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A Hydroacoustic Survey of Pacific Hake on the Continental Shelf off British Columbia from the Canada/U.S. Boundary to Queen Charlotte Sound: August 13 to 28, 1991

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A HYDROACOUSTIC SURVEY OF PACIFIC HAKE ON THE CONTINENTAL SHELF OFF BRITISH COLUMBIA FROM THE CANADA/U.S. BOUNDARY TO QUEEN CHARLOTTE SOUND: AUGUST 13 TO 28, 1991

by

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ABSTRACT

Cooke, K., R. Kieser, M. W. Saunders, W. T. Andrews, and M. S. Smith. 1992. A hydroacoustic survey of Pacific hake on the continental shelf off British Columbia from the Canada/U.S. Boundary to Queen Charlotte Sound: August 13 to 28, 1991. Can. Manuscr. Rep. Fish. Aquat. Sci. 2174: 40 p.

A hydroacoustic survey for Pacific hake was conducted off the lower west coast of Vancouver Island and into Queen Charlotte Sound from August 13 to 28, 1991. Total and hake biomass estimates are given for the survey area. Summary information of associated midwater trawl catches is included. Acoustic biomass estimates from research conducted on the influence of environmental factors on hake distribution are reported. Successive passes were made over a 350 km^2 grid to compare day and night acoustic biomass, observe fish distribution and diel behavior patterns, examine variability in acoustic abundance estimation and obtain information on optimal survey procedures.

Key words: Hydroacoustic survey, Pacific hake, echo integration, biomass, abundance, distribution, behaviour.

RÉSUMÉ

Cooke, K., R. Kieser, M. W. Saunders, W. T. Andrews, and M. S. Smith. 1992. A hydroacoustic survey of Pacific hake on the continental shelf off British Columbia from the Canada/U.S. Boundary to Queen Charlotte Sound: August 13 to 28, 1991. Can. Manuscr. Rep. Fish. Aquat. Sci. 2174: 40 p.

Du 13 au 28 août 1991, on a effectué un relevé hydroacoustique du merlu du Pacifique près de la partie inférieure de la côte ouest de l'île de Vancouver et dans le détroit Reine-Charlotte. Les estimations de la biomasse totale et de la biomasse de merlu sont indiquées pour la zone à l'étude. Des renseignements sommaires sur les prises associées effectuées par chaluts pélagiques sont inclus. On indique des estimations de la biomasse réalisées par des méthodes acoustiques, obtenues à partir de recherches sur l'influence de facteurs environementaux sur la répartition du merlu. Des passages successifs sur une grille de 350 km^2 ont permis de comparer la biomasse diurne et nocturne, d'observer la répartition des poissons et les profils nycthéméraux de comportement, d'étudier la variabilité de l'estimation de l'abondance et d'obtenir des informations sur les méthodes permettant d'optimaliser les relevés.

Mots-clés: Relevé hydroacoustique, merlu du Pacifique, écho-intégration, biomasse, abondance, répartition, comportement.

INTRODUCTION

Pacific hake (*Merluccius productus*) is a migratory species that spawns annually in U.S. waters off California and feeds during summer months from northern California to Queen Charlotte Sound. Hake in Canadian waters tend to be larger and predominantly female.

Pacific hake is a valuable resource that is harvested by annual fisheries in the U.S. and Canada. Pacific hake were underutilized in the past, however in recent years quotas have been fully subscribed. Hydro-acoustic estimates of abundance of this stock are used in assessments and in studies of the factors influencing distribution.

The first Canadian quantitative hydroacoustic survey to determine the distribution and abundance of Pacific hake off southwest Vancouver Island was conducted in 1983 (Barner et al. 1984). From 1987 through 1989, qualitative surveys to examine the distribution and biology of hake from the Canada/U.S. border to Queen Charlotte Sound were carried out (M. Saunders, unpublished data). Results from these surveys indicate substantial hake concentrations from the Canada/U.S. border, northward along the west coast of Vancouver Island to Triangle Island and into Goose Island Gully in Queen Charlotte Sound. The presence of signatory strong year-classes, not found in local populations, indicated that these hake were part of the migratory offshore stock. In 1990, the first quantitative survey of this larger area was conducted (Saunders et al., in press). This report describes the 1991 follow-up survey of the area. The primary objective of the 1991 survey was to determine the distribution and abundance of hake in the study area. Mid-water trawls were conducted to verify acoustic targets and to examine the hake size distributions and age compositions as a function of latitude.

Hake distributions were also examined in relation to plankton aggregations and oceanographic parameters. Additional research examined hake behaviour, acoustic survey strategy and variability in acoustic abundance estimation.

This report includes a description of the study areas, survey designs, hydroacoustic data acquisition system, analysis procedures, and fishing results. Acoustic biomass estimates and distribution maps for all fish species and for Pacific hake are presented. Catch composition and biological information for Pacific hake from trawl catches are provided.

MATERIALS AND METHODS

The survey was conducted August 13 to 28, 1991 from the R/V W.E. RICKER, a 58 m, 2500 h.p. research trawler. The survey design and instrumentation were similar to those used in earlier surveys (Barner et al. 1984; Kieser 1983).

SURVEY AREA

The overall survey area extended from the Canada/U.S. boundary (approximately 48° 15') to 51° 35' north latitude and from the 50 to the 300 m depth contour. This area includes the traditional Canadian hake fishing area between 48° 15' and 49° as well as northern areas where earlier surveys indicated the presence of hake.

The survey area was divided into three major transect groups. 'A' and 'B' series transects cover the near shore area of southwest Vancouver

Island (Figure 1a). 'C' series transects extended the coverage from Barkley Sound to Queen Charlotte Sound (Figure 1b). A grid of east/west parallel transects was used for the 'A' and 'B' series. The distance between transects was 3.62 km (2.5 nm). Previous sounding surveys indicated that in areas north of the La Perouse region hake are generally found in an intermittent band along the 200 m shelf-break (Saunders et al. in press). In this region, the 'C' series, zig-zag transects maximized the northward progression and the number of times the shelf-break was crossed. The survey was conducted during daylight hours only, approximately 0600 to 2100 PDT.

ADDITIONAL RESEARCH

Two additional experiments were conducted to examine: 1) the distribution of hake in relation to plankton aggregations and oceanographic parameters such as temperature, salinity, and currents (joint work with Dr. D. Mackas, Institute of Ocean Sciences, Sidney, B.C.); 2) small scale variation in distribution patterns and diel behaviour of hake; and 3) variability in acoustic abundance estimation.

The first experiment was conducted August 15 and 16 to confirm the proximity between hake and plankton concentrations, and to examine related oceanographic parameters. Two study areas covered by the 'SA' and 'SB' series were identified (Fig. 1c). Each series consisted of 2 transects, 2.3 km (1.25 nm) apart, ranging in length from 18.8 to 27.5 km, and covering an area of about 50 km^2 each. Data were collected over a 12 h period from successive passes along each transect series.

Two vessels were employed for data collection. The R/V PARIZEAU collected 100 kHz acoustic data to map concentrations of macrozpooplankton. An acoustic current profiler was used to collect three-dimensional ocean current data for the entire water column along the track of the vessel. In addition, stations were occupied to collect plankton samples and CTD profiles.

The second vessel, the R/V W.E. RICKER collected soundings at 38 kHz to characterize and quantify hake distributions. Two fishing sets were also carried out from the W.E. RICKER to confirm the echo traces as hake. The W.E. RICKER followed the PARIZEAU at about 500 m (0.25 nmi) distance to obtain comparable data sets.

A second experiment was conducted from the W.E. RICKER to obtain information on diel distribution patterns of hake and on spatial and temporal variability of acoustic abundance estimates. Data were collected from a day and a night pass over a series of 7 short transects, spaced at about 1.85 km (1.0 nm) intervals and ranging in length from about 7 to 19.2 km ('T' Series, August 20-21, Figure 1c). A subset of two transects from this series was monitored at dusk and dawn to observe hake behaviour during the day-night and night-day transitions. 'T0' was covered three times from dusk to full darkness and 'T6' was repeated four times from about 1 h before until about 1 h after sunrise.

DATA ACQUISITION and ANALYSIS

The calibrated echo integration system was installed on the W.E. RICKER. The "dry end" consisted of a BioSonics 38 kHz echo sounder, a BioSonics chart recorder, a BioSonics digital echo integrator, a PCM/VCR tape recording system and auxiliary equipment. The "wet end" included a towed body with a Simrad ceramic transducer and armoured tow cable. The echo integrator was programmed to analyze the return echoes for a series of strata (range slices) starting just below the transducer and continuing to bottom. Bottom tracking was obtained with a 5 m bottom buffer. An echo integration sequence was completed every 60 pings (1 minute) and the measured echo intensities were stored on a personal computer. The echo integrator and chart recorder thresholds were set to 0.2 V. Thus all integrated echoes were displayed on the echogram. At this low threshold level some noise pulses caused by the increasing time-varied gain were visible on the deeper portions of the echogram. Significant noise levels were excluded during the analysis. These included flow and vessel noise, as well as noise from the navigational sounder and porpoises in the vicinity of the towed body. Standard data acquisition and analysis procedures were used (Burczynski 1982; Clay and Medwin 1977; Forbes and Nakken 1972; Kieser et al. 1987). Appendix 1 outlines the echo integration equation, system calibration constants and values used in estimation of fish density. A target strength of -35 dB/kg was used for hake and -32 dB/kg for all species other than hake, to calculate surface density and biomass estimates.

Figure 2 illustrates a typical echogram that was recorded at the shelf break. Horizontal range, vertical sequence and short minute marks are indicated by the solid lines. The dashed vertical lines represent event marks. Bottom tracking is monitored by a line paralleling the bottom. Although not visible in Figure 2, a surface echo occasionally appears between 10 and 25 m range. This signal is used to estimate the depth of the towed body and transducer. It is excluded from the analysis to avoid an inflated biomass estimate. The range of the surface echo is added to the target range shown on the echogram to estimate target depth. Typical diurnal rockfish schools are shown at a range of 80 to 120 m just at the shelf break. Hake appear between 70 and 140 m in a dense band that continues outward from the shelf break; plankton are indicated by a diffuse scattering layer that starts at the shelf break.

Estimation of biomass by species requires target identification. Targets observed on the echogram were classified according to the following criteria: In the day, hake schools form cone-like clusters which produce a zig-zag pattern across the echogram as illustrated in Figure 2. At dusk, dawn, and at night, Pacific hake disperse to form layers of single fish, over a considerable depth range. Potentially confusing species include pollock, herring, rockfish and dogfish. Pollock are mixed with the hake and, while they cannot be separately identified, test fishing showed that, in this survey, pollock contributed very little to hake schools. Herring are often characterized by dense 'haystack-type' schools near the bottom or 'needle shaped' schools in mid-water. Column-like schools just beyond the shelf break or near steep slopes or pinnacles often indicate rockfish (Figure 2). Unless densely schooled, the target strength of dogfish is so low that they generally appear as a haze on the echogram and contribute relatively little to the measured echo intensity. Trawl catch information was also used for target identification.

The integrated output was processed with custom software to exclude ocean bottom, noise, and echoes from unwanted sources in the water column. All echoes from fish-like targets were included in the analysis to obtain total (all species) surface density measurements along each transect. Surface densities were expanded to cells bounded by equidistant lines between adjacent transects and by lines perpendicular to and midway between each measurement along a transect. An estimate of the total fish biomass was obtained by summing the product of surface densities and cell areas.

FISHING SURVEY

Test fishing sets were carried out from the W.E. RICKER to obtain species composition for verification of echogram interpretations and to obtain biological information. Trawl gear consisted of a Canadian Diamond-7 midwater mesh trawl with 13.5 m vertical opening and 3.8 cm cod end mesh, a pair of 5 m^2 Superkrub mid-water trawl doors, 80 m sweeps with 300 kg chain weights, and a SIMRAD FS3300 third wire head-rope transducer. Fishing positions were selected to sample major fish concentrations that were encountered during the acoustic survey. Typically, 2 to 3 hours elapsed from the time targets were selected for sampling and subsequently fished.

Trawl catches were spilled from the codend into a hopper and the fish were sorted by species into tubs, as they moved along a conveyor. All tubs of fish were weighed on a platform scale to the nearest kilogram. Representative subsamples of hake were selected by retaining at least 3 tubs of fish from approximately the first, middle and last parts of of the hopper load. From the 12 tubs retained, 7 were randomly selected for routine biological sampling. In the case of small catches, the entire catch was sampled.

Measurements of fork length (to the nearest cm), sex and maturity (Weir et al. 1978) were recorded for all sampled fish. Otoliths were collected and stored in a 50/50 glycerine/freshwater solution with thymol, for subsequent age determination. The stomach contents of the fish in one tub from each sample were examined. Prey items were identified to the lowest possible taxon and the volume of each item was estimated visually to the nearest 1 cc. The state of digestion was also recorded and any herring in the stomach were counted and measured.

OCEANOGRAPHIC DATA

Conductivity and temperature were sampled at one meter depth intervals at pre-selected stations using a GUILDLINE CTD (8770 series) oceanographic probe. Sea surface temperatures were collected at 10 minute intervals using the CSAIL software/hardware system (Revlis Electronics Ltd. Vernon, B.C., and Simmie Software Solutions, Regina, Sask.; Saunders et al., in press). The vessel's sea-water intake is approximately 4 m below the surface. Plankton samples were collected at pre-selected stations for use by both the La Perouse (La Perouse Annual Reports 1988, 1989, and 1990) and COPRA (Cooperative Plankton Research) programs. The sampling gear consisted of a 0.5 m diameter bongo frame with a 230 micron mesh net attached to each opening. Oblique tows were conducted to within 20 m of the bottom or to a maximum depth of 700 m from the surface. Wire was paid out at a rate of 1 m/sec and retrieved at a rate of 0.3 m/sec. The samples were preserved in labelled jars with 10% formalin.

RESULTS

BIOMASS ESTIMATES: MAIN SURVEY AREA

A total of 93 transects were run encompassing a survey area of 10500 km^2 (Figures 1a-b). Positional information, date, and time for each transect are reported in Table 1. We summed the estimates for species other than hake and for hake only to give volume and surface densities and biomass estimates for all species by transect (Table 2). The estimates of total biomass (all species) and hake biomass for the survey areas are as follows:

Area (km^2)		Total biomass (kt)	Hake biomass (kt)	
A	2518	317	120	
B	3341	359	321	
C	4370	195	117	
BRK	70	7	7	(see Note)
N	201	6	3	(see Note)
TOTAL	10500	884	568	

Note: 'BRK' and 'N1' transects were repeated (Table 2). The transect from each repeat with the maximum hake biomass was included in the TOTAL.

Plots of the biomass distribution for all fish and for hake only are shown in Figures 3a-b and 4a-b, respectively. For data processing simplicity, we plot the surface densities using a single target strength (-35 dB/kg).

BIOMASS ESTIMATES: 'SA', 'SB' and 'T' TRANSECTS

Figure 1c indicates the 'SA', 'SB', and 'T' transect study areas. For clarity, only one of the repeats from each group of transects has been plotted. Total and hake biomass estimates for each pass along these transects are presented in Table 3.

FISHING RESULTS

A total of 7 midwater sets were conducted to obtain species composition and biological samples (Figure 5). Bridge log and catch data are listed in Table 4. Pacific hake were present in 5 of 7 sets and accounted for 66% of the total catch by weight. Biological samples of hake are reported in Table 5. Length frequencies by set and sex are presented in Table 6 and Figure 6. A total of 89 stomachs, from two sets, were frozen for subsequent laboratory analysis. The abundance of zooplankton in the guts will be estimated and compared with the abundance of euphausiids as determined from plankton samples collected on-board the PARIZEAU. Results from these analyses will be presented in a subsequent report (D. Mackas, Institute of Ocean Sciences, Sidney, B.C., pers. comm.). A length stratified sample of body and ovary weights was collected from 159 hake for inclusion with an on-going gonadosomatic index (M. Saunders, unpublished data). Lists of LA PEROUSE program and COPRA stations occupied, with associated bridge log data, are presented in Tables 7 and 8, respectively.

DISCUSSION

The 1991 hake survey covered an area off Vancouver Island extending from the Canada/U.S. boundary (approximately 48° 15') to 51° 35' north latitude and in the east/west direction from the 50 to the 300 m depth contour. Coverage was slightly greater in 1991 with 10500 km^2 surveyed compared to 9800 km^2 in 1990 (Saunders et al., in press).

Overall, biomass estimates were about twice that reported in 1990 (Saunders et al in press), however, we recognize that our procedure of extrapolating surface densities equidistant between adjacent transects may not be appropriate for densely schooling species like herring or rockfish. The near doubling of overall biomass from 459 kt in 1990 to 884 kt in 1991 occurred, for the most part, along a single transect (A12W, Table 2, Figure 3a) where extremely dense schools of herring were observed. The area over which these schools extended is unknown, therefore these results may represent an inflated biomass estimate for this species. Nonetheless, we consider the total biomass estimates, although relative, to be generally comparable between years. Total biomass estimate for series 'A' in 1991 was 317 kt which represents a three fold increase over the 1990 estimate of 100 kt. Series 'B' total biomass estimates in 1991 were also about three times that estimated in 1990 (359 kt compared to 109 kt). Conversely, total biomass was reduced by about 22% for the 'C' transects from 250 kt in 1990 to 195 kt in 1991.

Hake only biomass was estimated at 568 kt in 1991 and 316 kt in 1990. Hake biomass for series 'A' in 1991 was about double that reported for the same area in 1990, 120 kt (1991) compared to 63 kt (1990). For the 'B' series, hake biomass estimates were more than four times greater in 1991 than 1990 (321 kt and 75 kt, respectively). Hake biomass estimates in the 'C' survey area showed a 35% reduction between 1990 (178 kt) and 1991 (117 kt).

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Table 1. Transect location data with date, start time, and start and end latitude and longitude position.

TRANSECT				START POSITION				END POSITION			
EVENT #	NAME	Date	Time	LATITUDE deg	min	LONGITUDE deg	min	LATITUDE deg	min	LONGITUDE deg	min
2.0	A12W	13-AUG-91	06:21	48	30.29	124	34.19	48	30.00	125	43.58
180.0	A1E	17-AUG-91	06:06	48	55.04	125	46.99	48	55.02	125	38.04
184.0	A2W	17-AUG-91	06:53	48	54.15	125	37.96	48	54.11	125	47.25
187.0	A3E	17-AUG-91	07:45	48	52.51	125	47.09	48	52.22	125	30.80
190.1	A4W	17-AUG-91	09:04	48	50.30	125	30.00	48	50.07	125	42.20
196.0	A5E	17-AUG-91	10:22	48	47.70	125	42.15	48	48.00	125	16.21
213.0	A6W	17-AUG-91	16:14	48	44.92	125	12.74	48	45.06	125	50.27
222.0	A7E	17-AUG-91	19:13	48	42.28	125	49.76	48	42.37	125	26.25
231.0	A7ME	18-AUG-91	06:02	48	42.52	125	26.13	48	42.49	125	10.10
237.0	A8W	18-AUG-91	07:44	48	39.91	125	5.19	48	40.04	125	42.20
246.0	A9E	18-AUG-91	11:47	48	37.56	125	28.46	48	37.40	124	49.10
257.0	A10W	18-AUG-91	15:17	48	34.94	124	45.95	48	35.21	125	39.64
270.0	A11E	18-AUG-91	19:34	48	32.64	125	39.65	48	32.46	125	21.18
280.0	A11W	19-AUG-91	06:04	48	32.36	124	33.75	48	32.55	125	24.30
296.0	A13W	19-AUG-91	10:29	48	27.86	125	25.32	48	27.88	125	37.63
301.0	A13E	19-AUG-91	15:43	48	27.58	125	12.07	48	27.40	125	5.26
51.0	B1E	14-AUG-91	07:41	48	15.04	125	49.92	48	15.03	125	41.13
57.0	B2W	14-AUG-91	08:57	48	17.54	125	34.70	48	17.64	126	5.91
65.0	B3E	14-AUG-91	11:36	48	20.17	126	6.26	48	19.33	125	27.37
76.0	B4W	14-AUG-91	14:59	48	21.85	125	33.16	48	21.74	125	47.71
38.0	B4E	13-AUG-91	19:17	48	22.91	126	4.06	48	22.56	125	45.50
30.0	B5W	13-AUG-91	16:17	48	25.68	125	34.90	48	24.96	126	7.33
304.0	B5W	19-AUG-91	16:33	48	25.08	125	5.54	48	25.33	125	34.73
22.0	B6E	13-AUG-91	13:37	48	27.76	126	10.48	48	27.76	125	40.70
16.0	B7W	13-AUG-91	11:07	48	30.00	125	43.58	48	30.10	126	12.00
85.0	B8W	14-AUG-91	17:16	48	31.94	125	50.33	48	31.97	126	17.21
91.0	B9E	14-AUG-91	19:35	48	34.40	126	19.83	48	34.32	126	3.04
327.0	B10E	20-AUG-91	06:02	48	37.66	126	18.60	48	37.66	125	58.51
334.0	B11W	20-AUG-91	07:53	48	40.15	125	56.16	48	40.21	126	25.92
342.0	B12E	20-AUG-91	10:35	48	42.45	126	24.80	48	42.55	126	4.82
437.0	B12E	21-AUG-91	07:56	48	42.49	126	7.31	48	42.54	126	1.15
441.0	B13W	21-AUG-91	08:48	48	44.96	126	2.65	48	45.06	126	26.26
448.0	B14W	21-AUG-91	16:25	48	47.50	126	8.26	48	47.42	126	12.56
450.0	B14A	21-AUG-91	16:44	48	47.42	126	12.56	48	47.10	126	14.55
451.0	B14B	21-AUG-91	16:53	48	47.10	126	14.55	48	47.45	126	20.33
453.0	B14C	21-AUG-91	17:18	48	47.45	126	20.33	48	47.60	126	30.31
471.0	B14E	22-AUG-91	06:13	48	47.67	126	37.68	48	47.67	126	26.26
458.0	B15E	21-AUG-91	18:21	48	50.04	126	30.14	48	49.95	126	7.94
476.0	B15W	22-AUG-91	07:20	48	50.01	126	26.16	48	50.01	126	37.73
465.0	B16W	21-AUG-91	20:16	48	52.07	126	7.96	48	52.40	126	16.11
480.0	B16E	22-AUG-91	08:27	48	52.23	126	37.99	48	52.30	126	9.27
487.0	B17W	22-AUG-91	10:54	48	54.89	126	9.28	48	54.99	126	42.08
496.0	B18E	22-AUG-91	13:46	48	57.51	126	43.43	48	57.43	126	12.16
504.0	B19W	22-AUG-91	16:21	49	0.04	126	12.31	48	59.99	126	51.85
513.0	C1	22-AUG-91	19:16	49	0.28	126	51.78	49	9.89	126	32.09
523.0	C2	23-AUG-91	05:59	49	5.03	126	42.14	49	5.03	126	57.37
528.0	C3	23-AUG-91	07:09	49	5.26	126	57.47	49	10.96	126	48.21
532.0	C4	23-AUG-91	08:14	49	10.08	126	49.93	49	10.19	127	3.17
534.0	C5	23-AUG-91	09:14	49	10.19	127	3.17	49	15.03	126	53.59
536.0	C6	23-AUG-91	10:05	49	15.03	126	53.59	49	15.16	127	8.14
538.0	C7	23-AUG-91	11:07	49	15.16	127	8.14	49	20.67	127	1.86
559.0	C8	23-AUG-91	19:31	49	20.21	127	2.72	49	20.07	127	12.90
562.0	C9	23-AUG-91	20:14	49	20.07	127	12.90	49	25.06	127	6.06

Table 1. (cont'd.)

TRANSECT				START POSITION				END POSITION	
EVENT #	NAME	Date	Time	LATITUDE deg	min	LONGITUDE deg	min	LATITUDE deg	min	LONGITUDE deg	min
571.0	C10	24-AUG-91	06:07	49	25.18	127	6.01	49	24.89	127	17.98
574.0	C11	24-AUG-91	06:59	49	24.89	127	17.98	49	32.01	127	7.78
576.0	C12	24-AUG-91	08:04	49	32.01	127	7.78	49	31.93	127	19.76
581.0	C13	24-AUG-91	08:58	49	31.93	127	19.76	49	35.20	127	9.90
583.0	C14	24-AUG-91	09:47	49	35.20	127	9.90	49	35.19	127	20.19
585.0	C15	24-AUG-91	10:33	49	35.19	127	20.19	49	40.29	127	16.60
588.0	C16	24-AUG-91	11:13	49	40.29	127	16.60	49	40.62	127	24.28
591.0	C17	24-AUG-91	11:58	49	40.62	127	24.28	49	45.45	127	23.52
594.0	C18	24-AUG-91	12:34	49	45.45	127	23.52	49	45.66	127	33.35
597.0	C19	24-AUG-91	13:22	49	45.66	127	33.35	49	47.96	127	28.55
599.0	C20	24-AUG-91	13:57	49	47.96	127	28.55	49	48.12	127	42.85
604.0	C21	24-AUG-91	15:02	49	48.12	127	42.85	49	50.54	127	37.25
607.0	C22	24-AUG-91	15:34	49	50.54	127	37.25	49	50.62	127	45.03
609.0	C23	24-AUG-91	16:09	49	50.62	127	45.03	49	52.79	127	39.02
611.0	C24	24-AUG-91	16:42	49	52.79	127	39.02	49	52.76	127	46.39
613.0	C25	24-AUG-91	17:17	49	52.76	127	46.39	49	56.02	127	41.72
615.0	C26	24-AUG-91	17:49	49	56.02	127	41.72	49	55.87	127	56.64
620.0	C27	24-AUG-91	19:00	49	55.87	127	56.64	49	57.73	127	42.48
624.0	C28	24-AUG-91	20:02	49	57.73	127	42.48	49	57.79	127	53.08
631.0	C33	25-AUG-91	12:40	50	6.19	127	57.59	50	3.55	128	10.49
634.0	C32	25-AUG-91	13:37	50	3.55	128	10.49	50	3.45	127	50.22
637.0	C31	25-AUG-91	15:03	50	3.45	127	50.22	50	0.72	128	11.63
640.0	C30	25-AUG-91	16:40	50	0.72	128	11.63	50	0.59	127	42.09
645.0	C29	25-AUG-91	18:38	50	0.59	127	42.09	49	57.85	127	51.21
650.0	C34	26-AUG-91	14:04	50	6.19	127	58.72	50	6.20	128	16.68
655.0	C35	26-AUG-91	15:32	50	6.20	128	16.68	50	9.06	128	3.18
659.0	C36	26-AUG-91	16:41	50	9.06	128	3.18	50	8.82	128	13.04
663.0	C37	26-AUG-91	17:28	50	8.82	128	13.04	50	11.63	128	4.53
666.0	C38	26-AUG-91	18:12	50	11.63	128	4.53	50	11.28	128	20.54
670.0	C39A	26-AUG-91	19:25	50	11.28	128	20.54	50	15.00	128	7.57
675.0	C39B	26-AUG-91	20:44	50	15.10	128	7.30	50	15.81	128	3.78
678.0	C40	27-AUG-91	06:09	50	15.05	128	7.19	50	13.98	128	21.84
682.0	C41	27-AUG-91	07:12	50	13.98	128	21.84	50	19.04	128	10.16
685.0	C42	27-AUG-91	08:13	50	19.04	128	10.16	50	18.56	128	23.68
688.0	C43	27-AUG-91	09:16	50	18.56	128	23.68	50	22.33	128	17.59
690.0	C44	27-AUG-91	09:54	50	22.33	128	17.59	50	22.20	128	32.62
693.0	C45	27-AUG-91	11:02	50	22.20	128	32.62	50	27.06	128	28.19
695.0	C46	27-AUG-91	11:38	50	27.06	128	28.19	50	26.95	128	40.54
698.0	C47	27-AUG-91	12:36	50	26.95	128	40.54	50	34.14	128	31.46
701.0	C48	27-AUG-91	13:36	50	34.14	128	31.46	50	32.07	128	43.28
703.0	C49A	27-AUG-91	14:32	50	32.07	128	43.28	50	36.56	128	38.44
709.5	C49C	27-AUG-91	19:13	50	36.56	128	38.44	50	40.07	128	35.17
711.0	C50	27-AUG-91	19:38	50	40.07	128	35.17	50	36.14	128	52.30
721.0	C51	28-AUG-91	06:02	50	36.36	128	52.29	50	43.19	128	52.85
723.0	C52	28-AUG-91	06:49	50	43.19	128	52.85	50	42.42	129	7.04
726.0	C53	28-AUG-91	07:47	50	42.42	129	7.04	50	45.61	129	13.18
730.0	C54	28-AUG-91	11:16	50	45.66	129	12.82	50	44.26	129	22.43
732.0	C55	28-AUG-91	12:01	50	44.26	129	22.43	50	51.12	129	26.64
736.0	C56	28-AUG-91	12:50	50	51.12	129	26.64	50	50.78	129	37.72
740.0	C57	28-AUG-91	14:00	50	50.97	129	39.65	50	57.95	129	42.28
742.0	C58	28-AUG-91	14:51	50	57.95	129	42.28	51	3.54	129	29.39
745.0	C59	28-AUG-91	15:56	51	3.54	129	29.39	51	10.00	129	40.15
749.0	C60	28-AUG-91	17:39	51	9.79	129	38.21	51	24.37	129	3.59
758.0	C61	28-AUG-91	20:38	51	24.37	129	3.59	51	22.95	128	59.76
203.0	BRK2E	17-AUG-91	12:21	48	48.70	125	15.38	48	57.04	125	7.62

Table 1. (cont'd.)

TRANSECT				START POSITION				END POSITION			
EVENT #	NAME	Date	Time	LATITUDE deg	min	LONGITUDE deg	min	LATITUDE deg	min	LONGITUDE deg	min
207.0	BRK3W	17-AUG-91	14:29	48	58.54	125	8.51	48	52.00	125	16.00
552.0	N1	23-AUG-91	16:56	49	35.67	126	35.60	49	20.21	127	2.72
540.0	N1	23-AUG-91	11:53	49	20.67	127	1.86	49	33.74	126	37.80
99.0	SA1E	15-AUG-91	06:37	48	30.39	126	7.04	48	36.98	125	53.96
104.0	SA3W	15-AUG-91	07:59	48	35.94	125	53.20	48	29.07	126	7.21
111.0	SA1E	15-AUG-91	09:25	48	30.14	126	7.69	48	36.93	125	54.11
115.0	SA3W	15-AUG-91	10:45	48	36.24	125	53.40	48	29.32	126	6.80
128.0	SA3W	15-AUG-91	16:58	48	36.13	125	53.34	48	29.47	126	7.18
135.0	SA1E	15-AUG-91	18:23	48	30.31	126	7.58	48	37.07	125	54.57
146.0	SB1E	16-AUG-91	07:44	49	15.48	127	15.53	49	22.45	127	4.10
151.0	SB3W	16-AUG-91	09:00	49	21.63	127	3.03	49	14.38	127	14.53
156.0	SB1E	16-AUG-91	10:20	49	15.43	127	15.36	49	22.47	127	4.19
160.0	SB5W	16-AUG-91	11:25	49	22.47	127	4.19	49	25.50	126	59.52
162.0	SB7W	16-AUG-91	12:04	49	24.51	126	58.34	49	21.68	127	2.79
164.0	SB3W	16-AUG-91	12:33	49	21.68	127	2.79	49	14.18	127	14.04
171.0	SB7W	16-AUG-91	18:05	49	24.58	126	58.19	49	14.03	127	14.17
347.0	T1W	20-AUG-91	12:04	48	42.54	126	4.63	48	42.51	126	20.38
353.0	T2E	20-AUG-91	13:28	48	41.74	126	19.86	48	41.71	126	12.33
356.0	T3W	20-AUG-91	14:05	48	40.84	126	12.25	48	40.93	126	20.84
359.0	T4E	20-AUG-91	14:54	48	40.06	126	20.04	48	40.04	126	11.62
362.0	T5W	20-AUG-91	15:36	48	39.32	126	10.53	48	39.42	126	19.06
365.0	T6E	20-AUG-91	16:36	48	38.42	126	16.17	48	38.32	126	8.83
368.0	T7W	20-AUG-91	17:13	48	37.67	126	9.48	48	37.64	126	18.42
371.0	T8E	20-AUG-91	18:02	48	36.80	126	18.58	48	36.70	126	6.78
391.0	T1W	20-AUG-91	22:26	48	42.45	126	12.53	48	42.53	126	20.37
394.0	T2E	20-AUG-91	23:12	48	41.73	126	20.55	48	41.69	126	11.83
398.0	T3W	20-AUG-91	23:56	48	40.78	126	12.00	48	40.85	126	20.85
401.0	T4E	21-AUG-91	00:46	48	40.07	126	20.84	48	40.00	126	10.94
405.0	T5W	21-AUG-91	01:33	48	39.33	126	10.85	48	39.39	126	19.05
408.0	T6E	21-AUG-91	02:20	48	38.40	126	19.50	48	38.23	126	8.76
412.0	T7W	21-AUG-91	03:10	48	37.68	126	8.97	48	37.72	126	18.84
415.0	T8E	21-AUG-91	04:09	48	36.63	126	17.97	48	36.72	126	6.00
379.0	T0E	20-AUG-91	20:19	48	43.33	126	20.41	48	43.39	126	12.24
383.0	T0W	20-AUG-91	21:00	48	43.42	126	11.85	48	43.43	126	20.35
387.0	T0E	20-AUG-91	21:47	48	43.48	126	20.44	48	43.14	126	12.52
422.0	T6W	21-AUG-91	05:22	48	38.40	126	9.53	48	38.37	126	15.29
425.0	T6E	21-AUG-91	05:50	48	38.55	126	15.12	48	38.32	126	9.18
428.0	T6W	21-AUG-91	06:19	48	38.53	126	9.19	48	38.36	126	15.32
431.0	T6E	21-AUG-91	06:50	48	38.55	126	15.26	48	38.26	126	8.87

Table 2. Total and Hake Biomass Data for 'A', 'B, 'C', 'BRK', and 'N' series. Transect length, surface density cell area, volume and surface densities, and biomass by transect are given.

TRANSECT				BIOMASS: TOTAL			BIOMASS: HAKE		
EVENT #	NAME	Len km	Area km^2	Vol D kg/m^3	Surf D kg/m^2	ALL FISH t	Vol D kg/m^3	Surf D kg/m^2	HAKE t
2	A12	85.2	434.2	5.01E-03	4.31E-01	1.71E+05	2.98E-03	1.92E-01	7.67E+04
180	A1E	10.9	50.4	2.01E-04	1.16E-02	5.80E+02	0.00E+00	0.00E+00	0.00E+00
184	A2W	11.3	52.4	2.03E-04	6.55E-03	3.42E+02	0.00E+00	0.00E+00	0.00E+00
187	A3E	19.8	91.9	7.70E-05	1.23E-03	1.13E+02	0.00E+00	0.00E+00	0.00E+00
190.1	A4W	14.9	68.9	5.30E-05	9.50E-04	6.55E+01	0.00E+00	0.00E+00	0.00E+00
196	A5E	31.7	146.5	2.86E-04	1.26E-02	1.85E+03	0.00E+00	0.00E+00	0.00E+00
213	A6W	45.8	212.2	5.94E-04	4.00E-02	8.48E+03	5.45E-04	3.67E-02	7.79E+03
222	A7E	28.7	133.0	9.61E-04	6.44E-02	8.54E+03	8.52E-04	3.89E-02	5.18E+03
231	A7ME	19.6	90.7	4.56E-04	1.79E-02	1.63E+03	4.56E-04	1.79E-02	1.62E+03
237	A8W	45.3	209.6	8.91E-04	4.78E-02	1.00E+04	6.71E-04	3.52E-02	7.39E+03
246	A9E	48.2	223.1	2.17E-04	9.45E-03	2.11E+03	2.29E-05	9.98E-04	2.23E+02
257	A10W	65.8	304.6	4.53E-03	2.41E-01	7.34E+04	7.32E-04	3.85E-02	1.17E+04
270	A11E	22.6	104.9	4.49E-04	2.76E-02	2.89E+03	3.79E-04	2.33E-02	2.44E+03
280	A11W	62.0	287.0	1.60E-03	1.14E-01	3.28E+04	2.63E-04	1.67E-02	4.78E+03
296	A13W	15.1	70.0	2.21E-04	1.69E-02	1.19E+03	0.00E+00	0.00E+00	0.00E+00
301	A13E	8.4	38.8	6.00E-04	6.38E-02	2.48E+03	5.37E-04	4.82E-02	1.87E+03
51	B1E	10.8	50.2	4.82E-04	5.96E-02	2.99E+03	5.30E-04	3.79E-02	1.90E+03
57	B2W	38.5	178.1	6.21E-04	9.33E-02	1.66E+04	4.03E-04	6.06E-02	1.08E+04
65	B3E	47.9	221.8	1.48E-03	1.97E-01	4.36E+04	8.97E-04	1.19E-01	2.63E+04
76	B4W	17.9	82.9	3.85E-04	3.82E-02	3.17E+03	0.00E+00	0.00E+00	0.00E+00
38	B4E	22.8	105.8	1.42E-04	2.13E-02	2.26E+03	1.08E-04	1.45E-02	1.54E+03
30	B5W	39.9	184.6	5.03E-04	5.15E-02	9.52E+03	5.36E-04	4.84E-02	8.93E+03
304	B5W	35.9	203.4	1.58E-03	1.65E-01	3.39E+04	1.58E-03	1.65E-01	3.39E+04
22	B6E	36.6	169.3	1.09E-03	1.23E-01	2.08E+04	1.07E-03	1.21E-01	2.04E+04
16	B7W	34.9	161.5	8.06E-05	7.58E-03	1.23E+03	2.92E-05	2.75E-03	4.44E+02
85	B8W	33.0	152.6	3.11E-04	3.01E-02	4.58E+03	2.66E-04	2.57E-02	3.92E+03
91	B9E	20.6	95.3	1.56E-04	2.20E-02	2.10E+03	1.49E-04	2.10E-02	2.00E+03
327	B10E	24.6	113.9	1.65E-03	2.01E-01	2.30E+04	1.73E-03	1.99E-01	2.27E+04
334	B11W	36.4	168.5	6.94E-04	8.73E-02	1.48E+04	6.86E-04	8.64E-02	1.46E+04
342	B12E	24.4	113.1	1.28E-04	1.81E-02	2.04E+03	5.27E-05	7.15E-03	8.08E+02
437	B12E	7.5	34.9	1.81E-04	1.29E-02	4.50E+02	1.81E-04	1.29E-02	4.50E+02
441	B13W	28.8	133.5	5.99E-04	7.80E-02	1.04E+04	5.63E-04	7.33E-02	9.78E+03
448	B14W	5.2	24.3	7.35E-04	5.84E-02	1.42E+03	7.35E-04	5.84E-02	1.42E+03
450	B14A	2.5	11.6	5.22E-03	5.50E-01	6.36E+03	5.22E-03	5.50E-01	6.36E+03
451	B14B	7.1	32.8	7.80E-03	9.94E-01	3.26E+04	7.80E-03	9.94E-01	3.26E+04
453	B14C	12.2	56.4	1.16E-04	2.15E-02	1.21E+03	0.00E+00	0.00E+00	0.00E+00
471	B14E	13.9	64.5	4.82E-05	8.20E-03	5.30E+02	0.00E+00	0.00E+00	0.00E+00
458	B15E	27.1	125.3	9.03E-04	1.06E-01	1.33E+04	8.90E-04	1.04E-01	1.31E+04
476	B15W	14.1	65.3	1.27E-04	2.18E-02	1.42E+03	4.85E-05	8.32E-03	5.43E+02
465	B16W	9.9	46.1	1.60E-03	1.19E-01	5.46E+03	1.60E-03	1.19E-01	5.46E+03
480	B16E	35.0	162.0	1.44E-03	1.67E-01	2.71E+04	1.40E-03	1.63E-01	2.64E+04
487	B17W	39.9	184.8	1.47E-03	1.43E-01	2.64E+04	1.63E-03	1.38E-01	2.56E+04
496	B18E	38.0	176.1	1.11E-03	1.15E-01	2.02E+04	1.31E-03	1.14E-01	2.00E+04
504	B19W	48.0	222.4	1.32E-03	1.43E-01	3.19E+04	1.51E-03	1.39E-01	3.09E+04
513	C1	29.8	137.9	1.89E-04	2.13E-02	2.94E+03	2.05E-04	2.09E-02	2.89E+03
523	C2	18.5	85.5	1.08E-04	1.64E-02	1.40E+03	2.64E-05	3.31E-03	2.83E+02
528	C3	15.4	71.3	1.06E-03	1.48E-01	1.06E+04	1.13E-03	1.47E-01	1.05E+04
532	C4	16.0	74.2	8.94E-05	1.28E-02	9.52E+02	5.97E-05	9.74E-03	7.23E+02
534	C5	14.7	67.8	1.68E-04	2.50E-02	1.70E+03	1.49E-04	2.38E-02	1.62E+03
536	C6	17.6	81.4	1.75E-04	2.44E-02	1.98E+03	1.62E-04	2.20E-02	1.79E+03
538	C7	12.7	58.9	7.56E-05	1.02E-02	6.03E+02	7.38E-05	9.99E-03	5.88E+02
559	C8	12.3	56.9	4.59E-04	6.42E-02	3.66E+03	3.23E-04	4.52E-02	2.57E+03

Table 2. (cont'd.)

TRANSECT				BIOMASS: TOTAL			BIOMASS: HAKE		
EVENT #	NAME	Len km	Area km^2	Vol D kg/m^3	Surf D kg/m^2	ALL FISH t	Vol D kg/m^3	Surf D kg/m^2	HAKE t
562	C9	12.4	57.3	2.62E-04	2.81E-02	1.61E+03	0.00E+00	0.00E+00	0.00E+00
571	C10	14.4	66.8	2.07E-04	2.97E-02	1.98E+03	0.00E+00	0.00E+00	0.00E+00
574	C11	18.0	83.4	1.14E-04	1.64E-02	1.37E+03	0.00E+00	0.00E+00	0.00E+00
576	C12	14.4	66.7	1.02E-04	1.29E-02	8.57E+02	6.06E-05	6.04E-03	4.03E+02
581	C13	13.3	61.6	2.66E-04	3.24E-02	2.00E+03	0.00E+00	0.00E+00	0.00E+00
583	C14	12.4	57.2	3.78E-05	4.64E-03	2.66E+02	0.00E+00	0.00E+00	0.00E+00
585	C15	10.4	48.1	3.03E-05	2.92E-03	1.40E+02	0.00E+00	0.00E+00	0.00E+00
588	C16	9.2	42.7	9.00E-05	1.16E-02	4.94E+02	0.00E+00	0.00E+00	0.00E+00
591	C17	9.0	41.6	1.35E-04	1.41E-02	5.85E+02	0.00E+00	0.00E+00	0.00E+00
594	C18	11.8	54.5	1.15E-04	1.38E-02	7.50E+02	0.00E+00	0.00E+00	0.00E+00
597	C19	7.1	33.1	5.90E-05	6.35E-03	2.11E+02	0.00E+00	0.00E+00	0.00E+00
599	C20	17.1	79.2	1.94E-04	1.86E-02	1.47E+03	0.00E+00	0.00E+00	0.00E+00
604	C21	8.1	37.3	6.40E-05	9.85E-03	3.67E+02	0.00E+00	0.00E+00	0.00E+00
607	C22	9.3	43.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
609	C23	8.2	38.1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
611	C24	8.8	40.7	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
613	C25	8.2	38.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
615	C26	17.8	82.4	1.30E-04	2.09E-02	1.72E+03	0.00E+00	0.00E+00	0.00E+00
620	C27	17.2	79.7	6.55E-05	1.09E-02	8.70E+02	0.00E+00	0.00E+00	0.00E+00
624	C28	12.6	58.5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
645	C29	12.0	55.5	2.83E-05	2.47E-03	1.37E+02	0.00E+00	0.00E+00	0.00E+00
640	C30	35.2	162.8	4.75E-05	3.23E-03	5.25E+02	0.00E+00	0.00E+00	0.00E+00
637	C31	26.0	120.2	6.60E-06	1.15E-03	1.39E+02	0.00E+00	0.00E+00	0.00E+00
634	C32	24.1	111.6	1.15E-04	8.10E-03	9.05E+02	0.00E+00	0.00E+00	0.00E+00
631	C33	16.1	74.5	2.12E-03	1.76E-01	1.31E+04	2.10E-03	1.71E-01	1.27E+04
650	C34	21.3	98.8	2.16E-04	1.56E-02	1.54E+03	0.00E+00	0.00E+00	0.00E+00
655	C35	16.9	78.2	6.39E-04	2.67E-02	2.09E+03	7.87E-04	2.67E-02	2.09E+03
659	C36	11.7	54.2	8.43E-04	1.26E-01	6.83E+03	3.65E-04	1.79E-02	9.69E+02
663	C37	11.4	52.6	1.20E-03	1.02E-01	5.33E+03	1.56E-03	6.71E-02	3.53E+03
666	C38	19.0	87.9	1.34E-03	1.10E-01	9.65E+03	1.82E-03	9.78E-02	8.60E+03
670	C39	16.8	78.0	1.68E-03	1.16E-01	8.99E+03	1.66E-03	1.11E-01	8.66E+03
675	C39	4.4	20.2	5.11E-03	4.09E-01	8.28E+03	5.11E-03	4.09E-01	8.28E+03
678	C40	17.5	80.9	1.13E-03	1.59E-01	1.29E+04	1.09E-03	1.53E-01	1.24E+04
682	C41	16.7	77.3	2.11E-03	2.15E-01	1.66E+04	2.33E-03	2.06E-01	1.59E+04
685	C42	16.0	74.1	2.21E-04	2.78E-02	2.06E+03	0.00E+00	0.00E+00	0.00E+00
688	C43	10.0	46.4	2.11E-04	2.24E-02	1.04E+03	0.00E+00	0.00E+00	0.00E+00
690	C44	17.8	82.2	1.05E-03	9.82E-02	8.06E+03	1.43E-03	8.43E-02	6.93E+03
693	C45	10.4	48.2	2.26E-04	3.36E-02	1.62E+03	0.00E+00	0.00E+00	0.00E+00
695	C46	14.6	67.4	1.28E-04	1.76E-02	1.18E+03	0.00E+00	0.00E+00	0.00E+00
698	C47	17.1	79.1	1.72E-04	2.50E-02	1.98E+03	0.00E+00	0.00E+00	0.00E+00
701	C48	14.4	66.8	2.16E-04	2.93E-02	1.96E+03	0.00E+00	0.00E+00	0.00E+00
703	C49	10.1	46.7	1.76E-04	2.28E-02	1.06E+03	0.00E+00	0.00E+00	0.00E+00
709.5	C49	7.6	35.0	5.45E-05	7.05E-03	2.47E+02	0.00E+00	0.00E+00	0.00E+00
711	C50	21.4	99.1	9.75E-05	1.50E-02	1.48E+03	0.00E+00	0.00E+00	0.00E+00
721	C51	12.7	58.6	1.11E-03	1.50E-01	8.80E+03	1.33E-03	1.48E-01	8.70E+03
723	C52	16.7	77.3	5.52E-04	8.41E-02	6.51E+03	5.28E-04	8.27E-02	6.40E+03
726	C53	9.3	43.1	3.26E-04	4.63E-02	2.00E+03	0.00E+00	0.00E+00	0.00E+00
730	C54	11.6	53.5	2.03E-03	3.00E-01	1.61E+04	0.00E+00	0.00E+00	0.00E+00
732	C55	13.6	63.1	7.15E-04	1.11E-01	7.00E+03	0.00E+00	0.00E+00	0.00E+00
736	C56	13.0	60.1	1.61E-04	2.98E-02	1.79E+03	0.00E+00	0.00E+00	0.00E+00
740	C57	13.3	61.5	1.73E-04	3.28E-02	2.02E+03	0.00E+00	0.00E+00	0.00E+00
742	C58	18.2	84.5	7.95E-05	1.35E-02	1.14E+03	0.00E+00	0.00E+00	0.00E+00
745	C59	17.3	80.1	4.73E-05	7.75E-03	6.20E+02	0.00E+00	0.00E+00	0.00E+00
749	C60	48.3	223.8	6.60E-05	1.08E-02	2.42E+03	0.00E+00	0.00E+00	0.00E+00
758	C61	5.1	23.8	1.68E-04	2.66E-02	6.35E+02	0.00E+00	0.00E+00	0.00E+00

Table 2. (cont'd.)

TRANSECT				BIOMASS: TOTAL			BIOMASS: HAKE		
EVENT #	NAME	Len km	Area km^2	Vol D kg/m^3	Surf D kg/m^2	ALL FISH t	Vol D kg/m^3	Surf D kg/m^2	HAKE t
203	BS2E	18.1	83.8	8.69E-04	4.11E-02	3.45E+03	7.61E-04	3.60E-02	3.02E+03
207	BS3W	15.2	70.2	2.19E-03	1.08E-01	7.55E+03	2.19E-03	1.08E-01	7.55E+03
540	N1E	37.7	174.8	5.55E-04	2.79E-02	4.87E+03	0.00E+00	0.00E+00	0.00E+00
552	N1W	43.4	201.0	5.81E-04	2.90E-02	5.83E+03	3.38E-04	1.68E-02	3.39E+03

Table 3. Total and Hake Biomass Data for 'SA', 'SB', and 'T' series. Transect length, surface density cell area, volume and surface densities, and biomass by transect are given.

TRANSECT				BIOMASS: TOTAL			BIOMASS: HAKE		
EVENT #	NAME	Len km	Area km^2	Vol D kg/m^3	Surf D kg/m^2	ALL FISH t	Vol D kg/m^3	Surf D kg/m^2	HAKE t
REPEATS: 'SA' SERIES									
99	SA1E	20.1	46.6	6.21E-04	5.21E-02	2.43E+03	6.17E-04	5.18E-02	2.41E+03
104	SA3W	21.4	49.5	1.02E-04	8.75E-03	4.33E+02	0.00E+00	0.00E+00	0.00E+00
111	SA1E	20.9	48.3	3.48E-04	3.04E-02	1.47E+03	2.99E-04	2.61E-02	1.26E+03
115	SA3W	20.8	48.2	2.59E-04	2.18E-02	1.05E+03	1.90E-04	1.59E-02	7.67E+02
128	SA1E	21.0	48.6	8.27E-04	7.35E-02	3.57E+03	8.27E-04	7.35E-02	3.57E+03
135	SA3W	20.3	46.9	1.03E-03	9.26E-02	4.35E+03	1.03E-03	9.26E-02	4.35E+03
REPEATS: 'SB' SERIES									
146	SB1E	18.9	43.7	3.21E-05	5.11E-03	2.24E+02	1.99E-05	3.17E-03	1.39E+02
151	SB3W	19.3	44.7	4.49E-05	6.32E-03	2.83E+02	2.62E-05	3.69E-03	1.65E+02
156	SB1E	18.8	43.4	2.68E-05	3.77E-03	1.64E+02	1.33E-05	1.88E-03	8.16E+01
160	SB5W	7.9	18.4	6.65E-05	6.40E-03	1.18E+02	0.00E+00	0.00E+00	0.00E+00
162	SB7W	7.5	17.4	3.65E-05	3.38E-03	5.87E+01	1.98E-05	1.83E-03	3.18E+01
164	SB3W	19.4	45.0	3.08E-05	4.88E-03	2.20E+02	0.00E+00	0.00E+00	0.00E+00
171	SB7W	27.5	63.6	4.92E-05	6.08E-03	3.87E+02	1.84E-05	2.61E-03	1.66E+02
REPEATS: 'T' SERIES; 1st PASS									
347	T1W	19.2	35.6	4.08E-04	5.29E-02	1.88E+03	2.07E-04	2.69E-02	9.58E+02
353	T2E	9.2	17.0	7.18E-04	1.19E-01	2.03E+03	7.22E-04	1.15E-01	1.96E+03
356	T3W	10.5	19.5	4.87E-04	8.44E-02	1.65E+03	4.52E-04	7.84E-02	1.53E+03
359	T4E	10.3	19.1	5.67E-04	1.00E-01	1.91E+03	5.67E-04	1.00E-01	1.91E+03
362	T5W	10.4	19.3	1.06E-03	1.89E-01	3.65E+03	9.29E-04	1.62E-01	3.14E+03
365	T6E	9.0	16.6	3.21E-04	5.25E-02	8.72E+02	2.82E-04	4.41E-02	7.34E+02
368	T7W	10.9	20.3	1.31E-04	2.30E-02	4.65E+02	5.45E-05	8.90E-03	1.80E+02
371	T8E	14.4	26.8	3.12E-05	5.50E-03	1.48E+02	0.00E+00	0.00E+00	0.00E+00
REPEATS: 'T' SERIES; 2nd PASS									
391	T1W	9.6	17.7	5.62E-04	8.33E-02	1.48E+03	5.72E-04	7.34E-02	1.30E+03
394	T2E	10.7	19.7	4.09E-04	5.31E-02	1.05E+03	4.06E-04	3.65E-02	7.22E+02
398	T3W	10.8	20.0	3.14E-04	3.93E-02	7.89E+02	3.52E-04	3.16E-02	6.34E+02
401	T4E	12.1	22.4	3.12E-04	4.26E-02	9.52E+02	3.15E-04	3.14E-02	7.03E+02
405	T5W	10.0	18.6	2.38E-04	3.43E-02	6.38E+02	2.26E-04	2.49E-02	4.63E+02
408	T6E	13.1	24.3	3.92E-04	5.47E-02	1.33E+03	4.24E-04	4.66E-02	1.13E+03
412	T7W	12.1	22.4	2.42E-04	3.47E-02	7.78E+02	2.34E-04	2.57E-02	5.76E+02
415	T8E	14.7	27.1	1.74E-04	2.32E-02	6.29E+02	1.90E-04	2.08E-02	5.65E+02
REPEATS: 'TO' and 'T6' SERIES									
379	TOE	10.4	18.5	4.19E-04	6.06E-02	1.12E+03	3.01E-04	4.42E-02	8.17E+02
383	TOW	10.4	19.2	5.84E-04	8.48E-02	1.63E+03	5.52E-04	6.97E-02	1.34E+03
387	TOE	9.7	18.0	2.88E-04	4.40E-02	7.88E+02	2.45E-04	3.15E-02	5.66E+02
422	T6W	7.0	13.1	1.84E-04	2.31E-02	3.01E+02	1.95E-04	2.15E-02	2.80E+02
425	T6E	7.3	13.5	8.18E-04	1.02E-01	1.37E+03	9.11E-04	1.00E-01	1.35E+03
428	T6W	7.5	13.9	2.00E-03	2.83E-01	3.93E+03	2.00E-03	2.83E-01	3.93E+03
431	T6E	7.8	14.5	5.11E-04	7.29E-02	1.06E+03	5.11E-04	7.29E-02	1.06E+03

Table 4. Bridge log and species composition, by set, during the Pacific hake hydroacoustic cruise, R\V W.E.RICKER, August 12-30,1991.

SET NO.	1	2	3	4	5	6	7	TOTAL CATCH kg.	%
DATE	AUG. 15	AUG. 16	AUG. 21	AUG. 21	AUG. 26	AUG. 27	AUG. 27		
AREA(MAJ. MIN. LOC.)	3 23 10	4 25 2	3 23 12	3 23 12	4 27 2	5 11 6	5 11 6		
TIME START (PDT)	1332	1545	1304	1428	1232	1546	1736		
DURATION (MIN)	8	40	16	26	10	34	19		
START N. LAT. (DEG)	48	49	48	48	50	50	50		
(MIN)	31.6	18.7	41.2	41.2	7.1	36.2	35.2		
W. LONG. (DEG)	126	127	126	126	128	128	128		
(MIN)	2.0	9.9	15.4	9.6	3.3	38.9	39.9		
DIRECTION (DEG.TRUE)	350	325	330	275	260	220	020		
FINISH N. LAT. (DEG)	48	49	48	48	50	50	50		
(MIN)	32.0	20.6	41.8	41.3	7.1	34.8	36.1		
W.LONG. (DEG)	126	127	126	126	128	128	128		
(MIN)	2.0	11.8	16.3	11.4	4.1	40.9	39.3		
LENGTH OF SET(KM).	0.3	2.3	1.1	1.4	0.5	2.1	1.2		
TARGET DEPTH(M)(MODAL)	125	-	160	130	213	140	165		
(MIN)	125	210	150	120	210	120	150		
(MAX)	135	-	170	140	216	160	180		
CAPTURE DEPTH(M)(MODAL)	122	200	180	135	220	186	180		
(MIN)	120	-	180	130	220	186	180		
(MAX)	125	-	180	140	220	186	180		
TYPE OF GEAR	CANADIAN DIAMOND NO.7 MIDWATER TRAWL								
MOUTH OPENING(M)	12	11	11	11	11	11	11		
TOTAL CATCH WEIGHT(KG)	1952	74	732	2617	1115	909	1874	9273	100.0
ROUNDFISH									
PACIFIC HAKE	1944	70	674	2596	1043	..	..	6327	68.2
EULACHON	..	..	..	10	..	..	..	10	0.1
LINGCOD	6	..	..	..	..	..	..	6	0.1
ROCKFISH									
S. REEDI	..	..	..	..	..	877	1792	2669	18.8
S. ALUTUS	..	..	50	1	64	4	45	164	1.8
S. PRORIGER	..	..	..	..	..	14	27	41	0.4
S. FLAVIDUS	2	..	4	10	..	1	..	17	0.2
S. PAUCISPINIS	..	..	..	..	6	3	6	15	0.2
S. ZACENTRUS	..	..	..	..	..	6	2	8	0.1
S. BREVISPINIS	..	..	2	..	..	..	2	4	0.0
S. ENTOMELAS	..	..	2	..	..	..	..	2	0.0
FLATFISH									
TURBOT	..	4	..	..	2	..	..	6	0.1
INVERTEBRATES									
JELLYFISH	..	TRACE	..	TRACE	..	..	..	TRACE	0.0
SQUID	..	..	..	..	..	4	..	4	0.0
REMARKS	USABLE	USABLE	USABLE	USABLE	USABLE	USABLE	USABLE		

Table 5. Summary of Pacific hake biological samples collected, by set, during the Pacific hake hydroacoustic cruise, R/V W.E.RICKER, August 12-30, 1991.

Set no	Location	Length M	Length F	Length T	Maturity	Stomach contents	Body weights	Paired otoliths	Fish no	Remarks *
1	LaPerouse 032306	140	261	401	304	60	170	170	49412-49581	3 tubs l/s/m/o/wt
										1 tub l/s/m/st
										1 tub l/s/m
										2 tubs l/s
2	Nootka 042502	27	47	74	74	74	-	74	49582-49655	total catch
										53 st preserved
3	LaPerouse 032312	133	270	403	289	62	-	173	49656-49828	3 tubs l/s/m/o
										1 tub l/s/m/st
										1 tub l/s/m
										2 tubs l/s
										36 st preserved
4	LaPerouse 032312	109	270	379	159	109	192	159	49829-49987	3 tubs l/s/m/o
										2 tubs l/s/st
										2 tubs l/s
									49829-50020	118 stratified
										liver/ovary wt
5	Brooks 042702	101	246	347	248	98	-	150	50021-50170	3 tubs l/s/m/o
										2 tubs l/s/m/st
									2 tubs l/s	
	Totals	510	1094	1604	1074	403	362	726		

*l=fork length o=paired otoliths for ageing
s=sex st=stomach contents
m=maturity wt=body weights

Table 6. Length frequency of Pacific hake, by set, during the Pacific hake hydroacoustic cruise, R\V W.E.RICKER, August 12-30, 1991.

SET NO.	1			2			3			4			5			TOTAL		
FORK LENGTH (CM)	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
42	-	-	-	1	-	1	-	2	2	-	-	-	-	-	-	1	2	3
43	4	2	6	0	-	0	5	3	8	5	1	6	-	-	-	14	6	20
44	4	4	8	1	1	2	10	8	18	8	5	13	2	2	4	25	20	45
45	14	15	29	2	0	2	16	30	46	11	15	26	4	4	8	47	64	111
46	20	34	54	4	3	7	25	32	57	15	47	62	12	15	27	76	131	207
47	32	50	82	0	6	6	27	51	78	27	47	74	17	31	48	103	185	288
48	22	46	68	1	5	6	19	46	65	22	48	70	15	30	45	79	175	254
49	18	37	55	5	6	11	12	33	45	9	35	44	10	41	51	54	152	206
50	18	25	43	5	5	10	8	23	31	7	27	34	13	29	42	51	109	160
51	4	19	23	2	5	7	5	15	20	2	11	13	13	21	34	26	71	97
52	3	8	11	5	8	13	1	11	12	0	15	15	2	21	23	11	63	74
53	0	9	9	0	1	1	2	2	4	1	8	9	4	23	27	7	43	50
54	1	1	2	0	1	1	1	3	4	0	3	3	5	9	14	7	17	24
55	-	3	3	0	2	2	0	6	6	2	3	5	2	11	13	4	25	29
56	-	2	2	1	1	2	2	1	3	-	1	1	1	2	3	4	7	11
57	-	2	2	-	1	1	-	0	0	-	0	0	0	1	1	0	4	4
58	-	1	1	-	0	0	-	0	0	-	0	0	0	2	2	0	3	3
59	-	1	1	-	2	2	-	1	1	-	2	2	0	3	3	0	9	9
60	-	1	1	-	-	-	-	1	1	-	1	1	0	0	0	0	3	3
61	-	0	0	-	-	-	-	0	0	-	0	0	0	0	0	0	0	0
62	-	1	1	-	-	-	-	0	0	-	1	1	0	1	1	0	3	3
63	-	-	-	-	-	-	-	1	1	-	-	-	0	-	0	0	1	1
64	-	-	-	-	-	-	-	0	0	-	-	-	0	-	0	0	0	0
65	-	-	-	-	-	-	-	1	1	-	-	-	0	-	0	0	1	1
66	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0	0	-	0
67	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	-	1
TOTAL	140	261	401	27	47	74	133	270	403	109	270	379	101	246	347	510	1094	1604

Table 7. Summary of CTD stations occupied during the Pacific hake hyroacoustic survey, R/V W.E.Ricker, August 12-30, 1991.

Stn No	Location Latitude	Location Longitude	App.Depth (m)	Date	Time (PDT)	Actual Location Latitude	Actual Location Longitude	Depth (m)
LC05	48 39.94N	125 47.40W	65	Aug 15	2045	48 39.92W	125 47.50N	50
LC06	48 36.46	125 54.00	92	Aug 15	2130	48 36.48	125 53.83	80
LC07	48 32.96	126 00.50	131	Aug 15	2215	48 32.91	126 00.52	110
LC08	48 29.45	126 07.10	203	Aug 15	2315	48 29.51	126 07.10	180
LF07	48 54.10	126 44.80	718	Aug 21	2320	48 53.95	126 44.69	700
LF06	48 58.10	126 38.90	458	Aug 22	0140	48 58.17	126 38.96	380
LF05	49 02.00	126 33.20	151	Aug 22	0240	49 01.97	126 33.36	100
LF04	49 05.90	126 27.50	126	Aug 22	0325	49 05.86	126 27.65	100
LK13	49 58.00	128 13.60	720	Aug 25	2056	49 58.01	128 13.47	690
LK12	50 01.40	128 07.10	1200	Aug 25	2115	50 01.36	128 06.95	750
LK11	50 03.20	128 03.60	1100	Aug 25	2247	50 03.70	128 03.69	900
LK10	50 04.60	128 00.80	191	Aug 25	2340	50 05.16	128 00.98	150
LK09	50 05.82	127 58.50	100	Aug 26	0010	50 05.90	127 58.53	80
				Aug 27	2230	50 42.91	128 40.32	96
				Aug 28	0023	50 41.04	128 53.23	190
				Aug 28	0110	50 40.03	128 59.88	789
				Aug 28	0340	50 38.61	129 08.44	860

Table 8. Summary of COPRA* stations occupied during the Pacific hake hyroacoustic survey, R/V W.E.Ricker, August 12-30, 1991.

Stn No	Location Latitude	Location Longitude	App.Depth (m)	Date	Time (PST)	Actual Location Latitude	Actual Location Longitude	Depth (m)
PLA3	48 24.70N	126 15.80W	900	Aug 13	2330	48 24.68N	126 15.64W	700
PLA2	48 22.70	126 03.80	400	Aug 12	0233	48 22.42	126 04.12	400
PLC2	48 27.61	125 08.06	115	Aug 17	2340	48 27.66	125 08.15	140
PLC3	48 23.45	125 20.80	120	Aug 18	0140	48 22.69	125 17.96	95
CPE2	50 43.00	128 40.00	140	Aug 27	2230	50 42.91	128 40.32	95
LQO3	50 39.79	129 01.86	999	Aug 28	0130	50 40.03	128 59.88	900

*COPRA = Cooperative plankton research : one ctd and one oblique plankton tow made at each station.

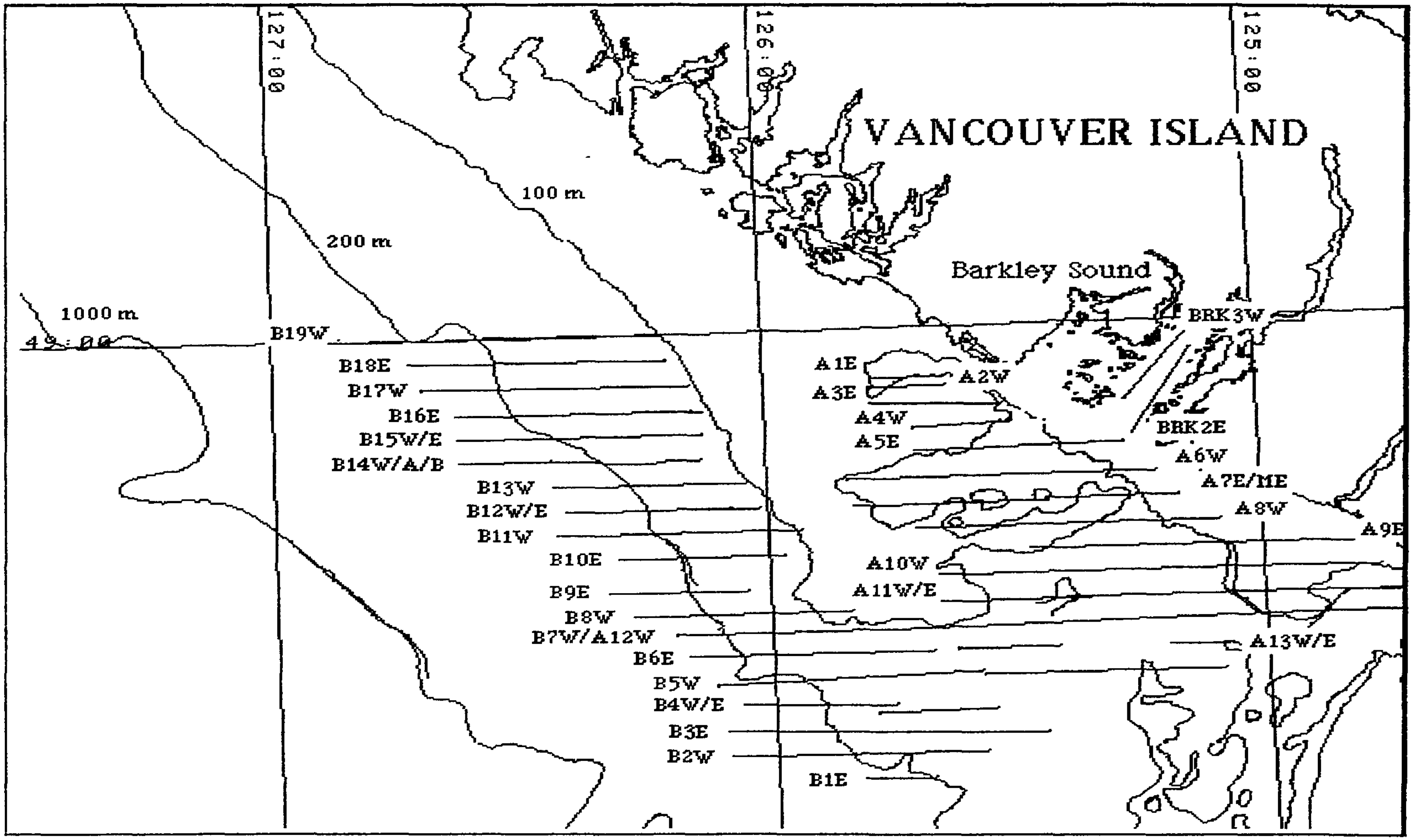


Figure 1a. 'A' and 'B' Transects occupied during the Pacific hake hydroacoustic survey, August 13-22, 1991. All chart plots are depicted on the same scale.

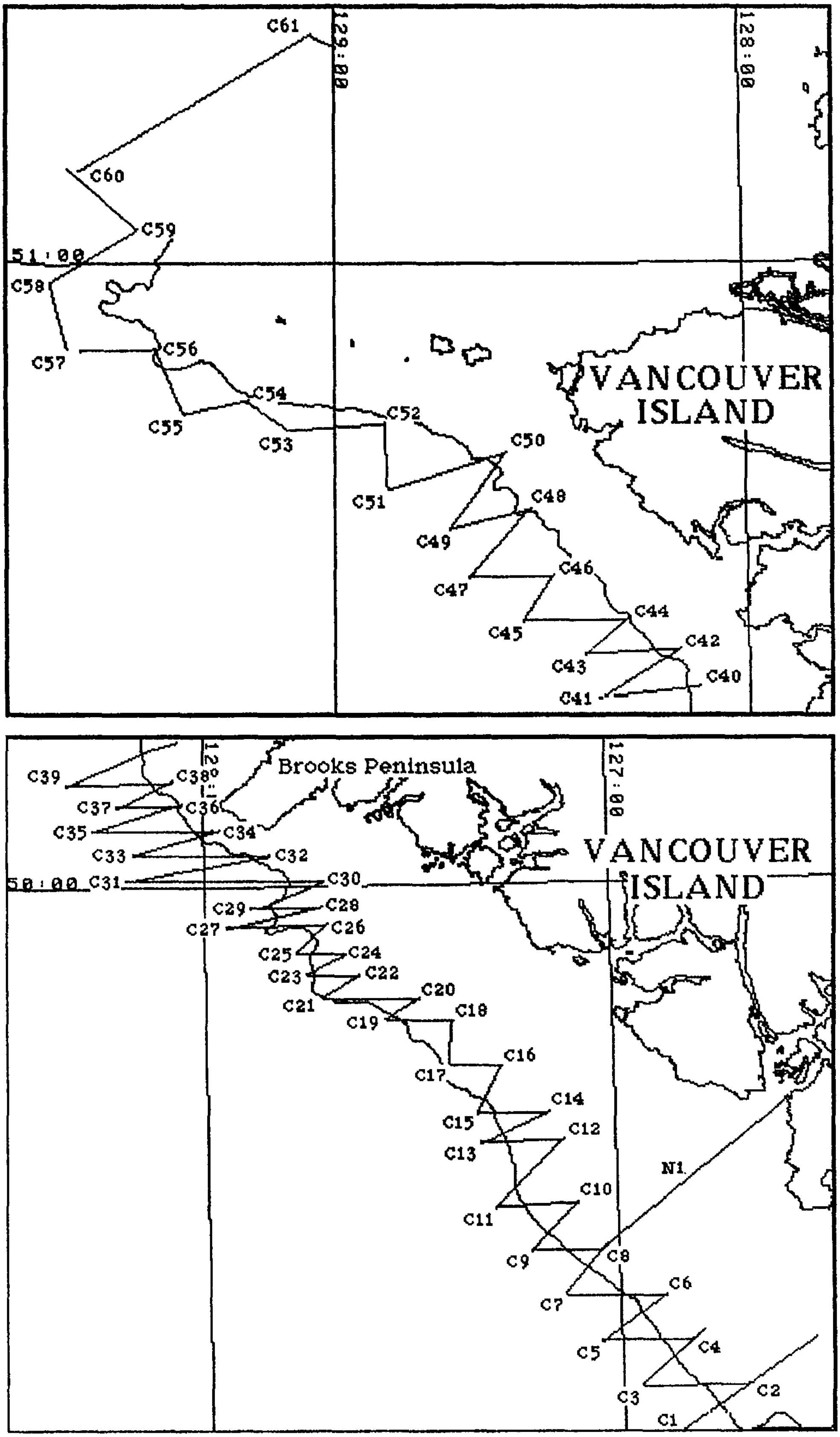


Figure 1b. 'C' Transects, Northern (top) and Southern (bottom) portions, occupied during the Pacific hake hydroacoustic survey, August 22-28, 1991.

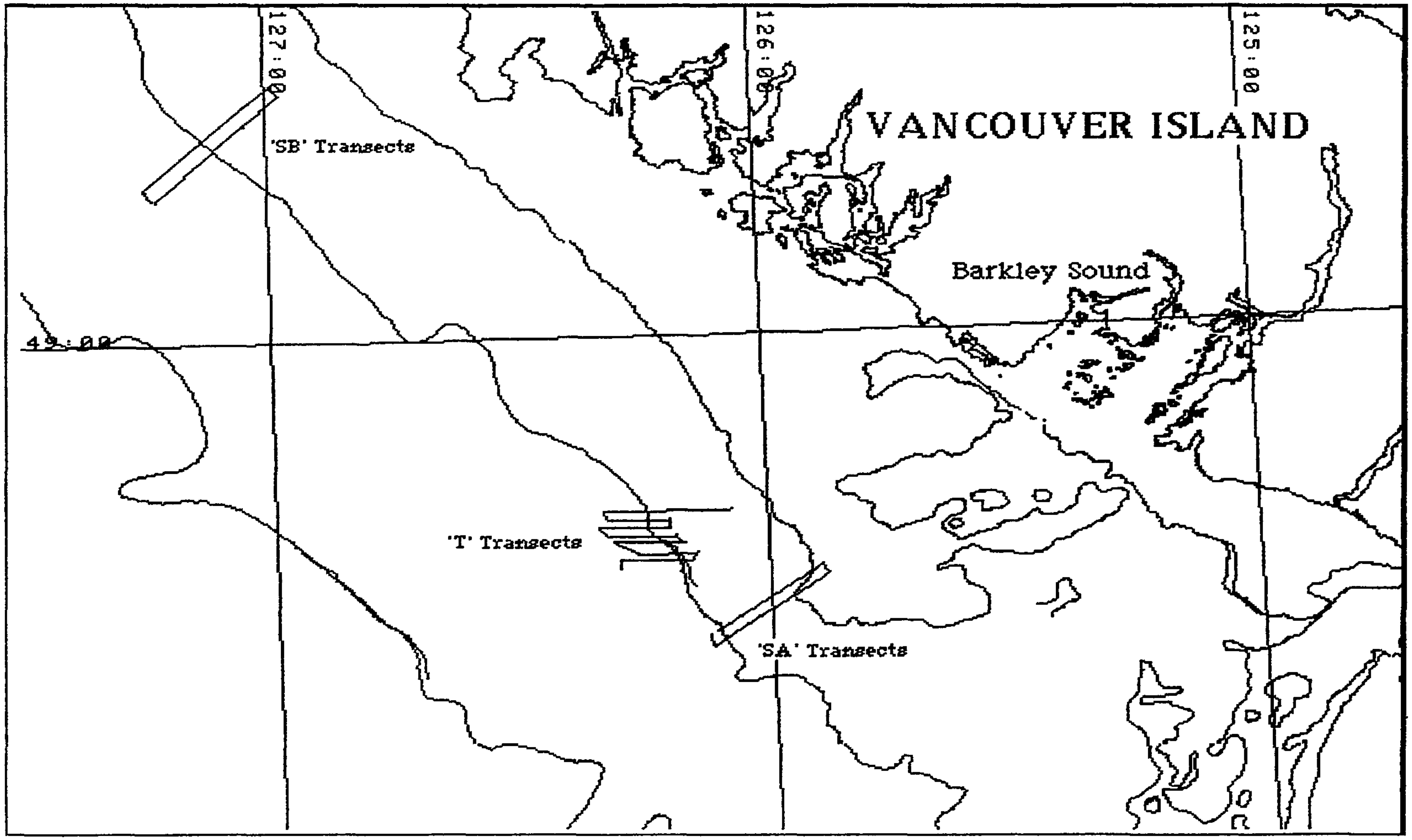
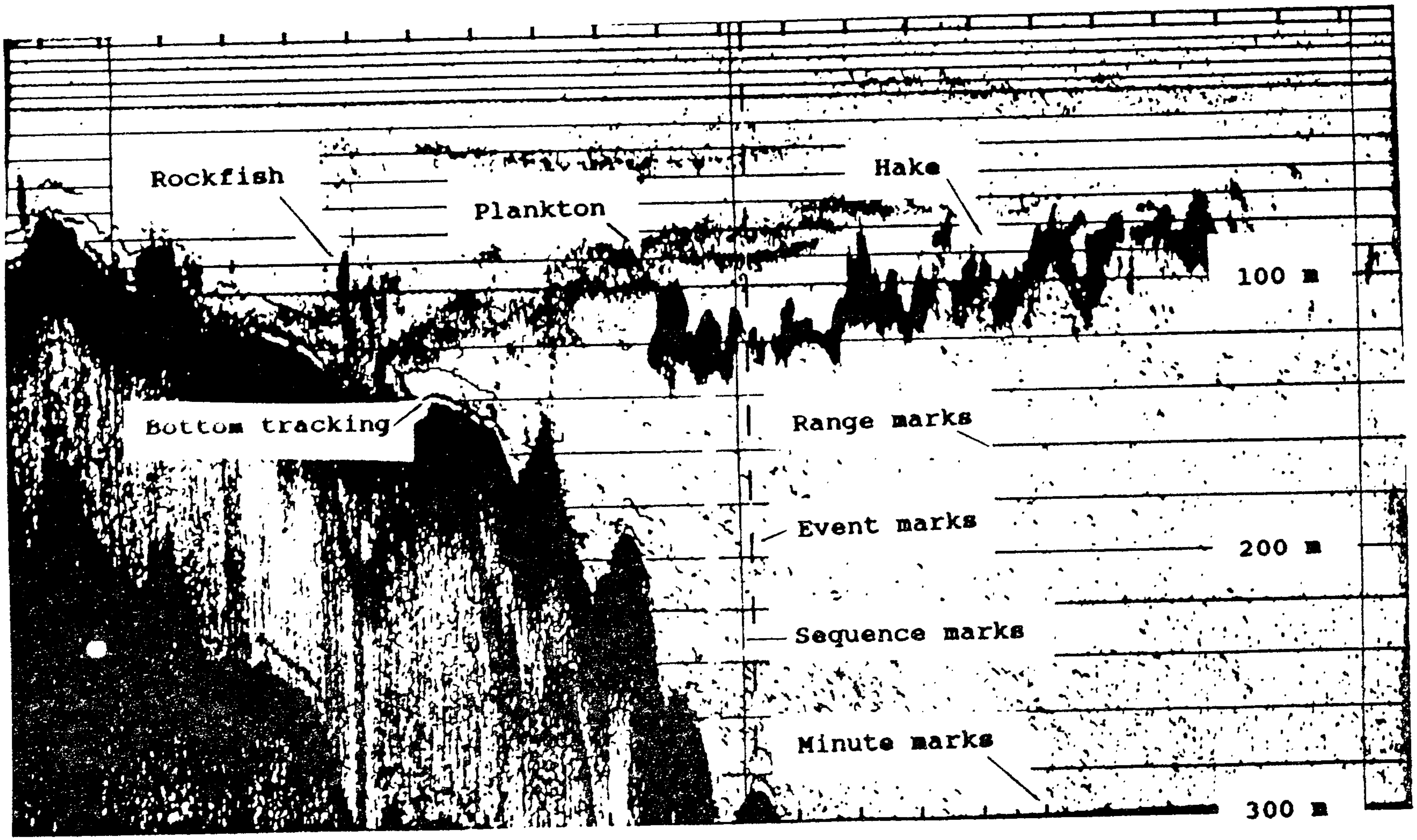


Figure 1c. 'SA', 'SB' (August 15-16, 1991), and 'T' (August 20-21, 1991) transects occupied during the Pacific hake hydroacoustic survey.

Figure 2 Section of typical echogram recorded at the shelf break. Horizontal range, vertical sequence and short minute marks are indicated by the solid lines. The dashed vertical lines represent event marks. Bottom tracking is monitored by a line paralleling the bottom.



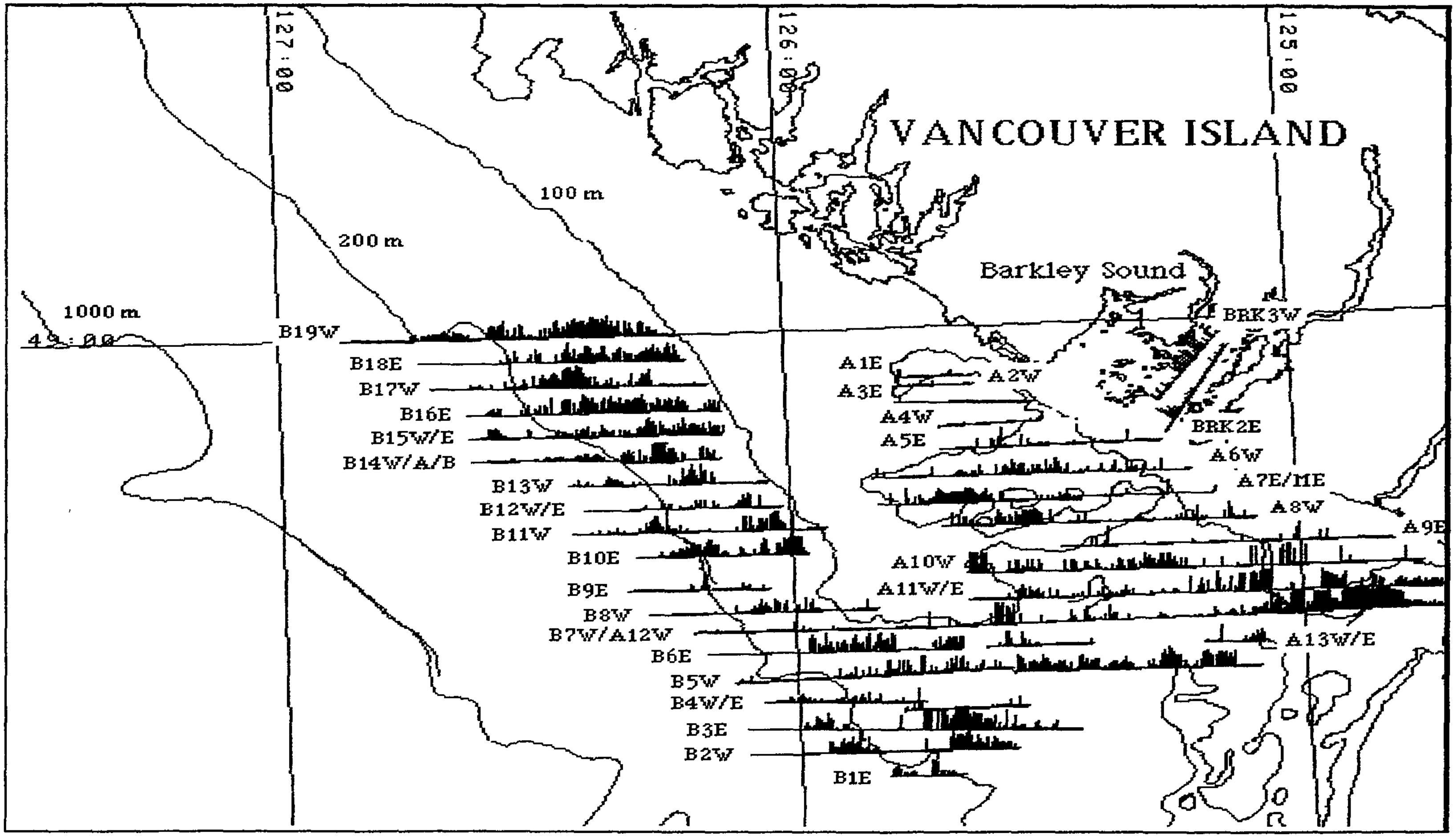


Figure 3a. The surface density for all species observed during the August 1990 hydroacoustic survey, 'A' and 'B' transects. The surface densities are represented by vertical bars on a log scale ranging from 0.01 to 1.0 kg/m^2.

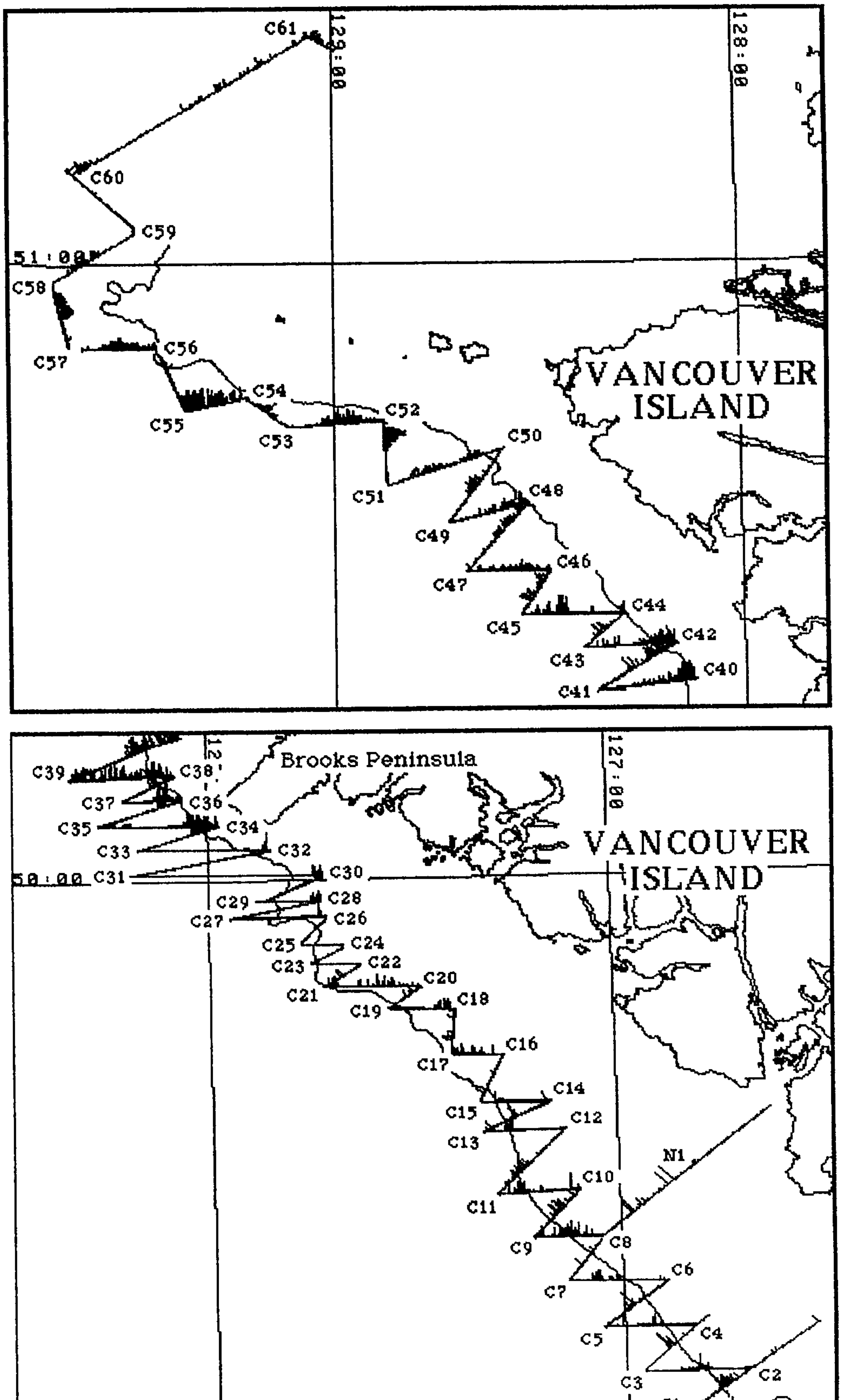


Figure 3b. The surface density for all species, 'C' transects observed during the August 1990 hydroacoustic survey. Surface densities are represented by vertical bars on a log scale ranging from 0.01 to 1.0 kg/m^2.

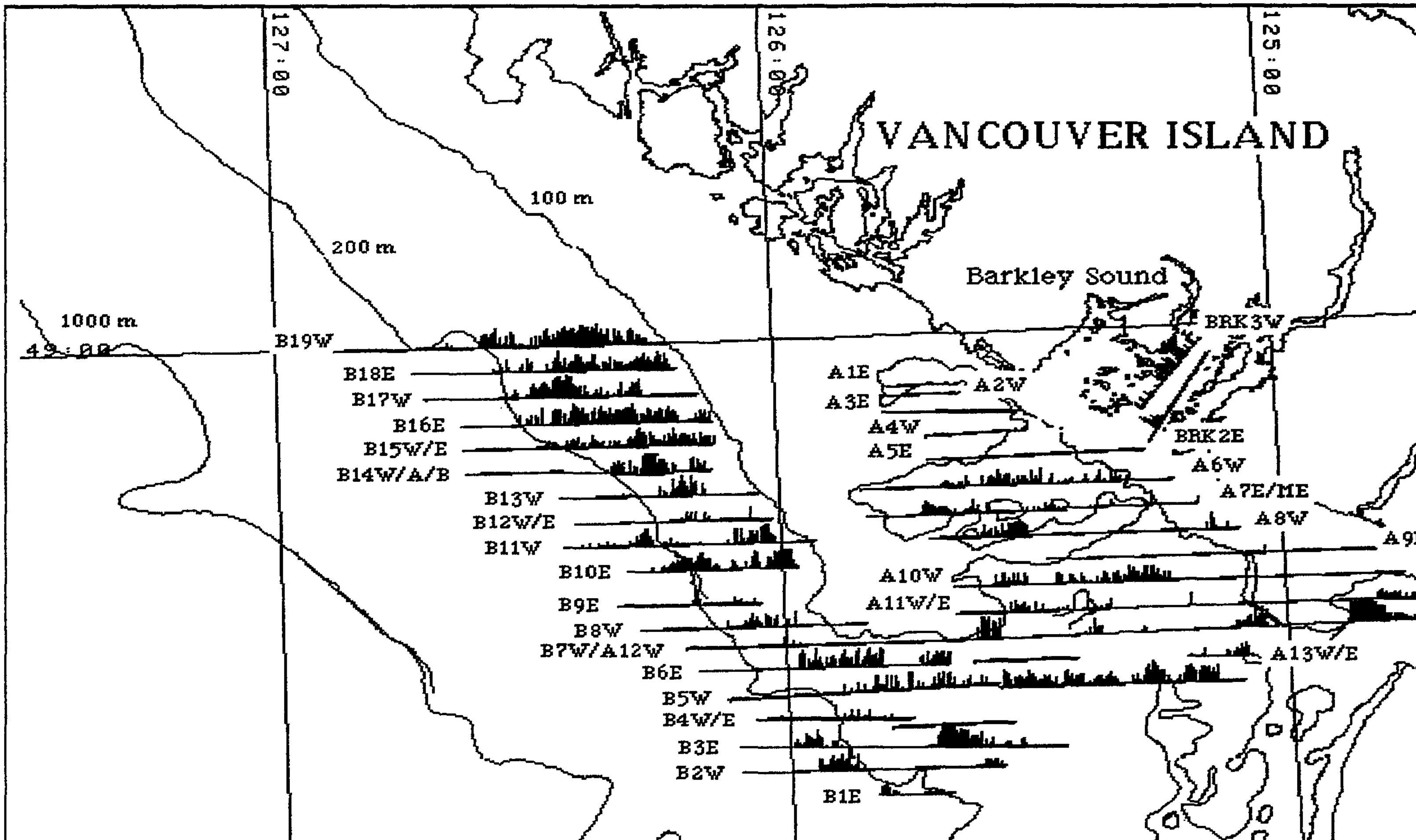


Figure 4a. The surface density for hake only, 'A' and 'B' transects. Surface densities are represented by vertical bars on a log scale ranging from 0.01 to 1.0 kg/m^2.

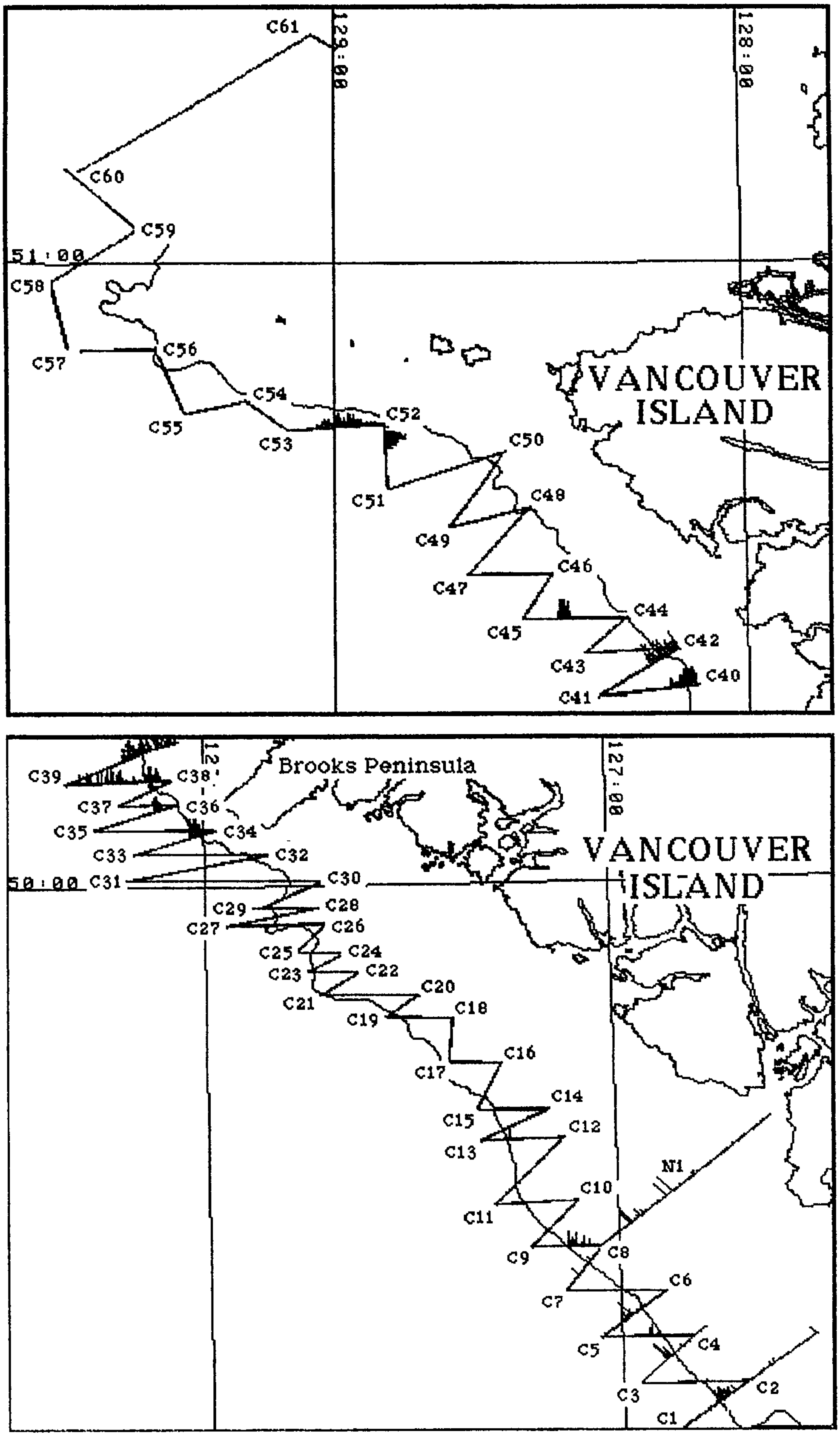


Figure 4b. The surface density for hake only observed on the 'C' Northern (top) and Southern (bottom) transects. Surface densities are represented on a log scale ranging from 0.01 to 1.0 kg/m^2.

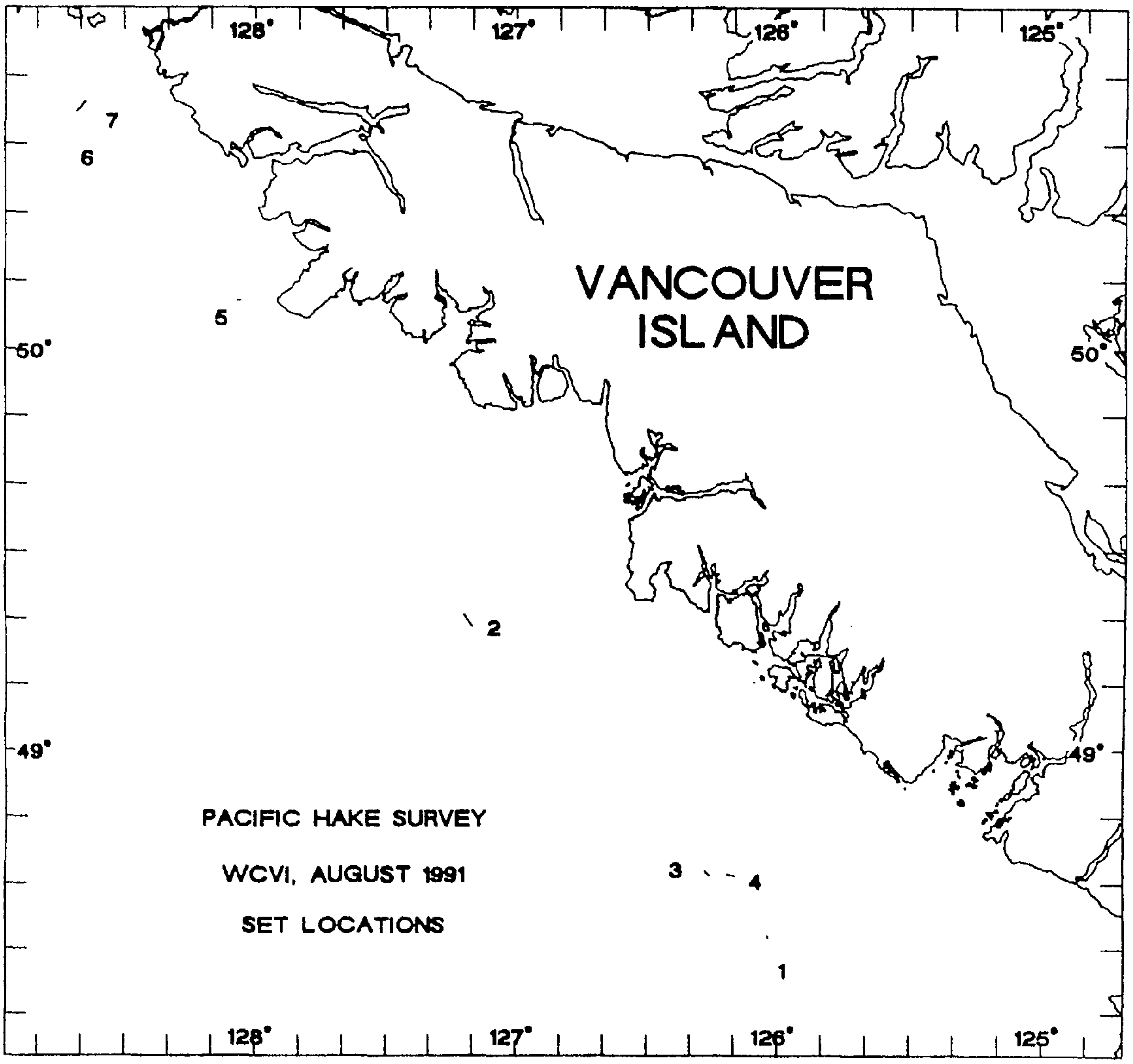


Figure 5. Fishing haul locations during the hydroacoustic survey conducted during August, 1991 off the west coast of Vancouver Island (WCVI).

APPENDIX 1

Echo integration equation and systems calibration constants.

Echo integration can be described by an equation that accounts for the physical aspects of the hydroacoustic measurement. The equation is valid if a good signal to noise ratio is present and an average fish target strength can be defined. For convenience, the parameters are given in logarithmic form. For each range stratum and integration sequence, the integrator outputs an intensity, I, that is given by:

$$I = TL + RS + SG + SA + \Omega + CT + BW + RG + TS + \rho$$

The following definitions are used:

I		Echo Intensity, dB re: 1 V^2
TL		Transmit level, dB re 1μPa at 1 m
RS		Receive sensitivity, dB re 1V/μPa at 1 m
SG		Two way gain through shell of the towed body, dB
SA		Spreading and absorption gain, $-(20\cdot\log\cdot R_0+2\cdot\alpha\cdot R_0)$
	R_0	Reference range, m
	α	Absorption, dB re 1/m
Ω		Beam factor = $10\cdot\log[\iint b^2(\theta,\Phi)\cdot\sin(\theta)\ d\theta d\Phi]$
	$b(\theta,\Phi)$	One way transducer directivity function, Power
CT		Range increment = $10\cdot\log(c\cdot\tau/2)$
	c	Velocity of sound in water, m/s
	τ	Transmit pulse width, s
BW		Bandwidth factor = $10\cdot\log(I_1/I_0)$
	I_1	I generated by a bandwidth limited input pulse
	I_0	I generated by a square input pulse of the same height
RG		Receiver gain setting, dB
TS		Average fish target strength, dB re 1/kg
ρ		Fish volume density, kg/m^3

APPENDIX 1 (cont'd.)

The following values are used in the echo integration equation.

Quantity			Source/Comment
TL		219.70 dB	mean value; see NOTE 1
RS		-134.37 dB	mean value; see NOTE 1
SG		-0.6 dB	see NOTE 2
SA		-0.0198 dB	
	R_0	1.0 m	
	α	0.0099 dB/m	
Ω		-17.55 dB	
CT		-3.50 dB	
	c	1490 m/s	
	τ	0.6 ms	
BW		- 0.8 dB	Kieser et al. 1987
RG		-12.0 dB	
TS		-35.0 dB	TS value for Pacific Hake
TS		-32.0 dB	TS value for all species other than hake
ρ			Fish density to be estimated

NOTE 1: mean values for TL and RS calculated from calibrations March 1990, August 1990, and July 1991 at Applied Physics Laboratory, University of Washington, Seattle (Kieser; unpubl. data).

NOTE 2: shell gain established from March 1982 calibration at Applied Physics Laboratory, University of Washington, Seattle (Kieser; unpubl. data., plots 3717 and 3718).

TL, RS, SH, and $b(\theta,\Phi)$ were measured at the hydroacoustic calibration barge of the Applied Physics Laboratory, University of Washington, Seattle. The calibration is performed periodically and provides a check on the overall system performance and stability. The receiver sensitivity, RS, refers to a reference range of 1.0 m, however, it is measured with TVG at 30 m. The echo sounder was operated with 20 log R + 2 α R time varied gain, 0.6 ms transmit pulse length, 1,000 W power and 1 Hz repetition rate. With this gain, echo levels of 0.2 V to 10.0 V correspond to densities of 0.00104 to 2.59 kg/m^3.