Exxon Valdez Oil Spill
Restoration Project Annual Report

Forage Fish Influence on Recovery of Injured Species: Forage Fish Diet Overlap

Restoration Project 94163
Annual Report

This annual report has been prepared for peer review as part of the *Exxon Valdez* Oil Spill Trustee Council restoration program for the purpose of assessing project progress. Peer review comments have not been addressed in this annual report.

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Study History: Restoration Project 94163 was initiated in 1994 to increase our understanding of the causes of recent declines in seabird and marine mammal populations. Marbled murrelets, pigeon guillemots, arctic terns, black-legged kittiwakes and harbor seals were injured by the *Exxon Valdez* oil spill (EVOS). These species have not yet recovered from the EVOS and some are still declining. All these species feed on forage fish. Declining seabird and marine mammal populations indicate that forage fish abundance or species composition may have declined in Prince William Sound during the past 20 years. In 1990, a small pilot study was conducted to begin developing techniques to assess forage fish abundance, species composition, and distribution.

Abstract: Our goal was to estimate the degree of prey resource partitioning among important forage fish species in Prince William Sound (PWS). Juvenile walleye pollock (*Theragra chalcogramma*), Pacific herring (*Clupea harengus pallasi*), pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) were found to be widely distributed in the upper 20 m of the water column in western PWS during sampling period. Principal components analysis identified a prey species complex associated with prey resource partitioning among these species. Two species pairs (juvenile walleye pollock and Pacific herring; juvenile pink and chum salmon) exhibited a relatively high degree of diet overlap within each pair and little overlap between pairs. Schoener's proportional diet similarity index was 33% for Pacific herring and walleye pollock and 25% for pink and chum salmon. Prey resource partitioning was associated largely with differences in the amounts of *Pseudocalanus spp.*, small calanoid copepods, and fish larvae consumed by the species pairs. Juvenile Pacific herring and walleye pollock consumed *Pseudocalanus spp*. and small calanoid copepods; pink and chum salmon consumed fish larvae. Diet composition and overlap among the studied species also changed significantly over a diel period. Juvenile chum salmon preferred gelatinous prey such as ctenophores, cnidaria, and *Oikopleura spp*.

Key Words: *Ammodytes hexapterus*, capelin, chum salmon, *Clupea harengus pallasi*, diet overlap, forage fish, habitat overlap, *Mallotus villosus*, *Oncorhynchus gorbuscha*, *Oncorhynchus keta*, Pacific herring, Pacific sandlance, pink salmon, prey electivity, prey resource partitioning, *Theragra chalcogramma*, walleye pollock.

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Introduction:

This project was designed to estimate the degree of diet overlap among forage fish species in Prince William Sound (PWS). Forage fish are an important food resource for several seabird and mammal species injured by the *Exxon Valdez* Oil Spill (EVOS). Damage assessment studies after the spill documented injury to common murres (*Uria aalge*), marbled *murrelets (Brachyramphus marmoratus)*, pigeon guillemots (*Cepphus columba*) and harbor seals (*Phoca vitulina richardsi*). Reproduction of black-legged kittiwakes (*Rissa tridactyla*) was also apparently affected immediately after the spill and widespread breeding failures have occurred more recently in PWS. All of these species feed largely on pelagic schooling fish (forage fish) such as Pacific herring *(Clupea harengus pallasi*), capelin (*Mallotus villosus*), sandlance (*Ammodytes hexapterus*) and walleye pollock (*Theragra chalcogramma*) (Sanger 1983); although, benthic fish are an important component of the diet of pigeon guillemots (Kuletz 1983). Seabird and mammal species that feed on forage fish have exhibited reductions in population size by more than 50% since the early 1970's. Other seabird and mammal species such as harlequin ducks, black oystercatchers and sea otters that feed on benthic invertebrates have not exhibited population declines throughout PWS. These data suggest that changes in the abundance or availability of forage fish may be linked to declines in seabird and mammal populations.

The reproductive success of several seabird species has been linked to the type of prey delivered to chicks. The reproductive success of several seabird species is greater when sandlance is available (Pearson 1968, Harris and Hislop 1978, Hunt et al. 1980). This may be due to the relatively high lipid content of sandlance compared to other forage fish species (Montevecchi et al. 1984, Barrett et al. 1987, Massias and Becker 1990). In PWS, adult pigeon guillemots delivered substantially fewer sandlance to their chicks in 1994 (8%) compared with 1979 (55%) (Kuletz 1983, Oakley and Kuletz 1993). During this same period, the proportion of the diet comprised of gadids increased from approximately 7% (1979-1981) to about 30% in 1994 (Kuletz 1983, Oakley and Kuletz 1993). Similar patterns observed in other areas of the northern Gulf of Alaska has lead to speculation that the ecosystem has shifted from dominance of pelagic schooling species (e.g. herring, capelin, sandlance) to more demersal species (e.g. Pacific cod, walleye pollock).

Marine ecosystems are characterized by shifts in the dominance of pelagic schooling fish. Dominance shifts between sardine and anchovy have been observed off California (Sharp 1992, Cury et al. 1995), Peru (Pauly and Tsukayama 1987), Japan (Belyaev and Shatilina 1995), and South Africa (Lluch-Belda et al. 1989). In the western English Channel, pilchard replaced herring in the 1930's, and the change was reversed in the 1970's (Cushing 1975). In the Bering Sea, a considerable increase in walleye pollock abundance coincided with a decline in the herring population (Wespestad and Fried 1983). The causes of these dominance shifts is not well understood. In some cases they are associated with broader changes in ocean temperature and the plankton community (Cushing 1975, Hollowed and Wooster 1992). However, excessive fishing mortality or high recruitment may lead to dominance shifts by allowing a competitor to gain a numerical advantage (Rothschild 1986). The abundance of sandlance (*Ammodytes marinus*) increased sharply in the North Sea after overfishing depressed populations of herring and mackerel (Furness 1984). An outbreak of viral hemorrhagic septicemia virus and later *Ichthyophonus hoferi* coincided with a collapse of the herring population in PWS (Marty et al. 1995). Interspecific competition may affect the rate of recovery of the PWS herring population.

Competition often involves use of preferred food resources or habitats. Under foraging theory, prey selection is determined by the relative profitabilities of potential prey (Charnov 1976, Mittelbach 1981, Osenberg and Mittelbach 1989). Profitability is a function of the energy content of prey and the time (energy) required to capture and ingest prey. Similarly, habitat choice is determined by the relative profitability associated with each habitat use; although, excessive predation risk (Dill 1987, Lima and Dill 1990, Milinski 1993) or the presence of a competitor (Crowder and Magnuson 1982, Fausch and White 1986, Persson 1986, Freeman and Stouder 1989, Klemetsen et al. 1989, Taylor 1991) may cause selection of a less profitable habitat. Selection of suboptimal habitats often leads to reduced growth (Sogard 1994).

Competition during critical lifestages (Hjort 1914) likely has the greatest effect on population dynamics. Individuals exhibiting lower growth during critical lifestages have a higher probability of mortality, because membership in vulnerable size classes is prolonged (Parker 1971, Folkvord and Hunter 1986, Post and Evans 1989a, Luecke et al. 1990, Willette 1995). Many co-occurring fish species occupy a common predation refuge during vulnerable early lifestages (Power 1984, Werner 1986).

Prior to the 1970's, our knowledge of the fish communities in the northern Gulf of Alaska and PWS was limited to single species of commercial interest and taxonomic descriptions (Wilimovsky 1954, Hubbard and Reeder 1965, Quast and Hall 1972). The Outer Continental Shelf Environmental Assessment (OCSEAP) program provided funding for much more detailed descriptions of fish communities and ecological analyses in the PWS region (Rosenthal et al. 1982, Rosenthal 1983). These studies documented the spatial and temporal distributions of 72 fish species from 18 families. Fish abundance and species richness were generally low through May and increased steadily until August. The assemblage of pelagic schooling fishes encountered in these surveys was comprised of dusky rockfish (*Sebastes ciliatus*), black rockfish (*Sebastes melanops*), juvenile yellowtail rockfish (*Sebastes flavidus*), Pacific sandlance and Pacific herring. Rosenthal (1983) examined the stomach contents of 486 specimens from 26 species; however, among the pelagic schooling fishes, only dusky rockfish and black rockfish were examined. A high degree of diet overlap was documented among benthic fishes.

Objectives:

This project will achieve the following objectives:

1. Collect samples of forage fish for analysis of stomach contents as well as available prey (zooplankton and epibenthic invertebrates) in three habitat types during four sampling periods (month).

2. Conduct laboratory analyses of fish stomach contents as well as epibenthic invertebrate/zooplankton samples.

3. Test for differences in prey composition and stomach fullness (% body weight) between laboratories.

4. Test for differences in diet overlap among fish species in three habitat types during four sampling periods.

5. Test for prey electivity for each fish species during the August-September sampling period.

6. Conduct diel feeding periodicity study and test for differences in diet overlap among fish species by time of day.

Methods:

Objective 1:

A stratified-random sampling design was employed to estimate diet overlap among forage fish species. Strata were established based upon date (May, June, July, August-September) and habitat type (shallow bay, moderate-slope passage, steep-slope passage). Site was used as the sample unit in the analysis. A randomly selected sample of ten to fifteen individuals (whole fish) were preserved in 10% buffered formaldehyde solution from each species at each site. In cases where distinct size classes occurred within species, samples were preserved from each size class. Size related shifts in diet have been noted in several fish species including Pacific cod (*Gadus macrocephalus*, Livingston 1989) and walleye pollock (*Theragra chalcogramma*, Dwyer et al. 1987).

During May, June and July, the field sampling for this project was conducted as part of the Sound Ecosystem Assessment program (Willette et al. 1995a, Willette et al. 1995b). Fish sampling was conducted within the SEA study area in western PWS (Figure 1). In nearshore habitats and shallow bays, fish were collected with (1) a small-mesh purse seine (70 m long x 10 m deep, 0.5 cm stretch mesh) deployed from a 6 m long aluminum skiff or (2) an anchovy seine (240 m long x 20 m deep, 1.5 cm stretch mesh) deployed from a chartered purse seine vessel. An approximately 25 m long vessel provided logistical support for the skiff crew. In shallow nearshore habitats, fish schools were located from visual surveys along the shoreline. An approximately 30 m trawl vessel sampled fish in offshore areas using a 40 m x 28 m mid-water wing trawl equipped with a net sounder . The cod end of the trawl was lined with approximately 1.5 cm stretch-mesh web to retain small specimens. During August and September, fish samples were collected at 17 sites in western PWS with an anchovy seine (240 m long x 20 m deep, 1.5 cm stretch mesh) deployed from a chartered purse seine vessel. This sampling trip was conducted between August 27 and September 7, 1994.

During August and September, quantitative zooplankton and epibenthic invertebrate samples were collected at each site to evaluate prey electivity. Replicate zooplankton samples were collected with a ring-net (0.5 m diameter, 102 micron mesh) towed vertically from 25 m depth to the surface. Replicate samples were combined in a single sample bottle and preserved in 10% buffered formaldehyde solution. Epibenthic prey were sampled with a pump at 5, 12, and 20 m by SCUBA divers at each site. The pump was operated for 120-140 seconds at each depth. The flow rate produced by the pump ranged from .0012 to .0124 m^3 per second. The water stream from the pump was passed through a ring net (102 micron mesh) to retain prey animals. Epibenthic invertebrate samples from all three depths were combined in a single sample bottle and preserved in 10% buffered formaldehyde solution.

Objective 2:

Forage fish stomach samples and prey samples (zooplankton/epibenthic invertebrates) collected by the Alaska Department of Fish and Game were jointly analyzed at (1) the National Marine Fisheries Service Auke Bay Laboratory (under the direction of Molly Sturdevant) and (2) the University of Alaska Fairbanks, Institute of Marine Science (under the direction of Stephen Jewett). At the laboratory, samples were allowed to remain in formaldehyde solution for a minimum of 20 days to stabilize shrinkage. They were then transferred to 50% isopropanol for preservation.

Stomach contents were examined after fish samples had been in 50% isopropanol for a minimum
of 10 days. Specimens were selected using a random number table. Each laboratory processed 5 fish in good condition per species per site. Extra fish remaining in the set were saved in 50% isopropanol in the original sample bottle. Length and weight was measured for fish that were not processed for stomach analysis. Whole fish were blotted dry, weighed to the nearest 0.01 g and measured (standard fork length) to the nearest 0.5 mm. Fish showing evidence of regurgitation (gaping mouths and/or prey regurgitated into the fixative solution) were not analyzed. Fish stomachs were excised from the body cavity (this included the region from the pharynx immediately behind the gills to the pylorus). The foregut was blotted dry and weighed full to an accuracy of 1.0 mg, the contents were removed, and the stomach lining was blotted and weighed again. Total stomach contents wet weight was estimated by subtraction. Stomach fullness and prey digestion were visually assessed and semiquantitative

index values were recorded. Relative fullness was coded as: 1=empty, 2=trace, 3=25%, 4=50%, 5=75%, 6=100% full, 7=distended, to provide an index of the amount of food consumed relative to the fish's stomach size. The state of digestion was coded as: 1=partially digested, 2=mostly digested, 3=stomach empty. The digestion index indicated how recently the fish ate as well as general prey condition, which also reflects the level of identification possible.

Prey items in the gut were completely teased apart and identified to the lowest possible taxonomic level and enumerated. Efforts were concentrated on identifying copepods to examine prey selection by genus or species, sex and life history stage, and within large (> 2.5 mm total length) and small (< 2.5 mm total length) copepod size groups (Sturdevant et al 1995). Where possible, partially digested large copepods which could not be completely identified were distinguished as pristane-manufacturing species (*Neocalanus spp.*, *Calanus spp.*; personal communication, J. Short, Auke Bay Laboratory) or non-pristane-manufacturing species (e.g., *Metridia spp.*, *Epilabidocera longipedata*). A prey species code list was developed during the project and linked to the National Oceanographic Data Center's (NODC) numeric taxonomic code for archiving. Standard subsampling techniques were employed when stomachs were so large and/or full that counting every prey item was not practical. The protocol for subsampling stomach contents was patterned after general methods (Kask and Sibert 1976), and included consideration of qualities such as content mushiness and oiliness. Individual prey codes and the number counted or estimated by subsampling were recorded for each fish specimen. The processed gut contents from each fish specimen were placed in separate, labeled vials containing 50% isopropanol.

Three primary techniques were used to ensure quality assessment/quality control between laboratories. Each laboratory built a voucher collection (preserved in 50% isopropanol) composed of specimens from important taxonomic groups. These were used for reference and training purposes at the respective laboratories. A joint training workshop was held at the University of Alaska-Fairbanks in September, 1994 to confirm prey identifications and address any discepancies. Continual dialog by telephone allowed information sharing. After the first batch of samples was completely processed, the laboratories exchanged a subsample (n=20) of stomach contents from their collections, examined those from the alternate laboratory, then discussed differences and corrected any discrepancies.

The composition of available prey resources was estimated from laboratory analyses of ring net and epibenthic pump samples. Prey resource samples were first scanned whole in a dissecting tray under a magnifying lamp for removal of large or rare organisms. Epibenthic samples including large amounts of debris were washed through a large mesh net to separate algae and detritus from finer material containing prey organisms. A Hansen-stempel pipette (1, 5, or 10 ml capacity) and Folsom plankton splitter were then used to collect random subsamples of prey resources from each sample. Samples were diluted to achieve < 200 of the dominant taxon or a total count of 300 organisms. Zooplankton and epibenthic invertebrates were identified to the lowest practical taxon and enumerated in each subsample.

Total abundance of organisms in each sample was estimated as the product of the subsample count and the volume fraction analyzed. Total biomass in each taxonomic group was estimated by the product of average body blotted-dry weight and abundance. As with prey organisms observed in the stomachs, literature values for average blotted-dry wet weight of each species or developmental stage were used when available. When literature values were not available, specimens were segregated from the rest of the sample material and pooled to generate mean weights of prey categories. The mean blotted-dry wet weight was determined by weighing a sample of at least 50 intact specimens.

Objective 3:

A subsample of each forage species/size-class from each site ($n \geq 5$ fish) were sent to each of the two laboratories for analysis of stomach contents. A Paired-t statistic was used to test for differences between laboratories in the measurement of abundance and biomass in each prey category as well as fish stomach fullness (% body weight). A multivariate analysis of variance (MANOVA) statistic was used to test for no overall laboratory effect on the diet composition estimate of each forage fish species at each site.

Objective 4:

This report primarily describes results from the August-September sampling period. The August-September sampling trip was focused only on collection of samples for project 94163; whereas, sampling during May-July was conducted opportunistically as part of the SEA program. In addition, quantitative zooplankton and epibenthic invertebrate samples were collected only during the August-September sampling period for analysis of prey electivity. As a result, the samples obtained during this late summer period provide for analyses that will not be possible for the May-July period.

A summary of the diet of each of the seven fish species captured in August-September was prepared by summing total prey biomass over broad taxonomic groups (i.e. amphipods, euphausiids, larvaceans, etc.). Diet composition was expressed as a proportion of total prey biomass for each taxonomic group. Prey taxa that comprised less than 1% of total biomass were pooled into a general category called 'other'. Pie diagrams were prepared for each fish species.

Principal components analysis was used to describe common modes of variability in the diet composition of all fish species collected during August-September, 1994 (Gauch 1982). The dependent variables in the analysis were the mean proportion of total stomach biomass in each prey taxonomic group for each fish species and site. Data were only used for fish species with a minimum sample size of five at each site. The principal components were derived from the covariance matrix of the prey diet data. The sampling errors associated with each principal component were estimated as described by North et al. (1982) assuming independence among sites.

Analyses of variance (ANOVA) were conducted to test for differences in diet composition among fish species. Separate ANOVA's were conducted using the scores from each significant principal component as the dependent variable. Site was used as a block effect in each ANOVA with fish species as a class variable. Pairwise comparisons were used to test for differences in diet composition between specific fish species. Hierarchical agglomerative cluster analysis (Euclidean metric, complete linkage) was used to classify fish species by diet composition and to indicate the degree of similarity or dissimilarity between species (Gauch 1982).

Schoener's (1968) similarity index was used to describe the degree of diet overlap between pairs of fish species, i.e.

$$D = 1 - \frac{1}{2}\sum_{i=1}^{n}|p_i - q_i| \qquad (1)$$

where p_i is the proportion of total biomass in prey taxon i in fish species 1 and q_i is the proportion of total biomass in prey taxon i in fish species 2. The Schoener's similarity index (D) ranges from 0 to 1, representing no and complete diet overlap, respectively. Site was used as the sample unit in the analysis.

Objective 5:

Prey selection was investigated using Ivlev's (1961) electivity index (E) defined as $E_i = (r_i - p_i)/(r_i + p_i)$, where r_i is the relative abundance of prey taxon i in the fishes' diet and p_i is the relative abundance of prey taxon i in each zooplankton or epibenthic pump sample. Site was used as the sample unit in the analysis. The mean E_i was estimated for all sites, and the student's t-statistic was used to test whether the mean E_i was different from zero. Separate analyses were conducted using data from zooplankton and epibenthic pump samples collected at each site. Summary tables were prepared indicating prey organisms that occurred in fish stomach contents at frequencies significantly ($P \leq .01$) greater than (preference) or less than (avoidance) in zooplankton ring net or epibenthic pump samples, respectively. Only prey species that occurred in both prey samples and stomachs contents were included in the summary tables.

Objective 6:

Diel changes in diet composition and diet overlap were evaluated from fish samples collected at Iktua Bay (shallow bay habitat) in southwest PWS during early September. Samples were collected every four hours over a twenty-four hour period. A randomly selected sample of ten to fifteen individuals (whole fish) were preserved in 10% buffered formaldehyde solution from each species at each sampling time during the diel study. Samples were processed as described in objective 2.

Principal components analysis was used to describe common modes of variability in the diet composition of all fish species combined (Gauch 1982). The dependent variables in the analysis were the proportion of total stomach biomass in each prey taxonomic group for each fish specimen. ANOVA was used to test for diel changes in diet overlap among fish species. Separate ANOVA's were conducted using the scores from each significant principal component as the dependent variable. A factorial model (with interaction) was used with fish species and time of day as class variables.

Results:

Objective 1:

With the exception of juvenile salmon, fish catches in nearshore habitats increased considerably from May to June in western PWS (Table 1). Mean lengths for all species combined ranged from 32.0 - 212.0 mm during during the May to August sampling period (Table 2). Walleye pollock, Pacific herring, pink salmon and chum salmon dominated net catches during the August-September period. The spatial distribution of net catches for these four species is summarized in Figure 2.

Objective 2:

Stomach contents analyses have been completed for 2,298 specimens from 11 fish species (Table 3). In addition, all zooplankton (22) and epibenthic invertebrate (24) samples collected during the August-September period have been analyzed.

Objective 3:

This objective will be addressed in 1995.

Objective 4:

Mean stomach fullness of all fish specimens processed to date is summarized in Table 4. No prey category contributed more than 45% of total prey biomass for any fish species. Euphausiids contributed approximately 39% of the diet of Pacific cod and sandlance, but only 16-24% of the diet of walleye pollock, chum salmon and Pacific herring (Figure 3). Teleost prey contributed 29-45% of total prey biomass among tomcod, pink and chum salmon but was a minor component of the diet of walleye pollock, Pacific herring and sandlance. Hyperiid amphipods and gastropods generally contributed less than 10% to fish diets; however, *Limacina helicina* and unidentified benthic gastropods contributed 16% to the diet of tomcod. Large calanoid copepods comprised 30-39% to total prey biomass among Pacific herring, sandlance, and salmon. Small copepods comprised 38% of the diet of walleye pollock and only 16-20% of the diet of Pacific herring and sandlance.

Principal components analysis of the fish diet composition data from the August-September sampling period indicated two significant ($\alpha = .1000$) principal components (Figure 4). The first principal component described 15% of the total variance in the diet composition data. Examination of the component loadings (eigenvectors) indicated that the first principal component largely described variability in fish larvae, small calanoid copepods (<2.5 mm), and *Pseudocalanus spp*. (Table 5). The second principal component described 11% of the total variance in the diet composition data. Examination of these component loadings indicated that the second principal component largely described variability in large calanoid copepods (>2.5 mm), fish larvae, *Pseudocalanus spp.*, small calanoid copepods (<2.5 mm), and malacostraca (Table 6). Results from ANOVA indicated that the scores from the first principal component were significantly different among fish species ($P < .0001$). Pairwise comparisons between fish species indicated that the diets of pink salmon and chum salmon were signficantly different from Pacific herring and walleye pollock (Table 7). The scores from the second principal component were not significantly different among fish species ($P = .1421$).

Diets of walleye pollock, Pacific herring, pink salmon and chum salmon were further examined to characterize the nature of the diet overlap among these species. Results from a cluster analysis indicated the greatest diet similiarity between Pacific herring and walleye pollock and between pink and chum salmon (Figure 5). Schoener's similarity indices also indicated a relatively high diet overlap between Pacific herring and walleye pollock (33%) and between pink and chum salmon (25%) compared to the other species pairs (Table 8). Mean diet proportions for all sites combined indicated that pink and chum salmon consumed relatively large quantities of fish larvae compared to Pacific herring and walleye pollock; whereas, Pacific herring and walleye pollock consumed relatively large quantities of small calanoid copepods (<2.5 mm) and *Pseudocalanus spp*. compared with pink and chum salmon (Table 9).

Objective 5:

Prey electivity indices indicated that Pacific herring is a more selective predator than walleye pollock, pink salmon or chum salmon. The number of prey organisms preferred and avoided was generally greater for Pacific herring than the other fish species (Tables 10-13). Pacific herring tended to prefer small copepods (2.5mm) as well as relatively large copepods such as *Epilabidocera longipedata*, *Metridia pacifica,* and *Calanus pacificus*. Pacific herring avoided copepod nauplii, cnidaria and harpacticoid copepods. Walleye pollock tended to prefer relatively small copepods such as *Pseudocalanus spp*. but avoid copepod nauplii. Pink salmon preferred *Metridia pacifica* and *Oikopleura spp*. and avoided early developmental stages of euphausiids. Chum salmon tended to prefer gelatinous organisms such as ctenophores, cnidaria, and *Oikopleura spp.*, but avoided small copepods such as *Acartia longerimis* and *Pseudocalanus spp*. All prey electivity indices are summarized in Appendices I and II.

Objective 6:

Results from a diel feeding study indicated a pattern of diet overlap among walleye pollock, Pacific herring, chum salmon and pink salmon similar to that described in objective 4. Principal components analysis of the fish diet composition data from diel study indicated two significant ($\alpha = .1000$) principal components (Figure 6). The first principal component described 15% of the total variance in the diet composition data. Examination of the component loadings (eigenvectors) indicated that the first principal component largely described variability in fish larvae, small calanoid copepods (<2.5 mm), *Pseudocalanus spp.*, euphausiids, *and Oikopleura spp.* (Table 14). The second principal component described 10% of the total variance in the diet composition data. Examination of these component loadings indicated that the second principal component largely described variability in *Oikopleura spp.*, malacostraca, *Pseudocalanus spp.*, and *Epilabidocera longipedata* (Table 15). Results from ANOVA indicated that the scores from the first principal component were significantly different among fish species ($P < .0001$) and time periods ($P = .0214$). The interaction term in the model was marginally significant at $P = .0947$. Pairwise comparisons between fish species indicated that the diets of pink salmon and chum salmon were signficantly different from Pacific herring and walleye pollock. Changes in the mean principal component scores over the diel study indicated that the diet of Pacific herring was strongly associated with the prey species complex described by the first principal component in the afternoon (Figure 7). This association decreased in the evening as light levels declined (2000 hours). Diet overlap between walleye pollock and Pacific herring and between pink and chum salmon was greatest in the early morning (0400 hours) immediately after the darkest period of the study. The scores from the second principal component were not significantly different among fish species ($P = .5935$) or time periods ($P = .1263$).

Discussion:

Catches of pelagic schooling fishes increased considerably from May to June in nearshore habitats in western PWS. A similar seasonal increase in abundance was observed among benthic nearshore fishes in western PWS during April to July, 1994 (Willette et al. 1995a, Willette et al. 1995b). Rosenthal (1983) also observed a seasonal increase in the abundance of nearshore fishes in PWS, and similar patterns have been observed in other areas of the North Pacific (Simenstad et al. 1977, Moulton 1977, Miller et al. 1976, Cross et al. 1978, Rosenthal and Lees 1979). Simenstad et al. (1977) postulated that winter movements of nearshore fishes to deeper habitats may be related to wave action nearshore or food abundance. Rosenthal (1983) observed a marked decline in the abundance of food for nearshore fishes in PWS during autumn. Temperature may affect the timing of inshore movements of fish in the spring. Salmon et al. (1995) documented the occurrence of a temperature minimum layer in PWS at approximately 75 m. This temperature minimum layer may act as a barrier to inshore movements of fish in the spring.

The relatively high diet overlap between walleye pollock and Pacific herring and between pink and chum salmon indicates that competition for limited food resources may occur within these species pairs. The competitive interaction between pollock and herring appears to center around *Pseudocalanus spp.* which was an important prey item for both species. The proportion of the diet comprised of *Pseudocalanus spp.* was only 10% and 15% for herring and pollock, respectively. However, it is likely that many of the organisms in the 'small calanoid copepod' category were *Pseudocalanus spp.* that were too digested to identify. If this is true, the diet proportions for *Pseudocalanus spp.* approach 30%. This is approximately the proportional diet similarity observed between pollock and herring (Table 8). Several studies from various parts of the world have documented the apparent preference for *Pseudocalanus spp.* among walleye pollock (Kamba 1977, Cooney et al. 1980, Lee 1985, Grover 1990, Grover 1991) and Pacific herring (Karaseva 1982, Hinrichs 1985, Evtyukhova et al. 1986).

Competition between pollock and herring may affect the growth and survival of juvenile herring. Herring growth (size at age) in the Baltic Sea was density dependent and related to the abundance of *Pseudocalanus spp.* (Evtyukhova et al. 1986). However, growth of juvenile herring in the Riga Gulf was dependent on zooplankton productivity and not temperature or the biomass of competitors (Kostrichkina and Oyaveer 1982). Reduced growth of juvenile herring may lead to poor overwinter survival because the fish do not have sufficient energy reserves to survive until spring. Overwinter survival is typically size dependent (Shuter et al. 1980, Post and Evans 1989b). Smaller fish are expected to have a higher overwinter mortality, because their energy reserves are relatively low and their metabolic rate is relatively high (Paloheimo and Dickie 1966, Brett et al. 1969, Brett and Glass 1973). The magnitude of energy reserves at the onset of winter and winter temperature largely determine the length of time elapsed before starvation and death occur (Shuter et al. 1980). An apparent inverse relationship between the abundance of herring and pollock in the Bering Sea suggests a competitive interaction between these species (Wespestad and Fried 1983). Predation by pollock on herring may be a factor in this interaction (Laevastu and Favorite 1978); however, results from the present study suggest that competition for food among juveniles may also be important.

Similarity between the diets of pink and chum salmon has been documented at other lifestages. During the fry stage (< 60 mm), both species have been found to consume harpacticoid copepods, calanoid copepods, amphipods, euphausiids, chaetognaths, and fish larvae (LeBrasseur and Barner 1964, Birman 1969, Andrievskaya 1970, Okada and Taniguchi 1971, Healey 1980, Simenstad and Salo 1982, Simenstad et al. 1982, Shershnev et al. 1982). Despite these similarities, chum salmon fry tend to feed more heavily on epibenthic species such as harpacticoid copepods and gammarid amphipods (Simenstad et al. 1980, Simenstad and Salo 1982, Simenstad et al. 1982). Pearcy et al. (1987) calculated proportional diet similarity indices for immature pink and chum salmon in the North Pacific. The mean diet similarity index was 38% for pink and chum salmon captured at 25 sites in the North Pacific over a 6-year period. Pearcy et al. (1987) also documented a high occurrence of ctenophores and other gelatinous zooplankton in the diet of immature chum salmon in the North Pacific. Results from isotopic studies later supported the conclusion that gelatinous zooplankton comprise a large portion of the diet of immature chum salmon in the North Pacific (Welch and Parsons 1993). A high occurrence of gelantinous prey (ctenophores, cnidaria, larvaceans) in the diet of juvenile chum has apparently not been previously documented. Hartt et al. (1970) examined the stomach contents of juvenile chum salmon in August and September in the Bering Sea. Fish larvae (*Mallotus, Ammodytes*, and *Clupea*) and euphausiids were the principal food items.

Prey electivity indices indicated that pollock and herring did not select fish larvae; whereas, pink and chum salmon preferred fish larvae (Appendices I and II). Several studies have documented the occurrence of fish larvae in the diets of pink (LeBrasseur and Barner 1964, Birman 1969, Andrievskaya 1970, Shershnev et al. 1982) and chum salmon (Hartt et al. 1970, Okada and Taniguchi 1971, Healey 1980, Simenstad and Salo 1982, Simenstad et al. 1982). However, in contrast to results from the present study, herring have been found to consume large quantities of fish larvae. In the North Sea, fish eggs and larval fish comprised a high proportion of the diet of herring (Pommeranz 1981). A similar pattern was observed in British Columbia where juvenile herring fed on larval herring when they were available (Hourston et al. 1981). Conversely, juvenile herring in the White Sea consumed only small quantities of fish larvae (Slonova 1977). Selection for fish larvae and other prey is likely determined by the relative profitabilities of potential prey, which is strongly affected by their relative densities (Charnov 1976, Mittelbach 1981, Osenberg and Mittelbach 1989).

In the present study, herring were found to select for *Calanus pacificus* and *Metridia pacifica*. Bollens et al. (1993) found that 39 species/size classes of fish exhibited greater electivity for *Calanus pacificus* than for *Metridia lucens*. In the laboratory, juvenile Pacific herring exhibited a strong preference for *C. pacificus* over *M. lucens*. Bollens et al. (1993) rejected the hypothesis that *M. lucens* exhibits diel vertical migration to avoid predation by planktivorous fish. In the present study, prey electivity indices were greater for *C. pacificus* (.97) than for *M. pacifica* (.83) and the indices for both species were statistically significant.

In the present study, diel changes in diet composition and prey resource partitioning were detected. Diel changes in trophic interactions between planktivorous fish and their prey have been widely documented in freshwater (Hall et al. 1979, Bohl 1980, Wustbaugh and Li 1985, Forsyth et al. 1990, Jessop 1990, Kwak et al. 1992, Johnson and Dropkin 1993, Johnson and Dropkin 1995) and much less so in the ocean (Robb 1981). Such changes are often associated with vertical migrations of predators or prey and appear to be largely driven by light level and its affect on prey visibility and predation risk (Clark and Levy 1988). Patterns of diel feeding may be determined by the relative densities of prey and predators at different times in various habitats (Clark and Levy 1988). Frost and Bollens (1992) observed highly variable diel vertical migratory behavior among *Pseudocalanus newmani* in a Pacific coast embayment. Migratory behavior patterns often changed dramatically over a period of a few weeks, sometimes in response to the presence of planktivorous fish.

In the present study, herring apparently continued to select prey in the species complex described by the first principal component at night (Table 5). Laboratory studies have documented that juvenile herring feed by particle biting and filtering in the light; but in the dark, herring only filter feed (Batty et al. 1986). Juvenile herring also filter feed in the light at high prey densities, but switch to particle biting and gulping when prey concentrations decline below 50 nauplii liter^{-1} (Gibson and Ezzi 1985). In the present study, prey resource partitioning between pollock/herring and pink/chum salmon was maintained during the dark hours indicating that these two groups continued to select prey differently. It is not clear how prey selection may occur in the dark when visual feeding is not likely.

Conclusions:

(1) Two fish species pairs (juvenile walleye pollock and Pacific herring, and juvenile pink and chum salmon) exhibited a relatively high degree of diet overlap within each species pair and little overlap between species pairs.

(2) Prey resource partitioning was associated largely with differences in the amounts of *Pseudocalanus spp.,* small calanoid copepods, and fish larvae consumed by the two species pairs. Juvenile Pacific herring and walleye pollock consumed *Pseudocalanus spp.* and small calanoid copepods; whereas, pink and chum salmon consumed fish larvae.

(3) Diet composition and diet overlap among walleye pollock, Pacific herring, chum salmon, and pink salmon changed significantly over a diel period.

(4) Juvenile chum salmon preferred gelatinous prey such as ctenophores, cnidaria, and *Oikopleura spp.*

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Table 1: Summary of fish catches by species and month in Prince William Sound, 1994.

Species	May	June	July	August
Pacific Cod	0	0	0	213
Pacific Herring	71	46946	19	16219
Pacific Tomcod	0	4327	418	406
Walleye Pollock	4	53287	3713	53744
Sockeye Salmon	8	24134	14455	8
Pink Salmon	206637	631717	356127	174
Chum Salmon	3049	24159	197	410
Northern Smoothtongue	4139	0	0	0
Capelin	187	3047	13	3
Pacific Sandlance	50	3602	3336	1002
Threespine Stickleback	168	16	0	9

Table 2: Summary of mean fish length (mm) by species and month in Prince William Sound, 1994.

Species	May	June	July	August
Pacific Cod	-	-	-	88.5
Pacific Herring	133.5	123.3	137.2	118.1
Pacific Tomcod	-	51.9	69.4	105.5
Walleye Pollock	24.9	39.9	58.8	90.1
Sockeye Salmon	-	106.1	127.3	212.5
Pink Salmon	40.3	61.0	94.8	141.6
Chum Salmon	48.3	56.7	105.6	146.1
Northern Smoothtongue	73.2	-	-	-
Capelin	93.4	95.3	100.8	78.5
Pacific Sandlance	85.2	127.4	135.0	85.8
Threespine Stickleback	65.7	64.3	-	-

Table 3: Summary of fish stomach samples that have been laboratory processed by species and month.

		Month	Sample	Collected
Species	May	June	July	August
Pacific Cod	0	71	0	13
Pacific Herring	29	239	0	367
Pacific Tomcod	0	33	0	33
Walleye Pollock	0	102	0	222
Sockeye Salmon	0	65	0	0
Pink Salmon	91	279	0	77
Chum Salmon	75	173	0	186
Northern Smoothtongue	60	0	0	0
Capelin	52	12	0	5
Pacific Sandlance	0	30	0	7
Threespine Stickleback	77	0	0	0

Table 4: Summary of mean fish stomach fullness (% body weight) by species and month

in Prince William Sound, 1994.

Species	May	June	July	August
Pacific Cod	-	1.7	-	1.6
Pacific Herring	0.7	0.6	-	1.3
Pacific Tomcod	-	2.7	-	2.0
Walleye Pollock	-	1.8	-	0.8
Sockeye Salmon	-	1.2	-	-
Pink Salmon	2.0	1.4	-	1.5
Chum Salmon	2.3	1.5	-	2.0
Northern Smoothtongue	0.5	-	-	-
Capelin	0.3	0.4	-	0.5
Pacific Sandlance	-	2.8	-	4.1
Threespine Stickleback	1.1	-	-	-

Table 5: Summary of the loadings (eigenvectors) for the first principal component describing fish diet composition in western Prince William Sound, August-September, 1994.

Prey species	loadings
Fish larvae, general	-0.631
Calanoid, general small (<2.5 mm)	0.540
Calanoid, Pseudocalanus sp., general	0.475
Malacostraca	0.154
Fish, juvenile, general	-0.140
Amphipod, Hyperiid, unknown juvenile	0.078
Euphausiid, general unknown	-0.072
Unknown invertebrate egg, small (<0.2mm)	0.065
Calanoid, Pseudocalanus AF	0.060
Larvacea, Oikopleura sp.	-0.051
Gastropod, general juvenile	0.049
Barnacle, adult molt (cirri)	-0.047
Calanoid, Epilabidocera longipedata, AM	-0.046
Euphausiid, Thysannoessa sp., adult	-0.045
Ctenophore, general (<2mm)	-0.039
Fish, Ammodytes hexapterus (sandlance)	-0.036
Fish, Clupea harengus pallasi (herring)	-0.035
Amphipod, Gammarid, Cyphocaris sp.	-0.031
Cnidaria (>2mm), general large jellyfish	-0.024
Amphipod, Hyperiid, Hyperia sp.	0.023
Calanoid, Metridia sp., General	0.021
Euphausiid, T. raschii, general	-0.020
Amphipod, Gammarid, Cypho. challengeri	-0.019
Calanoid, Metridia pacifica, general	-0.019
Euphausiid juvenile	-0.019
Cnidarian or Ctenophore mush	-0.018
Decapod, megalops, unknown crab	-0.018
Calanoid, Metridia pacifica, AF	-0.018
Amphipod, Hyperiid, Primno macropa, gen.	-0.017
Calanoid, Epilabidocera longipedata, AF	-0.016
Ctenophore, general (>2mm)	-0.015
Larvacea, Oikopleura dioica	-0.014
Euphausiid, Thysanoessa sp. juvenile	-0.012
Decapod, Cancridae megalops	-0.010
Amphipod, Hyperiid/Parath. pacifica gen.	0.009
Fish egg (~1.0 mm)	0.008

Table 5: continued

Prey Species	loadings
Isopod, general	-0.008
Calanoid, general large (>2.5 mm)	-0.007
Calanoid, Euchaeta elongata, general	-0.007
Calanoid, Euchaeta elongata ad. male	-0.007
Euphausiid, T. spinifera	-0.007
Fish, walleye pollock	-0.007
Decapod zoea, general unknown group	0.006
Shrimp, Hippolytid, Heptacarpus sp.	-0.006
Calanoid, Epilabidocera longipedata, cop	-0.006
Malacostraca, eyes only	0.005
Euphausiid furcilia	0.005
Euphausiid, T. raschii males	-0.005
Calanoid, Calanus marshallae	-0.005
Calanoid, Centropages abdominalis, adult	0.005

Table 6: Summary of the loadings (eigenvectors) for the second principal component describing fish diet composition in western Prince William Sound, August-September, 1994.

Prey species	loadings
Calanoid, general large (>2.5 mm)	0.571
Fish larvae, general	-0.539
Calanoid, Pseudocalanus sp., general	-0.360
Calanoid, general small (<2.5 mm)	-0.338
Malacostraca	0.238
Euphausiid, general unknown	0.134
Fish, juvenile, general	-0.102
Calanoid, Metridia pacifica, general	0.099
Amphipod, Hyperiid, unknown juvenile	-0.085
Calanoid, Metridia pacifica, AF	0.081
Euphausiid, Thysannoessa sp., adult	0.081
Calanoid, Calanus marshallae	0.074
Euphausiid, T. raschii, general	0.055
Unknown invertebrate egg, small (<0.2mm)	-0.054
Cnidarian or Ctenophore mush	0.045
Gastropod, general juvenile	-0.042
Mysidae, general adult (stage 6)	0.038
Calanoid, Epilabidocera longipedata, AM	-0.036
Larvacea, Oikopleura dioica	0.030
Calanoid, Pseudocalanus AF	-0.030
Fish, Clupea harengus pallasi (herring)	-0.029
Fish, walleye pollock	0.027
Larvacea, Oikopleura sp.	0.024
Calanoid, Metridia pacifica, adult	0.019
Decapod zoea, general unknown group	0.019
Ctenophore, general (<2mm)	0.017
Euphausiid juvenile	0.017
Amphipod, Gammarid, Cyphocaris sp.	-0.015
Calanoid, Epilabidocera longipedata, AF	-0.013
Calanoid, Epilabidocera longipedata, gen	0.012
Decapod, megalops, unknown crab	0.011
Euphausiid, Thysanoessa sp. juvenile	-0.011
Decapod, Cancridae megalops	0.011
Ctenophore, general (>2mm)	0.011
Calanoid, Euchaeta elongata, general	0.010
Calanoid, Metridia sp., General	-0.010

Table 6: continued

Prey species	loadings
Euphausiid, T. spinifera	0.010
Amphipod, Gammarid, Cypho. challengeri	-0.009
Cnidaria (>2mm), general large jellyfish	0.009
Gastropod, Pteropod, Limacina helicina	0.008
Isopod, general	-0.008
Euphausiid, T. raschii females	0.008
Calanoid, large, Neocalanus/Calanus	-0.008
Calanoid, Euchaeta elongata ad. male	0.007
Malacostraca, eyes only	0.007
Fish, Mallotus villosus (capelin)	0.007
Fish, Ammodytes hexapterus (sandlance)	-0.006
Fish egg (~1.0 mm)	-0.006
Amphipod, Hyperiid, P. libellula	0.006
Shrimp, Hippolytid, Heptacarpus sp.	-0.006

Table 7: Pairwise comparisons of diet composition described by the first principal component between fish species in western Prince William Sound, August-September, 1994.

Species	d	se	n	T.stat	p.value
Pacific cod - herring	-0.0587	0.1462	23	-0.4018	0.6919
Pacific cod - tomcod	0.0000	0.2022	2	0.0000	-
Pacific cod - pollock	-0.1031	0.1484	14	-0.6951	0.5002
Pacific cod - pink salmon	0.1523	0.1544	7	0.9863	0.3693
Pacific cod - chum salmon	0.1043	0.1471	18	0.7091	0.4885
Pacific cod - sandlance	-0.0543	0.2022	2	-0.2685	-
Herring - tomcod	0.0587	0.1462	23	0.4018	0.6919
Herring - pollock	-0.0444	0.0500	35	-0.8875	0.3812
Herring - pink salmon	0.2110	0.0658	28	3.2051	0.0036 *
Herring - chum salmon	0.1631	0.0462	39	3.5318	0.0011 *
Herring - sandlance	0.0044	0.1462	23	0.0304	0.9760
Herring - pollock	-0.1031	0.1484	14	-0.6951	0.5002
Tomcod - pink salmon	0.1523	0.1544	7	0.9863	0.3693
Tomcod - chum salmon	0.1043	0.1471	18	0.7091	0.4885
Tomcod - sandlance	-0.0543	0.2022	2	-0.2685	-
Pollock - pink salmon	0.2554	0.0706	19	3.6200	0.0021 *
Pollock - chum salmon	0.2074	0.0527	30	3.9382	0.0005 *
Pollock - sandlance	0.0488	0.1484	14	0.3291	0.7477
Pink salmon - chum salmon	-0.0480	0.0679	23	-0.7069	0.4874
Pink salmon - sandlance	-0.2066	0.1544	7	-1.3379	0.2386
Chum salmon - sandlance	-0.1586	0.1471	18	-1.0781	0.2970

Table 8: Schoener's similarity diet indices for several fish species collected in western Prince William Sound, August-September, 1994.

Sites	herring - pollock	herring - pink salmon	herring - chum salmon	herring - sandlance	pollock - pink salmon	pollock - chum salmon	pollock - sandlance	pink salmon - chum salmon
9	-	-	-	-	-	-	-	0.2800
10	-	0.0819	0.0527	-	-	-	-	0.1270
13	0.5348	0.1004	0.1634	-	0.0108	0.0731	-	0.1286
14	0.0904	0.0723	0.3416	-	0.0924	0.0742	-	0.5048
37	-	-	-	-	-	-	-	-
116	-	-	-	-	-	-	-	-
117	-	-	0.0630	-	-	-	-	-
123	-	-	-	-	-	-	-	-
126	-	-	-	-	-	-	-	-
127	-	-	-	-	-	-	-	-
151	-	-	0.3973	-	-	-	-	-
158	-	-	0.0427	-	-	-	-	-
159	0.2176	-	-	-	-	-	-	-
160	0.4772	-	0.3549	-	-	0.2718	-	-
161	-	-	-	-	-	-	-	-
175	-	-	0.0849	-	-	-	-	-
176	0.4024	-	-	-	-	-	-	-
178	-	-	-	-	-	-	-	-
185	0.4512	0.1819	0.1014	-	0.2154	0.1079	-	0.0789
191	-	-	-	-	-	-	-	-
207	0.4681	-	-	0.6258	-	-	0.2840	-
216	-	-	-	-	-	-	-	-

Table 8: continued

Sites	herring - pollock	herring - pink salmon	herring - chum salmon	herring - sandlance	pollock - pink salmon	pollock - chum salmon	pollock - sandlance	pink salmon - chum salmon
218	-	-	-	-	-	-	-	-
235	-	-	0.0001	-	-	-	-	-
239	-	-	-	-	-	-	-	-
241	-	-	-	-	-	0.0018	-	-
242	0.1304	0.0559	0.0564	-	0.1343	0.4098	-	0.3980
247	0.4182	-	0.1781	-	-	0.0391	-	-
250	-	-	-	-	-	-	-	-
251	0.1164	-	0.0959	-	-	0.0747	-	-
mean	0.3307	0.0985	0.1487	0.6258	0.1132	0.1315	0.2840	0.2529
se	0.0544	0.0221	0.0367	-	0.0426	0.0487	-	0.0700
n	10	5	13	1	4	8	1	6

Table 9: Diet proportions for (a) fish larvae, (b) small calanoid copepods (<2.5 mm), and (c) Pseudocalanus spp. in the diets of Pacific herring, walleye pollock, pink salmon, and chum salmon from western Prince William Sound, August-September, 1994.

(a): Fish larvae

Site	Pacific Herring	Walleye Pollock	Pink Salmon	Chum Salmon
9	-	-	0.000	0.000
10	0.010	-	0.043	0.000
13	0.086	0.000	0.645	0.114
14	0.002	0.000	0.000	0.019
37	-	-	-	-
116	-	-	-	0.017
117	0.000	-	-	0.040
123	-	0.000	-	-
126	0.000	-	-	-
127	0.000	-	-	-
151	0.154	-	-	0.000
158	0.000	-	-	0.057
159	0.000	0.000	-	-
160	0.025	0.000	-	0.584
161	-	0.000	-	-
175	0.000	-	-	0.000
176	0.000	0.000	-	-
178	0.000	-	-	-
185	0.029	0.061	0.295	0.000
191	-	-	-	-
207	0.022	0.000	-	-
216	0.041	-	-	-
218	0.000	-	-	-
235	0.000	-	-	0.329
239	-	-	-	0.315
241	-	0.000	-	0.139
242	0.000	0.000	0.605	0.241
247	0.053	0.000	-	0.000
250	0.000	-	-	-
251	0.000	0.078	-	0.057
Mean	0.019	0.011	0.265	0.113
SE	0.008	0.007	0.123	0.040
n	22	13	6	17

Table 9 (b): Small calanoid copepods (<2.5 mm)

Site	Pacific Herring	Walleye Pollock	Pink Salmon	Chum Salmon
9	-	-	0	0.000
10	0.075	-	0	0.001
13	0.218	0.308	0	0.000
14	0.001	0.159	0	0.002
37	-	-	-	-
116	-	-	-	0.000
117	0.000	-	-	0.000
123	-	0.026	-	-
126	0.444	-	-	-
127	0.054	-	-	-
151	0.161	-	-	0.006
158	0.328	-	-	0.000
159	0.005	0.289	-	-
160	0.018	0.146	-	0.000
161	-	0.096	-	-
175	0.082	-	-	0.000
176	0.153	0.293	-	-
178	0.411	-	-	-
185	0.069	0.185	0	0.000
191	-	-	-	-
207	0.105	0.043	-	-
216	0.059	-	-	-
218	0.041	-	-	-
235	0.530	-	-	0.000
239	-	-	-	0.000
241	-	0.301	-	0.000
242	0.011	0.012	0	0.001
247	0.042	0.152	-	0.000
250	0.103	-	-	-
251	0.603	0.002	-	0.001
Mean	0.160	0.155	0	0.001
SE	0.039	0.032	0	0.000
n	22	13	6	17

Table 9 (c): Pseudocalanus spp.

Site	Pacific Herring	Walleye Pollock	Pink Salmon	Chum Salmon
9	-	-	0	0
10	0.000	-	0	0
13	0.222	0.039	0	0
14	0.004	0.221	0	0
37	-	-	-	-
116	-	-	-	0
117	0.888	-	-	0
123	-	0.012	-	-
126	0.015	-	-	-
127	0.000	-	-	-
151	0.001	-	-	0
158	0.326	-	-	0
159	0.003	0.240	-	-
160	0.019	0.169	-	0
161	-	0.186	-	-
175	0.021	-	-	0
176	0.000	0.211	-	-
178	0.186	-	-	-
185	0.043	0.071	0	0
191	-	-	-	-
207	0.037	0.038	-	-
216	0.035	-	-	-
218	0.008	-	-	-
235	0.000	-	-	0
239	-	-	-	0
241	-	0.332	-	0
242	0.000	0.001	0	0
247	0.019	0.345	-	0
250	0.307	-	-	-
251	0.102	0.046	-	0
Mean	0.102	0.147	0	0
SE	0.043	0.033	0	0
n	22	13	6	17

Table 10: Summary of zooplankton species preferred by Pacific herring, walleye pollock, pink salmon, and chum salmon in western Prince William Sound in August-September, 1994. Preference is defined as a greater frequency of occurrence of the organism in the fishes' stomach compared with the vertical zooplankton ring net sample from the same site.

Pacific Herring	Walleye Pollock	Pink Salmon	Chum Salmon
Epilabidocera longipedata AF	juvenile hyperiid amphipod	juvenile hyperiid amphipod	Epilabidocera longipedata AF
Epilabidocera longipedata AM	small calanoid copepod (<2.5mm)	Metridia pacifica (general)	Epilabidocera longipedata AM
Epilabidocera longipedata (general)	Pseudocalanus spp. AF	decapod zoea	ctenophore (general)
juvenile hyperiid amphipod	Pseudocalanus spp. (general)	Oikopleura spp.	juvenile hyperiid amphipod
Euphausiid furcilia			fish larvae
decapod zoea			cnidaria or ctenophore remains
Calanus pacificus			Oikopleura spp.
Metridia pacifica AF			
Metridia pacifica			
small calanoid copepod (<2.5mm)			
Oikopleura dioica			
Oikopleura spp.			
invertebrate eggs			
Euphausiid calyptopis			
Centropages abdominalis			

Table 11: Summary of zooplankton species avoided by Pacific herring, walleye pollock, pink salmon, and chum salmon in western Prince William Sound in August-September, 1994. Avoidance is defined as a lesser frequency of occurrence of the organism in the fishes' stomach compared with the vertical zooplankton ring net sample from the same site.

Pacific Herring	Walleye Pollock	Pink Salmon	Chum Salmon
calanoid nauplius	calanoid nauplius	euphausiid nauplii	Acartia longerimis
Oithona similis		euphausiid calyptopis	Pseudocalanus spp.
juvenile polycheate		barnacle cyprid	Evadne spp.
cnidaria (>2mm)			
cyphonautes larvae			

Table 12: Summary of epibenthic species preferred by Pacific herring, walleye pollock, pink salmon, and chum salmon in western Prince William Sound in August-September, 1994. Preference is defined as a greater frequency of occurrence of the organism in the fishes' stomach compared with the epibenthic pump sample from the same site.

Pacific Herring	Walleye Pollock	Pink Salmon	Chum Salmon
Centropages abdominalis AF	Malacostraca	decapod megalops	none
Cladocera (general)	invertebrate egg (<.2mm)	Oikopleura dioica	
invertebrate egg (<.2mm)	decapod zoea		
decapod zoea	Pseudocalanus spp. AF		
Evadne spp.	Oikopleura dioica		
Oikopleura dioica	Centropages abdominalis		
Pseudocalanus spp. AF	Pseudocalanus spp.		
small calanoid copepod (<2.5mm)	small calanoid copepod (<2.5mm)		

Table 13: Summary of epibenthic species avoided by Pacific herring, walleye pollock, pink salmon, and chum salmon in western Prince William Sound in August-September, 1994. Avoidance is defined as a lesser frequency of occurrence of the organism in the fishes' stomach compared with the epibenthic pump sample from the same site.

Pacific Herring	Walleye Pollock	Pink Salmon	Chum Salmon
Tisbe spp.	Harpacticus spp.	Harpacticoid (general)	Pseudocalanus spp.
Harpacticus spp.	bivalve larvae	bivalve larvae	
Harpacticus (general)	calanoid nauplius	juvenile polychaete	
Oithona spp.		Pseudocalanus spp.	
Amphipod, Caprellidae		calanoid copepod (<2.5mm)	
Polychaeta, Polynoidae			
Zaus spp.			
calanoid nauplius			
juvenile polychaete			
bivalve larvae			

Table 14: Summary of the loadings (eigenvectors) for the first principal component describing fish diet composition from a diel study conducted at Iktua Bay in western Prince William Sound, August-September, 1994.

Prey species	loadings
Calanoid, general small (<2.5 mm)	0.6505
Calanoid, Pseudocalanus sp., general	0.4189
Larvacea, Oikopleura sp.	0.3022
Euphausiid, general unknown	-0.2923
Fish larvae, general	-0.2714
Larvacea, Oikopleura dioica	0.1727
Cnidarian or Ctenophore mush	-0.1623
Euphausiid calyptopis	0.1176
Calanoid, Epilabidocera longipedata, AM	-0.1017
Gastropod, general juvenile	0.0930
Calanoid, Pseudocalanus AF	0.0845
Ctenophore, general (<2mm)	-0.0831
Gastropod, Pteropod, Limacina helicina	0.0728
Cnidaria (>2mm), general large jellyfish	-0.0690
Euphausiid furcilia	0.0683
Euphausiid, Thysannoessa sp., adult	-0.0677
Calanoid, Epilabidocera longipedata, AF	-0.0641
Calanoid, Centropages abdominalis, adult	0.0564
Unknown invertebrate egg, small (<0.2mm)	0.0513
Amphipod, Hyperiid, P. libellula	-0.0374
Amphipod, Hyperiid, Primno macropa, gen.	-0.0356
Decapod, megalops, unknown crab	-0.0356
Calanoid, Acartia longiremis , General	0.0324
Calanoid, Neocalanus spp. adult	-0.0310
Ctenophore, general (>2mm)	-0.0297
Calanoid, Calanus marshallae	-0.0286
Amphipod, P. pacifica, general juvenile	-0.0273
Amphipod, Hyperiid, Hyperia sp.	-0.0262
Cladoceran, Podon sp.	0.0245
Calanoid, Acartia longiremus adult	0.0241
Calanoid, Epilabidocera longipedata, gen	-0.0234

Table 14: continued

Prey species	loadings
Calanoid, Epilabidocera longipedata, cop	-0.0228
Calanoid, Metridia pacifica, general	0.0217
Fish egg (~1.0 mm)	-0.0216
Calanoid, Centropages abdominalis, AF	0.0214
Calanoid, Calanus marshallae AF	-0.0200
Amphipod, Hyperiid, P. macropa, 7+mm	-0.0185

Table 15: Summary of the loadings (eigenvectors) for the second principal component describing fish diet composition from a diel study conducted at Iktua Bay in western Prince William Sound, September, 1994.

Prey species	loadings
Larvacea, Oikopleura sp.	-0.5734
Larvacea, Oikopleura dioica	0.5385
Malacostraca	-0.2876
Calanoid, Pseudocalanus sp., general	0.2829
Calanoid, Epilabidocera longipedata, gen	-0.2456
Fish larvae, general	0.1688
Calanoid, Epilabidocera longipedata, AM	0.1630
Calanoid, general large (>2.5 mm)	-0.1219
Calanoid, Epilabidocera longipedata, AF	0.1179
Gastropod, general juvenile	0.0979
Calanoid, Pseudocalanus AF	0.0940
Calanoid, Metridia pacifica, general	-0.0846
Amphipod, Hyperiid, unknown juvenile	-0.0837
Euphausiid, general unknown	0.0820
Calanoid, Epilabidocera longipedata, cop	0.0744
Calanoid, large, Neocalanus/Calanus	0.0611
Decapod, Cancridae megalops	-0.0562
Malacostraca, eyes only	0.0524
Calanoid, Metridia pacifica, AF	0.0409
Unknown invertebrate egg, small (<0.2mm)	0.0406
Euphausiid furcilia	0.0399
Euphausiid, Thysannoessa sp., adult	-0.0365
Calanoid, Calanus marshallae	-0.0357
Gastropod, Pteropod, Limacina helicina	0.0325
Calanoid, Eucalanus bungii, general	-0.0318
Calanoid, Calanus sp. copepodids	-0.0296
Calanoid, general small (<2.5 mm)	0.0254
Decapod zoea, general unknown group	0.0250
Calanoid, Centropages abdominalis, adult	-0.0248
Cnidaria (>2mm), general large jellyfish	-0.0232

Table 15: continued

Prey species	loadings
Calanoid, Calanus marshallae AF	0.0220
Amphipod, P. pacifica, general juvenile	-0.0197
Calanoid, Centropages abdominalis, AF	0.0195
Amphipod, Hyperiid, P. libellula	0.0178
Decapoda, Cancrid crab, Atelecyclidae	-0.0177
Cnidarian or Ctenophore mush	-0.0166
Calanoid, Acartia longiremis , General	-0.0157

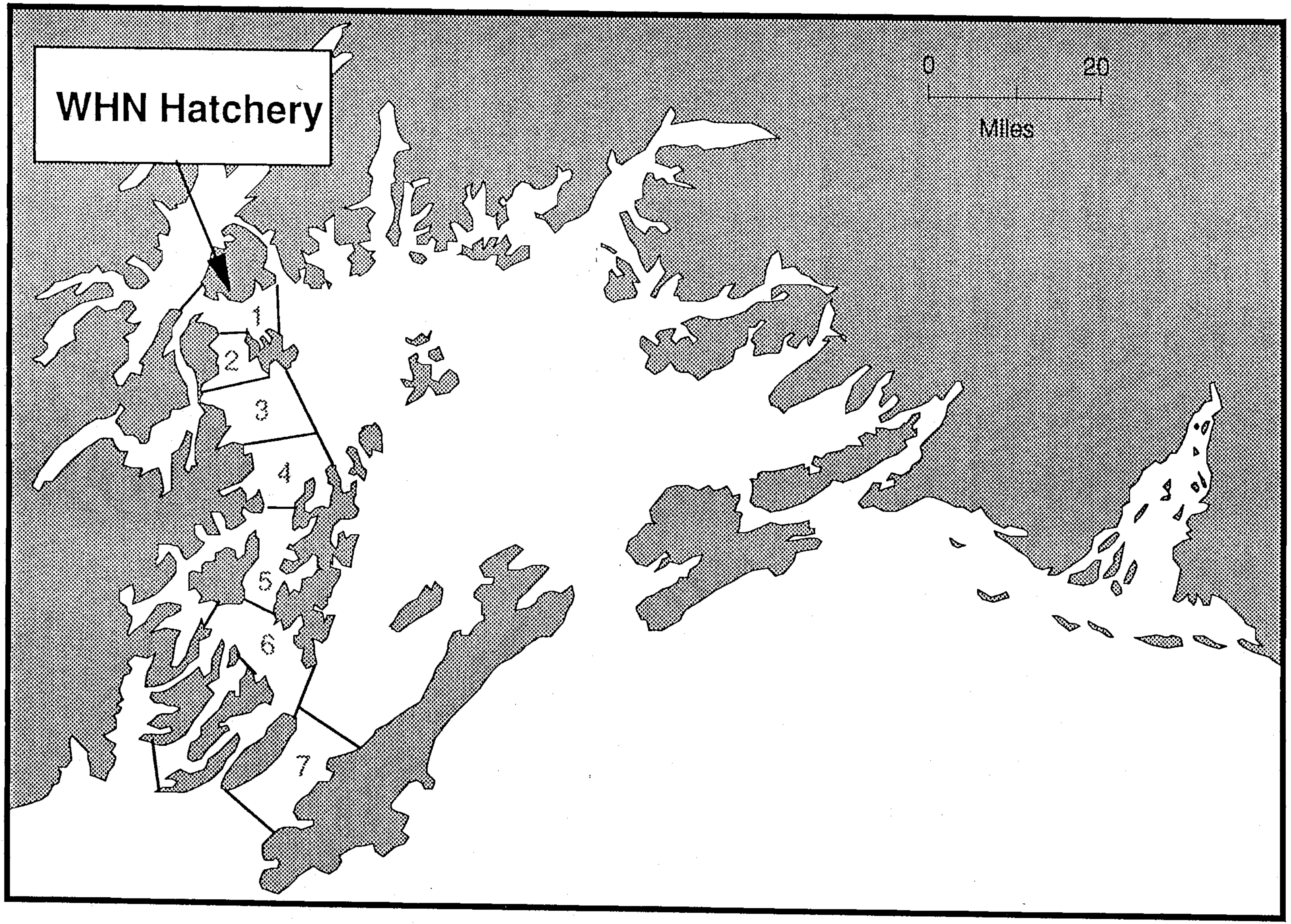


Figure 1: Sound Ecosystem Assessment study area in western Prince William Sound, 1994.

WALLEYE POLLOCK

a.

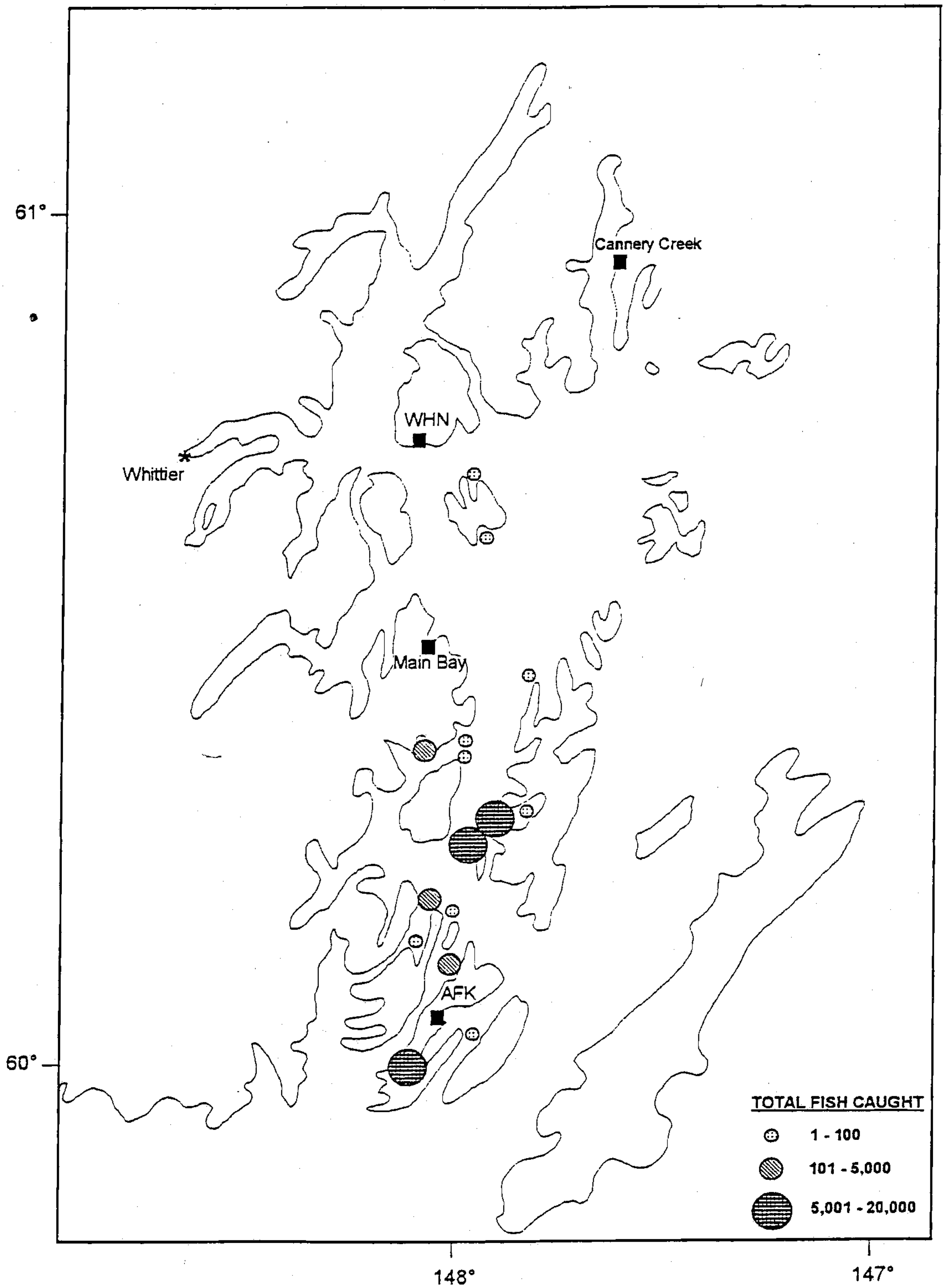


Figure 2: Spatial distribution of total catch of (a) walleye pollock, (b) Pacific herring, (c) pink salmon, and (d) chum salmon in Prince William Sound, 1994.

PACIFIC HERRING

b.

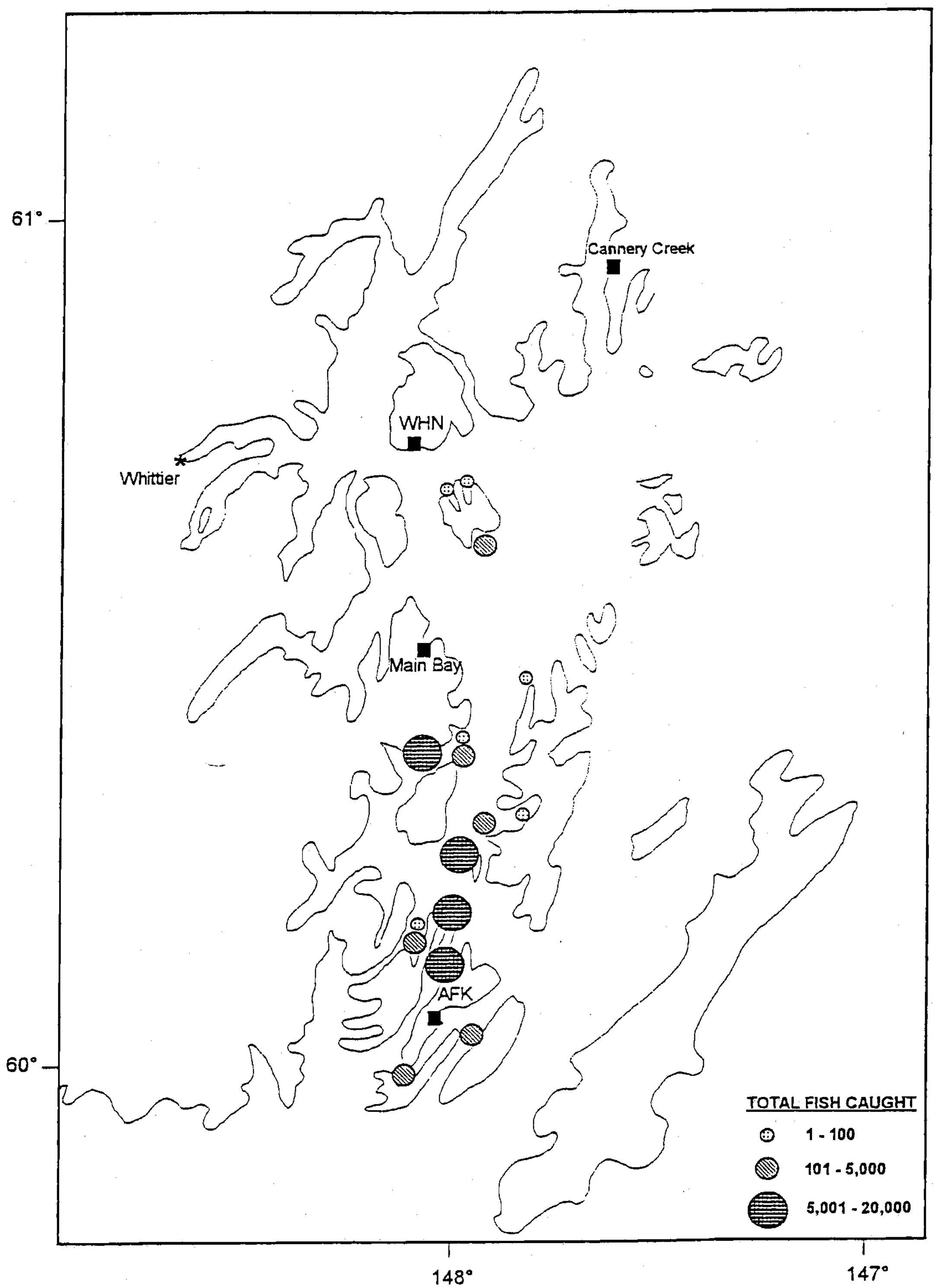


Figure 2: continued

c.

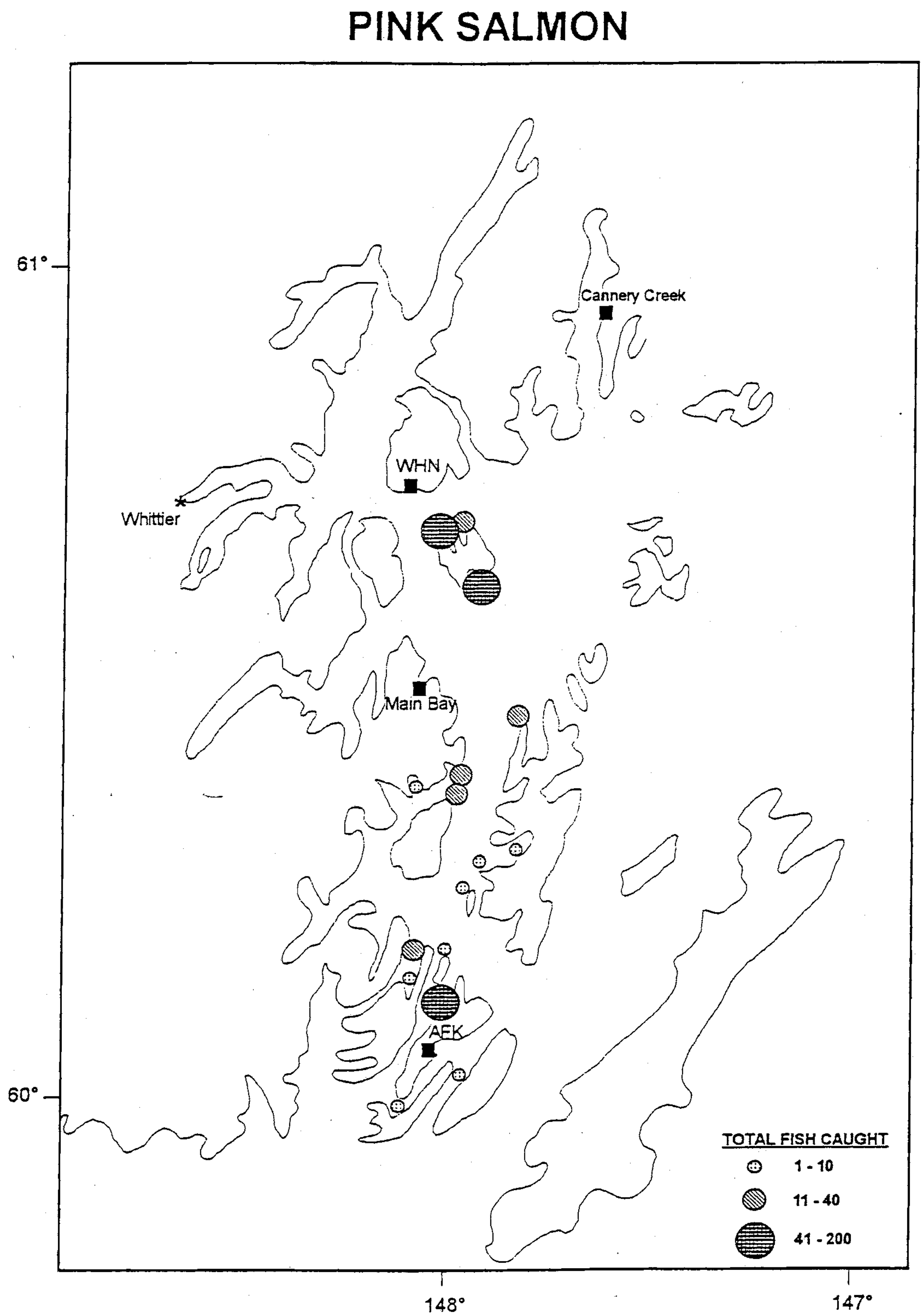


Figure 2: continued

d.

CHUM SALMON

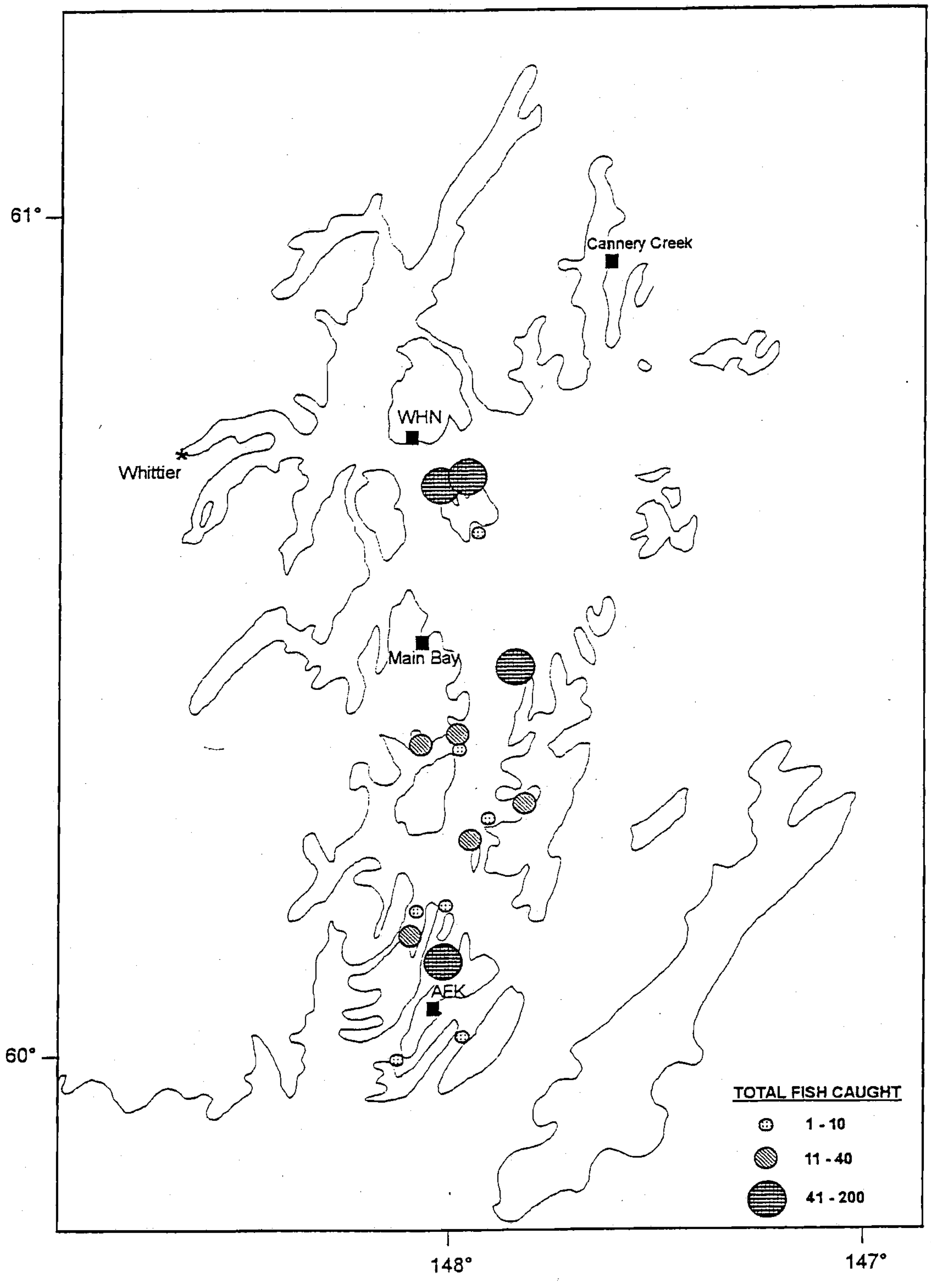


Figure 2: continued

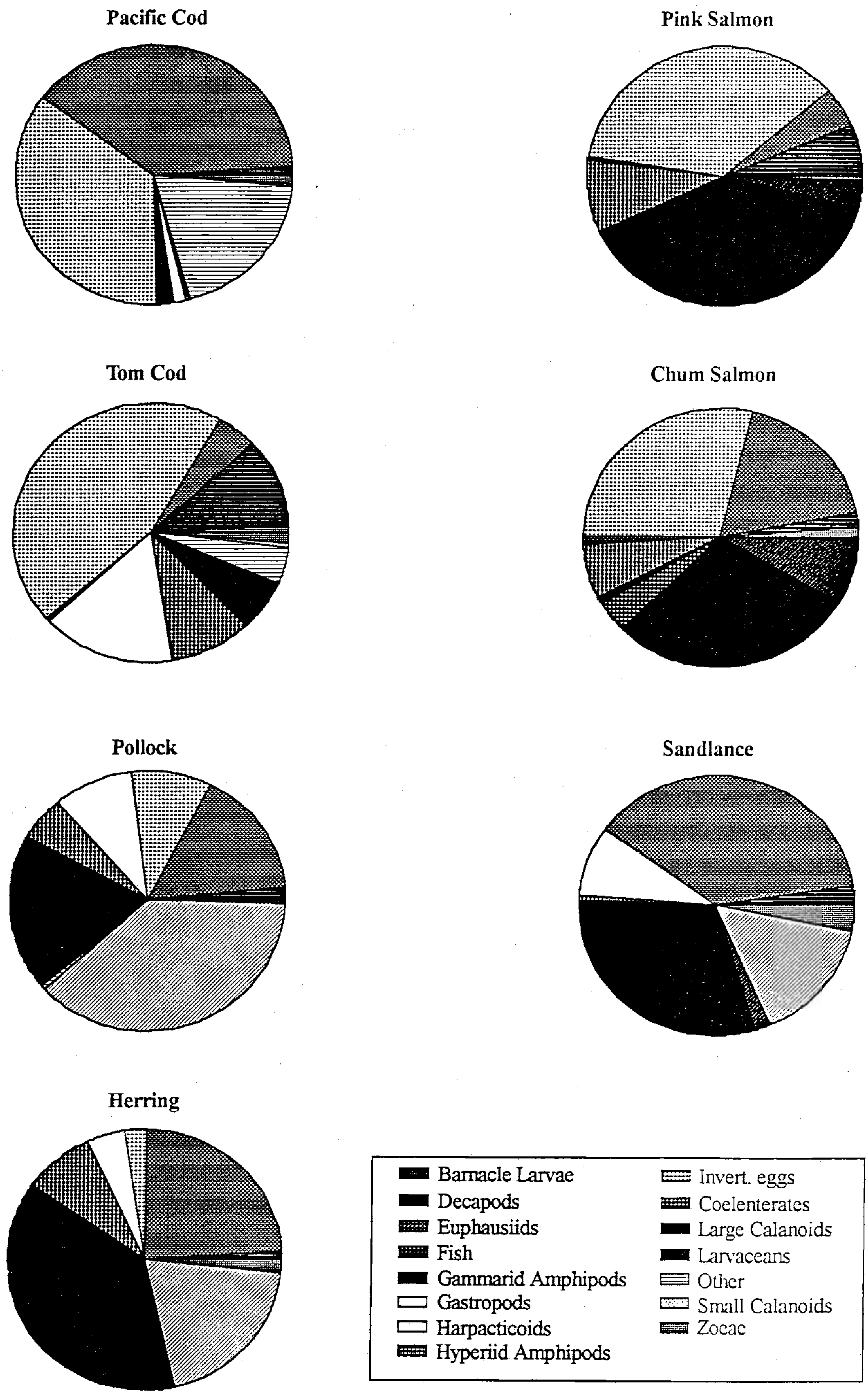


Figure 3. Diet composition of seven species of forage fish collected in fall, 1994, as percent biomass of 15 prey categories.

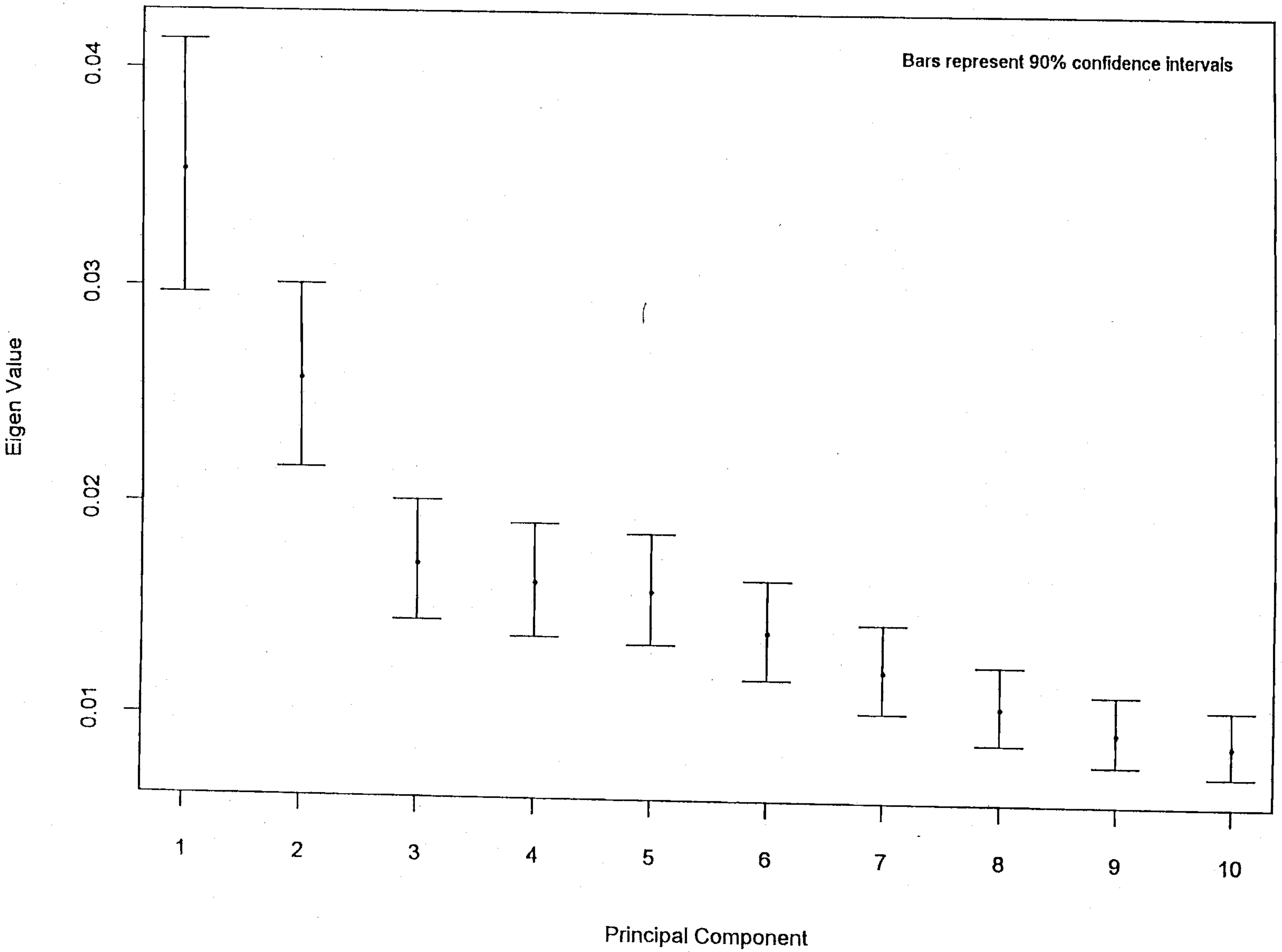


Figure 4: Eigenvalues obtained from a principal components analysis of fish diet composition data from western Prince William Sound, 1994.

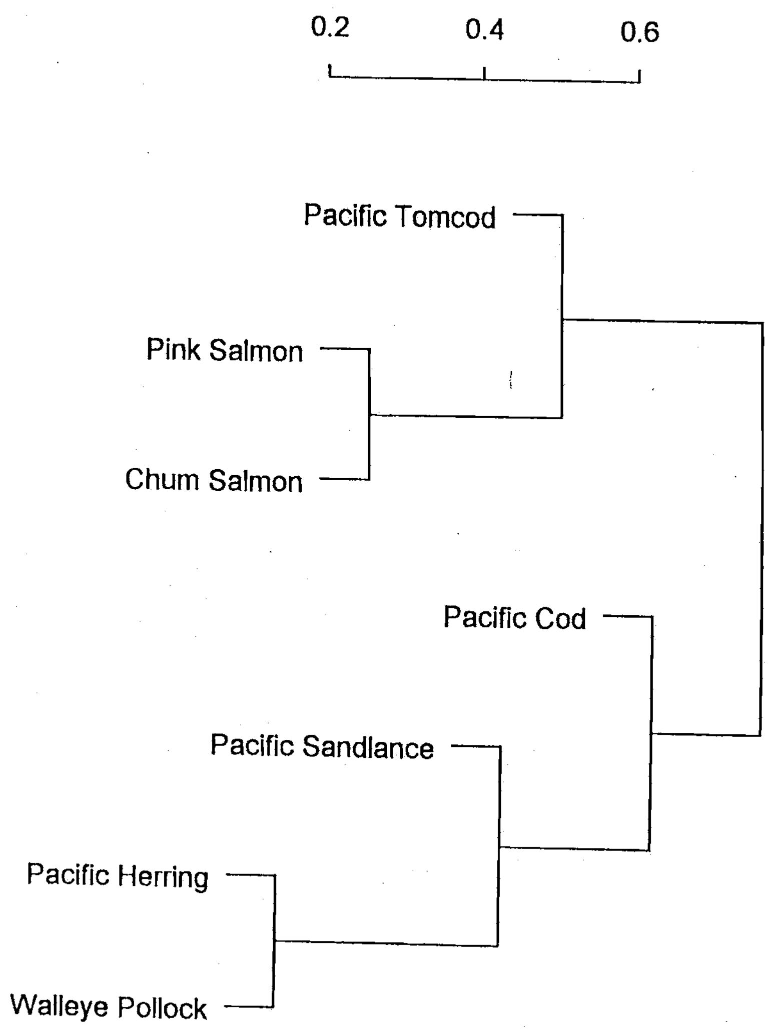


Figure 5: Dendrograms obtained from a cluster analysis of fish diet composition data from western Prince William Sound, 1994.

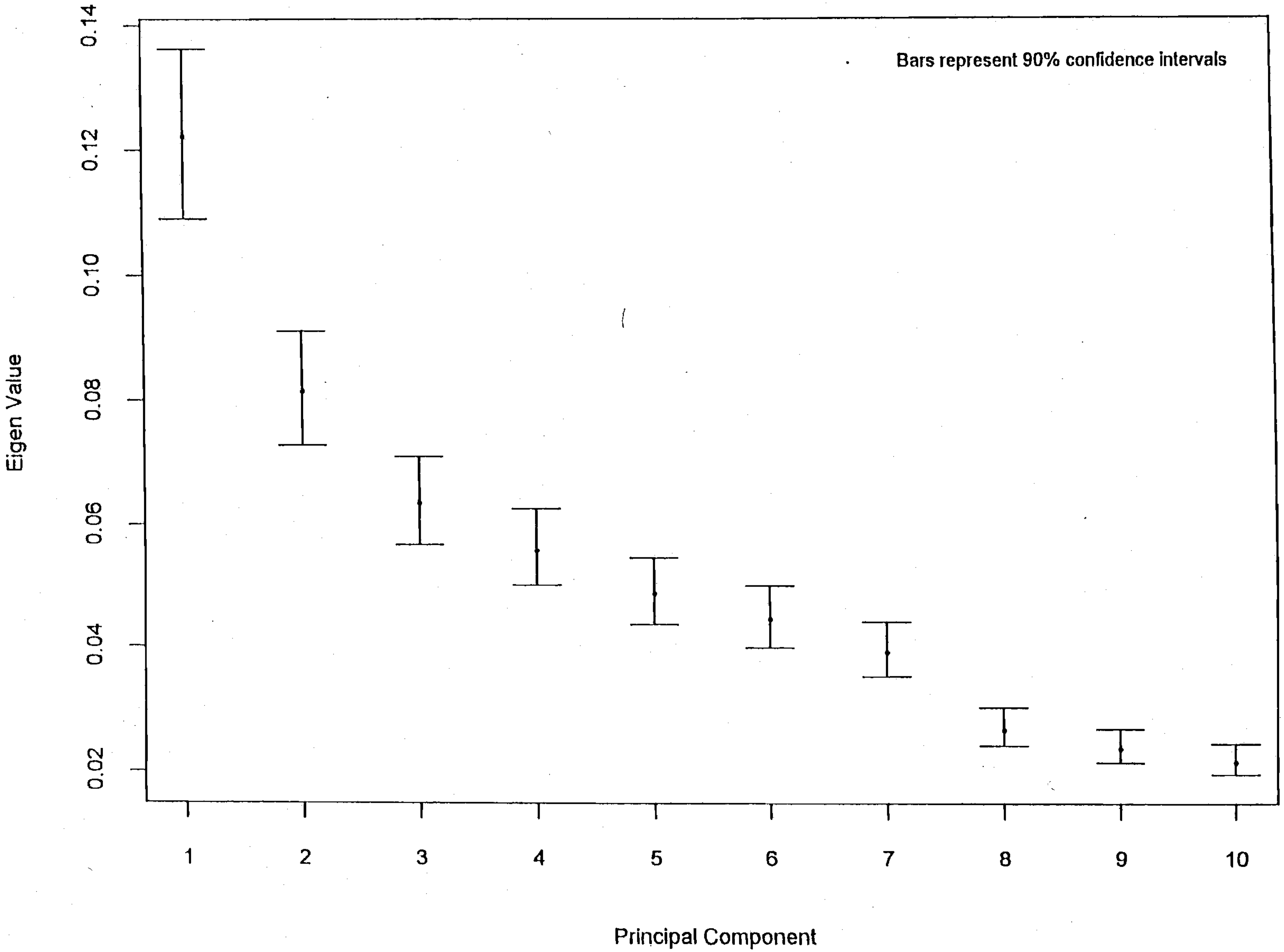


Figure 6: Eigenvalues obtained from a principal components analysis of fish diet composition data from a diel study conducted at Iktua Bay in western Prince William Sound, September 1994.

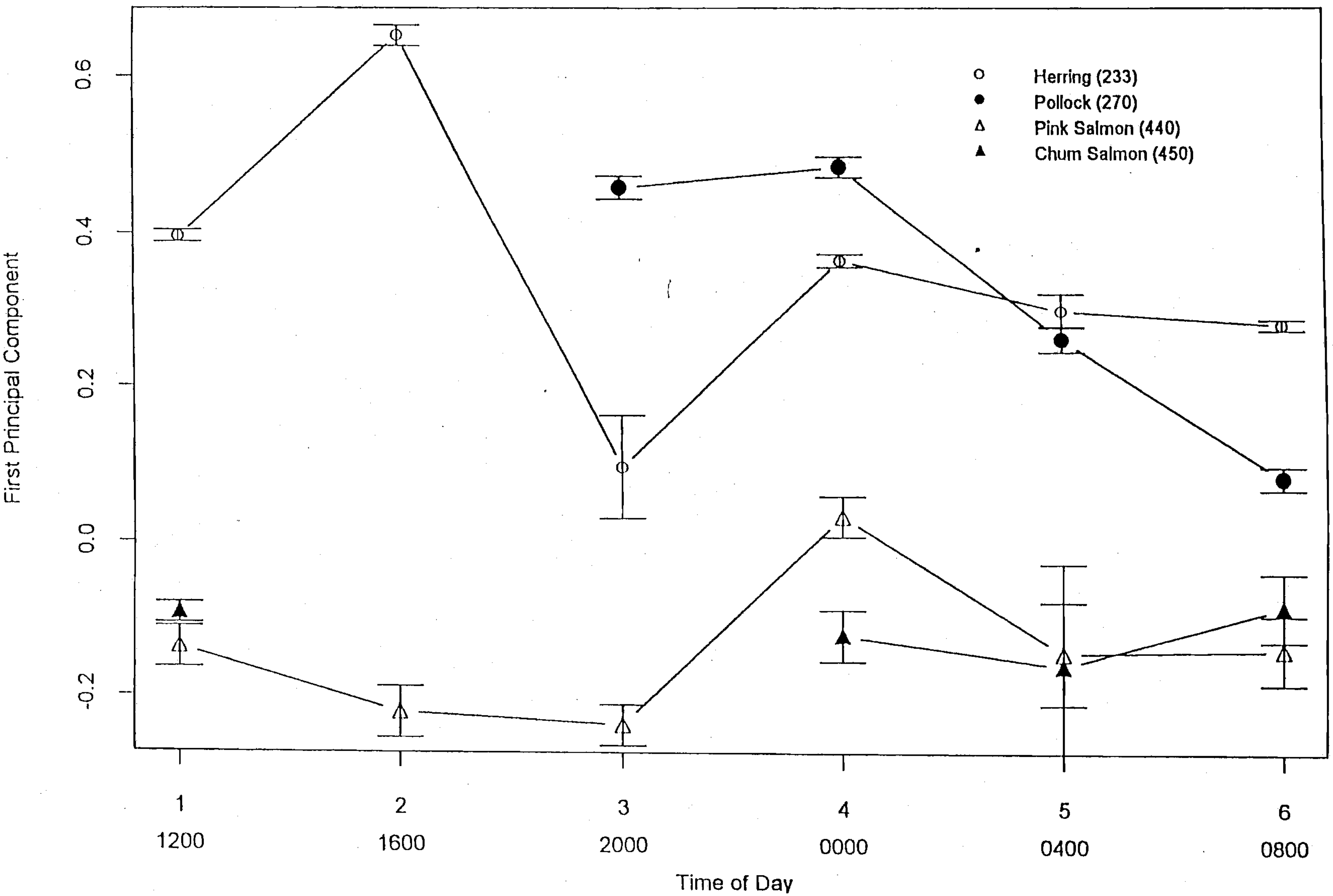


Figure 7: Mean principal component scores obtained from an analysis of variance of fish diet composition data from a diel study conducted at Iktua Bay in western Prince William Sound, September 1994.

Appendix I: Summary of prey electivity indices for zooplankton species consumed by Pacific herring, walleye pollock, pink salmon and chum salmon in western Prince William Sound, September 1994.

Table 1: Summary of zooplankton species preferred by walleye pollock in western Prince William Sound, 1994. Preference is defined as a greater frequency of occurrence of an organism in fish stomach contents compared with the zooplankton sample from the same site.

Species	mean	se	n	p.value
Harpacticoid, Tisbe sp., adult	1.0000	-	1	-
Euphausiid, T. spinifera	1.0000	0.0000	2	0.0000
Euphausiid, T. raschii females	1.0000	-	1	-
Euphausiid, Thysannoessa sp., adult	1.0000	0.0000	5	0.0000
Amphipod, Hyperiid, P. libellula	1.0000	0.0000	2	0.0000
Amphipod, Hyperiid, P. libellula 2-6.9mm	1.0000	-	1	-
Amphipod, P. pacifica, general juvenile	1.0000	-	1	-
Amphipod, P. pacifica juvenile, <2mm	1.0000	-	1	-
Larvacea, Oikopleura vanhoeffeni	1.0000	0.0000	2	0.0000
Larvacea, O. vanhoeffeni capsule	1.0000	0.0000	2	0.0000
Calanoid, Neocalanus spp. adult	1.0000	0.0000	2	0.0000
Mysidae, general adult (stage 6)	1.0000	-	1	-
Calanoid, M. ochotensis copepodite MALE	1.0000	-	1	-
Calanoid, Metridia pacifica, AM	1.0000	0.0000	2	0.0000
Calanoid, Metridia pacifica, adult	1.0000	0.0000	2	0.0000
Calanoid, Metridia sp., General	1.0000	0.0000	3	0.0000
Calanoid, Metridia sp. copepodids I-IV	1.0000	-	1	-
Malacostraca	1.0000	0.0000	9	0.0000
Malacostraca, eyes only	1.0000	0.0000	7	0.0000
Larvacea, general	1.0000	-	1	-
Isopod, general	1.0000	-	1	-
Harpacticoid, Harpacticus sp. general ad	1.0000	-	1	-
Harpacticoid, general adult	1.0000	0.0000	2	0.0000
Harpacticoid, Harpacticus female adult	1.0000	-	1	-
Harpacticoid, general, unknown stage	1.0000	0.0000	2	0.0000
Amphipod, Hyperiid, Hyperia sp.	1.0000	-	1	-
Fish, Clupea harengus pallasi (herring)	1.0000	-	1	-
Gastropod, general juvenile (EPI)	1.0000	0.0000	7	0.0000

Table 1: continued

Species	mean	se	n	p.value
Amphipod, Gammarid, unknown, medium	1.0000	-	1	-
Euphausiid, general unknown	1.0000	0.0000	4	0.0000
Euphausiid egg	1.0000	-	1	-
Decapod, Brachyura general, zoeae	1.0000	-	1	-
Decapod, megalops, unknown crab	1.0000	0.0000	2	0.0000
Ostracod, Conchoecia sp.	1.0000	-	1	-
Calanoid, large, NOT Neocalanus/Calanus	1.0000	0.0000	5	0.0000
Cladocera, General	1.0000	-	1	-
Chaetognath, species unknown	1.0000	-	1	-
Calanoid, Centropages abdominalis, AM	1.0000	0.0000	7	0.0000
Calanoid, general large (>2.5 mm)	1.0000	0.0000	9	0.0000
Decapod, Cancridae megalops	1.0000	0.0000	2	0.0000
Calanoid, Centropages abdominalis, AF	1.0000	0.0000	6	0.0000
Calanoid, Acartia longiremus AM	1.0000	-	1	-
Calanoid, Acartia longiremis AF	1.0000	0.0000	2	0.0000
Calanoid, Acartia longiremus copepodite	1.0000	-	1	-
Amphipod, Hyperiid, unknown juvenile	0.9965	0.0035	10	0.0000
Calanoid, Metridia pacifica, general	0.9903	0.0042	2	0.0000
Calanoid, Eucalanus bungii, general	0.9319	-	1	-
Calanoid, general small (<2.5 mm)	0.9137	0.0456	10	0.0000
Gastropod, Pteropod, Limacina helicina	0.8779	0.1221	8	0.0001
Unknown invertebrate egg, small (<0.2mm)	0.7903	0.0723	10	0.0000
Calanoid, Calanus sp. copepodids	0.7143	0.2857	7	0.0410
Calanoid, Epilabidocera longipedata, gen	0.7030	0.2840	7	0.0425
Calanoid, Calanus marshallae	0.6703	0.2799	7	0.0479
Calanoid, Pseudocalanus AF	0.6597	0.1406	9	0.0011
Calanoid, Metridia pacifica, AF	0.6503	0.3304	6	0.0966
Calanoid, large, Neocalanus/Calanus	0.6252	0.3276	6	0.1049
Calanoid, Epilabidocera longipedata, AF	0.5987	0.3997	5	0.1944
Decapod zoea, general unknown group	0.5864	0.3968	5	0.1995
Euphausiid furcilia	0.5550	0.2939	9	0.0915
Calanoid, Euchaeta elongata, general	0.5000	0.5000	4	0.3739
Calanoid, Centropages abdominalis, adult	0.4917	0.2902	7	0.1340
Larvacea, Oikopleura dioica	0.4696	0.2736	9	0.1202
Calanoid, Pseudocalanus sp., general	0.4309	0.1294	10	0.0076
Amphipod, Hyperiid/Parath. pacifica gen.	0.4264	0.3683	7	0.2850
Larvacea, Oikopleura sp.	0.4202	0.2695	10	0.1500

Table 1: continued

Species	mean	se	n	p.value
Decapod zoea, crab, Oregoninae	0.3333	0.6667	3	0.6514
Calanoid, Epilabidocera longipedata, AM	0.3333	0.6667	3	0.6514
Calanoid, Calanus pacificus AF	0.3333	0.6667	3	0.6514
Calanoid, Calanus marshallae AF	0.3333	0.4216	6	0.4593
Euphausiid calyptopis	0.3150	0.3106	8	0.3403
Calanoid, Acartia longiremus adult	0.2105	0.4835	5	0.6815
Barnacle, cyprid	0.1270	0.3501	8	0.7262

Table 2: Summary of zooplankton species avoided by walleye pollock in western Prince William Sound, 1994. Avoidance is defined as a lesser frequency of occurrence of an organism in fish stomach contents compared with the zooplankton sample from the same site.

Species	mean	se	n	p.value
Calanoid, Acartia clausi	-1.0000	-	1	-
Calanoid, Acartia sp. copepodids	-1.0000	-	1	-
Bryozoa, cyphonautes larva	-1.0000	0.0000	6	0.0000
Insect, Chironomidae, adult	-1.0000	-	1	-
Calanoid, C. marshallae copepodite	-1.0000	-	1	-
Cnidaria (>2mm), general large jellyfish	-1.0000	0.0000	4	0.0000
Cnidaria (<2mm), general small jellyfish	-1.0000	0.0000	5	0.0000
Calanoid, Calanus pacificus, general	-1.0000	-	1	-
Calanoid, Calanus pacificus AM	-1.0000	-	1	-
Ctenophore, general (>2mm)	-1.0000	0.0000	6	0.0000
Ctenophore, general (<2mm)	-1.0000	-	1	-
Decapod zoea, crab, Brachyrhyncha	-1.0000	0.0000	3	0.0000
Larvacea, Fritilaria sp. (borealis)	-1.0000	-	1	-
Gastropod, general juvenile (ZOOP)	-1.0000	0.0000	10	0.0000
Decapod zoea, Shrimp, Hippolytidae	-1.0000	-	1	-
Harpacticoid, general copepodite	-1.0000	-	1	-
Cnidaria, Eirene indicans	-1.0000	0.0000	3	0.0000
Cnidaria, Eirene flavicirratus	-1.0000	-	1	-
Cnidaria, Melicertum sp.	-1.0000	0.0000	3	0.0000
Harpacticoid, Microsetella rosea	-1.0000	-	1	-
Copepod, Monstrilla sp.	-1.0000	0.0000	2	0.0000
Larvacea, Oikopleura < 2mm (IMS)	-1.0000	0.0000	2	0.0000
Larvacea, Oikopleura > 2mm (IMS)	-1.0000	-	1	-
Copepod, Oithona egg cases	-1.0000	0.0000	3	0.0000
Cyclopoid, Oithona copepodite	-1.0000	0.0000	4	0.0000
Cyclopoid, Oithona similis AF	-1.0000	0.0000	5	0.0000
Calanoid, Pseudocalanus copepodids I-IV	-1.0000	0.0000	2	0.0000
Decapod zoea, hermit crab, Paguridae	-1.0000	0.0000	2	0.0000
Polychaeta, Polynoidae	-1.0000	0.0000	2	0.0000
Amphipod, Hyperiid, Parathemisto sp.<2mm	-1.0000	-	1	-
Amphipod, Hyperiid, Parathem. sp.2-6.9mm	-1.0000	-	1	-
Decapod zoea, general shrimp	-1.0000	-	1	-
Polychaeta, trochophore larva	-1.0000	0.0000	3	0.0000
Unknown egg mass	-1.0000	-	1	-
Gastropod, general veliger	-1.0000	0.0000	2	0.0000
Cyclopoid, Oithona similis, general	-0.9992	0.0006	9	0.0000

Table 2: continued

Species	mean	se	n	p.value
Calanoid, Copepodite small	-0.9991	0.0009	5	0.0000
Calanoid, general nauplius	-0.9942	0.0057	10	0.0000
Euphausiid nauplii	-0.9471	0.0529	4	0.0001
Polychaeta, general, juvenile	-0.9316	0.0640	7	0.0000
Calanoid, Acartia sp.	-0.5995	0.3999	5	0.1941
Calanoid, Acartia longiremis , General	-0.5964	0.3251	6	0.1163
Calanoid, M. ochotensis AM	-0.5283	-	1	-
Bivalve, larvae	-0.4286	0.3689	7	0.2834
Barnacle, nauplius	-0.4043	0.4767	4	0.4441
Cladoceran, Podon sp.	-0.4021	0.3078	7	0.2327
Shrimp, Hippolytid, general	-0.3449	0.6551	3	0.6350
Unknown nauplius	-0.3333	0.4216	6	0.4593
Cladoceran, Evadne sp.	-0.3283	0.4201	6	0.4642
Calanoid, Epilabidocera longipedata, cop	-0.2000	0.4899	5	0.7000
Fish larvae, general	-0.2000	0.4899	5	0.7000
Chaetognath, Sagitta	-0.0836	0.5335	4	0.8831
Calanoid, Centropages abdominalis, copdt	0.0000	1.0000	2	1.0000
JELLY: Cnidarian or Ctenophore mush	0.0000	1.0000	2	1.0000
Unknown invertebrate egg, large (>0.2mm)	0.0000	0.4472	6	1.0000
Fish egg (~1.0 mm)	0.0000	1.0000	2	1.0000
Calanoid, Metridia pacifica, copepodite	0.0000	1.0000	2	1.0000
Nematode	0.0000	1.0000	2	1.0000
Calanoid, Pseudocalanus AM	0.0000	0.5774	4	1.0000

Table 3: Summary of zooplankton species preferred by Pacific herring in western Prince William Sound, 1994. Preference is defined as a greater frequency of occurrence of an organism in fish stomach contents compared with the zooplankton sample from the same site.

Species	mean	se	n	p.value
Harpacticoid, Tisbe copepodite	1.0000	0.0000	2	0.0000
Harpacticoid, Tisbe sp., adult	1.0000	0.0000	2	0.0000
Euphausiid, T. spinifera	1.0000	0.0000	5	0.0000
Euphausiid, T. raschii, general	1.0000	0.0000	2	0.0000
Euphausiid, T. inermis	1.0000	-	1	-
Euphausiid, Thysannoessa sp., juvenile	1.0000	-	1	-
Euphausiid, Thysannoessa sp., adult	1.0000	0.0000	5	0.0000
Shrimp, Hippolytid, Spirontocaris sp.	1.0000	-	1	-
Amphipod, Hyperiid, P. libellula	1.0000	0.0000	7	0.0000
Amphipod, Hyperiid, Primno macropa, gen.	1.0000	-	1	-
Amphipod, Hyperiid, P. macropa, 7+mm	1.0000	-	1	-
Amphipod, Hyperiid, P. macropa, 2-6.9mm	1.0000	-	1	-
Amphipod, Hyperiid, P. libellula 2-6.9mm	1.0000	-	1	-
Decapod zoea, Shrimp, Pandalidae	1.0000	0.0000	2	0.0000
Copepod, Caligidae, parasitic copepod	1.0000	-	1	-
Amphipod, P. pacifica, general juvenile	1.0000	0.0000	6	0.0000
Amphipod, P. pacifica juvenile, 2-6.9mm	1.0000	-	1	-
Amphipod, P. pacifica juvenile, <2mm	1.0000	-	1	-
Cyclopoid, Oithona spinirostris	1.0000	-	1	-
Larvacea, O. vanhoeffeni capsule	1.0000	0.0000	2	0.0000
Cyclopoid, Oithona sp., general	1.0000	-	1	-
Calanoid, Neocalanus spp. adult	1.0000	0.0000	2	0.0000
Bivalve, Mytilidae	1.0000	-	1	-
Fish, Mallotus villosus (capelin)	1.0000	-	1	-
Calanoid, M. ohkotensis, female copepodt	1.0000	0.0000	3	0.0000
Bivalve, juvenile mussel	1.0000	-	1	-
Calanoid, Metridia pacifica, AM	1.0000	0.0000	4	0.0000
Calanoid, Metridia pacifica, adult	1.0000	0.0000	7	0.0000
Calanoid, Metridia ochotensis, no sex	1.0000	-	1	-
Calanoid, M. ochotensis AM	1.0000	-	1	-
Calanoid, Metridia ochotensis AF	1.0000	0.0000	2	0.0000
Copepod, Monstrillid	1.0000	-	1	-
Calanoid, Metridia sp., General	1.0000	0.0000	3	0.0000
Calanoid, Metridia sp. copepodids I-IV	1.0000	-	1	-
Malacostraca	1.0000	0.0000	14	0.0000
Malacostraca, eyes only	1.0000	0.0000	13	0.0000

Table 3: continued

Species	mean	se	n	p.value
Larvacea, general	1.0000	0.0000	3	0.0000
Isopod, general	1.0000	-	1	-
Harpacticoid, Zaus copepodite	1.0000	-	1	-
Harpacticoid, Harpacticus sp. general ad	1.0000	-	1	-
Harpacticoid, general adult	1.0000	0.0000	3	0.0000
Harpacticoid, general gravid (eggs)	1.0000	-	1	-
Amphipod, Hyperiid, Hyperia sp.	1.0000	0.0000	7	0.0000
Harpacticoid, general eggsac	1.0000	-	1	-
Harpacticoid, Ectinosomatidae	1.0000	-	1	-
Gastropod, general juvenile (EPI)	1.0000	0.0000	13	0.0000
Amphipod, Gammarid head	1.0000	0.0000	2	0.0000
Euphausiid, general unknown	1.0000	0.0000	6	0.0000
Euphausiid juvenile	1.0000	-	1	-
Euphausiid egg	1.0000	0.0000	4	0.0000
Euphausiid, Euphausia pacifica	1.0000	-	1	-
Calanoid, Epilabidocera longipedata adul	1.0000	0.0000	2	0.0000
Calanoid, Euchaeta elongata ad. male	1.0000	-	1	-
Calanoid, Eucalanus bungii, copepodite	1.0000	-	1	-
Decapod, megalops, Lithodidae	1.0000	-	1	-
Decapod, megalops, unknown crab	1.0000	0.0000	5	0.0000
Calanoid, Calanus marshallae AM	1.0000	0.0000	2	0.0000
Calanoid, large, NOT Neocalanus/Calanus	1.0000	0.0000	3	0.0000
Cladocera, General	1.0000	0.0000	10	0.0000
Chaetognath, species unknown	1.0000	0.0000	3	0.0000
Calanoid, Neocalanus cristatus V	1.0000	0.0000	2	0.0000
Amphipod, Caprellidae	1.0000	-	1	-
Calanoid, Centropages abdominalis, AM	1.0000	0.0000	8	0.0000
Calanoid, general large (>2.5 mm)	1.0000	0.0000	16	0.0000
Decapod, Cancridae megalops	1.0000	0.0000	4	0.0000
Calanoid, Centropages abdominalis, AF	1.0000	0.0000	9	0.0000
Calanoid, single egg or clutch	1.0000	-	1	-
Calanoid, Centropages abdominalis, copdt	1.0000	0.0000	2	0.0000
Barnacle, adult molt (cirri)	1.0000	0.0000	4	0.0000
Decapoda, Cancrid crab, Atelecyclidae	1.0000	0.0000	3	0.0000
Calanoid, Acartia longiremus AM	1.0000	0.0000	2	0.0000
Calanoid, Acartia longiremis AF	1.0000	0.0000	7	0.0000
Calanoid, Acartia longiremus copepodite	1.0000	-	1	-
Calanoid, Aetideidae sp.	1.0000	-	1	-
Calanoid, Acartia clausi adult	1.0000	0.0000	3	0.0000

Table 3: continued

Species	mean	se	n	p.value
Calanoid, Epilabidocera longipedata, AF	0.9983	0.0016	10	0.0000
Amphipod, Hyperiid, unknown juvenile	0.9976	0.0024	15	0.0000
Calanoid, Epilabidocera longipedata, AM	0.9976	0.0024	10	0.0000
Euphausiid furcilia	0.9932	0.0045	16	0.0000
Decapod zoea, general shrimp	0.9822	0.0178	4	0.0000
Calanoid, Calanus pacificus, general	0.9792	0.0183	4	0.0000
Decapod, Brachyura general, zoeae	0.9631	0.0369	6	0.0000
Decapod zoea, general unknown group	0.9583	0.0361	14	0.0000
Calanoid, general small (<2.5 mm)	0.8964	0.0624	16	0.0000
Calanoid, Metridia pacifica, general	0.8322	0.1666	12	0.0003
Calanoid, Metridia pacifica, AF	0.8233	0.1660	12	0.0003
Decapod zoea, hermit crab, Paguridae	0.8070	0.1808	11	0.0010
Calanoid, large, Neocalanus/Calanus	0.7490	0.2499	8	0.0171
Larvacea, Oikopleura dioica	0.7421	0.1581	13	0.0004
Calanoid, Epilabidocera longipedata, gen	0.7358	0.1699	14	0.0007
Unknown invertebrate egg, small (<0.2mm)	0.7167	0.0899	17	0.0000
Calanoid, Calanus pacificus AF	0.7143	0.2857	7	0.0410
Euphausiid calyptopis	0.6542	0.1624	13	0.0014
Decapod zoea, crab, Oregoninae	0.6372	0.2269	9	0.0205
Decapod zoea, Shrimp, Hippolytidae	0.6000	0.4000	5	0.1939
Calanoid, Epilabidocera longipedata, cop	0.5995	0.2666	10	0.0483
Larvacea, Oikopleura sp.	0.5986	0.1680	16	0.0026
Calanoid, Centropages abdominalis, adult	0.5652	0.1953	14	0.0118
Calanoid, Calanus marshallae	0.5651	0.2096	15	0.0166
Calanoid, Calanus marshallae AF	0.5556	0.2940	9	0.0914
Gastropod, Pteropod, Limacina helicina	0.5162	0.2159	13	0.0326
Harpacticoid, general copepodite	0.5000	0.5000	4	0.3739
Harpacticoid, general, unknown stage	0.5000	0.3273	8	0.1651
Unknown invertebrate egg, large (>0.2mm)	0.3813	0.3119	9	0.2526
Calanoid, Euchaeta elongata, general	0.3775	0.6225	3	0.5870
Calanoid, Pseudocalanus AF	0.3681	0.2136	13	0.1085
Calanoid, Pseudocalanus AM	0.3333	0.4216	6	0.4593
Larvacea, Oikopleura vanhoeffeni	0.3333	0.6667	3	0.6514
Calanoid, Metridia pacifica, copepodite	0.3333	0.6667	3	0.6514
Decapod, megalops, Paguridae	0.3333	0.6667	3	0.6514
Decapod zoea, crab, Brachyrhyncha	0.2597	0.3071	10	0.4175
Calanoid, Acartia longiremus adult	0.2246	0.3165	9	0.4958
Unknown egg mass	0.2000	0.4899	5	0.7000
Cladoceran, Podon sp.	0.1886	0.1895	16	0.3344

Table 3: continued

Species	mean	se	n	p.value
Bivalve, larvae	0.1660	0.2676	14	0.5450
Fish larvae, general	0.0769	0.2878	13	0.7935
Calanoid, Calanus sp. copepodids	0.0325	0.3662	8	0.9314
Amphipod, Hyperiid/Parath. pacifica gen.	0.0233	0.2982	11	0.9392

Table 4: Summary of zooplankton species avoided by Pacific herring in western Prince William Sound, 1994. Avoidance is defined as a lesser frequency of occurrence of an organism in fish stomach contents compared with the zooplankton sample from the same site.

Species	mean	se	n	p.value
Calanoid, Acartia clausi	-1.0000	-	1	-
Calanoid, Acartia sp. copepodids	-1.0000	-	1	-
Insect, Chironomidae, adult	-1.0000	-	1	-
Cnidaria (<2mm), general small jellyfish	-1.0000	0.0000	10	0.0000
Calanoid, Copepodite small	-1.0000	0.0000	12	0.0000
Calanoid, Calanus pacificus AM	-1.0000	-	1	-
Ctenophore, general (>2mm)	-1.0000	0.0000	12	0.0000
Gastropod, general juvenile (ZOOP)	-1.0000	0.0000	16	0.0000
Cnidaria, Eirene indicans	-1.0000	0.0000	7	0.0000
Cnidaria, Eirene flavicirratus	-1.0000	0.0000	3	0.0000
Cnidaria, Melicertum sp.	-1.0000	0.0000	7	0.0000
Harpacticoid, Microsetella rosea	-1.0000	-	1	-
Copepod, Monstrilla sp.	-1.0000	0.0000	2	0.0000
Nematode	-1.0000	-	1	-
Larvacea, Oikopleura < 2mm (IMS)	-1.0000	0.0000	3	0.0000
Larvacea, Oikopleura > 2mm (IMS)	-1.0000	-	1	-
Copepod, Oithona egg cases	-1.0000	0.0000	3	0.0000
Cyclopoid, Oithona copepodite	-1.0000	0.0000	4	0.0000
Amphipod, Hyperiid, Parathemisto sp.<2mm	-1.0000	-	1	-
Shrimp, Hippolytid, general	-1.0000	0.0000	7	0.0000
Gastropod, general veliger	-1.0000	0.0000	2	0.0000
Cyclopoid, Oithona similis AF	-0.9997	0.0003	5	0.0000
Calanoid, general nauplius	-0.9980	0.0014	17	0.0000
Cyclopoid, Oithona similis, general	-0.9968	0.0018	16	0.0000
Polychaeta, general, juvenile	-0.9844	0.0109	13	0.0000
Cnidaria (>2mm), general large jellyfish	-0.7778	0.2222	9	0.0067
Bryozoa, cyphonautes larva	-0.7744	0.1276	10	0.0001
Chaetognath, Sagitta	-0.7143	0.2857	7	0.0410
Unknown nauplius	-0.6000	0.4000	5	0.1939
Calanoid, Pseudocalanus copepodids I-IV	-0.5000	0.5000	4	0.3739
Euphausiid nauplii	-0.4834	0.3241	8	0.1742
Polychaeta, trochophore larva	-0.4610	0.3198	8	0.1874
Calanoid, Acartia longiremis , General	-0.3447	0.2194	14	0.1384

Table 4: continued

Species	mean	se	n	p.value
Polychaeta, Polynoidae	-0.2605	0.7395	2	0.7583
Calanoid, Acartia sp.	-0.2500	0.3660	8	0.5138
Calanoid, Pseudocalanus sp., general	-0.2320	0.1476	16	0.1355
Barnacle, cyprid	-0.1918	0.2729	13	0.4945
Cladoceran, Evadne sp.	-0.1070	0.2053	15	0.6099
Barnacle, nauplius	-0.0477	0.2919	9	0.8738
Calanoid, Eucalanus bungii, general	-0.0211	0.5654	4	0.9720
JELLY: Cnidarian or Ctenophore mush	0.0000	1.0000	2	1.0000
Calanoid, C. marshallae copepodite	0.0000	1.0000	2	1.0000
Ctenophore, general (<2mm)	0.0000	1.0000	2	1.0000
Larvacea, Fritilaria sp. (borealis)	0.0000	1.0000	2	1.0000
Fish egg (~1.0 mm)	0.0000	1.0000	2	1.0000
Amphipod, Hyperiid, Parathem. sp.2-6.9mm	0.0000	1.0000	2	1.0000

Table 5: Summary of zooplankton species preferred by pink salmon in western Prince William Sound, 1994. Preference is defined as a greater frequency of occurrence of an organism in fish stomach contents compared with the zooplankton sample from the same site.

Species	mean	se	n	p.value
Euphausiid, T. spinifera	1.0000	-	1	-
Euphausiid, T. raschii, general	1.0000	-	1	-
Euphausiid, T. longipes	1.0000	-	1	-
Euphausiid, T. inermis	1.0000	-	1	-
Euphausiid, Thysanoessa sp. juvenile	1.0000	-	1	-
Euphausiid, Thysannoessa sp., adult	1.0000	0.0000	2	0.0000
Decapod zoea, general shrimp	1.0000	-	1	-
Insect, Sciaridae (beetle)	1.0000	-	1	-
Gastropod, Pteropod, unidentified	1.0000	-	1	-
Amphipod, Hyperiid, P. libellula	1.0000	-	1	-
Amphipod, Hyperiid, Primno macropa, gen.	1.0000	0.0000	2	0.0000
Amphipod, Hyperiid, P. macropa, 2-6.9mm	1.0000	-	1	-
Amphipod, Hyperiid, P. libellula 2-6.9mm	1.0000	-	1	-
Decapod zoea, Shrimp, Pandalidae	1.0000	-	1	-
Copepod, Caligidae, parasitic copepod	1.0000	-	1	-
Amphipod, P. pacifica, general juvenile	1.0000	0.0000	5	0.0000
Amphipod, P. pacifica juvenile, 2-6.9mm	1.0000	-	1	-
Amphipod, P. pacifica juvenile, <2mm	1.0000	-	1	-
Larvacea, O. vanhoeffeni capsule	1.0000	-	1	-
Calanoid, Neocalanus spp. adult	1.0000	0.0000	2	0.0000
Nematode	1.0000	-	1	-
Calanoid, Metridia pacifica, AM	1.0000	-	1	-
Calanoid, Metridia pacifica, adult	1.0000	-	1	-
Malacostraca	1.0000	0.0000	2	0.0000
Malacostraca, eyes only	1.0000	0.0000	3	0.0000
Insect, general	1.0000	-	1	-
Amphipod, Hyperiid, Hyperia medusarum	1.0000	-	1	-
Harpacticoid, general, unknown stage	1.0000	-	1	-
Amphipod, Hyperiid, Hyperoche medusarum	1.0000	-	1	-
Amphipod, Hyperiid, Hyperia sp.	1.0000	-	1	-
Insect, Homopteran	1.0000	-	1	-
Amphipod, Gammarid, unknown, medium	1.0000	-	1	-
Fish, juvenile, general	1.0000	-	1	-
Euphausiid, general unknown	1.0000	0.0000	3	0.0000
Euphausiid juvenile	1.0000	-	1	-

Table 5: continued

Species	mean	se	n	p.value
Calanoid, Epilabidocera longipedata, gen	1.0000	0.0000	4	0.0000
Chaetognath, Eukrohnia hamata	1.0000	-	1	-
Insect, Dipteran larvae	1.0000	0.0000	2	0.0000
Decapod, megalops, Paguridae	1.0000	0.0000	2	0.0000
Decapod, megalops, Lithodidae	1.0000	-	1	-
Insect, Dipteran adult	1.0000	0.0000	4	0.0000
Decapod, Brachyura general, zoeae	1.0000	-	1	-
Decapod, megalops, unknown crab	1.0000	0.0000	3	0.0000
Cumacea	1.0000	-	1	-
Calanoid, Calanus pacificus, adult	1.0000	-	1	-
Insect, Collembola, general	1.0000	-	1	-
Ostracod, Conchoecia sp.	1.0000	-	1	-
Calanoid, Calanus marshallae AM	1.0000	-	1	-
Calanoid, large, NOT Neocalanus/Calanus	1.0000	-	1	-
Cladocera, General	1.0000	-	1	-
Chaetognath, species unknown	1.0000	0.0000	2	0.0000
Amphipod, Gammarid, Cypho. challengeri	1.0000	0.0000	2	0.0000
Calanoid, general large (>2.5 mm)	1.0000	0.0000	5	0.0000
Decapod, Cancridae megalops	1.0000	-	1	-
Calanoid, Candacia columbiae	1.0000	-	1	-
Barnacle, adult molt (cirri)	1.0000	-	1	-
Decapoda, Cancrid crab, Atelecyclidae	1.0000	-	1	-
Fish, Ammodytes hexapterus (sandlance)	1.0000	-	1	-
Calanoid, Acartia longiremus adult	1.0000	-	1	-
Fish larvae, general	1.0000	0.0000	4	0.0000
Amphipod, Hyperiid, unknown juvenile	0.9949	0.0051	3	0.0000
Calanoid, Metridia pacifica, general	0.9879	0.0119	2	0.0001
Fish egg (~1.0 mm)	0.9813	-	1	-
Decapod zoea, general unknown group	0.9676	0.0184	3	0.0000
Larvacea, Oikopleura dioica	0.7183	0.2817	3	0.0840
Larvacea, Oikopleura sp.	0.7042	0.1248	4	0.0049
Euphausiid furcilia	0.5000	0.5000	4	0.3739
Calanoid, Metridia pacifica, AF	0.4973	0.4991	4	0.3754
Gastropod, Pteropod, Limacina helicina	0.3336	0.6664	3	0.6511
Calanoid, Epilabidocera longipedata, AM	0.3333	0.6667	3	0.6514
Calanoid, Epilabidocera longipedata, AF	0.3333	0.6667	3	0.6514
Calanoid, large, Neocalanus/Calanus	0.3333	0.6667	3	0.6514
JELLY: Cnidarian or Ctenophore mush	0.3333	0.6667	3	0.6514
Calanoid, Epilabidocera longipedata, cop	0.3333	0.6666	3	0.6515

Table 5: continued

Species	mean	se	n	p.value
Calanoid, Calanus marshallae AF	0.3330	0.6665	3	0.6517
Cnidaria (>2mm), general large jellyfish	0.3328	0.6664	3	0.6518
Calanoid, general small (<2.5 mm)	0.2127	0.4822	5	0.6775
Calanoid, Calanus marshallae	0.1960	0.4883	5	0.7047

Table 6: Summary of zooplankton species avoided by pink salmon in western Prince William Sound, 1994. Avoidance is defined as a lesser frequency of occurrence of an organism in fish stomach contents compared with the zooplankton sample from the same site.

Species	mean	se	n	p.value
Calanoid, Acartia sp.	-1.0000	-	1	-
Calanoid, Acartia clausi	-1.0000	-	1	-
Calanoid, Acartia sp. copepodids	-1.0000	-	1	-
Calanoid, Acartia longiremis , General	-1.0000	0.0000	3	0.0000
Barnacle, nauplius	-1.0000	0.0000	2	0.0000
Calanoid, Centropages abdominalis, adult	-1.0000	0.0000	2	0.0000
Calanoid, general nauplius	-1.0000	0.0000	5	0.0000
Bryozoa, cyphonautes larva	-1.0000	0.0000	5	0.0000
Calanoid, C. marshallae copepodite	-1.0000	-	1	-
Cnidaria (<2mm), general small jellyfish	-1.0000	0.0000	4	0.0000
Calanoid, Copepodite small	-1.0000	0.0000	3	0.0000
Calanoid, Calanus sp. copepodids	-1.0000	-	1	-
Calanoid, Calanus pacificus AF	-1.0000	-	1	-
Ctenophore, general (>2mm)	-1.0000	0.0000	4	0.0000
Unknown invertebrate egg, small (<0.2mm)	-1.0000	0.0000	3	0.0000
Unknown invertebrate egg, large (>0.2mm)	-1.0000	0.0000	2	0.0000
Calanoid, Eucalanus bungii, general	-1.0000	0.0000	2	0.0000
Calanoid, Euchaeta elongata, general	-1.0000	-	1	-
Larvacea, Fritilaria sp. (borealis)	-1.0000	-	1	-
Gastropod, general juvenile (ZOOP)	-1.0000	0.0000	5	0.0000
Harpacticoid, general copepodite	-1.0000	-	1	-
Harpacticoid, Microsetella rosea	-1.0000	-	1	-
Calanoid, Metridia pacifica, copepodite	-1.0000	-	1	-
Copepod, Monstrilla sp.	-1.0000	-	1	-
Copepod, Oithona egg cases	-1.0000	0.0000	2	0.0000
Cyclopoid, Oithona similis, general	-1.0000	0.0000	4	0.0000
Cyclopoid, Oithona copepodite	-1.0000	0.0000	2	0.0000
Cyclopoid, Oithona similis AF	-1.0000	0.0000	2	0.0000
Polychaeta, Polynoidae	-1.0000	0.0000	2	0.0000
Amphipod, Hyperiid, Parathemisto sp.<2mm	-1.0000	-	1	-
Calanoid, Pseudocalanus AF	-1.0000	0.0000	2	0.0000
Calanoid, Pseudocalanus AM	-1.0000	0.0000	2	0.0000
Chaetognath, Sagitta	-1.0000	-	1	-
Shrimp, Hippolytid, general	-1.0000	0.0000	2	0.0000
Polychaeta, trochophore larva	-1.0000	-	1	-

Table 6: continued

Species	mean	se	n	p.value
Unknown nauplius	-1.0000	0.0000	2	0.0000
Calanoid, Pseudocalanus sp., general	-0.9988	0.0012	3	0.0000
Polychaeta, general, juvenile	-0.9919	0.0081	3	0.0000
Euphausiid nauplii	-0.9533	0.0467	2	0.0024
Euphausiid calyptopis	-0.9533	0.0467	2	0.0024
Barnacle, cyprid	-0.9023	0.0977	3	0.0027
Cladoceran, Podon sp.	-0.5189	0.3825	5	0.2329
Cladoceran, Evadne sp.	-0.4518	0.4861	4	0.4052
Bivalve, larvae	-0.3333	0.6667	3	0.6514
Decapod zoea, crab, Oregoninae	-0.3333	0.6667	3	0.6514
Amphipod, Hyperiid/Parath. pacifica gen.	-0.3333	0.6667	3	0.6514
Calanoid, Calanus pacificus AM	0.0000	1.0000	2	1.0000
Ctenophore, general (<2mm)	0.0000	1.0000	2	1.0000
Decapod zoea, crab, Brachyrhyncha	0.0000	0.5774	4	1.0000
Calanoid, Pseudocalanus copepodids I-IV	0.0000	1.0000	2	1.0000
Decapod zoea, hermit crab, Paguridae	0.0000	1.0000	2	1.0000
Amphipod, Hyperiid, Parathem. sp.2-6.9mm	0.0000	1.0000	2	1.0000

Table 7: Summary of zooplankton species preferred by chum salmon in western Prince William Sound, 1994. Preference is defined as a greater frequency of occurrence of an organism in fish stomach contents compared with the zooplankton sample from the same site.

Species	mean	se	n	p.value
Euphausiid, T. spinifera	1.0000	0.0000	2	0.0000
Euphausiid, T. raschii males	1.0000	-	1	-
Euphausiid, T. raschii females	1.0000	-	1	-
Euphausiid, T. longipes	1.0000	-	1	-
Insect, Dipteran, Tipulidae (larvae)	1.0000	-	1	-
Euphausiid, Thysannoessa sp., adult	1.0000	0.0000	5	0.0000
Amphipod, Hyperiid, P. libellula	1.0000	0.0000	2	0.0000
Amphipod, Hyperiid, Primno macropa, gen.	1.0000	0.0000	2	0.0000
Amphipod, Hyperiid, P. macropa, 7+mm	1.0000	-	1	-
Amphipod, Hyperiid, P. macropa, 2-6.9mm	1.0000	0.0000	2	0.0000
Amphipod, Hyperiid, Primno macropa, <2mm	1.0000	-	1	-
Amphipod, Hyperiid, P. libellula 2-6.9mm	1.0000	-	1	-
Amphipod, Hyperiid, P.libellula <2mm	1.0000	-	1	-
Decapod zoea, Shrimp, Pandalidae	1.0000	-	1	-
Amphipod, P. pacifica, general juvenile	1.0000	0.0000	7	0.0000
Amphipod, Hyperiid/Parath. pacifica ad.	1.0000	-	1	-
Amphipod, P. pacifica juvenile, 2-6.9mm	1.0000	0.0000	2	0.0000
Calanoid, Neocalanus spp. adult	1.0000	0.0000	3	0.0000
Nematode	1.0000	0.0000	5	0.0000
Mytiloida, Musculus sp.	1.0000	-	1	-
Calanoid, Metridia pacifica, adult	1.0000	0.0000	2	0.0000
Calanoid, Metridia ochotensis AF	1.0000	-	1	-
Gastropoda, Nudibranch, Melibe sp.	1.0000	-	1	-
Malacostraca	1.0000	0.0000	8	0.0000
Malacostraca, eyes only	1.0000	0.0000	3	0.0000
Insect, general	1.0000	-	1	-
Amphipod, Hyperiid, Hyperia medusarum	1.0000	-	1	-
Cnidaria, Hydrozoan, general	1.0000	0.0000	2	0.0000
Amphipod, Hyperiid, unknown adult	1.0000	0.0000	2	0.0000
Amphipod, Gammarid, unknown, medium	1.0000	-	1	-
Fish, juvenile, general	1.0000	0.0000	2	0.0000
Euphausiid, general unknown	1.0000	0.0000	4	0.0000
Euphausiid juvenile	1.0000	0.0000	2	0.0000
Calanoid, Euchaeta elongata ad. male	1.0000	-	1	-
Calanoid, Euchaeta elongata, AF	1.0000	-	1	-

Table 7: continued

Species	mean	se	n	p.value
Decapod, megalops, Lithodidae	1.0000	-	1	-
Insect, Dipteran adult	1.0000	-	1	-
Decapod, megalops, unknown crab	1.0000	0.0000	4	0.0000
Calanoid, Calanus marshallae AM	1.0000	-	1	-
Cladocera, General	1.0000	0.0000	3	0.0000
Chaetognath, species unknown	1.0000	0.0000	2	0.0000
Amphipod, Gammarid, Cypho. challengeri	1.0000	0.0000	2	0.0000
Calanoid, general large (>2.5 mm)	1.0000	0.0000	8	0.0000
Decapod, Cancridae megalops	1.0000	0.0000	6	0.0000
Barnacle, adult molt (cirri)	1.0000	0.0000	4	0.0000
Fish, Ammodytes hexapterus (sandlance)	1.0000	0.0000	2	0.0000
Calanoid, Acartia longiremis AF	1.0000	-	1	-
Calanoid, Epilabidocera longipedata, AF	0.9996	0.0004	3	0.0000
Ctenophore, general (<2mm)	0.9995	0.0004	15	0.0000
Calanoid, Epilabidocera longipedata, AM	0.9982	0.0018	3	0.0000
Amphipod, Hyperiid, unknown juvenile	0.8182	0.1818	11	0.0009
Fish larvae, general	0.8182	0.1818	11	0.0009
JELLY: Cnidarian or Ctenophore mush	0.7778	0.2222	9	0.0067
Larvacea, Oikopleura sp.	0.7527	0.1435	14	0.0001
Calanoid, Metridia pacifica, general	0.7140	0.2857	7	0.0410
Euphausiid furcilia	0.6503	0.3304	6	0.0966
Calanoid, Centropages abdominalis, AF	0.5000	0.5000	4	0.3739
Calanoid, Metridia pacifica, AF	0.4283	0.3688	7	0.2835
Calanoid, general small (<2.5 mm)	0.3618	0.2778	11	0.2195
Calanoid, Epilabidocera longipedata, gen	0.3468	0.3555	7	0.3618
Calanoid, Calanus pacificus, general	0.3333	0.6667	3	0.6514
Calanoid, Acartia longiremus adult	0.3333	0.4216	6	0.4593
Cnidaria (>2mm), general large jellyfish	0.3211	0.2813	12	0.2760
Calanoid, Calanus marshallae	0.2674	0.3030	11	0.3963
Chaetognath, Sagitta	0.2456	0.3647	8	0.5196
Gastropod, Pteropod, Limacina helicina	0.1515	0.4001	7	0.7161
Larvacea, Oikopleura dioica	0.1256	0.3046	11	0.6881

Table 8: Summary of zooplankton species avoided by chum salmon in western Prince William Sound, 1994. Avoidance is defined as a lesser frequency of occurrence of an organism in fish stomach contents compared with the zooplankton sample from the same site.

Species	mean	se	n	p.value
Calanoid, Acartia sp.	-1.0000	0.0000	4	0.0000
Calanoid, Acartia clausi adult	-1.0000	-	1	-
Calanoid, Acartia clausi	-1.0000	-	1	-
Calanoid, Acartia sp. copepodids	-1.0000	-	1	-
Calanoid, Acartia longiremus copepodite	-1.0000	-	1	-
Calanoid, Acartia longiremus AM	-1.0000	-	1	-
Bivalve, larvae	-1.0000	0.0000	6	0.0000
Calanoid, general nauplius	-1.0000	0.0000	15	0.0000
Bryozoa, cyphonautes larva	-1.0000	0.0000	9	0.0000
Insect, Chironomidae, adult	-1.0000	-	1	-
Calanoid, C. marshallae copepodite	-1.0000	-	1	-
Cnidaria (<2mm), general small jellyfish	-1.0000	0.0000	9	0.0000
Calanoid, Copepodite small	-1.0000	0.0000	11	0.0000
Calanoid, Calanus sp. copepodids	-1.0000	0.0000	5	0.0000
Calanoid, Calanus pacificus AM	-1.0000	-	1	-
Decapod, Brachyura general, zoeae	-1.0000	-	1	-
Decapod, megalops, Paguridae	-1.0000	-	1	-
Unknown invertebrate egg, large (>0.2mm)	-1.0000	0.0000	3	0.0000
Euphausiid calyptopis	-1.0000	0.0000	4	0.0000
Calanoid, Eucalanus bungii, general	-1.0000	0.0000	3	0.0000
Larvacea, Fritilaria sp. (borealis)	-1.0000	0.0000	2	0.0000
Gastropod, general juvenile (ZOOP)	-1.0000	0.0000	14	0.0000
Harpacticoid, general, unknown stage	-1.0000	0.0000	2	0.0000
Harpacticoid, general copepodite	-1.0000	-	1	-
Cnidaria, Eirene indicans	-1.0000	0.0000	5	0.0000
Cnidaria, Eirene flavicirratus	-1.0000	-	1	-
Cnidaria, Melicertum sp.	-1.0000	0.0000	5	0.0000
Harpacticoid, Microsetella rosea	-1.0000	-	1	-
Calanoid, Metridia pacifica, copepodite	-1.0000	-	1	-
Copepod, Monstrilla sp.	-1.0000	0.0000	2	0.0000
Larvacea, Oikopleura < 2mm (IMS)	-1.0000	0.0000	2	0.0000
Larvacea, Oikopleura > 2mm (IMS)	-1.0000	-	1	-
Copepod, Oithona egg cases	-1.0000	0.0000	4	0.0000
Decapod zoea, crab, Oregoninae	-1.0000	0.0000	3	0.0000
Cyclopoid, Oithona similis, general	-1.0000	0.0000	14	0.0000

Table 8: continued

Species	mean	se	n	p.value
Cyclopoid, Oithona copepodite	-1.0000	0.0000	4	0.0000
Cyclopoid, Oithona similis AF	-1.0000	0.0000	5	0.0000
Polychaeta, general, juvenile	-1.0000	0.0000	10	0.0000
Amphipod, Gammarid,Pleustes cataphractus	-1.0000	-	1	-
Polychaeta, Polynoidae	-1.0000	0.0000	2	0.0000
Amphipod, Hyperiid, Parathemisto sp.<2mm	-1.0000	0.0000	2	0.0000
Calanoid, Pseudocalanus AM	-1.0000	0.0000	4	0.0000
Decapod zoea, general shrimp	-1.0000	0.0000	2	0.0000
Shrimp, Hippolytid, general	-1.0000	0.0000	6	0.0000
Polychaeta, Spionidae	-1.0000	-	1	-
Polychaeta, trochophore larva	-1.0000	0.0000	6	0.0000
Unknown egg mass	-1.0000	0.0000	2	0.0000
Gastropod, general veliger	-1.0000	-	1	-
Calanoid, Acartia longiremis , General	-0.9968	0.0032	9	0.0000
Calanoid, Pseudocalanus sp., general	-0.9936	0.0064	12	0.0000
Cladoceran, Evadne sp.	-0.7006	0.2066	10	0.0069
Euphausiid nauplii	-0.6667	0.3333	6	0.0924
Barnacle, nauplius	-0.6346	0.2566	8	0.0385
Unknown invertebrate egg, small (<0.2mm)	-0.6317	0.2433	11	0.0248
Decapod zoea, hermit crab, Paguridae	-0.5000	0.5000	4	0.3739
Unknown nauplius	-0.5000	0.5000	4	0.3739
Cladoceran, Podon sp.	-0.4349	0.2195	13	0.0691
Calanoid, Centropages abdominalis, adult	-0.4301	0.3679	7	0.2806
Amphipod, Hyperiid/Parath. pacifica gen.	-0.4005	0.3052	10	0.2188
Barnacle, cyprid	-0.3890	0.2648	11	0.1699
Calanoid, large, Neocalanus/Calanus	-0.3333	0.6667	3	0.6514
Calanoid, Epilabidocera longipedata, cop	-0.3333	0.6667	3	0.6514
Calanoid, Pseudocalanus copepodids I-IV	-0.3333	0.6667	3	0.6514
Amphipod, Hyperiid, Parathem. sp.2-6.9mm	-0.3333	0.6667	3	0.6514
Decapod zoea, general unknown group	-0.2785	0.4462	5	0.5598
Calanoid, Pseudocalanus AF	-0.2032	0.3261	9	0.5488
Ctenophore, general (>2mm)	-0.1048	0.3103	11	0.7420
Calanoid, Calanus marshallae AF	-0.0014	0.9986	2	0.9990
Decapod zoea, crab, Brachyrhyncha	-0.0001	0.4472	6	0.9998
Calanoid, Neocalanus cristatus, adult	0.0000	1.0000	2	1.0000
Calanoid, Calanus pacificus AF	0.0000	1.0000	2	1.0000
Calanoid, Euchaeta elongata, general	0.0000	1.0000	2	1.0000
Fish egg (~1.0 mm)	0.0000	1.0000	2	1.0000
Calanoid, Metridia pacifica, AM	0.0000	1.0000	2	1.0000

Appendix II: Summary of prey electivity indices for epibenthic invertebrate species consumed by Pacific herring, walleye pollock, pink salmon and chum salmon in western Prince William Sound, September 1994.

Table 1: Summary of epibenthic species preferred by walleye pollock in western Prince William Sound, 1994. Preference is defined as a greater frequency of occurrence of an organism in fish stomach contents compared with the epibenthic pump sample from the same site.

Species	mean	se	n	p.value
Euphausiid, T. spinifera	1.0000	0.0000	2	0.0000
Euphausiid, T. raschii females	1.0000	-	1	-
Euphausiid, Thysannoessa sp., adult	1.0000	0.0000	5	0.0000
Chaetognath, Sagitta	1.0000	0.0000	2	0.0000
Calanoid, Pseudocalanus AM	1.0000	0.0000	2	0.0000
Amphipod, Hyperiid, P. libellula	1.0000	0.0000	2	0.0000
Amphipod, Hyperiid/Parath. pacifica gen.	1.0000	0.0000	5	0.0000
Amphipod, Hyperiid, P. libellula 2-6.9mm	1.0000	-	1	-
Amphipod, P. pacifica, general juvenile	1.0000	-	1	-
Amphipod, P. pacifica juvenile, <2mm	1.0000	-	1	-
Decapod zoea, crab, Oregoninae	1.0000	0.0000	2	0.0000
Larvacea, Oikopleura vanhoeffeni	1.0000	0.0000	2	0.0000
Larvacea, Oikopleura sp.	1.0000	0.0000	8	0.0000
Larvacea, O. vanhoeffeni capsule	1.0000	0.0000	2	0.0000
Calanoid, Neocalanus spp. adult	1.0000	0.0000	2	0.0000
Calanoid, M. ochotensis copepodite MALE	1.0000	-	1	-
Calanoid, Metridia pacifica, AM	1.0000	0.0000	2	0.0000
Calanoid, Metridia pacifica, AF	1.0000	0.0000	5	0.0000
Calanoid, Metridia pacifica, copepodite	1.0000	-	1	-
Calanoid, Metridia pacifica, adult	1.0000	0.0000	2	0.0000
Calanoid, M. ochotensis AM	1.0000	-	1	-
Calanoid, Metridia sp., General	1.0000	0.0000	3	0.0000
Calanoid, Metridia pacifica, general	1.0000	0.0000	2	0.0000
Calanoid, Metridia sp. copepodids I-IV	1.0000	-	1	-
Malacostraca, eyes only	1.0000	0.0000	7	0.0000
Larvacea, general	1.0000	-	1	-
Gastropod, Pteropod, Limacina helicina	1.0000	0.0000	8	0.0000
Amphipod, Hyperiid, unknown juvenile	1.0000	0.0000	10	0.0000
Amphipod, Hyperiid, Hyperia sp.	1.0000	-	1	-

Table1: continued

Species	mean	se	n	p.value
Fish, Clupea harengus pallasi (herring)	1.0000	-	1	-
Gastropod, general juvenile (EPI)	1.0000	0.0000	7	0.0000
Fish larvae, general	1.0000	0.0000	2	0.0000
Fish egg (~1.0 mm)	1.0000	-	1	-
Calanoid, Euchaeta elongata, general	1.0000	0.0000	3	0.0000
Calanoid, Eucalanus bungii, general	1.0000	-	1	-
Euphausiid furcilia	1.0000	0.0000	7	0.0000
Euphausiid calyptopis	1.0000	0.0000	6	0.0000
Euphausiid egg	1.0000	-	1	-
Calanoid, Epilabidocera longipedata, AM	1.0000	0.0000	2	0.0000
Calanoid, Epilabidocera longipedata, gen	1.0000	0.0000	6	0.0000
Calanoid, Epilabidocera longipedata, AF	1.0000	0.0000	4	0.0000
Calanoid, Epilabidocera longipedata, cop	1.0000	0.0000	2	0.0000
Decapod, Brachyura general, zoeae	1.0000	-	1	-
Calanoid, Calanus pacificus AF	1.0000	0.0000	2	0.0000
Calanoid, Calanus sp. copepodids	1.0000	0.0000	6	0.0000
Calanoid, Copepodite small	1.0000	-	1	-
Calanoid, Calanus marshallae AF	1.0000	0.0000	4	0.0000
Calanoid, Calanus marshallae	1.0000	0.0000	6	0.0000
Calanoid, large, NOT Neocalanus/Calanus	1.0000	0.0000	5	0.0000
Calanoid, large, Neocalanus/Calanus	1.0000	0.0000	5	0.0000
Chaetognath, species unknown	1.0000	-	1	-
JELLY: Cnidarian or Ctenophore mush	1.0000	-	1	-
Calanoid, Centropages abdominalis, AM	1.0000	0.0000	7	0.0000
Calanoid, general large (>2.5 mm)	1.0000	0.0000	9	0.0000
Decapod, Cancridae megalops	1.0000	0.0000	2	0.0000
Calanoid, Centropages abdominalis, copdt	1.0000	-	1	-
Calanoid, Acartia longiremus AM	1.0000	-	1	-
Calanoid, Acartia longiremis AF	1.0000	0.0000	2	0.0000
Calanoid, Acartia longiremus copepodite	1.0000	-	1	-
Malacostraca	0.9807	0.0193	9	0.0000
Unknown invertebrate egg, small (<0.2mm)	0.9718	0.0162	10	0.0000
Decapod zoea, general unknown group	0.8662	0.1338	4	0.0029
Calanoid, Pseudocalanus AF	0.8235	0.0963	9	0.0000
Larvacea, Oikopleura dioica	0.7778	0.2222	9	0.0067
Calanoid, Centropages abdominalis, adult	0.7263	0.1799	6	0.0068
Calanoid, Pseudocalanus sp., general	0.7146	0.1344	10	0.0003
Calanoid, Centropages abdominalis, AF	0.7143	0.2857	7	0.0410
Calanoid, general small (<2.5 mm)	0.6835	0.1553	10	0.0013

Table 1: continued

Species	mean	se	n	p.value
Calanoid, Acartia longiremus adult	0.6667	0.3333	6	0.0924
Euphausiid, general unknown	0.6000	0.4000	5	0.1939
Cladoceran, Evadne sp.	0.5000	0.5000	4	0.3739
Barnacle, cyprid	0.3554	0.3670	6	0.3703
Decapod, megalops, unknown crab	0.3333	0.6667	3	0.6514
Barnacle, nauplius	0.3333	0.6667	3	0.6514
Nematode	0.0000	1.0000	2	1.0000
Isopod, general	0.0000	1.0000	2	1.0000
Harpacticoid, general adult	0.0000	0.5774	4	1.0000
Harpacticoid, Harpacticus female adult	0.0000	1.0000	2	1.0000
Cladocera, General	0.0000	1.0000	2	1.0000

Table 2: Summary of epibenthic species avoided by walleye pollock in western Prince William Sound, 1994. Avoidance is defined as a lesser frequency of occurrence of an organism in fish stomach contents compared with the epibenthic pump sample from the same site.

Species	mean	se	n	p.value
Calanoid, Acartia clausi adult	-1.0000	-	1	-
Calanoid, Acartia clausi copepodite	-1.0000	-	1	-
Calanoid, Acartia sp. copepodids	-1.0000	-	1	-
Polychaeta, Ampharetidae	-1.0000	-	1	-
Amphipod, Caprellidae, gravidfemale	-1.0000	0.0000	2	0.0000
Amphipod, Caprellidae	-1.0000	0.0000	8	0.0000
Bryozoa, cyphonautes larva	-1.0000	0.0000	3	0.0000
Polychaeta, Cistenides granulata	-1.0000	-	1	-
Cumacea	-1.0000	0.0000	2	0.0000
Cyclopoid, general unknown	-1.0000	-	1	-
Shrimp, Hippolytid, Eualus sp.	-1.0000	0.0000	3	0.0000
Shrimp, Hippolytid, Eualus fabricii	-1.0000	-	1	-
Shrimp, Hippolytid, Eualus biunguis	-1.0000	-	1	-
Polychaeta, Exogone sp.	-1.0000	0.0000	2	0.0000
Calanoid, Eurytemora pacifica AF	-1.0000	-	1	-
Amphipod, Gammarid, unknown, small	-1.0000	-	1	-
Amphipod, general gravid gammarid	-1.0000	-	1	-
Amphipod, Gammarid, Ampithoe	-1.0000	-	1	-
Amphipod, Gammarid, unknown, no size	-1.0000	0.0000	4	0.0000
Amphipod, Gammarid Ischyocerus, gravid	-1.0000	-	1	-
Amphipod, Gammarid, Ischyocerus type	-1.0000	0.0000	5	0.0000
Gastropod, general juvenile (EPI)	-1.0000	0.0000	8	0.0000
Amphipod, Gammarid, Halirages bungei	-1.0000	-	1	-
Harpacticoid, Dactylopodia, general	-1.0000	0.0000	6	0.0000
Harpacticoid, Ectinosomatidae	-1.0000	0.0000	5	0.0000
Harpacticoid, Ectinosomatid, gravid	-1.0000	-	1	-
Harpacticoid, general eggsac	-1.0000	0.0000	5	0.0000
Shrimp, Hippolytid, Heptacarpus sp.	-1.0000	-	1	-
Polychaeta, Hesionidae	-1.0000	0.0000	2	0.0000
Bivalve, Hiatella arctica	-1.0000	-	1	-
Shrimp, Hippolytid, He. tenuissimus	-1.0000	-	1	-
Harpacticoid, general copepodite	-1.0000	0.0000	5	0.0000
Harpacticoid, general gravid (eggs)	-1.0000	0.0000	2	0.0000
Harpacticoid, Harpacticus gravid female	-1.0000	0.0000	3	0.0000
Harpacticoid, Harpacticus copepodite	-1.0000	0.0000	3	0.0000

Table 2: continued

Species	mean	se	n	p.value
Harpacticoid, general nauplius	-1.0000	0.0000	4	0.0000
Harpacticoid, unknown, brown	-1.0000	-	1	-
Harpacticoid, general, unknown female	-1.0000	-	1	-
Harpacticoid, Zaus, general adult	-1.0000	0.0000	3	0.0000
Harpacticoid, Zaus copepodite	-1.0000	0.0000	2	0.0000
Harpacticoid, Laophontidae, copepodite	-1.0000	-	1	-
Harpacticoid, Laophontidae, adult	-1.0000	0.0000	8	0.0000
Gastropoda, Lacuna sp.	-1.0000	-	1	-
Shrimp, Hippolytid, Lebbeus sp.	-1.0000	0.0000	2	0.0000
Polychaeta, Lumbrineris sp.	-1.0000	-	1	-
Gastropoda, snail, Margarites sp.	-1.0000	-	1	-
Gastropoda, Micronellum crebricinctum	-1.0000	-	1	-
Arthropod, Arachnid, Halacarid mite	-1.0000	-	1	-
Calanoid, Metridia ochotensis, no sex	-1.0000	-	1	-
Isopod, Munna sp.	-1.0000	0.0000	4	0.0000
Mytiloida, Musculus sp.	-1.0000	-	1	-
Mytiloida, Musculus vernicosus	-1.0000	-	1	-
Mysidae, general, stage unknown	-1.0000	-	1	-
Mysidae, general juv. (stage 5)	-1.0000	0.0000	2	0.0000
Amphipod, Gammarid, Najna sp.	-1.0000	-	1	-
Polychaeta, Nereidae	-1.0000	0.0000	2	0.0000
Mysidae, Neomysis kadiakensis	-1.0000	-	1	-
Amphipod, Gammarid, Odius sp.	-1.0000	0.0000	3	0.0000
Amphipod, Gammarid, Oedicerotidae	-1.0000	0.0000	2	0.0000
Copepod, Oithona egg cases	-1.0000	-	1	-
Cyclopoid, Oithona sp., general	-1.0000	0.0000	5	0.0000
Oligochaete	-1.0000	-	1	-
Polychaeta, Onuphis sp.	-1.0000	-	1	-
Cyclopoid, Oithona copepodite	-1.0000	-	1	-
Cyclopoid, Oithona similis AF	-1.0000	-	1	-
Ostracod, general unknown	-1.0000	0.0000	7	0.0000
Calanoid, Pseudocalanus copepodids I-IV	-1.0000	0.0000	2	0.0000
Decapod zoea, hermit crab, Paguridae	-1.0000	-	1	-
Polychaeta, Pholoe minuta	-1.0000	0.0000	3	0.0000
Polychaeta, adult	-1.0000	-	1	-
Amphipod, Gammarid, Pleustidae	-1.0000	-	1	-
Harpacticoid, Porcellidium	-1.0000	0.0000	5	0.0000
Amphipod, Gammarid, Pontogeneia sp.	-1.0000	-	1	-
Polychaeta, Polynoidae	-1.0000	0.0000	5	0.0000

Table 2: continued

Species	mean	se	n	p.value
Calanoid, Pseudocalanus GF	-1.0000	-	1	-
Shrimp, general unknown juv./adult	-1.0000	-	1	-
Decapod zoea, general shrimp	-1.0000	-	1	-
Shrimp, Hippolytid, Heptacarpus stylus	-1.0000	-	1	-
Polychaeta, Sphaerosyllis erinaceus	-1.0000	0.0000	2	0.0000
Shrimp, Hippolytid, Spirontocaris sp.	-1.0000	-	1	-
Polychaeta, Spionidae	-1.0000	-	1	-
Polychaeta, Syllidae	-1.0000	-	1	-
Amphipod, Gammarid, Tiron biocellata	-1.0000	-	1	-
Polychaeta, trochophore larva	-1.0000	-	1	-
Harpacticoid, Tisbe copepodite	-1.0000	0.0000	5	0.0000
Harpacticoid, Tisbe sp., gravid female	-1.0000	0.0000	3	0.0000
Harpacticoid, Tisbe sp., stage unknown	-1.0000	0.0000	9	0.0000
Unknown egg mass	-1.0000	0.0000	3	0.0000
Harpacticoid, Harpacticus sp. general ad	-0.9991	0.0009	9	0.0000
Harpacticoid, general, unknown stage	-0.9983	0.0016	7	0.0000
Bivalve, larvae	-0.9771	0.0217	9	0.0000
Calanoid, general nauplius	-0.8361	0.1633	9	0.0006
Polychaeta, general, juvenile	-0.6765	0.2819	7	0.0475
Unknown nauplius	-0.6663	0.3333	6	0.0925
Harpacticoid, Tisbe sp., adult	-0.6000	0.4000	5	0.1939
Calanoid, Acartia longiremis , General	-0.5394	0.3873	5	0.2225
Amphipod, Gammarid, unknown, medium	-0.5000	0.5000	4	0.3739
Shrimp, Hippolytid, general	-0.5000	0.5000	4	0.3739
Cyclopoid, Oithona similis, general	-0.4941	0.4981	4	0.3773
Unknown invertebrate egg, large (>0.2mm)	-0.4210	0.3670	7	0.2890
Ostracod, Conchoecia sp.	-0.3333	0.6667	3	0.6514
Euphausiid nauplii	-0.3333	0.6667	3	0.6514
Mysidae, general adult (stage 6)	-0.3333	0.6667	3	0.6514
Calanoid, Acartia sp.	-0.3315	0.6657	3	0.6528
Cladoceran, Podon sp.	-0.1107	0.4607	5	0.8197

Table 3: Summary of epibenthic species preferred by Pacific herring in western Prince William Sound, 1994. Preference is defined as a greater frequency of occurrence of an organism in fish stomach contents compared with the epibenthic pump sample from the same site.

Species	mean	se	n	p.value
Euphausiid, T. spinifera	1.0000	0.0000	5	0.0000
Euphausiid, T. raschii, general	1.0000	0.0000	2	0.0000
Euphausiid, T. inermis	1.0000	-	1	-
Euphausiid, Thysanoessa sp. juvenile	1.0000	-	1	-
Euphausiid, Thysannoessa sp., adult	1.0000	0.0000	5	0.0000
Chaetognath, Sagitta	1.0000	-	1	-
Calanoid, Pseudocalanus AM	1.0000	0.0000	4	0.0000
Amphipod, Hyperiid, Parathem. sp.2-6.9mm	1.0000	-	1	-
Amphipod, Hyperiid, P. libellula	1.0000	0.0000	7	0.0000
Amphipod, Hyperiid, Primno macropa, gen.	1.0000	-	1	-
Amphipod, Hyperiid, P. macropa, 7+mm	1.0000	-	1	-
Amphipod, Hyperiid, P. macropa, 2-6.9mm	1.0000	-	1	-
Amphipod, Hyperiid/Parath. pacifica gen.	1.0000	0.0000	6	0.0000
Amphipod, Hyperiid, P. libellula 2-6.9mm	1.0000	-	1	-
Decapod zoea, Shrimp, Pandalidae	1.0000	0.0000	2	0.0000
Copepod, Caligidae, parasitic copepod	1.0000	-	1	-
Amphipod, P. pacifica, general juvenile	1.0000	0.0000	6	0.0000
Amphipod, P. pacifica juvenile, 2-6.9mm	1.0000	-	1	-
Amphipod, P. pacifica juvenile, <2mm	1.0000	-	1	-
Cyclopoid, Oithona spinirostris	1.0000	-	1	-
Decapod zoea, crab, Oregoninae	1.0000	0.0000	8	0.0000
Larvacea, Oikopleura vanhoeffeni	1.0000	0.0000	2	0.0000
Larvacea, Oikopleura sp.	1.0000	0.0000	15	0.0000
Larvacea, O. vanhoeffeni capsule	1.0000	0.0000	2	0.0000
Calanoid, Neocalanus spp. adult	1.0000	0.0000	2	0.0000
Fish, Mallotus villosus (capelin)	1.0000	-	1	-
Calanoid, M. ohkotensis, female copepodt	1.0000	0.0000	3	0.0000
Bivalve, juvenile mussel	1.0000	-	1	-
Calanoid, Metridia pacifica, AM	1.0000	0.0000	4	0.0000
Calanoid, Metridia pacifica, AF	1.0000	0.0000	11	0.0000
Calanoid, Metridia pacifica, copepodite	1.0000	0.0000	2	0.0000
Calanoid, Metridia pacifica, adult	1.0000	0.0000	7	0.0000
Calanoid, M. ochotensis AM	1.0000	-	1	-
Calanoid, Metridia ochotensis AF	1.0000	0.0000	2	0.0000
Calanoid, Metridia sp., General	1.0000	0.0000	3	0.0000

Table 3: continued

Species	mean	se	n	p.value
Calanoid, Metridia pacifica, general	1.0000	0.0000	11	0.0000
Calanoid, Metridia sp. copepodids I-IV	1.0000	-	1	-
Malacostraca	1.0000	0.0000	14	0.0000
Malacostraca, eyes only	1.0000	0.0000	13	0.0000
Larvacea, general	1.0000	0.0000	3	0.0000
Gastropod, Pteropod, Limacina helicina	1.0000	0.0000	13	0.0000
Isopod, general	1.0000	-	1	-
Amphipod, Hyperiid, unknown juvenile	1.0000	0.0000	15	0.0000
Amphipod, Hyperiid, Hyperia sp.	1.0000	0.0000	7	0.0000
Decapod zoea, Shrimp, Hippolytidae	1.0000	0.0000	4	0.0000
Gastropod, general juvenile (EPI)	1.0000	0.0000	13	0.0000
Amphipod, Gammarid head	1.0000	0.0000	2	0.0000
Fish larvae, general	1.0000	0.0000	7	0.0000
Fish egg (~1.0 mm)	1.0000	-	1	-
Larvacea, Fritilaria sp. (borealis)	1.0000	-	1	-
Euphausiid juvenile	1.0000	-	1	-
Calanoid, Euchaeta elongata, general	1.0000	0.0000	3	0.0000
Calanoid, Eucalanus bungii, general	1.0000	0.0000	2	0.0000
Euphausiid furcilia	1.0000	0.0000	16	0.0000
Euphausiid calyptopis	1.0000	0.0000	12	0.0000
Euphausiid egg	1.0000	0.0000	4	0.0000
Euphausiid, Euphausia pacifica	1.0000	-	1	-
Calanoid, Epilabidocera longipedata, AM	1.0000	0.0000	10	0.0000
Calanoid, Epilabidocera longipedata, gen	1.0000	0.0000	13	0.0000
Calanoid, Epilabidocera longipedata, AF	1.0000	0.0000	10	0.0000
Calanoid, Epilabidocera longipedata, cop	1.0000	0.0000	8	0.0000
Calanoid, Epilabidocera longipedata adul	1.0000	0.0000	2	0.0000
Calanoid, Euchaeta elongata ad. male	1.0000	-	1	-
Calanoid, Eucalanus bungii, copepodite	1.0000	-	1	-
Decapod zoea, crab, Brachyrhyncha	1.0000	0.0000	7	0.0000
Decapod, megalops, Paguridae	1.0000	0.0000	2	0.0000
Decapod, megalops, Lithodidae	1.0000	-	1	-
Decapod, Brachyura general, zoeae	1.0000	0.0000	6	0.0000
Ctenophore, general (<2mm)	1.0000	-	1	-
Calanoid, Calanus pacificus AF	1.0000	0.0000	6	0.0000
Calanoid, Calanus sp. copepodids	1.0000	0.0000	6	0.0000
Calanoid, Calanus pacificus, general	1.0000	0.0000	4	0.0000
Cnidaria (>2mm), general large jellyfish	1.0000	-	1	-
Calanoid, Calanus marshallae AM	1.0000	0.0000	2	0.0000

Table 3: continued

Species	mean	se	n	p.value
Calanoid, Calanus marshallae AF	1.0000	0.0000	7	0.0000
Calanoid, C. marshallae copepodite	1.0000	-	1	-
Calanoid, Calanus marshallae	1.0000	0.0000	12	0.0000
Calanoid, large, NOT Neocalanus/Calanus	1.0000	0.0000	3	0.0000
Calanoid, large, Neocalanus/Calanus	1.0000	0.0000	7	0.0000
Chaetognath, species unknown	1.0000	0.0000	3	0.0000
Calanoid, Neocalanus cristatus V	1.0000	0.0000	2	0.0000
JELLY: Cnidarian or Ctenophore mush	1.0000	-	1	-
Calanoid, Centropages abdominalis, AM	1.0000	0.0000	8	0.0000
Calanoid, general large (>2.5 mm)	1.0000	0.0000	16	0.0000
Calanoid, single egg or clutch	1.0000	-	1	-
Calanoid, Centropages abdominalis, copdt	1.0000	0.0000	2	0.0000
Barnacle, adult molt (cirri)	1.0000	0.0000	4	0.0000
Decapoda, Cancrid crab, Atelecyclidae	1.0000	0.0000	3	0.0000
Calanoid, Acartia longiremus AM	1.0000	0.0000	2	0.0000
Calanoid, Acartia longiremus copepodite	1.0000	-	1	-
Calanoid, Aetideidae sp.	1.0000	-	1	-
Calanoid, Acartia clausi adult	1.0000	0.0000	3	0.0000
Calanoid, Centropages abdominalis, AF	0.9722	0.0278	9	0.0000
Cladocera, General	0.9545	0.0455	10	0.0000
Unknown invertebrate egg, small (<0.2mm)	0.9047	0.0546	17	0.0000
Decapod zoea, general unknown group	0.8828	0.1172	14	0.0000
Cladoceran, Evadne sp.	0.8392	0.1608	12	0.0002
Larvacea, Oikopleura dioica	0.8296	0.1532	13	0.0001
Decapod zoea, hermit crab, Paguridae	0.8182	0.1818	11	0.0009
Calanoid, Acartia longiremis AF	0.7500	0.2500	8	0.0171
Euphausiid, general unknown	0.7143	0.2857	7	0.0410
Decapod, megalops, unknown crab	0.6667	0.3333	6	0.0924
Calanoid, Pseudocalanus AF	0.6512	0.1575	12	0.0014
Calanoid, general small (<2.5 mm)	0.6283	0.1175	17	0.0001
Decapod zoea, general shrimp	0.6000	0.4000	5	0.1939
Decapod, Cancridae megalops	0.6000	0.4000	5	0.1939
Cladoceran, Podon sp.	0.5786	0.1929	15	0.0090
Calanoid, Acartia longiremus adult	0.5639	0.2869	8	0.0849
Barnacle, nauplius	0.5556	0.2940	9	0.0914
Polychaeta, trochophore larva	0.5304	0.4696	4	0.3219
Calanoid, Centropages abdominalis, adult	0.5118	0.1973	15	0.0203
Barnacle, cyprid	0.4626	0.2776	11	0.1238
Bryozoa, cyphonautes larva	0.2674	0.3578	8	0.4763

Table 3: continued

Species	mean	se	n	p.value
Calanoid, Pseudocalanus sp., general	0.2527	0.1986	17	0.2203
Cyclopoid, Oithona similis, general	0.0984	0.3124	11	0.7586
Unknown egg mass	0.0000	0.4472	6	1.0000
Shrimp, Hippolytid, Spirontocaris sp.	0.0000	1.0000	2	1.0000
Cyclopoid, Oithona similis AF	0.0000	1.0000	2	1.0000
Calanoid, Metridia ochotensis, no sex	0.0000	1.0000	2	1.0000
Copepod, Monstrillid	0.0000	1.0000	2	1.0000
Harpacticoid, general gravid (eggs)	0.0000	1.0000	2	1.0000
Euphausiid nauplii	0.0000	0.4472	6	1.0000

Table 4: Summary of epibenthic species avoided by Pacific herring in western Prince William Sound, 1994. Avoidance is defined as a lesser frequency of occurrence of an organism in fish stomach contents compared with the epibenthic pump sample from the same site.

Species	mean	se	n	p.value
Calanoid, Acartia clausi copepodite	-1.0000	0.0000	2	0.0000
Calanoid, Acartia sp. copepodids	-1.0000	0.0000	2	0.0000
Gastropoda, snail, Alvania sp.	-1.0000	0.0000	2	0.0000
Polychaeta, Ampharetidae	-1.0000	-	1	-
Echinodermata, Ophiuroid, Amphiuridae	-1.0000	0.0000	2	0.0000
Amphipod, Caprellidae, gravidfemale	-1.0000	-	1	-
Gastropoda, snail, Cerithiidae	-1.0000	-	1	-
Polychaeta, Cistenides granulata	-1.0000	-	1	-
Ostracod, Conchoecia sp.	-1.0000	0.0000	3	0.0000
Cnidaria (<2mm), general small jellyfish	-1.0000	-	1	-
Amphipod, Gammarid, Corophium sp.	-1.0000	0.0000	2	0.0000
Gastropoda, snail, Crepidula sp.	-1.0000	-	1	-
Polychaeta, Crucigera zygophora	-1.0000	0.0000	2	0.0000
Cumacea, Cumella sp.	-1.0000	-	1	-
Cumacea	-1.0000	0.0000	5	0.0000
Cyclopoid, general unknown	-1.0000	-	1	-
Gastropoda, Opisthobranchia, Cylichnidae	-1.0000	-	1	-
Cumacea, Diastylis sp.	-1.0000	-	1	-
Gastropoda, Opisthobranc,Diaphana minuta	-1.0000	-	1	-
Decapod, Pagurid,Elassochirus tenuimanus	-1.0000	0.0000	2	0.0000
Shrimp, Hippolytid, Eualus sp.	-1.0000	0.0000	6	0.0000
Shrimp, Hippolytid, Eualus fabricii	-1.0000	-	1	-
Shrimp, Hippolytid, Eualus biunguis	-1.0000	-	1	-
Polychaeta, Exogone sp.	-1.0000	0.0000	5	0.0000
Calanoid, Eurytemora pacifica AF	-1.0000	-	1	-
Calanoid, Eurytemora pacifica AM	-1.0000	-	1	-
Amphipod, Gammarid, unknown, small	-1.0000	0.0000	2	0.0000
Amphipod, Gammarid, unknown, medium	-1.0000	0.0000	5	0.0000
Amphipod, Gammarid, unknown, large	-1.0000	-	1	-
Amphipod, general gravid gammarid	-1.0000	-	1	-
Amphipod, Gammarid, Ampithoe	-1.0000	0.0000	3	0.0000
Amphipod, Gammarid, unknown, no size	-1.0000	0.0000	10	0.0000
Amphipod, Gammarid Ischyocerus, gravid	-1.0000	-	1	-
Amphipod, Gammarid, Ischyocerus type	-1.0000	0.0000	11	0.0000
Gastropoda, Granulina margaritula	-1.0000	-	1	-

Table 4: continued

Species	mean	se	n	p.value
Gastropod, general juvenile (EPI)	-1.0000	0.0000	13	0.0000
Amphipod, Gammarid, Guerneavsp.	-1.0000	-	1	-
Amphipod, Gammarid, Halirages bungei	-1.0000	0.0000	4	0.0000
Harpacticoid, Dactylopodia, general	-1.0000	0.0000	7	0.0000
Harpacticoid, Ectinosomatid, gravid	-1.0000	0.0000	2	0.0000
Shrimp, Hippolytid, Heptacarpus sp.	-1.0000	0.0000	3	0.0000
Polychaeta, Hesionidae	-1.0000	0.0000	4	0.0000
Bivalve, Hiatella arctica	-1.0000	0.0000	3	0.0000
Shrimp, Hippolytid, He. tenuissimus	-1.0000	-	1	-
Harpacticoid, Harpacticus female adult	-1.0000	-	1	-
Harpacticoid, Harpacticus gravid female	-1.0000	0.0000	4	0.0000
Harpacticoid, Harpacticus copepodite	-1.0000	0.0000	3	0.0000
Harpacticoid, general nauplius	-1.0000	0.0000	6	0.0000
Harpacticoid, unknown, brown	-1.0000	0.0000	3	0.0000
Harpacticoid, general, unknown female	-1.0000	-	1	-
Harpacticoid, Zaus, general adult	-1.0000	0.0000	4	0.0000
Harpacticoid, Zaus sp. general	-1.0000	0.0000	3	0.0000
Harpacticoid, Laophontidae, copepodite	-1.0000	-	1	-
Cumacea, Lamprops sp.	-1.0000	-	1	-
Harpacticoid, Laophontidae, adult	-1.0000	0.0000	11	0.0000
Gastropoda, Lacuna sp.	-1.0000	0.0000	4	0.0000
Shrimp, Hippolytid, Lebbeus sp.	-1.0000	0.0000	4	0.0000
Gastropoda, Lottidae	-1.0000	-	1	-
Polychaeta, Lumbrineris sp.	-1.0000	-	1	-
Bivalve, Lyonsia bracteata	-1.0000	-	1	-
Gastropoda, snail,Margarites beringensis	-1.0000	0.0000	2	0.0000
Gastropoda, snail, Margarites pupillus	-1.0000	-	1	-
Gastropoda, snail, Margarites sp.	-1.0000	0.0000	3	0.0000
Gastropoda, Nudibranch, Melibe leonina	-1.0000	-	1	-
Gastropoda, Micronellum crebricinctum	-1.0000	-	1	-
Arthropod, Arachnid, Halacarid mite	-1.0000	-	1	-
Isopod, Munna sp.	-1.0000	0.0000	11	0.0000
Mytiloida, Musculus sp.	-1.0000	-	1	-
Mytiloida, Musculus vernicosus	-1.0000	0.0000	5	0.0000
Mysidae, general, stage unknown	-1.0000	-	1	-
Mysidae, general juv. (stage 5)	-1.0000	0.0000	3	0.0000
Mysidae, general adult (stage 6)	-1.0000	0.0000	5	0.0000
Amphipod, Gammarid, Najna sp.	-1.0000	-	1	-
Nematode	-1.0000	0.0000	2	0.0000

Table 4: continued

Species	mean	se	n	p.value
Polychaeta, Nereidae	-1.0000	0.0000	5	0.0000
Mysidae, Neomysis kadiakensis	-1.0000	-	1	-
Mysidae, Neomysis sp.	-1.0000	-	1	-
Amphipod, Gammarid, Odius sp.	-1.0000	0.0000	6	0.0000
Amphipod, Gammarid, Oedicerotidae	-1.0000	0.0000	2	0.0000
Copepod, Oithona egg cases	-1.0000	-	1	-
Oligochaete	-1.0000	-	1	-
Gastropoda, snail, Olivella baetica	-1.0000	-	1	-
Gastropoda,Nudibr., Onchidoris muricata	-1.0000	0.0000	3	0.0000
Polychaeta, Onuphis sp.	-1.0000	-	1	-
Polychaeta, Ophelidae	-1.0000	0.0000	2	0.0000
Ostracod, general unknown	-1.0000	0.0000	13	0.0000
Decapod, Paguris hirsutiusculus	-1.0000	-	1	-
Decapod, Pagurus sp.	-1.0000	0.0000	3	0.0000
Polychaeta, Pectinariidae	-1.0000	-	1	-
Polychaeta, Pholoe minuta	-1.0000	0.0000	5	0.0000
Amphipod, Gammarid, Phoxocephalidae	-1.0000	0.0000	5	0.0000
Polychaeta, adult	-1.0000	0.0000	2	0.0000
Polychaeta, Platynereis bicanaliculata	-1.0000	-	1	-
Amphipod, Gammarid, Pleustidae	-1.0000	0.0000	3	0.0000
Amphipod, Gammarid,Pleustes cataphractus	-1.0000	0.0000	2	0.0000
Polyplacophora	-1.0000	-	1	-
Harpacticoid, Porcellidium	-1.0000	0.0000	11	0.0000
Amphipod, Gammarid, Pontogeneia sp.	-1.0000	0.0000	5	0.0000
Decapod, Pugettia gracilis	-1.0000	-	1	-
Shrimp, general unknown juv./adult	-1.0000	0.0000	3	0.0000
Shrimp, Hippolytid, Heptacarpus stylus	-1.0000	-	1	-
Shrimp, Hippolytid, general	-1.0000	0.0000	5	0.0000
Polychaeta, Sphaerosyllis erinaceus	-1.0000	0.0000	5	0.0000
Polychaeta, Spionidae	-1.0000	0.0000	2	0.0000
Porifera	-1.0000	0.0000	3	0.0000
Echinodermata, Strongylocentrotus	-1.0000	0.0000	2	0.0000
Polychaeta, Syllidae	-1.0000	0.0000	5	0.0000
Amphipod, Gammarid, Tiron biocellata	-1.0000	-	1	-
Harpacticoid, Tisbe sp., gravid female	-1.0000	0.0000	3	0.0000
Harpacticoid, Tisbe sp., stage unknown	-1.0000	0.0000	16	0.0000
Harpacticoid, Harpacticus sp. general ad	-0.9996	0.0004	16	0.0000
Harpacticoid, general, unknown stage	-0.9994	0.0003	13	0.0000
Cyclopoid, Oithona sp., general	-0.9990	0.0010	11	0.0000

Table 4: continued

Species	mean	se	n	p.value
Amphipod, Caprellidae	-0.9987	0.0013	15	0.0000
Polychaeta, Polynoidae	-0.9985	0.0015	7	0.0000
Harpacticoid, Zaus copepodite	-0.9874	0.0126	3	0.0000
Calanoid, general nauplius	-0.9518	0.0267	16	0.0000
Polychaeta, general, juvenile	-0.9434	0.0530	8	0.0000
Bivalve, larvae	-0.7450	0.1363	16	0.0001
Harpacticoid, Ectinosomatidae	-0.7143	0.2857	7	0.0410
Harpacticoid, general eggsac	-0.7143	0.2857	7	0.0410
Unknown nauplius	-0.6667	0.3333	6	0.0924
Harpacticoid, Tisbe copepodite	-0.5000	0.3273	8	0.1651
Harpacticoid, general copepodite	-0.4994	0.3272	8	0.1654
Harpacticoid, Tisbe sp., adult	-0.4286	0.3689	7	0.2834
Bivalve, Mytilidae	-0.3333	0.6667	3	0.6514
Calanoid, Pseudocalanus copepodids I-IV	-0.3333	0.6667	3	0.6514
Calanoid, Acartia sp.	-0.3223	0.4183	6	0.4702
Harpacticoid, general adult	-0.1974	0.4889	5	0.7030
Calanoid, Acartia longiremis , General	-0.1810	0.2665	12	0.5099
Unknown invertebrate egg, large (>0.2mm)	-0.1775	0.3206	10	0.5921

Table 5: Summary of epibenthic species preferred by pink salmon in western Prince William Sound, 1994. Preference is defined as a greater frequency of occurrence of an organism in fish stomach contents compared with the epibenthic pump sample from the same site.

Species	mean	se	n	p.value
Euphausiid, T. spinifera	1.0000	-	1	-
Euphausiid, T. raschii, general	1.0000	-	1	-
Euphausiid, T. longipes	1.0000	-	1	-
Euphausiid, T. inermis	1.0000	-	1	-
Euphausiid, Thysanoessa sp. juvenile	1.0000	-	1	-
Euphausiid, Thysannoessa sp., adult	1.0000	0.0000	2	0.0000
Insect, Sciaridae (beetle)	1.0000	-	1	-
Gastropod, Pteropod, unidentified	1.0000	-	1	-
Amphipod, Hyperiid, Parathem. sp.2-6.9mm	1.0000	-	1	-
Amphipod, Hyperiid, P. libellula	1.0000	-	1	-
Amphipod, Hyperiid, Primno macropa, gen.	1.0000	0.0000	2	0.0000
Amphipod, Hyperiid, P. macropa, 2-6.9mm	1.0000	-	1	-
Amphipod, Hyperiid/Parath. pacifica gen.	1.0000	-	1	-
Amphipod, Hyperiid, P. libellula 2-6.9mm	1.0000	-	1	-
Decapod zoea, Shrimp, Pandalidae	1.0000	-	1	-
Copepod, Caligidae, parasitic copepod	1.0000	-	1	-
Amphipod, P. pacifica, general juvenile	1.0000	0.0000	5	0.0000
Amphipod, P. pacifica juvenile, 2-6.9mm	1.0000	-	1	-
Amphipod, P. pacifica juvenile, <2mm	1.0000	-	1	-
Decapod zoea, crab, Oregoninae	1.0000	-	1	-
Larvacea, Oikopleura sp.	1.0000	0.0000	4	0.0000
Larvacea, O. vanhoeffeni capsule	1.0000	-	1	-
Calanoid, Neocalanus spp. adult	1.0000	0.0000	2	0.0000
Calanoid, Metridia pacifica, AM	1.0000	-	1	-
Calanoid, Metridia pacifica, AF	1.0000	0.0000	3	0.0000
Calanoid, Metridia pacifica, adult	1.0000	-	1	-
Calanoid, Metridia pacifica, general	1.0000	0.0000	2	0.0000
Malacostraca	1.0000	0.0000	2	0.0000
Malacostraca, eyes only	1.0000	0.0000	3	0.0000
Gastropod, Pteropod, Limacina helicina	1.0000	0.0000	3	0.0000
Insect, general	1.0000	-	1	-
Amphipod, Hyperiid, unknown juvenile	1.0000	0.0000	3	0.0000
Amphipod, Hyperiid, Hyperia medusarum	1.0000	-	1	-
Amphipod, Hyperiid, Hyperoche medusarum	1.0000	-	1	-
Amphipod, Hyperiid, Hyperia sp.	1.0000	-	1	-

Table 5: continued

Species	mean	se	n	p.value
Insect, Homopteran	1.0000	-	1	-
Fish larvae, general	1.0000	0.0000	4	0.0000
Fish, juvenile, general	1.0000	-	1	-
Fish egg (~1.0 mm)	1.0000	-	1	-
Euphausiid, general unknown	1.0000	0.0000	3	0.0000
Euphausiid juvenile	1.0000	-	1	-
Euphausiid furcilia	1.0000	0.0000	3	0.0000
Euphausiid calyptopis	1.0000	-	1	-
Calanoid, Epilabidocera longipedata, AM	1.0000	0.0000	2	0.0000
Calanoid, Epilabidocera longipedata, gen	1.0000	0.0000	4	0.0000
Calanoid, Epilabidocera longipedata, AF	1.0000	0.0000	2	0.0000
Calanoid, Epilabidocera longipedata, cop	1.0000	0.0000	2	0.0000
Chaetognath, Eukrohnia hamata	1.0000	-	1	-
Decapod zoea, crab, Brachyrhyncha	1.0000	0.0000	2	0.0000
Insect, Dipteran larvae	1.0000	0.0000	2	0.0000
Decapod, megalops, Paguridae	1.0000	0.0000	2	0.0000
Decapod, megalops, Lithodidae	1.0000	-	1	-
Insect, Dipteran adult	1.0000	0.0000	4	0.0000
Decapod, Brachyura general, zoeae	1.0000	-	1	-
Ctenophore, general (<2mm)	1.0000	-	1	-
Calanoid, Calanus pacificus AM	1.0000	-	1	-
Calanoid, Calanus pacificus, adult	1.0000	-	1	-
Insect, Collembola, general	1.0000	-	1	-
Cnidaria (>2mm), general large jellyfish	1.0000	0.0000	2	0.0000
Ostracod, Conchoecia sp.	1.0000	-	1	-
Calanoid, Calanus marshallae AM	1.0000	-	1	-
Calanoid, Calanus marshallae AF	1.0000	0.0000	2	0.0000
Calanoid, Calanus marshallae	1.0000	0.0000	3	0.0000
Calanoid, large, NOT Neocalanus/Calanus	1.0000	-	1	-
Calanoid, large, Neocalanus/Calanus	1.0000	0.0000	2	0.0000
Cladocera, General	1.0000	-	1	-
Chaetognath, species unknown	1.0000	0.0000	2	0.0000
JELLY: Cnidarian or Ctenophore mush	1.0000	0.0000	2	0.0000
Amphipod, Gammarid, Cypho. challengeri	1.0000	0.0000	2	0.0000
Calanoid, general large (>2.5 mm)	1.0000	0.0000	5	0.0000
Decapod, Cancridae megalops	1.0000	-	1	-
Calanoid, Candacia columbiae	1.0000	-	1	-
Barnacle, adult molt (cirri)	1.0000	-	1	-
Decapoda, Cancrid crab, Atelecyclidae	1.0000	-	1	-

Table 5: continued

Species	mean	se	n	p.value
Fish, Ammodytes hexapterus (sandlance)	1.0000	-	1	-
Decapod, megalops, unknown crab	0.9986	0.0014	3	0.0000
Larvacea, Oikopleura dioica	0.9779	0.0221	3	0.0000
Decapod zoea, general unknown group	0.5000	0.5000	4	0.3739
Cladoceran, Evadne sp.	0.3333	0.6667	3	0.6514
Cladoceran, Podon sp.	0.2000	0.4899	5	0.7000
Decapod zoea, general shrimp	0.0000	1.0000	2	1.0000
Decapod zoea, hermit crab, Paguridae	0.0000	1.0000	2	1.0000
Calanoid, Pseudocalanus copepodids I-IV	0.0000	1.0000	2	1.0000
Nematode	0.0000	1.0000	2	1.0000
Euphausiid nauplii	0.0000	1.0000	2	1.0000
Calanoid, Acartia longiremus adult	0.0000	1.0000	2	1.0000

Table 6: Summary of epibenthic species avoided by pink salmon in western Prince William Sound, 1994. Avoidance is defined as a lesser frequency of occurrence of an organism in fish stomach contents compared with the epibenthic pump sample from the same site.

Species	mean	se	n	p.value
Calanoid, Acartia sp.	-1.0000	-	1	-
Calanoid, Acartia clausi copepodite	-1.0000	-	1	-
Calanoid, Acartia sp. copepodids	-1.0000	-	1	-
Calanoid, Acartia longiremis , General	-1.0000	-	1	-
Gastropoda, snail, Alvania sp.	-1.0000	-	1	-
Barnacle, nauplius	-1.0000	-	1	-
Calanoid, Centropages abdominalis, adult	-1.0000	0.0000	2	0.0000
Calanoid, Centropages abdominalis, AF	-1.0000	-	1	-
Amphipod, Caprellidae, gravidfemale	-1.0000	-	1	-
Calanoid, general nauplius	-1.0000	0.0000	4	0.0000
Amphipod, Caprellidae	-1.0000	0.0000	4	0.0000
Bryozoa, cyphonautes larva	-1.0000	-	1	-
Polychaeta, Cistenides granulata	-1.0000	-	1	-
Cyclopoid, general unknown	-1.0000	-	1	-
Cumacea, Diastylis sp.	-1.0000	-	1	-
Unknown invertebrate egg, small (<0.2mm)	-1.0000	-	1	-
Unknown invertebrate egg, large (>0.2mm)	-1.0000	0.0000	2	0.0000
Decapod, Pagurid,Elassochirus tenuimanus	-1.0000	-	1	-
Shrimp, Hippolytid, Eualus sp.	-1.0000	0.0000	3	0.0000
Shrimp, Hippolytid, Eualus fabricii	-1.0000	-	1	-
Shrimp, Hippolytid, Eualus biunguis	-1.0000	-	1	-
Polychaeta, Exogone sp.	-1.0000	-	1	-
Calanoid, Eurytemora pacifica AF	-1.0000	-	1	-
Amphipod, Gammarid, unknown, small	-1.0000	-	1	-
Amphipod, general gravid gammarid	-1.0000	-	1	-
Amphipod, Gammarid, Ampithoe	-1.0000	-	1	-
Amphipod, Gammarid, unknown, no size	-1.0000	0.0000	3	0.0000
Amphipod, Gammarid Ischyocerus, gravid	-1.0000	-	1	-
Amphipod, Gammarid, Ischyocerus type	-1.0000	0.0000	4	0.0000
Gastropod, general juvenile (EPI)	-1.0000	0.0000	4	0.0000
Amphipod, Gammarid, Halirages bungei	-1.0000	0.0000	2	0.0000
Harpacticoid, Dactylopodia, general	-1.0000	0.0000	3	0.0000
Harpacticoid, Ectinosomatidae	-1.0000	0.0000	2	0.0000
Harpacticoid, general eggsac	-1.0000	0.0000	2	0.0000
Shrimp, Hippolytid, Heptacarpus sp.	-1.0000	0.0000	2	0.0000

Table 6: continued

Species	mean	se	n	p.value
Polychaeta, Hesionidae	-1.0000	0.0000	2	0.0000
Bivalve, Hiatella arctica	-1.0000	0.0000	2	0.0000
Shrimp, Hippolytid, He. tenuissimus	-1.0000	-	1	-
Harpacticoid, general copepodite	-1.0000	0.0000	2	0.0000
Harpacticoid, general gravid (eggs)	-1.0000	-	1	-
Harpacticoid, Harpacticus female adult	-1.0000	-	1	-
Harpacticoid, Harpacticus gravid female	-1.0000	-	1	-
Harpacticoid, Harpacticus copepodite	-1.0000	0.0000	2	0.0000
Harpacticoid, general nauplius	-1.0000	0.0000	2	0.0000
Harpacticoid, general adult	-1.0000	-	1	-
Harpacticoid, Harpacticus sp. general ad	-1.0000	0.0000	4	0.0000
Harpacticoid, unknown, brown	-1.0000	-	1	-
Harpacticoid, general, unknown female	-1.0000	-	1	-
Harpacticoid, Zaus, general adult	-1.0000	-	1	-
Harpacticoid, Zaus copepodite	-1.0000	-	1	-
Harpacticoid, Zaus sp. general	-1.0000	-	1	-
Harpacticoid, Laophontidae, copepodite	-1.0000	-	1	-
Cumacea, Lamprops sp.	-1.0000	-	1	-
Harpacticoid, Laophontidae, adult	-1.0000	0.0000	4	0.0000
Gastropoda, Lacuna sp.	-1.0000	-	1	-
Shrimp, Hippolytid, Lebbeus sp.	-1.0000	0.0000	2	0.0000
Bivalve, Lyonsia bracteata	-1.0000	-	1	-
Gastropoda, Micronellum crebricinctum	-1.0000	-	1	-
Copepod, Monstrillid	-1.0000	-	1	-
Isopod, Munna sp.	-1.0000	0.0000	3	0.0000
Mytiloida, Musculus sp.	-1.0000	-	1	-
Mytiloida, Musculus vernicosus	-1.0000	-	1	-
Mysidae, general juv. (stage 5)	-1.0000	-	1	-
Bivalve, Mytilidae	-1.0000	-	1	-
Polychaeta, Nereidae	-1.0000	-	1	-
Amphipod, Gammarid, Odius sp.	-1.0000	0.0000	2	0.0000
Amphipod, Gammarid, Oedicerotidae	-1.0000	-	1	-
Cyclopoid, Oithona sp., general	-1.0000	0.0000	3	0.0000
Oligochaete	-1.0000	-	1	-
Gastropoda,Nudibr., Onchidoris muricata	-1.0000	-	1	-
Polychaeta, Ophelidae	-1.0000	-	1	-
Cyclopoid, Oithona similis, general	-1.0000	0.0000	2	0.0000
Ostracod, general unknown	-1.0000	0.0000	5	0.0000
Decapod, Pagurus sp.	-1.0000	-	1	-

Table 6: continued

Species	mean	se	n	p.value
Polychaeta, Hesionidae	-1.0000	0.0000	2	0.0000
Bivalve, Hiatella arctica	-1.0000	0.0000	2	0.0000
Shrimp, Hippolytid, He. tenuissimus	-1.0000	-	1	-
Harpacticoid, general copepodite	-1.0000	0.0000	2	0.0000
Amphipod, Gammarid, Pleustidae	-1.0000	-	1	-
Harpacticoid, Porcellidium	-1.0000	0.0000	3	0.0000
Amphipod, Gammarid, Pontogeneia sp.	-1.0000	-	1	-
Polychaeta, Polynoidae	-1.0000	0.0000	2	0.0000
Calanoid, Pseudocalanus AF	-1.0000	-	1	-
Shrimp, general unknown juv./adult	-1.0000	-	1	-
Shrimp, Hippolytid, general	-1.0000	0.0000	3	0.0000
Polychaeta, Sphaerosyllis erinaceus	-1.0000	0.0000	3	0.0000
Shrimp, Hippolytid, Spirontocaris sp.	-1.0000	-	1	-
Porifera	-1.0000	-	1	-
Polychaeta, Syllidae	-1.0000	-	1	-
Amphipod, Gammarid, Tiron biocellata	-1.0000	-	1	-
Harpacticoid, Tisbe sp., adult	-1.0000	0.0000	2	0.0000
Harpacticoid, Tisbe copepodite	-1.0000	0.0000	2	0.0000
Harpacticoid, Tisbe sp., gravid female	-1.0000	0.0000	2	0.0000
Harpacticoid, Tisbe sp., stage unknown	-1.0000	0.0000	4	0.0000
Unknown egg mass	-1.0000	-	1	-
Unknown nauplius	-1.0000	0.0000	2	0.0000
Harpacticoid, general, unknown stage	-0.9933	0.0067	4	0.0000
Bivalve, larvae	-0.9791	0.0209	5	0.0000
Polychaeta, general, juvenile	-0.9784	0.0216	4	0.0000
Calanoid, Pseudocalanus sp., general	-0.9405	0.0595	4	0.0001
Calanoid, general small (<2.5 mm)	-0.7122	0.1788	5	0.0105
Barnacle, cyprid	-0.3333	0.6667	3	0.6514
Cumacea	-0.3333	0.6667	3	0.6514
Amphipod, Gammarid, unknown, medium	-0.1585	0.8415	2	0.8680

Table 7: Summary of epibenthic species preferred by chum salmon in western Prince William Sound, 1994. Preference is defined as a greater frequency of occurrence of an organism in fish stomach contents compared with the epibenthic pump sample from the same site.

Species	mean	se	n	p.value
Euphausiid, T. spinifera	1.0000	0.0000	2	0.0000
Euphausiid, T. raschii males	1.0000	-	1	-
Euphausiid, T. raschii females	1.0000	-	1	-
Euphausiid, T. longipes	1.0000	-	1	-
Insect, Dipteran, Tipulidae (larvae)	1.0000	-	1	-
Euphausiid, Thysannoessa sp., adult	1.0000	0.0000	5	0.0000
Chaetognath, Sagitta	1.0000	0.0000	5	0.0000
Amphipod, Hyperiid, Parathem. sp.2-6.9mm	1.0000	-	1	-
Amphipod, Hyperiid, P. libellula	1.0000	0.0000	2	0.0000
Amphipod, Hyperiid, Primno macropa, gen.	1.0000	0.0000	2	0.0000
Amphipod, Hyperiid, P. macropa, 7+mm	1.0000	-	1	-
Amphipod, Hyperiid, P. macropa, 2-6.9mm	1.0000	0.0000	2	0.0000
Amphipod, Hyperiid, Primno macropa, <2mm	1.0000	-	1	-
Amphipod, Hyperiid/Parath. pacifica gen.	1.0000	0.0000	3	0.0000
Amphipod, Hyperiid, P. libellula 2-6.9mm	1.0000	-	1	-
Amphipod, Hyperiid, P.libellula <2mm	1.0000	-	1	-
Decapod zoea, Shrimp, Pandalidae	1.0000	-	1	-
Amphipod, P. pacifica, general juvenile	1.0000	0.0000	7	0.0000
Amphipod, Hyperiid/Parath. pacifica ad.	1.0000	-	1	-
Amphipod, P. pacifica juvenile, 2-6.9mm	1.0000	0.0000	2	0.0000
Larvacea, Oikopleura sp.	1.0000	0.0000	13	0.0000
Calanoid, Neocalanus spp. adult	1.0000	0.0000	3	0.0000
Calanoid, Metridia pacifica, AM	1.0000	-	1	-
Calanoid, Metridia pacifica, AF	1.0000	0.0000	5	0.0000
Calanoid, Metridia pacifica, adult	1.0000	0.0000	2	0.0000
Calanoid, Metridia ochotensis AF	1.0000	-	1	-
Gastropoda, Nudibranch, Melibe sp.	1.0000	-	1	-
Calanoid, Metridia pacifica, general	1.0000	0.0000	6	0.0000
Malacostraca	1.0000	0.0000	8	0.0000
Malacostraca, eyes only	1.0000	0.0000	3	0.0000
Gastropod, Pteropod, Limacina helicina	1.0000	0.0000	6	0.0000
Insect, general	1.0000	-	1	-
Amphipod, Hyperiid, unknown juvenile	1.0000	0.0000	10	0.0000
Amphipod, Hyperiid, Hyperia medusarum	1.0000	-	1	-
Cnidaria, Hydrozoan, general	1.0000	0.0000	2	0.0000

Table 7: continued

Species	mean	se	n	p.value
Amphipod, Hyperiid, unknown adult	1.0000	0.0000	2	0.0000
Fish larvae, general	1.0000	0.0000	10	0.0000
Fish, juvenile, general	1.0000	0.0000	2	0.0000
Fish egg (~1.0 mm)	1.0000	-	1	-
Euphausiid juvenile	1.0000	0.0000	2	0.0000
Calanoid, Euchaeta elongata, general	1.0000	-	1	-
Euphausiid furcilia	1.0000	0.0000	5	0.0000
Calanoid, Epilabidocera longipedata, AM	1.0000	0.0000	3	0.0000
Calanoid, Epilabidocera longipedata, gen	1.0000	0.0000	5	0.0000
Calanoid, Epilabidocera longipedata, AF	1.0000	0.0000	3	0.0000
Calanoid, Epilabidocera longipedata, cop	1.0000	-	1	-
Calanoid, Euchaeta elongata ad. male	1.0000	-	1	-
Calanoid, Euchaeta elongata, AF	1.0000	-	1	-
Decapod zoea, crab, Brachyrhyncha	1.0000	0.0000	3	0.0000
Decapod, megalops, Lithodidae	1.0000	-	1	-
Insect, Dipteran adult	1.0000	-	1	-
Ctenophore, general (<2mm)	1.0000	0.0000	15	0.0000
Ctenophore, general (>2mm)	1.0000	0.0000	5	0.0000
Calanoid, Calanus pacificus AF	1.0000	-	1	-
Calanoid, Calanus pacificus, general	1.0000	0.0000	2	0.0000
Cnidaria (>2mm), general large jellyfish	1.0000	0.0000	9	0.0000
Calanoid, Calanus marshallae AM	1.0000	-	1	-
Calanoid, Calanus marshallae AF	1.0000	-	1	-
Calanoid, Calanus marshallae	1.0000	0.0000	7	0.0000
Calanoid, large, Neocalanus/Calanus	1.0000	-	1	-
Chaetognath, species unknown	1.0000	0.0000	2	0.0000
JELLY: Cnidarian or Ctenophore mush	1.0000	0.0000	8	0.0000
Calanoid, Neocalanus cristatus, adult	1.0000	-	1	-
Amphipod, Gammarid, Cypho. challengeri	1.0000	0.0000	2	0.0000
Calanoid, general large (>2.5 mm)	1.0000	0.0000	8	0.0000
Barnacle, adult molt (cirri)	1.0000	0.0000	4	0.0000
Fish, Ammodytes hexapterus (sandlance)	1.0000	0.0000	2	0.0000
Decapod, Cancridae megalops	0.9909	0.0091	6	0.0000
Larvacea, Oikopleura dioica	0.7086	0.2475	8	0.0211
Cladoceran, Podon sp.	0.6132	0.2762	7	0.0619
Euphausiid, general unknown	0.6000	0.4000	5	0.1939
Decapod, megalops, unknown crab	0.6000	0.4000	5	0.1939
Cladocera, General	0.5000	0.5000	4	0.3739
Calanoid, Centropages abdominalis, AF	0.5000	0.5000	4	0.3739

Table 7: continued

Species	mean	se	n	p.value
Cladoceran, Evadne sp.	0.4766	0.5234	3	0.4297
Nematode	0.4286	0.3689	7	0.2834
Calanoid, Acartia longiremus adult	0.4208	0.3953	5	0.3358
Decapod zoea, general unknown group	0.3333	0.6667	3	0.6514
Barnacle, nauplius	0.2000	0.4899	5	0.7000
Calanoid, Pseudocalanus AF	0.1429	0.4041	7	0.7341
Barnacle, cyprid	0.1429	0.4041	7	0.7341
Decapod zoea, hermit crab, Paguridae	0.0000	1.0000	2	1.0000
Mytiloida, Musculus sp.	0.0000	1.0000	2	1.0000
Calanoid, Acartia longiremis AF	0.0000	1.0000	2	1.0000

Table 8: Summary of epibenthic species avoided by chum salmon in western Prince William Sound, 1994. Avoidance is defined as a lesser frequency of occurrence of an organism in fish stomach contents compared with the epibenthic pump sample from the same site.

Species	mean	se	n	p.value
Calanoid, Acartia sp.	-1.0000	0.0000	4	0.0000
Calanoid, Acartia clausi copepodite	-1.0000	0.0000	2	0.0000
Calanoid, Acartia sp. copepodids	-1.0000	-	1	-
Gastropoda, snail, Alvania sp.	-1.0000	0.0000	2	0.0000
Polychaeta, Ampharetidae	-1.0000	-	1	-
Echinodermata, Ophiuroid, Amphiuridae	-1.0000	0.0000	2	0.0000
Bivalve, larvae	-1.0000	0.0000	14	0.0000
Amphipod, Caprellidae, gravidfemale	-1.0000	-	1	-
Calanoid, general nauplius	-1.0000	0.0000	13	0.0000
Amphipod, Caprellidae	-1.0000	0.0000	14	0.0000
Gastropoda, snail, Cerithiidae	-1.0000	-	1	-
Bryozoa, cyphonautes larva	-1.0000	0.0000	2	0.0000
Polychaeta, Cistenides granulata	-1.0000	-	1	-
Ostracod, Conchoecia sp.	-1.0000	0.0000	4	0.0000
Cnidaria (<2mm), general small jellyfish	-1.0000	-	1	-
Amphipod, Gammarid, Corophium sp.	-1.0000	-	1	-
Gastropoda, snail, Crepidula sp.	-1.0000	-	1	-
Polychaeta, Crucigera zygophora	-1.0000	0.0000	2	0.0000
Cumacea, Cumella sp.	-1.0000	-	1	-
Cumacea	-1.0000	0.0000	5	0.0000
Cyclopoid, general unknown	-1.0000	-	1	-
Gastropoda, Opisthobranchia, Cylichnidae	-1.0000	-	1	-
Cumacea, Diastylis sp.	-1.0000	-	1	-
Gastropoda, Opisthobranc,Diaphana minuta	-1.0000	-	1	-
Unknown invertebrate egg, large (>0.2mm)	-1.0000	0.0000	6	0.0000
Decapod, Pagurid,Elassochirus tenuimanus	-1.0000	0.0000	2	0.0000
Shrimp, Hippolytid, Eualus sp.	-1.0000	0.0000	6	0.0000
Shrimp, Hippolytid, Eualus fabricii	-1.0000	-	1	-
Shrimp, Hippolytid, Eualus biunguis	-1.0000	-	1	-
Polychaeta, Exogone sp.	-1.0000	0.0000	4	0.0000
Calanoid, Eurytemora pacifica AF	-1.0000	-	1	-
Calanoid, Eurytemora pacifica AM	-1.0000	-	1	-
Amphipod, Gammarid, unknown, small	-1.0000	0.0000	3	0.0000
Amphipod, general gravid gammarid	-1.0000	-	1	-
Amphipod, Gammarid head	-1.0000	-	1	-

Table 8: continued

Species	mean	se	n	p.value
Amphipod, Gammarid, Ampithoe	-1.0000	0.0000	3	0.0000
Amphipod, Gammarid, unknown, no size	-1.0000	0.0000	8	0.0000
Amphipod, Gammarid Ischyocerus, gravid	-1.0000	-	1	-
Amphipod, Gammarid, Ischyocerus type	-1.0000	0.0000	9	0.0000
Gastropoda, Granulina margaritula	-1.0000	-	1	-
Gastropod, general juvenile (EPI)	-1.0000	0.0000	11	0.0000
Amphipod, Gammarid, Guerneavsp.	-1.0000	-	1	-
Amphipod, Gammarid, Halirages bungei	-1.0000	0.0000	4	0.0000
Harpacticoid, Dactylopodia gravid female	-1.0000	-	1	-
Harpacticoid, Dactylopodia, general	-1.0000	0.0000	7	0.0000
Harpacticoid, Ectinosomatidae	-1.0000	0.0000	6	0.0000
Harpacticoid, Ectinosomatid, gravid	-1.0000	0.0000	2	0.0000
Harpacticoid, general eggsac	-1.0000	0.0000	6	0.0000
Shrimp, Hippolytid, Heptacarpus sp.	-1.0000	0.0000	4	0.0000
Polychaeta, Hesionidae	-1.0000	0.0000	3	0.0000
Bivalve, Hiatella arctica	-1.0000	0.0000	3	0.0000
Shrimp, Hippolytid, He. tenuissimus	-1.0000	-	1	-
Harpacticoid, general, unknown stage	-1.0000	0.0000	11	0.0000
Harpacticoid, general copepodite	-1.0000	0.0000	6	0.0000
Harpacticoid, general gravid (eggs)	-1.0000	-	1	-
Harpacticoid, Harpacticus female adult	-1.0000	-	1	-
Harpacticoid, Harpacticus gravid female	-1.0000	0.0000	5	0.0000
Harpacticoid, Harpacticus copepodite	-1.0000	0.0000	3	0.0000
Harpacticoid, general nauplius	-1.0000	0.0000	5	0.0000
Harpacticoid, general adult	-1.0000	0.0000	2	0.0000
Harpacticoid, Harpacticus sp. general ad	-1.0000	0.0000	14	0.0000
Harpacticoid, unknown, brown	-1.0000	0.0000	4	0.0000
Harpacticoid, general, unknown female	-1.0000	-	1	-
Harpacticoid, Zaus, general adult	-1.0000	0.0000	4	0.0000
Harpacticoid, Zaus copepodite	-1.0000	0.0000	3	0.0000
Harpacticoid, Zaus sp. general	-1.0000	0.0000	3	0.0000
Isopod, general	-1.0000	-	1	-
Harpacticoid, Laophontidae, copepodite	-1.0000	0.0000	2	0.0000
Harpacticoid, Laophontidae, gravid fem.	-1.0000	-	1	-
Cumacea, Lamprops sp.	-1.0000	-	1	-
Harpacticoid, Laophontidae, adult	-1.0000	0.0000	10	0.0000
Gastropoda, Lacuna sp.	-1.0000	0.0000	4	0.0000
Shrimp, Hippolytid, Lebbeus sp.	-1.0000	0.0000	4	0.0000
Gastropoda, Lottidae	-1.0000	-	1	-

Table 8: continued

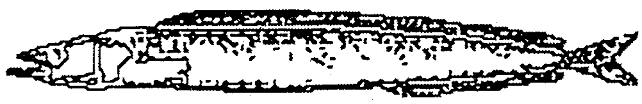
Species	mean	se	n	p.value
Polychaeta, Lumbrineris sp.	-1.0000	-	1	-
Bivalve, Lyonsia bracteata	-1.0000	-	1	-
Gastropoda, snail,Margarites beringensis	-1.0000	0.0000	2	0.0000
Gastropoda, snail, Margarites pupillus	-1.0000	-	1	-
Gastropoda, snail, Margarites sp.	-1.0000	0.0000	2	0.0000
Gastropoda, Micronellum crebricinctum	-1.0000	-	1	-
Copepod, Monstrillid	-1.0000	-	1	-
Isopod, Munna sp.	-1.0000	0.0000	10	0.0000
Mytiloida, Musculus vernicosus	-1.0000	0.0000	4	0.0000
Mysidae, general juv. (stage 5)	-1.0000	0.0000	2	0.0000
Mysidae, general adult (stage 6)	-1.0000	0.0000	3	0.0000
Bivalve, Mytilidae	-1.0000	0.0000	2	0.0000
Amphipod, Gammarid, Najna sp.	-1.0000	-	1	-
Polychaeta, Nereidae	-1.0000	0.0000	4	0.0000
Amphipod, Gammarid, Odius sp.	-1.0000	0.0000	5	0.0000
Amphipod, Gammarid, Oedicerotidae	-1.0000	0.0000	2	0.0000
Copepod, Oithona egg cases	-1.0000	-	1	-
Cyclopoid, Oithona sp., general	-1.0000	0.0000	9	0.0000
Oligochaete	-1.0000	-	1	-
Gastropoda, snail, Olivella baetica	-1.0000	-	1	-
Gastropoda,Nudibr., Onchidoris muricata	-1.0000	0.0000	3	0.0000
Polychaeta, Onuphis sp.	-1.0000	-	1	-
Polychaeta, Ophelidae	-1.0000	0.0000	2	0.0000
Cyclopoid, Oithona similis, general	-1.0000	0.0000	6	0.0000
Cyclopoid, Oithona similis AF	-1.0000	-	1	-
Ostracod, general unknown	-1.0000	0.0000	12	0.0000
Decapod, Paguris hirsutiusculus	-1.0000	-	1	-
Decapod, Pagurus sp.	-1.0000	0.0000	4	0.0000
Polychaeta, Pectinariidae	-1.0000	-	1	-
Polychaeta, Pholoe minuta	-1.0000	0.0000	3	0.0000
Amphipod, Gammarid, Phoxocephalidae	-1.0000	0.0000	5	0.0000
Polychaeta, adult	-1.0000	0.0000	2	0.0000
Polychaeta, Platynereis bicanaliculata	-1.0000	-	1	-
Amphipod, Gammarid, Pleustidae	-1.0000	0.0000	2	0.0000
Polychaeta, general, juvenile	-1.0000	0.0000	9	0.0000
Amphipod, Gammarid,Pleustes cataphractus	-1.0000	0.0000	2	0.0000
Polyplacophora	-1.0000	-	1	-
Harpacticoid, Porcellidium	-1.0000	0.0000	9	0.0000
Amphipod, Gammarid, Pontogeneia sp.	-1.0000	0.0000	3	0.0000

Table 8: continued

Species	mean	se	n	p.value
Polychaeta, Polynoidae	-1.0000	0.0000	5	0.0000
Decapod, Pugettia gracilis	-1.0000	-	1	-
Shrimp, general unknown juv./adult	-1.0000	0.0000	3	0.0000
Decapod zoea, general shrimp	-1.0000	-	1	-
Shrimp, Hippolytid, general	-1.0000	0.0000	5	0.0000
Polychaeta, Sphaerosyllis erinaceus	-1.0000	0.0000	4	0.0000
Shrimp, Hippolytid, Spirontocaris sp.	-1.0000	-	1	-
Polychaeta, Spionidae	-1.0000	0.0000	2	0.0000
Porifera	-1.0000	0.0000	2	0.0000
Echinodermata, Strongylocentrotus	-1.0000	-	1	-
Polychaeta, Syllidae	-1.0000	0.0000	3	0.0000
Amphipod, Gammarid, Tiron biocellata	-1.0000	-	1	-
Polychaeta, trochophore larva	-1.0000	-	1	-
Harpacticoid, Tisbe sp., adult	-1.0000	0.0000	5	0.0000
Harpacticoid, Tisbe copepodite	-1.0000	0.0000	6	0.0000
Harpacticoid, Tisbe sp., gravid female	-1.0000	0.0000	3	0.0000
Harpacticoid, Tisbe sp., stage unknown	-1.0000	0.0000	14	0.0000
Unknown egg mass	-1.0000	0.0000	3	0.0000
Calanoid, Pseudocalanus sp., general	-0.9925	0.0075	12	0.0000
Calanoid, Acartia longiremis , General	-0.7143	0.2857	7	0.0410
Unknown nauplius	-0.7143	0.2857	7	0.0410
Amphipod, Gammarid, unknown, medium	-0.6667	0.3333	6	0.0924
Calanoid, Pseudocalanus copepodids I-IV	-0.5000	0.5000	4	0.3739
Calanoid, general small (<2.5 mm)	-0.4796	0.1705	15	0.0131
Calanoid, Centropages abdominalis, adult	-0.4286	0.3689	7	0.2834
Euphausiid nauplii	-0.3333	0.6667	3	0.6514
Unknown invertebrate egg, small (<0.2mm)	-0.2500	0.3660	8	0.5138

Exxon Valdez Oil Spill
Restoration Project Annual Report

Forage Fish Study in Prince William Sound, Alaska



This report has been prepared for peer review as part of the *EXXON Valdez* Oil Spill Trustee Council restoration program for the purpose of assessing project progress. Peer review comments have not been addressed in this annual report.

UAF-NMFS Forage Fish Research Contract
Restoration Project 94163
Annual Report
Start-up Date August 1994

School of Fisheries and Ocean Sciences
University of Alaska Fairbanks

September 1995

CONTENTS

SUMMARY

Hydrographics

Because the work during the August cruise focused on hydroacoustic aspects, and because use of the vessel winch was dedicated to hydroacoustic equipment, hydrographic data were not collected.

For the November cruse, the temperature-depth profiles for the open areas of the Prince William Sound showed that temperature was cool at the surface, at about 7.0 C and warmed to 9.0 C at a depth of 50 m. The water then cooled to about 5 C with further increase in depth. Salinity gradually increased through this depth range, indicating that there was little mixing of the water column and that cooling was occurring from the surface downward due to cold air temperatures. Over the shallow shelf areas the profiles were different, being at 8.0 C, and mixed to 70 m. Mixing may have been due to tidal currents.

Invertebrate Forage Species

Invertebrate net sampling was not carried out in August. In November, five stations were sampled with a one-m NIO net (National Institute of Oceanography) with 1 mm mesh. The hauls were made with oblique, vertical pulls. At most stations, euphausiids were the abundant crustacean, though the shrimp *Pasiphaea pacifica* were abundant, and in another haul Pandalidae, Crangonidae, and Hippolytidae were abundant. Another haul contained only pelagic amphipods. Since crustacea are the prey of the herring and young pollock, determining the distribution of these invertebrates will help in our understanding of the distribution of fishes. In some areas kittiwakes have been found to eat quantities of euphausiids, so at times crustacea are a major prey for sea birds.

Acoustic and Net Sampling Analysis of Fish Species

Fish schools occurred mainly in the more shallow water regions near the bottom in August according to the hydroacoustic data. Fish were apparently absent from mid-water layers over the deep passages. The most intense near-surface sound scattering was observed in Bainbridge Passage. Sea birds were foraging in this area, associated with the fish concentrations. Details of the sea-bird work have been developed by W. Ostrand (Appendix B). Net sampling was not carried out in the preliminary August cruise.

In November hydroacoustic analysis showed that fishes were mainly located above the temperature maximum at depths of 20 to 40 m. Acoustic data were calculated as number of fish targets per cubic meter. Hydrographic data indicated that the fish aggregations were at temperatures of 7.0 to 7.5 ^{O}C. A second layer of fish was seen near the bottom in the hydroacoustic record. The temperature at these concentrations was 5 ^{O}C.

Net sampling in November showed that the fish seen with the hydroacoustic apparatus at depths to 40 m were young herring mixed with young pollock. They are mostly 0+ and 1+ aged fish. Eulachon were found in some hauls 40 - 80 m in the deep Port Gravina area. The layer of fish seen near the bottom in the hydroacoustic record was likely adult pollock. However, due to the rough bottom the net could not be deployed to verify the identification.

INTRODUCTION

This report represents the written portion of the year-end report of the UAF NMFS Forage Fish Research contract. The oral reporting was given at a workshop on April 26, 1995 at the *Exxon Valdez* Oil Spill Trustee Council, 645 G Street, Anchorage, AK. Notes from this meeting are included as Appendix C of this report.

As written in the original Proposal, the objectives of the UAF-NMFS Forage Fish Research Project were as follows:

1. Provide an initial estimate of the distribution of forage species relative to areas of known concentrations of marine seabirds and mammals.

2. Describe the species composition of the forage base, and size distributions of the most abundant forage species.

3. Generate an acoustic data set that can be used to design the best acoustic data survey in subsequent years of the study.

4. Coordinate forage fish surveys with personnel from the United States Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) to insure that data are taken in known foraging areas of marine birds and mammals.

5. Determine size composition of important forage species in the study area.

6. Provide suitable forage fish samples to ADF&G for food habits and stable isotope analyses.

7. Gather basic oceanographic data describing conditions in the study area, and salinity, temperature, and sigma-t profiles of the water column and water depth at all sites of data collection.

8. Generate a detailed proposal for quantitative evaluation of forage fish distribution and abundance in subsequent years and describe the ecological role of forage fish in the PWS ecosystem.

9. Provide, to the COTR, raw and summarized data describing the distribution and abundance of forage species as outlines in the RFP.

Progress has been made on all objectives. Results of distribution analyses (Objective 1) are provided in Chapters 3 and 5. Species composition (Objective 2) is presented in Chapter 4 and 5. Hydroacoustic data and consideration of survey design (Objective 3) is discussed in Chapter 3 as well as in the new research proposal for next year's program.

Forage fish size and species composition (Objective 5) is given in Chapter 5. As a result of trawling, samples were provided to ADF&G, NMFS and the Institute of Marine Science for various laboratory analyses (Objective 6). Basic oceanographic data is given in Chapter 2 (Objective 7). Raw data was provided to the contracting agency (Objectives 8,9).

Monthly meetings with relevant agencies were held from September through January (Objective 4). Larger workshops were held in September 1994 and April 1995. The objective of the September 1994 Workshop was to familiarize investigators of the Forage Fish Project with the SEA Project that had been on-going for a year at that time. This was also the first meeting between the seabird investigators and the fish biologists. An understanding of objectives of seabird and fish subprojects, and the problems faced by each, was achieved at this meeting. The purpose of the April, 1995 meeting was to give an oral version of the Project Annual Report, including presentations of findings of the fish biology to the project managers of the state and federal agencies and the COTR of the Forage Fish Project. These managers requested clarifications that are incorporated into this written version of the Annual Report.

Other monthly meetings were to develop a sense of integration among the PI's of the various seabird and fish subprojects. The result was a new understanding of how to approach and integrate the aspects of seabird biology and fish biology. As a result funding was arranged for a general project manager by the COTR and the EVOS Chief Scientist. Out of this reorganization was born the integrated APEX Project.

The Forage Fish Project is continuing as part of the APEX project. An extensive draft dealing with the biology of forage fishes was given to the contracting agency in January 1995. This was further revised into the APEX Project Proposal in March, 1995. Readers are referred to this proposal for the forward continuation of the objectives of the Forage Fish Project as integrated with the seabird sub-projects. The means of coordinating with the SEA Project are also dealt with in the APEX Proposal.

A description of the general procedures of the work on fishes is as follows. In 1994 SFOS conducted two cruises, in August and November, the primary objectives of these cruises were to make an initial evaluation of the distribution of forage species in PWS, to develop transect techniques that allowed simultaneous recording of acoustic data and bird distributional and behavior data, to incorporate the new digital acoustic technology into the sampling program, to evaluate the utility of various net sampling techniques, and to provide input to the design of sampling programs for subsequent years of study.

The objective of the August research cruise (FOR94-01) was to generate an acoustic data set describing the distribution of organisms in the size range of forage species. The cruise was conducted on the RV Little Dipper, a 26' diesel-powered vessel operated by the University of Alaska out of the Seward Marine Center. The cruise began on 15 August and terminated when the vessel had a disabling breakdown of the main propulsion unit on the morning of 21 August. The small size of the vessel precluded use of sampling equipment to identify species composition of acoustic targets. The November cruise (FOR 94-02) was conducted on the R/V MEDIEA, a 110 foot research vessel operated by the Alaska Department of Fish and Game, from November 6 - 15. The objectives of the November cruise were to evaluate net sampling options, to collect specimens for biological studies of forage species, to describe hydrographic conditions in study areas, and to document the distribution of forage species.

HYDROGRAPHIC ANALYSIS

L. Haldorson

General
The dominant feature at most stations was a stable water column with a temperature maximum layer of about 9° C around 50 m depths. Somewhere below 50 m most stations had sharp or gradual thermocline where temperatures dropped to just below 6° C. Surface temperatures were typically 5° - 7° C.

Water column properties were recorded at 35 CTD stations during cruise FOR94-2 in November 1994 (Appendix A, Table 1, Figure 1). Several profiles were collected at stations in the open waters of the Sound, and transects of six to seven stations were run into four embayments: Ewan Bay, Galena Bay, Saint Matthews Bay and Port Gravina.

Deep, Open-Water Stations (depths > 250 m)
Deep water stations outside of Bays were sampled at CTD 4, 12, 20, and 35 (Appendix A, Figures 3, 13, 21, 36)). All of these stations had similar profiles of temperature, salinity and sigma-t. Surface temperatures were close to 7° C, with temperatures rising steadily to a temperature maximum of about 9° at depths between 50 and 100 m. Below 100 m temperatures dropped steadily to around 6° between 100 and 150 m, below which the water was almost isothermal to the maximum depth recorded.

The water column at all deep water stations appears to have been stable, as a result of salinities rising gradually from the surface down to the maximum depth recorded. Density followed a pattern similar to salinity, indicating that the temperature structure was likely to persist. Surface salinities varied from 28.5 - 31.5 o/oo, with lower values at CTD 4 and 12 on the west side of the sound.

Shallow, Open-Water Stations (Depths < 250 m)
CTD1 and CTD 2 between Montague and Knight Islands were over relatively shallow water. Station 1 was over a shallow (74 m) shelf NW of Green Island, and displayed little temperature variation down to about 50 m. Salinity and Sigma-t also were without any definite structure at this station. CTD 2 was in 140 m of water and in the main channel that runs parallel to Montague Island. It had a temperature maximum similar to that observed at the deep open-water stations, and also had a stable density structure.

Icy Bay.
One station. CTD 3, was occupied in Icy Bay. The water column had a temperature maximum at 40 - 50 m and was similar to deep-open water stations, except for a fairly sharp thermocline at around 60 m.

Ewan Bay.
A series of seven CTD stations (CTD 5 - 11) was run from the mouth to the head of the Ewan Bay. Surface temperatures were around 6^{o}, and increased gradually to a temperature maximum of 8^{o} - 9^{o} at about 50 m. Below the maximum temperatures dropped slightly to 7^{o} 8^{o}. Salinity and density increased gradually from the surface to the maximum depth.

Galena Bay.
Galena Bay (CTD 13 -20) also had a temperature maximum of 9^{o}C at around 40 - 50 m, with a gradual thermocline leading to temperatures $< 6^{o}$ at 150 m. Near the head of the Bay there was a surface lens of colder, fresher water that resulted in an unstable density inversion in the upper water column.

Saint Mathews Bay.
Saint Mathews Bay (CTD 21 - 27) is relatively shallow < 100 m, and had a broad temperature maximum layer (8^{o} - 9^{o}) from about 20 m through 60 m. In the deeper sections of the Bay temperatures dropped to 7^{o} - 8^{o} at depths over 70 m.

Port Gravina.
The transect at Port Gravina (CTD 28 - 35) ran from a location off the mouth of Saint Mathews Bay westward until depths exceeded 100 m. Temperature profiles in this area were variable, without the well-defined temperature maximum that typified most areas sampled. The water column was almost isohaline and isopycnal, suggesting that the water over this shelf was relatively well-mixed. Water column structure in this area was most similar to the shallow-area NW of Green Island (CTD 1)

HYDROACOUSTIC ANALYSIS

K. Coyle, R. Thorne

Introduction

Seabirds suffered substantial mortality from the Exxon Valdez oil spill and some taxa have not yet recovered. Continued breeding failures may be linked to food shortages related to oil spill damage. Since small fish are a major component of the diets of several seabird taxa in Prince William Sound, the causes of seabird population declines cannot be evaluated without concurrent estimates of fish populations in foraging regions in proximity to the nest sites.

Modern techniques for evaluation of fish populations include both net sampling and quantitative acoustic surveys. While net samples provide estimates of the size and species composition of individual schools, net samples alone cannot provide data at spatial scales necessary for fish stock assessment. However, acoustic surveys using multiple frequencies, in combinations with data on the size and species composition of the surveyed stocks, can provide reasonable estimates of the spatial distribution and size of fish schools in the foraging regions. Acoustic surveys are therefore a central component in any attempt to evaluate foraging conditions for seabirds in Prince William Sound. In 1994 the EVOS trustees initiated a multidisciplinary study of seabirds and their prey stocks in an attempt to determine the causes of continuing breeding failure at several seabird colonies in the sound. The following is a report on the results of preliminary acoustic surveys done in 1994 to evaluate gear and sampling designs for more detailed studies in subsequent years.

Sampling

Due to delays in funding, we were unable to charter a trawl vessel during August 16-20, 1994. Nevertheless, a preliminary acoustic survey was done in western Prince William Sound in August aboard the Little Dipper, a 26 ft. vessel operated by the University of Alaska. Constraints on fueling and crew accommodations limited sampling to 6-8 hours a day and engine failure terminated the cruise after five days. Despite these difficulties, about 330 km of acoustic and bird count transects were completed (Figure 1).
A second cruise aboard the stern trawler R/V Medeia was done, November 6-15. Emphasis was placed on locating and sampling fish schools so that net sampling gear could be tested and evaluated. Acoustic data was concurrently collected to field test a new digital sounder system which will be used to collect data during the 1995 field season. Since the goals of the cruise emphasized gear evaluation, we actively sought out fish schools to sample rather than adhere to a specific sampling plan designed to estimate fish populations. The sampling transects are shown in Figure 2.

Methods

Acoustic surveys during the August cruise were done with a model 102 echosounder and ESP echointegrator. A down-looking 120 kHz and a side-looking 420 kHz transducer were towed beside the vessel in a 4 ft. biofin. Samples were integrated for 30 seconds before being written to disk. The 420 kHz data were binned in 2 m intervals and the 120 kHz data were binned in 5m intervals.

Acoustic surveys during the November cruise were done with a 120 kHz DT4000 digital echosounder. System parameters were as follows: the source level was 217.969, the receive level -57.781 dB/sample, the beam pattern 8.69 X 10-4. Analytical software for the DT4000 system is still under development. I therefore wrote a preliminary program for data analysis. The data were integrated for 30 second intervals and discrete integrations were obtained for 5 m depth intervals from 5 m below the surface to the bottom. Salinity temperature depth data were obtained with a Seabird model SBE 19 CTD.

Results

The August survey indicated that fish schools occurred mainly in the shallower regions near the bottom. Targets were absent from midwater layers over the deep passages. Typical target distributions are illustrated in Figures 3 and 4. The most intense near-surface sound scattering was observed in Bainbridge Passage (Figure 5, upper). Birds appeared to be foraging in the near-surface acoustic feature at km 6-8. Highest surface scattering (upper 20 m) occurred in Bainbridge Passage (For1-33, Figure 5) and at the entrance of Little Bay (For1-3b4). The high surface value on transect For1-55 was due to a single intense feature at 5 to 10 m depth near the start of the transect. The remaining instances of high back scattering above 20 m depth were observed in shallow regions where epibenthic scattering was occurring at depths of less than 20 m.

Most sound scattering during the November cruise occurred in the epibenthic layer, between the bottom and 20 m above the bottom. Substantial scattering in the upper 20 m occurred only when bottom depths were less than 20 m (transect For-38). Herring schools were sampled both acoustically and with nets at transects For2-8 and For2-53, in Montague Passage and Port Gravena respectively. The average length of herring at the two sites was 172 and 231 mm respectively, yielding target strengths of -41 and -43 dB per fish. We estimated target strength in the epibenthic layer (the bottom to 20 m above the bottom) at both sites using EMS techniques and obtained results approximately equal to those predicted from the net data. The herring tows were taken during the day when the schools were within 20 m of the bottom, however, when bottom depths were less than 40 m, substantial concentration occurred near the surface and may have been accessible to birds (Figure 6). Both birds and whales were observed around the fish schools. Fish density in the schools was about 0.1 to 10 fish m-3 (Figure 6).

In addition to herring, juvenile pollock were also taken in midwater trawls. Pollock layers were observed in the upper 30 m during the day in Icy Bay and at night in Galena Bay (Figure 7). We were unable to sample the epibenthic layers in the above locations and are therefore unable to identify the deep targets. The average length of the pollock was 107 mm, yielding a target strength of about -45 dB per kg. Estimates using EMS techniques yielded target strengths of about -61 dB kg. Although more than 300 discreet targets were detected in each transect within the pollock layers, no signals over -60 dB were recorded. The cause of the discrepancy between target strength estimates using EMS and length measurements from trawl samples is not yet known, however, Thorne suspects a calibration error. The layers in the upper 40 m (Figure 7) have been adjusted using the -45 dB/fish target strength estimate. Highest scattering intensity occurred in Dangerous Passage (For2-17 to For2-26). The most intense scattering occurred in the epibenthic layer, however, a weaker scattering layer occurred above the deep layer and was similar to that produced by juvenile pollock (Figure 8).

The coefficient of variation in scattering intensity was examined with respect to transect length by pooling the data and sub-sampling with replacement using a random number generator to choose a starting point for each transect. Transect lengths of roughly 40 km would be required to lower the coefficient of variation in the August data to about 0.5 (Figure 9, upper). The coefficient of variation in the November data initially dropped off very quickly, but did not reach 0.5 till transect lengths reached about 20-30 km (Figure 9, lower). The standard error for both August and November data was examined by taking transect lengths of 40 km and computing the standard error for gradually incrementing numbers of sub-samples randomly generated as described above. The standard error of both data sets decreased at a similar rate relative to increasing sample size (Figure 10). Roughly 15 to 20 replicate sub-samples would be required from this data set before the standard error approaches its asymptote. The total sampling length would be about 800 km, 2 to 3 times the total sample distance sampled during each of the 1994 cruises. The variance is much greater than the mean, indicating that this data set is highly clustered until sampling distances approach about one third the total distance sampled during the cruises.

The potential effect of stratification by depth was examined by comparing the variances for average values computed from samples obtained by sub-sampling the acoustic data as described above. The data set was divided into two strata at selected depth intervals between 40 and 130 m inclusive. A total of 30 sub-samples of 4 km length was taken and the depth interval was increment by 10 m for each trial. A tendency toward lower standard deviations was observed when the samples were stratified at 50-60 m depth intervals (Figure 11).

CTD stations were occupied in Montague Strait, Icy Bay, and at the deep region to the east of Lone Island. In addition, CTD transects were done into Ewan Bay, Galena Bay and Port Gravina. CTD profiles revealed a subsurface temperature maximum layer with a warm core at about 30-50 m depth (Figure 12). Nevertheless, the water column remained stable due to lower surface salinities; the sigma-t profiles closely follow the salinity profiles (Figure 12). The warm subsurface layer could be detected clear into the bays, where it formed a warm layer just above the bottom (Figures 13, 14). The somewhat lower standard deviation when the acoustic data set was stratified at 50-60 m depth (Figure 11) and the warmer water temperature at 30-50 m depth may indicate a temperature preference by the target species.

Sampling Strategies
Of various possible sampling strategies for fish surveys, a random design is almost never employed (Gavaris, S. and S. J. Smith. 1987, Leaman, B. M. 1981, Mohn, R.K., G. Robert and D.L. Roddick. 1987). In addition, systematic surveys have an advantage over random surveys in that they provide for a more uniform coverage of the target area and are easier to plan and carry out. However, systematic survey of highly aggregated data can yield imprecise estimates of average fish densities due to autocorrelation problems. On the other hand, encounter response designs reduce the requirement of homogeneity over the target area and greatly reduce the number of zeros in the data set. However, areas between aggregations may be under sampled. The combination of acoustics and net sampling takes advantage of both survey designs. A systematic acoustic survey can be completed fairly quickly and inexpensively, while the net tows can be targeted acoustically to sample specific aggregations in an encounter response fashion. The above design will insure adequate coverage of the target area and permit us to identify specific targets in the acoustic data, information central to interpretation of any acoustic survey. Although the 1994 data suggest some gains in precision may result from stratification at the 50-60 m depth contour, the data were insufficient to justify a stratified sampling design at this time.

Side-look Acoustic Data
During the cruise in August, data were collected with a side-looking transducer as well as the down-looking transducer. The side-looking transducer scanned horizontally, just below the surface of the water. The objectives in this mode were to enhance sampling capability in the upper depth intervals. Data collection consisted of simply alternating pings between the down-look and the side-look transducers. The basic echo integration analysis for the side-looking data was very similar to the down-look. Echo integration measurements were made in 5 m range intervals, integrated over 30 second periods.

Side-look data are very sensitive to reverberation from waves, and require careful editing. In this case, the range was limited to 50 m to minimize surface reverberation problems. Returns from surface reverberation were edited from the data set, then the relative fish density for the entire 50 m range was calculated for each 30 second output.

Figure 1. Acoustic survey track during 16-20 August, 1994.

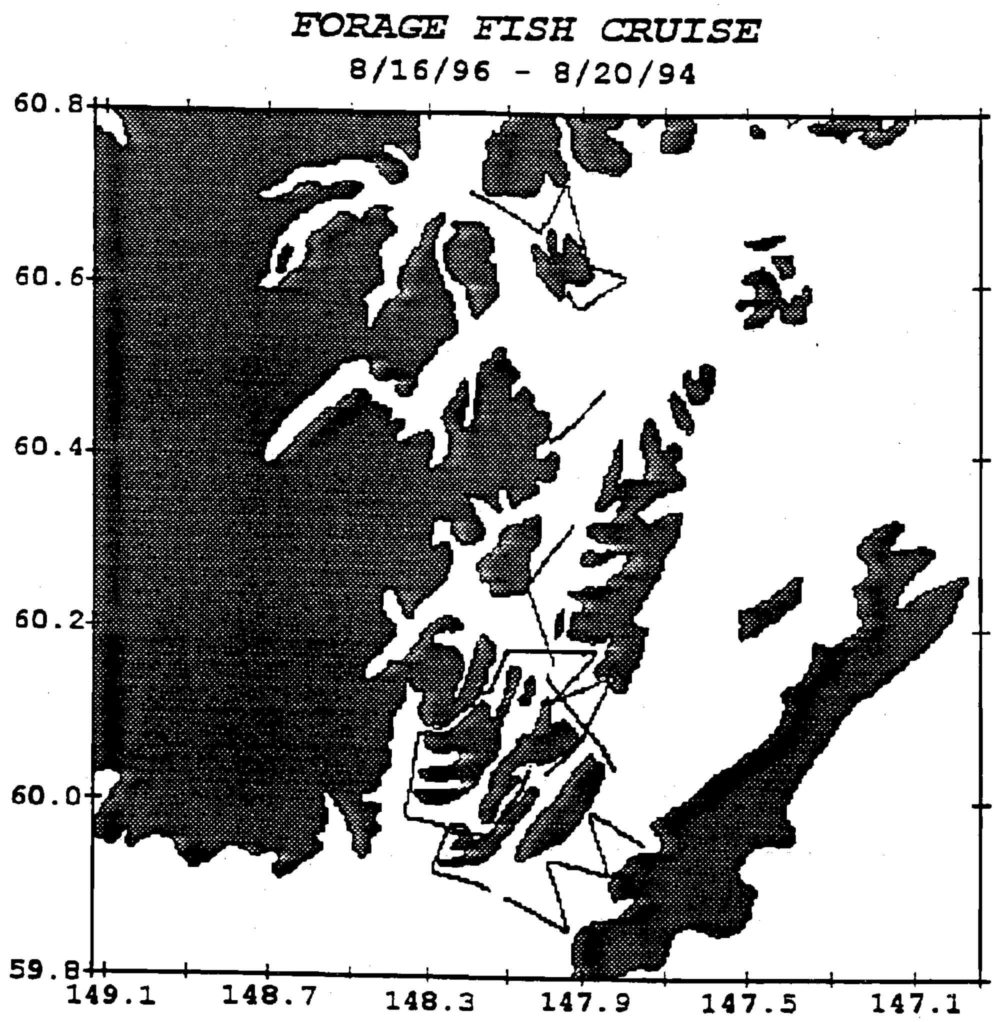


Fig. 1. Aoustic survey track during 16-20 August, 1994.

Figure 2. Acoustic survey track during 5-15 November, 1994.

Forage Fish Cruise

11/5/1994 - 11/15/1994

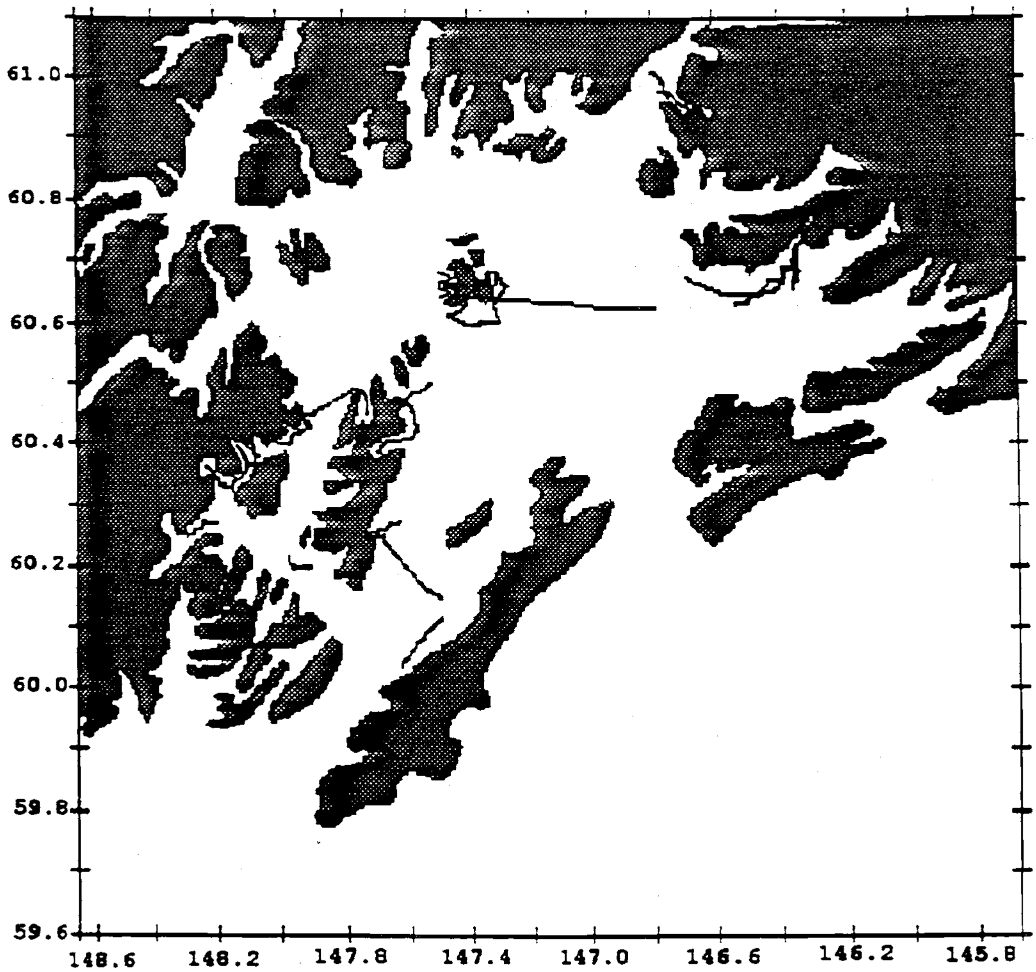
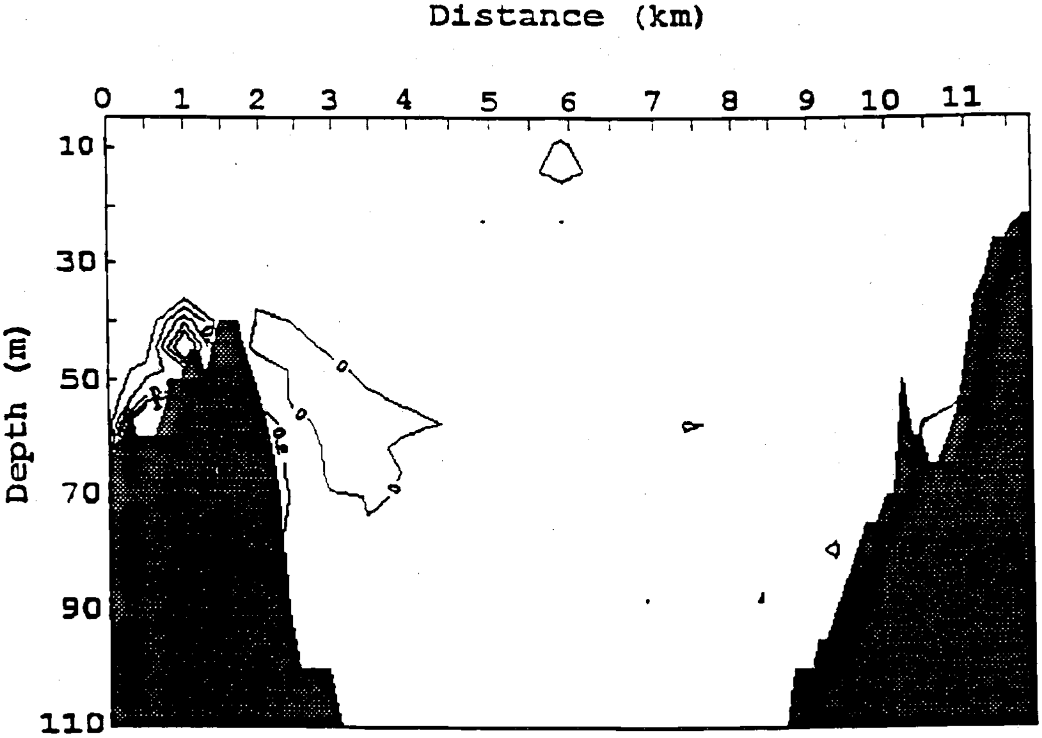


Fig. 2. Acoustic survey track during 5-15 November, 1994.

Figure 3. Profile of acoustic targets, relative backscattering intensity (Transect information in Appendix Table).

Fig. 3. Profile of acoustic targets, relative backscattering intensity (Transect information in Appendix Table).

August Cruise, Transect FOR1-2B2



August Cruise, Transect FOR1-32

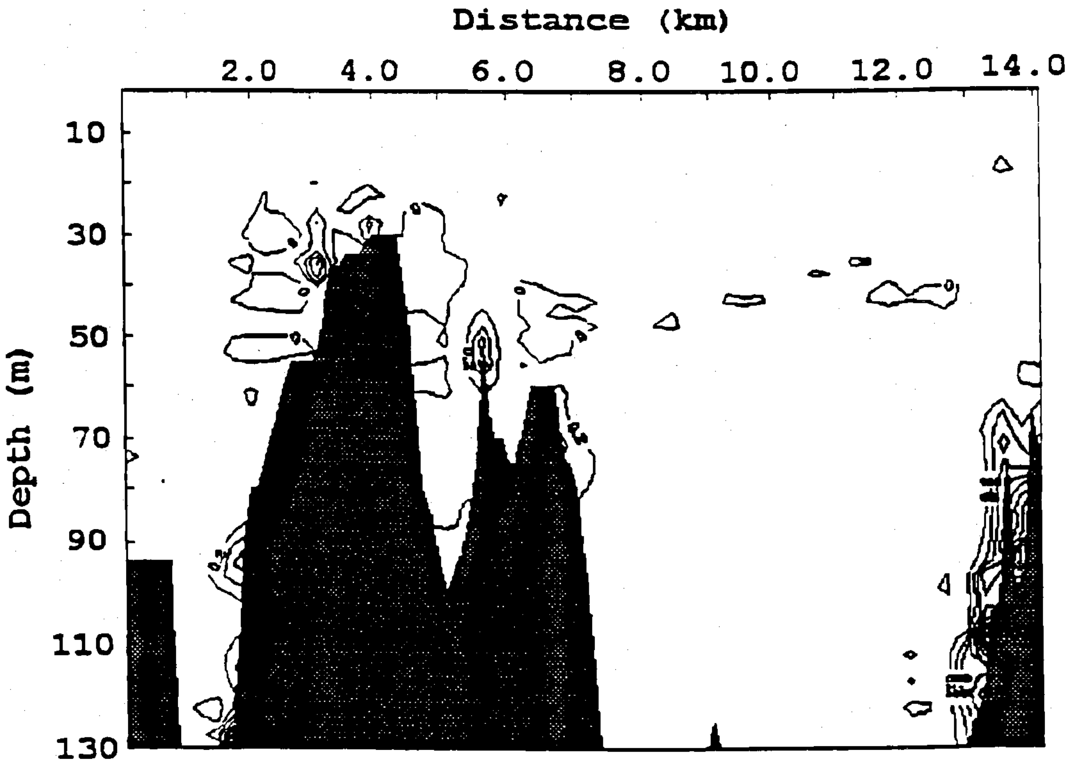
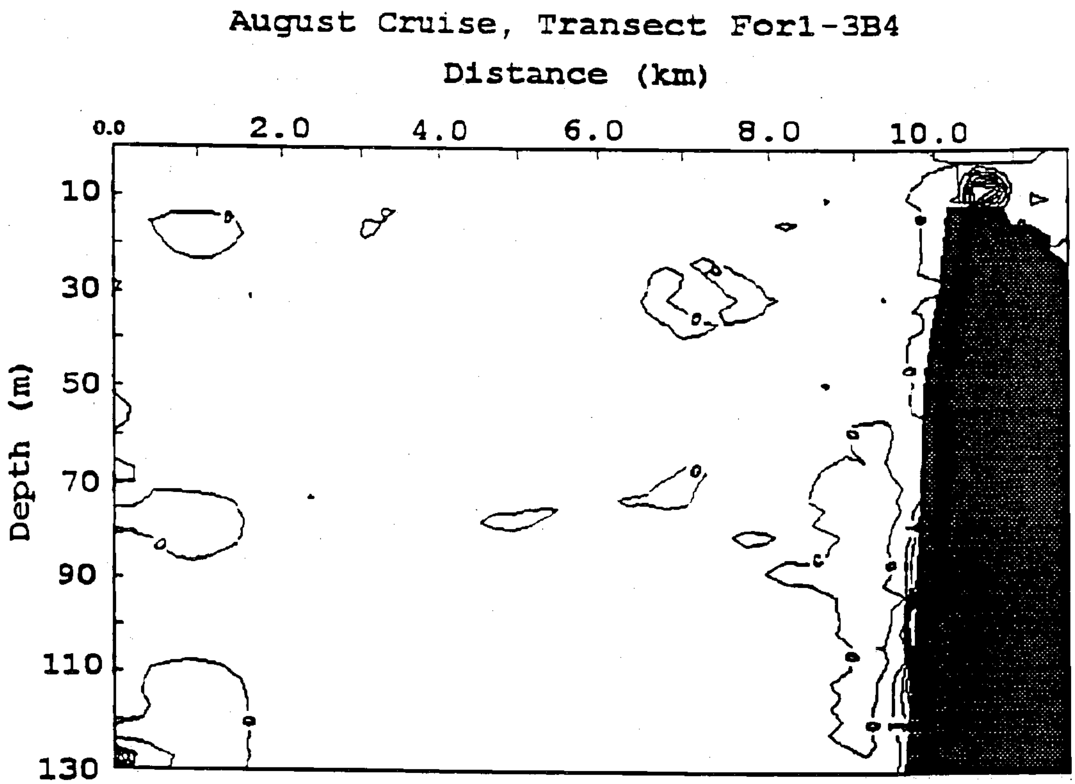


Figure 4. Profile of acoustic targets relative, backscattering intensity (Transect information in Appendix Table).

Fig. 4. Profile of acoustic targets relative, backscattering intensity (Transect information in Appendix Table).



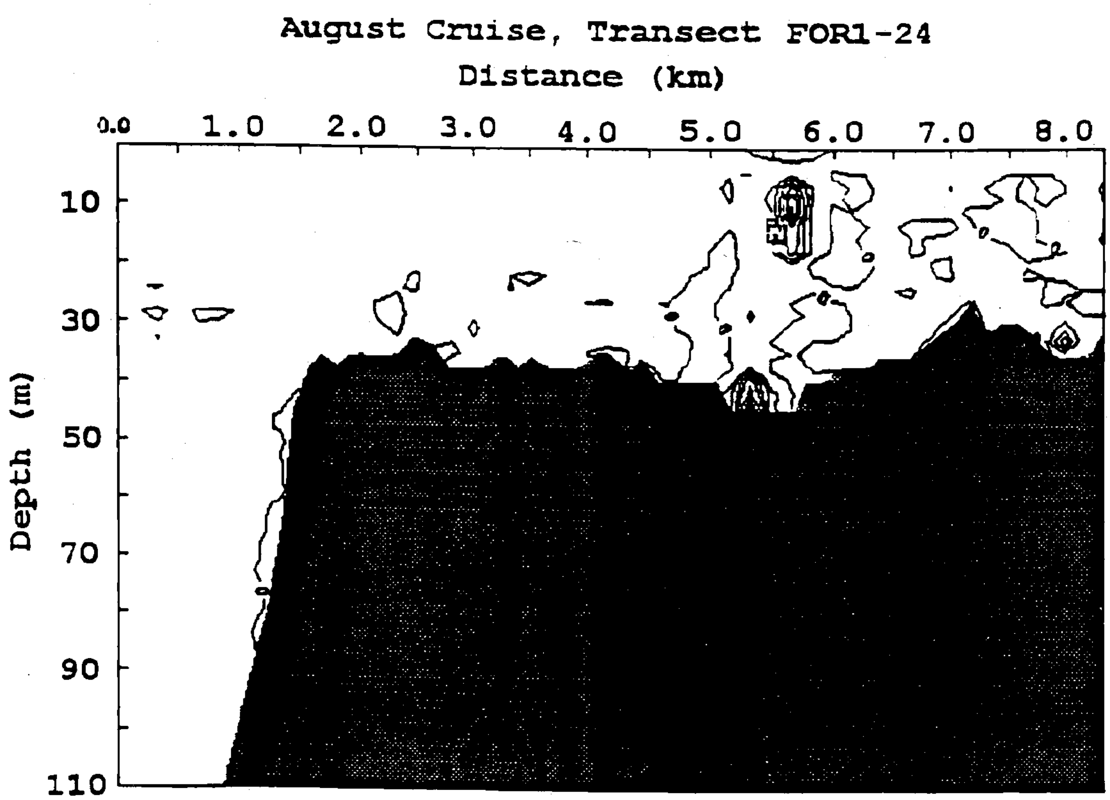
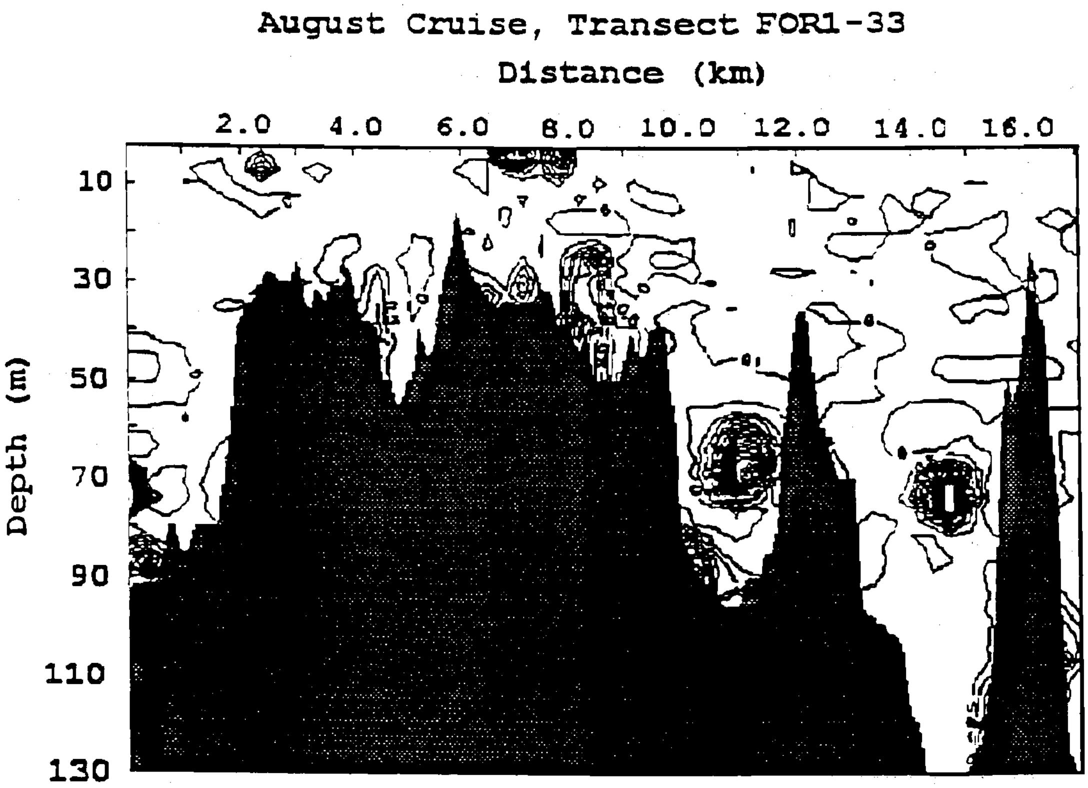


Figure 5. Profile of acoustic targets, relative backscattering intensity (Transect information in Appendix Table).

Fig. 5. Profile of acoustic targets, relative backscattering intensity (Transect information in Appendix Table).



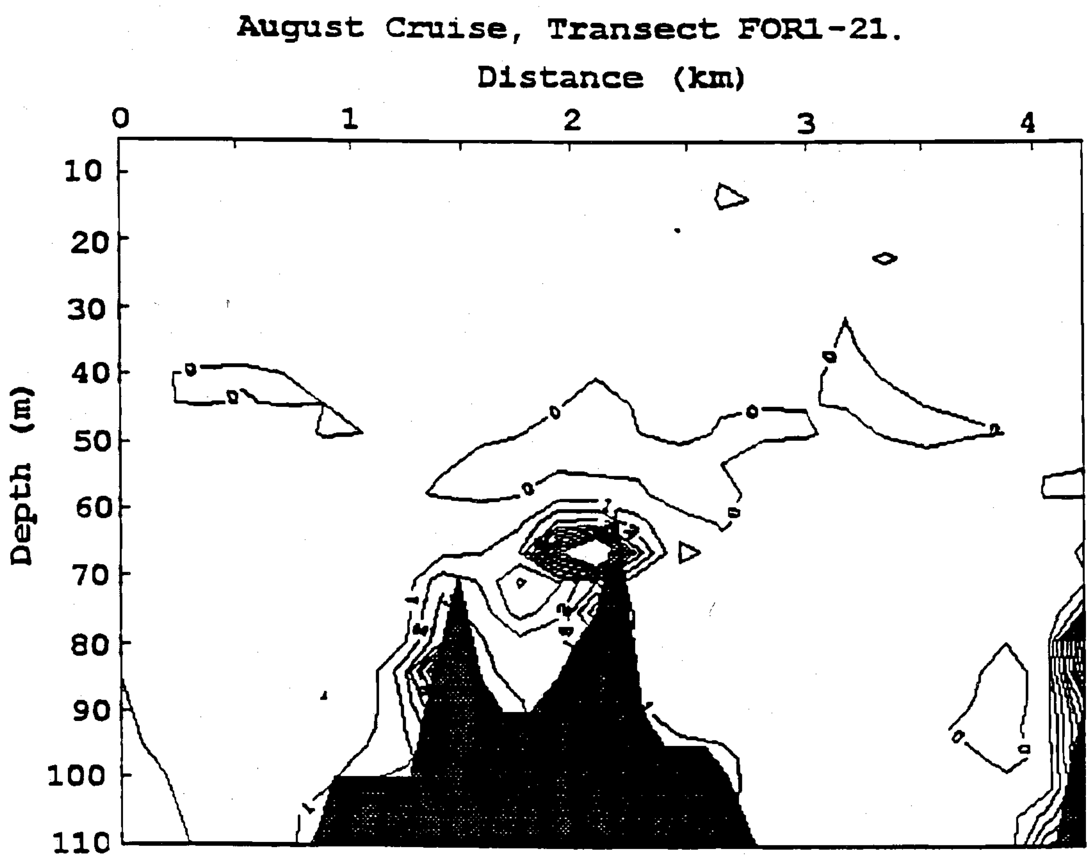


Figure 6. Herring schools in Montague Strait (upper) and Port Gravina (lower). Density estimates in fish/m3. Transect information in Appendix Table.

Fig. 6. Herring schools in Montague Strait (upper) and Port Gravina (lower). Density estimates in fish/m^3. Transect information in Appendix Table.

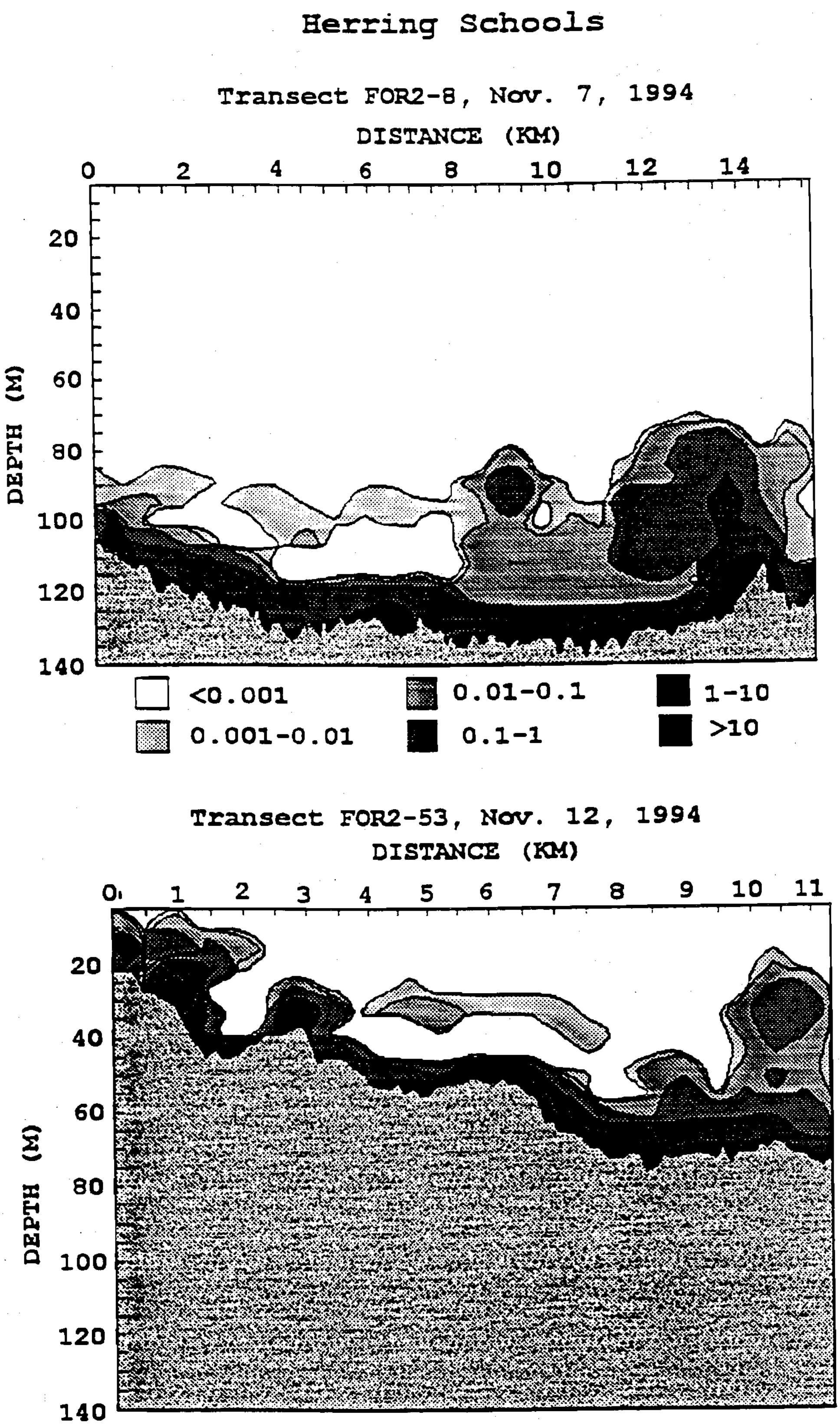


Figure 7. Pollock schools in upper 40 m depth in Icy Bay during the day (upper) and Galena Bay at night (lower). Density estimates in fish/m3. Transect information in Appendix Table.

Fig. 7. Pollock schools in upper 40 m depth in Icy Bay during the day (upper) and Galena Bay at night (lower). Density estimates in fish/m^3. Transect information in Appendix Table.

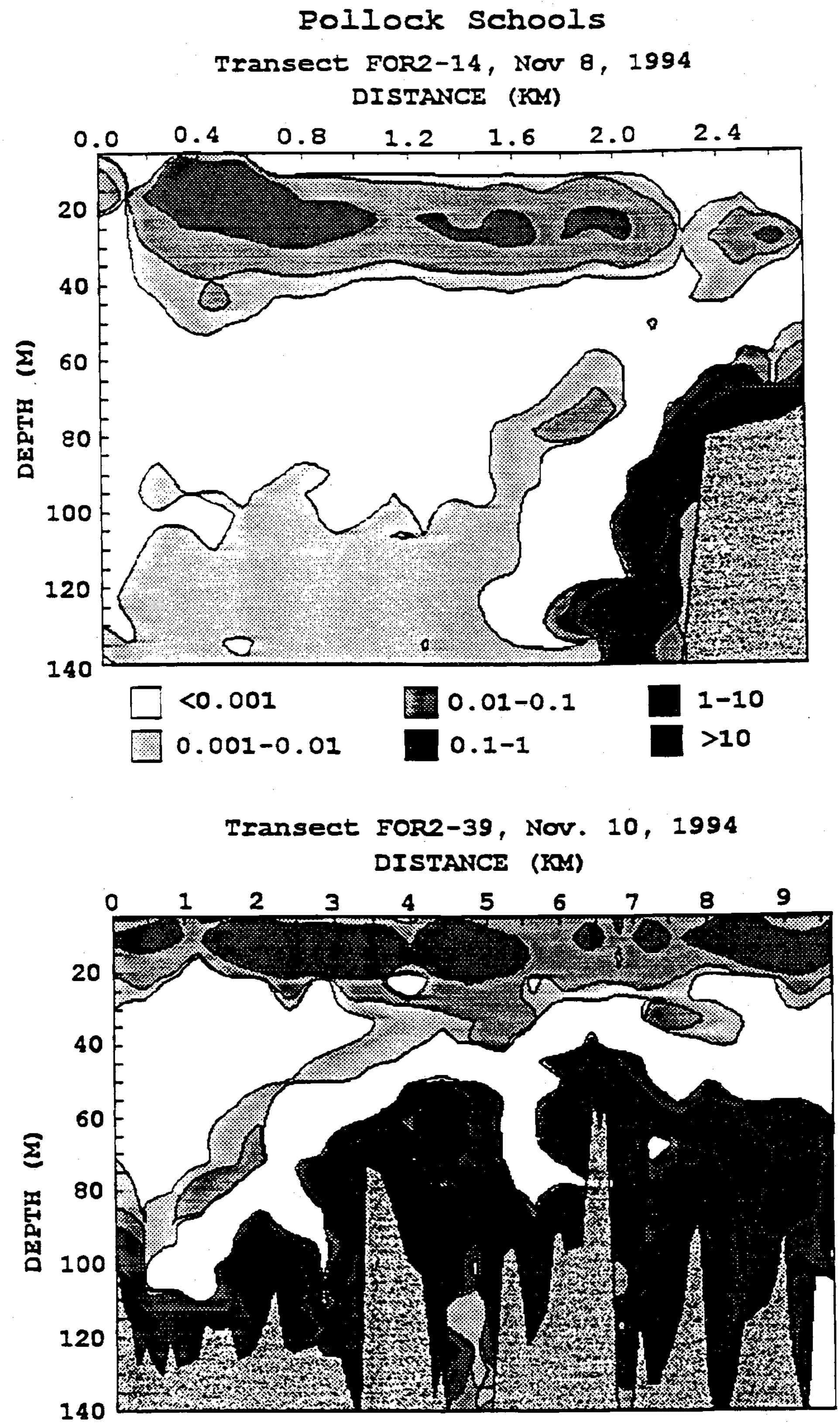


Figure 8. Relative backscattering in Dangerous Passage. Transect information in Appendix Table.

Fig. 8. Relative backscattering in Dangerous Passage. Transect information in Appendix Table.

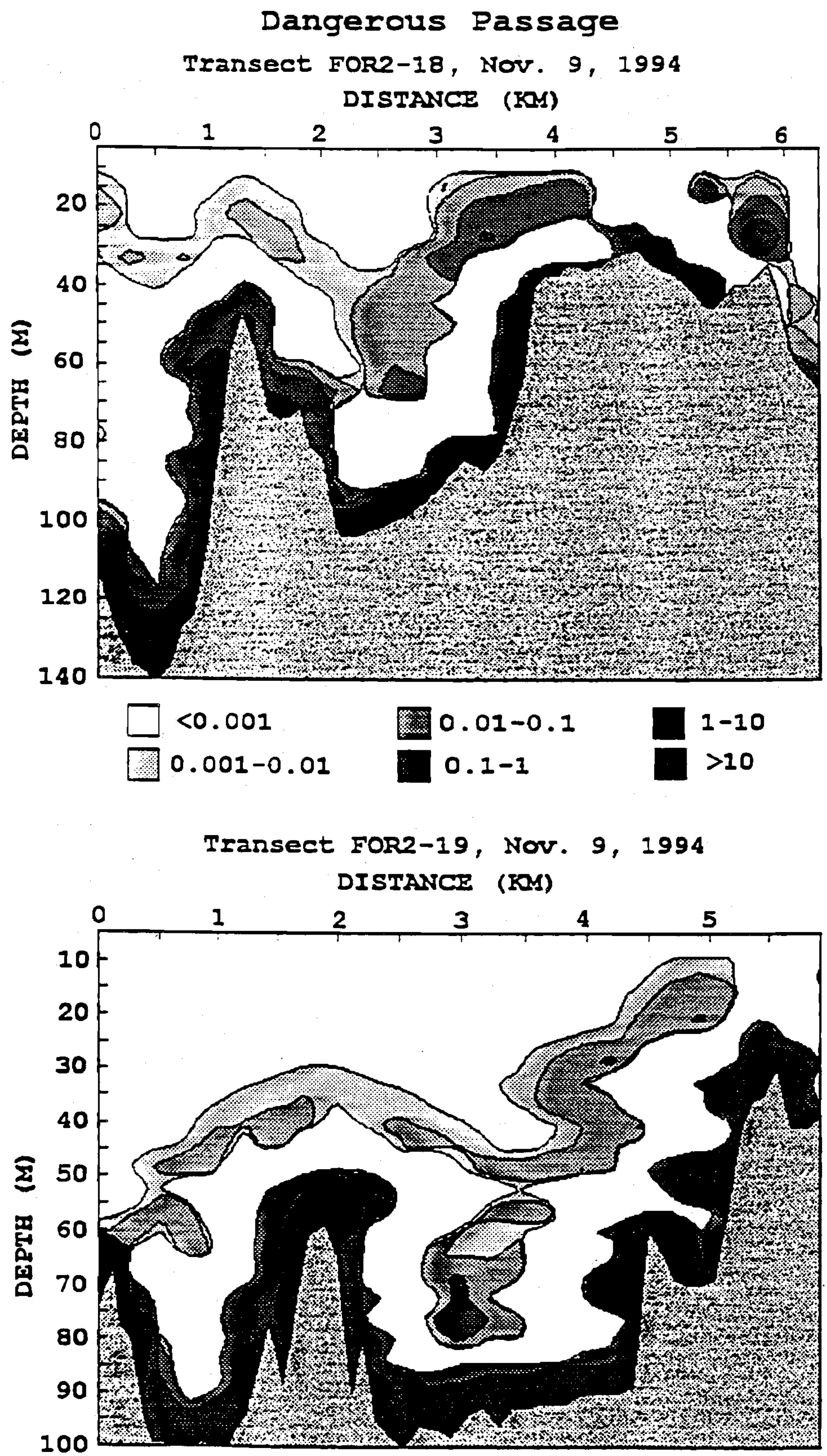


Figure 9. Coefficient of variation for five trials of 30 sub-samples vs. transect length for August (upper) and November (lower) acoustic data sets.

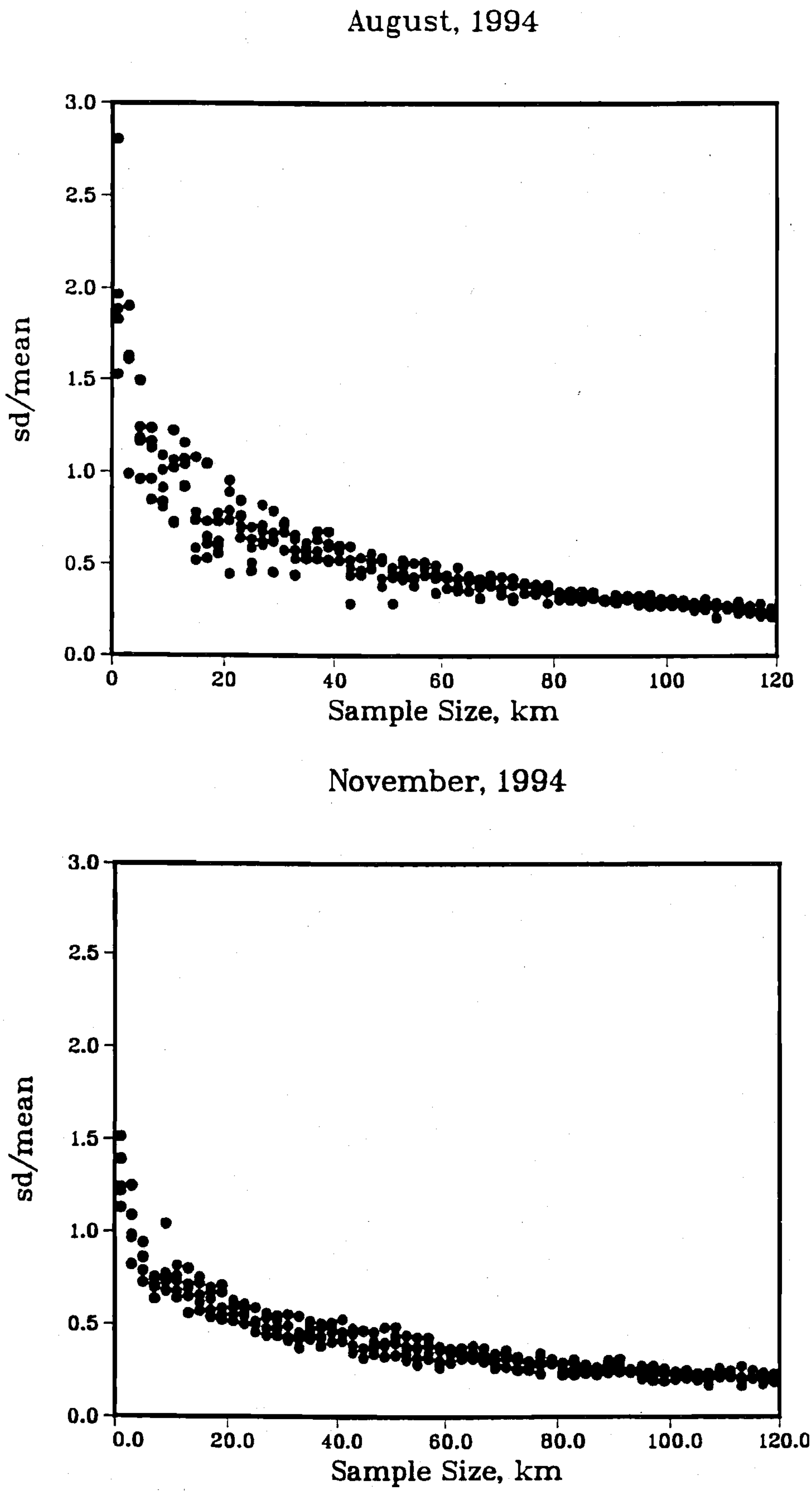
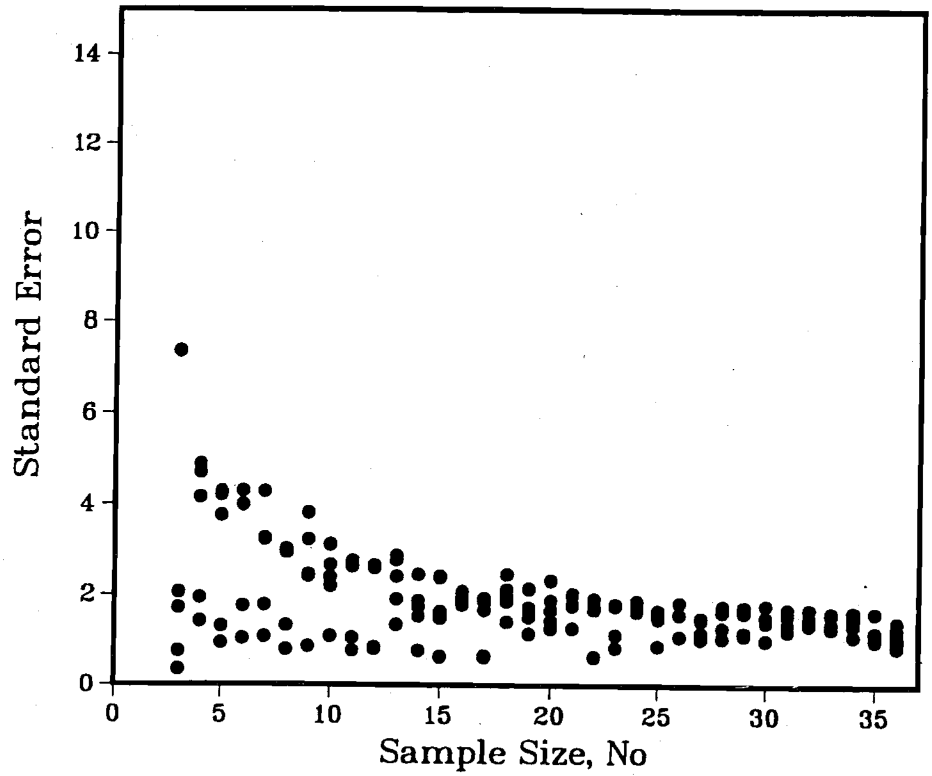


Fig. 9. Coefficient of variation for five trials of 30 subsamples vs. transect length for August (upper) and November (lower) acoustic data sets.

Figure 10. Standard error vs. sample size, for 40 km sub-samples from the August (upper) and November (lower) acoustic data sets.

August, 1994



November, 1994

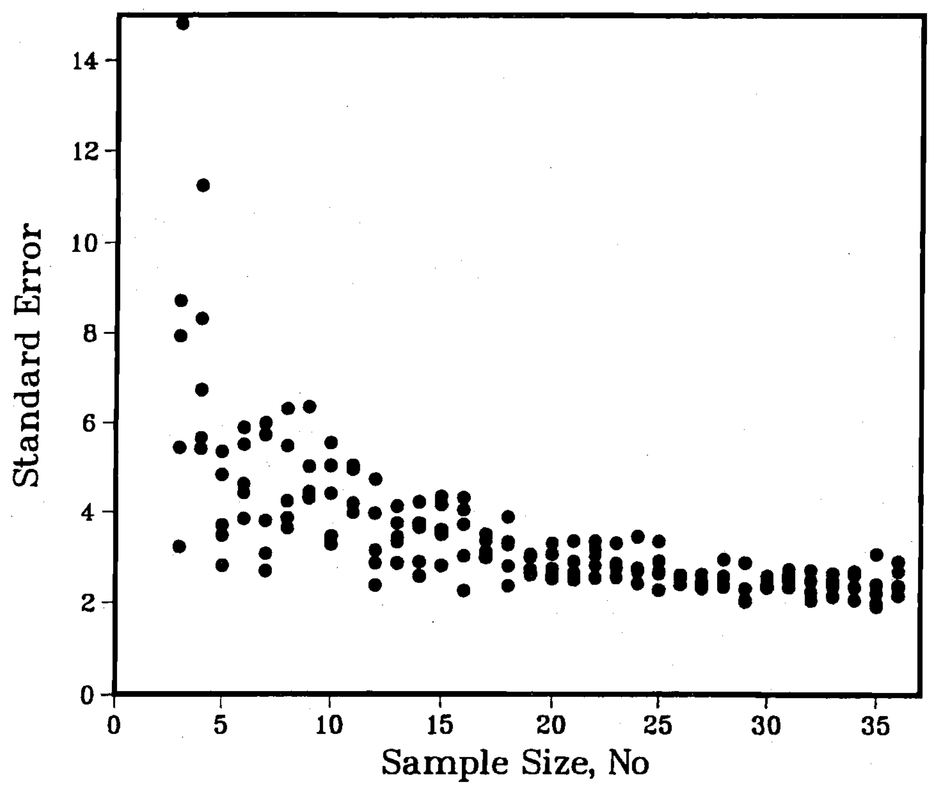


Fig. 10. Standard error vs sample size, for 40 km subsamples from the August (upper) and November (lower) acoustic data sets.

Figure 11. Standard deviation computed for the shallow portion of the November acoustic data set, when the data are stratified at depth intervals on the ordinate (samples size = 30, number of trials = 10).

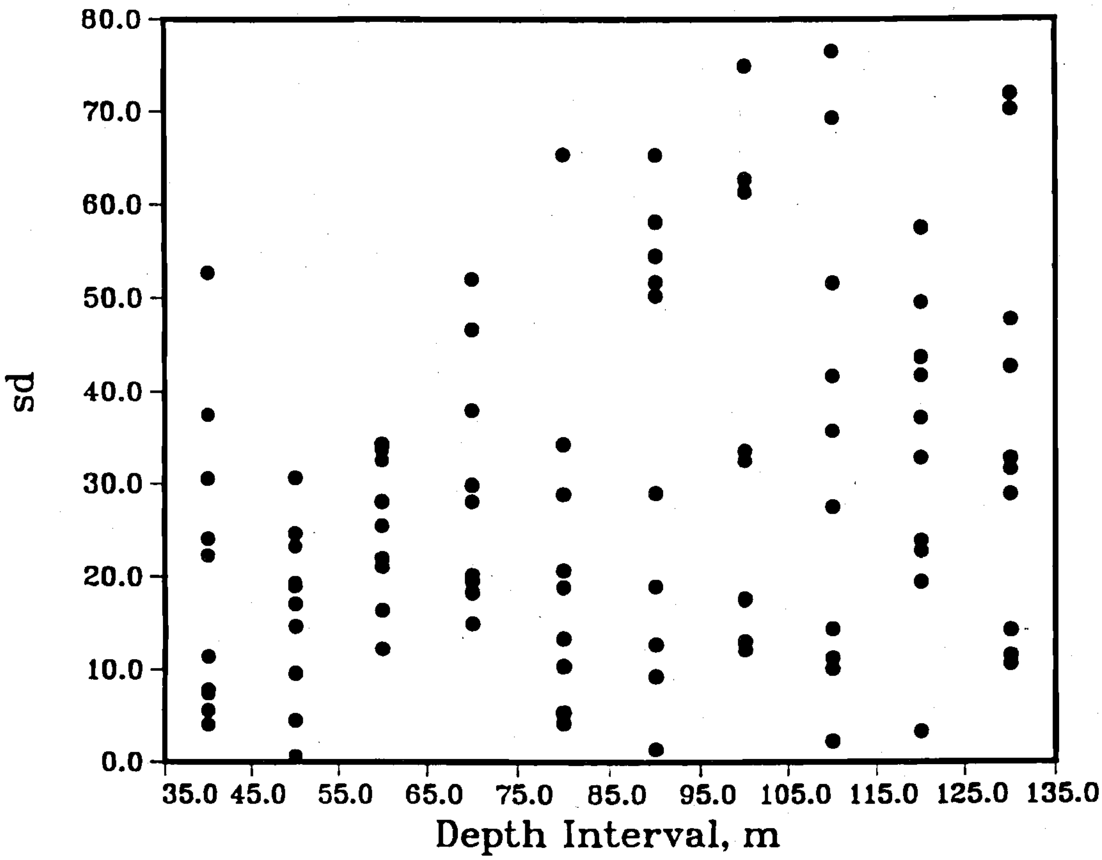


Fig. 11. Standard deviation computed for the shallow portion of the November acoustic data set, when the data are stratified at depth intervals on the ordinate (samples size = 30, number of trials = 10).

Figure 12. Temperature (solid line), salinity (dashed line) and sigma-t (dotted line) depth profiles at stations in Montague Strait and Icy Bay.

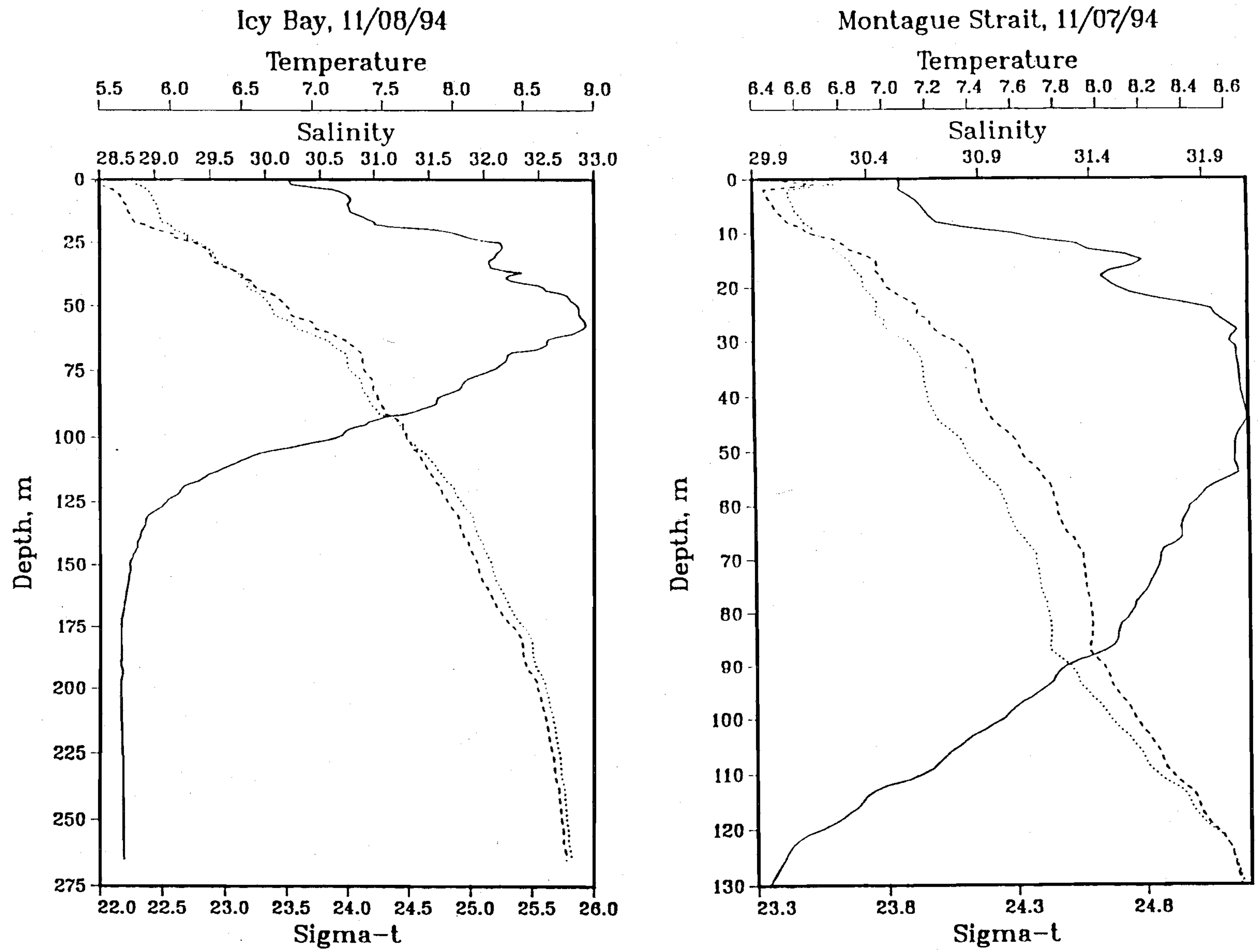
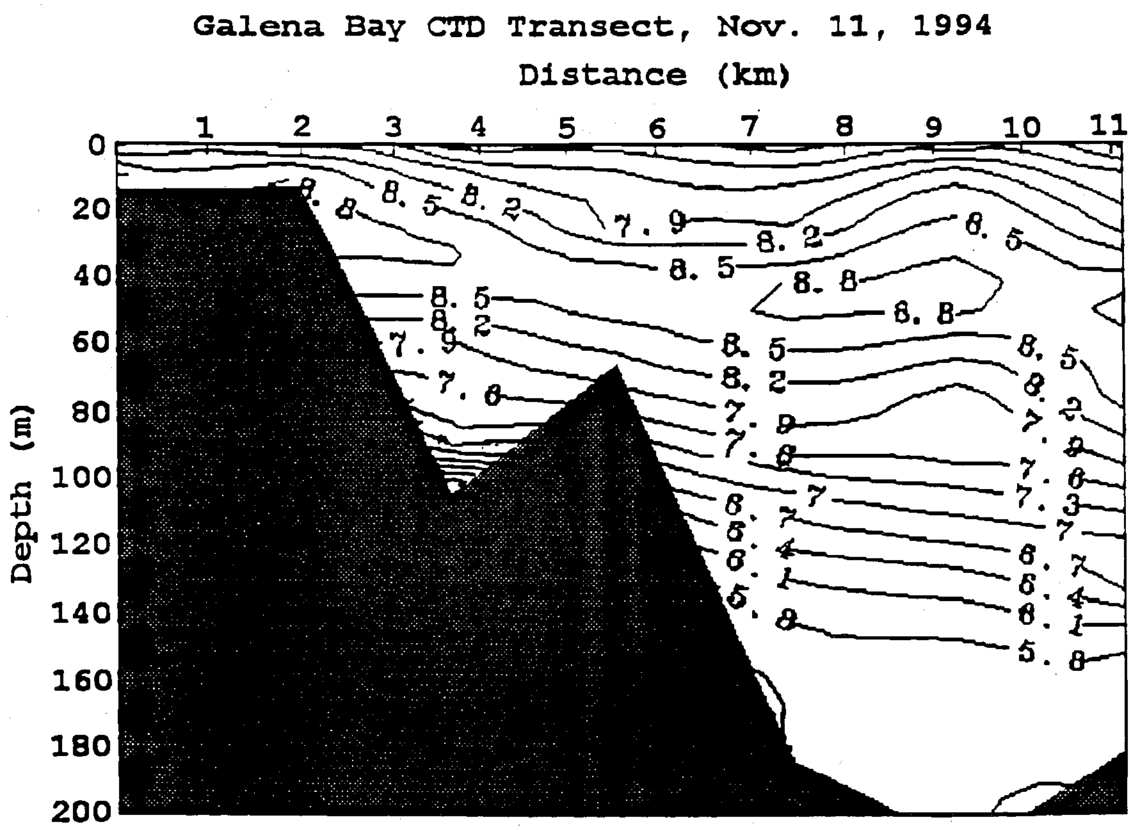


Fig. 12. Temperature (solid line), salinity (dashed line) and sigma-t (dotted line) depth profiles at stations in Montague Strait and Icy Bay.

Figure 13. Temperature profiles along transects in Galena Bay and Port Gravina.

Fig. 13. Temperature profiles along transects in Galena Bay and Port Gravina.



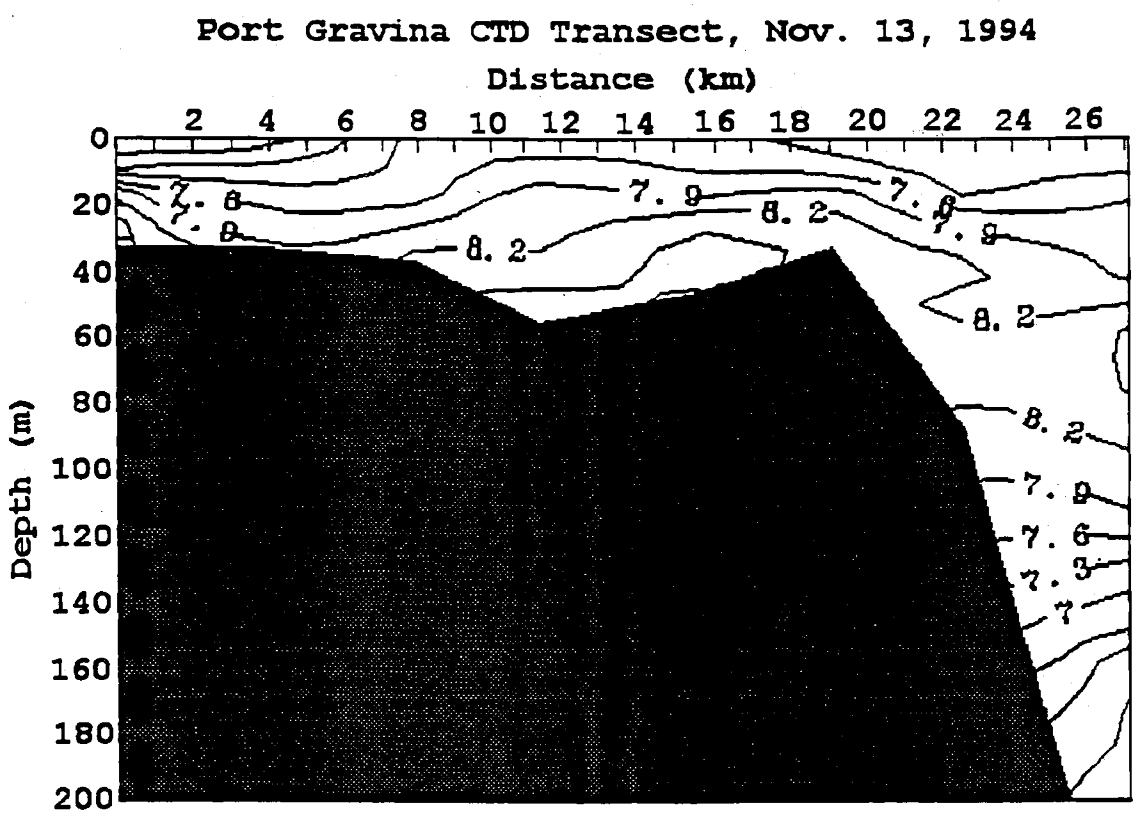


Figure 14. Temperature profiles along a transect across Dangerous Passage into Ewan Bay.

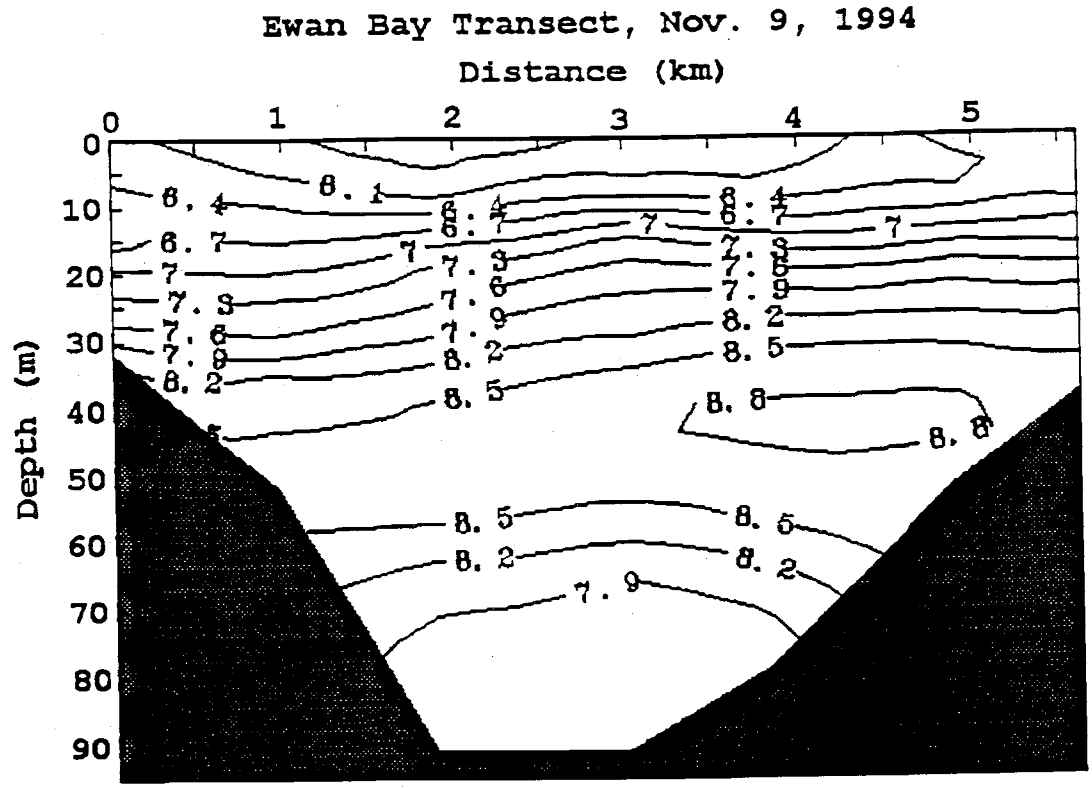


Fig. 14. Temperature profiles along a transect across Dangerous Passage into Ewan Bay.

INVERTEBRATE FORAGE SPECIES

A.J. Paul

Introduction

This preliminary survey of the macrozooplankton in Prince William Sound was carried out to identify the some of the potential targets appearing in hydroacoustic profiles. This first survey served to provide a taxa list.

Methods

Out goal in this preliminary year was to test the NIO Net and make a taxa list. A one-m^2 National Institute of Oceanography (NIO) net with 1 mm was fished double obliquely (once down and then up) through the water column at night. The net was fished open at varying of depths. There was no way to open and close the net, thus no relation to vertical physics could be deduced. Not enough samples were taken for horizontal physics to be considered. How the invertebrate data relates to the fish is unknown at this time. That work is for the future when longer cruises will be planned. There were 5 stations, all sampled in triplicate (Table 1). Dates and times of samples occur on the figures. Station locations occur in the cruise log table (Appendix A).

Table 1. Location of NIO net sampling for invertebrates.

Place	Station No.	Start lat.	Start long.
Montague St	2	60 08.87	147 30.18
Pleidaes Is.	4	60 11.999	147 57.034
Icy Bay	5	60 16.575	148 13.299
Galena Bay	6	60 56.65	146 38.61
Port Gravina	7	60 39.35	146 21.63

Taxa Found

At Station 2 euphausiids were the most common macrozooplankton (Figure 1). The common species were *Eupahusia pacifica*, and*Thysanoessa spinifera*, with *T. rashii* and *T. inermis* also present. At station 4 the same euphausiids were encountered and Amphipods (not identified to genus) appeared in two hauls (Figure 2). Glass shrimp, *Pasiphaea pacifica,* contributed noticeable to the biomass in one haul. At station 5 only amphipods were captured by the NIO net (Figure 3). At Stations 6 and 7 (Figures 4, 5) all the euphausiid types mentioned above, amphipods and shrimp all contributed significantly to the biomass. The taxa composition of the macrozooplankton is typical of that found in nearshore waters throughout the northern Gulf of Alaska region.

Implications for Summer Sampling

The preliminary sampling indicates that large crustaceans dominate the macrozooplankton in fall and that the common species are big enough to provide a hydroacoustic signal. Assuming that the same community composition occurs during summer, it is imperative that macrozooplankton be collected concurrently with forage fish samples and hydroacoustic measures in order to identify the prey concentrations found associated with sea birds.

The large crustaceans that comprise that bulk of the macrozooplankton are adequately sampled by NIO nets but for the samples to be useful in relating bird foraging behavior to the prey fields it is necessary to fish the net in opening and closing mode. This was not possible on the fall trip due to the incompatibly with the hydrographic wire-diameter and the closing mechanism. It is imperative that the macrozooplankton be sampled at the depths the birds are feeding.

The variation in both the species composition, and the biomass of macro invertebrates captured suggest that there is considerable horizontal patchiness in taxa distribution. However, more than five stations will need to be sampled to quantify this patchiness. Euphausiids, the most common macroinvertebrate are known to form dense aggregations or swarms. Both fish and bird predators are dependent on prey aggregation, the physical or biological conditions that promote it, or the ability of predators to exploit prey swarms. However, it logical to hypothesize that forage fishes will exploit aggregations of macroinvertebrates and birds will seek both fish and invertebrate concentrations. Thus, understanding factors that induce prey aggregation in critical to understanding distribution, abundance and biology of forage species.

Figure 1. Macroinvertebrates present at station 2 in Prince William Sound during fall sampling in 1994. Species abundance in the figure occurs in the same order as that in the key listing.

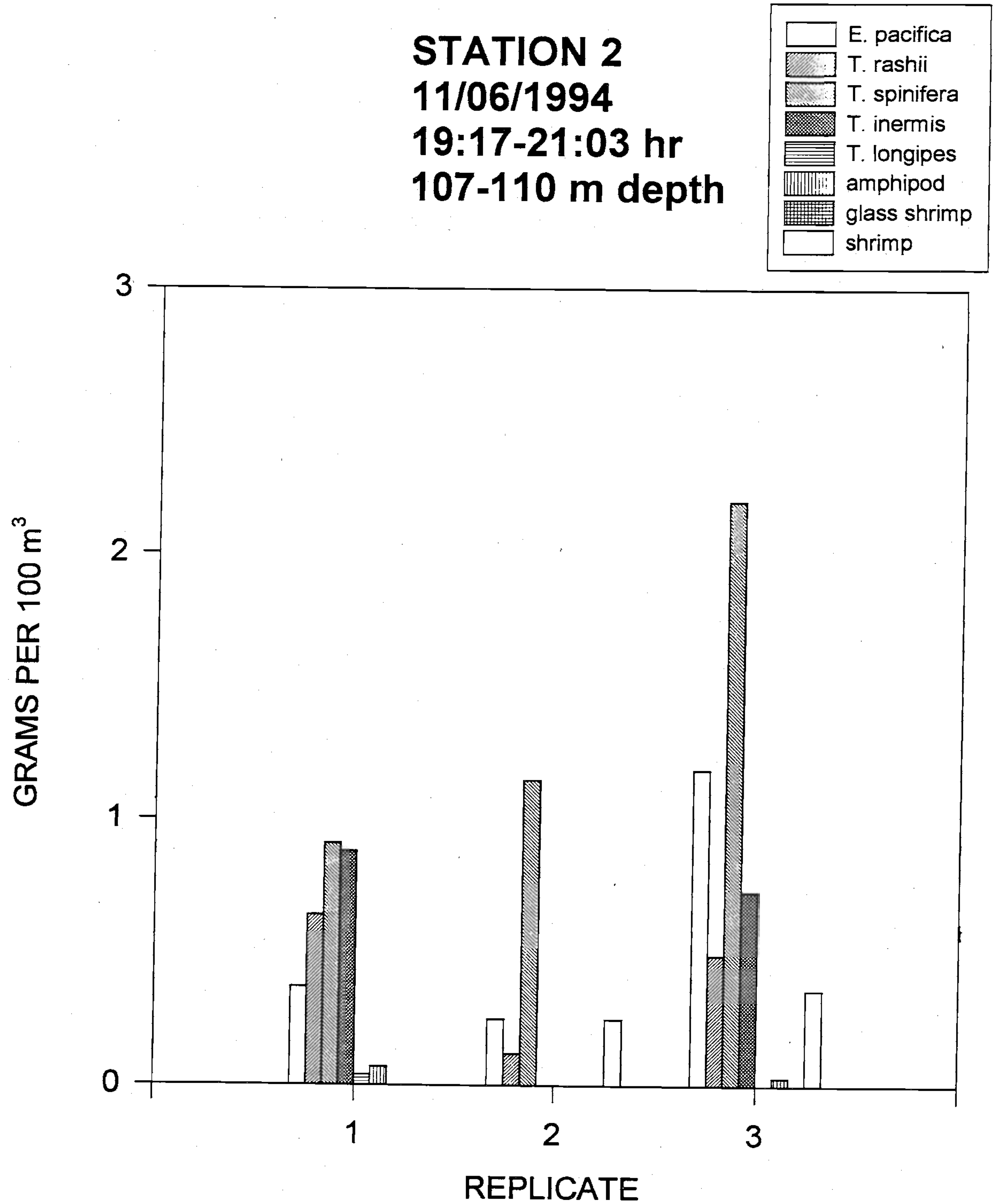

STATION 2
11/06/1994
19:17-21:03 hr
107-110 m depth
E. pacifica
T. rashii
T. spinifera
T. inermis
T. longipes
amphipod
glass shrimp
shrimp
GRAMS PER 100 m3
3
2
1
0
1
2
3
REPLICATE

Figure 1

Figure 2. Macroinvertebrates present at station 4 in Prince William Sound during fall sampling in 1994. Species abundance in the figure occurs in the same order as that in the key listing.

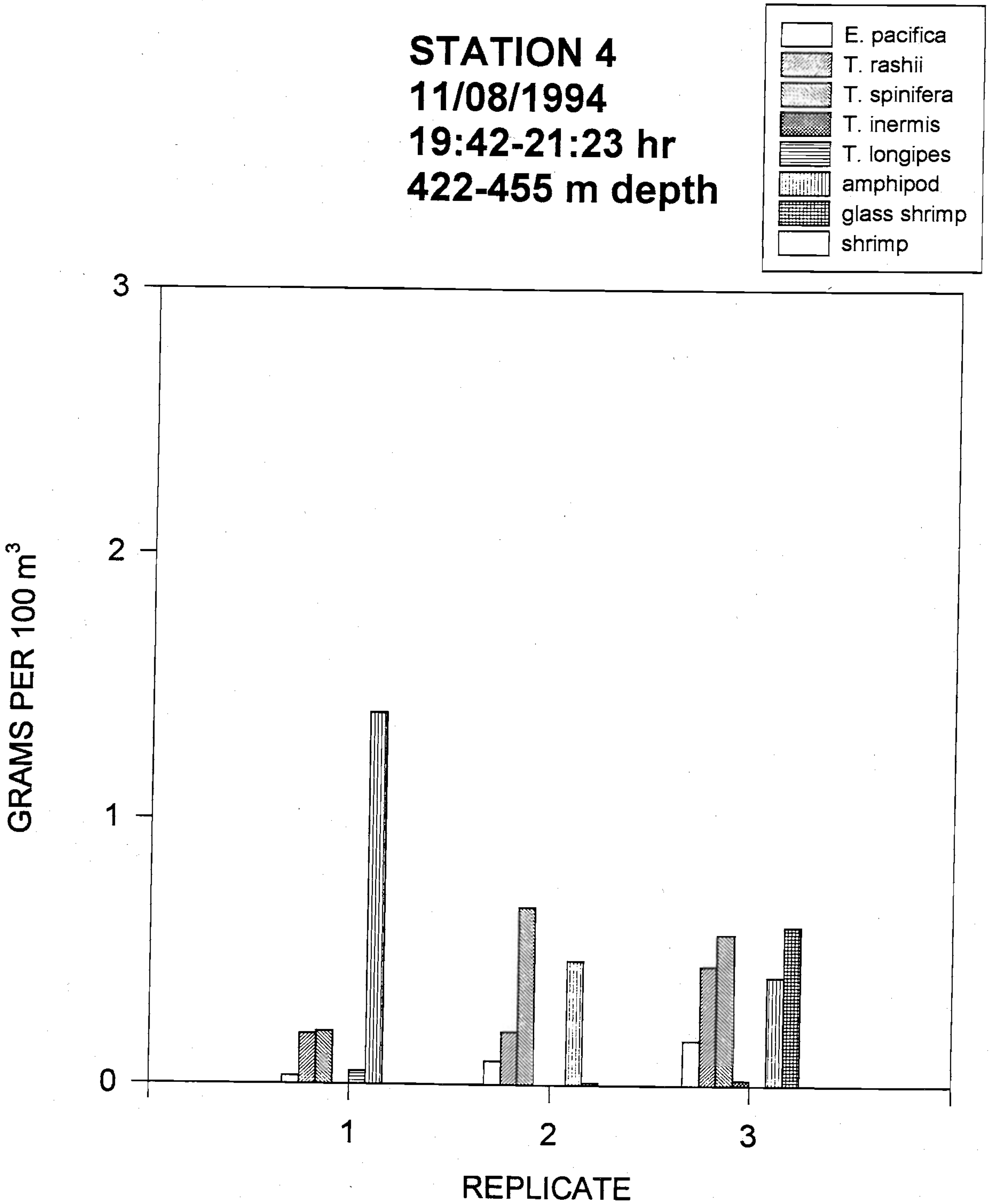

STATION 4
11/08/1994
19:42-21:23 hr
422-455 m depth
E. pacifica
T. rashii
T. spinifera
T. inermis
T. longipes
amphipod
glass shrimp
shrimp
GRAMS PER 100 m3
0
1
2
3
1
2
3
REPLICATE

Figure 2

Figure 3. Macroinvertebrates present at station 5 in Prince William Sound during fall sampling in 1994. Species abundance it the figure occurs in the same order as that in key listing.

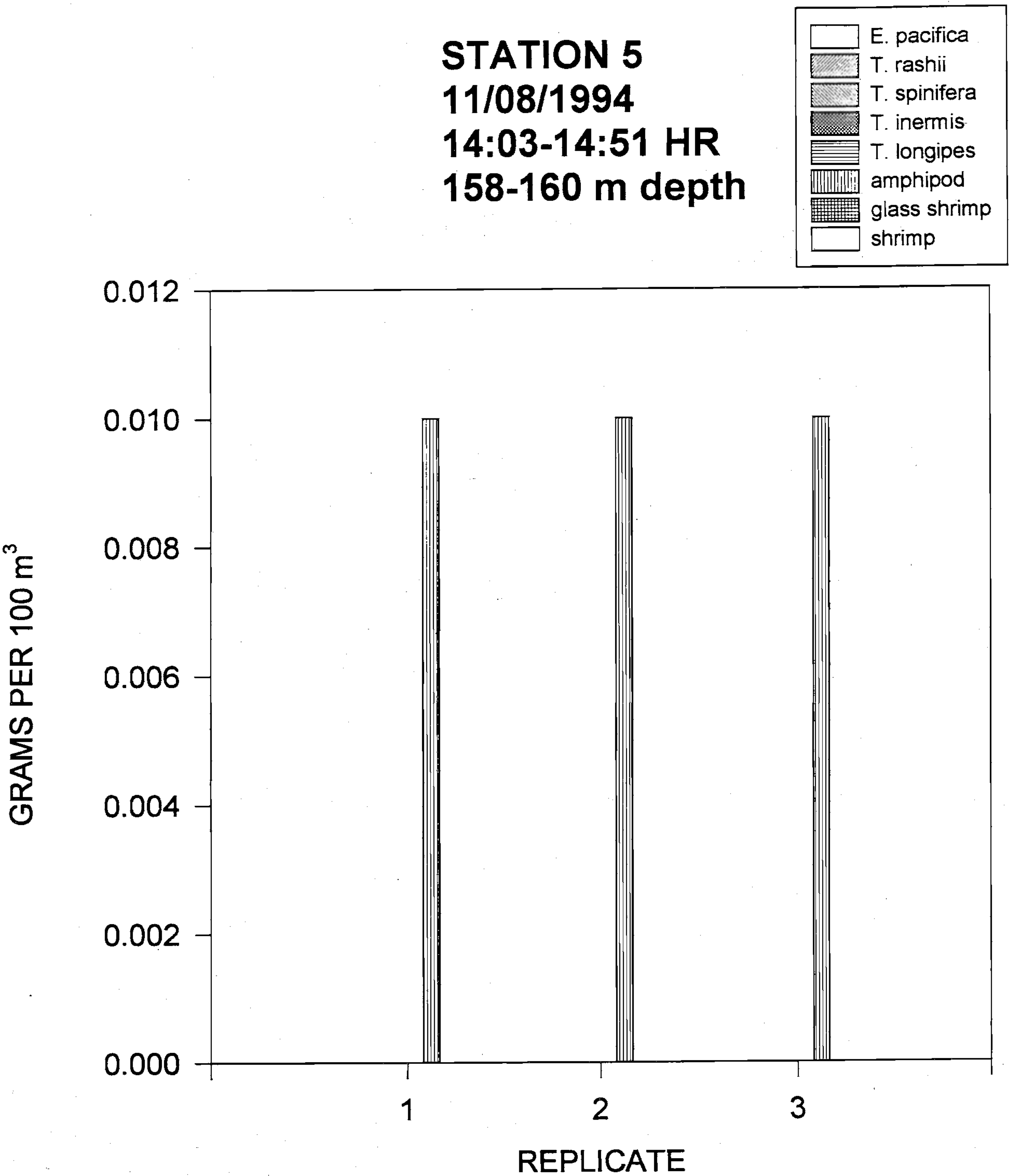
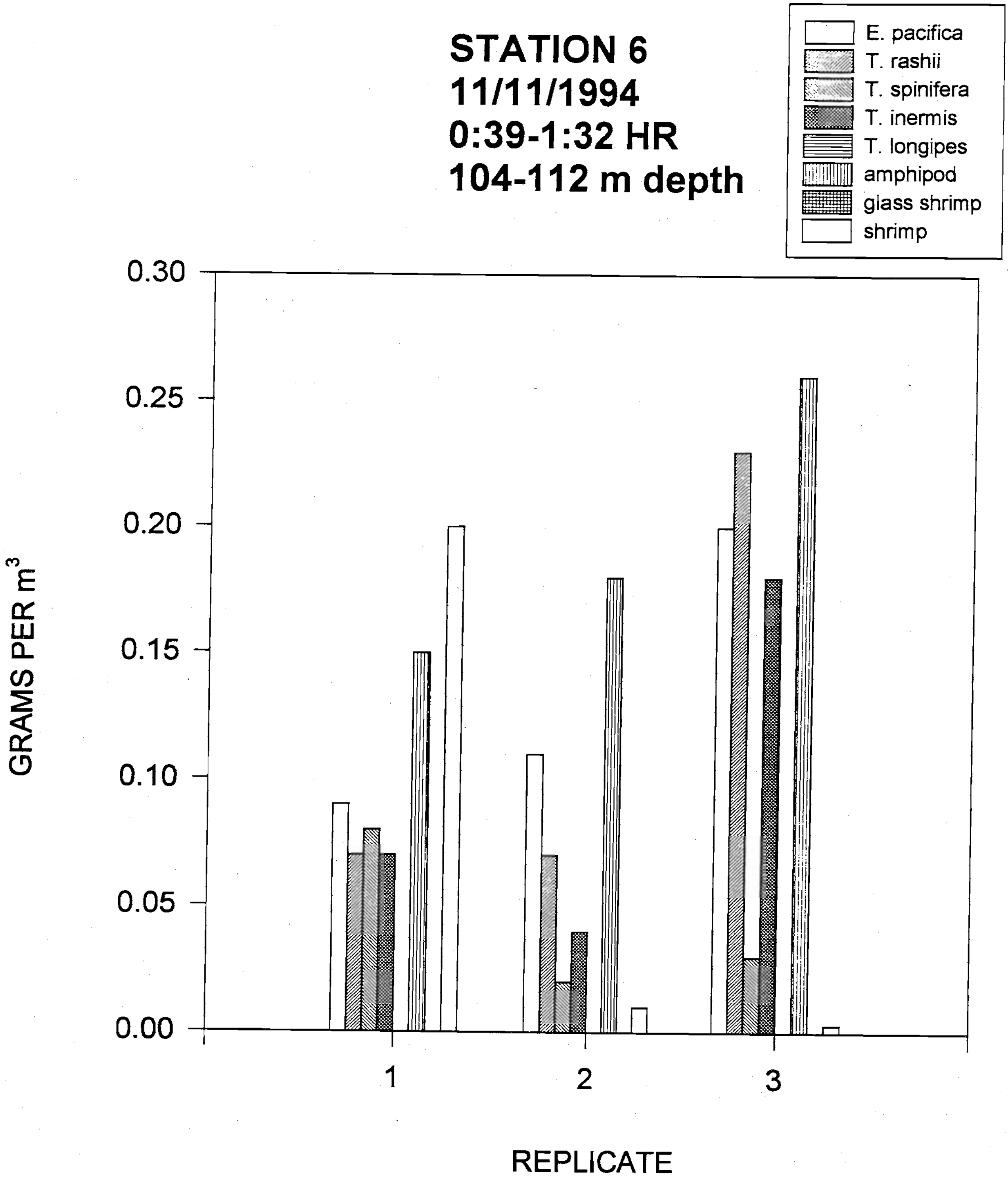

STATION 5
11/08/1994
14:03-14:51 HR
158-160 m depth
E. pacifica
T. rashii
T. spinifera
T. inermis
T. longipes
amphipod
glass shrimp
shrimp
0.012
0.010
0.008
0.006
0.004
0.002
0.000
GRAMS PER 100 m3
1
2
3
REPLICATE

Figure 3

Figure 4. Macroinvertebrates present at station 6 in Prince William Sound during fall sampling in 1994. Species abundance it the figure occurs in the same order as that in key listing.



STATION 6
11/11/1994
0:39-1:32 HR
104-112 m depth
E. pacifica
T. rashii
T. spinifera
T. inermis
T. longipes
amphipod
glass shrimp
shrimp
0.30
0.25
0.20
0.15
0.10
0.05
0.00
GRAMS PER m3
1
2
3
REPLICATE

Figure 4

Figure 5. Macroinvertebrates present at station 7 in Prince William Sound during fall sampling in 1994. Species abundance it the figure occurs in the same order as that in key listing.

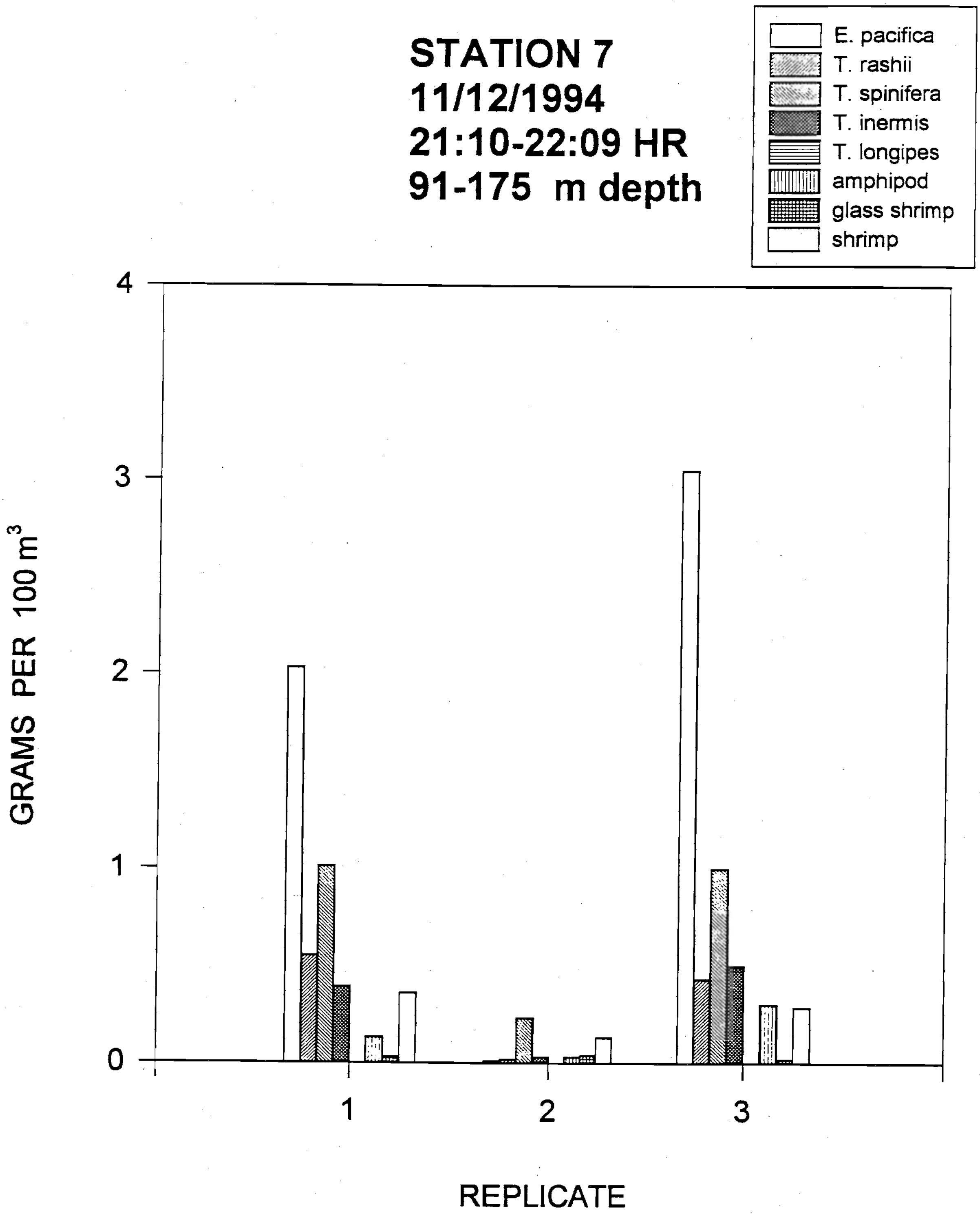

STATION 7
11/12/1994
21:10-22:09 HR
91-175 m depth
E. pacifica
T. rashii
T. spinifera
T. inermis
T. longipes
amphipod
glass shrimp
shrimp
GRAMS PER 100 m3
0
1
2
3
4
1
2
3
REPLICATE

Figure 5

FISH NET SAMPLING

L. Haldorson

Methods
Nine samples of acoustic layers were collected with the mid-water trawl from 7 - 13 November 1994 at locations in the southwest and northeast sections of Prince William Sound (Table 1 , Figure 1). Depths sampled ranged from less than 20 m to over 90 m (Table 1). The locations sampled included Montague Strait (station 3), Icy Bay (station 5), Galena Bay (station 6) inner Port Gravina (station 7) and outer Port Gravina (station 8).

The dominant forage species in all cases were herring and young of the year (0+) walleye pollock. At two stations, Montague Strait and outer Port Gravina, catches were made up almost exclusively of herring older than 1 year (Table 2). At Icy Bay, Galena Bay and inner Port Gravina, 0+ walleye pollock were the dominant forage species. At Icy Bay walleye pollock were the only species caught at 35 - 50 m depth; however, at Galena Bay and inner Port Gravina they comprised 63 - 97% of the catch, with 0+ herring accounting for most of the other catch (Table 2). In the deeper (40 - 80 m) sample from inner Port Gravina, eulachon were a notable (28%) component of the catch.

Pacific Herring
Our sampling suggests that herring populations in PWS are structured by age, geography and depth. The catches in Montague Strait were in relatively deep water (> 90 m) and were dominated by older herring over 220 mm (fork length), although there was an indication, especially in the second trawl haul (3-2T), of a bimodal length distribution with a second mode near 200 mm length (Figure 2). At Galena Bay and inner Port Gravina, 0+ herring (< 130 mm fork length) apparently occurred in mixed schools with 0+ walleye pollock in depths from 10 - 80 m (Table 2 , Figures 3, 4). Herring were the only species found in the two samples at outer Port Gravina, where catches were comprised mainly of fish 150 - 220 mm (Figure 5); suggesting that they were 1+ age fish with YOY herring present in one of the two samples.

Three age categories of herring sampled in November could be inferred from length distributions, including:

Category 1: 0+ age (< 130 mm) - Herring in the 1995 year class were the only herring caught in Galena Bay and inner Port Gravina. They also co-occurred with 1+ size herring (160 - 220 mm) in one sample from outer Port Gravina. Most of the 0+ herring sampled were found with 0+ age walleye pollock in depths where acoustic signals were concentrated around the temperature maximum.

Category 2: 1+ age (160 - 220 mm) - these juveniles occurred as a unimodal length group in outer Port Gravina, although in one sample they were mixed with 0+ size fish. The also co-occurred with larger herring (220 - 270 mm) in Montague Strait.

Category 3: Age 2+ and older (> 220 mm) - Larger herring were found only in Montague Strait.

Walleye Pollock

Nearly all walleye pollock sampled were in a size range (< 150 mm fork length) indicating they were 0+ age fish in the 1995 year class (Figure 6). These 0+ age fish apparently were the dominant species in an assemblage of small fishes, including herring and eulachon, that coincided in depth with the temperature maximum.

Eulachon

Eulachon were an important component (28%) in a relatively deep (40 - 80 m) assemblage of small fishes at inner Port Gravina that included 0+ walleye pollock and herring (Table 2). Nearly all were small (< 100 mm) fish that appear to be 0+ age (Figure 7). Several larger and older fish (apparently including age 2+ and 3+) were also in the sample. The larger specimens were sexually mature.

Under-yearling (0+) Walleye Pollock Length, Weight and Condition

Walleye pollock in the 0+ age group were in a distinct size range, and were the dominant midwater forage species in Icy Bay, Galena Bay, and inner Port Gravina. The mean length of 0+ walleye pollock differed significantly ($P < 0.01$) among those locations, due to smaller fish at Galena Bay (Figure 8). Galena Bay walleye pollock also had the lowest mean weights among the four samples, and the significant difference among mean weights was primarily due to the smaller fish at Galena Bay (Figure 9). Fulton's condition index also varied significantly among the sites, in this case due mainly to the higher condition indices observed at the shallow and deep samples from Port Gravina (Figure 10).

Table -1. Dates, times, depths and locations of mid-water trawl samples collected during Research Cruise FOR94-2 in November 1994 in Prince William Sound.

DATE	STATION	LOCAL	TIME	TRAWL DEPTH	BOTTOM DEPTH	START LAT	START LONG
7-11	3-1T	MONTAGUE	1405	95	130	60 03.44	147 36.02
7-11	3-2T	MONTAGUE	1456	94	130	60 04.48	147 38.8
8-11	5-5T	ICY BAY	1551	35-50	110-150	60 16.605	148 14.26
10-11	6-1T	GALENA	2310	15-20	15-100	60 56.44	146 37.29
12-11	7-4T	GRAVINA	2255	12-21	118	60 40.06	146 20.92
13-11	7-5T	GRAVINA	0005	40-80	113	60 38.15	146 24.25
13-11	8-1T	GRAVINA	1414	50	100	60 36.37	146 33.99
13-11	8-2T	GRAVINA	1535	36	50	60 37.79	146 32.67
13-11	8-3T	GRAVINA	1700	30-35	40-50	60 39.42	146 25.87

Table -2. Catch composition, mean lengths, standard deviations and samples sizes of fishes sampled with mid-water trawl during Research Cruise FOR94-2 in November 1994 in Prince William Sound.

TRAWL	SPECIES	NO.	PERCENT	MEAN LENGTH	STD. DEV LENGTH	N LENGTH
3-1T	Herring	98	100	229.6	17.6	98
3-2T	Herring	964	100	232.8	19.3	100
5-5T	Pollock	110	100	109.7	6.0	58
6-1T	Pollock	145	85	103.2	7.9	145
	Herring	26	15	92.0	13.2	26
7-4T	Pollock	398	97	108.1	7.6	110
	Herring	14	3	96.1	11.8	14
7-5T	Pollock	69	63	117.9	29.7	69
	Herring	7	6	99.0	7.8	7
	Eulachon	31	28	95.6	21.8	31
	Capelin	1				
	Spiny Lump S.	1				
8-1T	No Fish Caught					
8-2T	Herring	156	100	181.9	14.4	177
8-3T	Herring	359	100	162.1	52.2	154

Figure 1. Locations of mid-water trawl samples collected during cruise FOR94-2 in November 1994 in Prince Wiliam Sound.

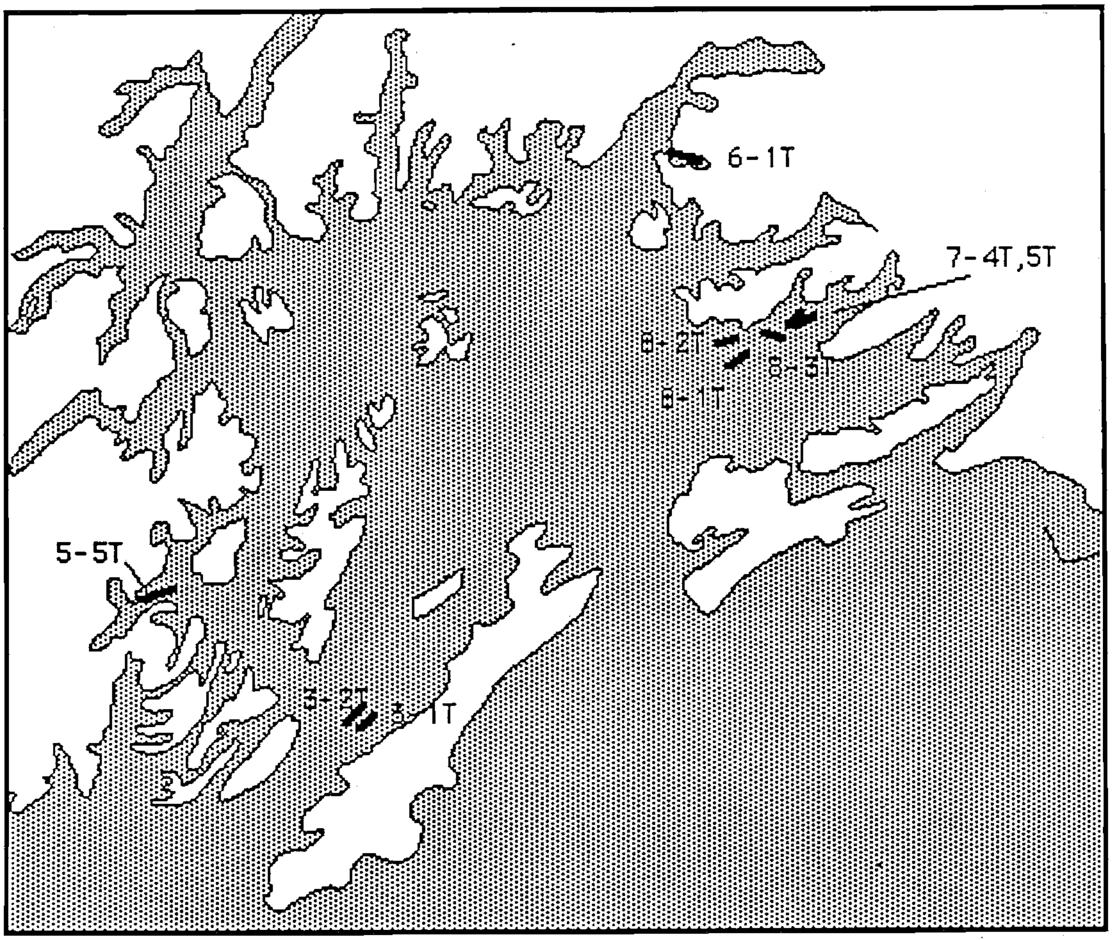


Figure -1. Locations of mid-water trawl samples collected during cruise FOR94-2 in November 1994 in Prince William Sound.

Figure 2. Length distributions of herring caught in mid-water trawls in Montague Strait in November 1994.

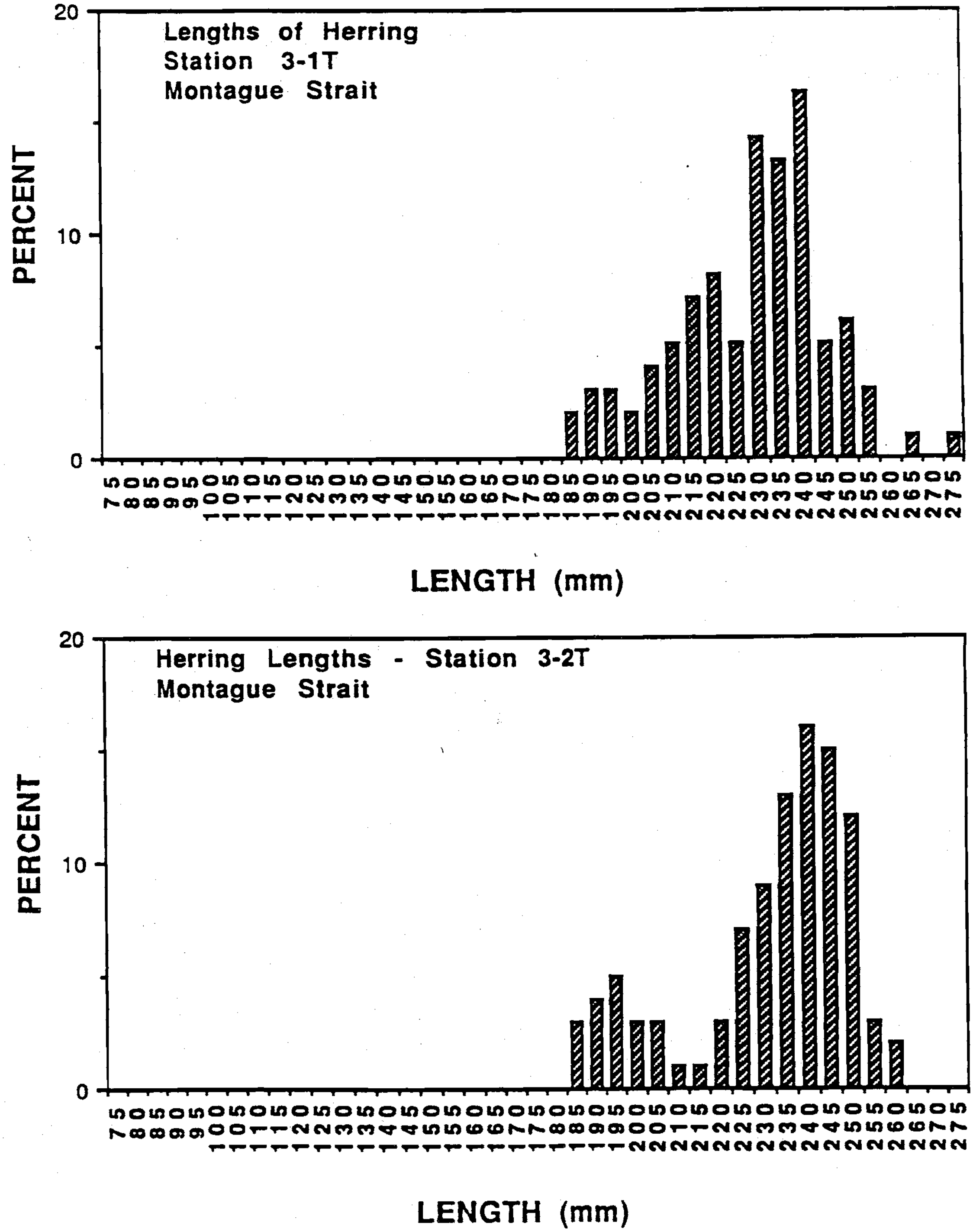


Figure 2.
Length distributions of herring caught in mid-water trawls in Montague Straight in November 1994.

Figure 3. Length distributions of herring caught in mid-water trawls in Galena Bay in November 1994.

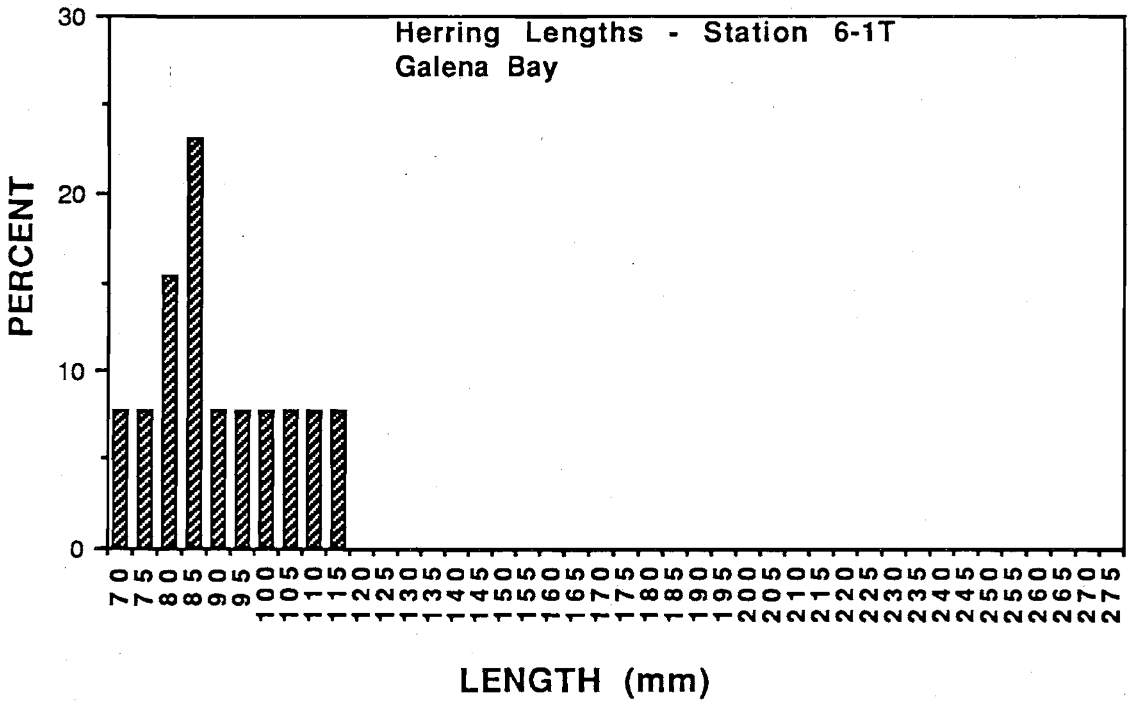


Figure 3.
Length distributions of herring caught in mid-water trawls in Galena Bay in November 1994

Figure 4. Length distributions of herring caught in mid-water trawls in Inner Port Gravina in November 1994.

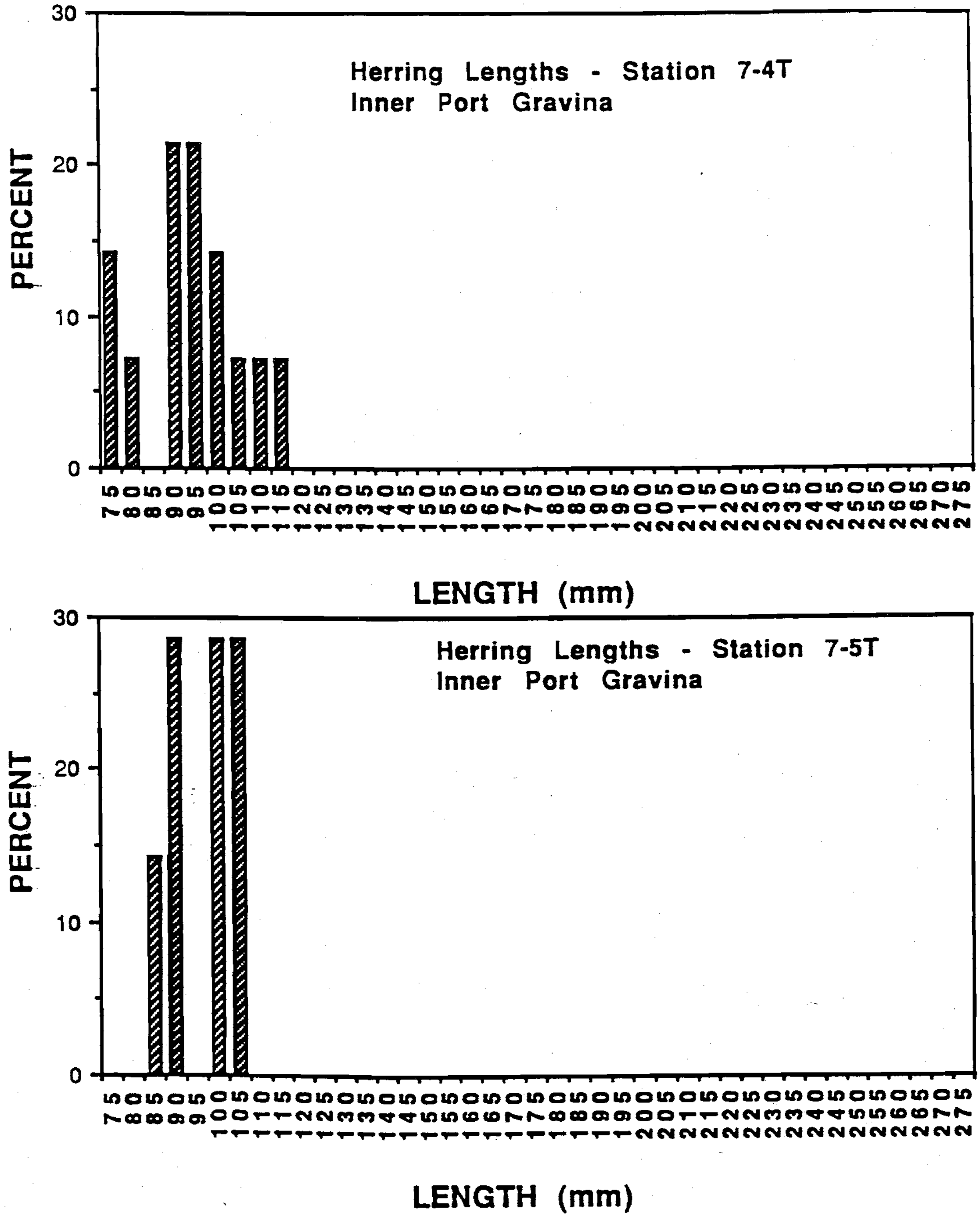


Figure 4.
Length distributions of herring caught in mid-water trawls in inner Port Gravina in November 1994.

Figure 5. Length distributions of herring caught in mid-water trawls in outer Port Gravina in November 1994.

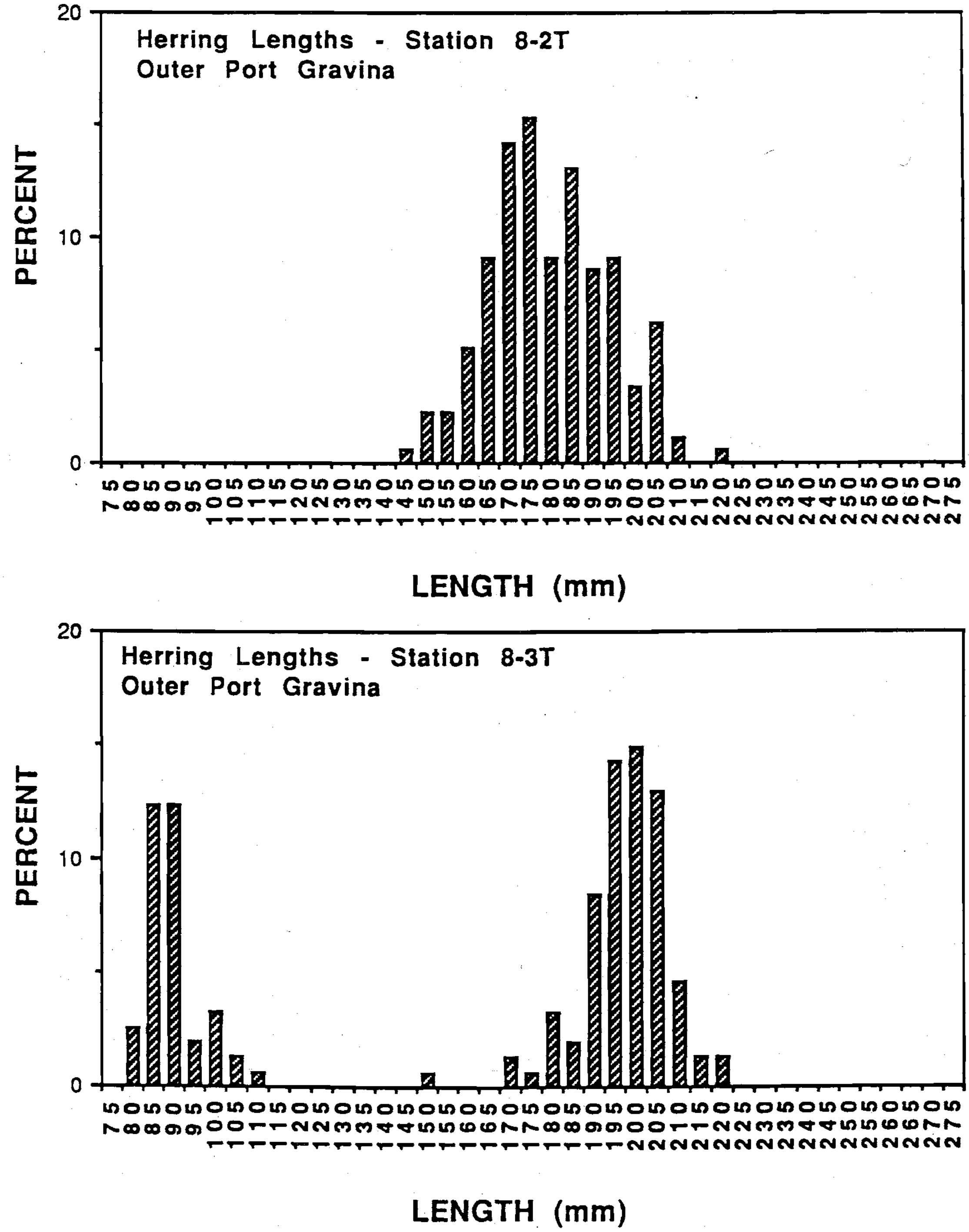


Figure 5.
Length distributions of herring caught in mid-water trawls in Outer Port Gravina in November 1994.

Figure 6. Length distributions of walleye pollock caught in mid-water trawls in Icy Bay, Galena Bay, and Port Gravina in November 1994l

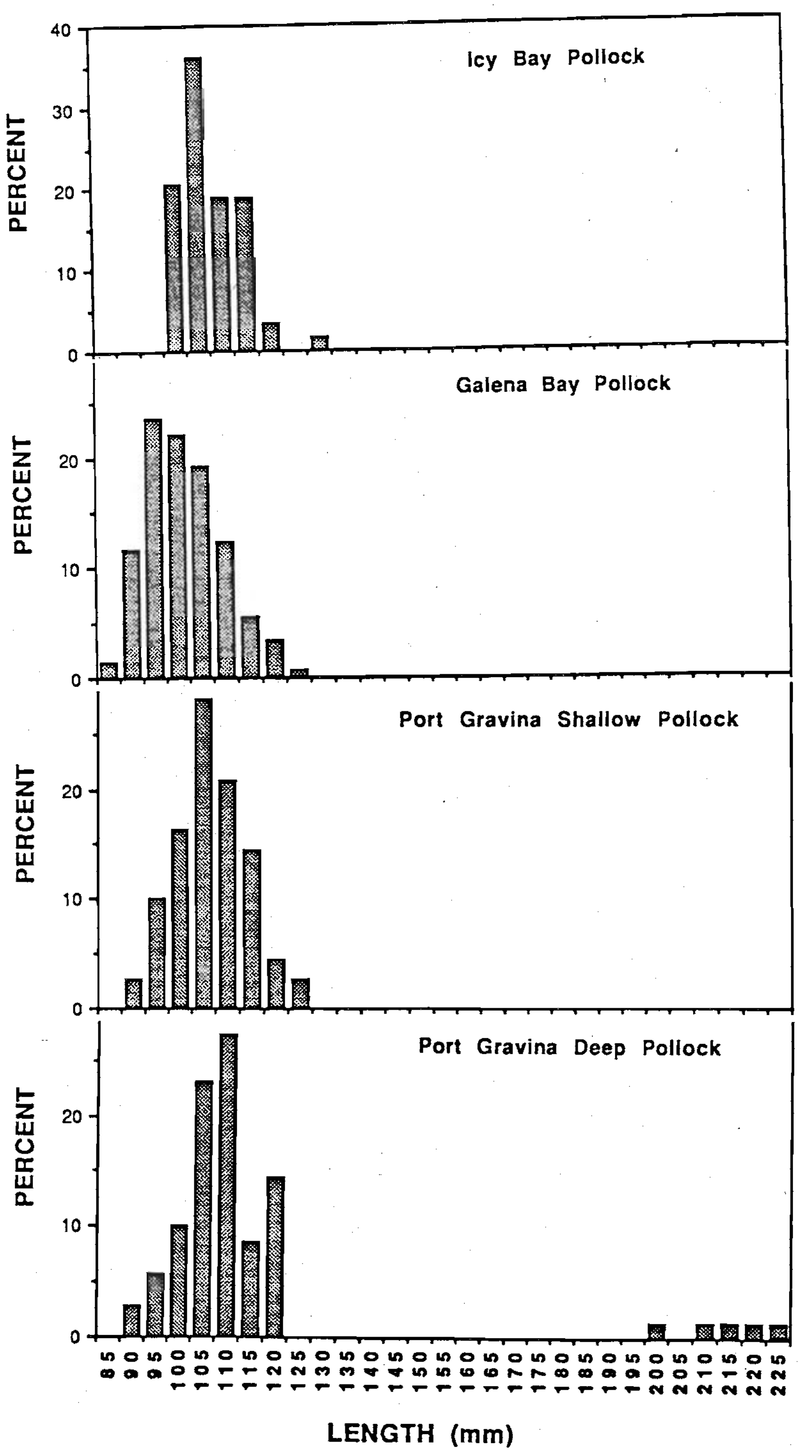


Figure 6.
Length distribution of walleye pollock caught in mid-water trawls in Icy Bay, Galena Bay, and Port Gravina in November 1994.

Figure 7. Length distributions of eulachon caught in mid-water trawls at Port Gravina in November 1994.

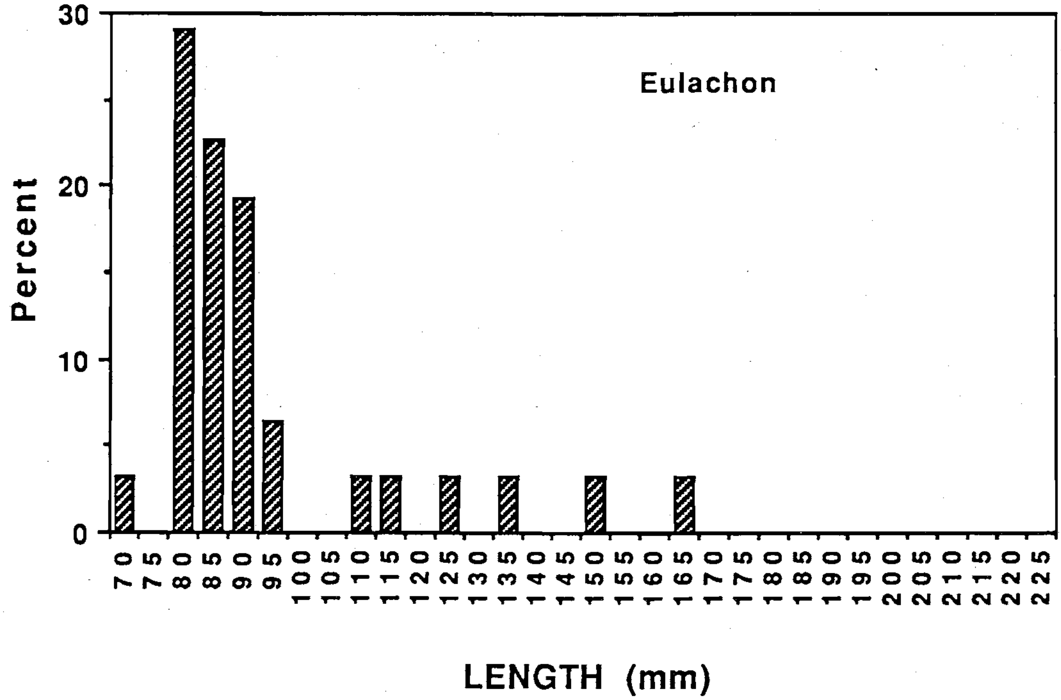


Figure 7.
Length distributions of eulachon caught in mid-water trawls at Port Gravina in November 1994.

Figure 8. Mean lengths, with one standard error, of 0+ age walleye pollock at Icy Bay (station 5), Galena Bay (station 6), and shallow and deep samples in Port Gravina (stations 7-S, 7-D) in November 1994.

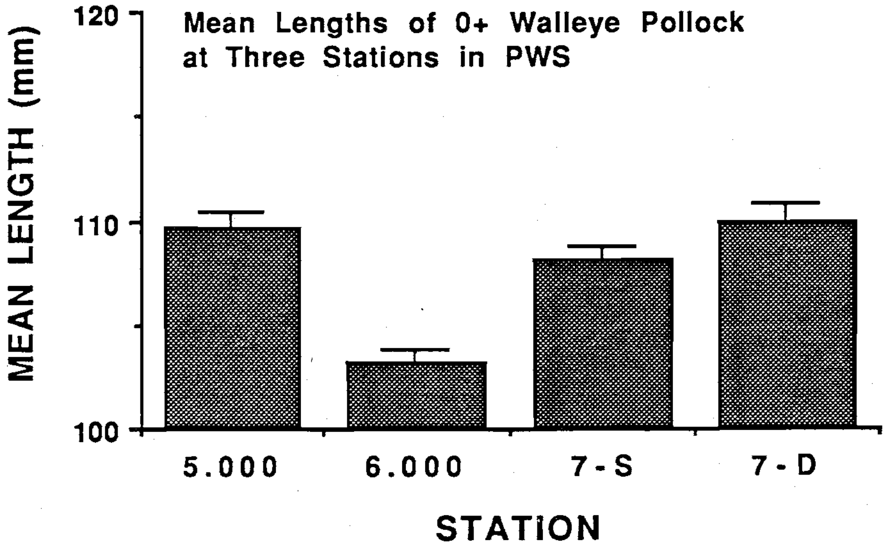


Figure 8.
Mean lengths, with one standard error, of 0+ age walleye pollock at Icy Bay (station 5), Galena Bay (station 6), and shallow and deep samples in Port Gravina (stations 7-S, 7-D) in November 1994.

Figure 9. Mean dry weights, with one standard error, of 0+ age walleye pollock at Icy Bay (station 5), Galena Bay (station 6), and shallow and deep samples in Port Gravina (stations 7-S, 7-D) in November 1994.

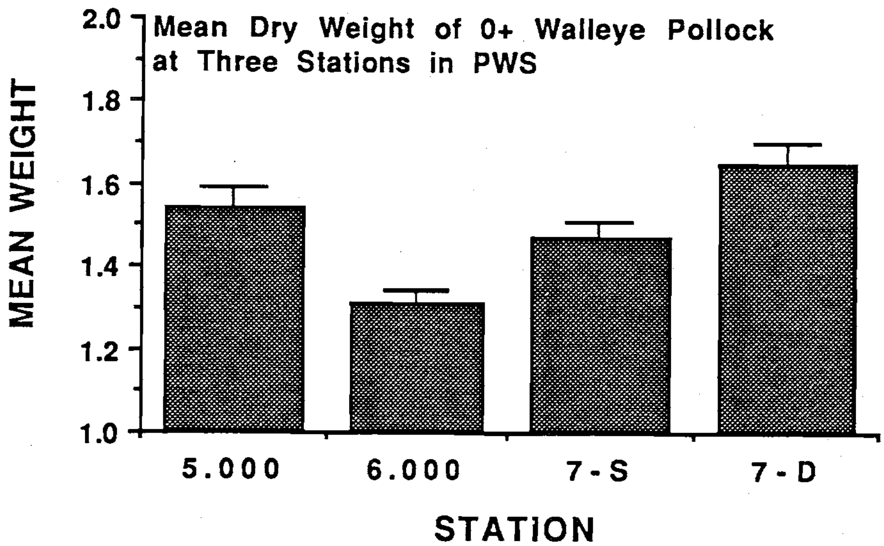


Figure 9.
Mean dry weights, with one standard error, of 0+ age walleye pollock at Icy Bay (station 5), Galena Bay (station 6), and shallow and deep samples in Port Gravina (stations 7-S, 7-D) in November 1994.

Figure 10. Mean Fulton condition index, with one standard error, of 0+ age walleye pollock at Icy Bay (station 5), Galena Bay (station 6), and shallow and deep samples in Port Gravina (stations 7-S, 7-D) in November 1994.

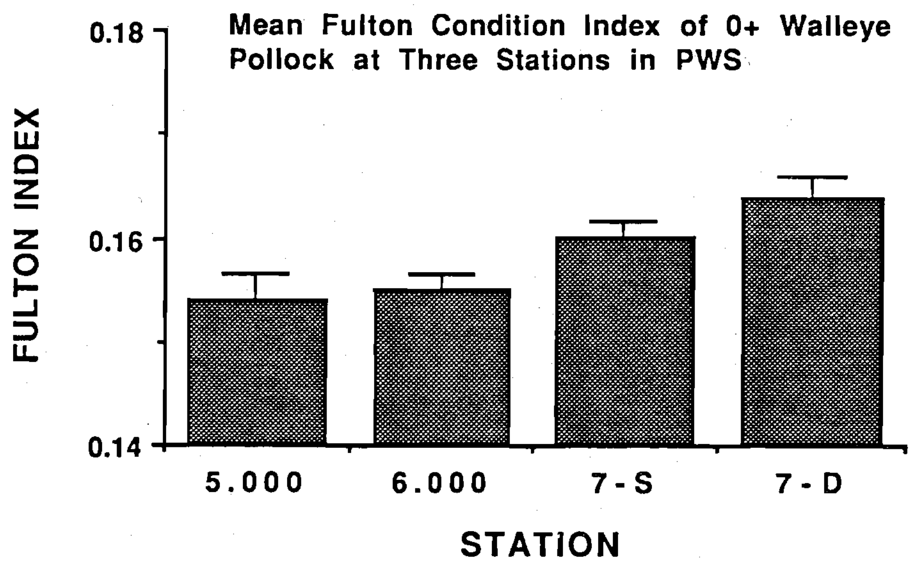


Figure 10.
Mean Fulton condition index, with one standard error, of 0+ age walley pollock at Icy Bay (station 5), Galena Bay (station 6), and shallow and deep samples in Port Gravina (stations 7-S, 7-D) in November 1994.

DISCUSSION

L. Haldorson

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 apparently has been a decline in populations of apex predators in 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 either 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, Sealy 1975); walleye pollock, Theragra *chalcogramma* (Springer and Byrd 1989, Divoky 1981); capelin, *Mallotus villosus* , and eulachon, *Thaleichthys pacificus* (Warner and Shafford 1981, Baird and Gould 1984). 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).

In 1994, the School of Fisheries and Ocean Sciences (SFOS), University of Alaska Fairbanks, began studies of the distribution and abundance of forage species. This research was part of a program designed to determine if prey availability was limiting the recovery of seabird populations that had been impacted by the EVOS. The main tool for measuring the distribution and abundance of forage fishes is hydroacoustics. Hydroacoustics can measure horizontal and vertical abundance and biomass at scales not possible by traditional net sampling techniques, and has 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 tidal-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, net sampling must be conducted concurrently with acoustics to identify species and to provide size distribution data necessary for biomass estimations.

In the August cruise, schools of pelagic fishes were found primarily in areas with shallow water (<100 m) and were most often near the bottom. Relatively few acoustic targets were encountered in the water column over the deeper areas. Acoustic targets were rare near the surface, and, when encountered, were near-shore (Bainbridge Passage and at the entrance to Little Bay). The species composition of acoustic targets was not determined in the August cruise.

The distribution of foraging birds was documented simultaneously with acoustic observations in August by observers from the U.S. Fish and Wildlife Service. Although the association between foraging seabirds and hydroacoustic targets was not consistent, it was clear that when flocks of seabirds co-occurred with acoustic returns, those targets were near the surface (Research details are given in Appendix B, by Ostrand and Flint).

In November the hydrographic structure of PWS was generally consistent, with a temperature maximum of about 9^{o} found at depths from 30 - 60 meters. Surface temperatures were typically 5 - 7 ^{o} C. The structure of the water column would be the result of seasonal cooling from the surface. The water column appeared generally stable due to increasing salinity with depth; although over shallow areas (< 100 m) found in Montague Strait and Port Gravina, the shallow water column was relatively uniform - probably due to tidal mixing.
The distribution of acoustic targets in November varied among areas, with patterns that were associated with hydrographic structure features. Acoustic aggregations in mid-water over shallow shelves in Montague Strait and Port Gravina proved to be relatively large herring, suggesting that they occur in tidally mixed areas in the autumn months. In areas of the Sound where a distinct temperature maximum occurred, acoustic targets typically were observed at depths from 30 - 50 m, in the region of the warmest water. Fish collected from those depths were predominately young-of-the-year (YOY) walleye pollock, although YOY herring and eulachon were also present in those aggregations. There was also a consistently strong acoustic return from the epibenthic layer (bottom to 20 m over the bottom) in those depths (<100m) adequately sampled by acoustic equipment. The composition of those targets remains unknown.

In November we tested two types of midwater sampling gear - a research-scale mid-water trawl and a Methot Net (Methot 1986). The mid-water trawl proved most effective and was selected as the sampling gear to be used in mid-water.

The acoustic data sets from both cruises were subsampled to quantify distributional characteristics that would influence estimation of acoustic biomass. The data were highly clustered with variances much higher than the mean for short transect lengths (<20 km). The number of transects necessary to stabilize standard error appears to be 15 - 20. The pattern of acoustic targets suggests that stratification by depth may increase the precision of biomass estimates. Analyses indicated that stratification into shallow and deep regions at the 50 m isobath would maximize the gains in precision by stratification.

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Appendix A

Hydrographic stations, Fish Net log and traces for depth versus temperature, salinity and water density for the November 1994 Research Cruise.

Table 1.

FORAGE FISH NET
AND CTD LOG

DATE	START TIME	END TIME	STN NO.	HAUL NO.	GEAR	LOC	START LAT	START LONG	END LAT	END LONG	BOT DEP (M)	GEAR DEP (M)	CATCH
11/6/94	13:30	13:40	1	1	N	N GREEN IS.	60 18.75	147 24.60	60 18.87	147 25.50	73	100 WO	AMPHIPHODS
11/6/94	14:25	14:50	1	2	M	N GREEN IS.	60 18.73	147 25.57	60 19.25	147 24.21	70		JELLIES, AMPHIPODS; NO FISH
11/6/94	15:15	15:40	1	3	T	N GREEN IS.	60 19.09	147 24.35	60 18.256	147 27.43	80		JELLIES; FISHED UNEVENLY
11/6/94	16:05		1	0	CTD	N GREEN IS.	60 17.725	147 28.781			74	50	FORGOT TO EQUILIBRATE
11/6/94	19:17	19:32	2	1	N	MONTAGUE ST.	60 08.87	147 30.18	60 08.92	147 30.89	107	125 WO	EUPHAUSIIDS
11/6/94	19:42	20:00	2	2	N	MONTAGUE ST.	60 08.98	147 31.05	60 08.94	147 30.273	102	102	MUD HAUL! POLYCHAETES, CLAMS
11/6/94	20:28	20:41	2	3	N	MONTAGUE ST.	60 08.81	147 28.18	60 08.86	147 29.16	110	61	EUPHAUSIIDS
11/6/94	20:51	21:03	2	4	N	MONTAGUE ST.	60 08.91	147 29.67	60 09.06	147 30.77	106	61	EUPHAUSIIDS
11/7/94	13:25	14:05	3	1	T	NEEDLES AREA	60 03.44	147 36.02	60 04.13	147 35.48	130	95	HERRING, JELLIES
11/7/94	14:40	14:56	3	2	T	NEEDLES AREA	60 04.48	147 35.10	60 02.27	147 38.8	130	94	HERRING (~1000)
11/7/94	16:45	17:18	3	3	M	NEEDLES AREA	60 03.95	147 35.87	60 03.18	147 36.7	132	110	EUPHAUSIIDS, LARVAL FISH, 3 EULACHO[illegible]
11/7/94	17:39		3	0	CTD	NEEDLES AREA	60 03.10	147 37.68			140	125	
11/7/94	19:42	[illegible]	[illegible]	[illegible]	[illegible]	PLEIADES IS.	60 11.975	147 55.42	60 11.96	147 56.42	437	250 WO	AMPHIPODS- KLINE
11/7/94	20:13	20:48	4	2	N	PLEIADES IS.	60 11.999	147 57.034	60 12.179	147 58.374	422	300 WO	EUPHAUSIIDS
11/7/94	20:57	21:23	4	3	N	PLEIADES IS.	60 12.291	147 58.478	60 12.579	147 58.810	455	300 WO	EUPHAUSIIDS
11/7/94	21:28	21:52	4	4	N	PLEIADES IS.	60 12.670	147 58.802	60 12.485	147 58.972	472	300 WO	EUPHAUSIIDS
11/8/94	10:40		[illegible]	[illegible]	[illegible]	ICY BAY	60 14.97	148 17.97			150	125	
11/8/94	13:09	[illegible]	[illegible]	[illegible]	[illegible]	ICY BAY	60 16.185	148 16.14	60 16.52	148 13.571	121-150	40 30	EULACHON, LARVAE, GARBAGE
11/8/94	14:03	14:12	5	2	N	ICY BAY	60 16.575	148 13.299	60 16.579	148 13.948	160	75 WO	PLEUROBRACHIA, EUPHAUSIIDS
11/8/94	14:18	14:28	5	3	N	ICY BAY	60 16.568	148 14.432	60 16.449	148 15.168	158	61	CTENOPHORES
11/8/94	14:42	14:51	5	4	N	ICY BAY	60 16.609	148 14.059	60 16.700	148 13.363	159	52	CTENOPHORES
11/8/94	15:32		[illegible]	[illegible]	[illegible]	ICY BAY	60 16.605	148 14.262	60 17.12	148 12.36	150-110	35-50	POLLOCK (61); LUMPSUCKER
11/8/94	16:21		5	1	CTD	ICY BAY	60 17.34	148 11.015			276	250	
11/9/94	11:39			0	CTD	EWAN BAY	60 21.224	148 6.84			40		CTD TRANSECT SERIES INTO EWAN BAY
11/9/94	11:54			1	CTD	EWAN BAY	60 21.715	148 6.567			60		CTD TRANSECT SERIES INTO EWAN BAY
11/9/94	12:14			2	CTD	EWAN BAY	60 22.125	148 7.051			94		CTD TRANSECT SERIES INTO EWAN BAY
11/9/94	12:34			3	CTD	EWAN BAY	60 22.645	148 7.615			102		CTD TRANSECT SERIES INTO EWAN BAY
11/9/94	12:52			4	CTD	EWAN BAY	60 23.024	148 8.04			85		CTD TRANSECT SERIES INTO EWAN BAY
11/9/94	13:10			5	CTD	EWAN BAY	60 23.526	148 8.512			64		CTD TRANSECT SERIES INTO EWAN BAY
11/9/94	13:22			6	CTD	EWAN BAY	60 23.87	148 8.89			40		CTD TRANSECT SERIES INTO EWAN BAY
11/10/94	16:31			0	CTD	LONG IS	60 40.48	147 40.72			750	250	NORTHERN KNIGHT ISLAND PASSAGE
11/10/94	22:42	23:10	6	1	T	GALENA BAY	60 56.44	146 37.29	60 56.49	146 40.08	100-15	15-20	POLLOCK, JUVENILE HERRING
11/11/94	10		6	1	CTD	GALENA BAY	60 56.72	146 38.6			112	100	CTD AT TRAWL SITE IN GALENA BAY
11/11/94	18:58			0	CTD	GALENA BAY	60 55.85	146 36.18			25		CTD TRANSECT INTO GALENA BAY
11/11/94	19:30			1	CTD	GALENA BAY	60 56.45	146 37.94			100		CTD TRANSECT INTO GALENA BAY
11/11/94	19:58			2	CTD	GALENA BAY	60 56.51	146 39.81			82		CTD TRANSECT INTO GALENA BAY
11/11/94	20:17			3	CTD	GALENA BAY	60 56.59	146 41.88			187		CTD TRANSECT INTO GALENA BAY

Table 1.(cont)

FORAGE FISH NET
AND CTD LOG

ATE	START TIME	END TIME	STN NO.	HAUL NO.	GEAR	LOC	START LAT	START LONG	END LAT	END LONG	BOT DEP (M)	GEAR DEP (M)	CATCH
/11/94	20:48			4	CTD	GALENA BAY	60 57.37	146 43.14			211		CTD TRANSECT INTO GALENA BAY
/11/94	21:12			5	CTD	GALENA BAY	60 58.21	146 44.36			207		CTD TRANSECT INTO GALENA BAY
/11/94	21:45			6	CTD	GALENA BAY	60 58.68	146 46.00			380		VALDEZ ARM
1/11/94	23:33	[illegible]	[illegible]	[illegible]	[illegible]	GALENA BAY	60 55.92	146 36.67	60 56.66	146 38.67	40-100	20-12	1 POLLOCK,, 1 HERRING, SCYPHAZOANS
1/12/94	0:39	0:53	6	3	N	GALENA BAY	60 56.65	146 38.61	60 5[illegible]24	146 37.87	112	66	SMALL EUPHAUSIIDS, CYPHOCARIS
1/12/94	1:00	1:15	6	4	N	GALENA BAY	60 56.24	146 37.63	60 56.63	146 38.3	104	64	SMALL EUPHAUSIIDS, CYPHOCARIS
1/12/94	1:20	1:32	6	5	N	GALENA BAY	60 56.57	146 38.00	60 56.26	146 38.6	107	64	SMALL EUPHAUSIIDS, CYPHOCARIS
1/12/94	14:06			0	CTD	PORT GRAVINA	60 45.77	146 18.43			26		TRANSECT, ST. MATTHEWS BAY
1/12/94	14:17			1	CTD	PORT GRAVINA	60 44.78	146 19.28			40		TRANSECT, ST. MATTHEWS BAY
1/12/94	14:34			2	CTD	PORT GRAVINA	60 43.61	146 19.56			35		TRANSECT, ST. MATTHEWS BAY
1/12/94	14:50			3	CTD	PORT GRAVINA	60 42.56	146 20.03			27		TRANSECT, ST. MATTHEWS BAY
1/12/94	15:05			4	CTD	PORT GRAVINA	60 41.53	146 20.65			59		TRANSECT, ST. MATTHEWS BAY
1/12/94	15:20			5	CTD	PORT GRAVINA	60 40.48	146 20.79			89		TRANSECT, ST. MATTHEWS BAY
1/12/94	15:41			6	CTD	PORT GRAVINA	60 39.16	146 20.79			128		TRANSECT, ST. MATTHEWS BAY
11/12/94	21:10	21:24	7	1	N	PORT GRAVINA	60 39.35	146 21.63	60 39.92	146 21.85	124	70	EUPHAUSIIDS
11/12/94	21:30	21:40	7	2	N	PORT GRAVINA	60 40.09	146 21.88	60 40.46	146 21.81	91-60	60	NO EUPHAUSIIDS
11/12/94	21:56	22:09	7	3	N	PORT GRAVINA	60 39.64	146 20.69	60 40.06	146 20.95	175	70	EUPHAUSIIDS
11/12/94	22:33	22:55	[illegible]	[illegible]	[illegible]	PORT GRAVINA	60 40.06	146 20.92	60 39.23	146 23.05	118	15-21	POLLOCK, HERRING
11/12/94	23:25	0:05	7	5	M	PORT GRAVINA	60 38.15	146 24.25	60 39.57	146 21.54	113	80-40	POLLOCK, HERRING, EULACHON
11/13/94	13:09	14:14	8	1	M	PORT GRAVINA	60 36.37	146 33.99	60 38.1	146 28.81	100	50	SCYPHAZOANS
11/13/94	15:10	15:35	8	2	M	PORT GRAVINA	60 37.79	146 34.59	60 37.88	146 32.67	50	36	HERRING
11/13/94	16:15	17:00	8	3	M	PORT GRAVINA	60 39.42	146 25.87	60 41.02	146 22.10	40-50	30-35 M	HERRING, 5-15 M OFF BOTTOM
11/13/94	17:31			0	CTD	PORT GRAVINA	60 42.18	146 19.70			51		CTD TRANSECT OUT OF PORT GRAVINA
11/13/94	18:00			1	CTD	PORT GRAVINA	60 40.84	146 22.82			45		CTD TRANSECT OUT OF PORT GRAVINA
11/13/94	18:19			2	CTD	PORT GRAVINA	60 39.18	146 25.78			50		CTD TRANSECT OUT OF PORT GRAVINA
11/13/94	18:40			3	CTD	PORT GRAVINA	60 38.27	146 29.13			60		CTD TRANSECT OUT OF PORT GRAVINA
11/13/94	19:00			4	CTD	PORT GRAVINA	60 37.85	146 33.41			53		CTD TRANSECT OUT OF PORT GRAVINA
11/13/94	19:45			5	CTD	PORT GRAVINA	60 37.87	146 37.44			43		CTD TRANSECT OUT OF PORT GRAVINA
11/13/94	20:04			6	CTD	PORT GRAVINA	60 37.82	146 41.31			93		CTD TRANSECT OUT OF PORT GRAVINA
11/13/94	10:39			7	CTD	PORT GRAVINA	60 37.76	146 41.23			385		CTD TRANSECT OUT OF PORT GRAVINA
11/14/94	21:09		9	1	n	KNIGHT IS. PASS	60 39.52	147 38.37			585	500 M WO	BETWEEN NAKED AND LONG ISLANDS

Table 2. CTD stations on the November 1994 forage fish project cruise (Cruise FOR94-2) in Prince William Sound.

DATE	TIME	CAST NO	CAST CODE	LOCAL	LAT		LONG		BOTTOM DEPTH	CAST DEPTH
6-11	1605	1	110600	N. GRN IS.	60	17.725	147	28.781	74	50
7-11	1739	2	110700	NEEDLES	60	03.10	147	37.68	140	125
8-11	1040	3	110800	ICY BAY	60	14.97	148	17.97	150	125
8-11	1621	4	110801	ICY BAY	60	17.34	148	11.015	276	250
9-11	1139	5	110900	EWAN BAY	60	21.224	148	06.84	40	33
9-11	1154	6	110901	EWAN BAY	60	21.715	148	06.567	60	54
9-11	1214	7	110902	EWAN BAY	60	22.125	148	07.051	94	92
9-11	1234	8	110903	EWAN BAY	60	22.645	148	07.615	102	93
9-11	1252	9	110904	EWAN BAY	60	23.024	148	08.04	85	80
9-11	1310	10	110905	EWAN BAY	60	23.526	148	08.512	64	55
9-11	1322	11	110906	EWAN BAY	60	23.87	148	08.89	40	38
10-11	1631	12	111000	LONG IS.	60	40.48	147	40.72	750	250
11-11	1000	13	111100	GALENA	60	56.72	146	38.6	112	100
11-11	1858	14	111101	GALENA	60	55.85	146	36.18	25	14
11-11	1930	15	111102	GALENA	60	56.45	146	37.94	100	98
11-11	1958	16	111103	GALENA	60	56.51	146	39.81	82	68
11-11	2017	17	111104	GALENA	60	56.59	146	41.88	187	185
11-11	2048	18	111105	GALENA	60	57.37	146	43.14	211	210
11-11	2112	19	111106	GALENA	60	58.21	146	44.36	207	185
11-11	2145	20	111107	GALENA	60	58.68	146	46.00	380	250
12-11	1406	21	111200	S MATT B	60	45.77	146	18.43	26	14
12-11	1417	22	111201	S MATT B	60	44.78	146	19.28	40	37
12-11	1434	23	111202	S MATT B	60	43.61	146	19.56	35	28

12-11	1450	24	111203	S MATT B	60	42.56	146	20.03	27	26
12-11	1505	25	111204	S MATT B	60	41.53	146	26.65	59	55
12-11	1520	26	111205	S MATT B	60	40.48	146	20.79	89	82
12-11	1541	27	111206	S MATT B	60	39.16	146	20.79	128	115
13-11	1731	28	111300	GRAVINA	60	42.18	146	19.70	51	35
13-11	1800	29	111301	GRAVINA	60	40.84	146	22.82	45	35
13-11	1819	30	111302	GRAVINA	60	39.18	146	25.78	50	38
13-11	1840	31	111303	GRAVINA	60	38.27	146	29.13	60	57
13-11	1900	32	111304	GRAVINA	60	37.85	146	33.41	53	49
13-11	1945	33	111305	GRAVINA	60	37.87	146	37.44	43	36
13-11	2004	34	111306	GRAVINA	60	37.82	146	41.31	93	88
13-11	2039	35	111207	GRAVINA	60	37.76	146	41.23	385	260

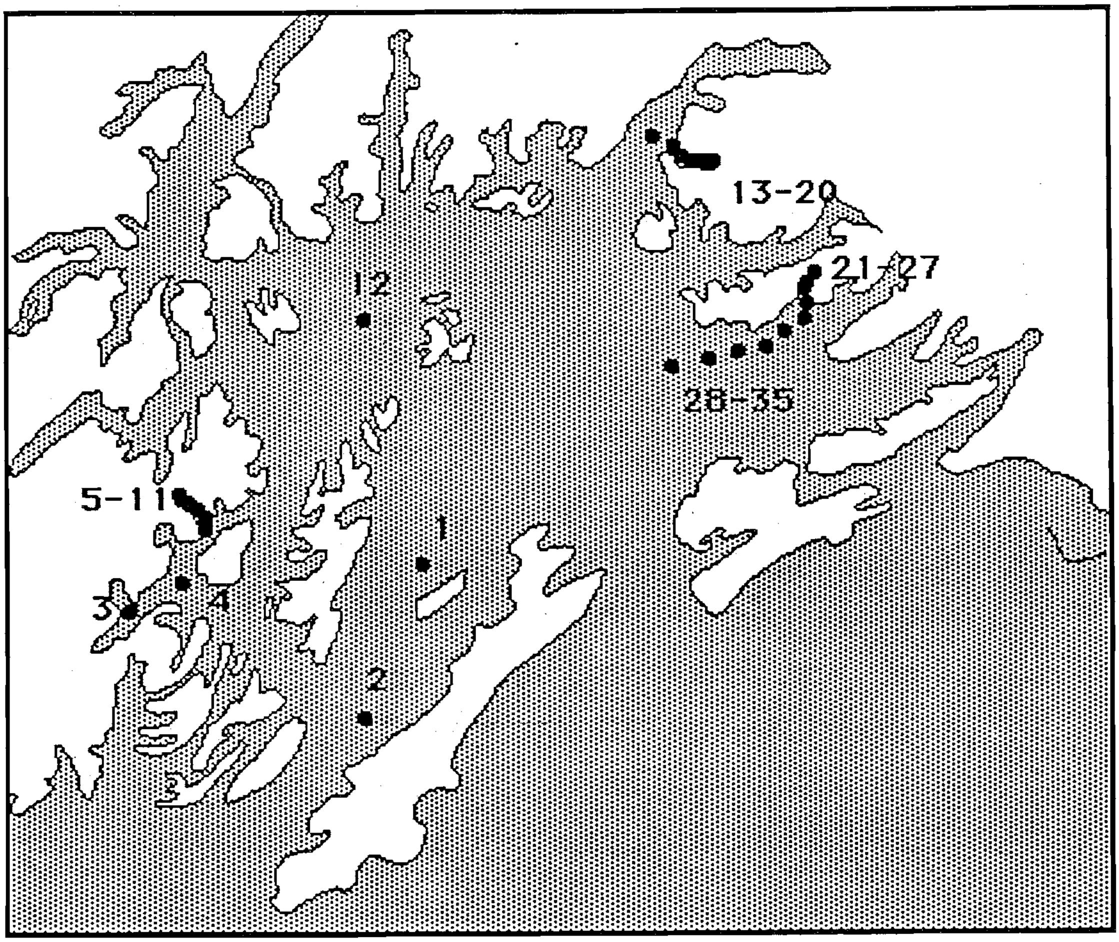


Figure 1. CTD stations sampled for temperature, salinity and density on the November 1994 Forage Fish Research Cruise (FOR94-2).

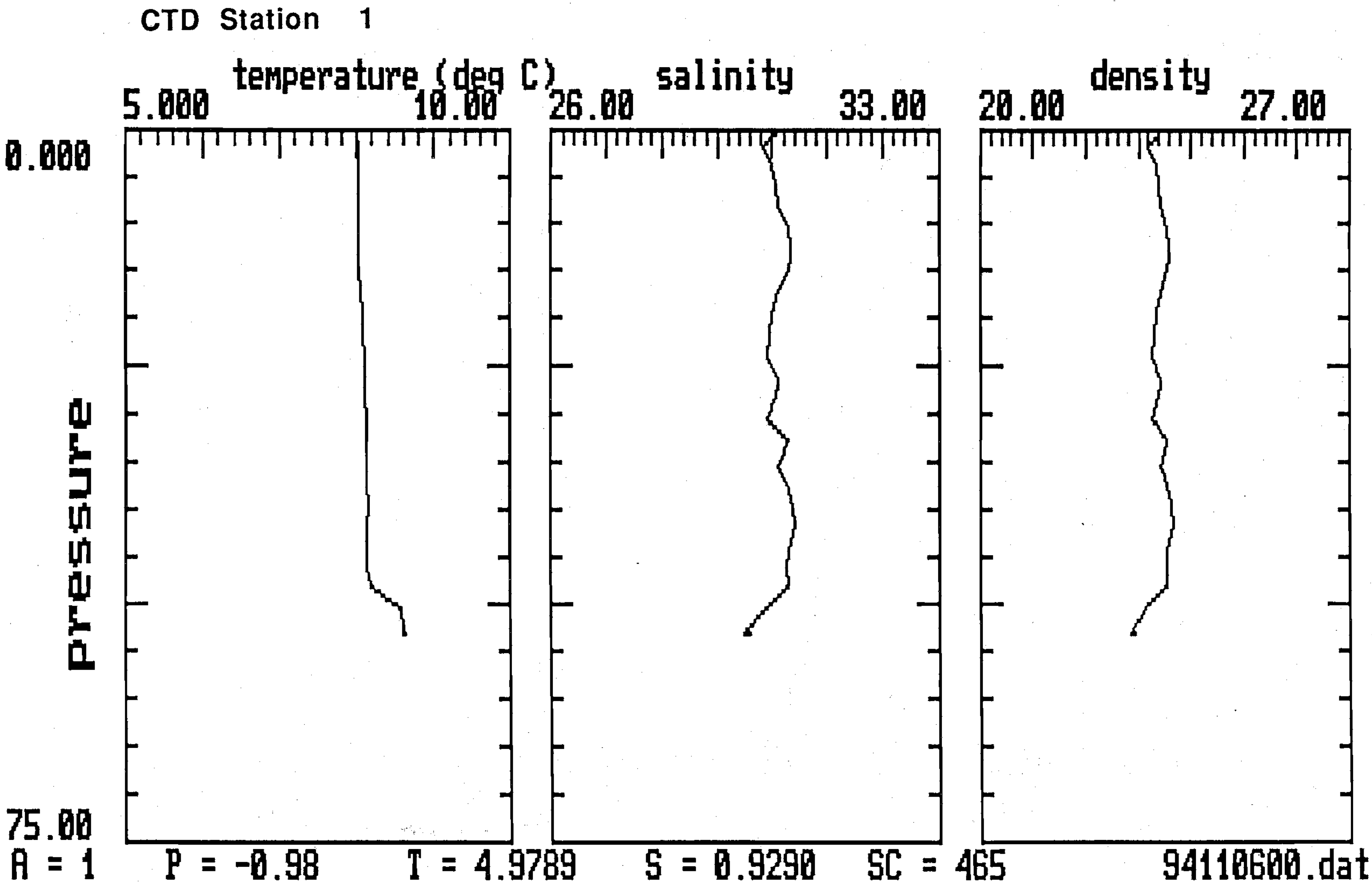

CTD Station 1
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
75.00
A = 1
P = -0.98
T = 4.9789
S = 0.9290
SC = 465
94110600.dat

Figure 2

CTD Station 2

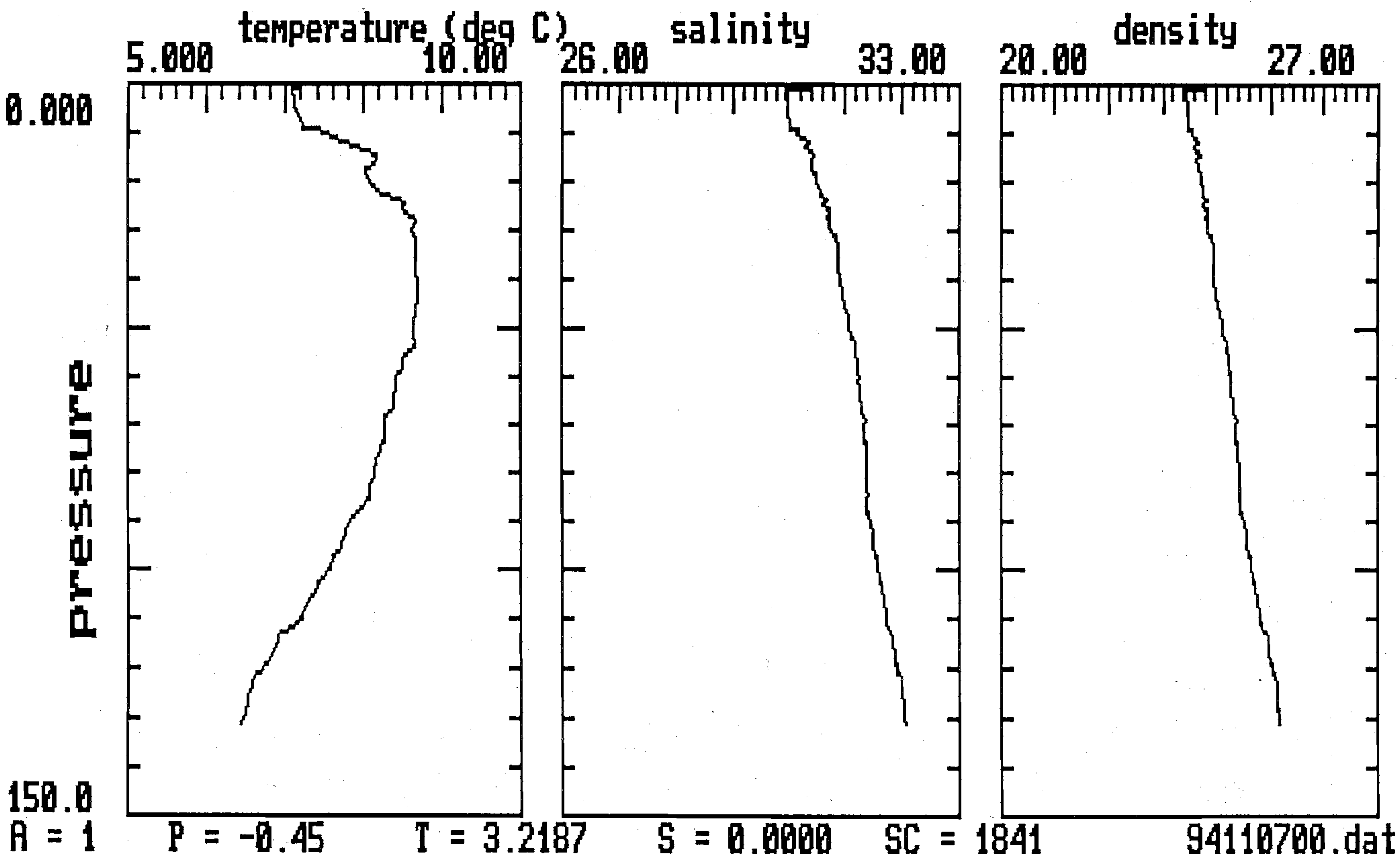


Figure 3

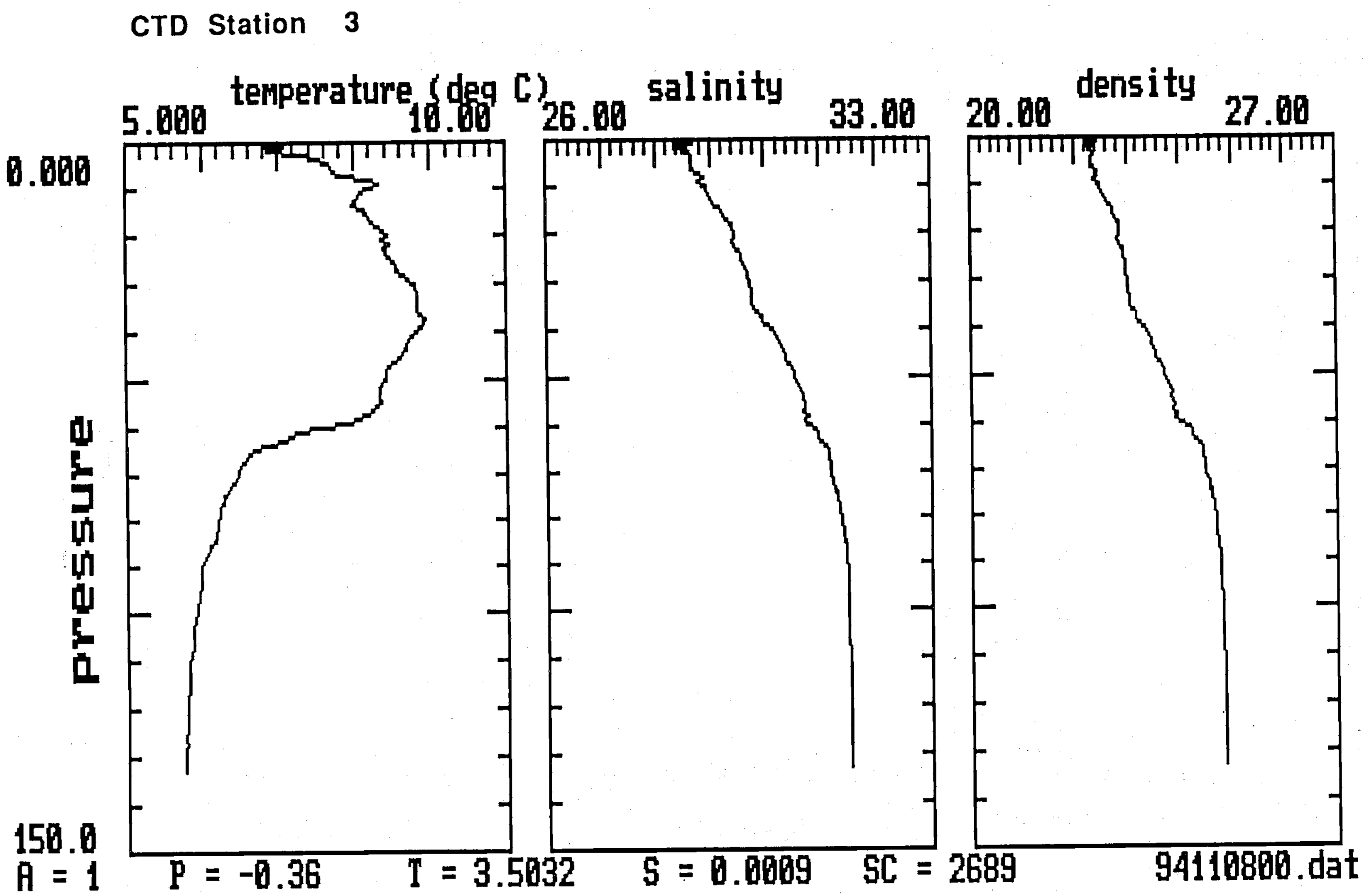

CTD Station 3
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
150.0
A = 1
P = -0.36
T = 3.5032
S = 0.0009
SC = 2689
94110800.dat

Figure 4

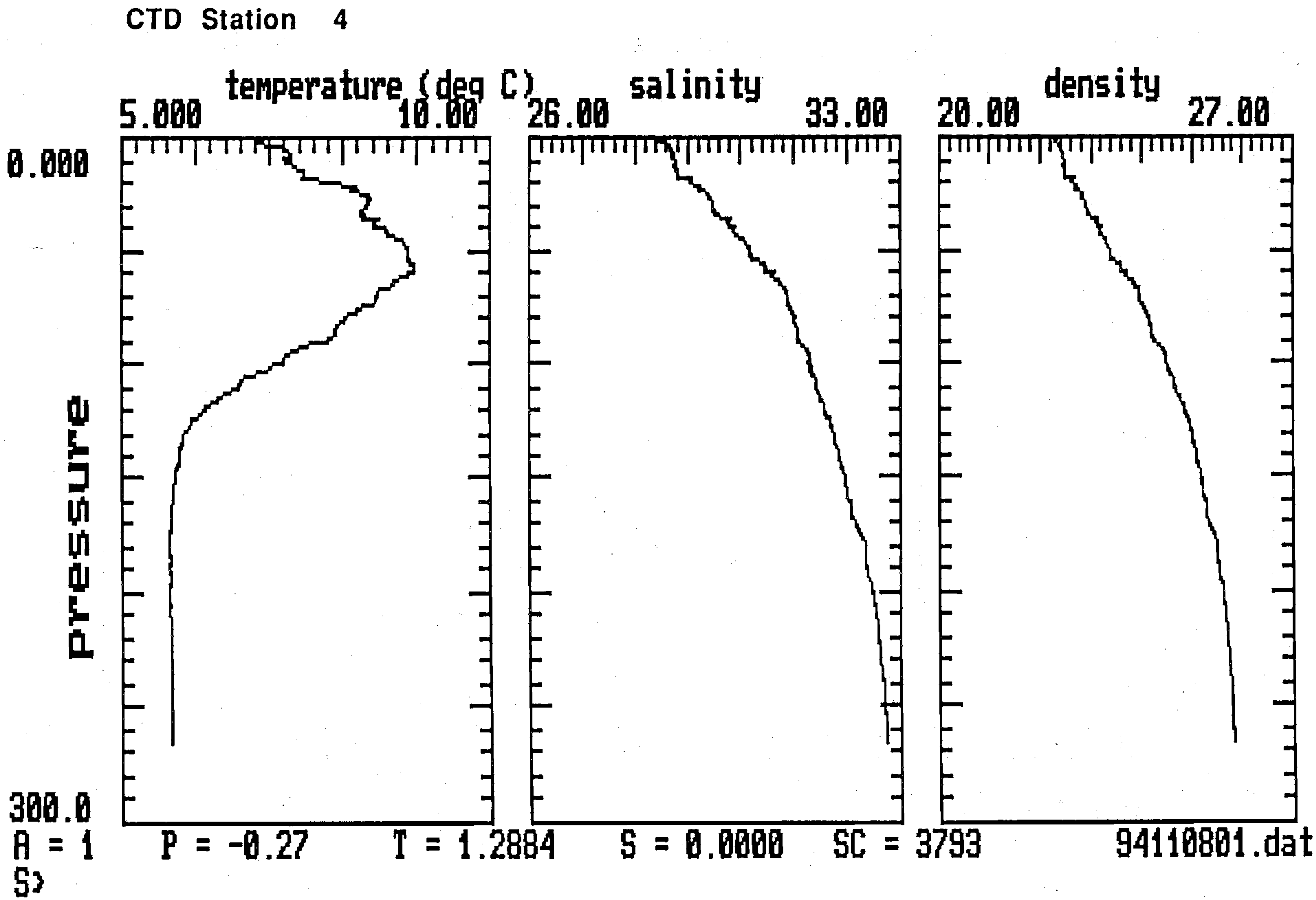

CTD Station 4
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
300.0
A = 1
P = -0.27
T = 1.2884
S = 0.0000
SC = 3793
94110801.dat
S>

Figure 5

CTD Station 5

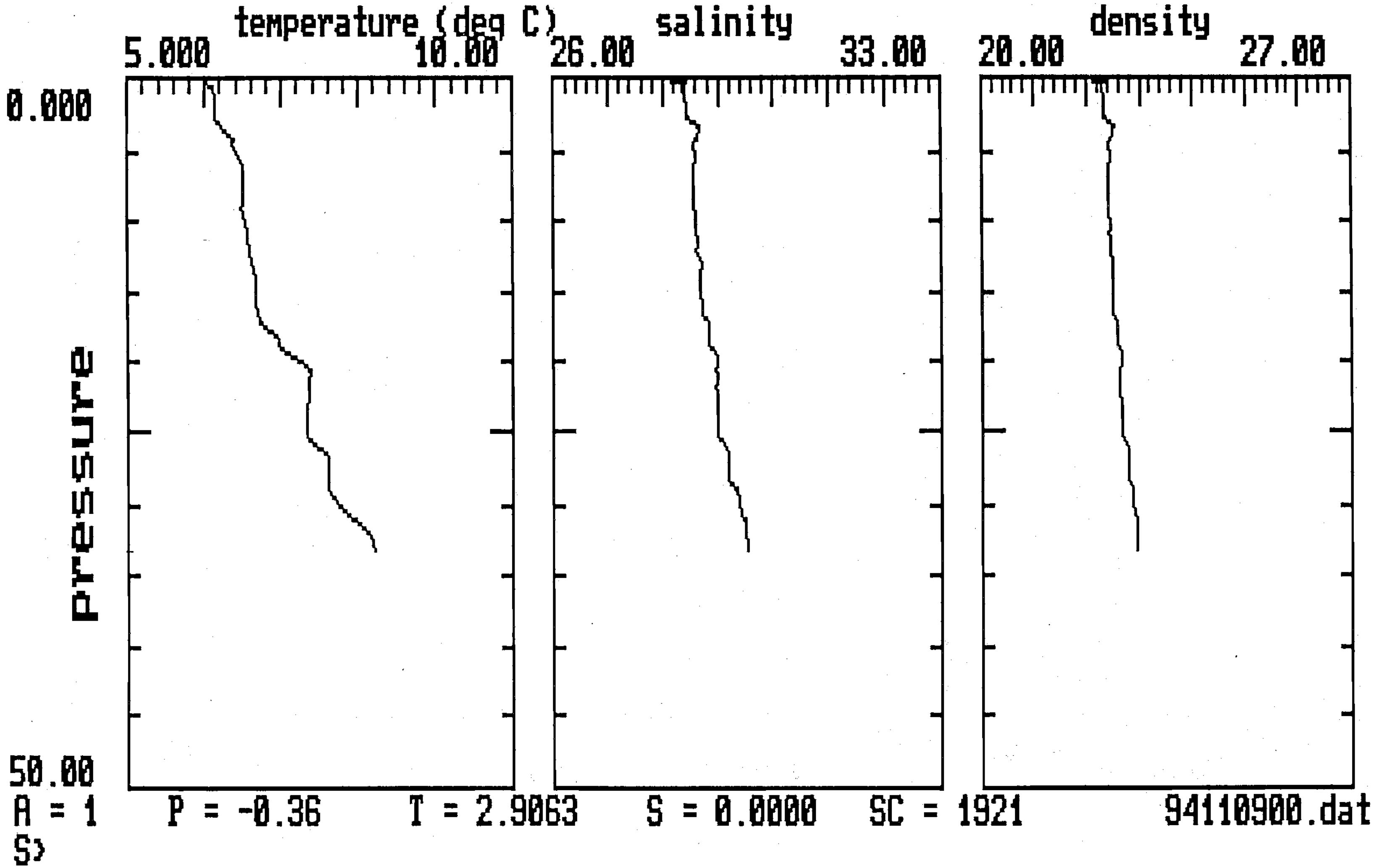


Figure 6

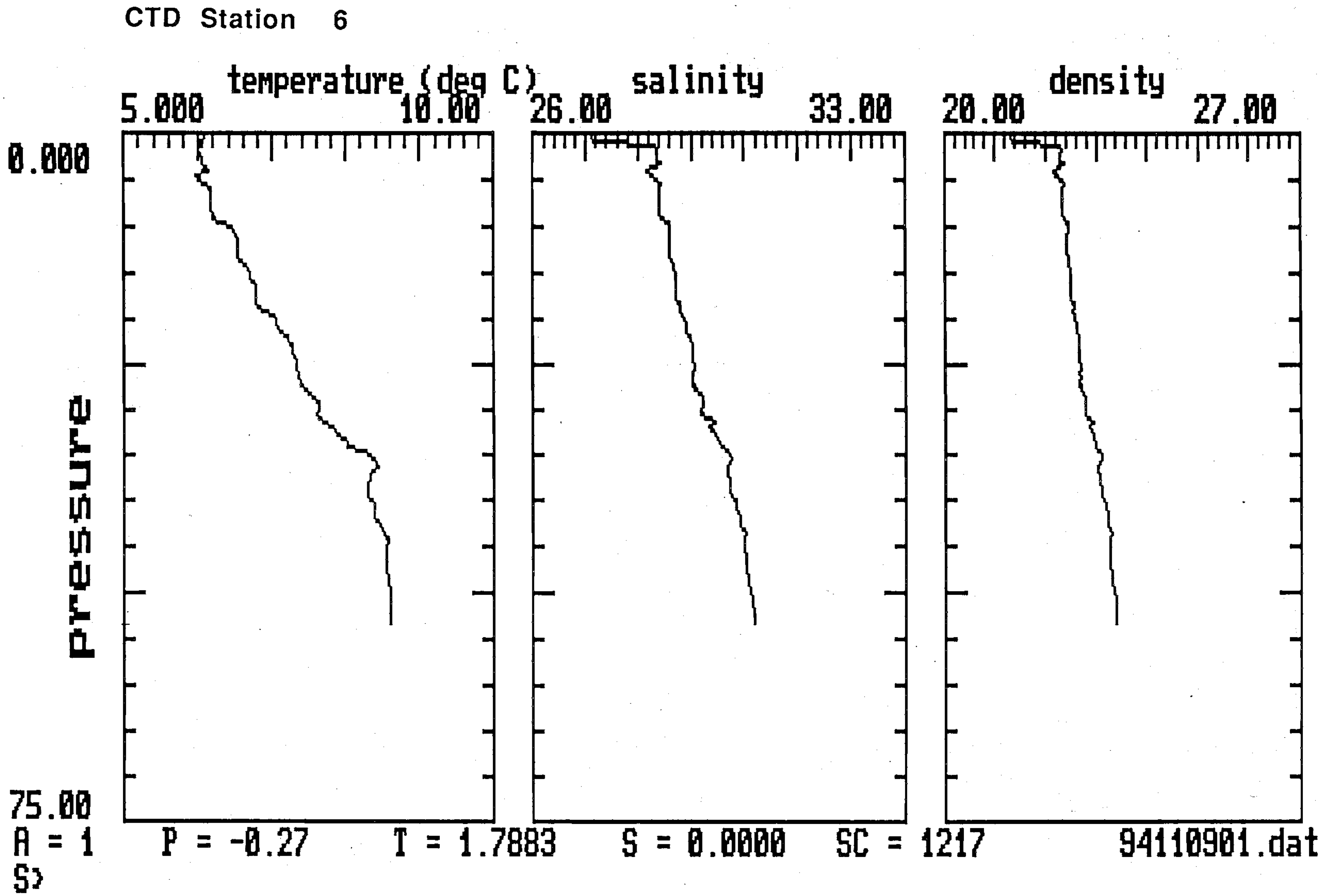

CTD Station 6
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
Pressure
75.00
A = 1
P = -0.27
T = 1.7883
S = 0.0000
SC = 1217
94110901.dat
S>

Figure 7

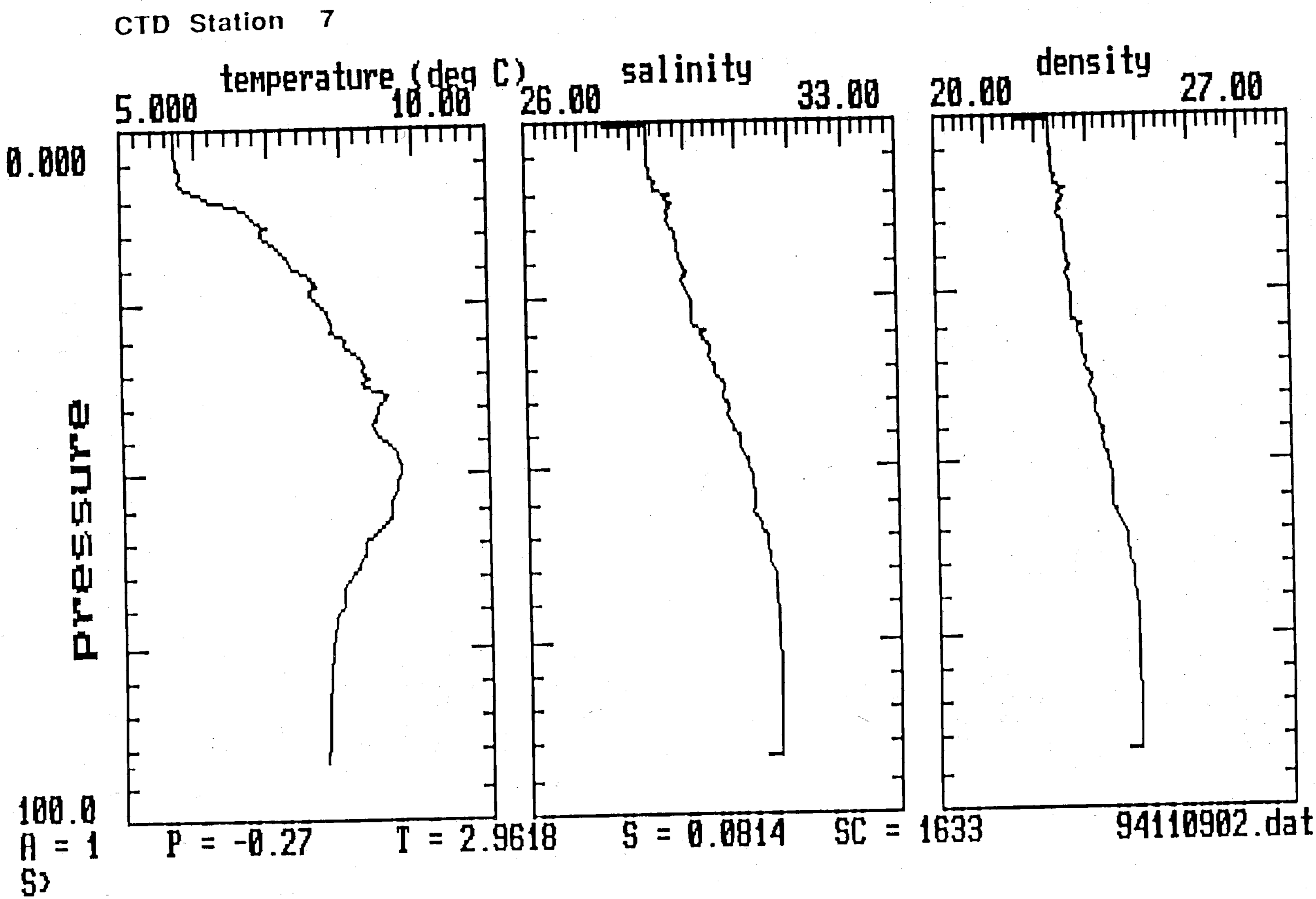

CTD Station 7
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
100.0
A = 1
S>
P = -0.27
T = 2.9618
S = 0.0814
SC = 1633
94110902.dat

Figure 8

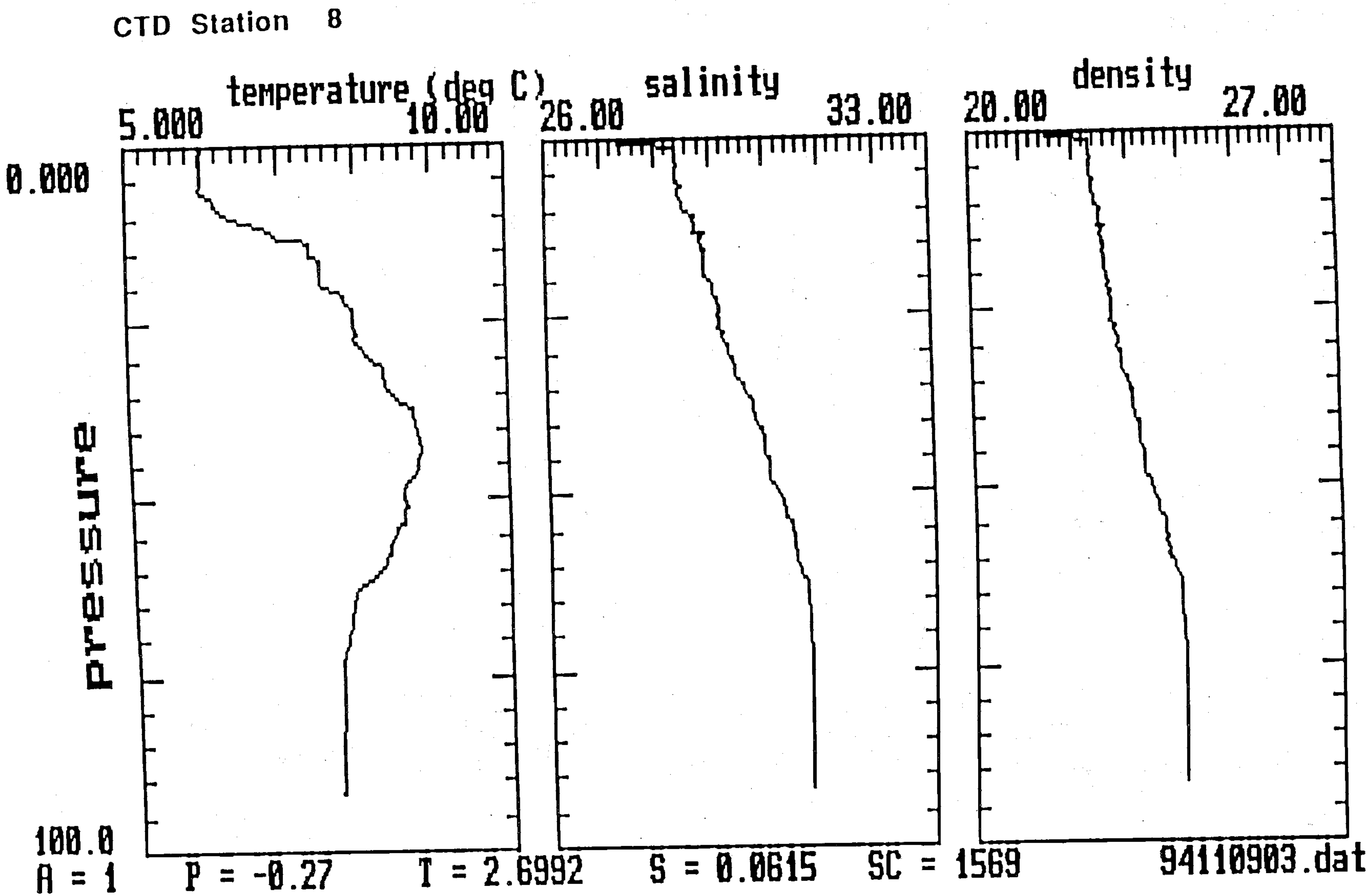

CTD Station 8
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
100.0
A = 1
P = -0.27
T = 2.6992
S = 0.0615
SC = 1569
94110903.dat

Figure 9

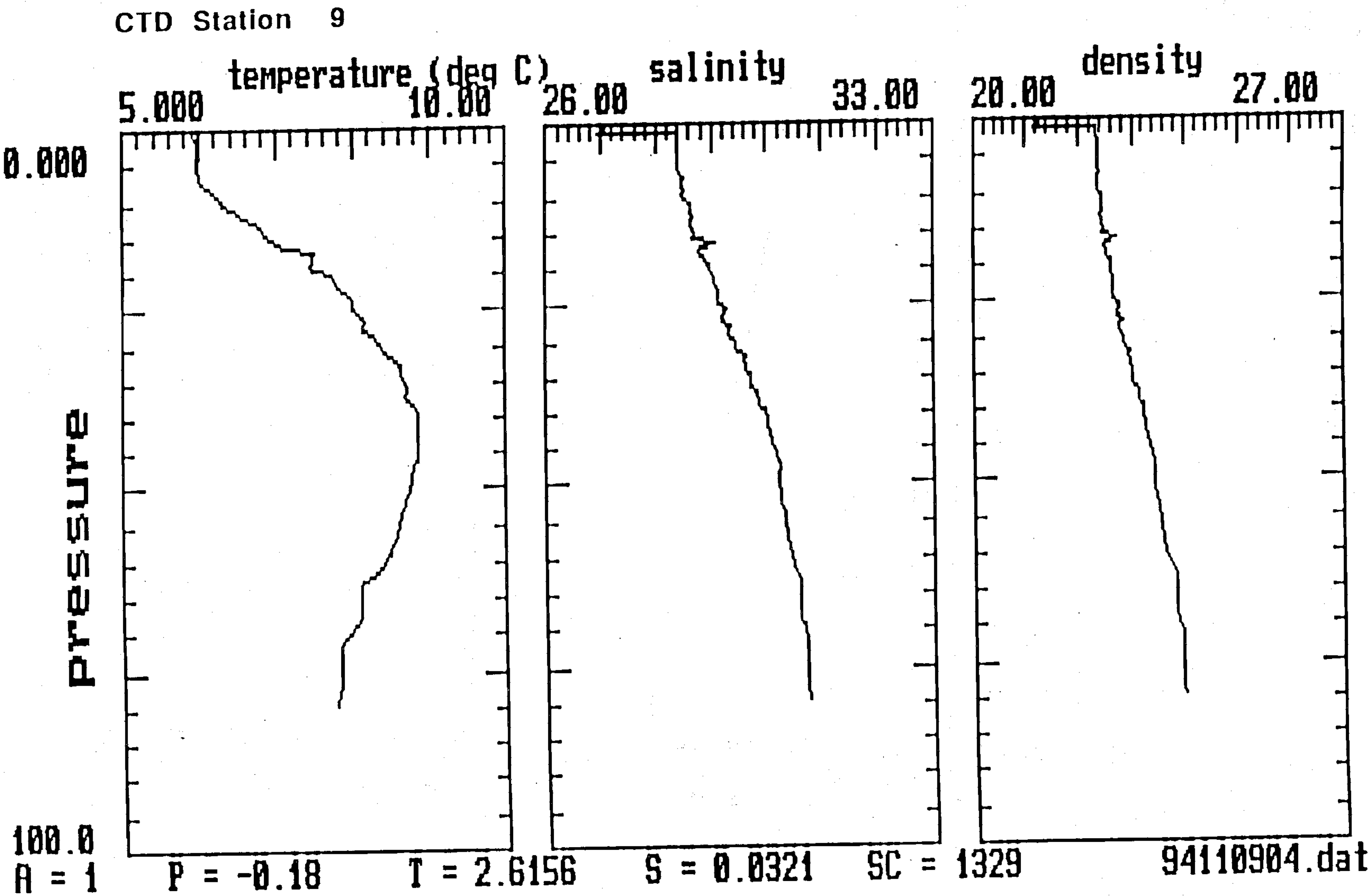
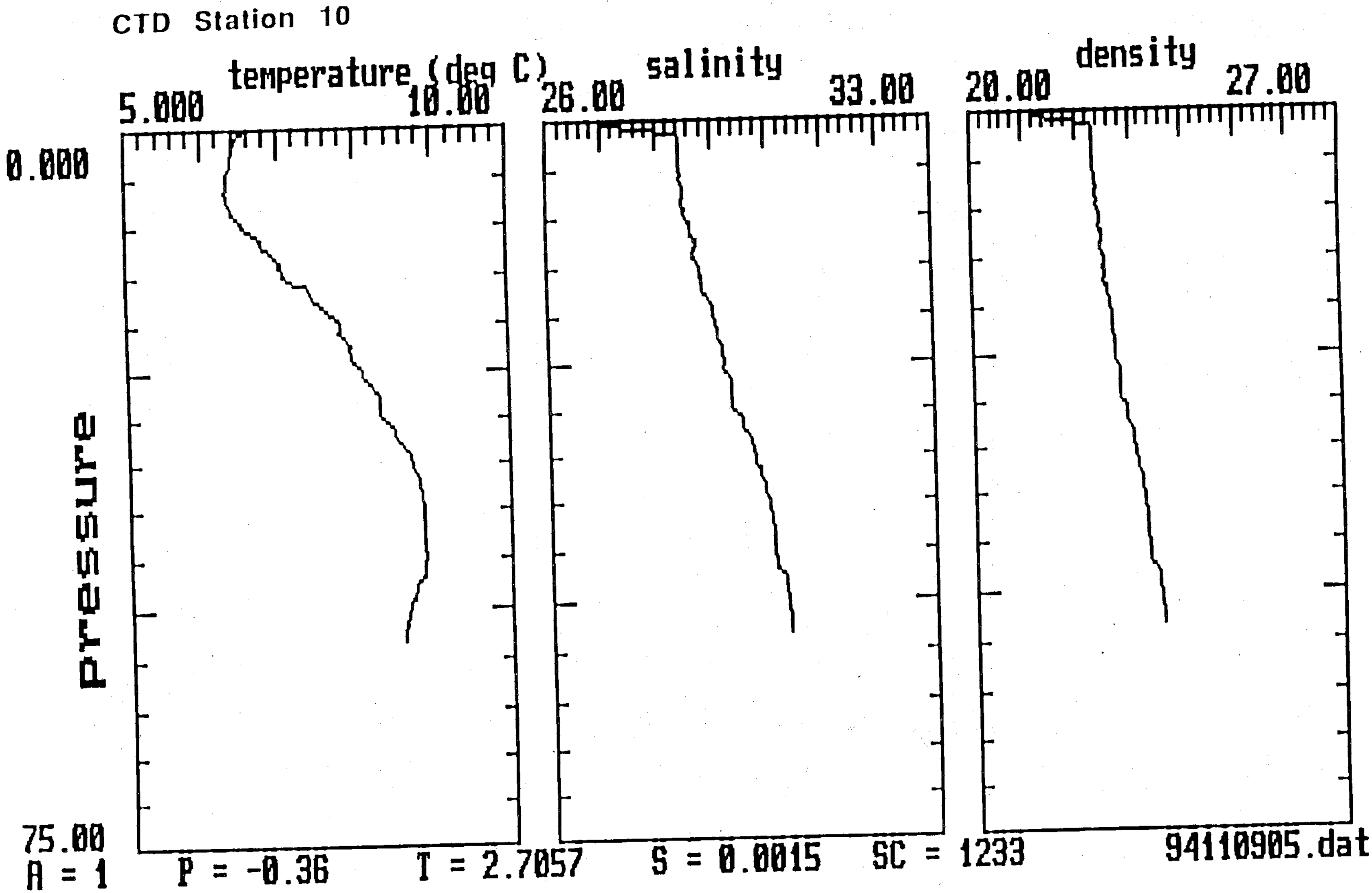

CTD Station 9
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
100.0
A = 1
P = -0.18
T = 2.6156
S = 0.0321
SC = 1329
94110904.dat

Figure 10



CTD Station 10
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
Pressure
75.00
A = 1
P = -0.36
T = 2.7057
S = 0.0015
SC = 1233
94110905.dat

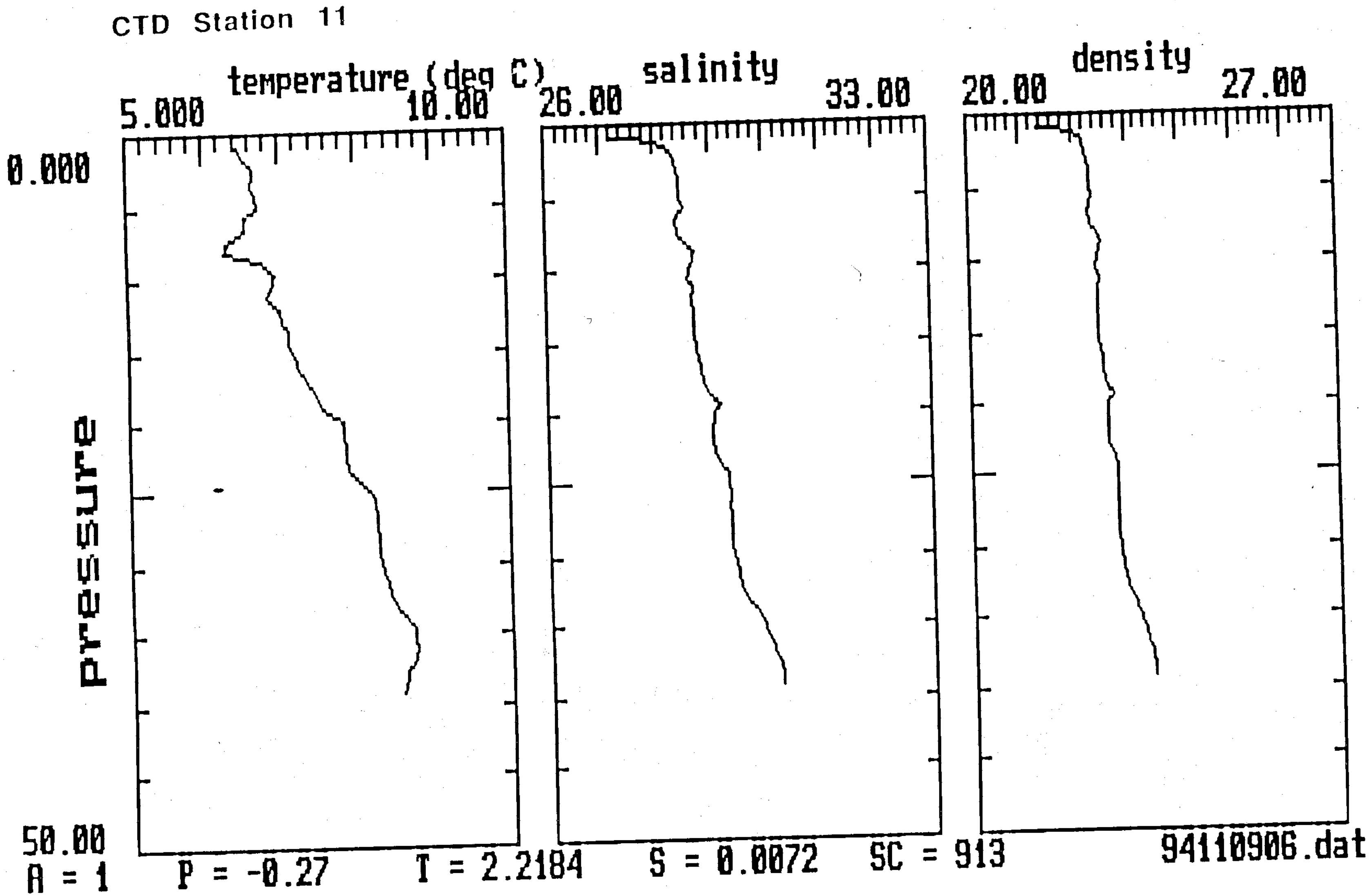
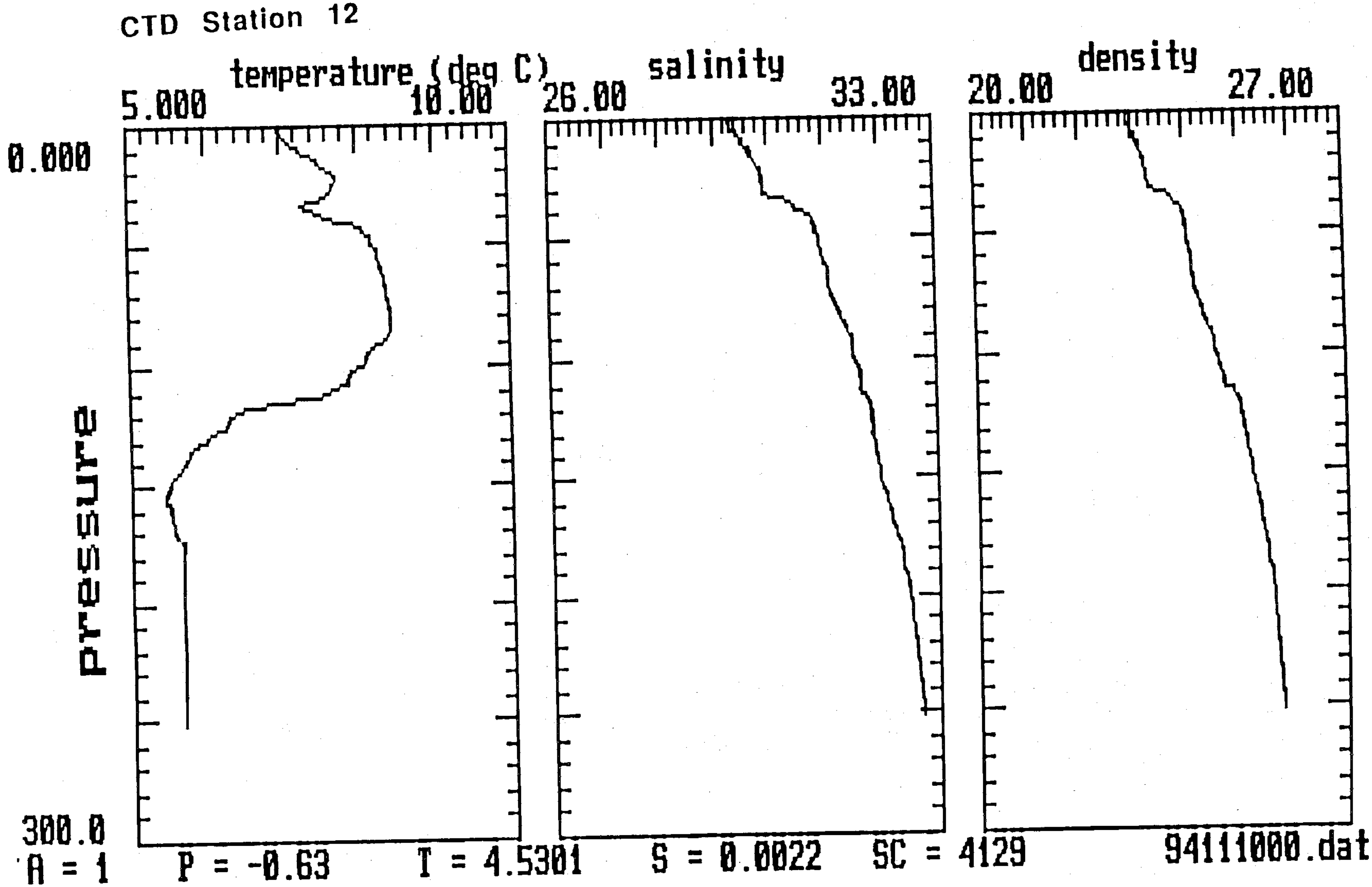
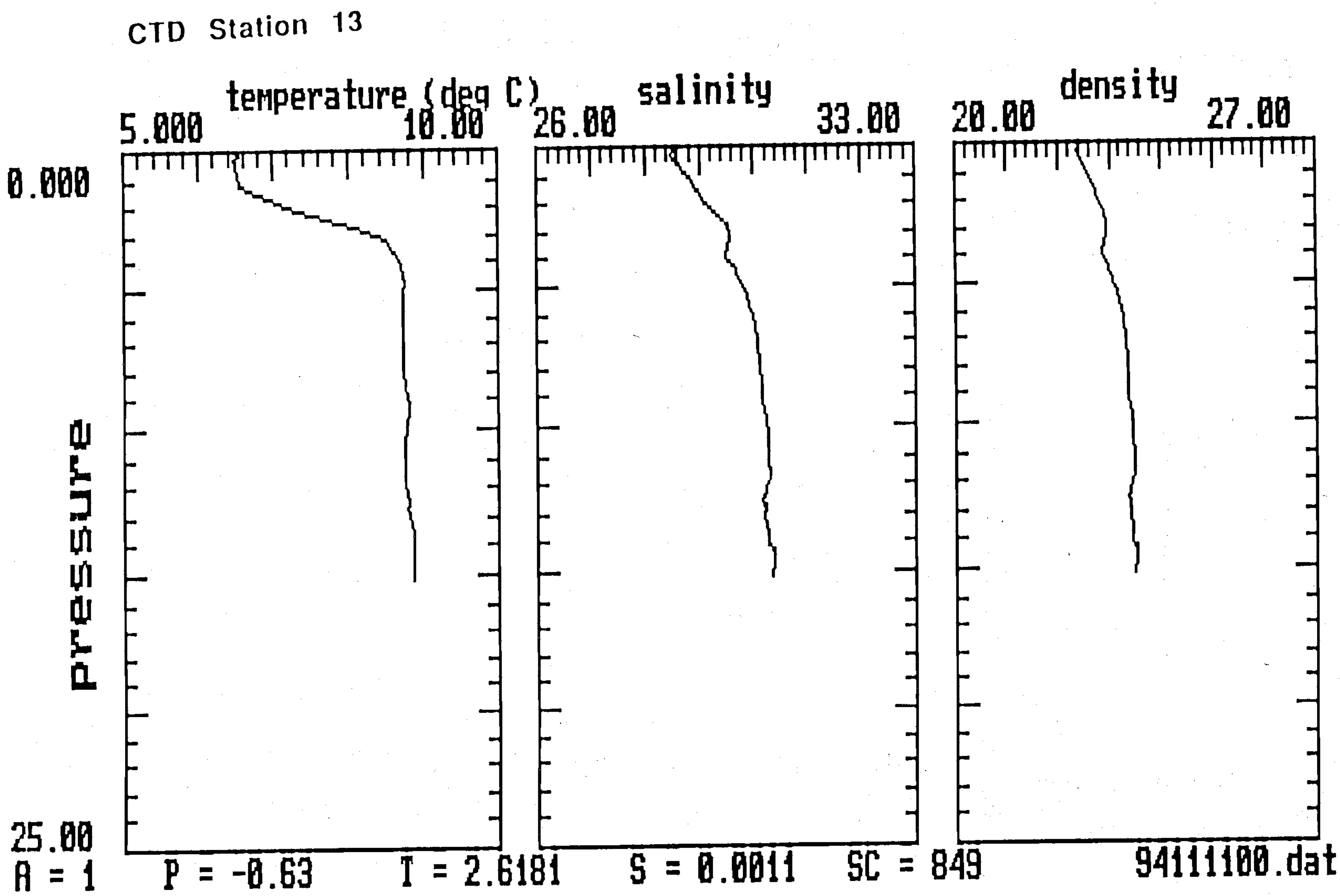
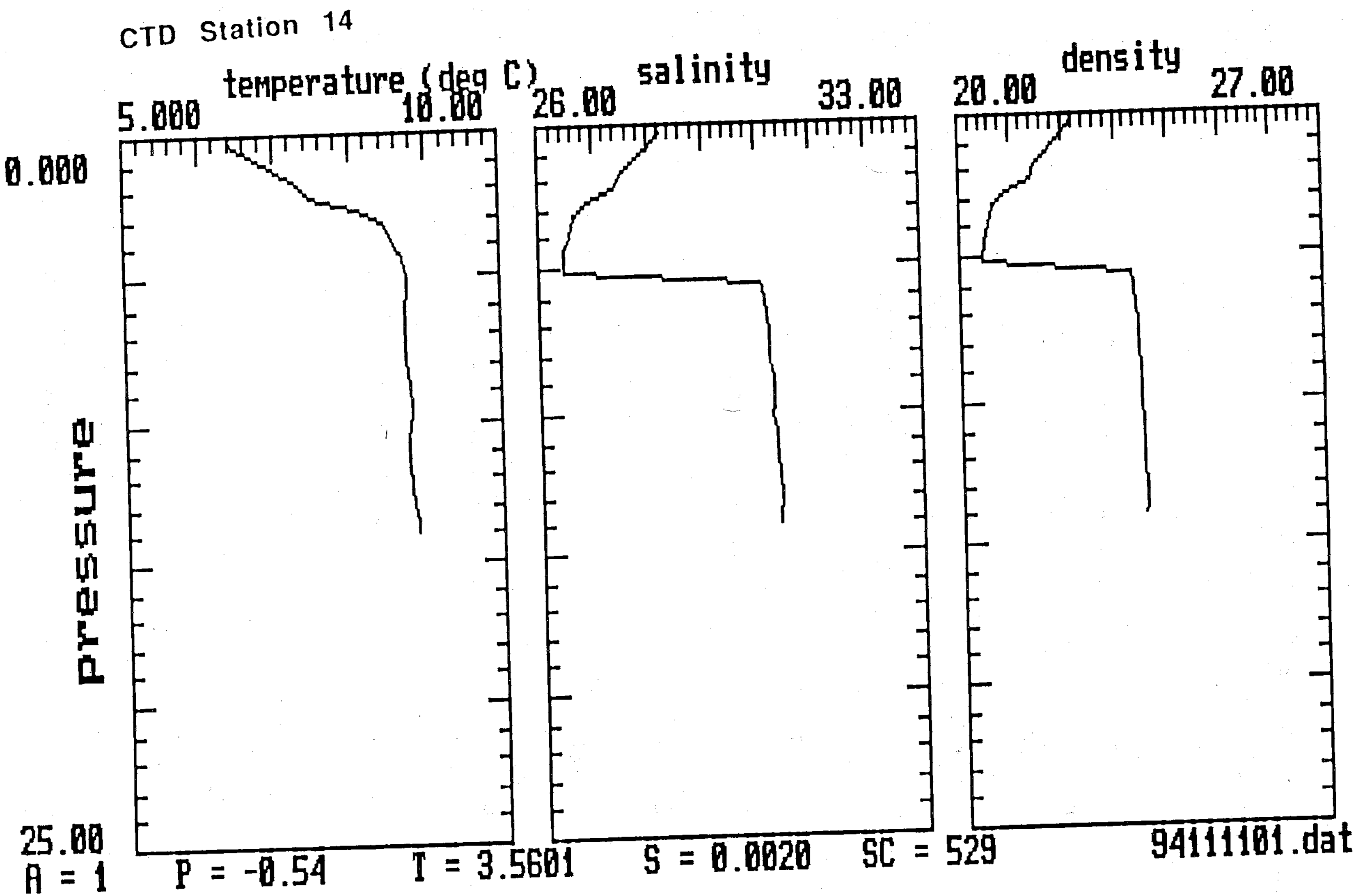

CTD Station 11
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
50.00
A = 1
P = -0.27
T = 2.2184
S = 0.0072
SC = 913
94110906.dat

Figure 12


CTD Station 12
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
300.0
A = 1
P = -0.63
T = 4.5301
S = 0.0022
SC = 4129
94111000.dat


CTD Station 13
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
25.00
A = 1
P = -0.63
T = 2.6181
S = 0.0011
SC = 849
94111100.dat

igure 14



CTD Station 14
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
25.00
A = 1
P = -0.54
T = 3.5601
S = 0.0020
SC = 529
94111101.dat

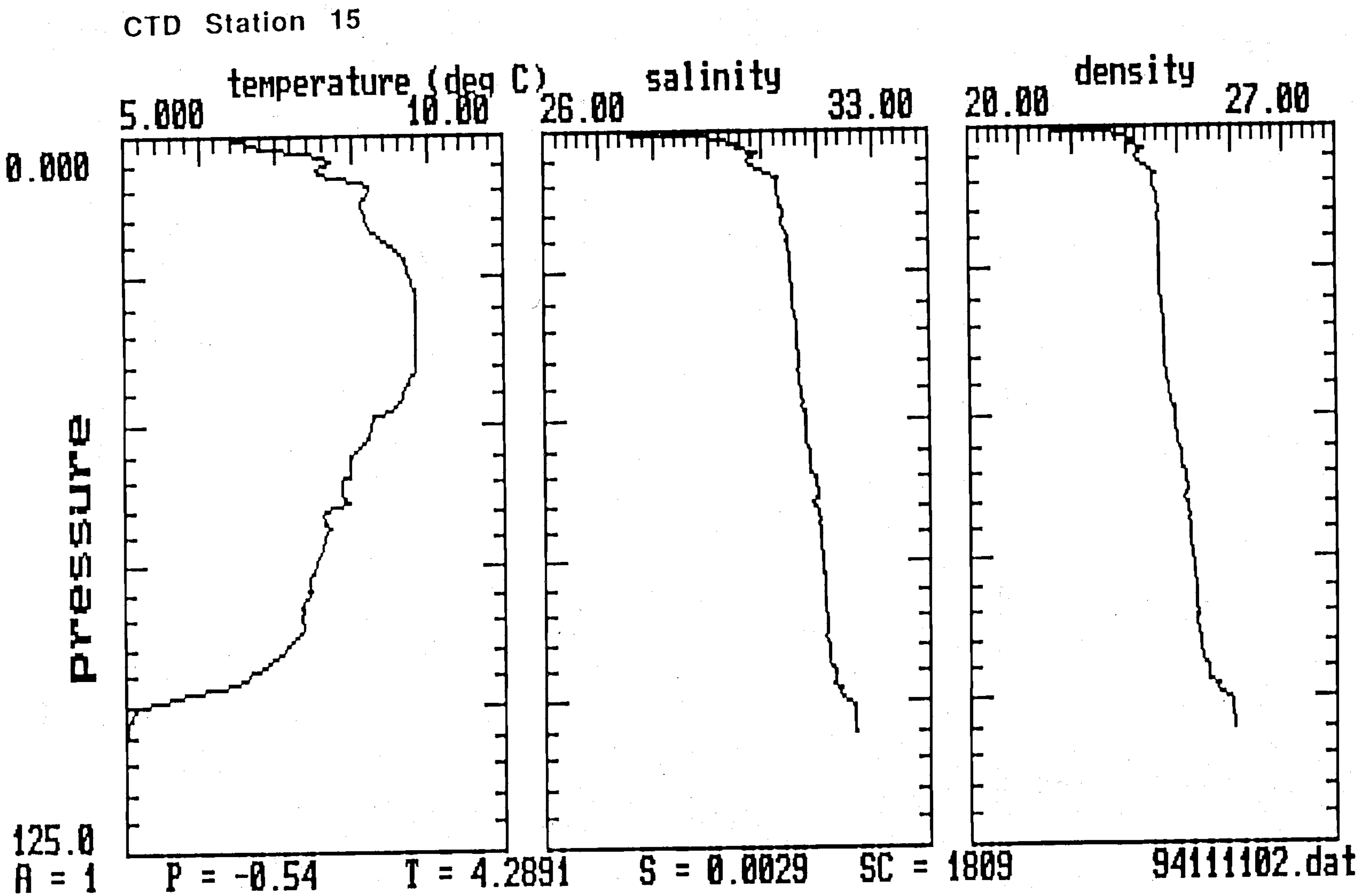

CTD Station 15
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
125.0
pressure
A = 1
P = -0.54
T = 4.2891
S = 0.0029
SC = 1809
94111102.dat

Figure 16

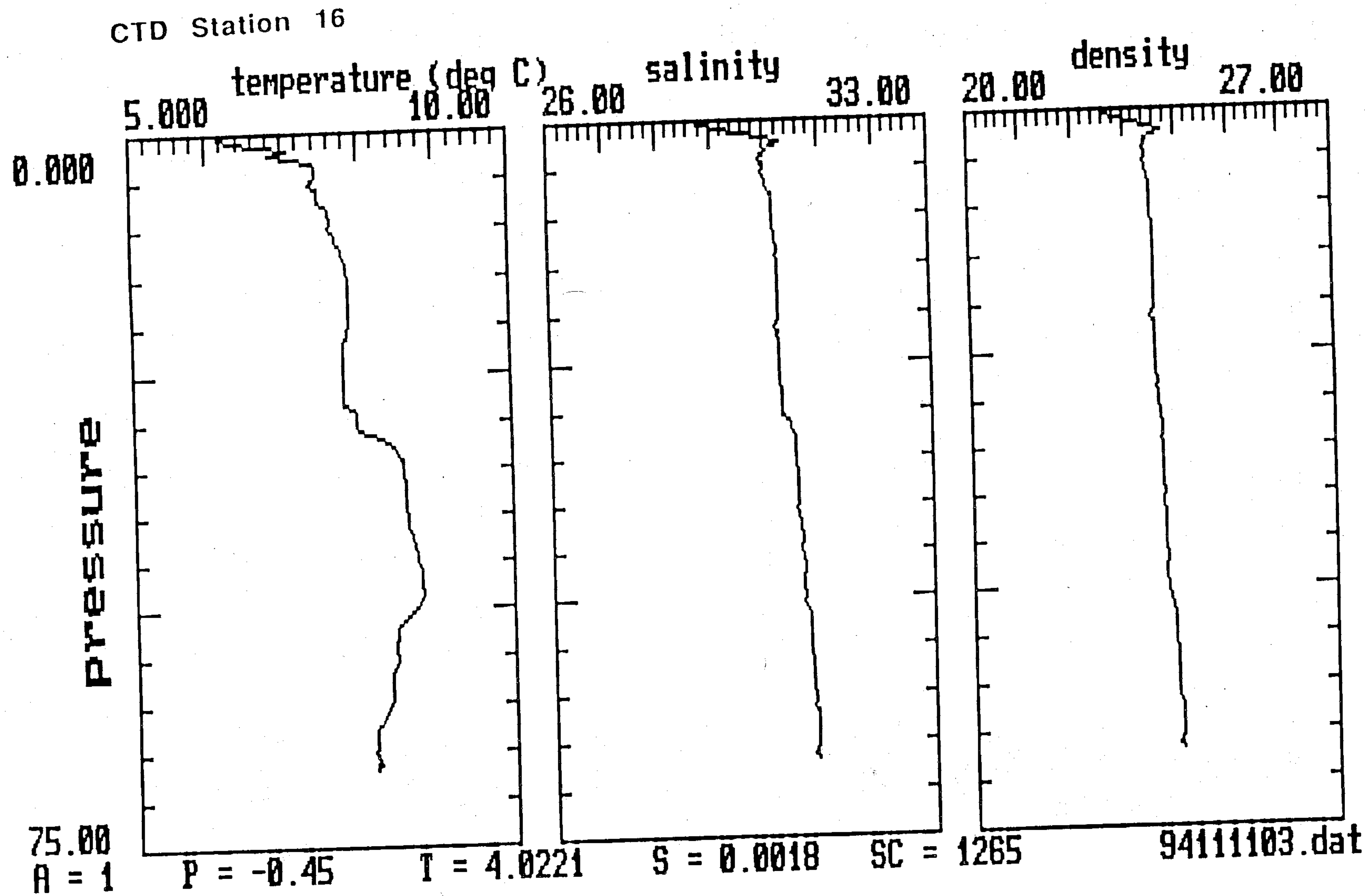
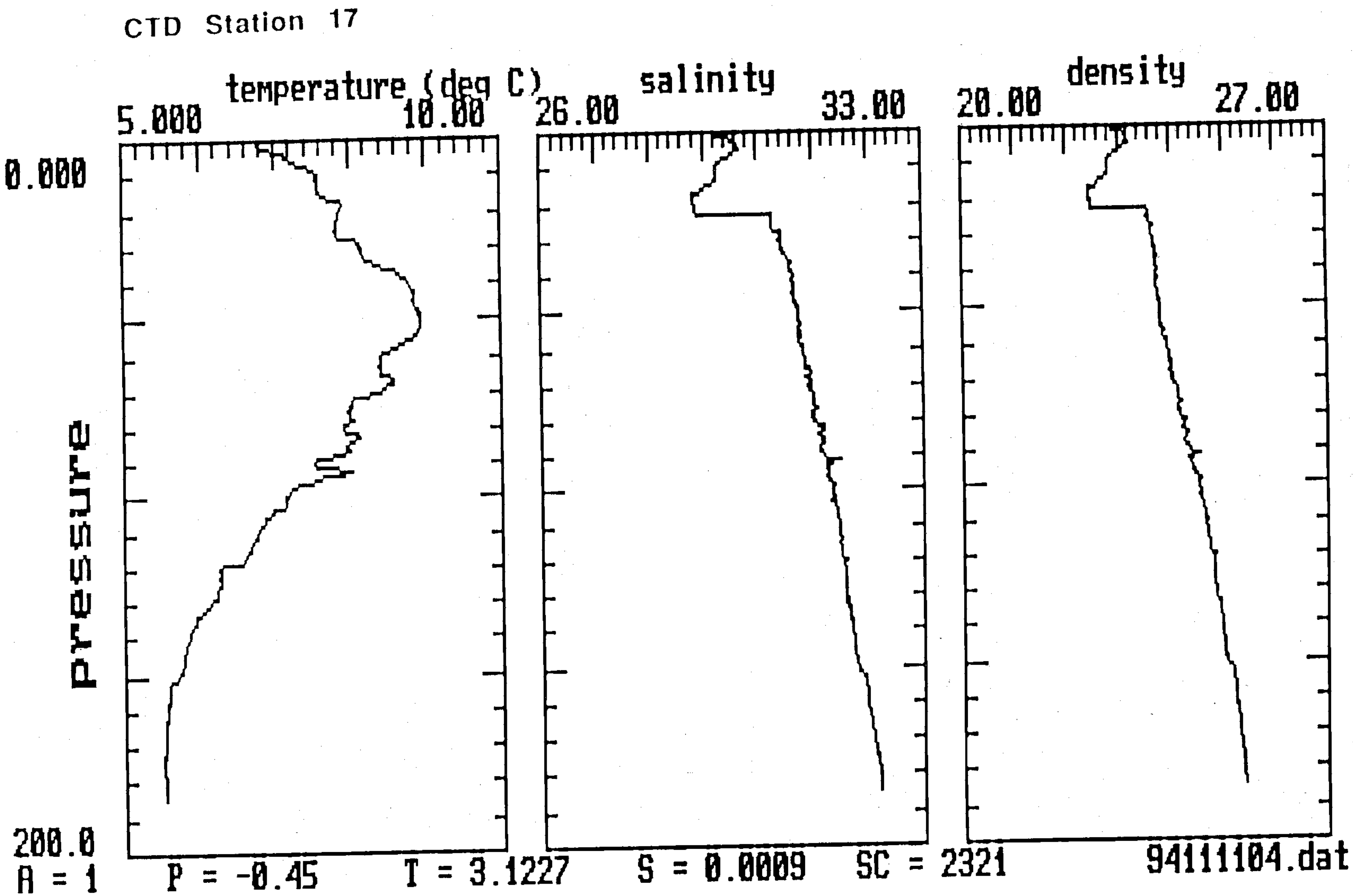

CTD Station 16
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
75.00
A = 1
P = -0.45
T = 4.0221
S = 0.0018
SC = 1265
94111103.dat

Figure 17



CTD Station 17
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
200.0
A = 1
P = -0.45
T = 3.1227
S = 0.0009
SC = 2321
94111104.dat

Figure 18

CTD Station 18

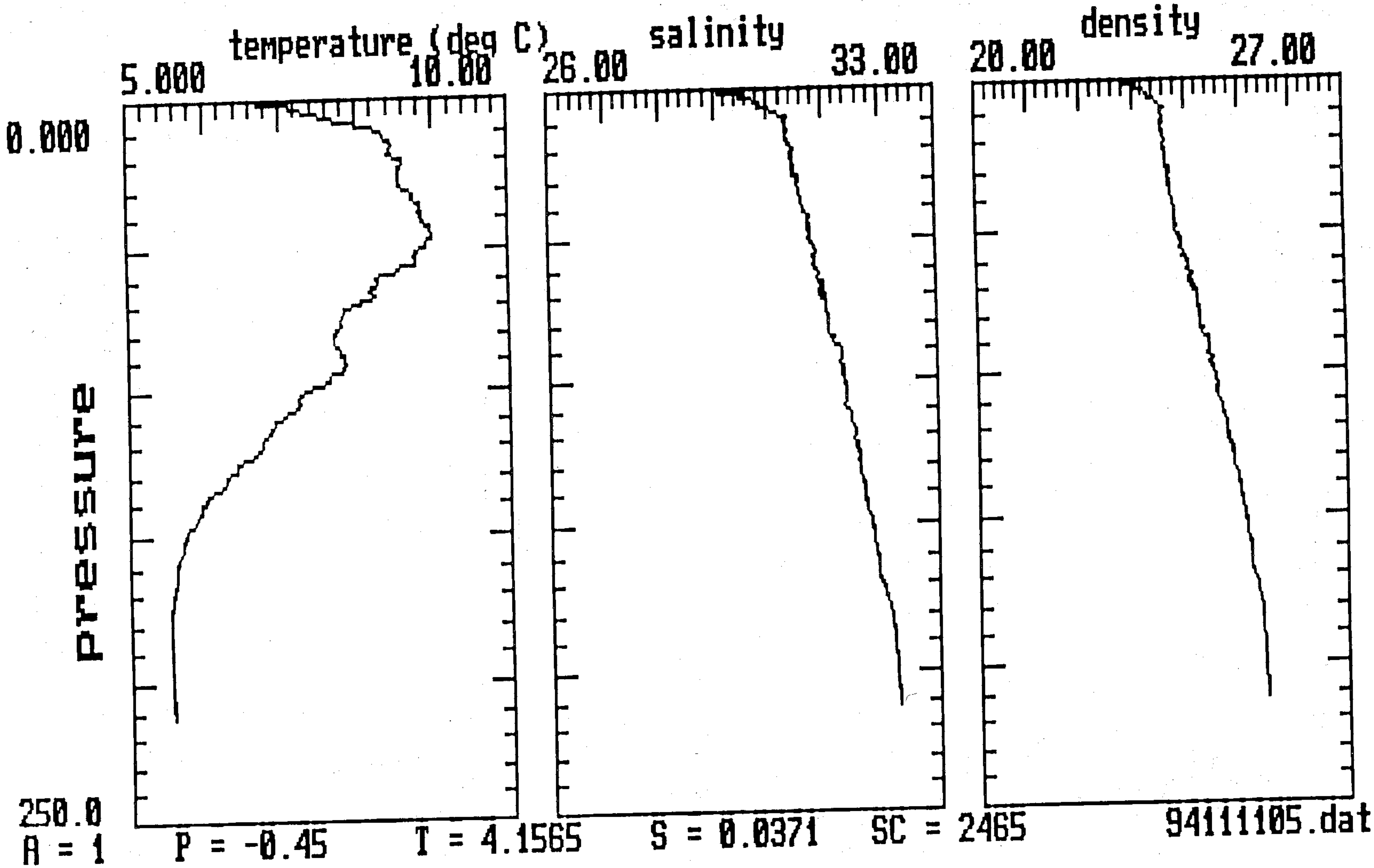
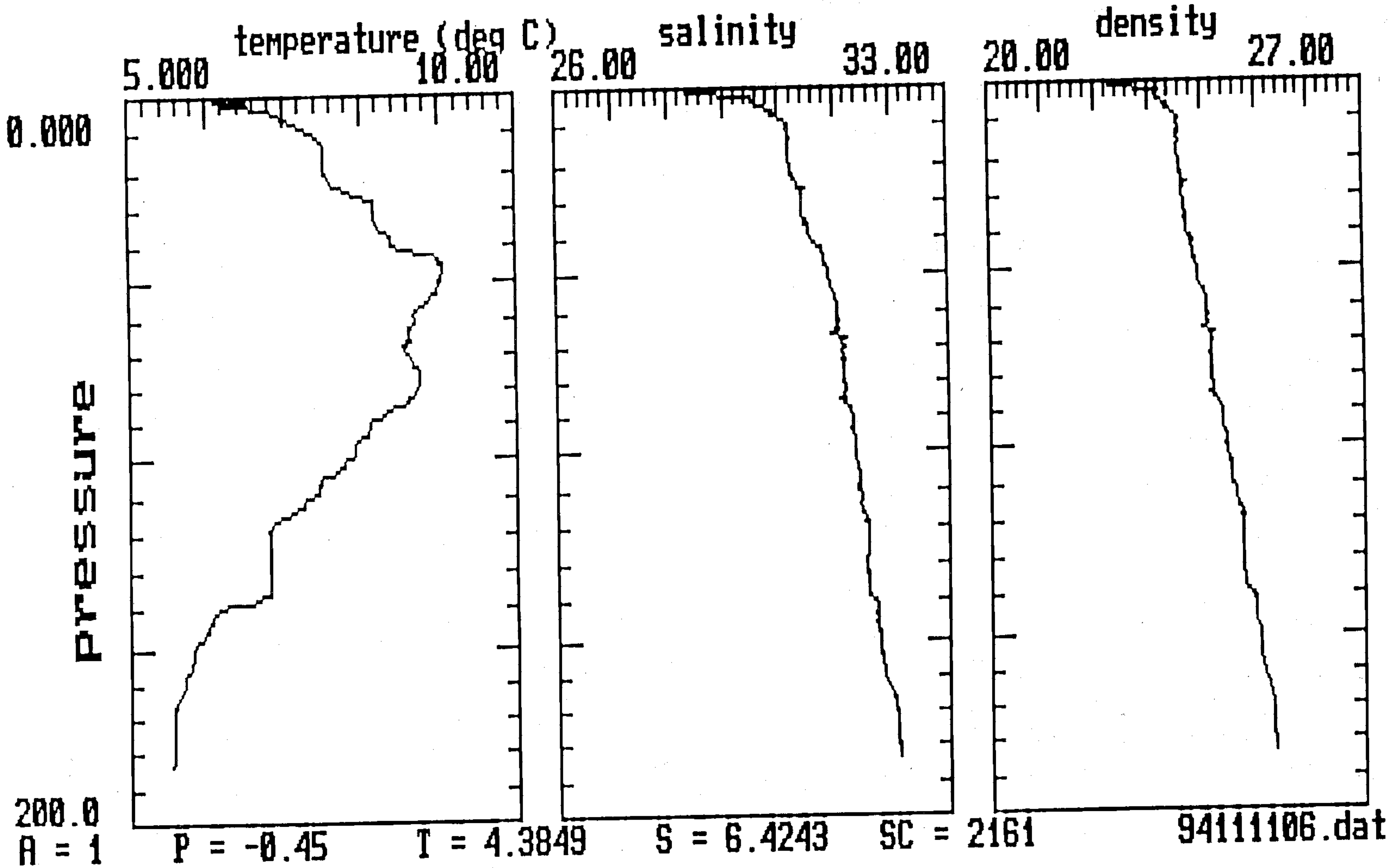


Figure 19

CTD Station 19



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igure 20

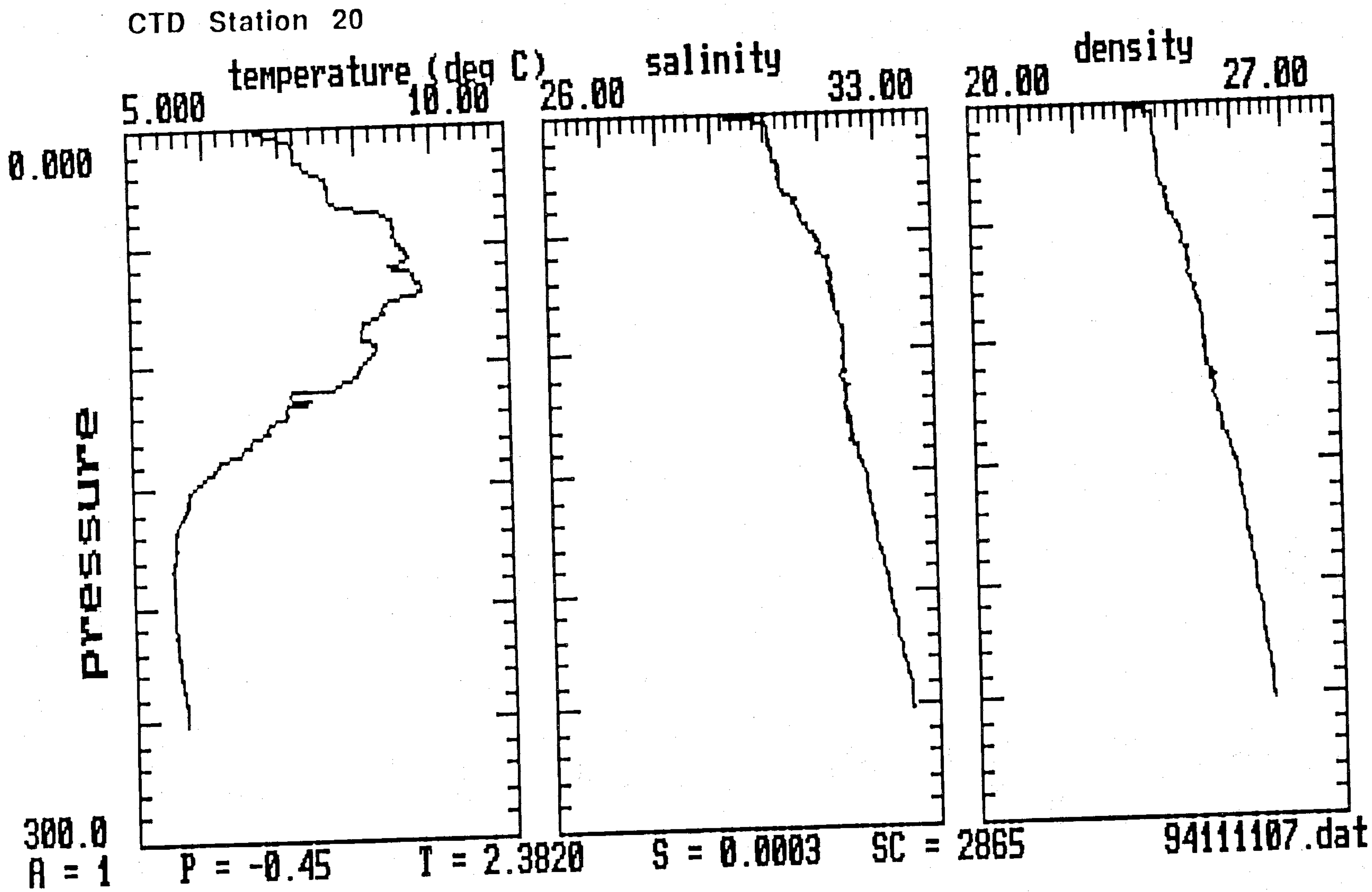
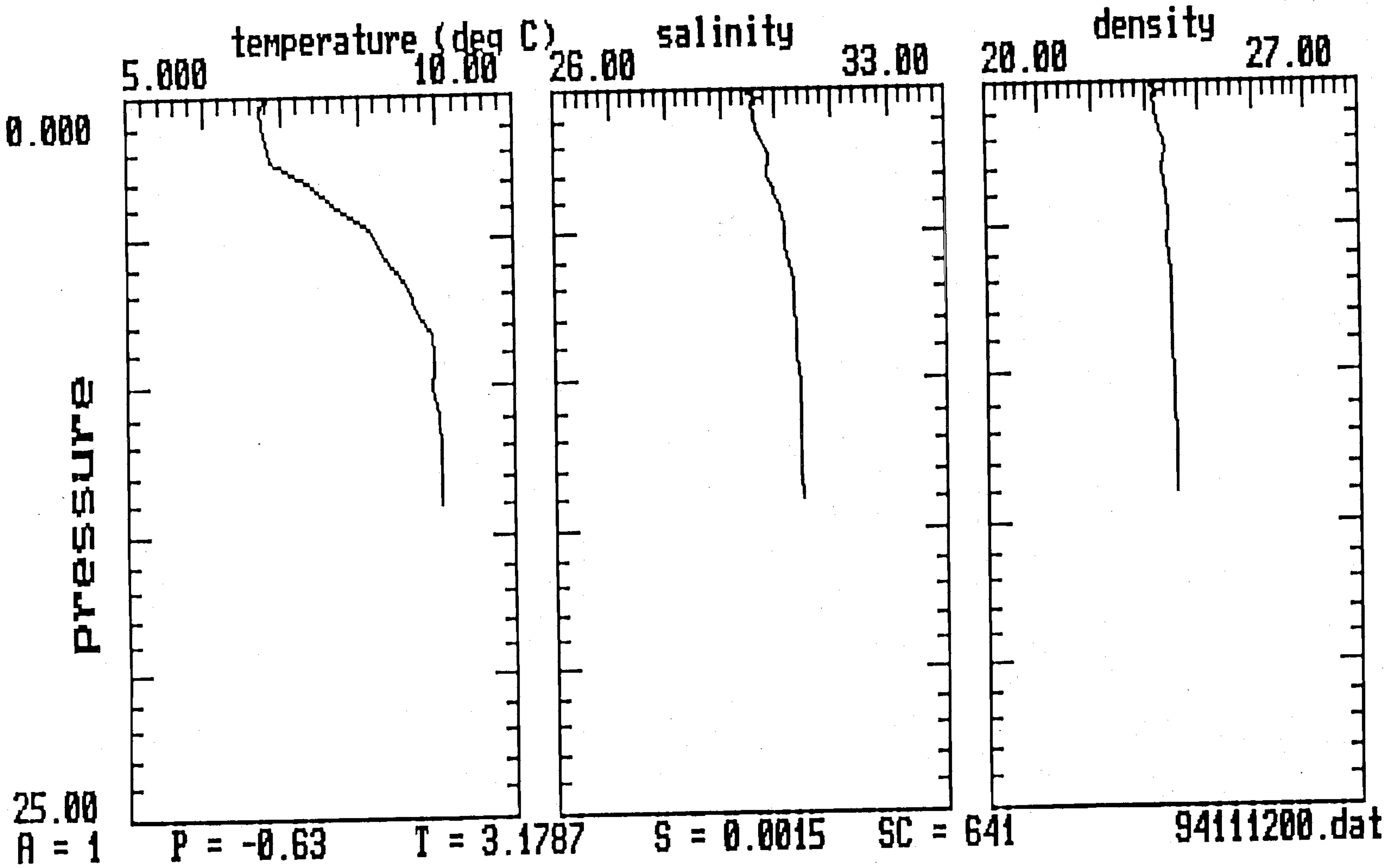

CTD Station 20
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
300.0
A = 1
P = -0.45
T = 2.3820
S = 0.0003
SC = 2865
94111107.dat

Figure 21

CTD Station 21



igure 22

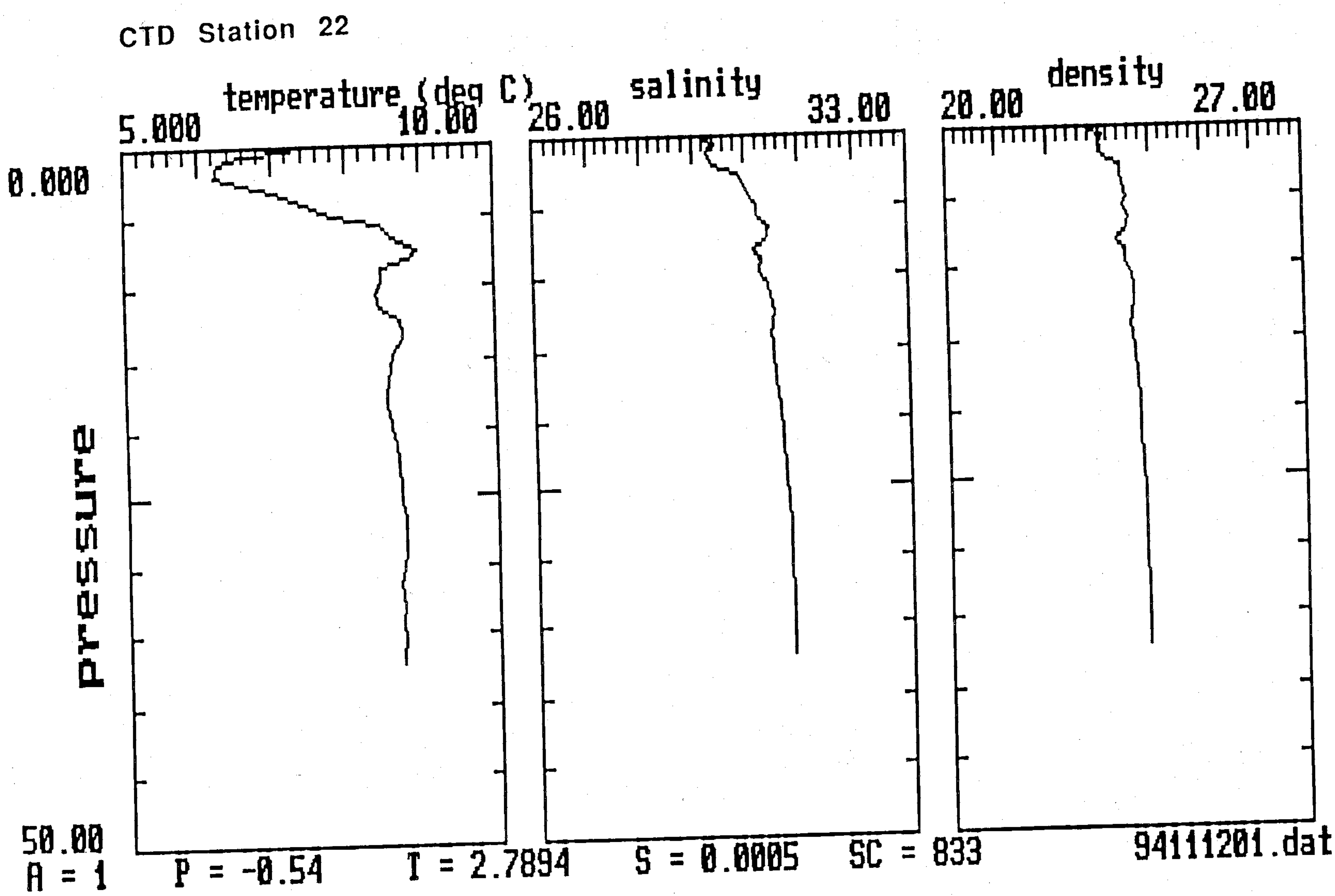
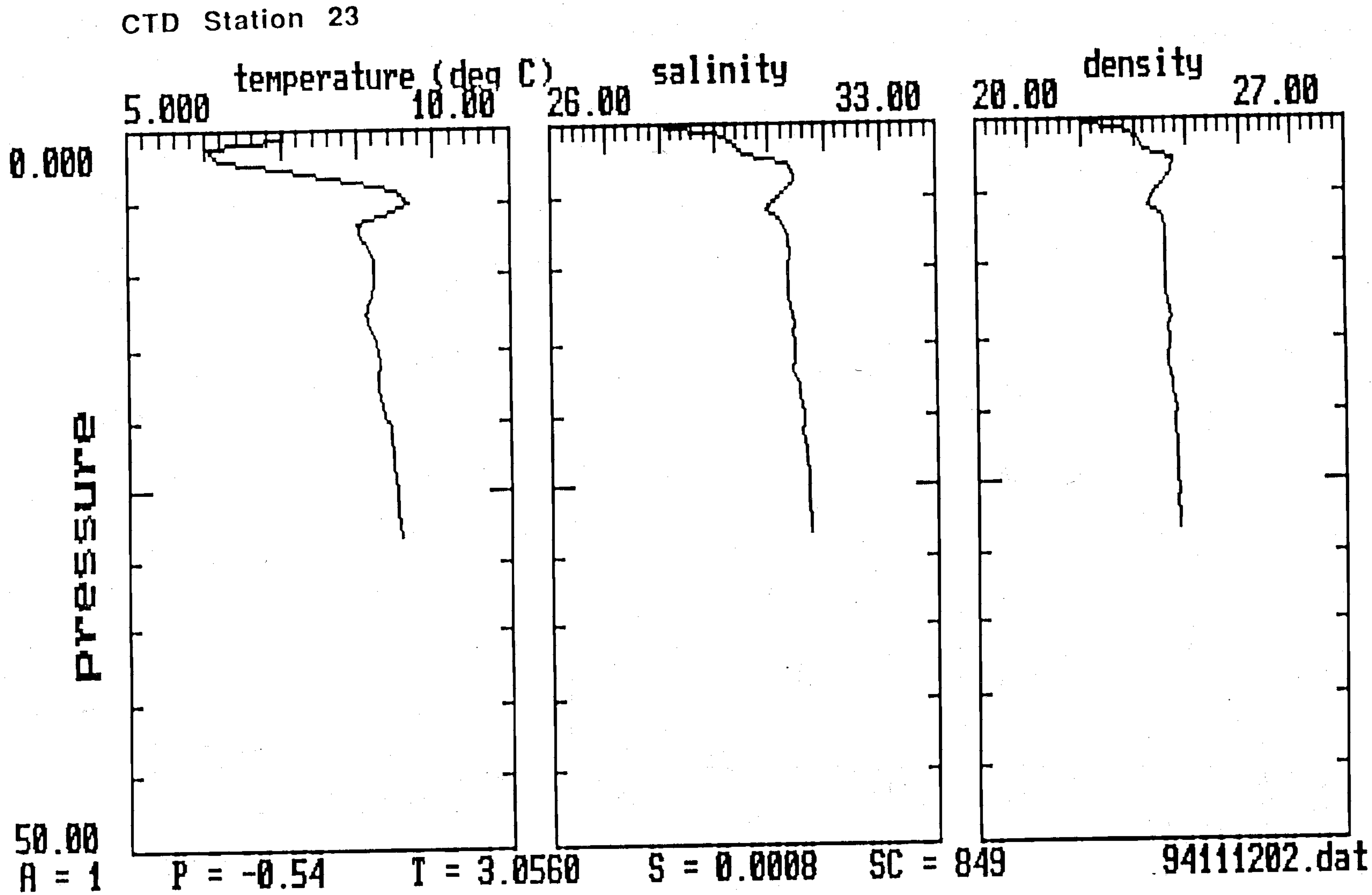

CTD Station 22
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
50.00
A = 1
P = -0.54
T = 2.7894
S = 0.0005
SC = 833
94111201.dat

Figure 23



112

Figure 24

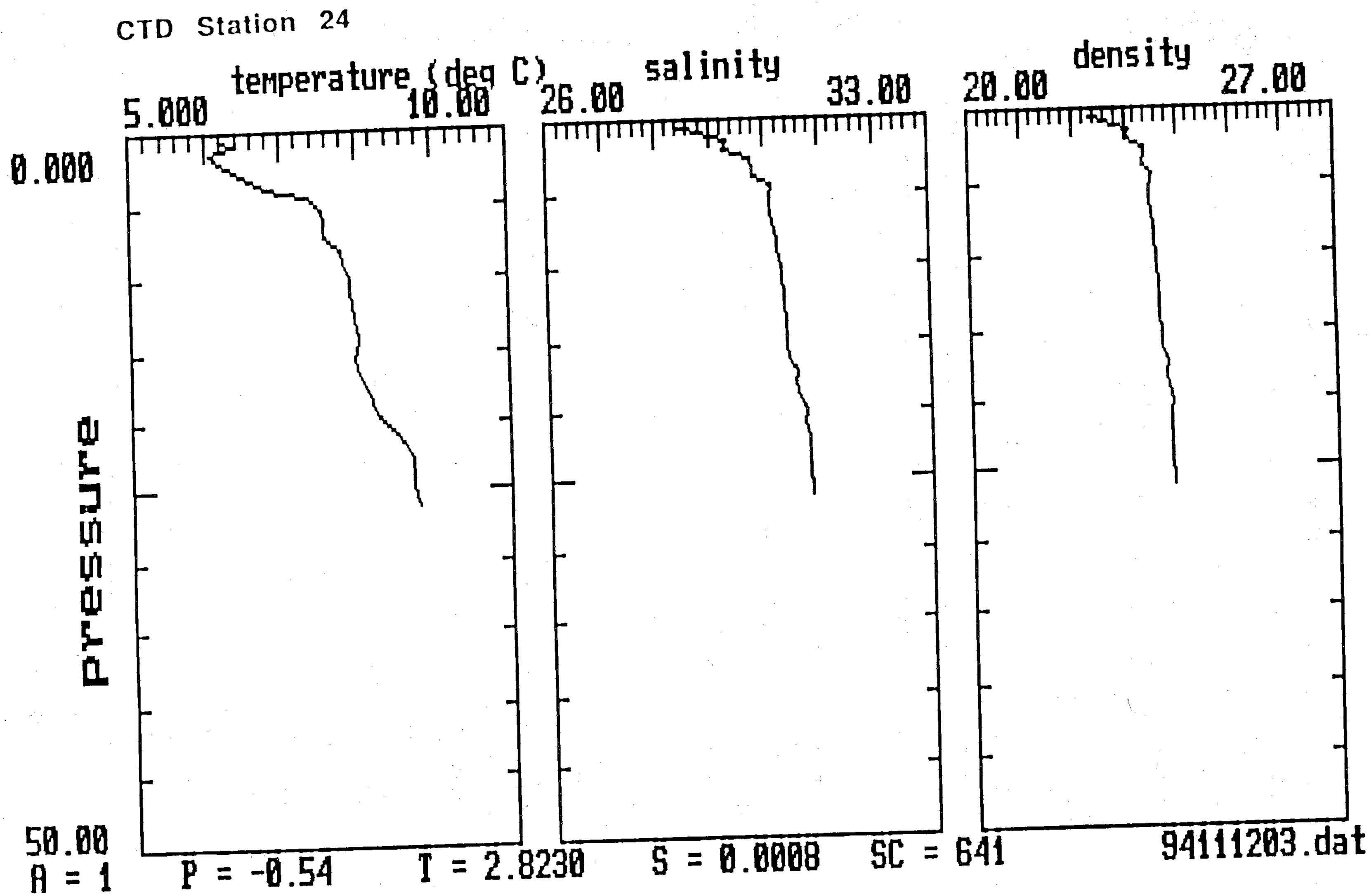

CTD Station 24
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
Pressure
50.00
A = 1
P = -0.54
T = 2.8230
S = 0.0008
SC = 641
94111203.dat

Figure 25

CTD Station 25

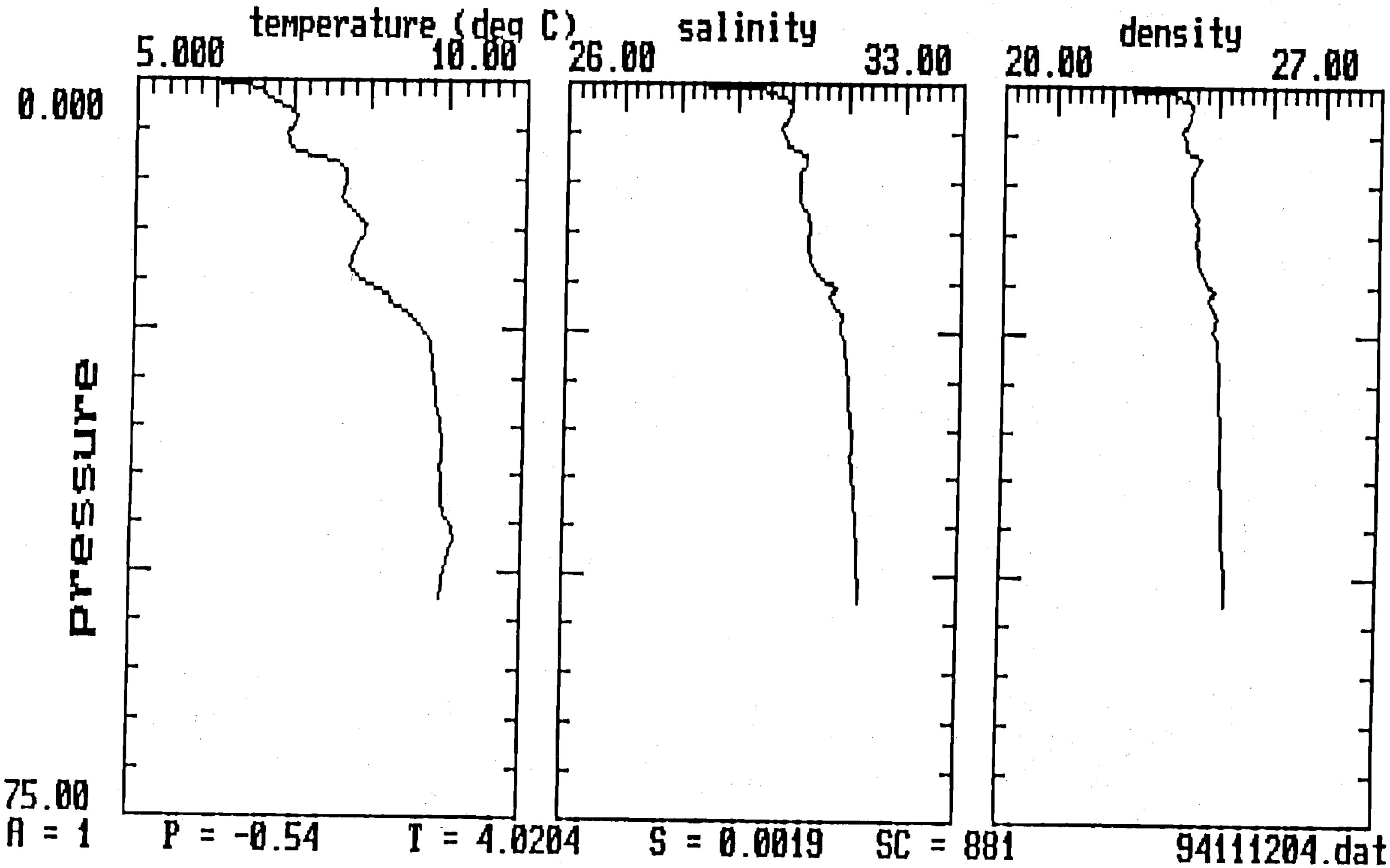
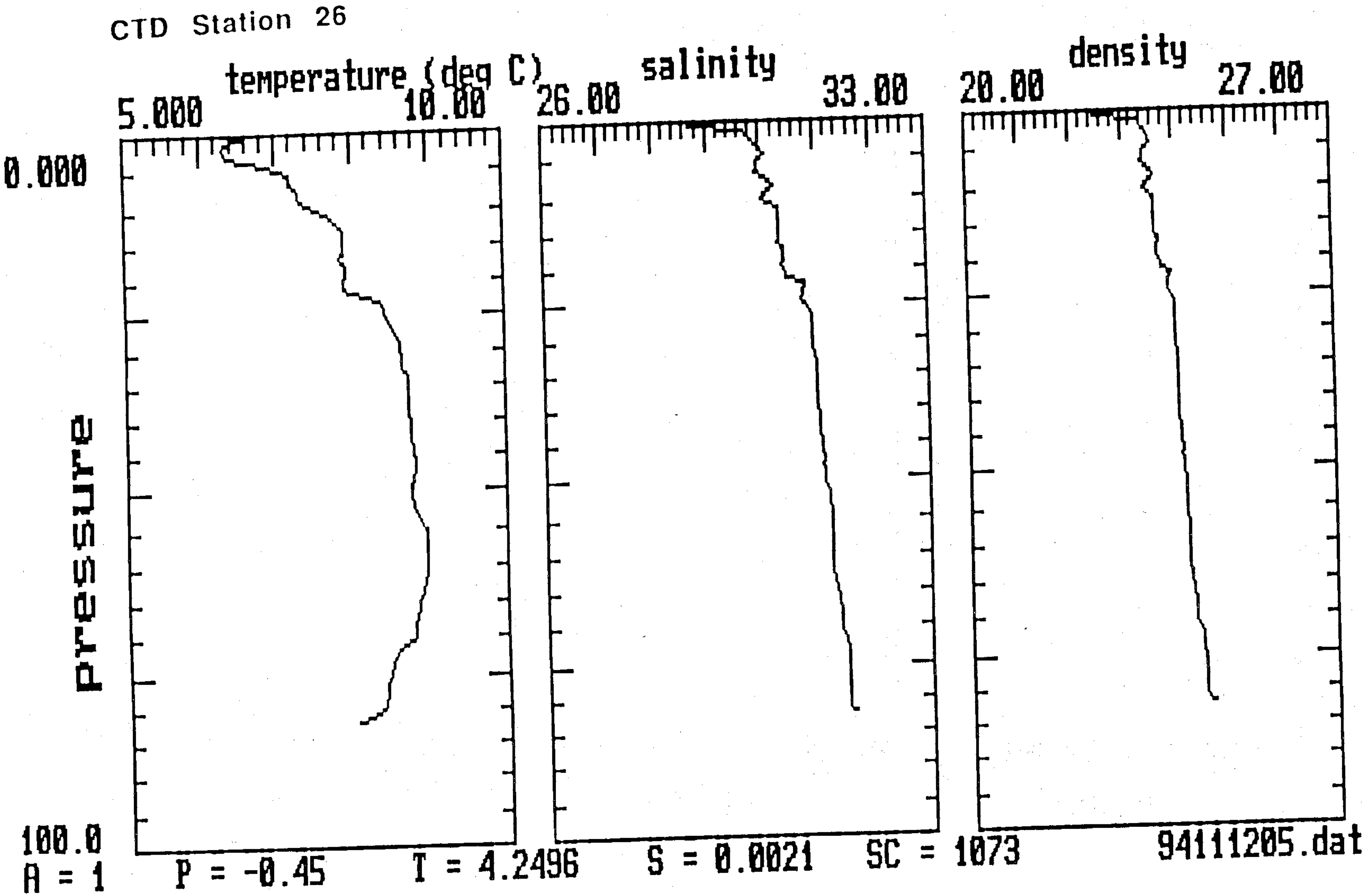


Figure 26


CTD Station 26
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
100.0
A = 1
P = -0.45
T = 4.2496
S = 0.0021
SC = 1073
94111205.dat

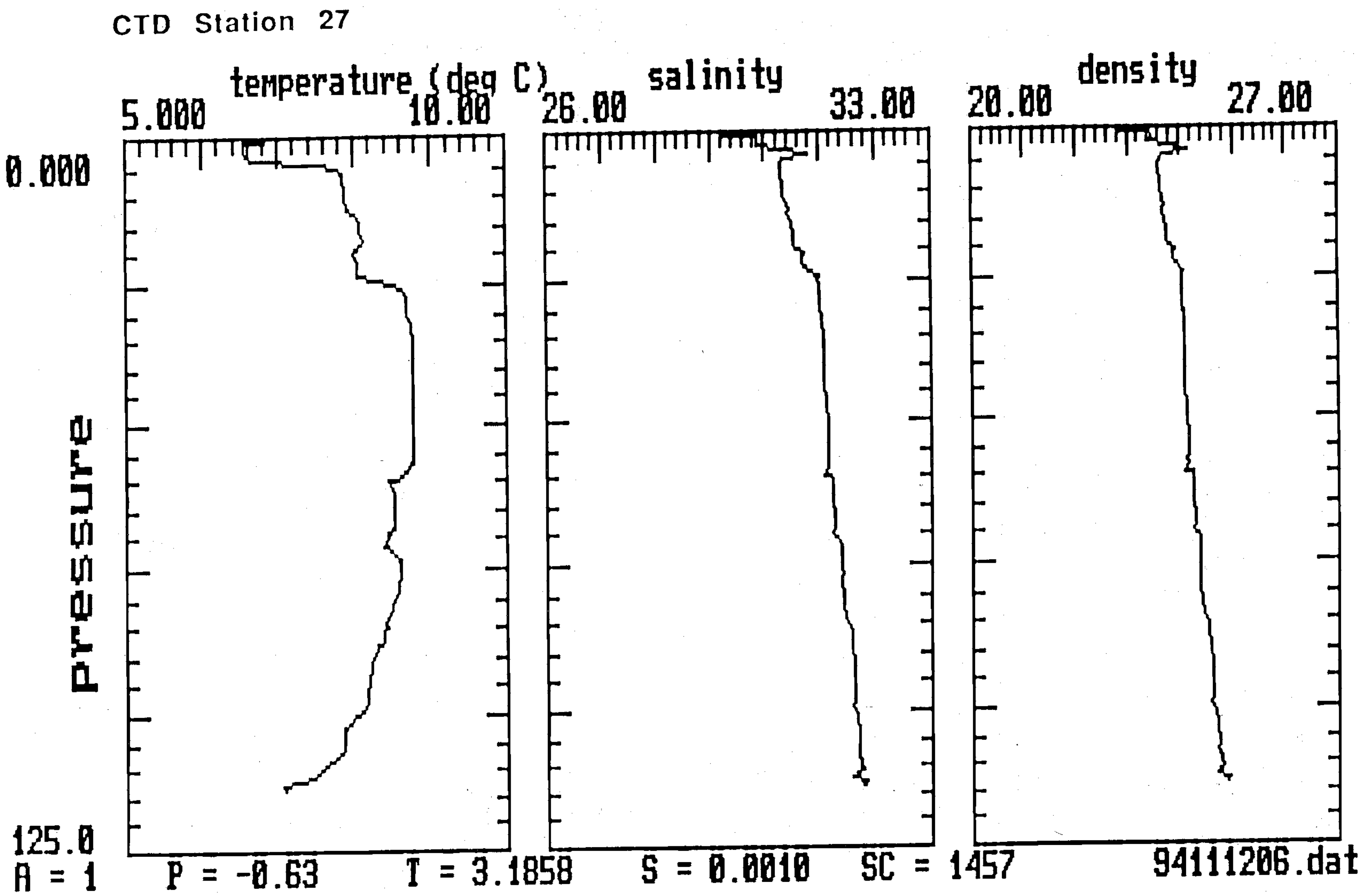

CTD Station 27
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
125.0
A = 1
P = -0.63
T = 3.1858
S = 0.0010
SC = 1457
94111206.dat

Figure 28

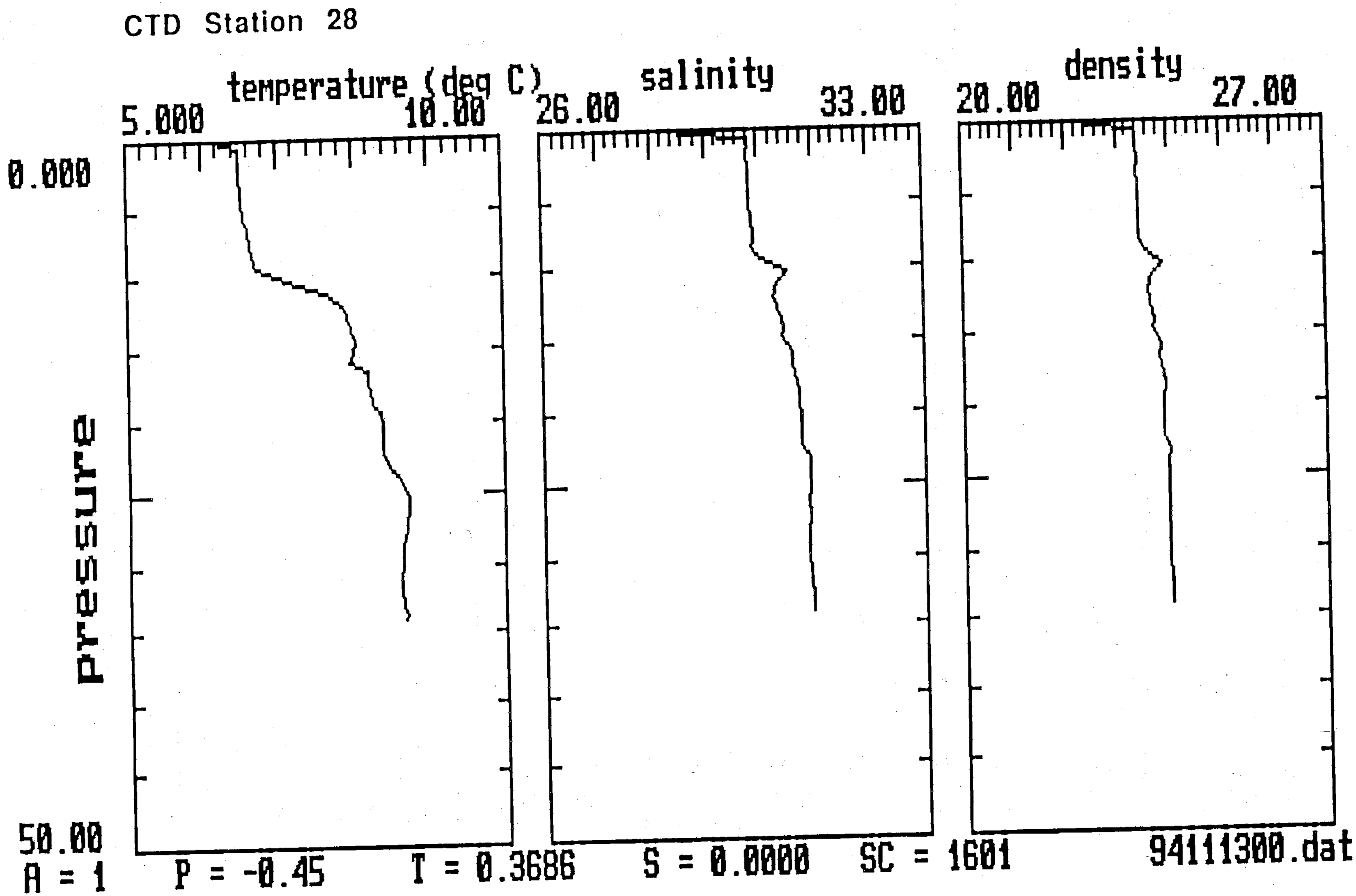


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Figure 29

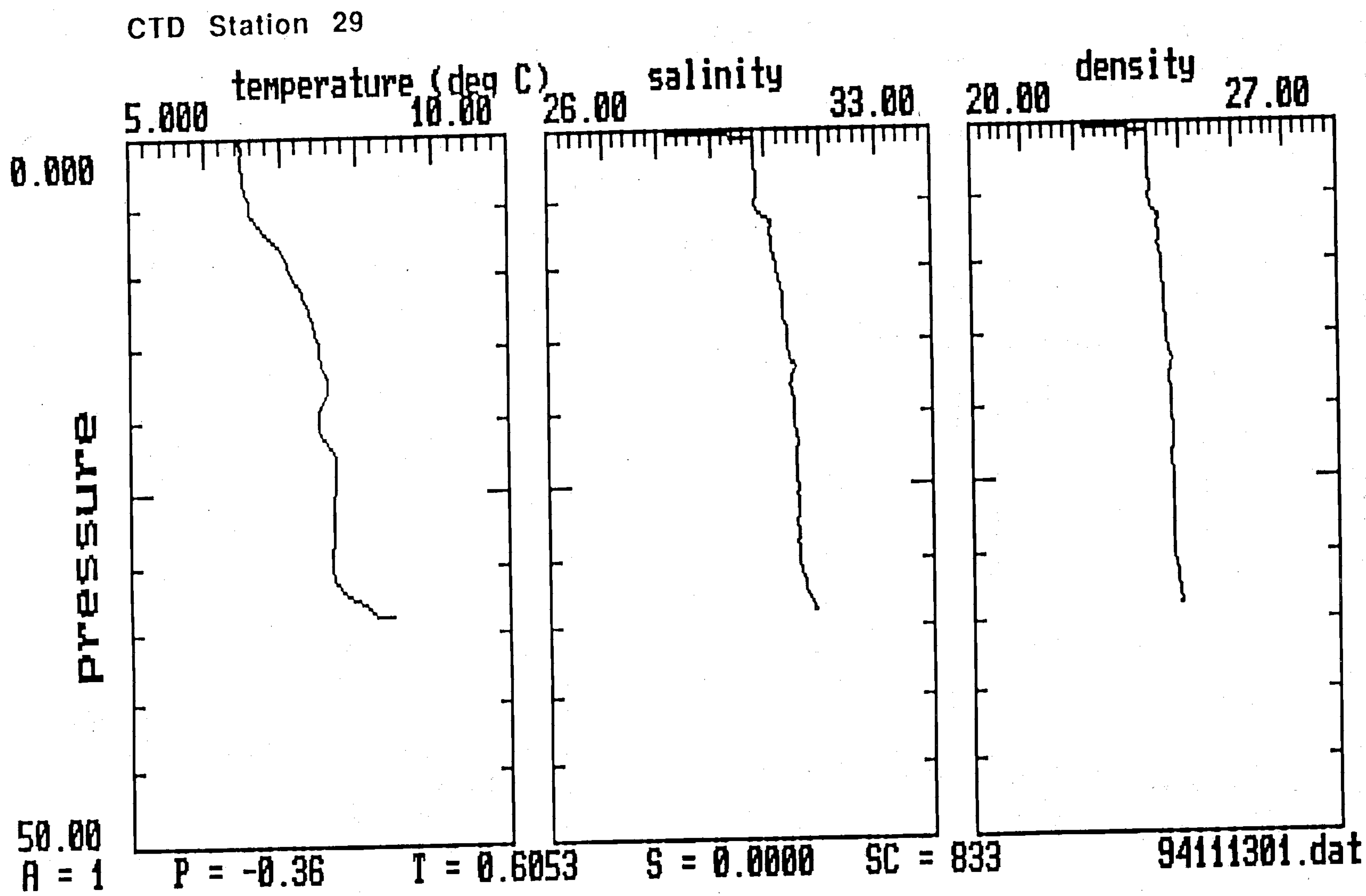
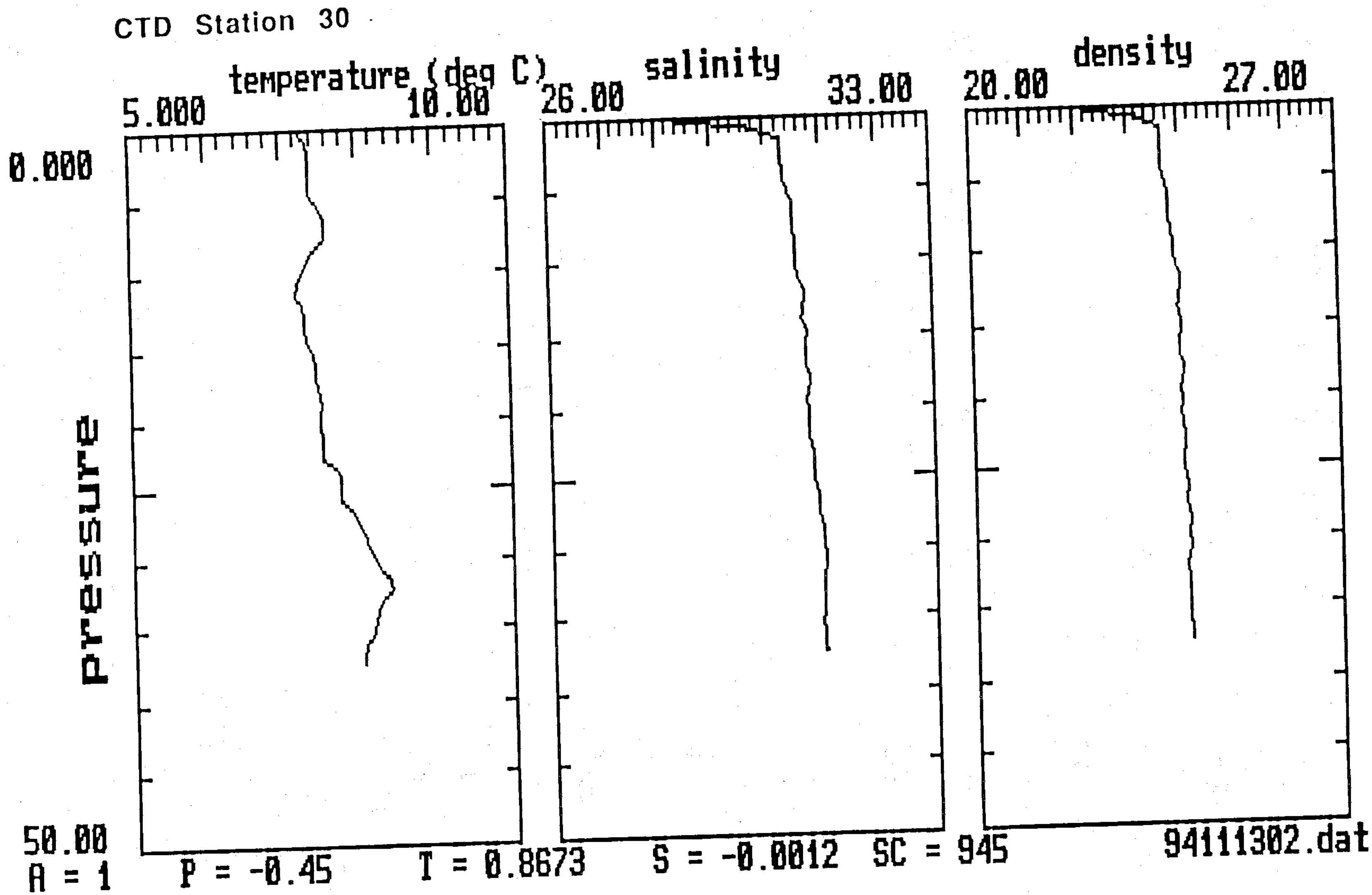

CTD Station 29
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
50.00
A = 1
P = -0.36
T = 0.6053
S = 0.0000
SC = 833
94111301.dat

Figure 30



119

Figure 31

CTD Station 31

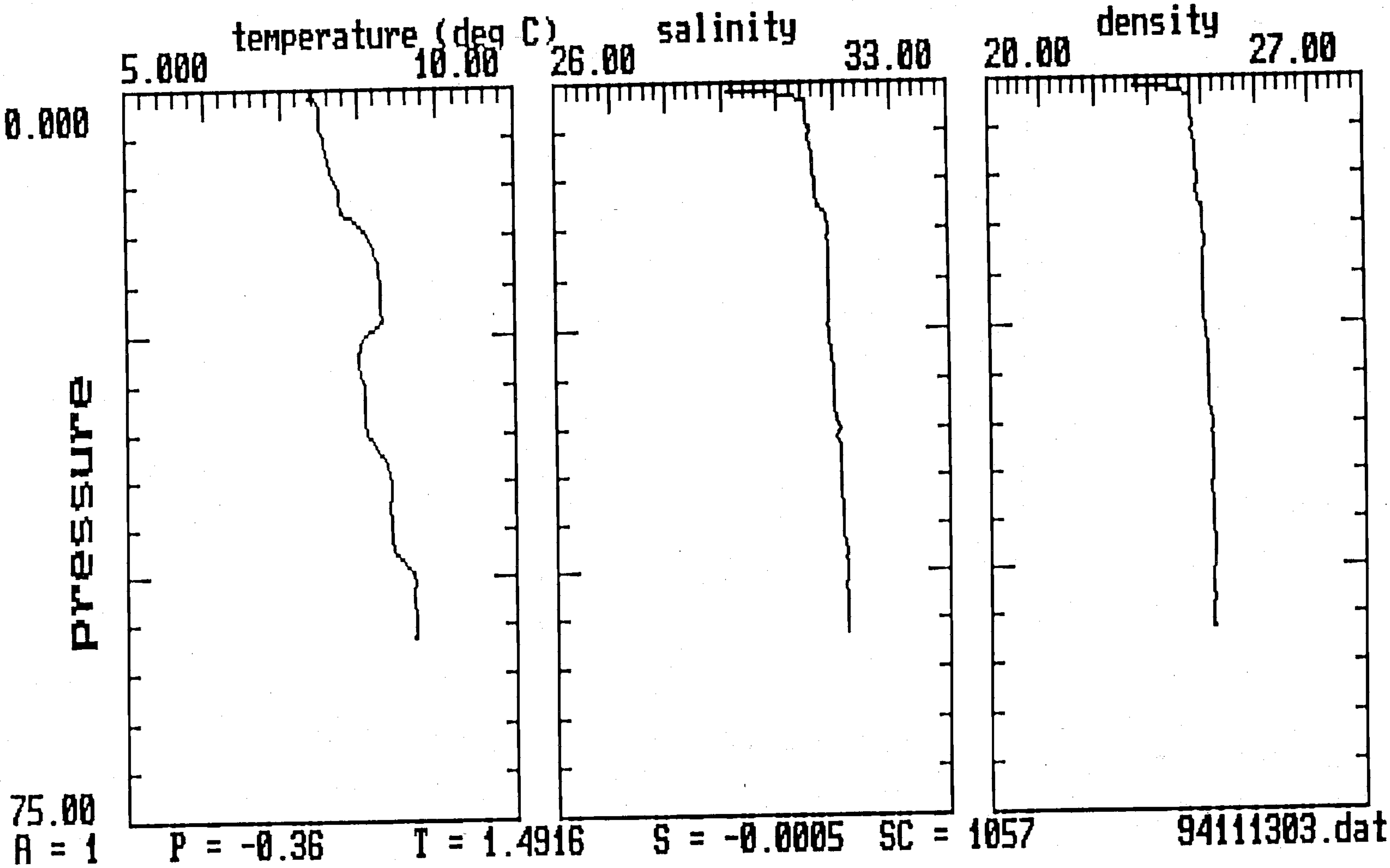
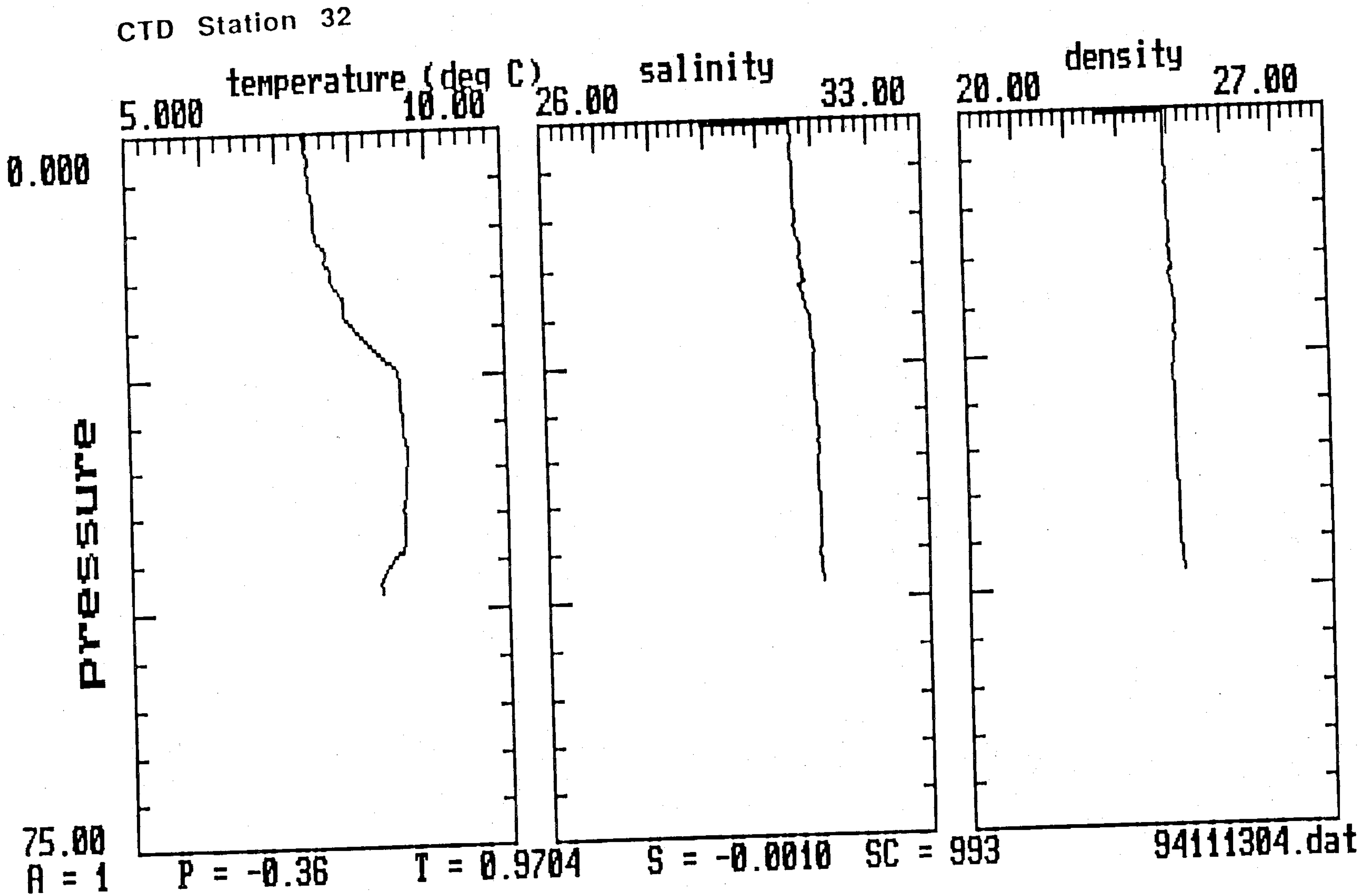
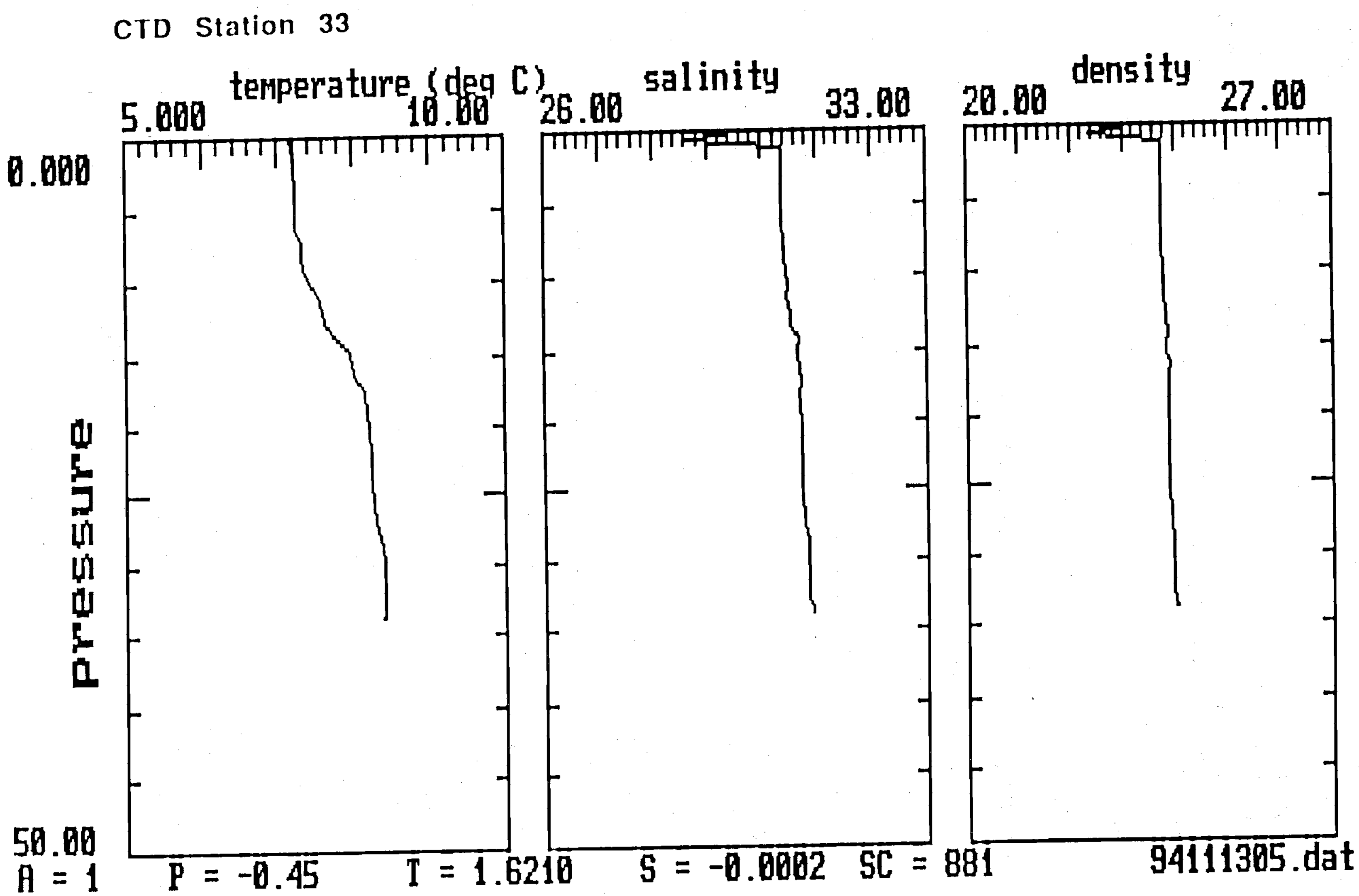


Figure 32


CTD Station 32
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
Pressure
75.00
A = 1
P = -0.36
T = 0.9704
S = -0.0010
SC = 993
94111304.dat



CTD Station 33
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
50.00
A = 1
P = -0.45
T = 1.6210
S = -0.0002
SC = 881
94111305.dat

Figure 34

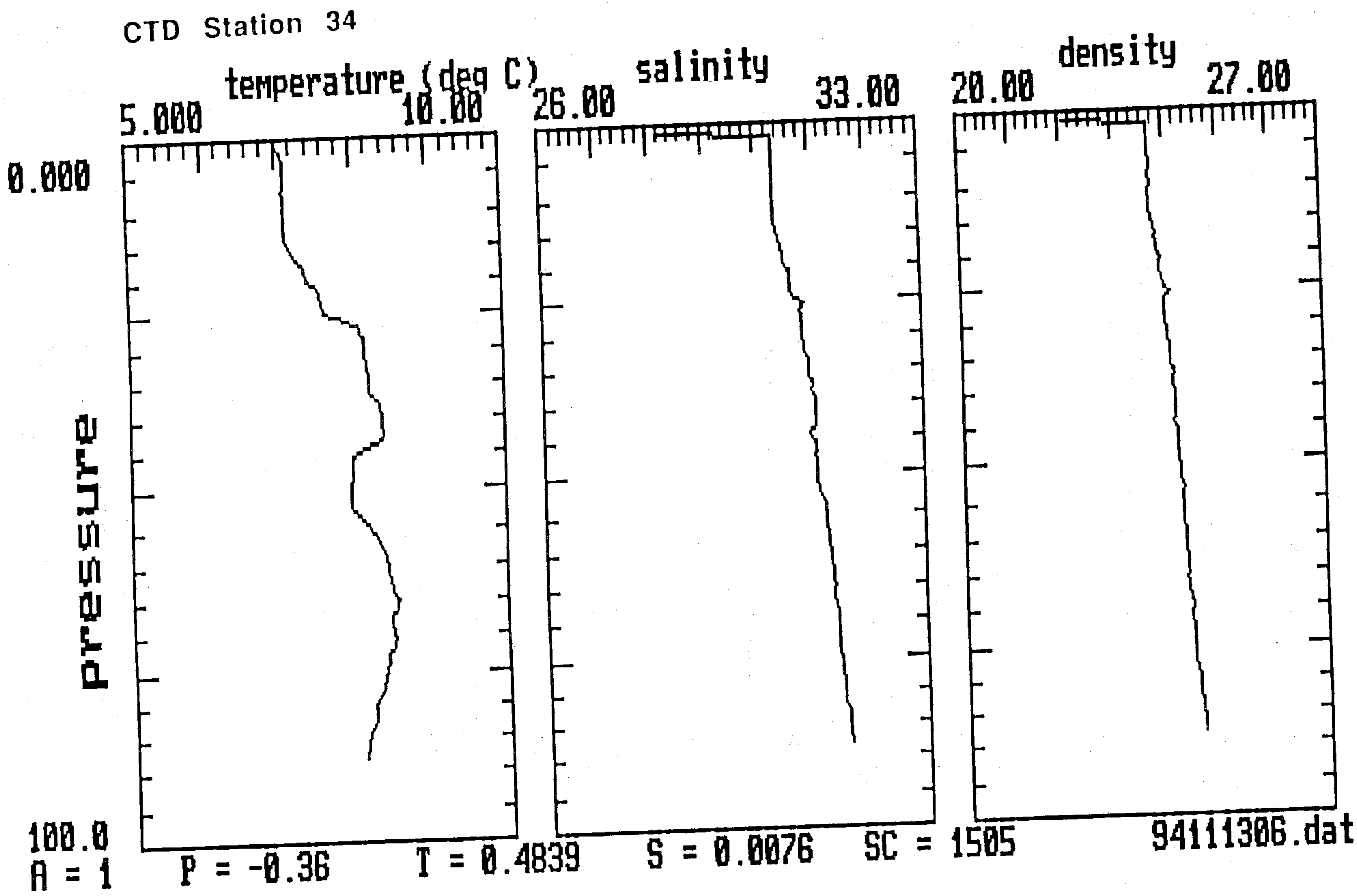

CTD Station 34
temperature (deg C)
5.000
10.00
salinity
26.00
33.00
density
20.00
27.00
0.000
pressure
100.0
A = 1
P = -0.36
T = 0.4839
S = 0.0076
SC = 1505
94111306.dat

Figure 35

CTD Station 35

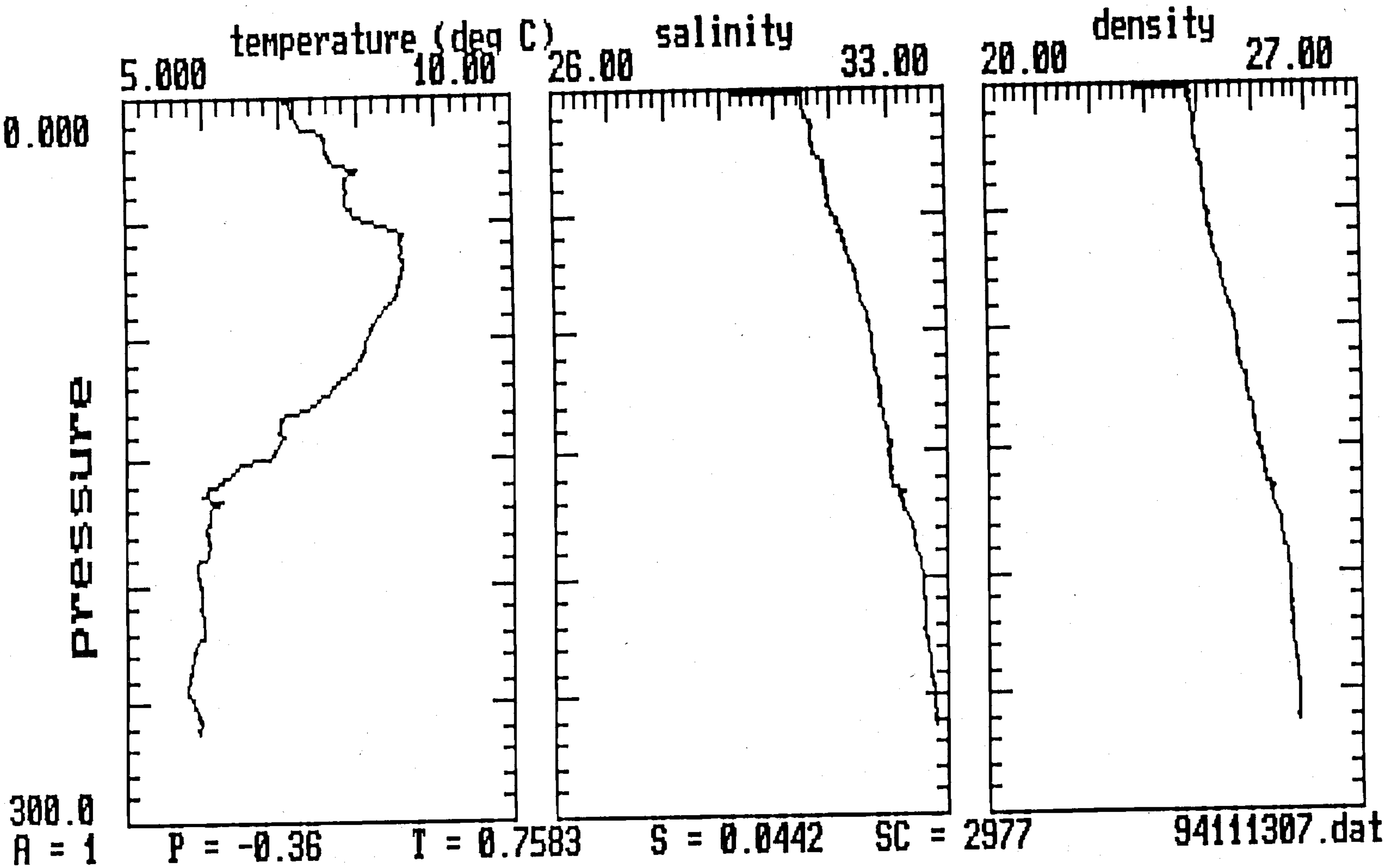


Figure 36

Appendix B

William D. Ostrand and Debora A. Flint

Seabird/Forage Fish Interactions Component

Forage Fish Project
Seabird/Forage Fish Interactions Component
1994 Field Report

April 1995

William D. Ostrand
Debora A. Flint

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Migratory Bird Management
1011 East Tudor Road
Anchorage, Alaska

Abstract: In 1994 the *Exxon Valdez* Oil Spill Trustee Council funded the Forage Fish pilot project to investigate methods of studying the hypothesized food limitation of piscivorous species. The objectives of the Seabird/Forage Fish Interactions component were: 1. Perfect sampling techniques. 2. Appraise the relationship between hydroacoustic data collected on abundance of forage and the presence of seabirds. 3. Assess seabird distribution to aid in the design of sampling for future years. Thirty and 41 transects were conducted during August and November 1994 cruises, respectively. Plotting of hydroacoustic data with seabird data indicated that there was a relationship between the presence of seabirds and forage fish and that the precision of the relationship could be improved by closely matching the area of the seabird survey to the area covered by hydroacoustic data collection. When flocks of seabirds were associated with acoustic targets, the targets were located near the surface. Analysis of seabird distribution for both surveys indicated that there was not a significant ($\underline{P} = 0.05$) relationship between the ratio of seabirds using the marine habitat per unit transect length and distance from shore. In August, the ratio seabirds using marine habitats per unit of transect length was significantly greater for shallow (>20 m) than deep (<60 m) habitats. Analysis of the August seabird data set split into categories of surface and diving foragers indicated that surface feeders were more abundant in shallow water while divers did not show significant differences in the use of water of differing depths. There was not a significant relationship between total seabird abundance and water depth for the November survey. The analysis indicated the importance of sampling shallow water areas. These habitats were sampled the least during the 1994 cruises. The high levels of variance in the data indicated that there is a need to increase sample sizes in future years of this study.
Key words: forage fish, habitat selection, hydroacoustics, Prince William Sound, seabirds.

Seabirds were severely impacted by the *Exxon Valdez* oil spill (EVOS); 30,000 carcasses were recovered and estimates of losses exceed several hundred thousand (Piatt et al. 1990). Three species [common murre (Uria aalge), marbled murrelet (Brachyramphus marmoratus), and pigeon guillemot (Cepphus columba)] have not recovered from the population perturbation (Agler et al. 1994a,b, Klosiewski and Laing 1994). In addition, black-legged kittiwakes (Rissa tridactyla) have experienced nesting failures throughout Prince William Sound (PWS) (Irons unpublished data). Harbor seals (Phoca vitalina) within PWS have also been declining (Kelly et al. 1994). These species have few life history traits in common with the exception that they are all piscivorous. These data suggest that several piscivorous species share a common food limitation and that major changes have occurred to the forage fish resource. In 1994 the *Exxon Valdez* Oil Spill Trustee Council funded the Forage Fish pilot project to investigate methods of studying the hypothesized food limitation of piscivorous species.

Food limitation of seabirds could have resulted from three possible changes in the forage resource:

1. A reduction in the total forage biomass.
2. A shift in the species composition of the forage resource resulting in lower food quality species becoming dominant.
3. Food is present in the ecosystem but no longer available to birds.

Each of these changes, or some combination of them, could have occurred in the spill area. A perturbation or other environmental change could have resulted in a decline in forage fish recruitment that caused a decline in total biomass. It is also probable that a perturbation caused only some species of the forage fish guild to decline and others have responded to the availability of resources, freed by competitor declines, by increased recruitment. If forage fish guild composition shifts resulted in species of lower food quality becoming dominant, food may become limiting to predator species. A shift in forage fish guild composition could also result in dominance of species that spend most of their life history in water too deep for foraging birds, thereby causing food limitation. Additionally, it is possible that inter and/or intra-specific interactions among seabirds influence access to forage. These interactions may fluctuate in response to changes in forage patch size, depth to patch, density of forage fish within patches, and the frequency of occurrence of forage patches. The Forage Fish/Seabird Interactions component of the Forage Fish Project was developed to determine if food limitation has resulted from item three, above, and to examine the possibility of limitation do to social interactions.

The objectives of the Forage Fish/Seabird Interactions component for 1994 were:

1. To perfect seabird data collection techniques that will facilitate linking bird data to the hydroacoustic data set.
2. Plot hydroacoustic and bird data to make a visual appraisal of the relationship between hydroacoustic signals and the presence of seabirds.
3. Analyze seabird distribution data to aid in the design and possible stratification of sampling for subsequent years.
   Seabird survey data (Agler et al. 1994a,b) indicated that more birds were observed on shoreline transects than on pelagic transects, suggesting two possible hypotheses on seabird distribution that were testable with the data available from the 1994 cruises:

1. Seabirds are associated with nearshore areas.
2. Seabirds are associated with shallow water.

Intuitively, these hypotheses appear to be redundant, however there are coast lines, such as Knight Island Passage (Fig. 16), within PWS where water depth exceeds 200 meters within a few meters of shore. Other coastlines, such as the north shore of Montague Island (Fig. 24) slope gradually to depths greater than 200 meters. This variation in coastal slope allowed us to test both hypotheses.

We wish to thank the individuals who provided assistance throughout this study. Funding was provided by the EVOS Trustee Council. J. M. Maniscalco and B. A. Agler assisted in data collection. K. O. Coyle developed the data entry computer program. D. B. Irons provided advice and supervision.

METHODS

We conducted 2 cruises in PWS (Fig. 1) during 1994, 17-20 August and 4-16 November. The August cruise was conducted on a 7.5-m boat and bird data was collected at water level. A 33.5-m vessel was used on the November cruise and bird data was collected at approximately 6 m above the water. Data on seabirds was collected continuously along transects of varying lengths (Figs. 2-10). Thirty and 41 transects were run on the August and the November cruises, respectively. During the November cruise, 8 of the 41 transects were replicated for a total of 49 runs, however the replicates were not included in the analysis for this report to avoid pseudoreplication (Hurlbert 1984). Transects were arbitrarily selected, therefore data and analysis should not be considered as samples of PWS or extrapolated to infer conditions beyond the area actually covered by the transects.

Seabird data collection was conducted simultaneously with hydroacoustic surveys employing techniques similar to those used to conduct population surveys in PWS (Klosiewski and Laing 1994). Hydroacoustic methods are described in the University of Alaska's 1994 Forage Fish report. While conducting hydroacoustic transects, all birds and mammals observed within 100 m of both sides of the survey vessel were identified and recorded. On the first cruise data were recorded manually. For each bird entry, a time of observation was recorded in 30 second blocks. A computer program was used on the second cruise that electronically entered time, latitude and longitude for each entry. Bird behavior was recorded categorically as: (a) in the air, (b) on floating object, (c) on water, (d) following boat, (e) foraging, or (f) potential foraging. Foraging (e) was defined as actual observation of foraging behavior such as diving for food or holding food in the bill. Behavior was categorized as (f) potential foraging when 2 grouped birds were observed on the water or circling above the surface.

Hydroacoustics data were not available as of the writing of this report however selected transects were graphically represented and the seabird data was overlaid on the corresponding transects (Figs 11-14). Picivorous birds observed on the water, foraging, or potentially foraging were assumed to be using the aquatic habitat and were included in the presentation. These representations were descriptively analyzed.

To test the hypotheses on bird distribution, only data on piscivorous seabirds observed using the aquatic habitat and were included in the analysis (Table 1). We used Atlas Geographical Information System (Strategic Mapping, Inc. 1994) to partition transects into segments based on distance from shore. Five distance zones were used: 0-200 m, 200-500 m, 500-1000 m, 1000-1500 m, and > 1500 m. Both the length of segments and the number of birds observed along each segment was determined. Segments of the same distance zone within a transect were summed to determine total length and number of birds for each zone category per each transect. A ratio of birds per unit length for each zone of each transect was then calculated. A one way analysis of variance (ANOVA) and a Ryan-Einot-Gabriel-Welsch Multiple Range Test (REGWQ) was used to determine if the use of distance zones was significantly different ($\underline{P}$ = 0.05) (SAS Inst., Inc. 1988) for each cruise. To determine seabird use of various water depths the above analysis was repeated using depth zones rather distance zones. Nine distance zones were used: 0-20 m, 20-40 m, 40-60 m, 60-80 m, 80-100 m, 100-120 m, 120-200 m, and >200 m (National Oceanic and Atmospheric Administration unpubl. data) (Figs. 15-24). When a significant difference in zone use was found the bird data was seperated by foraging method, surface and diving foragers (Table 1). A two way ANOVA was then performed to determine if birds of different foraging strategies differed in their use of the surveyed habitats.

RESULTS

Figures. 11-14 give a graphical representation of seabird and hydroacoustic data.

Data analysis for both cruises indicated that there was not a significant difference in the use of distance zones by seabirds per unit length of transect ($\underline{P}$ = 0.10 and 0.26 for the first and second cruises, respectively). Analysis of data on seabird use per unit length of depth zones did show a significant difference for the August cruise (Table 2) ($\underline{P}$ = 0.027). Our multiple comparison test indicated that during August the proportion of seabirds per unit length using shallower depth zones was significantly greater (Table 2). A two way ANOVA performed with the data set split into diving and surface feeding categories, for the August cruise was also significant ($\underline{P}$ = 0.003). Multiple comparison analysis indicated that the proportion of surface feeders per unit length was greater for shallow water than deep water zones. Surface feeders also made greater use of shallow zones than did divers. The proportion of divers per unit length did not significantly differ for any depth zone (Table 2). Significant differences in depth zone use were not observed for the November cruise ($\underline{P}$ = 0.50).

DISCUSSION

The graphical representation of the hydroacoustic data show qualitatively the relationship between the hydroacoustics data and seabird activity. When flocks of seabirds were associated with acoustic targets, the targets were located near the surface (Figs 11-14). Transect For94-32 (Fig. 11) shows a scattering of acoustic targets and seabirds that appear not to have a strong association. Transect For94-24 (Fig. 12) shows a flock of six foraging seabirds with no associated acoustic target. Transects For94-33 and For94-3B4 (Figs. 13 and 14) both show flocks of seabirds and associated schools. The figures show that the association between foraging seabirds and hydroacoustic targets is not consistent. These observations suggest two alternative hypotheses:

1. The presence of seabirds and forage fish is not tightly linked and using seabirds as predictors of the presence of fish will have limited success.

2. There are technological limitations in our ability to measure the association between seabirds and forage fish.

There are several papers that support the first hypothesis (Obst 1986, Heinemann et al. 1989, Schneider and Piatt 1986, Erikstad et al. 1990, Hunt et al. 1990, Piatt 1990). A major limitation of all of these studies was the use downward aimed transducers and their inability to observe activity directly beneath flocks of seabirds. The August cruise did use side-viewing hydroacoustics but there were limitations because surface disturbance complicated the interpretation of near surface signals. Interpretation was further confounded because the bird survey area did not precisely match the area of acoustic coverage. In this study and probably others as well, hypothesis two better explains the variation and lack of precision of the results. In future cruises a closer match of coverage for hydroacoustics and bird surveys and experience in interpreting data from side viewing hydroacoustics will improve the precision of the results. A level of precision in which there is no instrument error is not currently possible and will require technological advances in hydroacoustic data collection.

Analysis of bird distribution data indicate that there is seasonal variation of surface foraging seabirds. During August surface foragers made significantly greater use of the shallowest water depths. The results from the November cruise did not indicate there was differential use of habitats based on depth. The results of these analysis are not so dramatic as to indicate that stratification based on depth during summer cruises is necessary. The data do suggest that sampling of shallow water areas is necessary to understand habit utilization as well as the relationship between seabirds and forage fish. During 1994, the sampling of the 0-20 m zone, the area of highest use by surface feeders, was the lowest of all classes. Seven of 30 transects (23.3%) and 15 of 41 transects (36.6%) contained segments of 0-20 m for the August and November cruises, respectively. Sampling of shallow water was increased in November in difference to using a much larger ship because of the onboard availability of directionally variable sonar. Specifying that contract ships will have to survey shallow water and mandating that sophisticated sonar be on the ship will improve sampling of this important habitat.

The analysis of data failed to show the large differences in bird distribution that we expected. We propose that there were 2 reasons for this outcome. The distribution of both birds and forage fish is very patchy. The occurrence of a patch of either trophic group is relatively rare. This condition results in high variance that creates problems in determining differences using parametric tests. We conducted statistical trials with nonparametric test, Kruskal-Wallis, and coded data (SAS Inst., Inc. 1988). These trials and manipulations proved to be less powerful than parametric test, as anticipated. The only approach to sampling that can improve power while maintaining confidence levels is to increase sample size (Zar 1984). We therefore suggest in future years that sampling efforts be greatly expanded.

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Table 1. Piscivorous seabirds, separated into foraging classes, observed using aquatic habitat on August and November 1994 cruises in Prince William Sound, Ak.

Surface foragers	Diving foragers
Bald eagle[a]	Common loon[b]
Black-legged kittiwake[ab]	Common merganser[ab]
Glaucous-winged gull[ab]	Common murre[ab]
Herring gull[b]	Horned grebe[b]
Mew gull[ab]	Horned puffin[a]
	Marbled murrelet[ab]
	Pelagic cormorant[ab]
	Pigeon guillemot[ab]
	Red-breasted merganser[b]
	Red-necked grebe[b]
	Red-throated loon[b]
	Rhinoceros auklet[a]
	Tufted puffin[a]
	Sooty shearwater[a]
	Yellow billed loon[b]

[a] These species were observed on the August cruise.
[b] These species were observed on the November cruise.

Table 2. Mean number of seabirds/unit length per transect observed using distance from shore zones during August and November 1994 cruises in Prince William Sound, Ak.

Distance form shore	August	November
0-200 m	2.2[a]	6.5[a]
200-500 m	8.2	4.6
500-1000 m	2.6	3.2
1000-1500 m	1.9	2.9
>1500 m	1.4	2.5

[a] Values within columns are not significantly different ($\underline{P}$ = 0.05).

Table 3. Mean number of seabirds/unit length per transect observed using water depth zones during August and November 1994 cruises in Prince William Sound, Ak.

Depth zone	August, all seabirds	August, surface feeders	Aug ust, diver s	Nove mber, all seabird s

0-20 m	8.7a[a]	7.1a[b]	1.6b[b]	5.6a[a]
20-40 m	5.6ab	4.5ab	1.2b	5.0a
40-60 m	3.8ab	2.7b	1.1b	43.3a
60-80 m	2.0b	1.2b	0.8b	2.8a
80-100 m	1.6b	1.3b	0.3b	3.4a
100-120 m	2.5b	2.1b	0.4b	2.4a
120-200 m	1.8b	1.3b	0.4b	1.0a
>200 m	0.8b	0.4b	0.4b	2.2a

[a] Values sharing a common letter within a column are not significantly different at P = 0.05.

[b] Comparisons may be made among columns for surface feeders and divers. Values sharing a common letter for these 2 columns are not significantly different at P = 0.05.

Fig. 1. The Prince William Sound, Ak. study area.

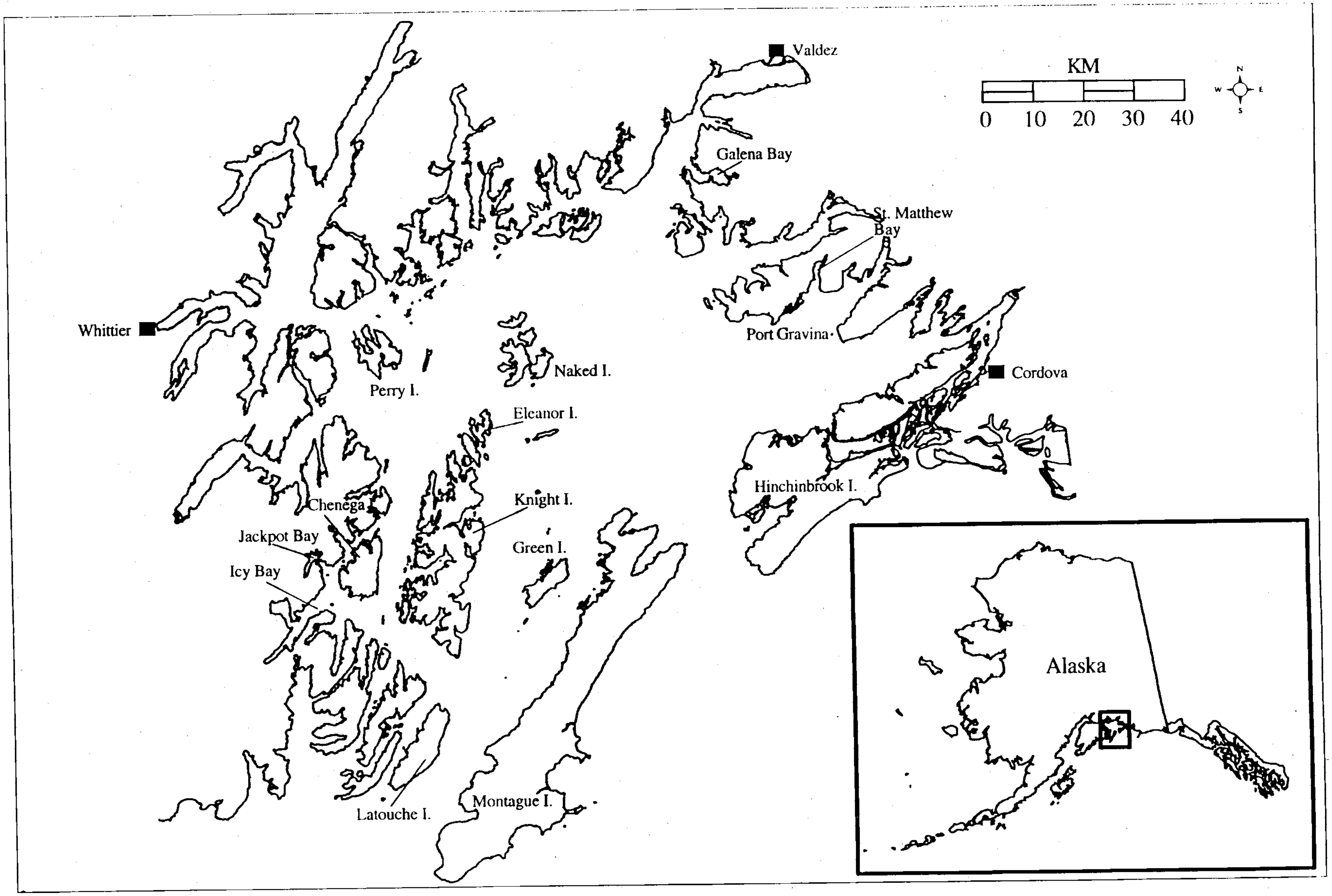

Valdez
KM
0 10 20 30 40
N
W
E
S
Galena Bay
St. Matthew Bay
Whittier
Port Gravina
Cordova
Naked I.
Perry I.
Eleanor I.
Hinchinbrook I.
Knight I.
Chenega
Jackpot Bay
Green I.
Icy Bay
Alaska
Latouche I.
Montague I.

Fig. 2. Transect tracks and locations of piscivorous seabirds observed using aquatic habitat near Perry Island in Prince William Sound, Ak. during the August 1994 cruise.

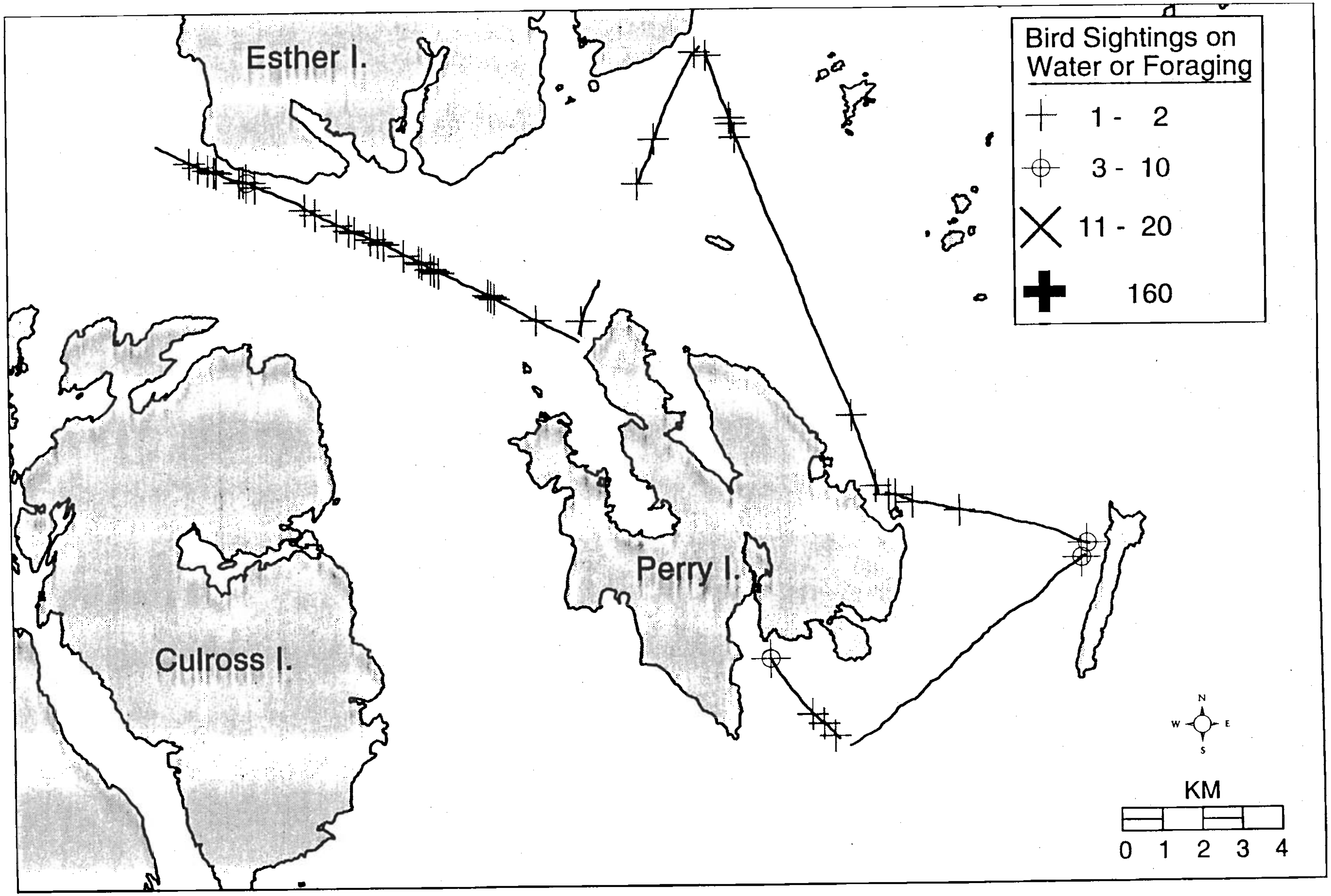

Esther I.
Perry I.
Culross I.
Bird Sightings on Water or Foraging
1 - 2
3 - 10
11 - 20
160
N
W
E
S
KM
0 1 2 3 4

Fig. 3. Transect tracks and locations of piscivorous seabirds observed using aquatic habitat near Knight Island in Prince William Sound, Ak. during the August 1994 cruise.

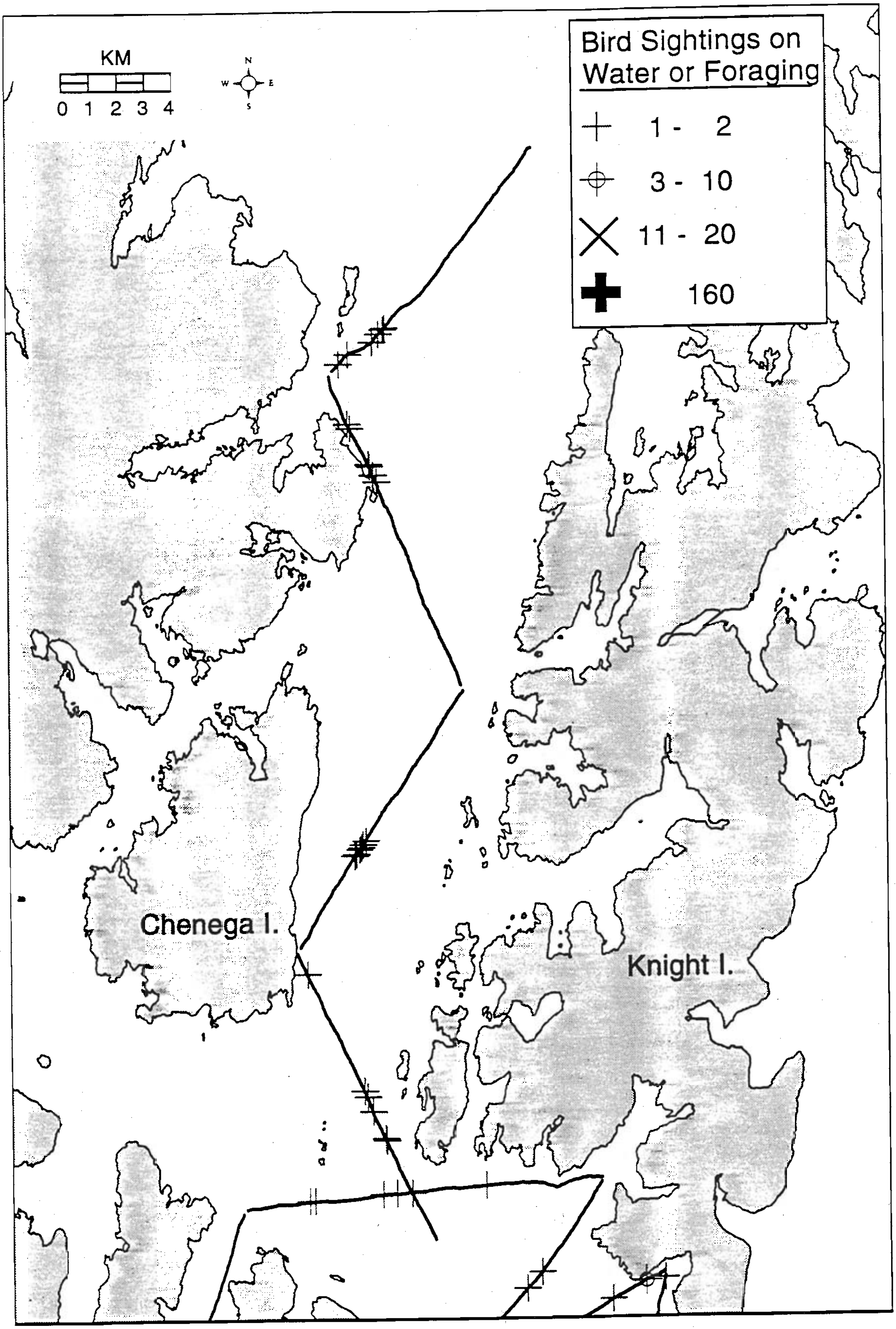

Bird Sightings on Water or Foraging
1 - 2
3 - 10
11 - 20
160
KM
0 1 2 3 4
N
W
E
S
Chenega I.
Knight I.

Fig. 4. Transect tracks and locations of piscivorous seabirds observed using aquatic habitat near Evans Island in Prince William Sound, Ak. during the August 1994 cruise.

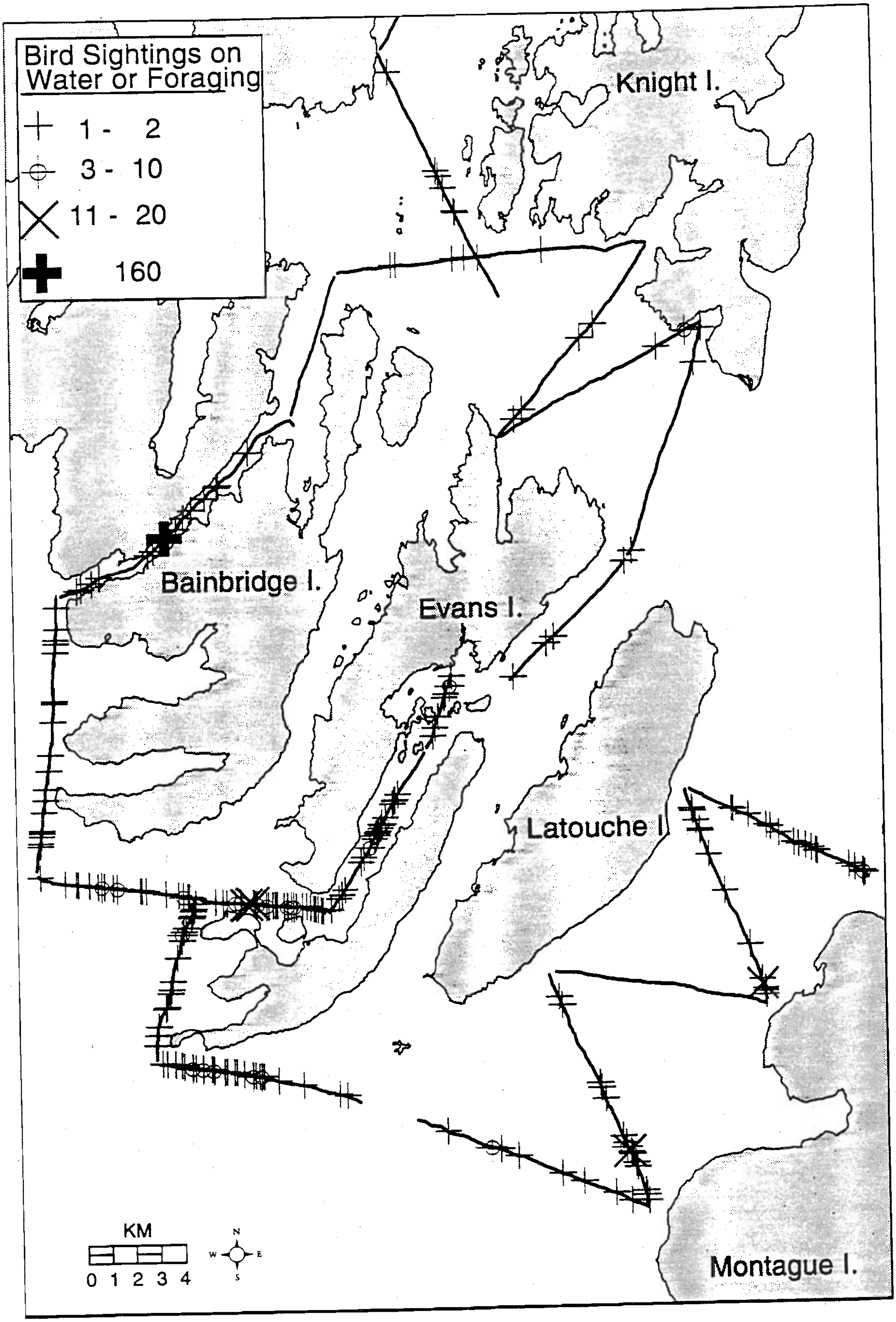

Bird Sightings on Water or Foraging
1 - 2
3 - 10
11 - 20
160
Knight I.
Bainbridge I.
Evans I.
Latouche I.
Montague I.
KM
0 1 2 3 4
N
W
E
S

Fig. 5. Transect tracks and locations of piscivorous seabirds observed using aquatic habitat near Galena Bay in Prince William Sound, Ak. during the November 1994 cruise.

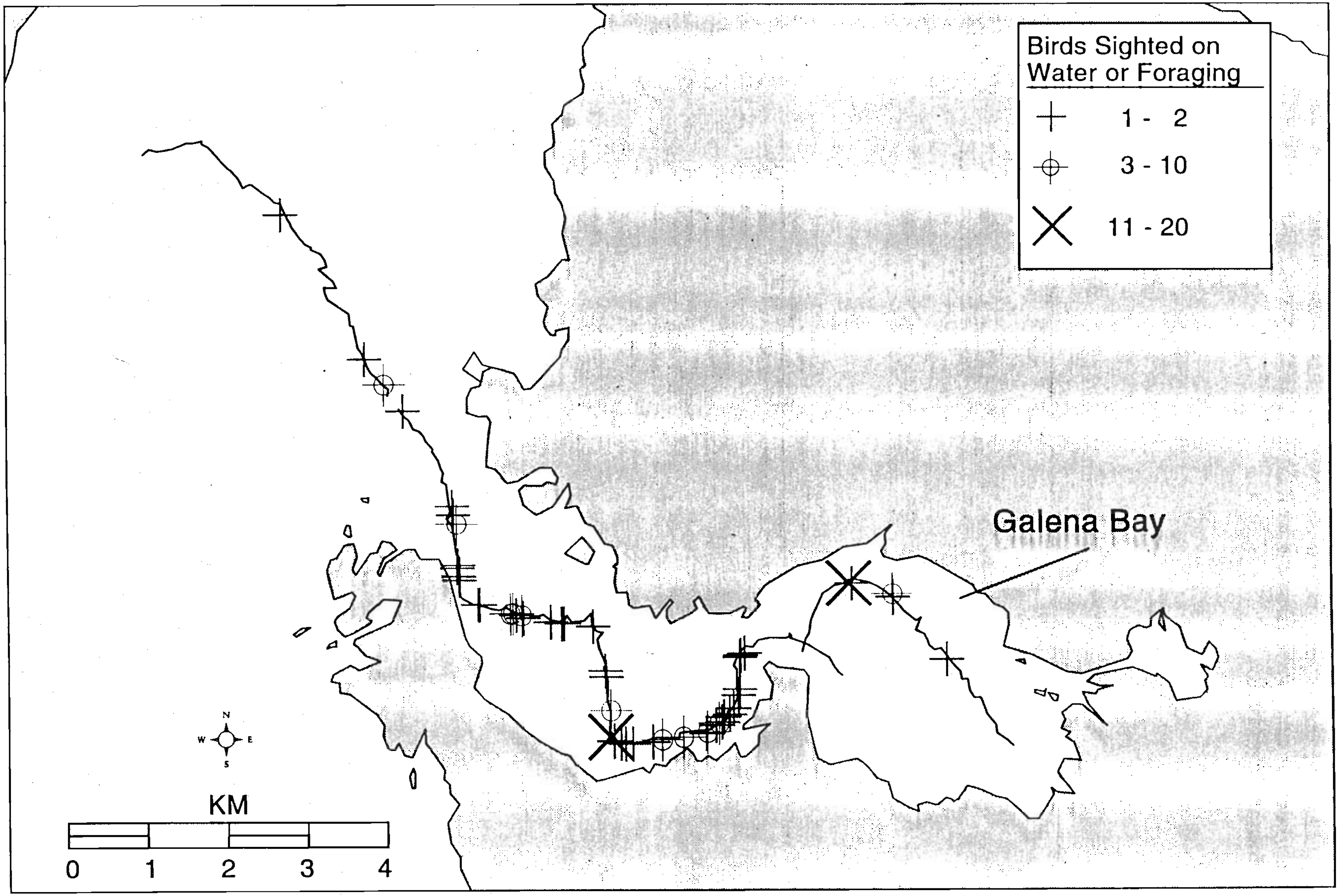

Birds Sighted on Water or Foraging
1 - 2
3 - 10
11 - 20
Galena Bay
KM
0 1 2 3 4
N
E
S
W

Fig. 6. Transect tracks and locations of piscivorous seabirds observed using aquatic habitat near Port Gravina in Prince William Sound, Ak. during the November 1994 cruise.

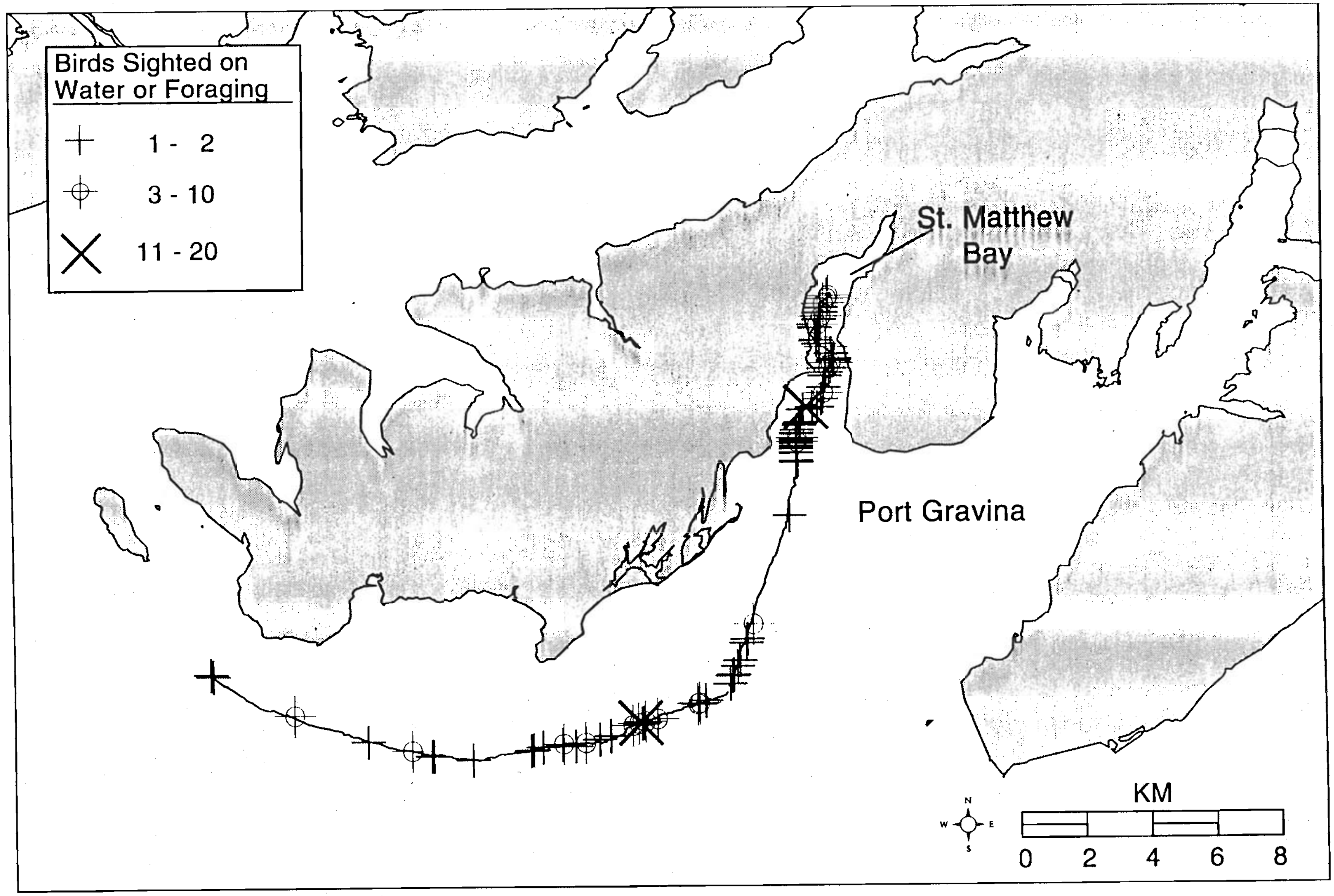

Birds Sighted on
Water or Foraging
1 - 2
3 - 10
11 - 20
St. Matthew
Bay
Port Gravina
KM
0
2
4
6
8
N
W
E
S

Fig. 7. Transect tracks and locations of piscivorous seabirds observed using aquatic habitat near Naked Island in Prince William Sound, Ak. during the November 1994 cruise.

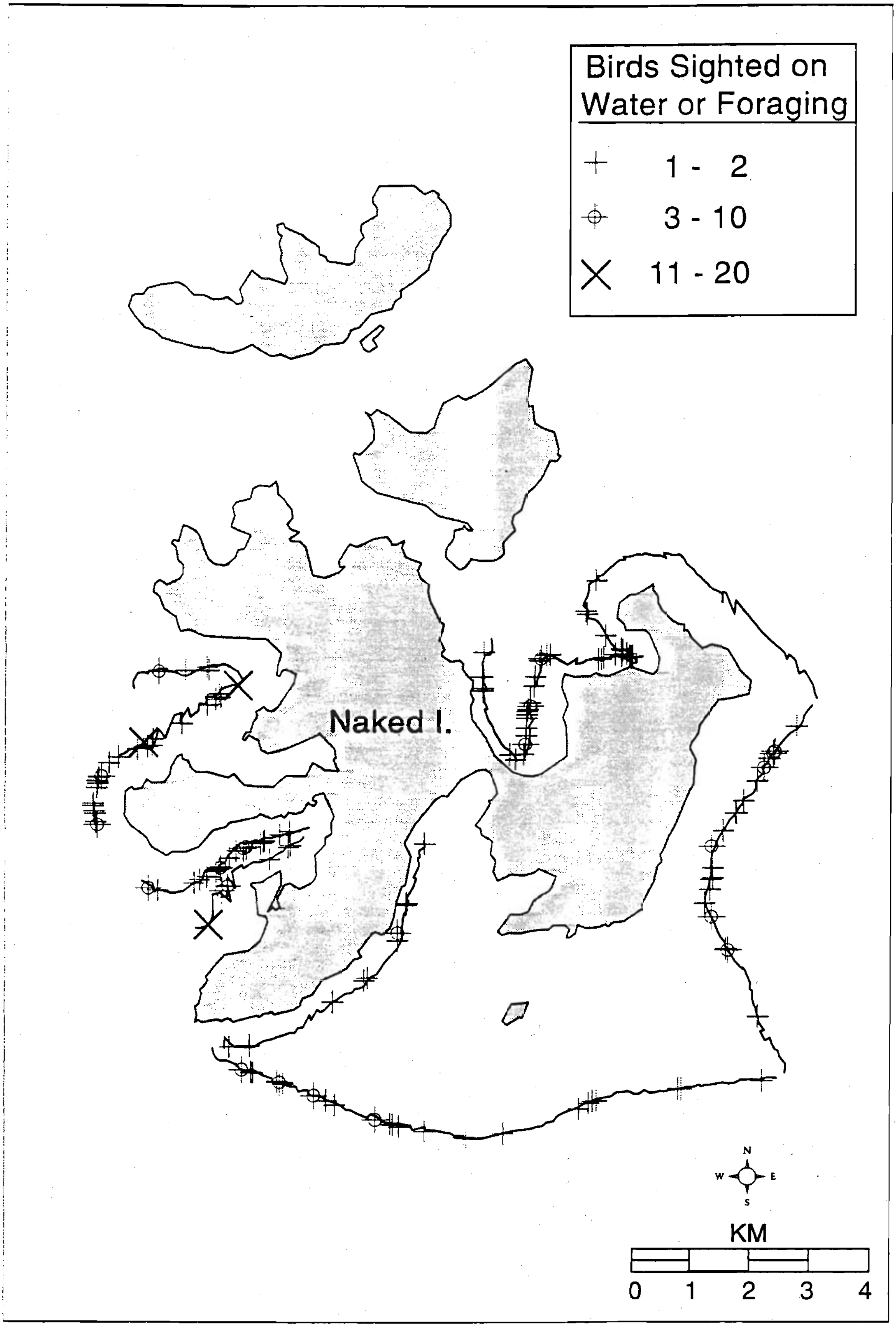

Birds Sighted on Water or Foraging
1 - 2
3 - 10
11 - 20
Naked I.
N
W
E
S
KM
0
1
2
3
4

Fig. 8. Transect tracks and locations of piscivorous seabirds observed using aquatic habitat near Jackpot Bay in Prince William Sound, Ak. during the November 1994 cruise.

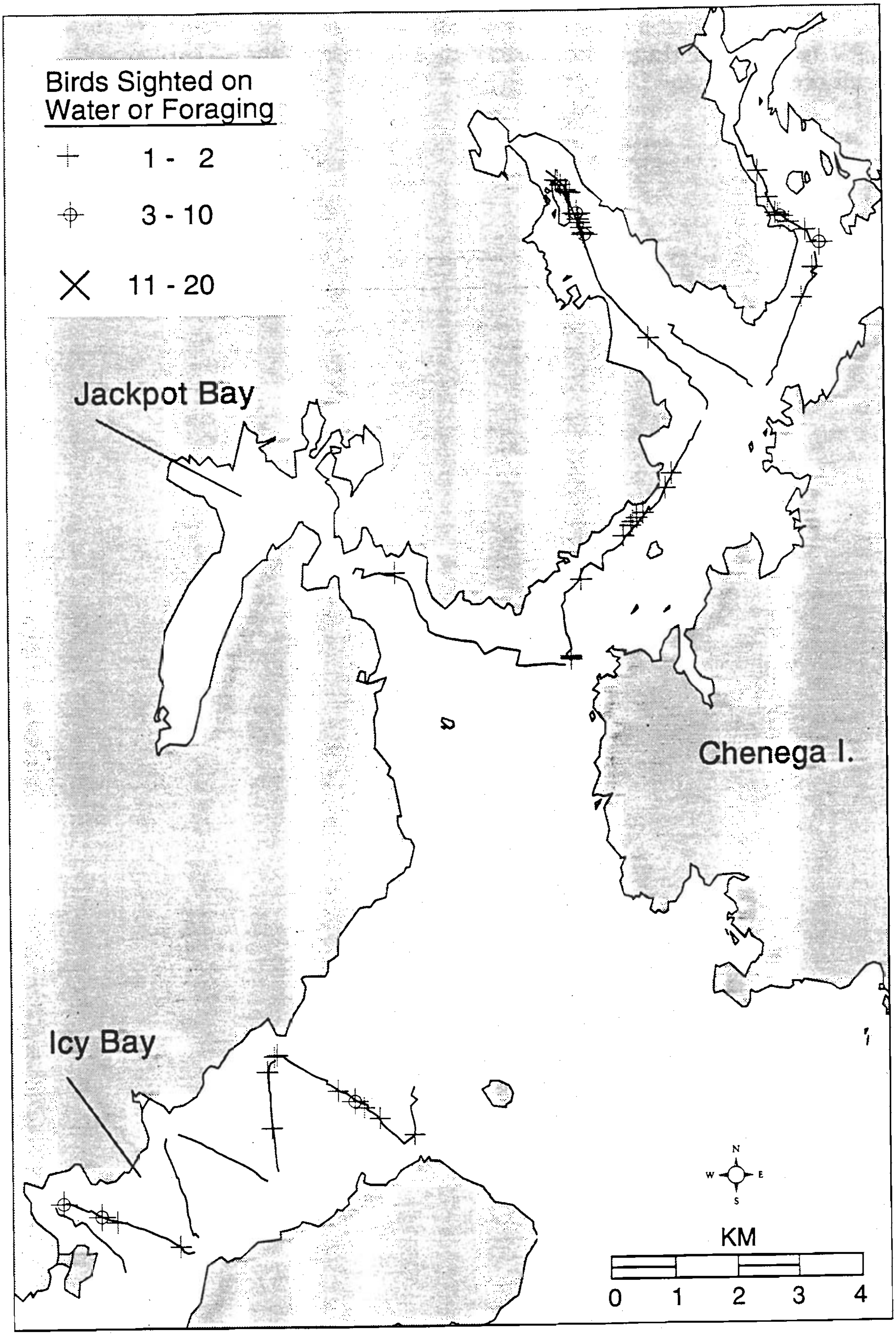

Birds Sighted on
Water or Foraging
1 - 2
3 - 10
11 - 20
Jackpot Bay
Chenega I.
Icy Bay
N
W
E
S
KM
0 1 2 3 4

Fig. 9. Transect tracks and locations of piscivorous seabirds observed using aquatic habitat near Knight Island in Prince William Sound, Ak. during the November 1994 cruise.

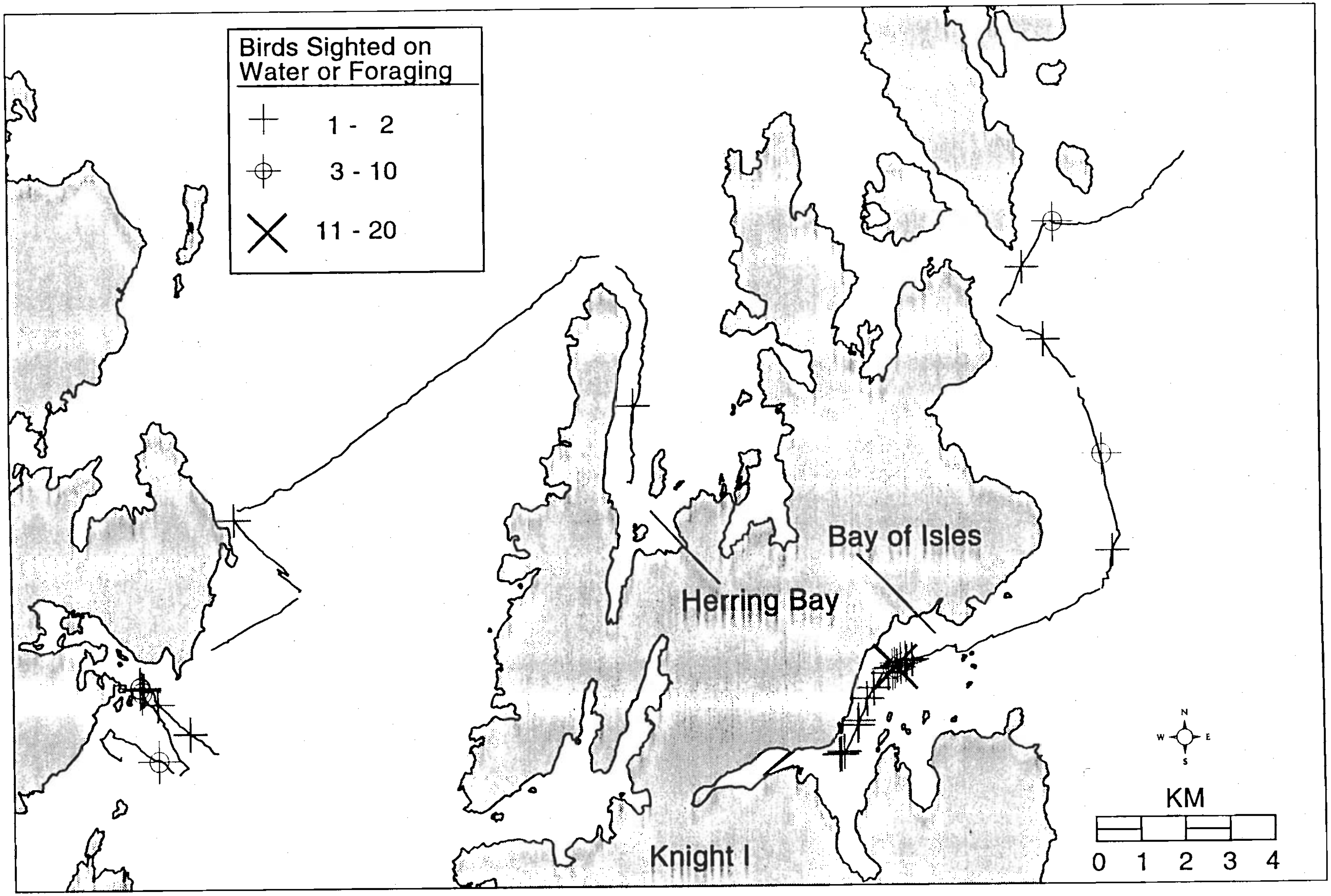

Birds Sighted on Water or Foraging
1 - 2
3 - 10
11 - 20
Herring Bay
Bay of Isles
Knight I
N
W
E
S
KM
0 1 2 3 4

Fig. 10. Transect tracks and locations of piscivorous seabirds observed using aquatic habitat near Montague Island in Prince William Sound, Ak. during the November 1994 cruise.

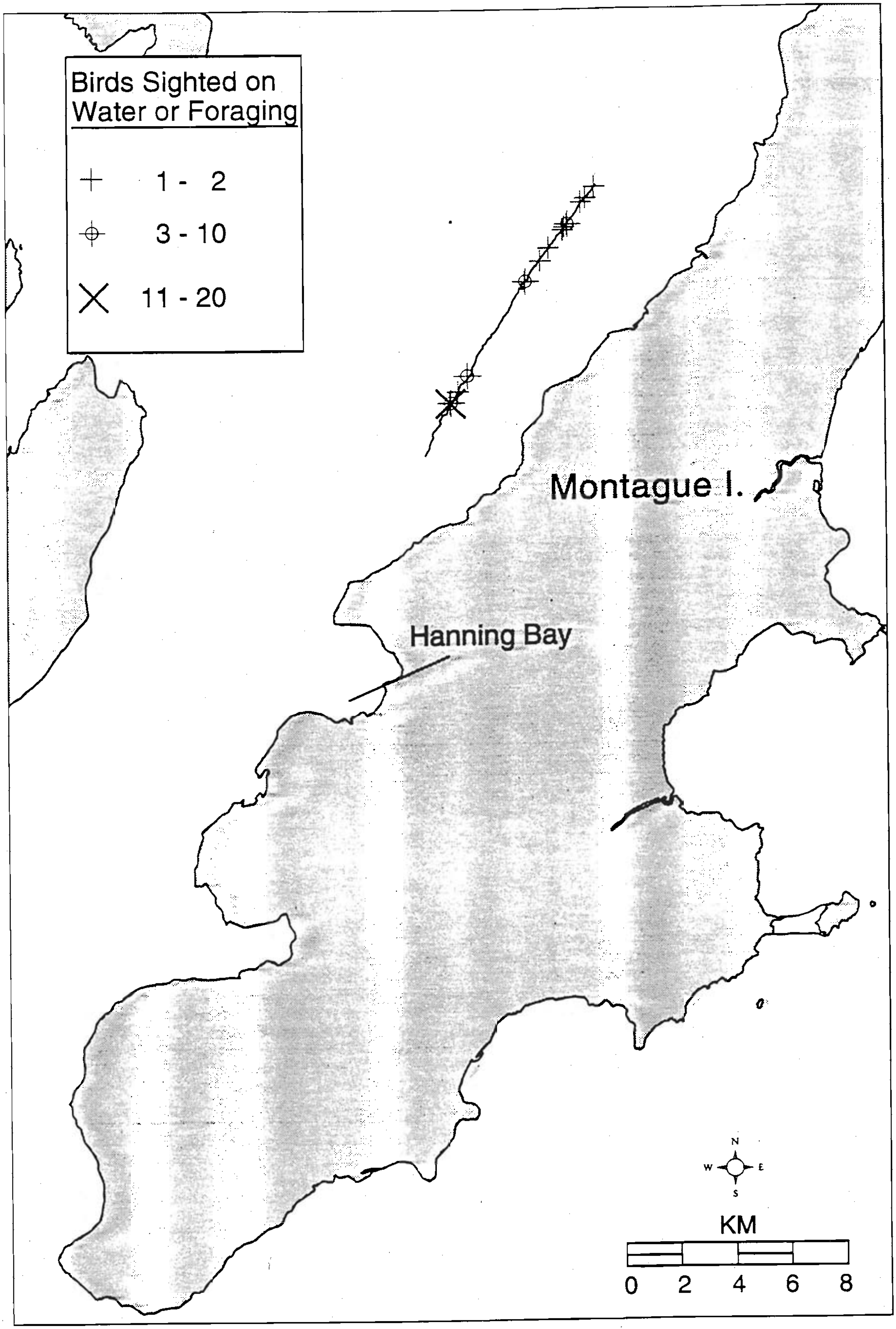

Birds Sighted on Water or Foraging
1 - 2
3 - 10
11 - 20
Montague I.
Hanning Bay
N
W
E
S
KM
0
2
4
6
8

Fig. 11. Hydroacoustic targets and bird data from the August 1994 cruise for transect For94-32 located in Port Bainbridge, Prince William Sound, Ak. Concentric lines indicate acoustic targets. Solid areas indicate bottom.

August Cruise, Transect For94-32

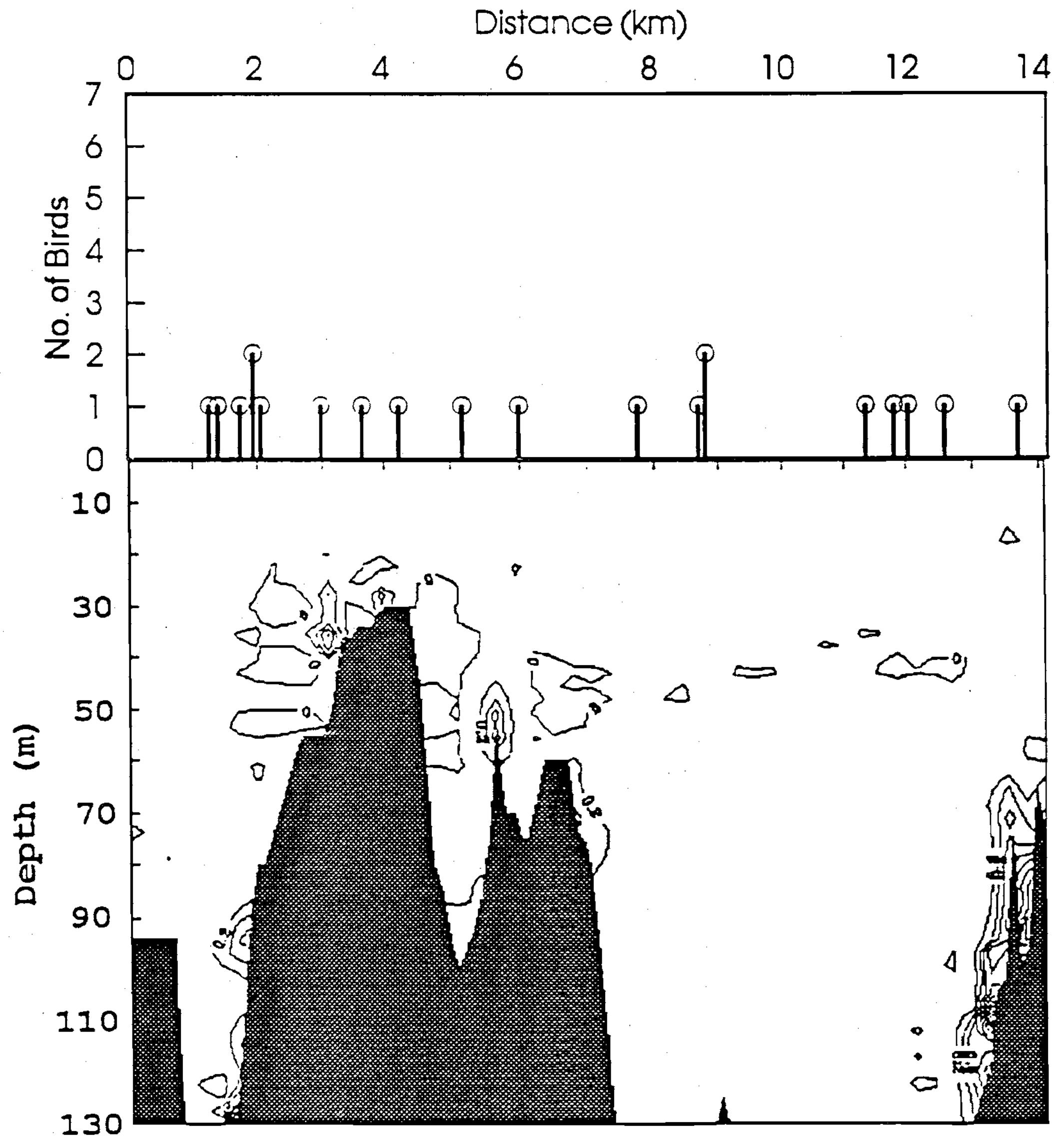


Fig. 12. Hydroacoustic targets and bird data from the August 1994 cruise for transect For94-24 located near Evans Island, Prince William Sound, Ak. Concentric lines indicate acoustic targets. Solid areas indicate bottom.

August 94 Cruise, Transect For94-24

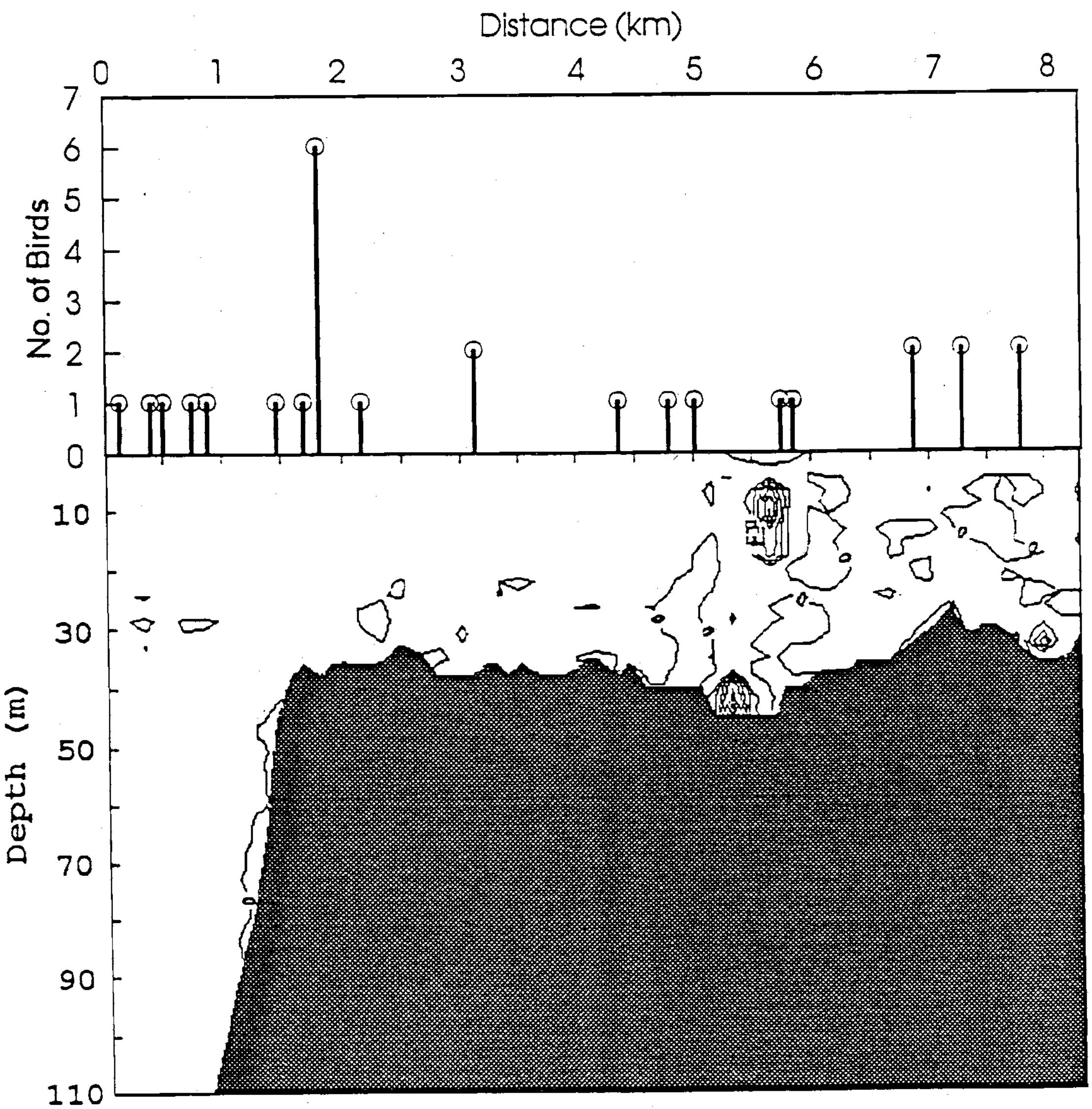


Fig. 13. Hydroacoustic targets and bird data from the August 1994 cruise for transect For94-33 located in Bainbridge Passage, Prince William Sound, Ak. Concentric lines indicate acoustic targets. Solid areas indicate bottom.

August 94 Cruise, Transect For94-33

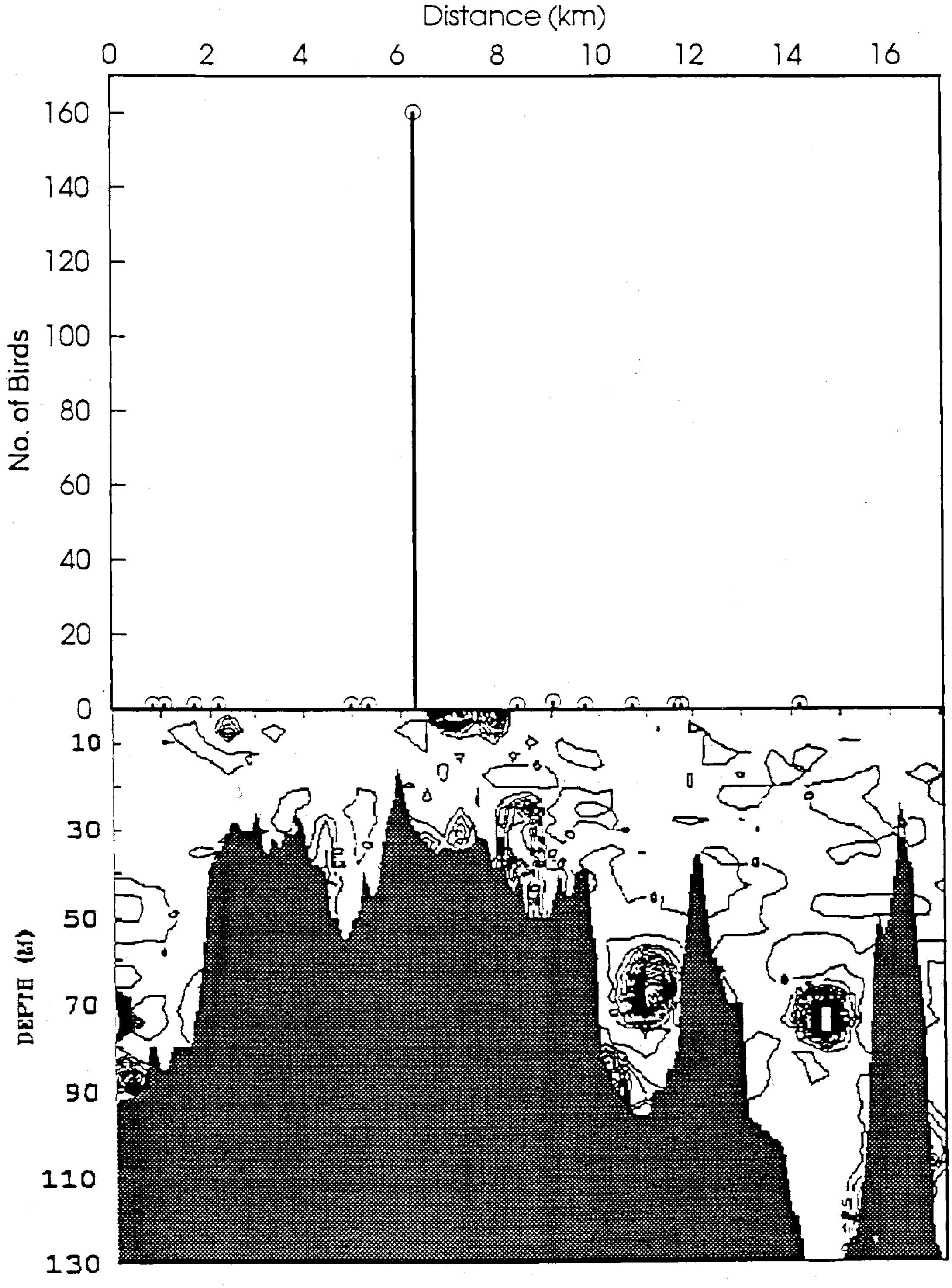


Fig. 14. Hydroacoustic targets and bird data from the August 1994 cruise for transect For94-3B4 located at the southern end of Knight Island, Prince William Sound, Ak. Concentric lines indicate acoustic targets. Solid areas indicate bottom.

August 94 Cruise, Transect For94-3B4

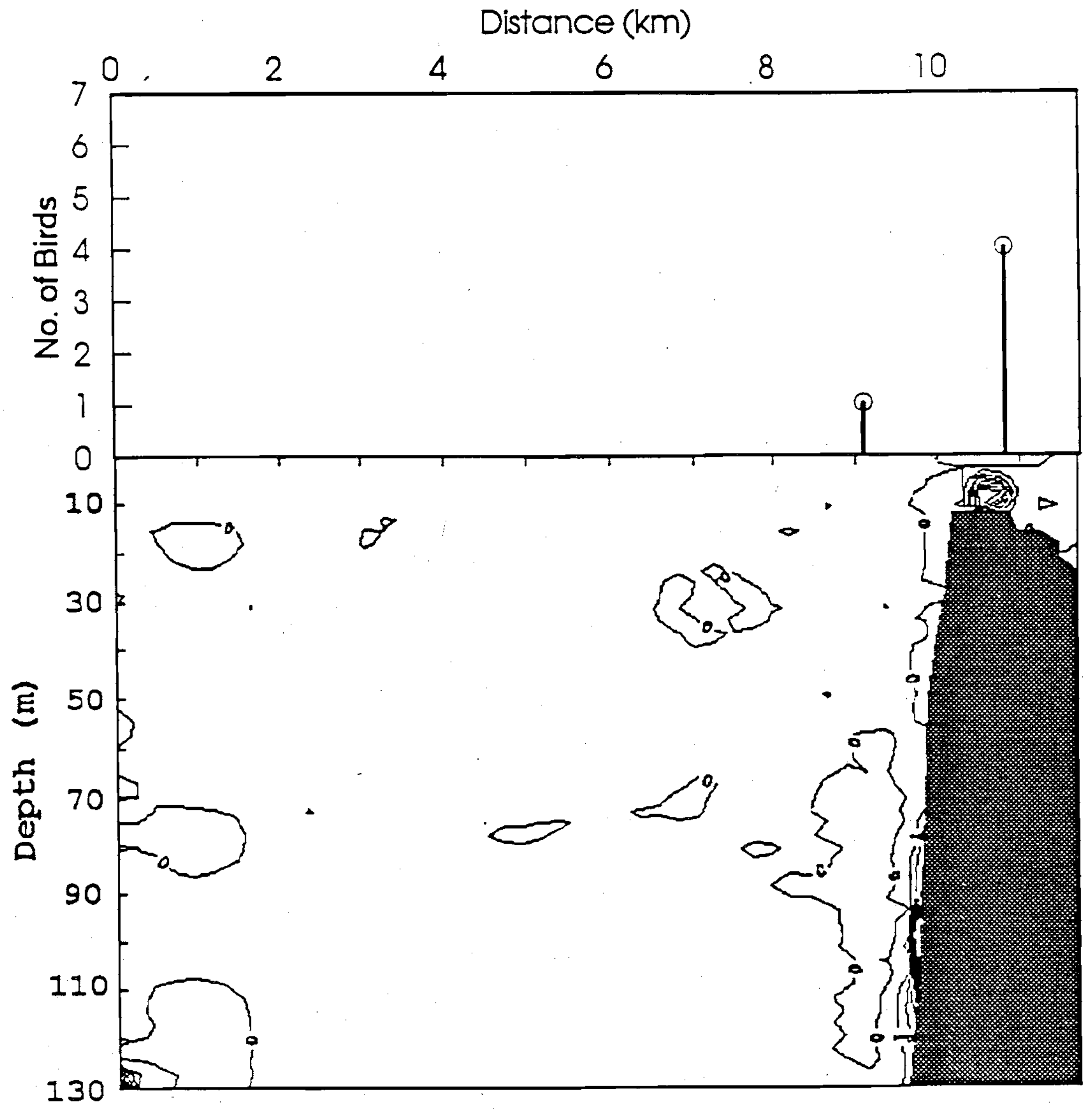


Fig. 15. Bathymetric data and transect tracks of the August 1994 cruise near Perry Island in Prince William Sound, Ak.

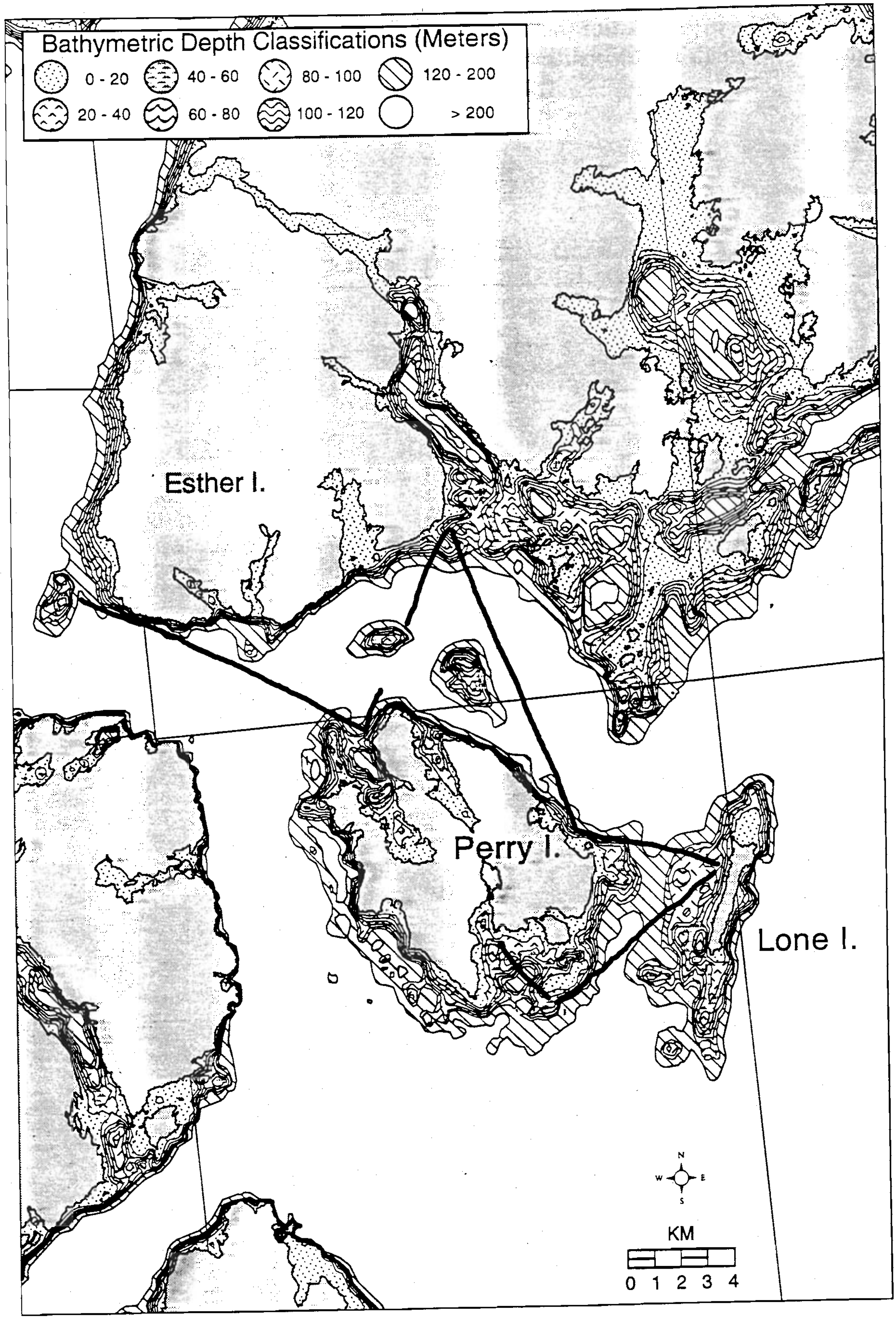
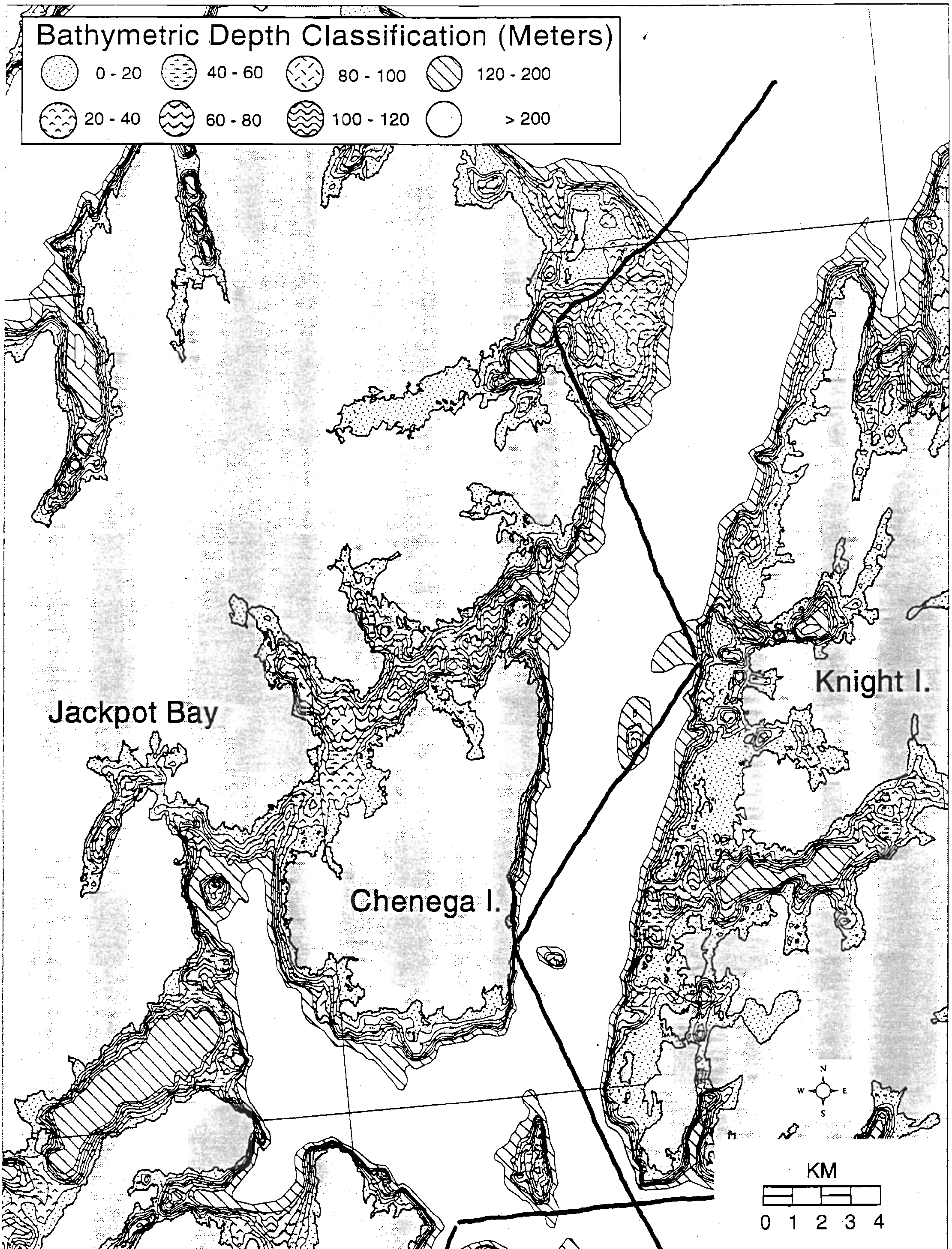

Bathymetric Depth Classifications (Meters)
0 - 20
40 - 60
80 - 100
120 - 200
20 - 40
60 - 80
100 - 120
> 200
Esther I.
Perry I.
Lone I.
N
W
E
S
KM
0 1 2 3 4

Fig. 16. Bathymetric data and transect tracks of the August 1994 cruise near Knight Island in Prince William Sound, Ak.



Bathymetric Depth Classification (Meters)
0 - 20
40 - 60
80 - 100
120 - 200
20 - 40
60 - 80
100 - 120
> 200
Jackpot Bay
Chenega I.
Knight I.
N
W
E
S
KM
0 1 2 3 4

Fig. 17. Bathymetric data and transect tracks of the August 1994 cruise near Bainbridge Island in Prince William Sound, Ak.

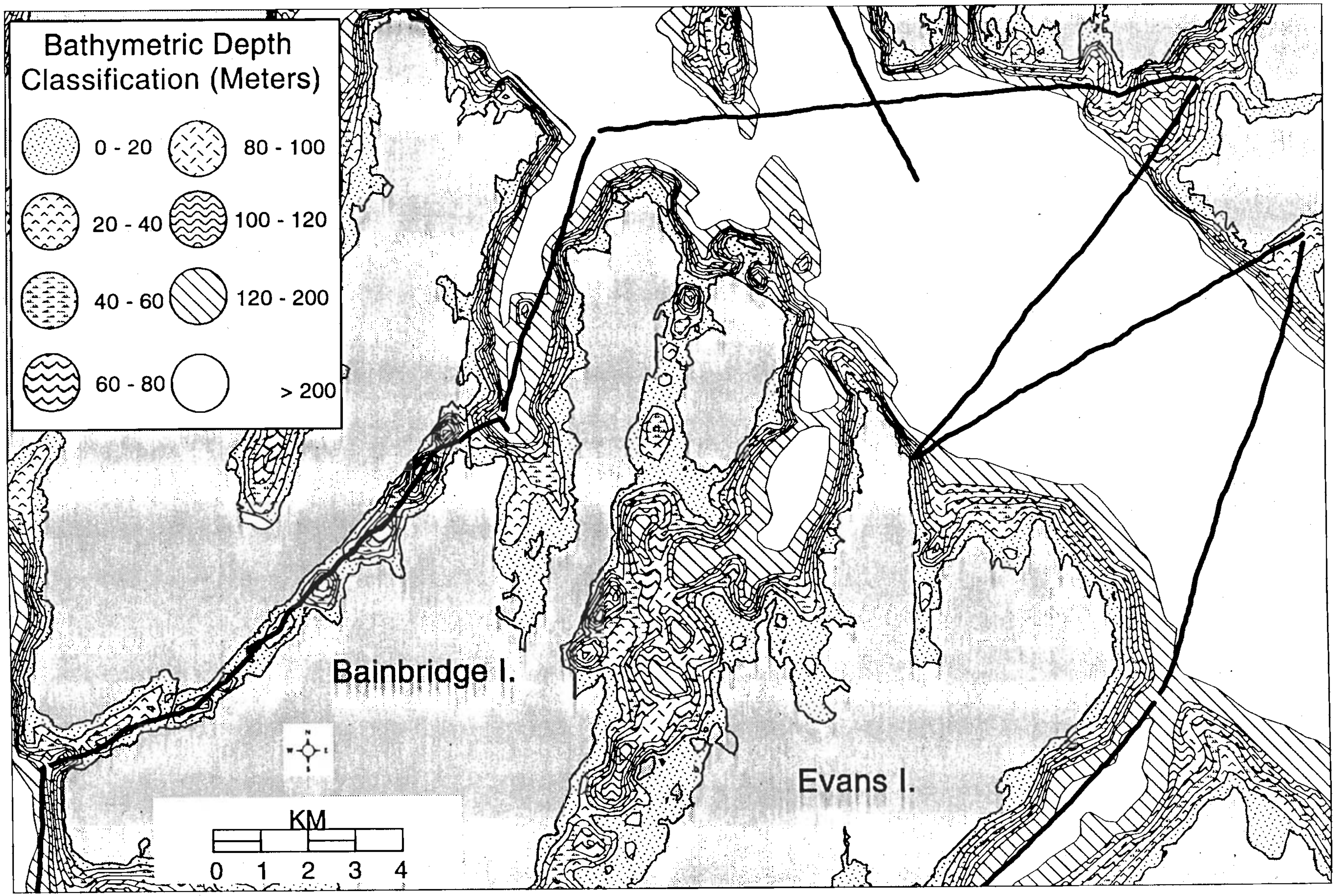

Bathymetric Depth
Classification (Meters)
0 - 20
80 - 100
20 - 40
100 - 120
40 - 60
120 - 200
60 - 80
> 200
Bainbridge I.
Evans I.
KM
0 1 2 3 4

Fig. 18. Bathymetric data and transect tracks of the August 1994 cruise near Latouche Island in Prince William Sound, Ak.

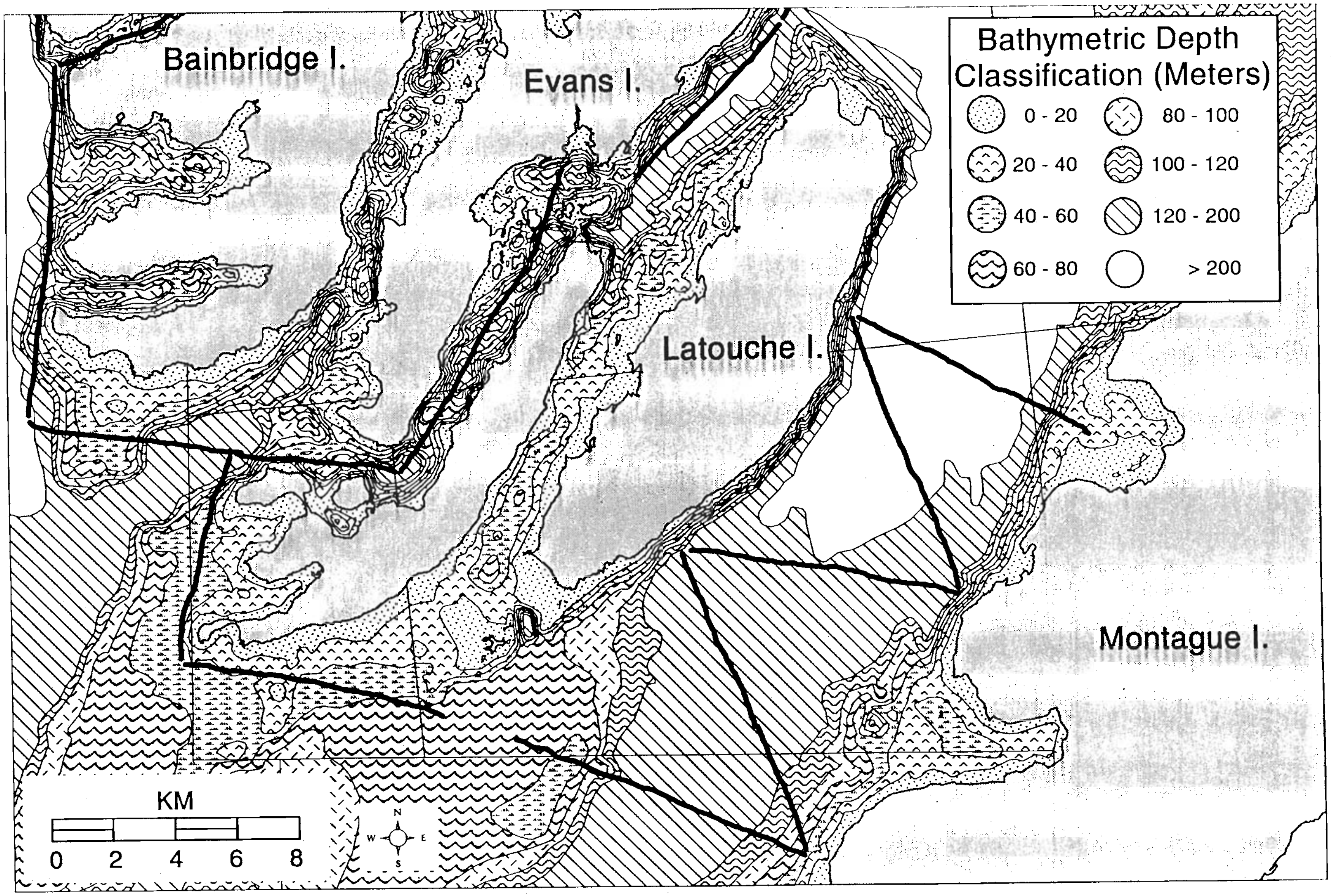

Bainbridge I.
Evans I.
Latouche I.
Montague I.
Bathymetric Depth Classification (Meters)
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
100 - 120
120 - 200
> 200
KM
0 2 4 6 8
N
W
E
S

Fig. 19. Bathymetric data and transect tracks of the November 1994 cruise near Galena Bay in Prince William Sound, Ak.

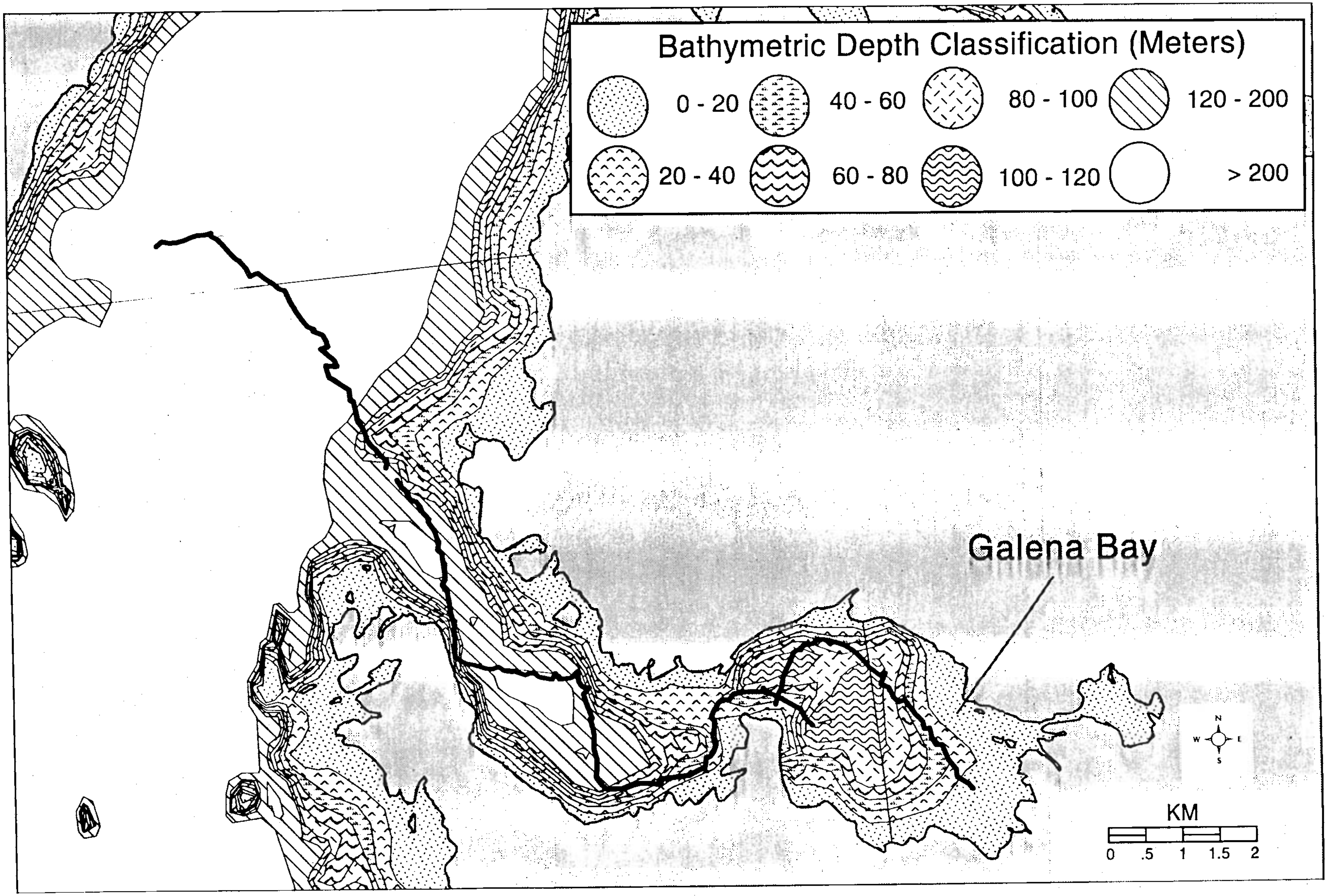

Bathymetric Depth Classification (Meters)
0 - 20
40 - 60
80 - 100
120 - 200
20 - 40
60 - 80
100 - 120
> 200
Galena Bay
KM
0
.5
1
1.5
2

Fig. 20. Bathymetric data and transect tracks of the November 1994 cruise near Port Gravina in Prince William Sound, Ak.

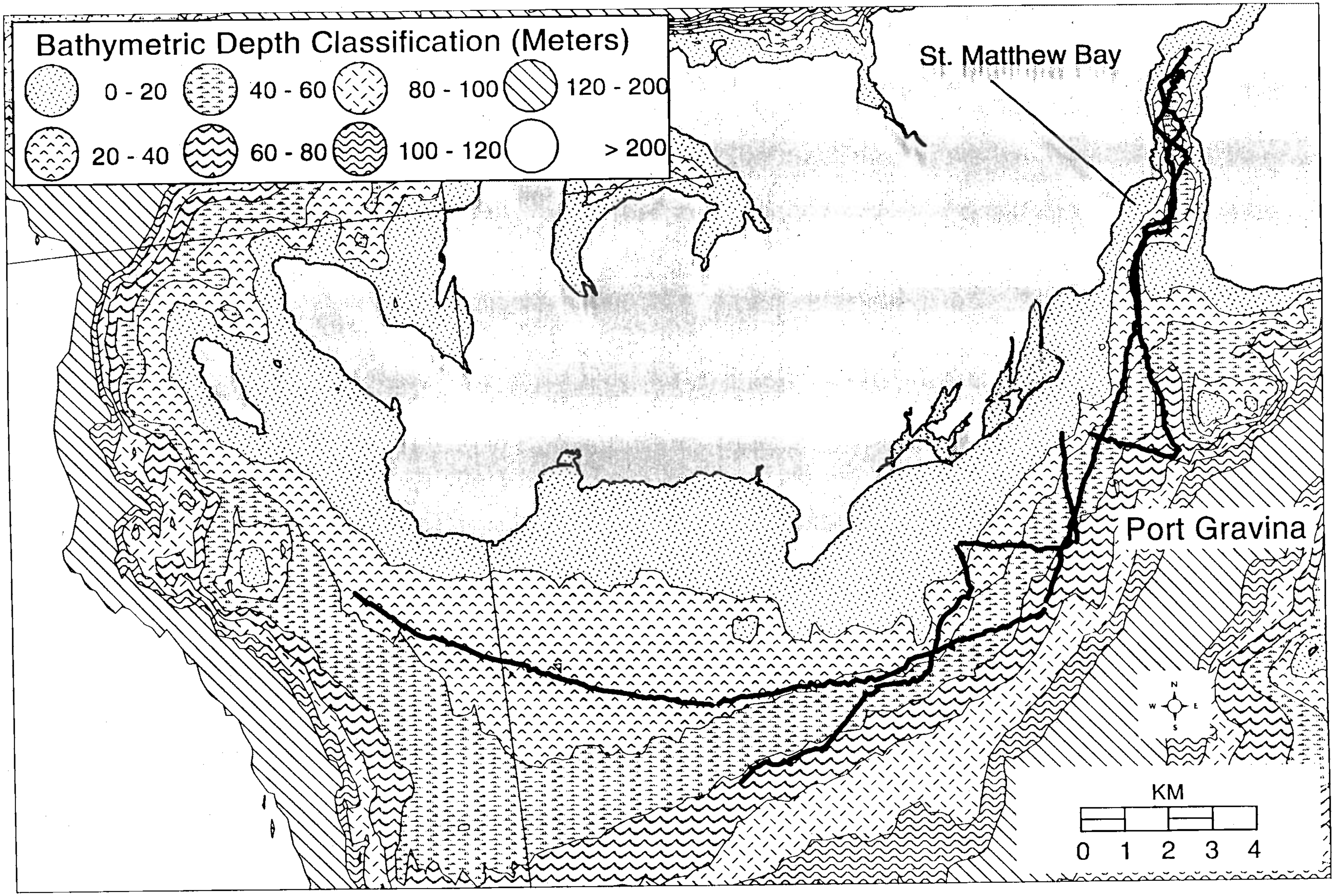

Bathymetric Depth Classification (Meters)
0 - 20
40 - 60
80 - 100
120 - 200
20 - 40
60 - 80
100 - 120
> 200
St. Matthew Bay
Port Gravina
KM
0 1 2 3 4

Fig. 21. Bathymetric data and transect tracks of the November 1994 cruise near Naked Island in Prince William Sound, Ak.

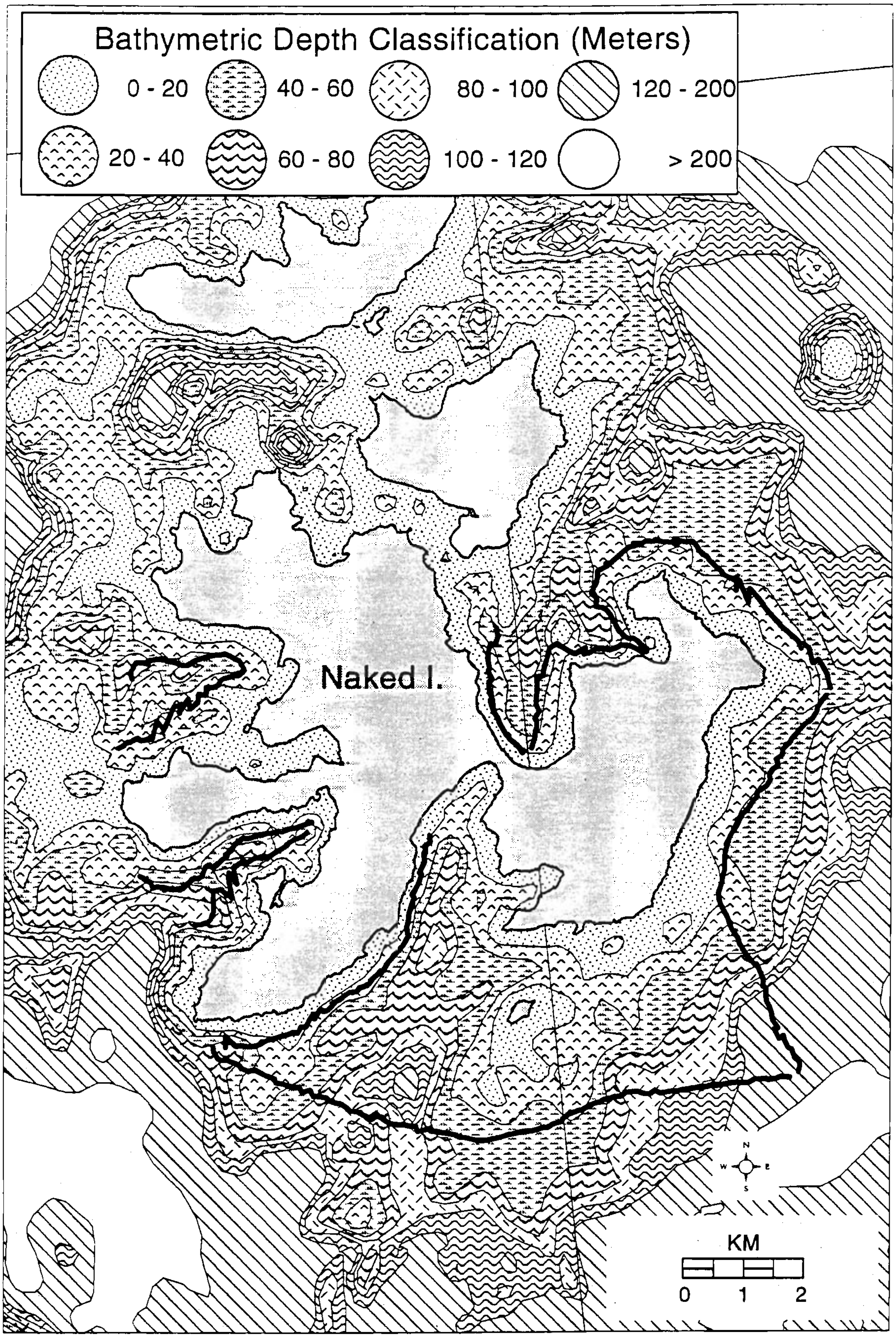

Bathymetric Depth Classification (Meters)
0 - 20
40 - 60
80 - 100
120 - 200
20 - 40
60 - 80
100 - 120
> 200
Naked I.
KM
0
1
2

Fig. 22. Bathymetric data and transect tracks of the November 1994 cruise near Knight Island in Prince William Sound, Ak.

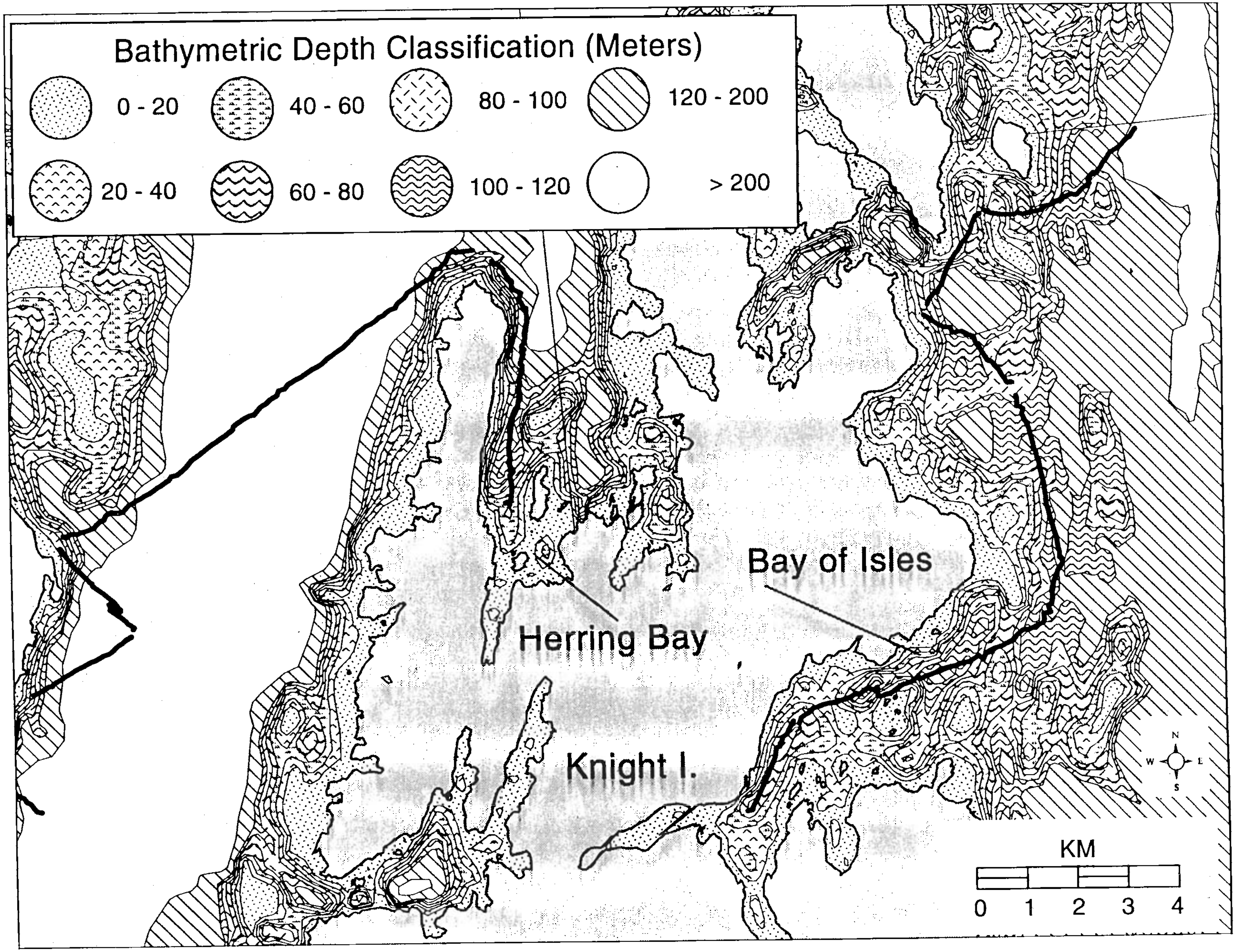
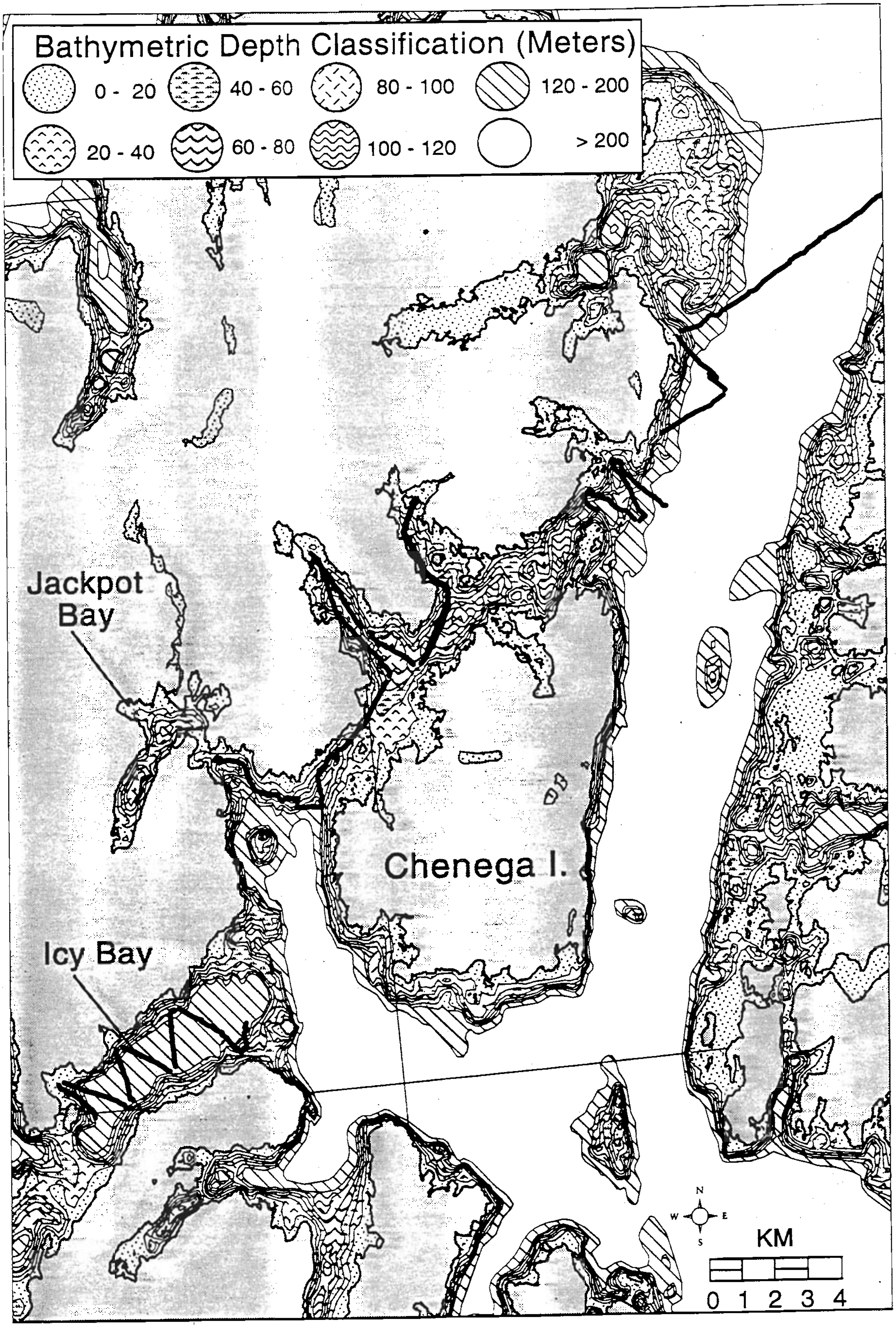
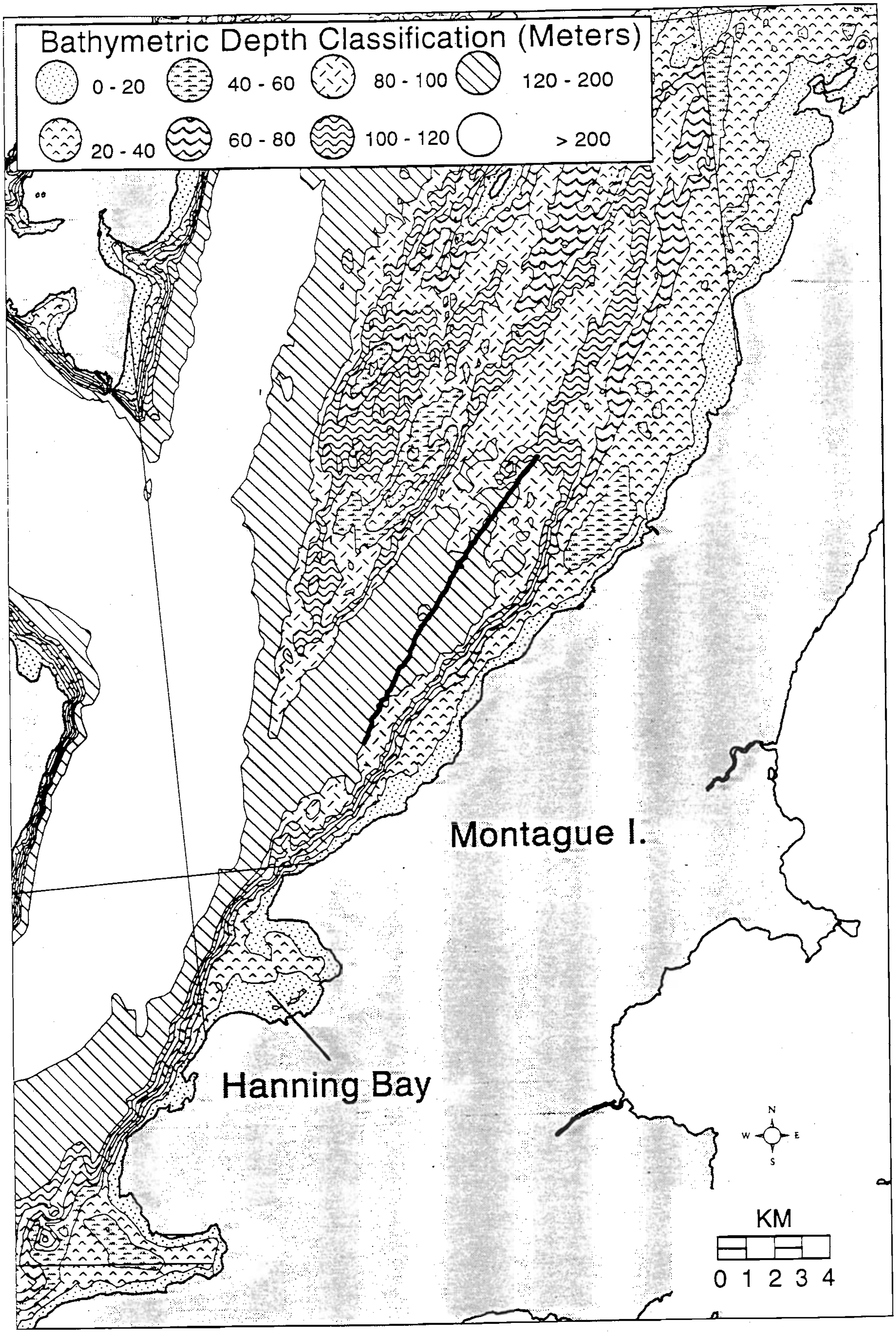

Bathymetric Depth Classification (Meters)
0 - 20
40 - 60
80 - 100
120 - 200
20 - 40
60 - 80
100 - 120
> 200
Bay of Isles
Herring Bay
Knight I.
KM
0 1 2 3 4
N
W
L
S

Fig. 23. Bathymetric data and transect tracks of the November 1994 cruise near Chenega Island in Prince William Sound, Ak.



Bathymetric Depth Classification (Meters)
0 - 20
40 - 60
80 - 100
120 - 200
20 - 40
60 - 80
100 - 120
> 200
Jackpot Bay
Chenega I.
Icy Bay
N
W
E
S
KM
0 1 2 3 4

Fig. 24. Bathymetric data and transect tracks of the November 1994 cruise near Montague Island in Prince William Sound, Ak.



Bathymetric Depth Classification (Meters)
0 - 20
40 - 60
80 - 100
120 - 200
20 - 40
60 - 80
100 - 120
> 200
Montague I.
Hanning Bay
N
W
E
S
KM
0 1 2 3 4

Appendix C
Notes from the final workshop
April 26, 1995

MEETING NOTES

Year-end Meeting on Forage Fish Research Findings
NOAA-UAF Research Contract

Meeting date: 26 April, 1995

Time: 10 am to 5 pm

Place: *Exxon Valdez* Oil Spill Trustee Council
645 G Street, Suite 401 (4th Floor)
Anchorage, AK

The agenda followed for the meeting was as follows:

1. Introductory Remarks - Al Tyler
2. Hydrographic measurements - Lew Haldorson
3. Hydroacoustic analysis - Ken Coyle
   - Dick Thorne
4. Invertebrate forage species - A.J. Paul
5. Fish forage species - Lew Haldorson
6. Merging seabird data with hydroacoustic data - Bill Ostrand
7. Overview of Forage Fish Research in the APEX Project - Lew Haldorson
8. General Discussion

Attendance
The following people were in attendance: Jennifer Bolt, Ken Coyle, David Duffy, Lew Haldorson, Lindsey Hayes, David Irons, Bill Ostrand, John Piatt, A. J. Paul, Martin Robards, Stan Senner, Dick Thorne, Al Tyler, Thomas Van Pelt and Bruce Wright.

Introductory Remarks:

This meeting represents the oral portion of the year-end report of the UAF NMFS Forage Fish Research contract. Co-investigators have agreed to provide Al Tyler with written versions of their talks, and he will collate them into an annual report for the project.

The objectives of the project were reviewed as follows:

1. Provide an initial estimate of the distribution of forage species relative to areas of know n concentration of marine seabirds and mammals.

2. Describe the species composition of the forage base and size distributions of the most abundant forage species.

3. Generate an acoustic data set that can be used to design the best acoustic data survey in subsequent years of the study.

4. Coordinate forage fish surveys with personnel from the United States Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) to insure that data are taken in known foraging areas of marine birds and mammals.

5. Determine size composition of important forage species in the study area.

6. Provide suitable forage fish samples to ADF&G for food habits and stable isotope analyses.

7. Gather basic oceanographic data describing conditions in the study area, and salinity, temperature, and sigma-t profiles of the water column and water depth at all sites of data collection.

8. Generate a detailed proposal for quantitative evaluation of forage fish distribution and abundance in subsequent years and describe the ecological role of forage fish in the PWS ecosystem.

9. Provide, to the COTR, raw and summarized data describing the distribution and abundance of forage species as outlines in the RFP.

Hydrographic measurements and hydroacoustic analysis

For the November cruse, the temperature-depth profiles for the open areas of the Prince William Sound showed that temperature was cool at the surface, at about 7.0 C and warmed to 9.0 C at a depth of 50 m. The water then cooled to about 5 C. Salinity gradually increased through this depth range, indicating that there was little mixing of the water column and that cooling was occurring from the surface downward due to cold air temperatures. Over the shelf areas the profiles were constant and mixed to 70 m., indicating mixing perhaps by tidal currents. Only hydroacoustic data were taken in the August cruise, with no hydrographic data.

In August fishes were mainly located above the temperature maximum at depths of 20 to 40 m and at temperatures of 7.0 to 7.5 ^{o}C. Net sampling showed that these fish were young herring mixed with young pollock. They are mostly 0+ and 1+ aged fish. Eulachon were found in some hauls 40 - 80 m in the deep Port Gravina area. A second layer of fish was seen near the bottom that was likely adult pollock as interpreted by the hydroacoustic trace. Because of the rough bottom the net could not be deployed to verify the identification. Acoustic data were expressed as number of fish per cubic meter.

Net sampling was not carried out in the August preliminary cruise.

Invertebrates

In November, five stations were sampled via a one-m NIO net (National Institute of Oceanography) with 1 mm mesh fished obliquely. At most stations euphausiids were the abundant crustacean, though the shrimp *Pasiphaea pacifica* were abundant, and at another haul pandalids, crangonids, and hippolytidae were abundant. Another haul contained only pelagic amphipods.

Since crustacea are the prey of the herring and young pollock, determining the distribution of the invertebrates will help in our understanding of the distribution of fishes.

In some areas kittiwakes have been found to eat quantities of euphausiids, so at times they are a major prey item.

Merging seabird data with hydroacoustic data, and notes on the 1995 Seabird-forage fish Project (Apex Project)

During the August cruse, bird counts were made along transects, and later superimposed on the hydroacoustic results. In the transect at the southern end of Knight Island the concentrations of kittiwakes and marbled murrelets were later found to be coincident with the concentrations of fish showing in the hydroacoustic traces.

It will be important in next year's work to respond to concentrations of sea birds and switch to a detailed or fine-scaled grid pattern of combined hydroacoustic and hydrographic measurements. In this way it will be possible to take data on the physical structure of the water mass in order to interpret the mechanism behind the formation of the concentrations of birds and their forage.

The cruise in 1995 will be for 30 days during the summer, starting about July 15. The hydroacoustic work will be carried out on one vessel and simultaneously net sampling and hydrographics will be carried out on a second vessel. The vessel survey will be concentrated on the Naked Island-Eleanor Island area. Three separate grid samplings will be done in this central core area. A two nautical mile grid will be followed to standardize the hydroacoustics data. Other grid sampling will be carried out in the Jackpot Bay area and the Valdez Arm area.

Appendix D
Cruise Reports
Cruise FOR94-01, August 1994
Cruise FOR94-02, November, 1994

CRUISE REPORT
CRUISE: FOR94-01
15-22 AUGUST 1994

The School of Fisheries and Ocean Sciences, Fisheries Division, is conducting a study of forage species in Prince William Sound, through a contract with the National Marine Fisheries Service. The project objectives are to quantitatively describe populations of those species that are preyed upon by apex predators (birds and mammals), and to identify the functional role of those forage species in the PWS food web. This report covers the initial sampling effort of the project, a second research cruise is planned for October 1994.

The objective of research cruise FOR94-01 was to generate an acoustic data set describing the distribution of organisims in the size range of forage species.

Summary of Activities

The cruise was conducted on the RV Little Dipper, a 26' diesel-powered vessel operated by the University of Alaska out of the Seward Marine Center. The size of the vessel restricts operations to day trips, and requires shore facilities for housing and meals for personnel.

The cruise was designed to be completed in two phases, with the first phase operating in the southwestern part of PWS, with personnel housed at Chenega Village, and the second phase operating in the northwest, with shore facilities at Whittier.

A cruise plan was developed at a meeting in Anchorage on 10 August 1994, with participants from Alaska Department of Fish and Game, National Marine Fisheries Service, U. S. Fish and Wildlife Service, Biosonics Inc. and the University of Alaska. The cruise was planned to operate from 14 - 26 August, with scientific crew to be comprised of scientists from the University of Alaska, Biosonics Inc., and USFWS.

The sequence of activities following the planning meeting were:

11 - 14 August	Acoustic equipment installed and tested on the RV Little Dipper at Seward.
15 August	Vessel travels from Seward to Chenega Village in PWS
16 - 18 August	Vessel conducts series of hydroacoustic transects in the southwestern sections of PWS.
19 August	Hydroacoustic transects are completed in Knight Island Passage, vessel travels to Whittier.
20 August	Hydroacoustic transects are completed in the northwest section of PWS
21 August	Vessel has breakdown of main propulsion system enroute to sampling area, and is towed back to Whittier.
22 August	Research cruise is terminated, equipment and personnel leave the field.

The vessel had a disabling breakdown of the main propulsion unit on the morning of 21 August, and was towed back to Whittier by a fishing vessel. The travel-lift at Whittier was not operational due to mechanical breakdown; consequently, there was going to be at least a two or three day delay before the Little Dipper could be hauled out to diagnose the problem, which apparently was in the outdrive unit. It appeared likely that the vessel would not be repaired before the scheduled end of the cruise; therefore the Chief Scientist terminated the cruise.

Personnel

Ken Coyle	UAF, Chief Scientist	15 - 20 August
Lewis Haldorson	UAF, Chief Scientist	20 - 21 August
Jerry King	UAF, Vessel Operator	15 - 21 August
Richard Thorne	Biosonics, Inc.	15 - 21 August
William Ostrand	USFWS	16 - 21 August
Beverly Agler	USFWS	16 - 19 August
John Maniscalco	USFWS	20 - 21 August

Operations

A series of connected hydroacoustic transects were run on each day, with concurrent recording of acoustic signals and counts of birds. Acoustic data was collected with the Biosonics model 102 echosounder and ESP integrator. Transducers were towed beside the vessel at 6 knots in a 4 foot biofin. A side-looking 420 kHz echosound collected data on near-surface targets up to 60 m from the vessel, and a 120 kHz down looking transducer collected data to 150 m depth. Bird data were collected by visual counts on both sides of the vessel during each transect. A GPS system provided positional data for each transect. The location all transects is plotted in Figure 1, and the individual day transects are plotted in Figures 2 - 6.

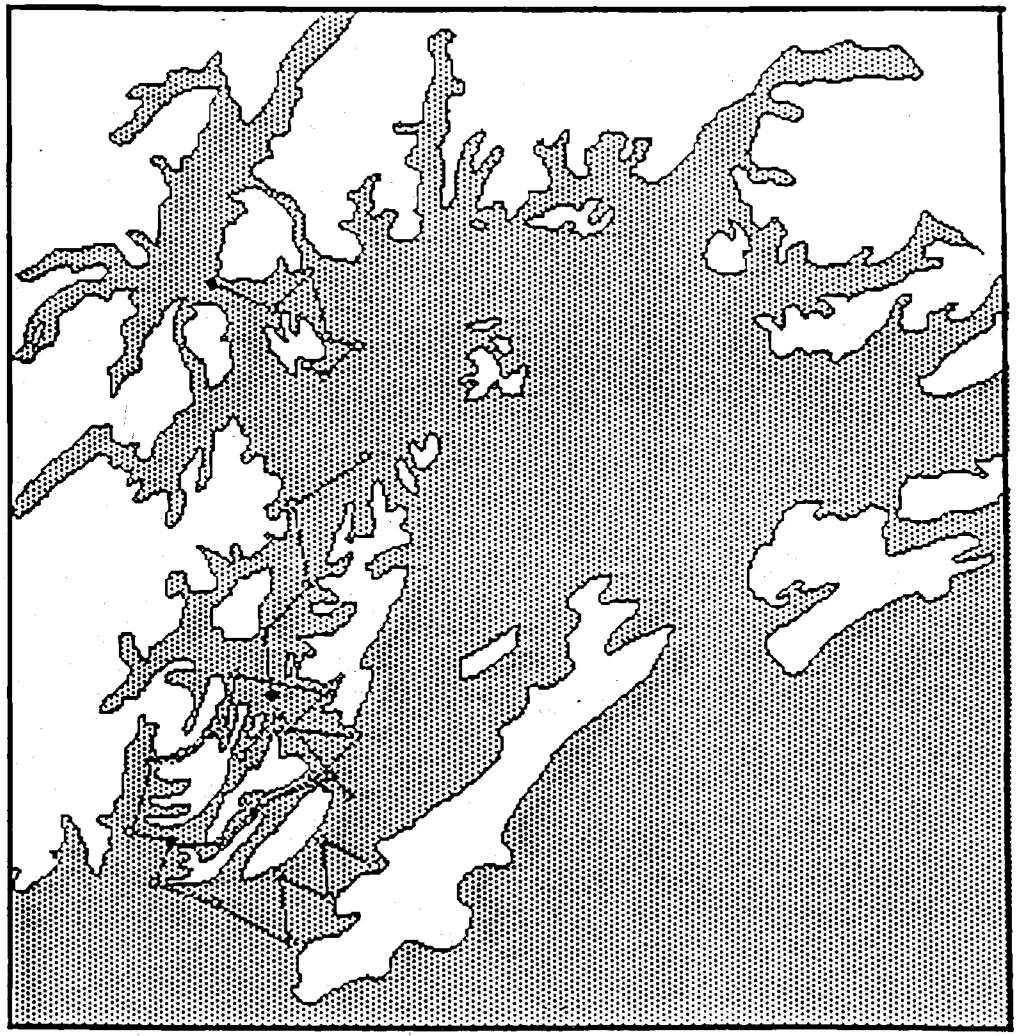


Figure 1. Summary of hydroacoustic transects completed in Prince William Sound during cruise FOR94-1.

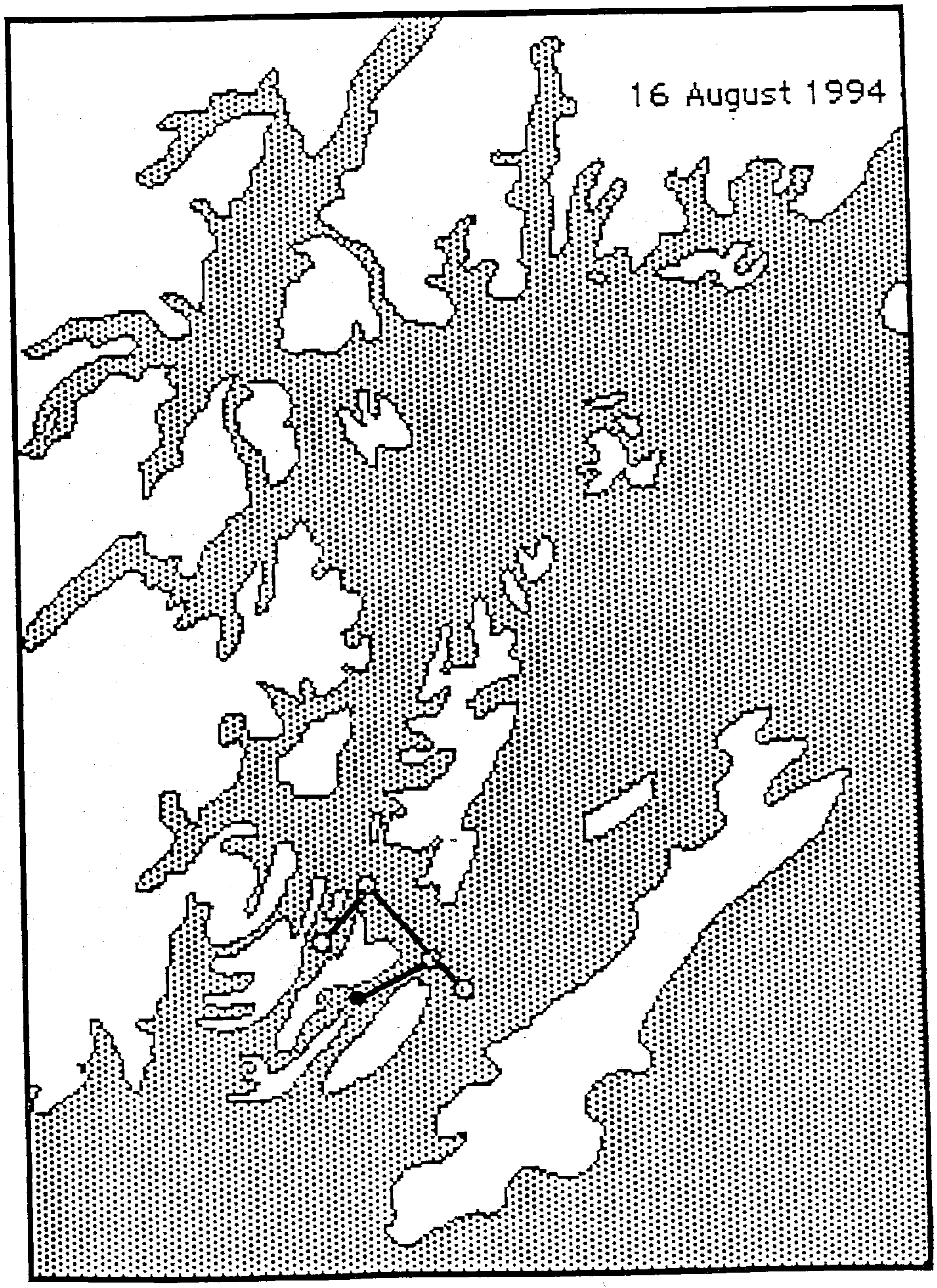


Figure 2. Hydroacoustic transects completed on 16 August in Prince William Sound during cruise FOR94-1.

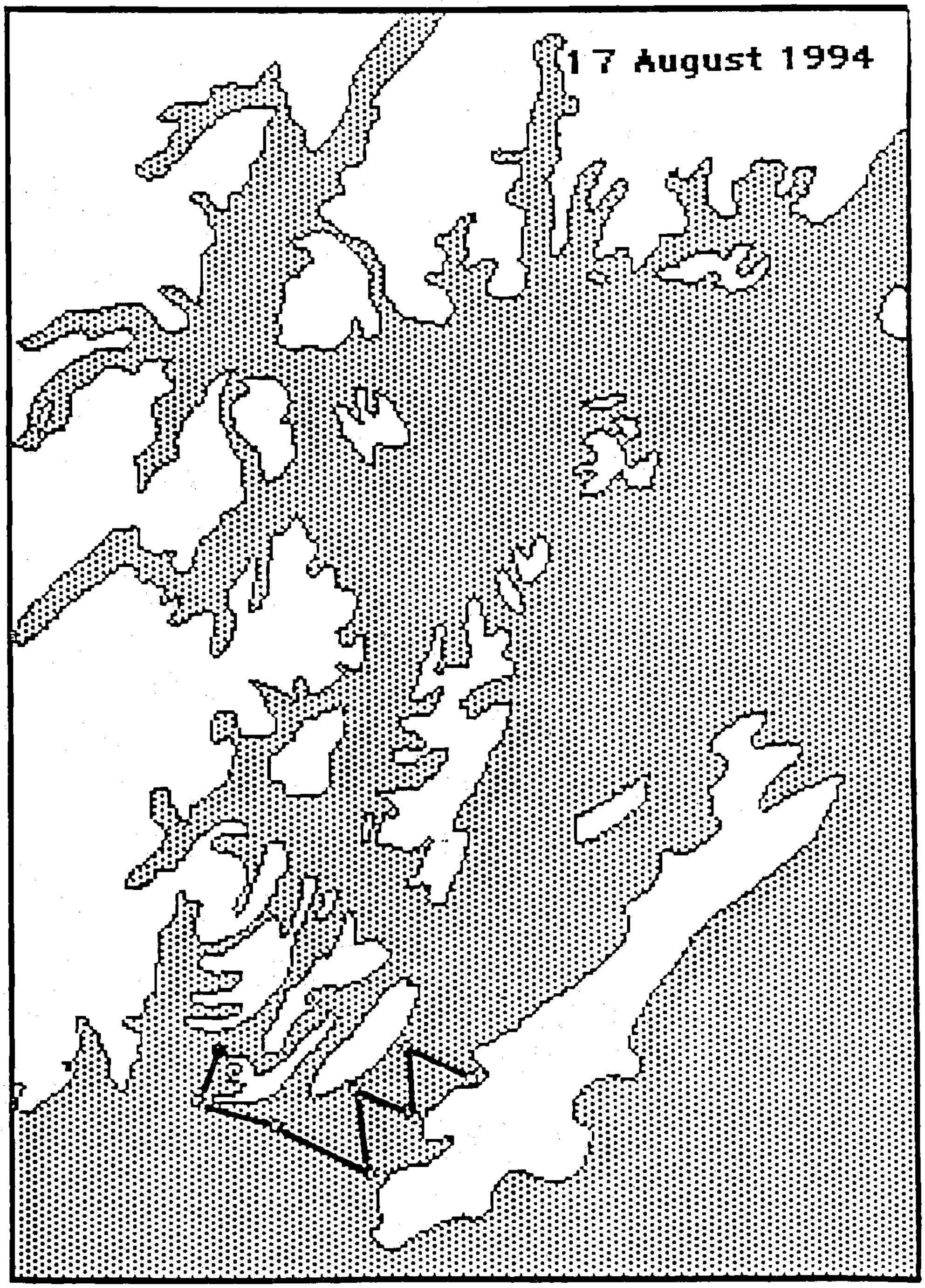


Figure 3. Hydroacoustic transects completed on 17 August in Prince William Sound during cruise FOR94-1.

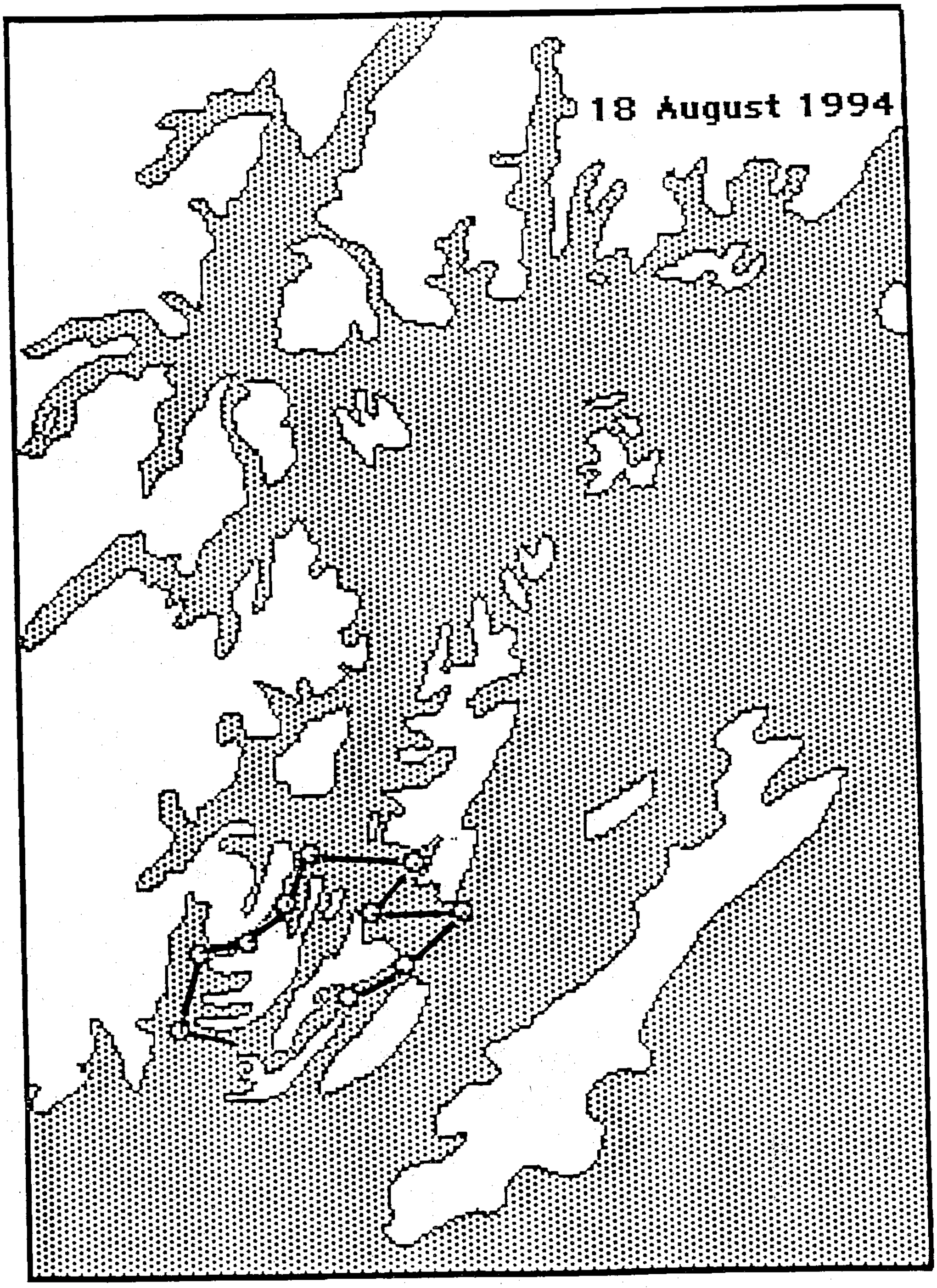


Figure 4. Hydroacoustic transects completed on 18 August in Prince William Sound during cruise FOR94-1.

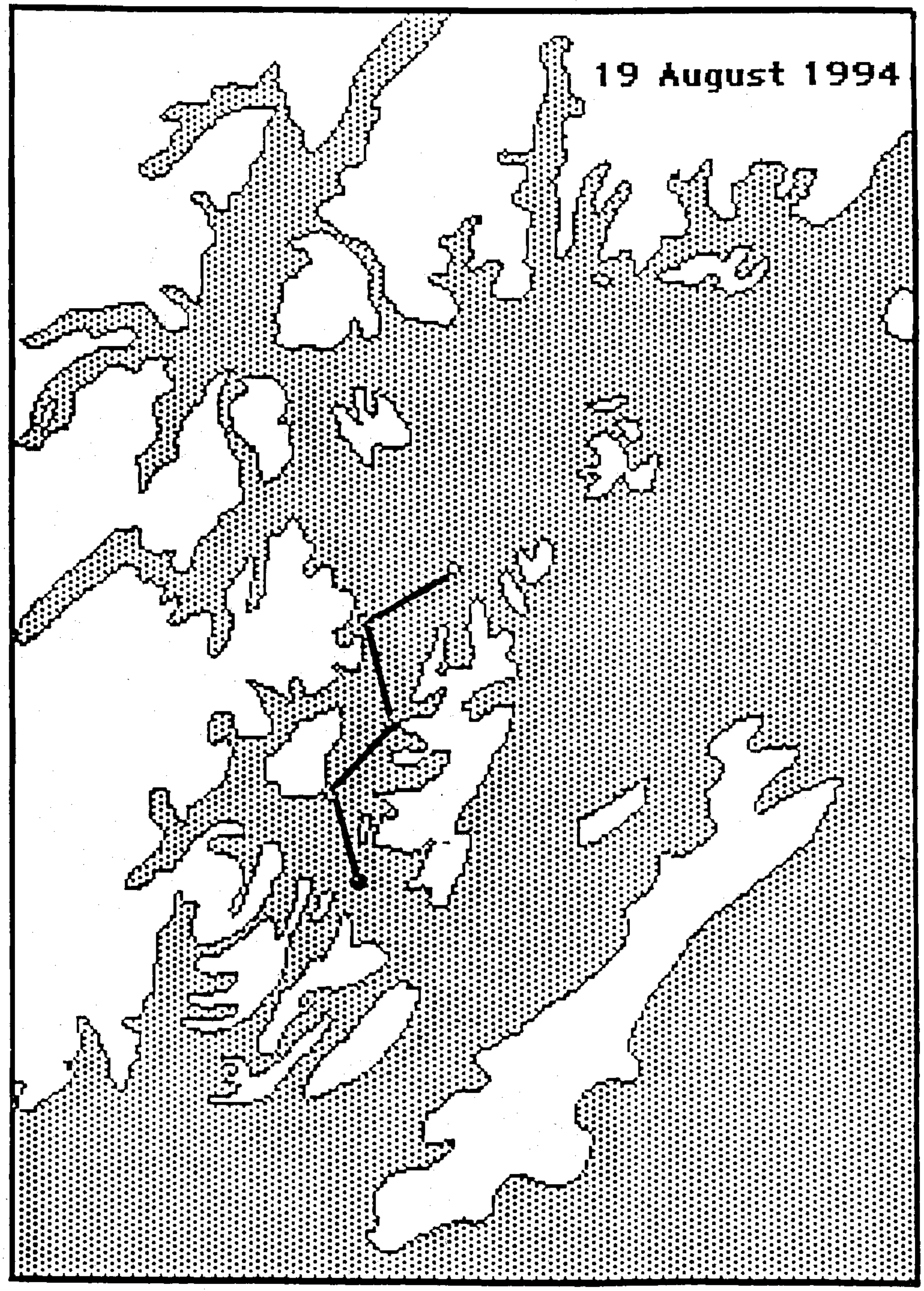


Figure 5. Hydroacoustic transects completed on 19 August in Prince William Sound during cruise FOR94-1.

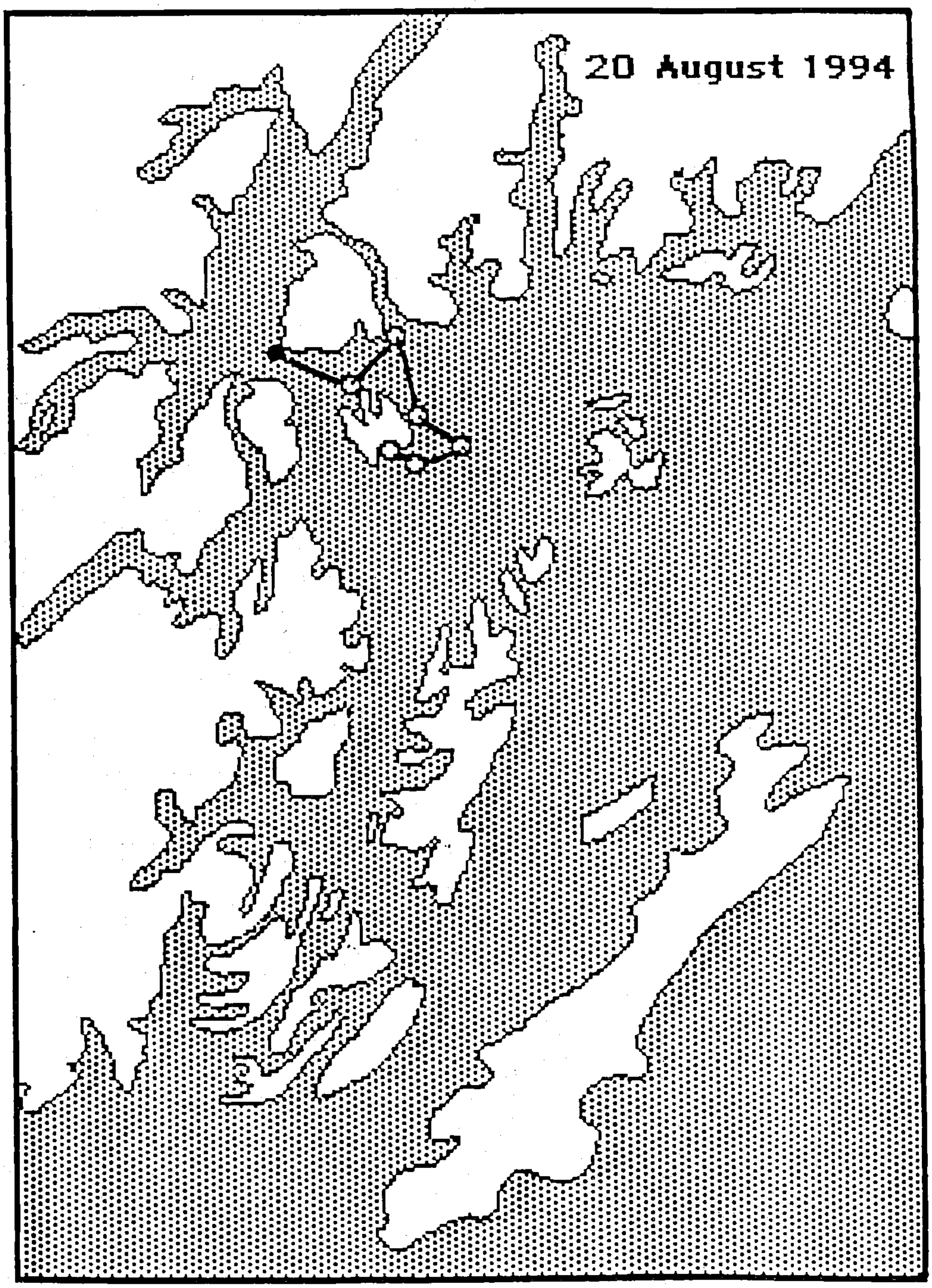


Figure 6. Hydroacoustic transects completed on 20 August in Prince William Sound during cruise FOR94-1.

CRUISE PLAN

PROJECT: Forage Fish Studies in Prince William Sound
VESSEL: R/V MEDEIA, Alaska Dept. of Fish and Game
AREA: Prince William Sound
ITINERARY: 3 November 1994 - Depart Cordova
15 November 1994 - Arrive Cordova

Participating Organizations:

School of Fisheries and Ocean Sciences
University of Alaska Fairbanks

Biosonics, Seattle

USFWS, Anchorage

Cruise Description and Objectives:

The Forage Fish Project is a joint effort by scientists at the University of Alaska Fairbanks (UAF) the National Marine Fisheries Service (NMFS), the U. S. Fish and Wildlife Service (USFWS) and the Alaska Department of Fish and Game (ADF&G) to understand how the distribution and abundance of forage fishes affects the population dynamics of piscivorous birds and marine mammals in the Prince William Sound (PWS) area. The objectives of this cruise are to: (1) conduct a hydroacoustic survey of the western part of PWS. (2) observe the distribution of birds and mammals in relation to small fishes and large zooplankton distributions, (3) Collect samples of acoustic targets to describe species composition and size distributions (4) assess the effectiveness of several midwater nets for collecting forage species, (5) Collect selected species for related studies by other investigators.

Personnel

Chief Scientist:

The Chief Scientist will be Ken Coyle, University of Alaska Fairbanks. [(907) 474-7705).

The Chief Scientist has the authority to revise or alter the technical portion of the cruise plan as work progresses provided that, after consultation with the Captain, it is ascertained that the proposed changes will not: (1) jeopardize the safety of personnel or the ship, (2) exceed the overall time allotted for the project, (3) result in undue additional expenses, (4) alter the general intent of the cruise plan.

Participating Scientists:

	NOV 3 - 7	NOV 8 - 11	NOV 12 -15
UAF Seward Marine Center -	2	2	2
UAF Juneau Center -	2	1	1
USFWS -	3	3	3
Biosonics -	1	1	1
NMFS -	1	2	
TOTAL	9	9	7

Schedule of Operations:

Scheduling of individual activities will depend upon weather conditions and progress of scientific work; therefore, firm advance scheduling of events will not be possible, and a continual dialogue between scientific and ships personnel will be important. Operations will be conducted 10 - 12 hours a day. with the vessel anchoring overnight in the study area. Each evening the Chief Scientist and the vessel Captain will meet to plan the activities for the coming day. On November 7 and 11 a chartered float plane will meet the vessel to provide changes of personnel. This flight will be scheduled to meet the vessel early on the morning, before the commencement of operations on those days.

Summary of Activities.

On each day, the vessel will conduct a series of hydroacoustic transects in one or more of ten quadrangles covering the western part of Prince William Sound (Figure 1):

1. Perry Island
2. Naked Island
3. Glacier Island
4. Knight Island Passage
5. Smith Island
6. North Montague
7. Bainbridge Island
8. Montague Strait
9. Green Island
10. Valdez Arm

The transects will be in a pattern of connected zig-zag legs through each area, terminating at shorelines as close as possible to the shore. Patterns to be run in each area will be determined in consultation with the vessel Captain, the Chief Scientist, and the senior biologist from the USFWS. The areas identified above are for planning purposes, and actual transect patterns may overlap two or more of the nine areas, depending on weather, vessel operating restrictions or scientific objectives. The order in which the quadrangle areas are sampled will depend on weather and other operational considerations.

In addition to the acoustic survey, a series of net samples will be collected during each days operations, weather permitting. At least one double-oblique haul of three gear types will be conducted in areas where acoustic transects have indicated the presence of possible forage species. The gear types are: (1) Tucker Trawl, (2) Methot Trawl (3) Mid-water herring trawl. In addition to the double-oblique hauls, the various gear types will be fished in directed sampling of selected acoustic targets. Net sampling will be conducted for 3 - 4 hours each day.

On each day of operations at least 3 CTD profiles of the water column will be collected. When possible, the stations will coincide with SEA program CTD stations.

Specimens will be collected from net sampling for gut content analyses by ADF&G, fatty acid composition studies by ADF&G, and stable isotope studies by SEA researchers.

ADF&G fatty acid Studies - 10 individuals, 15 - 25 cm. of pollock, herring, capelin, tomcod, Pacific cod, eulachon, and squid.

SEA stable isotope studies - up to 50 individuals of euphausids, glass shrimp, large copepods, eulachon, capelin and sandlance.

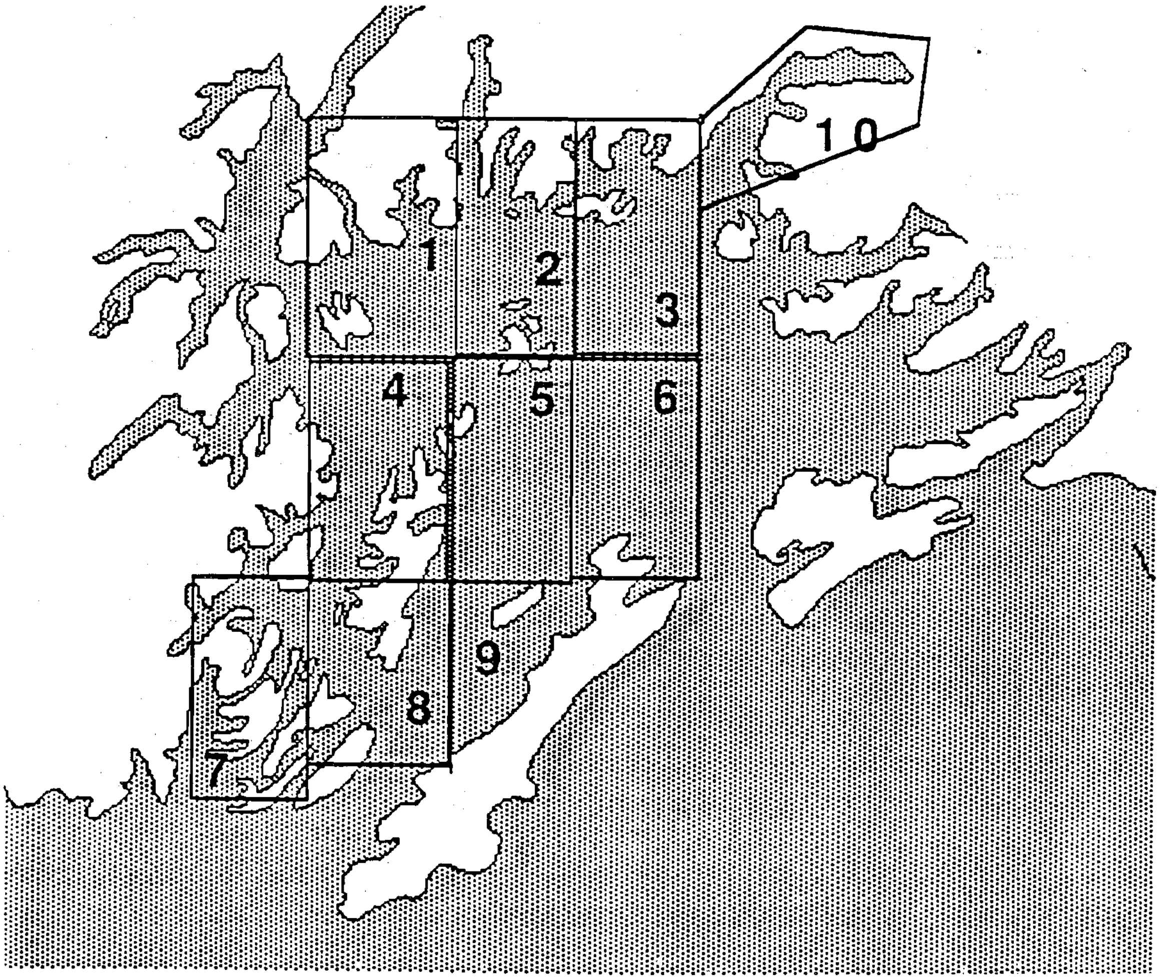


Figure 1. Location of study quadrangles in Prince William Sound.

CRUISE REPORT, FORAGE FISH, NOVEMBER 5 - 15, 1994

The major goals of the second Forage Fish cruise were the following: 1. Conduct a hydroacoustic survey of forage fishes at selected bird foraging sites in Prince William Sound; 2. Collect population data on birds and marine mammals along hydroacoustic survey transects; 3. Collect samples of acoustic targets to describe species composition and size distribution of forage fishes; 4. Assess the effectiveness of the midwater trawl, Methot trawl and Tucker trawl for collection of forage species; 5. Collect selected species for related studies by other researchers.

Hydroacoustic and bird population transects were run in Montague Passage, Knight Island Passage, Icy Bay, Dangerous Passage, Herring Bay, around Naked Island, Valdez Arm, Galena Bay, Port Gravina and the northeastern shore of Knight Island. Fish targets were generally confined to the side bays and shallow coves. There were very few fish targets observed along transects across the major passages. Major targets in the bays were concentrated in two layers: one near the bottom and another in midwater, usually about 20 m depth at night. The midwater layer was absent during the day; apparently the fish in midwater at night had descended to the epibenthic layer during the day.

Trawl samples were taken in Montague Strait, Icy Bay, Galena Bay and Port Gravina. Trawls were done through intense scattering layers near the bottom in Montague Strait and in Port Gravina. The epibenthic layers were composed almost entirely of adult and juvenile herring, with a few specimens of eulachon and pollock. The trawls through the midwater layer during the day in Icy Bay and at night in Galena Bay and Port Gravina were composed primarily of zero-age pollock. Length measurements were made on the fish, and portions were divided up for the various individuals and agencies requesting material.

Detailed CTD transects were done in Dangerous Passage, Galena Bay and Port Gravina. CTD data were also collected at the trawl sites. The water column was weakly stratified, with a temperature maximum usually occurring about 20 m depth, where pollock scattering layers developed at night. Temperature maxima usually occurred in the bottom water in the shallower bays.

The following recommendations are indicated, based on gear comparison and preliminary data work up:

1. A meter wheel is needed to deploy the CTD on 3/8" cable.
2. The Methot net was difficult to deploy and took very few fish. The larval fish taken by the Methot Net could be fished more effectively by the Tucker trawl with 1-mm mesh. In addition, the difficulty in deploying the Methot trawl makes its use highly weather dependent. We recommend replacing the Methot trawl with an Issac Kid trawl, which is easier to deploy and can be towed at higher speeds to reduce escapement.
3. Many of the targets seen in the shallower bays and inlets were too close to the bottom to be accessible to our gear during the day. A small bottom trawl or a net with roller gear would be desirable for sampling these populations. Since foraging birds were often present in the shallow bays, the epibenthic fish layers in these bays need to be sampled.

4. Additional collaboration with Biosonics personnel needs to be done to develop software for data recovery in ASCII format. This will permit real time data analysis and plotting using a variety of software, thus allowing us to more effectively target our net sampling efforts.

Enclosed are lists of the samples taken and acoustic-bird transects run.

FORAGE FISH NET
AND CTD LOG

ATE	START TIME	END TIME	STN NO.	HAUL NO.	GEAR	LOC	START LAT	START LONG	END LAT	END LONG	BOT DEP (M)	GEAR DEP (M)	CATCH
1/6/94	13:30	13:40	1	1	N	N GREEN IS.	60 18.75	147 24.60	60 18.87	147 25.50	73	100 WO	AMPHIPHODS
1/6/94	14:25	14:50	1	2	M	N GREEN IS.	60 18.73	147 25.57	60 19.25	147 24.21	70		JELLIES, AMPHIPODS; NO FISH
1/6/94	15:15	15:40	1	3	T	N GREEN IS.	60 19.09	147 24.35	60 18.256	147 27.43	80		JELLIES; FISHED UNEVENLY
1/6/94	16:05		1	0	CTD	N GREEN IS.	60 17.725	147 28.781			74	50	FORGOT TO EQUILIBRATE
1/6/94	19:17	19:32	2	1	N	MONTAGUE ST.	60 08.87	147 30.18	60 08.92	147 30.89	107	125 WO	EUPHAUSIIDS
1/6/94	19:42	20:00	2	2	N	MONTAGUE ST.	60 08.98	147 31.05	60 08.94	147 30.273	102	102	MUD HAUL! POLYCHAETES, CLAMS
1/6/94	20:28	20:41	2	3	N	MONTAGUE ST.	60 08.81	147 28.18	60 08.86	147 29.16	110	61	EUPHAUSIIDS
1/6/94	20:51	21:03	2	4	N	MONTAGUE ST.	60 08.91	147 29.67	60 09.06	147 30.77	106	61	EUPHAUSIIDS
1/7/94	13:25	14:05	3	1	T	NEEDLES AREA	60 03.44	147 36.02	60 04.13	147 35.48	130	95	HERRING, JELLIES
1/7/94	14:40	14:56	3	2	T	NEEDLES AREA	60 04.48	147 35.10	60 02.27	147 38.8	130	94	HERRING (~1000)
1/7/94	16:45	17:18	3	3	M	NEEDLES AREA	60 03.95	147 35.87	60 03.18	147 36.7	132	110	EUPHAUSIIDS, LARVAL FISH, 3 EULACHON
1/7/94	17:39		3	0	CTD	NEEDLES AREA	60 03.10	147 37.68			140	125	
1/7/94	19:42	20:00	4	1	N	PLEIADES IS.	60 11.975	147 55.42	60 11.96	147 56.42	437	250 WO	AMPHIPODS- KLINE
1/7/94	20:13	20:48	4	2	N	PLEIADES IS.	60 11.999	147 57.034	60 12.179	147 58.374	422	300 WO	EUPHAUSIIDS
1/7/94	20:57	21:23	4	3	N	PLEIADES IS.	60 12.291	147 58.478	60 12.579	147 58.810	455	300 WO	EUPHAUSIIDS
1/7/94	21:28	21:52	4	4	N	PLEIADES IS.	60 12.670	147 58.802	60 12.485	147 58.972	472	300 WO	EUPHAUSIIDS
1/8/94	10:40		5	0	CTD	ICY BAY	60 14.97	148 17.97			150	125	
1/8/94	13:09	13:45	5	1	M	ICY BAY	60 16.185	148 16.14	60 16.52	148 13.571	121-150	40-30	EULACHON, LARVAE, GARBAGE
1/8/94	14:03	14:12	5	2	N	ICY BAY	60 16.575	148 13.299	60 16.579	148 13.948	160	75 WO	PLEUROBRACHIA, EUPHAUSIIDS
1/8/94	14:18	14:28	5	3	N	ICY BAY	60 16.568	148 14.432	60 16.449	148 15.168	158	61	CTENOPHORES
1/8/94	14:42	14:51	5	4	N	ICY BAY	60 16.609	148 14.059	60 16.700	148 13.363	159	52	CTENOPHORES
1/8/94	15:32	15:51	5	5	T	ICY BAY	60 16.605	148 14.262	60 17.12	148 12.36	150-110	35-50	POLLOCK (61); LUMPSUCKER
1/8/94	16:21		5	1	CTD	ICY BAY	60 17.34	148 11.015			276	250	
1/9/94	11:39			0	CTD	EWAN BAY	60 21.224	148 6.84			40		CTD TRANSECT SERIES INTO EWAN BAY
1/9/94	11:54			1	CTD	EWAN BAY	60 21.715	148 6.567			60		CTD TRANSECT SERIES INTO EWAN BAY
1/9/94	12:14			2	CTD	EWAN BAY	60 22.125	148 7.051			94		CTD TRANSECT SERIES INTO EWAN BAY
1/9/94	12:34			3	CTD	EWAN BAY	60 22.645	148 7.615			102		CTD TRANSECT SERIES INTO EWAN BAY
1/9/94	12:52			4	CTD	EWAN BAY	60 23.024	148 8.04			85		CTD TRANSECT SERIES INTO EWAN BAY
1/9/94	13:10			5	CTD	EWAN BAY	60 23.526	148 8.512			64		CTD TRANSECT SERIES INTO EWAN BAY
1/9/94	13:22			6	CTD	EWAN BAY	60 23.87	148 8.89			40		CTD TRANSECT SERIES INTO EWAN BAY
1/10/94	16:31			0	CTD	LONG IS	60 40.48	147 40.72			750	250	NORTHERN KNIGHT ISLAND PASSAGE
1/10/94	22:42	23:10	6	1	T	GALENA BAY	60 56.44	146 37.29	60 56.49	146 40.08	100 15	15-20	POLLOCK, JUVENILE HERRING
1/11/94	10		6	1	CTD	GALENA BAY	60 56.72	146 38.6			112	100	CTD AT TRAWL SITE IN GALENA BAY
1/11/94	18:58			0	CTD	GALENA BAY	60 55.85	146 36.18			25		CTD TRANSECT INTO GALENA BAY
1/11/94	19:30			1	CTD	GALENA BAY	60 56.45	146 37.94			100		CTD TRANSECT INTO GALENA BAY
1/11/94	19:58			2	CTD	GALENA BAY	60 56.51	146 39.81			82		CTD TRANSECT INTO GALENA BAY
1/11/94	20:17			3	CTD	GALENA BAY	60 56.59	146 41.88			187		CTD TRANSECT INTO GALENA BAY

FORAGE FISH NET
AND CTD LOG

DATE	START TIME	END TIME	STN NO.	HAUL NO.	GEAR	LOC	START LAT	START LONG	END LAT	END LONG	BOT DEP (M)	GEAR DEP (M)	CATCH
11/11/94	20:48			4	CTD	GALENA BAY	60 57.37	146 43.14			211		CTD TRANSECT INTO GALENA BAY
11/11/94	21:12			5	CTD	GALENA BAY	60 58.21	146 44.36			207		CTD TRANSECT INTO GALENA BAY
11/11/94	21:45			6	CTD	GALENA BAY	60 58.68	146 46.00			380		VALDEZ ARM
11/11/94	23:33	0:06	6	2	M	GALENA BAY	60 55.92	146 36.67	60 56.66	146 38.67	40-100	20-12	1 POLLOCK,, 1 HERRING, SCYPHAZOANS
11/12/94	0:39	0:53	6	3	N	GALENA BAY	60 56.65	146 38.61	60 56.24	146 37.87	112	66	SMALL EUPHAUSIIDS, CYPHOCARIS
11/12/94	1:00	1:15	6	4	N	GALENA BAY	60 56.24	146 37.63	60 56.63	146 38.3	104	64	SMALL EUPHAUSIIDS, CYPHOCARIS
11/12/94	1:20	1:32	6	5	N	GALENA BAY	60 56.57	146 38.00	60 56.26	146 38.6	107	64	SMALL EUPHAUSIIDS, CYPHOCARIS
11/12/94	14:06			0	CTD	PORT GRAVINA	60 45.77	146 18.43			26		TRANSECT, ST. MATTHEWS BAY
11/12/94	14:17			1	CTD	PORT GRAVINA	60 44.78	146 19.28			40		TRANSECT, ST. MATTHEWS BAY
11/12/94	14:34			2	CTD	PORT GRAVINA	60 43.61	146 19.56			35		TRANSECT, ST. MATTHEWS BAY
11/12/94	14:50			3	CTD	PORT GRAVINA	60 42.56	146 20.03			27		TRANSECT, ST. MATTHEWS BAY
11/12/94	15:05			4	CTD	PORT GRAVINA	60 41.53	146 20.65			59		TRANSECT, ST. MATTHEWS BAY
11/12/94	15:20			5	CTD	PORT GRAVINA	60 40.48	146 20.79			89		TRANSECT, ST. MATTHEWS BAY
11/12/94	15:41			6	CTD	PORT GRAVINA	60 39.16	146 20.79			128		TRANSECT, ST. MATTHEWS BAY
11/12/94	21:10	21:24	7	1	N	PORT GRAVINA	60 39.35	146 21.63	60 39.92	146 21.85	124	70	EUPHAUSIIDS
11/12/94	21:30	21:40	7	2	N	PORT GRAVINA	60 40.09	146 21.88	60 40.46	146 21.81	91-60	60	NO EUPHAUSIIDS
11/12/94	21:56	22:09	7	3	N	PORT GRAVINA	60 39.64	146 20.69	60 40.06	146 20.95	175	70	EUPHAUSIIDS
11/12/94	22:33	22:55	7	4	M	PORT GRAVINA	60 40.06	146 20.92	60 39.23	146 23.05	118	15-21	POLLOCK, HERRING
11/12/94	23:25	0:05	7	5	M	PORT GRAVINA	60 38.15	146 24.25	60 39.57	146 21.54	113	80-40	POLLOCK, HERRING, EULACHON
11/13/94	13:09	14:14	8	1	M	PORT GRAVINA	60 36.37	146 33.99	60 38.1	146 28.81	100	50	SCYPHAZOANS
11/13/94	15:10	15:35	8	2	M	PORT GRAVINA	60 37.79	146 34.59	60 37.88	146 32.67	50	36	HERRING
11/13/94	16:15	17:00	8	3	M	PORT GRAVINA	60 39.42	146 25.87	60 41.02	146 22.10	40-50	30-35 M	HERRING, 5-15 M OFF BOTTOM
1/13/94	17:31			0	CTD	PORT GRAVINA	60 42.18	146 19.70			51		CTD TRANSECT OUT OF PORT GRAVINA
1/13/94	18:00			1	CTD	PORT GRAVINA	60 40.84	146 22.82			45		CTD TRANSECT OUT OF PORT GRAVINA
1/13/94	18:19			2	CTD	PORT GRAVINA	60 39.18	146 25.78			50		CTD TRANSECT OUT OF PORT GRAVINA
1/13/94	18:40			3	CTD	PORT GRAVINA	60 38.27	146 29.13			60		CTD TRANSECT OUT OF PORT GRAVINA
1/13/94	19:00			4	CTD	PORT GRAVINA	60 37.85	146 33.41			53		CTD TRANSECT OUT OF PORT GRAVINA
1/13/94	19:45			5	CTD	PORT GRAVINA	60 37.87	146 37.44			43		CTD TRANSECT OUT OF PORT GRAVINA
1/13/94	20:04			6	CTD	PORT GRAVINA	60 37.82	146 41.31			93		CTD TRANSECT OUT OF PORT GRAVINA
1/13/94	10:39			7	CTD	PORT GRAVINA	60 37.76	146 41.23			385		CTD TRANSECT OUT OF PORT GRAVINA
1/14/94	21:09		9	1	n	KNIGHT IS. PASS	60 39.52	147 38.37			585	500 M WO	BETWEEN NAKED AND LONG ISLANDS

FORAGE FISH
BIOSONICS TRANSECTS

FILE	DATE	TIME	LATITUDE	LONGITUDE	LOCATION
FOR2-2	6/11/94	10:00	60 17.0	147 19.0	MONTAGUE. GREEN ISLAND
FOR2-3	6/11/94	10:22	60 19.5	147 18.5	CHANGED SENSATIVITY - 100
FOR2-4	6/11/94	11:09	60 18.1	147 27.7	DATA GOOD TO ABOUT 100 M
FOR2-5	6/11/94	11:25	60 17.1	147 30.5	
ENDLINE	6/11/94	11:55	60 16.7	147 37.0	END MONTAGUE LINE
FOR2-6	6/11/94	16:43	60 16.6	147 37.7	
		17:19			
FOR2-7	6/11/94	17:23	60 15.0	147 44.0	MONTAGUE STRAIT
FOR2-7B	6/11/94	18:21	60 09.6	147 32.0	MONTAGUE STRAIT
FOR2-7C	6/11/94	18:51			MONTAGUE STRAIT
END	6/11/94	19:06	60 8.9	147 29.8	MONTAGUE STRAIT
FOR2-8	7/11/94	12:03	60 7.1	147 30.2	MONTAGUE STRAIT
END	7/11/94	13:08	60 8.1	147 38.1	
FOR2-9		19:40	60 11.9	147 55.2	
END		21:53			
FOR2-10	8/11/94	9:14	60 16.2	148 12.7	ICY BAY
FOR2-11	8/11/94	9:33	60 16.6	148 14.9	ICY BAY
FOR2-12	8/11/94	9:45	60 15.5	148 15.4	ICY BAY
FOR2-13	8/11/94	9:55	60 16.0	148 17.0	ICY BAY
FOR2-14	8/11/94	10:06	60 15.0	148 16.7	ICY BAY
FOR2-15	8/11/94	10:14	60 15.5	148 18.9	ICY BAY
END	8/11/94	10:24	60 14.8	148 17.9	ICY BAY
FOR2-16	8/11/94	16:48	60 17.5	148 11.1	ICY BAY TO JACKPOT BAY
END	8/11/94	17:31	60 21.0	148 13.7	
FOR2-17	9/11/94	8:32	60 20.6	148 12.9	DANGEROUS PASSAGE
FOR2-18	9/11/94	8:55	60 19.6	148 9.3	DANGEROUS PASSAGE
FOR2-19	9/11/94	9:23	60 21.6	148 6.6	EWAN BAY
FOR2-20	9/11/94	9:52	60 23.7	148 8.8	EWAN BAY
FOR2-21	9/11/94	10:08	60 22.4	148 7.2	DANGEROUS PASSAGE
FOR2-22	9/11/94	10:19	60 21.8	148 5.5	DANGEROUS PASSAGE
FOR2-23	9/11/94	10:32	60 23.0	148 4.5	PADDY BAY
FOR2-24	9/11/94	10:53	60 24.5	148 5.1	PADDY BAY
FOR2-25	9/11/94	11:12	60 23.0	148 4.4	DANGEROUS PASSANGE
END	9/11/94	11:24	60 21.8	148 5.5	END
FOR2-26	9/11/94	17:11	60 23.7	148 08.8	EWAN BAY FISH SURVEY
END	9/11/94	18:23	60 23.8	148 08.8	
FOR2-27	10/11/94	9:05	60 24.2	147 59.4	DANGEROUS PASSAGE
FOR2-28	10/11/94	9:21	60 23.8	147 58.0	KNIGHT ISLAND PASSAGE
FOR2-29	10/11/94	9:34	60 24.8	147 58.7	KNIGHT ISLAND PASSAGE
FOR2-30	10/11/94	9:49	60 23.9	147 56.8	KNIGHT ISLAND PASSAGE
FOR2-31	10/11/94	10:03	60 23.4	147 56.9	KNIGHT ISLAND PASSAGE

BIOSONICS TRANSECTS

FILE	DATE	TIME	LATITUDE	LONGITUDE	LOCATION
FOF2-32	10/11/94	10:18	60 27.7	147 54.6	KNIGHT ISLAND PASSAGE
FOR2-33	10/11/94	10:34	60 26.8	147 55.9	KNIGHT ISLAND PASSAGE
FOR2-34	10/11/94	11:27	60 29.2	147 46.1	HERRING BAY
END	10/11/94	11:59	60 26.6	147 46.5	
FOR2-35	10/11/94	14:05	60 37.9	147 29.0	NAKED IS., OUTSIDE BAY
FOR2-36	10/11/94	14:21	60 38.8	147 26.5	NAKED IS., OUTSIDE BAY
FOR2-37	10/11/94	14:43	60 38.4	147 29.9	TRANSIT TO CABIN BAY
FOR2-38	10/11/94	14:59	60 39.5	147 30.4	NAKED IS., CABIN BAY
END	10/11/94	15:29	60 40.2	147 29.7	
FOR2-39	10/11/94	21:41	60 56.1	146 37.2	GALENA BAY
END	10/11/94	22:21	60 56.6	146 37.7	
FOR2-40	11/11/94	9:03	60 55.8	146 32.2	GALENA BAY
END	11/11/94	9:25	60 56.5	146 38.9	STOPPED FOR PLANE
FOR2-41	11/11/94	9:56	60 56.4	146 38.4	GALENA BAY
FOR2-42	11/11/94	10:50	60 58.5	146 44.2	VALDEZ ARM
END	11/11/94	11:18	60 0.3	146 47.4	
FOR2-43	11/11/94	22:04	60 58.5	146 45.5	GALENA BAY
END	11/11/94	23:03	60 55.9	146 36.6	
FOR2-44	12/11/94	10:58	60 56.6	146 38.6	PORT GRAVENA
FOR2-45	12/11/94	11:48	60 38.7	146 32.2	PORT GRAVENA
FOR2-46	12/11/94	12:32	60 39.4	146 23.8	ST. MATTHEWS BAY
END	12/11/94	13:48	60 45.3	146 19.1	ST. MATTHEWS BAY
FOR2-47	12/11/94	19:48	60 45.9	146 18.3	ST. MATTHEWS BAY
END	12/11/94	20:57	60 39.4	146 21.0	PORT GRAVENA
FOR2-48	13/11/94	0:21	60 40.1	146 20.1	PORT GRAVENA
END	13/11/94	1:22	60 45.6	146 18.7	ST. MATTHEWS BAY