1984. Mar. Fish. Rev. 46(2):1-17

Groundfish Fisheries and Research in the Vicinity of Seamounts in the North Pacific Ocean

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ABSTRACT—The trawl fishery over the central North Pacific seamounts expanded rapidly after 1967 when exploratory fishing by Soviet trawlers demonstrated commercial concentrations of pelagic armorhead, Pentaceros richardsoni, *and smaller quantities of alfonsin,* Beryx splendens. *In 1969, Japanese trawlers entered the fishery but developmental problems led to wide catch fluctuations in 1969-71. After 1971, catches stabilized and then peaked at 34,538 metric tons in 1974.*

Hancock Seamounts, within the 200-mile U.S. Fishery Conservation Zone around the Hawaiian Archipelago, were fished in 1972-76 by Japanese trawlers, producing annual catches from 653 to 8,518 metric tons. In 1978-81, U.S. observers accompanied three Japanese trawlers which made six trips to Hancock Seamounts. Observer data indicated that the pelagic armorhead stock had recovered to some extent from the intense fishing prior to 1977. The catch per unit of effort in 1980 and 1981 improved and showed an upward trend.

Introduction

In the central and western North Pacific Ocean, one of the chief topographic characteristics of the ocean floor is the large submarine volcanoes, which were once high islands. Some of these former volcanic islands are now worn down into low, sandy atolls such as Kure Atoll in the Hawaiian Archipelago (Menard and Hamilton, 1963; Carlquist, 1970). However, many others have subsided 0.5 km or more below the sea surface and their summits lack a coral cap. These are the guyots or seamounts identifiable as former islands by their form and by the presence of shallow-water fossils that have been dredged from their summits. By definition, a seamount is an elevation that rises 1,000 m or more from the sea floor and is flat and of limited extent across the summit (U.S. Board on Geographic Names, 1969).

The Hawaiian Archipelago and the numerous seamounts to the north and northwest of the chain are shown in Figure 1. Those to the north are the Musicians Seamounts which have summits that are rather deep, most of them well over 1,650 m below the sea surface. The seamounts discussed in this report lie on the Hawaiian and Emperor Seamount Ridges. The Hawaiian Ridge extends for some 1,350 n.mi. from the Island of Hawaii on the southeastern extremity to Kure Atoll on its northwestern end. The Emperor Seamount Ridge then continues in a northerly direction and terminates at the juncture of the Aleutian and Kurile Islands arc and trench systems (Malahoff and Woollard, 1970).

The 200-mile Fishery Conservation Zone (FCZ) around the Hawaiian Archipelago includes the Northwestern Hawaiian Islands (NWHI), a chain of small islands stretching from Nihoa to Kure Atoll. Surrounding these islands are numerous submerged banks and seamounts, including Hancock Seamounts, which in recent years have been fished by Japanese trawlers under a quota established by the preliminary management plan (PMP)[1] for seamount-groundfish resources.

In October 1976, just 5 months before enactment of the Magnuson Fishery Conservation and Management Act (MFCMA), the Honolulu Laboratory of the Southwest Fisheries Center (SWFC), National Marine Fisheries Service (NMFS), launched an investigation of the marine resources of the NWHI. Because the extent of the investigation was beyond the capabilities of the staff and facilities of any single research agency in Hawaii, the SWFC proposed a cooperative effort with the Hawaii Division of Aquatic Resources (HDAR), Hawaii Department of Land and Natural Resources, and the U.S. Fish and Wildlife Service (USFWS). From the proposal evolved a formal tripartite agreement which, in effect, gave responsibility to the HDAR for the survey and assessment of the inshore fishery resources and to the USFWS for land-associated resources such as sea and land birds. The SWFC assumed responsibility for developing a quantitative fishery survey and assessment of the slope, coastal pelagic, and seamount resources. A short time after the agreement was signed, a fourth agency, the University of Hawaii Sea Grant College Program, became an active participant in the investigation by assuming responsibility for research to fill obvious gaps in the tripartite investigation.

This report reviews the historical de-

[1]Southwest Region, National Marine Fisheries Service, NOAA, Terminal Island, California. Final environmental impact statement/Preliminary fishery management plan. Seamount groundfish fishery resources (pelagic armorheads and alfonsins). NOAA, NMFS, January 1977, 27 p.

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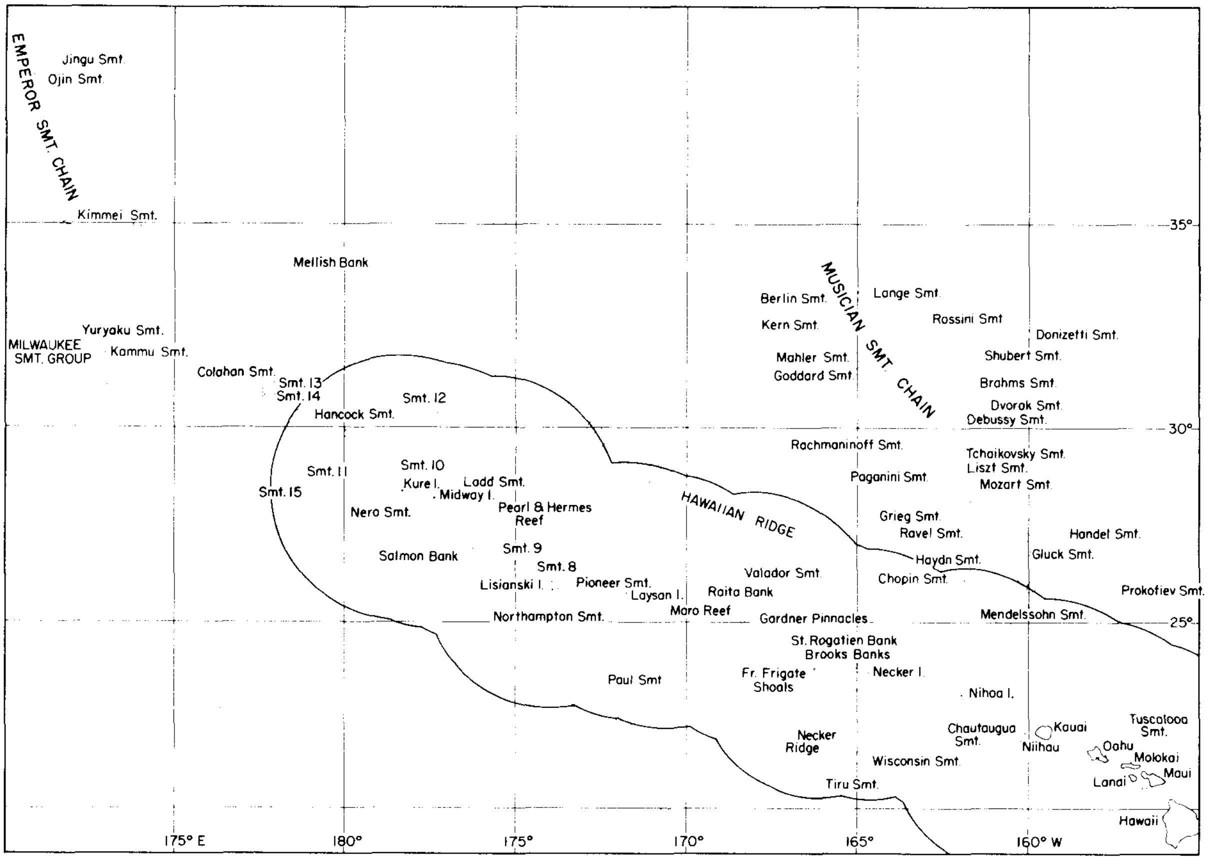

Figure 1.—Hawaiian Archipelago and nearby seamount chains and groups.

velopment of the seamount-groundfish trawl fishery over the central North Pacific seamounts, presents an analysis of the data collected by U.S. observers on Japanese trawlers fishing over Hancock Seamounts in 1978-81, and describes the results of the SWFC's surveys over the seamounts within the FCZ around the Hawaiian Archipelago. An earlier report described the exploratory survey at Hancock Seamounts from October 1976 through May 1979 (Gooding, 1980).

Description of the Fishery

History

The historical development of the seamount-groundfish fishery in the central North Pacific has been described in detail by Chikuni (1970, 1971b), Sakiura (1972), Sasaki (1974), and Takahashi and Sasaki (1977). Until 1967, the seamounts aroused very little interest because most fishery scientists were unaware of the resources associated with them.

The U.S.S.R. was the first nation to commercially exploit the seamount-groundfish resources in this area. In November 1967 a Soviet commercial trawler discovered large concentrations of pelagic armorhead, *Pentaceros richardsoni*, on the Emperor Seamount Chain which led to an almost immediate exploitation of the resource by the Soviet trawling fleet and prompted further exploratory fishing on seamounts closer to the Hawaiian Archipelago including Kimmei Seamount, the Milwaukee Seamount group, and Hancock Seamounts (Sakiura, 1972).

The initial catches of the Soviet trawlers were impressive: As much as 20-30 metric tons (t) were taken in hauls of 10-20 minutes (Sakiura, 1972). The catch rate averaged 5.8 t per half-hour tow in 1968 and doubled to 11.7 t per half-hour tow in 1969. Furthermore, in one 8-month period from December 1969 to July 1970, Soviet trawlers reportedly harvested 133,400 t of pelagic armorhead from the seamounts. A second species of commercial value, the alfonsin, *Beryx splendens*, made up as much as 30 percent of some of the trawl hauls. The Soviet trawlers reported that the thickness of the schools of pelagic armorhead over the seamounts was as much as 160 m but usually was closer to 30 m. The size of the catches reported by the Soviets, however, was questioned by Sakiura (1972).

In August 1969, Japanese trawlers of 1,500-4,000 gross tons entered the fishery. Their initial effort was mostly exploratory, but they set the stage for full-scale commercial operations by 1972. Frequently, some trawling was conducted by Japanese trawlers en route to and from the Bering Sea and the Gulf of Alaska. To assist in the development of the fishery, Japanese research vessels conducted extensive surveys in 1972 to determine the distribution of pelagic armorhead and alfonsin and their potential for development. They explored the central North Pacific for uncharted seamounts, verified the positions of known seamounts, produced charts on the topography and profile of most of the seamounts, and collected oceanographic data to determine the physical, chemical, and biological characteristics of the waters in the vicinity of these seamounts (Japan Marine Fishery Resource Research Center (JAMARC), 1973; Japan Fisheries Agency, 1974). Additional surveys followed in 1973 and 1974. Results of these surveys showed that many of the seamounts were too deep for effective trawling. Those suitable for trawling were located on the southern end of the Emperor Seamount Chain, beginning with Kimmei Seamount and extending south-southeast to Hancock Seamounts in the U.S. FCZ (Sasaki, 1978).

When first marketed in Japan, the pelagic armorhead met stiff consumer resistance and the fishing firms temporarily suspended trawling owing to poor sales (NMFS, 1975). Extensive advertising and sales promotion, however, boosted market demands. By 1973, consumer demand was on an upward trend and the Japanese trawlers expanded their operations over Milwaukee, Colahan, and Hancock Seamounts, but the catch rates were already declining. In 740 hours of trawling in 1973, the catch rate was 33.8 t per hour, down considerably from the 1972 catch rate of 60.1 t per hour (Takahashi and Sasaki, 1977). A strong surge in demand in early 1975 continued into 1977, but landings remained low (NMFS, 1977).

Historical Japanese Catches

Because the early years (1969-71) of the Japanese seamount-groundfish trawl fishery were exploratory and developmental, annual catches fluctuated widely; 1972 is regarded as the real beginning of the commercial fishery.

The annual catch, trawling effort, and catch per unit of effort (CPUE) of pelagic armorhead for all the major seamounts fished by the Japanese in 1969-76 are given by Takahashi and Sasaki (1977). The Milwaukee Seamount group was by far the most productive, accounting for nearly 55 percent of the 1969-76 catch. Next in importance was Kimmei which produced 17 percent of the pelagic armorhead catches, followed by Colahan, Hancock, C-H (unnamed seamount located between Colahan and Hancock), "others," and Mellish. The relative abundance of pelagic armorhead was highest at Hancock, followed closely by Colahan and C-H (discounting Mellish because of the small effort there). These were followed by Milwaukee, "others," and Kimmei.

From 1969 to 1971, Japanese landings of pelagic armorhead fluctuated widely between 3,280 t in 1969 and 30,047 t in 1970; however, from 1972 to 1976, the catches stabilized, fluctuating between 18,952 t in 1975 and 34,538 t in 1974. Effort, on the other hand, increased from 157 to 2,807 hours during the exploratory phase, dropped to 496 hours in 1972, then rose steadily thereafter to 2,667 hours in 1976, an increase of more than five times during the latter period. The result was that the CPUE declined steadily from the 1972 peak of 60.2 t per hour to 9.7 t per hour in 1976[2] (Fig. 2). Figure 2 also shows the catch statistics (discussed later in greater detail) for three Japanese trawlers that fished Hancock in 1978-81 after the enactment of the MFCMA.

Because Hancock Seamounts fall within the U.S. FCZ, it is of interest to compare the catch and trawling effort over them with the total central North Pacific catch and effort. The Japanese commercial trawling effort at Hancock Seamounts in 1972-76 varied from 24 to 212 hours and averaged 74.6 hours (Takahashi and Sasaki, 1977). Hancock Seamounts received from <1 to 29 percent of the entire central North Pacific trawling effort. Catches made during the same period varied between 653 and 8,518 t and averaged 2,804 t. The landings from Hancock constituted from 3 to 34 percent of the entire central North Pacific seamount landings. Catches at Hancock were usually <7 percent of the total central North Pacific landings, but the 1973 catch was slightly more than one-third of the 25,047 t landed by the Japanese trawlers, because there was a drastic decline in catches that year at Milwaukee Seamount, which normally contributed the largest proportion of the pelagic armorhead catches from the central North Pacific seamounts.

Although the seamount fishery concentrated on pelagic armorhead, a small amount, usually <5 percent of the catch, included a second species of commercial value, the alfonsin. The annual Japanese catches of alfonsin from the central North Pacific seamounts varied widely from 26 to 2,807 t during 1969-71. Between 1972 and 1976, the catches fluctuated from 0 in 1974-75 to 1,726 t in 1976[3]. Overall, from 1969 to 1976, <2 percent of the catches were alfonsin (excluding other miscellaneous species taken by the trawl). Kimmei Seamount was by far the most productive for alfonsin, accounting for about 69 percent of the landings, followed by the Milwaukee Seamount group which produced 24 percent of the landings. The remaining seamounts, all south of Milwaukee (except, perhaps, for some unknown location in the "others" group),

[2] Unpublished data obtained through the courtesy of Takashi Sasaki of the Far Seas Fisheries Research Laboratory, Japan Fisheries Agency, indicated that the catch rates declined 2.4 per hour in 1977 and fluctuated within a narrow range of 0.3 and 0.8 per hour in 1978-81. Trawling effort ranged from 1,631 to 2,642 hours during 1977-81 while total catch varied between 500 and 6,245 t.

[3] Unpublished data from the source cited in footnote 2 indicated that the 1977-81 catch varied between 1,649 and 8,638 t with CPUE fluctuating between 0.7 and 4.8 t per hour. The trawling effort remains the same as noted in footnote 2.

contributed about 3 percent or less of the total landings. Kimmei also had the highest catch rate of alfonsin, 0.6 t per hour, far better than at Hancock which had the second highest catch rate of 0.1 t per hour. The data suggest that the center of abundance of alfonsin in the central North Pacific is near Kimmei whereas that for pelagic armorhead is more to the south near Colahan, C-H, and Hancock Seamounts.

In addition to trawls, alfonsin are caught by bottom longlines. The Japanese bottom longline fishery for this species began on the Milwaukee Seamount group in 1972. At present, virtually nothing is known about this so-called "open fishery" because no permits or licenses are required in Japan. Information provided by the fishing master of the FV *Biko Maru*, a bottom longliner, revealed that the alfonsin resource over the central North Pacific seamounts appears to be declining (Suisan Sekai, 1976). Furthermore, fishing intensity has increased over the years with more Japanese and Korean vessels entering the fishery. The result was that whereas a full load could be obtained in as few as 13 days in previous years, many boats nowadays are not only forced to stay on the grounds longer, but also, to fish for other less desirable species such as rockfish or "akodai," *Sebastes matsubari*, to make up for the lack of alfonsin.

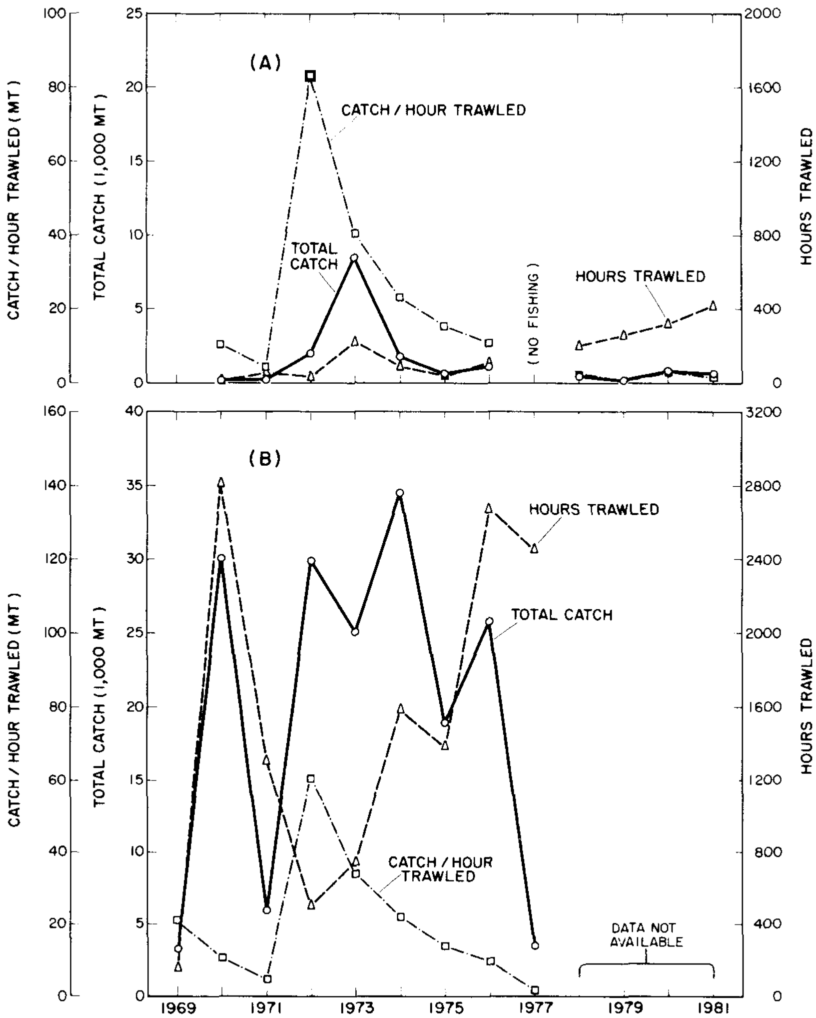

Figure 2.—Catch, hours trawled, and catch per hour trawled in the Japanese trawl fishery for pelagic armorhead over (A) Hancock Seamounts and over all the (B) central North Pacific Seamounts, 1969-81 (data for 1969-76 are from Takahashi and Sasaki, 1977).

Fishery at Hancock Seamounts

Because a fishery management plan (FMP) for pelagic armorhead and alfonsin has not been prepared, temporary measures were set forth in a PMP for the seamount-groundfish fishery resources within the U.S. FCZ around the Hawaiian Archipelago. The regulations temporarily restrict the foreign harvest to a 2,000 t catch quota by trawling or bottom longlining and to 60 vessel-days of effort, and, in addition, establish a licensing procedure for foreign vessels, require the submission of detailed catch and effort data, and placement of U.S. observers on any foreign fishing vessel.

In 1978, an application submitted by JAMARC for a trawling survey at Hancock Seamounts was approved. Since then, two commercial trawlers have received approval to fish at Hancock. Each trip, including the survey conducted in 1978, was accompanied by a U.S. observer who collected detailed data on catch by species and fishing effort, and measured and weighed representative samples of the catch. As time permitted, the observers made observations on food and feeding habits and on gonad condition[4].

[4]Seamount fishery, foreign vessel observer reports, available as Southwest Fisheries Center Administrative Reports at the SWFC Honolulu Laboratory, NMFS, NOAA, Honolulu, HI 96812: T. K. Kazama. 1978. *Ryuyo Maru No. 2* (22 April-3 June 1978). SWFC Admin. Rep. 15H, 10 p. G. C. Evering. 1979. *Aso Maru* (27 May-10 July 1979). SWFC Admin. Rep. H-79-14, 10 p. A. R. Everson. 1980. *Kitakami Maru* (9 August-4 October 1980). SWFC Admin. Rep. H-80-15, 13 p. A. R. Everson. 1980. *Aso Maru* (24-30 September 1980). SWFC Admin. Rep. H-80-16, 10 p. N. T. Shippen. 1981. *Aso Maru* (9-19 June 1981). SWFC Admin. Rep. H-81-4, 8 p. W. B. Barnett. 1981. *Kitakami Maru* (15 August-1 October 1981). SWFC Admin. Rep. H-81-9, 12 p.

Table 1.—Vessel specifications and other statistics of Japanese independent stern trawlers fishing for pelagic armorhead at Hancock Seamounts, 1978-81.

	Vessel code		
Item	A	B	C
Vessel specifications			
Length (m)	56.62	91.60	95.11
Gross ton	549.86	2,961.07	3,608.29
Net ton	215.92	1,501.27	1,968.81
Width (m)	9.20	15.50	16.00
Draft (m)	4.15	6.50	9.80
Engine type	Diesel	Diesel	Diesel
Horsepower	1,500	4,000	3,900
Company/owner	Nippon Suisan, Ltd.	Hokkaido Gyogyokosha	Nippon Suisan, Ltd.
Year commissioned	1966	1967	1964
Home port	Konmon-Ko, Tobata	Tokyo Harbor	Konmon-Ko, Tobata
Personnel (no.)			
Officers	9	10	9
Crew	25	40	41
Total	34	50	50

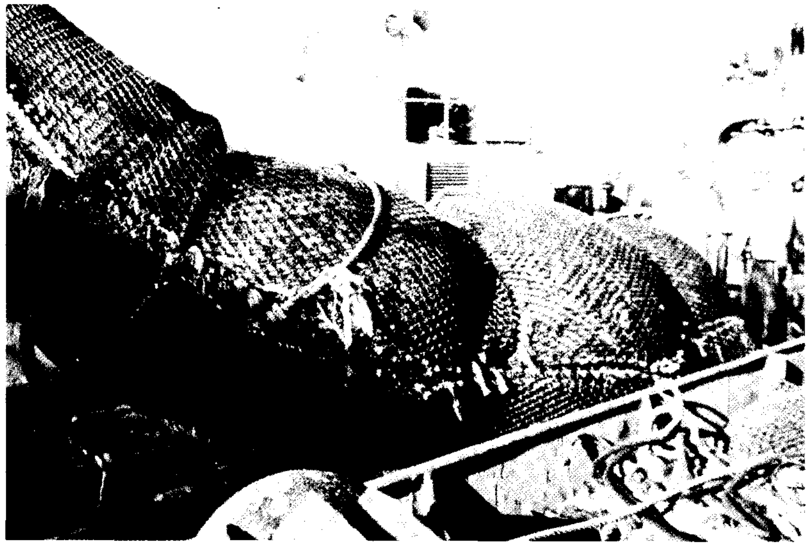

Figure 3.—The cod end of a trawl holding an estimated 7,000 kg of pelagic armorhead and alfonsin aboard Vessel A.

Table 2.—Dimensions of trawl doors and nets used on Japanese trawlers fishing at Hancock Seamounts, 1978-81.

	Vessel code		
Item	A	B	C
Trawl doors			
Shape	Rectangular	Rectangular	Rectangular
Type	Longitudinal	Concave	Longitudinal
Dimensions (m)	2.0 × 3.0	2.7 × 4.3	2.2 × 4.4
Weight (kg)	1,200	4,167	3,100
Nets			
Dandyline (m)	80	150	120
Headrope (m)	28.0	46.0	50.5
Footrope (m)	40.0	59.4	59.0
Vert. opening (m)	6	6	6
Horiz. opening (m)	16	14	22
Warp length (m)	700	1,200	800
Floats			
Number used	30-36	36	46-50
Size (mm)	300-360	360	300-360
Material	*Cycolac*	*Plastic*	*Cycolac*
Shape	Round	Round	Round
Bobbins			
Number used	23	114	35
Size (mm)	530	540-580	530
Material	Rubber; iron	Steel; rubber	Rubber; iron
Shape	Round	Round (car tires)	Round
Mesh size			
Wing (mm)	240	240	180
Square (mm)	180	50/90	150
Belly (mm)	150/120	50/90	150/120; 90
Cod end (mm)	90	90	90

The three trawlers that fished at Hancock Seamounts fell into two of three basic types licensed by Japan (Nelson et al., 1981). Vessel A[5], in the first class of small, independent trawlers, can process the catch into frozen products but cannot produce fish meal and oil. A cod end full of fish caught on Vessel A is shown in Figure 3. Vessels B and C belong to the third class of large freezer trawlers and can produce frozen products as well as fish meal and oil. Vessel specifications and other data are given in Table 1, and description of the trawling gear is given in Table 2. Data on the catch of pelagic armorhead, alfonsin, and other miscellaneous species, number of hauls, total trawling time, average time per haul, and CPUE for all trips to Hancock Seamounts by the three trawlers are given in Table 3. No adjustment was made to standardize the effort unit to account for possible differences in fishing power between the two classes of trawlers. Usually, fishing power is proportional to the gross tonnage of the vessel or to the engine horsepower. However, because neither Vessel B nor C fished the same stock at the same time and place as did Vessel A, comparison of fishing power could not be attempted.

We did find it necessary, however, to adjust the total fishing time for Vessel B to make the effort unit comparable with those of the other vessels. For Vessel B, effort (fishing time) was based on bottom time of the trawl, whereas for Vessels A and C, effort included not only the actual bottom trawling time, but also, the time required for the net to reach the bottom, ascend to the surface, and the turnaround time, because these vessels usually made several passes over the seamount before haulback to empty the net. The turnaround is accomplished by raising the doors completely out of the water and fastening them to the gallows. Then, with the net still in the water and streaming aft, the vessel is turned and positioned for another pass. Admittedly, the measure of effort is not precise. The fact that Vessel B was operating under a charter with JAMARC and that the others were commercial trawlers may explain the discrepancy in the way effort was calculated.

In 1978, the catch rate (adjusted) rose to 2.1 t/hour, then declined in 1979 to 0.7 t/hour, the lowest level at Hancock since fishing began there in 1970. Fish-

[5]To preserve anonymity of the Japanese trawlers that fished over Hancock Seamounts, the vessels are identified with code letters.

Table 3.—Catch of (in metric tons) pelagic armorhead, alfonsin, and other species, number of hauls, total trawling time, average time per haul, and catch per hour of three Japanese trawlers that fished over Hancock Seamounts, 1978-81.

						Catch					Adjusted		
Seamount	Vessel code	Cruise dates	No. of hauls	Total trawling time[1] (min.)	Time per haul (min.)	Pelagic armorhead (t)	Alfonsin (t)	Others (t)	Total catch (t)	Catch per hour[2] (t)	Total trawling time[3] (min.)	Time per haul (min.)	Catch per hour
NW Hancock	B	4/22-6/3/78	39	335	8.6	178.3	1.3	1.8	181.4	32.5	3.822	98.0	2.8
SE Hancock	B	4/22-6/3/78	62	1,662	26.8	228.8	2.4	3.8	235.0	8.5	8.041	129.7	1.8
Total			101	1,997	19.8	407.1	3.7	5.6	416.4	12.5	11.863	117.4	2.1
NW Hancock	C	5/27-7/10/79	57	5,595	98.2	67.6	7.2	23.7	98.5	1.0			
SE Hancock	C	5/27-7/10/79	69	9,570	138.7	67.0	10.7	2.1	79.8	0.5			
K Bank	C	5/27-7/10/79	12	223	18.6	0.9	6.8	0.3	8.0	2.2			
Total			138	15,388	111.5	135.5	24.7	26.1	186.3	0.7			
NW Hancock	A	8/9-10/4/80	59	5,050	85.6	192.9	7.8	4.6	205.3	2.4			
NW Hancock	C	9/24-9/30/80	20	1,925	96.2	40.2	1.6	3.3	45.1	1.4			
SE Hancock	A	8/9-10/4/80	102	9,650	94.6	461.1	23.7	14.1	498.9	3.1			
SE Hancock	C	9/24-9/30/80	14	2,190	156.4	40.5	0.9	4.0	45.4	1.2			
K Bank	A	8/9-10/4/80	2	10	5.0	0.0	0.2	0.2	0.4	2.4			
Total			197	18,825	95.6	734.7	34.2	26.2	795.1	2.5			
NW Hancock	C	6/9-6/19/81	19	1,885	99.2	118.0	8.7	5.8	132.5	4.2			
NW Hancock	A	8/15-10/1/81	155	10,522	67.9	164.7	5.8	8.7	179.2	1.0			
SE Hancock	C	6/9-6/19/81	25	2,250	90.0	259.3	11.2	3.0	273.5	7.3			
SE Hancock	A	8/15-10/1/81	118	9,799	83.0	34.7	8.6	7.2	50.5	0.3			
K Bank	C	6/9-6/19/81	5	70	14.0	12.1	0.0	<0.1	12.1	10.4			
K Bank	A	8/15-10/1/81	34	171	5.0	9.0	3.6	1.3	13.9	4.9			
Total			356	24,697	69.4	597.8	37.9	26.0	661.7	1.6			

[1] Total trawling time on Vessel B based on bottom time of the trawl; those for Vessels A and C based on total time the gear was in the water.
[2] No adjustment made for differences in fishing power of the trawlers.
[3] Adjusted by using data from Vessel C which was similar in vessel characteristics to Vessel B. Adjustment made by calculating an overall time per haul for Vessel A for each of the seamounts fished and multiplying those values by the number of hauls made by Vessel B to obtain the total adjusted trawling time.

ing improved significantly in 1980, particularly for the first vessel trawling at Hancock that year, Vessel A, which had a catch rate of 2.7 t/hour, or nearly four times that of the previous year. Fishing continued to improve in 1981 when the first vessel fishing Hancock, Vessel C, had a catch rate of 5.6 t/hour, or more than twice that for Vessel A in 1980.

In 1980 and 1981, it was obvious that the stock was reduced drastically by the first vessel that fished earlier in the year; the second vessel to arrive on the scene invariably experienced poorer fishing. In 1980, Vessel A, which operated at Hancock Seamounts from 9 August to 4 October, had relatively good catch rates at Northwest (NW) Hancock, Southeast (SE) Hancock, and at K Bank (Table 3). However, Vessel C, which fished after Vessel A from 24 to 30 September, experienced poor catches at NW and SE Hancock. Similarly, in 1981, Vessel C fished Hancock Seamounts from 9 to 19 June and made relatively good catches at NW and SE Hancock and K Bank, indicating that the stock had recovered from the previous year's fishing. When Vessel A arrived at Hancock Seamounts about 2 months later, however, the catch rates once again dropped to very low levels. The poor fishing of the second vessel at Hancock may have resulted from altered behavior or breakup of the pelagic armorhead school brought about by previous fishing activities or by changes in seasonal availability.

Of particular interest is the sharp increase in trawling effort which obviously occurred as a result of placing the pelagic armorhead and alfonsin stocks at Hancock under management (Fig. 2). For example, compared with effort at Hancock during the pre-MFCMA years, 1978 trawling effort reached an estimated 198 hours, or nearly as high as the 1973 peak of 212 hours. Furthermore, the increase in effort continued into 1979-81; effort in 1981 was 412 hours, nearly double the 1973 peak. However, the increase in effort was not accompanied by an increase in total catch, which tended to remain at less than 735 t, considerably below the 1,000 t allocated to Japan and the 2,000 t designated as the total allowable level of foreign fishing (TALFF) as set forth in the PMP.

Pelagic armorhead comprised 73-98 percent of the annual catch from 1978 to 1981. Alfonsin catches varied widely from 3.7 t in 1978 to 37.9 t in 1981, and comprised between 0.9 and 13.3 percent of the annual take in 1978-81.

Research Vessel Survey Results

From October 1976 to April 1981, surveys were conducted on nine cruises of the NOAA ship *Townsend Cromwell* to Seamounts 8, 9, 10, 11, Hancock, Ladd, and Nero (Table 4). These surveys were necessary not only to gather information on the status of the stocks at Hancock Seamounts but also to collect samples and data for studies on geographic distribution, species composition, size composition, food and feeding habits, age and growth, sexual maturity, and spawning.

Bottom Topography

Hancock Seamounts actually consist of two seamounts—one called Northwest (Fig. 4) and the other Southeast—

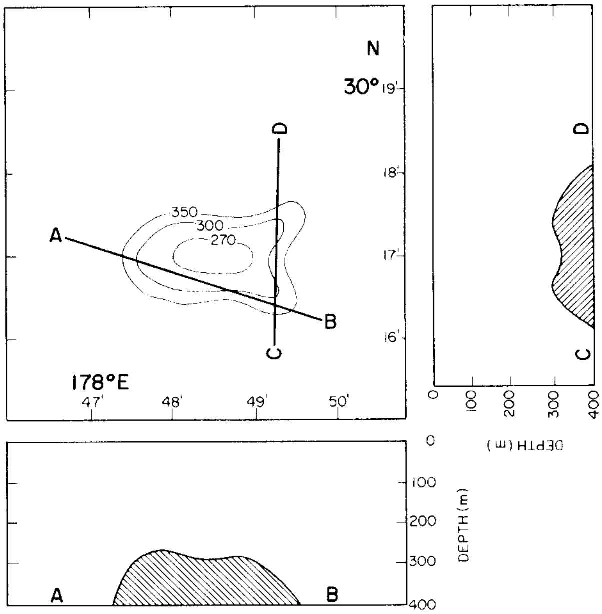

Figure 4.—Bathymetry (m) and lateral profiles (A-B, C-D) of NW Hancock Seamount (from Japan Fisheries Agency, 1974).

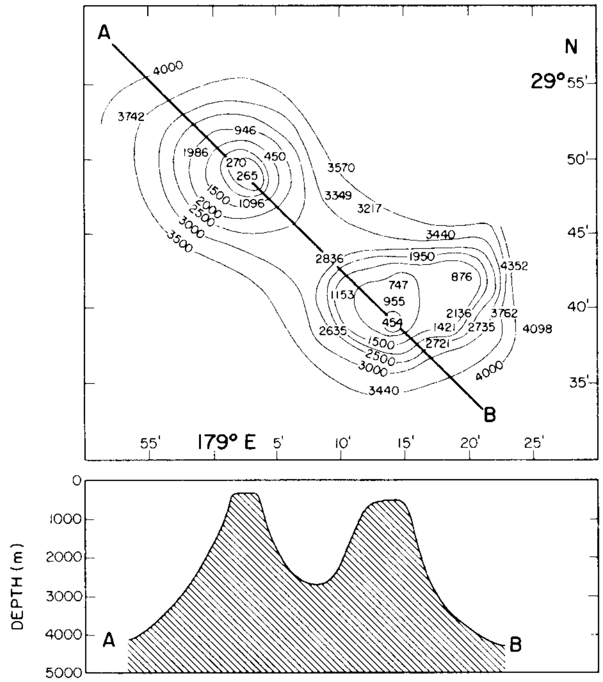

Figure 5.—Bathymetry (m) and lateral profile (A-B) of SE Hancock Seamount (from Japan Fisheries Agency, 1974).

separated by about 34 n.mi. The shallowest point on NW Hancock is 263 m; however, the north-south axis, which is the flat part of the seamount, is very narrow (0.5 n.mi.). Once past the flat portion, the slope is very steep on all sides (Japan Fisheries Agency, 1974).

SE Hancock (Fig. 5) consists of two summits. The summit on the northwestern end (Fig. 6) is flat, narrow, and 265 m at the shallowest area. The flat area extends for 1-2 n.mi., but beyond the 265 m depth contour, the bottom is steeply sloped. The southeastern side of this summit is sloped much more steeply than the northwestern side. The peak on the southeastern end of SE Hancock, also known as K Bank, is about 16 n.mi. to the southeast of the northwestern summit and is relatively rough; the shallowest point is 454 m deep (Japan Fisheries Agency, 1974). The summit of this peak was beyond the trawling depth capability of the *Townsend Cromwell*.

Ladd Seamount, located about 50 n.mi. east-northeast of Midway Islands, is described as rather wide, flat, and about 64 m at the shallowest point (Fig. 7). There are, however, moderate amounts of outcroppings rising from the flat surface making the bottom quite irregular and rugged (Japan Fisheries Agency, 1974). The sides beyond the summit drop off very sharply.

Table 4.—Seamount surveys of the *Townsend Cromwell*, October 1976-April 1981.

Cruise no.	Cruise period	Survey areas	Operations[1] Trawl	Handline	Trap
76-06	10/12-11/21/76	SE Hancock and Seamount 10	X	X	—
77-02	5/12- 6/27/77	SE Hancock	X	X	—
78-01 (Part II)	1/16- 3/ 9/78	Seamount 11	—	X	X
78-03 (Part II)	9/ 6- 9/24/78	NW Hancock and Seamount 8	X	X	X
79-02 (Part II)	5/ 1- 6/ 6/79	NW and SE Hancock	X	X	X
80-02	3/24- 5/14/80	NW and SE Hancock, and Seamounts 9 and 11	X	X	X
80-03 (Part I)	5/28- 6/27/80	Ladd and Nero Seamounts	—	X	—
80-05 (Part II)	11/ 3-12/16/80	Ladd and Nero Seamounts	—	X	X
81-02	3/18- 4/23/81	SE Hancock and Ladd Seamounts	X	X	X

[1]X = conducted as part of cruise mission; — = not included in cruise mission.

Because of the lack of adequate bathymetric data on Nero Seamount (Fig. 8), located about 38 n.mi. southwest of Midway Islands, an extensive survey of the seamount was conducted between June and November 1980 on the *Townsend Cromwell*. The preliminary smooth-plot boat sheets prepared from the unprocessed and unverified depth data indicated that the shallowest area on Nero Seamount was about 62 m.

Seamount 8, a relatively small seamount about 64 m deep at its shallowest point, is located about 40 n.mi. northwest of Lisianski Island. Seamount 9 is actually a sea peak or pinnacle with a

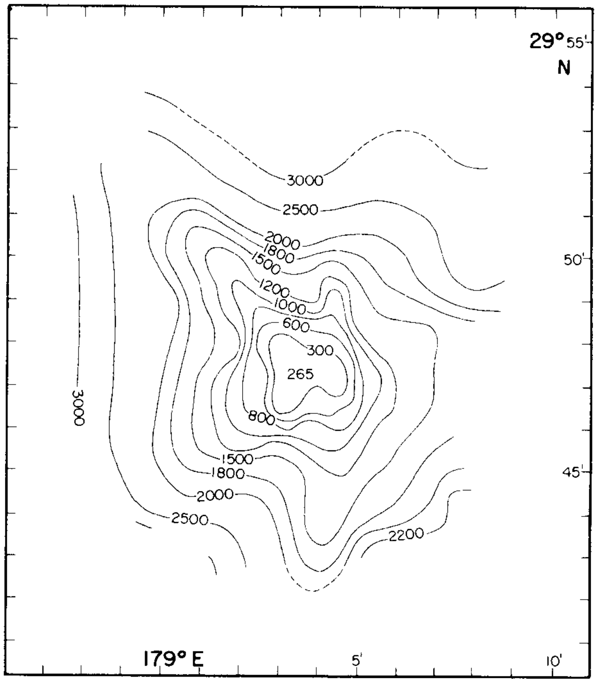

Figure 6.—Bathymetry (m) of the northwest peak of SE Hancock Seamount (from Japan Fisheries Agency, 1974).

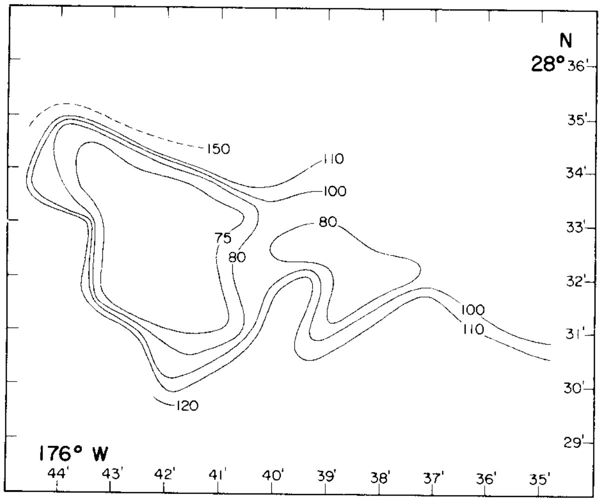

Figure 7.—Bathymetry (m) of Ladd Seamount (from Japan Fisheries Agency, 1974).

recorded depth of 115 m. About 40 n.mi. northwest of Kure is Seamount 10 which has a reported depth of 329 m. Seamount 11, located 135 n.mi. southeast of Hancock, is reported to average less than 180 m deep. The eastern edge of this seamount is steep, whereas the western side is gently sloped. The summit is very rough.

Sampling Gear

Our primary sampling tool was the bottom trawl operated in an exploratory mode to determine the distribution and composition of the seamount community. Before deploying the trawl at each seamount, acoustic soundings were made to determine its topographic profile. After mapping, the trawl was deployed on the basis of seabed conditions.

Trawling was conducted initially with an 80 percent scale, high-opening Norwegian fish trawl with a 20 m headrope, 25 m footrope, 3.8 cm mesh codend cover, and equipped with 36 cm diameter rollers. In mid-1977, this was replaced with a Noreastern otter trawl

Figure 8.—Uncorrected bathymetry in fathoms (number in parentheses denotes meters) of Nero Seamount. Bathymetric chart prepared from soundings made during a hydrographic survey of the seamount by the *Townsend Cromwell* in June-November 1980.

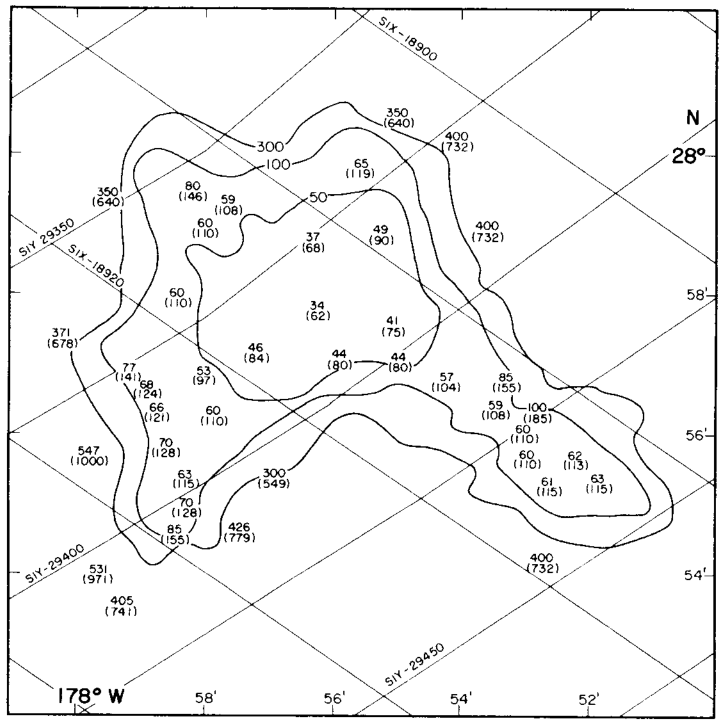

Table 5.—Fishes caught on the *Townsend Cromwell* by trawling over Hancock and other seamounts. The species are listed in descending order of their abundance (total catch) in weight.

Scientific name	Family	No.	Weight (kg)	Scientific name	Family	No.	Weight (kg)
Pentaceros richardsoni	Pentacerotidae	11,546	5,277				
Promethichthys prometheus	Gempylidae	282	172	*Beryx* sp.	Berycidae	1	<1
Beryx splendens	Berycidae	893	147	*Symphysanodon typus*	Lutjanidae	1	<1
Zenopsis nebulosa	Zeidae	269	94	*Parabothus* sp.	Bothidae	1	<1
Squalus blainvillei	Squalidae	61	67	*Laemonema rhodochir*	Moridae	3	<1
Cookeolus boops	Priacanthidae	42	36	*Polymixia* sp.	Polymixiidae	1	<1
Ariomma lurida	Nomeidae	184	29	*Argentina* sp.	Argentinidae	36	<1
Caprodon schlegelii	Serranidae	34	19	*Physiculus* sp.	Moridae	24	<1
Antigonia steindachneri	Antigoniidae	105	5	*Lophiomus miacanthus*	Lophiidae	3	<1
Polymixia japonica	Polymixiidae	35	4	*Isistius brasiliensis*	Squalidae	4	<1
Etmopterus pusillus	Squalidae	6	4	*Symphysanodon maunaloae*	Lutjanidae	5	<1
Antigonia eos	Antigoniidae	124	3.34		Sternoptychidae	11	<1
Ruvettus pretiosus	Gempylidae	1	3.30	*Beryx decadactylus*	Berycidae	1	<1
Macrorhamphosus sp.	Macrorhamphosidae	20	2.78	*Hoplichthys* sp.	Hoplichthyidae	1	<1
Diaphus trachops	Myctophidae	145	2.60	*Plectranthias kelloggi*	Serranidae	5	<1
	Brotulidae	36	2.54	*Astronesthus lucifer*	Astronesthidae	1	<1
Emmelichthys sp.	Emmelichthyidae	17	2.50	*Argyropelecus aculeatus*	Sternoptychidae	2	<1
Chromis struhsakeri	Pomacentridae	19	1.82	*Physiculus grinnelli*	Moridae	1	<1
Physiculus edelmanni	Moridae	18	1.69	*Argyripnus atlanticus*	Gonostomatidae	1	<1
Hyperoglyphe japonica	Nomeidae	7	1.44	*Parapercis roseoviridis*	Parapercidae	2	<1
Conger sp.	Congridae	11	<1	*Peristedion engyceros*	Peristediidae	1	<1
Chascanopsetta prorigera	Bothidae	5	<1	*Antigonia* sp.	Antigoniidae	8	<1
Rhynchocymba nystromi					Gonostomatidae	1	<1
nystromi	Congridae	4	<1	*Callanthias* sp.	Serranidae	9	<1
	Gempylidae	1	<1		Zeidae	14	<1
Parabothus coarctatus	Bothidae	2	<1		Lophotidae	1	<1
Peristedion sp.	Triglidae	1	<1		Muraenidae	1	<1
	Bothidae	11	<1	*Symphysanodon* sp.	Lutjanidae	2	<1
				Parapercis multifaciata	Parapercidae	1	<1

(Gunderson and Sample, 1980) which was larger than the Norwegian trawl, having headrope and footrope lengths of 27 and 32 m, respectively, 3.2 cm mesh cod-end liner, and rubber bobbins with diameters of 36 and 46 cm. Doors used to spread the two types of trawls were 1.8 × 2.7 m steel V-type, each weighing about 454 kg. A net sonde was attached to the center of the headrope to monitor the depth of fishing.

Day and night tows at an average speed of 2-3 knots were made at each trawl station. Trawling time varied from 5 to 38 minutes but was usually between 15 and 25 minutes depending on the extent of the trawlable area over the seamount. Catches were sorted by species, counted, and weighed. Large catches were subsampled to obtain estimates of the total catch. Biological collections were made for age, growth, and feeding studies.

In addition to the trawl, we used handlines, fish traps, and lobster pots to sample species that would not be caught in a trawl or in areas where trawling was not practical due to the rough summits of some of the seamounts. Handlines, operated with hydraulic gurdies, were fitted with either short terminal rigs of 4-6 incurved hooks (No. 18-32) or long droplines of 20 incurved hooks (No. 16-18). Bait was cut fish or squid. Fish traps, either single or in strings of up to four, measured 1.5 × 0.9 × 0.6 m; the reinforcing steel frame was covered with 2.5 cm square galvanized welded wire mesh. The two types of lobster pots used were the large-mesh pot measuring 0.9 × 0.6 × 0.4 m and covered with 5.1 × 10.2 cm heavy-duty, galvanized wire mesh, and the small-mesh pot measuring 1.1 × 0.8 × 0.5 m and covered with 1.2 × 2.5 cm hardware cloth. Traps and pots, baited with mackerel, had identical conical entrances with outer and inner diameters of 30.0 and 16.5 cm, respectively.

Trawling

The *Townsend Cromwell* trawled over the seamounts during 6 cruises, making 12 hauls at NW Hancock, 7 at SE Hancock, and 1 each at Seamounts 10 and 11[6]. All remaining seamounts, including Ladd and Nero and Seamounts 8 and 9, were sampled with other gear owing either to the roughness or very limited extent of the summit.

We noted a variation in catches and progressively better catches on later cruises. Although most of the trawl hauls were made when the echo sounder showed "fish signs" near the bottom, a few midwater hauls were made when the sounder indicated fish schools at middepths, but these hauls were invariably unproductive. Furthermore, because near-bottom trawling over the seamounts was a new operation for the ship's officers, crew, and Honolulu Laboratory scientists, we needed sufficient opportunity to become familiar with the net in the limited time available on each cruise. Therefore, catches made prior to 1979 (*Townsend Cromwell* cruises 76-06, 77-02, and 78-03) may have been greatly influenced by lack of experience and other factors.

The trawl catches, composed of 47 fish species representing 30 families (Table 5), included a diverse variety of species of commercial and noncommercial value. By far the most important was the pelagic armorhead, followed by the snake mackerel, *Promethichthys pro-*

[6]Unlike the Japanese commercial trawlers, the *Townsend Cromwell*'s trawl haul represents only bottom time of the net; therefore, trawling time is not comparable with that of the Japanese trawlers.

Table 6.—Trawl station data and catches of predominant species at Hancock and other seamounts, 1976-81.

Seamount	Cruise	Date	Gear	Time started	Trawling time (min.)	Depth of tow (m)	Distance trawled (km)	Surface temp. (°C)	Bottom temp. (°C)	Catch (kg) Pelagic armorhead	Alfonsin	Mirror dory	Snake mackerel	Horny dogfish	Others	Total	Total catch per hour (kg)	Pelagic armorhead in catch (%)
NW Hancock	78-03	9/8/78	Noreastern	2010	5	283-302	0.6			0.0	0.0	0.0	0.0	0.0	<1.0	<1.0	0.0	0.0
NW Hancock	78-03	9/9/78	Noreastern	1324	10	285-302	0.9	26.6	12.0	0.0	0.1	3.2	0.0	0.0	<1.0	3.3	19.8	0.0
NW Hancock	78-03	9/9/78	Noreastern	2150	15	283-302	1.3	26.6	12.0	69.5	5.7	23.8	25.4	0.0	16.3	140.7	562.8	49.4
NW Hancock	78-03	10/9/78	Noreastern	0925	23	283-302	2.2	26.6	12.0	11.2	0.0	6.9	0.0	0.0	0.6	18.7	48.8	59.9
NW Hancock	78-03	10/9/78	Noreastern	1115	20	283-302	1.8	26.6	12.0	9.2	18.1	9.9	0.0	0.0	<1.0	37.2	111.6	24.7
NW Hancock	79-02	5/4/79	Noreastern	1458	14	269-272	1.3	19.9	15.0	9.8	0.0	0.5	0.0	0.0	0.8	11.1	47.6	88.3
NW Hancock	79-02	5/5/79	Noreastern	1000	17	263-366	1.5	20.9	14.9	3.5	0.0	2.8	0.0	0.0	0.5	6.8	24.0	51.5
NW Hancock	79-02	5/5/79	Noreastern	2116	11	263-293	1.1	20.4	14.2	93.7	4.7	1.0	10.5	0.0	4.1	114.0	621.8	82.2
NW Hancock	79-02	5/5/79	Noreastern	2320	13	258	1.1	20.5	14.9	207.5	1.4	1.4	7.0	8.5	2.4	228.2	1,053.2	90.9
NW Hancock	79-02	5/6/79	Noreastern	0155	12	263	1.1	20.5	14.4	25.1	7.8	4.7	128.2	0.0	0.0	165.8	829.0	15.1
NW Hancock	80-02	4/17/80	Noreastern	1647	11	260	1.1	19.8		[1]4.2	[1]0.2	[1]2.1	0.0	0.0	0.0	6.5	35.4	64.6
NW Hancock	80-02	4/17/80	Noreastern	1934	18	260	1.7	19.7		1,308.8	51.1	4.6	0.0	9.5	2.1	1,376.1	4,587.0	95.1
Total					169					1,742.5	89.1	60.9	171.1	18.0	26.8	2,108.4		
Average catch per hour										618.6	31.6	21.6	60.7	6.4	9.5		748.5	82.6
SE Hancock	76-06	10/29/76	Norwegian	2133	19	265-293	1.8	25.2	13.5	20.9	0.4	0.0	0.0	0.0	4.1	25.4	80.2	82.3
SE Hancock	77-02	5/25/77	Noreastern	2200	20	269-530	1.8			0.0	0.0	0.0	0.0	0.0	<1.0	<1.0	0.0	0.0
SE Hancock	77-02	5/26/77	Noreastern	0848	20	263-311	1.8	21.5	12.6	20.0	0.6	3.6	0.0	0.0	[2]41.9	66.1	198.3	30.2
SE Hancock	79-02	5/6/79	Noreastern	2100	38	256	3.5	19.9	14.8	545.9	7.4	6.8	1.1	43.5	10.8	615.5	971.8	88.7
SE Hancock	80-02	4/16/80	Noreastern	1555	25	258	2.2	20.1		15.4	0.0	14.7	0.0	0.4	0.0	30.5	73.2	50.5
SE Hancock	80-02	4/16/80	Noreastern	2157	23	258	2.2	20.0		1,332.8	44.4	7.4	0.0	0.0	0.0	1,384.6	3,612.0	96.2
SE Hancock	81-02	3/31/81	Noreastern	2230	21		1.8	20.0		1,599.1	4.8	0.6	0.0	3.4	0.5	1,608.4	4,595.4	99.4
Total					166					3,534.1	57.6	33.1	1.1	47.3	57.3	3,730.5		
Average catch per hour										1,277.4	20.8	12.0	0.4	17.1	20.7		1,348.4	94.7
Seamount 11	78-01	2/12/78	Noreastern	1305	12	188-207	0.9	17.2		0.0	0.0	0.0	0.0	0.0	<1.0	<1.0	0.0	0.0
Seamount 10	76-06	10/30/76	Norwegian	2306	30	164-170	2.8	25.1	15.3	0.0	0.0	0.0	0.0	2.0	[3]59.2	61.2	122.4	0.0

[1]Estimated from average weights.
[2]Predominantly driftfish, *Ariomma lurida*.
[3]Predominantly red bigeye, *Cookeolus boops*, and a grouper, *Caprodon schlegelii*.

metheus; alfonsin; mirror dory, *Zenopsis nebulosa*; and horny dogfish, *Squalus blainvillei*. The duration of the trawl hauls at NW Hancock ranged from 5 to 23 minutes/haul and averaged 14.1 minutes for a total of 2.8 hours of trawling (Table 6). The 12 hauls produced 1,742 kg of pelagic armorhead and 89 kg of alfonsin, or a ratio of 19:1. The CPUE varied from <1 to 4,587 kg/hour and averaged 748 kg/hour. Of the 12 hauls made at NW Hancock, only one produced a fairly large catch (1,309 kg) of pelagic armorhead. The remaining hauls produced 208 kg or less. The percentage of pelagic armorhead in the catch varied widely from 15 to 95 percent and averaged 83 percent.

The average catch rate at SE Hancock was higher than that at NW Hancock; however, monitoring of both seamounts will be required before definitive conclusions can be drawn about the stock. Trawling time per haul at SE Hancock ranged from 19 to 38 minutes, averaged 23.7 minutes/haul, and totaled 2.8 hours over seven trawl stations. The total catch included 3,534 kg of pelagic armorhead and 58 kg of alfonsin, or a ratio of 49:1. The CPUE varied from <1 to 4,595 kg/hour and averaged 1,348 kg/hour. Pelagic armorhead constituted between 30 and 99 percent of the catch.

At Seamount 10, the catch was practically nil in a 12-minute haul. A single haul at Seamount 11 with the Norwegian trawl produced only small numbers of red bigeye, *Cookeolus boops*, and grouper, *Caprodon schlegelii*. Both seamounts, however, require considerable additional sampling before reliable estimates can be made of the resources.

Handlining

Results from handline fishing indicated that the trawl catches were not representative of the seamount community. Handline fishing stations were occupied nine times each at NW and SE Hancock Seamounts, four times at Seamount 11, seven times at Ladd Seamount, and twice each at Nero Seamount, Seamount 9, and Seamount 8; the catches included 25 fish species representing 15 families (Table 7, 8). Of the 15 families sampled, 10 were also rep-

Table 7.—Fishes caught on the *Townsend Cromwell* by handlining on Hancock and other seamounts. The species are listed in descending order of their abundance (total catch) in weight.

Scientific name	Family	No.	Weight (kg)
Etelis carbunculus	Lutjanidae	170	363.06
Epinephelus quernus	Serranidae	36	359.64
Pentaceros richardsoni	Pentacerotidae	343	149.78
Hyperoglyphe japonica	Nomeidae	23	66.45
Scomber japonicus	Scombridae	46	65.93
Seriola dumerili	Carangidae	7	64.82
Squalus blainvillei	Squalidae	53	62.85
Caranx ignobilis	Carangidae	1	28.70
Cookeolus boops	Priacanthidae	9	19.40
Etelis coruscans	Lutjanidae	2	16.69
Pristipomoides zonatus	Lutjanidae	11	16.52
Decapterus tabl	Carangidae	12	13.28
Promethichthys prometheus	Gempylidae	13	12.04
Pontinus macrocephalus	Scorpaenidae	9	11.11
Beryx splendens	Berycidae	13	11.09
Pristipomoides sieboldii	Lutjanidae	8	6.95
Pseudocaranx dentex	Carangidae	1	5.20
Seriola aureovittata	Carangidae	1	5.00
Bodianus oxycephalus	Labridae	2	2.50
Decapterus sp.	Carangidae	1	1.25
Polymixia japonica	Polymixiidae	2	0.80
	Emmelichthyidae	1	0.73
Plectranthias kelloggi	Serranidae	2	0.60
Anthias bicolor	Serranidae	1	0.20
Sphoeroides cutaneous	Tetraodontidae	1	

resented in the trawl catches. In terms of species, however, only eight were also sampled by the trawl. Most of the remaining 17 species (including one unidentified species) were from the families Carangidae and Lutjanidae; members of the families Scombridae, Scorpaenidae, Labridae, and Tetraodontidae contributed most of the remainder.

Although handline fishing is selective in that the bait used, depth fished, hook size, and bottom type influence the species composition of the catch, the catch results were particularly valuable in providing information on fish distribution. Going from northwest to southeast, we found the Hancock Seamounts' handline catches dominated by pelagic armorhead; alfonsin; butterfish, *Hyperoglyphe japonica*; chub mackerel, *Scomber japonicus*; mackerel scad, *Decapterus tabl*; two groupers, *Plectranthias kelloggi* and *Anthias bicolor*; and horny dogfish. At Seamount 11, catches of horny dogfish predominated; however, members of the tropical snapper-grouper complex were also more in evidence (Table 8). At Ladd and Nero Seamounts, members of the pelagic armorhead-alfonsin complex were almost completely absent, whereas fishes of the snapper-grouper complex such as red snapper, *Etelis carbunculus* (formerly *E. marshi*); grouper, *Epinephelus quernus*; amberjack, *Seriola dumerili*; Brigham's snapper, *Pristipomoides zonatus*; and pink snapper, *P. sieboldii*; were prominent in the catches.

Our results corroborated those of Japanese investigators who found that the pelagic armorhead-alfonsin complex over the summits of the central North Pacific seamounts gave way to a fish community dominated by tropical species in areas with warmer waters and over those seamounts to the east of the 180th meridian (Japan Marine Fishery Resource Research Center, 1973; Japan Fisheries Agency, 1974; Sasaki, 1974, 1978).

Table 8.—Number of fish caught by handline at the various seamounts and arranged by families in their phyletic order (weight in kilograms in parentheses).

Family and species	NW Hancock	SE Hancock	Seamount 11	Ladd	Nero	Seamount 9	Seamount 8
Squalidae							
Squalus blainvillei	8 (14.17)	34 (42.96)	10 (1.56)	1 (4.16)	—	—	—
Polymixiidae							
Polymixia japonica	—	—	—	<1	2 (0.80)	—	—
Berycidae							
Beryx splendens	11 (9.55)	2 (1.54)	—	<1	—	—	—
Scorpaenidae							
Pontinus macrocephalus	—	—	—	5 (6.22)	3 (3.50)	1 (1.39)	—
Serranidae							
Epinephelus quernus	—	—	4 (36.92)	8 (92.32)	10 (73.50)	6 (72.51)	8 (84.39)
Anthias bicolor	1 (0.20)	—	—	<1	—	—	—
Plectranthias kelloggi	1 (0.40)	1 (0.20)	—	<1	—	—	—
Priacanthidae							
Cookeolus boops	—	—	4 (6.80)	2 (5.20)	3 (7.40)	—	—
Carangidae							
Pseudocaranx dentex	—	—	—	<1	1 (5.20)	—	—
Caranx ignobilis	—	—	—	—	—	—	1 (28.70)
Decapterus sp.	—	—	—	1 (1.25)	—	—	—
D. tabl	1 (1.25)	11 (12.03)	—	<1	—	—	—
Seriola aureovittata	—	—	—	1 (5.00)	—	—	—
S. dumerili	—	—	—	<1	—	1 (9.57)	6 (55.25)
Lutjanidae							
Etelis carbunculus	—	—	—	55 (126.39)	77 (153.90)	7 (10.11)	31 (72.66)
E. coruscans	—	—	—	2 (16.69)	—	—	—
Pristipomoides sieboldii	—	—	—	5 (5.31)	1 (0.70)	2 (0.94)	—
P. zonatus	—	—	—	<1	—	1 (2.08)	10 (14.44)
Emmelichthyidae	—	—	—	<1	—	1 (0.73)	—
Pentacerotidae							
Pentaceros richardsoni	188 (85.67)	154 (62.11)	—	1 (2.00)	—	—	—
Labridae							
Bodianus oxycephalus	—	—	—	<1	2 (2.50)	—	—
Gempylidae							
Promethichthys prometheus	—	—	—	12 (11.24)	1 (0.80)	—	—
Scombridae							
Scomber japonicus	2 (2.56)	44 (63.37)	—	<1	—	—	—
Nomeidae							
Hyperoglyphe japonica	15 (29.75)	7 (27.70)	—	1 (9.00)	—	—	—
Tetraodontidae							
Sphoeroides cutaneous	—	—	—	1 (<1)	—	—	—

Table 9.—Fishes and invertebrates caught on the *Townsend Cromwell* by trap on Hancock and other seamounts. The species are listed in descending order of their abundance (total catch) in weight.

Scientific name	Family	No.	Weight (kg)
Squalus blainvillei	Squalidae	134	148.41
Epinephelus quernus	Serranidae	15	91.64
Seriola dumerili	Carangidae	3	27.00
Pristipomoides filamentosus	Lutjanidae	5	19.91
Pseudocaranx dentex	Carangidae	3	12.49
Polypus sp.	Polypodidae	4	10.27
Gymnothorax steindachneri	Muraenidae	9	7.50
Etelis carbunculus	Lutjanidae	2	5.22
Physiculus grinnelli	Moridae	19	5.03
Gymnothorax sp.	Muraenidae	3	4.19
	Congridae	2	3.73
Ariosoma bowersi	Congridae	1	2.40
Scyllarides squammosus	Scyllaridae	1	1.38
	Moridae	7	1.34
Conger wilsoni	Congridae	1	1.27
	Muraenidae	1	1.15
Pentaceros richardsoni	Pentacerotidae	2	1.01
Plectranthias kelloggi	Serranidae	4	0.80
Gymnothorax berndti	Muraenidae	1	0.77
Congrellus aequoreus	Congridae	2	0.68
Coris ballieui	Labridae	5	0.58
Antigonia steindachneri	Antigoniidae	2	0.20
Etmopterus villosus	Squalidae	1	0.10
Antigonia eos	Antigoniidae	2	0.06
Parapercis multifasciata	Parapercidae	1	—
Squalus sp.	Squalidae	1	—
Gymnothorax undulatus	Muraenidae	1	—
	Bramidae	2	—
Chaetodon miliaris	Chaetodontidae	2	—
Chaetodon fremblii	Chaetodontidae	1	—
Lupocyclus quinquedentatus	Portunidae	1	—
	Astropectinidae	16	—
	Paguridae	81	—
	Echinometridae	8	—
Calappa sp.	Calappidae	2	—
	Gastropoda	2	—

Table 10.—Number of fish caught by fish and lobster traps at various seamounts and arranged by families in phyletic order (weight in kilograms in parentheses, when available).

Family and species	NW Hancock	SE Hancock	Seamount 11	Nero	Ladd	Seamount 8
Astropectinidae			1	5	10	—
Echinometridae			—	8	—	—
Gastropoda (Class)	—	—	—	—	2	—
Polypodidae						
Polypus sp.	—	—	—	—	[1]— (10.27)	—
Scyllaridae						
Scyllarides squammosus	—	—	—	—	—	1 (1.38)
Paguridae						
Dardanus spp.	—	—	—	31	38	12
Calappidae						
Calappa sp.	—	—	—	—	—	2
Portunidae						
Lupocyclus quinquedentatus	—	—	—	—	1	—
Squalidae						
Etmopterus villosus	—	1 (0.10)	—	—	—	—
Squalus sp.	—	1	—	—	—	—
Squalus blainvillei	7 ([2]8.26)	120 (121.63)	6 (13.27)	1 (5.25)	—	—
Muraenidae						
Gymnothorax sp.	—	—	3 (4.19)	—	—	—
G. berndti	—	—	—	—	1 (0.77)	—
G. steindachneri	—	—	—	2 ([3]1.88)	7 (5.62)	—
G. undulatus	—	—	—	1	—	—
Moray (unidentified)	—	—	—	—	1 (1.15)	—
Congridae						
Ariosoma bowersi	—	—	—	—	1 (2.40)	—
Conger wilsoni	—	—	1 (1.27)	—	—	—
Congrellus aequoreus	—	—	—	—	2 (0.68)	—
Conger eels (unidentified)	—	—	—	—	2 (3.73)	—
Moridae						
Physiculus grinnelli	—	—	—	6 (1.70)	13 (3.33)	—
Morid fishes	—	1 (0.17)	6 (1.17)	—	—	—
Antigoniidae						
Antigonia eos	1 ([2]0.03)	1 (0.03)	—	—	—	—
A. steindachneri	2 ([1]0.20)	—	—	—	—	—
Serranidae						
Epinephelus quernus	—	—	7 (33.04)	—	8 (58.60)	—
Plectranthias kelloggi	4 ([2]0.80)	—	—	—	—	—
Carangidae						
Pseudocaranx dentex	—	—	—	—	3 (12.49)	—
Seriola dumerili	—	—	—	3 (27.00)	—	—
Lutjanidae						
Etelis carbunculus	—	—	—	—	2 (5.22)	—
Pristipomoides filamentosus	—	—	—	2 (12.01)	—	3 (7.90)
Bramidae	—	—	—	—	2	—
Chaetodontidae						
Chaetodon fremblii	—	—	—	—	—	1
C. miliaris	—	—	—	—	1	1
Pentacerotidae						
Pentaceros richardsoni	—	2 (1.01)	—	—	—	—
Labridae						
Coris ballieui	—	—	—	—	4 (0.46)	1 ([3]0.12)
Parapercidae						
Parapercis multifasciata	1	—	—	—	—	—

[1]Number caught not recorded; estimated to be fewer than seven animals.
[2]Estimated from average weight of handline and trawl-caught specimens.
[3]Estimated from average weight of trap-caught specimens.

Trapping

The fishes and invertebrates caught in the fish traps and lobster pots on the six cruises are presented in Table 9. Of primary interest is that only two pelagic armorhead and no alfonsin were caught in 60 trap-nights and 176 pot-nights of effort expended. It was suggested that pelagic armorhead and alfonsin do not feed in the area immediately adjacent to the summits and, therefore, are not vulnerable to traps. Examination of our handline catches, however, showed that they were usually taken on hooks fishing closest to the bottom. This indicated that although these species feed near the bottom, they cannot be trapped readily.

Representatives of 13 fish families including 24 species were caught in the traps (Table 10); the horny dogfish was the dominant species in the catches. Of the 13 families, 9 were also represented in the trawl catch; however, 15 of the positively identified species were not present in the trawl catch. With the exception of pelagic armorhead and alfonsin, the handline catches differed from the trawl catches in that most of the other species in the handline catches included members of the snapper-grouper complex. The trap and pot catches, on the other hand, included large numbers of not only horny dogfish, snappers, groupers, and carangids, but also bottom-dwelling forms such as conger eels, including *Ariosoma bowersi*, *Conger wilksoni*, *Congrellus aequoreus*, and an unidentified species; and moray eels, including *Gymnothoras berndti*, *G. steindachneri*, *G. undulatus*, *Gymnothorax* sp., and an unidentified species; and invertebrates such as starfish, Astropectinidae; and hermit crabs, *Dardanus* spp. Other invertebrates caught in the traps and pots

Figure 9.—Pelagic armorhead, *Pentaceros richardsoni*. Examples of "fat" (upper right), "intermediate" (center), and "lean" (lower right) fish, which are discussed in the section "Pelagic Armorhead."

included octopus, *Octopus* sp.; slipper lobster, *Scyllarides squammosus*; swimming crab, *Lypocyclus quinquedentatus*; box crab, *Calappa* sp.; sea urchin, Echinometridae; and unidentified gastropods.

Target Species' Biology

Pelagic Armorhead

Formerly considered a rare species because of the paucity of reports on its capture, the pelagic armorhead (Fig. 9), in the family Pentacerotidae, is broadly distributed in the North Pacific between lat. 30° and 50°N (Takahashi and Sasaki, 1977). The outstanding feature of members of this family is the unusual armature of the head, which is almost completely enclosed in exposed, rough, striated bones (Smith, 1964).

Very little is known about the life history of this species. Eggs and larvae are thought to be free-floating and dispersed by waters of the North Equatorial Current (Chikuni, 1971b). It has also been hypothesized that the juveniles remain pelagic until age 4-5 (25-30 cm fork length) when they begin a demersal existence over the seamounts.

In addition to the Pacific seamounts we have discussed, pelagic armorhead have been recorded from New Zealand, Australia, the northern part of the Hawaiian Archipelago, Japan, Gulf of Alaska, British Columbia, Oregon, and California (Abe, 1957; Clemens and Wilby, 1961; Wagner and Bond, 1961; Follett and Dempster, 1963; Honma and Mizusawa, 1969).

Not all seamounts in the North Pacific have populations of pelagic armorhead. Trawling surveys over Patton (lat. 54°40′N, long. 150°30′W) and Cobb Seamounts (lat. 46°46′N, long. 130°49′W) in the northeastern Pacific have not demonstrated the presence of pelagic armorhead (Chikuni, 1971a, b). Seamounts north of lat. 35°N in the Emperor Chain have summits so deep that the possibility of finding pelagic armorhead on them appears rather remote. Furthermore, those seamounts located on the Hawaiian Ridge to the east of the 180th meridian are relatively shallow and trawling surveys have demonstrated that their fauna is subtropical and do not include the pelagic armorhead (Sasaki, 1978).

Pelagic armorhead also make extensive vertical migrations, depending on the location in the North Pacific. Japanese trawlers have fished for pelagic armorhead in depths varying from 300 to 600 m over the central North Pacific seamounts. However, unlike other mesopelagic species that ascend into the surface layers at night and descend to great depths during the day, pelagic armorhead have been found close to the top of the seamounts at night in most instances. Furthermore, reports of their capture by handlines suggested that the pelagic armorhead may also be schooling at the surface at night (Chikuni, 1970).

Other reports suggest that pelagic armorhead do not confine their vertical migration to the water mass overlying the tops of the seamounts. Observations by Kitani and Iguchi (1974) showed that they rise above and descend below the top of the seamount during the day and night, respectively. The catch per unit of effort by trawling usually peaked between 0300 and 0700 hours and between 1700 and 1900 hours. Therefore, the pelagic armorhead appear to migrate through the level of the seamount summit twice a day—once in the morning and again in the evening.

Studies on feeding behavior support the contention that pelagic armorhead feed at night near the surface. Observations on aquarium-held fish indicate that pelagic armorhead in their natural environment probably feed at night on organisms occurring near the surface (Hart, 1973). Stomach contents of pelagic armorhead caught over the seamounts contained euphausids, mysids, copepods, salps, shrimps, myctophids, and other organisms usually associated with the deep-scattering layer (Sasaki, 1973, 1974). Since the deep-scattering layer ascends toward the surface at night and remains deeper during daylight, the results of the stomach analysis tend to agree with aquarium observations.

The fork lengths of unsexed pelagic armorhead caught by trawling showed strong unimodal distributions. At NW Hancock, the fish ranged from 23.3 to 39.8 cm (average 29.7 cm) and 67 percent were between 29 and 31 cm (Fig. 10). The fish from SE Hancock showed a similar narrow length range of 23.3-35.9 cm and averaged 29.9 cm, which was nearly identical to that found for NE Hancock (Fig. 11). Here about 62 percent of the fish fell within the 29-31 cm

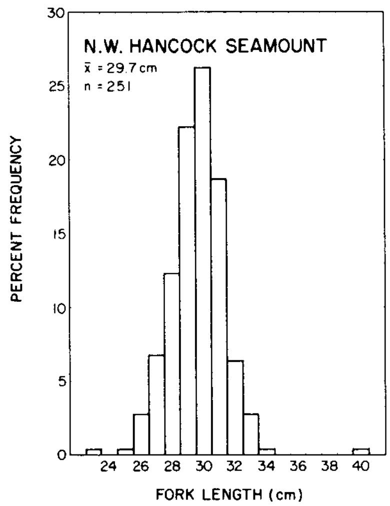

Figure 10.—Length-frequency distribution of pelagic armorhead caught at NW Hancock Seamount during *Townsend Cromwell* cruise 80-02.

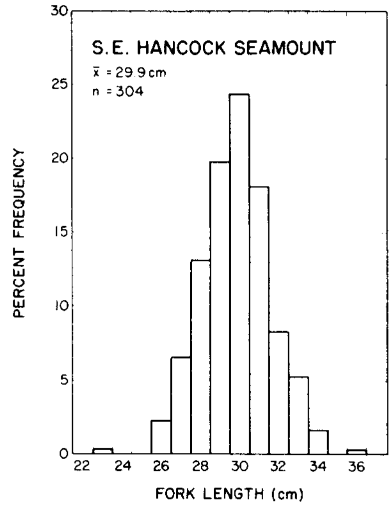

Figure 11.—Length-frequency distribution of pelagic armorhead caught at SE Hancock Seamount during *Townsend Cromwell* cruise 80-02.

Table 11.—Analysis of variance on the mean length of pelagic armorhead measured by sex, at NW and SE Hancock Seamounts.

		No. measured		Mean length (cm)			
Seamount	Cruise	Male	Female	Male	Female	Values of F	Probability
NW Hancock	78-03	23	46	29.6	30.7	7.70	0.01
	80-02	77	45	28.7	30.1	27.73	0.01
SE Hancock	78-01	19	53	29.0	30.1	17.19	0.01
	81-02	49	26	28.9	29.7	9.36	0.01

Table 12.—The percentage of "fat," "lean," and "intermediate" body types of pelagic armorhead in the catch of Japanese trawlers fishing at Hancock Seamounts in 1978-81.

			Percentage		
Vessel name	Date	Seamount	"Fat"	"Lean"	"Intermediate"
Ryuyo Maru No. 2	4/22- 6/ 3/78	Hancock	2	98	
Aso Maru	5/27- 7/10/79	Hancock	5	95	
Kitakami Maru	8/ 9-10/ 4/80	NW Hancock	27	73	
		SE Hancock	43	57	
Aso Maru	9/24- 9/30/80	NW Hancock	11	45	43
		SE Hancock	13	35	52
Aso Maru	6/ 9- 6/19/81	NW Hancock	60	25	15
		SE Hancock	59	24	17
Kitakami Maru	8/15-10/ 1/81	NW Hancock	67	33	
		SE Hancock	61	39	

length range. An analysis of variance showed that mean size at NW Hancock was not significantly different from that at SE Hancock ($F = 1.65$; df = 1 and 553; $P > 0.05$). Males, however, differed significantly in size from females (Table 11). The average size of females was from 0.8 to 1.4 cm larger than that of the males.

One of the more perplexing problems in the life history of the pelagic armorhead is the morphological differences of fish over the various seamounts in the Pacific. Sasaki (1974) reported that the northeastern Pacific stock has a higher proportion of the "fat" type, whereas the central North Pacific stock has more "lean" fish. Coloration also differs. The "fat" type has a dark blue dorsal and white ventral regions which are typical of surface-dwelling fish. Some are also reticulated. The "lean" fish over the central North Pacific seamounts have been reported to be uniformly gray and without any markings.

On cruises of the *Townsend Cromwell* prior to 1980, as much as 95 percent of the pelagic armorhead caught at Hancock Seamounts were "lean." In 1980, however, about 20 percent of the fish at NW Hancock and about 15 percent at SE Hancock were "fat." By 1981 we found that proportion of "fat" to "lean" completely reversed from former years. From one trawl haul at SE Hancock, the catch included 94 percent "fat" and only 6 percent "lean." Furthermore, many of the "fat" fish could be classified into a third "intermediate" category and there actually was a gradation of body types from "very fat" to "very lean" (Fig. 9). This gradation of body types can also be seen in data collected by U.S. observers on the Japanese trawlers in 1980-81 (Table 12).

One explanation offered for the occurrence of "fat" and "lean" fish is that the body types are related to reproductive condition because a large number of the gonads of both sexes of "lean" fish were in the spent stage (Takahashi and Sasaki, 1977). This points to a possibility that the "lean" fish were unable to recover from the spawning ordeal. The "lean" fish, in many cases, showed signs of deterioration (i.e., the skin peeled off their bodies very readily (Kuroiwa, 1973)).

Studies conducted by the Soviets and Japanese have demonstrated that spawning of pelagic armorhead begins in November-December, peaks in January-February, and declines in March (Iguchi, 1973; Sasaki, 1974; Takahashi and Sasaki, 1977). Therefore, one would expect the proportion of "lean" fish in the catch to be high during the post-spawning period. Data from our research cruises indicate otherwise. For example, from one trawl haul by the *Townsend Cromwell* at SE Hancock in March 1981, the catch was composed of 94 percent "fat" and 6 percent "lean" fish. If spawning peaked in January-February, then there should be a large proportion of "lean" fish in the catch in March. In addition, data from a Japanese trawler fishing from April through June 1978 indicated that "lean" fish represented 98 percent of the catch from Hancock, whereas on another trip from May through July 1979, 95 percent of the catch was "lean" (Table 12). It also appears that "fat" and "lean" fish are not segregated by depth because both body types are found in the same trawl haul. The inconsistency in these results points out the complexity of the pelagic armorhead's life history pattern and that additional studies are necessary to understand the changes in their morphological characteristics.

Alfonsin

The alfonsin (Fig. 12) which belongs to the Berycidae, a high-seas family of fishes, is bright red and inhabits rocky bottom several hundred meters deep. The species is found mainly in the western North Pacific where for many years it has been caught by handlines in Sagami Bay and Kashima Nada in the inshore areas of Japan and on the banks and slopes around Izu (South Honshu Ridge). In 1970, alfonsin were reported from Kinancho on the Kinan Seamount Range and the Kyushu-Palau Seamount Range. They also occur over the Emperor Seamounts where they were first taken by Soviet trawlers in November 1967 (Sakiura, 1972), and were caught by hook and line beginning in 1973 (Masuzawa et al., 1975). In the trawl fishery, alfonsin constitute only a small percentage of the catch.

A closely related species, *Beryx decadactylus*, has been taken in small numbers together with alfonsin. *Beryx decadactylus* has also been taken near Saipan in the Commonwealth of the Northern Mariana Islands with bottom gill nets.

Near Japan, alfonsin spawn between August and October and the eggs are transported by the Kuroshio (Chikuni, 1971b). Artificial propagation experiments showed that the berycoid eggs float and hatch in about 2 days at 23°C and newly hatched larvae float for 2-3 days before they begin to swim on the fourth day (Onishi, 1967). Therefore, the distribution of the larvae is wholly dependent on the Kuroshio and its offshoots.

Alfonsin migrate vertically during the evening to feed near the surface. Analysis of stomach contents of fish caught over the Emperor Seamount Chain disclosed that small fish predominated in 43 percent of the stomachs, whereas crustaceans (decapods, mysids, and euphausids) predominated in 37 percent of the samples. No information was available on the remaining 20 percent of the fish sampled (Aomori Prefectural Fisheries Experimental Station, 1976).

Figures 13 and 14 show the length-frequency distributions of unsexed al-

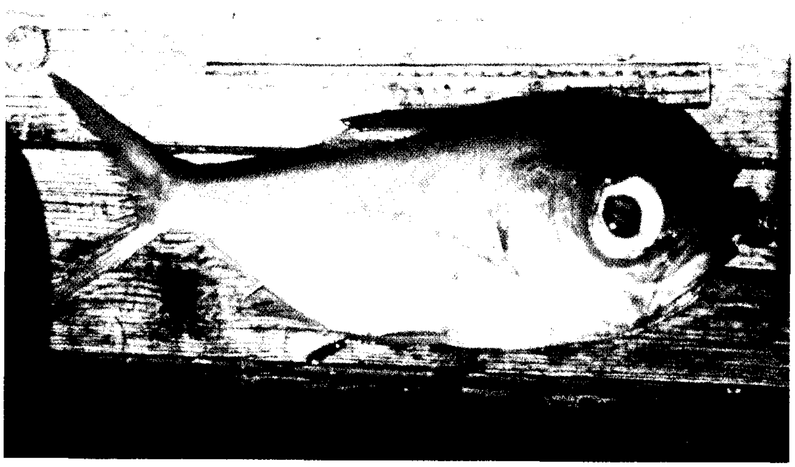

Figure 12.—Alfonsin, *Beryx splendens*.

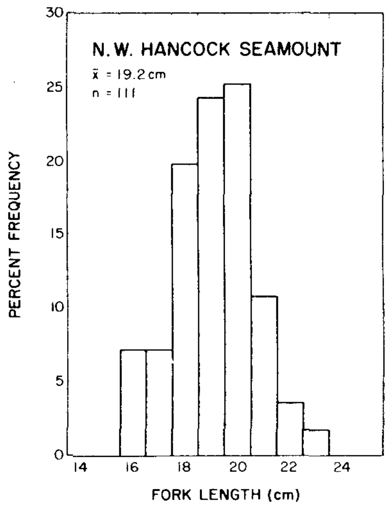

Figure 13.—Length-frequency distribution of alfonsin caught at NW Hancock Seamount on *Townsend Cromwell* cruise 80-02.

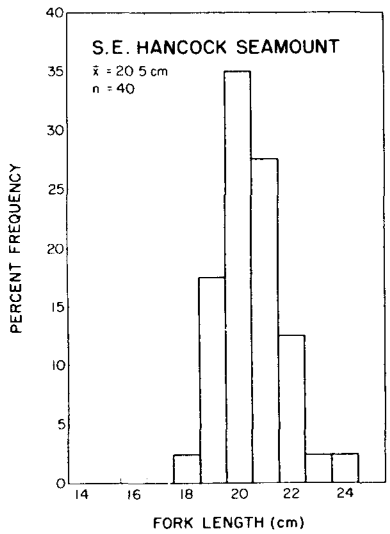

Figure 14.—Length-frequency distribution of alfonsin caught at SE Hancock Seamount on *Townsend Cromwell* cruise 80-02.

fonsin caught by trawl at NW and SE Hancock. Those caught at NW Hancock ranged from 15.7 to 23.0 cm and averaged 19.2 cm whereas those caught at SE Hancock had a narrower size range, from 18.2 to 23.7 cm, and averaged 20.5 cm. There was a highly significant difference in sizes of fish from the two seamounts ($F = 25.69$; df = 1 and 149; $P < 0.01$).

Summary and Conclusions

The seamount-groundfish trawl fishery expanded rapidly after 1967 when exploratory fishing by Soviet trawlers demonstrated the presence of commercial concentrations of pelagic armorhead and smaller quantities of alfonsin. In 1969, Japanese trawlers entered the fishery and their catches fluctuated widely until 1972, thereafter stabilizing at 18,952-34,538 t. Although the catch peaked in 1974, CPUE peaked much earlier, reaching 60.2/hour in 1972, then declined steadily to 9.7/hour by 1976. Unpublished Japanese data indicate that CPUE continued its downward trend in 1977-81, fluctuating between 0.3 and 2.4 t/hour.

During 1972-76, Hancock Seamounts, which fall within the U.S. FCZ around the Hawaiian Archipelago, received from 1 to 29 percent of the entire central North Pacific trawling effort by the Japanese. The catches during this period fluctuated from 653 to 8,518 t or roughly from 3 to 34 percent of the central North Pacific pelagic armorhead catch.

Based on catch data, the center of abundance of pelagic armorhead is near Colahan, C-H, and Hancock Seamounts, whereas that for alfonsin is in more northerly latitudes near Kimmei Seamount in the Emperor Seamount Chain.

In 1978-81, U.S. observers collected data on three Japanese trawlers that made six trips to Hancock Seamounts. These data indicated that after the intense fishing pressure applied prior to 1977, it had begun to improve and showed an upward trend although the CPUE was still considerably below the pre-1977 level.

Life history aspects of the pelagic armorhead are not well understood at present; however, much of the alfonsin's biology and ecology have been investigated by the Japanese.

Data collected by the *Townsend Cromwell* during research cruises to the seamounts in the Hawaiian Archipelago demonstrated that the species complex changes abruptly near Midway Islands. The pelagic armorhead-alfonsin complex predominated at Hancock Seamounts near the northern edge of the U.S. FCZ; however, slightly south of Hancock near Midway Islands and Kure Atoll, the snapper-grouper complex predominated at Ladd, Nero, and other unnamed seamounts in that area.

There was no significant difference in the mean length of pelagic armorhead from NW and SE Hancock. However, females were consistently larger than males. Significant differences in mean sizes were evident in alfonsin caught at NW and SE Hancock. One of the peculiarities noted among the pelagic armorhead population at Hancock Seamounts was the occurrence of "lean" and "fat" fish in the catch. Japanese investigators have hypothesized that body types are related to spawning with "lean" fish, the result of a postspawning condition. Research cruise data collected by the Honolulu Laboratory failed to substantiate this hypothesis. The manner in which apparent abundance (CPUE) of pelagic armorhead declined from its peak in 1972 while effort rose steadily from 1972 to 1976 and remained at relatively high levels in 1977-81 indicates that the trawl fishery has had a real effect on the stock. The failure of total catch to increase with increasing effort suggests that the rate of fishing has been sufficiently intense and may have surpassed the level corresponding to optimum fishing effort.

Although preliminary assessment studies have been attempted, reliable estimates are not possible until several critical problems are addressed. For example, there is a complete lack of catch and effort data from Soviet trawlers, no evidence that the stock and fishery dynamics over one seamount are independent of events occurring over other central Pacific seamounts, no information on what governs recruitment to the seamount habitat, and no logical explanation for the existence of "fat" and "lean" types on the same seamount. To solve these problems, we must promote not only careful assessment of the pelagic armorhead stock over its entire range, but also international management action, should it become necessary.

Acknowledgments

We thank Thomas Dark, NMFS Northwest and Alaska Fisheries Center, Seattle, Wash., and Jack V. Tagart, Washington Department of Fisheries, Seattle, for reviewing the manuscript during its preparation. We also thank Takashi Sasaki, Far Seas Fisheries Research Laboratory, Shimizu, Japan, for providing unpublished catch and effort data for 1977-81.

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