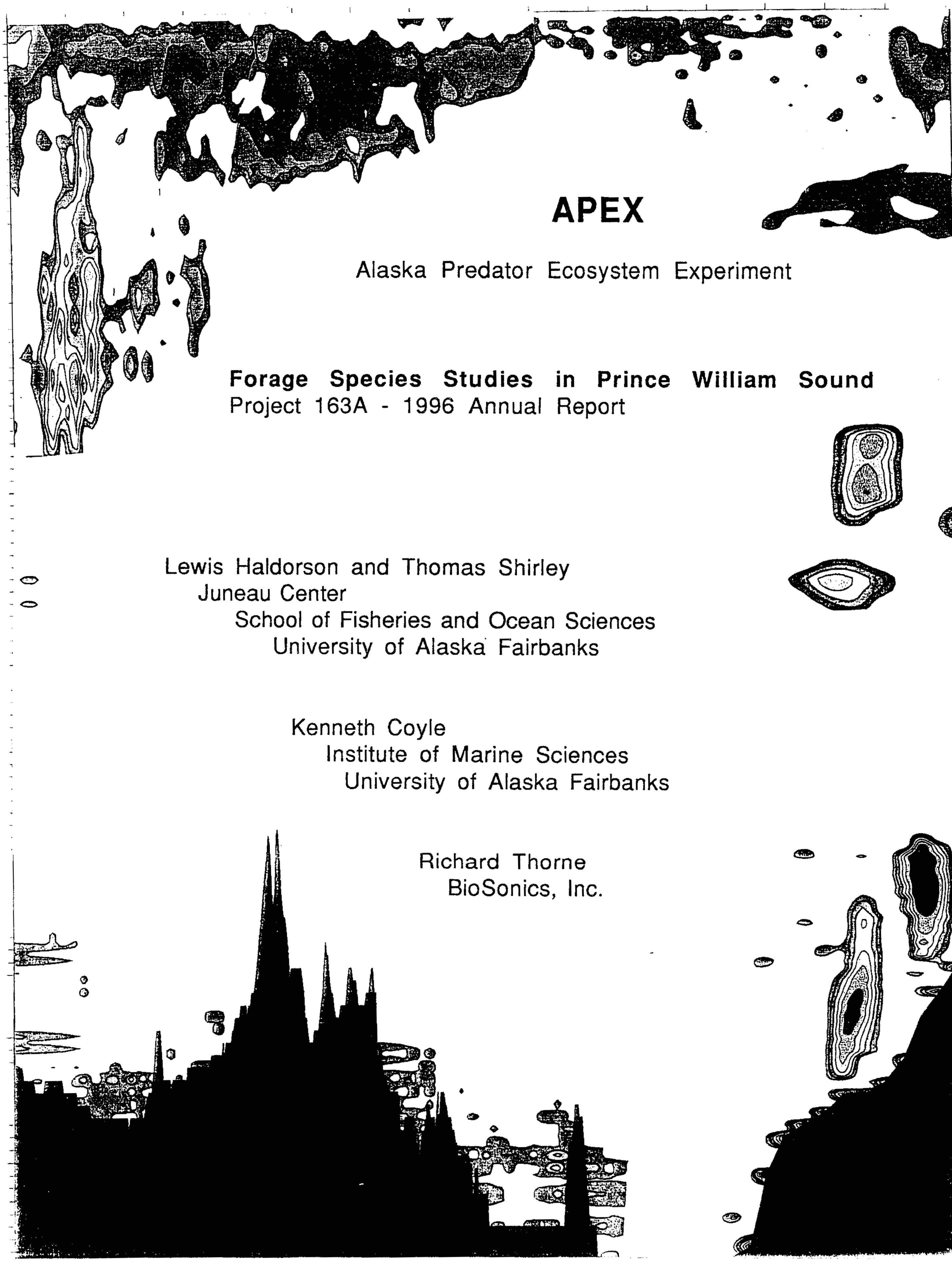
APPENDIX A

APEX: 96163A



APEX

Alaska Predator Ecosystem Experiment

Forage Species Studies in Prince William Sound
Project 163A - 1996 Annual Report

Lewis Haldorson and Thomas Shirley
Juneau Center
School of Fisheries and Ocean Sciences
University of Alaska Fairbanks

Kenneth Coyle
Institute of Marine Sciences
University of Alaska Fairbanks

Richard Thorne
BioSonics, Inc.

ABSTRACT

The abundance of forage fishes was assessed in three areas of Prince William Sound in July 1996 using acoustic surveys of offshore and nearshore areas, and a beach seine survey for the very shallow nearshore zone. Offshore biomass was similar in depths above and below 25 m, and was about four times higher in the North area than in either the Central or South areas. The only fishes sampled by net in the offshore survey were walleye pollock over 200 mm in length.

Herring were by far the most abundant forage species in the nearshore acoustic survey, based on both net sampling and video observations of acoustic targets. Most herring were juveniles aged 1 or 2 years; however, large schools of young-of-the-year (YOY) herring were found in the North area, and notable numbers of adult herring occurred in the South area. Other species encountered in the nearshore acoustic survey were sand lance and YOY walleye pollock, both in the North study area. Nearshore acoustic biomass was considerably higher in the North study area than in either the South or Central areas. Most nearshore biomass was concentrated in distinct schools of fish that occurred on relatively few transects - from 10% of transects in the South, to 25% of transects in the North. The number of nearshore acoustic transects where large schools (mean transect estimate > 10 g/m^2) were encountered was approximately three times higher in the North study area than the South, and ten times higher than the Central area. Video observations were very valuable in identifying acoustic targets, and allowed confirmation of distinctly different patterns of acoustic return associated with schools of herring, sand lance and YOY walleye pollock.

Beach seine catches were highly variable, but trends were similar to those in the acoustic surveys. More fish were caught in the North - about five and twenty-five times as many as in the South and Central areas, respectively; with approximately equal effort. Nearly all fish caught in the North were herring or sand lance. Some sandlance did occur in catches from the Central area, although they ranked third in total catch after pink salmon and tomcod. In the South herring were about 80% of total catch, followed by tomcod at about 15% of total. In frequency of occurrence (the proportion of seine hauls that had a species present in the catch), herring and sand lance ranked highest

in the North, whereas pink salmon and tomcod ranked one and two in both the South and Central areas.

All surveys (offshore acoustic, nearshore acoustic, beach seine) indicated that forage species were much more abundant in the North than in either the Central or South areas. Herring were the most common and widespread forage fishes, and were most abundant in the North, where many schools of YOY herring and older (age 1 and 2) juveniles occurred. In addition the North area had notable occurrences of sand lance and YOY pollock.

There was no obvious explanation for the dramatic differences we observed in the abundance and distribution of forage fishes in Prince William Sound. Temperature and salinity distributions in the water column were very similar in the three study areas. We examined salinity and temperature distributions along nearshore to offshore transects in all three study areas to determine if nearshore frontal zones could be associated with distributions of forage fishes. In all cases, the pronounced stratification of the water column persisted into very shallow nearshore areas, indicating that the energy of tidal mixing was insufficient to break down stratification in the nearshore areas.

TABLE OF CONTENTS

List of Tables

List of Figures

ACKNOWLEDGMENTS

This research program was conducted with the aid of many individuals. Especially valuable were the contributions in field work by Jennifer Boldt, Cathy Coon, Lee Hulbert, Malcolm McEwen, Jill Mooney, Chris Rooper and Molly Sturdevant. Lyman MacDonald provided very valuable assistance in sampling design and data analyses.

INTRODUCTION

Prince William Sound (PWS) is one of the largest areas of protected waters bordering the Gulf of Alaska (GOA), and provides a foraging area for large populations of apex predators including piscivorous seabirds. These avian predators were severely impacted by the EXXON VALDEZ oil spill (EVOS), and many - especially common murres, marbled murrelets, pigeon guillemots - suffered population declines that have not recovered to pre-EVOS levels (Agler et al. 1994). Piscivorous seabirds in PWS are near the apex of food webs based on pelagic production. They feed on an assemblage of forage species that include several fishes and may also prey on invertebrates such as euphausiids, shrimps and squid. Recovery of apex predator populations in PWS depends on restoration of important habitats and the availability of a suitable forage base. Since the 1970's there has apparently been a decline in populations of apex predators of the pelagic plankton production system, and it is not clear if failure to recover from EVOS-related reductions is due to long-term changes in forage species abundance or to EVOS effects.

Forage species include planktivorous fishes and pelagic invertebrates. Planktivorous fish species that occur in PWS and are known or likely prey of apex predators include Pacific herring, *Clupea pallasi* ; Pacific sand lance, *Ammodytes hexapterus* (Drury et al. 1981, Springer et al. 1984, Wilson and Manuwal 1984); walleye pollock,*Theragra chalcogramma* (Springer and Byrd 1989, Divoky 1981); capelin, *Mallotus villosus* , and eulachon, *Thaleichthys pacificus* (Warner and Shafford 1981, Baird and Gould 1985). Pelagic invertebrates; including euphausiids, shrimp, mysids, amphipods; are found in the diets of sand lance, capelin and pollock, as well as young salmon (Clausen 1983, Coyle and Paul 1992, Livingston et al. 1986, Straty 1972). When aggregated in sufficient densities, macrozooplankton are fed on directly by marine birds (Coyle et al. 1992, Hunt et al 1981, Oji 1980).

We used hydroacoustics to estimate the distribution and abundance of forage fishes. Hydroacoustics measure horizontal and vertical abundance at scales not possible by traditional net sampling techniques, and have been used to quantify fish (Thorne et al. 1977, Thorne et al. 1982, Mathisen et al. 1978) and the spatial patterns of a variety of aquatic populations (Gerlotto 1993; Baussant et al. 1993; Simard et al. 1993). In Alaskan waters, acoustics have been used to measure biomass relative to tidally-generated frontal features (Coyle and Cooney 1993) and the relationship between murre foraging, tidal currents and water masses in the southeast Bering Sea (Coyle et al. 1992). Acoustic sampling cannot positively identify the species of targets; consequently, other sampling must be conducted concurrently with acoustics to identify species and to provide size distribution data necessary for biomass estimations.

This report describes the second year of research that is part of a program (APEX) designed to determine if forage species availability is limiting the recovery of seabird populations that were impacted by the EVOS. In the first year of the study (1995), the most significant aggregation of forage species occurred offshore in the central part of the Sound where large schools of young-of-the year walleye pollock were found at depths from 30 - 70 m. Studies of seabirds in 1995 indicated they foraged principally within 1 km of the shoreline. As a consequence of those observations our research program in 1996 directed much more effort to quantifying the abundance of forage species in the nearshore area, and we added a nearshore acoustic survey and a beach seine survey.

OBJECTIVES

1. Provide an estimate of the abundance and distribution of forage species in nearshore (within 1 km) and offshore zones of three study areas in Prince William Sound.

2. Describe size distributions of the most abundant forage species.

3. Provide samples of forage fishes to NMFS for food habits studies, and other samples of forage species to other APEX and EVOS funded researchers.

4. Describe oceanographic conditions in the study area, and determine if forage fish distributions are associated with hydrographic features such as tidal fronts.

FIELD METHODS

Field studies were conducted in July 1996. The survey was conducted in three areas designated as the north, central and south study sites (Figure 1). The study began on 14 July and ended on 28 July:

14 July	Loaded gear on vessels in Cordova, traveled to South study area
15-19	Conducted surveys in South study area
19-22	Conducted surveys in Central study area
23-27	Conducted surveys in North study area.
28 July	Traveled to Cordova, unloaded equipment.

Offshore Survey.

The offshore survey was conducted from two vessels, an acoustic/bird observation vessel (F/V CAPE ELRINGTON) and a mid-water trawl vessel (F/V CARAVELLE). Surveys were conducted during daylight hours, typically between 0600 and 2000. The acoustic vessel surveyed a series of transects. The transects were in a pattern of parallel transects through each area, terminating at shorelines as close as possible to the shore. Patterns to be run in each area followed a pre-selected series of transects spaced at two mile intervals (Table 1, Figures 2 - 4). Data were collected with a 120 kHz BioSonics Model 101 Scientific Echosounder, with the transducer deployed in down-looking mode from the towed vehicle. Signal processing was accomplished with a BioSonics Model 221 ESP Echo Integrator.

The F/V CARAVELLE collected mid-water trawl samples of targets designated by the acoustic vessel (Table 2). The location of net sampling was determined by acoustic and bird observations. Where acoustic signals or bird activity indicated the presence of forage species, scientists on the acoustic vessel directed the midwater trawl vessel to the location and depth where collections were desired.

CTD profiles were collected at net collection stations and on each transect line (Table 3). A Seabird SEACAT SBE 19 CTD was used to sample the water column from the surface to 200 m depth, or to within 10 m of the bottom at shallower stations.

Nearshore Survey

The F/V MISS KAYLEE conducted a series of hydroacoustic transects in the three study areas, working in the same general area as the offshore survey on each day. On July 26 and 27 the CAPE ELRINGTON conducted the nearshore survey due to failure of acoustic equipment on the MISS KAYLEY. The equipment on the MISS KAYLEE was a Biosonics ESP 420 kHz analog down-looking and side-looking system multiplexed with a 130 kHz DT6000 digital down-looking system. On July 19th the ESP 420 kHz system failed and beginning on July 20th the inshore survey was continued with only the DT6000 system. On July 25th the DT6000 system also failed, and it was replaced with a DT5000 system. The DT5000 system failed almost immediately; consequently, the nearshore survey was completed using the CAPE ELRINGTON and the ESP 120 kHz system.

Inshore transects were in a pattern of zig-zags within 12 km segments of shoreline. The 12 km study site segments were laid out sequentially through the shoreline within each study area. The number of 12 km study sites within each study are: North - 26, Central - 8, South 21 (Figures 5 - 7). Since time constraints precluded sampling all of the shoreline in the North and South areas, a systematic sampling plan was followed, and every other study site segment was sampled, with random removal of additional segments to further reduce the number as necessary. Segments sampled were:

North	1, 3, 5, 7, 9, 13, 15. 17, 19
Central	1-8
South	2, 4, 6, 10, 14, 16, 18, 20

Each 12 km study site was further divided into ten 1.2 km beach sections, with the starting and ending points of each beach section marking the shoreward turning point in a series of 20 transects were laid out following a zig-zag pattern (10 zigs, 10 zags), with each transect about 1.2 km long (Table 4, Figure 8). The acoustic transects are identified by a alpha-numeric designation, for example: N03-02A

N - indicates the North study area

03 - indicates the third 12 km shoreline segment

02 - indicates the second beach section, or second set of zig-zags

A - indicates the first of the two zig-zag transects off beach section 2.

Acoustic targets found by the survey vessel in the inshore study areas were sampled by the F/V PAGAN using purse seine, dip nets, cast nets (Table 5) or a video-equipped ROV (Remote Operated Video) (Table 6).

CTD profiles were collected at representative sites at each 12 km segment sampled acoustically (Table 7). A Seabird SEACAT SBE 19 CTD was used to sample the water column from the surface to 200 m depth, or to within 10 m of the bottom at shallower stations.

Beach-seine survey

Beach seining was conducted in each study area in the same 12 km beach segments that were sampled in the inshore survey. The beach sections within each segment sampled were chosen randomly. The ten 1.2 km sections within each study site segment were randomly ranked, using a random number table (Table 8). The first three ranked sections had one seine haul made on any beach that was thought to be fishable. If there were no fishable beaches in a top-ranked beach section, the next ranked section was used.

Net Sampling methods

A mid-water trawl was the primary sampling tool used to sample acoustic targets offshore. This net is a research-scale version of a mid-water commercial herring trawl used in Canada. Although the absolute net mouth opening is about 100 m^2, the effective opening is about 50 m^2. This size net has proven effective on larger nektonic forage fishes such as herring (Mike Halstead, Research Nets Inc. Seattle, Personal communication). The mesh sizes diminish stepwise from about 2" in the wings to 3/8" (9.5 mm) in the codend. An additional cod end liner with 1/8" (3.2 mm) mesh netting was sewn into the midwater trawl, this inner liner terminated in a plankton bucket with 0.5 mm nytex mesh that retained smaller macroplanktonic organisms. Midwater trawl samples were collected at locations and depths specified by the researchers monitoring the acoustic sampling.

A purse seine was the primary net sampling gear used to collect samples of acoustic targets in the nearshore survey, although dip nets and cast nets were used occasionally to collect fishes very near the surface. The purse seine was 200 m long by 20 m deep with 25 mm stretched mesh.

The beach seine is a 37 m long net equipped with bridles and 30 m long lines attached to each bridle. The net tapers from 5 m depth at the center to 1.5 m depth at the end of each wing. The mesh size is 20 mm stretched mesh except for a center panel 9 m long that has 10 mm stretched mesh.

<u>Sample Processing</u>

MacroInvertebrates.

Gelatinous zooplankton were identified to the lowest possible taxon in the field. All other zooplankton were either frozen for future energetic studies or preserved in buffered 5% formalin.

Fishes.

Fish larger than about 50 mm were identified in the field and sorted to species. All fish were measured (fork length) unless net hauls contain large numbers of individuals of some species. Large catches were randomly subsampled by splitting the catch down to 100 - 200 individuals for measurement. Subsamples of all forage fish species were frozen and returned to the laboratory for future life history and energetics studies.

ANALYTIC AND STATISTICAL METHODS

Acoustic data

Offshore survey.

Averages were caculated for each transect within two depth strata: 1 - 25 m and 26 - 100 m. the deeper stratum exends further than the previous year (100 m ve. 65 m) because of the lower frequency (120 kHz vs. 420 kHz) used in 1996. A scaling factor of - 30 dB/Kg of fish biomass was used to convert echo integration measurements to fish density.

Nearshore survey.

Biomass estimates were developed by scaling down-looking acoustic data based on the length distributions of the dominant fish species collected in each study area. Estimates of the number of individual fish per cubic meter are determined by an equation relating acoustic target strength to fish length. Data were collected using the default target strength of -42.2 dB. Equations to convert fish length (L, in cm, log base 10) to target strength (TS) were:

pollock	$TS = 20 (\log L) - 66$	
herring	$TS = 20 (\log L) - 68$	
sand lance	$TS = 20 (\log L) - 93.7$	(based on 38 kHz system)

Differences between the computed target strength and the default target strength were used to rescale the data.

Estimates of fish numbers were converted to an estimate of biomass per cubic meter using the length-weight relationship for the dominant species. Equations to compute biomass (W - in grams, L - in mm) were:

pollock	$W = (1.89 \times 10^{-6}) L^{3.272}$
herring	$W = (5.007 \times 10^{-6}) L^{3.196}$
sand lance	$W = (4.81 \times 10^{-7}) L^{3.451}$

Biomass per cubic meter estimates were converted to biomass per square meter of surface by integrating the results over the depth of the sampled water column. Length to target strength relationships were taken from the literature, and the length-weight equations were from our unpublished data in PWS.

Geographic distributions of forage species were assessed by developing area plots of biomass density gradients determined through a kriging routine. The kriging method has a gridding algorithm (we used a minimum curvature algorithm) that estimates the data between transect lines based on spatial variation along the transect lines. Therefore, the most accurate point estimates are those occurring closest to the lines in regions where transect density is highest. Land masses were overlaid on the area plots after the gridding algorithm had been run.

Biomass estimates for each of the nearshore 12 km sampling sites were developed by calculating the mean for each set of zigs and zags separately, and an overall estimate was calculated by including all transects (zigs and zags) in the average. The estimate of nearshore biomass in each of the three study areas (North, Central, and South) was produced by averaging the overall estimate from each of the sampling sites.

Depth profiles of temperature, salinity and sigma-t were plotted for all CTD casts. We also evaluated geographic patterns in offshore water structure by plotting isotherm and isohaline lines over series of stations in the North (Valdez Arm), Central (east of Knight Is.) and South (Knight Island Passage) study areas.

Geographic patterns of temperature and salinity were plotted for series of CTD stations extending from nearshore to offshore in the North (Port Fidalgo), Central (MacPherson Passage), and South (Knight Island Passage) study areas to determine if tidal fronts were found in the nearshore areas of the Sound. In addition, two diel CTD stations were sampled every 6 hours over a 24 hour period in Bainbridge Passage to determine if tidal currents were strong enough to break down the vertical stratification of the water column.

RESULTS - OFFSHORE SURVEY

Hydroacoustic

Aggregations of forage fishes were seldom encountered in the offshore survey. This was a sharp contrast to the results from the 1995 survey, when large aggregations of young-of-the-year walleye pollock were found in the Central area east of Knight Island (Figures 9, 10). In most cases densities were low, less than one gram/square meter (Table 9). The North area had average densities of acoustic biomass that were over three times higher than either the Central or South areas (Table 10).

Net Sampling

Midwater trawl samples were collected at twelve stations in the offshore survey (Table 11). The only fish in midwater catches were walleye pollock at stations 65 (Central area, mean fork length 281 mm) and 119 (North area, mean fork length 260 mm), these lengths indicate they were at least two years of age. Jellyfish were the dominant component of midwater trawl catches, the most abundant genera of jellyfish were *Aequorea* and *Cyanea* (Table 11).

Hydrographic

Prince William Sound is a large estuary, with large amounts of freshwater input from rainwater and meltwater from glaciers and snowfields. The resultant salinity gradients are largely responsible for stratification of the water column in the Sound. In the summer of 1996 all three study areas had gradients in temperature and salinity in the upper 50 m, with surface temperatures ranging from 12 - 15 ^{o} C. and salinities from 17 - 30 ^{o}/oo (Figure 11). Below about 50 m temperatures were typically $<5^{o}$ C with salinities above 32 ^{o}/oo.

Physical conditions in the three study areas were very similar, both in termperature and salinity. Unlike 1995, there was no layer of cold water near the surface in the South, and the Central area was not notably less saline at the surface than the North or South areas. The upper 20 meters of the Sound was generally more saline in 1996 than in 1995. All of these observations are consistent with the lower rainfall that occurred in the Prince William Sound area in 1996, relative to 1995; and the consequent reduction in fresh water run-off into the Sound.

Conditions within a survey area were relatively uniform. In the North area a south to north series of stations on transect lines 2 - 8 (Figure 12, stations are spaced every 2 nautical miles) have quite flat isothermal and isohaline profiles, except for colder surface water near glaciers (station N03A) and colder, less saline water at the north end of the transect. (Figure 13) . In a south to north transect of stations in the Central area (Figure 14), temperatures and salinities are more uniform (Figure 15). At 9 stations through Knight Island Passage in the South area (Figure 16), the water column is colder and more saline at shallow depths at the southern end of the transect (Figures 17).

RESULTS - NEARSHORE SURVEY

Hydroacoustics

Biomass estimates varied among the three major study areas, largely due to the variability in the rate at which schools of forage fishes were encountered. Within each of the 12 km sampling sites, the mean biomass for each set of zigs and zags often differed sharply - reflecting the fact that usually much of the biomass within a sampling site was due to the presence of one or two schools of fish that occurred on one or two of the 20 transects that made up the set of zigs and zags at a site. As a consequence of this pattern the standard errors for each set of zigs and zags are relatively large (Table 12). The distribution of biomass estimates of individual transects provides an index of the number of schools of forage fishes in each of the study areas (Figure 18). The North area had substantially more transects where fish schools were encountered than did the South or Central areas. Large schools on a transect typically resulted in average biomass exceeding 10 g/m2. The North area had 21 such transects, whereas the South and Central areas had 7 and 2 high value transects, respectively. The mean biomass estimates of zigs only, zags only, and total transects were all also higher in the North study area (Table 12).

The geographic distribution of biomass among the transects in the study areas indicated that schools of forage fishes were not randomly distributed (Figures

19, 20, 21). In the North, Port Gravina had the highest concentration of biomass which was comprised of sand lance, YOY herring, and YOY walleye pollock. In the Central area most biomass occurrred around the north end of Knight Island. In the South, biomass was concentrated in Prince of Wales Passage, where schools of juvenile and adult herring occurred.

Acoustic returns from herring, sand lance and walleye pollock displayed distinctively different patterns. Herring schools were typically tightly organized in roughly symetrical oval shapes in the upper water column with high acoustic backscattering (Figure 22). Sand lance schools were widely spread above the bottom with relatively low acoustic backscatter (Figure 23). YOY pollock were found in patchy schools, well off the bottom with moderately high acoustic backscatter (Figure 24).

Net and Video Sampling

Net samples were collected in the three study areas (Tables 13, 14, 15) to identify acoustic targets and to collect samples for size, condition and energetics studies. More samples were collected in the North study area as the acoustic survey found many more schools of forage fishes in that area.

Video sampling was used extensively in all study areas, and proved to be an effective way to identify species of fish schools that were located by the acoustic survey vessel. Herring were by far the most commonly identified species in video sampling of acoustic targets (Table 16).

Fishes collected by the nearshore net/video sampling vessel were mostly herring with size distributions indicating they were young-of-the year (< 100 mm), 1+ years (100 - 130 mm) 2+ years (130 - 170 mm) or older adults (>180 mm). Lengths of fishes sampled varied among the study areas (Table 17).

Hydrographic

Physical conditions in the nearshore were very similar to those in the offshore stations in all three study areas. We examined geographic patterns in temperature and salinity at a series of CTD stations extending from nearshore to offshore to determine if tidal fronts were present nearshore in the Sound. At a series in Port Fidalgo (Figures 25, 26), Naked Island (Figures 27, 28) and Bainbridge/Knight Is. Passage (Figures 29, 30), we found no indication that the strong vertical stratification that exists offshore was being being broken down in the nearshore. Examination of temporal variation in temperature and salinity at two stations in Bainbridge passage on July 18 also indicated that the vertical structure was not disrupted over several tide changes in this narrow passage that experiences considerable tidal flushing (Figures 31, 32, 33). In that series, high tides occurred at about 3:20 AM (+ 12.3 ft) and 4:20 PM (+ 11.2 ft), and low tides at about 9:50 AM (- 0.9 ft) and10:00 PM (+2.5 ft). This date had the greatest tide range that occurred during our field season.

RESULTS - BEACH SEINE SURVEY

Catches in beach seine sampling were highly variable, as most of the fish were caught in a few hauls in each of the three study areas. Among the 73 hauls that comprised the beach seine survey, ten hauls accounted for over 95% of the total catch (Figure 34). Large samples typically occurred when schools of herring or sand lance were intercepted by the seine. Highest catches occurred in the North study area, and fewest in the South (Tables 18, 19, 20). The differences were not tested statistically because of the extremely high variability in catches; however, the data suggest that there were differences in the species composition and abundance among the three areas. The proportions of beach seine samples that included the most commonly occurring species also suggest that there were differences among the three study areas. Pink salmon and tomcod were the most frequently occurring species in the South and Central study areas, whereas herring and sand lance had the highest frequency of occurrence in the North (Figure 34).

DISCUSSION/SUMMARY

Pronounced water column structure in the form of strong vertical gradients in temperature, salinity and density were evident throughout the North, Central and South sampling areas in Prince William Sound in summer 1996. This is expected in an estuarine ecosystem such as PWS which receives large amounts of rain, snowmelt and glacial meltwater discharge. Surface temperatures ranged from 12 - 15 ^{o}C and decreased rapidly with depth. Temperatures below 50 m were 3 - 5 ^{o}C. Surface salinities varied from 19 - 30 ppt, while salinities below 50 m were relatively isohaline at 31-33 ppt. In general, offshore stations had warmer temperatures and higher salinities in surface waters than inshore stations. Surface waters at stations in the North area were generally colder and less saline than stations in the South area, but the proximity of stations to glacial meltwater and riverine discharge introduces considerable variability. Although considerable spatial variability existed, in general waters in PWS during our cruise in summer 1996 were warmer and more saline than in 1995. This is consistent with the lower amounts of rainfall in the area in 1996.

Differences in the relative abundance of birds in the offshore and nearshore areas led to a hypothesis that differences in water column structure from offshore to inshore might explain the larger abundance of seabirds feeding nearshore. Nearshore frontal zones - boundaries between stratified offshore waters and well-mixed nearshore waters - occur when turbulence from tidal currents is strong enough to break down stratification. Such frontal zones may concentrate zooplankton, which could cause planktivorous fishes to aggregate nearshore; and, consequently, result in more birds foraging nearshore.

To examine the possible changes of hydrographic structure from offshore to nearshore waters, a series of CTD transects were established in several locations within the North (Port Fidalgo), Central (McPherson Bay) and South (Bainbridge Passage) areas. In the north and central parts of Bainbridge Passage, CTD samples were collected at 6 hour intervals for 24 hours, spanning two spring cycles.

No differences in hydrographic structure were evident from offshore to inshore, or over tidal cycles. Horizontal thermopleths and halopleths were uniformly smooth between stations located along transects extending from offshore to inshore, indicating that tidal fronts are not consistent features of the nearshore environment. Similarly, only a few deep anomalies in thermal and salinity isopleths are obvious in diel hydrographic sampling over a spring tide series. Although the concept sounds plausible, we found no evidence to support the hypothesis that water column structure might explain changes in availability of forage species to seabirds.

In 1996 we repeated the offshore survey of 1995, and added extensive nearshore acoustic and beach seine surveys. The main difference in the offshore survey in 1996 relative to 1995 was the absence of large schools of young-of-the-year walleye pollock that were a dominant feature of the forage fish complex in 1995. The YOY walleye pollock may have been absent from the 1996 survey if they were located outside the three study areas we surveyed; or, there may have been relatively few pollock produced in Prince William Sound in 1996. Walleye pollock populations in the Gulf of Alaska and the Bering Sea typically have high variability in year-class abundance; consequently, it would not be surprising to observe similar variability in Prince William Sound. We suspect that relatively low numbers of YOY walleye pollock in 1996 was due to a weak year class, although we cannot rule out the possibility that there were large numbers of pollock outside the study areas. Except for the areas where walleye pollock schools occurred in 1995, the acoustic biomass estimates for 1996 were similar in scale to those observed in 1995. As in 1995, the 1996 survey found distinctly higher acoustic biomass in the North study area than in the Central or South areas.

The nearshore acoustic survey found that herring were by far the most abundant forage species in nearshore areas, although there were some differences in herring age and size composition in the three study areas. In all areas, juvenile herring that were probably age 1+ or 2+ were the most commonly encountered sizes; young-of-the-year herring were encountered mainly in the North study area, whereas adult herring occurred mainly in the South. Larger herring are probably less vulnerable to bird predation;

therefore, these observations suggest that the North study area provided enhanced foraging conditions for avian predators.

Acoustic biomass estimates in the nearshore survey were mainly a function of the number of fish schools encountered on transects. The North area had the highest mean biomass estimates, followed by the South and Central areas. This result was due to the substantially higher number of transects with fish schools in the North. The fish schools were principally herring, although the North was the only area where schools of sand lance and schools of YOY pollock were found in the nearshore acoustic survey. It appears that the North study area provided substantially more opportunities for birds to encounter schools of fish in the nearshore area than did the South or Central study areas. Within the North area, schools of fish appeared to be concentrated in Port Gravina and to a lesser extent in the outer parts of Port Fidalgo. Port Gravina was also the area where schools of sand lance and YOY pollock were found.

The beach seine survey provided highly variable results, with total catches dominated by a few hauls that caught schools of forage species. Nevertheless, beach seine data provide indications of forage species distributions that are consistent with the nearshore acoustic results. The beach seine survey caught the highest total of fish in the North study area, followed by the South and Central areas. In addition, the frequency of occurrence of commonly caught species differed among areas, as herring and sandlance were ranked first and second in frequency of occurrence in the North, whereas in the South and Central areas pink salmon and tomcod ranked first and second. Statistically, the beach seine data set has very limited power to identify differences among areas, due mainly to the high variability within areas. Nevertheless, trends in beach seine results are similar to results from the acoustic surveys, and reinforce a conclusion that the North study area, especially waters around Port Gravina, provided substantially enhanced availability of forage fishes within Prince William Sound.

REFERENCES

Agler, B. A., P. E. Seiser, S. J. Kendall and D. B. Irons. 1994. Marine bird and sea otter population abundance of Prince William Sound, Alaska: trends following the T/V Exxon Valdex oil Spill, 1989-93. Exxon Valdez oil spill restoration fial reports, Restoration Project 93045. U.S. Fish and Wildlife Service, Anchorage.

Baird, P. A. and P. J. Gould. (eds.). 1985. The breeding biology and feeding ecology of marine birds in the Gulf of Alaska. OCSEAP Final Reports 45:121-504.

Baussant, T., F. Ibanez and M. Etienne. 1993. Numeric analysis of planktonic spatial patterns revealed by echograms. Aquatic Living Resources 6:175-184.

Clausen, D. 1983. Food of walleye pollock, *Theragra chalcogramma,* in an embayment of southeastern Alaska. Fish. Bull. 81:637-642.

Coyle, K. O. and R. T. Cooney. 1993. Water column sound scattering and hydrography around the Pribiliof Islands, Bering Sea. Cont. Shelf. Res. 13:803-827.

Coyle, K. O., G. Hunt, M. Decker and T. Weingartner. 1992. Murre foraging, epibenthic sound scattering and tidal advection over a shoal near St. George Island, Bering Sea. Mar. Ecol. Prog. Ser. 83:1-14.

Coyle, K. O. and A. J. Paul. 1992. Inteannual differences in prey taken by capelin, herring and red salmon relative to zooplankton abundance during the spring bloom in a southeast Alaskan embayment. Fish. Oceanog. 14:294-305.

Divoky, G. J. 1981. Birds of the ice-edge ecosystem in the Bering Sea. In: D. W. Hood and J. A. Calder (eds.) The eastern Bering Sea shelf: Oceanography and Resources, Vol 2. Office of Marine Pollution Assessment, NOAA, Juneau.

Drury, W. H., C. Ramshell and J. B. French,Jr. 1981. Ecological studies in the Bering Strait. U.S. Dept. Commer., NOAA OCSEAP Final Rept. Biol. Studies. 11:175-487. RU-237.

Gerlotto, F. 1993. Identification and spatial stratification of tropical fish concentrations using acoustic populations. Aquatic Living Resources 6:243-254.

Hunt, G. L., Jr., Z. Eppley, B. Burgeson and R. Squibb. 1981. Reproductive ecology, food and foraging areas of sea birds nesting on the Pribilof Islands. U. S. Dept. Commerce, NOAA OCSEAP Final Report 2.

Livingston, P. A. D. A. Dwyer, D. L. Wencker, M. S. Yang and G. M. Lang. 1986. Trophic interactions of key fish species in the eastern Bering Sea. Int. No. Pac. Fish. Comm. Bull. 47:49-65.

Mathisen, O., R. Thorne, R. Trumble and M. Blackburn. 1978. Food composition of pelagic fish in an upwelling area. Pp. 111-123 in: R. Boje and M. Tomczak (eds.) Upwelling Ecosystmes. Springer-Verlag.

Oji, H. 1980. The pelagic feeding ecology of thick-billed murres in the north Pacific, March-June. Bull. Fac. Fish. Hokkaido Univ. 31:50-72.

Simard, Y., D. Marcotte and G. Bourgault. 1993. Exploration of geostatistical methods for mapping and estimating acoustic biomass of pelagic fish in the Gulf of St. Lawrence: size of echo integration unit and auxiliary environmental variables. Aquatic Living Resources 6:185-199.

Springer, A. M. and G. V. Byrd. 1989. Seabird dependence on walleye pollock in the southeastern Bering Sea. In: Proc. Int. Symp. Biol. Mgmt. Walleye Pollock. Alaska Sea Grant Program. University of Alaska Fairbanks.

Springer, A. M., D. G. Roseneau, E. C. Murphy and M. I Springer. 1984. Environmental controls of marine food webs: Food habits of seabirds in the eastern Chukchi Sea. Can. J. Fish. Aquat. Sci. 41:1202-1215.

Straty, R. R. 1972. Ecology an behavior of juvenile sockeye salmon (*Oncorhynchus nerka*) in Bristol Bay and the eastern Bering Sea. In D. W. Hood and E. J. Kelly (eds.) Oceanography of the Bering Sea. pp 285-319. occasional Publ. 2. Inst. Mar. Sci. U. of Alaska,Fairbanks.

Thorne, R., O. Mathisen, R. Trumble and M. Blackburn. 1977. Distribution and abundance of pelagic fish off Spanish Sahara during CUEA Expedition Joint 1. Deep-Sea Reserch 24:75-82.

Thorne, R., R. Trumbel and N. Lemberg. 1982. The Strait of Georgia herring fishery: a case history of timely management aided by hydroacoustic surveys. Fisheries Bulletin 80:381-388.

Warner, I. M. and P. Shafford. 1981. Forage fish spawining surveys - southern Bering Sea. pp 1 - 64. In: Environ. Assess. Alaskan Cont. Shelf. Final Rept. Biol. Studies. Vol 10. OCSEAP/ NOAA. Boulder, Colorado.

Wilson, U. W. and Manuwal. 1984. Breeding biology of the Rhinoceros auklet (*Cerorhinca monocerata*) in Washington. Condor 88:143-155).

Table 1. Offshore transect locations in APEX Prince William Sound study areas.

North Area

Transect Number	Latitude	General Location	From/To
N01A	60º 46.2'	S Port Fidalgo	shore to 147º 0'
N02A	60º 48.2'	S Bligh Is.	146º 0.0 to 147º 5'
N03LLB	60º 50.2'	Landlocked Bay	shore to shore
N03TT	60º 50.2'	S Tatitlek Narrows	shore to shore
N03VA	60º 50.2'	Bligh Reef	shore to 147º 0'
N04BB	60º 52.2'	Boulder Bay	shore to shore
N04VA	60º 52.2'	E Glacier Is.	shore to shore
N05VA	60º 54.2'	Valdez Arm	shore to shore
N05GIW	60º 54.2'	W. Glacier Is.	shore to 147º 0'
N06GBE	60º 56.2'	inner Galena Bay	shore to shore
N06GBW	60º 56.2'	outer Galena Bay	shore to shore
N06VA	60º 56.2'	Valdez Arm	shore to shore
N06CB	60º 56.2'	Columbia Bay ent.	shore to shore
N06LB	60º 56.2'	Long Bay ent.	shore to shore
N07VA	60º 58.2'	Valdez Arm	shore to shore
N08VA	61º 0.2'	Valdez Arm	shore to shore
N09VA	61º 2.2'	Valdez Arm/ Jack B.	shore to shore
N10VN	61º 4.2'	Valdez Narrows	shore to shore
N11PV	61º 6.2'	Port Valdez	shore to shore
N12 A	60º 44.2'	Outer Port Fidalgo	146º 50.0' to shore
N13W	60º 42.2'	Goose Island	146º 55.0' to shore
N13E	60º 42.2'	Port Gravina	shore to shore
N14W	60º 40.2'	Port Gravina	146º 45.0' to Red Head
N14E	60º 40.2'	Port Gravina	Red Head east to shore

Central Area

Transect Number	Latitude	General Location	From/To
C01A	60º 22.3'	N Montague St.	147º 12.0' to shore
C02A	60º 24.3'	Manning Rocks	147º 12.0' to shore
C03A	60º 26.3'	N Seal Is.	147º 12.0' to shore
C04A	60º 28.3'	N Knight Is.	147º 12.0' to shore
C05A	60º 30.3'	S Smith Is.	147º 2.0' to shore
C06A	60º 32.3'	N Smith Is.	147º 2.0' to shore
C07E	60º 34.3'	NE Eleanor Is.	147º 2.0' to shore
C07W	60º 34.3'	NW Eleanor Is.	shore to 147º 2.0'
C08A	60º 36.3'	Eleanor Pass.	147º 12.0' to 147º 42.0'
C09E	60º 38.3'	SE Naked Is.	147º 12.0' to shore
C09W	60º 38.3'	SW Naked Is.	shore to 147º 42.0'
C10E	60º 40.3'	E Naked Is.	147º 12.0' to shore
C10C	60º 40.3'	McPherson Bay	shore to shore
C10W	60º 40.3'	W. Naked Is.	shore to 147º 42.0'
C11E	60º 42.3'	E Peak Is.	147º 12.0' to shore
C11W	60º 42.3'	W Peak Is.	shore to 147º 42.0'
C12E	60º 44.3'	E. Storey Is.	147º 12.0' to shore
C12W	60º 44.3'	W. Storey Is.	shore to 147º 42.0'

South Area

Transect Number	Latitude	General Location	From/To
S01E	60º 15.0'	Whale Bay Entr.	148º 5' to shore
S01W	60º 15.0'	Icy Bay	shore to shore
S02W	60º 17.0'	Lower Dang. Pass.	shore to shore
S02E	60º 17.0'	Knight Is Pass.	shore to shore
S03W	60º 19.0'	S Jackpot Is.	shore to shore
S03E	60º 19.0'	Knight Is. Pass.	shore to shore
S04W	60º 21.0'	Dangerous Pass.	shore to shore
S04E	60º 21.0'	Knight Is. Pass	shore to shore
S06W	60º 11.0'	Bainbridge Pass.	shore to shore
S06E	60º 11.0'	Bainbridge Pass.	shore to shore
S07A	60º 09.0'	Shelter Bay to Pt. Helen	shore to shore
S08A	60º 07.0'	So. end Knight Is. Pass.	shore to 147º 46.0'
S09W	60º 23.0'	Dangerous Passage	shore to shore
S09E	60º 23.0'	Knight Is. Pass.	shore to shore

TABLE 2. Midwater trawl samples collected in the offshore survey during APEX cruise 96-1

DATE	TIME	STN #	LOCATION	LATITUDE	LONGITUDE	DEPTH (m)	GEAR DEPTH (m)
15/07	13:51	5		60 07.271	147 50.285	340	40
16/07	11:56	12	Prince of Wales Pass.	60 2.464	148 07.928	76	35
16/07	13:20	12	Prince of Wales Pass.	60 03.872	148 07.668	90	40-50
20/07	12:36	48	C02A	60 24.008	147 32.043	173	70
20/07	13:30	48	C02A	60 24.186	147 28.153	128	60
21/07	14:23	65	C04A	60 28.156	147 21.516	80.6-163	128
23/07	12:23	83	Galena Bay	60 56.429	146 40.391	220	170
23/07	13:51	84	Galena Bay	60 56.350	146 41.557	780	230
25/07	9:50	102	1 km from shore	60 47.51	146 25.84	102	55
25/07	15:46	111	off Knowles Head	60 40.156	146 38.946	31	25
26/07	11:54	119	N01-13E	60 41.855	146 12.848	136	125-130
26/07	14:07	122	N14E	60 40.000	146 17.557	135	60

Table 3. CTD data collected in the offshore survey during APEX cruise 96-1.

DATE	TIME	STN #	LOCATION	LATITUDE	LONGITUDE	DEPTH (m)	GEAR DEPTH (m)
15/07	13:27	5	S08A	60 07.4	147 49.9	292	200
15/07	15:04	6	S07A	60 09.0	147 50	289	200
15/07	16:10	8	S06E	60 10.966	147 55.077	382	200
15/07	16:50	9	S05E	60 12.877	148 0.00	368	200
15/07	17:27	10	S01E	60 14.93	147 59.96	592	200
16/07	17:15	17	S01E	60 15	148 10	324	200
17/07	10:36	19	S02W	60 17	148 09.85	288	200
17/07	11:15	21	S03W	60 19.031	148 10.000	260	200
17/07	12:23	22	S02E	60 16.980	148 00.059	522	200
17/07	12:50	23	S03E	60 18.991	147 57.924	404	200
17/07	13:16	24	S04E	60 20.986	147 57.983	368	200
17/07	13:43	25	S09E; S18-10A	60 22.970	147 57.956	270	200
20/07	9:54	45	C01A	60 22.293	147 30.033	151	140
20/07	10:19	46	C02A	60 24.390	147 29.853	161	140
20/07	10:53	47	C03A	60 26.318	147 30.030	159	140
20/07	15:01	49	C04A	60 28.311	147 29.989	185	180
20/07	15:28	50	C05A	60 30.273	147 30.022	196	180
21/07	8:56	55	C08A	60 36.311	147 15.020	196	180
21/07	9:20	56	C09E	60 38.274	147 14.999	167	160
21/07	9:45	57	C10E	60 40.350	147 15.013	125	120
21/07	10:05	58	C11E	60 42.333	147 15.968	172	160
21/07	10:30	59	C12E	60 44.276	147 14.891	275	200
21/07	15:21	65	C04A	60 28.233	147 18.554	179	160
21/07	16:40	66	C06A	60 32.271	147 29.930	191	180
21/07	17:13	67	C07A	60 34.304	147 30.090	196	180
21/07	18:31	68	C08A	60 36.374	147 35.020	334	200
22/07	8:53	69	C09W	60 38.306	147 34.992	350	200
22/07	9:15	70	C10W	60 40.307	147 34.965	498	200
23/07	8:57	77	N09A	61 02.036	146 43.828	337	200
23/07	9:27	78	N08A	61 00.22	146 47.522	346	200
23/07	9:52	79	N07A	60 58.250	146 50.140	374	200
23/07	10:23	80	N06A	60 56.224	146 53.309	322	200
24/07	9:53	89	N05A	60 54.279	146 56.568	341	200
24/07	10:59	90	N04A	60 52.326	146 56.466	359	200
24/07	11:33	91	N03A	60 50.322	146 59.947	372	200
24/07	11:56	92	N02A	60 48.326	147 00.021	320	200
24/07	12:20	93	N01A	60 46.274	146 59.981	444	200
24/07	12:30	93	N01A	60 46.301	146 59.881	446	200
25/07	14:10	109	N01A	60 46.180	146 40.037	102	100

Table 4. Locations of nearshore transects sampled in APEX cruise 96-1.

TRANSECT	LAT START	LONG START	LAT END	LONG END
N0101A	60 37.25	146 15.6	60 37.4	146 16.9
N0101B	60 37.4	146 16.9	60 37.8	146 16.1
N0102A	60 37.8	146 16.1	60 38.0	146 17.2
N0102B	60 38.0	146 17.2	60 38.45	146 16.4
N0103A	60 38.45	146 16.4	60 38.8	146 17.6
N0103B	60 38.8	146 17.6	60 39.0	146 16.3
N0104A	60 39.0	146 16.3	60 39.6	146 16.5
N0104B	60 39.6	146 16.5	60 39.5	146 15.1
N0105A	60 39.5	146 15.1	60 40.05	146 15.5
N0105B	60 40.05	146 15.5	60 39.9	146 14.5
N0106A	60 39.9	146 14.5	60 40.55	146 14.6
N0106B	60 40.55	146 14.6	60 40.4	146 13.7
N0107A	60 40.4	146 13.7	60 41.0	146 13.6
N0107B	60 41.0	146 13.6	60 40.8	146 12.4
N0108A	60 40.8	146 12.4	60 41.9	146 12.0
N0108B	60 41.9	146 12.0	60 41.35	146 11.3
N0109A	60 41.35	146 11.3	60 41.95	146 11.8
N0109B	60 41.95	146 11.8	60 41.8	146 10.8
N0110A	60 41.8	146 10.8	60 42.45	146 11
N0110B	60 42.45	146 11	60 43.3	146 9.6
N0301A	60 42.8	146 15.4	60 42.3	146 16.3
N0301B	60 42.3	146 16.3	60 42.75	146 16.8
N0302A	60 42.75	146 16.8	60 42.2	146 17.4
N0302B	60 42.2	146 17.4	60 42.75	146 18.1
N0303A	60 42.75	146 18.1	60 42.45	146 19.2
N0303B	60 42.45	146 19.2	60 43.0	146 18.9
N0304A	60 43.0	146 18.9	60 43.3	146 20.8
N0304B	60 43.3	146 20.8	60 43.5	146 19.1
N0305A	60 43.5	146 19.1	60 44.05	146 20.5
N0305B	60 44.05	146 20.5	60 44.2	146 18.8
N0306A	60 44.2	146 18.8	60 44.75	146 19.7
N0306B	60 44.75	146 19.7	60 45.2	146 18.2
N0307A	60 45.2	146 18.2	60 45.95	146 17.8
N0307B	60 45.95	146 17.8	60 45.6	146 19.35
N0308A	60 45.6	146 19.35	60 44.9	146 18.8
N0308B	60 44.9	146 18.8	60 44.8	146 19.6
N0309A	60 44.8	146 19.6	60 43.7	146 17.7
N0309B	60 43.7	146 17.7	60 43.8	146 20.3
N0310A	60 43.8	146 20.3	60 43.2	146 19.8
N0310B	60 43.2	146 19.8	60 42.5	146 21.5
N0501A	60 40.7	146 26.8	60 39.95	146 27.0
N0501B	60 39.95	146 27.0	60 40.35	146 26.9
N0502A	60 40.35	146 26.9	60 39.7	146 28.1
N0502B	60 39.7	146 28.1	60 40.1	146 29.3
N0503A	60 40.1	146 29.3	60 39.4	146 29.7
N0503B	60 39.4	146 29.7	60 40.05	146 30.3
N0504A	60 40.05	146 30.3	60 39.75	146 31.4
N0504B	60 39.75	146 31.4	60 40.5	146 31.2
N0505A	60 40.5	146 31.2	60 40.3	146 32.4
N0505B	60 40.3	146 32.4	60 40.95	146 32.3
N0506A	60 40.95	146 32.3	60 40.35	146 33.1
N0506B	60 40.35	146 33.1	60 41.0	146 33.55
N0507A	60 41.0	146 33.55	60 40.4	146 34.2
N0507B	60 40.4	146 34.2	60 40.9	146 35.1
N0508A	60 40.9	146 35.1	60 40.25	146 35.6
N0508B	60 40.25	146 35.6	60 60.8	146 36.4
N0509A	60 60.8	146 36.4	60 40.15	146 36.9
N0509B	60 40.15	146 36.9	60 40.7	146 37.8
N0510A	60 40.7	146 37.8	60 40.2	146 38.6
N0510B	60 40.2	146 38.6	60 40.8	146 39.0

Table 4. Continued.

N0701A	60 44.0	146 44.55	60 43.4	146 44.5
N0701B	60 43.4	146 44.5	60 43.9	146 43.2
N0702A	60 43.9	146 43.2	60 43.9	146 42.3
N0702B	60 43.9	146 42.3	60 44.3	146 42.3
N0703A	60 44.3	146 42.3	60 44.8	146 43.4
N0703B	60 44.8	146 43.4	60 44.9	146 42.1
N0704A	60 44.9	146 42.1	60 45.4	146 41.3
N0704B	60 45.4	146 41.3	60 44.6	146 40.8
N0705A	60 44.6	146 40.8	60 45.05	146 39.5
N0705B	60 45.05	146 39.5	60 44.4	146 39.4
N0706A	60 44.4	146 39.4	60 44.5	146 38.2
N0706B	60 44.5	146 38.2	60 44.8	146 36.7
N0707A	60 44.8	146 36.7	60 45.45	146 38.2
N0707B	60 45.45	146 38.2	60 45.05	146 37.3
N0708A	60 45.05	146 37.3	60 45.75	146 37.9
N0708B	60 45.75	146 37.9	60 45.75	146 36.0
N0709A	60 45.75	146 36.0	60 46.3	146 35.6
N0709B	60 46.3	146 35.6	60 45.6	146 35
N0710A	60 45.6	146 35	60 45.65	146 33.4
N0710B	60 45.65	146 33.4	60 45.5	146 34.2
N0901A	60 48.4	146 31.9	60 47.4	146 31.15
N0901B	60 47.4	146 31.15	60 48.4	146 30.5
N0902A	60 48.4	146 30.5	60 47.3	146 29.5
N0902B	60 47.3	146 29.5	60 48.15	146 29.1
N0903A	60 48.15	146 29.1	60 46.65	146 28.3
N0903B	60 46.65	146 28.3	60 46.55	146 27.8
N0904A	60 46.55	146 27.8	60 47.2	146 27.5
N0904B	60 47.2	146 27.5	60 46.85	146 26.5
N0905A	60 46.85	146 26.5	60 47.5	146 26.2
N0905B	60 47.5	146 26.2	60 46.95	146 25.1
N0906A	60 46.95	146 25.1	60 47.7	146 24.75
N0906B	60 47.7	146 24.75	60 47.2	146 23.8
N0907A	60 47.2	146 23.8	60 47.75	146 23.25
N0907B	60 47.75	146 23.25	60 47.3	146 22.5
N0908A	60 47.3	146 22.5	60 47.95	146 22.05
N0908B	60 47.95	146 22.05	60 47.5	146 21.05
N0909A	60 47.5	146 21.05	60 48.1	146 20.6
N0909B	60 48.1	146 20.6	60 47.7	146 19.6
N0910A	60 47.7	146 19.6	60 47.85	146 19.9
N0910B	60 47.85	146 19.9	60 48.1	146 18.7
N1301A	60 50.9	146 35.1	60 50.35	146 34.5
N1301B	60 50.35	146 34.5	60 50.35	146 35.95
N1302A	60 50.35	146 35.95	60 49.85	146 35.1
N1302B	60 49.85	146 35.1	60 49.65	146 36.45
N1303A	60 49.65	146 36.45	60 49.15	146 35.7
N1303B	60 49.15	146 35.7	60 49.05	146 36.5
N1304A	60 49.05	146 36.5	60 48.4	146 37.4
N1304B	60 48.4	146 37.4	60 48.9	146 38.3
N1305A	60 48.9	146 38.3	60 48.5	146 39.3
N1305B	60 48.5	146 39.3	60 49.2	146 38.9
N1306A	60 49.2	146 38.9	60 49.45	146 40.0
N1306B	60 49.45	146 40.0	60 49.8	146 38.7
N1307A	60 49.8	146 38.7	60 50.2	146 39.8
N1307B	60 50.2	146 39.8	60 50.65	146 38.7
N1308A	60 50.65	146 38.7	60 51.05	146 39.3
N1308B	60 51.05	146 39.3	60 51.1	146 38.5
N1309A	60 51.1	146 38.5	60 51.7	146 38.6
N1309B	60 51.7	146 38.6	60 51.5	146 37.4
N1310A	60 51.5	146 37.4	60 52.05	146 37.9
N1310B	60 52.05	146 37.9	60 52.7	146 38.0

Table 4. Continued.

N1501A	60 48.65	146 42.5	60 48.0	146 42.5
N1501B	60 48.0	146 42.5	60 48.4	146 43.9
N1502A	60 48.4	146 43.9	60 47.9	146 44.5
N1502B	60 47.9	146 44.5	60 48.45	146 45.3
N1503A	60 48.45	146 45.3	60 47.65	146 45.8
N1503B	60 47.65	146 45.8	60 48.15	146 46.85
N1504A	60 48.15	146 46.85	60 47.5	146 47.1
N1504B	60 47.5	146 47.1	60 48.0	146 48.0
N1505A	60 48.0	146 48.0	60 47.9	146 49.5
N1505B	60 47.9	146 49.5	60 48.6	146 48.9
N1506A	60 48.6	146 48.9	60 48.85	146 50.3
N1506B	60 48.85	146 50.3	60 49.3	146 49.3
N1507A	60 49.3	146 49.3	60 49.65	146 50.45
N1507B	60 49.65	146 50.45	60 50.05	146 49.3
N1508A	60 50.05	146 49.3	60 50.8	146 49.5
N1508B	60 50.8	146 49.5	60 50.3	146 50.65
N1509A	60 50.3	146 50.65	60 50.45	146 52.0
N1509B	60 50.45	146 52.0	60 50.9	146 51.0
N1510A	60 50.9	146 51.0	60 51.55	146 51.4
N1510B	60 51.55	146 51.4	60 51.45	146 50.0
N1701A	60 45.15	146 47.4	60 54.7	146 47.4
N1701B	60 54.7	146 47.4	60 54.0	146 46.25
N1702A	60 54.0	146 46.25	60 54.3	146 44.9
N1702B	60 54.3	146 44.9	60 53.65	146 43.65
N1703A	60 53.65	146 43.65	60 54.35	146 44.4
N1703B	60 54.35	146 44.4	60 54.35	146 44.4
N1704A	60 54.35	146 44.4	60 54.6	146 45.7
N1704B	60 54.6	146 45.7	60 54.9	146 44.4
N1705A	60 54.9	146 44.4	60 55.0	146 45.8
N1705B	60 55.0	146 45.8	60 55.55	146 45.0
N1706A	60 55.55	146 45.0	60 56.2	146 46.45
N1706B	60 56.2	146 46.45	60 56.25	146 45.95
N1707A	60 56.25	146 45.95	60 56.8	146 47.25
N1707B	60 56.8	146 47.25	60 57.4	146 46.55
N1708A	60 57.4	146 46.55	60 57.55	146 47.4
N1708B	60 57.55	146 47.4	60 57.55	146 46.1
N1709A	60 57.55	146 46.1	60 58.1	146 46.6
N1709B	60 58.1	146 46.6	60 58.15	146 45.3
N1710A	60 58.15	146 45.3	60 58.5	146 43.95
N1710B	60 58.5	146 43.95	60 57.8	146 43.95
N1901A	60 55.85	146 36.0	60 55.85	146 37.35
N1901B	60 55.85	146 37.35	60 56.3	146 36.7
N1902A	60 56.3	146 36.7	60 56.25	146 37.9
N1902B	60 56.25	146 37.9	60 56.85	146 37.55
N1903A	60 56.85	146 37.55	60 56.4	146 38.4
N1903B	60 56.4	146 38.4	60 56.95	146 38.8
N1904A	60 56.95	146 38.8	60 56.6	146 39.6
N1904B	60 56.6	146 39.6	60 56.3	146 40.95
N1905A	60 56.3	146 40.95	60 56.5	146 41.05
N1905B	60 56.5	146 41.05	60 57.0	146 42.3
N1906A	60 57.0	146 42.3	60 57.1	146 43.6
N1906B	60 57.1	146 43.6	60 57.65	146 42.8
N1907A	60 57.65	146 42.8	60 56.7	146 44.2
N1907B	60 56.7	146 44.2	60 58.2	146 43.5
N1908A	60 58.2	146 43.5	60 58.6	146 44.6
N1908B	60 58.6	146 44.6	60 59.15	146 43.7
N1909A	60 59.15	146 43.7	60 59.8	146 43.7
N1909B	60 59.8	146 43.7	60 59.45	146 42.55
N1910A	60 59.45	146 42.55	60 59.9	146 43.3
N1910B	60 59.9	146 43.3	61 0.1	146 42.0

Table 4. Continued.

C0101A	60 21.3	147 37.6	60 21.45	147 36.9
C0101B	60 21.45	147 36.9	60 21.85	147 37.9
C0102A	60 21.85	147 37.9	60 22.2	147 35.9
C0102B	60 22.2	147 35.9	60 22.5	147 37.0
C0103A	60 22.5	147 37.0	60 22.8	147 35.9
C0103B	60 22.8	147 35.9	60 23.1	147 37.9
C0104A	60 23.1	147 37.9	60 23.8	147 36.6
C0104B	60 23.8	147 36.6	60 23.65	147 37.9
C0105A	60 23.65	147 37.9	60 23.85	147 39.1
C0105B	60 23.85	147 39.1	60 23.4	147 40.1
C0106A	60 23.4	147 40.1	60 23.9	147 41.1
C0106B	60 23.9	147 41.1	60 24.15	147 40.0
C0107A	60 24.15	147 40.0	60 23.75	147 41.1
C0107B	60 23.75	147 41.1	60 24.5	147 41.1
C0108A	60 24.5	147 41.1	60 23.9	147 40.0
C0108B	60 23.9	147 40.0	60 24.5	147 40.0
C0109A	60 24.5	147 40.0	60 24.05	147 37.8
C0109B	60 24.05	147 37.8	60 24.71	147 37.9
C0110A	60 24.71	147 37.9	60 24.55	147 36.7
C0110B	60 24.55	147 36.7	60 25.25	147 36.8
C0201A	60 25.25	147 36.8	60 25.35	147 35.4
C0201B	60 25.35	147 35.4	60 25.8	147 36.2
C0202A	60 25.8	147 36.2	60 26.5	147 35.9
C0202B	60 26.5	147 35.9	60 26.35	147 37.2
C0203A	60 26.35	147 37.2	60 27.0	147 37.0
C0203B	60 27.0	147 37.0	60 27.05	147 38.6
C0204A	60 27.05	147 38.6	60 27.05	147 37.3
C0204B	60 27.05	147 37.3	60 27.65	147 37.1
C0205A	60 27.65	147 37.1	60 28.1	147 36.2
C0205B	60 28.1	147 36.2	60 28.3	147 37.4
C0206A	60 28.3	147 37.4	60 28.85	147 36.4
C0206B	60 28.85	147 36.4	60 28.9	147 37.5
C0207A	60 28.9	147 37.5	60 29.1	147 37.8
C0207B	60 29.1	147 37.8	60 28.85	147 38.3
C0208A	60 28.85	147 38.3	60 29.2	147 39.6
C0208B	60 29.2	147 39.6	60 28.85	147 36.3
C0209A	60 28.85	147 36.3	60 29.2	147 35.1
C0209B	60 29.2	147 35.1	60 29.5	147 36.2
C0210A	60 29.5	147 36.2	60 30.15	147 35.3
C0210B	60 30.15	147 35.3	60 30.5	147 36.4
C0301A	60 30.5	147 36.4	60 30.5	147 35.3
C0301B	60 30.5	147 35.3	60 31.3	147 35.0
C0302A	60 31.3	147 35.0	60 31.15	147 33.6
C0302B	60 31.15	147 33.6	60 31.75	147 34.0
C0303A	60 31.75	147 34.0	60 31.6	147 32.9
C0303B	60 31.6	147 32.9	60 32.25	147 33.1
C0304A	60 32.25	147 33.1	60 32.1	147 31.9
C0304B	60 32.1	147 31.9	60 32.7	147 30.25
C0305A	60 32.7	147 30.25	60 33.1	147 31.3
C0305B	60 33.1	147 31.3	60 33.35	147 32.6
C0306A	60 33.35	147 32.6	60 33.8	147 31.5
C0306B	60 33.8	147 31.5	60 33.5	147 32.9
C0307A	60 33.5	147 32.9	60 34.55	147 32.0
C0307B	60 34.55	147 32.0	60 34.65	147 33.3
C0308A	60 34.65	147 33.3	60 35.25	147 32.6
C0308B	60 35.25	147 32.6	60 35.25	147 33.9
C0309A	60 35.25	147 33.9	60 35.35	147 35.25
C0309B	60 35.35	147 35.25	60 34.75	147 34.9
C0310A	60 34.75	147 34.9	60 34.65	147 36.1
C0310B	60 34.65	147 36.1	60 34.2	147 35.4

Table 4. Continued.

C0401A	60 38.0	147 23.1	60 38.05	147 24.5
C0401B	60 38.05	147 24.5	60 37.45	147 23.6
C0402A	60 37.45	147 23.6	60 37.05	147 22.6
C0402B	60 37.05	147 22.6	60 37.4	147 21.5
C0403A	60 37.4	147 21.5	60 37.0	147 20.3
C0403B	60 37.0	147 20.3	60 37.7	147 20.2
C0404A	60 37.7	147 20.2	60 37.65	147 18.9
C0404B	60 37.65	147 18.9	60 38.2	147 19.55
C0405A	60 38.2	147 19.55	60 38.2	147 18.2
C0405B	60 38.2	147 18.2	60 38.75	147 18.8
C0406A	60 38.75	147 18.8	60 38.75	147 17.5
C0406B	60 38.75	147 17.5	60 39.35	147 18.1
C0407A	60 39.35	147 18.1	60 39.75	147 17.1
C0407B	60 39.75	147 17.1	60 40.05	147 18.3
C0408A	60 40.05	147 18.3	60 40.65	147 17.8
C0408B	60 40.65	147 17.8	60 40.5	147 19.1
C0409A	60 40.5	147 19.1	60 41.2	147 19.3
C0409B	60 41.2	147 19.3	60 40.8	147 20.4
C0410A	60 40.8	147 20.4	60 40.7	147 21.7
C0410B	60 40.7	147 21.7	60 40.1	147 20.8
C0501A	60 40.15	147 20.8	60 40.5	147 21.9
C0501B	60 40.5	147 21.9	60 39.9	147 22.0
C0502A	60 39.9	147 22.0	60 39.3	147 21.9
C0502B	60 39.3	147 21.9	60 38.85	147 23.2
C0503A	60 38.85	147 23.2	60 40.35	147 21.9
C0503B	60 40.35	147 21.9	60 40.5	147 23.6
C0504A	60 40.5	147 23.6	60 40.5	147 22.2
C0504B	60 40.5	147 22.2	60 41.15	147 22.0
C0505A	60 41.15	147 22.0	60 41.1	147 20.7
C0505B	60 41.1	147 20.7	60 41.7	147 21.2
C0506A	60 41.7	147 21.2	60 41.95	147 19.9
C0506B	60 41.95	147 19.9	60 42.9	147 20.9
C0507A	60 42.9	147 20.9	60 43.1	147 20.0
C0507B	60 43.1	147 20.0	60 43.5	147 21.5
C0508A	60 43.5	147 21.5	60 42.85	147 22.4
C0508B	60 42.85	147 22.4	60 42.85	147 22.8
C0509A	60 42.85	147 22.8	60 43.1	147 24.0
C0509B	60 43.1	147 24.0	60 43.75	147 23.0
C0510A	60 43.75	147 23.0	60 43.95	147 21.6
C0510B	60 43.95	147 21.6	60 44.4	147 22.7
C0601A	60 44.4	147 22.7	60 45.1	147 23.0
C0601B	60 45.1	147 23.0	60 44.6	147 23.8
C0602A	60 44.6	147 23.8	60 45.15	147 24.9
C0602B	60 45.15	147 24.9	60 44.4	147 25.2
C0603A	60 44.4	147 25.2	60 45.0	147 26.2
C0603B	60 45.0	147 26.2	60 44.3	147 26.4
C0604A	60 44.3	147 26.4	60 44.7	147 27.6
C0604B	60 44.7	147 27.6	60 44.05	147 27.8
C0605A	60 44.05	147 27.8	60 44.6	147 28.6
C0605B	60 44.6	147 28.6	60 43.9	147 29.1
C0606A	60 43.9	147 29.1	60 43.5	147 30.3
C0606B	60 43.5	147 30.3	60 43.25	147 29.0
C0607A	60 43.25	147 29.0	60 42.6	147 28.5
C0607B	60 42.6	147 28.5	60 43.05	147 27.6
C0608A	60 43.05	147 27.6	60 42.45	147 27.3
C0608B	60 42.45	147 27.3	60 42.9	147 26.3
C0609A	60 42.9	147 26.3	60 42.55	147 25.1
C0609B	60 42.55	147 25.1	60 42.1	147 26.1
C0610A	60 42.1	147 26.1	60 42.4	147 27.3
C0610B	60 42.4	147 27.3	60 41.9	147 28.0

Table 4. Continued.

C0701A	60 41.9	147 28.0	60 42.05	147 29.4
C0701B	60 42.05	147 29.4	60 41.4	147 29.1
C0702A	60 41.4	147 29.1	60 41.2	147 30.5
C0702B	60 41.2	147 30.5	60 40.75	147 29.4
C0703A	60 40.75	147 29.4	60 40.1	147 29.35
C0703B	60 40.1	147 29.35	60 40.4	147 28.3
C0704A	60 40.4	147 28.3	60 39.8	147 28.7
C0704B	60 39.8	147 28.7	60 39.65	147 29.1
C0705A	60 39.65	147 29.1	60 39.95	147 30.3
C0705B	60 39.95	147 30.3	60 39.3	147 30.25
C0706A	60 39.3	147 30.25	60 38.95	147 31.5
C0706B	60 38.95	147 31.5	60 38.6	147 30.25
C0707A	60 38.6	147 30.25	60 38.05	147 29.5
C0707B	60 38.05	147 29.5	60 38.6	147 28.8
C0708A	60 38.6	147 28.8	60 38.45	147 27.5
C0708B	60 38.45	147 27.5	60 38.4	147 27.5
C0709A	60 38.4	147 27.5	60 38.35	147 28.9
C0709B	60 38.35	147 28.9	60 37.65	147 28.8
C0710A	60 37.65	147 28.8	60 37.6	147 30.3
C0710B	60 37.6	147 30.3	60 37.0	147 29.4
C0801A	60 37.0	147 29.4	60 36.4	147 28.5
C0801B	60 36.4	147 28.5	60 36.95	147 28.0
C0802A	60 36.95	147 28.0	60 36.45	147 27.0
C0802B	60 36.45	147 27.0	60 37.1	147 26.5
C0803A	60 37.1	147 26.5	60 36.8	147 25.2
C0803B	60 36.8	147 25.2	60 37.65	147 25.45
C0804A	60 37.65	147 25.45	60 37.5	147 24.0
C0804B	60 37.5	147 24.0	60 38.2	147 24.7
C0805A	60 38.2	147 24.7	60 38.1	147 23.5
C0805B	60 38.1	147 23.5	60 38.5	147 24.3

Table 4. Continued.

S0201A	60 1.3	147 57.3	60 1.9	147 58.0
S0201B	60 1.9	147 58.0	60 1.85	147 56.7
S0202A	60 1.85	147 56.7	60 2.35	147 57.4
S0202B	60 2.35	147 57.4	60 2.4	147 56.2
S0203A	60 2.4	147 56.2	60 3.1	147 56.4
S0203B	60 3.1	147 56.4	60 3.0	147 55.1
S0204A	60 3.0	147 55.1	60 3.5	147 55.6
S0204B	60 3.5	147 55.6	60 3.4	147 54.4
S0205A	60 3.4	147 54.4	60 3.95	147 54.7
S0205B	60 3.95	147 54.7	60 3.85	147 53.4
S0206A	60 3.85	147 53.4	60 4.5	147 53.8
S0206B	60 4.5	147 53.8	60 4.4	147 52.6
S0207A	60 4.4	147 52.6	60 5.0	147 52.8
S0207B	60 5.0	147 52.8	60 4.85	147 51.5
S0208A	60 4.85	147 51.5	60 5.4	147 51.2
S0208B	60 5.4	147 51.2	59 59.05	148 7.0
S0209A	59 59.05	148 7.0	59 58.95	148 6.0
S0209B	59 58.95	148 6.0	59 59.6	148 6.6
S0210A	59 59.6	148 6.6	59 59.45	148 5.2
S0210B	59 59.45	148 5.2	60 1.15	148 5.7
S0401A	60 3.6	147 58.6	60 3.4	147 57.35
S0401B	60 3.4	147 57.35	60 4.1	147 57.4
S0402A	60 4.1	147 57.4	60 3.85	147 56.1
S0402B	60 3.85	147 56.1	60 4.5	147 56.5
S0403A	60 4.5	147 56.5	60 4.3	147 55.1
S0403B	60 4.3	147 55.1	60 4.95	147 55.5
S0404A	60 4.95	147 55.5	60 4.8	147 54.1
S0404B	60 4.8	147 54.1	60 5.45	147 54.5
S0405A	60 5.45	147 54.5	60 5.2	147 53.1
S0405B	60 5.2	147 53.1	60 5.85	147 53.4
S0406A	60 5.85	147 53.4	60 6.1	147 52.0
S0406B	60 6.1	147 52.0	60 6.5	147 53.1
S0407A	60 6.5	147 53.1	60 6.8	147 52.0
S0407B	60 6.8	147 52.0	60 7.05	147 53.1
S0408A	60 7.05	147 53.1	60 7.65	147 52.6
S0408B	60 7.65	147 52.6	60 7.7	147 53.8
S0409A	60 7.7	147 53.8	60 8.25	147 53.4
S0409B	60 8.25	147 53.4	60 8.2	147 54.8
S0410A	60 8.2	147 54.8	60 8.5	147 55.7
S0410B	60 8.5	147 55.7	60 7.9	147 56.1
S0601A	60 1.05	148 11.3	60 .08	148 10.0
S0601B	60 .08	148 10.0	60 1.45	148 10.3
S0602A	60 1.45	148 10.3	60 1.2	148 9.0
S0602B	60 1.2	148 9.0	60 1.85	148 9.2
S0603A	60 1.85	148 9.2	60 1.75	148 7.9
S0603B	60 1.75	148 7.9	60 2.4	148 8.3
S0604A	60 2.4	148 8.3	60 2.85	148 7.45
S0604B	60 2.85	148 7.45	60 3.4	148 8.1
S0605A	60 3.4	148 8.1	60 3.45	148 6.8
S0605B	60 3.45	148 6.8	60 4.0	148 7.0
S0606A	60 4.0	148 7.0	60 4.05	148 6.3
S0606B	60 4.05	148 6.3	60 4.6	148 6.6
S0607A	60 4.6	148 6.6	60 4.7	148 5.4
S0607B	60 4.7	148 5.4	60 5.2	148 6.2
S0608A	60 5.2	148 6.2	60 5.3	148 4.8
S0608B	60 5.3	148 4.8	60 5.8	148 5.3
S0609A	60 5.8	148 5.3	60 5.9	148 4.1
S0609B	60 5.9	148 4.1	60 6.4	148 5.0
S0610A	60 6.4	148 5.0	60 6.95	148 4.3
S0610B	60 6.95	148 4.3	60 7.0	148 5.6

Table 4. Continued.

S0801A	60 9.9	148 0.04	60 10.3	147 58.9
S0801B	60 10.3	147 58.9	60 10.6	148 0.15
S0802A	60 10.6	148 0.15	60 11.3	147 59.7
S0802B	60 11.3	147 59.7	60 11.2	148 1.0
S0803A	60 11.2	148 1.0	60 11.7	148 1.5
S0803B	60 11.7	148 1.5	60 11.2	148 2.3
S0804A	60 11.2	148 2.3	60 11.8	148 1.9
S0804B	60 11.8	148 1.9	60 12.1	148 3.0
S0805A	60 12.1	148 3.0	60 12.6	148 3.95
S0805B	60 12.6	148 3.95	60 11.95	148 4.2
S0806A	60 11.95	148 4.2	60 12.2	148 5.45
S0806B	60 12.2	148 5.45	60 11.45	148 5.3
S0807A	60 11.45	148 5.3	60 11.2	148 6.5
S0807B	60 11.2	148 6.5	60 10.9	148 5.15
S0808A	60 10.9	148 5.15	60 10.6	148 6.3
S0808B	60 10.6	148 6.3	60 10.25	148 5.1
S0809A	60 10.25	148 5.1	60 10.15	148 6.45
S0809B	60 10.15	148 6.45	60 9.6	148 5.7
S0810A	60 9.6	148 5.7	60 9.2	148 6.7
S0810B	60 9.2	148 6.7	60 8.85	148 5.7
S1001A	60 12.8	148 4.5	60 13.4	148 4.2
S1001B	60 13.4	148 4.2	60 13.35	148 5.4
S1002A	60 13.35	148 5.4	60 14	148 5.1
S1002B	60 14	148 5.1	60 13.8	148 6.45
S1003A	60 13.8	148 6.45	60 14.5	148 5.1
S1003B	60 14.5	148 5.1	60 14.35	148 7.5
S1004A	60 14.35	148 7.5	60 15.05	148 7.9
S1004B	60 15.05	148 7.9	60 14.45	148 8.55
S1005A	60 14.45	148 8.55	60 14.5	148 9.9
S1005B	60 14.5	148 9.9	60 13.9	148 9.4
S1006A	60 13.9	148 9.4	60 13.55	148 10.8
S1006B	60 13.55	148 10.8	60 13.15	148 9.5
S1007A	60 13.15	148 9.5	60 12.95	148 10.9
S1007B	60 12.95	148 10.9	60 12.5	148 9.6
S1008A	60 12.5	148 9.6	60 12.5	148 11.05
S1008B	60 12.5	148 11.05	60 11.9	148 10.4
S1009A	60 11.9	148 10.4	60 11.7	148 11.6
S1009B	60 11.7	148 11.6	60 11.15	148 10.6
S1010A	60 11.15	148 10.6	60 10.9	148 10.7
S1010B	60 10.9	148 10.7	60 10.4	148 10.9
S1201A	60 12.9	148 16.5	60 12.2	148 15.2
S1201B	60 12.2	148 15.2	60 13.8	148 14.5
S1202A	60 13.8	148 14.5	60 13.6	148 13.2
S1202B	60 13.6	148 13.2	60 14.1	148 12.4
S1203A	60 14.1	148 12.4	60 13.75	148 11.2
S1203B	60 13.75	148 11.2	60 13.4	148 11.2
S1204A	60 13.4	148 11.2	60 14.7	148 9.9
S1204B	60 14.7	148 9.9	60 15.15	148 10.9
S1205A	60 15.15	148 10.9	60 15.8	148 10.8
S1205B	60 15.8	148 10.8	60 15.55	148 12.0
S1206A	60 15.55	148 12.0	60 16.3	148 12.4
S1206B	60 16.3	148 12.4	60 15.7	148 13.3
S1207A	60 15.7	148 13.3	60 16.2	148 14.4
S1207B	60 16.2	148 14.4	60 15.5	148 14.6
S1208A	60 15.5	148 14.6	60 15.95	148 15.6
S1208B	60 15.95	148 15.6	60 15.2	148 16.0
S1209A	60 15.2	148 16.0	60 15.7	148 17.3
S1209B	60 15.7	148 17.3	60 15.0	148 17.3
S1210A	60 15.0	148 17.3	60 14.9	148 18.4
S1210B	60 14.9	148 18.4	60 14.35	148 17.5

Table 4. Continued.

S1401A	60 17.8	148 12.0	60 18.25	148 10.9
S1401B	60 18.25	148 10.9	60 18.45	148 12.2
S1402A	60 18.45	148 12.2	60 18.9	148 11.0
S1402B	60 18.9	148 11.0	60 19.2	148 12.3
S1403A	60 19.2	148 12.3	60 19.6	148 11.2
S1403B	60 19.6	148 11.2	60 19.85	148 12.3
S1404A	60 19.85	148 12.3	60 20.5	148 11.9
S1404B	60 20.5	148 11.9	60 20.65	148 13.3
S1405A	60 20.65	148 13.3	60 21.4	148 13.6
S1405B	60 21.4	148 13.6	60 20.9	148 14.5
S1406A	60 20.9	148 14.5	60 20.5	148 15.8
S1406B	60 20.5	148 15.8	60 20.9	148 15.2
S1407A	60 20.9	148 15.2	60 21.4	148 14.4
S1407B	60 21.4	148 14.4	60 20.15	148 11.4
S1408A	60 20.15	148 11.4	60 19.5	148 10.9
S1408B	60 19.5	148 10.9	60 20.15	148 10.0
S1409A	60 20.15	148 10.0	60 19.9	148 8.6
S1409B	60 19.9	148 8.6	60 20.65	148 8.8
S1410A	60 20.65	148 8.8	60 20.15	148 7.7
S1410B	60 20.15	148 7.7	60 20.8	148 7.21
S1601A	60 24.65	148 4.9	60 24.2	148 5.8
S1601B	60 24.2	148 5.8	60 23.75	148 4.8
S1602A	60 23.75	148 4.8	60 23.2	148 5.2
S1602B	60 23.2	148 5.2	60 23.35	148 4.1
S1603A	60 23.35	148 4.1	60 22.75	148 4.9
S1603B	60 22.75	148 4.9	60 23.0	148 3.5
S1604A	60 23.0	148 3.5	60 22.8	148 2.2
S1604B	60 22.8	148 2.2	60 23.4	148 2.9
S1605A	60 23.4	148 2.9	60 22.95	148 1.7
S1605B	60 22.95	148 1.7	60 23.6	148 1.6
S1606A	60 23.6	148 1.6	60 23.35	148 0.3
S1606B	60 23.35	148 0.3	60 24.1	148 0.5
S1607A	60 24.1	148 0.5	60 23.8	147 59.1
S1607B	60 23.8	147 59.1	60 24.5	147 59.3
S1608A	60 24.5	147 59.3	60 24.1	147 58.3
S1608B	60 24.1	147 58.3	60 24.8	147 58.0
S1609A	60 24.8	147 58.0	60 24.8	147 56.6
S1609B	60 24.8	147 56.6	60 25.35	147 57.0
S1610A	60 25.35	147 57.0	60 25.6	147 55.8
S1610B	60 25.6	147 55.8	60 26.0	147 56.5
S1801A	60 16.3	148 1.3	60 15.45	148 0.0
S1801B	60 15.45	148 0.0	60 17.0	148 1.2
S1802A	60 17.0	148 1.2	16 17.3	147 59.6
S1802B	16 17.3	147 59.6	60 17.6	148 0.9
S1803A	60 17.6	148 0.9	60 17.9	147 59.4
S1803B	60 17.9	147 59.4	60 18.3	148 0.6
S1804A	60 18.3	148 0.6	60 18.6	147 59.3
S1804B	60 18.6	147 59.3	60 19.1	148 0.4
S1805A	60 19.1	148 0.4	60 19.3	147 59.1
S1805B	60 19.3	147 59.1	60 19.6	148 0.0
S1806A	60 19.6	148 0.0	60 19.8	147 58.7
S1806B	60 19.8	147 58.7	60 20.4	147 59.6
S1807A	60 20.4	147 59.6	60 20.5	147 58.0
S1807B	60 20.5	147 58.0	60 20.95	147 59.1
S1808A	60 20.95	147 59.1	60 21.4	147 58.1
S1808B	60 21.4	147 58.1	60 21.65	147 59.2
S1809A	60 21.65	147 59.2	60 22.0	147 58.1
S1809B	60 22.0	147 58.1	60 22.3	147 59 .1
S1810A	60 22.3	147 59 .1	60 22.8	147 58.6
S1810B	60 22.8	147 58.6	60 23.0	147 59.6

Table 4. Continued.

S2001A	60 17.35	147 56.8	60 17.1	147 58.2
S2001B	60 17.1	147 58.2	60 16.5	147 57.4
S2002A	60 16.5	147 57.4	60 16.4	147 58.9
S2002B	60 16.4	147 58.9	60 15.8	147 58.0
S2003A	60 15.8	147 58.0	60 15.7	147 59.5
S2003B	60 15.7	147 59.5	60 15.15	147 58.5
S2004A	60 15.15	147 58.5	60 14.65	147 59.6
S2004B	60 14.65	147 59.6	60 14.45	147 58.1
S2005A	60 14.45	147 58.1	60 13.85	147 58.9
S2005B	60 13.85	147 58.9	60 13.75	147 57.6
S2006A	60 13.75	147 57.6	60 13.0	147 57.9
S2006B	60 13.0	147 57.9	60 13.2	147 56.6
S2007A	60 13.2	147 56.6	60 12.5	147 55.9
S2007B	60 12.5	147 55.9	60 13.1	147 55.1
S2008A	60 13.1	147 55.1	60 12.5	147 54.6
S2008B	60 12.5	147 54.6	60 13.0	147 53.6
S2009A	60 13.0	147 53.6	60 12.35	147 53.1
S2009B	60 12.35	147 53.1	60 12.9	147 52.5
S2010A	60 12.9	147 52.5	60 12.3	147 51.6
S2010B	60 12.3	147 51.6	60 12.8	147 50.7

Table 5. Net samples collected by the inshore survey of cruise 96-1.
P - Purse Seine, D - Dip Net, C - Cast Net

DATE	TIME IN	STN #	GEAR	LOCATION	LATITUDE	LONGITUDE	DEPTH (m)
SOUTH STUDY AREA							
15/07	14:46	1	P		60 03.97	147 53.47	47.2
15/07	16:28	2	P	N. end La touche	60 04.97	147 51.14	36.0
16/07	15:48	3	P		60 03.20	148 08.22	35.7
CENTRAL STUDY AREA							
19/07	12:30	18	P	C01-05B	60 23.13	147 40.60	18.3
19/07	15:30	19	P	C01-07B	60 23.85	147 40.38	45.7
20/07	12:00	24	P	C02-10A	60 29.88	147 35.97	76.2
21/07	9:00	26	P	C04-01B	60 37.90	147 23.05	27.4
21/07	12:00	29	P	C04-08A	60 40.20	147 18.20	25.9
NORTH STUDY AREA							
22/07	13:00	38	P	C07-02B	60 40.04	147 29.73	24.4-30.5
23/07	9:30	41	P	N19-09A	60 58.81	146 42.43	16.8
23/07	12:30	44	P	N19-01A	60 55.89	146 36.05	21.3
23/07	17:30	47	C	N17-03A	60 53.29	146 45.16	12.2
23/07	16:15	47	P	N17-03A	60 53.32	146 44.60	7.6
24/07	10:30	48	P	N15-07B	60 49.95	146 49.59	24.4
24/07	15:00	52	P	N13-07B	60 50.40	146 38.87	36.6-38.1
24/07	16:50	55	D		60 49.14	146 36.38	36.6
25/07	13:30	58	P	N09-01A	60 46.59	146 33.13	18.3-24.4
25/07	13:30	59	P	N07-05B	60 44.68	146 39.18	36.6
26/07	9:30	62	P	St. Matthews Bay	60 43.59	146 19.70	33.5-35.1
26/07	19:00	68	P	N07-01B	60 43.94	146 42.96	24.4-27.4
27/07	9:00	69	D	N03-06B	60 45.32	146 18.94	35.1

Table 6. Video samples collected on inshore survey of cruise 96-1

DATE	TIME	STN #	LOCATION	LATITUDE	LONGITUDE	DEPTH (m)	SAMPLE D (m)
SOUTH STUDY AREA							
16/07	15:40	3		60 03.24	148 08.09	33.5	12.2
17/07	9:15	4	Whale Bay	60 12.90	148 10.7	30.5	30.5
17/07	10:14	5	Whale Bay	60 12.51	148 09.45	32.0	30.5
17/07	10:58	6	Whale Bay, S107A	60 12.52	148 10.86	76.2	15.2-18.3
17/07	13:15	7	near S10-02A	60 13.28	148 05.61	31.1	15.2
17/07	15:08	8	S14-01A	60 17.98	148 12.56	36.6	12.2
17/07	17:13	9	S14-08A	60 20.17	148 11.45	32.0	12.2
17/07	17:55	10	S14-09	60 20.55	148 08.96	18.3	16.8
18/07	8:42	11	Paddy Bay	60 24.45	148 04.94	15.2-21.3	12.2-15.2
18/07	9:25	12	S16-04B	60 23.45	148 03.76	10.7-15.2	3.0-4.6
18/07	10:30	13	S6-04B	60 23.72	148 01.63	19.8-24.4	12.2-18.3
18/07	11:06	14	S16-04B	60 23.72	148 01.63		
18/07	11:55	14		60 24.93	147 58.24	36.6	15.2-18.3
18/07	14:12	15	S02-01A	60 17.01	147 56.37	12.2	10.7
18/07	17:06	16	S02-07A	60 13.10	147 52.51	67.1	15.2
18/07	17:33	17	S02-09A	60 12.72	147 51.79	19.8	9.1-15.2
CENTRAL STUDY AREA							
19/07	12:00	18	C01-05B	60 23.13	147 40.06	30.5	12.2-15.2
19/07	14:55	19	C01-07B	60 23.75	147 40.19	67.1	10.7-12.2
19/07	16:45	20	C02-04B	60 27.37	147 38.29		6.1
19/07	17:05	21	C02-04B	60 27.57	147 37.11	85.6	6.1
19/07	18:15	22	C02-06B	60 28.75	147 36.54		12.2-18.3
19/07	18:41	23	C02-06B	60 29.05	147 36.85	33.5	12.2
20/07	11:10	24	C02-10A	60 29.88	147 35.97	76.2	9.1
20/07	14:07	25	C03-08A	60 34.72	147 33.45	22.9	9.1-12.2
20/07	14:35	25	C03-08A	60 34.40	147 33.51	15.2	12.2
20/07	14:55	25	C03-08A	60 34.86	147 33.36	12.2-15.2	18.3
21/07	8:20	26	C04-01B	60 37.81	147 23.11	15.2	12.2
21/07	8:40	26	C04-01B	60 37.90	147 23.05	27.4	9.1
21/07	10:45	27	C04-05B	60 38.64	147 18.71	30.5-39.6	12.2-15.2
21/07	11:15	28	C04-06B	60 39.34	147 18.13	24.4-27.4	15.2
21/07	11:36	29	C04-08A	60 40.20	147 18.20	25.9	12.2-15.2
21/07	12:40	30	McPherson Passage	60 40.88	147 19.87	15.2-30.5	12.2-16.8
21/07	13:36	31		60 39.43	147 22.00	27.4-36.6	30.5
21/07	14:30	32	C05-03A	60 40.30	147 22.36	45.7	18.3-30.5
21/07	15:53	33	C05-10B	60 43.00	147 21.65	22.9	21.3
22/07	8:50	34	C07-10A	60 37.58	147 29.30	30.5-36.6	24.4-36.6
22/07	10:03	35	C07-07A	60 38.65	147 29.29	1.5-9.1	1.5-7.6
22/07	11:10	36	C07-04B	60 39.54	147 27.76	9.1-12.2	7.6-9.1
22/07	11:45	37	C07-03B	60 40.56	147 28.11	3.0-6.1	3.0-6.1
22/07	16:15	39	C07-06A	60 47.63	147 29.69	29.0	18.3
22/07	17:05	40	C06-03B	60 44.59	147 26.49	27.4-36.0	30.5
NORTH STUDY AREA							
23/07	10:00	42		60 57.79	146 43.14	36.6	3.0-6.1
23/07	11:30	43	N19-02B	60 56.48	146 36.46	22.9	3.0-9.1
23/07	11:48	44	N19-01A	60 55.94	146 36.16	25.9	15.2
23/07	12:10	44	N19-01A	60 55.71	146 36.39	16.8	15.2
23/07	14:26	45	N17-05B	60 55.23	146 44.34	24.4	12.2
23/07	14:43	46	N17-04B	60 54.88	146 44.52	45.7-48.8	13.7-15.2
24/07	10:10	48	N15-07B	60 49.95	146 49.59	24.4	9.1-12.2

Table 6. Continued

DATE	TIME	STN #	LOCATION	LATITUDE	LONGITUDE	DEPTH (m)	SAMPLE D (m)
24/07	11:15	49	N15-06A	60 49.93	146 49.14	9.1-10.7	6.1-9.1
24/07	12:12	50	N15-02A	60 48.18	146 44.78	22.9-27.4	12.2-18.3
24/07	13:00	51		60 48.62	146 42.21	30.5-38.1	12.2-15.2
24/07	14:37	52	N13-07B	60 50.40	146 38.87	36.6-38.1	12.2
24/07	15:45	53	N13-05B	60 48.76	146 39.25	45.7	18.3-21.3
24/07	16:00	54	N13-04B	60 48.52	146 38.57	36.6-42.7	21.3
24/07	16:13	54	N13-04B	60 48.58	146 38.12	51.8-53.3	22.9
24/07	17:15	56	N13-03A	60 49.52	146 36.48	30.5	21.3-24.4
25/07	10:07	57	N09-07B	60 47.27	146 23.18	54.7	1.5-4.6
25/07	13:08	58	N09-01A	60 46.59	146 33.13	18.3-24.4	10.7-13.7
25/07	13:15	59	N07-05B	60 44.68	146 39.18	36.6	9.1-13.7
25/07	16:35	60		60 43.55	146 42.64	13.7	10.7
25/07	17:43	61		60 41.01	146 36.35	7.6-10.7	7.6-10.7
26/07	9:03	62	St. Matthews Bay	60 43.59	146 19.70	33.5-35.1	10.7-15.2
26/07	11:04	63	St. Matthews Bay	60 43.82	146 19.87	29.0-30.5	24.4-30.5
26/07	14:00	64	N05-10A	60 40.01	146 27.12	18.3	12.2
26/07	14:18	65	N05-09B	60 40.05	146 28.06	10.7-12.2	4.6-6.1
26/07	16:00	66	N05-06A	60 40.95	146 32.80	9.1-10.7	6.1
26/07	16:20	66	N05-06A	60 40.86	146 33.14	9.1-10.7	4.6
26/07	17:05	67	N05-03A	60 41.02	146 36.30	7.6-9.1	7.6-9.1
26/07	18:51	68	N07-02B	60 43.94	146 42.96	18.3-19.8	6.1-9.1
27/07	9:54	70	N03-05B	60 44.48	146 19.19	42.9	42.7
27/07	12:00	71	N03-08B	60 42.25	146 14.31	121.9	36.6
27/07	12:21	72	N03-09A	60 42.98	146 13.45	70.1	30.5
27/07	13:17	73	N01-10A	60 42.06	146 09.87	29.0-38.1	15.2-18.3
27/07	13:44	74	N01-09A	60 41.85	146 11.39	45.7	15.2-18.3
27/07	14:23	75	N01-07B	60 40.55	146 13.41	38.1-61.0	15.2-30.5

Table 7. CTD data collected in the inshore survey during APEX cruise 96-1

DATE	TIME IN	LOCATION	LATITUDE	LONGITUDE	DEPTH (m)	GEAR D (m)
SOUTH STUDY AREA						
15/07	10:00	Shelter Bay	60 07.580	147 55.564	27	10
15/07	11:41	S02-01A	60 1.93	147 58.0	73	60
15/07	11:57	S04-01A	60 03.4	147 57.3	161	140
15/07	12:53	S02-08A	60 05.36	147 51.24	88	80
15/07	15:32	S04-09A	60 8.25	147 53.4	247	200
16/07	11:38	S06-01A	60 00.9?	148 09.8?	117	100
16/07	14:01	S06-10A	60 07.021	148 04.252	108	100
16/07	14:45	S08-01A	60 10.245	147 58.835	162	140
16/07	16:00	S08-091A	60 09.378	148 06.179	132	120
16/07	16:38	S10-01A	60 13.458	148 04.259	480	200
16/07	17:56	S10-10A	60 10.910	148 11.165	106	100
17/07	10:58	S14-01A	60 18.331	148 11.049	281	200
17/07	14:23	S16-10A	60 25.58	147 55.841	296	200
17/07	15:18	S16-09A	60 23.213	148 04.864	73	60
CENTRAL STUDY AREA						
20/07	8:04	C02-06A	60 28.708	147 37.036	160	140
20/07	8:37	C02-01A	60 25.440	147 34.947	111	100
20/07	9:12	C01-01A	60 21.395	147 36.926	64	60
20/07	16:05	C03-01A	60 30.390	147 34.776	28.6	20
20/07	17:51	C03-07A	60 34.588	147 32.868	191	180
20/07	18:43	C04-02A	60 37.205	147 22.152	29	20
21/07	8:12	C08-03	60 37.522	147 24.940	52	40
21/07	11:08	C05-10A	60 43.915	147 21.676	53	40
21/07	11:41	C05-05A	60 41.113	147 20.529	71	60
21/07	11:53	C05-04A	60 40.545	147 21.858	44	40
21/07	12:14	C04-08A	60 40.685	147 17.864	62	60
21/07	12:37	C04-06A	60 38.862	147 17.302	106	100
22/07	9:59	C07-07A	60 38.108	147 29.652	92	80
22/07	10:33	C07-03A	60 40.111	147 29.408	56	40
22/07	11:00	C07-01A	60 42.028	147 29.270	43	40
22/07	11:12	C06-07A	60 42.563	147 28.530	107	100
22/07	11:38	C06-05A	60 44.557	147 28.557	151	140
NORTH STUDY AREA						
23/07	8:28	N17-08A	61 59.765	146 43.681	338	200
23/07	11:22	N19-05A	60 56.804	146 42.631	210	200
23/07	11:54	N19-02A	60 56.228	146 37.580	106	100
23/07	15:34	N17-08A	60 57.447	146 47.301	348	200
23/07	15:59	N17-06A	60 55.654	146 46.505	252	200
23/07	16:16	N17-01A	60 54.722	146 46.344	66	60
23/07	16:56	N15-10A	60 51.800	146 51.089	68	60
24/07	13:57	N15-08A	60 24.6	146 50.015	66	60
24/07	14:25	N15-05A	60 47.871	146 49.477	40	35
24/07	14:54	N15-01A	60 47.953	146 42.917	81	80
24/07	15:43	N13-10A	60 52.095	146 37.936	51	40
24/07	16:45	N02-01A	60 48.186	146 39.873	79	60
24/07	17:01	N13-04A	60 48.447	146 37.738	103	95
24/07	18:31	N13-01A	60 50.35	146 34.67	94	80
25/07	9:20	N09-01A	60 47.4	146 31.15	197	180
25/07	10:27	N09-05A	60 47.533	146 26.178	186	180
25/07	12:05	N09-01A	60 47.872	146 19.925	182	180
25/07	13:19	N07-10A	60 45.674	146 33.811	36	20
25/07	13:53	N07-05A	60 45.148	146 39.552	43	20
25/07	14:40	N07-01A	60 44.492	146 43.39	41	40
25/07	16:28	N05-10A	60 40.227	146 38.643	26	20
25/07	17:12	N05-05A	60 40.037	146 32.535	21	20
25/07	17:38	N05-01A	60 39.749	146 27.036	21	20
26/07	10:06	N03-01	60 45.449	146 19.013	32	20
26/07	10:36	N03-07	60 43.021	146 20.702	32	20
26/07	11:01	N03-01A	60 42.282	146 16.400	63	60
26/07	11:36	N01-10A	60 42.456	146 11.030	165	160
26/07	12:57	N01-05A	60 40.524	146 15.478	108	100
26/07	13:37	N01-01A	60 37.441	146 17.009	35	20

Table 8. Beach seine samples collected on APEX cruise 96-1

DATE	TIME	STN #	LOCATION	LATITUDE	LONGITUDE
SOUTH STUDY AREA					
15/07	13:15	1	S02-03	60 02.24	147 55.03
15/07	14:30	2	S02-06	60 03.92	147 53.00
15/07	16:00	3	S02-04	60 03.00	148 54.31
15/07	16:30	4	S04-01	60 04.01	147 58.25
15/07	17:20	5	S04-02	60 04.15	147 56.95
15/07	18:15	6	S04-04	60 05.52	147 55.05
16/07	11:05	7	S06-01	60 01.40	148 11.50
16/07	13:00	8	S06-09	60 06.00	148 05.50
16/07	13:35	9	S06-10	60 05.50	148 05.70
16/07	15:30	10	S08-05	60 11.89	148 03.83
16/07	17:25	11	S08-06	60 11.59	148 04.53
16/07	17:40	11	S08-06	60 11.59	148 04.53
17/07	8:30	12	S10-08	60 11.59	148 09.09
17/07	9:35	13	S10-05	60 13.95	148 09.00
17/07	10:10	14	S10-02	60 13.33	148 07.40
17/07	12:30	15	S14-06	60 20.80	148 14.40
17/07	13:30	16	S14-07	60 21.31	148 15.40
17/07	15:25	17	S14-09	60 20.50	148 09.59
17/07	16:30	18	S16-03	60 23.15	148 03.80
17/07	17:30	19	S16-07	60 24.24	148 00.45
17/07	18:42	20	S16-09	60 25.18	147 57.60
18/07	9:10	21	S18-05	60 19.61	148 00.60
18/07	9:40	22	S18-04	60 18.70	148 01.10
18/07	10:40	23	S18-03	60 18.05	148 01.30
18/07	13:00	24	S20-08	60 13.54	147 53.70
18/07	12:35		S20-10		
18/07	15:00	25	S20-04	60 14.44	147 56.80
18/07	15:35	26	S20-03	60 15.40	147 56.41
CENTRAL STUDY AREA					
19/07	11:48	27	C01-05	60 23.60	147 38.20
19/07	13:15	28	C01-06	60 22.11	147 40.00
19/07	15:30	29	C01-10	60 23.26	147 36.91
19/07	17:20	30	C02-03	60 26.54	147 37.26
19/07	17:50	31	C02-04	60 26.47	147 36.96
19/07	19:05	32	C02-01	60 27.89	147 37.29
20/07	9:10	33	C03-03	60 32.54	147 34.47
20/07	9:30	33	C03-03	60 32.54	147 34.47
20/07	11:05	34	C03-07	60 34.28	147 32.70
20/07	12:30	35	C03-09	60 34.67	147 33.13
20/07	14:40	36	C04-02	60 37.67	147 21.10
20/07	15:50	37	C04-05	60 38.69	147 19.69
20/07	16:55	38	C04-07	60 39.60	147 17.31
21/07	8:40	39	C08-01	60 37.13	147 28.10
21/07	9:00	39	C08-01	60 37.13	147 28.10
21/07	10:30	40	C08-03	60 37.15	147 25.99
21/07	11:35	41	C08-04	60 37.77	147 25.70
21/07	13:30	42	C05-01	60 39.90	147 20.77
21/07	14:45	43	C05-02	60 39.16	147 22.64
21/07	15:45	44	C05-03	60 40.22	147 23.75
21/07	16:20	45	C05-04	60 41.07	147 23.17
22/07	9:10	46	C07-03	60 40.77	147 28.68

Table 8. Continued.

DATE	TIME IN	STN #	LOCATION	LATITUDE	LONGITUDE
22/07	9:25	46	C07-03	60 40.77	147 28.68
22/07	9:55	47	C07-05	60 39.32	147 29.41
22/07	10:50	48	C07-01	60 41.26	147 28.79
22/07	12:10	49	C06-08	60 43.20	147 26.95
22/07	12:50	50	C06-09	60 43.13	147 25.55
22/07	11:50	51	C06-07	60 43.20	147 27.62
NORTH STUDY AREA					
23/07	8:28	52	N19-09	60 42.10	146 58.82?
23/07	9:00	53	N19-08	60 58.49	146 43.30
23/07	11:10	54	N19-04	60 58.49	146 43.30?
23/07	12:35	55	N17-06	60 56.33	146 45.10
23/07	13:15	56	N17-05	60 55.42	146 44.13
23/07	13:50	57	N17-03	60 54.28	146 43.50
23/07	15:30	58	N15-08	60 50.39	147 48.91
23/07	17:50	59	N15-03	60 48.42	146 45.81
24/07	9:50	60	N15-07	60 49.78	146 48.89
24/07	11:45	61	N13-02	60 49.90	146 36.90
24/07		62	N13-04	60 49.13	146 37.50
24/07		63	N13-06	60 49.65	146 38.20
24/07		64	N09-05	60 46.72	146 25.40
24/07		65	N09-10	60 47.61	146 19.27
24/07		65	N09-10	60 47.61	146 19.27
24/07		66	N09-09	60 47.32	146 19.30
25/07	9:45	67	N07-09	60 45.68	146 35.96
25/07	10:40	68	N07-04	60 44.60	146 41.68
25/07	11:40	69	N07-02	60 43.41	146 43.49
25/07	13:30	70	N05-07	60 41.43	146 33.20
25/07	14:30	71	N05-06	60 41.40	146 32.00
25/07	15:20	72	N05-05	60 41.30	146 31.11
26/07	8:50	73	N03-09	60 44.39	146 19.90
26/07	9:25	74	N03-07	60 45.30	146 18.38
26/07	10:05	75	N03-05	60 44.09	146 18.61
26/07	11:20	76	N01-09	60 41.65	146 10.61
26/07	12:25	77	N01-08	60 40.92	146 11.90
26/07	13:25	78	N01-01	60 37.58	146 15.51
27/07	8:55	79	N05-05	60 41.30	146 31.11
27/07	11:10	80	N05-06	60 41.40	146 32.00
27/07	13:50	81	N15-03	60 48.42	146 45.81
27/07	14:45	82	N15-07	60 49.78	146 48.89
27/07	17:45	83	N05-05	60 41.30	146 31.11
27/07	18:00	84	N05-06	60 41.40	146 32.00
27/07	20:40	85	N15-07	60 49.78	146 48.89
27/07	21:45	86	N15-03	60 48.42	146 45.81
28/07	4:55	87	N05-05	60 41.30	146 31.11
28/07	6:25	88	N05-06	60 41.40	146 32.00
28/07	9:10	89	N15-07	60 49.78	146 48.89
28/07	9:35	90	N15-03	60 48.42	146 45.81

Table 9. Fish densities (g/square meter) in shallow and deep depth strata in offshore transects in South, Central and North areas.

	Biomass Estimate (g/sq.m)		
Transect	1-25m	26-100m	TOTAL
NORTH STUDY AREA			
N01A-1	3.91	2.11	6.01
N01A-2	0.32	1.66	1.99
N01A-3	0.01	0.19	0.20
N02A-1	0.22	0.15	0.37
N02A-2	13.75	6.97	20.72
N02A-3	0.23	2.85	3.08
NZ02N	0.57	1.32	1.89
NO3A-1	0.70	0.09	0.79
N03A-2	10.36	9.92	20.28
N03A-3	4.22	0.27	4.49
NO3TT	0.08	0.21	0.29
NO3LL	0.07	12.42	12.49
NZ03S	0.60	3.09	3.69
N04A	0.41	1.22	1.62
NZ04N	4.69	0.23	4.92
N05A-1	0.41	0.11	0.51
N05A-2	0.38	0.44	0.83
NZ05S	0.04	1.06	1.10
N06A	0.41	0.24	0.65
NZ06N	0.32	0.06	0.38
NZ06S	2.41	0.86	3.26
N06GBW	0.52	0.93	1.45
N06GBE	0.79	2.36	3.14
N07A	0.26	0.38	0.64
NZ07N	1.18	0.38	1.56
NZ07S	0.59	1.29	1.88
N08A	0.17	0.43	0.60
N09A	7.92	1.53	9.45
N10A	0.71	1.01	1.73
N12A	0.39	0.90	1.29
N13E	0.13	1.70	1.83
N13W	0.38	0.11	0.50
N14E	1.42	2.09	3.51
N14W	0.81	1.48	2.28
CENTRAL STUDY AREA			
C01A-1	0.41	1.07	1.48
C01A-2	0.50	0.04	0.54
CZ01S	0.53	0.06	0.59
C02A-1	0.72	0.44	1.16
C02A-2	0.59	1.84	2.43
CZ02N	0.82	0.06	0.88
CZ02S	0.07	0.50	0.56
C03A-1	0.34	0.21	0.55
C03A-2	0.15	0.45	0.60
CZ03N	0.28	0.61	0.89
C04A-1	0.31	0.45	0.77
C04A-2	0.34	0.08	0.42
CZ04N	0.24	0.35	0.59
CZ04S	0.32	0.00	0.33

Table 9. Continued.

Transect	1-25m	26-100m	TOTAL
	Biomass Estimate (g/sq.m)		
C05A-1	0.35	0.13	0.48
C05A-2	0.19	0.14	0.33
C06A-1	0.49	0.14	0.64
C06A-A	0.53	0.20	0.74
CZ06N	1.32	1.15	2.47
CZ06S	0.11	0.28	0.38
C07W	0.39	0.15	0.54
C07E-1	0.20	0.13	0.32
C07E-2	0.23	0.75	0.98
C08A-1	0.32	0.01	0.33
C08A-2	0.17	0.27	0.44
C09E	0.09	0.40	0.48
C10C	0.17	0.05	0.22
C10W	0.36	0.01	0.37
C10E	0.09	0.05	0.14
C11E	0.28	0.05	0.33
C12E	0.24	0.20	0.44
SOUTH STUDY AREA			
SO1W	1.22	0.09	1.31
S01S	0.20	0.00	0.21
S01E	0.32	0.13	0.45
S01N	0.23	0.04	0.27
S02E	0.22	0.06	0.28
S03N	0.27	0.07	0.34
S03S	0.35	0.01	0.35
S03W	0.12	0.17	0.29
S04E	0.25	0.11	0.36
S04W	0.19	0.00	0.20
S05E	0.24	0.06	0.30
S05W	0.09	0.02	0.11
S06W	0.20	0.13	0.33
S07A	0.17	1.25	1.42
S08A	0.77	0.75	1.52
S09E	0.01	0.01	0.02
S09W	0.08	0.05	0.13

Table 10. Average fish densities (g/square m) for South, Central and North areas

	Biomass Estimate (g/sq.m)		
Depth (m)	North	Central	South
1-25	1.80	0.37	0.29
26-100	1.55	0.38	0.31
TOTAL	3.34	0.75	0.60

Table 11. Fish and jellyfish in midwater trawl samples collected on APEX cruise 96-1 in Prince William sound

Station	Pollock	Aequora	Cyanea	Aurelia	Eutonia	Other Jellyfish
5		960	16			4
12a		109	33			
12b		50	12			
48a		31	2		1	1
48b		35				
65	128	22				
83		7	9	6	4	
84		19	5	6	5	
102			6	3	1	
119	11	37	7			
122		40	1			
TOTAL	139	1310	91	15	11	5

Table 12. Biomass estimates for nearshore study sites in three study areas of Prince William Sound in APEX cruise 96-1.

	ZIGS				ZAGS			
SITE	MEAN BIOMASS	STD DEV	N	STD ERR.	MEAN BIOM	STD DEV	N	STD ERR.
NORTH STUDY AREA								
N1	0.76	0.91	10	0.29	0.64	0.89	10	0.28
N3	0.25	0.27	10	0.09	0.39	0.6	10	0.19
N5	28.01	24.32	10	7.69	29.21	18.44	10	5.83
N7	15.22	36.31	6	14.82	1.92	2.87	5	1.28
N9	0.12	0.29	10	0.09	0.88	2.37	10	0.75
N13	1.59	4.31	10	1.36	2.28	5.41	10	1.71
N15	0.94	2.59	10	0.82	0.09	0.11	10	0.03
N17	5.38	16.9	10	5.34	0.64	1.82	10	0.58
N19	0.54	1.6	10	0.51	0.24	0.38	10	0.12
MEAN	**5.87**				**4.03**			
STD ERR	**3.21**				**3.16**			
CENTRAL STUDY AREA								
C1	0.28	0.5	10	0.16	1.85	3.16	10	1.00
C2	4.48	12.81	10	4.05	1.27	2.7	10	0.85
C3	0.93	2.09	10	0.66	5.08	15.28	10	4.83
C6	0.16	0.2	10	0.06	1.23	1.81	10	0.57
C7	0.24	0.46	10	0.15	0.2	0.46	10	0.15
C8	0.01	0.01	5	0.00	0.12	0.26	5	0.12
MEAN	**1.02**				**1.63**			
STD ERR	**0.70**				**0.74**			
SOUTH STUDY AREA								
S2	4.05	8.69	10	2.75	3.41	10.02	10	3.17
S4	0.01	0.02	9	0.01	0.27	0.66	10	0.21
S6	0.12	0.15	10	0.05	15.5	32.52	10	10.28
S10	0.55	1.47	10	0.46	0.63	1.17	10	0.37
S14	5.04	15.86	10	5.02	0.06	0.15	10	0.05
S16	0.08	0.13	10	0.04	0.08	0.15	10	0.05
S18	4.79	13.69	10	4.33	0.06	0.13	10	0.04
MEAN	**2.09**				**2.86**			
STD ERR	**0.91**				**2.16**			

TABLE 13. Fish catches in nearshore net sampling in the North Study Area of Prince William Sound on APEX cruise 96-1.

STATION NO.	41	44	47	47	48	52	58	62	68	69	
SITE	N19-09A	N19-01A	N17-03A	N17-03A	N15-07B	N13-07B	N09-01A	ST MATT	N07-01B	N03-06B	
DATE	23-Jul	23-Jul	23-Jul		24-Jul	24-Jul	25-Jul	26-Jul	26-Jul	27-Jul	
											TOTAL
				CAST NET						DIPPNET	
HERRING			176	414				10000	10000	450	21040
PINK SALMON	5				2	7	61				75
POLLOCK		1	2								3
TOM COD		1			2						3
PAC COD			32								32
GREENLING											
GREEN WH SP			1								1
GREEN KELP			1								1
ARCTIC SHANNY			3								3
SNAKE PRICKL											
SCULPIN			3								3
STICKLEBACK	2	4			1	2	200				209
CREST GUNN	1				2	4					7
PROWFISH	2	2	1			1	2				8
WOLFFISH			1								1
ALL FISH	10	8	220	414	7	14	263	10000	10000	450	21386

Table 14. Catches of fish in purse seine samples in the Central Study Area of Prince William Sound on APEX cruise 96-1

STATION NO.	18	19	24	26	29	38	
SITE	C01-05B	C01-07B	C02-10A	C04-01B	C04-08A	C07-02B	
DATE	19-Jul	19-Jul	20-Jul	21-Jul	21-Jul	22-Jul	
							TOTAL
HERRING	1300	2	1				1303
SANDLANCE	28						28
PINK SALMON		2	200				202
COHO SALMON				3			3
CHUM SALMON							
POLLOCK					1	2	3
TOM COD						1	1
LINGCOD					1		1
STICKLEBACK		2					2
CREST GUNN		7					7
PROWFISH		2			1		3
ALL FISH	1328	15	201	3	3		1550

Table 15. Catches of fish in purse seine samples in the South Study Area of Prince William Sound in APEX cruise 96-1.

STATION NO.	1	2	3	
SITE				TOTAL
DATE	15-Jul-96	15-Jul-96	16-Jul-96	
HERRING		3	650	653
PINK SALMON	472	550	78	1100
CHUM SALMON	107	39	19	165
ALL FISH	579	592	747	1918

Table 16. Video samples identifications on inshore survey of cruise 96-1

DATE	TIME	STN #	LOCATION	DEPTH (m)	TARGET IDENTIFICATION
			SOUTH STUDY AREA		
16/07	15:40	3		12.2	NONE
17/07	9:15	4	Whale Bay	30.5	NONE
17/07	10:14	5	Whale Bay	30.5	NONE
17/07	10:58	6	S107A	15.2-18.3	HERRING >100 MM
17/07	13:15	7	near S10-02A	15.2	SALMON SHARKS
17/07	15:08	8	S14-01A	12.2	HERRING >100 MM
17/07	17:13	9	S14-08A	12.2	NONE
17/07	17:55	10	S14-09	16.8	NONE
18/07	8:42	11	Paddy Bay	12.2-15.2	YOY POLLOCK
18/07	9:25	12	S16-04B	3.0-4.6	NONE
18/07	10:30	13	S16-04B	12.2-18.3	ROCKFISH
18/07	11:06	14	S16-04B	15.2 - 18.3	HERRING >100 MM
18/07	14:12	15	S02-01A	10.7	NONE
18/07	17:06	16	S02-07A	15.2	UNIDENTIFIED SCHOOL
18/07	17:33	17	S02-09A	9.1-15.2	HERRING
			CENTRAL STUDY AREA		
19/07	12:00	18	C01-05B	12.2-15.2	HERRING > 100 MM
19/07	14:55	19	C01-07B	10.7-12.2	NONE
19/07	16:45	20	C02-04B	6.1	NONE
19/07	17:05	21	C02-04B	6.1	NONE
19/07	18:15	22	C02-06B	12.2-18.3	HERRING > 100 MM
19/07	18:41	23	C02-06B	12.2	UNIDENTIFIED SCHOOL
20/07	11:10	24	C02-10A	9.1	HERRING > 100 MM
20/07	14:07	25	C03-08A	9.1-12.2	HERRING > 100 MM
20/07	14:35	25	C03-08A	12.2	NONE
20/07	14:55	25	C03-08A	18.3	NONE
21/07	8:20	26	C04-01B	12.2	NONE
21/07	8:40	26	C04-01B	9.1	UNIDENTIFIED SCHOOL
21/07	10:45	27	C04-05B	12.2-15.2	NONE
21/07	11:15	28	C04-06B	15.2	UNIDENTIFIED SCHOOL
21/07	11:36	29	C04-08A	12.2-15.2	HERRING > 100 MM
21/07	12:40	30	McPherson Passage	12.2-16.8	ROCKFISH
21/07	13:36	31		30.5	ADULT SALMON
21/07	14:30	32	C05-03A	18.3-30.5	HERRING > 100 MM
21/07	15:53	33	C05-10B	21.3	ROCKFISH
22/07	8:50	34	C07-10A	24.4-36.6	NONE
22/07	10:03	35	C07-07A	1.5-7.6	ROCKFISH JUVENILES
22/07	11:10	36	C07-04B	7.6-9.1	NONE
22/07	11:45	37	C07-03B	3.0-6.1	GADID - JUVENILE
22/07	16:15	39	C07-06A	18.3	NONE
22/07	17:05	40	C06-03B	30.5	NONE
			NORTH STUDY AREA		
23/07	10:00	42		3.0-6.1	JELLYFISH
23/07	11:30	43	N19-02B	3.0-9.1	JELLYFISH
23/07	11:48	44	N19-01A	15.2	UNIDENTIFIED SCHOOL
23/07	12:10	44	N19-01A	15.2	NONE
23/07	14:26	45	N17-05B	12.2	UNIDENTIFIED SCHOOL
23/07	14:43	46	N17-04B	13.7-15.2	HERRING > 100 MM
24/07	10:10	48	N15-07B	9.1-12.2	UNIDENTIFIED SCHOOL
24/07	11:15	49	N15-06A	6.1-9.1	UNIDENTIFIED SCHOOL

Table 16. Continued

DATE	TIME	STN #	LOCATION	SAMPLE D (m)	IDENTIFICATION
24/07	12:12	50	N15-02A	12.2-18.3	UNIDENTIFIED SCHOOL
24/07	13:00	51		12.2-15.2	HERRING > 100 MM
24/07	14:37	52	N13-07B	12.2	HERRING > 100 MM
24/07	15:45	53	N13-05B	18.3-21.3	HERRING > 100 MM
24/07	16:00	54	N13-04B	21.3	HERRING > 100 MM
24/07	16:13	54	N13-04B	22.9	HERRING > 100 MM
24/07	17:15	56	N13-03A	21.3-24.4	NONE
25/07	10:07	57	N09-07B	1.5-4.6	NONE
25/07	13:08	58	N09-01A	10.7-13.7	HERRING > 100 MM
25/07	13:15	59	N07-05B	9.1-13.7	HERRING > 100 MM
25/07	16:35	60		10.7	NONE
25/07	17:43	61		7.6-10.7	SANDLANCE
26/07	9:03	62	St. Matthews Bay	10.7-15.2	HERRING - YOY
26/07	11:04	63	St. Matthews Bay	24.4-30.5	NONE
26/07	14:00	64	N05-10A	12.2	NONE
26/07	14:18	65	N05-09B	4.6-6.1	NONE
26/07	16:00	66	N05-06A	6.1	NONE
26/07	16:20	66	N05-06A	4.6	NONE
26/07	17:05	67	N05-03A	7.6-9.1	NONE
26/07	18:51	68	N07-02B	6.1-9.1	HERRING > 100 MM
27/07	9:54	70	N03-05B	42.7	NONE
27/07	12:00	71	N03-08B	36.6	NONE
27/07	12:21	72	N03-09A	30.5	NONE
27/07	13:17	73	N01-10A	15.2-18.3	HERRING - YOY
27/07	13:44	74	N01-09A	15.2-18.3	POLLOCK - YOY
27/07	14:23	75	N01-07B	15.2-30.5	NONE

Table17. Mean lengths of dominant species (n >10) in net samples collected by the inshore survey of cruise 96-1.
P - Purse Seine, D - Dip Net, C - Cast Net

DATE	STN #	GEAR	LOCATION	DEPTH (m)	SPECIES	FORK LENGTH (mm)	STAND. DEV.	N
			SOUTH AREA					
15/07	1	P		47.2	Pink Salmon	92.6	6.2	279
15/07	2	P	N. end La touche	36.0	Pink Salmon	99.1	12.6	234
16/07	3	P		35.7	Herring	192	12.2	204
					Pink Salmon	115.3	14.6	78
			CENTRAL AREA					
19/07	18	P	C01-05B	18.3	Herring	125.8	12.1	270
					Sand lance	101.2	2.5	11
20/07	24	P	C02-10A	76.2	Juv. Salmon	111.8	13.4	200
			NORTH AREA					
23/07	47	C	N17-03A	12.2	Herring	118.3	6.0	177
23/07	47	P	N17-03A	7.6	Herring	54.1	2.8	414
25/07	58	P	N09-01A	18.3-24.4	Juv. Salmon	98.7	9.2	61
26/07	62	P	St. Matthews Bay	33.5-35.1	Herring	55.6	2.5	247
26/07	68	P	N07-01B	24.4-27.4	Herring	135.2	9.4	234
27/07	69	D	N03-06B	35.1	Herring	54.8	3.0	220

Table 18 . Composition of beach seine samples collected in the North study area of Prince William Sound in APEX cruise 96-1.

										TOTAL
SITE	N 01	N03	N05	N07	N09	N13	N15	N17	N19	
DATE										
TOTAL HAULS	3	3	3	3	3	3	3	3	3	27
HERRING	1109		597	10	127	1	32006	16	17	33883
SANDLANCE			13500	0	706	52	600			14858
EULACHON			6	1						7
PINK SALMON							4	1	67	72
COHO SALMON										
RED SALMON								3		3
POLLOCK										
TOM COD								17		17
PAC COD										
GREENLING						4		1		5
GREEN WH SP			1							1
GREEN MASK			1					1		2
LINGCOD			2					1		3
SCULPIN						1			1	2
GREAT SCULPIN		1							1	2
STICKLEBACK									3	3
SANDFISH							20			20
PIPEFISH						1		2		3
CREST GUNN						1		2	1	4
GUNNEL										
TUBESNOUT								13		13
OTHER			2							2
ALL FISH	1109	1	14109	11	833	60	32630	57	90	48900

Table 19. Composition of beach seine samples collected in the Central study area of Prince William Sound on APEX cruise 96-1

SITE	C01	C02	C03	C04	C05	C06	C07	TOTAL
DATE								
TOTAL HAULS	3	3	3	3	4	3	3	22
HERRING					1	1		2
SANDLANCE	1			1			262	264
PINK SALMON	6	1	114	500	1	137	65	824
COHO SALMON			2					2
RED SALMON					2	2		4
POLLOCK			10	1	20			31
TOM COD	140		325		29		1	495
PAC COD			33		2			35
GREENLING			1					1
GREEN WH SP	1		1					2
GREEN MASK	1		2					3
LINGCOD	1		20					21
SCULPIN	1		1	1	1			4
GREAT SCULPIN	3							3
SANDFISH			1	4	2			7
TUBESNOUT	1							1
OTHER	1							1
ALL FISH	156	1	510	507	58	140	328	1700

Table 20. Composition of beach seine samples collected in the South study area of Prince William Sound in APEX cruise 96-1.

										TOTAL
SITE	S 02	S 04	S 06	S08	S 10	S14	S16	S18	S20	
DATE										
TOTAL HAULS	3	3	3	1	3	3	3	2	3	24
HERRING		6			36	8001	56	1	48	8148
SANDLANCE			6	33	1				1	41
PINK SALMON	13		2		6	3	48	6	25	103
POLLOCK	1						1			2
TOM COD	98	7			190	904	222	1	31	1453
GREENLING										
GREEN WH SP				2						2
GREEN KELP								10		10
GREEN MASK	1									1
LINGCOD	3	1							1	5
SNAKE PRICKL	1									1
SCULPIN	2				1				1	4
GREAT SCULPIN							7			7
STICKLEBACK							1			1
TUBESNOUT					3	11		2		16
OTHER										
										0
ALL FISH	119	14	8	35	237	8919	335	20	107	9794

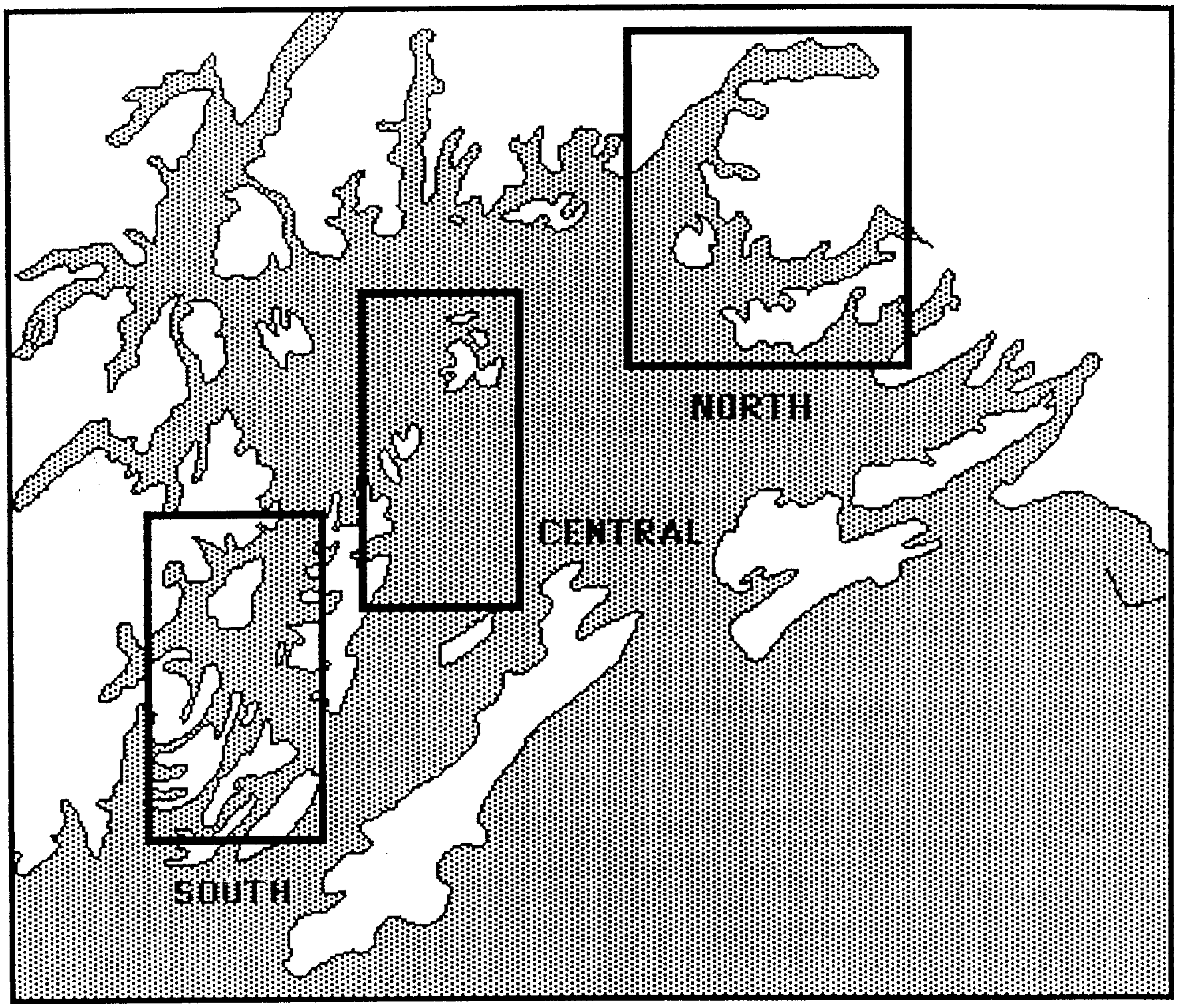


Figure 1. Locations of North, Central and South study areas for the APEX forage fish project.

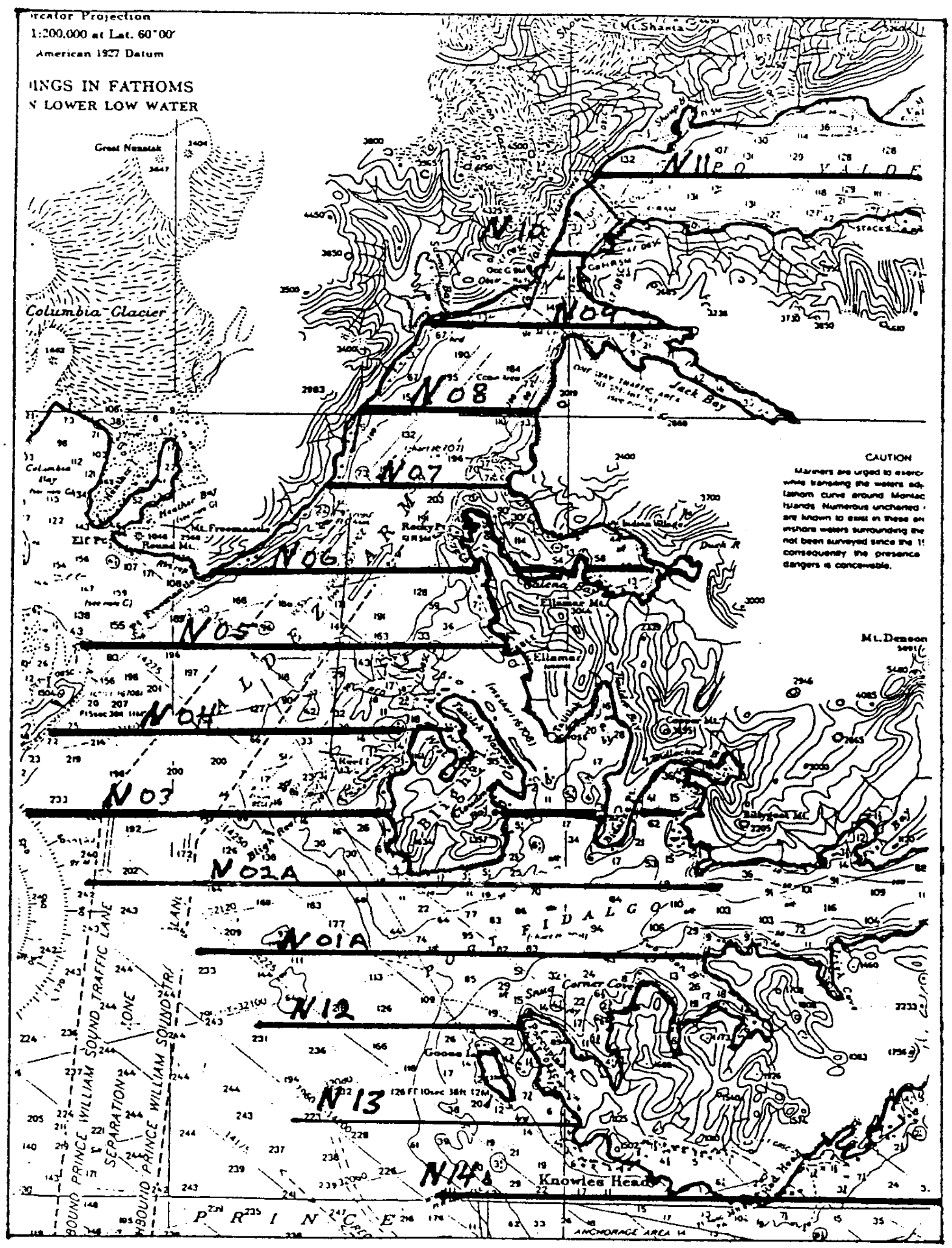


Figure 2. Offshore hydroacoustic transect locations in the North study area of Prince William Sound.

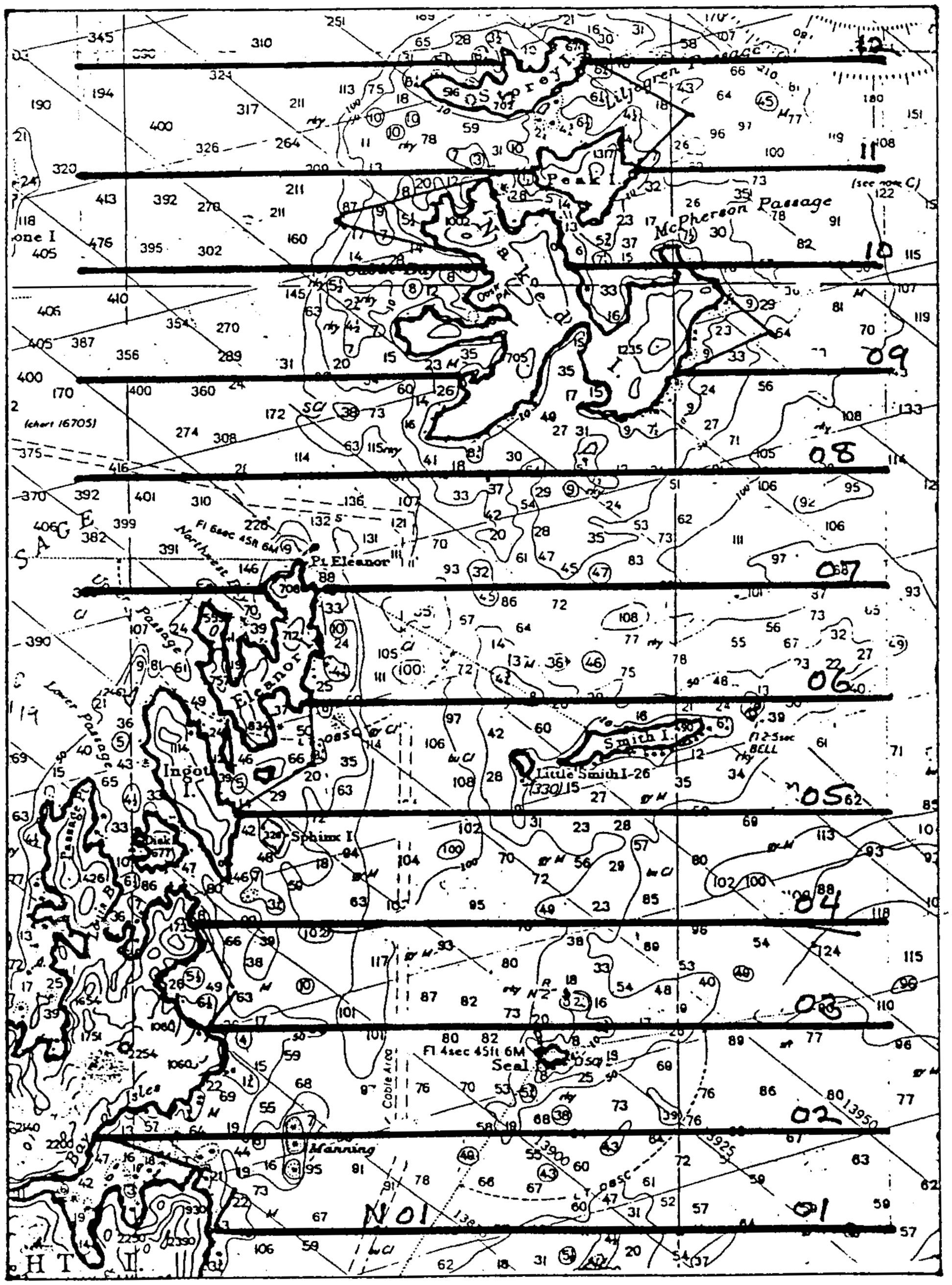


Figure 3. Offshore hydroacoustic transect locations in the Central study of Prince William Sound.

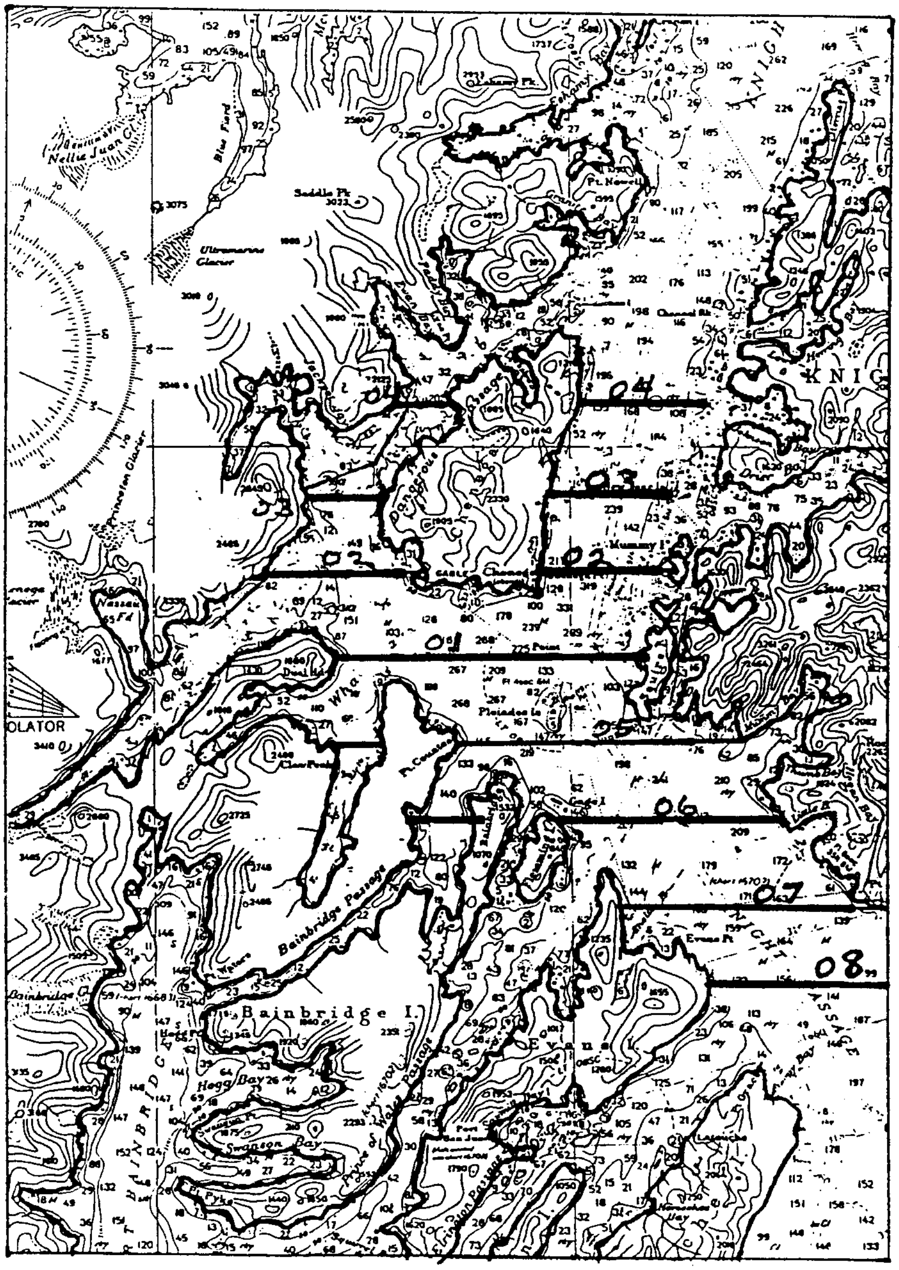


Figure 4. Offshore hydroacoustic transect locations in the South study area of Prince William Sound.

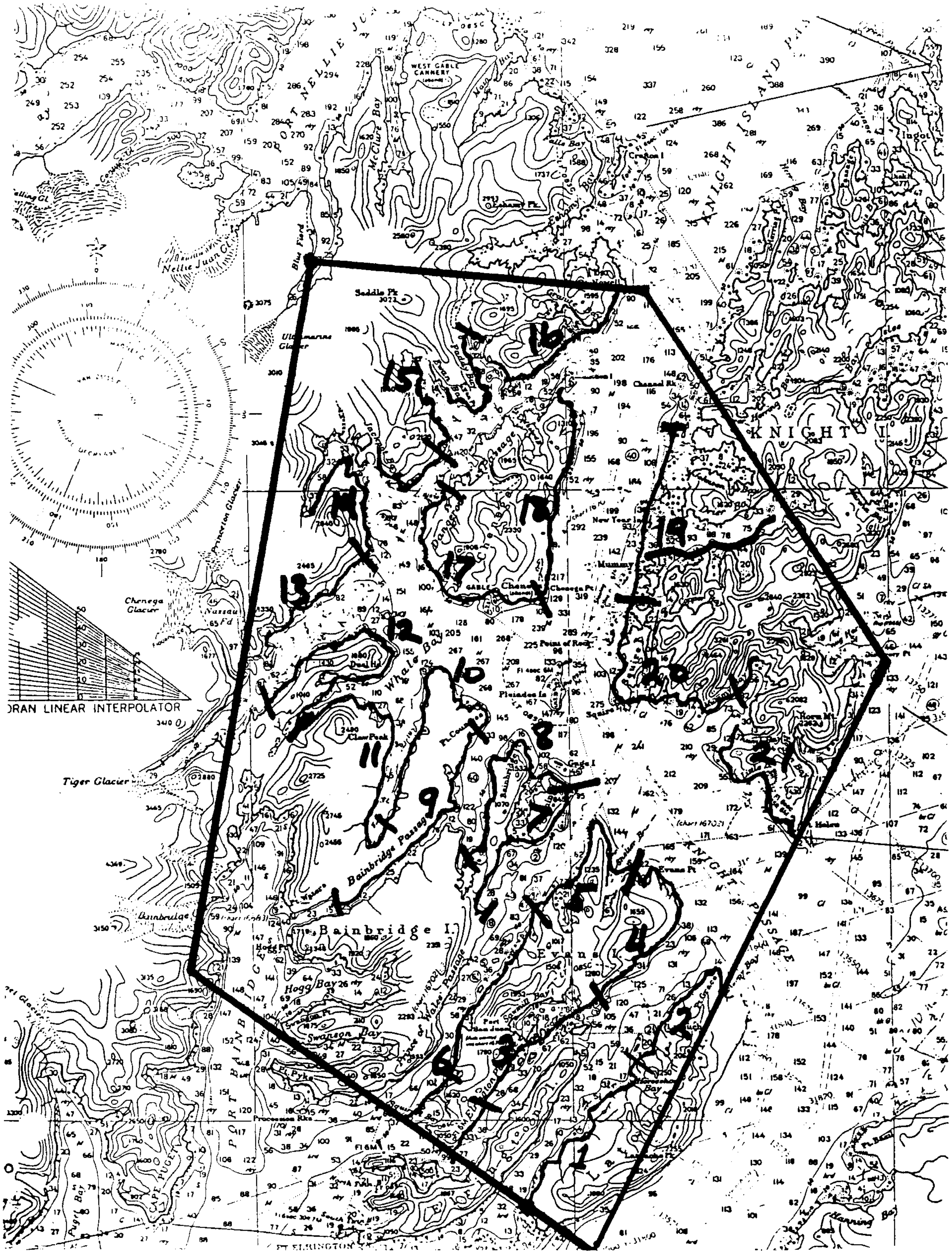


Figure 5. Layout of shoreline segments 12 km in length in the South study area

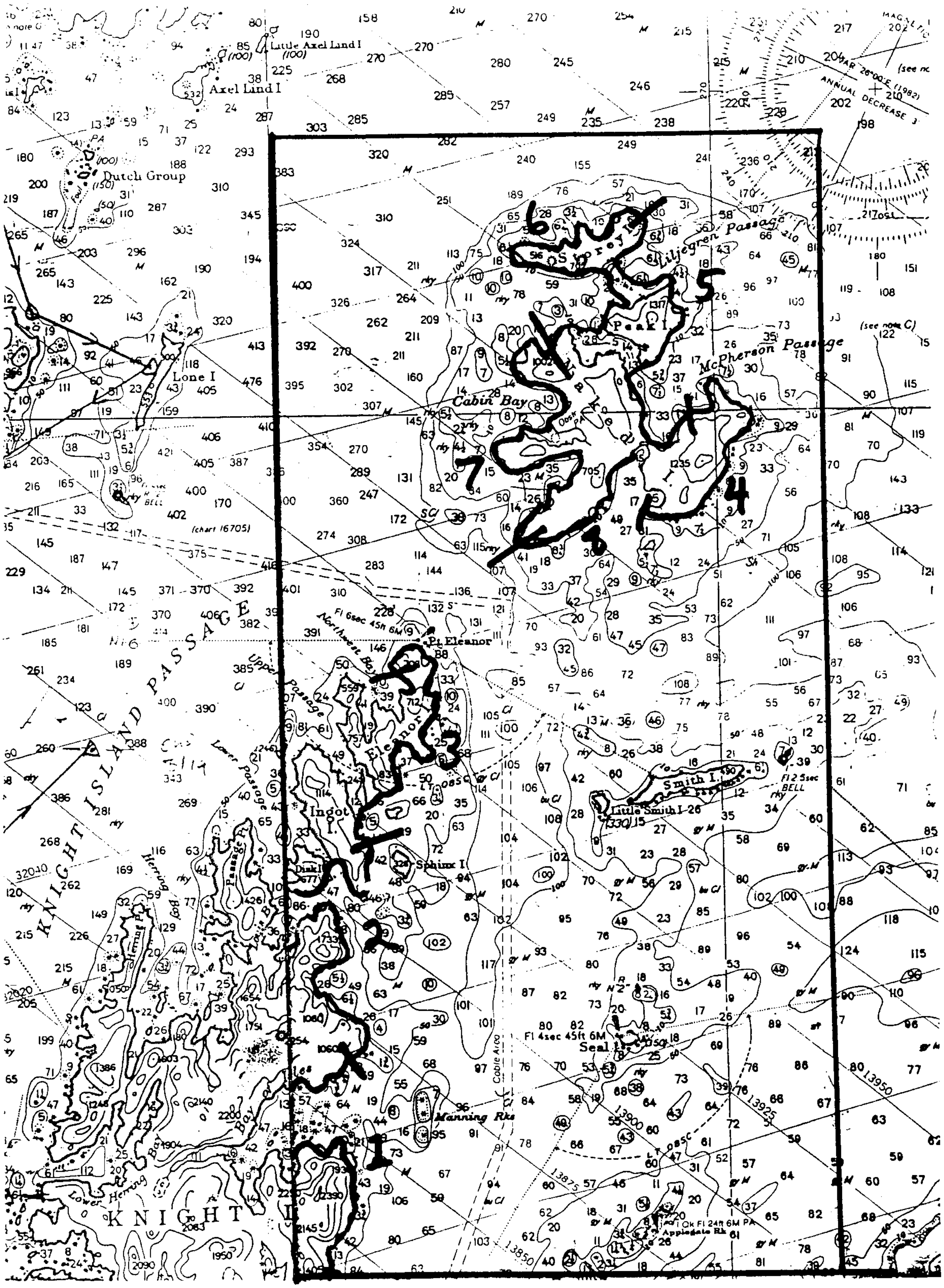


Figure 6. Layout of shoreline segments 12 km in length in the Central study

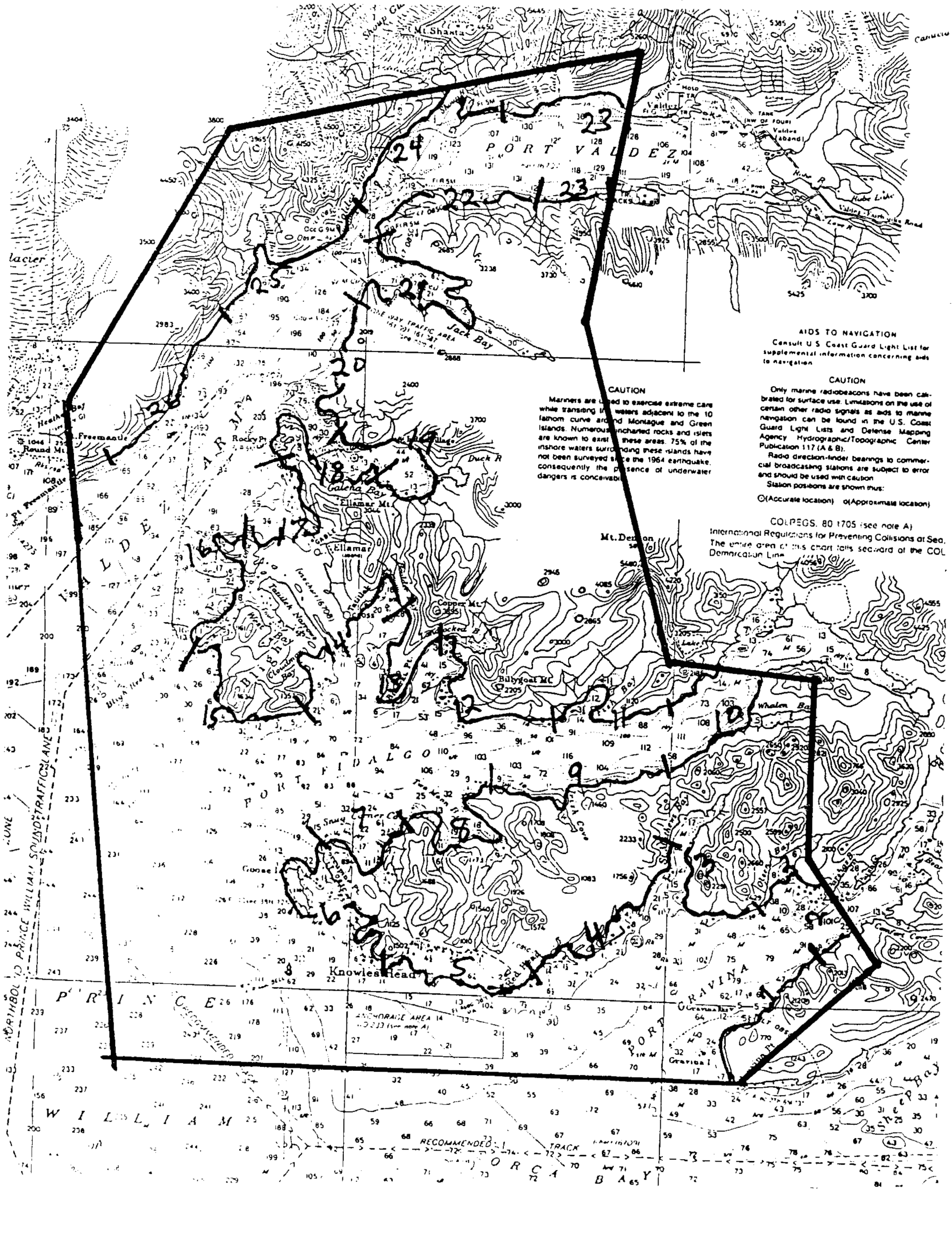


Figure 7. Layout of shoreline sements 12 km in length in the North study area

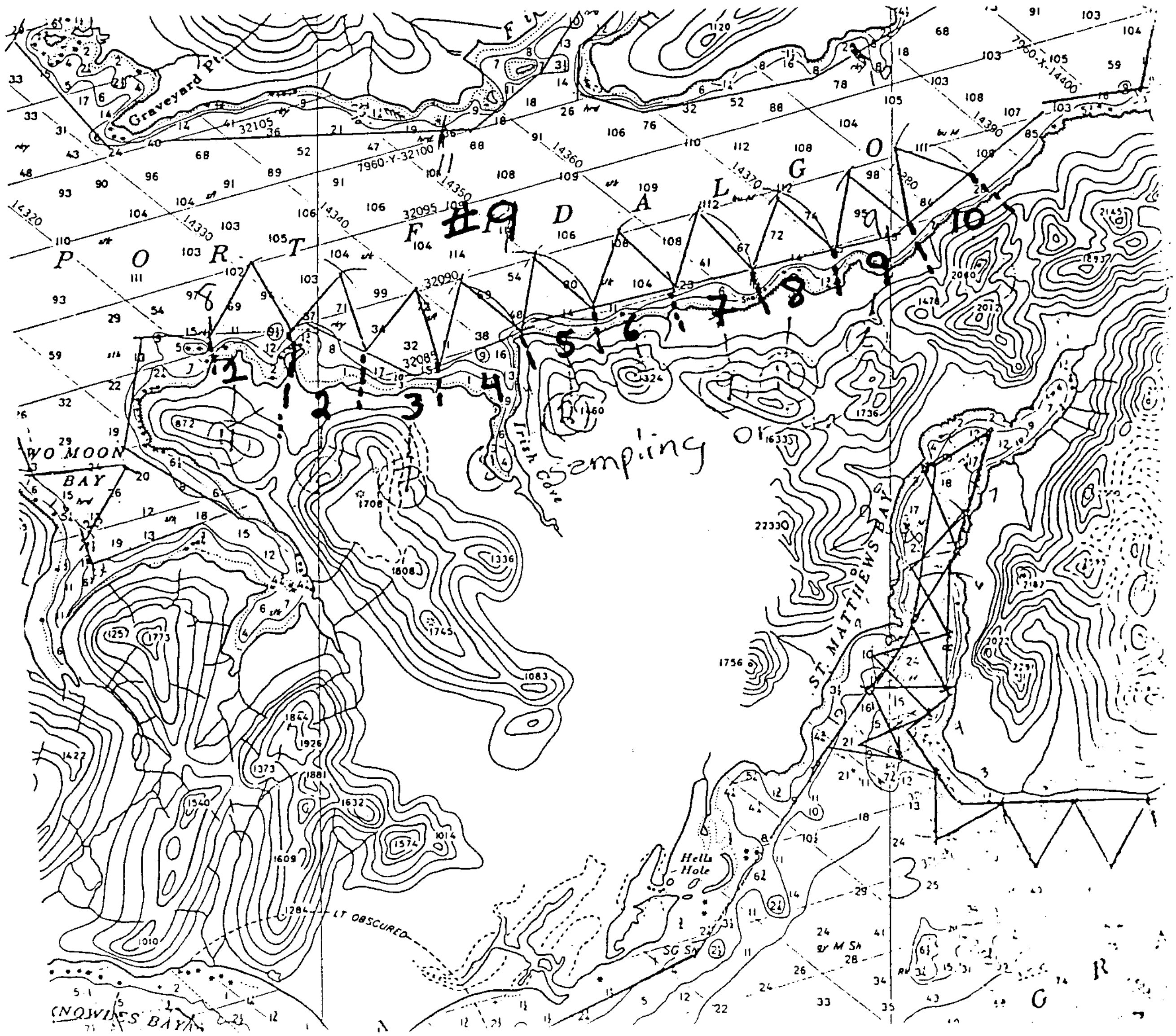


Figure 8. Typical layout of beach sections within a 12 km shoreline segment, with set of zig-zag acoustic transects. Example is segment N09, located on the south side of Port Fidalgo

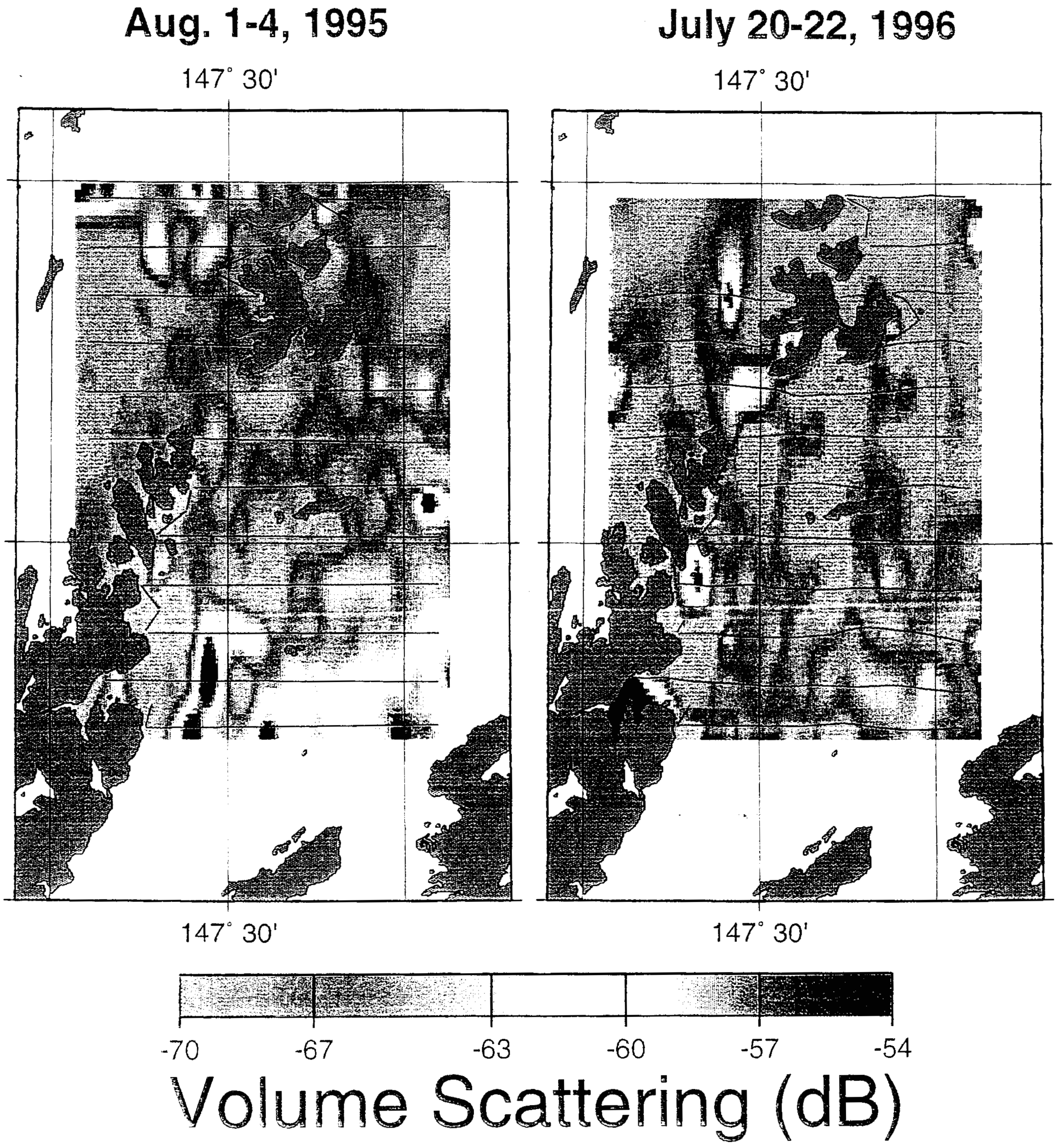


Figure 9. Area plot of acoustic backscatter in offshore surveys of the Central study area in 1995 and 1996.

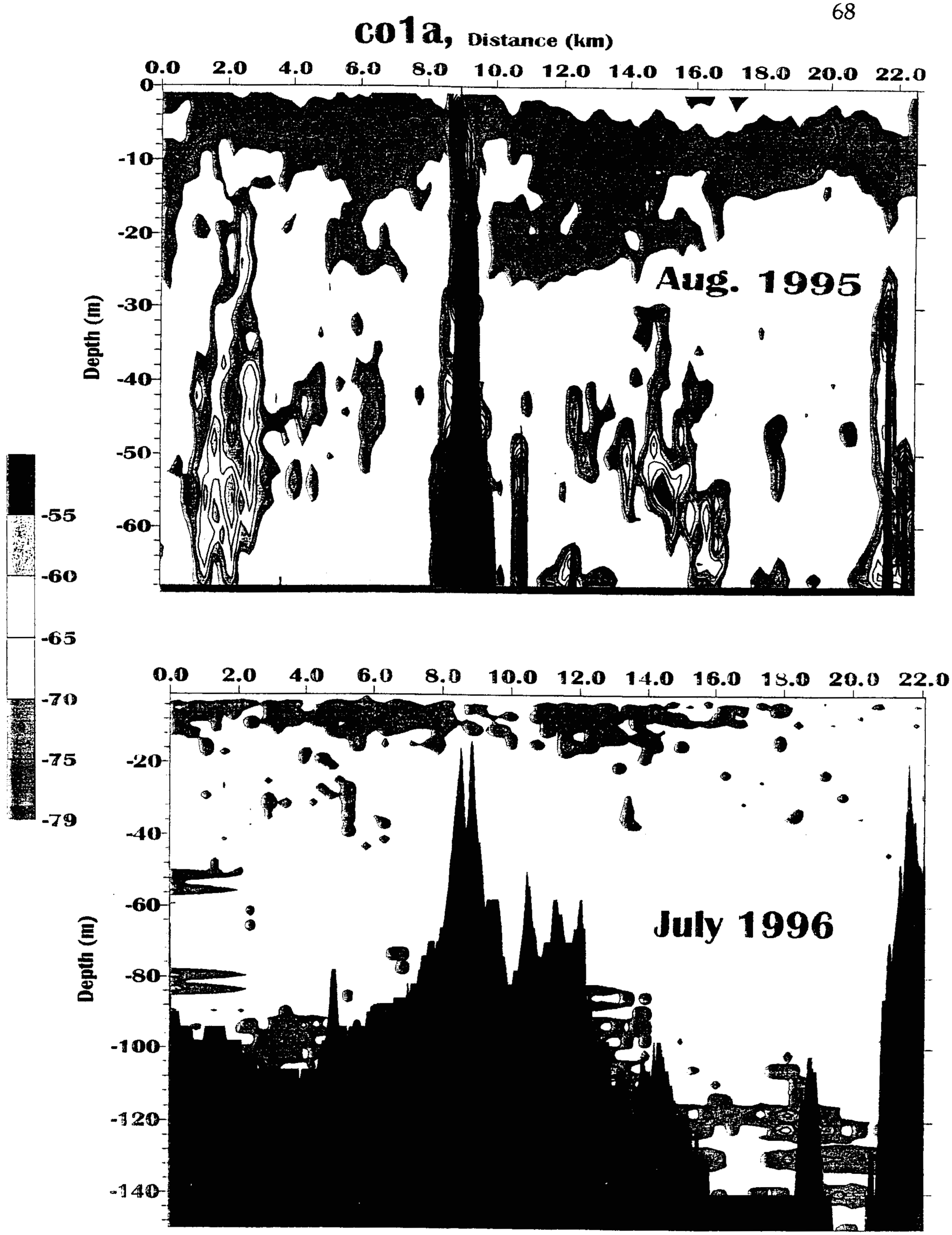


Figure 10. Vertical distribution of acoustic backscatter on transect C01A in the Central study area in 1995 and 1996

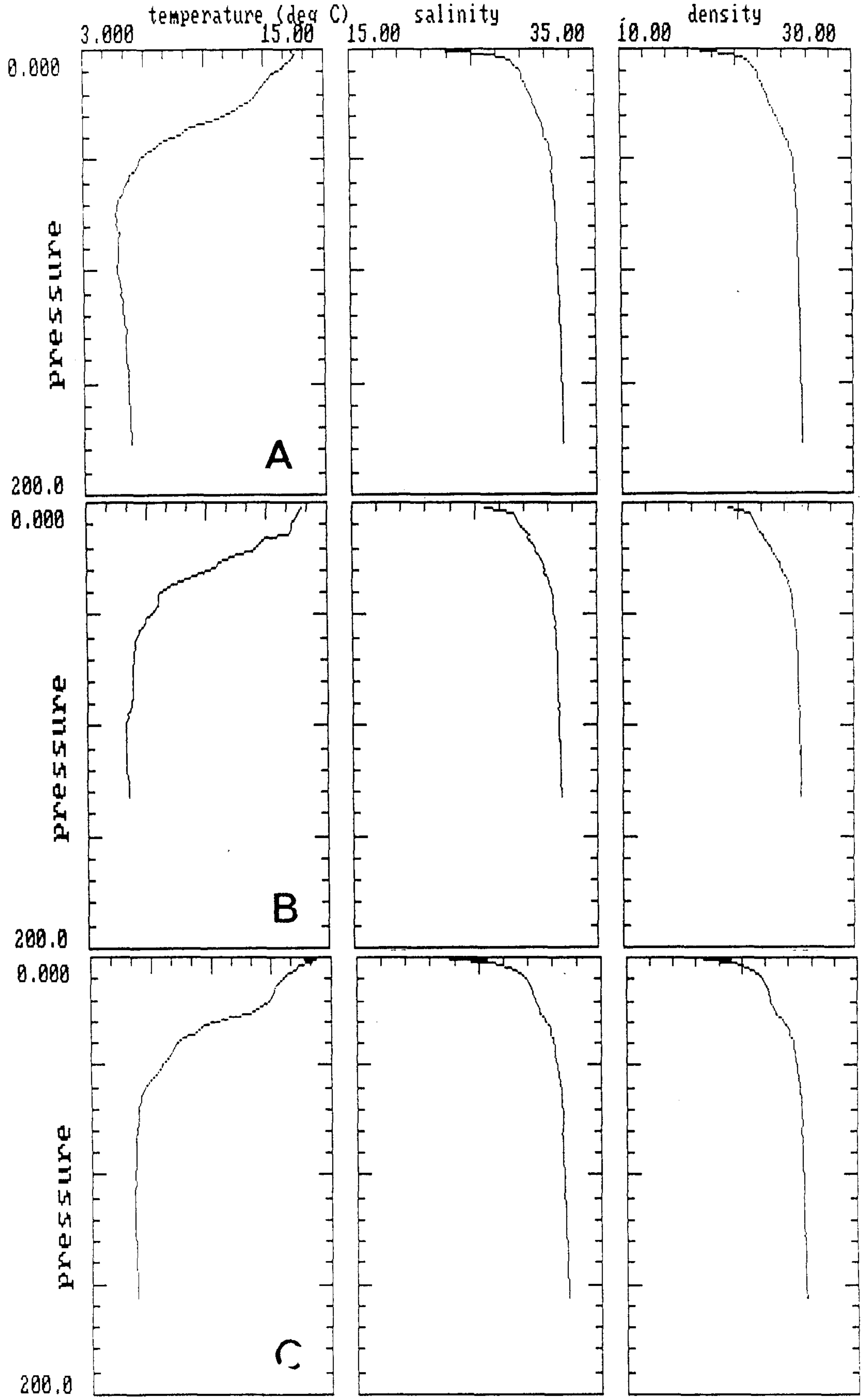


Figure 11. Vertical profiles of temperature, salinity and density at representative stations located in the: A. North. B. Central. C. South.

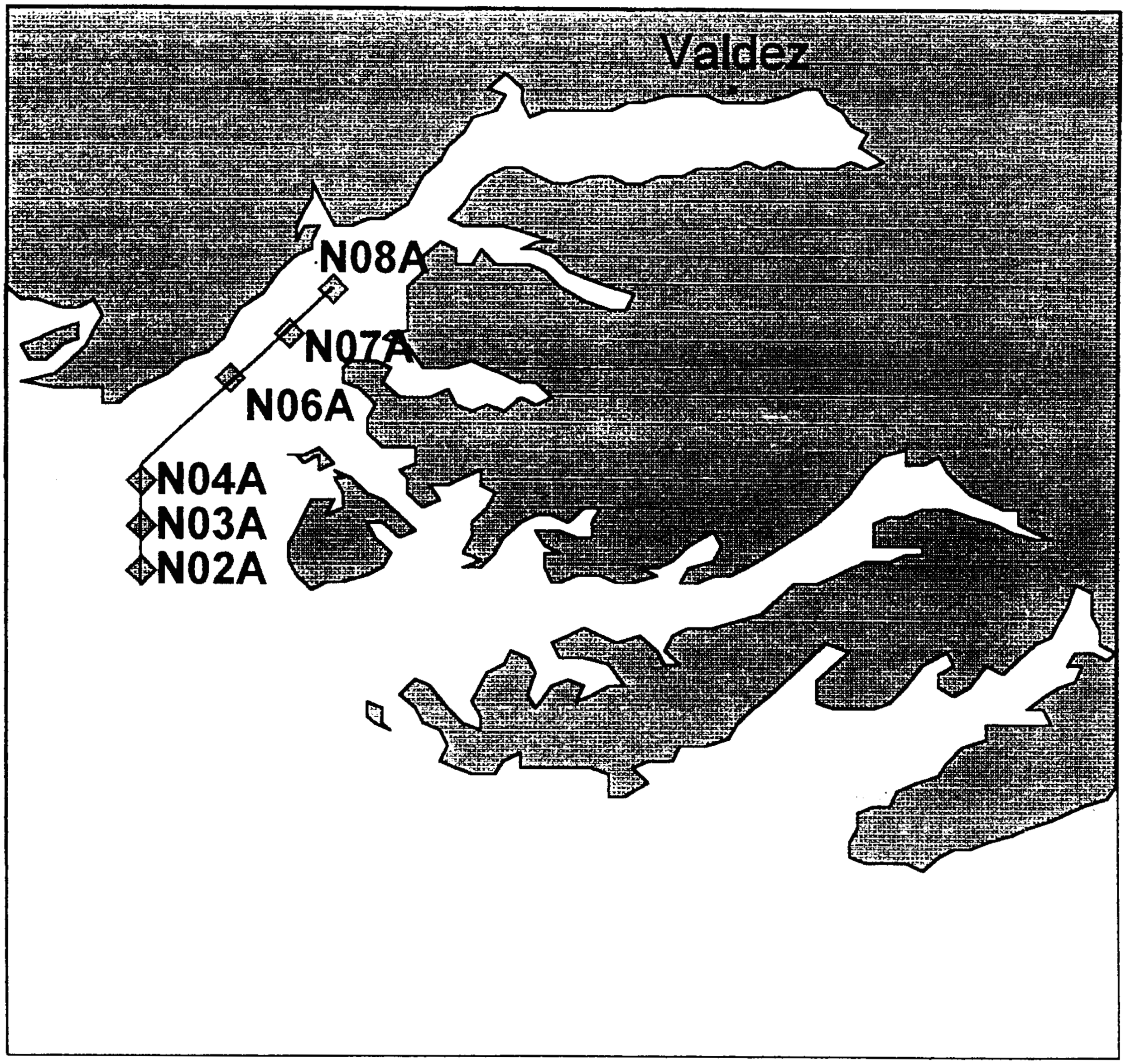


Figure 12. Locations of CTD stations used to examine horizontal variation in the water column in the North study area.

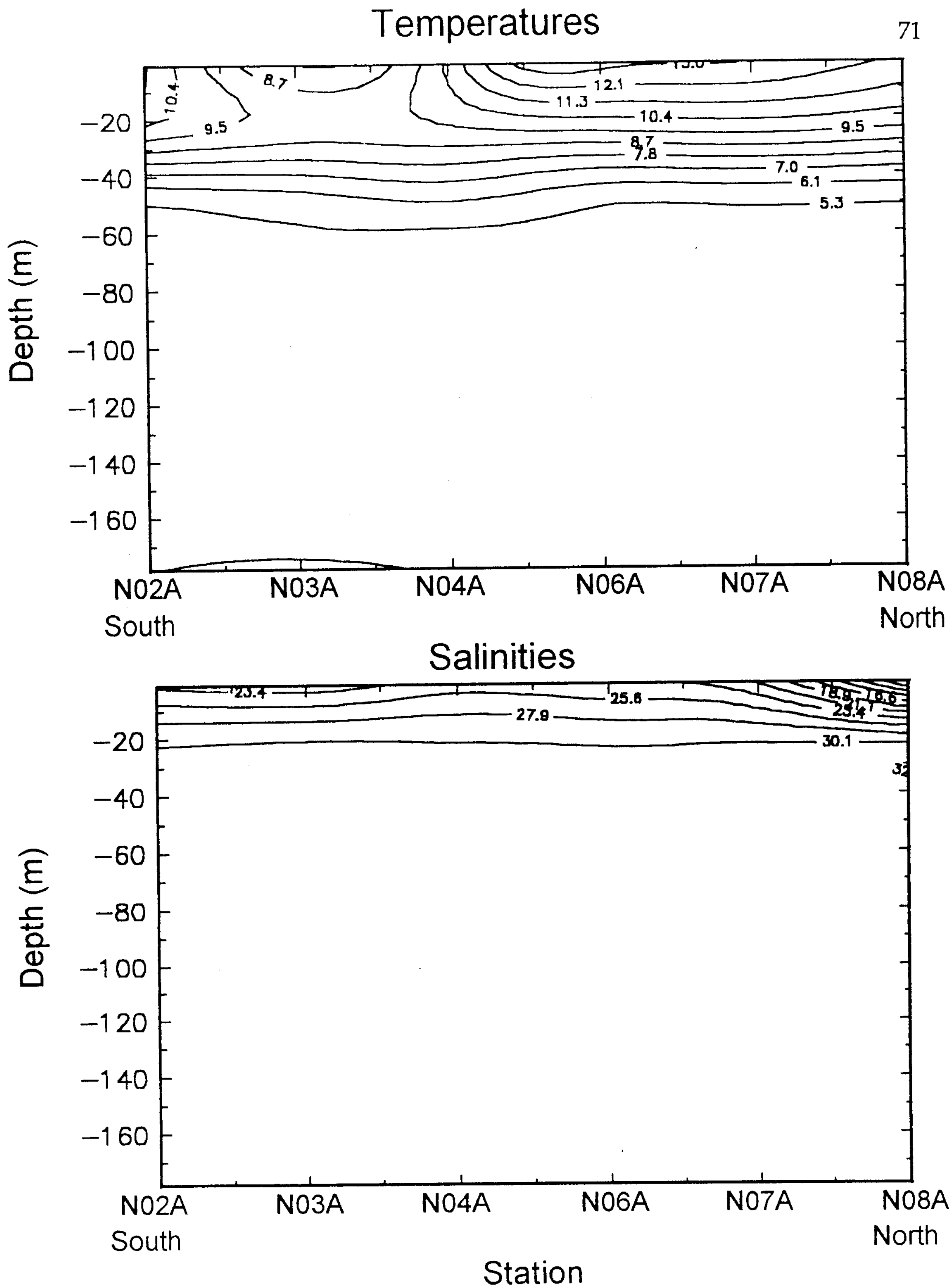


Figure 13. Isothermal and isohaline profiles at CTD stations in the North study area.

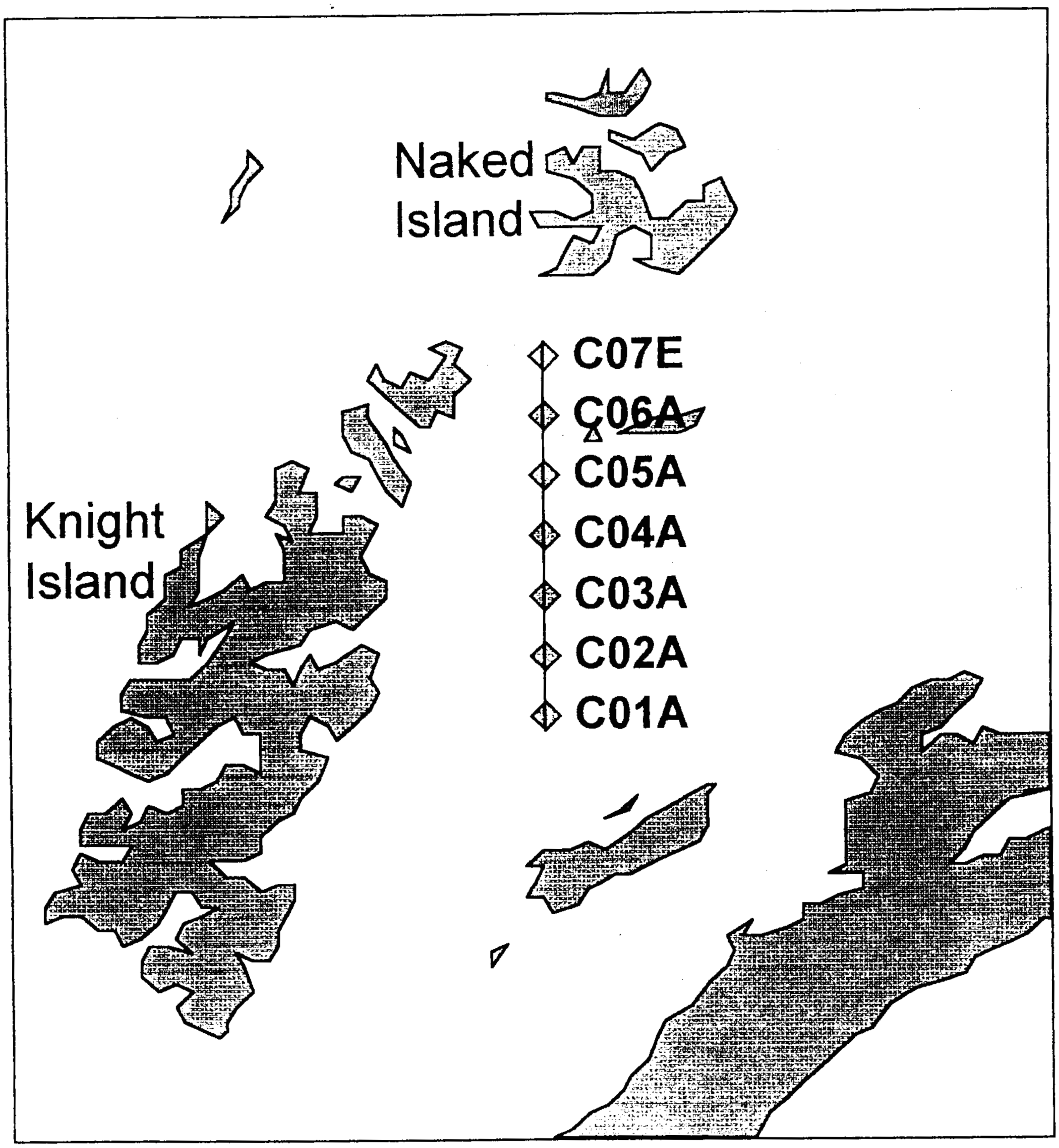


Figure 14. Locations of CTD stations used to examine horizontal variation in the water column in the Central study area.

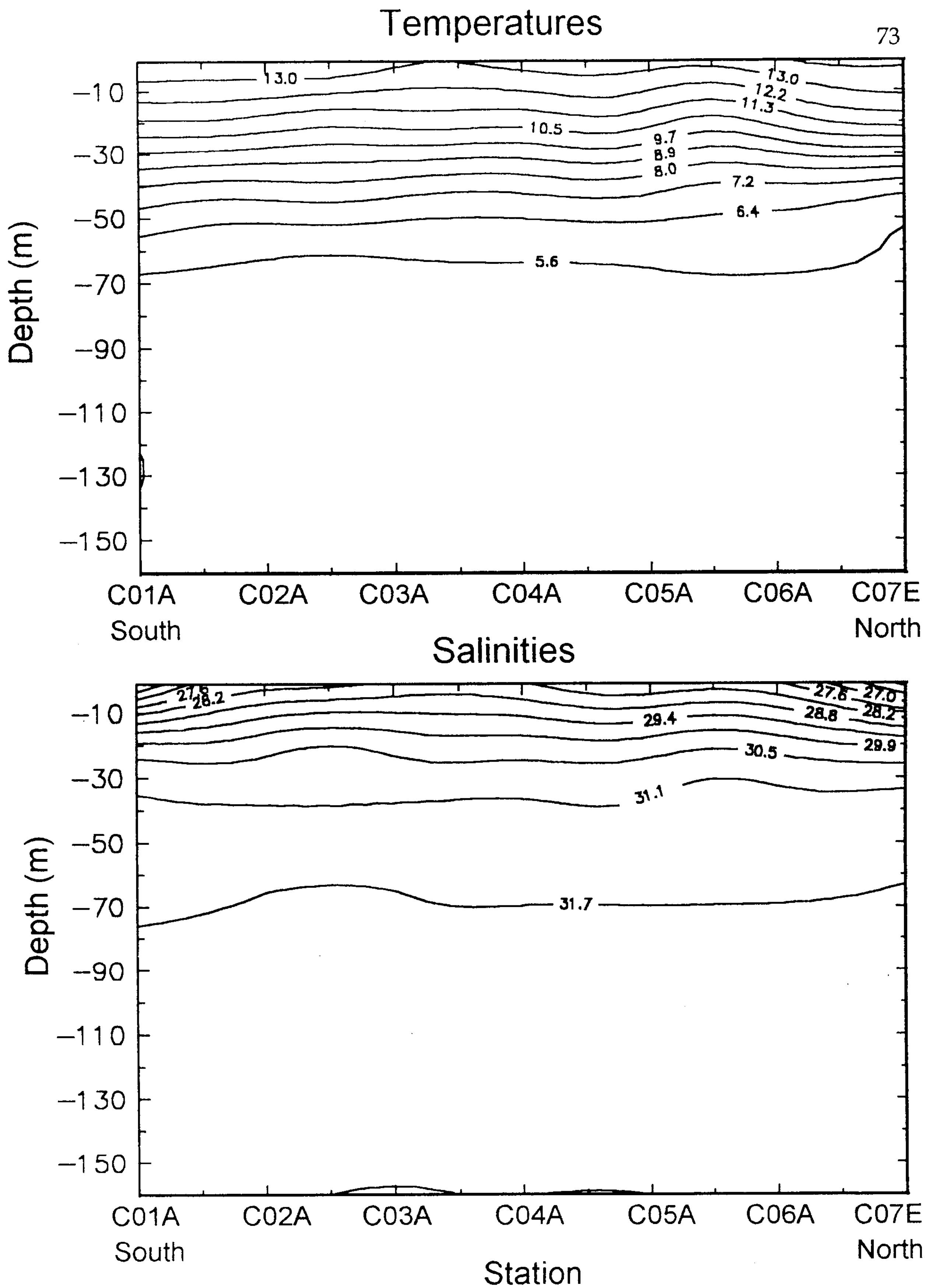


Figure 15. Isothermal and isohaline profiles at CTD stations in the Central study area.

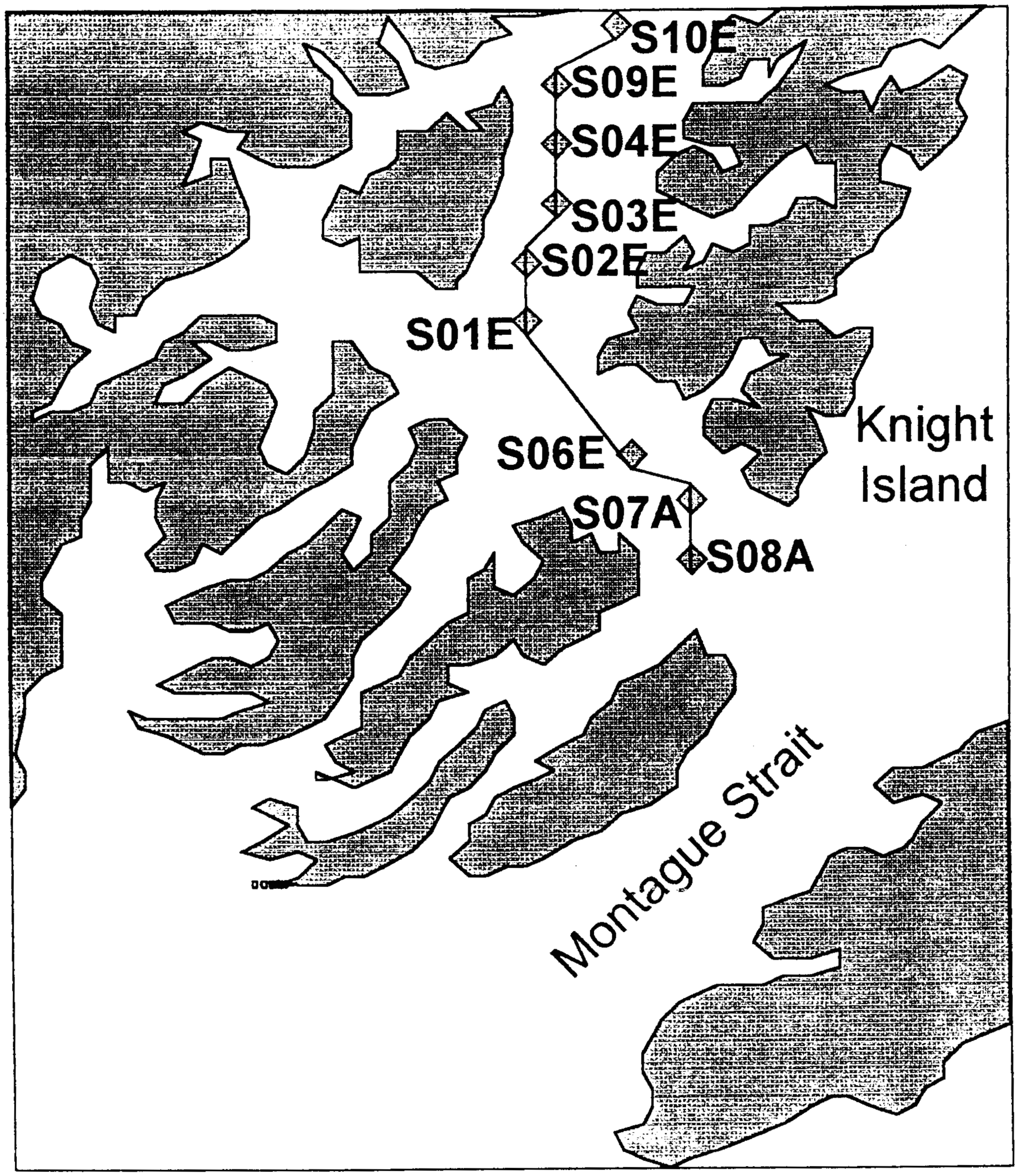


Figure 16. Locations of CTD stations used to examine horizontal variation in the water column in the South study area.

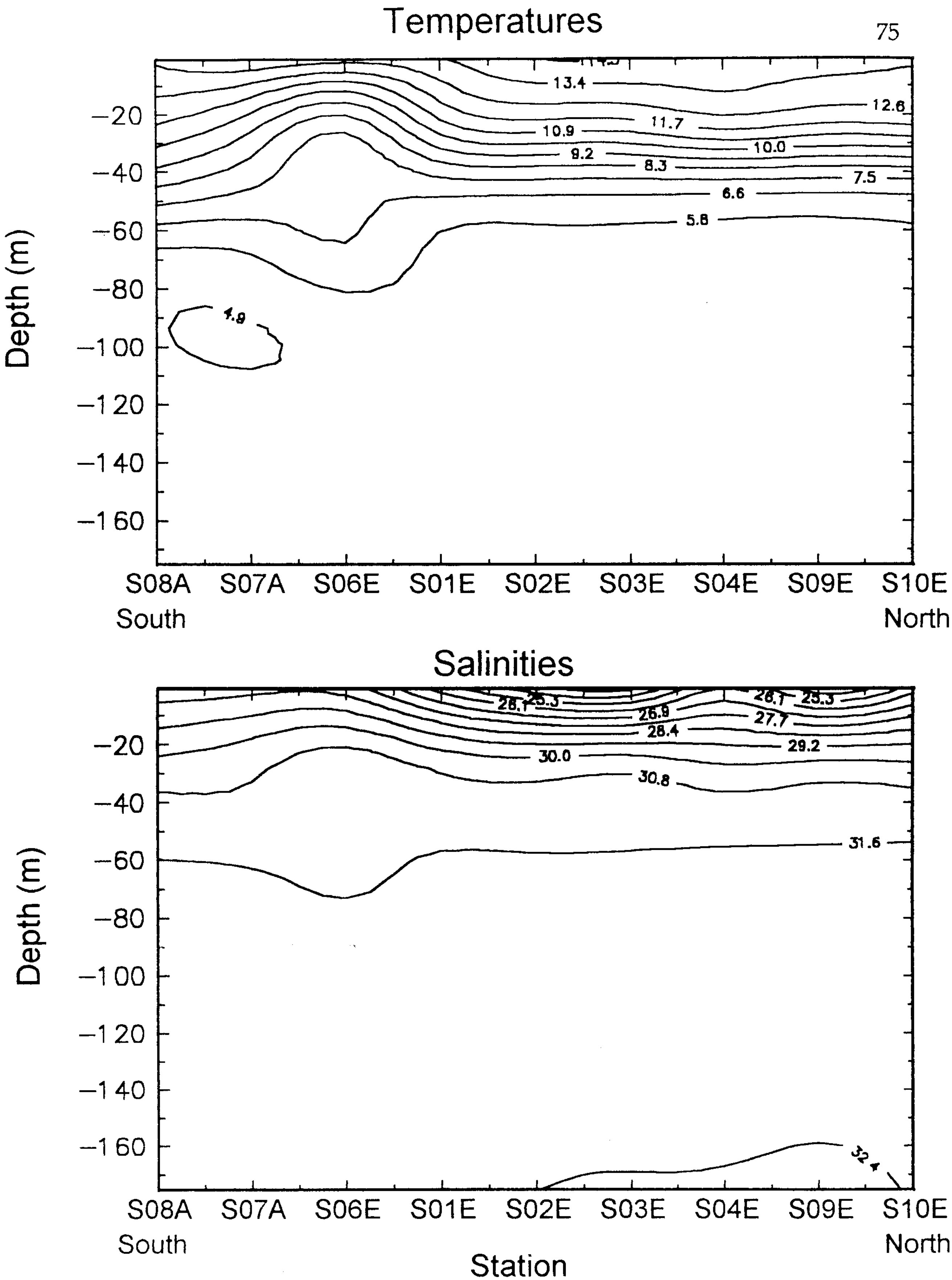


Figure 17. Isothermal and isohaline profiles at CTD stations in the South study area.

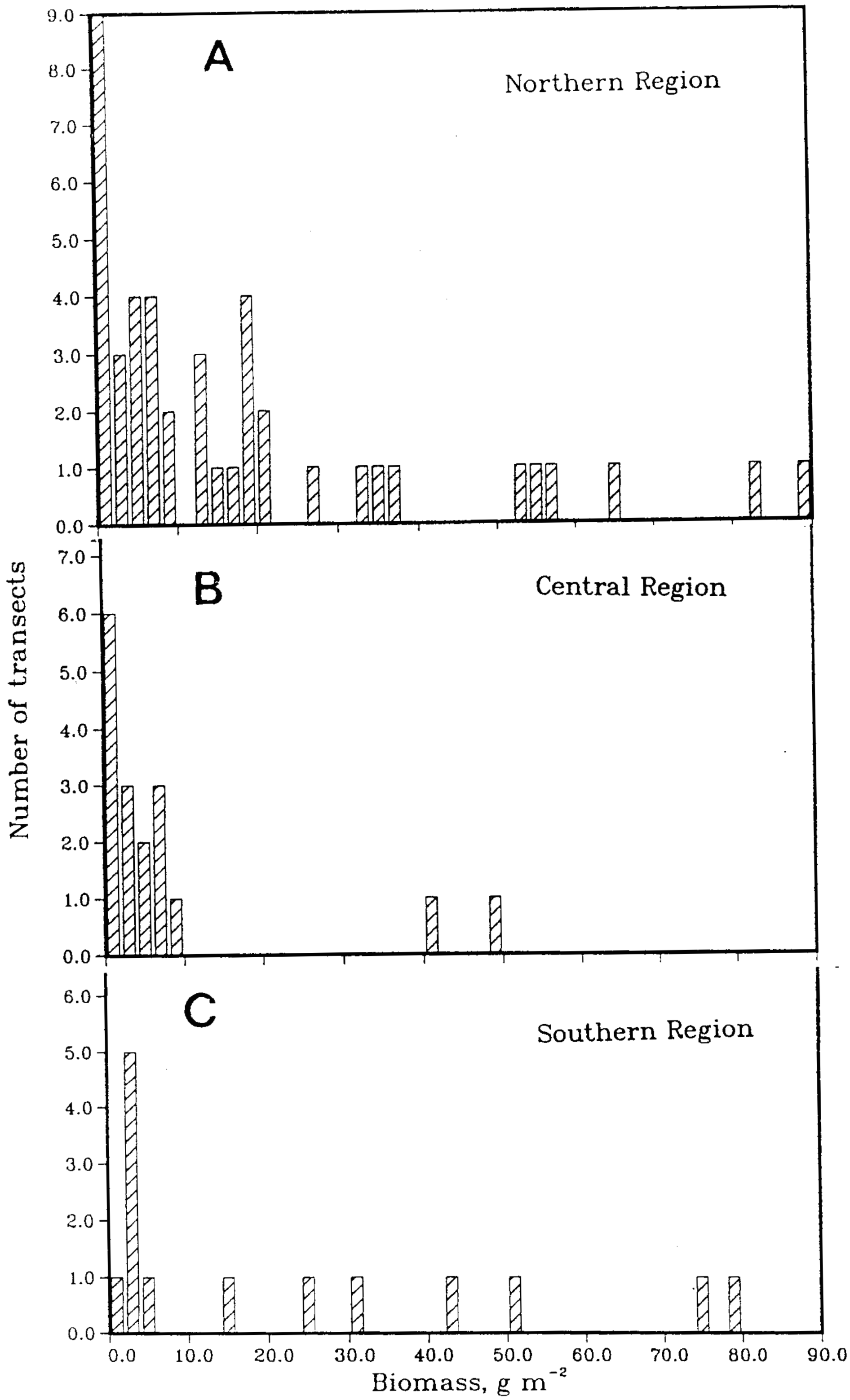


Figure 18. Distribution of biomass on individual transects in the: A. North, B. Central, and C. South study areas.

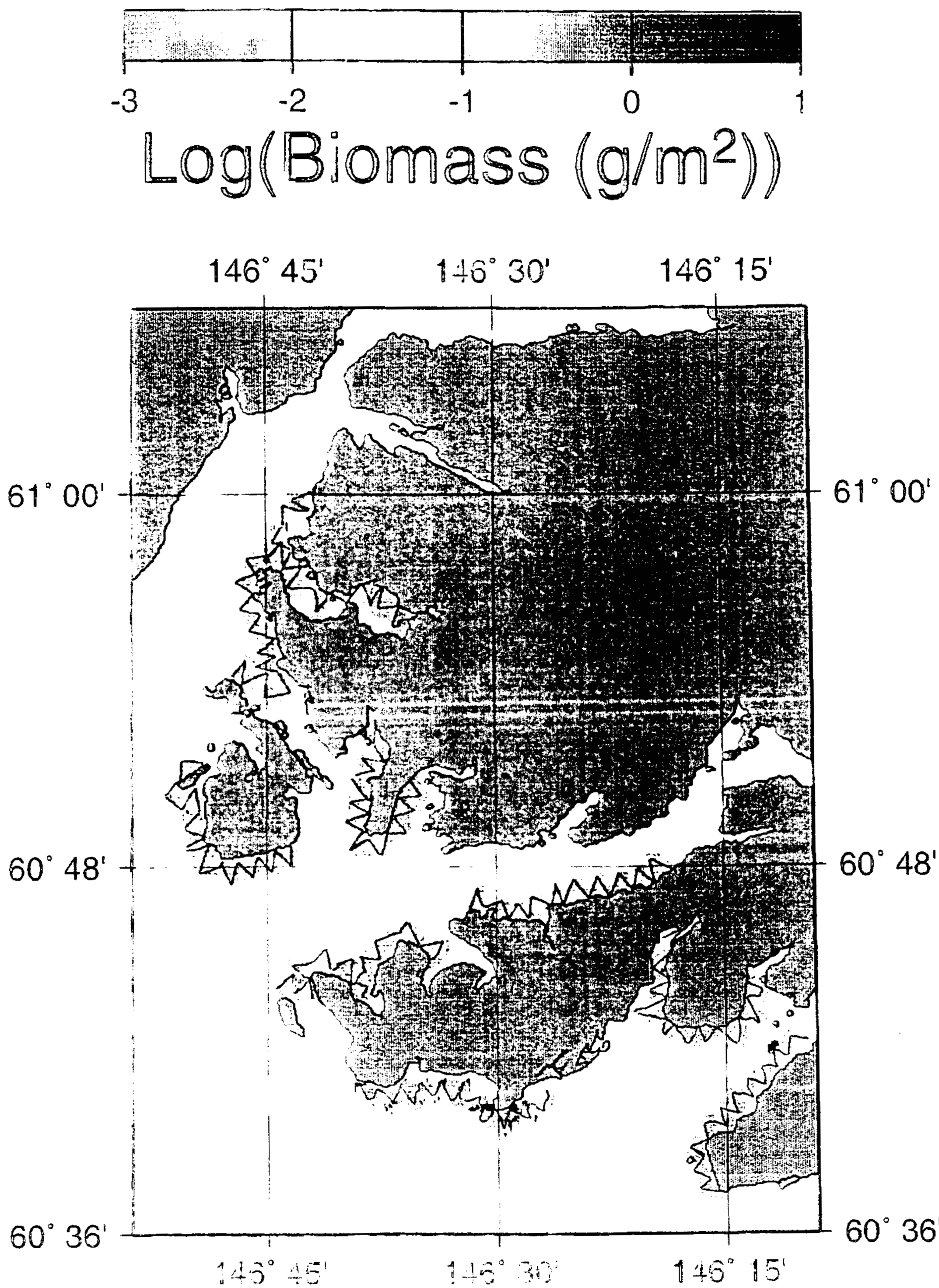


Figure 19. Geographic distribution of biomass on nearshore transects in the North study area.

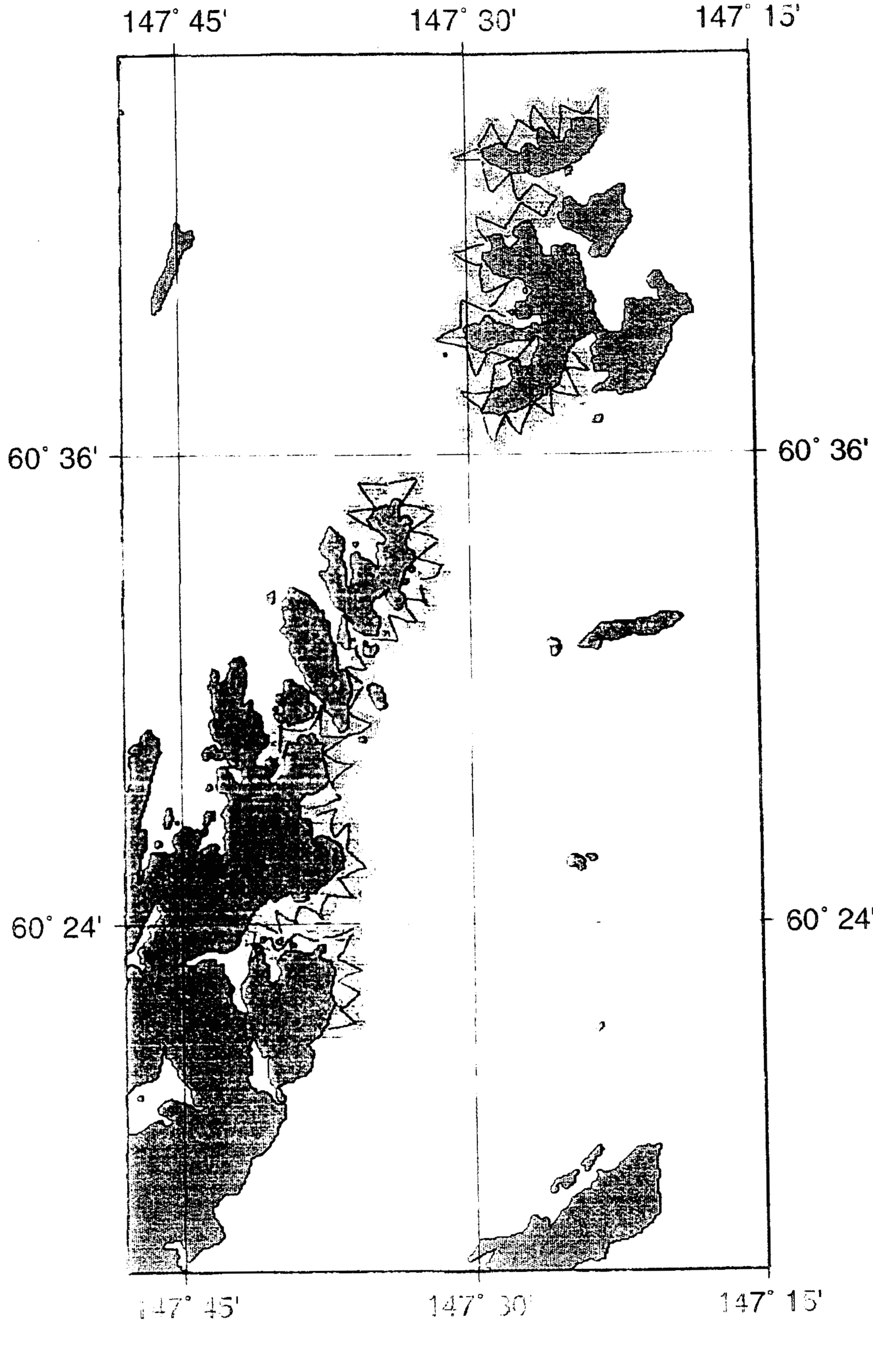


Figure 20. Geographic distribution of biomass along nearshore transects in the Central study area.

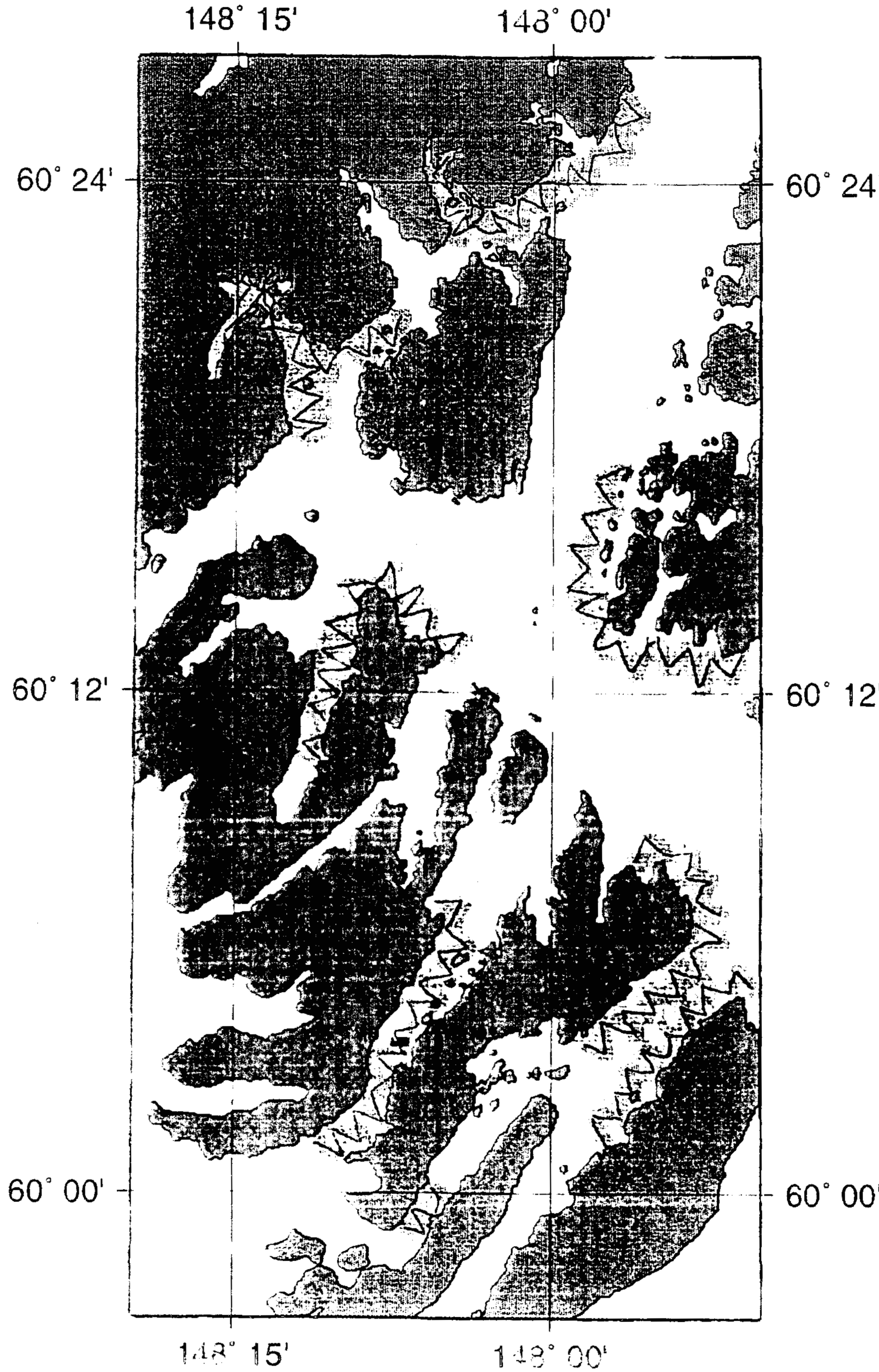


Figure 21. Geographic distribution of biomass along nearshore transects in the South study area.

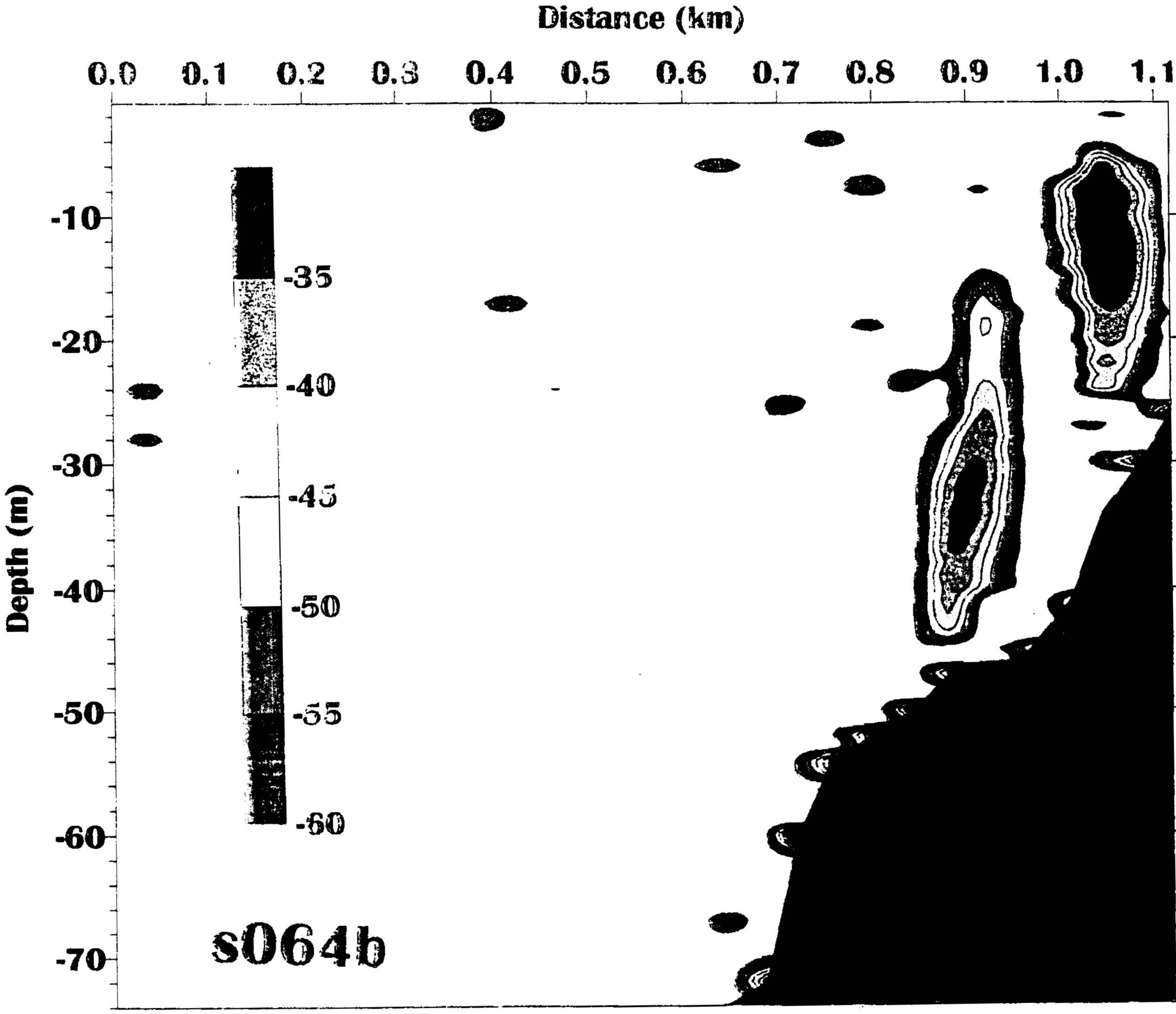


Figure 22. Example of a herring school on an individual nearshore transect (S06-04B) in the South study area.

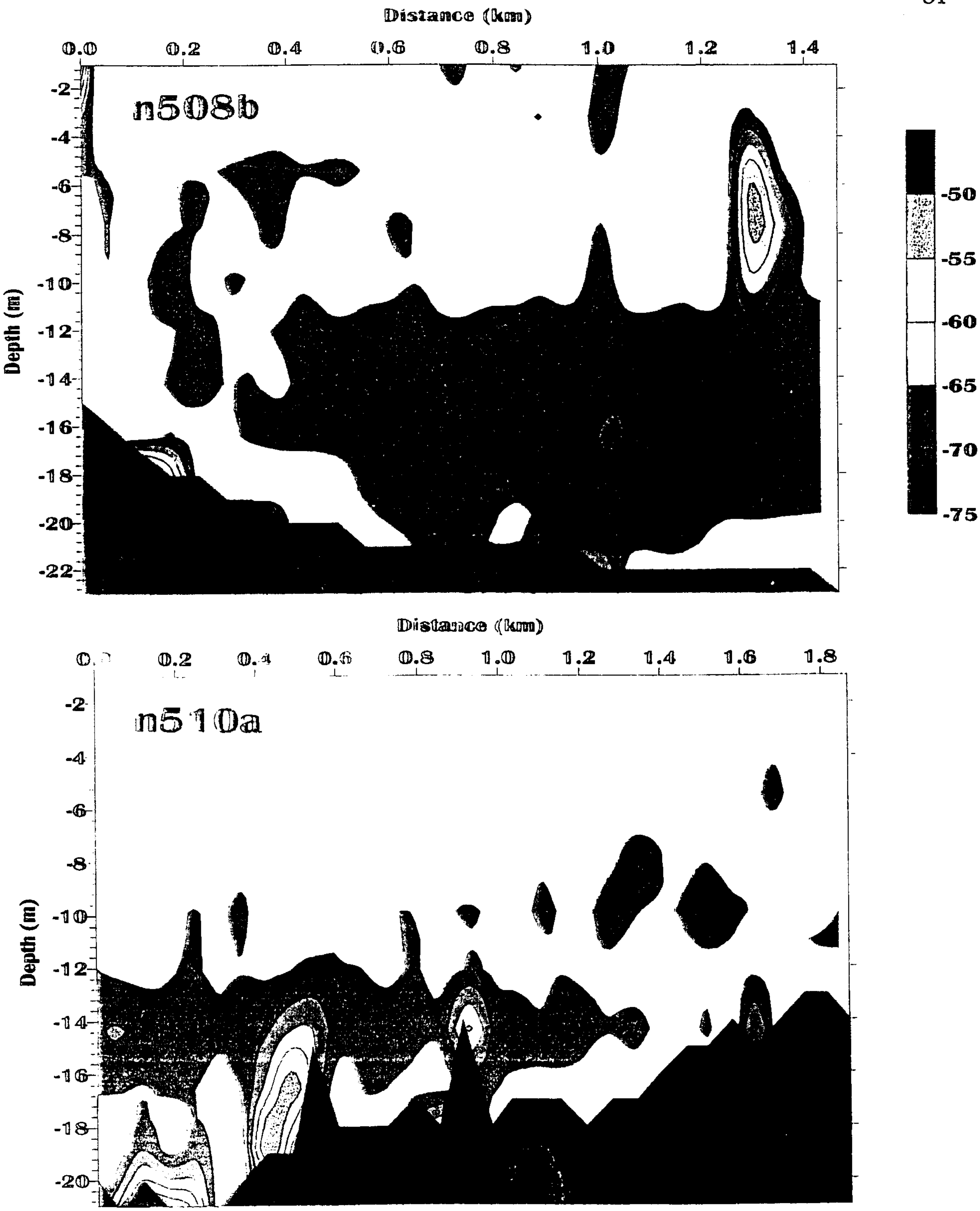


Figure 23. Example of sand lance schools on two nearshore transects (N05-08B, N05-10A) in the North study area.

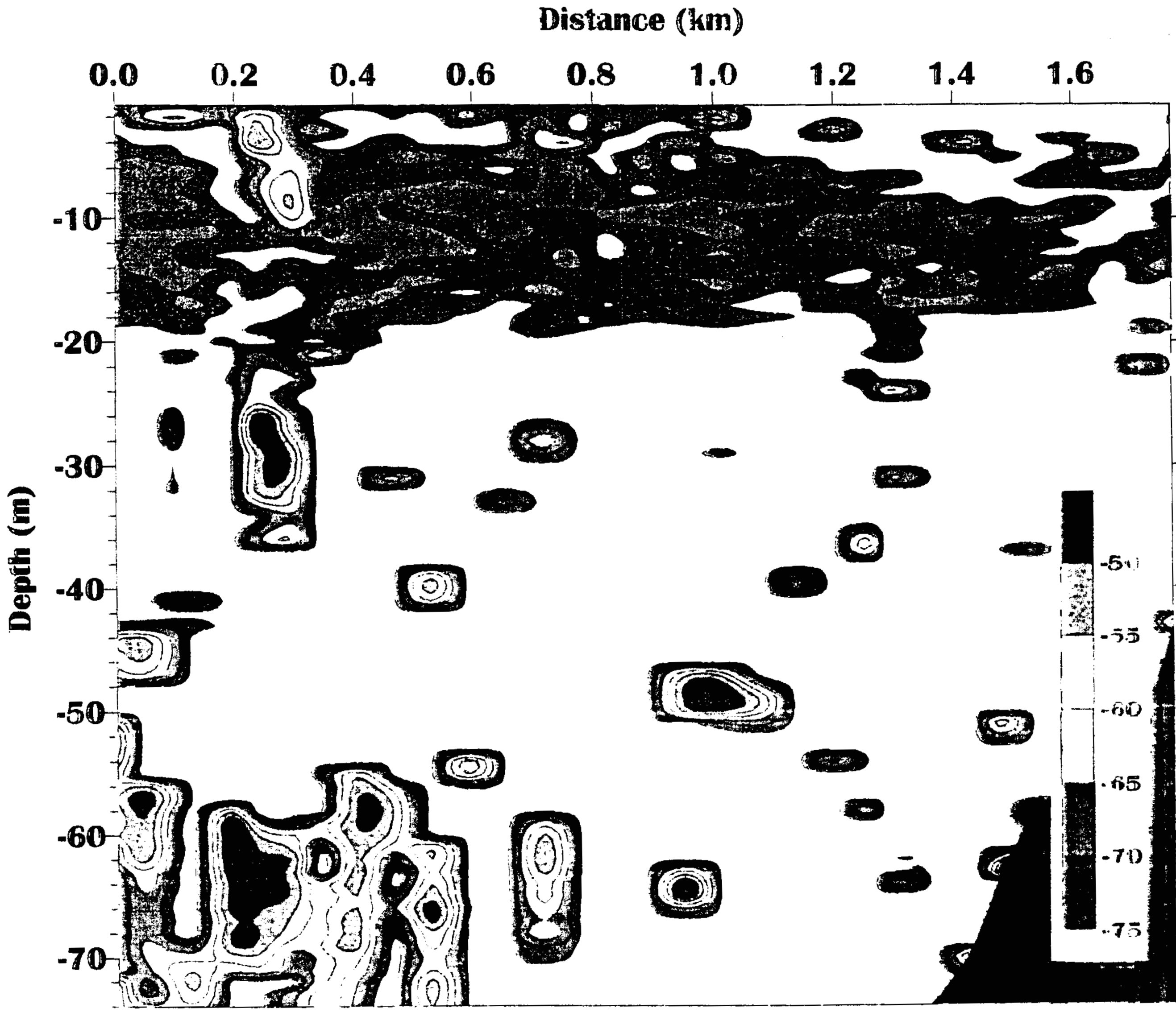


Figure 24. Example of YOY pollock schools on an individual nearshore transect (N10-03A) in the North study area.

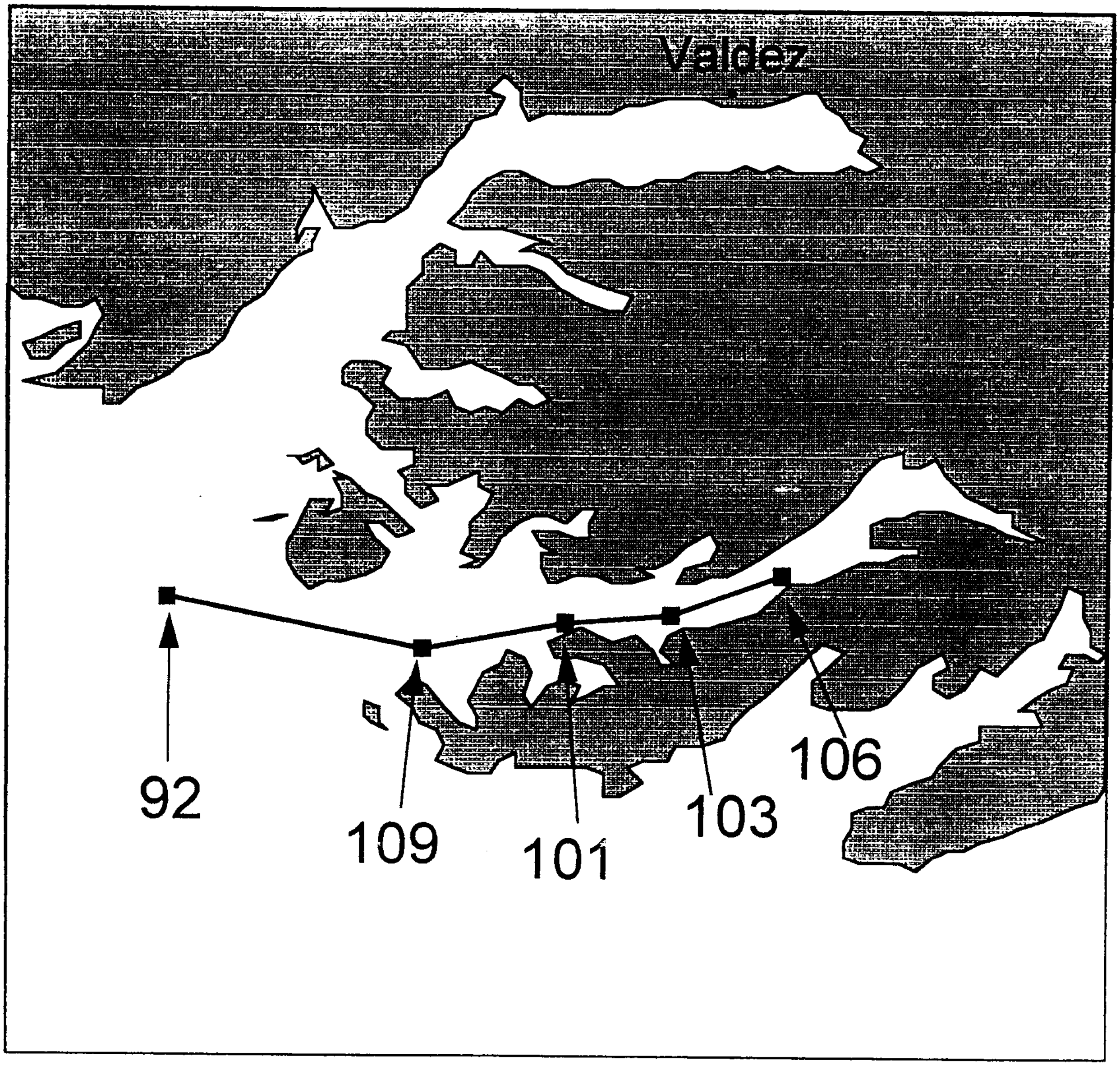


Figure 25. Locations of CTD stations examined for evidence of tidal fronts in nearshore areas of the North study area.

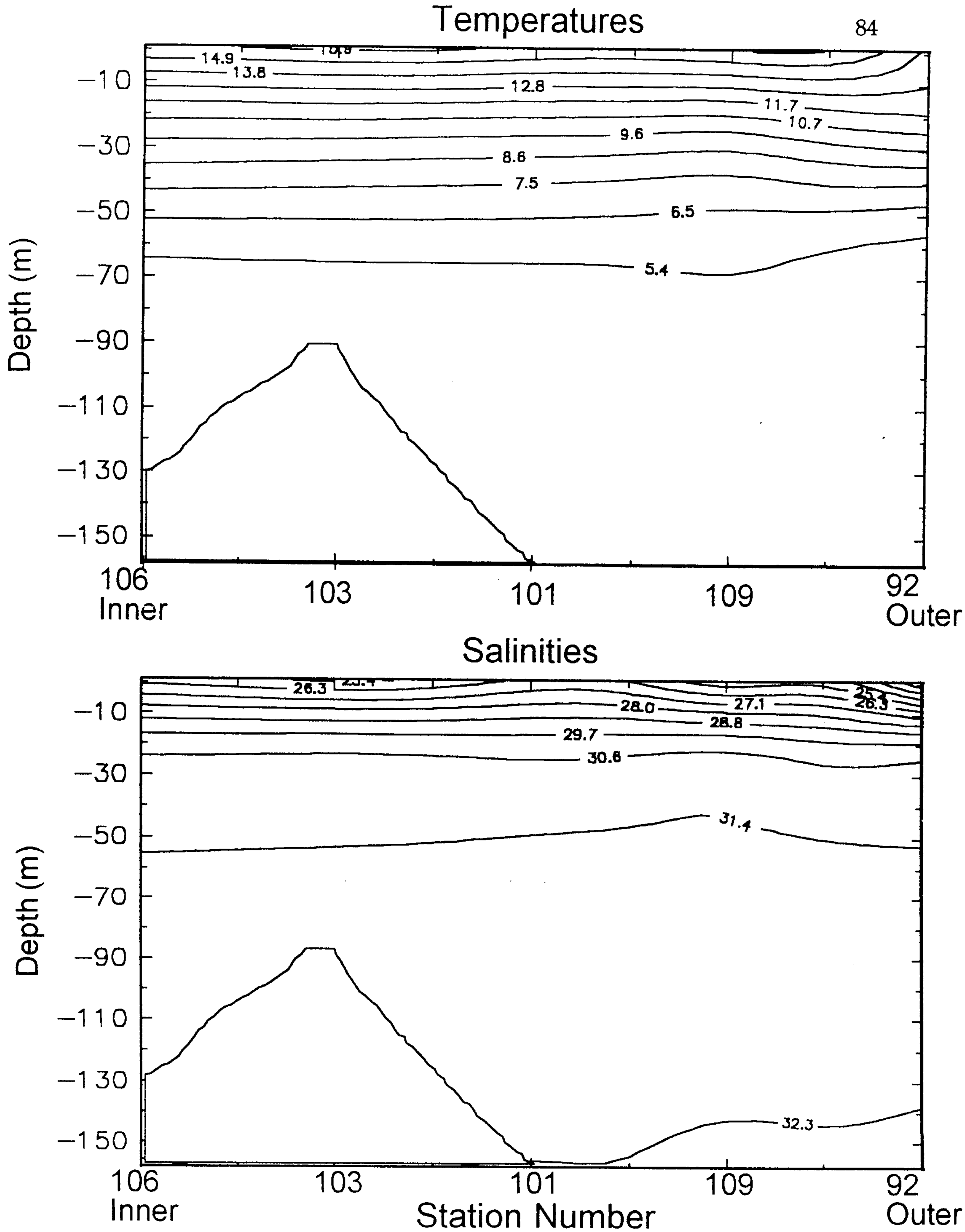


Figure 26. Isotherm and Isohaline profiles along the CTD transect in Port Fidalgo in the Northern study area.

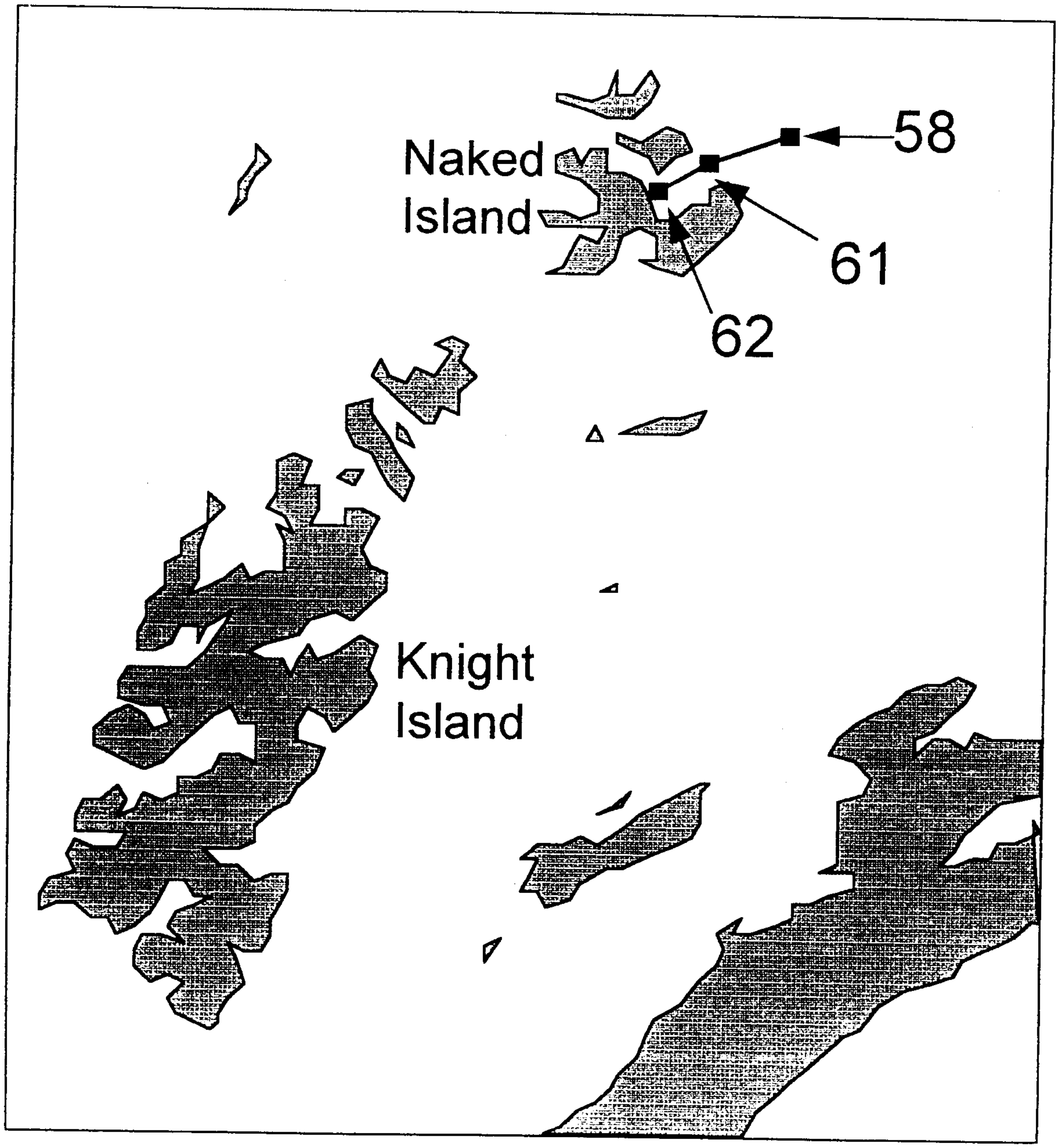


Figure 27. Locations of CTD stations examined for evidence of tidal fronts in nearshore areas of the Central study area.

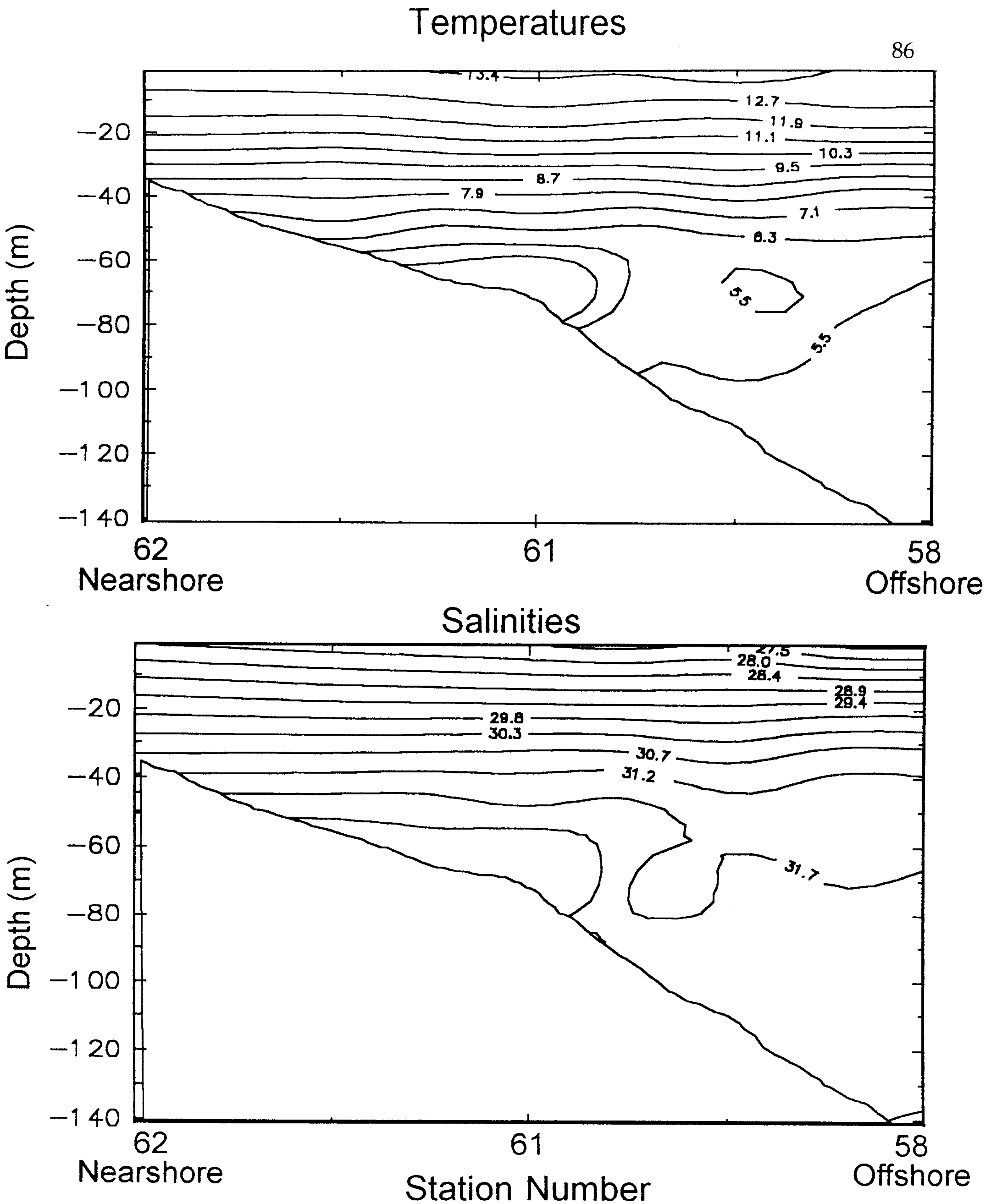


Figure 28. Isotherm and Isohaline profiles along the CTD transect at McPherson Passage in the Central study area.

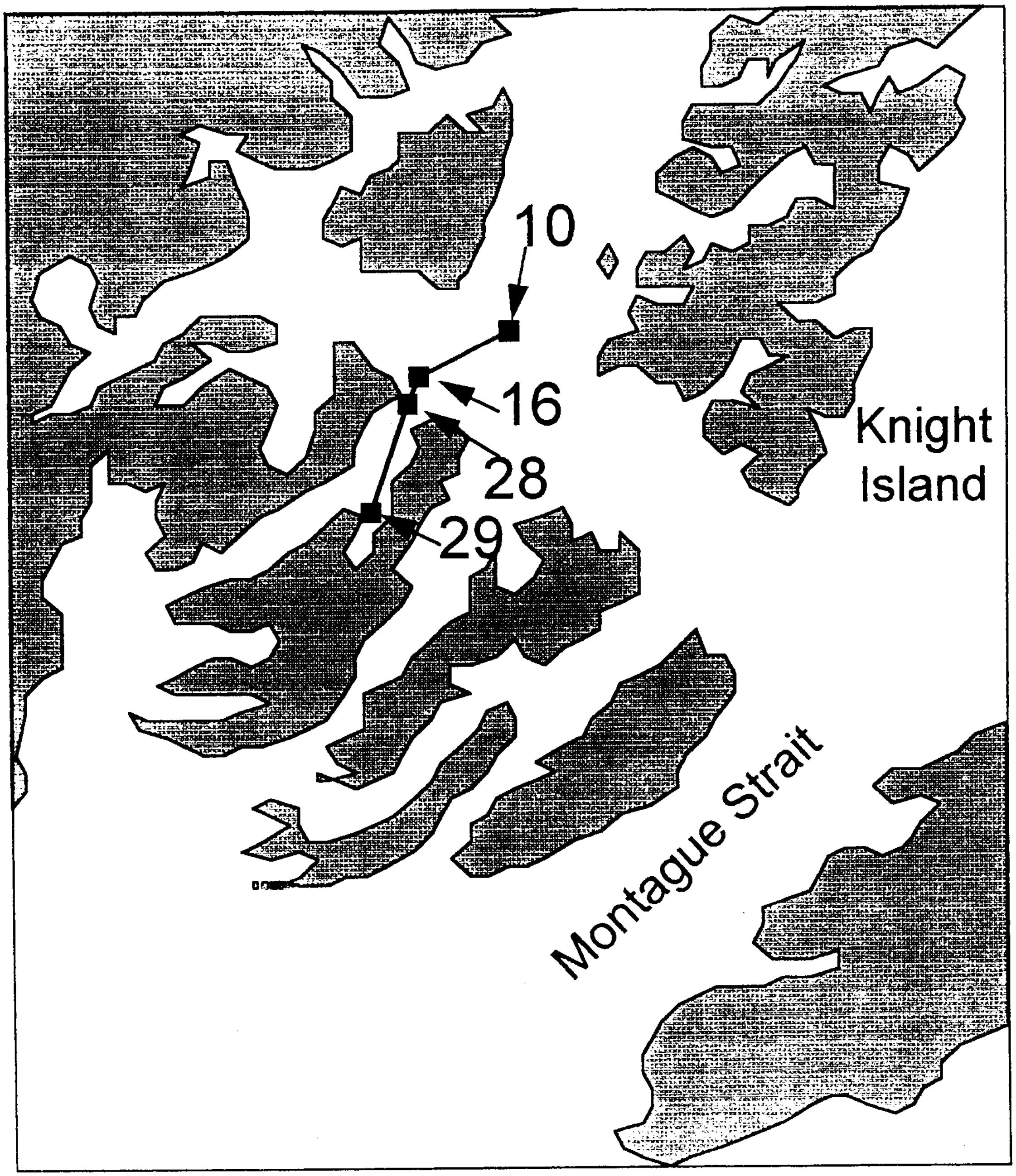


Figure 29. Locations of CTD stations examined for evidence of tidal fronts in nearshore areas of the South study area.

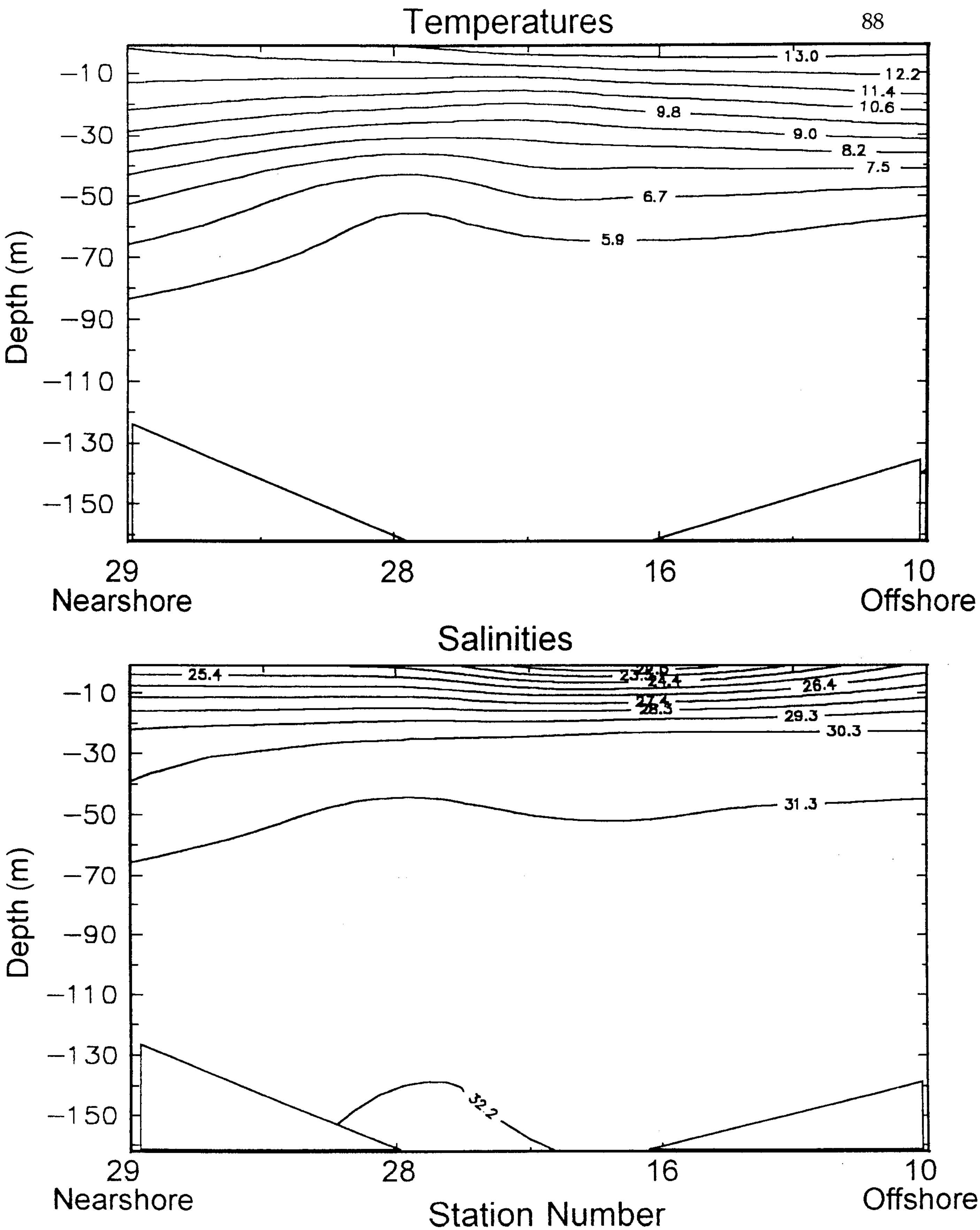


Figure 30. Isotherm and Isohaline profiles along the CTD transect in Bainbridge Passage in the South study area.

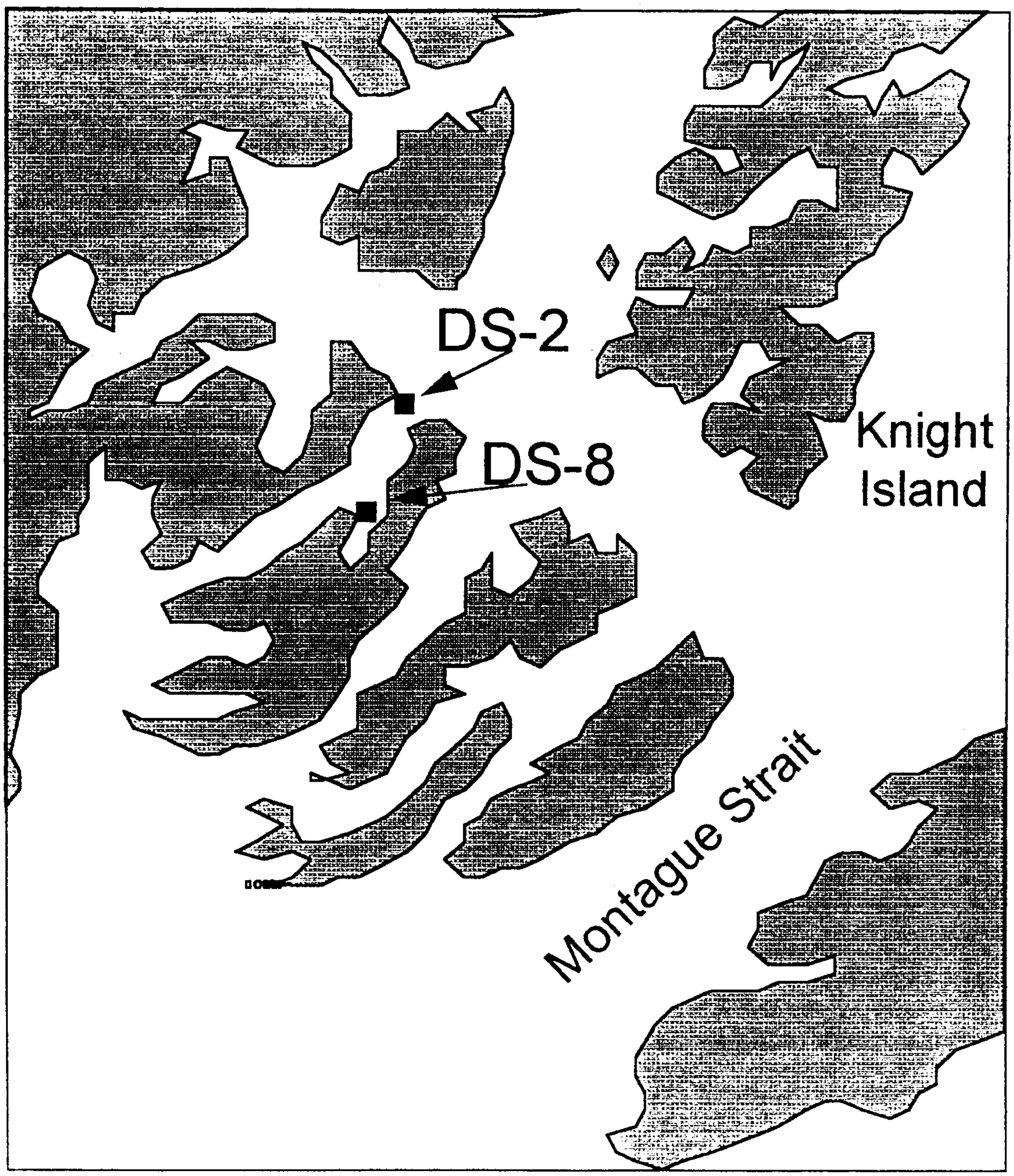
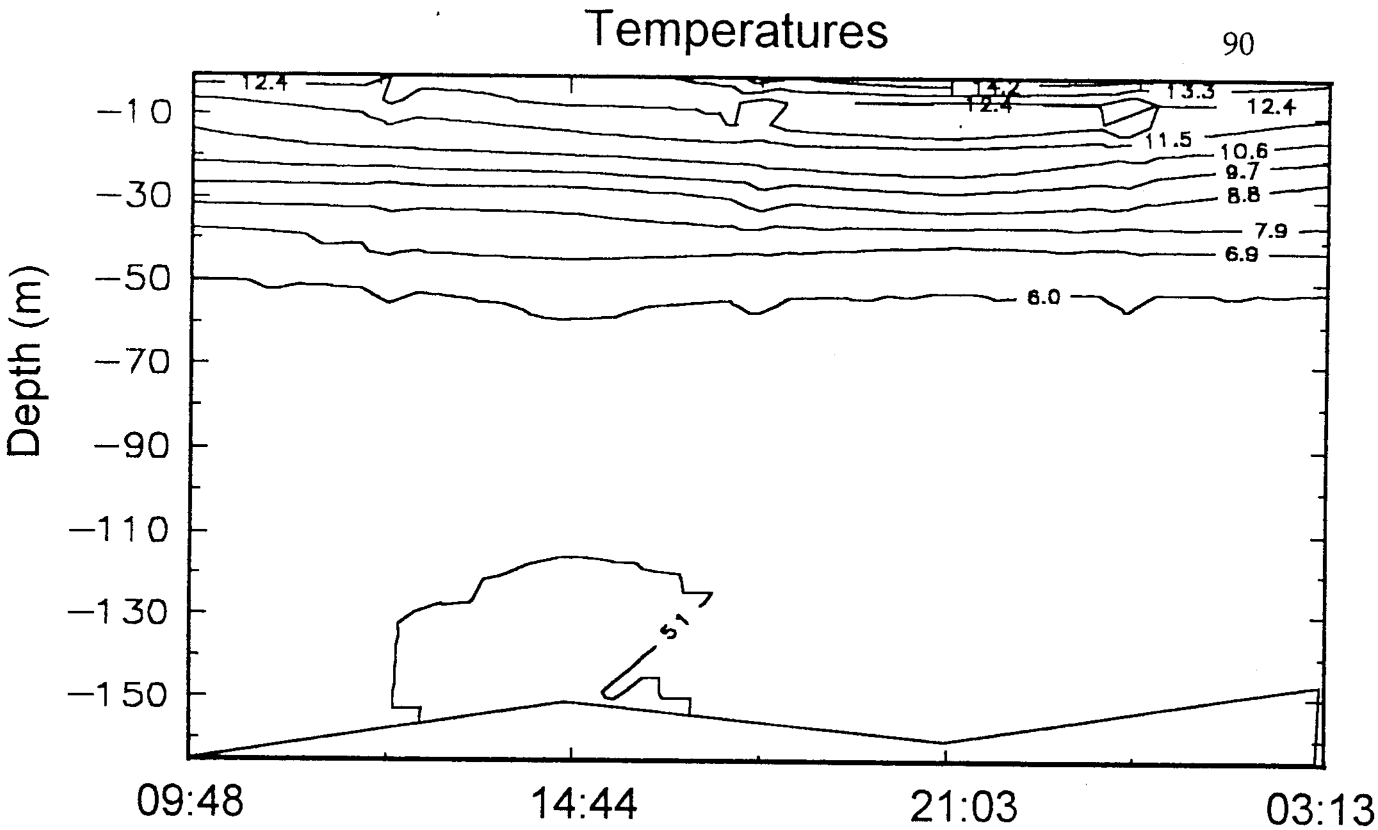


Figure 31. Locations of CTD stations where 24 hour series of temperature and salinity profiles were sampled.



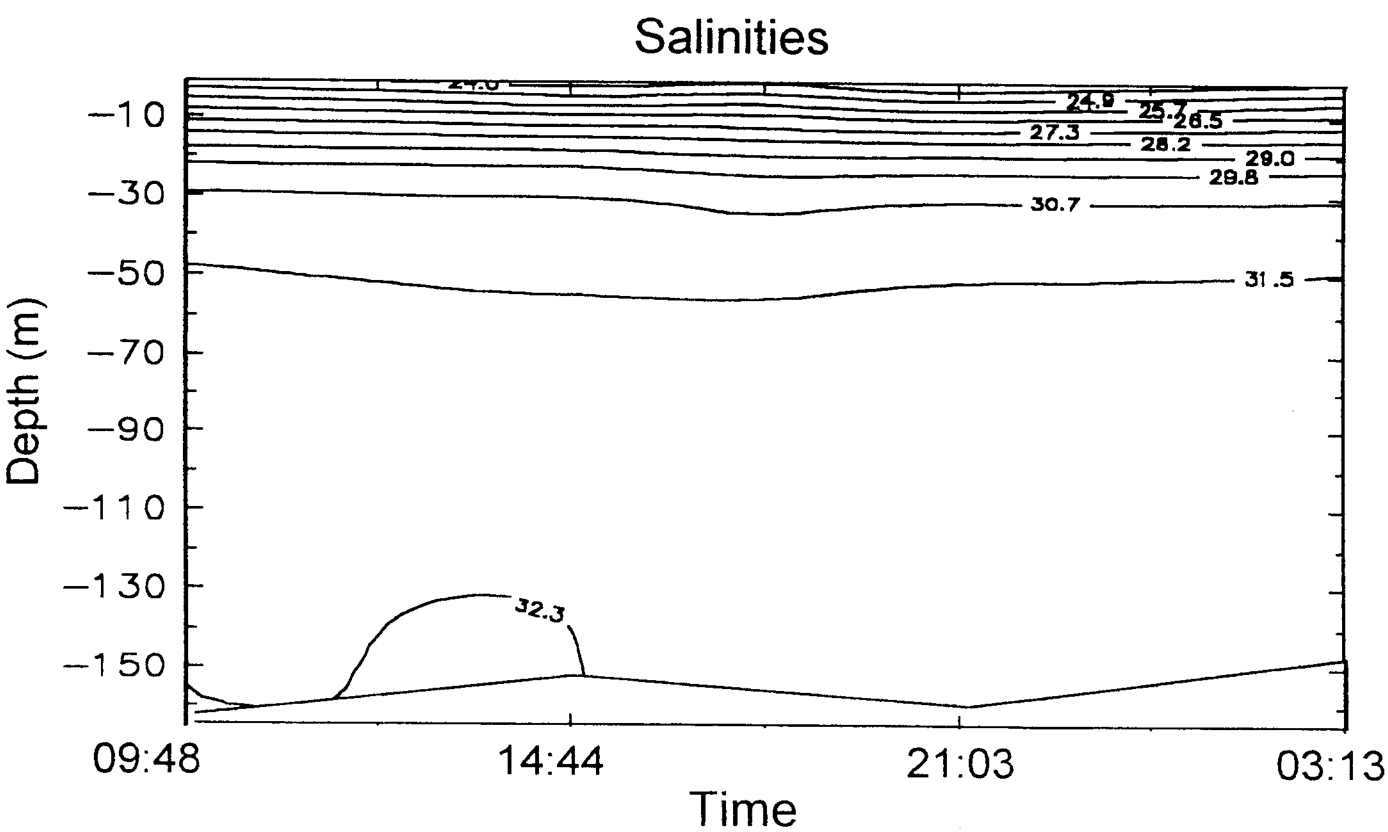


Figure 32. Isotherm and isohaline profiles over 24 hours at station DS 2 in Bainbridge Passage.

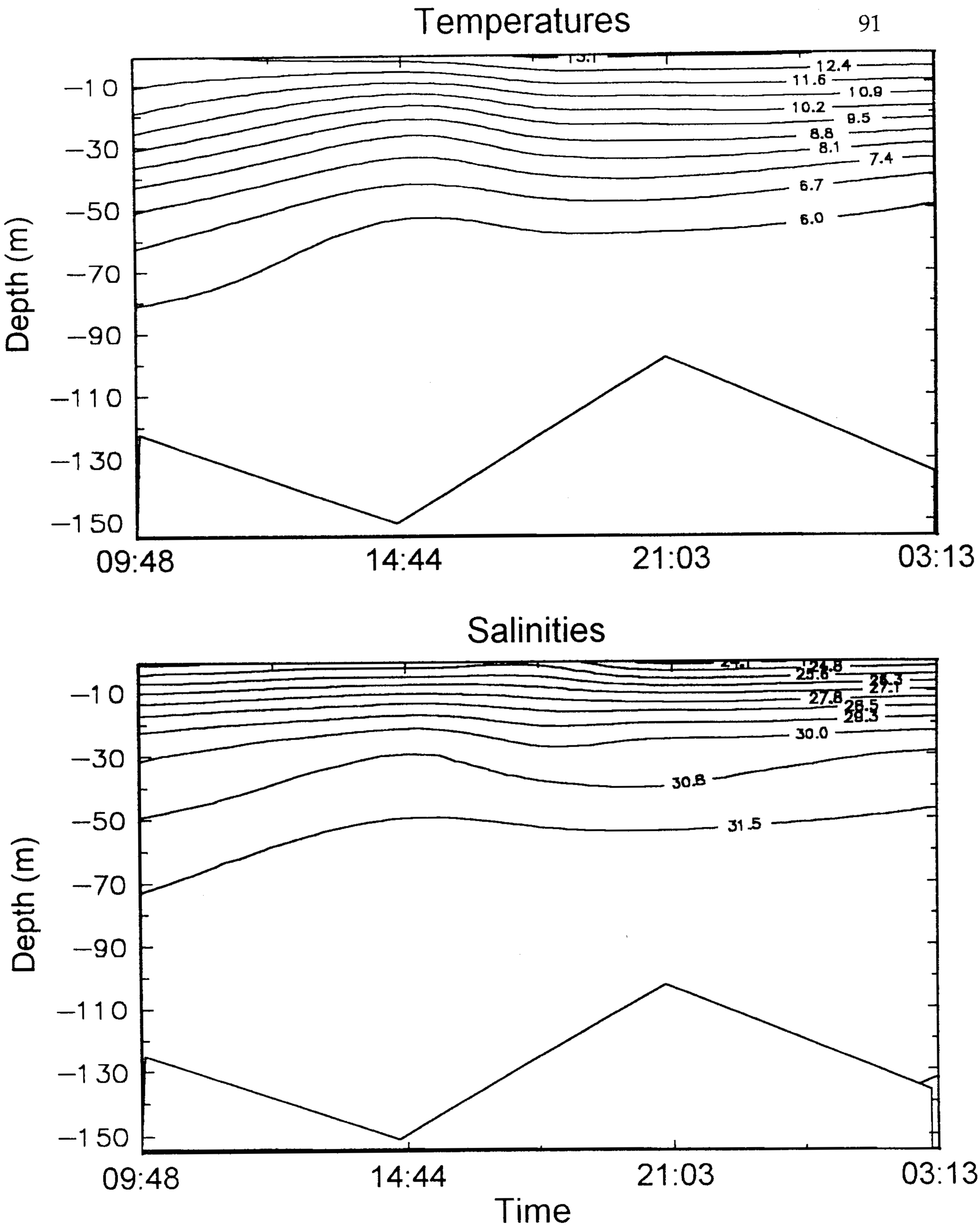


Figure 33. Isotherm and isohaline profiles over 24 hours at station DS 8 in Bainbridge Passage.

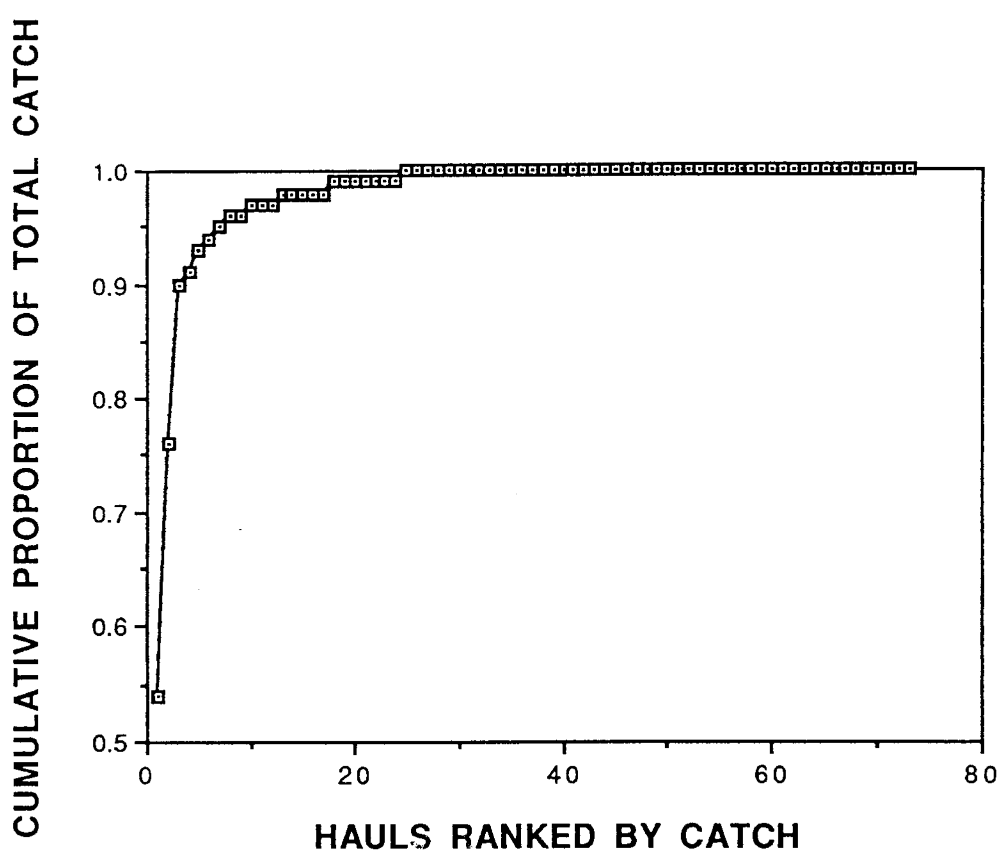


Figure 34. Cumulative frequency distribution of total catch in beach seine samples, ranked by total catch.

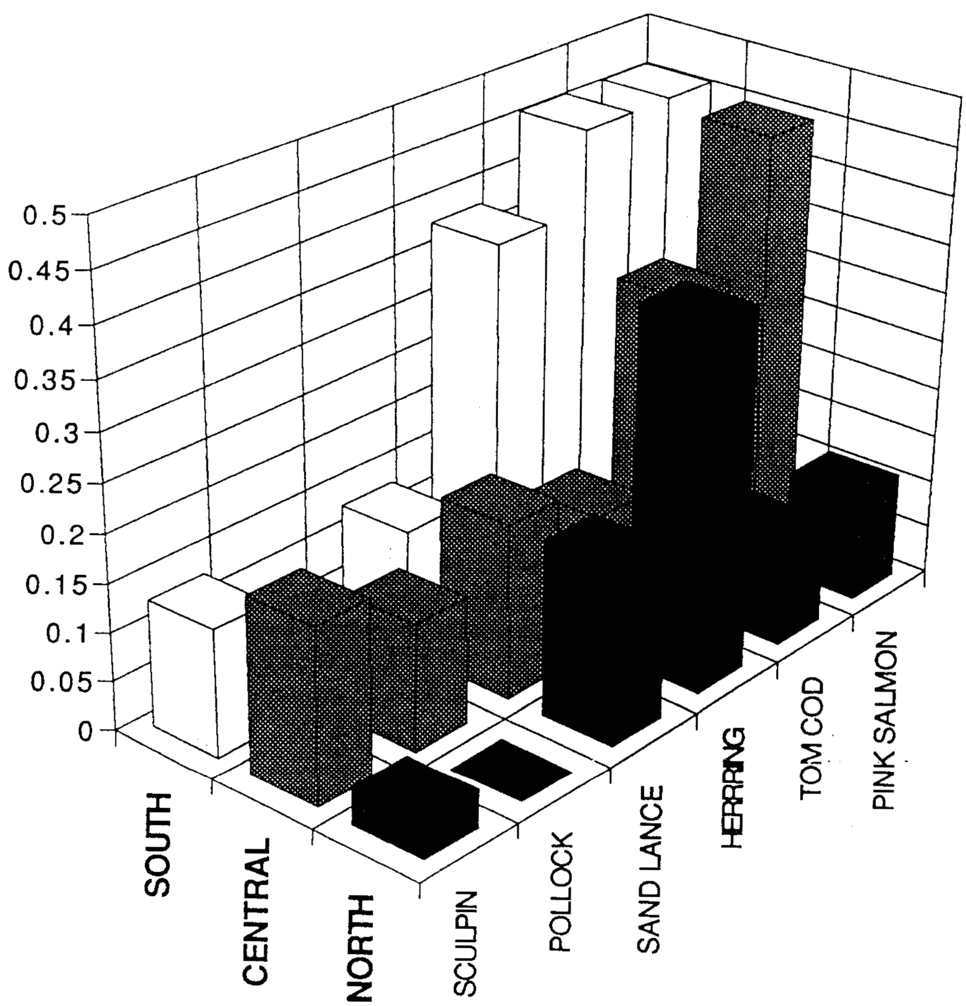


Figure 35. Frequency of occurrence (proportion of samples where a species was present) of most abundant species in beach seine samples from the North, Central and Southern study areas.