



**UNITED STATES DEPARTMENT OF COMMERCE**  
**National Oceanic and Atmospheric Administration**  
NATIONAL MARINE FISHERIES SERVICE  
Northwest & Alaska Fisheries Center  
Resource Assessment & Conservation Engineering  
7600 Sand Point Way NE, Bldg. 32  
Seattle, Washington 98115

May, 1978

CRUISE RESULTS

NOAA R/V MILLER FREEMAN

Cruise No. MF-77-02

Rockfish and Pacific Hake  
Hydroacoustic/Midwater Trawl Survey

July 12 - September 30, 1977

CRUISE PERIOD, AREA AND ITINERARY

The Miller Freeman returned to the Pacific Marine Center, Seattle on September 30, 1977 after completing a 70 day hydroacoustic/midwater trawl survey along the Pacific Coast between Port Hueneme, California (34°08'N) and Kyuquot Bay, Vancouver Island, British Columbia (50°00'N). During the survey hydroacoustic system inter-calibration studies were conducted with the Polish R/V Profesor Siedlecki and the Canadian R/V G.B. Reed. The vessel's itinerary was as follows:

Leg I

- July 12-15 Hydroacoustic data recording system and midwater trawl tests in Puget Sound.
- July 15-19 Transit to Port Hueneme.
- July 20-Aug. 4 Survey: Port Hueneme to Trinidad Head, California (41°03'N).
- Aug. 4-5 Transit to San Francisco.

Leg II

- Aug. 10-11 Transit to Trinidad Head
- Aug. 11-30 Survey: Trinidad Head to Cape Flattery, Washington (48°30'N).
- Aug. 30-31 Transit to Pacific Marine Center, Seattle.

Leg III

- Sept. 8-10 Computerized hydroacoustic data recording/processing system and midwater trawl tests in Puget Sound.



- Sept. 11-16 Hydroacoustic system intercalibration survey off Cape Flattery with R/V Profesor Siedlecki and R/V G. B. Reed.
- Sept. 17-26 Survey: Cape Flattery to Kyuquot Bay.
- Sept. 27-29 Resurvey of selected area off Cape Flattery.
- Sept. 29-30 Transit to Pacific Marine Center, Seattle.

#### OBJECTIVES

The cruise was conducted as part of a cooperative Federal/State rockfish resource survey. In the California-Washington (Port Hueneme to Cape Flattery) region, it complemented an extensive (680 station) bottom trawl survey conducted by the NOAA R/V David Starr Jordan and three charter vessels. These vessels were the Pacific Raider (Northwest and Alaska Fisheries Center), Commando (Washington Department of Fisheries and Northwest and Alaska Fisheries Center) and the Tordenskold (Oregon Department of Fish and Wildlife). In addition, as part of a cooperative N.E. Pacific U.S. - Poland fisheries research program, the Profesor Siedlecki conducted a hydroacoustic survey and bottom trawl sampling in the Point Arena, California to southern Vancouver Island region during August to October.

The primary objectives of the survey conducted by the Freeman were to: (1) determine the distribution, abundance, and biological composition of midwater (off-bottom) aggregations of important rockfish species and Pacific hake; (2) obtain information on variation in the diel behavior and availability of rockfish; (3) collect individual fish acoustic target strength data on rockfish and hake. Target rockfish species included bocaccio (Sebastes paucispinis), chilipepper (S. goodei), and shortbelly rockfish (S. jordani) off California, and yellowtail rockfish (S. flavidus), Pacific ocean perch (S. alutus), and canary rockfish (S. pinniger) in the Oregon-Vancouver Island region.

Other objectives were to: (1) test new components/refinements in a computerized hydroacoustic system; (2) conduct hydroacoustic system intercalibration studies with the cooperating foreign research vessels mentioned above; and (3) to assess the feasibility of using a programmable data logger at sea for recording of selected trawl data.

#### EQUIPMENT AND GEAR

A hydroacoustic data recording system was used during Legs I and II. During Leg III a van-contained computerized data recording and processing system was employed. Each system had a 38 kHz echo sounder with three receivers, newly developed echo signal

detector units, a 7 track FM tape recorder, and a dual beam transducer housed in a V-fin towed body. The data recording system included a modified commercial echo sounder transceiver. The computerized system included a new transmitter and new receivers with digitally controlled time-varied-gain amplifiers. A larger transducer and towed body were also used with the computerized system.

Echo sign was sampled with a modified standard Cobb pelagic trawl (the wings and first section of the trawl were 8-in. (20.3 cm) mesh and the second section was 4-in. (10.2 cm) mesh, stretched measure). The trawl was fished with 30 fm (55 m) dandylines, 7 x 10-ft. (2.1 x 3.0 m) steel V doors, and had a 1½-in. (3.2 cm) codend liner. It was positioned with a direct link (cable) netsounder with an up/down looking headrope transducer. Netsounder recordings indicated the trawl's average vertical mouth opening was approximately 4 fm (7.3 m).

A programmable desk-top data collection terminal equipped with a cassette drive was used during Leg III to record stratum, catch and length frequency data for each trawl haul.

#### METHODS

The basic hydroacoustic (digital echo integration) survey was done during daylight hours along a trackline consisting of a continuous series of zig-zag transects spaced at 10 nautical mile intervals. Between Port Hueneme and Cape Flattery the trackline was normally run between the 50 fm (91 m) and 250 fm (457 m) isobaths. North of Cape Flattery the inshore boundary of the survey area was the 30 fm (55 m) isobath.

Vessel speed averaged about 9 knots and the transducer was towed at an average depth of 15 fm (27 m). During Leg III the computer was programmed to integrate echo signal intensities by 20 m depth strata from the V-fin to the bottom and outputs were obtained at one minute intervals. Simultaneously, outputs were generated for 9 bottom referenced depth strata within 25 m of the bottom. Following the cruise the data recorded during Legs I and II were processed using the same depth strata and time intervals.

Each night the vessel operated in a selected part of the area surveyed during the day in an attempt to obtain information on diel changes in the vertical distribution, density, and availability of the target species, and to locate fish for the collection of target strength data.

During both day and night periods trawl hauls were made on selected aggregations of echo sign for species identification and to obtain biological data and samples. For each trawl haul, the total weight caught was determined for each species and total numbers were estimated for each species of fish. Usually the entire catch

was sorted and weighed, but large catches, i.e., those exceeding about 2,500 lbs. (1,134 kg), were sampled and the total catch per species was obtained by extrapolation. Sex and length composition data and otolith samples were collected for the target species. These and other biological data and/or samples were also obtained for certain other species, particularly other rockfish and the most abundant species in each catch. Samples of all catches of cephalopods were saved for taxonomic studies being conducted at the School of Oceanography, Oregon State University.

XBT casts were usually made at each trawl station and, between Port Hueneme and Cape Flattery, on approximately every other daytime survey transect at the 50, 100, 150, 200, and 250 fm (91, 183, 274, 366, and 457 m) isobaths. Light intensity measurements were recorded every half hour throughout the survey period.

Hydroacoustic system performance tests made at the beginning of Legs I and III included: (1) measurement of system noise levels as a function of several propellor RPM/pitch combinations and determining an optimum combination for the survey operation; (2) testing operation of the new transceiver system used during Leg III; and (3) adjusting the transducer towing assembly to maximize V-fin stability.

During the cooperative hydroacoustic system intercalibration period the three vessels followed one another at one half mile intervals along preselected transects in an area off Cape Flattery where hake were abundant. Data were collected and/or processed in a manner such that comparison of echo integrator outputs could eventually be made for each nautical mile surveyed. The G. B. Reed was equipped with a multi-channel digital echo integration system similar to that used on the Freeman. The Professor Siedlecki used a Simrad two channel analog integrator. The foreign vessels also used 38 kHz echo sounders.

## RESULTS AND DISCUSSION

### Hydroacoustic Survey and Underwater Trawl Sampling Effort

The daytime hydroacoustic survey was completed on a 3,490 nautical mile trackline composed of 225 transects. Two hundred transects totaling 2,715 miles were run off the California-Washington coast (Port Hueneme to Cape Flattery) during Legs I and II and 295 hours of hydroacoustic data were tape recorded for later computer processing in the laboratory. During Leg III, when the hydroacoustic data were processed directly, a 775 mile trackline composed of 25 transects was completed in the Cape Flattery to Kyuquot Sound, Vancouver Island region.

On Legs I and II echogram records were collected at night for approximately 2,000 miles of selected transects. While observing aggregations of fish composed primarily of hake, about 8 hours of data were recorded for target strength measurement analysis. Night activities during Leg III focused mainly on locating aggregations of fish suitable for target strength measurement studies and about 80 hours of data were obtained in areas where hake was the dominant midwater species. While engaged in the cooperative hydroacoustic intercalibration work, data were collected on 230 miles of transects in two areas southwest of Cape Flattery.

A total of 83 midwater trawl hauls (41 daytime hauls and 42 night hauls) were completed along the California-Washington coast. Another 33 hauls were made during Leg III, including 10 during the 6 day intercalibration study conducted at the start of the Leg. Stratum and catch data for each trawl haul are shown in Table 1. The geographic distribution of the trawl sampling is shown in Figure 1. Table 2 lists all species captured during the survey.

#### Distribution and Abundance of Principal Species

Rockfish: Except for shortbelly rockfish, the survey was generally unsuccessful in providing information on the abundance of the off-bottom components of species of rockfish. This was due mainly to the lack of survey intensity relative to the exceptionally contagious distributions of acoustically detectable schools of adults of most species. As shown in Table 1, the largest trawl catches of rockfish were shortbelly rockfish. Off California, where it occurred in 14 of 40 trawl hauls, it was the most frequently captured rockfish species and was found in large midwater schools in a relatively small area off Central California (approximately 37°00' - 37°30' N). During a similar survey of this area in 1976 it was the dominant species in midwater trawl catches. Bocaccio, chilipepper, and splitnose rockfish each occurred in several hauls made off California, but no large schools were detected, and the catches were usually small. North of California these species and shortbelly rockfish were taken very infrequently.

In the Oregon-Vancouver Island region, yellowtail and widow rockfish were the most frequently occurring and abundant species in trawl catches. However, aggregations of these species for which hydroacoustical estimates of abundance could be attempted were not located. Canary rockfish and especially Pacific Ocean perch were encountered much less frequently than expected. A substantial amount of night survey effort was devoted specifically to locating Pacific Ocean perch in traditional fishing areas, but it was unsuccessful.

The biomass of the concentration of shortbelly rockfish found off Central California (Figure 1) was estimated to be 295,000 metric tons. Information on the target strength of this species is not available, and the estimate was derived assuming an average value of -35 dB per kilogram.

The survey results obtained for rockfish did not significantly supplement the data base on rockfish abundance, which was provided by the complementary bottom trawl survey. The cruise demonstrated that hydroacoustic/trawl surveys for rockfish will generally not be effective unless the survey effort can be much more intensive, which is not a realistic possibility on large scale surveys. However, hydroacoustic/midwater trawl work could effectively supplement bottom trawl sampling in situations where surveys of localized stocks are required.

Pacific hake: Except south of Bodega Bay, California (38°15' N), where catches were limited mainly to small quantities of juvenile fish, hake were abundant throughout most of the region surveyed and were the dominate species taken in trawl catches. They occurred in 72 of 83 hauls made during the survey off the California-Washington coast (Legs I and II) and in 28 of the 33 hauls made during the intercalibration study and Cape Flattery-Kyuquot Bay survey conducted on Leg III (Table 1).

North of Bodega Bay adult hake were found in large, dense aggregations except between Cascade Head, Oregon (45°03' N), and Destruction Island, Washington (47°40' N), and in the most northern part of the survey region (49°50' N). The distribution of hake aggregations for which biomass estimates were made is shown in Figure 1. Only 5 percent of the estimated biomass was located in the Cascade Head-Destruction Island area. Biomass estimates (which were made using a target strength value of -35 dB per kilogram) summarized by INPFC statistical area are shown below:

<u>INPFC Area</u>	<u>Estimated biomass (m.t.)</u>	<u>95% C.I.</u>
Monterey (35°30'-40°30' N)	111,517	22,184
Eureka (40°30'-43°00' N)	360,942	51,495
Columbia (43°00'-47°30' N)	311,698	49,576
Vancouver (47°30'-50°30' N) <sup>1/</sup>	334,947	65,289
Totals	1,119,104	188,544 (+ 16.9%)

<sup>1/</sup> As indicated above, the area from 50°00'-50°30' N was not surveyed.

In the Port Hueneme - Cape Flattery area an additional estimate of 70,000 m.t. was derived from the bottom trawl survey data. The biomass estimates are conservative from the standpoint that in the Port Hueneme - Cape Flattery area there was no survey effort inside the 50 fm isobath by either the Freeman or the bottom trawl vessels, and there was no bottom trawl survey in the Cape Flattery - Kyoquot Bay area. Also, during the summer hake were sometimes taken in significant quantities by foreign midwater trawl vessels working off southern Oregon and northern California seaward of the survey region.

The hake biomass estimate for the California - Washington region was approximately three times larger than that determined from a similar combination of bottom trawl and hydroacoustic/midwater trawl surveys conducted in 1975. Also, there were significant differences between 1977 and 1975 in the resource's bathymetric distribution, and age composition, and the relative size of its off-bottom and on-bottom components. These differences are discussed in a more detailed report on the 1977 survey being prepared as part of the U.S.-Poland Cooperative Research Program.

#### Biological and Environmental Data Collection

Numbers of length measurements and otoliths collected by species are shown in Table 3. Except for shortbelly rockfish and yellowtail rockfish, relatively few data were obtained for the target rockfish species. A substantial amount of data was obtained for hake size and age composition studies. The length composition of hake (for fish > 20 cm) in each of the INPFC areas for which biomass estimates were determined is shown in Figure 2. As has often been observed, there was a significant increase in mean size with latitude. Small catches of juvenile hake (< 20 cm) taken during the survey occurred primarily south of Monterey.

During the survey, 546 valid XBT casts were made and light intensity measurements were recorded every half hour. The XBT measurements together with CTD data collected on the Profesor Siedlecki's survey provided a unique and valuable set of data on the physical oceanography of the survey region.

#### Other Results

During Leg III, new components in the hydroacoustic system, including receiver electronics, V-fin and dual beam transducer, were successfully tested. Also, the programmable data collection terminal was used to record all station, catch and length frequency data for each trawl haul. No electrical or mechanical problems were encountered at sea and the data were rapidly transferred to the Center's disk data storage system.

Discussion of the results of the hydroacoustic intercalibration study is beyond the scope of this report. A separate report on the study is being prepared and will be included in the U.S.-Poland information exchange.

Scientific Personnel

Leg I

Martin Nelson	Chief Scientist, NWAFC, Seattle
Jimmie Traynor	Fishery Biologist, NWAFC, Seattle
Edmund Nunnallee	Fishery Biologist, NWAFC, Seattle
Susumu Kato	Fishery Biologist, SWFC, Tiburon, Calif.
Katharine Jefferts	Student Aide, Oregon State University
Barbara Rosene	Student Aide, Oregon State University
Daniel Twohig	Electronic Technician, NWAFC, Seattle (July 12-15)
Walter Marshall	Electronic Engineer, NWAFC, Seattle (July 12-14)

Leg II

Martin Nelson	Chief Scientist, NWAFC, Seattle
Edmund Nunnallee	Fishery Biologist, NWAFC, Seattle
Vivian Shinobu	Biological Aide, NWAFC, Seattle
John Boettner	Fishery Biologist, Wash. Dept. Fisheries
Gary Hewitt	Student Aide, Oregon State University
Keith Kreuz	Student Aide, Oregon State University

Leg III

Jimmie Traynor	Chief Scientist, NWAFC, Seattle
Daniel Twohig	Electronic Technician, NWAFC, Seattle
James Mason	Fishery Biologist, NWAFC, Seattle
Ralph Mintel	Computer Scientist, NWAFC, Seattle
Norman Lemberg	Fishery Biologist, Wash. Dept. Fisheries
Kiyoshi Wakabayashi	Fishery Biologist, Japanese Fishery Agency
Donna Worden	Student Aide, Oregon State University
Jo-lyn Keniston	Student Aide, Oregon State University

-----

For further information, contact Dr. Murray L. Hayes, Director, Division of Resource Assessment & Conservation Engineering, Northwest & Alaska Fisheries Center, 2725 Montlake Boulevard East, Seattle, Washington 98112, Telephone: 206-442-4760.

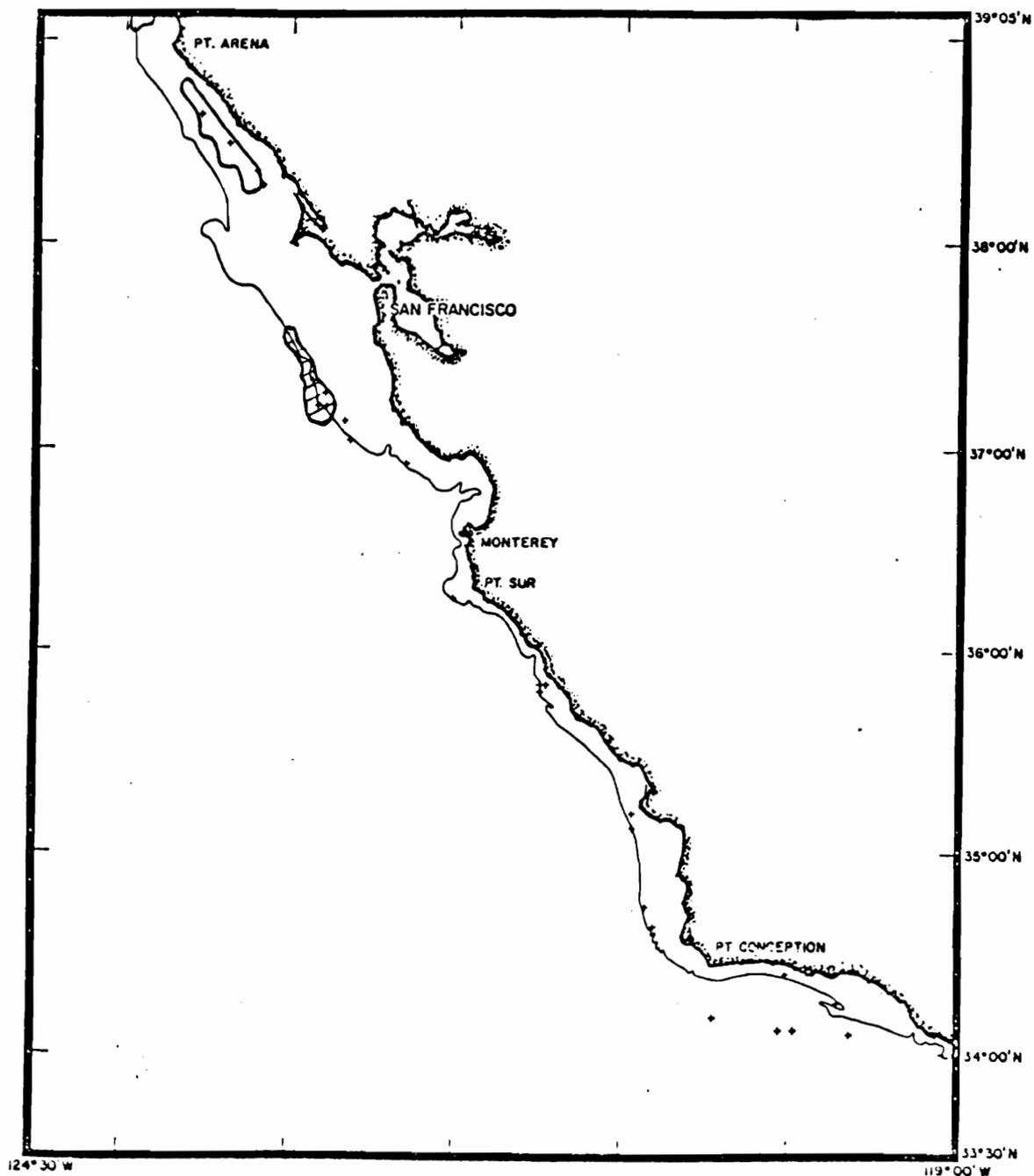


Figure 1. Location of midwater trawl hauls (+ and ⊙), and fish aggregations (hake and shortbelly rockfish) for which biomass estimates were made. ⊙ indicates trawl haul made during hydroacoustic intercalibration survey. Hatched area indicates shortbelly rockfish aggregation.

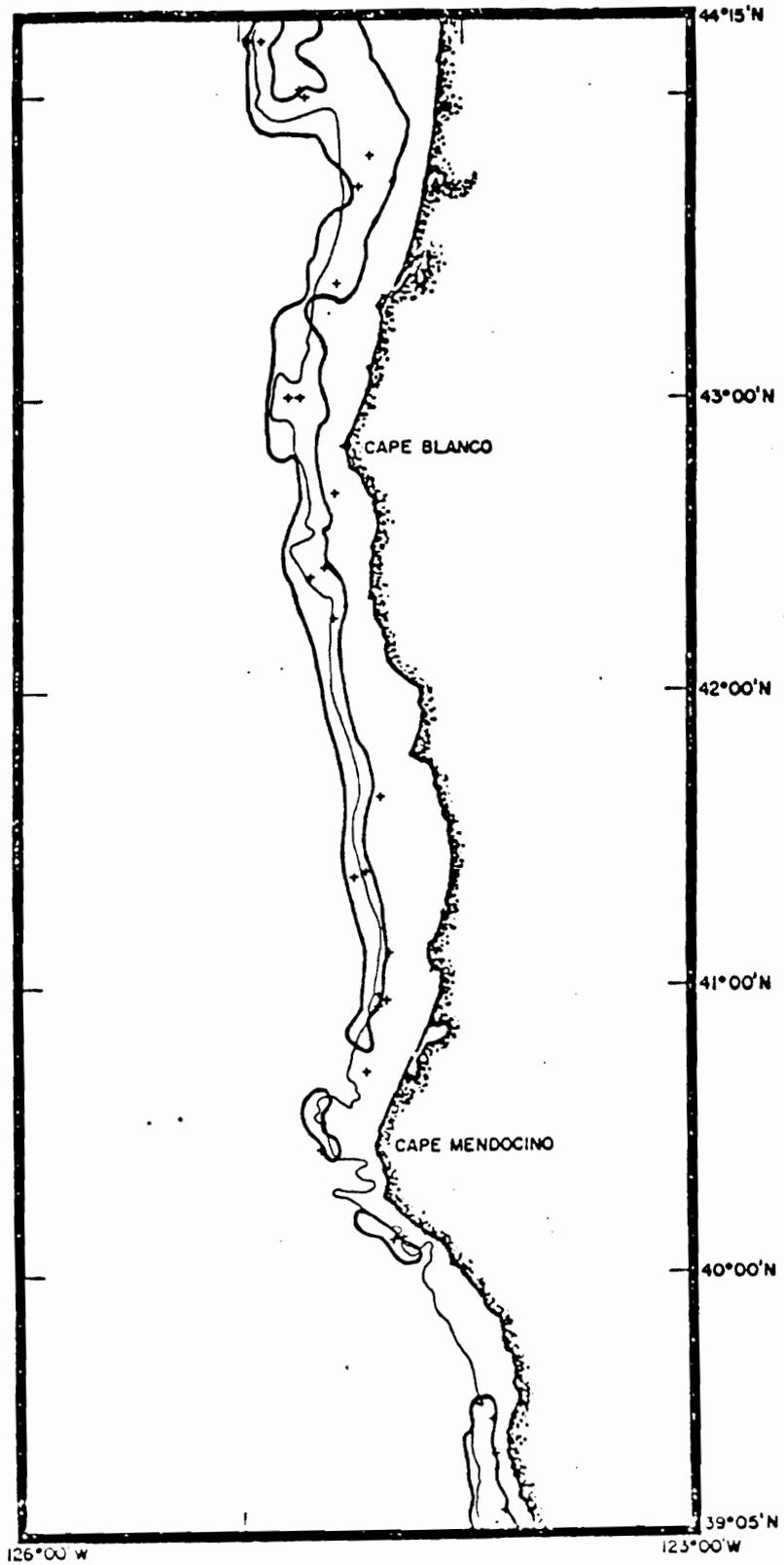


Figure 1, part two of three,

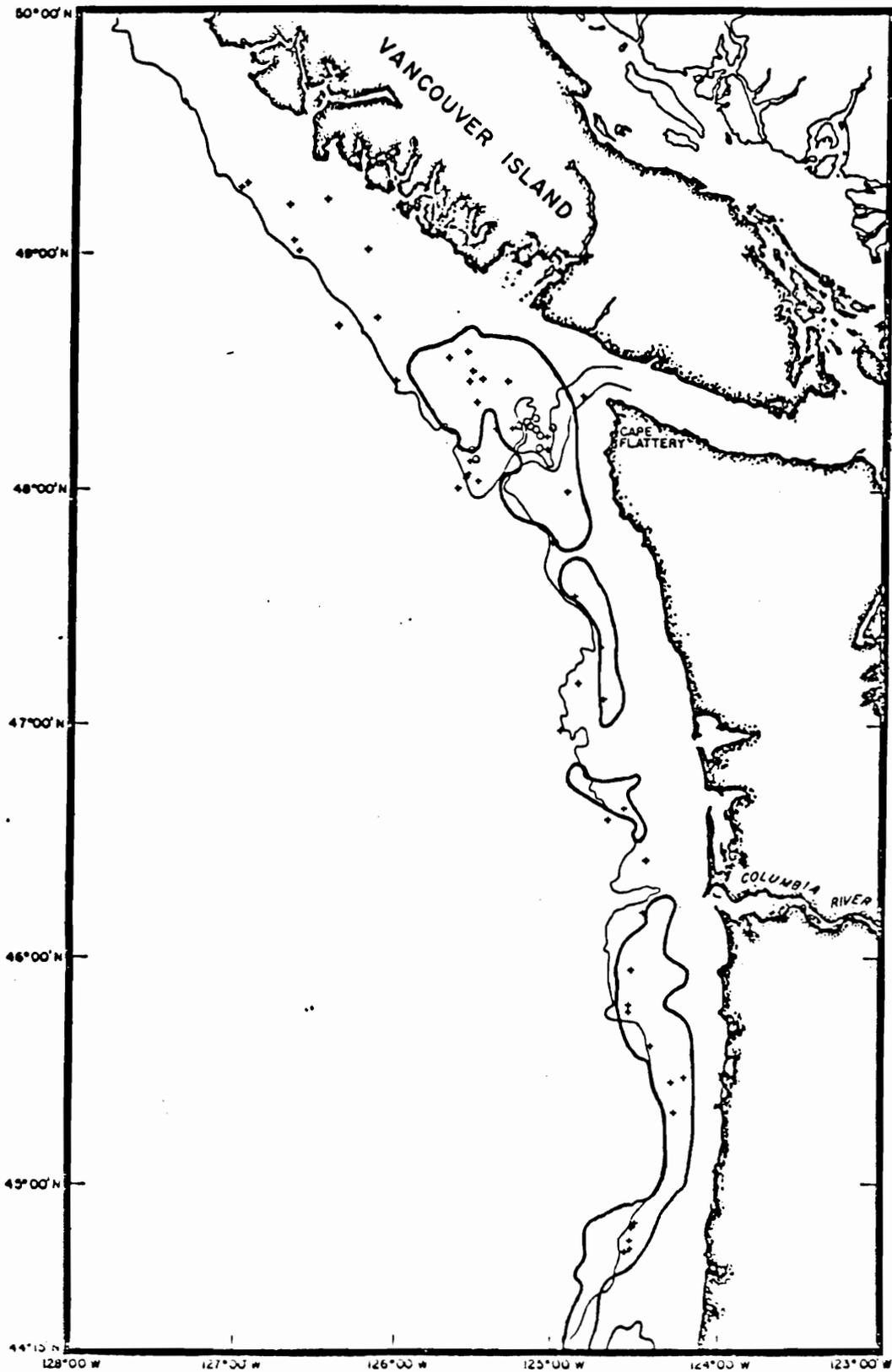


Figure 1, part three of three.

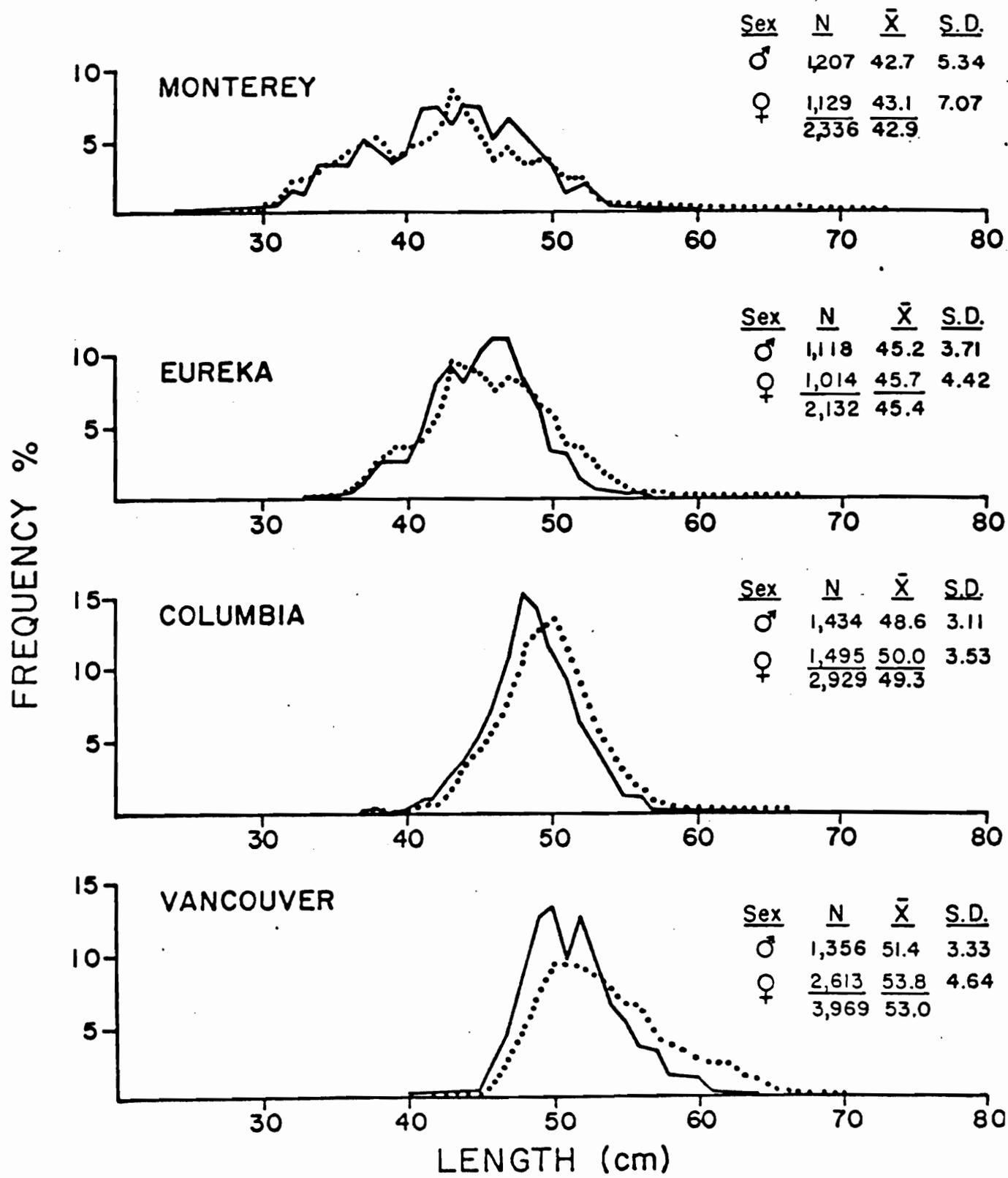


Figure 2. Percentage length composition of midwater trawl hake samples (fish > 20 cm) by INPFC statistical areas for which biomass estimates were made.









Table 2. species of fish captured during Miller Freeman Cruise 77-2 (Legs I and II)

<u>Family</u>	<u>Common Name</u>	<u>Scientific Name</u>
Alopiidae	Thresher shark	<u>Alopias vulpinus</u>
Squalidae	Spiny dogfish	<u>Squalus acanthias</u>
Scyliorhinidae	Brown cat shark Filetail cat shark	<u>Apristurus brunneus</u> <u>Parmaturus xaniurus</u>
Torpedinidae	Pacific electric ray	<u>Torpedo californica</u>
Rajidae	Big skate Longnose skate Sandpaper skate	<u>Raja binoculata</u> <u>Raja rhina</u> <u>Raja kincaidii</u>
Chimaeridae	Ratfish	<u>Hydrolagus colliei</u>
Clupeidae	Pacific herring	<u>Clupea harengus pallasii</u>
Engraulidae	Northern anchovy	<u>Engraulis mordax</u>
Salmonidae	King salmon	<u>Oncorhynchus tshawytsch</u>
Osmeridae	Eulachon Whitebait smelt Smelt (unidentified)	<u>Thaleichthys pacificus</u> <u>Allosmerus elongatus</u> --
Argentinidae	Pacific argentine	<u>Argentina sialis</u>
Myctophidae	Lanternfishes (unidentified)	
Gadidae	Pacific hake Pacific cod Walleye pollock	<u>Merluccius productus</u> <u>Gadus macrocephalus</u> <u>Theragra chalcogramma</u>
Scomberesocidae	Pacific saury	<u>Cololabis saira</u>
Scorpaenidae	Shortspine thornyhead Halfhanded rockfish Shortbelly rockfish Chilipepper Bocaccio Splitnose rockfish Widow rockfish Vermilion rockfish Cowcod Stripetail rockfish Yellowtail rockfish Bank rockfish Greenspotted rockfish Sharpchin rockfish	<u>Sebastolobus alascanus</u> <u>Sebastes semicinctus</u> <u>Sebastes jordani</u> <u>Sebastes goodei</u> <u>Sebastes paucispinis</u> <u>Sebastes diploprora</u> <u>Sebastes entomelas</u> <u>Sebastes miniatus</u> <u>Sebastes levis</u> <u>Sebastes saxicola</u> <u>Sebastes flavidus</u> <u>Sebastes rufus</u> <u>Sebastes chlorostictus</u> <u>Sebastes zacentrus</u>

Table 2. (continued)

- 2 -

<u>Family</u>	<u>Common Name</u>	<u>Scientific Name</u>
Scorpaenidae	Speckled rockfish	<u>Sebastes ovalis</u>
	Canary rockfish	<u>Sebastes pinniger</u>
	Redstripe rockfish	<u>Sebastes proriger</u>
	Pacific ocean perch	<u>Sebastes alutus</u>
	Harlequin rockfish	<u>Sebastes variegatus</u>
	Rosethorn rockfish	<u>Sebastes helvomaculatus</u>
	Silvergray rockfish	<u>Sebastes brevispinis</u>
	Darkblotched rockfish	<u>Sebastes crameri</u>
	Greenstriped rockfish	<u>Sebastes elongatus</u>
	Unidentified red rockfish (juvenile)	--
Anoplopomatidae	Sablefish	<u>Anoplopoma fimbria</u>
Hexagrammidae	Lingcod	<u>Ophiodon elongatus</u>
Agonidae	Sturgeon poacher	<u>Podothecus acipenserinus</u>
	Poacher (unidentified)	--
Carangidae	Jack mackerel	<u>Trachurus symmetricus</u>
Scombridae	Chub mackerel	<u>Scomber japonicus</u>
Trichiuridae	Razorback scabbardfish	<u>Assurger anzac</u>
Stromateidae	Pacific butterfish	<u>Peprilus simillimus</u>
Zoarcidae	Unidentified eelpout	--
Bothidae	Pacific sanddab	<u>Citharichthys sordidus</u>
Pleuronectidae	Slender sole	<u>Lyopsetta exilis</u>
	Rex sole	<u>Glyptocephalus zachirus</u>
	Arrowtooth flounder	<u>Atheresthes stomias</u>
	Flathead sole	<u>Hippoglossoides elassodon</u>
	Petrale sole	<u>Eopsetta jordani</u>
	English sole	<u>Parophrys vetulus</u>
	Dover Sole	<u>Microstomus pacificus</u>
	Unidentified flatfish larvae	--

Table 3. Length measurements and otoliths collected during Miller Freeman Cruise 77-2.

<u>Species</u>	<u>No. Lengths</u>	<u>No. Otoliths</u>
<u>Sebastes jordani</u>	1,279	597
<u>Sebastes goodei</u>	224	224
<u>Sebastes diploprora</u>	483	105
<u>Sebastes flavidus</u>	1,123	386
<u>Sebastes paucispinis</u>	69	69
<u>Sebastes entomelas</u>	1,992	--
<u>Sebastes proriger</u>	428	--
<u>Sebastes saxicola</u>	361	--
<u>Sebastes ovalis</u>	146	--
<u>Sebastes miniatus</u>	95	--
<u>Sebastes pinniger</u>	19	--
<u>Sebastes crameri</u>	10	--
<u>Merluccius productus</u>	12,092	3,836
<u>Theragra chalcogramma</u>	1,342	--
<u>Engralis mordax</u>	139	--
<u>Clupea harengus pallasii</u>	310	--
<u>Anoplopoma fimbria</u>	82	--
<u>Thaleichthys pacificus</u>	51	--
<u>Allosmerus elongatus</u>	50	--
<u>Oncorhynchus tshawytscha</u>	6	--
<u>Microstomus pacificus</u>	82	--
<u>Argentina sialis</u>	16	--
<u>Squalus acanthias</u>	209	--
<u>Trachurus symmetricus</u>	8	--