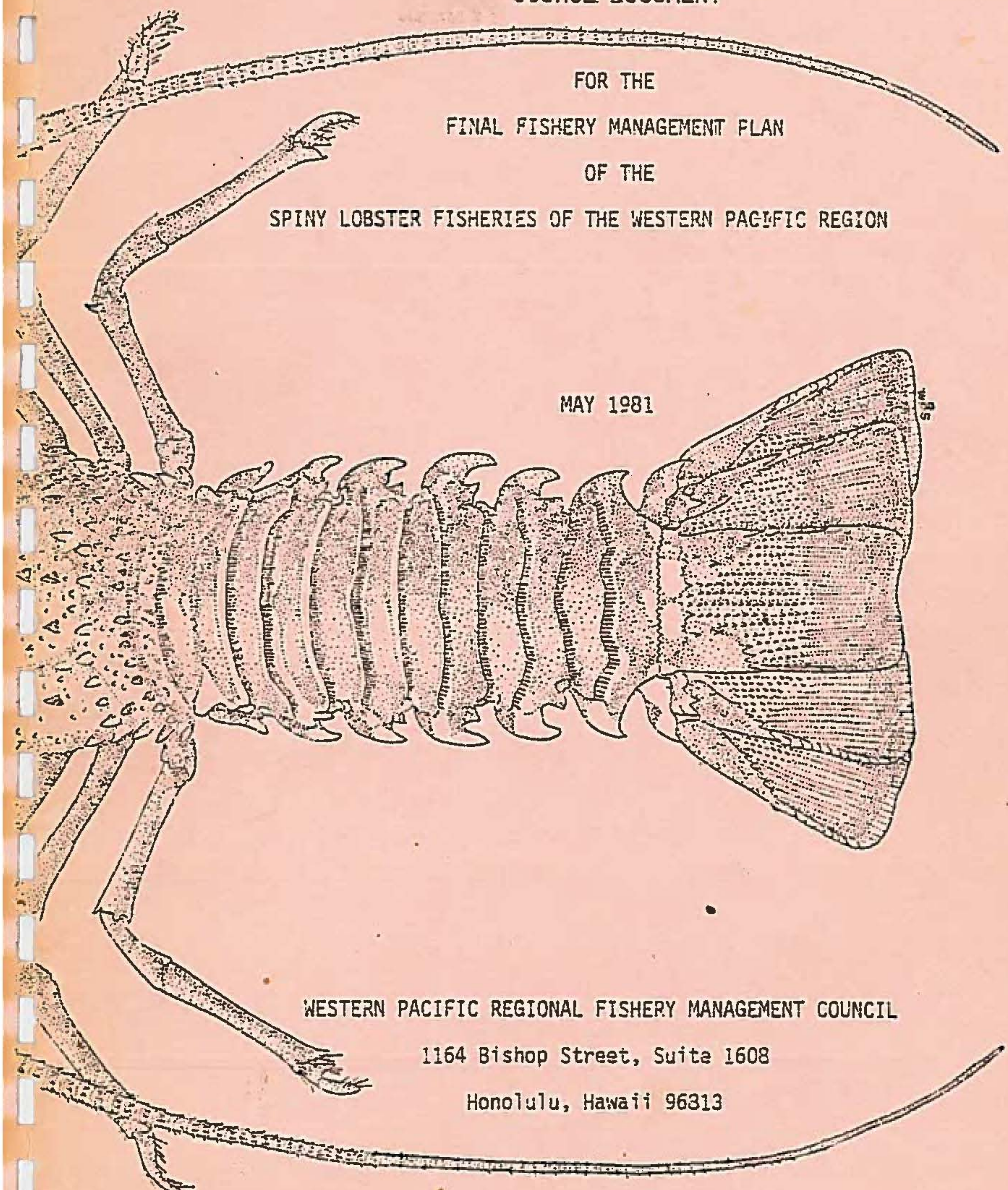

SOURCE DOCUMENT

FOR THE

FINAL FISHERY MANAGEMENT PLAN

OF THE

SPINY LOBSTER FISHERIES OF THE WESTERN PACIFIC REGION

MAY 1981

WESTERN PACIFIC REGIONAL FISHERY MANAGEMENT COUNCIL

1164 Bishop Street, Suite 1608

Honolulu, Hawaii 96813

SPINY LOBSTER FISHERIES OF THE WESTERN PACIFIC

Section 1.0 PREFACE TO SOURCE DOCUMENT

The Fishery Management Plan for the Spiny Lobster Fisheries of the Western Pacific Region (FMP), is the Council's conservation and management regime for spiny lobster stocks in the U.S. Fishery Conservation Zone (FCZ) around American Samoa, Guam, and Hawaii. The FMP proposes conservation and management measures for the fishery around the Northwestern Hawaiian Islands (NWHI) and establishes only permit and reporting requirements for commercial fishing in the FCZ portions around the main Hawaiian Islands, Guam and American Samoa. The National Marine Fisheries Service and the U.S. Coast Guard, in cooperation with state, territorial and federal agencies, are responsible for implementing the FMP after approval by the Secretary of Commerce.

The Source Document contains detailed technical discussion, tables, figures and appendixes not found in the FMP. The FMP concentrates on material specifically required by the FCMA, NEPA, and Executive Order 12291. The Spiny Lobster FMP has been prepared to reduce duplication by including all statutory and administrative requirements within one document. The bulk of the document is reduced to facilitate public review and understanding by limiting technical information and analysis to the Source Document. The Source Document also contains related materials such as the NMFS Biological Opinion for the Draft FMP, draft "Determinations of Consistency" with State and Territorial Coastal Zone Management Plans, and a summary of comments, and responses to comments on the draft FMP.

The Source Document reproduces the full text of Section 7.0 (Description of the Fishery) from the Final FMP with additional discussion considered useful in providing background information on the fishery. The additional material is indicated by the sub-heading "Additional Discussion". The Source Document has been sent to all organizations and individuals who commented on the Draft FMP.

The responsible agencies for planning and for implementing spiny lobster fisheries management measures are the Western Pacific Fishery Management Council and U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS). For further information, contact:

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SPINY LOBSTER FISHERY MANAGEMENT PLAN FOR THE WESTERN PACIFIC REGION

—SOURCE DOCUMENT—

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SPINY LOBSTER FISHERY MANAGEMENT PLAN FOR THE WESTERN PACIFIC REGION

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Section 7.0 DESCRIPTION OF THE FISHERY (with Additional Discussion)

7.1 Description of the Stocks

7.1.1 Species Identity

The target species taken in the spiny lobster fishery are:

Spiny Lobsters:

Panulirus marginatus - (local name - ula)	NWHI, main Hawaiian Islands
Panulirus penicillatus -	NWHI, main Hawaiian Islands, Guam
Panulirus sp. -	American Samoa, Guam and Hawaii

The incidental species taken by lobster trapping are slipper lobsters and Kona crab.

Slipper Lobsters

Scyllaridae sp. - (local name - ula papapa)	NWHI; possibly other areas

Kona Crab

Ranina ranina -	NWHI and other areas

7.1.2 Morphology

Spiny lobsters are non-clawed, decapod crustaceans with two horns and antennae projected forward of the eyes. The walking legs are slender and about equal in size. Spiny lobsters have a large, spiny carapace covering the anterior part of the body, and a powerful abdomen or tail which terminates in a flexible fan (see Figures 4.1 and 4.2).

7.1.3 Incidental Species

Slipper lobsters (family Scyllaridae) are caught in association with spiny lobsters. Their appearance is markedly different, but their similarity as a food item suggests that commercial use may expand in the future. Despite the absence of biological information on this species, slipper lobsters are included in the management unit so that reports of incidental catches in the lobster fishery will be assured. However, no restrictions on catch of slipper lobsters are proposed.

Kona crab (family Raninidae) are also caught in association with spiny lobsters. They are included in the management unit as incidental species to provide catch information which may be used for future management considerations.

7.1.4 Distribution

Spiny lobster species occur throughout the Pacific islands. P. marginatus is endemic to Johnston Island and the NWHI, and is the dominant species in the NWHI fishery to date. In the NWHI, this species generally occurs in waters between 5-100 fathoms (fm) in depth in the NWHI. Around Oahu, P. penicillatus are found in greater relative abundance in waters deeper than 5 meters. Spiny lobsters of both species have been found within the lagoons of atolls in the NWHI as well as on the seaward side of the reefs. Distribution by species around Guam and American Samoa is unknown, but various species occur in both areas.

Spiny lobsters are nocturnal predators which occupy dens or crevices during the day. The range and availability of spiny lobsters vary greatly throughout the NWHI. Variation also occurs within the main islands of Hawaii. Table 7.1 shows density figures obtained from research cruises prior to commercial exploitation in the NWHI.

Size variation occurs throughout the NWHI chain, with the smallest lobsters occurring at Necker Island (Table 7.2). Comparative biological data are also available on lobsters from Oahu, Midway and Kure Islands (Morris; McGinnis; MacDonald & Thompson).

Additional Discussion

In some lobster species, there is generally a biological "pecking order", whereby the larger and stronger lobsters occupy the best habitat. Thus, smaller lobsters would appear to be more prone to predation.

Observations on the distribution of lobsters in the NWHI are available from NMFS research cruises and from commercial vessels. Numerous observations have been made for Necker Island, Maro Reef, Midway Islands, Pearl and Hermes Reef, and Laysan Island. The range and availability of spiny lobsters vary greatly throughout the NWHI, with spatial, temporal and size variation.

Since Necker Island is the most heavily fished area in the NWHI, it provides the greatest amount of information on which to base density and sustainable yield estimates. Unfortunately, there is a clear indication in the size data that the lobsters from Necker Island are on the average smaller than lobsters from elsewhere in the NWHI. This was evident even in the early stages of sampling and exploitation, and thus does not simply represent a reduction in the average size usually associated with intensive fishing effort. Because the Necker Island population is of smaller average size it is difficult to make size limit management decisions affecting the entire NWHI on the basis of the Necker Island fishery.

TABLE 7.1 THE POSITION OF THE ISLANDS, BANKS, AND REEFS, TOTAL NUMBER OF LOBSTERS CAUGHT, NUMBER OF TRAP-NIGHTS OF EFFORT EXPENDED, AND CATCH/TRAP-NIGHT OF ALL LOBSTERS INCLUDING LEGALS (8.25 CM OR MORE IN CARAPACE LENGTH), SUBLEGALS, AND BERRIED FEMALES IN THE NORTHWESTERN HAWAIIAN ISLANDS. CATCH DATA ARE FOR OCTOBER 1967-NOVEMBER 1978.

	Position		Total Catch (No.)		
	Latitude (N)	Longitude (W)	Catch	Trap-Night	Catch/Trap-Night
Middle Bank	22°42'	161°02'	0	40	0.00
Nihoa	23°03'	161°55'	255	178	1.43
Nihoa (west bank)	22°58'	162°14'	161	218	0.74
Necker Island	23°34'	164°42'	7,937	1,680	4.72
French Frigate Shoals	23°46'	166°18'	140	359	0.39
St. Rogatien Bank	24°25'	167°15'	41	59	0.69
Gardner Pinnacles	25°01'	167°59'	307	209	1.47
Raita Bank	25°35'	169°35'	169	92	1.84
Maro Reef	25°29'	170°35'	2,684	663	4.04
Laysan Island	25°42'	171°44'	575	341	1.69
Pioneer Bank	26°00'	173°25'	0	24	0.00
Lisianski Island	26°02'	174°00'	9	179	0.05
No-name Bank #8	26°17'	174°34'	0	24	0.00
Salmon Bank	26°56'	176°28'	2	48	0.04
Pearl and Hermes Reef	27°48'	175°51'	232	236	0.98
Midway Islands	28°12'	177°22'	576	280	2.06
Kure Island	28°25'	178°25'	158	240	0.66
Total			13,214	4,835	2.73

It is quite evident that spiny lobsters are distributed throughout the entire NWHI chain from Nihoa to Kure. The data also show that the shelves surrounding Necker and Maro Reef were the most productive during the survey period. Necker, because of its proximity to Oahu where the lobster fleet is based, received considerable trapping effort from the commercial boats only months after the Cromwell obtained catch rates as high as 17.80 lobsters/ trap-night in some areas around the island during the October-November 1976 cruise. During our surveys, we expended 1,680 trap-nights at Necker and caught 7,937 lobsters or an average of 4.72 lobsters/trap-night.

Maro Reef, which was found to be almost as productive as Necker, was first visited and fished with significant amounts of effort during cruise TC-77-02 (Part III) in May-June 1977. In the course of our surveys, we expended 663 trap-nights and caught 2,684 spiny lobster or an average of 4.04 lobsters/trap-night (Table 1). Curiously, Maro Reef is unlike Necker with conditions. Dives made at Maro Reef during TC-77-02 (Part III) indicated that the bottom there was mostly sand and coral rubble and had virtually none of the habitat features usually associated with lobsters. The substrate at Necker, on the other hand, is largely coral with portions of it consisting of sandstone and sandy patches.

Source: Uchida et al

TABLE 7.2

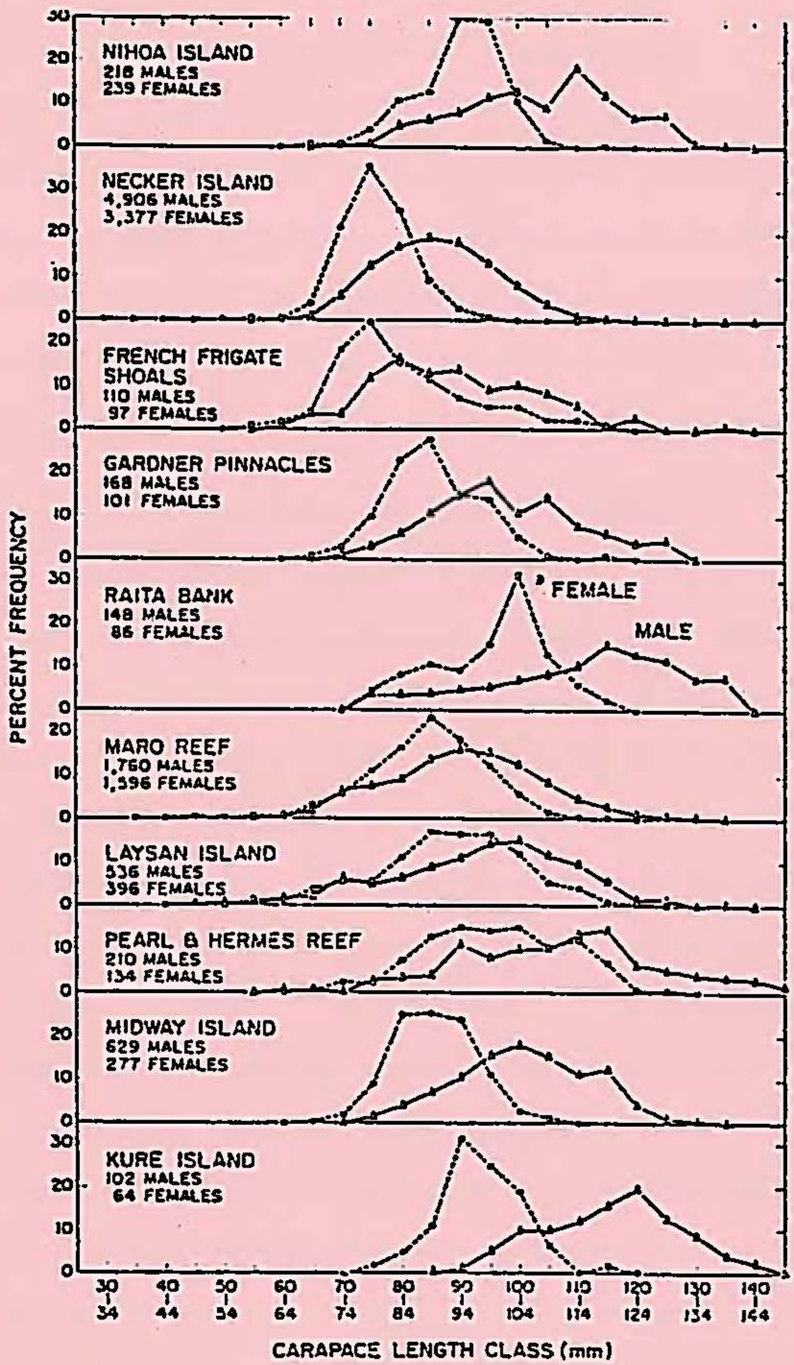


TABLE 7.2 Percentage frequency distributions of carapace lengths of male and female spiny lobsters sampled in waters of the Northwestern Hawaiian Islands, October 1976-November 1978. This data is presented for comparative purposes. There may be a sampling bias against smaller sized lobsters.

Source: Uchida, et al

7.1.5 Relative Abundance

P. marginatus is more abundant in catches than P. penicillatus in the Midway Islands, composing about 98% of the diver-caught lobsters. However, the two species were caught in approximately equal numbers in Oahu trap samples. Because P. marginatus is the preponderant species in the NWHI fishery, biological information in the FMP concentrates on this species (Brock; MacDonald & Thompson).

There are certain unknowns about the lobster populations of the NWHI that are quite important. First, there is almost no information on density dependence factors. That is, it is unknown whether or to what degree fishery removals of lobsters will generate changes in egg production, larvae survival, growth rates, or juvenile survival. Also, we do not know whether a change in the density of P. marginatus may result in increased relative abundance of P. penicillatus, which apparently is less catchable by traps (MacDonald); and if this occurred, the extent to which changes in reproductive capacity and yield per recruit might result is unknown. Also unknown is the extent to which density rates derived from samples are representative of actual density for the full amount of lobster habitat (i.e., 0-100 fm.) at the respective islands. Finally, we do not know the extent of migration undertaken by lobsters from shallow to deep waters as they grow from year to year, or even in a season, as appears to occur in the Gulf of Mexico and South Atlantic (South Atlantic Council); or from lagoons to seaward sides of reefs. Section

11.1 identifies high priority research needs so these factors can be determined.

Additional Discussion

Table 7.1 and the associated notes summarize the results of trap sampling during the October 1976 - November 1978 period. Table 7.2 graphically displays the percent frequency of male and female lobsters by size class in the samples. Appendix 3 presents recent results of a research project at Kure Island, where population size structure, seasonal recruitment of puerulus larvae, and annual growth rates were studied. Observations suggest that lobsters on average are smaller at Necker Island than at Kure Island for all age classes, and for males and females. They also suggest that trap samples generally bias against smaller size classes of lobster; that is, smaller lobsters are apparently more numerous than trap samples indicate. Further, they indicate that lobsters of all sizes and both sexes occur within lagoons, occasionally in fairly dense concentrations.

7.1.6 Life History

In the genus *Panulirus*, the mature male spiny lobster deposits a spermatophoric mass on the mature female's thorax. The viable spermatozoa are released when the female scratches and breaks the mass. The ova are released from the oviduct, fertilized, and attached to the setae of the female's pleopods. The female spiny lobster is then technically termed ovigerous or "berried".

Spiny lobsters are considered to be very fecund. A female

P. marginatus may release from 150,000 to 575,000 ova per spawn, and may spawn four or five times a year around the main Hawaiian Islands; and may release from 91,000 to 852,000 ova two or three times a year around Midway Islands.

Lobsters in the warmer waters of the NWHI south of Maro Reef and throughout the main islands of Hawaii are found to be "berried" year-round, and reproduction is apparently continuous. On the other hand, in the cooler waters at the northern end of the chain, a distinct seasonality occurs, with reproduction apparently occurring mostly in the summer months.

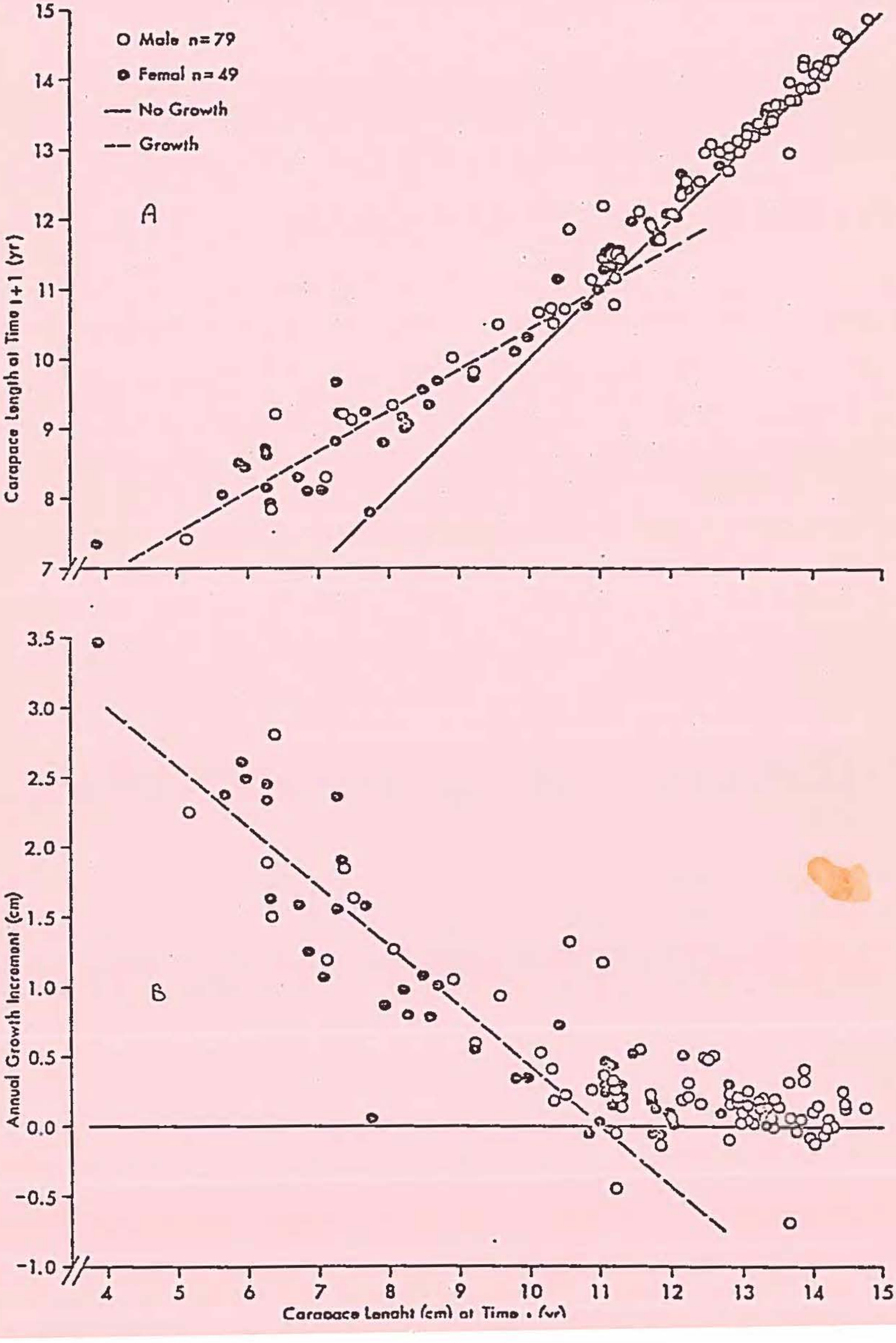
After hatching, the larvae (or phyllosoma) float to the surface and are planktonic. The duration of the planktonic stage differs between species and areas of the world. The mechanisms by which larvae are retained within the various areas of the Hawaiian Archipelago are not yet understood. One study indicates, however, that no genetic differences could be determined between lobsters at different islands, suggesting that there is a single stock in the NWHI (Shaklee).

The phyllosoma stage is followed by the puerulus stage when the lobster can swim horizontally, apparently allowing the animal to enter near-shore areas for subsequent settling. The animals settle to the bottom in sheltered areas and begin to take on their adult form. The relationships concerning egg production, larval survival and settling, and mortality are unknown (McGinnis; MacDonald & Thompson).

The planktonic larval stage can take up to one year from hatching of the eggs. The puerulus stage may take less than six months, after which growth slows. Although some female lobsters are sexually mature as early as 5 cm (2 in.) CL, it may take two years from the settling out process for most lobsters to become reproductively active. Lobsters are thought to live up to ages of 20-30 years, with some reaching a carapace length of 14 cm (5.5 in).

Recent evidence indicates that growth up to 7.0 cm (2.75 in.) CL can occur within 2 years of the onset of the puerile stage which is more rapid than in a variety of other lobster fisheries. Figure 7.1 provides information on growth rates of tagged lobsters at Kure Island (MacDonald, 1980).

FIGURE 7.1 PRELIMINARY RESULTS OF ANNUAL GROWTH.
Craig D. MacDonald, Zoology Department, University of Hawaii.
Panulirus marginatus-Kure Atoll



Additional Discussion

Observations on berried lobsters in aquaria indicate an incubation period for P. marginatus and P. penicillatus of 30 days. A female P. marginatus may release from 150,000 to 575,000 ova per spawning and may spawn four or five times a year around the main Hawaiian Islands and from 91,000 to 852,000 ova up to two or three times per year around Midway Islands. P. penicillatus may release 120,000 to 440,000 ova per spawning and spawn at least twice a year around the main Hawaiian Islands.

The duration of the planktonic phyllosoma stage differs between species and areas of the world. For one species in California waters, P. interruptus, it was determined that the larval stage extended for a period of nearly eight months (Johnson 1960b). Such long larval periods would allow considerable time for wide dispersal of the phyllosoma — depending on the flow of local currents. For an endemic population such as Hawaiian P. marginatus, wherein the adult benthic population cannot be restocked from recruitment of larvae from outside the Hawaiian Archipelago, there must be retention of larvae within the overall area. In the Caribbean it was found that young lobsters grow rapidly to a sexually mature stage, at which point their energy goes into reproduction and growth slows considerably.

7.1.7 Reproductive Potential

Earlier studies of spiny lobster reproductive potential in the NWHI used the frequencies cited in Table 7.2, combined with data on the relative weight of the egg mass in each size class, to estimate the population's reproductive potential. These studies suggested that the majority of reproductive effort occurred in size classes above 8.5 cm CL at Oahu and 9.5 cm CL at Midway. Therefore it was thought that lower carapace length restrictions might imperil the reproductive potential of the population (Thompson and MacDonald).

However, a recent NMFS Honolulu Laboratory study shows a different relationship between size frequencies and reproductive potential. The key difference derives from the method by which the number of female lobsters in the population at each size class is estimated. New information on growth rates recently provided by MacDonald was used to "back calculate" an estimate of the population size distribution from the sampling frequencies. The study estimates a much larger contribution to total reproductive potential for size classes below 8.25 cm CL than had previously been estimated.

The reason for the difference lies in problems with sampling small sized lobsters, which do not enter or do not remain in traps with the same frequencies as larger animals, and with the rapid growth of smaller lobsters.

Based on a revised estimate of population size frequencies, the relative contribution of egg production as a function of female carapace length at three levels of natural mortality is indicated in Figure 7.2. It is estimated that 30%-40% of the eggs produced by all females come from females with a CL less than 7.7 cm (Polovina).

Given information on larval mixing throughout the archipelago and the highly fecund characteristics of lobsters, a minimal carapace length between 7.5-8.5 cm is considered an adequate protection of the lobsters' reproductive potential (see SSC Report, Section 12.3).

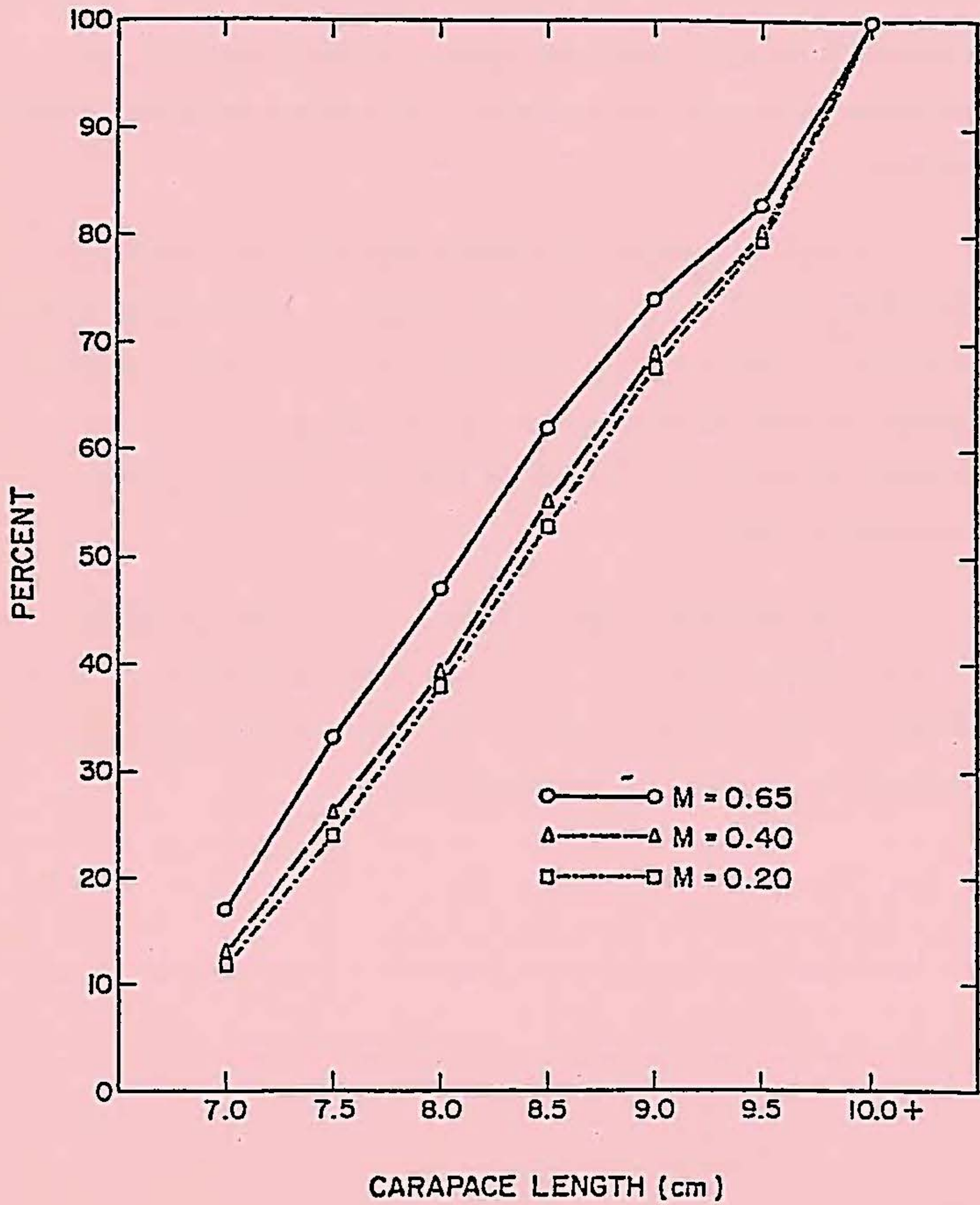
There are cases of lobster fisheries in other parts of the world where reproductive capacity apparently has been maintained even with very high levels of fishing effort and low size limits. In the Australian rock lobster fishery, the minimum size is less than the size of first maturity. A high percentage of legal-sized lobsters apparently is caught each year, and in spite of a limited entry program effected in 1963, effort levels generally exceed the 1963 level. Catches, however, have generally been high and stable since 1968. It appears that yield and recruitment have not differed significantly since 1968 except for year-to-year fluctuations (Morgan).

The fishery off Florida and in the Gulf of Mexico also appears to demonstrate relatively high and stable recruitment and yields in spite of very large increases in fishing effort and probable decreases in spawning. Reported catches have fluctuated very little since 1969. The reported catch is presumably a good index of recruitment since the fishery takes almost all the available recruits each year. It appears that density dependent growth and mortality effects in the juvenile stage absorb most of the fluctuation in postlarvae recruitment (South Atlantic Council).

The fishery at Oahu and other main islands presents a complicated situation. At first glance, even a size limit of 8.25 cm appears to have been inadequate to maintain reproductive capacity. Reported commercial landings have declined steadily since 1949, the peak year. It must be noted, however, that the main Hawaiian Islands fishery is not similar to the NWHI, Australian, or Florida fisheries. The main islands fishery is essentially a sport fishery, and sport catches are not recorded in a systematic fashion. At the same time, there is very limited ability to enforce the size limit for the large number of recreational SCUBA divers who take lobster. The commercial landings are made by fishermen using tangle nets (as do some subsistence and recreational fishers), traps (often incidental to trapping bottomfish), and SCUBA, but none of these fishers are known to be dependent on spiny lobster catches for their income (see Section 7.4). In practical terms, one cannot determine the effect of the size limit now in force; productivity may still be high, but there are no counts of the actual harvest.

FIGURE 7.2 CUMULATIVE PERCENT OF EGG PRODUCTION AS A FUNCTION OF FEMALE CARAPACE LENGTH AT THREE LEVELS OF NATURAL MORTALITY (M) BASED ON REPRODUCTION, FECUNDITY, AND SIZE FREQUENCY ESTIMATES FROM DATA COLLECTED AT SEVERAL LOCATIONS IN THE NWHI.

Source: Polovina



Additional Discussion

Figure 7.1 includes a line of "no growth". This indicates that if a tagged lobster did not grow appreciably during the year between its release and its recapture, it fell along the line of no growth. All lobsters had molted at least once during that year so that growth was possible. Spiny lobsters have potentially long lifespans during which conditions for growth may vary between years. Unless an increase in carapace length was measured during a year that was favorable for growth, the growth of large lobsters would not be readily apparent.

Size frequencies of lobsters sampled at Oahu and Midway Islands are shown in Figure 7.3 and represent a crude measure of the reproductive contribution of each size class to the whole population. However, because of sampling bias against smaller lobsters, the Polovina estimates were required to make better projections of reproductive capacity.

The estimated relative distribution of female lobsters with carapace lengths between 9.0 and 6.5 cm in the Northwestern Hawaiian Islands is indicated in Figure 7.4 which differs significantly from the sampling distribution, as previously noted.

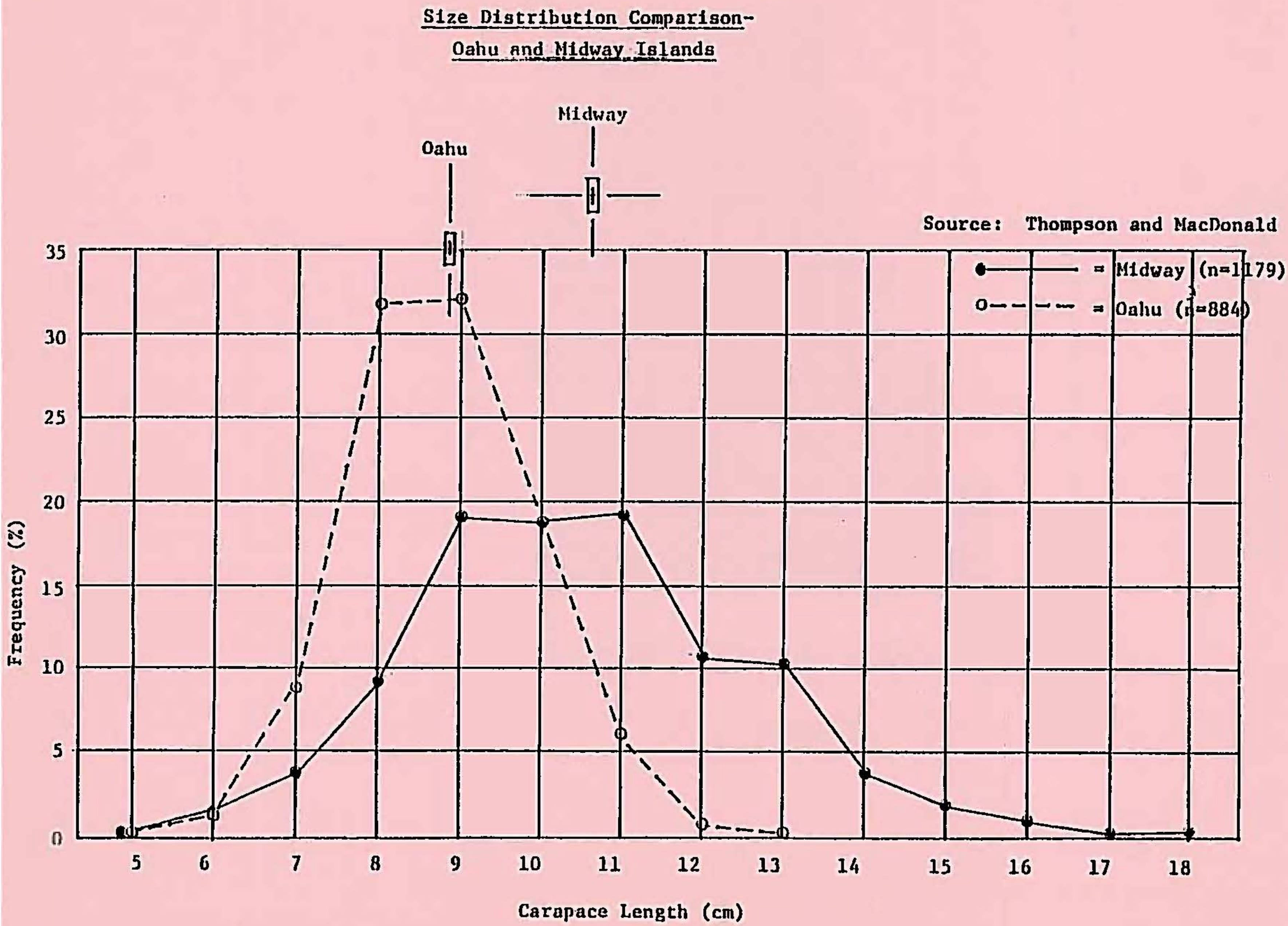
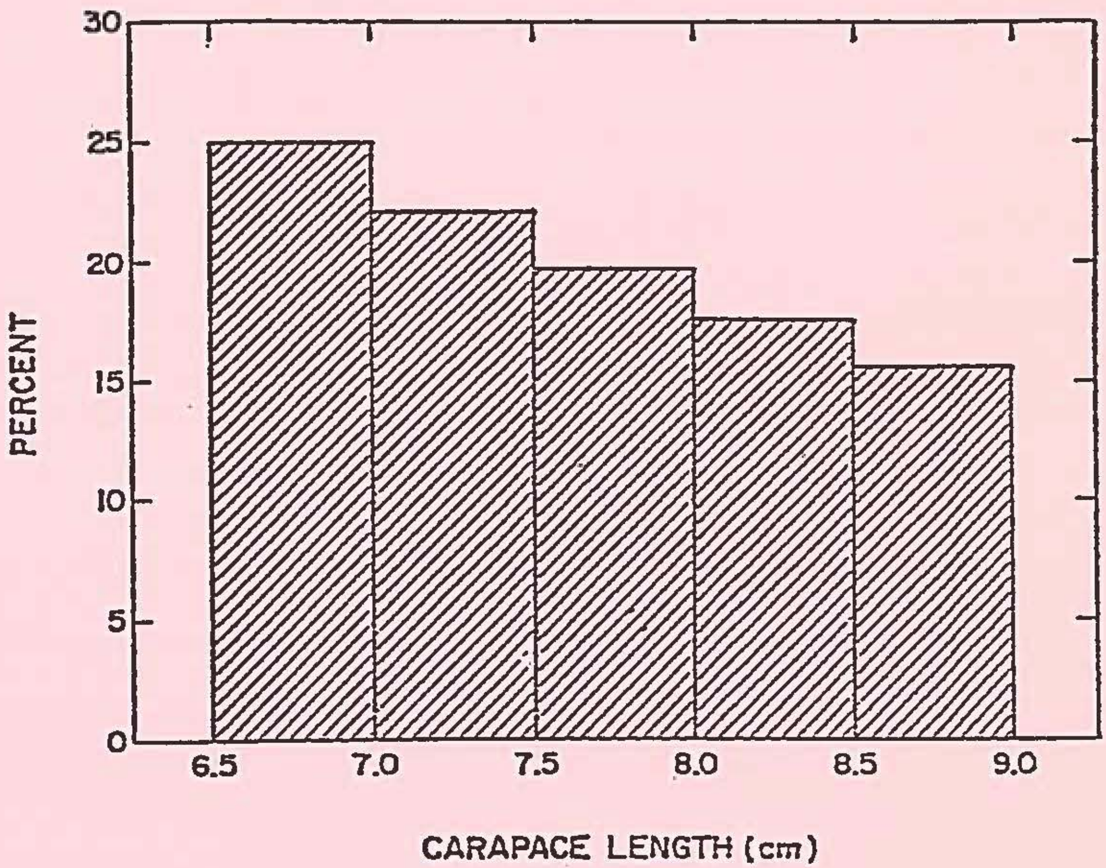


FIGURE 7.3 SIZE DISTRIBUTION COMPARISON - OAHU AND MIDWAY ISLANDS

Source: Polovina

FIGURE 7.4 ESTIMATED RELATIVE SIZE FREQUENCY FOR FEMALES WITH CARAPACE LENGTH FROM 6.5 to 9.0 CM IN THE NORTHWESTERN HAWAIIAN ISLANDS BASED ON ANNUAL NATURAL MORTALITY OF 0.4.



Source: Polovina

7.1.8 Size-Weight and Carapace Length-Tail Width Relationships

The relationships for carapace length and total weight for male and female P. marginatus from various islands in the NWHI are given in Table 7.3. For 7.7 cm (3.1 in.) carapace length lobsters, linear regression equations predict a total weight of 13.3 ounces for males and 14.5 ounces for females. A tail weight of 4.6 ounces for males and 5.5 ounces for females is predicted for 7.7 cm CL lobsters, while average tail segment widths are 4.7 cm and 5.0 cm, respectively. Freezing does not significantly affect weight and length, but tail width has yet to be verified (Uchida, et al).

Discriminant analysis was used on a sample of 1615 lobsters to estimate a decision rule which will classify a lobster as either having a carapace length greater than or equal 7.7 cm (legal) or as having a carapace length less than 7.7 cm (sublegal) based on the width of the first tail segment. The decision rule derived classifies lobsters with a width of the first tail segment equal to or exceeding 4.9 cm as legal and lobsters with a width of the first tail segment less than 4.9 cm as sublegal. Based on the sample of 1615 lobsters classified under this rule, 94.6% of the sublegals were correctly classified and 85.8% of the legals were correctly classified (Polovina, personal communication).

For enforcement purpose, where the fishers measure the carapace length, separate and freeze the tails, and discard the carapaces, and where the enforcement agents have only tail width to insure the size limit is observed, the carapace length to frozen tail width relationship must be verified. There is a natural variation of the relationship between legal length lobsters and their tail sizes. Therefore the Council chose to allow a tolerance factor related to a revised discriminant analysis of percent legals misclassified. This factor and the exact equivalent tail width will be specified in the regulations.

TABLE 7.3 RELATIONSHIP OF CARAPACE LENGTH TO WEIGHT AND WIDTH

Carapace Length	Average Tail Width		Average Tail Weight	
cm	cm		oz.	
	Male	Female	Male	Female
7.70	4.7	5.0	4.6	5.5
8.00	4.8	5.2	5.0	6.1
8.25	4.9	5.3	5.3	6.3
9.00	5.2	5.7	6.5	8.4

Sources: Tail Weight - Uchida, *et al*
Tail Width - Council report

Based on linear regression estimates

7.1.9 Migration and Depth

Data on migration or movements of lobsters are inconclusive. Spiny lobsters in the NWHI undertake some limited local movement within their habitat area, but they do not appear to migrate between islands. Some evidence suggests that their movement offshore and inshore relates to their choice of depth at various ages. However, even this result is uncertain as adult and juvenile are intermixed at most depths at Kure Atoll (MacDonald & Stimson) as well as within the French Frigate Shoals barrier reef (MacDonald). Migration is not considered a major issue at this time.

7.1.10 Stock Strength and Historic Fluctuations

Most of the habitat in the NWHI has not been fished and the stocks have not been affected by fishing, except at Necker Island and Maro Reef. Historic fluctuations in the stocks, based on natural variation and response to fishing efforts, are not yet determined for the NWHI stocks.

7.1.11 Maximum Sustainable Yield

Maximum sustainable yield (MSY) from a stock of fish is the largest average catch per period (usually per year) which can be taken on an indefinite basis from a stock. The basis for the concept of MSY is the fact that a stock of fish will have a net gain in productivity as the stock is fished down, at least to a certain point. A "virgin" lobster stock may produce hundreds of millions of eggs, from which very few juvenile lobsters are recruited and survive to become large adults. Forage may be limiting, or shelter from predation may be limiting, or a combination of factors will limit survival as density increases. Growth may be very slow, and natural mortality rates will likely be high. Hence, in the unfished population, there is probably little correspondence between total egg production and ultimate survival to maturity.

When the stock is fished, however, changes are likely to occur in the stock if density dependence factors occur (which usually is true with such species as lobster). First, there will be an immediate reduction in the number of large, adult lobster and most likely a decrease in the absolute number of eggs produced. Assuming no change in hatching and settling rates, there will be a reduction in the number of puerulus settling on the bottom as juvenile lobsters recruited to the stock. There will probably be a significant increase, however, in the survival rate and growth rate of these juveniles, as competition for forage and for shelter may no longer be limiting. The net effect will be a stock of lobsters which is smaller in numbers than before the start of the fishery, but which is nonetheless more productive (i.e., annual growth is greater than mortality) than the unfished stock (where annual growth equalled natural mortality). It is this growth increment which is being fished.

In theory one can manage a fishery to generate maximum sustainable yield by controlling the time, location, and manner of fishing. In most established fisheries, the MSY for the stock can be derived (albeit qualifiedly) by one or more conventional stock assessment methods. These methods use a combination of data from the fishery (catch, effort, size distribution, sex ratio of catch, etc.) and research data (natural mortality, fecundity, growth rates, etc.) to estimate potential yields. In some cases, MSY estimates can be quite reliable.

This is not the case for the spiny lobster stock of the NWHI. The fishery is relatively new and the history of the fishery is uneven. The fishery has operated (so far as is known) only at Necker Island and Maro Reef. While NMFS sampling results are available for all islands, the level of sampling has not been sufficient to generate precise estimates of lobster densities and size, age and sex distribution of lobsters at all locations.

Preliminary analyses have been conducted to assess potential yields, notwithstanding the inability to derive a reliable and precise estimate of MSY. Polovina and Tagami used a simplified Allen's method with commercial catch and effort data from November 1976 through April 1979 to estimate population size and catchability, assuming the ratio of the rate of natural mortality to the recruitment rate is constant. This produced an estimate of about 132,400 "legal" (i.e., larger than 8.25 cm CL) lobsters in the most heavily fished portion of Necker Island lobster habitat at the start of the period of analysis. Further analysis indicated that the population had declined to 68,571 "legal" lobsters by April 1979. The analysis concluded that a yield in the range of 10,000 - 21,000 legal size lobsters per year may be sustainable with a CPUE of 3.00 lobsters per trap night from the area studied. This can also be expressed as 13.3 - 27.5 "legal" lobsters per km^2 per year.

Polovina and Tagami also raised the possibility that sustainable yields could be much higher with lower carapace length size limits. A Beverton-Holt equilibrium yield equation was used to estimate yield-per-recruit at several levels of fishing effort and several minimum carapace lengths. This study determined that in the majority of situations, a minimum carapace length of 6.75 cm achieved the maximum yield per recruit. In the worst case, a 6.75 cm size limit would result in a 15% decrease in yield per recruit compared to the 8.25 cm size limit; and in the best case, there would be a 167% increase in yield per recruit. The authors cautioned, however, that there is insufficient information to conclude that the level of recruitment will remain unchanged if the minimum size were reduced to 6.75 cm CL. (Polovina and Tagami).

Extrapolation of the Necker Island-Region I estimates of the MSY range to the entire NWHI lobster habitat area provides a range of possible MSY estimates for the full area as follows:

Low: 15,821 km^2 x 13.3 lobsters/km^2/yr = 210,000 lobsters/yr
High: 15,821 km^2 x 27.5 lobsters/km^2/yr = 435,000 lobsters/yr

This range can be adjusted to account for differences in the distribution of lobsters by island based on catch sampling rates (see Table 7.4). This results in the following lower range of possible MSY values:

Low: 200,000 lobsters/yr.

High: 378,000 lobsters/yr.

Yield per recruit analysis demonstrated that sustainable yield from the fishery could be considerably higher with a reduction in the size limit of "legal" lobsters below 8.25 cm CL. The precise magnitude of the impact of different carapace lengths cannot be conclusively determined, but over the set of combinations analyzed, it appears that a 15% increase in yields would be sustainable at a 7.7 cm CL size limit, compared to the 8.25 cm CL size limit (Polovina and Tagami). The increase is in total weight of harvest, and since the 7.7 cm CL lobster weighs less than the 8.25 cm CL lobster, the gain in number of lobsters harvested could be greater.

In summary, a precise estimate of MSY for the stock of the NWHI cannot be determined at this time. The Council has concluded, however, that MSY in the NWHI is likely to be within the ranges of possible MSY levels previously discussed (435,000 to 200,000 lobsters). Inasmuch as the ranges given are based on an 8.25 cm CL minimum size, and yield per recruit analysis suggests there would be higher yields at lower size limits, the range of MSY estimates is probably on the conservative side. It must be emphasized that these ranges do not represent quotas or production targets for the fishery in the short-term or long-term. Harvests above or below the ranges can be expected. Analysis of catch and effort data and research results will be needed to determine more precise estimates of MSY.

There are insufficient data to derive even preliminary estimates of MSY for spiny lobster stocks in the other three areas of fishery.

TABLE 7.4 DERIVATION OF "HIGH" POINT OF RANGE ASSOCIATED WITH MSY AFTER ADJUSTMENT FOR SAMPLING

Area	(1) Sampling* Catch Rate	(2) Weighted MSY/Km2	(3) Km2**	(4) Total MSY
Middle	0	0	172	0
Nihoa	1.43	8.4	695	5838
West Nihoa	0.74	4.3	402	1729
French Frigate Shoals	0.39	2.3	1,152	2,650
St. Rogatien	0.69	4.0	476	1,904
Gardner Pinnacles	1.47	8.5	3,008	25,568
Raita	1.84	10.7	714	7,640
Necker	4.72	27.5	1,913	52,608
Maro	4.04	23.5	2,888	67,868
Laysan	1.69	9.8	556	5,449
Pioneer	0	0	436	0
Lisianski	0.05	0.3	1,250	375
Salmon	0.04	0.3	159	49
Pearl and Hermes	0.98	5.7	835	4,760
Midway	2.06	12.0	364	4,368
Kure	0.66	3.8	66	251
Other	2.73	15.9	1,235	19,637
			15,821	200,694

* Sample catch rate from Table 7.1

** Km^2 from Table 7.5

$$\text{Column 2} = \frac{\text{Column 1}}{4.72} \times 27.5$$

Column 4 = Column 2 X Column 3

27.5 = "higher" MSY/km^2 at Necker

4.72 = Necker sample catch rate

TABLE 7.5 AREA BY DEPTH IN NWHI*

Area	Km2 0 - 10 fm	10 - 100 fm	0 - 100 fm
Nihoa		694.9	694.9
West Nihoa		402.0	402.0
Necker		1913.2	1913.2
French Frigate Shoals	612.9	538.8	1151.7
St. Rogatien		476.4	476.4
Gardner Pinnacles	7.6	3000.4	3008.0
Raita	15.9	697.9	713.8
Maro	500.5	1887.6	2388.1
Laysan	73.4	482.2	555.6
Pioneer		436.1	436.1
Lisianski	328.2	922.2	1250.4
Pearl and Hermes	407.8	426.7	834.5
Midway	95.9	268.4	364.3
Other Areas		1632.1	1632.1
TOTAL	2042.2	13,778.9	15,821.1

* Area by depth is not a precise calculation, especially since the contours of the NWHI are still being explored and charted. The data provided is the Council's best estimate. One km^2 is an area 1000 m. x 1000 m. or about .39 times as large as one square mile.

Additional Discussion

Attainment of the theoretical MSY for a stock depends on the ability to exercise full control over fishing practices. For example, there will normally be a trade-off possible between size and numbers of lobsters caught. The fishery can take a small number of larger lobsters, or a large number of smaller lobsters. The magnitude of the trade-off in terms of total poundage yield and numbers of lobsters will depend on growth, natural mortality, and reproductive rates of the exploited stock. A qualitative comparison of the trade-off in an exploited stock, assuming most lobsters reaching the size limit are harvested each year, is as follows:

Choice	
Large minimum size	Fewer lobsters available to fishery
	Greater yield per lobster caught
	More spawners protected
	Loss of lobsters to predation, disease, old age
	Added opportunities for spawning
	More eggs per average spawn
	Fewer spawners to be caught
Small minimum size	Larger number of lobsters available to fishery
	Smaller yield per lobster
	Fewer spawners protected
	Less loss to natural mortality
	Fewer opportunities to spawn

Fewer eggs per average spawn

More spawning lobsters to be caught

New data on the lobster population at Kure Atoll have become available in recent months, but the extent to which these are representative of all the NWHI is unknown. For example, on average, lobsters at Necker Island are smaller than lobsters at Kure Atoll and some other NWHI locations. This may reflect differences in environmental conditions, in density and distribution of lobsters, or some combination of factors. Studies are underway to determine these differences.

Other estimates of MSY for P. marginatus can be obtained by examining production rates for the closely related species, P. argus in the western central Atlantic.

The Puerto Rican fishery has shown an MSY density of 118.5 pounds of lobster/km^2, and that in the Bahamas ranged from 72.4 to 96.2 pounds/km^2. (An 8.25 cm CL lobster in Hawaii weighs about one pound.) The State of Hawaii Fisheries Development Plan used such comparison to estimate MSY in the NWHI at 1.4 million lobsters annually. (Hawaii FDP).

Experience at Oahu indicates that lobster stocks subjected to heavy pressure need not experience catastrophic declines if properly managed, even though the reported commercial lobster catch has fallen substantially over the 25 years following World War II (perhaps more than offset by increased recreational and subsistence catches).

Although evidence on spiny lobster life history and reproductive behavior is still sketchy, the best evidence suggests that the population in the NWHI can be adequately protected if its reproductive potential is maintained at a sufficiently high level.

7.1.12 Interspecies Relationships

The NWHI fishery for spiny lobsters is based almost exclusively on P. marginatus while catches of P. penicillatus remain incidental. It is entirely possible, however, that the relative importance of P. penicillatus will increase as a direct result of increased exploitation of P. marginatus if these species are competitors for food and shelter. A similar inter-action may occur with slipper lobsters (MacDonald & Thompson; MacDonald & Stimson).

Both species exhibit the same depth distribution from shore to approximately 100 fm throughout the Hawaiian Archipelago and they are very likely to demonstrate similar shelter preferences. In view of the apparently similar ecological requirements, a reduction in the number of one species may result in preempting of resources by the other with a subsequent increase in its relative abundance. There is evidence to suggest this has happened to the spiny lobster species at Oahu and that a similar shift is liable to occur throughout the island chain as fishing pressure intensifies in the NWHI.

If interspecific competition largely determines the population size of P. penicillatus in Hawaii, P. penicillatus can be expected to increase in economic importance in the NWHI as the fishery grows.

In that eventuality, however, the concept of single species maximum sustainable yield will no longer be applicable to determining optimum harvesting levels and an understanding of biology of P. penicillatus sufficiently detailed to be directly comparable to what is known of P. marginatus will be required. The inter-species role of slipper lobsters (family Scyllaridae) and Kona crab (family Raninidae) are not yet known.

7.2 Habitat

7.2.1 Condition of Habitat

Lobsters are found throughout the Hawaiian Archipelago which comprises a group of islands, reefs and shoals extending southeast to northwest for about 1500 nautical miles. The main Hawaiian islands to the southeast are volcanic domes, while extending to the northwest are the NWHI comprising 26 islets, reefs and shoals. Most of the islands lie in tropical water, although the northernmost, Midway and Kure, experience cooler winter temperatures. Reef building coralline algae and coral flourish throughout the archipelago.

In most of the areas covered by the management plan, the environment is characterized by very little pollution or disturbance from industrial or agricultural activity; by absence of concentrated human habitation; and by absence of intensive fishing of any kind. There are no known threats to the condition of this habitat through construction, dumping, dredging, or other activities.

Because the inshore or shallow-water areas are either located along the sides or on summits of steep undersea mountains, shallow areas are limited in the Hawaiian Archipelago. For the same reason the habitat within depths where spiny lobsters are usually found is limited. The total bottom area of the NWHI in depths less than 100 fathoms is about 15,800 km^2 (see Table 7.5).

Not all areas within this total are equally suitable for spiny lobsters. The species is normally found in abundance only where there are numerous boulder and coral formations offering cracks, crevices, and other types of shelter. Specific sites where densities are high are only beginning to be identified.

Additional Discussion

Observations made off the west coast of Oahu indicated the presence of at least three well-defined submarine terraces: (1) the Lualualei Terrace, deeper than 180 m, (2) the Mamala Terrace at depths of 70 to 120 m, and (3) the Penguin Bank Terrace shallower than 70 m. Vertical and near-vertical rock escarpments, in many places over 35 m high, separate the Mamala Terrace from the Lualualei Terrace. Between the Penguin Bank Terrace and the Mamala Terrace a broken line of reef rock outcrops from 5 to 10 m in height and generally aligned parallel to the shore extended up above the level of the terraces. On the shelves in depths less than 12 m large sand "channels" and interconnected sand patches were present. Presumably, more or less similar formations are present around the other islands in the Hawaiian chain.

The Hawaiian Archipelago is located near the northern edge of the Pacific North Equatorial Current, which is a westerly component of the large anti-cyclonic circulatory pattern that dominates the north Pacific Ocean. As the water flows past the islands it breaks up downstream of the islands into large, semi-permanent eddies, some cyclonic and others anti-cyclonic. Closer to shore the semi-permanent currents and eddies are acted upon and sometimes completely dominated by strong tidal currents.

In the near shore or reef habitat, in addition to the chemical composition of the water and the amount of light, which ordinarily varies with depth, the environment is influenced by wave action and the nature of the sea floor and the adjacent land. The effect of land is primarily that of the volume and character of the freshwater runoff from land into the sea. As for temperature, the inshore habitat does not experience a wide fluctuation, at least in the southern part of the Hawaiian chain; the inshore shallow-water temperature ordinarily ranges from about 24° to 27°C.

Midway Island and Kure, which is the most northerly located atoll in the world, lie outside of the area usually defined as the tropics and experience colder winter temperatures than the more southerly located islands in the Hawaiian Archipelago. In spite of their northerly location, however, reef building coralline algae and corals flourish and the groove and buttress structures typical of tropical reefs are well developed.

The deeper benthic habitat may be subjected to greater fluctuations in temperature and chemical composition of the water. The thickness of the mixed layer is influenced by the velocity and duration of the wind. During periods when the trade winds tend to be less vigorous the isothermal layer may be only about 30 to 45 m thick and the water temperature at that depth may be as high as about 25° or 27°C.

7.2.2 Areas of Concern

The spiny lobster grounds around the main Hawaiian islands mostly lie within the State's jurisdiction. In the NWHI, while the extent of waters under State jurisdiction is disputed (see Section 7.3.2) the fishery is largely within the FCZ. This jurisdictional relationship is a point of concern to the Council, which seeks to increase inter-jurisdictional cooperation.

The impact of the spiny lobster fishery on the habitat of endangered species and other elements of the flora and fauna of the NWHI is also a concern of the Council. The HINWR refuge is an onshore reserve but the offshore area, whether in State or FCZ waters, provides an area for interaction between a fishery and wildlife. The proposed management measures seek to achieve long-term protection of this environment.

7.2.3 Protection Programs in Effect

The State of Hawaii and the Territories of Guam and American Samoa retain jurisdiction over fishing within their territorial seas, and over all fishing by vessels registered under the laws in the respective jurisdictions, so long as their regulations are not in conflict with Federal regulations to implement a FMP. The State of Hawaii has regulatory measures for the spiny lobster fishery in waters under State jurisdiction which prohibit use of spears, taking lobsters smaller than 3.25 inches (8.25 cm) carapace length, taking berried lobsters, or taking lobsters during the months of June, July and

August. Lobsters must be landed whole. In the territorial sea of the NWHI spiny lobsters may be taken during the closed season with a special permit; but the minimum size limit still applies. A special permit is also required to land frozen tails, but lobsters taken in the FCZ are currently regarded as "imports" to Hawaii and are not subject to State fishing regulations. A State import license is required.

Guam prohibits the capture of lobsters under one pound, or berried lobsters during May, June and July. American Samoa has no regulations.

7.2.4 Tern and Midway Islands

The status of proposed fishery support services at Midway and Tern Islands is uncertain at this time, but success in developing these islands as fishery stations would change the nature of commercial (and perhaps recreational) fishing effort in the NWHI. Midway Island has been used as a refueling and transfer station for albacore tuna trollers in the Northern Pacific fishery.

7.3 Fishery Management Jurisdiction

7.3.1 Boundaries

Seaward boundaries of the FCZ in the Western Pacific have been defined by the Department of State for most areas. The only portion of the boundary not yet established is the FCZ around American Samoa. However, a treaty defining this boundary has been proposed for ratification by the U.S. Senate.

Legislation is pending in Congress to include the Commonwealth of the Northern Mariana Islands as a voting member of the Council. An amendment to the FCMA to include the FCZ of the Pacific islands of Wake, Howland, Baker, Jarvis, Johnston, Palmyra, Midway and Kingman Reef within the Council's jurisdiction is also being considered.

7.3.2 Status of the Northwestern Hawaiian Islands (NWHI)

Hawaiian Islands National Wildlife Refuge (HINWR)

The HINWR is administered by the U.S. Fish and Wildlife Service (FWS) of the Department of the Interior. The refuge islands in the NWHI include: (1) Nihoa Island, (2) Necker Island, (3) French Frigate Shoals, (4) Gardner Pinnacles, (5) Maro Reef (entirely submerged except for a single rock extending about 2 feet above high water), (6) Laysan Island, (7) Lisianski Island, and (8) Pearl and Hermes Atoll. Kure Atoll and Midway Islands are not part of the HINWR. Offshore waters are not included in the HINWR.

Commercial fishing is prohibited within the boundaries of the Refuge. The FMP's recommended area restrictions for lobster fishing (prohibition of fishing within lagoons and in waters shallower than 10 fathoms around all of the NWHIs) are fully consistent with U.S. Fish and Wildlife Service regulations governing uses of the refuge.

Midway Islands

The Midway Islands, lying at the northwest end of the NWHI, is a "possession" of the United States, administered by the U.S. Navy. Entry to Midway is strictly prohibited unless authorized by the Secretary of the Navy. Midway is not a part of the State of Hawaii nor of the HINWR. The plan recommends that complementary management measures be adopted by the Navy to control fishing by Navy personnel within the 5-mile Naval Defensive Sea Frontier around Midway Islands.

State of Hawaii Seabird Sanctuary

Kure Atoll, the northernmost island of the NWHIs, is a State Seabird Sanctuary administered by the Hawaii Department of Land and Natural Resources. State regulations govern fishing in waters under State jurisdiction around Kure, including recreational fishing for lobster by Coast Guard personnel at the LORAN station at Kure.

Boundaries of State of Hawaii

With the exception of Midway, each of the NWHIs is a part of the State of Hawaii.1/ As such, they are bounded by a territorial sea which is under the jurisdiction of the State.

The extent of the State's territorial sea is a matter of

1/ See Appendix 6 for State of Hawaii position on jurisdictional authority.

some controversy between the State and the Federal government. Hawaii's 1978 Legislature called for a moratorium on Federal "encroachment" on the State's territorial waters. The dispute includes not only the extent of Federal control of waters in the NWHI but also concerns the waters between the islands of the Hawaiian Archipelago, which Hawaii considers inland waters under the jurisdiction of the State. No resolution of this dispute is anticipated in the near future, and its relevance to the spiny lobster fishery is limited. The State of Hawaii and the Council are cooperating in developing complementary management and conservation measures for the entire region so this FMP can be effective.

7.3.3 Environmental Protection

Marine Mammal Protection

The Marine Mammal Protection Act of 1972 (MMPA) imposes a moratorium on the taking of marine mammals and includes provisions prohibiting harassment of marine mammals. Permits may be granted for the incidental "take" of marine mammals in commercial fishing operations, provided these are not endangered marine mammals. Non-endangered marine mammals found in the areas in which lobster fishing occurs include the bottlenosed dolphin (*Tursiops trancatus*) and the Hawaiian spinner dolphin (*Stenella longirostris*).

Endangered Species

The Endangered Species Act of 1973 (ESA) prohibits the taking or harassment of any species declared as endangered.

As indicated earlier, several species listed as endangered or threatened under the ESA are resident in or occasional visitors to the NWHI, including the sperm whale (Physter catodon), humpback whale (Megaptera novaeangliae), Hawaiian monk seal (Monachus schauinslandi), hawksbill turtle (Eretmochelys imbricata), leatherback turtle (Dermochelys coriacea), and green sea turtle (Chelonia mydas). Of these species, only the Hawaiian monk seal and green sea and leatherback turtles are believed to be possibly impacted by lobster fishing.

The potential impacts of lobster fishing on monk seals are: injury or mortality from entanglement in traps or other lobster fishing gear; harassment from increased frequency of contact with fishing vessels in the NWHI; and adverse impacts (direct and indirect) from possible decreased availability of lobster as a food source.

Injury or mortality from gear entanglement has not been reported to date. No incidents of any injury have been recorded or reported either by fishers or by observers of commercial operations in the NWHI.

Harassment has not been a problem to date. The number of vessels involved in the fishery, and the number of fishing trips within the NWHI, have been low. Most of the fishing until 1980 occurred at Necker Island where the count of monk seals has increased in recent years(NMFS). Also, most of the fishing has occurred in the FCZ, more than three miles from shore.

The potential for adverse impacts on monk seals from a reduced supply of spiny lobsters cannot be determined with confidence. Monk seals apparently feed on a variety of food sources, one of which is spiny lobster. The importance of spiny lobster relative to other sources is unknown. Under this FMP, however, there appears to be relatively low risk of any impacts.

There seems to be little likelihood that removal of spiny lobsters will result in adverse impacts on monk seals but the Council recommends that NMFS continue and even accelerate food habit studies to address this issue.

The green sea turtle could be adversely affected by gear entanglement if tangle nets, explosives or chemicals are permitted; they would not be permitted in the NWHI under the FMP. There is a major breeding colony of green turtles at French Frigate Shoals. Predation on hatchlings could occur if they are attracted to boats with lights on at night in the NWHI. There could be an occasional entanglement of a turtle in lobster traps or lines. The plan provides for reporting of such incidents if they occur.

The four species of endangered birds in the NWHI are the Laysan duck (Anas wyvilliana laysanensi), Laysan finch (Psittirostra cantans cantans), Nihoa millerbird (Acrocephala familiaris kingi), and Nihoa finch (Psittirostra contans ultima). These will not be affected by the fishery operating under the FMP.

The long-term, cumulative impacts of expanded fisheries in the NWHI cannot be determined with any confidence. Fishery yield potentials above present harvest levels have been estimated to range from 60 to 104 million pounds per year for all Hawaiian fisheries, including open ocean tuna fisheries (Hawaii Fisheries Development Plan). The same source indicates planned growth of the fleet could result in 105 new vessels by the year 2000. Most of the increase would be for tuna fisheries and quite far from the NWHI.

Concern also has been expressed that as general NWHI fishery expansion occurs, there will be increased risk of interactions with marine mammals and turtles from unauthorized landings on the NWHI for emergency or other purposes. This is beyond the control of the Council under this (or any other) FMP. The Council's authority is limited to the particular fishery being managed under a FMP, and to only that part of a fishery in the FCZ. The Council notes, however, that U.S. Fish and Wildlife Service and State of Hawaii regulations governing landings on and use of NWHI resources are very strict. The Council believes current controls are sufficient to protect against harassment, disturbance, or other events unfavorable to NWHI species.

Additional Discussion

In response to a request in 1975 for comments and recommendations concerning a NMFS proposal to designate the monk seal as "depeleted" under the MMPA, the Marine Mammal Commission (MMC) recommended that NMFS designate the monk seal as depleted under the MMPA and as "endangered" under the ESA. This was done by NMFS in 1976.

Areas which historically represented major breeding and hauling out habitat (e.g., Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island) have experienced substantial population declines (NMFS, 1980). At Laysan, some 50-60 monk seals died in 1978 of unknown causes. At French Frigate Shoals and Necker Island, on the other hand, population increases have occurred. There is apparently little interisland movement of seals of all ages, suggesting that a geographic shift in abundance has occurred. This may be due to low survival of young in the western island populations and high survival of young at French Frigate Shoals and possibly Necker Island (NMFS, 1980).

One study indicates that pups make daily sorties from the beaches for three months after weaning, presumably to feed. They are seen in waters in close proximity to shore. After four months, pups begin spending up to ten days at a time away from their home island. Females, on the other hand, have been observed to leave an island immediately after weaning for at least 20 days. They leave in an emaciated condition and return in relatively good condition. After a one to four day stay, they leave for about 20 more days, reappearing well nourished. They are assumed to be feeding during these trips.

Lobsters are known to occur within lagoons as well as on the seaward banks of reefs and islands. These would not be subject to exploitation under Fish and Wildlife Service and State regulations in the HINWR. Second, both in the FCZ and in waters under State jurisdiction, the fishery would not be permitted within 10 fathoms, which probably includes the majority of the seals' foraging areas. Third, the plan is designed to protect the reproductive capacity of the lobster stocks. There would be a shift in size distribution of lobsters in areas subject to fishing, but there likely will be an increase in the survival rate of juvenile lobsters (a normal density-dependence response to a fishery). Absolute lobster population levels probably would decrease where the fishery occurs, but not in other areas, some of which will be in waters deeper than 10 fathoms. It should be kept in mind that many parts of the FCZ and State waters may have fishable lobster concentrations but have not been fished yet by fishermen. Other areas may have concentrations insufficient to attract fishing effort but sufficient to provide forage for monk seals and other predators. Finally, it may be that a fishery removing one biomass component will provide room for increases in numbers of other components. Removal of P. marginatus may provide space and food for the less trapable P. penicillatus or for Scyllaridae or for other marine species equally edible by monk seals.

A single leatherback was found entangled in a lobster trap line near Kure Atoll in 1980 but was released alive. In fact, the vessel owner/operator personally jumped into the water to release the turtle by hand with no apparent injury to the turtle. Turtles have been reportedly been taken on foreign longline fishing gear in the Pacific. There is potential for future harm to or disturbance of individual turtles exists under any future outcome, regardless of this FMP. Turtle hatchlings have been observed being attracted to boats with lights on at night (J. Naughton, pers. comm.). Whether this would occur with subsequent risk of mortality from predation is unknown.

It seems unlikely that this FMP will generate investment in a large number of new vessels directed primarily at the lobster fishery. Success (or failure) of vessels now in the lobster fishery may generate optimism (or pessimism) about future development prospects in the NWHI in general; but the range of harvest potentials under the measures proposed in this plan is, in the Council's view, sufficiently conservative that there will not be a substantial increase in the number of vessels in the lobster fishery and that monk seal or sea turtle harassment or taking would be unlikely.

Proposals for Designation of Critical Habitat for the Hawaiian Monk Seal

Under the authority of the ESA, the NMFS has proposed the designation of critical habitat for the Hawaiian monk seal in the NWHI. The draft EIS for this action proposes that all beach areas, lagoons waters, and surrounding water areas out to a depth of either (a) 10 fathoms, (b) 20 fathoms, or (c) three nautical miles around Necker Island, French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Island and Kure Atoll be designated Critical Habitat under the Act. No restrictions on human activity were proposed. To complement the critical habitat designation, the NMFS proposed to establish a monk seal recovery team to prepare a comprehensive research and management plan for the Hawaiian monk seal (Recovery Plan). The recovery team has been named, but the Recovery Plan has not yet been submitted to nor adopted by NMFS. The NMFS also indicated it would continue to work with the State of Hawaii and the U.S. Fish and Wildlife Service in carrying out the Tripartite Cooperative Agreement for the Survey and Assessment of the Living Resources of the Northwestern Hawaiian Islands.

The 10-fathom alternative for monk seal critical habitat would cover approximately 1260 km^2 according to the draft EIS, while a 20-fathom isobath seaward extension of a monk seal critical habitat would encompass about 4,095 km^2 or over 25 percent of the total spiny lobster habitat. The 3-nautical-mile alternative (2523 km^2) would be only sixty percent as large as the 20-fathom option.

Additional Discussion

It is important to bear in mind that NMFS did not propose any specific controls on fishing or other activities under any of the Critical Habitat alternatives. As the DEIS notes, "The designation of Critical Habitat is not equivalent to the establishment of a wilderness area or wildlife sanctuary, and does not automatically close an area to all or most human uses" (p. 13). The Critical Habitat designation essentially requires only that Federal agencies exercise even more care in their actions by engaging in Section 7 consultations if those actions may affect some component of the area designated as Critical Habitat.

Section 7 Consultation

The Council requested consultation with NMFS under Section 7 of the ESA to determine whether the actions proposed in this FMP will jeopardize the continued existence of any threatened or endangered species or will adversely modify any Critical Habitat. A biological opinion has been prepared and is included in this Source Document.

The biological opinion concludes that there is insufficient information to demonstrate conclusively that the proposed action will not jeopardize the continued existence of the monk seal and sea turtle populations of the NWHI. Implementation of the FMP, however, is preferable to the "no action" alternative because the FMP offers safeguards that reduce the potential of adverse impacts. The biological opinion made several recommendations regarding research, monitoring, and establishment of a provision for controlling fishing to investigate the courses of any seal or turtle mortality.

The biological opinion (as well as other reviewers) also indicated the importance of complementary management in waters under the jurisdiction of the State of Hawaii. There has been considerable progress in drafting State regulations to complement FCZ regulations, and the Hawaii Department of Land and Natural Resources has expressed its intent to proceed with such regulations.

7.3.4 Coastal Zone Management (CZM)

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 fishery resources.

Section 307 (c) (1) of the CZMA requires that all Federal activities which directly affect the coastal zone be conducted in a manner which is consistent with approved State coastal zone management programs to the maximum extent practicable. The State of Hawaii and the Territories of Guam and American Samoa all have federally approved State CZM programs. This fishery management plan, therefore, must be reviewed to determine if the measures proposed will or are likely to affect the coastal zone, and if so, whether the proposed measures are consistent with each State's program. The Source Document, provides the full text of these determinations of consistency, and copies of the plan are being sent to each CZM program director for concurrence.

Hawaii: Full Text

A federally approved CZM program has been in effect in Hawaii since 1978 and was set into law by Chapter 205A of the Hawaii Revised Statutes. Hawaii CZM Program Objectives and policies which are applicable to lobster fishing and associated activities include:

1. Coastal Ecosystems - Protect valuable coastal ecosystems

from disruption and minimize adverse impacts on all coastal ecosystems.

a) Improve the technical basis for natural resource management;

b) Preserve valuable coastal ecosystems of significant biological or economic importance.

2. Economic Uses - Provide public or private facilities and improvements important to the State's economy in suitable locations. Permit coastal dependent development outside of presently designated areas when:

a) Utilization of presently designated locations is not feasible;

b) Adverse environmental effects are minimized; and

c) Important to the State's economy.

3. Managing Development - Improve the development, review process, communication, and public participation in the management of coastal resources and hazards.

Although the CZM plan does not explicitly refer to the FCZ in either the main Hawaii islands or the NWHI, the spirit of the FCMA suggests that such considerations should be addressed.

A significant problem which would arise if there were conflict between the Council's implementation of the FCMA and the State's actions under the CZM Act concerns the definition of jurisdictional authority; that is, the question of the limits of the territorial sea, generally considered to be the "three-mile limit", and the State of Hawaii claim for archipelagic status and jurisdiction throughout the Hawaiian Islands (see Section 7.3.2). However, since the Council is working with the Hawaii Division of Fish and Game to develop regulations which are consistent and complementary, there is no problem in this regard.

The FMP and the management measures selected by the Council are considered consistent with the policies outlined in Hawaii's CZM Program. In particular:

1. Coastal Ecosystems

   a) Technical basis: The FMP proposes a thorough information-gathering scheme to obtain base-line data on lobster resources in the NWHI, the offshore areas in the NWHI, and in the offshore areas of the main Hawaiian islands. Observers which may accompany lobster vessels may be able to provide much more detailed observations of the ecological interrelationships in the NWHI than has been possible to date.

   b) Preserve ecosystems: The FCMA requires that biological overfishing be avoided. The various management measures proposed for the NWHI would provide protection for the reproductive potential of spiny lobsters and would promote the recovery of Hawaiian monk seal and leatherback and green sea turtle populations. Conservation and management measures would be applicable to all vessels in the FCZ. State landing laws are currently not applied to Hawaii-registered fishers by the State of Hawaii for lobster caught outside the territorial sea, nor to any out-of-state vessels.

The FMP includes extensive measures to protect the endangered Hawaiian monk seals, including gear restriction (only traps will be allowed); prohibition of fishing in waters shallower than 10 fathoms, which goes beyond existing State of Hawaii fishing regulations; and a 20-mile closure in the FCZ around Laysan Island, which would provide an excellent biological and ecological baseline in the NWHI. The FMP also recommends that biological research be undertaken on lobster resources in the NWHI, including ongoing monitoring of the resource through catch and effort data and through experiments with larval collectors.

Although neither the Hawaii State Plan nor the CZM Program make specific provisions for the priority of the fishing industry within marine resource management and development, the Hawaii Fisheries Development Plan prepared in 1979 sets priorities for developing the NWHI fishery, including the lobster fishery, which is considered to be the leading edge of commercial development for the State of Hawaii fisheries program.

2. Economic Uses: Permit Coastal Development

   a) Although the FMP may be viewed as a stimulus for commercial fisheries development in the NWHI, especially with a smaller carapace length restriction than existing State of Hawaii regulations, it also will serve to direct such development away from the apparently fully exploited stocks near the main Hawaii islands.

   b) Environmental impacts are reduced through a variety of the measures incorporated in the FMP.

   c) The FMP is consistent with State of Hawaii economic development goals.

3. Managing Development: Communicate Impact and Increase Public Involvement

   The FMP attempts to integrate the relevant substantive material on the fishery and its management to provide for improved public review of the proposed regulations. By integrating environmental, economic, social and fisheries requirements into a single, concise document, the Spiny Lobster FMP provides the public with a comprehensive review of the potential impacts of the proposed regulatory regime, as well as alternative policies, in a form much less bulky and unweildy as compared to most government documents. The draft FMP was sent to more than 300 individuals, organizations, and government agencies for review and comment.

In summary, the measures proposed in this plan are believed to be fully consistent with the State of Hawaii CZM Program. The plan promotes the achievement of optimum yield in the fishery from both biological and economic viewpoints, while preventing overfishing and protecting the environmental components of social importance in the NWHI. No direct impact on the coastal zone is anticipated as a result of this plan. There may be some indirect effects if expansion of the domestic fishery occurs and additional moorage and processing facilities in the shoreside area of the coastal zone are required; but this is anticipated in the State's Fishery Development Plan, whether or not the FMP is implemented. The FMP does not take or imply a position vis-a-vis Hawaii's claim over "archipelagic" waters.

This "Determination of Consistency" has been prepared for review and concurrence by the Hawaii Department of Planning and Economic Development.

Guam: Full Text

The Territory of Guam CZM Program was approved in August, 1979. The seaward boundary extends to the outer limit of the U.S. territorial sea, i.e., three miles out to sea. Principal activities under the first year implementation grant include master plan implementation for a commercial port; preparation of a Fisheries Management and Development Plan; and increased management of fish and wildlife resources.

The dominant management policy in the CZM program is to achieve economic development within the limits of Guam's natural resource base. The State Plan states: "All living resources within the territorial waters of Guam, particularly corals and fish, shall be protected from over-harvesting and, in the case of marine mammals, from any taking whatsoever".

The GCMP notes the need for more effective administration of natural resource related laws, programs, and policies through improved coordination between territorial and Federal agencies. The GCMP called for providing technical and financial assistance to the Marine Fisheries Advisory Council in preparing a Fishery Development and Management Plan (since completed in draft). Participation in the Western Pacific Fishery Management Council is viewed as a mechanism to promote the full and proper utilization of Guam's fishery resources. Guam has internal laws, regulations, and procedures to establish appropriate regulations for taking and landing spiny lobsters.

The measures proposed in this FMP are consistent with the Guam CZM policies and requirements and lobster fishing regulations. The FMP's recommended management measures which require all commercial vessels fishing for spiny lobsters within the FCZ of Guam to obtain permits and submit catch records are expected to increase the data base for coastal zone planning in the territorial sea.

Given the information available at this time, Guam's regulations appear sufficient to prevent overfishing. The Council's FMP establishes permit and data submission requirements for commercial lobster fishing so that a data base can be built to monitor the fishery. The Council is ready to work with the Government of Guam to insure that timely action can be taken if landing records demonstrate future management problems requiring a cooperative approach.

This "Determination of Consistency" has been prepared for concurrence by the Territory of Guam Bureau of Planning.

American Samoa: Full Text

The Territory of American Samoa CZM Program was approved by the U.S. Office of Coastal Zone Management on September 9, 1980. The seaward boundary extends three miles out to sea from land, excluding Rose Island. Principal activities under the CZM plan include policies for:

i) shoreline development
ii) coastal hazards
iii) fisheries development
iv) slope erosion
v) major facility siting
vi) agricultural development.

The program will be implemented by the Development Planning Office of the Government of American Samoa.

Because the Spiny Lobster FMP does not anticipate commercial development of lobster resources in American Samoa in the near future, shoreside developments which might occur from a growing fishery do not pertain to the FMP. However, the objective of encouraging development of Samoa's fisheries does pertain to the general concerns of the Council.

The CZM Program notes that while the tuna canneries which are the major source of employment in American Samoa, drawing their fish from Korean and Taiwanese vessels, the small local commercial fishing industry has experienced a signficiant decline in the past four years. Furthermore, offshore sport fishing is seen to be extremely limited at this time, despite fishable concentrations of popular sports fish. Approximately 40% of American Samoa's households catch fish for their own use at some time during the year, using the near-shore waters in the traditional manner. The major impediment to the commercial and sports fisheries is said to be limited infrastructure in terms of docking, equipment, and cold storage facilities.

The American Samoa Office of Marine Resources is developing a comprehensive fisheries development plan which is supported by the CZM program. Several surveys are currently underway to assess fishery resources and fishing activity patterns in American Samoa.

The measures proposed in this FMP are consistent with the American Samoa CZM policies and requirements. The FMP's recommended management measures which would require all commercial vessels fishing for spiny lobster in American Samoa's FCZ to report their catch are expected to increase the data base upon which future fisheries management and development can be based, not only in the FCZ but also in the territorial sea. The Council is ready to work with the Territory of American Samoa to insure timely action can be taken if landing records demonstrate the development of a commercial lobster fishery requiring management to prevent over-fishing.

This "Determination of Consistency" has been prepared for concurrence by the Territory of American Samoa's Development Planning Office.

7.3.5 Surveys and Research

The Honolulu Laboratory of the NMFS, the Department of Land and Natural Resources of the State of Hawaii, and the U.S. Fish and Wildlife Service are in midstream of a five-year program to investigate the marine resources of the Northwest Hawaiian Islands. The University of Hawaii is also cooperating in the program. The study program is scheduled to conclude in 1983.

A critical element of the research program is work underway at Kure Atoll and planned at French Frigate Shoals by MacDonald. Current efforts are focusing on growth and reproductive rates, mortality rates, population structure, recruitment, and movement patterns at Kure. Similar work at French Frigate Shoals should help demonstrate differences and similarities between lobsters at the two locations. Data from continuation of this work, in combination with data from other surveys and commercial fishing, should provide a reasonably sound basis for recognizing any significant changes in stock or habitat conditions.

7.4 Description of Fishery Activities

7.4.1 Main Hawaii Islands

The spiny lobster fishery in the main Hawaii islands has been primarily an incidental or recreational fishery since World War II. The commercial catch has declined from a high of 43,632 pounds in 1949 to 6,317 pounds in 1976. Probably this is offset by an increase in recreational catch. The commercial catch is a small percentage of Hawaii's total fishery, and most if not all is caught within the territorial sea.

The main islands fishery also includes a substantial recreational and subsistence catch, but the extent of these fisheries is unknown at this time.

Additional Discussion

Although lobster fishing is conducted around the eight major islands, the bulk of the commercial catch (80%) is made around Oahu, where the bulk of the human population resides. The bottom area between 0 and 100 fathoms lies primarily within the territorial sea, indicating the rapid fall off of Hawaii's coastline. The incidental nature of the spiny lobster commercial fishery is shown by the low total catch of lobster (10,000 lbs.) which have been trapped in any one year in recent periods.

Nets, traps and SCUBA are used in the lobster fishery and catches are almost entirely within three miles of shore. Trap catches are apparently incidental to attempts to catch various species of fish. Most net fishermen drop nets in depths from 1 to 5 fathoms along Oahu's windward (northern) shore while trap fishing occurs along the leeward shore in depths from 5 to 30 fathoms. No full-time commercial fishermen are known to concentrate on spiny lobster in local waters.

A three month fishery feasibility study was conducted by Chany in the summer of 1975 off the east coast of the island of Hawaii. The limited results of the study indicated that a commercial trap fishery for spiny lobster would not likely be economically feasible.

Table 7.6 COMMERCIAL CATCH OF SPINY LOBSTER
STATE OF HAWAII DIVISION OF FISH AND GAME

Year	Pounds Caught	Value
1948	42,370	27,848
1949	43,632	26,869
1950	34,012	17,770
1951	17,230	10,149
1952	18,052	11,088
1953	17,938	11,230
1954	14,999	8,369
1955	16,136	10,677
1956	12,732	7,371
1957	14,392	8,966
1958	9,192	5,964
1959	12,339	7,975
1960	10,473	7,049
1961	12,642	8,542
1962	7,890	5,232
1963	10,277	7,834
1964	9,846	7,895
1965	8,158	6,639
1966	5,481	4,397
1967	4,415	3,676
1968	4,751	4,296
1969	9,250	9,678
1970	5,398	6,205
1971	6,140	7,893
1972	5,349	8,153
1973	5,577	8,229
1974	4,467	7,415
1975		
1976	6,317	11,357
1977	85,839	199,065
1978	33,719	99,087

7.4.2 Northwestern Hawaiian Islands

A research cruise of the NOAA ship R/V Townsend Cromwell during 1975 revealed the presence of high concentrations of lobsters near Necker Island and a few other areas in the NWHI.

Utilization of these resources began gradually in 1976 with a few vessels venturing into the fishery on an experimental basis. Early emphasis was on the fresh, whole lobster market, but this market appeared to have limited capacity.

Between 1976 and 1980, six firms have fished for lobster in the NWHI. Vessels have increasingly utilized on-board processing as a means to overcome the limitations of the fresh market and to take advantage of the international market for frozen lobster tails (see Sections 7.5.2 and 7.6). Participation in the fishery has been limited due to the distance from port to the fishing grounds (500-1500 miles each way) and the uncertainty concerning yield potentials.

Catch data for the NWHI fishery are extremely limited because the small number of firms in the fishery imposes confidentiality restrictions on the publishing of this data. Council estimates, based on a variety of sources, indicates this fishery grew from 72,000 pounds ($208,800) in 1977 to 200,000 - 400,000 lobsters ($680,000 - $1,360,000) in 1980. Estimates of fishing effort are unavilable.

Estimate of NWHI Lobster Landings

	Whole-Weight	Ex-Vessel Price	Revenue
1977	72,000	$2.90	$ 208,800
1978	45,000	$3.00	$ 135,000
1979	100,000	$3.20	$ 320,000
1980	400,000	$3.40	$1,360,000

Sources: NMFS; State of Hawaii Division of Fish and Game; direct interview by Council staff.

7.4.3 American Samoa and Guam

There is no documented commercial fishery for spiny lobster in American Samoa or Guam. Sport and subsistence fishing in inshore and reef waters takes place but catch is believed to be small. Interest has been expressed in developing the spiny lobster fishery in these areas, but the locally-based fishing industries are small and undeveloped at this time.

7.5 Economic Characteristics of the Fishery (revised text)

7.5.1 Harvesting and Processing Sector

The traditional commercial lobster fishery in Hawaii was simply an incidental fishery associated with fish trapping. Volumes of lobster sold prior to the opening of the NWHI fishery were very small, in the range of five to ten thousand pounds during the past ten years. The lobsters were sold whole, and usually alive, through the fresh fish market and directly to retail outlets and restaurants. The NWHI fishery represents a fundamental transformation in Hawaii's commercial lobster fishery.

NWHI Fishery

Six vessels comprise the fleet participating in the NWHI spiny lobster fishery at the beginning of 1981. These vessels are primarily in the 65-100 foot class. Five of the vessels have on-board processing and freezing capabilities. Four of the vessels entered the industry in 1981 from fisheries on the West Coast of the United States. On the other hand, the largest vessel which has participated in the NWHI fishery to date left Hawaii for other fisheries at the end of 1980.

Over the six years since lobsters have been commercially exploited in the NWHI, the fishery has been characterized by volatile participation. Twelve vessels have participated in the fishery; some for only one trip, others on a regular basis throughout the annual fishing seasons. Only one vessel has operated in the fishery the entire period. Table 7.6 describes the entry and exit of firms by tracking individual vessels over the six year period and showing their level of participation in the fishery.

TABLE 7.6 ANNUAL ENTRY AND EXIT OF FISHING VESSELS FOR THE NWHI LOBSTER FISHERY, 1976-1981.[a]

Vessel	Year 1976	1977	1978	1979	1980	1981
A	- - -	———	- - -	———	———	———
B	- - -	———	- - -	*	*	*
C		———				
D		- - -				
E		- - -				
F				———	*	
G					———	
H					———	———
I[b]						———
J[b]						———
K[b]						———
L[b]						———

a Code:

- ——— regular lobster fishing
- - - - occasional lobster fishing
- * participation only in Hawaiian fisheries other than lobster
- (blank) no participation in Hawaiian fisheries

b In Hawaii April, 1981 prepared to fish throughout the season.

Participants in the NWHI fishery first attempted to sell their catch in the fresh fish market. Record landings were made in 1977, when 72,000 pounds of whole live lobsters were landed (Table 7.6). The market became saturated, however, and retail prices fell. The whole lobster market apparently was limited. Several vessels stopped fishing for lobsters in the NWHI, and others spread their effort to a variety of species.

In 1978 and 1979, several vessels attempted to fish for lobsters and process them at sea. The target market was the frozen lobster tail export market, where price is generally established by international market forces. Total landings in 1978 were about 45,000 pounds (in whole lobster equivalent weights), and an estimated 100,000 pounds in 1979.

Three vessels carrying as many as 2500 traps were fishing in the NWHI lobster fishery during the summer of 1980. The combined hold capacity of these vessels was about 340,000 pounds. All three vessels had processing and freezing capacity. Fishing occurred not only at Necker Island but at Maro Reef, about 350 miles farther up the NWHI chain. Total 1980 harvests are unknown, since catch data are being maintained on a confidential basis; but unofficial estimates range from 200,000 to 400,000 lobsters, primarily landed as frozen tails.

The six vessels in the spiny lobster fleet available for the NWHI during 1981 have about 3400 traps and a combined freezer capacity for 1.3 million lobster tails. This represents a major increase during the past two years and indicates that despite the rapid turnover of the fleet, interest in the fishery continues.

7.5.2 Markets

Virtually all of the lobster trapped in the NWHI are processed to frozen tails for the restaurant industry. Most vessels sell to wholesale food brokers who in turn sell the processed product to markets in Hawaii, the mainland U.S. and Japan. One firm has begun to specialize in exporting frozen seafood to the Mainland U.S. and to Japan, and other fishing interests may be attracted to the processing and exporting sector as Hawaii's overall fishery develops. It appears that the Hawaii seafood market system can readily absorb the entire production from the fishery.

The price of frozen lobster tail is determined in an international market by the nature of the product. The cost of transporting frozen tails for international trade is relatively small; and, the product produced internationally is fairly homogenous, at least as consumers perceive the final product. Those firms producing frozen tails face a perfectly elastic demand for these product. Unlike the firms landing live lobster now and in past years, firms can sell all the frozen tails they can produce without lowering the price.

In recent years the world price of frozen lobster tails has been increasing about 18% per year. In 1980 food brokers paid about $8.50 per pound (6-8 ounce tails) for imports from Australia and New Zealand. The 1981 (April) wholesale price is $10.00 per pound (NMFS, Fishery Market News Report N-46). Firms operating in the NWHI fishery should receive this price during 1981 if their product is equivalent to Australia and New Zealand imports. They should receive even more if they incur the extra costs of marketing the product directly to restaurants.

Hawaii's consumers, including tourists, purchased approximately 245,000 pounds in frozen lobster tails (or equivalent dinners), worth about $2.5 million ex-warehouse in 1980. The tails are mostly imported, with Australia and New Zealand being the prime sources. Until recently, domestic production has been a small percentage of the local market. The current wholesale price is about $3/pound for whole lobster.

Only one vessel now serves the live, whole lobster market in a part-time operation. It is unlikely increased production of frozen tail will result in a lower price in Hawaii, even if vessels produce more lobsters than are demanded in Hawaii. Firms will continue to export their catch to Japan or ship to the mainland U.S. to receive the world price rather than drive the price down at home by increasing local supplies of frozen tails.

The market for spiny lobsters in American Samoa, Guam and the Northern Mariana Islands is not known, but based on an equivalent per capita consumption, the market would be 44,000 pounds, worth $452,000 retail.

The NWHI lobster fishery has developed outside the confines of the local fresh fish market by opening the export market in frozen seafood products. Both established and new entrepreneurs are involved in this marketing endeavor, which is indirectly supported by the State of Hawaii.

7.5.3 Employment

Current employment in the spiny lobster fishery fluctuates with the entry and exist of vessels. During 1980 approximately 30 people were employed on the vessels, most of which processed their catch on board. Total employment in the fleet for 1981 is estimated to be up to 50 workers, with an additional 10-15 on-shore. Earned income in 1980 was about $500,000 with total revenue about $1.4 million (Adams, pers. comm.).

7.5.4 Economic Feasibility

The chronology of the NWHI fishery, with peak participation followed by slumps and then renewed interest, indicates the ease of entry into the fishery but the difficulty in maintaining a persistent presence. The economic rewards from the fishery have yet to be determined. Only the marketers and the lone vessel selling whole lobsters have been consistently involved in the fishery.

The State of Hawaii Fisheries Development Plan estimates a catch rate of 938 pounds per day, or about 2.0 pounds per trap night would provide an 80 foot multi-purpose vessel with a marginally profitable operation. Based on historic catches in the NWHI, a compromise catch rate of 2.5 pounds per trap night would create a monthlyoperating profit of $1,265, at 1978 prices.

The fishery remains volatile largely due to the sensitivity of the firms profitability to catch rates. This can be seen by at a graph of minimum feasible catch rates for different mean lobster sizes and different discount rates (Adams). In Figure 7.7, over a wide range of discount rates, say from 0.05 to 0.15, the minimum feasible catch rate is between 1.0 and 2.5 lobsters per trap-night for 4 different lobster sizes. This is developed from a 1978 proposed investment project to harvest and process frozen lobster tails in the NWHIs. For assessing the economic viability of such an investment, the results also show that the economic success of a sustained investment in the fishery will be relatively sensitive to the catch rates. For example, for a 0.375 pound lobster tail, the internal rate of return from the proposed project falls from 10% to 5% if the average catch rate declines from 2.0 to 1.7. In the multi-species case, the relative sensitivity of profitability to catch rate will not change very much as long as lobster sales are the primary source of revenue as the case has been.

FIGURE 7.7 MINIMUM FEASIBLE CATCH RATE BY DISCOUNT RATE AND AVERAGE LOBSTER TAIL SIZE.

Source: Adams. (See Source Document)

7.5.5 Fisheries Development

The State of Hawaii has embarked on an ambitious fishery development program. The State's Fishery Development Plan was approved by the Governor in 1979, and was endorsed by the legislature in 1980, when more than $500,000 was appropriated for fishery development projects. It is estimated that annual Hawaii fishery landings could increase as much as 60 to 104 million pounds over current yearly landings (Fisheries Development Plan). A large portion of this increase (especially high seas tuna) would likely come from fisheries in and even beyond the FCZ around the NWHI.

There are, however, some serious constraints to development of fisheries in the NWHI. The foremost is distance, with the associated time and fuel costs just going to and returning from the NWHI. The 1000-3000 mile round trip may take 5-10 days of transit time for each trip.

Viewed in this context, the spiny lobster fishery has played an important role in NWHI fishery development to date. A few, large, multi-fishery vessels have been able to use the spiny lobster fishery to cover the early costs of exploring the NWHI to locate other harvestable resources. That is, revenues have covered the operating costs of lobster fishing operations so that exploratory fishing for other species could continue even if not at an immediate profit. The relative certainty of catching at least some lobsters has been an inducement to overall increases in NWHI fisheries.

In the future, however, the spiny lobster fishery is expected to stabilize near its current levels of production unless new, high productive grounds are discovered. A major fishery targetting primarily on spiny lobster is not anticipated in the long-term. Most spiny lobster harvesting in the NWHI will probably be done by multi-fishery vessels which spend only part of their time and effort fishing for spiny lobsters.

Additional Discussion

Vessel Profitability

The essence of economic consideration for harvesting spiny lobster in the NWHI is the profitability of the vessels. There has been considerable apprehension concerning the feasibility of lobster fishing in the NWHI. These questions can not really be answered prior to experience. However, analysis of appropriate factors can be useful in assessing the relevance of economic considerations to the management objectives of the spiny lobster plan.

Given the pristine nature of the NWHI it is not surprising that initial catch rates in the region have been among the highest in the world. However, even under fairly extensive fishing pressure and declining average size, the Necker fishery, which is most convenient to landing live lobster in Honolulu, still provides high catch rates.

The question is, how do catch rates relate to costs of operation, and how does cost relate to the ex-vessel price fishers can obtain? This also relates to the fishing strategy of the vessel involved. If we assume that onboard processing merely extends the range of operation (a fairly heroic assumption), then we can make a projection of catch based only on harvesting capability. The State of Hawaii Fisheries Development Plan provided the following pro forma financial statement for an 80-foot multi-purpose vessel which could operate in the NWHI. (Figure 7.7). The months concentrating on lobster provide an actual loss of $1,256 per month, but still cover variable costs by $7,236 per month, indicating a viable fishing strategy in a multi-species fishery during months when other species are not available.

A major operating expense is the cost of fuel in transit to the fishing grounds, especially as exploitation of the fishery moves away from Honolulu. At present it takes 6 days to run to the fishing grounds. The State of Hawaii is attempting to obtain use of Tern and Midway Islands as fisheries bases. Success in this regard would substantially change the cost structure of the lobster fishery, with greater effort possible at lower operating costs.

FIGURE 7.8 Pro Forma Financial Statement
Monthly[1]

80-Foot Multipurpose Vessel

GROSS REVENUE[2]		
Mixed species (shrimp, lobster, bottomfish)		$29,472
LESS:		
Food and Fuel Expenses		8,242
fuel[3]	$7,019	
food[4]	1,223	
Other Operating Expenses[5]		3,718
maintenance and repair	1,910	
gear replacement	455	
moorage	80	
miscellaneous	1,273	
Fixed Expenses[6]		8,885
insurance, hull at 2.5%	1,500	
insurance, P&I	455	
depreciation @ 15 years	4,000	
cost of capital (10% on 25% equity)	2,930	
Crew Expense		8,492
INCOME BEFORE TAXES		$ 135

Assumptions:

[1]assumes 11 month operations
pro forma based on mixed fishing strategy
individual species pro forma also available

[2]catch:	4 month shrimp:	56,160 lb @ $0.65 = $36,504
	3 month lobster:	12,832 lb @ 1.75 = 22,456
		675 lb @ 3.00 = 2,025
	assorted fish:	9,000 lb @ 0.40 = 3,600
	4 mo. bottomfish:	6,515 lb @ 1.30 = 8,599
		19,845 lb @ 0.75 = 14,884

[3]unrevised ECI estimates prorated over 3 species
[4]$11/person/day for a 6 person crew for 24 days
[5]based on shrimp costs
[6]$660,000 vessel with 15 year useful life; $30,000 delivery cost
450 traps

Source: Hawaii Fisheries Development Plan, 1979, p. 25

7.6 Socio-Cultural Framework

The subsistence and recreational fisheries of American Samoa and Guam are important, but spiny lobster is not a major component of these fisheries. Spiny lobster is an important recreational catch in Hawaii's main island waters.

Two social aspects of the NWHI spiny lobster fishery are especially important. First, as noted, the NWHI represents a chance for Hawaii's fishing industry to expand. Although spiny lobsters are not likely to be a major component of Hawaii's overall fishery in the long-term, it does represent a leading component of current fisheries development. The NWHI fishery is a sharp departure from the main islands commercial fishery, which has been in decline since World War II. However, several of those involved in the local fishery are also involved in developing the NWHI fishery, thus extending Hawaii's link to the sea. For most residents and visitors to the state this is witnessed in the wide availability of fresh fish in local markets.

Second, the NWHI are a significant natural resource, where the impact of industrial society has been minimal. Although incidental intrusion into the area's ecology occurs from a variety of sources, a commercial fishery would have a more sustained impact on the ecosystem than many other activities. How society weighs the value of a region like the NWHI relates to the social characteristics of the community. The management plan attempts to balance economic and ecological concerns.

7.7 Native Hawaiian Fishing Rights

Unlike the native Americans in the continental United States, where a series of treaties and agreements has provided formal legal ground for allocation of fishing rights to native Americans, no such treaties were formed in Hawaii. Traditional Hawaiian society was significantly affected in the quarter century prior to annexation of Hawaii by the United States in 1900. Formal agreements between the two governments concerning fishing rights were not incorporated into the Organic Acts relevant to Hawaii's political integration into the United States.

However, there is a growing concern about the manner in which Hawaii was annexed and Hawaiian land ceded to the United States government. The relationship between ancient Hawaiian land and water rights, including the extent of allocation by traditional leaders such as the Konohiki, and the developing commercial fisheries is not known. There does not appear to be an interaction between the FCMA in the Western Pacific region and native Hawaiian rights, but further research may be required on this issue.

This plan will not affect any native Hawaiian, Samoan, or Chamorran cultural or religious practices so far as can be determined at this time.

16.0 COMMENTS AND RESPONSES

16.1 Summary of Extent of Comments Received

The Council received 37 reviews of the draft FMP. The Environmental Protection Agency, Region IX, categorized the draft FMP/EIS in Category LO-1. This means, first, that there is no objection to the proposed action as described in the draft; and, second, that the draft document adequately described the environmental impacts of the proposed action and of alternatives to the action. Eight letters submitted through the State of Hawaii Office of Environmental Quality Control (OEQC) essentially indicated the originating agency had no comment on the draft plan. The OEQC offered several substantive comments which are discussed in later sections of this summary. The Hawaii Department of Land and Natural Resources (DLNR) presented several substantive comments as well as a large number of much appreciated editorial corrections. The Hawaii Department of Planning and Economic Development (DPED) commented principally with respect to consistency requirements of the FMP in relation to the Hawaii Coastal Zone Management (CZM) Program. These State agency concerns have been addressed in subsequent discussions.

The Council received technical comments from individuals at the University of Guam and at the Office of Marine Resources, Government of American Samoa. The Environmental Center of the University of Hawaii at Manoa offered comments on several substantive issues (e.g., determinations of MSY and OY, minimum size limit).

Federal agencies commenting on the draft FMP included the U.S. Fish and Wildlife Service, the Department of the Interior, the Marine Mammal Commission, the Honolulu District of the U.S. Army Engineers, and the Headquarters and Fourteenth District offices of the U.S. Coast Guard. The National Marine Fisheries Service provided review comments on the plan as well as a Biological Opinion under Section 7 of the Endangered Species Act of 1973 (ESA).

Two individuals who formerly worked on aspects of the FMP offered comments. Four organizations with environmental protection and conservation concerns offered comments as well. The comments from the Center for Environmental Education were extremely detailed and reflected in-depth analysis. More than 60 pages of material were submitted, which have been extremely useful in revision of the FMP.

Finally, public hearings were held in Honolulu, Pago Pago, and Agana for public comment.

It has not been possible to include copies of the comments received in the Source Document or FMP. The cost of doing so is prohibitive. We have attempted in the following pages to identify the substantive and technical comments and to indicate either the changes made in the FMP in response to the comments or the reasons why changes in the FMP were deemed not necessary. The Council believes this presents a qualitative response to comments and is within the framework encouraged by Council on Environmental Quality (CEQ) regulations governing preparation of environmental statements. Individuals or organizations who want a full set of comments may order a set by writing to the Council.

16.2 Summaries of the Comments and Responses Received

1. Center for Environmental Education (CEE) Cover Letter: Proposes that a very conservative harvest approach be adopted in view of uncertainty to

provide a greater margin for safety; agrees a FMP is needed but must assure minimum disturbance of monk seals and must assess long-term implications of the FMP in terms of future development and impacts on the NWHI.

Response: The Council is aware of and sensitive to the risk of reaching wrong conclusions based on incomplete data. This risk is acknowledged in Section 6. The Council believes there is sufficient margin for error and is prepared to act quickly to amend the FMP if new information demonstrates the need for such changes (Section 11.3). The Council believes that the minimum size, area closure and gear restrictions will protect monk seals and sea turtles. We also believe, however, that expansion of other fisheries will not be dependent on the expansion of the spiny lobster fishery. The FMP has been revised to indicate that the spiny lobster fishery has been able to cover some exploratory fishing costs in the past and may do so to some extent in the future, but that expansion into other fisheries will require locating fishable concentrations of other species. Finally, the Council notes that restricting the fishing activities of vessels in other fisheries in the NWHI is beyond the scope of the Spiny Lobster FMP, which can only address the spiny lobster management unit; and that controlling vessel landings on islands in the NWHI is the responsibility of the U.S. Fish and Wildlife Service and State of Hawaii.

2. Daniel Goodman (for CEE): Agrees that the plan would reasonably guarantee the continued presence of viable populations of spiny lobster but questions the derivation of MSY and OY and the degree of protection for monk seals; through technical analysis and criticism of determination of MSY, concludes that the MSY range of estimates is most likely on the high side, and since OY was set equal to MSY, the OY range is overoptimistic; raises concern about

the amount of time it might take to replenish the population if overfishing occurs; suggests evaluation of the role of larger lobsters relative to population dynamics, given their greater fecundity; also proposes exploring the benefits of an extended schedule for harvesting the "non-renewable" surplus of large lobsters to reduce risk of overfishing; argues that extrapolation of Kure Atoll growth data to all NWHI lobster populations may lead to underestimating size of first reproduction, which would mean that a lower size limit takes even a larger portion of total reproductive potential than indicated in the FMP; questions whether the 16% of habitat "closed" to fishing has been analyzed to determine the proportion of lobster population protected; proposes alternatives for the 10 fathom and Laysan 20-mile closures to protect monk seals; proposes a 9.0 cm CL size limit; and proposes that research on density dependence factors be the highest priority research effort.

<u>Response</u>: Mr. Goodman's critique of the MSY derivation was exceptionally thorough and many points are well taken. The discussion of MSY has been changed considerably to address those points. Section 7.11 discusses MSY for the entire stock throughout its range as well as changes in potential yield if fishing practices (e.g., size limits) vary. The definition of OY for the fishery as it would be managed notes that OY would likely be less than MSY for the stock. Area closures requiring release of berried lobsters will remove substantial portions of the population above 7.7 cm CL from the exploitable biomass, thus protecting reproductive capacity and maintaining forage for monk seals and other predators. It is emphasized that the sequence of harvests which may occur - that is, the range of OY in early years and in the long term - is neither a quota nor a harvest. It is meant only as a basis for comparing what

actually happens to what was estimated to happen. If there is considerable difference, the Council and NMFS will try to find out why. The alternative controls proposed (9.0 cm CL, additional refugia, 20 fathom closure) would essentially preclude a fishery if recent experience and current information on lobster distribution, abundance, and population characteristics are representative of conditions throughout the NWHI. Discussion of these alternatives is included in Section 10.1.5. Research on density dependence factors and the role of larger animals is proposed in Section 11.1.1.

3. <u>Vladimir Kaczynski and Robert L. Stokes (for CEE)</u>: Setting OY equal to MSY (and above MSY in the first two years) doesn't satisfy FCMA requirements to define OY in terms of a set of objectives and the national interest; national standards require consideration of efficiency and allocation objectives, but this FMP fails to provide the data and tools for determining appropriate harvest and effort levels; suggest that year-to-year management for spiny lobster is much more relevant because the species can be overfished so easily; the present and future capacity and intent of the fishery is not clearly defined; propose greater need to consider overcapitalization problems and to establish controls over "inputs" to the fishery; instituting limited entry now would avoid need for painful process of reducing excess effort later; society would benefit by assuring that output (harvest) is achieved at lower cost than with open access fisheries; note that available excess capacity from Alaska could easily move to NWHI when Alaska fisheries are closed; risk of oligopoly or monopoly effects would be limited since frozen lobster tails prices are set on the international market.

<u>Response</u>: The description of the fishery (Section 7) has been revised

considerably since these comments (and some others) indicated the earlier description apparently led to confusion. The plan's objectives clearly incorporate social and economic factors which were important in decision making. The new discussion of OY further elaborates on this matter. The Council notes, however, that the emphasis of the commenters reflects a strong devotion to limited entry principles. As indicated in Section 10.1.5, the Council considered but rejected the application of limited entry in the NWHI spiny lobster fishery at this time. This is not due to lack of concern for economic efficiency, but to the inability to demonstrate that an effective and fair limited entry program, consistent with FCMA requirements, would have the desired efficiency effects without adverse social effects. Further research and fishery data are needed to evaluate the benefits and costs of alternative limited entry programs in the context of multiple-fishery participants. The plan proposes that such research be undertaken. Meanwhile, the discussion of OY demonstrates that, in the long term, OY will likely be less than the MSY for the overall stock; but in the first couple of years, OY will exceed MSY with attendant net present value benefits.

4. CEE (unnamed author): The FMP underestimates the precarious status of the Hawaiian monk seal; fears extinction of the genus unless most prudent protective actions are taken; have to address overall, cumulative effects of the FMP; evidence of seal diving patterns is cited to support argument for 20-fathom (or 3-mile) closure, since 10-fathom closure is often close to shore and may not protect forage; propose that all boats be required to carry observers and that log books record all fishing, monk seal, and sea turtle interaction; FMP also understates risk of entanglement in or injury from gear; raised concern that lobster reproductive capacity may not be protected, which may adversely affect

that the FMP could be more effective than the ESA to protect monk seals; FMP should require reports by fishermen on all injury to or mortality of monk seals and turtles, with penalty for failure to report.

Response: Turtles have been reported to be attracted to or disoriented by fishing vessels which are or may be lit at night but this appears to be unavoidable. Entanglement risks have been discussed in the FMP (Section 7.3.3). Diving experiments to date suggest that neither seals nor fish will attack released lobsters except when other materials (e.g., discarded bait) are simultaneously thrown overboard. There is unknown risk that bait will introduce exotic pathogens to the NWHI. Tiger sharks are omniverous, opportunistic feeders, and the reduction in overall lobster populations is not expected to affect feeding patterns. It is acknowledged that vessels may occasionally run aground, but the risk of such events will not be affected by this FMP. Combining the EIS/FMP/RA components in one document has resulted in reduced bulk of the document and, we believe, has facilitated public review. The language concerning ESA-FCMA relationships has been changed (Section 4). Reporting requirements include description of incidents of monk seal or turtle interaction.

7. Greenpeace: Criticizes lack of quotas given the uncertainties of stock response to harvests; more attention should be given to the risks of the yield-per-recruit analysis as basis for selecting size limit and area closures to manage the fishery; did not address the critical nature of monk seals' predicament; cumulative effects of management strategy not dealt with, especially in context of Hawaii fishery development plans for NWHI; should address 20-fathom closures as an alternative; possible food source importance has not

been adequately recognized, especially considering potential timelag between expanded fishery and observable impacts on seals, and the long time required for recovery of lobster stocks; risk of vessel groundings also understated; implied opposition to any fishery expansion, noting if the fishery is to be permitted, then there should be independent (i.e., non-government) observers, quotas, and measures to release lobsters at the bottom; questioned whether Council perception of "socio-cultural" values included the value of protecting an area from exploitation or pollution.

Response: Information available to the Council indicates that the size limit in combination with area closures and required release of berried lobsters offers sufficient protection against overfishing, although there is some risk given the limited data available. Quotas were not established because there is no factual basis for setting quotas, because enforcement would be very expensive, and because quotas often lead to inefficient effort patterns (Section 10.1.5). Additional information on the status of monk seals has been incorporated into the plan. The cumulative effects of the fishery in relation to other NWHI fishery potentials are discussed in Section 7.5.2. The Council considered 20-fathom closures but found no data indicating a need for such closures in the FCZ. NMFS did not propose any activity restrictions, including fishery controls, within any of the Critical Habitat options. Diving behavior has been discussed in Section 7.3.3. It is probably correct that substantial time would pass to discover the effects of lobster population reduction on monk seals if no research were being done on this aspect. That is why the FMP recommends that such research be given high priority by NFMS. Vessel groundings will neither be generated by nor controlled under the FMP, which affects fishing in the FCZ.

The risk of groundings probably is less with area closures (complemented by State action) than with no plan at all. The FMP provides authority for NMFS to place observers on fishing vessels when needed. "Independent" observers are not needed for data collection. There is no information on which to base requirements for specific release mechanisms for sub-legal and berried lobster. The language has been modified concerning FMP-ESA relationships (see Preface). Information on "other" lobster fisheries is now included in Section 7.1.7. The intrinsic resource values of the NWHI are not questioned by the Council; however, a balanced use of productive fishery resources for the long-term is not in conflict with those values.

8. Hawaii Office of Environmental Quality Control: Recommended clarification of MSY estimates, analysis of enforcement, State regulations, possible indirect and cumulative biological impacts, criteria for evaluation of impacts, role of lobsters in ecosystem, and relationship to State Fishery Development Plan; and offered corrections to in Table 7.5.

Response: Changes have been made where apprporiate.

9. Hawaii Department of Land and Natural Resources (two sets of comments): Agrees the FMP permit and reporting requirements and research recommendations will provide quantitative and qualitative data to revise FMP if necessary to assure long-term sustainability of resource; the carapace length/tail width relationship needs to be corrected; applicability of plan to FCZ areas other than around NWHI should be clarified; proposes that measures identical to State regulations be adopted for FCZ around main islands of Hawaii; suggest modification of language concerning waters under State jurisdiction; indicates willingness to adopt State regulations consistent with FMP for State

waters in NWHI; and identified a large number of editorial corrections.

Response: The support and cooperation of the Department is recognized and appreciated. The fishery management unit description has been clarified as suggested, as has the relationship between FCZ measures and State and Territorial measures in all components of the fishery. The plan notes that State or Territorial measures will continue to have force and effect over their vessels in all areas. The language concerning waters under State jurisdiction has been modified. The technical, editorial corrections have been useful.

10. Hawaii Department of Planning and Economic Development: A "Determination of Consistency" with Hawaii's Coastal Zone Management Program should be prepared; the position of the State of Hawaii relative to jurisdiction over archipelagic waters should be clearly described; spiny lobster management should not be viewed in isolation; further quantitative analysis is needed of the number of vessels, amount of effort, possible waste disposal problems, and magnitude of impacts on bottom habitat; the FMP should more clearly describe the information needed to assure long-term protection of the species and the habitat.

Response: A "Determination of Consistency" is included in Section 7.3.4, and a copy of the plan has been sent to the Department with a request for concurrence. The position of the State on archipelagic waters jurisdiction has been clarified. A discussion of the lobster fishery in relation to other ocean fisheries has been added to Section 7.5.5. Quantitative analysis of impacts cannot be conducted with available data. Information needs are more clearly described in the revised Section 11.

11. The following agencies in Hawaii had either no objections or no comments:

Department of Health

Department of Accounting and General Services

Department of Transportation

Department of Agriculture

University of Hawaii Water Resources Research Center

Maui County Planning Department

Hawaii County Planning Department

12. University of Hawaii (Manoa) Environmental Center: Further analysis of the risk of overfishing with a 7.7 cm CL size limit is needed; suggests that a 8.25 cm CL size limit without requiring release of berried females may be equally effective; questions enforceability of size limit if State regulations differ from FCZ regulations; further evaluation of biodegradable panels and escape gaps is needed; relationship of lobster fishery to other fisheries and development should be discussed; FMP fails to assess the harvest level which would produce maximum net economic yield; suggests further consideration of limited entry; FMP should address need for research natural areas and whether this need is provided for by present organizations.

Response: The discussions of MSY, OY, and lobster biological data provide the basis for concluding that the 7.7 cm CL size limit, in combination with area closures and non-retention of berried lobsters, provides sufficient protection for reproductive capacity. The 8.25 cm CL size limit may yield about equal poundage, but the lobsters would be larger; the lower limit is expected to yield a larger number of lobster tails with higher market value at a lower production cost per unit. There is insufficient information to determine the level at which maximum economic yield accrues. State cooperation is anticipated so enforcement will not be a problem. Research on the effectiveness of escape ports and rot-out panels is proposed, and the FMP can be amended if appropriate. As noted above (comment #3), limited entry was not deemed appropriate for the fishery at this time. There is substantial research being done now in the NWHI, and the Laysan closure will provide a baseline study area. No new research areas need to be set aside in the Council's view.

13. Office of Marine Resources, American Samoa: The species list should include species (by local and scientific names) of lobster in American Samoa and Guam as well as Hawaii; species composition of NWHI commercial catches should be reported; catch reports should be species specific; tail width/carapace length ratio should be checked; FCZ boundary discussion for American Samoa should be clarified.

Response: The recommended changes were made.

14. University of Guam Marine Laboratory: The FMP should be clarified with respect to applicability of permit and reporting requirements for vessels and individuals fishing in the FCZ around Guam, American Samoa, and the main Hawaiian Islands.

Response: The FMP has been changed to indicate that only commercial fishers in the FCZ around these areas must obtain permits and report catches under this plan. They must continue to observe the other requirements of State or Territorial regulations in the adjacent territorial sea.

15. Dr. Tim Smith: Monitored stock closures (e.g., island-by-island closures based on some criterion) have been too quickly dismissed; in view of the imprecision of data on stock abundance and population dynamics, such closures are necessary to assure that the management measures will protect reproductive capacity; the definition of MSY as that which will be achieved under the management measures proposed is circular and misleading; notes that multi-fishery boats can continue to exploit lobsters even at very low catch rates; is concerned that lobster populations will be reduced to and maintained at very low levels at the nearest islands unless quotas are imposed.

Response: There are insufficient data to set island quotas, and enforcement of localized quotas would be inordinately expensive. The FMP notes that MSY cannot be determined with precision, but that OY will likely be less than MSY for the stock in the long term. Reproductive capacity is expected to be protected by the size limit in combination with area closures and non-retention of berried lobsters. If catch rates and research data demonstrate that greater control is needed, the FMP can be amended.

16. Roy Mendelssohn: Recommended the Council undertake discriminant analyses to determine the appropriate tail width equivalent for the 7.7 cm CL size limit.

Response: The analysis was carried out and the results have been incorporated into Section 7.1.8.

17. U.S. Marine Mammal Commission: Agrees that the FMP is preferable to no plan to prevent overfishing and provide for protection of monk seals and other endangered or threatened species, but questioned effectiveness of proposed

plan in that regard; OY determination and description of fishery need revision to address potential for overcapitalization and for monk seal interaction; proposed change in language concerning FMP-ESA relationship; believes the FMP understates the degree of decrease in monk seals' population; more complete discussion of possible direct and indirect effects of the fishery on monk seals is needed, e.g., subtle changes due to reduced food supply, disturbance from groundings or unauthorized landings, or increased monk seal reliance on fish which may carry ciguatoxin; the lobster fishery should be described more clearly in relation to other fisheries in NWHI; suggests evaluation of phased decrease in minimum size limits, or island-by-island differences in management to test responses; insufficient basis for concluding that gear restrictions, area closures, and size limit will preclude entanglement and prevent adverse effects of food supply reduction, especially if controls apply only in FCZ; suggested consideration of tying limited entry to size, area and season restrictions; proposed improvement of reporting requirements; proposed change in OY by including 8.25 cm CL and 20 fathom closures to give greater weight to ecological factors; recommended that research needs above and beyond NMFS and others' planned activities be identified; observers should be placed on all vessels until it can be concluded the fishery poses no direct threat to monk seals; and the plan should include an "orientation program" to help fishermen understand ESA and MMPA.

<u>Response</u>: The FMP has been revised to distinguish between MSY for the species, assuming control over fishing so MSY can be achieved; and OY for the fishery, representing the amount that can safely be harvested under the management measures chosen. OY will most likely be less than MSY due to area closures and release of egg-bearing lobsters. Area closures also maintain foraging areas for monk seals. The language on FMP-ESA relationships was changed. Information

on the status of monk seals was added. Direct and indirect effects have been addressed, although we have not speculated at length on all possible outcomes or events but have focused on reasonably foreseeable conditions. The description of the fishery includes information on related fisheries and development prospects. A phased size limit decrease does not appear to be necessary. The proposed gear restrictions will minimize the risk of any such incidents without precluding fishing activities. Limited entry in combination with size, area and season restrictions was not originally considered; this alternative is one of many that can be looked at if fishery and research data indicate the FMP is not achieving the stated objectives. The Council believes its decisions reflect careful weighing and balancing of ecological, biological and economic factors, and that the MMC recommendations go beyond what is needed for ecological purposes. Research programs of NMFS have not been assessed for "adequacy"; the Council has, however, proposed that certain research be given high priority, including monk seal research. The Council believes it would be unwise to require that all vessels carry observers; rather, observer placement should be viewed as one of several possible ways to obtain the necessary information. It is more appropriately the responsibility of NMFS to develop orientation programs regarding ESA and MMPA provisions.

18. U.S. Fish and Wildlife Service: The management program appears to provide safeguards for protection of the lobster breeding stock; regulations should state that waters in the Hawaiian Islands National Wildlife Refuge are closed to commercial fishing; several detailed comments were included.

Response: The draft regulations of the plan pertain only to fishing in the FCZ. The plan acknowledges State of Hawaii and Fish and Wildlife Service authorities in their respective areas of jurisdiction. We have addressed the detailed comments by changes in the FMP.

19. U.S. Department of the Interior (San Francisco): In the absence of good growth and reproduction data, an 8.25 cm CL restriction to complement State controls appears reasonable; agrees tangle nets and other gear potentially damaging to endangered species should not be permitted; subsistence fishing by native populations may represent a significant historical/cultural activity; native fishing rights should be researched further; potential relationship to the Native American Religious Freedom Act should be addressed.

Response: State waters and FCZ waters will have similar measures in force under this plan. We have no information on native fishing practices in Hawaii, Guam, and American Samoa with respect to FCZ waters. There is no resriction proposed concerning subsistence or religious uses of spiny lobster.

20. U.S. Army Engineer District, Honolulu: Urges that the FMP consider additional research and interim regulations to minimize ghost fishing; review need for minimum tail width measure; describe events in the fishery since 1976 more clearly; reporting requirements should include identification of sites and frequency of trap losses; and many technical, editorial comments.

Response: There is insufficient information to demonstrate a problem with ghost fishing at this time, but the Council has proposed research on this aspect. The FMP indicates the regulations will specify the method for determining the appropriate tail width standard. The description of the fishery has been improved. Reporting of trap losses is now required.

21. U.S. Coast Guard (two letters): The plan should prohibit molesting of berried lobsters; vessels landing their catch outside Honolulu should be required to report to NMFS through the 14th Coast Guard District prior to such landing so catch can be inspected; the FMP should require filling in logbooks within 24 hours of catching lobsters if at-sea inspections are to be meaningful; area closures should be defined (as proposed) by reference to National Ocean Survey Charts.

Response: The appropriate changes have been made.

22. Environmental Protection Agency, Region IX: The Draft FMP/EIS was classified in category LO-1, meaning EPA had no objection to the proposed action, and that the draft impact statement adequately set forth the environmental impact of the proposed action and alternatives reasonably available.

Response: The Council acknowledges the EPA categorization.

23. National Marine Fisheries Service: Further discussion of the adequacy of the 7.7 cm CL size limit to prevent overfishing is needed; the management unit needs to be defined more clearly; efficiency considerations and enforcement costs need to be discussed further; the need for the plan should be demonstrated; information on the likelihood of State cooperation would be useful; the fishery could be described more clearly, especially with respect to markets for lobsters in Hawaii; CZM consistency should be discussed; the discussions of MSY and OY need clarification; some citations are erroneous or need clarification; long-term yields and economic returns indicated in the FMP should be reviewed; stripping of eggs from a berried lobster should probably be prohibited; data needs should be described clearly, while detailed regulations

by NMFS can specify the proper format; questioned whether the tail width measurement would be equally precise for live and for frozen lobsters; Biological Opinion concluded there is insufficient information to demonstrate that the plan will not jeopardize the continued existence of endangered or threatened species, but agree that the FMP is preferable to no action; proposes that procedure for restricting the fishery in the event of incidental mortality be included in the plan; and recommended certain minor technical change.

Response: Further discussion of the size limit has been added. The definition of the management unit has been clarified. Additional information on the NWHI fishery has been presented to address the efficiency concern. Enforcement costs are discussed more clearly. The need for the plan is clearly described. The State of Hawaii has indicated its intent to promulgate complementary regulations. The lobster markets are described more clearly. CZM consistency determinations have been added, and the plan will be sent to each CZM agency with a formal request for concurrence. The relationship between MSY and OY has been described more clearly. Potential yields and economic returns are discussed more clearly. The plan would prohibit "stripping" berried lobsters. Data submission requirements are identified, with NMFS to specify formats and procedures in cooperation with State and Territorial agencies. Tail width is not expected to change with freezing. The FMP acknowledges the authority of the Secretary of Commerce to deal with emergencies in the fishery under the ESA and FCMA.

24. Office of the Chief Economist, Department of Commerce: Commended Council for willingness to consider and propose new measures as new information became available; urged Council to consider approach for rapid FMP adjustment to

further improvements in data base; suggested expanded Executive Summary in lieu of short Regulatory Analysis (RA) and EIS sections; proposed consideration of performance standard rather than gear design standard to protect monk seal; costs need clarification.

<u>Response</u>: The plan indicates the Council's willingness to act rapidly to amend the plan as new information becomes available, but the FMP process is very long and cumbersome. Amendments can probably not be implemented in less than six months except in near-emergency situations. The Executive Summary has been expanded, but RA and EIS sections have been retained and improved. Costs have been clarified.

Section 16.3 List of Reviewers

DATE	PERSON/ORGANIZATION	
11/26/80	Jake Makenzie	U.S. Environmental Protection Agency, Region IX, San Francisco, California
12/3/80	Roy Mendelssohn	Center for Coastal Marine Studies, University of California at Santa Cruz
12/8/80	Public Hearing	Honolulu, Hawaii
12/8/80	Susumu Ono	Chairman and Member, Board of Land and Natural Resources, State of Hawaii
12/8/80	Hideto Kono	Director, Department of Planning and Economic Development, State of Hawaii
12/11/80	Public Hearing	Pago Pago, American Samoa
12/11/80	Douglas Perkins	Pago Pago, American Samoa
12/11/80	Richard Wass	Office of Marine Resources, Government of American Samoa
12/12/80	Dale Coggeshall	Pacific Islands Administrator, U.S. Fish and Wildlife Service, Honolulu, Hawaii
12/17/80	Kisuk Cheung	Chief, Engineering Division, Army Engineer District, Honolulu, Hawaii
12/17/80	RADM B.E. Thompson	Commander, 14th Coast Guard District, Honolulu, Hawaii
12/17/80	Kelley Dobbs	Greenpeace Foundation, Honolulu, Hawaii
12/18/80	Public Hearing	Agana, Guam
12/18/80	Eileen Cooney	Office of General Counsel, S.W. Region, Terminal Island, California
12/26/80	Harry Akagi (8)	Acting Director, Office of Environmental Quality Control, Honolulu, Hawaii
12/30/80	R.W. Christiansen	Chief, Fisheries Law Enforcement Branch, U.S. Coast Guard, Washington, D. C.

DATE	PERSON/ORGANIZATION	
12/30/80	Patricia Port	Regional Environmental Office, U.S. Department of Interior, San Francisco, California
12/30/80	Susumu Ono (2nd)	Chairman and Member, Board of Land and Natural Resources, State of Hawaii
1/2/81	Tim Smith	NMFS Southwest Fisheries Center, La Jolla, California
1/5/81	Mits Hataoka	Fisherman, Honolulu, Hawaii
1/5/81	Steven Amesbury	Marine Laboratory, University of Guam, Agana, Guam
1/6/81	Doak Cox	Director, Environmental Center, University of Hawaii, Honolulu, Hawaii
1/9/81	Courtenay M. Slater	Chief Economist, U.S. Department of Commerce
1/19/81	Marilyn Milberger	Hawaii Audubon Society, Honolulu, Hawaii
1/19/81	Thomas Grooms	Executive Director, Center for Environmental Education, Washington, D.C.
1/21/81	Ernest Kosaka	U.S. Fish and Wildlife Service, Honolulu, Hawaii
1/21/81	John R. Twiss	Executive Director, Marine Mammal Commission
1/21/81	Steven L. Montgomery	Conservation Council for Hawaii, State Board Member and Representative, National Wildlife Federation, Honolulu, Hawaii
2/12/81	Jeff Polovina	NMFS Southwest Fisheries Center, Honolulu, Hawaii
2/12/81	Terry L. Leitzell	Assistant Administrator for Fisheries, NOAA-NMFS, Washington, D.C. (Biological Opinion)
2/18/81	Alan Ford	Regional Director, NMFS Southwest Region, Terminal Island, California

FEB 23 1981

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Washington, D.C. 20235

SECTION 17.0 BIOLOGICAL OPINION

FEB 18 1981

F/MM2:CK

Mr. Wadsworth Y.H. Yee
Chairman
Western Pacific Fishery Management Council
1161 Bishop Street, Suite 1608
Honolulu, Hawaii 96813

Dear Wads,

Enclosed is the biological opinion prepared by the National Marine Fisheries Service (NMFS) pursuant to Section 7 of the Endangered Species Act of 1973, as amended, concerning the impact of the proposed Fishery Management Plan for Spiny Lobster Fisheries of the Western Pacific Region on the threatened and endangered species of the Northwest Hawaiian Islands for which NMFS is responsible.

The Council does not have sufficient information to insure that the proposed plan is not likely to jeopardize the Hawaiian monk seal or the green sea turtle population of the Northwest Hawaiian Islands. However, if the plan is not adopted and implemented the spiny lobster fishery may continue to grow and will operate without regulation. We believe that the potential for adverse impacts to endangered and threatened species is much greater from an unregulated fishery than from a regulated fishery. Therefore, we recommend that the proposed plan be adopted and implemented in accordance with the reasonable and prudent alternatives set forth in our biological opinion. This recommendation is contingent upon implementation of the provision contained in the plan for collecting information concerning the nature and extent of any interactions between endangered and threatened species and the lobster fishery and the use of the lobster resource as a diet item by endangered and threatened species. This information is necessary to evaluate the impacts of the fishery on endangered and threatened species and will enable the Council to fulfill its obligations pursuant to Section 7 of the Endangered Species Act.

We encourage the Western Pacific Fisheries Management Council to continue consulation with NMFS in order to evaluate the information concerning the nature and extent of monk seal/fishery interaction. If consultation is not continued, the Western Pacific Fisheries Management Council must reinitiate consultation if new information becomes available, if the plan is modified in a way other than considered in our biological opinion, or if another species that occurs in the project area is listed as threatened or endangered.

We look forward to continued cooperation in future consultations.

Sincerely yours,

Terry L. Leitzell
Assistant Administrator
for Fisheries

Enclosure

Endangered Species Act
Section 7 Consultation/Biological Opinion

AGENCY: Western Pacific Regional Fishery Management Council

ACTIVITY: Implementation of a Fishery Management Plan for Spiny Lobster in Hawaii

CONSULTATION CONDUCTED BY: National Marine Fisheries Service

BACKGROUND INFORMATION

The Western Pacific Regional Fishery Management Council (the Council) has developed a Fishery Management Plan (FMP) and Draft Environmental Impact Statement (DEIS) for the spiny lobster fishery in Hawaii. By letter dated January 28, 1980, and received February 1, 1980, the Council requested formal consultation pursuant to Section 7 of the Endangered Species Act (ESA) of 1973, as amended, for possible impacts of the proposed action on endangered species in the project area. On April 4, 1980, the National Marine Fisheries Service (NMFS) requested an extension of the consultation period pending receipt of a final review draft of the FMP/EIS. On August 11, 1980 the Council requested that formal consultation be reinitiated. On October 4, 1980 the Western Pacific Program Office, Southwest Region, received from the Council, a draft spiny lobster FMP/EIS intended for NMFS review prior to the public hearings scheduled in December 1980. Although not specified in the request for consultation we have considered the potential impacts of the proposed project on the threatened green sea turtle (Chelonia mydas) as well as the impacts on the Hawaiian monk seal (Monachus schauinslandi).

The documents reviewed during the consultation for development of the biological opinion include the Fishery Management Plan; Environmental Impact Statement and Regulatory Analysis fo: the Spiny Lobster Fisheries of the Western Pacific Region, marked for Public Review; the Proposed Regulations for the Spiny Lobster Fisheries; the Source Document for the FMP; and the DEIS for the Proposed Critical Habitat for the Hawaiian Monk Seal in the Northwestern Hawaiian Islands.

PROPOSED ACTIVITIES

The proposed action is the implementation of a spiny lobster fishery management plan which was developed in order to create a management system for spiny lobster fisheries in the Fishery Conservation Zone (FCZ) of the Western Pacific Region between 3 and 200 nautical miles (nmi) off the Hawaiian Islands, American Samoa, and Guam. Currently there is no management system for these fisheries. However, State or Territorial fishing and landing regulations may indirectly affect lobster fishing beyond the territorial sea.

The emphasis of the proposed management regime is directed at conservation of the spiny lobster stocks of the Northwest Hawaiian Islands (NWHI). These are the only known stocks of significant commercial potential under the jurisdiction of the Council. Currently spiny lobster fishing in American Samoa and Guam consists of sport and subsistence fishing in inshore and reef waters. Interest has been expressed in developing the fishery around American Samoa and Guam but locally based fishing industries are small and undeveloped.

The species of spiny lobster which forms the basis of the Hawaiian fishery is Panulirus marginatus. A second species, Panulirus penicillatus, is taken to a lesser degree. The NWHI are essentially uninhabited and only within the last four years have the spiny lobster stocks there come under any intensive fishing effort.

Approximately 84 percent of the spiny lobster habitat in the NWHI lies within the FCZ. Although the State of Hawaii requires a special permit to land lobster taken in the FCZ, when lobster caught in the FCZ is landed it is regarded as an import and not subject to fishing regulations or landing laws. The only extant regulation of the fishery in the NWHI is the prohibition against commercial fishing within the boundaries of the Hawaiian Islands National Wildlife Refuge (HINWR).

This management plan recommends a management regime to control the catch of spiny lobsters in the FCZ of the NWHI by establishing a minimum carapace length (CL) of 7.7 cm (3 inches), gear restrictions on commercial exploitation, area closures in shallow waters, prohibition of retention of ovigerous or "berried" lobsters, and an area closure within 20 miles of Laysan Island.

The Council has determined that the maximum sustainable yield (MSY) for the NWHI spiny lobster fishery is the greatest catch of lobster that can be taken annually under the recommended management regime. They believe this management regime will protect the reproductive potential of the spiny lobster stocks.

Precise estimates of MSY are precluded by an insufficient data base. Good estimates of abundance and stock condition of spiny lobster in the NWHI are not available. Lobster life history parameters are poorly understood, and the survival rates of eggs and larvae to the age of recruitment are unknown. The FMP identifies these data deficiencies and provides for the collection data relevent to these unknowns. This data gathering program will be used to monitor the health of the lobster stocks and assess the impacts of the fishery on the loster resource.

Based on information that is available, MSY under the proposed management regime has been estimated to be within the range of 236,000 to 500,000 lobsters. This estimate does not constitute a management quota, but is intended to provide a basis upon which the impacts of the proposed regulations can be judged.

In order to encourage economic development in Hawaii's fishing industry, the Council also determined that the range associated with optimum yield (OY) should be between 419,000 to 908,000 lobsters in the first year of the FMP; 331,000 to 717,000 lobsters in the second year; and 230,000 to 500,000 (the MSY range) lobsters in the third year and thereafter. This would reduce the virgin stocks to MSY densities.

The Council expects that the OY will be harvested on a sustained basis by a small number of Hawaii-based multi-fishery vessels, and a number of deep sea trolling vessels on a sporadic or incidential basis.

In addition to conservation of the lobster resources the FMP purports protection of threatened and endangered species in the NWHI. Area closures will provide forage reserves for monk seals and sea turtle hauling, breeding, and nesting beaches. Trap opening sizes are regulated to reduce the potential for monk seal entrapment, and methods of collecting information to fill pertintent data gaps regarding impacts of the fishery on threatened and endangered species are identified.

Main Hawaiian Islands

The spiny lobster fishery in the main Hawaiian Islands has been primarily an incidental fishery since World War II. The commercial catch has fluctuated between 4,145 and 9,250 pounds since 1966. This represents a small percentage of Hawaii's total fishery. As lobster habitat is generally limited by the 100 fathom (fm) contour and the 100 fm contour around the main islands is generally within three nmi of shore, most of the catch is from within the Territorial Sea and is subject to the State regulations. The bulk of this commercial catch (80 percent) is made near Oahu, where the majority of the human population resides.

Both tangle nets and traps are used in the lobster fishery in the main islands. Trap catches are apparently incidental to attempts to catch various species of fish. Most net fishermen drop nets in depths from one to five fm along Oahu's windward (northern) shore. Trap fishing occurs along the leeward shore in depths from 5 to 30 fm. No full-time commercial fishermen are known to concentrate on spiny lobster in local waters.

The main islands fishery also includes a significant recreational and subsistence catch, but their extent is unknown.

Northwest Hawaiian Islands

A research cruise of the NOAA ship R/V Townsend Cromwell during 1975 revealed the presence of high concentrations of lobsters near Necker Island and a few other areas in the NWHI.

Major utilization of these resources began gradually in 1976 with a few multi-gear vessels venturing into the fishery on an experimental basis.

Since 1976, about six firms have fished for lobster in the NWHI. Vessels ve increasingly utilized on-board processing as a means to overcome the limitations of the fresh fish market and to take advantage of the international market for frozen lobster tails.

The vessels currently attempting to exploit the resource are approximately 100 feet in length and utilize on-board processing and freezing. They use a version of the California two-chambered trap, deployed on a main line and spaced at intervals of 6 to 30 fm. Each main line contains 75 to 150 traps. Vessels carry between 500 to 1,200 traps. Traps are set each day prior to sundown, fished overnight, and retrieved the next morning.

The traps are rectangular box shapes, framed with steel reinforcing rods, and covered with wire mesh of varying sizes. Entrances to the traps are conical, with two entrances to the outside chamber and usually a single entrance to the inner chamber.

Catch data for 1976-1979 in the NWHI given in Table 7.8 of the FMP indicate an apparent decline since the 1977 peak of 72,000 pounds. However, complete data for 1979 have not been published because questions have arisen concerning their proprietary nature. The catch in 1980 exceeded 100,000 lobsters (a lobster with an 8.25 cm carapace length weighs about one pound).

No foreign fishing for spiny lobster in the NWHI is known.

LIST OF THREATENED AND ENDANGERED SPECIES FOUND IN WATERS OFF THE NWHI

Monachus schauinslandi - Hawaiian monk seal
Megaptera novaeangliae - Humpback whale
Chelonia mydas - Green sea turtle
Dermochelys coriacea - Leatherback sea turtle

Hawaiian Monk Seal (*Monachus schauinslandi*)

The Hawaiian monk seal population was almost eliminated due to sealing and harassment in the nineteenth century. Historical records indicate that monk seals were utilized for oil and pelts during that time. Only the cessation of sealing and the monk seal's isolated habitat in the NWHI allowed the species to survive. After recovering somewhat since the turn of the century, the monk seal is again experiencing a decline in total population. Current population estimates indicate there are probably no more than 1,000 monk seals and periodic surveys conducted since the late 1950's indicate that this population may be declining.

The breeding range of the monk seal is restricted to the ten NWHI. They have been observed in waters around the main Hawaiian Islands and as far away as Johnston Atoll (240 nmi SW of French Frigate Shoals). There is no evidence to indicate that the range has been significantly different from this, although Kenyon (1972) postulated that prior to the arrival of the Polynesians, monk seals bred on favorable beaches of the main Hawaiian Islands.

There has been a definite decline in the number of monk seals at the westernmost islands: Kure, Midway, Pearl and Hermes Reef, Lisianski, and Laysan. The greatest declines have been observed at Pearl and Hermes Reef and Midway where means of recent counts have shown a 90 percent decrease from counts made in 1957-1958. At Lisianski and Kure the means of counts made from 1976 to 1979 show decreases from counts made in the late 1950's of 65 percent and 75 percent, respectively. The counts at Laysan have shown the least decline, about 50 percent. Generally the reasons for these declines are unknown. Kenyon (1972) has attributed the decline at Kure and Midway to human disturbance.

While the population as a whole has been declining the counts at French Frigate Shoals, Necker, and Nihoa indicate an increase in the number of monk seals utilizing these easternmost Islands. The population at French Frigate

Shoals has increased by about sixfold and has been stable since 1975. The cause of this increase is unknown. Immigration from disturbed areas does not appear to be an important factor, because data from tagged seals indicate there was no more movement of animals into French Frigate Shoals than into other Island populations. Strict use of permits issued by the HINWR has limited human activity to Tern Island and near shore waters. These controls combined with the long distances between Tern Island and the other islets at French Frigate Shoals have reduced the impacts of human activity and could have contributed to the increase of monk seals at French Frigate Shoals. The counts at Necker and Nihoa have increased from 0 in 1957 and 1958 to 46 in 1977. This increase is unlikely to continue as there is little suitable beach habitat available.

Coral sand beaches are the preferred habitat for pupping, hauling out and nursing. Protected reef and water areas adjacent to reefs and beaches are utilized extensively by adult females with nursing pups and weaned pups that are learning to feed. Pupping occurs from late December to mid-August with the majority of pups born between March and May. Females do not leave their pups during the five to six week nursing period, and the pups gain many times their birth weight during this short interval. If nursing is interrupted or if weaning is premature, the probability of pups surviving is thought to decrease significantly because they lose a large percentage of their body weight during their first year while learning to fend for themselves.

Observations of mating behavior indicate that the nearshore waters adjacent to pupping and hauling beaches are part of the breeding habitat of monk seals.

When at the breeding islands, monk seals feed on fish and invertebrates associated with the coral structures of the inner reef and outer reef slopes.

Known prey items include octopus, spiny lobster, eels, and various species of reef fish.

A monk seal recovery team has been established for the purpose of developing a management plan to promote the conservation and recovery of the monk seal populations. This plan will include a list of research priorities designed to define the position of the monk seals in the NWHI ecosystem, to identify causes for the decline of the monk seal population, and to recommend management measures to eliminate factors contributing to the decline including minimizing monk seal/human interactions.

Humpback Whales (Megaptera novaeangliae)

The humpback whale population that winters in Hawaiian waters numbers between 500 to 700. They migrate between higher latitude North Pacific summer feeding grounds and winter breeding/calving areas around the main Hawaiian Islands. Their numbers peak in late January through February and remain fairly constant through mid-March. In April they begin migrating out of Hawaiian waters and by late May or early June the last whales usually have departed.

Humpback whales are particularly attracted to broad bank areas and during the winter breeding season usually concentrate in waters less than 100 fm deep. In the Hawaiian Islands, major areas of concentration are Penguin Bank; the waters bounded by the islands of Molokai, Maui, Lanai, and Kaholawe; and the nearshore waters of the island of Hawaii between Upolu Point and Keahole Point. They are consistently found, although in smaller numbers, in several other areas of the main Hawaiian Islands, including Oahu and Kauai. During the latter stages of the winter migration humpbacks have occasionally been sighted in and around the NWHI, particularly at French Frigate Shoals.

Because their distribution is generally restricted to the main islands and the occasional visits to the NWHI occur when the population begins the northward migration, we do not anticipate any adverse interactions between humpback whales and the spiny lobster fishery.

Green Sea Turtle (*Chelonia mydas*)

Green sea turtles have been exploited for food since at least Captain James Cook's arrival in Hawaii in 1778, and probably as early as 600 A.D. with the initial occupation of Hawaii by Pacific area Polynesians. Under the strictly enforced "kapu" system that remained in effect until 1819, turtles could be eaten only by priests or nobility. The traditional, controlled exploitation of turtles by Hawaiians gradually disappeared with the abolition of the "kapu" system, the influx of immigrants, and the discovery of the unexploited and uninhabited NWHI. Numerous commercial expeditions to the NWHI took place during the 1800's and early 1900's to exploit green sea turtles, seabirds, guano, pearl shell, monk seals, and sharks. Turtles were taken principally for meat, oil, and use as shark bait. When the Japanese chartered fishing vessel *Ada* visited these islands for five months in 1882, at least 410 turtles were taken off the beaches and from the adjacent waters. Shipwrecks were another factor in the exploitation of Hawaiian *Chelonia*. The survivors of vessels that struck reefs in the NWHI often had to depend on turtles and other marine and terrestrial animals for food sources. The 30 stranded crew members of a whaling vessel wrecked at French Frigate Shoals in March of 1859 killed and ate in excess of 100 turtles before being rescued.

Even though most the NWHI were declared a preserve for native birds in 1909 and later redesignated a National Wildlife Refuge in 1940, this refuge status had not served as a signficant deterrent to the exploitation of turtles until recent years. In 1946 a commercial fishing base was established at French Frigate Shoals. Both turtles and fish were captured in the area and transported to Honolulu by aircraft using the abandoned airstrip on Tern Island. One of two fishing companies using the base estimated taking about 200 turtles from 1946 until they terminated operations in 1948. During the summer of 1959, turtles were again taken at French Frigate Shoals by a commercial fishing company based in Honolulu.

Green sea turtles were known to nest in the main Hawaiian Islands as recently as 45 to 50 years ago, but there have been no recent documented reports of nesting at these islands. There remains, however, considerable nesting in the NWHI, primarily on the islets within French Frigate Shoals: East, Whale-Skate, Trig, Tern, Gin, and Little Gin Islands. The approximate number of females nesting annually at French Frigate Shoals has ranged from 94 in 1967 to 248 in 1979, with a annual mean number of 180 for this period. Nesting occurs from the middle of May to early August with the peak season during late June. The majority of breeding females nest on East (55 percent) and Whale-Skate (35 percent) Islands. Preliminary results from a recently completed tagging study at French Frigate Shoals indicated that for the most part the females remain in nearshore shallow waters adjacent to the nesting beaches during the internesting interval.

Incubation lasts from approximately two to three months with the average just over 64 days. It is unknown if the population of green turtles at French Frigate Shoals is stable at the present time. The number of females nesting annually since 1973 has fluctuated substantially, and no trends can be detected.

Although the majority of the *Chelonia* grazing areas thus far identified are found in the main Hawaiian Islands, juvenile *Chelonia* have been observed feeding on *Caulerpa* sp., *Codium* sp., and small anthozoans that grow on the calcareous reef structures near East, Whale-Skate, and Tern Islands at French Frigate Shoals.

Leatherback Turtle (*Dermochelys coricea*)

The leatherback is not known to nest in Hawaii, however, they are regularly sighted in the offshore waters of the Hawaiin Archipelago. This essentially pelagic species of sea turtle feeds mainly on jellyfish with crustacea and algae also reported from stomach contents. Although this turtle has never been highly valued due to its soft shell and reported unpalatability of its flesh, it has been heavily exploited for its eggs and oil.

On several occasions leatherbacks accidentally have been caught or entangled in fishing gear (lines and nets) around the Hawaiian Islands. During August of 1979, at least ten leatherbacks were sighted in pelagic waters northwest of Midway between 41°-43°N and 175°-179°W. In May of 1980 foreign vessels fishing gill nets for squid in this area were found to have entangled at least five and drowned three leatherbacks. During a cruise of the F/V *Easy Rider Too* in October of 1980 a leatherback was found entangled in a lobster trap line near Kure Atoll. The turtle was released alive.

POTENTIAL IMPACTS TO PROPOSED CRITICAL HABITAT

Critical habitat has not been designated within the project area for any of the threatened or endangered species for which NMFS is responsible. However, critical habitat has been proposed for the monk seal. Although Section 7 does not require formal consultation on proposed critical habitat it does require the Federal action agency (the Council) to confer with the service (NMFS) on any agency action which is likely to result in the destruction or adverse modification of proposed critical habitat. We believe that consolidating the conference on potential impacts to the proposed monk seal critical habitat with this biological opinion will avoid conflicts that might arise if monk seal critical habitat is designated. On February 29, 1980, NMFS published the DEIS for the proposed designation of monk seal critical habitat and requested public comment. The preferred alternative described in the DEIS includes designating all beach areas, lagoon waters, and ocean waters out to a specified distance or depth offshore around Kure Atoll, Midway Island (except Sand Island), Pearl and Hermes Reef, Lisianski Island, Laysan Island, French Frigate Shoals, and Necker Island.

Three options were presented for defining the seaward limit of critical habitat. Option 1 includes all waters out to the 10 fm contour, Option 2 includes all waters out to the 20 fm contour, and Option 3 includes all waters out to three nautical miles around the islands or barrier reefs of the atolls. The selection of the preferred option has been deferred until studies of the diving and feeding behavior of monk seals at Lisianski Island are completed. These studies will provide information for the evaluation of the relative amount of protection provided by each option.

No specific regulations or restriction of activities were proposed in the DEIS. The primary purpose for designating critical habitat is to bring to the attention of all Federal agencies operating in the area, the endangered status of the monk seal and the importance of maintaining the habitat upon which the continued existence of that species depends. Pursuant to Section 4(f) of the

ESA, the NMFS will promulgate specific regulation to restrict activities which adversely impact monk seals. The promulgation of regulations is not contingent upon the existence of formally designated critical habitat.

The definition of critical habitat includes, "those physical and biological features essential to the conservation of the species" (emphasis added). Therefore, the proposed critical habitat of the monk seal will be modified by the presence of fishing vessels, the placement of fishing gear, and alteration of the lobster populations. There is insufficient information available to fully assess the extent of these modifications.

The proposed FMP reduces these impacts in the FCZ through area closures, gear restrictions, and management measures designed to perpetuate the breeding stocks of lobsters. However, there continues to be no management of the lobster fishery in state waters and impacts associated with the fishery in those waters may be more severe as a result of being closer to breeding, hauling, and nesting beaches. We urge the Council to work with the State of Hawaii toward the development of state regulations for lobster fishing in the territorial sea of the NWHI. State regulations should complement the proposed regulations in the lobster FMP for fishing in the FCZ around the NWHI. This would result in the establishment of a comprehensive management regime for the conservation of the NWHI populations of spiny lobster. The impacts of the proposed activities are discussed in more detail in the next section. Recommendations to monitor these impacts are made to ensure that they do not pose a threat to the continued existence of the endangered species considered in this biological opinion.

POTENTIAL IMPACTS

Potential impacts of the spiny lobster fishery on endangered marine species can be placed into three categories: disturbance, incidental mortality, and reduction of a known food resource. The Council believes that the management measures proposed in the FMP would preclude any of these impacts. We are concerned that the available information is too sparse to allow adequate evaluation of the potential impacts of the lobster fishery with or without implementation of the FMP. However, the FMP's promise of access to pertinent information weighs in favor of its implementation.

Monk seals and sea turtles may be disturbed by the presence of fishing vessels in the vicinity of preferred beaches and by crewman ashore either for recreation or as the result of grounding. There is too little information available to allow an assessment of the impacts of such disturbance, but human interaction has been implicated in the reduction of monk seal populations at Kure and Midway (Kenyon, 1972).

Additional adverse impacts associated with groundings include oil spills, which could result in monk seal and sea turtle mortality and pollution of habitat; displacement of animals from preferred habitat as the result of human interaction; and introduction of rats, which could decimate sea turtle nests. Area closures and landing restrictions proposed in the FMP reduce the threat of adverse impacts from disturbance and groundings, but more information is needed to assess the acceptability of the potential for these kinds of impacts even at the reduced levels of risk offered by the FMP.

Incidental mortality could have severe impacts on the monk seal population and could be a threat to the sea turtle population. Monk seals and sea turtles may drown as the result of becoming tangled in lines or getting caught in traps. On several occasions monk seals have been observed tangled in lines or netting (Andre and Ittner, 1980; Balazs, 1979; Kenyon, 1980). Although the fate of those animals is unknown, these observations identify incidental mortality as a potential problem.

Loggerhead sea turtles and to a lesser degree green sea turtles have been identified as the cause of damage to gear and loss of catch in the spiny lobster fishery of southern Florida (Higman and Davis, 1977). If we may generalize from southern Florida to the NWHI, a similar sea turtle/fishery conflict could arise in the NWHI.

We believe any incidental mortality of monk seals is unacceptable and we do not know what level of incidental mortality, if any, the green sea turtle population could survive. The FMP offers safeguards to help reduce the potential of incidental mortality. These include: area closures, which have the effect of restricting fishing to areas removed from high monk seal and sea turtle densities; gear restrictions designed to prevent monk seals from getting caught in traps; and prohibitions on the use of nets, explosives, and chemicals which reduce the potential for incidental take. Based on available information, we cannot conclude that these safeguards are sufficient to protect monk seals and sea turtles.

Maximum size restriction for lobster trap openings are proposed to help eliminate the potential for monk seal entrapment. The proposed regulations restrict the greatest diagonal or diameter of the inner-most opening to a trap to no greater than 6.5 inches, and the outer-most opening to no greater than 10.5 inches. Measurements of cranial circumference, taken from dead monk seals ranged from 15.9 inches to 23.8 inches (Johnson and Johnson, personal communication). The smallest measurement is from a pup of unknown age and the largest from an adult. Assuming these circumferences are circular the range of diameters would be from 5.1 to 7.6 inches. Measurements taken at the zygomatic width (widest point) of prepared skulls ranged from 4.7 inches to 6.9 inches (DeLong, personal communication). These measurements indicate that the maximum size restrictions of trap openings are not sufficient to eliminate the potential for entrapment, particularly in view of the fact weaned pups learning to feed and juveniles dispersing from the islands are the animals most likely to investigate lobster traps.

The predator-prey relationship between monk seals and lobsters is poorly understood. The lobster fishery has the potential of reducing the lobster populations to levels at which lobsters are no longer available to monk seals. Although the spiny lobster has been identified as a prey species for monk seals (DeLong, 1978), its relative importance in the monk seal diet is unknown. What is known of monk seal food habits has been acquired through analysis of regurgitations, fecal samples, and stomach contents acquired opportunistically from dead animals. Information from such analyses indicates monk seals are opportunistic feeders supported by a diverse prey base. Therefore, we believe that if lobster were to become unavailable to monk seals, monk seals probably could adapt by shifting to other prey species. However, with the available information we cannot assess the amount of stress such a shift would place on the monk seal population, nor can we evaluate the impact of that stress on the monk seal population.

The FMP proposes to protect the monk seal from the reduction in availability of lobster by maintaining lobster populations at MSY levels. Regulations proposed to conserve the lobster populations include the size limit (minimum 7.7 cm CL), the release of berried lobsters, and restriction of fishing inside the 10 fm contour. This area restriction will provide a lobster breeding sanctuary, from which significant amounts of recruitment are expected, and as a monk seal forage reserve.

We are concerned that the Council's estimates of MSY and OY may be too high. They base their estimates of MSY and OY on the assumption that the lobster stocks in the NWHI are unexploited. However, the NWHI lobster fishery has been active in certain areas of NWHI since 1976. Yearly harvest from Necker, Gardner Pinnacles, and Maro Reef have yielded 2,000 pounds of whole lobster in 1976; 72,000 pounds in 1977; 45,000 pounds in 1978; and 15,000 pounds in 1979 (partial). In 1980 the catch to mid-year was approximately 100,000 lobsters. These data suggest that fishable stocks at these locations may no longer be at unexploited levels. If OY is overestimated the fishery could result in a depletion of the lobster resource. Therefore the FMP does not insure the availability of lobster to monk seals.

The FMP contains a proposal to gather data for the purpose of monitoring the status of lobster stocks, as well as elucidating some of the lobster life history parameters which are poorly understood. This monitoring program should identify declines in lobster stocks in time to protect the lobster stocks from depletion and insure that lobster continue to fulfill their role as a prey species.

CONCLUSION

There is insufficient information available for the Council to be able to insure that the proposed activity will not jeopardize the continued existence of the monk seal and green sea turtle populations of the NWHI. The predator-prey relationship of monk seals and spiny lobster is poorly understood and there is essentially no information available on the importance of the spiny lobster in the monk seal diet. Of greater concern though, is the lack of information necessary to assess the potential for incidental injury, mortality, and disturbance of monk seals and sea turtles as the result of interaction with the fishery.

We are faced with a unique situation in which we believe implementation of the proposed activity is preferable to the no action alternative, even though we are unable to reach a conclusion regarding the likelihood of jeopardy as the result of implementing the proposed FMP. The no action alternative would allow the existing fishery to grow at an unrestricted rate and continue to operate in an unregulated fashion. The FMP offers safeguards that reduce the potential of adverse impacts that may result from the no action alternative. These safeguards include regulations designed to protect the reproductive capacity of the lobster stocks; gear restrictions to reduce the potential for monk seal entrapment; and area closures, which act as reserves from which recruitment to the lobster population can occur. The area closures will also act as buffer zones between the fishery and monk seals and sea turtles, assuming the State of Hawaii promulgates complementary regulations.

The FMP recommends an information gathering program to collect data for the purpose of defining the life history parameters of the lobster, monitoring the status of lobster stocks, and assessing the effectiveness of the FMP in conserving the lobster stocks. These types of data are necessary for more accurate estimates of MSY and may provide indication of the availability of lobster to monk seals. Without the FMP these data would be difficult to collect.

We believe these safeguards and the information gathering program offer some protection to monk seals and sea turtles from the impacts of the fishery. Therefore, we recommend that the FMP be implemented provided the Council adopts the reasonable and prudent alternatives discussed below. This recommendation in no way alleviates the Council of its obligation under Section 7(a)(2) of the ESA to insure that the activities conducted under the spiny lobster FMP are not likely to jeopardize the continued existence of the threatened and endangered species which occur in the NWHI and should not be construed as a "no jeopardy" opinion.

REASONABLE AND PRUDENT ALTERNATIVES

The Council has the responsibility of assuring that the information necessary for a proper assessment of the FMP is collected. This information is required in order that we may complete a biological opinion concerning the likelihood of jeopardy from the proposed action. Methods of collecting this information are offered below.

Studies of monk seal food habits have been conducted by NMFS and will continue to be conducted as part of the monk seal recovery plan. We anticipate these will be long term studies because we must rely on observational data and analysis of scats, spewings, and stomach contents of dead animals. The Council should continue periodic consultation with the NMFS endangered species staff as these studies could produce biological reasons for adjusting OY.

Collection of information on incidental mortality and disturbance is of high priority and should be addressed in the FMP. The provision of making this information available is a key factor in our recommending implementation of the

FMP. We offer three methods for collection of monk seal and sea turtle/fishery interaction data. This list is not exhaustive and we realize that the Council may prefer some other method of collecting this information.

1. Modification of the proposed observer program: The FMP recommends that observers be placed on lobster vessels at the discretion of the Regional Director, NMFS, Southwest Region, for the purpose of collecting lobster data. These observers could be instructed to collect data on disturbance, incidental injury, and incidental mortality of monk seals and sea turtles resulting from interaction with the loster fishery. Observers could also collect opportunistic information on monk seal and sea turtle food habits, distribution, movements, etc., and they could contribute to the data base used for assessing the status of the monk seal and sea turtle populations.

2. Implementation of a voluntary observer program: Under this program observers would be placed on board lobster vessels at the invitation of the vessel owners or operators. The information items collected would be identical to those collected by the discretionary program just described. However, the Council should recognize that information collected by a voluntary program may be biased by an inability to design a random sampling scheme. Furthermore, there is also the possibility of underestimating levels of interaction because those vessels that voluntarily carry observers are generally the vessels that are more likely to abide by the ESA and the FMP.

3. Design and initiate an independent research project: This method could be utilized to gather all the information that would be provided by a discretionary observer program without concern for introduction of bias. This method would be more expensive than the other methods because it would require chartering commercial lobster vessels for the purpose of observing monk seal

and sea turtle/fishery interactions.

As discussed in the potential impacts section incidental mortality of monk seals is expected to have severe impacts on the health of the monk seal population. Therefore, our final reasonable and prudent alternative is that the Council include in the proposed regulations, provisions for restricting lobster fishing at any or all of the NWHI for the purpose of investigating and identifying the cause(s) of any incidental mortality. These restrictions should apply until such time as the cause(s) of the mortality has been identified and eliminated.

Consultation must be reinitiated should new or additional information reveal impacts of the proposed activities that may affect listed species or their habitats; the proposed activities are modified, by other than the adoption of the above reasonable and prudent alternatives or a new species within the geographical boundaries of the proposed action is listed.

Nothing in this biological opinion should be construed as authorizing any "take" of endangered or threatened species pursuant to Section 10 (a) of the ESA nor immunizing any actions from the prohibition of Section 9 (a) of ESA.

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18.0 TECHNICAL APPENDIXES

Appendix 1	Reproduction Estimates, Polovina
Appendix 2	Population Estimates, Polovina/Tagami
Appendix 3	Reproduction Estimates, MacDonald
Appendix 4	Population Estimates, Marten
Appendix 5	Economic Feasibility, Adams
Appendix 6	State of Hawaii Boundaries, Kono
Appendix 7	State of Hawaii Fisheries Development Plan, Technical Report
Appendix 8	State of Hawaii Regulations
Appendix 9	Area by Depth in NWHI
Appendix 10	Spiny Lobster Fisheries in Other Areas
Appendix 11	Charts of NWHI
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APPENDIX 1

AUG 25 1980

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
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August 19, 1980 F/SWC2:RSS

To: W. Yee, Chairman, WPFMC

From: Richard S. Shomura, Director, Honolulu Laboratory

Subject: Spiny Lobster FMP--Consideration for a change in minimum carapace size

The Council is scheduled to review and possibly approve the Spiny Lobster FMP at its next meeting scheduled to be held in Pago Pago, American Samoa, on 16-17 September 1980. The proposed regulation in this draft FMP calls for a minimum carapace size of 8.25 cm to separate "legal" from "illegal" sized lobsters. I believe the selection of this minimum carapace length was based on a number of considerations. These included:

1. Concern that a minimum carapace size of less than 8.25 cm would substantially reduce the reproductive capacity of the lobster population. This conclusion was based on a study of a limited amount of data showing the relationship of fecundity with carapace size.

2. Based on limited data, the study of growth of the Hawaiian spiny lobster suggested a very slow growth rate. However, sufficient data were not available to construct a valid age-growth relationship.

3. Information of the size at first maturity for female lobsters was lacking.

Recently scientists of the Honolulu Laboratory have reexamined the 8.25 minimum carapace size limit issue. Much of the impetus for this re-examination came from extensive discussions held with Dr. Bruce Phillips of CSIRO, Australia. Dr. Phillips, who is an authority on the Australian spiny lobster, recently spent 3 weeks in Hawaii to work with members of my staff.

I believe the results of this reassessment are sufficient to recommend that the Council reconsider the 8.25 cm minimum carapace size limit. I believe the data support the establishment of a minimum size limit less than the recommended 8.25 cm. Briefly my comments and views that led to this recommendation are as follows:

1. A concern that a substantial reduction in reproductive potential would occur if the minimum carapace size were to be set less than 8.25 cm. is based on a discussion provided in section 7.1.5 of the 8th draft FMP (March 1980). I believe the interpretation of the data in this section is in error. The data provided in Figure 7.1 are used to construct other figures in this section. The error is in assuming that the histogram of catches by sex for the Midway and Oahu samples represent the population-at-large. This is not the case. A sampling bias must be in effect since a "normal" population should have substantially more smaller (younger) animals than larger (older) animals. If one makes an adjustment for this bias it may be that the contribution to the reproductive capacity by lobsters smaller than 8.25 cm may be substantial.

2. A comprehensive study has not been undertaken on the reproductive profile of the Hawaiian lobster, especially the size at first maturity. The available data, however, suggest that a notable amount of spawning does take place even at the 8.0 cm size class. Appendix A provides an analysis of the available data comparing the spawning potential of females as a function of carapace size.

3. While results from one fishery cannot be applied to another without some justification, it is heartening to note that the Western Australia spiny lobster fishery has been successfully managed with a minimum carapace size of 7.6 cm. The feature that is all the more remarkable for this fishery is that the minimum size is lower than the size at first maturity (egg bearing). This means the lobsters are subjected to fishing pressure even before they reach the egg-bearing age.

4. Dr. Phillips expressed a view that the data for the Hawaiian lobster population are inadequate to establish a minimum carapace size that will provide for a reliable measure of reproductive capacity; however, he felt that the minimum size could be set below 8.25 cm if it could be demonstrated that spawning took place below the 8.25 cm level. Dr. Phillips stressed the point that whatever minimum size is selected in the final decision, effort should be made to maintain this minimum size limit over a sufficient time period, e.g., 4-5 years. This is to assure a means of measuring the impact of the minimum size on the population. During this period data should be collected from the fishery to monitor the changes in catch rates, reproduction, and growth rates.

5. I understand that Dr. Craig MacDonald has collected data over the past year from Kure Island that suggest a much more rapid growth than has been postulated heretofore. If this is true, some of the concerns which led to taking a conservative approach in the current FMP may not exist. I believe the

Planning Team and the SSC were concerned with the long time interval between spawning and age at first maturity. It was feared that the animals would be subjected to intensive fishing effort over a number of years before the animal reached the size at first maturity.

In summary, I would like to recommend that the Council ask the Spiny Lobster Planning Team and the SSC to review the minimum carapace size issue again before the Council's American Samoa meeting. Dr. Polovina and other members of my staff will available to work with the Planning Team and the SSC.

Attachments

AN ESTIMATE OF THE RELATIONSHIP BETWEEN FEMALE SIZE AND THEIR CONTRIBUTION TO TOTAL POPULATION EGG PRODUCTION

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This report presents the most recent data available concerning the reproductive potential of the spiny lobster in the Northwestern Hawaiian Islands. This updates the data in the spiny lobster FMP.

To determine the contribution to egg production as a function of carapace length we need the following three relationships:

i) The ratio of the number of berried females to total females in the population as a function of carapace length and season.

ii) The number of eggs produced by an "average" female as a function of carapace length.

iii) The proportion of females in the population as a function of carapace length.

An estimate of the first relationship, the number of berried females to total females by carapace size, is determined from sampling data presented in Table 1. The relationship between the number of eggs produced and female carapace length is obtained from work done at NMFS (Victor Honda) and is presented in Table 2 and Figure 1. The proportion of females in the population by carapace size is estimated by back calculating from the upper tail of the sampling distribution based on an annual natural mortality of .4 and a growth curve recently obtained by Craig MacDonald (Fig. 2).

For a given month, the number of eggs produced by all the females in a given carapace length interval is obtained from the product of the female population size (N) times the proportion of the population in the size interval i (P_i) times the proportion of berried females in the size interval i (B_i) times the number of eggs produced by an average female in the size interval i (e_i). If the number of eggs produced by the population of females in carapace size interval i is denoted E_i then this can be expressed as;

$$E_i = N P_i B_i e_i$$

If we then sum the E_i values over carapace size classes less than or equal the minimum carapace size then we obtain an estimate of the total number of eggs produced by all females of carapace len[illegible] less than or equal the minimum carapace length.

Since the total female population size is not known, the absoluate number of eggs cannot be estimated. However, for a given carapace length the proportion of the eggs produced by females with carapace length not exceeding the given carapace length relative to the total number of eggs produced by all females less than say 8.25 cm carapace length can be computed. This computation has been performed for carapace lengths of 7.5, 7.75, and 8.0 cm both for selected banks separately as well as for the banks pooled (Figs. 3, 4).

An interpretation of Figure 4 in terms of the effect on population egg production of a reduction from a minimum carapace length of 8.25 cm to 7.8 cm, for example, in a heavily fished situation where the vast majority of eggs come from females below the minimum carapace length would be to estimate that the 7.8 cm restriction results in an egg production which is 72% of the eggs produced with an 8.25 cm carapace length minimum.

However, in the dynamic situation of actually reducing the minimum carapace length two additional factors may become important. First egg production of females below say 7.8 cm may increase as may survival of these eggs due to a reduction in density. However, this trend is opposed by an increased growth rate again due to the reduced density which if size of reproduction is age specific will increase the carapace length at first reproduction and reduce the number of females below 7.8 cm which have reproductive potential.

While based on the estimates in this report it appears that a reduction of the minimum carapace length from 8.25 cm to 7.8 cm will not destroy the reproductive potential of the stock, however, the condition of the stock must be constantly monitored to observe the impact of the dynamic factors.

Table 1. Percent of berried females to total females (sample size) by carapace length.

		Carapace length (cm)							
		<6.5	6.5-7	7-7.5	7.5-8	8-8.5	8.5-9	9-9.5	>9.5
Location and date	Necker 11-12/76		36.4% (55)	31.5% (203)	22.8% (254)	32.9% (152)	51.3% (39)	33.3% (6)	
	Necker 8-9/77	18.2% (11)	21.6% (97)	21.9% (465)	21.8% (705)	26.5% (460)	23.8% (185)	12.5% (40)	6.7% (15)
	Maro 8/77		33.3% (9)	6.5% (31)	27.1% (85)	25.4% (142)	30.1% (163)	28.1% (89)	32.7% (101)
	Midway 7/77	14.3% (14)	27.3% (11)	20.0% (20)	23.5% (34)	26.9% (26)	20.0% (75)	16.7% (60)	15.3% (333
	Total	16.0% (25)	27.3% (172)	23.9% (719)	22.5% (1078)	27.6% (780)	27.7% (462)	21.6% (195)	18.9% (449)

TABLE 2. CARAPACE LENGTH AND THE ESTIMATED NUMBER OF EGGS CARRIED BY SPINY LOBSTER, *PANULIRUS MARGINATUS*, CAUGHT AT NECKER ISLAND AND MARO REEF

Carapace Length (mm)	Estimated No. of Eggs	Carapace Length (mm)	Estimated No. of Eggs
56.7	129,266	85.6	133,350
58.6	96,602	86.3	339,289
58.8	94,053	86.6	235,003
60.9	60,101	86.7	330,095
61.8	136,534	86.7	242,887
63.0	160,196	86.8	193,560
64.7	166,897	87.2	228,322
67.9	171,607	87.5	178,780
67.9	143,005	88.3	299,581
68.9	105,767	88.8	246,068
71.5	161,370	89.0	257,692
71.6	166,050	89.9	303,233
73.4	202,428	91.4	161,562
77.8	237,730	93.4	389,552
78.0	194,075	96.8	315,518
81.2	207,247	99.4	282,183
82.4	240,533	104.6	454,362

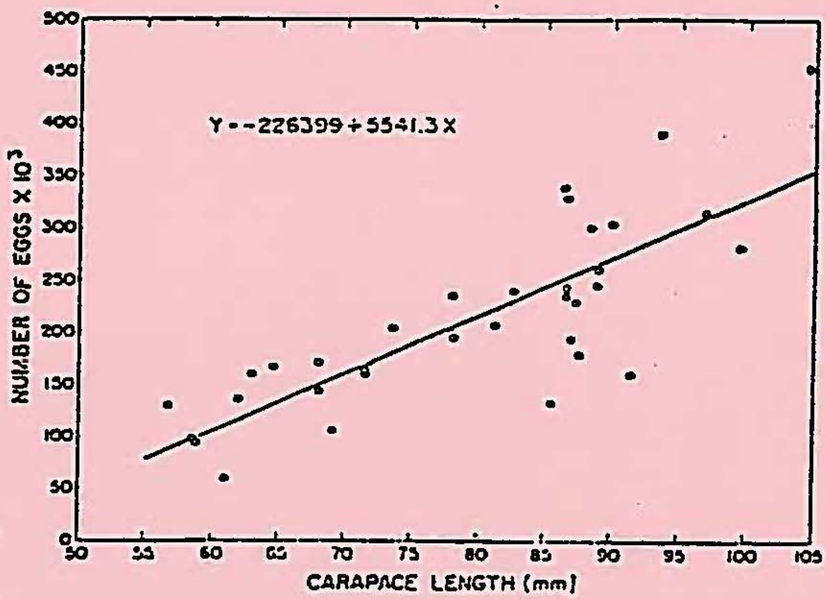

Figure 1.—Relationship between the number of eggs carried and carapace length in the spiny lobster, *Panulirus marginatus*.

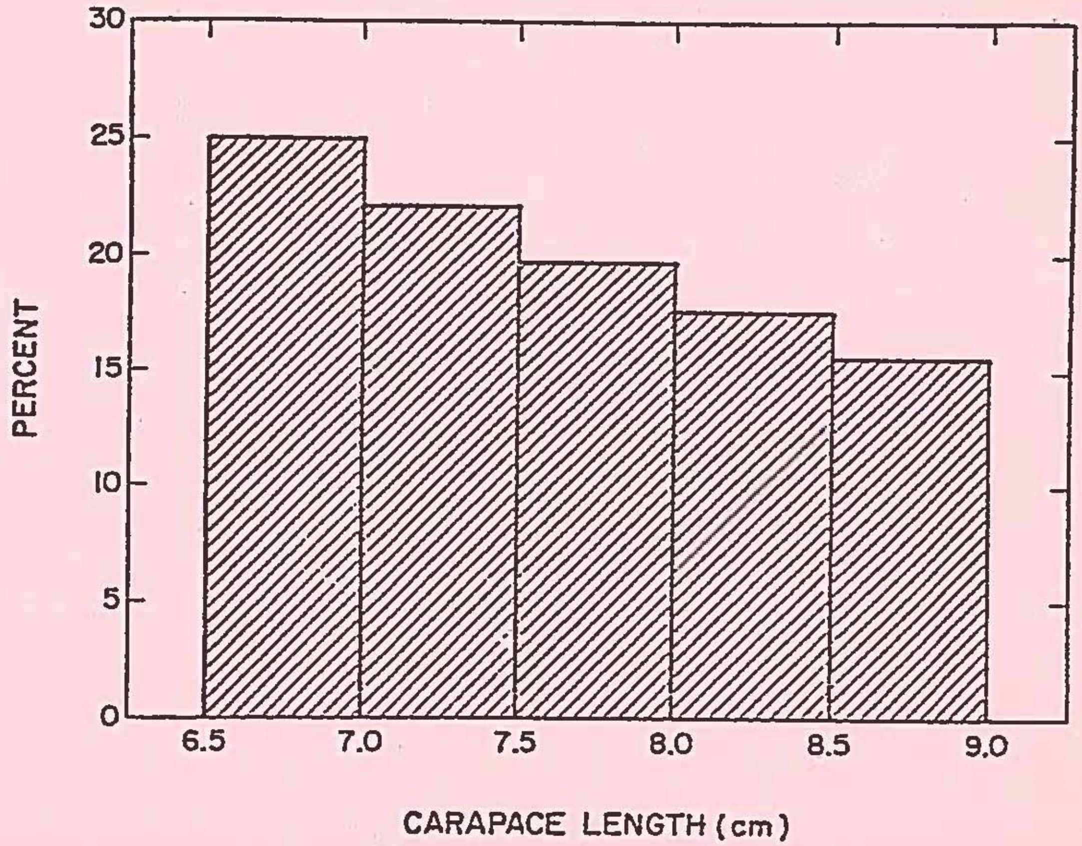

Figure 2.--Estimated relative size frequency for females with carapace length from 6.5 to 9.0 cm in the Northwestern Hawaiian Islands based on annual natural mortality of 0.4.

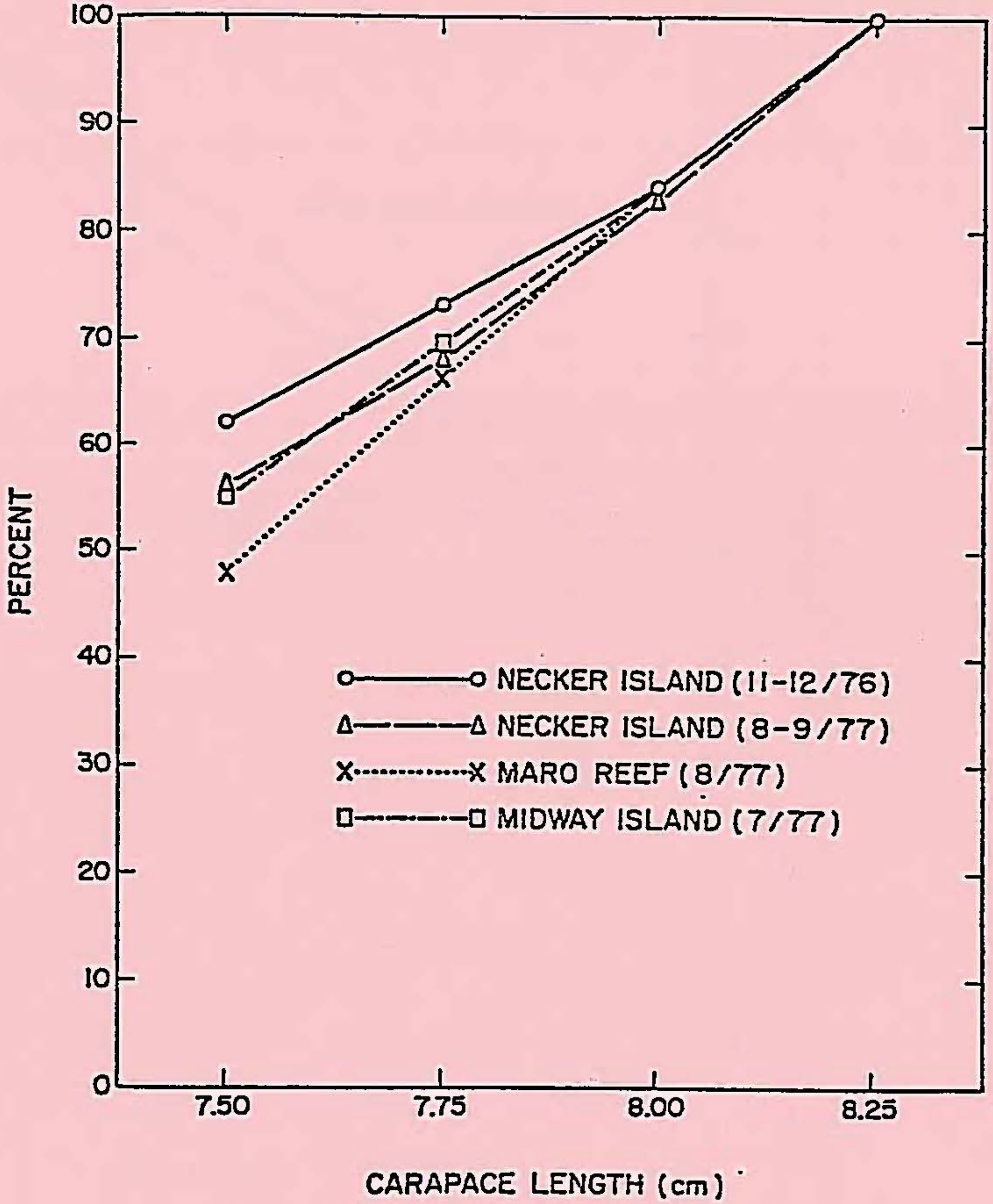

Figure 3.--The contribution to the total egg production of females with carapace length not exceeding 8.25 cm of females by carapace length.

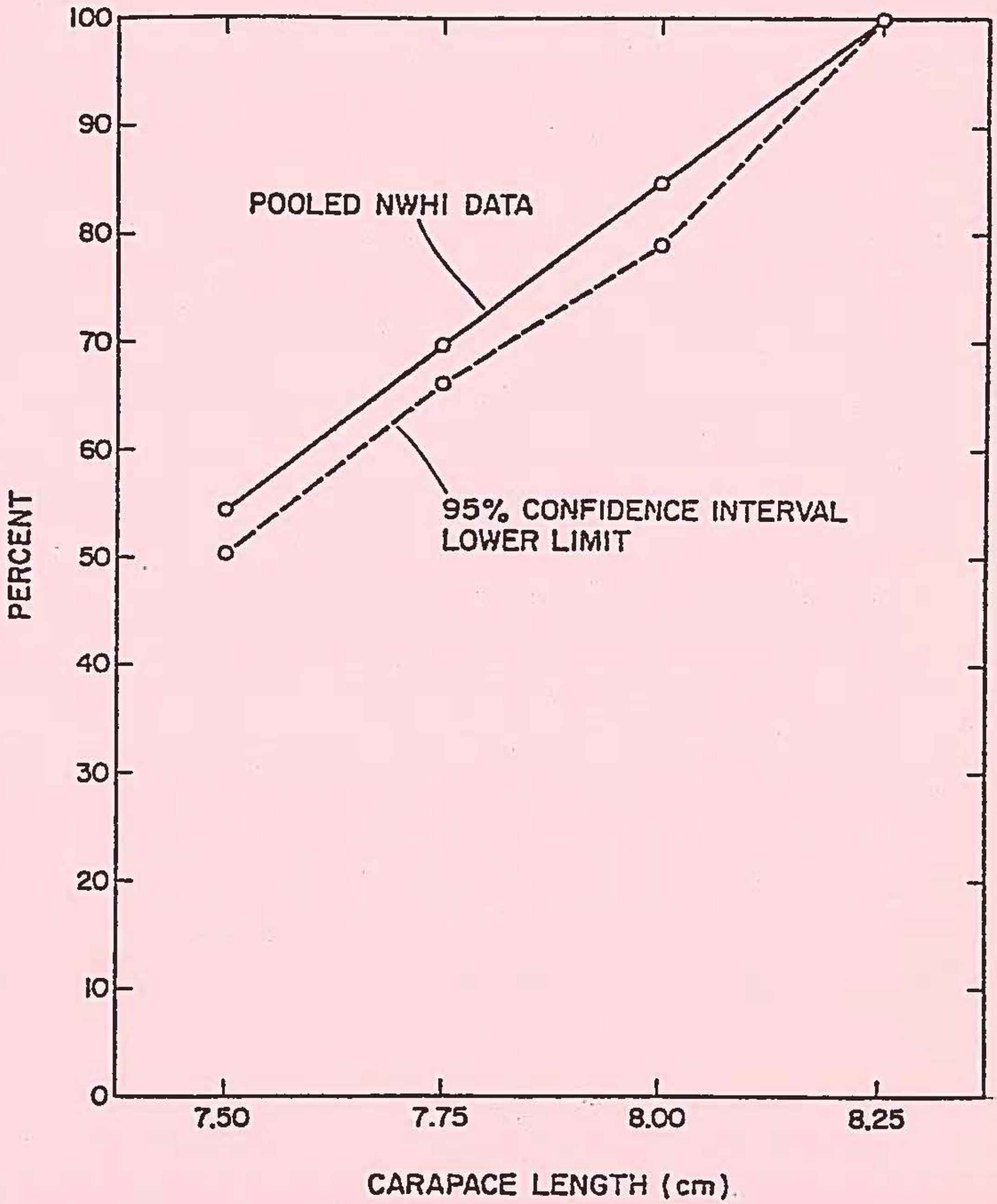

Figure 4.--Relative contribution to egg production as a function of carapace length for entire Northwestern Hawaiian Islands.

APPENDIX 2

POPULATION ESTIMATES AND YIELD-PER-RECRUIT ANALYSIS FOR THE SPINY LOBSTER, PANULIRUS MARGINATUS, AT NECKER ISLAND

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Data from commercial fishermen and research sampling for lobster fishing at Necker Island are examined. The abundance of lobster appears to be very heterogeneous with the greatest abundance in the northwestern part of the Necker bank. Estimates of virgin population size and catchability for this region are 125,000 legal lobsters and 3.94×10^{-5} per trap-night, respectively. The estimated range of sustainable yield from the northwest region based on the minimum legal size of 8.25-cm carapace length and the present population size is 10,000-21,000 legal lobsters per year. Yield-per-recruit analysis indicates that substantially greater yields may be possible if the minimum legal size is reduced from 8.25 cm. However, this latter result is based on strong assumptions about recruitment which can only be confirmed by field tests.

Necker Island sustainable yield
spiny lobsters yield per recruit

Commercial spiny lobster, *Panulirus marginatus*, fishing began on a regular basis off Necker Island in the Northwestern Hawaiian Islands in November 1976. Seven commercial fishing vessels from Honolulu reported lobster catches during the period November 1976 through April 1979. Some of these vessels trapped in the area frequently while others trapped only occasionally.

This report analyzes and summarizes commercial and research data for the *P. marginatus* fishery off Necker Island during the period from November 1976 through April 1979. Estimates of virgin population size, catchability, and sustainable yield are obtained and yield-per-recruit analysis is performed. The commercial data consist of monthly totals of the number of legal lobsters caught and the effort expended (Table 1). A legal lobster is defined as a lobster with a carapace length equal to or exceeding 8.25 cm. These data were collected by National Marine Fisheries Service (NMFS) observers aboard commercial vessels or were

TABLE 1. TOTAL MONTHLY CATCH (IN NUMBERS) AND EFFORT (IN TRAP-NIGHTS) IN THE COMMERCIAL FISHERY FOR LEGAL LOBSTERS AT NECKER ISLAND, OCTOBER 1976-APRIL 1979

	Region I		Region II		Total	
Date	Catch	Effort	Catch	Effort	Catch	Effort
1976						
Oct.	107	73	--	--	107	73
Nov.	616	156	--	--	616	156
Dec.	984	276	--	--	984	276
1977						
Jan.	10,030	1,656	1,599	1,081	11,629	2,737
Feb.	--	--	--	--	--	--
Mar.	--	--	--	--	--	--
Apr.	--	--	--	--	--	--
May	15,588	3,480	67	53	15,655	3,533
June	7,132	1,936	461	122	7,593	2,058
July	9,727	2,447	24	75	9,751	2,522
Aug.	5,404	1,832	678	534	6,082	2,366
Sept.	10,524	2,944	293	120	10,817	3,064
Oct.	2,901	916	58	120	2,959	1,036
Nov.	1,885	600	--	--	1,885	600
Dec.	2,485	824	--	--	2,485	824
1978						
Jan.	1,314	254	203	92	1,517	372
Feb.	978	300	--	--	978	300
Mar.	3,687	1,482	54	60	3,741	1,600
Apr.	3,022	719	398	112	3,420	831
May	3,160	687	--	--	3,160	[1]687
June	2,940	1,260	--	--	3,849	1,724
July	2,167	603	--	--	2,167	603
Aug.	2,014	585	--	--	2,014	585
Sept.	202	246	--	--	202	246
Oct.	1,574	606	1,373	401	2,947	1,007
Nov.	116	56	5,222	2,349	5,338	2,405
Dec.	--	--	7,040	3,139	7,040	3,139
1979						
Mar.	1,563	658	--	--	1,563	658
Apr.	1,925	958	--	--	1,925	958

[1]Two stations with no positions.

reported in catch reports submitted by the vessels' owners. The unit of effort is measured as one baited trap fished on the lobster ground for 1 night, henceforth referred to as a trap-night. The research data consist of total number and effort, as well as length and sex observations, for lobsters caught at sampling sites from the RV Townsend Cromwell.

The island of Necker is surrounded by a large bank (Figure 1). The commercial catch by position indicates that the fishermen have primarily trapped in the northwest region of this bank, indicated as Region I in Figure 1. There were 90,368 legal lobsters trapped in Region I from January 1977 through April 1979; only 17,470 legal lobsters were trapped on the rest of the bank (Region II) during the same period (Table 2). The catch per unit effort (CPUE) in Region II (Figure 2) shows considerable variation, and some of the more recent values for CPUE approach those for Region I (Figure 3). However, because of the lack of a longer series of catch and effort data for Region II, this report will focus only on Region I. By isolating Region I for study, we are making the assumption that the lobster population in this region is closed. This may not be an unreasonable assumption for adult lobsters because tagging experiments by NMFS indicate minimal migration. However, in the case of larval recruitment this may not be the case and for the long term, the assumption of a closed population in Region I may not be valid.

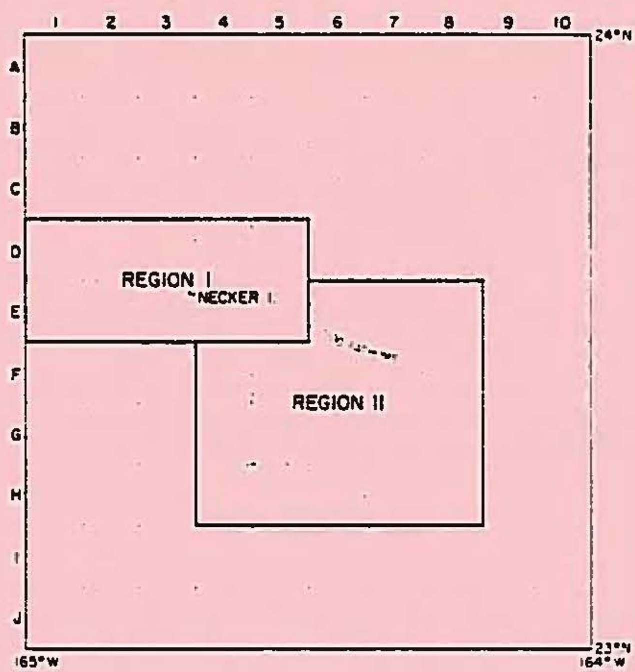

Figure 1. Necker bank

TABLE 2. THE ANNUAL CATCH (IN NUMBERS OF LOBSTERS), EFFORT EXPENDED (IN TRAP-NIGHTS), AND CATCH PER UNIT EFFORT FOR LEGAL LOBSTERS AT NECKER ISLAND BY COMMERCIAL VESSELS FROM JANUARY 1977-APRIL 1979

Year	Catch	Effort	Catch Per Unit Effort
		Region I	
1977	65,676	16,635	3.95
1978	21,201	6,798	3.12
1979 (1/1-4/30)	3,491	1,616	2.16
		Region II	
1977	3,180	2,105	1.51
1978	14,290	6,153	2.32
		Combined (Regions I and II)	
1977	68,856	18,740	3.67
1978	35,491	12,951	2.74

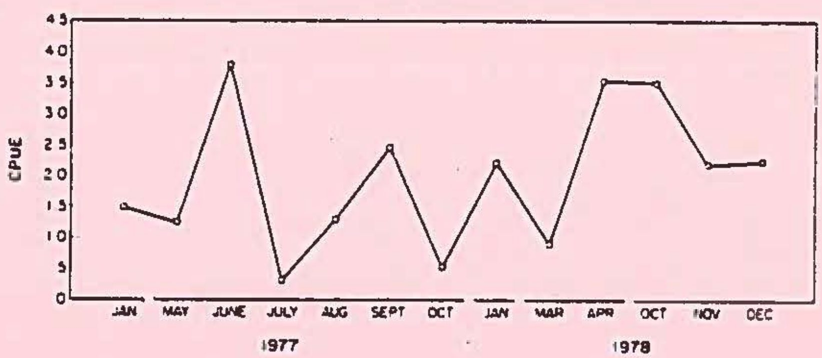

Figure 2. Catch per unit effort (in legal lobsters per trap-night) from Region II at Necker Island

RELATIVE ABUNDANCE

Catch per unit of effort provides a measure of relative abundance. Changes in CPUE over time can result from changes in population structure and size, as well as changes in fishery methods and gear. In the case of the lobster fishery at Necker between November 1976 and April 1979, the changes in fishing methods and gear have been minimal. A graph of CPUE for legal lobsters from Region I on a monthly basis is presented in Figure 3. Considerable month-to-month variation as well as a declining trend is apparent.

One reason for some of the month-to-month variation in CPUE is that the monthly CPUE is computed by pooling the catch and effort for all the

Figure 3. Catch per unit effort (in legal lobsters per trap-night) from Region I at Necker Island

vessels reporting trips to Necker during the month. These vessels are not always the same vessels but a subset of the seven commercial vessels which comprise the fleet.

Catch per unit effort computed on an annual basis has declined each year from 1977 to 1979, although the 1979 figure should be treated with caution because it is based on only an effort of 1,616 trap-nights and may change when more 1979 data are available (Table 2).

A regression of CPUE against month, weighted by effort, indicates that at the 5% level the decreasing trend in CPUE for 1977 is significant while the trend in 1978 is not significant. The CPUE for January 1977 and January 1978 represents a sharp increase from the preceding and following months indicating a possible seasonal trend which should be examined as more data become available.

The percentage of legal lobsters in the total lobster catch provides an index of the proportion of legal lobsters in the population to the total lobster population. A decrease in this index could mean that the number of legal lobsters in the population has been reduced and/or the number of sublegal lobsters in the population has increased due to increased reproduction, survival, or immigration. We found that the percentage of legal lobsters in the catch for the RV Townsend Cromwell decreased from 54.2% in November 1976 to 23% in May 1979 (Table 3).

POPULATION ESTIMATES

The primary approach we selected to estimate population size was a method proposed by Allen (1966) (see Appendix 1). Basically, this method consists of a least squares procedure which estimates population size and catchability by minimizing the sum of squares between the actual catch and the predicted catch based on effort.

TABLE 3. THE AMOUNT OF EFFORT EXPENDED (IN TRAP-NIGHTS) AND PERCENTAGE OF LEGAL LOBSTERS CAUGHT AT NECKER ISLAND BY THE RV TOWNSEND CROMWELL

Date	Effort (Trap-Night)	Percent Legals in Catch
	Region I	
Oct.-Nov. 1976	145	54.2
May 1977	32	40.0
Oct. 1977	116	42.0
Mar. 1978	57	35.0
Oct.-Nov. 1978	104	37.1
May 1979	48	22.8
	Region II	
Sept.-Oct. 1977	234	62.6
Mar. 1978	61	81.0
Oct. 1978	52	67.0

We used the monthly commercial catch and effort data from November 1976 through April 1979 to estimate population size and catchability. Allen's model assumes natural mortality and recruitment operate in the population. In its most general form, this model assumes that the rate of natural mortality is constant while recruitment may vary over time. This most general form requires that the user supplies estimates of the natural mortality rate and the recruitment rates. We do not have any size and age data which might allow us to estimate these parameters and consequently, we used a simplified version of Allen's model. We assumed that the ratio of the rate of natural mortality to the recruitment rate ($e^{-M}/1-W_1$) in Appendix 1 is constant. Given effort, we then estimated this constant as the value which gave the best fit of predicted catch to actual catch. We feel the assumption that the ratio, rate of natural mortality to recruitment rate into the fishery is constant, may not be too unreasonable for the 2-year period of our study. If it takes 6 or more years for a lobster to grow from larval stage to legal size, and if the majority of the mortality occurs during the early years of life, then, even an intense reduction of the population of legal lobsters in 1977 will not have a major effect on the ratio of natural mortality rate to recruitment rate until 6 years later.

The plots of actual monthly catch and predicted monthly catch estimated by Allen's method are presented in Figure 4. The fit of the model to the data is good. Based on this method, we estimate that there were 132,406 legal lobsters in Region I at the beginning of November 1976. This number declined to 68,571 legal lobsters by April 1979. A plot of the monthly estimated population size is given in Figure 5. As could be expected from the catch and CPUE data, the population size of legal lobsters dropped severely during 1977 and decreased very slowly during 1978.

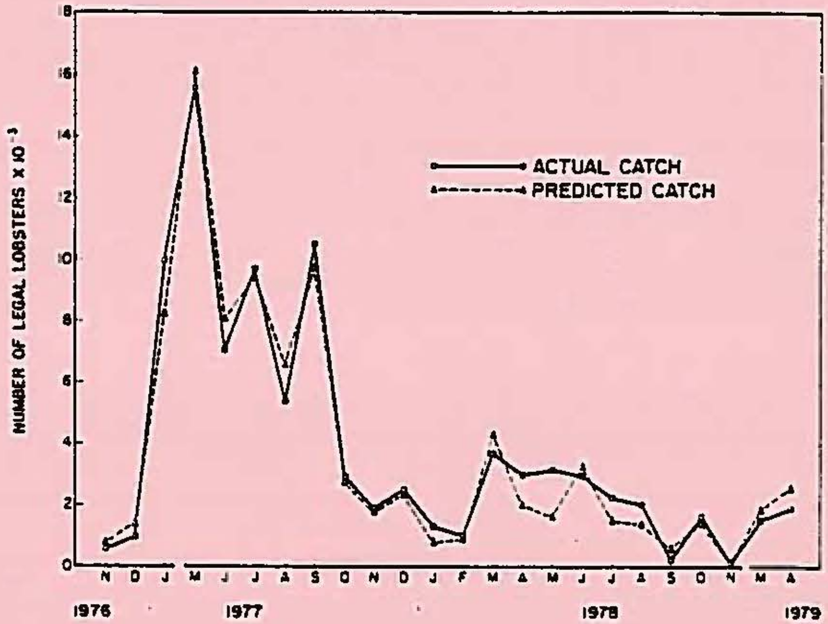

Figure 4. Catch predicted from Allen's model versus actual catch of legal lobsters from Region I at Necker Island

Figure 5. Estimated population size of legal lobsters from Allen's model for Region I at Necker Island

As an independent check on the results obtained by Allen's method, we used Leslie's method of population estimation. This method is used to estimate population size and catchability in situations where there has been intensive fishing of a closed population over a short period of time. Since this method applies to fishing over a short period of time, we assume that natural mortality and recruitment are negligible.

We noticed from Table 1 that trapping was very intense from May through August 1977. We used these data to estimate the population size of legal lobsters at the beginning of May 1977 and the catchability by Leslie's method. The estimated population size and catchability obtained from Leslie's method is in agreement with the estimates obtained by Allen's method (Table 4).

TABLE 4. A COMPARISON OF THE ESTIMATES FROM THE LESLIE AND ALLEN METHODS

	Leslie	Allen
N_{May}	127,000	125,000
q	3.58×10^{-5}	3.94×10^{-5}

N_{May} is an estimate of the number of legal lobsters in Region I beginning May 1977.

q is the catchability coefficient.

Lobster yield-per-recruit analysis

We can explore the relationship between size at entry into the fishery (minimum carapace size) and yield with the Beverton-Holt equilibrium yield equation. We will assume that over the range of minimum legal sizes of interest, the number of recruits to a given size is constant, that the lobster growth can be approximated by a von Bertalanffy equation, and that the lobster weight can be expressed as: weight = a (length)^b. We then write the yield per recruit into the fishery Y/R as:

$$\frac{Y}{R} = \left(\frac{F}{K}\right)\left(W_\infty\right)\left(e^{Zt_m}\right)\left[B\left(X,\ b,\ \frac{Z}{K}\right)\right]$$

where F is the fishing mortality, K is the growth coefficient for the von Bertalanffy curve, W is the asymptotic lobster weight, $Z = F + M$, M is the natural mortality, $t_m = t_{min} - t_o$, where t_{min} is the minimum age of entry into the fishery and t_o is the age of zero length in the von Bertalanffy curve, and B(X, b, Z/K) is the incomplete beta function evaluated at $X = e^{-Kt_m}$, b = the allometric coefficient, and Z/K.

We will evaluate Y/R at several levels of fishing effort and several minimum carapace lengths. We selected fishing effort (f) at the following levels (trap-nights): 2,500, 5,000, 7,500, 10,000, 12,500, and 15,000. Based on these values of f we can estimate F as $F = qf$ where $q = 4 \times 10^{-5}$ from Allen's method. We selected the following values for the minimum legal carapace length: 6.75, 7.25, 7.75, and 8.25 cm. The value of t_m corresponding to these lengths can be estimated from the von Bertalanffy curve. We determined W_∞ to be 3,580 g and the coefficient b in the weight-length relationship as b = 2.6 from data in McGinnis (1972). There is not any one data set for lobster growth which appears sufficiently reliable. Results from tagging and modal analysis by the NMFS estimates K = 0.26/yr and L_∞ = 12.5 cm. Observations by McDonald of an 18-cm carapace curve suggests L_∞ could be as high as 18. We, thus, performed the yield-per-recruit analysis for the following sets of K and L_∞ values: (K = 0.05, L_∞ = 18), (K = 0.1, L_∞ = 15), (K = 0.2, L_∞ = 12). We used the relationship:

$$\frac{F + M}{K} = \frac{(L_\infty - \bar{l})}{\bar{l} - l_{min}}$$

where l_{min} is the minimum carapace length, $\bar{l}$ is the mean carapace length of the population above l_{min}, and F and M are the fishing and natural mortality, respectively (Beverton and Holt, 1956).

We are able to estimate the ratio M/K by taking a length-frequency distribution from a sample of the population taken from Necker Island in November 1976--before any substantial fishing effort was applied to the region. This sample, consisting of 744 lobsters, estimated M/K at approximately 3.5 for L_∞ = 12 cm. For the yield-per-recruit analysis, we used values for M/K as 2, 3, and 4.

From the results of the yield-per-recruit analysis, we determined the carapace length, from among the set 6.75, 7.25, 7.75, and 8.25 cm, which gave the greatest yield (Table 5). In the majority of situations, a minimum carapace length of 6.75 cm achieved the maximum yield per recruit. Only when M and M/K are low and L_∞ is large is the yield per recruit achieved with a minimum carapace length greater than 6.75 cm.

TABLE 5. CARAPACE LENGTH (IN CENTIMETERS) AT WHICH THE MAXIMUM YIELD PER RECRUIT (IN GRAMS) IS OBTAINED

		Fishing Effort					
		2,500	5,000	7,500	10,000	12,500	15,000
$\frac{M}{K} = 2$	K = 0.05, L_∞ = 18	7.75	8.25	8.25	8.25	8.25	8.25
	K = 0.1, L_∞ = 15	6.75	6.75	6.75	7.25	7.25	7.75
	K = 0.2, L_∞ = 12	6.75	6.75	6.75	6.75	6.75	6.75
$\frac{M}{K} = 3$	K = 0.05, L_∞ = 18	6.75	6.75	7.25	7.25	7.75	7.75
	K = 0.1, L_∞ = 15	6.75	6.75	6.75	6.75	6.75	6.75
	K = 0.2, L_∞ = 12	6.75	6.75	6.75	6.75	6.75	6.75
$\frac{M}{K} = 4$	K = 0.05, L_∞ = 18	6.75	6.75	6.75	6.75	6.75	6.75
	K = 0.1, L_∞ = 15	6.75	6.75	6.75	6.75	6.75	6.75
	K = 0.2, L_∞ = 12	6.75	6.75	6.75	6.75	6.75	6.75

An examination of the yield-per-recruit results suggest that an adoption of a 6.75-cm minimum carapace length could, in the worst case ($K = 0.05$, $L_\infty = 18$, $M = 0.1$, and $F = 15{,}000$), result in a 15% decrease in yield per recruit from the minimum carapace length of 8.25 cm, and at best ($K = 0.2$, $L_\infty = 12$, $M = 0.8$, $F = 1{,}500$), achieve a 167% increase in yield per recruit over an 8.25-cm minimum carapace length (Table 6). Clearly, these results should be interpreted cautiously because we have no evidence to suggest that the level of recruitment will remain unchanged when the minimum carapace length is lowered to 6.75 cm. However, the magnitude of the possible increase in yield which may be achieved with a reduction from the existing minimum carapace length should serve as impetus for further study and testing.

TABLE 6. YIELD PER RECRUIT (IN GRAMS) AS A FUNCTION OF FISHING EFFORT (IN TRAP-NIGHTS) AND MINIMUM LEGAL CARAPACE LENGTH (IN CENTIMETERS) FOR SELECTED GROWTH AND MORTALITY PARAMETERS

	Fishing Effort					
l_{min}	2,500	5,000	7,500	10,000	12,500	15,000
			$\frac{M}{K} = 4$, $K = 0.2$, $L_\infty = 12$			
6.75	124	216	287	343	388	425
7.25	90	157	210	252	286	314
7.75	64	112	150	180	205	226
8.25	44	78	105	126	144	159
			$\frac{M}{K} = 3$, $K = 0.1$, $L_\infty = 15$			
6.75	210	305	355	384	402	415
7.25	194	285	334	364	383	397
7.75	177	262	310	340	360	373
8.25	160	239	284	313	332	346
			$\frac{M}{K} = 2$, $K = 0.05$, $L_\infty = 18$			
6.75	318	339	335	327	321	315
7.25	321	351	351	347	342	338
7.75	321	358	363	361	349	356
8.25	319	362	371	372	371	370

CONCLUSION

The analysis of commercial catch and effort data indicating the decline in CPUE from 3.95 in 1977 to 3.12 in 1978 strongly suggests that a population size of 65,676 legal lobsters is not sustainable with a CPUE of 3.90. This is further supported by the decline in the percentage of legal lobsters per trap from the Cromwell sampling data. The fact that we do not reject the hypothesis that CPUE did not decline during 1978, based on the test of the slope of the regression line, suggests that a yield of 21,201 legal lobsters per year may be sustainable with a CPUE of

Allen's population estimation procedure

A method developed by Allen (1966) was used to estimate population size at time t (N_t), catchability (q) given effort at time t (X_t), and catch (C_t). M is the natural mortality and W_i is the proportion of the new recruits in the exploited stock for the i^{th} season. The essential relationships of this model are given below:

Year 1 Initial population $= N_1$

Survival to beginning of next season $= (N_1 - C_1)e^{-M}$

Expected catch $= \left(N_1 - \frac{C_1}{2}\right)qX_1$

Year 2 Initial population $= N_2 = \frac{(N_1 - C_1)e^{-M}}{1 - W_2}$

Survival to beginning of next season $= \left[\frac{(N_1 - C_1)e^{-M}}{1 - W_2} - C_2\right]e^{-M}$

Expected catch $= \left[\frac{(N_1 - C_1)e^{-M}}{1 - W_2} - \frac{C_2}{2}\right]qX_2$

Continuing in this way we can show that at the beginning of year t the population equals

$$N_t = \frac{e^{-(t-1)M}}{\prod_{i=2}^{t}(1-W_i)}\left[N_1 - C_1 - \frac{C_2(1-W_2)}{e^{-M}} \ldots \frac{C_i\prod_{j=2}^{i}(1-W_j)}{e^{-(i-1)M}} \ldots \frac{C_{t-1}\prod_{j=2}^{t-1}(1-W_j)}{e^{-(t-2)M}}\right]$$

$$= A_t\left[N_t - f(C)_{t-1}\right],$$

where

$$A = \frac{e^{-(t-1)M}}{\prod_{i=2}^{t}(1-W_i)}$$

and

$$f(C)_{t-1} = C_1 + \sum_{i=2}^{t-1}\frac{C_i}{A_i} .$$

about 3.00. We can use the result of Allen's model to compute the surplus production which can be harvested without reducing the population size. This value is obtained by multiplying the population size of legal lobsters by the ratio of the natural mortality rate to the recruitment rate for legal lobsters and subtracting the initial population size. We estimated the population size at the beginning of 1979 to be 67,766 legal lobsters and the ratio of the monthly rate of natural mortality to recruitment to be 1.0116. Consequently for 1979, we estimate that slightly over 10,000 legal lobsters can be harvested for the year without reducing the population size of legals. Thus, based on the data presented here, the annual surplus production of legal lobsters in 1979 is estimated to be between 10,000 and 21,000.

Finally, due to the results of our theoretical yield-per-recruit analysis, it is suggested that future research undertake field trials to ascertain the impact of a lower legal size on yield per recruit.

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APPENDIX 3

University of Hawaii at Manoa

Department of Zoology
Edmondson Hall • 2538 The Mall
Honolulu, Hawaii 96822

March 19, 1981

MEMORANDUM

TO: Mr. Svein Fougner, Executive Director, WPRFMC

FROM: Craig D. MacDonald, Member, Spiny Lobster Planning Team

SUBJECT: Update of research results at Kure Atoll

This memo is to update information on growth (refer to my memo Sept. 8, 1980) and introduce new information on the demography and variation in year-class strength of the spiny lobster, Panulirus marginatus, at Kure Atoll. These results are strictly preliminary as data are still being collected, certain assumptions need to be tested, and more highly resolved analyses remain to be undertaken.

Annual Growth

The updated estimates of growth are based on the recapture of 128 tagged lobsters between June 1979 and January 1981. The interval between release and recapture of each of these lobsters was 1 yr. ± 1 wk. Both sexes were sampled over a wide range of carapace lengths and these data afford a relatively precise estimate of annual growth (Figure 1).

The departure from linearity in the relationship between annual growth increment and initial carapace length (Figure 1B) among lobsters greater than about 11 cm carapace length (CL) indicates that the von Bertalanffy growth model strictly may not be the most appropriate model to describe growth in this species. For practical purposes, however, it is most useful to do so because it is fundamental to the Beverton-Holt yield equation in exploitation population dynamics. Since the age relationship inferred from the progression of several modes in seasonal size distributions at Kure agrees well with the size-age relationship generated from the von Bertalanffy growth model, the violation of assumptions inherent in these data apparently does not seriously bias parameter estimation. This is particularly true for estimates of growth in animals less than about 9 cm CL which will be the primary focus of the industry as fishing-down occurs. Note also that the estimates of asymptotic carapace length for both sexes are realistic. These updated results indicate that growth was somewhat slower than originally estimated and are presented in Figure 2 and Table 1. In Figure 2, the horizontal line indicates the 7.7 cm CL recommended minimum size for both sexes and the arrow indicates the size at sexual maturity of females in relation to the ages inferred.

Demographic Factors

Estimated values for several important demographic factors that pertain to management of the spiny lobster fishery are listed in Table 1. All of these values rely upon parameters estimated by fitting the von Bertalanffy model to the annual growth data. Estimates of the instantaneous mortality coefficient (M) are based on the assumption that mortality is constant across all sizes. This assumption remains to be tested. Since lobsters cannot be individually aged, estimates of natural mortality must be derived indirectly through growth or directly by calculating death rates or survivorship from the multiple recapture of tagged animals. This latter method will be used as a check on the estimates of natural mortality presented in Table 1. The values of estimates presented in Table 1 compare well with published accounts of corresponding estimates in other species of spiny lobsters.

Variation in Year-Class Strength

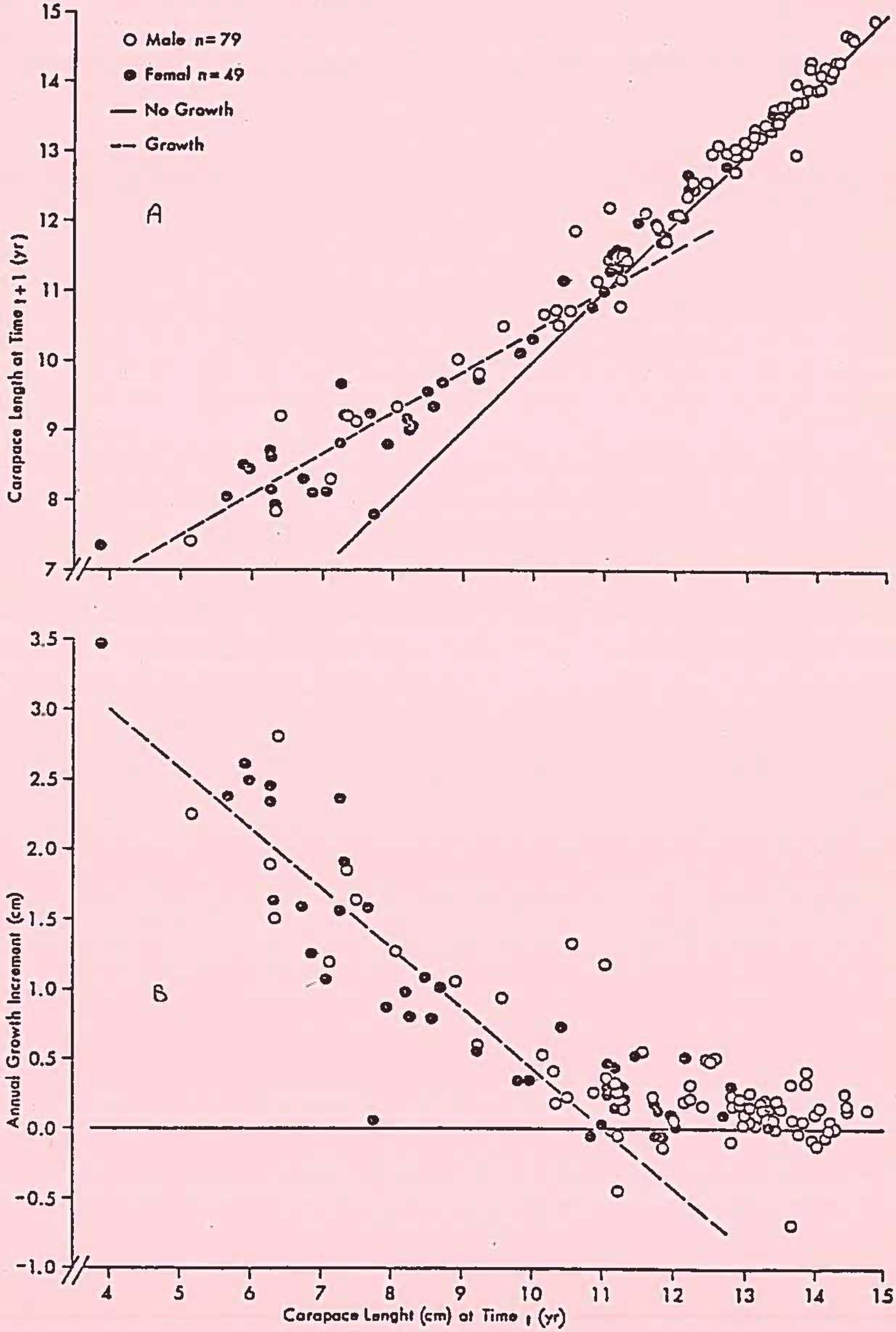
Differences between years in the absolute strength of recruitment by puerulus larvae were significant (Figure 3). During June-October 1979, a total of 306 pueruli were collected. During the same period in 1980, a total of only 121 pueruli were collected with approximately equal effort. This represented a 60% reduction in the strength of larval recruitment in 1980 relative to 1979.

Significant differences between years in year-class strength were also indicated by the relative abundance of one-year old (4-5 cm CL) lobsters (shaded bars, Figure 4). These lobsters were sampled by divers in June and September in both 1979 and 1980. Size classes of 5 cm CL and greater are considered to be fully represented. Lobsters in the 4-5 cm CL classes in 1980 were recruited as puerulus larvae in 1979. In both June and September 1980, the relative year-class strength of one-year old lobsters was reduced by 50% over the previous year. These results signify that year-to-year differences in the strength of larval recruitment may persist at least through the first year post-settlement and may be further manifested in year-to-year differences in fishery yields unless density-dependent factors dampen population fluctuations during the second and third year post-settlement.

Table 1. - Preliminary estimates of von Bertalanffy growth parameters and demographic factors of the spiny lobster, Panulirus marginatus at Kure Atoll.

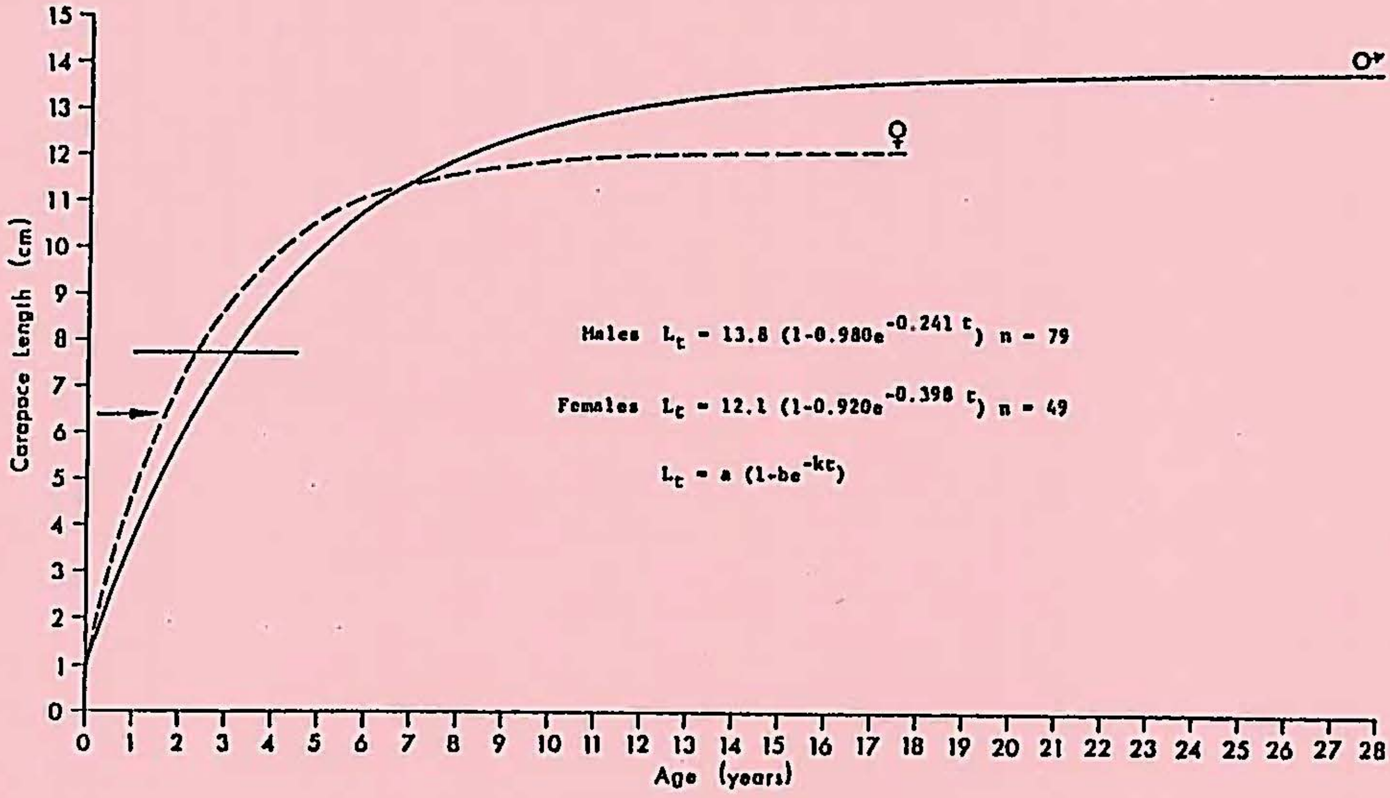
Estimate	Males	Females
Growth constant (k)	0.241	0.398
Asymptotic length (L_∞) in cm.	13.8	12.1
Instantaneous mortality coefficient (M)	0.1530	0.3089
* $\left[M = \dfrac{k\ (L_\infty - \bar{\ell})}{\bar{\ell} - \ell'} \right]$		
Annual mortality rate (%) $(1-e^{-M})$	14.2	26.6
Average individual lifespan (yrs) * (1/M + age at ℓ')	7.7	4.2
Age at entry to fishery (yrs)	2.3	1.7
Age at proposed minimum size (yrs)	2.9	2.3
Age at sexual maturity (yrs)	-	1.8

*ℓ' = 4.6 cm



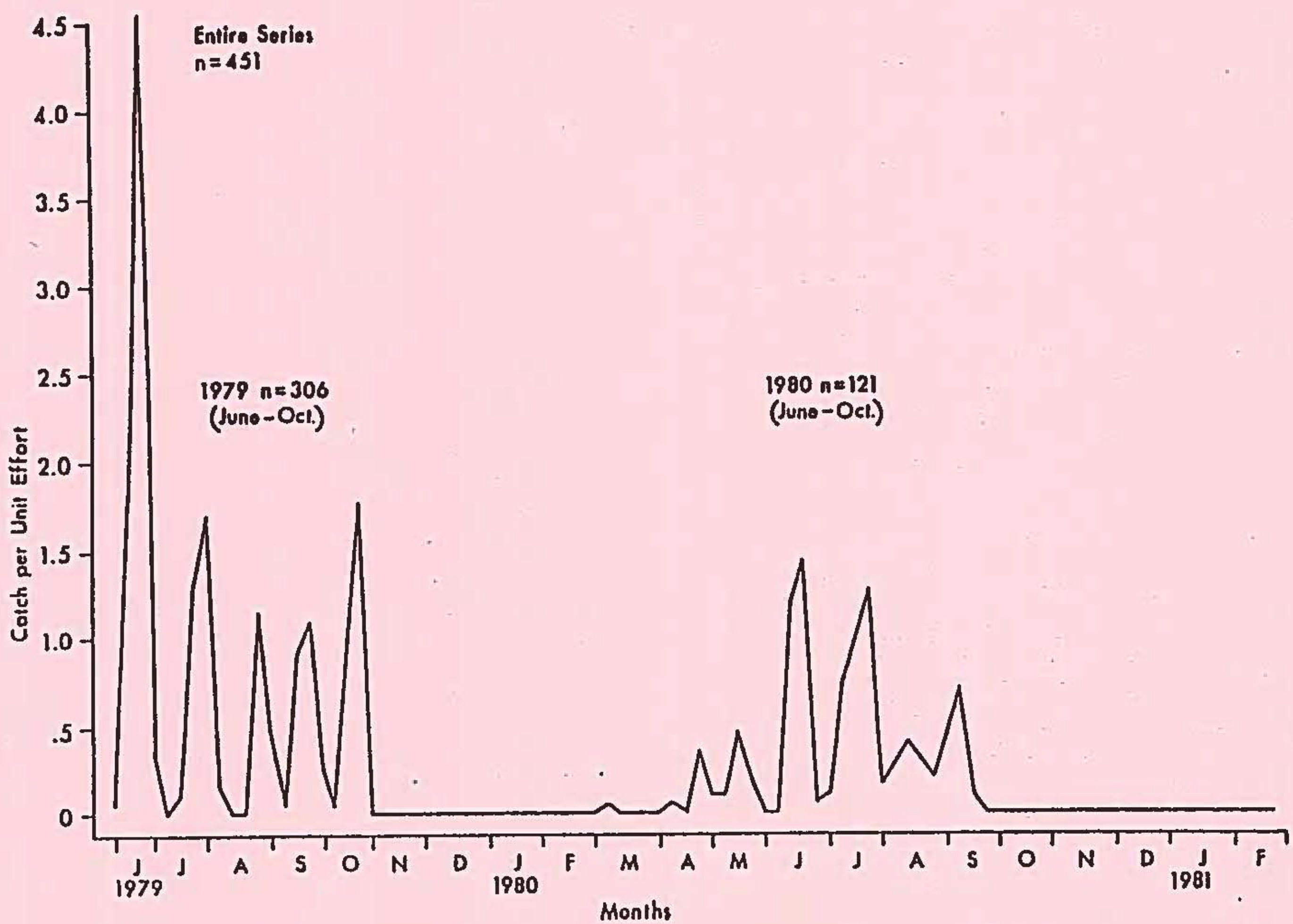
Male n=79
Femal n=49
No Growth
Growth
A
B
Carapace Length at Time t+1 (yr)
Annual Growth Increment (cm)
Carapace Lenght (cm) at Time t (yr)

Figure 1



Carapace Length (cm)
Age (years)
♂
♀
Males $L_t = 13.8\ (1-0.980e^{-0.241\ t})$ n = 79
Females $L_t = 12.1\ (1-0.920e^{-0.398\ t})$ n = 49
$L_t = a\ (1-be^{-kt})$

Figure 2



Entire Series
n=451
1979 n=306
(June-Oct.)
1980 n=121
(June-Oct.)
Catch per Unit Effort
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0
J J A S O N D J F M A M J J A S O N D J F
1979
1980
1981
Months

Figure 3

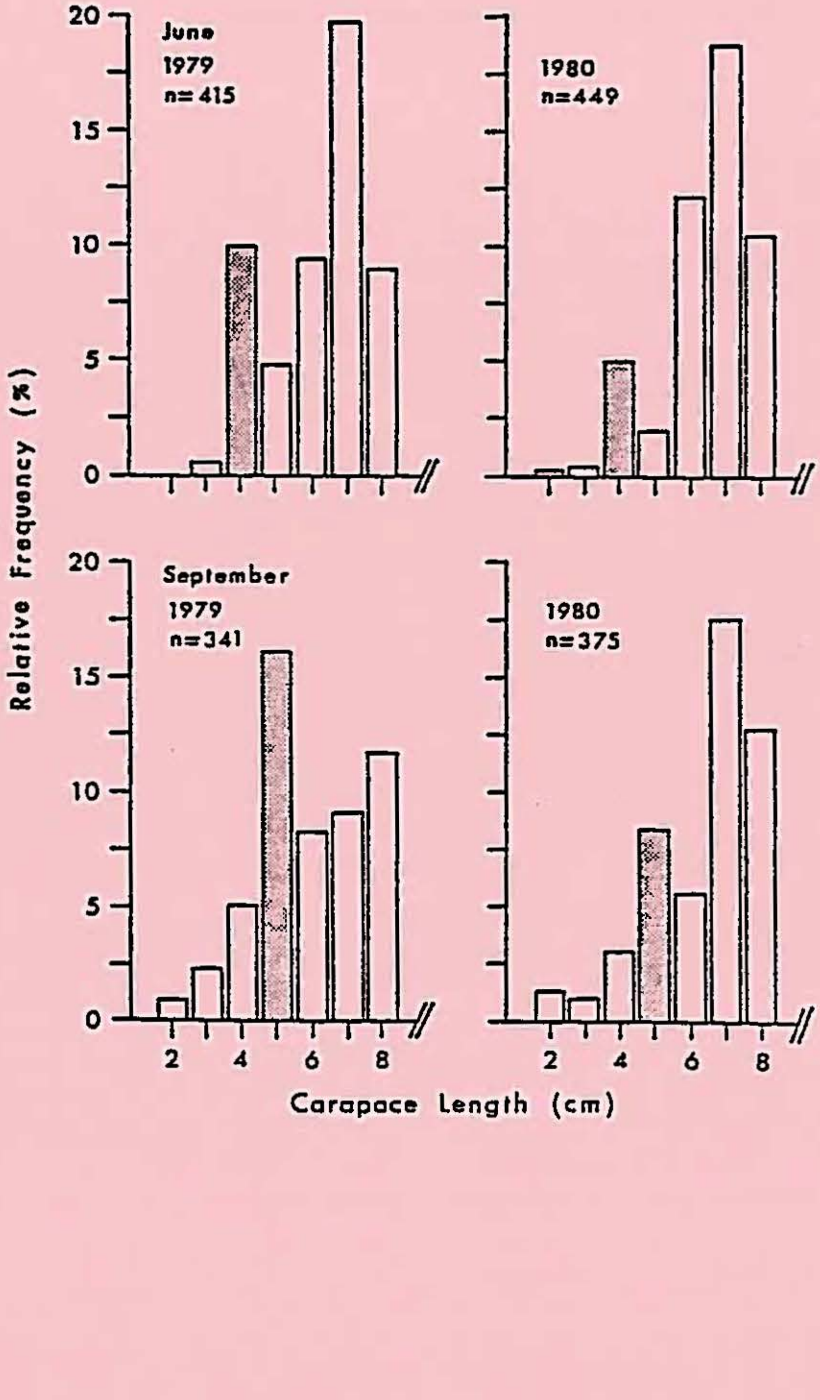

June
1979
n=415
1980
n=449
September
1979
n=341
1980
n=375
Relative Frequency (%)
Carapace Length (cm)

Figure 4

APPENDIX 4

The EAST-WEST CENTER

EAST-WEST ENVIRONMENT AND POLICY INSTITUTE

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February 11, 1980

Mr. Doyle Gates, Chairman
Scientific and Statistical Committee
Western Pacific Fishery Management Council
1164 Bishop Street
Suite 1608
Honolulu, HI 96813

Dear Doyle:

The purpose of this letter is to report my understanding of the basis and meaning of MSY figures in the spiny lobster draft FMP. I want to thank Paul Struhsaker and Jed Inouye for discussing their experiences with me, and I particularly want to acknowledge the full cooperation I received from Jeff Polovina and the National Marine Fisheries Service.

I talked with Jeff and Paul in order to clarify the basis of the MSY estimates for the Northwest Hawaiian Islands. The starting point is a report by Polovina and Tagami (Appendix IV of the FMP) on the 40% of Necker Island bank which has the best lobster fishing. The report is based on catch records from 1976-1979, a period during which fishing reduced the legal-sized population from a nearly virgin state to about half its original abundance. The report used Allen's method to estimate three population parameters (population size, recruitment rate, and catchability) on the basis of changes in catch over a two-year period as lobsters were removed from the population. The line of reasoning was that the MSY for legal-sized lobsters (8.25 cm carapace length and above) should be the same as recruitment of lobsters to that size class.

The estimate of recruitment for the portion of Necker Island covered by the report was 10,000-21,000 lobsters per year. Although the estimation procedure seems basically sound to me, the data are not sufficient to make it highly precise. Estimates for recruitment as low as 10,000 or as high as 30,000 lobsters per year are compatible with the data. The figure of 10,000 in the Necker report comes from the conservative end of this range, and the 21,000 is the total catch in 1978, when catch per unit effort seems to have stabilized at approximately two lobsters per trap. I would be inclined to put the MSY at the upper end of the 10,000-30,000 range because:

(1) even higher catches than in 1978 should be possible if a lower catch per unit effort is tolerated, and

(2) after a reduction in the legal population due to fishing, intraspecific competition with the pre-legal population should be reduced, possibly increasing the recruitment rate to the legal size class.

On a square kilometer basis, the 30,000 translates to 39.2 lobsters per km^2 per year recruited to the legal size class.

As an independent approach, I looked at an equation suggested by Richard Shomura, which for fish is customarily

$$MSY = 0.5 \times M \times (\text{virgin biomass})$$

Taking a virgin standing crop estimate of 130,000 lobsters from the Necker report, a length frequency estimate of $M/K = 3.5$, and tagging growth study estimates that K is between .15 and .30 (I used $k = .24$),

$$MSY = 0.5 \times (3.5 \times .24) \times 130,000 = 54,000$$

which supports selection of the upper end of the 10,000-30,000 range. This should not be considered definitive, however, since I don't know whether 0.5 is really an appropriate coefficient for lobsters, particularly when I am dealing with numbers rather than biomass.

In preparing the FMP, Paul took the Necker Island figures of 10,000 and 21,000, expressed them on a square kilometer basis, and multiplied them by the number of square kilometers of potentially suitable (bank) habitat in the NWHI to obtain the MSY figures for the FMP (157,200-330,000). Much of that area (including the part of Necker Island that was not included in the Necker report) is known to have virgin lobster abundances well below virgin levels in the Necker report. In talking with Jed and Paul about the results of recent exploratory fishing, they estimated that only about 20% of the bank area (Necker Island, Moro Island, and Midway) is well known to have lobster populations comparable to the Necker report and that lobster abundances in much of the rest of the potentially suitable habitat might not be high enough to justify commercial exploitation. Although Jed and Paul both felt there are commercial quality lobster beds that are not generally known, for proprietary reasons they were not able to give any detailed supporting evidence. It seems to me that to assume all of the potentially suitable habitat could produce like the Necker report is an overestimate and that a more realistic assessment would be that the equivalent of 20% to 50% of the potentially suitable habitat may be commercially exploitable. For MSY purposes I would put the figure at 50%.

To summarize to this point, there was a possible underestimate (because Jeff selected a conservative range of estimates for Necker Island) and an overestimate (because Paul made an optimistic extrapolation from Necker to all potentially suitable NWHI habitat). I would use the 30,000 Necker figure (39.2 lobsters/km^2) and 50% of potential NWHI habitat (50% of 12,000 km^2) to estimate the MSY at 235,000 per year. Although the line of reasoning is slightly different from that behind the MSY numbers in Section 6.2.1 of the FMP (157,200-330,000 legal lobsters per year), my estimate falls in the middle of that range.

It is important to appreciate the very specific context of an MSY figure based on Necker, because it applies only to the legal lobster population (unberried animals above 8.25 cm in carapace length), as defined both by state law during the 1976-1979 fishing period and by the present draft FMP. However, if we think of an MSY as the greatest yield that can be harvested any means on a sustained basis, then the lobster MSY may be considerably greater than a figure based on the 8.25 cm carapace length restriction.

The possibility of a higher MSY derives from evidence that the catch per unit effort could be increased by harvesting smaller animals. Calculations that Jeff has done with length frequency data since the Necker report suggest that the lobsters have a high mortality rate compared to their growth rate and that the maximum weight yield per recruit at a recruitment size of 6.75 cm carapace length could be as much as three times the maximum yield per recruit at a recruitment size of 8.25 cm. (The increase in numbers yield would be even greater.) By waiting until the lobsters reach 8.25 cm, a substantial portion of the possible harvest is lost to natural mortality, most likely predation. After examining the length-frequency data, it seems very likely to me that the maximum weight yield per recruit from fishing even smaller sizes could be even higher than the three-fold possible increase suggested by Jeff.

It is important to realize that a higher yield per recruit would not necessarily lead to a higher overall yield unless recruitment could be sustained despite the harvest of smaller animals. I have heard a variety of conflicting opinions about size restrictions and recruitment and have not been able to form any firm conclusion.

Because graphs in the FMP indicate that there is virtually no egg production below 7 cm carapace length, we could almost surely expect recruitment to be reduced if the legal size were at or below 7 cm, berried females were not protected, and the fishery were fished very intensely down to the legal limit. Although the graphs demonstrate that a length of 8.25, or possibly even 9 cm, is necessary to ensure adequate recruitment, I am not convinced that the lobsters need such cautious management, because we don't know how much egg production is necessary to sustain recruitment. We do know that egg production is greatly in excess of the numbers that reach commercial size and that density dependent mortality might cause recruitment to commercial sizes to be sustained even when egg production is substantially reduced. Therefore, it is possible that sustained recruitment is compatible with a lower size limit if there are other measures to protect berried animals (including closure during the spawning season where spawning is seasonal).

Data from NMFS exploratory fishing in the NWHI show considerable variation in the percent of berried legals (5%-30%) from one occasion to another, but 15% is a rough average. We could therefore expect an increase of 15% at most in the harvest if berried females were retained, and then only if retaining berried females does not reduce recruitment.

The FMP also includes MSY estimates ranging as high as 711,500 lobsters per year, based on applying production per square kilometer in Puerto Rico-Virgin Islands and Bahama Islands fisheries to potential suitable habitat in the NWHI. Although I believe this kind of extrapolation can only suggest an order of magnitude for the NWHI, catches from established lobster fisheries in the Carribean seem to have one characteristic that suggests the NWHI MSY could be higher than implied by fishing to date: the observed yield per square kilometer from very heavily fished lobsters can be quite high, even when the fishery is fished down to the point where catch per unit effort is not satisfactory for the people who must earn a living from the fishery.

For this and other reasons, the MSY as a biological maximum may be much higher than the commercially feasible harvest. Furthermore, there may be extensive areas in the NWHI which have a biological lobster productivity which could be harvested in theory but which will not be harvested in practice because catch per unit effort is too low to justify the expense of fishing.

In summary, the MSY figure of 400,000 selected by the SSC is on the high side (compared to my figure of 235,000) if we restrict ourselves to legal lobsters as now defined by the FMP. However, I think the MSY could be as much as 700,000 or more if smaller lobsters were allowed to be harvested while protecting berried females, though we don't know what protective measures will suffice to ensure the reproduction to sustain such high yields.

Whether the FMP-specifies the MSY to be 235,000, 400,000, or some other figure, I think it should also specify that in the future the MSY may have to be revised downward (if it is found there is not as much NWHI commercial lobster habitat as was hoped) or upward (if there turns out to be more commercial habitat than expected or if the possibilities from harvesting smaller animals prove to be realizeable). I also feel the FMP should allow exploration of the potential from harvesting smaller sizes by permitting trial relaxation of the size restriction and testing of alternative measures for protecting reproduction in specified areas under controlled conditions.

Respectfully,

Gerald G. Marten
Research Associate

GGM:jn

cc: Executive Director, Western Pacific Fishery Management Council
Director, National Marine Fisheries Service, Honolulu Laboratory

APPENDIX 5

.—Economic feasibility of lobster fishing in the Northwestern Hawaiian Islands.*

Introduction. This appendix can be used to identify critical catch rates for lobster in the Northwestern Hawaiian Islands (NWHI). At issue is the ability of society to benefit from the natural marine endowments available in the waters of the NWHI. Combinations of management measures for minimum size and maximum harvest quotas will imply average catch rates and average lobster size from broad fishing areas. The purpose of this appendix is to assess the minimum feasible catch rate for different average lobster sizes and for different discount rates.

Discounted cash flow. Estimating the feasibility of lobster fishing begins with total revenue during the ith period, R_i, which will vary for changes in the catch rate, γ_i (number of lobster per trap-day) and the average lobster size, σ_i (pounds per lobster tail). Total production of the firm is relatively small, such that changes do not influence the market price. However, the price per pound may vary by the size of the fish. Price, $P_i(\sigma_i)$ (dollars per pound for lobster tail), is given for each average lobster size. Associating a unique price to a catch with a particular average lobster size assumes a catch with that average lobster size has a unique size

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*Summarized from Michael F. Adams, "Economic feasibility of lobster fishing in the Northwestern Hawaiian Islands," Southwest Fisheries Center Administrative Report 23H, 1978, revised April 1979.

distribution. Fishing effort, E_i (number of trap-days), which may vary each period is constant in the analysis. Total revenue is written as

$$R_i = E_i \gamma_i \sigma_i P_i (\sigma_i) \tag{1}$$

Subtracting total operating costs, C_i, and depreciation, D_i, from total revenue yields taxable income. The combined state and federal income tax rate is t_i. The discount rate is δ_i. For i = 1, 2, ..., n, the discounted cash flow from period 1 to n-1 is

$$DCF_{1,\, n-1} = \sum_{i=1}^{n-1} \left[\frac{\left((R_i - C_i - D_i)\ (1 - t_i)\right) + D_i}{(1 + \delta_i)^i} \right] \tag{2}$$

Upon termination of the investment, the cash flow at the end of the n^{th} period is increased by the operating capital and the scrap value of the capital equipment. Represented as fractions of depreciable capital, I, are operating capital, f, and scrap value, s. The discounted cash flow from all n periods may then be written as

$$DCF = DCF_{1,\, n-1} + \frac{\left((R_n - C_n - D_n)\ (1 - t_n) + D_n\right) + I(f + s)}{(1 + \delta_n)^n} \tag{3}$$

Using the notation for depreciable capital and scrap value, the straight-line method of depreciation is

$$D_i = \left(I(1 - s)\right) / n \tag{4}$$

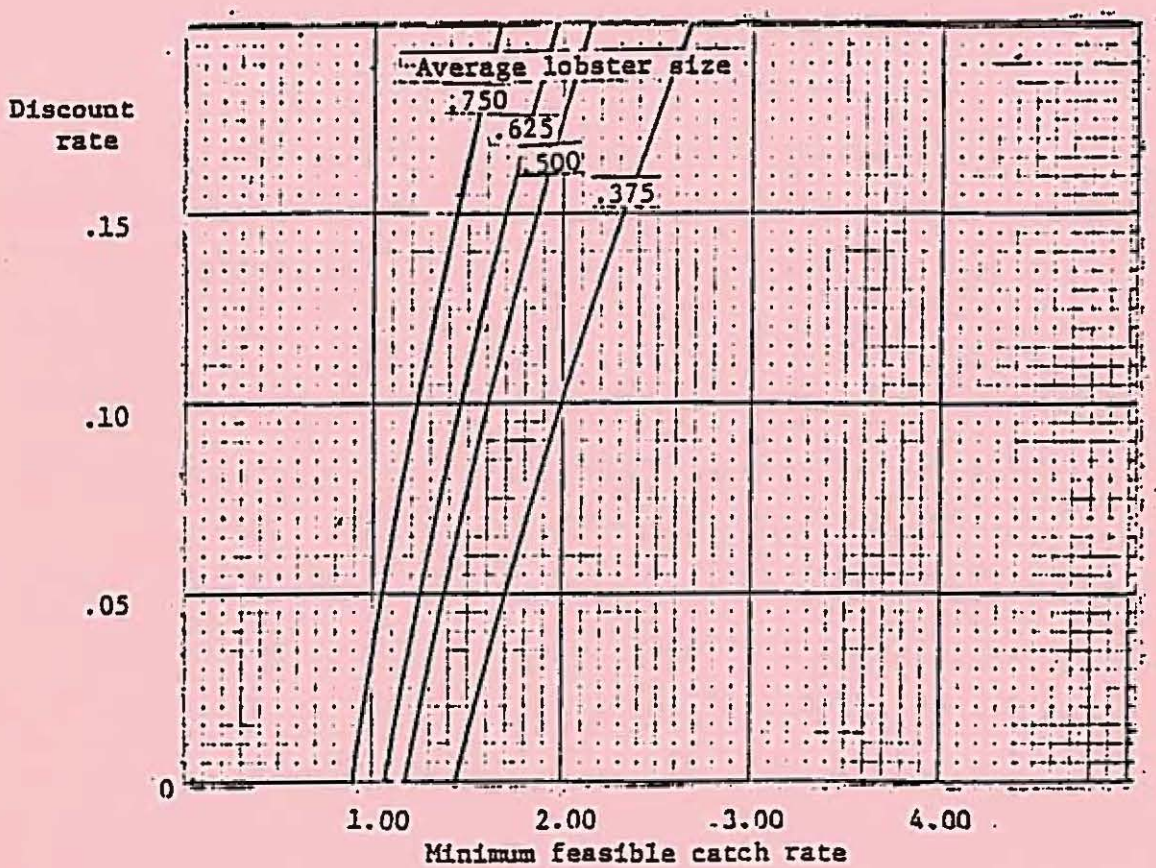
<u>Net present value and the discount rate</u>. The total capital investment minus the discounted cash flow equals the net present value, NPV:

$$NPV = I(1+f) - DCF \tag{5}$$

This assumes that all investment occurs at the beginning of the first period. For an appropriately chosen discount rate, if NPV $\geq$ 0 then the investment is considered feasible. The discount rate an investor chooses reflects the returns of the best alternative investment and the risk of the investment. For example, if the best alternative investment yields 7% return and the proposed investment is considerably more risky, then the appropriate discount rate may be 12%. If NPV = 0 for a proposed investment using this discounted rate, then the investor is indifferent between the proposed investment and the best alternative investment. If NPV > 0 then the investor will prefer the proposed investment. Using the net-present-value criteria, then, the feasibility of an investment is relative to alternative investments with consideration for differences in risk between investments.

Minimum feasible catch rates. To evaluate the impact of regulatory policies on the feasibility of an investment in the NWHI lobster fishery requires, in part, an estimate of the minimum feasible catch rate. Given the specific operating conditions of the investment, a schedule of minimum feasible catch rates is estimated for a range of discount rates using the net-present-value criteria. Estimates of depreciable capital, operating costs, and effort were obtained from a proposed investment project in 1978 and most data are held in confidence. Effort is assumed to be constant. The variables n, t_1, f, and s are equal to 20 years, 0.50, 0.05, and 0.10, respectively. Again, it is assumed that changes in the total landings for this firm do not influence the prices or catch rate. Under the net-present-value criteria, NPV $\geq$ 0, an average lobster size, and thus an ex-vessel price, will imply a minimum feasible catch rate for each discount rate. Four average lobster tail sizes (σ_i), 0.375, 0.500, 0.625, and 0.750 pounds, are evaluated with four associated ex-vessel prices $\left(P_i(\sigma_i)\right)$, 6.38, 6.00, 5.24, and 5.15, respectively. The prices are taken from Fishery Market News Report, National Marine Fisheries Service.

Figure 1 illustrates a schedule of minimum feasible catch rates for each average lobster size over a range of discount rates. The discount rate and minimum catch rate are positively related for each average lobster size. That is, the larger the discount rate used to evaluate the economic feasibility of the investment, the larger the required minimum feasible catch rate. On the other hand the average lobster size is inversely related to the minimum catch rate holding the discount rate constant. That is, a higher catch rate is required for the investment to be feasible if the average lobster size is smaller. Although price per pound is greater for the smaller size lobster, the increased revenue per pound is not enough to offset the decreased total weight due to the smaller average size. In the absence of price differentials by lobster sizes, the four curves in Figure 1 would be further dispersed. For a likely range of discount rates, say from 0.05 to 0.15, the minimum feasible catch rate is between 1.00 and 2.50 for all the average lobster sizes considered.



Figure—1. Minimum feasible catch rate by discount rate and average lobster tail size.

Unique marketing circumstances may cause shifts or discontinuities in the curves in Figure 1. For example, shippers or wholesalers may require a minimum total weight from a firm if all lobster tails are above some minimum size. Another peculiarity which may shift the curves is informal tying sales. Some major suppliers of lobster require the buyer to purchase larger size lobster tails in order to receive the smaller size tails. The investors express the concern that a minor supplier in the world market with a catch of only larger size lobsters may find it necessary to sell the larger tails below the existing market prices. This event would mean the shifting of the curves in Figure 1 to the right--increasing the minimum feasible catch rates. Currently the industry is uncertain about marketing conditions. Figure 1 must be revised as the fishery develops to account for the specific marketing peculiarities. Furthermore, the biology of the lobster stocks in the NWHI may be such that some parts of the schedules in Figure 1 are irrelevant. Nevertheless, the feasibility of the operation may be estimated for alternative regulatory policies which result in different legal catch rates and different average lobster sizes. The accuracy of such estimates will be greatly improved with more information on the long-term impacts on the stocks and therefore on the catch rates and average lobster sizes over time. Variations in these variables over time will give rise to unequal cash flows between periods, when effort is constant, possibly changing the estimates of feasibility in this appendix.

APPENDIX 6

STATE OF HAWAII 1959

DEPARTMENT OF PLANNING AND ECONOMIC DEVELOPMENT

GEORGE R. ARIYOSHI
Governor

HIDETO KONO
Director

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March 30, 1981

Mr. Wadsworth Y. H. Yee
Chairman
Western Pacific Regional Fishery Management Council
1164 Bishop Street, Suite 1608
Honolulu, Hawaii 96813

Dear Mr. Yee:

Thank you for your letter of March 23, 1981 in regard to the "Final Fishery Management Plan for the Spiny Lobster Fisheries of the Western Pacific Region."

In your letter you request a statement on "the current position of the State of Hawaii pertaining to jurisdictional and managerial programs developed for the spiny lobster resources." The jurisdictional position of the State is that the State has jurisdiction over the channels between Hawaii's islands. There are a number of legal theories which, when applied to the facts, support this jurisdiction. These theories include: (1) historic custom and use; (2) U.S. Supreme Court and federal statutory definitions of State boundaries and inland waters; and (3) international definitions of mid-ocean archipelagos and rules for drawing straight baselines. Whichever theory is applied, the result is that the State has jurisdiction over the interisland channels. This jurisdiction can be described as those ocean areas inside straight baselines drawn between the headlands of the islands, plus the first three miles seaward of those baselines, known as the territorial sea. This jurisdiction has most recently been exercised over the harvesting of coral and the operation of OTEC-1 in channel waters.

On page 73 of the Final Fishery Management Plan (FMP), it is stated that the "extent of the State's territorial sea is a matter of some controversy between the State and the federal government." In fact, the controversy appears to be about the extent of the State's inland, internal, or archipelagic waters. The extent of those waters determines where the territorial sea begins. The breadth of the territorial sea, and the State's jurisdiction over it, do not appear to be in dispute.

The determination of jurisdiction is a critical issue when State and federal plans are in conflict. However, as the final FMP notes at page 73, "the State of Hawaii and the Council are cooperating in developing complementary management and conservation measures for the entire region so this FMP can be effective." This is the key concept. If State and federal management and conservation measures can be made consistent or complementary, the question of the jurisdiction of each government loses its practical importance.

The State wishes to maintain its jurisdication over the spiny lobster, and believes that the spiny lobster FMP has a significant relationship to the Hawaii Coastal Zone Management Program. If the State and federal governments apply the same management and conservation measures, the State would be able to fulfill the purposes for which it would exercise jurisdiction, without the need to resolve jurisdictional issues. The immediate question, as noted in my letter of December 8, 1980 to Mr. Akagi, is whether the FMP is consistent with the Hawaii Coastal Zone Management Program.

In your letter you also requested information on the Ocean Management Program, which is under the guidance of the Hawaii Coastal Zone Management Program (HCZM). HCZM has contracted with the University of Hawaii Urban and Regional Planning Program to develop issue papers which discuss the current status and problems facing various areas of ocean use in Hawaii. These areas include:

1. Sewage disposal in nearshore waters by marine vessels
2. Waste disposal in offshore waters by marine vessels
3. Ocean disposal of nuclear wastes
4. Coastal energy generation facilities
5. Ocean thermal energy conversion (OTEC)
6. Manganese nodule mining
7. Fishery development
8. Precious coral harvests
9. Sand mining
10. Nearshore ocean recreation
11. Saltwater aquaculture
12. Harbor development and use
13. Marine sanctuaries
14. Leeward Hawaiian Islands
15. Marine research

Draft issue papers have been written and are being circulated for accuracy checks. We would be pleased to provide copies of any of the papers in which the Council is interested. Final documents will be prepared for discussion in a public forum. The Coastal Zone Management Program is also trying to develop a broad framework for these issue papers so that they will serve as useful tools in making policy decisions on ocean use in Hawaii.

I hope that this information is responsive to your request. Please do not hesitate to contact me if you have any futher questions.

Sincerely,

Hideto Kono

HK/lyk

APPENDIX 7

HAWAIIAN SPINY
LOBSTER RESOURCES

STATE OF HAWAII FISHERIES DEVELOPMENT PLAN (1979)

---Technical Report

SPINY LOBSTER RESOURCES

Biological Knowledge

Two species of the spiny lobster genus Panulirus are of commercial importance in the Hawaiian Islands. *Panulirus marginatus* is endemic to Johnson Island and the Hawaiian Islands. *P. penicillatus* is widely distributed, occurring from the Red Sea, throughout the Indian and Pacific Oceans as far east as the Galapagos Islands.

The Hawaiian Island populations of spiny lobsters are one of the species groups to be managed by the Western Pacific Regional Fisheries Management Council under the Fisheries Conservation and Management Act of 1976. The draft Fisheries Management Plan for these two species has been completed and excerpts of the sections on biology and life history are given below.

The life history patterns of species in the Palinuridae family of spiny lobsters are relatively well known. For the genus *Panulirus* mating involves the male spiny lobster depositing a spermatophoric mass on the external, ventral surface of the female's thorax. The spermatophoric mass is white, soft and putty-like when first attached to the female but later turns dark and hardens. Fertilization of the ova is believed to be external. The viable spermatozoa stored in the spermatophoric mass are released by the scratching and breaking of the spermatophoric mass by the female. The ova are released from the oviduct, fertilized, and attached to the setae of the female's pleopods. The female is then termed "berried". Observations on berried females in aquaria indicated an incubation period of the fertilized ova of P. marginatus and P. penicillatus of 30 days (McGinnis, 1972). A female P. marginatus may spawn from 150,000 to 575,000 ova per spawning and may spawn four or five times a year around the main Hawaiian Islands (McGinnis, 1972) and from 91,000 to 852,000 ova up to twice per year around Midway Islands (MacDonald & Thompson, MS). P. penicillatus may spawn 120,000 to 440,000 ova per spawning and spawn at least twice a year around the main Hawaiian Islands (McGinnis, 1972). McGinnis also found that an average of 41% of the female P. marginatus and 38% of the female P. penicillatus in Maunalua Bay, Oahu during 1960-1962 were berried and that berried females were found throughout the year. Around the Midway Islands, MacDonald and Thompson observed that the frequency of ovigerous P. marginatus was at a maximum in June and July.

After hatching, the larvae or phyllosoma of all species in the Palinuridae family float to the surface and are planktonic. The phyllosoma of P. marginatus have been found between 15° and 30° north latitude and 155° and 175° west longitude. P. penicillatus phyllosoma are widely distributed in the central Pacific between about 20° south and 25° north latitude and 110° west and 170° west longitude (Johnson 1968 and 1974), and are found in many other parts of the world.

The duration of the planktonic phyllosoma stage of species in the Palinuridae family is not well established. For one species in California waters, P. interruptus, it was determined that the larval stage extended for a period of nearly eight months (Johnson

1960). Such long larval periods would allow much time for wide dispersal of the phyllosoma depending on the local currents. For an endemic population such as P. marginatus wherein the adult benthic population cannot be restocked from recruitment of larvae from outside the Hawaiian archipelago there must be retention of larvae within the overall area. It is not known, however, if the larvae are retained by eddies and counter currents around each island, or around the Archipelago as a whole.

The phyllosoma stage is followed by the puerulus stage. In this form the lobster can actively swim horizontally, apparently returning the animal to shallow areas for subsequent settling. The animals settle to the bottom in sheltered areas, and this settling activity appears to have both a diel and a lunar component. Upon settling the animals begin to resemble the adult form. Juvenile P. interruptus in California increase by about 1 cm in total length per molt, and molt most frequently before they attain secual maturity. Sexually mature P. interruptus molt twice a year, and grow approximately 2 cm per year (Lindberg, 1955). Juvenile P. marginatus between 20 and 49 mm in carapace length increased by about 1 to 2 mm/per molt carapace length (McGinnis, 1972). The survival rate of juvenile lobsters is quite low, and poorly known in most situations. It is thought that this rate is dependent on the size of the current lobster population in the western Australian population of P. longipes cygnus (Chittleborough, 1970).

Some of the species of the Palinuridae family of the spiny lobsters are known to undertake long migrations. These movements are poorly understood, and appear to be restricted to those species inhabiting continental areas. Insular species are not expected to undertake corresponding long migrations (Herrnkind, 1978). This has been confirmed by studies on Oahu (Morris, 1962) and in the Solomon Islands (Prescott, pers. comm). The spiny lobsters in the NWHI are thought to undertake extensive local movements (MacDonald, pers. comm).

Spiny lobsters live on the sea bottom at depths from 0.5 to 100 fm. There are differences in distribution by depth of different species. For instance P. penicillatus is generally found in water from 1 to 5 meters deep throughout most of its range, while P. marginatus is frequently found to much greater depths. The maximum depth at which P. marginatus has been reported is 100 fm. P. penicillatus on Oahu, however, departs from its usual shallow depth range and is regularly found to much greater depths. In the NWHI few P. penicillatus are found, but they have been reported there at depths of approximately 50 fm.

The general biology of P. marginatus has been studied at Oahu by Morris (1968) and further documented by McGinnis (1972). A comparable study of lobsters from the Midway Islands has recently been completed which included a reanalysis of the results of these earlier studies, providing an overview of the general biology of the species at the northern and southern limits of its range (MacDonald and Thompson, MS). Comparable analyses for P. penicillatus from these two locations are not possible due to the limited numbers of this species collected from the Midway Islands.

P. marginatus is more abundant than P. penicillatus at the Midway Islands, making up about 98% of the diver-caught catch. The two species were caught in approximately equal abundance in the trap samples at Oahu. From that study the differential catch of tagged lobsters suggests that the trap catches are biased with respect to species, and with respect to sex for _P. penicillatus_. Analyses presented in MacDonald (1978) suggest that _P. marginatus_ are equally likely to be caught regardless of sex, that male _P. penicilllatus_ are 80% as likely to be caught as _P. marginatus_, and that female _P. penicillatus_ are only 35% as likely as _P. marginatus_ to be caught in traps. Thus the apparent equal abundance of the two species in the trap catches at Oahu reflects a substantially higher abundance of _P. penicillatus_ than _P. marginatus_.

Several possibilities exist to explain this difference in relative abundance of the two species at Oahu and the Midway Islands. These include differences in temperature tolerance, differences in larval mortality and recruitment, and interspecific competition. The actual importance of each of these possible factors is not known. Due to the relative importance of _P. marginatus_ in the Midway Island catches (and in other areas of the Leeward Islands), most of the following comparisons will be made only for this species.

From inspection of size frequency distributions it appears that the lobsters of both sexes caught at Oahu are smaller than those caught at the Midway Islands. Additionally, it appears that the sexes differ in average size at the Midway Islands (males tend to be larger) but not at Oahu. It has been noted that the size distributions are skewed for the lobsters from Oahu, with a very few rather large animals, and that the corresponding distributors from the Midway lobsters are more symmetrical. This suggests that the Oahu lobsters are capable of larger sizes and is the expected result considering the existance of a substantial fishery at Oahu.

The reproductive condition of females was observed as either non-productive, with spermatophoric, or with egg mass ("berried"). The data from the Midway Islands suggest a marked seasonality with peak porportion of females with eggs following the peak proportion of females with spermataphores by about four or five months. Peak numbers of females with eggs are found during the period May through August. Given probable rates of ovarian development and incubation two spawnings seem possible each year. The data from Oahu do not show similar pronounced seasonality: substantial proportions of females with eggs are found in all months except perhaps December.

Temperature may have an important role in reproductive seasonality and frequency. The monthly water temperature at the Midway Islands is similar to that at Oahu between June and October, falling below that at Oahu from November through May. The increased proportion of the females with spermatophores in November in the Midway Islands sample corresponds to the decline in water temperature, and correspondingly the increased proportion of ovigerous females in May corresponds to the increase in water temperature. The lack of such marked temperature changes at Oahu agrees with the apparent lack of seasonality at Oahu.

Taken together these data suggest a strong correlation between temperature and reproductive activity. This correlation does not imply causation as many other factors such as food and availability and light levels may also be chaning similarly. However, correlation itself provides a way of predictiory periodicity of reproductive activity in other areas of the NWHI.

For example, water temperature data at French Frigate Shoals indicates that the temperature never falls as low in any one month as the temperature during May at the Midway Islands. Additionally generalized temperature profiles for the NWHI (Seckel, 1968) indicate that this warmer water may occur as far north as Maro Reef, suggesting that reproduction may be continuous or at least not strongly seasonal for those islands south of Maro Reef.

The pattern of larval recruitment at each island within the Hawaiian Islands can be conceived as lying somewhere along a continuum between: 1) recruitment depending entirely upon locally produced larvae, and; 2) recruitment depending entirely upon larvae produced on other islands "upstream" or "downstream" in the island chain. Oceanic circulation within these islands is probably the overriding factor that determines the position along the continuum. Taken together, the available oceanographic information does not suggest a consistent mechanism for regular transfer of larvae between islands.

The little biological information available is consistent with this conclusion. Johnson (1968) observed the phyllosoma stage of the spiny lobsters in the plankton at several locations throughout the Hawaiian Archipelago. He noted that phyllosoma of both species of spiny lobsters which occur in the Hawaiian Islands were collected around Oahu and to the southwest of the main islands, but that only the phyllosoma of _P_. _marginatus_ were collected around French Frigate Shoals and the Midway Islands. This distribution of phyllosoma corresponds to the observed distribution of adults where only a few of the lobsters caught in the NWHI are _P_. _penicillatus_.

As noted above, the two species of spiny lobster found in the Hawaiian Islands are differentially abundant at the Midway Islands and at Oahu. Also at Oahu P. penicillatus occurs to much greater depths than elsewhere in its geographic range. At the Midway Islands P. marginatus is far more abundant than P. penicillatus. One possible cause of these differences is that the harvesting of spiny lobsters at Oahu has reduced the abundance of P. marginatus, allowing P. penicillatus to increase. For this to have occurred it is necessary that these two species compete in some way for the same resources, such as food and shelter.

Generally, P. penicillatus is thought to be more specialized than P. marginatus. It occurs throughout most of its range in shallow areas, primarily wave-swept high energy zones immediately seaward of insular reef flats and rocky shores (Holthues and Loesch, 1967; MacDonald, 1971; George, 1972, 1974). P. marginatus, on the other hand, displays no apparent morphological specialization and appears to be able to more efficiently exploit a wider variety of habitat types and food resources. Based on general understanding of food habits of palinurid lobsters it is likely that the two species feed on similar things (Lindber, 1955; Chittleborough, 1975; Herrnkind, et al, 1975; and others). Both species have been observed in the same shelter at Kure Island (MacDonald, pers. comm).

Hawaiian Fishery and Status of Stocks.

The catch of spiny lobsters in the Hawaiian commercial fishery from 1948 to 1978 is shown in fig. _____. The catch statistics are maintained by the Hawaii Division of Fish and Game and do not difderentiate the two species, P. marginatus and P. penicillatus, that make up the spiny lobster catches. Although the fishery is conducted around the eight major islands, the bulk of the catch prior to 1976 (about 80%) was made around Oahu; fishing effort was also greatest on Oahu (McGinnis 1972).

Nets and traps are used to catch spiny lobsters in the Hawaiian fishery in the main Hawaiian Islands. The nets are gill nets measuring up to 100 feet long by three feet deep and have mesh sizes up to seven inches. The traps are 6' x 4' x 3' rectangular metal frames covered with one inch mesh poultry wire. The primary use of the traps is to catch fish, and lobsters are only taken incidentally. Net fishermen fish primarily along the northern or windward shore of Oahu in depths from 1 to 5 fathoms and trap fishermen fish along the leeward shore in depths from 5 to 30 fathoms.

Since late 1976 increasing interest has been shown in the spiny lobster resources in the NWHI. At present there are 2 to 3 boats fishing intermittently for lobsters there, with most of the fishing being done around the nearer islands. From this effort an average catch of 4,450 legal lobsters have been taken per month for the twenty three months when fishing has occurred. On an annual basis this is considerably more that the highest catches ever reported from the main islands.

/in the Leeward Islands
The domestic annual harvest will likely be higher than in the past, which was approximately 70,000 and 31,000 lobsters for the calendar years 1977 and 1978. One new vessel is currently active, and plans have been revealed for a second new vessel to be constructed and in the fishery by September. Allowing for these changes one

might anticipate a domestic catch of roughly 2 or 3 times that which has been observed. Thus catches of 100,000 to 150,000 might be expected.

The boats fishing for spiny lobster in the NWHI are using some version of the California two-chambered trap. The traps are put out on a line, spaced from 6 to 30 fathoms apart, single lines containing from 75 to 150 traps.

Observations on the size of the lobsters in the NWHI are available from the NMFS research cruises and from chartered commercial vessels creuises where scientific observors were placed aboard. Significant numbers of observations have been made for Necker Island, Maro Reef, the Midway Islands, Pearl and Hermes Reef, and Laysan Island. Statistical analyses have shown that there is considerable difference in the size distribution in the several different areas.

There is a clear indication in the size data that the lobsters from Necker Island are on the average smaller than lobsters from elsewhere in the Leeward Islands. This difference in size was evident even in the early stages of exploitation, and thus does not represent just the usual reduction in the average size associated with increasing fishing effort. That the Necker Island population is smaller on average makes it difficult to base management decisions on size limits solely on the experience of the fishery to date here and at other locales in the Leeward Islands.

Predictions of the sustainable commercial production of a new resource is difficult until appropriate statistics have accumulated after several years of harvest. In addition to the unknown nature of a virgin fishery, other factors compound long range prognostications, such as: environmental fluctuations resulting in variable strength year classes, fluctuating economic conditions and resource mismanagement.

A minimal estimate of the potential sustainable annual yield in the Leeward Hawaiian Islands has been promulgated by the WPRFMC Lobster Planning Team. This was based on 23 months of commercial harvest at Necker Island Bank. The derived figure for the entire Leeward Islands is 445,000 individual lobsters (about 350,000 - 660,000 lb). This estimate was based on a potential yield of 97 lobsters/nm^2 (120 - 145 lb/nm^2). This estimate was qualified as being tentative because of the great variation in lobster abundance and average sizes throughout the Leeward Islands.

Other estimates may be derived from other fisheries. Because the Hawaiian spiny lobster is morphologically (and presumably genetically) very closely related to Panulirus argus of the central western Atlantic the characteristics of fisheries for P. argus provided examples which may be applied to the Hawaiian Island stocks. The spiny lobster fisheries of the Puerto Rico-Virgin Is. area, Bahama Islands and southern Florida are among the best documented in the world.

Puerto Rico-Virgin Is. shelf area: Catches of spiny lobsters have been made in this area from at least 1951 when 467,000 lb. of whole lobster were landed. Yearly statistics collected since 1964 show a steady increase from 150,000 lb then to 384,000 lb in 1976. Only three surveys have been conducted on Virgin Is. landings: during 1976 there were 86,000 lb recorded (an additional unreported 225,000 lb. were thought to have been taken). In both areas lobsters are usually taken incidentally with fish in fish traps, but some fishermen conduct a lobster-directed fishery. Characteristically, the catch rates decreased within the initial, heavily fished areas and then reached a plateau of steady production. This was followed by increased fishing effort (following demand) in the heavily fished areas as well as on more distant grounds.

The combined Puerto Rico-Virgin Is. catch for 1976 was 470,000 lb. The draft fishery management plan for this region estimates a maximum sustainable yield (MSY) of 831,000 lb. The Puerto Rico-Virgin Is. shelf area has about 2,100 square nautical miles (nm^2) of suitable lobster habitat. Thus, there is a present lobster harvest of 224 lb/nm^2 with an estimated MSY of 396 lb/nm^2 that may be reached sometime in the future.

Bahama Islands: Spiny lobsters have been harvested for many years in the Bahama Islands. Fishing regulations were first incorporated in the mid 1930's. U.S. fishermen have been harvesting this resource since the early 1950's. Legal harvest of this resource by U.S. fishermen ceased August, 1975 after the Bahamian Government declared the spiny lobster a creature of the continental shelf. During 1974, the combined U.S.-Bahamian harvest was 7.8 million lb. This is well below the MSY of 9.9 million lb estimated by the Joint Scientific Committee and the MSY estimate of 13.2 million lb of Wise (1976).

The Bahamian statistics have shown a steady increase in lobster landings since 1971, reaching a high of 5.1 million lb in 1977. There are about 40,000 nm^2 of lobster grounds in the Bahamas.

Bahamians currently fish about half of this area. This yields an estimated current production of about 253 lb/nm^2. Using the MSY estimates for the entire Bahamian shelf area provides annual yield estimates of 248 and 330 lb/nm^2.

<u>Southern Florida</u>: The southern Florida lobster fishery has been conducted since the early 1900's, and increasingly utilized since 1950. This area (from Palm Beach south through they Keys to Dry Tortuga, approximately 4,300 nm^2) has produced 1.9-6.8 million lb annually. These are the reported, legal commercial catches. An extensive recreational harvest as well as illegal trade in undersized and gravid lobsters place an additional strain on this resource. Nevertheless, the reported 1977 production of 4.0 million lb is only slightly below the 1964-1977 average of 4.4 million lb. The estimated commercial MSY for this area (based on 1973-74 catches) is 5.9-8.9 million lb. Maximum economic yield (MEY) is 5.8 million lb.

Some unit yield estimates from this complex fishery follow. 14-year Average through 1977; 1023 lb/ nm^2. MSY; 1395-1860 lb/nm^2. MEY; 1348 lb/nm^2.

Thus, we have documented commercial catches ranging from 224-253 lb/nm^2 and estimated MSY's of 248-396 lb/nm^2 in the developing fisheries of the Bahamas and Puerto Rico-Virgin Is. areas. Documented average commercial catches and estimated MSY's for the fully developed southern Florida fishery range from 1023 to 1860 lb/nm^2.

These examples demonstrate the spiny lobster resources are able to withstand decades of moderate to heavy fishing pressure with only a modicum of resource management (regulations exist, but are widely ignored except for closed seasons). Sustained production is due somewhat to harvesting smaller, faster growing individuals after the initial phases of a fishery. Also, it was long thought that local production was maintained by pelagic larvae produced by populations exogenous to the exploited stock. However, recent hypotheses suggest that the exploited population may produce a large share of its own recruitment, larvae being "held" in the local area by oceanographic conditions (such as off the Florida Keys) and complex behavior on the part of the larvae. Thus, nonharvest of gravid females presently seems a positive management philosophy, as well as that of permitting animals at lease one period of reproduction by setting a minimum size limit before harvest.

Estimates of the potential Hawaiian harvest may be made from exploratory fishing and early commercial catches in conjunction with the yield figures from the fisheries discussed above. Initial catch rates of 20-50 lb/trap day in the Leeward Hawaiian Islands are some of the highest known and are indicative of the high carrying capacity of the grounds there. The amount of bottom area in the Leeward Hawaiian Islands suitable for lobster habitat is about 3,500 nm^2 (not including depths less than 10 fathoms and within lagoon areas). Additionally, there are approximately 1,600 nm^2 of bottom suitable for lobsters within the Main Group of the Hawaiian Islands.

Using the ranges of observed and esimated production rates for the Bahama Islands and the Puerto Rico-Virgin Is. area (about 225-400 lb/nm^2/year) results in minimum sustained production estimates for the 3,500 nm^2 of the Leeward Hawaiian Islands of 787,500-

1,400,000 lb/yr. A maximal estimate using the figure of 1,000-1,800 lb/nm^2 from the Florida fishery indicates a sustained annual yield of 3.5-6.3 million lb. However, it's doubtful that these latter figures could be obtained because of the difficulty in effecting the high harvesting pressure required in the distant waters of the Leeward Islands.

Thus, it appears that the limiting nature of the fishery (distant waters and marginal weather conditions) in conjunction with an effective management plan would ensure that the Leeward Islands lobster stocks remain a viable fishery for many years.

Research and Development Programs.

The stocks of *P. marginatus* in the Leeward Islands are capable of increased utilization and are currently the object of a budding commercial fishery. The stocks there outside the 3-mile limit will soon be under management by the WPRFMC.

It appears that the present levels of harvest of the spiny lobster resources in the main Hawaiian Islands are close to the sustainable maximums and increased catches will only come from relatively unfished areas. Possibly, one contribution to increased utilization of the lobster resource would be a modest exploratory fishing program in the more isolated fishing grounds of the main islands. This is discussed in more detail in the section on the plan for "Development of Crustacean Resources".

Table 7.7 COMMERCIAL CATCH OF SPINY LOBSTER
STATE OF HAWAII DIVISION OF FISH AND GAME

Year	Pounds Caught	Value
1948	42,370	27,848
1949	43,632	26,869
1950	34,012	17,770
1951	17,230	10,149
1952	18,052	11,088
1953	17,938	11,230
1954	14,999	8,369
1955	16,136	10,677
1956	12,732	7,371
1957	14,392	8,966
1958	9,192	5,964
1959	12,339	7,975
1960	10,473	7,049
1961	12,642	8,542
1962	7,890	5,232
1963	10,277	7,834
1964	9,846	7,895
1965	8,158	6,639
1966	5,481	4,397
1967	4,415	3,676
1968	4,751	4,296
1969	9,250	9,678
1970	5,398	6,205
1971	6,140	7,893
1972	5,349	8,153
1973	5,577	8,229
1974	4,467	7,415
1975		
1976	6,317	11,357
1977	85,839	199,065
1978	33,719	99,087

APPENDIX 8

STATE OF HAWAII
Department of Land and Natural Resources
Honolulu

DIVISION OF FISH AND GAME

* * * * * * * * *

The Board of Land and Natural Resources (hereinafter referred to as "Board"), pursuant to Section 187-2, Hawaii Revised Statutes, and every other law hereunto does hereby amend in its entirety Regulation 22 of the Division of Fish and Game, Department of Land and Natural Resources to read as follows:

REGULATION 22. RELATING TO THE MANAGEMENT OF NATIVE LOBSTERS OR ULA

SECTION 1. Definition. As used herein:

"Lobster" or "ula" means only the spiny lobster species Panulirus penicillatus and Panulirus marginatus (formerly named Panulirus japonicus) and excludes the slipper lobster or "ula-papapa".

SECTION 2. Prohibitions. Except as otherwise provided in Sections 3 and 4 of this regulation, it shall be unlawful within any areas under the jurisdiction of the State of Hawaii, to take, trap, kill, possess, sell or offer to sell, any lobster:

a. During the months of June, July and August (hereinafter "closed season"); or
b. Less than three and one-fourth (3-1/4) inches (or 82.5mm) in length measured in a straight line along the carapace (or head) from the ridge between the two largest spines above the eyes, back to the rear edge of the carapace (see attached figure); or
c. Carrying eggs externally; or
d. With any puncture wound, or other mutilations of the body, or in such condition where the lobster is not whole (i.e., carapace or head and tail separated).

SECTION 3. Exceptions. It shall be lawful with a permit issued by the Board to:

a. Take or possess any lobster for scientific use, propagation, or other experimentation under such terms and conditions as specifically set forth in the permit; or
b. Possess, sell or offer to sell any lobster taken outside areas within the jurisdiction of the State of Hawaii and landed in the State; provided that such possession or sale is subject to all applicable State laws and regulations including but not limited to Section 189-6, Hawaii Revised Statutes and Division of Fish and Game Regulation 11; or
c. Take or possess any lobster from the waters of the Leeward Islands pursuant to the provisions in Section 188-37 and 188-38, Hawaii Revised Statutes and Division of Fish and Game Regulation 10.

SECTION 4. Selling of Lobster During Closed Season. During the closed season, any wholesale dealer or retail market may sell or offer to sell, or any hotel or other public eating house may serve lobster by first procuring a license granting this privilege pursuant to Section 188-57, Hawaii Revised Statutes.

SECTION 5. Taking of Lobster for Commercial Purposes. The taking or trapping of any lobster for commercial purposes within areas under the jurisdiction of the State of Hawaii shall be subject to the commercial fishing requirements of Chapter 189, Part I, Hawaii Revised Statutes, and the provisions contained in Section 2 of this regulation.

SECTION 6. Revocation of Permits. The Board shall revoke for a period of one-year for any violation of this regulation or of the terms and conditions of the permit any permit issued pursuant to this regulation. Any person whose permit has been revoked shall not be eligible to apply for another permit until the expiration of one-year from the date of revocation.

SECTION 7. Penalty. In addition to the penalties prescribed by the applicable sections of the Hawaii Revised Statutes, any person violating the provisions of this regulation shall be found guilty of a petty misdemeanor.

SECTION 8. Severability. Should any section, subsection, sentence, clause, or phrase of this regulation, for any reason be 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 23rd day of June, 1978, by the Board of Land and Natural Resources.

/s/ W. Y. Thompson
W. Y. THOMPSON, Chairman and Member
Board of Land and Natural Resources

/s/ Thomas S. Yagi
Member
Board of Land and Natural Resources

Approved this 22nd day of July, 1978.

/s/ George R. Ariyoshi
Governor of Hawaii

Approved as to Form:

/s/ Glenn M. Adachi
Deputy Attorney General

Date July 13, 1978

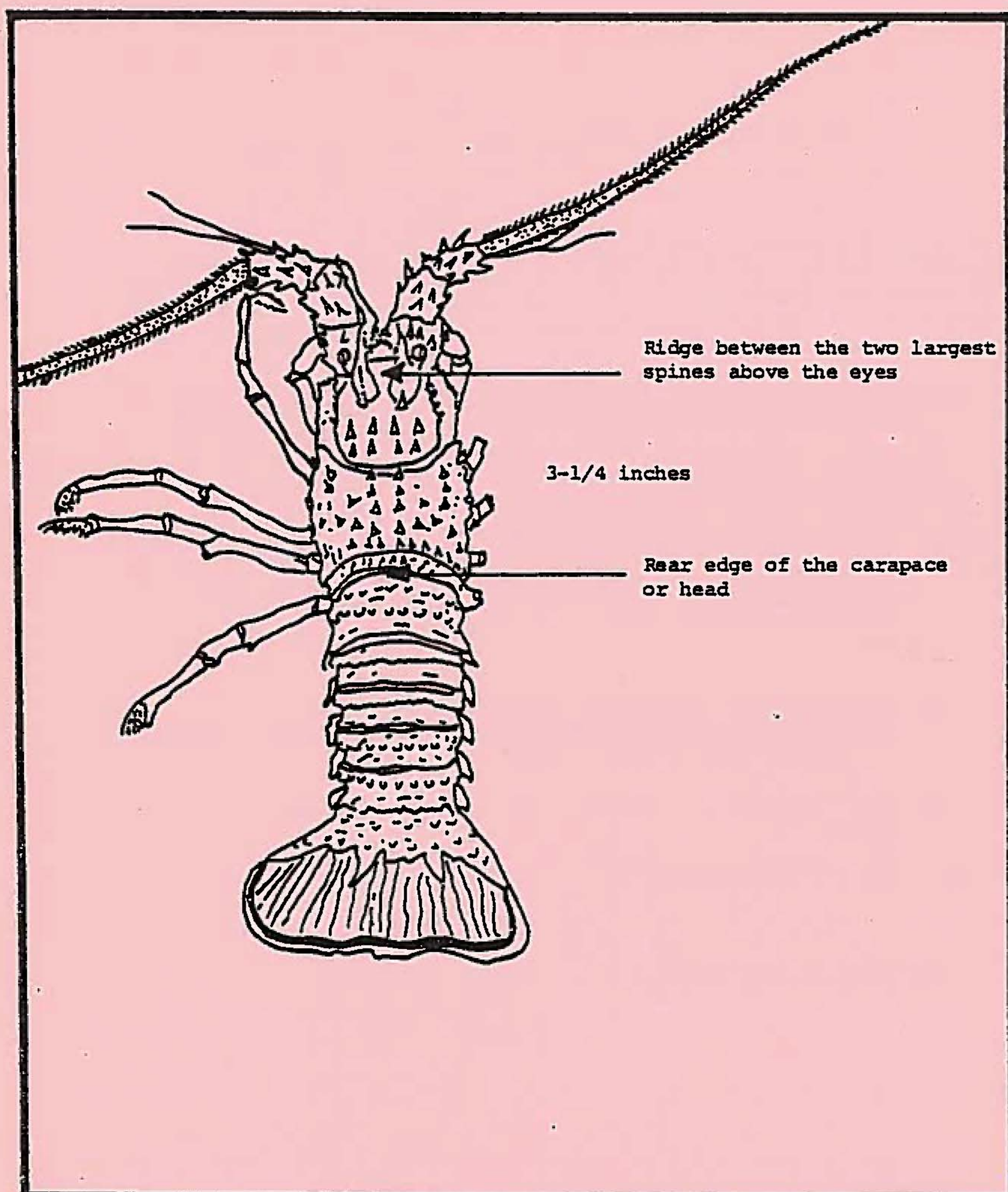
PUBLICATION OF
NOTICE OF PUBLIC HEARING
Honolulu Star-Bulletin/Advertiser - March 5, 1978
Hawaii Tribune-Herald - March 5, 1978
Maui News - March 6, 1978
The Garden Island - March 6, 1978

C E R T I F I C A T E

I hereby certify that the foregoing copy of Regulation 22, 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/ W. Y. Thompson

W. Y. Thompson, Chairman and Member
Board of Land and Natural Resources



Location of points on the carapace or head used to determine if a lobster or ula is of legal size.

Appendix 9 - Area by Depth for the Northwestern Hawaiian Islands

Area determination by depth for the Northwestern Hawaiian Islands was accomplished by cutting out the contoured areas from nautical charts and weighing the individual pieces. These weights were then compared to the weight of a known area from the same chart and from the proportion the area by depth was calculated.

The charts were prepared by the Coastal and Geodetic Survey Office (C&GS), now called the National Ocean Survey. The C&GS identification numbers were used. The charts numbered 4181, 4182, 4183 were all of approximately the same scale and covered the entire Northwestern chain. These areas are listed in Table 1. Table 2 is a compilation of the areas obtained from C&GS charts numbered 4172-4175, 4177, 4185, 4186, which were of greater detail of the individual islands. These two tables are compared where possible in Table 3. Furthermore, data on area by depth calculated by use of a planimeter are compared in Tables 4 and 5 with Table 1. Some of the differences may be due to different divisions of the banks between islands.

Seamounts which lie in line with the natural progression of the rest of the islands were numbered from southeast to northwest. " Outlying seamounts" are described as to their general vicinity.

The conversion factor used to transform square nautical miles to square kilometers was 3.4299.

Total area from 0 to 100 fathoms :	(nm^2)	4612.7
	(km^2)	15821.1
Total area from 0 to 1000 fathoms :	(nm^2)	19544.8
	(km^2)	67036.7

TABLE 1

Area by Depth of the Northwestern Hawaiian Islands

Depth (fm)		0-10	10-100	100-200	200-300	300-400	400-500	500-1000
Area								
Middle Bank	(nm^2)		50.1	26.2	18.2	12.5	10.2	120.7
	(km^2)		171.8	89.8	62.4	42.9	35.0	414.0
Nihoa	(nm^2)		202.6	36.4	36.4	27.3	22.8	148.0
	(km^2)		694.9	124.8	124.8	93.6	78.2	507.6
W. Nihoa	(nm^2)		117.2	45.5	27.3	25.0	19.4	112.7
	(km^2)		402.0	156.1	93.6	85.7	66.5	386.5
Seamount#1	(nm^2)			21.6	28.4	44.4	38.7	133.2
	(km^2)			74.1	97.4	152.3	132.7	456.9
E. Twin Banks	(nm^2)		27.3	15.9	25.0	23.9	19.4	64.9
	(km^2)		93.6	54.5	85.7	82.0	66.5	222.6
W. Twin Banks	(nm^2)		28.4	17.1	29.6	22.8	13.7	66.0
	(km^2)		97.4	58.6	101.5	78.2	47.0	226.4
Seamount#2	(nm^2)		1.1	8.0	6.8	10.2	20.5	62.6
	(km^2)		3.7	27.4	23.3	35.0	70.3	214.7
Necker	(nm^2)		557.8	179.8	186.7	86.5	113.8	335.8
	(km^2)		1913.2	616.7	640.4	296.7	390.3	1151.8
Seamount#3	(nm^2)						28.4	53.5
(NW of FFS)	(km^2)						97.4	183.5
French Frigate Shoals	(nm^2)	178.7	157.1	206.0	272.1	154.8	155.8	523.6
	(km^2)	612.9	538.8	706.6	933.13	530.9	534.4	1795.9
Brooks Bank #1	(nm^2)		10.2	13.7	30.7	83.1	43.2	119.5
	(km^2)		35.0	47.0	105.3	285.0	148.2	409.9
Brooks Bank #2	(nm^2)		50.1	29.6	44.4	38.7	18.2	66.0
	(km^2)		171.9	101.5	152.3	132.7	62.4	226.4
Brooks Bank #3	(nm^2)		58.1	85.4	31.9	27.3	27.3	53.5
	(km^2)		199.3	292.9	109.4	93.6	93.6	183.5
St. Rogatien Bank	(nm^2)		138.9	130.1	84.2	51.2	36.4	134.3 + [illegible]
	(km^2)		476.4	446.2	288.8	175.6	124.8	460.6 + [illegible]

Depth (fm)		0-10	10-100	100-200	200-300	300-400	400-500	500-1000
Area								
Seamount#4	(nm^2)		25.0	44.4	102.4	84.2	167.3	383.6
	(km^2)		85.7	152.3	351.2	288.8	573.8	1315.7
Outlying	(nm^2)		St. Rogatien Bank Vicinity					37.1
Seamounts	(km^2)							127.4
Gardner	(nm^2)	2.2	874.8	214.2	290.5	174.1	242.7	2812.2
Pinnacles	(km^2)	7.6	3000.4	734.6	996.6	597.2	832.5	9645.4
Raita	(nm^2)	4.6	203.5	36.9	61.1	35.6	34.1	284.4
Bank	(km^2)	15.9	697.9	126.6	209.4	122.2	117.1	975.4
Maro Reef	(nm^2)	145.9	550.3	230.9	167.5	107.6	154.6	956.4
	(km^2)	500.5	1887.6	791.9	574.5	369.1	530.3	3280.3
Laysan	(nm^2)	21.4	140.6	51.5	17.3	21.6	22.8	222.6
	(km^2)	73.4	482.2	176.8	59.4	74.1	78.3	763.6
E. North-	(nm^2)		42.8		27.9 *			75.0
ton Bank	(km^2)		146.9		95.9 *			257.4
W. North-	(nm^2)		10.2		146.2 *			317.3
ampton Bank	(km^2)		35.0		501.4 *			1088.3
Pioneer	(nm^2)		127.1	35.0	32.7	31.4	38.2	305.8
Bank	(km^2)		436.1	119.9	112.1	107.6	130.9	1048.9
Lisianski	(nm^2)	95.7	268.9	31.0	31.4	27.8	28.0	866.9
	(km^2)	328.2	922.2	106.3	107.9	95.5	96.0	2973.3
Outlying	(nm^2)		(Northampton Banks vicinity)					157.1
Seamounts	(km^2)		(total of three)					538.8
Seamount#5	(nm^2)		46.2					
NW of Lisianski	(km^2)		158.6					
Seamount#6	(nm^2)		2.6			124.7 **		
NW of Lisianski & of Salmon B.	(km^2)		8.8			427.6 **		
Salmon	(nm^2)		46.3		62.5 *			64.8
Bank	(km^2)		158.9		214.5 *			222.3
Pearl and	(nm^2)	118.9	124.4		69.7 *			326.7
Hermes Reef	(km^2)	407.8	426.7		239.2 *			1120.4

* 100-500 fm.

** 100-1000 fm.

Depth (fm)		0-10	10-100	100-200	200-300	300-400	400-500	500-1000
Area								
Gambia	(nm^2)		5.5					
Shoal	(km^2)		18.8					
Seamount #7	(nm^2)		52.8		55.4*			89.8
N. of Gambia Shoal	(km^2)		181.0		190.1*			308.1
Midway	(nm^2)	27.9	78.3	12.9	12.5	12.4	13.8	99.9
	(km^2)	95.9	268.4	44.2	42.9	42.6	47.4	342.5
Outlying	(nm^2)		(Midway and Kure Is. area)					45.2
Seamounts	(km^2)							155.0
Kure Is.	(nm^2)		19.2***					
	(km^2)		66.0***					

Total area from 0 to 100 fathoms: (nm^2) 4612.7

(km^2) 15821.1

* 100-500 fm.

*** Lagoon to 20 fm.

APPENDIX 10

SPINY LOBSTER FISHERIES IN OTHER AREAS AND COMPARISONS WITH HAWAII

The spiny lobster fisheries in Florida and Australia harvest species phylogenetically similar to *P. marginatus*. *P. argus* is fished very intensively in the Bahamas, Bermuda, Florida, the Caribbean and Brazil. *P. longipes cygnus* is heavily fished along the west coast of Australia. Both of these species have supported large fisheries which started following World War II (Chase and Dumont, 1979). Intensive research programs aimed at strengthening the management base have been developed in both fisheries. Consequently, more information is available pertaining to the biology and fishery management of these two species of *Panulirus* than any other species in the genus.

Both species are similar to *P. marginatus* in several ways. All three species are very closely related morphologically and are thought to have evolved from a common ancestral stock during the same interglacial period (George and Main, 1967). Although they are geographically isolated, they have very similar habitat preferences and have presumably evolved under similar selection pressures. It appears for *P. marginatus* that the minimum and mean sizes of first breeding for females are similar to those for *P. longipes cygnus* and *P. argus*. The size distributions of the three species are generally similar, although they may be affected by fishing pressure. (Sheard, 1962; Munro, 1974; Davis, 1975, 1977; Chittleborough, 1976b; Kanciruk and Herrnkind, 1976). Also, for both *P. marginatus* and *P. longipes cygnus* size specific fecundity has been shown to be independent of latitude (Morgan, 1972; MacDonald and Thompson, MS).

The fishery for spiny lobsters in South Africa harvests Jasus lalandii. Management of this fishery dates back to 1940 (Soares-Rebilo, 1964) and has in recent years been accompanied by a significant research effort. Although this spiny lobster is of another genus and species, the animal appears biologically similar to P. marginatus. The most important aspect of the management history of this species relative to management of the fishery in the NWHI is that refuge experiments have been conducted. These give some idea of recovery times for depleted stocks.

Closed areas have been established in a number of spiny lobster fisheries, notably Australia (George, 1957; Chittleborough, 1974b, 1975; Morgan, 1974a, b) and South Africa (Crous, 1976) and Florida (Davis, 1974, 1975, 1977). These areas have been used primarily for studies of fishery impact by providing temporarily unfished areas. In Australia, there is close cooperation between industry and fishery management. Various areas have been temporarily designated as refugia for specific research projects. In Florida the refuge area has been a constant feature and has been used to determine the unfished population structure. Refuges are currently being used to investigate the role of nursery areas.

Finally, the last spiny lobster fishery to be considered in comparison to the NWHI is a brief intensive international effort on Jasus tristani on the Vema Seamount in the mid-Atlantic. This fishery is interesting because it was centered on a seamount and exhibits similarities to the situation in the NWHI.

General Management Histories

Florida

Management programs for the spiny lobster fishery in Florida were put into effect between 1965 and 1970. The management program was designed to insure the highest possible production of lobster (Prochaska and Baarda, 1975). Vessels participating in this fishery are required to have permits. Lobster traps are required to be wooden, at least in part, and are limited in size. Fishing is not allowed during the summer as this is thought to be the season of maximum reproduction. The minimum size lobster which can be landed is 7.6 cm carapace length, or if only tails are landed, 15.2 cm tail length. Females with eggs may not be taken.

It appears that this management program has to date done little to improve the fishery (Beardsley et al., 1975). The catch rate has declined seriously in recent years and currently is around one legal lobster per trap-night. The main cause of this decline is thought to be excessive effort.

Australia

Management programs for the fishery harvesting *P. longipes cygnus* on the west coast of Australia are complex and involve both federal and state controls. The principal goal of management is to maintain a maximum average annual sustainable yield (Bowen, 1971). The main management measures are: a minimum size limit of 7.6 cm carapace length, limited entry, limited numbers of traps per boat, protection of berried females, closed seasons, and escape gap in the traps.

It appears that the limited entry policy adopted in 1963 has resulted in substantial benefits to the industry. The economic return per boat has increased and provides a higher standard of living for those in the industry. Most of the participants have developed a responsible attitude towards the management program and have participated in management discussions and decision making (Bowen, 1971). There is still concern, however, that insufficient numbers of females are being allowed to reproduce under the current carapace limit of 7.6 cm.

South Africa

The fishery for *J. lalandii* on the western coast of South Africa is managed with the following policies: closed seasons during the reproductive season; minimum carapace length of 8.9 cm (or second tail segment width of 2.4 cm), no ovigerous females allowed to be taken, only whole lobsters allowed to be landed, and closed areas.

Vema Seamount

The Vema Seamount was discovered in 1959, and was observed to have large numbers of spiny lobsters of the species *Jasus tristani* (Simpson and Heydorn, 1965). An intensive fishery started in 1964 and ended in 1966. There were essentially no management controls on the fishery. The total catch of lobsters resulted in the export of approximately 600,000 pounds of frozen tails in 1965, but only 66,000 pounds in 1966.

The size distribution of the catch was analyzed by scientists of the Division of Sea Fisheries of the Republic of South Africa. They suggested in 1964 that a minimum carapace length of 9.0 cm be observed, but this was reduced to 8.0 in 1965 and to 6.0 cm in 1966 (Heydorn, 1969). The harvest decrease in this fishery points out that there is no compelling reason to feel that economic factors alone will protect the resource from overfishing.

Size Distributions

The size distributions of *P. marginatus*, *P. argus* and *P. longipes cygnus* are generally similar, especially prior to exploitation. Males are on the average larger than females and appear to be disproportionately removed by fishing. This results in decreased size differences between the sexes, females becoming relatively more abundant than males and an overall reduction of resource. Morgan (1972) investigated the size structure of the population of P. longipes cygnus on Rat Island where this species is intensively fished. The size distribution of females is shown in Appendix V, Figure 1. It is interesting to note that the entire legal catch in such a fishery has grown above the minimum size in the present year (Morgan, 1974; George, 1972; Sheard, 1962). It has been noted that under such exploitation the modal size tends to be one size class below the legal size limit (Morgan, 1972; Crous, 1976).

Reproduction

Populations of P. longipes cygnus and P. argus demonstrate a relationship between lobster size and water depth. The lobsters appear to move offshore with age where the females reproduce in deep water. It is not known if this occurs in Hawaiian P. marginatus. In Florida and Australia these inshore sites are known as nursery areas. The exact nature of the nursery areas or their role in the life cycle of the populations is not understood. Studies are currently underway to investigate the nursery areas of Dry Tortugas National Monument, a refuge area in Florida. Preliminary observations at Kure Island suggest that all size classes may be found in the lagoon (MacDonald and Stimson, pers. comm.).

In Florida and Australia, it appears that females start reproducing at ages of 2 to 3 years and 7 to 8 years respectively. Reproduction starts at the same size in these two species, suggesting that the growth rates in time are greatly different in these two areas. The reproductive importance of males of different sizes in the population is unknown. It appears from data from South Africa that males are sexually mature at slightly smaller sizes than are females (Heydorn, 1965), but they are probably only able to mate with females smaller than themselves.

Egg production is dependent on size specific reproductive rates and on the size distribution of the population. Size specific reproductive rates are known for _P. marginatus_, but the size distribution resulting from the current level of harvesting is unknown. Some reduction in the abundance of the larger size classes has been observed (Section 5.1.5). Should the size structure change to one similar to Rat Island, the total reproductive output of the population would be reduced by approximately 50%.

For both _P. argus_ and _P. longipes cygnus_, it appears that breeding is continuous when temperatures are greater than 22° C, and that breeding is seasonal at lower temperatures. Two spawnings per season are possible in the higher latitudes, while under warmer temperatures 4 to 6 spawnings are possible.

The phyllosoma larvae of _P. longipes cygnus_ are planktonic for 9 months, while those of _P. argus_ are planktonic for 5-12 months. The larvae eventually settle in shallow areas, usually where there is extensive algal cover. Survival of the larvae is thought to be extremely low.

The nature of the regulation of population size and structure of spiny lobsters is not well known, but appears to vary from area to area. In western Australia it is thought that (at least in the central portion of its range) _P. longipes cygnus_ is regulated primarily by changes in the growth rate of females as population size changes, and by changes in the survival of juvenile lobsters as the number of juveniles in the nursery area changes. Increases in egg production and in juvenile survival are thought to have enabled this population to withstand very heavy fishing pressure. However, recent evidence suggests that the minimum carapace limit of 7.6 cm has allowed too great a reduction in the numbers of reproducing females (Anonymous, 1977).

For *P. argus* the situation is less clear. There is a considerable body of literature which emphasizes the great importance of size specific reproduction rates in females greater than about 8 cm carapace length (Munro, 1974; Davis, 1975; Kanciruk and Herrnkind, 1976). No evidence of changes in these rates have been presented. Similarly, no relationship between the survival of juveniles and population size has been documented. In the absence of density-dependent changes in the population as the population size is reduced due to fishing, the overall production from the population will be lower. This will result in lower sustainable yields.

While such relationships for Hawaiian *P. marginatus* cannot be established until the fishery has operated for a period of time, the above information suggests that density-dependent responses are a key factor in determining the sustainable yield. In the event that such changes do not occur, it will be all the more important to have protected the reproductive stock.

Catch Rates and Densities

The catch rates in a fishery generally tend to decline as the fishery reduces the population. The catch rates at the beginning of a fishery provide some indication of the initial density of the lobsters. The initial catch rates in some areas have been much higher than those experienced in the NWHI. For instance, the catch rates of *P. argus* in the Dry Tortugas National Monument, a refuge, were a factor of ten higher than those which were observed initially at Necker Island (Davis, 1977).

A more direct measure of abundance is available in terms of the density of animals per unit area. Estimates of such densities vary by a factor of 150 in different fisheries. Thus for P. argus densities of 6000 animals per km^2 are reported in Florida, while corresponding densities in the Virgin Islands are less than 1000. In western Australia densities of P. longipes cygnus in the range of 90,000 lobsters per km^2 have been reported (Morgan, 1974a). It was in this latter situation that density-dependent juvenile survival was reported (Section 7.3).

Although corresponding density estimates have not been made in the NWHI, a lower limit can be estimated from the total catch taken per unit area. For Necker Island, the total catch (including both legals and sub-legals) since November of 1976 has been approximately 130,000 lobsters. Only approximately 80,000 of these lobsters were legal and removed from the population, therefore, some of those returned may have been caught more than once. From these data, a catch of approximately 68 lobsters per km^2 is estimated. Thus, even if only one in every one hundred lobsters which were present at Necker Island were caught, the density would be no greater than that found at Florida. The catch would have to represent one lobster captured for every 1000 lobsters in the resource to equal the density found in Australia.

Seamount Fisheries

The Vema Seamount fishery described in Section 7.1.4 represents a commercial lobster fishery not associated with a continental land mass. There are some similarities between the Vema fishery and the developing fishery of the NWHI. For example, both fisheries are far removed from ports, and thus difficult and expensive to fish. Vema Seamount is similar to the NWHI in being one of several seamounts in the same general area supporting a particular endemic species.

The Vema Seamount is currently considered to have been "fished out" in three years. The discussion in 1965 of the fishery potential for this area offer an interesting insight into the potential within the NWHI. Simpson and Heydorn (1965) concluded that the intensive commercial exploitation of this community which was in progress should afford a unique opportunity of observing the effect of fishing on a virgin resource. This conclusion was followed with a statement by Heydorn (1969, p. 7):

> A few remarks concerning the chances of recovery of the rock lobster ground on Vema Seamount may be of interest....In large fishing areas, the complete coverage of an exploitable population by the fishing fleet is unlikely for purely geographical reasons and recruitment of stocks in the exploited areas by adult migration can take place. At Vema Seamount this is most unlikely as the sharply increasing depth of the steep flanks of the seamount must severely limit the portion of the population inaccessible to the fisherman. Recruitment, therefore, can only take place by growth of young rock lobsters too small to be caught in traps and by settlement and subsequent growth of planktonic larvae. Growth of young rock lobsters may lead to a temporary recovery in two or three years but repopulation by settlement of planktonic larvae is an extremely slow process. Long term commercial prospects, therefore, seem poor at Vema Seamount although this certainly does not imply that stocks have suffered permanent damage.

This experience relates to points which have been made by participants in the fishery in the NWHI. In discussions with the

Advisory Subpanel, it has been argued that the high costs of fishing in the NWHI, coupled with the cost of "learning the grounds" effectively protects the lobster populations from over-harvesting. Such mechanisms did not protect the sustainable yield of Vema Seamount. Heydorn's analysis of the commercial recovery of the fishing grounds is also pertinent in that discussions of fishing in the NWHI emphasize current catch rates, with too little consideration given to possible long-term catch rates.

Recovery of Depleted Populations

The experience in South Africa with refugia provides some insight into the processes of recovery of overfished populations. Heydorn, Newman and Rossouw (1968) describe the establishment of a refuge between Duiker Point and Logies Rock in 1940, apparently after overfishing. After 12 years of protection the area was opened to commercial fishing in 1952. Initially high catch rates were followed by a steady decline until 1960, when the area was again made a sanctuary. The area was opened again 29 months later, but the population had not recovered enough to make the fishery profitable.

Although this example does not allow extrapolation of recovery times, it does indicate that lobsters can easily be overfished. Populations demonstrate the ability to recover if fishing pressure is removed for substantial periods of time.

Predation by Seals

Seals are known to prey on lobsters in several parts of the world. In South Africa the Cape Fur Seal (*Arctocephalus pusillius*) depends on the spiny lobster *Jasus lalandii* for at least a part of its diet (Rand, 1959; Heydorn, 1969a). Spiny lobsters from Ackland Island, *Jasus edwardsii*, have been noted in the stomachs of seals (Yaldwyn, 1958).

P. marginatus has been observed in the spewings of the Hawaiian Monk Seal (*Monachus schauinslandi*) (B. and P. Johnson, pers. comm.), and SCUBA divers have observed such predation in the NWHI (Naftel and Taylor, pers. comm.). It would appear that seals prey upon spiny lobsters, but the degree of dependence of seals on this food source is unknown.

Hawaiian Monk Seals are listed as an endangered species. Attempts are currently underway to define "critical habitat" for these animals and Kenyon (1976) summarized what is known about the life history and habitat of the Hawaiian monk seal. The area within the fringing reef around each island appears to be used extensively by monk seals for birthing and rearing of the pups. Areas outside the reef are used by adults for foraging, but the details of their habits are unknown. The seals appear to be very sensitive to the presence of humans.

Processing at Sea

In fisheries for *J. lalandii* in South Africa and for *P. longipes cygnus* in western Australia it has been shown that that lobsters are repelled by the dead bodies of their compatriots. The practice of removing the tails and discarding the remains of the lobsters at sea has been banned in South Africa and has been advised against in the fishery for *P. ornatus* in the Torres Strait (Mathews, 1962; Chittleborough, 1974c). There is as yet no evidence of similar repulsion in *P. marginatus* in the NWHI.

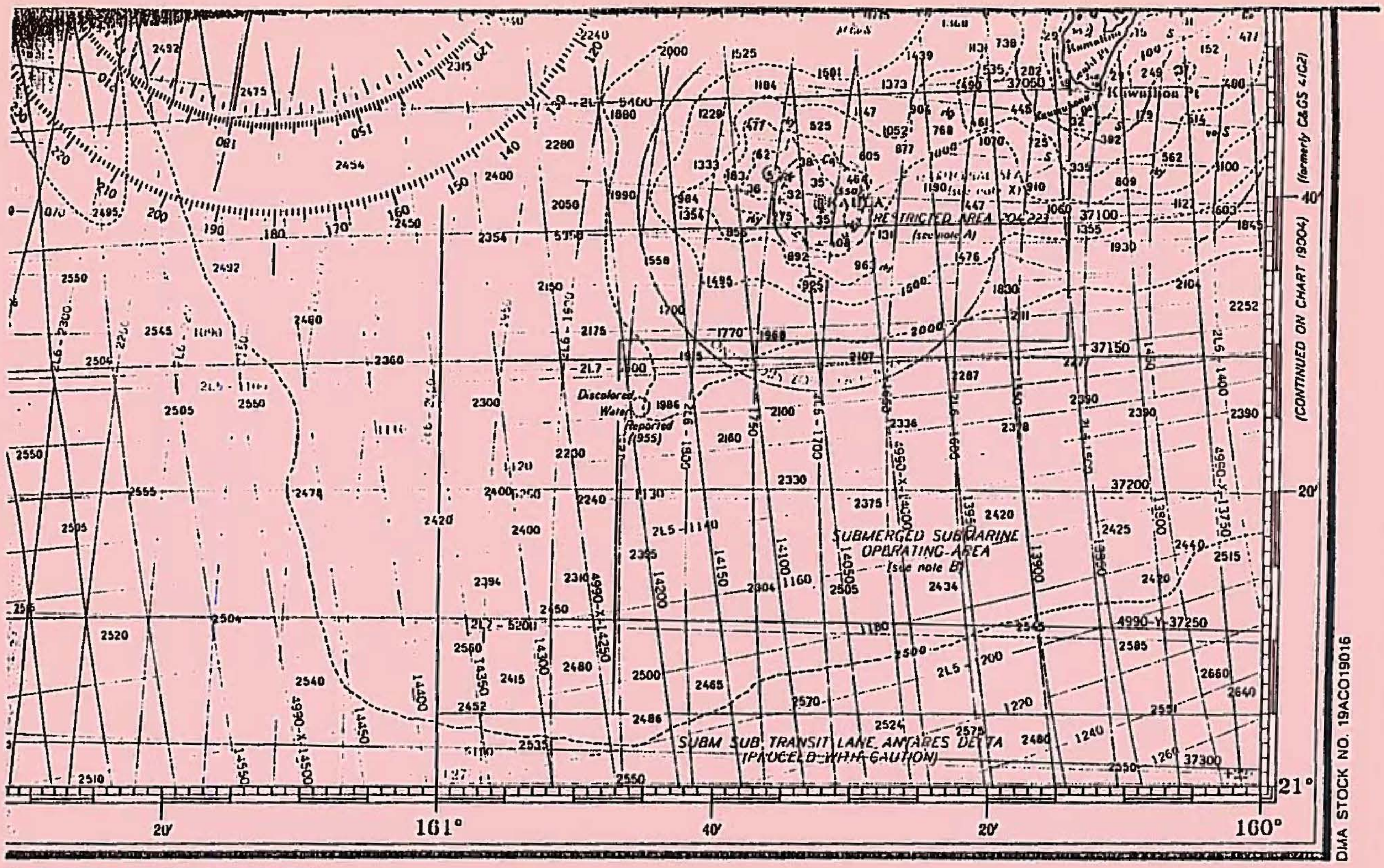
The present uncertainty, however, should not critically influence initial management of the developing fishery since processing at sea has not yet become the general practice. If this practice becomes widespread or is applied intensely by a few firms, the potential for repulsion of lobsters from discarded carapaces should be tested to determine the lobsters' response and possible impacts upon the fishery.

APPENDIX 11

CHARTS OF THE NORTHWEST HAWAIIAN ISLANDS

National Oceanic & Atmospheric Administration,
U.S. Dept of Commerce --- National Ocean Survey

Chart Numbers	Area
19016	Niihau to French Frigate Shoals
19019	French Frigate Shoals to Laysan
19022	Laysan Island to Kure



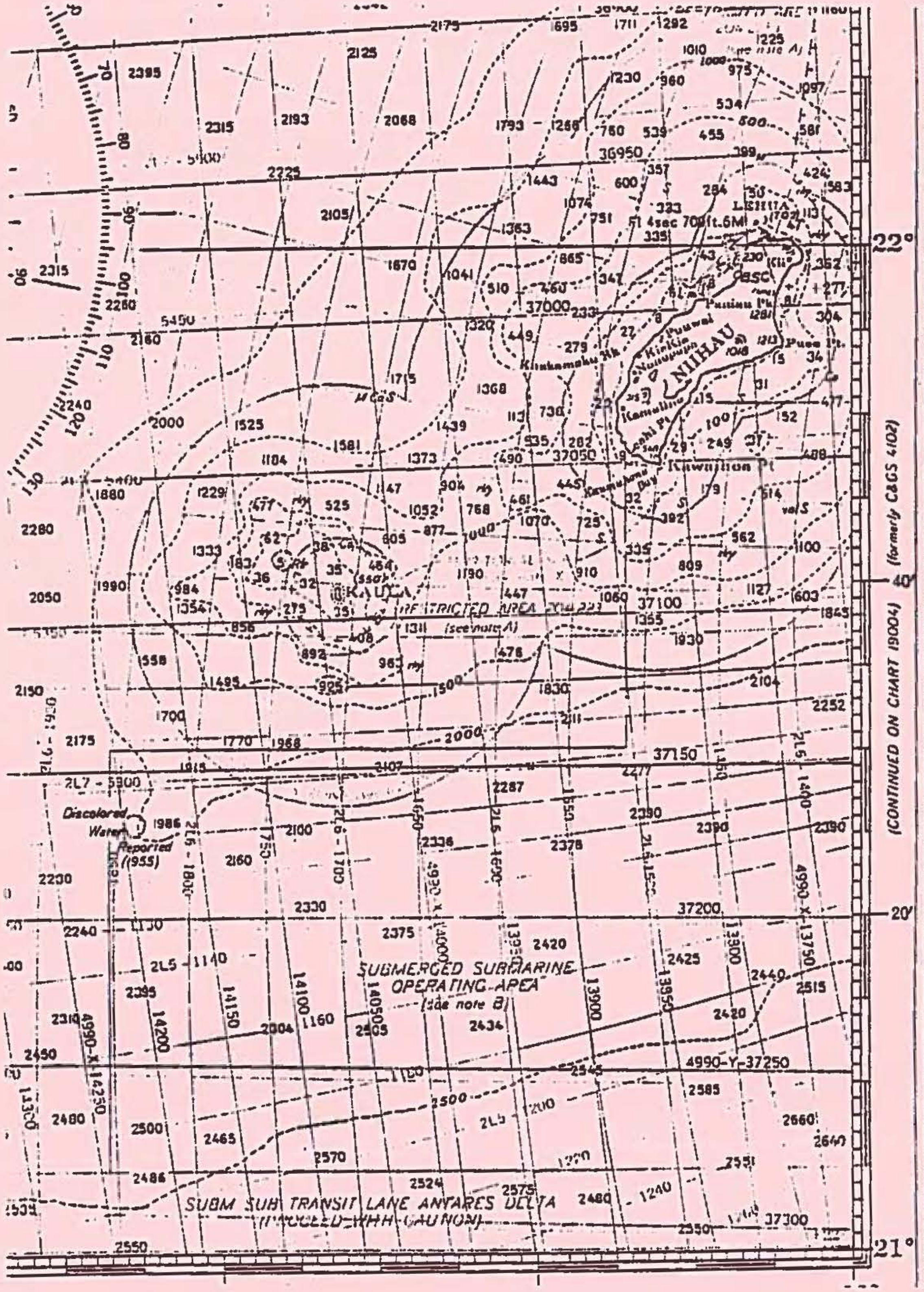
(Niihau Island to French Frigate Shoals)

SOUNDINGS IN FATHOMS - SCALE 1:663,392

19016

(formerly C&GS 4181)

LORAN-A/C OVERPRINTED



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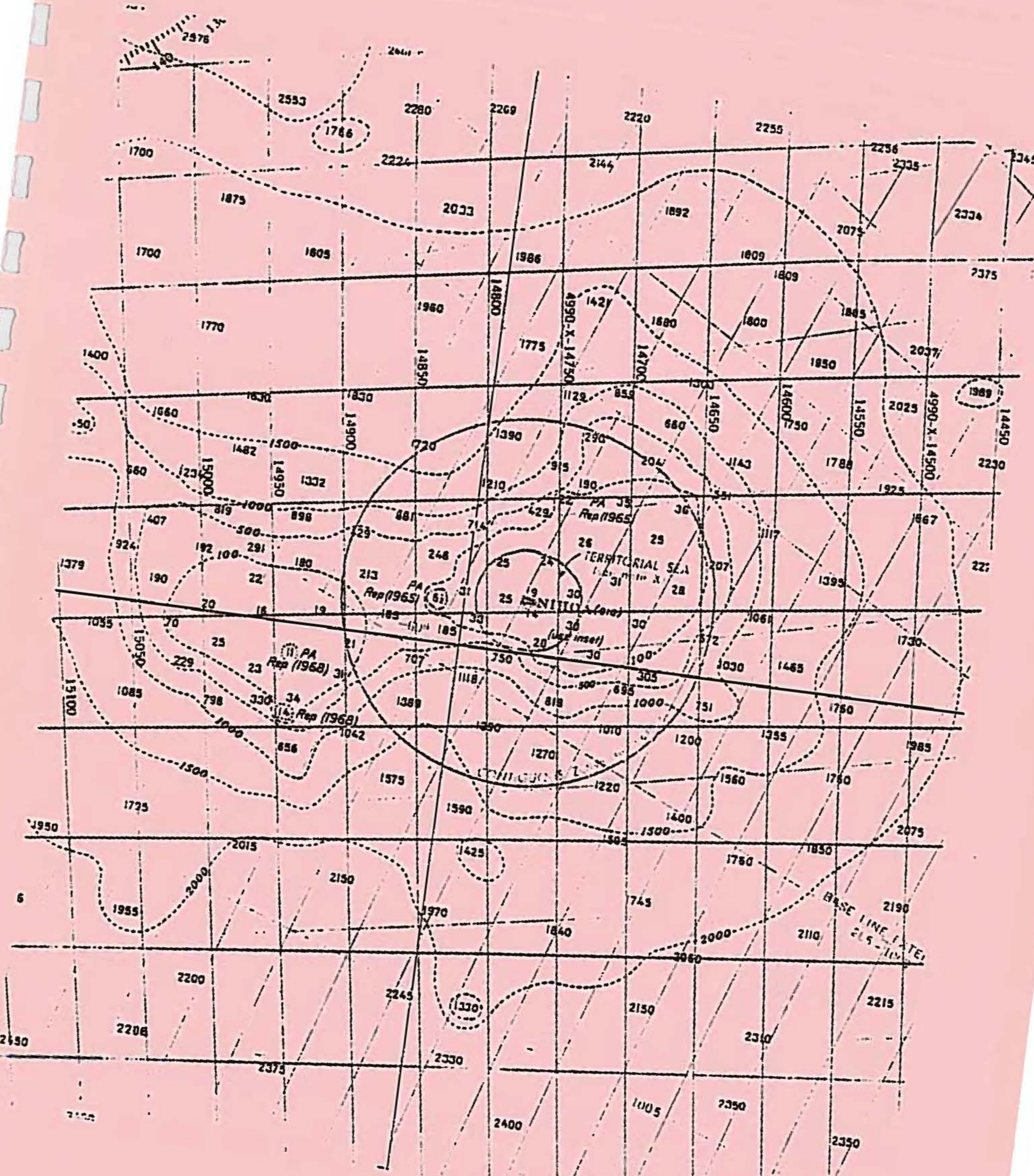

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14950
15000
15050
15100
4990-X-14750
14700
14650
14600
14550
4990-X-14500
14450
TERRITORIAL SEA
PA Rep (1965)
PA Rep(1965)
PA Rep (1968)
Rep (1968)
(see inset)
BASE LINE
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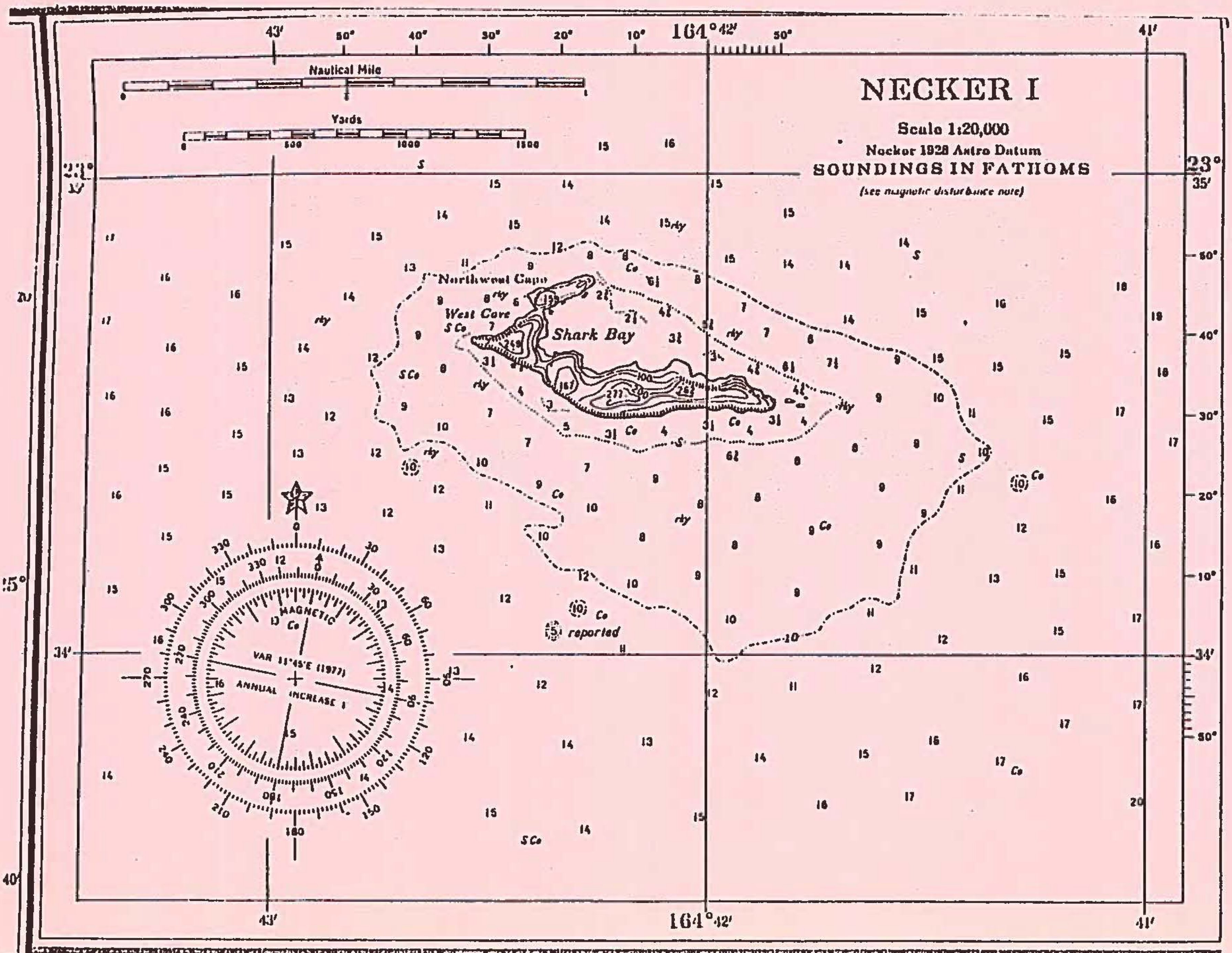
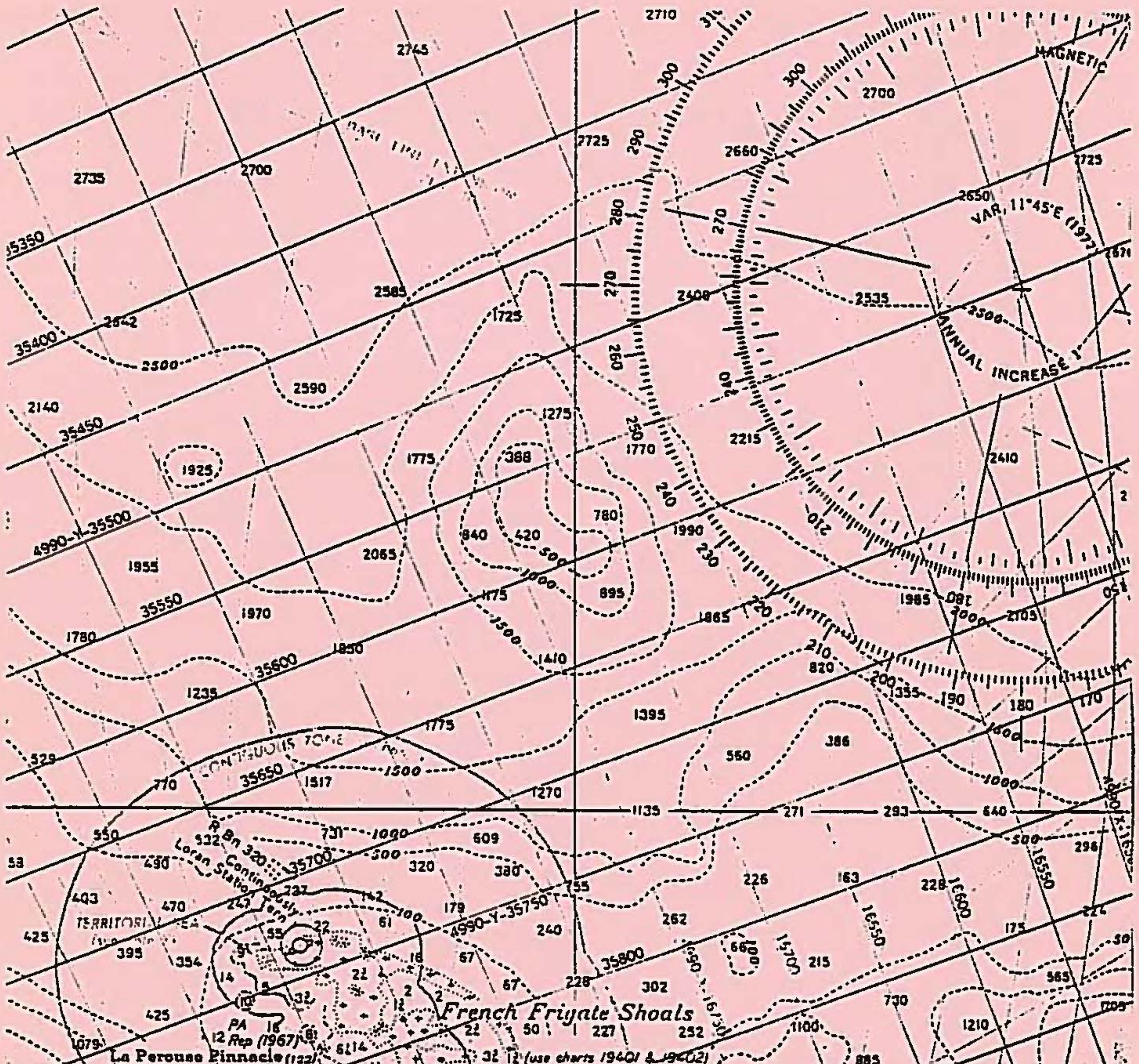
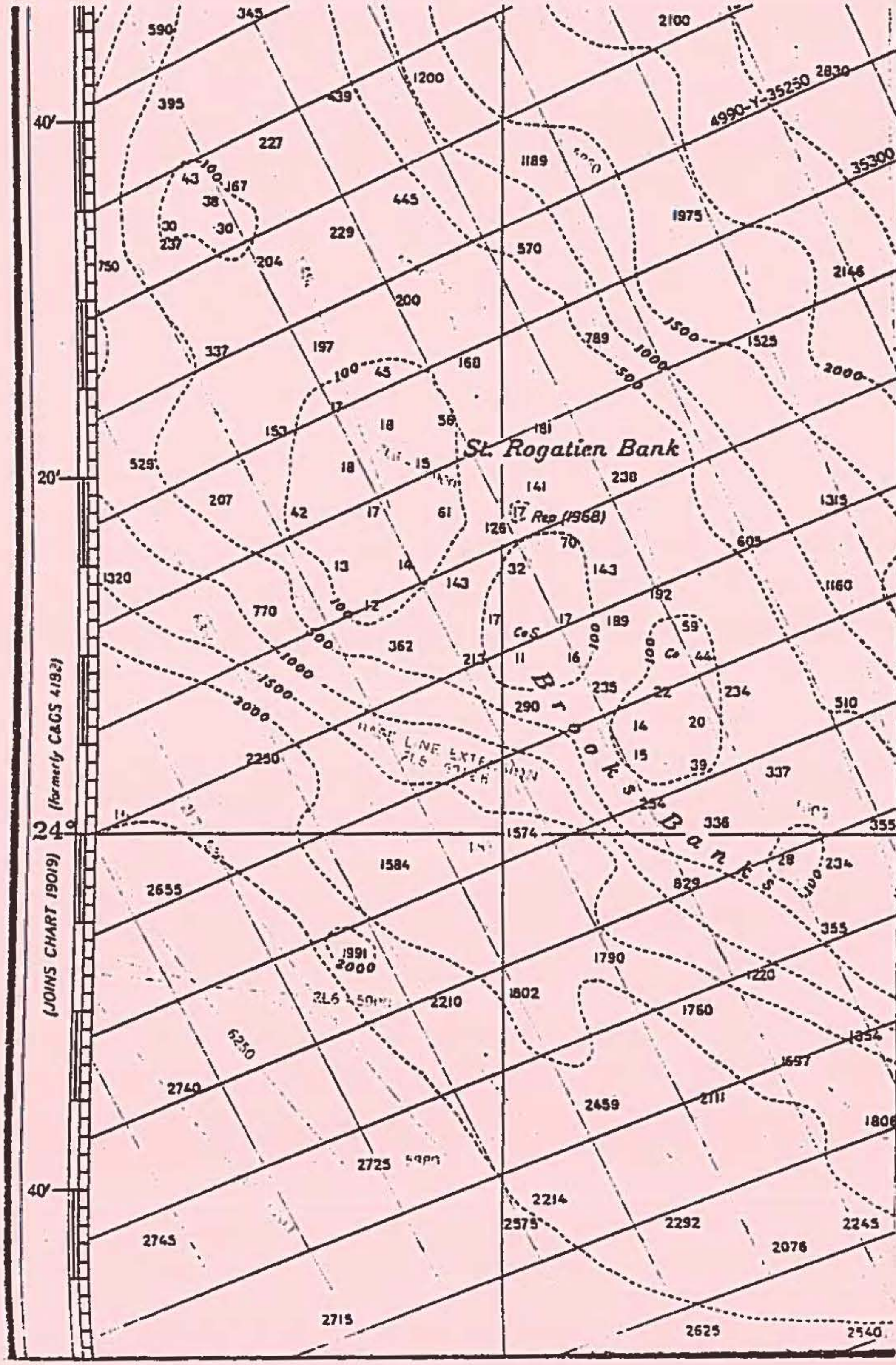
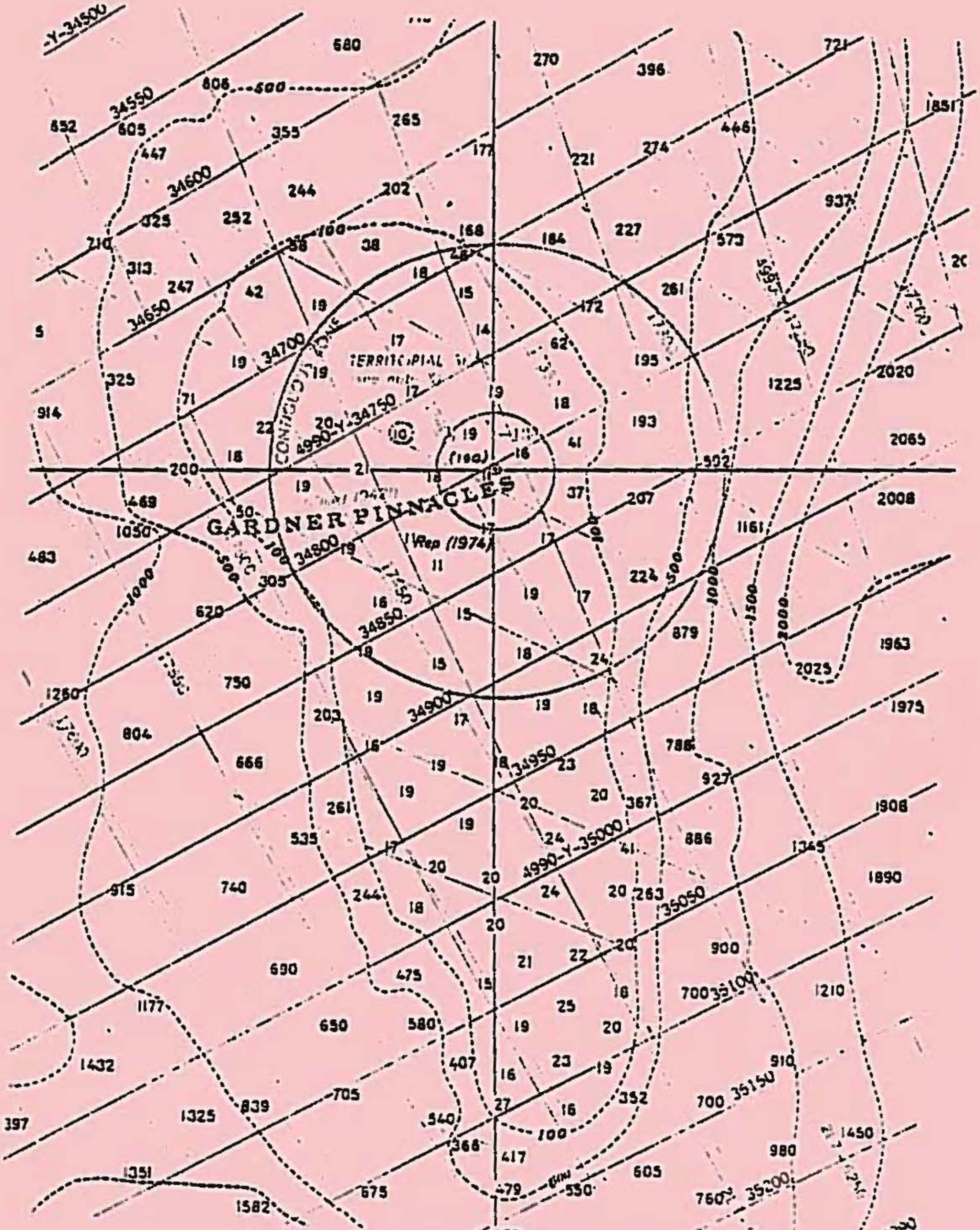
1000
500
100
2000

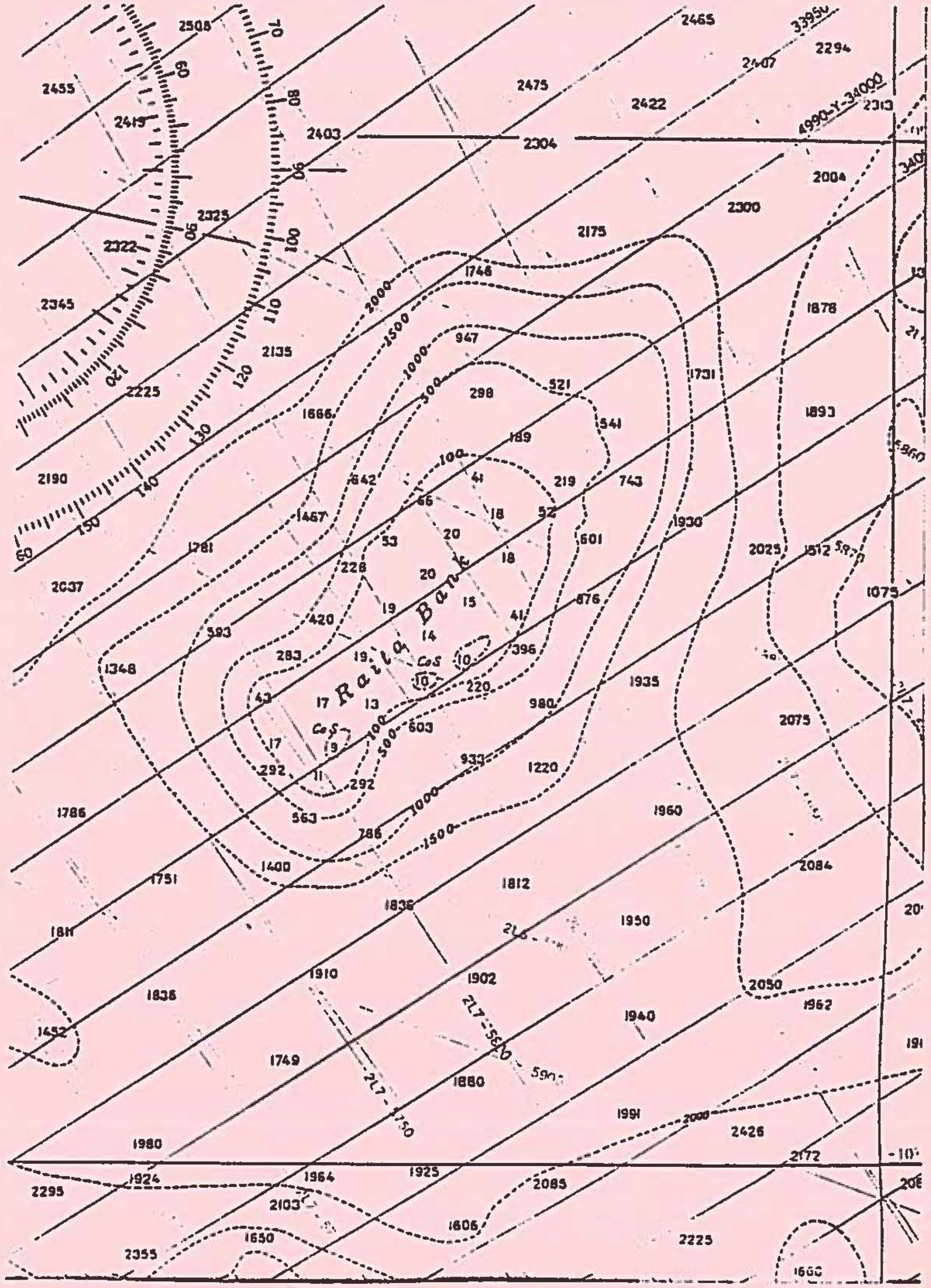


NECKER I
Scale 1:20,000
Necker 1928 Astro Datum
SOUNDINGS IN FATHOMS
(see magnetic disturbance note)
Nautical Mile
Yards
Northwest Cape
West Cove
Shark Bay
reported
VAR 11°45'E (1977)
ANNUAL INCREASE 1'
MAGNETIC
164°42'

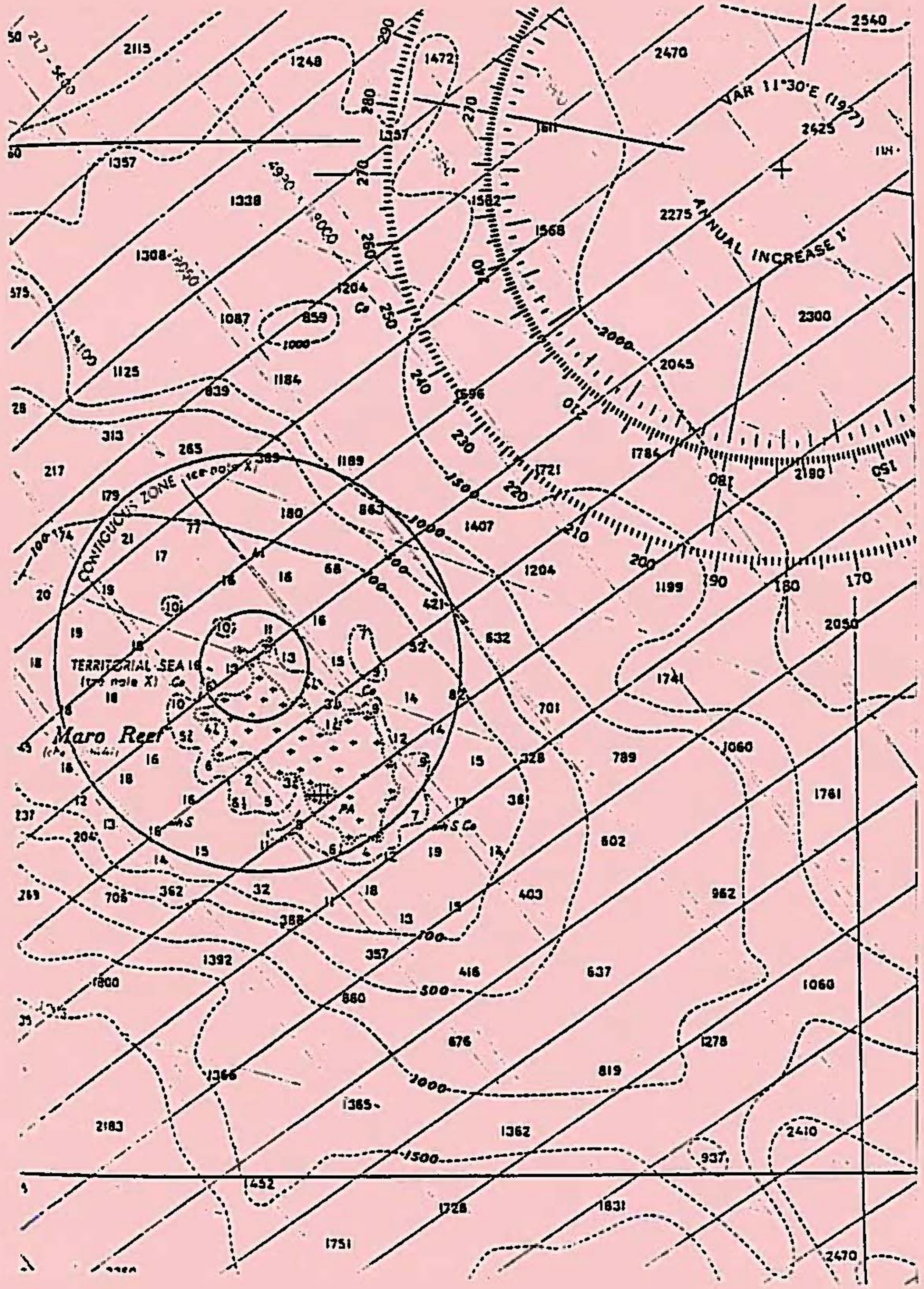

MAGNETIC
VAR. 11°45'E (1977)
ANNUAL INCREASE 1'
CONTIGUOUS ZONE
TERRITORIAL SEA
R Bn 320
Continuously
Loran Station
Tern
4990-Y-35500
4990-Y-35750
French Frigate Shoals
(use charts 19401 & 19402)
PA
Rep (1967)
La Perouse Pinnacle (122)


St. Rogatien Bank
Brooks Banks
Rep (1968)
4990-Y-35250
35300
(JOINS CHART 19019) (formerly C&GS 4192)
40'
20'
24°
40'

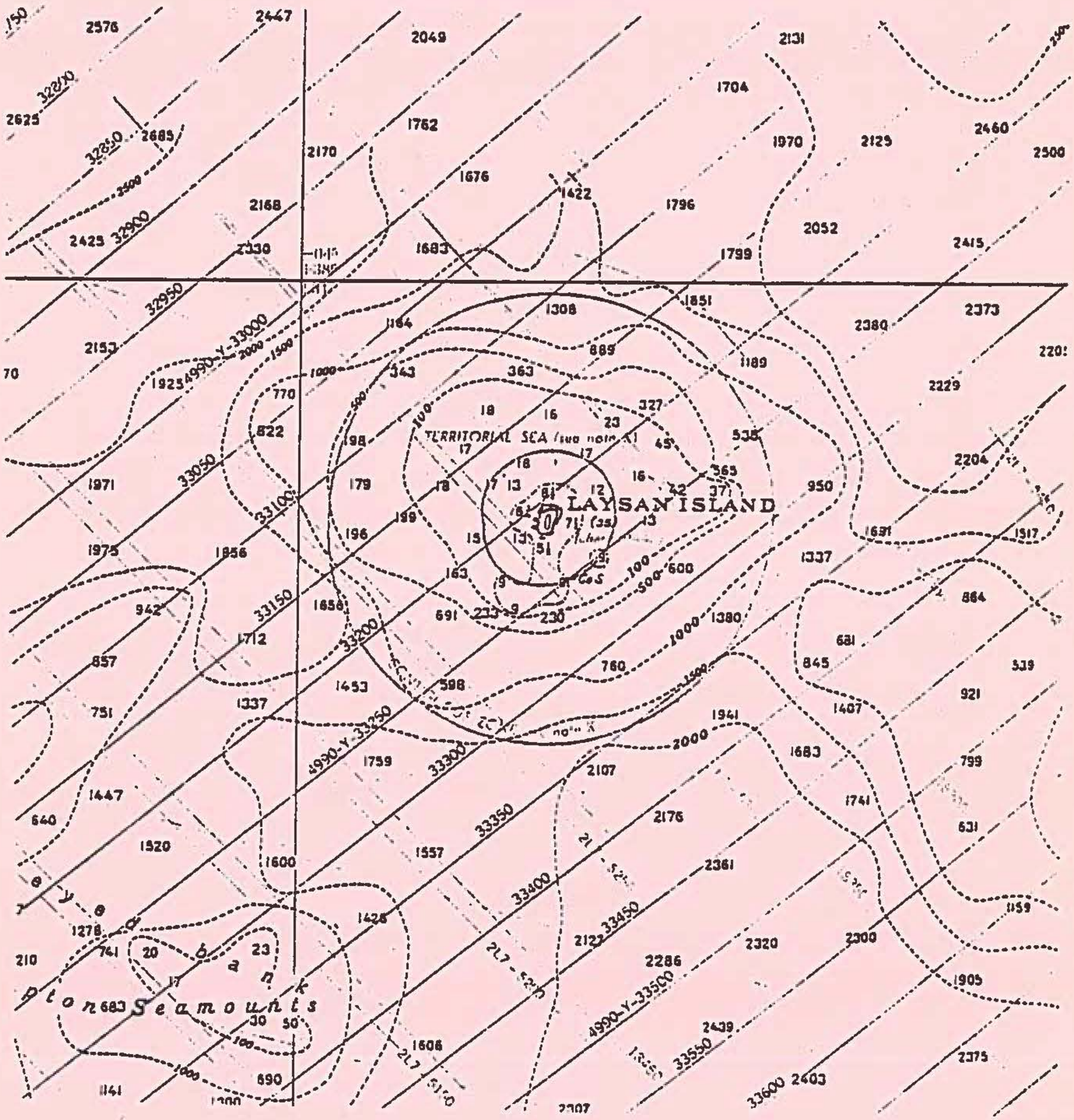

GARDNER PINNACLES
Rep (1974)
TERRITORIAL
Y-34500
4990-Y-34750
4990-Y-35000



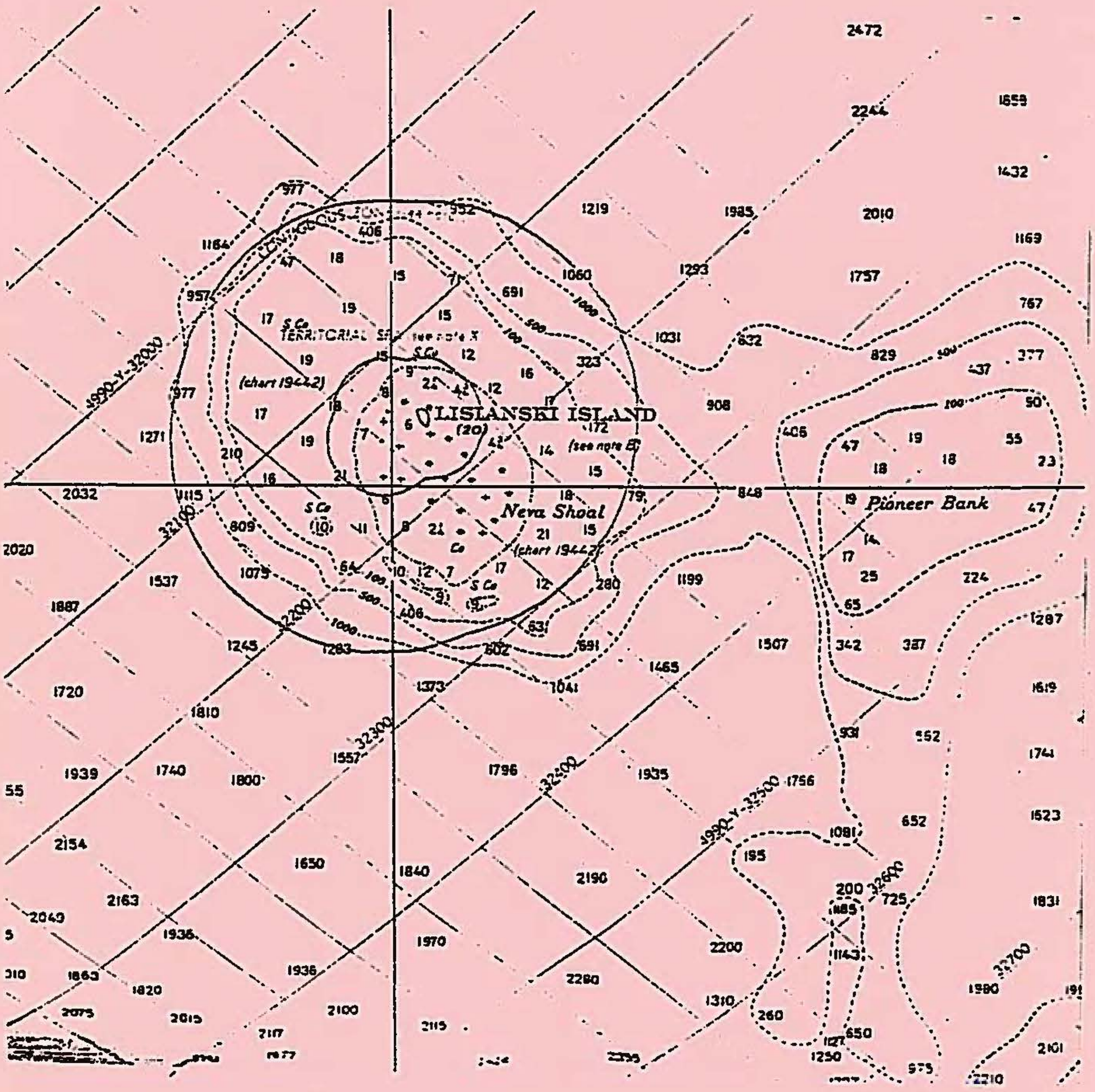
Raita Bank
CoS
CoS
4990-Y-34000
2000
1500
1000
500
100

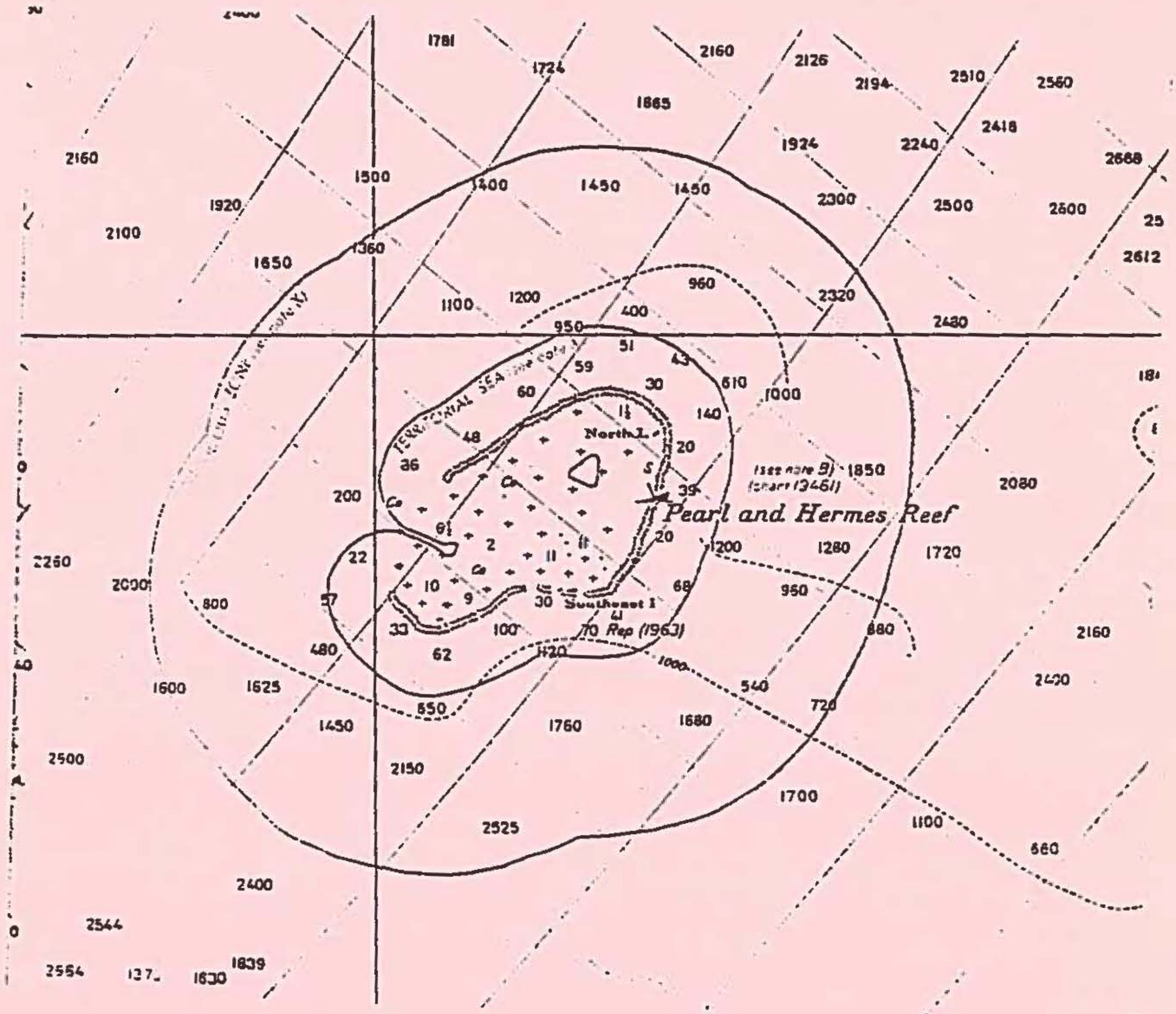


VAR 11°30'E (1977)
ANNUAL INCREASE 1'
CONTIGUOUS ZONE (see note X)
TERRITORIAL SEA
(see note X)
Maro Reef

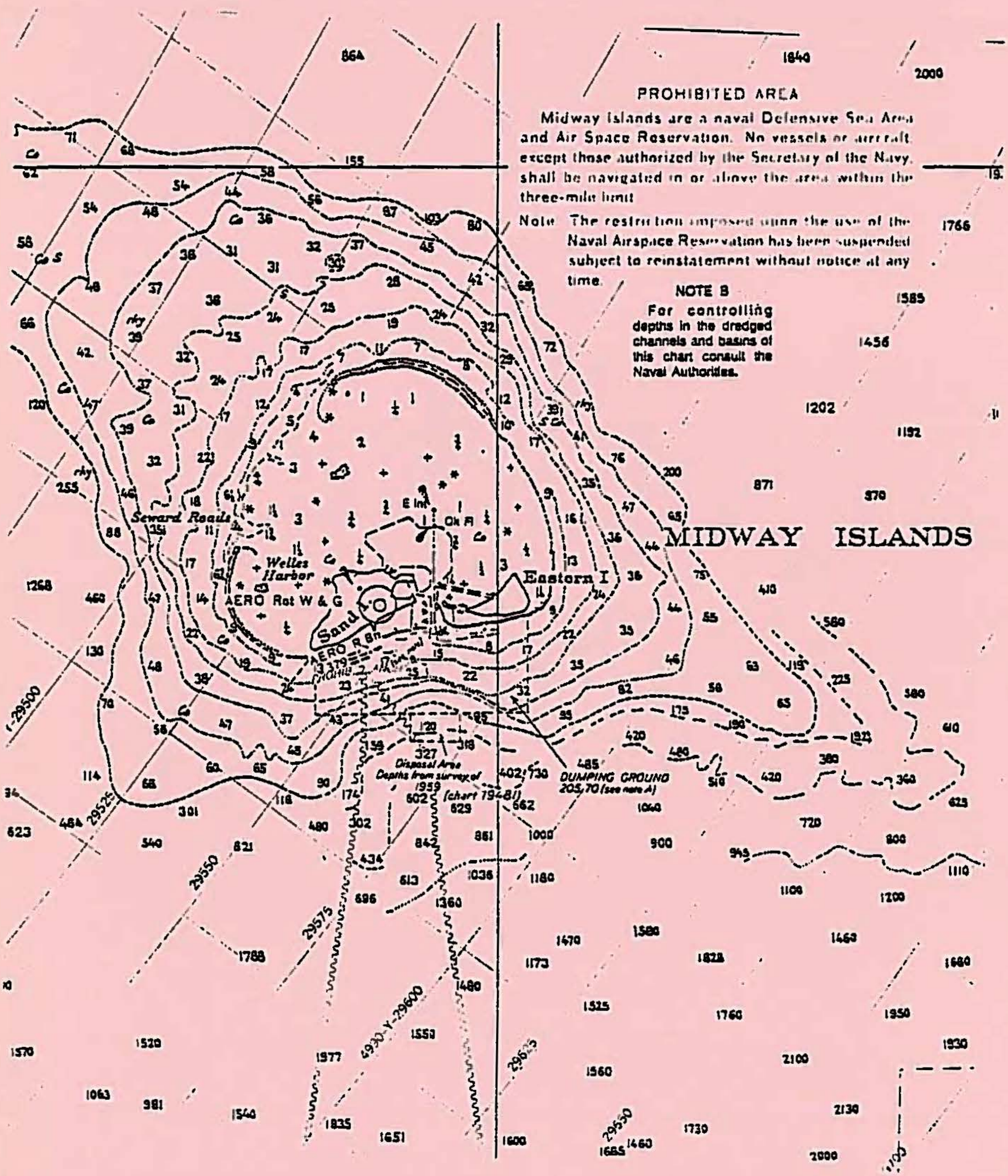


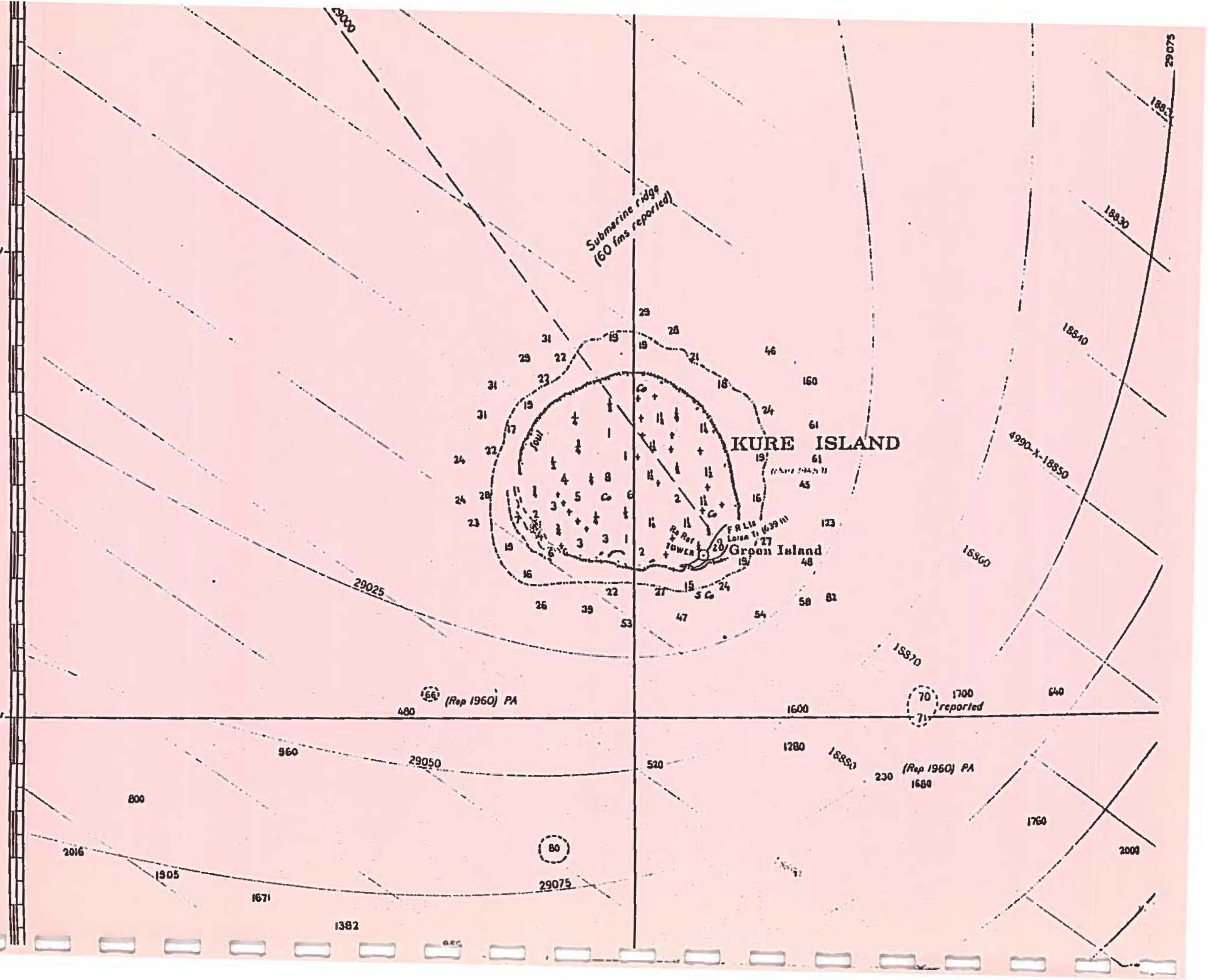
LAYSAN ISLAND
TERRITORIAL SEA
Seamounts
4990-Y-33000
4990-Y-33250
4990-Y-33500


LISIANSKI ISLAND
(20)
Neva Shoal
Pioneer Bank
TERRITORIAL SEA (see note X)
(chart 19442)
(see note E)
(chart 19442)
1990-Y-32000
32100
32200
32300
32400
1990-Y-32500
32600
32700



Pearl and Hermes Reef
North I.
Southeast I
70 Rep (1963)
TERRITORIAL SEA
(see note B)
(chart 19461)


PROHIBITED AREA
Midway Islands are a naval Defensive Sea Area and Air Space Reservation. No vessels or aircraft except those authorized by the Secretary of the Navy, shall be navigated in or above the area within the three-mile limit.
Note. The restriction imposed upon the use of the Naval Airspace Reservation has been suspended subject to reinstatement without notice at any time.
NOTE B
For controlling depths in the dredged channels and basins of this chart consult the Naval Authorities.
MIDWAY ISLANDS
Seward Roads
Welles Harbor
AERO Rot W & G
Sand I
Eastern I
AERO R Bn
Disposal Area
Depths from survey of 1959 (chart 19481)
DUMPING GROUND
205,70 (see note A)


KURE ISLAND
Green Island
Submarine ridge (60 fms reported)
reported
(Rep 1960) PA
(Rep 1960) PA
30′
20′
29000
29025
29050
29075
18830
18840
4990-X-18850
18860
18870
18880

APPENDIX 12

SECTION 12.5

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