry)

Response: The first point has been partially addressed in comment 4. No destruction of the bottom substrata is anticipated from dredging. Observations from the submersible Star II of areas previously dredged support this conclusion. An assessment of alternative technologies is beyond the scope of the FMP, although research needs have been recognized in Section IV-K.

64. Comment: Harvest should be managed to prevent future collapse of the industry. (Greenpeace)

Response: One objective of the plan is to obtain optimum yield on a continuing basis; another is to prevent overfishing.

65. Comment: The Northwestern Hawaiian Islands including all precious coral beds in the area should be considered an ecosystem sanctuary. (Greepeace)

Response: See response to comment 23. Further, the Council received from NMFS a biological opinion that the proposed action is not likely to jeopardize the continued existence of any endangered species, including the Hawaiian monk seal. That opinion has been attached to the FMP. Inasmuch as access to the Hawaiian Islands National Wildlife Refuge and Midway Islands is strictly controlled, human disturbance to the Leeward Islands is unlikely under this FMP. The Council has no authority to designate an ecosystem sanctuary.

66. Comment: The Makapuu Coral Bed has been overexploited since the data on which the plan is based were collected. New data are needed. (Greenpeace, Ed Henry)

Response: New data would be useful. While levels of exploitation in the Makapuu Bed exceeded MSY in 1974, 1975 and 1977, this does not mean the bed has been over-exploited. During the initial years of a virgin fishery levels greater than MSY are often obtained. Also, the FMP will establish a basis for preventing overfishing in the future and collection of additional data to determine whether any changes in harvest levels or techniques are needed.

67. Comment: No size limit is set for gold and bamboo coral. This is not conservative policy. (Greenpeace, George Kent)

Response: See response to comment 3, 34 and 42.

68. Comment: Further study of gold and bamboo coral is needed before safe quotas can be set. (Greenpeace)

Response: Research needs are discussed in Section IV-k of the plan. It is believed that by allowing controlled harvest of gold and bamboo coral, better data will be provided. See responses to comments 3, 34, 42 and 67.

69. Comment: In a Conditional Bed where non-selective methods are allowed, the bed should be closed when the quota of any one species is reached. (Greenpeace)

Response: See responses to comments 19 and 61.

70. Comment: Foreign fishing may have depleted some Conditional Beds in the past and should be taken into account. (Greenpeace)

Response: Foreign fishing may have occurred, but the foreign harvest of precious corals is undocumented in the FCZ.

71. Comment: More data are needed to effectively manage precious corals. (Greenpeace)

Response: The need for research is recognized. The FCZ in the central and western Pacific Ocean, however, covers about 1.5 million square miles. Locating and assessing corals stocks in this area would be prohibitively expensive if left solely to government agencies. It is hoped that providing the opportunity to catch and retain a limited amount of corals will induce domestic and foreign vessels to carry out at least some exploratory activities. If and when beds are identified, stock assessment would be a high priority research task. See response to comment 9.

72. Comment: Dredging is wasteful and should be disallowed. (Greenpeace, Ed Henry, BLM, DLNR)

Response: See response to comment 15.

73. Same as comment 65. (Sierra Club)

74. Comment: Precious coral harvesting should be banned in all Conditional Beds and Exploratory Areas. (Greenpeace, BLM, OEQC, George Kent)

Response: The Council believes that a ban on harvesting in all Conditional and Exploratory Beds is not warranted.

75. Comment: A moratorium should be placed on the harvesting of precious coral in the Makapuu Bed until further notice. (Greenpeace)

Response: A moratorium on corals harvesting at Makapuu Bed is not necessary at this time. The FMP will control against overfishing.

76. Comment: If the plan is not amended, no dredging should be allowed anywhere. (DOI, Sierra Club, Greenpeace, Ed Henry, BLM, DLNR, NMFS, LOL)

Response: Allowance of limited dredging may result in location of new beds which subsequently may be set aside for selective harvest. See responses to comments 17 and 32.

77. Comment: If dredging is allowed quotas should be reduced. (Greenpeace)

Response: This has been done. See comments 13, 15 and 60.

78. Same as comment 69.

79. Comment: The quotas for Makapuu should be lowered to take into account past harvesting. (Greenpeace, Ed Henry)

Response: The consequences of past harvesting in the Makapuu Bed have been considered (See Figure 19). According to the model, an annual yield of 1,000 kg of pink coral is sustainable over the long-term.

80. Comment: The public should have access to all information regarding enforcement and monitoring of the plan. (Greenpeace, Ed Henry)

Response: Enforcement and monitoring data will be released to the public to the extent permitted by the FCMA and other law.

81. Comment: An immediate effort should be taken to gather new data on several aspects of the plan. (Greenpeace)

Response: Research needs are discussed in Section IV-k of the plan.

82. Comment: Harvest quotas using non-selective methods should be reduced from 50% to 20% of quotas for selective methods. (James Maragos)

Response: This has been done. See comments 13 and 15.

83. Comment: The acquisition of information by fishermen should be a requirement of the plan. (James Maragos)

Response: All catch data and other information (outlined in Section IV-F-2) must be reported.

84. Same as comment 83. (Sierra Club)

85. Comment: More discussion on royalties, fees, fines and penalties and other measures is needed. (James Maragos)

Response: The discussion in the plan on royalties has been revised. More information on enforcement measures will be contained in the regulations.

86. Comment: The protection of precious coral stocks should be an objective of the plan. (James Maragos)

Response: It is. See response to comment 1.

87. Comment: A complete listing of U.S. Pacific Island possessions revised accordingly should be included in the plan. (James Maragos)

Response: The FMP has been revised accordingly. (Section II-A)

88. Comment: Clarify how quotas for Conditional Beds or Exploratory Areas will be revised once adequate informtaion is obtained. (James Maragos)

Response: See response to comment 2.

89. Comment: The justification for not setting size limits on gold and bamboo coral is not adequate. (James Maragos)

Response: See responses to comments 3, 34 and 42.

90. Comment: In the EIS a more balanced discussion is needed between economic and environmental impacts. (James Maragos)

Response: The discussion on environmental impacts has been revised.

91. Comment: What is the timetable for including the Northern Marianas in the plan? (James Maragos)

Response: See response to comment 5.

92. Comment: More justification is needed for the reduction of yields using non-selective methods. (James Maragos)

Response: See response to comment 13.

93. Comment: Is the differentiation between live and dead coral a pertinent management consideration? (James Maragos)

Response: Live and dead coral can be distinguished by a trained enforcement officer. See response to comment 6.

94. Comment: Conditional Beds should be listed in the EIS. (James Maragos)

Response: A list is provided in the FMP. The EIS/FMP will be published as one document.

95. Comment: Why is the NMI included in some parts of the plan and not in others? (James Maragos)

Response: The FMP recommendations for the Northern Marianas Islands are intended to be complete.

96. Comment: The distinction between a bed and an area needs to be clarified. (James Maragos)

Response: Sections II-2-3b of the EIS and IV-F-2 of the FMP have been revised to clarify the distinction.

97. Comment: How accurate are the areas of Conditional Beds? (James Maragos)

Response: Area estimates are conservative because they are based on few dredge hauls. Beds probably include some unsurveyed surrounding area.

98. Comment: How will size limits be enforced? (James Maragos)

Response: Dockside examination of the catch will be the primary means of enforcement. One method is described in Section IV-F-1 of the FMP.

99. Comment: Will the number of vessels that acquire precious coral in incidental catch be sufficiently large as to warrant more stringent guidelines? (James Maragos)

Response: There are no documented instances of incidental coral harvest by trawlers and the probability is low that significant increases will occur in the near future.

100. Comment: A section on enforcement should be included in the EIS. (James Maragos)

Response: A section on regulations will be developed by the NMFS in cooperation with the Coast Guard. See responses to comments 8 and 9.

101. Comment: The term human environment includes the environmental and scientific value of precious coral. (James Maragos, Sierra Club)

Response: This is implicit in both the EIS and FMP.

102. Comment: Accurate information on population size should be obtained before exploitation is allowed. (James Maragos, DOI)

Response: The Council believes its proposals to be sufficiently conservative that risk of significant environmental damage is slight.

103. Comment: The statement in the EIS that the dredge is the harvesting device used in all coral fisheries of the world needs revision. (James Maragos)

Response: The statement has been revised.

104. Comment: More discussion is needed on the importance of precious coral as a habitat for other species. (James Maragos)

Response: Section IV-1 of the EIS and Sections III-A and V-C of the FMP have been revised accordingly.

105. Comment: The basis for rejecting royalties is vague. (James Maragos)

Response: The section on royalties has been revised to clarify why they are not recommended. See response to comment 10.

106. Same as comment 105.

107. Comment: The impact of loss of habitat for associated species caused by harvesting precious coral needs to be discussed. (James Maragos)

Response: See response to comment 15. Sections IV-1 of the EIS and III-A of the FMP have been revised accordingly.

108. Comment: It should be stated that there is a remote possibility of irreversible and irretrievable damage due to dredging. (James Maragos)

Response: This is implicit in the use of the term biological risk.

109. Comment: The statement "that dredging is prohibited in all areas where selective harvesting is current" is misleading since there is only one such area. (James Maragos)

Response: The statement is intended as general policy.

110. Comment: Why is only one bed designated as a refuge? (James Maragos)

Response: See response to comment 11.

111. Comment: How accurate and precise are the estimates of dredging efficiency of 40%. (James Maragos)

Response: Only simulated trials have been conducted in shallow water. The range of 5 trials was 35 to 44%. Research needs on this subject are described in Section IV-k of the FMP. See also the response to comment 12.

112. Comment: Dredging quotas should be reduced from 50% to 20% of quotas for selective methods. (James Maragos)

Response: The FMP has been revised in compliance with this recommendation. See response to comment 13.

113. Same as comment 112. (LOL)

114. Comment: The accuracy and confidence limits on the standing crops of Conditional Beds should be given. (James Maragos)

Response: See response to comment 97. Area is based on cumulative dredge hauls.Therefore variance and confidence limits can't be calculated.

115. Comment: Stock assessment should precede harvesting. (James Maragos, Ed Henry)

Response: The ideal situation would be to fully assess the virgin stocks. As a practical matter, however, it is necessary to identify beds and their sizes before detailed assessments can be made. Placing limits on the amount which may be taken by dredge provides a balance between no exploitation producing no data and limited harvest based on incomplete data. See Section IV-D of the FMP.

116. Comment: Clarify purpose of using the equivalent of a 10 inch size limit for pink coral. (James Maragos)

Response: Pink coral is broken during collection.

117. Comment: Explain the implications of using wet or dry weight for the quota for pink coral. (James Maragos)

Response: Data in the model are based on dry weight (at least 24 hours air dry),Therefore, dry weight should be used for setting the quota and enforcement.

118. Same as comment 111. (James Maragos)

119. Comment: The State CZM plan has been approved. (James Maragos)

Response: See response to comment 46.

120. Comment: It should be stated that a good plan will also be beneficial to foreign fishermen. (James Maragos)

Response: This is implicit in the plan, but Section V-F has been revised accordingly.

121. The plan should include royalties on harvested coral. (Ed Henry, James Maragos, George Kent, BLM, LOL)

Response: See response to comment 10.

122. Comment: The plan should disallow TALFF in Exploratory Areas. (Government of Guam, DLNR)

Response: The TALFF is provided in Exploratory Areas because it is likely there exists a surplus in these areas and because the reporting requirements of foreign fishing permits would be a source of new information on the resource.

123. Comment: The plan should contain provisions for Hawaiian or other native rights. (Nolan Chock)

Response: The plan has been revised to provide for amendment if such rights can be identified.

124. Comment: A moratorium should be placed on all coral harvesting until more research is done and an acceptable plan is implemented. (Greenpeace, DOI)

Response: If the revised plan is accepted this should satisfy the intent of this comment. Future research needs are outlined in the plan.

125. Comment: Coral harvesting should be accomplished with technology more sophisticated than in current use. (Ed Henry)

Response: Research needs on all aspects of precious corals are discussed in Section IV-k of the plan. The Star II submersible is considered to be an example of sophisticated technology by the Council. See response to comment 49.

126. Comment: Catch data provided in the plan may be in error. (Ed Henry)

Response: Catch data provided in the plan agrees with catch records on file at the Division of Fish and Game, DLNR, State of Hawaii.

127. Comment: The plan should contain instructions for concerned citizens how they may obtain coral harvesting data. (Ed Henry, LOL) - Data

Response: Concerned citizens may obtain such instructions by calling or writing the Western Pacific Regional Fisheries Management Council, 1164 Bishop Street, Room 1608, Honolulu, Hawaii, 96813, (808)523-1368. Data submitted with this plan will be confidential, but aggregate summary data may be released if the identity of institutions or firms cannot be determined from such data.

128. Comment: Maui Divers of Hawaii, Ltd. should be required to file an environmental assessment. (Ed Henry)

Response: An environmental impact statement which covers the activities of this firm is part of the EIS/FMP on precious coral fisheries of the Western Pacific.

129. Comment: A statement on domestic processing capabilities should be included in the plan. (NMFS)

Response: Section IV-E has been revised accordingly.

130. Comment: A permanent reserve for domestic fishing in Exploratory Areas may violate the national standards of the FCMA. (NMFS)

Response: The rationale for this approval is described in Section IV-D on the FMP, and the council believes it is consistent with mature standards. An approach for a domestic test fishery and foreign research fishing is suggested as an alternate to a domestic reserve.

131. Comment: Additional justification for pulse fishing is needed. (NMFS)

Response: The Council feels this question has been adequately treated in the plan. In this connection eleven (11) options were considered before choosing a biannual catch quota.

132. Comment: The fishermen should be bonded. (Ed Henry)

Response: Since bonding is ordinarily used for contract work the Council rejected this suggestion.

133. Comment: Dredging is unacceptable. (Ed Henry)

Response: See responses to comments 76, 17 and 32.

134. Comment: The mathematic model used in the plan is inappropriate and should be re-evaluated, and if determined inaccurate should be removed from consideration. (Ed Henry)

Response: All assumptions used in the model have been stated. A yield production model is used because it provides an estimate of MSY, a requirement of the FCMA. Data that might be used for other types of models are lacking.

135. Comment: WesPac Refuge should not be referred to as a Conditional Bed. (NMFS)

Response: The plan has been revised accordingly.

136. Comment: The section on economies should be revised to reflect the importance of local production in Hawaii. (NMFS)

Response: The plan has been revised in accordance with this comment.

137. Comment: Any waters tranversed by humpback whales should be part of the proposed refugia. (Sierra Club)

Response: This would in effect stop all coral fishing activity in the Hawaiian Islands and is considered to be unreasonable.

138. Comment: Catch per unit effort data could remain at high levels until an entire bed was destroyed and hence may not be a good measure by which to monitor the fishery. (DOI)

Response: In the case of harvest using a submersible, midwater currents are so variable during launch and descent to the bottom that a strategy of systematic search is not feasible. Weight quotas and size limits (where they apply) are designed to prevent overharvest.

FISHERY MANAGEMENT PLAN

for the

PRECIOUS CORAL FISHERIES (and ASSOCIATED NON-PRECIOUS CORALS)

of the

WESTERN PACIFIC REGION

PREPARED BY

WESTERN PACIFIC REGIONAL FISHERY MANAGEMENT COUNCIL
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SEPTEMBER 1979

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ADDENDUM 114

Executive Summary

The Fishery Conservation and Management Act of 1976 (Public Law 94-265) provides for United States exclusive management authority over the fishery resources and fisheries within a Fishery Conservation Zone (FCZ) extending from the seaward boundary of the territorial sea (3 miles from shore) to a distance of 200 nautical miles from shore. The responsibility for developing management plans for the fisheries in the FCZ is vested by the Act in eight Regional Fishery Management Councils. The Western Pacific Fishery Management Council is responsible for the fisheries off the coasts of Hawaii, Guam and American Samoa. The Council may also recommend measures to be implemented in the FCZ beyond the area of concern in the Northern Mariana Islands. Implementation and enforcement of any regulations pertinent to fishery management within the FCZ are the responsibility of the Secretary of Commerce. This Precious Corals Fishery Management Plan has been developed by the Western Pacific Fishery Management Council and will be submitted to the Secretary of Commerce for approval and implementation. The major objectives of the Plan are to obtain Optimum Yields of precious corals in the FCZ and maximize the benefits of the precious coral fisheries to the nation. Precious corals are known or believed to occur in the FCZ seaward of Hawaii, American Samoa, Guam, the Commonwealth of the Northern Mariana Islands and off other United States island possessions in the central and western Pacific Ocean.

In the Management Plan, precious coral beds are treated as separate management units. The beds are classified as Established, Conditional or Exploratory. Established Beds are those which have a history of harvest and for which firm Optimum Yields have been determined on the basis of scientific data. Conditional Beds are those for which locations and approximate area are known and for which estimates of Optimum Yield can

be derived by analogy with Established Beds but which require additional data for determination of firm Optimum Yields. Exploratory Areas comprise all other area in the FCZ of the Western Pacific Region. Only one coral bed has been studied adequately enough to be classified as Established. It is off Makapuu, Oahu, Hawaii. Five other peds are classified as Conditional, all of them off the Hawaiian Islands (See Figures 1 and2).

Management measures are prescribed for commercial harvest from all three bed categories, otherwise referred to as permit areas. There is no recreational fishery. The prescribed measures are summarized as follows: 1) Optimum Yields have been determined for pink (Corallium secundum), gold (Gerardia sp.) and babboo (Lepidisis olapa) coral populations in the Makapuu Bed. These Optimum Yields are based on estimates of Maximum Sustained Yield (MSY). Rounded estimates of MSY for the three species in the Makapuu Bed are 1,000 kg/year for pink coral, 300 kg/year for gold coral and 250 kg/year for bamboo coral. Optimum Yields have been set at double these values for twice the time, i.e. for 2 years. The adjustment to 2 year periods is proposed because of socio-economic considerations; 2) Optimum Yields for Conditional Beds are determined by their areas in relation to the area of the Makapuu Bed, assuming the same MSY per unit area, and reducing the OY to 20% of the MSY if non-selective harvesting methods are used; 3) U.S. harvesting and processing capacity and expected annual harvest and processing levels from the Makapuu Bed and all Conditional Beds are equal to the levels proposed for Optimum Yield, and therefore no surplus exists in these areas which can be allocated to foreign fisherman or to joint venture operations. Domentic processing capacity is sufficient to process expected domestic harvest; 4) Until the definitive Optimum Yields of

beds in Exploratory Areas can be determined, an initial Optimum Yield and Total Allowable Level of Foreign Fishing (TALFF) for each of those Areas (Hawaii, Samoa, Guma, and the Northern Marianas and other U.S. island possessions) is set at 1,000 kg total of all species, of which 500 kg are to be set aside as a reserve for potential domentic fishing and 500 kg are available as TALFF; 5) Other species of precious corals and associated non-precious corals which are known or are believed to occur in the FCZ are included in the plan. No specific conservation and Management measures are proposed at this time and Optimum Yields have not been determined. This plan may be amended to manage these species as more data become available and as the need arises; 6) A prohibition on the use of dredging techniques is recommended for all permit areas where selective harvesting methods are current practice and for the FCZ seaward of the main Hawaiian Islands; 7) A quota for dredging is provided in all other permit areas under specified conditions; 8) Taking of precious coral in the FCZ incidental to other fisheries is allowed for both domestic and foreign fishermen, subject to reporting requirements and return of the coral to the sea; 9) A recommendation is made to provide for closing certain coral beds to commercial or exploratory fishing as refugia or preserves, and to designate as the first such preserve the WesPac Bed, situated between Nihoa and Necker Islands, off the Northwestern Hawaiian Islands. Other refugia may be designated by amendment to this plan; 10) Permits are required for domestic and foreign fishermen, subject to extensive reporting requirements and conditions which embody the above provisions. Vessels may be required to carry observers. The proposed management measures are designed to maximize overall benefits to the nation and are consistent with the National Standards of the FCMA.

I. INTRODUCTION

This is a Fishery Management Plan (FMP) for the precious coral and associated non-precious coral fisheries within the United States Fishery Conservation Zone of the central and western Pacific region. It has been prepared by the Western Pacific Regional Fishery Management Council under the authority of the Fishery Conservation and Management Act of 1976 (FCMA) (P.L. 94-265).

The FCMA provides for the conservation and management of fishery resources of the United States by establishing a Fishery Conservation Zone of 200 nautical miles, within which the United States has exclusive management authority over all fishery resources except highly migratory species which are defined as tuna. The Act calls for the preparation and implementation of Fishery Management Plans, through which the objectives of a national fishery management program may be accomplished.

The Fishery Management Plans provide the basis for the determination of annual harvest predicated on scientific information and involving the needs of the States, the fishing industry, recreation groups, consumers, environmental organizations and other interested parties. In essence, the allowable catch of any fishery resource will be based on the Optimum Yield from that resource.

The fishery management unit in this case comprises a number of discrete populations or beds of precious corals and associated non-precious corals within the FCZ off the shores of U.S. islands in the central and western tropical and subtropical Pacific. At present only one such bed is the object of consistent exploitation by a domestic fishery. Others are or may have been subject to poorly documented harvesting by foreign fishermen, while others have been located by exploratory surveys but are not yet under exploitation.

There are undoubtedly other precious coral beds in the region which will eventually be prospected and exploited, and it is prudent to make some preliminary provision for their conservation, in view of the ease with which this resource can be depleted.

In this FMP, precious coral beds which have a history of exploitation and for which a Maximum Sustainable Yield (MSY) can be estimated based on scientific data, are designated Established Beds. Others for which only the locations and approximate area are known are called Conditional Beds, while those which are yet to be located are referred to as Exploratory Areas. (See Section IV.F.2, for fuller definition of these categories.) Under this plan, five portions of the FCZ - the portions around Hawaii, Guam, American Samoa, U.S. Possessions and the Northern Mariana Islands - are designated Exploratory Areas for purposes of setting quotas for identification of and harvests from Exploratory Beds.

The major objective of the Plan is to achieve the optimum yield of precious corals which occur within the Fishery Conservation Zone (FCZ) of the United States in the Central and Western Pacific Ocean. The term optimum yield is defined in the Act as that amount of "fish" which will provide the greatest overall benefit to the Nation, and which is prescribed as such on the basis of the maximum sustained yield (MSY) as modified by any relevant economic, social or ecological factor. Species of precious corals which are considered in this document include the precious pink coral, *Corallium secundum*, the gold coral, *Gerardia* (formerly *Parazoanthus*) sp., and the bamboo coral, *Lepidisis Olapa*. (formally Keratoisis nuda). Other species of precious coral and other corals on the continental shelf or in the FCZ are also included in the plan although no specific Conservation and Management Measures are limited at this time to a permit and data collection requirements. Further management measures for these corals will be included in the plan sequentially on an as needed basis.

Areas considered in this document include the Hawaiian Islands, American Samoa, Guam, the Commonwealth of the Northern Marianas and other U.S. island possessions in the Central and Western Pacific Ocean.*

Included in the management plan are estimates of optimum yield for species of greatest commercial importance and recommendations for measures that are deemed necessary in order to achieve optimum yield.

II. Description of the Fishery

A. Stocks

Within the FCZ of the United States in the Pacific (Figures 1-4) the only fishery for precious corals is in the Hawaiian Islands. The fishery is based on two groups of species, one in deep water near 400 meters and another in much shallower between 40 and about 80 meters. Both fisheries are entirely commercial, i.e. non-recreational. At the present time the bulk of the catch of deep species consists of pink (*Corallium secundum*) and gold coral (*Gerardia* sp., = *Parazoanthus* sp.). A third species, bamboo coral (*Lepidisis olapa*) co-occurs with pink and gold coral and is considered to be of immediate economic potential. Other potential species of precious coral including the shallow water black corals are listed in Table I.

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*Pending amendment of the Fishery Conservation and Management Act, the Western Pacific Fishery Management Council has no statutory authority to prescribe management measures for fisheries in the Fishery Conservation Zone off the Northern Marianas or minor United States Pacific island possessions. References to management measures for precious coral fishing in those areas in this Plan are in the nature of recommendations which may be implemented by the Secretary of Commerce by actions pursuant to Sec. 201 (g) or Sec. 304 (c) of the Act.

immediate economic potential.

The shallow water fishery consists of three species of black coral *Antipathes dichotoma, Antipathes grandis* and *Antipathes ulex*. About 90% of the catch consists of the first species, 9% the second and 1% the third. Approximately 85% of all black corals harvested in the state of Hawaii are taken within the Territorial Sea.

The FMP contains specific management measures for Corallium secundum, Gerardia sp. and Lepidisis olapa. Measures for black corals are currently being developed jointly by the State of Hawaii and the WPRFMC, and will be added to the plan on a sequential basis. As it appears likely that other species of precious coral and other corals in the FCZ will be subject to harvest, additional measures for these species will also be added to the plan on a sequential basis.

C. secundum and the bamboo coral *Lepidisis olapa* belong to the Order Gorgonacea in the Subclass Octocorallia of the class Anthozoa in the Phylum Coelenterata. *Gerardia* sp. and *Antipathes* spp. belong to separate Orders, Zoanthidea and Antipatharia, in the Subclass Hexacorallia, also in the class Anthozoa and the Phylum Coelenterata.

Precious corals are known to exist in Hawaii, Samoa, Guam and the Commonwealth of the Northern Marianas and other U.S. possessions, but little is known of their distribution and abundance. What little knowledge is available of the distribution and abundance of precious corals in the Western Pacific can be summarized as follows:

American Samoa -- One or more species of black coral of commercial quantity and quality are known to exist at depths of 40 meters and deeper, but these stocks are within the jurisdiction of American Samoa.

Table I Actual and potential precious corals in the Western Pacfic.

Scientific name	Common name	harvest status
Corallium secundum	Pink coral	harvested
Corallium regale	Pink coral	not harvested
Corallium laauense	Pink coral	not harvested
Gerardia sp.	Gold coral	harvested
Callogorgia gilberti	Gold coral	not harvested
Narella sp.	Gold coral	not harvested
Calyptrophora sp.	Gold coral	not harvested
*Lepidisis olapa**	Bamboo coral	not harvested
Acanella sp.	Bamboo coral	not harvested
Antipathes dichotoma	Black coral	harvested
Antipathes grandis	Black coral	harvested
Antipathes ulex	Black coral	harvested

*previously known as Keratoisis nuda

The only information available on deeper water precious corals comes from reports by fishermen. Pink coral has been reported off Cape Taputapu, but there are no data on quantity, quality and depth (Ian Swan, personal communication). Unidentified precious corals have also been reported off Fanuatapu Island at a depth of 90 m (possibly bamboo coral) and on the sides of an uncharted seamount three-fourths of a mile off the northwest tip of Falealupo at a depth of about 300 meters (Bill Travis, personal communication).

Guam and the Commonwealth of the Northern Marianas -- No commercially important quantities of precious coral have been found on U.S. surveys in the Nothern Marianas (Grigg and Eldredge 1975). However, Japanese fishermen (personal communication) claim to have taken some *Corallium* off Rota, Saipan and north of Pagan Island.

Other U.S. island possessions -- Japanese fishermen report that in 1975 alone, a harvest of 100 metric tons of red corals (*Corallium* spp.) was taken from grounds within 200 miles of Midway, Wake, Yap and Saipan (EIS/PMP Precious Corals, DOC, 1977). However, the magnitude of this estimate (approximately the world production in 1970) casts some doubt on its validity. On the other hand, none of the deep precious coral beds off Wake or Yap have been surveyed by U.S. scientists and only the most preliminary U.S. data are available for the Saipan and Midway areas.

Hawaii -- Beds of pink, gold and/or bamboo coral have been found at six locations off the Hawaiian Archipelago (Grigg 1974) (Figures 1 & 2). These are as follows:

Description	Lat. N.	Long. W.	Area in km^2
1. Off Ke-ahole Point, Hawaii	19°46.0'	156°06.0'	0.24
2. Off Makapuu, Oahu (Fig. 5)	21°18.0'	157°35.5'	3.60
3. Off Kaena Point, Oahu	21°35.4'	158°22.9'	0.24
4. WesPac Bed, between Nihoa and Necker Islands	23°18'	162°35'	0.8
5. Brooks Bank	24°06.0'	166°48.0'	1.6
6. 180 Fathom Bank, north of Kure Is.	28°50.2'	178°53.4'	0.8

With the exception of the Makapuu Bed and those beds (if any) harvested by Japanese fishermen, all other precious coral beds within the U.S. fishery conservation zone are believed to be in an unexploited or "virgin" state. The Makapuu Bed has been harvested off and on since 1966 (see Table II, page 10). The area and the pre-fishery standing crop of pink coral in the bed are estimated to be 4.5 km^2 and 43,500 kg, respectively. Over a 10-year period only about 16% of the original standing crop of pink coral has been harvested; this averages 1.6% per year, and is below estimates of MSY (see section III-F). However, in three of four years the estimate of MSY has been exceeded (see Table II). Of the other five areas, WesPac Bed, Brooks Bank and 180 Fathom Bank are considered to hold the most promise for domestic harvesters. There are undoubtedly many other undiscovered beds, especially off the Northwestern Hawaiian Islands, where few surveys have been conducted. The large yields (see following section) are reported to have been taken by foreign fishermen from the Milwaukee Banks (Lat. 32.5°N, Long. 173.0°E), which are outside the U.S. Fishery Conservation Zone, are indications of the potential in the Northwestern Hawaiian Isalnds. Because of the sessile habit of precious corals and the large distances which separate the known beds, it is a reasonable assumption to treat each bed as a separate management unit, even though nothing is known of the relationship between stock and recruitment.

There are no known Indian or native Hawaiian traditional uses or rights associated with precious corals. If any rights or ceremonial values are identified, this plan can be amended as necessary.

B. History of Exploitation

Although a precious coral fishery has existed in the Mediterranean Sea since about 3000 B.C., precious coral was not discovered in the Pacific until the early 19th century off Japan. Historically, the primary method of fishing in both the Mediterranean Sea and off Japan has been dredging. Initially little fishing occurred off Japan until 1868, the year of the Meiji Reform. Prior to 1868, coral was confiscated from fishermen by the Shoguns, therefore little incentive existed for commercial fishing. After 1868, however, this custom was abolished and the fishermen were allowed to market coral products freely. Shortly after 1868, about 100 boats began harvesting coral, soon exhausting local grounds near Japan. Subsequent catch and effort depended on the discovery of new grounds and has been extremely variable up to the present time. The pattern of the coral fishery in Japan has been one of exploration, discovery, exploitation and depletion. In spite of the obvious need to control fishing effort, there has been no effective management of the fishery.

The extremely variable nature of the fishery is demonstrated by data for catch and effort collected in Taiwan between the years 1925 and 1940 (Anon. 1956) (Figure 6 and 7). These data show that catch and effort correlate fairly well and indicate the boom or bust nature of the fishery.

Until recent years, the precious coral fishery in the Pacific was centered off Japan, Okinawa and Taiwan (Grigg, 1971). Depletion of the beds in these areas, however, led to wide ranging exploratory efforts primarily on the part of Japanese fishermen. In 1965, Japanese coral fishermen discovered a very large bed of pink coral contiguous with the Hawaiian Archipelago on the Milwaukee Banks about 500 miles northwest of Midway Island. Milwaukee Banks including Kinmei Seamount have an area slightly greater than 300 km^2. Little data are available concerning the amount of pink coral Japanese fishermen harvested from Milwaukee Banks. However in 1969 alone, they reportedly took about 113,000 kg (H. Ozawa*, personal communication, 1970).

Prompted by the discovery of pink coral on the Milwaukee Banks, U.S. scientists in 1966 discovered a commercial bed of *Corallium secundum* between 350 and 450 m depth in the Molokai Channel off Makapuu Oahu. Shortly thereafter, a small group of fishermen began dredging this Makapuu bed on a limited scale. This activity continued on and off for about 3 years until high costs of operation and bad weather led to its discontinuation. About 1,800 kg (4,000 lb) were harvested during this period. After an abortive attempt in 1969 at harvesting with a remote T.V. camera assembly by a Seattle firm (Jacobsen Brothers), research at the University of Hawaii by the Sea Grant Program led to the development of a selective harvesting system utilizing a submersible. Maui Divers of Hawaii, Ltd. incorporated this system and began harvesting the Makapuu Bed in 1973. Total annual landings of pink and gold coral from the Makapuu Bed between 1966 and 1977 are given in Table II.[1]

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*H. Ozawa was the Managing Director of the All Nippon Coral Fishery Union in 1970.

TABLE II

Annual harvest of pink and gold coral from the Makapuu Bed[1].

Harvest (kg)

Year	Gear	Pink	Gold	Knockdown*
1966-69	Dredge	1,800	0	2700
1970-72	----------No harvesting----------			
1973	Submersible	538	0	
1974	"	2,209	734	
1975	"	1,385	621	
1976	"	400	363	
1977	"	1,421	329	
1978 (Jan-June)	"	474	50	

*During 1966 to 1969 when dredges were used in the Makapuu Bed the amount of coral dislodged from the bottom and not recovered must also be considered. Simulated harvesting trials in shallow water indicate that tangle dredges are about 40% efficient for one drag. Therefore for every kilogram harvested, 1.5 kg is assumed to have been knocked down and lost.

1. In 1977, 2.7 kg of pink coral and 106 kg of gold coral were harvested from the Kea-hole Point Bed off the island of Hawaii.

In the past, there has been no documented foreign harvest of precious coral within the U.S. conservation zone. However, in 1975 Japanese vessels reportedly harvested about 100 MT of precious corals within 200 miles of Midway, Wake, Yap and Saipan Islands (EIS/PMP Precious Corals, DOC, 1977). However, because the world landings in 1970 were only about 85 MT (H. Ozawa, personal communication), this report is somewhat doubtful. In 1976 and 1977, Taiwanese dredgers were reportedly operating on the Milwaukee Banks and may also have harvested precious corals within the U.S. Fishery Conservation Zone. On June 8, 1977, the U.S. Coast Guard reported entry of a Taiwanese coral fishing vessel, C/B Hai Tien No. 2, to Midway Island, which informed the Coast Guard that about 30 other vessels would soon be dredging in the Milwaukee Banks area. The Milwaukee Banks are approximately 280 miles northwest of the U.S. 200 mile limit. Japanese and Taiwanese vessels are presently allowed to fish on seamounts west of 180° longitude and north of 28° latitude in the FCZ for pelagic armorheads and alfonsins. Some incidental catch of precious corals may result from this activity, but retention of the incidentally caught coral is prohibited. Catches must be reported.

II.C.1 Vessels and Gear

Historically, both in the Mediterranean Sea and in the far western Pacific, the primary method used to harvest precious coral has been dredging with tangle nets. Over the long history of the fishery, gear design has varied, but it has always centered around the basic idea of a dredge (weighted tangles) (Figure 8). The weights serve to keep the dredge on the bottom as well as dislodge the coral while the nets entangle it.

Off Hawaii the first attempt to selectively harvest precious coral was by the Jacobsen Brothers in 1969 using a remotely controlled manipulator guided by a television camera. This technology proved to be uneconomical but was the first step which led to the development of a successful system of selective harvest utilizing a manned submersible. Remotely controlled vehicles for the harvest of precious coral are currently being developed by separate companies in Hawaii and Taiwan.

The vessels utilized in the coral fishery differ largely as a function of the method of collection. Foreign dredge haulers range between 40 and 100 feet in length and employ crews which vary between 3 and 20 men. Typically, the dredges are lowered and raised by line haulers which are located amidships and operated over the side of the vessel. Dredging usually is accomplished without power. The ship is simply allowed to drift positioned at right angles to the current. Japanese fishermen usually deploy from 4 to 8 dredges simultaneously. Some larger vessels are able to handle up to 16 lines at once. Given good weather, Japanese coral fishermen continue dredging 24 hours a day, rotating the crew. The same grounds are often redredged.

In 1975, about 90 Japanese vessels (of which 26 were specialized) were engaged in harvesting precious corals off Midway, Wake, Yap and Saipan (Akira Matsura*, personal communication). Most likely the entire Japanese coral fleet is considerably larger. In Taiwan, about 30 coral dredgers operate seasonally (summer) out of the Peng-hu (Pescadores) Islands.

The vessels employed by the domestic fishery off Hawaii include a two-man submersible, a towing barge (the LRT) and a 70-foot surface support and towing vessel.

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*Japanese Fishery Agency

The submersible, Star II, is launched and recovered from the LRT below the surface at a depth of about 60 feet. Three SCUBA divers are required for this operation. The coral harvesting gear on Star II consists of a coral cutter, wire basket and hydraulic claw (Figure 9). Coral which is harvested selectively is packed in the basket. Maximum payload is about 200 pounds, but the average is about 60 pounds.

II.C.2 Evaluation of Gear Performance and Efficiency

Off Hawaii in 1972, experimental trials using dredging and selective harvesting methods were conducted in the Makapuu Bed. The dredge consisted of a concrete-filled cylinder (80 lbs.) with 6-foot hanks of nylon netting attached to eyebolts (Figure 8). The selective method was Star II. Data were compared in order to evaluate the ecological and economic efficiency of both techniques (Grigg, Bartko and Brancart, 1973). The results favored the selective method. However, this was in part due to the method of dredging employed. Only one dredge was used in the test whereas Japanese fishermen may drag up to 16 dredges simultaneously.

The size frequency distribution of coral collected with the submersible was characterized by larger pieces of higher quality than fragments collected by dredging (Figure 10). On the average, one day of effort with the submersible produced a catch about 10 times the value of an equal day's effort dredging with one coral net. However, if 10 nets were deployed simultaneously, the value of the coral produced should be about the same. Hence the major advantage of utilizing a submersible was not gross production but rather selectivity.

The advantages and disadvantages of the two methods are outlined in Table III.

There are several advantages of a submersible over a dredge. First, the use of a submersible permits selective harvest; immature colonies can be avoided and other benthic species are not disturbed. Second, the capacity for selectivity allows the use of a size limit as a management tool. The advantage of this is that the maximum sustained yield at an optimum size is theoretically about twice what it is if no size limit is imposed (dredging) (see Section III-F). This is because dredging leads to growth-overfishing, that is young colonies are harvested before reaching their maximum potential for growth. Thirdly, with a submersible, nearly all the coral dislodged from the bottom is brought to the surface. Dredges, on the other hand, only recover about 40% of what is initially "knocked down".[1] Dredges, of course, can be dragged repeatedly over the same area. Hence overall recovery with a dredge could be significantly greater than 40%. For example, three replicate hauls should theoretically collect 78% of the coral, four hauls, 87% recovery. Catch per unit effort, of course, would be progressively less and at some point, depending on costs, the operation would cease to be profitable. Exactly where this point lies no doubt varies with the quality and quantity of coral in each bed. A fourth advantage of a submersible over dredging is that a larger percentage of high quality coral may be collected.

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[1]The estimate of efficiency for tangle nets is based on simulated trails in shallow waters in Kaneohe Bay, Hawaii. Recovery of planted coral on the bottom for the five trails was 35, 39, 44, 40, 42 percent producing an average recovery of 40%.

TABLE III

Advantages and disadvantages of two coral-harvesting systems

Submersible	Dredging
Advantages	
. Permits selective harvesting, i.e. little or no damage to other components of the ecosystem	. Relatively inexpensive, low capital and operating costs
. Permits the use of a size limit as an aid to conservation, however breakage makes enforcement difficult	. May be more productive per 24 hour day, if multiple dredges employed
. Practically no waste	. Able to harvest continuously
. Larger percentage of high quality coral	. Major equipment readily adaptable for other uses
Disadvantages	
. High capital and operating costs	. Nonselective harvesting, immature colonies unprotected
. Requires preparation, maintenance and repairs of expensive, specialized equipment	. Ecologically more destructive, other species and habitats disturbed
. Need for support vessels	. More wasteful, some coral dislodged from the bottom may not be recovered
. Shutdown idles high capital investment	. Larger percentage of lower-valued coral
. May have limited depth capability and not fully utilize the resource	

Advantages of dredging over a submersible include the following. First, dredging is considerably less costly than operating a submersible. In some cases, dredging may also be actually more economical since more than one dredge can be employed and because the operation may be continuous on a 24 hour basis. The equipment is also readily adaptable to other fishing technologies, which may have economic advantages in areas where diversified fishing is profitable. A submersible requires several support vessels and service and maintenance, both quite costly. A major breakdown of a submersible system or a closed season would both result in idling a significant amount of capital investment. Also, dredges have no depth limits per se while submersibles do. In Hawaii, Star II has an operational depth limit of 1200 feet (365 m) which curtails full utilization of precious corals (see Table IV). Finally, in the event that distant or deeper coral beds are discovered, selective harvesting may be economically prohibitive or simply not possible, in which case dredging may be the only feasible alternative. Exploration for beds might also be best accomplished by dredging techniques.

Depending on desired goals and varying circumstances, such as the abundance of the resource, either system might be a more "efficient" or desirable alternative. It may be more profitable for industry to utilize a submersible so as to more fully utilize the resource, or if quotas are not overly restrictive, dredging may offer clearcut economic advantages.

Hence, the benefits of selective harvest vis-a-vis dredging must be considered on a case by case basis. Clearly there are economic and social tradeoffs which may not be the same for all locations in the Pacific.

II.D.1 Global Economics of the Precious Coral Industry

Worldwide, the precious coral jewelry industry is valued at about $500 million/year (retail sales). This arises from a world production of raw coral worth between $5 - $10 million (H. Ozawa, personal communication). In 1976, about 95% of the world's production was harvested from the Pacific Ocean. Most of this coral is sold to international buyers through a system of closed auctions in Japan that are operated by coral fishing associations. World jewelry production today is dominated by Japanese and Italian manufacturers.

In Hawaii most precious coral sold in the market place is purchased by local retailers who buy polished but unset "stones" from markets in the Orient. These stones are mounted in Hawaii in order to save import taxes on finished jewelry. A survey in 1971 showed at least 15 manufacturers producing jewelry and 150 to 100 retail outlets (Poh, 1971). Since then, there has been little or no increase in the number of major manufacturers. however, the number of retail outlets has increased by a factor of about two or three.

Retail sales in 1978 in Hawaii for both imported and locally produced coral jewelry were about $20 million (Clifford Slater, personal communication). This total represents a sevenfold increase since 1969 (see Thompson, 1975). This is based on pink, black and gold coral sales. Of the pink coral, about 80% is imported from the orient in a polished but uncut state. Almost 100% of the black and gold coral sales are of locally harvested coral.

II.D.2 Domestic Commercial Harvest

The domestic fishery for pink and gold coral in Hawaii is carried out by one submersible, two support craft, and about 12 personnel. The annual harvest capacity of the fishery is at least 3000 kg of pink and gold coral combined. The actual annual harvest in the 1974-77 period averaged less than 2000 kg (Table II).

Estimates of the ex-vessel value of raw pink and gold coral are given in Table IV. Also, for purposes of management analysis, an estimate of the ex-vessel price may be determined from: the price of imported polished-unset coral, the retail price differential between pink and gold coral jewelry, the relative value of the coral gem in a jewelry setting, and the costs of production at the harvesting and processing stages. The total ex-vessel value of pink and gold coral for 1977 was $262,000 (Table IV).

Table IV — Estimated ex-vessel value of pink and gold raw precious coral harvested in Hawaii, by year, 1975-77.

Year	Pink	per/kg	Gold	per/kg	Total
1975	$190,000	$137	$71,000	$114	$261,000
1976	94,000	136	42,000	114	136,000
1977*	215,000	150	47,000	147	262,000

*Projection based on the actual in the first three quarters of the year.

The value of raw coral is determined by color, size and condition (living or dead and solid versus wormy). For pink coral, the most valuable pieces are light pink or "angelskin." Lighter pink or darker red shades are lower priced. For gold coral, the most valuable shades are dark golden-brown. No dollar value can be estimated for bamboo coral at this time.

II.D.3 Domestic Commercial Processing

The processed commercial product relevant to the Fishery Management Plan is polished-unset precious coral. The primary supply of this product is imports to Hawaii. The domestic harvest of precious coral from the Makapuu bed and other potential exploitable beds provides the domestic industry with the raw material to produce an alternate source of polished-unset precious coral. About 35 jobs are directly related to processing raw coral harvested locally.

Value added at the processing stage of producing polished-unset coral from landed raw coral is approximately 100%. That is, $100 of value is added to every $100 of raw coral processed to produce $200 worth of polished-unset precious coral. These estimates are based on the cost of imported polished-unset coral and average costs of different stages of production reported confidentially from industry sources.

The estimated value of pink and gold polished-unset coral produced in 1976 was about $423,000. This included some raw coral from previous years' inventories. In the same year the coral jewelry manufacturers imported polished-unset coral at a cost of about $1,538,000 (see Table IV).

Table V -- Value of polished-unset precious coral imports to Hawaii; percent of total coral imports, by country of orgin and year, 1973-76.

	1973		1974		1975		1976	
Country	$	%	$	%	$	%	$	%
Hong Kong	59,192	11.3	66,770	13.2	17,633	3.3	64,226	4.2
Japan	241,862	46.4	226,109	44.7	153,929	28.4	277,592	18.1
Philippines	0		0		73,450	13.6	42,005	2.7
Taiwan	220,496	42.3	203,354	40.8	247,167	45.7	1,130,382	73.5
Others	264	0.05	7,020	1.4	49,025	9.1	23,442	1.5
TOTAL	521,814	100.0	506,253	100.0	541,204	100.0	1,537,737	100.0

Source -- Hawaii Custom District, Report Number IA-253, 1973-76.

II.E. Employment

While the number of people directly employed in the harvesting (12) and processing (35) of locally produced precious coral in Hawaii is not great, about 800 persons are engaged to some extent in the precious coral business there. Most jobs are in wholesale and retail sales.

II.F. State and Federal Tax Revenues and Multiplier Effects

Considering the excise tax on all retail precious coral products sold in Hawaii, revenues to the State (4%) amounted to about $800,000 in 1978 (Clifford Slater, Personal communication). About 20% of this can be attributed to local production of pink and gold coral in 1978. If wholesale taxes, State and Federal income taxes and operational taxes associated with the entire industry are taken into account, State and Federal tax revenues combined are about 2.5 million annually. About $500,000 of this is based on local production.

If a multiplier effect of two (Anderson et al., 1975) is used to show the impact of the total retail sales of the industry based on local production (4 million) on the economy of the State, a figure of about $8 million annually is produced. Eight million dollars is about one tenth of one percent of the Gross State Product of $6.6 billion (Bank of Hawaii, 1976). If the total industry is considered with the same multiplier, the value is 40 million or 0.6 percent of the Gross State Product in 1976.

The relevance of economic data for the total precious coral trade of Hawaii to the management of the domestic pink coral fishery has been questioned, in view of the small contribution of domestically harvested coral to the overall business.

Some persons in the business believe that the existence of even this small fishery tends to enhance the acceptance of all precious coral products in the market by lending a background of local color to the jewelry, particularly when it is offered as souvenir items for visitors. This contention is of course, difficult to evaluate or, if valid, to quantify the effect. It is deemed, however, sufficient reason to include some data on the larger trade within which the domestic coral business operates.

II.G. Jurisdiction

The Departments of Interior and Commerce share jurisdiction over precious corals in the FCZ. Until a Fishery Management Plan is prepared and implemented to govern fishing for corals in specific areas of the FCZ, the Department of the Interior's Bureau of Land Management (BLM) maintains control over all activities including fishing which may affect viable coral communities on the outer continental shelf. The BLM has established a permit system to exercise this control. When an FMP is implemented, the jurisdiction over fishing for the corals covered in the FMP is assumed by the Department of Commerce. The BLM, however, will retain authority to control certain non-fishing activities which would affect the corals involved. These agencies are considering a Memorandum of Understanding to assure coordination of efforts and achieve sound management of corals throughout the FCZ.

Federal jurisdiction over natural resources on the Continental Shelf outside of 3 miles was established in 1953 by the passage of the Outer Continental Shelf Lands Act. This Act delegated to the Secretary of Interior the responsibility for managing natural resources of the seabed and subsoil of the outer shelf.

In the 1958 Convention on the Continental Shelf, natural resources were defined as "mineral and other non-mineral resources of the sea-bed and subsoil together with living organisms belonging to sedentary species." Had there been a need to manage precious coral fisheries in 1958, this definition would have probably been used to establish jurisdiction within the Department of Interior.

In 1964, legislation was passed which prohibited foreign fishermen from harvesting Continental Shelf fishery resources within the contiguous zone of the United States (12 miles) except as provided by international treaty or Federal permit. Known as the Bartlett Act (PL 88-308), this legislation was amended in 1971 to specifically include six species of precious coral, which thereby defined them as creatures of the Continental Shelf. Since the Bartlett Act referred to all creatures of the Continental Shelf, other species of precious coral which are sedentary and occur on the shelf, even though not specifically listed in the Act by name, were covered by the legislation. The Bartlett Act reserved harvesting rights to U.S. nationals but did not contain any provisions for management. On March 1, 1977, the Bartlett Act was replaced by P.L. 94-265, the FCMA. In 1977, policies for foreign harvest of precious corals within the Fishery Conservation Zone were established by the Secretary of Commerce and are contained in a draft Preliminary Management Plan (PMP) for precious corals and a PMP for seamount fisheries. These policies would prohibit all foreign harvest everywhere in the Central and Western Pacific FCZ except incidental to trawling on seamounts west of 180° longtitute and north or 28°N latitude. Such incidental catches of precious coral must be recorded and returned to sea.

The PMP for precious corals has not been implemented, as it provided a zero TALFF, and no foreign fishing applications were received. The seamount fishery, however, is controlled by a PMP with prohibition on retention of corals taken by trawl.

With regard to domestic fisheries, most functions within the Department of Interior having to do with marine species were transferred to the Department of Commerce (DOC) in 1970 under Reorganization Plan No. 4 prepared by President Richard M. Nixon. However, the Department of Interior (DOI) retained authority to manage natural resources, including coral communities, of the Outer Continental shelf, and will continue to do so under the previously referred to draft memorandum of understanding between DOI and DOC until the FMP is implemented. After the Secretary of Interior (Secretarial Order 2978, 40 FR 42039) placed a moratorium on the taking of any viable corals in Federal waters on September 10, 1975, the Department of Interior developed a set of regulations which presently allow U.S. commercial coral harvesters to operate in Federal waters under permits issued by the Outer Continental Shelf offices of the Bureau of Land Management of the D.O.I. (Federal Register Document-76-27063; Federal Register, Vol. 41, No. 181, September 16, 1976). See Section IV-I and Appendix IV for details on provisions of the DOI permits. Present DOI regulations concerning fishing for corals in the FCZ will be replaced by the provisions in this plan on the date that implementing regulations for this plan take effect.

In Hawaii, the State also exercises some authority under S306 of the FCMA over the harvesting of precious corals outside of 3 miles. The State adopted Regulation 41 of the Division of Fish and Game, Department of Land and Natural Resources, in July, 1977.

This Regulation establishes a quota and/or permit system for the management of pink and gold coral in the Makapuu Bed, which lies about 6 miles off the island of Oahu. The quota applies only to pink coral. The state of Hawaii's jurisdiction over the Makapuu bed as well as other interisland waters remains an unsettled issue between the State of Hawaii and the Federal Government, but the management approach in this plan is consistent in most respects with the State of Hawaii regulations.

III. Biology

A. Life History

Precious corals are characterized by great longevity, slow growth, and relatively low rates of mortality and recruitment (Grigg, 1976). As a result, unfished coral populations should be relatively stable from year to year, and moderate changes in vital rates should have comparatively small effects on total abundance. Not unexpectedly, precious coral populations recover very slowly from overharvesting, and must be exploited with caution. Evidence that precious corals do recover comes from the history of the fishery in the Mediterranean Sea, where in the 19th century beds were rotated every 9 years (Tescione, 1965). Japanese fishermen claim that more like 50 years are required for recovery in the Pacific (Japanese fishermen, personal communication).

Pink, gold, and bamboo corals and other corals covered by this plan all have larval planktonic and sessile adult stages. Larvae settle on solid substrata, where they form colonial branching colonies. The length of the larval stage for all deep species is unknown. In the species of primary commercial importance, *Corallium secundum*, the sexes are separate and the reproductive cycles are

annual with spawning occurring during summer months in Hawaii (Grigg, 1976). Very little is known about predator-prey and other ecological relationships between the sessile stages of precious corals and other plants and animals. The sparse research that has been done suggests that microzooplankton and particulate organic matter are important in the diet of gorgonians (Grigg, 1970). There are no known predators on precious corals.

A large number of commensals are known generally (Hyman, 1940) to be associated with anthozoans. Many other species of gorgonian corals as well as invertebrates and fish are known to occur within the habitat of pink, gold and bamboo corals in the Hawaiian Islands. At least 37 species in the Order Gorgonacea alone have been described from the Makapuu Bed (Grigg and Bayer,1976). Ten species of black coral (Order Antipatharia) are also known to occur in the depth zone of precious corals (300-475 m) in the Hawaiian Islands (Grigg and Opresko, 1977). None of these black corals are of commercial importance. Species of possible commercial importance although they are rarely observed in the Makapuu Bed, include the shrimp *Heterocarpus ensifer* and the fishes, *Seriola dumerilii*, (kahala) and *Etelis carbunculus* (onaga). No species of either threatened or endangered wildlife are known to occur at depths where precious corals are found in the Western Pacific (see Appendix IV).

At least two species are known to be epizoic commensals of *Corallium secundum*. These are an anemone *Palythoa* sp. and a polychaete worm, *Palynoe* sp. The anemone attaches to the skeleton but causes no injury to the coral tissue or skelton; rarely more than 2 or

3 anemones occur on the same colony. The polychaete worms live in burrows or worm runs of their own making in the coral tissue or coenenchym. They cause no injury to the skeleton or the living tissue.

III.B. Distribution and Abundance and Habitat

The distribution of precious coral beds in the Hawaiian Archipelago, Samoa, Guam, the Commonwealth of the Northern Marianas and other U.S. Pacific island possessions is described in Section II.A. of this report. The vertical or depth zonation of precious corals in Hawaiian waters is given in Table VI.

TABLE VI

Vertical zonation of species of precious corals in Hawaii

Common Name	Scientific Name	Depth range (m)
Black coral	*Antipathes dichotoma*	30 - 100[a]
" "	*Antipathes grandis*	40 - 100[a]
Pink coral	*Corallium secundum*	350 - 475[b]
Gold Coral	*Gerardia* sp.	300 - 400[b]
Bamboo Coral	*Lepidisis* olapa	330 - 475[b]

[a]Based on submersible observations.

[b]Based on submersible observations and data collected with a remotely operated television camera.

In the Hawaiian Archipelago, stocks of precious corals may be more abundant in the northwestern end of the island chain, where large areas of potential habitat exist on seamounts and banks near 400 m depth. The combined area of the Milwaukee Banks and Kinmei Seamount (400 - 500 miles northwest of Midway Island), for example, is over 300 km^2. In contrast, the area of the major bed off Oahu (Makapuu) is estimated to be 3.6 km^2. The dimensions of the Makapuu Bed actually cover about 4.5 km^2 (Figure 5). However, observations from the submersible Star II have shown that about 20% of this area includes barren patches and irregular lenses of thin sand deposits. Therefore the area used for the purpose of extrapolating density is taken as 80% of 4.5 km^2 or 3.6 km^2.

Annual harvest of *Corallium* in 1969 by the Japanese on the Milwaukee Banks was reported to be 113,000 kg (H. Ozawa, personal communication). This compares to a range of annual harvest of *Corallium* of Makapuu of 438 to 2209 kg in the years 1966 to 1976. If the highest yields for both areas are expressed on a per km^2 basis (Milwaukee = 376 kg/km^2, Makapuu = 611 kg/km^2), Makapuu actually has a higher yield. However, since comparative data on fishing effort are lacking, interpretation of these figures is difficult. Nevertheless, the habitat area and yields at the Milwaukee Banks are far greater in absolute terms than off the high islands at the southeastern end of the Archipelago.

In the high islands, beds of precious corals have been found only within island channels and off promontories such as Ke-ahole Point on the Big Island of Hawaii.

Precious corals are only found on solid substrata, which in deep water invariably occurs only where bottom currents are frequently strong (>25 cm/sec).

The only bed that has been accurately surveyed in the Hawaiian chain is off Makapuu, Oahu. In 1971, densities of commercial species were determined in an unexploited section of the bed and the size frequency distribution of pink coral was determined (Grigg, 1976). The average density of pink coral in the Makapuu Bed is 0.022 colonies/m^2. Extrapolation of this figure to the entire bed (3.6 million m^2) gives a standing crop of 79,200 colonies. The 95% confidence limits of the standing crop are 47,200 to 111,700 colonies. Conversion of standing crop of colonies to biomass ($\Sigma N_i W_i$) produced an estimate of 43,500 kg for *C. secundum* in the Makapuu Bed.

The estimates of density for gold coral *(Gerardia* sp.) and bamboo coral *(Lepidisis olapa)* in the Makapuu Bed are 0.003 colonies/m^2 and 0.01 colonies/m^2, respectively (Grigg, 1974). However, the distributional patterns of both of these species are very patchy, much more so than *Corallium secundum*, and the area where they occur is only about half that for pink coral or 1.8 km^2. The corresponding estimates of unfished abundance for gold and bamboo coral are 5,400 and 18,000 colonies, respectively. Data for the mean weight of colonies in the populations of gold and bamboo coral in the Makapuu Bed are lacking, but rough estimates are 2.2 kg for gold coral and 0.6 kg for bamboo coral. Multiplying mean weights by densities led to rough estimates of standing crop of about 11,880 kg for *Gerardia* sp. and 10,800 kg for *Lepidisis* sp.

III.C. Growth and Mortality Rates

An analysis of growth rings in the cross sections of pink coral branches suggests that colony height increases about 0.9 cm/yr, at least to an age of about 30 years (Grigg, 1976). The equation for the regression of height against time is as follows:

$$H = \alpha + \beta T$$

where H = height (cm)

T = Time (yr)

$\alpha = 2.63$

$\beta = 0.89$

A similar relation for weight 1/ as a function of height is given by the equation:

$$W = aH^b$$

where W = weight (gm) (landed weight)

a = 0.8

b = 2.27

1/ landed weights approximately 24 hours air dry.

The largest colonies of pink coral found at Makapuu are rarely more than 60 cm in height. Gold coral colonies may reach a height of 250 cm, while *Lepidisis* olapa grows to about 300 cm.

The natural mortality rate for pink coral was calculated by first converting the size-frequency distribution of the unfished stock to an age frequency distribution and then determining the rate of diminution in progressively older age classes (Grigg, 1976). The best estimate of the annual instantaneous natural mortality rate of *C. secundum*

in the Makapuu Bed turned out to be 0.066. This is equivalent to an annual survival rate of about 93% in the absence of fishing. Mortality rates for gold and bamboo coral are not available because their growth rates and age structures are unknown.

III.D. Reproduction and Recruitment

Pink corals reach sexual maturity at a height of about 12 cm (13 years), however, the data are not very precise (Grigg, 1976). The reproductive cycle is annual with spawning taking place during June and July.

The relationship between parent stock and recruitment in pink coral is unknown. However, because pink coral is long lived, and the population is composed of many year-classes, the standing stock should be relatively stable even with moderate year-to-year fluctuations in recruitment.

An estimate of steady state recruitment of the unexploited Makapuu stock was obtained by multiplying the virgin stock size (79,200 colonies) by the best estimate of annual instantaneous natural mortality (0.066). Given steady state, the instantaneous rate of recruitment should equal the instantaneous rate of natural mortality. This gives an estimate of annual recruitment to the Makapuu Bed of 5,277 colonies.

III.E. Biomass per recruit

Biomass per recruit as a function of age was calculated in the absence of fishing using a cohort production model (Wetherall and Yong, 1977). In the model, the cohort gains weight until an age is reached where growth gains are overtaken by natural mortality losses.

This is the "critical age" at which the cohort reaches its maximum biomass in the absence of fishing. The formula for critical age is

$$T = \left(\frac{b}{M} - \frac{\alpha}{B} \right)$$

where b = exponential coefficient in the weight-height relationship (p.30)

M = instantaneous natural mortality rate

α = intercept of linear growth in height equation (p.30)

B = slope of linear growth in height equation (p.30)

The numerical result for pink coral is T = 31.4 years.

The corresponding maximum biomass per recruit is given by the formula

$$MBPR = e^{-(b - \frac{\alpha M}{B})} \; a \left(\frac{B^b}{M} \right)^b$$

where the new symbols are

e = base of natural logarithms
= 2.71828

a = coefficient in weight-height relationship (p. 30)

For pink coral the maximum biomass per recruit, attained by a cohort at age 31.4 years, is MBPR = 237 gm. This is shown as the peak in the top curve of Figure II. Other curves in Figure II show the relationship between biomass per recruit and age when fishing takes place at constant rates (F>0) and there is no minimum age limit for harvested coral. Corresponding biomass per recruit curves for the case of a 25-year minimum harvest age are shown in Figure 12.

III.F. Yield per Recruit

When fishing is done in such a way that all colonies of a cohort are removed at once, then the yield per recruit is identical to the biomass per recruit at the harvest age. Therefore the maximum yield per recruit is achieved by harvesting all survivors in a cohort of pink coral exactly at the critical age of 31.4 years, and in this case the maximum yield per recruit (MYPR) is = 237 gm. In practice this would require applying an infinite instantaneous fishing mortality rate exactly at age 31.4 years. Since this is not feasible, the 237 gm/recruit is a theoretical upper limit to the harvest that may actually be obtained.

More realistic figures of yield per recruit are obtained by considering a fishery which applies a steady finite fishing mortality rate to all ages in the cohort above a specified minimum harvest age. The results in this case are displayed in Figure 13. The effect of an age limit of maximum yield per recruit is easily seen. For example, with a minimum harvest age of 30 years the maximum yield per recruit is essentially equal to the upper limit of 237 gm, whereas with a minimum harvest age of zero years the greatest yield per recruit possible is only 119 gm. Hence if non-selective methods of harvest (e.g., dredging) are employed, the highest yield per recruit that can be expected is only half of the maximum yield per recruit theoretically possible under selective harvesting.

III.G. Sustainable Yield and MSY

The analysis above reflects a biological management approach in which the main consideration is achieving the highest possible efficiency in utilizing biological production for a cohort.

As long as recruitment is constant or independent of stock size, a fishing policy which maximizes the yield per recruit will also maximize the total yield on a sustained basis, i.e., it will also produce the maximum sustainable yield (MSY). However, in many fisheries the level of recruitment may be strongly affected by the abundance of reproductive individuals in the stock, which is in turn determined partly by the fishing policy (such as minimum harvest age and fishing mortality rate).

Even though no specific information is available on the actual stock-recruitment relationship in pink coral, it is important to see how various hypothetical relationships would alter the analysis of best fishing policy. If recruitment is not constant, but is instead some decreasing function of spawning stock, then MSY will be reduced accordingly. Several hypothetical stock-recruitment curves are diagrammed in Figure 14. The diagonal line (curve 1) shows a proportional decline in recruitment as a direct function of spawning stock. The curves above the diagonal also show recruitment declining as a function of spawning stock, but at lesser rates, such that when the spawning stock (S) is 50% of its original level (SMAX), recruitment (R) is either 60% (curve 2), 70% (curve 3), 80% (curve 4), or 90% (curve 5) of its maximum level (RMAX). Curve 6 shows the model of constant recruitment.

Possible combinations of sustainable yield and minimum harvest age are shown in Figure 15, as computed in Wetherall and Yong (1977). The outer boundary (curve 6) gives the combination of sustainable yield and minimum harvest age for the constant recruitment case, assuming a steady recruitment of 5,000 colonies per year.

The maximum sustainable yield under this constant recruitment rate is

$$\begin{aligned} MSY &= MYPR \times R \\ &= 237 \text{ gm/recruit} \times 5{,}000 \text{ recruits/yr} \\ &= 1185 \text{ kg/yr} \end{aligned}$$

This assumes a minimum harvest age of about 30 years and a very high instantaneous fishing mortality rate. When selective harvesting is not possible, then the maximum possible sustainable yield is less than 600 kg/yr.

The other curves (5, 4, 3, and 2) show the outer limits of the policy space (combinations of annual sustainable yield and minimum harvest age) corresponding to the other stock-recruitment models. As the stock-recruitment curves get steeper (i.e., progressively lower rate of recruitment for a given spawning stock), the minimum age limit necessary to maintain a specified sustainable yield increases. Further, the MSY is significantly less than 1185 kg/yr when recruitment is not constant. This analysis suggests a range of conservative alternative policies which might be adopted in the absence of any understanding of the true stock-recruitment relationship.

Maximum sustainable yield for the constant recruitment case was computed above analytically using the expression

$$\begin{aligned} MSY &= A \cdot D \cdot M \cdot e^{-\left(b - \frac{\alpha M}{B}\right)} \cdot a \left(\frac{B}{M}\right)^b \\ &= R \cdot MYPR \end{aligned}$$

where the new symbols are

A = area of Makapuu bed

D = average density of pink coral colonies on the bed before exploitation

M = instantaneous natural mortality rate

$R = A \times D \times M$

A rougher but quicker approach to estimating MSY is the approximation of Gulland (1970), viz.

$$MSY^* = 0.4\ M\ B_o$$

where $B_o = A \times D \times W$ = total biomass of unfished stock

and W = weighted average weight of a colony in the unexploited stock.

In the case of pink coral on the Makapuu bed

$$MSY^* = (0.4)\ (.066)\ (43{,}500)$$

$$= 1148 \text{ kg/yr}$$

The Gulland method is useful especially for gold and bamboo coral where details of population dynamics are relatively unkown. Using the guesses of unfished biomass (B_o) and substituting the pink coral natutal mortality rate (M = 0.066) in place of the unkown values, rough estimates of MSY for gold and bamboo coral were computed to be 313 kg/yr and 285 kg/yr. All estimates of MSY are summarized in Table VII. MSY cannot be estimated for other corals at this time.

TABLE VII

Estimates of MSY of precious corals in the Makapuu Bed

Species	Common name	MSY*	Rounded downward	Method of Calculation
Corallium secundum	Pink Coral	1185 kg/yr	1000 kg/yr	Cohort Production Model
" "	" "	1148 kg/yr	1000 kg/yr	Gulland
Gerardia sp.	Gold Coral	313 kg/yr	300 kg/yr	Gulland
Lepidisis olapa	Bamboo Coral	285 kg/yr	250 kg/yr	Gulland

* landed dry weight

IV. Management

A. History of Research and Management

The precious coral fishery can be traced back to the Sumerian and Minoan cultures around 3000 B.C. in the Mediterranean Sea. Through this long history, occasional efforts to manage the fishery have been made. Periods of prohibition have been attempted more than once in several places, but invariably they were unsuccessful. The pattern of fishing usually was one of exploration, discovery, exploitation and depletion. When recovery occurred, it usually was brought about unintentionally by interruption of fishing by war. Between 1879 and 1890, off the Barbary Coast in Africa, fishing grounds were rotated (closed) for 9 or 10 year periods. However, lack of enforcement eventually led to severe depletion of the beds. The selection of a 9-10-year period for recovery was based on observations of fishermen and the early research of Lacaze-Duthier (1864), who first investigated the life history of *Corallium rubrum* in the Mediterranean Sea.

Until 1970, research on precious coral in the Pacific was limited to the early work of Kishinouye (1901) on reproductive behavior and studies by Kitahara (1904), who described the coral fishery in Japan in the late 19th century. Before 1868, coral fishing in Japan was inadvertently managed by virtue of the societal customs of the Shoguns, who confiscated coral thereby eliminating incentive for a commercial fishery. After 1868, no management of the stocks was attempted in Japan, probably because fishing activity ranged far beyond local waters.

In 1963, rich beds of *Corallium* were discovered about 100 miles south of Okinawa, and the Government in Okinawa attempted to regulate the harvest by requiring permits and limiting entry into the fishery. Unfortunately, too many permits were issued and the beds were rapidly depleted. Furthermore, enforcement was lacking to prevent unlicensed fishermen from entering the fishery and this accelerated the decline.

In 1970, a Sea Grant research program was started at the University of Hawaii to investigate the ecology of precious coral and to determine the economic feasibility of developing a fishery in Hawaii. This research led to the development of a selective harvesting system which is currently in use in Hawaii (the Star II submersible and support craft). This research also generated data concerning distribution, abundance, growth, natural mortality, recruitment, and maximum sustained yield of precious corals in Hawaii and is the basis of the analysis presented in this report. A detailed account can be found in a Sea Grant Technical Report entitled "Fishery Management of Precious and Stony Corals in Hawaii" (Grigg, 1976).

The Makapuu Bed has been exploited periodically since 1966. Estimates of the harvest of pink and gold coral during this period are given in Table I. The first attempt to manage the precious coral fishery in Hawaii was by the State Division of Fish and Game. In 1977, the Division of Fish and Game passed Regulation 41, which contains provisions concerning permits, annual quotas and size limits (see Appendix II). The history of efforts to manage precious coral resources by the Federal government is given in Section II.G on Jurisdiction. The regulations of the Department of Interior which are now in effect are described in Section IV.I and Appendix III.

IV.B.1 Management Objectives and Philosophy

The major objectives of this management plan are to obtain optimum yields of precious corals in the U.S. 200-mile fishery conservation zone, and to maximize the benefits of the resource to the nation. Optimum Yield is defined in the Act as the amount of "fish" which will provide the greatest overall benefit to the nation and is prescribed on the basis of MSY as modified by socio-economic and ecological factors. Given this definition, estimates of MSY have been calculated for pink, gold and bamboo corals in the Makapuu Bed and modified according to the definition given above.

In order to obtain maximum sustained yields of precious corals, several of their biological properties must be considered. Precious coral populations are relatively stable in nature because many year classes are usually present. Annual differences in recruitment and age specific mortality rates therefore tend to be offsetting. This pattern of life history has two important consequences with respect to exploitation. First, the response of the population to exploitation

or changes in the exploitation rate is drawn out over many years (see Figs. 16 & 17). The data presented in Figures 16 and 17 were produced by simulating the past history and future condition of a fishery for C. secundum in the Makapuu bed between 1964 and 2014 (50 years). In 1978, six different rates of exploitation were applied to a model of population for one year after which it was assumed that the fishery was closed and monitored for 37 years. In the model, recruitment was assumed to be constant until a level of two-thirds the spawning biomass was reached, after which recruitment was calculated as a direct function of spawning biomass. Examination of Figures 16 and 17 reveals that about 25 years are required before the population biomass and the spawning biomass recover within 95% of original values. Thus, age structure may be in a transitional state for many years.

The second important consequence of great longevity, and the associated slow rates of turnover in the populations, is that if a stock has been overexploited for several years, a long period of reduced fishing effort is required to restore the ability of the stock to produce a maximum sustained yield (Figures 16 and 17). Because of the long recovery time of precious corals, the most prudent policy for the management of newly discovered beds would be to permit commercial exploitation in Exploratory Areas only after assessments of the virgin stocks are made. The assessment should at least include total area of the bed and estimates of density of various species present. The most economical method of obtaining this information would be fishermen operating under exploratory fishing permits with detailed reporting requirements.

IV.B.2 Specific Management Objectives

The specific objectives to be achieved by management measures adopted under this fishery management plan are as follows:

1) to allow a fishery for precious coral in the fishery conservation zone in the western Pacific but to limit the fishery so as to achieve the Optimum Yield on a continuing basis

2) to prevent overfishing and wastage of the resource

3) to encourage the use of selective harvesting methods

4) to minimize the harvest of colonies of coral which are immature

5) to minimize the harvest of colonies of coral which have not reached their full potential for growth

6) to preserve an opportunity for low-investment equipment in the fishery (dredges)

7) to encourage the discovery and exploration of new beds

8) to provide for the establishment of refugia, i.e., beds completely protected from exploitation

9) to encourage the development of new information concerning the distribution, abundance and ecology of precious corals.

IV.C. Optimum Yield

A stated purpose of the Fishery Conservation and Management Act of 1976 is to provide for preparation and implementation, in accordance with national standards, of Fishery Management Plans which will achieve and maintain, on a continuing basis, the Optimum Yield (OY) from each fishery. Calculation of OY in this management plan involves several steps. First, MSY is estimated. OY is then derived by adjusting

MSY lower or higher for ecological reasons, for example, to rebuild overfished stocks. OY may also be adjusted upward or downward depending on socio-economic considerations or information received via the public hearing process.

In the case of pink coral in the Makapuu Bed, the (downward rounded) estimate of MSY is 1,000 kg. On the basis of past harvest records, the Makapuu Bed does not appear to be in an overfished condition. Therefore, it is reasonable to base OY on MSY, with appropriate modification to include economic and social factors. See Appendix I for an economic analysis of various management options.

This analysis shows that pulse fishing is more economically efficient than fishing continuously, if there are alternative uses for the fixed factors of production. Otherwise, continuous fishing is more efficient at annual quotas of about 1,000 kg for pink coral and 300 kg for gold coral for the single firm now harvesting the Makapuu bed.

The most likely situation is that the firm now harvesting coral with a submersible in the Makapuu bed will find alternative uses for the submersible and its support vessels during zero harvest years of a pulse fishing strategy. Without adequate information on the world coral market, projections of coral prices are not available. Projections on cost changes are not available either. Therefore, assuming prices and costs change at the same rate and the fixed costs are defrayed during zero production years by alternative employment, pulse fishing is deemed the most efficient policy.

If the Optimum Yield is to be based on pulse fishing, the biological implications of different catch levels must also be examined. Although setting a 2-year quota of 2,000 kg would concentrate fishing effort in the first year and slightly reduce MSY over the long term, the decrease is negligible (Figure 18). When pulse fishing is simulated for 3- and 4-year periods (again with the entire catch in the first year), the biomass of the exploited population gradually decreases. The biological consequences of harvesting more than an average of 1,000 kg in one year are described in Section IV.F.1.B. Eight such options were tested, and in all cases the rates were not sustainable. Thus, a strategy of 2-year pulse fishing appears to be the best combination in terms of minimizing the biological risks and maximizing economic benefits. For this reason, Optimum Yields for precious corals in the Makapuu Bed have been set on the basis of 2-year quotas. Applying this criterion to pink, gold and bamboo coral gives (downward rounded) Optimum Yields of 2,000 kg, 600 kg, and 500 kg respectively for 2 years for the Makapuu Bed.

Optimum Yields are established for the Conditional Beds by assuming the same densities and population dynamics as for the Makapuu Bed, taking into account the areas of the beds relative to that of the Makapuu Bed, and reducing the resulting figure by 80%, if harvesting is to be by non-selective coral dredges. Thus the annual quotas on each of these beds will be fractions or multiples of 200 kg of pink coral, 60 kg of gold coral and 50 kg of bamboo coral proportional to the area of the bed. If fishing on a bed is by nonselective methods, the bed will be closed when the quota is filled for any one of the three species, to prevent overharvesting.

Because of the potential vulnerability of precious corals to over exploitation, a prudent policy for newly discovered and unsurveyed beds would be to fix Optimum Yields only after a careful assessment of their production potential. However, an assessment of abundance and productivity can be accomplished only after a bed has been located, and as a practical matter, neither Federal nor State agencies are likely to receive funding to search the FCZ to locate coral beds. It must be left to private interests to conduct this exploratory fishing. This in turn poses a serious management problem: there must be a limit to the amount of corals allowed to be taken from an Exploratory Area to reduce the risk of overfishing, but the limit must be large enough to provide the economic incentive to engage in exploratory fishing.

There is no statistical basis for determining this limit; rather, the limit must be a judgmental decision. With respect to abundance, it is believed that there are coral beds scattered throughout the FCZ. Reports of past foreign operations and the detection of illegal foreign operations in 1978 provide evidence of foreign interest in (and perhaps knowledge of) coral resources in the FCZ. With respect to economic incentive, precious coral ex-vessel prices were about $150/kg. in Hawaii in 1977 (see Tables II and IV). Little is known, however, about the costs of operation for a submersible or for dredging, thus, breakeven harvests for exploratory fishing cannot be estimated.

The Council's judgement is that an optimum yield of 1000 kg per year per Exploratory Area should provide sufficient incentive for both domestic and/or foreign exploratory fishing while posing little risk of overfishing. For this purpose, there are considered to be

five Exploratory Areas, comprising the FCZ off American Samoa, Guam, the Northern Marianas, and the minor U.S. island possessions in the central and western Pacific Ocean, and those portions of the FCZ off the Hawaiian Islands that are not included in Established and Conditional Beds, as defined in this Plan. A quota of 1,000 kg of combined species for each Exploratory Area is considered conservative. In Hawaii, this figure represents about one-third of the estimated MSY for these species in all Established and Conditional beds. However, it is large enough to offer an economic incentive for exploration.

IV.D. Domestic Fishing Capacity, Expected Harvest Level, and TALFF

Domestic harvest from the Makapuu bed of all corals in 1974 was nearly 3,000 kg. (see Table II). The industry was operational on a continuous basis that year. Harvests then declined for two years, but increased again in 1977. The reasons for this pattern of harvests are not known, but it appears that the popularity of coral jewelry may be increasing such that demand and prices for corals (see Table V) justify more intensive fishing.

It has been pointed out that the maximum payload of the submersible in the corals fishery is about 200 pounds, or 90 kg. (Sec. II.C.2). If it is assumed that the average haul on a dive is only one-half the maximum payload, the submersible would have had to make only 67 dives to achieve the 3,000 kg. harvest made in 1974. This number of dives can be accomplished in about 22 weeks. Thus the 3,000 kg. harvest would seem to be a minimal measure of domestic capacity. It seems reasonable to estimate that domestic capacity would be a least one-third higher (i.e. 4,000 kg.) given the right conditions of

price, harvest costs, and resource abundance.

Estimating expected domestic harvest is more difficult given the limited data available. Domestically harvested corals constitute only a small portion of the entire corals industry, and it appears that a large volume of low-priced imports could easily drive down the price and make the domestic product less competitive. On the other hand, coral jewelry is a popular item in the tourist markets, and producers may be willing to pay a premimum or engage in long-term contracts to insure a stable supply of domestically harvested corals. It also would seem reasonable to conclude that domestic producers have learned how to use the submersible more effectively since 1974, and that the same number of dives would produce more coral per dive than in 1974, assuming sufficient availability of corals for harvest. Considering all these factors, the expected annual harvest is estimated to be 3,300 kg. per year (assuming management measures permit). This represents a 10% increase over the 1974 (peak year) harvest.

The OY for the Makapuu Bed is established to be 3,100 kg. (all species combined) over a two year period. This is the most fished and best studied bed in the FCZ and is quite close to the dominant processing and retailing center of Hawaii. It also is reserved for selective fishing techniques. It appears reasonable to expect that the OY for Makapuu will be harvested in the first year of the two year period so the submersible can be employed during the second year in alternative areas or uses. Thus, there would be more than 3,000 kg/year of "idle" selective capacity available to harvest the OY from the four Conditional Beds from which corals may be harvested (the fifth Conditional Bed is to

be a refugium). If selective gear is used, OY for Conditional Beds (in aggregate) would be not more than 1,250 kg. per year, or 2,500 kg over a two year period (all species combined). If non-selective gear is used, OY would be less. Therefore it appears reasonable to conclude that domestic vessels can and will harvest the OY from Established and Conditional Beds. Therefore, the TALFF for these beds is zero.

There is no evidence to indicate that owners of U.S. vessels have either the intention or the desire to conduct exploratory fishing in the FCZ, especially seaward of Guam and American Samoa. Conditions may be somewhat more favorable off Hawaii, given the proximity of the dominant market and the possibility that a vessel fishing a Conditional Bed with dredging gear could conduct some exploratory fishing with little additional cost. Domestic interests, however, are unlikely to make any investments in vessels and gear without some assurance that corals will be available.

The Council proposes, therefore, that 500 kg. per year in each Exploratory Area be reserved for domestic fishing. Unlike reserves in other fisheries, this reserve would not be released to foreign fishing even if no domestic fishing were to occur. The reserve is sufficiently small that it could be taken in a very short time in any month of the year. It is not possible to survey the fishery to determine in advance what the domestic harvest is likely to be and how much could be released to foreign fishing, hence this reserve would not be released to foreign fishing even if no domestic

fishing were to occur. Further, corals are long-lived animals, and natural mortality rates are quite low, so there is little "waste" or loss if an amount of corals is not harvested in a given year. Finally, this permanent reserve is meant to insure that domestic interests will have the certainty of a quota for their own exploratory fishing.

The remainder of the OY for each Exploratory Area will be available for foreign fishing, i.e., the total allowable level of foreign fishing (TALFF) is 500 kg., all species combined, per Exploratory Area per year.

IV. E. Domestic Processing Capacity and Expected Processing Level

The largest annual domestic harvest since the submersible entered the fishery has been about 2940 kg. (1974). There are no indications that domestic processing capacity was insufficient to process this level of harvest. The size of the market for polished-unset coral (Table V) suggests that domestic processing would expand rapidly with increased domestic harvests. The Council believes that domestic processing capacity and expected processing levels will equal the domestic harvest for the future. There is no known or suspected interest in joint ventures involving foreign vessel processing of U.S. harvested corals.

IV. F.1 Management Measures--Options, Recommendations and Rationale

In developing a management plan for precious corals in the Western Pacific, a number of options were considered for each management provision. All options for each provision are listed below. The policies recommended by the Western Pacific Council and the rationale for these decisions are also described.

Where appropriate, reference is made to previous sections of the plan which contain more complete documentation and support for the recommendations of the Council. A draft set of suggested conservation and management measures which implement the recommendations is presented in Section IV.F.2 of the plan.

A. Gear

With regard to gear restrictions, six options were considered by the Council. They are as follows

1) To prohibit all forms of non-selective harvest (dredging) in the FCZ
2) To allow unconditional dredging everywhere in the FCZ
3) To allow conditional dredging everywhere in the FCZ
4) To allow conditional dredging in some areas where selective methods are not in current use
5) To allow unconditional selective harvest everywhere in the FCZ
6) To allow conditional selective harvest everywhere in the FCZ

Policies 4) and 6) are recommended: to allow conditional dredging in Exploratory Areas and on some Conditional Beds, excluding the FCZ seaward of the main Hawaiian Islands, i.e. south and east of a line midway between Niihau and Nihoa Islands; and to allow conditional selective harvest everywhere[1] in the FCZ. This would prohibit dredging in areas such as Makapuu, where selective harvesting methods are established and capable of taking the Optimum Yield; or Ke-ahole Point or Kaena Point, which are such small beds that dredging poses too great a risk of damage in view of the low economic return.

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[1] Except Refugia

A discussion of the advantages and disadvantages of selective and non-selective (dredging) technologies is presented in Section II.C of the plan. Where allowed, dredging would be subject to reduced quotas relative to quotas for selective methods (see below). This is because young colonies are not protected from exploitation during the period when their growth exceeds losses from natural mortality. Hence with dredging some growth-overfishing occurs. Also, with dredging full recovery of pieces knocked down does not occur (Section II.C.2). The reason an allowance for dredging is provided at all is the impracticality of utilizing selective methods in certain remote areas. Restricting harvest to selective methods could in practice close off large areas. This would be wasteful of the resource and would not produce new information concerning distribution and abundance. Both dredging and selective harvest are subject to further conditions which are outlined below.

Both options recommended are consistent with the objectives of the plan (see Section IV.B.2) and the national standards of P.L. 94-265.

B. Weight Quotas

Two options were considered: to require or not require weight quotas on a per bed basis. The Council proposes to establish weight quotas for both dredging and selective harvesting methods. For dredging, the weight quota would be set equal to 20% of the quota that would apply if selective methods were in use. The rationale for this restriction is the finding that the MSY for pink coral with no size limit is approximately half what it is at optimum size of first capture (Section III.F).

Taking into account the efficiency of the dredges (40%) results in a further reduction of the quota to 20% (40% of 50%). For selective methods, the weight quotas are based on estimates of MSY (Section III.G). In the Makapuu Bed, eleven weight quotas for pink coral were considered. They are as follows: 1,000 kg/yr, 1,200 kg/yr, 2,000 kg/yr, 3,000 kg/yr, 4,000 kg/yr, 5,000 kg/yr, 6,000 kg/yr, 7,000 kg/yr, 8,000 kg/yr, 2,000 kg/2 yr, and 3,000 kg/3 yr. The option recommended is the tenth: 2,000 kg/2 yr. This option is selected because it is the most efficient quota considering all biological, economic and social factors (Section IV.D). Multiple year quotas in which fishing effort is concentrated in the first year also favor exploration in "off-years" when the equipment might otherwise not be in use. The 2-year quota is based on an estimate of MSY for pink coral, simply being double the amount for twice the time. The same formula was used to develop optimum yields for gold and bamboo coral.

For all harvest levels greater than 1,000 kg for one year, the harvest (even up to 8,000 kg) can be sustained only for several years, after which the population and catch severely decline. Two levels of harvest, 2,000 kg/yr and 4,000 kg/yr, were simulated using a computer model over a 37-year period to show the effects of these policies on both the parent population (Figure 18) and the catch (Figure 19). In the model, recruitment is assumed to be constant until a level of two-thirds the spawning biomass was reached after which it was set as a linear function of spawning biomass. In the case of continuous harvest at the 2,000 kg/yr level, the population is able to produce this yield for only 14 years after which significant

reduction occurs. The 4,000 kg/yr option leads to collapse of this level of harvest in just 5 years. In the Makapuu Bed both the 2,000 kg/yr and the 4,000 kg/yr are wasteful in the long term and are inconsistent with the national standards of FCMA.

For Conditional beds for which there are not good estimates of MSY but for which estimates of area are available, the quota, for each species of precious coral initially, could be set according to the ratio of the area of a bed to the area of the Makapuu Bed, i.e.

$$\frac{\text{Area of Bed}}{\text{Area of Makapuu Bed}} \times \text{MSY for Makapuu Bed}$$

Such beds are defined as Conditional Beds. For Conditional Beds on which dredging is allowed the quota would be reduced by 80%.

For areas outside the Makapuu Bed and Conditional Beds, it is proposed to allow either nonselective or selective methods, subject to a limit of 1,000 kg. per Exploratory Area per year. The quota for Exploratory Areas is suggested on the basis of providing a minimum economic incentive for exploration (See p. 44). Of the 1000 kg per Exploratory Area per year, 500 kg are suggested to be set aside as a permanent reserve for domestic fishermen. A 500 kg quota is judged to be of sufficient value as to provide an economic incentive for exploratory fishing. For this reason the absolute amount of the quota is the same regardless of the type gear employed (selective or nonselective).

The plan envisions that a new bed identified in a Exploratory Area will be designated a Conditional Bed, with a quota based on its estimated area, once an area estimate has been made. Fishing in Exploratory Areas will be controlled by permits to be granted by the Regional Director, NMFS for a one-year term, with provision for a one-year renewal.

All weight quotas recommended in the plan are consistent with the objectives of the plan (Section IV.B) and the national stan-

ards of P.L. 94-265. With respect to the Makapuu Bed, the quota recommended for pink coral is also consistent with State law (Appendix III), except that the quota is based on dry weight of live coral only.

C. Size Limits

The options for a size limit apply only to selective harvesting methods in the Makapuu Bed and the Conditional Beds off Kea-hole Point, Hawaii and Kaena Point, Oahu. Since dredging is allowed everywhere else, the size limit at this time can apply only to these beds. The alternatives considered were whether or not to require a size limit and if so, what it should be and whether it should be voluntary or compulsory. For pink coral, four size limits were considered: 8, 9, 10 or 11 inches in height measured from the base to the greatest vertical extremity of the colony.

For pink coral a compulsory size limit of 10 inches is proposed for beds on which only select harvesting techniques may be used. Size limits for gold and bamboo corals are not recommended at this time because of inadequate information. The rationale for selecting a 10-inch limit is based on several arguments. First, the size limit which corresponds to MSY is actually 11 inches (Section III.F). However, a slightly smaller size is favored because catch per unit effort would be greater than it is with an 11-inch limit while the effect on yield would be negligible (Figures 11 and 13). MSY is adjusted downward to account for a 10-inch size (Section III.G). Second, a 10-inch limit is consistent with current practice. Industry claims that harvesting colonies less than 10 inches is not economically practical, because the return does not justify the time spent harvesting. Third, a 10-inch size limit is equivalent to an age of 28 years, and this is approximately 15 years after colonies reach reproductive maturity. Hence, an adequate reproductive cushion (Grigg, 1976) would appear to be provided by a 10-inch size limit.

Because a size limit of 10 inches almost doubles the MSY that

would be obtained with no size limit (Section III.G and Figure 13), it promotes efficiency in the utilization of the resource, which is consistent with the national standards of P.L. 94-265, Hawaii State Division of Fish and Game Regulation 41 (Appendix III) and the objectives of this plan (Section IV.B).

Unfortunately much of the pink coral is unavoidably broken during collection, making enforcement of any size limit difficult. Breakage varies depending on handling which itself is a variable due to weather, size of the load and chance. One method that might work would be to calculate an average weight and stem diameter for colonies 10 inches in height. The weight of the load could then be divided by the average weight of a 10-inch colony. This division would produce a number that would equal the minimum number of pieces equal to or larger than the stem diameter equivalent to 10 inches in height. For example, if the stem diameter equivalent to 10 inches in height is one inch and the average weight of a 10-inch colony of pink coral is 2 pounds and if a particular day's load is 50 pounds, then at least 25 pieces in the load should measure at least one inch in maximum diameter.

The calculations for the example are as follows:

$$\frac{50 \text{ lbs (catch)}}{2 \text{ lbs (weight average of colony of 10 in.)}} = 25 \text{ pieces} \geq \begin{matrix}\text{stem diameter} \\ 1 \text{ inch}\end{matrix}$$

The Council will reconsider this size limit as a management measure if it is found that enforcement is inordinately difficult or expensive.

D. Royalties

The options considered for this provision were whether or not to impose royalty fees on the basis of the weight or value of precious coral harvested. Royalties are a feature of management regime for coral fisheries established by BLM, DOI. The recommendation is against the imposition of royalties because the FCMA states that regulations promulgated to implement fishery management plans may not require fees for domestic fishermen beyond the cost of administering the permit system. Presumably royalties would exceed the cost of administration. Also the Council sees no merit in proposing royalties for corals when no other FMP has proposed royalties. The Council considers the employment and taxes generated by the industry to be adaquate compensation to the public for use of a common property resource.

E. Incidental Catch

The options considered were whether or not to allow incidental catch of corals by vessels fishing for other species of fish and if so under what conditions. The recommendation is to allow incidental catch of all precious corals in the FCZ for both domestic and foreign fishermen, however, subject to certain conditions. It is recommended that domestic and foreign fishermen be allowed to incidentally harvest precious coral but that they be required to submit detailed monthly reports of such catches to the NMFS. It is further recommended that non-retention apply for both domestic and foreign fishermen. It is also proposed that should the amount of incidental harvest of precious coral be significant (more than 50 kg per vessel per year), the Secretary of Commerce should be so notified so that more restrictive measures can be imposed on an emergency basis.

This policy seeks to encourage the development of fisheries which may take coral incidentally, such as trawling for finfish; gaining new information on coral resources from such incidental taking; and discouraging uncontrolled coral harvesting under the guise of incidental catches.

F. Refugia

With respect to Refugia or preserves, that is, beds which would be closed for some period of time to exploitation, the options considered were whether provision should be made for such preserves, and if so, which areas, if any, should be so designated at this time. It is recommended that one Refuge be established immediately. The reasons for establishing Refugia are: (1) to preserve coral beds as natural areas for purposes of research: (2) to establish control areas that could be used in the future to measure environmental impacts of coral harvesting; and (3) to establish possible reproductive reserves for enhancement of recruitment into adjacent areas. WesPac Bed, between Nihoa and Necker Islands (Lat. 23° 18.0'N, Long. 162° 35.0'W), is recommended for designation as the first such refuge because of its central location within the Hawaiian Archipelago, which favors recruitment into adjacent areas. No commercial or exploratory harvest of precious coral is permitted in Refuge areas. However, other types of fishing will be allowed subject to restrictions on incidental catch of corals (Section IV.F.1.E.).

G. Season

Seasons were also considered. The recommendation is against setting any seasonal restrictions. This decision rests on the observation that there is little biological basis for establishing a closed

season, other than to reduce fishing effort. Natural mortality rates are relatively low for pink corals and are probably also low for gold and bamboo coral as judged by their longevity. Therefore it matters little in terms of the reproductive potential of a colony whether it is harvested before, during or after the reproductive season. The reproductive season for pink coral in Hawaii is June and July (Grigg, 1976). Because reproduction is iteroparous (year after year), the impact of removing a colony in June of any given year is essentially the same as removing that colony in any other month. Hence if summer months were closed to the fishery, and the annual harvest did not change, the benefit would be insignificant. By contrast, an adverse effect could occur if the safest and most accessible months (due to weather) were not open. Summer closure could pose a hardship on the industry and discourage exploration.

H. Limited Entry

Limited entry was considered but is not recommended. There is no sign at the present time that the fishery is being overfished due to excess capital investment or to the open acess nature of the resource. In the precious coral fishery in the western Pacific, the need to increase information concerning the resource would favor entry (increased effort) so long as this did not decrease the present value of the fishery.

I. Permits and Conditions

A requirement for permits, and the conditions under which required, were considered. The Council is in favor of permits, to include all conditions covered in provisions A-H as well as extensive reporting requirements.

Information is to be documented in daily log books and be provided to the appropriate representative of the Secretary of Commerce.

Permits are to be area specific with reference to Established Beds, Conditional Beds or Exploratory Areas (see next section for definitions). The duration of the permits is also area specific.

Further details concerning permits and other management measures are contained in the next section of the plan.

IV. F.2. Proposed Specific Conservation and Management Measures

The following are recommended management measures under which permits to harvest and possess precious corals and associated non-precious corals for domestic fishermen are to be granded:

Limitation of Permit

Not more than one permit shall be issued to any one person. No permit shall be valid on more than one vessel. Permits shall not be assigned or transferred from person to person nor from vessel to vessel .

Duration of Permit

Permits shall be effective from July 1st* through June 30th* or, if issued after the beginning of such term, for the remainder thereof.

Permit Areas

A permit will be required for the harvest of precious corals, including the species *Corallium secundum, Gerardia sp.* and *Lepidisis olapa*,

*The selection of a July 1 date for the beginning of the term for permits was made in order that the terms for Federal permits coincide with State permits.

and for nonprecious corals taken with precious corals, in any or all Western Pacific Regional Fishery Management Council (FCZ) permit areas described below.

For the purposes of this plan there are three designated permit area categories. These are:

I. ESTABLISHED BEDS (E-B) shall include only coral beds having a history of harvest and those sufficiently documented to the extent that an optimum yield quota consistent with the provisions of the FCMA of 1976 has been established.

Makapuu (Oahu) E-B-1 Permit Area shall include the waters enclosed by the lined area delineated in Figure 5.

II. CONDITIONAL BEDS (C-B) shall include known coral beds for which optimum yield quotas are derived through size relationships to the Makapuu Bed. Estimates of areas of Conditional Beds are based on data accumulated from over 200 dredge haul stations and 33 submersible dives in Star II throughout the Hawaiian Islands.

Ke-ahole Point (Hawaii), C-B-1 Permit Area, shall include the waters within a 0.24 km^2 area around a midpoint of Lat. 19° 46.0'N, Long. 156° 06.0'W.

Kaena Point (Oahu), C-B-2 Permit Area shall include the waters within a 0.24 km^2 area around a midpoint of Lat. 21° 35.4' N, Long. 158° 22.9'W.

Brooks Banks, C-B-3 Permit Area, shall include the waters within a 1.6 km^2 area around a midpoint of Lat. 24°06.0'N, Long. 166° 48.0'W.

180 Fathom Bank (northwest of Kure), C-B-4 Permit Area, shall include the waters within a 0.8 km^2 area around a midpoint of Lat. 28° 50.2'N, Long. 178° 53.4'W.

III. REFUGIA

Wespac Bed, _____, R-1 Permit Area, shall include the waters within a 0.8 km^2 area around a midpoint of Lat. 23° 18.0'N, Long. 162° 35.0'W.

IV. Exploratory Permit Areas (X-P) Area shall include all beds, other than Established and Conditional Beds and Refugia in each of five areas: Hawaii, American Samoa and Guam, the Northern Marianas and the combined FCZ's around all other U.S. islands in the central and western Pacific. These may be designated X-P-H, X-P-AS, X-P-G, X-P-NM and X-P-I. A new bed located by exploratory fishing will become a Conditional Bed when sufficient data have been collected to estimate size and yield from the bed.

Season and Quotas

(1) The coral harvesting season shall open July 1 in all permit areas.

(2) Closing Date Makapuu, E-B-1, Permit Area. The coral harvesting season in Makapuu E-B Permit Area will be a 2-year period extending from July 1 of the first year through June 30 of the second year. The season shall be closed prior to June 30 of the second year by the Regional Director, NMFS if it is estimated that the season catch in Permit Areas in E-B-1 will have reached 2,000 kg of pink coral, 600 kg of gold coral, and 500 kg of bamboo coral prior to June 30. All live coral harvested will be retained by the permittee and shall be counted against the Quota.

(3) Closing date C-B-1-4 Permit Areas. Coral harvesting in Permit Areas C-B-1 through 4, shall be for one-year periods extending from July 1 through June 30. The season shall be closed prior to June 30 by the Regional Director if it is estimated that the season catch for C-B-1-4 Permit Areas will have filled the one-year quota prior to June 30. One-year quotas for dredging can be computed on the basis of the following formulas.

(i) $\frac{\text{Area of C-B-1-4 Beds}}{\text{Area of Makapuu Bed}} \times 200 \text{ kg} =$ 1-year conditional quota for pink coral

(ii) $\frac{\text{Area of C-B-1-4 Beds}}{\text{Area of Makapuu Bed}} \times 60 \text{ kg} =$ 1-year conditional quota for gold coral

(iii) $\frac{\text{Area of C-B-1-4 Beds}}{\text{Area of Makapuu Bed}} \times 50 \text{ kg} =$ 1-year conditional quota for bamboo coral

Permit Areas C-B-1-4 shall be closed to further non-selective harvesting of all species of coral whenever the OY of one species has been attained. This measure is to prevent overharvesting of the first species that could occur by way of non-selective harvest of other species.

(4) Closing date Exploratory Permit (XP) Areas. Exploratory Permit (XP) Area season shall be a one-year period extending from July 1 through June 30. Announcement of closing dates by the Regional Director in each permit area will be made not less than forty-eight (48) hours in advance of a closing date, except that if the closing date is to be June 30 there need be no announcement. Each Exploratory Permit Area will be closed to foreign fishing when the total foreign harvest of pink, gold and bamboo coral in the Area reaches 500 kg and to domestic fishing when the total harvest of the three species reaches 1,000 kg.

Gear Limitations

The use of selective harvesting methods shall be encouraged in all permit areas.

(1) In all permit areas where selective harvesting is current practice and an optimum yield has been determined, dredging techniques are prohibited.

(2) Coral dredging is prohibited in all portions of the FCZ seaward of the main Hawaiian Islands, i.e. south and east of a line midway between Niihau and Nihoa Islands.

(3) Coral dredging will be allowed in all other permit areas under specified conditions. If coral tangle dredges are to be employed, the weight quota is to be 20% of that allowed using selective methods.

Identification of Vessel

Each vessel operating under the provisions of this plan shall carry on an exposed part of the superstructure of the vessel the number of the owner's permit in fourteen-inch (14-in.) black numbers on a white background. The permittee shall keep the number clearly legible in good repair, and insure that no part of the vessel, its rigging or its fishing gear obstructs the view of the number from an enforcement vessel or aircraft.

Records

Each permittee shall keep an accurate record of his coral harvesting operations in a log book furnished by NMFS. All information requested shall be given completely and accurately.

Whenever a permittee makes a sale or delivers coral harvested under a permit, the permittee shall within 72 hours of landing mail to Regional Director, NMFS, a copy of the NMFS log with complete harvest information for the corals

sold or delivered including:

1) area fished
2) depth of water
3) weight of coral harvested by species (landed weight, air dried for at least 24 hours)
4) fishing effort (days or hours) and dates of harvest
5) method of harvest
6) observations about the habitat (current, bottom type, bottom topography, bottom slope, proximity to land, etc.)
7) sales of precious coral including the amount by species, value, date of sale and name(s) of buyer(s), and
8) other data as specified in the permit or regulations.

Size Limitation

Makapuu Bed (E-B-1), Ke-ahole Point (C-B-1) and Kaena Point (C-B-2) Permit Areas. Any pink coral harvested from these Beds shall be from colonies of at least 10 inches in height.

All other Permit Areas. There are no size limits established.

Incidental Harvest

All domestic and foreign fishermen shall keep accurate records of all precious coral harvested incidentally. Records shall include but not be limited to: gear type and size, species harvested, landed weight, location and depth. Records shall be submitted to the NMFS on a basis specified by NMFS. Non-retention is an added requirement for both domestic and foreign fishermen.

Observers

A permittee may be required to carry a NMFS observer, particularly for fishing in exploratory areas.

Permit Cancellation

Permits shall be subject to suspension or revocation as specified by regulation.

IV.G. Enforcement

Enforcement activities will include aircraft and surface patrols and dockside inspections, and observers may be placed on foreign and domestic vessels. The NMFS estimate of requirements to achieve 95% compliance and 100% off-load inspection levels include over 1100 hours per year of aerial patrols (multi-purpose, including seamount fishery and billfish fishery) and 200 days per year of surface patrols (also multi-purpose) for the FCZ seaward of the Hawaiian Islands; 168 hours of aerial and 96 days of surface patrols off Guam and the Northern Mariana Islands; 144 hours of aerial and 48 days of surface patrols around American Samoa; and aerial and surface patrols as resources permit off U.S. Possessions. Total fishery enforcement, of which an unspecified percentage would be attributable to corals, are estimated at ten (10) agents and $275,000 for NMFS. To the extent possible, NMFS and the Coast Guard will coordinate with State enforcement authorities to prevent duplication of effort.

IV.H. Administrative Costs

It is not possible to predict with any certainty the cost of observer coverage. Foreign vessels pay the cost of U.S. observer placements, thus, there is no net cost to the U.S. Government, although

NMFS would pay the immediate costs. There has been no expression of foreign interest in fishing for corals in the FCZ; however, for the purposes of considering management costs, it is estimated that observer placement entails an estimated $2,000 per observer per month, whether on a domestic or foreign vessel.

Data collection would involve little cost, given the low level of participation in the fishery. Preparation and distribution of logbooks would cost not more than $1000, and compilation and analysis of the data probably would not cost more than $1000, per year, per area. The "cost" of recording and submitting data would be negligible. The permit system also would be easy to administer since participation is so limited. The cost would not be large enough to warrant an administrative fee. Total administrative costs are estimated to be not more than $25,000 per year as the fishery is now constituted.

IV.1. Relationship to Existing Laws

Implementation of this FMP replaces the Department of Interior's (Bureau of Land Management) regulations regarding the areas covered in ths FMP. DOI regulations for all other areas not covered by this FMP remain in effect. The regulations of the Department of Interior are described in Appendix III and below. DOI permits may be suspended or revoked if the permittee fails to comply with any of the provisions of the permit. The permittee must be bonded and pay $25.00, a non-refundable permit filing fee. In the case of commercial harvesters a fee or royalty will be assessed based upon the fair market

value of the coral. Violation of the regulation carries a fine of not more than $2,000 or imprisonment for not more than 6 months or both such fine and imprisonment for each occurrence of the violation.

The State of Hawaii has promulgated regulations for the management of pink and gold coral, which are given in Appendix II. As written, the regulations apply generally to "waters subject to the jurisdiction of the State," but they include provisions, including a catch quota for pink coral, specifically applying to the Makapuu Bed. Questions relating to State jurisdiction over that bed are beyond the scope of this Fishery Management Plan. The pink coral quota for the Makapuu Bed in the State regulations, 4,400 pounds for 2 years, is consistent with the quota defined in this Plan, except that the State specifies that this is to be wet weight of live and dead coral. The State's minimum size limit of 10 inches in colony height is also consistent with that of this FMP, except that observance of the State's limit is made voluntary. Potential conflicts between the State's regulations and the measures prescribed in this Plan will depend largely on how the extent of the State's jurisdiction may be interpreted in the future.

Local jurisdictions in the other areas covered by this Plan do not have any laws or regulations specifically for the management of coral resources or coral fisheries of the species covered by this Plan.

A determination of consistency of this plan with the CZM plan for the State of Hawaii is given in Section V.B.

There are no Indian treaty or native Hawaiian rights or other

types of native claims known to involve the precious coral resources or fisheries that will be managed in accordance with this FMP.

IV.J. Council Review and Amendment of the Plan

A review by the Council is to be conducted annually unless information is brought to the attention of the Council which indicates that emergency actions are needed to protect the resource.

As additional information on number, location, and sizes of coral beds becomes available, and as data on other species of precious coral becomes available, the Council will amend the plan as necessary.

IV.K. Future Research Needs

The Council recognizes and this plan emphasizes, the critical need for research. The most important needs for future research of precious corals in the Pacific Ocean are stock assessment and the collection of economic data. Until the extent and magnitude of the resource are defined, the development of U.S. precious coral fisheries will be hampered. Moreover, stock assessment is the first step in defining Conditional Beds and developing a strategy of management. More specifically, better information on the size of Conditional Beds and rates of growth and mortality of their precious coral populations are needed before they can be upgraded to Established Beds with correspondingly more accurate and precise estimates of MSY. Once this information is available, information regarding stock-recruitment relationships must be obtained before more effective management plans can be developed.

Other important biological research is needed to asses the impact of management decisions on the status of the resources. For example, it will be important to know the impact of harvesting precious coral on recruitment as well as on adult stocks. Records of catch and effort can be used in part to determine if overfishing has occurred. Research is also needed before the impacts of incidental catch by domestic and foreign fishermen can be assessed. Records of incidental catch coupled with television or submersible surveys would be necessary for this. Another important subject for biological research is the impact of harvesting precious corals on other benthic species which occupy the same habitat.

In terms of gear, further research is needed in two areas. First, to better evaluate the efficiency of dredges and secondly to improve methods of selective harvest using submersibles and remote vehicles. For dredges, it is important to know their efficiency so improvements in design can be made and to attain a better idea of the degree to which precious coral is knocked down but not retrieved.

In the area of economics, better data are needed in Hawaii on cost of harvest, ex-vessel value of precious coral, costs of production, total sales of precious coral jewelry produced from local production, and total sales of precious coral jewelry produced from imported coral. In regions of the FCZ other than Hawaii, market studies are needed to assess the potential of precious coral industry considering both local sources of supply and imports.

IV.L. Alternative Exploratory Areas Management Approach

The Council recognizes that its proposed method for defining optimum yield, domestic "reserve" and TALFF for Exploratory Areas constitutes a departure from the conventional approach under the FCMA. Where the "reserve" approach has been used in other plans, it has been used to accommodate the possibility that actual domestic harvest will exceed the estimated expected harvest. The reserve has been subject to release for foreign fishing if domestic catches are at or below estimated levels. The permanent, unallocable corals reserve is different in that it gurantees that a particular amount will be kept available for domestic exploratory fishing. It is believed this is necessary to provide an incentive for domestic investment in vessels, equipment and manpower. Inasmuch as there has been no documented and permitted foreign coral fishing in the FCZ and the plan would allow exploratory fishing by foreign vessels for the first time, the permanent reserve appears reasonable and equitable, and is believed to be consistent with the spirit and the letter of the FCMA.

Nonetheless, the Council appreciates that this would be a precedent-setting decision and that approval is not assured. The Council proposes therefore a second-best approach to govern domestic and foreign harvests in Exploratory Areas, as follows, if the unallocable reserve approach is disapproved:

1. Domestic vessels would be permitted to engage in test fisheries, with a limit of 500 kg. per year, all species combined, per Exploratory Area. Such test fishing would be under permits granted by the Regional Director in consultation with the Western Pacific Council

and State agencies. The Regional Director may allow dredging in Exploratory Areas, provided no dredging is permitted in the "major" Hawaiian Islands (south and east of a line midway between Niihau and Nihoa Islands).

2. Foreign vessels will be permitted to take up to 500 kg. per year, all species combined, per Exploratory Area under a scientific research plan approved by the Southwest Fisheries Center, NMFS, in consultation with the Council and State agencies. This is consistent with present NMFS policies and procedures.

V. ENVIRONMENTAL IMPACTS

V.A. Relation to National Standards

The management measures proposed herein are fully consistent with the national standards as outlined in P.L. 94-265. In brief, the management plan is designed to achieve optimum yields from each fishery; the plan is based on the best scientific information available; stocks are managed on the basis of a unit (individual beds); the plan does not discriminate between residents of different States; the plan promotes efficient utilization of the resource, the plan accounts for variation in the resource;and it is designed to minimize management costs.

V.B. Relationship of the Proposed Action to OCS and CZM

With regard to the OCS, manganese crusts and precious corals are known to co-occur at depths of 1,200 to 2,000 feet in some areas in the Hawaiian Archipelago such as the Wahoo Shelf off Oahu and the bank immediately to the southeast of French Frigate Shoals. Mining of manganese crusts could directly damage precious corals by

the effects of silt and sediments. The potential of such specific impacts have not been determined, although an assessment of the environmental impact of mining for manganese nodules in the Pacific, in general, has been completed by the Environmental Research Laboratory of NOAA (Hirota, unpublished manuscript).

The Coastal Zone Management Act (CZMA) of 1972 encourages states to establish policies and programs for the conservation of coastal resources balanced by the needs of economic development. Conservation and the rational use of living resources in the offshore coastal zone (territorial sea) are among the objectives of the National CZMA. Promotion of domestic fisheries, the development of unutilized or underutilized fishery stocks, and fisheries management according to sound conservation principles are the major objectives of the FCMA. While the geographic area of management authority and application differs under each statute, the CZMA and the FCMA embody unanimity of objectives with regard to transboundary fishery resources.

An approved CZM program has been in effect in Hawaii since 1978. State CZM policies directly relating and pertaining to the proposed action are contained in the coastal ecosystems and economic use resources categories of the Hawaii CZM statute (Act 188 of 1977, Chapter 205A, HRS, as amended). They are as follows: (1) improve the technical basis for natural resource management, (2) preserve valuable coastal (offshore) ecosystems of significant biological or economic importance, and (3) minimize adverse environmental effects from economic uses of coastal zone resources. These CZM policies are fully consistent with the objectives of this Plan and with the selected

management measures for precious corals which are: (1) to allow harvesting of precious corals in known beds and to encourage the exploration and discovery of new beds but subject to limitations to prevent overfishing, (2) to encourage the use of selective harvesting methods and also to prevent the wastage of resources by allowing dredging in those areas where large distances would make selective harvesting economically infeasible, (3) to minimize the harvest of immature colonies that have not reached their full potential for growth, (4) to provide for the establishment of refugia, and (5) to encourage the development of new information on the distribution, abundance, and ecology of precious corals so as to improve the technical basis for management. As with the Hawaii CZM program which has been established to balance the needs of economic development with the long-term conservation of coastal resources, the proposed action provides a combination of measures designed to maximize opportunities from the harvest of precious corals while minimizing the biological risks involved. The relationship of the proposed action to coastal zone management planning in Guam, American Samoa, and the Northern Mariana Islands cannot be determined at this time because CZM plans have not been completed and approved for these areas.

The Hawaii offshore CZM Program area extends from the shoreline to the seaward limit of the State's jurisdiction. While the offshore coastal zone is defined for National CZM Program purposes as not extending beyond the territorial sea of the United States, the State of Hawaii does not relinquish or in any way waive its rights, authority, or claims, present and future, over those waters within the State's

jurisdiction that exist outside the conventional 3-mile seaward boundary of the territorial sea.* Section 6 of Article IX of the State of Hawaii Constitution expressly provides: "The State shall have the power to manage and control the marine, seabed and other resources located within the boundaries of the State, including the archipelagic waters of the State, and reserves to itself all such rights outside state boundaries not specifically limited by federal or international law" (emphasis supplied). As such, the degree of State sovereignty over the management of precious corals of the Hawaiian Archipelago is dependent on a legal determination on the actual geographic extent of the State's offshore boundaries including archipelagic waters. Jurisdiction over the interisland waters and resources remains an unsettled question between the State of Hawaii and the Federal Government. The resolution of this issue is beyond the scope of this Fishery Management Plan.

Other coastal zone plans for other areas covered by this plan have not been completed at this date (July 1979).

V.C. Biological Impacts of Domestic Fishing

The management plan is based on the national standards and should not result in unacceptable biological impacts to populations of precious coral. The recommended management measures result in only

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*U.S. DOC, Office of Coastal Zone Management, *State of Hawaii Coastal Zone Management Program and Final Environmental Impact State,* 1978.

about 2% removal of precious coral populations in any harvesting period. However, the proposed regulations are based on an analysis in which natural mortality, recruitment and growth are assumed to be constant. To the extent that these parameters vary from year to year, it may be necessary to revise management measures. Also caution should be exercised because of the sampling errors inherent in the data on which the analysis is based. If significant changes in the population dynamics of any species of precious coral considered here were to occur in the future, management plans should be revised accordingly.

Biological impacts of harvesting precious corals on <u>other</u> species which occupy the same habitat can be expected to be similar to or less than the biological impacts of harvesting precious corals themselves. Even if a two year quota of pink coral were taken in one year, only about 4% of the standing crop of pink coral would be affected. For species which live on, in or around pink corals a similar impact would be expected. Similarly, other benthic species that may be damaged by non-selective methods should not suffer a proportionately greater impact than target species of precious coral. Indeed, many species of gorgonian corals have flexible skeletons and do not break as easily as pink or bamboo coral (both have calcareous skeletons) and therefore should be impacted proportionately less than calcareous precious corals. While many species of fish occur on or near the bottom in the depth zone of precious corals, none are known to depend directly or indirectly on precious corals for food or habitat space.

It is noted that there is risk in extrapolating pink coral

characteristics to other species, but this appears to be minimal and the error can be in either direction. There also is a risk of overfishing by allowing dredging. The quotas however appear to be sufficiently low that this risk is low.

Consideration has been given to the possibility of any impact of the precious coral fisheries covered by this Plan and the recommended management measures on marine mammals or endangered species. It is concluded that because of the characteristics of the precious coral habitat and the fishing techniques used to harvest precious corals there is little or no possibility of any such impact. A biological opinion from NMFS confirms this conclusion (Appendix 4). Access to the Hawaiian Islands National Wildlife Refuge is restricted and this plan should have minimal effect on those islands.

V.D. Impacts to Industry

If the Hawaii precious coral industry is to survive and prosper, it should have access to a reliable and controllable supply of raw material. The Makapuu Bed is a small fraction of the total area thought to be potentially commercially productive in the Hawaiian Archipelago. Thus an increased supply appears to be locally available which may decrease the need for some imports. With rising tourist expenditures and growth in personal income of the residents of Hawaii, expansion in the local market can be expected (Poh, 1971). In addition there is the potential of developing a larger mainland market. The potential for growth in these markets may not be realized unless imports combined with local supplies keep pace with demand.

Hence it is important for the industry to establish new sources of supply in U.S. waters to ensure a steady and reliable domestic supply of raw material.

The proposed action may slightly reduce the past annual harvesting rates for pink and gold coral. This is an unavoidable constraint imposed by the limited nature of the resource. Management measures have been proposed which take into account the economics of the industry and are designed to increase benefits to the nation. The proposed action should cause no loss in jobs, and while total production may be slightly reduced, this is considered to be favorable to the long term interest of producers and consumers.

V.E. Alternatives to the Proposed Plan

For each management measure recommended, several options were considered. These have been thoroughly discussed in Sections IV.F.1 and IV.F.2

Other conceivable alternatives listed below were not given serious consideration for the following reasons:

1. To rely on the Preliminary Management Plan indefinitely -- As noted earlier, the draft PMP for precious corals has not been implemented. Even if it were, it would provide no control over domestic fishing, nor would it provide any opportunity for foreign fishermen to develop new exploratory beds and thereby furnish much needed information on coral resources of the FCZ, as it would establish a zero TALFF. Also, failure to implement an FMP would be contrary to the intent of the FCMA.

2. To leave management of precious coral resources in the region to the State of Hawaii, which has a management regulation in place, and the Territorial Governments -- The legal basis for the local governments to regulate coral fisheries which are carried on in the FCZ, if the coral is not landed in the State, is questionable, especially with regard to foreign fishermen, and the states appear to lack the capability to enforce any regulations with respect to coral beds at any distance from their shores.

3. To allow the Bureau of Land Management to continue to regulate coral fishing on the Outer Continental Shelf -- The BLM regulations (see Appendix III) do not constitute a fishery management regime which would meet the requirements of the FCMA, which gives priority to the Department of Commerce in this field. This fact is also recognized in the draft Memorandum of Understanding between the Departments of Commerce and Interior on the subject of coral fishery management.

V.F. Impacts on Foreign Fishing

The proposed action may partially displace foreign precious coral harvesters from areas near Midway, Wake, Guam and the Commonwealth of the Northern Mariana Islands. The proposed plan allows foreign vessels to harvest under permit up to 500 kg of pink, gold, bamboo and other precious corals combined in exploratory areas in Hawaii, Samoa, Guam and the Northern Marianas and to incidentally harvest but not to retain precious corals incidentally harvested in other fishery operations in the United States FCZ. It therefore provides for reasonable foreign use of U.S. fish stocks having a harvestable surplus

as long as such use does not conflict unduly with the development of the U.S. precious coral industry and with long-term conservation requirements.

V.G. Adverse Impacts of Foreign Fishing

Certain kinds of foreign fishing, such as bottom trawling, will kill or harvest precious corals incidentally in certain areas. To the extent that such fishing operations are permitted and take place, a small reduction in the amount of precious coral available to U.S. harvesters will occur. Further, because most trawling operations are not efficient in capturing or recovering colonies dislodged from the bottom, there will be some wastage of the resource. Recovery of previously damaged beds may be delayed. However, the policies set by the PMP for the Seamount Groundfish Fisheries limit trawling by foreign vessels to a small portion of the FCZ where precious corals may occur, and damage (if any) would be restricted to a very small area.

V.H. Relationship Between Local Short-term Use of Man's Environment and the Maintenance and Enhancement of Long-term Productivity

The proposed action provides for full commercial harvest of precious coral stocks only after they have been assessed and optimum yields have been estimated. Limited harvest is allowed so new beds may be located, and once located, may be studied to determine area of bed, abundance of corals and other critical factors. Thus precious corals are protected from negligent, wasteful over-exploitation which might lead to short-term economic gains for domestic fishermen but to long-term shortages and economic losses for U.S. industry.

V.I. Irreversible and Irretrievable Commitments of Resources Involved in the Proposed Action Should It Be Implemented

If the resource is inadvertently overexploited, commercial harvest would almost certainly cease for economic reasons before any coral species approached biological extinction. The major change in the population dynamics of precious corals that can be expected to occur as a result of harvesting is a non-irreversible shift in age structure toward younger age classes. Mean age would be somewhat reduced, but natural mortality might decrease as a consequence of pre-emption, and growth and recruitment might increase in response to reduced competition.

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VII GLOSSARY

BLM-DOI	Bureau of Land Management, U.S. Department of Interior
CZM	Coastal Zone Management
DFG	Division of Fish and Game, State of Hawaii
DOC	U.S. Department of Commerce
Domestic Fishing Capacity	Annual production capacity of domestic fishing firms
Domestic Processing Capacity	Annual production capacity of domestic processing firms
EIS	Environmental Impact Statement
Expected Harvest level	Anticipated annual harvest by domestic fishing firms
Expected Processing Level	Anticipated annual production of domestic harvesting firms
FCMA	Fishery Conservation and Management Act
FCZ	Fishery Conservation Zone
Fixed capital costs	Cost of depreciable equipment
FMP	Fishery management plan
MSY	Maximum sustained yield
Net present value	Future net income stream discounted to the present
NMFS	National Marine Fishery Service
OCS	Outer continental shelf
OY	Optimum yield
PMP	Preliminary fishery management plan
TALFF	Total allowable level of foreign fishing
WPRFMC	Western Pacific Regional Fisheries Management Council

Appendix I

Economic Analysis of Harvest Quotas and Optimum Yield

Bioeconomic models are developed to evaluate the economic efficiency of several harvest quotas under different assumptions of price changes and alternative uses for fixed factors of production. The net present value[1] under each quota is estimated for four different models. The results indicate that the net present value of pink and gold coral in the Makapuu Bed is greatest when pulse-fished, if there exist alternative uses for the fixed factors of production. If during the off years the fixed factors cannot be used in other operations, then it makes little difference if the bed is fished continuously or periodically. Different assumptions about price changes alter the results slightly.

The important assumptions of the models are: prices are determined exogenously (due to import supplies); marginal cost is constant for different levels of production; the change in average variable cost is inversely proportional to the change in the exploitable biomass from one year to the next, i.e. if the exploitable biomass declines so does catch/effort; pink and gold coral are multiple products

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[1] Net present value (NPV) $= \sum_{i=o}^{n} \frac{(R_i - C_i)}{(1 + D)^i}$ where: R_i = total revenue during i^{th} period; C_i = total cost during i^{th} period; D = discount rate

Appendix I

harvested in fixed proportions; and the full quota is harvested during the year (the first year in the case of the multiple-year quotas) unless the exploitable biomass falls below the quota.

Four models are evaluated over a 37-year time horizon beginning with 1978. (Shorter time horizons were considered but the qualitative results are almost identical). In the first model the imputed values, or estimated prices of pink and gold raw coral are constant over the 37-year production period and the firms incur fixed costs during periods of zero production. In the second model, prices increase at a constant rate. In the third and fourth models prices are constant and increase, respectively, but the firms do not incur fixed costs during years of zero production. In the last two models, it is assumed that there are alternative uses for the fixed factors of production. The alternative uses may include exploration and harvest of other coral beds or activities unrelated to a coral fishery.

In each model, five alternative harvest quotas for pink coral are evaluated: (1) 1,000 kg/year, (2) 2,000 kg/year, (3) 3,000 kg/year, (4) 2,000 kg/2 years, (5) 3,000 kg/3 years. Due to the assumption of fixed proportions output, a quota on pink coral implies a quota for gold coral. The quotas for gold coral are: (1) 370 kg/year, (2) 740 kg/year, (3) 1,100 kg/year, (4) 740 kg/2 years, (5) 1,100 kg/3 years.[1/] The first values tested for both pink and gold coral (1,000 kg/year and 370 kg/year) correspond to estimates of MSY for each. Subsequent values are various multiples of these values.

1/ These values do not correspond exactly to MSY or multiples of MSY for gold coral because in this analysis figures were rounded upward instead of downward as was done for MSY.

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The differentials of the discounted revenues and discounted costs (net revenue) are summed over all production years to obtain the net present value of the quota alternatives for each model. The absolute amount of the net present values is not the prime concern in this analysis. Rather, the relative outcome of the values allows some conclusions to be drawn about the economic efficiency of different quota proposals--the economic efficiency of a quota proposal being greater if the net present value is greater.

In all the models in which the quotas exceed a mean annual harvest of 1,000 kg, for pink coral the outcome is economically inefficient. This results in the long run because the harvest is not sustainable. In the short run, when the harvest is sustainable, the above outcome is due primarily to accelerating costs caused by a rapid decline in the exploitable biomass.

For the other pink coral quota alternatives (1,000 kg/year, 2,000 kg/2 years, 3,000 kg/3 years) economic efficiency varies due to changes in price and the ability to defray fixed costs. When price increases 6 percent annually relative to costs, a quota of 3,000 kg/3 years is more efficient whether fixed costs can be defrayed or not. In the case of incurring fixed costs during zero-harvest years, the annual rate increase in prices shifts the most efficient quota from 1,000 kg/year to 3,000 kg/3 years. When costs can be defrayed the most efficient quota shifts from 2,000 kg/2 years to 3,000 kg/3 years due to the price increases. These shifts can be explained by the exponential increase in the

Appendix I

prices and the assumption that a 2000 kg or 3000 kg quota is harvested in the first year of the 2 or 3 year quota period. When the harvest in some years can be taken one or two years earlier the entire flow of net revenues is shifted closer to the present and, therefore becomes more valuable due to a positive rate of time preference. This impact of pulse fishing only results in the models when prices increase each year.

The impact of defraying the fixed cost when pulse fishing is negligible for the two models with increasing prices. The most efficient allocation is 3000 kg/3 years whether or not there exist alternative uses for the fixed factors of production. When prices are held constant, the ability of firms to explore and harvest other coral beds shifts the most efficient quota from 1000 kg/year to 2000 kg/2 years. This results in the models when the average total cost of harvesting coral at the Makapuu Bed decreases by employing the fixed factors of production elsewhere and defraying the cost of those factors.

Considering the characteristics of the coral harvesting firms in Hawaii and the history of the world coral market, pulse fishing the Makapuu Bed is more efficient for the existing firms. Whether or not pulse fishing at 3000 kg/3 years is overall more efficient than 2000 kg/2 years, as indicated in the models, must depend on the existence of other firms wanting to enter the fishery.

APPENDIX II

State of Hawaii
Department of Land and Natural Resources
Honolulu

DIVISION OF FISH AND GAME

* * * * * * * * * * *

The Board of Land and Natural Resources in conformity with Chapters 187 through 190, Hawaii Revised Statutes and every other law hereunto enabling does hereby adopt the following regulation relating to the management of pink coral and gold coral.

REGULATION 41. RELATING TO THE MANAGEMENT OF PINK CORAL AND GOLD CORAL.

SECTION 1. Definitions (as used herein).

a. Pink coral means all species of coral belonging to the genus Corallium in their raw state.

b. Gold coral means all species of coral belonging to the genus Parazoanthus in their raw state (= Gerardia).

SECTION 2. Prohibition.

It shall be unlawful to take or destroy pink coral or gold coral in waters subject to the jurisdiction of the State of Hawaii, or to possess, sell or offer to sell such corals within the State of Hawaii, except as provided in this regulation.

SECTION 3. Permits

It shall be lawful with a permit issued by the Board of Land and Natural Resources under such terms and conditions as it deems necessary to:

a. take or possess pink coral or gold coral for scientific or educational purposes.

b. take or possess pink coral or gold coral for commercial or domestic purposes from the Makapuu Bed provided that the taking of pink coral (Corallium secundum) shall be subject to the provisions stipulated in Section 5, relating to the management of the Makapuu Bed pink coral resources, and provided further that such taking for commercial purposes shall be subject to the commercial fishing license requirement of Section 189-2, Hawaii Revised Statutes.

Appendix II

SECTION 4. Cancellation of Permits.

The Board of Land and Natural Resources may cancel any permit issued pursuant to this regulation for any infraction of the terms and conditions of the permit as determined by the Board.

SECTION 5. Management of the Makapuu Bed (located approximately 6 miles East of Makapuu Point, Oahu) Pink Coral (Corallium secundum) Resources.

A two-year quota of 4,400 pounds dry weight is hereby established for the taking of live and dead Corallium secundum at the Makapuu Bed beginning July 1, 1977, provided that the quota shall be for the combined harvest of all permittees, and provided further that harvesters shall make every effort to collect only mature colonies ten (10) inches or larger in height.

SECTION 6. Prohibited Methods of Coral Harvesting.

It shall be unlawful to use nets, dredges, trawls, mops, explosives or any other destructive or non-selective means to take pink coral or gold coral within waters subject to the jurisdiction of the State of Hawaii.

SECTION 7. Landing of Pink Coral and Gold Coral.

All pink coral and gold coral taken:

a. in waters subject to the jurisdiction of the State of Hawaii for any purpose shall be landed in the State.

b. in waters outside of the jurisdiction of the State of Hawaii and landed in the State shall be subject to this regulation and all other applicable State laws and regulations.

SECTION 8. Possession and Sale of Pink Coral and Gold Coral Legally Obtained.

Nothing in this regulation shall be construed as making it unlawful for any person to possess or sell pink coral or gold coral obtained prior to the effective date of this regulation.

SECTION 9. Authority to Suspend the Taking of Pink Coral and/or Gold Coral.

The Division of Fish and Game shall have the authority to order an immediate suspension on the taking of all pink

Appendix II

coral and/or gold coral from the Makapuu Bed when deemed necessary for the management of these coral resources on a sustainable yield basis.

SECTION 10. Penalty.

Any person who violates any of the provisions of this regulation or whoever violates the terms and conditions of any permit issued as provided for in this regulation shall be fined not more than $500.00.

SECTION 11. Severability.

Should any section, subsection, sentence, clause, or phrase of this regulation be for any reason held by a court of competent jurisdiction to be invalid, such decision shall not affect the validity of the remaining portions of this regulation.

Adopted this 27th day of May, 1977 by the Board of Land and Natural Resources.

/s/ Moses W. Kealoha
Member
Board of Land and Natural Resources

/s/ Shinichi Nakagawa
Member
Board of Land and Natural Resources

Approved this 13th day of

September, 1977.

/s/ George R. Ariyoshi
Governor of Hawaii

APPROVED AS TO FORM:

/s/ Susan Y. M. Chock
Deputy Attorney General

Date: June 23, 1977

Appendix II

PUBLICATION OF
NOTICE OF PUBLIC HEARING

Honolulu Star Bulletin/Advertiser - January 16, 1977

C E R T I F I C A T E

I hereby certify that the foregoing copy of Regulation 41, Division of Fish and Game, Department of Land and Natural Resources, is a full, true, and correct copy of the original which is on file in the office of the Division of Fish and Game of the Department of Land and Natural Resources.

/s/ William Y. Thompson
Chairman and Member
Board of Land and Natural Resources

APPENDIX III

Regulations of the Department of Interior for the Taking of Precious Coral in Federal Waters

Permits.

Requirement for a permit.

No person shall engage in any operation which directly causes damage or injury to a viable coral community that is located on the Outer Continental Shelf without having obtained a permit for said operations.

Application for a permit.

(a) Application for a permit shall be filed in the proper office of the Bureau.

(b) No specific form is required.

(c) Each application shall include:

1. The name, legal mailing address and telephone number of each person intending to participate in the operations covered by the application.

2. A description of the proposed area of the operations.

3. A map or maps, such as a National Ocean Survey Map, with a scale of not less than 1:30,000 delineating the proposed area of operations.

4. Information in detail describing the nature of the proposed operations and how the operation will be conducted.

5. If coral specimens are to be taken, the purpose of such taking, the method of taking, the currents and their velocity in the area of taking, the depth of taking, the size, estimated dry weight, and type of coral to be taken, and the estimated fair market value of the coral to be taken.

6. The approximate dates of commencement and termination of the operation.

Appendix III

7. An affirmative statement that the operation will use methods that are designed to do minimum harm and disturbance to the viable coral community covered by a permit and those viable coral communities adjacent thereto. Also, an explanation of the procedures that will be taken to assure protection of said viable coral communities during said operation.

Appendix IV

Coral Plan

OCT 5 1978

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
Western Pacific Program Office
P. O. Box 3830
Honolulu, Hawaii 96812

October 4, 1978 FSW1/JJN

TO: Wilvan G. Van Campen, Executive Director, Western Pacific Regional Fishery Management Council

FROM: Doyle E. Gates, Administrator, WPPO, NMFS

SUBJECT: Endangered species consultation concerning the fishery management plan for precious corals in the Western Pacific

This is in reference to your memorandum of September 12, 1978 concerning formal consultation between the Council and NMFS during development of FMP's. If a Federal Agency (in this case the Council) determines that an action may affect endangered or threatened marine species, it should request consultation with NMFS providing the species in question fall under the responsibility of NMFS. Upon receipt of a request for consultation, NMFS will conduct a threshold examination which usually results in a biological opinion as to whether the proposed action is likely to jeopardize the species or destroy or adversely modify its critical habitat.

We realize that you are in the process of finalizing the FMP for precious corals in the Western Pacific. Therefore, utilizing your memorandum of September 12, 1978 as a request for consultation, we offer the following biological opinion on the implication of the precious coral fishery on endangered and threatened marine species.

Endangered marine mammals (humpback whale, sperm whale, and the Hawaiian monk seal) and endangered and threatened sea turtles (leatherback and green turtle) are known for, or suspected of, inhabiting waters overlaying precious coral beds in the central and western Pacific. However, considering the methods utilized for harvesting precious corals, it is our opinion that this fishery does not constitute a threat to these endangered and threatened species or will it destroy or adversely modify their critical habitat.

cc: G. V. Howard

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Washington, D.C. 20235

JAN 16 1979

F6/TRL

1/23/79

Mr. Edwin K. Lee
Administrative Officer
Western Pacific Regional
Fishery Management Council
1164 Bishop Street
Room 1506
Honolulu, Hawaii 96813

Dear Mr. Lee:

This letter is to inform you that I concur with the October 4, 1978, memo (enclosure) to Mr. Wilvan G. Van Campen, Executive Director, from Mr. Doyle Gates, Administrator, Western Pacific Program Office, National Marine Fisheries Service, transmitting the Section 7 consultation regarding the fishery management plan for precious corals in the Western Pacific. The consultation concluded that the coral fishery does not constitute a threat to endangered or threatened species or their habitat.

Please contact my office if you require further clarification.

Sincerely,

for Terry L. Leitzell
Assistant Administrator
for Fisheries

Enclosure

FIGURE CAPTIONS

Figure 1. The southeastern half of the Hawaiian Archipelago showing the extent of the fishery conservation zone and the location of major known beds of precious coral.

Figure 2. The northwestern half of the Hawaiian Archipelago showing the extent of the fishery conservation zone and the location of precious coral beds.

Figure 3. The fishery conservation zone for Guam.

Figure 4. The fishery conservation zone for the islands of Samoa.

Figure 5. The precious coral bed off Makapuu, Oahu.

Figure 6. Catch of precious coral at Taiwan, 1924-1940 (Anon, 1956).

Figure 7. Effort of coral fishing in Taiwan, 1924-1940 (Anon, 1956).

Figure 8. Photo of a coral dredge.

Figure 9. The coral harvesting system on the submersible Star II consists of a wire basket, cutter and hydraulic claw (manipulator).

Figure 10. Size-frequency distribution of precious coral collected with tangle nets (A) and the submersible (B).

Figure 11. Biomass per recruit curves of *C. secundum* using a constant rate of natural mortality (M=0.066) and progressively increasing rates of fishing mortality (F) applied over all year classes. The age of entry into the fishery is zero, i.e. no age limit is applied.

Figure 12. Biomass per recruit curves for a cohort of *C. Secundum* using a constant rate of natural mortality (M=0.066) and progressively increasing rates of fishing mortality (F) applied after a minimum age of 25 years.

Figure 13 Biomass per recruit isopleths for *C. secundum* in the Makapuu Bed, given a constant rate of natural mortality of 0.066. Contour units are in grams per recruit.

Figure 14. Various spawning stock recruitment functions.

Smax = original spawning stock

S = spawning stock after fishing

Rmax = original recruitment

R = recruitment after fishing

Figure 15. MSY as a function of reduced recruitment (curves 2-6) and age at first capture.

Figure 16. Population biomass of *C. secundum* in the Makapuu Bed between 1964 and 1977 and after 1977 given six different exploitation rates in 1978 followed by a complete closure of the bed.

Figure 17. Spawning biomass of *C. secundum* in the Makapuu Bed between 1964 and 1977 and after 1977 given six different exploitation rates in 1978 followed by a complete closure of the bed.

Figure 18. Population biomass of *C. secundum* in the Makapuu Bed between 1964 and 1977 and after 1977 given different rates of exploitation.

Figure 19. Yields of *C. secundum* in the Makapuu Bed between 1964 and 1977 after which different rates of harvest are simulated.

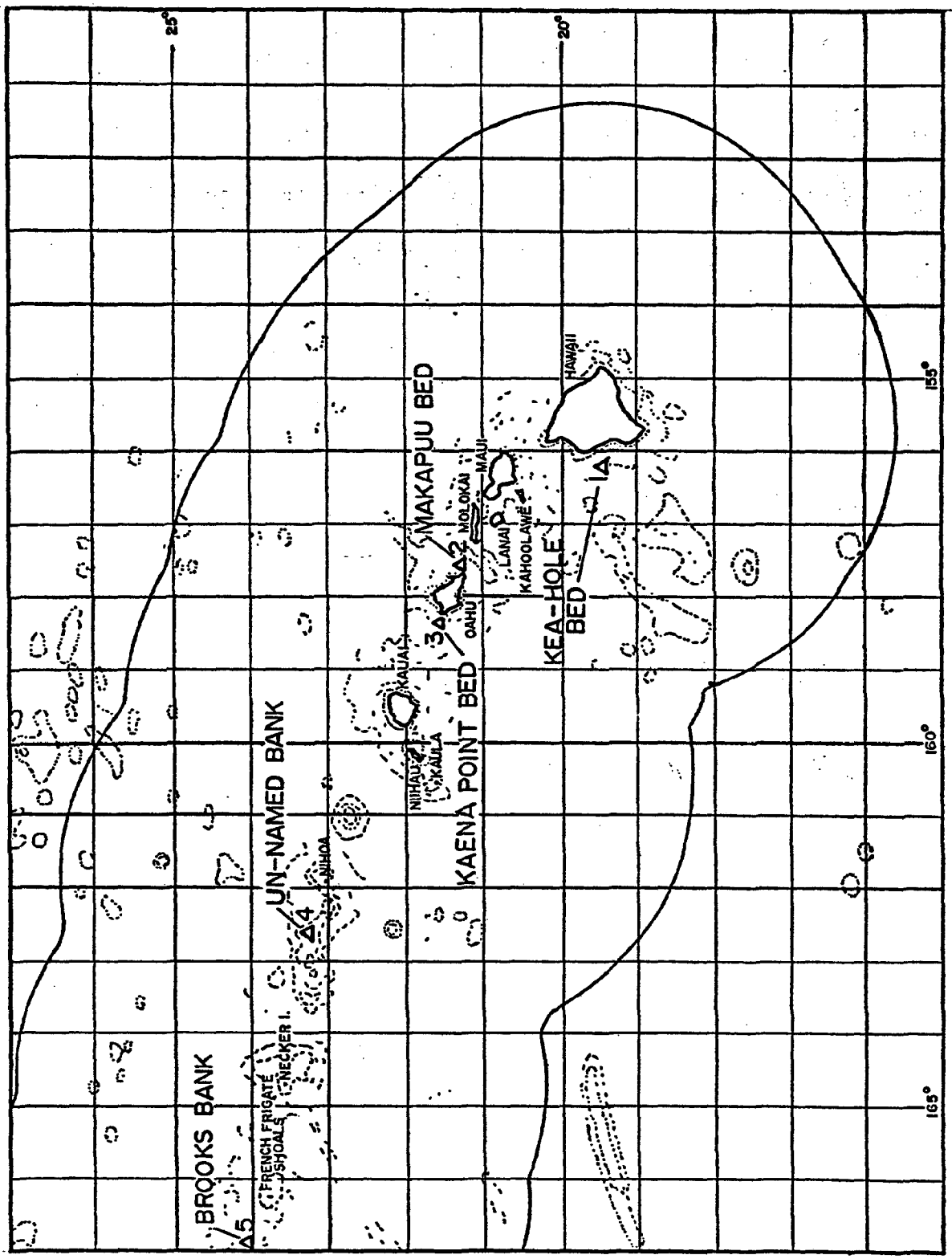

Figure 1. The southeastern half of the Hawaiian Archipelago showing the extent of the fishery conservation zone and the location of major known beds of precious coral.

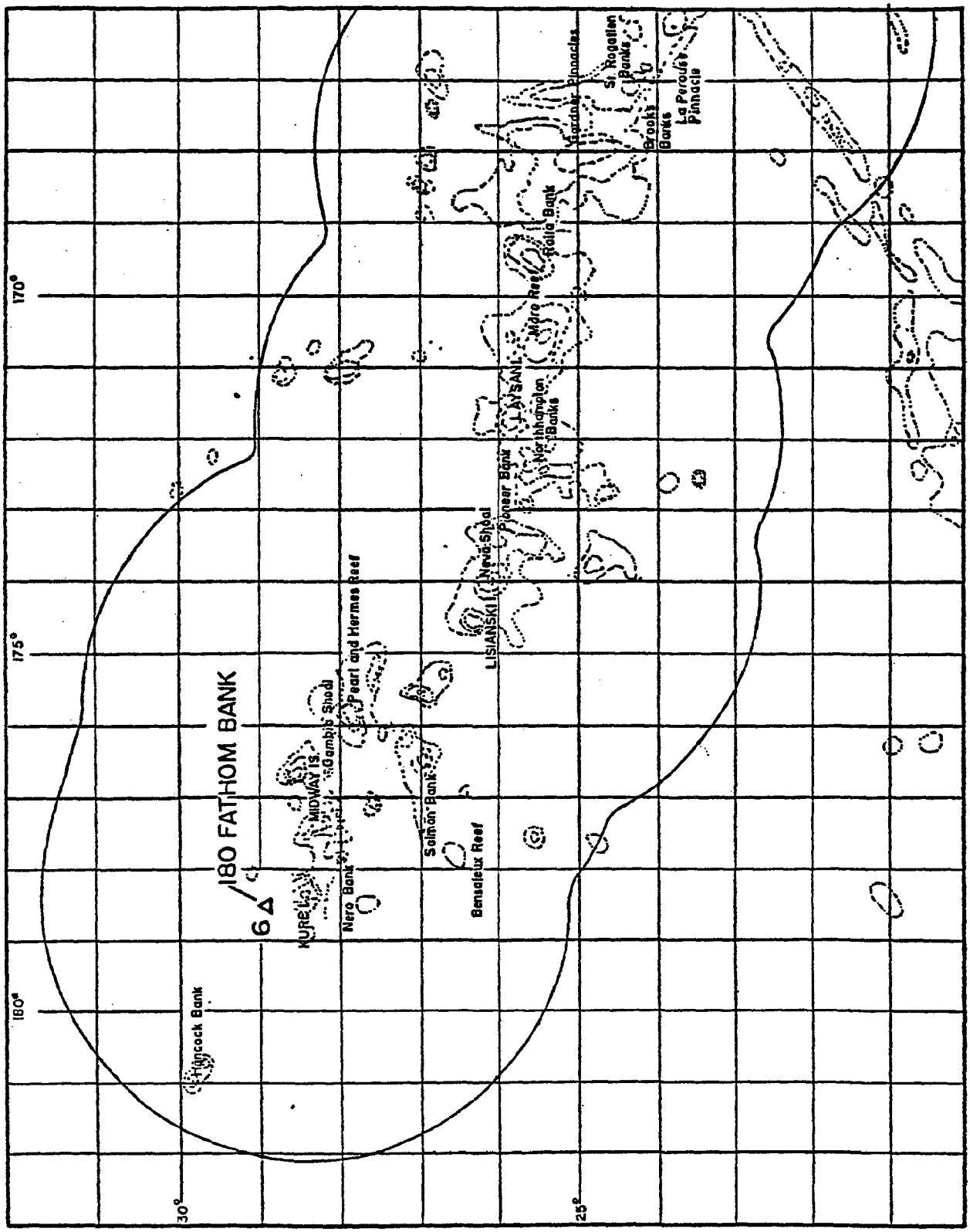

Figure 2. The northwestern half of the Hawaiian Archipelago showing the extent of the fishery conservation zone and the location of precious coral beds.

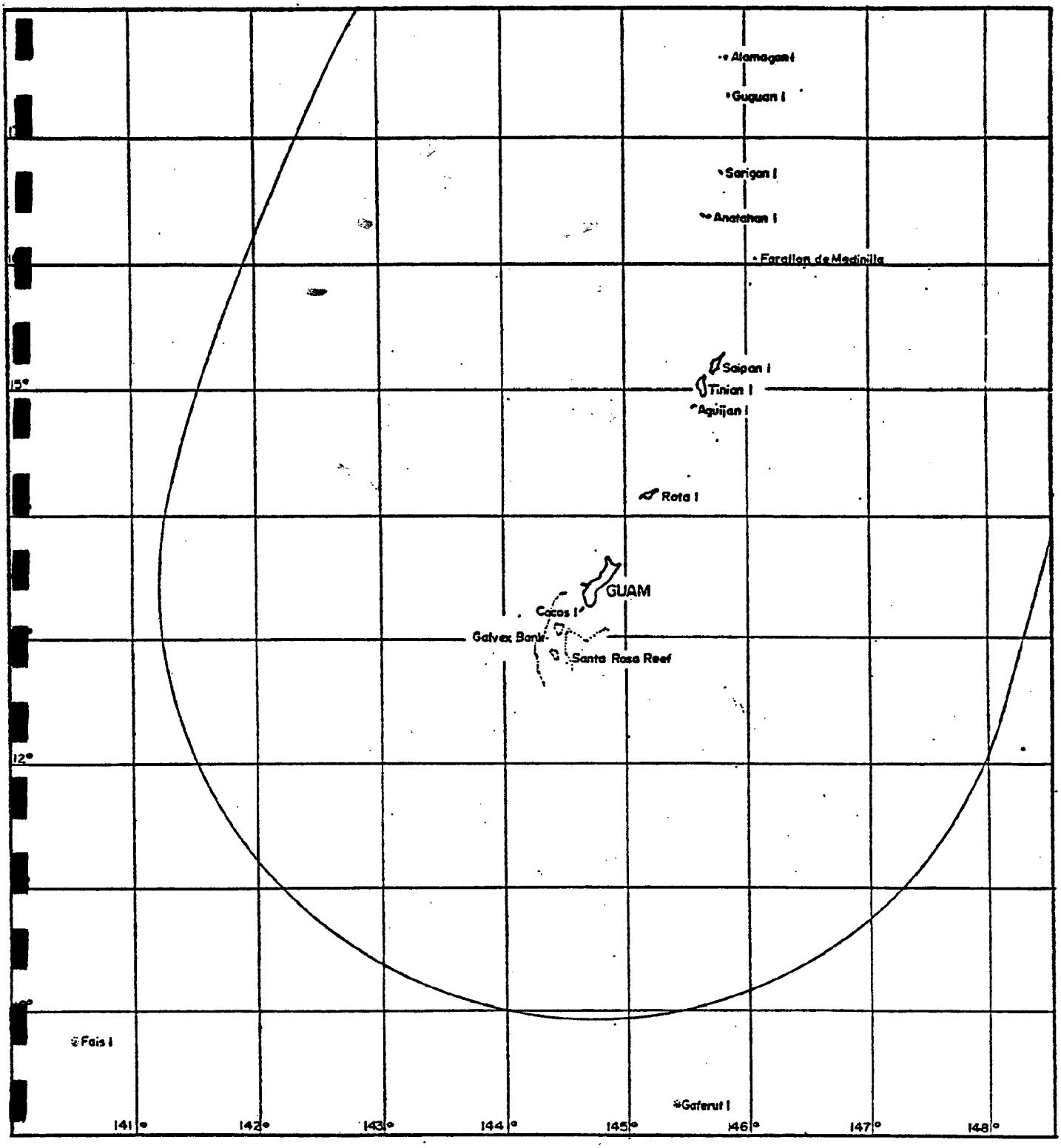

Figure 3. The fishery conservation zone for Guam.

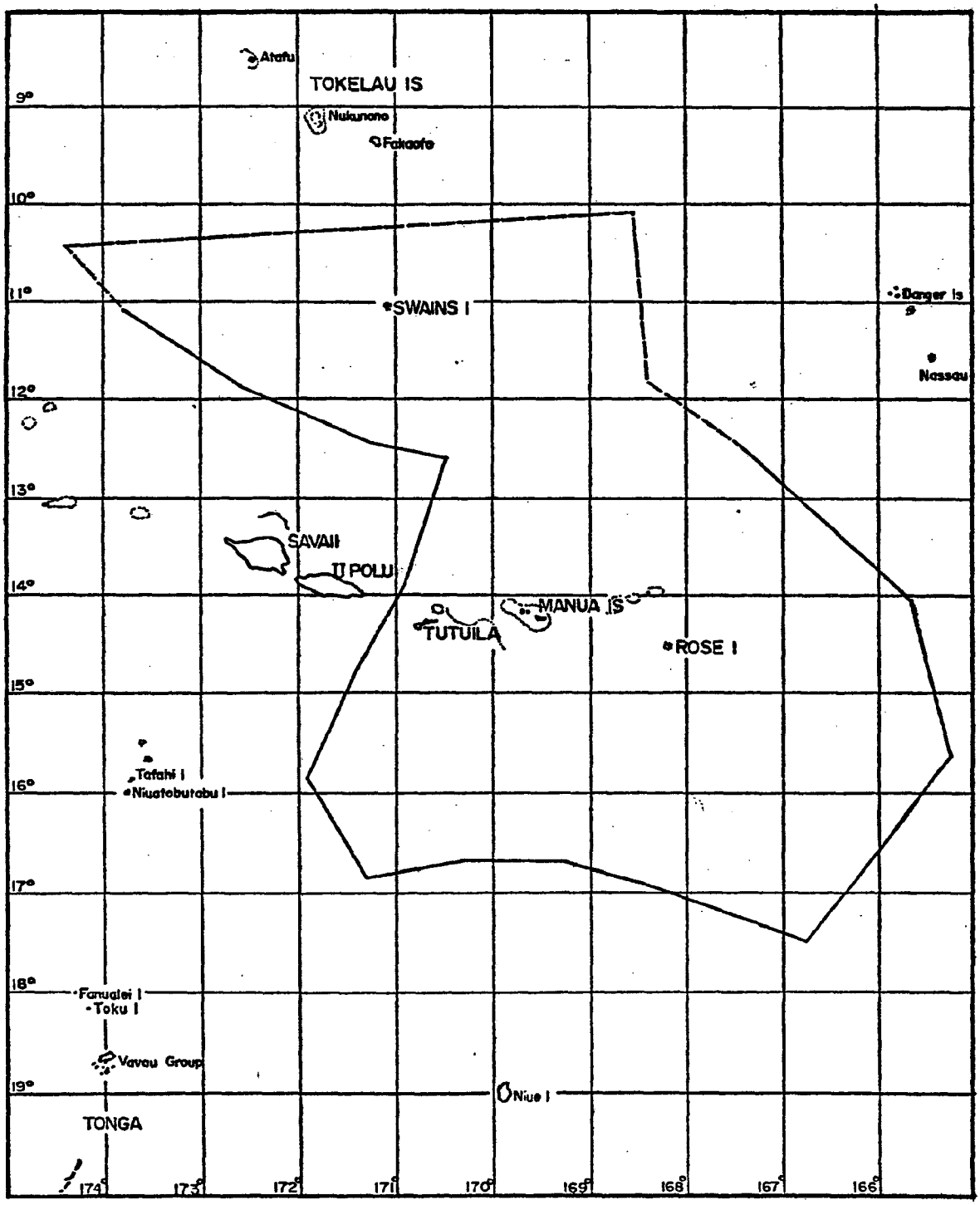

Figure 4. The fishery conservation zone for the islands of Samoa.

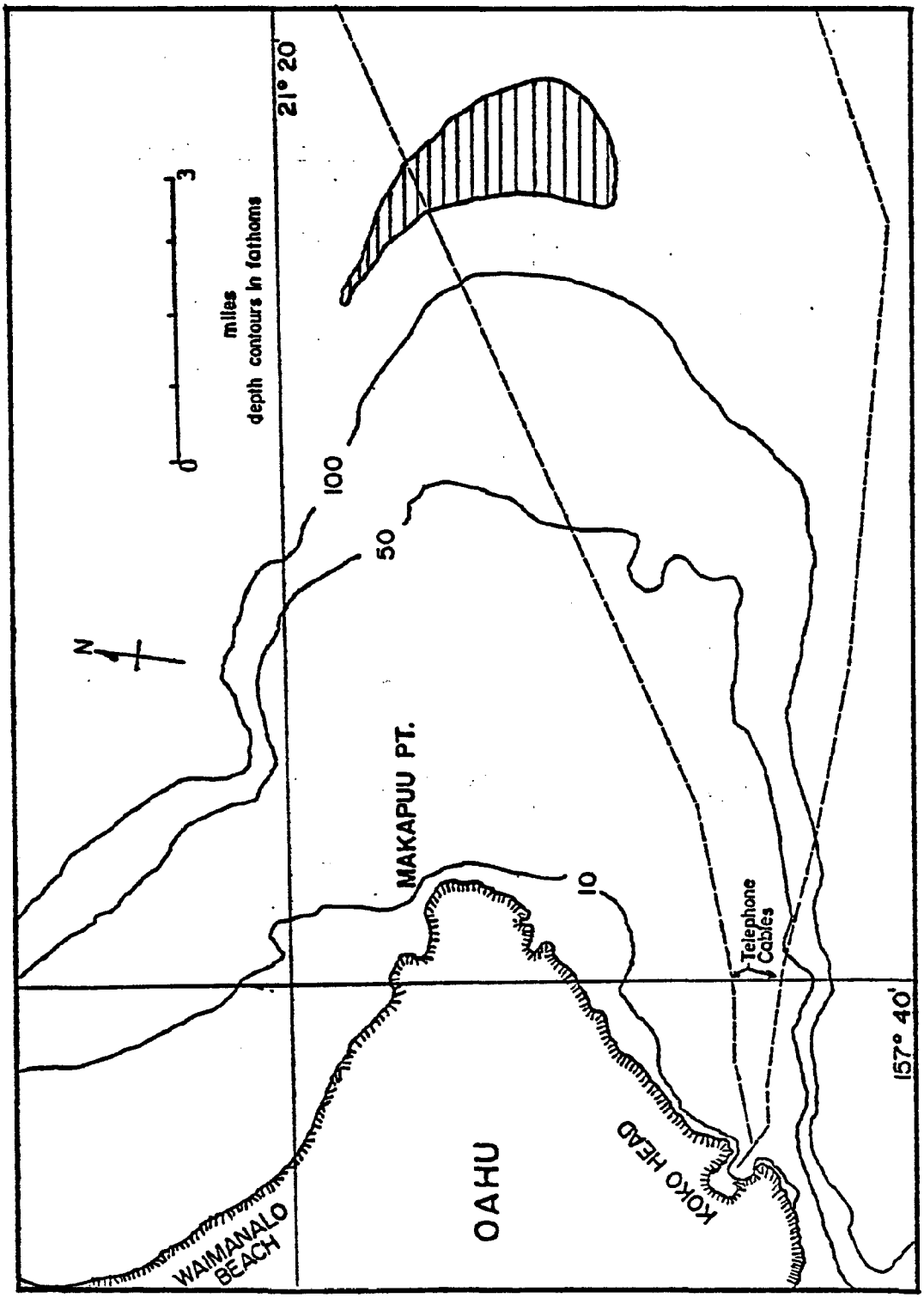

Figure 5. The precious coral bed off Makapuu, Oahu.

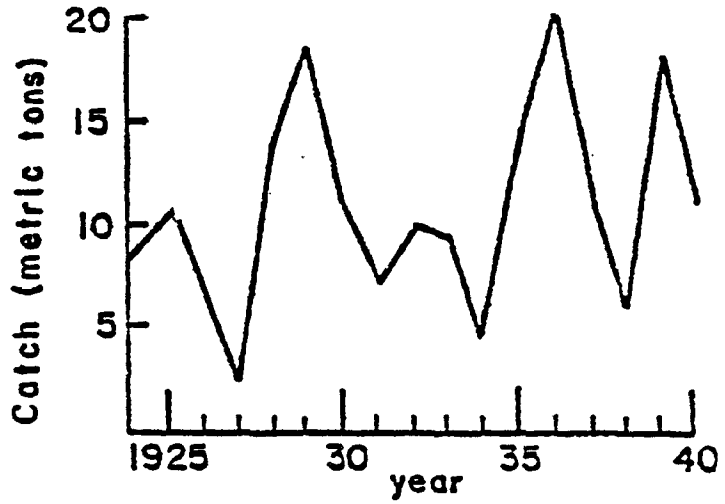

Figure 6. Catch of precious coral at Taiwan, 1924-1940 (Anon, 1956).

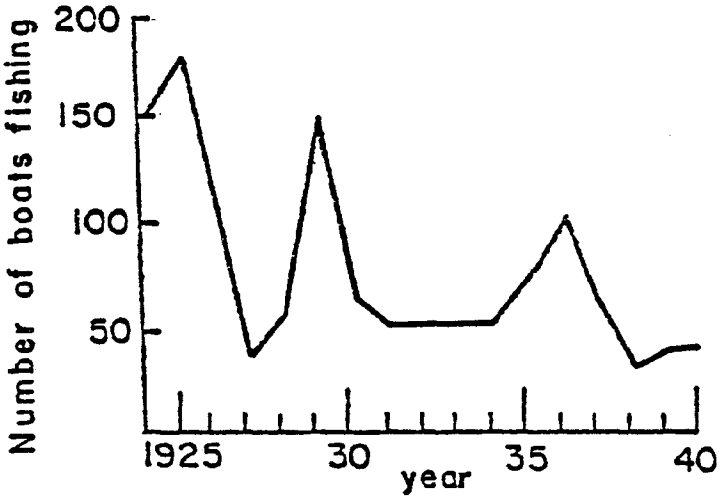

Figure 7. Effort of coral fishing in Taiwan, 1924-1940 (Anon, 1956).

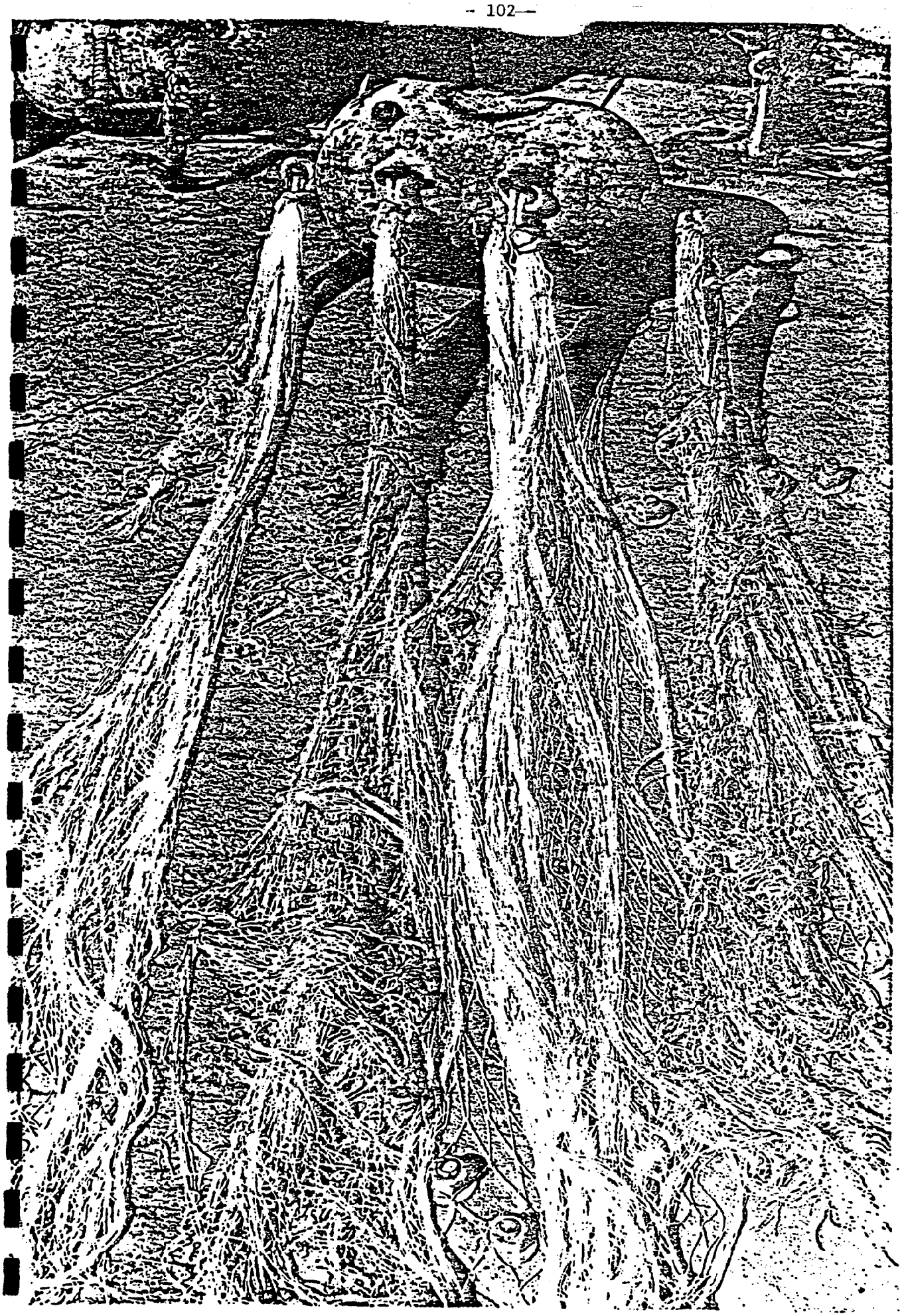

Figure 8 (photo by Mike Palmgren)
Photo of a coral dredge.

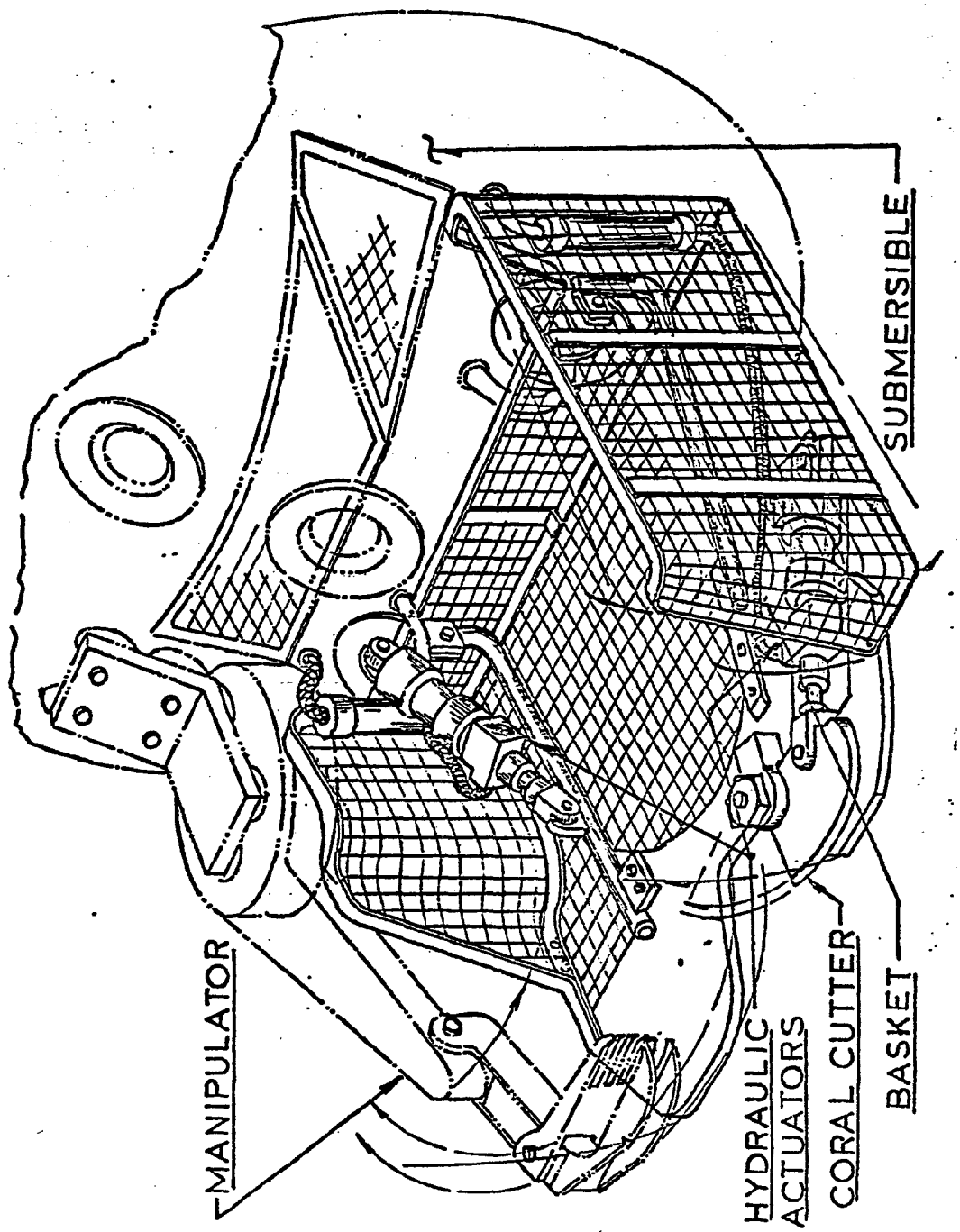

Figure 9. The coral harvesting system on the submersible Star II consists of a wire basket, cutter and hydraulic claw (manipulator).

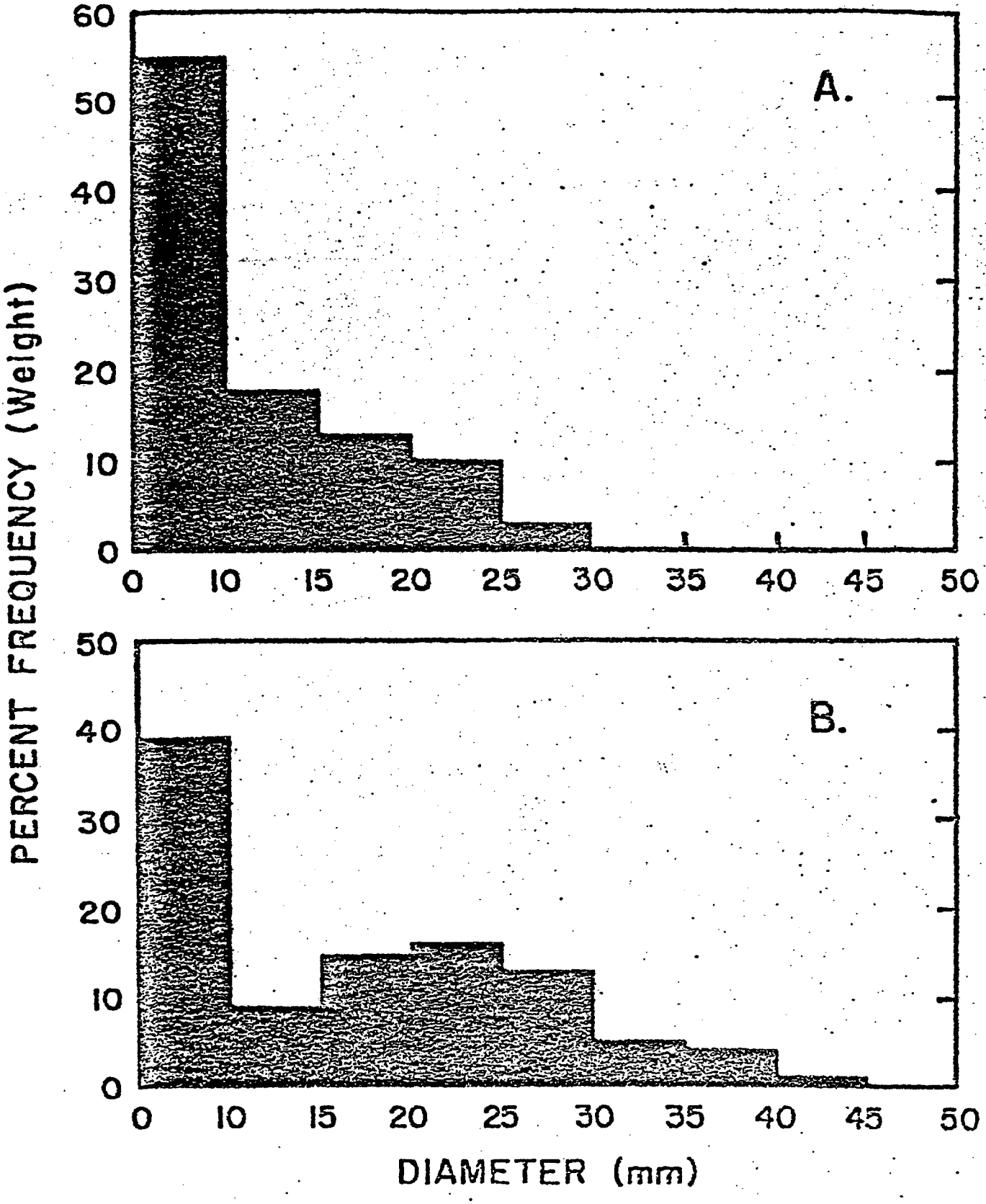

Figure 19. Size-frequency distribution of precious coral collected with tangle nets (A) and the submersible (B).

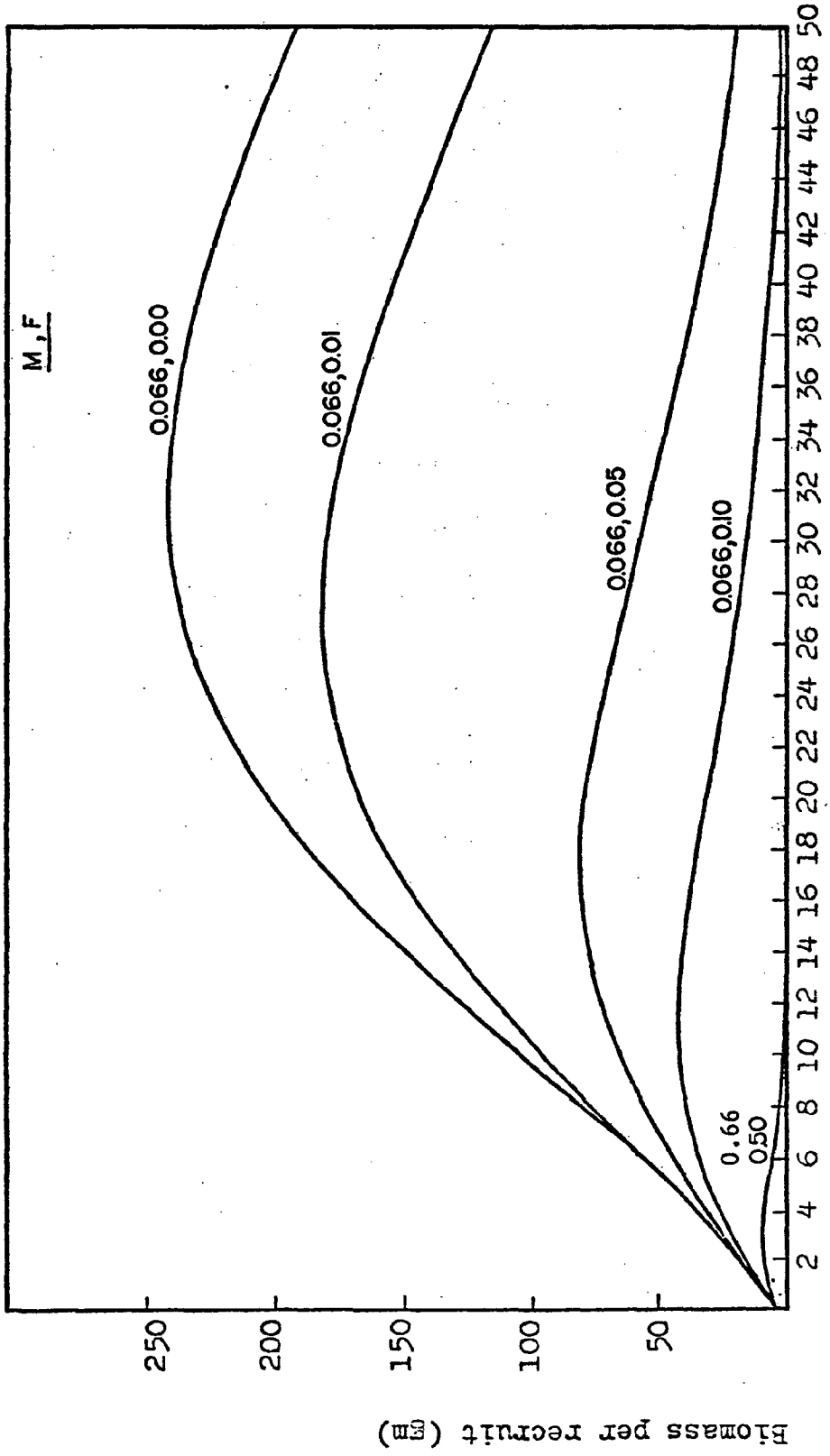

Figure 11 Biomass per recruit curves of *C. secundum* using a constant rate of natural mortality (M=0.066) and progressively increasing rates of fishing mortality (F) applied over all year classes. The age of entry into the fishery is zero, i.e. no age limit is applied.

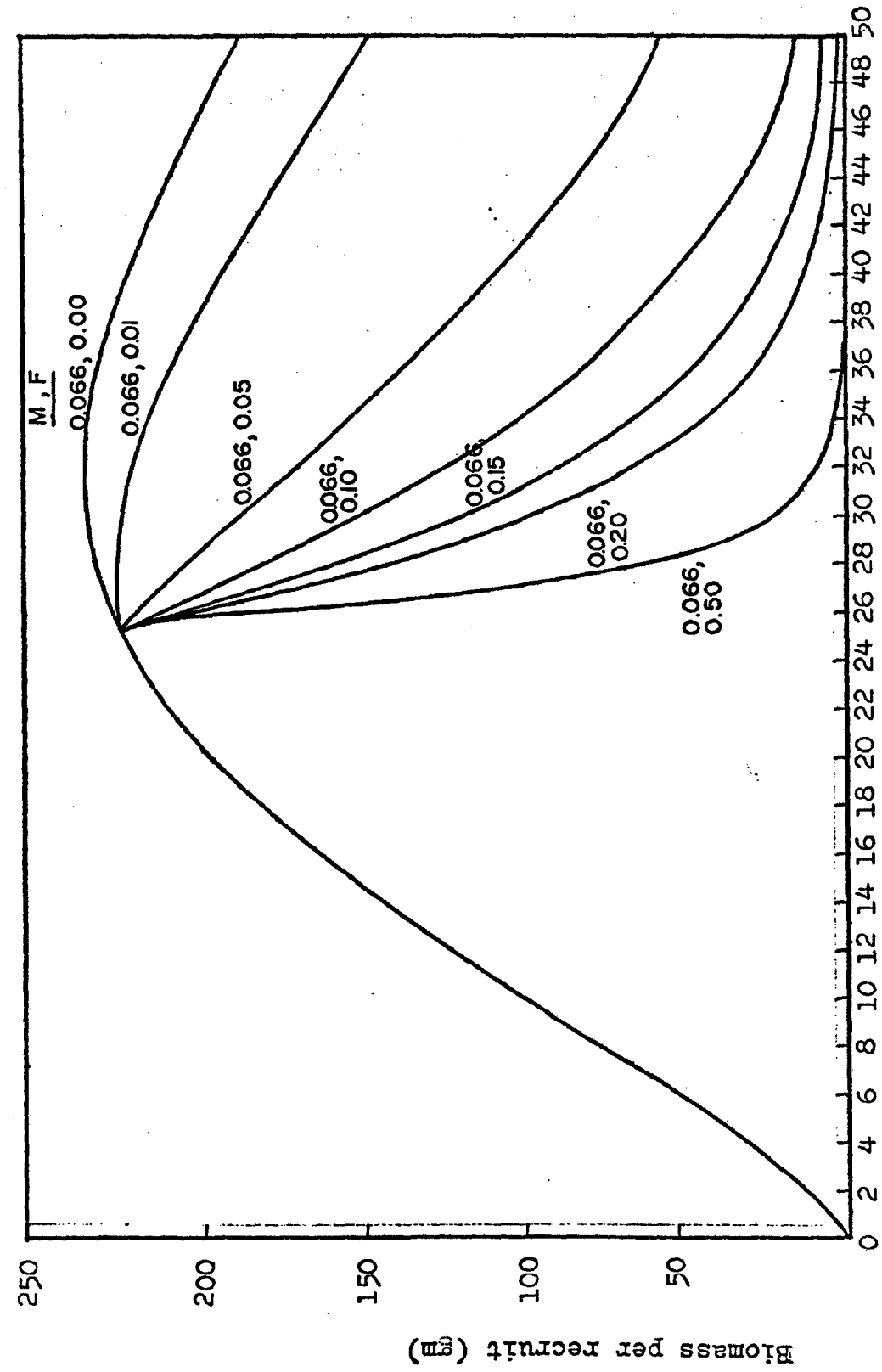

Figure 12. Biomass per recruit curves for a cohort of *C. Secundum* using a constant rate of natural mortality (M=0.066) and progressively increasing rates of fishing mortality (F) applied after a minimum age or 25 years.

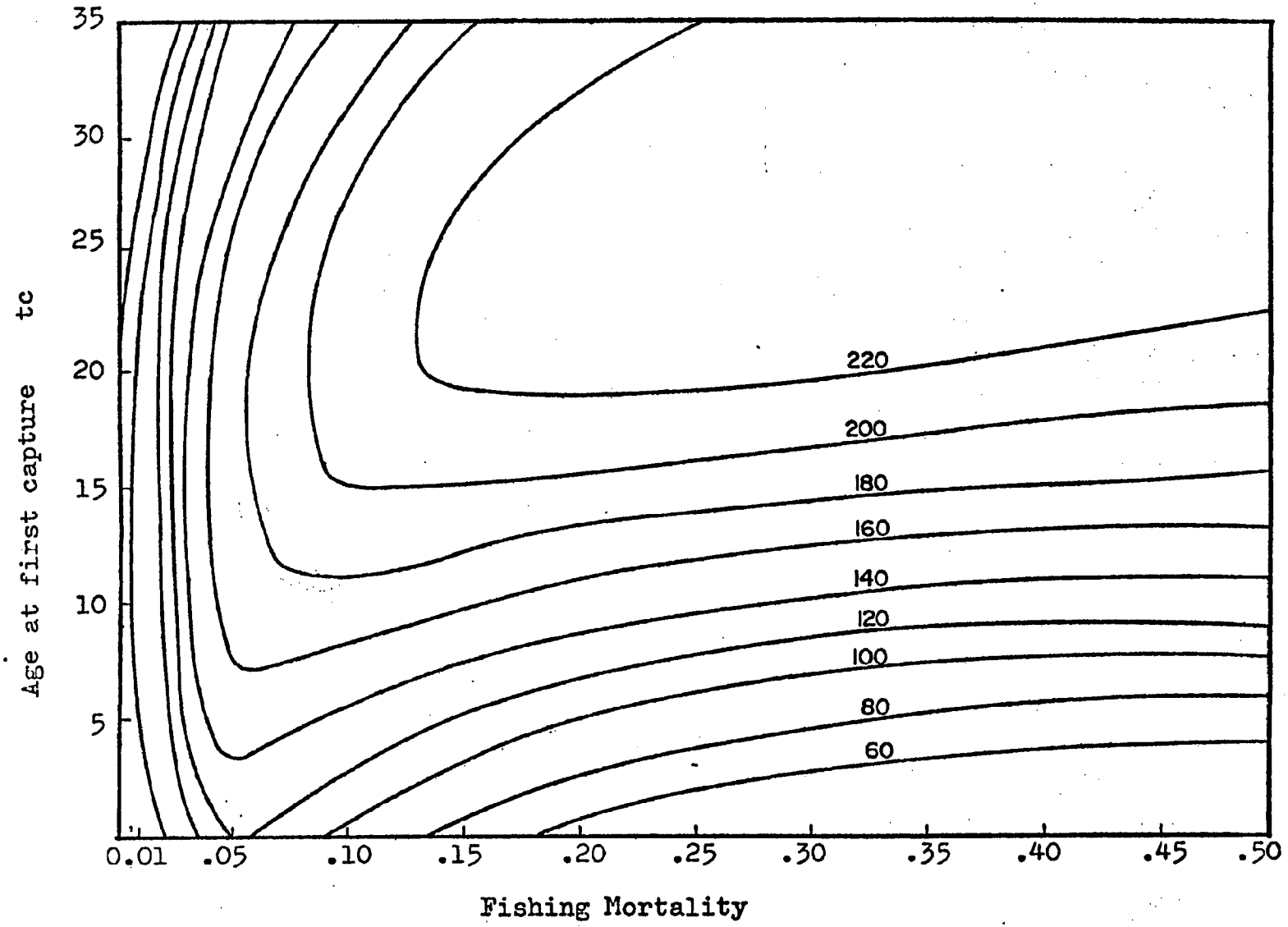

Figure 13. Yield per recruit isopleths for *C. secundum* in the Makapuu Bed, given a constant rate of natural mortality of 0.066. Contour units are in grams per recruit.

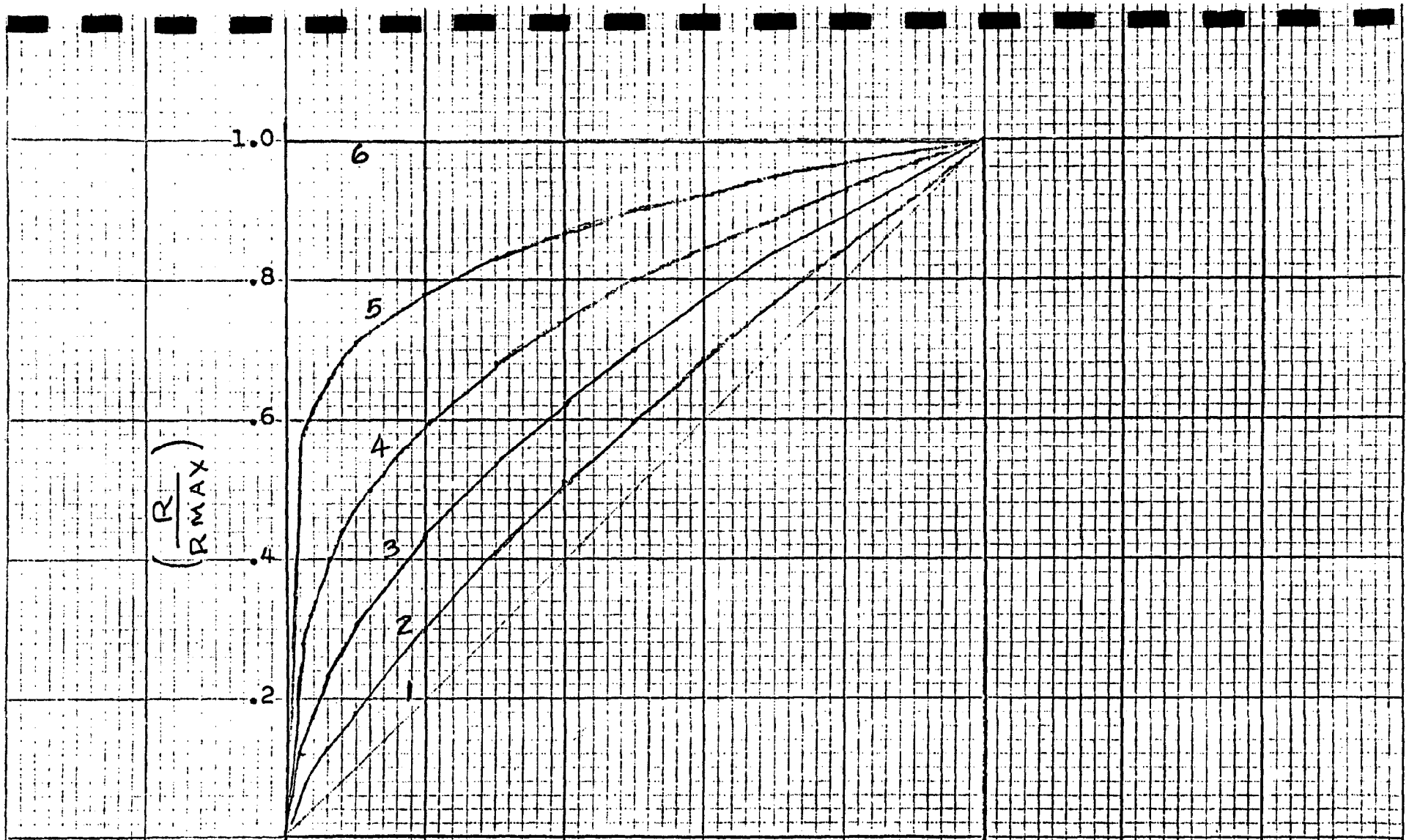

Figure 14. Various spawning stock recruitment functions.

Smax = original spawning stock
s = spawning stock after fishing
Rmax = original recruitment
R = recruitment after fishing

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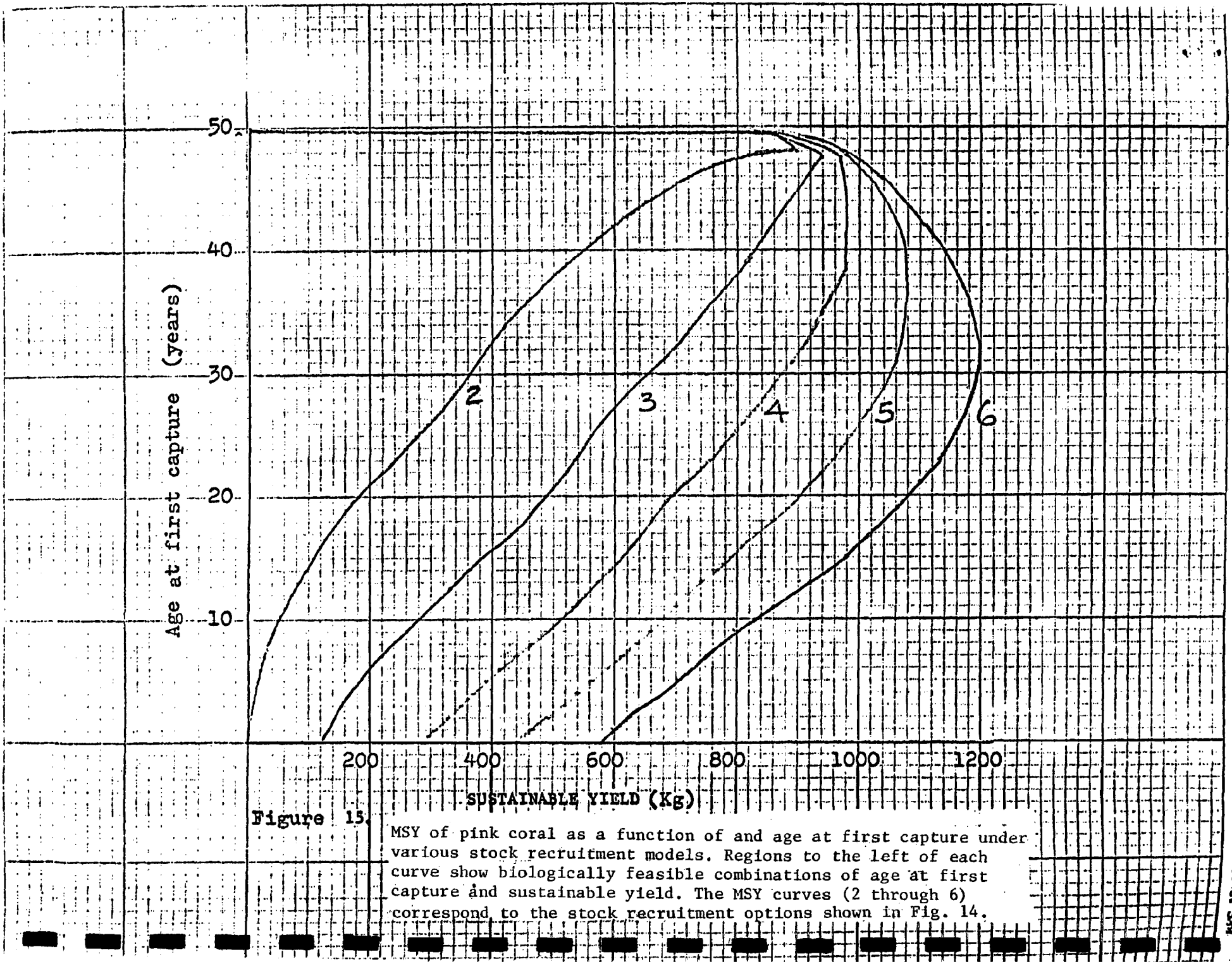

Figure 15. MSY of pink coral as a function of and age at first capture under various stock recruitment models. Regions to the left of each curve show biologically feasible combinations of age at first capture and sustainable yield. The MSY curves (2 through 6) correspond to the stock recruitment options shown in Fig. 14.

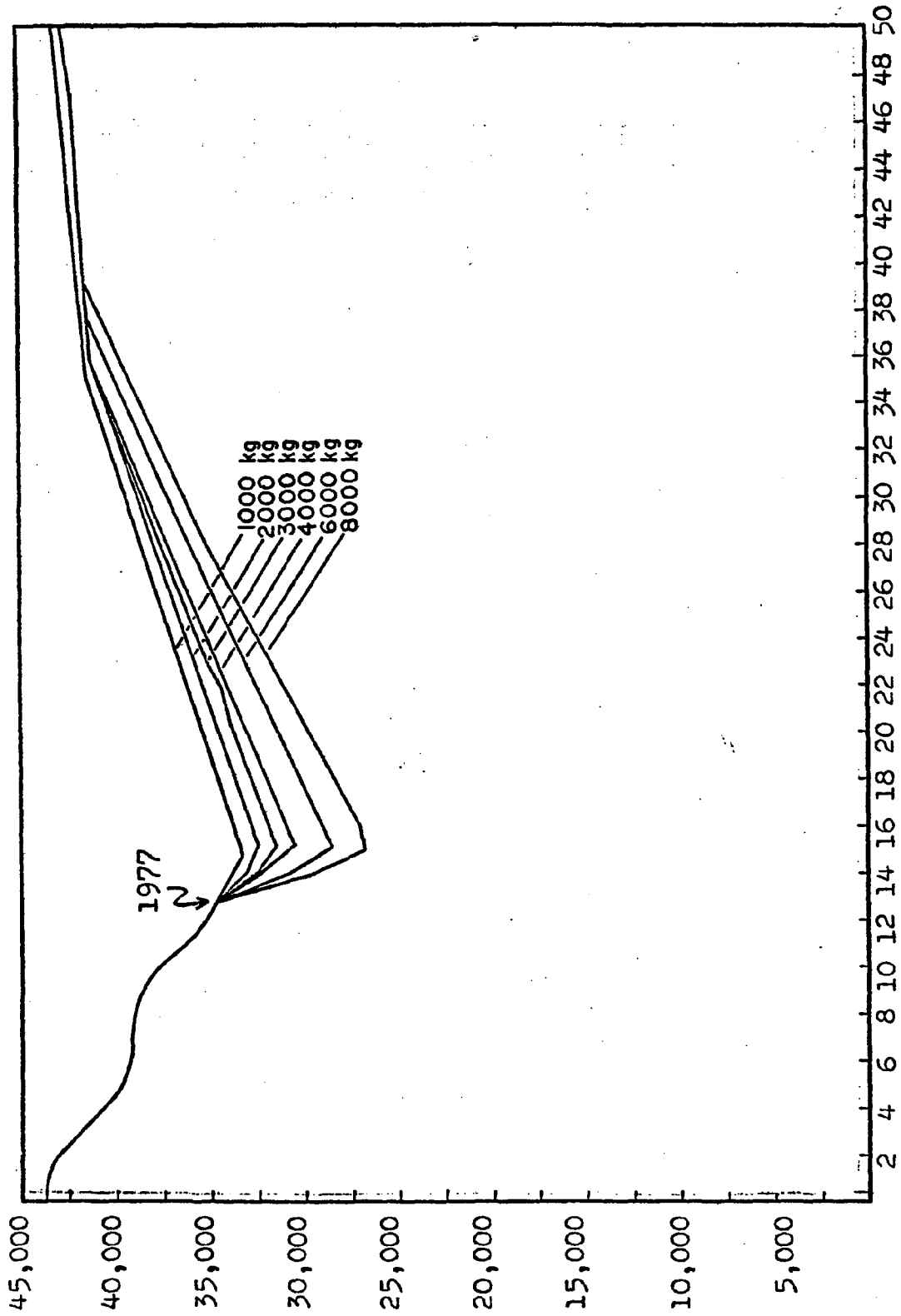

Figure 16. Population biomass of *C. secundum* in the Makapuu Bed between 1964 and 1977 and after 1977 given six different exploitation rates in 1978 followed by a complete closure of the bed.

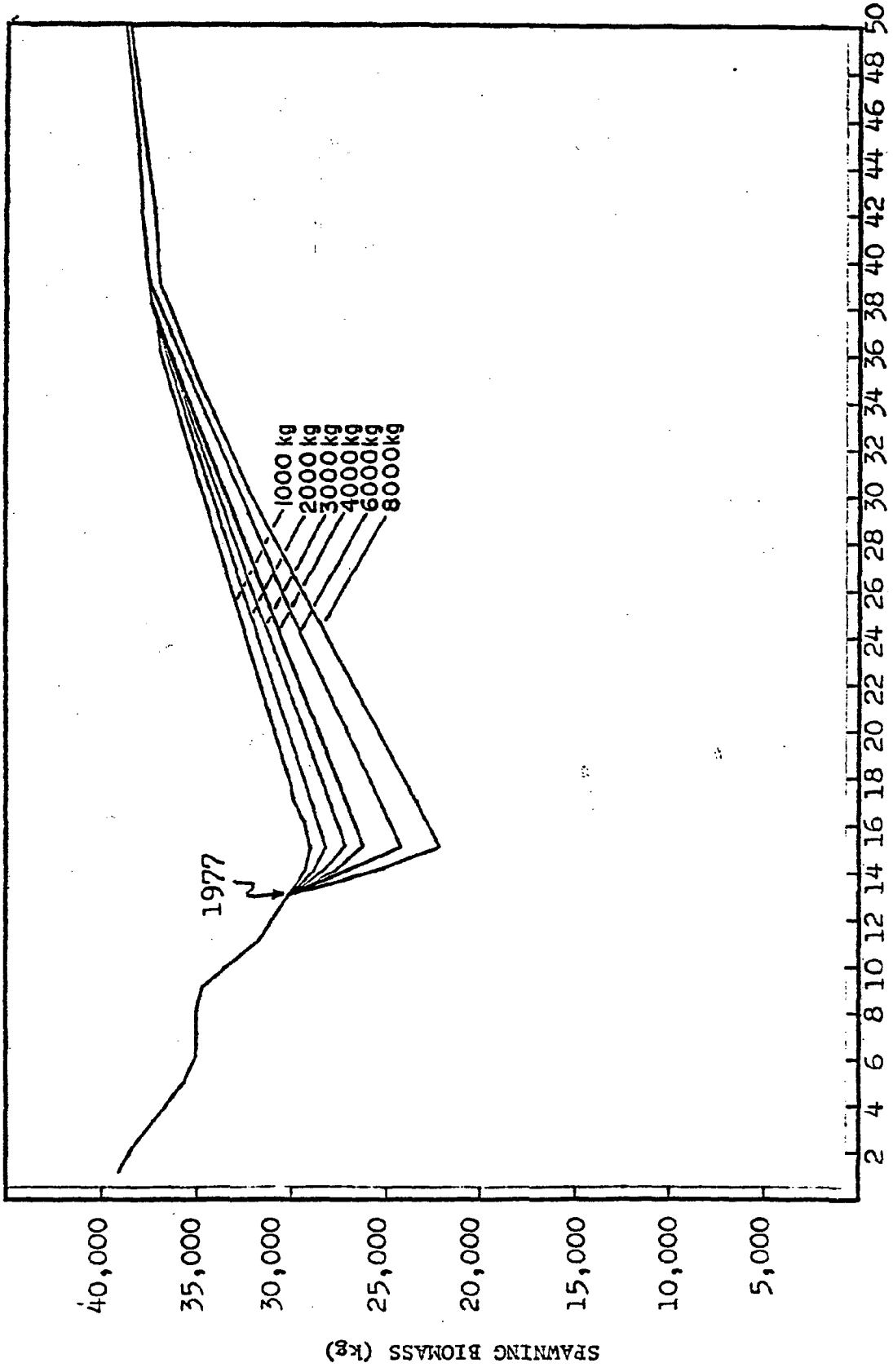

Figure 17. Spawning biomass of *C. secundum* in the Makapuu Bed between 1964 and 1977 and after 1977 given six different exploitation rates in 1978 followed by a complete closure of the bed.

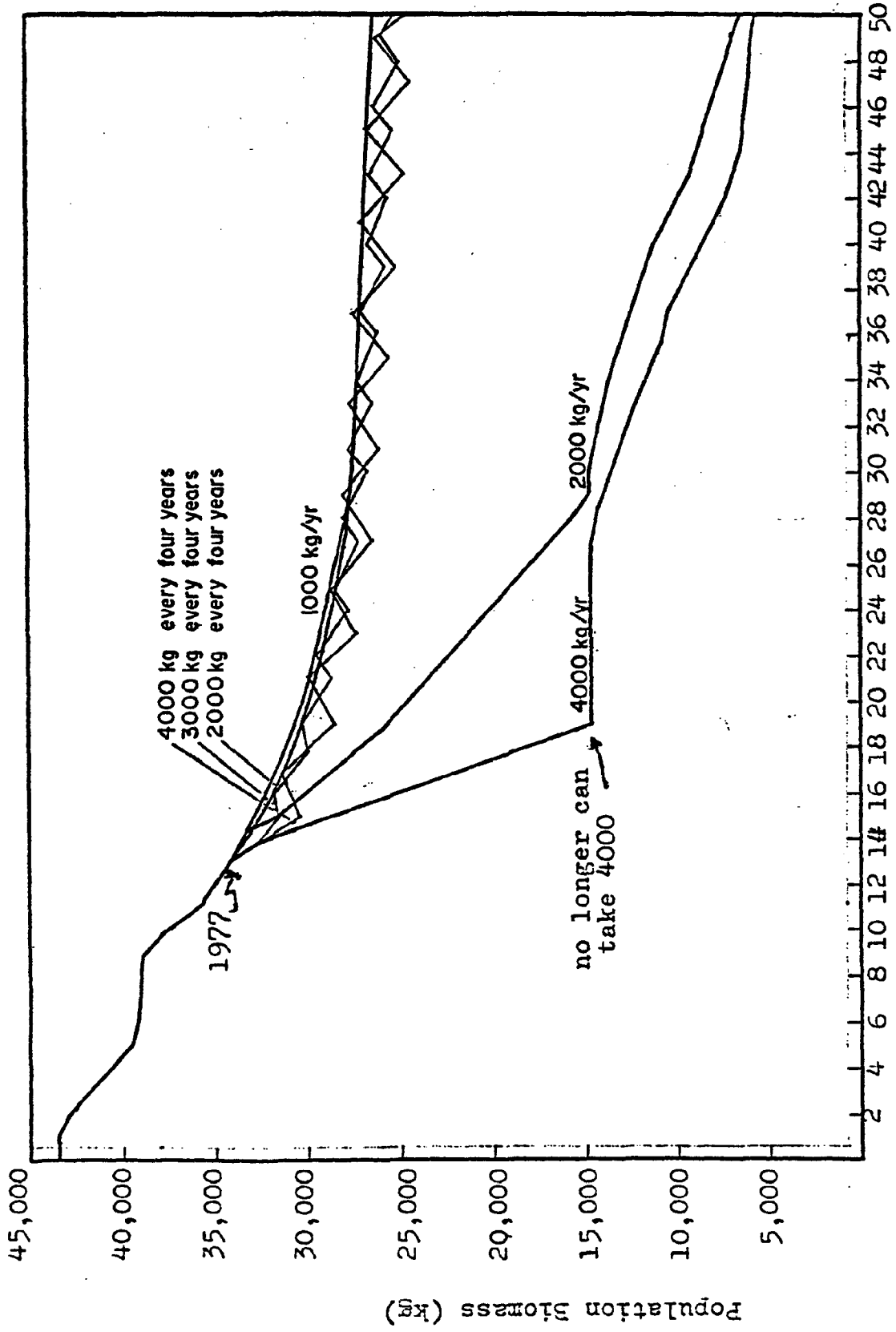

Figure 18. Population biomass of *C. secundum* in the Makapuu Bed between 1964 and 1977 and after 1977 given different rates of exploitation.

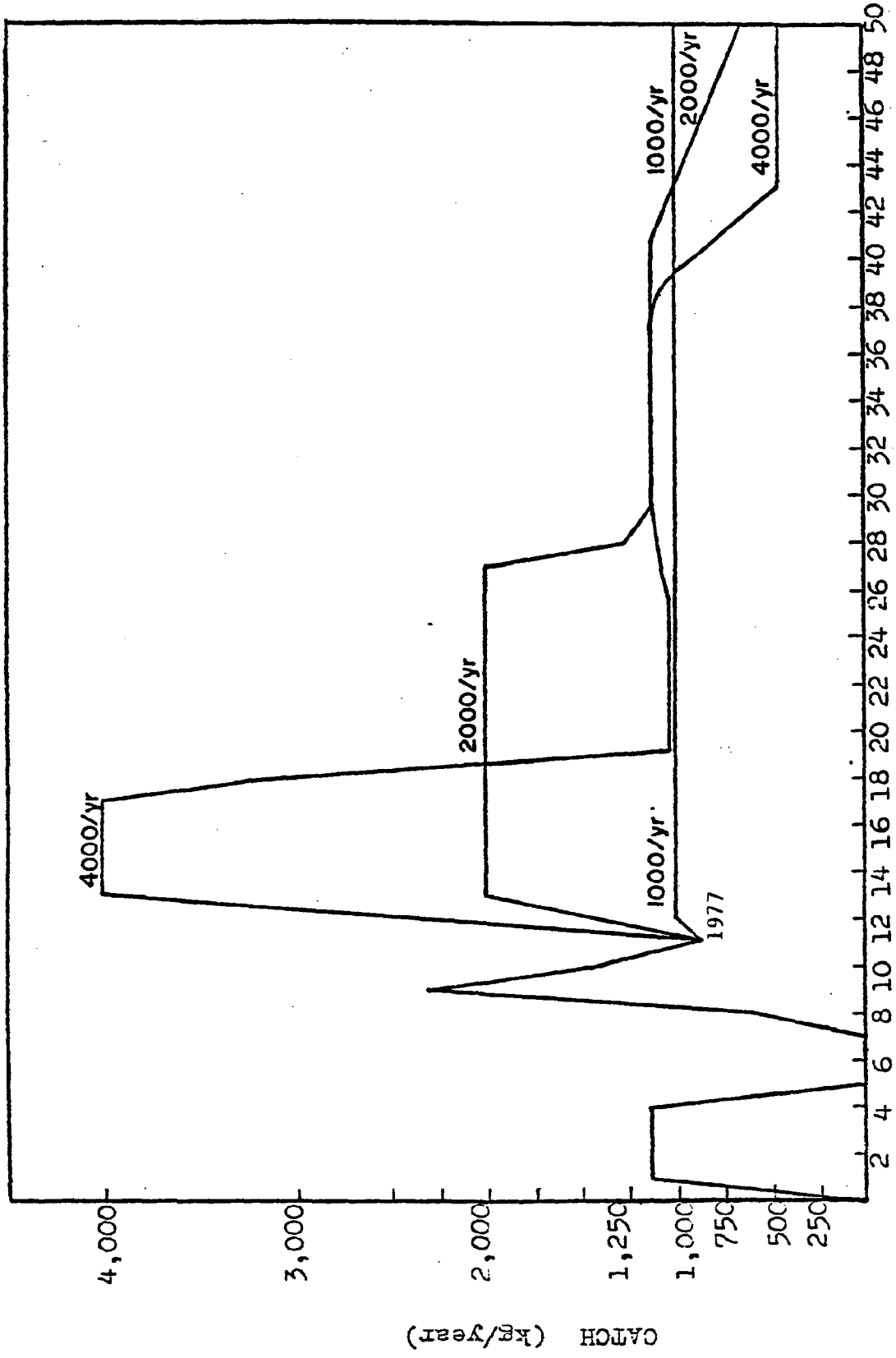

Figure 19. Yields of *C. secundum* in the Makapuu Bed between 1964 and 1977 after which different rates of harvest are simulated. See text for further explanation.

WESTERN PACIFIC REGIONAL FISHERY MANAGEMENT COUNCIL

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HONOLULU, HAWAII 96813
TELEPHONE (808) 523-1368

December 14, 1979

Terry L. Leitzell
Assistant Administrator
for Fisheries
Office of Fisheries, NOAA
Page Building No. 2, Room 400
3300 Whitehaven Street, N. W.
Washington, D. C. 20235

Dear Terry:

In view of the unique nature of the Precious Coral resource and the novel management measures recommended by the Western Pacific Fishery Management Council, and in response to questions raised by NOAA/NMFS, the Scientific and Statistical Committee and the Council at meetings held November 27-30, 1979, adopted the enclosed explanatory statements and plan clarifications.

With aloha and warm regards,

Sincerely,

Wadsworth Y. H. Yee
Chairman

Enclosures

STATEMENT OF THE SCIENTIFIC AND STATISTICAL COMMITTEE OF THE WESTERN PACIFIC FISHERY MANAGEMENT COUNCIL, IN SUPPORT AND FURTHER EXPLANATION OF THE FISHERY MANAGEMENT PLAN FOR THE PRECIOUS CORAL FISHERIES OF THE WESTERN PACIFIC REGION.

1. 500 kg optimum yield in Exploratory Areas (all species combined).

To reiterate the rationale used in defining optimum yield in Exploratory Areas, the basic premise is to create a sufficient economic incentive while minimizing the bioligical risk of overfishing. An optimum yield of 500 kg is considered sufficient to stimulate exploration but is in all likelihood a very small fraction of the precious corals present in Exploratory Areas. The reason the optimum yield in Exploratory Areas does not vary to reflect differences in efficiency between selective and non-selective gear is because it is based on the concept of a minimum economic incentive, i.e. 500 kg is considered a minimum value irrespective of the type of gear employed. Admittedly, the impact of dredging 500 kg is judged to be 5 times greater than the impact of harvesting 500 kg with selective gear. However, in either case the biological risk of overfishing the resource by harvesting 500 kg in all of each Exploratory Area (except seaward of the main Hawaiian Islands) is judged to be small and less than the benefit of the information that would be produced.

2. 2 year optimum yield.

Because the domestic capacity is approximately twice the optimum yield calculated for the Makapuu Bed and because the industry is faced with the problem of amortizing costs on an annual basis, a 2 year quota has been provided recognizing that it can be taken in one year. This will allow transfer of capital investment during the second year. The analysis outlined in the plan and illustrated in Figure 18 of the plan clearly demonstrates that the biological impact of doubling the quota for twice the time is almost identical to that of an annual quota. The SSC therefore strongly reiterates support for this measure, even though it is an example of pulse fishing which is a management measure that has not been previously used under the FCMA.

3. The environmental impact of dredging vis-a-vis selective harvest.

Quotas allowable for non-selective gear are 20% of those provided for selective gear (except in Exploratory Areas). This provision adjusts for the difference in environmental impact between the two types of gear. In other words, a 20% quota using non-selective gear is judged to be equivalent to a full quota for selective gear. A full quota would result in the taking of approximately 2% of the standing crop per year. Therefore, in the case of non-selective gear when non-precious corals are incidently harvested, even for species which have the same patterns of distribution and abundance as precious corals (such as obligate commensals), the impact on these species would be no greater than 2% of their standing crops per year. Therefore the environmental impact of dredging with quotas reduced by 80% is judged to be minimal and acceptable for all species affected.

Other reasons why conditional dredging is permitted at all, include preventing the formation of a monopoly in Hawaii, providing reasonable opportunity for the development of a precious coral fishery in under-developed

and remote areas and to provide for a possible new source of information in the future.

4. The location and selection of the refuge.

The SSC feels that adequate rationale for the selection of a refuge is given in the plan. Only one refuge was designated at this time because of the limited number (6) of known beds. If more beds are discovered in the future, it would be reasonable to establish additional refugia. The plan establishes that the plan be reviewed on an annual basis.

November 28, 1979

PLAN CLARIFICATIONS

(1) On page 70, the sentence starting on line 5 should be changed to read:

> "2. It is recommended that foreign vessels be permitted to take up to 500 kg. per year, all species combined, per Exploratory Area, under a scientific research plan approved by the Southwest Fisheries Center, NMFS, in consultation with the Council and State agencies."

(2) On page 52, the following sentence should be added after the last full paragraph.

> "As conditional beds are established in an exploratory area, the appropriateness of the quota for that exploratory area will be reevaluated."

(3) (a) On page 22, II.G. Jurisdiction, delete first paragraph. On page 24, second paragraph, delete second sentence.

(b) On page 65, under IV.1 Relationship to Existing Laws, the second sentence, commencing with "DOI regulations . . . " should be stricken.

(c) On page 77, in the paragraph numbered "3," the last sentence, beginning with "This fact is also . . . " should be deleted.

(4) The Council wishes to make clear its intention that non-selective harvesting methods not be allowed in the FCZ seaward of the main Hawaiian Islands. Therefore, the following clarifications should be added.

(a) On Page 52, the second full paragraph, the first sentence should be revised to read:

> "For areas outside the Makapuu Bed, Conditional Beds, and the FCZ seaward of the main Hawaiian Islands, it is proposed to allow either non-selective or selective methods subject to a limit of 1,000 kg per Exploratory Area per year."

(b) On page 53, in the first full paragraph, the second sentence should be revised to read:

> "Since dredging is allowed everywhere else (except in the FCZ seaward of the main Hawaiian Islands) the size limit at this time can apply only to these beds."

(5) The Council wishes to clarify that in areas where dredging is prohibited, any form of non-selective harvesting is prohibited. There, at the following places in the Plan, the term "non-selective harvesting" should be substituted for the word "dredging."

> Page 49, lines 11, 12, 13, 18, 21, and 24
> Page 50, lines 3, 7, 9, 14, and 22
> Page 52, line 11
> Page 61, line 6
> Page 62, lines 2, 4, and 7
> Page 70, lines 1, and 2
> Page 75, line 3

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