Fisheries and Oceans / Pêches et Océans

Canadian Stock Assessment Secretariat
Research Document 98/49

Secrétariat canadien pour l'évaluation des stocks
Document de recherche 98/49

Not to be cited without
permission of the authors[1]

Ne pas citer sans
autorisation des auteurs[1]

Distribution and Abundance of Atlantic Cod from the 1997 Div. 3KL Inshore Acoustic Survey

by

J. T. Anderson, J. Brattey, E. Colbourne, D. S. Miller,
D. R. Porter, C. R. Stevens and J. P. Wheeler

(Authors by alphabetical order)

Department of Fisheries and Oceans
Science Branch
P. O. Box 5667
St. John's NF
A1C 5X1

[1] This series documents the scientific basis for the evaluation of fisheries resources in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

[1] La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Research documents are produced in the official language in which they are provided to the Secretariat.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au secrétariat.

ISSN 1480-4883
Ottawa, 1998
Canada

ABSTRACT

An acoustic survey was conducted during the fall of 1997 to estimate the biomass of Atlantic cod (Gadus morhua) in the coastal waters of NAFO Div. 3KL. A biomass estimate of 18300 t was calculated for the survey area, approximately 60% of which was detected in Trinity and Bonavista Bays. Highest cod densities occurred in depths greater than 20 m and less than 150 m. A wide range of age classes were present in biological samples collected during the survey; however, very few were older than age 8 years. This paper also describes acoustic and biological survey design, technology, analysis procedures and an examination of sources of error.

RÉSUMÉ

Un relevé acoustique a été réalisé à l'automne de 1997 pour estimer la biomasse de la morue de l'Atlantique (*Gadus morhua*) dans les eaux côtières des divisions 3KL de l'OPANO. La biomasse a été estimée à 18 300 t dans la zone du relevé et 60 % de cette valeur était concentrée dans les baies Trinity et Bonavista. Les plus fortes densités de morue ont été décelées à des profondeurs se situant entre 20 m et 150 m. Une large gamme de classes d'âge étaient présentes dans les échantillons biologiques prélevés au cours du relevé, mais très peu de poissons étaient âgés de plus de 8 années. On trouve aussi une description du plan du relevé acoustique et biologique et des techniques et procédures d'analyse utilisées et les sources d'erreur font l'objet d'une discussion.

Table of Contents

1.0 Introduction and Overview

During the spring of 1997, the Gadoids Section of Science Branch, Newfoundland Region, recognized the need to independently estimate the biomass of cod in the coastal waters of NAFO Div. 3KL prior to the 1998 assessment of this stock. There had been many reports from the area of significant concentrations of cod close to shore, landward of the inner boundary of the traditional Science Branch bottom trawl survey. It was deemed impractical to extend the inner boundary of the bottom trawl survey due to the very rough bottom topography within the coastal zone. It was determined that an inshore acoustic survey could best provide a biomass estimate for this coastal zone. This estimate could then be used in an additive manner with that from the bottom trawl survey to derive an overall biomass estimate for the Div. 2J3KL cod stock.

A Working Group was formed in September 1997, consisting of members from various Divisions within Science Branch, Newfoundland Region. The mandate of the Working Group was to design and conduct an acoustic survey to estimate the biomass of cod and herring in the coastal waters of Div. 3KL during the fall of 1997. Sub-groups were formed to arrange for vessels and equipment, to develop the acoustic survey design, to determine biological sampling criteria, and to examine potential sources of error.

In planning the survey, the Working Group relied heavily upon previous acoustic surveys within the area. Inshore herring acoustic surveys had been conducted in Div. 3KL since the 1980's (Wheeler et al. 1997). Small scale cod acoustic surveys had also been conducted in recent years (Rose 1996, Brattey and Porter 1997, Porter et. al. 1998). However, technically and logistically, the current survey was the most complex ever planned in the Newfoundland Region.

The Working Group identified five sources of variance associated with this and any acoustic survey: 1) target strength, 2) survey design, 3) biological data, 4) acoustic instrumentation calibration and stability, and 5) vessel avoidance. Within the survey area, there were also recognized exclusion zones, variable in area, which could not be acoustically surveyed. These included an area of approximately one meter above the bottom, near shore shallow water areas inaccessible to the acoustic survey vessels, areas of steep bottom topography affected by acoustic shadowing and a surface zone of approximately eight meters as the transducer was towed three meters below the surface and data acquisition began five meters below the transducer. Some of the sources of variance, such as that associated with survey design, could be quantified. Others, such as the bottom and near shore exclusion zones could be examined. However, many of the sources of variance, variable in magnitude and direction, could not be estimated.

The survey commenced on October 6, 1997 at Cape St. Mary's, St. Mary's Bay and proceeded northward, concluding at Great Harbour Deep, White Bay on December 14, 1997. It included the majority of the coastal zone of NAFO Div. 3KL with the exception of the northern part of White Bay (Fig. 4.1.1).

This paper describes the acoustic and biological survey design, technology, analysis procedures, and results specific to Atlantic Cod. Results include: a biomass estimate, distributional and density information, and an examination of sources of error.

2.0 Materials and Methods

2.1 Vessels

Five vessels were used to conduct the survey, three acoustic platforms and two biological sampling platforms. The *Louis M. Lauzier*, a 37.1 m Department of Fisheries and Oceans research vessel, was used as an acoustic platform for the entire survey, from October 6th to December 14th. The *Shamook*, a 24.4 m Department of Fisheries and Oceans research vessel, was used as an acoustic platform from November 1st to December 14th and the *Hood*, a 23.2 m Department of Fisheries and Oceans Coast Guard vessel, was used as an acoustic platform from October 18th to 21st. Two commercial fishing vessels were chartered for the entire survey to conduct biological sampling, the *Sea Gem*, a 19.8 m otter trawler, and the *Andrew and Nicholas*, 15.9 m purse seiner.

2.2 Acoustic Survey Design

2.2.1 Definition and Stratification of the Survey Area

The survey area was defined to include inshore waters from White Bay to St. Mary's Bay. The inner survey boundary was defined as the coastline although it was recognized that the acoustic vessels could not survey contiguous to the coast. The outer boundary, in open coastal areas, was defined as the 120 m depth contour or 5 n.mi. offshore (whichever occurred first). In all areas the outer boundary overlapped the depth zones included in the offshore bottom trawl survey (Murphy et al. 1997). Within the bays, inlets and fjords, all waters to 500 m depth were included in the survey area. The defined survey area was calculated to be 13550 km^2.

The survey area from White Bay to St. Mary's Bay was divided into 55 geographically based strata (Table 2.2.1). Strata were defined as areas of low, low to medium, medium, medium to high, and high density for cod based upon distributional information from a previous survey (Wheeler and Miller 1997) and from information derived from the sentinel fishery. Acoustic sampling intensity (total n.mi. surveyed) was allocated proportionally (1.0:1.5:2.0:2.5:3.0) to each of these strata categories based upon stratum area. A second level of stratification, based upon geographical considerations, was then overlaid on the density stratification. Strata were defined as being easy, moderate, or hard to survey based upon considerations such as coastline exposure and obstructions (eg: islands). An acoustic sampling ratio of 2.0:1.5:1.0 (easy, moderate, hard) was overlaid on the first level of stratification. Essentially, this meant that acoustic sampling intensity (n.mi. of transects) was apportioned to a stratum based upon a combination of assumed fish density and geographical considerations in relation to the stratum area.

2.2.2 Multi-start Systematic Design

Initial discussions in planning the survey centered on a systematic survey design, with equidistant parallel transects. A systematic design was considered advantageous as it allowed for the estimation of mean backscatter and for the provision of distributional information of the target species throughout the survey area. However, a variance estimate could not be calculated from a simple systematic design. Therefore, it was decided to use a multi-start systematic design in which each stratum was sub-divided into blocks with equal number of parallel transects per block. Placement of the transects were randomly selected in the first block but were defined by this placement in the remaining blocks. Therefore, the number of random sampling units in a stratum was determined by the number of randomly selected transects in the first block. It was concluded that a multi-start systematic design was a good compromise for this survey as it allowed for survey based variance estimation while maintaining a semi-systematic approach. This was considered to be important given the exploratory nature of the survey for cod and the importance in obtaining distributional information throughout the survey area.

2.2.3 Apportionment of Acoustic Sampling

To determine the transect coverage per stratum, it was first necessary to determine the expected transect coverage for the survey period. Given two acoustic vessels for most of the survey period, an estimate of 20 n.mi. of transects per vessel per day, and an estimate of 30% downtime due to weather, vessel delays, crew changes etc. (Wheeler et al. 1997), the total transect coverage was calculated to be 1900 n.mi.

The expected transect coverage per stratum (n.mi.) was then calculated from the estimate of total transect coverage for the survey and the rate of sampling intensity for the stratum (Table 2.2.1). The expected number of transects per stratum (Table 2.2.2) was calculated from the expected transect coverage in the stratum and the estimate of mean transect length in the stratum. In some cases, the expected number of transects in a stratum had to be adjusted (+/- 1) to allow for the calculation of the number of multi-start blocks in the stratum. The number of multi-start blocks in a stratum and the number of transects per block were pre-determined based upon the number of transects which had to be surveyed within the stratum. The guiding principle for the multi-start design was to equalize the number of blocks within a stratum and the number of transects within a block. The size (ie. length) of a block within a stratum was calculated from the total baseline length within the stratum and the number of blocks within the stratum. The placement of transects within the first stratum block was chosen randomly along the baseline with transects placed perpendicular to the baseline. The placement of transects within the remaining blocks followed the same sequence as in the first block. There was one stipulation in the random placement of transects. Adjacent transects could not be any closer than 0.2 n.mi., estimated from previous surveys to be the navigational precision of the survey vessels.

Using the above design, the average transect separation from White Bay to St. Mary's Bay was approximately 2 n.mi. For strata defined as high density areas, this average distance was reduced to approximately 1.25 n.mi. given the increased weighting for these strata. In planning the survey, it was concluded that the acoustic sampling coverage based upon this survey design was acceptable to estimate mean backscatter and a variance estimate based upon survey design.

2.2.4 Acoustic Sampling Protocol

In planning the survey, consideration was also given to the most effective deployment of the two acoustic vessels and the two biological sampling vessels. It was determined that all vessels should remain in reasonably close proximity throughout the survey, certainly within strata. It was further decided that the acoustic vessels should survey alternate transects or groups of transects within the stratum in a sequential manner. By surveying adjacent transects concurrently, the risk of detecting the same fish twice was reduced. It was also considered important that the two biological sampling vessels remain in close proximity to the two acoustic vessels as one was equipped for purse seining and the other for bottom trawling. There were also safety considerations in keeping the vessels in close proximity when working close to shore.

2.3 Biological Sampling Design

The objectives of the biological sampling were: 1) to obtain an unbiased estimate of the mean length and weight of cod in each stratum, 2) to determine the species composition of acoustic targets, 3) to verify the density of acoustic targets, and 4) to provide information on the distribution, age composition, and maturities of cod in the survey area.

The *Sea Gem* was equipped with a small otter trawl (IC 300) with the cod-end lined with 0.25" mesh. Standard trawl mensuration was conducted with Scanmar gear to estimate swept volumes for each tow. Tows were generally limited to a maximum of 15 min duration and, whenever possible, were run directly behind the acoustic vessel; some tows were conducted perpendicular to transect lines in narrow fjords. Both the *Sea Gem* and the *Andrew and Nicholas* were equipped with standardized hand-line gear comprising a Norwegian jigger and four feathered hooks. Hand-line sets were designated as 15 min jigging by four persons, or the time required for four persons to catch 30 fish, whichever occurred first. Both vessels were also equipped with gill nets and line trawls, but these were rarely deployed during the survey and are not discussed any further in this report. One experienced Department of Fisheries and Oceans technician accompanied the crews of the fishing vessels at all times.

Biological sampling was conducted only on transect lines and as soon as possible after acoustic sampling. Biological sampling was dispersed within a stratum as much as logistic constraints (time, depth, and bottom topography) would permit and was designed to include areas of zero, low, medium, and high acoustic densities. In general, sampling in shallow water (<50 m) was done mainly with hand-lines, and in deep water (>50 m) mainly with the otter trawl. It was not possible to conduct fishing on every transect, but the majority of transects were sampled.

Biological sampling was conducted using similar procedures and data recording forms as in research vessel trawl surveys. Fishing set numbers were assigned sequentially for each vessel. Length frequencies of all cod were recorded, except for large trawl sets which were randomly sub-sampled (minimum 150 fish). All cod, except those required for age analysis, were returned to the water alive. Weights of individual fish were recorded to the nearest gram when weather conditions permitted. Otoliths were collected in a length-stratified manner to a maximum of two per 1 cm length group per bay. Sex and maturity were also recorded from fish sampled for otoliths. Stomach fullness and percent major food items were also recorded. Numbers and estimated weights of all other fish and invertebrates were also recorded.

2.4 Acoustic Technology and Calibration

2.4.1 Technology - Power 38/49

The two primary acoustic data acquisition systems used on the *Lauzier*, *Hood* and *Shamook* were composed of a Power 38/49 echosounder, a Femto model 9001 digitizer, and a personal computer (PC).

The sounder components were: Edo Acoustics Corporation model SP303LT-38 transducer (38 kHz., 7 degree beam width) mounted in an underwater towed vehicle, 50 meter tow cable, 50 meter deck cable, Cable/Transceiver Interface Unit, Instruments Inc. model S-14 transmitter (38/49 kHz), BioSonics model ES2000 receiver (38/49 kHz).

Underwater towed vehicles were deployed over the side of the vessels and towed at approximately three meters depth.

The echosounders were operated with 0.4 msec pulse width, 5 kHz bandwidth and a 4-400 meter TVG range. The detected 20 Log R output of each sounder was connected to the digitizer. The Femto Hydroacoustic Data Processing Software (version 5.5) was installed on the PCs to control the digitizers and log data to hard drives.

Throughout the survey, two digitizers (#1 and #2), were used with two sounders in four different combinations. The two sounders were known as the Even Sounder and the Odd Sounder. The Even Sounder was composed of components with serial numbers ending in an even digit while those of the Odd Sounder ended in an odd digit. The details of these configurations are documented in Table 2.4.1.

2.4.2 Calibration - Source Level and Receive Sensitivity

The combined Source Level and Receive Sensitivity (CALDB) of each sounder was calculated through measurements made on standard targets. The Calibration Sphere Positioning System developed by the Hydroacoustics Section, Science Branch, Newfoundland Region, was used to position a standard target on the transducer's acoustic axis at a range of 15 meters below the transducer face. CALDB estimates are given in Table 2.4.2.

2.4.3 Calibration - Receiver Fixed Gain and TVG Performance

The fixed gain and TVG performance of each echosounder/digitizer combination were calculated from measurements made during and/or after the survey. Measurements were made by injecting continuous carrier signals of known amplitudes into the receivers and digitizing the detected output signals with the respective Femto units. For each echosounder/digitizer combination, data were analyzed to compute a mean fixed gain value and a table of TVG correction factors appropriate for one-meter intervals from 5 to 500 meters. Fixed gain estimates are given in Table 2.4.1.

2.5 Oceanographic Technology

XBT data were collected with a Sippican XBT-07, with an accuracy of 0.02 °C. Profiles were obtained in water depths ranging from approximately 20 m to 300 m depth. An attempt was made to cover water depths of 20, 40, 60, 80, 100, and greater than 100 m depth in each survey stratum.

2.6 Examination of Sources of Error - Near Shore Exclusion Zone

2.6.1 Survey Design

The objective of the near shore survey component was to estimate the densities of cod which occurred in shallow depths near the shore, under the assumption that fish densities would be underestimated by the survey ships, *Shamook* and *Lauzier*. This underestimation would occur either because the survey ships could not maneuver close to shore or because of ship avoidance in shallow waters.

The near shore survey utilized a smaller boat, the 12.8 m *Shanadithii II* as an acoustic platform. The primary survey design was to sample the ends of transects, within a sub-section of the overall survey area, maneuvering as close to shore as possible. The secondary survey design was to sample along the shoreline, as close to shore as possible, in order to estimate the densities of cod and the extent of their alongshore distributions. The near shore survey was confined to the southern part of Bonavista Bay for operational reasons. These included: the persistent reports from people in Bonavista Bay of the abundance of cod close to shore, the availability of the *Shanadithii II* from Terra Nova National Park, current research being conducted on cod in southern Bonavista Bay, and the limited resources allocated to this component of the inshore acoustic survey.

2.6.2 Technology - BioSonics Model 105

A BioSonics model 105 echosounder, a Femto model 9001 digitizer and PC were used aboard the *Shanadithii II* for the near shore survey in Bonavista Bay. The sounder components were: International Transducer Corporation model 5344 transducer (120 kHz, 6 degree beam width) mounted in an underwater towed vehicle, 100 ft tow cable, 100 ft deck cable, and a BioSonics model 105 transceiver (120 kHz). The transducer was deployed in a Vemco 0.5 meter V-fin; deployment was mid-ship, starboard side and the v-fin was towed at a depth of approximately 1.5 meters. The echosounder was operated with 0.4 msec pulse width (5 kHz bandwidth) and a 2-200 meter TVG range. The detected 20 Log R output of the sounder was connected to the digitizer. The Femto Hydroacoustic Data Processing

Software (version 5.5) was installed on the PC to control the digitizer and log data to a hard drive.

3.0 Analyses

3.1 Acoustic Data Editing

Acoustic data were edited using Femto hydroacoustic data processing system (HDPS) software. The data editor provides an interface between the collection and processing phases of hydroacoustic data. It uses a set of custom algorithms which provide the ability to replay an acoustic file and remove portions of the data that are not appropriate for analysis. The programs allow for the removal of such things as bottom, shadowing, and unwanted species. It is totally visual and thus shows how the data are affected by the editing process. The editor also provides a series of icons (geometric shapes) and four bottom removal algorithms that highlight the areas of interest for removal. The bottom removal algorithms allow for the removal of bottom without removing any species of interest. The range scale (zooming) of the transect can also be changed so that accurate removal of unwanted data is possible.

For this survey several types of information were collected to help determine which species were recorded acoustically. A detailed log was kept for each transect which included such data as time, depth and accurate species descriptions. A high-resolution paper echogram was created from the acoustic data and used to study details of single targets observed close to the bottom. Fishing sets were completed along each transect which provided immediate identification of what was being observed acoustically. All these data were utilized during the editing process. One operator was assigned the task of editing all data collected to ensure consistency in the editing process. These sources of information greatly helped reduce the amount of subjectivity in species identification.

Acoustic data were stored digitally in single files that represented an individual transect.

The editing procedure involved four steps: bottom identification and removal, removal of bottom artifacts, water column editing, and creation of data files for each species.

Bottom was detected automatically during data collection within set parameters (e.g. bottom window, bottom threshold). Additional data samples were collected below the detected bottom which provided the operator with a better visual representation of the bottom. An algorithm was used to remove a fixed distance from the bottom of the data samples. This method provided consistency and easy verification of how much bottom echo was removed. Removal of the same amount of bottom samples from file to file allowed for the efficient identification of fish that were close to the bottom.

Bottom artifacts such as shadowing along steep topography and second bottom echoes were then removed. The first step removed all samples to the detected bottom. It was then used again to remove a smaller portion of an area where fish were close to the bottom. Smaller amounts (<0.5 m) were removed to ensure that no bottom signal was included in the data to be processed. A polyline editing tool, which allowed an irregular shape to be highlighted for removal, was used to remove artifacts such as shadowing. Other icons (circles and rectangles) were also used to remove second bottom echoes.

Once the bottom was successfully removed, the focus changed to the remaining water column which contained the species of interest plus anything else recorded by the echosounder, (e.g. propeller noise, plankton, etc.). Using the available icons, everything except the species of interest was removed.

Modified data files were then created containing only the species of interest. These files were then ready for further analyses.

3.2 Target Strength Estimation

A single target strength value was calculated for each stratum as follows. The mean length of cod was calculated for each trawl and/or hand-line set. The mean length of cod by transect was calculated as the mean of the mean lengths from each fishing set on that transect. A comparison of this mean versus the arithmetic mean indicated there was no difference (Figure 3.2.1). A standardized mean acoustic backscatter was calculated to provide a relative index for each transect within a stratum (Table 3.2.1). This was then used as a weighting factor to calculate the weighted mean length of cod by stratum (Len_{cm}) from the mean lengths by transect. Target strength for each stratum (in dB/g) was then calculated using a target strength - fish length regression for cod (Rose and Porter 1996) and a cod length – weight relationship calculated from samples collected during the survey:

$$TS_{dB/g} = (20\log_{10}(Len_{cm})-66) - 10\log_{10}(0.000009129496 * Len_{cm}{}^{3.009841}) - 30$$

These calculations are shown in detail in Table 3.2.1.

3.3 Acoustic Data Integration

Cod density (in g/m^3) was estimated using the following formula:

$$density_{g/cubic\ meter} = V_R{}^2\ K$$

where V_R is the average rms. voltage at depth R and K is as follows:

$$K = 10^{-(Rs+Tx+Bf+TS+Go+10\log(c t \pi))/10}$$

Rs is the transducer receiving sensitivity in decibels
Tx is the transducer source level in decibels
Bf is the average expected beam pattern for the transducer in decibels
TS is the target strength per gram in decibels
Go is the fixed gain of the echo sounder in decibels
c is the speed of sound in seawater in meters/second
t is the pulse length of the echosounder

Cod density (in g/m^2) of surface area was then calculated by summing the estimates of cubic meter densities over the depth of the acoustic sampling.

Data were integrated to provide estimates of cod density by one minute intervals, for entire transects, and for randomized sampling units. Mean densities, variances, and biomass estimates were calculated using the formulas described in Wheeler (1991).

3.4 Oceanography

A total of 233 temperature profiles were collected during the survey. After data quality control and editing, the profiles were sorted by bay and bottom temperatures extracted. In addition, a group of stations that best approximated a straight line from near shore out to the deeper sections of the bay were selected and used to form a vertical cross section of the temperature field for each bay. Insufficient data were available from the White Bay to complete any analysis.

4.0 Results

4.1 Distribution of Acoustic Transects and Biological Sampling

658 acoustic transects, totaling 1600 n.mi., were surveyed in the coastal waters from St. Mary's Bay to White Bay (Figure 4.1.1). Sample sizes ranged from 4 transects (two random sampling units) per stratum in several strata to 28 transects (four random sampling units) in stratum 38 (Figures 4.1.2 - 4.1.8). All 55 strata were acoustically sampled.

Biological samples of cod were collected from 422 transects using the trawl and/or hand-lines (Figures 4.1.2 - 4.1.8). This represented 77% of the transects on which cod were detected.

4.2 Length and Age Distributions of Sampled Cod

A total of 200 trawl sets and 418 hand-line sets were conducted during the survey (Table 4.2.1) and length measurements were obtained from over 11,000 cod. Sampling was well distributed throughout the surveyed area, with the number of otter trawl sets ranging from 7 to 43 per bay, and the number of hand-line sets ranging from 18 to 98. With the exception of White Bay where few cod were encountered, the number of length measurements taken per bay was generally high, ranging from 662-1791 for the trawl and 96-1642 for hand-lines. Over 800 otoliths were also taken to investigate the age composition of cod sampled in each bay.

Among otter trawl catches, the length frequencies of sampled cod were variable among bays (Figure 4.2.1). Larger fish with modes at 45-60 cm dominated the catches in the more northerly areas (Notre Dame Bay and Bonavista Bay). Smaller cod with modal lengths around 25-35 cm were seen in all bays, but dominated the catches south of Bonavista Bay. The trawl caught few cod smaller than 20 cm or larger than 80 cm.

Among the hand-line catches, the length frequencies were generally unimodal with large fish (40-70 cm) dominating the catches (Figure 4.2.2). However, there was some evidence of a much smaller second mode at 30-35 cm in St. Mary's Bay and to a lesser extent in Notre Dame Bay, Conception Bay and along the Southern Shore. Comparison of length frequencies between the two gears suggested that the catchability of small cod (<35 cm) was much lower with the hand-lines. However, it should be noted that the hand-lines tended to fish only in shallow water (<50 m) and the differences could partly be due to the different locations fished by each gear.

Age compositions of cod catches within each bay, weighted by the length frequency, were also constructed for each gear type (Figures 4.2.3 and 4.2.4). Among trawl catches a wide range of age classes was present (mostly ages 2-7 years). Age compositions were heterogeneous among bays. In the trawl catches, there was no evidence of any dominant age classes throughout the surveyed area, although fish aged 2 and 3 years were common among catches in all bays. Larger cod were mainly ages 5-7 years, with very few cod older than age 8. There were some differences in size at age among bays. The hand-line catches were dominated by age 5 fish in all bays, although fish aged 3 and 4 years were often well represented.

4.3 Biomass Estimation

Biomass estimates were calculated for each stratum; these were then summed to calculate a biomass estimate for the entire survey area (Table 4.3.1). To derive the stratum biomass estimates, integrated densities (g/m^2) were calculated for each of the random sampling units within the stratum. These were then weighted to account for differences in transect lengths in the random sampling units. A mean weighted stratum density was then calculated; this was extrapolated to the stratum area to estimate the stratum biomass (t). The results of the strata by strata calculations are summarized in Table 4.3.2. A biomass estimate of 18340 t was calculated for the survey area, of which approximately 61% was derived from Trinity and Bonavista Bays. Cod were detected in all strata, none of which accounted for greater than 10% of the estimated biomass. Consequently, the coefficient of variation based upon survey design was low (0.123).

4.4 Distribution of Cod Density

Cod were detected on 83% of the acoustic transects. Densities of cod (square root g/m^2) were plotted by transect for each of the seven geographical areas in the survey (Figures 4.4.1 - 4.4.7). Cod were neither widely distributed nor densely aggregated from St. Mary's Bay to Conception Bay (Figures 4.4.1 - 4.4.3). Cod were more widely distributed in Trinity Bay (Figure 4.4.4) but were mainly concentrated in the inner part of the bay and in the three western arms (Smith Sound, Northwest Arm and Southwest Arm). Cod were also widely distributed throughout Bonavista Bay (Figure 4.4.5) but were not densely aggregated in any area. The distribution of cod in Notre Dame Bay (Figure 4.4.6) was patchy, with concentrations in the Fogo Island area, and in the Bay of Exploits and New Bay areas. There were very few cod detected in White Bay (Figure 4.4.7).

Although plotted on a transect-by-transect basis, densities for biomass estimation were calculated by sampling unit (Table 4.3.1). Densities for the 169 random sampling units throughout the survey ranged from 0.0 - 30.1 g/m^2 with a mean of 2.0 g/m^2. Mean densities were low throughout the survey and there were no continuous high density aggregations that extended over several miles.

4.5 Cod Densities by Water Depth

Summed and mean cod densities (g/m^2) by water depth were plotted in relation to the distribution of acoustic sampling by water depth for each of the seven geographical regions within the survey area (Figures 4.5.1 - 4.5.7). For most of the regions, the distribution of acoustic sampling by water depth was skewed towards depths less than 150 m. With the exception of White Bay, the minimum water depth sampled was less than 10 m below the transducer. Although cod were detected in shoal water (<20 m) in all areas, peak densities (summed and mean) occurred in depths greater than 20 m and generally less than 150 m.

4.6 Oceanography

At the start of the survey in St. Mary's Bay during early October, the water mass was characterized by an isothermal layer approximately 30 to 40 m thick at a temperature between 8.0 - 9.0 °C. As the survey progressed in time and moved further north the upper mixed layer cooled down to 3 - 4 °C in November in Bonavista Bay to 2.0 °C in Notre Dame Bay by December. A strong vertical gradient was present at approximately 60 - 80 m depths where the temperature decreased from about 5.0 °C to sub zero °C values in most regions. Minimum temperatures of less than -1.0 C were observed below 150 m depth. Horizontal temperature gradients were generally weak over all regions (Figure 4.6.1). The cold intermediate layer was not present in St. Mary's Bay, but extended from about 100 m to 250 m depth in Trinity and Notre Dame Bays, thus intersecting the bottom over most regions in this depth range. Temperatures in the deep channels of these bays increased to above 0.5 °C and reached above 2.0 °C in Notre Dame Bay below 300 m depth (Figure 4.6.2). Temperature measurements from Station 27 indicated that fall temperatures were slightly above normal in the upper water column (0 to 50 m depth), below normal from 50 to 100 m and near normal below 100 m depth (Colbourne, AFA WP 98 5/6-3).

Figure 4.6.3 shows the summed densities of cod over 0.5 m depth bins with the bottom temperatures superimposed for St. Mary's Bay to Notre Dame Bay. The horizontal dashed line indicates 0.0 °C. In St. Mary's Bay most of the cod were observed in water depths from 10 to 60 m where ambient temperatures ranged from 1.0 to 8.0 °C , the peak of the cod distribution occurred at about 42 m depth where the vertical temperature gradient was at a maximum. Below the thermocline where temperatures were near 0.0 °C, very few cod were observed. The scatter in the bottom temperatures at near constant depth is a measure of the spatial variations in the bottom temperature field over the bay. Along the Southern Shore and in Conception Bay, most of the observed cod were again found above and near the thermocline, the exception being the large biomass estimated at about 100 m depth along the Southern Shore, where temperatures were slightly below 0.0 °C. A similar, although somewhat weaker, association of cod occurrence in relation to the thermocline was observed in the bays on the northeast coast, Trinity Bay being the main exception, where a significant amount of cod occurred in the depth range of 100 to 200 m in water temperatures from –0.5 to –1.0 °C.

4.7 Examination of Sources of Error - Near Shore Exclusion Zone

4.7.1 Commonly Sampled Transects

A total of 18 transect lines sampled by the *Shamook / Lauzier* inshore acoustic survey were re-sampled by the *Shanadithii II* during the period November 14-28, 1998. These sampling dates ranged from two to eight days later than the inshore survey and were on average five to six days later. Due to the small distances at the end of each transect line not sampled by the *Shamook / Lauzier*, and the often confined areas in which the transects occurred, entire transect lines were re-sampled versus simply sampling the ends. These commonly sampled transects occurred in Strata 31-33 in the southern part of Bonavista Bay (Figure 4.7.1).

Comparisons of the inshore (*Shamook / Lauzier*) and near shore (*Shanadithii II*) data sets demonstrated that waters < 10 m water depth were not sampled by the inshore survey (Figure 4.7.2). However, mean densities of cod sampled by the near shore survey for all areas <10 m depth were very low, averaging 0.044 g/m^2. This density was significantly lower than densities measured between 10-70 m by the near shore survey. This result was consistent for all transect lines, demonstrating that significant cod densities did not occur within the near shore exclusion zone not sampled by the inshore survey.

Comparison of cod densities sampled in 10 m depth intervals demonstrated that much higher densities were sampled by the near shore survey, compared to the inshore survey, particularly between 10-70 m depth (Figure 4.7.2). This difference tended to occur among all transect lines, although the biggest difference was for transects 308-311, which occurred within Goose Bay (Figure 4.7.3).

For these commonly sampled transects, the inshore survey encountered cod 30.4% of the time while the near shore survey encountered cod 15.0% of the time. Density of cod sampled by the inshore survey averaged 3.135 g/m^2, and ranged from 0 to 338.17 g/m^2. For the near shore survey, density averaged 16.188 g/m^2 for the same transects, and ranged from 0 to 2117.56 g/m^2. These results indicate that cod were more dispersed at much lower densities during the inshore survey, compared to the near shore survey. On average, density during the near shore survey was 5.2 times higher than during the inshore survey.

The mean density sampled during the inshore survey equates to 0.0026 fish/m^2 (at 50 cm) while the upper density equates to 0.291 fish/m^2. These numbers indicate that one 50 cm fish occurred approximately every 385 m^2 (i.e. every 19.6 m x 19.6 m), while at peak densities one 50 cm cod occurred every 3.44 m^2. In comparison the near shore survey estimated, on average, there were 0.014 fish/m^2 (i.e. one fish every 8.5 m x 8.5 m) and at peak densities there were 1.8 fish/m^2.

The difference in densities measured by the inshore and near shore surveys persisted for different combinations of the data. For example, if transects were combined by different geographic areas, there was some fluctuation in the ratio, from 1.48 in inner Clode Sound to 6.18 in Goose Bay, but overall the average densities estimated by the near shore survey were 3.87 times higher.

4.7.2 Along Shore Sampling Lines

There are a number of important questions that must be addressed when assessing the abundance of fish using acoustic techniques. Some of these questions are technical in nature, involving such things as hardware calibrations, target strength estimation and the bottom exclusion zone. However, many other important questions include the distributions and behaviours of fish and how these characteristics affect both the way surveys are carried out and the way that data are interpreted. Of particular concern for this survey were the persistent reports by fishers of high concentrations of cod very near the coast. Accurate estimation of abundance requires a good understanding of fish distributions, in this case, how extensive were the concentrations of cod along the shore?

A number of inshore fishers were interviewed from five communities which spanned the southern part of Bonavista Bay (Figure 4.7.4). In each case, the fishers were asked about the local occurrence of cod near the coast and their observations were marked on a bathymetric chart. During the survey from the *Shanadithii II*, as much as possible, areas reported by these fishers to have high cod concentrations were sampled during the along shore sampling component of the near shore survey. A significant amount of along shore sampling was completed in the southern part of Bonavista Bay (Figure 4.7.4). High winds during the final week of the sampling period prevented any sampling on the eastern side of Bonavista Bay.

The areas sampled were divided into six discrete geographic locations, and cod densities (g/m^2) were mapped at a high resolution (Figures 4.7.5 - 4.7.10). It is apparent from these maps that concentrations of cod were highly aggregated along the coast and, in some cases, at high densities. However, the highest densities observed near the coast typically occurred where water depths were deeper. Overall, cod only occurred over 13.7% of the areas sampled, ranging from a low of 6.6% in Swale Island Tickle to a high of 28.8% in Goose Bay. This was consistent with the patchy distribution observed in the overall survey.

Analysis of the complete near shore data set demonstrated that densities of cod near the coast were low in shallow waters < 10 m depth, compared to densities measured at deeper depths (Figure 4.7.11). In all areas sampled, highest densities occurred between 20-60 m depth. At depths exceeding 70-80 m densities declined in all areas sampled.

4.8 Examination of Sources of Error - Bottom Exclusion Zone

From the outset of the survey, there was a concern that, due to their demersal nature, substantial densities of cod would not be detected and measured acoustically within the bottom exclusion zone (approximately 1 m above detected bottom). To examine this, an analysis was conducted to determine if any relationship existed between cod densities measured acoustically and cod densities from the otter trawl samples during the survey. A sample of 111 paired observations (acoustic and trawl densities) were available from St. Mary's Bay to White Bay, where acoustic densities were measured and the otter trawl was subsequently set on bottom and directly on the transect. Trawl densities (g/m^3) were calculated from catch numbers, mean lengths, the weight - length relationship calculated during the survey, the distance swept by the trawl and the trawl parameters (wingspread and opening) as calculated by Scanmar (B. McCallum pers. comm.). The acoustic densities (g/m^3) were calculated for the 4 m interval above bottom in those locations where the trawl had been set. A 4 m interval was chosen to match the height of the trawl opening. Logarithms (base 10) of acoustic and trawl densities were calculated; a value of 0.00001 g/m^3 was added to each data point prior to this calculation to eliminate 0.0 g/m^3 values.

The resulting plot (Figure 4.8.1) indicated that there was no significant relationship between the acoustic and trawl densities as there were multiple occurrences where acoustic densities up to 0.5 g/m^3 yielded no catch and similarly cases where acoustic densities of 0.0 g/m^3 yielded catches up to 0.5 g/m^3. However, where significant acoustic densities (>0.5 g/m^3) were measured, both trawl and acoustic sampling proportionally measured changes in cod densities throughout the trawlable areas of the survey. If the catchability of the *Sea Gem's* trawl were high (ie. ~1.0), it would suggest that the density of cod not detected acoustically in the bottom exclusion zone is low. Conversely, if the catchability of the trawl were low, then the density of cod in the bottom exclusion zone could be high. Unfortunately, it was not possible to measure the catchability of the trawl during the survey.

Mean densities within 4 m of the bottom (0.66 g/m^2), compared with mean densities above 4 m off bottom (0.013 g/m^2), indicated that the vast majority of cod detected during the survey were relatively close to the bottom. Similarly, when the 4 m window above bottom was divided in two; ie. 0 - 2 m and 2 - 4 m, cod densities from 0 - 2 m above bottom were 2. 5 times greater than from 2 - 4 m off bottom. This indicates that the density of cod increased closer to the bottom, suggesting that the density of cod in the bottom exclusion zone may be high. Although the non-detectability of cod in the bottom exclusion zone results in a negative bias in the acoustic biomass estimate, preliminary analyses indicate that it would not change the overall perception that cod were not abundant in the survey area.

5.0 Summary

- An inshore acoustic survey of NAFO Div. 3KL commenced on October 6, 1997 and finished on December 14, 1997, concurrent with the offshore bottom trawl survey.

- The survey area of 13550 km^2 included all coastal waters from Cape St. Mary's, St. Mary's Bay to Great Harbour Deep, White Bay.

- The inner boundary was defined as the coastline and the outer boundary in open coastal areas was defined as the 120 m depth contour or 5 n.mi., whichever occurred first; it also included all waters to 500 m within coastal inlets.

- The outer boundary overlapped depth zones included in the offshore bottom trawl survey.

- A multi-start systematic survey design was used with an average separation of 2 n.mi. between parallel transects for a total survey transect coverage of 1600 n.mi..

- The survey was conducted by four vessels, two vessels equipped with identical acoustic data acquisition systems and two commercial fishing vessels, chartered to conduct biological sampling.

- Biological sampling was conducted on transect lines only, normally by hand-lines in water depths less than 50 m and by otter trawl in depths greater than 50 m.

- A total of 200 trawl sets and 418 hand-line sets were conducted; length measurements were obtained from 11,100 cod, of which 830 were aged.

- A wide range of age classes was present in the biological samples, mostly ages 2 - 7 years; very few cod older than age 8 were caught.

- Acoustic backscatter was converted to biomass using Rose and Porter's (1996) target strength - fish length relationship and a length - weight relationship derived from biological samples collected during the survey.

- A biomass estimate of 18300 t was calculated for the survey area, with a C.V. = 0.12 based upon survey design alone.

- Most of the cod biomass was detected within 4 m of the bottom.

- There was no north to south cline in the pattern of population abundance; however, approximately 60% of the biomass was detected in Trinity and Bonavista Bays and only 3% in White Bay.

- Cod were patchily distributed throughout the survey area and mean densities were low. There were no continuous high density aggregations of cod that extended over several miles.

- Pelagic concentrations of capelin and herring were detected during the survey; no significant numbers of demersal species, other than cod, were detected.

- Highest cod densities occurred in depths greater than 20 m and less than 150 m.; this generally coincided with the warmer waters (>0 C) above and along the thermocline.

- Four exclusion zones were recognized within the survey area as potential sources of error: an area of approximately one meter above the bottom, near shore shallow water areas inaccessible to the acoustic survey vessels, a surface zone of approximately five meters above the transducer, and areas of steep bottom topography affected by acoustic shadowing.

- A separate near shore acoustic survey conducted in southern Bonavista Bay demonstrated that cod densities in shallow water (<10 m), not covered in the survey, were very low. However, densities from 10 - 70 m were consistently and substantially higher than the inshore survey. Potential reasons for this difference include temporal changes in cod distribution and behavior and vessel avoidance. To explain the higher densities due to fish movements requires a number of specific conditions to be met.

- Where significant acoustic densities were measured, both trawl and acoustic sampling proportionally measured changes in cod densities throughout the trawlable areas of the survey. At very low densities, there was no statistical relationship between trawl and acoustic sampling.

- There are sources of error and bias associated with the biomass estimate. The variance based upon survey design is low. Negative bias associated with the near shore exclusion zone appears to be very small. Negative bias associated with the bottom exclusion zone could not be quantified but does not appear to change the perception that cod were not abundant in the survey area. Positive and/or negative biases associated with fish behavior, vessel avoidance, acoustic shadowing, and target strength have not been quantified.

Acknowledgments

This survey could not have been successfully completed without the help and cooperation of many people.

We would like to extend our sincere thanks to the crews of the Department of Fisheries and Oceans vessels *Louis M. Lauzier*, *Shamook*, and *Hood* who did everything within their power to ensure that acoustic data were collected in an efficient and accurate manner.

We were very fortunate to secure the services of Gary Daley and the crew of the *Sea Gem* and Jack Greenham and the crew of the *Andrew and Nicholas* to collect biological samples during the survey. Their knowledge, dedication, and tireless efforts ensured that acoustic measurements were backed up by sound biological information throughout the entire survey.

In total, 31 scientific and technical staff participated directly in the survey and others provided background support. The survey was successful due to the collaborative and cooperative efforts of a diverse multi-disciplinary team; our sincere thanks to all of you.

References

Brattey, J. and D. Porter. 1997. An acoustic survey of Atlantic cod (Gadus morhua) from three inshore areas of western Trinity Bay (NAFO Div. 3L). NAFO SCR Doc. 97/49, 23 p.

Colbourne, E. 1998. Oceanographic conditions in the Newfoundland region in 1997. DFO Atl. Fish. Res. Doc. 98/29, 34 p.

Murphy, E. F., D. E. Stansbury, P. A. Shelton, J. Brattey, and G. R. Lilly. 1997. A stock status update for NAFO Div. 2J+3KL cod. NAFO SCR Doc. 97/59, 58 p.

Porter, D., J. Anderson, and J. Brattey. 1998. Acoustic surveys for cod in Trinity Bay and Bonavista Bay during spring 1997. DFO Atl. Fish. Res. Doc. 98/27.

Rose, G. 1996. Cross-shelf distributions of cod in NAFO Divisions 2J3KL in May and June 1995: some preliminary findings of a longer term study. NAFO SCR Doc. 96/57, 15 p.

Rose, G. A. and D. R. Porter. 1996. Target-strength studies on Atlantic cod (*Gadus morhua)* in Newfoundland waters. ICES Journal of Marine Science, 53: 259-265. 1996

Wheeler, J.P. 1991. Newfoundland east coast herring – 1990 acoustic survey results. CAFSAC Res. Doc. 91/1, 43 p.

Wheeler, J. P. and D. S. Miller. 1997. Distribution and abundance of Atlantic cod from an acoustic survey of Bonavista Bay - Trinity Bay during the fall of 1996. DFO Atl. Fish. Res. Doc. 97/81, 22 p.

Wheeler, J. P., G. H. Winters, and B. Squires. 1997. Newfoundland east and southeast coast herring - an assessment of stocks to the spring of 1996. DFO Atl. Fish. Res. Doc. 97/56, 67 p.

Table 2.2.1 1997 Div. 3KL inshore acoustic survey stratum areas, stratum categorization (by fish density and geographical topography), and acoustic sampling rate (percent of total acoustic sampling).

			Stratum Categorization			
			Fish Density		Geographical	
Area	Stratum Number	Stratum Area (sq. km)	Stratum Category	Sampling Rate (%)	Stratum Category	Sampling Rate (%)
SMB	58	775	High	8.39	Hard	6.07
SMB	57	142	High	1.54	Easy	2.23
SMB	56	73	Low - Med	0.39	Easy	0.57
SMB	55	279	Low - Med	1.51	Moderate	1.64
SMB	54	515	Low - Med	2.79	Hard	2.02
SMB	53	643	Low - Med	3.48	Hard	2.52
SS	52	485	Low - Med	2.62	Hard	1.90
SS	51	219	Low - Med	1.18	Hard	0.86
SS	50	137	Low	0.49	Hard	0.36
CB	49	308	Med - High	2.78	Moderate	3.02
CB	48	356	High	3.85	Moderate	4.18
CB	47	352	Low	1.27	Hard	0.92
TB	46	186	Low	0.67	Hard	0.49
TB	45	95	Low	0.34	Moderate	0.37
TB	44	164	Med - High	1.48	Easy	2.14
TB	43	142	Med - High	1.28	Easy	1.85
TB	42	181	Low - Med	0.98	Moderate	1.06
TB	41	64	Med - High	0.58	Easy	0.84
TB	40	94	Med - High	0.85	Easy	1.23
TB	39	95	Low - Med	0.51	Moderate	0.56
TB	38	106	High	1.15	Easy	1.66
TB	37	141	High	1.53	Moderate	1.66
TB	36	771	Low - Med	4.17	Hard	3.02
BB	35	297	Low - Med	1.61	Hard	1.16
BB	34	157	High	1.70	Moderate	1.85
BB	33	73	High	0.79	Easy	1.14
BB	32	96	High	1.04	Easy	1.50
BB	31	134	High	1.45	Moderate	1.57
BB	30	301	High	3.26	Moderate	3.54
BB	29	218	High	2.36	Moderate	2.56
BB	28	203	High	2.20	Easy	3.18
BB	27	294	High	3.18	Easy	4.61
BB	26	400	High	4.33	Hard	3.13
NDB	25	522	High	5.65	Hard	4.09
NDB	24	727	High	7.87	Hard	5.70
NDB	23	501	Low	1.81	Moderate	1.96
NDB	22	367	Low - Med	1.99	Moderate	2.16
NDB	21	164	Low	0.59	Moderate	0.64
NDB	20	126	Low	0.45	Moderate	0.49
NDB	19	178	Low	0.64	Moderate	0.70
NDB	18	243	Low - Med	1.31	Moderate	1.43
NDB	17	125	Medium	0.90	Easy	1.31
NDB	16	191	Low - Med	1.03	Easy	1.50
NDB	15	118	Low - Med	0.64	Easy	0.92
NDB	14	86	Medium	0.62	Easy	0.90
NDB	13	115	Low - Med	0.62	Moderate	0.68
NDB	12	110	Low - Med	0.60	Easy	0.86
NDB	11	104	Medium	0.75	Easy	1.09
NDB	10	88	Med - High	0.79	Easy	1.15
NDB	9	100	Low - Med	0.54	Easy	0.78
NDB	8	220	Low - Med	1.19	Moderate	1.29
WB	7	445	Low - Med	2.41	Hard	1.74
WB	6	85	Low	0.31	Moderate	0.33
WB	5	260	High	2.81	Easy	4.07
WB	4	205	Low	0.74	Moderate	0.80

Survey Area = 13576 km

Table 2.2.2 Apportionment of acoustic sampling intensity (n.mi. transects) and calculatio of the number of transects per stratum and stratum block for the 1997 Div. 3KL inshore acoustic survey.

Area	Stratum Number	Sampling Rate (%)	Average Transect Lgt (n.mi)	Expected Stratum Transects (n.mi.)	Expected Number of Transects in Stratum	Actual Number of Transects in Stratum	Number of Multi-start Blocks in Stratum	Actual Number of Transects per Block
SMB	58	6.07	6.5	115.6	18	18	6	3
SMB	57	2.23	2.5	42.4	17	16	4	4
SMB	56	0.57	1.6	10.9	7	6	3	2
SMB	55	1.64	4.7	31.2	7	6	3	2
SMB	54	2.02	5.0	38.4	8	8	4	2
SMB	53	2.52	3.7	48.0	13	12	4	3
SS	52	1.90	4.6	36.2	8	8	4	2
SS	51	0.86	2.2	16.3	7	6	3	2
SS	50	0.36	2.1	6.8	3	4	2	2
CB	49	3.02	3.8	57.4	15	15	5	3
CB	48	4.18	4.8	79.7	17	16	4	4
CB	47	0.92	3.2	17.5	5	4	2	2
TB	46	0.49	1.8	9.2	5	4	2	2
TB	45	0.37	2.0	7.1	4	4	2	2
TB	44	2.14	3.3	40.8	12	12	4	3
TB	43	1.85	2.8	35.3	12	12	4	3
TB	42	1.06	3.2	20.2	6	6	3	2
TB	41	0.84	0.9	15.9	18	18	6	3
TB	40	1.23	1.1	23.4	22	21	7	3
TB	39	0.56	3.3	10.6	3	4	2	2
TB	38	1.66	1.1	31.6	28	28	7	4
TB	37	1.66	3.3	31.5	10	10	5	2
TB	36	3.02	3.9	57.5	15	15	5	3
BB	35	1.16	3.4	22.2	7	6	3	2
BB	34	1.85	2.5	35.1	14	15	5	3
BB	33	1.14	1.2	21.8	18	18	6	3
BB	32	1.50	1.5	28.6	19	20	5	4
BB	31	1.57	2.4	30.0	12	12	4	3
BB	30	3.54	5.3	67.4	13	12	4	3
BB	29	2.56	2.7	48.8	18	18	6	3
BB	28	3.18	2.4	60.6	25	25	5	5
BB	27	4.61	4.5	87.7	19	20	5	4
BB	26	3.13	4.6	59.7	13	12	4	3
NDB	25	4.09	4.6	77.9	17	16	4	4
NDB	24	5.70	3.1	108.4	35	35	7	5
NDB	23	1.96	4.3	37.4	9	9	3	3
NDB	22	2.16	2.5	41.1	16	16	4	4
NDB	21	0.64	3.0	12.2	4	4	2	2
NDB	20	0.49	2.0	9.4	5	4	2	2
NDB	19	0.70	3.0	13.3	5	4	2	2
NDB	18	1.43	4.1	27.2	7	6	3	2
NDB	17	1.31	1.5	24.9	17	16	4	4
NDB	16	1.50	2.3	28.5	13	12	4	3
NDB	15	0.92	2.0	17.6	9	9	3	3
NDB	14	0.90	2.2	17.1	8	8	4	2
NDB	13	0.68	2.0	12.9	6	6	3	2
NDB	12	0.86	1.9	16.4	9	9	3	3
NDB	11	1.09	1.6	20.7	13	12	4	3
NDB	10	1.15	2.9	21.9	8	8	4	2
NDB	9	0.78	1.2	14.9	13	12	4	3
NDB	8	1.29	1.8	24.6	14	15	5	3
WB	7	1.74	4.2	33.2	8	8	4	2
WB	6	0.33	1.0	6.3	7	6	3	2
WB	5	4.07	3.3	77.6	24	24	6	4
WB	4	0.80	2.1	15.3	7	6	3	2

Total Transects = 1904.0 n.mi.

Table 2.4.1	Echosounder and Femto Model 9001 Digitizer Configurations.		
Vessel	**Dates**	**Components**	**Fixed Gain Estimate (dB)**
LAUZIER	6 - 9 Oct	Odd Sounder with Digitizer # 2	6.25
LAUZIER	10 Oct - 14 Dec	Even Sounder with Digitizer # 2	4.65
HOOD	14 - 18 Oct	Odd Sounder with Digitizer # 1	7.35
SHAMOOK	30 Oct - 03 Nov	Odd Sounder with Digitizer # 1	7.35
SHAMOOK	04 Nov - 14 Dec	Odd Sounder (Reduced Gain) with Digitizer # 1	-0.12
SHANANDITHI	13 - 28 Nov	Biosonics Model 105 (120 kHz) with Digitizer "RED DOT"	11.48
LAUZIER	04 - 14 Dec	Biosonics Model 105 (120 kHz) with Digitizer "RED DOT"	9.53

Notes:
1) Two Femto Digitizers, #1 and #2, were used with the Power 38/49 Echosounders.
2) There were two Power 38/49 Echosounders, known as the Even Sounder and the Odd Sounder.
3) The Even Sounder was composed of components with even serial numbers.
4) The Odd Sounder was built from components with odd serial numbers.
5) On 04 November, the receiver gain of the Odd Sounder was reduced by approximately 7 dB.

Table 2.4.2 Combined Source Level and Receive Sensitivity (CALDB) estimates for each echosounder.

Echosounder	Measurement Date	CALDB Estimate (dB)
Power 38/49 - Even Sounder	July 1997	64.73
Power 38/49 - Odd Sounder	July 1997	64.68
Model 105 Serial # 105-87-025	April 1997	42.32

Table 3.2.1 Calculation of weighted mean length, weight, and target strengths for cod from the 1997 Div. 3KL inshore acoustic survey.

Area	Stratum	Transect Number	Relative Index	Mean Length (cm)	Weighted Mean Length	Fish Weight (kg)	TS/Fish (dB)	TS/g (dB)
SMB	58	2	0.0124	45.81				
		3	0.0090	52.87				
		9	0.0000	49.00				
		12	0.0001	46.00				
		13	0.0000	7.00				
		16	0.0004	31.13				
		17	0.0005	35.80				
		18	0.0006	54.26	48.25	1.07	-32.3	-62.6
	57	20	0.0012	42.50				
		21	0.0022	40.69				
		22	0.0182	26.20				
		23	0.0610	49.83				
		25	0.0018	33.45				
		26	0.0029	54.05				
		27	0.0047	26.70				
		29	0.0102	41.82				
		30	0.0111	49.00	43.87	0.80	-33.2	-62.2
	56	36	0.0011	53.00				
		37	0.0003	42.61				
		38	0.0035	26.12				
		39	0.0021	42.97	36.10	0.45	-34.8	-61.3
	55	41	0.0002	60.50				
		42	0.0035	28.00				
		45	0.0001	77.00				
		46	0.0117	49.06	44.73	0.85	-33.0	-62.3
	54	47	0.0187	56.19				
		48	0.0090	55.58				
		49	0.0217	54.47				
		50	0.0590	55.44				
		51	0.0330	59.16				
		52	0.0001	56.00				
		53	0.0034	57.00	56.28	1.69	-31.0	-63.3
	53	59	0.0006	15.00	15.00	0.03	-42.5	-57.5
SS	52	69	0.0035	28.89				
		70	0.0085	29.91				
		71	0.0413	50.15				
		74	0.0106	46.15	45.63	0.90	-32.8	-62.4
	51	75	0.0011	48.54				
		76	0.0011	49.15				
		77	0.0039	45.15				
		78	0.1358	41.21				
		79	0.0712	50.04				
		80	0.0001	47.50	44.31	0.82	-33.1	-62.2
	50	81	0.0000	47.29				
		83	0.0426	44.90				
		84	0.0006	51.13	44.99	0.86	-32.9	-62.3
CB	49	86	0.0028	60.27				
		87	0.0009	45.33				
		88	0.0019	42.37				
		89	0.0064	47.04				
		90	0.0010	37.52				
		92	0.0018	56.33				
		93	0.0003	43.41				
		94	0.0001	37.00				
		95	0.0053	38.81				
		96	0.0209	45.78				
		97	0.0052	38.10	45.19	0.87	-32.9	-62.3
	48	103	0.0019	41.52				

Table 3.2.1 (cont.'). Calculation of weighted mean length, weight, and target strengths for cod from the 1997 Div. 3KL inshore acoustic survey.

Area	Stratum	Transect Number	Relative Index	Mean Length (cm)	Weighted Mean Length	Fish Weight (kg)	TS/Fish (dB)	TS/g (dB)
CB	48	104	0.0010	49.53				
(cont.')	(cont.')	105	0.0002	35.08				
		106	0.0062	52.50				
		107	0.0012	43.58				
		108	0.0081	40.65				
		109	0.0033	44.05				
		110	0.0077	50.23				
		111	0.0026	38.58				
		112	0.0074	47.73				
		113	0.0014	34.64				
		114	0.0002	31.71	45.73	0.91	-32.8	-62.4
	47	116	0.0394	43.34				
		117	0.0079	46.05				
		118	0.0142	50.61				
		119	0.0546	44.03	44.74	0.85	-33.0	-62.3
TB	46	121	0.0022	41.37				
		123	0.0138	65.00	61.71	2.23	-30.2	-63.7
	45	124	0.0567	65.00				
		125	0.0333	65.67				
		126	0.0002	33.32				
		127	0.0127	50.75	63.41	2.42	-30.0	-63.8
	44	128	0.0104	51.66				
		129	0.0172	52.57				
		130	0.0110	44.30				
		131	0.0021	50.82				
		132	0.0093	56.18				
		133	0.0100	44.37				
		135	0.0013	42.31				
		136	0.0001	63.40				
		138	0.0040	55.00				
		139	0.0018	56.02	50.36	1.21	-32.0	-62.8
	43	143	0.0578	35.03				
		144	0.0077	53.58				
		150	0.1975	49.89				
		151	0.0079	53.62	46.62	0.96	-32.6	-62.5
	42	152	0.0146	56.78				
		153	0.0126	57.57				
		154	0.0400	58.70				
		155	0.0134	56.26				
		156	0.0087	44.39	56.47	1.71	-31.0	-63.3
	41	158	0.0160	64.50				
		159	0.0486	47.85				
		163	0.2612	55.00				
		166	0.0127	57.00				
		172	0.0458	6.00	48.71	1.10	-32.2	-62.6
	40	177	0.0906	59.80				
		183	0.2143	57.42				
		184	0.0050	57.70				
		185	0.0547	57.47				
		187	0.0005	71.00				
		190	0.1429	62.63				
		191	0.6691	58.41				
		192	0.0008	59.87				
		193	0.0013	57.66	58.81	1.93	-30.6	-63.5
	39	197	0.0249	57.70				
		198	0.5410	52.10				
		199	0.0252	41.21	51.87	1.32	-31.7	-62.9
	38	205	0.4067	60.10				
		206	0.3090	60.97				

Table 3.2.1 (cont.'). Calculation of weighted mean length, weight, and target strengths for cod from the 1997 Div. 3KL inshore acoustic survey.

Area	Stratum	Transect Number	Relative Index	Mean Length (cm)	Weighted Mean Length	Fish Weight (kg)	TS/Fish (dB)	TS/g (dB)
TB (cont.')	38 (cont.')	207	0.2097	61.57				
		208	0.2588	65.50				
		209	0.1724	57.18				
		210	0.0487	67.00				
		212	0.3313	60.33				
		213	0.0517	61.24				
		214	0.0067	57.64				
		216	0.0002	58.36				
		217	0.0274	76.50				
		218	0.0425	67.60				
		219	0.0001	60.94				
		220	0.0084	68.50				
		221	0.0152	61.06				
		222	0.0250	62.44				
		223	0.0128	53.26				
		225	0.0004	59.41				
		227	0.0016	29.00				
		228	0.0531	63.41	61.55	2.22	-30.2	-63.7
	37	229	0.0093	58.24				
		230	0.0003	62.75				
		231	0.0153	48.17				
		232	0.0009	53.46				
		233	0.0035	56.67				
		235	0.0001	51.42				
		236	0.0014	54.64				
		238	0.0408	44.19	47.89	1.04	-32.4	-62.6
	36	239	0.0064	43.68				
		240	0.0025	63.00				
		241	0.0000	61.92				
		242	0.0011	44.10				
		243	0.0054	45.64				
		247	0.0001	55.57				
		248	0.0000	66.14				
		249	0.0004	50.62				
		251	0.0001	51.00				
		252	0.0000	56.18	47.76	1.03	-32.4	-62.6
BB	35	258	0.0089	59.91				
		259	0.0140	63.00	61.80	2.24	-30.2	-63.7
	34	260	0.0206	54.23				
		263	0.0043	64.20				
		264	0.0280	60.58				
		265	0.0014	65.00				
		266	0.0358	49.64				
		267	0.1247	59.09				
		268	0.0346	57.00				
		269	0.0162	58.50				
		270	0.0088	59.40				
		271	0.0195	61.78				
		273	0.0091	68.75	58.08	1.86	-30.7	-63.4
	33	276	0.0820	60.57				
		279	0.0350	62.73				
		281	0.0189	49.08				
		282	0.0716	70.11				
		283	0.0625	59.54				
		287	0.0457	56.51				
		289	0.0123	64.00				
		290	0.0129	76.14				
		291	0.0172	61.50				
		292	0.0204	73.50	62.72	2.35	-30.1	-63.8

Table 3.2.1 (cont.'). Calculation of weighted mean length, weight, and target strengths for cod from the 1997 Div. 3KL inshore acoustic survey.

Area	Stratum	Transect Number	Relative Index	Mean Length (cm)	Weighted Mean Length	Fish Weight (kg)	TS/Fish (dB)	TS/g (dB)
BB (cont.')	32	296	0.0409	65.57				
		300	0.0075	61.44				
		302	0.0004	59.90				
		304	0.0573	56.74				
		305	0.0322	62.91				
		306	0.1031	58.03				
		307	0.1669	53.97				
		308	0.2268	58.69				
		309	0.1460	68.50				
		310	0.0386	59.47				
		311	0.0001	63.35	59.83	2.04	-30.5	-63.5
	31	314	0.0225	37.83				
		315	0.0059	33.57				
		316	0.0348	58.07				
		319	0.0031	55.68				
		321	0.0154	37.00				
		324	0.0003	66.00	46.73	0.97	-32.6	-62.5
	30	328	0.0338	60.67				
		329	0.0561	60.63				
		330	0.0068	57.00				
		332	0.0001	51.80				
		482	0.0051	53.70				
		483	0.0023	51.25	59.86	2.04	-30.5	-63.6
	29	335	0.0003	41.00				
		336	0.0572	55.46				
		337	0.0835	58.09				
		339	0.0150	32.00				
		341	0.0160	60.86				
		342	0.0087	54.79				
		343	0.0067	62.36				
		344	0.0434	63.46				
		345	0.0085	56.52				
		346	0.0149	62.45				
		349	0.1200	60.81	58.38	1.89	-30.7	-63.4
	28	357	0.0135	28.20				
		360	0.0212	5.00				
		366	0.0185	56.00				
		368	0.0119	47.75				
		369	0.0165	57.70				
		370	0.0076	61.08				
		372	0.0265	55.91				
		373	0.0695	59.91	49.44	1.15	-32.1	-62.7
	27	378	0.0030	27.60				
		380	0.0092	64.89				
		381	0.0059	55.54				
		382	0.0099	53.67				
		385	0.0331	60.60				
		386	0.0231	38.36				
		389	0.0257	43.13				
		390	0.0167	33.28				
		391	0.0253	47.31				
		392	0.0001	32.80	48.00	1.05	-32.4	-62.6
	26	398	0.0114	44.53				
		401	0.0006	67.17				
		402	0.0119	61.50				
		404	0.0113	51.50				
		407	0.0185	20.25	41.63	0.68	-33.6	-62.0
NDB	25	408	0.0164	62.50				
		415	0.0046	38.75				

Table 3.2.1 (cont.'). Calculation of weighted mean length, weight, and target strengths for cod from the 1997 Div. 3KL inshore acoustic survey.

Area	Stratum	Transect Number	Relative Index	Mean Length (cm)	Weighted Mean Length	Fish Weight (kg)	TS/Fish (dB)	TS/g (dB)
NDB	25	419	0.0131	54.00				
(cont.')	(cont.')	420	0.0019	49.27				
		423	0.0093	40.56	52.56	1.38	-31.6	-63.0
	24	446	0.0114	46.71				
		448	0.0149	56.50				
		451	0.0014	58.00				
		452	0.0012	53.00				
		453	0.0032	32.75				
		454	0.0041	17.75				
		455	0.0027	74.00				
		456	0.0247	3.00	30.97	0.28	-36.2	-60.7
	23	457	0.0065	35.21				
		460	0.0026	50.17				
		462	0.0034	62.88				
		464	0.0002	56.00	46.03	0.92	-32.7	-62.4
	22	466	0.0035	46.17				
		467	0.0020	52.86				
		468	0.0026	49.22	48.81	1.10	-32.2	-62.7
	21	486	0.0000	54.00				
		489	0.0043	22.00				
		490	0.0143	41.17	36.78	0.47	-34.7	-61.4
	20	494	0.0071	59.00	59.00	1.95	-30.6	-63.5
	19	499	0.0402	39.00				
		500	0.0074	6.00				
		501	0.0643	39.00	36.81	0.47	-34.7	-61.4
	18	504	0.0084	57.43				
		507	0.0626	28.00				
		508	0.0543	32.33				
		509	0.0035	21.00				
		511	0.0433	31.00	31.41	0.29	-36.1	-60.7
	17	515	0.0224	32.00				
		518	0.0300	57.00				
		521	0.0088	37.58				
		523	0.0006	25.12				
		527	0.1673	29.75	33.82	0.37	-35.4	-61.0
	16	536	0.0008	24.77	24.77	0.14	-38.1	-59.7
	15	554	0.0001	29.00	29.00	0.23	-36.8	-60.4
	14	562	0.0181	61.00				
		563	0.0009	40.60				
		566	0.0017	44.00				
		570	0.0028	3.00	51.98	1.33	-31.7	-62.9
	13	573	0.0043	55.40				
		574	0.0004	52.69	55.18	1.60	-31.2	-63.2
	12	584	0.0744	27.00				
		585	0.0249	47.05				
		587	0.0002	41.00	32.04	0.31	-35.9	-60.8
	11	595	0.0437	49.48				
		600	0.1212	53.33				
		602	0.0182	49.29				
		608	0.0316	55.59				
		610	0.0246	5.00	47.65	1.03	-32.4	-62.6
	10	619	0.0001	22.71				
		622	0.0007	24.00				
		624	0.0013	28.75	26.82	0.18	-37.4	-60.0
	9	630	1.0000	43.50				
		639	0.0165	37.00				
		643	0.0051	20.67	43.28	0.77	-33.3	-62.1
	8	660	0.0015	38.75	38.75	0.55	-34.2	-61.6

Table 4.2.1 Summary of cod biological sampling conducted during the 1997 Div. 3KL inshore acoustic survey.

Area	Otter Trawl		Hand-Lines	
	No. of Sets	No. Measured	No. of Sets	No. Measured
White Bay	7	0	18	6
Notre Dame Bay	38	662	78	372
Bonavista Bay	28	1190	94	1201
Trinity Bay	43	1335	98	1642
Conception Bay	33	1310	48	348
Southern Shore	10	934	17	207
St. Mary's Bay	41	1791	65	96
Totals	200	7222	418	3872
Total Cod Aged	352		479	

Table 4.3.1 Cod biomass estimate, by stratum and bay, from the 1997 Div. 3KL inshore acoustic survey.

AREA	STRATUM	STRATUM AREA (sq. m.)	TRANSECT NUMBER	TRANSECT LENGTH (n.ml.)	RANDOMIZED SAMPLING UNIT	WEIGHTING FACTOR	MEASURED DENSITY (g/sq. m.)	WEIGHTED DENSITY (g/sq. m.)	MEAN WEIGHTED DENSITY	STRATUM BIOMASS (t)	AREA BIOMASS (t)
SMB	58	7.75E+08	1	4.60							
			4	4.93							
			10	4.90							
			13	6.88							
			16	5.02	1	0.940	0.1128	0.1061			
			2	5.00							
			5	4.70							
			8	4.90							
			11	5.00							
			14	6.26							
			17	5.00	2	1.102	0.2584	0.2847			
			3	4.59							
			6	3.35							
			9	4.90							
			12	4.54							
			15	5.26							
			18	4.18	3	0.958	0.1943	0.1861	0.1923	149	
	57	1.42E+08	19	3.69							
			23	2.03							
			27	2.25							
			31	1.54	4	1.344	1.2032	1.6167			
			20	3.52							
			24	2.24							
			28	0.99							
			32	0.47	5	1.020	0.0478	0.0487			
			21	2.72							
			25	1.92							
			29	1.00							
			33	0.23	6	0.829	0.2592	0.2150			
			22	2.47							
			26	1.98							
			30	1.02							
			34	0.24	7	0.807	0.2989	0.2412	0.5304	75	
	56	7.30E+07	35	1.67							
			37	2.20							
			39	1.74	8	1.020	0.0734	0.0749			
			36	2.30							
			38	2.44							
			40	0.65	9	0.980	0.2708	0.2654	0.1701	12	
	55	2.79E+08	41	4.07							
			43	5.50							
			45	4.44	10	0.954	0.3023	0.2883			
			42	6.75							
			44	5.20							
			46	3.42	11	1.046	0.3796	0.3971	0.3427	96	
	54	5.15E+08	47	4.76							
			49	4.74							
			51	4.90							
			53	5.00	12	1.014	2.1341	2.1636			
			48	4.53							
			50	4.90							
			52	4.84							
			54	4.60	13	0.986	1.6967	1.6732	1.9184	988	
	53	6.43E+08	55	0.80							
			58	1.50							

Table 4.3.1 (cont.'). Cod biomass estimate, by stratum and bay, from the 1997 Div. 3KL inshore acoustic survey.

AREA	STRATUM	STRATUM AREA (sq. m.)	TRANSECT NUMBER	TRANSECT LENGTH (n.ml.)	RANDOMIZED SAMPLING UNIT	WEIGHTING FACTOR	MEASURED DENSITY (g/sq. m.)	WEIGHTED DENSITY (g/sq. m.)	MEAN WEIGHTED DENSITY	STRATUM BIOMASS (t)	AREA BIOMASS (t)
SMB	53		61	0.80							
(cont.')	(cont.')		64	5.00	14	0.631	0.0094	0.0059			
			56	3.70							
			59	4.80							
			62	3.00							
			65	4.50	15	1.245	0.0113	0.0140			
			57	2.50							
			60	4.63							
			63	4.00							
			66	3.31	16	1.124	0.0155	0.0175	0.0125	8	1328
SS	52	4.85E+08	67	4.87							
			69	4.70							
			71	3.73							
			73	1.87	17	1.108	1.0703	1.1860			
			68	4.94							
			70	4.70							
			72	2.00							
			74	0.57	18	0.892	0.3453	0.3080	0.7470	362	
	51	2.19E+08	75	0.30							
			77	2.08							
			79	0.79	19	0.742	1.8583	1.3780			
			76	2.82							
			78	1.97							
			80	0.59	20	1.258	4.1028	5.1633	3.2706	716	
	50	1.37E+08	81	1.99							
			83	3.07	21	1.206	1.9795	2.3877			
			82	0.93							
			84	2.40	22	0.794	0.0315	0.0250	1.2063	165	1243
CB	49	3.08E+08	85	0.13							
			88	6.58							
			91	1.95							
			94	5.27							
			97	2.57	23	0.896	0.1345	0.1205			
			86	0.36							
			89	7.15							
			92	3.18							
			95	4.68							
			98	1.05	24	0.891	0.3696	0.3295			
			87	6.18							
			90	5.35							
			93	5.84							
			96	4.25							
			99	0.72	25	1.213	0.0651	0.0789	0.1763	54	
	48	3.56E+08	100	0.52							
			104	3.66							
			108	5.24							
			112	7.20	26	1.018	0.4409	0.4488			
			101	0.80							
			105	3.94							
			109	5.26							
			113	6.85	27	1.032	0.1291	0.1332			
			102	0.76							
			106	4.47							
			110	5.06							
			114	6.74	28	1.043	0.3922	0.4090			
			103	2.33							

Table 4.3.1 (cont.'). Cod biomass estimate, by stratum and bay, from the 1997 Div. 3KL inshore acoustic survey.

AREA	STRATUM	STRATUM AREA (sq. m.)	TRANSECT NUMBER	TRANSECT LENGTH (n.mi.)	RANDOMIZED SAMPLING UNIT	WEIGHTING FACTOR	MEASURED DENSITY (g/sq. m.)	WEIGHTED DENSITY (g/sq. m.)	MEAN WEIGHTED DENSITY	STRATUM BIOMASS (t)	AREA BIOMASS (t)
CB (cont.')	48 (cont.')		107	5.96							
			111	5.61							
			115	0.91	29	0.907	0.1590	0.1442	0.2838	101	
	47	3.52E+08	116	2.41							
			118	1.00	30	0.646	2.4148	1.5610			
			117	3.78							
			119	3.36	31	1.354	2.5325	3.4278	2.4944	878	1033
TB	46	1.86E+08	120	1.31							
			122	0.93	32	0.686	0.0312	0.0214			
			121	3.54							
			123	0.75	33	1.314	0.4266	0.5606	0.2910	54	
	45	9.50E+07	124	0.96							
			126	1.18	34	0.674	2.9669	1.9997			
			125	1.52							
			127	2.69	35	1.326	2.2376	2.9670	2.4833	236	
	44	1.64E+08	128	2.11							
			131	4.47							
			134	3.37	36	0.836	1.2223	1.0217			
			129	4.26							
			132	5.30							
			135	2.41							
			139	1.69	37	1.148	1.8803	2.1578			
			130	4.65							
			133	4.42							
			136	1.33							
			138	1.70	38	1.017	4.9387	5.0203	2.7333	448	
	43	1.42E+08	140	1.91							
			143	5.81							
			146	2.42							
			149	0.68	39	1.020	5.8571	5.9749			
			141	2.51							
			144	7.02							
			150	0.43							
			147	1.66	40	1.096	7.0694	7.7447			
			142	3.80							
			145	3.93							
			148	0.94							
			151	0.71	41	0.884	1.3472	1.1914	4.9704	706	
	42	1.81E+08	152	2.28							
			154	3.06							
			156	3.69	42	0.983	2.1108	2.0741			
			153	3.09							
			155	1.59							
			157	4.67	43	1.017	0.7084	0.7207	1.3974	253	
	41	6.40E+07	158	0.66							
			161	0.58							
			164	0.85							
			167	0.75							
			170	1.05							
			173	0.83	44	1.006	2.7459	2.7635			
			159	1.00							
			162	0.67							
			165	0.30							
			168	0.72							
			171	1.22							
			174	0.54	45	0.949	2.2327	2.1185			

Table 4.3.1 (cont.'). Cod biomass estimate, by stratum and bay, from the 1997 Div. 3KL inshore acoustic survey.

AREA	STRATUM	STRATUM AREA (sq. m.)	TRANSECT NUMBER	TRANSECT LENGTH (n.mi.)	RANDOMIZED SAMPLING UNIT	WEIGHTING FACTOR	MEASURED DENSITY (g/sq. m.)	WEIGHTED DENSITY (g/sq. m.)	MEAN WEIGHTED DENSITY	STRATUM BIOMASS (t)	AREA BIOMASS (t)
TB (cont.')	41 (cont.')		160	0.57							
			163	0.77							
			166	0.97							
			169	1.15							
			172	1.13							
			175	0.31	46	1.045	5.4337	5.6770	3.5196	225	
	40	9.40E+07	176	0.48							
			179	1.16							
			182	1.52							
			185	0.87							
			188	0.70							
			191	0.96							
			194	0.73	47	1.089	12.9655	14.1162			
			177	0.76							
			180	0.98							
			183	1.20							
			186	0.71							
			189	0.59							
			192	0.82							
			195	0.71	48	0.979	5.8582	5.7323			
			178	1.00							
			181	1.09							
			184	0.90							
			187	0.68							
			190	0.53							
			193	0.76							
			196	0.54	49	0.933	5.8602	5.4660	8.4382	793	
	39	9.50E+07	197	1.36							
			199	6.29	50	1.005	2.2800	2.2905			
			198	4.38							
			200	3.20	51	0.995	30.2177	30.0789	16.1847	1538	
	38	1.06E+08	201	0.40							
			205	1.01							
			209	1.10							
			213	1.01							
			217	0.71							
			221	0.61							
			225	2.35	52	1.114	10.3750	11.5609			
			202	0.53							
			206	0.88							
			210	0.84							
			214	0.92							
			218	0.76							
			222	0.80							
			226	1.11	53	0.905	7.5796	6.8601			
			203	0.74							
			207	1.38							
			211	0.95							
			215	0.41							
			219	0.61							
			223	0.94							
			227	0.81	54	0.905	5.6480	5.1119			
			204	0.93							
			208	1.41							
			212	1.22							
			216	0.97							

Table 4.3.1 (cont.'). Cod biomass estimate, by stratum and bay, from the 1997 Div. 3KL inshore acoustic survey.

AREA	STRATUM	STRATUM AREA (sq. m.)	TRANSECT NUMBER	TRANSECT LENGTH (n.mi.)	RANDOMIZED SAMPLING UNIT	WEIGHTING FACTOR	MEASURED DENSITY (g/sq. m.)	WEIGHTED DENSITY (g/sq. m.)	MEAN WEIGHTED DENSITY	STRATUM BIOMASS (t)	AREA BIOMASS (t)
TB	38		220	0.75							
(cont.')	(cont.')		224	0.62							
			228	1.04	55	1.076	11.9731	12.8777	9.1026	965	
	37	1.41E+08	229	3.13							
			231	2.12							
			233	3.50							
			235	3.48							
			237	3.25	56	0.965	0.6777	0.6539			
			230	3.90							
			232	2.28							
			234	3.09							
			236	4.67							
			238	2.67	57	1.035	0.6065	0.6278	0.6408	90	
	36	7.71E+08	239	2.00							
			242	1.63							
			245	4.82							
			248	4.83							
			251	5.00	58	0.960	0.0769	0.0738			
			240	2.51							
			243	1.81							
			246	4.88							
			249	5.17							
			252	5.00	59	1.017	0.0810	0.0823			
			241	1.34							
			244	3.38							
			247	4.96							
			250	4.80							
			253	5.00	60	1.023	0.0025	0.0025	0.0529	41	5349
BB	35	2.97E+08	256	3.74							
			258	3.48	61	1.383	0.5127	0.7091			
			257	2.79							
			259	0.43	62	0.617	1.0966	0.6764	0.6928	206	
	34	1.57E+08	260	2.97							
			263	1.21							
			266	4.78							
			269	2.16							
			272	0.63	63	1.102	4.9455	5.4495			
			261	2.60							
			264	0.94							
			267	5.25							
			270	2.13							
			273	0.53	64	1.074	7.1064	7.6307			
			262	2.26							
			265	1.02							
			268	3.96							
			271	1.46							
			274	0.09	65	0.824	4.9324	4.0659	5.7154	897	
	33	7.30E+07	275	0.25							
			278	0.69							
			281	0.58							
			284	0.98							
			287	0.82							
			290	1.32	66	0.859	4.3421	3.7310			
			276	1.07							
			279	1.17							
			282	1.11							

Table 4.3.1 (cont.'). Cod biomass estimate, by stratum and bay, from the 1997 Div. 3KL inshore acoustic survey.

AREA	STRATUM	STRATUM AREA (sq. m.)	TRANSECT NUMBER	TRANSECT LENGTH (n.ml.)	RANDOMIZED SAMPLING UNIT	WEIGHTING FACTOR	MEASURED DENSITY (g/sq. m.)	WEIGHTED DENSITY (g/sq. m.)	MEAN WEIGHTED DENSITY	STRATUM BIOMASS (t)	AREA BIOMASS (t)
BB	33		285	0.60							
(cont.')	(cont.')		288	0.38							
			291	1.13	67	1.011	4.8390	4.8928			
			277	0.86							
			280	1.19							
			283	1.40							
			286	0.67							
			289	1.30							
			292	0.68	68	1.130	5.5079	6.2219	4.9486	361	
	32	9.60E+07	293	0.37							
			297	2.28							
			301	2.16							
			305	1.85							
			309	0.78	69	1.101	3.3796	3.7195			
			294	0.51							
			298	2.02							
			302	1.92							
			306	2.10							
			310	0.66	70	1.067	4.2520	4.5350			
			295	0.60							
			299	2.06							
			303	1.14							
			307	0.62							
			311	0.52	71	0.731	6.7906	4.9624			
			296	1.86							
			300	3.22							
			304	1.27							
			308	0.86							
			312	0.24	72	1.102	5.8792	6.4792	4.9240	473	
	31	1.34E+08	313	0.66							
			316	4.89							
			319	2.64							
			322	0.98	73	1.010	2.6206	2.6456			
			314	3.96							
			317	3.44							
			320	2.01							
			323	0.98	74	1.144	1.0369	1.1861			
			315	3.46							
			318	2.63							
			321	0.81							
			324	0.79	75	0.847	4.1996	3.5554	2.4624	330	
	30	3.01E+08	325	0.74							
			328	4.76							
			331	4.84							
			483	5.33	76	0.904	1.2872	1.1639			
			326	1.46							
			329	4.04							
			332	3.17							
			484	9.09	77	1.025	1.5139	1.5515			
			327	4.56							
			330	3.81							
			482	6.49							
			485	3.70	78	1.071	1.0639	1.1394	1.2849	387	
	29	2.18E+08	333	1.30							
			336	3.20							
			339	1.77							

Table 4.3.1 (cont.'). Cod biomass estimate, by stratum and bay, from the 1997 Div. 3KL inshore acoustic survey

AREA	STRATUM	STRATUM AREA (sq. m.)	TRANSECT NUMBER	TRANSECT LENGTH (n.ml.)	RANDOMIZED SAMPLING UNIT	WEIGHTING FACTOR	MEASURED DENSITY (g/sq. m.)	WEIGHTED DENSITY (g/sq. m.)	MEAN WEIGHTED DENSITY	STRATUM BIOMASS (t)	AREA BIOMASS (t)
BB	29		342	4.64							
(cont.')	(cont.')		345	3.36							
			348	1.85	79	1.067	6.4616	6.8951			
			334	0.10							
			337	2.06							
			340	2.54							
			343	3.57							
			346	3.14							
			349	1.28	80	0.840	6.3133	5.3034			
			335	1.05							
			338	1.00							
			341	5.85							
			344	6.53							
			347	1.52							
			350	0.56	81	1.093	11.6224	12.7021	8.3002	1809	
	28	2.08E+08	351	0.74							
			356	0.37							
			361	1.75							
			366	5.27							
			371	4.03	82	1.141	1.5341	1.7510			
			352	1.07							
			357	0.48							
			362	1.45							
			367	3.76							
			372	3.43	83	0.956	2.1046	2.0129			
			353	0.52							
			358	0.89							
			363	2.68							
			368	4.00							
			373	2.12	84	0.958	3.4050	3.2631			
			354	0.44							
			359	1.06							
			364	3.04							
			369	3.84							
			374	1.71	85	0.947	4.4385	4.2035			
			355	1.01							
			360	1.11							
			365	3.57							
			370	3.55							
			375	1.38	86	0.997	1.5170	1.5122	2.5485	530	
	27	2.94E+08	380	2.85							
			384	4.19							
			388	5.86							
			392	5.00	87	1.069	1.9851	2.1214			
			377	1.73							
			381	3.16							
			385	5.10							
			389	5.33	88	0.915	2.2718	2.0778			
			378	1.20							
			382	2.68							
			386	5.31							
			390	5.25							
			394	2.97	89	1.039	1.6270	1.6911			
			379	1.19							
			383	3.07							

Table 4.3.1 (cont.'). Cod biomass estimate, by stratum and bay, from the 1997 Div. 3KL inshore acoustic survey.

AREA	STRATUM	STRATUM AREA (sq. m.)	TRANSECT NUMBER	TRANSECT LENGTH (n.ml.)	RANDOMIZED SAMPLING UNIT	WEIGHTING FACTOR	MEASURED DENSITY (g/sq. m.)	WEIGHTED DENSITY (g/sq. m.)	MEAN WEIGHTED DENSITY	STRATUM BIOMASS (t)	AREA BIOMASS (t)
BB (cont.')	27 (cont.')		387	6.10							
			391	4.61							
			395	1.40	90	0.977	1.8739	1.8314	1.9304	568	
	26	4.00E+08	396	1.37							
			399	4.79							
			402	5.20							
			405	4.51	91	0.914	0.5851	0.5350			
			398	1.62							
			401	4.24							
			404	5.64							
			407	7.34	92	1.086	0.8968	0.9736	0.7543	302	5863
NDB	25	5.22E+08	408	4.65							
			412	4.31							
			416	4.67							
			420	4.96	93	0.995	0.5419	0.5392			
			411	4.73							
			415	4.47							
			419	4.88							
			423	4.69	94	1.005	0.8451	0.8492	0.6942	362	
	24	7.27E+08	455	4.55	95	0.324	0.1435	0.0465			
			451	3.97							
			456	4.92							
			438	4.87							
			441	2.22							
			446	2.54	96	1.317	1.1120	1.4649			
			452	4.67							
			424	3.06							
			429	4.96							
			434	1.48							
			439	3.40							
			447	2.20	97	1.406	0.4214	0.5926			
			453	4.55							
			448	4.10	98	0.615	0.4535	0.2791			
			454	4.14							
			426	4.70							
			431	4.42							
			436	4.71							
			449	0.83	99	1.337	0.4367	0.5840	0.5934	431	
	23	5.01E+08	457	3.52							
			460	6.22							
			463	10.69	100	1.458	0.2958	0.4313			
			458	4.50							
			461	5.05							
			464	2.38	101	0.852	0.2651	0.2258			
			459	4.40							
			462	4.94							
			465	0.33	102	0.690	0.1728	0.1193	0.2588	130	
	22	3.67E+08	466	1.76	103	0.764	0.3132	0.2394			
			481	1.32	104	0.573	0.2565	0.1470			
			467	2.74	105	1.190	0.3225	0.3838			
			468	3.39	106	1.472	0.2186	0.3219	0.2730	100	
	21	1.64E+08	486	8.30							
			489	1.10	107	1.896	0.1177	0.2232			
			487	2.90							
			490	1.09	108	0.805	0.3417	0.2750			
			488	1.10							

Table 4.3.1 (cont.'). Cod biomass estimate, by stratum and bay, from the 1997 Div. 3KL inshore acoustic survey.

AREA	STRATUM	STRATUM AREA (sq. m.)	TRANSECT NUMBER	TRANSECT LENGTH (n.mi.)	RANDOMIZED SAMPLING UNIT	WEIGHTING FACTOR	MEASURED DENSITY (g/sq. m.)	WEIGHTED DENSITY (g/sq. m.)	MEAN WEIGHTED DENSITY	STRATUM BIOMASS (t)	AREA BIOMASS (t)
NDB	21		491	0.38	109	0.299	0.0000	0.0000	0.1661	27	
(cont.')	20	1.26E+08	492	0.43							
			495	2.61	110	1.473	0.7189	1.0592			
			493	0.85							
			496	0.51	111	0.659	0.3462	0.2282			
			494	1.50							
			497	0.29	112	0.868	0.5935	0.5149	0.6008	76	
	19	1.78E+08	498	5.07							
			501	2.86	113	1.092	1.9123	2.0888			
			499	5.30							
			502	1.35	114	0.916	2.6128	2.3933			
			500	5.42							
			503	1.78	115	0.992	0.3634	0.3604	1.6141	287	
	18	2.43E+08	504	1.38							
			507	5.63							
			510	2.45	116	0.870	2.1232	1.8473			
			505	3.47							
			508	4.50							
			511	3.78	117	1.081	2.1092	2.2793			
			506	2.99							
			509	4.80							
			512	3.62	118	1.049	1.8693	1.9616	2.0294	493	
	17	1.25E+08	513	1.10							
			518	2.06							
			523	1.40							
			528	0.73	119	1.141	0.7045	0.8035			
			514	1.13							
			519	1.64							
			524	1.78							
			529	1.25	120	1.251	1.4415	1.8026			
			515	1.70							
			520	1.00							
			525	0.81	121	0.757	0.7292	0.5518			
			516	1.39							
			521	0.84							
			526	1.33							
			531	0.18	122	0.806	1.6496	1.3302			
			517	2.33							
			522	0.90							
			527	0.79							
			532	0.83	123	1.046	1.7644	1.8451	1.2666	158	
	16	1.91E+08	533	0.55							
			537	3.10							
			541	2.27							
			545	1.10	124	1.014	2.4134	2.4465			
			534	0.41							
			538	3.13							
			542	1.55							
			546	1.32	125	0.926	1.0277	0.9513			
			535	3.75							
			539	2.95							
			543	0.79	126	1.082	1.1133	1.2041			
			536	2.25							
			540	2.88							
			544	1.65	127	0.979	0.3928	0.3846	1.2466	238	
	15	1.18E+08	549	0.33							

Table 4.3.1 (cont.'). Cod biomass estimate, by stratum and bay, from the 1997 Div. 3KL inshore acoustic survey.

AREA	STRATUM	STRATUM AREA (sq. m.)	TRANSECT NUMBER	TRANSECT LENGTH (n.mi.)	RANDOMIZED SAMPLING UNIT	WEIGHTING FACTOR	MEASURED DENSITY (g/sq. m.)	WEIGHTED DENSITY (g/sq. m.)	MEAN WEIGHTED DENSITY	STRATUM BIOMASS (t)	AREA BIOMASS (t)
NDB	15		553	1.47							
(cont.')	(cont.')		557	2.09	128	0.878	0.5125	0.4501			
			550	1.45							
			554	0.47							
			558	3.12	129	1.138	0.2990	0.3402			
			551	1.33							
			555	1.26							
			559	2.01	130	1.038	0.0479	0.0497			
			552	0.99							
			556	3.20	131	0.946	0.0001	0.0001	0.2100	25	
	14	8.60E+07	561	0.17							
			564	2.32							
			567	2.74							
			570	1.63	132	1.127	0.3718	0.4191			
			562	0.63							
			565	0.33							
			568	2.25							
			571	0.77	133	0.654	0.3126	0.2044			
			563	1.93							
			566	3.24							
			569	1.90							
			572	0.35	134	1.219	0.2449	0.2986	0.3073	26	
	13	1.15E+08	573	0.57							
			576	2.70	135	0.913	0.4580	0.4183			
			574	1.83							
			577	3.59	136	1.514	0.0358	0.0542			
			575	2.05	137	0.573	0.1371	0.0785	0.1837	21	
	12	1.10E+08	582	0.60							
			586	1.40							
			590	1.75	138	1.232	0.3205	0.3948			
			583	1.82							
			587	2.37	139	1.376	0.7250	0.9976			
			584	0.81							
			588	1.29	140	0.690	1.5490	1.0683			
			585	1.29							
			589	0.85	141	0.703	1.0241	0.7197	0.7951	87	
	11	1.04E+08	594	0.38							
			599	1.22							
			604	1.38							
			609	1.66	142	0.949	0.0595	0.0565			
			595	0.60							
			600	1.87							
			605	1.14							
			610	1.56	143	1.058	4.7728	5.0482			
			596	0.66							
			601	1.50							
			606	0.86							
			611	1.53	144	0.931	0.7625	0.7098			
			597	0.60							
			602	1.05							
			607	1.20							
			612	1.67	145	0.925	0.6909	0.6389			
			598	0.92							
			603	1.39							
			608	1.81							
			613	1.44	146	1.137	2.5257	2.8729	1.8652	194	

Table 4.3.1 (cont.'). Cod biomass estimate, by stratum and bay, from the 1997 Div. 3KL inshore acoustic survey.

AREA	STRATUM	STRATUM AREA (sq. m.)	TRANSECT NUMBER	TRANSECT LENGTH (n.mi.)	RANDOMIZED SAMPLING UNIT	WEIGHTING FACTOR	MEASURED DENSITY (g/sq. m.)	WEIGHTED DENSITY (g/sq. m.)	MEAN WEIGHTED DENSITY	STRATUM BIOMASS (t)	AREA BIOMASS (t)
NDB	10	8.80E+07	614	0.10							
(cont.')			618	0.73							
			622	3.25							
			626	4.58	147	0.889	0.1900	0.1690			
			615	0.07							
			619	1.08							
			623	3.42							
			627	4.07	148	0.887	0.1609	0.1427			
			616	0.20							
			620	1.69							
			624	5.76							
			628	4.84	149	1.282	0.2660	0.3411			
			617	0.15							
			621	2.18							
			625	4.78							
			629	2.06	150	0.941	0.0645	0.0608	0.1784	16	
	9	1.00E+08	630	0.37							
			635	0.60							
			639	1.20							
			644	1.00	151	0.764	11.1890	8.5468			
			631	0.60							
			636	0.40							
			640	1.60							
			645	1.28	152	0.935	0.0452	0.0422			
			632	1.10							
			637	0.40							
			641	1.80							
			646	1.31	153	1.111	0.4342	0.4823			
			633	0.90							
			638	0.40							
			642	1.40							
			647	1.04	154	0.901	0.1314	0.1184			
			634	0.62							
			649	0.40							
			643	3.25							
			648	1.08	155	1.289	0.2069	0.2668	1.8913	189	
	8	2.20E+08	650	1.03							
			654	1.02							
			658	1.71							
			662	2.06							
			666	2.77	156	0.916	0.0410	0.0376			
			651	1.00							
			655	0.91							
			659	0.65							
			663	2.30							
			667	3.80	157	0.923	0.0636	0.0587			
			652	0.90							
			656	0.67							
			660	1.09							
			664	2.44							
			668	4.20	158	0.991	0.1385	0.1373			
			653	0.96							
			657	0.91							
			661	2.00							
			665	3.10							
			669	4.00	159	1.170	0.0003	0.0004	0.0585	13	2873

Table 4.3.1 (cont.'). Cod biomass estimate, by stratum and bay, from the 1997 Div. 3KL inshore acoustic survey.

AREA	STRATUM	STRATUM AREA (sq. m.)	TRANSECT NUMBER	TRANSECT LENGTH (n.ml.)	RANDOMIZED SAMPLING UNIT	WEIGHTING FACTOR	MEASURED DENSITY (g/sq. m.)	WEIGHTED DENSITY (g/sq. m.)	MEAN WEIGHTED DENSITY	STRATUM BIOMASS (t)	AREA BIOMASS (t)
WB	7	4.45E+08	670	3.34							
			672	3.50							
			674	2.50							
			676	5.40	160	1.157	0.3323	0.3844			
			671	1.60							
			673	3.91							
			675	1.60							
			677	3.64	161	0.843	0.5153	0.4346	0.4095	182	
	6	8.50E+07	678	0.40							
			680	0.90							
			682	1.40	162	0.871	0.0368	0.0321			
			679	0.80							
			681	2.00							
			683	0.70	163	1.129	0.2990	0.3376	0.1848	16	
	5	2.60E+08	684	1.53							
			688	6.00							
			692	5.38							
			696	2.45							
			700	1.30							
			704	0.69	164	1.139	1.0682	1.2169			
			685	4.60							
			689	5.90							
			693	4.70							
			697	1.50							
			701	1.26							
			705	0.55	165	1.215	0.7742	0.9410			
			686	4.90							
			694	5.50							
			698	1.47							
			702	1.15							
			706	0.60	166	0.894	0.0001	0.0000			
			687	5.85							
			691	0.80							
			695	2.46							
			699	1.22							
			703	0.66							
			707	0.45	167	0.751	0.0357	0.0268	0.5462	142	
	4	2.05E+08	708	0.42							
			710	1.20							
			712	2.08	168	0.739	1.4662	1.0828			
			709	2.40							
			711	2.72							
			713	1.20	169	1.261	1.5229	1.9211	1.5020	308	648
										Total Biomass =	18340
										S.E. =	2262
										C.V. =	0.123

Table 4.3.2 Summary of results from the 1997 Div. 3KL inshore acoustic survey, including strata areas, target strengths, and biomass estimates by strata and area.

AREA	STRATUM	STRATUM AREA (sq. km.)	TS / g (dB)	STRATUM BIOMASS (t)	AREA BIOMASS (t)
SMB	58	775	-62.6	149	
	57	142	-62.2	75	
	56	73	-61.3	12	
	55	279	-62.3	96	
	54	515	-63.3	988	
	53	643	-57.5	8	1328
SS	52	485	-62.4	362	
	51	219	-62.2	716	
	50	137	-62.3	165	1243
CB	49	308	-62.3	54	
	48	356	-62.4	101	
	47	352	-62.3	878	1033
TB	46	186	-63.7	54	
	45	95	-63.8	236	
	44	164	-62.8	448	
	43	142	-62.5	706	
	42	181	-63.3	253	
	41	64	-62.6	225	
	40	94	-63.5	793	
	39	95	-62.9	1538	
	38	106	-63.7	965	
	37	141	-62.6	90	
	36	771	-62.6	41	5349
BB	35	297	-63.7	206	
	34	157	-63.4	897	
	33	73	-63.8	361	
	32	96	-63.5	473	
	31	134	-62.5	330	
	30	301	-63.6	387	
	29	218	-63.4	1809	
	28	208	-62.7	530	
	27	294	-62.6	568	
	26	400	-62.0	302	5863

AREA	STRATUM	STRATUM AREA (sq. km.)	TS / g (dB)	STRATUM BIOMASS (t)	AREA BIOMASS (t)
NDB	25	522	-63.0	362	
	24	727	-60.7	431	
	23	501	-62.4	130	
	22	367	-62.7	100	
	21	164	-61.4	27	
	20	126	-63.5	76	
	19	178	-61.4	287	
	18	243	-60.7	493	
	17	125	-61.0	158	
	16	191	-59.7	238	
	15	118	-60.4	25	
	14	86	-62.9	26	
	13	115	-63.2	21	
	12	110	-60.8	87	
	11	104	-62.6	194	
	10	88	-60.0	16	
	9	100	-62.1	189	
	8	220	-61.6	13	2873
WB	7	445	-61.6	182	
	6	85	-61.6	16	
	5	260	-61.6	142	
	4	205	-61.6	308	648
				Total Biomass =	18340
				S.E. =	2262
				C.V. =	0.123

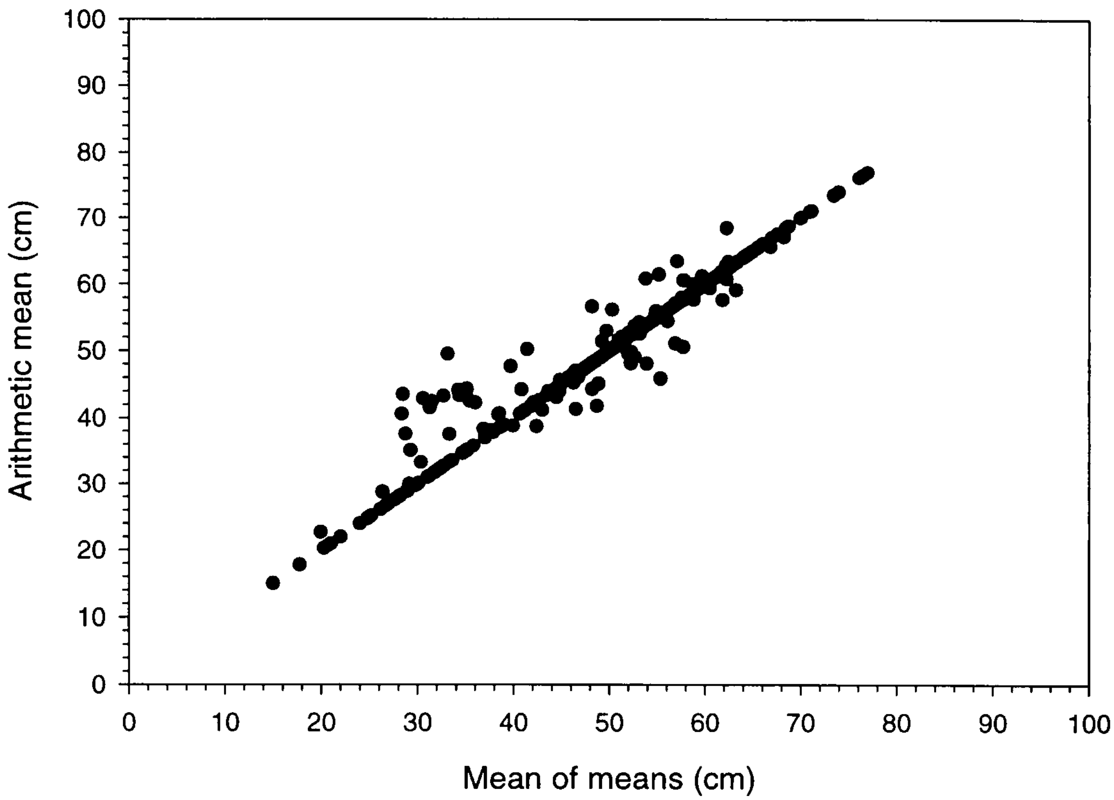

Figure 3.2.1. Mean lengths of cod by transect.
Plot of arithmetic mean vs mean of means (all gears).

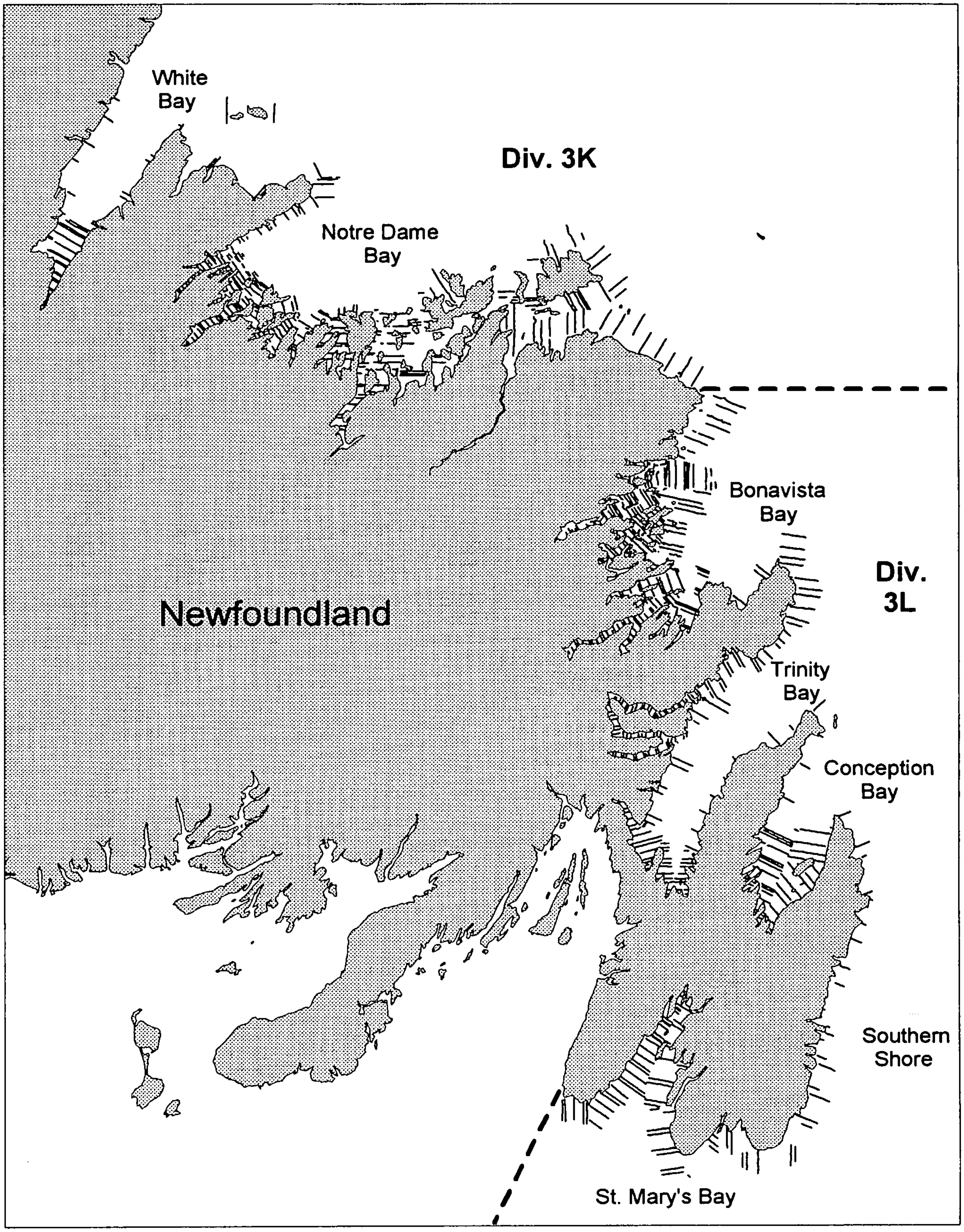

Figure 4.1.1 Area map indicating the distribution of all acoustic transects for the 1997 Div. 3KL inshore acoustic survey.

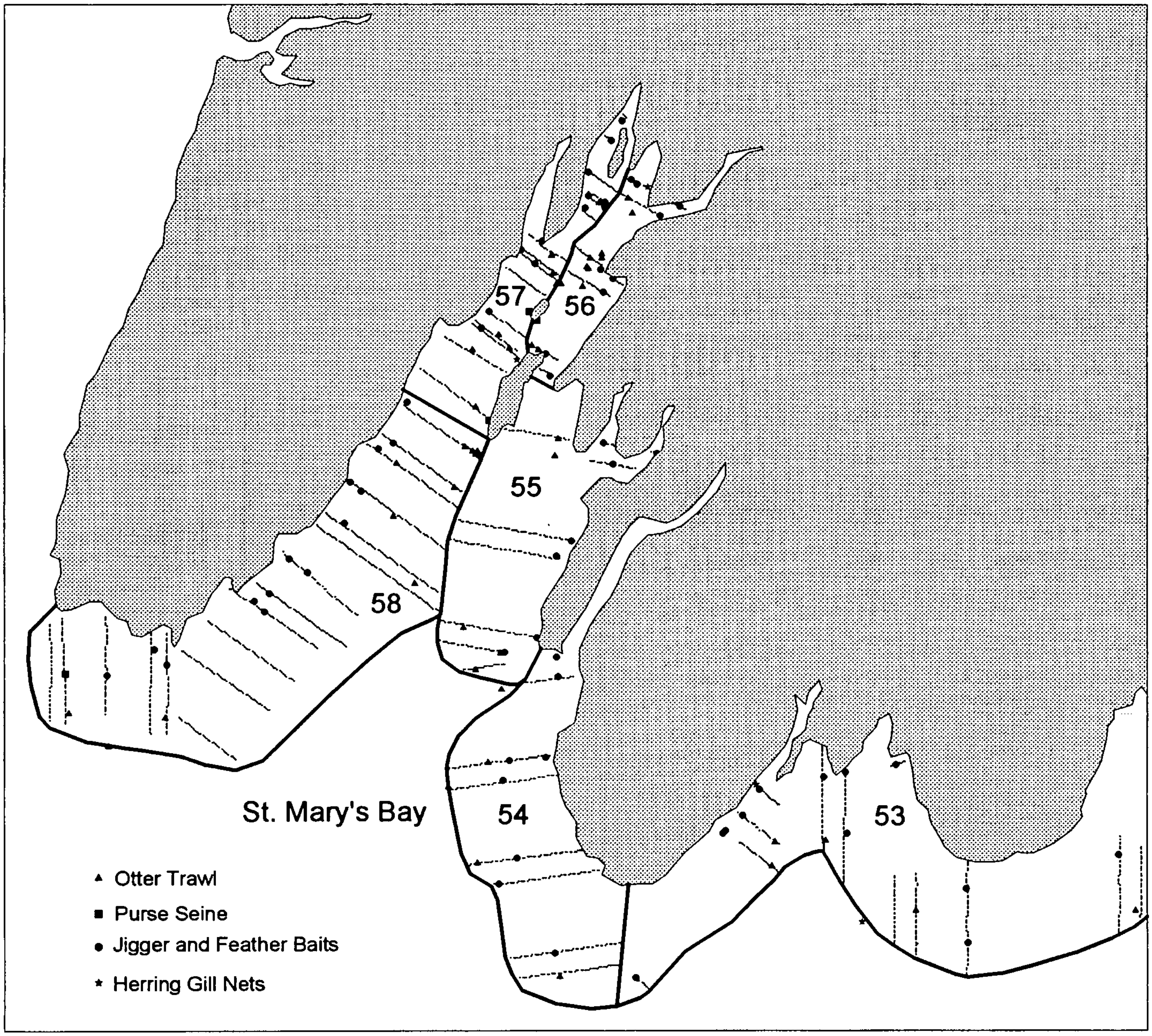

Figure 4.1.2 Area map of St. Mary's Bay indicating survey strata, transects, and biological sampling locations for the 1997 Div. 3KL inshore acoustic survey.

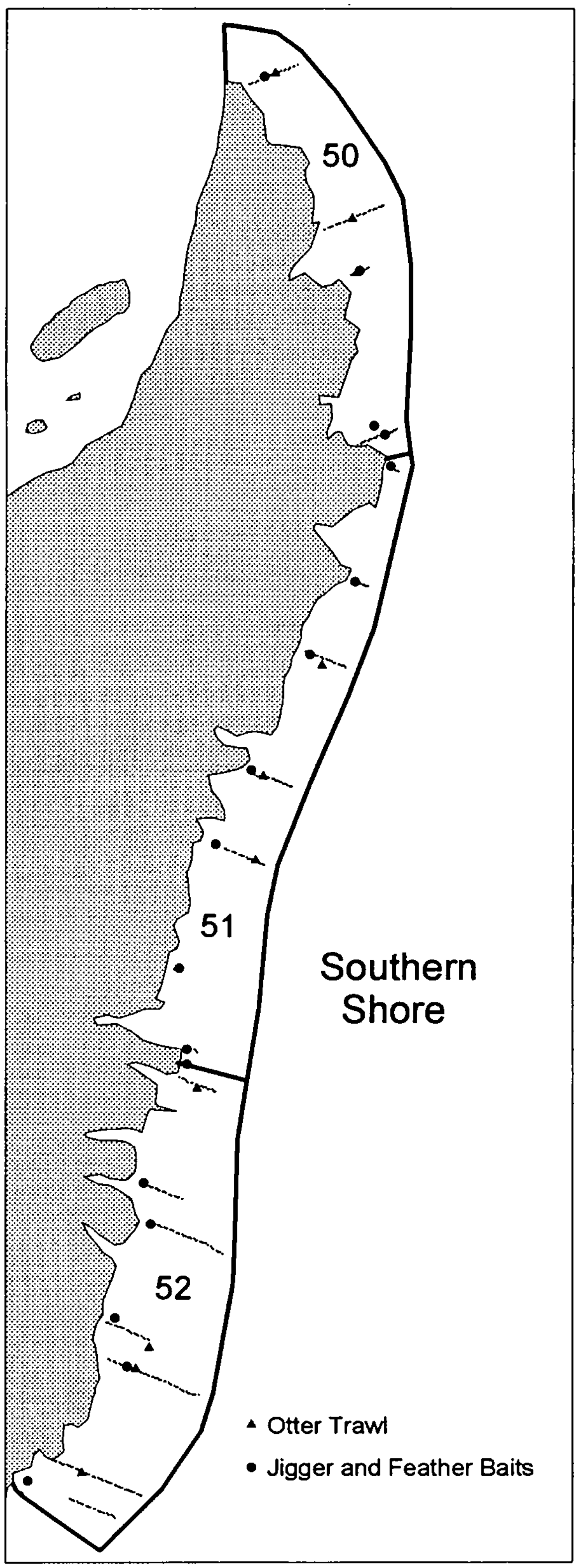

Figure 4.1.3 Area map of the Southern Shore indicating survey strata, transects, and biological sampling locations for the 1997 Div. 3KL inshore acoustic survey.

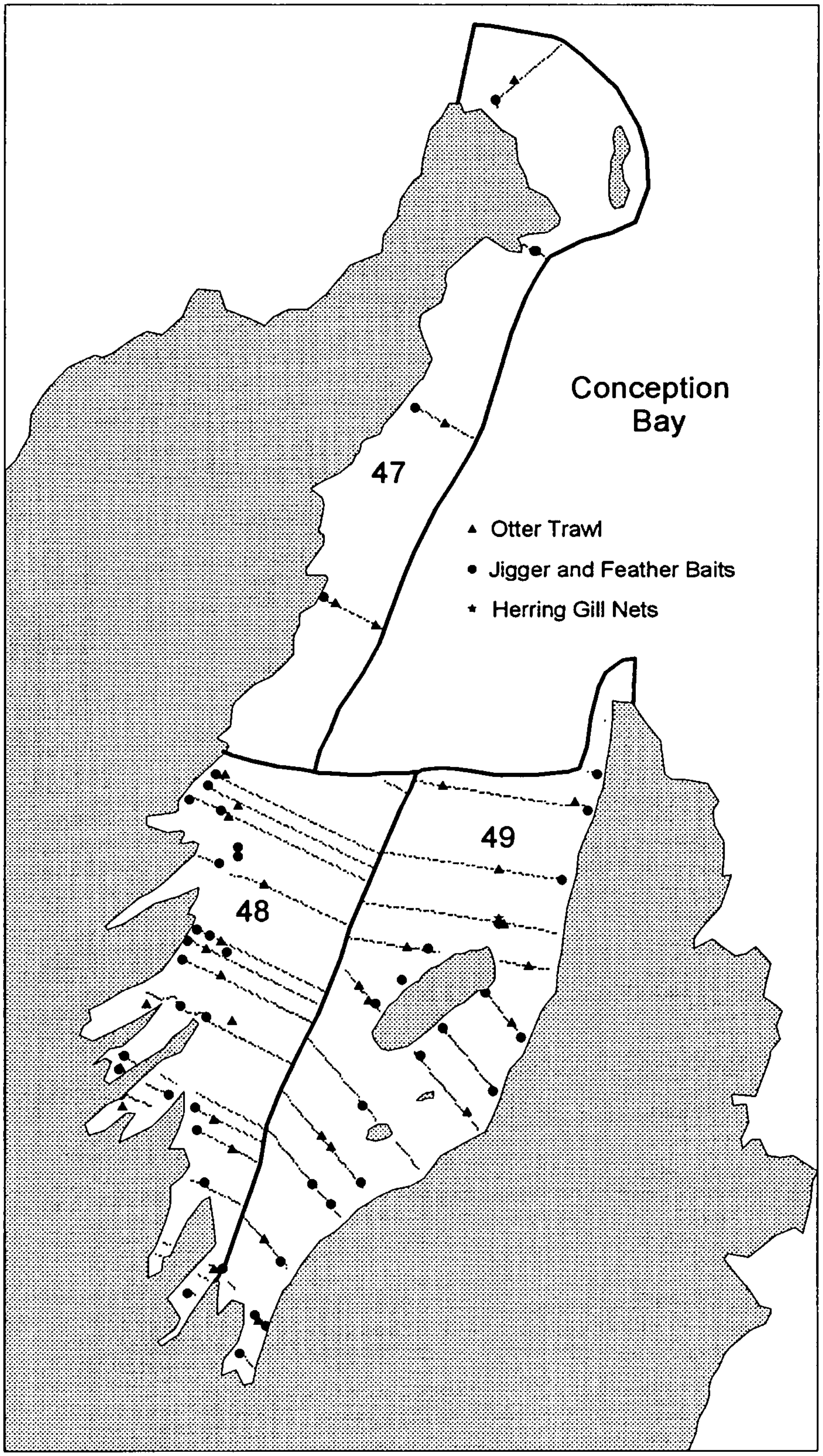

Figure 4.1.4 Area map of Conception Bay indicating survey strata, transects, and biological sampling locations for the 1997 Div. 3KL inshore acoustic survey.

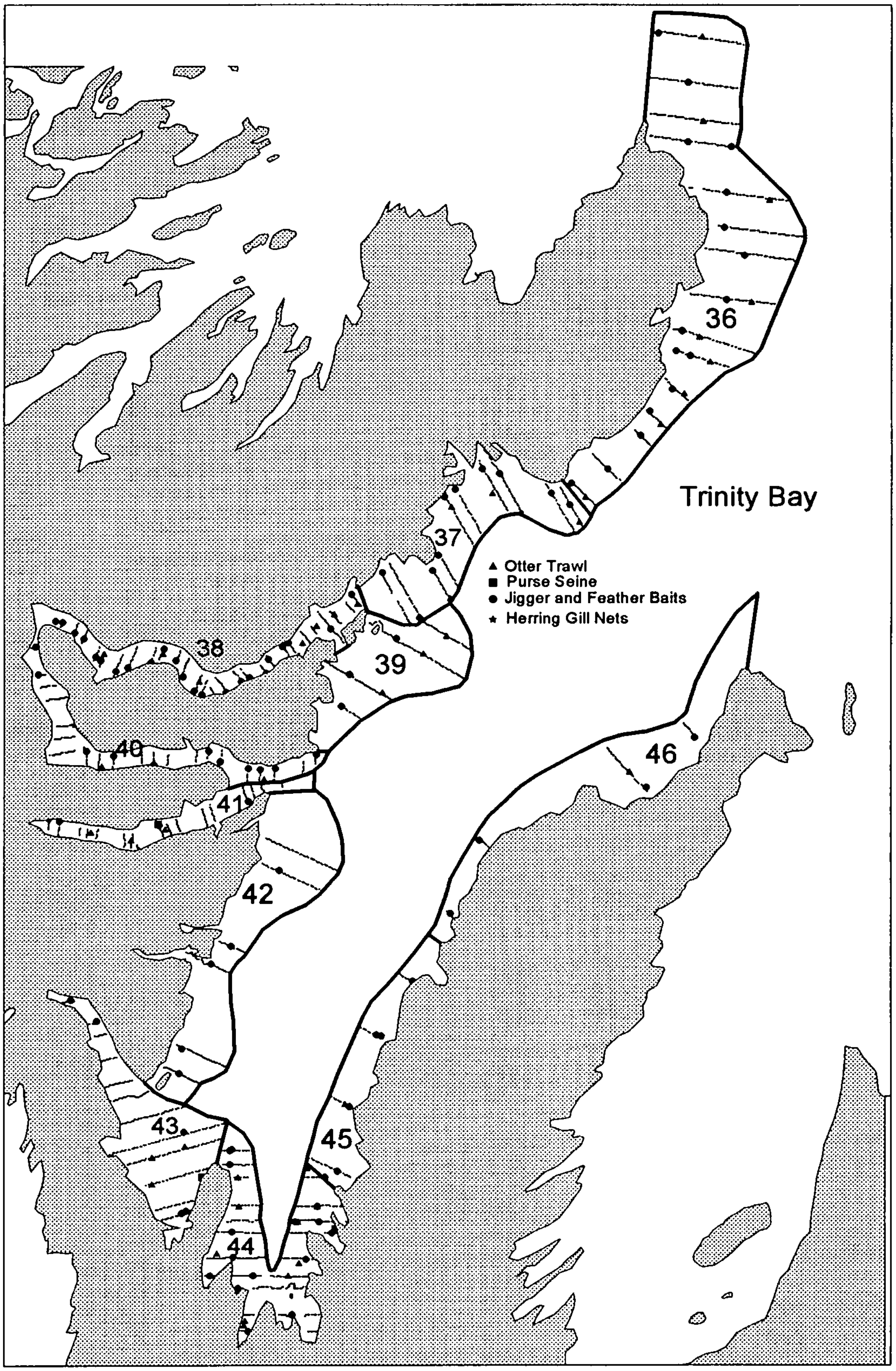

Figure 4.1.5 Area map of Trinity Bay indicating survey strata, transects, and biological sampling locations for the 1997 Div. 3KL inshore acoustic survey.

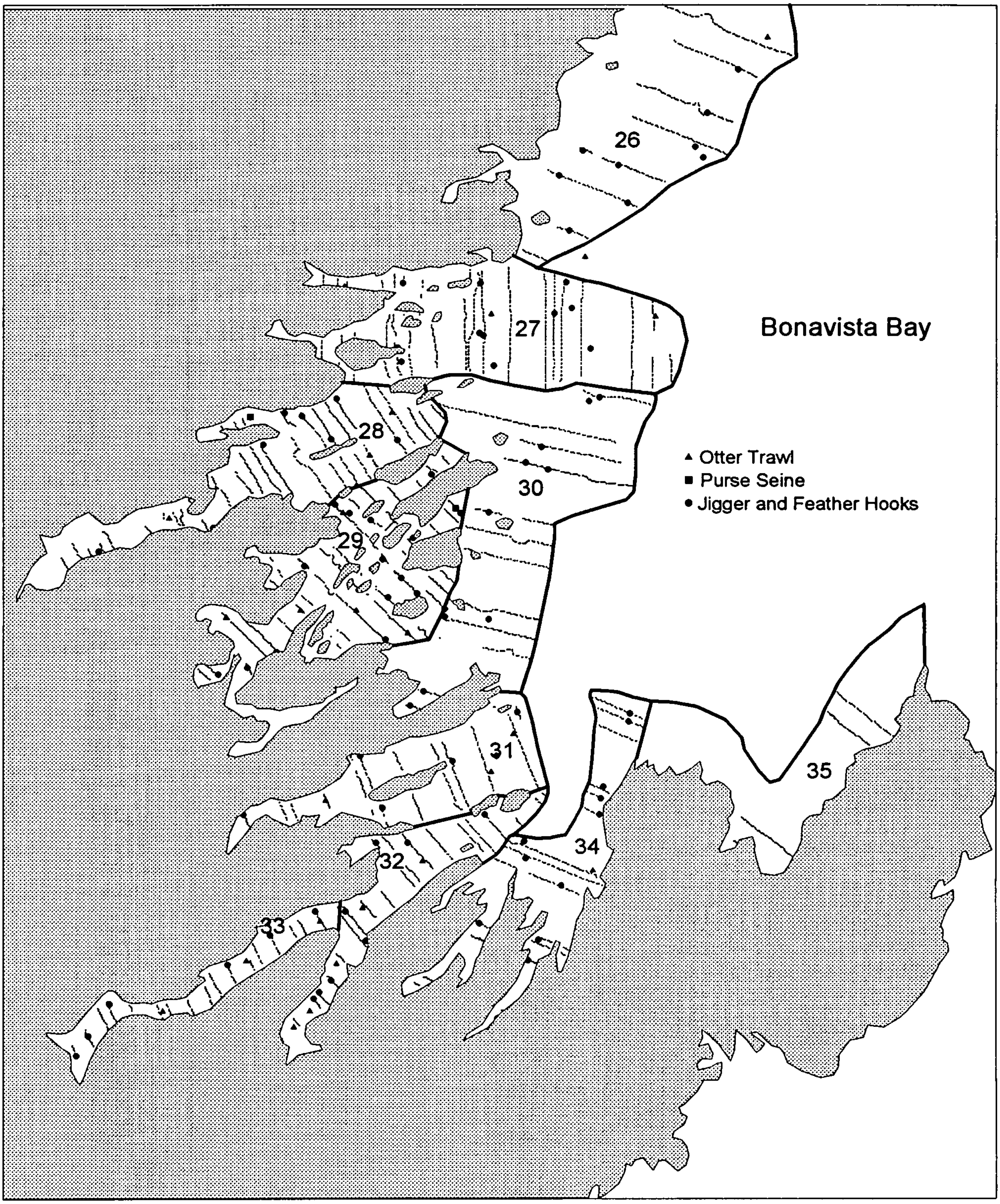

Figure 4.1.6 Area map of Bonavista Bay indicating survey strata, transects, and biological sampling locations for the 1997 Div. 3KL inshore acoustic survey.

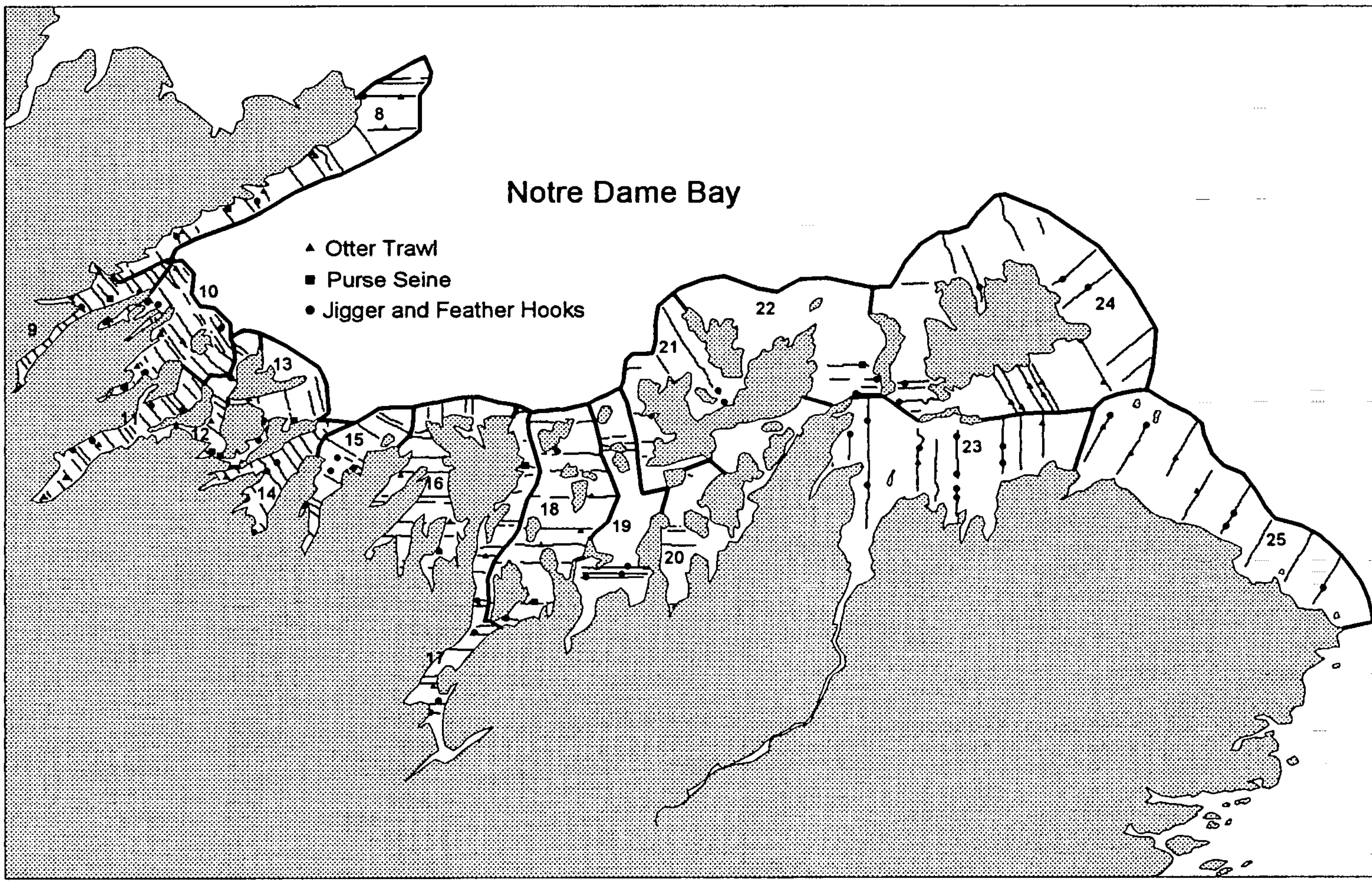

Figure 4.1.7 Area map of Notre Dame Bay indicating survey strata, transects, and biological sampling locations for the 1997 Div. 3KL inshore acoustic survey.

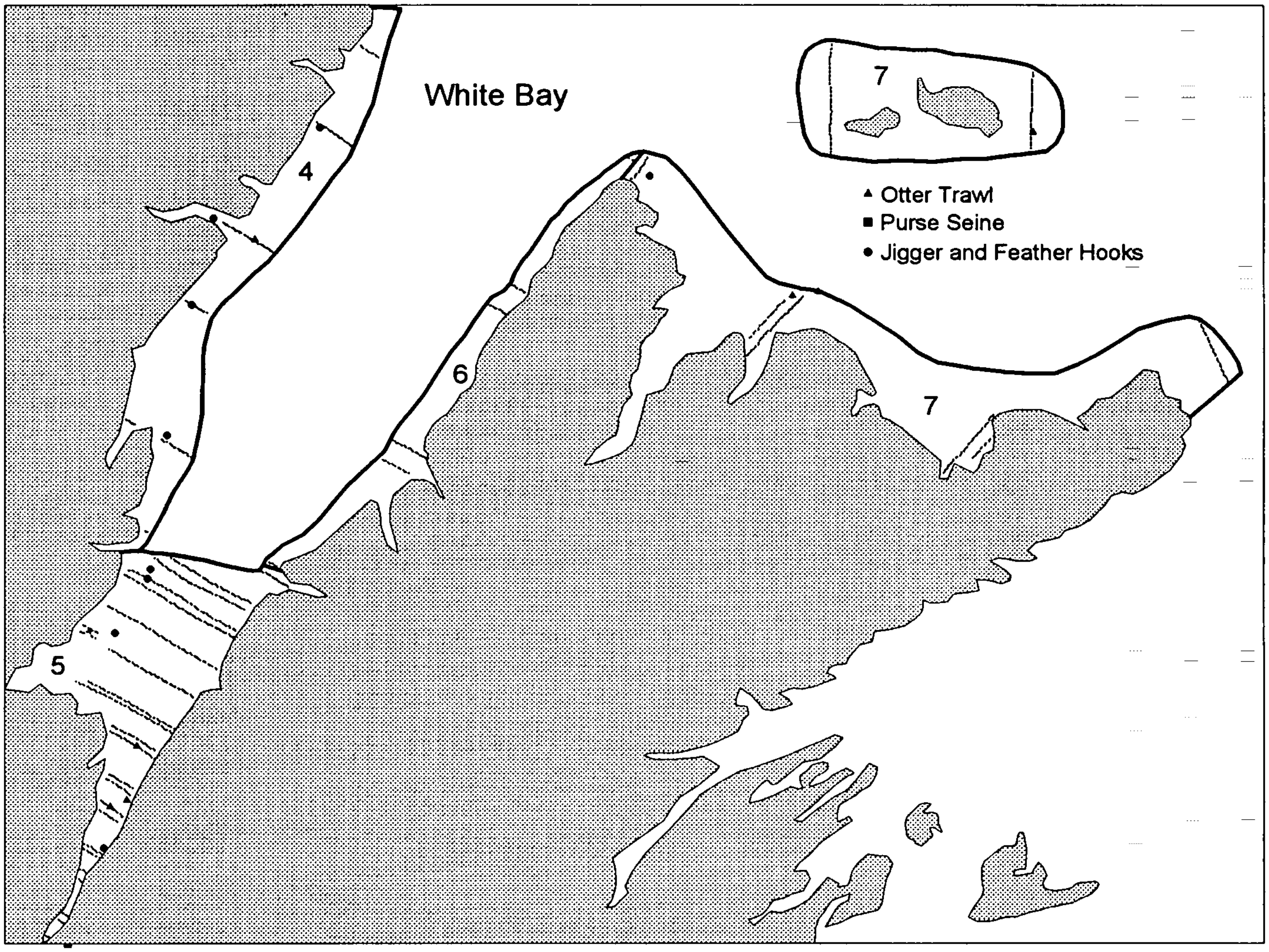

Figure 4.1.8 Area map of White Bay indicating survey strata, transects, and biological sampling locations for the 1997 Div. 3KL inshore acoustic survey.

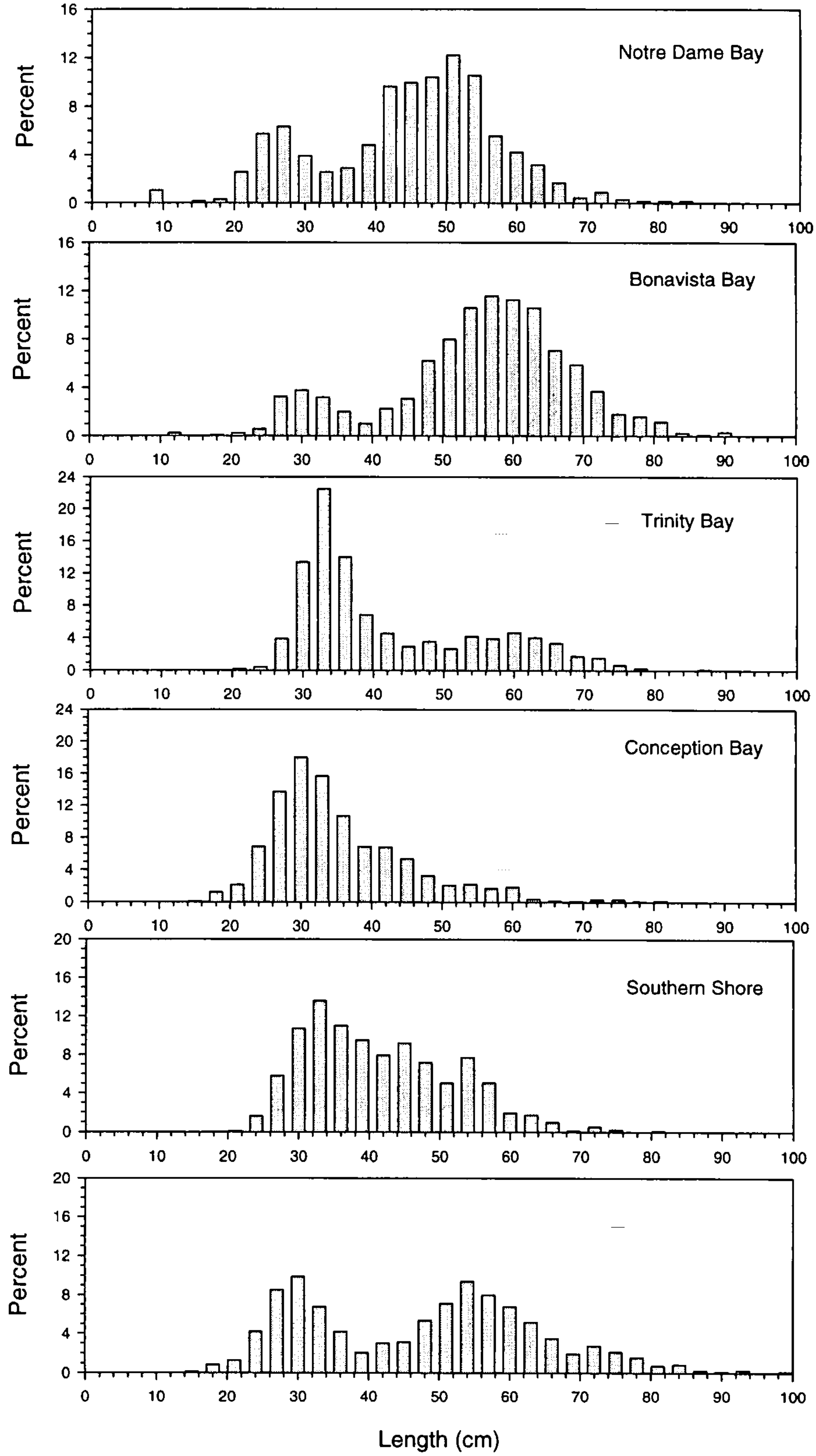

Fig. 4.2.1. Length frequency of cod caught with otter trawl.

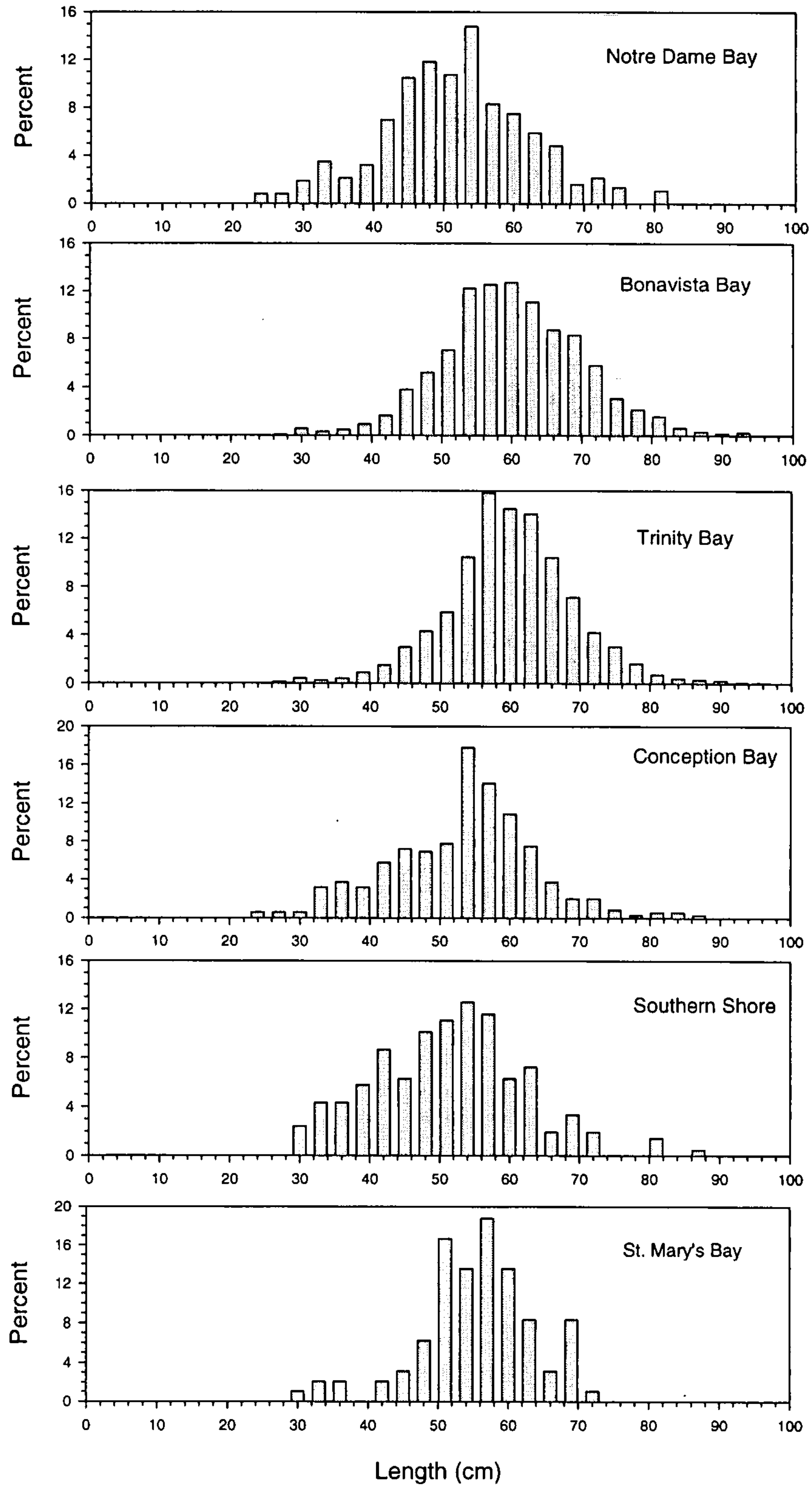

Fig. 4.2.2. Length frequency of cod caught with handline (jigger and feather hooks).

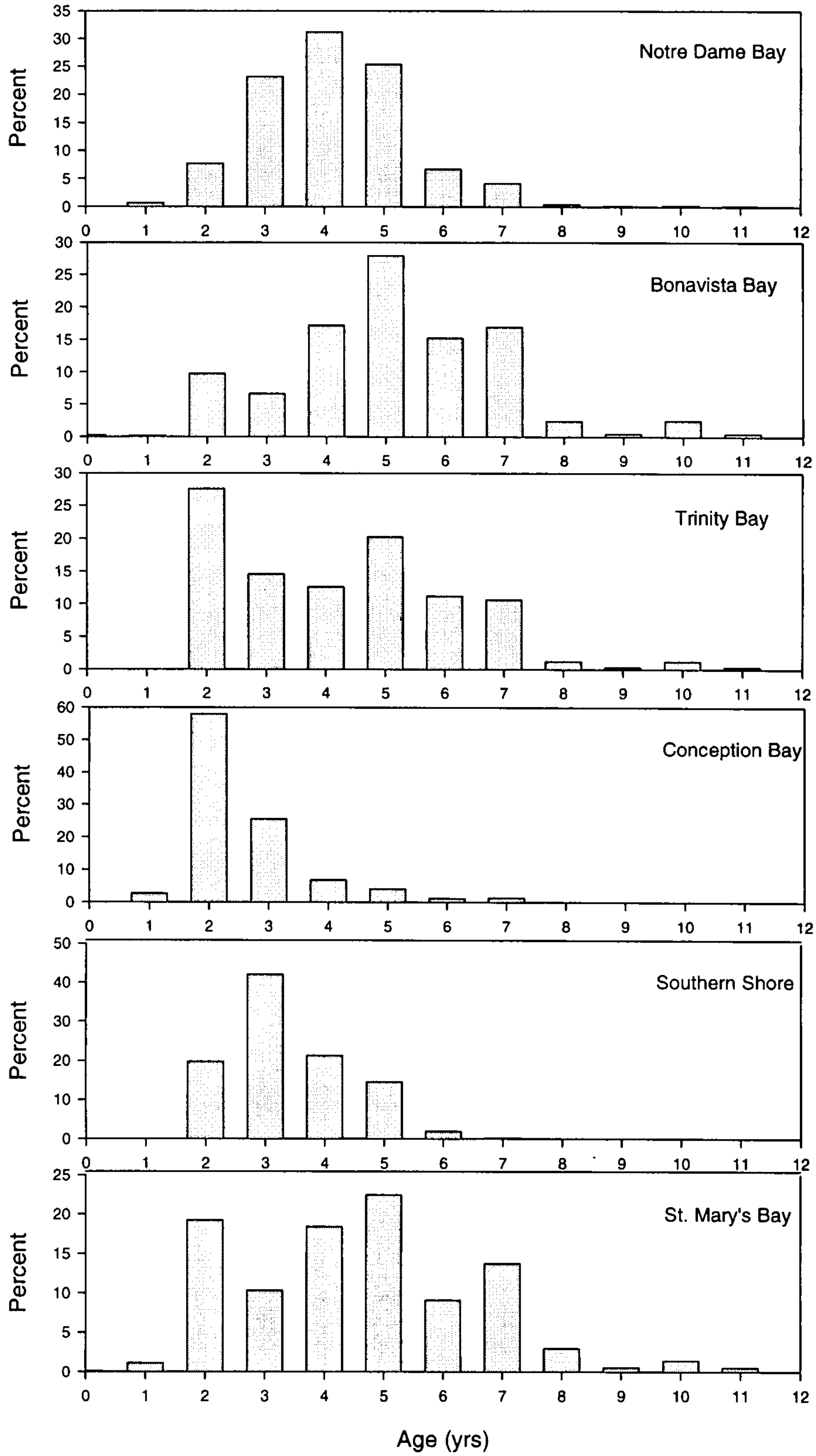

Figure 4.2.3. Age composition of cod caught with otter trawl.

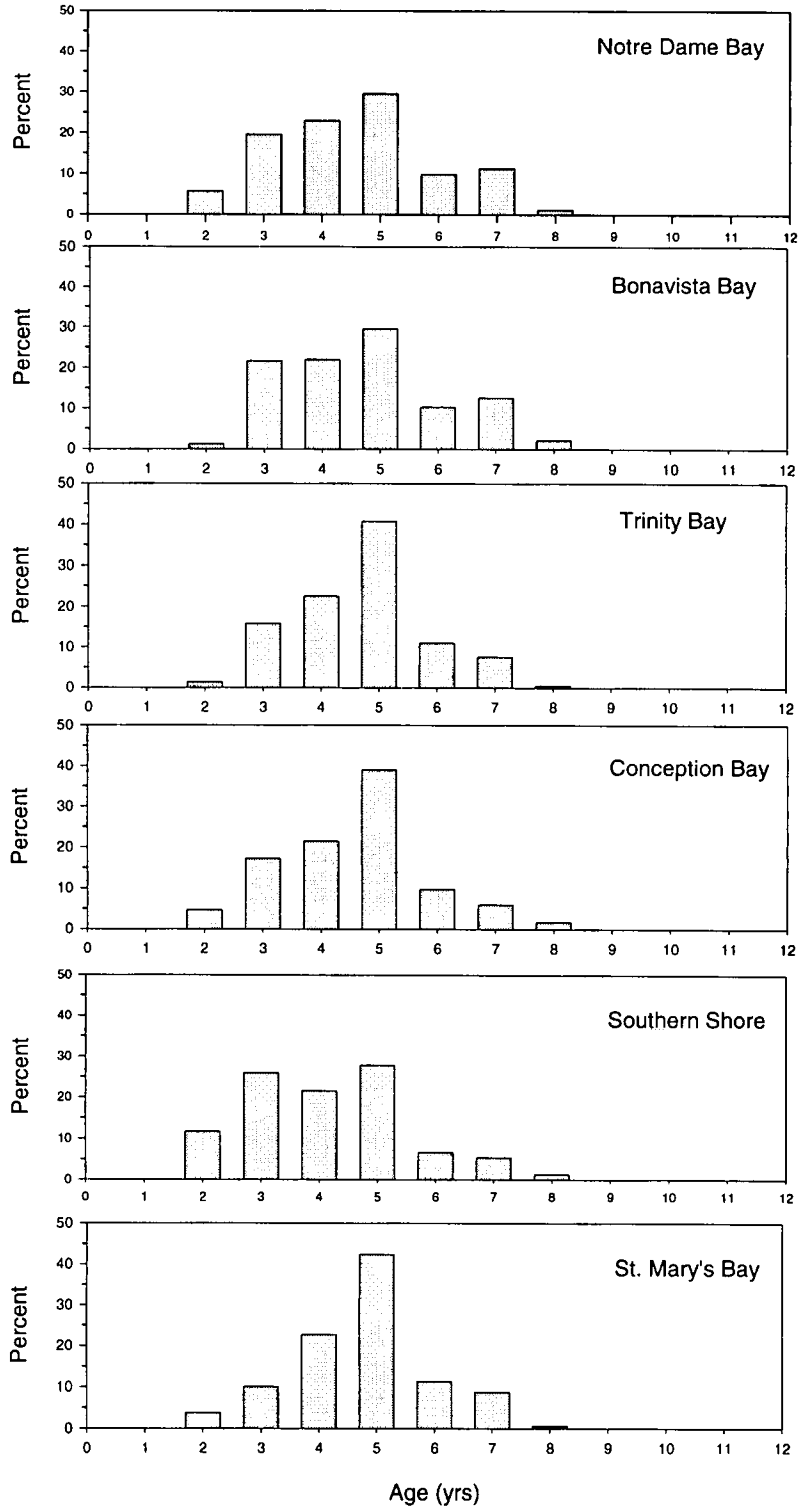

Figure 4.2.4. Age composition of cod caught with handline (jigger and feathered hooks).

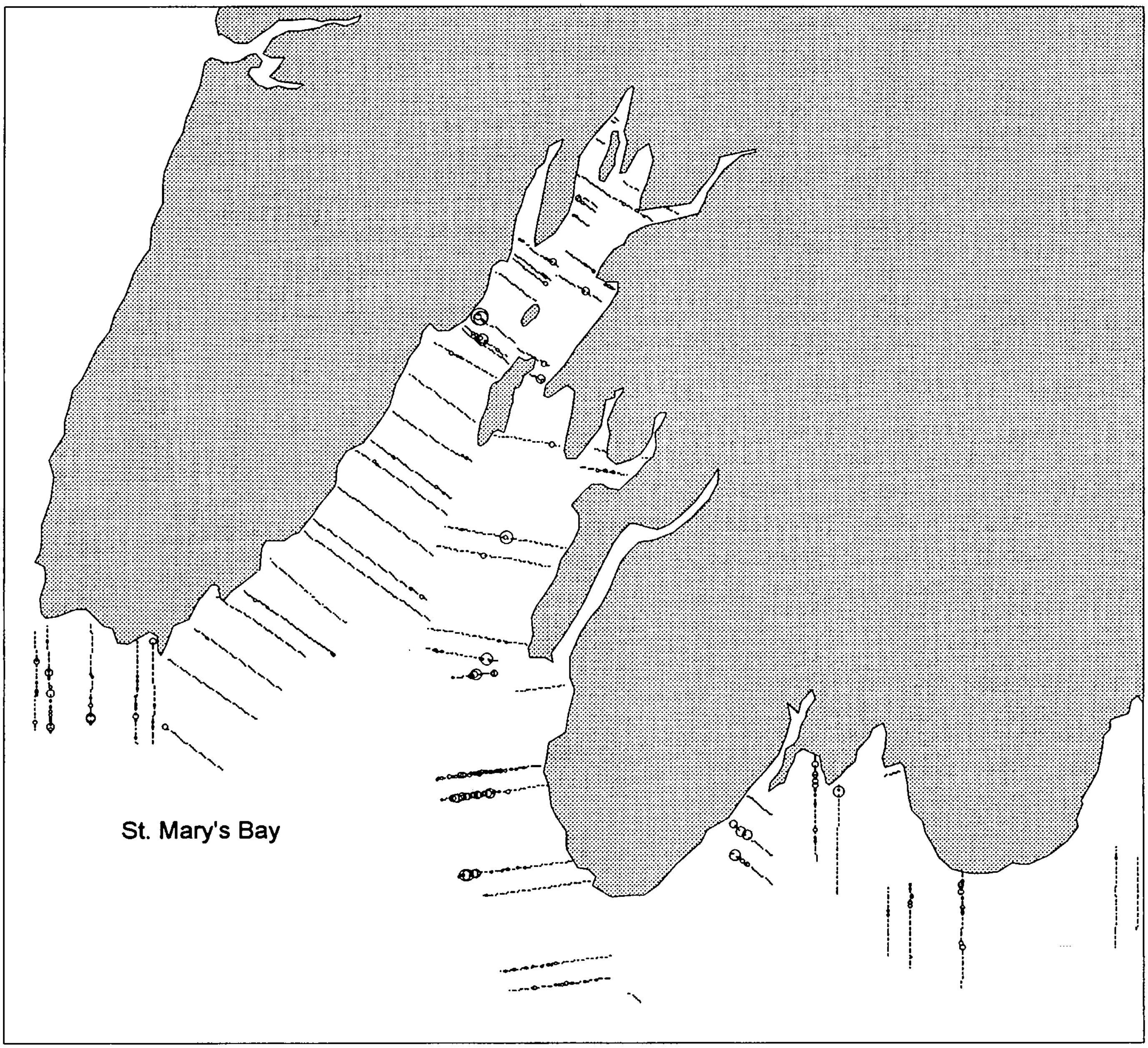

Figure 4.4.1 Distributions and densities (sq. root g. / sq. m.) of cod on transects in St. Mary's Bay during the 1997 Div. 3KL inshore acoustic survey.

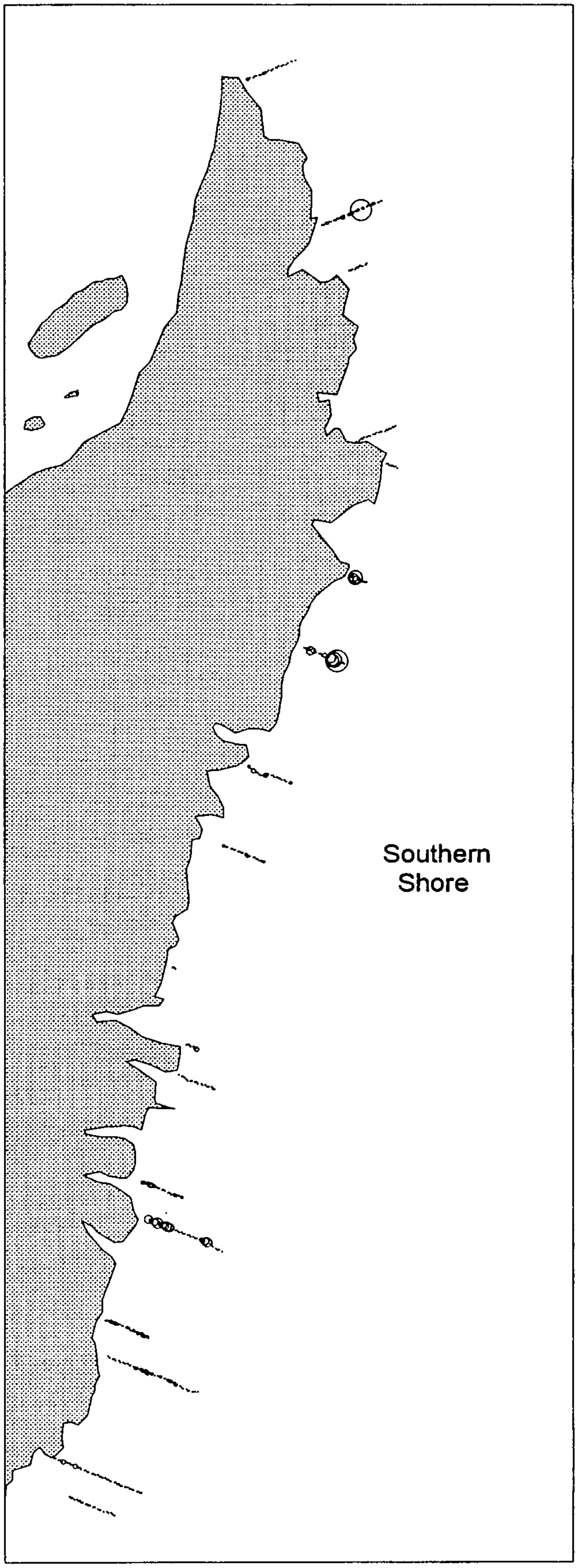

Figure 4.4.2 Distribution and densities (sq. root g. / sq. m.) of cod on transects along the Southern Shore during the 1997 Div. 3KL inshore acoustic survey.

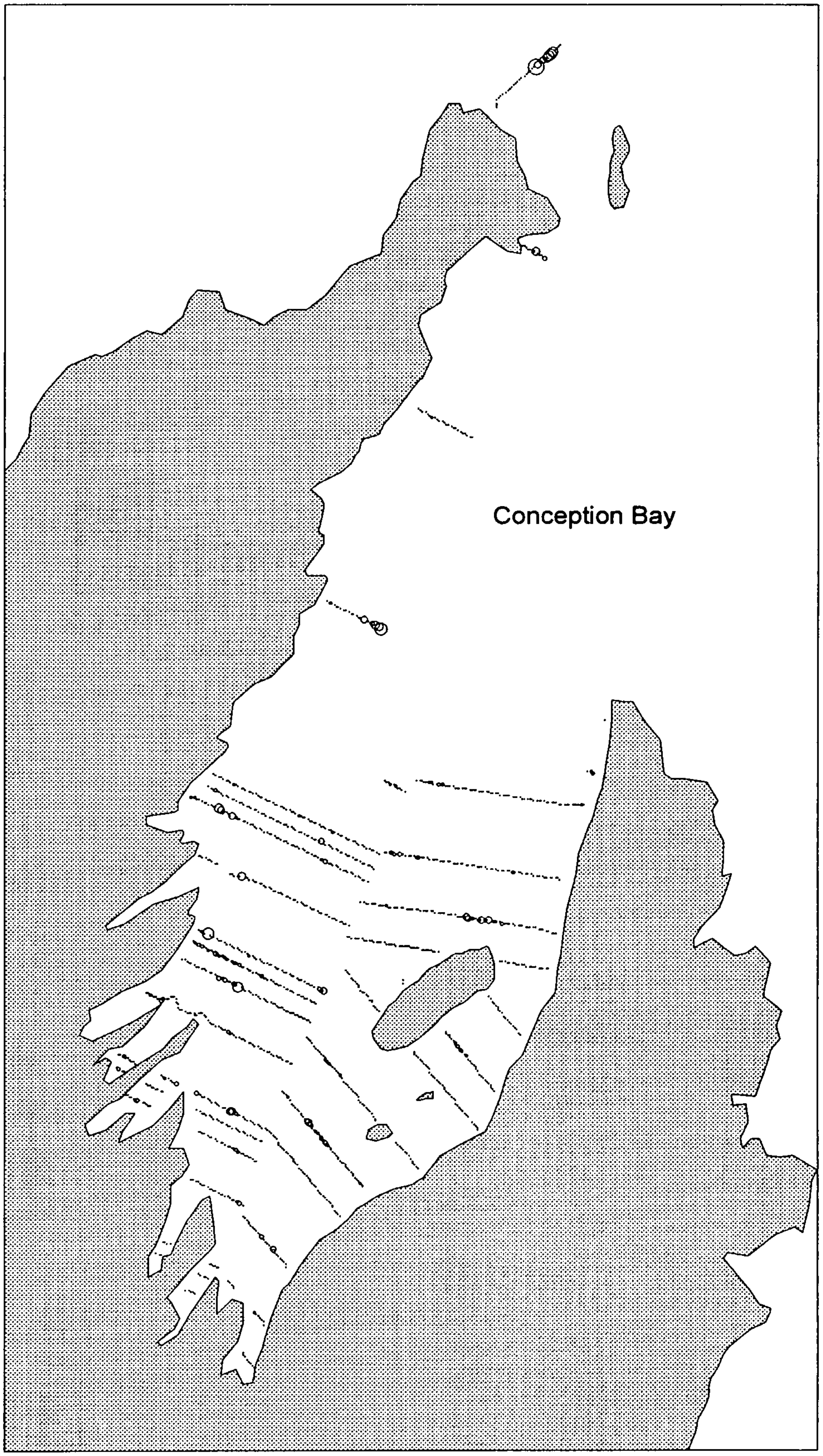

Figure 4.4.3 Distributions and densities (sq. root g. / sq. m) of cod on transects in Conception Bay during the 1997 Div. 3KL inshore acoustic survey.

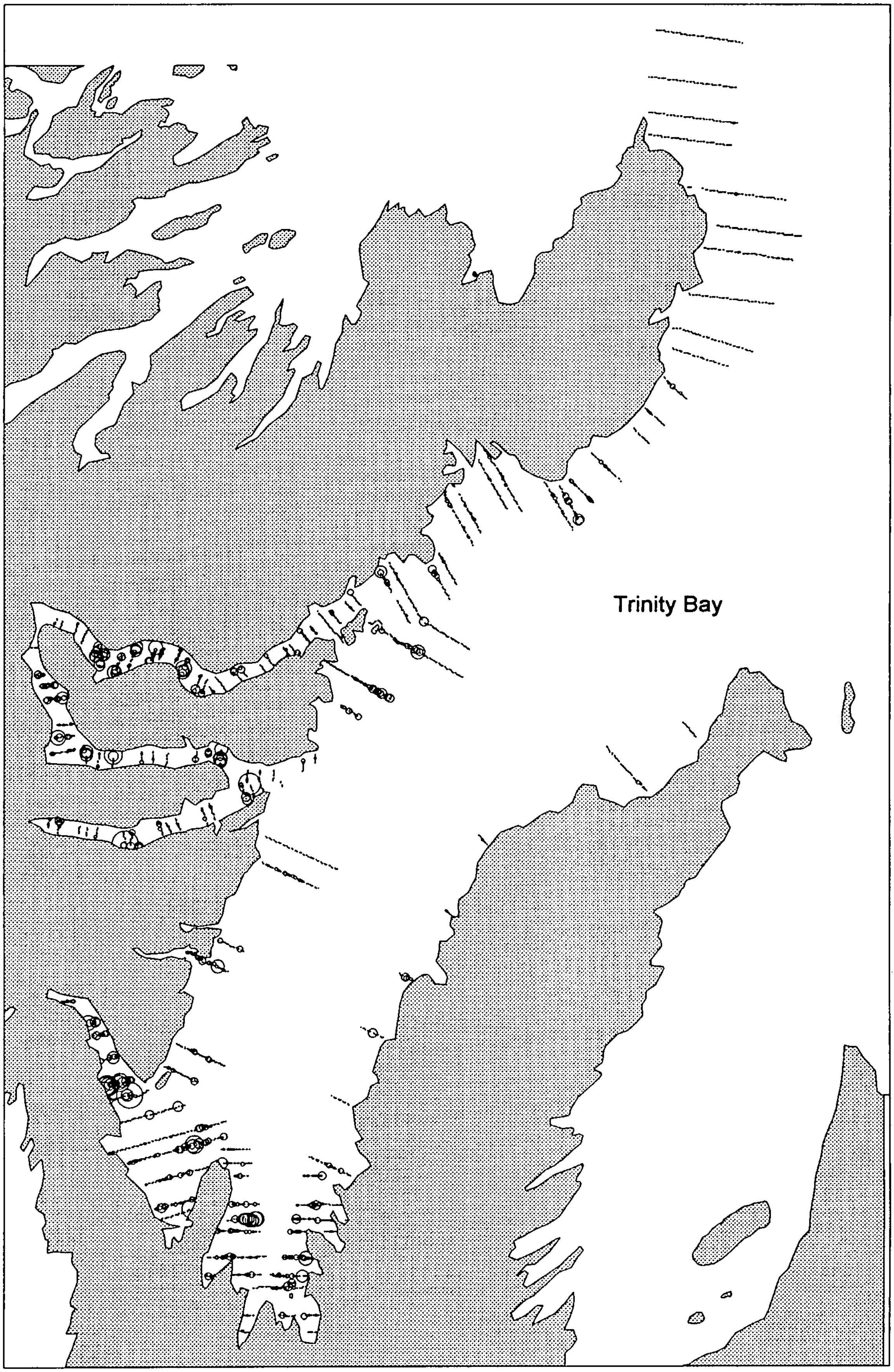

Figure 4.4.4 Distributions and densities (sq. root g. / sq. m.) of cod on transects in Trinity Bay during the 1997 Div. 3KL inshore acoustic survey.

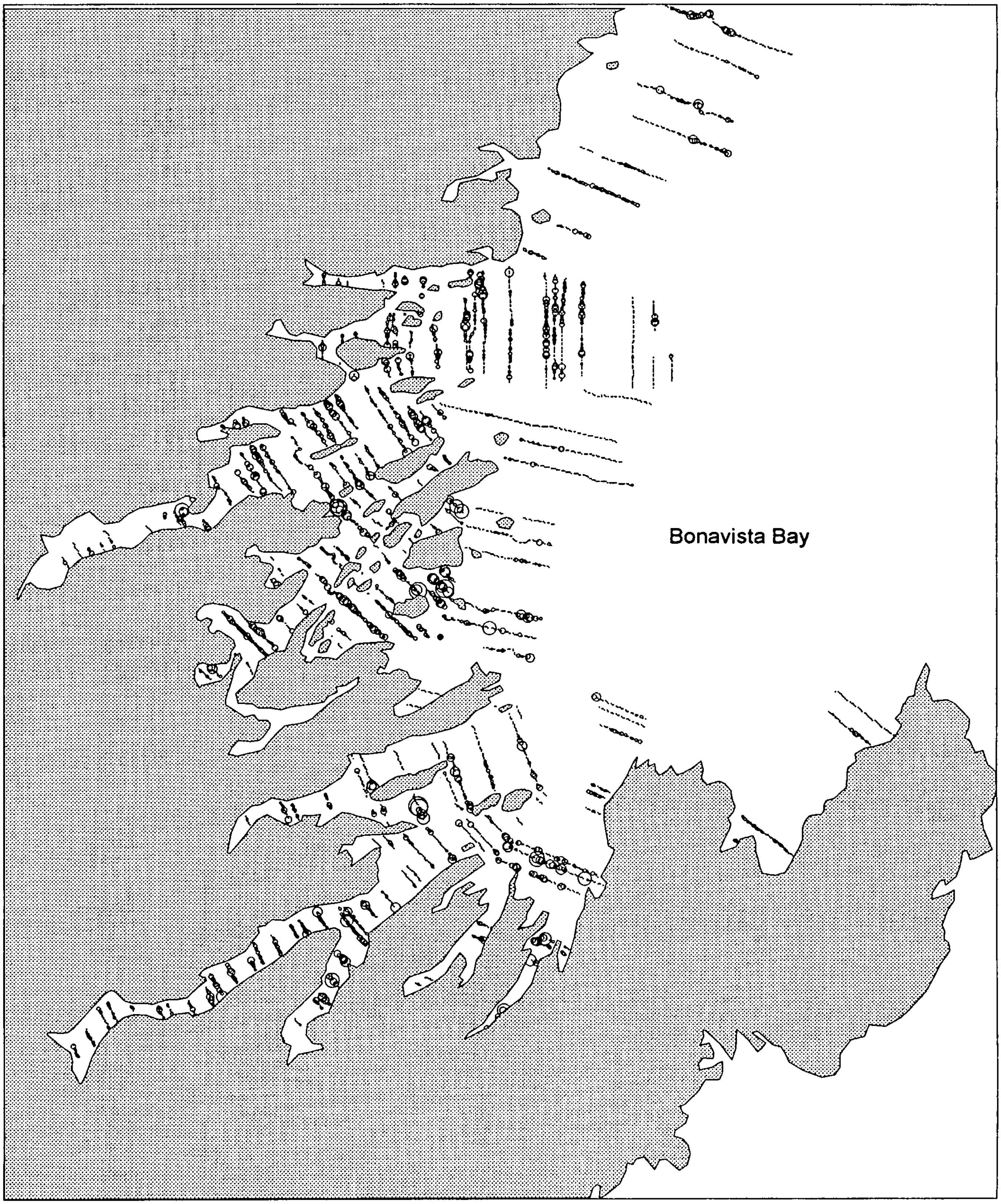

Figure 4.4.5 Distributions and densities (sq. root g. / sq. m.) of cod on transects in Bonavista Bay during the 1997 Div. 3KL inshore acoustic survey.

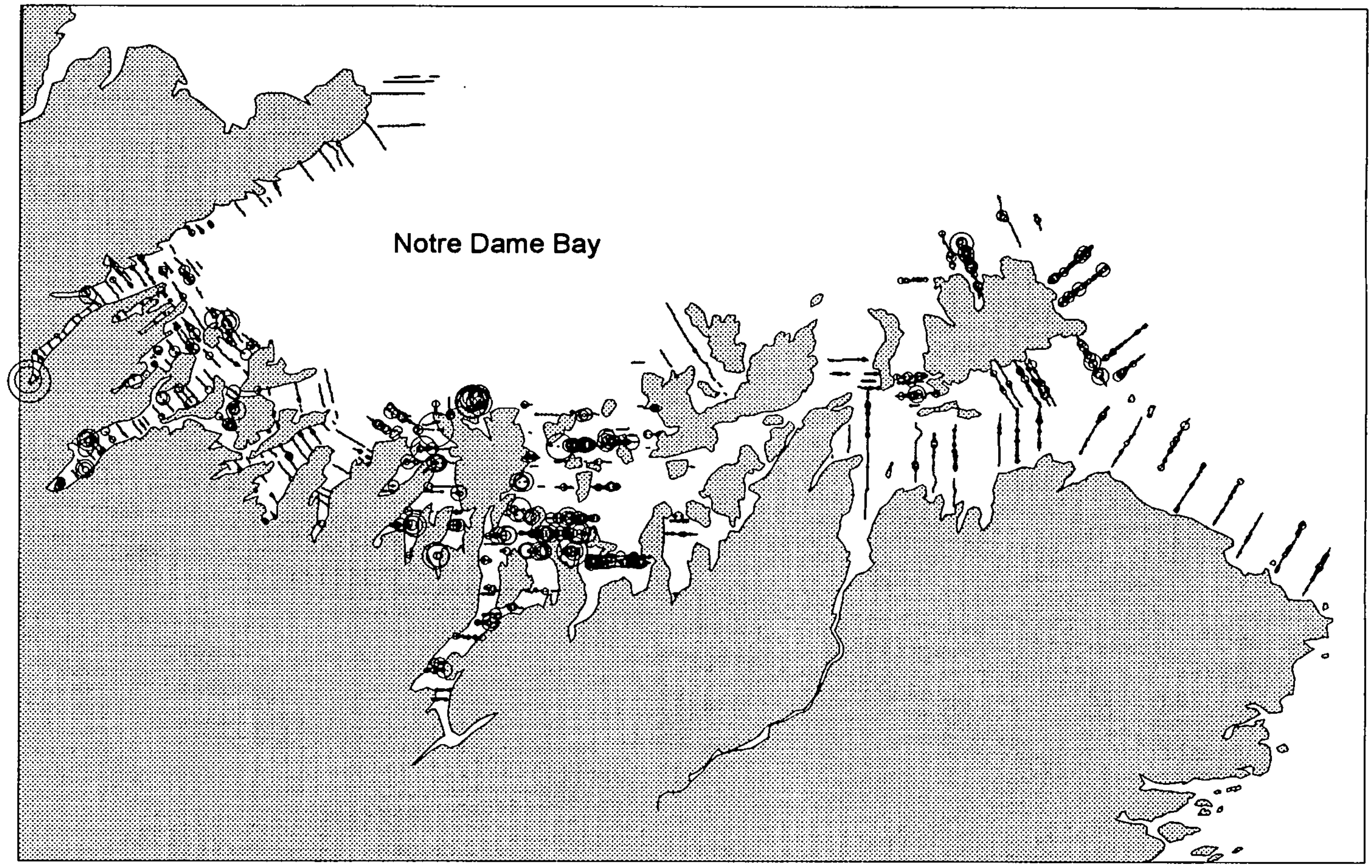

Figure 4.4.6 Distributions and densities (sq. root g. / sq. m.) of cod on transects in Notre Dame Bay during the 1997 Div. 3KL inshore acoustic survey.

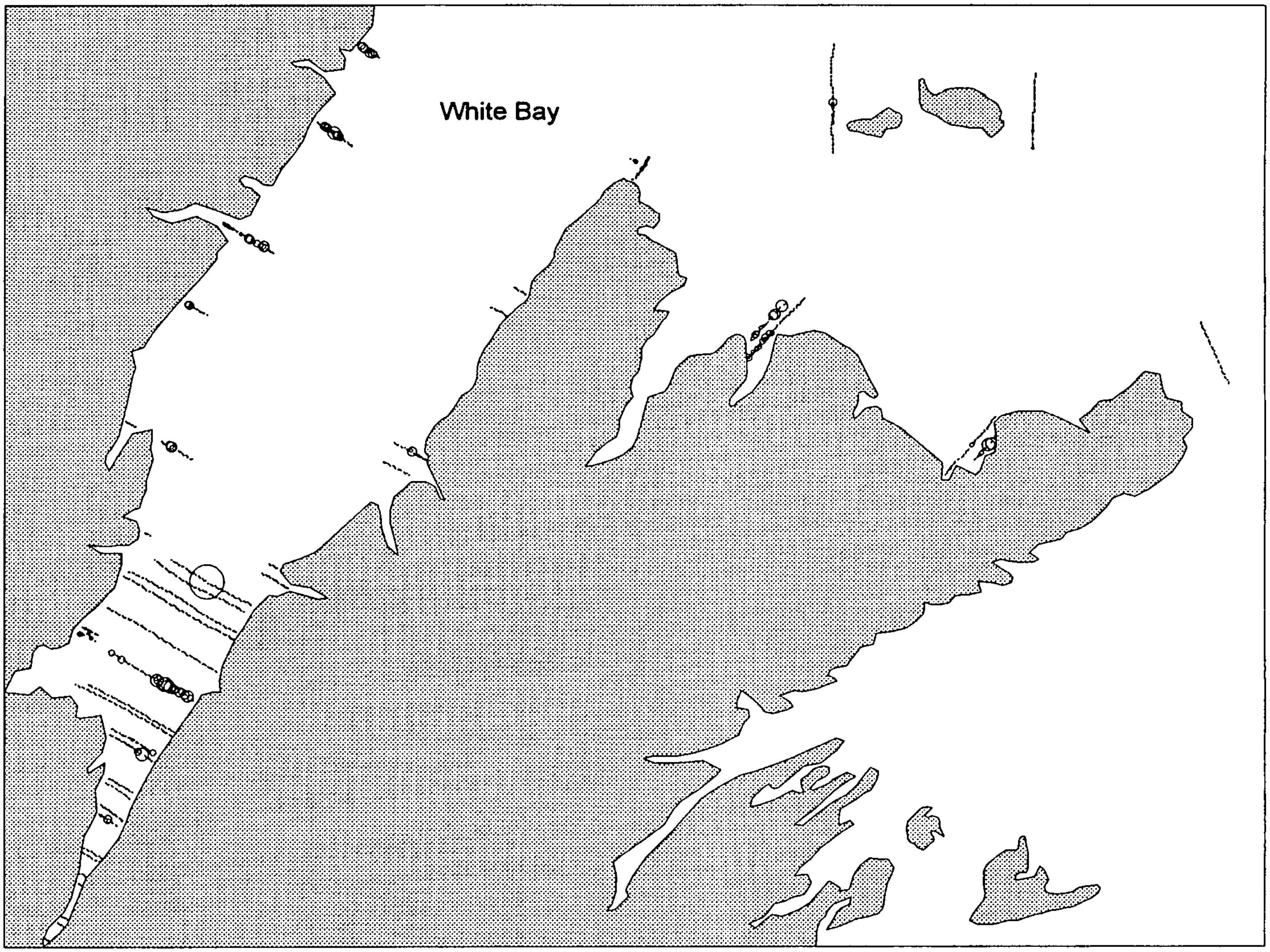

Figure 4.4.7 Distributions and densities (sq. root g. / sq. m.) of cod on transects in White Bay during the 1997 Div. 3KL inshore acoustic survey.

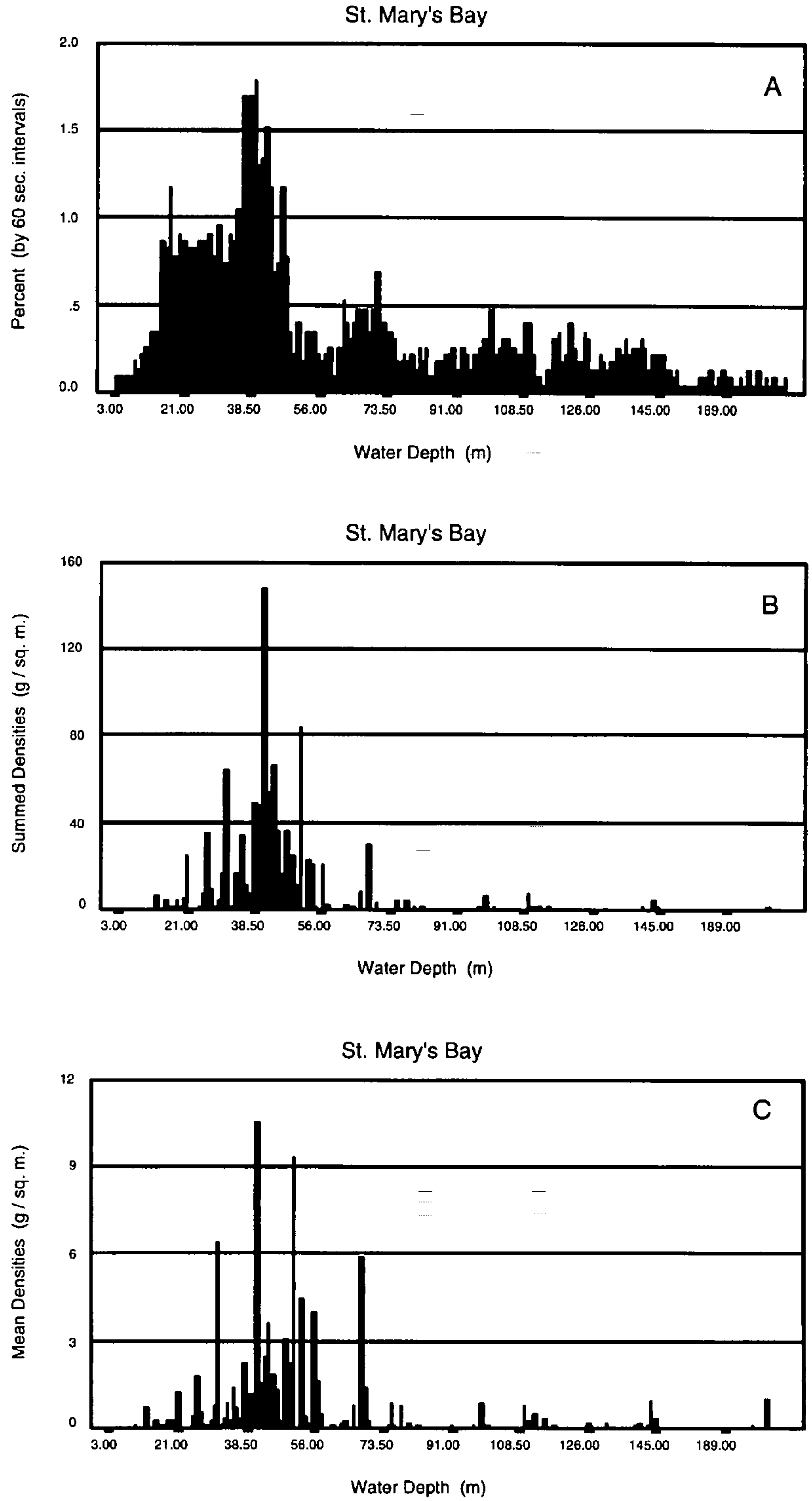

Figure 4.5.1 Distribution of acoustic sampling by water depth (Panel A), summed densities of cod by water depth (Panel B), and mean densities of cod by water depth (Panel C), for St. Mary's Bay, from the 1997 Div. 3KL inshore acoustic survey.

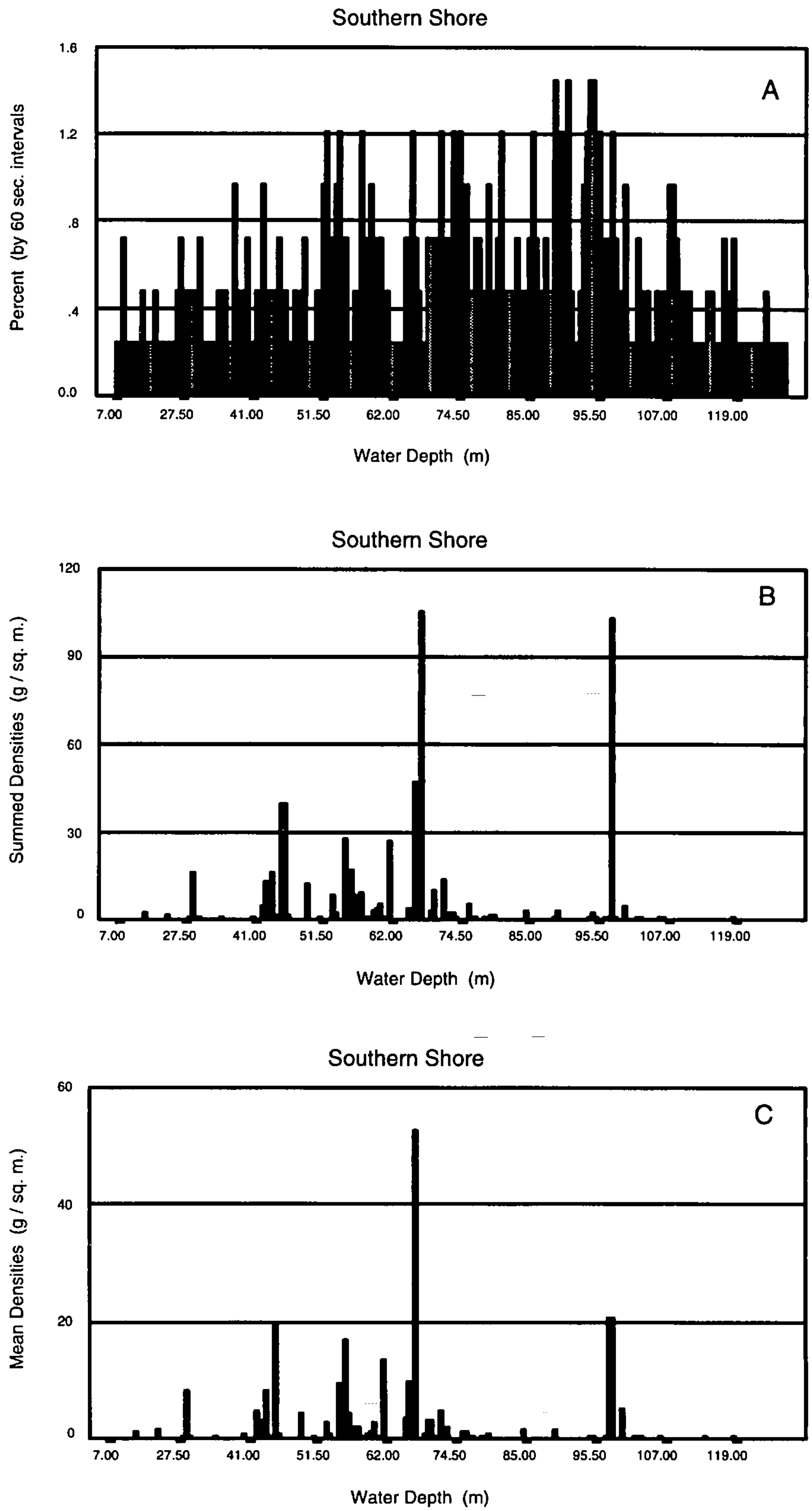

Figure 4.5.2 Distribution of acoustic sampling by water depth (Panel A), summed densities of cod by water depth (Panel B), and mean densities of cod by water depth (Panel C), for the Southern Shore, from the 1997 Div. 3KL inshore acoustic survey.

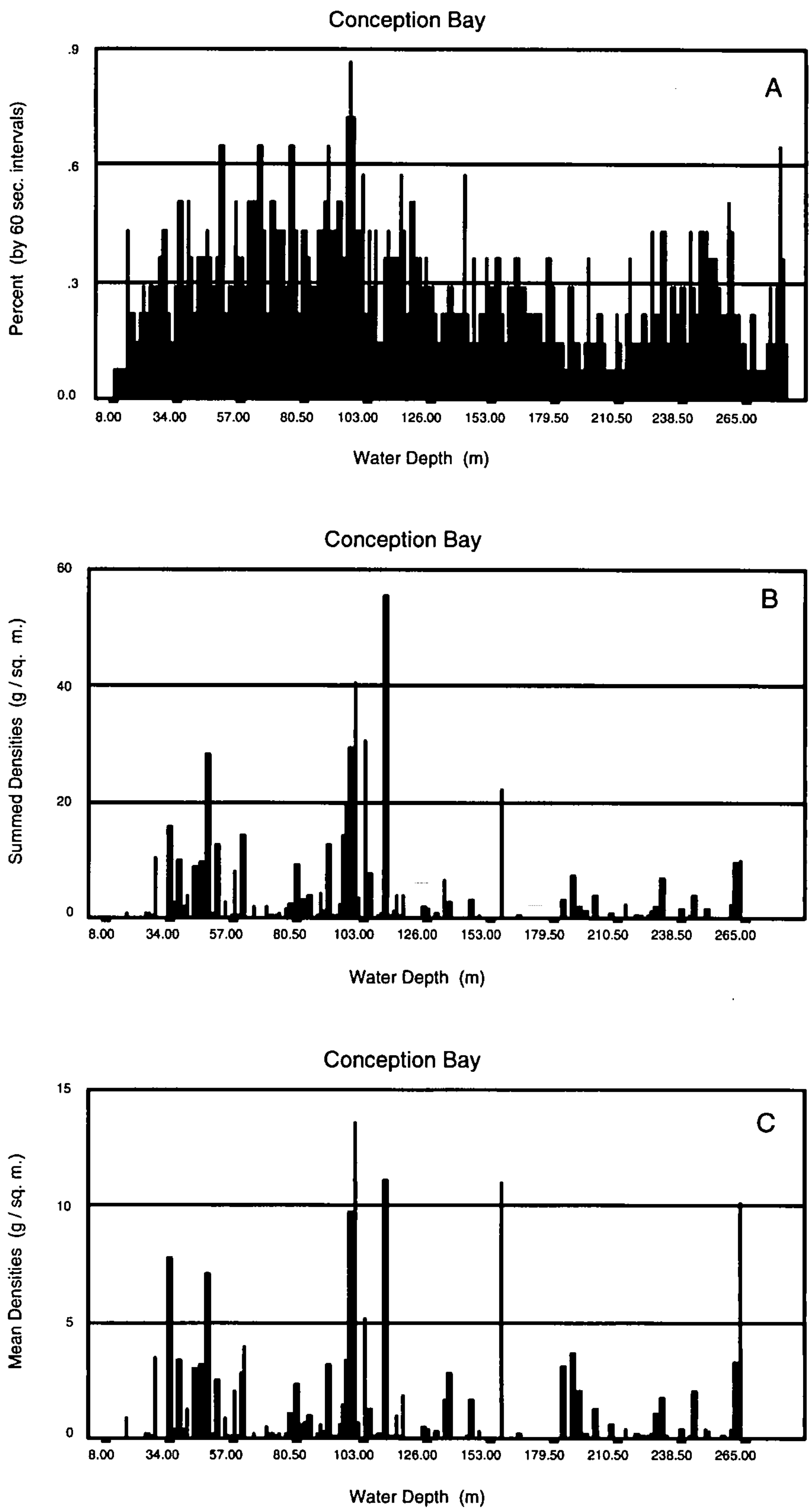

Figure 4.5.3 Distribution of acoustic sampling by water depth (Panel A), summed densities of cod by water depth (Panel B), and mean densities of cod by water depth (Panel C), for Conception Bay, from the 1997 Div. 3KL inshore acoustic survey.

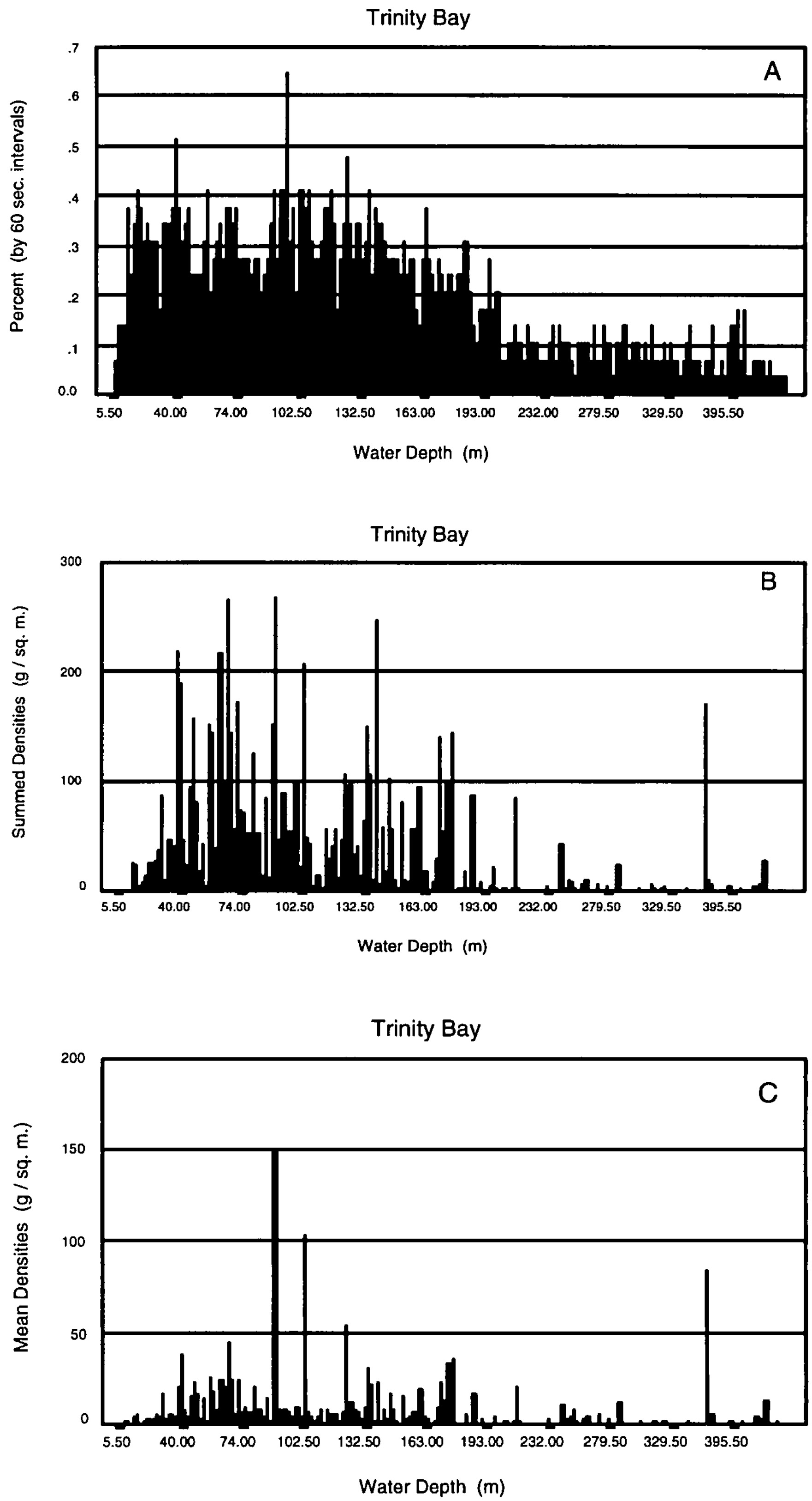

Figure 4.5.4 Distribution of acoustic sampling by water depth (Panel A), summed densities of cod by water depth (Panel B), and mean densities of cod by water depth (Panel C), for Trinity Bay, from the 1997 Div. 3KL inshore acoustic survey.

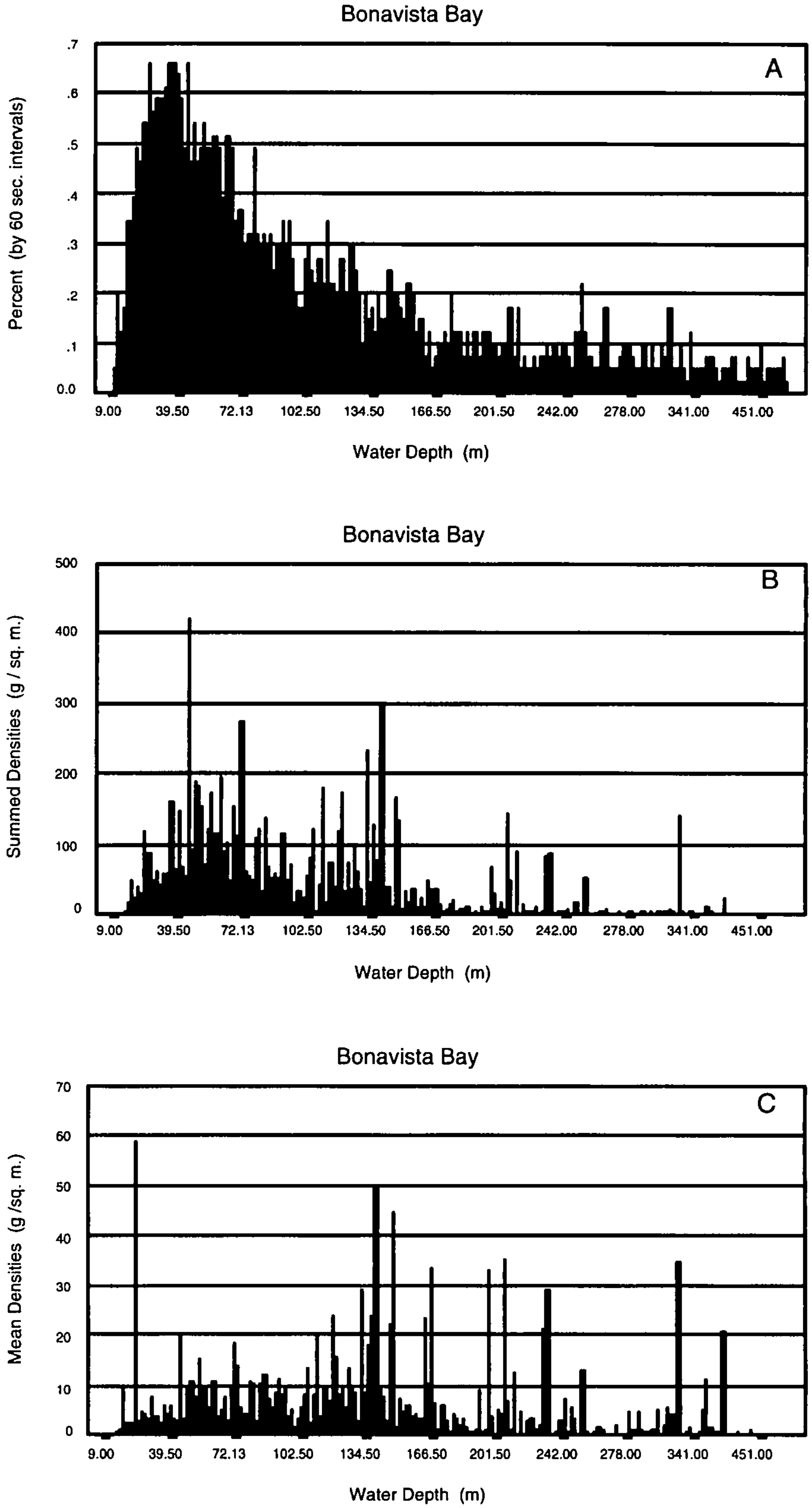

Figure 4.5.5 Distribution of acoustic sampling by water depth (Panel A), summed densities of cod by water depth (Panel B), and mean densities of cod by water depth (Panel C), for Bonavista Bay, from the 1997 Div. 3KL inshore acoustic survey.

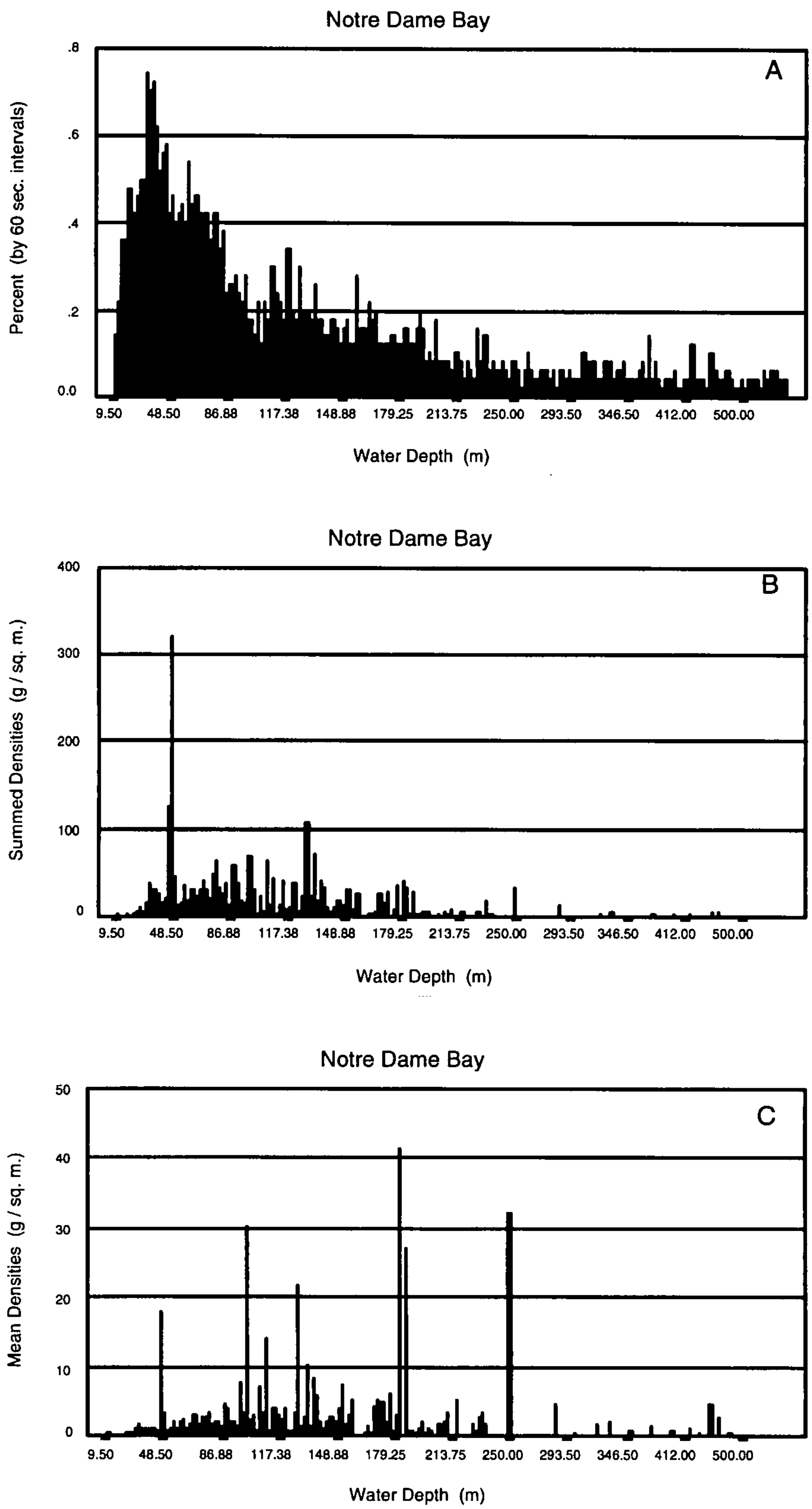

Figure 4.5.6 Distribution of acoustic sampling by water depth (Panel A), summed densities of cod by water depth (Panel B), and mean densities of cod by water depth (Panel C), for Notre Dame Bay, from the 1997 Div. 3KL inshore acoustic survey.

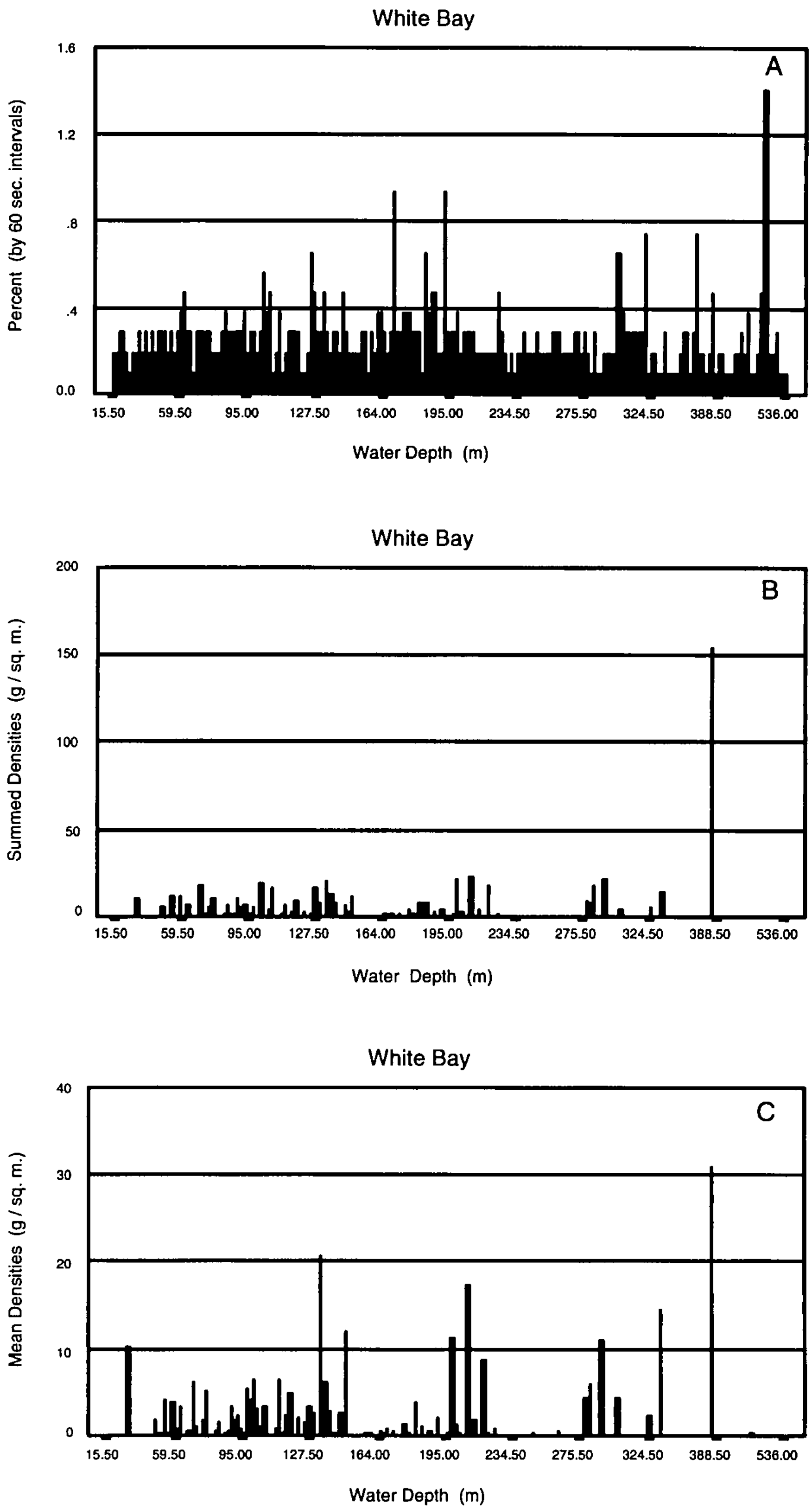

Figure 4.5.7 Distribution of acoustic sampling by water depth (Panel A), summed densities of cod by water depth (Panel B), and mean densities of cod by water depth (Panel C), for White Bay, from the 1997 Div. 3KL inshore acoustic survey.

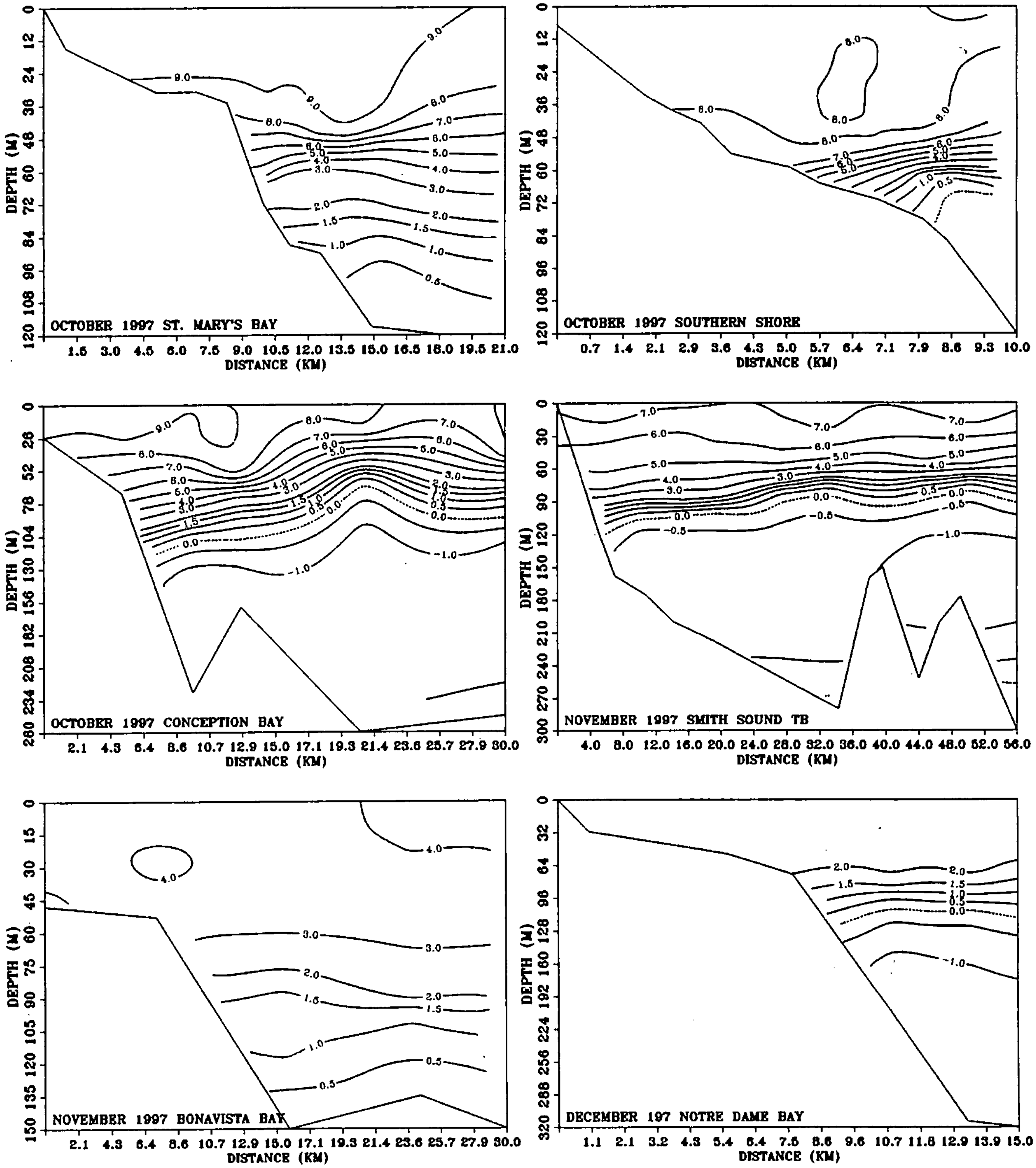

Figure 4.6.1 The vertical temperature distribution along transects within selected bays of Newfoundland during the fall of 1997. The contour intervals are 0.5 °C from -1.0 to 2.0 °C and 1.0 °C from 2.0 to 9.0 °C.

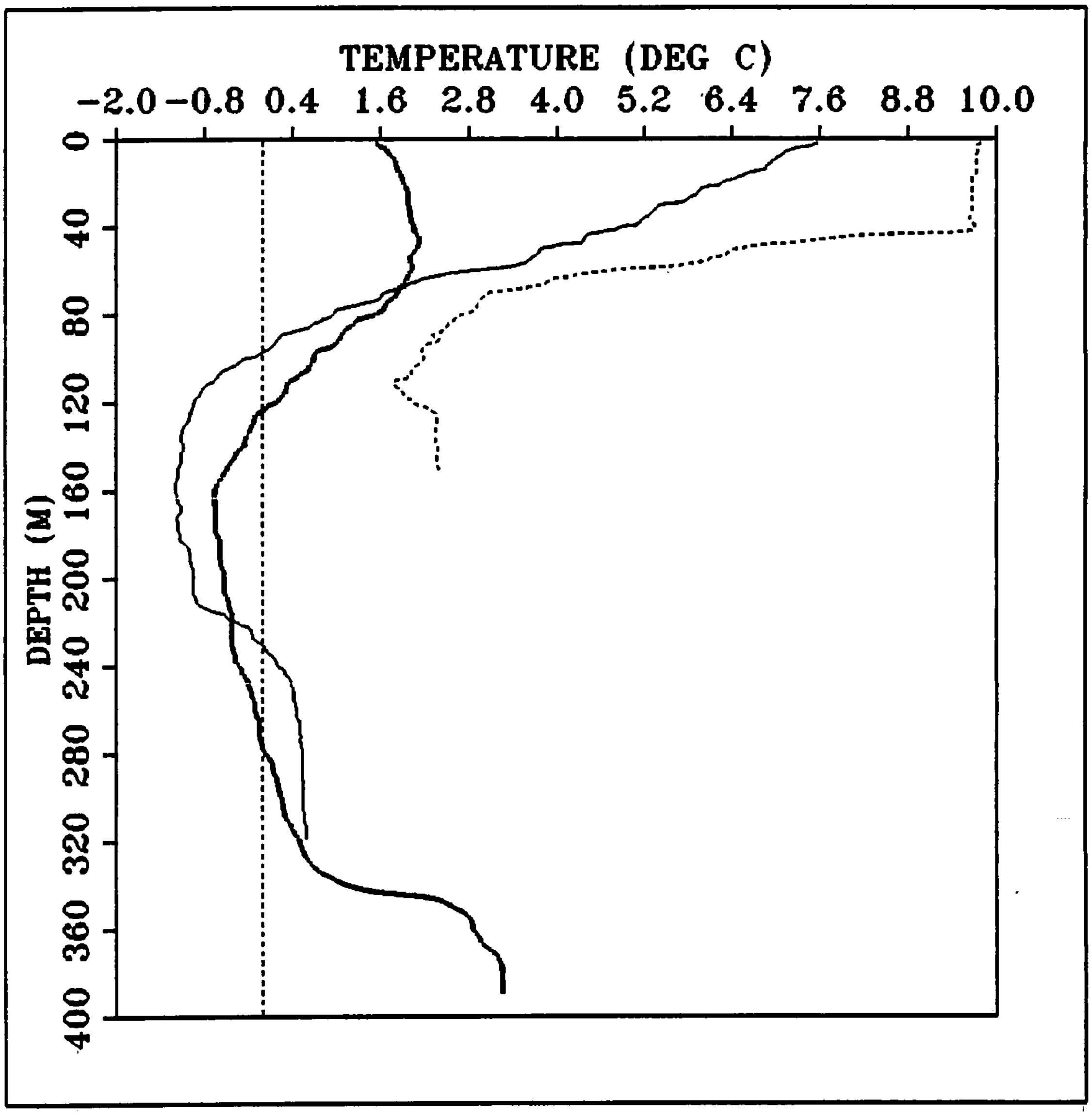

Figure 4.6.2 Vertical temperature profiles in St. Mary's Bay in October (dashed), Trinity Bay in November (light solid line) and in Notre Dame Bay in December (heavy solid line). The vertical dashed line indicates 0.0 °C.

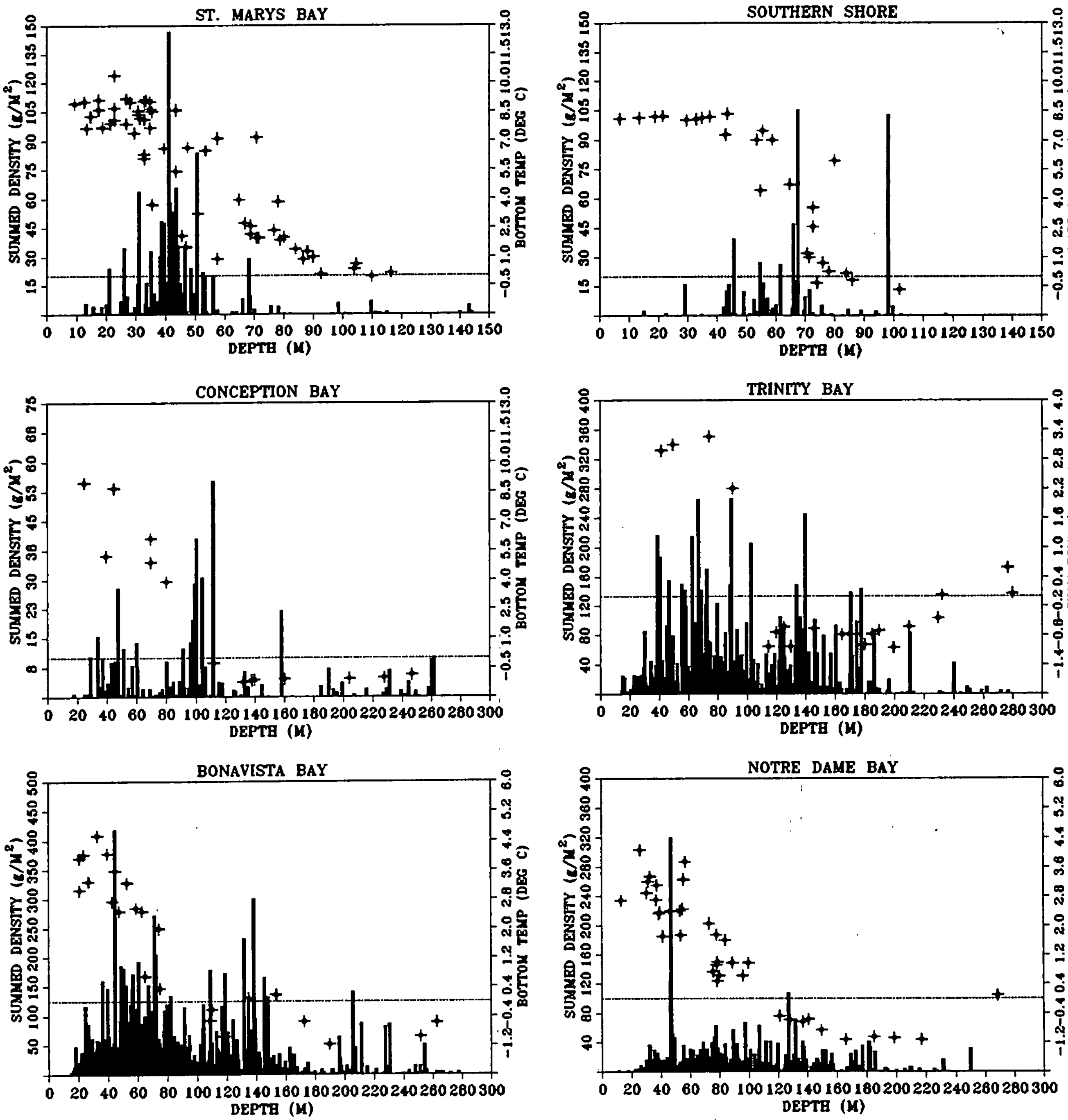

Figure 4.6.3 The summed densities of cod in 0.5 m depth bins for each bay with the ambient bottom water temperatures shown as the crosses. The dashed line indicates 0.0 °C.

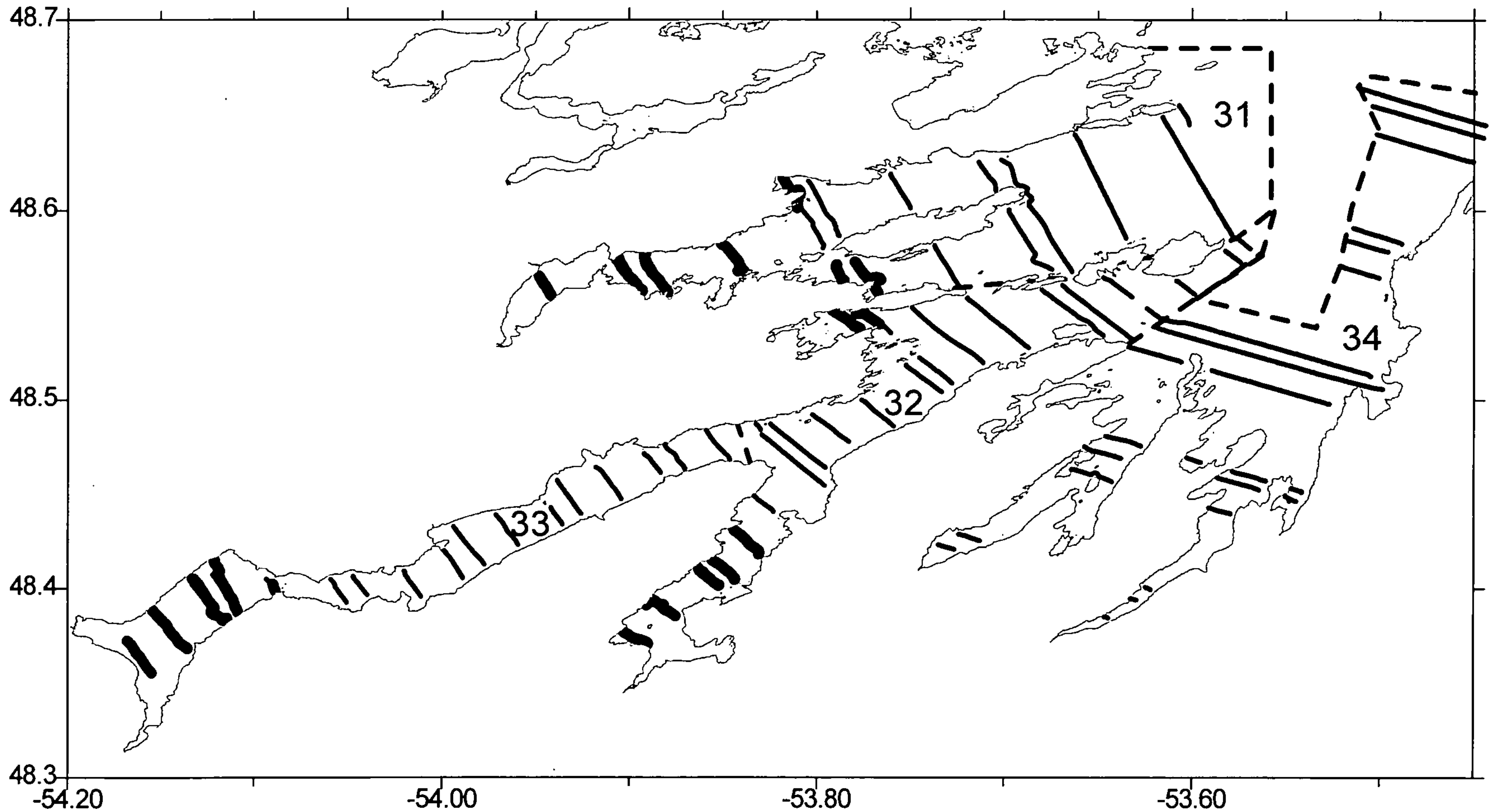

Figure 4.7.1. Location of overlapping transect lines sampled by the nearshore (Shanadithii) component, in relation to the total number of transect lines sampled by the inshore component (Shamook/Lauzier) within Strata 31-34, southern Bonavista Bay.

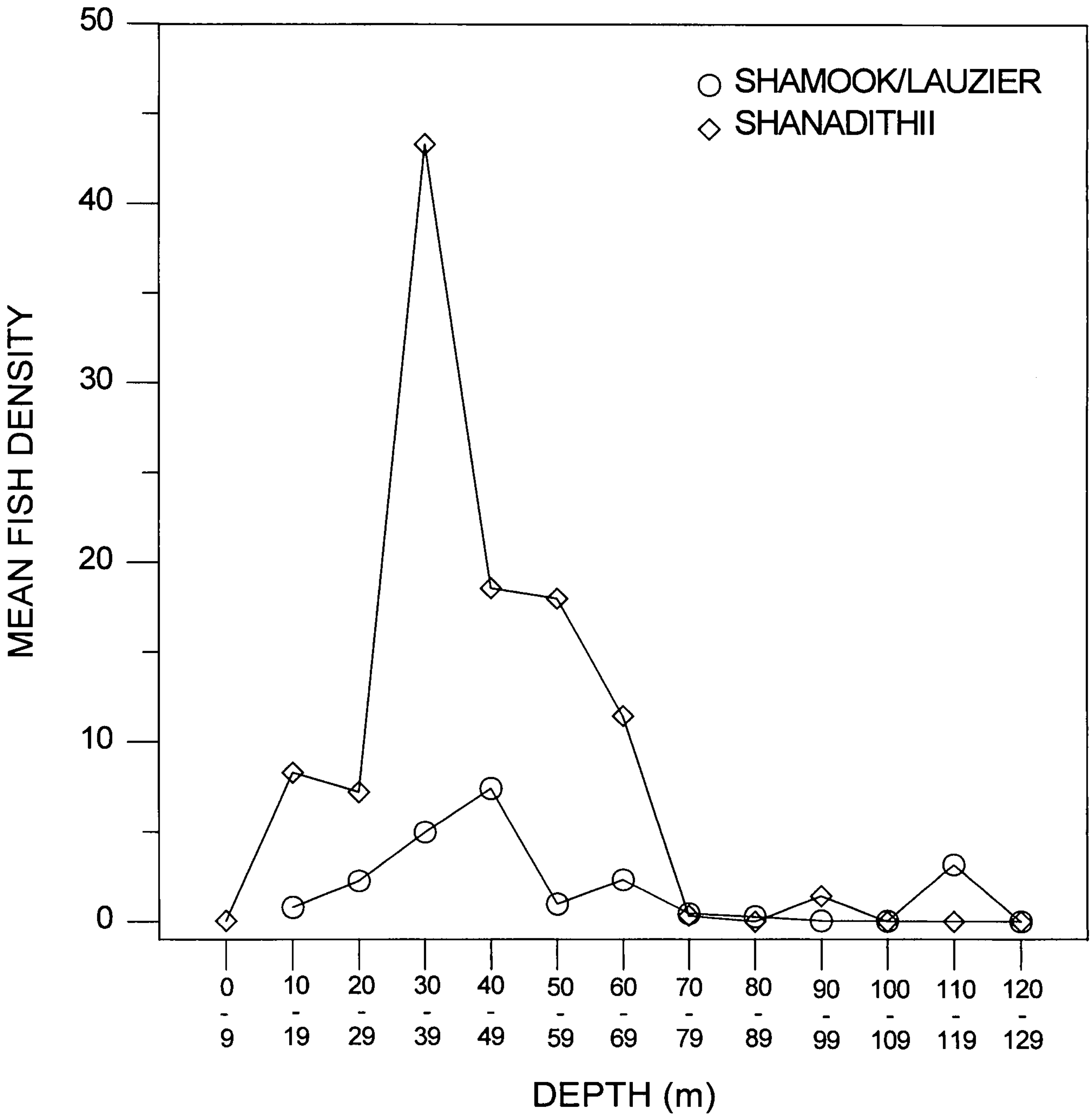

Figure 4.7.2. Plot of mean fish density vs. depth in meters.

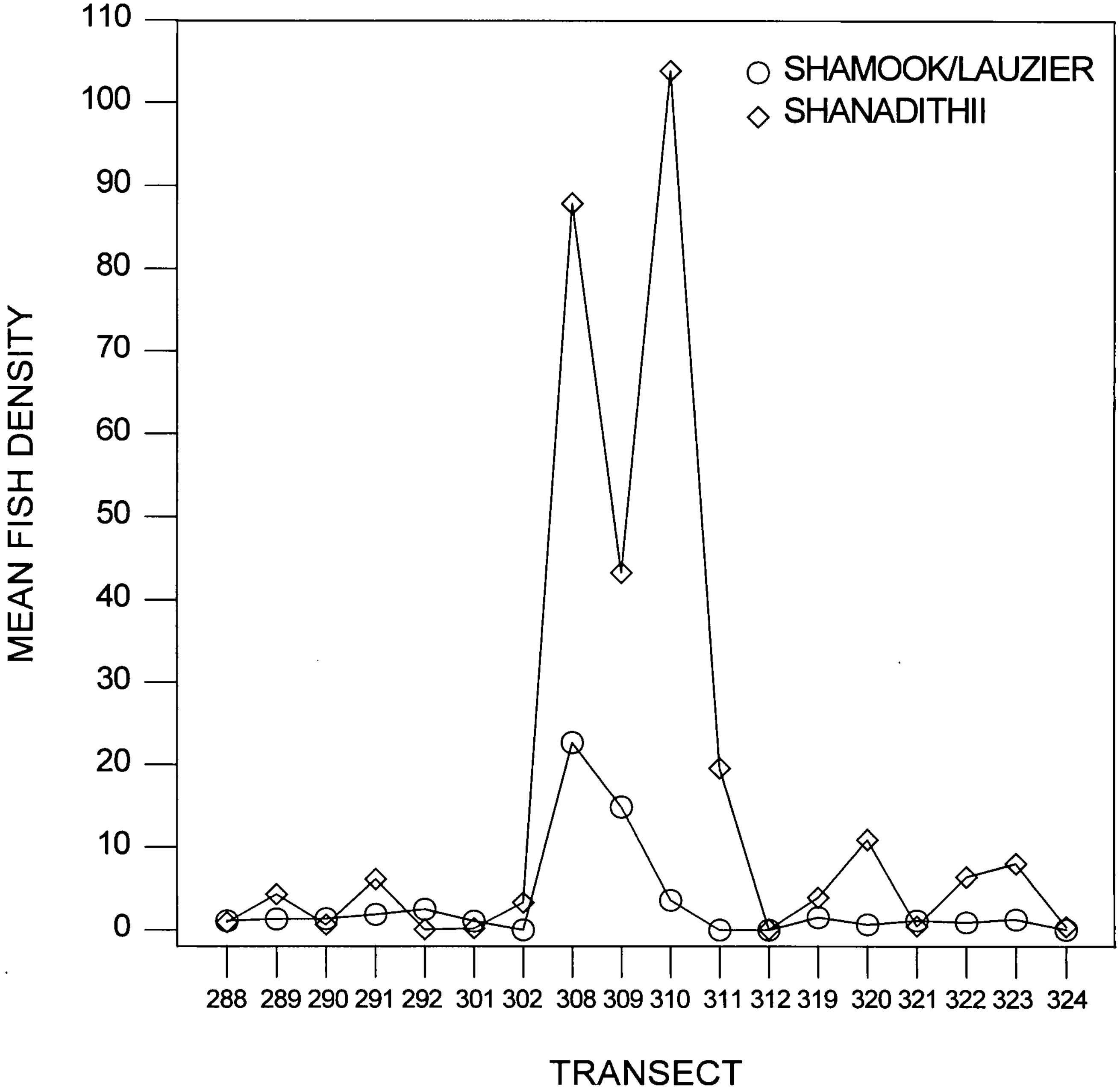

Figure 4.7.3. Plot of mean density vs. transect line.

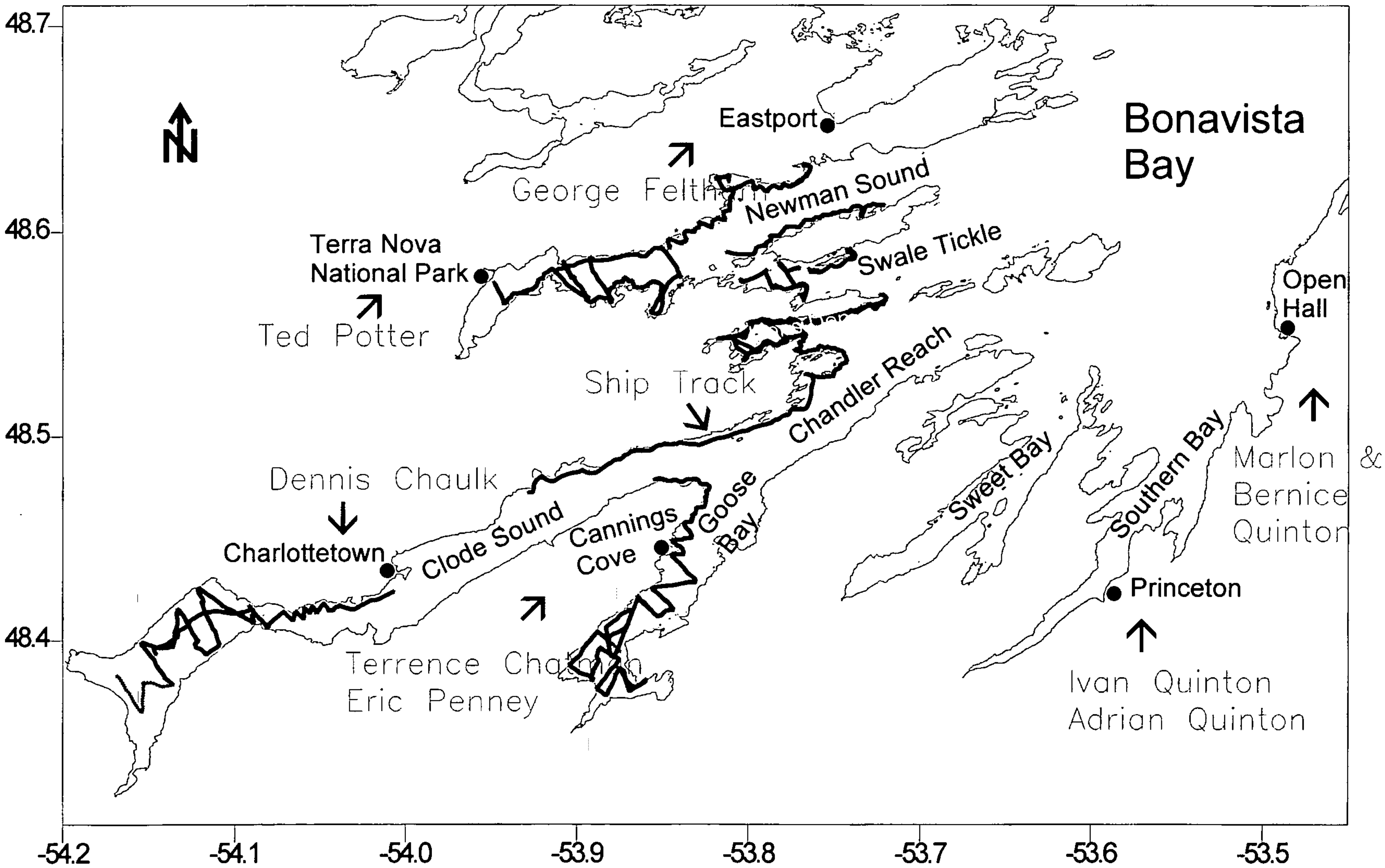

Figure 4.7.4. Southern Bonavista Bay nearshore study area. Communities are shown where inshore fishers were interviewed prior to the sampling program. The nearshore sampling track of the Shanadithii II represents areas where fish densities were estimated acoustically, November 14-28, 1997. Biological sampling was carried out at sites along these acoustic sampling lines (not shown).

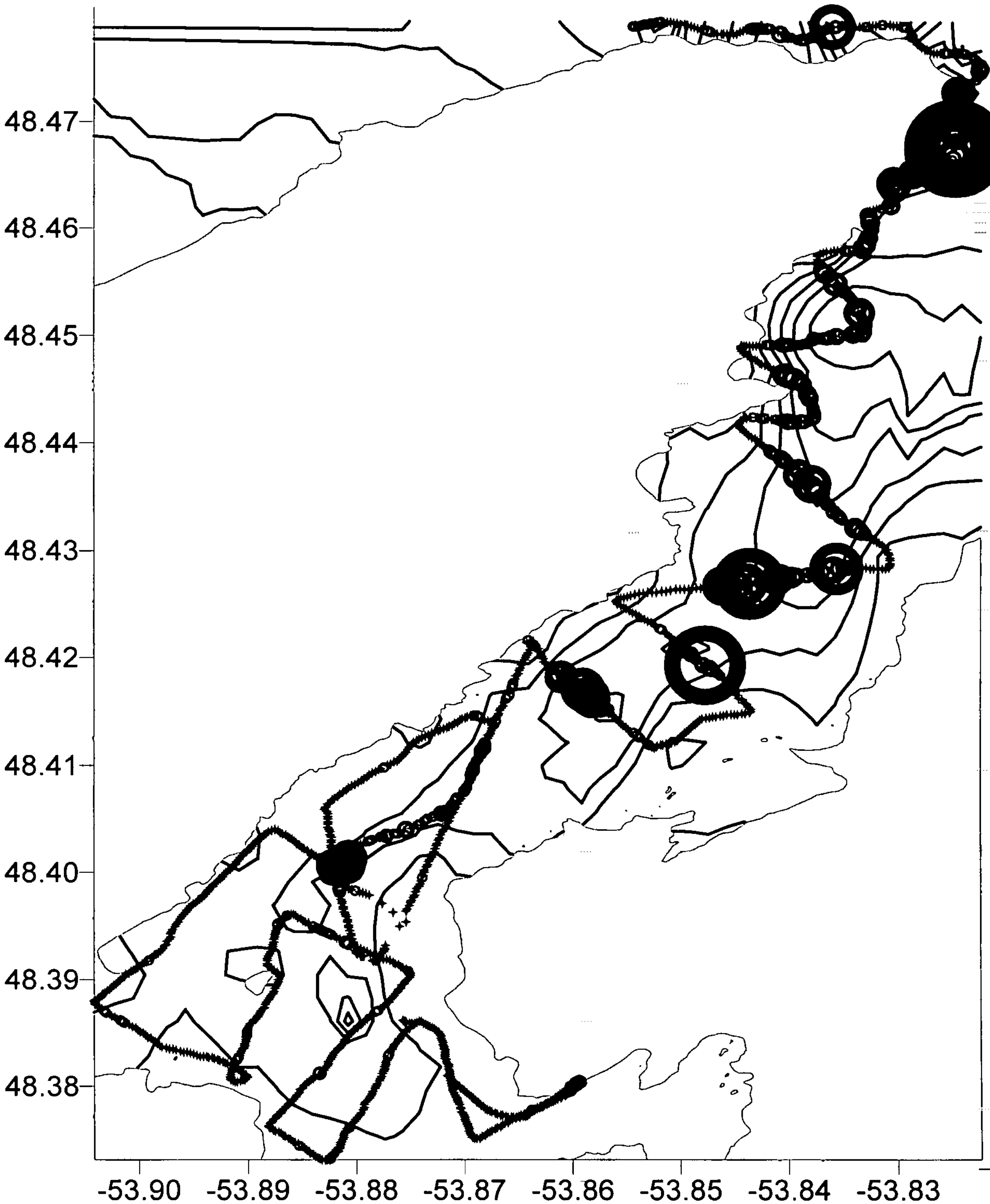

Figure 4.7.5. Plot of inshore acoustic survey - Goose Bay.

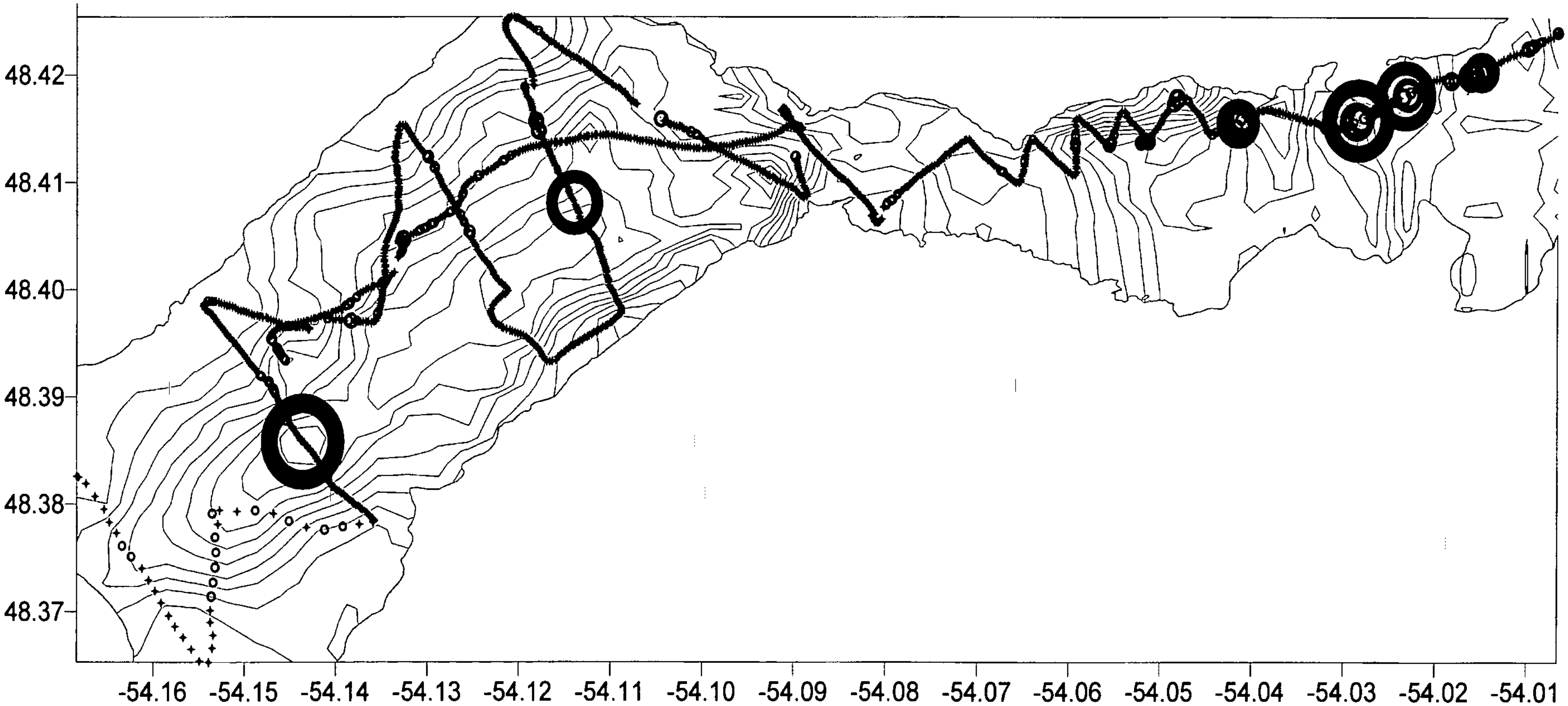

Figure 4.7.6. Plot of nearshore acoustic survey - Clode Sound.

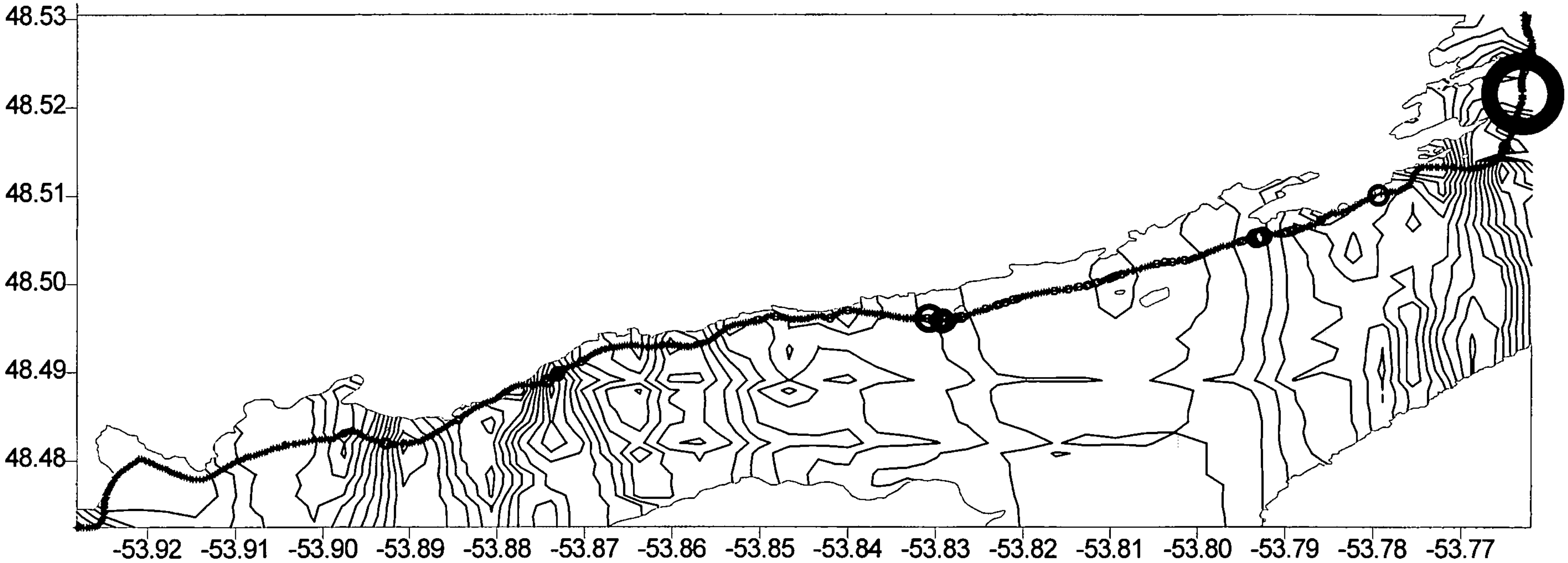

Figure 4.7.7. Plot of nearshore acoustic survey - Upper Clode Sound.

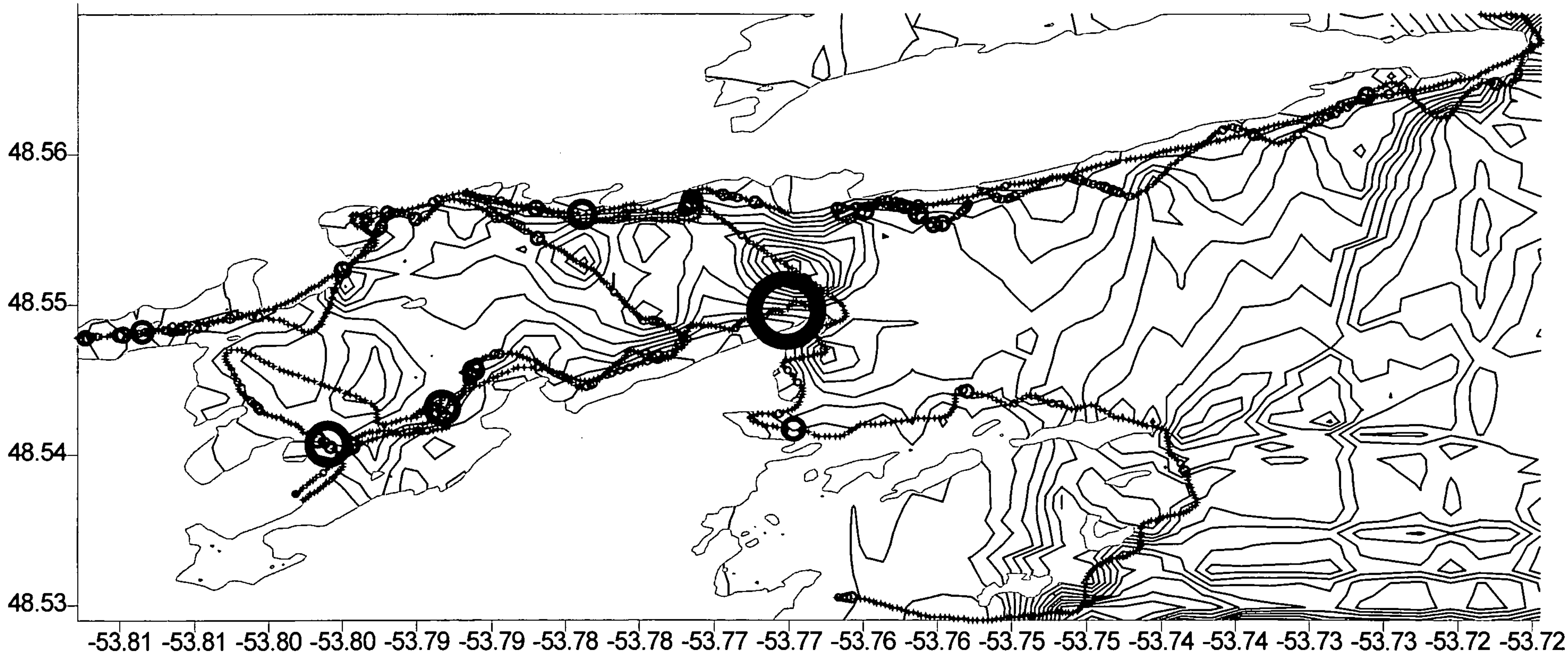

Figure 4.7.8 Plot of nearshore acoustic survey - Lion's Den.

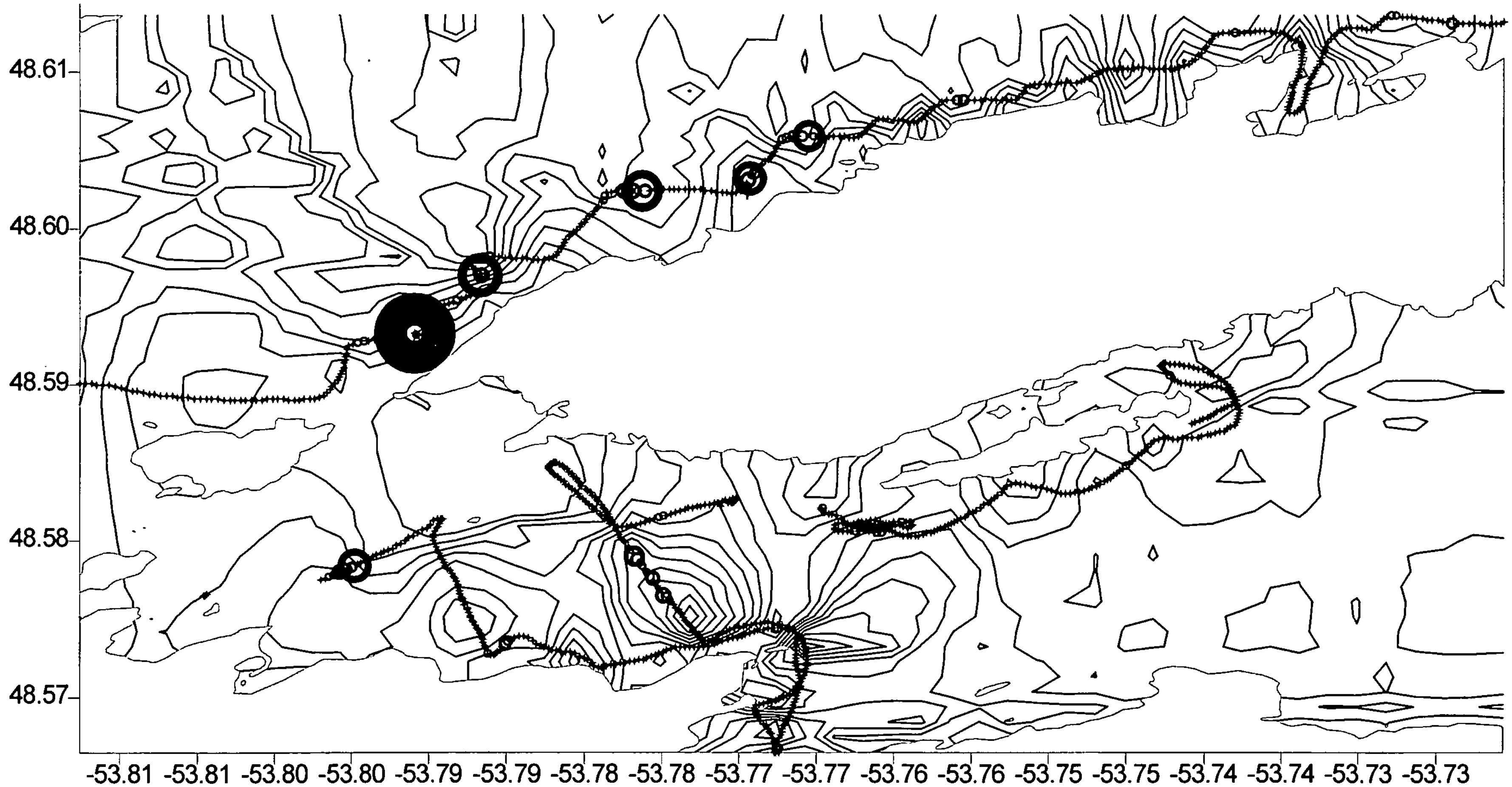

Figure 4.7.9. Plot of nearshore acoustic survey - Swale Island/Tickle.

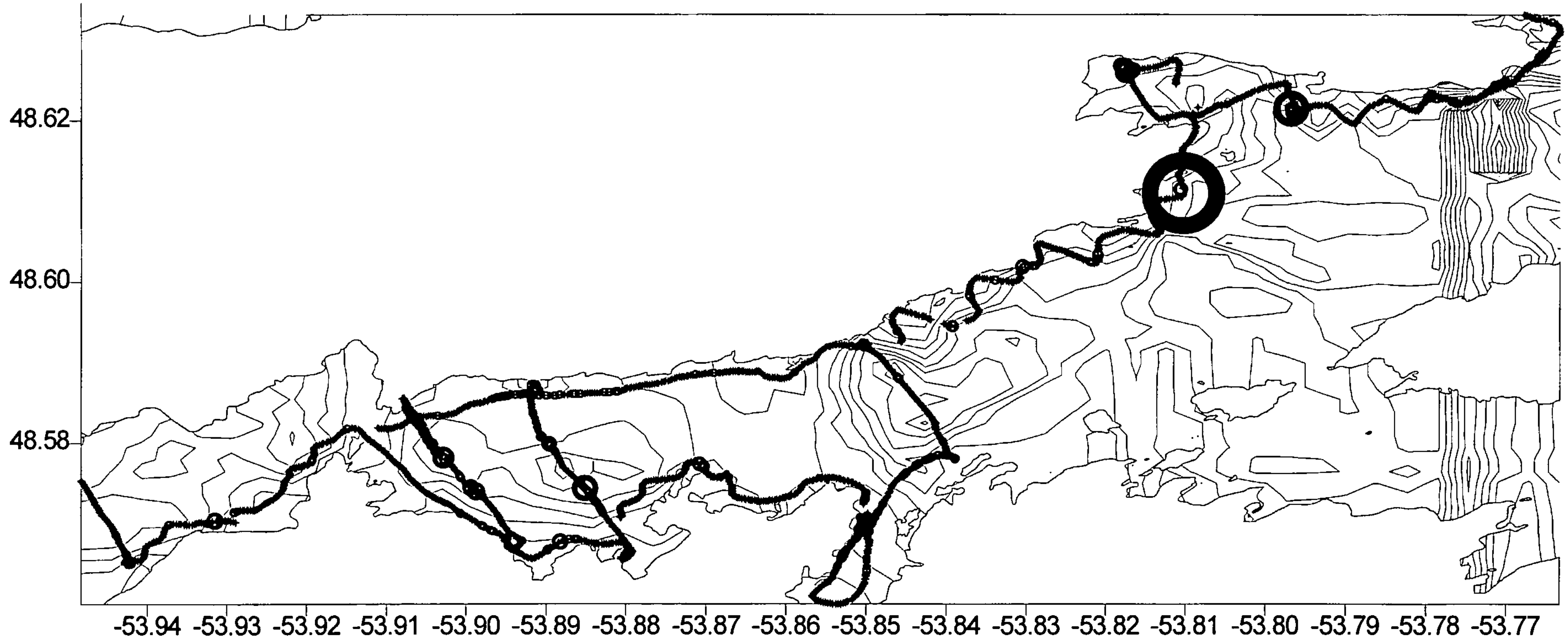

Figure 4.7.10. Plot of nearshore acoustic survey - Newman Sound.

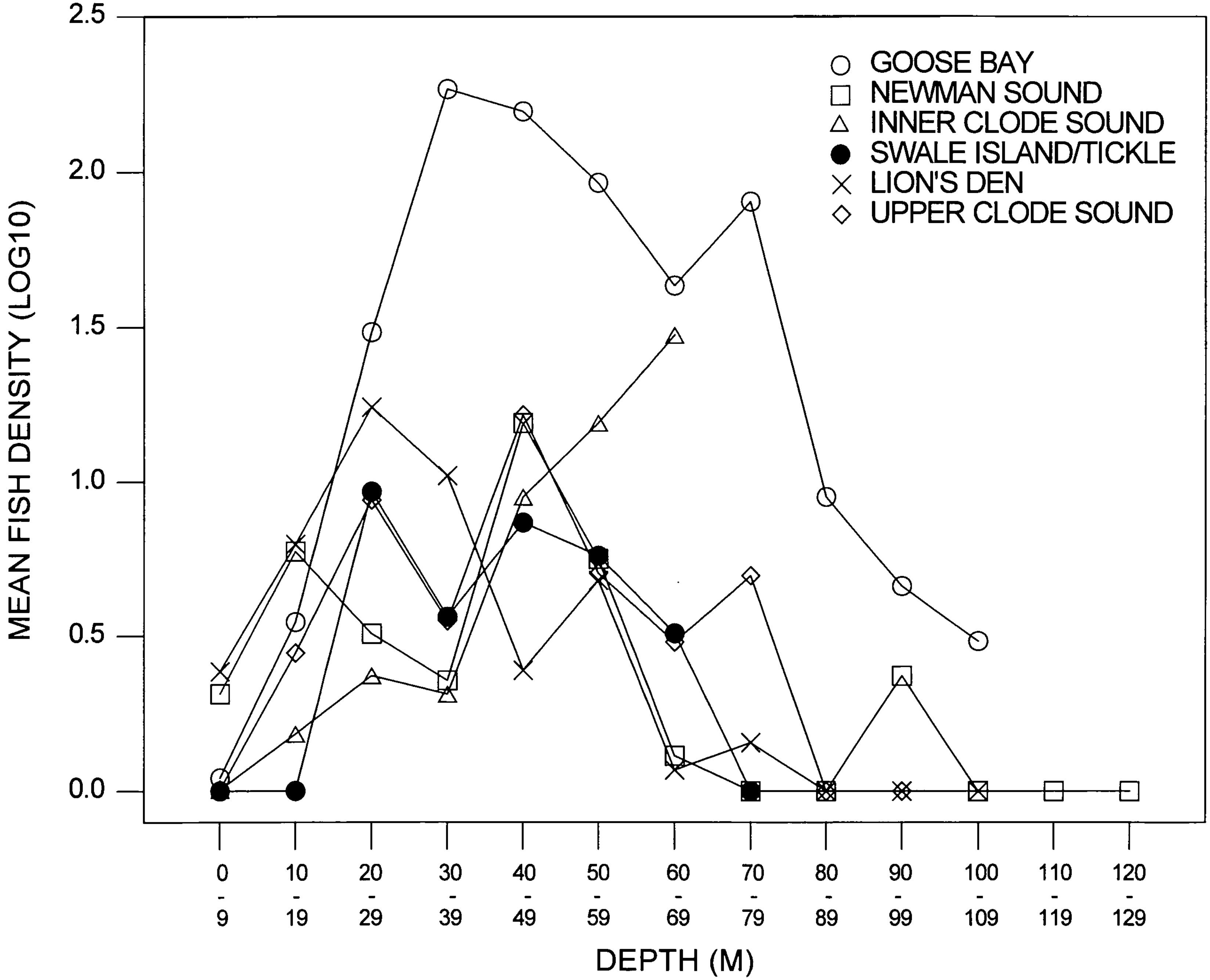

Figure 4.711. Plot of log10 mean fish density vs. depth by area.

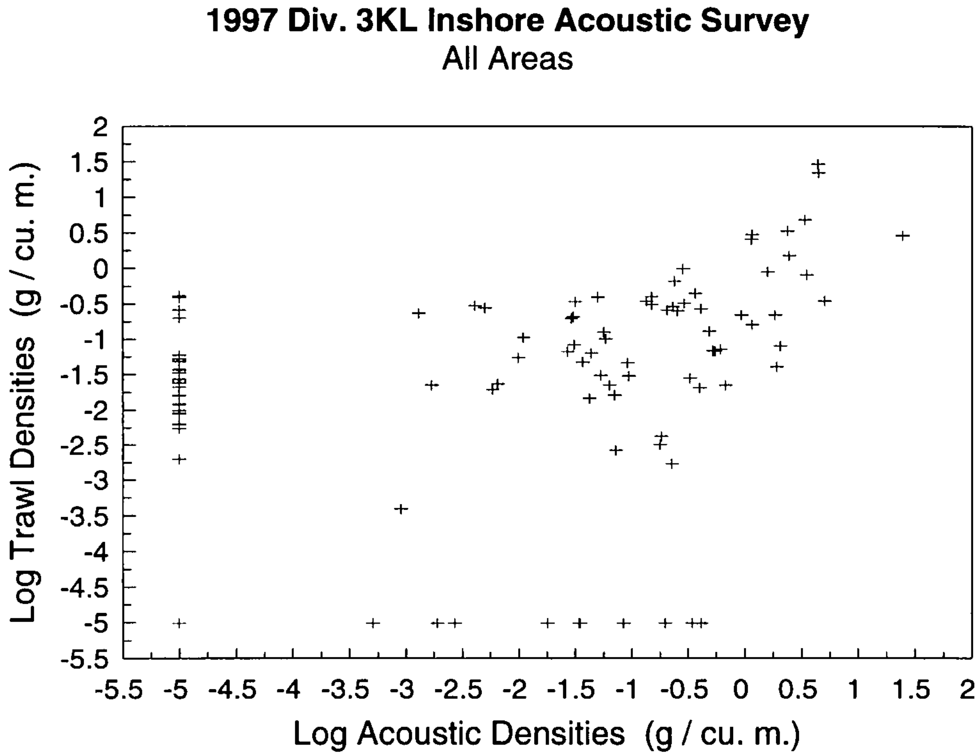

Figure 4.8.1 Cod acoustic densities (g/cu.m.) vs. cod trawl densities (g/cu.m.) from the 1997 Div. 3KL inshore acoustic survey.