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SUMMARY OF ENVIRONMENTAL AND FISHING INFORMATION ON GUAM AND THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS : A REVIEW OF THE PLANKTON COMMUNITIES AND FISHERY RESOURCES

Richard N. Uchida

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Center

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Malcolm Baldrige, Secretary
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National Marine Fisheries Service
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INTRODUCTION

The Resource Assessment Investigation of the Mariana Archipelago (RAIOMA) Program is a study by the Honolulu Laboratory which will be conducted in close cooperation with the Governments of Guam and the Commonwealth of the Northern Mariana Islands and by the University of Guam Marine Laboratory. The investigation will address the problem of determining the potential for development of crustacean, bottom fish, seamount groundfish, benthopelagic, and pelagic resources over the inner and outer shelves, shelf edge, reefs, and slope zones of these islands and adjacent seamounts.

This document was prepared to provide a comprehensive overview of the environmental and fishery information that has been published to date for the benefit of RAIOMA investigators currently involved in the field survey and resource assessment.

Eldredge,[1] gives a historical background on Guam and the Northern Mariana Islands, provides a description of each of the islands in the archipelago, and summarizes the present state of knowledge of the climatic, oceanographic, and submarine topographic features of the area.

This report reviews some of the past studies on the oceanic and neritic plankton communities in waters around Guam and the Northern Marianas, discusses historical fishery development in the pre- and post-World War II eras, presents an overview of the current status of fisheries in these islands, and summarizes the present state of knowledge of the stocks of fish, shellfish, corals, and algae with respect to their developmental potential. It also incorporates discussions on unique and endangered species and ciguatera.

Results of research described in 170 papers and 25 unpublished documents were reviewed; however, I have not read all the published and unpublished papers cited. Some citations originally appeared in other reports and are listed here as references. Also, because of the voluminous nature of the report, many tables and figures have been either intentionally omitted or compiled into a single table.

ZOOPLANKTON

Almost all of the phyla of the animal kingdom are represented in the zooplankton. Many benthic and pelagic marine fishes as well as crustaceans spend their larval stages as members of the zooplankton community either bound strictly to coastal waters or existing normally only in offshore or oceanic waters. These requirements provide the basis for two divisions of

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[1]Eldredge, L. G. 1983. Summary of environmental and fishing information on Guam and the Commonwealth of the Northern Mariana Islands: Historical background, description of the islands, and review of the climate, oceanography, and submarine topography. (Manuscr. in prep.)

zooplankton, based on their relative dependence on the coast. One is the oceanic division, which includes forms that occur typically at some distance from the coast and over great depths in the open sea (Sverdrup et al. 1946). Characteristic organisms of the oceanic plankton are Vellela, salps, Salpa spp., and copepods, Copepoda. The second is the neritic division which includes forms that inhabit coastal waters and extend only a short distance seaward. Neritic forms, as a rule, prefer relatively warm water with some reduction in salinity. Vast swarms of pelagic larvae belonging to benthic invertebrates and many fish eggs and fish larvae are found in the neritic plankton. It is not possible to distinguish sharply between neritic and oceanic populations because there is much overlapping. The neritic forms, however, are the greatest producers of the sea for it is in coastal waters that food materials are readily available for phytoplankton and plants and through these successively for small and large animals.

In general, zooplankton volume in the Pacific Ocean is distributed in a similar manner as PO_4-P (Reid 1962). Volumes are usually high in the eastern boundary currents, low in central water, and relatively high along the Equator, and in two zones north and south of the Equator corresponding to the equatorial divergence.

Detailed information on the oceanic plankton community in waters around Guam and the Northern Marianas is practically nonexistent. One research cruise of the NOAA ship Townsend Cromwell (TC-76-05) to the western Pacific obtained some data on zooplankton volumes but these are too few to be of any practical value in examining species composition and abundance (seven stations with usable data). Data from other surveys conducted in waters to the east, south, and north of the Mariana Archipelago, however, do provide some insight into the productivity of the water.

The Mariana Archipelago, bathed by the North Equatorial Current, is situated in relatively plankton-poor water. Bogorov (1960) characterized the waters of the north equatorial zone at lat. 10° to 12° N as relatively low in phosphate but moderately high in bacteria (Table 1). Taniguchi (1973), who studied the phytoplankton-zooplankton relationships in the western Pacific Ocean and adjacent seas, found that the total zooplankton biomass between the surface and 150 m was lowest in the North Equatorial Current in comparison with 10 other areas examined, reaching only 1.35 g wet weight/m^2 (Table 2). Based on biomass of the daily food ingestion of the herbivorous plankton, Taniguchi concluded that the temperature-affected rate of energy expenditure of small herbivores living in tropical seas is 6.3 times higher than that of large-sized herbivores in seas of high latitudes. Apparently, tropical zooplankters grow and reproduce more rapidly (Kinne 1963, 1970); therefore, they must graze on more phytoplankton and at a higher filtering rate per unit body weight than high latitude herbivores. Taniguchi found that although the biomass of herbivores is quite small in the tropics, particularly in the oligotrophic North Equatorial Current, their ingestion rate per unit biomass is very high compared with results obtained from the Bering Sea. He speculated that the herbivorous biomass which can be sustained by a unit amount of primary production is relatively small in the high-temperature, less productive tropics, and large in the low-temperature, more productive high latitudes.

Table 1.--Physical, chemical, and biological characteristics of the geographical water zones established for the central Pacific Ocean (Bogorov 1960).

Zone	Temperature °C			Transparency, m	O_2 (ml/liter, at 0 m)	$P-PO_4$ (mg/m^3 at 0 m)	$P-PO_4$ (mg/m^3 at 100 m layer)	Number of bacteria per 50 ml	Number of phyto-plankton cells (m^3)	Biomass of zooplankton (mg/m^3)	Biomass of fish (mg/m^3) (1,000-0 m)	Benthos (mg/m^2)	Benthic sediments (g/cc)
	Air	Water											
		0 m	300 m										
Northern[1] subtropical	17.0	21.0	13.0	32	5.0	3.2	12.5	18	3,600	97	2.0	500-100	1.46
Northern equatorial	25.5	27.6	14.0	36	4.6	2.3	3.0	72	3,100	26	0.7	50	1.40
Equatorial counter-current	27.5	29.1	10.9	26	4.1	9.0	14.0	150	19,900	46	1.4	50	0.90
Southern equatorial	27.0	28.4	14.5	38	4.4	8.0	10.0	95	4,300	12	0.7	50	1.00
Southern subtropical	22.0	21.7	15.0	39	5.5	4.9	7.1	38	3,600	36	1.2	160-400	1.20

[1]The characteristics of the subtropical zones are presented as a mean of the values of the northern and southern portions of these zones.

Table 2.--Total zooplankton biomass in upper 150 m of water column, phytoplankton standing crop, and daily primary production in euphotic layer, observed in 11 sea areas in western Pacific Ocean and adjacent seas (Taniguchi 1973).

Sea area	Total zooplankton biomass, 0-150 m (g wet weight/m^2)	Phytoplankton standing crop in euphotic layer (mg chlorophyll *a*/m^2)	Daily primary production (mg C/m^2/day)
Bering Sea	67.35	72.13	490
Subarctic current area	23.70	27.30	160
Oyashio area			
Spring	86.95	172.50	1,510
Summer	31.50	14.60	450
Okhotsk Sea	9.90	6.86	80
South of Japan	1.95	--	60
East of Philippines	2.85	12.67	140
Kuroshio Countercurrent area	2.85	14.98	160
North Equatorial Current area	1.35	13.35	90
Equatorial Countercurrent area	4.80	18.00	190
South Equatorial Current area	11.40	[1]24.25	290
East of New Zealand	3.75	[1]20.43	290

[1]These two values were determined fluorometrically, the others tricolorimetrically.

The area just slightly north of the Marianas, between lat. 20° and 30° N, has been studied extensively by Japanese scientists. Motoda et al. (1970) measured average standing crop of zooplankton and phytoplankton and standing reserves of nutrient salts in the euphotic layer for areas to the north and south of the Subtropical Convergence. For zooplankton, they found that in 1966 the volumes in the upper 150 m of water were only slightly higher in the north (Kuroshio Countercurrent) than in the south (subtropical water). In 1967, however, the volumes in the north were considerably higher than in the south (Figure 1). The zooplankton biomass in the euphotic zone, estimated from measurements of zooplankton carbon, also followed a similar pattern with average carbon content for 1966-67 reaching 421 mg/m^2 in the north and 185 mg/m^2 in the south (Table 3). Estimates of primary or photosynthetic production of standing crop of chlorophyll a, of pigment contents, and of standing reserve of seston carbon are also given in Table 3.

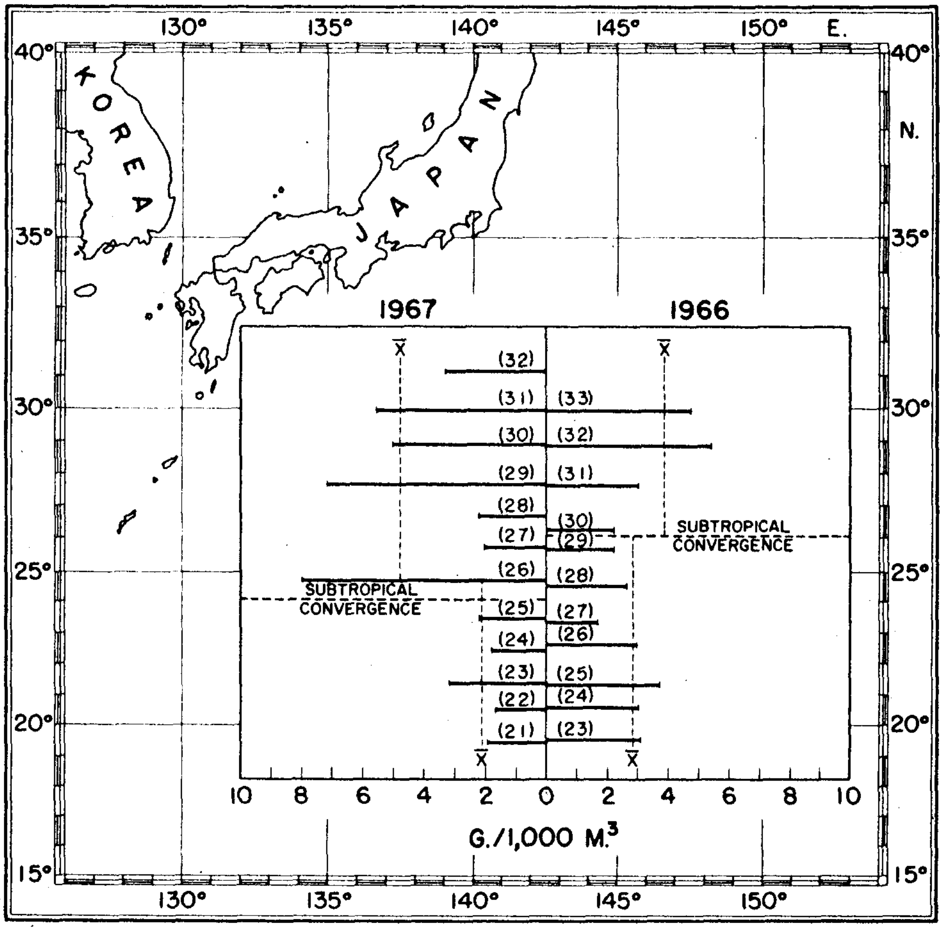

Figure 1.--Plankton volumes taken in the upper 150 m by a 0.10-mm mesh net hauled vertically, January 1966 and January 1977 (station numbers in parentheses) (Motoda et al. 1970).

Quantitative estimates of the distribution of large and more mobile macroplankton are also available from a study by Vinogradov and Parin (1973), who selected four study areas in the tropical Pacific. At the station nearest the Mariana Archipelago at lat. 13°31' N and long. 139°58' E (Study Area IV), they found the plankton biomass very low with the mesoplankton and macroplankton in the 0- to 500-m layer reaching only about 10.0 and 1.7 mg/m^3, respectively. Further south, at two stations (Study Areas I and II) near the Caroline Islands, Vinogradov and Parin found the mesoplankton biomasses in the 0- to 200-m layer averaging 26.1 and 26.5 mg/m^3, whereas the macroplankton biomasses in the 0- to 500-m layer were 5.3 and 4.0 mg/m^3. Study Area III, which was located in the Sulu Sea, had the highest macroplankton biomass, reaching 7.2 mg/m^3 in the 0- to 500-m layer or almost 35% of the mesoplankton biomass (Figure 2).

Table 3.--Average values of organic and inorganic particulate materials observed at long. 142° E between lat. 20° and 30° N in January 1966 and January 1977. Values for areas north and south of the Subtropical Convergence are given separately (number of stations observed in parentheses) (Motoda et al. 1970).

	1966		1967		Grand average	
	North	South	North	South	North	South
Zooplankton (mg C/m^2)	380	227	462	142	421	185
Number of observations	(6)	(7)	(6)	(5)		
Photosynthetic production (mg C/m^2/day)	400	130	53	40	226	85
Number of observations	(1)	(3)	(1)	(2)		
Chlorophyll a (mg/m^2)	22.0	15.0	8.5	10.5	15.2	12.8
Number of observations	(2)	(3)	(1)	(3)		
Pigments:						
Chlorophyll a	--	--	2.8	2.2		
Number of observations			(2)	(1)		
Phaeophytin	--	--	11.1	7.1		
Number of observations			(2)	(1)		
Seston (mg C/m^2)	3,770	6,480	4,720	4,600	4,245	5,540
Number of observations	(2)	(3)	(2)	(1)		
Dissolved organic N (mg N/m^2)	9,230	8,300	10,800	9,040	10,015	8,670
Number of observations	(2)	(3)	(2)	(1)		
Nitrate-N (mg N/m^2)	1,800	424	316	282	1,058	353
Number of observations	(4)	(5)	(9)	(6)		
Ammonia-N (mg N/m^2)	236	477	395	141	316	309
Number of observations	(3)	(3)	(2)	(1)		
Phosphate-P (mg P/m^2)	247	186	158	40	202	113
Number of observations	(6)	(7)	(7)	(5)		

Studies on the neritic zooplankton communities around Guam have been reviewed by Eldredge and Kropp.[2] These studies focused on communities found in Apra Harbor and Piti Reef (Marsh et al. 1977, 1980;[3] University of Guam Marine Laboratory (UGML) 1977), and along several sites between Agana Bay and Ajayan Bay (Tsuda and Grosenbaugh 1977; Amesbury 1978). Eldredge and Kropp pointed out that most of the plankton studies from Guam had been conducted in conjunction with general environmental surveys and, therefore, were all results of short-term projects.

In general, the abundance of neritic plankton around Guam is highly variable not only between and within sampling locations but also from month to month. Furthermore, the Guam studies, according to Eldredge and Kropp, have shown that plankton is more abundant and the community structure is significantly different at night than it is during the day. Moon phase may also influence community composition but its effect is still unclear.

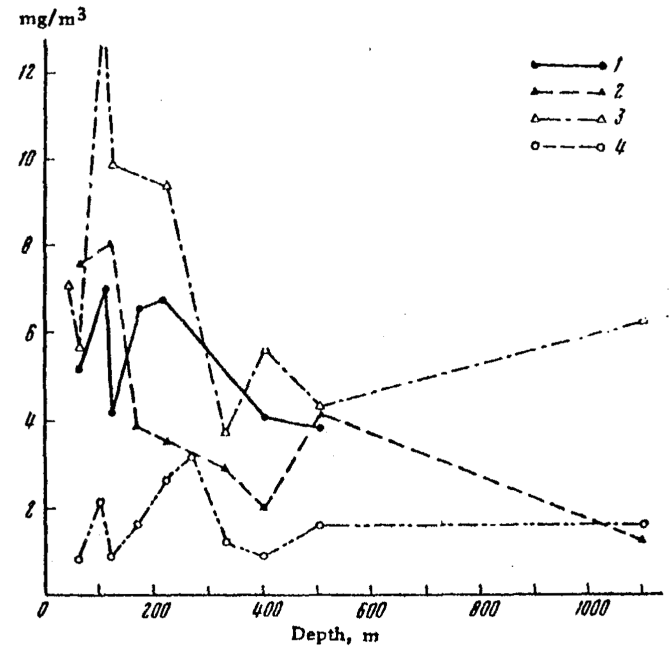

Figure 2.--Macroplankton biomass according to catches with a variable-depth trawl, in mg/m^3. 1 - Study Area I; 2 - Study Area II; 3 - Study Area III; 4 - Study Area IV (Vinogradov and Parin 1973).

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[2]Eldredge, L. G., and R. K. Kropp. [1981.] Guam's oceans. A review of the physical, chemical, and biological oceanographic literature for the waters surrounding Guam. Final draft for Lawrence Berkeley Laboratory, Univ. Calif., 199 p.

[3]Marsh, J. S., Jr., S. deC. Wilkins, D. E. Pendleton, and A. Hillman-Kitalong. 1980. Cabras seawater scrubber project: Phase II. Ecological studies. Report submitted to R. W. Beck Assoc., 102 p.

In a study of the distribution of planktonic eggs and larvae, Amesbury (1978) found fish egg density varying from 4.2 to 223.3/m^3 of water and relative abundance varying from 2.7 to 91.1% of planktonic organisms. Despite the wide range in abundance, fish eggs were found to be distributed randomly in the water, whereas fish larvae were considerably less abundant than fish eggs, their greatest density reaching 6.3/m^3 of water in a sample where they constituted only 5.1% of the planktonic organisms. In fact, several tows failed to produce any fish larvae, because they appeared to be aggregated in their distribution. The data also suggested some seasonality in the abundance of fish eggs with highest densities usually in summer when fish larvae density was lowest. Amesbury also examined the association of fish larvae and nursery areas and concluded that although it might be tempting to rate the various areas on the basis of their importance in the production of young fishes, it must be emphasized that the larvae and juveniles of hundreds of fish species have specific habits and preferences which differ from one another. He suggested that preservation of a wide variety of environments will insure that species with differing ecological requirements will be able to complete their life cycles. The mean zooplankton abundance for the several sites sampled by Amesbury is given in Table 4.

Several studies conducted at Apra Harbor have demonstrated that this area has several different zooplankton communities (Figure 3). In the outer harbor, chaetognaths predominated (up to 152/m^3) during the day whereas ostracods predominated (up to 1,402/m^3) at night (Marsh et al. 1977; UGML 1977). Furthermore, compared with the rest of the harbor, the outer harbor community was relatively low in numbers of decapod crustacean larvae, foraminiferans, and fish eggs but high in fish larvae. In the commercial port area, which ranked first in plankton abundance, the predominant organisms in the zooplankton community were copepods, pteropods, and decapod crustaceans, but their relative abundance varied considerably. For example, the number of copepods in daylight tows in October 1976 reached 1,470/m^3 whereas in December 1976, it was only 9/m^3. Marsh et al. (1977) also found that pteropod abundance varied widely, ranging from 18 to 3,920/m^3.

Piti Channel in the northeastern sector of Apra Harbor ranked second in overall abundance (Marsh et al. 1977). Decapod zoeae predominated and were more abundant than in any other part of Apra Harbor, except at Sasa Bay located on the inner sector of the harbor.

The powerplant area, which includes the outfall lagoon, the Piti Canal, and the Tepungan Channel in the extreme northeast corner of Piti Channel, was the poorest area in terms of zooplankton density. Here, crab zoeae, fish eggs, and foraminiferans predominated (Marsh et al. 1977, 1980, footnote 3).

In a survey to collect baseline information on the composition of the zooplankton communities in Tanapag Harbor, Saipan (Figure 4), Amesbury and Doty (1977) found that in the inner sector of the harbor (Baker and Charlie Bays), the number and volume of zooplankton were larger during the day than at night whereas the day-night pattern was reversed in the outer harbor (Table 5). They also noted a significant diurnal change in the plankton composition with copepods from the inner sector comprising more than 90% of the daytime samples whereas larval crabs and shrimps predominated in the night samples. The outer harbor samples, on the other hand, had very few copepods and the predominant organisms were crustacean larvae, particularly in the night samples where crab zoeae comprised 76% of the samples.

Amesbury and Doty concluded from their study that plankton feeding may be an important nutritional niche in the harbor's marine communities and the high abundance of plankton-feeders suggests this. They also stated that the sharp difference in plankton composition between the inner and outer harbors suggests that very little water mixing is occurring between these two areas; therefore, warm water or effluents discharged into Tanapag Harbor would likely undergo less dispersion and dilution.

A second study of the zooplankton community in waters around the Northern Marianas, this time taking in all of Saipan Lagoon (Figure 5), revealed that zooplankton in the lagoon as a whole was rather sparse, with densities averaging only 66.2 individuals/m^3 (Table 6). Amesbury et al. (1979) found that this was considerably lower than densities found in Yap Lagoon where it averaged 257.7/m^3 and far lower than the 617/m^3 found near Ebeye in Kwajalein Atoll. The study also revealed that the distribution of fish eggs and larvae was widespread in the lagoon. Fish eggs, together with the ubiquitous copepods, occurred in all 17 tows whereas fish larvae occurred in 14 tows. Other taxons that contributed to the density of the zooplankton community were the brachyura crab zoeae, foraminifera, and shrimp larvae. Occasionally numerous were chaetognaths and larvaceans.

The results also revealed that tows 1 and 4, which were made in proximity to areas with rich Halodule sea grass beds, had the highest egg densities, reaching 54.8 and 66.4/m^3, respectively. The authors concluded

Table 4.--Mean daytime zooplankton abundance for several locations around Guam (Amesbury 1978).

	Sampling dates								
	1977					1978			
Location	3/14	4/15	7/1	7/6	8/18	1/5	Total	Number of tows	Mean number/m^3
Agat Bay									
Nimitz Channel	44.3	116.8	131.7	60.4	14.2	56.2	423.6	6	70.6
Nimitz reef front	32.3	101.3	202.9	--	--	108.8	877.0	8	109.6
	58.3	123.8	83.3	--	--	166.3			
1/4-mile offshore	20.8	11.5	--	--	--	--	32.3	2	16.2
1/2-mile offshore	--	17.9	108.8	--	--	32.8	159.5	3	53.2
1-mile offshore	--	--	88.8	--	--	--	88.8	1	88.8
Agana Bay	97.5	--	--	--	--	--	152.8	2	76.4
	55.3	--	--	--	--	--			
Achang Bay	--	--	--	440.8	275.4	--	716.2	2	358.1
Manell Channel	--	--	--	191.1	267.1	834.0			
	--	--	--	465.8	--	--	2,194.7	5	438.9
	--	--	--	436.7	--	--			
Ajayan Bay	--	--	--	194.2	61.7	905.8	1,161.7	3	387.2
Cocos Lagoon	--	--	--	136.3	--	--	136.3	1	136.3
Umatac Bay	--	--	--	96.7	39.6	34.2	170.5	3	56.8

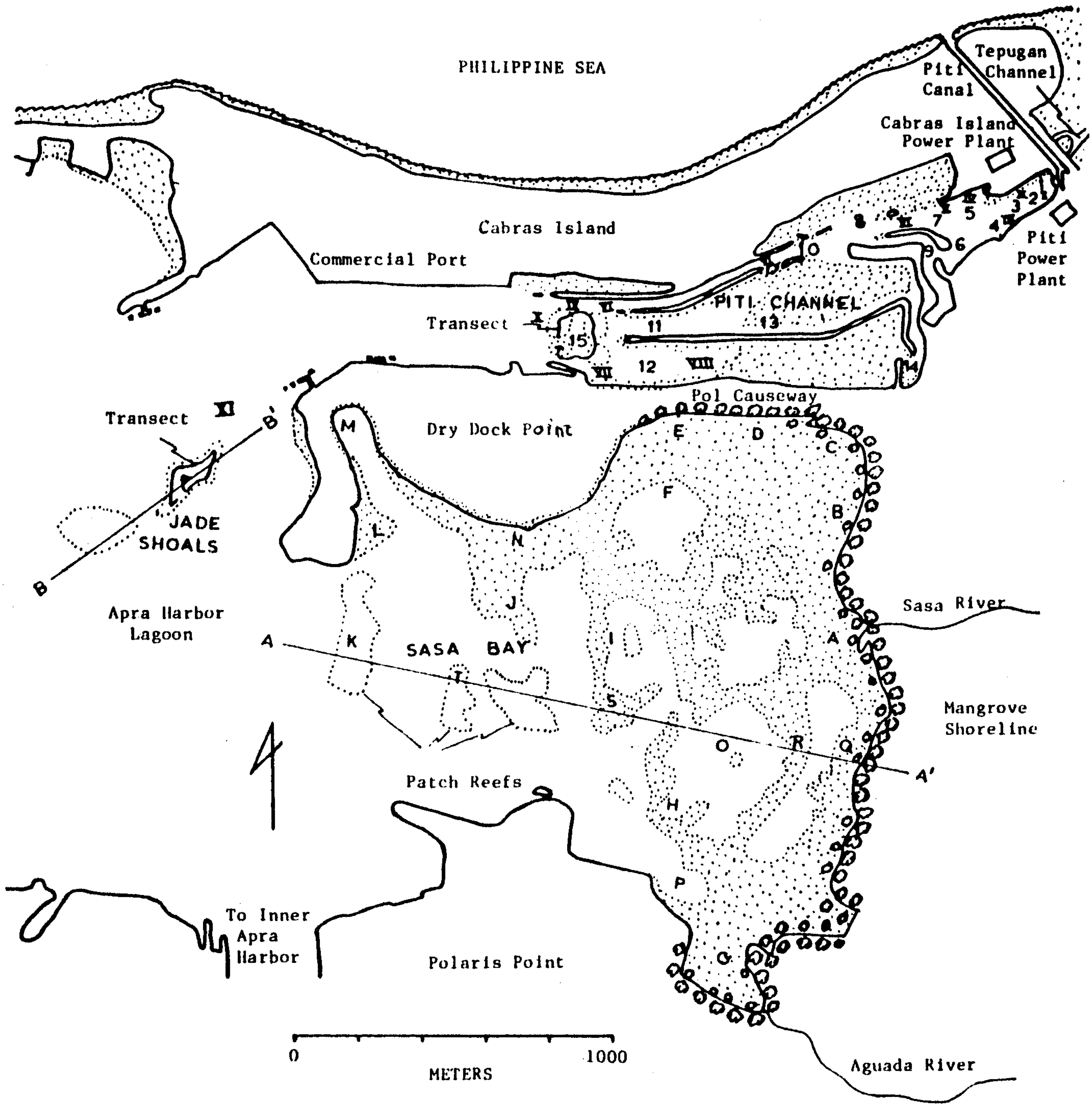

Figure 3.--Map of study area showing coral station and transect locations. Stations A-T are located in Sasa Bay and 1-15 in Piti Channel. Patch reefs are enclosed by dotted lines and fringing reefs are stippled (University of Guam Marine Laboratory 1977).

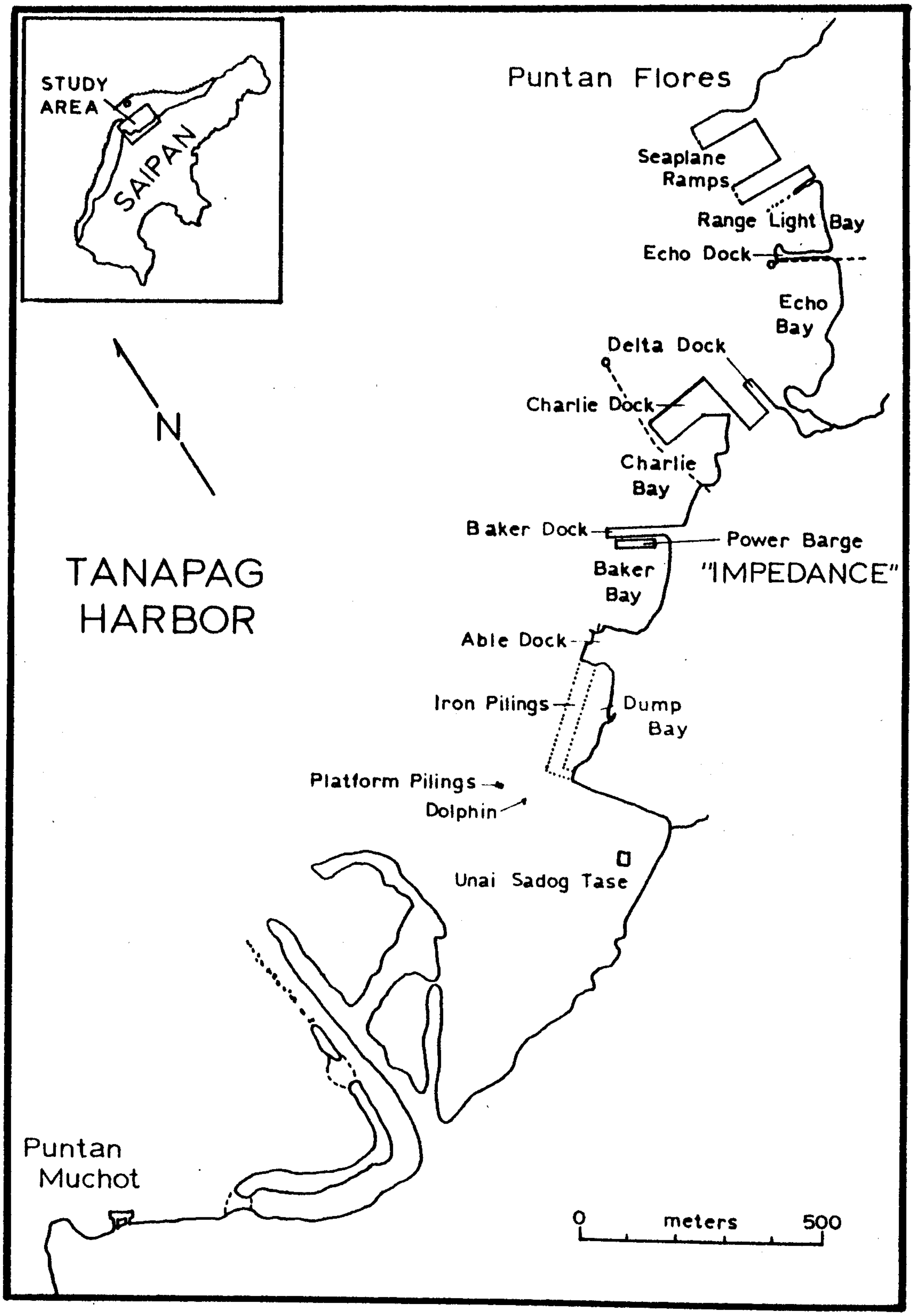

Figure 4.--Map of Tanapag Harbor (Doty 1977).

Table 5.--Plankton organisms collected in Tanapag Harbor, 12 June 1976. Abundance in number of organisms/m^3 of water filtered. Percent composition of total catch given in parentheses. For outer harbor tows, only percent composition is given (Amesbury and Doty 1977).

Plankton group	Baker Bay Day 1045	Baker Bay Night 2000	Charlie Bay Day 1100	Charlie Bay Night 2015	Outer harbor Day 1630	Outer harbor Night 2045
Foraminifera				0.7 (0.4)	(0.6)	(0.7)
Medusae	5.5 (0.8)		1.4 (0.3)	0.7 (0.4)	(0.6)	
Siphonophores					(1.8)	
Gastropods				1.4 (0.8)		
Copepods	656.8 (92.4)	71.3 (33.2)	381.5 (92.5)	64.9 (35.6)	(4.9)	(0.4)
Mysids	3.3 (0.5)		4.9 (1.2)			
Isopods	1.1 (0.2)					
Amphipods						(0.2)
Stomatopods				0.4 (0.2)		
Lucifer					(19.6)	(11.4)
Crab zoea	2.2 (0.3)	55.9 (26.0)	7.8 (1.9)	73.0 (40.0)	(24.5)	(76.0)
Shrimp zoea	19.7 (2.8)	45.0 (20.9)		22.6 (12.4)	(25.8)	(4.4)
Unidentified crustaceans			0.7 (0.2)	0.7 (0.4)		
Mites		1.1 (0.5)				
Chaetognaths	5.5 (0.8)	2.2 (1.0)	8.5 (2.1)	4.9 (2.7)		
Larvaceans	14.3 (2.0)	38.4 (17.9)	6.3 (1.5)	9.5 (5.2)	(3.1)	
Fish eggs	2.2 (0.3)		0.7 (0.2)	1.4 (0.8)	(19.0)	(6.4)
Fish larvae		1.1 (0.5)	0.7 (0.2)	2.1 (1.2)		(0.4)
Estimated number collected	32,400	9,800	29,250	12,925	8,150	22,750
Estimated number/m^3	710.5	214.9	412.6	182.3	--	--
Estimated volume collected	12.1 ml	8.9 ml	9.6 ml	8.1 ml	8.4 ml	12.6 ml
Estimated volume/m^3	0.265 ml	0.195 ml	0.135 ml	0.114 ml	--	--

Figure 5.--Locations of zooplankton tows in Saipan Lagoon, January 1979 (Amesbury et al. 1979).

Table 6.--Individual and total zooplankton densities for horizontal surface tows in Saipan Lagoon in January 1979 (Amesbury et al. 1979).

	Density (individuals/m^3)																
Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Fish eggs	54.8	1.2	26.0	66.4	15.7	2.1	3.5	1.3	3.0	18.5	1.0	5.1	10.3	0.7	26.5	6.6	0.9
Fish larvae	<0.1		0.1	0.2	0.1	<0.1		<0.1	<0.1	0.4	0.3	3.1	0.1	<0.1	0.1	0.3	
Copepods	0.1	0.1	2.1	13.9	0.4	0.3	0.7	1.0	0.8	1.1	117.6	485.1	2.4	0.4	0.6	2.0	0.1
Brachyuran zoeae	1.1	0.4	0.9	0.3	1.3		0.5	0.1	0.4	4.8	1.0	15.8	0.7	0.2	0.3	12.2	
Shrimp larvae	0.2	0.1		1.4	0.1		0.2	0.1	0.1	4.2	6.1	32.5	1.7	0.2	0.2	2.5	
Chaetognaths			0.1	0.5	0.1		<0.1	0.1	<0.1	2.2	13.6	52.4		<0.1			
Larvaceans		<0.1		0.3			0.1		0.1	0.3	30.2	25.4		<0.1			
Foraminifera	0.1	0.2	2.5	0.3	0.5	1.0	0.2	0.7	1.2	0.4	0.7	1.0			1.3	1.2	1.2
Gastropod larvae	0.6			0.2	0.4	0.2	<0.1	0.1	<0.1	1.4		9.2	0.2		1.1	0.2	0.1
Bivalve larvae						<0.1											<0.1
Medusae							<0.1				0.3						
Pagurid megalopas							<0.1										
Lucifer											0.3	1.5					
Insects		<0.1			0.1				<0.1				0.1				
Mysids								<0.1				0.5		0.1	0.1		0.1
Ascidian tadpoles							<0.1	<0.1					0.2	<0.1			
Radiolaria	<0.1				0.1	<0.1			<0.1				0.1	<0.1	0.2		<0.1
Polychaetes	<0.1					<0.1		<0.1	<0.1							0.2	<0.1
Heteropods						<0.1											
Isopods	<0.1		0.1		0.1	<0.1											<0.1
Egg case						<0.1	<0.1	<0.1								0.2	
Amphipods										0.1					0.1		<0.1
Stomatopod larvae										0.5							
Nauplii									<0.1								
Cumaceans									<0.1								
Miscellaneous worms						<0.1								<0.1			
Miscellaneous unknowns	<0.1	<0.1	0.2	—	0.1	0.1	<0.1	0.1	<0.1	—	—	—	0.2	—	0.2	0.2	—
Total	57.0	2.1	32.0	83.5	19.0	3.8	5.4	3.6	5.8	33.9	171.1	631.6	16.0	1.7	30.7	25.6	2.5

that tows made in richly developed sea grass beds primarily composed of *Halodule uninervis*, seemed to be exceptionally productive in terms of production of fish egg. They suggested that the protection and management of the areas surrounding the rich *Halodule* beds and the mangrove channel were essential to the maintenance and development of a viable fishery in Saipan Lagoon.

FISHERIES DEVELOPMENT

The development of commercial fisheries in the Trust Territory of the Pacific Islands, formerly the Japanese Mandated Islands (JMI) of which the Northern Mariana Islands were a part, was among the most important and outstanding achievement in Micronesia during the pre-World War II era (Nishi 1968). It is important therefore, to review the developments that took place under Japanese rule prior to World War II and discuss the important developments that have taken place in the postwar era. Some of this information can also be found in Uchida and Sumida.[4]

Pre-World War II Period

Briefly, after World War I, Japan took possession of JMI under the Treaty of Versailles and was given the mandate to administer all the former German possessions north of the Equator. Japanese Civil Administration of JMI began on 1 April 1922. In 1935, Japan withdrew from the League of Nations and promptly annexed the islands.

Japan was keenly aware of the developmental potential of the fishery resources of JMI and in the decade 1921-30, the government initiated a general inquiry into the potential of the marine resources in waters around the numerous islands and atolls. An intensive fishery research and exploratory fishing program in 1925-29 demonstrated that many of the islands possessed tremendous potential as fishing bases for large commercial fishing operations (South Seas Government-General Fisheries Experiment Station 1937a). That the Japanese accurately appraised the tuna fishing potential of JMI is attested to by the increase in the landings of skipjack tuna, *Katsuwonus pelamis*, and other tunas by Japanese vessels (Figure 6).

In addition to fishery research, the Japanese Government inquired into the potential for agricultural development, but the conclusion drawn from the years of intensive study both on land and at sea revealed that although the possibilities of the islands were limited with respect to agricultural production, the sea offered unlimited potential for development (Nishi 1968).

Initial fishery development effort had no restrictions on fishing rights for natives, Japanese, or foreigners although the latter two groups

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[4]Uchida, R. N., and R. F. Sumida. 1975. A summary of environmental and tuna fishing information of the U.S. Trust Territory of the Pacific Islands. Southwest Fish. Cent. Admin. Rep. 9H, 193 p. Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

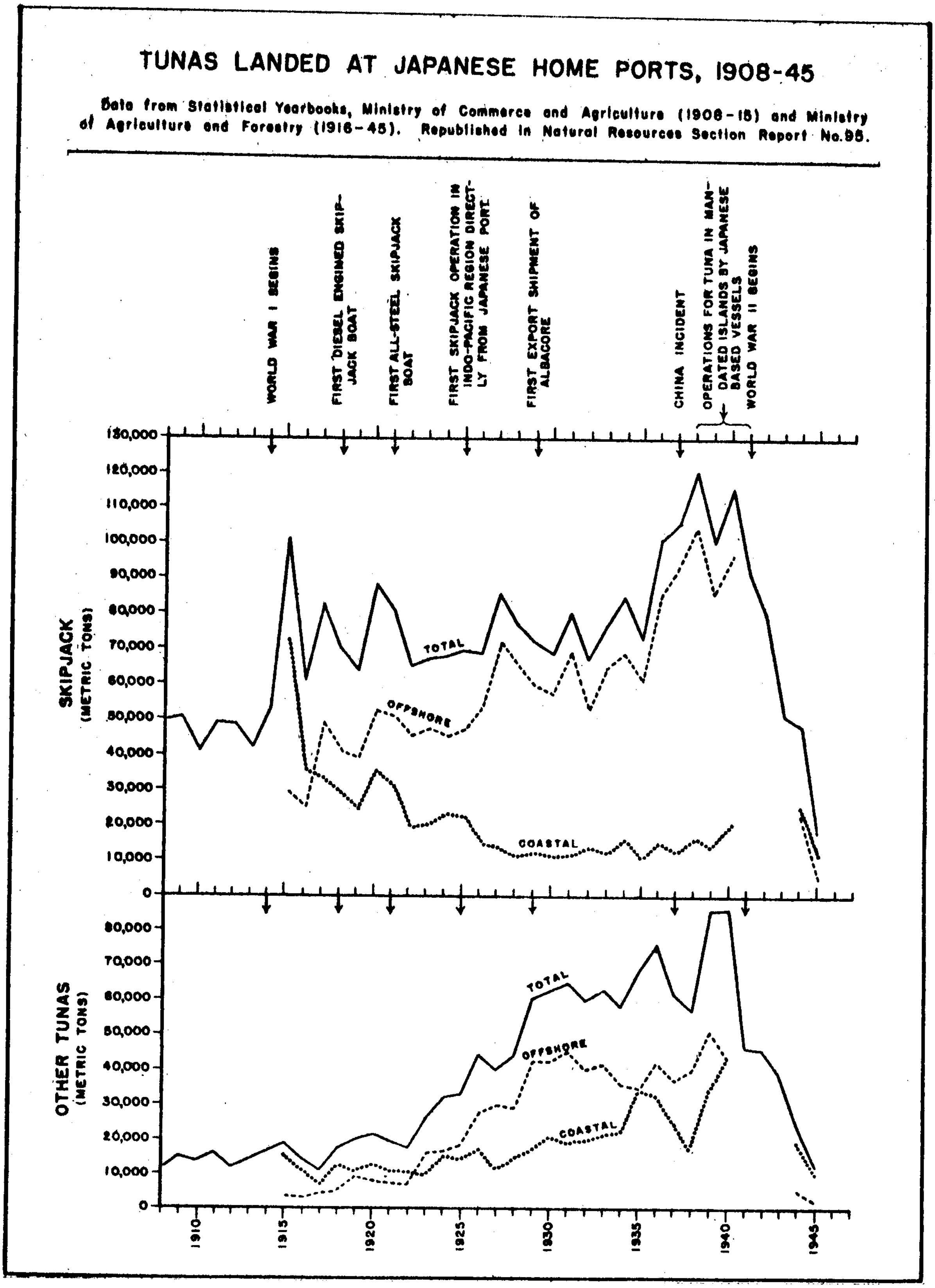


Figure 6.--Tunas landed at Japanese home ports, 1908-45 (Shapiro 1948).

were required to obtain permission from the South Seas Government to engage in fishing (Nishi 1968). Large numbers of Japanese fishermen, attracted to the JMI, first engaged in small, individual enterprises requiring only a minimum amount of investment capital for a boat and for a simple fish processing plant. Later, the trend was away from small enterprises and large companies began to supplant the small operations and gradually monopolized commercial fisheries.

The Pole-and-Line Skipjack Tuna Fishery

The Japanese skipjack tuna fishery in the JMI, which was an outstanding example of fishery development, evolved only after a lengthy period of persistent effort (Cleaver and Shimada 1950). Even with government subsidized ventures, early efforts failed but gradually, as suitable bait species were found and catching and handling methods were established, the fishery developed into a viable and valuable industry.

Attempts by the Japanese to establish a pole-and-line fishery for skipjack tuna in the JMI began at Saipan, but after some trial fishing it became obvious that bait was inadequate and fishing was unsatisfactory. Further exploration revealed, however, that the Palau Islands had a large, reliable supply of bait and the Japanese devoted considerable effort to developing a fishery base there (South Sea Government-General Fisheries Experiment Station 1937a; Smith 1947a). Favorable reports regarding the abundance of skipjack tuna schools and the ease of fishing in calm tropical waters throughout the year reached Japan and induced several Japanese fishing companies to establish bases in the JMI (Shapiro 1948). To encourage fishery development in their far-flung South Sea Island outposts, the Japanese Government not only sent its nationals overseas but also provided subsidies to induce Okinawan fishermen to migrate to the JMI (South Seas Government-General Fisheries Experiment Station 1937a).

From about 1930, the Japanese systematically established shore-based operations using fleets of small sampans. Fishing operations, started in Saipan in the Marianas, expanded to Palau and Truk in the Caroline Islands, then to Yap, Ponape, and Kusaie, and finally to Jaluit in the Marshalls (Figure 7) (Ikebe and Matsumoto 1937; Smith 1947a). The long distances of these fishing bases from the Japanese homeland precluded the transport of fresh fish. As a result, all the skipjack tuna caught were processed for export in the form of dried sticks called "katsuobushi."

The burgeoning South Seas pole-and-line fishery, however, was not without problems. To conduct pole-and-line fishing, the Japanese found it more efficient and practical to use small vessels or sampans, ranging from 8 to 15 m (26 to 50 ft) which carried crews of 5 to 25 men. Large vessels, the Japanese found, were unnecessary because skipjack tuna fishing was limited for the most part to waters close to the widely scattered major fishing bases established at Palau, Saipan, Truk, Ponape, Kusaie, and Yap (Cleaver and Shimada 1950). Furthermore, because live bait was always in short supply and once caught, almost impossible to keep alive for any length of time, the sampans usually made 1-day trips and rarely operated beyond 50 nmi from land.

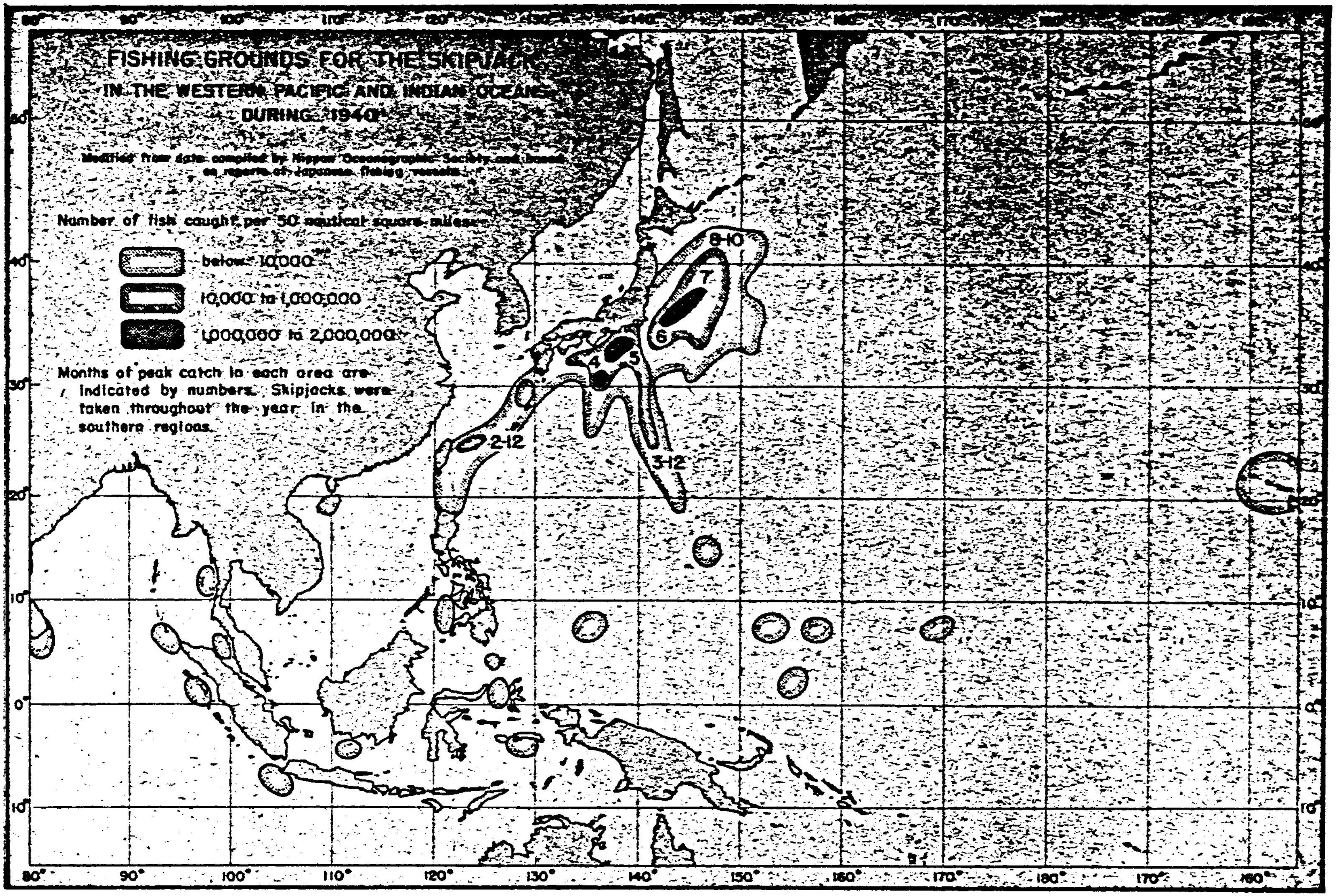


Figure 7.--Fishing grounds for skipjack tuna in the western Pacific and Indian Oceans during 1940 (Shapiro 1948).

Scarcity of suitable live bait in many of the island outposts forced the Japanese fishermen to adapt themselves to using a wide variety of other species, such as reef fishes belonging to several families, in addition to the anchovies and herringlike fishes (Cleaver and Shimada 1950). Table 7 lists the scientific and common Japanese names of fishes that were considered suitable live bait for skipjack tuna fishing in the JMI. Table 8 lists the scientific, English, and local names of all the fishes discussed in the remainder of the text.

According to Cleaver and Shimada, Spratelloides delicatulus or "fool bait" was preferred by fishermen at Saipan and Tinian but young carangids, filefish, Monacanthus sp., atherinids, and Caesio sp. were also caught near the reefs and used for fishing. Other historical accounts indicated that in September-November, there were no suitable live bait for skipjack tuna fishing in Saipan waters although in June-August, large schools of baitfish identified as "tarekuchi," Stolephorus heterolobus, and "akamuro," C. chrysozona, were seen but their occurrence was highly sporadic (Ikebe and Matsumoto 1938). In Palau, the best bait was the anchovy, S. heterolobus, but during periods of bait shortage, numerous other small fishes were also used (South Seas Government-General Fisheries Experiment Station 1937a).

The Japanese also found an abundant supply of "tarekuchi" in Yap Bay (Ikebe and Matsumoto 1937) whereas juvenile Priacanthus sp. and Decapterus sp. were the dominant bait species at Ponape (South Seas Government-General Fisheries Experiment Station 1937b). At Truk, both juvenile Priacanthus sp. and anchovy, Stolephorus sp. were the best bait.

Baitfishing techniques developed by Japanese fishermen in their homeland were not always suitable for capturing bait in the JMI's pole-and-line fishery. Because bait species that were caught in Japanese waters did not occur south of lat. 20° N, fishermen operating in the JMI experimented with various new techniques until a satisfactory system evolved (Cleaver and Shimada 1950). But the development of one baiting technique did not necessarily mean success, because it was found that the same procedures could not be used from one season to another or between island groups.

Purse seine, lift net, and several other types of gear were used in capturing bait in the JMI (Cleaver and Shimada 1950). A lift net used in combination with a night light was particularly effective in capturing bait at Palau. At Tinian, where a variation of the lift net was adopted, the fishermen set the net first, then swam along the cliffs herding schools of "fool bait" into it.

To capture reef fish for bait likewise required adaptation in technique. Cleaver and Shimada (1950) reported that the Okinawan drive-in net, consisting of a large pocket flanked by wings of netting, was regularly used throughout the JMI to capture reef fish (Kask 1947). After setting the net in an open channel between two reefs, the fishermen formed a large semicircle and herded reef fishes into it, then converged to close the opening.

Bait handling technique was another area that required improvisation. The difference in handling bait caught in Japanese waters and in the JMI

Table 7.--Some baitfishes used by the Japanese skipjack tuna fishery (Cleaver and Shimada 1950).[1]

Scientific name	Common Japanese name
	Japan and Ryukyu Islands
Apogon notata	Kurohoshi-tenjikudai, ufuni
A. truncata	Ufuni
Atherina bleekeri	Tōgoro-iwashi
A. tsurugae	Aoharara, gin-isō-iwashi
Beryx decadactylus	Gasagasa, nanyō-kinmedai
Caesio caerulaureus	Saneera, shimamuro-gurukun
C. diagramma	Gurukun
Caranx djeddaba	Gatsun
Engraulis japonicus	Katakuchi-iwashi, segurō-iwashi, tarekuchi-iwashi
Harengula zunashi	Sappa
Lutjanus vaigiensis	Mochinogwa, okifuefuki
Parupeneus sp.	Himeji
Pomacentrus anabatoids	Hichigwa, hikigwa
Sardinella mizun	Mizun
Sardinops immaculata	Hoshinashi-iwashi, shiira
S. melanosticta	Ma-iwashi
Scomber japonicus	Ōsabanoko, saba
	South Seas
Apogon sp.	Akadoro
Archamia lineolata	Atohiki-tenjikudai
Atherina sp.	Kokera, tobi-iwashi, tōgoro-iwashi
A. valenciennesii	Nanyō-tōgoro-iwashi
Caesio chrysozona	Akamuro, gurukun, saneera, umeiro
Caranx sp.	Aji, gatsun
C. leptolepis	Aji
C. malabaricus	Shima aji
Chilodipterus sp.	Akadoro
Dascyllus trimaculatus	Montsuki
Decapterus sp.	Muro, shima-muro
D. russelli	Akamuro
Gazza equulasformis	Hiiragi
Harengula ovalis	Ma-iwashi, nanyō-ma-iwashi
Labracoglossa argentiventris	Takabe
Mullus sp.	Ojisan
Parupeneus sp.	Ojisan
Rastrelliger kanagurta	Saba
Sardinella leiogaster	Mangurōbu-iwashi
Selar crumenophthalmus	Me-aji
Sphyraena obtusata	Kamasu
Spratelloides delicatulus	Ao-iwashi, baka, nanyō-kibinago
S. japonicus	Bakasako, kibiko-iwashi, sururu
Stolephorus heterolobus	Nanyō-katakuchi-iwashi, tarekuchi

Table 7.--Continued.

Scientific name	Common Japanese name
Trachurus japonicus	Ma-aji
Upeneus sp.	Ojisan
U. tragula	Yomehimeji

[1]The bait species listed herein were not limited in use exclusively to the area for which listed. They were used by the fishery wherever available in quantity.

Note: The data were obtained from: Prog. Rep. Okinawa Pref. Fish. Exp. Stn. for 1937; Marukawa, H., South Sea Fisheries 5(5), 1939; and Dr. Y. Hiyama, Tokyo University, Tokyo, Japan.

Table 8.--Scientific, English, and local names of fishes discussed in this report (Car = Carolinian; Cha = Chamorro; G = Guamanian).

Scientific name	English name	Local name
Abudefduf coelestinus (= A. sexfasciatus)	Stripetailed damselfish	--
Acanthocybiun solandri	Wahoo	Ngenl (Car) Saowarag-tosun (Cha) Tosun (G)
Acanthurus xanthopterus	Ringtailed surgeonfish	Igaingun (Car) Hugupao (Cha) Ugupao (G)
Adioryx spinifer	Squirrelfish	Tiper (Car) Sesebug, sesiok (Cha)
A. andamanensis	Squirrelfish, fanfin soldier	--
A. tiere	Squirrelfish	--
Apogon notatus	Cardinalfish	--
A. truncata	Cardinalfish	--
Aphareus furcatus	Olive smalltooth jobfish	--
A. rutilans	Rusty smalltooth jobfish	Lehi (G)
Aprion virescens	Gray snapper, blue-gray snapper	Aiwe (Car) Aluhun laiguan (Cha) Salmon, uku (G)
Archamia lineolata	Crossbanded cardinalfish	--
Atherina bleekeri (= Allanetta bleekeri)	Flathead silverside	--
A. tsurugae	Silverside	--
A. valenciennesii	Silverside	--
Beryx decadactylus	Broad alfonsin	--
B. splendens	Alfonsin	--
Caesio caerulaureus	Blue-and-gold fusilier	--
C. chrysozona	Blacktipped fusilier	--
C. diagramma	Darkbanded fusilier	--
Canthigaster solandri	Sharpbacked puffer	--
Carangoides ferdau	Blue trevally, Ferdau's cavalla	Tarakito (G)
C. hemigymnostethus	Jack	--
Caranx djeddaba	Evenbellied crevalle	--
C. lugubris	Blackjack	Tarakito (G)
C. leptolepis	Yellowstriped crevalle slender trevally	--
C. malabaricus	Malabar jack	--
C. melampygus	Bluefinned crevalle, spotted trevally	Etam (Car) Tarakiton atelong (Cha) Tarakito (G)
C. sexfasciatus	Horse-eye jack, yellow jack	Dchep (small) (Car) Etam (big) (Car) Tarakiton apaka (Cha) Tarakito (G)

Table 8.--Continued.

Scientific name	English name	Local name
Carcharhinus menisorrah	Gray reef shark	--
Cephalopholis aurantius	Orange rockcod	--
C. sexmaculatus	Sea bass	--
Chaetodon corallicola	Butterflyfish	--
Chelon vaigiensis	Mullet	Araf (Car) Laiguan (Cha)
Chromis caeruleus	Damselfish	--
Coryphaena hippurus	Mahimahi	Mahimahi (G)
Ctenochaetus striatus	Surgeonfish	--
Dascyllus aruanus	Damselfish	--
D. trimaculatus	Damselfish	--
Decapterus russelli	Mackerel scad, round scad	--
Elagatis bipinnulata	Rainbow runner, Hawaiian salmon	--
Engraulis japonicus	Japanese anchovy	--
Epinephelus emoryi	Sea bass	--
Etelis carbunculus	Red snapper	Ehu (G)
E. coruscans	Red snapper, ruby snapper	Onaga (G)
Euthynnus affinis	Kawakawa	Asil leu (Car) Kachug apaka (Cha) Black skipjack tuna (G)
Gazza equulasformis	Soapy	--
Gerres argyreus	Mojarras	Majarras (G)
Ginglymostoma ferrugineum	Nurse shark	--
Gnathodentex aurolineatus	Striped large-eye bream	--
Gymnocranius japonicus	Pigface bream	--
Gymnosarda unicolor	Dogtooth tuna, dog tuna, scaleless tuna, white tuna	--
Gymnothorax flavimarginatus	Yellow-edged moray eel	--
G. eurostus	Moray eel	--
Harengula ovalis	Spotted herring	--
H. zunashi	Scaled sardine	--
Heniochus acuminatus	Featherfin bullfish	--
Istiophorus platypterus	Sailfish	--
Katsuwonus pelamis	Skipjack tuna	Angarap (Car) Kacho (Cha)
Kuhlia rupestris	Rock flagtail	Umatan (G)
Labracoglossa argentiventris	--	--
Leiognathus equulus	Ponyfish	--
Lethrinus miniatus	Green snapper, longnosed snapper	U-Lul (Car) Lililug (Cha) Liliok (G)
L. ramak	Yellowbanded porgy	Mafuti (Cha)

Table 8.--Continued.

Scientific name	English name	Local name
Lethrinus variegatus	Variegated emperor	--
Lutjanus argentimaculatus	Gray snapper, silver-spotted gray snapper	--
L. bohar	Twinspot snapper, two-spotted snapper	Mos (Car) Buha (Cha) Tagafi (G)
L. gibbus	Humpbacked red snapper	Fafaet (G)
L. kasmira	Bluelined snapper, yellow and blue seaperch	Sas (Car) Sas (Char) Funai (G)
L. monostigma	Red snapper	Kakaka (G)
L. rivulatus	Speckled snapper	--
L. vaigiensis	Yellowmargined seaperch	--
Makaira indica	Black marlin	--
M. nigricans	Blue marlin	Takular (Car)
Megalops cyprinoides	Oxeye tarpon	--
Monotaxis grandoculis	Roundtooth large-eye bream	Masetmas (Car) Matanhagon (Cha)
Mugil cephalus	Mullet, striped mullet	Aguas (<20.3 cm) (G) Liguan (>20.3 cm) (G)
Mulloidichthys auriflamma	Goldstriped goatfish	--
Myripristis berndti	Squirrelfish	Sasag (G)
Naso vlamingi	Bignose unicorn, unicornfish	--
Pagrus major	Porgy, sea bream	--
Parapercis cephalopunctata	Sandperch	--
Paracaesio caeruleus	Fusilier	--
P. xanthurus	Yellowback fusilier	--
Parupeneus porphyreus	Whitestriped goatfish	--
P. trifasciatus	Threebar goatfish	Salmonete acho (G)
Pentaceros richardsoni	Pelagic armorhead	--
Plectorhynchus orientalis	Oriental sweetlip	--
Polydactylus sexfilis	Pacific threadfin	Boca dulce (G)
Pomacentrus anabatoids	Damselfish	--
P. pavo	Peacock damselfish	--
Priacanthus cruentatus	Red bigeye	Mamagas (G)
Pristipomoides amoenus	Snapper	--
P. auricilla	Yellowtail snapper	Yellowtail kalekale (G)
P. filamentosus	Pink snapper, crimson snapper	Pink paka, pink opakapaka (G)
P. flavipinnis	Yellow-eye snapper	Yellow-eye opakapaka (G)
P. sieboldii	Pink snapper	Pink kalekale (G)
P. zonatus	Obliquebanded snapper	Gindai (G)
Rastrelliger kanagurta	Indian mackerel	--

Table 8.--Continued.

Scientific name	English name	Local name
Sardinella leiogaster	Smoothbelly sardinella	--
S. mizun	Sardinella	--
Sardinops immaculata	Sardine	--
S. melanosticta	Japanese sardine	--
Scarus pectoralis	Parrotfish	--
Scomber japonicus	Chub mackerel	--
Selar crumenophthalmus	Bigeye scad	Peti (Car) Atulai (Cha) Hiting (G)
Seriola dumerili	Greater amberjack	--
Siganus argenteus	Silver spinefoot	--
S. punctatus	Rabbitfish, spinefoot	Palawa (Car) Hiting feda (Cha)
S. rostratus	Rabbitfaced spinefoot	--
S. spinus	Rabbitfish, bluntnosed spinefoot	Sesjun (G)
Sphyraena argentea	Pacific barracuda	--
S. barracuda	Great barracuda	Sarau (Car) Alu or halu (Cha) Alu (G)
S. jello	Banded barracuda	--
S. obtusata	Obtuse barracuda	--
Spratelloides delicatulus	Delicate round herring bluebacked sprat	--
S. gracilis	Banded blue sprat	--
S. japonicus	Whitestriped blue sprat	--
Stolephorus buccaneeri	Buccaneer anchovy	--
S. heterolobus	Shorthead anchovy	--
Sufflamen fraenatus	Bridle triggerfish	--
Tetrapturus angustirostris	Shortbill spearfish	--
Tetrapturus audax	Striped marlin	--
Thunnus alalunga	Albacore	--
T. albacares	Yellowfin tuna	Manguro (Car) Kacho (Cha)
T. obesus	Bigeye tuna	--
T. thynnus	Northern bluefin tuna	-
Trachurus japonicus	Japanese horse mackerel	--
Triaenodon obesus	Reef whitetip shark	--
Upeneus tragula	Mottled goatfish	--
Uraspis helvolus	Whitetongued crevalle	--
Variola louti	Grouper	Bule-lei-lonlon (Car) Fafahid (Cha) Gadao (G)
Xiphias gladius	Swordfish	--

was that bait taken in tropical waters was almost never held for any length of time prior to use (Cleaver and Shimada 1950). The tropical anchovies and herringlike fishes were all extremely delicate and usually died within a day of impoundment. To minimize bait losses, therefore, the Japanese fishermen caught bait at night or during the early morning and left for the fishing grounds immediately. The system proved very practical, because the baiting grounds were usually within a few hours from the fishing grounds.

Unlike conditions in Japanese waters where skipjack tuna fishing was confined to the summer months, weather in the JMI was generally ideal most of the year for fishing. The exception was in November-February when the northeast trades prevailed and although it was possible to catch skipjack tuna in almost all seasons, fishing was slowest in January-February. The fishermen in the South Seas fisheries considered May-September the best for skipjack tuna fishing.

In addition to all the problems encountered by the Japanese with bait catching, bait handling, and weather conditions, changes in oceanographic conditions also caused a great deal of apprehension. With changes in currents and water temperature came wide fluctuations in catches. In January-March 1939, for example, abnormal oceanographic conditions prevailed over a wide expanse of ocean from Palau eastward to long. 150° E. during this period, longline catches of yellowfin tuna declined and catches of bigeye tuna and albacore increased. In the pole-and-line fishery at Palau, Truk, and Ponape, the fleet experienced very poor fishing (Inanami 1941, 1942). The good catches of bigeye tuna and albacore meant temperatures in the surface layers were cooler than normal which in turn affected yellowfin tuna and skipjack tuna distribution. By May, when oceanographic conditions returned to normal, fishing for skipjack tuna improved significantly at Palau, Truk, and Ponape.

The rapidity with which the skipjack tuna fishery expanded in the JMI from 1922 to 1940 is reflected in the catches given in Table 9. Maximum fishing intensity was reached in 1937 when the catch from the JMI reached 33,060 metric tons (t) (36,442 short tons (st). The fleet in Palau landed 42% of the total catch whereas that based at Truk produced 38%. The large 1937 catch resulted from the operation of an unusually large number of fishing vessels (Table 10). The fleet was reduced in 1938 because of protests from Japanese producers in Japan and subsequent government restrictions on the number of vessels that could be operated in the JMI (Smith 1947b). By 1940, the fleet was reduced to 132 pole-and-line vessels.

The Tuna Longline Fishery

Waters around the JMI had an abundance of not only surface-schooling skipjack tuna but also deep-swimming yellowfin tuna, albacore, bigeye tuna, northern bluefin tuna and billfishes, Istiophoridae. It was logical, therefore, to expect the Japanese to develop a longline fishery for these resources, but the historical accounts show that a longline fishery never really developed on a scale as the skipjack tuna fishery (Shapiro 1948). In 1931-34, several large Japanese fishing firms began to show increased interest in the deep-swimming tunas, and together with several research stations, began surveys to determine the fishing grounds and the density of

Table 9.--Skipjack tuna catch landed in the former Japanese Mandated Islands, 1922-40, in metric tons (Shapiro 1948).

Year	Saipan	Yap	Palau	Truk	Ponape	Jaluit	Total
1922	2.36	ND	ND	3.60	3.75	ND	9.71
1923	2.81	1.46	ND	3.04	ND	ND	7.31
1924	9.10	1.76	1.56	5.21	0.11	ND	17.74
1925	14.81	1.99	8.53	6.05	4.95	ND	36.33
1926	44.84	2.16	42.41	2.76	0.11	ND	92.28
1927	28.11	0.73	14.77	7.50	1.62	0.22	52.95
1928	26.49	1.13	131.45	4.50	0.15	ND	163.72
1929	24.69	0.89	228.90	214.50	0.53	ND	469.51
1930	258.00	0.90	157.06	913.39	6.38	ND	1,335.73
1931	564.26	0.44	548.12	1,097.13	525.24	81.26	2,816.45
1932	1,309.73	ND	1,592.33	810.26	534.18	614.76	4,861.26
1933	1,762.30	ND	2,144.46	1,883.36	926.85	172.43	6,889.40
1934	2,516.00	4.19	3,778.65	1,199.98	1,202.46	255.13	8,956.41
1935	1,785.98	ND	5,390.99	3,002.43	1,313.12	229.78	11,722.30
1936	1,696.01	ND	3,835.97	5,870.23	2,695.84	167.73	14,265.78
1937	2,697.30	ND	13,774.70	12,433.53	4,063.96	91.30	33,060.79
1938	2,392.03	149.28	3,420.21	5,294.78	1,495.58	6.71	12,758.59
1939	2,086.99	36.06	3,548.77	7,639.63	3,707.75	ND	17,019.20
1940	3,379.05	3.64	6,047.38	7,217.09	1,586.30	0.51	18,233.97

ND: No data available.
Source: Statistical yearbook of South Sea Islands, published by South Sea Government General.

Table 10.--Number of fishing vessels in the former Mandated Islands, 1937 (Smith 1947b).

Port	Below 20 tons	Above 20 tons	Total	Number in crew
Saipan	34	3	37	630
Yap	4	--	4	96
Palau	89	160	249	3,154
Truk	47	3	50	817
Ponape	18	1	19	586
Jaluit	1	--	1	21
Total	193	167	360	5,304

the population (Nakamura 1951). The surveys covered the area from the JMI westward through the Dutch East Indies and into the Indian Ocean. The results were encouraging, particularly for the development of longline fishing for yellowfin tuna, and marlins, Makaira sp. (Ikebe 1941). The fishing grounds for yellowfin tuna in 1940 are shown in Figure 8.

It was the scarcity of capital for the purchase of large, well-equipped fishing vessels and refrigeration equipment that contributed to the lack of growth of the fishery (Smith 1947b). Experienced fishermen were also in short supply, thus keeping longline operations limited to a few vessels (Shapiro 1948). By 1938, however, longline vessel operators in Japan became aware of the potential of the JMI's fishing grounds for yellowfin tuna and billfishes and began to send large vessels of up to 60 gross tons (gt) to fish that area. Catches of these large vessels on the fishing grounds around the JMI were good, with catch per unit effort higher than those in Japanese waters (lat. 30°-40° N) and in Ryukyu and Bonin waters (lat. 24°-30° N) (Table 11). The principal species taken was yellowfin tuna followed by sizable quantities of albacore, swordfish and other billfishes, and small numbers of sharks. Figure 9 shows the fishing grounds for albacore in 1940 in the western Pacific.

Table 12 shows that tuna landings were highest in Palau, which was also the leading port of landing for skipjack tuna. Although fishing could be conducted throughout the year in the calm tropical waters, the catch rates were usually higher during the summer southwest monsoons than during the winter northeast monsoons (Table 13).

Other Marine Fisheries

While the JMI of which the Northern Marianas were a part bustled with tuna fishery development activities under the Japanese, the fishery in Guam under U.S. military rule can be described only as subsistence fishing. Jennison-Nolan (1979) gives an excellent account of Guam's prewar economy and fishing, basing her review and summary on Thompson's (1947) published book. Briefly, it appears that some military policies fostered development of a money economy whereas others did not. Thompson noted that a good example of the former is employment where approximately 25% of the employable males on the island were working for the U.S. Navy.

It was Thompson's opinion that the prewar fishing techniques on Guam probably derived from ancient prototypes. Hook and line were commonly used and with passing years this gear still persisted with only the materials from which they were made changing to any degree. Hand fishing was done mainly by women, who also engaged in clam digging, spear fishing, and rod-and-reel fishing. Men played the principal role in net fishing and trap or weir fishing, the latter method being a licensed activity on Guam. Other methods commonly in use were the cast net for small inshore fishes, pole and line, night spearing by torchlight, narcotics for stupefying fish, and seine dragging for manahac or rabbitfishes, Siganidae.

In the Marianas, although the Japanese concentrated much of their effort in developing the pole-and-line skipjack tuna fishery, and to some degree, the longline fishery for tunas and billfishes, they also exploited other species in their effort to maximize harvest of the marine resources.

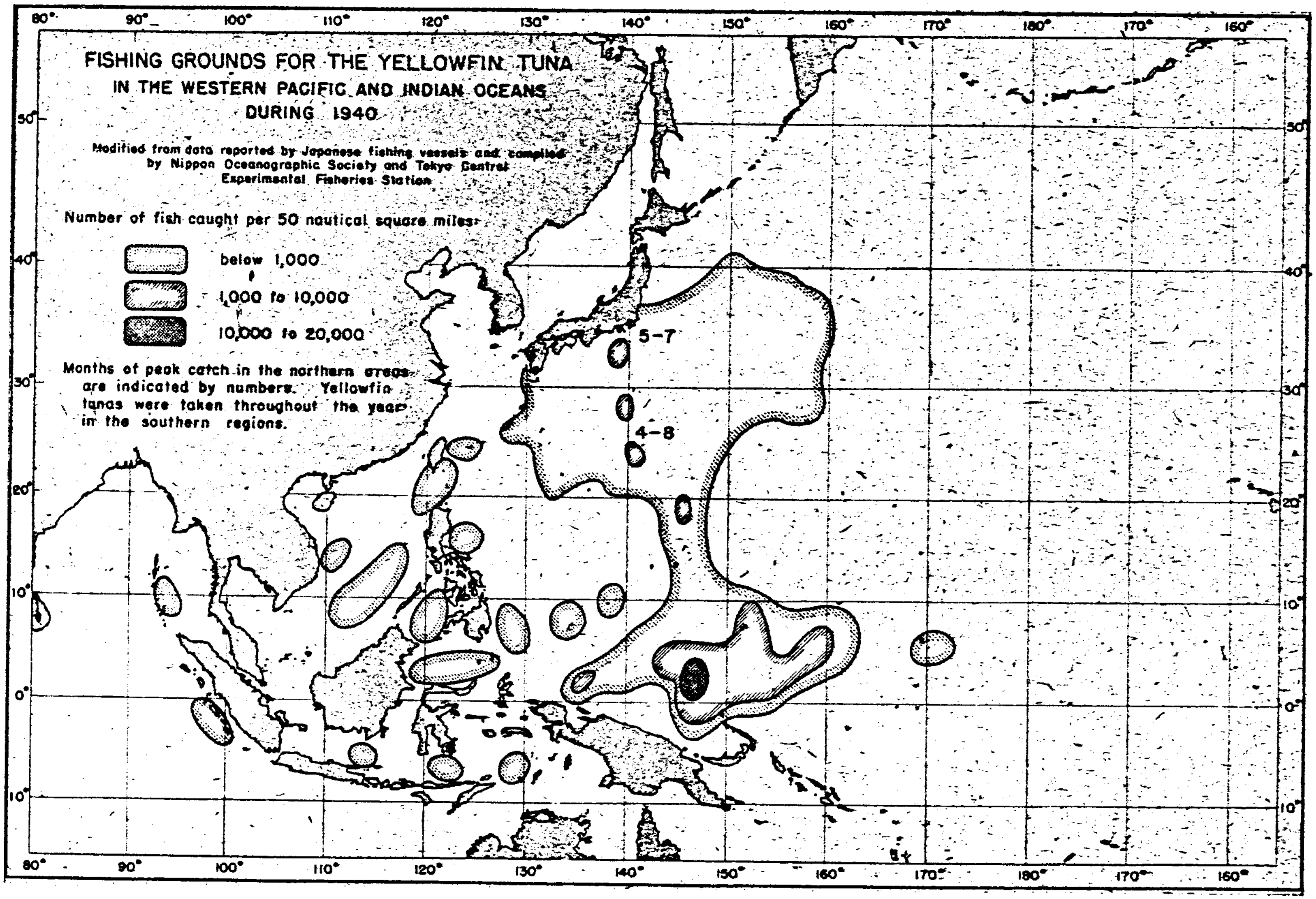


Figure 8.--Fishing grounds for yellowfin tuna in the western Pacific and Indian Oceans during 1940 (Shapiro 1948).

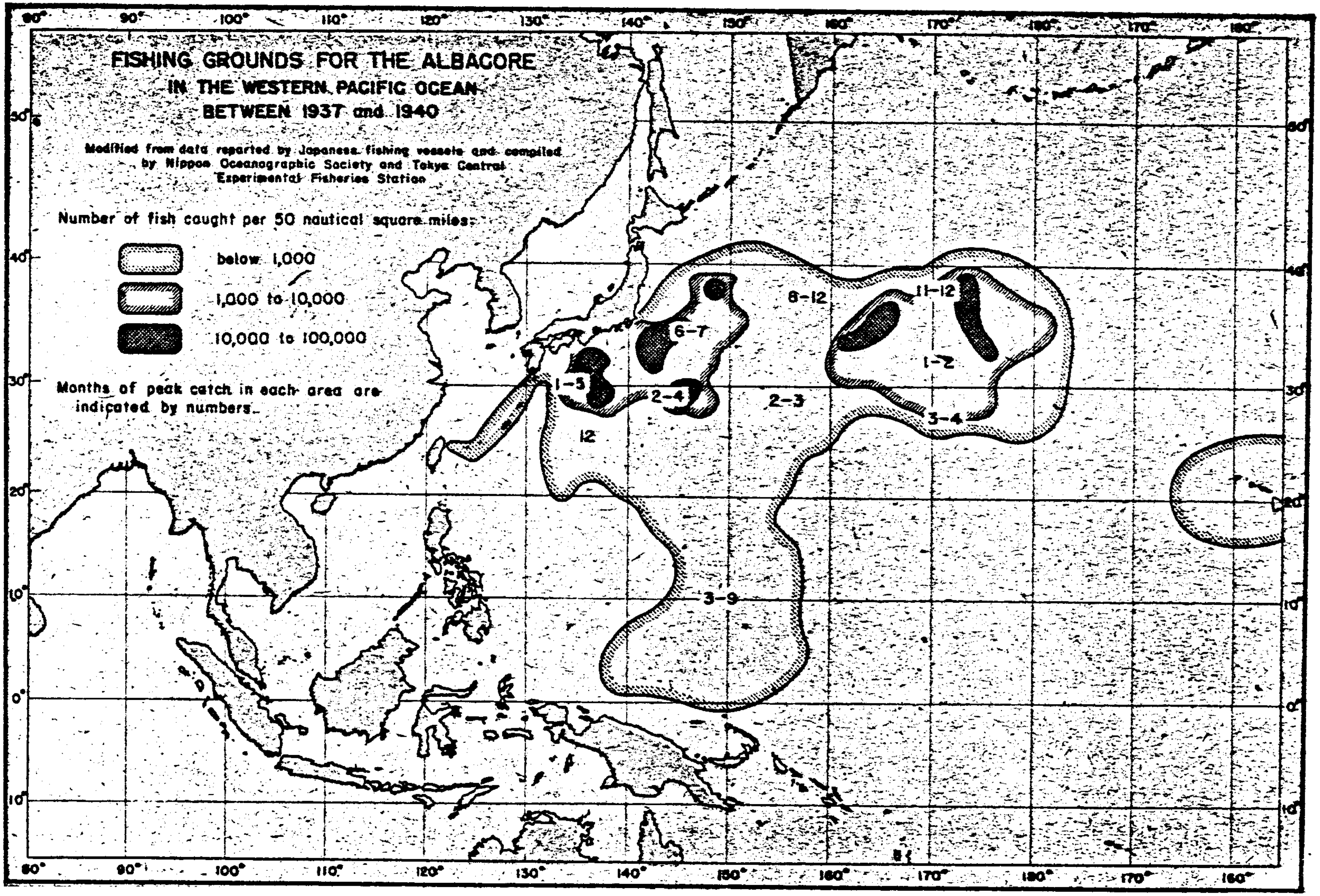


Figure 9.--Fishing grounds for albacore in the western Pacific Ocean between 1937 and 1940 (Shapiro 1948).

Table 11.--Tuna longline catch in three major fishing areas by vessels operating from the port of Misaki during 1939 (Shapiro 1948).

Area	Number of voyages	Average fishing days per voyage	Average tonnage per vessel	Total catch (t)	Average catch per fishing day per ton of vessel
Japanese waters (lat. 30°-40° N)	412	15	45	5,312	0.0191
Ryukyu and Bonin area (lat. 24°-30° N)	212	14	56	2,571	0.0155
Former mandated area (lat. 0°-24° N)	239	13	113	8,470	0.0241

Table 12.--Tunas, excluding skipjack tuna, landed in the former Japanese Mandated Islands, 1922-40, in metric tons (Shapiro 1948).[1]

Year	Saipan	Yap	Palau	Truk	Ponape	Jaluit	Total
1922	1.31	ND	ND	ND	2.36	2.40	6.07
1923	1.25	1.24	ND	ND	1.76	2.40	6.65
1924	1.53	1.54	6.75	ND	0.80	1.34	11.96
1925	1.40	1.48	5.31	ND	2.54	1.50	12.23
1926	2.31	0.75	46.80	0.34	4.50	0.83	55.53
1927	2.91	0.38	41.22	0.14	6.58	3.05	54.28
1928	1.26	1.05	152.83	ND	7.75	1.29	164.18
1929	0.56	0.76	167.94	0.90	1.62	0.22	172.00
1930	4.53	0.77	92.26	8.53	3.54	2.37	112.00
1931	16.73	0.46	156.61	29.43	4.83	3.85	211.91
1932	48.24	ND	137.62	5.18	34.69	135.72	361.45
1933	0.31	ND	242.23	55.39	41.42	25.87	365.22
1934	27.26	7.67	278.88	55.39	26.49	31.36	427.05
1935	42.92	0.08	301.18	98.50	23.50	13.91	480.09
1936	151.02	ND	213.26	178.02	29.96	14.85	587.11
1937	88.88	ND	189.78	342.18	56.37	3.96	681.17
1938	33.94	2.21	73.13	101.44	60.21	ND	270.93
1939	34.88	7.40	188.94	93.60	31.58	5.14	361.54
1940	84.51	15.82	686.57	46.62	17.31	7.97	858.80

[1]Includes spearfishes.
ND: No data available.
Source: Statistical yearbook of South Sea Islands, published by South Sea Government General.

Table 13.--Seasonal tuna catch by longline operations in southwest Pacific and Indo-Pacific regions (Shapiro 1948).

Area	Southwest monsoon season (summer)		Northeast monsoon season (winter)	
	Number of hooks used	Total catch per 100 hooks[1]	Number of hooks used	Total catch per 100 hooks[1]
East of Formosa to 120°30' E	900	1.78	7,032	2.94
East of Philippine Islands to 130° E	7,840	7.98	2,394	0.67
Former Mandated Islands: 0°-12° N and 130°-170° E	115,099	5.40	105,527	4.18
South China Sea off Palawan	4,158	3.32	106,402	4.69
Celebes Sea	10,493	8.86	146,663	4.06
North of New Guinea and Solomon Islands: from 130° to 160° E	10,500	4.39	11,292	4.04
Banda Sea: southeast and south of Celebes	80,089	8.56	1,690	7.34
Neighboring waters of Timor Island	2,215	6.23	46,546	9.33
Southern coast of Sumatra	300	3.67	147,128	10.72

[1]Includes yellowfin tuna, bigeye tuna, and marlins.
Source: Data obtained by Japanese research and fishing vessels from 1930 to 1940 and compiled by H. Nakamura of the Tokyo Central Fisheries Experimental Station.

Table 14 gives the 1941 production from the more important marine fisheries at bases in the JMI.

Sponge.--Smith (1947a) gives a historical account of an attempt by the Japanese to culture sponge, Spongidae, in the Marshalls in 1939-40. Imported live sponges were planted at Ailinglaplap Atoll by the Japanese but unfortunately, absolutely no records were kept on where the sponges came from, how they were kept alive in transit, how they were planted, and the size of each cutting. After conferring with the natives on the island, Smith found that the plantings were made by the natives under Japanese supervision. Briefly, the sponge culture bed had cement blocks as anchors from which a piece of solid aluminum wire was stretched upward and buoyed by a sealed beer bottle. Usually, 24 sponge cuttings were strung on each wire and allowed to grow. Mortalities, according to the natives, were minimal.

This sponge was later identified as fine levant or turkey solid, *Spongia officinalis*, subspecies *mollissima*, which is found almost exclusively in the eastern Mediterranean (Smith 1947a). At one time it was considered a high-quality sponge and commanded a good price.

Pearl shells.--Although the Japanese production of pearl shells was exclusively from Palau, the black-lip pearl oyster, *Pinctada margaritifera*, was widely distributed throughout the JMI. In addition to Palau, where this species was most abundant, specimens have been collected from Saipan, Ponape, Kapingamarangi, Nukuoro, and Likiep (Smith 1947a).

Pearl culture.--The Japanese also attempted pearl culture in the JMI but eventually concentrated most of their efforts in Palau (Smith 1947a). Plantings there were made as early as 1930 and at the outbreak of World War II, four companies were engaged in pearl culture. Production figures are unavailable but in 1939, 17,783 cultured pearl were exported from Palau. Smith pointed out that this figure does not necessarily represent the total 1939 production, because the finished product was usually accumulated and shipped whenever the Japanese producers found it necessary to do so.

Sea cucumber.--There were perhaps a dozen species of sea cucumbers, Holothuroidea, that were abundant in Micronesia and a few were eaten raw by the natives but only sparingly. During the Japanese colonization, five species were exploited to produce trepang or bêche-de-mer, the boiled and dried product used for making soup. The chief production centers in the JMI were at Truk, Palau, Ponape, Saipan, and Yap. Catch and production statistics are given for 1941 in Table 15.

Table 14.--Production from the most important marine fisheries at centers in the former Japanese Mandated Islands, 1941 (adapted from Smith 1947a). Weight in kilograms.

	Saipan	Yap	Palau	Truk	Ponape	Jaluit	Total
Fresh bonito	1,297,354		3,308,160	4,346,259	2,424,260	169,020	11,545,053
Bonito sticks	182,152		370,290	724,800	332,266	24,332	1,633,840
Fresh tuna	33,669		906,150	24,150	12,768	46,356	1,023,093
Tuna sticks			54,533	3,956	2,730	5,500	66,719
Horse mackerel	4,014	1,896	1,613	7,559	14,830		29,912
King mackerel	5,767		14,092				19,859
Fresh mullet	75				6,075		6,150
Sharks	10,705		42,858		2,665		56,228
Shark fins	150		22,028				22,178
Other fish	288,688	46,742	334,877	56,419	134,973	26,724	888,423
Trochus shell		21,080	[1]	48,835			69,915
White pearl shell			[2]212,688				212,688
Black pearl shell			559				559
Sea cucumbers (trepang)	2,117	3,136	9,556	14,486	9,172		38,467
Coral			18,236				18,236
Other shells	53,555		206,875	135,131	12,075		407,636
Total	1,878,246	72,854	5,502,515	5,361,595	2,951,814	271,932	16,038,956

[1]No open season for trochus in Palau in 1941.
[2]Pearling fleet based at Koror, Palau, but shells taken elsewhere.

Table 15.--The catch of sea cucumbers and trepang production in the former Japanese Mandated Islands, 1941 (Smith (1947a).

Island	Sea cucumber catch		Trepang production	
	Wet weight (kg)	Value (dollars)	Weight (kg)	Value (dollars)
Saipan	54,284	678	2,112	1,109
Yap	31,277	1,567	3,129	1,223
Palau	154,788	556	9,536	3,181
Truk	518,364	1,818	14,456	5,557
Ponape	91,529	458	9,153	3,829
Total	850,242	5,177	38,386	14,899

Trochus shells.--Although several species of trochus or topshell were common in the JMI, only one species, *Trochus niloticus*, found mainly at Palau and Yap was of commercial value (Smith 1947a). To increase production of this species, the Japanese carried out a program of transplantings between 1930 and 1937, taking samples from Palau to Saipan, Truk, Ponape, Ant, Mokil, Kuop, Pakin, Ngatik, Nukuoro, Kapingamarangi, Pingelap, Jaluit, Ailinglaplap, and probably other islands for which no records exist. Apparently, the transplantings were highly successful and collection of trochus was turned over completely to the natives, who were permitted to harvest individuals over 7.6 cm (3 inches) in base diameter during a 2-week period in May or June for sale to the Japanese. The shells were shipped to Japan for producing pearl buttons. Although no shell production records exist, Smith found that it exceeded 113 t (125 st) of which 91 t (100 st) came from Palau.

Sea turtles.--Two species of sea turtles--the green turtle, *Chelonia mydas*, and the hawksbill turtle, *Eretmochelys imbricata*--occurred in Micronesian waters but they appeared to be more abundant in the Carolines than in the Marianas and Marshalls (Smith 1947a). In the JMI, turtle hunting was mainly a native pursuit and captured turtles were sold to the Japanese. The green turtle was mainly used for food but the shell was not particularly attractive. The hawksbill turtle, on the other hand, was mainly hunted for its shell; the flesh was not highly regarded as food.

Post-World War II Developments

In the course of World War II, almost all of the fishery bases that were developed by the Japanese during the twenties and thirties were destroyed (Nathan Associates 1966). A postwar survey of the fisheries resources of the JMI and Guam was begun as part of the general economic development survey undertaken by the Pacific Ocean Division of the United States Commercial Company, Reconstruction Finance Corporation (RFC), at the request of the U.S. Navy Department (Smith 1947b). The survey covered all aspects of the native economy and was concentrated in several islands in the Mariana Archipelago, the Caroline Islands, and the Marshall Islands. Among the islands surveyed were Guam, Saipan, Tinian, and Rota. The following sections deal with the results of some of the surveys conducted in and around Guam and the Northern Marianas and with the resurgence of the Japanese tuna fisheries in southern waters.

Revival of the Skipjack Tuna Fishery

Attempts to revive the skipjack tuna fishery, which thrived under the Japanese administration, were first started in Saipan in 1946 (Smith 1947b). Two sunken Japanese sampans at Saipan were refloated, repaired, and subsequently operated by the U.S. military government. The sampans were manned by 26-28 fishermen who were paid only the regular daily wages established by the military government. Fish caught on the sampans were distributed free to the native population. This operation was short-lived. Inexperienced crews, inadequate fishing gear and maintenance facilities, and lack of dockside refrigeration facilities all contributed to the abandonment of the project (Wilson 1963).

In 1948, the Pacific Exploration Company, operating under contract with the RFC, dispatched two fishing vessels to prospect for tuna in the western Pacific (Smith and Schaefer 1949). The MV Oregon, equipped for live-bait fishing, was sent to the Marianas and between 15 March and 19 April, fished for bait and scouted for tuna from Guam north to Farallon de Pajaros and back to Guam. Although much time was devoted to prospecting for bait along the beaches and cliffs of all the major islands in the Marianas, very little bait was found. Night-light fishing at Guam, Tinian, Alamagan, Pagan, Maug, and Rota was also tried and 1.4-2.3 kg (3-5 lb) of bait could sometimes be netted under the light, but these amounts were hardly sufficient for a vessel the size of the MV Oregon.

Among the islands surveyed, Guam was the best baiting area (Smith and Schaefer 1949). Night baiting produced 6.8-9.1 kg (15-20 lb) of bait per night at Apra Harbor, Port Nerizo, and Talofofo Bay, whereas day baiting produced similar amounts at places along the cliffs on the leeward coast. The species taken were mixed. Half to three-fourths of the bait caught was round herring, Spratelloides sp., the rest being a small, unidentified anchovy. Smith and Schaefer concluded that the supply of live bait was uncertain but recommended further investigation.

The scouting reports of the MV Oregon indicated that sufficient numbers of skipjack tuna schools could be found in waters around the Marianas to warrant the development of a commercial fishery. But because of the limited quantities of bait in the Marianas, small boats of limited cruising range were recommended. In 5-6 days of scouting, the MV Oregon sighted 35 bird flocks and 8 fish schools, 3 of which were identified as skipjack tuna and 1 as yellowfin tuna.

Further exploration by the MV Oregon in the Carolines and Marshalls revealed the potential for skipjack tuna fishery development was best in Palau. Here, bait was plentiful and tuna school sightings were numerous. Smith and Schaefer (1949) recommended the use of small vessels for any fishery that may be developed, because they would have the capability of baiting within the narrow confines of many of the small limestone islands around which much of the bait were seen. A large tuna clipper might be necessary only if fishing were carried on outside the Palau area.

Despite the promising outlook for a commercial fishery for skipjack tuna in Palau, the Trust Territory Government, working with a limited budget, believed that fisheries development should be kept at a level sufficient only to provide food for the Micronesian people. But it became increasingly apparent that the Trust Territory needed to develop its marine resources and the government saw that fishing, a traditional economic activity of the people of Micronesia, was an important source of jobs and income.

The revival of the skipjack tuna pole-and-line fishery in Palau is well documented in reports published by Wilson (1963, 1965, 1966), Rothschild (1966b), Uchida (1970, 1975), and Muller (1977).

Japanese Southern Water Pole-and-Line Fishery

The most dramatic increase in fishing effort and catches of skipjack tuna from Trust Territory waters since the end of World War II has been made by the Japanese pole-and-line fishing fleet. The development of Japan's southern water (refers to waters south of lat. 24° N) fishery stems from the realization that the skipjack tuna resource in Japan's coastal waters was nearing the limit of exploitation (Tohoku Regional Fisheries Research Laboratory undated a). A second prime consideration for expansion southward was that the large available skipjack tuna resource in southern waters could be exploited during the off-season for skipjack tuna in Japanese coastal waters.

Figure 10 depicts the geographical location of skipjack tuna fisheries and fishing areas in the Pacific in the early 1960's. All the fishing at that time was confined to areas relatively close to the coastlines of Central and South America and Japan and near island groups in the central and western Pacific. From about 1962, Japanese vessels operating out of ports in several prefectures (Kagoshima, Mie, Shizuoka, Ibaraki, and Miyagi) and carrying live Japanese anchovies obtained from bait stations in southern Japan, began to move into southern waters along the Bonin Islands and Mariana Archipelago (Tohoku Regional Fisheries Research Laboratory undated b).

The principal fishing grounds in the southern water fishery are divided into the Bonin-Mariana region, which is usually fished in July-October, and the Caroline Islands region fished from November through March (Iwasaki 1970b). The expansion of the fishing grounds continued over the years so that by 1971 some vessels were fishing in equatorial waters between Truk and the Marshalls and south of the Equator from lat. 1° to 5° S between long. 147° and 157° E (Figure 11). Generally, large vessels (>300 gt) tended to seek out the newer, more distant fishing grounds, whereas the medium-sized vessels (about 200 gt) remained on the established grounds in spite of poor fishing. Figure 12 shows the extent of the fishing grounds for skipjack tuna not only in the southern water area but also throughout the Pacific basin in 1973.

Figure 13 shows the statistical areas established for the principal fishing ground in the southern water fishery and Table 16 shows the percentage of fishing effort and catch per day's fishing in these statistical areas in 1963-69. In general, the areas west of the Marianas and around the Western Carolines received the largest proportion of the fishing effort.

The supply of live bait is an extremely important factor in the survival of the southern water fishery (U.S. National Marine Fisheries Service (NMFS)).[5] Presently, all the bait used in this fishery is obtained in southern Japan and carried by the vessels to the fishing

[5]U.S. National Marine Fisheries Service. 1974. Summary of Japanese skipjack tuna fishing activities in the Pacific, 1973. Southwest Fish. Cent. Admin. Rep. 1H, 5 p. Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

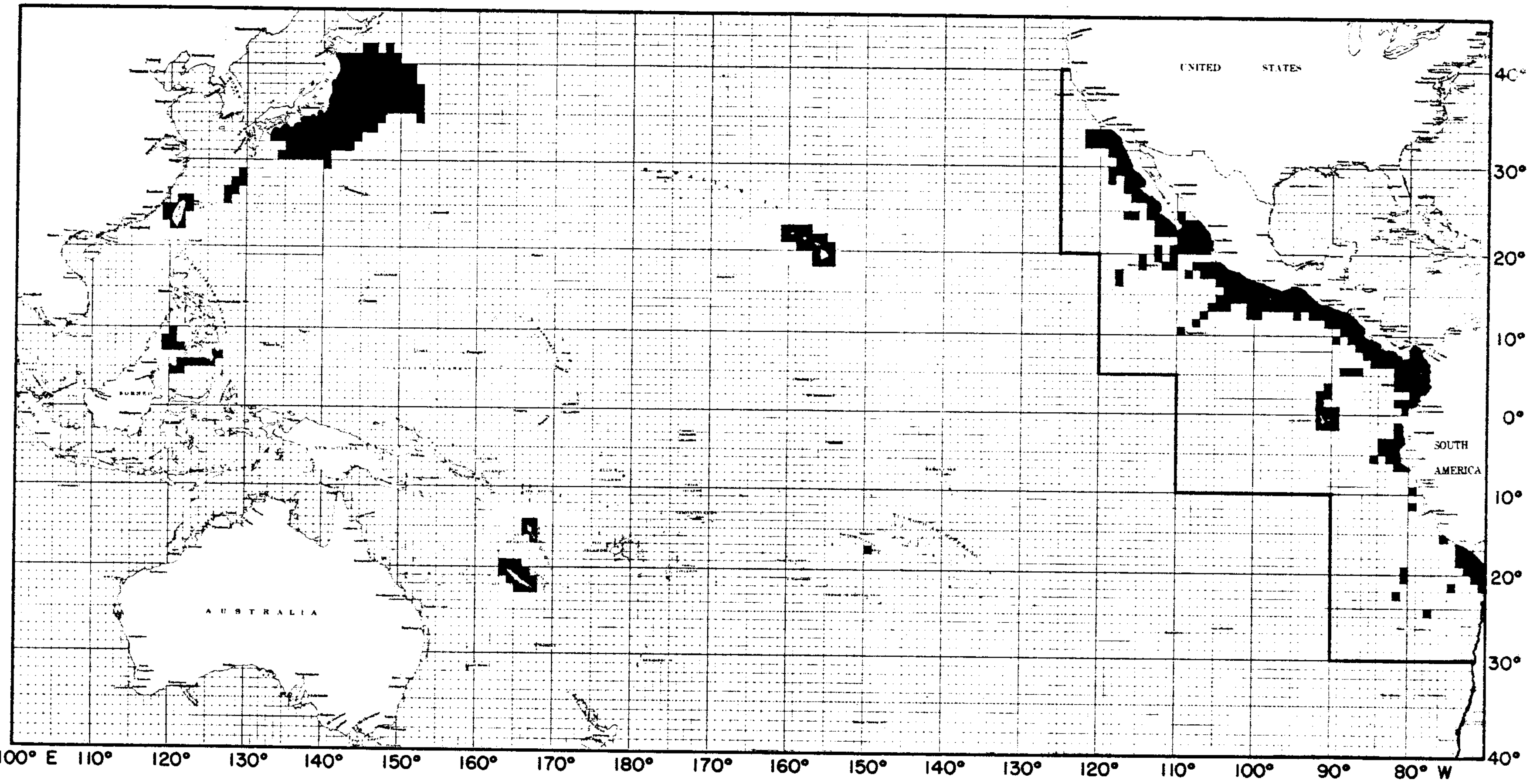


Figure 10.--Location of skipjack tuna fisheries in the Pacific Ocean in 1960 (Uchida and Sumida text footnote 4).

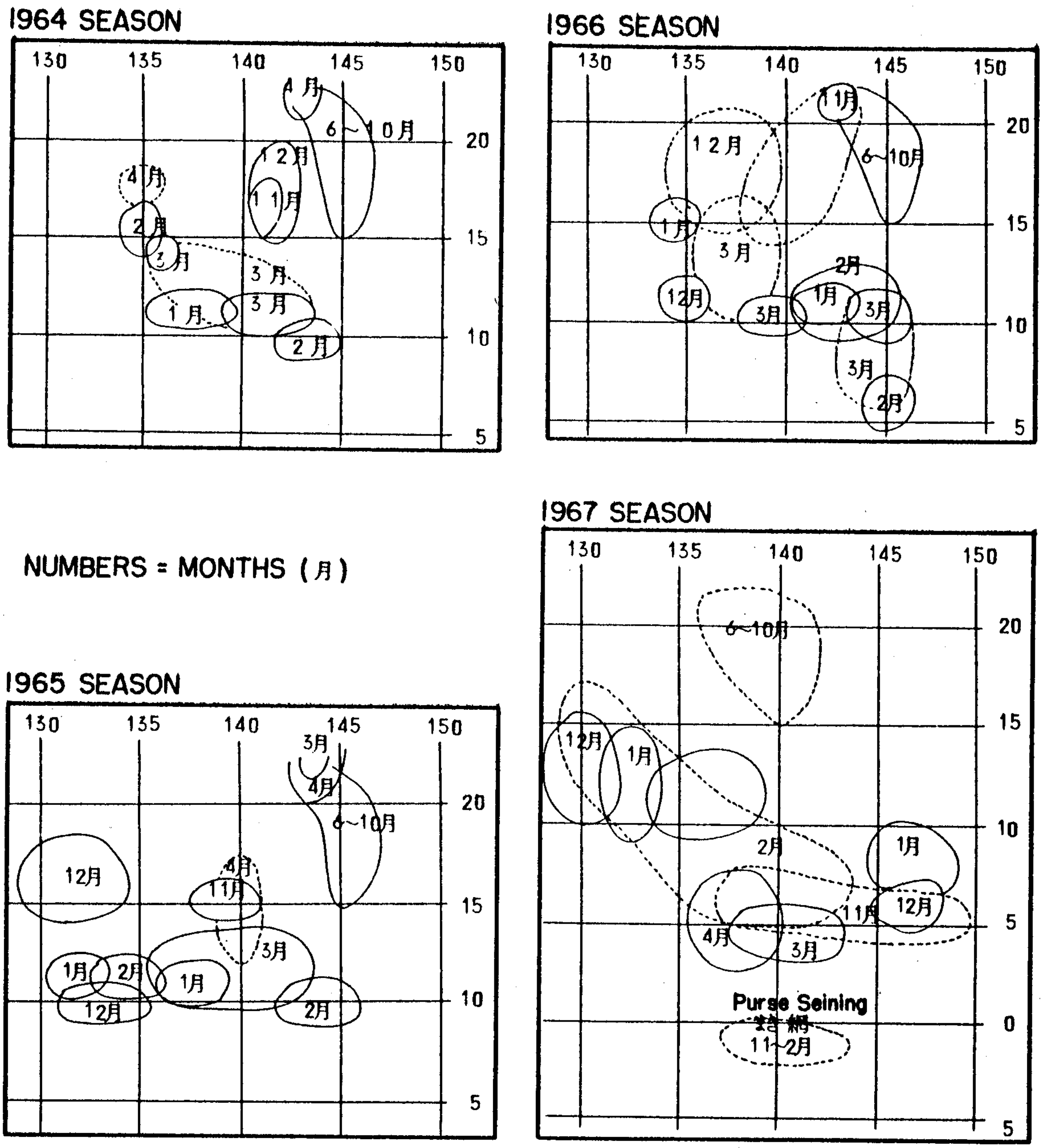
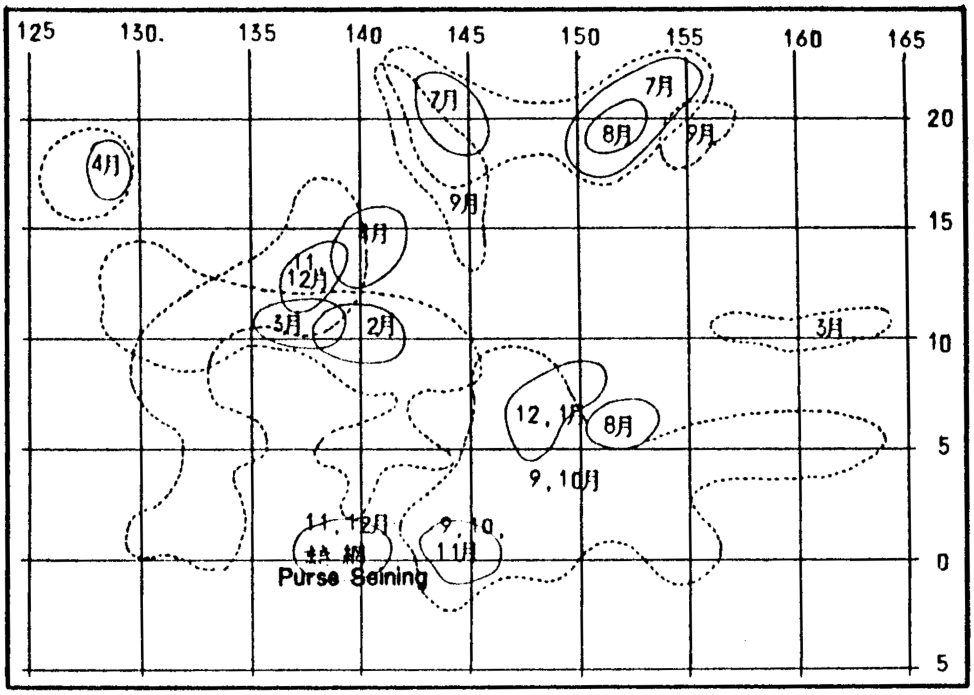


Figure 11.--The monthly movements of the skipjack tuna fishing grounds in southern waters. Areas of intense fishing effort encircled by solid line; area of moderate effort shown by broken line (Tohoku Regional Fisheries Research Laboratory undated d). Note: Numerals denote months of year.

1968 SEASON



1969 SEASON

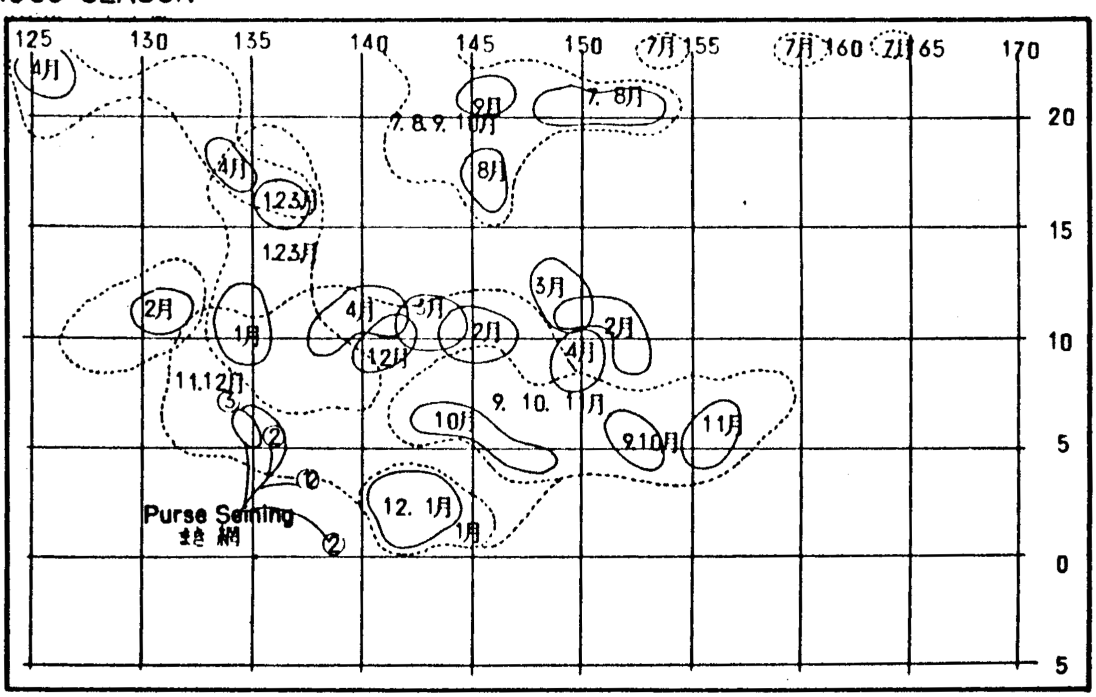
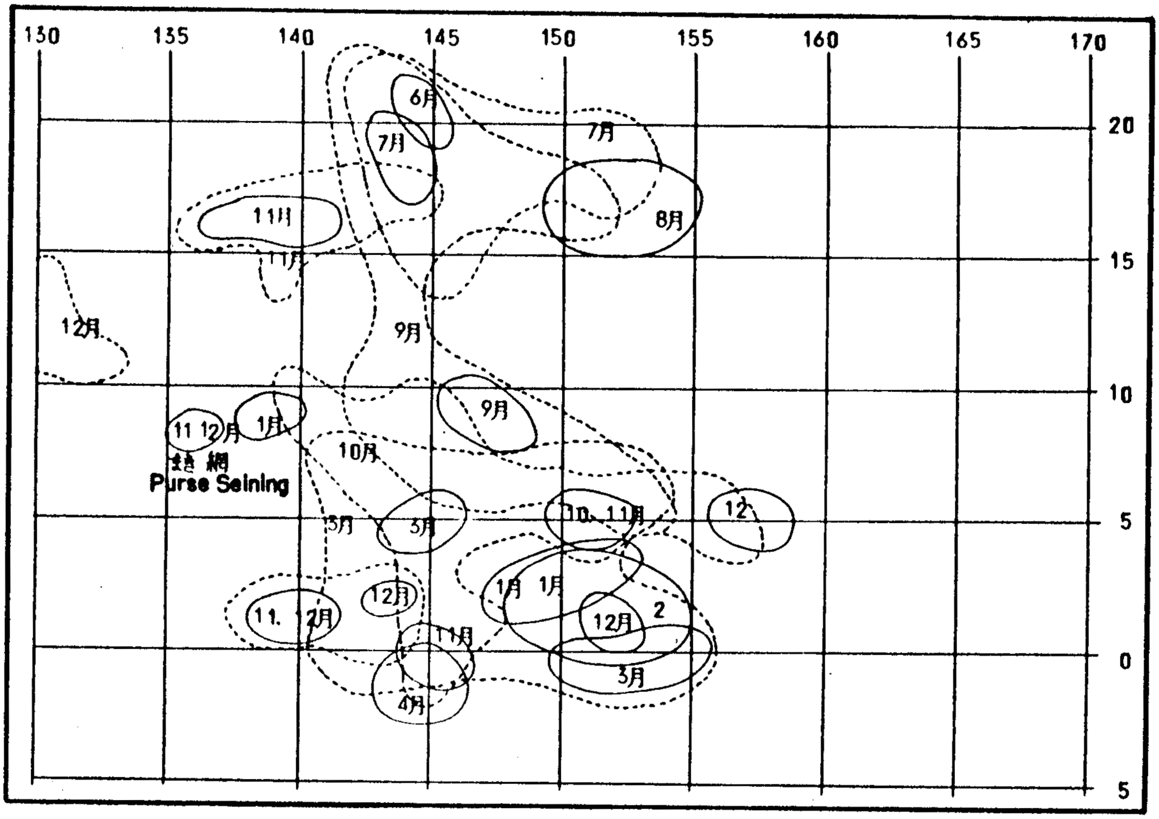


Figure 11.--Continued.

1970 SEASON



1971 SEASON

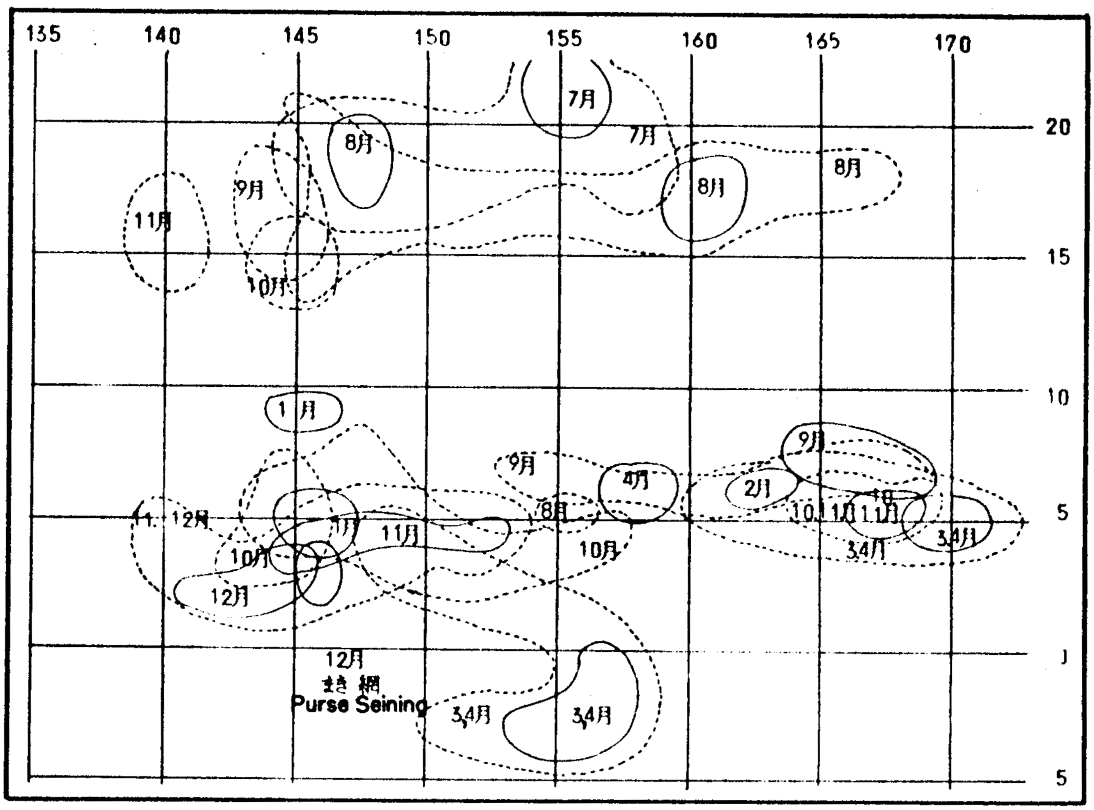


Figure 11.--Continued.

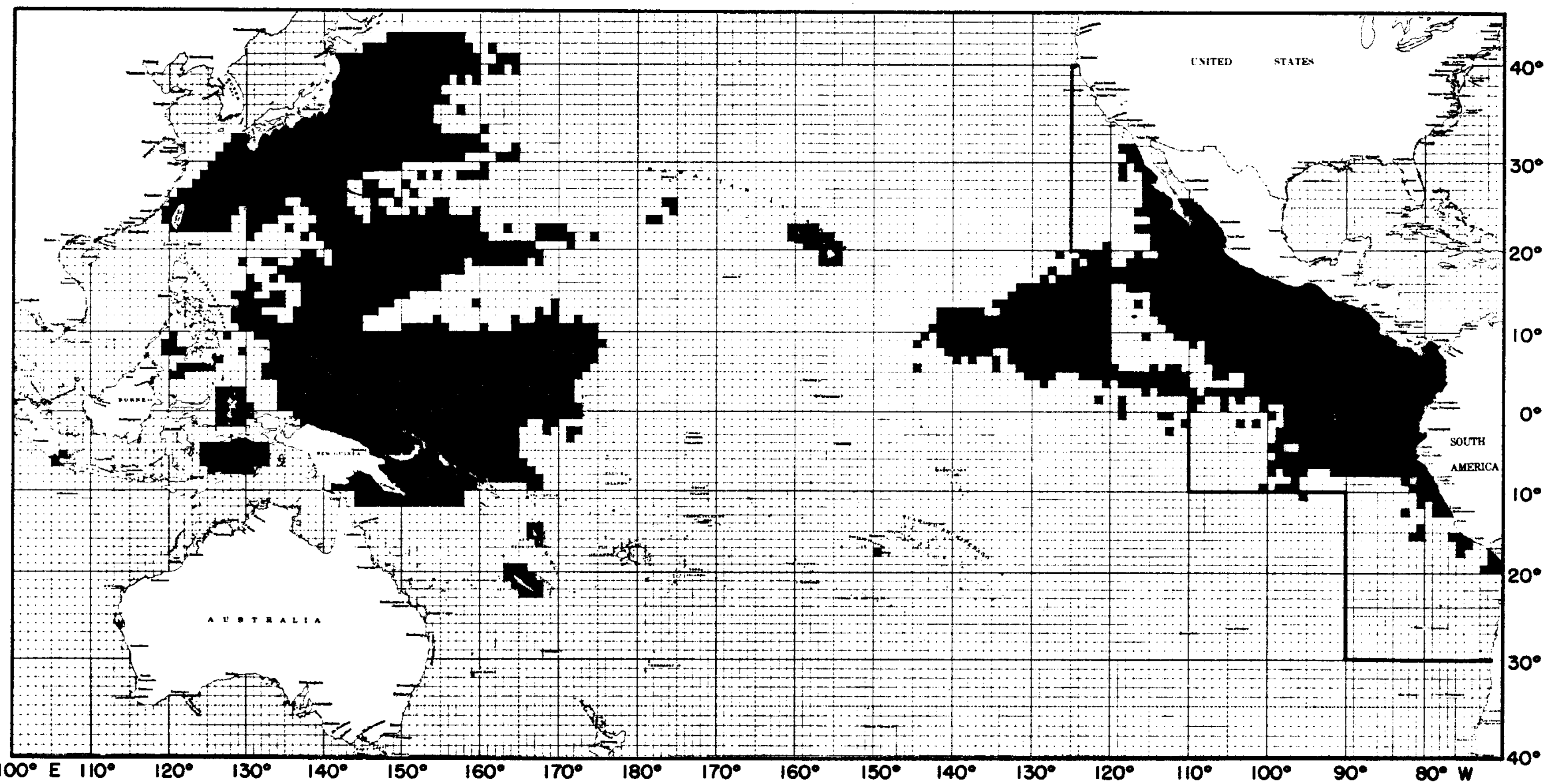


Figure 12.--Location of skipjack tuna fisheries and fishing areas in the Pacific Ocean in 19/3 (Uchida and Sumida text footnote 4).

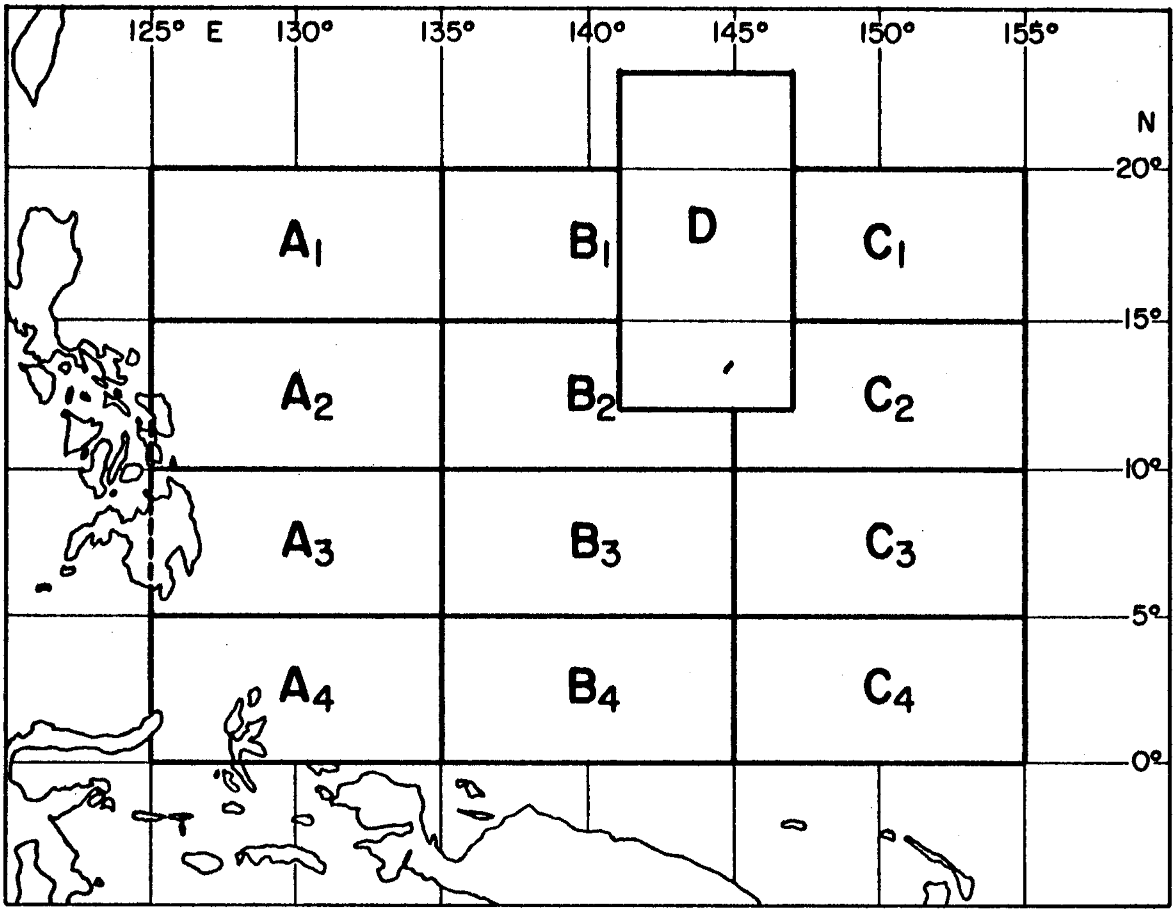


Figure 13.--The subdivision of the principal fishing area in southern waters from November through April (Kasahara 1971).

Table 16.--The percentage fishing effort (upper row) and the catch per day's fishing (lower row), in metric tons, shown by subareas as designated in Figure 13 from November through April (Kasahara 1971).

Subarea	Season						
	1963	1964	1965	1966	1967	1968	1969
A_1		3.3 3.2	5.9 3.6	5.7 4.4	0.5 5.4	5.5 4.1	11.1 0.2
A_2		1.5 3.1	21.6 4.9	6.8 3.6	0.5 5.9	20.3 4.0	8.0 6.7
A_3		0.6 3.5	3.6 6.1	1.8 3.9	0.8 5.9	3.4 6.6	4.6 5.5
A_4						1.9 4.2	0.2 2.4
B_1		11.1 4.1	5.8 3.0	14.5 4.0	0.7 3.9	2.3 2.4	7.1 5.4
B_2		42.0 7.3	42.4 5.8	25.0 6.1	17.1 5.2	39.3 4.5	12.2 6.7
B_3	37.0 7.6	3.7 7.1	6.4 8.8	12.3 5.3	32.0 6.0	7.8 4.1	23.7 5.2
B_4				2.5 8.7	6.2 7.7	3.5 2.6	6.5 6.1
C_1						1.1 6.5	
C_2		0.6 9.1	0.3 5.7	0.3 9.2	1.4 4.4	0.3 2.8	5.5 9.0
C_3		0.3 5.6	0.8 5.7	8.4 8.5	30.7 7.2	1.1 4.6	8.6 4.3
C_4					4.6 10.8	1.1 4.9	3.0 4.2
D	50.0 3.4	36.6 4.6	12.4 3.8	21.4 3.7	4.7 4.2	1.6 2.3	0.5 3.4

grounds. Bait-carrying capacity varies with vessel size; for example, a 190-ton vessel carries about 370 buckets of bait whereas a 350-ton vessel can carry 500-600 buckets.

Based on skipjack tuna landings data obtained at the port of Yaizu, Kasahara (1971) showed that generally, very few vessels fished the southern waters in May-June (Figure 14), reflecting the shift to albacore fishing in Japanese coastal waters. In July, the number of vessels returning from southern waters increased then decreased steadily until October followed by a gradual increase through December. The increase in October reflected the end of the skipjack tuna season in coastal waters off Japan and the entrance of many vessels to the southern water fishery. The sharp decrease in January reflected the tie-up of many vessels during the New Year's holidays; the landings then gradually increased in February and March.

Usually, landings from the southern water fishery were high in November-December and February-March. Landings per trip show small variation ranging between 30 and 50 t (33 and 55 st). At the end of the 1971 fishing season, it was estimated that the southern water fishery for skipjack tuna contributed from 20 to 30% of the total Japanese skipjack tuna landings.

Figure 15 shows the number of vessels returning to Yaizu, total reported landings, and average catch per vessel in 1964-79. For the southern water fishery, a season extends from May to the following April. Reported landings of southern water skipjack tuna at Yaizu represent roughly 50-80% of the total southern water fishery landings (U.S. NMFS footnote 5).

The landings at Yaizu have grown from 14,020 t (15,454 st) in 1964 (Table 17) to about 85,000 t (93,670 st) in 1973 (estimated from Figure 15). The drop in landings in 1966 was attributed to a decrease in fishing intensity as many of the pole-and-line vessels experienced good fishing in coastal waters and remained there instead of heading for southern waters. In 1968, a typhoon in the Marianas curtailed fishing. Furthermore, it is believed that many vessels fishing further west in southern waters chose to unload at the ports of Makurazaki and Yamakawa (Tohoku Regional Fisheries Research Laboratory undated c).

Iwasaki (1970b) noted that the trend toward higher seasonal landings does not necessarily reflect better than average catches. He found considerable variation in the average annual catch of all vessels over 150 tons (Figure 16). Iwasaki also found that in the Bonin-Mariana area the average catch per vessel was good in 1963-67 and poor in 1959-61 and 1968. In the Carolines area, average catches were rather stable; the exceptions were a very good season in 1967 and a very poor one in 1968.

Recognizing that when the average catch per vessel in the Bonin-Mariana area was high in July-September the catches were also above average in the Carolines in November-March, Iwasaki (1970b) indicated that it may be possible to estimate the Carolines catches on the basis of the Bonin-Mariana catches. Iwasaki found that variations in surface temperature and catch per vessel showed similar tendencies in the Bonin-Mariana area (Figure 17). Low temperature in 1963 and 1968 correlated positively with very poor fishing seasons. Temperatures were relatively high in 1964, 1967, and 1969, and fishing was good. He concluded that fishing conditions for skipjack and yellowfin tunas in the Bonin-Mariana area in any given year is largely influenced by prevailing water temperature.

In areas where fishing is good, the Japanese pole-and-line vessels average up to 8.0 t (8.8 st) of fish per vessel per day of fishing (U.S. NMFS 1971). In October 1971, for example, the vessels reported that on the main fishing ground located near the Equator and lat. 8° N between long. 150° and 160° E (between Truk and Kapingamarangi south of Ponape), the catch was 3-6 t (3.3-6.6 st) of skipjack tuna per vessel per day. Further

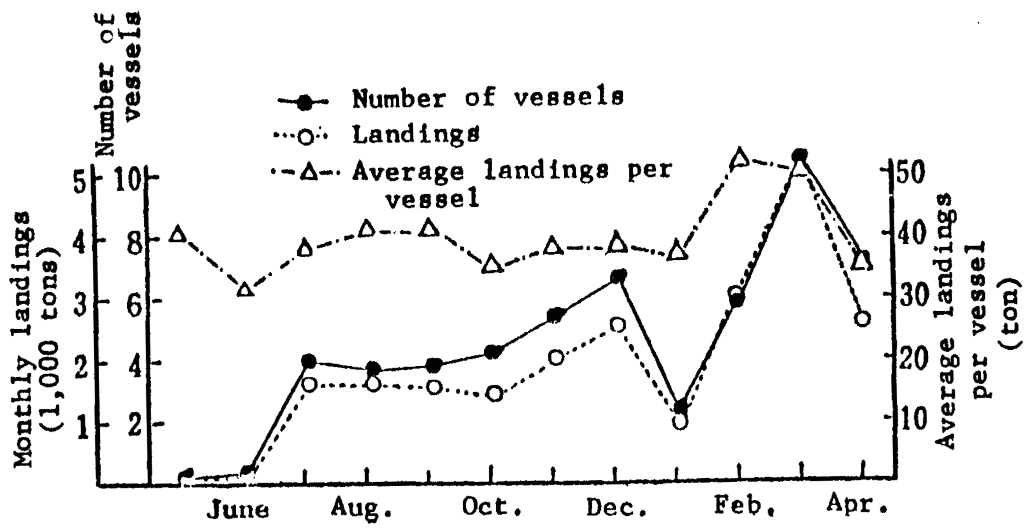


Figure 14.--The monthly average number of vessels, landings, and landings per vessel of vessels returning to Yaizu Port from the southern water fishery (averaged for the years 1964-70) (Kasahara 1971).

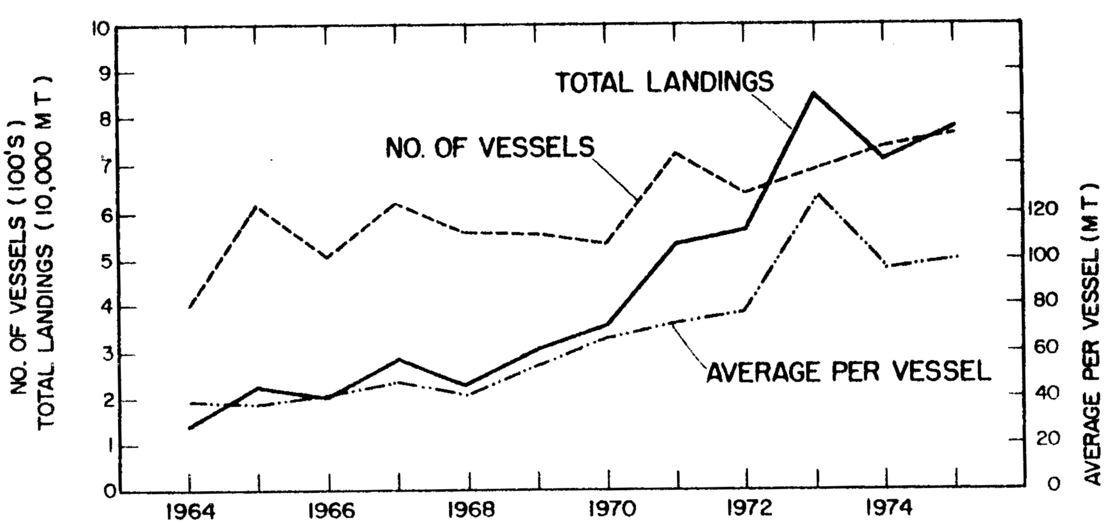


Figure 15.--The number of vessels returning to Yaizu from southern waters, their landings, and the average landings per vessel for the years 1964 through 1975 (Kasahara 1977).

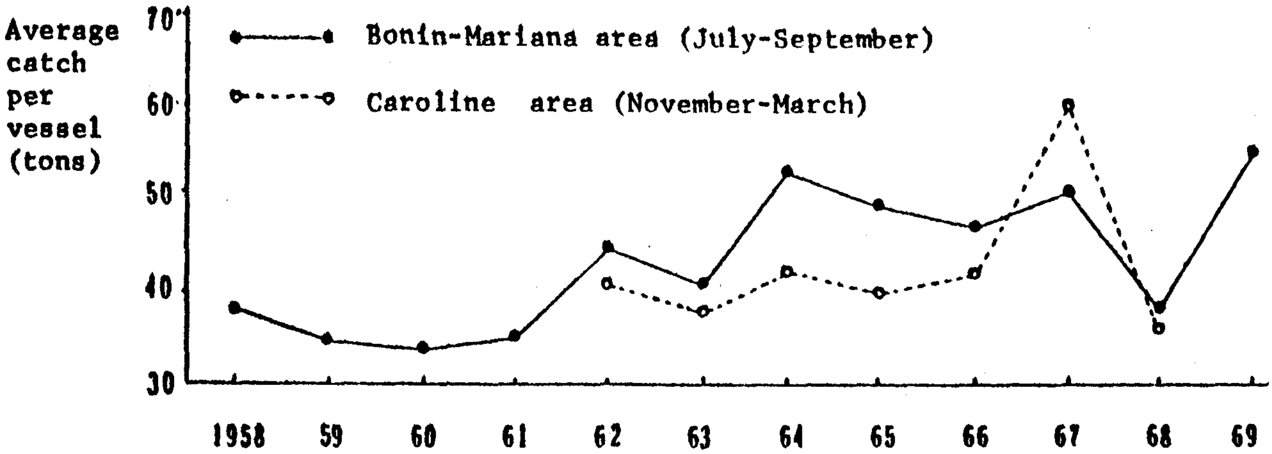


Figure 16.--The variations in annual average catch (Iwasaki 1970b).

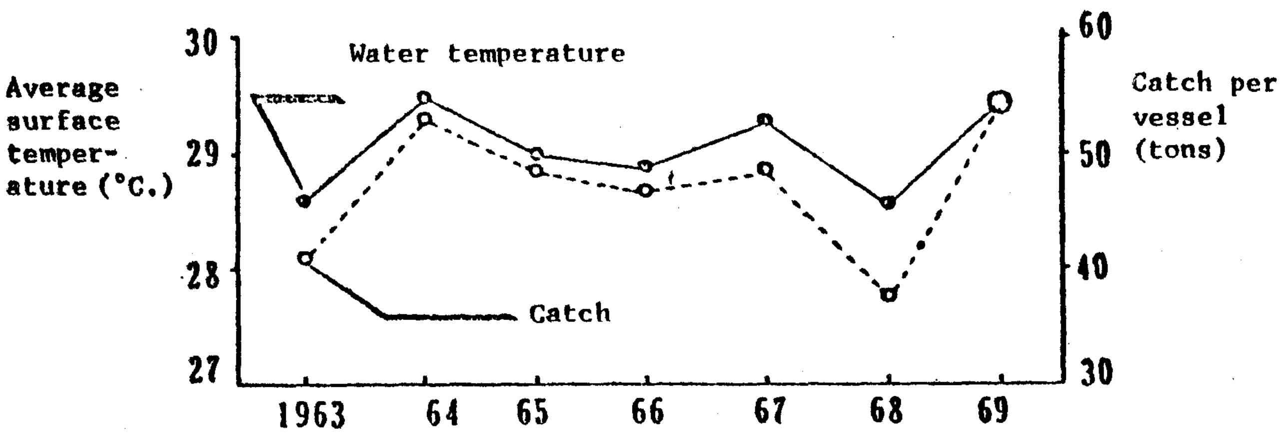


Figure 17.--Annual variations in water temperature and catches (Iwasaki 1970b).

north near lat. 14°-20° and between long. 142° and 148° E (between Guam and Farallo de Pajaros in the Marianas), the catch per vessel per day was slightly better, averaging between 4 and 8 t (4.4 and 8.8 st).

Although small, the landings of yellowfin tuna caught by the pole-and-line vessels operating in southern waters should be mentioned. Kikawa and Warashina (1972) found that the landings of yellowfin tuna averaged 4.9% of the total pole-and-line vessel landings with monthly averages varying between 1.6 and 9.9%. The yellowfin tuna ranged from 0.5 to 19.5 kg (1 to 43 lb) but most were between 1.4 and 2.3 kg (3 and 5 lb). Kikawa and Warashina also estimated that the monthly percent of fishing days with catches of yellowfin tuna averaged 30.1% with monthly averages between 16.8 and 48.3%.

Table 17.--Monthly number, total landings (estimated), and landings per vessel of Japanese bait boats operating in southern waters and returning to Yaizu (Otsu;[1] Tanaka undated a, b, c, d, 1978, 1980; Tohoku Regional Fisheries Research Laboratory undated d, e).

Month	1964			1965			1966			1967		
	Number of vessels	Landings (tons)	Landings per vessel	Number of vessels	Landings (tons)	Landings per vessel	Number of vessels	Landings (tons)	Landings per vessel	Number of vessels	Landings (tons)	Landings per vessel
May										8	277	34.5
June	9	328	37.4	3	58	19.3				5	161	32.2
July	26	1,050	40.4	63	2,225	35.3	6	264	44.0	46	1,853	40.3
Aug.	37	1,771	47.8	49	1,724	35.2	24	903	37.6	29	1,363	47.0
Sept.	40	1,559	39.0	43	2,084	48.4	23	972	42.3	30	1,225	40.9
Oct.	38	1,044	27.5	44	1,312	29.8	31	1,022	32.9	54	1,844	34.2
Nov.	38	1,215	32.0	52	1,528	29.4	56	1,929	34.5	67	3,110	46.5
Dec.	52	1,852	35.6	60	1,445	24.1	59	2,033	34.4	64	3,162	49.5
Jan.	7	305	43.6	19	702	36.9	26	1,090	42.0	67	1,754	26.2
Feb.	13	667	51.3	63	2,547	40.4	76	3,684	48.5	78	5,628	72.2
Mar.	86	3,443	40.1	136	6,484	47.5	123	5,881	47.8	100	4,729	47.3
Apr.	24	735	30.6	66	2,212	33.5	53	1,883	35.6	61	3,216	52.7
Total	370	14,020	37.9	598	22,321	37.3	477	19,661	41.2	609	28,292	46.7

Month	1968			1969			1970			1971		
May	4	232	58.0									
June	9	303	33.7	4	73	18.3				8	208	26.0
July	67	2,609	39.1	32	1,542	48.2	45	2,657	59.0	60	4,193	70.0
Aug.	44	1,897	43.1	38	1,847	48.6	35	1,833	52.4	89	6,049	68.0
Sept.	35	1,178	33.7	40	1,864	46.6	35	1,652	44.4	45	2,673	59.5
Oct.	37	1,364	36.9	43	1,975	45.9	35	1,959	56.0	82	4,594	56.0
Nov.	46	1,561	34.0	48	2,516	52.4	71	3,613	50.9	94	6,857	73.0
Dec.	80	2,586	32.4	67	3,693	55.1	[2]62	3,654	58.9	94	6,456	68.7
Jan.	11	719	65.4	9	588	65.3	12	927	77.2	15	1,243	82.9
Feb.	61	2,598	42.6	51	2,777	54.5	65	6,423	98.8	54	3,975	73.7
Mar.	74	3,058	41.3	108	7,421	68.8	78	6,065	77.7	77	6,183	80.3
Apr.	71	3,123	44.0	86	3,934	45.7	63	4,454	71.0	66	6,152	93.2
Total	539	21,228	39.5	526	28,230	53.9	501	33,237	66.5	[3]713	51,286	71.9

Table 17.--Continued.

Month	1972 Number of vessels	1972 Landings (tons)	1972 Landings per vessel	1973 Number of vessels	1973 Landings (tons)	1973 Landings per vessel	1974 Number of vessels	1974 Landings (tons)	1974 Landings per vessel	1975 Number of vessels	1975 Landings (tons)	1975 Landings per vessel
May	[4]			[4]			54	[6]9,200	170.4	39	4,299	110.2
June	[4]			[4]			[4]			15	[5]1,185	79.7
July	56	2,650	47.3	14	1,088	77.7	12	751	62.6	47	[5]3,799	80.4
Aug.	39	2,430	62.3	54	[5]4,149	76.8	61	5,676	93.0	69	[5]7,907	114.5
Sept.	22	1,369	62.2	61	[5]8,120	133.1	50	4,311	86.2	83	[5]7,818	94.2
Oct.	70	4,706	67.2	83	[5]10,875	131.0	96	7,915	82.4	87	5,524	63.5
Nov.	81	5,150	63.6	82	[5]9,665	117.9	78	6,527	83.6	78	6,592	84.5
Dec.	76	5,515	72.5	99	[5]10,556	106.6	95	7,949	83.6	100	8,315	83.1
Jan.	[4]			24	[5]3,213	133.9	23	2,495	108.4	20	[5]2,176	108.8
Feb.	[4]			52	7,152	137.5	41	4,354	106.2	42	[5]4,496	107.0
Mar.	[4]			70	[5]9,086	129.8	113	11,040	97.6	88	[5]11,696	132.9
Apr.	[4]			79	[5]11,178	141.5	100	11,093	110.9	83	11,931	143.7
Total	—	—	—							751	75,738	100.8

Month	1976 Number of vessels	1976 Landings (tons)	1976 Landings per vessel	1977 Number of vessels	1977 Landings (tons)	1977 Landings per vessel	1978 Number of vessels	1978 Landings (tons)	1978 Landings per vessel	1979 Number of vessels	1979 Landings (tons)	1979 Landings per vessel
May	[4]			[4]			[4]			[4]	[5]6,324	
June	[4]			13	[5]933	71.8	5	[5]314	62.8	[4]	[5]1,063	
July	39	[5]1,344	34.4	80	[5]10,710	133.8	71	[5]5,470	77.0	[4]	[5]1,582	
Aug.	24	[5]2,151	89.6	66	[5]7,820	118.4	[4]	2,652		[4]	[5]2,097	
Sept.	52	[5]5,354	102.9	65	[5]5,590	86.0	[4]	[5]2,214		[4]	[5]2,968	
Oct.	65	[5]6,885	105.9	69	[5]6,656	96.5	59	[5]6,532	110.7	46	[5]5,433	118.1
Nov.	72	[5]8,879	123.3	76	[5]8,143	107.1	53	[5]5,856	110.4	34	[5]3,009	88.5
Dec.	87	[5]9,192	105.6	84	[5]9,208	109.6	90	[5]10,548	117.2	77	[5]8,733	113.4
Jan.	24	[5]2,761	115.0	24	[5]3,921	163.4	9	[5]1,044	116.0	15	[5]1,659	110.6
Feb.	34	[5]3,209	94.4	47	[5]6,205	132.0	24	[5]2,496	104.0	25	[5]3,148	125.9
Mar.	100	[5]10,924	109.2	96	[5]15,304	159.4	86	[5]9,484	110.3	75	[5]9,106	121.4
Apr.	66	[5]7,315	110.8	91	13,368	146.9	[4]	5,079	—	66	[5]8,623	130.7
Total												

[1]Otsu, T. 1973. Trip report: Trip to Japan, February 3-22, 1973. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.
[2]Includes 55-ton catch of one purse seiner.
[3]Includes 2,703 tons taken by 29 vessels in May 1972.
[4]Data unavailable.
[5]Includes small quantities of yellowfin and bigeye tunas.
[6]Includes landings of 1-10 May only.
Note: Annual totals for 1972-74 and 1976-79 not included because some of the monthly values were not available.

Data from Yong and Wetherall (1980) indicate that the Japanese bait boat catch and effort in the U.S. Fishery Conservation Zone (FCZ) around Guam and the Northern Mariana Islands (Figure 18) fluctuated irregularly but showed a declining trend from 1970 to 1977 (Table 18 and Figure 19). The decline in catch and effort of the bait boats in the vicinity of the Mariana Archipelago is perhaps a reflection of the gradual expansion of the fishing grounds in the Japanese southern water skipjack tuna fishery. Kasahara (1977) showed that during the October-May period in the early beginnings of the southern water fishery, the bait boat fishing grounds were pretty much confined to the vicinity of the Marianas. By 1968, the bait boats began to fish farther south in the vicinity of the Western Caroline Islands and by 1971 had moved into the Eastern Caroline Islands. From there, the fishing grounds gradually shifted eastward and by 1973 had reached waters around the Northwestern Hawaiian Islands (between Hawaii and Midway Islands) (Figure 20).

Kasahara also examined the November-April period of the southern water fishery and noted that fishing during the early years was concentrated in waters north of lat. 10° N and west of the Marianas; however, by 1967, the grounds rapidly shifted southward and eastward to an area bounded by lat. 3° and 10° N and long. 135° and 155° E near the Carolines. In 1971, the bait boats expanded not only into the Marshalls but also south of the Equator into the Bismarck Archipelago. By 1973 and 1974 the fishing grounds had extended into the Coral Sea and to the vicinity of the Solomon and Gilbert Islands.

According to a migration model developed by Matsumoto (1975), at least three groups of skipjack tuna, and perhaps more, are found in the north-western Pacific (north of the Equator and west of long. 180°). The west-ernmost groups, one originating off the Philippines (NW1) and the other in the Marianas-Marshalls (NW2) in the first quarter, apparently move north-ward through Japanese waters in the second and third quarters, then return south in the fourth quarter (Figure 21). The third group (NW3) originates east of the Marshalls in the first quarter, then moves northwestward into Japanese offshore waters in the second and third quarters before returning southeastward to the area southwest of Midway Islands in the fourth quarter. These movements of skipjack tuna in the western Pacific, hypo-thesized from longline catches, generally agree with migration routes of skipjack tuna developed by Fujino (1972), who identified genetic charac-teristics of various subpopulations in the Pacific. However, recent studies by the South Pacific Commission indicates an even greater complexity in the subpopulation structure (South Pacific Commission 1976).

Japanese Southern Water Purse Seine Fishery

Despite the success of the southern water pole-and-line fishery, some Japanese fishery scientists anticipated serious future problems of bait shortages. They saw not only the entrance of more and more vessels into the fishery but also the construction of larger vessels with greater bait-carrying capacities. In 1972, Yabe (1972) reported that anchovy used as live bait by the Japanese pole-and-line vessels survived for a maximum of 50 days, but more normally for only about 5 weeks. Therefore, even if larger pole-and-line vessels were built, their operating range would still be limited and their eastern limit would probably be around the Marshall

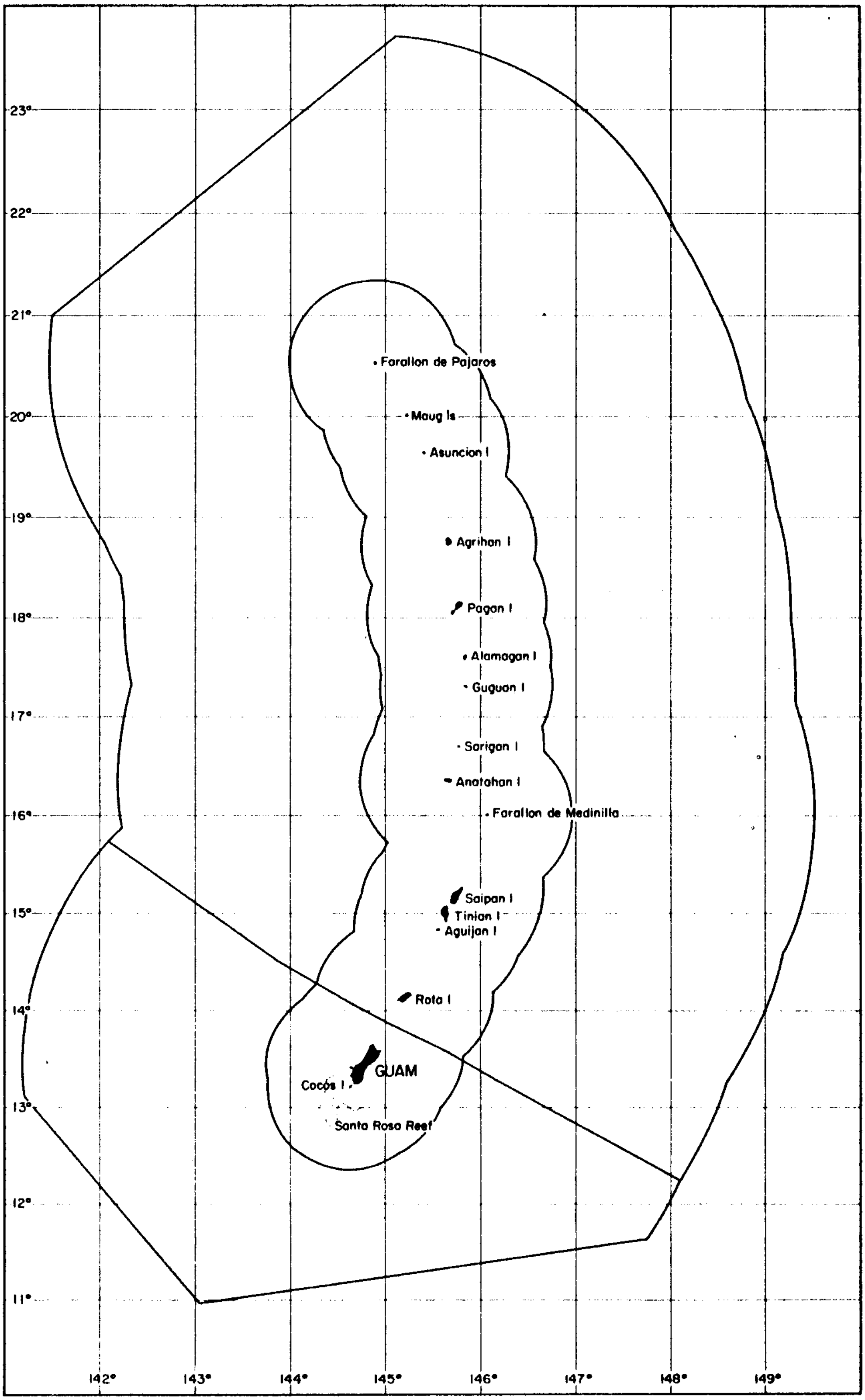


Figure 18.--The 50-mile limits and the Fishery Conservation Zone around Guam and the Northern Mariana Islands (Yong and Wetherall 1980).

Table 18.--Estimated catch and effort by Japanese bait boats around Guam and the Northern Mariana Islands, 1970-77 (Yong and Wetherall 1980).

Year	Effort in vessel days	Total tuna catch (t)
1970	1,944	9,534
1971	2,810	13,008
1972	1,766	7,406
1973	1,657	7,612
1974	1,442	5,005
1975	1,902	7,753
1976	794	2,663
1977	1,442	5,504

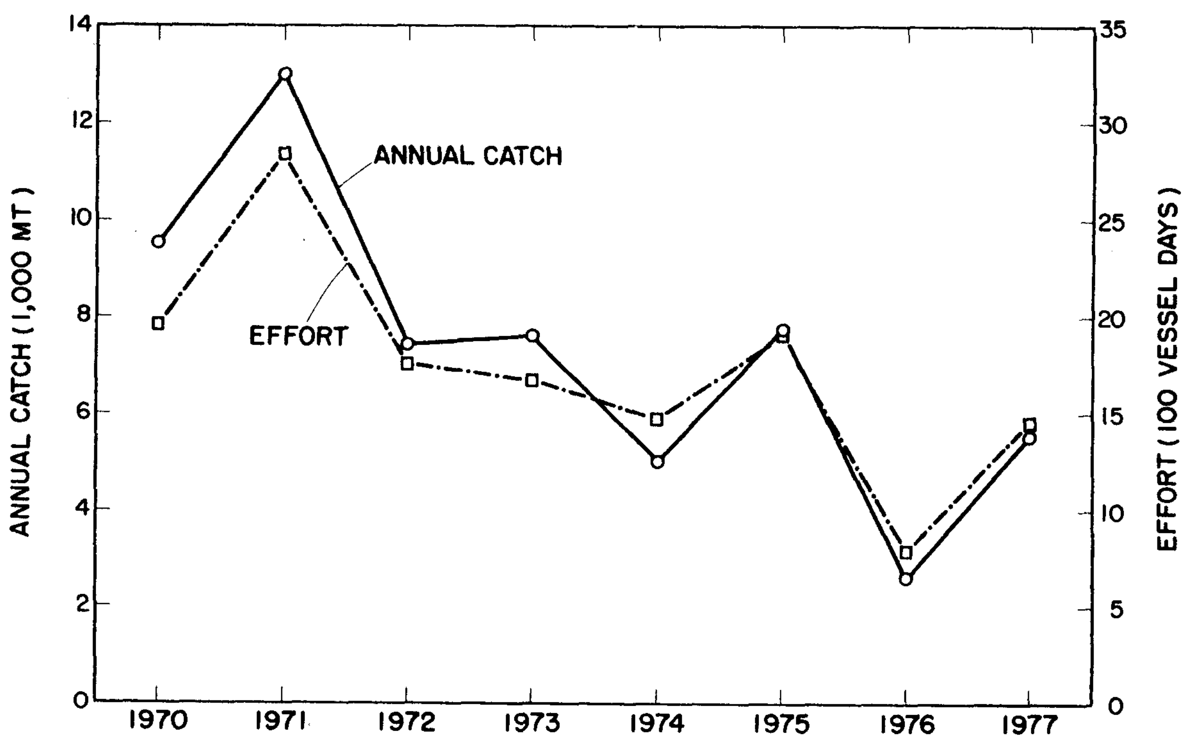


Figure 19.--Estimated catch and effort by Japanese bait boats around Guam and the Northern Mariana Islands, 1970-77 (Yong and Wetherall 1980).

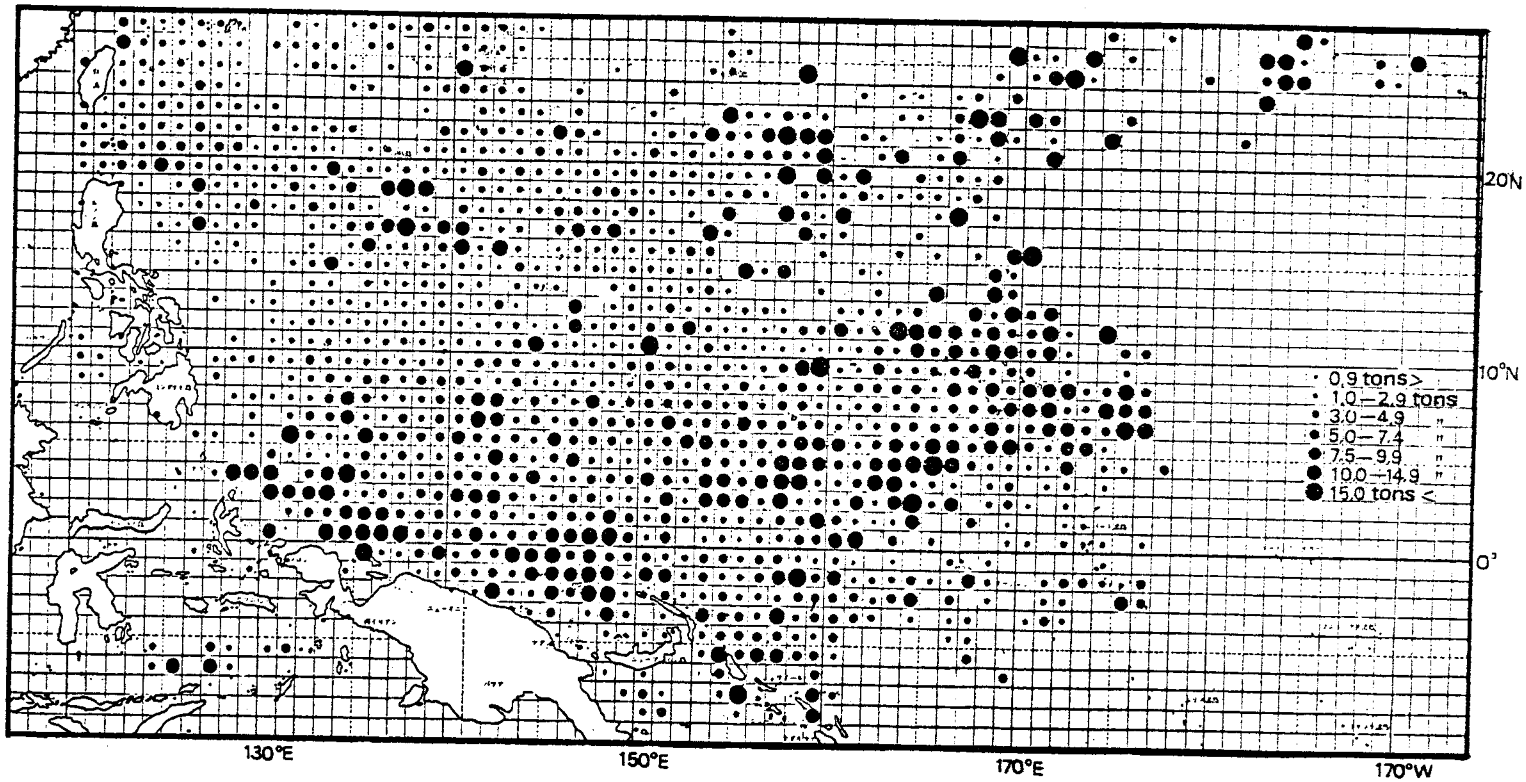


Figure 20.--The fishing grounds of Japanese skipjack tuna vessels in southern waters (Kasahara 1977).

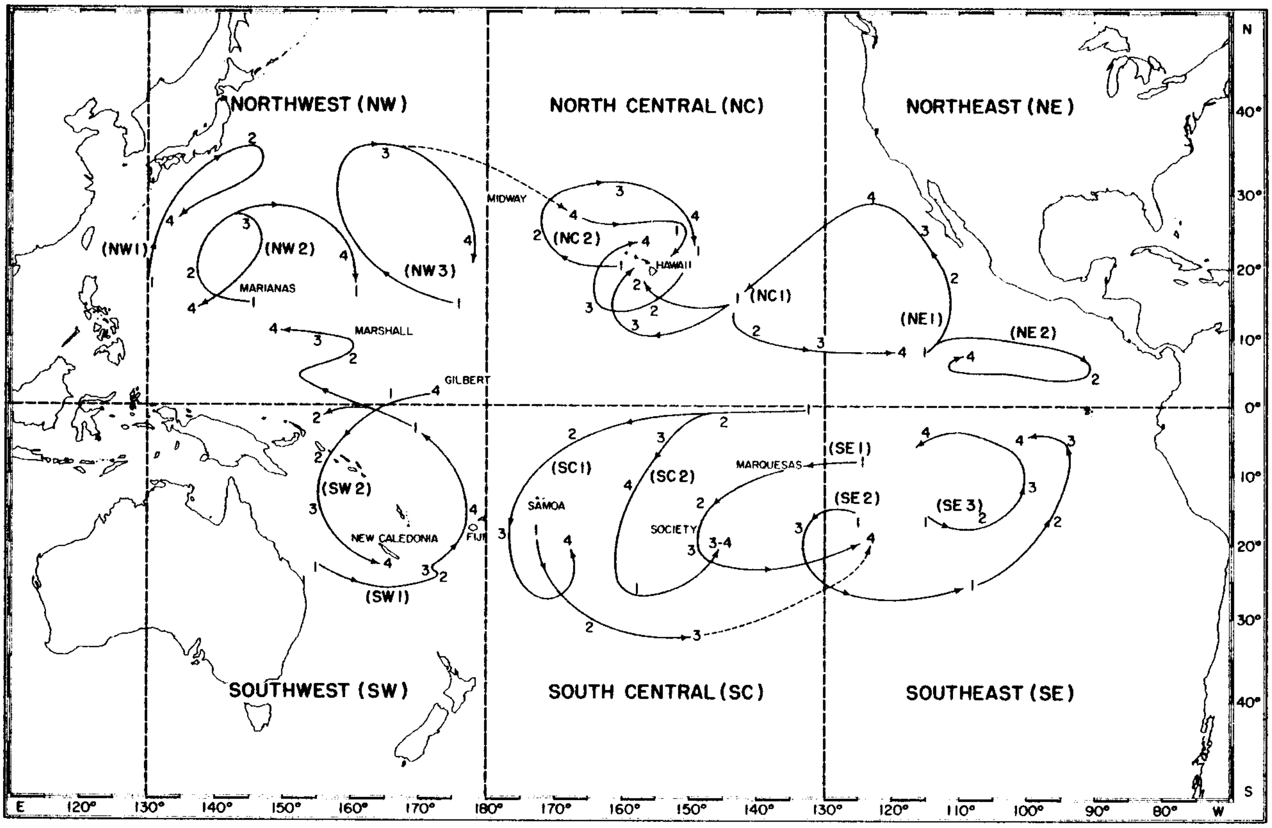


Figure 21.--Assumed movement of the various stocks of skipjack tuna in the Pacific Ocean. The numerals along the migratory routes represent quarters and locations of high catch per unit effort cells of skipjack tuna taken by the Japanese tuna longline fishery, 1964-67. Stock designations are shown in parentheses (Matsumoto 1975).

Islands. Yabe estimated that about 40 Japanese tuna longline vessels will be replaced each year by pole-and-line vessels and that within 3 years there may be many as 200 large pole-and-line vessels fishing in southern waters. Because of the problem of keeping these bait boats supplied with bait, Yabe encouraged more rapid development of the tuna purse seine fishery which is not dependent on live bait.

Japanese attempts to capture surface schools of tuna with purse seine in southern waters started in 1964 when the Taiyo Fishing company dispatched the 240-ton seiner, FV Kenyo Maru, to the New Guinea-New Zealand area (Watakabe 1970). Attempts to seine large- and medium-sized schools of skipjack tuna in waters north of New Guinea failed. In 1966, the Japan Fisheries Agency undertook the development of tuna purse seining and a full-scale test was started in the western equatorial Pacific during the slack, winter months (early November through mid-March) in the Japanese coastal skipjack tuna fishery.

Watakabe (1970) found that the purse seiners experienced a success rate of only 30% on the early trials near the Equator (lat. 0°-5° N, long. 137°-140° E) to the north of New Guinea and near the Palau Islands.

Problems with variable weather, clear water, deep thermocline, and subsurface currents have all been mentioned as hindering the progress of exploratory purse seining in the western Pacific.

The erratic behavior of skipjack tuna schools in the western Pacific was also mentioned as a cause of failure in purse seining (Watakabe 1970). Many of the schools in the vicinity of islands and banks were reported feeding on young sardine or flyingfish and could be seen breaking the surface and causing the water to "boil." These fish aggregated in large schools. Offshore schools appeared to be moving faster and often the direction of movement was unpredictable. The poor results obtained by the four seiners operating in the Trust Territory waters in 1966-69 are given in Table 19.

In the early 1970's the semigovernmental Japan Marine Fishery Resource Research Center (JAMARC) assumed responsibility for the developmental purse seining work (U.S. NMFS footnote 5). During October 1970-March 1971, two seiners were chartered to continue exploratory fishing. Although these seiners captured up to 18.0 t (19.8 st) of skipjack tuna in a single set, most of the catches were smaller (Table 20). The conclusions drawn from these tests were that (1) skipjack tuna schools can be seined in tropical waters under certain conditions, (2) seinable schools were usually associated with floating logs, and (3) purse seine success rate increased if sets were made at dawn or dusk rather than during midday (Yabe 1972).

Table 19.--Catch records of four Japanese purse seiners operating in southern waters, 1966-69 (Watakabe 1970).

	Year			
Vessel	1966	1967	1968	1969
No. 3 *Hayabusa Maru*		(3 trips) Skipjack tuna 80 tons Yellowfin tuna 50 tons	(1 trip) Skipjack tuna 60 tons	(1 trip) Skipjack tuna 67 tons
No. 3 *Taikei Maru*	(3 trips) Skipjack tuna 104 tons Yellowfin tuna 31 tons	(2 trips) Skipjack tuna 43 tons Yellowfin tuna 5 tons	(3 trips) Skipjack tuna 80 tons Yellowfin tuna 36 tons	Did not fish
Nissho Maru	(1 trip) No catch	(4 trips) Skipjack tuna 146 tons Yellowfin tuna 56 tons	(1 trip) Skipjack tuna 26 tons Yellowfin tuna 56 tons	(1 trip) Skipjack tuna 53 tons Yellowfin tuna 25 tons
No. 58 *Tokiwa Maru*		(3 trips) Skipjack tuna 73 tons Yellowfin tuna 102 tons	Did not fish	(1 trip) Skipjack tuna 81 tons

Table 20.--Results of experimental purse seining by Japanese Government chartered vessels, FV No. 23 Taikei Maru (210 gt) and FV No. 58 Tokiwa Maru (358 gt) (Japan Fisheries Agency undated).

Date	Position	Time of day	Type of school set on	Catches made	Vessel
11/9/70	00°09' S, 143°36' E	0455	Drift log; small yellowfin tuna; found by fish finder.	No catch.	No. 23 Taikei Maru
11/11/70	05°53' N, 144°57' E	0814	do	do	Do.
11/12/70	07°02' N, 146°49' E	1625	With whale shark; small yellowfin tuna jumping.	10 yellowfin tuna (30-40 kg) 2 tons of small yellowfin tuna (4-6 kg).	Do.
11/14/70	06°37' N, 149°39' E	1243	Skipjack tuna jumping.	3 tons of small yellowfin tuna (3-4 kg).	Do.
11/15/70	06°37' N, 150°20' E	1200	Skipjack tuna with bird flock.	5 tons of small yellowfin tuna (3-4 kg).	Do.
11/16/70	06°50' N, 151°12' E	1200	Drift log and small yellowfin tuna.	No catch.	Do.
11/22/70	03°06' S, 149°26' E	0755	Skipjack tuna jumping; bird flock.	No catch.	Do.
11/23/70	03°00' S, 149°23' E	1141	Drift log; skipjack tuna jumping; many schools in vicinity.	No catch; Auxis escaped net.	Do.
11/30/70	03°58' S, 147°01' E	1438	Skipjack tuna jumping.	0.5 ton of skipjack tuna (3 kg).	Do.
12/2/70	02°54' S, 145°07' E	1400	Skipjack tuna jumping; bird flock.	7 tons of skipjack tuna (2-3 kg).	Do.
12/15/70	08°34' N, 141°45' E	1550	With whale shark; small yellowfin tuna jumping.	No catch.	Do.
11/30/70	09°29' N, 133°32' E	0840	Drift log and yellowfin tuna.	11 yellowfin tuna (20-25 kg).	No. 58 Tokiwa Maru
12/10/70	02°16' N, 140°14' E	1040	do	1 yellowfin tuna.	Do.
12/12/70	05°06' N, 139°33' E	1020	With drifting bamboo; school on fish finder.	1.5 tons of skipjack tuna (3-4 kg).	Do.
12/16/70	09°36' N, 133°59' E	1216	Skipjack tuna with whale shark.	17 tons of skipjack tuna (4-5 kg).	Do.
1/21/71	02°46' N, 138°47' E	1140	Skipjack tuna breezing school.	No catch.	No. 23 Taikei Maru
2/3/71	03°43' S, 149°07' E	0615	Small skipjack tuna school.	2 tons of skipjack tuna (2-3 kg).	Do.
2/5/71	03°48' S, 146°19' E	1055	do	1.5 tons of skipjack tuna (3 kg).	Do.
2/9/71	01°41' S, 143°35' E	0800	Skipjack tuna breezing school.	No catch.	Do.
2/9/71	01°36' S, 143°35' E	1200	do	No catch.	Do.
2/10/71	02°00' S, 142°25' E	1610	Small school skipjack tuna with bird flock.	1 ton skipjack tuna (2-3 kg).	Do.
2/11/71	02°07' S, 142°21' E	0805	"Boiling" skipjack tuna school with bird flock.	No catch.	Do.
2/12/71	02°00' S, 141°35' E	1330	Small breezing skipjack tuna school.	No catch.	Do.
2/13/71	02°31' S, 142°28' E	1505	Small breezing skipjack tuna school with birds.	5 tons of skipjack tuna (2-3 kg).	Do.
3/5/71	03°12' N, 139°15' E	0525	Drift log, small school.	1 ton of yellowfin tuna (10-15 kg).	Do.
3/7/71	03°38' N, 135°20' E	1345	Drift log, small school.	0.3 ton of yellowfin tuna (1-1.5 kg); 0.7 ton of rainbow runner.	Do.

Table 20.--Continued.

Date	Position	Time of day	Type of school set on	Catches made	Vessel
3/11/71	06°00' N, 140°00' E	1300	Jumping yellowfin tuna with birds.	No catch.	No. 23 Taikei Maru
3/11/71	05°54' N, 140°08' E	1745	do	9 yellowfin tuna (40 kg).	Do.
3/12/71	05°38' N, 140°31' E	1715	do	No catch.	Do.
3/13/71	05°49' N, 140°36' E	0645	School with drift log.	6 tons of yellowfin tuna; 2 tons of small yellowfin tuna; 2 tons of skipjack tuna.	Do.
3/15/71	05°49' N, 140°10' E	0615	do	1 ton of yellowfin tuna; 4 tons of small yellowfin tuna; 10 tons of skipjack tuna.	Do.
1/25/71	06°46' N, 139°43' E	0947	"Boiling" school of skipjack tuna with birds.	8 tons of skipjack tuna (3 kg).	No. 58 Tokiwa Maru
2/8/71	00°05' S, 146°47' E	0520	Small school of yellowfin tuna with drift log.	1 ton of yellowfin tuna (25-30 kg).	Do.
2/23/71	00°11' S, 141°05' E	0545	Skipjack-yellowfin tuna mixed school with drifting bamboo.	1.5 tons of yellowfin tuna (2-3 kg); 1.5 tons of skipjack tuna (3-4 kg).	Do.
3/13/71	05°56' N, 140°24' E	0532	do	18 tons of skipjack tuna (3-4 kg); 2 tons of yellowfin tuna (10-20 kg).	Do.
3/13/71	05°50' N, 140°28' E	1328	Jumping yellowfin tuna school.	No catch.	Do.
3/15/71	06°10' N, 140°05' E	0512	Skipjack-yellowfin tuna mixed school with drift log.	2 tons of skipjack tuna (3-4 kg); 6 tons of yellowfin tuna (3-20 kg).	Do.

In 1974, JAMARC chartered a 499-gt purse seiner the FV Fukuichi Maru, which made three exploratory purse seining cruises around the Marshall Islands and Carolines (U.S. NMFS 1974a, 1974b). During the first 2-month survey, the seiner caught 229 t (252 st) of skipjack tuna and 53 t (58 st) of yellowfin tuna, a total of 282 t (310 st) of tuna in 27 sets or an average of 10.4 t (11.5 st) per set (U.S. NMFS 1974c; Otsu 1975). On her second cruise to the southeast of Palau, the Fukuichi Maru found fishing slower. In 10 sets, 22 t (24 st) of skipjack tuna and 33 t (36 st) of yellowfin tuna were taken or an average of 5.5 t (6.1 st) of tuna per set. The third cruise started in the Eastern Carolines (lat. 4°-8° N and long. 145°-151° E) where three sets yielded 19 t (20 st) of fish. Heading to waters southeast of Palau, the seiner continued to experience poor fishing. Fourteen sets yielded 127 t (140 st) or an average of 9.1 t (10.0 st) per set. Toward the end of the survey, the Fukuichi Maru caught 20 t (22 st) in one set at lat. 2° and long. 144° E.

On the three cruises the Fukuichi Maru set on 53 schools associated with drifting objects and caught 168 t (185 st) of yellowfin tuna, 320 t (353 st) of skipjack tuna, and 12 t (13 st) of miscellaneous species.

Because of the success of Japanese seiners in setting around skipjack tuna and yellowfin tuna schools that were associated with drifting objects, Japanese researchers initiated studies on the possibility of aggregating tuna under artificial drifting objects (Otsu 1975). Preliminary results indicated that there is some merit in this approach.

By 1975, the Japanese fishermen considered purse seining to be commercially feasible and several seiners began operating in the western Pacific and in the Coral Sea (Otsu 1975). Overall, the catches averaged 10 t (11 st) per set and about 80% of the sets were successful in catching tuna. Data from 1977 to 1979, however, indicated that the catch per set has improved significantly (Table 21) and has been as high as 48.8 t (53.0 st) per set (Tanaka 1978).

Compared with U.S. seiners in the eastern tropical Pacific tuna fishery, Japanese seiners are considerably smaller, varying from 250 to 500 gt, and average smaller catches per set. The Japanese fishermen believe that they can achieve success under the following conditions:

- Schools must be associated with drifting objects (driftwood, etc.)
- Sets must be made either early in the morning or at dusk.
- Nets must be larger than those used in the eastern Pacific.

When a school associated with a drifting object is found, a seiner may often follow it until dusk or early morning (Otsu 1975). Marking the drifting object with a radio buoy or lights, the seiner may track a school overnight and set on it in the early morning.

The success that the Japanese seiners enjoyed in the western Pacific did not go without notice. United States seiners, faced with the fact that the yellowfin tuna resource in the eastern Pacific was fully exploited and that the restriction placed on the stock shortened their fishing season,

Table 21.--Catch data from Japanese purse seiners operating in the western Pacific, June-October 1977, June 1978-April 1980 (Tanaka 1978, 1980, undated d). Number in parentheses are averages.

		Catch (t)			
Month/year	Number of sets	Skipjack tuna	Yellowfin and bigeye tunas	Total	Catch per set
June 1977	127	--	--	1,905.1	15.0
July	70	--	--	1,391.3	19.9
Aug.	--	1,303.2	546.7	1,849.9	--
Sept.	--	1,487.1	836.5	2,323.6	--
Oct.	103	1,538.8	885.6	2,424.4	23.5
June 1978	70	--	--	1,022.5	14.6
July	157	--	--	2,693.6	17.1
Aug.	124	--	--	1,783.1	14.3
Sept.	95	--	--	1,551.8	16.3
Oct.	155	--	--	2,813.6	18.2
Nov.	134	--	--	2,308.4	17.2
Dec.	80	--	--	2,025.6	25.3
Jan. 1979	79	--	--	2,091.4	26.5
Feb.	150	--	--	3,371.0	22.5
Mar.	11	--	--	304.0	27.6
Apr.	149	--	--	3,300.4	22.2
May	--	1,128.0	503.0	1,631.0	--
June	--	1,544.2	682.4	2,226.6	--
July	15-31 (22.5)	[1]1,566.8	815.7	2,382.5	11.7-27.5 (17.5)
Aug.	15-32 (19.7)	[1]2,926.9	1,336.3	4,253.2	-- (21.3)
Sept.	13-40 (26.2)	949.3	1,064.7	2,014.0	-- (16.0)
Oct.	11-36 (26.0)	1,132.8	941.1	2,073.9	10.7-18.9 (13.3)
Nov.	-- (31.2)	1,348.4	507.6	1,856.0	-- (14.8)
Dec.	22-36 (30.0)	1,135.7	457.1	1,592.8	-- (13.3)
Jan. 1980	-- (25.8)	1,940.9	1,441.7	3,382.6	-- (16.4)
Feb.	10-43 (23.9)	2,420.4	[1]1,014.9	3,435.2	-- (18.0)
Mar.	13-25 (18.2)	1,867.5	1,198.7	3,066.2	-- (21.0)
Apr.	8-31 (16.9)	3,166.6	1,339.5	4,506.1	-- (26.7)

[1]Includes some deliveries by transport vessels.

looked to the western Pacific as an area with considerable promise for expansion. In 1976, the Pacific Tuna Development Foundation (PTDF), a cooperative enterprise among the U.S. tuna industry, NMFS, and the Governments of Hawaii, American Samoa, Guam, and the Northern Marianas, chartered three tuna seiners--MV Apollo, MV Mary Elizabeth, and MV Zapata Pathfinder--to conduct experimental purse seining operations in the western Pacific (Figure 22). This venture produced not only catch data (Table 22), but also a wealth of information on tuna school behavior and on water characteristics in the western Pacific (Living Marine Resources (LMR)).[6] Among the recommendations by the captains and scientific observers were:

- Seiners should be in the 400- to 600-ton capacity range.
- Purse seines should be fabricated of light webbing, be 1,829 m (1,000 fathoms) in length, and 20-22 strips in depth.
- Fishing should be concentrated on schools associated with floating objects, either man-made or natural.
- If possible, long-range aerial surveys should be conducted prior to the start of fishing operations.

Japanese Longline Fishery Development

Longline fishing for subsurface tunas in the western Pacific was reestablished by the Japanese after the end of World War II in the area authorized by the Supreme Commander for the Allied Powers (SCAP) on 22 June 1946 (Figure 23). On 11 May 1950, roughly 4-1/2 years after the war, a new phase of the Japanese tuna longline fisheries was launched when the Commander-in-Chief, U.S. Pacific Fleet (CINCPAC) and SCAP permitted the Japanese to send tuna mother ship expeditions to defined areas of the high seas adjacent to the Carolines, Marianas, and Marshall Islands (Shimada 1951).

Figure 23 shows not only the original area authorized by SCAP, but also the area authorized for inspection vessels and that designated for mother ship operations. The first mother ship fleet, consisting of a large refrigerated carrier and 25 longline vessels, was outfitted in Japan and began fishing on 17 June 1950 in Trust Territory waters (Figure 24) (Shimada 1951).

In 79 days of operation in waters south of the Carolines (between 17 June and 5 September) the total catch reached 3,683 t (4,059 st) (Shimada 1951). Among the subsurface tunas in Trust Territory waters, the yellowfin tuna was by far the most abundant, comprising 50% of all the fish landed (Table 23). Next in importance was the bigeye tuna. Albacore, bluefin, and skipjack tunas comprised only a small percentage of the catch.

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[6]Living Marine Resources. 1977. Tuna purse-seine charter to the western Pacific, July-November 1976. Final report submitted to Pacific Tuna Development Foundation, Honolulu, 14 p.

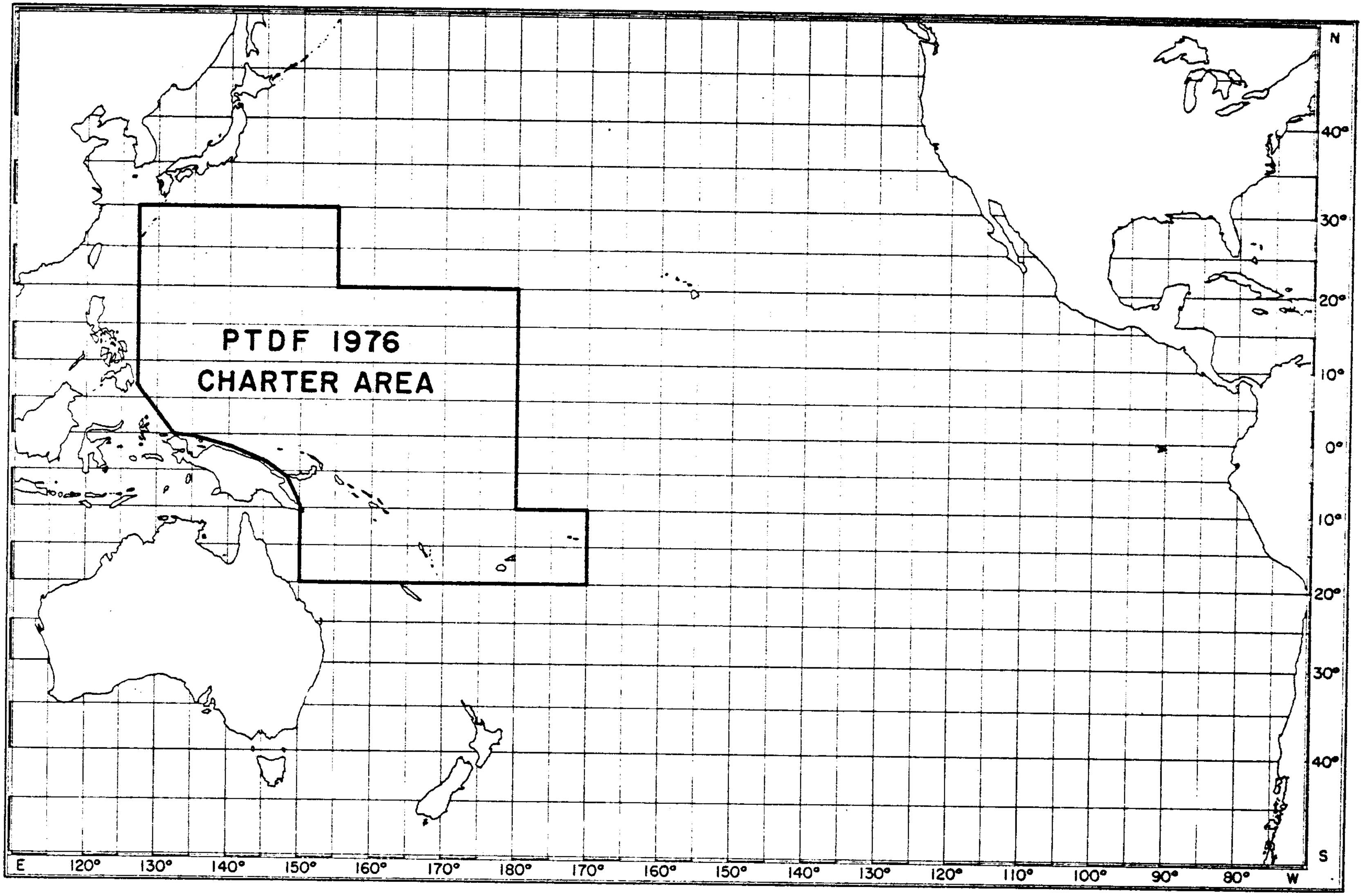


Figure 22.--Operating area of the U.S. tuna seiners during the 1976 Pacific Tuna Development Foundation charter (Living Marine Resources text footnote 6).

Table 22.--Catch of U.S. seiners, by species and size, in the western Pacific, July-October 1976 (Living Marine Resources text footnote 6).

	Skipjack tuna (st)				Yellowfin/bigeye tunas (st)			
	Under 4 lb	4-5 lb	Over 5 lb	Total	Under 7.5 lb	Over 7.5 lb	Total	Total
Apollo	111.8	64.4	81.7	257.9	61.7	5.6	67.3	325.2
Mary Elizabeth	55.5	31.5	47.2	134.2	52.9	24.4	77.3	211.5
Zapata Pathfinder	--	15.0	100.0	115.0	8.0	59.6	67.6	182.6
Total	167.3	110.9	228.9	507.1	122.6	89.6	212.2	719.3
Percent size	33.0	21.9	45.1	100.0	57.8	42.2	100.0	
Percent species				70.5			29.5	100.0

Table 23.--Total catch, by species, of the first Japanese tuna mother ship expedition, June-September 1950 (Shimada 1951).

Species	Quantity caught (kg)
Yellowfin tuna	2,074,929
Bigeye tuna	317,073
Albacore	29,655
Northern bluefin tuna	1,556
Skipjack tuna	3,161
Blue marlin	798,512
Black marlin	21,855
Striped marlin	557
Sailfish[1]	12,773
Swordfish	6,194
Shark	405,982
Others[2]	10,455
Total	3,682,702

[1]Includes shortbill spearfish.
[2]Includes Pacific barracuda, wahoo, and mahi-mahi.

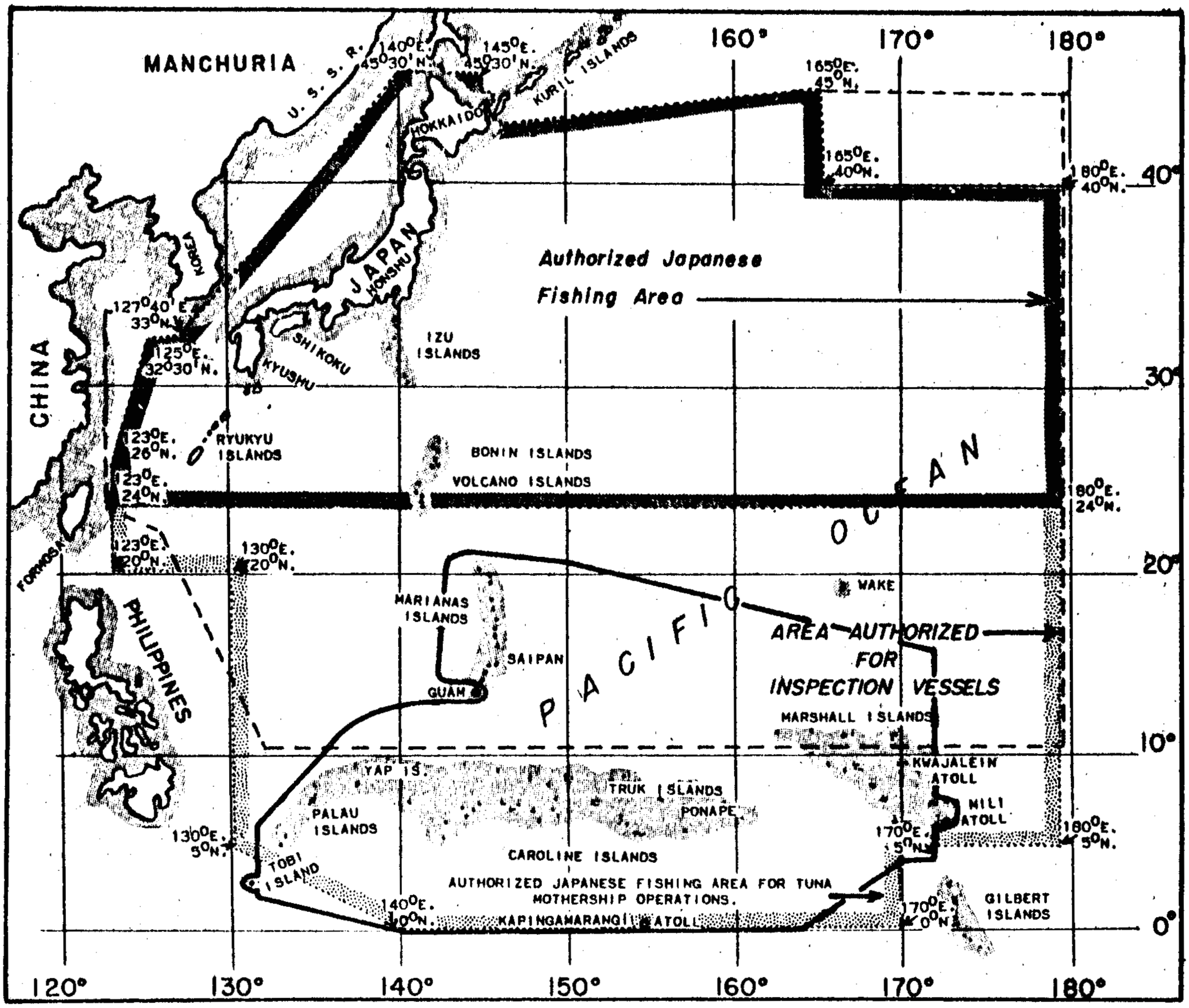


Figure 23.--Horizontally lined border indicates extent of the CINCPAC-SCAP authorized Japanese fishing area as of 11 May 1950. Broken black line indicates area authorized for Japanese inspection vessels. Dotted-stippled border shows extension south of lat. 24° N to the Equator for Japanese tuna mother ship operations. Solid black line around Mariana, Marshall, and Caroline Islands shows the U.S. Trust Territory of the Pacific Islands (Shimada 1951).

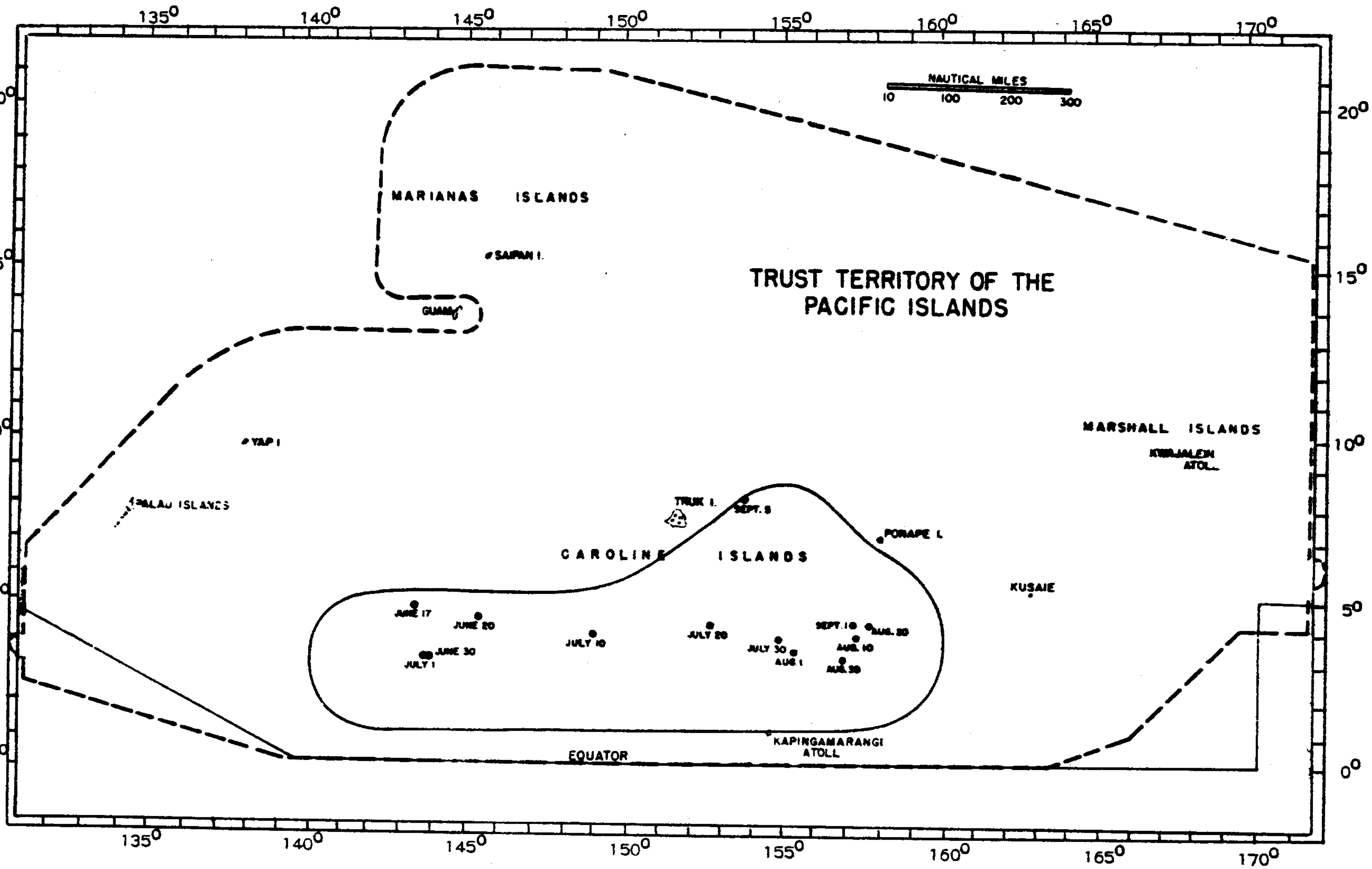


Figure 24.--General area of operations (solid black line) in waters surrounding Trust Territory of the Pacific Islands (dotted line) of the first Japanese tuna mother ship expedition. Dated positions are those of the mother ship during the season, from 17 June to 5 September 1950 (Shimada 1951).

Shimada (1951) noted that the catcher boats attached to the expedition experienced wide fluctuations in catches. The average catch per vessel was high when operations first commenced but fell to about 2.0-2.5 t (2.2-2.8 st) per vessel per day as the peak fishing season in May-June passed (Figure 25). The expedition moved eastward and found new productive grounds. In mid-July, the vessel had several days of good fishing in waters adjacent to Kapingamarangi near lat. 1°-2° N between long. 153° and 154° E. In late July and early August, some of the best fishing was encountered near Kapingamarangi. Based on current drifts, Shimada believed that the zone of good fishing was probably within the Equatorial Countercurrent and close to its southern border. In late August, at the close of the season catches fell to lower levels as the expedition shifted northward out of the productive area.

Catch rates were 3.23 tunas and spearfishes per 100 hooks and 3.85 fish per 100 hooks for all species (Shimada 1951) (Table 24). In contrast, Nakamura (1943) reported an average of 6.05 fish per 100 hooks from Trust Territory waters in prewar years. According to the fishermen, changes in hydrographic conditions were probably most responsible for the lower catches made by the expedition.

After the initial tuna mother ship operation and until October 1951, eight others took place (Murphy and Otsu 1954). General observations on the methods, catch, and area fished during these expeditions have been published in Ego and Otsu (1952) and Van Campen (1952). Ego and Otsu found that the catch rates did not vary much during the first six expeditions (Table 25). The first expedition achieved the lowest catch rate for all species with 3.85 fish per 100 hooks whereas the third recorded the highest with 4.76 fish per 100 hooks. Van Campen reported catch rates of 4.47, 4.04, and 3.55 fish per 100 hooks during the seventh, eighth, and ninth expeditions, respectively. The overall average of all species for the nine expeditions was 4.10 fish per 100 hooks.

The subsequent development of the longline fishing grounds in the western Pacific resulted from the lifting of all restrictions imposed immediately after the war. According to Nippon Suisan Shimbun (1953), the SCAP boundary, also called the MacArthur Line, severely restricted the operating radius of the Japanese longliners. But on 25 April 1952, the MacArthur Line was removed so that Japanese vessels were no longer restricted. International complications with the People's Republic of China followed and the result was that Japanese vessels could no longer operate freely in Korean waters, the East China Sea, and the Yellow Sea. Furthermore, the North Pacific fisheries were also markedly restricted. Thus, the Japanese longliners spread southward into Micronesian waters and the South Pacific, and eastward into the central and eastern Pacific.

In tracing the expansion of the Japanese longline fishing effort after 1952, Rothschild (1966a) found that effort tended to be concentrated off Japan in the western Pacific in the early 1950's, shifted more toward the central Pacific in the mid- and late-1960's, and was largely concentrated at the longitude of Baja California in the southeastern Pacific by the early 1960's (Figure 26). By latitude, the expansion went from the North Pacific in 1953 to the South Pacific by 1963.

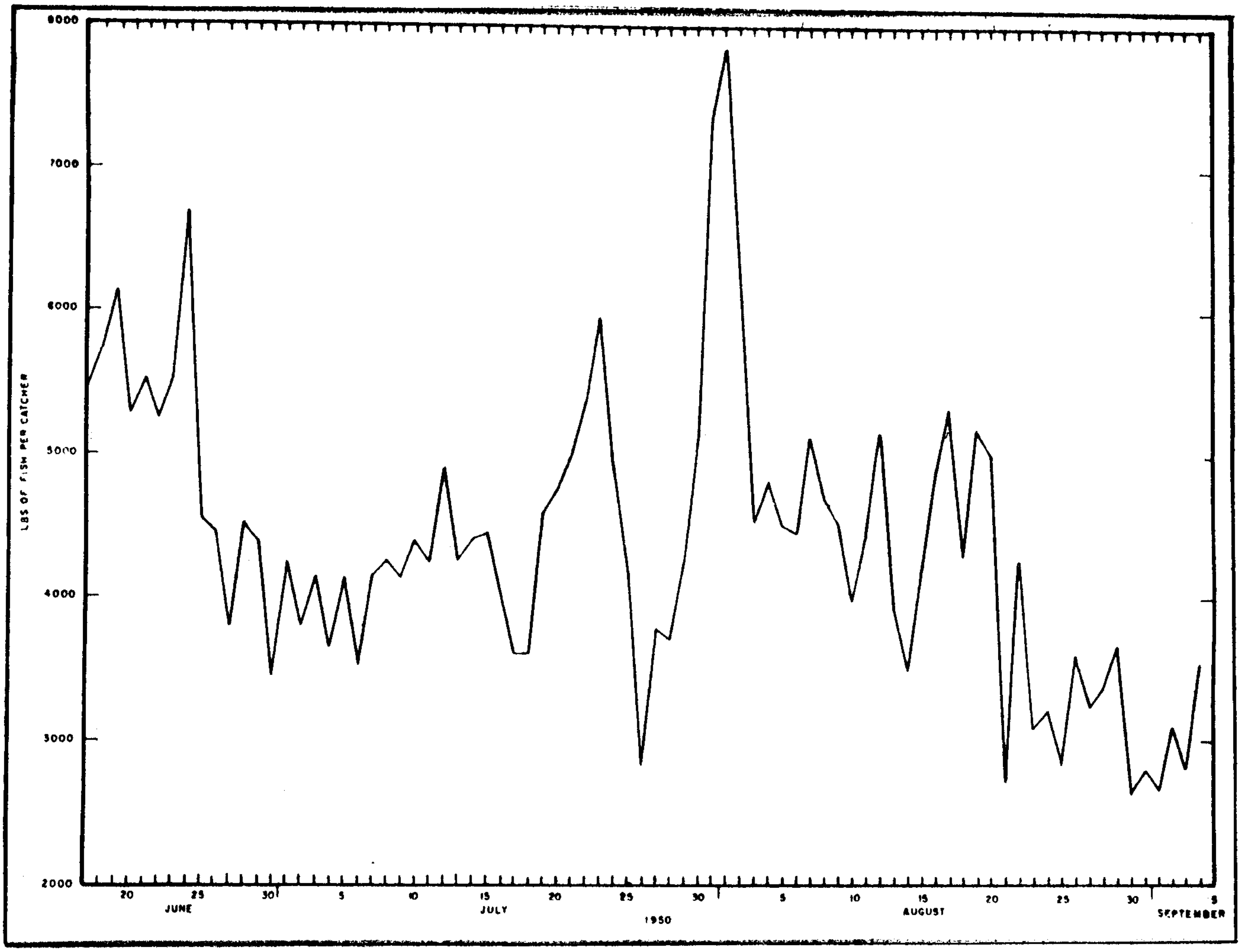


Figure 25.--Average catch of fish per day per catcher based on daily reported landings (Shimada 1951).

Table 24.--Japanese tuna mother ship expeditions, catches, and average weights (in kilograms), by species (Ego and Otsu 1952).

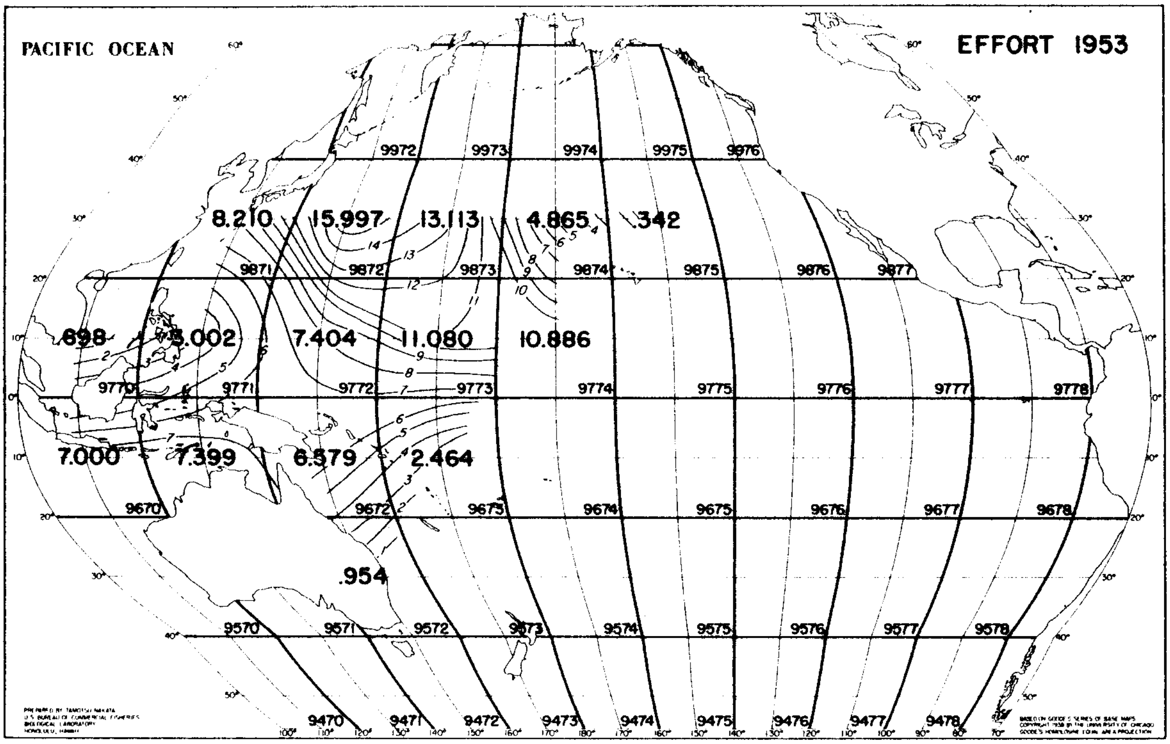
	Expeditions											
	First		Second		Third		Fourth		Fifth		Sixth	
Species	Total	Avg.	Total	Avg.	Total	Avg.	Total	Avg.	Total	Avg.	Total	Avg.
Yellowfin tuna	2,074,176	34	1,472,606	46	179,575	30	365,424	35	1,071,717	34	322,391	34
Bigeye tuna	316,958	36	180,040	44	38,426	41	63,041	44	391,487	39	71,940	44
Albacore	29,645	20	1,099	22	3,641	19	4,543	21	5,310	22	403	16
Northern bluefin tuna	1,555	156	--	--	--	--	--	--	400	165	--	--
Skipjack tuna	3,160	4	7,562	5	560	4	228	3	379	5	1,152	3
Blue marlin	798,223	59	656,594	68	32,935	53	133,856	60	298,916	59	95,896	57
Black marlin	21,847	78	1,128	75	2,492	78	3,613	68	9,495	66	1,031	57
Sailfish[1]	12,769	20	5,398	14	1,432	18	3,903	17	15,877	17	4,907	18
Swordfish	6,192	34	2,861	41	1,658	26	1,072	44	5,280	38	1,622	46
Striped marlin	557	56	728	56	86	36	105	53	236	39	168	56
Shark	405,835	25	182,582	33	16,794	43	13,117	33	174,971	30	18,936	31
Others[2]	10,453	13	9,661	13	1,857	8	5,549	10	10,612	9	7,532	10
Total	3,681,370		2,520,259		279,456		594,451		1,984,680		525,978	

[1]Includes shortbill spearfish.
[2]Includes barracuda, wahoo, and mahimahi.

Table 25.--Catch rates of Japanese tuna mother ship expeditions (Ego and Otsu 1952; Van Campen 1952).

	Number of fish caught per 100 hooks, by expeditions									Average for expeditions 1 through 9
Species	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth	
Yellowfin tuna	2.28	2.50	3.38	2.71	2.24	2.49	2.09	1.64	1.40	2.14
Bigeye tuna	0.33	0.32	0.37	0.38	0.70	0.43	0.93	0.80	0.88	0.62
Albacore	0.05	0.04	0.11	0.06	0.02	<0.01	0.06	0.16	0.10	0.07
Northern bluefin tuna	<0.01	--	--	--	<0.01	--	<0.01	<0.01	<0.01	<0.01
Skipjack tuna	0.03	0.11	0.08	0.02	<0.01	0.09	0.07	0.06	0.08	0.05
Blue marlin	0.50	0.76	0.36	0.59	0.35	0.45	0.60	0.48	0.75	0.53
Black marlin	0.01	0.01	0.02	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sailfish[1]	0.02	0.03	0.04	0.06	0.07	0.07	0.04	0.04	0.03	0.04
Broadbill swordfish	<0.01	0.01	0.04	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Striped marlin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Shark	0.60	0.44	0.23	0.10	0.41	0.16	0.57	0.75	0.14	0.54
Others[2]	0.03	0.06	0.13	0.14	0.08	0.19	0.09	0.10	0.16	0.08
Tunas and marlins	3.23	3.77	4.40	3.84	3.40	3.55	--	--	--	--
Total	3.85	4.27	4.76	4.08	3.89	3.89	4.47	4.04	3.55	4.10

[1]Includes shortbill spearfish.
[2]Includes barracuda, wahoo, and mahimahi.



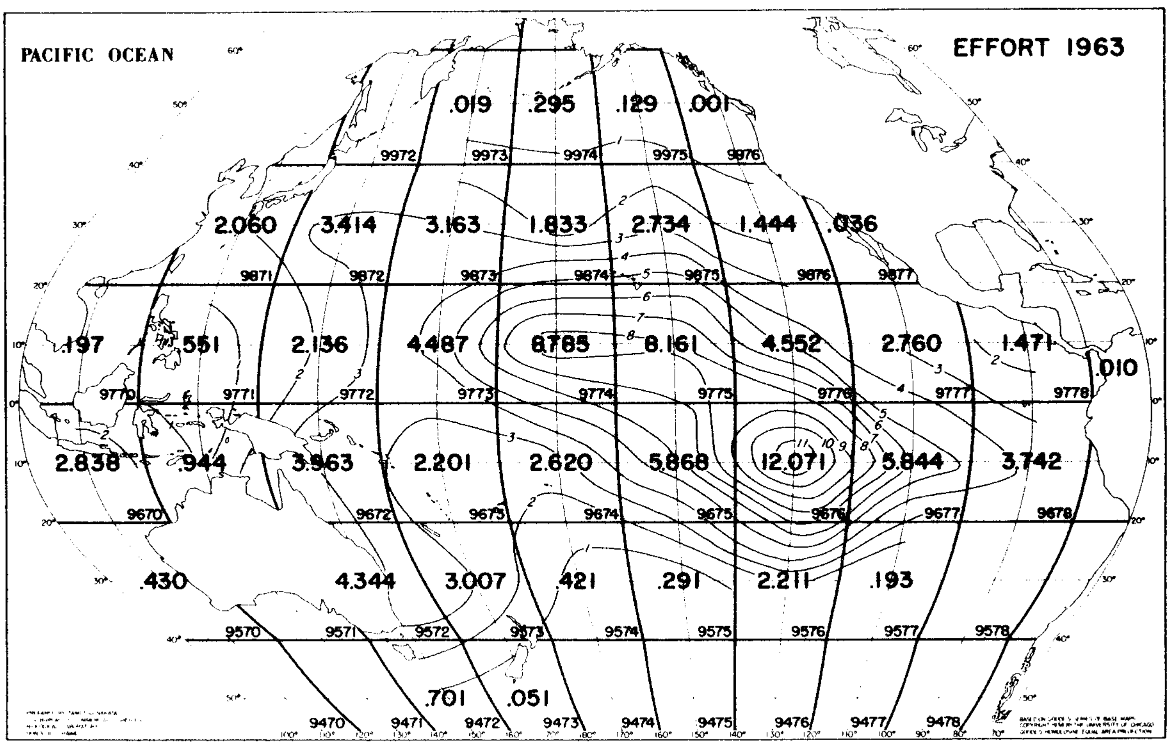


Figure 26.--Percentage of reported total annual effort (numbers of hooks) expended in each 20° quadrangle (Rothschild 1966a).

It was not until the enactment of the Magnuson Fishery Conservation and Management Act (MFCMA) in 1976 that the United States fishing industry first began to realize the impact of the Japanese longline fishery on stocks in waters around Guam and the Northern Marianas. Yong and Wetherall (1980) found that since the enactment of the MFCMA, the Japanese longliners fishing in the western Pacific increased their effort and catch of tunas significantly. Effort by Japanese longliners in terms of vessel days fluctuated between 288 and 1,040 in 1965-75, increased to 1,235 days in 1976 and reached 2,076 days in 1977, more than tripling the average annual effort expended in the years prior to 1976 (Table 26 and Figure 27). This significant rise in the effort was accompanied by a similar rise in catches of tunas. The 1965-75 annual catches fluctuated in a relatively narrow range from 189 to 503 t and averaged 365 t; in 1976 the catch reached 1,299 t or more than three times the 1965-75 average. In 1977, the annual catch increased to 3,366 t or more than nine times the 1965-75 average. The increased effort in 1976-77 did not produce any significant changes in the annual catches of billfishes.

Other Types of Fishery Development

At the end of World War II, the agricultural division of the military government attempted to encourage seafood production by abolishing price ceilings on seafood, by designating certain men of each village as fishermen, by assigning exclusive trap fishing rights to single individuals, and by offering vessels for rent to the fishermen (Smith 1947b). These measures, however, were largely unsuccessful. Van Pel (1961) reported that the presence of the U.S. Naval Command on Guam in the immediate postwar years resulted in the availability of lucrative employment for most of the population. As a result, fishing was relegated to a part-time endeavor.

The failure of this initial attempt to establish a commercial fishery in the island resulted in the gradual dependence of the population on imported fish, some of which were supplied frozen from Palau and the Philippines. In 1967, the Guam Division of Aquatic and Wildlife Resources began an intensive exploration of the grounds beyond the reef, which were believed to be inhabited by a substantial population of prime-quality fish that were almost entirely underutilized (Ikehara et al. 1972).

In the Northern Marianas as in most Pacific islands following World War II, fishing was an important daily activity. Smith (1947b) reported that the Saipan islanders consumed nearly 0.45 kg (1 lb) of fish per person per day and that there was a steady market for fishery products. In postwar Saipan, however, fish were scarce inside the fringing reef. Smith indicated that in contrast to this scarcity of inshore fish, the outer edge of the reef was well populated with surgeonfish, Acanthuridae; squirrelfish, Holocentridae; jacks, Carangidae; and parrotfish, Scaridae. Spiny lobsters, Palinuridae, were common on the reef at Maniagassa Island as were top shell and sea cucumbers.

At Tinian, Smith (1947b) found the inshore area well populated with fish such as mullet, Mugilidae; goatfishes, *Mulloidichthys* sp. and *Parupeneus* sp.; Pacific threadfin; and surgeonfish, *Hepatus* sp. Spiny lobsters, *Panulirus* spp., were abundant at night and could easily be taken by torch fishing. Along the outer edge of the reef, Smith found large

Table 26.--Estimated catch and effort by Japanese longliners around Guam and the Northern Mariana Islands, 1965-77 (Yong and Wetherall 1980).

		Total catch (t)	
Year	Effort in vessel days	Tunas	Billfishes
1965	878	497	149
1966	535	343	106
1967	634	296	98
1968	699	364	102
1969	531	308	59
1970	1,003	502	206
1971	1,040	500	154
1972	613	339	75
1973	288	189	36
1974	610	305	149
1975	620	371	109
1976	1,235	1,299	136
1977	2,076	3,366	187

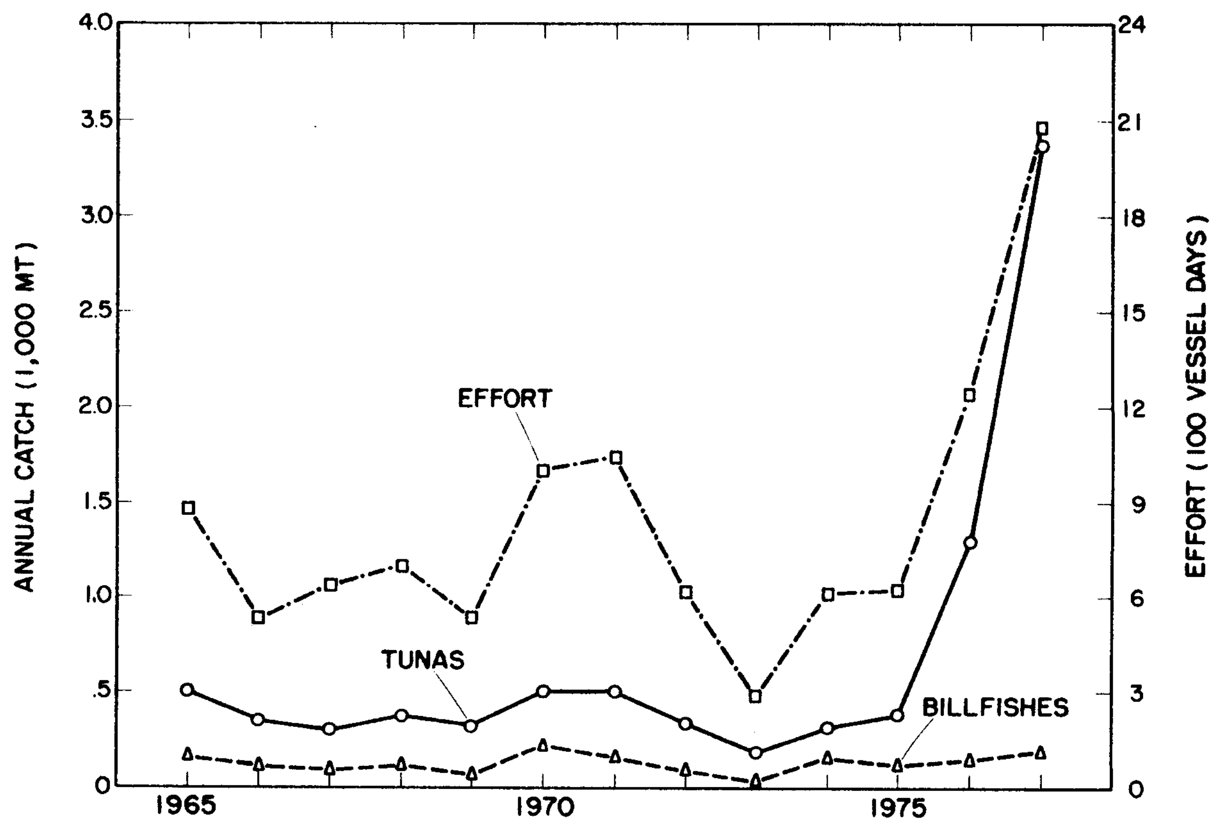


Figure 27.--Estimated catch and effort by Japanese longliners around Guam and the Northern Mariana Islands, 1965-77 (Yong and Wetherall 1980).

populations of fish including parrotfish, Calliodon sp., mullet, goatfishes, and jacks. Octopi, Octopoda, were seen occasionally and yellow sea cucumbers were abundant. Smith also reported sighting schools of anchovies, Stolephorus sp., which were abundant under the bluffs.

Around Rota the fringing reef was only a few kilometers offshore and therefore provided only a comparatively small inshore area suitable for fishing (Smith 1947b). The natives there fished with throw nets and spears and gathered trochus, cat's-eye, Turbo sp., and spiny lobsters from the reef. Smith also reported that in May-June, large schools of a small silvery fish, 5.1-7.6 cm long (2-3 inches) called "manahag" were taken in large quantities by throw net and preserved with salt for later use. Large schools of this species (believed to be young herring by Smith),[7] appeared annually at Rota and Guam but stayed only a few weeks.

Partly as a result of the general shortage of labor in Saipan and because most of the islanders were employed first by the armed services and later by the Trust Territory Government headquartered on the island, fishing remained a subsistence-type activity and never developed to any extent in the Northern Marianas. Since the Smith (1947b) survey, several attempts were made to establish a commercial fishery but all of them failed, largely because of mismanagement. There also were other forces that presented obstacles. Lord (1979) concluded that economic development in Micronesia lagged as a result of American military policies which not only discouraged development but also prohibited outside investment. The result was that traditional fisheries and agriculture declined. American policies made Micronesia's cash economy highly dependent on grants from the U.S. Government. It was not until 1974 that the U.S. ended its prohibition on foreign investment. Among the industries considered for development in the Northen Marianas, fishing was recognized as having a major potential in the islands' economic growth.

CURRENT STATUS OF FISHERIES

Guam

The potential demand for fresh or frozen fish on Guam has been estimated to be more than 900 t per year (Ikehara et al. 1972), yet no commercial fishery existed on the island until recently when a fishery cooperative was organized. The supply of fresh fish, which is usually provided by weekend recreational fishermen who sell part of their catches, annually amounts to less than 140 t.

By virtue of its geographic location near the Indo-Pacific center of radiation of species, Guam would be expected to have a more diverse ichthyofauna than the Hawaiian Islands (150 families and 584 species) (Gosline and Brock 1960). The fishes collected from Guam, however, includes only 94 families and 673 species (Kami et al. 1968; Kami 1971,

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[7] Smith's reference to "manahag" as young herring is probably in error. Kami and Ikehara (1976) refer to manahac hatang and manahac leso as juveniles of rabbitfishes, Siganus spinus and S. argenteus, respectively.

1975). Jones and Larson (1974), who published a key to the families of fishes as recorded from Guam (prior to Kami's checklist of Guam fishes, supplement II, 1975), noted that a complete key is not possible at this time because all of the families that are likely to occur in Guam waters are not yet known. They noted that sampling effort, particularly for the deepwater forms, has not been as intensive in Guam as in the Hawaiian Islands, resulting in a smaller collection.

Guam's present-day fisheries can be conveniently separated into inshore and offshore components, each using different methods to catch a wide variety of species. Based on creel census data, the five basic methods of inshore fishing are hook and line, cast net, gill net, surround net, and spearfishing. Also included in inshore fishing are the catches by fish weirs. Inshore fishermen also collected octopi and eels, Anguilliformes, on the reef with hooks and spear, collected various shellfish, primarily topshell, but also including strawberry conch, Strombus luhuanus, clams, Periglypta puerpera, giant clam, Tridacna maxima, spiny lobsters, Palinuridae, shrimps, Penaeidae, crabs, Brachyura, and harvested edible algae, Rhodophyta (Kami et al. 1978; Anderson et al. 1979; Jennison-Nolan 1979).

Although the creel census data do not reflect the usual commercial landing statistics, they provide valuable information on the relative importance of not only the species harvested but also the type of gear and amount of effort used to catch the various species. Table 27 gives the relative importance of different types of inshore fishing methods and their contribution to the total inshore catch for fiscal years 1978 and 1979. By far, the most popular method of inshore fishing was hook and line with 30% participation in fiscal year 1978 and 42% in fiscal year 1979; however, in terms of catch in weight, the most important was surround-net fishing with 35% of the annual catch produced by this method.

Among the more important fish groups represented in the catches of five inshore gear are the atulai or bigeye scad and jacks, Carangidae; snappers, Lutjanidae; soapys, Leiognathidae; goatfish, and rabbitfish, Siganidae. Other fishes commonly taken by the inshore gear include surgeonfish, squirrelfish, and parrotfish (Table 28).

For offshore fishing there are three major methods used--trolling, deep-sea bottom fishing, and nearshore spearfishing from boats at locations which are generally inaccessible to those fishermen that use other means of transportation (Kami et al. 1978; Anderson et al. 1979). The most widely practiced method is multiple-line surface trolling from small recreational boats, usually less than 9 m (30 feet) long (Table 29). The offshore waters of Guam abound in a wide variety of game fish including black marlin, blue marlin, sailfish, yellowfin tuna, skipjack tuna, mahimahi, rainbow runner, wahoo, great barracuda, and sharks, Carcharhinidae (Squire and Smith 1977). Anderson et al. (1979) also list members of the families Carangidae, Belonidae, and Xiphiidae in the troll-caught category. Most of the troll-caught species are seasonal, occurring in abundance in Guam waters only during certain times when their migration bring them within reach of the fishermen. Some billfish, wahoo, and tuna always occur in small numbers in Guam and can be caught throughout the year, whereas mahimahi are usually plentiful in January-February. Yellowfin and skipjack

Table 27.--Annual participation, effort, catch per unit effort, and total catch for the five major inshore fishing methods during fiscal years 1978 and 1979 (Anderson et al. 1979).

Fishing method	Fiscal year 1978								Fiscal year 1979							
	Number of persons	Percent	Number of person-hours	Percent	Kilograms per person-hours	Kilograms per gear-hours	Catch (kg)	Percent	Number of persons	Percent	Number of person-hours	Percent	Kilograms per person-hours	Kilograms per gear-hours	Catch (kg)	Percent
Hook and line	2,016	30	6,548	31	0.21	0.20	1,387	14	2,714	40	11,116	42	0.10	0.10	1,073	10
Cast net	1,046	16	2,507	12	0.57	0.67	1,421	14	1,034	16	2,820	11	0.34	0.29	949	9
Gill net	2,045	31	6,685	31	0.46	1.14	3,063	30	1,233	18	4,884	19	0.67	1.00	3,288	30
Surround net	808	12	3,795	18	1.00	6.67	3,574	35	1,086	16	5,623	21	0.67	5.67	3,783	34
Spearfishing	743	11	1,785	8	0.40	0.42	737	7	650	10	1,701	7	1.09	1.24	1,852	17
Total	6,658	100	21,320	100	0.48	0.73	10,182	100	6,717	100	26,144	100	0.42	0.56	10,945	100

Table 28.--Species composition of the catch by four basic methods of inshore fishing in Guam waters (Jennison-Nolan 1979). The Guamanian equivalent of the English name, when available, is given in parentheses.

Surround net (lagua)	Gill net (tekin)	Throw net (talaya)	Spearfishing
Bigeye scad (atulai)	Goatfish (salmonetijos)	Bigeye scad	Barracuda
Flounder (tampat)	Jacks	Goatfish	Dogtooth tuna
Goatfish (tiao), juvenile	Mullet	Jack	Eel
Jacks (tarakitos)	Rabbitfish (hiting)	Mullet	Grouper
Mullet (laiguan)	Red snapper (tagafi)	Parrotfish	Octopus
Needlefish	Silver perch (guaguas)	Rabbitfish	Parrotfish
Parrotfish	Squirrelfish	Rudderfish	Sea cucumber
Rabbitfish (manahac)	Surgeonfish	Surgeonfish	Sea urchin
Snapper	White snapper (mafute)	White snapper	Skipjack tuna
Squirrelfish (suksuk)			Snapper
Surgeonfish (kechu)			Squirrelfish
			Surgeonfish
			Turtle
			Wrasse

tunas are usually most abundant from February through August. The relative importance of the various species in the monthly troll catch is shown in Tables 30 and 31 for fiscal years 1978 and 1979, respectively.

Bottom fishing, another of the offshore component, is also conducted from small boats either drifting or anchored with the fishermen using handlines rigged with a drop line to which 5-9 hooks may be attached (Ikehara et al. 1972). Species usually taken by this method included most members of the snapper-grouper complex, the most important of which were lehi, "salmon" or uku, onaga, ehu, yellowtail kalekale, and gindai, (Kami et al. 1978; Anderson et al. 1979). Other species which contributed lesser amounts to the total harvest were black jack, twinspot snapper, pink opakapaka, yellow-eye opakapaka, pink kalekale, and groupers.

Spearfishing is the least important of all offshore activities, contributing less than 8% of the effort expended and producing only 2-5% of the catch (Table 29). The major species taken by this method were the surgeonfish, jacks, squirrelfish, rudderfish, Kyphosidae; wrasses, Labridae; groupers, and parrotfish. Other marine organisms contributing to the total spearfishing harvest included green turtle, topshell, spiny lobsters, octopus, and an occasional giant clam.

The creel census data collected by the Guam Division of Aquatic and Wildlife Resources have been expanded and used to estimate total fishing effort and the resulting catch for inshore and offshore fishing (Table 32). In fiscal year 1978, the best estimate of islandwide catch was 284,500 kg (627,322 lb) produced by nearly 22,000 person-days of fishing effort. The estimates for fiscal year 1979 were down slightly in terms of catch, reaching 241,168 kg (531,775 lb) but produced with roughly one-third increase in fishing effort of 29,788 person-days.

Table 29.--Comparison of participation, effort, catch per unit effort, and total catch for the three major offshore fishing methods censused at the Agana Boat Basin during fiscal years 1978 and 1979 (August and September 1979 totals included in fiscal year 1979 totals) (Kami et al. 1978; Anderson et al. 1979).

Fishing method	Fiscal year 1978										Fiscal year 1979									
	Number of boats	Percent	Number of men	Percent	Number of person-hours	Percent	Kilograms per person-hours	Kilograms per gear-hours	Catch (kg)	Percent	Number of boats	Percent	Number of men	Percent	Number of person-hours	Percent	Kilograms per person-hours	Kilograms per gear-hours	Catch (kg)	Percent
Trolling	2,785	79	8,069	79	48,645	76	1.74	1.49	84,878	82	3,460.6	87	10,113.5	86	65,185.4	87	1.03	0.82	67,141.0	91
Bottom fishing	468	13	1,287	13	10,835	17	1.22	1.66	13,189	13	391.5	10	1,017.7	9	5,003.8	7	1.09	0.66	5,454.1	7
Spearfishing	283	8	838	8	4,307	7	1.32	2.74	5,668	5	136.6	3	545.0	5	4,614.5	6	0.29	0.46	1,338.2	2
Total	3,536		10,194		63,787		1.42	1.35	103,735		3,988.7		11,676.2		74,803.7		2.41	1.94	73,933.3	
Adjusted total[1]	--		--		--		--	--	--		4,431.9		12,973.5		83,115.1		2.67	2.15	82,148.1	

[1]Total adjusted to 100% of effort.

Table 30.--Monthly and annual catch census data and expanded estimates for the major offshore trolling species, fiscal year 1978. All weights are in kilograms. The percentage values refer to the portion of the total trolling catch (adapted from Kami et al. 1978).

	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total
Skipjack tuna													
Censused	336	91	205	212	18	169	143	228	261	404	195	801	3,063
Expanded	5,725	947	2,620	2,340	180	2,077	2,644	1,577	1,789	3,506	977	5,549	29,931
Percent	93.7	39.3	34.4	43.5	2.6	32.5	44.2	24.8	20.8	25.8	32.1	45.5	35.3
Yellowfin tuna													
Censused	23	80	114	205	58	52	99	67	24	215	56	495	1,488
Expanded	385	859	1,461	2,262	600	635	1,830	465	163	1,867	278	3,426	14,231
Percent	6.3	34.7	19.2	42.1	8.6	9.9	30.6	7.3	1.9	13.7	9.2	28.1	16.8
Wahoo													
Censused			133	33	461	190		261	154	289	42	54	1,617
Expanded			697	368	4,745	2,326		1,806	1,054	2,508	212	372	14,088
Percent			22.3	6.8	67.9	36.3		28.4	12.0	18.5	7.0	3.1	16.6
Mahimahi													
Censused		4		7	57	27	77	322	785	401	122	26	1,828
Expanded		40		74	589	335	1,435	2,227	5,374	3,487	614	183	14,358
Percent		1.6		1.4	8.4	5.2	24.0	35.1	61.3	25.7	20.2	1.5	16.9
Blue marlin													
Censused										94	30	65	189
Expanded										819	148	452	1,419
Percent										6.0	4.9	3.7	1.7
Barracuda													
Censused			2	2	26	4		22	9	40	12	8	125
Expanded			24	22	266	44		152	60	345	59	56	1,028
Percent			0.3	0.4	3.8	0.7		2.4	0.7	2.5	2.0	0.5	1.2
Rainbow runner													
Censused		10	14			2	4			9	1	32	72
Expanded		112	180			28	71			76	7	218	692
Percent		4.5	2.4			0.4	1.2			0.6	0.2	1.8	0.8
Total censused	359	185	468	459	620	444	323	900	1,233	1,452	458	1,481	8,382
Total expanded	6,110	1,958	4,982	5,066	6,380	5,445	5,980	6,227	8,440	12,608	2,295	10,256	75,747

Table 31.--Monthly and annual census data and expanded estimates for the major offshore trolling species, fiscal year 1979. All weights are in kilograms. The percentage values refer to the portion of the total trolling catch (adapted from Anderson et al. 1979).

	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total
Rainbow runner													
Censused	6.4	15.4	17.1	--	--	--	--	--	--	--	4.8	17.5	61.2
Expanded	46.9	148.6	85.5	--	--	--	--	--	--	--	44.8	65.6	391.4
Percent	1.2	1.5	1.4	--	--	--	--	--	--	--	1.7	2.2	0.8
Mahimahi													
Censused	--	1.1	--	2.1	12.3	147.0	229.3	704.5	380.3	417.9	22.1	95.1	2,081.7
Expanded	--	4.8	--	11.6	64.4	1,645.5	1,493.1	4,063.8	2,547.2	4,067.5	206.3	423.9	14,528.1
Percent	--	0.0	--	0.3	4.0	48.3	59.4	64.8	55.1	52.7	7.9	14.3	26.8
Barracuda													
Censused	11.2	15.8	4.3	8.3	--	1.6	16.3	47.8	--	9.1	2.1	12.7	129.2
Expanded	73.2	90.0	24.0	73.7	--	15.2	90.3	245.1	--	84.3	19.6	47.6	763.0
Percent	1.9	0.9	0.4	0.4	--	0.4	3.6	3.9	--	1.1	0.7	1.6	1.7
Skipjack tuna													
Censused	191.8	419.7	215.6	102.0	160.9	139.2	61.8	51.5	181.5	324.3	116.7	258.0	2,223.0
Expanded	1,297.8	3,558.2	1,339.5	885.8	842.3	1,465.2	389.3	379.8	1,090.1	2,629.6	1,305.8	967.5	16,150.9
Percent	33.5	36.4	22.7	20.9	52.4	43.0	15.5	6.1	23.6	34.0	49.8	32.6	28.6
Yellowfin tuna													
Censused	224.8	537.8	429.2	319.1	44.2	--	26.4	99.0	24.7	45.6	26.4	131.6	1,980.8
Expanded	1,807.6	4,657.2	2,624.0	2,504.0	231.4	--	231.9	940.5	156.0	402.5	280.6	493.5	14,329.2
Percent	46.6	47.6	44.4	58.9	14.4	--	9.2	15.0	3.4	5.2	10.7	16.6	24.5
Wahoo													
Censused	24.2	63.6	73.9	27.6	83.7	22.4	61.8	82.2	103.6	51.5	29.2	63.8	687.5
Expanded	158.3	276.8	408.5	151.8	438.2	254.1	303.5	408.9	833.2	539.2	272.5	692.6	4,737.6
Percent	4.1	2.8	6.9	3.6	27.3	7.5	12.1	6.5	18.0	7.0	10.4	8.8	23.4
Blue marlin													
Censused	40.9	113.8	175.0	65.2	--	--	--	47.3	--	--	52.7	68.6	563.5
Expanded	427.4	832.3	1,100.0	546.0	--	--	--	212.9	--	--	491.8	257.3	3,867.7
Percent	11.0	8.5	18.6	12.9	--	--	--	3.4	--	--	18.8	8.7	7.2
Total censused[1]	507.0	1,217.2	957.2	531.1	306.8	312.9	446.7	1,034.6	690.1	848.4	254.0	651.8	7,777.8
Total estimated	3,874.9	9,785.5	5,907.0	4,248.4	1,605.9	3,405.6	2,512.9	6,272.7	4,627.0	7,723.1	2,621.4	2,964.9	55,549.3

[1]Totals include nonmajor species as well.

Table 32.--Estimated fishing effort and catch in Guam, 1969-79. (Data from Kami;[1] Kami et al. (1978); Anderson et al. 1979).

Year	Fishing effort			Catch (kg)		
	Fishermen-hours	Boat-days	Person-days	By fishermen	By boat	Total
1969	79,276		--	93,782		93,782
1970	67,584		--	66,784		[2]66,784
1971	57,480	12,918	--	35,862	24,896	[2]77,374
1972	58,675	7,049	--	15,586	5,724	[3]69,677
1973	55,557	4,054	--	23,718	31,512	[3]83,829
1974	38,649	7,306	--	28,843	11,099	[3]91,180
1975	80,190	8,694	--	84,492	17,474	[3]131,098
1976	67,713	9,874	--	75,969	10,613	86,582
1977[4]	43,751.74	12,286.54	--	5,828	58,955	[2]75,413
1978[5]	--	--	22,000	--	--	284,500
1979[5]	--	--	29,788	--	--	241,168

[1]H. T. Kami. Division of Aquatic and Wildlife Resources, Department of Agriculture, Government of Guam, P. O. Box 23367, GMF, Guam, MI 96921. Pers. commun., September 1981.
[2]Includes rabbitfish, Siganus sp., and fish weir catches.
[3]Includes rabbitfish, fish weir, and bigeye scad catches.
[4]Data are for January to June only.
[5]Data are for fiscal year July to June only.

A recent publication of the University of Guam Marine Laboratory (1981) provides an excellent working list of marine organisms from Guam (and the southern Mariana Islands for the section on fishes). Among the taxa included in this first edition are marine benthic diatoms (12 families, 83 species) by Zolan (1981), marine benthic algae (44 families, 220 species) and seagrasses (2 families, 3 species) by Tsuda (1981), Foraminifera (28 families, 157 species) by Clayshulte (1981), hydrocorals (2 families, 9 species) by Randall (1981a), Octocorallia (7 families, 33 species) by Randall and Gawel (1981), Actiniaria (3 families, 6 species) by Dunn (1981), Scleractinia (19 families, 267 species) by Randall (1981b), Sipuncula (8 species) and Echiura (2 species) by Edmonds (1981), Polychaeta (13 families, 37 species) by Kohn and White (1981), and anomuran crustaceans (5 families, 56 species) by Kropp et al. (1981). Other taxa for which a checklist is provided and for which a serious study has been made by a recognized authority are shelled gastropods (6 families, 91 species) by Eldredge et al. (1981), Opisthobranchia (44 families, 140 identified and 356 collected species) by Carlson and Hoff (1981), Echinodermata (32 families, 96 species) by UGML (1981), and fishes (115 families, 801 species) by Shepard and Myers (1981).

Table 31.--Monthly and annual census data and expanded estimates for the major offshore trolling species, fiscal year 1979. All weights are in kilograms. The percentage values refer to the portion of the total trolling catch (adapted from Anderson et al. 1979).

	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total
Rainbow runner													
Censused	6.4	15.4	17.1	--	--	--	--	--	--	--	4.8	17.5	61.2
Expanded	46.9	148.6	85.5	--	--	--	--	--	--	--	44.8	65.6	391.4
Percent	1.2	1.5	1.4	--	--	--	--	--	--	--	1.7	2.2	0.8
Mahimahi													
Censused	--	1.1	--	2.1	12.3	147.0	229.3	704.5	380.3	417.9	22.1	95.1	2,081.7
Expanded	--	4.8	--	11.6	64.4	1,645.5	1,493.1	4,063.8	2,547.2	4,067.5	206.3	423.9	14,528.1
Percent	--	0.0	--	0.3	4.0	48.3	59.4	64.8	55.1	52.7	7.9	14.3	26.8
Barracuda													
Censused	11.2	15.8	4.3	8.3	--	1.6	16.3	47.8	--	9.1	2.1	12.7	129.2
Expanded	73.2	90.0	24.0	73.7	--	15.2	90.3	245.1	--	84.3	19.6	47.6	763.0
Percent	1.9	0.9	0.4	0.4	--	0.4	3.6	3.9	--	1.1	0.7	1.6	1.7
Skipjack tuna													
Censused	191.8	419.7	215.6	102.0	160.9	139.2	61.8	51.5	181.5	324.3	116.7	258.0	2,223.0
Expanded	1,297.8	3,558.2	1,339.5	885.8	842.3	1,465.2	389.3	379.8	1,090.1	2,629.6	1,305.8	967.5	16,150.9
Percent	33.5	36.4	22.7	20.9	52.4	43.0	15.5	6.1	23.6	34.0	49.8	32.6	28.6
Yellowfin tuna													
Censused	224.8	537.8	429.2	319.1	44.2	--	26.4	99.0	24.7	45.6	26.4	131.6	1,980.8
Expanded	1,807.6	4,657.2	2,624.0	2,504.0	231.4	--	231.9	940.5	156.0	402.5	280.6	493.5	14,329.2
Percent	46.6	47.6	44.4	58.9	14.4	--	9.2	15.0	3.4	5.2	10.7	16.6	24.5
Wahoo													
Censused	24.2	63.6	73.9	27.6	83.7	22.4	61.8	82.2	103.6	51.5	29.2	63.8	687.5
Expanded	158.3	276.8	408.5	151.8	438.2	254.1	303.5	408.9	833.2	539.2	272.5	692.6	4,737.6
Percent	4.1	2.8	6.9	3.6	27.3	7.5	12.1	6.5	18.0	7.0	10.4	8.8	23.4
Blue marlin													
Censused	40.9	113.8	175.0	65.2	--	--	--	47.3	--	--	52.7	68.6	563.5
Expanded	427.4	832.3	1,100.0	546.0	--	--	--	212.9	--	--	491.8	257.3	3,867.7
Percent	11.0	8.5	18.6	12.9	--	--	--	3.4	--	--	18.8	8.7	7.2
Total censused[1]	507.0	1,217.2	957.2	531.1	306.8	312.9	446.7	1,034.6	690.1	848.4	254.0	651.8	7,777.8
Total estimated	3,874.9	9,785.5	5,907.0	4,248.4	1,605.9	3,405.6	2,512.9	6,272.7	4,627.0	7,723.1	2,621.4	2,964.9	55,549.3

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1972	58,675	7,049	--	15,586	5,724	[3]69,677
1973	55,557	4,054	--	23,718	31,512	[3]83,829
1974	38,649	7,306	--	28,843	11,099	[3]91,180
1975	80,190	8,694	--	84,492	17,474	[3]131,098
1976	67,713	9,874	--	75,969	10,613	86,582
1977[4]	43,751.74	12,286.54	--	5,828	58,955	[2]75,413
1978[5]	--	--	22,000	--	--	284,500
1979[5]	--	--	29,788	--	--	241,168

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[5]Data are for fiscal year July to June only.

A recent publication of the University of Guam Marine Laboratory (1981) provides an excellent working list of marine organisms from Guam (and the southern Mariana Islands for the section on fishes). Among the taxa included in this first edition are marine benthic diatoms (12 families, 83 species) by Zolan (1981), marine benthic algae (44 families, 220 species) and seagrasses (2 families, 3 species) by Tsuda (1981), Foraminifera (28 families, 157 species) by Clayshulte (1981), hydrocorals (2 families, 9 species) by Randall (1981a), Octocorallia (7 families, 33 species) by Randall and Gawel (1981), Actiniaria (3 families, 6 species) by Dunn (1981), Scleractinia (19 families, 267 species) by Randall (1981b), Sipuncula (8 species) and Echiura (2 species) by Edmonds (1981), Polychaeta (13 families, 37 species) by Kohn and White (1981), and anomuran crustaceans (5 families, 56 species) by Kropp et al. (1981). Other taxa for which a checklist is provided and for which a serious study has been made by a recognized authority are shelled gastropods (6 families, 91 species) by Eldredge et al. (1981), Opisthobranchia (44 families, 140 identified and 356 collected species) by Carlson and Hoff (1981), Echinodermata (32 families, 96 species) by UGML (1981), and fishes (115 families, 801 species) by Shepard and Myers (1981).

Commonwealth of the Northern Mariana Islands

The present-day multispecies fishery in the Marianas is prosecuted by about 70 full-time and 90-100 part-time commercial fishermen with a fleet of small boats, 3.4-7.6 m (11-25 ft), powered by outboard motors (University of California).[8] There are 113 boats smaller than 7.6 m (25 ft) and 8 larger. In addition, there are four recreational charter boats. Trips usually last about one-half day primarily because the bulk of the fleet, consisting of small boats of 4.3-5.8 m (14-19 ft), has only limited fish-carrying and fuel capacities and the fishermen who operate these small boats prefer to return by early afternoon to sell their catch before dark (Commonwealth of the Northern Mariana Islands).[9] The larger vessels can make longer trips and occasionally venture to the northern islands in the Marianas to fish the more productive, isolated grounds, using a wide variety of gear including handlines, trolling lines, gill nets, and traps.

Other commonly used gear for fishing over the reef or along the shoreline includes beach or drag seine, stationary pole and line, spin reel and rod, spear, cast net, and surround net. Table 33 gives the names of fishes or groups of fishes that are commonly caught in the inshore and offshore areas, by gear types.

Table 34 gives the monthly landings of reef and pelagic fishes in 1975; Table 35 gives the annual landings, by species; and Table 36 the catch and percentage of catch, by area of capture for 1975-78. Data presented in Tables 34-36 have been judged to be gross underestimates of actual landings in the Northern Marianas.

DEVELOPMENTAL POTENTIAL

In the previous sections, we examined the historical accounts of fishery development by the Japanese in the JMI and the present-day fisheries operating in waters around Guam and the Northern Marianas. The growth of fishing in the immediate postwar years, however, has been slow but in recent years, there has been a resurgence of interest in fishery development in the western Pacific. It would be appropriate, at this time, to review the kinds of surveys that have been carried out in Guam and the Northern Marianas and to discuss the potential for developing certain types of fisheries.

Apparently, opinions vary among researchers about the potential of the various insular resources to support harvest on a commercial scale. Smith and Stimson (1979), in reviewing the status of harvested marine resources

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[8]California. University of California, Santa Cruz. 1980. Draft report on the social, cultural, and economic aspects of fishery development in the Commonwealth of the Northern Mariana Islands. Report submitted to the Pacific Marine Fisheries Commission by the Center for Coastal Marine Studies, University of California, Santa Cruz; Michael K. Orbach, Associate Director.

[9]Commonwealth of the Northern Mariana Islands, Fisheries Development Plan. Undated, no pagination.

Table 33.--Some of the more important food fish species caught in the Northern Marianas, the area of capture, and the method of fishing (Commonwealth of the Northern Mariana Islands text footnote 9).

Species	Where taken		Method[2]
	Inshore[1]	Offshore	
Wahoo		x	A
Rainbow runner		x	A
Tunas		x	A
Mahimahi		x	A
Marlin		x	A
Snappers	x	x	B, C, D, E, F, G, H, J
Surgeonfish	x		B, C, D, E, F, G, H, J
Barracuda	x	x	A, C, D, E, H, J
Squirrelfish	x		B, C, D, E
Jacks	x	x	All
Parrotfish	x		B, C, F, H, J
Wrasses	x		B, C, F, H, J
Mullets	x		B, C, E, F, H, J
Goatfish	x		B, C, F, H, J

[1]Inshore is the area from the beach extending to the 10-fathom curve.

[2]Method: A = trolling, B = spearing, C = gill netting, D = pole and line, E = spinning, F = cast netting, G = bottom fishing or hand lining, H = beach seine or drag netting, J = surround netting.

for the Hawaiian Islands and the Trust Territory of the Pacific Islands, noted that some investigators believe that many of the species in Micronesian waters are unable to support intensive exploitation at levels sufficient for significant commercial enterprises. The result is that frequent recommendations are made to restrict export fisheries. This policy, according to Smith and Stimson, is apparently consistent with a U.S. Department of State (1976) document in which it is noted that the inshore resources are not considered suitable for major commercial exploitation because of limited productivity of the coral reef and the adverse effect of intensive harvesting of reef organisms which in many cases have territorial characteristics. The U.S. Government's position, therefore, is to adhere to a policy of limiting utilization of these resources to local consumption. The offshore resources, however, are not as limited, and development of skipjack tuna fishing was strongly supported.

Smith and Stimson also noted that there is, on the other hand, some doubt as to the validity of applying this type of rationale to all inshore species. Although it is certainly clear that some nearshore organisms are not able to withstand much fishing pressure, this is not unique to tropical island ecosystems. For example, the belief that coral reefs have limited productivity is probably unfounded (Odum 1971). Their high diversity, the cryptic nature of much of their fauna, the low concentration of phyto- and

Table 34.--Monthly inshore and offshore catches in the Northern Mariana Islands, January to December 1975 (data from Department of Natural Resources, Commonwealth of the Northern Mariana Islands).

Month	Inshore reef fishes (kg)	Offshore pelagic and benthic fishes (kg)[1]	Total (kg)
January	401	148	549
February	52	780	832
March	246	623	869
April	307	701	1,008
May	169	83	252
June	188	96	284
July	202	558	760
August	61	69	130
September	33	531	564
October	28	25	53
November	53	264	317
December	457	4,181	4,638
Total	2,197	8,059	10,256

[1]Includes tunas, wahoo, mahimahi, billfishes, onaga, pink opakapaka, and other members of the snapper-grouper complex.

Table 35.--Annual catches, by species, in the Northern Mariana Islands (data from Department of Natural Resources, Commonwealth of the Northern Mariana Islands).

Species	Catch (kg) 1976	Catch (kg) 1977
Skipjack tuna	[1]43,334	23,629
Yellowfin tuna	1,122	553
Dogtooth tuna	2,069	1,134
Wahoo	1,108	6,011
Blue marlin	191	0
Reef fish	5,381	17,970
Total	53,441	53,284

[1]Includes tuna, wahoo, mahimahi, billfishes, onaga, pink opakapaka, and other members of the snapper-grouper complex for January to October 1976 when no monthly records were available.

Table 36.--Annual reef and offshore fish catch and their percentages in 1975-78, Northern Mariana Islands (Commonwealth of the Northern Mariana Islands text footnote 9).

Year	Catch (kg)				Total
	Reef fish		Offshore		
1975	2,197	(21.4%)	8,059	(78.6%)	10,256
1976	5,381	(10.1%)	48,060	(89.6%)	53,441
1977	17,970	(33.7%)	35,314	(66.3%)	53,284
1978	2,804	(10.8%)	23,108	(89.2%)	25,912
Total	28,352	(19.8%)	114,541	(80.2%)	142,893
Average	7,088		28,635		
Average value[1]	$10,938		$44,184		$55,122

[1]Assumes a static price of $1.54 per kg ($0.70 per lb).

zooplankton in tropical waters, and the consequent lack of development of extensive beds of filter feeders may all contribute to low standing crops of exploitable species. Furthermore, as Smith and Stimson argue, if low phyto- and zooplankton standing crop are indicative of low productivity, then certainly one should consider some of the offshore waters around the islands of Micronesia as having limited productivity.

There have been a number of research cruises in waters around Guam and the Northern Marianas either by the Cromwell or by foreign and domestic chartered commercial fishing vessels (Table 37). These cruises have indicated the presence of certain species and species groups that are potentially important to the islands' economies. Needless to say, neither Guam nor the Northern Marianas have a sufficiently large inshore area to warrant any expectation of providing fish in large enough quantities so that the excess can be exported. The exception, perhaps, is the atulai.

Offshore Pelagic Fishes

For many of the island governments in the central and western Pacific, the tunas represent the single most important fishery resource, because various species are available in their waters and are among the highest priced fishery commodity on the international market. Guam and the Northern Marianas are no exception; however, the development of tuna fisheries in these islands is not likely to follow the examples of other oceanic islands where bait dependent pole-and-line fishery has become established. Rather, because the pre-World War II Japanese experience and postwar surveys have demonstrated that there is no reliable, steady source of baitfish either in Guam or the Northern Marianas, other methods of tuna fishing, for example, purse seining would have to be considered. Trolling may also be suggested as a possible alternative, but a trolling operation will not provide enough fish to make it economically feasible for a commercial troller (Ikehara et al. 1972).

Table 37.--Summary of research cruises in waters around Guam and the Northern Mariana Islands.

Vessel	Agency	Date of cruise	Missions
Panglau Oro	Aquatic and Wildlife Resources Division, Government of Guam	1967-68	Gear test, mackerel handline fishing, deep-sea handline fishing, trolling, and bottom trotline fishing.
Townsend Cromwell, TC-53	Honolulu Laboratory, Southwest Fisheries Center, NMFS	4/8-7/8/71	Baitfish survey, trolling, deep-sea handline fishing, mackerel handline fishing, trapping, and shrimp trawling.
Townsend Cromwell, TC-55	do	10/21-12/17/71	Fish school scouting, current system investigation, plankton tows, and midwater trawl hauls.
Akitsu Maru	JAMARC	Few days in 1974	Pole-and-line fishing, baitfish survey, plankton tows, and oceanographic survey.
(No name given)	Korean Fishing Agency	One month in 1974	Shark longline fishing and oceanographic survey.
(No name given)	do	One month in 1975	Shark longline fishing and oceanographic survey.
Daikatsu Maru	Mendiola Fishing Co. and Japan Micronesia Coordinated Development Co.	January-February 1976	Deep-sea bottom fishing and oceanographic survey.
Townsend Cromwell, TC-76-05	Honolulu Laboratory, Southwest Fisheries Center, NMFS	6/21-9/16/76	Fish school scouting, environmental survey, fish aggregating device monitoring, and plankton tows.
Olwol	Commonwealth Fishing Co. charter	June 1976-May 1977	Vertical longline fishing and net fishing.
Wooseong No. 1 and Wooseong No. 2	do	1/14-2/13/77	Deep-sea bottom and bottom longline fishing.
Eiryo Maru	Matsunaga Fishing Co. charter	1977-78	Vertical and deep-sea bottom longline fishing.
Townsend Cromwell, TC-78-02	Honolulu Laboratory, Southwest Fisheries Center, NMFS	5/9-6/21/78	Baitfish survey, trolling, deep-sea handline fishing, mackerel handline fishing, lobster, fish, and shrimp trapping, precious coral drag, night-light observations, bottom and midwater trawl hauls, environmental survey, ciguatoxin sampling, bottom topographical survey, and tuna tagging.
Pacific Nomad and Iwa	Pacific Tuna Development Foundation charters	April 1979	Tuna trolling and oceanographic surveys.
Typhoon	do	5/20-9/21/80	Deep-sea handline fishing, bottom longline fishing, mackerel handline fishing, fish, lobster, and shrimp trapping, ciguatoxin sampling, trolling, seamount groundfish survey.
Typhoon	Honolulu Laboratory, Southwest Fisheries Center, NMFS charter	2/9-4/15/81	Shrimp trapping, deep-sea handline fishing, mackerel handline fishing, kona crab netting, and trolling.

Guam currently serves as a transshipment point for tuna. This operation began in 1974 with a shipment of tuna destined for California canneries (Callaghan and Simmons 1980) (Table 38). Most tuna discharged at the Commercial Port of Guam comes primarily from foreign carrier vessels (reefers) or purse seiners; pole-and-line and longline vessels seldom discharge their catches at Guam. Figure 28 shows the general upward trend in the monthly tonnages of tuna transshipped from Guam in May 1974-August 1979.

Table 38.--Monthly tonnages (in metric tons) of tunas transshipped through Guam, May 1974 to August 1979 (Callaghan and Simmons 1980).

	1974	1975	1976	1977	1978	1979
January	NA	281.31	1,118.06	720.40	1,286.93	1,445.01
February	NA	113.43	277.86	954.26	671.60	*958.33
March	NA	9.07	576.59	1,354.81	1,901.63	*1,546.63
April	NA	226.86	0.00	1,785.30	1,341.38	*1,226.52
May	299.46	953.90	519.24	415.52	1,654.99	*283.75
June	598.91	423.05	765.43	655.17	975.50	*746.96
July	644.20	2,290.29	661.07	701.91	1,398.73	*278.27
August	653.36	643.56	923.14	756.17	1,364.07	*1,053.81
September	807.62	428.49	790.11	1,158.26	822.50	NA
October	612.52	1,099.91	1,494.65	1,518.60	1,056.90	NA
November	490.94	1,049.91	2,157.80	1,381.58	289.02	NA
December	435.57	707.35	447.91	1,222.87	2,257.80	NA
Total	4,532.58	7,627.13	9,731.86	12,624.85	15,021.05	7,539.28

Sources: Port Authority of Guam. 1979. Tuna tonnage [1975-78]. (Mimeogr.); Van Camp Guam. 1979. Van Camp tuna transshipped from Guam. May 1974-Jan. 1979. (Mimeogr.).

NA = Not available.

* = Assembled from project data.

Alverson and Van Campen[10] stated in their fact-finding field trip report that Guam is strategically located with respect to future development of tuna fishing in the western Pacific by American seiners and trollers. A seiner making 15 knots can undertake 5-day runs in almost any direction into tuna-rich waters; to the north, there are the Marianas, the Bonins, and the entire eastern coast of Japan to the upper tip of Honshu; to the east, the entire Trust Territory of the Pacific Islands; to the southeast, the Kiribatis, the lower Solomons, and the Santa Cruz Islands; to the south, Papua New Guinea and New Britain, New Ireland, and northern Australia; and to the west, the Philippines and Indonesia. For a troller with an operating range of 1,500-2,000 nmi and an ability to remain at sea

[10]Alverson, F. G., and W. G. Van Campen. 1975. Report of field trip to Honolulu, Guam, Saipan, Truk, Majuro, and American Samoa, April 26-May 9, 1975, 16 p.

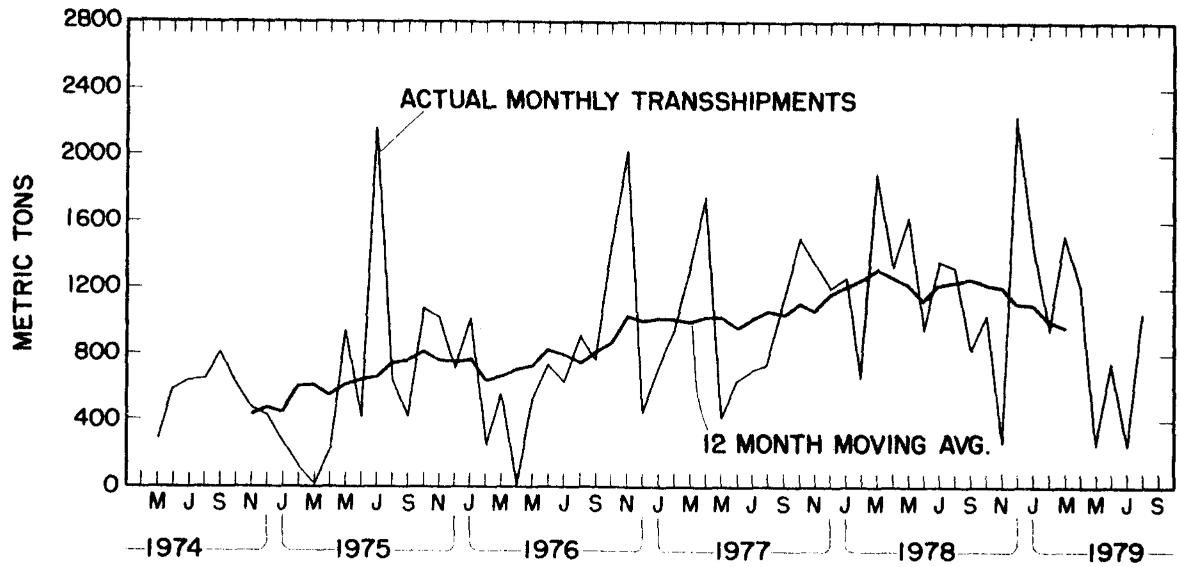

Figure 28.--Monthly tonnages of tuna transshipped from Guam, May 1974-August 1979 (Callaghan and Simmons 1980).

for 40 days, there are not only yellowfin tuna and skipjack tuna stocks to fish in the western Pacific, but also albacore in the North Pacific in a broad area bounded by the coast of Japan and long. 165° E between lat. 27° and 40° N.

Data on bird flock and school sightings are available from three research cruises of the Cromwell,[11] from one survey cruise of the FV No. 20 Akitsu Maru (JAMARC 1975), and from three U.S. purse seiners that operated in the western Pacific (LMR footnote 6). The results of these cruises indicate that the number of sightings are usually high during the summer and low during the fall and winter. For example, on Cromwell cruises 76-05 (21 June-16 September 1976) and 78-02 (9 May-21 July 1978) and on the survey cruise of the No. 20 Akitsu Maru, the sightings report indicated relatively good concentrations of bird flocks and fish schools in the vicinity of the Mariana Archipelago. Data from Cromwell cruise 76-05 are of particular interest because scouting was one of the major activities carried out during the cruise. The results of this cruise showed that in the area northeast of Guam, 19 bird flocks were sighted in 14 days of scouting, 12 of which were described as medium to large and were associated with unidentified fish schools. West of Guam, the Cromwell encountered eight flocks in 7 days and four were described as large. Sightings in both areas were hampered by the presence of storms. In the area just to the southeast of Guam from long. 145° E to 180°, bird flocks were very numerous, totaling 49 flocks in 20 days or an average of 2.45 flocks per day. Eleven were

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[11] Narrative report, Townsend Cromwell cruise 55, 21 October-17 December 1971; narrative report, Townsend Cromwell cruise 76-05 (TC-72), 21 June-16 September 1976; and cruise and narrative reports, Townsend Cromwell cruise 78-02 (TC-79), 9 May-21 July 1978. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

described as large and 28 were associated with tuna schools including 8 skipjack tuna, 1 yellowfin tuna, 1 mixed skipjack-yellowfin tuna, and 18 unidentified tuna. All of the 10 identified tuna schools were large. The yellowfin and mixed tuna schools, estimated at 50-70 t, were associated with four and two fin whales, *Balaenoptera physalus*, respectively, and described as "boiler" schools.

On *Cromwell* cruise 78-02, 68 bird flocks were sighted, but because other missions had higher priorities, none were investigated. For those flocks observed close to the vessel, four were associated with yellowfin tuna, six with skipjack tuna, two with mixed skipjack-yellowfin tuna schools, one with rainbow runner, and two with flyingfish, Exocoetidae. All other flocks were associated with unidentified fish schools. On the one fall-winter cruise (*Cromwell* cruise 55) only 12 schools were sighted near the Mariana Archipelago, one of which was associated with yellowfin tuna.

On the run from the Ogasawara Islands to Truk in July 1974, the FV *No. 20 Akitsu Maru* sighted 77 schools, 71 of which were skipjack tuna and 6 yellowfin tuna. The vessel fished 26 schools, catching fish from 21. The 9 days of fishing produced 8,676 kg (19,130 lb) of tuna or an average of 964 kg per day (2,126 lb per day). Both skipjack and yellowfin tunas taken during the survey were small, the former averaging 3.6 kg (7.9 lb) and the latter about 3.2 kg (7.1 lb).

Earlier, it was brought out that three U.S. purse seiners conducted a survey in the western Pacific to investigate the tuna resources, seining techniques, and fishing conditions (see Table 22). Data on school sightings from these seiners are also of interest (Table 39). Of the 286 schools sighted in July-October 1976 by the three seiners, 43.3% were estimated to be less than 15 tons, 15.0% were more than 15 tons, and 41.6% were of unknown size. A breakdown of the 286 sightings further into school types showed that 58.7% were school fish, 3.5% were associated with marine mammals, and 37.8% were associated with logs (Table 40).

Data from troll surveys are also of interest. The survey by Ikehara et al. (1972) demonstrated the commercial potential of skipjack and yellowfin tunas found in the offshore waters of Guam. They found skipjack tuna, which represented 67% of the troll catch, available throughout most of the

Table 39.--Tuna sightings by school size and type, July to October 1976 (adapted from Living Marine Resources text footnote 6).

	Schools under 15 tons			Schools over 15 tons			School size not estimated			
	Fish school	Marine mammals[1]	Logs	Fish school	Marine mammals[1]	Logs	Fish school	Marine mammals[1]	Logs	Total sightings
Apollo	35	1	4	14	3	1	8	1	16	83
Mary Elizabeth	14	0	6	7	2	3	37	1	41	111
Zapata Pathfinder	36	1	27	11	1	1	6	0	9	92
Total	85	2	37	32	6	5	51	2	66	286
Percent		43.3			15.0			41.6		

[1]Only sightings where marine mammals were associated with tunas.

year but in higher abundance from February through August (Table 41). Other species caught in good numbers were mahimahi (13%), yellowfin tuna (11%), and kawakawa (5%). The Cromwell survey in 1978 produced excellent catches of tunas and rainbow runner not only around the Northern Marianas but also in the vicinity of the offshore seamounts and banks such as Stingray Shoal, Pathfinder Reef, Supply Reef, and two unnamed banks located at lat. 14°13.5' N, long. 142°53.0' E and at lat. 17°44.2' N and long. 142°51.5' E (Table 42).

Table 40.--Total tuna sightings by school type, July to October 1976 (Living Marine Resources text footnote 6).

	Fish school	Marine mammals[1]	Logs	Total
Apollo	57	5	21	83
Mary Elizabeth	58	3	50	111
Zapata Pathfinder	53	2	37	92
Total	168	10	108	286
Percent	58.7	3.5	37.8	

[1]Only sightings where marine mammals were associated with tunas.

Baitfish

It was mentioned earlier that the development of tuna fisheries in Guam and the Northern Marianas is unlikely to be based on pole-and-line fishing because of the undependable supply of bait. The results of two Cromwell cruises provide some evidence of the availability of buccaneer anchovy in waters around the Mariana Archipelago. During midwater trawling operations with the Cobb trawl on cruise 55, buccaneer anchovy was present in six of the eight hauls made and on one station, about 18 kg (40 lb) of adult and juveniles were collected. Although it is mentioned here that at least one anchovy species may occur in abundance, considerable further research is required to determine their seasonal availability and abundance and on effective methods to capture, transfer, and keep them alive on the high seas.

On Cromwell cruises 53[12] and 78-02 (footnote 11) inshore observations indicate that, in general, bait does not occur in sufficient quantities along the shoreline. Ikehara et al. (1972) concluded from their baiting operations and observations in Guam that scouting for bait along the island's shoreline is futile and that the most a fishing vessel can expect

[12]Narrative report, Townsend Cromwell cruise 53, 8 April-8 July 1971. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

Table 41. --Cumulative catch results of trolling by month and species, 1967-68 (Ikehara et al. 1972).

Month	Skipjack tuna		Mahimahi		Yellowfin tuna		Wahoo		Kawakawa		Rainbow runner		Blue marlin		Dogtooth tuna		Total		Total line hours	Catch/100 line hours	
	No.	Kg	No.	Kg	No.	Kg	No.	Kg	No.	Kg	No.	Kg	No.	Kg	No.	Kg	No.	Kg		No.	Kg
Jan.	3	6.4	6	22.7	—	—	—	—	8	5.4	—	—	—	—	—	—	17	34.5	188	9	18.4
Feb.	32	63.1	18	51.7	1	9.1	1	6.8	1	0.2	—	—	—	—	—	—	53	130.9	189	28	69.2
Mar.	3	4.5	3	9.5	—	—	1	10.9	5	2.5	1	0.9	—	—	—	—	13	28.3	189	7	15.0
Apr.	23	21.8	6	34.0	1	2.7	—	—	1	2.3	—	—	—	—	—	—	31	60.8	368	8	16.5
May	44	76.2	3	22.7	—	—	1	8.2	2	1.8	—	—	1	57.6	—	—	51	166.5	635	8	26.2
June	77	120.7	4	20.0	8	67.1	—	—	—	—	1	1.4	1	52.2	—	—	91	261.4	415	22	63.0
July	12	14.5	1	10.9	—	—	—	—	—	—	—	—	—	—	—	—	13	25.4	109	12	23.3
Aug.	36	70.8	4	7.3	16	126.6	1	11.3	1	0.1	—	—	—	—	1	3.6	59	219.7	474	12	46.4
Sept.	—	—	—	—	1	9.1	—	—	—	—	—	—	—	—	—	—	1	9.1	137	1	6.6
Oct.	1	3.2	—	—	9	124.7	2	20.9	—	—	1	1.4	—	—	—	—	13	150.2	241	5	62.3
Nov.	—	—	1	5.0	1	5.4	—	—	—	—	—	—	—	—	—	—	2	10.4	55	4	18.9
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	56	0	0.0
Total	231	381.2	46	183.8	37	344.7	6	58.1	18	12.3	3	3.7	2	109.8	1	3.6	344	1,097.2	3,056	$\bar{x}$ = 9.7	$\bar{x}$ = 30.5
Catch/100 line hours	7.6	12.5	1.5	6.0	1.2	11.3	0.2	1.9	0.6	0.4	0.1	0.1	0.07	3.6	0.03	0.1	11.3	35.9	—		

Table 42.--Summary of trolling catches and tagging, Townsend Cromwell cruise TC-78-02 (TC-79) (see text footnote 11).

Date 1978	Direct or incidental	Location	Zero catch	Catch: Skipjack tuna	Catch: Yellowfin tuna	Catch: Mahimahi	Catch: Rainbow runner	Tagged: Skipjack tuna	Tagged: Yellowfin tuna	Tagged: Rainbow runner	Total catch	Hours trolled	Catch per line-hour
5/11	Incidental	Honolulu to Guam	x	—	—	—	—	—	—	—	—	4.00	0.00
5/12	do	do	x	—	—	—	—	—	—	—	—	3.00	0.00
5/15	do	do	x	—	—	—	—	—	—	—	—	2.00	0.00
5/18	do	do	—	1	—	—	—	—	—	—	1	5.00	0.07
5/19	do	do	x	—	—	—	—	—	—	—	—	4.00	0.00
5/20	do	do	x	—	—	—	—	—	—	—	—	10.00	0.00
5/21	do	do	x	—	—	—	—	—	—	—	—	9.00	0.00
5/25	Direct	Santa Rosa Bank	x	—	—	—	—	—	—	—	—	4.50	0.00
5/26	do	do	—	—	5	6	2	—	—	—	13	3.83	1.13
5/27	do	Galvez Banks	x	—	—	—	—	—	—	—	—	5.05	0.00
5/28	do	do	—	—	—	1	—	—	—	—	1	3.75	0.09
5/29	do	17-Mile Bank	x	—	—	—	—	—	—	—	—	1.03	0.00
5/30	Incidental	Run to Guam	x	—	—	—	—	—	—	—	—	1.72	0.00
5/31	Direct	No-Name Bank A	—	1	4	—	1	1	1	—	6	4.57	0.44
6/1	do	do	—	8	16	—	36	6	13	—	60	5.73	3.49
6/2	do	Arakane Reef	—	—	—	—	1	—	—	1	1	1.43	0.23
6/4	do	Pathfinder Reef	—	1	5	—	13	1	2	—	19	1.75	3.62
6/5	do	No-Name Bank B	—	2	9	—	—	1	6	—	11	0.83	4.42
6/6	do	do	—	13	10	—	6	7	7	—	29	7.25	1.33
6/8	do	Stingray Shoal	—	3	32	—	8	3	28	5	43	2.42	5.92
6/9	do	Supply Reef	—	2	18	—	13	1	17	13	33	3.17	3.47
6/11	do	Asuncion Island	—	—	—	—	—	—	—	—	—	1.88	0.00
6/12	do	Agrihan Island	—	—	2	1	—	—	1	—	3	3.00	0.33
6/21	do	Sarigan Island	x	—	—	—	—	—	—	—	—	1.50	0.00
6/23	do	Saipan	x	—	—	—	—	—	—	—	—	1.50	0.00
6/24	do	do	x	—	—	—	—	—	—	—	—	1.33	0.00
6/25	do	do	x	—	—	—	—	—	—	—	—	2.50	0.00
6/28	do	No-Name Bank C	x	—	—	—	—	—	—	—	—	3.50	0.00
7/1	do	No-Name Bank D	x	—	—	—	—	—	—	—	—	3.25	0.00
Total				31	101	8	80	20	75	19	226	102.49	

to catch would be a few buckets of young mullet, Mugilidae; soldierfish, Apogonidae; and delicate round herring. Data from scouting observations during cruise 53 showed that at Saipan, only a few scattered juveniles of mullet, goatfish, Mullidae, and rabbitfish, Siganidae, were seen along the northwestern shore and one small school of sardinelike fish along the southwestern part of the island. On cruise 78-02 night-light observations indicated the presence of about 60 buckets of banded blue sprat in Maug Lagoon, 30 buckets of a mixture of silverside, Atherinidae, and round herring, Dussumieriidae, at Cocos Island, and 10 buckets of soldierfish at Tinian Harbor. None of the other night-light stations occupied attracted significant quantities of baitfish to the light.

Amesbury et al. (1979) evaluated the abundance of several fish groups in terms of their potential as live bait and found no clupeoid-type fishes of the families Clupeidae, Dussumieriidae, and Engraulidae in Saipan Lagoon; however, Chromis spp. were quite abundant. The latter species are not considered ideal as baitfish for tuna fishing, but are adequate in the absence of more ideal species. Amesbury et al. noted that the major difficulty with Chromis spp. is in collecting enough of them without damaging the corals they normally inhabit. Other species considered were atherinids, Atherinidae, cardinalfishes, Apogonidae, and fusiliers, Caesionidae, but all were not abundant enough in Saipan Lagoon to provide a steady source of baitfish.

Atulai (Bigeye Scad)

The resource of atulai or bigeye scad in the Mariana Archipelago is probably second in importance to the tunas. Several reports and observations have indicated that this schooling fish can occur in very large numbers (Ikehara et al. 1972; Cromwell cruise 78-02 footnote 11). There is a small but established seasonal fishery for this species which schools and occasionally enters the shallow bays and harbors in large enough numbers to be caught by the thousands in surround nets and with hook and line. These inshore "runs," however, are erratic; Anderson et al. (1979) reported that the total summer and fall harvest of atulai was 50% higher in fiscal year 1979 than in fiscal year 1978 and that the estimated catch from various locations around the island including Agana Boat Basin, Apra Harbor, Umatac, Merizo, and Inarajan totaled 15 t.

Atulai can be found off Guam all year long except in July-August when their availability is lower (Ikehara et al. 1972) (Table 43). Catches ranged from 0.0 to 9.1 kg per line-hour (0.0 to 20.1 lb per line-hour) and averaged 1.8 kg per line-hour (4.0 lb per line-hour), and were made only during the dark moon phases. The scarcity of fish in July-August may be related to spawning, according to Ikehara et al. who observed that juveniles of about 78 g (2.8 oz) first appeared in the catch in August. Most of the atulai fishing was conducted with handlines consisting of 5-7 hooks while anchored in waters from 37 to 82 m (20 to 45 fathoms); the best fishing was usually at 73 m (40 fathoms) (Table 44).

The Cromwell's survey in 1978 substantiated the results of exploratory fishing conducted by Ikehara et al. (1972) and showed that atulai occur in good numbers in waters around the high islands as well as over the offshore banks and seamounts. Among the high islands, particularly productive was

Table 43.--Monthly summary of the results of handline mackerel fishing covering the period January 1967 to June 1969 (Ikehara et al. 1972).

	Catch			Effort	Catch per unit effort	
Month	Number	Average weight (kg)	Total weight (kg)	Line-hour	Number per line-hour	Kilograms per line-hour
			1967			
Jan.	196	0.257	50.3	37	5.3	1.4
Feb.	707	0.223	157.8	129	5.5	1.2
Mar.	1,675	0.213	357.0	120	14.0	3.0
Apr.	1,158	0.206	239.0	86	13.5	2.8
May	515	0.222	114.3	85	6.1	1.3
June	488	0.232	113.4	45	10.9	2.5
July	96	0.212	20.4	32	3.0	0.6
Aug.	81	0.146	11.8	32	2.5	0.4
Sept.	120	0.151	18.1	23	5.2	0.8
Oct.	379	0.266	100.7	68	5.6	1.5
Nov.	240	0.287	68.9	32	7.5	2.2
Dec.	336	0.298	100.2	90	3.7	1.1
			1968			
Jan.	716	0.260	186.4	95	7.5	2.0
Feb.	120	0.227	27.2	45	2.7	0.6
Mar.	57	0.198	11.3	18	3.2	0.6
Apr.	212	0.248	52.6	48	4.4	1.1
May	1,418	0.253	359.3	102	13.9	3.5
June	933	0.244	227.3	66	14.1	3.4
July	16	0.225	3.6	6	2.7	0.6
Aug.	503	0.078	39.0	29	17.3	1.3
Sept.	728	0.091	66.2	16	45.5	4.1
Oct.	228	0.119	27.2	20	11.4	1.4
Nov.	150	0.109	16.3	6	25.0	2.7
Dec.	--	--	--	--	--	--
			1969			
June	304	0.227	68.9	22	13.8	3.1
Total	11,376	--	2,436.6	1,252	244.3 $\bar{x}$ = 10.2	43.2 $\bar{x}$ = 1.8

Table 44.--Mackerel catch results by depth of anchorage (Ikehara et al. 1972).

Depth (m)[1]	Catch (kg)	Number of line-hours	Kilograms per line-hours
36.6-43.9	129.3	93	1.4
45.8-53.1	129.7	74	1.8
54.9-62.2	317.5	90	3.5
64.0-71.4	545.2	283	1.9
73.2-80.5	136.1	29	4.7
82.4-89.7	824.2	446	1.8
91.5-98.8	14.5	12	1.2
100.6-108.0	0.0	5	0.0
109.8-117.1	90.7	27	3.4
119.0-126.3	0.0	4	0.0
128.1-135.4	9.1	18	0.5
137.2-144.6	--	--	--
146.4-153.7	--	--	--
155.6-162.9	--	--	--
164.7-172.0	--	--	--
173.8-181.2	2.3	14	0.2
183.0-190.3	56.2	30	1.9
192.2-199.5	--	--	--
201.3-208.6	114.3	28	4.1

[1]Depth in meters converted from the original 5-fathom depth intervals.

Agrihan in the Northern Marianas; highly productive banks were Galvez Banks, located about 22 nmi southwest of Guam; Arakane Reef, located about 180 nmi due west of Saipan; Pathfinder Reef, located about 152 nmi due west of Anatahan; and an unnamed bank at lat. 17°44.2' N and long. 142°51.5' E, about 180 nmi due west of Alamagan (Table 45).

Bottom Fish

In addition to bigeye scad, other species identified as having good developmental potential in a handline bottom fish fishery included onaga, lehi, an unidentified grouper, Epinephelus sp., blackjack, gindai, and yellowtail kalekale (Ikehara et al. 1972) (Table 46). Ehu, pink kalekale, and yellow-eye opakapaka also occurred in good numbers but were less desirable because of their small size. Grounds that were sufficiently productive and potentially capable of supporting commercial exploitation included 45-Degree Bank, 17-Mile Bank, Haputo, Galvez Banks, Ritidian Point, and Pati Point (Table 47). The most consistently productive bottom fishing grounds were in depths between 148 and 220 m (80 and 120 fathoms) (Table 48). Larger individuals of onaga, lehi, and groupers appeared to be concentrated at depths from 221 to 293 m (121 to 160 fathoms). Of interest is the results of the intensive fishing experiment reported by Ikehara et

Table 45.--Catch summary of night-light fishing stations, Townsend Cromwell cruise TC-78-02 (TC-79) (see text footnote 11).

Date 1978	Stn. No.	Depth or range (m)	Location	Lutjanus bohar	Selar crumenophthalmus	Epinephelus emoryi	Lethrinus variegatus	Lutjanus gibbus	Caranx sexfasciatus	Caranx lugubris	Myripristis berndti	Priacanthus cruentatus	Gymnosarda unicolor	Lutjanus kasmira	Gnathodentex aurolineatus	Sufflamen fraenatus	Aphareus rutilans	Adioryx tiere	Sphyraena jello	Carangoides ferdau	Others
5/27	8	44	Galvez Banks	3	307	1	1	1	--	--	--	--	--	--	--	--	--	--	--	--	2 Lutjanus rivulatus
5/28	12	27	Galvez Banks	--	6	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	
5/29	15	48	17-Mile Bank	3	--	--	--	1	--	1	3	--	--	--	--	--	--	--	--	--	1 Aphareus furcatus, 1 Pagrus major
5/31	19	46	No-Name Bank A	6	6	1	--	--	--	2	--	1	3	2	1	--	--	--	--	--	1 Triaenodon obesus, 1 Sphyraena barracuda
6/02	24	18	Arakane Reef	3	340	2	--	--	--	6	50	--	--	10	--	--	--	1	--	--	
6/03	26	15	Pathfinder Reef	--	500	2	--	--	--	27	14	--	--	9	2	--	8	6	--	--	1 Aprion virescens
6/05	32	48	No-Name Bank B	3	550	--	3	--	--	3	--	--	--	--	--	--	--	--	--	--	
6/09	37	91	Maug Island	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
6/10	40	1,829	Asuncion Island	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2 squids
6/12	48	46	Agrihan Island	--	510	--	--	--	--	--	--	--	--	6	--	--	--	--	--	--	
6/13	51	27	Pagan Island	2	--	--	--	--	--	--	8	--	5	2	1	--	--	--	6	--	1 Adioryx spinifer
6/19	54	31	Alamagan Island	--	--	--	--	--	1	--	--	--	1	--	--	--	--	--	--	--	
6/23	65	22	Saipan Island	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	
6/27	78	9	Tinian Island	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	
6/30	82	35-42	Cocos Island	--	23	--	--	--	1	--	--	--	--	2	--	--	--	--	1	--	
7/01	84	46	Galvez Banks	2	60	--	2	2	3	1	3	4	--	6	5	--	2	--	--	--	1 Parupeneus porphyreus, 1 Monotaxis grandoculis, 1 L. monostigma
7/02	86	46	Galvez Banks	--	480	--	3	--	4	2	--	--	--	--	--	3	--	--	--	1	1 Cephalopholis sp.
Total				22	2,787	6	9	4	11	42	78	5	9	37	9	3	10	7	8	4	14

Table 46.--Rank of the more important fish species caught over the period January 1967 through June 1969, by weight and number (adapted from Ikehara et al. 1972).

	Species	Weight (kg)		Species	Number
1.	Mackerel	2,428	1.	Mackerel	11,376
2.	Onaga	1,959	2.	Yellowtail kalekale	681
3.	Lehi	1,471	3.	Gindai	483
4.	Large grouper, *Epinephelus* sp.	1,001	4.	Lehi	381
5.	Blackjack	514	5.	Onaga	316
6.	Gindai	450	6.	Skipjack tuna	231
7.	Yellowtail kalekale	440	7.	Ehu	208
8.	Red snapper	415	8.	Blackjack	194
9.	Skipjack tuna	381	9.	Pink kalekale	173
10.	Yellowfin tuna	367	10.	Pink opakapaka	161
11.	Dogtooth tuna	330	11.	Yellow-eye opakapaka	155
12.	Pink opakapaka	318	12.	Rainbow runner	133
13.	Ehu	257	13.	Red snapper	62
14.	Amberjack, *Seriola* sp.	240	14.	Amberjack, *Seriola* sp.	59
15.	Mahimahi	217	15.	Mahimahi	52
16.	Yellow-eye opakapaka	178	16.	Jack, *Caranx helvolus*	49
17.	Rainbow runner	157	17.	Yellowfin tuna	39
18.	Pink kalekale	127	18.	Dogtooth tuna	36

al. A small pinnacle such as Haputo, which appeared to concentrate fish, was found to be highly susceptible to overfishing (Table 49).

In 1976, the Government of the Commonwealth of the Northern Marianas entered into a joint venture with Japan's Kanagawa Prefecture to survey some of the islands for bottom fish, skipjack tuna, and deep-swimming tunas such as yellowfin, bigeye, and albacore. The survey, conducted on the FV *Daikatsu Maru* and concentrated mostly around Aguijan, Tinian, Saipan, Pagan, Agrihan, Asuncion, and Maug, revealed that ehu, pink kalekale, lehi, northern bluefin tuna, dogtooth tuna, and jack occurred in good numbers in most of the areas surveyed (Ikeda).[13] Particularly productive were Aguijan, Pagan, Asuncion, and Maug; Tinian, Saipan, and Agrihan were less productive (Table 50). However, the survey was brief and one of the recommendations was to continue the exploratory fishing to obtain additional information.

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[13]Ikeda, Y. Undated. Fishing survey report of waters surrounding the Mariana Islands, fisheries situation and on-the-spot survey reports in Saipan, Tinian and Rota Island. Fish. Sect. Agric. Div., Kanagawa Pref., 18 p. (Mimeogr.)

Table 47.--Handline bottom fishing catch results by areas (Ikehara et al. 1972).

Area	Catch (kg)	Number of line hours	Catch per unit effort Kilograms per line-hour
45 Degree Bank	1,161	86	13.5
17-Mile Bank	254	22	11.5
Lafac Point	19	3	6.3
Haputo	3,322	684	4.9
Ritidian Point	90	24	3.8
Inarajan	3.6	1	3.6
Galvez Banks	488	138	3.5
Pati Point	220	75	2.9
Babi Island	130	45	2.9
Asan	64	23	2.8
Tarague	515	202	2.5
Anae Island	363	152	2.4
Facpi Point	245	109	2.2
Anao Point	11.3	5	2.3
Umatac	710	346	2.1
Adelupe Point	59	30	2.0
Cette Bay	64	36	1.8
Orote	461	312	1.5
Uruno	37.2	26	1.4
Hospital Point	18.1	13	1.4
Two Lovers Leap	23.6	17	1.4
Merizo - Cocos Islands	215	188	1.1
Togcha	2.3	2	1.2
Camel Rock	8.2	9	0.9
Mobil Oil	1.4	2	0.7
Rota Bank	2.7	11	0.2

Table 48.--Handline bottom fishing catch results by depth (Ikehara et al. 1972).

Depth (m)	Number of line hours	Kilograms caught	Number caught	Kilograms per line-hour	Number per line-hour
Shallow (0-73)	43	228	207	5.3	4.8
Intermediate (75-146)	333-1/2	1,001	495	3.0	1.5
Medium-deep (148-220)	1,501-1/2	5,383	1,774	3.6	1.2
Deep (221-293)	65-1/2	364	73	5.6	1.1

Table 49.--Haputo (178-m pinnacle) bottom handlining catch results by month (Ikehara et al. 1972).

Month	Number of line hours	Kilograms caught	Kilograms per line-hour	Number caught	Number per line-hour
1967					
June	18	244	13.8	34	1.9
July	50-1/2	369	7.3	85	1.7
Aug.	153-1/2	1,568	10.2	318	2.1
Sept.	33	38	1.2	20	0.6
Oct.	13	32	2.5	6	0.5
Nov.	--	--	--	--	--
Dec.	78-1/2	264	3.4	56	0.7
1968					
Jan.	78-1/2	143	1.8	62	0.8
Feb.	--	--	--	--	--
Mar.	64	233	3.6	91	1.4
Apr.	23	40	1.7	19	0.8
May	30	38	1.3	28	0.9
June	28	92	3.3	13	0.5
July	46	49	1.1	22	0.5
Aug.	40	52	1.3	14	0.4
Sept.	--	--	--	--	--
Oct.	4	0	0.0	0	0.0

Table 50.--The number of days fished, total catch, and catch per day during the bottom fish survey conducted by the FV Daikatsu Maru in the Northern Marianas, 1976 (Ikeda text footnote 13).

Island	Days fished	Total catch (kg)	Catch per day (kg)
Aguijan	3	1,730	577
Tinian	2	500	250
Saipan	1	300	300
Pagan	3	2,000	667
Agrihan	1	500	500
Asuncion	2	1,500	750
Maug	4	2,000	500
	16	8,530	533

The results of bottom fishing stations occupied during the 1978 Cromwell survey demonstrated that like bigeye scad, the fishes of the snapper-grouper complex occurred in good numbers not only along the high islands but also in waters over the offshore reefs and banks. During the early phase of the cruise when most of the operations were concentrated around the offshore banks and reefs, handline catches were relatively good; however, as the cruise progressed and operations shifted to waters around the high islands, it became quite apparent that the catch rates began falling off rather sharply (Table 51). Catch rates around the offshore banks varied from 0.25 to 3.70 fish per line-hour and averaged 1.89 whereas around the high islands, they varied between 0.27 and 5.75 fish per line-hour but averaged only 1.03. The largest catch at one station occurred at the unnamed bank 180 nmi due west of Alamagan where fishing in 110-256 m (60-140 fathoms) of water with four lines produced 37 fish, mostly gindai. The species most frequently landed from around the offshore banks were gindai, black ulua, pink opakapaka, and yellowtail kalekale. From around the high islands, gindai still dominated the catch followed closely by yellowtail kalekale.

In a report prepared for the Western Pacific Regional Fishery Management Council, Ralston[14] analyzed estimated landings of bottom fish caught by Guam's recreational fishermen and found that catches in some years fluctuated very widely (Figure 29). For example, he noted that the bottom fish catches were less than 2,270 kg (5,000 lb) in fiscal year 1969-70 but rose very abruptly to 13,600 kg (29,990 lb) in fiscal year 1971 then declined to its former level from fiscal years 1972 through 1976. In fiscal year 1977, it again rose precipitously to 17,719 kg (39,071 lb) then declined slightly in fiscal year 1978 to about 13,189 kg (29,083 lb). Using boat-hour as a measure of effort, Ralston demonstrated that the estimates of catch per unit effort of Guam's bottom fishes do not show any trends over the fiscal years 1969 through 1978 (Figure 30), which would indicate either annual changes in catchability or in stock abundance due to the effects of fishing. It is also apparent that changes in the catch per boat-hour are not associated with changes in fishing intensity (boat-hours) (Figure 31), but that the total catch is significantly correlated with fishing intensity (Figure 32). Ralston concluded that the present level of fishing is apparently negligible; therefore, further increases in yield are possible by increasing effort. Although his study did not detect any fishery-related changes in bottom fish apparent abundance, Ralston suggested that a more meaningful or refined measure of effort may show that the fishery was substantially affecting abundance.

Caridean Shrimp

During the past decade, there has been considerable interest in the deepwater shrimp species belonging to the Tribe Caridea, Family Pandalidae. The biology of caridean shrimps is not well known and only a few commercially harvested species have been researched. Most are deepwater benthic

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[14]Ralston, S. 1979. A description of the bottomfish fisheries of Hawaii, American Samoa, Guam, and the Northern Marianas. Report submitted to the Western Pacific Regional Fishery Management Council, Honolulu, HI 96813, 102 p.

Table 51.--Catch summary of handline fishing stations occupied around offshore seamounts and high islands, Townsend Cromwell cruise TC-78-02 (TC-79) (see text footnote 11).

Date 1978	Stn. No.	Day or night	Depth (m)	Location	Total No. of fish caught	No. of line-hours fished	No. caught per line-hour	Lutjanus bohar	Lethrinus variegatus	Pristipomoides filamentosus	P. auricilla	P. sieboldii	P. flavipinnis	P. zonatus	Seriola dumerili	Caranx lugubris	Epinephelus emoryi	Aphareus rutilans	Etelis carbunculus	E. coruscans	Gymnosarda unicolor	Others
AROUND OFFSHORE SEAMOUNTS																						
5/26	3	Day	146-238	Santa Rosa Reef	15	12.32	1.22	--	--	2	--	5	1	6	--	1	--	--	--	--	--	
5/26	5	Night	27-329	Santa Rosa Reef	1	4.00	0.25	--	--	--	--	--	--	--	--	--	--	1	--	--	--	
5/27	6	Day	146-238	Galvez Banks	19	6.00	3.17	--	--	--	--	2	6	6	--	1	--	--	2	--	1	1 unidentified serranid
5/28	11	Night	201	Galvez Banks	1	1.00	1.00	--	--	--	--	--	--	1	--	--	--	--	--	--	--	
5/29	14	Day	137-247	17-Mile Bank	5	5.32	0.94	1	--	--	2	--	--	2	--	--	--	--	--	--	--	
5/31	17	Day	91-256	No-Name Bank A[1]	30	12.90	2.32	1	--	6	2	--	--	7	3	11	--	--	--	--	--	
6/02	22	Day	91-219	Arakane Reef	22	12.56	1.75	1	--	11	--	--	--	4	1	1	1	--	2	--	--	1 *Cephalopholis aurantius*
6/04	28	Day	146-238	Pathfinder Reef	35	10.64	3.29	--	--	1	--	--	2	6	5	20	--	--	--	--	--	1 *Sufflamen fraenatus*
6/05	30	Day	110-256	No-Name Bank B[1]	37	10.00	3.70	3	--	--	9	--	1	19	--	3	--	--	1	--	--	1 *S. fraenatus*
6/08	34	Day	91-256	Stingray Shoal	30	14.00	2.14	--	--	--	4	--	--	17	2	7	--	--	--	--	--	
6/28	79	Day	110-293	No-Name Bank C[1]	8	10.00	0.80	--	--	--	1	--	1	2	--	2	--	--	--	--	--	1 *Variola louti*, 1 *Tropidinius amoenus*
7/02	85	Day	128-274	Galvez Banks	16	17.32	0.92	--	--	--	8	--	1	6	--	--	--	--	1	--	--	
Total					219	116.06	1.89	6	0	20	26	7	12	76	11	46	1	1	6	0	1	

Table 51.--Continued.

Date 1978	Stn. No.	Day or night	Depth (m)	Location	Total No. of fish caught	No. of line-hours fished	No. caught per line-hour	*Lutjanus bohar*	*Lethrinus variegatus*	*Pristipomoides filamentosus*	*P. auricilla*	*P. sieboldii*	*P. flavipinnis*	*P. zonatus*	*Seriola dumerili*	*Caranx lugubris*	*Epinephelus emoryi*	*Aphareus rutilans*	*Etelis carbunculus*	*E. coruscans*	*Gymnosarda unicolor*	Others
				AROUND HIGH ISLANDS																		
6/10	38	Day	128-238	Maug Island	23	4.00	5.75	—	—	—	9	—	—	8	—	1	—	—	1	—	—	1 *V. louti*, 3 unidentified serranid
6/11	42	Day	146-219	Asuncion Island	13	8.00	1.62	—	—	5	—	—	—	2	—	2	—	—	—	—	—	1 *V. louti*, 3 unidentified snappers
6/12	45	Day	128-366	Agrihan Island	7	13.00	0.54	—	—	1	—	—	—	2	—	1	—	—	—	1	—	1 unidentified snapper, 1 unidentified grouper
6/19	52	Day	128-274	Alamagan Island	22	15.00	1.47	—	—	1	8	—	—	5	—	1	—	—	1	1	—	2 *V. louti*, 1 *Paracaesio caeruleus*, 1 *Lethrinus* sp., 1 *C. aurantius*
6/20	55	Day	128-329	Guguan Island	20	16.25	1.23	1	—	3	2	—	1	4	—	2	—	2	—	—	—	2 *Lutjanus kasmira*, 1 *C. aurantius*, 1 *Cephalopholis* sp., 1 *Parupeneus* sp.
6/21	57	Day	164-274	Sarigan Island	8	10.00	0.80	—	—	—	2	—	—	2	—	—	—	—	—	—	—	1 *C. sexmaculatus*, 1 *Lethrinus* sp., 2 *Paracaesio caeruleus*
6/22	61	Day	128-311	Farallon de Medinilla	2	7.50	0.27	—	2	—	—	—	—	—	—	—	—	—	—	—	—	
6/24	66	Day	181-274	Saipan Island	12	17.50	0.68	—	—	—	—	—	2	2	1	2	—	1	1	—	—	2 *C. aurantius*, 1 *T. amoenus*
6/26	75	Day	164-274	Tinian Island	7	10.42	0.67	—	—	—	—	—	7	—	—	—	—	—	—	—	—	
6/30	80	Day	128-366	Cocos Island	5	13.32	0.38	—	—	—	—	—	1	2	—	—	—	—	2	—	—	
Total					119	114.99	1.03	1	2	10	21	0	11	27	1	9	0	3	5	2	0	

[1]No-Name Bank A is located at lat. 14°13.5' N, long. 142°53.0' E; No-Name Bank B at lat. 17°44.2' N, long. 142°51.5' E; and No-Name Bank C at lat. 15°05.7' N, long. 145°25.9' E.

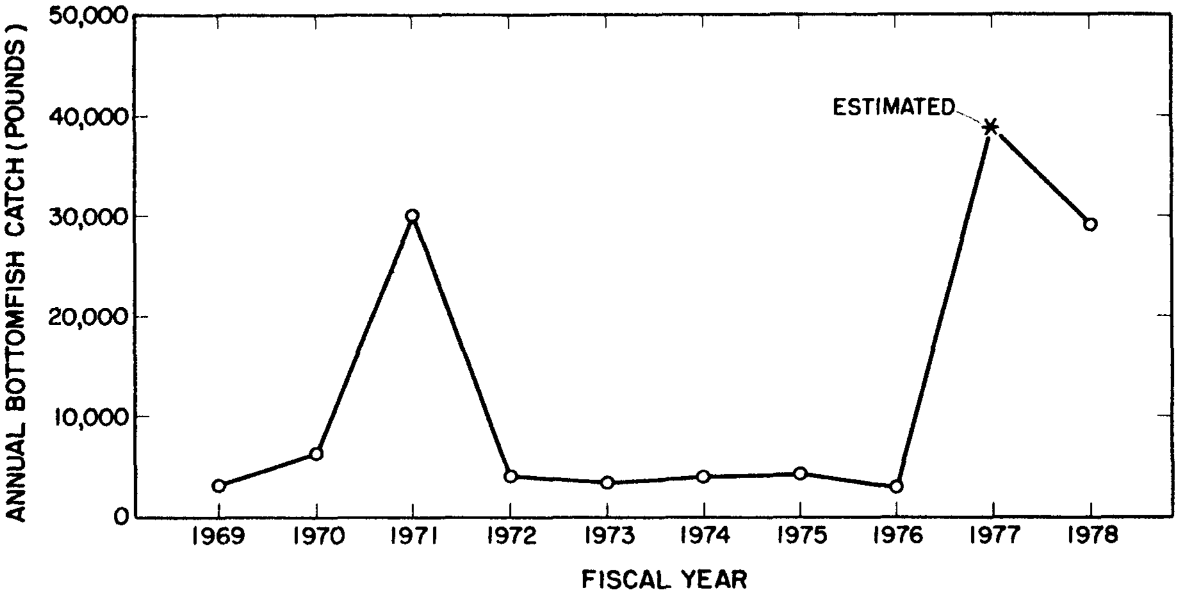

Figure 29.--Estimated annual landings of bottom fishes from the waters around Guam (Ralston text footnote 14).

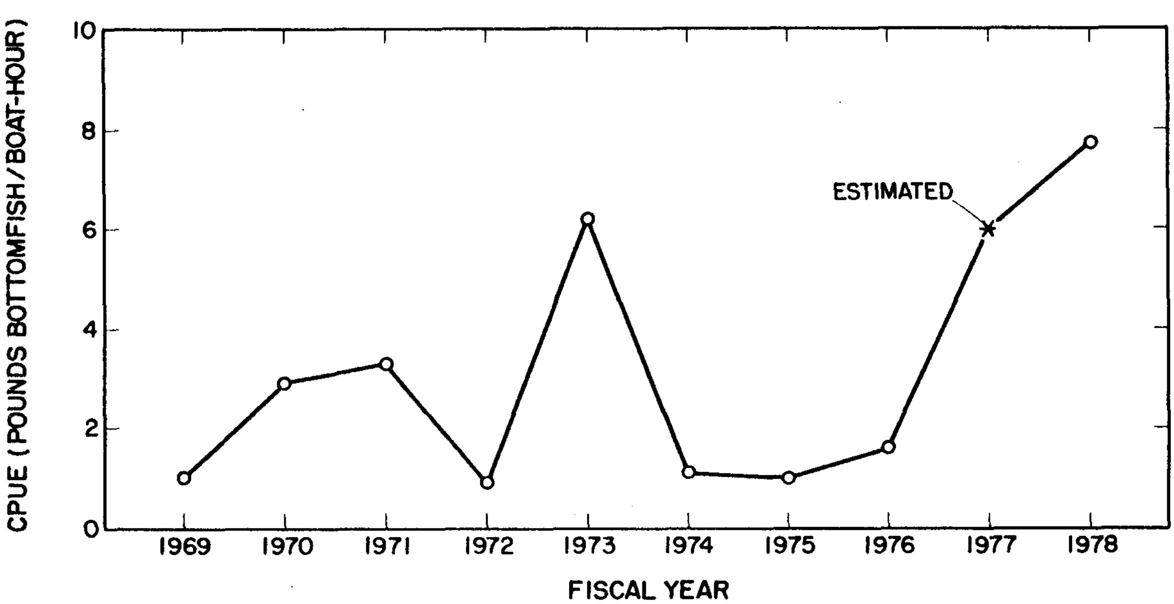

Figure 30.--Catch rates of bottom fish during the last 10 years (Ralston text footnote 14).

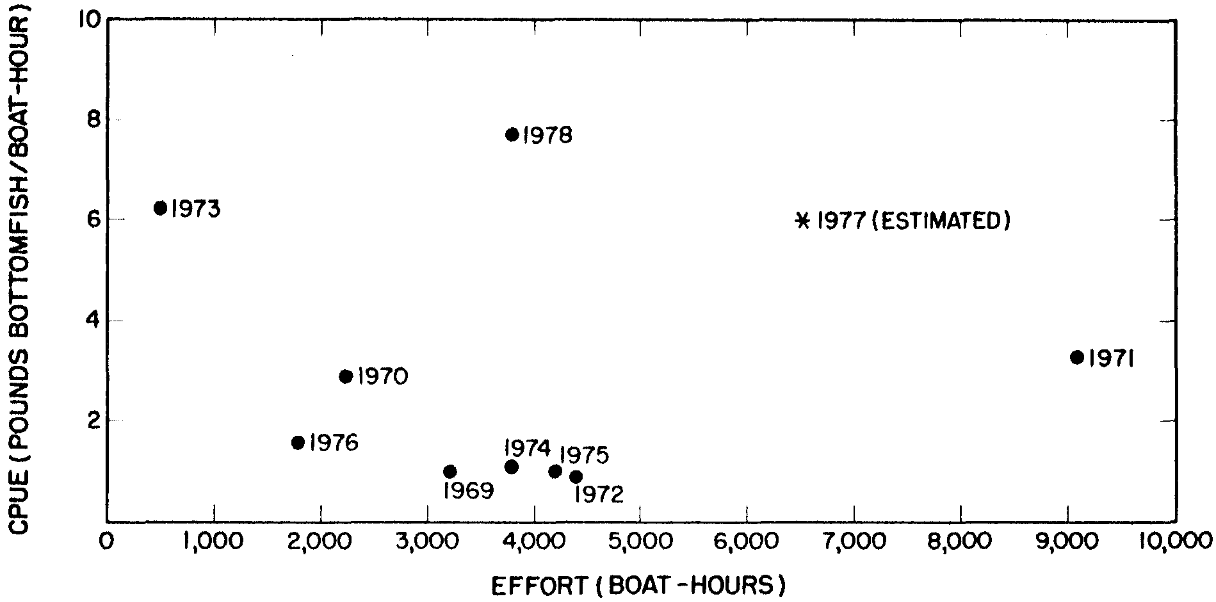

Figure 31.--Relationship between catch rate and fishing effort (Ralston text footnote 14).

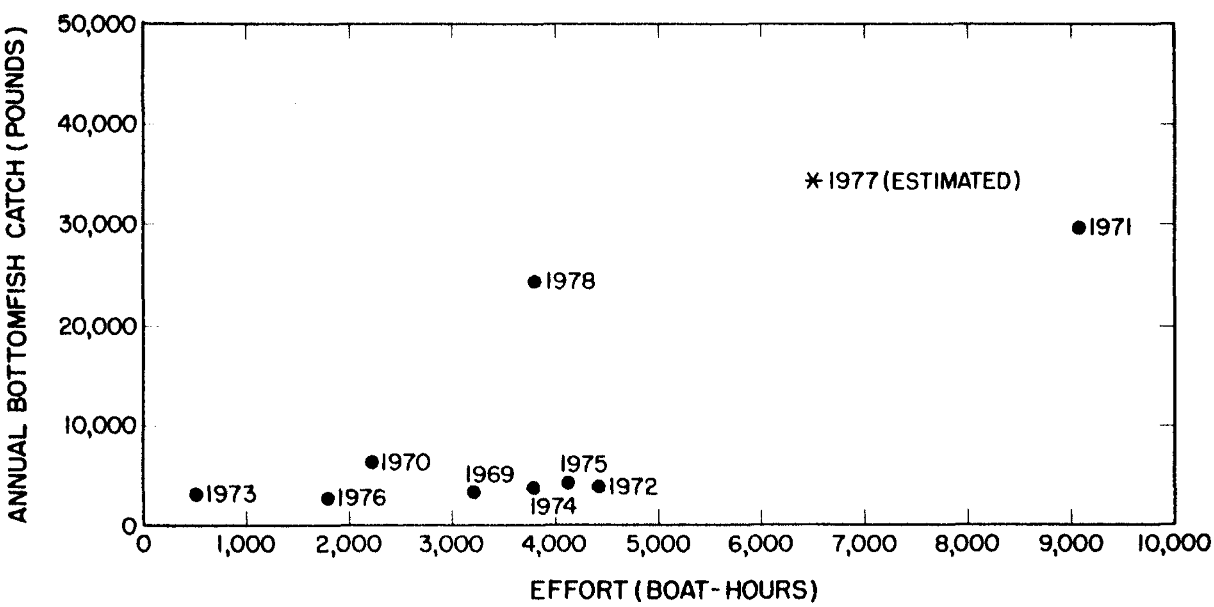

Figure 32.--Catch as a function of fishing effort. (Ralston text footnote 14).

forms and may make vertical diel migrations up into midwater layers. In the Pacific, experimental fishing for deepwater shrimps have been conducted in places such as Hawaii (Struhsaker and Aasted 1974), Guam (Wilder 1977, 1979), New Caledonia (Intès 1978), Fiji (Brown and King 1979), New Hebrides (King 1980a), and Western Samoa (King 1980b).

Results of exploratory trapping off Guam and the Northern Marianas indicate that there is considerable potential for development of a fishery for two species of carideans, *Heterocarpus ensifer* and *H. laevigatus*. Wilder (1977, 1979) demonstrated that deepwater shrimps can be caught in sufficiently large numbers in Guam's offshore waters with only moderate initial capital investment. His preliminary survey indicates that average catches of 1.81-2.72 kg per trap (4-6 lb per trap) can be expected, that the resource is distributed around the entire island, and that depth is the single most important factor to be considered in the distribution of caridean shrimps with the largest concentrations occurring at about 475 m (250 fathoms) (Wilder 1979). He also showed that *H. ensifer* was distributed between 213 and 732 m (116 and 400 fathoms) and that it was most abundant between 366 and 457 m (200 and 250 fathoms) whereas *H. laevigatus* was found between 451 and 732 m (246 and 400 fathoms) and it was most abundant at 610-732 m (333-400 fathoms) (Wilder 1977).

Results of shrimp trapping operations conducted on the *Cromwell* in 1978 showed that there was considerable overlap in the depth distribution of the two species of *Heterocarpus*. For example, at Tinian and Cocos Islands, *H. laevigatus* predominated in the catch at 638-678 m (349-371 fathoms), but at Farallon de Medinilla and Saipan, *H. ensifer* predominated at 640-702 m (350-384 fathoms) (Table 52). Also *H. laevigatus* was found at depths exceeding 732 m (400 fathoms); in fact, several traps fished deeper than 732 m and some as deep as 823 m (450 fathoms) producing moderately good catches of *H. laevigatus*.

Shrimp trapping experiments carried out aboard the NMFS-chartered FV *Typhoon*[15] in waters around Saipan, Tinian, and Esmeralda Bank indicated a lower overall catch rate of 0.99 kg per trap (2.2 lb per trap). An experiment to determine species composition and relative abundance by depth showed that at 366 m (200 fathoms), *H. ensifer* predominated in the catches; the catch rate was 0.58 kg per trap (1.3 lb per trap) and the shrimps were 107 per kg (48.5 shrimps per lb). At 732 m *H. laevigatus* predominated; the catch rate averaged 1.59 kg per trap (3.5 lb per trap) and the average size of the shrimp was 28.6 per kg (13 shrimps per lb). The catch at 1,097 m (600 fathoms) was likewise dominated by what was believed to be *H. laevigatus* or a closely related species; the catch rate averaged 0.65 kg per trap (114 lb per trap) and the average size of the shrimp was 52.9 per kg (24 shrimps per lb).

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[15]Cruise and narrative reports, FV *Typhoon* charter cruise 81-01. Part I: 9-22 February 1981; Part II: 15 March-15 April 1981. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

Table 52.--Catch summary (in numbers) of shrimp trapping stations, *Townsend Cromwell* cruise TC-78-02 (TC-79 (see text footnote 11).

Date 1978	Stn. No.	Depth (m)	Location	*Heterocarpus laevigatus*	*Heterocarpus ensifer*	*Heterocarpus* sp.	*Conger* sp.	Majidae (Spider crab)	Paguridae (Hermit crab)	Other
5/27	7	750	Galvez Banks	163	—	—	7	1	—	
6/09	36	426-442	Maug Island	4	122	—	6	—	12	1 brotulid; unidentified shrimps
6/10	39	651-700	Asuncion Island	783	—	—	1	1	—	Unidentified shrimps
6/12	47	722-737	Agrihan Island	1,451	—	—	1	—	—	
6/13	50	741-823	Pagan Island	1,427	—	—	—	—	—	
6/19	53	730-733	Alamagan Island	456	29	—	6	3	—	
6/20	56	656-730	Guguan Island	1,577	—	—	5	1	—	
6/21	58	668-732	Sarigan Island	258	—	—	4	1	—	
6/22	62	640-649	Farallon de Medinilla	7	907	50	1	1	—	Unidentified shrimps
6/23	64	647-702	Saipan Island	223	350	28	1	—	—	Unidentified shrimps
6/24	67	710-744	Saipan Island	335	2	—	—	1	—	
6/25	70	722-742	Saipan Island	129	—	—	4	—	—	Unidentified shrimps
6/26	76	655-678	Tinian Island	317	24	—	2	—	—	
6/30	81	638-642	Cocos Island	301	2	—	2	—	—	Unidentified shrimps
7/01	83	732-746	Galvez Banks	375	—	—	11	—	—	Unidentified shrimps
	Total			7,806	1,436	78	51	9	12	

Inshore Fishes

Habitat improvement projects have been in progress since 1970 in the inshore lagoon waters of Guam to concentrate and increase fish populations (Kami et al. 1978; Anderson et al. 1979). Two artificial reefs constructed from discarded tires were placed in Cocos Lagoon and a third, a 16.7-m Navy barge modified with the addition of 0.2-m diameter pipes to provide a roof over the barge pan, was placed in Agat Bay. Neither of the two tire reefs attracted significant numbers of large fish. In general, coral growth on the tire reefs was poor due to heavy siltation. The barge reef, on the other hand, attracted fish at the rate of 17 fish per month. Significant increases were noted in the numbers of planktivores above the barge, nocturnal carnivores residing under the barge, and grazing herbivores along the sides. The most important change, however, was the increase in the numbers of large fishes (0.5 kg or larger), mostly serranids and lutjanids, visiting the artificial reef.

The study also demonstrated that each of the 120 species observed at the artificial reefs fell into one of three patterns with respect to their abundance. Most were classified as irregular, that is, their abundance varied randomly with no distinct pattern. Others showed net increases over time and a third group showed distinct seasonal variations. Increases in seasonal species were attributed to settling of larval fish onto the artificial reef and by immigration of older juveniles from outside the reef. Decreases in seasonal species appeared to be the result of predation. The increase and decrease of three predatory species appeared to be a distributional response to spatio-temporal variation in prey abundance. It was concluded that to continuously attract large carnivores to the artificial reef, prey density must be maintained at a higher level than in surrounding areas.

Studies on the community structure of fishes in Cocos Lagoon showed that the lagoon as a whole did not support an exceptionally rich ichthyofauna (Jones and Chase 1975). In fact, the lagoon would have been considerably more depauperate were it not for the reef development within the lagoon and the rubble tract and seagrass beds. Jones and Chase reasoned that the sand-dominated biotope, which makes up a considerable portion of the total lagoon, did not provide adequate cover and food for the fishes. Qualitative observations, however, disclosed that juvenile fishes occurred in the lagoon in large numbers and that the enclosed nature and natural cover (reef and seagrass beds) make Cocos Lagoon a valuable nursery ground for many species which constitute important components of Guam's sport and commercial fishery. They concluded that physical disruption of any part of the lagoon could seriously affect not only the fish populations but also the rate of recruitment of subadults to nearby reef areas outside it.

Other studies on inshore fish communities were conducted primarily in conjunction with coastal surveys of bays and harbors. A study of Talofofo Bay by Randall (1974) brought out that most of the fishing conducted in the bay is noncommercial in nature, and that several marine species there are of recreational value including various species of carangids, great barracuda or alu, yellowmargined sea perch, silver-spotted gray snapper, rock flagtail or umatan, striped mullet, mullet, laiguan, oxeye tarpon, spinefoot, rabbitfaced spinefoot, and bluntnosed spinefoot. Gawel (1977) found the fish fauna of Agat Bay, to be diverse and numerous in numbers of species. He listed 202 species belonging to 99 genera and 44 families. The overall density was 0.54 fish/m^2 in the four biotopes examined. The richness of the fish communities, however, differed considerably with respect to environmental facies; e.g., no fish was found in the submarine terrace of unconsolidated sediments. The fish communities of the fringing reef-flat platform, reef margin, and reef-front biotopes were relatively dense and diverse.

At Piti Bay and Piti Channel the dominant species was the ringtailed surgeonfish or ugupao which occurred in small schools throughout the lagoon (Marsh et al. 1977). The 1977 survey by Marsh et al. also showed an increase in the number and species of the Family Apogonidae over the 1976 count. They concluded that, in general, the numbers of species and individuals have remained constant or increased slightly for most fish families. The study also demonstrated that there were occasional fish kills in the outfall lagoon primarily affecting large fishes. The major species in the fish kills included the goldstriped goatfish, yellowmargined sea perch, majarras, ponyfish, sesjun, sandperch, and bluefinned crevalle. Marsh and Doty (1976) and Marsh et al. (1977) concluded that the fish kills resulted from episodic discharges of chlorine from the powerplants.

During the 1978 survey cruise of the Cromwell, 22 fish-trapping stations were occupied in depths ranging from 13 to 71 m (7 to 39 fathoms) to collect data on the distribution, species composition, and relative abundance of the fishes in the inshore community. The results of these trapping operations indicated that two species of lutjanids--bluelined snapper and twinspot snapper--were by far the most frequently caught; both species were caught at 20 of the 22 stations. The catch rates for the two species, however, were relatively low. Based on fish trap catches alone (some bluelined snapper and twinspot snapper were also taken in the lobster pots) the 321 trap-nights of effort expended during the cruise produced only 0.48 taape per trap-night and 0.18 red snapper per trap-night.

Of interest are the sharks that were taken on the cruise for they represent a potentially important resource of commercial value. Table 53 shows that the reef whitetip shark, *Triaenodon obesus*, occurred in the trap catches in relatively good numbers. They were particularly abundant around Farallon de Medinilla where the fish traps caught 35, at Galvez Banks where 21 were taken on station 83, and at an unnamed bank 137 nmi due west of Rota (lat. 14°12.4' N, long. 142°52.5' E) where 12 were caught.

In the Northern Marianas, Amesbury et al. (1977) found more than 5,000 fishes of some 75 different species in the Tanapag Harbor area. The most abundant groups were the damselfishes, with two species--*Chromis caerulea* and *Dascyllus aruanus*--accounting for about 50% and 20%, respectively, of the fishes seen. Among other species frequently observed in the harbor were the sharpbacked puffer which occurred in 15 of the 18 transects, and the surgeonfish. Amesbury et al. (1977) concluded that there were undoubtedly many species that were not observed during the census because of their behavioral pattern, e.g., the roving predators including the jacks, snappers, and goatfishes. Also not observed were seasonally abundant fishes like the rabbitfishes, nocturnally active forms such as squirrelfishes, and cardinalfishes, Apogonidae, and cryptic or secretive

Table 53.--Summary of fish and lobster trapping stations, Townsend Cromwell cruise TC-78-02 (TC-79) (see text footnote 11).

Date 1978	Stn. No.	Depth (m)	Location	Panulirus femoristriga	P. versicolor	P. penicillatus	Calappa calappa	Carpilius maculatus	Dardanus sp.	Lutjanus bohar	L. kasmira	L. gibbus	Lethrinus variegatus	L. miniatus	Gnathodentex aurolineatus	Epinephelus emoryi	Myripristis berndti	Gymnothorax eurostus	Heniochus acuminatus	Triaenodon obesus	Ginglymostoma ferrugineum	Others
5/25	1	20-35	Santa Rosa Reef	—	—	—	—	—	—	—	2	1	3	—	1	—	—	—	—	3	—	
5/26	4	31-53	Santa Rosa Reef	—	—	—	—	—	—	2	4	—	6	—	—	—	—	—	—	—	—	1 Chaetodon corallicola
5/27	7	38-58	Galvez Banks	—	—	—	—	—	—	10	36	—	7	—	—	—	—	—	—	3	—	1 Naso vlamingi
5/28	9	36-40	17-Mile Bank	—	—	—	—	—	—	2	1	—	—	—	—	—	—	—	—	2	—	
5/28	10	35-53	Galvez Banks	—	1	—	—	—	—	9	7	—	—	1	—	1	—	—	—	3	3	2 Plectorhynchus orientalis
5/31	18	46-49	No-Name Bank A	—	—	—	—	—	—	11	14	—	—	—	—	—	4	—	—	12	—	1 Scarus pectoralis
6/02	23	13-16	Arakane Reef	—	—	—	—	—	—	5	4	—	—	—	—	—	2	—	—	1	—	2 Caranx lugubris
6/03	25	15-22	Pathfinder Reef	—	—	—	—	—	—	8	10	—	—	—	—	—	1	1	—	—	—	
6/05	31	48-71	No-Name Bank B	—	—	—	—	—	—	2	2	—	4	—	—	—	—	—	—	6	—	
6/10	39	33-58	Asuncion Island	—	—	—	—	—	—	1	10	—	3	—	—	1	—	—	1	—	—	1 Balistidae, 1 Adioryx andamanensis
6/12	47	36-55	Agrihan Island	—	—	—	2	—	—	—	6	—	—	—	—	—	—	—	12	—	—	2 Carangoides ferdau
6/13	50	16-53	Pagan Island	—	—	—	—	—	—	12	4	—	1	—	—	—	—	—	—	—	—	1 Parupeneus trifasciatus
6/19	53	31-36	Alamagan Island	—	—	1	—	—	—	1	2	—	—	—	—	—	—	—	—	—	—	
6/20	56	20-42	Guguan Island	—	—	—	—	—	—	7	9	—	—	—	—	—	—	1	—	—	1	
6/21	58	40-48	Sarigan Island	—	—	—	2	1	1	1	—	—	—	—	—	—	—	—	—	1	—	
6/22	62	38-58	Farallon de Medinilla	—	—	2	—	—	—	14	—	—	2	1	—	—	—	—	—	35	1	1 A. spinifer, 1 Carcharhinus menisorrah
6/24	64	27-31	Saipan Island	—	—	—	—	—	—	6	19	4	1	—	4	—	—	—	—	8	2	1 A. spinifer
6/24	67	35-49	Saipan Island	2	—	—	—	2	1	5	9	1	1	—	1	—	1	1	—	1	—	1 Balistidae, 2 Lethrinus ramak
6/25	70	15-26	Saipan Island	—	—	—	—	—	1	3	7	1	11	1	—	—	—	—	—	2	—	
6/26	76	31-44	Tinian Island	—	—	—	—	1	—	9	2	1	1	—	—	—	1	—	—	7	—	1 A. andamanensis, 1 A. tiere
6/30	81	25-64	Cocos Island	—	—	—	—	—	—	2	6	3	1	—	1	1	—	—	—	—	—	1 Gymnocranius japonicus, 1 Gymnothorax flavimarginatus
7/01	83	40-46	Galvez Banks	—	—	—	—	—	—	13	7	—	—	—	—	1	—	—	—	21	1	1 Dromidiopsis dormia
	Total			2	1	3	4	4	3	123	161	11	41	3	7	4	9	3	13	84	8	

fishes like gobies, Gobiidae, blennies, Blenniidae, scorpaenids, Scorpaenidae, and eels, Muraenidae.

A 1979 survey of Saipan Lagoon by Amesbury et al. (1979) provided estimates of annual equilibrium harvest for fish groups of potential economic importance (Table 54). Based on surveys of 24 habitats (Table 55) within the lagoon, in terms of numbers, blue Chromis was by far the most abundant followed by surgeonfishes, rabbitfishes, barracuda, and large wrasses (Table 56). By weight, however, the surgeonfishes were dominant followed by blue Chromis, rabbitfishes, large wrasses, high-bodied jacks, and large groupers (Table 57). The authors also recommended that certain habitats should be preserved intact, because of high densities of economically valuable fish species (Table 58).

Rabbitfish

Based on the number of studies that have been conducted on the rabbitfishes in Guam over the past few years, they must rank among the top food fishes on the island. Several of these studies appear in Tsuda et al. (1976). Of the eight species of siganids recorded from Guam (Shultz et al. 1953; Kami et al. 1968; Kami 1975), only six have been observed over the past 20 years (Kami and Ikehara 1976). Of these, only two--bluntnosed and silver spinefoot--are important food fish. Although both juvenile and adult rabbitfishes are sought by the local people, the juveniles are by far the most important with respect to Guamanian culture. Traditionally, the annual harvesting of the juvenile siganids when they first appear on the shallow reef flats is a major village event. The arrival of the juvenile siganid run, which has been described as a return to nearshore waters of fish completing their pelagic larval stages, can be predicted with surprising accuracy and is almost certain to fall a few days before or after the last quarter of the moon (called Quarto Menquate locally) in April and May. Kami and Ikehara also noted that occasionally, juveniles occur in June and October, with the runs again falling close to the last phase of the moon.

From creel census data, Kami and Ikehara estimated that in the 13-year period from 1963 to 1975, 5 years (1964, 1968, 1969, 1973, and 1974) had exceptionally low harvests; the catch in 1973 amounted to less than 0.1 t. The high occurred in 1972 when nearly 15 t were harvested. It should be noted, however, that the calculated annual catches are underestimates because it would be impossible to obtain complete islandwide coverage during the period of the run. The data do provide a fair estimate of the relative magnitudes of the annual runs.

The fact that rabbitfishes are part of the diet of tunas (Kami and Ikehara 1976) and that they are highly desirable food fish make them ideal for consideration as mariculture species. If mariculture is economically feasible, then the rabbitfishes could be confined and fed until a desirable size is reached, either for food or baitfish in pole-and-line fishing for tunas.

Tsuda and Bryan (1973) investigated the food preference of two species of rabbitfishes, bluntnosed and rabbitfaced spinefoot, and found that only 10 of the 45 plant genera tested were always eaten by the juveniles of

Table 54.--Density (number per 1,000 m^2) and estimated total abundance of economically important fish groups in various habitats of Saipan Lagoon (Amesbury et al. 1979).

Habitat	Total area (m)	Sharks Density	Sharks Total abundance	Milkfish Density	Milkfish Total abundance	Large squirrelfish Density	Large squirrelfish Total abundance	Mullets Density	Mullets Total abundance
1	8,813	--	--	--	--	--	--	8.165	72
2	2,215,101	--	--	--	--	--	--	--	--
3	1,844,938	--	--	--	--	--	--	--	--
4	1,166,307	--	--	--	--	0.750	875	--	--
5	290,842	--	--	--	--	--	--	--	--
6	778,517	--	--	--	--	--	--	--	--
7	1,222,125	--	--	--	--	--	--	--	--
8	1,010,603	--	--	--	--	--	--	--	--
9	240,900	--	--	--	--	--	--	--	--
10	6,045,992	--	--	--	--	0.915	5,532	--	--
11	3,246,269	--	--	0.085	[1]129	--	--	--	--
12	749,139	--	--	--	--	--	--	--	--
13	831,397	--	--	--	--	--	--	--	--
14	1,695,111	--	--	--	--	--	--	--	--
15	91,072	--	--	--	--	14.250	1,298	--	--
16	496,488	--	--	--	--	0.085	42	--	--
17	951,847	--	--	--	--	0.165	157	--	--
18	2,273,857	--	--	--	--	--	--	--	--
19	531,742	--	--	--	--	--	--	--	--
20	1,633,417	0.085	139	--	--	--	--	--	--
21	2,743,905	--	--	--	--	0.085	233	--	--
22	637,503	--	--	--	--	--	--	--	--
23	2,834,977	--	--	--	--	0.085	241	--	--
24	1,624,603	0.085	138	--	--	0.335	544	--	--
Total	35,165,466		277		129		8,922		72

Table 54.--Continued.

Habitat	Barracuda		Large groupers		Slender jacks		High-bodied jacks	
	Density	Total abundance	Density	Total abundance	Density	Total abundance	Density	Total abundance
1	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--
3	--	--	0.085	157	--	--	--	--
4	--	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--	--
6	--	--	--	--	--	--	0.250	195
7	16.665	20,367	--	--	--	--	--	--
8	--	--	0.085	86	--	--	0.085	86
9	--	--	--	--	--	--	12.415	2,991
10	--	--	0.085	514	--	--	--	--
11	--	--	--	--	0.085	276	--	--
12	--	--	--	--	0.585	438	--	--
13	--	--	--	--	--	--	--	--
14	--	--	--	--	--	--	--	--
15	--	--	0.085	8	--	--	--	--
16	--	--	0.250	124	--	--	--	--
17	--	--	0.085	81	--	--	--	--
18	--	--	--	--	--	--	--	--
19	--	--	--	--	--	--	--	--
20	--	--	--	--	--	--	--	--
21	--	--	--	--	--	--	--	--
22	--	--	0.085	54	--	--	0.085	54
23	--	--	0.250	709	--	--	0.085	241
24	--	--	0.085	138	0.085	138	--	--
Total		20,367		1,871		852		3,567

Table 54 --Continued.

Habitat	Snappers		Leiognathids		Sparids		Rudderfish	
	Density	Total abundance	Density	Total abundance	Density	Total abundance	Density	Total abundance
1	0.085	1	0.750	7	--	--	--	--
2	3.250	7,199	0.415	919	--	--	--	--
3	18.500	34,131	--	--	0.250	461	--	--
4	--	--	--	--	--	--	--	--
5	--	--	0.250	73	--	--	--	--
6	0.415	323	--	--	--	--	--	--
7	--	--	--	--	--	--	--	--
8	2.250	2,274	--	--	--	--	--	--
9	2.085	502	--	--	--	--	--	--
10	10.415	62,969	--	--	--	--	--	--
11	0.085	276	--	--	--	--	--	--
12	0.335	251	--	--	--	--	--	--
13	--	--	--	--	--	--	--	--
14	1.585	2,687	--	--	--	--	--	--
15	3.500	319	--	--	0.085	8	--	--
16	0.750	372	--	--	0.085	42	--	--
17	0.665	633	--	--	--	--	--	--
18	0.584	1,330	--	--	--	--	--	--
19	2.585	1,375	--	--	--	--	--	--
20	0.335	547	--	--	--	--	--	--
21	0.500	1,372	--	--	0.085	233	--	--
22	1.415	902	--	--	--	--	--	--
23	0.500	1,417	--	--	--	--	--	--
24	1.000	1,625	--	--	--	--	0.250	406
Total		120,505		999		744		406

Table 54.--Continued.

Habitat	Goatfish		Large wrasses		Juvenile parrotfish		Adult parrotfish	
	Density	Total abundance	Density	Total abundance	Density	Total abundance	Density	Total abundance
1	0.165	2	--	--	--	--	--	--
2	4.915	10,887	--	--	0.250	554	0.165	365
3	15.085	27,831	0.165	304	10.250	18,911	0.085	157
4	1.165	1,359	0.085	99	22.415	26,143	--	--
5	0.335	97	--	--	2.000	582	--	--
6	17.085	13,301	0.085	66	1.585	1,234	--	--
7	0.585	715	0.165	202	21.915	26,783	0.085	104
8	5.165	5,220	1.000	1,011	70.415	71,162	0.165	167
9	5.250	1,265	0.250	60	12.500	3,011	1.165	281
10	8.835	53,416	0.585	3,540	6.000	36,276	9.415	56,923
11	--	--	--	--	--	--	--	--
12	0.335	251	--	--	--	--	--	--
13	0.915	761	--	--	0.085	71	--	--
14	42.585	72,186	0.165	280	55.335	93,799	0.415	703
15	25.335	2,307	0.165	15	30.750	2,800	0.335	31
16	6.000	2,979	2.250	1,117	9.915	4,923	8.835	4,386
17	9.665	9,200	1.250	1,190	11.165	10,627	4.335	4,126
18	16.500	37,519	0.165	375	20.415	46,421	0.165	375
19	5.665	3,012	0.335	178	31.835	16,928	0.665	354
20	23.085	37,707	0.335	547	33.500	54,719	0.665	1,086
21	1.585	4,349	2.085	5,721	28.915	79,340	1.250	3,430
22	9.250	5,897	0.665	424	22.835	14,557	10.585	6,748
23	2.835	8,037	2.585	7,328	1.415	4,011	45.415	128,750
24	3.915	6,360	1.085	1,763	2.335	3,793	10.250	16,652
Total		304,658		24,220		516,645		224,638

Table 54.--Continued.

Habitat	Surgeonfish		Rabbitfish		Silversides		Cardinalfish	
	Density	Total abundance	Density	Total abundance	Density	Total abundance	Density	Total abundance
1	0.500	4	--	--	--	--	--	--
2	1.335	2,957	19.835	43,937	--	--	1.000	2,215
3	2.835	5,230	28.835	53,199	--	--	0.165	304
4	1.585	1,849	2.835	3,306	3.335	3,890	2.250	2,624
5	1.165	339	1.750	509	2.500	727	--	--
6	0.415	323	0.165	128	--	--	3.415	2,659
7	3.665	4,479	0.665	813	--	--	2.915	3.562
8	7.250	7,327	12.415	12,547	--	--	1.165	1,177
9	20.750	4,999	1.935	442	--	--	--	--
10	28.500	172,311	0.585	3,540	--	--	4.335	26,209
11	0.915	2,970	0.085	276	--	--	1.250	4,058
12	--	--	--	--	--	--	--	--
13	0.665	553	0.085	71	--	--	2.085	1,733
14	3.915	6,636	5.915	10,027	--	--	1.750	2,966
15	18.415	1,677	7.415	675	--	--	0.085	8
16	36.415	18,080	5.665	2,813	--	--	--	--
17	42.335	40,296	1.000	952	--	--	0.250	238
18	6.250	14,212	2.665	6,060	--	--	--	--
19	17.085	9,085	13.915	7,399	--	--	0.500	266
20	29.415	48,047	3.000	4,900	--	--	--	--
21	17.500	48,018	9.750	26,753	--	--	--	--
22	47.835	30,495	3.165	2,018	--	--	--	--
23	81.595	231,292	1.915	5,429	--	--	--	--
24	81.665	132,673	0.250	406	--	--	0.165	268
Total		783,852		186,200		4,617		48,287

Table 54.--Continued.

Habitat	Fusiliers Density	Fusiliers Total abundance	Blue Chromis Density	Blue Chromis Total abundance
1	--	--	--	--
2	--	--	--	--
3	--	--	--	--
4	--	--	--	--
5	--	--	--	--
6	--	--	--	--
7	--	--	67.585	82,597
8	--	--	70.085	70,828
9	--	--	64.250	15,478
10	--	--	335.415	2,027,917
11	--	--	--	--
12	--	--	--	--
13	--	--	5.000	4,157
14	--	--	132.165	224,034
15	--	--	269.165	24,513
16	--	--	2.915	1,447
17	--	--	73.000	69,485
18	--	--	105.415	239,699
19	--	--	1.250	665
20	--	--	49.690	81,164
21	--	--	574.165	1,575,454
22	--	--	8.835	5,632
23	--	--	--	--
24	2.500	4,062	--	--
Total		4,062		4,423,070

[1] Only part of habitat 11 considered appropriate for milkfish.

Table 55.--Characteristic, depth, and substrate of the habitats within Saipan Lagoon (Amesbury et al. 1979).

Habitat	Characteristic and location	Depth (m)	Substrate
1	Small embayment east of Charlie Dock; surrounded by mangrove trees.	0.5	Fine silt
2	Stands of sea grass, *Enhalus acoroides*; adjacent to Achugau Beach.	1.0-1.5	Fine sand
3	Heavy stands of sea grass, *Halodule uninervis*; south of Susupe Point.	1.0-3.0	Sand
4	Dominated by *Halodule* in patches (no location given).	--	Dead coral and algae
5	North end of lagoon; shallow water.	0.5-1.5	Sandy, including algae and scattered coral
6	Scattered patches of *Sargassum polycystum* and small sea cucumbers; off Susupe Point.	0.8-2.0	Sandy
7	Mid-lagoon; growth of *Padina*, *Caulerpa*, and *Dictyota*; also other algae.	1.5-3.0	Sand and rubble
8	Mid-lagoon patch reef with living and dead coral and coralline algae.	0.5-2.0	Coral
9	Inshore dredged area from Charlie Dock to Puntan Muchot.	3.0	Silt with rubble, wreckage, and coral growth
10	Main harbor area with extensive stretches of sand and isolated outcrops of coral heads.	12.0	Sand
11	Extensive stretches of sand; small patches of *Halodule* (no location given).	2.5	Sand
12	Uninterrupted stretches of sand covered by blue-green alga, *Microcoleus lyngbyaceus*; northern Tanapag Lagoon.	3.0	Sand
13	Extensive cover of small sea grass, *Halophila minor* and other algae; central Garapan Lagoon.	1.2-2.5	Sand
14	Fairly numerous clusters of *Acropora* scattered throughout; mid-Garapan Lagoon.	1.5	Sand
15	Well-developed *Acropora formosa* colonies near reef channel; northern Garapan Lagoon.	0.5-3.5	Coral
16	Lagoon fringing reef south and east of Managaha Island.	0.5-4.5	Coral and algae
17	Area with numerous patch reefs; west of Managaha Island.	0.5-5.0	Coral
18	Near barrier reef in northern part of lagoon; contains scattered *Acropora*, *Padina*, and other algae.	1.0-4.0	Sand, rubble, coral, and algae

Table 55.--Continued.

Habitat	Characteristic and location	Depth (m)	Substrate
19	Lagoon side fringe of barrier reef at southern end of Garapan Lagoon.	0.2-2.0	Coralline algae with sand and some coral growth
20	Band of rich coral growth near northern Tanapag Lagoon barrier reef.	0.5-1.5	Coral
21	Lagoon side fringe of barrier reef at northern and western margins of Garapan Lagoon.	0.5-2.0	Coral
22	Highly dissected habitat of submerged barrier reef; northeast edge of Garapan Lagoon	0.5-5.0	Coral, sand, and algae
23	Zone of spur and groove topography seaward of barrier reef; immediately north of Afetna Point	1.0-4.0	Coral
24	Deep zone seaward of western barrier reef; northern end of Garapan Lagoon.	6.0-10.0	Coralline algae and sand

Table 56.--Equilibrium harvesting rates for fishes of potential economic importance in Saipan Lagoon (Amesbury et al. 1979).

	A	B		$C = \frac{A}{B}$
	Estimated abundance in Saipan Lagoon	Estimated turnover time[1] (years)	Source of turnover time[2]	Estimated yearly equilibrium harvest
Sharks	277	12	Randall 1977	23
Milkfish	129			
Large squirrelfish	8,922			
Mullets	72			
Barracuda	20,367	1.5	DeSylva 1963	13,578
Large groupers	1,871	1.5	Thompson and Munro 1976	1,247
Slender jacks	852			
High-bodied jacks	3,567	2.0	Watarai 1973	1,784
Snappers	120,505			
Leiognathids	999			
Sparids	744			
Rudderfish	406			
Goatfish	304,658			
Large wrasses	24,220	2.0	Roede 1972	12,110
Adult parrotfish	224,638			
Surgeonfish	783,852	1.5	Randall 1961	522,568
Rabbitfish	186,200	1.5	Tsuda et al. 1976; Hasse et al. 1977	124,133
Silversides	4,617			
Cardinalfish	48,287			
Fusiliers	4,062			
Blue Chromis	4,423,070	1.0	Swerdloff 1970	4,423,070

[1]Turnover time defined as the average time it takes for a newly spawned fish egg to hatch and the larvae grow to maturity, i.e., a reproductively active adult fish.

[2]Sources cited may be found in Amesbury et al. 1979.

Table 57.--Weight estimates of selected fishes as listed in Table 56 indicating potential annual harvest (Saipan Lagoon only) (Commonwealth of the Northern Mariana Islands text footnote 9).

	A	B	C	D	$E = \frac{C^3 \times A \times D}{B}$
Species	Abundance	Turnover time (year)	Assumed harvest size (inches)	Assumed constant	Assumed potential yearly harvest (pounds)
Large groupers	1,871	1.5	8	0.00080	511
High-bodied jacks	3,567	2.0	8	0.00064	585
Large wrasses	24,220	2.0	8	0.00048	2,976
Surgeonfish	783,852	1.5	5	0.00080	52,257
Rabbitfish	186,200	1.5	5	0.00074	11,482
Blue *Chromis*	4,423,070	1.0	2	0.00065	23,000

Table 58.--Habitats recommended for preservation and the economically important fish species within them (Amesbury et al. 1979).

Habitat	Important fish resources
2	Rabbitfish
3	Snappers, rabbitfish, goatfish
4	Juvenile parrotfish
6	Goatfish
7	Juvenile parrotfish, barracuda
8	Large wrasses, juvenile parrotfish, rabbitfish
9	High-bodied jacks, surgeonfish
10	Snappers, adult parrotfish, surgeonfish, blue *Chromis*
12	Slender jacks
14	Goatfish, juvenile parrotfish, blue *Chromis*
15	Squirrelfish, goatfish, juvenile parrotfish, surgeonfish, blue *Chromis*
16	Large groupers, large wrasses, adult parrotfish, surgeonfish
17	Large wrasses, surgeonfish
18	Goatfish, juvenile parrotfish, blue *Chromis*
19	Juvenile parrotfish, surgeonfish, rabbitfish
20	Goatfish, juvenile parrotfish, surgeonfish
21	Large wrasses, juvenile parrotfish, surgeonfish, rabbitfish, blue *Chromis*
22	Juvenile and adult parrotfish, surgeonfish
23	Large groupers, large wrasses, adult parrotfish, surgeonfish
24	Large wrasses, adult parrotfish, surgeonfish

Table 59.--Results of feeding experiments (0 = rejected, - = occasionally ingested, and + = ingested) on mixed populations of Siganus rostratus and S. spinus utilizing benthic plants found on the reefs of Guam during May to June 1972. Number of algal species tested enclosed in parentheses (Tsuda and Bryan 1973).

Filamentous		Noncalcareous fleshy		Calcareous	
Genera	Results	Genera	Results	Genera	Results
Cyanophyta		Chlorophyta		Chlorophyta	
Calothrix (1)	-	Avrainvillea (2)	-	Halimeda (2)	0
Hormothamnion (1)	-	Boergesenia (1)	0	Neomeris (1)	0
Microcoleus (1)	-	Caulerpa (2)	+	Tydemannia (1)	0
Schizothrix (2)	0	Codium (1)	-	Udotea (1)	0
Chlorophyta		Dictyosphaeria (1)	0	Phaeophyta	
Boodlea (1)	+	Valonia (1)	0	Padina (2)	-
Bryopsis (1)	-	Phaeophyta		Rhodophyta	
Chlorodesmis (1)	-	Dictyota (3)	-	Actinotrichia (1)	0
Cladophoropsis (1)	+	Lobophora (1)	0	Amphiroa (1)	0
Derbesia (1)	+	Ralfsia (1)	0	Cheilosporum (1)	0
Enteromorpha (2)	+	Sargassum (2)	0	Galaxaura (2)	0
Phaeophyta		Turbinaria (1)	0	Jania (2)	-
Feldmannia (1)	+	Rhodophyta		Mastophora (1)	0
Sphacelaria (1)	+	Desmia (1)	0		
Rhodophyta		Gelidiella (1)	0		
Asparagopsis (1)	0	Gelidium (1)	-		
Dasyphila (1)	+	Gracilaria (1)	-		
Leveillea (1)	+	Hypnea (1)	+		
Polysiphonia (1)	-	Seagrasses			
		Enhalus (1)	0		
		Halodule (1)	0		

these species. Of the 10, 8 were categorized as filamentous and 2 noncalcareous, fleshy algae, i.e., Caulerpa racemosa and Hypnea pannosa (Table 59). Their studies also demonstrated that both S. rostratus and S. spinus are highly selective in the type of algae consumed.

Other studies on the mariculture potential of rabbitfishes by Tsuda et al.[16] revealed that silver spinefoot grow faster than bluntnosed spinefoot and that although both species are basically herbivorous and feed exclusively on plant material in their natural habitat, their growth rates can be increased significantly if their diet is supplemented by the addition of some protein such as that found in commercially prepared trout chow. They concluded, however, that since trout chow was not economically feasible as fish feed at $0.30 per pound, other sources of protein will have to be tested.

[16]Tsuda, R. T., P. G. Bryan, W. J. FitzGerald, Jr., and W. J. Tobias. 1974. Juvenile-adult rearing of Siganus (Pisces: Siganidae) in Guam. South Pac. Comm. Seventh Technical Meeting on Fisheries, Nuku'Alofa, Tonga, July 15-19, 1974, 6 p. (Mimeogr.)

Spiny Lobster

The volcanic islands of the Mariana Archipelago all have narrow reefs and essentially little or no shelf zone such as that found off many continental areas. This lack of shelf habitats creates some problems for the settling larvae, juveniles, and adults of spiny lobster because suitable habitat is at a premium. Therefore, regardless of the availability of larvae in the plankton, the lack of suitable grounds is considered a primary limiting factor of abundance and a major determinant of population size (MacDonald).[17]

George (1972a) reported that three species of spiny lobsters of the genus Panulirus are known from the waters of Micronesia: P. penicillatus, P. versicolor, and P. femoristriga. In addition, fishermen at Truk and Ponape have described a white lobster with olive mottling on the carapace. Also, large spiny lobsters have been reported from deep waters on the outside of Ngulu, Woleai, and Truk, and from inside the lagoon at Ulithi. George believes that these reports indicate the presence of a fourth species, P. ornatus, which is a large species of variable color.

According to MacDonald (footnote 17) and George (1972a), P. penicillatus is the most abundant species but it can only be fished profitably during the calm-weather months from June to September, when fishermen can walk through ankle- and knee-deep water over the reef flats at night during the lowest tides. Night fishing by this method requires illumination by lantern or flashlight. Animals seen foraging over the reef flats are firmly stepped on to prevent escape, lifted by hand out of the water, and dropped into burlap bags. Panulirus versicolor is not as abundant as P. penicillatus and is usually found in calm waters inside and outside the lagoon to a depth of 21 m. Panulirus femoristriga appears to be intermediate in ecological preference between P. penicillatus and P. versicolor. It prefers clear water just on the lagoon side of the active reef edges amongst dense coral growth, shallow water along seaward channel mouths, and well-washed limestone caves along the limestone islands. It is not as common as P. penicillatus and P. versicolor.

In 1978, the Cromwell occupied 22 trapping stations and found convincing evidence that spiny lobsters either do not occur in any abundance in waters 13 m or deeper or that they do not enter baited traps in any appreciable numbers. Of six spiny lobsters taken during the cruise, three were identified as P. penicillatus, one as P. versicolor, and two as P. femoristriga (Table 53). According to George (1972b), P. versicolor ordinarily do not enter traps; the lone P. versicolor caught on the cruise, therefore, is an indication that this species although present in waters around Guam and probably also around the Northern Marianas, may have to be fished by methods other than traps, perhaps with tangle nets.

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[17]MacDonald, C. D. 1971. An initial report on the spiny lobsters of Micronesia. Mar. Resour. Div., Koror, Palau, Western Caroline Islands 96940, 6 p. (Mimeogr.)

Other attempts have been made to trap lobsters in waters around Guam and the Northern Marianas. Harrington[18] conducted a trapping survey for spiny lobsters from 7 March to 6 April 1977 and found that they can be caught in shallow water at the rate of 2.7-3.6 kg per trap (6-8 lb per trap) near the edges of the reef in about 13-15 m (7-8 fathoms) at Rota, which is believed to have the highest concentration of spiny lobsters. At Tinian, none was caught. All the lobsters taken during this survey were never identified to species. Morris[19] reported that on Cruise No. 7 of the FV Typhoon, one lobster pot set in 37 m (20 fathoms) of water for 14 hours produced one berried P. versicolor weighing 0.6 kg (1.3 lb).

Seamount Groundfish Resources

A seamount groundfish trawl fishery in the North Pacific began in the late sixties after a Soviet trawler discovered pelagic armorhead and alfonsin on the Emperor Seamount chain northwest of Midway Islands. The fishery is now prosecuted not only by Soviet trawlers but also by those of Japan around all of the major seamounts in the North Pacific including Kinmei, Colahan, Hancock, Yuryaku, and Kanmu (Chikuni 1970, 1971a, 1971b; Sakiura 1972; JAMARC 1973; Sasaki 1973; Japan Fisheries Agency 1974; Takahashi and Sasaki 1977).

In the western Pacific, there is an extension of the South Honshu Ridge, which is within the U.S. FCZ around Guam and the Northern Marianas. Among the undersea features belonging to this ridge are Arakane Reef, Pathfinder Reef, Stingray Shoal, and several unnamed pinnacles and seamounts (Table 60). None of the marine resources surveys to date (both PTDF and NMFS charters of the FV Typhoon and the Cromwell survey) have uncovered the presence of armorhead and alfonsin in waters around Guam and the Northern Marianas; however, some reports indicate that alfonsins are present. In the Seamount Groundfish Fishery Resources Environmental Impact Statement/Preliminary Management Plan (EIS/PMP), dated January 1977, comments and responses received from Akira Matsuura of the Japan Fisheries Agency indicated that eight Japanese vessels operated in waters off Guam and the Northern Marianas before the MFCMA went into effect and that the catch of approximately 700 t included a variety of species including alfonsin. Furthermore, it has also been reported that a Japanese fishing vessel under charter to the Government of the Northern Marianas recently caught 227 kg (500 lb) of broad alfonsin near Saipan with a bottom gill net (Kamimura).[20] Two Korean longliners chartered from 13 January to 13

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[18]Harrington, R. 1977. A report submitted to the Government of the Commonwealth of the Northern Marianas, 4 p.

[19]Morris, D. 1980. Cruise report, FV Typhoon cruise 7, 25 July-1 August 1980. Guam Aquat. Wildlife Resour. Div., Dep. Agric., Gov. Guam, Agana, GU 96910.

[20]Kamimura, K. K. K. Industries, Inc., Saipan CM 96950. Pers. commun., May 1981.

Table 60.--Names, designations, and positions of several undersea features in the Guam-Northern Mariana Islands area (U.S. Board on Geographic Names 1969).

Name of undersea feature	Designation	Position	
		Latitude (N)	Longitude (E)
Arakane Reef	Reef	15°38'	142°45'
Esmeralda Bank	Seamount	14°57'	145°15'
Galvez Banks	Seamounts	13°04'	144°27'
Pathfinder Reef	Reef	16°31'	143°08'
Santa Rosa Reef	Reef	12°50'	144°25'
Stingray Shoal	Reef	20°30'	142°22'
Supply Reef	Reef	20°09'	145°06'
Taga Seamount	Seamount	14°24'	144°49'
Tatsumi Reef	Reef	14°54'	145°40'
Tracey Seamount	Seamount	13°39'	144°25'
Zealandia Bank	Reef	16°53'	145°51'

February 1977 by the Commonwealth Fishing Company also caught a total of 15 broad alfonsin while fishing with bottom longline gear (Commonwealth of the Northern Marianas).[21]

The alfonsins are highly regarded as food fish in Japan and if stocks of this or related species can be found over the seamounts and other undersea features within the South Honshu Ridge or over deep banks along the island chain, then Guam and the Northern Marianas would be in a strategic position to harvest and export them to Japanese markets. The extent of the seamount groundfish resource, however, is unknown and intensive surveys would be required to evaluate their potential.

Corals (Including Precious Corals), Shells, and Algae

Corals

Coral reefs, which comprise one of nature's most diverse ecosystems, serve as protective barriers against waves for many coastal communities as well as provide a natural habitat for plant and animal life. These in turn provide a variety of food and other products of commercial value including sand, shells, jewelry coral, decorative materials, leather (shark skin), tools (bones, teeth, and other hard parts of reef dwellers), and pharmaceuticals (Grigg 1979). Perhaps of equal importance are nonconsumptive uses of coral reef associated with recreational activities.

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[21]Commonwealth of the Northern Marianas, Divison of Marine Resources, Memorandum on fish catch data, dated July 9, 1981, 11 p.

There are three basic types of reefs associated with tropical Pacific islands: the fringing reefs, barrier reefs, and atolls. Guam is encircled completely by fringing reefs except along certain sections of the limestone cliffs (Randall and Holloman 1974). In addition, there are two locations where barrier reefs have developed and partially or fully enclose small lagoons. These are at Apra Harbor on the west coast and at Cocos Island at the southwest end of the island.

Guam's fringing reefs vary from narrow cut benches around limestone headlands with a thin veneer of encrusting algae below sea level to broad reef flats which are more than 0.9 km in width; they contain a variety of corals and algae (Randall and Holloman 1974). Guam's reefs vary widely in character from one to another; however, development of specific features depends to some extent on the reef's particular location.

Cocos Lagoon, located at the southern tip of Guam, has one of the most diverse coral communities on the island (Eldredge 1979). The distribution, however, is highly variable with corals absent on the intertidal reef flats and along the inner lagoon fringing reef flat. Along the outer fringing reef flat and the inner and outer barrier reef flats, there are sectors that are totally devoid of corals whereas other sectors have very dense growth. Corals are widely scattered on the shallow lagoon terrace but in the deep lagoon, they are abundant, forming scattered patch reefs, mounds, knolls, and pinnacles.

Productivity estimates of a Guam reef flat community were comparable with those reported for other Pacific reef flats in general and for a Hawaiian reef in particular (Marsh 1974). Preliminary estimates of net community productivity on the Guam reef ranged from 0.19 to 1.8 g O_2/m^2/hour and averaged 0.87. The gross productivity was estimated to be 1.6 g O_2/m^2/hour.

Ikehara et al. (1972) pointed out that the inner reef flats of Guam appear to be fully exploited and that there were strong indications of overfishing in most of the areas fished. Furthermore, the reef flats are recipients or potential recipients of all effluent discharges from the island. To better understand the ecological significance of present and future impacts on the reef environment, a study was conducted by Amesbury (1978) to identify some of the important ecological factors of the reef flat environment which promote the development and maintenance of these fish communities. The results indicated that none of the areas surveyed showed any signs of impoverishment due to human activities. Amesbury concluded that reef flat fishes produce large numbers of eggs during their lifetimes, thus making available more young fish than the reef can actually support. The high production of these reef inhabitants guarantees that there will always be an adequate number of new residents should a catastrophic fish kill occur. The habitats which become available after a die-off are quickly inhabited by new recruits.

Amesbury added that serious consequences could result if destruction of reef habitats are allowed to occur through man's activities such as blasting, dredging, and filling. Sedimentation resulting from these activities, together with changes in topography, in circulation patterns, in substrate composition, and in coral growth will undoubtedly be accompanied by significant changes in the reef-associated fish communities.

The Guam islanders utilize the reef to obtain food as well as for recreational purposes (Hedlund 1977). Reef organisms are considered harvestable and renewable resources; however, all are finite and care must be exercised to regulate their harvest. Hedlund reported that in recent years, more islanders have begun collecting corals, shells, and algae either for ornamental purposes or for food and commercial harvesting has expanded significantly. The most common species of coral harvested commercially in Guam waters and their value are given in Tables 61 and 62.

The results of a number of studies on corals in waters of the Northern Marianas have been published. Doty et al. (1977) cite studies conducted at Saipan by Cloud (1959) and between Puntan Flores and Puntan Muchot in Tanapag Harbor by Gawel (1974). Their own studies in Tanapag Harbor showed that Charlie Bay had the greatest coral cover followed by the northeastern side of Able Dock, Baker Bay, and the outer zone of Unai Sadog Tase (Table 63). The seaward face of Able Dock and the inner zone of Unai Sadog Tase had the least coral coverage of the sites sampled. The results also showed that three species, Pocillopora damicornis, Porites lutea, and Millepora dichotoma, occurred everywhere along the shore; Pocillopora damicornis was by far the most predominant and all three occurred at all 13 sites sampled.

Eldredge et al. (1977) found 31 genera and 74 species of scleractinian corals and 2 genera and 4 species of nonscleractinians in Maug Lagoon. They concluded from their studies that as a whole, the coral coverage on the lagoon slopes is low and that there are no actively accreting coral reefs. They also found sediments of volcanic origin and basaltic boulders predominating along most of Maug crater's submerged slopes and suggested that the sediments and rocks which perpetually rain down are mainly responsible for the lack of coral coverage inside the lagoon.

Table 64 gives the results of 19 dredge hauls between 36 and 364 m in an investigation of the ecology of precious corals in the area between Guam and Saipan (Grigg and Edlredge 1975). The survey produced 40 species of gorgonians, 38 species of scleractinian corals, 10 species of black corals, several alcyonarians, 2 sponges, 4 asteroides, several crinoids and echinoids, 3 algae, 2 crustaceans, and 1 fish.

The survey failed to locate commercial grade Corallium spp. (red and pink corals). Dead branches of Corallium sp. were collected at one station but the quality was extremely poor. Takahashi (1942) reported finding red coral, Corallium japonicum, and white coral, C. konjoi, in 1936 off Pagan and near Saipan. For a while, the coral fishery centered in Saipan, rapidly flourished and exploration soon spread to the outlying northern islands, Tinian and Aguijan. Although these new grounds produced corals, none were of good quality and operations soon ceased.

Interviews with Japanese fishermen who still reside on Rota and Tinian revealed that in pre-World War II days, large quantities of high-quality red coral were harvested in 109-146 m (60-80 fathoms) off these islands (Grigg and Eldredge 1975). But eight dredge hauls by Grigg and Eldredge in waters off Rota produced nothing.

Table 61.--Species, amounts, dates, and sources of supply of locally marketed coral (Hedlund 1977).

Store	Species	Amount (dollar)	Dates	Source
Orient Co. (Julale)	*Acropora acuminata*	$50-$100 per month	Jan. 1975-May 1976	Unknown student
Blue Pacific Gift Shop (Fujita)	*Acropora* sp.	$50 per month	Jan. 1975-Dec. 1975	Unknown naval seaman
Continental Gift Shop	*Acropora irregularis*	$50 per month	Jan. 1975-Jan. 1976	World Shells (Dr. Blair Sparks)
Shells of Micronesia	*Acropora irregularis* *Heliopora coerulea* *Tubipora musica*	[1] [1] [1]	[1] [1] [1]	Dr. Blair Sparks (owner) Mr. Sam Sparks
Elmar Corp. Ltd. (T.T.C. Building with outlets at Hilton, Gibsons, International Gift Center, Jennys Fashion, Joelle, Okadaya	*Acropora* spp. (fossil and sub-fossil origin)	$2,000 per month	Jan. 1977-June 1977	Mr. Choi (owner)
Gold Guild Custom Jewelry (Julale)	*Antipathes dichotoma*	$25-$50 per month	Jan. 1975-June 1977	Mr. Mack
Tritons Treasures Jewelry	*Antipathes dichotoma*	$25-$50 per month	Jan. 1975-June 1977	Mr. Mack
Duty Free Shoppers	*Acropora irregularis* *Fungia fungites*	$600 per month $40 per month	Jan. 1975-Dec. 1976 Jan. 1975-Dec. 1976	World Shells (Dr. Blair Sparks)

[1]Information was not freely provided by owner.

Table 62.--Estimates of the monetary value of annual commercial consumption of the most commonly harvested corals from Guam waters (Hedlund 1977).

Species harvested	1975	1976	1977	Total
Acropora acuminata	$ 900	375	--	$ 1,275
Acropora spp. (fossil and subfossil origin)	--	--	$12,000	12,000
Acropora irregularis	7,200	7,200	--	14,400
Acropora spp.	600	--	--	600
Antipathes dichotoma	450	450	225	1,125
Fungia fungites	400	400	--	800
	$9,550	$8,425	12,225	$30,200

Grigg and Eldredge reported that in recent years, considerable quantities of red and pink coral have been found in the Bonin Islands to the north of the Mariana Archipelago. They concluded that the southern limit of commercial grade Corallium in the Northern Marianas may be about lat. 18° N.

None of the 10 species of black corals collected (8 by dredge hauls and 2 by diving) occurred in large quantities (Grigg and Eldredge 1975). Divers in Guam have reported harvesting Antipathes dichotoma at depths greater than 50 m. Hardness tests of this species showed that the gem quality was the same as that of Hawaiian black coral. Grigg and Eldredge concluded that the resource of this species may not be sufficiently large to support an industry in Guam or the Northern Marianas; however, they recommend further exploration to accurately evaluate the extent and value of the resource.

Shells

In addition to their use as food, marine shells have been used as money, decorative jewelry, medicine, building materials, tools, horns and trumpets, objects of art, and in games. In Guam, some shells are sold in curio and jewelry shops, but the bulk of those collected end up in private collections (Hedlund 1977). Hedlund's study also demonstrated that compared with accounts of shelling in Tumon and Agana Bays and in Cocos Lagoon, recent shelling expeditions have found all the popular areas decimated of shells, either through pollution or increased harvesting. Among those shells that were common in former years but rarely seen today are the helmet shells, Cassius cornuta, the triton trumpet, Charonia tritonis, golden cowry, Cypraea aurantium, olive shell, Oliva miniacea, and two conchs, Strombus aurisdianae and S. bulla. Table 65 gives the names of the areas most commonly visited by shell collectors in Guam and the species most frequently hunted.

Table 63.--Distribution and abundance of corals in Tanapag Harbor. Numbers are relative importance values calculated as the sum of the relative density, cover, and frequency of each coral at each site. Values for the northeast side of Baker Dock represent relative cover and frequency and have been multiplied by a factor of 1.5 to produce values directly comparable to other data in the table. Qualitative observations are D = predominant, A = abundant, C = common, O = occasional, U = uncommon, R = rare, and P = present (Doty et al. 1977).

	Echo Dock	Echo Bay	Charlie Bay		Baker Dock			Baker Bay	Able Dock		Iron pilings	Unai Sadog Tase		Number of occurrences
			Inner	Outer	NE side	End	SW side		NE side	End		Inner zone	Outer zone	
Anthozoa														
Acropora aspera (Dana)	6	C	38	13	—	—	—	—	—	—	—	15	P	6
Acropora convexa (Dana)	—	—	—	—	5	—	—	—	—	—	P	—	—	2
Acropora nasuta (Dana)	—	—	4	—	—	—	—	—	9	P	P	—	—	4
Acropora palifera (Lamarck)	—	—	—	P	—	—	—	—	—	P	P	P	P	5
Echinophyllia asper (Ellis & Solander)	—	—	—	—	—	—	—	—	—	—	P	—	—	1
Favia danae Verrill	—	—	—	—	5	—	—	—	2	P	P	—	—	4
Favia pallida (Dana)	—	—	—	—	P	—	—	—	—	—	P	—	—	2
Fungia fungites (Linnaeus)	—	—	—	—	—	—	—	—	—	P	P	—	—	2
Goniastrea parvistella (Dana)	—	—	—	—	—	—	—	—	—	P	P	P	P	4
Goniastrea pectinata (Ehrenberg)	—	—	—	—	—	—	—	—	—	10	—	—	—	1
Goniastrea retiformis (Lamarck)	—	—	—	—	12	U	U	22	7	P	P	—	—	7
Leptastrea purpurea (Dana)	—	—	—	12	9	O	70	4	2	72	24	—	—	8
Lobophyllia costata (Dana)	—	—	—	—	—	—	—	—	—	—	P	—	—	1
Montipora lobulata Bernard	56	C	5	6	32	—	—	9	—	P	116	10	P	10
Montipora verrilli Vaughan	P	U	P	P	O	O	P	—	—	P	—	—	—	9
Montipora sp. 1	—	U	—	—	—	—	—	—	—	—	—	—	—	1
Pavona obtusata (Quelch)	—	—	—	—	5	—	—	—	—	—	—	—	—	1
Platygyra daedalea (Ellis & Solander)	—	—	—	—	8	—	—	—	—	—	P	—	—	2
Pleurogyra sinuosa (Dana)	—	—	—	—	P	—	—	—	—	—	P	—	—	2
Pocillopora damicornis (Linnaeus)	153	D	155	200	101	D	178	186	257	113	114	153	256	13
Porites cocosensis Wells	—	—	—	—	—	—	—	—	—	—	—	92	—	1
Porites lutea Milne Edwards & Haime)	26	R	27	29	68	C	29	69	16	74	P	17	33	13
Psammocora (Stephanaria) togianensis Umbgrove	—	R	—	—	6	—	—	P	—	—	—	P	P	5
Stylocoeniella armata (Ehrenberg)	—	—	—	4	P	C	C	—	—	32	51	—	11	7
Symphyllia valenciennesii Milne Edwards & Haime	—	—	—	—	—	—	—	—	—	—	P	—	—	1
Tubastraea aurea (Quoy & Gaimard)	—	—	—	—	P	—	—	—	—	P	—	—	—	2
Hydrozoa														
Millepora dichotoma Forskal	59	A	76	37	53	A	22	12	8	A	P	P	P	13
Millepora platyphylla Hemprich & Ehrenberg	—	—	—	—	P	—	—	—	—	—	—	—	—	1
Total species	6	8	7	8	17	7	7	6	7	15	20	9	9	28
Total cover (percent)			32.5	27.1	9.2			13.7	20.0	8.4		4.5	12.8	

Table 64.--Stations occupied during the precious coral survey (Grigg and Eldredge 1975).

Dredge haul	Date	Location	Latitude In/Out	Longitude In/Out	Depth (m)	Substratum	Notes on collection
1	10/21/73	North of Ritidian Point, Guam	13°40.6' N 13°40.6' N	144°52.0' E 144°52.0' E	201	Rocky	Nodules of *Corallium* algae, one gorgonian (no *Corallium*), two stony corals covered with red colonial foraminifera.
2	10/21/73	North of Ritidian Point, Guam	13°41.5' N 13°42.1' N	144°51.9' E 144°51.8' E	245-327	Sandy with cobbles and few outcrops	Sclerosponge, crinoids, few gorgonians (no *Corallium*), alcyconarian, cushion star.
3	10/21/73	North of Ritidian Point, Guam	13°41.3' N 13°42.8' N	144°52.4' E 144°52.5' E	227-225	Rocky	Many gorgonians (no *Corallium*), dendrophyllid corals, sclerosponges.
4	10/24/73	Rota Banks	13°47.0' N 13°47.5' N	144°57.2' E 144°57.2' E	127-200	Dredging up rocky bank	Many gorgonians (no *Corallium*), *Antipathes* cf. *ulex*.
5	10/24/73	Rota Banks	13°48.2' N 13°49.0' N	144°57.7' E 144°57.5' E	200-298	Rocky	Missing.[1]
6	10/25/73	Rota, lee coast	14°08.0' N 14°08.3' N	145°07.0' E 145°07.1' E	127-135	Hard, flat, with rocky cobbles	No *Corallium*, *Antipathes* sp., *Antipathes* cf. *ulex*.
7	10/25/73	Rota, lee coast	14°08.4' N 14°09.0' N	145°07.2' E 145°07.5' E	124-136	Sand and cobbles partially rocky	No *Corallium*, *Antipathes* spp. (two), *Antipathes* cf. *ulex*, *Cirripathes spiralis*.
8	10/25/73	Rota, lee coast	14°09.3' N 14°10.0' N	145°07.9' E 145°08.7' E	127	Sand and cobbles	No *Corallium*, *Antipathes* sp., *Cirripathes spiralis*.
9	10/25/73	Rota, lee coast	14°10.2' N 14°10.5' N	145°09.0' E 145°09.5' E	109-116	Sand and cobbles	No *Corallium*, *Antipathes* sp., *Cirripathes spiralis*.
10	10/25/73	Rota, lee coast (54-fathom bank)	14°11.2' N 14°11.5' N	145°10.6' E 145°10.6' E	138-153	Rocky	Many gorgonians, no *Corallium*, *Antipathes* sp.
11	10/25/73	Rota, lee coast (54-fathom bank)	14°12.3' N 14°12.5' N	145°11.0' E 145°10.6' E	98-164	Rocky dredging up slope	No *Corallium*, many gorgonians.

Table 64.--Continued.

Dredge haul	Date	Location	Latitude In/Out	Longitude In/Out	Depth (m)	Substratum	Notes on collection
12	10/25/73	Rota, lee coast	14°12.3' N 14°12.5' N	145°13.2' E 145°13.4' E	124–135	Sand and cobbles	No *Corallium*, *Antipathes* spp. (three), *Antipathes* cf. *ulex*, one fish (*Uranoscopus* sp.).
13	10/27/73	Tinian channel	14°52.7' N 14°52.7' N	145°34.7' E 145°34.9' E	146–237	Rocky strong channel current	One piece dead *Corallium*, *Antipathes* spp. (two). *Antipathes* cf. *ulex*, *Antipathes undulata*.
14	10/27/73	Tinian channel	14°53' N 14°53.2' N	145°35' E 145°35' E	106–164	Rocky, strong channel current	Many gorgonians, no *Corallium*, many black corals.
15	10/27/73	Tinian channel	14°55' N 14°55' N	145°36.8' E 145°37.0' E	116–146	Rocky, strong channel current	No *Corallium*, *Antipathes undulata*, *Cirripathes* sp.
16	10/27/73	Tinian channel	14°54.2' N 14°54.3' N	145°36.6' E 145°36.6' E	364	Sand and mud	Hexactinellid sponge.
17	10/28/73	Saipan channel	15°06.0' N 15°06.5' N	145°39.7' E 145°39.3' E	246–273	Rocky, strong channel current	No *Corallium*, many gorgonians.
18	10/28/73	Saipan channel	15°06.1' N 15°06.4' N	145°40.1' E 145°40.3' E	109–127	Rocky, strong channel current	Many gorgonians, no *Corallium*.
19	10/28/73	Bank west of Saipan	15°09.2' N 15°10.0' N	145°36.8' E 145°36.9' E	36–360	Dredging up bank	No *Corallium*, *Antipathes* spp. (two), *Antipathes tanacetum*.

Diving station	Date	Location	Latitude In/Out	Longitude In/Out	Depth (m)	Substratum	Notes on collection
1	10/27/73	Aguijan	14°51.4' N	145°32.4' E	15–46	Limestone	*Antipathes dichotoma*, *Cirripathes anguina*
2	6/27/74	Guam (Orote Point)	13°26.0' N	144°37.4' E	25–75	Limestone (shear dropoff)	*Antipathes dichotoma*.

[1]Dead specimen.

Table 65.--The most commonly shelled areas of Guam, along with the most sought after species found therein (Hedlund 1977).

Location	Species
Scout Beach (east of Tarague)	Conus ebraeus Thais aculeata Trochus incrassatus Trochus niloticus
Tarague Beach	Cypraea maculifera
N.C.S. Beach	Conus textile Cypraea maculifera
Tumon Bay	Cypraea lynx
Adelup Point	Conus textile Conus tigrinus
Asan	Conus imperialis Cypraea ventriculus Lambis truncata
Piti - U.S.O. Beach	Cypraea poraria Cypraea talpa Mitra spp. Terebra babylonia
Apra Harbor (Hotel Wharf, Pine Tree Cove, Jade Shoals, Western and Middle Shoals, Gag Gab Beach)	Cypraea mauritiana Cypraea tigris
North and South Tipalao	Cypraea lynx Cypraea mauritiana Cypraea tigris Cypraea vitellus
Rizal Beach	Mitra terebralis
Agat Beach	Cypraea testudinaria
Nimitz Beach-Anae Island	Conus quercina
Cocos Lagoon	Cypraea tigris Conus leopardus Conus litteratus Lambis truncata

The six species of gastropods used as food in Guam are turban shells, Turbo argyrostoma and T. setosus; vase shells, Vasum ceranicum and V. turbinellus; strawberry conch, and top shell. Marine bivalves harvested in Guam include the white shell, Codakia tigerina; venus clam; tellin shell, Quidnipagus palatum; and giant clam.

Stojkovich and Smith (1978) carried out an intensive study to assess the commercial potential of Guam's shellfish and sea urchin resources, including their distribution, habitat preference, size, and standing crop. Table 66 lists the gastropod, bivalves, and sea urchin included in the study. The results indicate that the population of top shell is sufficiently dense to warrant a limited commercial fishery for this species, provided that harvesting is rigidly managed and regulations are strictly enforced. Furthermore, Stojkovich and Smith recommended either abolishing the current provision which allows harvesting of small shells for home consumption or raising the size limit to 76 mm, because concurrent harvesting of both mature and immature individuals would result in a significant reduction of the existing stock. Their studies also revealed that top shell apparently segregated by size groups and occupy different zones in the reef, with progressively larger individuals found seaward from the outer reef flat.

Data collected on tridacnid clams showed that of the three species found in Guam, only Tridacna maxima is relatively common along the reef front. Their small size and low densities, however, would probably preclude commercial harvesting. Stojkovich and Smith concluded that other

Table 66.--Species of shellfish and sea urchins surveyed in waters of Guam, June-August 1978 (Stojkovich and Smith 1978).

Gastropods	Trochus niloticus
Bivalves	Tridacna maxima
	Tridacna squamosa
	Hippopus hippopus
	Anodontia sternsiana
	Asaphis violascens
	Ctena delicatula
	Ctena divergens
	Fragum fragum
	Gafrarium pectinatum
	Gafrarium tumidum
	Modiolus (cf. auriculatus)
	Periglypta puerpera
	Quidnipagus palatum
	Saxostrea mordax
	Scutarcopagia scobinata
Sea urchins	Diadema savignyi
	Echinothrix diadema

bivalves occur in quantities only large enough to support a recreational fishery. None of the larger species such as Asaphis violascens, Q. palatum, Modiolus (cf. auriculatus), and Scutarcopagia scobinata occurred in sufficient numbers for commercial harvesting. They examined sea urchins, periodically for gonadal development but found none of them ripe. The highest densities of sea urchin, Diadema savignyi, were found at Piti and Agat and large populations of another species, Echinothrix diadema, were found at Tumon, Piti, and Agat. Both species inhabited the reef margin and front at Tumon and Agat where suitable overhangs and cavities provided refuge. There was no segregation by sizes among sea urchins with respect to reef zones.

The survey of molluscs and other benthic invertebrates by Dickinson (1977) in Tanapag Harbor, Saipan, revealed that the mollusc most frequently encountered was Lambis lambis which occurred in each of the six sampling sites. The next most common gastropod was Cypraea erosa and the most common bivalve was Saxostrea mordax. The most frequently observed sea urchin was Mespilia globulus which was most abundant in the narrow rubble zone of one sampling site. The gall crab, Hapalocarcinus marsupialis, was also very common, occurring at each of the six stations. Dickinson's list of major invertebrate species from Tanapag Harbor has several species of shells that are of commercial value either for consumption or to collectors.

Algae

The plants in the ocean are, as on land, the primary producers, that is, they are capable of elaborating complex organic substances from simple inorganic compounds found in sea water. In a coral reef ecosystem, the plants are probably the most important for without them, the reef would cease to exist. Micro- and macroscopic plants provide food and energy for the multitude of other reef inhabitants; some, in fact, are utilized as food by man.

Hedlund (1977) found that none of the local species of algae are marketed regularly in Guam. Three species that are harvested are the green alga, Caulerpa racemosa, or ado as it is called locally; Codium spp.; and red alga, Gracilaria edulis. Green alga is collected in Pago Bay on the reef flat south of Inarajan and is most abundant in January to May. The red alga is harvested mostly from Sella Bay.

Because of the increasing interest in seaweeds and seaweed products on the world market and in the development of seaweed mariculture, Nelson et al. (1980) conducted experiments to determine the specific growth rates and ammonium uptake by G. edulis and G. arcuata from Guam. Using salinities of 13, 23, and 34 ‰ for each species, the authors examined ammonium uptake over a wide range of substrate concentrations with the highest at 5×10^3 μg-at NH_4-N · l^{-1} and found a strong diffusion component in the species. The nitrogen content of the thalli was variable but averaged 2.07% for G. edulis and 3.31% for G. arcuata. The growth of the two species was generally higher in the raft culture as opposed to the tank culture system. For tank culture, the mean specific growth rates in the fall were 2.56% per day for G. edulis and 2.02% per day for G. arcuata. In raft culture, G. edulis exhibited a growth rate of 4.80% per day whereas that for G. arcuata was 3.50% per day. The authors also suggested that growth rates of these two species could most likely be enhanced by nutrient enrichment of the water.

There is no historical record of seaweed harvesting or utilization for the Northern Marianas; however, there are several genera of edible algae there that are utilized as food by other Pacific islanders including Caulerpa racemosa, Enteromorpha spp., Gracilaria spp., Laurencia spp., and Hypnea spp. A list of marine plants found in Tanapag Harbor, Saipan may be found in Tobias (1977). A recent study by Nelson et al. (1982) determined that G. lichenoides is seasonally available but limited in distribution in Saipan Lagoon; thus, large-scale development of this resource is not possible at this time. Rapid growth exhibited by detacehd thalli indicated that the species is ideal for outplanting and mariculture.

Sea Cucumbers

Like sea urchins, sea cucumbers, called bêche-de-mer or trepang in the processed state, form a very important segment of the bottom fauna within the coral reefs of many central and western Pacific islands. As noted in an earlier section of this report, five species of sea cucumbers were exploited by the Japanese during the pre-World War II period with production centered at Truk, Palau, Ponape, Saipan, and Yap. Truk, for example, exported 450 t (20 to 30 t per year) mostly to Japan during the period of Japanese colonization. Although World War II interrupted growth and further development of this fishery, there is growing interest among Pacific island governments to revive this industry (Smith 1947b; South Pacific Commission 1974; Uchida 1978). In Papua New Guinea, Solomon Islands, and Fiji, the fishery has made a modest revival in recent years.

Thirty species of holothurians occur on the reef flats and reef slopes of Guam; of these, 8 are utilizable as bêche-de-mer (Rowe and Doty 1977) (Table 67). In general, the distribution of the commercially valuable species is patchy with the most numerous in any one locality being the lollyfish, Holothuria atra, at Uruno with a density of $22/m^2$.

At Tanapag Harbor, Saipan, Dickinson (1977) also found the lollyfish to be the most frequently encountered species. This species, however, is the least attractive of the commercially valuable species with respect to marketability. Also found at Tanapag Harbor was Stichopus chloronotus, another species of commercial value; however, the distribution of this species was not as widespread as some of the other holothurians encountered.

Table 67.--Species of commercially valuable sea cucumbers, their distribution, and habitat in Guam waters (Rowe and Doty 1977).

Scientific name	Common name	Distribution in Guam	Habitat
Thelenota ananas	Pricklyfish	Ritidian Point, Uruno Point, Anae Island Tumon Bay (Gogna Beach sector).	Exposed, usually beyond reef fringe, 30-50 m depth.
Bohadschia marmorata	Chalkyfish	Adelup Point, Uruno Point, Sleepy Lagoon, Pago Bay, Hoover Beach, Piti, Tumon Bay, Cocos Lagoon, Agat.	Smaller specimens buried up to 50-100 mm in sand, larger specimens just subsurface or covered by a mound of sand, rarely exposed, but if so, then, with a covering of sand.
Actinopyga mauritiana	Surf redfish	Tumon Bay; Saupon Point; Pago Bay; Amantes Point; Adelup Point; Uruno Point; Tanguisson Point; Hoover Beach; Agat.	Exposed on outer reef flat on rock and amongst *Sargassum* and *Turbinaria*. This species is smooth and glossy dorsally, without a covering of sand.
Actinopyga echinites	Deepwater redfish	Asan; Amantes Point; Adelup Point; Pago Bay; Ipan; Uruno Point; Tumon Bay; Tarague; Hoover Beach; Agat; Cocos Island.	Exposed on sandy areas, always with a thin covering mantle of sand.
Microthele nobilis	Teatfish	Umatac Bay; Ipan; Uruno Point; Agat; Cocos Island.	Exposed on sand with a covering "cloak" of sand.
Holothuria atra	Lollyfish	On all shores; very common	Exposed on sandy areas of reef flats, particularly on inner reef flat platform. This species characteristically has a sand covering except for six or more pairs of bare patches along the dorsal surface.
Holothuria edulis		Asan; Piti; Cocos Lagoon; Agat.	Exposed on sand, or under rocks or among seaweeds; not covered with a "cloak" of sand.
Stichopus chloronotus		Asan Point; Tumon Bay; Adelup Point; Cocos Lagoon; Uruno Point; Hoover Beach; Agat.	Exposed on rock or sand to about 30 m depth.

UNIQUE AND ENDANGERED SPECIES

The subject of endangered species is dealt with in detail in Bakus (1979) and the reader is referred to his work for further information. Briefly, the law establishes two categories of endangerment:

- Endangered species are those in danger of extinction throughout all or a significant portion of their range.
- Threatened species are those which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

It is unlawful for any person or persons subject to the jurisdiction of the United States to import, sell, or ship in interstate or foreign commerce, harass, harm, or capture, any endangered species, within the United States and its territorial sea, or on the high seas. The restrictions on threatened species make it unlawful for any person or persons to violate any regulation promulgated for such species. All restrictions apply to live or dead specimens and to any product made from or including parts of the specimens (Bakus 1979).

In addition to endangered and threatened species, there are a number of rare species which is defined as one that has a small population in its range or may either be found in a restricted geographic region or occur sparsely over a wide area.

Pritchard (1977), who conducted an extensive survey of Micronesia to determine the status of marine turtles, reported that green and hawksbill turtles which are on the endangered or threatened list, apparently nest on beaches of Guam but only sporadically. In the period before World War II, turtle eggs were harvested but this practice is not as prevalent nowadays as in the past.

In the Northern Marianas, few turtles, if any, appear to nest anywhere in the island chain, probably as a result of shortage of nesting beaches (Pritchard 1977). Most of the uninhabited islands have no beaches whatsoever; Saipan has several miles of beach along the west coast but they are

Table 68.--Summary of turtle sightings by aerial survey regions for fiscal years 1975 through 1979 (adapted from Molina text footnote 22).

Fiscal year	Region												Total	Number of months
	1	2	3	4	5	6	7	8	9	10	11	12		
1975	14	5	18	3		23	11	9	37	16	6	143	285	6
1976	7	5	6	6		35	8	14	44	10	12	42	189	9
1977	0	3	1	1		4	1	5	10	0	8	8	41	2
1978	6	3	1	9		6	14	3	10	1	15	15	83	12
1979	4	1	1	1		1	6	2	43	31	18	77	185	12
Total	31	17	27	20		69	40	33	144	58	59	285	783	41
$\bar{x}$/region	6	4	6	4		15	8	8	31	12	13	59		

extensively developed to accommodate the islanders and tourists. Pritchard reported seeing in Saipan, mounted or stuffed turtles including green, hawksbill, and Pacific ridley, Lepidochelys olivacea, for sale, all of which were captured locally. He also learned that turtles were being caught in increasing numbers by local divers.

Because turtle harvesting in Guam and the Northern Marianas is geared for the luxury and souvenir trades rather than for subsistence, Pritchard recommended that the Endangered Species Act be enforced for the entire archipelago.

Data from aerial sightings for fiscal years 1975-79 (Tables 68 and 69) indicate that marine turtles occur around Guam not only throughout the year but also in almost every sector surveyed (Molina).[22] Although species identification was almost impossible from the airplane, it was generally agreed that a large proportion of the sightings included green turtle. The data demonstrated that the area from Pati Point to Ritidian Point (Region 12) was by far the most frequently visited; 36.4% of the sightings over the 5-year study were from this area (Figure 33). Molina attributed differences in sightings among the regions to the presence or absence of man's activities.

The Guam data also showed that marine turtle abundance peaks twice during the year, once in the winter (December to February) and again in late spring (May to June) (Figure 34). Molina (footnote 22) stated that there is a weak correlation between peak abundance and Guam's dry season which lasts from December to June. Although the data collected did not indicate a definite spawning period, information provided by local fishermen disclosed that nesting usually occurred in June.

Current turtle regulations appear in the Federal Register (Vol. 43, No. 146, p. 32800-32811). The Endangered Species Act of 1973, as amended, prohibits import, export, take, interstate commerce, possession, and selling of hawksbill, leatherback, Dermochelys coriacea, and Atlantic ridley

Table 69.--Summary of turtle sightings by months for fiscal years 1975 through 1979 (adapted from Molina text footnote 22).

Fiscal year	Month												Total	Number of flights
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June		
1975							45	44	32	46	54	64	285	12
1976		20	28	24	20	42	16	10	7	22			189	18
1977	23			18									41	4
1978	7	6	10	4	16	17	7	5	0	3	4	4	83	24
1979	12	3	6	6	7	12	18	52	24	14	20	11	185	24
Total	42	29	44	52	43	71	86	111	63	85	78	79	783	82
$\bar{x}$/month	14	12	15	13	14	24	22	28	16	21	26	26		

[22]Molina, M. E. 1979. Summary of marine turtle sightings made on aerial fishery surveys during fiscal years '75 through '79. Guam Aquat. Wildl. Resour. Div., Dep. Agric., Gov. Guam, Agana, GU 96910, 5 p. (Mimeogr.)

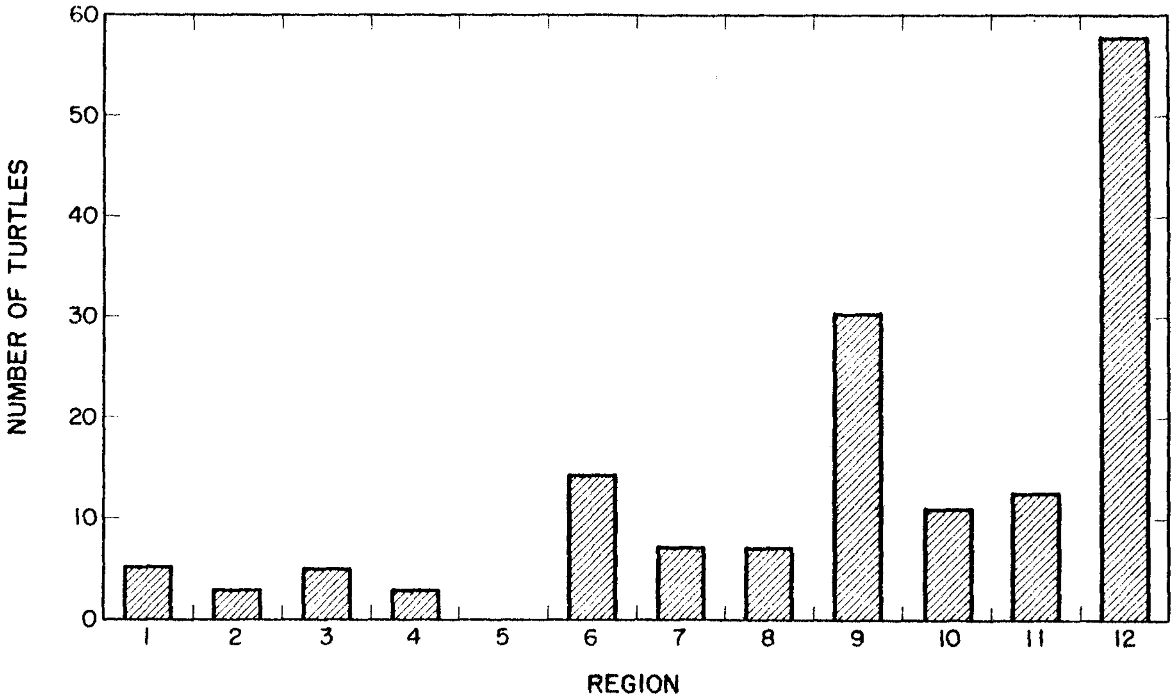

Figure 33.--Mean number of turtles observed in the survey regions during fiscal years 1975-79 (Molina text footnote 22).

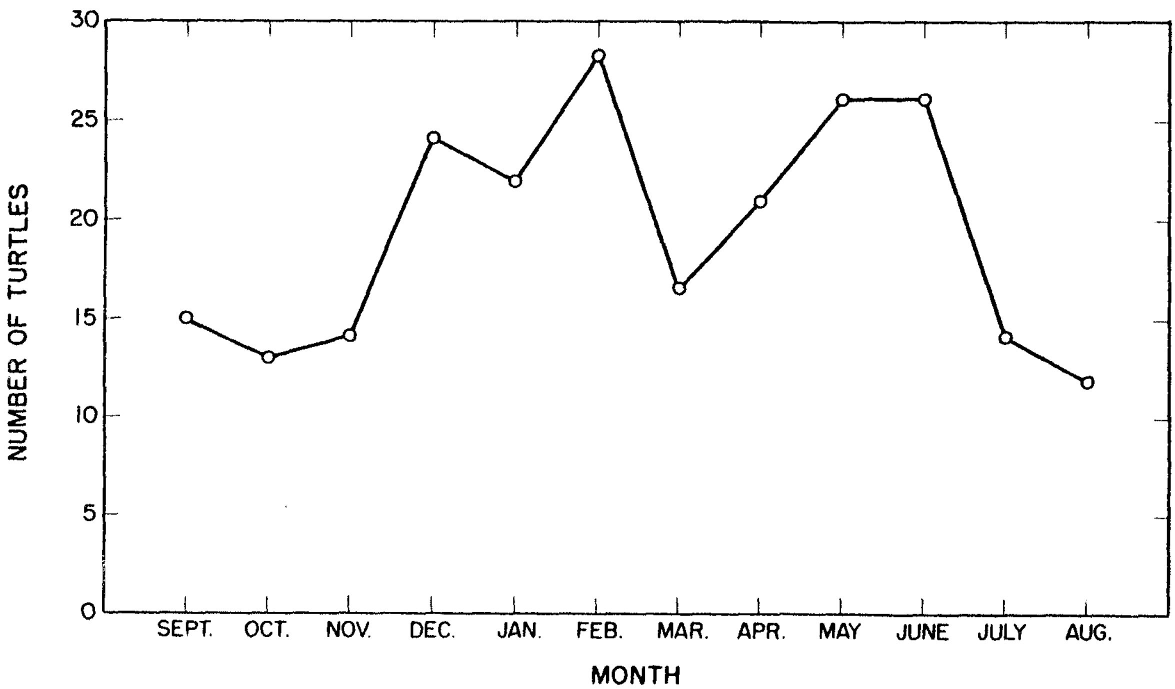

Figure 34.--Mean number of turtles observed per month during fiscal years 1975-79 (Molina text footnote 22).

turtle, L. kempii. Exceptions to the Act include the capture of turtles, by permit, for the following reasons:

- For scientific investigations.
- To enhance propagation or survival.
- To alleviate economic hardship.

Possession of turtle and turtle parts were also allowed under a grandfather clause. The penalties for violation are fines up to $10,000 in a civil case and $20,000 in a criminal case. Citizen suits may also enjoin persons who are allegedly violating provisions of the Act.

Changes in the Endangered Species Act of 1973 added three species to the endangered or threatened lists, as follows:

- Green turtle, endangered off Florida and Mexico's Pacific coast, and all other populations are considered threatened.
- Loggerhead turtle, Caretta caretta, all populations are threatened.
- Pacific ridley turtle, endangered off Mexico's Pacific coast, and all other populations are considerd threatened.

At the Honolulu meeting of the Planning Workshop for NMFS Research on Marine Turtles in the Central and Western Pacific, it was brought out that although both the green and hawksbill turtles occur in waters around the Mariana Archipelago, the occurrence of the leatherback, Pacific ridley, and loggerhead was questionable (Shomura[23]). It was further believed that green turtles were relatively abundant around Guam, but the hawksbill apparently were only occasional visitors.

Whales, porpoises or dolphins, and whale sharks (basking sharks) also occur in waters around Guam and the Northern Marianas. The sightings of fin whales by the Cromwell has already been mentioned and the humpback whale, Megapera novaeangliae, which is also found in these waters has been declared an endangered species. A background document for purse seining in the western Pacific, prepared by LMR,[24] reported that waters north of Papua New Guinea is a historical whaling area and that several species of marine mammals and the whale shark are found there. Among the species mentioned are:

- Spotted porpoise, Stenella dubia.--Found in "Tropical waters of the Atlantic, Indian, and Pacific Ocean, chiefly near coastal areas and

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[23]Shomura, R. S. (chairman). 1979. Summary report of the Planning Workshop for National Marine Fisheries Service Research on Marine Turtles in the Central and Western Pacific, Honolulu, Hawaii, 31 July-2 August 1979. Southwest Fish. Cent. Admin. Rep. H-79-23, 13 p. Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

[24]Living Marine Resources. 1976. Background information for purse-seining in the western Pacific. 64 p. (Mimeogr.)

islands." (Rice and Scheffer 1968:8). In the western Pacific, LMR (footnote 24) reported this species to be "widely distributed in tropical waters from the Queensland coast of Australia, north of New Zealand through the Solomons, northern coast of New Guinea, Philippines, Marianas, etc. to Japan."

- Spinner porpoise, S. roseiventris.--Rice and Scheffer (1968) described the type locality as the Banda Sea and Indonesia. LMR (footnote 24) reported the distribution of this species to be similar to that of the spotted porpoise.

- Striped porpoise, S. caeruleoalba.--The distribution is worldwide in temperate and tropical waters.

- White-belly or white-sided porpoise, Lagenorhynchus obliquidens.--Found off the coast of North America from southeastern Alaska to Baja California; also off the coast of the Asian Continent from the Kuriles to Japan (Rice and Scheffer (1968).

- Whale shark, Rhincodon typus.--Iwasaki (1970a) reported that skipjack tuna schools in the western Pacific are often found associated with whale sharks. His studies showed that sightings of whale sharks were usually numerous in Japanese waters from April to December and around the Ogasawara and Marianas Islands from July to December (Figure 35). In January to March, they also occur around Okinawa and the Western Caroline Islands.

Molina (footnote 22) provided data on sightings of porpoises around Guam. Comparison of aerial survey data for 1978 and 1979 revealed that total sightings of porpoises decreased nearly 22% in 1979 with significant declines noted for Regions 1 and 2 and an increase in Region 7. Region 11 sightings were highest in both years. In fact, in 1979, Regions 7 and 11 contributed the bulk of the sightings, reaching 84% of the total island count.

On a whale marking cruise in the western tropical Pacific, Miyazaki and Wada (1978) reported sighting 103 schools of cetacea (representing 13 species and 11 genera) including Bryde's whale, Balaenoptera edeni, sperm whale, Physeter catodon, striped porpoise, spotted porpoise, spinner porpoise, Fraser's porpoise, Lagenodelphis hosei, melon-headed whale, Peponocephala electra, false killer whale, Pseudorca crassidens, killer whale, Orcinus orca, Risso's porpoise, Grampus griseus, short-finned pilot whale, Globicephala macrorhynchus, pygmy killer whale, Feresa attenuata, and Cuvier's beaked whale, Ziphius cavirostris. However, only one sighting, that of a school of eight Risso's porpoise, was reported from near the Mariana Archipelago. Other sightings were mainly to the north, west, and south of the island chain.

Kami and Lujan (1976) reported that the first documented record of a whale stranding on Guam, which occurred in September 1962, involved a 12.2-m (40-ft) albino sperm whale, Kogia simus. They also reported on the stranding of two dwarf sperm whales on Guam beaches. The first was reported on 25 March 1970 and the second on 6 December 1974. Dwarf sperm whale has a distributional range extending to the seas of South Africa, India, Sri

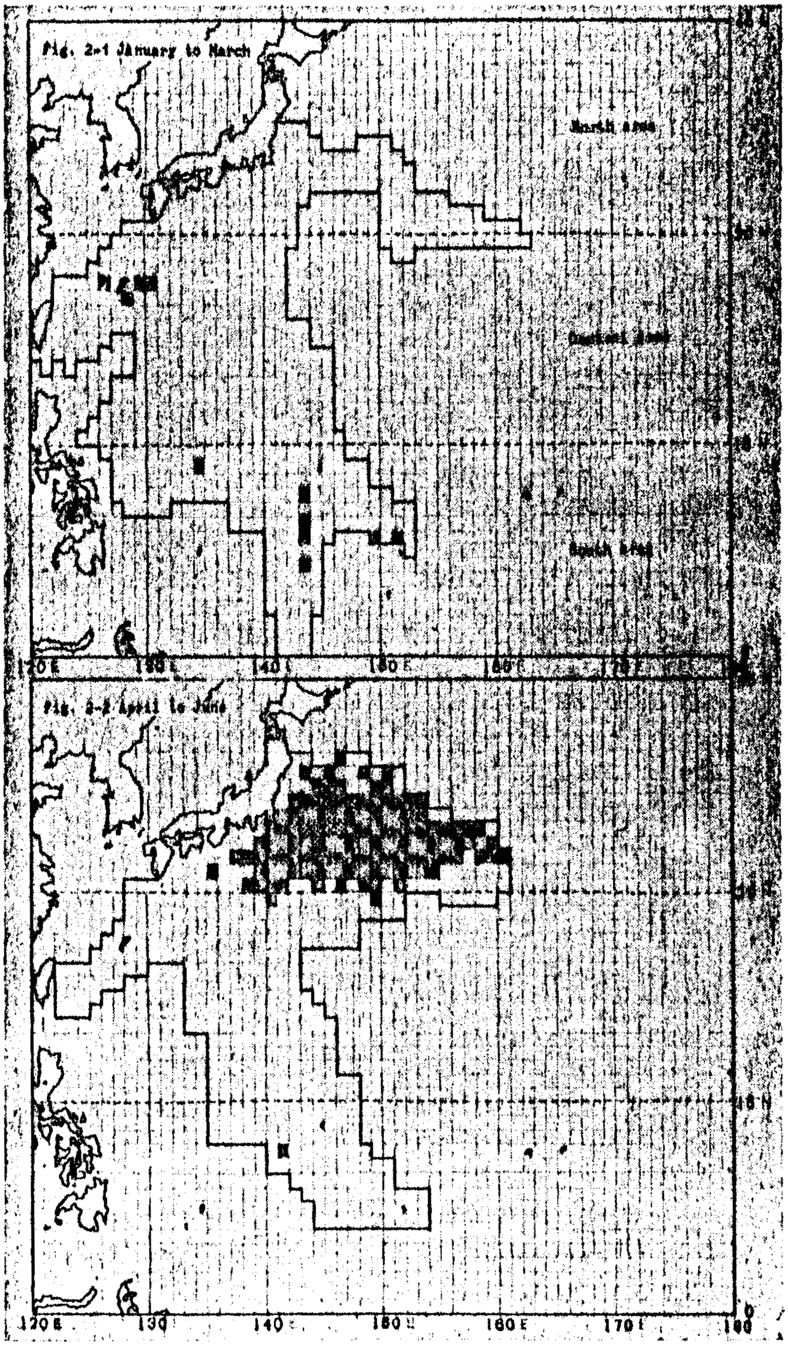
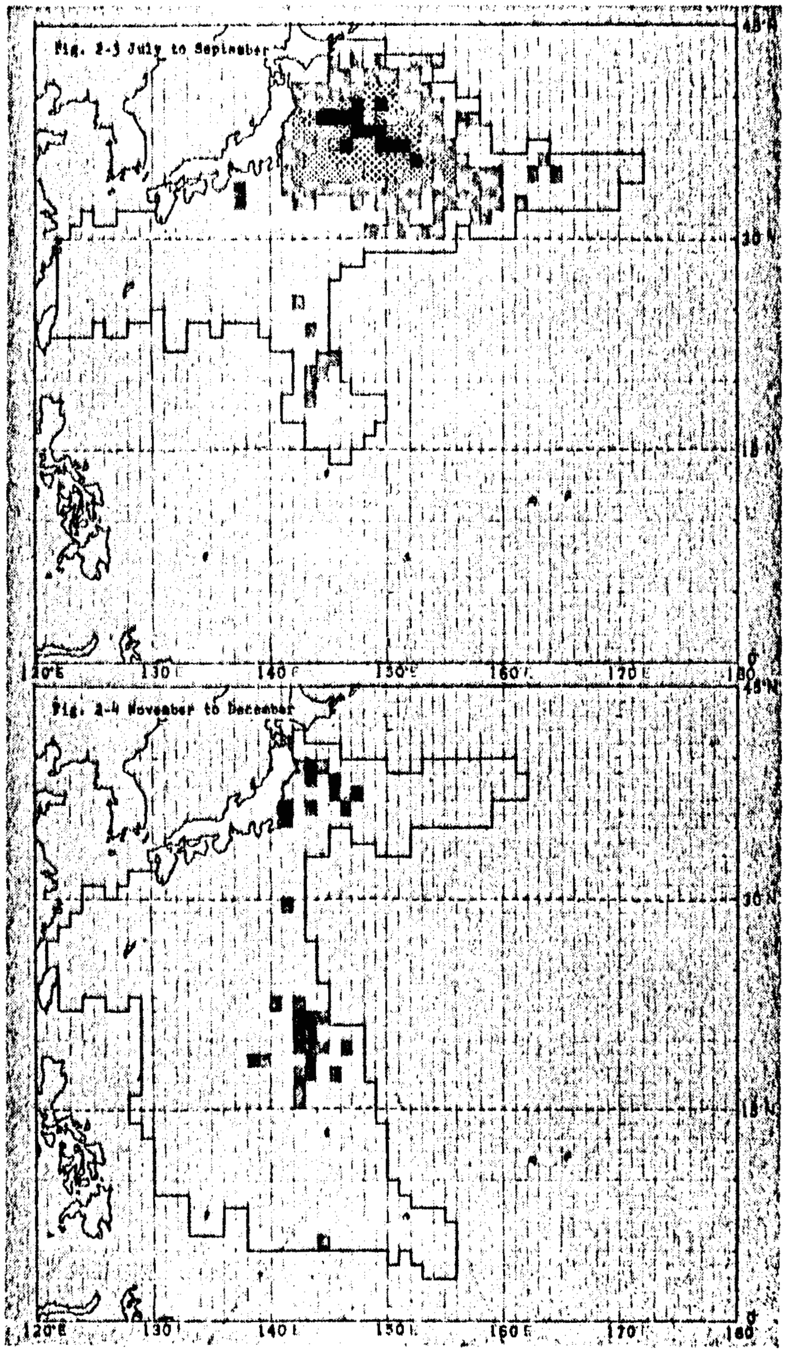


Figure 35.--Area of operation of skipjack tuna fishing vessels and distribution of whale shark in the western Pacific Ocean, 1955-67 (Iwasaki 1970a).



Number of whale shark appearance.

0   51—100   151<

1—50   101—150

Figure 35.--Continued.

Lanka, Japan, Hawaii, South Australia, and the eastern United States with strandings occurring most frequently on beaches of Japan and the central eastern United States (Handley 1966). Kami and Lujan cite a report by Costenable (1905) in which Saipan islanders drove a herd of 80 sperm whales into a shallow lagoon and eventually consumed them. They believe, however, that because the herding of sperm whales has never been documented and that most of the reported strandings are of single individuals, the Saipan incident most likely involved porpoises instead of sperm whales. They noted that large herds of porpoises are often observed close to shore along the coasts of Guam and presumably also occur along the island chain of the Northern Marianas.

Other species of marine mammals have also been reported from waters around Guam. Birkeland (1977) reported strandings of a Bryne's whale, Balaenoptera sp., estimated to weigh 15 tons, on 31 August 1978 near Sella Bay, and a pilot whale, Globicephala macrorhynchus, about 3.6 m long, on 7 July 1980 south of Ylig Point. Randall et al. (1975) observed a 2.1-2.4 m (7-8 ft) long dugong, Dugong dugong, in Cocos Lagoon in February 1974, but it was believed that this occurrence was probably a freak incident, because the animal has not since been reported from Guam.

Table 70 lists invertebrates that are considered rare or uncommon in Guam (Bakus 1979), and Table 71 lists marine mammals and reptiles observed or thought to occur around Guam and the Northern Marianas together with designations of those species that are thought to be threatened or endangered.

Table 70.--Rare and uncommon species of invertebrates from waters around Guam and the Northern Mariana Islands (Bakus 1979).

Scientific name	Common name	Status	Comments
Euphyllia sp.	Coral	Rare	
Pachyclavularia violacea	do	Uncommon	Orote submarine terrace
Pavona frondifera	do	do	Apra Harbor
Pectinia lactuca	do	do	Do.
Plerogyra sinuosa	do	Rare	
Tubastraea aurea	do	do	Double Reef, Apra Harbor, Manell Channel
Charonia tritonus	Triton trumpet	do	Guam
Cassis cornuta	Helmet shell	do	Do.
Cypraea aurantium	Golden cowry	do	Do.
Tridacna maxima	Giant clam	do	Do.
Linckia laevigata	Pacific blue starfish	do	Do.
Birgus latro	Coconut crab	do	Do.

CIGUATERA

Ciguatera poisoning results from the consumption of fish that contain ciguatoxin, a heat-stable toxin that can be found in piscivorous fish that prey on reef fish. According to Randall (1979), fishes with the worst reputation for causing ciguatera include the larger species of barracuda, Sphyraena, many of the groupers such as Epinephelus, Plectropomus, and Cephalopholis, some of the larger snappers, for example, Lutjanus, the

Table 71.--A partial list of marine mammals and reptiles observed or thought to be present in waters around Guam and the Northern Mariana Islands. Also indicated are species known or thought to be threatened or endangered (Nitta).[1]

Scientific name	Common name
Balaenoptera borealis[2]	Sei whale
Balaenoptera edeni	Bryde's whale
Megaptera novaeangliae[2]	Humpback whale
Physeter catodon[1]	Sperm whale
Kogia sp.	Pygmy or dwarf sperm whale
Ziphius cavirostris	Goose-beaked whale
Pseudorca crassidens	False killer whale
Grampus griseus	Risso's dolphin
Globicephala macrorhyncus	Short-finned pilot whale
Tursiops sp.	Bottlenose dolphin
Delphinus delphis	Common dolphin
Stenella sp.	Streaker, spinner, and spotted dolphins
Steno bredanensis	Rough-toothed dolphin
Chelonia mydas[3]	Green turtle
Eretmochelys imbricata[2]	Hawksbill turtle
Lepidochelys olivacea[2]	Olive ridley turtle
Dermochelys coriacea[2]	Leatherback turtle

[1]E. T. Nitta. Western Pacific Program Office, Southwest Region, National Marine Fisheries Service, NOAA, Honolulu, HI 96812. Pers. commun., August 14, 1981.

[2]Endangered.

[3]Threatened.

jacks, Caranx and Seriola, and moray eels, Gymnothorax. Certain lethrinids, Monotaxis and Lethrinus, that feed on molluscs and echinoids have also been implicated as were the larger wrasses such as Cheilinus and Coris. Randall also reported that obligately herbivorous fishes such as Scarus and Acanthurus are also known to cause ciguatera, but the symptoms caused by eating these fishes are milder than illness resulting from consumption of the carnivorous species. Banner and Helfrich (1964), Halstead (1967), and Helfrich and Banner (1968) provide extensive reviews of the incidence of ciguatera in the Pacific.

In the Pacific, ciguatera occurs between the 30° parallels of latitude (Helfrich et al. 1968). The occurrence of ciguatera in some valuable food fish found in the central and western Pacific not only affects the population by causing illness but also, as is often the case, deprives them of a major source of much needed protein. Furthermore, in areas where outbreaks have occurred, it has restricted full development of fisheries and utilization of the available fish stocks (Uchida 1978; Ito and Uchida 1980; Uchida et al.).[25]

Ciguatoxin, when ingested, causes discomfort of varying severity usually to the nervous and digestive systems. Fatalities are extremely rare. An attack is more likely to produce vomiting, diarrhea, itching of the skin, loss of motor ability, reversal of hot-cold sensation, tingling of the lips, mouth, and finger tips, and in some severe cases, respiratory difficulties.

Prior to 1977, ressearch on ciguatera relied heavily on relatively crude bioassays to detect the presence of the toxin in fish tissues (Banner et al. 1960, 1961). In 1977, significant breakthroughs in ciguatera research were made by Yasumoto et al. (1977), who identified a dinoflagellate, Gambierdiscus toxicus, as the likely causative agent in ciguatera outbreaks, and by Hokama et al. (1977), who developed the radioimmunoassay (RIA) method for detecting ciguatoxin.

The application of the sensitive immunological methods for the detection of marine toxins such as ciguatoxin led to extensive testing of fishes caught during NMFS field surveys by the NOAA ship Townsend Cromwell in waters around the Northwestern Hawaiian Islands (NWHI), American Samoa, Western Samoa, Guam, and the Northern Marianas.

Of the 296 fish sampled during cruise TC-78-02 in May-June 1978 to waters around Guam and the Northern Marianas, about 4% were rejected by RIA (Table 72). In comparison, the RIA rejected 15% of the NWHI fishes and 19% of the fishes sampled in American Samoa and Western Samoa. Uchida et al. (footnote 25) reported that species rejected one or more times from the Guam/Northern Marianas samples included pink opakapaka, twinspot snapper, blueline snapper, humpback snapper, blackjack, blue trevally, and rainbow runner. For samples of 10 or more fish, the highest rejection rate (17%) occurred in the taape. Concerning area, an isolated pinnacle located at lat. 14°13' N and long. 142°53' E and about 138 nmi due west of Rota had the highest rate of rejection.

[25]Uchida, R. N., B. M. Ito, P. M. Shiota, D. T. Tagami, K. P. Wendel, V. A. Honda, and M. P. Seki. 1981. Status of the Honolulu Laboratory ciguatera research on fishes of the Northwestern Hawaiian Islands, American Samoa, Western Samoa, Guam, and the Northern Mariana Islands. Report presented at the Pacific Ciguatera Workshop, Honolulu, Hawaii, 18-20 March 1981. WP/3, 18 p. (Mimeogr.)

Table 72.--The number of negative (N), borderline (B), and positive (P) reactions (N-B-P) obtained with the radioimmunoassay conducted on fishes caught during Townsend Cromwell cruise TC-78-02 (TC-79) to waters around Guam and the Northern Mariana Islands (Uchida et al. text footnote 25).

	Santa Rosa Reef	Galvez Banks	17-Mile Bank	Cocos Island	Bank #7	Tinian	Bank #15	Laguan Garapan	Puntan Naftan	Arakane Reef	Farallon de Medinilla	Pathfinder Reef
Snappers												
Pristipomoides filamentosus	2-0-0	—	—	—	5-0-0	—	—	—	—	5-0-0	—	—
P. zonatus	3-0-0	5-0-0	—	1-0-0	7-0-0	—	1-0-0	—	1-0-0	2-0-0	—	—
P. auricilla	3-0-0	1-0-0	—	—	—	—	1-0-0	—	—	—	—	—
P. flavipinnis	1-0-0	2-0-0	—	1-0-0	—	1-0-0	1-0-0	—	1-0-0	—	—	—
P. sieboldii	—	2-0-0	—	—	—	—	—	—	—	—	—	—
P. amoenus	—	—	—	—	—	—	1-0-0	—	—	—	—	—
Lutjanus bohar	2-0-0	24-0-0	2-0-0	2-0-0	18-0-0	2-0-0	—	1-0-0	1-0-0	3-0-0	3-0-0	7-0-0
L. kasmira	3-0-0	8-0-0	—	1-0-0	6-0-4	—	—	2-0-0	—	—	—	—
L. gibbus	—	0-1-0	—	2-0-0	—	1-0-0	—	1-0-0	—	—	—	—
Etelis carbunculus	—	2-0-0	—	1-0-0	—	—	—	—	1-0-0	1-0-0	—	—
E. coruscans	—	—	—	—	—	—	—	—	—	—	—	—
Aprion virescens	—	—	—	—	—	—	—	—	1-0-0	—	—	—
Aphareus rutilans	—	—	—	—	—	—	—	—	1-0-0	—	—	—
Paracaesio xanthurus	—	—	—	—	—	—	—	—	—	—	—	—
Groupers												
Epinephelus emoryi	—	—	—	1-0-0	—	—	—	—	—	1-0-0	—	—
Variola louti	—	—	—	—	—	—	1-0-0	—	—	—	—	—
Cephalopholis sexmaculatus	—	—	—	—	—	—	—	—	—	—	—	—
C. aurantius	—	—	—	—	—	—	—	—	2-0-0	1-0-0	—	—
Cephalopholis sp.	—	—	—	—	—	—	—	—	—	—	—	—
Jacks												
Caranx sexfasciatus	—	2-0-0	—	—	—	—	—	—	—	—	—	—
C. lugubris	—	—	—	—	11-0-0	—	1-0-0	—	1-0-0	—	—	11-0-0
Carangoides ferdau	—	—	—	—	—	—	—	—	—	—	—	—
Elagatis bipinnulata	—	—	—	—	19-1-0	—	—	—	—	—	—	—
Seriola dumerili	—	—	—	—	3-0-0	—	—	—	—	1-0-0	—	5-0-0
Emperors												
Gymnocranius japonicus	—	—	—	1-0-0	—	—	—	—	—	—	—	—
Gnathodentex aureolineatus	—	—	—	—	—	—	—	1-0-0	—	—	—	—
Lethrinus variegatus	—	1-0-0	—	1-0-0	—	1-0-0	—	—	—	—	1-0-0	—
L. miniatus	—	—	—	—	—	—	—	—	—	—	1-0-0	—
Lethrinus sp.	—	—	—	—	—	—	—	—	—	—	—	—
Others												
Gymnosarda unicolor	—	—	—	—	3-0-0	—	—	—	—	—	—	—
Sphyraena jello	—	—	—	—	—	—	—	1-0-0	—	—	—	—
Gymnothorax eurostus	—	—	—	—	—	—	—	—	—	—	—	1-0-0

Table 72.--Continued.

	Sarigan	Guguan	Alamagan	Bank #43	Pagan	Agrihan	Asuncion	Maug	Stingray Shoal	Total all banks	Rejection (%)
Snappers											
Pristipomoides filamentosus	—	1-0-0	1-0-0	—	—	1-0-0	4-0-0	—	—	19-1-1	10
P. zonatus	1-0-0	1-0-0	1-0-0	—	—	—	—	1-0-0	1-0-0	25-0-0	0
P. auricilla	1-0-0	1-0-0	1-0-0	—	—	—	—	1-0-0	1-0-0	10-0-0	0
P. flavipinnis	—	1-0-0	—	—	—	—	—	—	—	8-0-0	0
P. sieboldii	—	—	—	—	—	—	—	—	—	2-0-0	0
P. amoenus	—	—	—	—	—	—	—	—	—	1-0-0	0
Lutjanus bohar	1-0-0	7-1-0	1-0-0	4-0-0	1-1-0	—	1-0-0	—	—	80-2-0	2
L. kasmira	—	2-0-0	1-0-0	—	—	1-0-0	1-1-0	—	—	25-1-4	17
L. gibbus	—	—	—	—	—	—	—	—	—	4-1-0	20
Etelis carbunculus	—	—	1-0-0	—	—	—	—	—	—	6-0-0	0
E. coruscans	—	—	1-0-0	—	—	—	—	—	—	1-0-0	0
Aprion virescens	—	—	—	—	—	—	—	—	—	1-0-0	0
Aphareus rutilans	—	1-0-0	—	—	—	—	—	—	—	2-0-0	0
Paracaesio xanthurus	1-0-0	—	—	—	—	—	—	—	—	1-0-0	0
Groupers											
Epinephelus emoryi	—	—	—	—	—	—	1-0-0	—	—	3-0-0	0
Variola louti	—	—	1-0-0	—	—	—	—	—	—	2-0-0	0
Cephalopholis sexmaculatus	1-0-0	—	—	—	—	—	—	—	—	1-0-0	0
C. aurantius	—	1-0-0	—	—	—	—	—	—	—	4-0-0	0
Cephalopholis sp.	—	—	—	—	—	1-0-0	—	—	—	1-0-0	0
Jacks											
Caranx sexfasciatus	—	—	—	—	—	—	—	—	—	2-0-0	0
C. lugubris	—	1-0-0	0-1-0	2-0-0	—	1-0-0	2-0-0	1-0-0	6-0-0	37-1-0	3
Carangoides ferdau	—	—	—	—	—	0-0-1	—	—	—	0-0-1	100
Elagatis bipinnulata	—	—	—	—	—	—	—	—	—	19-1-0	5
Seriola dumerili	—	—	—	—	—	—	—	—	2-0-0	11-0-0	0
Emperors											
Gymnocranius japonicus	—	—	—	—	—	—	—	—	—	1-0-0	0
Gnathodentex aureolineatus	—	—	—	—	—	—	—	—	—	1-0-0	0
Lethrinus variegatus	—	—	—	4-0-0	—	—	1-0-0	—	—	9-0-0	0
L. miniatus	—	—	—	—	—	—	—	—	—	1-0-0	0
Lethrinus sp.	1-0-0	—	—	—	—	—	—	—	—	1-0-0	0
Others											
Gymnosarda unicolor	—	—	—	—	—	—	—	—	—	3-0-0	0
Sphyraena jello	—	—	—	—	—	—	—	—	—	1-0-0	0
Gymnothorax eurostus	—	—	—	—	—	—	—	—	—	1-0-0	0

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