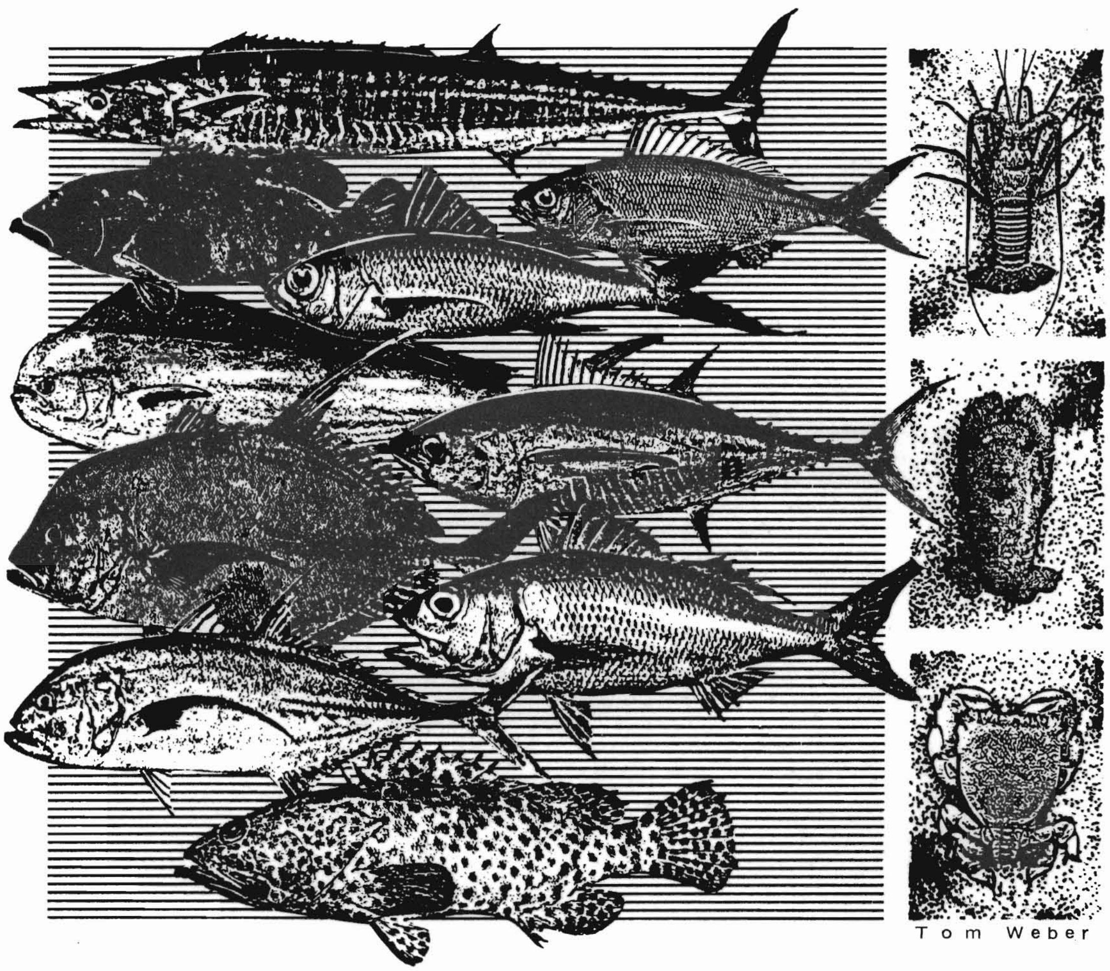
NOAA Technical Report NMFS 38 September 1986

Fishery Atlas of the Northwestern Hawaiian Islands

Richard N. Uchida and James H. Uchiyama (Editors)



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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NOAA TECHNICAL REPORT NMFS

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ABSTRACT

This atlas summarizes data on the crustaceans, molluscs, and fishes caught in a resource survey of the Northwestern Hawaiian Islands from October 1976 to September 1981. The geographical and depth distributions, size range, and the type of gear used to catch all of the crustaceans, molluscs, and fishes are tabulated. Species accounts of 37 crustaceans, molluscs, and fishes of commercial potential are presented. The geography, oceanography, and climate of the region are reviewed.

Note: Authors of species accounts are affiliated with the Southwest Fisheries Center Honolulu Laboratory, except for Steven H. Kramer, who is with Seafarms West, 4600 Carlsbad Blvd., Carlsbad, CA 92008.

INTRODUCTION

More than a decade ago, the Governor's Task Force on Oceanography, State of Hawaii, which included approximately 100 professionals from all segments of Hawaii's community, recognized that the fishery resources of the main islands (Hawaii, Maui, Kahoolawe, Lanai, Molokai, Oahu, Kauai, and Niihau) were being subjected to considerable fishing pressure and recommended exploration and development of marine resources in the Northwestern Hawaiian Islands (NWHI) ([Hawaii] 1969). In the years immediately following the Task Force's recommendation, fishing vessels capable of undertaking long voyages were added to the Hawaiian fishing fleet. The Governor's Advisory Committee on Science and Technology noted that marine resources in the NWHI were within the operating radius of many of these vessels, and recommended that State, Federal, and academic research agencies begin an intensive cooperative investigation of marine resources in the NWHI ([Hawaii] 1974). In response to these recommendations, the Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service (NMFS), reconnoitered waters of the NWHI on research cruises by the NOAA ships *David Starr Jordan* in 1973 and the *Townsend Cromwell* in 1975.

Concurrent with these activities in Hawaii were the discussions in Congress about the inadequacy of conservation and management practices for fishery resources off the coast of the United States. Under the authority of the Magnuson Fishery Conservation and Management Act (MFCMA) of 1976, the Federal Government established a fishery conservation zone (FCZ) from the 3-nmi territorial boundary out to 200 nmi from shore on 1 March 1977.[1]

The 200-nmi FCZ around the Hawaiian Archipelago (Fig. 1) encompasses the eight major islands in the group, and the NWHI, which with two exceptions were designated the Hawaiian Islands National Wildlife Refuge (Refuge) in 1909. The exceptions are Midway, which in addition to being a Naval Wildlife Refuge is a permanent U.S. Naval Air Installation, and Kure Atoll, a U.S. Coast Guard loran station which has been a State Wildlife Refuge since 1952 and a State Seabird Sanctuary since 1978 (Gilmartin 1983).

In October 1976, 5 months before the enactment of the MFCMA, the Honolulu Laboratory launched a full-scale investigation of marine resources in the NWHI. Discussions among the Department of Commerce, NOAA, NMFS, the Department of the Interior, U.S. Fish and Wildlife Service (FWS) in Honolulu, and the State of Hawaii, Department of Land and Natural Resources (DLNR), led to an agreement to participate in a joint investigation of the aquatic resources and the land-associated resources of the NWHI. From these discussions evolved the Tripartite Cooperative Agreement among NMFS, FWS, and DLNR to survey and assess the living resources of the NWHI.[2]

The NMFS assumed the lead role in implementing the provisions of the agreement, undertaking the survey of fishery resources over the islands' outer terraces, escarpments, submerged banks, and seamounts. After the onset of the investigation, NMFS also assumed responsibility for study of the endangered Hawaiian monk seal, *Monachus schauinslandi*, and the threatened green turtle, *Chelonia mydas*.

In the area inshore from the NMFS's area of responsibility, particularly the waters <20 m deep to the shoreline, the DLNR assumed responsibility of surveying the nearshore marine resources and habitat.

[1]To avoid confusion in expressing distances, statute mile has been converted to kilometer (km) and nautical mile (nmi) has been retained.

[2]Survey and assessment of the living resources of the Northwestern Hawaiian Islands. A Tripartite Cooperative Agreement, May 1978.

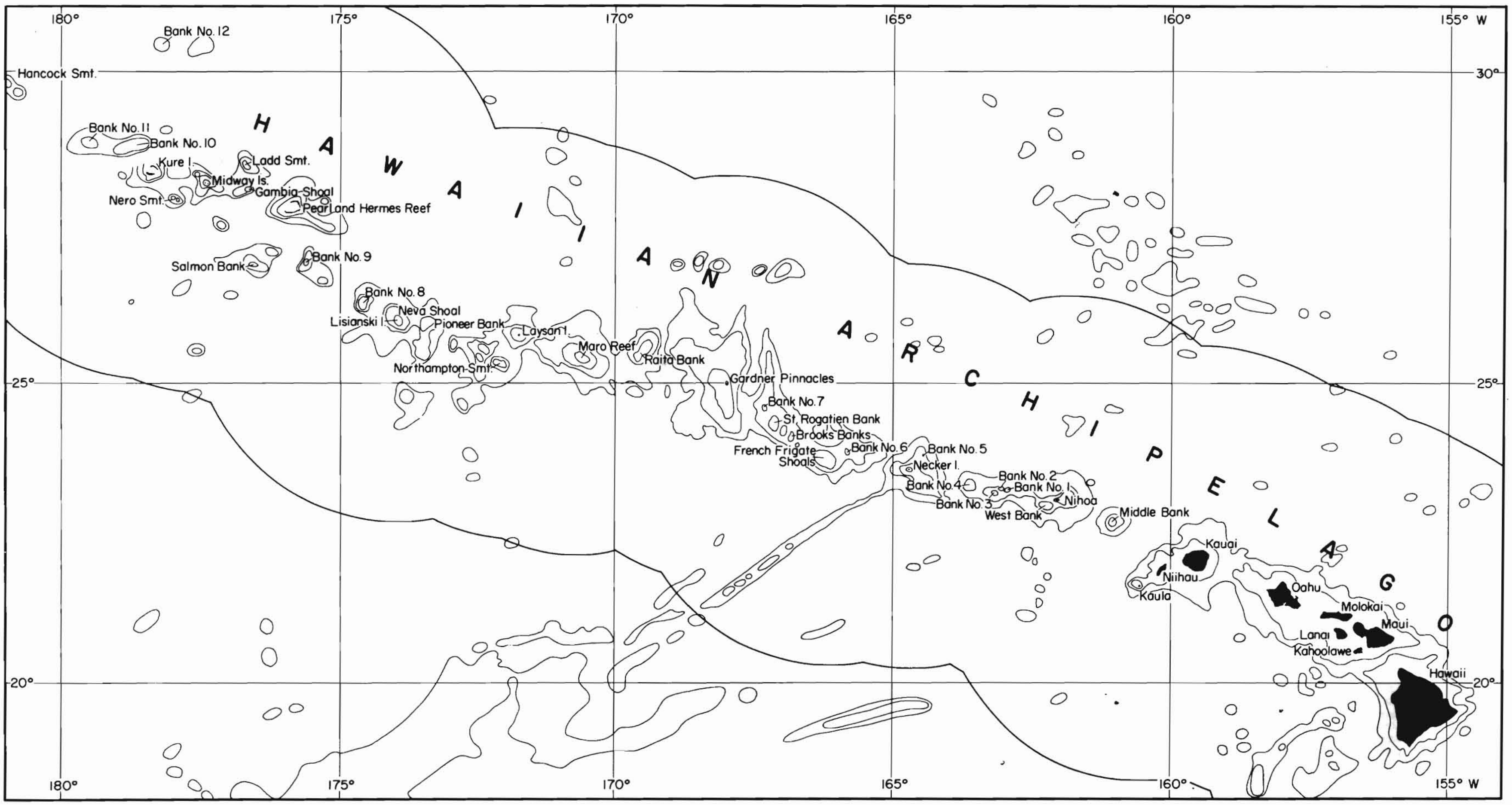

Figure 1.—Hawaiian Archipelago and its fishery conservation zone.

The FWS, as Refuge managers, had the responsibility to survey avian resources of the Refuge. Activities included population estimates of marine birds, studies of the food of birds, study major feeding areas and consumptive rates, and assessment of potential impact of commercial and recreational fishing upon Refuge inhabitants. After the signing of the Tripartite Cooperative Agreement, the University of Hawaii Sea Grant College Program (UHSGCP) expressed an interest in conducting research in the NWHI and became an active participant in the investigation.

Initially, little was known about the resources of the NWHI. The reconnaissance cruises of 1973 and 1975 by the *Jordan* and *Cromwell* revealed the presence of scattered small concentrations of baitfish at several of the islands and small-to-moderate aggregations of bottom fish of the snapper-grouper complex. Exploratory trawling also revealed the presence of the penaeid shrimp, *Penaeus marginatus*, and large schools of unicornfish, *Naso* sp. Trapping stations confirmed the presence of spotty but high densities of spiny lobster, *Panulirus marginatus*, and caridean shrimps, *Heterocarpus ensifer* and *H. laevigatus*. From October 1976 to September 1981, the NMFS, FWS, DLNR, and UHSGCP surveyed the islands, banks, reefs, shelves, seamounts, and overlying waters within the FCZ and amassed data on the various marine and land inhabitants. Two major symposia covering the above joint efforts were held at the University of Hawaii at Manoa in 1979 and 1983. The proceedings of these symposia contained the results of over 100 research projects (Grigg and Pfund 1980; Grigg and Tanoue 1984).

During the investigation the NMFS conducted resource surveys to determine the species of commercial value and their distribution in the area using standard types of gear. This atlas provides results of the NMFS studies of fish, crustacean, and molluscan resources and their distribution in the NWHI, description of the banks and seamounts visited, review of the climate and oceanography, and a short synopsis of those fish and shellfish of economic significance.

HISTORICAL BACKGROUND

The earliest record of commercial fishing in the NWHI appeared in the October 30 edition of the Honolulu Star-Bulletin (1917). In the 1930's up to five large (20-21 m long) vessels fished for bottom fish; the number of large vessels increased to nine after World War II (Hau 1984). One marginally profitable operation established a base at French Frigate Shoals and air shipped its catch to Honolulu by chartered plane (Amerson 1971). By early November 1946, two companies—Hawaiian American Fisheries, headed by Louis K. Agard, Jr., and Seaside Fishing Company, run by Frank Opperman and Warren Haines—established fishing bases on Tern Island at French Frigate Shoals; the catch was transported to Honolulu via a chartered DC-3 from Trans-Air Hawaii (Amerson 1971). Most of the catch consisted of trap-caught fish; however, a large proportion was green turtle, a profitable item.

The principals in this fishery eventually had difficulty keeping the operation financially viable (Amerson 1971). To reduce costs Hawaiian American Fisheries acquired new partners and formed a new corporation—Aero Fisheries—with a plane of its own. One flight was completed in July 1949, but mechanical problems with the plane and lack of financing forced Aero Fisheries to abandon its operation.

Several attempts to revive fishing in the NWHI during the 1950's met with varying success. In 1959, Agard formed another joint venture and purchased a refrigerated vessel and a plane to transport the catch but this venture was also short-lived.

Some commercial fishermen believed that an efficiently run operation in the NWHI could be profitable, whereas others maintained a cautious attitude about developing fisheries in those waters. Commercial deep-sea fishing vessels, using handline, traps, and trolling gear, made periodic trips to NWHI and enjoyed relatively good fishing. However, a limited local market was a serious obstacle and caused a decline in the number of vessels operating in the NWHI between the late 1940's and the early 1970's.

DESCRIPTION OF THE ISLANDS

The NWHI are part of the Hawaiian-Emperor chain, a quasi-linear array of shield volcanoes which extend nearly 6,000 km on the Pacific lithospheric plate. The Hawaiian chain extends southeast-northwest about 3,500 km and the Emperor Seamounts north-south about 2,300 km at the western end of the Hawaiian chain. It is presently accepted that all of the islands and almost all the seamounts in the Hawaiian-Emperor chain are geologically continuous and originated over a relatively stationary hot spot located under Mauna Loa and Kilauea volcanoes of the Island of Hawaii (Wilson 1963; Morgan 1972; Jackson et al. 1980; Grigg 1982, 1983). As volcanoes formed over the Hawaiian hot spot about 70 million years ago, the Pacific plate moved slowly northward, forming what are now the Emperor Seamounts. About 43 million years ago, the Pacific plate began moving northwesterly and formed the bend between the Emperor and the Hawaiian chains. The Hawaiian Archipelago is estimated to have originated within the last 30 million years. A detailed review of evidence supporting the hot spot hypothesis of the formation of the Hawaiian-Emperor chain is presented by Jackson et al. (1980).

Due to the varying degree of subsidence and erosion, the Hawaiian Archipelago may be divided into three groups. The southeast portion, which is composed of the eight high volcanic islands (main islands), is the youngest. A middle portion (Kaula Island, Nihoa, Necker Island, French Frigate Shoals, La Perouse Pinnacle, and Gardner Pinnacles), and a northwestern portion consisting mostly of low atolls, sandy islets, reefs, and shoals including Maro Reef, Laysan, Lisianski Island, Pearl and Hermes Reef, Midway, and Kure Atoll are the oldest (Carlquist 1970; McDonald and Abbott 1970).

Within the NWHI, there also exists a series of shallow submerged banks <1.6 to >80 km long which surround or lie amongst various islands in the group. The depths over these banks are between 4 and 146 m, although, the troughs between the banks and islands may be as deep as 5,300 m. Along the northern and southern boundaries of the NWHI, the 3,660-m contour is usually within 20 nmi of the shoals.

In addition to islands, atolls, and submerged banks, the archipelago has numerous seamounts. These are large submarine volcanoes some of which may have been high volcanic islands that have subsided to one-half kilometer or more below the sea surface. Some of these summits lack a coral cap, and are called ''guyots'' or flat-topped seamounts. Seamounts are identifiable as former islands by their form and the inshore fossils dredged from them (Menard and Hamilton 1963).

In the sections that follow, we provide brief descriptions of the islands, atolls, reefs, and seamounts where fishery assessment surveys were conducted. The dimensions and depths given are from published reports, navigational charts of the National Ocean Service (NOS), and data collected during our surveys. Table 1 gives the estimated areas of some of the major banks within the 183-, 914-, and 1,829-m contours.

Table 1.—Estimated areas (square nautical miles) within three depth ranges for some of the major islands and banks in the Northwestern Hawaiian Islands. Estimated from National Ocean Service navigation charts.

	Bottom area (nmi^2)		
Location	183 m (100 fm)	914 m (500 fm)	1,829 m (1,000 fm)
Nihoa Island	458	1,136	1,901
Necker Island	598	1,209	1,579
French Frigate Shoals	366	†2,773	†4,185
Brooks Banks	128	†2,773	†4,185
St. Rogatien	177	†2,773	†4,185
Gardner Pinnacles	937	1,915	4,904
Raita Bank	223	399	700
Maro Reef	741	1,438	2,447
Laysan Island	207	332	570
Northampton Seamounts	53+	206+	804
Pioneer Bank	102	289	‡1,555
Lisianski Island	465	611	‡1,555
Pearl and Hermes Reef	—	—	—
Midway Islands	144	—	—
Kure Atoll	—	—	—

†French Frigate Shoals, Brooks Banks, and St. Rogatien are connected at 914 m depth.

‡Pioneer Bank and Lisianski Island are connected at 1,829 m depth.

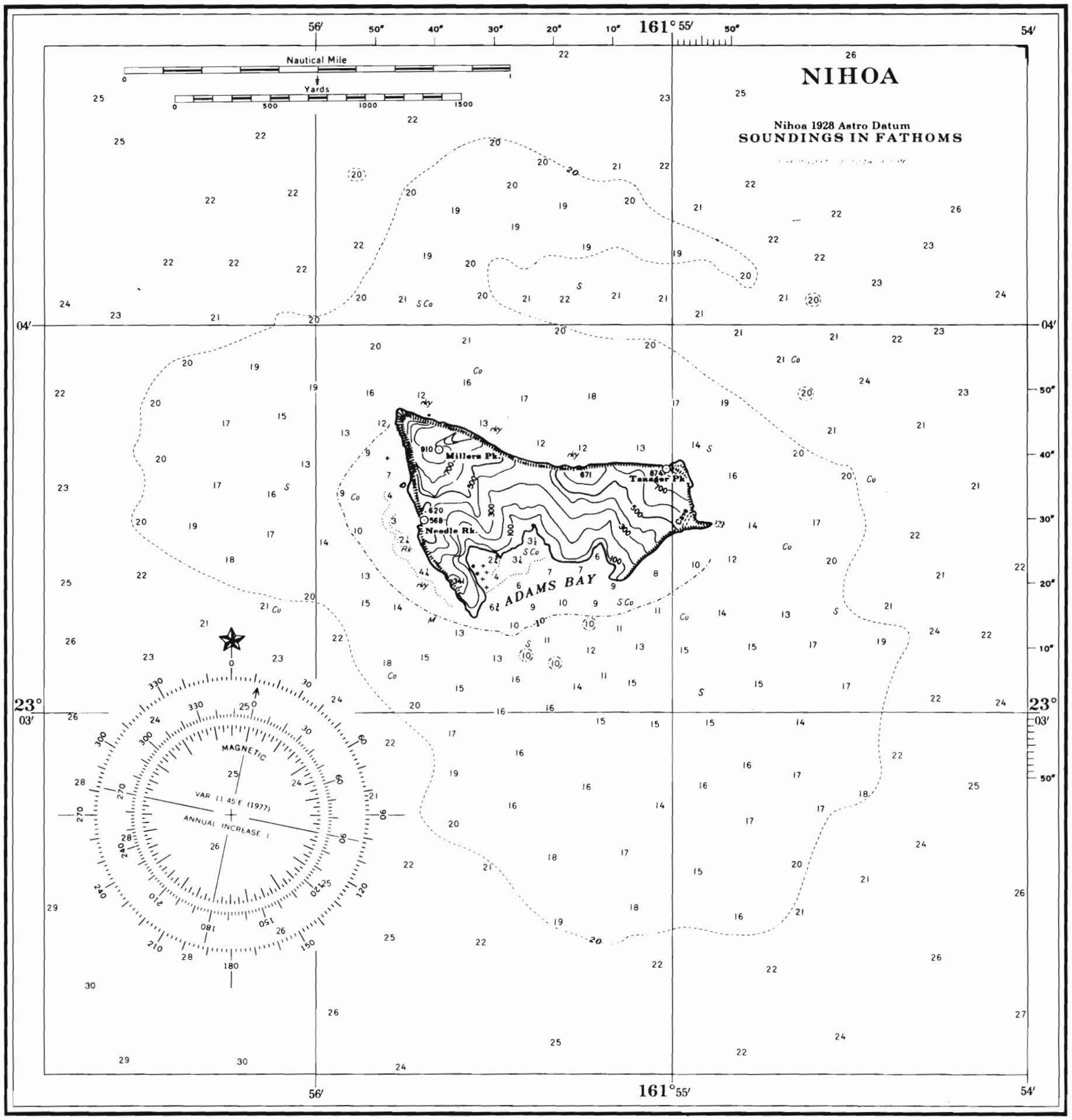

Figure 2.—Nihoa (National Ocean Service chart 19016).

Nihoa Island

The first of the uninhabited islands to the northwest of the main islands is Nihoa, located at lat. 23°06′N, long. 161°58′W, roughly 170 nmi west northwest of Kauai (Fig. 2). This small volcanic island of 0.7 nmi^2 (Carlquist 1970) is 1.4 km long, averages about 457 m wide, and is the largest of the lava islands west of Niihau. The island has two peaks—Miller's Peak on the western end rises 273 m above sea level and Tanager Peak on the eastern end rises 260 m. A broad swale separates these peaks (McDonald and Abbott 1970).

The northern edge of Nihoa is an abrupt cliff which plunges directly from the crest of the island into the sea. The southern side is gently sloped to low bluffs near the coast which is truncated by a cliff 15-30 m high. At the cliff's base is a wave-cut platform about 1.2-2.4 m above sea level. The east and west ends of the island are also bounded by cliffs (Emory 1928; McDonald and Abbott 1970).

Extending northwestward from the island for about 29 km is a platform about 37 to 76 m below sea level (McDonald and Abbott 1970). Apparently, the whole northwestern part of this volcanic island, perhaps 32 km across at sea level, has been eroded by wave action.

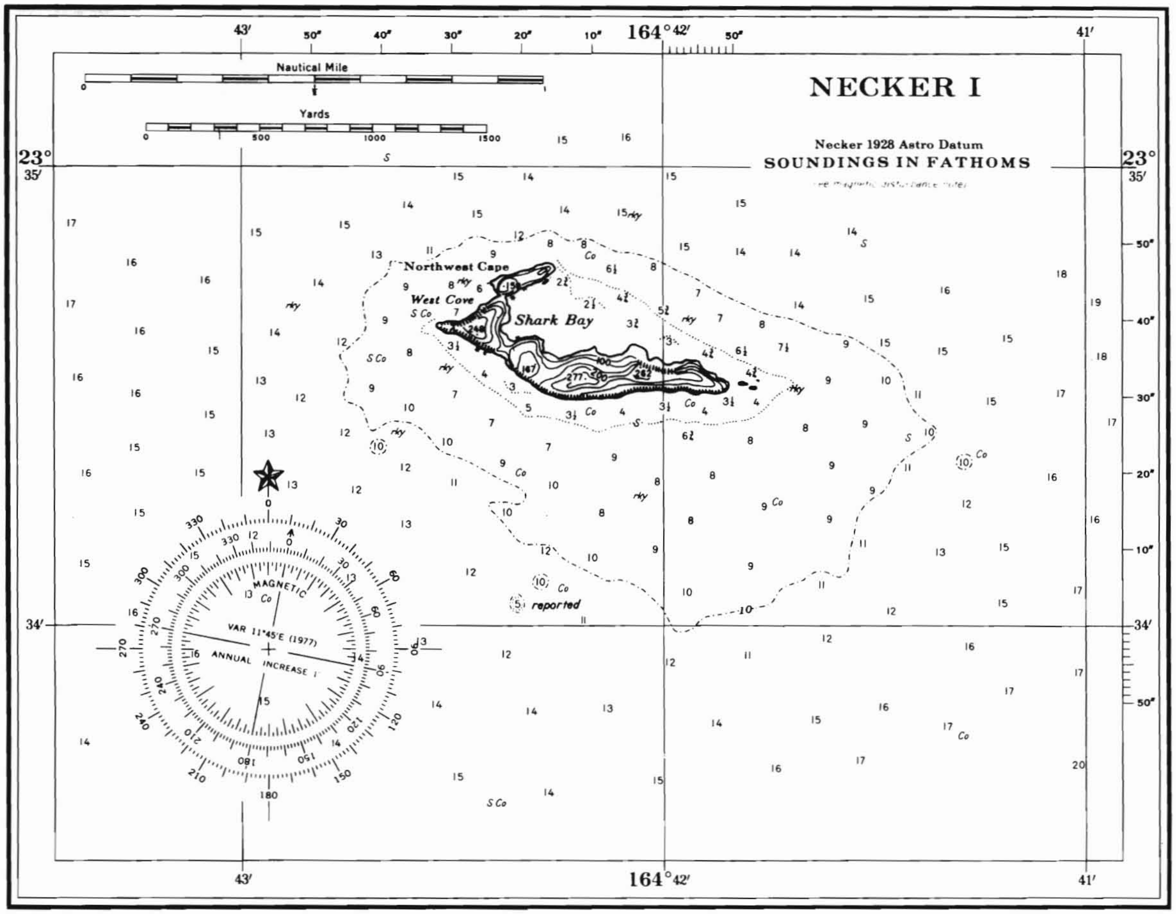

Figure 3.—Necker Island (National Ocean Service chart 19016).

Necker Island

Necker Island is a small 0.2 km^2 narrow island <1,200 m long and about 150 m wide (McDonald and Abbott 1970) located about 300 nmi northwest of Niihau at lat. 23°34′N, long. 164°42′W (Fig. 3). Its highest point is 84 m above sea level. It is shaped like a fishhook with the shank lying in an east-west direction and the barb pointing northeast (Emory 1928). At the east end is an islet about 61 m long and 23 m wide that is generally awash. Necker Island lies on a shallow, roughly oval platform which is 61 km long in the northwest-southeast direction and about 32 km wide (McDonald and Abbott 1970).

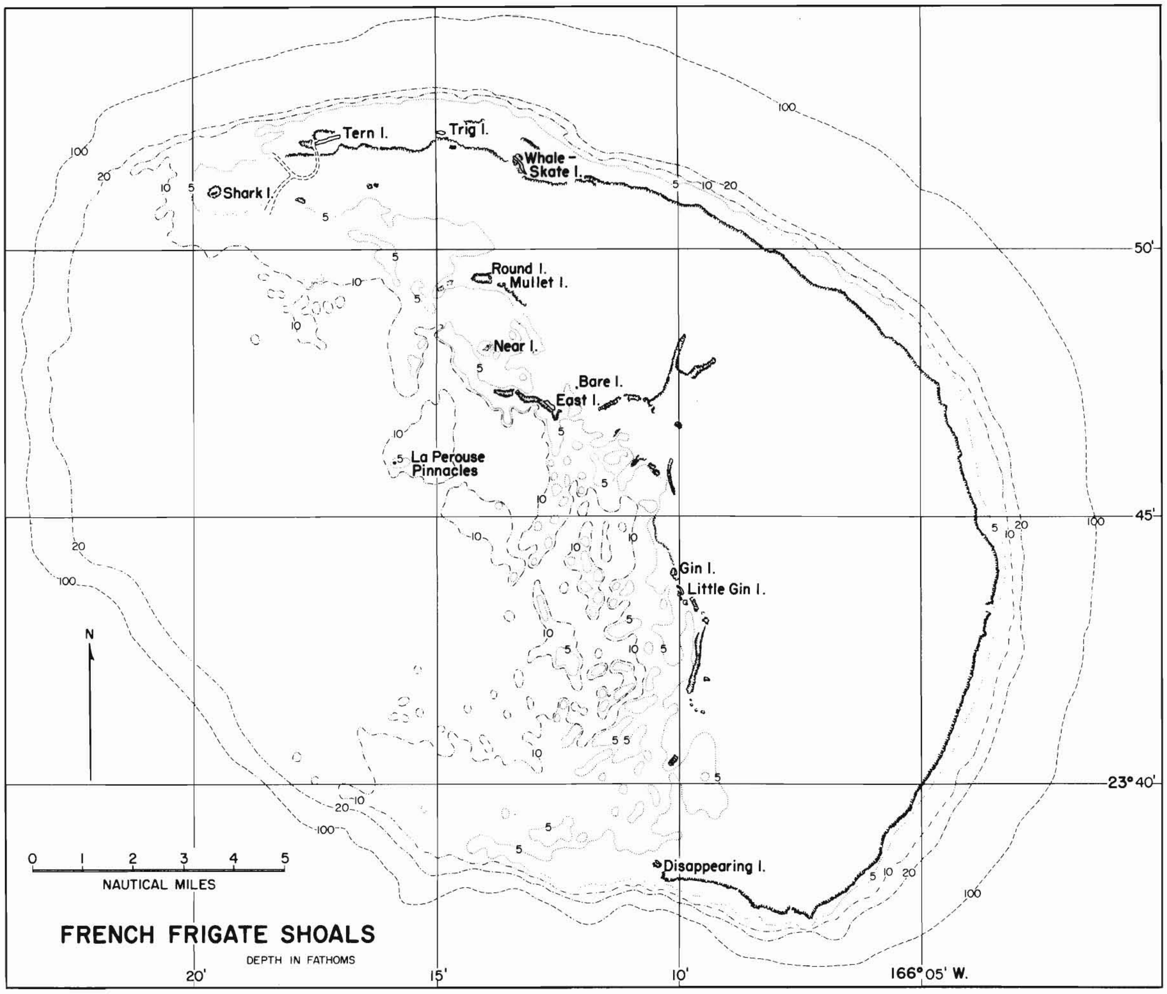

Figure 4.—French Frigate Shoals (adapted from National Ocean Service chart 19401).

French Frigate Shoals

Located at the midpoint of the Hawaiian Archipelago at lat. 23°45′N, long. 166°10′W, French Frigate Shoals (Fig. 4) is about 735 nmi northwest of the eastern tip of the Island of Hawaii and 780 nmi southeast of Kure Atoll (Amerson 1971). There are 13 small islets in the lagoon; 12 are low and sandy with sparse or no vegetation and one island is volcanic rock.

The atoll consists of a crescent-shaped reef on a platform, which to a depth of 55 m, covers about 648 km^2. The atoll, with the long axis stretching northwest-southeast 35 km, is actually a double crescentic reef (Amerson 1971). The 363 km^2 lagoon is 13 km wide at its midpoint. The broken inner arc of the reef is 33 km long and the almost continuous outer arc of the reef is 57 km long. The crescent tips, pointing westward, are about 28 km apart. La Perouse Pinnacle, which lies on an imaginary line between these two tips, is about 11 km southeast of the northern tip and 17 km northwest of the southern tip (Palmer 1927; Amerson 1971).

The 12 sand islands of French Frigate Shoals have an area of 0.4 km^2 of which 0.1 km^2 is covered with vegetation (Amerson 1971). Two exposed volcanic rocks exist near the center of the oval platform. Islands with well established vegetation include East, Tern, Trig, and Whale Islands. Skate and Little Gin Islands, although quite large, are only sparsely vegetated. Two other large islands—Gin and Disappearing—are without vegetation and La Perouse Pinnacle, in spite of its size and height, supports no vegetation. The rest—Bare, Mullet, Near, Round, and Shark Islands—are sandbars that shift continuously. Three other nameless sandy islets are submerged during periods of high tide.

Tern Island, the largest island in the atoll located near the northwest tip of the crescent, is largely a man-made island about 945 m long (Amerson 1971). A runway 76 m wide extends the length of the island. Formerly the site of a U.S. Coast Guard loran station, it is presently a FWS field station.

Shaped like a saddle, La Perouse Pinnacle (lat. 23°45′N, long. 166°15′W) is 6 nmi south-southwest of Tern Island and 3 nmi west-southwest of East Island (Amerson 1971). The main pinnacle at the northwestern end rises 37 m above sea level and is nearly as high (36 m) at the southeastern end. The main rock is roughly 222 m from northwest to southeast and 50 m at its widest point. A second rock, lying 119 m northwest of the main pinnacle, rises about 3 m above sea level and is about 61 m long and 20 m wide.

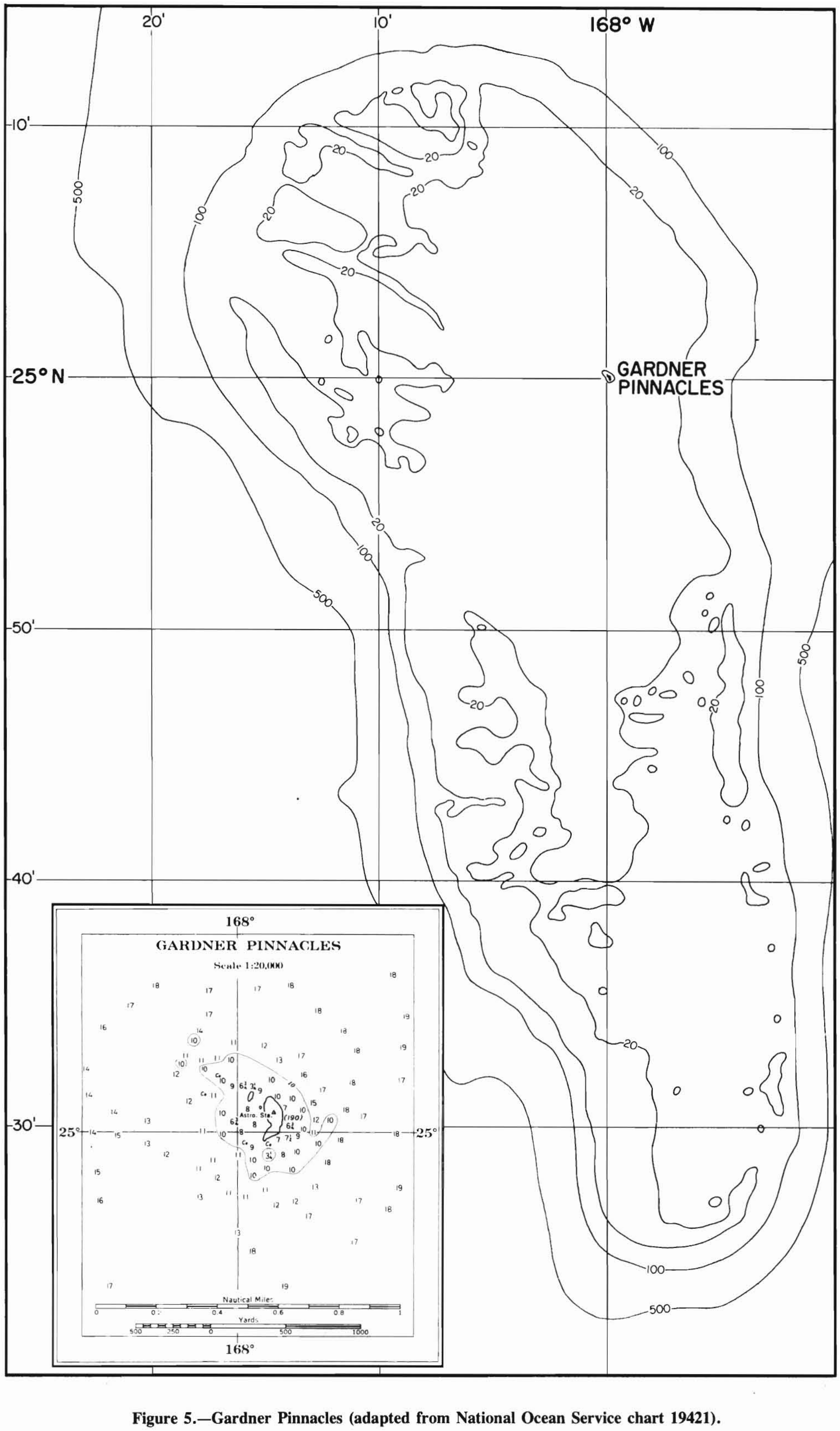

Figure 5.—Gardner Pinnacles (adapted from National Ocean Service chart 19421).

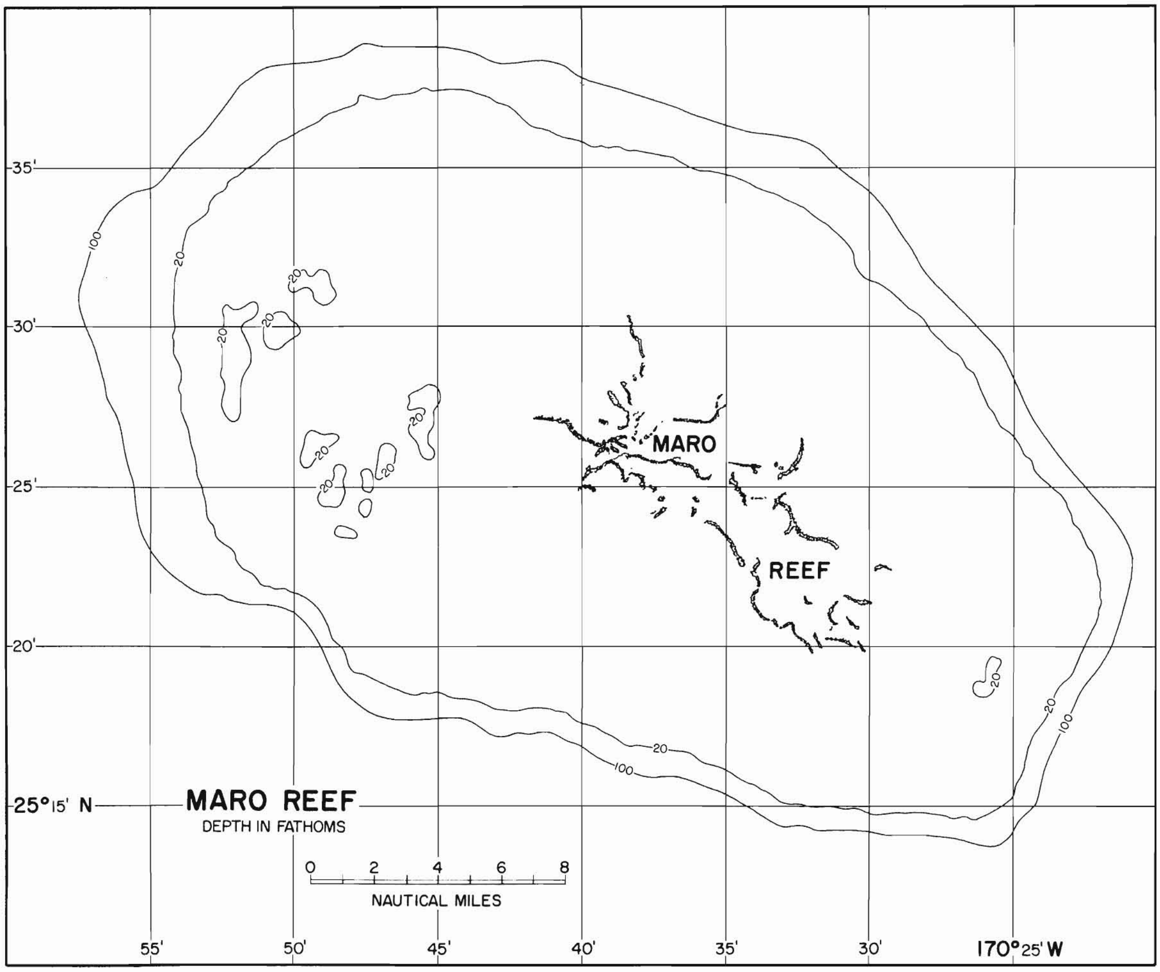

Figure 6.—Maro Reef (adapted from National Ocean Service chart 19441).

Gardner Pinnacles

Gardner Pinnacles (Fig. 5), which consists of two small volcanic rocks, is located at lat. 25°00′N, long. 167°55′W (Clapp 1972). Gardner Pinnacles are the westernmost volcanic islands in Hawaiian waters and stand on the northeastern part of a bank which is 32 km wide and 80 km long in depths ranging between 16 and 73 m.

The northwestern peak, the smaller of the two islands, rises about 30 m above sea level and is about 76 m long and 30 m wide (Clapp 1972). About 46 m to the southeast is the larger peak, which is about 213 m long and 152 m wide (Palmer 1927; Bryan 1939). The larger peak formerly rose to 52 m, but its height was reduced by blasting in 1961 to provide sites for astronomical stations. The two islets have an overall area of about 0.01 km^2. From a distance, Gardner Pinnacles have a snowcapped appearance because of the coating of guano (Freeman 1951; Clapp 1972).

Maro Reef

Maro Reef (Fig. 6) (lat. 25°25′N, long. 170°35′W), is about 80 nmi east southeast of Laysan Island. It is situated on a shallow bank, which is approximately 57 km long and 33 km wide and is presumably the truncated top of another large shield volcano (McDonald and Abbott 1970). The reef itself is about 22 km long and 9 km wide.

Within the 183-m contour, the bank extends east-west about 70 km and about 42 km north-south. There are numerous coral heads in and around the reef ranging between 2 and 18 m deep.

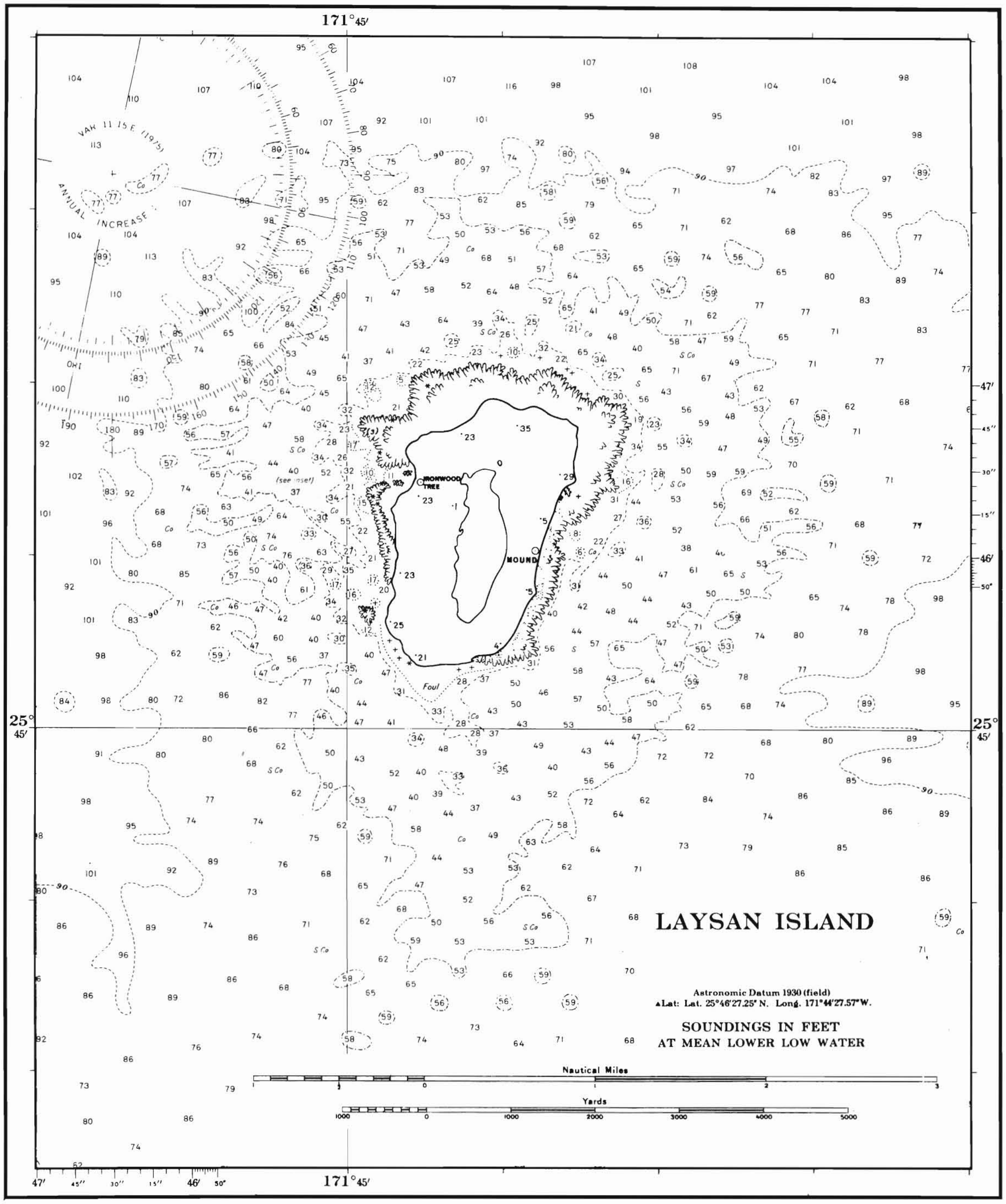

Figure 7.—Laysan Island (National Ocean Service chart 19442).

Laysan Island

Laysan Island (Fig. 7), roughly rectangular with the long axis slightly east of north, is the largest of the NWHI and is located at lat. 25°42′N, long. 171°44′W (Ely and Clapp 1973). Situated 115 nmi east of Lisianski, 202 nmi northwest of Gardner Pinnacles, and 709 nmi northwest of Honolulu, Laysan Island is 2.8 km long and just over 1.7 km wide. The total area is slightly under 4 km^2.

The island is capped by large sand accumulations and has a large saltwater lagoon occupying about one-fifth of the island's interior (Ely and Clapp 1973). A relatively shallow bank surrounds the island for some distance offshore; beyond that, the bottom drops off precipitously to an average depth of 3,292 m. The 180-m contour around Laysan Island encloses an area of about 544 km^2 (Warner 1963). The maximum elevation of just over 12 m is found in the sand dune area at the north end of the island.

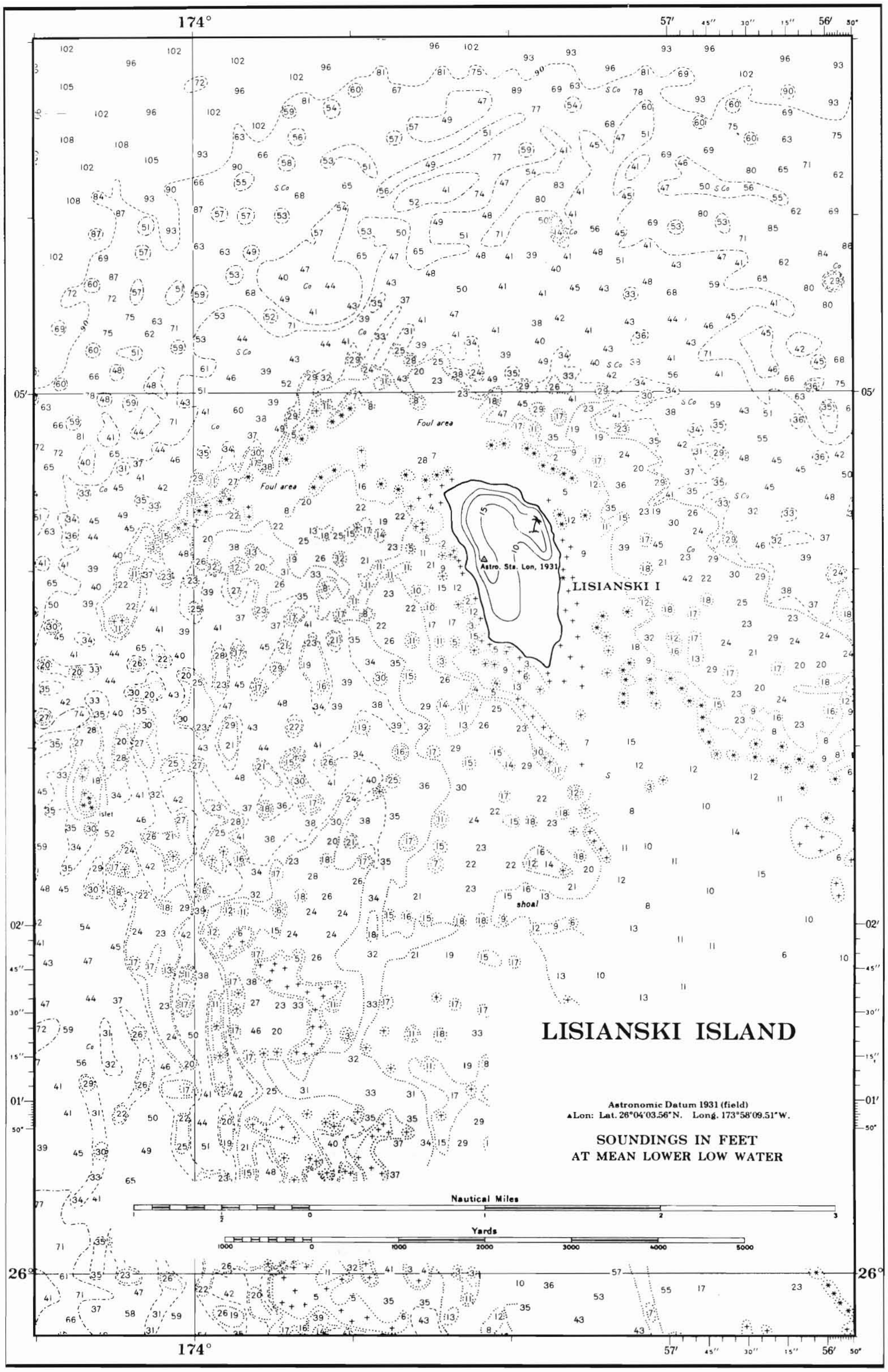

Figure 8.—Lisianski Island (National Ocean Service chart 19442).

Lisianski Island

Lisianski Island (Fig. 8) is a low sand and coral island of approximately 1.8 km^2 which is situated at lat. 26°02′N, long. 174°00′W (Freeman 1951; [U.S.] Office of Geography 1956). Located about 905 nmi northwest of Honolulu, Lisianski Island is at the northern end of a large, approximately 168 km^2 reef bank (Clapp and Wirtz 1975). The island (ringed mostly by sand and sand-coral beaches with the exception of the reef rock and small tidal pools) has a circumference roughly 5 km and resembles a parallelogram with the north-south axis about 1.8 km long and the east-west axis 1.0 km wide.

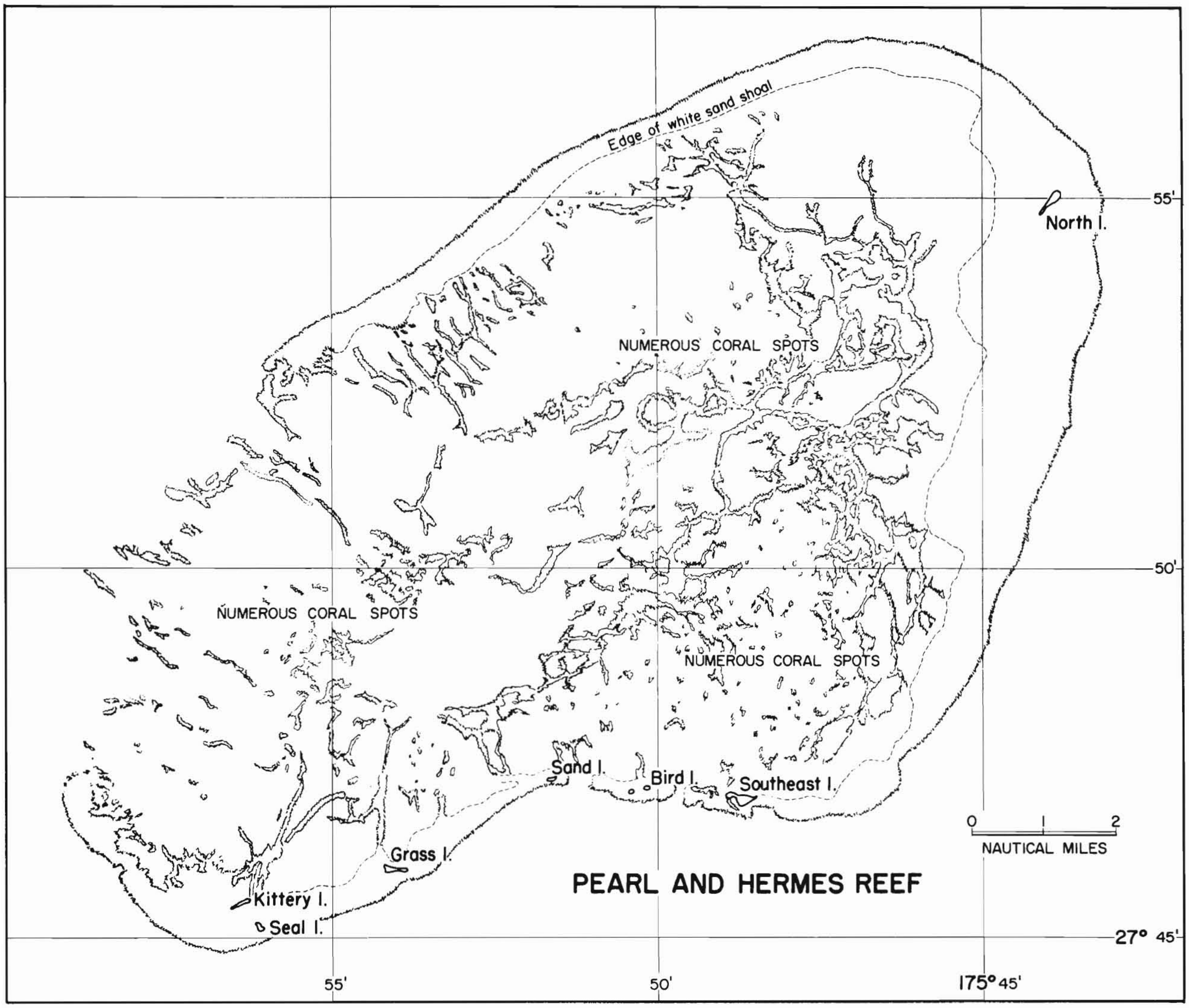

Figure 9.—Pearl and Hermes Reef (adapted from National Ocean Service chart 19461).

Pearl and Hermes Reef

Eighty-seven nautical miles east southeast of Midway and about 1,042 nmi northwest of Honolulu is Pearl and Hermes Reef (Fig. 9), a low coral atoll near the northwestern end of the Hawaiian Archipelago at lat. 27°55′N, long. 175°45′W (Amerson et al. 1974). This atoll has been known as Pearl and Hermes Reef since two ships bearing these names were wrecked there in 1822.

The fringing reef has a circumference of 69 km and is open to the west (Thorp 1936). The long northeasterly axis of the elliptical enclosed area is 32 km and the broadest point is 19 km. The area within this reef covers 370 km^2. Nine islands within the reef cover 0.3 km^2 (Amerson et al. 1974). Grass, North, Seal, and Southeast Islands have established vegetation; Little North Island, which has continued to emerge since it was first reported as a sandbar awash at high tide, has limited vegetation. Kittery Island is low and subject to occasional inundation despite its size and relative permanence. The remaining three islands—Bird, Planetree, and Sand—are shifting sandbars. Historical and recent data suggest that considerable changes in the topography of Pearl and Hermes Reef have occurred in the past 100 years as a result of continuous shifting, splitting, and reforming of sandspits (Gross et al. 1969; Amerson et al. 1974).

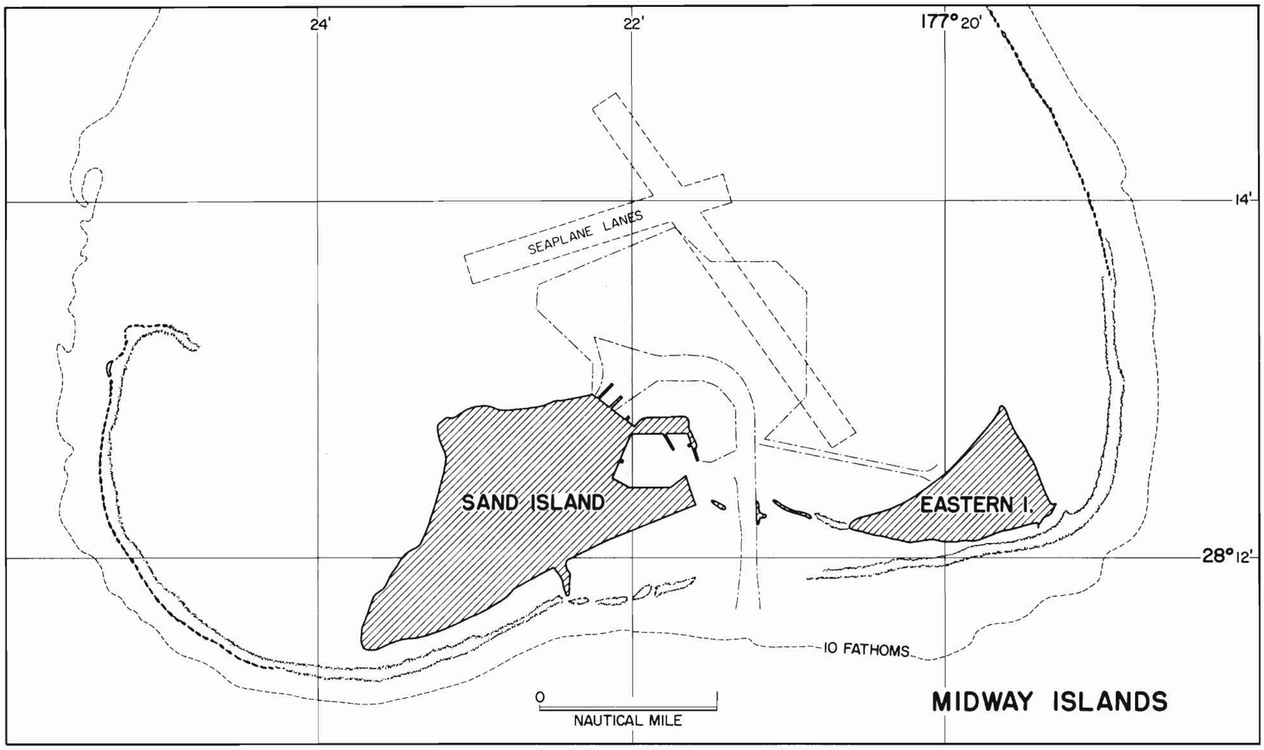

Figure 10.—Midway (adapted from National Ocean Service chart 19481).

Midway

Lying about 1,134 nmi west northwest of Honolulu at lat. 28°12′N, long. 177°23′W, Midway is near the extreme western end of the Hawaiian Archipelago and consists of two islands (Fig. 10). These islands are situated in the southeastern part of a lagoon, which is within a protective coral reef 24 km in circumference. The coral reef is submerged in some places but about 1.2-1.5 m above sea level in others. Sand Island, on which the runway is built, is 2.4 km long and 1.5 km wide (Bryan 1942) and is the larger of the two islands. About 1.5 km east of Sand Island is the triangular Eastern Island, which measures about 2.0 km long and 1.3 km wide. The entrance to the lagoon is on the south side between the two islands (Tudor 1972). Midway is presently under administrative control of the Department of the Navy.

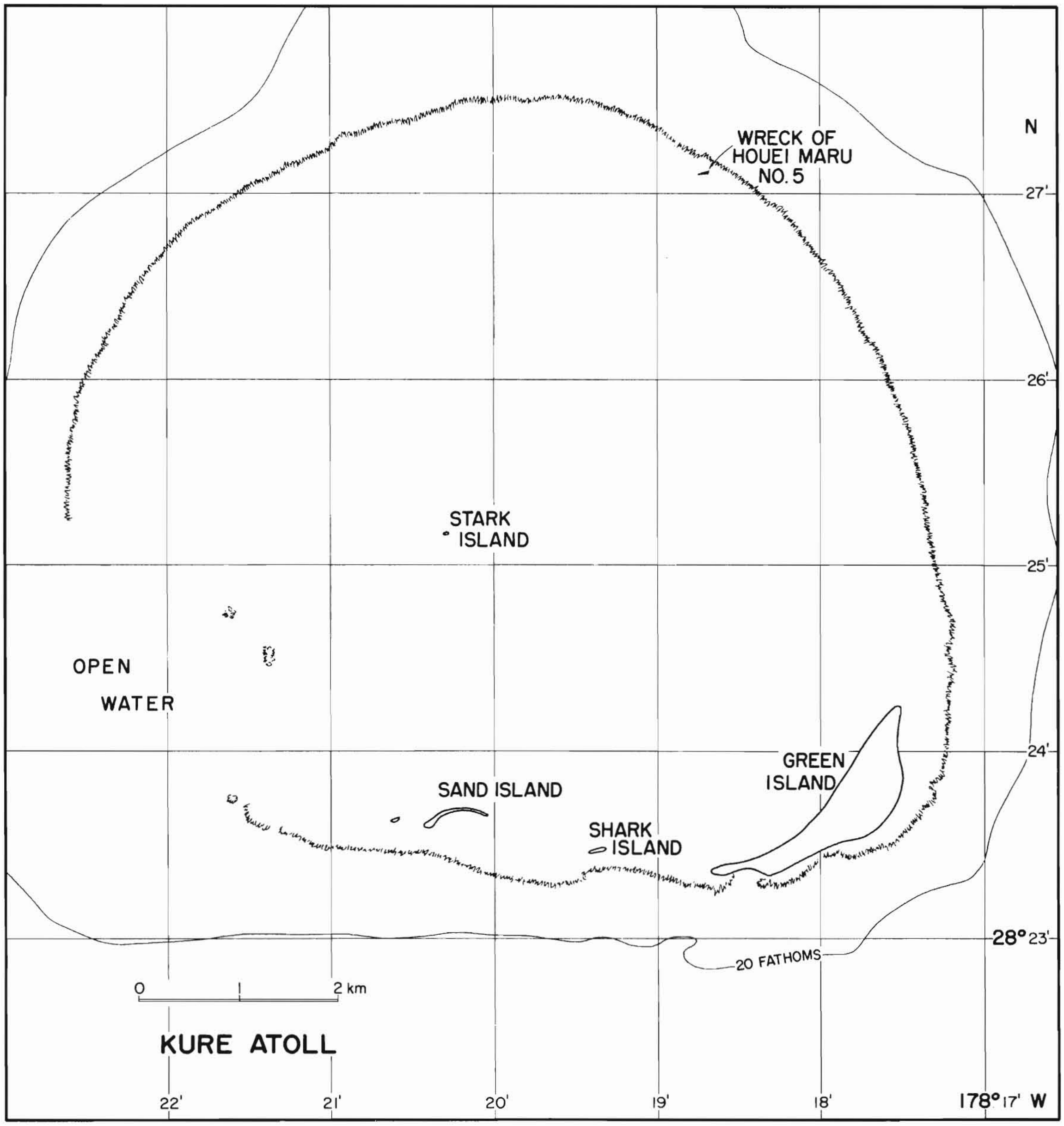

Figure 11.—Kure Atoll (adapted from National Ocean Service chart 19483). Although the opening to Kure Atoll is indicated as "open water," it is not navigable.

Kure Atoll

The northernmost coral atoll in the world, Kure Atoll is also the westernmost land of the NWHI (Fig. 11). It is located at lat. 28°25′N, long. 178°10′W, about 1,175 nmi northwest of Honolulu and 2,165 nmi southeast of Tokyo (Woodward 1972). The closest neighboring island is Midway, 49 nmi to the southeast. Situated atop a submerged volcano, it is nearly circular; the maximum diameter is about 9 km. The outer reef almost completely encircles the lagoon except for passages to the southwest. The reef is about 5 km^2, the lagoon depth is about 14 m (Gross et al. 1969).

The only permanent land in the atoll is crescent-shaped Green Island located near the fringing reef in the southeast part of the lagoon (Woodward 1972). Its long axis curves north to west 2 km and the maximum width is 0.6 km. The ocean side of Green Island is devoid of sand dunes and the elevation here does not exceed 5 m. The lagoon side is dominated by a series of sand dunes which vary up to 8 m high. The dunes decrease in elevation southwest along the beach, whereas, eastward behind them is a low, relatively flat, depression in the surface with elevations varying from 2 to 3 m.

The dominant feature of Kure Atoll is the U.S. Coast Guard 190-m loran tower and transmitter building complex near the center of the island (Woodward 1972).

UNDERSEA FEATURES

There are several undersea features intermixed among the islands, atolls, and reefs in the NWHI. Some have names and are classified as banks or seamounts ([U.S.] Board on Geographic Names 1981). Others have unofficial common names but many remain nameless and unclassified. For convenience in discussing these nameless undersea features within our area of study, we used the general term "bank" and gave them numerical designations.

Middle Bank

Located at lat. 22°42′N, long. 161°02′W about 67 nmi northwest of Niihau, Middle Bank is between 35 and 75 m beneath the sea surface. This bank is about 18 km along the northwest-southeast axis and 15 km along the northeast-southwest axis.

West Bank Nihoa

This relatively flat bank is located about 19 nmi west southwest of Nihoa at lat. 22°58′N, long. 162°14′W. Based on NOS charts, West Bank appears to be an extension of the bank on which Nihoa Island is situated. The depth of the area between Nihoa's main bank and West Bank is only about 338 m, whereas the slope surrounding the two banks drops off abruptly to more than 3,660 m. The long axis of the bank is oriented east-west and is about 27.4 km long. The shorter north-south axis of the bank is 21.9 km. The shallowest part of the bank is 20 m.

Bank 1

Bank 1 is one of four small banks and pinnacles located almost midway between Nihoa and Necker Island at lat. 23°15′N, long. 162°55′W. This flat bank has a long east-west axis of about 14.4 km, whereas the shorter north-south axis is 7.6 km. The shallowest depth is 53 m.

Bank 2

Bank 2 is a small, 16 m deep (to the top) pinnacle located at lat. 23°18′N, long. 163°02′W.

Bank 3

This small, flat, nearly oval bank is located at lat. 23°13′N, long. 163°09′W. The shallowest part is 60 m. The longer axis of 11.1 km is oriented east-west, whereas the shorter axis of 10.2 km is oriented north-south. Banks 1 and 3 are commonly referred to as Twin Banks.

Bank 4

Bank 4 is a small pinnacle 148 m below the sea surface located at lat. 23°19′N, long. 163°36′W.

Bank 5

This pinnacle is located at a depth of about 18.3 m at lat. 23°49′N, long. 164°28′W.

Bank 6

Sometimes called the 66-fathom bank, this pinnacle is located 28 nmi due east of Tern Island, French Frigate Shoals at lat. 23°50′N, long. 165°49′W.

Brooks Banks

Brooks Banks include a complex of three shallow banks on a long, narrow ridge that extends northwestward from French Frigate Shoals to St. Rogatien Bank then due north to parallel the large bank on which Gardner Pinnacles is located. The southeast bank, which has the shallowest depth of 51 m, is about 7.4 km long and 6.5 km wide, and is located at lat. 23°58′N and long. 166°42′W. The middle bank (lat. 24°07′N, long. 166°49′W) is about 25.6 m at the shallowest depth. It is roughly 17.8 km along the longer north-south axis and 12.6 km along the east-west axis. The northernmost bank of this group lies at lat. 24°12′N, long. 166°58′W. It is about 16.7 km long along the north-south axis, 13 km wide along the east-west axis, and its shallowest depth is 20 m.

St. Rogatien Bank

This is a relatively large bank located at lat. 24°25′N, long. 167°15′W. The shallowest place is 22 m; it is 27.8 km long in the north-south axis and 20.4 km wide in the east-west axis.

Bank 7

Located northwest of St. Rogatien Bank, this flat bank is at lat. 24°36′N, long. 167°18′W; the shallowest depth is 54.9 m. The bank is relatively small measuring 11.7 km long in the northwest-southeast axis and 8.2 km wide in the northeast-southwest axis.

Raita Bank

Raita Bank is a flat, relatively large bank located 65 nmi east northeast of Maro Reef at lat. 25°35′N, long. 169°35′W. Its long (41.1 km) axis is oriented roughly north northeast to south southwest and the shorter northwest-southeast axis is 20.8 km. The shallowest depth is about 16.4 m.

Northampton Seamounts

The Northampton Seamounts were transected in May-June 1980 on *Cromwell* cruise 80-03; they appear to be a group consisting of one large and three smaller pinnacles. The main pinnacle is located at lat. 25°18′N, long. 172°04′W and the shallowest depth is 31 m. The Y-shaped arrangement of the three pinnacles has a 31.0 km axis oriented northwest-southeast; the northeast-southwest axis is about 24.1 km. The northernmost pinnacle among three that are located to the northwest of the main summit is situated at lat. 25°36′N, long. 172°24′W and has a depth of 54.9 m. The pinnacle to the south is at lat. 25°32′N, long. 172°22′W and is 69.5 m deep. The southernmost pinnacle is 91.4 m deep and is located at lat. 25°24′N, long. 172°28′W.

Pioneer Bank

Pioneer Bank (officially Pioneer Tablemount) is about 33 nmi due east of Lisianski Island at lat. 26°00′N, long. 173°25′W, and is relatively large, measuring 31.5 km along the northeast-southwest axis and 17.4 km along the northwest-southeast axis. The shallowest depth of this bank is 31.1 m.

Bank 8

Approximately 40 nmi northwest of Lisianski Island at lat. 26°17′N, long. 174°34′W, is a relatively small bank with a shallowest depth of 64.0 m. The bank is flat and the northwest-southeast axis is 17.6 km. The northeast-southwest axis is about 7.4 km.

Bank 9

Located about two-thirds of the distance between Lisianski Island and Pearl and Hermes Reef at lat. 27°00′N, long. 175°15′W, Bank 9 is a pinnacle with a depth of 115.2 m. It is a narrow bank, about 2.1 km at its greatest width and extends 6.5 km north-south.

Salmon Bank

Salmon Bank is located at lat. 26°56′N, long. 176°28′W. The bathymetric surveys to 914.4 m over Salmon Bank during *Cromwell* cruises 80-02 and 80-03 indicated that the bank was relatively flat with a shallowest depth of about 54.9 m. The northwest-southeast axis of the bank is 20.6 km; the northeast-southwest axis is 10.9 km. The [U.S.] Board on Geographic Names (1981) classified this bank as a seamount.

Gambia Shoal

Reported at lat. 28°07′N, long. 176°38′W, this bank was never located during our surveys, despite transecting the area on two cruises. The position given, therefore, appears to be doubtful. The top of this shoal is reported to be 25.6 m.

Ladd Seamount

Ladd Seamount is located about 44 nmi northeast of Midway at lat. 28°32′N, long. 176°40′W. This seamount is somewhat flat but rough with numerous outcroppings and sloped on the eastern and western sides; the shallowest area is 64.0 m. The north northwest to south southeast axis is 19.4 km; the northeast-southwest axis is 13.0 km. The bottom type is calcareous deposits covered by sand and seashells (Japan Marine Fishery Resource Research Center (JAMARC) 1973).

Nero Seamount

Poorly charted and unsurveyed in the past, this seamount, located about 38 nmi southwest of Midway, was surveyed extensively between June and November 1980 on *Cromwell* cruises 80-03 and 80-05 (Uchida and Tagami 1984b). The preliminary smooth-plot boat sheets prepared from the unprocessed and unverified depth data indicate that the shallowest depth on Nero Seamount is 62.2 m. It measures 15.8 km long along the northwest-southeast axis and 12.0 km wide along the northeast-southwest axis, and is located at lat. 27°57′N, long. 177°58′W. Six nautical miles west of Nero Seamount is Pogy Bank which has a least depth of 75 m (Grace 1974).

Bank 10

Bank 10 is located 40 nmi northwest of Kure Atoll, at lat. 28°58′N, long. 178°42′W. The depth of the seamount summit is 329.2 m. The dimensions of this seamount are unknown.

Bank 11

About 55 nmi due west of Bank 10 is an unnamed seamount at lat. 28°53′N, long. 179°38′W. Dimensions are not available from NOS charts, and no hydrographic reconnaissance survey was made on this seamount. Data from Japanese sources, however, show that Bank 11 averages <180 m deep, and extends 2.8 km in the east-west axis and 3.0 km along the north-south axis. (There is no indication at which depth these dimensions were taken.) The eastern edge of this seamount is steep whereas the western side is gently sloped. The summit is rough (JAMARC 1973).

Bank 12

Bank 12 (lat. 30°23′N, long. 178°14′W), is a seamount located about 125 nmi north of Kure Atoll. The depth to the summit is about 54.9 m. No detailed information is available on this seamount.

Hancock Seamounts

Hancock Seamounts consist of two seamounts—one called the Northwest (NW) and the other Southeast (SE). At NW Hancock, which is located at lat. 30°15′30″N, long. 178°42′54″E, the shallowest point is 263 m. The north-south axis, which is the flat part of the seamount, is narrow and is only about 1.3 km long. Once past the flat portion, the slope is steep on all sides. The east-west axis measures about 0.9 km (JAMARC 1973).

Southeast Hancock (lat. 29°47′24″N, long. 179°03′36″E) is approximately 34 nmi southeast of NW Hancock. This seamount has two summits. The northwest summit is flat but narrow and the shallowest spot is 265 m. The flat area is roughly oval, about 1.8 km in diameter, but once past the flat area, the bottom becomes steep. The southeast summit, sometimes referred to as K Bank, is sloped and rugged; the shallowest spot is 454 m. The trawlable area is small. The northern and southern edges of SE Hancock slope steeply; whereas, the western edge is relatively smooth and slopes gradually (JAMARC 1973; Japan Fisheries Agency 1974).

CLIMATE OF NORTHWESTERN HAWAIIAN ISLANDS

Along the Hawaiian chain, the marine influence upon the climate is significant because of the archipelago's extreme insularity (U.S. Weather Bureau 1961). Around the main islands, the mountains, especially the massive ones on Hawaii and Maui, strongly modify this marine effect and the result is that conditions are somewhat continental in some localities. In the NWHI, however, the low profile of the islands and atolls results in conditions that are almost wholly marine and tropical.

The climatological data presented in the following sections for the NWHI are primarily from NOAA Buoy Station 51001, which was operational in February 1981-August 1982, and from French Frigate Shoals, Midway, and Kure Atoll, the latter three having manned installations. Climatic data collected from Midway Naval Station can be used to describe weather conditions not only at Midway but also at Lisianski Island and Pearl and Hermes Reef (Amerson et al. 1974; Clapp and Wirtz 1975). For a definitive study of weather in Hawaiian waters, the reader is referred to Haraguchi (1979).

Air temperature

A tropical marine environment prevails near Nihoa: mean air temperatures vary within a narrow range, reach a low of 21.6°C in March and a high of 26.3°C in September (Table 2).

At French Frigate Shoals, temperature variations are also typical of a tropical marine environment. The mean annual temperature is 24.2°C and the mean annual range is 5.6°C (Amerson 1971). In December-April, the means vary between 21.7° and 23.3°C; whereas in May-November, they vary from 23.9° to 26.7°C. August and September are the warmest months; February and March the coolest. The extreme high is 32.8°C and the extreme low 12.2°C. Figure 12 shows the mode of the mean monthly temperatures at French Frigate Shoals from December 1950 to December 1962.

Temperatures at Midway also show a mean monthly range indicative of a subtropical marine environment (Mauck 1975). Monthly mean temperatures vary from 18.9° to 20.6°C between December and April and from 21.1° to 27.2°C in May-November. The warmest months are July, August, and September and the coolest are January, February, and April. The extreme high is 31.7°C and the extreme low 11.1°C. The monthly maximum, minimum, and range of mean temperatures at Midway in 1953-63 are shown in Figure 13.

Kure Atoll's climate is subtropical marine and is influenced primarily by two air masses and by the surrounding ocean where changes in sea-surface temperatures and salinities are relatively small (Seckel 1962; Woodward 1972). The average maximum varies from 18.2° to 29.4°C, and the average minimum from 14.4° to 23.9°C. The extremes are 3.8° and 37.2°C. From December to April, the semimonthly maximum averages 21.1°C, but in May, June, and November, the averages vary between 21.1° and 26.7°C. Averages from 26.7° to 32.2°C occur from June to October. The average

Table 2.—Monthly mean values of various meteorological and oceanographic parameters measured hourly at NOAA Buoy Station 51001 (lat. 23°24′N, long. 162°18′W) from its initial deployment in February 1981 to September1982. (To convert wind velocity from meters/second to knots, multiply by 1.9426.)

Parameters	Height of measurement (m)	1981 Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Air pressure (mbar)	0	1,016.3	1,019.6	1,019.3	1,019.2	1,019.3	1,018.4	1,017.7	1,016.6	1,016.9	1,018.6	1,016.6
Air temperature (°C)	5	21.7	21.6	22.5	23.3	24.8	25.3	26.1	26.3	25.5	24.2	22.9
Water temperature (°C)	−1	21.9	22.5	23.7	24.3	25.4	26.1	26.8	27.1	26.4	25.2	23.9
Wave height (m)	0	3.5	2.6	2.4	2.0	1.8	1.9	1.6	1.8	2.1	3.0	3.1
Mean wave period (s)	0	7.1	6.9	6.4	5.8	5.0	5.5	5.2	5.5	5.7	6.7	7.4
Dominant wave period (s)	0	11.9	11.8	9.7	9.4	8.3	8.6	8.6	8.8	10.2	11.0	12.4
Wind velocity, east component (m/s)	5	3.0	3.8	4.1	4.4	5.6	5.9	4.5	4.2	4.4	4.5	1.8
Wind velocity, north component (m/s)	5	2.6	3.7	3.2	2.9	3.5	3.2	3.3	3.4	4.4	5.3	2.8
Wind gust sensor (m/s)	5	9.5	7.7	7.5	7.3	8.2	8.5	7.3	7.2	8.5	9.2	8.3
Wind magnitude (m/s)	5	7.8	6.3	6.0	6.0	7.1	7.0	5.8	5.8	6.9	7.5	6.6
Wind direction (°)	5	116.8	79.4	74.8	84.9	75.2	68.2	76.1	67.4	65.0	62.7	124.7

Parameters	Height of measurement (m)	1982 Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Air pressure (mbar)	0	1,014.4	1,012.6	1,017.7	1,018.5	1,018.0	1,016.8	1,016.8	1,016.6
Air temperature (°C)	5	22.1	22.2	21.6	22.2	23.5	24.8	25.7	26.2
Water temperature (°C)	−1	23.5	24.1	23.1	23.2	24.2	26.0	26.3	26.8
Wave height (m)	0	2.8	3.3	3.3	2.6	2.1	1.5	2.1	2.2
Mean wave period (s)	0	7.0	7.0	6.7	5.9	5.8	5.6	5.2	5.3
Dominant wave period (s)	0	11.0	11.8	10.6	9.2	9.4	8.7	8.3	8.4
Wind velocity, east component (m/s)	5	1.0	<1.0	6.1	6.7	5.6	3.0	6.8	7.5
Wind velocity, north component (m/s)	5	<1.0	0.9	4.4	3.4	1.9	2.6	4.6	3.8
Wind gust sensor (m/s)	5	8.2	10.3	10.8	10.0	8.2	5.8	10.0	10.3
Wind magnitude (m/s)	5	6.5	8.3	8.8	8.2	6.7	4.5	8.3	8.6
Wind direction (°)	5	166.4	178.5	70.0	81.2	85.2	71.4	62.5	70.4

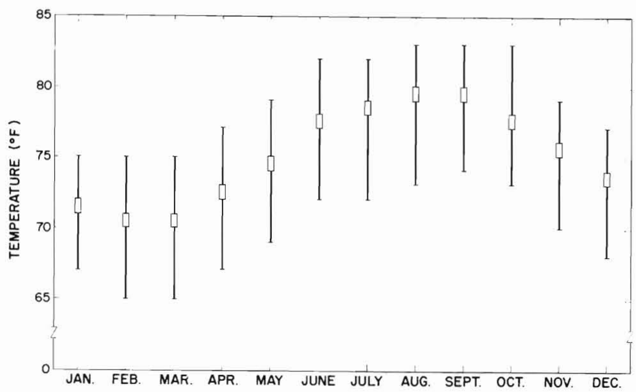

Figure 12.—Modes of monthly temperature means recorded over a 12-year period, December 1950 to December 1962, and the range of the maximum and minimum temperature means for French Frigate Shoals (Amerson 1971).

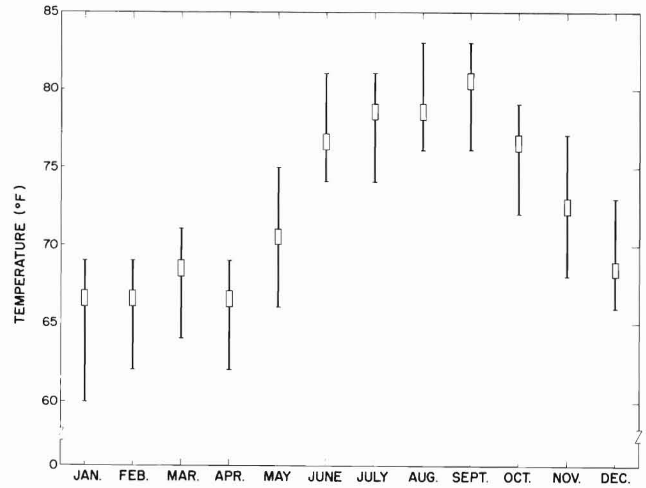

Figure 13.—Monthly temperature means and their maximum and minimum ranges for a 10-year period, 1953-63, at Midway (Amerson et al. 1974).

semimonthly minimum varies between 15.6° and 18.3°C in December-May and between 21.1° and 23.9°C in November.

The coldest months at Kure Atoll are January and February and the warmest are July, August, and September (Woodward 1972). The average temperature usually increases in May although the rise sometimes occurs in June. A decrease in average temperature is usually observed in September or October.

Wind direction and velocities

In this section, we will initially discuss the wind features on a broad scale and follow the discussion with more localized data from French Frigate Shoals, Midway, and Kure Atoll.

There are two prominent climatic features in the North Pacific that define the principal wind belts. These are the North Pacific High, also called the North Pacific Anticyclone, and the Aleutian Low. In general, the Hawaiian climate is characterized by these two natural meteorological seasons.

The North Pacific High, which is the more permanent feature, is from the northeast quadrant and represents an outflow of air from the subtropical pressure maximum. Together with the trade wind zone, it moves north-south seasonally reaching its northernmost limit in May-September at which time the trades prevail 80-90% of the time (Blumenstock and Price 1972). The mean northern limit of the northeast trades extends to lat. 33°N at long. 165°W in July-August and to lat. 36°N at long. 141°W (McGary and Stroup 1956).

High pressure systems north of the Hawaiian Archipelago are not static, particularly during the winter. At this time, highs move eastward from off the Asian Continent and pass within a thousand miles of the islands to replace or merge with the high-pressure system located northeast of the islands (Blumenstock and Price 1972). As these highs move eastward, their characteristics change and the speed of the trades over Hawaiian waters is directly related to the strength, shape, position, and movement of these highs (Haraguchi 1979). The consequence is that when one of these large, strong highs pass north of the islands in winter, trade winds become brisk. These winter highs are also responsible for the occurrence of gale winds in Hawaiian waters.

The Aleutian Low, which is a subpolar pressure minimum, becomes the predominant climatic feature in the North Pacific from October to April (Byers 1944; Namais 1953). During this period, the mean northern limit of the northeast trade wind belt is much farther south, resulting in winds of lower velocities and greater variation in direction as well as in a decrease in their frequency to 50-80%. Its most southern position is at about lat. 23°-24°N in November and February-March at long. 165°W but only during November at these latitudes at long. 141°W (McGary and Stroup 1956). Farther north, the prevailing winds are westerly because of cyclonic circulation around the Aleutian Low and anticyclonic circulation around the North Pacific High. The mean position of the southern boundary of the westerlies is farthest south in January-February when it reaches lat. 30°N between long. 155° and 165°W and extends northeastward to about lat. 34°N at long. 141°W.

Low pressure systems are directly related to kona winds, which are stormy, rain-bearing winds blowing from the opposite direction to the prevailing trades, whether from the southwest or south southwest (Blumenstock and Price 1972; Haraguchi 1979). The center of the low is positioned relatively close to the islands, usually within 500 nmi northwest of the major islands. These strong kona winds attain speeds from 25 to 40 knots and are concentrated over a width of about 200 nmi. Over water, kona winds may inflict considerable damage to boats caught in the open or anchored in locations that are exposed to the southwesterly winds.

At NOAA Data Buoy Station 51001, velocities were recorded for winds and gusts (instantaneous change of 10 or more knots above the low wind speed) prevailing from the east and north (Fig. 14). Although the data collected are only over a period of 19 months and hence not indicative of average conditions, it can be seen that the easterly component was stronger than the northerly, particularly in spring and summer. Gusts, on the other hand, occurred most frequently in March 1982.

French Frigate Shoals is influenced during most of the year by the North Pacific High with easterly trades predominating. In winter, the Aleutian Low moves southward to the Kure Atoll-Midway-Pearl and Hermes area. This affects the North Pacific High slightly and brings increased winds and higher precipitation. At French Frigate Shoals, the record for maximum sustained wind speed is 52 knots from east northeast in December (Amerson 1971). Monthly wind speeds average higher than the annual mean of 12.6 knots in November-April; whereas they are lower in March-October. Seasonal data on prevailing wind direction and speed (Fig. 15) indicate an easterly component. The mean wind speed in winter reaches 14.3 knots; winds usually blow from all directions but the higher speeds are recorded from northwest to east southeast. In

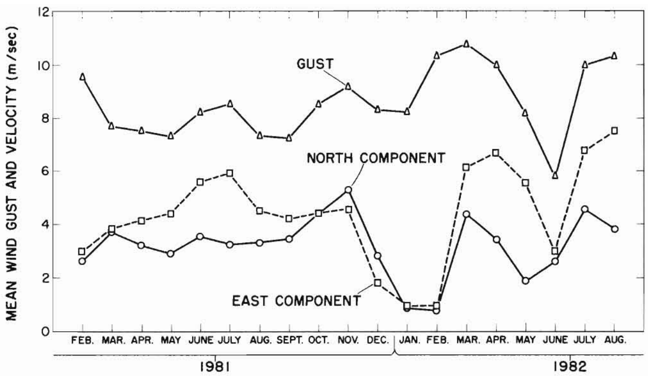

Figure 14.—Monthly mean wind gusts and velocities measured at NOAA Data Buoy 51001 from February 1981 to August 1982. Multiply meters per second by 1.9426 to obtain wind speed in knots (D. B. Gilhouse, Meteorologist, NOAA Data Buoy Center, NSTL Station, MS 39529, pers. commun., 17 August 1983).

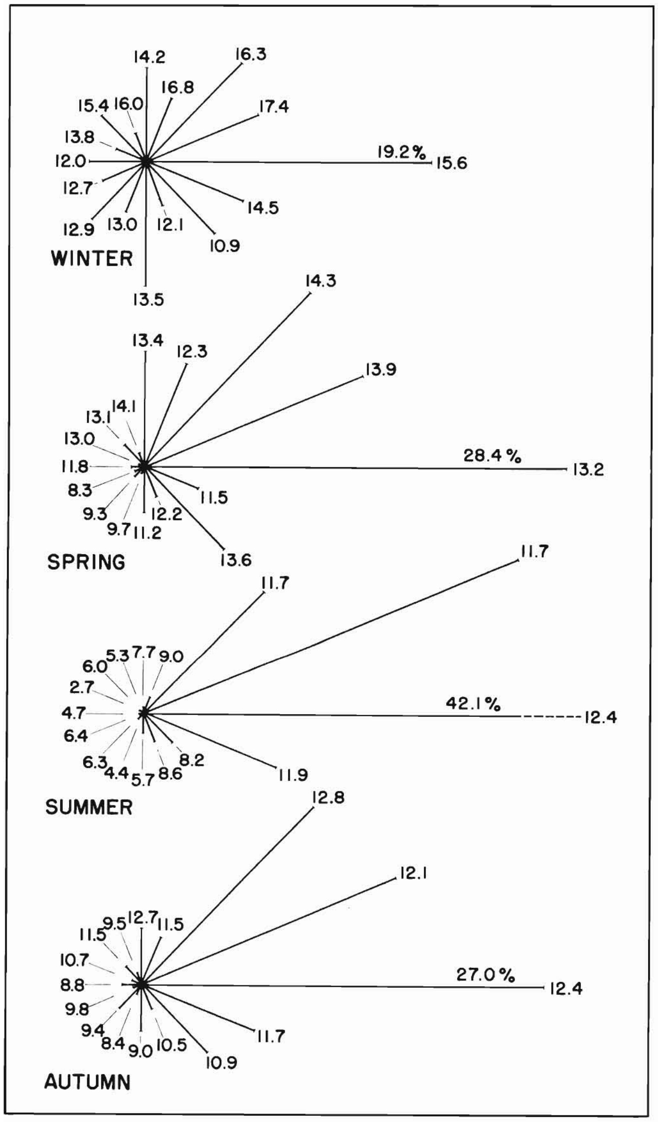

Figure 15.—Wind direction and speed at French Frigate Shoals from December 1950 to December 1962. Length of directional line indicates percent of observations from that direction; figure at end of directional line is mean wind speed in knots (Amerson 1971).

spring, the mean wind speed reaches 13.1 knots and higher speeds are from west to south. The summer wind speeds, which average 11.5 knots, are highest from northeast to east southeast. The change in mean wind speed from summer to autumn is insignificant since autumn winds average only 11.6 knots. During this time, the winds blow strongest from the west northwest and northwest, north through south southeast, and from the northeast.

In general, Midway's climate is influenced by marine tropical or North Pacific air masses depending on seasonal changes (Amerson et al. 1974; Clapp and Wirtz 1975). In summer, the North Pacific High predominates, placing the area around Midway under the influence of northeasterly trade winds (Mauck 1975). Especially in November-January, however, the Aleutian Low moves southward over the North Pacific and displaces the North Pacific High; the result is that the Kure Atoll-Midway area is affected by prevailing winds from the west and by frontal weather. These two atolls experience storms typical of the westerlies, many of which bring colder temperatures.

Winter storms in the Midway area are relatively common and bring significant increases in wind and rain especially in September-December. The prevailing wind is easterly in February-November, westerly in December-January, and averages 10 knots annually (Fig. 16) (Amerson et al. 1974). In July-October, maximum winds blow generally from the east; whereas in November-June, they blow from the west. High winds reaching 35-41 knots occur from September to April. Strong gusts reaching up to 77 knots usually occur in December; in January, gusts are still strong reaching up to 67 knots.

At Kure Atoll, which lies in the path of the northeast trades from the North Pacific High most of the year and because of its position along the southern edge of the Aleutian Low, westerly winds predominate in winter. In November-February, winds are variable but usually have a strong westerly component (Woodward 1972). In March-June and September, winds are again variable but the major component is easterly. The trades usually predominate in July-August when almost all the winds come from the east. Wind speeds range from 0 to 46 knots and the annual means vary between 4 and 7 knots. The strongest winds usually occur in winter and early spring and the weakest in summer.

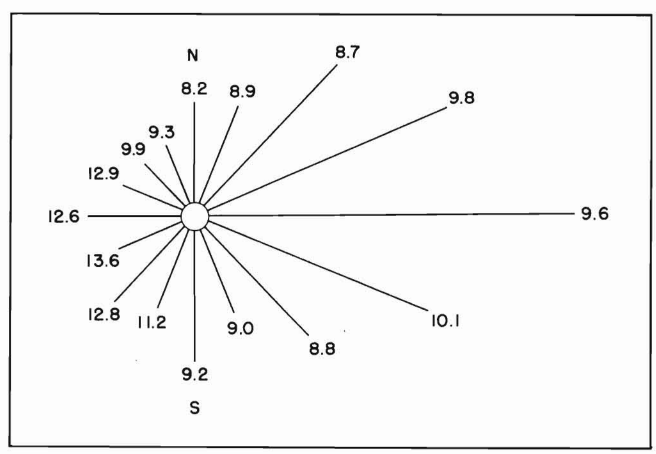

Figure 16.—Wind direction and speed at Midway from 1953 to 1963. Length of directional line indicates percent of observations from that direction; figure at end of directional line is mean wind speed in knots (Amerson et al. 1974).

Rainfall

Annual precipitation at French Frigate Shoals averages 1,150 mm (Amerson 1971). The mean number of days with measurable precipitation reaches 20 or more days in July, August, October, and January and is least frequent in February-June and September (Fig. 17). The heaviest rains are in December-March. Figure 18 shows the mean monthly precipitation in 1954-62 at French Frigate Shoals.

At Midway, May and June are the drier months; whereas July through February are usually wetter (Figs. 19, 20) (Amerson et al. 1974). The annual precipitation averages 1,082 mm. The monthly maximum (up to 129 mm) usually occurs in January and August, but a secondary high of up to 125 mm also occurs usually in October. The minimum which falls as low as 52 mm usually occurs in November. During the summer, rainfall is usually associated with scattered cumulus cloud buildups characteristic of the trade wind region; whereas during winter, the heaviest rainfall is associated with frontal passages (Mauck 1975).

No rainfall data are available from Kure Atoll.

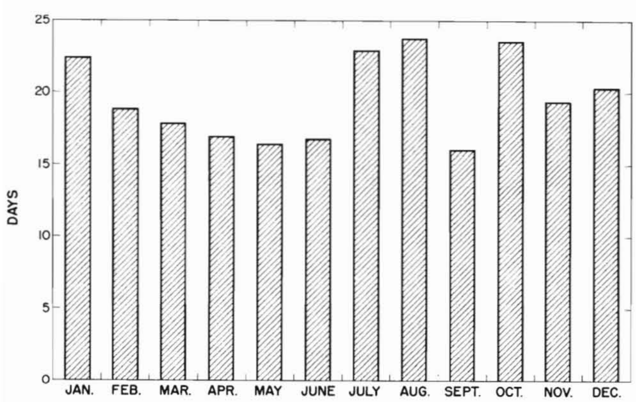

Figure 17.—Mean number of days with measurable precipitation for French Frigate Shoals, June 1954 to January 1960, March 1960 to December 1962 (adapted from Amerson 1971).

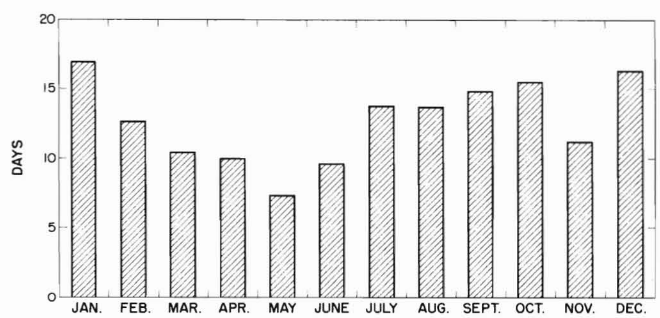

Figure 19.—Mean number of days with measurable precipitation for Midway, 1953 to 1963 (Amerson et al. 1974).

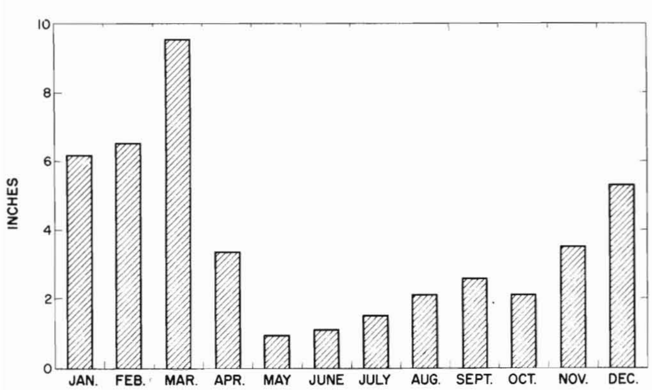

Figure 18.—Mean monthly precipitation in inches for French Frigate Shoals, June 1954 to January 1960, March 1960 to December 1962 (Amerson 1971).

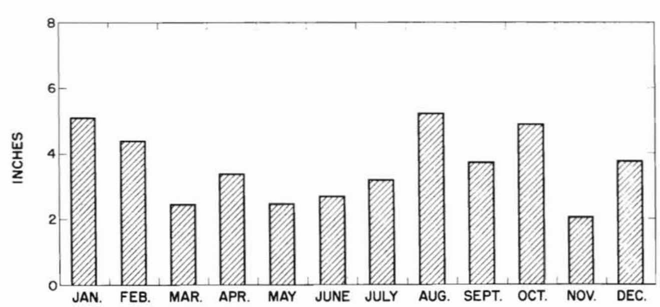

Figure 20.—Mean monthly precipitation in inches for Midway, 1953 to 1963 (Amerson et al. 1974).

OCEANOGRAPHY OF NORTHWESTERN HAWAIIAN ISLANDS

Early in the investigation, the Honolulu Laboratory established throughout the NWHI, environmental stations where CTD and XBT casts, midwater trawl hauls, and bongo net tows were made to obtain data on physical, chemical, and biological properties of the water column. This activity, however, was transferred to the UHSGCP soon after sampling was started (Hirota et al. 1980). It is of interest, however, to get some idea of the macroscale distribution of oceanographic properties around the Hawaiian Archipelago.

In the Hawaiian Islands region, not only the meteorological but also the oceanographic properties show little apparent seasonal variation. Ranging between 22.8° and 25.6°C, sea-surface temperatures show relatively small seasonal and year-to-year changes ([U.S.] Bureau of Commercial Fisheries (BCF) 1963). Surface salinity also varies little seasonally and averages range from 34.8 to 35.1‰, but in contrast to temperatures, the year-to-year variations in surface salinity are rather large. The result is that in some years, the change in salinity between seasons is not clearly detectable; whereas in others, it may be >0.5‰. A boundary near the Hawaiian region separates North Pacific Central water from the California Current Extension water (BCF 1963). The former has a salinity >35‰, the latter <34.8‰. The boundary, therefore, is identified by a relatively small and narrow salinity gradient.

This boundary shifts with the season from a position just south of the Hawaiian Islands during late fall and early winter to one just north of the islands in late summer (BCF 1963). Shifts of longer duration also occur possibly because there is either movement or dilations and contractions of the North Pacific Central system.

Surface temperature

North of the Hawaiian chain, there is a parallel isothermal structure between November and April and a latitudinal temperature gradient of about 0.6° to 0.8°C per degree of latitude. A change in this temperature structure first becomes apparent in May followed by a breakdown of the parallel isothermal structure in June. An irregular temperature regime persists in the northern section of the Hawaiian chain in July-September, but in October, the isotherms again become parallel (Seckel 1962).

Minimum and maximum temperatures generally occur in March and September, respectively (Fig. 21). Although the minimum temperature sometimes occurs in February and the maximum in August or October, they show no significant differences from those in March and September. The March and September mean profile at long. 153°-161°W and at long. 168°-176°W demonstrates that the annual temperature range between lat. 10° and 15°N is about 1.4°C in the eastern and western sections. The range increases to about 5.8° and 6.4°C in the eastern and western sections, respectively.

The mean zonal temperature profiles (Fig. 22) for March and September show that for these months, the temperature is about 1.7°C higher in the western than in the eastern part of the region, except in September in lat. 15°-20° and 20°-25°N where the increases are 2.2° and 2.8°C, respectively (Seckel 1962). The seasonal temperature range between long. 153° and 161°W at lat. 12°, 17°, 20°, and 26°N increased only slightly northward from 1.7°C at lat. 12°N to 2.8°C at lat. 22°N, but the range almost doubled to 5.3°C at lat. 26°N.

On a more local level, sea-surface temperatures can decrease to as low as 16.7°C in February or March in the Midway-Kure Atoll area as was experienced in four different years between 1944 and 1963 (Gross et al. 1969).

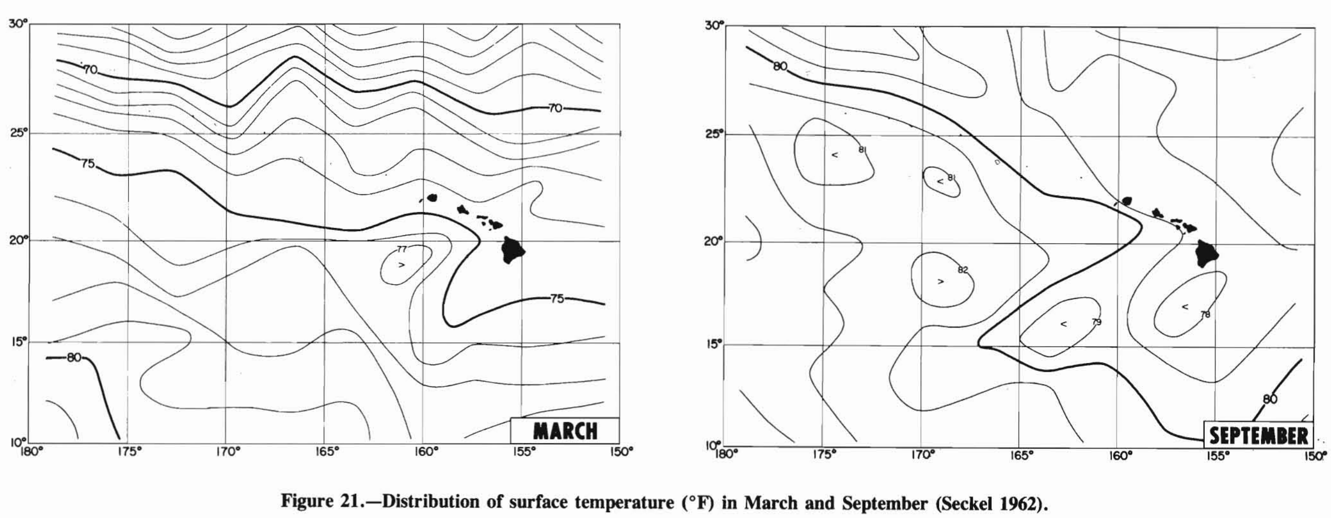

Figure 21.—Distribution of surface temperature (°F) in March and September (Seckel 1962).

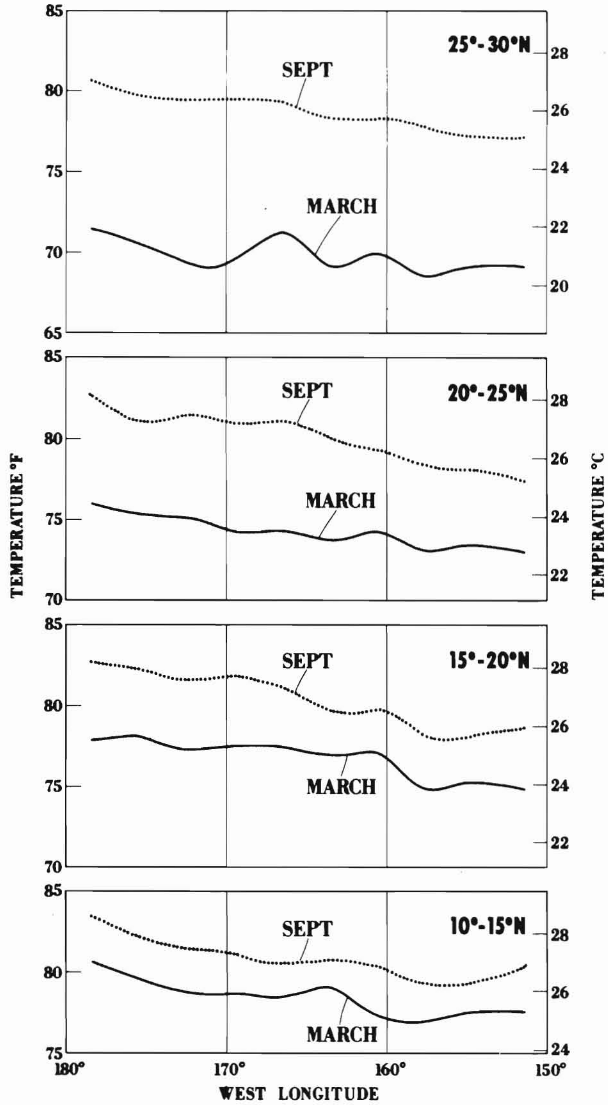

Figure 22.—Zonal profile of the surface temperature in March and September, lat. 10-15°, 15-20°, 20-25°, 25-30°N, and long. 150 to 180°W (Seckel 1962).

Thermocline depth

The permanent or main thermocline is always present in the Hawaiian region (Seckel 1962). Below the mixed layer, the average temperature gradient is about 15°, 6°, and 5°C per 100 m at lat. 10°, 20°, and 30°N, respectively. Superimposed on the permanent thermocline may be a seasonal thermocline and, in addition, there may also be a diurnal thermocline, which is defined as a small rise in surface temperature of the order of 1°C extending to a depth of about 10 m.

During January-February in the Hawaiian region, there is a prominent trough extending east to west between lat. 15° and 20°N in which the depth of the mixed layer is greater than in the surrounding areas (Fig. 23) (Seckel 1962). The depth is generally >76 m and west of long. 165°W, it exceeds 122 m. But in March-May, the depth of the mixed layer decreases except along the southern boundary east of long. 162°W where it tends to increase.

A new distributional pattern of the depth of the mixed layer is evident in June-August (Seckel 1962). A trough is established at lat. 10°-13°N to the west of long. 156°W where the depth reaches about 91 m, whereas to the east of long. 156°W, the trough reaches 61-76 m. Over much of the area north of lat. 20°, the mixed layer increases only slightly from <30 m deep in June to <46 m in July-August. In September, there appears to be a northward movement of a trough 76-91 m deep which is centered at about lat. 15°N west of long. 160°W. By October, the trough resumes its winter position. The depth of the mixed layer north of lat. 20°N increases and the beginning of the typical January-February structure is again evident.

The primary feature of the mixed layer in the Hawaiian Islands region, then, is the presence of a trough and seasonal differences in its location (Fig. 24). In January, there is a maximum development in the depth of the trough which may exceed 122 m east-west between lat. 15° and 20°N. The June distribution typifies the other extreme when the trough is found in its southernmost position and its depth is also at a minimum in the northern region. In the March-May transition period, the irregular depth distribution suggests disintegration of a pattern rather than a southward movement.

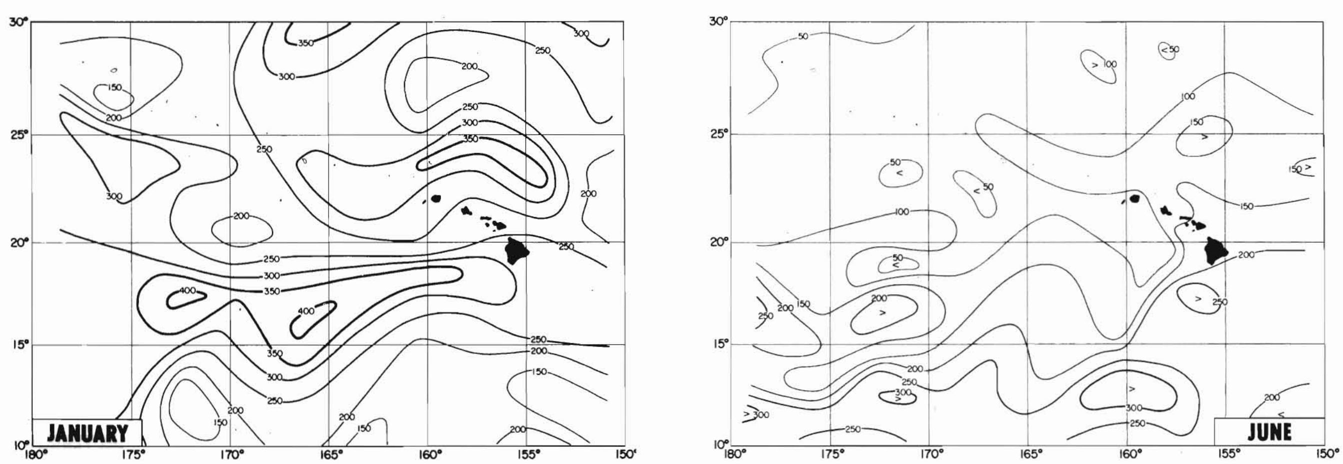

Figure 23.—Distribution of depth of the mixed layer (feet) in January and June (Seckel 1962).

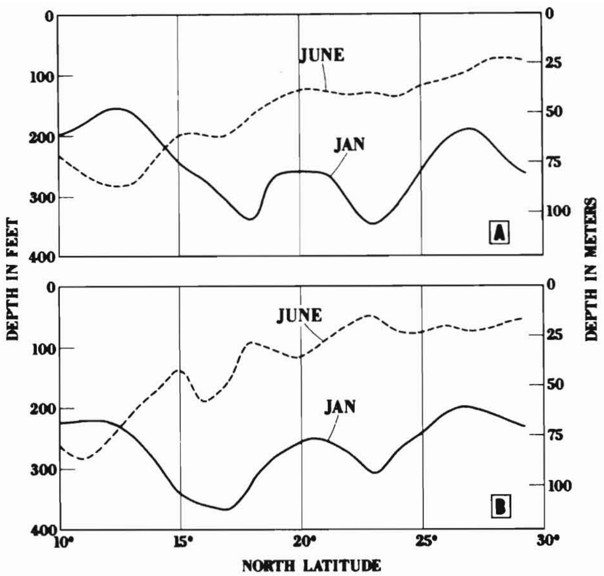

Figure 24.—Meridional profile of the depth of mixed layer in January and June, lat. 10-30°N. Panel A, long. 153-161°W. Panel B, long. 168-178°W (Seckel 1962).

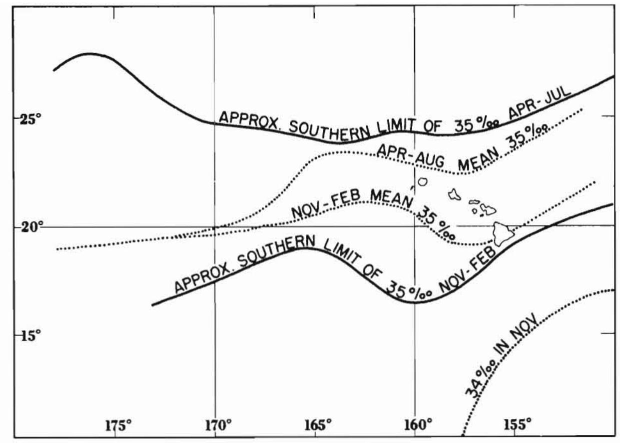

Figure 25.—Southern limit of the 35‰ salinity isopleth in April-July and November-February, and mean location of the 35‰ isopleth in April-August and November-February (Seckel 1962).

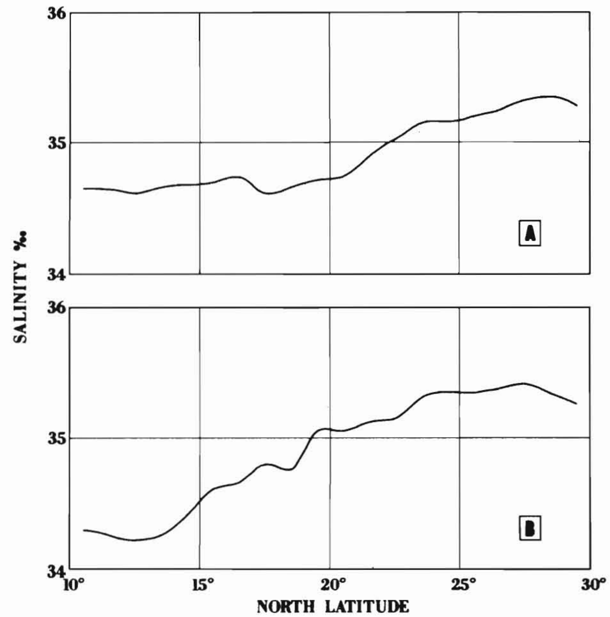

Figure 26.—Mean meridional salinity profile at lat. 10-30°N between long. 155° and 160°W. Panel A, April to August. Panel B, November to February (Seckel 1962).

Surface salinity

In the vicinity of the Hawaiian Archipelago, the maximum salinity occurs in November-February and the minimum in July (Seckel 1962). For example, the 35‰ salinity isopleth starts a northward movement in April and reaches an extreme position in July (Fig. 25). The southward movement eventually positions the 35‰ isopleth at lat. 17°-19°N, the extreme winter location, in November-February. In April-August, the salinity increases northward from 34.65‰ at lat. 10°N to 34.75‰ at lat. 20°N but only by an average of 0.01‰ per degree of latitude. The salinity then rises at an average rate of 0.13‰ at lat. 23°N (Fig. 26). The maximum of 35.35‰ is reached at lat. 28°N, the increase occurring at a rate of 0.04‰ per degree of latitude. Of significance here is the high salinity gradient which can be found within and slightly north of the Hawaiian chain, indicating the presence of a transition zone or boundary between different types of water. In winter, the salinity decreases from 34.3‰ at lat. 10°N to a minimum of 34.2‰ at lat. 12°N, then increases rapidly to 35.05‰ at lat. 19°N at a rate averaging 0.12‰ per degree of latitude.

In April-August, the high salinity gradient between lat. 20° and 25°N is well defined in the eastern region of the Hawaiian Islands (Fig. 27) (Seckel 1962). Of particular interest are two cells in which the salinity is higher than 35.4‰. In November-February (Fig. 28), the salinity gradient in the area southeast of the Hawaiian Islands has moved northwestward and the gradient formerly in that area has shifted southward.

To the north and south of the Hawaiian Islands, low and high salinities occur about the same time as low and high temperatures (Seckel 1962). In the vicinity of the Hawaiian Islands, however, low and high salinities occur about 3 months after the time that the mixed layer reaches its minimum and maximum depths, respectively. Finally, Midway is located near the salinity maximum; the sharp decline of about 0.35‰ in July in this region may be due to either a southward or a northward displacement of the high salinity cell. In the spring, the high salinity boundary moves northward east of long. 165°W and northwestward of long. 165°W, reaching Midway in July.

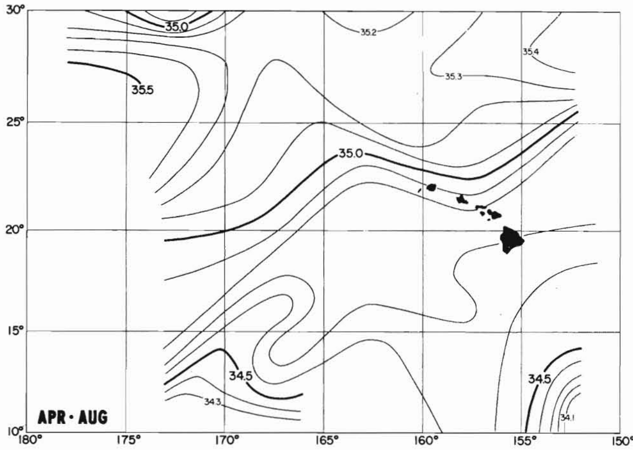

Figure 27.—Distribution of surface salinity (°/oo) in April-August (Seckel 1962).

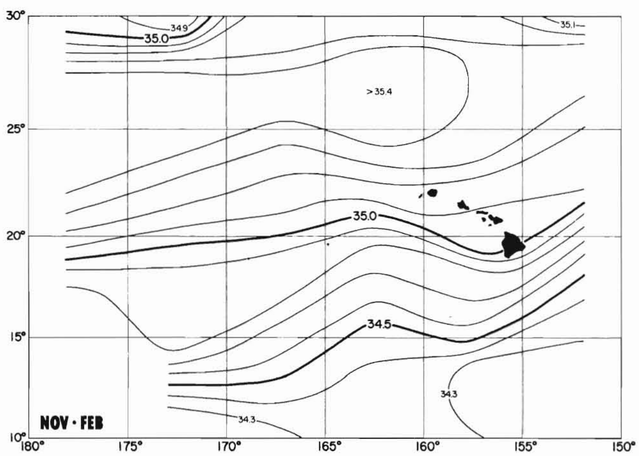

Figure 28.—Distribution of surface salinity (°/oo) in November-February (Seckel 1962).

Surface currents

The NWHI lie in an area of the Pacific where no major current system passes. For many years, it was believed that the North Equatorial Current was responsible for the mean flow through the Hawaiian Islands, but studies conducted by Seckel (1962) and Charnell et al. (1967a, 1967b, 1967c, 1967d, 1967e, 1967f) demonstrated that the circulation pattern in the Hawaiian region cannot be generalized as a steady North Equatorial flow (Patzert 1969). Seckel's studies showed a small geostrophic flow at mean rates between 10 and 20 cm/s. There is a net flow to the west in some areas of the archipelago, but the mean flow in most cases was <20 cm/s suggesting that the North Equatorial Current was not the controlling factor (Wyrtki et al. 1969).

Based on trade wind drift, one might expect a general current flow from east to west through the Hawaiian Archipelago; however, results of current measurements conducted in waters of the NWHI in March-June 1969 demonstrated that this was not so (Fig. 29). The data showed the presence of a northerly drift, which varied from 1.2 to 6.6 cm/s and averaged 4.6 cm/s at all stations in the NWHI except at Midway (east station) where the flow was 6.0 cm/s to the southwest (Patzert et al. 1970). This northerly flow could result from the subtropical countercurrent (Grigg 1981) or the eastern North Pacific anticyclonic gyre which is centered northeast of the Hawaiian chain and which generates a mean flow to the north (Sverdrup et al. 1946). It was also observed that there is an anticyclonic flow around Midway similar to the type of circulation observed around the main islands (Wyrtki et al. 1969).

Along the coastal areas of the islands, the current picture becomes exceedingly complex as a result of the combined effects of tides, countercurrents, and bottom topography. The highly variable currents are difficult to predict. Barkley et al. (1964) pointed out that an irregular series of eddies, which vary considerably in size, number, and location, characterize the dynamic topography of the sea surface near the Hawaiian Islands. Little is known about the growth and decay of these eddies, which obscure the patterns of mean flow around the islands. Barkley et al. through release and recoveries of drift bottles and cards demonstrated that the current system near the islands varies seasonally in strength. In May-September, velocities were estimated to vary from 6 to 11 nmi/day; whereas in October-April, they were 6 nmi/day or less.

Tidal currents

Tidal currents have pronounced effects on fishing in waters of the NWHI. United States ports in the Pacific are characterized by two high tides and two low tides per tidal day; however, there is a difference in height of the two highs and of the two lows, resulting in what is commonly called "mixed tides" (Dietrich et al. 1980). These "mixed tides" are intermediate to those predominantly semidiurnal and those predominantly diurnal.

Studies on tidal flow in waters of the NWHI have demonstrated that tidal variations are present as daily and semidaily changes in both speed and direction (Patzert et al. 1970). At Necker Island, there was a rotary semidiurnal tidal current which varies in direction but which had only small changes in speed. Observations at Nihoa demonstrated the same rotary tidal current variations for the diurnal tide. At a station located east of Midway, an alternating tidal current with marked changes in speed and direction was also reported.

The speed and direction of the major axis of the tidal ellipse for the semidiurnal and diurnal currents are shown in Figures 30 and 31 (Patzert et al. 1970). Because the tidal current does not necessarily coincide with high water in Honolulu, the time in hours of the occurrence of the maximum current before (−) or after (+) high water in Honolulu is given on each arrow. From Midway to Penguin Bank, the maximum strength of diurnal and semidiurnal tidal currents varied from 3.0 to 32.5 cm/s.

Current measurements using a taut-line deep-sea mooring (Deep-Mooring E) anchored in 5,490 m at lat. 27°30′N, long. 157°52′W (in the vicinity of the Musicians Seamount chain) also yielded data on tidal currents (Patzert et al. 1970). The net tidal current was observed flowing to the north northwest and was not in phase at different depths, going from 19.9 cm/s at 35 m, 11.3 cm/s at 150 m, and 9.2 cm/s at 300 m. At 1,000 m, an unusually strong flow to the north northeast of 20.2 cm/s was detected.

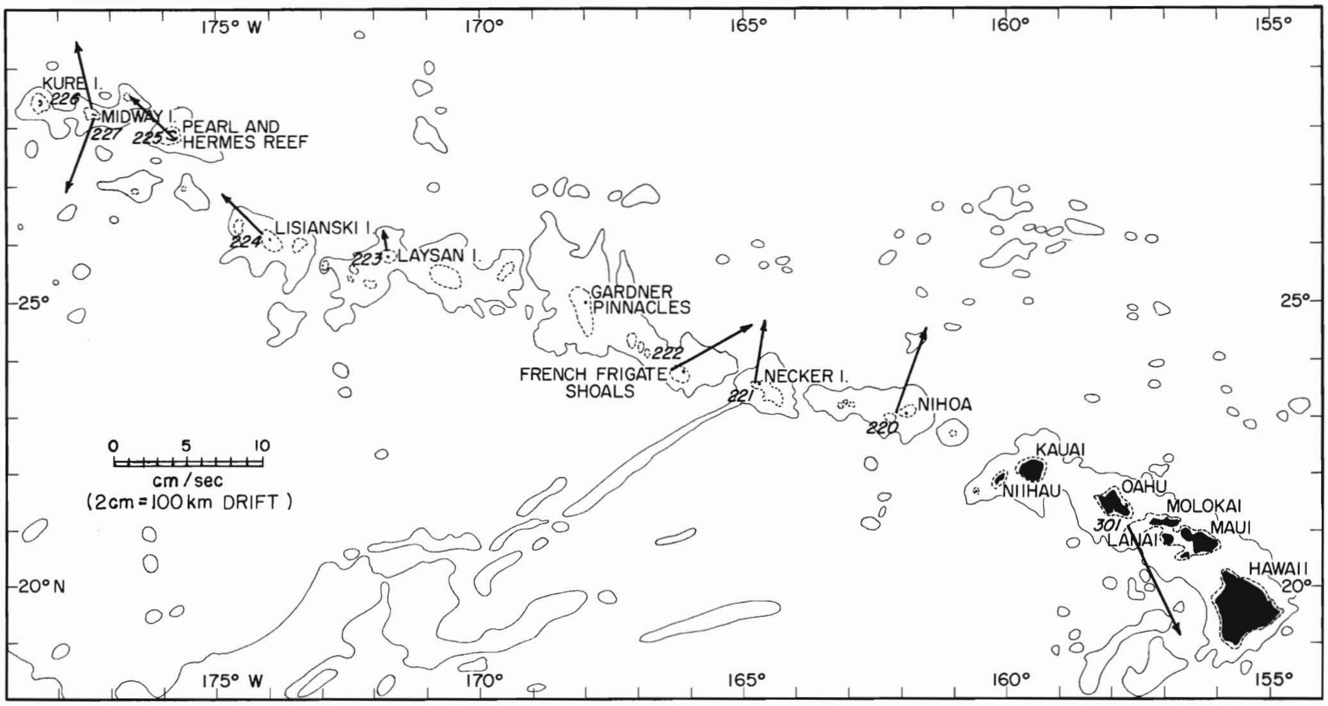

Figure 29.—Resulting drift or average vector velocity of current measurements in Hawaiian Archipelago from Molokai to Midway (Patzert et al. 1970).

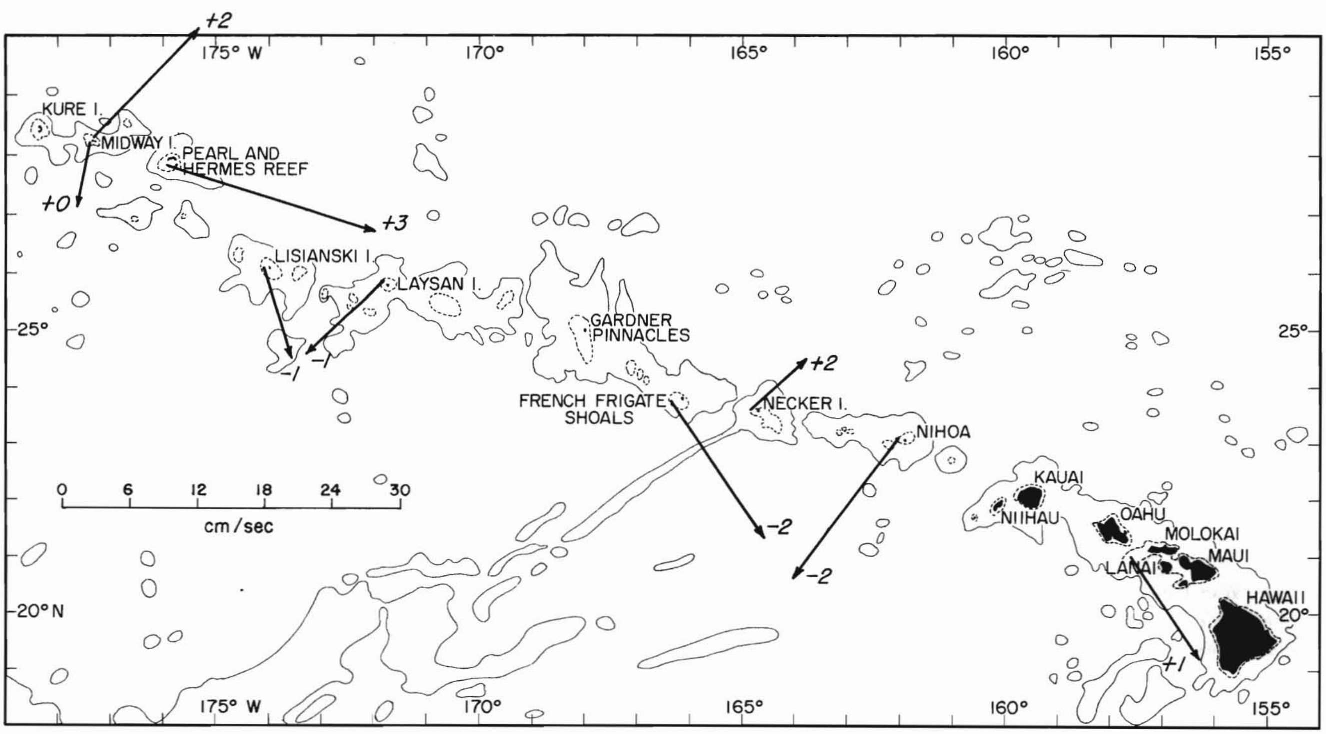

Figure 30.—Semidiurnal tidal currents in the direction of the major axis of the tidal ellipses in the Hawaiian Archipelago from Molokai to Midway (Patzert et al. 1970).

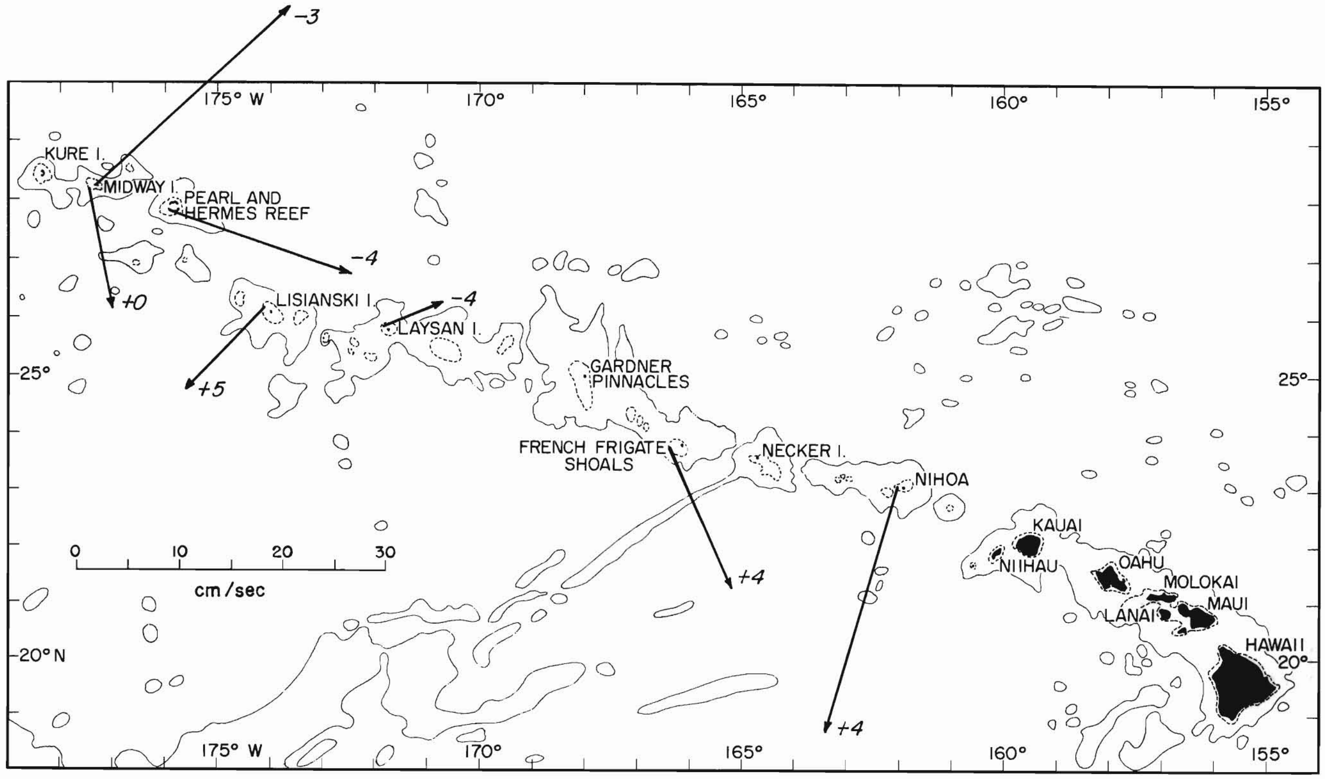

Figure 31.—Diurnal tidal currents in the direction of major axis of the tidal ellipses in the Hawaiian Archipelago, Molokai to Midway (Patzert et al. 1970).

Waves and swells

Along the Hawaiian coastline, almost all the energy available for transporting sediments and for reforming beaches arrives in the form of ocean swells. Chamberlain (1968) traced the origin of these waves to all parts of the Pacific as well as the South Indian Ocean. The waves that arrive in Hawaii may also have been generated from several areas simultaneously, resulting in the presence, at any one time, of various combinations of wave systems. This consideration, together with seasonal activity of the generating areas, the interaction of various wave trains, the weakening of waves over long distances, and the effect of local wind and waves on those generated away from Hawaii, contribute to very complex wave patterns in Hawaiian waters.

A study of wind and wave data suggests that the entire yearly wave spectrum in Hawaiian waters can be represented by a few generalized wave types (Fig. 32). Chamberlain (1968) classified these as:

Northeast trade wind waves—These waves are possibly present all year but are dominant between April and November. They are generated by the strong trade winds blowing from the northeast quadrant over long fetches of open ocean, have periods typically of 5-8 s, and heights between 1.2 and 3.6 m. The directions of approach varies from north through southeast but most frequently are northeast or east. Northeast trade waves are present 90-95% of the time in summer and 55-65% of the time in winter.

Southern swells—These swells, characterized by their low height usually 0.3-1.2 m, and long periods of 14-22 s, are generated in the region adjacent to Australia, Antarctica, and the southern Indian Ocean by strong winds blowing over long fetches during the Southern Hemisphere winter. They approach Hawaii from the southern quadrant. Typically, southern swells arrive in Hawaiian waters about 53% of the time between April and October.

Kona storm waves—These waves are generated by local or kona storms associated with local fronts or Hawaiian lows (see section on Climate). They occur rather infrequently and exhibit inconsistent patterns because of their association with erratic westerlies. They may develop into large waves and approach Hawaii from a direction completely opposite to that of the normal wind and wave regime; therefore, they are extremely important in nearshore water circulation and in beach accretion and erosion. Their direction of approach varies between southeast and west but the larger waves are usually from the southwest. Kona storm waves, characterized by periods of 8 to 10 s and heights from 3.0 to 4.6 m, arrive in Hawaiian waters about 9.3% of the time in winter.

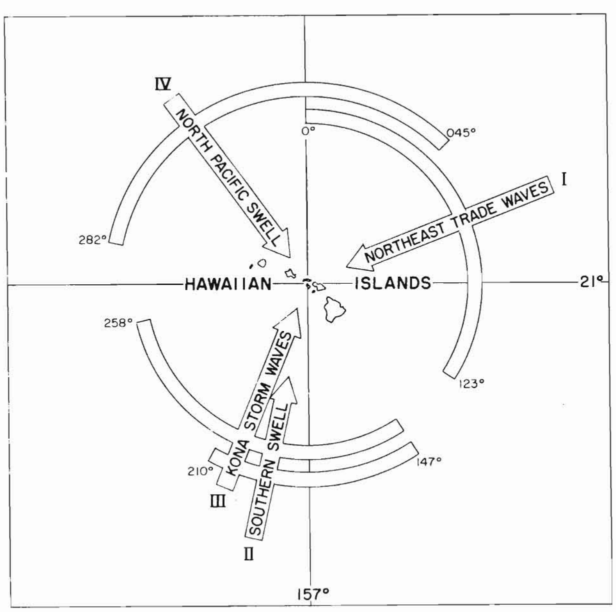

Figure 32.—Swell and wave types in Hawaiian waters (Chamberlain 1968).

North Pacific swells—Generated by storms in the Aleutians and by midlatitude lows, these swells arrive in Hawaii throughout the year but are largest and most numerous from October through April. They are characterized by periods of about 10-15 s, heights of 2.4-4.3 m, approach from the northwest, north, or northeast and represent some of the largest waves reaching the Hawaiian Archipelago.

Detailed wave data for the NWHI are rather limited and available only for the lower end of the chain from Buoy Station 51001. A plot of the mean, range, and standard deviation of wave height (Fig. 33), reveals that the mean wave height can be expected to be at about 3 m or more in the winter (November through March); maximums of 6-7 m or more, also are likely to be encountered. The remainder of the year from April through October can be expected to have mean wave heights of <3 m and maximums reach as high as 4 m.

The NWHI offers little shelter to fishing vessels during storms. Shallow waters, 18-36 m depth, can be extremely dangerous on banks exposed to large swells as these swells can become waves and break on the bank. Gardner Pinnacles is known to be dangerous during winter storms for this reason.

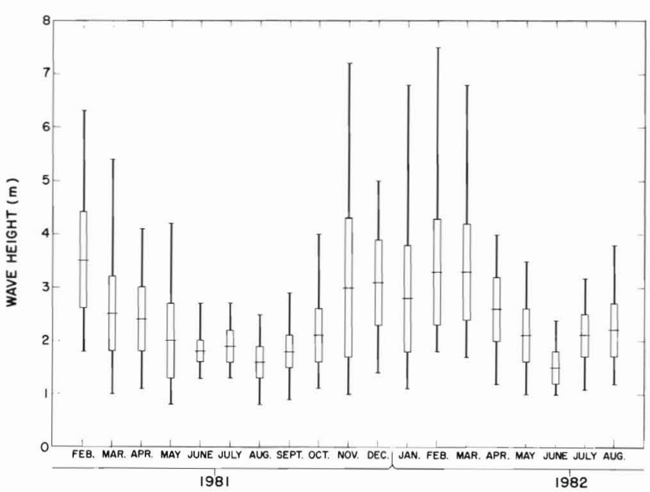

Figure 33.—Monthly means, ranges, and standard deviations of wave height at NOAA Buoy Station 51001 (lat. 23°24′N, long. 162°18′W) from January 1981 through August 1982 (D. B. Gilhouse, Meteorologist, NOAA Data Buoy Center, NSTL Station, MS 39529, pers. commun., 17 August 1983).

DESCRIPTION OF GEAR

The NOAA ship *Townsend Cromwell* was used extensively during the NWHI investigation. The 564-gross ton vessel is 49.7 m long, has a 10.0 m beam, and a maximum draft of 3.6 m. The *Cromwell* has a range of 15,000 km, an endurance of 33 days, and is capable of performing bottom and midwater trawling, and pole-and-line, longline, trap, and handline fishing. The vessel is also equipped to conduct oceanographic and topographic surveys.

During the 5-year period of the survey, 24 research cruises to the NWHI were completed. Of these, 18 had multiple objectives that involved field work by NMFS and one or more of the cooperating agencies, or by the UHSGCP program exclusively. Data were also collected by observers from 24 NWHI trips made by commercial fishing vessels and from 18 other commercial trips on which no observers were aboard.

At the onset of the investigation, we examined NOS navigational charts and published documents to identify target areas for surveys. We identified 51 islands, atolls, reefs, pinnacles, banks, shoals, and seamounts within the FCZ. The *Cromwell* conducted surveys to chart the topography of uncharted pinnacles and seamounts. Some of the reported shallow spots were never located, and others turned out to be rather complex interconnecting banks.

To survey the marine resources of the NWHI, we relied on a wide variety of gear, primarily standard types available through commercial sources. For demersal species such as spiny lobsters, crabs, shrimps, and bottom fishes, the primary gears used were fish and shrimp trawls, fish traps, lobster pots, shrimp pots, crab nets, vertical longline, and handline. For pelagic species, such as tuna and tunalike fishes, troll gear was used exclusively. For benthopelagic forms such as akule and opelu, we used mackerel handlines in conjunction with a night light.

Fish trawl

Initially, our surveys over trawlable banks and seamount summits were conducted with an 80% scale, 656-mesh, Norwegian fish trawl. The specifications for this net are: headrope = 20.1 m; footrope = 25.3 m; body = 10.1-cm mesh, No. 36 nylon twine; intermediate = 8.9-cm mesh, No. 64 nylon twine, 100 meshes around, 120 meshes long; cod end = 8.9-cm mesh, No. 72 nylon twine, 100 meshes around, 60 meshes long; cod end cover = 3.8-cm mesh, No. 48 nylon twine, 233 meshes around, 200 meshes long; chaffing bag = 0.8-cm diameter polypropylene rope, 24.1-cm mesh, 46 meshes around, 23 meshes long; floats = 41 FE-18 deep-sea aluminum floats, 20.3-cm diameter; and roller line = 35.6-cm diameter rollers spaced at 2.7-m intervals in the wings, gradually reducing to 0.6-m intervals towards the center. Scuba-equipped divers reported a vertical opening of 3.7 m and a horizontal spread of 10.7-12.2 m during trial hauls.

Our early evaluation of the Norwegian fish trawl indicated that the net was too small for the *Cromwell*'s engine horsepower. Furthermore, it was determined that the design of the trawl drew the belly over the sea bottom resulting in extensive tears and damage to the net. In mid-1977, we acquired a high opening Nor'Eastern trawl and used it almost exclusively for the remainder of the NWHI investigation. The trawl, roller gear, and dandy line configuration are described in Gunderson and Sample (1980). They reported that the Nor'Eastern trawl has a horizontal sweep (wingtip to wingtip) of 13.4 m and a vertical opening (at the center of the headrope) of 8.8 m.

The 1.8 × 2.7-m steel V-doors used with both trawls weighed 454 kg each except on *Cromwell* cruise 76-06 when the doors weighed only 340 kg.

To monitor the depth of net while trawling, we attached a Furuno 400 Mark II net sonde to the trawl. The net sonde, attached to the center of the headrope, monitored the distance of the headrope from the sea surface and the bottom.

Unlike continental shelves where large expanses of trawlable grounds can be found, the bottom in the NWHI is often hard, rough, and dotted with pinnacles and coral outcroppings, although relatively smooth sand or sand-coral rubble areas are common in deeper waters.

Before trawling, the selected ground was transected with the echo sounder to determine the nature of the bottom. If an area were considered trawlable, a trawling station was occupied. Stations were occupied during day and night. The hauls were made at an average speed of 2 knots and the duration at depth varied from 20 to 30 min.

Catches were sorted by species, counted, and weighed. With large catches, total catch in numbers and weights were estimated from subsamples. Biological data were also collected for age and growth and feeding studies.

Shrimp trawl

A 16-m, Gulf of Mexico, flat shrimp trawl, used on previous surveys around the main Hawaiian Islands by NMFS in 1967-68, was used occasionally in this survey of the NWHI. It was similar to the 12-m net described by Bullis (1951).

The net was rigged with a 6-mm loop chain on the footrope, and a 6-mm tickler chain riding a short distance in front of the footrope. Modified aluminum V-doors, 1.5 × 2.1 m, were used with the shrimp trawl.

Fish traps

Initially, a rectangular, single compartment fish trap with a conical entrance was used as the survey gear; however, because of doubts about the selective nature of the gear, we modified the entrance. The original design may have permitted fishes with fusiform, depressed, truncated, or attenuated bodies to enter while possibly restricting entry of fishes with laterally compressed bodies. Measuring 152.4 × 121.9 × 91.4 cm and covered with 2.5-cm^2, 16-gauge welded wire mesh, this single-chambered trap was fitted with a compressed entrance that measured 27.9 × 12.7 cm on the inner side. Being large, only a dozen could be taken on a cruise.

On later cruises smaller traps measuring 152.4 × 91.4 × ca. 60.9 cm were used. The trap was covered with 2.5-cm^2, galvanized, 16-gauge welded wire mesh, and had an off-center wire mesh panel 50.8 cm from one end of the trap to create two unequal compartments. The smaller of the two compartments, the chamber, had an entrance on both sides. Each entrance was conical and had an outer diameter of 30.0 cm and an inner diameter of 16.5 cm. From the chamber, the parlor, or the larger compartment (which contained the bait box) was entered through a third conical entrance of the same dimensions as the other two entrances. Some traps were also fitted with oval entrances which measured 22.9 cm high and 12.7 cm wide; however, these were used sparingly. An even smaller trap, lighter and easier to handle, was used on most of the cruises from 1979 to 1981. These traps were essentially a scaled-down version of the standard trap, but with identical entrances. They measured 108 × 77.5 × 46.3 cm, and were covered with 2.5- × 1.2-cm hardware cloth.

Lobster pots

The California two-chambered pot was the standard gear used to capture spiny lobster. It was rectangular and measured 95.2 × 71.8 × 41.3 cm. The lobster pot lacked a reinforcing steel framework; construction consisted simply of 5.1- × 10.2-cm heavy-duty galvanized wire mesh. The length of the pot was partitioned unequally into a smaller chamber, which measured 40.0 cm long, and a larger parlor, which was 55.2 cm long. The chamber had two conical entrances measuring 30.0 cm along the outer diameter and 16.5 cm along the inner. From the chamber, there was another entrance to the parlor. The bait box, fabricated of welded 1.27-cm^2 wire mesh, was located in the parlor and was attached to the off-center panel between the chamber and parlor.

The necessity to capture sublegal juvenile spiny lobster for studies on size at first maturity required a simple modification to the existing pot. To prevent the juveniles from escaping or falling through the larger mesh of the standard pot during soaking or hauling, we covered several pots with a second layer of 16-gauge welded 1.3- × 2.5-cm wire mesh. The entrances were modified so that the inner diameter of the cones measured about 10 cm.

Shrimp pots

Two types of shrimp pot were used during the survey. The first was a rectangular, single-chambered pot 91.4 × 72.4 × 40.6 cm. It was covered with two different sizes of wire mesh, an inner one of 5.1-cm^2 welded wire which served as a frame over which a finer 1.3-cm^2 welded wire mesh was placed. These pots were covered with burlap. Because of the fine mesh and the double layer of wire mesh, the pot retained small individuals and many of the shrimp caught between the two wire meshes were difficult to extricate. The pot had an entrance at each end. They were about 23 cm long and had an outer diameter of about 32-35 cm and an inner diameter of 6 cm. The bait box was centrally located.

We designed a completely new type of pot and began using it in 1978 after tests showed that it produced relatively good catches. This pot, half a cylinder in shape and similar in shape to a quonset was described and illustrated by Gooding (1984).

Crab nets

Early in the NWHI investigation, we had an incidental catch of kona crab, *Ranina ranina*, at several fish and lobster trapping stations. As a result, during the last 2 years more intense crab surveys were conducted.

The crab net was simple to construct and functioned as an entangling device, somewhat like a gill net. The spines or legs became entangled as the crab walked over the netting towards the bait which was tied in the center of the net. The net frame was a 93.0-cm diameter hoop made of 6-mm diameter galvanized fence wire. Over this hoop was stretched two layers of 5.1-cm stretched mesh multifilament nylon netting. Cut bait, wrapped in cheesecloth, was tied to the center of the hoop net.

One string of gear usually consisted of 50 nets. A 0.9-cm diameter polypropylene ground line, which was anchored and buoyed at each end, was marked at 9.1-m intervals and each net was simply snapped onto the ground line with an AK snap at a mark.

Crabbing stations included from one to six strings of nets, depending on the extent of the area, the time available, and the number of nets on hand. Strings were soaked for 1 to 2.75 h. Before setting, the bottom was scouted with the echo sounder and bottom grab samples obtained.

Deep-sea handlines

To sample bottom fish, we used standard Hawaiian deep-sea handline gear. On early cruises all handlines were hauled by hand. Later, electric reels and hydraulic-powered gurdies were used. Eventually we converted entirely to hydraulic-powered gurdies as they proved to be the most reliable. The hydraulic gurdies included a davit with block, a rotating base, and a brake and clutch assembly.

The hydraulic gurdy had a capacity of 1,100 m of 118-kg test hard braided nylon line, and the electric reel had a capacity of 640 m of 36-kg test braided dacron. The terminal rig for all types of handline (hand-, hydraulic-, or electric-powered) consisted of a drop line, hook line, hooks, and weight. Usually, four hooks were used. Each hook line consisted of 45-kg test monofilament leader and a recurved Hawaiian oio or Tankichi hook, which was attached to the 113-kg test monofilament drop line with a 2 × 3 swivel. Hook size varied from No. 18 to No. 32 depending on the target species. For a typical handline station targeting fishes of the snapper-grouper-jack complex, we used hook size No. 28 as the standard. The hook lines were 0.6 m long and spaced at intervals of about 1.5 m. The weight of either lead or cut sections of reinforcing steel rods, varied from 1.4 to 2.3 kg. Weights were doubled or tripled in areas of strong current.

Deep-sea handline fishing stations were occupied day or night and usually lasted from 1 to 4 h. At each station, four lines were usually fished, although occasionally six lines were fished. During fishing, the vessel was allowed to drift from shallow to deep waters or vice versa depending on current. A drift course paralleling a particular depth contour was desirable but rarely attainable.

A modified handline, sometimes called a vertical longline, was also used. With this gear the mainline remained the same; only the terminal rig was changed. It consisted of up to 20 No. 16 or No. 18 recurved Hawaiian oio hooks, tied to 13.6-kg test monofilament leaders attached to the drop line. The advantage of this gear over the simple handline is that the large number of hooks used maximizes the catching ability of the basic unit of gear by allowing multiple hookup in highly discontinuous schools of fishes such as those found over the seamounts.

Because of the difficulty in handling such large numbers of hooks on hand-hauled handline, the vertical longline was hauled only on hydraulic gurdies. Because of strong currents and the depth to the summit of seamounts, weights used on vertical longlines were usually doubled or tripled.

Mackerel handlines

The mackerel handline consisted of a 23-kg test braided nylon mainline wound on a freewheeling, wooden spool. The terminal rig consisted of a drop line, hook line, lure, and weight. The 5.4-kg test drop line, about 3 m long, had five hand-tied loops spaced at intervals of about 0.5 m. Hook lines of about 2.7- to 4.5-kg test monofilament, usually 0.3 m long, were attached to each loop. Lures were fabricated from white nylon floss ribbed with red and tied to a No. 4 Eagle-claw, off-center or straight shank hooks. Depending on the strength of the current, we used lead weights varying from 114 to 227 g at the end of the drop line.

Mackerel handline and rod and reel were used primarily at night-light stations conducted to not only capture akule and opelu but also to attract squid, baitfish, plankton, juvenile fish, and crustaceans. The light source was a 1,500-W bulb controlled with a rheostat.

Troll gear

Trolling lines were used throughout the NWHI investigation. The gear used was a 0.64-cm diameter nylon line about 26- to 54-m long. When direct trolling surveys were conducted, two outriggers were employed, one on each side of the vessel. To reduce strain and prevent fish loss, the lines were attached to shocks of either bungee cord (1.3-cm diameter rubber with a woven nylon cover) or springs.

A safety line was used with shocks to prevent gear loss. A heavy-duty, pigtail swivel was spliced on the end of the trolling line. The leader, either 113 kg monofilament or No. 15 stainless steel piano wire, was about 1.0-1.5 m long. We usually used two types of lures. The first and most commonly used was a 170-g lead-head jig with multicolored feather tail combined with either plastic or lae skin (the dried tough skin of the leatherback, *Scomberoides sancti-petri*) skirt. Usually, a 0/7 or 0/8 double trolling hook was used with this lure. The other lure was a JT-1 jet head with a 23-cm multicolored squid skirt and a 0/10 double trolling hook. Direct trolling speed was usually 7 knots. Indirect incidental trolling speed varied from 7-9 knots.

CRUSTACEANS, MOLLUSCS, AND FISHES CAUGHT IN NORTHWESTERN HAWAIIAN ISLANDS

Various fishing methods and sampling techniques have resulted in the capture of a wide variety of species: 263 species (75 families) of fishes, 43 species (22 families) of crustaceans, and 16 species (13 families) of molluscs (Table 3). For most fishes the valid scientific and common names, as recognized by the Committee on Names of Fishes of the American Fisheries Society (Robins 1980), were used. When a species was not included on that list, we used the most generally accepted and widely used name in the literature. Local or Hawaiian names were also listed when available.

Most identifications were made in the field; Gosline and Brock (1960), Smith (1950), Jordan and Evermann (1905), Masuda et al. (1975), and Tinker (1978) were references used at sea. However, commercially important species and some unusual specimens were sent to taxonomic experts for verification or identification. Due to an error in our field identification key, specimens identified as *Priacanthus cruentatus* may include a couple of other similar species: *P. meeki* and *P. alalaua*.

DISTRIBUTION BY AREA AND DEPTH

The geographical distribution of crustaceans, molluscs, and fishes in the NWHI was determined from catches made on the *Townsend Cromwell* from October 1976 to September 1981 (Table 4). The minimum (upper figure) and maximum (lower figure) depths given are those between which the organisms were caught by the various gears and are considered highly reliable. Although trawl catches may have been contaminated by midwater organisms or remains from a previous haul, we considered those occurrences to be rare. Troll catches were useful in determining geographic distributions of pelagic and carangid fishes, but of limited value for depth distribution. Therefore, for species caught on trolling gear, the minimum depth was considered to be 1 m; maximum depth was unknown and is indicated with a dash unless the species was caught by another gear which provided reliable depth information. Depth ranges recorded at handline stations were not used because of possible inaccuracy. The exception was when a station was conducted over flat bottom and the depth was constant.

SIZE RANGE AND METHODS OF CAPTURE

Ranges of carapace lengths of crustaceans, fork or standard lengths of fishes, and total body weights of species caught in the NWHI are listed in Table 5. Because more lengths than weights were collected, a length range may not correspond to a weight range, i.e., the maximum length and the maximum weight may have been obtained from two different specimens. Gears used in the capture of the organisms are presented in a checklist in Table 5. Other gear includes an assortment of throw net, spear, rod and reel, and shark line.

Table 3.—Crustaceans, molluscs, and fishes caught in the Northwestern Hawaiian Islands during the resource surveys, October 1976-September 1981.

Organisms	Common names	Hawaiian names
Arthropoda		
Crustacea		
Malacostraca		
Decapoda	Ten-footed crustacea	
Dendrobranchiata		
Penaeidae	Penaeid shrimps	
Penaeus marginatus		
Pleocyemata		
Oplophoridae		
Acanthephyra eximea		
Oplophorus gracilirostris		
O. spinosus		
Nematocarcinidae		
Nematocarcinus gracilis		
Pandalidae		
Heterocarpus ensifer	Armed nylon shrimp	
H. laevigatus	Smooth nylon shrimp	
Plesionika edwardsii		
P. ensis		
P. ocellus		
Palinura		
Palinuridae	Spiny lobsters	
Panulirus marginatus	Hawaiian spiny lobster	Ula
P. penicillatus	Four-spined spiny lobster	Ula
Scyllaridae	Slipperlike lobsters	
Parribacus antarcticus		Ulapapapa
Scyllarides haanii		
S. squammosus	Scaly slipper lobster	Ulapapapa
Anomura		
Galatheidae		
Munida sp.		
Lithodidae	Lithode crabs	
Lithodes nintokuae		
Diogenidae		
Dardanus brachyops	Short-eyed hermit	
D. gemmatus	Gemmate hermit crab	Unauna, papaiiwipupu
D. megistos	Large red hermit crab	Unauna, papaiiwipupu
Parapaguridae		
Parapagurus dofleini		
Brachyura	Short-tailed crabs	
Raninidae	Frog crabs	
Ranina ranina	Red frog crab	Kona crab
Dromiidae	Sponge crabs	
Dromidiopsis dormia	Sleepy sponge crab	Makuaokalipao
Homolidae	Homolid crabs	
Homola ikedai		
Hypsophrys williamsi		
Paromola japonica		
Leucosiidae		
Randallia distincta		
Calappidae	Box crabs	
Calappa bicornis	Two-horned box crab	Pokipoki
C. calappa	Large box crab	Pokipoki
C. hepatica		
Majidae	Spider crabs	
Cyrtomaia smithi		
Parthenopidae	Parthenope crabs	
Parthenope contrarius		
P. nummiferus		
Portunidae	Swimming crabs	
Charybis hawaiensis		
Lupocyclus quinquedentatus	Five-toothed swimming crab	
Macropipus corrugatus		
Portunus suborbicularis		
Thalamita auauensis		
Xanthidae		
Carpilius convexus	Convex pebble crab	
C. maculatus	Spotted pebble crab	Alakuma
Goneplacidae		
Progeryon sp.		
Cancridae		
Cancer macrophthalmus		
Stomatopoda	Mantis shrimps	
Squillidae		
Odontodactylus brevirostris		
Mollusca		
Gastropoda		
Prosobranchia		
Neogastropoda		
Xenophoridae	Collector shells	
Xenophora sp.		
Cassididae		
Phalium bulla		
P. kurodai		
Coralliophilidae		
Latiaxis kawamurai		
Fasciolariidae		
Fusinus sandvicensis		
Nassariidae		
Nassarius crematus		
Opisthobranchia		
Nudibranchia		
Bivalvia		
Pinnidae	Pen shells	
Pinna bicolor		
P. muricata		
Cephalopoda		
Octopoda		
Alloposidae		
Alloposus mollis		

Table 3.—Continued.

Organisms	Common names	Hawaiian names
Bolitaenidae		
Japetella diaphana		
Octopodidae		
Octopus cyanea	Day octopus	Hee mauli
O. ornatus	Night octopus	Hee puloa
Scaeurgus patagiatus		
Teuthoidea		Muhee
Ommastrephidae		
Nototodarus hawaiiensis		
Loliginidae	Common squids	Muhee
Enoploteuthidae		
Abralia sp.		
Histioteuthidae		
Histioteuthis miranda		
Chordata		
Chondrichthyes		
Squaliformes		
Carcharhinidae	Requiem sharks	
Carcharhinus falciformis	Silky shark	
C. galapagensis	Galapagos shark	
C. amblyrhynchos	Gray reef shark	
C. plumbeus	Sandbar shark	
Galeocerdo cuvieri	Tiger shark	
Triaenodon obesus	Whitetip reef shark	
Squalidae	Dogfish sharks	
Etmopterus pusillus		
E. villosus	Hawaiian shark	
Isistius brasiliensis	Cigar shark	
Squalus blainvillei	Horny dogfish	
Rajiformes		
Dasyatidae	Stingrays	
Dasyatis hawaiiensis	Hawaiian stingray	Lupe, hihimanu
D. lata	Brown stingray	Lupe, hihimanu
Osteichthyes		
Anguilliformes		
Anguilloidei		
Moringuidae	Spaghetti eels	
Moringua macrochir	Thread eel	
Muraenidae	Moray eel	Puhi
Echidna nebulosa	Starry moray	Puhi kapa
Gymnothorax berndti	Berndt's moray eel	
G. eurostus	Abbott's moray eel	
G. flavimarginatus	Yellowedged moray	Puhi paka
G. hepaticus	Liver-colored moray eel	
G. meleagris	Guineafowl moray	Puhi onio
G. nudivomer	Polkadot moray	
G. steindachneri	Steindachner's moray eel	
G. undulatus	Common moray eel	Puhi laumilo
Congridae	Conger eels	
Ariosoma marginatum		
Conger cinereus marginatus	White eel	Puhi uha
C. oligoporus	Conger eel	
Congrina aequoria		
Rhynchocymba nystromi nystromi		
Synaphobranchidae	Cutthroat eels	
Meadia abyssalis		
Synaphobranchus affinis		
Salmoniformes		
Argentinoidei		
Argentinidae	Argentines	
Argentina striata	Striated argentine	
Glossanodon struhsakeri	Struhsaker's deep-sea smelt	
Stomiatoidei		
Gonostomatidae	Lightfishes	
Argyripnus atlanticus		
Sternoptychidae	Hatchetfishes	
Argyropelecus aculeatus	Silver hatchetfish	
Astronesthidae	Snaggletooths	
Astronesthes lucifer	Snaggletooth	
Myctophiformes		
Myctophoidei		
Synodontidae	Lizardfishes	
Saurida gracilis	Slender lizardfish	Ulae nihoa
Synodus binotatus	Two-spot lizardfish	
S. dermatogenys	Fowler's lizardfish	Ulae
S. kaianus	Günther's lizardfish	
S. variegatus	Variegated lizardfish	
Trachinocephalus myops	Snakefish	
Myctophidae	Lanternfishes	
Benthosema fibulata		
Diaphus adenomus		
D. trachops		
Myctophum nitidulum		
Symbolophorus evermanni		
Lophiiformes		
Lophioidei		
Lophiidae	Goosefishes	
Lophiomus miacanthus	Deepwater goosefish	
Antennariodei		
Antennariidae	Frogfishes	
Antennarius drombus	Jordan's frogfish	
Chaunacidae	Gapers	
Chaunax umbrinus	Gilbert's deepwater angler fish	
Ogcocephalidae	Batfishes	
Halieutea retifera	Torpedo batfish	
Malthopsis jordani	Jordan's batfish	
Gadiformes		
Gadoidei		
Moridae	Codlings	
Laemonema rhodochir	Orange-finned codfish	
Physiculus edelmanni		

Table 3.—Continued.

Organisms	Common names	Hawaiian names
P. grinnelli	Grinnell's codfish	
Ophidioidei		
Ophidiidae	Cusk-eels	
Brotula multibarbata	Bearded brotula	
Carapidae	Pearlfishes	
Pyramodon ventralis	Dogtooth pearlfish	
Atheriniformes		
Atherinoidei		
Atherinidae	Silversides	
Pranesus insularum	Island silversidefish	Iao
Beryciformes		
Polymixioidei		
Polymixiidae	Beardfishes	
Polymixia japonica	Japanese beardfish	
Berycoidei		
Trachichthyidae	Slime heads	
Paratrachichthys sp.		
Berycidae	Alfonsins	
Beryx decadactylus	Broad alfonsino	
B. splendens	Alfonsino	
Holocentridae	Squirrelfishes	
Neoniphon aurolineatus	Jordan's squirrelfish	Alaihi
N. sammara	Longchin soldierfish	
Sargocentron diadema	Crowned squirrelfish	Alaihi kalaloa
S. fureatum	Hawaiian squirrelfish	
S. spiniferum	Spine-bearing squirrelfish	Uukanepou
S. xantherythrum	*Striped squirrelfish*	*Alaihi maoli*
Myripristis amaenus	Castelnau's squirrelfish	Uu
M. berndti	Blacktipped soldierfish	Uu
M. chryseres	Golden-finned squirrelfish	Pauu
M. kuntee	Cuvier's squirrelfish	Uu
Pristilepis archiepiscopus	Steindachner's squirrelfish	
Zeiformes		
Zeidae	Dories	
Zenopsis nebulosa	Mirror dory	
Caproidae	Boarfishes	
Antigonia eos	Gilbert's antigoniid fish	
A. steindachneri	Steindachner's antigoniid fish	
Cyttomimus stelgis	Gilbert's caproid fish	
Lampriformes		
Veliferoidei		
Veliferidae	Sailfin moonfishes	
Velifer multispinosus	Many spined veilfin fish	
Trachipteroidei		
Lophotidae	Crestfishes	
Gasterosteiformes		
Aulostomoidei		
Aulostomidae	Trumpetfishes	
Aulostomus chinensis	Painted flute mouth	Nuna Nunu
Fistulariidae	Cornetfishes	
Fistularia commersoni	Flutemouth	Nuna peke
F. petimba	Red cornetfish	
Macrorhamphosidae	Snipefishes	
Macrorhamphosus gracilis	Slender snipefish	
M. scolopax	Longspine snipefish	
Perciformes		
Percoidei		
Serranidae	Sea basses	
Anthias thompsoni	Thompson's grouper	
Caprodon schlegelii	Schlegel's grouper	
Epinephelus quernus	Seale's grouper	Hapuupuu, Hapuu
Plectranthias kelloggi	Kellogg's grouper	
Tosanoides filamentosus		
Kuhliidae		
Kuhlia sandvicensis	Mountain bass	Aholehole
Priacanthidae	Bigeyes	Aweoweos
Cookeolus boops	Bulleye	
Priacanthus alalaua		Alalaua
P. cruentatus	Glasseye snapper	Aweoweo
P. meeki	Meek's bigeye fish	
Apogonidae	Cardinalfishes	Aweoweo
Apogon coccineus	Ruby cardinalfish	
A. kallopterus	Spinyhead cardinalfish	Upapalu
A. maculiferus	Spotted cardinalfish	Upapalu makanui
A. taeniopterus	Jenkin's cardinalfish	Upapalu
Epigonus atherinoides	Smeltlike cardinalfish	
E. fragilis		
Synagrops argyrea	Silvery colored cardinalfish	
Carangidae	Jacks	
Carangoides orthogrammus	Yellow spotted crevalle	Ulua
Caranx ignobilis	Giant trevally	Pauu
C. lugubris	Black jack	Ulua
C. melampygus	Blue crevally	Omilu, ulua mikomoni
C. sexfasciatus	Bigeye trevally	Pake ulua
Decapterus macarellus	Mackerel scad	Opelu
D. macrosoma	Blue mackerel scad	
D. muroadsi	Brownstriped mackerel scad	
D. tabl	Redtail scad	Redtail opelu
Elagatis bipinnulata	Rainbow runner	Kamanu
Gnathanodon speciosus	Yellow jack	Ulua paopao
Pseudocaranx dentex	Underjaw kingfish	Pig ulua
Selar crumenophthalmus	Bigeye scad	Akule, hahalalu
Seriola dumerili	Greater amberjack	Kahala
S. lalandei	Yellowtail	Kahala opio
Uraspis helvola	Whitetongued crevalle	Black ulua
Coryphaenidae	Dolphins	
Coryphaena hippurus	Dolphin	Mahimahi
Bramidae	Pomfrets	
Emmelichthyidae	Bonnetmouths	
Erythrocles scintillans		
Emmelichthys struhsakeri		
Lutjanidae	Snappers	

Table 3.—Continued.

Organisms	Common names	Hawaiian names
Aphareus furca	Olive smalltooth jobfish	
Aprion virescens	Blue-gray snapper	Uku
Etelis carbunculus	Marsh's snapper fish	Ehu, ulaula
E. coruscans	Ruby snapper	Onaga, ulaula koae
Lutjanus kasmira	Blue stripe snapper	Taape
Pristipomoides auricilla		
P. filamentosus	Crimson snapper	Opakapaka
P. sieboldii	von Siebold's snapper fish	Kalekale
P. zonatus	Obliquebanded snapper	Gindai
Symphysanodon maunaloae		
S. typus		
Mullidae	Goatfishes	
Mulloides flaviolineatus	Samoan goatfish	Weke aa
M. pflugeri	Pfluger's goatfish	Weke ula
M. vanicolensis	Goldstriped goatfish	Weke ula
Parupeneus bifasciatus	Double barred goatfish	
P. chrysonemus	Yellow-thread goatfish	Weke nono
P. cyclostomus	Goldsaddle goatfish	Moano kea
P. multifasciatus	Red and black banded goatfish	Moana; moano
P. pleurostigma	Black spot goatfish	Malu -
P. porphyreus	Whitestriped goatfish	Kumu
Upeneus faeniopterus	Band-tailed goatfish	Weke pueo, weke pahula
Kyphosidae	Sea chubs	
Kyphosus bigibbus	Striped drummer	Nenue
Sectator ocyurus	Bluestriped chub	
Chaetodontidae	Butterflyfishes	
Chaetodon fremblii	Bluelined butterflyfish	Lauhau kikakapu, kapuhili
C. kleini	Whitespotted butterflyfish	
C. miliaris	Spotted butterflyfish	
C. multicinctus	Pebbled butterflyfish	
Heniochus diphreutes	Black and white butterflyfish	
Pomacanthidae	Angelfishes	
Centropyge fisheri	Fisher's angelfish	
Genicanthus personatus	Masked angelfish	
Pentacerotidae	Armorheads	
Histiopterus typus		
Pseudopentaceros wheeleri	Pelagic armorhead	
Pomacentridae	Damselfishes	
Abudefduf abdominalis	Banded damselfish	Maomao
Dascyllus albisella	White spotted damselfish	Aloiloi
Chromis ovalis	Oval damselfish	
C. struhsakeri		
C. verater	Black damselfish	
Stegastes fasciolatus	Jenkins' damselfish	
Cirrhitidae	Hawkfishes	
Cirrhites pinnulatus	Hardheaded hawkfish	Poopaa, Oopukai
Cheilodactylidae	Fingerfins	
Cheilodactylus vittatus	Striped hawkfish	Kikakapu
Labroidei		
Labridae	Wrasses	
Bodianus bilunulatus	Black spot wrasse	Aawa
B. sanguineus	Rare wrasse	
B. vulpinus	Sharpheaded wrasse	
Cheilinus bimaculatus	Ragged-tail wrasse	Poou, Pilikoa
C. unifasciatus	Rose colored wrasse	Poou
Cirrhilabrus jordani	Jordan's wrasse fish	
Coris ballieui	Light-colored wrasse	Malamalama
Xyrichtys baldwini	Baldwin's wrasse	Laenihi
X. niger	Black razor wrasse	Laenihi eleele
Hemipteronotus woodi	Wood's wrasse	
Pseudocheilinus sp.		
Thalassoma ballieui	Gray wrasse	Hinalea luahine
T. purpureum	Purple wrasse	Hou
Scaridae	Parrotfishes	
Calotomus carolinus	Halftoothed parrotfish	
C. zonarcha		
Scarus dubius	Brown parrotfish	
S. perspicillatus	Large blue parrotfish	Uhu
Mugiloidei		
Mugilidae	Mullets	
Mugil cephalus	Striped mullet	Amaama
Sphyraenoidei		
Sphyraenidae	Barracudas	
Sphyraena barracuda	Great barracuda	Kaku
S. helleri	Heller's barracuda	Kawalea
Polynemoidei		
Polynemidae	Threadfins	
Polydactylus sexfilis		Moi
Trachinoidei		
Mugiloididae		
Parapercis roseoviridis	Rosy green sea perch	
Percophididae	Flatheads	
Chrionema chryseres	Golden-spotted bembropsid	
Ammodytoidei		
Ammodytidae	Sand lances	
Embolichthys sp.		
Callionymoidei		
Callionymidae	Dragonets	
Callionymus decoratus	Decorated dragonet fish	
Synchiropus altivelis		
Acanthuroidei		
Acanthuridae	Surgeonfishes	
Acanthurus nigroris	Cuvier's surgeonfish	Maiko
A. olivaceus	Orangespot tang	Naenae
A. triostegus	Convict tang	Manini
A. xanthopterus	Yellow-finned surgeonfish	Pualu
Ctenochaetus strigosus	Yellow eyed surgeonfish	Kole
Naso brevirostris	Brown unicornfish	Kala
N. hexacanthus	Six-spined surgeonfish	Kala
N. maculatus	Dark-spotted surgeonfish	
N. unicornis	Unicornfish	Kala
Zanclus cornutus	Moorish idol	Kihikihi

Table 3.—Continued.

Organisms	Common names	Hawaiian names
Scombroidei		
Gempylidae	Snake mackerels	
Promethichthys prometheus	Purple snake mackerel	
Ruvettus pretiosus	Oilfish	Walu
Scombridae	Mackerels	
Acanthocybium solandri	Wahoo	Ono
Euthynnus affinis	Kawakawa	Kawakawa
Katsuwonus pelamis	Skipjack tuna	Aku
Sarda orientalis	Striped bonito	
Scomber japonicus	Chub mackerel	Opelu palahu
Thunnus albacares	Yellowfin tuna	Ahi
T. obesus	Bigeye tuna	Poonui
Istiophoridae	Billfishes	Au
Makaira nigricans	Blue marlin	
Stromateoidei		
Stromateidae	Butterfishes	
Ariomma lurida	Lurid nomeid fish	
Cubiceps pauciradiatus		
Hyperoglyphe japonica		
Scorpaeniformes		
Scorpaenoidei		
Scorpaenidae	Scorpionfishes	
Dendrochirus barberi	Barber's scorpionfish	
Iracundus signifer	Spotbearing scorpionfish	
Pontinus macrocephalus	Large headed scorpionfish	Oopu kainohu
Pterois sphex	Wasp scorpionfish	Nohu pinao
Rhinopias xenops	Strange-eyed scorpionfish	
Scorpaena colorata	Red scorpionfish	
S. coniorta	Small scorpionfish	
Scorpaenodes littoralis	Shoreline scorpionfish	
Scorpaenopsis diabolus	Humpbacked scorpionfish	Nohu omakaha
Setarches guentheri	Deepwater scorpionfish	
Triglidae	Sea robins	
Peristedion engyceros	Large armored sea robin	
P. hians	Small armored sea robin	
Hoplichthyoidei		
Hoplichthyidae	Spiny flatheads	
Hoplichthys citrinus	Yellow rattail fish	
H. platophrys		
Dactylopteriformes		
Dactylopteridae	Flying gurnards	
Dactyloptena orientalis	Purple flying gurnard	Lolooau
Pegasiformes		
Pegasidae	Seamoths	
Pegasus papilio	Hawaiian seamoth	
Pleuronectiformes		
Pleuronectoidei		
Bothidae	Lefteye flounders	
Arnoglossus debilis	Weak flounder	
Bothus pantherinus	Panther flounder	Paku, Uiui
B. thompsoni	Thompson's flounder	
Chascanopsetta prorigera	Gilbert's rare flounder	
Parabothus chlorospilus	Green-spotted flounder	
P. coarctatus	Coarctate flounder	
Taeniopsetta radula	Round-bodied flounder	
Pleuronectidae	Righteye flounders	
Poecilopsetta hawaiiensis	Hawaiian right eyed flounder	
Samariscus corallinus	Coralline-red flounder	
Tetraodontiformes		
Balistoidei		
Triacanthodidae	Spikefishes	
Hollardia goslinei	Gosline's spikefish	
Balistidae	Leatherjackets	
Alutera monoceros	Unicorn filefish	Loulu
A. scripta	Scrawled filefish	Oili lepa
Cantherhines dumerili	Whitespotted filefish	Oili
C. verecundus	Shy filefish	
Melichthys niger	Black durgon	Humuhumueleele
M. vidua	Pinktail triggerfish	Humuhumuhiukole
Pervagor melanocephalus	Redtail filefish	
P. spilosoma	Fan-tail filefish	Oiliuwiwi
Pseudomonacanthus garretti	Garrett's filefish	
Rhinecanthus aculeatus	Picasso fish	Humuhumunukunukuapuaa
Sufflamen fraenatus	Bridle triggerfish	
Xanthichthys mento	Redtail triggerfish	
Ostraciidae	Boxfishes	
Aracana aculeata	Spiny boxfish	
Lactoria diaphanus	Many-spined cowfish	
L. fornasini	Shortspined cowfish	Makukana
Ostracion meleagris	Speckled boxfish	Moa
Tetraodontoidei		
Tetraodontidae	Puffers	
Arothron hispidus	Spiny balloonfish	Oopuhue
A. meleagris	Speckled balloonfish	Opuhue, keke
Canthigaster amboinensis	Spotted toby	Puuolai
C. coronata	Crowned pufferfish	
C. epilampra	Rare Kihei pufferfish	Puuolai
C. jactator	Whitespotted pufferfish	Puuolai
C. rivulata	Schlegel's pufferfish	
Lagocephalus lagocephalus	Oceanic puffer	
Sphoeroides cutaneus	Slackskin blaasop	
Torquigener randalli	Bleeker's balloonfish	
Diodontidae	Porcupinefishes	
Chilomycterus affinis	Pacific burrfish	Oopuhue
Diodon holocanthus	Balloonfish	
D. hystrix	Porcupinefish	Oopukawa

Table 4.—Depth distribution (in meters) by bank of crustaceans, molluscs, and fishes in the Northwestern Hawaiian Islands during the resource surveys, October 1976-September 1981. Upper numbers are minimum depths and lower numbers are maximum depths. Dashes = no reliable depth information.

Species	Middle Bank	Nihoa and West Bank	Twin Banks	Necker	French Frigate Shoals	Brooks Banks	St. Rogatien Bank	Gardner Pinnacles	Raita Bank	Maro Reef	Laysan	Northampton Seamounts	Lisianski and Pioneer Bank	Bank 8	Pearl and Hermes Reef	Salmon Bank	Ladd Seamount	Midway	Nero Seamount	Kure Atoll	Bank 11	Hancock Seamounts
ARTHROPODA																						
CRUSTACEA																						
Penaeidae																						
Penaeid sp.		613								421												
		613								421												
Penaeus marginatus										112												
										366												
Oplophoridae																						
Acanthephyra eximea				867												602						
				867												602						
Oplophorus gracilirostris				375																		
				494																		
O. spinosus																						283
																						302
Nematocarcinidae																						
Nematocarcinus gracilis				867																		
				867																		
Pandalidae																						
Heterocarpus ensifer		454		375	435				395	192	331	534	561		271	507						
		613		686	629				422	627	335	682	561		271	640						
H. laevigatus		613		497	629					627	331	534				602						
		613		867	702					627	335	682				640						
Plesionika ensis				430																		
				494																		
P. edwardsii									395		331		561			141						
									422		335		561			141						
P. ocellus				*375*																		
				384																		
Palinuridae																						
Panulirus marginatus		35		24	20	26	29	24	29	4	15	37	11		11	60		15		18		
		60		84	66	42	51	66	51	174	97	38	69		68	64		64		53		
P. penicillatus										4												
										9												
Scyllaridae																						
Parribacus antarcticus	60			35	20	33		35	35	29	90		27		44							
	62			48	49	33		35	35	29	104		42		44							
Scyllarides haanii		55	77	33			102			112					29							
		55	91	33			102			112					55							
S. squammosus	64	48		22	20	26	31	24	29	22	15	37	16	71	15	60		22		13		
	66	68		110	137	51	51	53	51	62	97	44	69	71	82	62		64		66		
Galatheidae																						
Munida sp.				435																		
				494																		
Lithodidae																						
Lithodes nintokuae				697																		
				702																		
Diogenidae																						
Dardanus brachyops		68	62	22	42	29	73		44	31	29		27		33	59	64			35		
		68	91	126	210	35	73		123	31	51		46		101	93	130			35		
D. gemmatus			77	27	42	33	29		40	27	44	37	37		29		66					
			77	126	68	40	31		123	33	55	79	55		48		84					
D. megistos										29					33							
										33					33							
Parapaguridae																						
Parapagurus dofleini					629											507						
					629											507						
Raninidae																						
Ranina ranina				101	24			64		46	60				55					48		
				115	77			143		80	64				84					64		
Dromiidae																						
Dromidiopsis dormia		35		31	68	29		29				38			64							
		35		59	68	29		29				38			64							

Table 4.—Continued.

Species	Middle Bank	Nihoa and West Bank	Twin Banks	Necker	French Frigate Shoals	Brooks Banks	St. Rogatien Bank	Gardner Pinnacles	Raita Bank	Maro Reef	Laysan	Northampton Seamounts	Lisianski and Pioneer Bank	Bank 8	Pearl and Hermes Reef	Salmon Bank	Ladd Seamount	Midway	Nero Seamount	Kure Atoll	Bank 11	Hancock Seamounts
Homolidae																						
Homola ikedai					364																	
					364																	
Hypsophrys williamsi		719			699																	
		719			699																	
Paromola japonica					364					417												
					724					417												
Leucosiidae																						
Randallia distincta					364							534										
					629							534										
Calappidae																						
Calappa bicornis					59						55		55									
					73						55		55									
C. calappa				24	59					31			55		60							
				33	59					31			55		60							
C. hepatica													55									
													55									
Majidae																						
Cyrtomaia smithi				686	629							534				640						
				686	629							534				640						
Parthenopidae																						
Parthenope contrarius					49	69							55		60							
					57	69							55		102							
P. nummiferus						326																
						326																
Portunidae																						
Charybis hawaiensis				27																		
				27																		
Lupocyclus quinquedentatus				22	49					31	55									37		
				29	49					64	55									37		
Macropipus corrugatus																	68					
																	71					
Portunus suborbicularis					22																	
					24																	
Portunus sp.				29																		
				29																		
Thalamita auauensis					24					90												
					24					91												
Xanthidae																						
Carpilius convexus				33						—												
				40						—												
C. maculatus										31			11									
										31			27									
Goneplacidae																						
Progeryon sp.		454															101					
		454															101					
Cancridae																						
Cancer macrophthalmus				516					395													
				516					422													
Stomatopoda																						
Squillidae																						
Squillid sp.					146																	
					296																	
Odontodactylus brevirostris											88											
											95											
MOLLUSCA																						
GASTROPODA																						
Xenophoridae																						
Xenophora sp.																				—		
																				—		
Cassididae																						
Phalium bulla				285																		
				285																		

Table 4.—Continued.

Species	Middle Bank	Nihoa and West Bank	Twin Banks	Necker	French Frigate Shoals	Brooks Banks	St. Rogatien Bank	Gardner Pinnacles	Raita Bank	Maro Reef	Laysan	Northampton Seamounts	Lisianski and Pioneer Bank	Bank 8	Pearl and Hermes Reef	Salmon Bank	Ladd Seamount	Midway	Nero Seamount	Kure Atoll	Bank 11	Hancock Seamounts
Phalium kurodai				285																		
				285																		
Coralliophilidae																						
Latiaxis kawamurai								143														
								143														
Fasciolariidae																						
Fusinus sandvicensis																	71					
																	71					
Nassariidae																						
Nassarius crematus																	71					
																	71					
Opisthobranchia																						
Nudibranchia																						
Nudibranch sp.				269	84						71											
				269	93						214											
BIVALVIA																						
Pinnidae																						
Pinna bicolor				88	86																	
				99	91																	
P. muricata				71																		
				71																		
Pinna sp.											75	86										
											91	88										
CEPHALOPODA																						
Bolitaenidae																						
Japetella diaphana				867																		
				867																		
Octopodidae																						
Octopus cyanea				35	62			33		31	18				18			46		37		
				35	62			33		31	88				62			91		37		
O. ornatus											51											
											51											
Scaeurgus patagiatus										75												
										252												
Ommastrephidae																						
Nototodarus hawaiiensis				430																		
				494																		
Enoploteuthidae																						
Abralia sp.										90												
										91												
Histioteuthidae																						
Histioteuthis miranda																						256
																						256
CHORDATA																						
Carcharhinidae																						
Carcharhinus falciformis					—						—											
					—						—											
C. galapagensis		—		—						31	16		31		1			38		29		
		20		35						35	16		31		—			38		31		
C. amblyrhynchos				—	—			—		—	18		—		18							
				23	22			—		18	18		—		29							
C. plumbeus				77	73																	
				99	77																	
Galeocerdo cuvieri										26												
										26												
Triaenodon obesus		—													11					15		
		20													110					22		
Squalidae																						
Etmopterus pusillus																						263
																						311
E. villosus																						280
																						280

Table 4.—Continued.

Species	Middle Bank	Nihoa and West Bank	Twin Banks	Necker	French Frigate Shoals	Brooks Banks	St. Rogatien Bank	Gardner Pinnacles	Raita Bank	Maro Reef	Laysan	Northampton Seamounts	Lisianski and Pioneer Bank	Bank 8	Pearl and Hermes Reef	Salmon Bank	Ladd Seamount	Midway	Nero Seamount	Kure Atoll	Bank 11	Hancock Seamounts
Isistius brasiliensis																						256
																						302
Squalus blainvillei		329		29				—		177	293								112	165	165	252
		329		384				—		366	293								112	170	168	311
Squalus sp.																	205		116			256
																	205		116			256
Dasyatidae																						
Dasyatis hawaiiensis				311							342											
				342							355											
D. lata										112	351											
										112	357											
Moringuidae																						
Moringua macrochir				29																		
				33																		
Muraenidae																						
Echidna nebulosa		44																				
		48																				
Gymnothorax berndti				183											155		152					
				183											155		152					
G. eurostus																				137		
																				174		
G. flavimarginatus				27		27		51			27		27		33							
				27		33		51			27		37		37							
G. hepaticus				33	49	27		31		31					33					29		
				44	49	27		31		31					49					29		
G. meleagris				46	24			51														
				46	24			51														
G. nudivomer															271	141						
															271	141						
G. steindachneri	64	51	73	22	48	29	31	29	33	31	29		27		33	104	66	42	110			
	66	59	73	84	66	33	31	51	40	31	35		55		49	104	71	46	110			
G. undulatus				27						31			33		13				110			
				27						33			40		44				110			
Congridae																						
Ariosoma marginatum										75							71					
										91							71					
Conger cinereus marginatus				27				51										22				
				71				51										22				
C. oligoporus					364				48		88					507					168	
					364				48		88					507					168	
Conger sp.	454			48				31											170	29		283
	454			48				31											170	170		302
Congrina aequoria				66	699					181	79					640	71					
				686	699					181	97					640	71					
Rhynchocymba nystromi nystromi																						256
																						258
Synaphobranchidae																						
Meadia abyssalis																						263
																						293
Synaphobranchus affinis												887										
												887										
Argentinidae																						
Argentina striata				430																		
				494																		
Glossanodon struhsakeri										369												263
										373												278
Gonostomatidae																						
Argyripnus atlanticus																						263
																						293

Table 4.—Continued.

Species	Middle Bank	Nihoa and West Bank	Twin Banks	Necker	French Frigate Shoals	Brooks Banks	St. Rogatien Bank	Gardner Pinnacles	Raita Bank	Maro Reef	Laysan	Northampton Seamounts	Lisianski and Pioneer Bank	Bank 8	Pearl and Hermes Reef	Salmon Bank	Ladd Seamount	Midway	Nero Seamount	Kure Atoll	Bank 11	Hancock Seamounts
Sternoptychidae																						
Argyropelecus aculeatus																						256
																						302
Astronesthidae																						
Astronesthes lucifer																						258
																						258
Synodontidae																						
Saurida gracilis				311																		
				338																		
Synodus binotatus				29							88											
				33							88											
S. dermatogenys				36						31										88		
				36						33										97		
S. kaianus		48								194	320											
		48								252	320											
S. variegatus										31	79											
										31	97											
Trachinocephalus myops				71				—		75	88									88		
				121				—		117	88									97		
Myctophidae																						
Benthosema fibulata				84																		
				93																		
Diaphus adenomus				375																		
				494																		
D. trachops																						263
																						293
Myctophum nitidulum																						258
																						258
Symbolophorus evermanni																				152		
																				190		
Lophiidae																						
Lophiomus miacanthus										110												269
										113												293
Lophiomus sp.				375																		
				384																		
Antennariidae																						
Antennarius drombus				64							90											
				71							104											
Chaunacidae																						
Chaunax umbrinus				357																		
				384																		
Ogcocephalidae																						
Halieutaea retifera				117						88	79				75					152		
				129						214	97				75					190		
Malthopsis jordani										227												
										252												
Moridae																						
Laemonema rhodochir																507				164		
																507				170		
Physiculus edelmanni																						258
																						293
P. grinnelli															97		130		108	170		263
															99		137		112	170		293
Ophidiidae																						
Brotula multibarbata			119	35						90												
			119	119						91												
Carapidae																						
Pyramodon ventralis											79											
											355											
Atherinidae																						
Pranesus insularum				—	1						1				1					1		
				—	—						—				—					—		

Table 4.—Continued.

Species	Middle Bank	Nihoa and West Bank	Twin Banks	Necker	French Frigate Shoals	Brooks Banks	St. Rogatien Bank	Gardner Pinnacles	Raita Bank	Maro Reef	Laysan	Northampton Seamounts	Lisianski and Pioneer Bank	Bank 8	Pearl and Hermes Reef	Salmon Bank	Ladd Seamount	Midway	Nero Seamount	Kure Atoll	Bank 11	Hancock Seamounts
Polymixiidae																						
Polymixia japonica				357															—			263
				384															—			311
Trachichthyidae																						
Paratrachichthys sp.										75												
										214												
Berycidae																						
Beryx decadactylus																						263
																						293
B. splendens																						163
																						311
Holocentridae																						
Holocentrinae sp.			29	26	31				35	29			16		18			60		37		
			51	37	31				51	33			16		18			60		40		
Neoniphon aurolineatus		48																				
		48																				
N. sammara				66																		
				77																		
Sargocentron diadema				27																		
				77																		
S. furcatum		48		29																		
		48		29																		
S. spiniferum				42	18					33			27		—							
				42	20					33			38		24							
S. xantherythrum		48		26	33	33				31	18		27		35			27				
		48		37	33	33				33	33		27		68			27				
Myripristis amaenus				—											22							
				18											22							
M. chryseres		48		66	—										68							
		—		77	—										68							
M. kuntee											18				11							
											40				11							
M. murdjan		48		26	22	33		48					38		18							
		48		77	33	33		48					38		22							
Pristilepis archiepiscopus										90												
										91												
Zeidae																						
Zenopsis nebulosa																						256
																						311
Caproidae																						
Antigonia eos				311	73					194					95						166	263
				384	77					198					106						168	311
A. steindachneri				115						181	338									164		265
				121						252	355									170		311
Cyttomimus stelgis				430																		
				494																		
Veliferidae																						
Velifer multispinosus	60	48		62	73					31	79				75	62						
	62	48		106	77					66	97				75	62						
Lophotidae																						
Lophotid sp.																						256
																						256
Aulostomidae																						
Aulostomus chinensis	64		91	27		27				82	18		24		35			64				
	64		91	106		27				112	95		44		75			64				
Fistulariidae																						
Fistularia commersoni	60	48		15	73				53	31	31				49	62						
	62	48		296	77				132	113	104				106	62						
F. petimba		36																				
		—																				

Table 4.—Continued.

Species	Middle Bank	Nihoa and West Bank	Twin Banks	Necker	French Frigate Shoals	Brooks Banks	St. Rogatien Bank	Gardner Pinnacles	Raita Bank	Maro Reef	Laysan	Northampton Seamounts	Lisianski and Pioneer Bank	Bank 8	Pearl and Hermes Reef	Salmon Bank	Ladd Seamount	Midway	Nero Seamount	Kure Atoll	Bank 11	Hancock Seamounts
Macrorhamphosidae																						
Macrorhamphosus gracilis				77																		
				99																		
M. scolopax																						263
																						311
Serranidae																						
Anthias thompsoni	60	36		93				100							78	62		64		62		
	62	48		99				100							82	62		64		190		
Caprodon schlegelii								[1]—							75					152	166	
								—							75					190	168	
Epinephelus quernus	146	44	183	27	59	46	—	35	31	102	90	164	110	146	33	119	64	26	146	18	165	
	146	183	183	229	194	183	—	110	172	201	183	219	238	183	238	119	216	219	219	219	210	
Plectranthias kelloggi																						283
																						302
Tosanoides filamentosus																						283
																						302
Kuhliidae																						
Kuhlia sandvicensis															—			1				
															22			1				
Priacanthidae																						
Cookeolus boops															—		—		183	164	166	263
															—		—		183	311	206	311
Priacanthus alalaua				29						75										—		
				71						252										18		
P. cruentatus				29	26	—	86	27	—	90	16		20		36	93		29				
				296	77	—	86	27	—	186	97		31		68	93		29				
P. meeki		48		66	26				97	31	15		18		18			11			166	
		48		77	26				97	33	33		22		22			11			172	
Apogonidae																						
Apogon coccineus		48																				
		48																				
A. kallopterus		48			22								27									
		48			22								27									
A. maculiferus		48		119	13					33	24		24		49	64		31		20		
		48		119	13					33	24		24		49	64		48		40		
A. taeniopterus					26																	
					26																	
Epigonus atherinoides				66																		
				77																		
E. fragilis				66							79											
				494							97											
Epigonus sp.										113												
										117												
Synagrops argyrea											79											
											97											
Synagrops sp.																				88		
																				97		
Carangidae																						
Carangoides orthogrammus		18	—	18	26	[1]—	[1]—	16	[1]—	[1]—	20				110					—		
		—	—	26	26	—	—	46	—	—	20				110					13		
Caranx ignobilis				1	1	[1]—	—	16	[1]—	1	1	[1]—	1	73	1			1				
				24	31	—	—	46	—	35	35	—	55	73	91			4				
C. lugubris		—			[1]—	1	[1]—	110														
		—			—	—	—	110														
C. melampygus				1	1	[1]—	[1]—	46		1	1							—				
				55	183	—	—	46		36	20							—				
C. sexfasciatus								—							—							
								—							—							
Decapterus macarellus		—		27	22					22												
		—		33	26					22												

Table 4.—Continued.

Species	Middle Bank	Nihoa and West Bank	Twin Banks	Necker	French Frigate Shoals	Brooks Banks	St. Rogatien Bank	Gardner Pinnacles	Raita Bank	Maro Reef	Laysan	Northampton Seamounts	Lisianski and Pioneer Bank	Bank 8	Pearl and Hermes Reef	Salmon Bank	Ladd Seamount	Midway	Nero Seamount	Kure Atoll	Bank 11	Hancock Seamounts
D. macrosoma										208												
										214												
D. muroadsi											88											
											88											
D. tabl				325						113	340									7		—
				384						117	357									7		—
Elagatis bipinnulata		1	1	1	1			1		1	1	42			1		[1]—			1		
		37	—	55	42			—		—	—	42			—		—			—		
Gnathanodon speciosus				—				—							—			1				
				—				—							—			2				
Pseudocaranx dentex		—	27	66	110		—	16	183	102	146	201	27	—	42		84	1	183	1		
		—	46	174	165		—	183	183	201	174	201	194	—	238		106	128	183	183		
Selar crumenophthalmus		—		27	22					18	1		18		1			1		—		
		—		27	26					24	4		22		2			31		18		
Seriola dumerili	44	51	29	1	26	51	51	16	146	1	1		110	146	35			1	112	9		
	146	73	91	229	186	201	73	128	146	201	183		247	165	238			128	112	9		
S. lalandei									—								146	1		1		
									—								146	—		—		
Uraspis helvola				66																		
				77																		
Coryphaenidae																						
Coryphaena hippurus		1		1	1	1	1	1		1	1	1	1	1	1			1		1	1	
		—		—	—	—	—	—		—	—	—	—	—	—			—		—	—	
Bramidae																						
Bramid sp.																	95				168	
																	95				172	
Emmelichthyidae																						
Erythrocles scintillans					73																	
					77																	
Emmelichthys struhsakeri										194	338											263
										214	347											311
Lutjanidae																						
Aphareus furca					26	[1]—					—											
					26	—					—											
Aphareus sp.									—													
									—													
Aprion virescens		1				[1]—	[1]—											18				
		59				—	—											18				
Etelis carbunculus		48	183	139	113	[1]—	—	128	—	102	174	110	179	219	121	119	146	192	183	219		
		201	183	229	152	—	—	183	—	201	201	219	238	238	271	219	216	219	183	219		
E. coruscans		—	256	—	—	[1]—	—	—	—	[1]—	256		194	—	183	—				183		
		—	256	—	—	—	—	—	—	—	256		194	—	229	—				183		
Lutjanus kasmira	62	31	77	24	20	26		27		62												
	66	60	77	110	64	31		48		62												
Pristipomoides auricilla					—	[1]—		[1]—			—											
					—	—		—			—											
P. filamentosus	36	—	—	27	46	37	—	27	40	31	64	110	91	71	57	[1]—			108			
	73	—	—	328	186	161	—	187	40	187	174	201	179	71	164	—			108			
P. sieboldii		137	91	110	113	[1]—	—	128	172	102	—	146	194	—	164	219	146		219	—		
		137	91	128	201	—	—	128	183	102	—	201	194	—	198	219	216		219	—		
P. zonatus		—		183	128	201	—	—	—	102	201	164	183	183	146	—						
		—		183	164	201	—	—	—	201	201	201	238	183	186	—						
Symphysanodon maunaloae				357						177	318									88		283
				384						186	338									97		302
S. typus																						—
																						—
Mullidae																						
Mulloides flaviolineatus	60			66							31		31					1				
	62			77							97		37					1				

Table 4.—Continued.

Species	Middle Bank	Nihoa and West Bank	Twin Banks	Necker	French Frigate Shoals	Brooks Banks	St. Rogatien Bank	Gardner Pinnacles	Raita Bank	Maro Reef	Laysan	Northampton Seamounts	Lisianski and Pioneer Bank	Bank 8	Pearl and Hermes Reef	Salmon Bank	Ladd Seamount	Midway	Nero Seamount	Kure Atoll	Bank 11	Hancock Seamounts
M. pflugeri		48		99	49																	
		48		106	49																	
M. vanicolensis		48		26	44			31	33	31										88		
		48		99	44			31	33	95										97		
Parupeneus bifasciatus				33																		
				33																		
P. chrysonemus	60	48		27	37	33			108	26	29		55		37			60		48		
	62	48		29	77	33			108	91	97		55		75			64		69		
P. cyclostomus				33	2						1		31									
				71	2						2		31									
P. multifasciatus	60	18		18	55			22	33	26	27		44		27			1		40		
	64	48		77	59			22	33	29	33		44		37			6		48		
P. pleurostigma	60	48		22	24	33		22		26	29		31		37					40		
	62	48		69	77	33		31		37	68		31		40					40		
P. porphyreus	60			35							31				36			2				
	62			77							33				53			64				
Upeneus faeniopterus													31									
													31									
Kyphosidae																						
Kyphosus bigibbus								22	33				42					1				
								22	33				42					1				
Sectator ocyurus			—								18											
			—								18											
Chaetodontidae																						
Chaetodon fremblii		33		27	24	33				27	15			69	27					37		
		48		119	77	33				113	97			69	40					53		
C. kleini	60	31			24																	
	62	48			24																	
C. miliaris	60	31		22	31	27		31	33	29	38			69	18		71		55	48		
	62	57		119	77	33		31	33	113	97			69	75		71		55	60		
C. multicinctus	60																					
	62																					
Heniochus diphreutes	60	48		27	20					53	31		22									
	62	48		121	31					128	31		69									
Pomacanthidae																						
Centropyge fisheri										88			55									
										95			55									
Centropyge sp.		48																				
		48																				
Genicanthus personatus				64																		
				77																		
Pentacerotidae																						
Histiopterus typus				115																		
				121																		
Pseudopentaceros wheeleri																	—			—		252
																	—			—		311
Pomacentridae																						
Abudefduf abdominalis																		1				
																		9				
Dascyllus albisella		48		27						31												
		48		33						33												
Chromis ovalis				27						90	31							37		33		
				33						91	33							64		42		
C. struhsakeri																				164		
																				170		
C. verater	60	48		33						84										33		
	62	48		99						186										190		
Chromis sp.					73																	
					77																	
Stegastes fasciolatus																				33		
																				42		

Table 4.—Continued.

Species	Middle Bank	Nihoa and West Bank	Twin Banks	Necker	French Frigate Shoals	Brooks Banks	St. Rogatien Bank	Gardner Pinnacles	Raita Bank	Maro Reef	Laysan	Northampton Seamounts	Lisianski and Pioneer Bank	Bank 8	Pearl and Hermes Reef	Salmon Bank	Ladd Seamount	Midway	Nero Seamount	Kure Atoll	Bank 11	Hancock Seamounts
Cirrhitidae																						
Cirrhites pinnulatus																		6				
																		23				
Cheilodactylidae																						
Cheilodactylus vittatus		48												66	53			2		37		
		48												66	62			55		37		
Labridae																						
Bodianus bilunulatus		6		11	31	110	33	22	35	29	26		9		18	64		6		18		
		18		71	113	110	33	51	48	33	26		46		38	64		49		53		
B. sanguineus										88												
										95												
B. vulpinus				—	—				—		146				183				183	219		
				—	—				—		146				183				219	219		
Cheilinus bimaculatus		48			24					90												
		48			24					91												
C. unifasciatus					18												—	—				
					26												—	—				
Cirrhilabrus jordani										75												
										91												
Coris ballieui				29	55			46	108	69	51				48	79	73			27		
				71	55			46	108	91	84				49	79	73			27		
Coris sp.				42							33			69	18			40				
				46							33			69	38			44				
Xyrichtys baldwini					73				88													
					77				132													
X. niger				29																		
				35																		
Hemipteronotus woodi		48																				
		48																				
Pseudocheilinus sp.		48																				
		48																				
Thalassoma ballieui		18		37									18		18			1		40		
		18		37									18		55			60		44		
T. purpureum																		1				
																		1				
Scaridae																						
Calotomus carolinus				64							31											
				71							33											
C. zonarcha				29																		
				71																		
Calotomus sp.										33												
										35												
Scarus dubius																		1				
																		1				
S. perspicillatus				64														1				
				71														1				
Scarus sp.		48			2					31								1				
		48			2					33								1				
Mugilidae																						
Mugil cephalus																		1				
																		1				
Sphyraenidae																						
Sphyraena barracuda					198																	
					198																	
S. helleri				1	26			16			1									33		
				—	26			16			33									42		
Polynemidae																						
Polydactylus sexfilis																		1				
																		27				
Mugiloididae																						
Parapercis roseoviridis																						263
																						311

Table 4.—Continued.

Species	Middle Bank	Nihoa and West Bank	Twin Banks	Necker	French Frigate Shoals	Brooks Banks	St. Rogatien Bank	Gardner Pinnacles	Raita Bank	Maro Reef	Laysan	Northampton Seamounts	Lisianski and Pioneer Bank	Bank 8	Pearl and Hermes Reef	Salmon Bank	Ladd Seamount	Midway	Nero Seamount	Kure Atoll	Bank 11	Hancock Seamounts
Cantherhines dumerili				29 69																		
C. verecundus		48 48		33 99							31 33											
Melichthys niger				42 42				35 35														
M. vidua					26 26																	
Pervagor melanocephalus										31 33												
P. spilosoma				26 119	49 49	33 59				27 37	24 357		16 31							64 64		
Pseudomonacanthus garretti				29 121	62 62				53 132	75 187	31 104											
Rhinecanthus aculeatus		36 40																				
Sufflamen fraenatus	60 62	35 35		33 71																		
Xanthichthys mento	60 62			64 119					53 60	59 66												
Ostraciidae																						
Aracana aculeata										194 252												
Lactoria diaphanus				29 106							79 97											
L. fornasini	60 62	48 48		29 99	73 77				53 132	31 112	31 97		22 22		15 82	62 62				99 110		
Ostracion meleagris				64 71																		
Tetraodontidae																						
Arothron hispidus		48 48		29 121																		
A. meleagris				66 77						31 33			31 31									
Canthigaster amboinensis										137 165												
C. coronata	60 62			29 121																		
C. epilampra	60 62																					
C. jactator													22 27									
C. rivulata	60 62	48 48		33 121					101 108	75 91	31 33											
Canthigaster sp.					24 24					31 165	31 104		31 46			62 62				24 24		
Lagocephalus lagocephalus				33 296	64 77			66 66	93 122	121 165												
Sphoeroides cutaneus				62 338			— —	— —		111 187	84 357						216 216			— —		
Torquigener randalli		80 102		29 296	57 210		80 102	60 101	80 132	31 174	55 104				77 82			— —		60 110		
Diodontidae																						
Chilomycterus affinis				62 106																		
Diodon holocanthus	60 62	48 48		29 99						31 95	31 104											
D. hystrix		36 40		29 106	73 77				53 132	31 66	33 97		31 31		64 82	62 62						

[1]Northwestern Hawaiian Island Bottom Fish Project, Henry Sakuda, Director, Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii, Honolulu, HI 96813, pers. commun., 9 February 1984.

Table 5.—Size range and a checklist of types of gear used in the capture of crustaceans, molluscs, and fishes in the Northwestern Hawaiian Islands during the resource surveys, October 1976-September 1981.

Species	Length (mm)		Weight (g)		Fish trawl	Shrimp trawl	Lobster trap	Fish trap	Shrimp trap	Crab net	Handline	Trolling line	Night light	Bottom longline	Other
	Min	Max	Min	Max											
ARTHROPODA															
CRUSTACEA															
Penaeidae															
Penaeus marginatus	20	46	10	30	x	x		x							
Oplophoridae															
Acanthephyra eximea		26							x						
Oplophorus gracilirostris					x										
O. spinosus					x										
Nematocarcinidae															
Nematocarcinus gracilis									x						
Pandalidae															
Heterocarpus ensifer	11	53	3	30	x			x	x						
H. laevigatus	15	58	60	180					x						
Plesionika ensis	11	36							x						
P. edwardsii	9	28	2	13				x	x						
P. ocellus					x										
Palinuridae															
Panulirus marginatus	34	149	80	2,660	x		x	x							
P. penicillatus	67	177	580	3,800			x								
Scyllaridae															
Parribacus antarcticus	53	92	170	650	x		x	x							
Scyllarides haanii	105	160	650	2,280			x	x							
S. squammosus	50	167	90	2,420	x	x	x	x							
Galatheidae															
Munida sp.					x										
Lithodidae															
Lithodes nintokuae									x						
Diogenidae															
Dardanus brachyops	38	75	50	350			x	x							
D. gemmatus							x	x							
D. megistos							x	x							
Parapaguridae															
Parapagurus dofleini									x						
Raninidae															
Ranina ranina	70	167	50	1,940			x	x		x					
Dromiidae															
Dromidiopsis dormia		112		1,900			x	x							
Homolidae															
Homola ikedai									x						
Hypsophys williamsi									x						
Paromola japonica									x						
Leucosiidae															
Randallia distincta									x						
Calappidae															
Calappa bicornis								x		x					
C. calappa							x	x							
C. hepatica								x							
Majidae					x			x	x	x					
Cyrtomaia smithi									x						
Parthenopidae															
Parthenope contrarius							x	x		x					
P. nummiferus							x								
Portunidae															
Charybis hawaiensis								x							
Lupocyclus quinquedentatus								x							
Macropipus corrugatus								x							
Portunus suborbicularus								x		x					
Portunus sp.								x							
Thalamita auauensis							x			x					
Xanthidae															
Carpilius convexus								x							
C. maculatus		108		810			x	x							
Goneplacidae															
Progeryon sp.									x						

Table 5.—Continued.

Species	Length (mm) Min	Length (mm) Max	Weight (g) Min	Weight (g) Max	Fish trawl	Shrimp trawl	Lobster trap	Fish trap	Shrimp trap	Crab net	Handline	Trolling line	Night light	Bottom longline	Other
Cancridae															
Cancer macrophthalmus									x						
Stomatopoda															
Squillidae															
Odontodactylus brevirostris						x									
MOLLUSCA															
GASTROPODA															
Xenophoridae															
Xenophora sp.					x										
Cassidadae															
Phalium bulla								x							
P. kurodai								x							
Coralliophilidae															
Latiaxis kawamurai								x							
Fasciolariidae															
Fusinus sandvicensis								x							
Nassariidae															
Nassarius crematus								x							
OPISTHOBRANCHIA															
Nudibranchia					x	x		x							
BIVALVIA															
Pinnidae															
Pinna bicolor					x										x
P. muricata					x										x
Pinna sp.						x									
CEPHALOPODA															
Bolitaenidae															
Japetella diaphana									x						
Octopodidae															
Octopus cyanea					x		x	x							
O. ornatus								x							
Scaeurgus patagiatus						x		x							
Ommastrephidae															
Nototodarus hawaiiensis					x										
Enoploteuthidae															
Abralia sp.					x										
Histioteuthidae															
Histioteuthis miranda					x										
CHORDATA															
Carcharhinidae															
Carcharhinus falciformis		2,085									x				
C. galapagensis	593	2,060		23,000	x		x				x				x
C. amblyrhynchos	760	1,867	3,630	24,550							x	x			x
C. plumbeus					x		x								
Galeocerdo cuvieri	2,438	3,080													x
Triaenodon obesus	105	1,362	2,200	24,500			x								x
Squalidae															
Etmopterus pusillus		230		100	x										
E. villosus	283	346						x							
Isistius brasiliensis					x										
Squalus blainvillei	290	872	200	5,250	x		x	x			x				
Dasyatidae															
Dasyatis hawaiiensis		1,402			x										
D. lata					x										
Moringuidae															
Moringua macrochir					x										
Muraenidae															
Echidna nebulosa								x							
Gymnothorax berndti		804		940				x			x				
G. eurostus		780		1,100				x							
G. flavimarginatus	752	1,204	1,000	2,100			x	x							
G. hepaticus	1,003	1,167	1,100	1,500			x	x							
G. meleagris	777	979	800	1,720				x							
G. nudivomer								x							
G. steindachneri	455	966	200	1,400			x	x							
G. undulatus	866	909	1,040	1,290			x	x							

Table 5.—Continued.

Species	Length (mm) Min	Length (mm) Max	Weight (g) Min	Weight (g) Max	Fish trawl	Shrimp trawl	Lobster trap	Fish trap	Shrimp trap	Crab net	Handline	Trolling line	Night light	Bottom longline	Other
Congridae															
Ariosoma marginatum						x		x							
Conger cinereus marginatus		964		1,720	x		x	x							
C. oligoporus	330	942	385	2,300	x		x	x	x						
Conger sp.			1,830	1,920	x		x	x	x		x				
Congrina aequoria	385	452			x			x	x						
Rhynchocymba nystromi nystromi					x										
Synaphobranchidae															
Meadia abyssalis					x										
Synaphobranchus affinis									x						
Argentinidae															
Argentina striata					x										
Glossanodon struhsakeri					x										
Gonostomatidae															
Argyripnus atlanticus					x										
Sternoptychidae															
Argyropelecus aculeatus					x										
Astronesthidae															
Astronesthes lucifer					x										
Synodontidae															
Saurida gracilis	165	184			x										
Synodus binotatus	[1]165	240			x										
S. dermatogenys	144	190			x			x							
S. kaianus		149			x	x									
S. variegatus					x			x							
Trachinocephalus myops					x	x			x						
Myctophidae															
Benthosema fibulata					x										
Diaphus adenomus	120	175			x										
D. trachops					x										
Myctophum nitidulum					x										
Symbolophorus evermanni					x										
Lophiidae															
Lophiomus miacanthus					x										
Lophiomus sp.					x										
Antennariidae															
Antennarius drombus					x										
Chaunacidae															
Chaunax umbrinus		[2]117			x										
Ogcocephalidae															
Halieutaea retifera	112	139			x	x									
Malthopsis jordani						x									
Moridae															
Laemonema rhodochir	[1]210	250			x				x						
Physiculus edelmanni					x										
P. grinnelli	248	339	160	480	x			x							
Ophidiidae															
Brotula multibarbata		[2]179			x	x		x							
Carapidae															
Pyramodon ventralis	120	187			x										
Atherinidae															
Pranesus insularum		[2]87			x										
Polymixiidae															
Polymixia japonica	134	242	70	800	x						x				
Trachichthyidae															
Paratrachichthys sp.						x									
Berycidae															
Beryx decadactylus	[1]132	185			x										
B. splendens	153	368	60	1,030	x						x				
Holocentridae															
Holocentrinae sp.							x	x			x				
Neoniphon aurolineatus						x									
N. sammara	[1]110	200	80	130	x										
Sargocentron diadema	[1]90	120			x			x							
S. fureatum					x			x							

Table 5.—Continued.

Species	Length (mm) Min	Length (mm) Max	Weight (g) Min	Weight (g) Max	Fish trawl	Shrimp trawl	Lobster trap	Fish trap	Shrimp trap	Crab net	Handline	Trolling line	Night light	Bottom longline	Other
S. spiniferum	317	356	740	1,330			x	x							
S. xantherythrum	[1]75	136	50	60	x			x							
Myripristis amaenus	147	253	60	340	x										
M. chryseres	[2]108	224		310	x						x				
M. kuntee	156	203		130	x			x							
M. murdjan	138	259	30	540	x			x			x				
Pristilepis archiepiscopus						x									
Zeidae															
Zenopsis nebulosa	106	412	50	740	x										
Caproidae															
Antigonia eos	57	104			x	x		x							
A. steindachneri	54	[2]175			x	x		x							
Cyttomimus stelgis					x										
Veliferidae															
Velifer multispinosus	72	267			x										
Lophotidae					x										
Aulostomidae															
Aulostomus chinensis	392	836			x			x							
Fistulariidae															
Fistularia commersoni	270	1,121	230	320	x						x				
F. petimba						x									
Macrorhamphosidae															
Macrorhamphosus gracilis					x										
M. scolopax					x										
Macrorhamphosus sp.					x	x									
Serranidae															
Anthias thompsoni	60	156			x			x							
Anthias sp.						x									
Caprodon schlegelii	155	342			x										
Epinephelus quernus	172	1,106	130	34,700	x		x	x			x			x	
Plectranthias kelloggi	188	201		200	x			x			x				
Tosanoides filamentosus					x										
Kuhliidae															
Kuhlia sandvicensis	118	310	10	750											x
Priacanthidae															
Cookeolus boops	245	594	370	3,200	x						x				
Priacanthus alalaua	285	350	400	750	x	x					x				
P. cruentatus	[2]78	316	100	260	x	x		x			x		x		x
P. meeki	[2]80	366	110	700	x			x					x		x
Apogonidae								x							
Apogon coccineus					x										
A. kallopterus		[2]115		50	x			x							
A. maculiferus		134		80	x		x	x							
A. taeniopterus		182						x							
Epigonus atherinoides					x										
E. fragilis	74	117			x										
Synagrops argyrea		150			x										
Carangidae															
Carangoides orthogrammus	249	736	1,090	7,050	x						x	x			x
Caranx ignobilis	207	1,330	100	39,430			x	x			x	x	x		x
C. lugubris	243	760	200	8,230	x						x	x			
C. melampygus	93	847	150	6,400							x	x			x
C. sexfasciatus		707		4,700							x				
Decapterus macarellus	194	323	100	310	x						x		x		
D. macrosoma						x									
D. muroadsi					x										
D. tabl	[1]115	454		1,300	x							x			
Elagatis bipinnulata	371	972	700	11,400								x			
Gnathanodon speciosus	338	444	950	2,100							x				x
Pseudocaranx dentex	75	1,314	50	11,500	x		x	x			x				x
Selar crumenophthalmus	117	311	10	600							x		x		x
Seriola dumerili	318	1,494	500	26,500	x		x	x			x	x	x		x
S. lalandei	485	758	1,300	5,040							x	x			
Uraspis helvola		[2]275			x										
Coryphaenidae															
Coryphaena hippurus	483	1,230	2,000	19,000								x			

Table 5.—Continued.

Species	Length (mm) Min	Length (mm) Max	Weight (g) Min	Weight (g) Max	Fish trawl	Shrimp trawl	Lobster trap	Fish trap	Shrimp trap	Crab net	Handline	Trolling line	Night light	Bottom longline	Other
Bramidae					x			x							
Emmelichthyidae											x				
Erythrocles scintillans					x										
Emmelichthys struhsakeri	147	227			x	x									
Lutjanidae															
Aphareus furca		367		820							x				x
Aprion virescens	385	809	810	9,000	x			x			x	x			x
Etelis carbunculus	260	635	280	4,500				x			x				
E. coruscans	366	875	700	10,000							x				
Lutjanus fulvus											x				
L. kasmira	138	312	90	541	x			x			x				x
Pristipomoides auricilla	287	413	430								x				
P. filamentosus	173	779	110	8,000	x		x	x			x			x	
P. sieboldii	245	435	100	1,720							x				
P. zonatus	263	489	390	3,120	x						x				
Symphysanodon maunaloae	96	165			x										
S. typus		177			x										
Mullidae															
Mulloides flaviolineatus	129	410	10	1,420	x										x
M. pflugeri	155	440	30	1,550	x			x			x				
M. vanicolensis	[1]84	344	160	250	x	x		x				x			
Parupeneus bifasciatus			70					x							
P. chrysonemus	55	[2]196	90	100	x	x	x	x		x					
P. cyclostomus	91	398	10	150	x										x
P. multifasciatus	130	252	100	340	x			x		x	x				x
P. pleurostigma	54	308	40	570	x			x			x				x
P. porphyreus	[2]205	423	200	1,760	x		x	x			x				x
Upeneus faeniopterus	[2]199	285		130	x										
Kyphosidae															
Kyphosus bigibbus	159	358	110	1,200			x	x			x				x
Sectator ocyurus								x							
Chaetodontidae															
Chaetodon fremblii	[1]69	161			x	x	x	x							
C. kleini	[2]60	90			x			x							
C. lunula					x										
C. miliaris	[1]50	145			x	x	x	x							
C. multicinctus	84	93			x										
Heniochus diphreutes	[1]75	170			x	x		x							
Pomacanthidae						x									
Centropyge fisheri								x							
Centropyge sp.					x										
Genicanthus personatus					x										
Pentacerotidae															
Histiopterus typus	[1]100	125			x										
Pseudopentaceros wheeleri	132	498	200	2,800	x			x			x			x	
Pomacentridae															
Abudefduf abdominalis	[1]104	156	80	210				x							x
Dascyllus albisella	65	95			x			x							
Chromis ovalis	[1]115	130			x	x		x							
C. struhsakeri	[1]104	120			x										
C. verater	[1]85	155			x	x		x							
Stegastes fasciolatus		[2]130			x										
Cirrhitidae															
Cirrhites pinnulatus	187	273	60	350							x				x
Cheilodactylidae															
Cheilodactylus vittatus	[1]235	275	180	270	x			x							x
Labridae															
Bodianus bilunulatus	243	526	270	3,300	x		x	x			x				x
B. sanguineus						x									
B. vulpinus	366	550	800	2,900							x				
Cheilinus bimaculatus					x	x		x							
C. unifasciatus	182	416	100	1,120							x				
Cirrhilabrus jordani						x									
Coris ballieui	212	250	100	220	x	x		x		x	x				
Xyrichtys baldwini	310	375			x										
X. niger					x										

Table 5.—Continued.

Species	Length (mm) Min	Length (mm) Max	Weight (g) Min	Weight (g) Max	Fish trawl	Shrimp trawl	Lobster trap	Fish trap	Shrimp trap	Crab net	Handline	Trolling line	Night light	Bottom longline	Other
Hemipteronotus woodi					x										
Pseudocheilinus sp.					x										
Thalassoma ballieui	241	375	200	1,300				x			x				x
T. purpureum	[2]88	357	30	850											x
Scaridae															
Calotomus carolinus	160	[2]292			x										
C. zonarcha	[1]110	305		260	x										
Scarus dubius	414	427	1,590	1,670											x
S. perspicillatus		561		3,710	x										x
Mugilidae															
Mugil cephalus	140	494	550	1,800											x
Sphyraenidae															
Sphyraena barracuda		1,319		30,000							x				
S. helleri	562	747	1,000	2,100	x							x			x
Polynemidae															
Polydactylus sexfilis	247	503	320	2,190			x						x		x
Mugiloididae															
Parapercis roseoviridis		145			x			x							
Percophididae															
Chrionema chryseres	140	185			x										
Ammodytidae															
Embolichthys mitsukurii						x									
Callionymidae															
Callionymus decoratus										x					
Synchiropus altivelis						x									
Acanthuridae															
Acanthurus nigroris	156	213	110	350	x										
A. olivaceus	[1]72	240			x			x							
A. triostegus	119	230	30	340											x
A. xanthopterus		[2]386		2,470				x							
Ctenochaetus strigosus	[1]112	140	100	170				x							
Naso brevirostris	[1]210	362			x										
N. hexacanthus		[2]295			x										
N. maculatus		[2]185			x										
N. unicornis	225	533			x										
Zanclus cornutus	[1]128	196			x										
Gempylidae															
Promethichthys prometheus	295	689	90	2,000	x						x				
Ruvettus pretiosus	873	1,064	3,300	9,650	x						x				
Scombridae															
Acanthocybium solandri	493	1,648	2,200	28,000							x	x			
Euthynnus affinis	264	808	300	12,800							x	x			
Katsuwonus pelamis	300	702	700	8,100								x			
Sarda orientalis	632	662	3,750	5,000							x				
Scomber japonicus	317	477	360	1,800	x						x				
Thunnus albacares	291	1,506	1,500	66,000								x			
T. obesus	412	957	2,500	16,000								x			
Istiophoridae															
Makaira nigricans	1,644	2,031		64,500								x			
Stromateidae															
Ariomma lurida		[2]200			x										
Cubiceps pauciradiatus	[1]175	657		6,400	x										
Hyperoglyphe japonica	407	859	1,190	11,140	x						x				
Scorpaenidae															
Dendrochirus barberi	85	127			x	x		x		x					
Iracundus signifer								x							
Pontinus macrocephalus	340	502	640	2,500	x						x				
Pterois sphex					x			x							
Rhinopias xenops		[2]124			x										
Scorpaena colorata	43	363		700	x	x					x				
S. coniorta		[2]126			x										
Scorpaenodes littoralis	[1]73	134			x										
Scorpaenopsis diabolus								x		x					
Scorpaenopsis sp.											x				
Setarches guentheri	75	123			x										

Table 5.—Continued.

Species	Length (mm) Min	Length (mm) Max	Weight (g) Min	Weight (g) Max	Fish trawl	Shrimp trawl	Lobster trap	Fish trap	Shrimp trap	Crab net	Handline	Trolling line	Night light	Bottom longline	Other
Triglidae															
Peristedion engyceros	116	174			x										
P. hians	113	151			x										
Hoplichthyidae															
Hoplichthys citrinus						x									
H. platophrys	150	199			x										
Dactylopteridae															
Dactyloptena orientalis	101	295			x	x									
Pegasidae															
Pegasus papilio	60	76			x	x									
Bothidae															
Arnoglossus debilis					x	x									
Bothus pantherinus	67	126			x			x							
B. thompsoni		[2]132			x	x									
Chascanopsetta prorigera		[2]130			x										
Parabothus chlorospilus	83	240			x	x									
P. coarctatus		186			x	x									
Taeniopsetta radula						x									
Pleuronectidae															
Poecilopsetta hawaiiensis	92	134			x										
Samariscus corallinus					x	x									
Triacanthodidae															
Hollardia goslinei					x										
Balistidae															
Alutera monoceros	96	110			x										
A. scripta					x			x							
Cantherhines dumerili					x										
C. verecundus		80			x			x							
Melichthys niger	307	316	860	1,790			x	x							
M. vidua											x				
Pervagor melanocephalus	90	93			x										
P. spilosoma	68	94			x		x	x							
Pseudomonacanthus garretti	76	203			x	x	x	x							
Rhinecanthus aculeatus					x										
Sufflamen fraenatus	[1]209	315	260	840	x		x				x				
Xanthichthys mento	[2]105	200			x										
Ostraciidae															
Aracana aculeata					x										
Aracana sp.	75	106			x										
Lactoria diaphanus	141	222			x										
L. fornasini	5	[2]255			x	x		x							
Ostracion meleagris	[1]70	210			x										
Tetraodontidae															
Arothron hispidus					x										
A. meleagris	185	238			x										
Canthigaster amboinensis					x										
C. coronata					x			x							
C. epilampra	59	120			x										
C. jactator								x							
C. rivulata	80	135			x	x		x							
Canthigaster sp.	88	97			x			x							
Lagocephalus lagocephalus					x			x			x				
Sphoeroides cutaneus	132	500		1,660	x		x	x			x				
Torquigener randalli	116	239		100	x	x		x			x				
Diodontidae															
Chilomycterus affinis					x										
Diodon holocanthus	65	183			x	x									
D. hystrix	60	336			x										

Note: Carapace length was measured on crustaceans. Fork length or total length was measured on fishes except where noted by footnote.

[1]All specimens of species were measured in standard lengths.

[2]Single individual was measured in standard length; all others in fork lengths.

SPECIES ACCOUNTS

Commercially important or potentially important species, particularly in the Hawaiian market place, are presented in the following species accounts. Information developed as a result of NMFS surveys is incorporated with existing information on each species. Black-and-white photographs of freshly caught specimens are included.

Synonymys are provided as a reference because some species have undergone many name changes. Vernacular names listed include the local name used in catch statistics maintained by the Hawaii Division of Aquatic Resources (HDAR), DLNR, and, when available, the common names recognized by the American Fisheries Society (AFS) and the International Game Fish Association (IGFA). The distributions provided for each species are those within the Hawaiian Archipelago only, i.e., distribution outside Hawaiian waters are not listed. The distinguishing characteristics provided are condensed from published material and are intended as guides in identifying the species. Meristic counts are included for the dorsal (D.), anal (A.), pectoral (P1.) and pelvic (P2.) fins; gill rakers (Gr.); lateral line scales (LLs.); and lateral line pored scales (LLps.).

Life history information is from the existing literature as well as from results of our studies. The principal gears used to capture each species in the Hawaiian fishery are mentioned. Data on catch were obtained from annual fish catch statistics of HDAR and are for fisheries that operate mainly in waters of the main islands.

Terminology used in the section on distinguishing characteristics for each species is indicated on explanatory figures for crustaceans (Figs. 34, 35, and 36), for octopus (Fig. 37), and for fishes (Fig. 38).

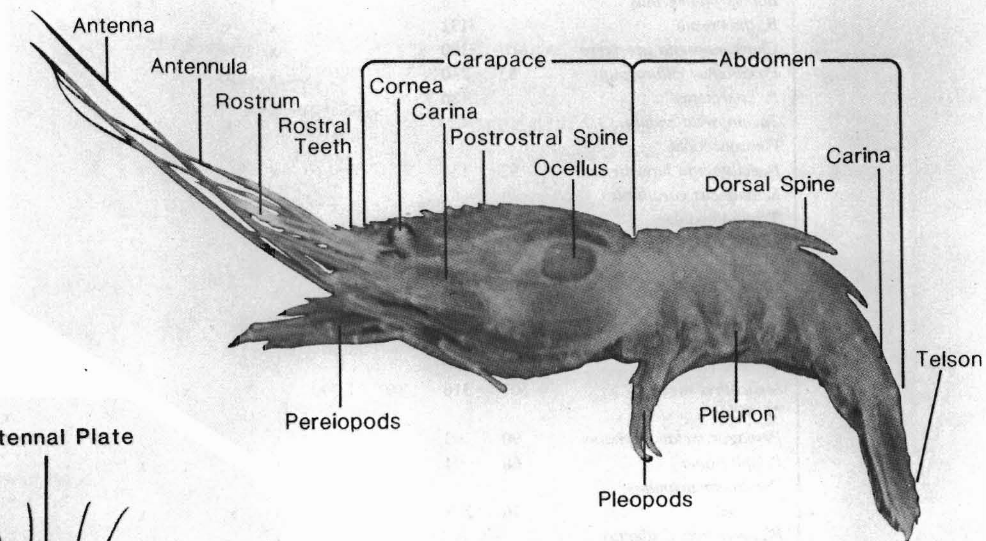

Figure 34.—Technical terms used in the description of shrimps.

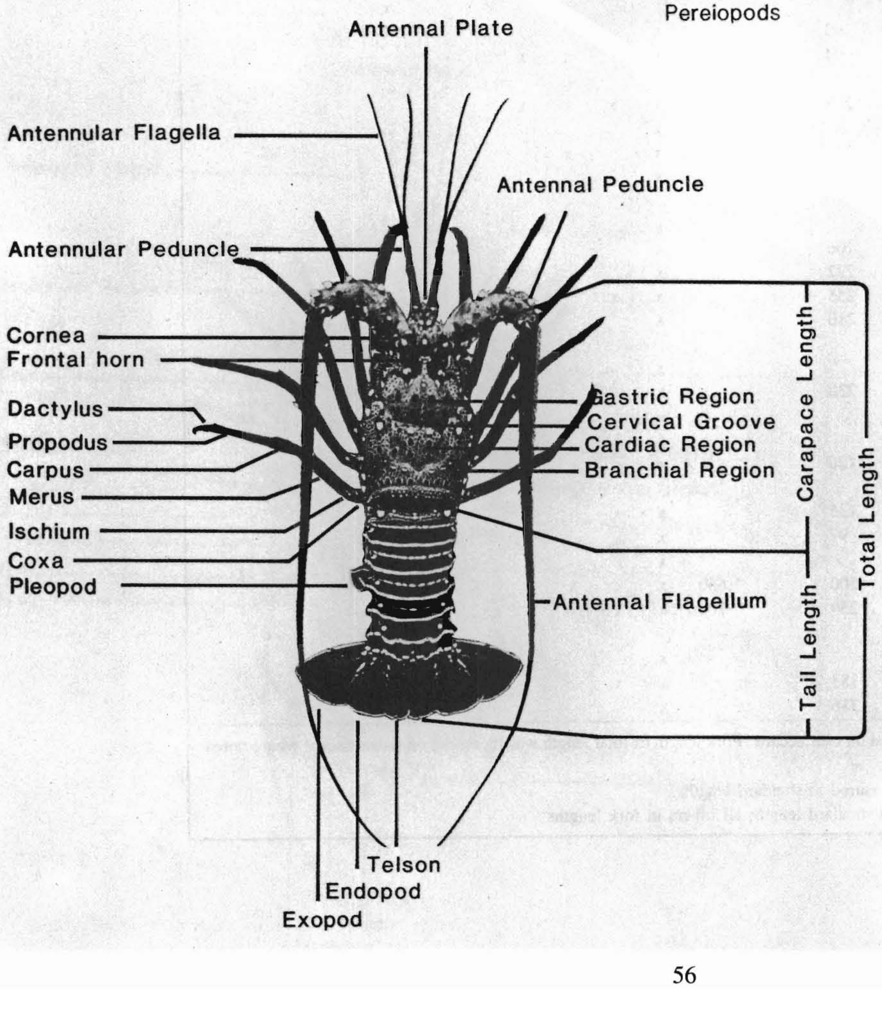

Figure 35.—Technical terms and principal measurements used in the description of lobsters.

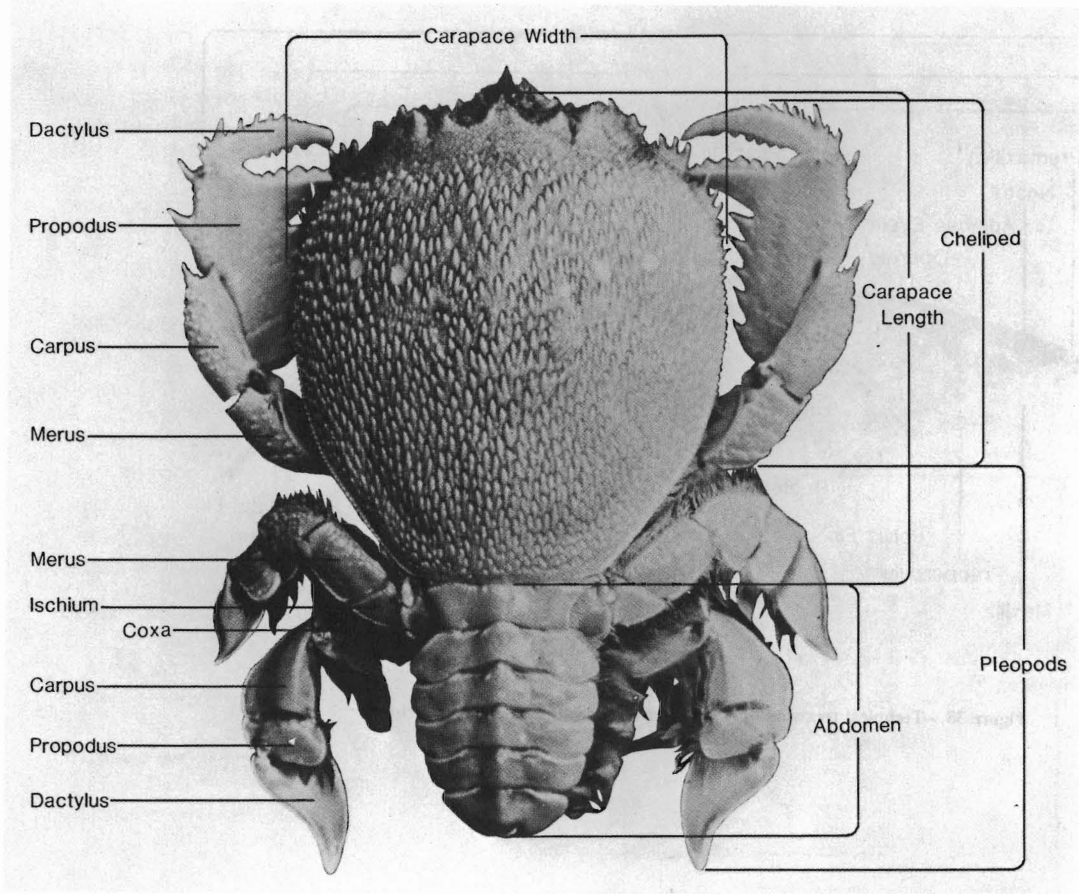

Figure 36.—Technical terms and principal measurements used in the description of crabs.

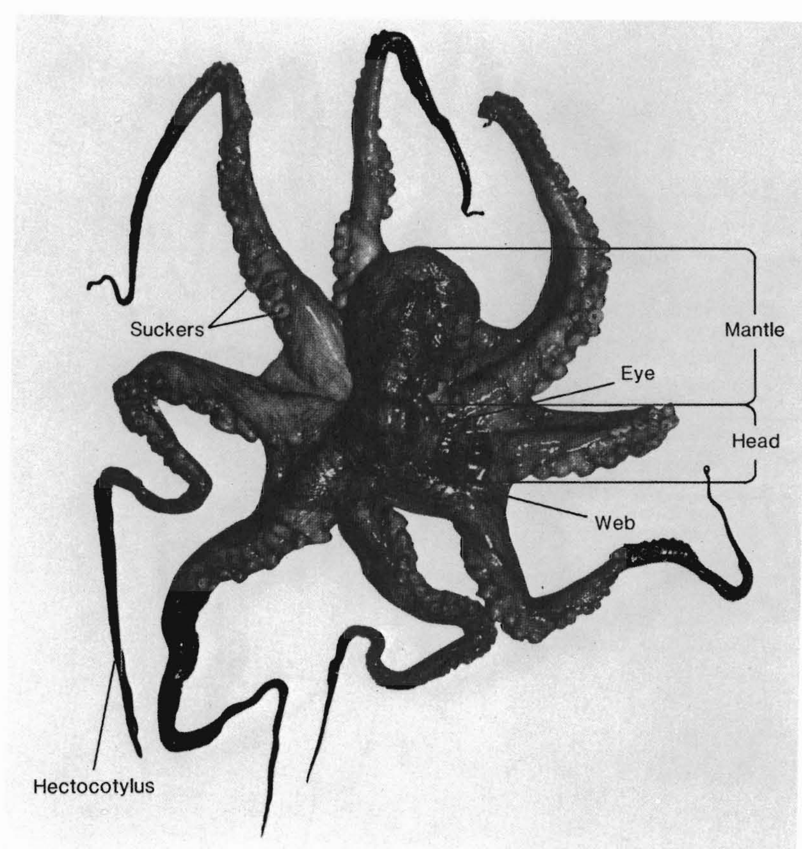

Figure 37.—Technical terms used in the description of an octopus.

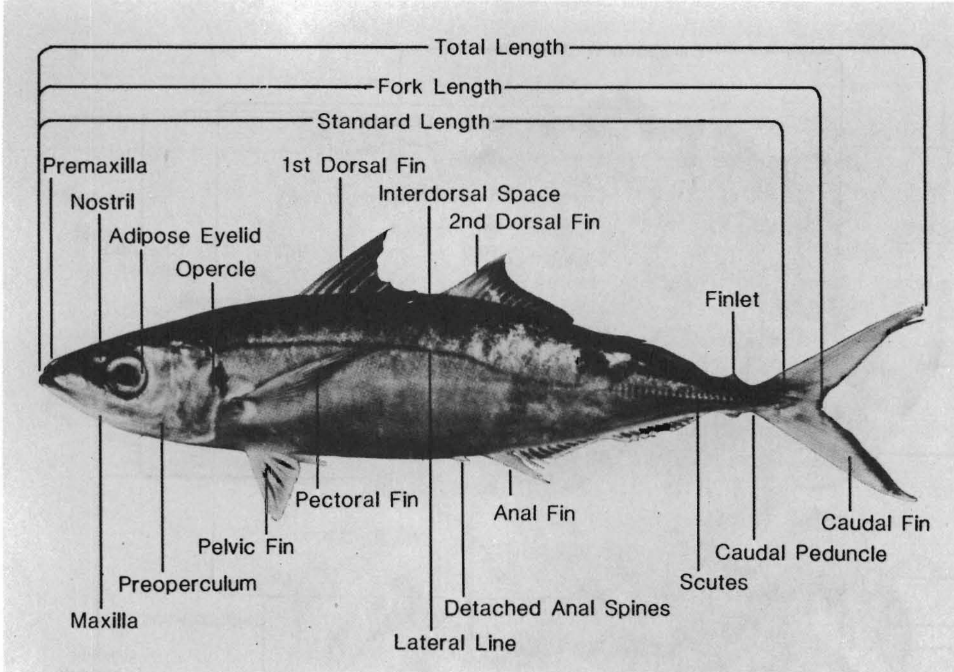

Figure 38.—Technical terms and principal measurements used in the description of bonyfishes.

CRUSTACEAN RESOURCES

Shallow-water crustaceans in Hawaiian waters are largely Indo-Pacific in origin; that is, many of the common crabs and shrimps in Hawaiian waters are also distributed from Madagascar and the Red Sea through the Indian and Pacific Oceans to Japan and the Tuamotu Archipelago (Edmondson 1946). Deep-water crustaceans, on the other hand, may be quite ubiquitous in their distribution.

There are a number of commercially valuable species of crustaceans in waters of the NWHI. The single most important species, one that has been responsible for the development of a multimillion dollar industry in Hawaii in recent years, is the spiny lobster, *Panulirus marginatus*, which is endemic to Hawaiian waters. Other crustaceans that are harvested in relatively high numbers are the slipper lobsters, *Scyllarides squammosus* and *S. haanii*, the caridean shrimps, *Heterocarpus ensifer* and *H. laevigatus*, and the kona crab, *Ranina ranina*. A species that has recently increased in commercial importance in Hawaii, being caught from time to time in waters off Molokai, is the penaeid shrimp, *Penaeus marginatus*.

A crustacean which is of no commercial importance but found in large numbers in NWHI waters is the hermit crab, *Dardanus gemmatus*. It lives in deep waters outside the reef and inhabits abandoned *Tonna* or tun shell which it decorates with sea anemones.

by Richard N. Uchida

Valid name	*Penaeus marginatus* Randall 1840 (Fig. 39)
Synonymy	*Penaeus teraoi* Kubo 1949
	Penaeus (*Melicertus*) *teraoi* Burukovsky 1972 (from Holthuis 1980)
Common and vernacular names	Royal Hawaiian shrimp; aloha prawn; opae; opaelolo

Distribution

Taken in the NWHI at Laysan (Rathbun 1906), French Frigate Shoals, Necker Island, and Maro Reef at depths of 112-243 m.

Distinguishing characteristics

Small chelae on the first three pereiopods; third pereiopod the longest. Relatively short, sharp-pointed rostrum, reaching a little beyond the tip of the antennular peduncle; armed dorsally with 9-10 teeth; 2-3 teeth on inferior margin. Postrostral crest extending nearly to posterior margin of carapace; bordered on either side by a broad furrow. Dorsomedian carina on abdomen beginning at about one-third the width of fourth somite and extending posteriorly into fifth and sixth somites, ending in acute spine directed posteriorly.

In life, red to pinkish red on dorsal surface and paler on sides; anterior portion of carapace below the eyes and outer edge of tail fan tinged with crimson.

Life history

Almost all members of the Family Penaeidae, with perhaps one or two exceptions, breed in offshore waters. The eggs are broadcast rather than clutched under the abdomen as in most decapods. The hatched larvae are pelagic and usually found far out to sea, although some may be washed into nearshore waters. As growth continues, the larvae are swept into shallow coastal waters where they metamorphose into juveniles. After completing the juvenile phase nearshore, the subadults move offshore into deeper waters. Opaelolo ≤40 mm total length (TL) have been found in nearshore and surface waters between Hawaii and Laysan Island (Rathbun 1906). Larger specimens, 40-95 mm TL, are usually found in harbors and shallow waters; whereas large specimens ≥125 mm are found in waters from 82 to 333 m.

Opaelolo apparently breeds throughout the year (Struhsaker and Yoshida 1975). Around the major islands, opaelolo makes nocturnal movements into shallower depths. Unlike other penaeids, opaelolo shows negative phototactic responses by moving offshore into deeper waters during daytime rather than burrowing. In captivity, however, it burrows readily, indicating that burrowing is also an important behavioral trait.

Gear and catch

Inshore, the species is taken by dip net at night, mostly by recreational fishermen. In deeper waters, for example, in Pailolo Channel, trawls are used. During the existence of a trawl fishery in the Pailolo Channel between 1974 and 1977, catches varied between 2,234 and 4,395 kg per year.

There is no fishery for this species in the NWHI.

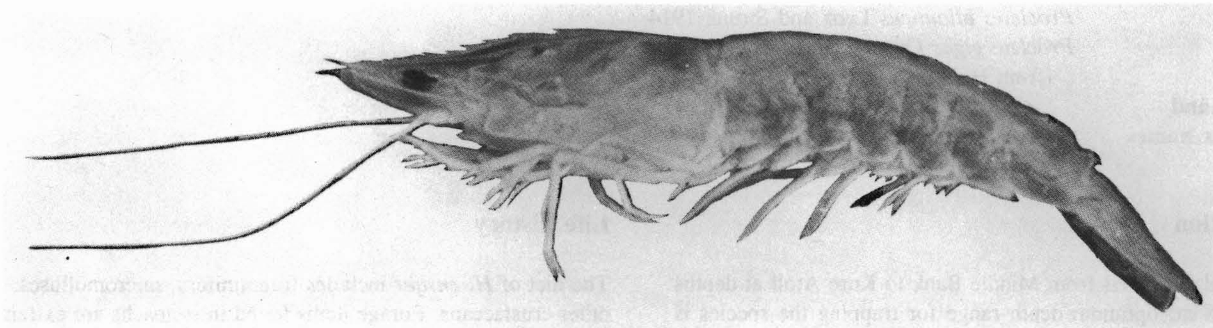

Figure 39.—*Penaeus marginatus*.

by Richard N. Uchida

Valid name	*Heterocarpus ensifer* A-Milne Edwards 1881 (Fig. 40)
Synonymy	*Pandalus carinatus* Smith 1882
	Heterocarpus carinatus Agassiz 1888
	Atlantocaris gigas Ortmann 1893
	Procletes atlanticus Lenz and Strunk 1914
	Proclete gigas Gurney and Lebour 1941 (from Holthuis 1980)
Common and vernacular names	Spot shrimp; armed nylon shrimp; two-spined shrimp

Distribution

Distributed in NWHI from Middle Bank to Kure Atoll at depths of 271-688 m; optimum depth range for trapping the species is 350-599 m (Gooding 1984). Occurs around the main islands most abundantly in depths of 365-440 m (Struhsaker and Aasted 1974).

Distinguishing characteristics

Three carinae (keels or ridges) and an ocellus (eyespot) on either side of the carapace. Postrostral crest and rostrum armed with 16-17 teeth along the dorsal border; 9 teeth along the ventral margin of rostrum. First and second abdominal somites relatively rounded and have no carinae; third and fourth abdominal somites armed with dorsal spines which posteriorly overhang; spine on third somite usually stronger than that on fourth, (although there is some variability in length of spine among non-Hawaiian samples (Hayashi and Miyake 1969)). Carapace translucent and internal anatomy of animal highly visible. Tip of rostrum, anterior portion of carapace, and pereiopods crimson and lighter or pinkish (posteriorly). Ocellus dark crimson and distinct in most specimens. Abdomen uniformly pinkish and ovigerous females carry blue eggs on pleopods.

Life history

The diet of *H. ensifer* includes foraminifers, micromolluscs, and other crustaceans. Forage items found in stomachs are extremely small, usually <0.5 mm. The species is cannibalistic, feeding on body parts, mostly pleopods of other shrimps.

Studies by Clarke (1972), Wilder (1977), and King (1980a, 1980b, 1981) suggested that *H. ensifer* is a protandrous hermaphrodite, that is, initially existing as a male before undergoing sex reversal into a female. Later studies, however, suggest that the species is dioecious and that the sexes can be distinguished by the endopods of the first two abdominal legs (King 1982; King and Moffitt 1984).

Gear and catch

This species is caught in pots of varying design and configuration (Struhsaker and Aasted 1974; Wilder 1979; King 1982; Klemm 1982).

No catch records are available from the fishery, although several boats have operated in the NWHI in the past few years.

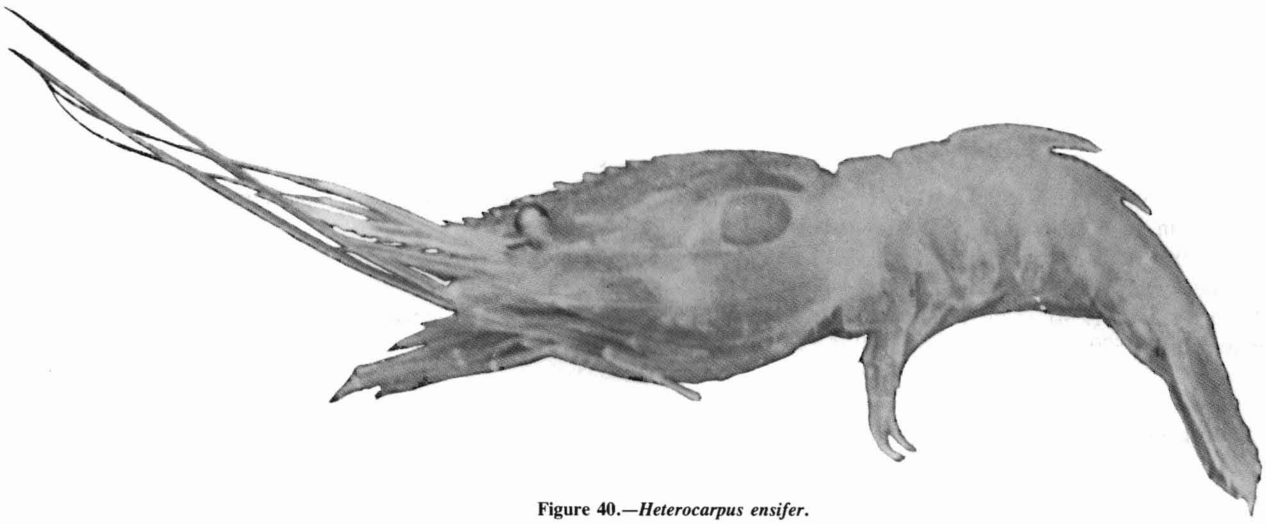

Figure 40.—*Heterocarpus ensifer*.

by Richard N. Uchida

Valid name	*Heterocarpus laevigatus* Bate 1888 (Fig. 41)
Synonymy	*Heterocarpus laevigatus occidentalis* Sivertsen and Holthuis 1956 (from Crosnier and Forest 1973)
Common and vernacular names	Smooth nylon shrimp; red-tipped shrimp; ono shrimp

Distribution

Distributed in the NWHI from Middle Bank to Kure Atoll at depths from 497 to 867 m. In most areas, the shallower end of the depth range overlaps that of the deeper end of *H. ensifer*. In the main islands, *H. laevigatus* is most abundant between 440 and 684 m (Struhsaker and Aasted 1974); in the NWHI, the optimum depth range for trapping is 500-799 m (Gooding 1984).

Distinguishing characteristics

Two carinae, but no ocellus on either side of carapace. Postrostral crest and rostrum armed dorsally with 6-7 teeth; ventral margin of rostrum has 10 teeth. Overhanging spines on the abdominal somites lacking; dorsal ridge on third abdominal somite.

Translucent carapace; entire rostrum crimson; orbital region lighter; carapace crimson anteriorly and fading to a lighter shade near the posterior margin. The pereiopods and pleopods crimson, abdomen lighter shade of red. Eggs blue.

Grows much larger (highly desirable commercial characteristic) than *H. ensifer*.

Life history

Male to female sex ratio of 46:54, based on 7,368 smooth nylon shrimp caught in Hawaiian waters departs significantly from equality.[3] Temporal factors rather than geographic ones appear to account for most major population variations in Hawaii. The relationships of sex ratios and sampling depths of smooth nylon shrimp and time of sampling indicate a gradual recruitment of small females from deep (760 m) to shallow (440 m) water, and that adult males and females move between depths of 550 and 700 m in synchrony with the ovigerous cycle of females.

In Hawaiian waters, smooth nylon shrimp spawn primarily in the fall and winter; spawning peaks between October and January. Less than 10% of the females are ovigerous in April-July. Females reach sexual maturity when the carapace length is 40 cm (4-year old). There is no evidence for protandrous hermaphroditism (see footnote 3).

Functional carapace length-weight relations of smooth nylon shrimp in Hawaii were examined separately for males, females without eggs, and females with eggs. These relationships are:

$$\text{Males: } \log_e W = -7.358 + 2.910 (\log_e CL)$$
$$\text{Nonovigerous females: } \log_e W = -6.757 + 2.745 (\log_e CL)$$
$$\text{Ovigerous females: } \log_e W = -5.498 + 2.470 (\log_e CL)$$

where W = weight (g) and CL = carapace length (mm). Slopes of the predictive regressions of males, nonovigerous females, and ovigerous females are significantly different (see footnote 3).

Growth rates were estimated by analysis of modal progression of length-frequency distributions. Von Bertalanffy growth equations are:

$$\text{Males: } L_t = 59.7 (1 - e^{-0.35t})$$
$$\text{Females: } L_t = 62.5 (1 - e^{-0.25t})$$

where L = carapace length (mm) expressed as a function of time t in years. From August 1983 through November 1984 mortality rates were $Z = 1.51 \text{ year}^{-1}$ for males and $Z = 0.73 \text{ year}^{-1}$ for female shrimps. Although male shrimps grow faster than females, they have a substantially higher mortality rate than females (see footnote 3).

Gear and catch

The gear used is identical to that for *H. ensifer* except that the float line (or drop line) must be considerably longer to reach the depths inhabited by this species.

Data on catch are not available, although commercial trapping for this species has begun in the NWHI.

[3]Dailey, M. D., and S. Ralston. Aspects of the reproductive biology, spatial distribution growth, and mortality of the deepwater caridean shrimp *Heterocarpus laevigatus* in Hawaii. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396 (manuscr. in prep.).

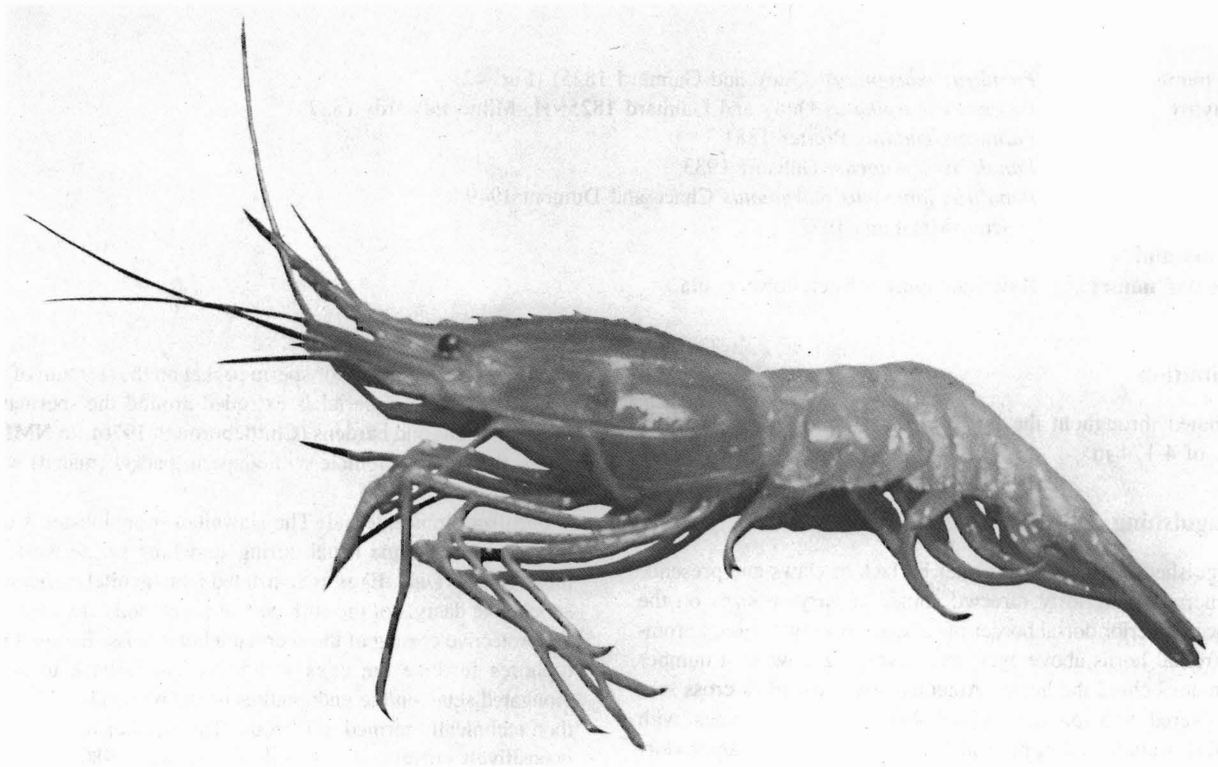

Figure 41.—*Heterocarpus laevigatus*.

by Richard N. Uchida

Valid name	*Panulirus marginatus* (Quoy and Gaimard 1825) (Fig. 42)
Synonymy	*Palinurus marginatus* Quoy and Gaimard 1825; H. Milne Edwards 1837
	Palinurus guttatus Pfeffer 1881
	Panulirus japonocum Galtsoff 1933
	Panulirus japonicus marginatus Chace and Dumont 1949 (from McGinnis 1972)
Common and vernacular names	Hawaiian spiny lobster; lobster; ula

Distribution

Distributed throughout the NWHI from Nihoa to Kure Atoll at depths of 4-174 m.

Distinguishing characteristics

Distinguished from the true lobster by lack of claws and presence of numerous, anteriorly directed spines of varying sizes on the carapace. Anterior dorsal border of carapace with two strong, prominent frontal horns above eyes; two diverging rows of a number of spinules behind the horns. Antennae long, round in cross section, covered with spinules. A pair of strong anterior spines, with several subsidiary spines proximally on antennal plate (anterodorsal surface of the carapace between the antennae). Fifth pereiopods chelate in the female.

Easily distinguished from *P. penicillatus*, the only other species of spiny lobster of commercial importance in Hawaii, by the two pairs of strong anterior spines on the antennal plate (Tinker 1965). *Panulirus penicillatus* occurs very rarely in catches in the NWHI.

Color usually purplish marbled with white but sometimes light yellow, light brown, or dark brown; brownish specimens usually tinted with red (McGinnis 1972). Carapace sometimes pale bluish or greenish behind the cervical groove and pinkish forward (George and Holthuis 1965). Supraorbital horns dark purplish or black with a whitish tip.

Abdominal somites purple with transverse yellow bands along the posterior margins as well as over the transverse groove. Pereiopods almost uniformly dark purple or black. Antennal peduncle pale purplish or pinkish. Telson and uropods purplish at base and bordered posteriorly by a thin yellowish-white stripe.

Life history

Panulirus marginatus is dioecious. Males have the genital orifices on the coxopodites of the fifth pair of pereiopods; whereas the females have orifices on the coxopodites of the third pair. The species is sexually dimorphic. Males are slightly heavier than females at carapace lengths (CL) below 65 mm. At 65 mm CL, males and females have almost identical weights; from about 70 mm CL and larger, females are heavier when compared with males of equivalent length (Uchida, Uchiyama, Tagami, and Shiota 1980).

Lobsters are sexually promiscuous. At Necker Island, females reach maturity at 60.7 mm CL; males at 59.2 mm (Prescott[4]). Males deposit a spermatophore or sperm packet on the sternum of females and a cementing material is extruded around the spermatophore which darkens and hardens (Chittleborough 1976). In NMFS sampling, the smallest female with a sperm packet (mated) was 48.3 mm CL.

Fertilization is external. The Hawaiian spiny lobster is believed to undergo the same ritual during spawning as the western rock lobster, *P. cygnus*. Eggs are extruded from genital orifices and the subchelate dactyls of the fifth pair of pereiopods are used to break the protective coating of the spermatophoric mass. Exposed spermatophores fertilize the eggs which are swept back to adhere to elongated setae on the endopodites of the pleopods. The female is then technically termed ovigerous. The number of eggs extruded is positively correlated with body size (Honda 1980; Honda[5]). The smallest ovigerous female, caught at Necker Island, measured 49.5 mm CL (Uchida and Tagami 1984a).

The spawning season of *P. marginatus* apparently differs within the NWHI chain. Around Nihoa, Necker Island, and French Frigate Shoals, ovigerous females occur mostly in late summer and early winter; toward the northwestern end of the chain, ovigerous females are prevalent in early summer (Uchida, Uchiyama, Tagami, and Shiota 1980). Off Oahu spawning occurs throughout the year and peak activity is concentrated in May-August and low activity is apparent in November-January (McGinnis 1972).

The incubation period lasts about 30 days (McGinnis 1972). After hatching, the phyllosoma larvae float to the surface and become planktonic; the duration of this pelagic phase may be up to 1 year from hatching. Little is known about how larvae are retained around the various islands and atolls of the archipelago. Based on water type oscillations in the Hawaiian region, a hypothesis has been developed to explain the geographic pattern of larval recruitment within the archipelago (MacDonald 1983).

Phyllosoma larvae, which are widely dispersed throughout the chain, pass through 11 dissimilar stages (Johnson 1968). The most advanced stage metamorphoses into a postlarval puerulus (Cooke and MacDonald 1981), a transitional stage between the phyllosoma and the juvenile. A puerulus can swim horizontally allowing it to move shoreward for subsequent settling. Once settled, it assumes the adult coloration.

The NWHI population consists of a single stock (Shaklee and Samollow 1980). There is an excess of males among prehatch embryos. On the assumption that little or no sex-related mortality occurs

[4]Prescott, J. H. Size at maturity in the Hawaiian spiny lobster, *Panulirus marginatus*, at Oahu and Necker Islands. Fish. Res. Stn., P.O. Box 5, Daru, Western Province, Papua New Guinea (manuscr. in prep.).

[5]Honda, V. A. Fecundity of the spiny lobster, *Panulirus marginatus* (Quoy and Gaimard), in the Northwestern Hawaiian Islands. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396 (manuscr. in prep.).

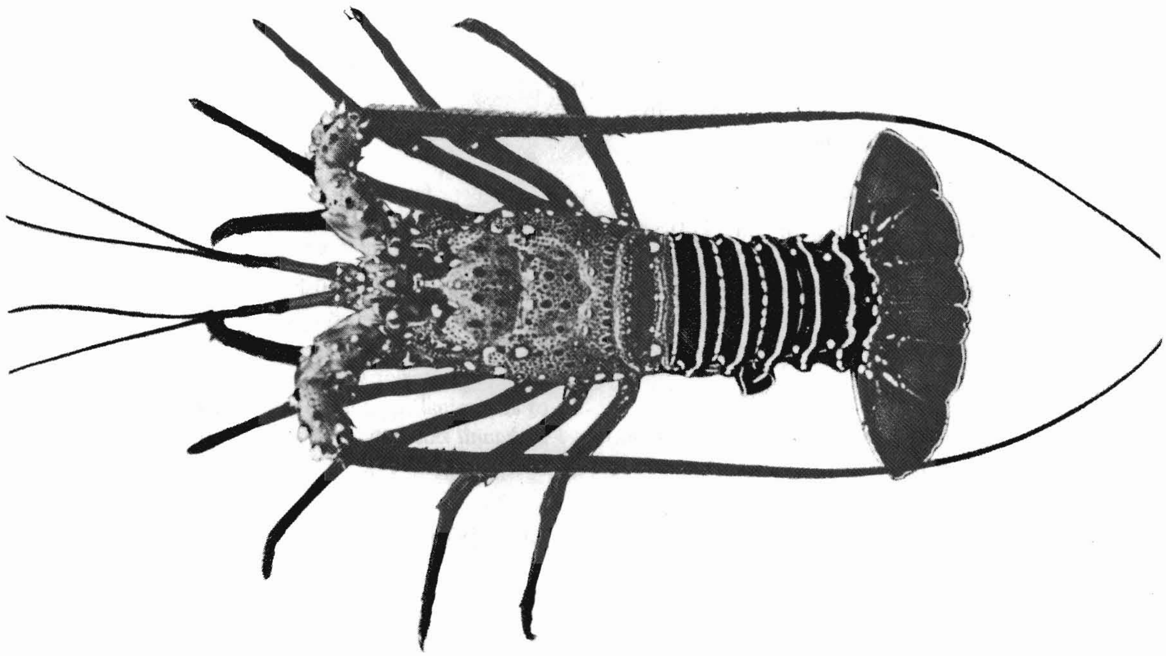

Figure 42.—*Panulirus marginatus.*

from fertilization to the embryo stage, it can be concluded that the sex ratio at fertilization is significantly different from 50:50. The excess of males at the embryonic stage is consistent with the results found in the adult population (Uchida, Uchiyama, Tagami, and Shiota 1980).

Preliminary NMFS study on age and growth for Necker Island lobsters shows that after settling to the bottom, males attain 3.7 cm CL in 1 year, 5.7 cm in 2 years, 7.3 cm in 3 years, 8.5 cm in 4 years, 9.4 cm in 5 years, and 10.1 cm in 6 years. The growth rate of females has not been calculated because of insufficient data. It is believed, however, that growth rates of sexually mature females may be somewhat slower than those of mature males (McGinnis 1972). Data on growth rates from Kure Atoll and French Frigate Shoals (MacDonald 1984) indicate that lobsters from those locations grow slightly faster than those around Necker and Oahu.

Unlike some continental shelf species of Palinuridae that are known to undertake long migrations, insular species like *P. marginatus* make rather short local movements. Tagging studies at Necker indicate that 91% had migrated <9.3 km (5 nmi) when recaptured (Uchida and Tagami 1984a), and a tagging study at Kure Atoll indicated that about 98% had moved <1 km when recaptured (MacDonald 1984). This species occasionally forms queues while moving between locations (MacDonald et al. 1984). Another interesting aspect of the NWHI spiny lobster population is that striking differences occur in average sizes among the various islands and banks surveyed. At Necker, where preexploitation catch rates were the highest in the island chain, the average sizes of males and females were the smallest (Uchida, Uchiyama, Tagami, and Shiota 1980; Uchida and Tagami 1984a).

Gear and catch

The principal gears used in this fishery in the main islands are tangle nets and fish traps. Tangle nets are set mainly for spiny lobsters, and fish traps are primarily used for capturing fish, although lobsters are an incidental catch. In the NWHI fishery, lobster pots of various dimensions and configurations are used.

Until 1976, the spiny lobster catches in the main Hawaiian Islands were small and constituted only a small part of the total marine fish and shellfish landings in the State. During 1961-75, the annual reported catch varied from 1,880 to 5,734 kg and averaged 3,005 kg or <1% of the State's total marine production. Spiny lobsters are also taken in the main islands by recreational fishermen who are not required to report their catches; therefore, the magnitude of the recreational catch is unknown at the present time.

The spiny lobster fishery in the NWHI is relatively new and its short history has been characterized by uneven landings. Populations at Necker Island and Maro Reef, two areas that have commercial concentrations of lobsters, contribute the bulk of the landings in the State. In 1977-82, landings fluctuated between 15,294 (1978) and 354,200 kg per year (1981).

by Richard N. Uchida

Valid Names	*Scyllarides squammosus* (H. Milne-Edwards 1837) (Fig. 43) and *S. haanii* (De Haan 1841) (Fig. 44)
Synonymy	(for *Scyllarides squammosus*) *Scyllarus squammosus* H. Milne-Edwards 1837 *Scyllarides squamosus* Holthuis 1946 (for *Scyllarides haanii)* *Scyllarus haanii* De Haan 1841 *Scyllarides haanii* Holthuis 1946 (from George and Griffin 1973)
Common and vernacular names	Slipper lobster; shovel-nosed lobster; scaly slipper lobster; sea crawfish; Spanish lobster; ulapapa

Distribution

Widely distributed in the NWHI from Middle Bank to Kure Atoll. The NMFS catch data indicate that *Scyllarides squammosus* is distributed at depths from 13 to 137 m, and *S. haanii* is distributed from 33 to 112 m.

Distinguishing characteristics

Scyllarides squammosus—Carapace slightly longer than broad, widest near the posterior margin; surface of carapace and terga granulate; granules low, smooth, and each surrounded by numerous small, fine, stiff setae; anterolateral corner of carapace only slightly wider than width at cervical groove, which is weakly defined; anterolateral margin forms an obtuse angle with anterior margin of carapace; entire lateral margin of carapace armed with small, blunt anteriorly directed spines, those anterior of the cervical groove slightly larger; gastric area of carapace elevated with the cardiac and branchial regions only weakly elevated; four anteriorly directed weak spines on supraorbital region of carapace; posterior transverse groove deep, prominent.

Antennae large, flat, distal segment rounded, the leading edge finely serrated; minute fine, short setae on upper surface penultimate segment small bearing two weak spines directed forward along the inner margin; second segment largest, broad, flat, and coarsely granulate, lateral margin slightly convex, and one weak spine at juncture of the anterior and lateral margins, which form an obtuse angle; inner margin of second segment also armed with two anteriorly directed spines; leading edge of second segment more strongly serrated than distal segment; a coarsely granulated proximal segment extending from outer edge of eye socket to center line in front of rostrum dorsally subtriangular; three spines on inner leading margin of proximal segment; two additional spines at center of distal margin, and a cluster of four spines at the outer distal margin.

First segment of abdomen short, narrow, and usually partially under the carapace; weak ridge along the middorsal line of second, third, and fourth segments; appearing as weak humps when viewed from the side. Sternum deeply emarginate; weak, blunt protuberances on lateral end near juncture with the pereiopods.

Scyllarides haanii—*Scyllarides haanii* and *S. squammosus* are morphologically similar and can be confused easily. Differences are: Dorsal carinae of carpus of first and second pereiopods low in *S. haanii* but distinct in *S. squammosus* (George and Griffin 1973). Carapace of *S. haanii* broader and more deeply emarginate along the anterior ventral margin of the carapace. Dorsal midline of abdominal segments 3 and 4 is strongly elevated or humped in *S. haanii* but only a weak ridge in *S. squammosus* (Morin and MacDonald 1984).

Life history

Female *Scyllarides* have never been observed with attached spermatophores or remnants of a spermatophoric mass, suggesting that fertilization is internal (Lyons 1970). Among 1,090 females collected throughout the chain from our NWHI cruises, none had a spermatophoric mass although 33% of the females examined were ovigerous.

Like spiny lobsters (see Uchida, Uchiyama, Humphreys, and Tagami 1980), catches of slipper lobsters during this study varied widely throughout the NWHI. Our data show that catch rates of slipper lobsters were relatively higher at Brooks Banks, Gardner Pinnacles, Maro Reef, Northampton Seamounts, Lisianski Island, and Pearl and Hermes Reef. Contrary to results of trapping at Lisianski where spiny lobsters were not abundant, slipper lobsters occurred in good numbers at this location. The highest catch rates occurred at depths between 20 and 55 m.

Slipper lobsters predominated over spiny lobsters in the catches at Brooks Banks (77%), Northampton Seamounts (89%), Lisianski Island (93%), and Salmon Bank (82%). Overall, however, the percentage of slipper lobsters in the catch throughout the NWHI was only 16%.

The sex ratio of slipper lobsters showed an interesting pattern. Whereas the male to female ratio was near 50:50 or in favor of females at the lower end of the NWHI chain from Middle Bank to St. Rogatien Bank, it was heavily in favor of males at Brooks Banks and northward from Gardner Pinnacles to Kure Atoll. Data combined for all areas showed a sex ratio of 56:44 (males to females).

The proportion of the various sizes of slipper lobsters in the catch also showed abrupt changes in the NWHI. Carapace length-frequency distributions of slipper lobsters taken from Middle Bank to Salmon Bank showed a large proportion of the catch (77%) was made up of lobsters 7.8-10.2 cm; most of the remainder (19%) were in the 5.3-7.7 cm range. In the northern end of the chain, Pearl and Hermes Reef, Midway, and Kure Atoll, however, small, medium, and large lobsters were equally represented; 29% in the 5.3-7.7 cm group, 26% in the 7.8-10.2 cm group, 21% in the 10.3-12.7 cm group, and 22% in the 12.8-15.2 cm group. The remaining 2% of the catch were lobsters >15.3 cm CL.

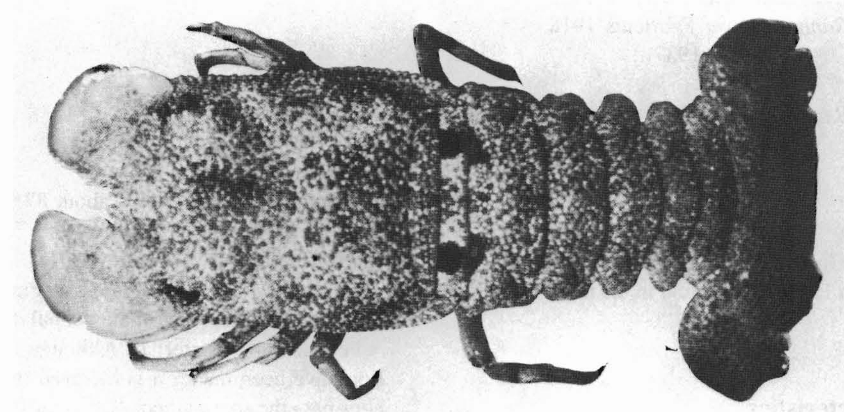

Figure 43.—*Scyllarides squammosus.*

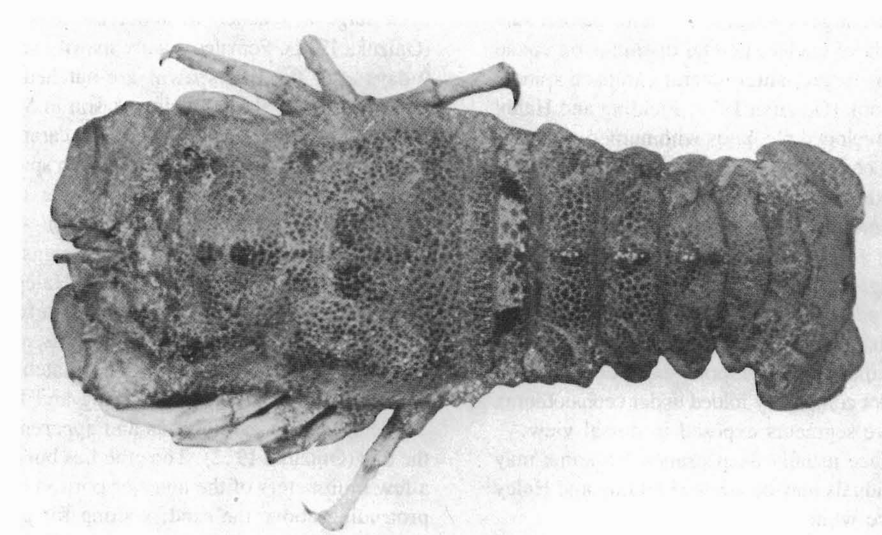

Figure 44.—*Scyllarides haanii.*

Gear and catch

Slipper lobsters are usually taken incidentally while trapping for spiny lobsters. During 1961-75 (1976-78 catches not given in HDAR annual catch reports), annual reported catches of slipper lobsters ranged from 2 to 126 kg and averaged only 33 kg; however, since the beginning of the NWHI spiny lobster fishery, incidental catches of slipper lobsters have risen. In 1979, the reported catch of slipper lobsters reached 344 kg, presumably almost all of which came from the NWHI.

by Richard N. Uchida

Valid name *Ranina ranina* (Linnaeus 1758) (Fig. 45)
Synonymy *Cancer raninus* Linnaeus 1758
Ranina dentata De Haan 1841
Ranina serrata Lamarck 1892
Ranina scabra Fabricius 1918
(from Sakai 1937)
Common and vernacular names Red frog crab; frog crab; spanner crab; kona crab; papaikualoa

Distribution

Distributed in the NWHI from Nihoa (Edmondson 1946) to Kure Atoll at depths from 24 to 115 m; also found in the main Hawaiian Islands.

Distinguishing characteristics

Carapace broad anteriorly, narrow posteriorly, strongly convex from side to side, and covered with numerous small rounded spines; anterolateral margins of carapace armed with dorsoventrally compressed sharp spines which occur either singly or in sets of three or four on protruding processes; anterolateral processes small in young of both sexes, but become prominent in large adult males.

Dioecious and sexually dimorphic. Seven segments forming abdomen relatively narrower in the male than in a female of similar size. Male grows larger, has larger chelae; setae on the palmar surface of dactyli and propoda of chelae, genital openings on coxae of fifth pair of pereiopods; larger, anterolateral carapace spines, giving carapace a square look (Onizuka 1972; Fielding and Haley 1976). Female has well-developed pleopods with numerous setae, oviducts that open on the coxae of third pair of pereiopods, and in mature individuals an external, medially located spermatheca on the seventh sternite between the third and fourth pairs of pereiopods (Gordon 1963).

Broad, flat chelae strong, equal in size, dorsal surface covered with small rounded spines similar to those found on carapace. Two sharp spines along the outer margin and five on the inner margin of flattened propodus. Remaining pereiopods expanded, paddle-shaped dactyli. Abdomen not completely folded under cephalothorax so that at least four to five segments exposed in dorsal view.

Color along dorsal surface usually deep orange but some may be bluish. Immature individuals may be white (Fielding and Haley 1976). The ventral surface white.

Life history

There are two separate studies on the reproduction of kona crab in the main islands. At Penguin Bank, the smallest mature male found was 43.6 mm CL, whereas, the smallest mature female was 54.3 mm CL (Fielding 1974). Mature individuals, however, may not necessarily be reproductively active. Off Oahu's north shore, females first became ovigerous at 63 mm CL (Onizuka 1972). Females smaller than 58 mm CL lacked developing ovaries. Among those averaging 60 mm CL (58-62 mm), 83% were mature whereas at 65 mm CL (63-67 mm), about 87% were mature. At Penguin Bank, 50% of the females in the 70-76 mm size group were reproductively active (Fielding 1974). Among males, all crabs ≥60 mm CL had mature spermatozoa (Fielding and Haley 1976), but the exact size at which males copulate has not been determined.

Fertilization is external. Although no observations on fertilization have been made, it is believed that it is accomplished as the eggs pass the spermatheca (Onizuka 1972). The fertilized eggs are then swept back and adhere to the numerous elongated setae on the pleopods.

Around the main islands, ovigerous females occur in the catch only from May through September (Onizuka 1972; Fielding and Haley 1976). Data collected in the NWHI were insufficient to define the spawning season; however, at Maro Reef ovigerous females were collected in July and none in January.

Kona crabs spawn at least twice per season. The spherical eggs, which are orange when newly spawned, become brown when the eyed stage is reached in about 24 days and hatch 5 days later (Onizuka 1972). Females usually spawn a second batch of eggs about 9 days after the first spawns are hatched.

At the start of the spawning season in May, the number of eggs produced is positively correlated with carapace length (Fielding and Haley 1976). A 63-mm CL female can spawn an estimated 27,000 eggs; whereas, a 114-mm CL female can produce more than 145,000 eggs at a time (Onizuka 1972). At the end of the spawning season, however, the number of eggs produced apparently is unrelated to body size (Fielding and Haley 1976). The number of eggs produced also varies from season to season.

Little is known about the planktonic dispersal stages of kona crabs. The first molt occurs 7-8 days after hatching and the second molt occurs about 7 days later (Fielding and Haley 1976).

The species is carnivorous and apparently feeds at any time of the day (Onizuka 1972). The crab lies buried in the sand with only a few millimeters of the anterior portion of the carapace and eyes protruding above the sand, waiting for prey or food particles.

At sizes <40 mm CL, the increase in carapace length during each molt is about the same for both sexes; however, at larger sizes, the female growth rate is slower than males (Onizuka 1972). Molting frequency and growth increment also decrease with age. Furthermore, it has been reported that in January and March, a large percentage of the females bear new shells. This indicates recent molting and suggests that most females molt at least once during the early months of the year before the onset of the spawning season. The males, on the other hand, have a protracted molting period beginning in January and lasting through August. It is estimated that a 5-year-old male is 10.2 cm CL; a female of the same age averages about 8.9 cm ([Hawaii] 1970).

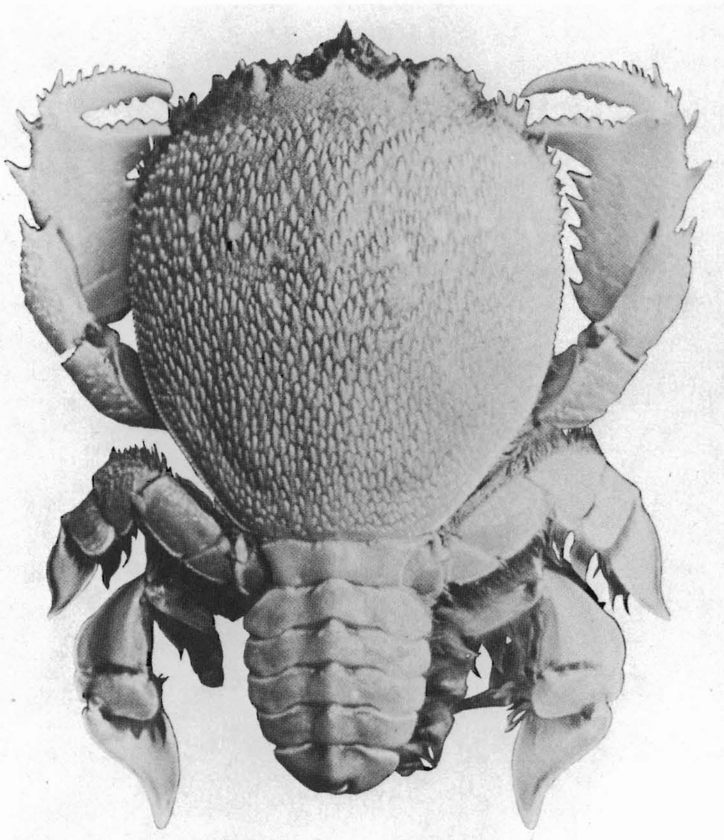

Figure 45.—Female *Ranina ranina*.

The male to female sex ratio deviates significantly from 50:50 (Onizuka 1972; Fielding and Haley 1976). At Oahu and Penguin Bank, stocks are roughly 55% males and 45% females. In the NWHI, male to female ratios were 66:34 at French Frigate Shoals, 62:38 at Maro Reef, and 75:25 at Pearl and Hermes Reef. Samples from elsewhere in the NWHI were too small to derive meaningful sex ratios.

Kona crab caught in the NWHI ranged from 70 to 167 mm CL. Carapace width-weight relationships of 501 males and 254 females were:

$$\text{Male: } W = 5.689 \times 10^{-4}\ CW^{2.9478}$$
$$\text{Female: } W = 7.719 \times 10^{-4}\ CW^{2.8070}$$

where W = weight (kg) and CW = carapace width (cm).

Gear and catch

There is a small fishery for kona crab in the main islands. The principal gear used is the kona crab net, although one vessel fishing in NWHI waters has successfully used crab traps. Commercial vessels usually set, haul, and reset the strings of nets several times during the day from sunrise to sunset. Soaking time, usually 1 h, is necessarily kept short because longer soaking attracts predators such as sharks and rays which can inflict extensive damage by tearing off the bait and entangled crabs from the netting.

During 1961-79, the annual catches of kona crab around the main islands fluctuated between 4,215 and 32,835 kg and averaged 13,519 kg.

At present, there is no fishery for kona crab in the NWHI. Two boats previously fished for kona crab experimentally in the NWHI, but have since quit fishing.

MOLLUSCAN RESOURCES

In Hawaiian waters, the phylum Mollusca constitutes the largest group of marine invertebrates. It includes such animals as octopuses, squids, clams, oysters, limpets, and many other insular marine fauna. Kay (1967) estimated that there are about 1,000 species in this group. Despite the numbers and diversity of the species, only a few are commercially utilized as food. In 1961-79, the average reported landings of molluscs were only about 22 metric tons (MT)/year or <1% of the total reported marine landings. This average, however, is probably far below what is actually caught from Hawaiian waters because of the difficulty in estimating the take of marine molluscs by recreational fishermen. Of the reported catch, about 47% is composed of octopus, *Octopus cyanea* and *O. ornatus*, 34% is squid, mostly *Sthenoteuthis oualaniensis* and *Nototodarus hawaiiensis*, and the remaining 19% is limpet, *Cellana exarata* and *C. sandvicensis*.

Octopus was among the species surveyed during the NWHI investigation; however, due to emphasis on other species such as spiny and slipper lobsters, only one attempt was made to directly fish for octopus using clay pots. Most of the data on octopus, therefore, was derived from our fish trapping operations in which octopus was occasionally caught in the small-mesh traps.

Octopus cyanea is one of the larger, most frequently encountered octopods caught locally. It is probably the most economically important of the octopods in Hawaii. Historically, Hawaiians preferred *O. cyanea* for food. The other species were either too small, less palatable, infrequently encountered, or used for other purposes (Titcomb et al. 1978). Due to its relative importance *O. cyanea* is the principal species discussed in this atlas.

by Steven H. Kramer

Valid name	*Octopus cyanea* Gray 1849 (Fig. 46)
Synonymy	*Octopus marmoratus* Hoyle 1885
	Octopus horsti Joubin 1898
	Polypus marmoratus Hoyle 1905
	Polypus horsti Hoyle 1907
	Polypus cyanea Massey 1916
	Polypus fontanianus (in error) Robson 1920
	Octopus glaber Wilker 1920 (from Robson 1929)
Common and vernacular names	Octopus; day octopus; day squid; tako; hee

Distribution

Captured in traps in the NWHI from Necker to Kure Atoll at depths from 18 to 91 m. It also inhabits rocky substrates and reef flats shoreward of the NMFS survey area.

Distinguishing characteristics

Body shape variable but usually pyriform, head rather small, narrow, and rounded, sometimes separated from the body by a slight constriction, eyes prominent. Arms subequal (rarely <30 mm difference in length) unless an appendage is missing or regenerated.

A small hectocotylus used to transfer spermatophore located on the distal end of the third right arm of males. Suckers on sexually mature males enlarged at the level of the web on each arm. Funnel organ small, conical. Skeletal structures consist of cephalic cartilages and dorsal stylets. Beak has insertion plate on which is fixed the upper and lower horny jaws. Shape differs little within the genus. Carnivorous type radula. Ink sac on ventral face of liver; gills consist of a number of filaments suspended from opposite sides of a central axis forming two closely opposed series; skin texture usually smooth but can assume a rough matted appearance in life and during preservation. Few large dorsal tubercles can be longitudinally extended. Supraocular cirrhus usually present, sometimes accompanied by subordinate tubercles. Ocellus below eye and between base of third and fourth arms.

Coloration usually cryptic but varies according to animal's physiological state and habitat; most often a warm ochreous red suffused and blotched with purple. Irregular dark dashes often present between suckers on ventral surface of the arms (Robson 1929).

Life history

Hee appears to spawn throughout the year (Van Heukelem 1973). Males copulate by inserting the hectocotylus into the female's oviduct. At the hectocotylus, spermatophores break open and expel sperm. The oviduct contracts and sperm is carried up to lodge in the spermathecae of the oviducal glands. Females do not have to be sexually mature for copulation to take place (Wells and Wells 1970).

Females reach sexual maturity 10-13 months after settling. Strings of 600-1,200 eggs measuring 4-10 cm long are laid in caves or holes. Brooding, which lasts 45-61 days, appears to be dependent on water temperature. Nocturnal hatching, which goes on for 3-5 successive nights, apparently reduces predation on newly hatched larvae. Females die following egg brooding and hatching.

Males develop extra large suckers at the level of the seventh and eighth pair of suckers (from the mouth) about 7-9 months after settling.

For both sexes, the average natural lifespan appears to be 12-15 months. The maximum size reached is associated with feeding and size is attained for the female when the ovaries enlarge and for the male after maximum sucker enlargement. Gonad and sucker development appear to be correlated primarily to age (Van Heukelem 1973).

Larvae are free swimming and pelagic for an undetermined time before settlement. Young settle from the plankton at a body length of about 1 cm and a weight of about 0.33 g (Wells and Wells 1970).

The growth of *O. cyanea* is expressed as:

$$W = 1.28 \times 10^{-6} X^{3.92},$$

where W = weight (g) and X = age in days (Van Heukelem 1973). A reasonable estimate of age can thus be calculated from weight at capture using the above expression.

The diet consists primarily of crustaceans and rarely fish (Van Heukelem 1966). Gastropods may also be included in the diet as evidenced by the use of cowrie shell octopus lures by fishermen. The crepuscular hunting methods of hee comprise either pouncing or grabbing prey with the arms (Yarnall 1969). The octopus then either paralyzes the prey with cephalotoxin from the posterior salivary gland or physically pulls the animal out of its shell. To paralyze prey, the octopus either bites with its beak or rasps through the shell using its radula before injecting cephalotoxin (Wodinsky 1969).

Octopus are high level predators in the food chain, preying on crustaceans, molluscs, and occasionally fishes. In turn, they are the prey of a variety of fishes, seals, and man. In the NWHI, octopus constitutes a major part of the diet of the endangered Hawaiian monk seal (Gilmartin 1983). Octopus have also been found to be in the diet of many of the larger predatory fishes found throughout the Hawaiian Archipelago.

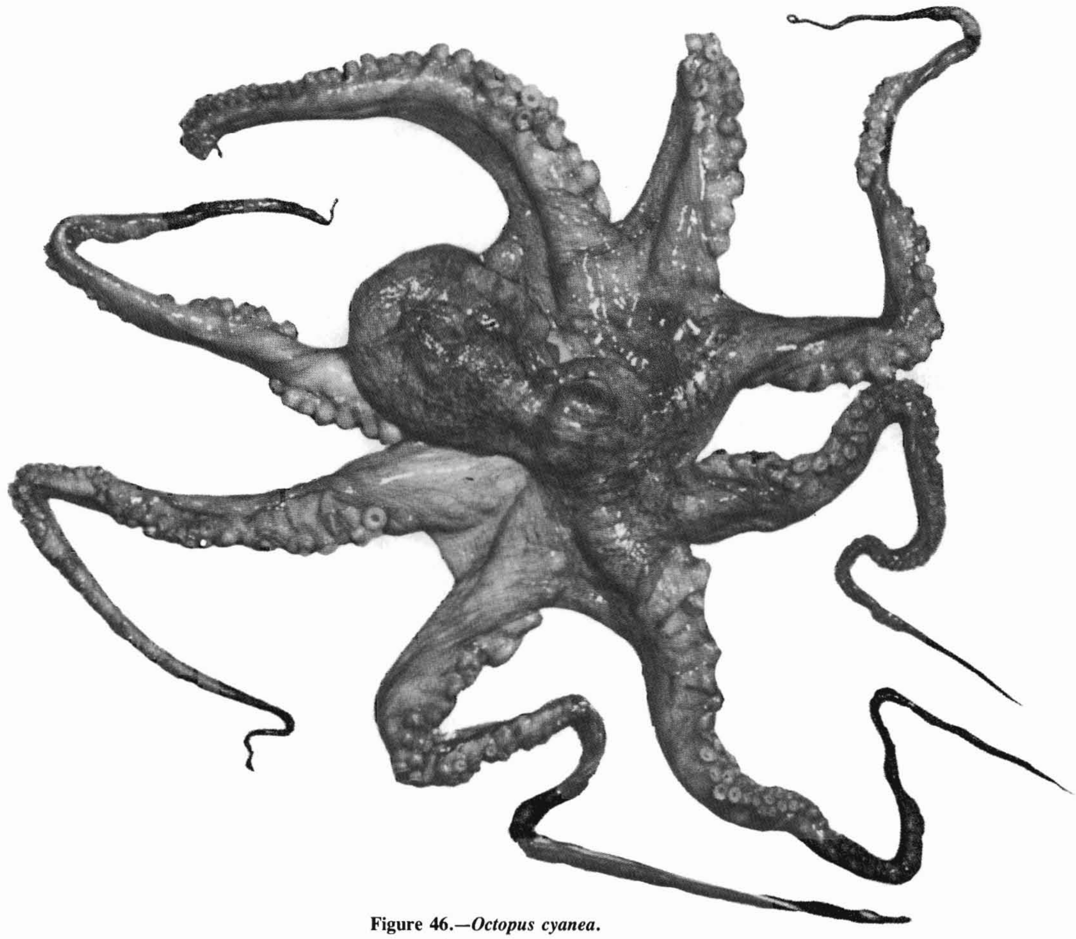

Figure 46.—*Octopus cyanea.*

Gear and catch

There is no major fishery for octopus in Hawaii. In the NWHI, most are caught incidentally in fish and shrimp traps. In the main islands octopuses are caught using spears, traps, and lures. During 1961-79, the annual landings varied between 1,722 and 10,988 kg and averaged 4,611 kg. Since octopus occurs in abundance in the inshore area, recreational harvest probably exceeds reported commercial landings. Octopus is seasonally abundant and most of the catch is made during the summer and fall months.[6]

[6]Okamoto, H. Aquatic Biologist, Department of Land and Natural Resources, Division of Aquatic Resources, Honolulu, HI 96813, pers. commun. December 1984.

FISH RESOURCES

The volcanic processes by which the Hawaiian Islands were built up from the ocean floor produced relatively steep-sided, undersea mountains which are <250 km wide at the base and whose slopes average about 400 m/km (Newman 1972). It is this steep underwater gradient that limits the shelf zone to a narrow band that surrounds each island. Unlike the continental shelf that characterizes most of the world's great fishing areas, the insular shelf in Hawaii is narrow, poorly developed, and does not offer the environmental conditions that are vital to high fishery yields.

The Hawaiian fishery commercially exploits about 60-70 of the 700 species of fish reported in Hawaiian waters. The bulk of the landings are fish caught within 20 nmi of the main islands; however, in recent years, long-ranging vessels of the Hawaiian fleet have expanded into areas such as the NWHI and the central North Pacific.

In the section that follows, brief synopses giving information on identity, distribution in the Hawaiian Archipelago, physical characteristics, and life history of those fishes which we believe are commercially or potentially valuable in the Hawaiian fishery are presented. Some synopses are for individually important species; others such as *Myripristis berndti*, *Priacanthus cruentatus*, *Parupeneus multifasciatus*, *Naso unicornis*, and *Acanthurus olivaceus* are representative of families with numerous members of commercial value. Like the shallow-water crustaceans, fishes in Hawaiian waters are largely Indo-Pacific in origin.

by Richard N. Uchida

Valid name	*Beryx splendens* Lowe 1833 (Fig. 47)
Synonymy	None
Common names	Alfonsines; alfonsin; alfonsino

Distribution

Caught only at Hancock Seamounts and Banks 10 and 11 in the NWHI between depths of 258 and 302 m.[7]

Distinguishing characteristics

D. IV, 13-15, A. IV, 26-29; P1. 17-18. Body elongate, compressed, bright red, and covered with moderate-sized ctenoid scales which are rather stiff and prickly giving the body a rough texture. Head large, compressed, eyes large. Snout blunt, mouth sharply oblique, and the lower jaw protruding beyond the snout. Small teeth in bands on jaw. Inside of mouth scarlet. A small spine anterior to the orbit projecting posteriorly.

A congener, *B. decadactylus* Cuvier and Valenciennes 1829, also occurs in Hawaiian waters from Hancock Seamounts to the major islands in the southeast end of the chain. Meristic counts are: D. IV, 16-20, A. III-IV, 27-30; P1. 16-18; P2. I, 9-10. *Beryx decadactylus* differs morphologically from *B. splendens* by having much larger and rougher scales, stronger more prominent preorbital spine, and deeper body. Body color of *B. decadactylus* is brighter than that of *B. splendens*.

Life history

Alfonsin spawn in August-October and the free floating eggs hatch in about 1 day. Newly hatched larvae are planktonic and float for about 2-3 days before they begin to swim on the fourth day (Onishi 1967; Chikuni 1971). In the western Pacific, the distribution of this species is highly dependent on the Kuroshio and its fractional systems.

Berycoid fishes assume a demersal existence at age 1 year or younger. Japanese studies indicate that they migrate from coastal waters to offshore grounds and that fish size increases with depth and decreases with increasing latitude (Kanagawa Prefectural Fisheries Experimental Station 1971). Alfonsin migrate vertically in the evening (Masuda et al. 1975) presumably to feed on surface dwelling organisms. Stomach analysis of fish taken over the Emperor Seamounts disclosed that small fish predominated in the diet; crustaceans including decapods, mysids, and euphausiids constituted almost all the remainder (Aomori Prefectural Fisheries Experimental Station 1976).

Alfonsin captured by NMFS at Hancock Seamounts ranged from 15.3 to 35.3 cm fork length (FL), whereas over all the central North Pacific seamounts, the size range was 13.0 to 46.0 cm FL (Takahashi and Sasaki 1977). Apparently, the number of age groups in the catch varies from year to year and among seamounts. In 1972, for example, fish captured at the Milwaukee Seamount group had modes at 21.0 and 38.0 cm; whereas fish taken at Colahan Seamount had one mode at 19.0 cm. The age-length relationship for alfonsin is as follows: age 1 = 8.8 cm; age 2 = 19.1 cm; age 3 = 25.8 cm; age 4 = 30.8 cm; and age 5 = 32.8 cm (Ikenouye 1969).

Gear and catch

In addition to bottom trawls, in which it is mostly a by-catch of fishing for pelagic armorhead, alfonsin is also taken by bottom longline and handline. The species rarely enters baited traps.

Annual catches of alfonsin in the Japanese trawl fishery at Hancock Seamounts in 1969-81 varied from 0 to 54 MT and averaged 8 MT. On seamounts located outside the Hawaiian Archipelago, the annual catches of alfonsin varied from 0 to as much as 8,628 MT, averaging about 2,151 MT.

[7]*Townsend Cromwell* cruise report TC-83-02, *Beryx splendens* were taken at Banks 10 and 11 in depths ranging from 274 to 549 m.

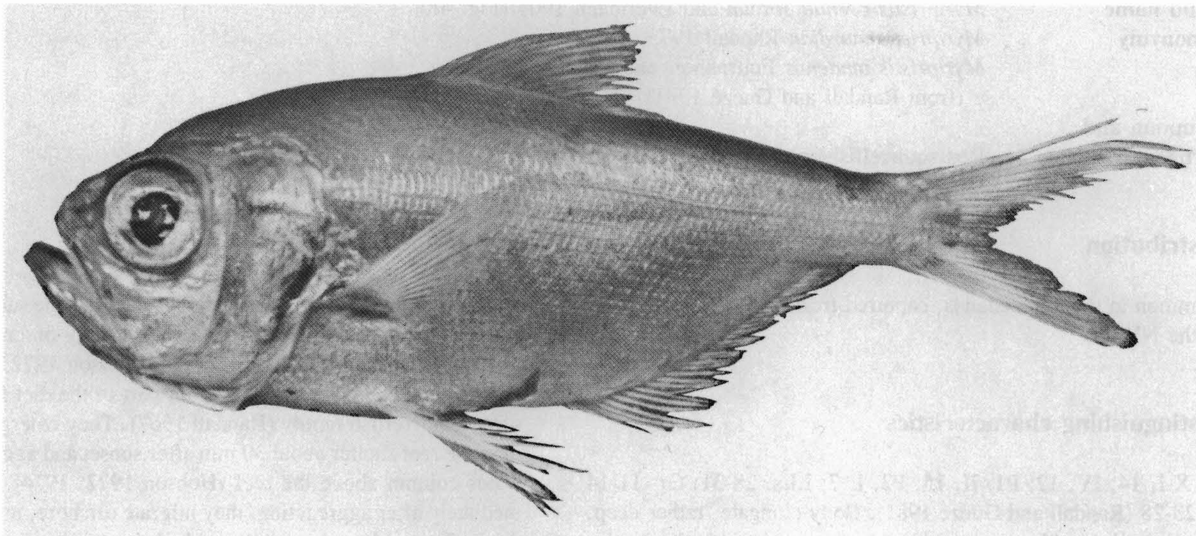

Figure 47.—*Beryx splendens*.

by Richard N. Uchida

Valid name *Myripristis berndti* Jordan and Evermann 1905 (Fig. 48)
Synonymy *Myripristis murdjan* Randall 1973
Myripristis amaenus Fournanoir and Laboute 1976
(from Randall and Guézé 1981)
Common and vernacular names Red squirrelfish; mempachi; uu

Distribution

Common in the main islands; captured from Nihoa to Kure Atoll in the NWHI.

Distinguishing characteristics

D. X-I, 14; IV, 12; P1. II, 15; P2. I, 7; LLs. 28-31; Gr. 11-14 + 23-28 (Randall and Guézé 1981). Body elongate, rather deep, compressed; head large; snout blunt, convex, its width about twice its length; eyes large, high, upper rims hardly impinging on upper profile of head; eye diameter slightly less than posterior part of head; mouth large, oblique; mandible of adult slightly projecting when closed; maxillary not reaching posteriorly to below posterior margin of eye; several enlarged and blunt teeth on outer front edge of jaws; teeth fine, in broad bands on jaws, vomer, and palatines. Tongue thick, pointed, and in front (Jordan and Evermann 1905).

Lips thick, fleshy; nostrils close together, bones on head finely serrated; opercle with well-developed spine; gill opening large; gill rakers long, fine; caudal forked, pectorals small; scales large, ctenoid, deep on middle of side; lateral line obliquely curved at first, then running obliquely down to base of caudal (Jordan and Evermann 1905).

Color in life red, center of each scale pale, a black bar across opercular region down to axil of pectoral; spines in first dorsal pink and membranes of basal half translucent, upper half orange-yellow; soft dorsal, anal, and caudal crimson but first rays white in each; pectoral red (Jordan and Evermann 1905).

Life history

Hiding in holes and cracks in reefs primarily in the subsurge zone, uu are a nocturnal planktivores feeding mainly on crab megalops and other crustaceans (Gosline 1965; Hobson 1972, 1974). Apparently fishes form an insignificant part of the diet for members of the squirrelfish family (Randall 1967). They emerge from their daytime reef shelter about 30 min after sunset and aggregate in the water column above the reef (Hobson 1972, 1974). Almost immediately after aggregating, they migrate offshore, possibly to the drop-off zone into deep water, which is a major feeding ground for diurnal planktivores (Hobson 1972). The offshore movement may be obscured because many individuals remain over the inshore reef. However, since there are consistently fewer uu over the reefs when there is no moon than on moonlit nights many may be moving offshore, especially on dark nights. About 40 min before sunrise, uu begin to reassemble over the reef and all the individuals take cover within 10 min (Hobson 1974).

Myripristis spp. hunt prey in the water column. This feeding habit is reflected by the sharply upturned mouth, a feature which is highly adapted for feeding on plankton (Hobson 1974). Studies on *M. leiognathus* (Hobson 1965, 1968) and *M. jacobus* (Randall 1980) indicate similar forage patterns.

Gear and catch

Uu are caught mainly by handline; smaller quantities are landed by net and spear fishermen. The species is also taken by trolling at night in relatively shallow water.

Highly prized as a food fish, *Myripristis* spp. (all species) are target species of not only commercial but also recreational fishermen. The State landings of *Myripristis* spp. in 1961-69 fluctuated over a relatively narrow range from 4,330 to 7,449 kg and averaged 5,830 kg. From 1970 through 1976, the catches rose slightly varying between 7,433 and 11,090 kg averaging 9,140 kg. In 1977-79, however, catches rose substantially and landings reached 21,003 kg in 1977, 23,546 kg in 1978, and 20,469 kg in 1979, averaging 21,673 kg. Landings increased in 1977 when speared fish were allowed to be sold.

There is no fishery for uu in the NWHI.

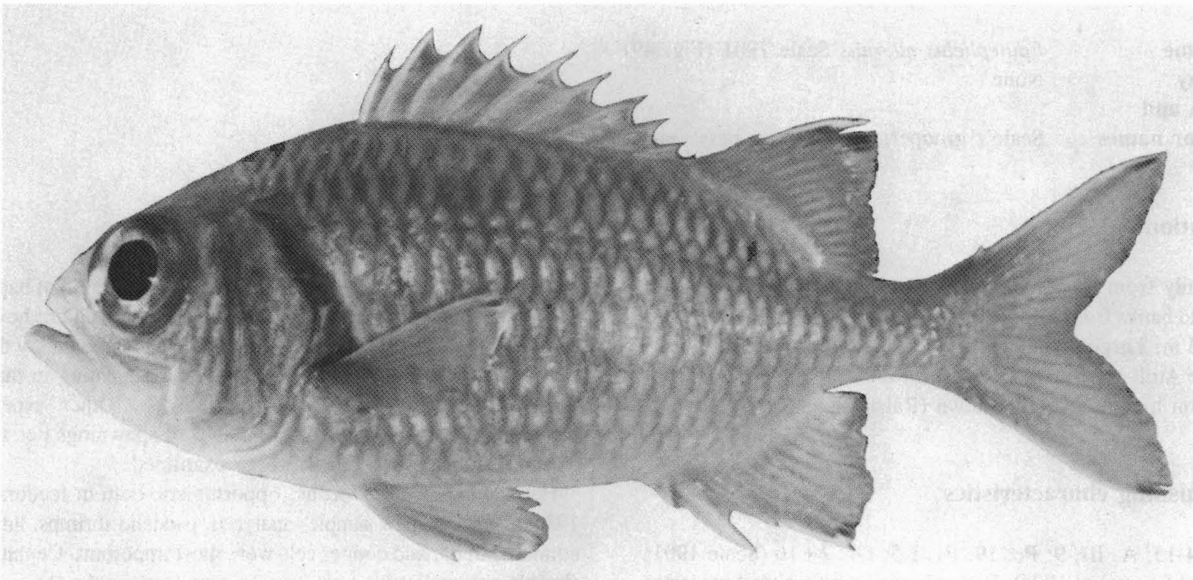

Figure 48.—*Myripristis berndti*.

by Michael P. Seki

Valid name *Epinephelus quernus* Seale 1901 (Fig. 49)
Synonymy None
Common and vernacular names Seale's grouper; grouper; sea bass; hapuupuu

Distribution

Known only from Hawaiian waters (Tinker 1978). Present at all islands and banks from Middle Bank to Bank No. 11 at depths from 18 to 230 m. Large numbers observed in waters as shallow as 5 m at Kure Atoll and Midway (Hobson 1980). No pattern of spatial distribution by age and size shown (Ralston 1980).

Distinguishing characteristics

D. XI, 14-15; A. III, 9; Pc. 19; P1. I,5; Gr. 7+16 (Seale 1901; Jordan and Evermann 1905). Body oblong, girth greatest posterior of nape becoming laterally compressed caudad; covered with small ctenoid scales; posterior edges of dorsal and anal soft rays and caudal fin rounded.

Like other groupers, this species has a large protractile mouth with maxillary reaching posterior of the orbit. Preoperculum is finely serrated along upper edge.

In life, varies from purplish brown to nearly black, they may be covered, particularly along the sides, with small light blue or white spots. Differences in body color between individuals may be attributable to physiological stress, behavioral responses, or the environment.

Life history

Little is known about this species. The spawning period of hapuupuu has not been determined throughout the Hawaiian chain; however, ovaries with hydrated eggs have been collected from January through early April in the NWHI indicating winter spawning in that area (Uchiyama and Tagami 1984; Kikkawa[8]). Other aspects of reproduction such as fecundity, number of spawnings per season, and hermaphroditism remain to be examined.

Hapuupuu are carnivorous, opportunistic bottom feeders (Seki 1984a). Among spew samples analyzed, pandalid shrimps, lutjanids, emmelichthids, and conger eels were most important. Cephalopods (mainly octopods) and crabs also occurred among the forage items.

A functional length-weight relationship of 547 hapuupuu ranging from 23.8 to 110.6 cm is:

$$W = 9.29 \times 10^{-9} L^{3.1028},$$

where W = weight (kg) and L = total length (mm) (Uchiyama et al. 1984).

Gear and catch

This species is usually taken with handline although it is also caught incidentally in traps and pots. Hapuupuu is the only serranid contributing significantly to the commercial landings in Hawaii. During 1961-79, the annual landings ranged from 9,311 to 33,799 kg, averaging 17,725 kg. The species ranked 21st among commercial marine species landed during this period.

[8]Kikkawa, B. S., Research Assistant, Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396, pers. commun. May 1982.

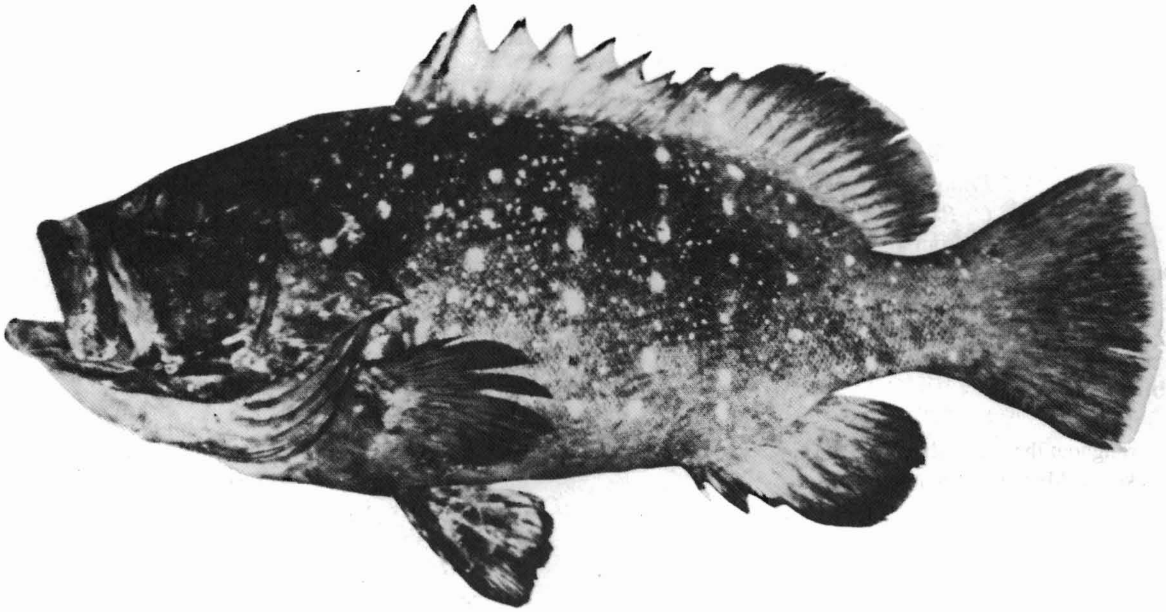

Figure 49.—*Epinephelus quernus*.

by Richard N. Uchida

Valid name	*Priacanthus cruentatus* (Lacepède 1802) (Fig. 50)
Synonymy	*Labrus cruentatus* Lacepède 1802
	Priacanthus carolinus Lesson 1826
	Priacanthus macrophthalmus Cuvier and Valenciennes 1829
	Priacanthus boops Cuvier and Valenciennes 1829
	Priacanthus blochii Günther 1851
	(?) *Priacanthus schlegelii* Hilgendorf 1879 (from Weber and De Beaufort 1929)
Common and vernacular names	Glasseye snapper, red bigeye, aweoweo

Distribution

Occurs throughout the main islands. In the NWHI, they occurred from Necker to Midway at depths from 20 to 296 m.

Distinguishing characteristics

D. X, 13; A. II, 14; LLs. 11-100-53 (Jordan and Evermann 1905). Body moderately elongate, deep, laterally compressed, covered with small, rough ctenoid scales; dorsal and ventral outlines similarly curved; snout bluntly pointed; lower jaw prominent, strong, and projecting; mouth moderate, oblique; lateral line runs dorsally to area of caudal fin base then descends to midlateral caudal peduncle (Jordan and Evermann 1905; Schultz et al. 1953).

Teeth small, villiform on jaws, vomer, and palatines; gill rakers long, slender; tongue broad, rounded and free; maxillary extends to anterior edge of pupil; eyes large; fins moderate with origin of spinous dorsal over upper base of pectoral; dorsal spines short, stout, blunt; soft dorsal rounded; caudal truncate; pectoral short, broad; preopercle strongly toothed with a strong rugose toothed sharp or blunt variable spine at angle (Jordan and Evermann 1905; Schultz et al. 1953).

Bright red mottled with silvery white in life; six dark red vertical bars alternating with fainter bars on side of back; dorsal and caudal fins rosy; iris and jaws deep red.

Life history

Glasseye snapper are nocturnal predators, feeding on free swimming organisms (mostly crustaceans and cephalopods), and inhabiting reefs, bays, and harbors (Hobson 1974). Fishes and polychaetes make up the bulk of the remaining food items (Randall 1967). A study conducted off Kona, Hawaii demonstrated that the species takes shelter in groups or singly under rocks or coral during daylight (Hobson 1974). At night, they emerge from the shelter, assemble in schools high in the water column, migrate offshore, and do not return to the reef until about 40 minutes before sunrise. Lesser numbers, mostly solitary or in small groups, remain over inshore reefs throughout the night. All fish were noted to return to daytime shelter 30 min before sunrise.

Gear and catch

Glasseye snapper is caught around the main islands primarily with handline and gill net.

The State annual landings of this species fluctuated between 780 and 4,764 kg, averaging 1,886 kg during the period 1961-69.

There is no fishery for priacanthids in the NWHI.

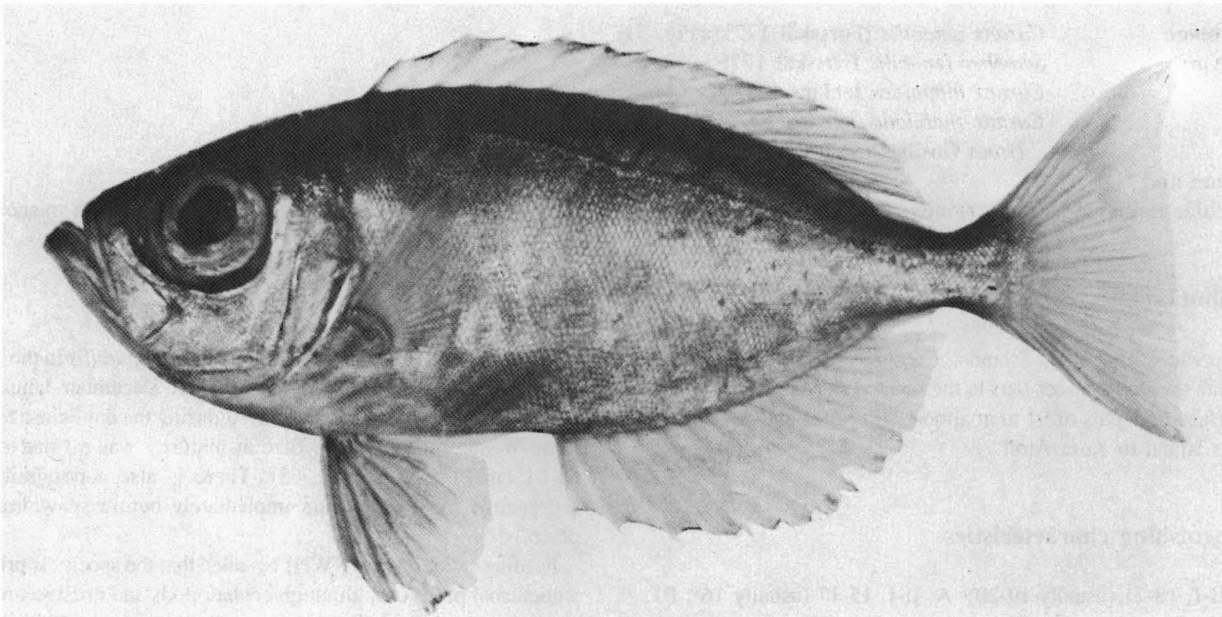

Figure 50.—*Priacanthus cruentatus*.

by Michael P. Seki

Valid name	*Caranx ignobilis* (Forsskål 1775) (Fig. 51)
Synonymy	*Scomber ignobilis* Forsskål 1775
	Caranx hippoides Jenkins 1903
	Caranx rhabdotus Jenkins 1903
	(from Gosline and Brock 1960)
Common and vernacular names	Giant trevally; jack; ulua (adult); papio (young); pauu; hon-ulua; sometimes called white ulua, a misnomer

Distribution

Widespread in the main islands. Captured anywhere from the shoreline through the reef flats to the benthic slopes in waters from the surface to depths of 91 m at almost all islands and banks from Necker Island to Kure Atoll.

Distinguishing characteristics

D. VIII-I, 18-21 (usually 19-20); A. II-I, 15-17 (usually 16); P1. I, 18-20. Body deep, slightly compressed, with a steep, strongly curved head, snout blunt. Breast mostly naked, a small central patch of scales may be covered with skin just anterior to pelvic fins. Scutes or plates along the straight portion of the lateral line scales 28-30 (Williams 1958; Fischer and Whitehead 1974; Berry et al. 1981).

Varies from silvery to black in life. Large fish may have small black spots on upper sides of the body. Color differences in ulua are associated with sex and maturity (Talbot and Williams 1956). Mature males possess dusky to black bodies, heads, and fins; whereas mature females have bodies and heads that are pale to silvery.

Ulua is the largest species of the genus; maximum verified size is 146.0 cm FL, and 52.6 kg (Berry et al. 1981). Specimens from 20.7 to 133.0 cm FL (mean 74.4 cm) were collected in the NWHI.

Life history

Observations of natural spawning of *Caranx ignobilis* in the Philippines showed two spawning seasons, one in December-January and the other in June. Spawning occurred during the day, close to shore (Von Westernhagen 1974). Size at maturity was estimated to be 54-61 cm FL (Williams 1965). There is also a possibility that segregation by sexes occurs immediately before spawning takes place.

Feeding studies in the NWHI revealed that the species is primarily a nocturnal piscivore, although cephalopods and crustaceans were also significant in the diet (Okamoto and Kawamoto 1980; Parrish et al. 1980). Similar diet and feeding behavior were found for the species off East Africa (Williams 1965). Of particular interest is that ulua may also prey voraciously on sublegal and berried lobsters which have been released at the surface from commercial fishing vessels (Gooding 1985[9]).

A length-weight relationship of 124 ulua, ranging from 20.7 to 133.0 cm FL caught in the NWHI was:

$$W = 2.73 \times 10^{-5} L^{2.9131},$$

where W = weight (kg) and L = fork length (mm).

Gear and catch

Taken primarily by handline and traps; it is also one of the target species in recreational fishing and may be caught with bottom set line or by casting from shore with rod and reel.

Ulua is one of the dominant species of the jack fishery in Hawaii. The statewide annual landings of ulua (including several species of carangids) in 1961-79 varied between 19,647 and 55,494 kg and averaged 35,692 kg.

Highly esteemed by the local population, the ulua is one of the target species of bottom fishing boats operating in the NWHI.

[9]Gooding, R. M. 1982. Predation on surface and bottom released spiny lobster, *Panulirus marginatus*, in the Northwestern Hawaiian Islands. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396, Admin. Rep. H-82-1, 20 p.

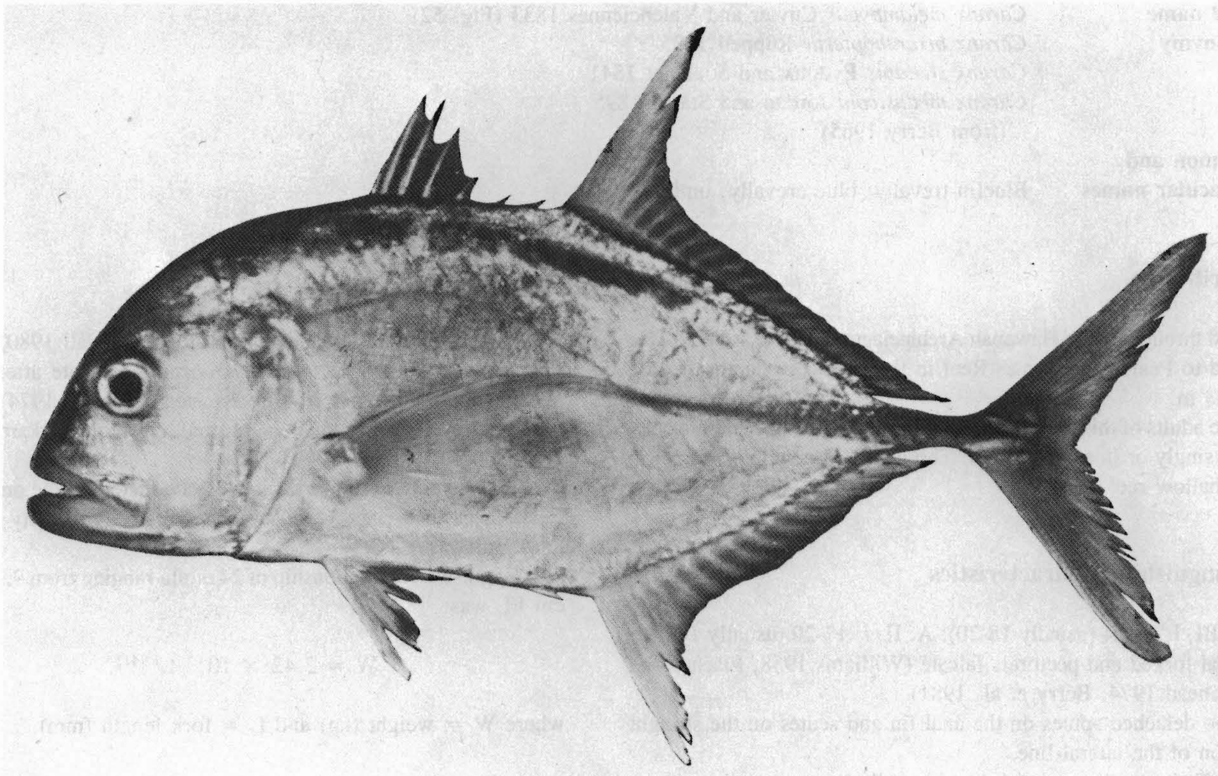

Figure 51.—*Caranx ignoblis*.

by Michael P. Seki

Valid name	*Caranx melampygus* Cuvier and Valenciennes 1833 (Fig. 52)
Synonymy	*Caranx bixanthopterus* Rüppell 1835
	Caranx stellatus Eydoux and Souleyet 1841
	Caranx medusicola Jordan and Starks 1895 (from Berry 1965)
Common and vernacular names	Bluefin trevally; blue crevally; omilu

Distribution

Found throughout the Hawaiian Archipelago, captured from Necker Island to Pearl and Hermes Reef in the NWHI at depths from 2 to 183 m.

The adults of this species roam the inner and outer coral or rocky reefs singly or in small groups. The juveniles generally school in the shallow reef areas.

Distinguishing characteristics

D. VIII, I, 20-24 (usually 18-20); A. II, I, 17-20 (usually 18-19). Caudal forked and pectorals falcate (Williams 1958; Fischer and Whitehead 1974; Berry et al. 1981).

Two detached spines on the anal fin and scutes on the straight portion of the lateral line.

In life is usually greenish blue dorsally becoming silvery ventrally with many small blue-black spots covering the body, primarily on upper sides. The species may vary in color; sometimes a uniform bluish black with infrequent spotting.

Specimens from the NMFS surveys in the NWHI ranged from 9.3 to 71.0 cm FL.

Life history

The species is predominantly piscivorous (Randall 1980). Omilu feed most frequently in the early morning and late afternoon to evening mainly on fish and crustaceans (Hobson 1974). In the NWHI, omilu is primarily a diurnal piscivore (Okamoto and Kawamoto 1980).

No reproductive studies have been conducted on the omilu. Off East Africa, however, *C. melampygus* reached maturity at 30-40 cm (Williams 1965).

A length-weight relationship of 24 omilu ranging from 9.3 to 71.0 cm FL was:

$$W = 2.42 \times 10^{-5} L^{2.9412},$$

where W = weight (kg) and L = fork length (mm).

Gear and catch

Omilu is taken primarily by handline and traps. In 1961-79, the annual landings fluctuated between 410 and 4,292 kg, averaging 1,400 kg in the main islands. Omilu is considered as an incidental species among bottom fishing boats operating in the NWHI.

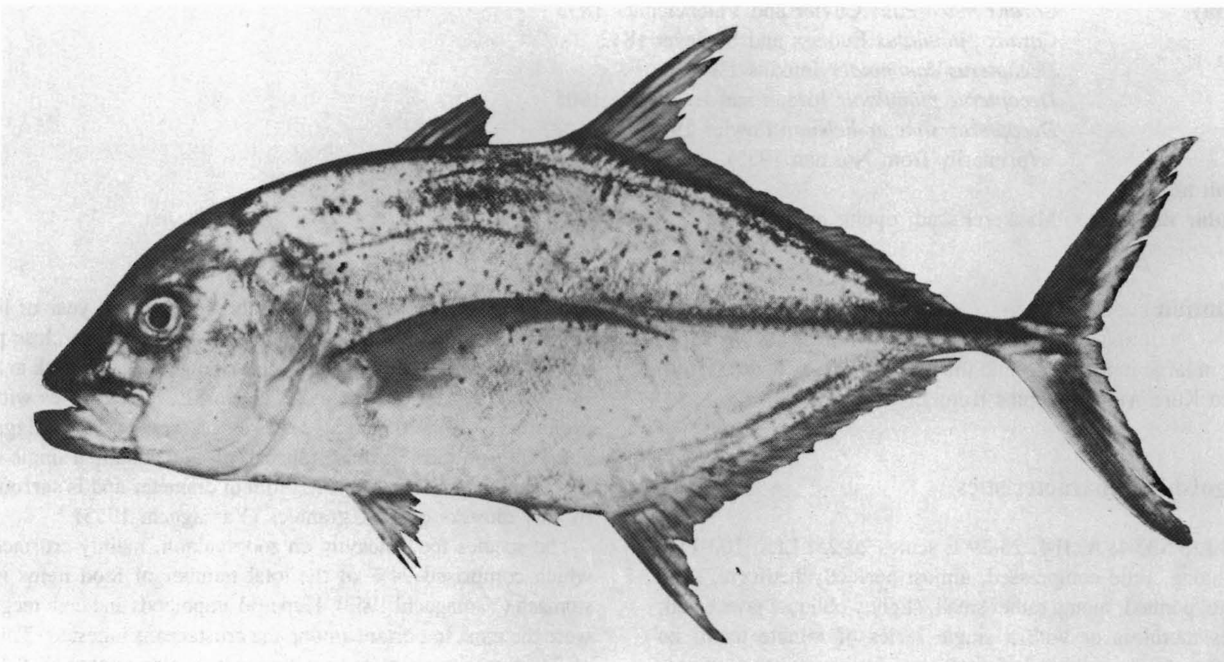

Figure 52.—*Caranx melampygus*.

by Paul M. Shiota

Valid name	*Decapterus macarellus* (Cuvier and Valenciennes 1833) (Fig. 53)
Synonymy	*Caranx macarellus* Cuvier and Valenciennes 1833
	Caranx pinnulatus Eydoux and Souleyet 1842
	Decapterus canonoides Jenkins 1903
	Decapterus pinnulatus Jordan and Evermann 1905
	Decapterus sanctae-helenae Fowler 1928
	(primarily from Norman 1935)
Common and vernacular names	Mackerel scad; opelu; opelu mama

Distribution

Present in large numbers around the main islands. Captured from Nihoa to Kure Atoll in depths from 22 to 38 m.

Distinguishing characteristics

D. VIII-I, 32-33-I; A. II-I, 28-29-I; scutes 20-25; LLs. 100-116. Body oblong, little compressed, almost perfectly fusiform; head moderate, pointed; mouth rather small, slightly oblique; jaws equal; palatines toothless or with a single series of minute teeth; no vomerine teeth; a small band of teeth posteriorly on tongue; adipose eyelid covering nearly entire eye; lateral line nearly straight from origin to interdorsal space, then descends until over fifth anal ray and continues straight to caudal fin (Jordan and Evermann 1905; Norman 1935).

Metallic bluish-black to bluish-green above and silvery white below in life. Small black spot near the upper margin of the opercle. Attains a length of about 50.0 cm (Gosline and Brock 1960).

During the NWHI surveys, three other *Decapterus* species were recorded. *Decapterus tabl* was easily separated from its Hawaiian congeners by its reddish tail. The other two species have yellow tails. *Decapterus macrosoma* has 28-30 rays on its anal fin and 25-30 scutes (Wakiya 1924; Berry and Smith-Vaniz 1978); *D. muroadsi* has 26-28 rays on its anal fin and 33 scutes (Wakiya 1924).

Life history

After hatching, the young fish remain in the pelagic environment, often forming large schools. Fishermen have reported schools of young fish as far as 80 nmi offshore.

Juvenile fish, 12.0-18.0 cm SL, first enter the coastal fisheries in late fall and winter. Once inshore, they grow at a fairly rapid rate, reaching 20.0, 27.1, and 30.7 cm SL after 12, 24, and 36 months, respectively (Yamaguchi 1953).

It attains sexual maturity by the end of the first year of life at about 18.0 cm SL. Spawning is in pelagic waters, in close proximity to its coastal habitat, from March-August, with a peak in May-July. Mature adults, 18.0 and 28.1 cm SL, have ovaries with approximately 83,000 and 212,500 eggs, respectively. Eggs are generally spherical, almost transparent, and contain a single shiny oil globule, which is 0.20-0.27 mm in diameter and is surrounded by tiny clusters of yolk granules (Yamaguchi 1953).

The species feeds heavily on zooplankton, mainly crustaceans, which comprised 94% of the total number of food items in the stomach (Yamaguchi 1953). Hyperiid amphipods and crab megalops were the most important among the crustaceans ingested. Thirteen of 24 stomachs examined by Yamaguchi also contained fish larvae. The stomach samples examined, however, may not reflect the true diet of opelu, because sampling was somewhat biased in that it was conducted under a night light which attracted phototaxic animals. It also did not account for possible seasonal and geographical differences in zooplankton abundance. For example, the diet of fish taken in Puerto Rico and the Virgin Islands was mainly pteropods (Randall 1967).

Gear and catch

An excellent food fish, mackerel scad is principally harvested commercially with hoop net and handline; gill nets and haul seines account for the remainder. In the late 1940's, hoop nets accounted for about 70% of the landings and handline the remaining 30%. However, in recent years (1971-78), the handline fishery accounted for a larger proportion of the landings (54%) compared with the hoop net fishery which produced only 39%.

In 1961-79, mackerel scad landings in Hawaii fluctuated between 77,874 and 194,143 kg and averaged 122,246 kg.

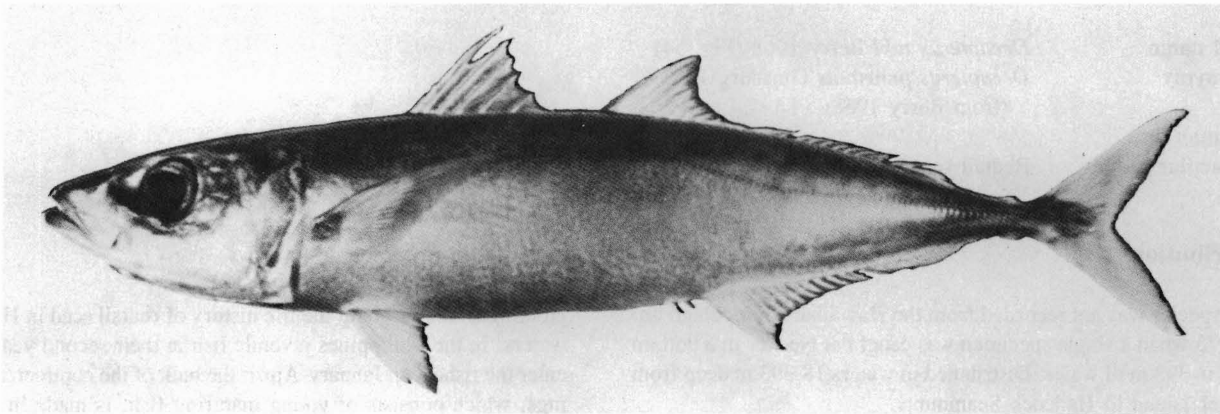

Figure 53.—*Decapterus macarellus*.

by Paul M. Shiota

Valid name	*Decapterus tabl* Berry 1968 (Fig. 54)
Synonymy	*Decapterus punctatus* Ginsburg 1952 (from Berry 1968)
Common and vernacular names	Redtail scad; redtail opelu

Distribution

This species was not recorded from the Hawaiian Archipelago until 1975 when a single specimen was caught at Necker in a bottom trawl in 393 m of water. Distributed in waters 18-393 m deep from Necker Island to Hancock Seamounts.

Distinguishing characteristics

D. VIII-I, 29-33; A. II-I, 24-26-I; LLs. 103-119; Gr. 10-12+30-33. Body rounded, elongate, slender; eye moderate; adipose eyelid well developed; teeth minute, in a single row in both jaws, becoming reduced in number and extent with growth; dorsal fins well separated; terminal ray of dorsal and anal fins consisting of a widely detached finlet; pectoral fins short; scales small, cycloid; lateral line arched to beneath the 13th to 16th dorsal soft ray; scales in curved part of lateral line 61-78, no scutes in curved part; anterior scales in straight part 0-8, scutes in straight part 34-44; dorsal accessory lateral line short, terminating near end of head; shoulder girdle with 2 slight papillae and a shallow groove above and below the pair, the lower papillae and groove the larger; vertebrae 10+14 (Berry and Smith-Vaniz 1978).

In life, metallic bluish-green to bluish-black above and silvery white below; tail reddish. Opercle with a small black spot near the upper edge. Largest Hawaiian specimen, taken at Hancock Seamounts, measured 42.8 cm FL.

Life history

Nothing is known about the life history of redtail scad in Hawaiian waters. In the Philippines juvenile fish in their second year of life enter the fishery in January-April; the bulk of the commercial landings, which consists of young maturing fish, is made in March-May (Tiews et al. 1970). As the fish begin to reach maturity in October-May during their third year of life, they exit the fishery for spawning grounds offshore (Tiews et al. 1970; Ronquillo 1972).

In the Philippines, spawning of *D. tabl* is slightly later than that of *D. macrosoma* which spawns between October and April (Magnuson 1970). Spawning occurs in the pelagic environment, the number of eggs spawned per fish ranging from 28,700 to 48,700 (Tiews et al. 1970).

Redtail scad feeds primarily in the water column on plankton such as copepods, mysis stages of crustaceans, and small fishes (Tiews et al. 1970).

Gear and catch

Red tail scad is harvested with mackerel handline, deep-sea handline, and bottom trawl. Catches up to 450 kg have been made with a fish trawl. There is no commercial fishery for this species in Hawaii.

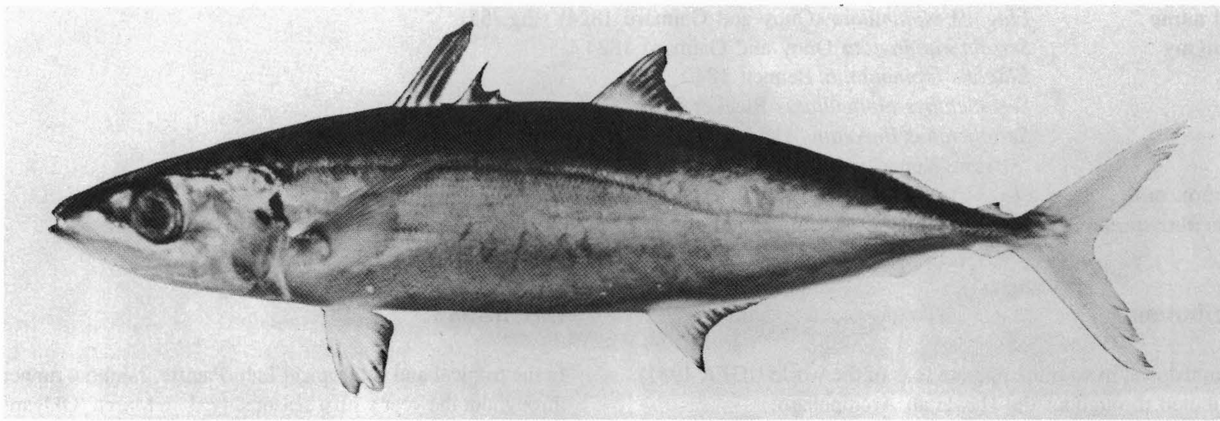

Figure 54.—*Decapterus tabl.*

by Michael P. Seki

Valid name	*Elagatis bipinnulata* (Quoy and Gaimard 1824) (Fig. 55)
Synonymy	*Seriola bipinnulata* Quoy and Gaimard 1824
	Elagatis bipinnulatus Bennett 1840
	Seriolichthys bipinnulatus Bleeker 1854
	Seriolichthys lineolatus Day 1867
	(from Weber and De Beaufort 1931)
Common and vernacular names	Rainbow runner; Hawaiian salmon; kamanu

Distribution

Circumtropical in warm temperate seas of the world (IGFA 1981). Distributed throughout the Hawaiian Archipelago.

Adult fish solitary, inhabiting surface waters of the open sea. Young have been known to frequent flotsam and may occur in small schools (Johnson 1978; IGFA 1981).

Distinguishing characteristics

D. VI, I, 25-30; A. I, I, 18-22 (the two detached terminal two-rayed finlets are included in the counts for both the dorsal and anal fins); Gr. 9-12+25-29. Lack scutes along the lateral line. Body slender, elongate, covered with ctenoid scales. Head and snout pointed, mouth small. Pectoral and pelvic fins short, about the same length; caudal fin forked (Fischer 1978; Johnson 1978).

In life, greenish blue dorsally becoming whitish silver ventrally, tinged with yellow. Two distinct blue bands, with a yellow band between them, run the length of the sides of the fish. The upper blue band begins just behind the eye, the lower at the snout, and both extend to the caudal peduncle. Fins greenish yellow.

The largest recorded specimen is 15.2 kg (IGFA 1981). Specimens taken in the NWHI ranged in size from 42.5 to 97.2 cm FL (2.5 to 10.2 kg).

Life history

In the tropical and subtropical Indo-Pacific, rainbow runner spawns throughout the year with a seasonal peak in March (Okiyama 1970). The larvae are the most abundant of the epipelagic carangids. Together with juveniles, the larvae are frequently associated with the pelagic sargassum community (Aprieto 1974).

Adults feed on crustaceans and fish (Fischer 1978). Copepods (mostly calanoid and *Corycaeus*) are the most important items in the diet of postlarvae and juveniles (Okiyama 1970).

A length-weight relationship of fish from Hawaiian waters is not available. For specimens from Guam and the Commonwealth of the Northern Marianas ranging from 40.2 to 89.1 cm FL, the relationship was:

$$W = 2.32 \times 10^{-4} L^{2.24},$$

where W = weight (kg) and L = fork length (mm).

Gear and catch

Rainbow runner is taken by trolling and occasionally by live bait, pole-and-line boats. Although it is an excellent food fish, the species does not contribute significantly to the commercial landings in Hawaii. In 1975-79, annual landings varied from 808 to 1,655 kg, averaging 1,196 kg.

There is no fishery for this species in the NWHI.

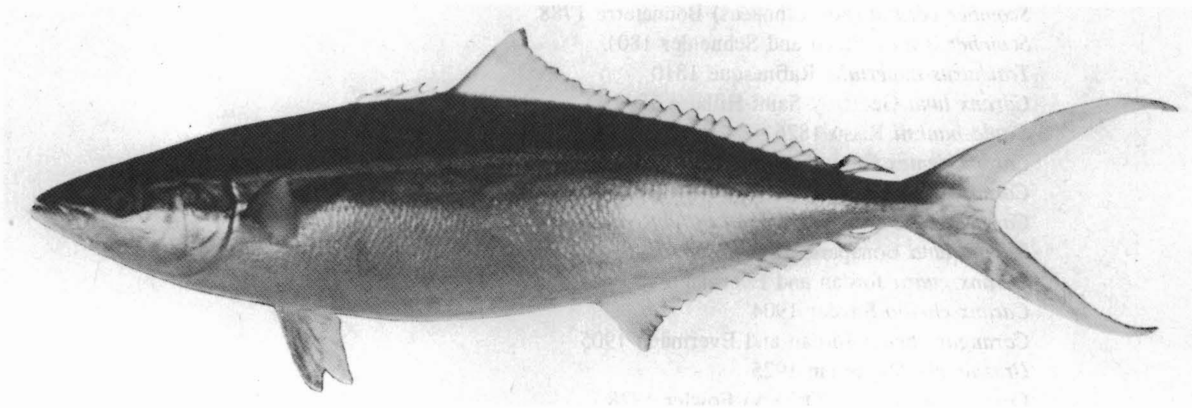

Figure 55.—*Elagatis bipinnulata*.

by Michael P. Seki

Valid name	*Pseudocaranx dentex* (Bloch and Schneider 1801) (Fig. 56)
Synonymy	(?) *Scomber adcensionis* Osbeck 1771
	Scomber cordila (non-Linnaeus) Bonnaterre 1788
	Scomber dentex Bloch and Schneider 1801
	Trachurus imperialis Rafinesque 1810
	Caranx luna Geoffroy Saint-Hillaire 1809
	Citula banksii Risso 1826
	Caranx dentex Cuvier 1833
	Caranx solea Cuvier 1833
	Caranx analis Cuvier 1833
	Selenia luna Bonaparte 1846
	Caranx guara Jordan and Evermann 1896
	Caranx cheilio Snyder 1904
	Carangus cheilio Jordan and Evermann 1905
	Uraspis cheilio Jordan 1925
	Caranx ascensionis (Osbeck) Fowler 1928
	Caranx adscensionis (Osbeck) Smith 1949
	(from Berry 1959; Fischer 1978)
Common and vernacular names	White trevally; thick-lipped trevally; butaguchi; buta ulua; pig ulua

Distribution

Uncommon in the main islands but abundant in the NWHI from the west bank of Nihoa to Kure Atoll. Inhabits not only banks and benthic slopes but also inshore areas. Found at depths between 18 and 183 m in the NMFS surveys. At Kure Atoll, HDAR field surveys found butaguchi in waters 1.5 m deep and occasionally in large schools of 200-300 individuals (Okamoto and Kawamoto 1980).

Distinguishing characteristics

D. VIII, I, 24-27; A. II, I, 20-23; P1. I, 19-20; Gr. 11-14+23-28 (Berry 1959; Fischer 1978). Body elongate, compressed; lips thick, fleshy, inferior jaw, unlike most of the other carangids; snout pointed, elongate in profile with a slight concave depression in the interorbital region.

In life, greenish blue dorsally becoming silver ventrally; a yellow stripe runs along the side of the body from the caudal peduncle through the eye. A distinctive black spot on posterodorsal edge of opercle; fins are yellow.

The NMFS samples from the NWHI ranged from 9.0 to 131.4 cm (0.05 to 11.5 kg).

Life history

Butaguchi in the NWHI are opportunistic bottom feeders (Seki 1984b). Of the stomach samples analyzed, fishes of the Families Congridae, Priacanthidae, and Serranidae, crustaceans such as crabs and shrimps, and octopuses were the most important. Time of feeding is unknown. Catch data suggest the species has a wide range of foraging grounds.

The functional length-weight relationship of 267 butaguchi (ranging from 33.3 to 89.0 cm) caught in the NWHI is:

$$W = 1.70 \times 10^{-8} L^{3.0074},$$

where W = weight (kg) and L = fork length (mm) (Uchiyama et al. 1984).

In NMFS age and growth studies, only a linear growth stanza was calculated because the largest fish examined had not reached the asymptotic growth phase. Preliminary estimates placed a 1-year-old at 30 cm and a 2-year-old at 66 cm.[10]

During the NMFS survey ripe ovaries were collected in January and July (Uchiyama and Tagami 1984).

Gear and catch

Butaguchi is taken principally by deep-sea handline, but has also been captured in traps.

Catch data are unavailable because the present statistical reporting system combines several species of carangids.

The species is scarce in the main islands; however, it is among the more abundant species in the NWHI and contributes significantly to the NWHI bottom fish landings (see footnote 6).

[10]Uchiyama, J. H., J. Enitan, and J. D. Sampaga. Age and growth estimates of snappers and jacks of the Northwestern Hawaiian Islands. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396 (manuscr. in prep.).

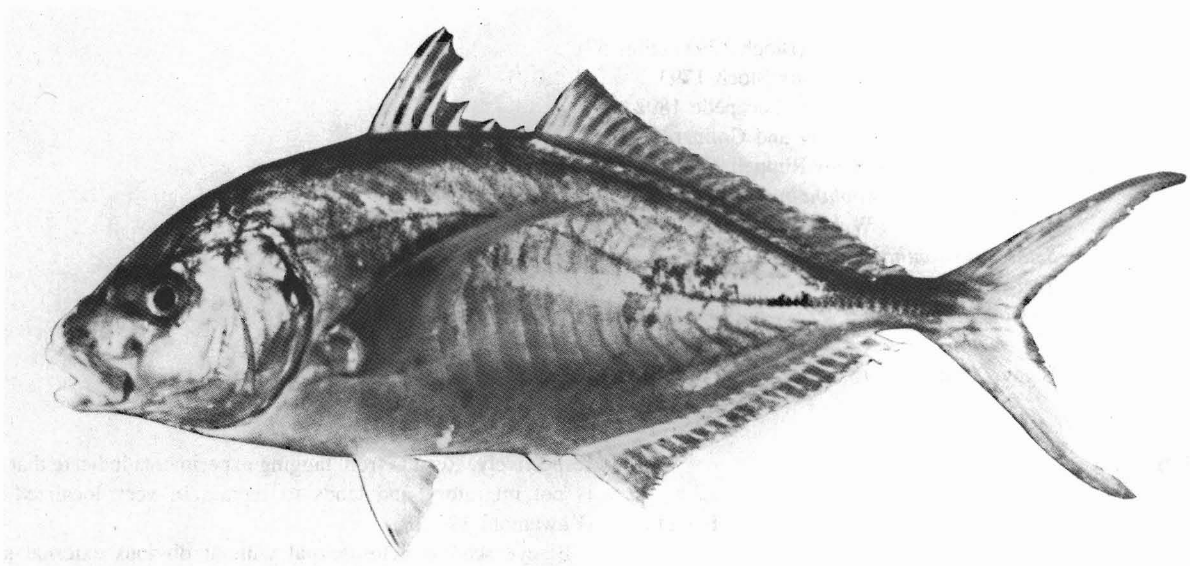

Figure 56.—*Pseudocaranx dentex*.

by Paul M. Shiota

Valid name	*Selar crumenophthalmus* (Bloch 1793) (Fig. 57)
Synonymy	*Scomber crumenophthalmus* Bloch 1793
	Caranx crumenophthalmus Lacepède 1802
	Caranx mauritianus Quoy and Gaimard 1824
	Caranx macrophthalmus Rüppell 1828
	Trachurops crumenophthalmus Gill 1863
	Selar mauritianus Wakiya 1924
	Selar macrophthalmus Wakiya 1924
	Trachurops mauritianus Jordan and Hubbs 1925 (from Jordan and Evermann 1905; Williams 1958)
Common and vernacular names	Bigeye scad; paaa (5.1-7.6 cm); hahalalu (7.6-22.8 cm); akule (>22.8 cm)

Distribution

Distributed throughout the entire Hawaiian Archipelago. Found from Necker Island to Midway in the NWHI.

In the main islands, bigeye scad inhabit coastal waters of all islands from shoreline to depths of about 100 m (Kawamoto 1973; Kazama[11]) and form schools numbering from a few to tens of thousands of individuals.

Distinguishing characteristics

D. VIII+I, 25-27 (usually 26); A. II+I, 20-22 (usually 22); P1. I, 19-20; P2. I, 5; LLs. 81-95 of which 28-37 are modified into scutes; Gr. 10-11+27-28 (Schultz et al. 1953). Body oblong, moderately slender, typically mackerel-like. Eye diameter contained three times or less in head length; adipose eyelids well developed and extend to pupil, leaving the eye as a narrow slit; portion of pectoral girdle that forms posterior margin of gill opening has a deep furrow; teeth in both jaws uniseriate; vomer and palatines toothed; lower jaw projecting; maxillary of moderate width, ending under anterior margin of pupil; first dorsal fin high, spines connected by membranes; two anal spines well developed; pectoral fin reaching origin of soft anal fin, soft dorsal and anal fins slightly elevated anteriorly, fin bases equal in length; anterior portion of lateral line with a long low arch, becoming straight below middle of soft dorsal fin; scutes only on straight portion of lateral line.

In life, bluish to greenish silver on the upper third of the body and silvery white on the lower two-thirds. Attains a maximum size of about 38.0 cm (Gosline and Brock 1960); the majority range from 21.0 to 26.5 cm FL (Kawamoto 1973).

Life history

The species is relatively fast-growing. Bigeye scad is 10.2-17.5 cm when it first appears in shallow coastal waters in large schools and grows to 22.9 and 30.5 cm by the end of the first and second year, respectively. Results from tagging experiments indicate that akule is not migratory and tends to remain in very localized areas (Kawamoto 1973).

Bigeye scad is heterosexual without obvious external sexual dimorphism, has a sex ratio of 50:50 in mature adults, and is believed to be promiscuous (Kawamoto 1973). Spawning is pelagic and eggs are spherical, with a single oil globule, nonadhesive, and free-floating (Kawamoto 1973; Johnson 1978). Females reach sexual maturity and begin spawning at about 23.5-25.0 cm when they are 10-12 months old, and males mature at about 22.0-23.0 cm when they are about 8-9 months old (Kawamoto 1973).

Samples collected during NMFS cruises indicate that the reproductive cycle is seasonal in the NWHI, similar to that of bigeye scad in the main islands. Specimens collected at Kure Atoll and Midway in June were mature; whereas fish from Laysan Island, Maro Reef, French Frigate Shoals, and Necker Island were mature in July. Sampling at Nihoa and French Frigate Shoals in November produced a predominance of juveniles. This is in agreement with results of studies in the main islands where gonads were predominantly mature or spent in April-November (Kawamoto 1973), and fish under 15.0 cm appeared in shallow coastal waters in large schools in July-December (Gosline and Brock 1960). The evidence suggests that spawning occurs in the spring and summer (February-August).

The NMFS surveys have demonstrated that before spawning, mature fish move into shallow water, similar to spawning adults which form large schools in shallow, sandy, or flat-bottomed areas <22 m in the main islands (Gosline and Brock 1960). For example, at Midway, sampling in the lagoon in June in waters <3.6 m produced large numbers of bigeye scad with mature gonads. Similarly, schools of large bigeye scad with mature gonads occurred in July in shallow water on the leeward side of Laysan Island.

Although in the main islands juveniles are caught by recreational fishermen with pole and line during daylight, bigeye scad are primarily night feeders. The bulk of their diet is composed of small fishes such as anchovies and holocentrids, and crustaceans such as copepods, crab megalops, stomatopods, and shrimps (Kawamoto 1973). This indicates that the species feeds primarily in the water column.

[11]Kazama, T. K. 1977. The "akule" fishery of Hawaii. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396, Admin. Rep. 1H, 1977, 5 p.

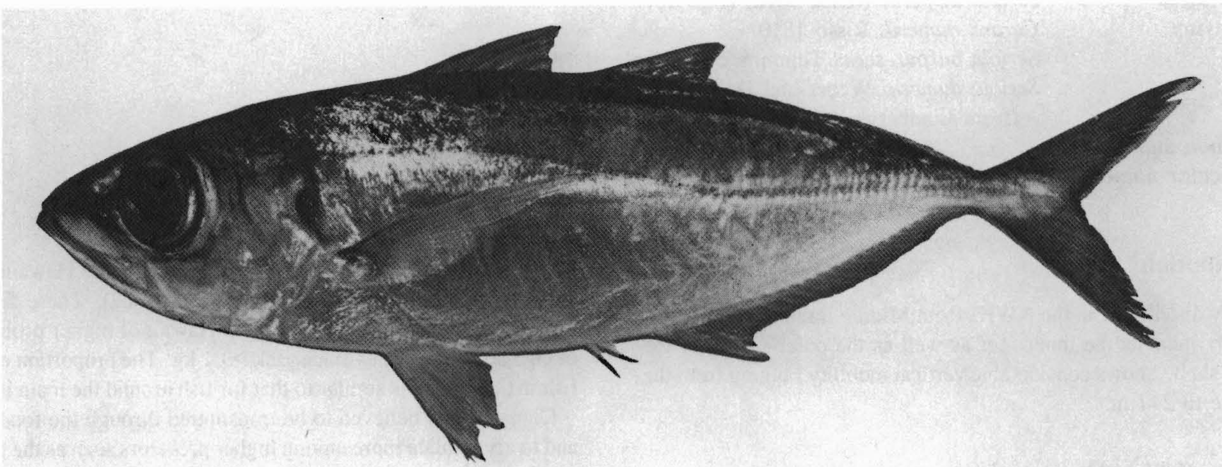

Figure 57.—*Selar crumenophthalmus.*

Gear and catch

In Hawaii, handlines, surround nets, and gill nets are the principal gear used to harvest bigeye scad. Handlining depends on the positive phototactic response of the akule (Powell 1968). Fishing is conducted at night from small boats in coastal waters to a depth of 100 m. The fish that accumulate under the light are jigged with a handline rigged with three to five baited hooks or artificial lures. Fishing is best during the new moon.

Landings of bigeye scad in Hawaii have fluctuated widely. From 1961 through 1979, the annual catch ranged from 68,342 to 444,556 kg and averaged 276,404 kg.

Presently, harvesting of bigeye scad occurs only in the main islands, although NMFS surveys have demonstrated the presence of large concentrations of this species at Necker Island, French Frigate Shoals, and Maro Reef. For the immediate future, it is unlikely that this species will be commercially harvested in the NWHI since there are adequate stocks in the main islands in close proximity to Honolulu where the largest demand for fresh fish exists.

by Robert L. Humphreys, Jr.

Valid name	*Seriola dumerili* (Risso 1810) (Fig. 58)
Synonymy	*Caranx dumerili* Risso 1810
	Seriola purpurescens Temminck and Schlegel 1844
	Seriola dumerili Weber and De Beaufort 1931 (from Lindberg and Krasyukova 1971)
Common and vernacular names	Greater amberjack; yellowtail; kahala

Distribution

Widely distributed in the NWHI from Middle Bank to Kure Atoll. Usually inhabits the inner reef as well as the outer slopes of the island shelf. Shows considerable vertical mobility ranging from the surface to 247 m.

Distinguishing characteristics

D. I, VII, I, 30-31; A. II, I, 19-21 (Jordan and Evermann 1905; Lindberg and Krasyukova 1971). Body elongated, oval in cross-section. Head conical in profile, eye moderate, mouth large, oblique. Maximum depth at midbody, tapering posteriorly to a short, narrow caudal peduncle. Broad bands of villiform teeth cover jaws, palatines, tongue, and vomer.

Dorsal fin composed of short spinous anterior portion followed by a long, low soft dorsal which is higher anteriorly; anal similar to soft dorsal, preceding spines short. Pectorals short; pelvics inserted posterior to and longer than pectorals; caudal strongly forked (Jordan and Evermann 1905).

Body covered with small cycloid scales; no enlarged scutes along lateral line. Scales not present on opercle, snout, and top of head.

In life predominantly yellow and brown with occasional greenish patches. A thick, prominent yellow stripe extends from maxillary to the eye, then posteriorly from eye, crossing above pectorals to caudal peduncle.

Data from NMFS cruises showed mean lengths and weights of 75.1 cm and 7.24 kg for males and 78.2 cm and 7.79 kg for females. Maximum length was 106.0 cm in males and 149.4 cm in females.

Greater amberjack can be distinguished from its congener, *S. lalandei*, by the presence of 15 or fewer gill rakers on the first lower gill arch, <33 second dorsal rays, maxillary extending back to mideye, and 150-175 transverse scale rows (Gosline and Brock 1960; Lindberg and Krasyukova 1971).

Life history

Based on samples from the Hawaiian Archipelago, size at maturity in females is 54 cm FL (Kikkawa and Everson 1984). Spawning occurs throughout the year with a peak in April. Fecundity estimates range from 1.3 to 4.0 million eggs for fish 83.0 to 118.6 cm FL.

In Hawaii, as elsewhere in the world, the greater amberjack has been implicated in numerous cases of ciguatera.[12] No relationship between size and ciguatoxicity among fish in the Hawaiian Archipelago has been found (Kimura et al. 1982). These findings dispute the commonly held notion in Hawaii of higher probability of ciguatoxin in greater amberjack >9.1 kg. The proportion of toxic fish in the NWHI is similar to that for fish around the main islands.

Ciguatoxin is believed to be transmitted through the food chain and to accumulate more among higher predators such as the greater amberjack. *Decapterus* sp. is the primary component in the diet of the greater amberjack caught in the main islands (Humphreys and Kramer 1984). However, ciguatoxic fish in the size group 4.00-8.99 kg has a lower *Decapterus* and higher bottom-associated prey content than the complementary nonciguatoxic group. These results indicate that a shift toward bottom-associated prey may be responsible for the transmission of ciguatoxin up the food chain.

There are dietary differences between greater amberjack sampled from the NWHI and the main islands. Octopus and bottom-associated prey are the predominant dietary components in the NWHI whereas *Decapterus* and water column-associated prey are predominant in the main islands. In both areas there is a dietary increase of *Decapterus* and water column-associated prey with increasing predator size.

The following growth rate of greater amberjack was determined using a freely fitted von Bertalanffy growth equation of:

$$L_t = 149.3(1\text{-}e^{-0.314(t-0.0420)}),$$

where L = fork length (cm) expressed as a function of time t in years (see footnote 10). This equation projects a length of 37.5 cm at 1 year, 67.5 cm at 2 years, and 89.6 cm at 3 years.

A male to female ratio of 60:40 (N = 209) was observed for specimens collected during NMFS cruises in the NWHI. A much larger sample (N = 3,989) from statewide catches shows a ratio of 52:48.[13]

The functional length-weight relationship for 181 greater amberjack ranging from 49.9 to 113.8 cm FL is:

$$W = 2.21 \times 10^{-8} L^{2.9412},$$

where W = weight (kg) and L = fork length (mm) (Uchiyama et al. 1984).

The catch rates of greater amberjack were fairly uniform from Nihoa to Pearl and Hermes Reef; however, the average size of fish caught from Gardner Pinnacles to Pearl and Hermes Reef was larger

[12]Kubota, W. 1981. Ciguatera fish poisoning cases: A summary from 1900 to December 1980. Pacific Ciguatera Workshop, Honolulu, HI, 18-20 March 1981, WP/7, 14 p.

[13]Polovina, J. J., and B. M. Ito. 1981. Analysis of data from the kahala ciguatera sampling program, April 1979 to December 1980. Pacific Ciguatera Workshop, Honolulu, HI, 18-20 March 1981, WP/1, 4 p.

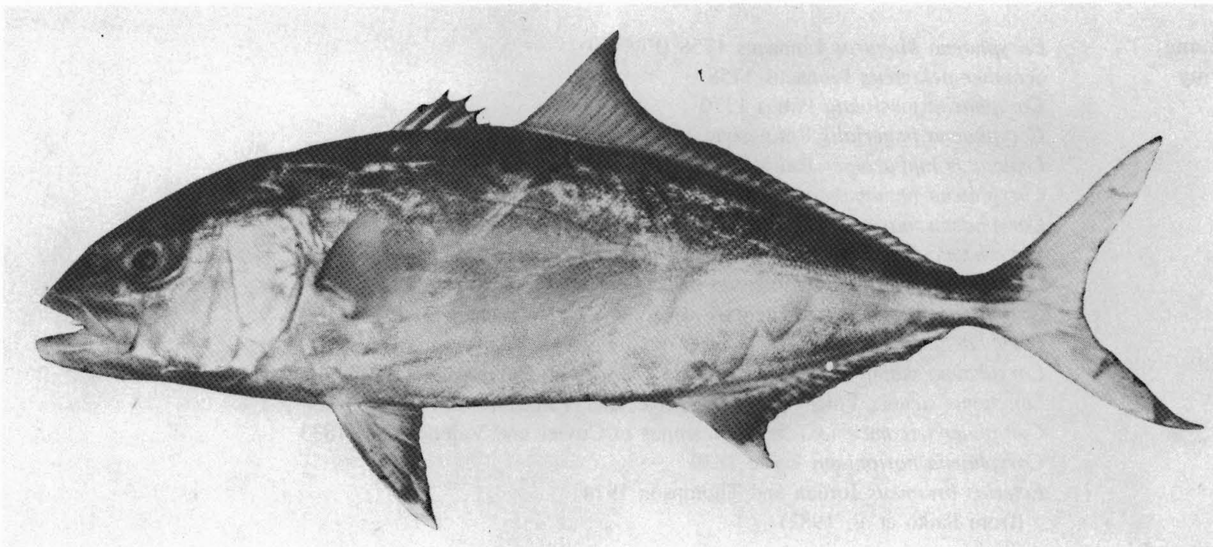

Figure 58.—*Seriola dumerili.*

than that caught from Middle Bank to St. Rogatien (Uchiyama and Tagami 1984). The catch per unit of effort was higher at night (Moffitt 1980).

The vertical mobility of the species theoretically allows it to become associated with members of the snapper-grouper complex; however, competition for bottom-related forage organisms may not be intense or may be limited because it also utilizes *Decapterus* and other water column organisms.

Gear and catch

The greater amberjack is taken mainly by deep-sea handline but also enters traps. Annual landings from the NWHI varied between 614 and 6,311 kg and averaged 3,029 kg during 1959-77.[14] Statewide annual landings for 1961-79 ranged from 13,629 to 47,938 kg and averaged 33,108 kg. Because greater amberjack has been implicated in several ciguatera attacks in Hawaii, the species is generally not sold in the local markets.

[14]Polovina, J. J., and R. B. Moffitt. 1980. Commercial bottom handline fishing in the Northwestern Hawaiian Islands 1959-77. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396, Admin. Rep. H-80-11, 2 p.

by James H. Uchiyama

Valid name *Coryphaena hippurus* Linnaeus 1758 (Fig. 59)

Synonymy
Scomber pelagicus Linnaeus 1758
Coryphaena fasciolata Pallas 1770
Coryphaena imperialis Rafinesque 1810
Lepimphis hippuroides Rafinesque 1810
Coryphaena immaculata Agassiz in Spix and Agassiz 1829
Coryphaena marcgravii Valenciennes in Cuvier and Valenciennes 1833
Coryphaena suerii Valenciennes in Cuvier and Valenciennes 1833
Coryphaena dorado Valenciennes in Cuvier and Valenciennes 1833
Coryphaena virgata Valenciennes in Cuvier and Valenciennes 1833
Coryphaena argyrurus Valenciennes in Cuvier and Valenciennes 1833
Coryphaena vlamingii Valenciennes in Cuvier and Valenciennes 1833
Lampugus siculus Valenciennes in Cuvier and Valenciennes 1833
Coryphaena scomberioides Valenciennes in Cuvier and Valenciennes 1833
Coryphaena nortoniana Lowe 1839
Ecterias brunneus Jordan and Thompson 1914
(from Palko et al. 1982)

Common and vernacular names Dolphin; mahimahi

Distribution

Circumtropical but also in warm waters between lat. 45°N and 45°S. Captured by surface trolling from Nihoa to Kure Atoll in the NWHI. Larvae and juveniles nektonic, generally pelagic but have been found inshore. Adults inhabit open ocean but also approach coastal waters. They often follow ships and tend to aggregate under floating objects. Small fish (<2.3 kg) are plentiful in summer; large fish (13.6-18.1 kg) are caught mostly from February to April (Squire and Smith 1977).

Distinguishing characteristics

D. 55-65; A. I-III, 25-30; P1. I, 17-21; P2. I, 5; LLs. 245-280. Gill raker counts decrease with age; juveniles have 10-15; whereas adults have 8-10 (Gibbs and Collette 1959). Body elongate, laterally compressed with single dorsal fin originating at nape, extending to caudal; anal fin slightly longer than half of body length; pelvic fins fit into groove in body; caudal fin deeply forked. Species sexually dimorphic. In males, pronounced bony crest on front of head; in females, forehead slightly convex. Terminal mouth extends to vertical axis through middle of eye in both sexes. Males larger than females. Lateral line curved upward above the pectoral.

Color in life variable but usually brilliant green on back, yellow to golden hues on sides, and yellow to white on bottom. Many small brilliant phosphorescent blue and black spots on head and body. Dorsal and anal fins dark.

Life history

The species is heterosexual. In the NWHI, well-developed and ripe ovaries were collected in March-September. Around the main islands, dolphin spawns throughout the year as evidenced by occurrence of juveniles in all months.[15]

Females begin to mature at 35 cm FL; all are mature at 55 cm (Beardsley 1967). Fecundity estimates were from 240,000 to 3,000,000 eggs per fish annually, depending on size.

The buoyant, colorless, spherical eggs measure about 1.2-1.6 mm in diameter and have a single, light-yellow oil globule 0.3-0.4 mm in diameter. The yolk appears to be coarsely segmented. The NMFS culture experiments demonstrated that eggs measure 1.58 mm in diameter and fertilized eggs hatch in 40-53 h at 24-26°C. At hatching, the larvae are 3.95 to 5.10 mm long.[16] The larvae absorb the yolk sac in 2-4 days (Mito 1960; see footnote 16). Male dolphin grow rapidly attaining 20 kg in the first year in Hawaiian waters (Uchiyama et al. 1986).

Dolphin are active and voracious feeders and prefer fast-moving large prey (Welsh 1950). Juveniles feed primarily on copepods; larger juveniles feed on fish and cephalopods (Shcherbachev 1973). Adults feed mainly on fish with flyingfish predominating (Welsh 1950; Ronquillo 1953; Tester and Nakamura 1957; Kojima 1961; Shcherbachev 1973; Rose and Hassler 1974).

Little is known about migration. The dolphin has long been known to be associated with drifting objects (Gooding and Magnuson 1967).

The species tend to school by sex as well as by size (Gibbs and Collette 1959; Kojima 1966; Beardsley 1967).

Dolphin caught during the NWHI investigations ranged from 52.2 to 130.5 cm among females and 48.3 to 110.0 cm for males. The length-weight relationship of dolphin in Hawaii is:

$$W = 6.359 \times 10^{-5} L^{2.7111},$$

where W = weight (lb) and L = fork length (cm) (Tester and Nakamura 1957). Due to sexual dimorphism, this relationship holds only for fish <68 cm. For fish >68 cm, males are heavier than females of the same length.

[15] Burch, R. K., Biologist, Waikiki Aquarium, Honolulu, HI 96815, pers. commun. May 1982.

[16] Kazama, T. K., Fishery Biologist, Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396, pers. commun. 6 April 1984.

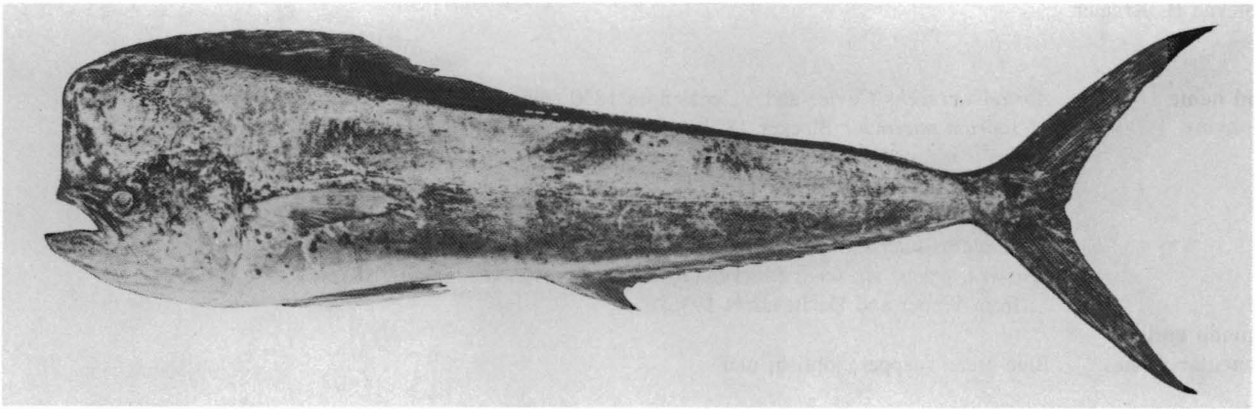

Figure 59.—Male *Coryphaena hippurus*.

Gear and catch

Dolphin is caught mainly by trolling but also taken incidentally by longline and pole and line. For 1961-79, the annual landings varied from 26,526 to 79,492 kg and averaged 50,556 kg.

by Steven H. Kramer

Valid name	*Aprion virescens* Cuvier and Valenciennes 1830 (Fig. 60)
Synonymy	*Mesoprion microchir* Bleeker 1853
	Lutjanus macrochir Bleeker 1863
	Sparopsis latifrons Kner 1868
	Sparopsis elongatus Kner 1868
	Chatopterus microchir Bleeker 1869
	Aprion (Aprion) virescens Bleeker (1872) 1873, revision *Lutjanus*, 1876-77 (from Weber and De Beaufort 1936)
Common and vernacular names	Blue-green snapper; jobfish; uku

Distribution:

Caught only at Nihoa, Brooks Banks, St. Rogatien, and Midway in the NWHI. Maximum depth recorded for this species was 58 m.

Frequently inhabits midwater near reefs and drop-offs in depths of 6-28 m and never takes shelter in the coral (Talbot 1960). Feeds in the water column from surface to the bottom (Ommanney 1953; Wheeler 1953).

Distinguishing characteristics

D. X, 11; A. III, 8; P1. 17; LLps. 48-50; Gr. 7+14-15 (Masuda et al. 1975). Body elongate, more cylindrical than slender with large scales. Head with prominent groove on either side of snout in front of eyes; eyes relatively small, high on head. Pectoral fins short, rounded; single dorsal fin without a notch; dorsal and anal fins scaleless. Caudal fin deeply forked. Attains a length of 1 m.

Mouth oblique; lower jaw slightly projected; both jaws with two strong anterior canines. Smaller canines located laterally and between the strong canines. Villiform bands on both jaws with outer series enlarged. Vomerine teeth form a curved patch, palatines an elongated ovate patch.

In life, light gray-blue or gray-green laterally, with blue reflections dorsally, becoming much lighter ventrally. Violet blotches occur at base of soft membrane of spinous dorsal fin. Pectoral and ventral fins are yellowish (Fischer and Whitehead 1974).

Life history

Little is known about the life history of uku in Hawaiian waters. On the East African coast, fully ripe females were found in all months except June and August, suggesting a breeding season in the warmer months (Ommanney 1953; Wheeler 1953; Williams 1956; Talbot 1960). Partially ripe females were recorded in all months, but the species may actually have an irregular extended breeding season (Talbot 1960). Williams (1956) reported sexual maturity occurring at about 60-75 cm for both sexes, but Talbot (1960) found females fully ripe at 46.5 cm SL and males at 50.0 cm SL. This species can be solitary or occur in loose, well-spaced aggregation of two to five fish. In the main islands, they appear to congregate during their spawning period which generally occurs in June (see footnote 6).

The length-weight relationships are probably the same for both sexes; however, no definitive equation expressing the relationship between length and weight is available (Williams 1956).

Uku is a high-level predator in the food chain, preying on fish, crustaceans, cephalopods, and zooplankton. It also feeds on larger fish such as scombrids (Reintjes and King 1953).

Food items found in *A. virescens* stomachs from East Africa consisted of fish (49%), plankton (17%), cephalopods (14%), nonplanktonic crustaceans (12%), and others (8%) (Talbot 1960). Identifiable food items included *Siganus oramin*, *Caesio caerulaureus*, *Sphyraena* sp., and *Sardinella* sp., members of the Families Callyodontidae, Ostraciontidae, and Bothidae; squids; portunids crabs, penaeid shrimps, and *Squilla* sp.; and planktonic organisms such as fish eggs, larval and postlarval fishes, stomatopod larvae, salps, and zoeae larvae (Ommanney 1953; Wheeler 1953; Williams 1956; Talbot 1960).

Uku has been reported to be ciguatoxic at Enewetak and Bikini Atolls (Randall 1980). In Hawaii, this species has been implicated in three ciguatera attacks since 1900 (see footnote 11).

Gear and catch

Uku is caught primarily by handline and set lines, rarely by rod and reel and trolling gear. The uku is the only Hawaiian lutjanid regularly caught at or near the surface with lures. Considered an excellent food and game fish, the annual landings in 1961-79 varied between 19,192 and 40,730 kg, and averaged 28,909 kg, making it second in importance to the opakapaka among the snappers in the local fishery. Landings are seasonal the bulk of the catch is made from June to December (see footnote 6).

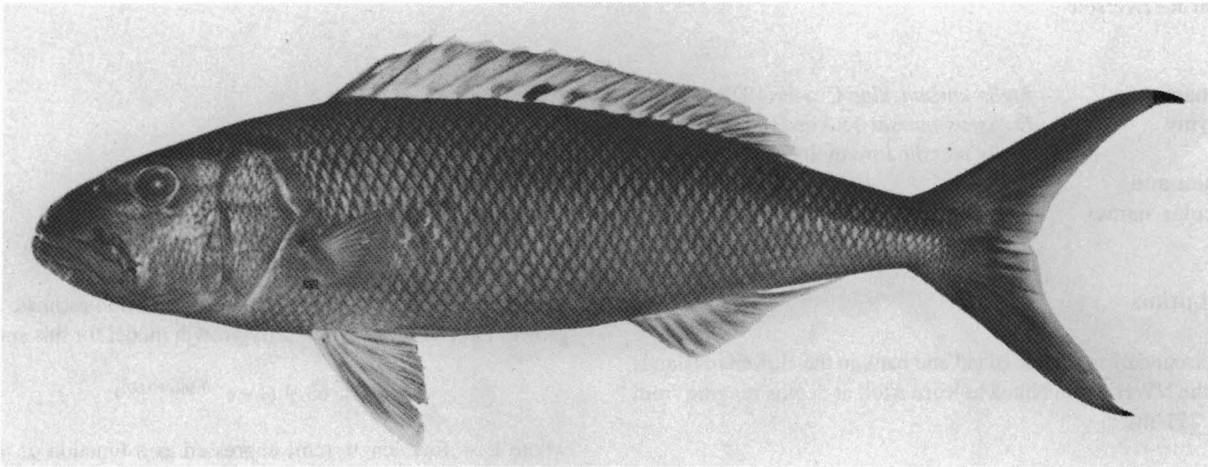

Figure 60.—*Aprion virescens*.

by Alan R. Everson

Valid name	*Etelis carbunculus* Cuvier 1828 (Fig. 61)
Synonymy	*Eteliscus marshi* Jenkins 1903
	Etelis marshi Jordan and Evermann 1905
Common and vernacular names	Red snapper; Marsh's snapper; squirrelfish snapper; ulaula; ehu

Distribution

Found around every major island and bank in the Hawaiian Islands and in the NWHI from Nihoa to Kure Atoll at depths ranging from 102 to 271 m.

Distinguishing characteristics

D. X, 11; A. III, 8; P1. 16; Gr. 6+12 (Jordan and Evermann 1905). Interorbital region flattened; maxilla with scales; dorsal fin continuous, but spinous portion of fin incised at its junction with soft portion; dorsal and anal fins without scales; ultimate dorsal and anal soft rays longer than penultimate soft rays (Anderson 1981).

Mouth rather large, somewhat oblique. Teeth on vomer and palatine. Teeth on the jaws in villiform bands; outer series of enlarged, widely spaced canines in each jaw; longest in front on each side; thicker in the upper jaw than lower. Body color uniform rose red in life (Jordan and Evermann 1905).

Ehu is sometimes confused with its congener, *E. coruscans*. It can be separated by the following features: horizontal yellow band along the middle of sides on ehu, absent on onaga; red coloration on inside of mouth lacking in ehu; long caudal rays on onaga; ehu is more robust and has fewer gill rakers than onaga (Jordan and Evermann 1905).

Life history

Ehu attains sexual maturity at about 29.8 cm FL. A fish, 50.8 cm FL, releases over 1.3 million eggs per batch and may release 2 or more batches of eggs per spawning season which extends from May through October (Everson 1984).

Because ehu are caught at considerable depths, the ascent causes the gas bladder to expand, thus forcing the stomach to evert. Therefore only a small number of stomach content samples was collected. Based on the number of small fishes and crustaceans found in stomachs, ehu is a carnivorous bottom feeder.[17]

Daily rings on the sagittae of ehu were used to estimate age and growth rate. The von Bertalanffy growth model for this species is:

$$L_t = 63.9\ (1-e^{-0.36(t-0.60)}),$$

where L = fork length (cm) expressed as a function of time t in years (see footnote 10). From this equation, ehu is estimated to be 28.4 cm at 1 year, 39.2 cm at 2 years, and 46.8 cm at 3 years.

The functional length-weight relationship of 754 ehu 26.8 to 63.5 cm long is:

$$W = 1.13 \times 10^{-8}\ L^{3.0740},$$

where W = weight (kg) and L = fork length (mm) (Uchiyama et al. 1984).

The NMFS catch data showed that ehu is the dominant species at banks west of Lisianski; ehu represents 22.7 to 86.5% of the catch (Uchiyama and Tagami 1984). In comparing mean lengths of ehu among banks of the NWHI, fish is larger west of Lisianski Island (Uchiyama et al. 1984). The relative apparent abundance of ehu is higher west of Lisianski Island; the catch rate was 4.1 fish per line hour at Nero Seamount (Uchiyama and Tagami 1984). Similar trends were also noted by Moffitt (1980). The sex ratio of ehu from the NMFS data is 67:33 (N = 926) in favor of females. The mean weight of females (2.13 kg) is somewhat greater than that of males (1.56 kg); however, the difference is not statistically significant (Uchiyama et al. 1984).

Gear and catch

Ehu is traditionally caught with deep-sea handlines, but it can also be trapped. In Hawaii, it is an important commercial species (Uchida et al. 1979). From 1961 through 1971, the annual catch fluctuated between 5,800 and 12,700 kg; however, during 1972-79 landings increased, ranging from 9,900 to 16,200 kg per year. The average annual landing during 1961-79 was 10,900 kg.

[17]Seki, M. P., Fishery biologist, Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396, pers. commun. March 1983.

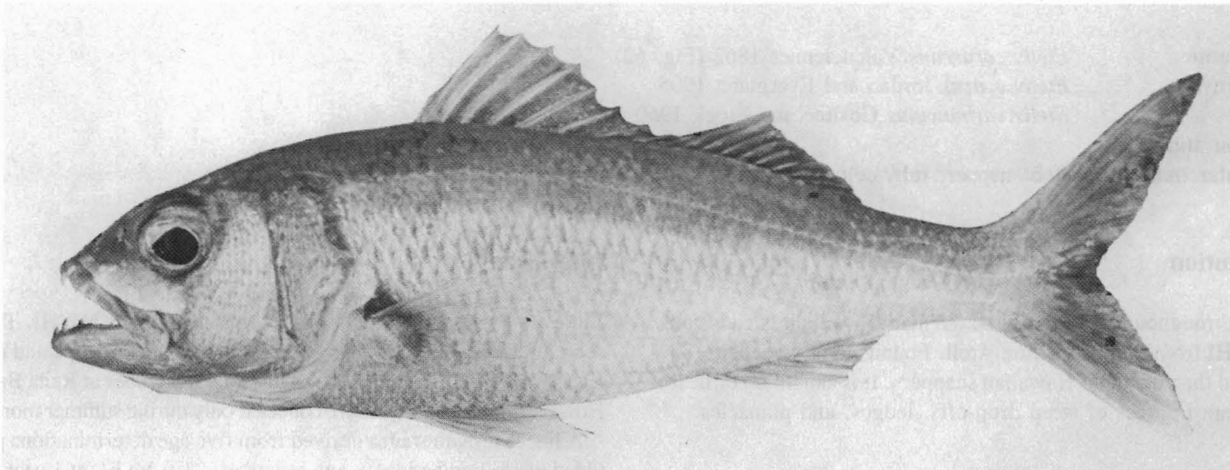

Figure 61.—*Etelis carbunculus*.

by Alan R. Everson

Valid name	*Etelis coruscans* Valenciennes 1862 (Fig. 62)
Synonymy	*Etelis evurus* Jordan and Evermann 1905
	Etelis carbunculus Gosline and Brock 1960
Common and vernacular names	Red snapper; ruby-colored snapper; longtail snapper; onaga; ulaula; ulaula koae

Distribution

Caught throughout the year around the main Hawaiian Islands and the NWHI from Bank 1 to Kure Atoll. Found slightly deeper (183 to 256 m) than the other Hawaiian snappers. It is caught on or near the bottom in areas of steep drop-offs, ledges, and pinnacles.

Distinguishing characteristics

D. X, 11; A. III, 8; Gr. 15+6 (Jordan and Evermann 1905). Body rather long, tapered, moderately compressed. Head longer than deep, bluntly pointed snout, large oblique mouth. Small bands of villiform teeth on the palatines and interior part of each jaw. Single row of small, wide set, slender canine teeth on the outer edge of each jaw, which also has a single canine tooth anteriorly. Deeply notched dorsal fin almost divided into two separate fins. Dorsal fin rays about equal in length. Anal fin similar in shape to soft dorsal. Caudal fin deeply notched producing long lobes; upper lobe longer; lobes get longer with age, taper into long caudal rays that are characteristic of onaga.

Color brilliant rose red.

Life history

Little is known about the life history of onaga in the NWHI. Their reproductive cycle is probably similar to that of ehu. Ripe and near ripe ovaries were collected in August and September at Raita Bank. However, onaga ovaries were collected only during summer months.

A linear growth stanza derived from five age determinations provided the following length-age estimates: 21.0 cm FL at 1 year and 58.1 cm at 2 years (Uchiyama and Tagami 1984).

The functional length-weight relationship for onaga 48.0 to 88.0 cm FL is:

$$W = 2.99 \times 10^{-8} L^{2.9003},$$

where W = weight (kg) and L = fork length (mm) (Uchiyama et al. 1984).

The sex ratio of fish caught in the NWHI is 69:31 (N = 64) in favor of females. The mean weight of males is 4.28 kg and for females 5.45 kg in the NWHI.

Gear and catch

The species is caught by deep-sea handline. Historically, onaga has been an important commercial species in Hawaiian waters (Uchida et al. 1979). It is a valuable fish commanding high wholesale prices (see footnote 14). During 1961-68, annual catch increased from 19,500 to 31,700 kg, but from 1969 to 1974, the annual catch decreased and fluctuated between a narrow range of 17,300 and 22,800 kg. The annual catch rose sharply to 30,000 kg in 1975 and 41,100 kg in 1976 then declined steadily to 22,100 kg in 1979. The average annual catch from 1961 to 1979 was 25,900 kg.

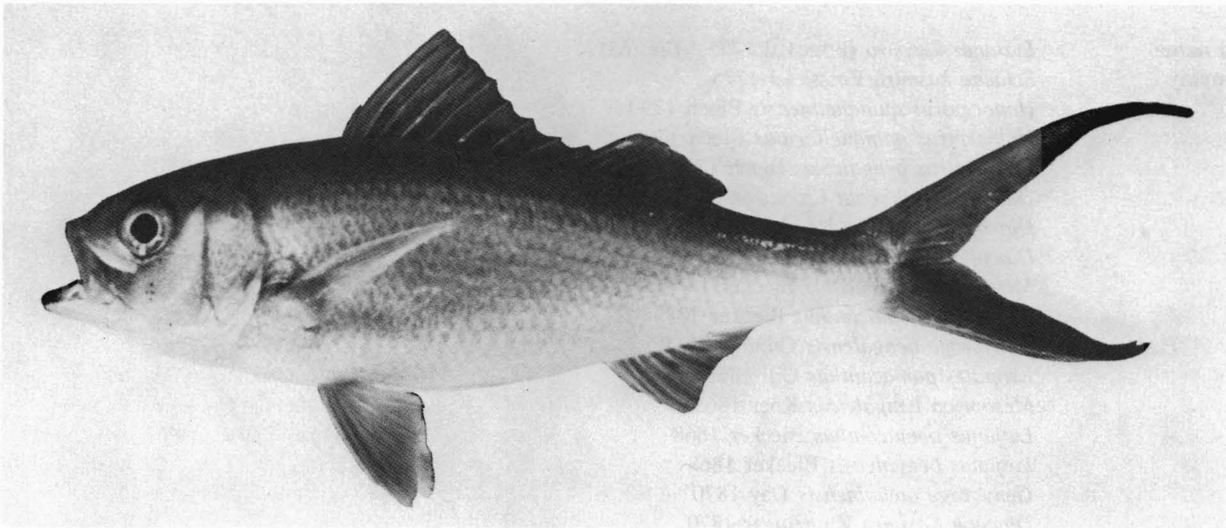

Figure 62.—*Etelis coruscans*.

by Richard N. Uchida

Valid name *Lutjanus kasmira* (Forsskål 1775) (Fig. 63)

Synonymy
Sciaena kasmira Forsskåal 1775
Honocentrus quinquelinearis Bloch 1790
Holocentrus quinquelineatus Bloch 1790
Holocentrus bengalensis Bloch 1790
Diacope octolineata Cuvier and Valenciennes 1828
Diacope notata Cuvier and Valenciennes 1828
Diacope decemlineata Cuvier and Valenciennes 1830
Mesoprion octolineatus Bleeker 1849
Mesoprion pomacanthus Bleeker 1855
Genyoroge bengalensis Günther 1859
Evoplites pomacanthus Gill 1862
Mesoprion bengalensis Kner 1865
Lutjanus pomacanthus Bleeker 1868
Lutjanus bengalensis Bleeker 1868
Genyoroge amboinensis Day 1870
Diacope Kasmira Klunzinger 1870
Lutjanus quinquelineatus Bleeker 1873
Lutjanus quinquelinearis Day 1888
Mesoprion kasmira Klunzinger 1884
Diacope octolineata Sauvage 1891
Evoplites kasmira Jordan and Evermann 1898
Evoplites decemlineatus Fowler 1904
Lutjanus caeruleolineatus Jordan and Seale 1906
Lutjanus notatus McCulloch 1929
Lutjanus spilurus Fowler 1931
(from Weber and De Beaufort 1936)

Common and vernacular names Blue-striped snapper; blue-banded sea perch; blue-line snapper; taape

Distribution

Introduced by the Hawaii DLNR into Hawaiian waters from the Marquesas Islands and Moorea in 1955 and 1961. Opened to public fishing in October 1966 after it became established ([Hawaii] 1967). Now occurs at all major islands and the lower NWHI. The NMFS surveys found taape distributed from Middle Bank to Maro Reef in depths from 24 to 110 m. The range of this species has extended to Laysan (Parrish et al. 1980).

Distinguishing characteristics

D. X-XI, 13-16; A. III, 8; P1. II, 14-15; LLs. 48-51; Gr. 7+1+14. Body moderately compressed; teeth in jaw in narrow bands, outer series enlarged, anterior ones caninoid; vomer with broad inverted V-shape patch of villiform teeth; knob of interopercle fits into notch on preopercle; scale rows above lateral line running obliquely to base of dorsal fin, those below horizontal; caudal fin emarginate (Schultz et al. 1953; Munro 1967).

Color in life vivid, varying from bright golden to lemon yellow with four blue stripes, edged in deep violet, running lengthwise from head to tail; fins and tail yellowish; blackish blotch sometimes present between front of soft dorsal base and lateral line.

Life history

Not much is known about the reproductive cycle of this species. The rapid spread of taape throughout the main islands and into the NWHI indicates that the eggs and larvae are free floating and are carried by ocean currents between the islands.

The species is an active nocturnal carnivore feeding on or near the bottom. Fish and a few species of adult crustaceans, mainly portunids, constitute the main prey items (Oda and Parrish 1981; Tabata 1981). Despite assertions that taape compete for food with other commercially valuable species such as mempachi, *Myripristis kuntee*, or weke, *Mulloides flavolineatus*, the diets of taape and mempachi caught incidentally with taape did not overlap. Mempachi fed mainly on crab megalops and other planktonic crustaceans.

Taape usually occurs in dense schools as evidenced by our trap catches, which frequently included 100-200 fish per trap in an overnight set. Talbot (1960) reported that off South Africa, females were mature at 125 mm and males with sperm were observed at 155 mm and were ripe at 165 mm.

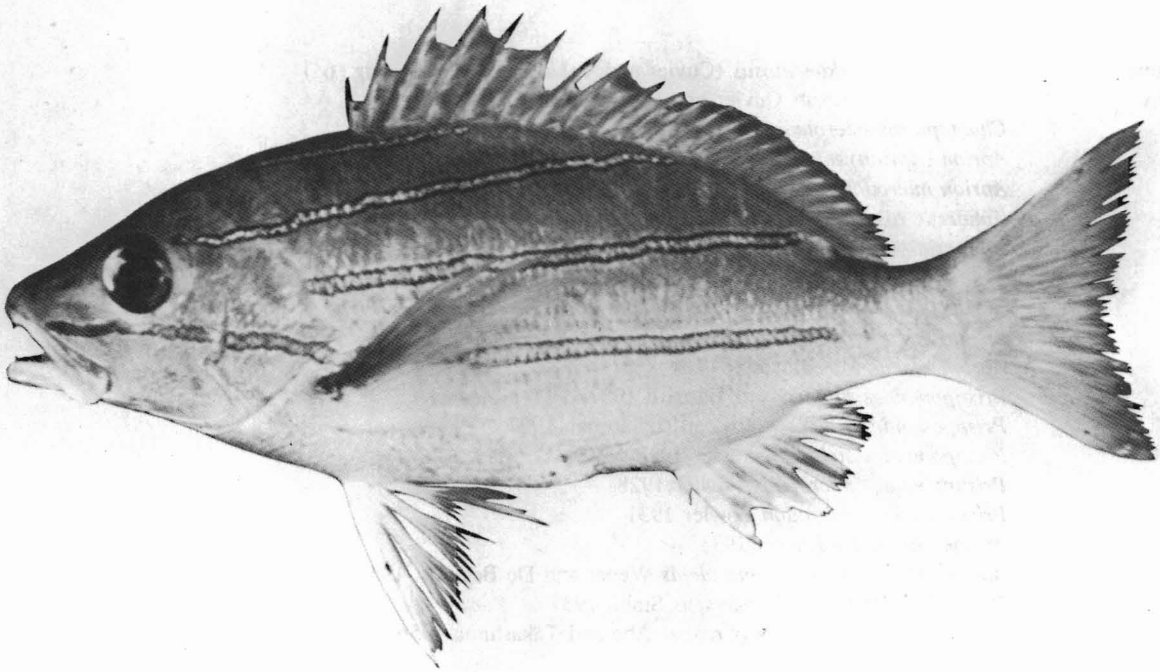

Figure 63.—*Lutjanus kasmira*.

Gear and catch

Usually caught nearshore, the species is harvested by a variety of gear including gill net, handline, rod and reel, purse seine, and traps.

Catches of taape were first reported in 1970 when about 500 kg were landed. By 1977, landings had multiplied nearly 33 times that of 1970, reaching 16,330 kg. The catch continued to increase sharply in 1978, amounting to 26,808 kg, but slowed its increase in 1979 when 27,397 kg were landed.

by Robert L. Humphreys, Jr.

Valid name *Pristipomoides filamentosus* (Cuvier and Valenciennes 1830) (Fig. 64)

Synonymy
Serranus filamentosus Cuvier and Valenciennes 1830
Chaetopterus microlepis Bleeker 1869
Aprion (Aprion) microlepis Bleeker 1876-77
Aprion microdon Steindachner 1876
Aphareus roseus Castelnau 1879
Bowersia violescens Jordan and Evermann 1904
Apsilus microdon Jordan and Evermann 1905
Aprion filamentosus Gilchrist and Thompson 1909
Aprion microlepis Ogilby 1916
Aprion roseus McCulloch 1917
Pristipomoides filamentosus Barnard 1927
Pristipomoides violescens Jordan and Jordan 1927
Pristipomoides sieboldii Fowler 1928
Pristipomoides microlepis Fowler 1928
Pristipomoides microdon Fowler 1931
Aprion kanekonis Tanaka 1935
Aprion (Pristipomoides) microlepis Weber and De Beaufort 1936
Pristipomoides argyrogrammiscus Smith 1937
Pristipomoides filamentosus roseus Abe and Takashima 1956
(from Kami 1973)

Common and vernacular names Pink snapper; opakapaka

Distribution

Inhabits the outer reef slopes of the islands and banks in the Hawaiian Archipelago. Found in the NWHI from Nihoa to Ladd Seamount on NMFS surveys in depths ranging from 27 to 328 m. Although not caught at NMFS sampling stations at Midway, known to occur there.[18]

Occurs in shallower water in the more northern islands and atolls in the NWHI (based on the maximum capture depth of 328 m at Necker Island, 201 m at Northampton Seamounts, and 108 m at Ladd Seamount). No apparent seasonal variation in distribution (Ralston 1981). Migrates into shallow water at night (based on trap and pot catches during NMFS surveys).

Distinguishing characteristics

D. X, 11; A. III, 8; P1. II, 12, II; P2, I, 5; Gr. 22-26; LLps. 55-65. Body elongate, somewhat laterally compressed. Distinguishable from its three congeners in Hawaii, *P. auricilla*, *P. sieboldii*, and *P. zonatus*, by the V-shape pattern of the vomerine (Gosline and Brock 1960; Kami 1973).

Broad bands of villiform teeth on jaws, palatine, tongue, and vomer. Outer row of teeth in upper and lower jaws canine, increasing in size near the symphysis (Jordan and Evermann 1905; Kami 1973).

Dorsal fin continuous, unnotched, last dorsal ray elongate. Origin of anal fin under base of third or fourth dorsal ray; last anal ray elongate, similar to last dorsal ray. Pelvic fins thoracic, pointed; when extended, tip of pectoral aligns with base of 10th dorsal spine. Caudal bifurcate, lobes usually equal.

Scales ctenoid, moderate. Scales not present on anterior portion of head including jaws, dorsal, and anal fins; small scales present on caudal. Lateral line complete, extending across upper half of body. Seven to eight rows of scales between origin of dorsal fin and lateral line; 14-16 rows between lateral line and origin of anal fin (Jordan and Evermann 1905; Lindberg and Krasyukova 1971; Kami 1973).

In life, rosy, with violet shades, becoming pale ventrally. Dorsal, anal, and caudal fins a combination of red and yellow hues with lavender margins; pelvic fins white (Jordan and Evermann 1905). No evidence of sexual dichromatism apparent from NMFS studies in the NWHI; however, differences occur in pigmentation of large adults collected from Guam (Kami 1973). Anal fin membranes of females clear, those in males dusky with orange and yellow hues at the anterior and posterior extremities.

Size data of opakapaka collected by NMFS reveal a mean length and weight of 53.8 cm FL and 3.06 kg, respectively. Maximum length and weight were 77.9 cm and 8.00 kg, respectively.

Life history

Size and age at maturity are similar between sexes (Ralston 1981). Testicular and ovarian weights increased greatly in fish from 30-35 cm to 35-40 cm. The age at maturity in both sexes is approximately 2 to 3 years (Ralston 1981; Uchiyama and Tagami 1984). A preliminary gonadal study showed heterogeneous egg development within the ovaries (Kikkawa 1980). A comparison of monthly mean gonadal-somatic indices revealed a single spawning period each year from June through December; spawning peaks in August (Kikkawa

[18]Ralston, S., Fishery Biologist, Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396, pers. commun. 1983.

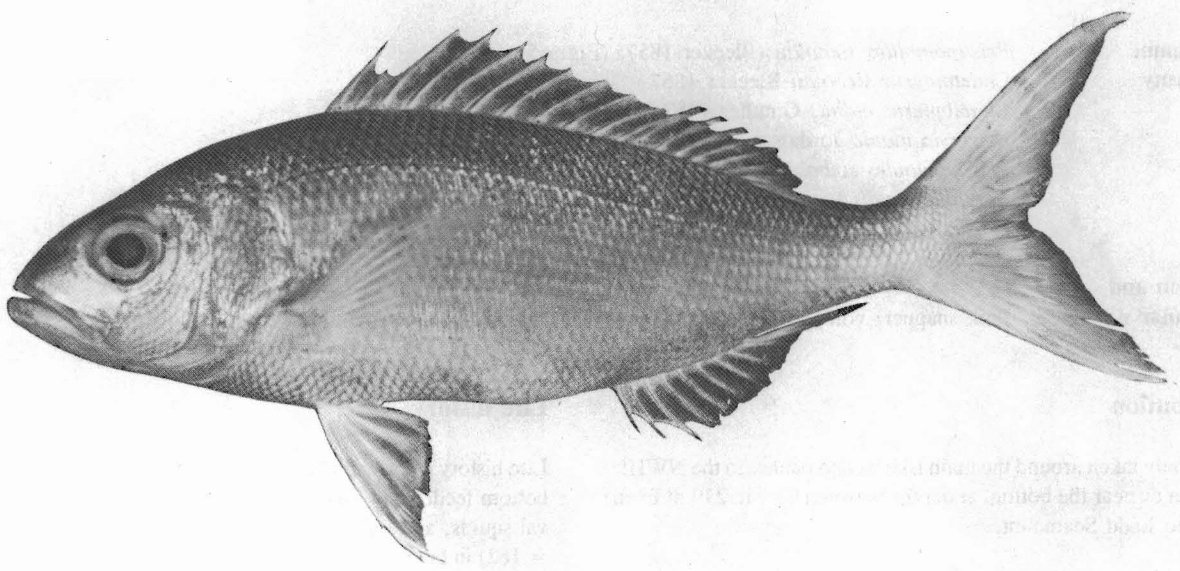

Figure 64.—*Pristipomoides filamentosus*.

1984). Fecundity estimates ranged from 478,000 to 1,461,875 eggs for fish ranging from 48.7 to 76.3 cm FL.

A preliminary analysis of spews from opakapaka in the NWHI shows *Pyrosoma* sp. as the dominant prey. Other items include fish, crustaceans, and molluscs (see footnote 18). *Pyrosoma* is also the predominant prey item of opakapaka caught at Guam (Kami 1973).

Currently there is disagreement on age and growth of opakapaka. Using annuli on the sagitta to estimate the age of opakapaka, NMFS studies indicate a von Bertalanffy growth equation as follows:

$$L_t = 97.1(1-e^{-0.31(t-0.02)}),$$

where L_t = fork length (cm) expressed as a function of t in years (see footnote 10). The projected length-age relationships are: 25.4 cm at 1 year, 44.5 cm at 2 years, 58.6 cm at 3 years, 68.8 cm at 4 years, and 76.4 cm at 5 years. Age estimates derived from whole counts of daily increments on sagittae agree well with those obtained from annuli counts.

Using increment widths as a measure of growth rate, Ralston and Miyamoto (1983) derived the following von Bertalanffy growth curve:

$$L_t = 78.0\ (1-e^{-0.146(t+1.67)}).$$

The projected length-age relationships are 25.2 cm at 1 year, 32.4 cm at 2 years, 38.6 cm at 3 years, 43.9 cm at 4 years, and 48.5 cm at 5 years. There is no significant difference in growth rate between sexes and for fish around the main islands and NWHI (Ralston 1981).

Among 452 opakapaka examined from Hawaii, the sex ratio was 50:50 (Ralston 1981). However, there is a greater number of male than female specimens collected from Guam (Kami 1973).

A functional length-weight relationship derived from 471 specimens ranging from 23.4 to 77.9 cm is:

$$W = 3.58 \times 10^{-8}\ L^{2.8806},$$

where W = weight (kg) and L = fork length (mm) (Uchiyama et al. 1984). The equation indicates that growth is allometric.

Studies on spatial homogeneity within the species habitat range provide some evidence of size-specific abundance differences with depth (Ralston 1981). Results from French Frigate Shoals and Necker Island show similar patterns of juvenile confinement to narrower depth ranges than adults. Maro Reef juveniles and adults, however, appear to occupy the same range of depths.

Catch per unit effort data indicate a higher relative abundance at Necker Island, French Frigate Shoals, and Brooks Banks than elsewhere in the NWHI (Uchiyama and Tagami 1984). Opakapaka is the dominant bottom fish species at Necker Island (44.6%), French Frigate Shoals (52.5%), and Brooks Banks (40.0%). A similar trend was noted by Moffitt (1980).

Preliminary results from electrophoretic analysis of 50 loci from opakapaka sampled throughout the Hawaiian Archipelago indicate low genetic variability; however, the results imply, but do not prove, a single stock within Hawaii because of the small sample size (Shaklee and Samollow 1980).

Gear and catch

Opakapaka is caught with deep-sea handline. Annual reported landings from the NWHI ranged between 349 and 12,828 kg and averaged 4,587 kg during 1959-77 (see footnote 14). Annual statewide landings in 1961-79 varied from 23,964 to 93,148 kg and averaged 52,683 kg. Commercially the most important bottom fish in Hawaii, opakapaka has dominated the statewide landings of bottom fish since 1948.

by Alan R. Everson

Valid name	*Pristipomoides sieboldii* (Bleeker 1857) (Fig. 65)
Synonymy	*Chaetopterus sieboldii* Bleeker 1857
	Chaetopterus dubius Günther 1859
	Bowersia ulaula Jordan and Evermann 1905
	Pristipomoides sieboldii Jordan and Thompson 1911
	Ulaula sieboldii Jordan and Jordan 1927
	Pristipomoides filamentosus Fowler 1931 (from Kami 1973)
Common and vernacular names	Pink snapper; von Siebold's snapper; ulaula, koae, kalekale; kalikali

Distribution

Commonly taken around the main islands and banks. In the NWHI, taken on or near the bottom at depths between 91 and 219 m from Nihoa to Ladd Seamount.

Distinguishing characteristics

D. X, 11; A. III, 8; Gr. 21+5. Body long, slender, head bluntly conic, with rather short snout; moderate, somewhat oblique mouth; jaws about equal, with bands of villiform teeth on vomer, palatines, and tongue; eye rather large, its lower border in line with the axis of the body. Dorsal fin continuous without a notch; caudal fin densely scaled, widely forked, with equal lobes; pectoral fin slightly hooked (Jordan and Evermann 1905).

Kalekale is often confused with opakapaka. Distinguishing characteristics to separate species are: vomerines form an elongate diamond-shaped patch, with the blunt end of the diamond facing forward versus a triangular vomerine patch in opakapaka; kalekale generally smaller, eye larger, and more scales on the lateral line (Gosline and Brock 1960).

Kalekale silvery red with faint longitudinal blue lines in life. Dorsal and pectoral fins yellowish, ventral and anal fins clear, and tail fin reddish (Tinker 1978).

Life history

Life history information on kalekale is limited. It is an opportunistic bottom feeder and eats a variety of small fishes, crustaceans, larval squids, and tunicates (Kami 1973). The sex ratio is 78:22 (N = 162) in favor of females. The functional length-weight relationship for 128 kalekale ranging from 24.5 to 43.5 cm FL is:

$$W = 2.06 \times 10^{-9} L^{3.3702},$$

where W = weight (kg) and L = fork length (mm) (Uchiyama et al. 1984).

Gear and catch

Kalekale is taken mainly with deep-sea handline and occasionally by trap. Historically, kalekale has been a fairly important commercial species in Hawaii (Uchida et al. 1979). During 1961-63, annual catches rose slightly from about 8,300 to 11,000 kg, then declined steadily until 1970 when only 2,000 kg were landed. Since then, the catch has fluctuated within a narrow range from 2,600 to 4,400 kg. The average annual catch during 1961-79 was 4,700 kg.

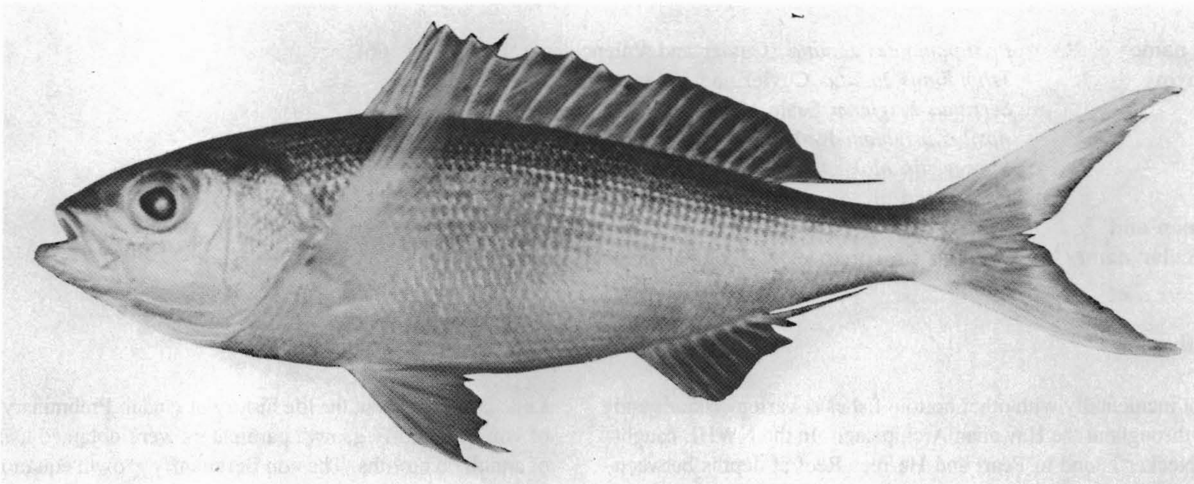

Figure 65.—*Pristipomoides sieboldii*.

by Alan R. Everson

Valid name	*Pristipomoides zonatus* (Cuvier and Valenciennes 1830) (Fig. 66)
Synonymy	*Tropidinius zonatus* Cuvier and Valenciennes 1830
	Serranus brighami Seale 1901
	Apsilus brighami Jordan and Evermann 1905
	Rooseveltia aloha Jordan and Snyder 1907
	Rooseveltia brighami Gosline and Brock 1960
Common and vernacular names	Brigham's snapper; ukiuki; kalikali; gindai; ukikikiki

Distribution

Caught incidentally with other bottom fishes at various islands and banks throughout the Hawaiian Archipelago. In the NWHI, caught from Necker Island to Pearl and Hermes Reef at depths between 102 and 238 m near ledges and drop-offs.

Distinguishing characteristics

D. X, 11; A. III, 8; P1. 16; LLps, 63-67; Gr. 7+13. Body short, stout, moderately compressed. Head large, bluntly conic, with a large slightly oblique mouth. Teeth on jaws, vomer, and palatines in villiform bands. Teeth in outer series on jaws enlarged, like canine. Single dorsal fin rather large, originating just over base of pectoral. Pectoral fairly long, about equal to head length, its tip reaching origin of anal fin (Masuda et al. 1975).

Distinguished from other snappers by its unique coloration. Four broad yellow bands on upper half of body, the last extending to the base of the caudal fin. Three light red bands about equal in width to the yellow bands between these yellow bands. Lower half of body yellow, head and snout bright golden red, underside of the body reddish (Jordan and Evermann 1905).

Life history

Little is known about the life history of gindai. Preliminary estimates of von Bertalanffy growth parameters were obtained using counts of annuli on otoliths. The von Bertalanffy growth equation for gindai is:

$$L_t = 43.1(1-e^{-1.09(t-1.51)})$$

where L_t = fork length (cm) expressed as a function of time t in years (Uchiyama and Tagami 1984). Estimates place a 3-year-old at 34.5 cm, 4-year-old at 40.2 cm, 5-year-old at 42.1 cm, and 6-year-old at 42.7 cm.

Gindai's reproductive cycle is probably similar to that of other snappers, and hydrated eggs develop in late summer; ovaries in ripe condition were collected in August at Laysan Island. The sex ratio is 57:43 (N = 106) in favor of females.

The functional length-weight relationship for 86 gindai ranging from 26.3 to 48.9 cm FL is:

$$W = 7.12 \times 10^{-9} L^{3.1878},$$

where W = weight (kg) and L = fork length (mm) (Uchiyama et al. 1984).

Gear and catch

Species is taken mainly by deep-sea handline. Gindai contributes little to the commercial bottom fish catch in the Hawaiian Islands. During 1961-70, the annual catch fluctuated between 212 and 1,680 kg and averaged 764 kg.

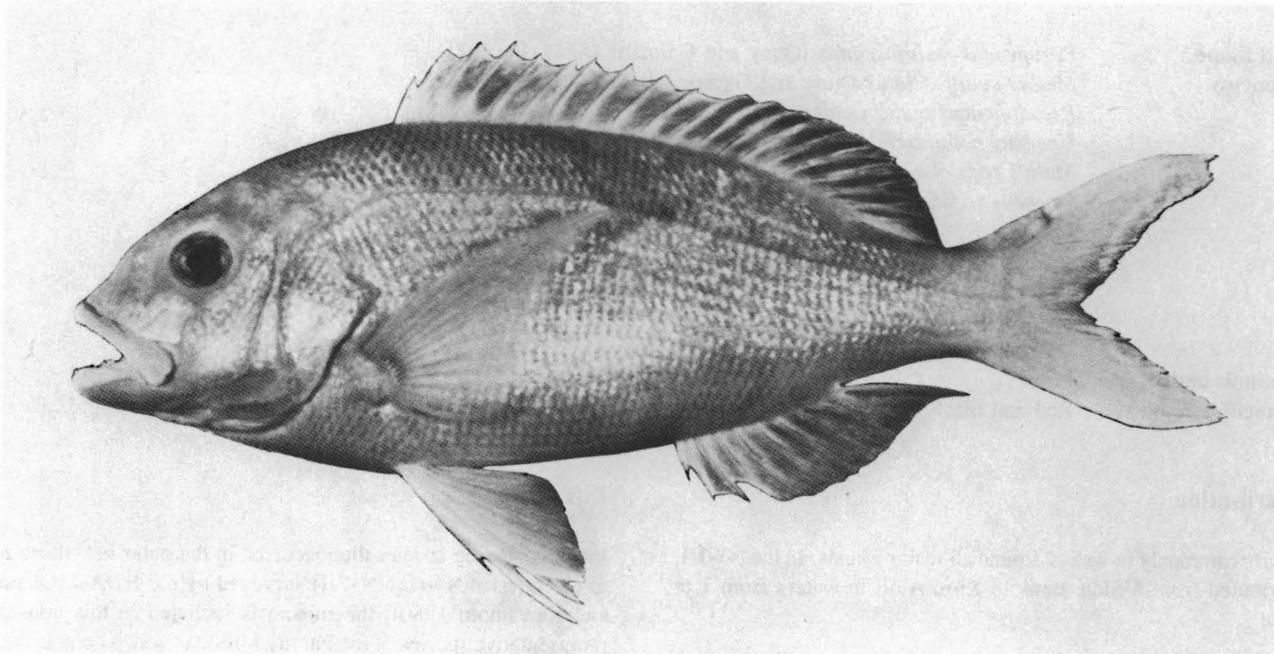

Figure 66.—*Pristipomoides zonatus*.

by Richard N. Uchida

Valid name	*Parupeneus multifasciatus* (Quoy and Gaimard 1824) (Fig. 67)
Synonymy	*Mullus multifasciatus* Quoy and Gaimard 1824
	Pseudupeneus multifasciatus Jenkins 1902
	Upeneus multifasciatus Fowler 1922
	Mullus trifasciatus (not Lacepède) Cuvier 1829
	Upeneus trifasciatus Lay and Bennett 1839
	Upeneus velifer Smith and Swain 1882
	Upeneus bifasciatus (not Lacepède) Sauvage 1891
	Upenoides vittatus (not Forsskål) Sauvage 1891
	Parupeneus trifasciatus Steindachner 1901 (from Fowler 1933)
Common and vernacular names	Red and black banded goatfish; moano

Distribution

Occurs commonly in waters around all major islands. In the NWHI, distributed from Middle Bank to Kure Atoll in waters from 1 to 77 m.

Distinguishing characteristics

D. VIII, 9; A. 7; LLs. 37. Body rather short, deep, compressed, head rather large, snout long, projecting; mouth slightly oblique, large; maxillary broad at tip; teeth rather large, wide set in a single row in each jaw, none on vomer or palatines; eye small, in posterior half of head; barbels long, reaching nearly to base of ventrals; interorbital space high, convex; opercular spine small, flat; scales large, not firm, edges finely and obscurely ctenoid; lateral line parallel with back, pores not numerously branched (Jordan and Evermann 1905).

Pale rosy red; snout and head smoky red; broad dark red band covering body from eye to origin of spinous dorsal, followed by a pale red band as broad as base of spinous dorsal. A double dark red band extending from the last dorsal spine to the eighth dorsal ray with much black above but scarcely any below the lateral line, followed by a pale band around the anterior end of caudal peduncle, and a dark band around the midregion of the caudal peduncle. Spinous dorsal fin rosy at base, black on distal portion, and a little yellowish in center. Soft dorsal greenish yellow at base, outer three-fourths blackish. Pectorals yellow, rosy on base and in axil; anal fin rosy with cross lines of whitish and anterior border blackish; and caudal dull rosy, edges black (Jordan and Evermann 1905).

Life history

Included among species that occurred in the outer nearshore zone of all the islands in the NWHI surveyed by the HDAR (Okamoto and Kawamoto 1980), the moano is included in this atlas as a representative species of the Family Mullidae which contains many members highly prized in the commercial and recreational fisheries in the Hawaiian Islands.

Moano feeds heavily on crabs and shrimps. At Midway, 95% of the gut content of moano consists of xanthid crabs, mainly *Leptodius exaratus*, and 65% portunid crabs, mostly *Thalamita integra*, and *T. admete* (Sorden 1983). The shrimps include unidentified carideans, alpheids, and *Rhynchocinetes rugulosus*, the latter found only in the moano among several species of goatfish diets studied. Polychaetes including glycerids, *Glycera tesselata*, opheliids, *Armandia intermedia* and *Polyophythalmus pictus*, and two nereid species are other food items in the sample.

Moano occurs over reef and sand pockets either solitarily or in groups of two or three and actively probes cracks and crevices on the reef and pockets of sand with their barbels (Hobson 1974). The species is active through twilight and inactive after dark, but on bright moonlit nights some individuals swim over the reef.

The species spawns at dusk 2 days before the full moon (Lobel 1978). Moano aggregates about a meter above sandy areas 10 m deep next to reefs. The largest fish, presumably the male, is darker than the others and darts conspicuously around and through the aggregation until another fish joins it. The pair then ascends, side by side, spawns while swimming forward just beneath the surface, then descends to the reef.

Gear and catch

Species is taken mainly by trap and handline. In 1961-79, the annual catch fluctuated from 3,206 to 9,528 kg and averaged 5,074 kg. There is no fishery for the species in the NWHI.

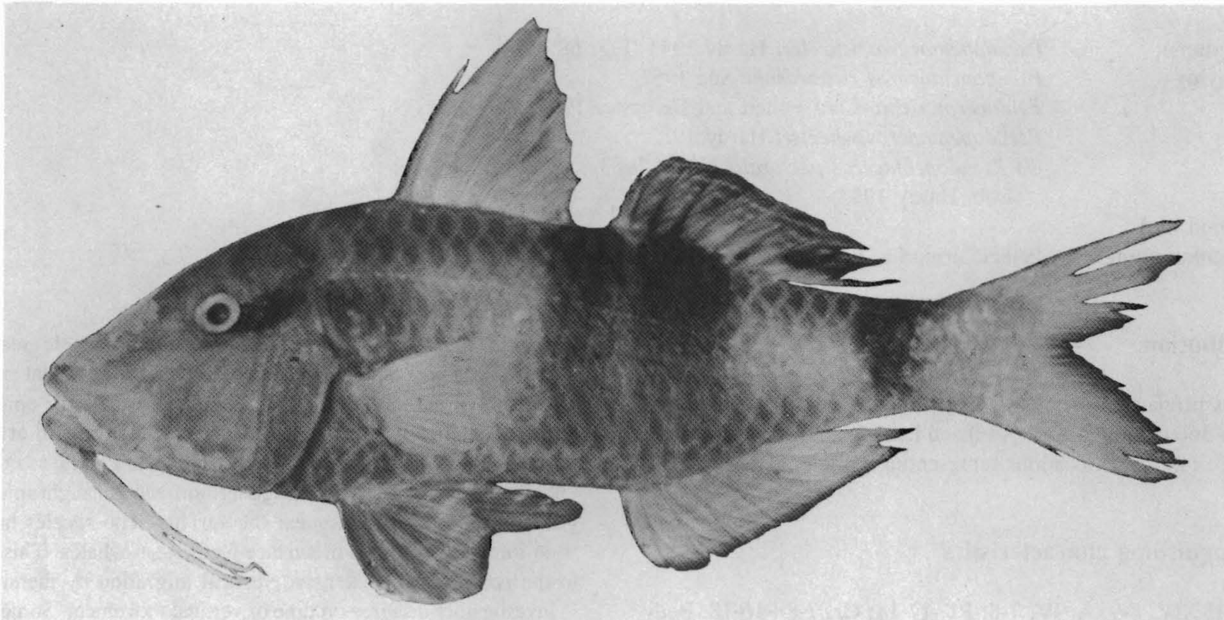

Figure 67.—*Parupeneus multifasciatus*.

by Richard N. Uchida

Valid name	*Pseudopentaceros wheeleri* Hardy 1983 (Fig. 68)
Synonymy	*Pseudopentaceros richardsoni* Abe 1957
	Pentaceros richardsoni Follett and Dempster 1963
	Pseudopentaceros wheeleri Hardy 1983
	(?) *Pseudopentaceros pectoralis* Hardy 1983 (from Hardy 1983)
Common and vernacular names	Pelagic armorhead; armorhead; boarfish; kusakari tsubodai

Distribution

Occurs primarily at Hancock Seamounts in the NWHI at depths of 256-366 m; also at Kure Atoll and Ladd Seamount (its presence at these latter two locations representing a range extension).[19]

Distinguishing characteristics

D. XIII-XIV, 8-9; A. IV, 7-8; P1. 17-18; Gr. 7-8+16-18. Body ovate and compressed; dorsal and anal fin profiles evenly curved; head pointed, encased in exposed striated bones, some of which are rugulose or finely wrinkled. Dorsal spines strong, heterocanth, longitudinally ridged. Generally odd-numbered spines inclined to the left, even-numbered ones to the right. However, this character is not consistent (Abe 1957).

Mouth moderate with cleft slightly oblique; lower jaw projecting forward of upper, with maxilla terminating at anterior edge of a wide irregular area of cheek which is covered with small scutelike scales. Nostrils close together and located slightly closer to the orbital margin than to tip of snout. Lateral line prominent, arching from its origin near the top of the opercle to the base of the fourth and fifth dorsal spines, then running almost parallel to the dorsal outline caudal peduncle and backwards to base of caudal.

Polymorphic; varies from "fat" pelagic type to "lean" seamount type. Morphometric measurements of this species may not be reliable characteristics because of extensive morphological variations, possibly related to spawning (Takahashi and Sasaki 1977; Humphreys et al. 1984; Uchida and Tagami 1984b).

In fresh specimens, upper half of body bluish-gray and paler below. Snout, interorbital, and occipital regions of the head tinged with brown.

Life history

In the central North Pacific, spawning of pelagic armorhead begins from about November-December, peaks in January-February, and declines in March (Takahashi and Sasaki 1977). The free-floating eggs and larvae are dispersed by the North Equatorial Current (Chikuni 1971). By March-April, large numbers of young pelagic armorhead are seen atop the seamounts (Sakiura 1972). The pelagic stage lasts until the juvenile attains 25-30 cm FL and descends to the seamount summits to begin a demersal existence.

The pelagic armorhead, unlike many mesopelagic seamount species, does not confine itself exclusively to the demersal environment throughout its lifetime but also migrates into the epipelagic regime. Catches by Japanese trawlers indicate the fish at depths between 300 and 600 m over the central North Pacific seamounts. Other reports indicate that pelagic armorhead is caught in salmon gill nets or with handline near the surface. The species has also been found in stomachs of surface feeding sei whales. This points to the possibility of extensive vertical migration by the species.

Investigators disagree on time of vertical movement. Some report that pelagic armorhead rises to the surface at night, feeding on organisms such as euphausids, mysids, copepods, salps, shrimps, and myctophids which are usually associated with the deep-scattering layer that ascends toward the surface at night (Hart 1973; Sasaki 1973). Others report that armorhead rises to the surface during the day and descends to the summits at night (Sakiura 1972; Kuroiwa 1973). The NMFS bottom trawl catches were better at night than day indicating that the species was associated with the seamount summit at night.

The fork lengths of unsexed armorhead taken by trawling on NMFS cruises show strong unimodal distributions. At NW Hancock fish ranges between 233 and 398 mm FL and averages 297 mm; 67% of the fish falls between 290 and 310 mm. At SE Hancock, the fish does not appear to differ in size from those at NW Hancock. It ranges from 233 to 359 mm and averages 299 mm, and about 62% of the fish falls within 290 and 310 mm. Females are significantly larger than males (Humphreys et al. 1984). Japanese data indicate that the size of armorhead taken from all the central North Pacific seamounts tended to decrease from 1969 to 1972, then to increase from 1973 to 1976. In all years studied, the size range was narrow. Other studies confirm that no significant differences in fish size occur among the seamounts (Sakiura 1972; Iguchi 1973; Sasaki 1974; Aomori Prefectural Fisheries Experimental Station 1976).

Annual marks are found on the sagittae (otoliths), centrum of vertebrae, and spines of the dorsal, pelvic, and anal fins. Annuli counts are consistent among these hard parts. Preliminary length-age relationships of the pelagic armorhead caught at Hancock Seamounts are 28.8 cm for males and 30.4 cm for females at 2 years and 29.5 cm for males and 31.0 cm for females at 3 years. A few age determinations made by enumerating daily increments on the sagittae are in agreement with ages estimated by annuli.[20] However, both methods used to estimate age of the pelagic armorhead have

[19]Tagami, D. T., Research Assistant, Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396, pers. commun. August 1983.

[20]Uchiyama, J. H., and J. D. Sampaga. Age and growth estimates of the pelagic armorhead, *Pentaceros richardsoni*. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396 (manuscr. in prep.).

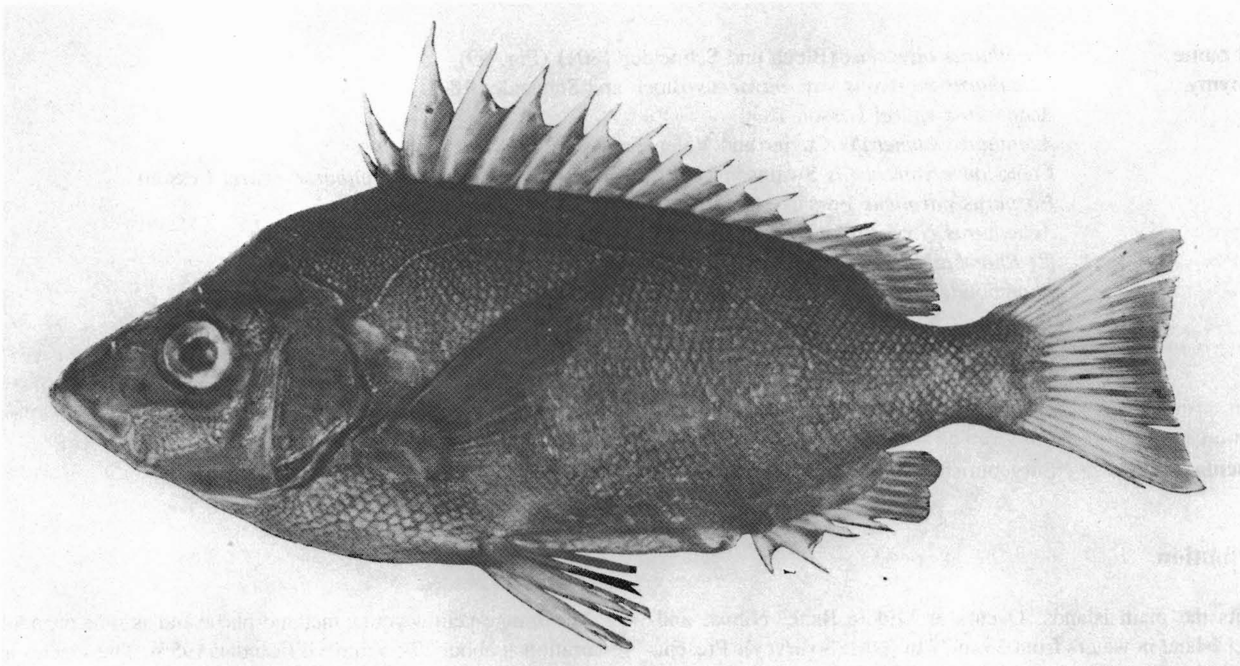

Figure 68.—*Pseudopentaceros wheeleri.*

not been validated. Another aging study using scales estimates that a 22-cm pelagic armorhead is 3 years old and a 32-cm fish is 6 years old (Chikuni 1970).

Gear and catch

Pelagic armorhead is taken mainly with bottom trawl, although small numbers are also taken by handline gear. Traps apparently are ineffective (Uchida and Tagami 1984b).

Catch data, available from the Japanese trawl fishery, showed that at Hancock Seamounts, the annual catch in 1969-81 varied between 67 and 8,518 MT and averaged 1,234 MT. Since 1977 when the MFCMA went into effect, however, annual catches have not exceeded 739 MT. Annual catches from the remaining seamounts in the central North Pacific varied from 433 to 32,794 MT and averaged 12,928 MT in 1969-81.

by Victor A. Honda

Valid name	*Acanthurus olivaceus* (Bloch and Schneider 1801) (Fig. 69)
Synonymy	*Acanthurus nigricans* var. *olivaceus* Bloch and Schneider 1801
	Acanthurus eparei Lesson 1830
	Acanthurus humeralis Cuvier and Valenciennes 1835
	Ctenodon erythromelas Swainson 1839 (error or emendation for *Acanthurus eparei* Lesson)
	Harpurus paroticus Forster 1844
	Acanthurus chrysosoma Bleeker 1857
	(?) *Rhombotides xanthosoma* Bleeker 1865
	Rhombotides olivaceus Bleeker 1865
	Teuthis olivaceus Seale 1901
	Hepatus olivaceus Jordan and Evermann 1905
	Hepatus chrysosoma Fowler 1928
	(from Randall 1956)
Common and vernacular names	Surgeonfish; orange spot tang; naenae

Distribution

Inhabits the main islands. Occurs at Middle Bank, Nihoa, and Necker Island in waters from 33 to 77 m (NMFS survey). Present inshore as far northwest as Maro Reef (Okamoto and Kawamoto 1980). Inhabits deeper waters of the subsurge zone (about 4-128 m), usually over sandy areas interspersed with coral or basalt structures (Jones 1968).

Distinguishing characteristics

D. IX, 23-25; A. III, 22-24; Pl. 16-27; Gr. 24-28 (Masuda et al. 1975). Body rather deeply ovoid, greatest depth at middle of pectoral; head deep, compressed, with steep, convex upper profile; jaws slightly produced, lower jaw inferior; mouth small, oblique; teeth broad with sharp cutting edge; margin of opercle oblique, angle below anterior margin of eye; nostrils round, close together, anterior to eye. Last dorsal spine longest; pectoral pointed, equal to head; caudal deep, broad, rays long, pointed; caudal spine depressible in a groove; scales ctenoid, small; lateral line arched following dorsal profile of back (Jordan and Evermann 1905).

In life purplish black, breast bluish, black edged orange bar on shoulder region running posteriorly from upper angle of opercle to area below sixth dorsal spine; dorsal nearly black, membranes slightly bluish; caudal nearly black, same as dorsal, posterior one-third white edged with black; anal same as ventrals edged with black, membranes mottled with blue; pectoral same as ventrals except posterior third dirty-white; iris black, inside edge bright yellow. Orange bar lacking in young specimens but solid orange-yellow in life (Jordan and Evermann 1905; Gosline and Brock 1960).

Life history

The orange-yellow young metamorphose and assume the adult coloration at about 29-55 mm SL (Randall 1956). The species is considered a grazer, picking up large quantities of the substratum while feeding, irrespective of whether the material is rasped away from rock or picked up as loose sand (Jones 1968). As a result, the gut contents include considerable inorganic sediments (Gosline and Brock 1960). Coralline algae, gastropods, and foraminiferans are found in stomachs of fishes in the Marshall Islands, but their presence may be due to accidental ingestion while feeding (Hiatt and Strasburg 1960).

Gear and catch

Naenae is caught mainly in traps although the species is also taken in gill nets. The annual commercial catch in 1976-79 varied from 385 to 963 kg and averaged 556 kg.

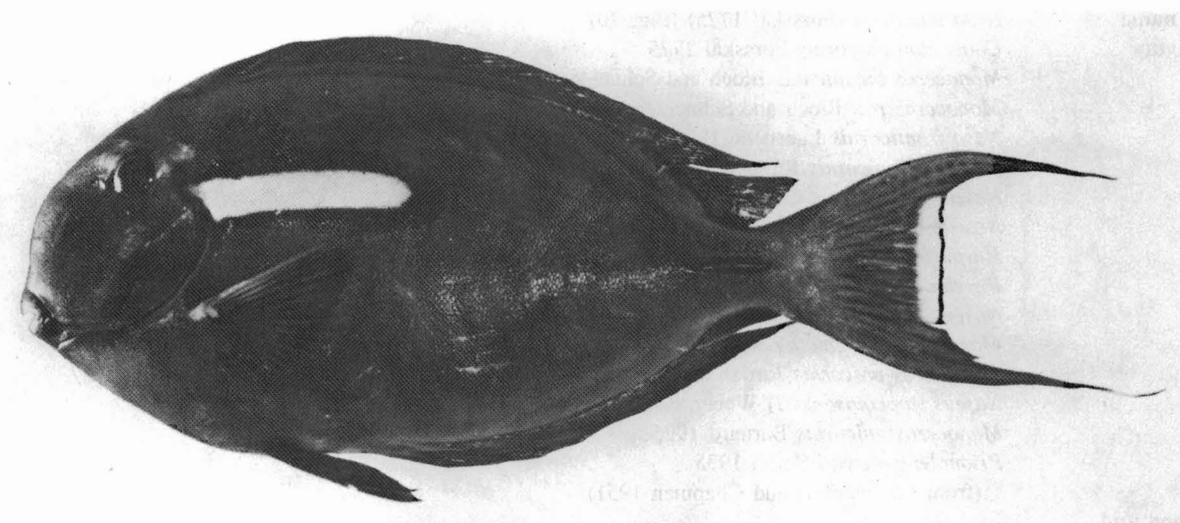

Figure 69.—*Acanthurus olivaceus*.

by Victor A. Honda

Valid name	*Naso unicornis* (Forsskål 1775) (Fig. 70)
Synonymy	*Chaetodon unicornis* Forsskål 1775
	Monoceros biaculeatus Bloch and Schneider 1801
	Monoceros raii Bloch and Schneider 1801
	Naso fronticornis Lacepède 1802
	Aspisurus unicornis Rüppell 1828
	Naseus fronticornis Cuvier and Valenciennes 1835
	Naseus olivaceus Cuvier and Valenciennes 1835
	Harpurus monoceros Foster and Lichtenstein 1844
	Priodon anginosus Bleeker 1854
	Naseus unicornis Günther 1861
	Monoceros marginatus Seale 1901
	Acanthurus unicornis Jordan and Evermann 1905
	Naseus (*tapeinosoma* ?) Weber 1913
	Monoceros unicornis Barnard 1925
	Prionolepis hewitti Smith 1935
	(from De Beaufort and Chapman 1951)
Common and vernacular names	Surgeonfish; unicornfish; long-snouted unicornfish; kala

Distribution

Occurs throughout the main islands. Present on all islands in the NWHI from Nihoa to Kure Atoll (Okamoto and Kawamoto 1980) and Bank 8 (JAMARC 1973). Inhabits subsurge areas (about 30 m) of moderate to dense coral growth, including fringing reefs, deepwater reef patches, reef filled bays, and coral rich parts of the lagoon (Jones 1968).

Distinguishing characteristics

D. V-VI, 27-31; A. II, 26-30; Gr. 4+9 (Masuda et al. 1975). Body short, deep, compressed, elevated anteriorly, highest at beginning of dorsal fin; snout pointed, usually projecting beyond frontal horn; horn projecting forward and downward from the preopercular region, varying greatly with age, most prominent in adult and scarcely developed in young; teeth small, bluntly pointed canines not serrated, close set, slightly recurved; short, nearly vertical shallow groove anterior to eye below nostrils. Origin of dorsal over upper end of gill opening; dorsal spines strong, rough, the first two in head, others successively short; dorsal ray slender, weak; origin of anal under base of sixth dorsal spine; anal spines and rays short; caudal deeply lunate; skin uniform, rough velvety; caudal peduncle with two low spiniferous plates on each side (Jordan and Evermann 1905).

In life, dirty olive, paler below; top of head and horn dark olivaceous; caudal spines pale blue; dorsal fin pale blue, crossed by six narrow pale yellow lines curving upward and backward, edge of fin narrowly blue; anal similarly marked.

Life history

Juveniles have rows of dark spots on a light-colored body. At about 12 cm SL, the horn becomes evident. Metamorphosis takes place at about 65 mm SL and the young are occasionally caught in tide pools (Gosline and Brock 1960). The lunate caudal fin of the adult undergoes a change with growth as the upper lobe elongates into a filament (Aoyagi 1943). Kala, a browser, is a true herbivore. It feeds by biting and tearing off bits of multicellular benthic algae without ingesting any of the inorganic substrate (Jones 1968).

Gear and catch

Kala is taken mainly by gill nets; traps and bag nets contribute smaller amounts. In 1961-79, the annual commercial catch of kala varied between 5,878 and 17,799 kg and averaged 10,081 kg.

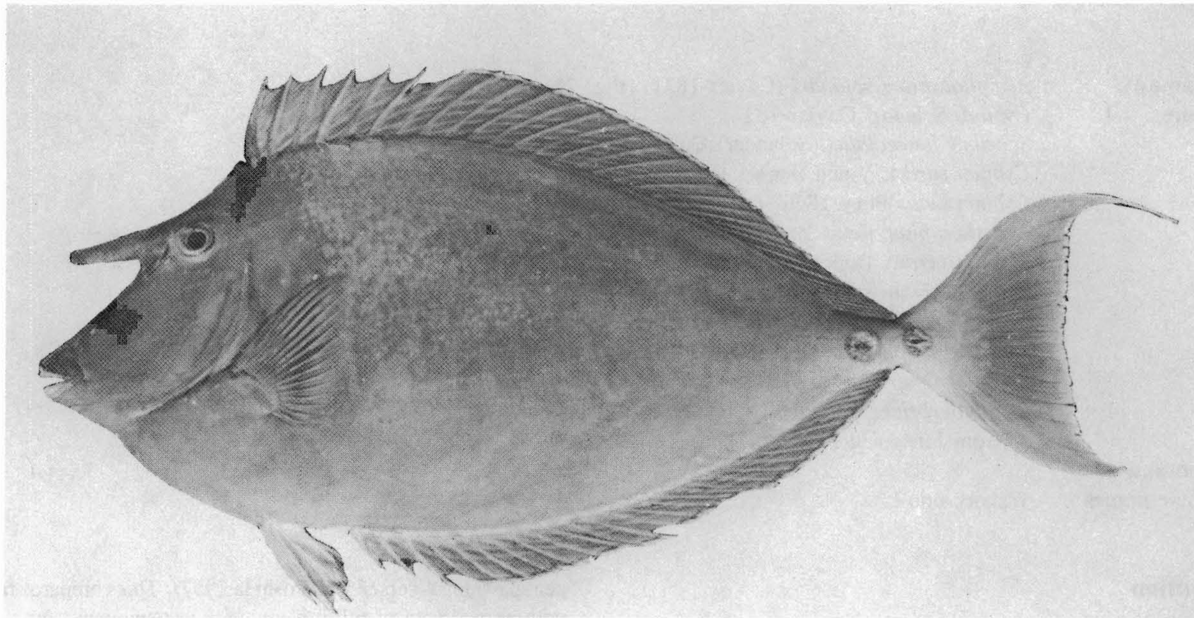

Figure 70.—*Naso unicornis*.

by Steven H. Kramer

Valid name	*Acanthocybium solandri* (Cuvier 1831) (Fig. 71)
Synonymy	*Cybium Solandri* Cuvier 1831 *Scomber lanceolatus* (Solander) Cuvier 1831 *Cybium sara* Lay and Bennet 1839 *Cybium petus* Poey 1868 *Acanthocybium petus* Poey 1868 *Cybium verany* Doderlain 1872 *Acanthocybium solandri* Jordan 1884 *Acanthocybium forbesi* Seale 1912 *Acanthocybium sara* Kishinouye 1915 *Scomber amarui* Curtis 1938 *Acanthocybrium solandri* Copley 1952 (misspelled) (from Jones and Silas 1964)
Common and vernacular names	Wahoo; ono

Distribution

Occurs widely in open ocean around the main islands. Present from Nihoa to Kure Atoll in the NWHI at depths from the surface to 183 m. Adult wahoo epipelagic and usually associates with banks, pinnacles, and islands; also found around flotsam far out at sea.

Distinguishing characteristics

D. XXIII-XXVII, III, 9-10+8-10; A. III, 9-10+8-9. Unique among the scombrids in having reticulated gills and lacking gill rakers. Body elongate and semifusiform, covered with small lanceolate scales. Head long, tapering to a conical snout from which the lower jaw projects slightly. Dentition consists of approximately 50 laterally compressed, slightly serrated, triangular teeth in a single series which increase in size posteriorly (Jones and Silas 1964).

Intermuscular bones inserted on ribs. First dorsal approximately uniform in height when erect. Pectorals short, reaching to below the 10th dorsal spine. Lateral line strongly arched under the 17th dorsal spine. Numerous branches extend dorsoventrally along the lateral line. Caudal fin lunate.

In life dark blue dorsally becoming silver ventrally. On young or stressed fish, 24-30 irregular dark blue vertical bars laterally on body.

Life history

Wahoo appears to spawn year round in the tropics and during the summer months in the higher latitudes, including Hawaii, as evidenced by dates and locations of larval collection in the central Pacific (Matsumoto 1967). Size at maturity is undetermined, although immature fish as large as 63 cm have been found in NMFS samples. In a preliminary study, gonad development was found to be highly heterogeneous with entirely different ova development laterally and longitudinally.[21]

Wahoo of about 131 cm spawns an estimated 6.1 million eggs per spawning (Iversen and Yoshida 1957). This compares favorably with an estimate of 6.9 million eggs per spawning for a 139-cm fish from the Gulf of Mexico.[22] Larvae are free floating and are found near and far from land. The number of spawnings per year remains undetermined.

In the NWHI, wahoo feeds on fish, cephalopods, and to a small extent, crustaceans.[23] Fish are the major prey items; *Decapterus* sp., Scombridae, and Balistidae most frequently occur in the diet. Cephalopods consist mostly of squid and to a lesser degree octopus. Crab megalops and stomatopods represent the small portion of crustaceans in the wahoo diet. It appears that wahoo forages on open water, outer reef, and flotsam-associated prey. Time of feeding is undetermined.

Wahoo are parasitized by copepods externally and trematodes and nematodes internally. The giant trematodes found posteriorly in the stomach have been identified as *Hirudinella ventricosa* (Nigrelli and Stunkard 1947).

Based on counts of daily growth rings on otoliths taken from five fish in the NWHI, the growth was linear for the size range examined (63-131 cm FL). The model predicts an age of 1 year for a fish 50.6 cm and 2 years for one 121.7 cm.[24]

The length-weight relationship of 139 wahoo from the NWHI is:

$$W = 3.55 \times 10^{-7} L^{3.5839},$$

where W = weight (kg) and L = fork length (cm). The large exponent, 3.5839, is approximately equivalent to the 3.50583 for wahoo in the Line Islands (Iversen and Yoshida 1957). Both reflect the elongate fusiform body of wahoo.

Wahoo is a high-level predator, preying on fish and cephalopods. In turn, the wahoo infrequently becomes the prey of billfish such as the sailfish, *Istiophorus americanus* (Beardsley et al. 1972). It

[21]Prescott, J. H., Fishery Biologist, Department of Primary Industry, Fisheries Research Station, P. O. Box 5, Daru, Western Province, Papua New Guinea, pers. commun. April 1982.

[22]Finucane, J. H., Southeast Fish. Cent. Panama City Lab., Natl. Mar. Fish. Serv., NOAA, Panama City, FL 32407, pers. commun. August 1980.

[23]Kramer, S. H. Diet of the wahoo, *Acanthocybium solandri* (Cuvier and Valenciennes), in the Northwestern Hawaiian Islands. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396 (manuscr. in prep.).

[24]Uchiyama, J. H., Fishery Biologist, Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396, pers. commun. April 1982.

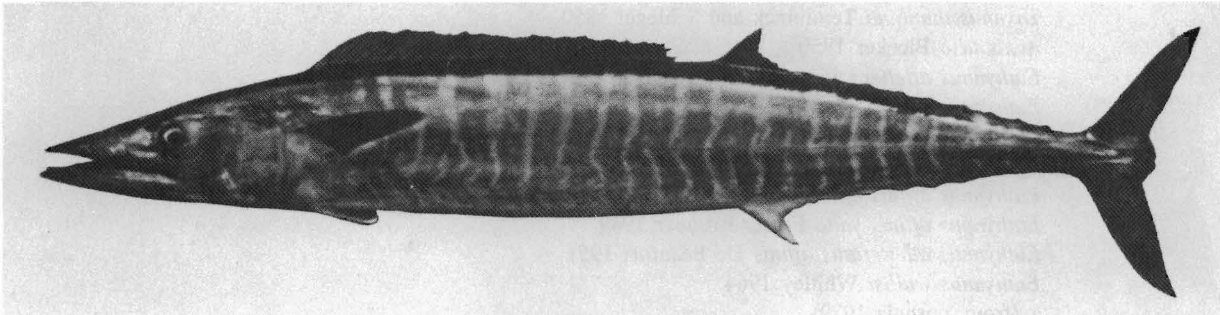

Figure 71.—*Acanthocybium solandri.*

is also conceivable that wahoo may fall prey to sharks of the Family Lamnidae or other fast-swimming predators. Juveniles may also be cannibalized by adults.[25]

Gear and catch

The species is caught principally by trolling and longline. Wahoo does not constitute a major fishery anywhere. In American Samoa, wahoo is landed as an incidental catch of the longline fishery and is canned, primarily for local consumption.

In Hawaii, wahoo is sold fresh. Annual landings in 1961-79 ranged from 10,093 to 101,347 kg and averaged 34,773 kg. Although wahoo is not a major species in the Hawaiian fishery, it is nonetheless an important food and sport fish. In recent years, the trend in catch of wahoo has been upward in response to an ever-increasing demand for the species. Many vessels now fishing in the NWHI troll for wahoo before returning to Honolulu.

[25]Kikkawa, B. T., Research Assistant, Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396, pers. commun. April 1982.

by James H. Uchiyama

Valid name	*Euthynnus affinis* (Cantor 1850) (Fig. 72)
Synonymy	*Thynnus affinis* Cantor 1850 *Thynnus thunnina* Temminck and Schlegel 1850 *Auxis taso* Bleeker 1850 *Euthynnus allettera* Jordan, Tanaka and Snyder 1913 *Euthynnus yaito* Kishinouye 1923 *Gymnosarda alletteratus* Meek and Hildebrand 1923 *Wanderer wallisi* Whitley 1937 *Euthynnus affinis affinis* Fraser-Brunner 1949 *Euthynnus affinis yaito* Fraser-Brunner 1949 *Euthynnus alletteratus affinis* De Beaufort 1951 *Euthynnus wallisi* Whitley 1964 (from Yoshida 1979)
Common and vernacular name	Little tuna; kawakawa

Distribution

Occurs around the main islands and in the NWHI from Middle Bank to Kure Atoll.

Completes its entire life cycle within the coastal province. Larvae captured in midocean probably carried away from coastal areas by prevailing currents (Yoshida 1979).

Distinguishing characteristics

D. XIV-XV, 12-13; A. 13-14; Gr. 7-9+1+22-24 (Godsil 1954). Body elongated, robust, and fusiform; two dorsal fins separated by a narrow interdorsal space, eight dorsal and seven anal finlets, and a lunate caudal fin. Pectoral fins not extending to interdorsal space. Body naked except for a corselet and lateral line. Snout pointed with a terminal mouth, which extends to or slightly beyond the vertical axis through the middle of the eye. Caudal keels not well developed.

In life, blue to indigo background up to the middle of the first dorsal fin on the back superimposed by black wavy lines. Top of the head and corselet black to dusky and sides of head silvery. Lower half of body silvery white. Black or dusky spots between the pectoral and pelvic fins but not always conspicuous (Godsil 1954; Fischer and Whitehead 1974).

Life history

Kawakawa is heterosexual; males and females are externally similar. There is no record of hermaphroditism. In the NWHI, milt was found in the testes of a male 40.9 cm FL, and ovaries in the developing stage were found in females as small as 38 cm FL. The spawning season is probably during the summer although spent ovaries were found in fishes captured in March and November.

Fecundity estimates of Indian Ocean kawakawa are 0.21 million eggs per spawning and 0.79 million eggs per year for a 48.0-cm fish and 0.68 million eggs per spawning and 2.5 million eggs per year for a 65.0-cm fish (Rao 1964).

Kawakawa has been induced to spawn in captivity (Kaya et al. 1981). Growth is rapid. In the NWHI kawakawa attains a length of 40 cm in 1 year and 67 cm in 2 years (Uchiyama 1980).

Kawakawa feeds opportunistically on crustaceans, fishes, and squid (Welsh 1950; Tester and Nakamura 1957).

Nothing is known about the migratory habits of the species. Because kawakawa are seldom caught beyond 20 nmi from an island or bank, they are thought to be constantly associated with coastal areas or submerged banks.

The length-weight relationship of kawakawa from Hawaiian waters is:

$$W = 2.3829 \times 10^{-5} L^{3.1544},$$

where W = weight (lb) and L = fork length (cm) (Tester and Nakamura 1957).

Gear and catch

The species frequently comprises the incidental catch of the pole-and-line skipjack tuna fishing vessels operating in Hawaiian waters. It is also taken by trolling. Annual landings of kawakawa in 1961-79 ranged from 936 to 43,862 kg and averaged 19,074 kg. The species is of minor importance in the commercial fishery in Hawaii.

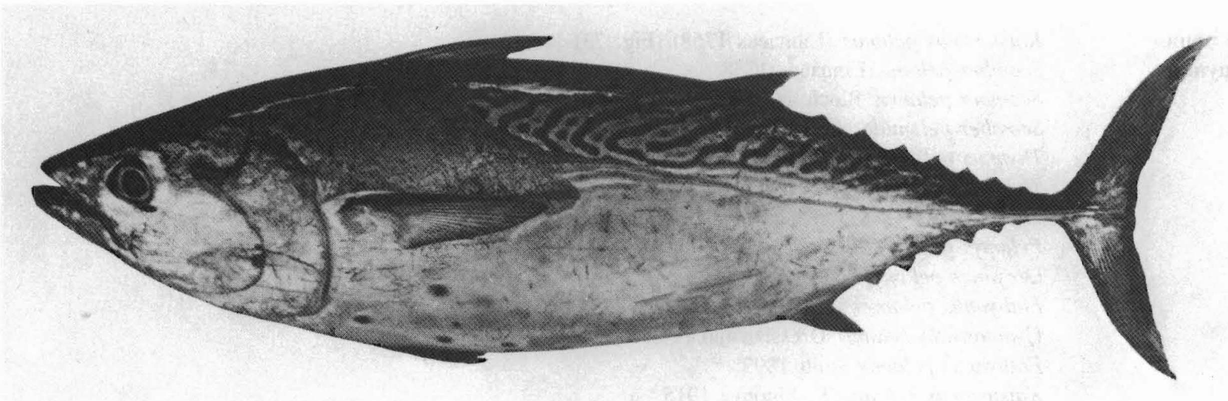

Figure 72.—*Euthynnus affinis*.

by James H. Uchiyama

Valid name	*Katsuwonus pelamis* (Linnaeus 1758) (Fig. 73)
Synonymy	*Scomber pelamis* Linnaeus 1758 *Scomber pelamys* Bloch and Schneider 1801 *Scomber pelamides* Lacepède 1802 *Thynnus pelamis* Risso 1826 *Thynnus vagans* Lesson 1828 *Thynnus pelamys* Cuvier and Valenciennes 1831 *Pelamys pelamys* Bleeker 1862 *Orcynnus pelamys* Poey 1868 *Euthynnus pelamys* Jordan and Gilbert 1882 *Gymnosarda pelamis* Dresslar and Fesler 1889 *Euthynnus pelamis* Smitt 1893 *Katsuwonus pelamys* Kishinouye 1915 *Gymnosarda pelamys* Thompson 1918 *Katsuwonus pelamis* Kishinouye 1923 *Katsuwonus vagans* Jordan, Evermann, and Clark 1930 *Katsuwonus pelamis* Herre 1933 *Euthynnus (Katsuwonus) pelamis* Fraser-Brunner 1950 (from Matsumoto et al. 1984)
Common and vernacular names	Skipjack tuna; aku

Distribution

Distributed throughout the Hawaiian Archipelago. Usually occurs in surface schools associated with bird flocks.

Distinguishing characteristics

D. XIV-XV, I, 13-14; A. II, 12-13; P1. 26-27; 7-9 dorsal and 7-8 anal finlets (Waldron 1963). Body elongate, robust, rounded in cross section, fusiform; two dorsal fins separated by a small interspace not larger than eye diameter; tail lunate; anal fin under second dorsal pectoral fins short, triangular; two flaps between pelvic fins. Head conical, mouth terminal, large; maxillary extends to about vertical axis through eye; body naked except for corselet and lateral line. Strong keel present on both sides of caudal peduncle with two smaller keels at caudal end.

In life dark purplish blue dorsally with occasional flashes of irregular line patterns of bright phosphorescent blue. Lower sides and belly silvery with four to six dark longitudinal bands.

Life history

Spawning occurs in late February-September in Hawaiian waters (Brock 1954). Skipjack tuna reaches sexual maturity at about 40-45 cm FL (about 1 year old) (Brock 1954). Fecundity estimates range from 290,000 to 1,880,000 eggs per spawning for fish 43.8 to 86.7 cm long (Morris 1966). Skipjack tuna are believed to be multiple spawners (Brock 1954; Morris 1966).

Fertilization is external (Waldron 1963). Fertilized eggs hatch in 30-31 h at 25°-26°C (Kaya et al. 1982). The larvae average 2.94 mm at hatching.[26] Growth is rapid; the fish reaches 44 cm in 1 year, 68 cm in 2 years, and 82 cm in 3 years (Uchiyama and Struhsaker 1981). The species attains 90 cm in Hawaiian waters.

Skipjack tuna feeds on a wide variety of organisms. Stomach contents of central Pacific fish consist primarily of fish; molluscs rank second, and crustaceans third (Yuen 1959; Waldron and King 1963). During summer, large skipjack tuna (>60 cm) feeds primarily on fish (90%); whereas among smaller fish (<60 cm) crustaceans and molluscs are predominant (Yuen 1959).

Skipjack tuna is known to migrate long distances. Fish tagged in the eastern and western Pacific have been recovered in Hawaiian waters (Josse et al. 1979).

Short-term local movement of skipjack tuna has been studied using sonic tags. A school of small skipjack tuna spent the day on the bank and off the bank at night (Yuen 1970). Small skipjack tuna also appears to keep its association with a school for a long time and remains in the same area for almost 3 months (Yamashita and Waldron 1959). Large skipjack tuna (ca. 70 cm) apparently behaves differently (Dizon et al. 1978). It is independent of bank and remains in waters above 20°C 85% of the time, occasionally making excursions into cold water.

The length-weight relationship of central Pacific skipjack is:

$$W = 4.546 \times 10^{-9} L^{3.36836},$$

where W = weight (lb) and L = fork length (mm) (Nakamura and Uchiyama 1966).

[26]Hendrix, S. B. 1982. Factors affecting the growth and survival of skipjack tuna, *Katsuwonus pelamis*, larvae reared in the laboratory. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396, Admin. Rep. H-82-23C, 15 p.

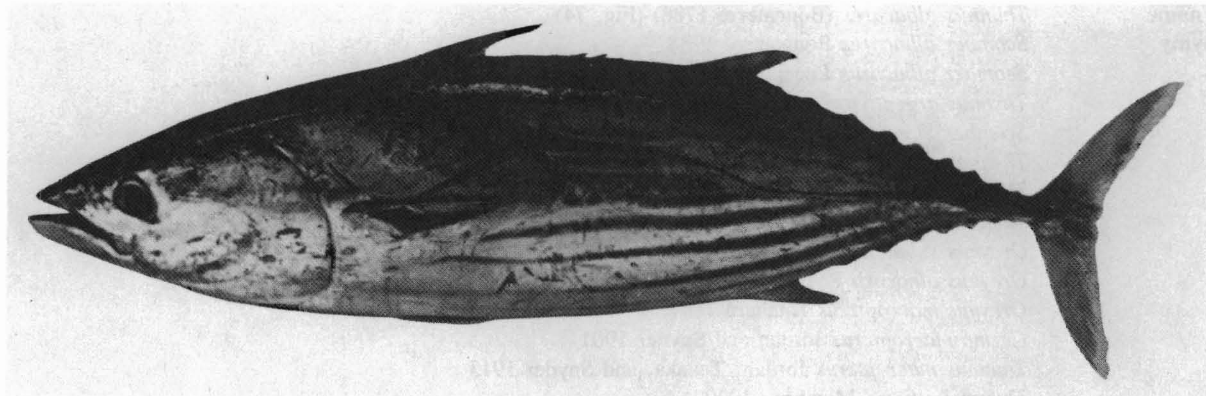

Figure 73.—*Katsuwonus pelamis.*

Gear and catch

In Hawaiian waters, the species is caught almost exclusively by pole and line and live bait; small quantities are also landed by trolling. Descriptions of the fishery and trends in catches are found in June (1951) and Uchida (1966, 1967, 1976).

Annual landings of skipjack tuna in 1961-79 from water around the main islands fluctuated widely from 2,292 to 7,329 MT and averaged 4,073 MT. Currently, there is no Hawaiian fishery for the species in the NWHI. A pole-and-line, live bait fishery, however, was known to operate in the NWHI during the 1970's as an outgrowth of the Japanese albacore fishery. In the summer of 1977, the Japanese harvested an estimated 4,375 MT within the FCZ of the NWHI (Yong and Wetherall 1980).

by James H. Uchiyama

Valid name *Thunnus albacares* (Bonnaterre 1788) (Fig. 74)

Synonymy
Scomber albacares Bonnaterre 1788
Scomber albacorus Lacepède 1800
Thynnus argentivittatus Cuvier and Valenciennes 1831
Scomber Sloanei Cuvier and Valenciennes 1831
Thynnus albacora Lowe 1839
Thynnus macropterus Temminck and Schlegel 1844
Thunnus argentivittatus South 1845
Orcynus subulatus Poey 1875
Orcynus albacora Poey 1875
Orcynus macropterus Kitahara 1897
Germo macropterus Jordan and Snyder 1901
Thunnus macropterus Jordan, Tanaka, and Snyder 1913
Thunnus allisoni Mowbray 1920
Germo argentivittatus Nichols and Murphy 1922
Germo allisoni Nichols 1923
Neothunnus macropterus Kishinouye 1923
Thunnus subulatus Jordan and Evermann 1926
Neothunnus catalinae Jordan and Evermann 1926
Neothunnus albacora Jordan and Evermann 1926
Neothunnus itosibi Jordan and Evermann 1926
Neothunnus albacores Jordan and Evermann 1926
Neothunnus allisoni Jordan and Evermann 1926
Kishinoella zacalles Jordan and Evermann 1926
Semathunnus guildi Fowler 1933
Semathunnus itosibi Fowler 1933
Neothunnus argentivittatus Beebe and Tee-Van 1936
Germo albacora Fowler 1936
Thunnus albacora Tortonese 1939
Germo itosibi Smith 1949
Neothunnus albacora brevipinna Bellón and Bardán de Bellón 1949
Neothunnus albacora longipinna Bellón and Bardán de Bellón 1949
Neothunnus macropterus macropterus Bellón and Bardán de Bellón 1949
Neothunnus macropterus itosibi Bellón and Bardán de Bellón 1949
Neothunnus brevipinna Postel 1950
Thunnus zacalles Fraser-Brunner 1950
Thunnus albacares Ginsburg 1953
Thunnus catalinae Ginsburg 1953
Neothunnus albacores Mather 1954
Thunnus albacares Le Danois 1954
Neothunnus albacora macropterus Schultz 1960
Thunnus albacares macropterus Jones and Silas 1963
Thunnus itosibi Jones and Silas 1963
(from Gibbs and Collette 1967)

Common and vernacular names Yellowfin tuna; ahi

Distribution

Occurs throughout the Hawaiian Archipelago.

Distinguishing characteristics

D. XIV-II, 12; A. II, 12 (Jordan and Evermann 1905). Body fusiform, slightly compressed laterally. Two dorsal fins separated by a narrow interspace; caudal fin lunate; moderately long pectoral fins reach beyond origin of second dorsal but not beyond end of its base; a pair of interpelvic processes between pelvic fins. On some large specimens the second dorsal and anal fins long (20% of FL). Head conical, terminal mouth reaching vertical axis through anterior of eye. Body wholly covered with small scales; corselet present. Well-developed keel on each side of the caudal peduncle between two small keels at the caudal end; 8-10 dorsal and 7-10 anal finlets

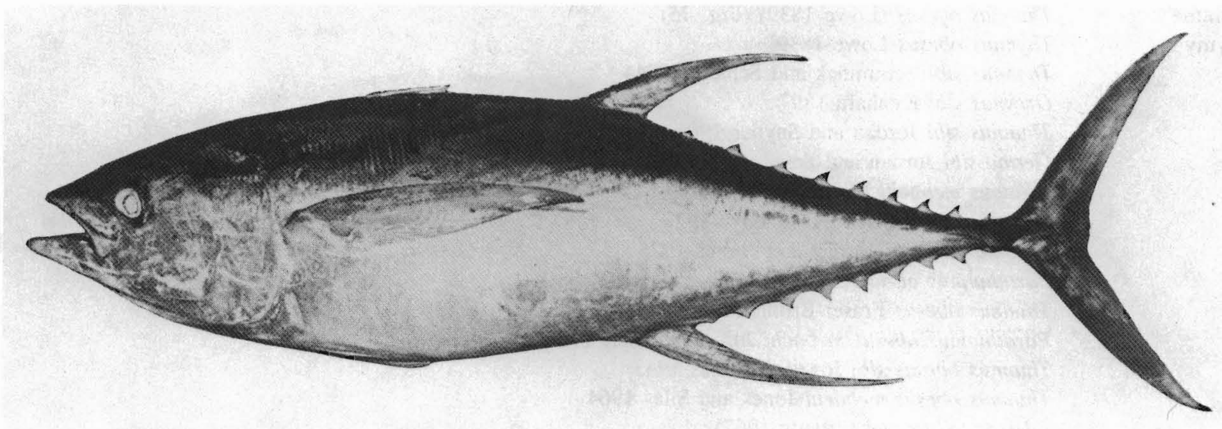

Figure 74.—*Thunnus albacares.*

on caudal peduncle. Individuals with undeveloped second dorsal and anal fins resemble bigeye tuna from which it can be distinguished by the lack of striations on the ventral surface of the liver (Fischer and Whitehead 1974).

In life, dark blue to black dorsally, silver ventrally; yellow or golden band occasionally visible from snout to tail on sides. Faint vertical lines alternating with vertical rows of spots present on the ventral half of the body. Dorsal and anal fins, all finlets, and caudal fin bright yellow. Finlets have narrow black border (Gibbs and Collette 1967).

Life history

The species is heterosexual and exhibits no externally visible sexual dimorphism (Cole 1980). Observations during NWHI survey cruises showed that sexually mature males can be as small as 88 cm; whereas the smallest female with ripe ovaries was 116 cm. These sizes at maturity agree with past estimates of sexual maturity for central and western Pacific yellowfin tuna (June 1953; Yuen and June 1957; Kikawa 1962). Spawning occurs from May through October in Hawaiian waters (June 1953). Fecundity estimates range from 2.37 to 8.59 million eggs per spawning for fish 47 to 88 kg (June 1953). The species is a multiple spawner; however, the frequency of spawning per season is undetermined.

Artificially fertilized eggs were observed to hatch in 25-36 h at a water temperature of 23.7° to 27.0°C. The larvae are 2.2 mm at hatching and grow to 3.1 mm in 4 days (Inoue et al. 1974). Growth is rapid; the species attains 53 cm at 1 year and 90 cm at 2 years (Uchiyama and Struhsaker 1981).

Yellowfin tuna around Hawaii feeds on fishes, crustaceans, and molluscs, primarily cephalopods (Welsh 1950; Tester and Nakamura 1957). Small yellowfin tuna (<100 cm) feeds primarily on crustacean larvae; medium-sized fish (100-129 cm) feeds mostly on crustacean larvae and squids; whereas large fish (>130 cm) feeds primarily on fish and squid (Reintjes and King 1953).

Not much is known about the migration of yellowfin tuna in the NWHI. Of 203 fish tagged, there was only a single recovery. The fish moved 31 nmi in 37 days.

The length-weight relationship derived from a sample of 4,822 fish is:

$$W = 3.256 \times 10^{-5} L^{3.05834},$$

where W = weight (lb) and L = fork length (mm) (Nakamura and Uchiyama 1966).

Gear and catch

Yellowfin tuna is caught mainly by longline, pole and line, trolling, and handline (ika-shibi and palu-ahi). Annual landings of this species, second only to skipjack tuna in importance in the Hawaiian fishery, fluctuated widely in 1961-79 from 17,457 to 962,641 kg and averaged 434,624 kg. Most of the fish are taken around the main islands and substantial numbers are now taken off the Island of Hawaii in the ika-shibi fishery (Yuen 1979).

In 1977 in the NWHI, 337 and 403 MT of yellowfin tuna were taken by Japanese baitboats and longliners, respectively (Yong and Wetherall 1980).

by James H. Uchiyama

Valid name *Thunnus obesus* (Lowe 1839) (Fig. 75)

Synonymy
Thynnus obesus Lowe 1839
Thynnus sibi Temminck and Schlegel 1844
Orcynus sibi Kitahara 1897
Thunnus sibi Jordan and Snyder 1901
Germo sibi Jordan and Snyder 1901
Thunnus mebachi Kishinouye 1915
Parathunnus mebachi Kishinouye 1923
Parathunnus sibi Jordan and Hubbs 1925
Parathunnus obesus Jordan and Evermann 1926
Thunnus obesus Fraser-Brunner 1950
Parathunnus obesus mebachi Jones and Silas 1960
Thunnus obesus sibi Jones and Silas 1963
Thunnus obesus mebachi Jones and Silas 1964
(from Gibbs and Collette 1967)

Common and vernacular names Bigeye tuna; poo-nui; mebachi shibi

Distribution

Occurs throughout the Hawaiian Archipelago, however, caught only at Ladd and Nero Seamounts and Raita Bank in NWHI during NMFS surveys. Young bigeye tuna (<20 kg) usually associated with shallow banks. Large individuals believed to inhabit deeper waters between 150 and 200 m (Hanamoto 1976).

Distinguishing characteristics

D. XIV, 15; A. 14 (Godsil and Byers 1944); Gr. 23-31 (Gibbs and Collette 1967). Body fusiform, slightly compressed laterally; dorsal fins separated by a narrow interspace; caudal fin lunate; pectoral fins extend past the anterior edge of second dorsal; two interpelvic processes between pelvic fins; second dorsal and anal fins only slightly higher than first dorsal; 8-10 dorsal, 7-10 anal finlets. Head conical with a terminal mouth which extends back to vertical axis through eye. Head and eye proportionally large. Head length nearly equal to body depth in young, less than equal in older individuals. Body covered with small scales; indistinct corselet. Ventral surface of liver striated. Keel well developed on caudal peduncle and extends to caudal fin where it is surrounded by two small keels (Gibbs and Collette 1967; Fischer and Whitehead 1974).

In life, dark blue to black dorsally, silvery white ventrally. Iridescent greenish-yellow patch present from eye to above base of pectoral; second dorsal and anal fins light yellow; finlets bright yellow with black edges (Gibbs and Collette 1967).

Life history

The species is heterosexual and has no external characteristics to distinguish males from females. In Hawaiian and central Pacific waters, females attain sexual maturity and spawn at 14-20 kg (Yuen 1955). The spawning area of the species is between lat. 12°N-12°S and long. 120°E-110°W (Kikawa 1962). Spawning occurs throughout the year in the equatorial region, but peaks from April through September (Kikawa 1962). Fecundity estimates for a single spawn range from 2.9 to 6.3 million eggs for fish 39 to 107 kg (Yuen 1955).

Newly hatched larvae are 1.5 mm in total length (Kume 1962). Growth is rapid but sexually dimorphic. Males attain a size of 23.7 kg in 2 years, 46.3 kg in 3 years, 66.7 kg in 4 years, and 115.3 kg in 7 years. For females, the sizes attained were 23.9 kg in 2 years, 45.7 kg in 3 years, 64.0 kg in 4 years, and 103.8 kg in 7 years (Shomura and Keala 1963).

Bigeye tuna feeds opportunistically on fishes, squids, other molluscs, and crustaceans. Small individuals (<140 cm FL) consume a larger proportion by volume of crustaceans and fishes and a smaller proportion of molluscs than large individuals (>140 cm) (King and Ikehara 1956).

The length-weight relationship of bigeye tuna is:

$$W = 8.071 \times 10^{-5} L^{2.90182},$$

where W = weight (lb) and L = fork length (cm) (Nakamura and Uchiyama 1966).

Gear and catch

In the Hawaiian fishery, bigeye tuna annual landings in 1961-79 varied widely from 77,064 to 553,744 kg and averaged 280,141 kg. Most of the fish were caught around the main islands by longline vessels; however, since 1971, the ika-shibi fishery using handline has developed significantly and contributed a large proportion to the statewide landings.

In the NWHI the species is caught primarily by Japanese longliners and baitboats, which produced an estimated 1,510 and 734 MT, respectively, from within the FCZ around the Hawaiian Islands in 1977 (Yong and Wetherall 1980).

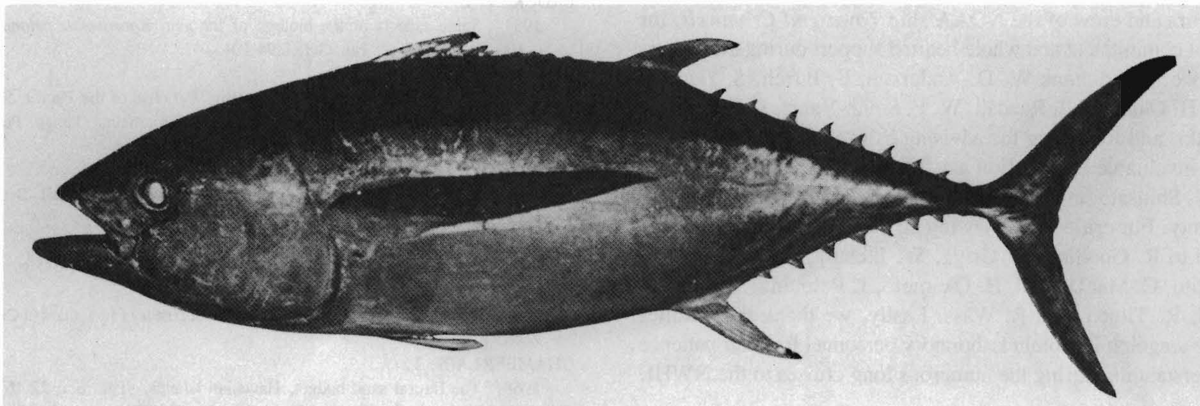

Figure 75.—*Thunnus obesus*.

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