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SEAMOUNT FISHERY RESOURCES WITHIN THE SOUTHERN EMPEROR-NORTHERN HAWAIIAN RIDGE AREA

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ABSTRACT

The summits of the seamounts comprising the southern Emperor Seamount Chain and northern Hawaiian Ridge (Koko-Hancock Seamounts) lie at depths of 250 to 400 m; Russian data indicate that the topography produces much surface current meandering and upwelling in the region. In 1967, Soviet trawl fishermen discovered vast quantities of pelagic armorhead, *Pentaceros richardsoni*, and to a lesser extent alfonsin, *Beryx splendens*, closely associated with summits of these seamounts. Two years later, Japanese trawlers entered the fishery. They achieved their highest annual catch per unit of effort in 1972 with a sharp decline after 1976. With the advent of the 200-mile U.S. fishery conservation zone, the Hancock Seamounts came under U.S. jurisdiction. Comparison of the U.S. foreign observer data obtained on Japanese trawlers in 1978-82 with earlier Japanese data show trawl catches on Hancock have generally been declining since the high catch of 1972. Seamounts of the Hawaiian Ridge located south of Hancock and east of 180° longitude differ in having shallower summits, higher summit water temperatures, and fish faunas dominated by subtropical reef and snapper-grouper species. Meristic and electrophoretic work on pelagic armorhead indicates the existence of one stock inhabiting the range of seamounts between Koko and Hancock. Morphological variation among pelagic armorhead is little understood.

alfonsin
pelagic armorhead
seamounts

INTRODUCTION

The islands, banks, reefs, and seamounts of the Hawaiian Ridge extend northwesterly from the island of Hawaii some 3,500 km to Colahan Seamount. To the northwest of Colahan the Emperor Seamounts extend from the Milwaukee Seamount Group northward 2,300 km to Meiji Seamount (Jackson et al., 1980). The Emperor-Hawaiian Ridge area is composed of at least 107 identifiable volcanoes from which all the associated topographical features originate. These volcanoes are thought to have been produced by the northward movement of the Pacific plate over a "hot spot" with the bend at the junction of the Emperor-Hawaiian Ridge area caused by a shifting of the plate to the northwest. Results from a variety of dating techniques on samples obtained from sites throughout the Emperor-Hawaiian Ridge area show a pattern of increasing age with distance from the island of Hawaii (Dalrymple et al., 1981). This indicates that the seamounts are among the oldest of topographic features within the Emperor-Hawaiian Ridge area. The seamounts discussed in this review are Koko, Yuryaku, and Kammu of the southern Emperor Seamounts Chain and Colahan, C-H, NW Hancock, SE Hancock, Ladd, Nero, and unnamed seamounts 8 to 11 of the northern Hawaiian Ridge. All are situated within an area bounded by lat. 26° to 36°N and long. 174°W to 171°E (Figure 1). A seamount is defined as a more-or-less isolated elevation of the sea floor appearing circular or elliptical in cross-section, with a minimum relief of 1 km, comparatively steep slopes, and a relatively small summit area. Most, if not all, seamounts are volcanic in origin (Menard, 1964).

The seamounts of the southern Emperor-northern Hawaiian Ridge area from Koko to Hancock Seamounts (hereafter designated SE-NHR), lie within the mean flow of the North Pacific Current. Results of Soviet investigations in this region indicate a substantial perturbance in the surface current field, apparently produced by the seamounts (Borets, 1980). Fedosova (1974) reported the existence of cyclonic and anticyclonic eddies over the SE-NHR seamounts. These eddies fluctuated seasonally in location and dimension, but apparently persisted throughout the year.

The sea-surface temperature (SST) annually ranges from 15 to 26°C at Koko Seamount, 18° to 27°C near the Hancock Seamounts, and 22° to 29°C to the south in the vicinity of seamounts 8 and 9. Maximum SST usually occurs during August-September and the temperatures are lowest in February-March (Eber et al., 1968). Unfortunately, temperature data for the seamount summits are scarce, and comparisons are complicated by the wide range in summit elevations. Available data indicate an annual range in summit temperatures of 8° to 15°C among the more northerly seamounts (summit depths of 250 to 400 m) from Yuryaku to SE Hancock. The southern seamounts, from Ladd to seamount 8, have shallower summit depths of 50 to 200 m and temperatures of 14° to 24°C (Japan Marine Fishery Resource Research Center, 1973; Japan Fisheries Agency, 1974; Gooding, 1980).

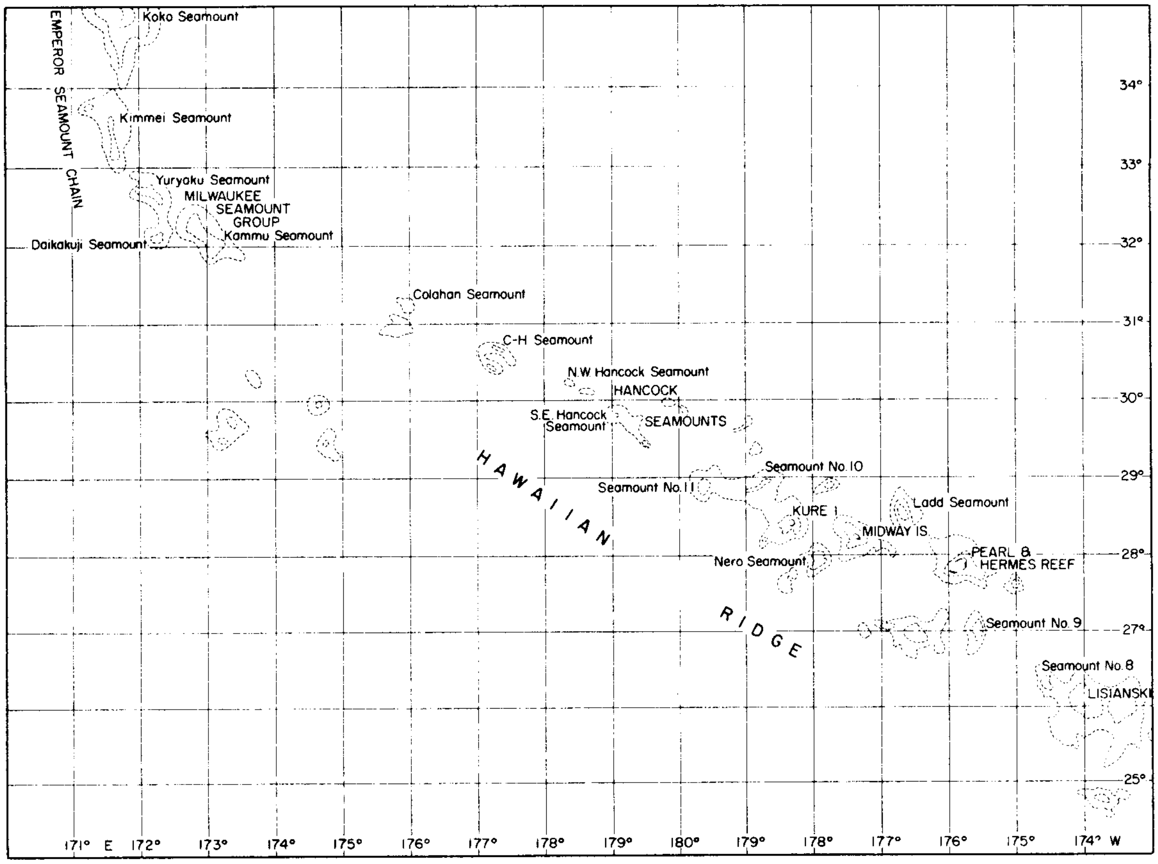


Figure 1. The southern Emperor-northern Hawaiian Ridge seamounts

Besides fluctuations in the current field and water temperature, seasonal changes in plankton biomass over the seamounts have been observed in the area between lat. 27° and 37°N, long. 170°E and 178°W. Soviet investigators found areas of highest plankton biomass in the spring. These areas were displaced downcurrent of upwelling zones in the winter-spring period, whereas in spring-summer they were found near eddies. The winter-spring conditions were explained relative to the intensification of the North Pacific Current and the directional coincidence of prevailing winds, whereas during spring-summer there was a weakening of this current (Fedosova, 1974). Pontekorvo (1974) suggested that zones of upwelling are produced on opposite sides of a seamount. These zones are roughly aligned with the prevailing current and intensified during the winter. Bezrukov and Natarov (1976) attributed the formation of high biological productivity over the SE-NHR seamounts to a favorable abiotic regime produced by the intense vertical water circulation.

SEAMOUNT TRAWL FISHERY -- PAST AND PRESENT

The discovery of a bottom trawl fishery resource on the SE-NHR seamounts was made by a Soviet commercial trawler in November 1967. The resource consisted primarily of pelagic armorhead, *Pentaceros richardsoni*, and alfonsin, *Beryx splendens* (Figures 2 and 3). Shortly thereafter, a Soviet trawl fishery began on the SE-NHR seamounts. From December 1969 through July 1970, Soviet trawlers harvested approximately 133,400 metric tons (MT) of pelagic armorhead from the seamounts (Sakiura, 1972). This is the only catch data available for the Soviet trawl fleet although Soviet trawlers have probably continued to fish the seamounts to the present. In 1968-69, two Soviet research cruises surveyed an area from lat. 21° to 36°N, and long. 160°E to 165°W. Seamounts surveyed were Koko, Milwaukee (consisting of Kammu, Yuryaku, and Daikakuji Seamounts), Hancock (refers to NW and SE Hancock Seamounts), and two unidentified seamounts. Pelagic armorhead was the principal species caught on each seamount. Total catch of alfonsin ranged from 5 to 30 percent at Koko and accounted for 25 percent at Milwaukee. The catch of alfonsin on the other seamounts was not given. Catches of pelagic armorhead at each seamount were found to vary diurnally. Catches would generally increase after 1800 hours and peak just before sunrise (Sakiura, 1972).

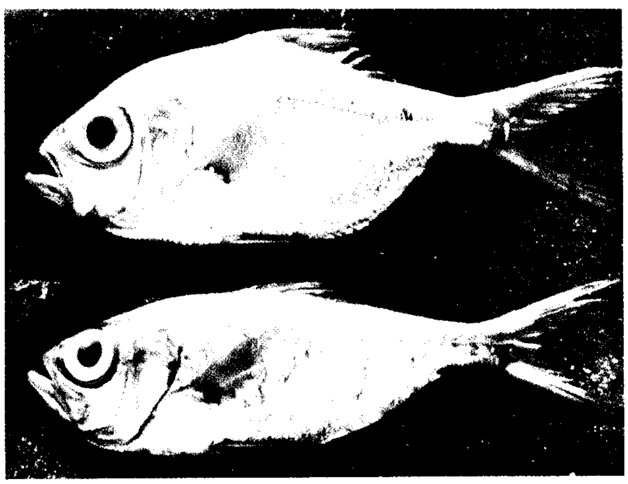
The Japanese seamount trawl fishery began in August 1969. An initial 2-year exploratory phase defined suitable trawl grounds and developed markets for the catch. Unlike the Soviets, the Japanese have made available their trawl catch and effort data, by seamount, for pelagic armorhead and alfonsin caught during 1969-81 (Takahashi and Sasaki, 1977; Sasaki, unpublished data). These data cover trawling on the following seamounts: Koko, Milwaukee, Colahan, C-H, Hancock, and others.

Figure 4 shows the annual effort (in trawl hours) at each of the seamounts during 1969-81. During the exploratory phase Milwaukee was surveyed intensively, whereas during 1972-73 effort was more equitably partitioned among all the seamounts. Effort during the following years (1974-81) was concentrated at Koko and Milwaukee.

The annual catch of pelagic armorhead is shown in Figure 5 for 1969-81. The annual catches fluctuated widely at Milwaukee during 1969-77, whereas they fluctuated less at Koko, Colahan, and Hancock. The fluctuations in catch at Koko and Milwaukee during 1969-71 and 1974-76 appear to coincide with fluctuations in effort. Outside of these fluctuations, the catch record shows two remarkable events. First was the high annual catches at Colahan in 1972 and Hancock in 1973 with a decline and modest increase in effort, respectively. Also, the 1972 catch at Milwaukee showed a large increase compared with the 1971 catch in spite of a decrease in effort. The second event was the plummeting of catches starting in 1977 at Koko and Milwaukee despite increased effort and a subsequent depression in catches at all seamounts through 1981, regardless of changes in effort.

Figure 2. Morphological variation in specimens of pelagic armorhead, Pentaceros richardsoni. Upper specimen represents the lean type, middle specimen the intermediate type, and lower specimen the fat type.

Figure 3. Specimens of alfonsin, genus Beryx. Upper specimen is B. decadactylus and the lower specimen, B. splendens.



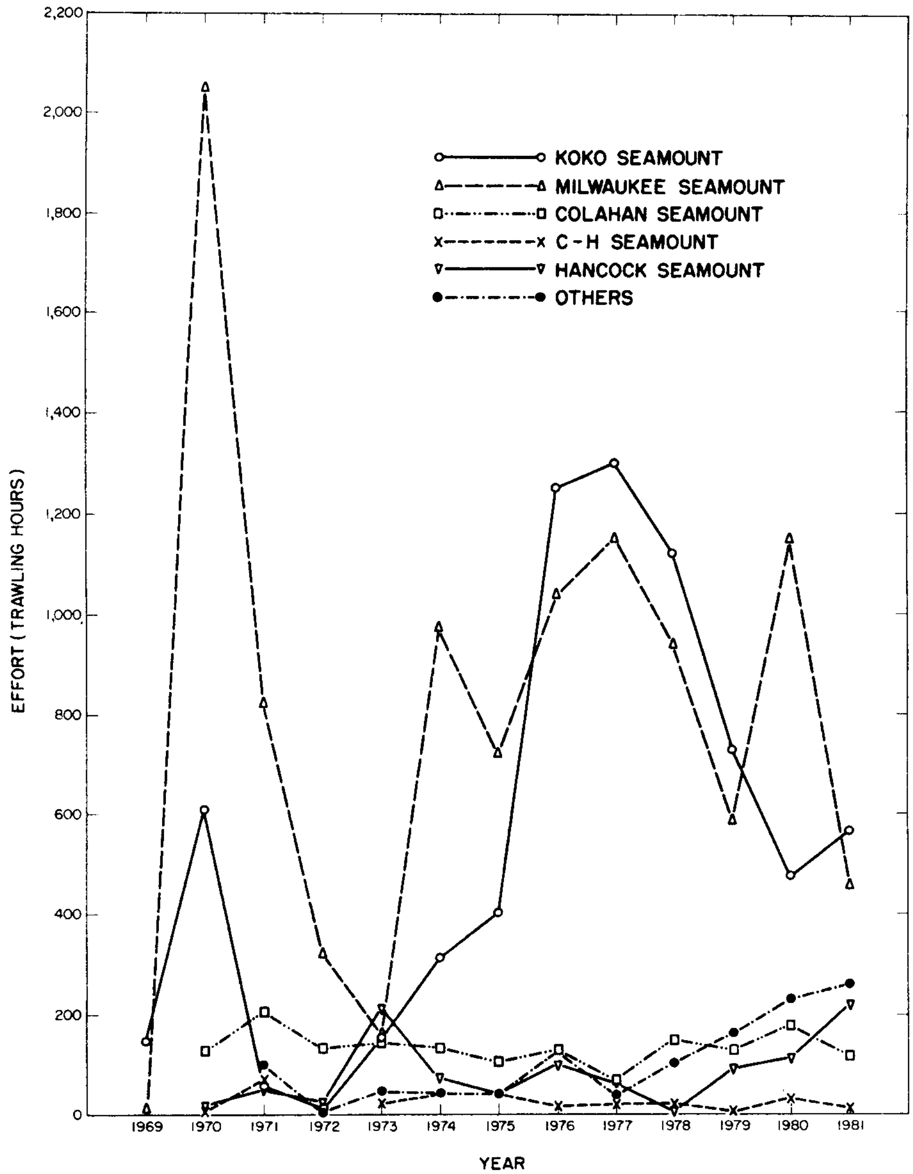


Figure 4. Yearly effort of Japanese trawl fishery for pelagic armorhead and alfonsin at six seamounts within the Emperor-Hawaiian Ridge

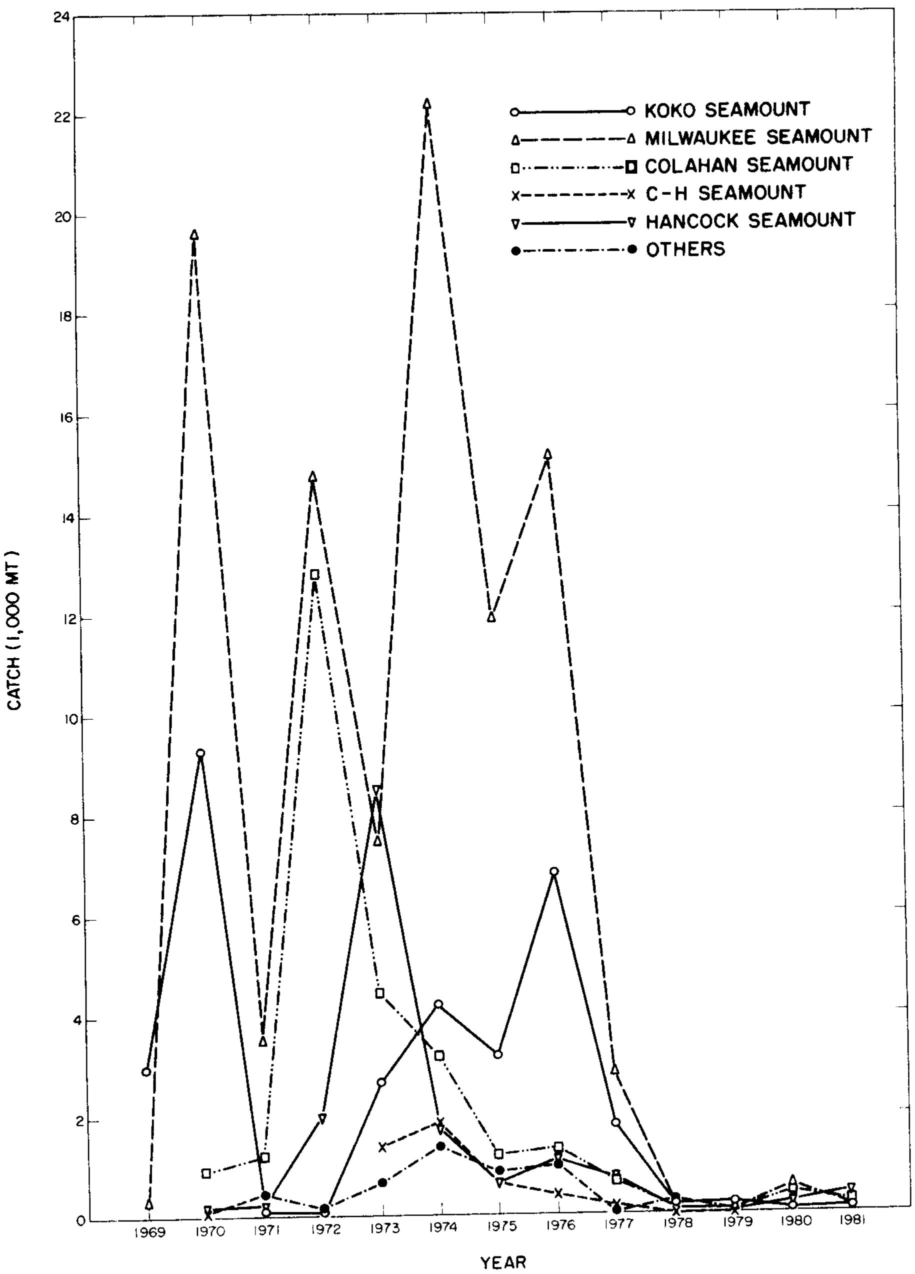


Figure 5. Yearly catch of pelagic armorhead taken by Japanese trawlers at six seamounts within the Emperor-Hawaiian Ridge

The annual Japanese catch per unit effort (CPUE) of pelagic armorhead during 1969-81 is shown in Figure 6. The depressed CPUE during 1969-71 is probably indicative of the exploratory nature of the fishery during this time. The CPUE for all seamounts rose during 1972-73, declined at most seamounts until 1978, and thereafter, remained at a low level through 1981. The general decline reflects the decline in catch over each seamount with the exception of Hancock in 1978 and C-H in 1981. The increased CPUE at Hancock in 1978 resulted from a 178-MT catch during 6 trawling hours in May. A 51-MT catch during 5 trawling hours in January and a 99-MT catch in 7 hours in February accounted for the increase at C-H in 1981. Also the peak CPUE at Hancock in 1972 resulted from a 1,870-MT catch in 24 trawling hours during July. All these CPUEs appear to represent fortuitous increases in pelagic armorhead availability over very short periods of time.

Figure 7 shows a plot of annual catch, effort, and CPUE of pelagic armorhead for all seamounts combined during 1969-81. Although CPUE steadily declined throughout 1973-79, catches were fairly steady during 1972-76 even if more effort was expended during 1974-76 than during the previous 2 years. Although only 5.7 percent (1,236 hours) of the total effort (21,625 hours throughout 1969-81) over all the seamounts was expended during 1972-73, the catch amounted to 29.8 percent (54,927 MT) of a total 184,109 MT harvested from all seamounts during 1969-81. In contrast, the total catch during 1977-81 was only 5.8 percent (10,679 MT) despite the fact that 48.5 percent (10,494 hours) of the total effort was expended.

The highest total catch of pelagic armorhead during 1969-81 occurred at Milwaukee (Figure 8). Milwaukee contributed 53.6 percent toward the total catch and also received the greatest effort (48.0 percent). Hancock contributed 8.7 percent toward the total catch with 4.7 percent of the total effort.

The second species of importance in the Japanese trawl fishery was alfonsin. The annual catches at each seamount, shown in Figure 9, were either small or incompletely reported during 1969-75. Since armorhead is the primary target species of the trawl fishery, catches of alfonsin, although important, are incidental. Apparently no alfonsin catch data were collected and/or published for 1974-75. From 1976 to 1981, all seamounts showed an overall catch increase with the exception of Hancock. Figure 10 also shows a similar trend in CPUE with the exception again at Hancock. These increases in alfonsin catch and CPUE closely coincide with the sharp decreases and sustained depression in catch and CPUE of pelagic armorhead.

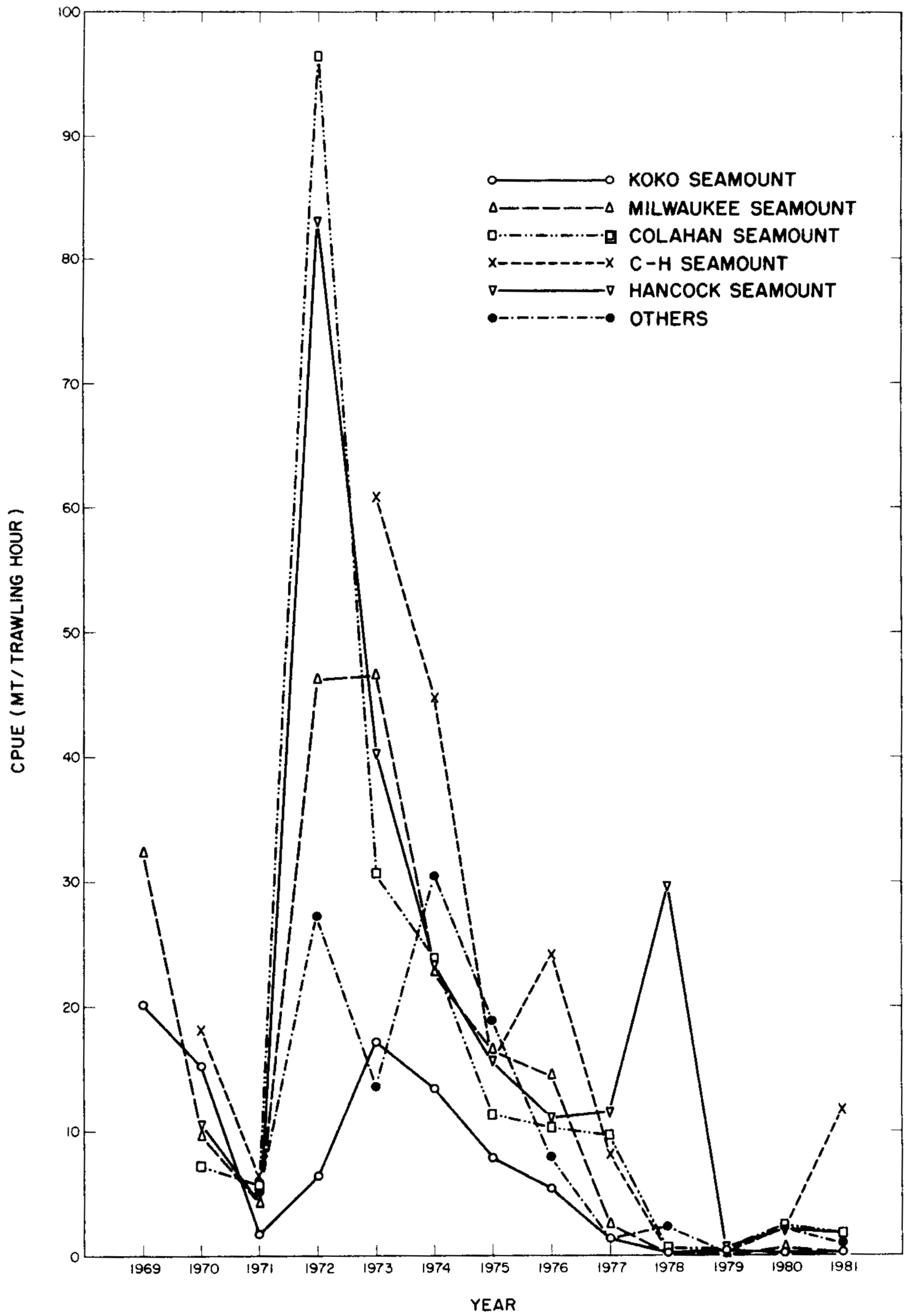


Figure 6. Yearly catch per unit effort of pelagic armorhead taken by Japanese trawlers at six seamounts within the Emperor-Hawaiian Ridge

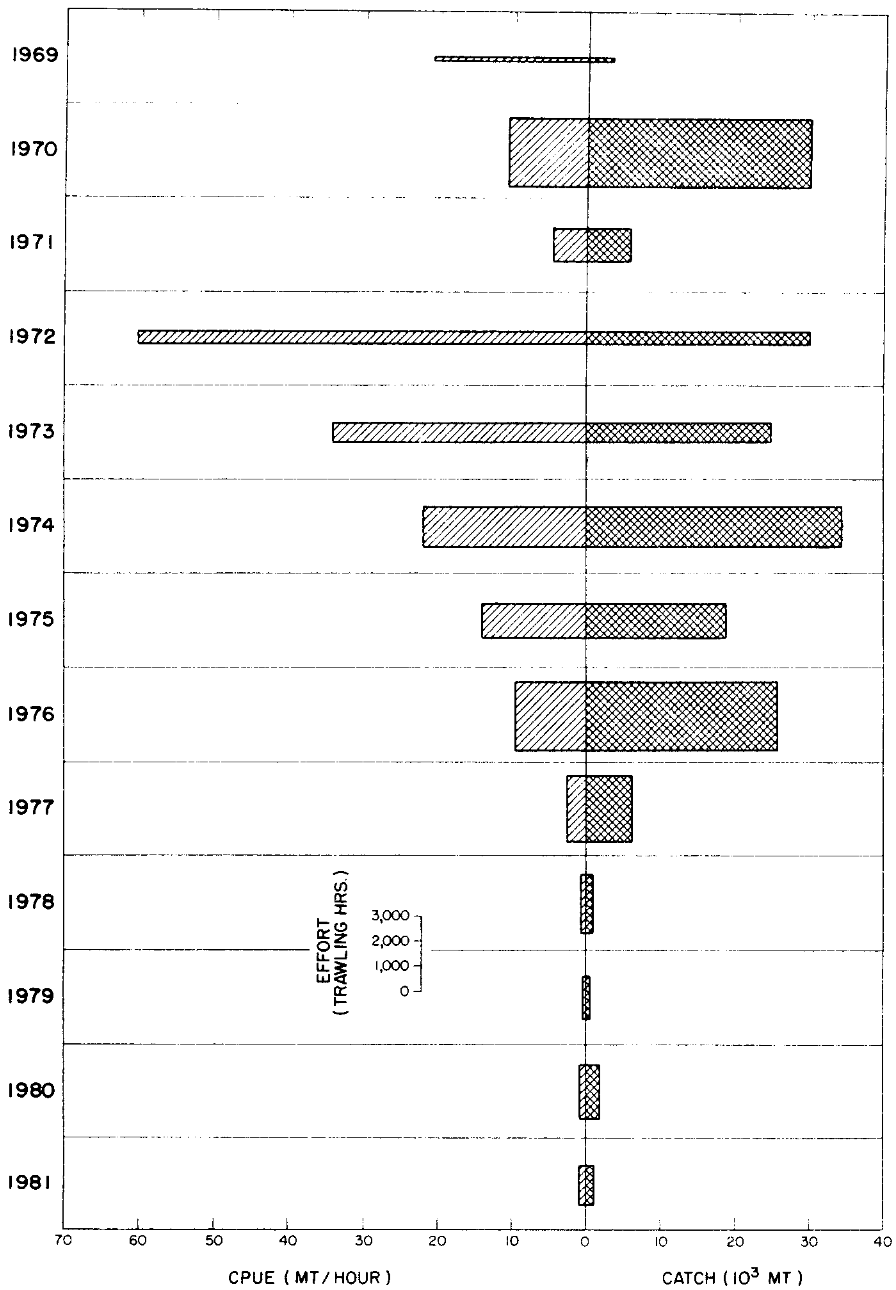


Figure 7. Three-way plot of yearly effort, catch, and catch per unit effort of pelagic armorhead from Japanese trawl fishery data; all seamounts combined

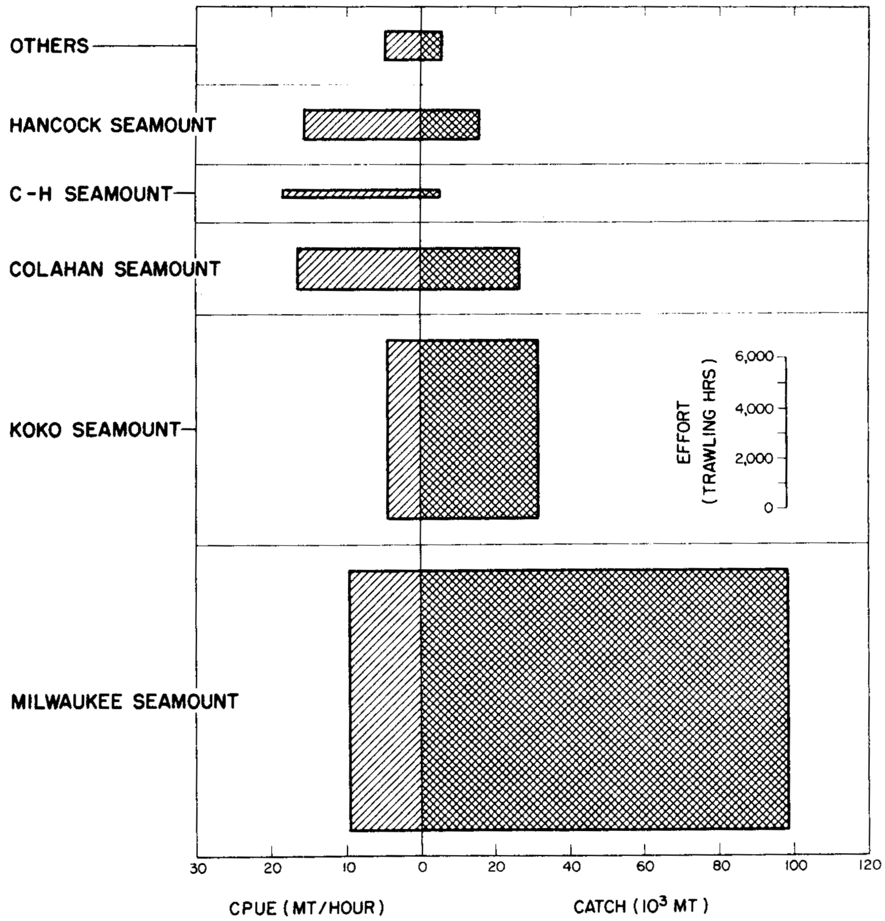


Figure 8. Three-way plot of effort, catch, and catch per unit effort of pelagic armorhead from Japanese trawl fishery data; years 1969-81 combined

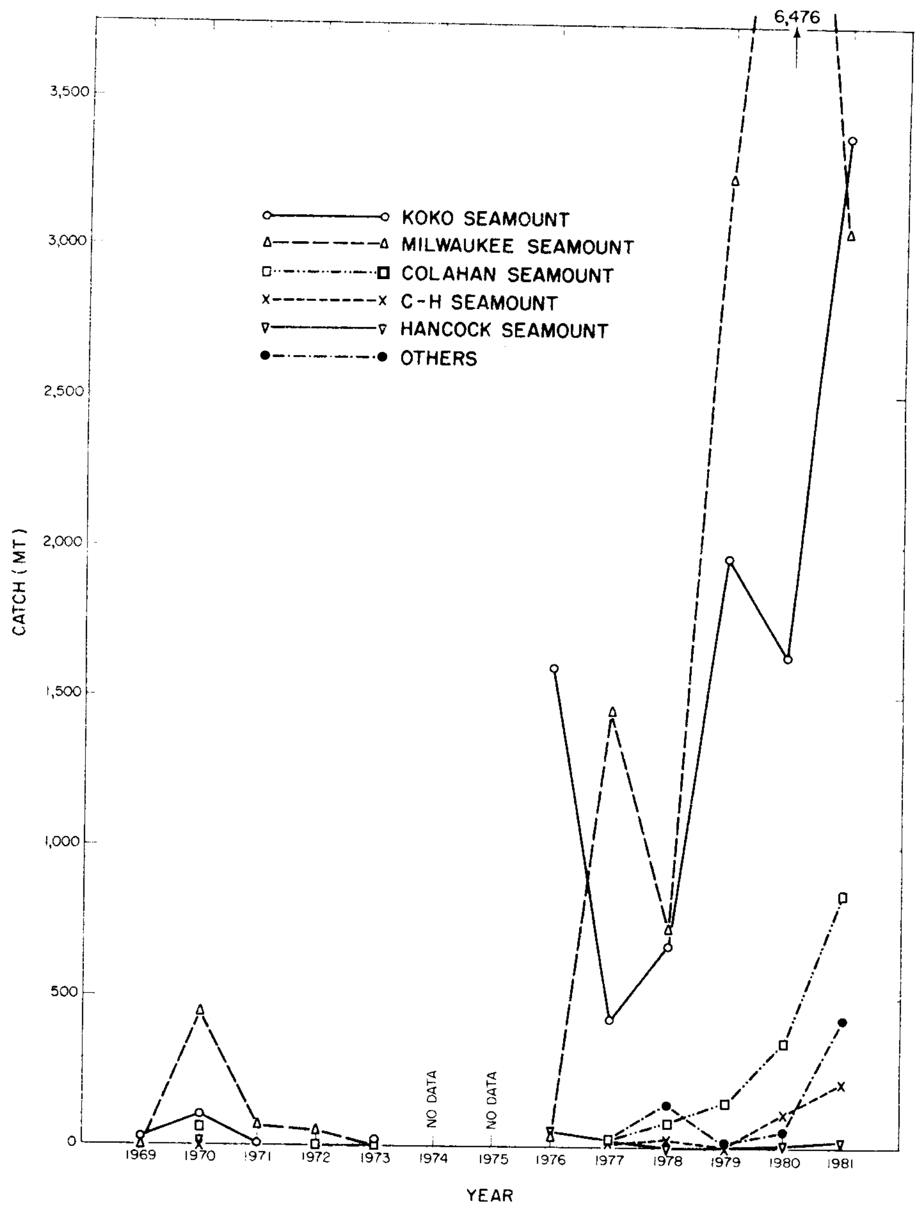


Figure 9. Yearly catch of alfonsin taken by Japanese trawlers at six seamounts within the Emperor-Hawaiian Ridge

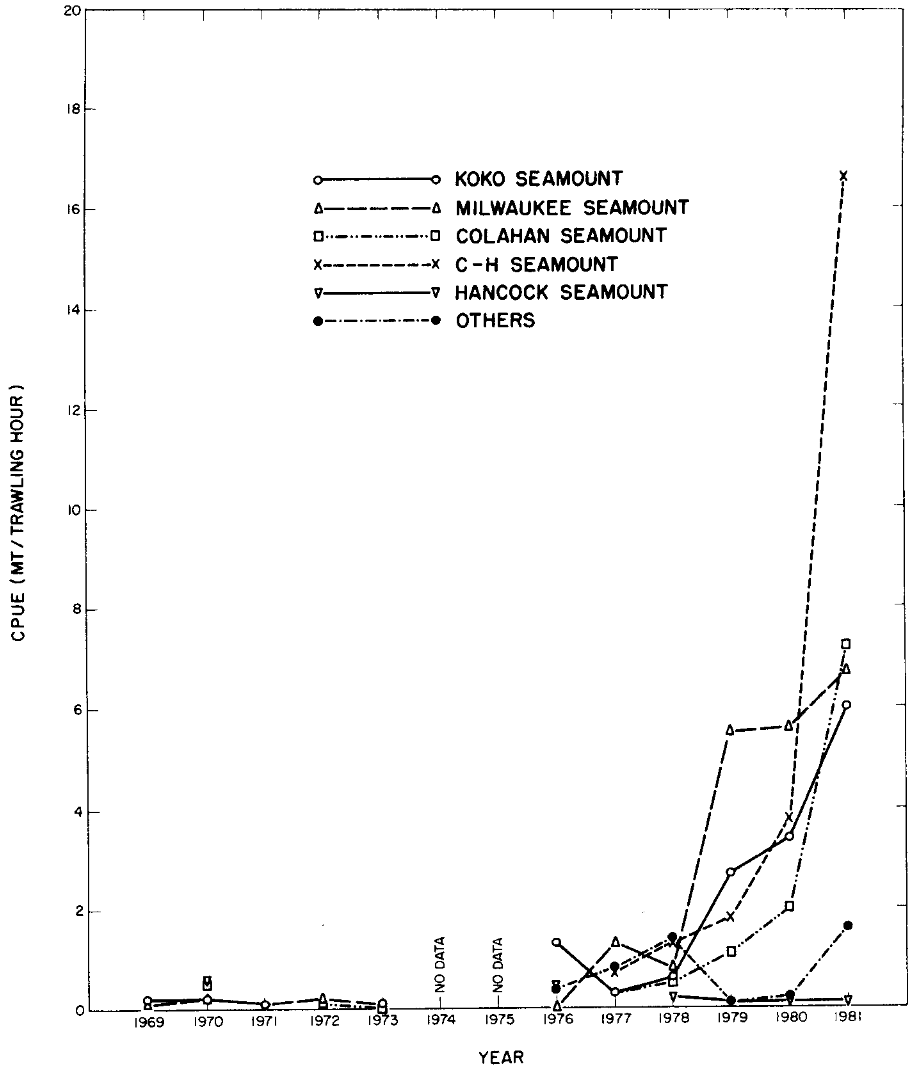


Figure 10. Yearly catch per unit effort of alfonsin taken by Japanese trawlers at six seamounts within the Emperor-Hawaiian Ridge

The largest catches of alfonsin were made during 1980-81, accounting for 59.0 percent (16,558 MT) of a total 28,063 MT reportedly harvested throughout 1969-81. During 1969-76 before pelagic armorhead catches dropped at all seamounts, its contribution to the total catch (only pelagic armorhead and alfonsin are considered here) was 98.6 percent (173,430 MT) and alfonsin 1.4 percent (2,532 MT). For 1977-81, when catches of pelagic armorhead remained low, it accounted for only 29.5 percent (10,679 MT) of the total catch while alfonsin rose to 70.5 percent (25,531 MT). The effort expended during the two periods was 11,131 trawling hours for 1969-76 and 10,494 trawling hours for 1977-81. In 1969-81, the largest amount of alfonsin was taken at Milwaukee, contributing 55.4 percent (15,534 MT) toward the total catch. The effort expended there was 48.0 percent (10,373 hours) of a total 21,625 hours for all seamounts.

Like the Soviets, the Japanese also observed diurnal fluctuations in the CPUE of pelagic armorhead. Results of trawl survey work at Kammu, Colahan, and Hancock showed two peaks in CPUE over a 24-hour day (Kitani and Iguchi, 1974). The CPUE generally peaked between 0300 to 0700 and 1600 to 1800 hours. With the possible exception of the exploratory phase, it is assumed that trawl hauls were mostly made at night.

The inclusion of Hancock within the 200-mile U.S. fishery conservation zone (FCZ) in March 1977 placed management of the fishery resources there under jurisdiction of the United States. Regulations were implemented and an annual catch quota for bottom trawling and bottom longlining of 2,000 MT and a limit on effort of 60 vessel-days were set. A license and complete catch reports for each trip are also required. Another requirement is the placement of a U.S. fishery observer onboard all vessels permitted to operate within the FCZ. This latter requirement allowed an onsite inspection of this fishery and the opportunity to independently gather catch data. Japan's total yearly catch quota for all species (except for nonretention ones) at Hancock was 1,000 MT. During 1978-82, nine Japanese trawlers operated under permit at Hancock, each with a U.S. observer onboard. In 1977, Japanese trawlers fished Hancock only during the period before its inclusion in the FCZ. The number of Japanese trawlers that fished at Hancock was one each in 1978 and 1979, two each in 1980 and 1981, and three during 1982.

The effort data collected by U.S. observers[1] at Hancock during 1978-82 are not in agreement with published Japanese data which apparently exclude effort and catch at SE Hancock during

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[1]U.S. foreign observer reports for Japanese permit trawling at Hancock Seamounts during 1978-82 are available from Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812. They include reports on the _Ryuyo Maru No. 2_, _Aso Maru_, _Kitakami Maru_, and _Takachiho Maru_.

1978-81, thereby explaining the higher effort and catches reported by U.S. observers (Figure 11). Since no independent estimates of catch and effort exist for earlier fishing conducted at Hancock, it is not known whether earlier data were also excluded for SE Hancock. In addition, the trawler fishing at Hancock in 1978 used a different measure of effort from the conventional one, i.e., elapsed time the trawl net was submerged. Effort was therefore roughly adjusted using data from a comparable-sized Japanese trawler. These discrepancies probably account for the differences in effort, catch, and CPUE at Hancock during 1978. The other discrepancies for 1979-81 may solely result from the exclusion by the Japanese of SE Hancock from the Hancock category. Despite these discrepancies, observer data collected during 1978-82 show a similar sustained trend of low pelagic armorhead catches.

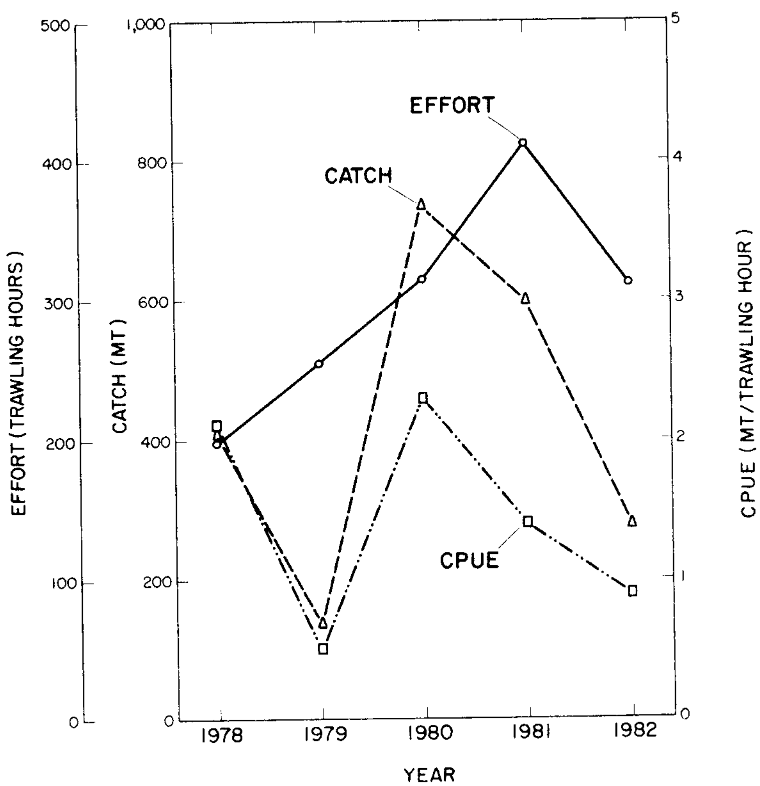

Figure 11. Yearly effort, catch, and catch per unit effort of pelagic armorhead taken by Japanese trawlers at Hancock Seamounts as determined by U.S. foreign observers

The observer data also show low alfonsin catches at Hancock during 1977-82, a trend apparent in earlier years (Figure 9) according to a report by Takahashi and Sasaki (1977). The 1982 observer data show a slight increase in catch and CPUE for alfonsin with less effort than that made in 1981 (Figure 12).

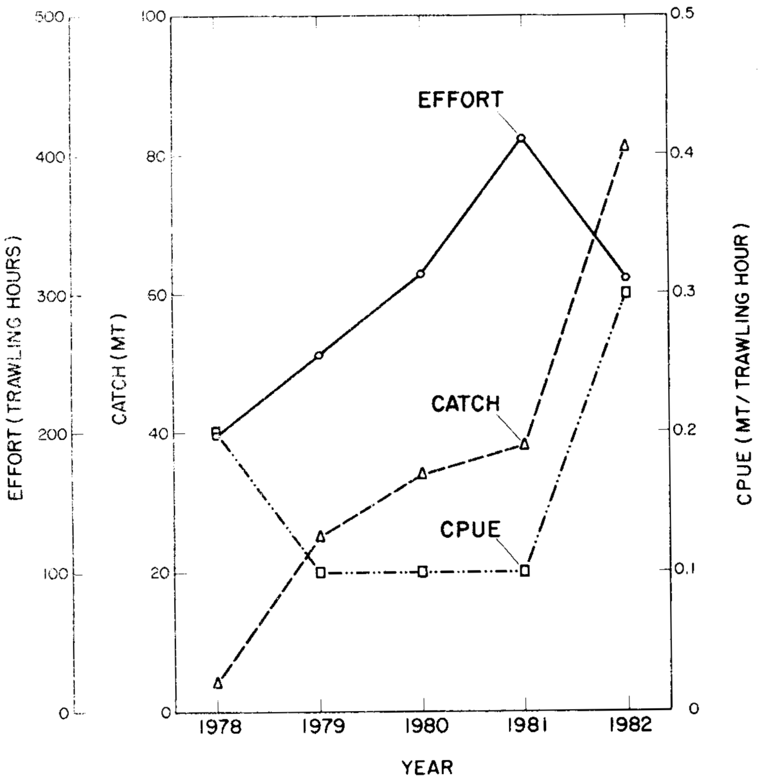

Figure 12. Yearly effort, catch, and catch per unit effort of alfonsin taken by Japanese trawlers at Hancock Seamounts as determined by U.S. foreign observers

Since 1976, the Southwest Fisheries Center Honolulu Laboratory of the National Marine Fisheries Service (NMFS) has made several very limited surveys of the fishery resources of the Emperor-Hawaiian Ridge seamounts as an adjunct to the tripartite and Sea Grant investigations of the Northwestern Hawaiian Islands (NWHI). Most of the effort was concentrated at Hancock. Because of differences in gear and technique, and the small amount of trawling effort, data from NMFS surveys are not directly comparable with the Japanese data. The NMFS surveys, however, were important as initial exploratory work and as a means for determining species composition of the seamount community and collecting samples for life history studies.

Besides trawling, NMFS investigated the Hancock summits with bottom handlines and traps. Bottomfishing was conducted primarily with 10-hook and 20-hook handline rigs powered by hydraulic gurdies. Catches consisted primarily of pelagic armorhead and spiny dogfish, Squalus sp. At Koko, the handline catch consisted solely of the rockfish, Helicolenus avius. Trapping was also conducted at Hancock using a variety of fish traps. Catches were dominated by Squalus sp. and pelagic armorhead was rare. Although catches of Squalus sp. were relatively high from handline and trap fishing, they were incidental in the trawl catches.

OTHER SEAMOUNT FISHERIES

Bottom longlining

Although emphasis has been on trawl fishing, other fisheries operate on and around the seamounts. In 1972-73, a bottom longline fishery which primarily targeted alfonsin was initiated at Milwaukee. Other species caught in this fishery are Hyperoglyphe japonica, Erilepus zonifer, Helicolenus avius, and Sebastes spp. (Sasaki, 1978). The gear is used to fish the summit and slopes and can be set in areas inaccessible to trawlers. I.I. Ikehara (1976: personal communication) reported that bottom longlining at Koko yielded an unspecified quantity of E. zonifer at depths of 800 to 900 m. However, no catch and effort data on the seamount bottom longline fishery are available. An interview with one of the fishing masters revealed that catches of alfonsin and Sebastes spp. were declining by 1976 and fewer Japanese vessels were fishing the area (Suisan Sekai, 1976). The fishing master also stated that a number of Korean vessels were involved in this fishery.

Gill netting

It was reported that 79 Taiwan gill net vessels began fishing in 1981 for the squid, Ommatrephes bartramii (Suisan Sekai, 1981). Fishing was conducted in the area of the Emperor Seamounts. However, since no specific locations were given it is unknown whether this fishery included the southern Emperor Seamounts. These vessels were reportedly catching 3 to 6 MT per day. Approximately 200 Japanese squid jigging vessels and 200 gill net vessels were also operating on the Emperor Seamounts.

Other Taiwan vessels were reported to be fishing for saury, Cololabis saira, in the same area. It was reported that larval and juvenile saury are abundant in waters around the SE-NHR (Selitskaya, 1972).

Coral dragging

The first fishery resource to be discovered on the SE-NHR seamounts occurred in 1965 when Japanese fishermen found extensive beds of pink coral at Milwaukee. H. Ozawa (1970: personal communication) revealed that 113 MT of pink coral was harvested at Milwaukee in 1969 by Japanese fishermen. The harvesting method employed in this fishery involves the dragging of a weighted object across the bottom. Tangle nets attached to the weight collect the pieces of dislodged coral. This fishery apparently targets two species of pink coral: *Corallium secundum*, present at depths of 275 to 458 m, and *Corallium* sp. nov., found between 915 and 1,281 m.

Precious coral resources are present at seamount 10 (Grigg, 1974) and at Hancock although precious corals at the latter have apparently been harvested by foreign fishermen prior to 1977. With the advent of the 200-mile U.S. FCZ, foreign harvesting of precious corals and their retention through incidental catches by foreign trawlers or longliners, under permit to fish Hancock, are prohibited. However, R.W. Grigg (1983: personal communication) has found that 20 MT of precious corals were illegally harvested within the FCZ by foreign fishermen during 1980-82. During this time, about 600 MT of precious corals were harvested throughout the Emperor Seamounts by Japan and Taiwan. Reports from U.S. foreign observers[2] indicate few incidental trawl catches of precious corals occur at Hancock; all such catches are not retained.

ICHTHYOFAUNA OF THE SEAMOUNTS

During the early 1970s, Japanese efforts to expand the trawl fishery for pelagic armorhead extended to various seamounts located throughout the NWHI. Survey results showed a distinct change in the ichthyofauna at the seamounts located southeast of Hancock. The commercial and incidental species of the SE-NHR seamounts were absent from the predominantly subtropical ichthyofauna on the southern seamounts (Ladd, Nero, and seamounts 8 to 11). These results indicated a sharp demarcation of the ichthyofauna coinciding with the 180th meridian (Iguchi, 1973; Japan Marine Fishery Resource Research Center, 1973; Japan Fisheries Agency, 1974). Seamount survey data collected by NMFS, plus published information (Barsukov, 1973; Barsukov and Fedorov, 1975; Katayama, 1975; Chen, 1980: Nakaya et al., 1980; Kanayama, 1981; Borets, 1982; Dolganov, 1982; Parin and Mikhailin, 1982; Nakabo et al., 1983; Yabe, 1983) and a personal communication (I.I. Ikehara, 1976) have provided new records of the distribution of species (Table 1). The few species reported from Colahan and seamounts 10 and 11 reflect the small effort expended there. No data on C-H seamount are available.

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[2]See footnote 1

TABLE 1. DISTRIBUTION OF FISH SPECIES BY SEAMOUNT

Species	Family	KS	MS	CS	HS	SS	LS	NS	S9	S8
Neoscopelus microchir	Myctophidae	x								
Beryx splendens	Berycidae	x	x	x	x					
Beryx decadactylus	Berycidae	x	x	x	x					
Gephroberyx japonicus	Trachichthyidae	x	x		x					
Diretmus argenteus	Diretmidae	x								
Zenopsis nebulosa	Zeidae	x	x	x	x					
Psenopsis anomala	Centrolophidae	x								
Epigonus atherinoides	Apogonidae	x	x							
Sebastes flammeus	Scorpaenidae	x	x							
Podonema longipes	Moridae	x								
Macrorhamphosus scolopax	Macrorhamphosidae		x	x	x					
Ariomma lurida	Nomeidae				x					
Antigonia rubescens	Antigoniidae		x		x					
Helicolenus avius	Scorpaenidae	x	x							
Halargyreus sp.	Moridae		x							
Lophiodes miacanthus	Lophiidae		x	x	x					
Scomber japonicus	Scombridae				x					
Chascanopsetta prorigera	Bothidae		x		x					
Lotella maximowiczi	Moridae		x							
Erythrocles scintillans	Emmelichthyidae				x					
Dalatias licha	Squalidae		x							
Nansenia ardesiaca	Bathylagidae		x							
Gonostoma elongatum	Gonostomatidae		x							
Maurolicus muelleri	Gonostomatidae		x							
Astronesthes ijiami	Astronesthidae		x							
Chauliodus sloani	Chauliodontidae		x							
Chlorophthalmus albatrossis	Chlorophthalmidae		x							
Coelorhynchus sp.	Macrouridae		x							
Trachipterus iris	Trachipteridae		x							
Malthopsis tiarelle	Ogcocephalidae		x							
Chaunax fimbriatus	Chaunacidae		x							
Parabothus coarctatus	Bothidae		x		x					
Microstomus pacificus	Pleuronectidae		x							
Bembradium roseum	Platycephalidae		x							
Foetorepus kamuensis	Callionymidae		x							
Peristedion engyceros	Peristediidae		x		x					
Lepidopus calcar	Trichiuridae		x							
Benthodesmus tenuis	Trichiuridae		x							
Anthias rubromaculatus	Serranidae		x							
Chimaera owstoni	Chimaeridae	x								
Helicolenus sp.	Scorpaenidae	x								
Hozukius guyotensis	Scorpaenidae	x	x							
Adelosebastes latens	Scorpaenidae	x								
Caprodon unicolor	Serranidae					x				
Lepidion inosimae	Moridae	x								
Lepidion schmidti	Moridae	x								
Marukawichthys pacificus	Ereuniidae	x								
Pentaceros japonicus	Pentacerotidae		x							
Plectranthias kelloggi	Serranidae		x		x					
Grammatonotus laysanus	Serranidae		x		x					
Bembrops filifera	Bembropsidae		x							
Rhynchocymba nystromi nystromi	Congridae				x					
Symphysanodon typus	Lutjanidae				x					
Antigonia steindachneri	Antigoniidae				x					
Emmelichthys struhsakeri	Emmelichthyidae				x					
Neopercis roseoviridis	Mugiloididae				x					

TABLE 1. DISTRIBUTION OF FISH SPECIES BY SEAMOUNT (continued)

Species	Family	KS	MS	CS	HS	SS	LS	NS	S9	S8
Etmopterus pusillus	Squalidae				x					
Isistius brasiliensis	Squalidae				x					
Argyropelecus aculeatus	Sternoptychidae				x					
Symphysanodon maunaloae	Lutjanidae				x					
Astronesthes lucifer	Astronesthidae				x					
Arnoglossus debilis	Bothidae				x					
Ruvettus pretiosus	Gempylidae				x					
Argyripnus atlanticus	Gonostomatidae				x					
Hoplichthys sp.	Hoplichthyidae				x					
Physiculus edelmanni	Moridae				x					
Myctophum nitidulum	Myctophidae				x					
Diaphus trachops	Myctophidae				x					
Parapercis multifaciata	Mugiloididae				x					
Tosanoides filamentosus	Serranidae				x					
Meadia abyssalis	Synaphobranchidae				x					
Glossanodon struhsakeri	Argentinidae				x					
Dasyatis matsubarai	Dasyatidae				x					
Echinorhinus cookei	Squalidae		x							
Paratrachichthys sp.	Trachichthyidae		x							
Etmopterus villosus	Squalidae				x					
Helicolenus fedorovi	Scorpaenidae	x								
Lepidopus lex	Trichiuridae		x							
Laemonema rhodochir	Moridae				x					
Stethopristes eos	Zeidae				x					
Hoplostethus mediterraneus	Trachichthyidae				x					
Prionace glauca	Carcharhinidae				x					
Hexanchus griseus	Hexanchidae				x					
Chlorophthalmus oblongus	Chlorophthalmidae				x					
Hollardia goslinei	Triacanthidae				x					
Brama orcini	Bramidae				x					
Alopias sp.	Alopiidae				x					
Erilepis zonifer	Anoplopomatidae	x								
Centroscyllium nigrum	Squalidae				x					
Decapterus tabl	Carangidae				x		x			
Hyperoglyphe japonica	Centrolophidae	x	x	x	x		x			
Cookeola boops	Priacanthidae				x	x	x	x		x
Antigonia eos	Antigoniidae	x	x	x	x	x				
Physiculus grinelli	Moridae				x		x	x		
Squalus sp.	Squalidae	x	x		x	x	x	x		
Promethichthys prometheus	Gempylidae				x		x	x		
Pentaceros richardsoni	Pentacerotidae	x	x	x	x		x			
Polymixia berndti	Polymixiidae	x	x		x			x		
Fistularia villosa	Fistulariidae						x			
Velifer multispinosus	Veliferidae						x			
Decapterus sp. (not *tabl*)	Carangidae						x			
Pseudocaranx dentex	Carangidae						x	x	x	
Seriola aureovittata	Carangidae						x		x	
Upeneus sp.	Mullidae						x			x
Pseudupeneus sp.	Mullidae									x
Bleekeria sp.	Ammodytidae						x			
Carapus sp.	Carapidae									x
Chaetodon miliaris	Chaetodontidae						x			x
Chaetodon fremblii	Chaetodontidae						x			x
Lactoria sp.	Ostraciontidae						x			
Canthigaster cinctus	Canthigasteridae									x
Amanses sp.	Balistidae						x			

TABLE 1. DISTRIBUTION OF FISH SPECIES BY SEAMOUNT (continued)

Species	Family	KS	MS	CS	HS	SS	LS	NS	S9	S8
Pristipomoides filamentosus	Lutjanidae							x	x	x
Caranx delicatissimus	Carangidae									x
Naso unicornis	Acanthuridae									x
Priacanthus meeki	Priacanthidae					x				
Caprodon schlegelii	Serranidae					x				
Dendrochirus barberi	Scorpaenidae									x
Cheilodactylus vittatus	Cheilodactylidae									x
Congrina aequoria	Congridae						x			
Ariosoma marginatum	Congridae						x			
Etelis carbunculus	Lutjanidae						x	x	x	x
Gymnothorax steindachneri	Muraenidae						x	x		
Gymnothorax berndti	Muraenidae						x			
Epinephelus quernus	Serranidae					x	x	x	x	x
Seriola dumerili	Carangidae							x	x	x
Gymnothorax undulatus	Muraenidae							x		
Conger oligoporus	Congridae					x				
Caranx ignoblis	Carangidae									x
Pristipomoides zonatus	Lutjanidae								x	x
Pristipomoides sieboldii	Lutjanidae						x	x	x	
Etelis coruscans	Lutjanidae						x		x	
Pontinus macrocephalus	Scorpaenidae						x	x	x	
Sphoeroides cutaneus	Tetraodontidae						x			
Bodianus vulpinus	Labridae							x		

Note: KS = Koko Seamount; MS = Milwaukee Seamount Group; CS = Colahan Seamount; HS = Hancock Seamounts; SS = Seamounts 10 and 11; LS = Ladd Seamount; NS = Nero Seamounts; S9 = Seamount 9; S8 = Seamount 8

Most fishes occurring on the summit of northern seamounts are deep-water, benthic-demersal forms. The predominance of these types is hardly surprising since the collections were derived almost solely from bottom trawls. Some mesopelagic types were also collected, although it is uncertain whether these species were collected in the water column above the seamount or represent mesopelagic species which exhibit more demersal affinities. Most fishes collected from the northern seamounts were small and of no commercial value. Of the 80 fish species found only among the northern seamounts, more than 50 percent are known to occur elsewhere within the Hawaiian archipelago. Table 1 also shows that 9 of the 90 species found at the northern seamounts are distributed beyond the 180th meridian. Most of the transitional species occurred at Ladd and Nero Seamounts. Two of them, *Hyperoglyphe japonica* and pelagic armorhead, have distributions centered in the northern seamounts. Only one specimen of *H. japonica* and two of pelagic armorhead were taken within the southern seamounts. The remaining seven transitional species are known from elsewhere in the Hawaiian archipelago.

Apart from the transitional species, subtropical reef fishes and members of the commercially important snapper-grouper complex characterize the ichthyofauna of the southern seamounts. Seamounts 10 and 11 may be exceptions. Although these new results confirm a distinct ichthyofaunal change near the 180th meridian, the ichthyofauna of Ladd and Nero (and probably seamounts 10 and 11) may be of a more transitional nature than originally thought. Since most of the fishes inhabiting the northern seamounts occur elsewhere in the deeper waters of the Hawaiian Archipelago, the shallower summits and warmer temperatures characteristic of southern seamounts apparently offer an unsuitable habitat for these species.

LIFE HISTORY OF TARGET SPECIES

Pelagic armorhead

Distributional information on the smallest reported sizes of pelagic armorhead came from results of Soviet ichthyoplankton surveys over the SE-NHR seamounts in 1969 and 1976 (Borets, 1979). These specimens ranged from 5 to 20 mm long and occurred more frequently south of 33°N. The egg, larval, and juvenile stages inhabit the surface layers and their distribution is subject to the meanderings of the surface currents (Borets, 1979). The first report of a juvenile was a 35-mm specimen collected off Cape Horn, South America and was initially given the name Pentaceros kneri by Steindachner in 1866 (Smith, 1964). Since then, juveniles have been collected off New Zealand (Smith, 1964), from south of the Aleutian Islands (Honma and Mizusawa, 1969; Randall, 1980), and off Gough Island in the southeast Atlantic (Borets, 1980).

Pelagic armorhead was first described in 1844 from a 530-mm adult specimen taken in deep water off Cape Point, South Africa (Smith, 1964). Adults are known elsewhere in the southeast Atlantic from Valdivian Seamount in the Walvis Ridge area (Borets, 1980). In the Pacific, adults are known from both hemispheres. Besides the large population inhabiting the SE-NHR seamounts, adults also occur at Mellish Bank (Takahashi and Sasaki, 1977) and at Ladd Seamount and Kure Atoll (from a single specimen collected at each) (Randall, 1980). In Japanese waters, adults occur around the Boso Peninsula (Abe, 1957) and off Hachijo Island and the Ogasawara Islands (Abe, 1969; Zama et al., 1977b). A few adult specimens have also been collected in waters along western North America from British Columbia (Welander et al., 1957; Clemens and Wilby, 1961; Hart, 1973), Oregon (Wagner and Bond, 1961), and California (Follett and Dempster, 1963; Smith, 1965). Adults and juveniles also inhabit waters south of the Aleutian Islands and around the Gulf of Alaska in the northeast Pacific (Welander et al., 1957; Chikuni, 1970). In the South Pacific, the Soviets collected five adult specimens from one of the seamounts located on the Sala y Gomez Ridge in the vicinity of Easter Island (Borets, 1980). The Japanese obtained three large adults off the east coast of Australia at Derwent Hunter Seamount.

Apparently, pelagic armorhead in the Pacific have an antitropical distribution. The lowest latitudinal records are at Kure Atoll (lat. 28°30.82'N, long. 178°20.86'W) in the North Pacific (Randall, 1980) and Sala y Gomez Ridge (lat. 24°57'S, long. 97°41'W) in the South Pacfic (Borets, 1980). A preliminary effort to locate pelagic armorhead in the Hawaiian islands (lat. 20° to 22°N) was unsuccessful (Okamoto, 1982). Borets (1980) recognized two distributional centers of reproductive adults: the SE-NHR seamounts and Walvis Ridge. Aside from these areas, "good" fishing grounds were reported near Hachijo Island (Abe, 1969). A number of pelagic armorhead have also been caught in oceanic waters of the northeastern Pacific by Japanese whaling ships. These fish were taken by night handlining at the surface under ship's lights. They have also been found in the stomachs of sei whales captured from this area (Chikuni, 1970; Sasaki, 1974). The presence of large numbers of pelagic armorhead in sei whale stomachs infers an epipelagic existence in these waters since these whales are known to preferentially feed on surface-dwelling fish (Chikuni, 1970).

Pelagic armorhead in the northeast Pacific are known only from surface or nearsurface waters during June-September (Welander et al., 1957; Honma and Mizusawa, 1969; Chikuni, 1970; Randall, 1980). Pelagic armorhead school in the surface waters of the northeast Pacific during daylight and nondaylight hours. Among the SE-NHR seamounts, pelagic armorhead are commercially taken from depths of 200 to 490 m (Takahashi and Sasaki, 1977). Aggregations of pelagic armorhead have been recorded on the slopes of seamounts at the 800- to 900-m depth (Sakiura, 1972; Borets, 1980). Chikuni (1970, 1971) suggested that the horizontal and vertical distribution of pelagic armorhead is correlated with a certain temperature range. He surmised that the absence of pelagic armorhead during northeast Pacific winters indicated a lower tolerance limit of 5°C, and that their year-round occurrence on the SE-NHR seamounts and during summer in the northeast Pacific suggested an upper limit of 15° to 20°C. Chikuni suggested a preferred range of 8°to 15°C and reasoned that their absence on the Emperor Seamounts north of Koko (depths of 1,000 m or more) and on Hawaiian Ridge seamounts east of the 180th meridian (shallow summits) was due to intolerably low and high temperatures, respectively.

As stated earlier, the catches of pelagic armorhead vary diurnally on the seamounts. The Soviets report that this is due to a vertical migration upwards from the summit as daylight approaches and a descent to the summit at dusk. The fish remain on the summit during darkness and in the upper water layers (80- to 100-m depth) during daylight (Sakiura, 1972). Barnett[3] reported a correlation between poor night catches and shipboard

[3]See footnote 1, specifically W.B. Barnett, 1981, Southwest Fisheries Center Administrative Report H-81-9.

fish finders showing concentrations of fish (presumed to be pelagic armorhead) at levels either above or beyond the summit. A variation of the hypothesis reported by Sakiura was proposed by Kitani and Iguchi (1974). They agreed that the fish rise off the summit during daylight, but they also maintain that the fish descend past the summit during the night. Consequently, it was felt these fish pass through the summit level twice during the night: once after dusk and again before dawn. Both Soviet and Japanese investigators suggest that these vertical movements are related to the foraging activity of pelagic armorhead. Soviet results (Sakiura, 1972) indicate that pelagic armorhead preferentially feed during daylight, especially between 0800 and 1000, and feed little or not at all during the night. The findings of Kitani and Iguchi (1974) are contrary to Soviet results since they found a higher proportion of stomachs with food between midnight and dawn. However, field observations by U.S. foreign observers[4] indicate that feeding takes place only during daylight, primarily in the morning and late afternoon.

The Soviets report that surface-dwelling crustaceans are important prey items of pelagic armorhead (Sakiura, 1972). A portion of the diet consists of deep-scattering layer organisms (Sasaki, 1974). Prey items are primarily amphipods, copepods, pteropods, euphausiids, sergestids, macrura, tunicates, and myctophids. Borets (1979) reported that juveniles feed on smaller plankters, particularly copepods, whereas adults prey chiefly on tunicates, euphausiids, and mesopelagic fishes. Stomach contents examined during a Japanese survey cruise consisted of copepods, krill, mysids, myctophids, and other mesopelagic fishes (Japan Fisheries Agency, 1974). Chen (1980) found two species of red deepsea shrimp to be the principal prey of pelagic armorhead taken at Kammu. The U.S. foreign observers[5] identified amphipods, copepods, euphausiids, salps, shrimps, myctophids, and other small fishes as principal prey items.

The spawning season of pelagic armorhead at the SE-NHR seamounts has been determined from several sources (Japan Fisheries Agency, 1974; Sasaki, 1974; Bilim et al., 1978; Borets, 1979) to extend from December to March. Spawning peaks during January-February. The proportion of spent individuals increases from February to March although some ovaries were found in a pre-spawning condition in March (Sasaki, 1974). The U.S. foreign observers[6] found most females in an early developing stage during April-June whereas Chen (1980) found well-developed ovaries in

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[4]See footnote 1, specifically T.K. Kazama, 1978, Southwest Fisheries Center Administrative Report 15H, 1978 and W.B. Barnett, 1982, Southwest Fisheries Center Administrative Report H-82-21.
[5]See footnote 1
[6]See footnote 1, specifically T.K. Kazama, 1978, Southwest Fisheries Center Administrative Report 15H, 1978 and W.B. Barnett, 1982, Southwest Fisheries Center Administrative Report H-82-12.

May. Soviet investigators found ovaries in an early developmental stage in summer and fall; moderate development began in September (Sakiura, 1972). Pre-spawning conditions were present among some females in mid-November (Bilim et al., 1978). No eggs were collected in plankton tows over the seamounts during spring; however, large numbers of juveniles were reported in March-April (Sakiura, 1972; Sasaki, 1974).

Fecundity estimates for 30-cm females of pelagic armorhead from three SE-NHR seamounts ranged from 99,000 to 110,000 eggs (Borets, 1979). Studies by Bilim et al. (1978) indicate that during spawning, eggs are released in four to six batches. Chikuni (1970) reported that 6-year-old fish are sexually mature and suggested that first maturity occurs at an earlier age. Age estimates of 3 years for 22-cm fork length (FL) and 6 years for 32-cm FL fish were determined by annular ring counts on scales. Chikuni estimated the age groups of pelagic armorhead taken in the trawl fishery (mean FL of 30.0 cm) are 5 to 7 years old. Results of spectrophotometric analysis on scales by Vasil'kov and Borets (1978) and information reported by Borets (1979) indicate ages of 6 to 8 years for 26- to 30-cm fish.

A growth of 7.5 cm in 3 years (from an initial length of 25.4 cm) was reported by Hart (1973) for a pelagic armorhead held in captivity at Vancouver Aquarium, British Columbia. However, yearly increment growth data indicate that a growth of 7.5 cm in the wild (from a similar initial length) requires more than 4 years (Borets, 1979). Borets showed a 7.5 to 7.7 cm growth from age 0 to 1 and growth between subsequent year classes decreasing to 1.0 to 1.4 cm from age 9 to age 10. At present, NMFS is conducting an otolith analysis to determine age and growth.

A perplexing aspect of pelagic armorhead biology is the presence of morphological variants among adults on the SE-NHR seamounts (Figure 2). A number of reports (Japan Fisheries Agency, 1974, Sasaki, 1974; Takahashi and Sasaki, 1977; Chen, 1980) have commented on this variation and recognized two or three types. Observations by NMFS personnel on Townsend Cromwell research cruises and on foreign vessels indicate three types of pelagic armorhead based on body depth and color. The "lean" type is more elongate and is brown to brownish-gray. The "fat" type has a relatively greater body depth, somewhat "square-shaped," with a bluish dorsal region and a white ventral region. An "intermediate" type has a body depth in-between the other types and a lean type coloration. It has also been noted by NMFS researchers and Takahashi and Sasaki (1977) that certain lean types captured at Hancock appear rather emaciated, with skin that is easily ruptured. Gonads are poorly developed in these fish and the viscera discolored. All of these apparent abnormalities indicate an unhealthy condition. These fish also lack fat deposits in the visceral cavity and other lean fish had limited amounts. Fat types and intermediate types to a lesser degree have large fat deposits in the visceral cavity.

All three types of pelagic armorhead are found within the SE-NHR seamounts although lean and intermediate types predominate in the catches. The fat types are relatively rare in the trawl catches on the seamounts. However, only the fat types have been found in the northeast Pacific. The distribution and coloration of fat types suggest a primarily epipelagic existence.

The variability in body type of adult pelagic armorhead is apparently absent in the juveniles. Photographs of juveniles appearing in Smith (1964) and Honma and Mizusawa (1969) show them to be relatively deep bodied with a mottled coloration, primarily in the dorsal region. Juveniles of a congeneric, P. japonicus, show similar coloration during the epipelagic phase. This coloration eventually disappears when juveniles shift to a deeper demersal existence (Zama et al,, 1977a).

To better define the nature and significance of the variations between types, a preliminary morphometric and meristic study was begun at NMFS. A breakdown of the sample size according to seamount, sex, and type appears in Table 2. The morphometrics and meristics of specimens by seamount, sex, and type are shown in Table 3. The means were analyzed within each of the three sources (plus their four possible combinations) using a three-way univariate ANOVA (Statistical Analysis System, 1979) (Table 4).

Highly significant differences within sex and type occur among all morphometric variables measured. However, there is also a significant sex-type interaction which probably influenced the results within each of the two previous sources. The sample sizes shown in Table 2 indicate that the lean sample was dominated by males, whereas in the intermediate sample, females predominated. Sex-type differences in body length may also have influenced the results. Maximum body depth is plotted against standard length by sex in Figure 13 and by body type in Figure 14. Aside from the sex and type variation in body depth, these plots also indicate that the males and lean types were smaller compared with females and intermediate types. Whether these tendencies within the sample accurately reflect the seamount population of pelagic armorhead is unknown. In light of probable interactive effects and possible sample bias, the results for sex and type are inconclusive. Results of the seamount-sex and seamount-type comparisons indicate that each particular sex and type alone are not significantly different morphometrically between seamounts. However, there were significant differences, especially in weight, between pelagic armorhead of different seamounts. Borets (1979) presented results of a morphometric study indicating no significant differences among samples of pelagic armorhead taken at four seamounts within the SE-NHR area.

TABLE 2. SAMPLES OF PELAGIC ARMORHEAD USED IN MORPHOMETRIC AND MERISTIC STUDIES

Specimen	SE Hancock	NW Hancock	C-H	All Three Seamounts Combined
Leans				
Female	11	19	24	54
Male	28	27	32	87
Total	39	46	56	141
Intermediates				
Females	32	44	31	107
Male	26	7	10	43
Total	58	51	41	150
Fats				
Females	7	2	0	9
Male	13	6	0	19
Total	20	8	0	28
Total by Sex				
Female	50	65	55	170
Male	67	40	42	149
TOTAL	117	105	97	319

The meristic results shown in Table 4 do not separate the three body types. Borets (1979) presented similar meristic results for four seamounts although no comparisons were made for sex, type, and their possible combinations. These meristic results are of interest because of speculation on whether the types represent genetically distinct species or subspecies. To better address this question, tissue samples from these types were collected for electrophoretic analysis; results are not yet available. An earlier electrophoretic study on 10 protein systems from samples collected at four SE-NHR seamounts detected no genetic differences in fish (Borets, 1979).

The ecological significance of the different body types is little understood. Borets (1980) reported that the young are pelagic until a certain size and later shift to a demersal habitat, especially over the seamounts. This shift occurs around age 7, which corresponds to the sizes constituting the bulk of pelagic armorhead taken in the trawl fishery. Borets, however, makes no specific mention of polymorphic variation in relation to the habitat change.

TABLE 3. MEAN VALUES DERIVED FROM THE MORPHOMETRICS AND MERISTICS STUDY OF PELAGIC ARMORHEAD

Characteristic	Location			Sex		Type		
	SE Hancock	NW Hancock	C-H	Female	Male	Lean	Intermediate	Fat
Morphometric								
Weight (g)	503.3	514.8	455.0	543.7	433.4	385.3	573.3	590.3
Standard Length (mm)	255.8	256.7	255.3	262.8	248.1	246.6	265.1	253.8
Fork Length (mm)	295.9	298.5	296.8	304.7	288.3	287.0	307.0	295.8
Greatest Orbit Length (mm)	24.1	24.5	25.0	24.7	24.3	25.0	24.5	22.6
Least Interorbital Length (mm)	26.5	26.7	25.5	27.1	25.4	24.7	27.5	28.1
Snout Length (mm)	32.3	32.3	31.9	33.2	31.1	30.6	33.5	33.0
Head Length (mm)	84.2	84.7	84.4	86.5	82.1	81.8	87.0	83.5
Predorsal Length (mm)	103.7	103.2	102.0	105.8	99.9	98.1	106.9	106.8
Predorsal to Prepelvic Length (mm)	96.4	94.8	91.7	97.9	90.4	85.4	100.7	105.6
Maximum Body Depth (mm)	94.0	92.3	89.2	95.5	88.0	82.9	98.2	103.5
Meristics								
Lateral Line Scales in Standard Length	72.9	73.1	72.1	72.8	72.7	72.7	72.8	72.5
Upper Gill Rakers on First Arch	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.5
Lower Gill Rakers on First Arch	17.8	17.8	17.6	17.7	17.8	17.7	17.7	17.8
Dorsal Spines	13.9	13.9	13.9	13.9	13.9	13.8	13.9	13.9
Anal Spines	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Dorsal Soft Rays	8.9	8.8	8.8	8.8	8.9	8.9	8.8	8.9
Anal Soft Rays	7.3	7.4	7.4	7.4	7.4	7.4	7.3	7.4
Pectoral Rays	17.8	17.7	17.7	17.7	17.7	17.7	17.8	17.7
Precaudal Vertebrata	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Caudal Vertebrata	12.9	13.0	12.9	13.0	12.9	12.9	12.9	13.0
Total Vertebrata	25.0	25.0	24.9	25.0	25.0	25.0	25.0	25.0

TABLE 4. RESULTS OF ANOVA ON MORPHOMETRIC AND MERISTIC DATA FROM PELAGIC ARMORHEAD

Characteristic	Seamount	Sex	Type	Seamount x Sex	Sex x Type	Seamount x Type	Seamount x Sex x Type
Degrees of Freedom	2	1	2	2	2	3	3
Morphometric							
Weight (g)	**	***	***	NS	***	NS	*
Standard Length (mm)	NS	***	***	NS	**	NS	*
Fork Length (mm)	NS	***	***	NS	**	NS	*
Greatest orbit Length (mm)	•	***	***	NS	•	*	NS
Least Interorbital Length (mm)	•	***	***	NS	***	NS	*
Snout Length (mm)	NS	***	***	NS	NS	NS	NS
Head Length (mm)	NS	***	***	NS	**	NS	*
Predorsal Length (mm)	NS	***	***	NS	***	NS	NS
Predorsal to Prepelvic Length (mm)	NS	***	***	NS	***	NS	NS
Maximum Body Depth (mm)	NS	***	***	NS	***	NS	NS
Meristic							
Lateral Line Scales in Standard Length	NS	NS	NS	NS	NS	NS	NS
Upper Gill Rakers on First Arch	NS	NS	NS	NS	NS	NS	NS
Lower Gill Rakers on First Arch	NS	*	NS	NS	•	NS	NS
Dorsal Spines	NS	NS	NS	NS	NS	NS	NS
Anal Spines	NS	NS	NS	NS	NS	NS	NS
Dorsal Soft Rays	NS	NS	NS	NS	NS	NS	NS
Anal Soft Rays	NS	NS	NS	NS	NS	NS	NS
Pectoral Rays	NS	NS	NS	NS	NS	NS	NS
Precaudal Vertebrata	NS	NS	NS	NS	NS	NS	NS
Caudal Vertebrata	NS	NS	NS	NS	NS	NS	NS
Total Vertebrata	NS	NS	NS	NS	NS	NS	NS

Note: NS = $P > 0.05$; * = $0.01 < P \leq 0.05$; ** = $0.001 < P \leq 0.01$; *** = $P \leq 0.001$

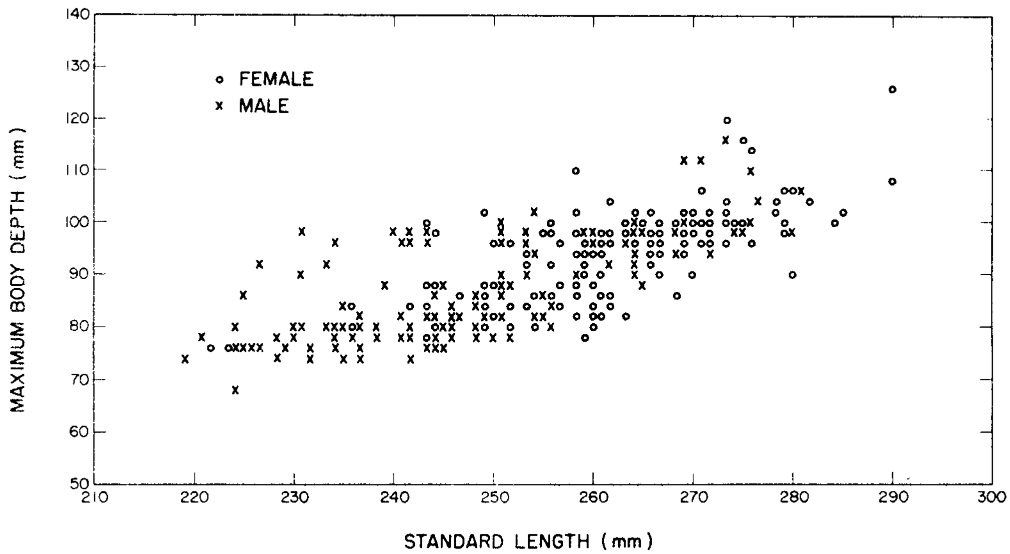

Figure 13. Relationship between maximum body depth and standard length, by sex, for pelagic armorhead

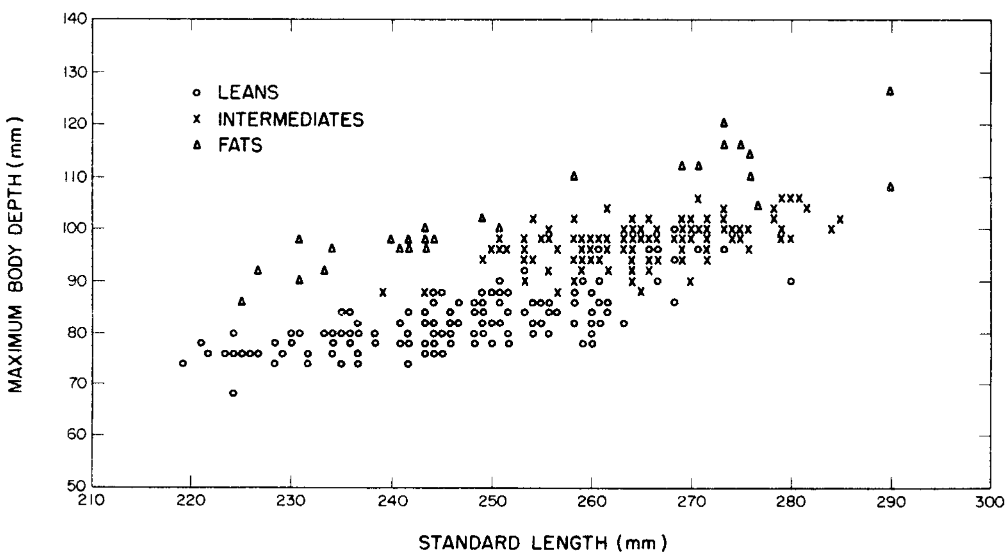

Figure 14. Relationship between maximum body depth and standard length, by body type, for pelagic armorhead

The annual mean FL of pelagic armorhead pooled for all seamounts is available from 1969 to 1976 (Takahashi and Sasaki, 1977) and for 1977-79 and 1981 (Sasaki, unpublished data) (Table 5). For 1972, the mean FL was apparently smaller than earlier and succeeding years. Perhaps coincidentally, the CPUE for 1972 was the highest recorded for three of the seamounts, and the CPUE was higher at the remainder (Figure 6). Length data from the Japanese trawl fishery at Hancock during 1971-74 and 1976 are given in Table 6, and NMFS data for 1978-82 are plotted in Figure 15. Data from all seamounts combined and those from Hancock show a tendency toward slightly higher mean FL in the later years of the fishery compared with the earlier years. The FL ranges at all seamounts combined and for those at Hancock indicate the trawl fishery is harvesting a very narrow length range. Apparently the smaller and larger pelagic armorhead are relatively rare inhabitants of the seamounts since the trawls are capable of retaining much smaller fish. The largest known specimens from the seamounts area are a 495-mm total length (TL) female and a 498-mm TL male (Randall, 1980). The largest recorded pelagic armorhead is a 555-mm TL specimen from Cape Point, South Africa (Smith, 1964).

Annual mean FL by sex was derived from data collected at Hancock by NMFS during 1978-82. Females have a slightly larger mean FL than males. Table 7 gives the results of a two-way univariate ANOVA which indicated a highly significant difference in mean FL between the sexes and that the pattern of this difference is also highly significant in each year. Pooled NMFS and Japan Fisheries Agency (1974) sex ratio data for Hancock indicate no departure from a 1:1 ratio.

A parasitic copepod, *Pennella hawaiiensis*, on pelagic armorhead has been reported by Borets (1979). This ectoparasite is commonly found attached to the musculature of the dorsal region. The infestation rate of this parasite was 44 percent at Koko and 55 percent at Milwaukee. The Japan Fisheries Agency (1974) reported the frequent occurrence of small unidentified ectoparasites on pelagic armorhead taken at SE Hancock. Numerous small, unidentified parasites were found in this study on the gill filaments of virtually all pelagic armorhead. Intermuscular parasites were rare.

TABLE 5. COMBINED FORK LENGTH DATA OF PELAGIC ARMORHEAD TAKEN BY JAPANESE TRAWLERS AT SEAMOUNTS

Year	Sample Size	Mean (cm)	Range (cm)
1969	375	29.2	24-36
1970	166	29.2	26-34
1971	4,400	28.9	24-40
1972	6,410	27.4	20-34
1973	3,138	29.0	25-35
1974	20,724	28.8	21-37
1975	11,736	28.9	23-35
1976	8,517	29.5	15-35
1978	5,508	31.3	23-44
1979	2,412	30.9	21-39
1981	2,664	32.1	27-40

TABLE 6. FORK LENGTH DATA OF PELAGIC ARMORHEAD TAKEN AT HANCOCK SEAMOUNTS BY JAPANESE TRAWLERS

Year	Sample Size	Mean (cm)	Range (cm)
1971	1,199	28.8	25-34
1972	599	27.8	26-34
1973	200	28.7	27-33
1974	900	28.5	24-33
1976	93	28.8	27-31

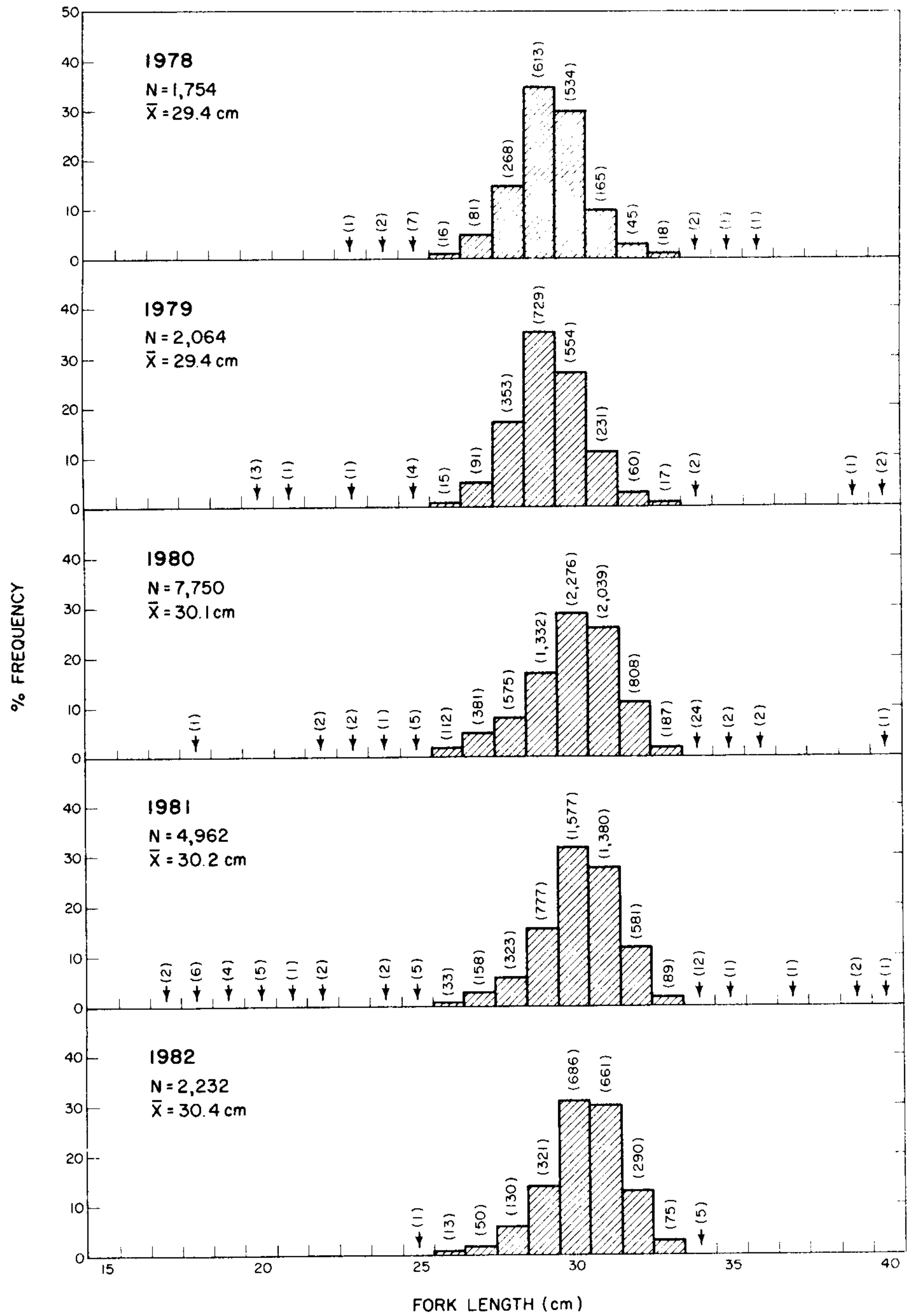

Figure 15. Yearly frequency distribution of pelagic armorhead at Hancock Seamounts from data collected by the Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service. Values above bars represent the number of measurements within the interval.

TABLE 7. ANOVA ON LENGTH DATA, BY SEX, FOR PELAGIC ARMORHEAD TAKEN AT HANCOCK SEAMOUNTS BY JAPANESE TRAWLERS

Year	Number of Males	Mean Fork Length of Males (cm)	Number of Females	Mean Fork Length of Females (cm)	ANOVA		
					Source	d.f.	PR > F
1978	222	29.1	325	29.7	Sex	1	***
1979	461	29.0	577	29.7	Year	4	***
1980	2,302	29.7	1,759	30.5	Sex and Year	4	NS
1981	620	29.7	817	30.7			
1982	578	29.9	790	30.7			

Note: NS = P > 0.05; *** $P \leq 0.001$

Alfonsin

Alfonsin are primarily distributed within two areas of the Pacific northern hemisphere. Within the central North Pacific, alfonsin are found from Koko to Hancock within the Emperor-Hawaiian Ridge Area. In the western Pacific, an alfonsin fishery has existed for many years in Sagami Bay, Japan. Their distribution also extends south of Honshu, Japan to Izu, Kinansho, and further south to Komabashi Seamount near Palau (Chikuni, 1971; Sasaki, 1978). In the central North Pacific alfonsin are only found on seamounts, whereas in the western Pacific they are also found on continental shelf areas. Information on the worldwide distribution of alfonsin is given in Busaklin (1982).

Alfonsin apparently have a pelagic early life history; they subsequently adopt a demersal habit by age one. In the western Pacific, dispersal of eggs and larvae is strongly affected by the Kuroshio current. No information is available on eggs and larvae over the SE-NHR seamounts. Chikuni (1971) suggested that early life stages may be recruited between the two central areas, especially toward the SE-NHR seamounts.

In a tagging study conducted in Sagami Bay, most alfonsin were recaptured offshore. Alfonsin length-frequency data from several locations in the western Pacific indicate a pattern of increasing size with depth and a decreasing size with latitude. The length range of alfonsin in Sagami Bay (representing higher latitudes) was 17 to 20 cm compared with 35 to 50 cm from southern areas (Chikuni, 1971). Length-frequency data collected by NMFS in 1978-82 for Hancock are shown in Figure 16.

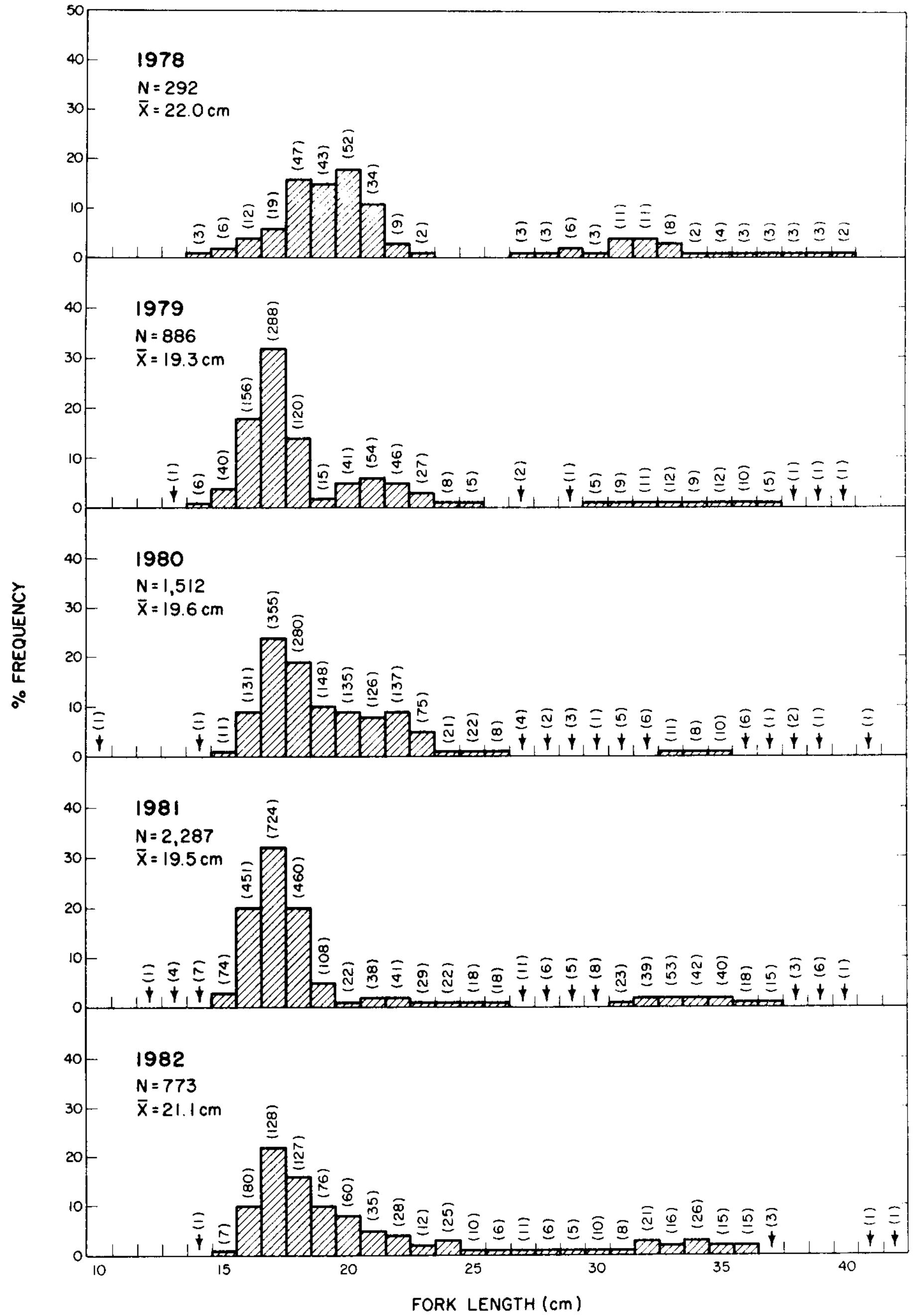

Figure 16. Yearly frequency distribution of alfonsin at Hancock Seamounts from data collected by the Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service. Values above bars represent the number of measurements within the interval.

Although the smaller size group (similar to that from Sagami Bay) predominates, a larger size group is also sometimes present. The size distribution of alfonsin at Hancock apparently does not follow the distributional patterns reported for the western Pacific by Chikuni (1971). Figure 17 shows the distribution, by sex, of alfonsin from Hancock (NMFS data from 1978 to 1982). The distribution of the two sexes indicates that sexual dimorphism is not responsible for the existence of different size groups. Combined NMFS and Japan Fisheries Agency (1974) data show a nearly equal sex ratio at Hancock.

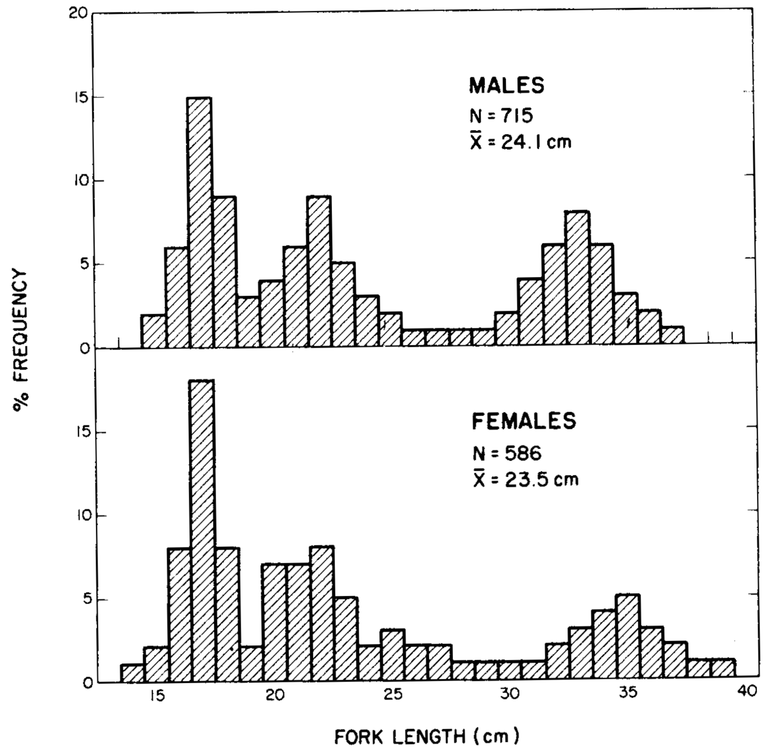

Figure 17. Frequency distribution for 1978-82 combined of alfonsin, by sex, at Hancock Seamounts from data collected by the Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service

No information is available on spawning season (or the existence of reproductive alfonsin) at the SE-NHR seamounts.

U.S. foreign observers[7] have reported that many of the small, trawl-caught alfonsin appear sexually immature. Chikuni (1971) reported that in the western Pacific the spawning season is from August to October.

Based on a study of otoliths, Ikenouye (1969) determined the following age-length relationships for alfonsin:

Age	FL (cm)
1	9
2	19
3	26
4	30
5	33

These results suggest that the bulk of the alfonsin caught in the seamount trawl fishery are 2 years old (Figure 16). Ikenouye reported that alfonsin in the western Pacific first reach maturity by age three.

The feeding habits of alfonsin on the SE-NHR seamounts are not well known. Krill, mysids, copepods, myctophids, and other mesopelagic fishes have been found in alfonsin stomachs (Japan Fisheries Agency, 1974). Results of other Japanese survey cruises (Aomori Prefectural Fisheries Experimental Station, 1976) showed small fish to be the most abundant prey, followed by decapod and schizopod crustaceans. Barnett[8] identified prey items consisting of benthic shrimp, fish, and tunicates and also found relatively large amounts of fine silt in the gut.

MANAGEMENT

Japan is the only foreign nation thus far to fish under permit at Hancock since the establishment of the FCZ in 1977. Beginning in 1978, Japan was allocated half of a yearly total allowed level of foreign fishing (TALFF) of 2,000 MT (all species included). However, the Japanese have never attained the allotted quota. The total yearly Japanese catches at Hancock, determined by U.S. foreign observers[9] are as follows: 1978, 393.0 MT; 1979, 205.4 MT; 1980, 795.4 MT; 1981, 662.0 MT; and 1982, 393.0 MT.

The 1982 ex-vessel value (in U.S. dollars) was $763/MT (dressed) for pelagic armorhead and $240/MT (round) for alfonsin landed in Japan (R.T.B. Iversen, 1983: personal communication).

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[7] See footnote 1
[8] See footnote 1, specifically W.B. Barnett, 1982, Southwest Fisheries Center Administrative Report H-82-21.
[9] See footnote 1

No U.S. fishermen have yet fished commercially at Hancock.

Set forth in the preliminary management plan for the seamount groundfish fishery of the Pacific, as published in the Federal Register, U.S. management policy ideally requires the determination of a maximum sustainable yield (MSY). Given MSY it would then be possible along with other considerations, to calculate optimum yield. After assessing the level or potential level of harvesting by U.S. fishermen, a TALFF could then be derived.

Determination of MSY requires an accurate assessment of stock structure. Available biological information on pelagic armorhead indicates that one common stock exists among the seamounts of the SE-NHR. Hence, catch and effort data from all these seamounts could be incorporated in determining MSY. In this regard, the Japanese fishery data could serve as a basis for this determination. Also needed is an accurate delineation of the stock's home range. A determination of the home range requires a consideration of the distribution of pelagic armorhead by body type. All three body types have been found on the seamounts; however, only fat types inhabit the northeast Pacific during summer, their whereabouts after summer being unknown. Consequently, there is a question of whether the home range of the fat type extends well beyond the seamounts or whether the fat type represents an independent stock. Available biological information is still insufficient to conclude that the fat type represents a pelagic, predemersal phase and that ultimately these fish return to the seamounts. Until the status of the fat type is better understood, the determination of MSY based on seamount catches alone may be of little value for management purposes. Another management problem is the accessibility of this fishery to other fishing nations. Because most of the SE-NHR seamounts are located in international waters, there is some question as to how effectively the pelagic armorhead resources within the FCZ could be independently managed. The most effective management plan would ultimately adopt a holistic approach and thereby require the involvement and cooperation of all nations participating in this fishery.

SUMMARY

Until fairly recently, investigations of the SE-NHR seamounts were principally geological. With the Soviet discovery in 1967 of fishery resources on the seamounts, a series of biological and oceanographic studies began. Soviet oceanographic studies show the existence of intense vertical circulation and the meandering of surface currents near the seamounts. These physical processes are believed to be responsible for the higher plankton biomass found in this area compared with the more oligotrophic environment of surrounding waters.

The main fishing activity in this region has been the initiation of a trawl fishery on the SE-NHR seamounts. Of principal commercial importance is the pelagic armorhead and, to a lesser extent, alfonsin. During a 7-month period at the beginning of the fishery, the Soviets reportedly harvested 133,400 MT of pelagic armorhead. In 1969, the Japanese also entered the seamount trawl fishery. Annual Japanese catches for all seamounts combined ranged from 19,000 to 35,000 MT during 1972-76. However, catches sharply declined during 1977-81, ranging from 500 to 6,200 MT. With the establishment of the U.S. FCZ, the Hancock Seamounts came under U.S. jurisdiction and consequently various regulations were developed. Japan was the only foreign nation to fish under permit at Hancock during 1978-82. During this period, catches of pelagic armorhead were very low, reflecting a similar trend among the rest of the SE-NHR seamounts. No U.S. fishermen have fished in the seamount fishery. Other smaller scale fisheries operating on the SE-NHR seamounts were bottom longlining, primarily for alfonsin; bottom dragging for precious corals; and gill netting for squid and saury.

Surveys of Hawaiian Ridge seamounts south of Hancock revealed large differences in the ichthyofauna. The primarily deep water, benthic, and demersal fishes of the SE-NHR seamounts are replaced by subtropical reef and snapper-grouper fishes of the shallower southern seamounts. Seamounts 10-11, Ladd, and Nero appear to have a more transitional ichthyofauna.

Little is known about the life history of pelagic armorhead. Evidence indicates a common, reproductive stock on the SE-NHR seamounts. These fish apparently undergo diurnal vertical movements, becoming closely associated with the summits at night and the upper water column during daylight. Mesopelagic organisms appear to be an important food resource.

A still unresolved problem concerns the existence of three different morphological types among pelagic armorhead. The lean and intermediate type are brownish and predominate over the seamounts. The fat type has blue and white pelagic coloration, is infrequently caught over the seamounts and is the only type known to inhabit oceanic waters far from the seamounts. No meristic differences were found among the three types. Although the fat type is suspected to be representative of a pelagic, predemersal stage common to all members of this species, conclusive evidence is lacking. Resolving the status of the fat type in the population is needed before stock structure can be determined. Until then estimates of MSY must be based solely on seamount commercial catch data.

REFERENCES

Abe, T. 1957. New rare or uncommon fishes from Japanese waters. VI. Notes on the rare fishes of the Family Histiopteridae. Japanese Journal of Ichthyology 6(1/2):35-39 and continued in 6(3):71-74.

Abe, T. 1969. Notes on some edible marine fishes collected between the Bonin Islands and the mouth of Sagami Bay--III.

Bulletin of the Tokai Regional Fisheries Research Laboratory 60:5-8.

Aomori Prefectural Fisheries Experimental Station. 1976. Report of a fishing ground development survey in the Emperor Seamounts area for 1976 (Tenno Kaizaniki ni okeru gyojyo kaihatsu chosa). Aomori Prefectural Fisheries Experimental Station, 66 pp. (Partial English translation by W.G. Van Campen, 1976, 6 pp; Western Pacific Regional Fishery Management Council, Honolulu, HI 96813.)

Barsukov, V.V. 1973. The species composition of the genus Helicolenus (Sebastinae, Scorpaenidae, Pisces) and a description of a new species. Journal of Ichthyology 13(2):161-167.

Barsukov, V.V., and V.V. Fedorov. 1975. Species of the genus Hozukius (Scorpaenidae, Sebastinae) from the guyots of the Hawaiian Submarine Ridge. Journal of Ichthyology 15(6):869-876.

Bezrukov, Y.F., and V.V. Natarov. 1976. Formation of abiotic conditions over the submarine eminences of some regions of the Pacific Ocean. Izvestiya of the Pacific Scientific Research Institute for Fisheries and Oceanography (TINRO) 100:93-99. (English translation by W.G. Van Campen, 1983; available Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Bilim, L.A., L.A. Borets, and L.K. Platoshina. 1978. Characteristics of ovogenesis and spawning of the boarfish in the region of the Hawaiian Islands. (In Russian, English abstract.) Izvestiya of the Pacific Scientific Research Institute for Fisheries and Oceanography (TINRO) 102:51-57. (English translation by W.G. Van Campen, 1983; available Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Borets, L.A. 1979. The population structure of the boarfish, Pentaceros richardsoni, from the Emperor Seamounts and the Hawaiian Ridge. Journal of Ichthyology 19(3):15-20.

Borets, L.A. 1980. The distribution and structure of the range of the boarfish Pentaceros richardsoni. Journal of Ichthyology 20(3):141-143.

Borets, L.A. 1982. The fish Anthias rubromaculatus sp. n., a new species of serranoid fishes from the seamounts of the Hawaiian ridge. (In Russian, English abstract). Marine Biology, Vladivostok 3:68-70.

Busaklin, S.V. 1982. Systematics and distribution of the family Berycidae (Osteichthyes) in the World Ocean. Journal of Ichthyology 22(6):1-21.

Chen, C.H. 1980. Primary studies of demersal fish resources investigation on trawl grounds at Kanmu Seamount. Bulletin of Taiwan Fisheries Research Institute 32:317-337. (English translation by W.G. Van Campen, Translation No. 79, 1982, 33 pp.; available Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Chikuni, S. 1970. The "phantom fish," "kusakari tsubodai" -- an outline. Enyo (Far Seas) Fisheries Research Laboratory News 3:1-4. (English translation by J.H. Shohara, 7 pp. National Marine Fisheries Service, Terminal Island, CA 90731.)

Chikuni, S. 1971. Groundfish on the seamounts in the North Pacific. Bulletin of the Japanese Society of Fisheries Oceanography 19:1-14. (English translation by K. Tatara, 1972, 12 pp.; Fisheries Research Board of Canada, Translation No. 2130.)

Clemens, W.A., and G.V. Wilby. 1961. Fishes of the Pacific coast of Canada. 2d ed. Bulletin of the Fisheries Research Board of Canada 68. 443 pp.

Dolganov, V.N. 1982. Discovery of a rare rabbitfish species, *Chimera owstoni* (Holocephali, Chimaeridae), in the region of the Northwestern Underwater Ridge. Journal of Ichthyology 22(6):145-146.

Dalrymple, G.B., D.A. Clague, M.O. Garcia, and S.W. Bright. 1981. Petrology and K-Ar ages of dredged samples from Laysan Island and Northampton Bank volcanoes, Hawaiian ridge, and evolution of the Hawaiian-Emperor chain: Summary. Geological Society of America Bulletin, Part I 92:315-318.

Eber, L.E., J.F.T. Saur, and O.E. Sette. 1968. Monthly mean charts, sea surface temperature, North Pacific Ocean, 1949-1962. U.S. Fish and Wildlife Service, Circular 258. 168 pp.

Fedosova, P.A. 1974. Distribution of the biomass mesoplankton in the region of the Hawaiian submarine mountain range. Izvestiya of the Pacific Scientific Research Institute for Fisheries and Oceanography (TINRO) 92:38-42. (English translation by W.G. Van Campen, 1983; available Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Follett, W.I., and L.J. Dempster. 1963. Relationships of the percoid fish *Pentaceros richardsoni* Smith, with description of a specimen from the coast of California. In Proceedings of the California Academy of Science, Fourth Series 32:315-338.

Gooding, R.M. 1980. Exploratory fishing on the Hancock Seamounts by the Townsend Cromwell 1976-79. In Proceedings of the symposium on status of resource investigations in the Northwestern Hawaiian Islands, Honolulu, Hawaii, April 24-25, 1980, ed. R.W. Grigg, and R.T. Pfund, pp. 241-250. UNIHI-SEAGRANT-MR-80-04. University of Hawaii Sea Grant College Program, Honolulu.

Grigg, R.W. 1974. Distribution and abundance of precious corals in Hawaii. In Proceedings of the Second International Coral Reef Symposium 2, pp. 235-240. Great Barrier Reef Committee, Brisbane.

Hart, J.L. 1973. Pacific fishes of Canada. Bulletin of the Fisheries Research Board of Canada 180. 740 pp.

Honma, Y., and R. Mizusawa. 1969. A record of the young of boar fish, Pseudopentaceros richardsoni, from North Pacific. (In Japanese, English summary.) Japanese Journal of Ichthyology 15(3):134-136.

Iguchi, K. 1973. Research by trawl fishery for commercialization of the fishing grounds by Japan Marine Fishery Resource Research Center. II. Outline of trawl fishery investigation for commercialization in the central North Pacific. Bulletin of the Japanese Society of Fishery Oceanography 23:47-56. (Partial English translation by W.G. Van Campen, 1983; available Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Ikenouye, H. 1969. Age determination by otolith of a Japanese alfonsin, Beryx splendens, with special reference to growth. Journal of the Tokyo University of Fisheries 55(2):91-98.

Jackson, E.D., I. Koisumi, G.B. Dalrymple, D.A. Clague, R.J. Kirkpatrick, and H.G. Greene. 1980. 1. Introduction and summary of results from DSDP Leg 55, the Hawaiian-Emperor hot-spot experiment. In Initial reports of the deep sea drilling project, v. 55, ed. E.D. Jackson, I. Koisumi, et al., pp. 5-31. Washington, D.C.: U.S. Government Printing Office.

Japan Fisheries Agency. 1974. Survey of the North Pacific seamounts (Kita Taiheiyō kaizan chōsa). Report of Kaiyo Maru survey cruises, 1972 season. Japan Fisheries Agency, 136 pp. (English translation of selected portions of the report by T. Otsu, Translation No. 54, 1981, 55 pp.; available Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Japan Marine Fishery Resource Research Center (JAMARC). 1973. Surveys of trawling grounds in the north central Pacific Ocean, 1972 season (Showa 47-nendo kaigai torōru shingyojyo kigyōka chōsa hokokusho-Hokubu chuo Taiheiyo kaiiki). Translation of Portions of JAMARC Report No. 7, March 1973, 89 pp. (English translation by T. Otsu, 1977, 27 pp., Translation No. 19; available Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Kanayama, T. 1981. Scorpaenid Fishes from the Emperor Seamount Chain. In Pelagic Animals and Environments Around the Subarctic Boundary in North Pacific, ed. S. Mishima, pp. 119-129. Research Institute of North Pacific Fisheries, Faculty of Fishes, Hokkaido University.

Katayama, M. 1975. Caprodon unicolor, a New Anthiine Fish from the North Pacific Ocean. Japanese Journal of Ichthyology 22(1):13-15.

Kitani, K., and K. Iguchi. 1974. Some observations on the feature of fishing ground on the sea-mount in the central North Pacific Ocean as surveyed through the trawl operation. (In Japanese, English abstract.) Bulletin, Far Seas Fisheries Research Laboratory (Shimizu) 11:33-36.

Menard, H.W. 1964. Marine Geology of the Pacific. New York: McGraw-Hill.

Nakabo, T., E. Yamamoto, and C.H. Chen. 1983. Two new species of the genus Foetorepus (Callionymidae) from the Emperor Seamounts, North-central Pacific. Japanese Journal of Ichthyology 29(4):349-354.

Nakaya, K., K. Amaoka, and K. Abe. 1980. A review of the genus Lepidion (Gadiformes, Moridae) from the Northwestern Pacific. Japanese Journal of Ichthyology 27(1):41-47.

Okamoto, H. 1982. Deep bottom fish surveys - Hawaii. Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii, Honolulu. 21 pp.

Parin, N.V., and S.V. Mikhailin. 1982. Lepidopus calcar, a new trichiurid fish from the Hawaiian Underwater Ridge. Japanese Journal of Ichthyology 29(1):27-30.

Pontekorvo, T.B. 1974. Certain peculiarities of distribution of hydrological and biological characteristics in the region of Hawaiian Undercurrent Mountains Banks. Izvestiya of the Pacific Scientific Research Institute for Fisheries and Oceanography (TINRO) 92:32-37. (Partial English translation by W.G. Van Campen, 1983; available Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Randall, J.E. 1980. New records of fishes from the Hawaiian Islands. Pacific Science 34(3):211-232.

Sakiura, H. (translator). 1972. The pelagic armorhead, Pentaceros richardsoni, fishing grounds off the Hawaiian Islands, as viewed by the Soviets (So-Ren kara mita Hawaii oki kusakari tsubodai gyojyo). Suisan Shuho (The Fishing and Food Industry Weekly) 658:28-31, June 15, 1972. (English translation by T. Otsu, 1977, 7 pp., Transl. No. 17; available Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Sasaki, T. 1974. The pelagic armorhead, Pentaceros richardsoni Smith, in the North Pacific (Kita Taiheiyo no kusakari tsubodai). Bulletin of the Japanese Society of Fisheries Oceanography 24:156-165. (English translation by T. Otsu, 1977, 13 pp., Translation No. 16; available Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Sasaki, T. 1978. The progress and present status of the seamount fishing ground development program (Kaizan gyojyo kaihatsu no keika to genjo). Bulletin of the Japanese Society of Fisheries Oceanography 33:51-53. (English translation by T. Otsu, 1979, 6 pp., Translation No. 35; available Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Selitskayá, L.V. 1972. Some data on the distribution of larvae and fry of the saury in the southern part of Emperor Seamount chain (Pacific Ocean). (In Russian, English abstract.) Izvestiya-Tikhookean skogo Nauchno-Issledovatel'skogo Instituta Rybnogo Khozyaustva i Okeanografii 81:242-244.

Smith, J.G. 1965. A second record of the pelagic armorhead, Pentaceros richardsoni Smith 1849, in California waters. California Fish and Game 51(3):213-214.

Smith, J.L.B. 1964. Fishes of the Family Pentacerotidae. Rhodes University, Department of Ichthyology, Ichthyological Bulletin 29:567-578.

Statistical Analysis System (SAS). 1979. SAS User's Guide, 1979 Edition. SAS Institute, Statistical Analysis System.

Suisan Sekai. 1976. The present status of the alfonsin, Beryx splendens, fishery in the Midway fishing grounds (Midway kai-iki no kin-me sogyo no genkyo). (Excerpt.) Suisan Sekai 25(8):28-32. (English translation by T. Otsu, 1977, 5 pp., Translation No. 18; available Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Suisan Sekai. 1981. Taiwan sends 79 vessels to gill net for squid in Emperor Seamount grounds (Taiwan gyosen no dōkō. Ika nagashi-amiryō ni 79-seki ga shutsugyō. O-nigiwai no Tenno-zan gyojō) Suisan Sekai 30(9):55. (English translation by T. Otsu, 1982, 3 pp., Translation No. 71; available Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Takahashi, Y., and T. Sasaki. 1977. Trawl fishery in the central North Pacific seamounts (Kita Taiheiyo chubu kaizan ni okeru torōru gyogyō). Hokuyo soko-uo gyogyō-Shiryo (3) (Northern waters groundfish fishery--Data (3)). Division of Northern Waters Groundfish Resources, Far Seas Fisheries Research Laboratory, 45 pp. (English translation by T. Otsu, 1977, 49 pp., Translation No. 22; available Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Vasil'kov, V.P., and L.A. Borets. 1978. Determining the age of boarfishes by spectrophotometric analysis of scale structure. Soviet Journal of Marine Biology 4(1):545-548.

Wagner, E.J., and C.E. Bond. 1961. The percoid fish Pseudopentaceros richardsoni from Oregon waters. Fish Commission of Oregon, Research Briefs 8(1):71-73.

Welander, A.D., R.C. Johnson, and R.A. Hajny. 1957. Occurrence of the boar fish, Pseudopentaceros richardsoni, and the zeid, Allocyttus verrucosus, in the North Pacific. Copeia 1957(3):244-246.

Yabe, M. 1983. A new cottoid fish of the family Ereuniidae, Marukawichthys pacificus, from the Central North Pacific. Japanese Journal of Ichthyology 30(1):18-26.

Zama, A., M. Asai, and F. Yasuda. 1977a. Changes with growth in bony cranial projections and color patterns in the Japanese boarfish, Pentaceros japonicus. Japanese Journal of Ichthyology 24(1):26-34.

Zama, A., M. Asai, and F. Yasuda. 1977b. Records of the pelagic armorhead, Pentaceros richardsoni, from Hachijo Island and the Ogasawara Islands. Japanese Journal of Ichthyology 24(1):57-60.