The Distribution, Abundance, and Biological Characteristics of Pacific Whiting, *Merluccius productus*, in the California-British Columbia Region During July-September 1977

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Introduction

The Pacific whiting, *Merluccius productus*, is a cod-like species which ranges from off Mexico northward to Alaska and has been the subject of an intensive foreign fishery since 1966. This fishery occurs mainly off northern California to southern British Columbia during spring, summer, and fall when Pacific whiting form feeding aggregations in waters over the continental shelf and upper slope. Spawning occurs off northern Mexico and southern California during December-April, at which time adult fish are not available to fishermen. Foreign annual catches have exceeded 200,000 metric tons (t) occasionally but have averaged about 167,000 t.

A small U.S. fishery for Pacific whiting took place during 1966-68 off southern Washington where a small factory was receiving hake for reduction to fish meal. The fishery was discontinued in 1968 when a depressed fish meal market forced the plant to close.

Since the United States extended its fishery jurisdiction on 1 March 1977 to 200 miles, there has been an increasing interest and investment on the part of domestic industry in the Pacific whiting resource. The covering legislation, known as the Fishery Conservation and Management Act of 1976 (Public Law 94-265), not only extended jurisdiction but required the development of comprehensive fishery management plans within guidelines set forth by national standards for fishery management and conservation.

These developments have significantly increased the need for detailed scientific information about the resource and have resulted in intensified research effort. In 1975, in anticipation of future information requirements, the Northwest and Alaska Fisheries Center of the National Marine Fisheries Service (NMFS) conducted a joint bottom trawl and hydroacoustic-midwater trawl survey of the Pacific whiting resource in continental shelf and upper slope waters along the coast from California to British Columbia (Dark and Nelson[1]). A similar, but more intensive survey was conducted in 1977. The main objectives of the 1977 survey were to determine the distribution, abundance, and biological characteristics of a variety of rockfish, *Sebastes*, species and Pacific whiting. This paper presents information on the distribution, abundance, and biology of Pacific whiting derived from the 1977 survey data.

Methods

The survey was conducted during 4 July-29 September. It employed four vessels for bottom trawl sampling and one for the hydroacoustic-midwater trawl survey. Operations commenced off Port Hueneme, Calif., (lat. 34°08′N) and were concluded off Kyuquot Bay, B.C. (lat. 50°00′N).[2] This area covers the latitudinal range in which Pacific whiting normally occur in commercial concentrations. The bottom depth range surveyed was 50-260 fathoms (91-475 m), except for the area north of Cape Flattery where the hydroacoustic-midwater trawl survey was extended shoreward to 30 fathoms (55 m). Because of constraints on available vessel time, waters shallower

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[1]Dark, T., and M. Nelson. 1977. The distribution and abundance of Pacific hake from Vancouver Island, British Columbia, to Monterey Bay, California, during September-October, 1975. Unpubl. manuscr., 45 p. Northwest and Alaska Fisheries Center, NMFS, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

[2]The area from Cape Flattery, Wash., (lat. 48°30′N) to Kyuquot Bay was surveyed by the hydroacoustic-midwater trawl vessel only.

ABSTRACT—The results of a 1977 trawl-hydroacoustic survey of the distribution and abundance of Pacific whiting, Merluccius productus, *off California, Oregon, Washington, and British Columbia are presented.*

Estimates of biomass are presented by International North Pacific Fisheries Commission (INPFC) statistical areas and depth strata. A total of 1,198,932 metric tons of Pacific whiting were estimated to be present in the survey area, 29.2 percent of which occurred in the INPFC Vancouver area; 29.1 percent in the Columbia area; 30.9 percent in the Eureka area; 10.5 percent in the Monterey area; and 0.2 percent in the Conception area. Only 5.8 percent of the total biomass was estimated by the bottom trawl survey while the remainder was estimated by the hydroacoustic-midwater trawl survey.

Age and length compositions reflected previously established latitudinal stratification of age-size groups with the relative abundance of the older, larger fish increasing from south to north. There were no consistent trends of size or age with depth. Age data revealed a high relative abundance of 4-year-old Pacific whiting. This extraordinarily large 1973 year-class at least partially explains the more than twofold increase in estimated biomass between 1975 and 1977 resource surveys.

than 50 fathoms (91 m) were generally not surveyed. Although Pacific whiting occur in the inner shelf region, it is unlikely that a significant portion of the exploitable resource was present inside the 50 fathom (91 m) isobath. The juvenile whiting biomass was probably underestimated, however, because juveniles occur south of the area surveyed and part of the juvenile population is broadly dispersed within scattering layers, making detection and abundance estimation very difficult.

Bottom Trawl Survey

The bottom trawl survey was conducted during 4 July-27 September beginning off Port Hueneme and ending at Cape Flattery. As described by Gunderson and Sample (1980) the survey area was divided into 14 geographic strata. However, for purposes of analyzing and presenting most survey results for Pacific whiting, the data from these strata were combined and geographic variation is shown only for the five International North Pacific Fisheries Commission (INPFC) statistical areas (Fig. 1) in the survey region. Each INPFC statistical area was subdivided into four depth strata: 50-100, 100-150, 150-200, and 200-260 fathoms (91-183, 183-274, 274-366, and 366-475 m) to examine depth-related differences in abundance and size-age composition. Other details of the methods, vessels, and equipment employed in the bottom trawl survey, are the same as those described by Gunderson and Sample (1980).

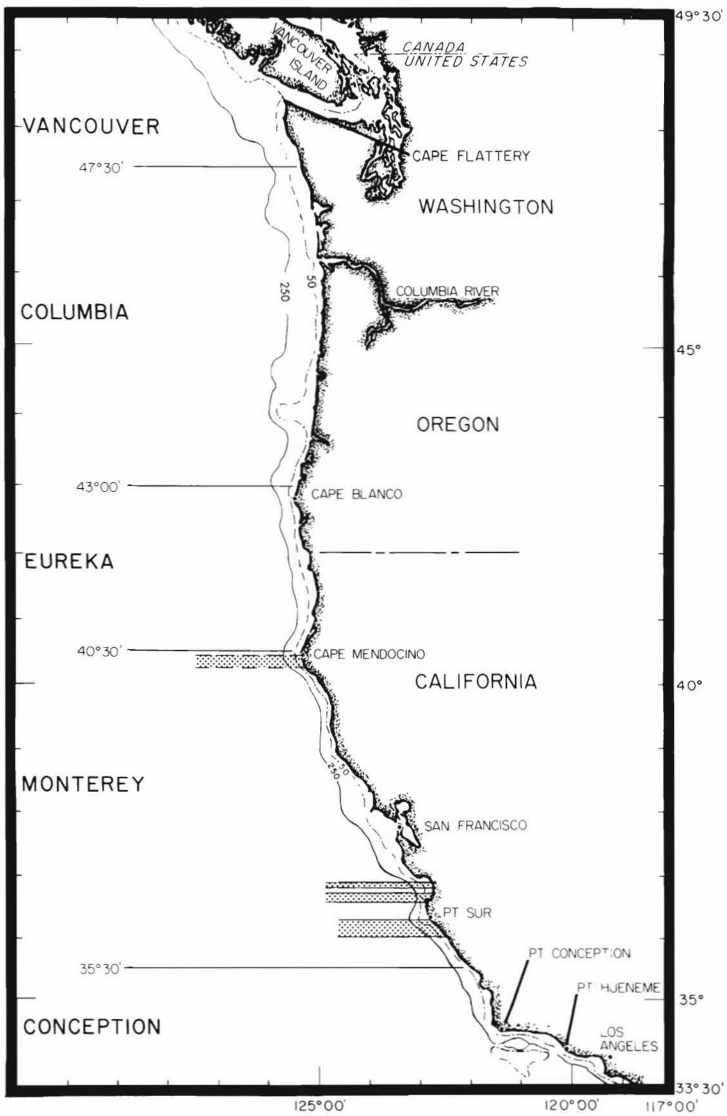

Figure 1.—Bottom trawl survey area showing International North Pacific Fisheries Commission statistical areas. Stippling indicates areas considered to be untrawlable which were not surveyed.

Hydroacoustic-midwater Trawl Survey

The hydroacoustic-midwater trawl survey was conducted between 20 July and 29 September by the NOAA research vessel *Miller Freeman*, a 66-m, 2,200-hp stern trawler. As indicated previously, it surveyed the entire area between Port Hueneme and Kyuquot Bay.

Hydroacoustic Data Acquisition and Processing Equipment and Echo Signal Processing Methods

A hydroacoustic data recording system was used on the California-Washington (Port Hueneme-Cape Flattery) portion of the survey. A computerized data recording and processing system contained in a portable sea-land van was employed while operating between Cape Flattery and Kyuquot Bay. Each system included a 38 kHz echo sounder with three receivers, newly developed echo signal detector units (Marshall and Nunnallee[3]), a Honeywell 5600C[4] seven track FM tape re-

[3]Marshall, W. C., and E. P. Nunnallee. 1980. Detector and synchronization modules for interfacing an echo sounder to a fisheries acoustic data acquisition and processing system. Unpubl. manuscr., 55 p. Northwest and Alaska Fisheries Center, NMFS, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

[4]Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

corder, and a dual beam transducer housed in a towed V-fin.

Echo sounder system specifications are shown in Appendix I together with calibration data obtained for each system prior to and following its use during the survey. System calibration methods, including those used to monitor system performance at sea, are briefly described in Appendix II. A simplified block diagram of the computerized data recording and processing system is shown in Figure 2. The system's digitally controlled time-varied-gain (TVG) amplifier was developed by Marshall (1977). System operation is synchronized using a control module described by Marshall and Nunnallee[3]. The 40 $\log_{10}$ R signal channels were used only to collect data for measuring individual fish target strength using the dual beam transducer method proposed by Ehrenberg (1974) and discussed by Weimer and Ehrenberg (1975), Ehrenberg (1979), Traynor (1976), and Traynor and Ehrenberg (1979).

The computer system was programmed to implement echo integration simultaneously in each of up to 50 contiguous user selectable depth strata between the transducer and the bottom and in as many as 10 similar bottom referenced depth strata. Echo integration[5] outputs, i.e., integrated echo signal intensities and corresponding estimates of target density for each depth stratum, could be generated as frequently as desired. The echo integration data were collected at a rate of 7.5k samples per second on the 20 $\log_{10}$R signal channel.

The computer system dual beam software consisted of two sets of programs. One acquires and another analyzes single target pulse voltage information. The former, which simultaneously samples each of the 40 $\log_{10}$ R signal channels at 15 k samples per second, accepts single targets on the basis of half amplitude pulse length in the narrow beam and measures maximum pulse voltage in each channel. A file is then produced which contains the peak voltage, range, and half amplitude pulse lengths on both narrow and wide beam channels for each target accepted. The analysis programs utilize this output file together with TVG measurement and other calibration data to: 1) Calculate the effective scattering cross section (σ) for each accepted target and 2) determine mean scattering cross section estimate distributions and their variances. The analysis is done using operator specified noise level and beam pattern threshhold values.

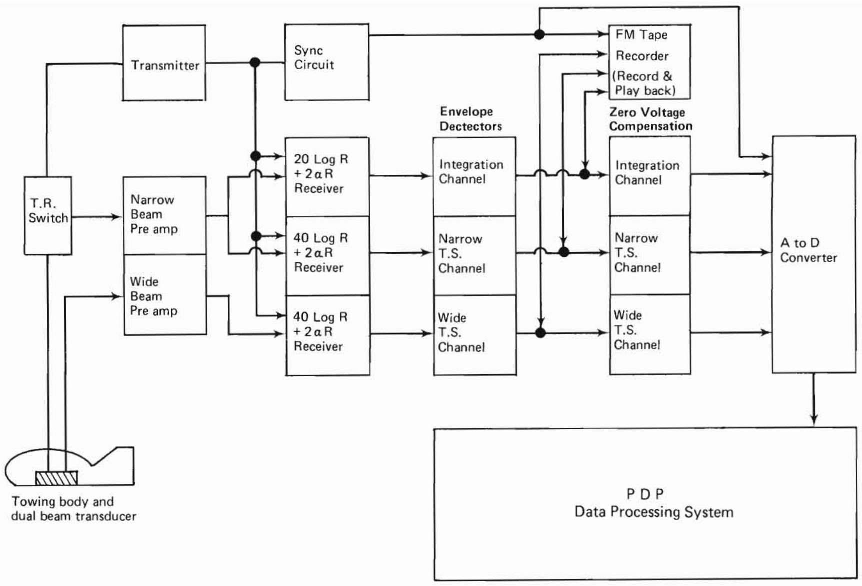

Figure 2.—Block diagram of computerized hydroacoustic data acquisition and processing system.

Midwater Trawl Gear and Accessories

A modified standard Cobb pelagic trawl (Fig. 3) was used to sample midwater echo sign. It was fished with 55-m bridles (2 per wing), 2.1- × 3.0-m steel V-doors, and had a 3.2-cm mesh codend liner.

The trawl was positioned with an Elac cable netsounder system which included an LAZ 17 echo recorder with a DSG scale expander unit and an up-down looking 30 kHz headrope transducer. Netsounder records indicated the trawl's average vertical mouth opening was approximately 7.3 m. The opening varied from 5.5 to 13 m depending upon towing speed and the amount of trawl cable set out. Most trawl hauls were made at a speed of 3.5-5 kn.

Survey Design and Data Collection-Processing Procedures

The survey was conducted during daylight hours along a trackline consisting of a continuous set of zigzag transects spaced at 10 nautical mile intervals. Between Port Hueneme and Cape Flattery, the trackline was normally run between the 50- and 250- fathom (91- and 457-m) isobaths. As mentioned previously, north of Cape Flattery the inshore boundary of the survey was 30 fathoms (55 m). Vessel speed averaged approximately 9 knots and the transducer was towed at an average depth of 15 fathoms (27 m).

During the part of the survey (between Cape Flattery and Kyuquot Bay) when the computer system was aboard the vessel, it was programmed to obtain

[5]The integration method of echo signal processing has been described by Forbes and Nakken (1972) and other authors. In simple form, the relation between the output of an echo integrator and fish density, which is valid for a substantial range of fish densities, is: $I = K\bar{\sigma}\rho$, where I = integrated echo signal intensities (squared echo signal voltages), K = constant dependent upon system parameters, $\bar{\sigma}$ = mean scattering cross section of an individual fish; the target strength, TS, of an object is defined as $TS = 10 \log_{10} (\sigma/4\pi)$, and ρ = number of fish per unit volume.

echo integrator data for each consecutive 11-fathom (20-m) depth stratum between the transducer and the bottom and, simultaneously, for each of nine bottom referenced depth strata within 13.7 fathoms (25 m) of the bottom. Outputs were obtained at 1-minute intervals along the entire trackline. After the survey was completed, the tape recorded data from the California-Washington region were processed in the laboratory using the same depth stratification and output frequency. In certain situations there may have been some overlap between the near bottom portion of the water column sampled by bottom trawl and the remainder of the water column sampled hydroacoustically. However, for all practical purposes the two types of sampling can be considered independent. This is mainly because of the basic constraints on near bottom sampling by hydroacoustic methods that are caused by the angular and range resolution limitations of the hydroacoustic system.

Each night the vessel usually operated in a selected part of the area surveyed during the preceding daytime period. Along the California-Washington coast, the primary objective at night was to detect certain species of rockfish and obtain information on diel changes in their vertical distribution and availability. Also, several nights were devoted to locating mono-specific dispersed aggregations of whiting and collecting target strength data with the dual beam system. The target strength data collection was intensified during the last part of the survey when the computer system was available and the data could be analyzed and examined immediately.

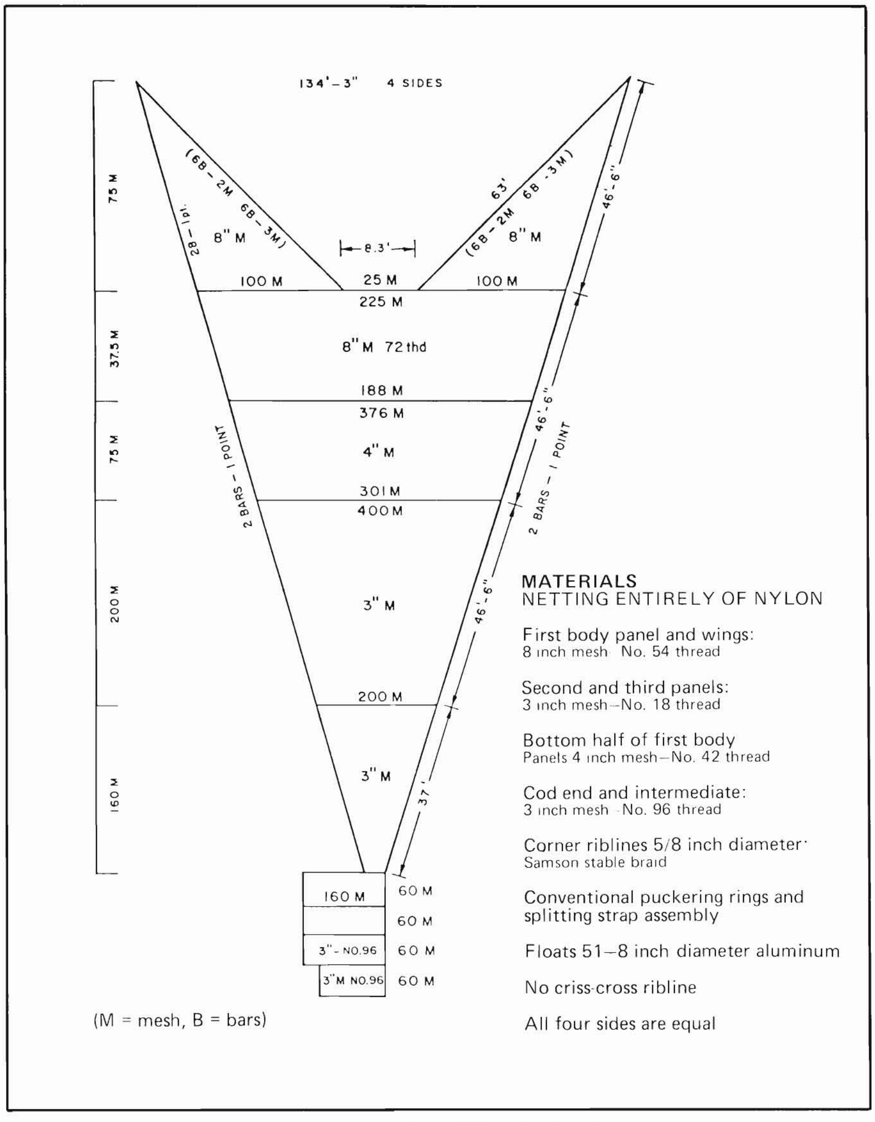

Figure 3.—Diagram of modified Cobb pelagic trawl.

Midwater trawl hauls were made both day and night throughout the survey period to identify echo sign and obtain biological data on whiting, rockfish, and other species. The duration of each haul was determined by the accuracy with which the trawl was positioned, the extent and density of the echo sign, and the apparent efficiency of the trawl as indicated by the net-sounder recording.

Procedures for sorting and sampling midwater trawl catches to determine species composition and obtain length frequency and otolith samples did not differ significantly from those described for the bottom trawl survey by Gunderson and Sample (1980). Length composition was determined for nearly all whiting catches. Except for juvenile fish (<20 cm in length), the data were always segregated by sex.

Expendable bathythermograph (XBT) casts were usually made at each trawl station. In addition, between Port Hueneme and Cape Flattery, there were additional XBT stations at the 50, 100, 150, 200, and 250 fathom (91, 183, 274, 366, and 457 m) isobaths on every other daytime survey transect.

Biomass and Size-Age Composition Estimation

Pacific whiting aggregations were identified by examination of echogram records and trawl species composition data. The biomass for each aggregation was estimated by extrapolating the average biomass per unit surface area estimate. The average was calculated from the individual echo integrator outputs, i.e., the estimates of biomass per unit surface area (D_B) computed at

1-minute intervals while sounding on whiting: D_B =kg/100 m^2 of surface area $= \sum_{i=1}^{n} (R_L - R_U)_i (D_S)_i$, where $(R_L)_i$ and $(R_U)_i$ = the lower and upper boundaries of the ith depth interval between the transducer and the seabed (the computer automatically compensates for differences in interval dimensions caused by changes in bottom depth) and $(D_S)_i$ = volumetric biomass density (kg/100 m^3) in the ith depth interval.

The distributions of individual biomass per unit surface area estimates along the transects were used to define the geographic boundaries required for extrapolation of the average density estimates.

During the survey an average target strength estimate of −38 dB/kg was obtained from dual beam data collected at night on dispersed fish aggregations consisting primarily of whiting. However, an estimate of −35 dB/kg was used to calculate density. The higher target strength value which, of course, results in a more conservative (by a factor of two) biomass estimate, was chosen because: 1) The "whiting" aggregations from which the −38 dB estimate was obtained also contained some walleye pollock, *Theragra chalcogramma*, and spiny dogfish, *Squalus acanthias*, and 2) a recent review of fish target strength research studies (Food and Agriculture Organization, 1978) suggests −35 dB is a more accurate estimate for whiting-like species of similar size and morphology. The review included evaluation of a paper (Traynor, In press) which described the work done on the survey that resulted in an estimate of −38 dB.

Major latitudinal differences in the distribution of the whiting resource were shown by estimating the biomass in each of four INPFC statistical areas. These biomass estimates were obtained from separate estimates made for six bottom depth zones in each of 11 latitudinal subareas.

Biomass and associated confidence interval (95 percent) estimation procedures were as follows. For each subarea, biomass (B) was estimated from: $\hat{B} = A\bar{D}$, where A = area over which density estimates were extrapolated, and $\bar{D}$ = mean density per unit surface area (kg/100m^2) within the subarea.

Because successive density estimates along the survey transects are serially correlated, and therefore not independent, an estimate of the variance of the mean which uses the sample variance s^2, may not be large enough to yield reliable confidence intervals[6]. To correct for this, variance estimation methods based on cluster sampling theory (Hansen et al., 1953) were used, as suggested by Shotton and Dowd (1975). Each survey transect was treated as a cluster. The estimated variance of the mean density in a subarea was then calculated as: $\text{Var}(\bar{D}) = (\bar{D})^2 (V^2 / T\bar{n}) \{1 + \delta(\bar{n} - 1)\}$ where T is the number of transects in the subarea, $\bar{n}$ is the mean number of density (kg/100 m^2) estimates per transect, V^2 is a relative variance term containing both within and between transect variance components, and δ measures the amount of within transect correlation. The variance of the biomass estimate is then $\text{Var}(\hat{B}) = A^2 \text{Var}(\bar{D})$.

To obtain biomass variance estimates for each INPFC statistical area and for the entire survey area, appropriate subarea estimates were summed. The 95 percent confidence interval for each biomass estimate was calculated as: C.I. $= \pm t_{.05} [\text{Var}(\hat{B})]^{1/2}$, where the value of $t_{.05}$ corresponded to the sample size used to estimate B.

The percentage size composition, by sex, of midwater whiting in each INPFC area was estimated by combining unweighted length frequency samples. Length frequencies for juvenile whiting (<20 cm) were obtained from unsexed samples. Age-length keys were derived for each area from the midwater trawl otolith-length samples and applied to the length frequency distributions to obtain percentage age composition estimates. The age composition estimates were made with the sexes combined.

[6]The results of recently completed hydroacoustic survey simulation analyses are being used to help define the magnitutde of this error (Neal Williamson, Northwest and Alaska Fisheries Center, NMFS, NOAA, Seattle, WA 98112. Pers. Commun.).

Results

Sample Density

The bottom trawl survey covered an area of 37,700 km^2 within which 664 usable bottom trawl hauls were made. Station locations are shown in Figure 4.

The daytime hydroacoustic survey was completed on a 6,464-km trackline composed of 225 transects (Fig. 5). Two-hundred transects, totaling 5,028 km, were run between Port Hueneme and Cape Flattery and 295 hours of hydroacoustic data were tape recorded for post-survey computer processing. On the 25 transects in the Cape Flattery-Kyuquot Bay area the hydroacoustic data were processed directly by the shipboard computer.

Station and selected species catch data for the 116 midwater trawl hauls made during the survey period are summarized in Appendix III. The geographic distribution of the hauls is shown in Figure 6. Hauls 1-83, which included 41 daytime and 42 night hauls, were made during the Port Hueneme to Cape Flattery portion of the survey. Hauls 94-116, which included 9 daytime and 14 night hauls, were made while surveying in the Cape Flattery to Kyuquot Bay area. Hauls 84-93, which were concentrated off Cape Flattery, were made during a comparative hydroacoustic survey conducted from 11 to 16 September with the Polish research vessel *Profesor Siedlecki* and the Canadian research vessel *G. B. Reed*.

Distribution and Abundance

Bottom Trawl Survey

The number of bottom trawl hauls and average catch rates (kg/km trawled) of Pacific whiting are presented in Table 1 by INPFC areas and depth zones. Estimates of biomass, 95 percent confidence intervals, and numbers of trawl hauls by INPFC areas and depths are shown in Table 2. Almost half of the total biomass estimate derived from the bottom trawl survey was in the Columbia area. The next highest abundance was in the Monterey area where 26 percent of the biomass estimated by bottom trawl was found. The

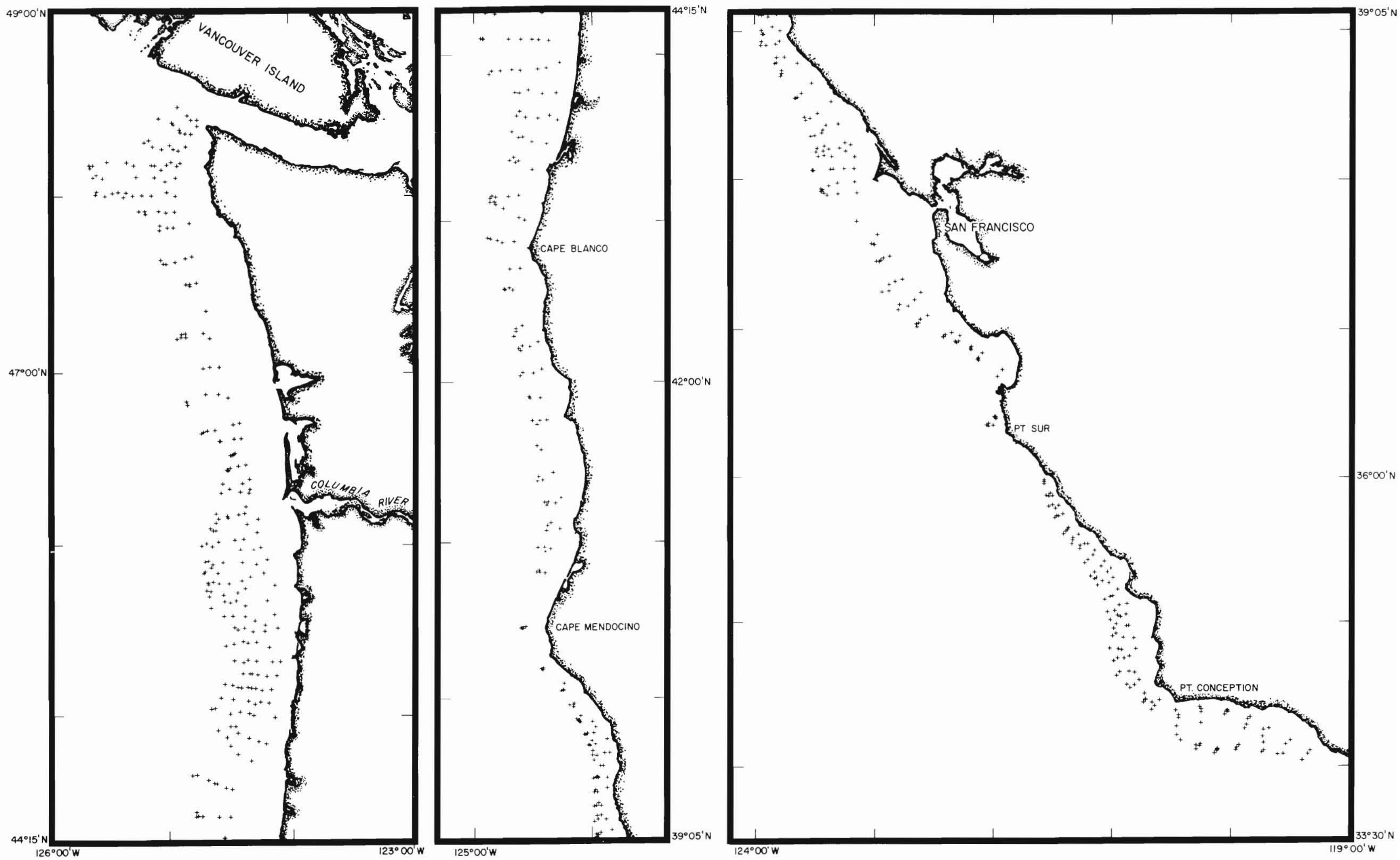

Figure 4.—Geographic distribution of bottom trawl stations.

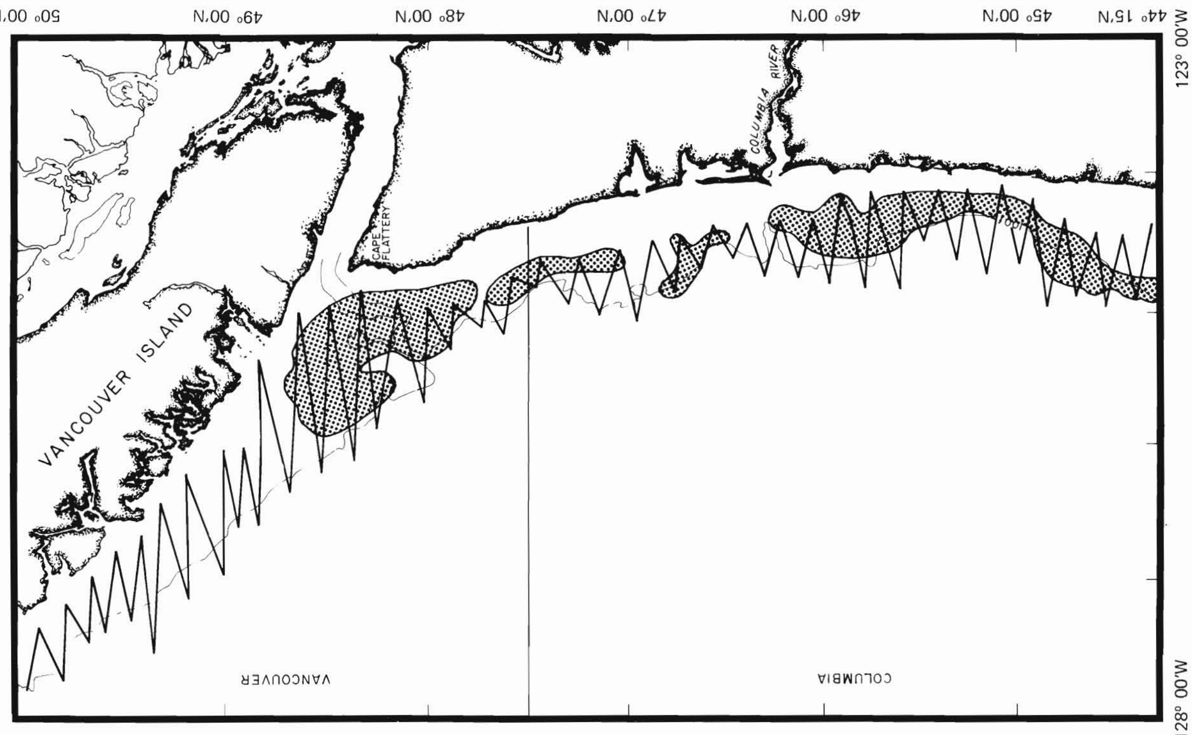

Figure 5.—Hydroacoustic-midwater trawl survey transects and locations of Pacific whiting aggregations (indicated by stippling) for which biomass estimates were made.

relatively small Eureka area was the third most important region and contained 14 percent of the estimated biomass. The relatively low biomass estimate (6,560 t) for the Vancouver area was probably due primarily to the fact that only a small part of the area was surveyed by bottom trawl. The Conception area typically contains relatively small quantities of whiting. Figure 7 presents whiting density contours for the survey area as derived from bottom trawl data.

In all areas, the abundance of whiting near the bottom tended to decrease with increasing depth (Table 2). Overall, 87 percent of the biomass was found on the shelf in waters less than 100 fathoms (183 m), about 7 percent in the 100-150 fathom (183-274 m) depth stratum, 4 percent in the 150-200 fathom (274-366 m) stratum, and 2 percent in the 200-250 fathom (366-457 m) stratum. A similar trend showing decreasing abundance with depth for bottom trawl caught whiting was observed during the 1975 survey.

Confidence intervals (95 percent) associated with area-depth biomass values are as great as ±152 percent of the

Table 1.—Pacific whiting catch per unit effort (kg/km trawled) by International North Pacific Fisheries Commission (INPFC) statistical area and depth stratum.

Depth (fm)	INPFC Area									
	Vancouver		Columbia		Eureka		Monterey		Conception	
	No. hauls	kg/km	No. hauls	kg/km	No. hauls	kg/km	No. hauls	kg/km	No. hauls	kg/km
50-100	32	19.7	105	42.1	21	48.1	78	36.9	28	7.4
100-150	17	6.9	51	9.0	14	9.0	43	13.8	29	10.5
150-200	14	14.5	33	5.8	13	6.0	44	10.7	19	8.5
200-260	7	2.3	40	5.1	12	1.7	41	4.1	25	1.6

Table 2.—Bottom trawl survey estimates of Pacific whiting biomass (t), associated 95 percent confidence intervals, and number of trawl hauls (*n*), by International North Pacific Fisheries Commission (INPFC) statistical area and depth stratum.

Depth (fm)	INPFC Area					
	Vancouver	Columbia	Eureka	Monterey	Conception	Total
50-100						
Biomass	5,680	29,703	8,792	15,546	780	60,501
C.I.	108-11,252	16,936-42,470	0-18,811	6,025-25,067	371-1,190	41,250-79,752
n	32	104	20	78	28	262
100-150						
Biomass	420	1,592	416	1,707	953	5,088
C.I.	110-730	520-2,664	195-637	0-4,310	503-1,403	2,270-7,906
n	17	51	14	43	29	154
150-200						
Biomass	423	800	227	758	540	2,748
C.I.	142-704	318-1,282	52-402	102-1,414	293-787	1,869-3,627
n	14	33	13	44	19	123
200-250						
Biomass	37	822	66	255	123	1,303
C.I.	7-67	496-1,148	0-136	169-341	33-213	955-1,651
n	7	40	12	41	25	125
Total (50-250) biomass	6,560	32,917	9,501	18,266	2,396	69,640
C.I.	0-14,433	19,963-45,868	0-19,724	8,231-28,302	1,744-3,048	53,325-85,953
n	70	228	59	206	101	664

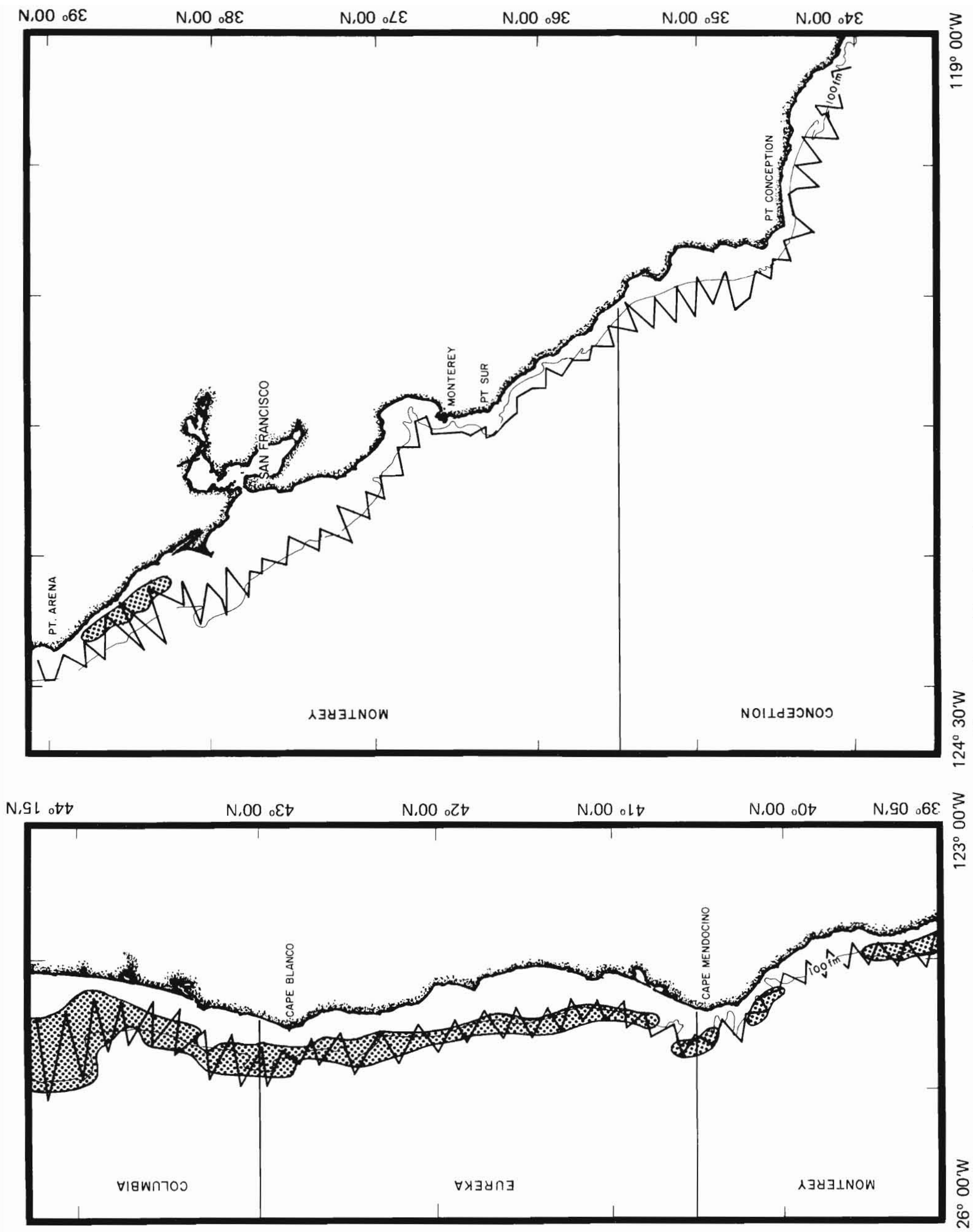

Figure 5.—Continued.

point estimate. While these intervals indicate substantial variation about the biomass estimates, they are generally smaller than those calculated from 1975 survey data, probably because of the increased station density.

Hydroacoustic-Midwater Trawl Survey

The distribution of Pacific whiting aggregations as determined by the hydroacoustic-midwater trawl survey is shown in Figure 5. The INPFC area biomass estimates and associated confidence intervals are shown in Table 3. South of Bodega Bay, Calif., (lat. 38°15'N) where significant sized schools were not located and trawl catches were generally small, it was not feasible to attempt biomass estimation.

Table 3.—Hydroacoustic-midwater trawl survey estimates of Pacific whiting biomass (t) and associated 95 percent confidence intervals, by International North Pacific Fisheries Commission (INPFC) statistical area.

INPFC area (latitude)	Biomass est. (t)	Percent of total	95% C.I.
Monterey (35°30'-40°30'N)	108,087	9.6	±32,949 (30.5%)
Eureka (40°30'-43°00'N)	360,944	32.0	±76,647 (21.2%)
Columbia (43°00'-47°30'N)	316,440	28.0	±68,276 (21.6%)
Vancouver (47°30'-50°30'N)[1]	343,821	30.4	±83,325 (24.2%)
Totals	1,129,292	100.0	±136,375 (12.1%)

[1]Area between lat. 50°00' and 50°30'N not surveyed.

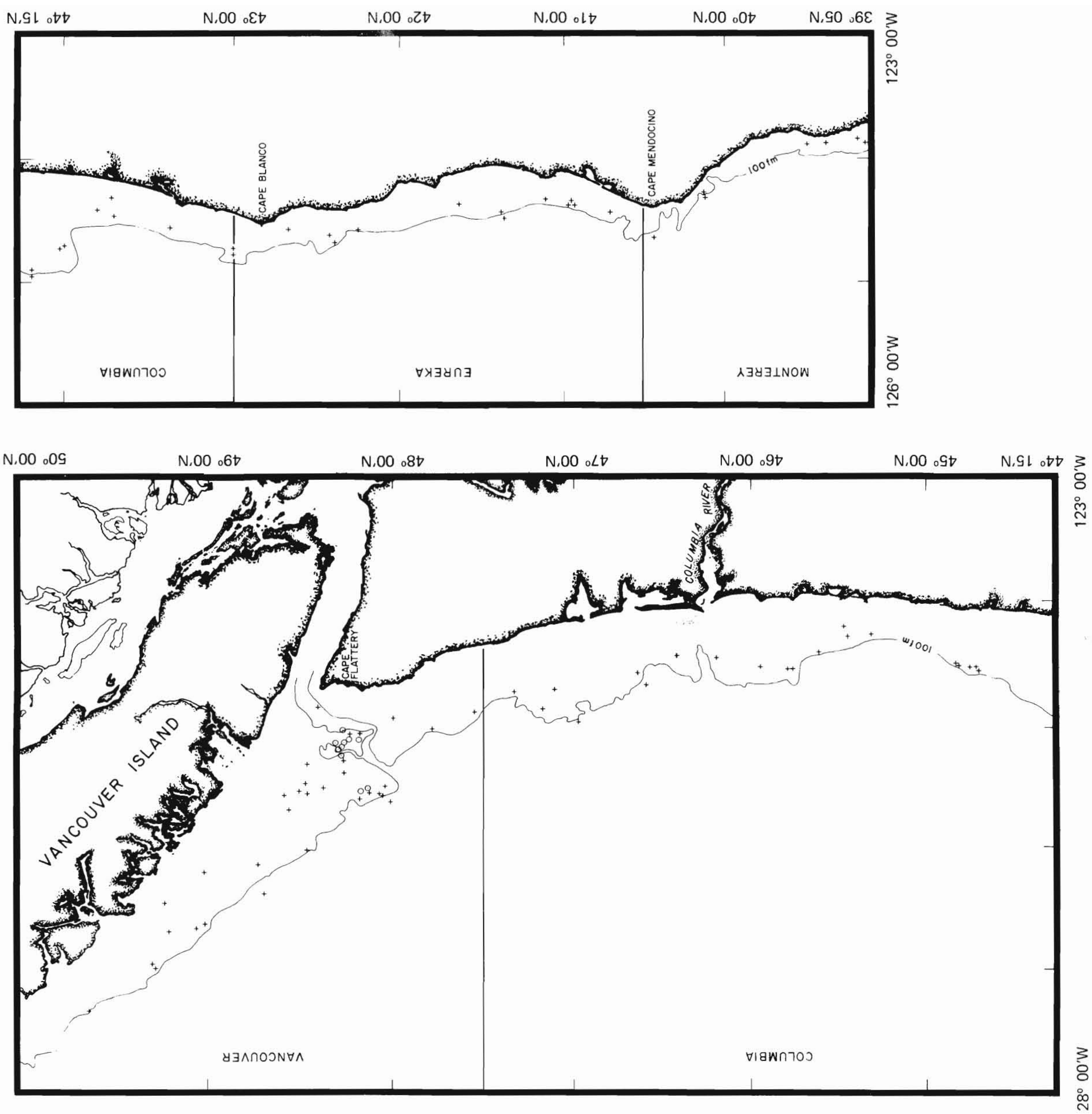

Figure 6.—Geographic distribution of midwater trawl hauls. Hauls off Cape Flattery indicated by circled dots were made during cooperative hydroacoustic intercalibration surveys.

The northernmost portion of the survey region (between lat. 49° 00′ and 50° 00′ N) was also an area of low abundance.

Except between Cascade Head, Oreg., and the Queets River, Wash., (lat. 45° 00′-47° 30′ N) whiting were abundant throughout the region from Bodega Bay to southern Vancouver Island (lat. 49° 00′ N). Only 5.4 percent of the total estimated biomass was located in the Cascade Head-Queets River area (Table 4).

The distribution of whiting by bottom depth and INPFC area is shown in Figure 8.[7] Abundance was highest in the 50-100 fathom (91-183 m) zone in all INPFC areas and, except in the Eureka area, the total for this zone exceeded that for the entire slope region (100-250 fathoms). Only 13.4 percent of the total biomass in the 50-250 fathom (91-457 m) depth zone was found beyond the 150 fathom (274 m) isobath. Between Cape Flattery and Kyuquot Bay 12 percent (17,290 t) of the biomass was located shoreward of the 50 fathom (91 m) isobath, i.e., between depths of 30 and 50 fathoms (55-91 m).

[7]Ninety-six and one-half percent (1,089,766 t) of the total biomass (1,129,292 t) estimated from the hydroacoustic-midwater trawl survey was located between the 50 and 250 fathom (91-457 m) isobaths. Approximately 1.5 percent (17,290 t) was in the 30 to 50 fathom (55-91 m) depth zone between Cape Flattery and Kyuquot Bay. The remainder (2 percent) was detected when transects occasionally extended slightly outside the depth boundaries (50-250 fathoms) planned for the survey.

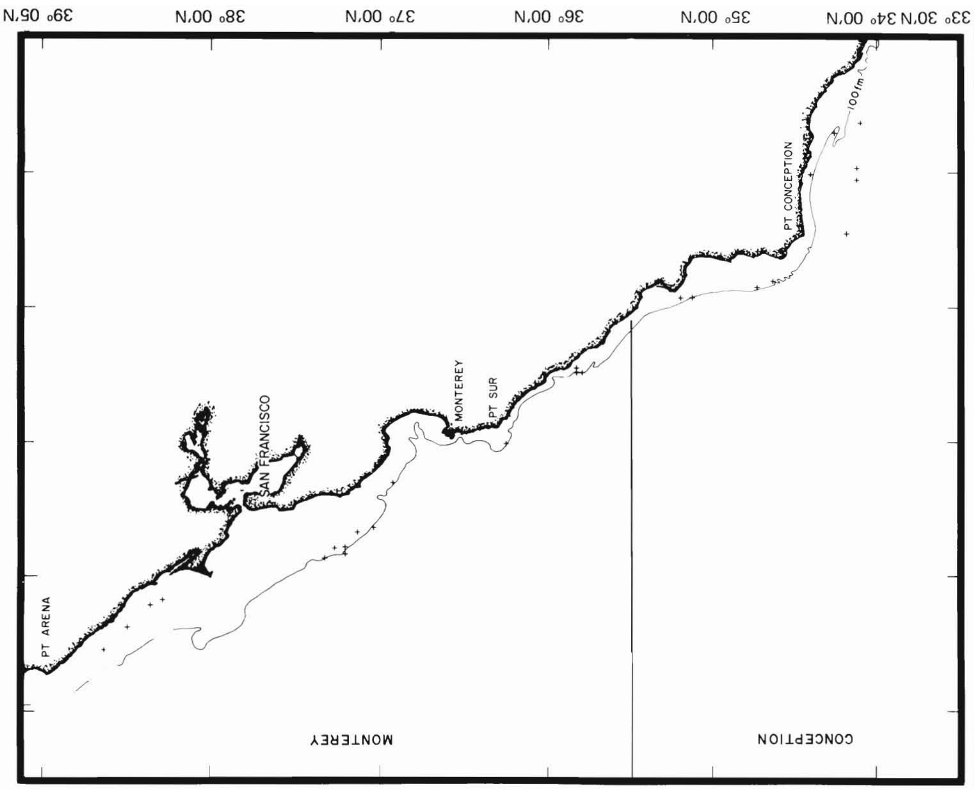

Figure 6.—Continued.

Age Composition

Bottom Trawl Survey

Figure 9 presents age composition by INPFC area. Pacific whiting spawn primarily between January and April so most ages are several months older than actually designated. Many otoliths contained an opaque margin beyond the last distinguishable annulus, indicating the passage of some time since the annulus was formed. In the Vancouver and Columbia areas, the population was dominated by 7-year-old whiting (1970 year class). However, even in those northern areas, where younger fish are relatively less abundant, there was an indication that the 1973 year class (age 4) may be unusually large. The 1973 year class was very abundant in the Eureka area and dominated in the Monterey area. In the Monterey area juvenile fish (less than age 4) composed a substantial portion of the population, and young-of-the-year (age 0) were present. In the Conception area, samples were dominated by age 0 specimens.

Table 4.—Hydroacoustic-midwater trawl survey estimates of Pacific whiting biomass by selected latitudinal subareas.

Sub-area no.[1]	N. latitude	No. of density estimates (kg/100m²)	Biomass Metric tons	Biomass Percent of total	95% C.I.
4	37°07'-38°49'	202	49,227	4.4	±25,705 (52.2%)
5	38°49'-40°16'	299	58,860	5.2	±20,758 (35.3%)
6	40°25'-41°47'	427	191,451	17.0	±60,156 (31.4%)
7	41°47'-43°00'	365	169,493	15.0	±47,710 (28.1%)
8	43°00'-44°08'	849	199,568	17.7	±65,879 (33.0%)
9	44°08'-45°00'	719	55,966	5.0	±14,441 (25.8%)
10	45°00'-45°50'	360	18,604	1.6	± 3,834 (20.6%)
11	45°50'-46°44'	341	26,776	2.4	± 3,415 (12.8%)
12	46°44'-47°30'	39	15,526	1.4	±10,358 (66.7%)
13	47°30'-48°26'	984	201,399	17.8	±77,549 (38.5%)
14	48°26'-49°26'	283	142,422	12.6	±30,808 (21.6%)
Totals			1,129,292	100.1	±136,375 (12.1%)

[1]Subareas 4-13 correspond to the biological sampling strata referred to by Gunderson and Sample (1980).

Percentage age composition was also analyzed by depth strata. Age data were not obtained for all area-depth strata and in the Vancouver and Eureka areas age compositions are available for only one stratum. In the Columbia area, there was a distinct tendency for younger fish (particularly age 4) to become more prevalent with increasing depth. A similar trend occurred in the age composition data from the Monterey area with age 0 and age 2 fish being most numerous in the deepest depth stratum sampled. The age-depth relationship in the Conception area was unclear. Whereas the relative abundance of 2-, 3-, and 4-year-old fish increased with increasing depth, the proportion of age 0 fish decreased markedly. Length frequency data (Table 5) suggest that there was a tendency for the relative abundance of younger fish to decrease with depth in the Vancouver area.

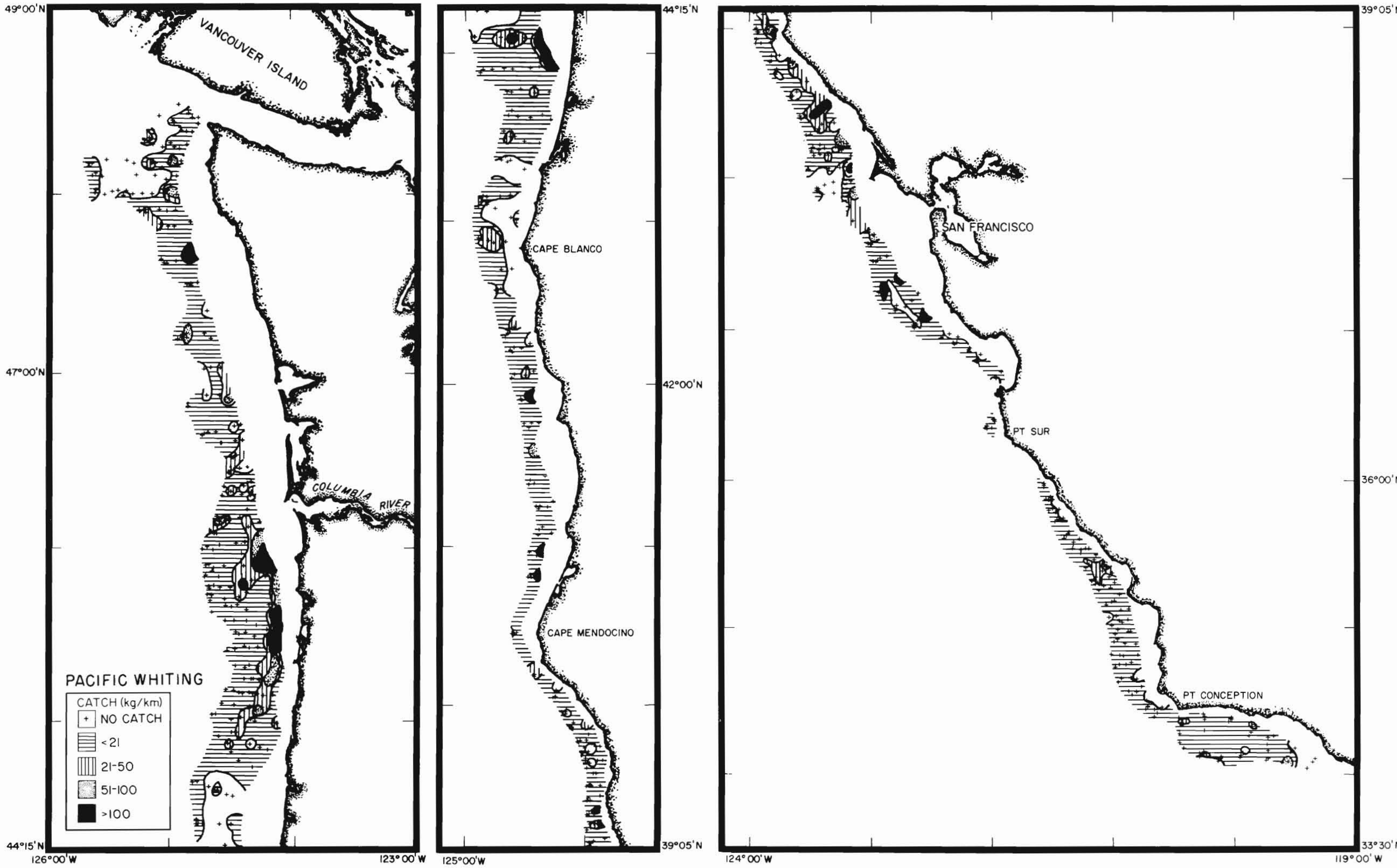

Figure 7.—Pacific whiting biomass density (kg/km) contours as determined from the bottom trawl survey.

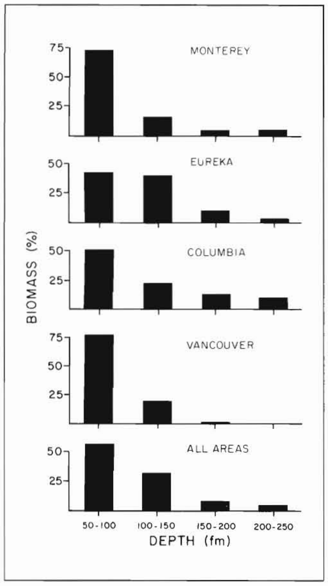

Figure 8.—Percentage distribution, by International North Pacific Fisheries Commission statistical area and depth, of hydroacoustic-midwater trawl survey whiting biomass estimates.

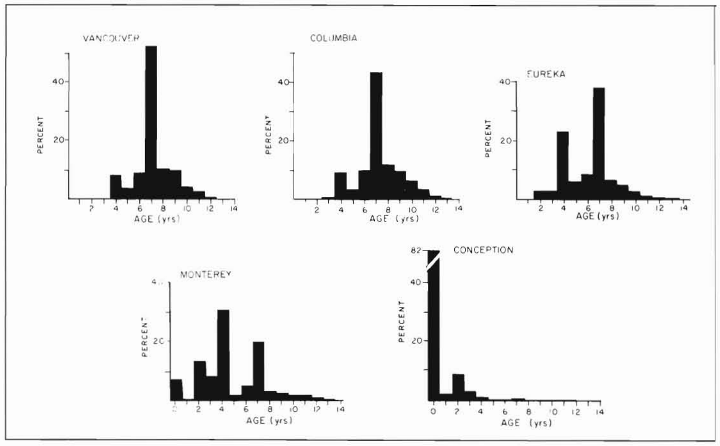

Figure 9.—Percentage age composition of Pacific whiting, by International North Pacific Fisheries Commission statistical area, as determined from bottom trawl samples.

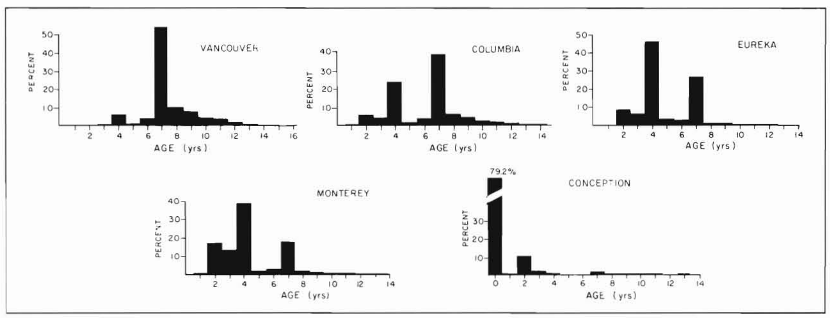

Figure 10.—Percentage age composition of Pacific whiting, by International North Pacific Fisheries Commission statistical area, as determined from midwater trawl samples.

Hydroacoustic-Midwater Trawl Survey

Percentage age composition from midwater trawl samples is presented in Figure 10. The trends in age composition by INPFC area generally parallel those from bottom trawl samples. The most notable differences occurred in the Columbia area, where a few 1- and 2-year-old whiting were present in midwater samples but absent in the bottom trawl samples; in the Eureka area, where 4-year-olds dominated in midwater samples instead of 7-year-olds; and in the Monterey area, where age 0 specimens were found in bottom trawl samples but not in midwater trawl samples.

Length Composition

Bottom Trawl Survey

Percentage length distributions by sex and INPFC area are shown in Figure 11. A north to south cline in mean

Table 5.—Mean lengths of bottom trawl caught whiting by sex, depth stratum, and International North Pacific Fisheries Commission (INPFC) statistical area.

	INPFC area				
Depth (fm)	Vancouver	Columbia	Eureka	Monterey	Conception
50-100					
Male	50.1	50.3	47.3	44.4	34.6
Female	52.1	51.7	48.8	46.7	34.2
Combined	51.5	51.1	48.1	[1]43.9	[1]11.3
100-150					
Male	52.1	50.3	44.7	43.3	28.3
Female	53.8	52.6	45.6	53.3	34.2
Combined	53.2	51.7	45.0	[1]46.2	[1]25.7
150-200					
Male	52.0	48.1	45.4	39.6	31.5
Female	55.4	49.1	47.4	43.7	37.6
Combined	54.6	48.6	46.5	[1]30.3	[1]31.8
200-260					
Male	—	47.2	48.2	41.2	32.4
Female	—	47.8	52.1	43.0	37.0
Combined	—	47.5	50.9	[1]36.6	[1]15.8
All depths					
Male	50.4	50.1	47.1	44.2	30.7
Female	52.5	51.6	48.6	47.0	35.1
Combined	51.8	50.9	48.0	[1]43.1	[1]14.0

[1]Includes unsexed age 0 specimens.

lengths is present in both sexes with the largest means occurring in the Vancouver area and the smallest in the Conception area. The range of observed lengths is smallest in northern samples and becomes wider in the more southern areas as younger fish were encountered. In the Monterey and Conception areas, age 0 whiting were commonly caught, but they are not included in the length distributions because their sex could not be determined.

There was no consistent trend between size and depth of capture. The average size increased with depth in the Vancouver area but tended to decrease with depth in the Columbia area (Table 5). In the more southern regions, the mean size fluctuated in a nonsystematic fashion with depth.

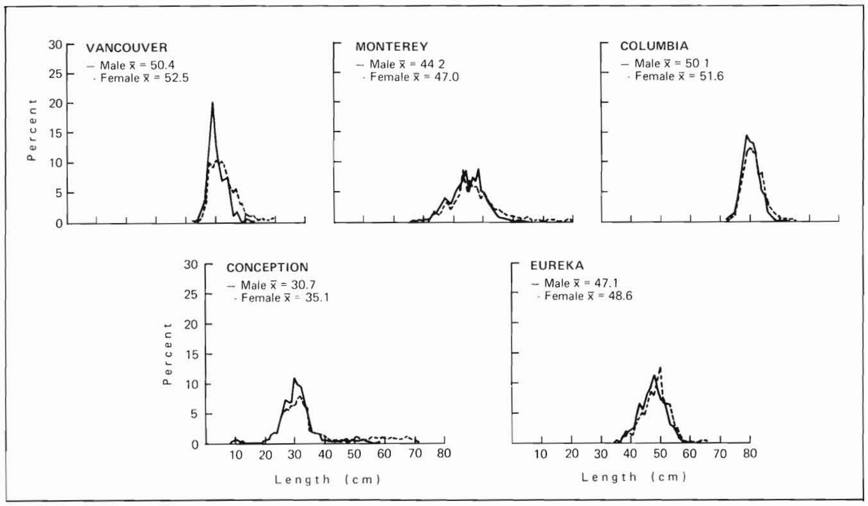

Figure 11.— Percentage length distribution and mean length of Pacific whiting, by sex and by International North Pacific Fisheries Commission statistical area, as determined from bottom trawl samples.

Hydroacoustic-Midwater Trawl Survey

Length compositions from midwater trawl catches were similar to those observed for bottom trawl samples (Fig. 12). Again, the greatest range of sizes occurred in the southern areas and the average size increased from south to north. In previous surveys (Dark and Nelson, footnote 1), there was a tendency for whiting caught in midwater to be somewhat smaller than those taken on or near the bottom. This phenomenon was observed again in the Columbia, Eureka, and Monterey areas, but the opposite situation occurred in the Vancouver and Conception areas.

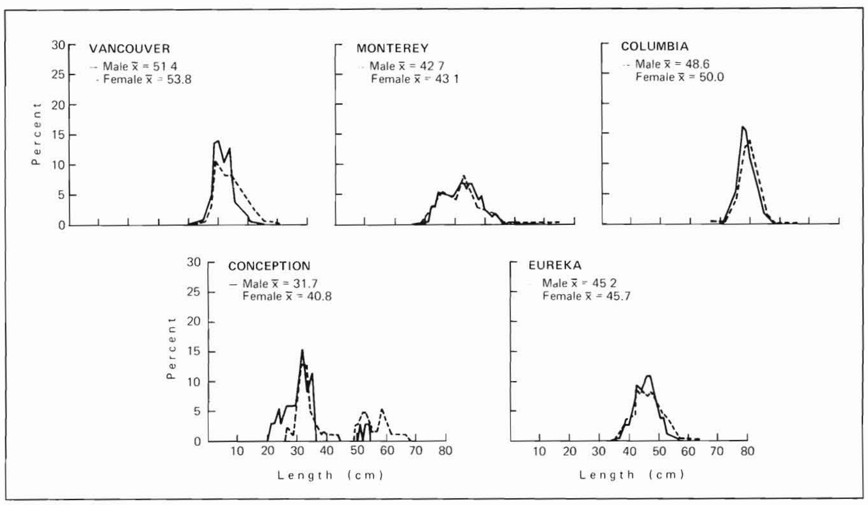

Figure 12.—Percentage length distribution and mean length of Pacific whiting, by sex and International North Pacific Fisheries Commission statistical area, as determined from midwater trawl samples.

Summary and Discussion

The 1977 survey provided a large amount of timely information on the size, geographical and vertical distribution, and biological composition of the Pacific whiting resource. This paper describes only the principal results of the survey. A more detailed analysis of the survey data, and of information available from the commercial fishery and surveys conducted in 1974 and 1975, could be significant in acquiring a better understanding of the distribution, availability, and dynamics of the resource.

During the 1977 survey, the latitudinal range of the species was covered more completely by the hydroacoustic-midwater trawl survey than by the bottom trawl survey which terminated at Cape Flattery. Also, over most of the survey area neither type of survey covered depths less than 50 fathoms (91 m). However, based on historical data and results from the hydroacoustic-midwater trawl survey north of Cape Flattery, it is not unreasonable to assume that the proportion of the total resource inhabiting the area inside the 50 fathom (91 m) isobath was relatively small. Also, since a very small proportion of the total biomass estimate for the resource was derived from trawling on the bottom, it is reasonable to conclude that the lack of bottom trawling north of Cape Flattery did not significantly influence survey results.

Table 6.—Combined bottom trawl survey and hydroacoustic-midwater trawl survey estimates of Pacific whiting biomass (t) by International North Pacific Fisheries Commission (INPFC) statistical area.

Item	Vancouver		Columbia		Eureka		Monterey		Conception		Total	
	t	%	t	%	t	%	t	%	t	%	t	%
Bottom trawl	6,560	1.9	32,917	9.4	9,501	2.6	18,266	14.5	2,396	100.0	69,640	5.8
Hydroacoustic	343,821	98.1	316,440	90.6	360,944	97.4	108,087	85.5	—	—	1,129,292	94.2
Area totals	350,381	100.0	349,357	100.0	370,445	100.0	126,353	100.0	2,396	100.0	1,198,932	100.0
Percent of total	29.2	—	29.1	—	30.9	—	10.5	—	0.2	—	99.9	—

The total Pacific whiting biomass estimate was 1,198,932 t (Table 6). Ninety-four percent of the total was estimated from the hydroacoustic-midwater trawl survey. The biomass was distributed almost evenly among the Vancouver, Columbia, and Eureka areas, with small fractions occurring in the Monterey and Conception areas. Both the midwater and on-bottom components of the resource were most abundant on the continental shelf. Fifty-eight percent of the biomass estimated by the hydroacoustic-midwater trawl survey and 87 percent of the bottom trawl survey estimate were inside the 100 fathom (183 m) isobath.

The 1977 biomass estimate is substantially larger than the generally comparable 1975 estimate of 444,974 t (Dark and Nelson, footnote 1). The more than twofold increase in biomass from 1975 to 1977 can be at least partially explained by the presence of what appears to be an unusually strong 1973 year class. Four-year-old hake were highly abundant in the Eureka and Monterey areas and were also a significant part of the population in more northern areas. This year class could be an important component of the population through 1980. The increase in biomass estimates between 1975 and 1977 cannot be fully ascribed to addition of the 1973 year class because other factors, such as changing availability to the capture gear and sampling variability, could also have resulted in the observed difference. The 1970 year class was very abundant, but it is 10 years old and the effects of fishing and natural mortality have reduced it to relatively low numbers.

Analysis of age data revealed the typical latitudinal stratification of ages, with fish less than age 4 only weakly represented or absent altogether in the northern part of the survey area. A comparison of age compositions in bottom trawl samples by depth showed a tendency for younger age groups to be more prevalent with increasing depth in the Columbia and Monterey INPFC areas, but length composition suggests an opposite trend in the Vancouver area. In the Eureka and Conception areas the trend is unclear, and, in general, there appear to be no consistent changes in age or length composition with bottom depth. A comparison of age compositions from bottom and midwater trawl samples showed they were basically similar. Observed differences were usually small and not consistent among areas.

A broader range of sizes was observed in the southern areas which reflects the presence of a greater number of age groups than in the north. Mean length, of course, increased from south to north as young whiting became relatively less abundant. There was no consistent trend in mean size with depth.

The survey demonstrated that it is not feasible to attempt to estimate either biomass or an index of abundance for the whiting resource from bottom trawl surveys alone. As opposed to the more than twofold increase in abundance estimated to have occurred between 1975 and 1977, the results of the bottom trawl surveys indicate a 66 percent decrease in abundance occurred during the 2-year period, i.e., the bottom trawl survey biomass estimates in 1975 and 1977 were 207,626 t and 69,640 t, respectively.

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Appendix I

Basic echo sounder system specifications and calibration data.

Item	Specifications: [1]System 1	Specifications: [2]System 2
Frequency	38 kHz	38 kHz
Transducer		
Dimensions	23 cm, circular	44 cm, circular
Material	barium titanate	barium titanate
Beam width (between-3dB pts.)		
Narrow beam	11°	6°
Wide beam	50°	25°
Directivity Index		
Narrow beam	22.6 dB	26.7 dB
Wide beam	12.0 dB	18.2 dB
Transmitter		
Type	Simrad EK 38 A	Instruments, Inc. (Model SPG-4B)
Nominal power output	1 kw	1 kw and 5 kw
Nominal pulse length	0.6 ms	0.6 ms
Pulse repetition rate	24, 48, and 96/min	60/min(selectable,1-99/min)
Receiver (TVG Amplifiers)		
Narrow beam (20 logR + 2αR)	Simrad EK 38A	Ithaco (custom design)
Narrow beam (40 logR + 2αR)	Simrad EK 38A	Ithaco (custom design)
Wide beam (40 logR + 2αR)	Simrad EK 38A	Ithaco (custom design)
TVG control	Analog	Digital
Echo recorder	Simrad EK 38A	Universal Graphics PGR
Towed V-fin	Braincon (4-ft)	Edo-Western Model 6315
Towing cable (faired)	2 cm; 13 conductors	2 cm; 13 conductors

Item	Calibration Data: [1]System 1	[1]System 1	[2]System 2	[2]System 2
Calibration date	6/30/77	9/6/77	9/8/77	10/3/77
Water temperature (°C)	18.8	19.8	19.8	16.0
Source level (dB//1 mpa at 1 m)	217.9	217.1	226.9	227.3
Transducer(narrow beam) transmitting sensitivity (dBmpa/V at 1 m)	169.4	168.6	173.4	173.7
Transducer receiving sensitivity (dBV/mpa)				
Narrow beam	−177.3	−176.8	−177.0	−177.3
Wide beam	−191.4	−190.9	−161.5	−161.8
System receiving sensitivity at 30 m (dBV/mpa)				
Narrow beam (20 logR + 2αR)	−138.8	−139.3	−155.4	−150.6[3]
Narrow beam (40 logR + 2αR)	−140.3	−141.0	−147.2	−151.2[3]
Wide beam (40 logR + 2αR)	−140.7	−140.5	−147.2	−146.8

[1]Used with data recording system during Port Hueneme, Calif., to Cape Flattery, Wash., part of survey.
[2]Used with computerized data recording and processing system during Cape Flattery to Kyuquot Bay, Vancouver Island, part of survey.
[3]System gain adjusted during survey.

Appendix II — Hydroacoustic System Calibration Methods

In addition to the calibration of specific system components, it is desirable to calibrate the entire system as a unit because different components of the system may affect the parameters of others. For example, the gain of a preamplifier may be affected by connecting a transducer to its input leads. Therefore, in addition to the transmitted power, the receiving response of the entire system is the primary calibration information required, i.e., what is the voltage detected by the computer, as a function of range, on each signal channel for a known signal intensity at the face of the transducer?

The following procedure is used to calibrate the system. The source level of the system is measured using standard calibration techniques. Using this source level, the intensity that would be returned from an acoustic target having a reference target strength (−30 dB) at a reference depth (30 m) is calculated (accounting for two-way spreading and absorption loss). A calibration transducer is then used to produce a sound pulse (equal in length to that used during data collection) of the calculated intensity at the transducer face. An internal calibration oscillator is then switched on and adjusted so that the resultant receiver output voltage at the reference depth equals that from the acoustic pulse. The calibration oscillator input signal to the receiver then corresponds to an echo from a target of the reference target strength at the reference depth. The output voltage of the receiver can then be monitored at all depths to determine changes in the system gain characteristics.

Time-varied-gain (TVG) characteristics for each receiver are measured using a computer program which samples the signal from the calibration oscillator at 1-m intervals. The system gain (G) at each sampling point is calculated by referencing the receiver output voltage to the input voltage from the calibration oscillator and, expressed in decibels:

$G = 20 \log_{10}(Vo/Vi)$, where Vo and Vi are output and input voltages, respectively. Deviations from the theoretically correct TVG are then determined by subtracting the actual, measured TVG values from the correct values. To be useful these deviations must be referenced to a particular point. This is accomplished by subtracting the TVG correction at a given point from all deviations. The deviation from ideal TVG is then 0 dB at the given point which serves as the reference point. The resultant TVG correction values (deviations from ideal TVG) thus obtained are independent of sounder gain. Since the calibration oscillator is set up to simulate a −30 dB target at 30 m, the usual procedure is to reference the TVG to 30 m.

In addition to the system calibration measurements made just prior to and after each part of the survey, possible variation in system performance was continuously, i.e., every 1.5 hours, measured at sea. This was done by measuring (and tape recording as a back-up procedure) the output of a known signal input to each receiver's preamplifier. This allowed any change in system gain or TVG characteristics to be readily detected. The known signal input was supplied by a calibration oscillator which was an integral part of both systems.

Appendix III

Summary of trawl station and catch data for hydroacoustic/midwater trawl survey.

		Start position							Catch (lb) of selected species (T = catch < 1 lb)															
										Rockfish														
Haul no.	Date	Lat(N)	Long(W)	INPFC area	Time of day (h: PDT)	Av. depth (fm) gear/ bottom	Duration (h)	Distance fished (n. mi.)	Pac. whiting	Bocaccio	Chilipepper	Shortbelly	Splitnose	Canary	Yellowtail	Pac. ocean perch	Widow	Redstripe	N. anchovy	Eulachon	Pac. herring	Walleye pollock	Spiny dogfish
1	7/20	34°06′	119°40′	Conception	1400	120/125	0.9	3.4	29	—	—	37	—	—	—	—	—	—	T	—	—	—	T
2	7/20	34°15′	119°45′	Conception	0000	99/100	0.5	1.7	8	8	2	8	T	—	—	—	—	—	T	—	—	—	—
3	7/21	34°07′	119°59′	Conception	0700	77/82	0.5	1.9	—	—	—	—	—	—	—	—	—	—	100	—	—	—	—
4	7/21	34°07′	120°04′	Conception	1400	140/160	0.5	1.4	4	—	—	—	—	—	—	—	—	—	43	—	—	—	—
5	7/22	34°23′	120°00′	Conception	0200	125/140	0.7	2.5	13	3	—	—	2	—	—	—	—	—	T	—	—	—	1
6	7/22	34°10′	120°28′	Conception	1100	65/70	0.8	2.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7	7/22	34°42′	120°52′	Conception	2300	97/99	1.0	3.5	13	13	114	10	—	—	—	—	2	—	—	—	—	—	11
8	7/23	34°38′	120°49′	Conception	0400	64/71	0.3	0.8	4	3	2	T	—	—	—	—	—	—	—	—	—	—	—
9	7/23	35°07′	120°56′	Conception	1500	95/104	0.3	0.8	46	—	3	5	—	—	—	—	—	—	—	—	—	—	—
10	7/24	35°10′	120°56′	Conception	0100	89/92	1.0	3.2	120	17	3	90	22	—	—	—	—	—	—	—	—	—	292
11	7/24	35°44′	121°29′	Monterey	1300	35/250	0.9	3.1	—	T	—	2	—	—	—	—	—	—	—	—	—	—	—
12	7/24	35°47′	121°27′	Monterey	1700	49/54	0.8	2.3	—	—	—	—	—	—	8	—	—	—	—	—	—	—	—
13	7/25	35°47′	121°29′	Monterey	0200	116/120	0.5	1.7	240	—	—	—	27	—	—	—	—	—	—	—	—	—	4
14	7/25	36°16′	122°01′	Monterey	1000	65/100	1.2	3.7	—	250	—	—	—	—	287	—	33	—	—	—	—	—	—
15	7/26	36°55′	122°19′	Monterey	1400	145/165	0.2	0.5	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16	7/26	37°08′	122°43′	Monterey	2100	154/160	1.0	3.2	620	—	—	18	468	—	—	—	—	—	—	—	—	—	1
17	7/27	37°03′	122°40′	Monterey	0400	172/181	1.0	3.0	219	—	—	T	240	—	—	—	2	—	—	—	—	—	—
18	7/27	37°13′	122°48′	Monterey	1000	134/135	0.5	1.8	924	41	58	8,931	—	—	—	—	—	—	—	—	—	—	—
19	7/27	37°21′	122°52′	Monterey	1700	103/105	0.5	1.7	20	—	—	7,880	—	—	—	—	—	—	—	—	—	—	—
20	7/27	37°16′	122°49′	Monterey	2300	74/102	0.7	1.8	65	6	—	792	—	—	—	—	—	—	—	—	—	—	—
21	7/28	37°14′	122°50′	Monterey	0200	125/155	0.6	1.6	17	—	—	5	—	—	—	—	—	—	—	—	—	—	—
22	7/29	38°15′	123°10′	Monterey	1400	52/53	0.3	0.9	10,450	6	—	—	—	—	—	—	—	—	—	—	—	—	51
23	7/29	38°21	123°13′	Monterey	0000	40/51	2.0	6.2	457	17	—	—	—	—	—	—	—	—	—	—	—	—	166
24	7/30	38°30′	123°34′	Monterey	1000	59/64	0.4	1.3	7,340	21	—	—	—	—	—	—	—	—	—	—	14	—	552
25	7/31	38°37′	123°33′	Monterey	0100	46/63	2.0	6.8	99	—	—	—	—	—	—	—	—	—	—	—	T	—	110
26	7/31	39°11	123°54′	Monterey	1300	77/80	1.0	2.9	487	—	—	—	—	74	—	—	—	—	—	—	—	—	12
27	8/1	39°05′	123°57′	Monterey	0100	129/133	0.5	1.8	46	6	213	34	46	—	—	—	—	—	—	—	—	—	—
28	8/1	39°23′	123°57′	Monterey	0500	134/138	0.5	1.2	199	—	—	—	2	—	—	—	—	—	—	—	—	—	—
29	8/1	39°31	123°58′	Monterey	0900	172/177	0.2	0.7	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
30	8/1	40°07′	124°20′	Monterey	1900	104/160	0.8	2.6	927	—	—	—	—	—	—	—	—	—	—	—	—	—	2
31	8/2	40°08′	124°17′	Monterey	0600	78/145	0.3	1.3	343	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32	8/2	40°21	124°38′	Monterey	1400	90/160	0.4	1.2	2,308	—	—	—	—	—	—	—	—	—	—	—	—	—	17
33	8/3	40°44	124°17′	Eureka	0400	48/51	0.6	1.9	1,207	—	—	—	—	5	—	—	60	—	—	—	—	—	268
34	8/3	41°07′	124°21	Eureka	1000	60/82	0.3	1.2	100	—	—	—	—	—	—	—	—	—	—	—	—	—	—
35	8/3	40°57′	124°24	Eureka	2100	54/100	0.6	2.0	347	—	—	—	—	—	2	—	12	—	—	—	—	—	29
36	8/4	40°58′	124°21	Eureka	0300	44/68	1.5	5.3	1,685	—	—	—	—	—	—	—	—	—	—	—	—	—	62
37	8/4	40°59′	124°24′	Eureka	0800	68/100	0.8	1.8	1,353	—	—	—	—	—	6	—	—	—	—	—	—	—	36
38	8/11	41°23′	124°30′	Eureka	1400	94/127	0.5	1.7	1,282	—	—	—	—	—	—	—	—	—	—	—	—	—	—
39	8/11	41°44′	124°24′	Eureka	2200	52/60	0.5	1.5	286	—	—	—	—	4	—	—	—	—	—	T	—	—	—
40	8/12	41°24′	124°27′	Eureka	0300	67/74	0.7	1.9	104	—	—	—	—	5	—	—	3	—	—	—	—	—	3
41	8/12	42°16′	124°35′	Eureka	1400	88/95	0.2	0.8	2,923	—	—	—	—	—	—	—	—	—	—	—	—	—	27
42	8/12	42°25′	124°42′	Eureka	2200	47/56	1.1	3.8	77	—	—	—	—	—	5	—	155	—	—	—	—	—	1
43	8/13	42°27′	124°38′	Eureka	0300	43/50	0.5	1.6	—	—	—	—	—	—	—	—	—	—	—	4	—	—	—
44	8/13	42°43′	124°36′	Eureka	0900	53/54	0.6	1.8	—	—	—	—	—	—	—	—	—	—	—	13	T	—	—
45	8/13	43°00′	124°48′	Eureka	1500	82/84	0.7	2.4	66	—	—	—	—	—	8	—	—	4	—	T	—	—	—
46	8/13	43°00′	124°48′	Eureka	2200	75/80	0.6	1.6	203	—	—	—	—	—	39	—	—	14	—	10	—	—	—
47	8/14	43°25′	124°35′	Columbia	2300	71/80	0.8	2.6	798	—	—	—	—	22	80	—	29	2	—	—	—	—	—
48	8/15	43°45′	124°28′	Columbia	1400	71/72	0.5	1.5	2	15	—	4	—	—	5	—	13	316	—	—	—	—	—
49	8/15	43°46′	124°20′	Columbia	1800	57/60	0.6	1.8	409	—	—	—	—	—	—	—	—	1	—	T	T	—	—
50	8/16	43°52′	124°26′	Columbia	0200	49/53	0.4	0.9	668	—	—	—	—	3	39	—	1,005	—	—	—	—	—	—
51	8/17	44°12′	124°55′	Columbia	1100	77/79	0.6	2.1	—	—	—	—	—	—	—	—	—	4	—	—	—	—	—
52	8/17	44°12′	124°58′	Columbia	1400	141/151	0.4	1.3	431	—	—	—	—	—	—	—	—	—	—	—	—	—	—
53	8/18	44°00′	124°43′	Columbia	0100	39/64	0.6	2.6	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
54	8/18	44°01	124°44′	Columbia	0400	34/64	0.7	2.3	2	—	—	—	—	—	—	—	—	—	—	2	—	—	—
55	8/18	44°46′	124°35′	Columbia	2100	54/100	1.0	3.5	3	—	—	—	—	—	—	—	—	—	—	1	—	—	—
56	8/18	44°49′	124°34′	Columbia	0000	133/136	1.0	2.7	119	—	—	—	T	—	—	—	—	—	—	—	—	—	—
57	8/19	44°47′	124°34	Columbia	1500	116/118	1.8	5.3	246	—	—	—	—	—	—	—	—	—	—	—	—	—	—
58	8/20	44°52′	124°32′	Columbia	0300	145/150	1.0	2.8	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—
59	8/21	44°50′	124°33′	Columbia	0000	148/152	2.3	6.0	94	—	—	—	2	—	—	—	—	—	—	—	—	—	—
60	8/21	45°22′	124°16′	Columbia	1100	88/98	0.7	2.3	26	—	—	—	—	—	—	—	—	—	—	6	—	—	—

Appendix III.-Continued.

Haul no.	Date	Start position Lat(N)	Start position Long(W)	INPFC area	Time of day (h; PDT)	Av. depth (fm) gear/bottom	Duration (h)	Distance fished (n. mi.)	Pac. whiting	Rockfish: Bocaccio	Rockfish: Chilipepper	Rockfish: Shortbelly	Rockfish: Splitnose	Rockfish: Canary	Rockfish: Yellowtail	Rockfish: Pac. ocean perch	Rockfish: Widow	Rockfish: Redstripe	N. anchovy	Eulachon	Pac. herring	Walleye pollock	Spiny dogfish
									Catch (lb) of selected species (T = catch<1 lb)														
61	8/21	45°30′	124°18′	Columbia	1700	99/100	0.7	2.3	928	—	—	—	—	—	—	—	—	—	—	2	—	—	—
62	8/22	45°32′	124°12′	Columbia	0400	58/74	0.5	1.8	23	—	—	—	—	—	—	—	520	—	—	1	—	—	4
63	8/22	45°41	124°25′	Columbia	1200	105/107	1.2	3.6	1,094	—	—	—	—	—	—	—	—	—	—	13	—	—	—
64	8/22	45°52′	124°33′	Columbia	2300	62/74	0.8	2.8	—	—	—	—	—	—	—	—	28	—	—	—	—	—	—
65	8/23	45°53′	124°34′	Columbia	0300	56/84	0.8	2.9	2	—	—	T	—	—	—	—	7	—	—	4	—	—	—
66	8/23	45°58′	124°32′	Columbia	1200	85/86	1.0	3.9	1,156	—	—	—	—	—	—	1	2	—	—	17	—	—	—
67	8/24	46°13′	124°28′	Columbia	0100	63/83	1.0	3.0	199	35	—	—	—	—	1,580	—	2,988	150	T	T	—	—	3
68	8/24	46°40′	124°40′	Columbia	1800	80/81	0.1	0.4	30	—	—	—	—	—	13	—	—	—	—	8	—	—	—
69	8/25	46°29′	124°27′	Columbia	0300	65/70	1.0	3.0	74	—	—	—	—	2	63	—	540	—	—	T	T	-	—
70	8/25	44°44′	124°35′	Columbia	0900	71/73	0.6	2.1	8,970	—	—	—	—	—	14	—	29	—	—	7	—	—	—
71	8/26	46°59′	124°58′	Columbia	0000	85/90	1.0	3.3	48	41	—	—	—	—	374	—	1,070	79	—	—	—	—	5
72	8/26	47°08′	124°43′	Columbia	1900	60/61	0.8	2.6	13	—	—	—	—	—	37	—	—	—	—	11	14	—	—
73	8/27	47°12′	124°53′	Columbia	0100	91/95	1.0	3.5	244	16	—	—	—	5	135	—	—	—	—	T	—	—	1
74	8/27	47°23′	124°46′	Columbia	0400	68/74	0.8	2.9	176	—	—	—	—	7	17	—	—	—	—	—	1	—	—
75	8/27	47°37′	124°56′	Vancouver	1000	80/83	0.1	0.3	497	—	—	—	—	—	3	—	—	—	—	2	T	—	—
76	8/27	48°00′	124°59′	Vancouver	1900	57/65	1.0	4.3	2,826	—	—	—	—	—	51	—	140	—	—	—	—	—	2
77	8/28	47°52′	125°02′	Vancouver	0200	81/82	0.7	3.1	95	—	—	—	—	30	502	—	—	—	—	—	—	7	6
78	8/28	48°04′	125°32′	Vancouver	1100	94/95	0.7	2.8	—	—	—	—	—	16	137	—	2,736	16	—	160	1,464	—	—
79	8/28	48°10′	125°33′	Vancouver	1600	78/80	1.5	5.0	—	—	—	—	—	—	—	—	—	—	—	—	6,400	—	—
80	8/29	48°13′	125°05′	Vancouver	0200	63/67	0.7	2.7	24	—	—	—	—	—	1	—	62	—	—	T	3	11	—
81	8/29	48°18′	125°25′	Vancouver	1600	74/75	1.7	5.0	11,233	—	—	—	—	—	165	—	214	115	—	—	16	1,414	6,809
82	8/30	48°21′	125°15′	Vancouver	1300	82/100	1.0	3.4	256	—	—	—	—	—	5	—	—	—	—	—	—	23	—
83	8/30	48°28′	124°54′	Vancouver	2100	95/105	0.7	2.6	184	—	—	—	—	—	35	—	3	—	—	—	—	499	1,286
84	9/11	48°21′	125°10′	Vancouver	1900	67/102	1.0	3.4	362	—	—	—	—	—	6	—	—	—	—	T	—	102	—
85	9/12	48°20′	125°11′	Vancouver	0400	41/91	1.0	3.4	132	—	—	—	—	—	3	—	—	—	—	—	—	126	48
86	9/12	48°20′	125°16′	Vancouver	1700	68/112	0.7	2.3	117	—	—	—	—	—	—	—	—	—	—	1	—	279	—
87	9/13	48°21′	125°14′	Vancouver	0200	44/101	1.5	4.9	408	—	—	—	—	—	3	—	—	—	—	—	—	456	11
88	9/13	48°16′	125°08′	Vancouver	1000	40/69	1.0	3.5	196	—	—	—	—	—	3	—	—	—	—	T	—	11	36
89	9/14	48°13′	125°08′	Vancouver	0100	51/71	0.9	3.1	161	—	—	—	—	—	139	—	6	—	—	—	—	2	4
90	9/14	48°17′	125°08′	Vancouver	1800	56/81	0.4	1.7	456	—	—	—	—	—	10	—	—	—	—	—	—	27	—
91	9/15	48°18′	125°03′	Vancouver	0300	54/98	0.6	1.7	685	—	—	—	—	—	—	—	—	—	—	—	T	143	18
92	9/15	48°09′	125°30′	Vancouver	1500	79/85	1.0	3.2	3,869	—	—	—	—	—	5	—	—	—	—	46	31	—	·311
93	9/16	48°13′	125°34′	Vancouver	0500	65/85	0.7	3.0	100	—	—	—	—	—	5	—	—	—	—	T	T	11	10
94	9/18	48°19′	125°15′	Vancouver	0300	45/98	1.0	3.3	35	—	—	—	—	—	—	—	—	—	—	—	—	16	6
95	9/18	48°26′	125°33′	Vancouver	1200	50/65	0.7	1.8	6	—	—	—	—	—	—	—	—	—	—	—	—	4	—
96	9/18	48°32′	125°21′	Vancouver	2100	50/65	1.5	4.6	514	—	—	—	—	—	134	—	—	117	—	3	T	97	—
97	9/19	48°32′	125°36′	Vancouver	0300	36/43	1.5	5.2	3,137	—	—	—	—	—	3	—	—	—	—	—	5	5	1,033
98	9/19	48°32′	126°01′	Vancouver	1000	70/75	0.2	0.4	4,433	—	—	—	—	—	—	—	—	—	—	—	—	32	—
99	9/20	48°34′	125°31′	Vancouver	0100	33/64	1.5	5.1	741	—	—	—	—	—	18	—	—	—	—	—	—	63	6
100	9/20	48°37′	125°35′	Vancouver	0500	32/71	1.5	4.2	1,859	21	—	—	—	—	—	—	—	—	—	T	—	69	9
101	9/21	48°40′	125°43′	Vancouver	0900	57/83	0.5	2.1	41	—	—	—	—	—	203	—	9	—	—	—	—	5	28
102	9/22	48°43′	125°37′	Vancouver	0400	37/60	1.5	5.0	594	—	—	—	—	—	19	—	—	—	—	2	1	7	663
103	9/22	48°48′	126°26′	Vancouver	2100	121/126	1.0	3.8	11	—	—	—	1	—	—	21	—	—	—	—	—	2	—
104	9/23	48°52′	126°11	Vancouver	0200	54/60	1.5	5.7	89	—	—	—	—	13	43	3	—	—	—	1	—	—	—
105	9/23	49°02′	126°13′	Vancouver	1400	48/54	1.0	3.7	404	—	—	—	—	—	5	—	—	—	—	1	T	2	5
106	9/23	49°02′	126°40′	Vancouver	2100	94/98	1.1	4.1	120	—	—	—	—	43	—	—	2	230	—	1	—	—	2
107	9/24	49°06′	126°42′	Vancouver	0900	72/81	0.2	1.0	4	—	—	—	—	—	—	—	—	—	—	5	1	—	—
108	9/24	49°17′	126°28′	Vancouver	1900	77/89	0.5	1.7	—	8	—	—	—	—	T	—	—	—	—	T	T	—	—
109	9/25	49°14′	126°43′	Vancouver	0200	45/60	2.0	6.6	2	—	—	—	—	—	26	—	—	—	—	1	—	—	—
110	9/25	49°22′	126°58′	Vancouver	2100	64/74	1.6	5.6	—	—	—	—	—	—	5	—	—	—	—	T	T	—	—
111	9/26	49°21	127°00′	Vancouver	0000	60/76	1.5	5.2	—	—	—	—	—	—	88	—	—	—	—	1	—	—	4
112	9/26	49°45′	127°22′	Vancouver	2300	46/48	0.5	1.8	—	—	—	—	—	5	32	—	—	—	—	T	T	—	—
113	9/27	48°04′	125°36′	Vancouver	1300	95/96	1.1	4.0	—	—	—	—	—	—	2	—	—	—	—	T	117	—	—
114	9/27	48°13′	125°35′	Vancouver	2300	89/90	1.0	3.3	410	—	—	—	—	—	128	—	1,242	25	—	—	—	—	—
115	9/28	48°06′	125°35′	Vancouver	0600	77/89	1.0	3.6	2	—	—	—	—	—	—	—	—	—	—	—	T	—	—
116	9/28	48°01	125°38′	Vancouver	1000	146/151	1.0	3.4	304	—	—	—	—	—	—	13	—	—	—	—	—	18	—