BIOLOGY, DISTRIBUTION, AND ESTIMATES OF APPARENT ABUNDANCE OF THE SPINY LOBSTER, PANULIRUS MARGINATUS (QUOY AND GAIMARD), IN WATERS OF THE NORTHWESTERN HAWAIIAN ISLANDS: PART I. DISTRIBUTION IN RELATION TO DEPTH AND GEOGRAPHICAL AREAS AND ESTIMATES OF APPARENT ABUNDANCE

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ABSTRACT

This paper describes the results of field surveys conducted by the Honolulu Laboratory on the spiny lobster, Panulirus marginatus, in the Northwestern Hawaiian Islands. Of 17 islands and submerged banks surveyed from October 1976 to November 1978, only Necker Island and Maro Reef had sufficiently large stocks of spiny lobsters to warrant commercial exploitation. The distribution of spiny lobsters in relation to geographical area and depth is also discussed. Future research needs are identified, including specialized data on the environment and the stocks to estimate their magnitude and potential yield, data on seasonal and spatial variation in stock distribution and abundance, and observations on behavior of spiny lobster in relation to biological and environmental conditions.

Northwestern Hawaiian Islands
spiny lobster
distribution
apparent abundance

INTRODUCTION

The Northwestern Hawaiian Islands (NWHI), often called the "Leeward Islands," are part of the Hawaiian Archipelago comprising a chain of small islands, islets, rocks, and shoals stretching 1,250 nmi west northwest of Niihau (Figure 1). All the land areas except Midway, which is a state-administered wildlife sanctuary and the site of a Coast Guard loran station, constitute the Hawaiian Islands National Wildlife Refuge and are seldom visited.

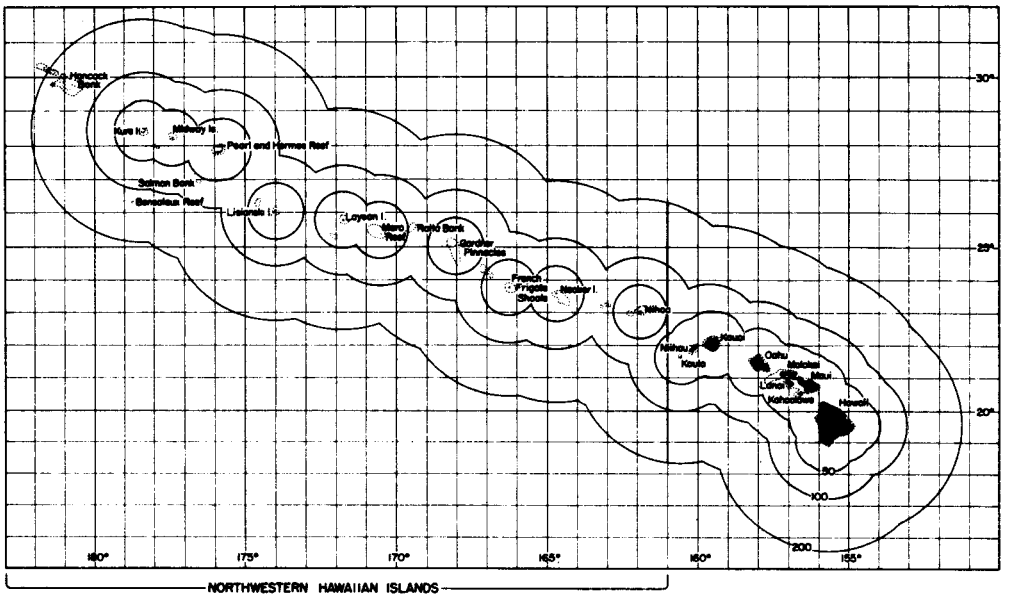

Figure 1. The Hawaiian Archipelago

In 1969, the Governor's Task Force on Oceanography of the State of Hawaii, recognizing the increase in fishing pressure being exerted on the fishery resources of Hawaii's main islands, recommended exploration and possible development of the fishery resources in waters of the NWHI (State of Hawaii, 1969, 1974). In response to these recommendations the Honolulu Laboratory of the Southwest Fisheries Center, National Marine Fisheries Service (NMFS), reconnoitered waters of the NWHI on a cruise of the NOAA ship David Starr Jordan in 1973 and followed that with two research cruises on the NOAA ship Townsend Cromwell in 1975.

In 1976, NMFS launched a full-scale investigation of the NWHI. Realizing that the extent of the investigation was beyond the capabilities of the staff and facilities of any single research agency in Hawaii, NMFS proposed a cooperative research effort with the Hawaii Division of Fish and Game (HDFG) and the U.S. Department of the Interior, Fish and Wildlife Service (USFWS). From the proposal evolved the Tripartite Cooperative Agreement which, in effect, gave responsibility for survey and assessment of the inshore fishery resources to the HDFG and for land-associated resources such as sea and land birds to the USFWS. The Honolulu Laboratory assumed responsibility for developing a quantitative fishery survey and assessment of the slope and coastal pelagic fish resources. A short time after the formation of the tripartite agreement, a fourth agency, the University of Hawaii Sea Grant College Program, became an active participant in the investigation.

Initially, very little was known about the slope and coastal pelagic resources in the NWHI; therefore, our objectives during the first two years of the investigation were simply to conduct exploratory fishing to determine the kinds of fish, shellfish, and molluscs present in waters of the NWHI, their spatial and temporal distribution, and their relative abundance in waters of the several islands and submerged banks. In this report, we summarize trapping results for the spiny lobster, Panulirus marginatus, from October 1976 to November 1978 aboard the Townsend Cromwell and a commercial fishing vessel chartered for two trips.

At the outset of our survey, we identified nearly 50 islands, submerged banks, and seamounts within 200 nmi of the NWHI. We have surveyed 17 of these for spiny lobster and this report covers what we found in waters around these islands and banks.

METHODS

Data used in this report were collected on six survey cruises of the Cromwell (TC-76-06, TC-77-02, TC-77-03, TC-78-01, TC-78-03, and TC-78-04) and on two NMFS-chartered cruises of the commercial fishing vessel Easy Rider (ER 77-02, Parts I and II) which operates out of Honolulu.

The standard gear used on all our lobster trapping operations was the California two-chambered lobster pot. In conjunction with our surveys of bottom fish resources, the large, Hawaiian-type fish trap was also used at the lobster trapping stations. Both the lobster pot and fish trap have been described in detail by Uchida and Hida (1977).

The fish traps were effective not only in capturing a wide variety of fish but also, as incidental catches, spiny lobsters. This report, however, covers only the data collected at our lobster trapping stations. Data on lobster catches made by the fish traps were used only to supplement that obtained on certain highly productive areas, to determine recruitment of juveniles, and for studies involving the length-frequency distributions of the stock(s).

To determine distribution and estimate relative abundance of spiny lobsters, banks were divided into a network of equal area squares or sampling units, measuring 0.1° to a side of latitude and longitude. Each square was identified by a six-digit code at the lower right corner. The first two digits give the whole latitude, the third identifies the 0.1° of latitude which is numbered from 0 to 9 starting at 00' of latitude. The fourth and fifth digits give the whole longitude minus 100, and the last digit identifies the 0.1° of longitude from 0 to 9 starting at 00' of longitude. For example, 220615 identified the square located at lat. 22°00'N and long. 161°30'W. When catches fell on a latitudinal line bordering a square, they were assigned to the square directly above; when they fell on a longitudinal line of a square, they were assigned to the square directly to the left (Figure 2).

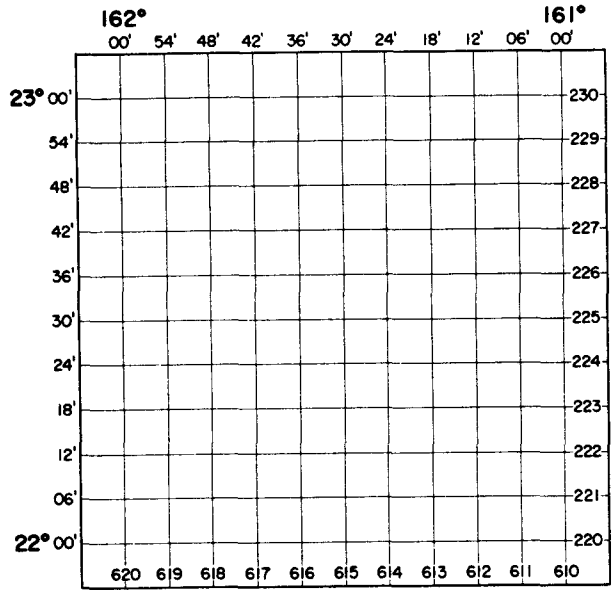

Figure 2. Codes for 0.1° squares established for the Northwestern Hawaiian Islands

RESULTS

Species composition

Our lobster trapping stations produced a great diversity of arthropods, molluscs, and fishes. Although Morris (1968) indicated that two species of spiny lobsters--P. marginatus and P. penicillatus--are commonly caught in waters around the major islands, our trapping stations produced none of the latter, primarily because it is essentially a shallow-water species that inhabits waters usually less than 5.5 m (3 fathoms) deep (De Bruin, 1962).

The second most important species caught in the lobster pots was the slipper lobster, Scyllarides squammosus.[1] Other commercially valuable species included the frog crab, Ranina ranina, octopus, Polypus marmoratus, pink snapper, Pristipomoides filamentosus, sea bass, Epinephelus quernus, amberjack, Seriola dumerili, and the thick-lip carangid, Caranx cheilio.

Distribution of fishing effort and apparent abundance

Confining our analysis to data collected with lobster pots during our survey and charter cruises between October 1976 and November 1978, 4,835 trap-nights were fished in waters of the NWHI producing 13,214

[1]We were informed recently by Dr. Craig MacDonald, University of Hawaii, Department of Zoology, Honolulu, Hawaii that in addition to S. squammosus, a second species, S. haanii, may be present in Hawaiian waters.

spiny lobsters for an overall catch rate of 2.73 lobsters/trap-night (Table 1). Catch rates varied considerably among the areas visited, ranging from 0.00 at Middle Bank, Pioneer Bank, and at No-name Bank #8 to 4.72 lobsters/trap-night at Necker Island.

TABLE 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 1976-NOVEMBER 1978

Island or Bank	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 Atoll	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 (Table 1 and Figure 3). 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

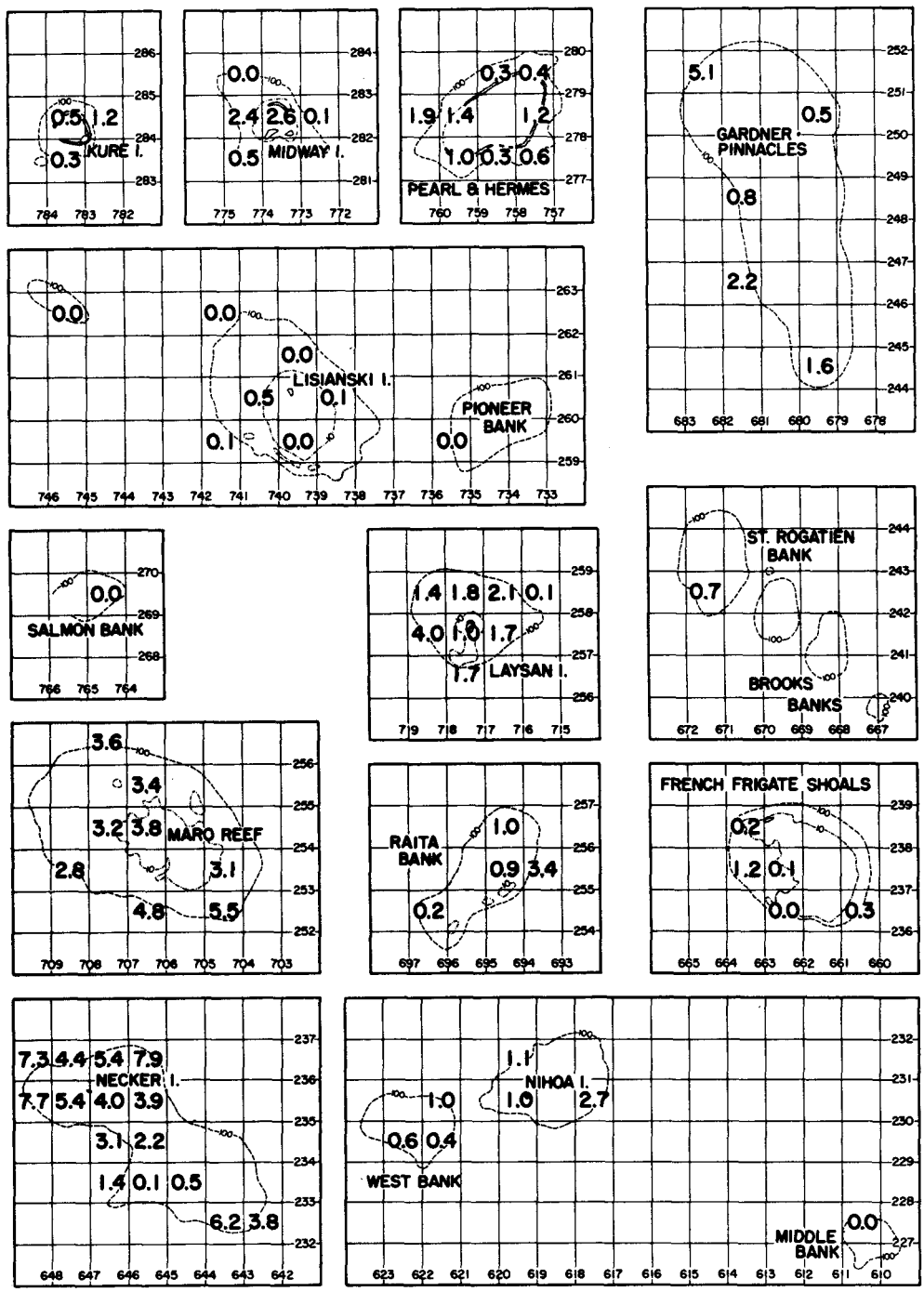

Figure 3. Distribution of spiny lobster catch rates, by 0.1° squares in the Northwestern Hawaiian Islands, October 1976-November 1978

surveys, we expended 663 trap-nights and caught 2,684 lobsters or an average of 4.04 lobsters/trap-night (Table 1).

Gardner Pinnacles, Raita Bank, and Laysan were other islands and banks that showed some highly productive areas; however, the overall catch rates never approached the magnitude we found for Necker and Maro Reef. These areas all require additional surveys to determine their productivity.

Relation between catch per trap-night and depth

Panulirus marginatus has been reported to occur at depths ranging from a few meters to 183 m in the Hawaiian Islands (McGinnis, 1972). To examine the relative abundance of this species with respect to depth in the NWHI, we grouped the catch data into 9-m (5-fathom) strata for each of the islands and banks. The relative abundance of P. marginatus at the lower end of the NWHI chain was higher at depths between 37 and 64 m (21 and 35 fathoms); however, in the middle and higher latitudes particularly from Gardner Pinnacles to Kure, there was a tendency for the catch/trap-night to be higher usually in waters 10 to 36 m (6 to 20 fathoms), except at Midway where the relative abundance of spiny lobsters was highest at 37 to 45 m (21 to 25 fathoms) (Figure 4). The relatively low catch rates we observed in waters deeper than 64 m (35 fathoms) in the northern part of the chain may be the consequence of differences in temperature regime from north to south.

Data from XBT casts made during two cruises of the Cromwell were examined for differences in the surface and subsurface (0-140 m) temperature at Necker and Midway (Table 2). It is evident that during both summer and winter, there is a pronounced cooling of the subsurface waters around Midway. Also of interest is the depth of the mixed layer, which is relatively shallow in summer and deep in winter. These data are similar to the results obtained by Seckel (1962) who studied the oceanographic climate of the Hawaiian Islands region.

DISCUSSION AND CONCLUSIONS

The pattern that emerges from our trapping results in the NWHI is one of uneven distribution of spiny lobsters with heavy concentrations located only at Necker and Maro Reef. There are, however, other sites such as Gardner Pinnacles, Raita Bank, and Laysan that show potential, but only additional surveys or commercial fishing at these locations will provide sufficient data to verify the potential. Furthermore, because fishing is still in its infancy, it is extremely difficult to draw inferences about catch rates. Catch/trap-night for spiny lobsters is influenced by dominance behavior of the large adults, of adult males, and perhaps by reproductive condition of the females.

Another interesting aspect of the distributional pattern of P. marginatus is its relationship to depth and possibly subsurface temperatures prevailing over the substrate. Whereas the catch/trap-night was relatively high in depths between 37 and 64 m around islands and banks southeast of Gardner Pinnacles, there was a trend for catch/trap-night

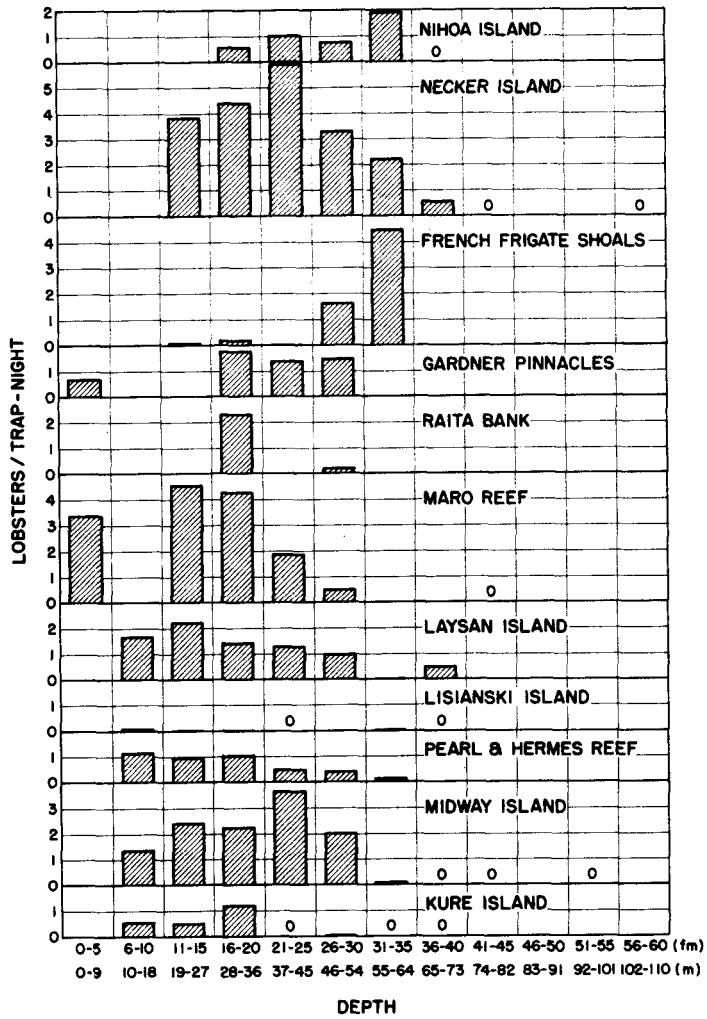

Figure 4. Distribution of spiny lobster catch rates, by depth, in the Northwestern Hawaiian Islands, October 1976-November 1978

to be higher at shallower depths between Gardner Pinnacles and Kure. In addition to the possible effects of subsurface temperatures on the depth distribution pattern of spiny lobsters, other factors such as substrate type and location of feeding or browsing pastures may also influence habitat selection.

At this time, nothing is known about the pattern of larval recruitment in the NWHI. Johnson (1968) reported catching spiny lobster phyllosoma in plankton samples at a number of locations in the Hawaiian Archipelago. Whereas the phyllosoma of both P. marginatus and P. penicillatus was collected around Oahu and in waters to the southwest

TABLE 2. SURFACE AND SUBSURFACE TEMPERATURES IN WATERS AROUND NECKER AND MIDWAY ISLANDS DURING THE SUMMER AND FALL MONTHS IN 1976-77

Depth (m)	Summer Temperature °C		Winter Temperature °C	
	Necker (May 17, 1977)	Midway (May 30, 1977)	Necker (Oct. 17, 1976)	Midway (Nov. 2, 1976)
0	24.9	24.9	25.8	26.1
10	24.7	24.4	25.7	26.1
20	24.4	23.9	25.7	26.1
40	24.2	22.8	25.7	26.1
60	23.9	21.2	25.7	26.1
80	23.1	20.4	25.3	23.6
100	22.2	19.6	23.1	21.6
120	21.9	19.2	22.0	21.3
140	21.7	18.7	21.0	18.5

of the main islands, Johnson found only P. marginatus phyllosoma at French Frigate Shoals. Thus, the distribution of these phyllosoma corresponds to some extent to the distributional pattern of the adults.

FUTURE RESEARCH NEEDS

Exploratory fishing to determine species composition and initial catch rates has been completed for most of the larger islands and banks in the NWHI. Several areas for future research include a need for specialized information on the environment and the stocks to estimate their magnitude and potential yield. Catch and effort data from commercial vessels are needed to calculate more precise catch rates. Additional studies are needed to determine how catch rates can be expected to change with increasing fishing pressure. We need a sufficiently large data base to be able to predict seasonal and spatial variation in stock distribution and year-to-year fluctuation in stock abundance or availability.

More research is also needed on the relationship between lobster behavior and changes in biological and environmental parameters, on predation of lobsters by large predators such as sharks and carangids, on gear competition, on ghost fishing, and on escape gaps.

The results of all these studies will assist us in making crucial decisions on the management of the fishery and will influence decisions of investors.

SUMMARY

The results of exploratory surveys conducted by the NMFS show that the spiny lobster, P. marginatus, is unevenly distributed throughout the NWHI. Two locations--Necker and Maro Reef--showed the highest concentrations; Gardner Pinnacles, Raita Bank, and Laysan showed signs of having good potential.

The study also revealed that the concentrations of lobsters are stratified by depth. South of Gardner Pinnacles, the highest catch rate occurred within 37 and 64 m, but around islands and banks to the north, the highest catch rate occurred between 10 and 36 m.

The exploratory phase of the NWHI investigation is well toward completion and future research needs are being considered.

REFERENCES

De Bruin, G.H.P. 1962. Spiny lobsters of Ceylon. Bulletin of the Fisheries Research Station Ceylon 14. 28 pp.

Johnson, M.W. 1968. Palinurid phyllosoma larvae from the Hawaiian Archipelago (Palinuridae). Crustaceana, Supplement 2:59-79.

McGinnis, F. 1972. Management investigation of two species of spiny lobsters, Panulirus japonicus and P. penicillatus. Division of Fish and Game Report, Department of Land and Natural Resources, State of Hawaii, 47 pp.

Morris, D.E. 1968. Some Aspects of the Commercial Fishery and Biology of Two Species of Spiny Lobsters, Panulirus japonicus (De Siebold) and Panulirus penicillatus (Oliver), in Hawaii. M.Sc. Thesis (Zoology), University of Hawaii. 82 pp.

Seckel, G.R. 1962. Atlas of the oceanographic climate of the Hawaiian Islands region. U.S. Fish and Wildlife Service, Fishery Bulletin 193, vol. 61:371-427.

State of Hawaii. 1969. Hawaii and the Sea: A Plan for State Action. Report to the Governor's Task Force on Oceanography. Published by the State of Hawaii, Department of Planning and Economic Development. 112 pp.

State of Hawaii. 1974. Hawaii and the Sea - 1974. Prepared for the Governor's Advisory Committee on Science and Technology. Published by the State of Hawaii, Department of Planning and Economic Development. 99 pp.

Uchida, R.N., and T.S. Hida. 1977. Preliminary results of lobster trapping in Northwestern Hawaiian Islands waters. Paper presented to South Pacific Commission, Ninth Regional Technical Meeting on Fisheries, Noumea, New Caledonia, 24-28 January 1977. SPC Fisheries 9/WP.19:9 pp. (Mimeo.) [Also Southwest Fisheries Center Administrative Report 13H, 1976, 7 pp.]