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Area Assesment methods for 4T fall spawning herring

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Abstract

A method is proposed for doing area assessments of 4T fall spawning herring. The method includes estimating biomass indices and relative fishing mortalities using acoustic data collected during regular fishing activity and surveys. Relative fishing mortality for each night of fishing would be estimated by dividing the catch by the biomass index. A weighted fishing mortality could be estimated for the season in each area by weighting the nightly fishing mortalities by the biomass estimates for each night. This method would use information collected from purse seiners and gillnetters.

A method for estimating recruitment using variable mesh size nets is proposed.

Issues to be resolved are: standardization of analytical technique for biomass estimates including how the polygons defining the boundaries of the estimated area or fishing grounds are made, variation among boats, the effect of averaging to reduce data points on final estimates, how catch locations may be included, and how out of season surveys should affect overall relative F calculation.

Résumé

Une méthode est proposée pour l'évaluation par zones des harengs géniteurs d'automne en 4T. Elle fait appel à l'estimation d'indices de biomasse et de taux relatifs de mortalité par pêche fondée sur les données acoustiques obtenues des opérations de pêche et des relevés. La mortalité par pêche relative pour chaque nuit de pêche serait estimée en divisant la valeur des captures par l'indice de biomasse. Un taux de mortalité par pêche pondéré pourrait être estimé pour la saison dans chaque zone en pondérant les taux de mortalité par pêche de nuit par la biomasse estimée pour chaque nuit. Cette méthode permettrait d'utiliser les renseignements recueillis par les pêcheurs à la senne coulissante et au filet maillant.

Une méthode permettant d'estimer le recrutement à l'aide de filets à maillage variable est proposée.

Les points non encore résolus sont : la normalisation de la technique analytique appliquée à l'estimation de la biomasse, notamment le mode de définition des polygones délimitant la zone d'estimation ou les fonds de pêche, les écarts entre les divers bateaux, l'effet de l'utilisation de moyennes pour la réduction des données ponctuelles aux fins des estimations définitives, la façon dont on peut prendre en compte les lieux de pêche et la façon dont les relevés effectués hors saisons peuvent influer sur le calcul du F relatif total.

1. Introduction

The objective for developing area assessment methods for 4T herring is to provide advice on target fishing levels for localized stock components of this population. Currently, biomass and target fishing levels are provided for the entire 4T herring population and are subdivided only between spring and fall spawners. The TACs are then allocated to separate areas based on a sharing formula. The biological input to the sharing formula has included examinations of run-timing, changes in catch rate within areas, and survey information. There is, however, no model for providing biological advice on localized stock components, as there is for the overall 4T area. This paper is the first attempt to develop a standardized method for providing advice on an area basis for 4T stock components.

The objectives for this model are to develop relative biomass and fishing mortalitiy indices that are standardized for direct comparisons among areas. These indices would then be used to determine if relative exploitation was equal on all spawning components. These indices would be consistent with objectives determined at industry, science, and management workshops (Anon 1997). In addition, we examine a method for determining the strength of incoming year-classes.

The information available to develop an area model includes, catch rates, catch or run-timing, age structure of the catch, survey results from the Fisherman's Bank spawning bed survey, the annual research acoustic survey, and relative biomass and fishing mortality determined from collecting acoustic data during regular fishing activity and by surveys conducted by fishing vessels during times when fishing was closed.

The method presented concentrates on fall spawners because most of the data collection comes from this group. Similar methods, with necessary adjustments, could also be developed for the spring spawning components.

2. Area Characteristics

The principal fall fishing areas in the southern Gulf of St. Lawrence are: Chaleur Bay (16B), Escuminac (16C), western Prince Edward Island (16E), Fisherman's Bank (16G), Gulf Nova Scotia (16F), and Magdelen Islands (16D) (Fig. 1). The biological characteristic common to each of these six areas is that dominant year-classes seem to occur in all areas simultaneously. For example, from 1995 to 1997, the major year-classes can be followed through the five areas accounting for most of the landings in 4T. These areas are management zones 16B,C,E,F,G (Fig. 2). In 1995, the 1990 year-class, as well as the very large 1987 and 1988 year-classes were dominant in each of these areas (Fig. 2). In 1997, the 1992 year-class was dominant in each area (Fig. 2). The Magdelen Islands had quite a different age structure from the rest of 4T in its 1996 inshore catches, while the 1992 and 1990 year-classes were dominant in 1997 (Fig. 2). These trends were also apparent in the seiner (>65') catches of fall spawners in Chaleur Bay (Fig. 3). Thus, for the most part, all areas of 4T exhibit a consistency in year-class strength (Tables 1-3).

Similarly, weights-at-age of two of the dominant ages in the inshore fishery are similar amongst the northern (4Tmnopq), middle (4Tl), and southern (4Tfghjk) areas of the southern Gulf (Fig. 1, Tables 4-6). These groupings correspond to the areas differentiated for catch-at-age analysis in the overall 4T assessment (Claytor et al. 1998a) and in general correspond to hypothesized stock differences within the 4T population. Ages 5 and 7 from the inshore catches show similar declines in weight-at-age amongst all areas and similar values for weights-at-age (Fig. 4). Weights-at-age amongst these areas are significantly correlated (Table 7).

Two biological characteristics in which these areas differ are trends in abundance indices and catch-timing. Differences amongst these two characteristics are indicative of the need for separate biological advice on harvest levels for the spawning components of the 4T fall spawner population. For example, while catch rates, the principal abundance index for 4T fall spawners showed increases in all areas from 1996 to 1997 this was not always the case (Fig. 5). Correlations amongst these areas were significant only between Chaleur Bay and Escuminac, Escuminac and West PEI, and Fisherman's Bank and Gulf Nova Scotia ($p<0.10$) (Table 8). Detailed comparisons amongst these sites indicate that abundance increases corresponded in

each of these pairs (Fig. 6). These relationships are those that would be expected given the east-west geographic distribution of these sites. Catch rates in the Magdelen Islands were not significantly correlated with any other locations.

The only significant correlation amongst the areas for catch-timing, occurred between Escuminac and Gulf Nova Scotia (Table 9). Thus, if catches were later than usual in Escuminac they were also later in Gulf Nova Scotia (Table 9). These sites have little geographic connection and it is difficult to explain why this would occur from a stock component perspective. Chaleur, Escuminac, and West PEI have a similar catch timing, compared to Fisherman's Bank which was the earliest area and Gulf Nova Scotia which was latest (Fig. 7). The Magdelen Islands were similar to Chaleur, Escuminac, and West PEI (Fig. 7).

Thus, within the 4T provision of advice there is a need to develop a model for providing biological advice on an area basis.

3. Acoustic estimates of relative biomass and fishing mortality using fishing fleets

3.1 Introduction

Development of this model requires data that can provide directly comparable relative abundance indices among the areas of interest. We have developed these indices using acoustic data collected by fishing vessels during regular fishing activity and surveys. The assumption is that in searching for fish, fishing vessels map the abundance in their area and collect enough data and of sufficient quality to estimate a relative abundance index or school size for each individual fishing night. These abundance indices are then divided by catches to develop relative fishing mortalities. An average weighted fishing mortality could then be calculated for the season in each area. The biological advice to managers would then be to allocate future quotas so that fishing mortality is more likely to be equal amongst all spawning components. An assessment might also indicate how exploitation rates are changing from year to year within an area and indicate when and how allocation adjustments could be made in that area.

These data collected during fishing could be augmented by surveys before and after the season, or during the season on closed fishing days. These surveys would allow a comparison of biomass indices during days when there was no exploitation to those during the season, and may help to identify additional fishing opportunities or to adjust seasons for creating the greatest economic or biological gain.

These data could also be used to test assumptions regarding the relationship between the catch rates currently used in the assessment and abundance. This comparison would consist of comparing these catch rates to the acoustic biomass indices developed from the fishing activity. A second comparison results from the collection of data that results in additional abundance indices related to the fishery. For example, with these data it is possible to identify search distance and time, and handling or fishing time, two characteristics that might be related to abundance.

The key to developing standard indices amongst areas using these methods is to be able to conduct good calibrations. Standardized calibrations make it possible to directly compare results among vessels. The calibration procedure used for vessels in the southern Gulf of St. Lawrence has been reviewed in a separate working document (Clay and Claytor 1998).

This section concentrates on initial methods of data collection, data analysis, and how these analyses would be used to provide advice. Research recommendations will be investigated as part of upcoming spring and fall projects in the southern Gulf.

3.2 Background on fleet acoustic data collection

Experiments began on the collection of data from fishing vessels in 4T in 1995 (Claytor et al. 1998b). In that year, data were successfully recorded from a herring purse seiner during fishing activity in Chaleur Bay and 4Vn from Aug. 23 to Nov. 24, 1995. Acoustic data were collected using an automated system similar to that used on the 4T annual acoustic surveys. The digitizing system in this case was attached to a 50khz Furuno FCV120 sounder that was not in regular use on board the purse seiner. The difference was that the system on board the purse seiner was

completely automated and only required the captain to turn the system on to begin recording and to turn it off when the trip was completed. A ball and time varied gain calibration was successfully completed in November in Sydney, Nova Scotia. The calibration protocols described elsewhere for research vessel acoustic surveys were followed (Clay and Claytor 1998). Sampling of the catch by on-board observers, dockside monitors, and DFO port samplers provided average weights and lengths for target strength estimation and species identification.

It was not possible to collect data from inshore vessels during the first year, and the second year of the project concentrated on developing a system that could be used to collect data from inshore vessels, testing survey methods for these vessels, and developing analytical tools. Automated systems were placed on two purse seiners fishing in Chaleur Bay and 4Vn and two inshore vessels fishing in Chaleur Bay. Successful ball and time varied gain calibrations were completed on only one of the inshore boats. Poor weather prohibited a calibration on one of the seiners, and equipment problems precluded calibration on the other two vessels.

The third year of the project consisted of collecting data designed to be incorporated into an area assessment model. Acoustic recorders were placed on one purse seiner fishing in Chaleur Bay and 4Vn, and six inshore boats, two each from West PEI, Escuminac, and Gulf Nova Scotia. Successful ball and time varied gain calibrations were completed on all vessels. Data were collected during fishing activity by the purse seiner, two boats from Gulf Nova Scotia, and one each from Escuminac and West PEI. Surveys were conducted by the purse seiner in 4Vn, two boats from Escuminac and two from Gulf Nova Scotia. No surveys were conducted in West PEI (Fig. 8).

3.3 Fleet Dynamics and Catch rates

Before developing biomass indices from the acoustic data collected during fishing activity, it is important to describe the fishing activity and determine what information concerning abundance and distribution of fish can be derived from it.

The first step in the analysis is to divide the fishing trip into important activities. Those associated with finding fish have been defined for inshore boats and purse seiners as traversing (time and distance from port to fishing grounds) and searching (time and distance spent searching for schools of fishable size on the fishing grounds). For purse seiners fishing activity has been divided into sets (time and distance spent setting the net) and pumping (time and distance spent pumping the catch into the boat). For the inshore, setting includes the time and distance spent setting the net, soak time for the net, and hauling the net.

The Gulf purse seiner fishery occurs in several types of fishing areas and time spent traveling to and from the fishing grounds can account for a considerable portion of the fishing trip. In addition, time spent searching for fish on the grounds can vary considerably. For the three examples provided, searching for fish on the grounds in Gaspé (Fig. 9) required about twice the time and distance spent searching on grounds in Chaleur (Fig. 10), and about three times the time and distance as in Aspy Bay in 4Vn (Fig. 11, Table 10). Catch/search varied by a factor of 20 times over the three nights examined, while catch/boat varied by about 8 times over these nights (Table 10). Each of these catch rates showed the same trend (Table 10).

The examples provided from the inshore fishery are from three nights fishing on Miscou Bank (Figs. 12-14). The time and distance spent searching for fish varied by a factor of three times as they did for the purse seiners fishing in different areas. The night with the least catch had the most search time, while the night with the greatest catch had the least search time (Table 11). Catch/search varied by a factor of 8 times for these three nights, while the arithmetic CUE varied by a factor of just under three for these nights (Table 11). As for the purse seiners, each of these catch rates showed the same trends (Table 11).

3.4 Target Strength - Density

The next step in the analysis was to determine target strength of each night of interest so that biomass abundance indices can be estimated. We use the target strength relationship determined by Foote (1987) as we do for the annual acoustic survey (LeBlanc and Dale 1995). The formula is:

$$\textbf{Target Strength} = (20 \times \log_{10}\text{length(cm)} - 71.9) - 10 \times \log_{10}\text{weight(kg)}$$

The steps for determining target strength are:

1. Determine the length-weight relationship from the samples that are most relevant to the acoustic signal being estimated. These are obtained using the detailed samples that consist of two fish from each 0.5 cm group that were retained for aging, maturity stage, length, and weight analysis. A weight-length regression is used to obtain the slope and intercept values that can be used to estimate weight as:

$$\text{weight} = (a) \times \text{length}^{b}$$

$$\text{or } \log_{10} \text{weight} = \log_{10}(a) + (b)\log_{10} \text{length}$$

where a=intercept and b=slope of weight-length regression.

2. Obtain the length frequency distribution(s) from the sample of interest, weighting them by catch if more than one is used.
3. Use the weight-length regression to estimate weight for each length interval in the length frequency distribution.
4. Estimate target strength(ts) using foote's formula and linearize by

$$Ts_{lin} = 10^{(ts_{log}/10)}$$

5. Determine the frequency distribution of the target strengths and decide if the mean or the mode most appropriately describes the distribution.
6. Linearize the area backscatter coefficients (sa) as:

$$Sa_{lin} = 10^{(sa_{log}/10)}$$

7. Estimate the density by:

$$\text{Density(kg/m}^2) = Sa_{lin} / TS_{lin}$$

These steps were followed for five inshore fishing data sets and two purse seiner data sets. For the inshore data sets, samples collected from experimental nets fished at Gulf Nova Scotia on September 18, 1997 were used to derive weight-length regressions and target strengths. The reason for using the samples from these nets was that they were a better representation of the population than samples from the commercial fishery. This better representation results from the use of mesh sizes that were smaller and larger than those used in the commercial fishery.

3.5 Biological Sampling - Target Strength

The experimental nets consisted of six panels of the following mesh sizes: 2", 2 1/4", 2 1/2", 2 5/8", 2 3/4" and 3". Each panel was 8 feet long after hanging at the head rope with a depth of 16.5 feet regardless of mesh size. Each panel was separated from the other by a distance of three feet. Mesh material was green knotted nylon. Net strings used in Gulf Nova Scotia were made at the Gulf Nova Scotia School of Fisheries. Each of the boats equipped with the acoustic recorders tried to fish these nets once a week during the fishery. All mesh sizes were successfully fished on three occasions by one boat, September 4, 18, and October 10. The second boat fished only the 2" and 2 1/4" mesh. Mesh sizes used in the inshore fishery were primarily 2 5/8" and 2 3/4".

In Escuminac, the experimental nets were fished only once, and the larger mesh sizes were combined on board the boat so they were not used for target strength estimates. Experimental nets were not fished in West PEI.

Samples from September 18 in Gulf Nova Scotia were used for all target strength determinations for inshore boats. This date was chosen because it was the closest in date to all inshore data sets, presented in this paper, and was the only one taken during the commercial fishery. The September 4 sample was taken before the fishery began and was on a very small school. The October 10 sample was taken during a survey after the season.

The procedure was to add the numbers at length for each mesh size to determine an overall catch at length for the population (Figs. 15, 16). Target strength was determined as above (Table 12).

For the purse seiner, sampling and length frequency distributions from observer on-board samples were used to determine target strength (Figs. 17,18, Table 12).

3.6 Biomass Abundance Indices

After target strength determination and conversion of backscatter to density, the next step was to map the spatial distribution of biomass and to prepare the data files for analysis. A fishing night consists typically of 6 to 12 hours of activity. Several thousand data points are collected each night. In order to summarize the data and produce data sets of reasonable size, the following steps were taken.

1. Data was coded with respect to type of fishing activity described above (traversing, fishing, pumping/ retrieving, searching, and others).
2. The fishing track for the night was divided into equal 100m intervals by fishing activity. The end of the fishing track in each activity, however, would usually be <100m.
3. An area scattering coefficient (Sa above) was determined for each navigation fix (approximately 1 per second) along the entire fishing track using the calibration constants for each vessel.
4. These coefficients were linearized as described above.
5. A distance weighted average of these linearized coefficients, along the 100m interval was calculated. This calculation was made by multiplying the distance traveled associated with each coefficient times the value of the coefficient and dividing the sum of these values by the length of the interval; usually 100m, or less at the end of a segment.
6. The data point became the center point of the interval. This point was 50m, for the 100m intervals, or less for those < 100m.
7. These data points were then converted to density values by the formula above.
8. The fishing area was divided into square blocks 100m on each side
9. All the points in each block were averaged and the data point for all analyses became the average at the center of the block.

By examining different density thresholds, the major concentrations at each fishing location could be identified (Figs.19-25).

The next step examined the density trends in the data sets over time during the nights fishing and the frequency distributions of backscatter. This examination helps in understanding the distribution of the data and in describing the fleet and fish behaviour during the night. This analysis was completed for two of the data sets.

Frequency distributions of density over time identify periods of peak density. In the example provided for September 28-29, 1997, there were four periods of peak densities ranging from 5 kg/m2 and 12 kg/m2 during fishing activity (Fig. 26). These could then be compared to the time spent in various fishing activities to understand the interaction between fleet, fish, and tidal behaviour.

Frequency distributions of density characterize school distributions. For example, the data from the inshore Gulf Nova Scotia fishery on Sep 11-12, 1997 shows a greater than 90% occurrence of very low density values indicating that most of the biomass is located in a few spots. In contrast, data from the purse seine on Oct 3 -4 indicate that only about 50% of the data points contain very low densities and that the biomass is more spread out (Fig. 27).

3.7 Estimation Methods: Adding Blocks, Arithmetic Mean, Kriging

Estimation of biomass indices to compare among these seven data sets began with a simple method of adding the biomass in each block. This estimate was obtained as explained above by determining the mean density of all the points within a 100m square block. This density was then multiplied by the area of the block to obtain an estimate of the tonnes in each block. The tonnes in each block were then added together to obtain a biomass index for each fishing ground (Figs. 19-25). Sets made by the seiner on Oct. 1-2, 1995 were examined in the same manner (Fig. 28). This method has the advantage of being simple but because not every 100m square is sampled on the fishing grounds, it will underestimate biomass.

Two methods which overcome this difficulty depend upon calculating mean densities over the fishing area and scaling these densities up to the area of the fishing grounds. The simplest of these methods uses the arithmetic mean of the points and expands these to the total estimated area. Where the points in this case are the mean values within each block. If every block on the fishing ground were sampled, this method would be equivalent to the one described above.

The second method is kriging, which has the advantage of taking into account spatial correlations observed and expected in the data. For example, regarding fish schools, we may expect that points of high density would be clustered together and have similar densities and that points further away would be less similar. Thus, the points closest to the area we are trying to estimate should receive the greatest weight in the estimation and those further away the least weight. Kriging is a method which determines how that weight varies with distance.

This spatial relationship is determined by examining the correlation among points at progressively greater distance until no correlation or relationship is observed. A model is then fit to these relationships and is used to estimate points or blocks without sampling.

In kriging the correlation among the points is described by a variogram. The parameters estimated by the variogram are:

1. The range, the distance at which there is no correlation among the points
2. The nugget, the value of the variogram at a separation distance of 0. This value should be zero but sampling error or short scale variability often causes a jump in the relationship at short distances.
3. The sill, the variance in the data as measured by the height at which the variogram reaches a plateau.

Several types of models can be used to fit variograms, among them are spherical, exponential, and gaussian. The spherical model is common and is the one we chose, but we did not test for better fits using other models. Directionality is also a feature that is present in some spatial data. We have made our first estimates assuming that the relationship among the points is the same in all directions, an omnidirectional variogram.

The program VARIOWIN (Pannatier 1996) was used to estimate the variograms for the two data sets examined using kriging. A program written in MATLAB and used by the Invertebrate Division (pers. comm. E. Wade, Department of Fisheries and Oceans, P.O. Box 5030, Moncton, New Brunswick, Canada, E1C 9B6) was made available to us to estimate density and biomass indices in the two data sets using Block Kriging. The area was divided into blocks and an estimate was obtained for each block. Point kriging, estimated by a graphical package TRANSFORM, was used for mapping.

The kriging method requires that a polygon be identified that encloses the area for which the biomass index is to be made. An iterative procedure is used to determine the optimum block size

with the requirements that the blocks include at least 95% of the area of the polygon and that the standard error is minimized.

3.8 Estimation Results

The block addition method was applied to the seven data sets identified above and on the sets made during one night of fishing by the purse seiner in Gaspé (Figs. 19-25, 28). Biomass indices using this method ranged from 267 tonnes to 11,000 tonnes (Table 13, 14).

The kriging and arithmetic mean method were used on only two data sets because of time limitations (Table 15).

The first data set examined was the Gulf Nova Scotia inshore data from September 11, 1997 (Fig. 19). Three variograms were estimated for this data set. The first included the entire fishing grounds as defined by a polygon (Fig. 29). The fishing ground was then divided and separate variograms were estimated for the western and eastern schools (Fig. 29).

The variograms for the combined two schools and for the eastern school were not well defined and probably have a higher nugget effect than indicated by this analysis (Fig. 30). The presence of the nugget effect should be tested. The variogram for the western school appears to be well defined (Fig. 30). Estimation proceeded with the parameters estimated from these variograms.

These results estimated a biomass of about 110-120 tonnes in the western school using either the arithmetic or kriging method (Table 15). The eastern school showed a bigger difference between the two methods, as did the combined variogram. The lower of the two estimates was the arithmetic method and it was about twice the simple square block method. One reason for the difference between the kriging and arithmetic method may be the presence of an undetected nugget effect and forcing a relationship on the data by kriging that was not appropriate (Fig. 30, Table 15). The distribution of the biomass estimated from the point kriging method indicates two major concentrations (Fig. 31).

The second data set examined was the purse seiner data from Oct. 3-4, 1995 while fishing in Chaleur Bay (Fig. 24). Two variograms were estimated from these data. The first consisted of the entire fishing grounds as defined by the overall polygon (Fig. 32) and a second of the central concentration (Fig. 32). The variograms from each of these data sets was well defined (Fig. 33) and the arithmetic and kriging methods were applied to these data. The kriging method produced a slightly lower overall estimate than the arithmetic method but they were within 14% of each other (Table 15). The estimates using the two methods were very similar for the central concentration (Table 15). The square block method produced a lower biomass estimate (Table 15). The distribution of the biomass by the point kriging method indicates a major concentration in the central portion and a lesser concentration to the east (Fig. 34).

The polygon describing the Gulf Nova Scotia fishing grounds was not precisely defined as the sum of the two school data sets. There was about a 0.5 km^2 difference. This difference added 100t to each estimate. Thus, achieving a standard method of defining the polygons will be very important in making comparisons among areas.

This definition is very important in dealing with data sets where the edge of the schools has not been found. Any increase in area will tend to greatly increase the overall biomass index for that area. Thus, it will be important for vessels equipped with the acoustic recorders to search for the edge of schools, if possible, at some point during the fishing night. A consistent method of defining the polygon is to exactly follow the edge of the school, as defined by some threshold data point value. In both data sets examined some of the major concentrations exhibit this edge effect (Figs. 31, 34).

Some assessment of the extent of the schools may be obtained by examining catch locations with respect to those recorded by the acoustic boats. Catch locations for Gulf Nova Scotia were reported through Dockside Monitoring Programs and through voluntary logbooks. A similarity between these catch locations and the area covered by the acoustic data would indicate that no major areas of herring concentrations were missed by the acoustic boats. There appears to be a similarity between these catch locations and the areas covered by the acoustic boats on

September 11-12, 1997 (Fig. 35). Other nights were not examined. Unfortunately, because these reports often represent a combination of sets or a location that it is not precise, a quantitative method of including these in the biomass index estimation has not yet been developed.

4.0 Relative Fishing Mortality

4.1 Calculation and Rationale

The assessment use for these data is in the estimation of a relative fishing mortality (F) amongst areas and in achieving the management objective of equalizing fishing pressure on all spawning components and over-time within components. Relative fishing mortality is defined as the ratio of the catch divided by the biomass estimate from the acoustic data collection and analysis. As a result, it is an index of exploitation rate, rather than an instantaneous rate of fishing.

Calculating F in this manner assumes, based on observations of fishing pattern, that the vessel with the acoustic equipment, searches for schools in a manner that will detect relative changes in biomass from night to night. Searching, in this case, corresponds to a hunting strategy, alone or in a group, finding a school of fishable size, and sailing over it several times to determine the best time and place to set the nets. If this assumption is correct then the ratio of catch over biomass is an index of exploitation on the school.

These estimates need not be, nor can they be expected to be absolute measures of school abundance or exploitation rate (Clay and Claytor 1998). As such, there is no appropriate level of F, such as $F_{0.1}$, that need be attained. Rather, these data would be used to spread F equally over a spawning component in time, or amongst spawning components in space, or at the very least to test whether current management measures were achieving these goals. These tests could be made by calculating F daily for each fishing area or group of sets (Table 13, 14). An overall relative F for the season would be estimated by weighting the daily estimates of F by the biomass estimate for each day. This weighting would give the most emphasis to fishing mortalities that occurred when the stock was most abundant.

This pattern of data collection is more amenable to the behaviour of the 4T spawning components than trying to conduct surveys during the season, calculating biomass, and then opening a fishery because the movement of herring in the 4T spawning areas is too dynamic. When gillnetters were asked to identify areas to conduct surveys, they responded, regardless of area, that the area is to big and the fish were too unpredictable. They commented that it takes many boats to locate the schools and where they will be on any given night cannot be predicted. In addition, the schools may only be available for one night of fishing, because of fish behaviour, weather, or numerous other factors. Knowing the relative exploitation rate on each night of fishing provides a better assessment of how well the fishing mortality is being distributed amongst the stock components than methods which would survey one biomass but likely fish another.

One place where surveys are the only method of collecting data are times when the fishery is closed, either before, during, or after the season. Before and after season surveys were conducted in Pictou and Escuminac (Fig. 36). These surveys are useful for determining when to start and end seasons, but also may affect the view of overall fishing mortality on a stock component if large amounts of fish appear before and after the season but have no fishing mortality.

4.2 Vessel Comparisons

It is important that any differences observed amongst the data are not the result of vessel or fishing pattern differences. Calibration as described elsewhere (Clay and Claytor 1998) ensures that differences in acoustic installations do not cause variation in biomass estimates. Direct comparisons between vessels are important to ensure that fishing patterns and captain behaviour do not influence results. In the data sets examined thus far, there were some opportunities to compare vessels. The first of these was at Gulf Nova Scotia on September 11, 1997. The two vessels equipped with acoustic recorders were in the same or adjacent 100m block the same time on eight occasions. The range in densities recorded for one boat was 0.33 to 5.75 kg/m2 and for the other boat was 1.29 to 5.89 kg/m2 (Fig. 37).

Another comparison was possible between the purse seiner and the acoustic research vessel F.G. Creed. The purse seiner was in the strata surveyed by the F.G. Creed Oct 1-2, 1995 on Oct. 3-4, 1995 (Fig. 24). The biomass estimate from the survey was about 6,000 t and from the purse seiner 8,000 to 9,500 tonnes using the arithmetic and kriging methods (Table 15). Given the differences in timing and the area covered, these results provide confidence that comparisons among vessels are valid.

A systematic examination of vessels should be done wherever possible, even when calibrations are made.

5. Recruitment indices

5.1 Introduction

An important part of the assessment process is making projections for future years. A large part of the accuracy of these projections depends on estimates of recruitment. Currently, average recruitment of 2 and 3 year-olds is used in projection models for 4T. A series of experimental nets as described above were fished to determine if these could be used to develop recruitment indices and test estimates regarding year-class strength derived from the assessment.

A second data set available for estimating recruitment in a local area, as well as, providing an index of spawning biomass is the spawning bed survey at Fisherman's Bank, PEI. The results of each of these projects are presented with the purpose of determining if and how they are achieving these goals.

5.2 Experimental Nets

Previous work with nets of this type and size identified the occurrence of the large 1987 fall spawner year-class at Fisherman's Bank as three year-olds (Fig. 38). For example, the small mode in the length frequency distribution at 27 cm in 1990 identifies three year-olds as a potentially large year-class. In 1991, this year-class formed a major part of the distribution at 30 cm as four year-olds. This 1987 year-class has since been determined to be one of the largest for the 4T fall spawning population (Claytor et al. 1998a). This age is one year before fish typically entered the fishery, at that time, and is essential for developing a time-series that can be used to predict recruitment. As a result, it seems possible that these nets could develop into a good recruitment index.

In the experimental nets fished this year in Gulf Nova Scotia, three and four year-olds were most numerous in the 2" mesh (Fig. 39). The 1992 year-class, age 5, was dominant in mesh sizes 2 1/4" to 2 5/8" mesh (Fig. 39). Age 2s were not caught in appreciable numbers by any mesh size and age 3s only in 2" (Fig. 38). In the coming years, indices of recruitment are likely to be developed from examinations of the smaller mesh sizes.

Overall, the sum of the catches in the gear is similar to the commercial catch age structure. (Fig. 40). Catches from these meshes confirm the smaller than average size of the 1989 and 1991 year-classes (Fig. 40).

Overall, the lengths in the commercial catch most closely resembled those from the 2 5/8" inch experimental nets (Fig. 41). Early in the season, there were appreciable differences in length of fish caught in the 2 5/8" and 2 3/4" experimental nets. Experimental nets were knotted nylon and the commercial nets are monofilament. The experimental nets may have a different selection pattern than the commercial nets and efforts will be made in 1998 to use the same material in the experimental nets as are used in the commercial fishery.

Results from the assessment of the 1997 fishery, indicate that full recruitment to the fishing gear occurs when 4T herring are five years-old. The assessment also indicated that four year-olds from the 1993 year-class were the largest since the very large 1987 year-class (Claytor et al. 1998a). The data from the experimental nets, large numbers of four year-olds in the 2" mesh was consistent with this result. These results lead to an expectation for a large number of 5 year-olds in the 1998 fall spawner gillnet catch. There will, however, be no substitute for collecting a time-series of data in the development of a good recruitment index.

5.3 Spawning Bed

The spawning bed survey at Fisherman's Bank (Fig. 42) has been conducted since 1985 (Fig. 43). In 1997, very few eggs were observed until October. This date was the latest that major egg depositions have been observed during the years of the survey. The last three years of the survey have been among the lowest recorded in the time series (Fig. 43).

This survey has two objectives: one, to provide an index of spawning biomass and two, as an index of expected year-class strength. Correlations with catch rates would indicate that spawning on the bank is indicative of spawning biomass. These two variables, however were not correlated (Fig. 44). Significant correlations with numbers of age 4 fish in the population, four years later, would indicate that the egg depositions are useful for predicting recruitment. These two variables were also not correlated (Fig. 44).

This survey does not seem to be providing indices of abundance that can be used quantitatively in the assessment. One reason could be that the survey does not cover an adequate area in time and space. If this is the case, current resources do not permit an expansion of the survey. As a result, the survey in its present form has been dropped from the stock assessment program.

Acknowledgments

We would like to thank the participants in each area for their help and cooperation with these projects. The vessel captains are particularly important to these projects and each went out of their way to make the projects successful, in particular one captain has been going out of his way to make this work since the beginning of the project, any successes that have been achieved are in large part because of where we started. J. Dale edited the acoustic data from 1997 and organized the field work in Gulf Nova Scotia. B. Crawford organized the sample and data collection in Gulf Nova Scotia and G. Egglisson organized and edited the catch location data for Gulf Nova Scotia and prepared the catch location maps. We especially thank E. Wade for his review and assistance with programming and mapping. Funding for the installation and calibration of acoustic equipment on fishing vessels was provided by the National Hydroacoustic Program.

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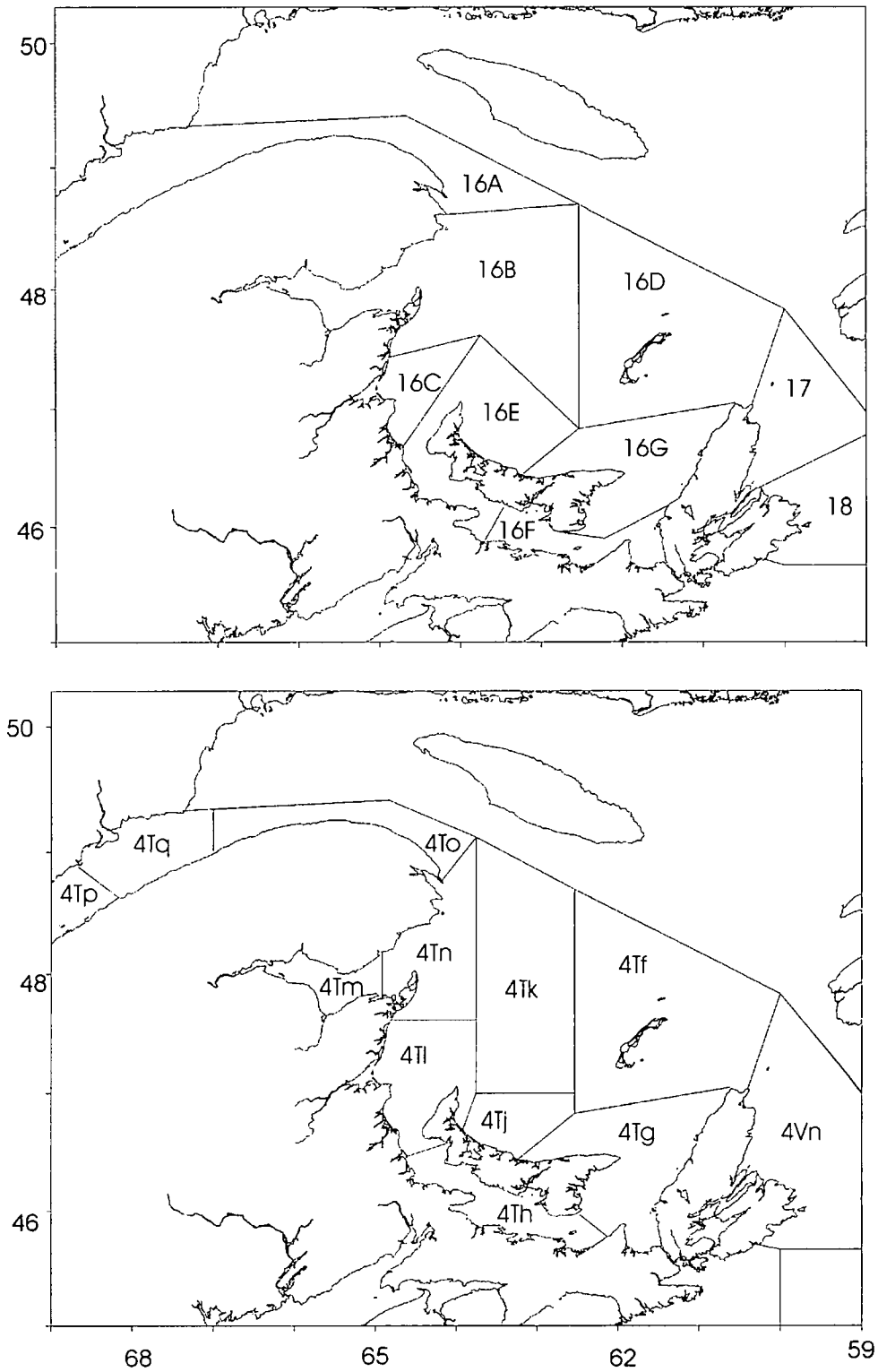


Fig. 1. Herring 4T managment zones (upper) and Northwest Atlantic Fisheries Organization (NAFO) unit areas in 4T (lower)

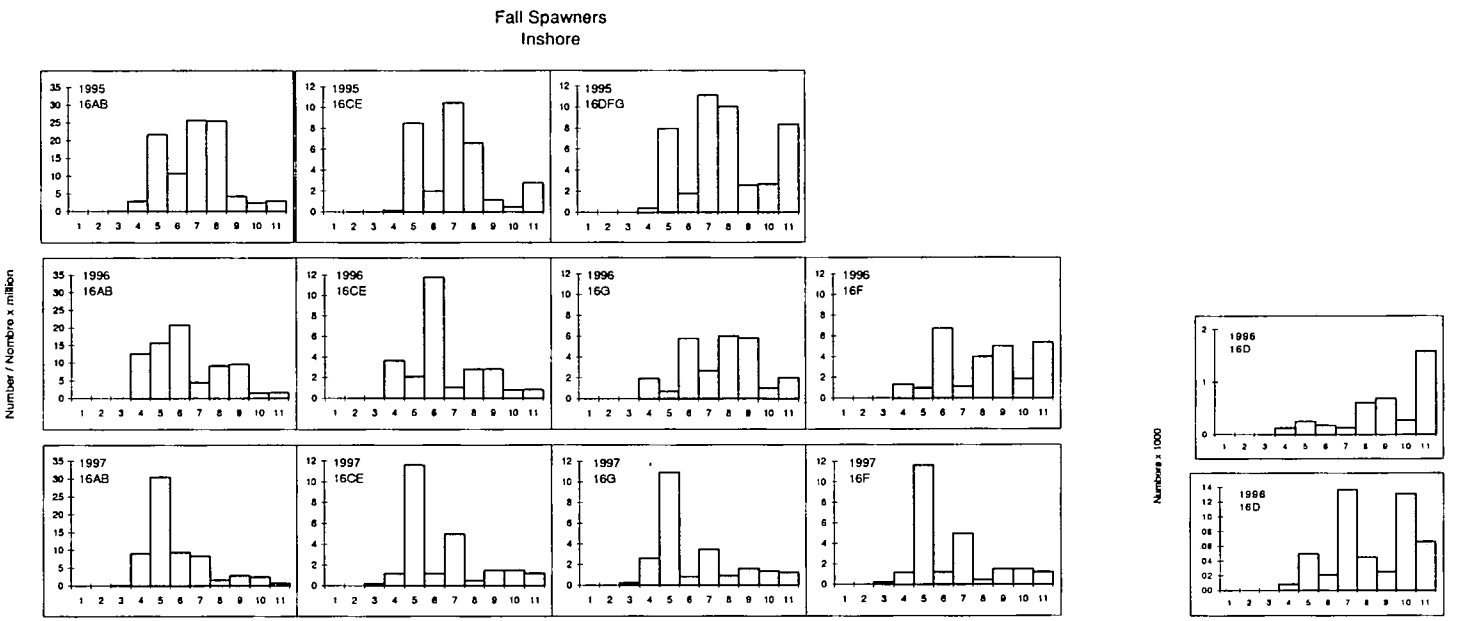


Fig. 2. Catch-at-age (numbers) for inshore fisheries in 4T from 1995 to 1997.

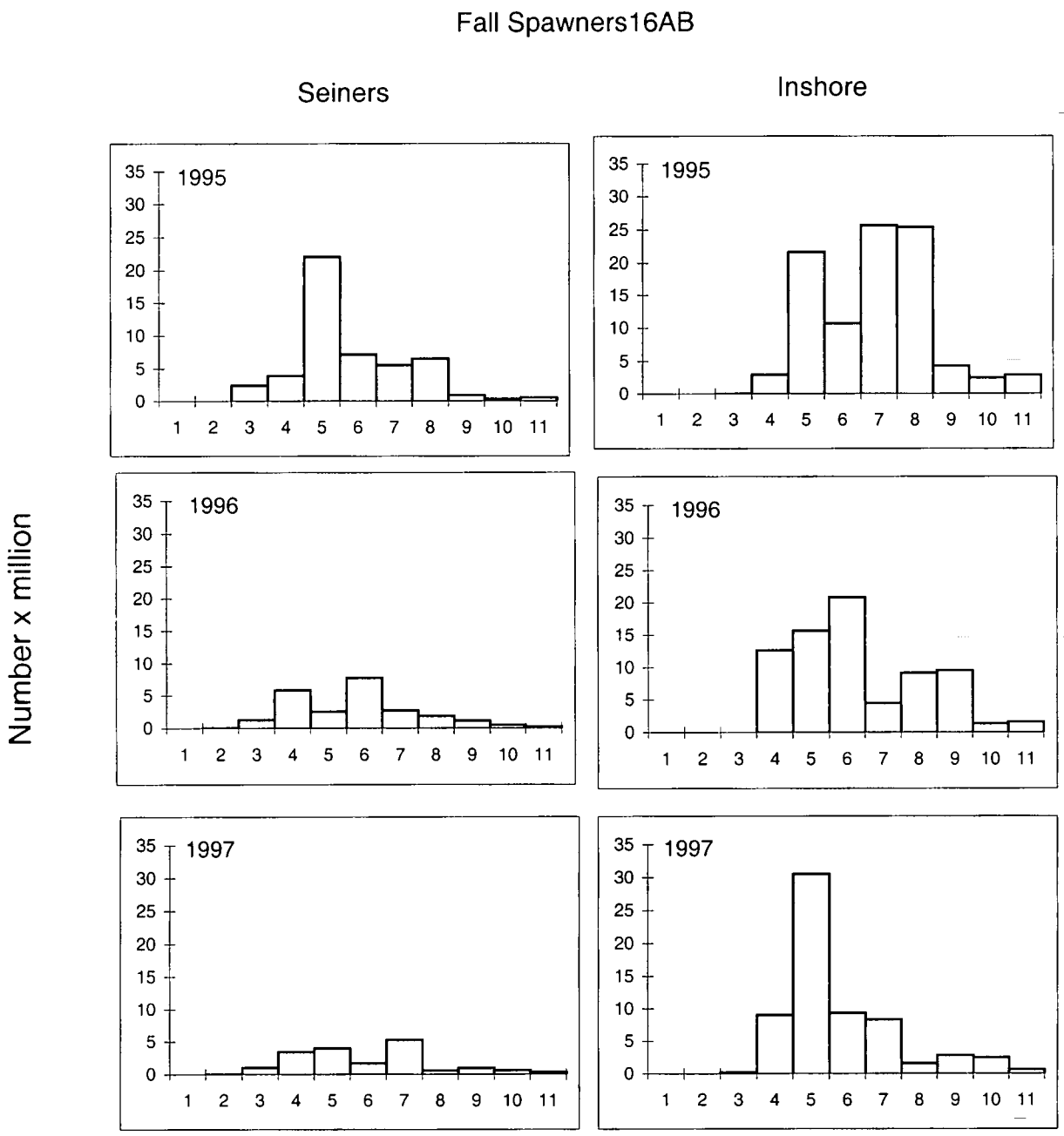


Fig. 3. Catch-at-age for northern areas of 4T from seiner and inshore fisheries.

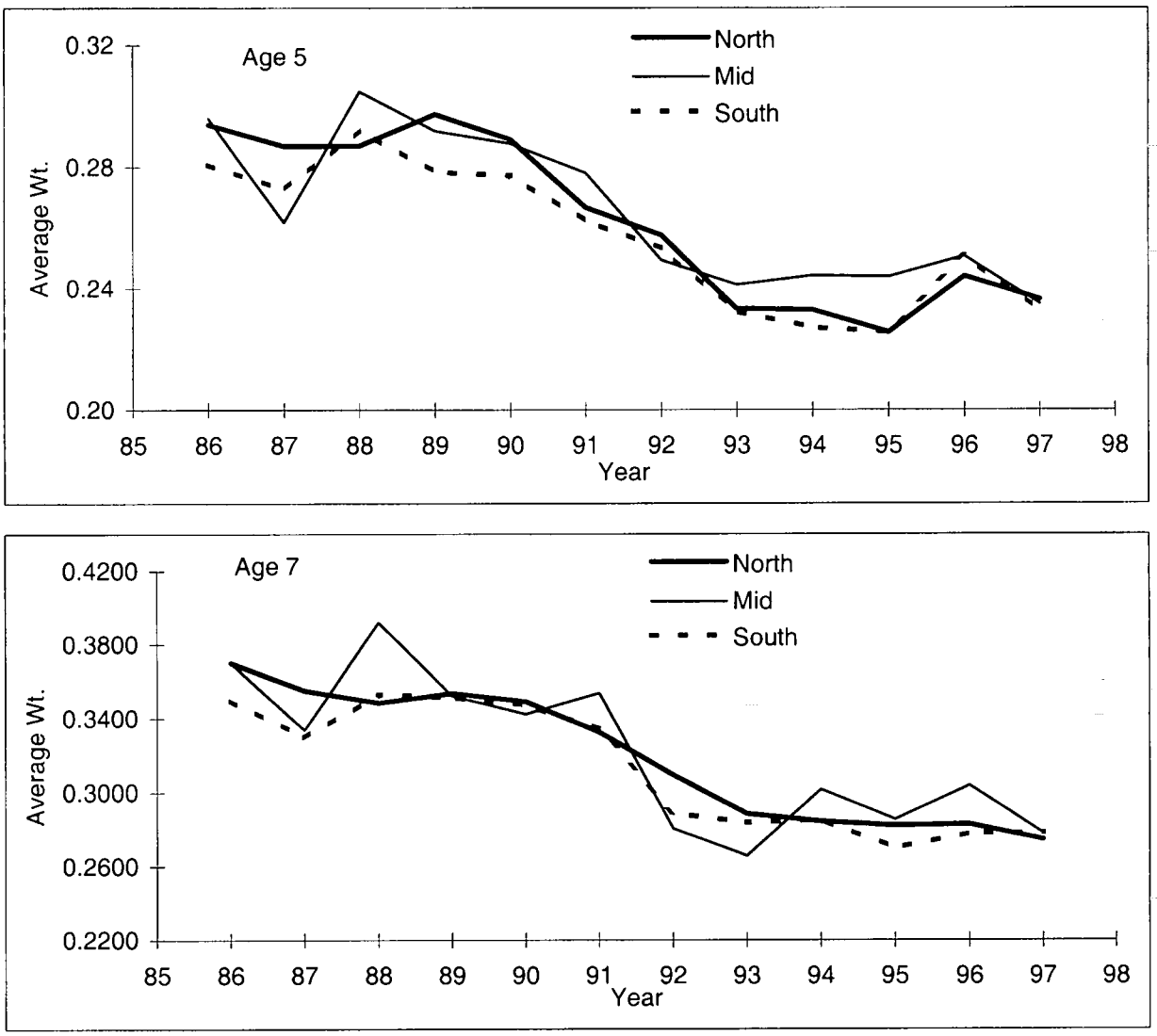


Fig. 4. Average weights-at-age for fall spawners by major areas in 4T inshore fishery.

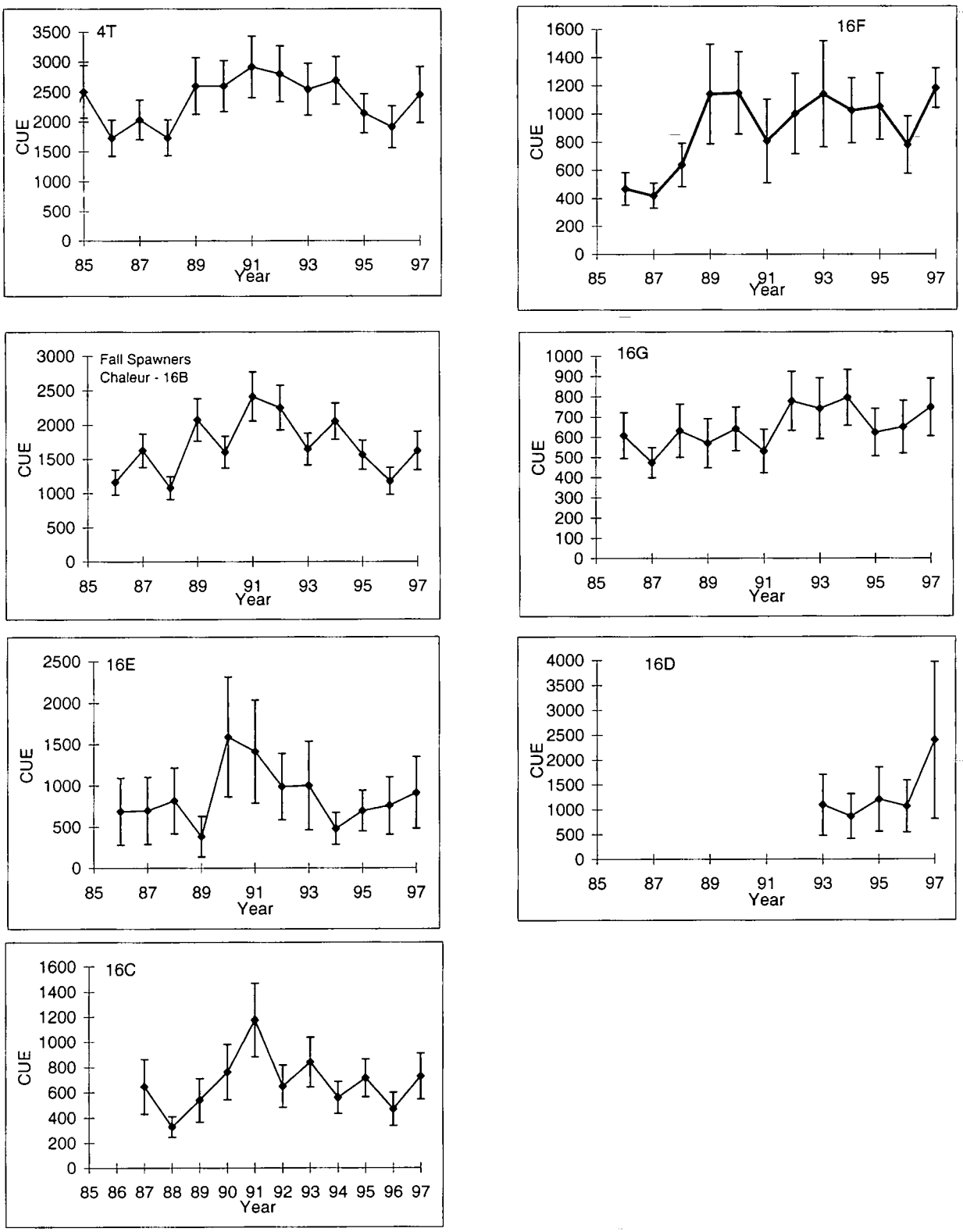


Fig. 5. Catch rates (kg/nets/trip) by area in 4T inshore fisheries.

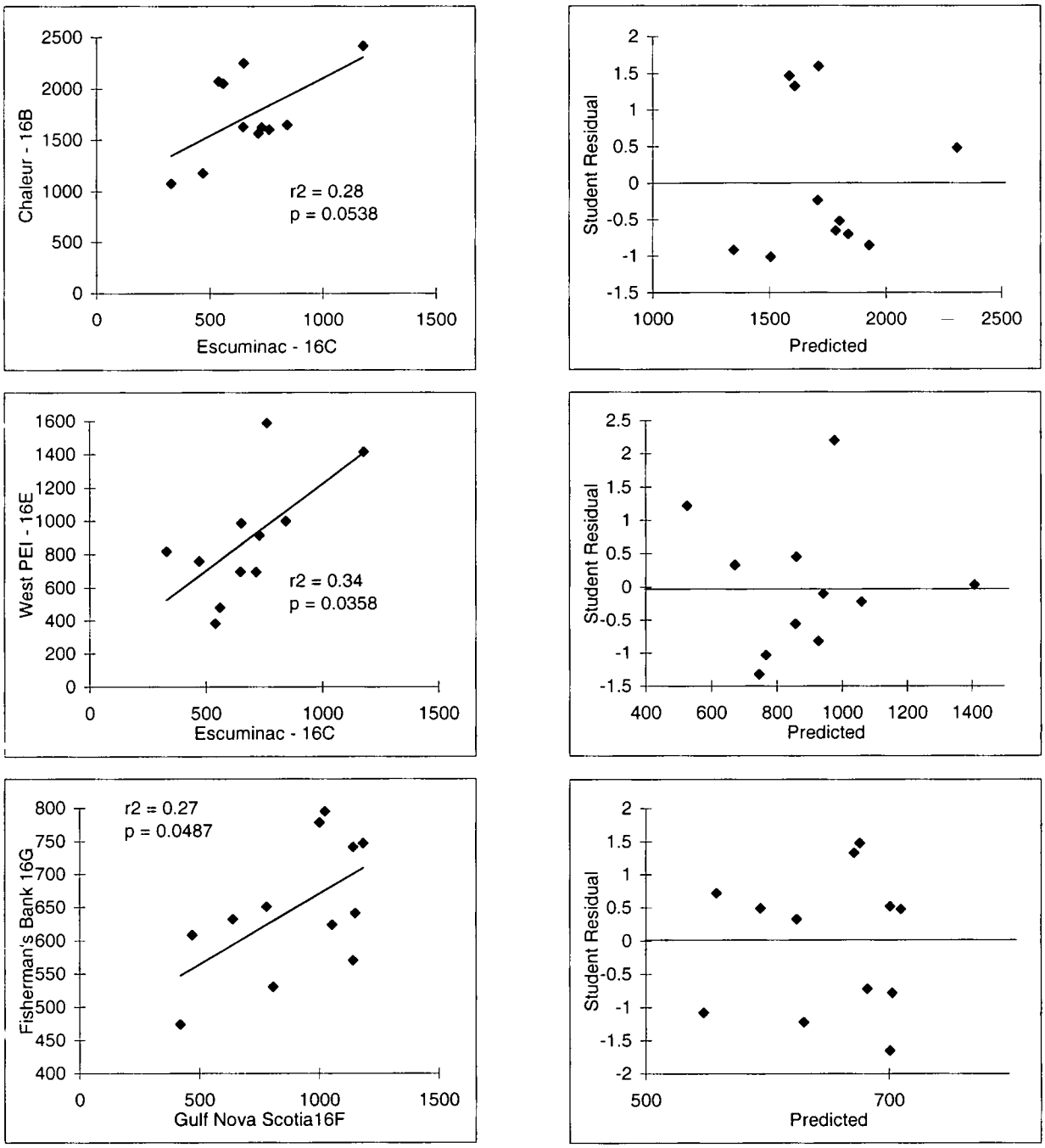


Fig. 6. Catch rate correlations between geographically adjacent inshore fishing areas in 4T.

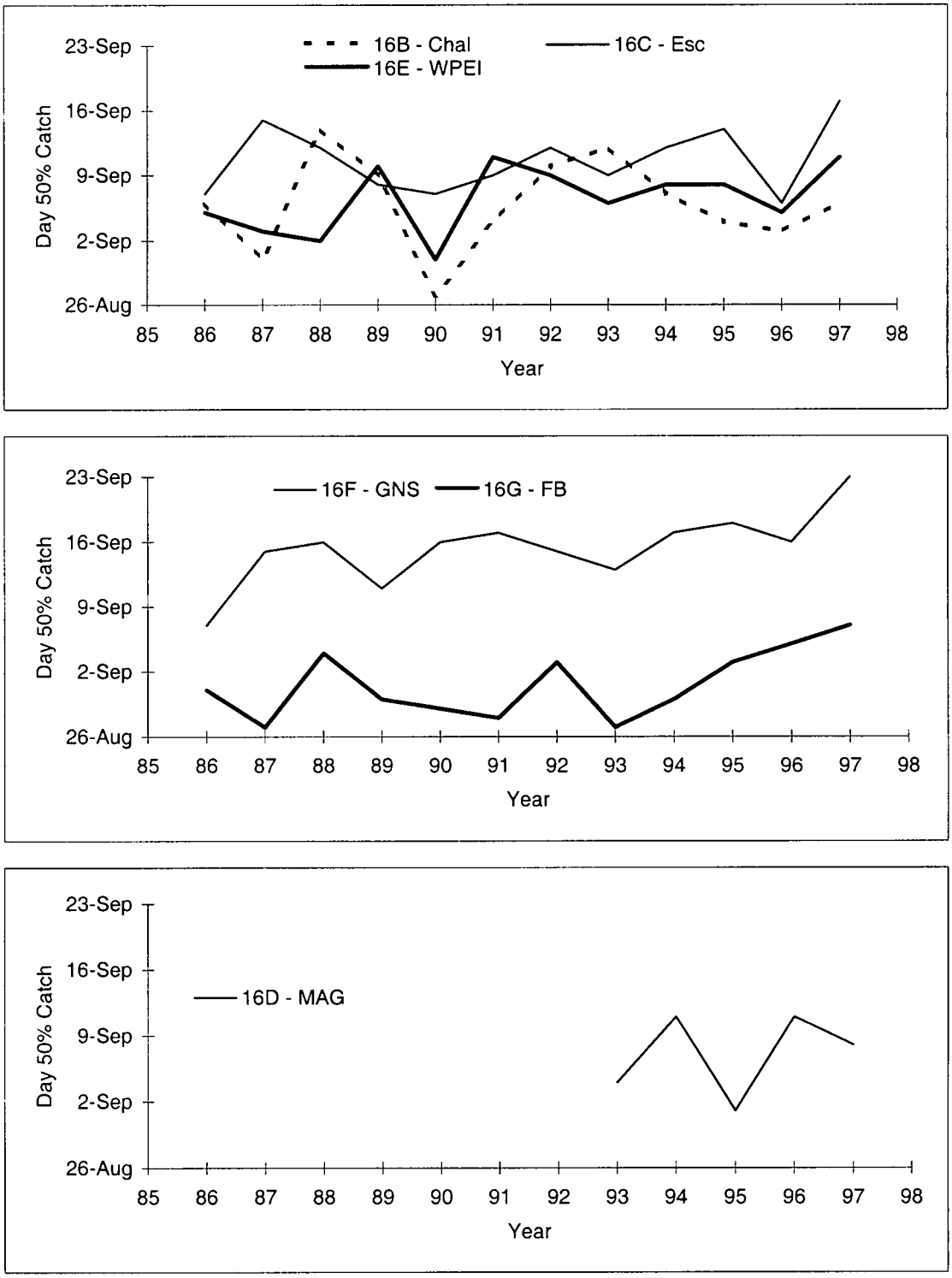


Fig. 7. Date when 50% of the herring caught for the season in 4T inshore fishing areas has occurred from 1986 to 1997.

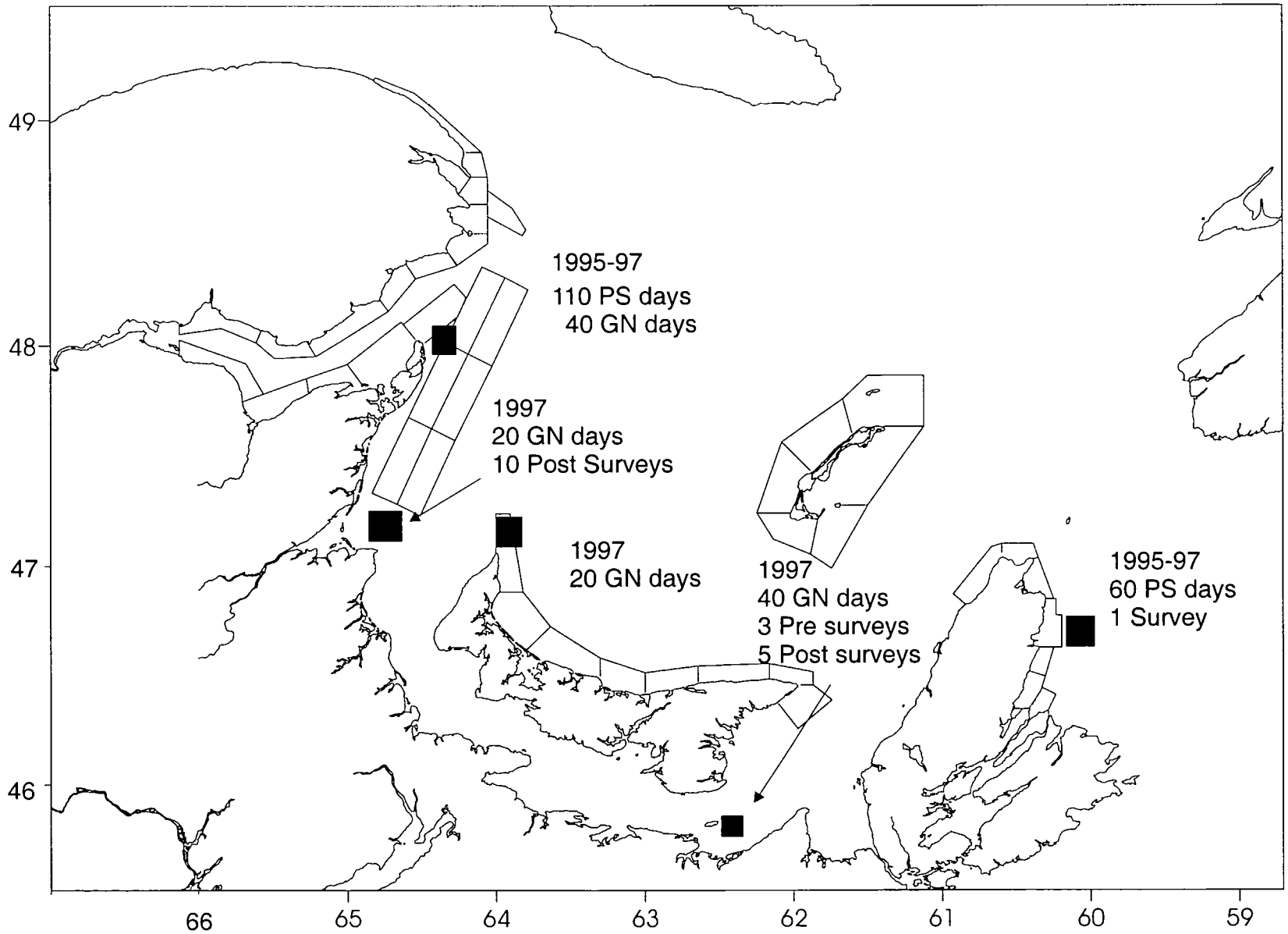
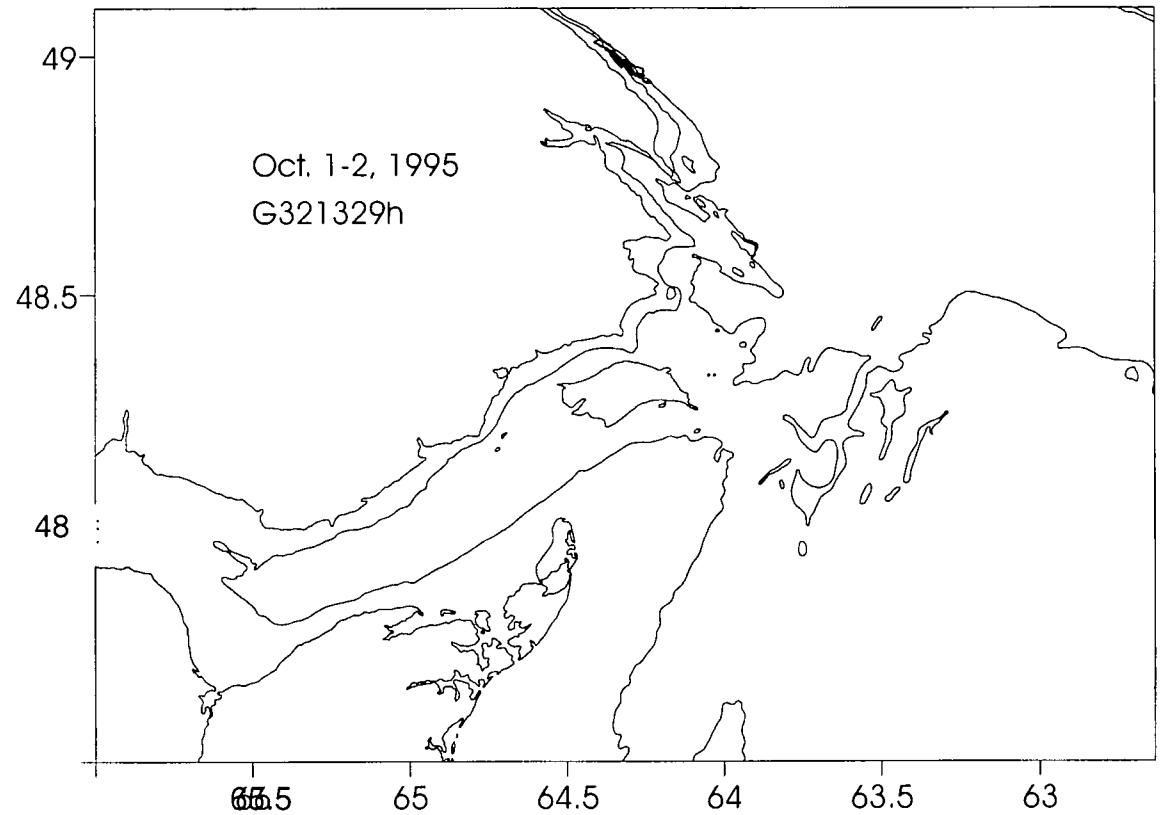


Fig. 8. Location of acoustic research survey strata (boxes) and fleet acoustic projects. PS, purse seiners; GN, gillnetters. Days refers to number of days of data collected during regular fishing activity.



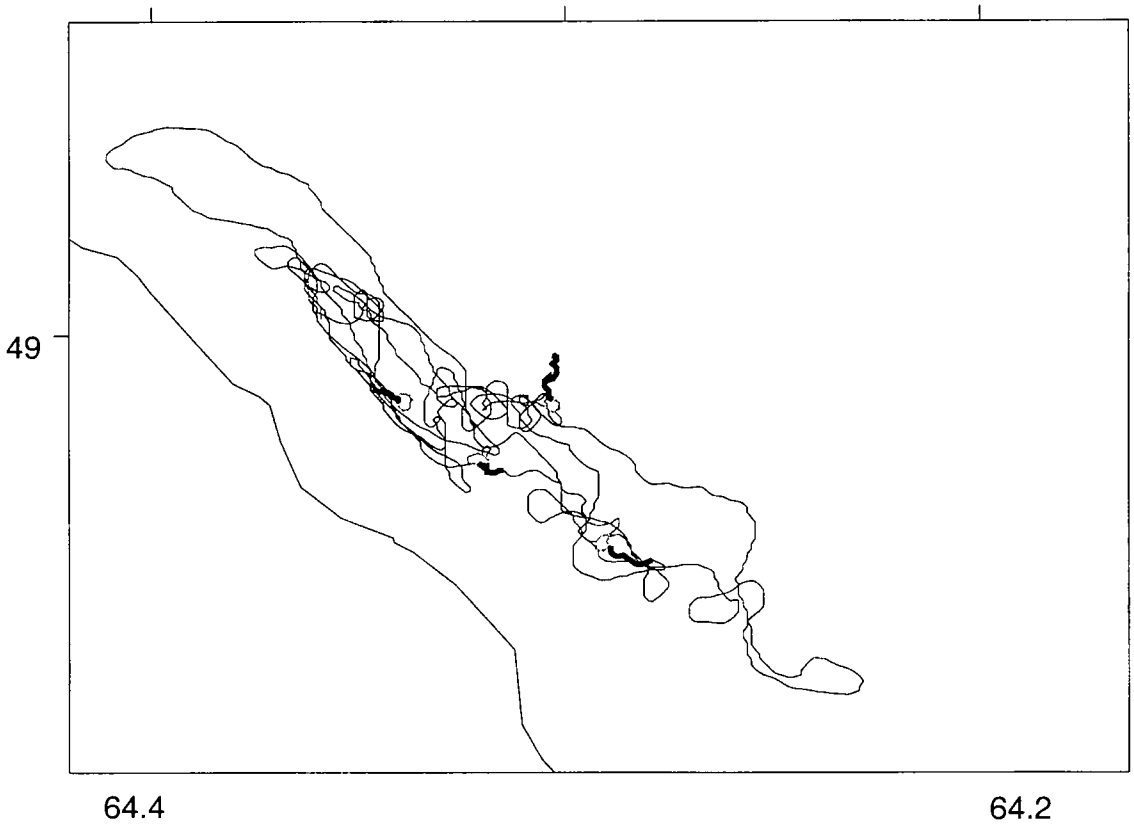


Fig. 9 Fishing activities, Gemini Oct. 1-2, 1995. Thin line: Searching/ Black thick line: Pumping; Grey thick line: Fishing.

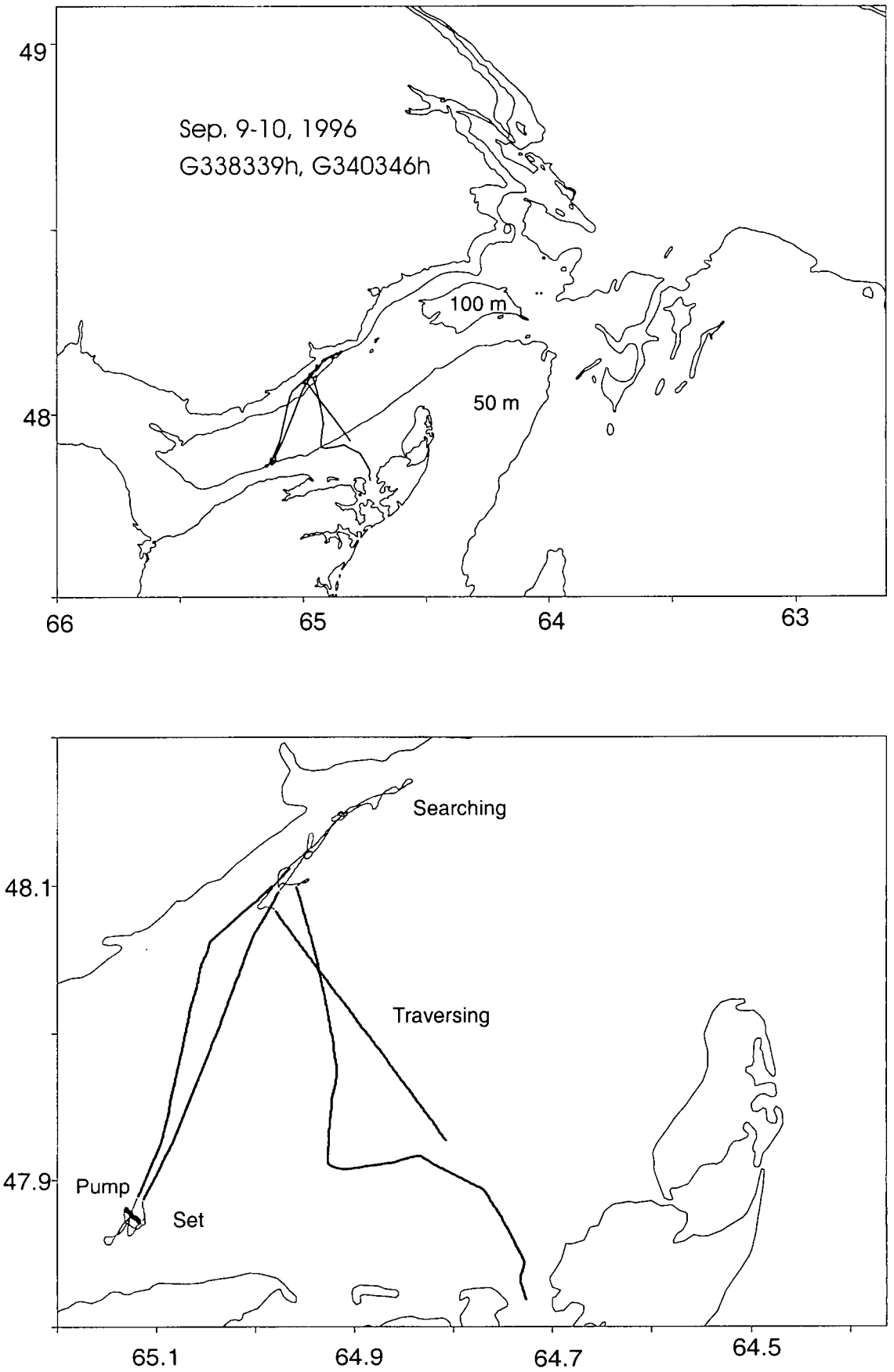
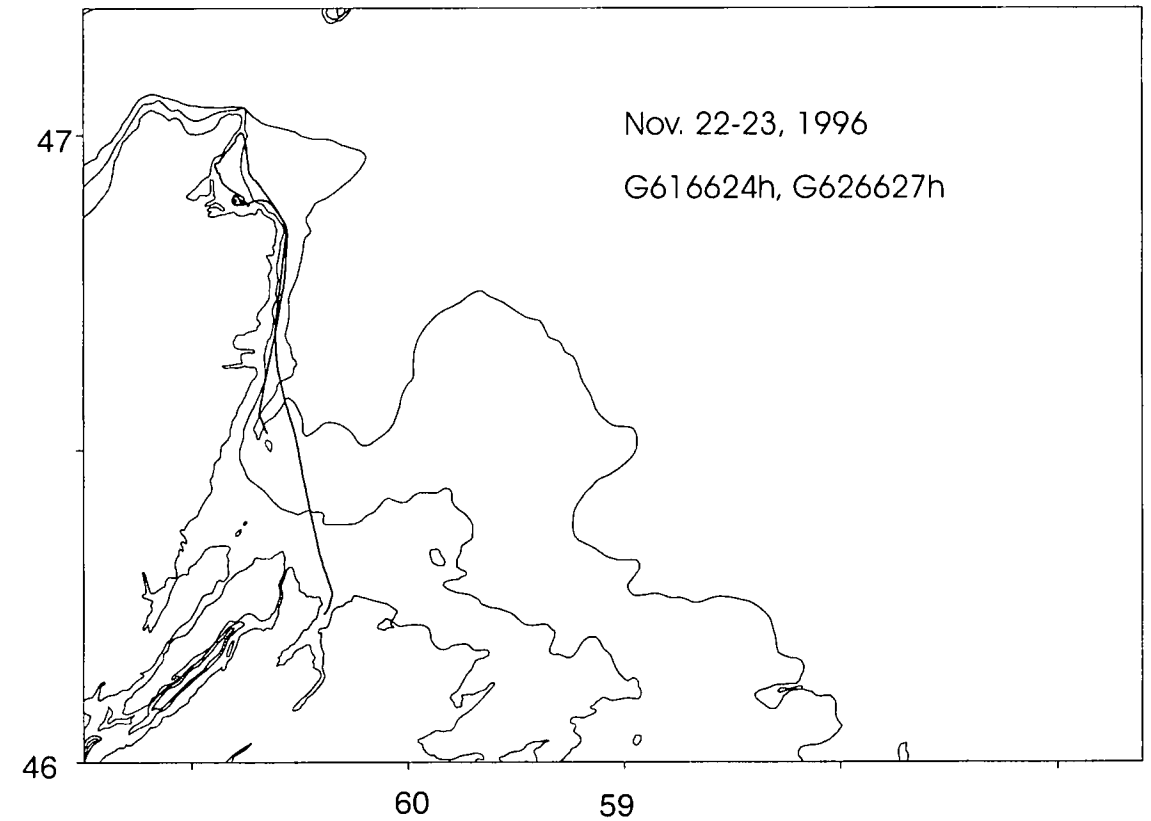


Fig. 10 . Fishing locations and activities by Gemini, Sep. 9-10, 1996



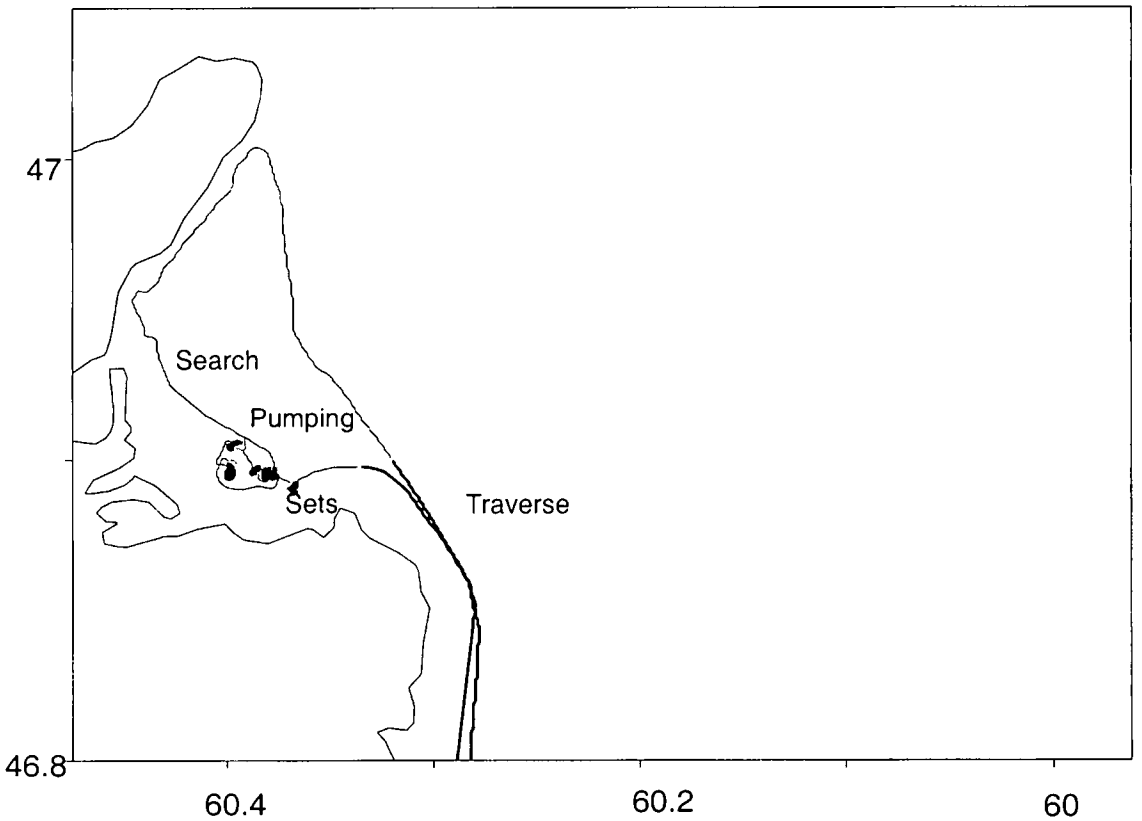
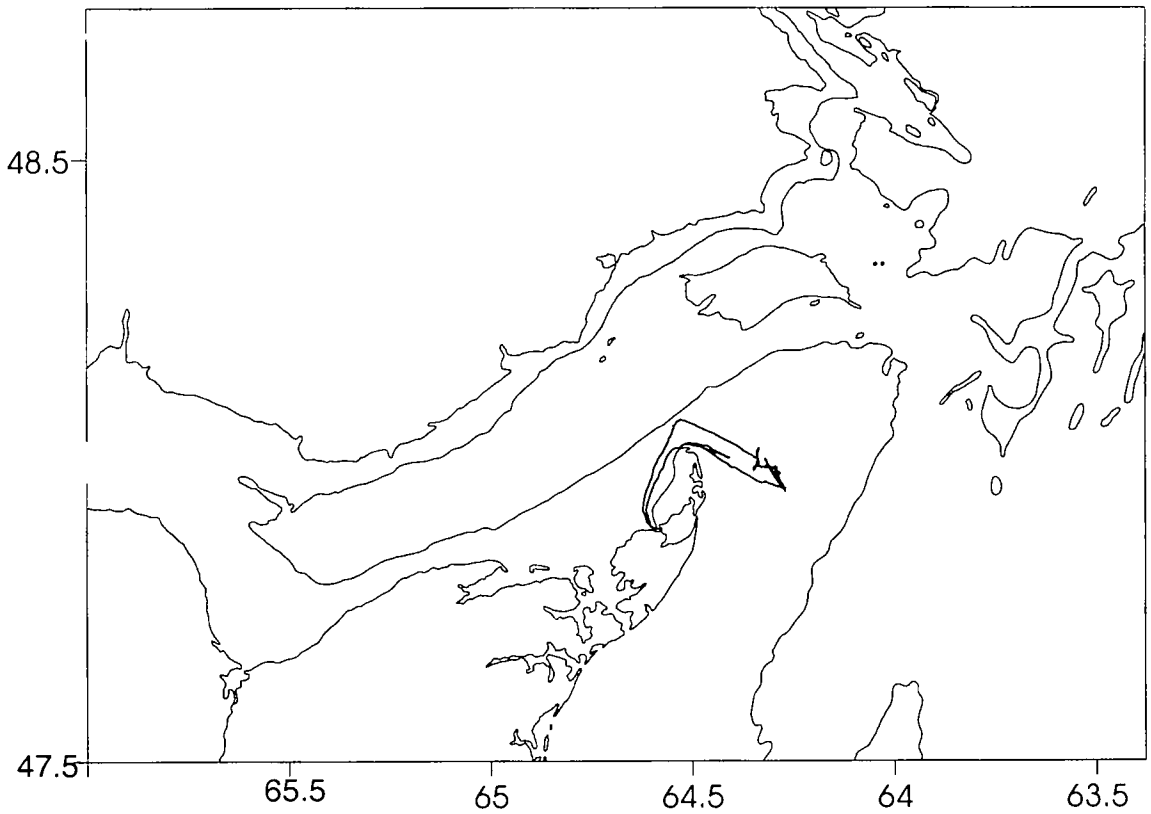


Fig. 11 . Fishing activity by Gemini, Nov. 22-23, 1996.Thick line, traversing to and from fising grounds, thin line, searching while on fishing grounds, dark blocks, sets, grey blocks, pumping.



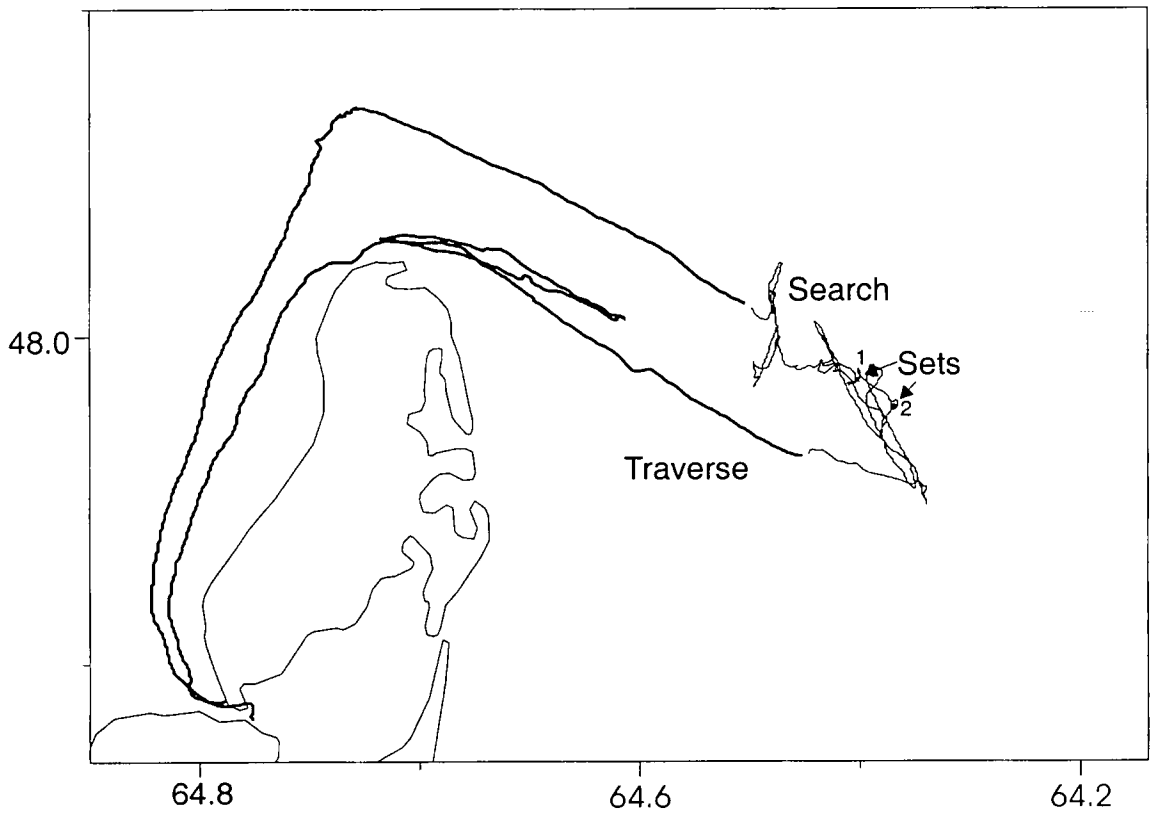
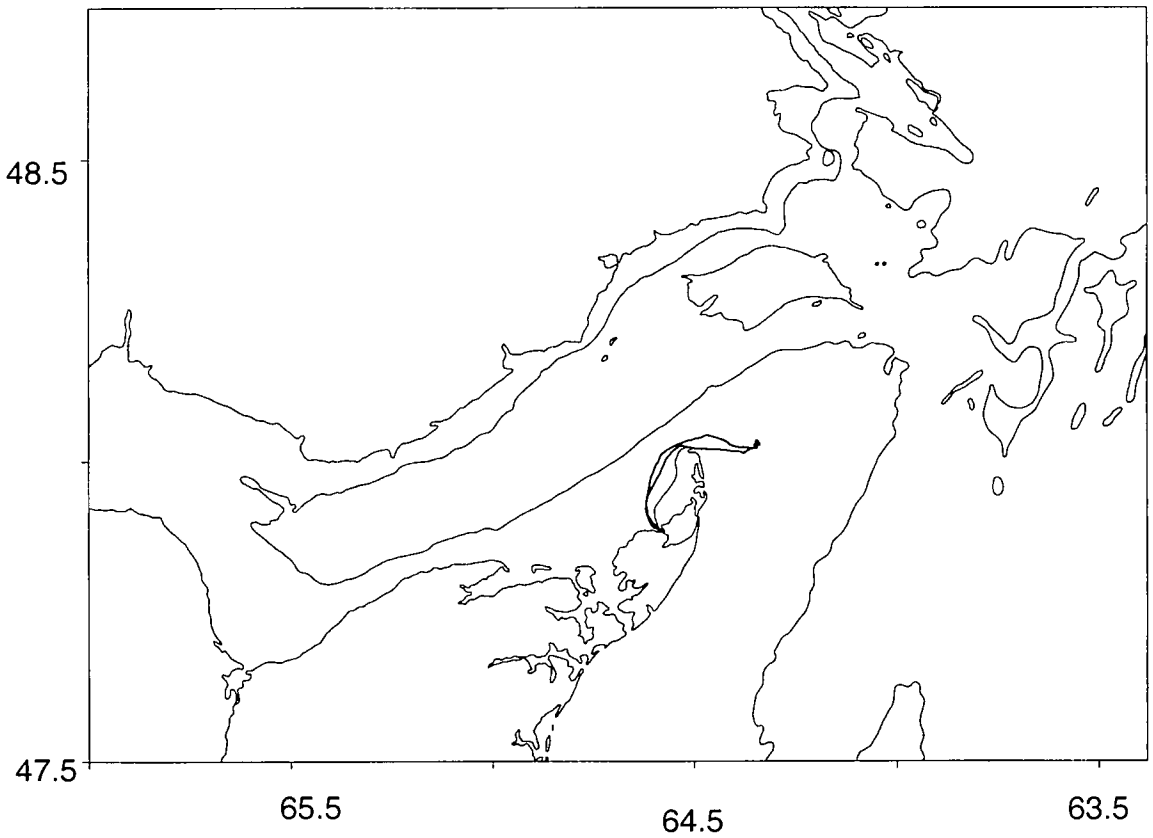


Fig. 12 . Fishing track and activities for gillnetter Gilbert G, Sep. 5-6, 1996.



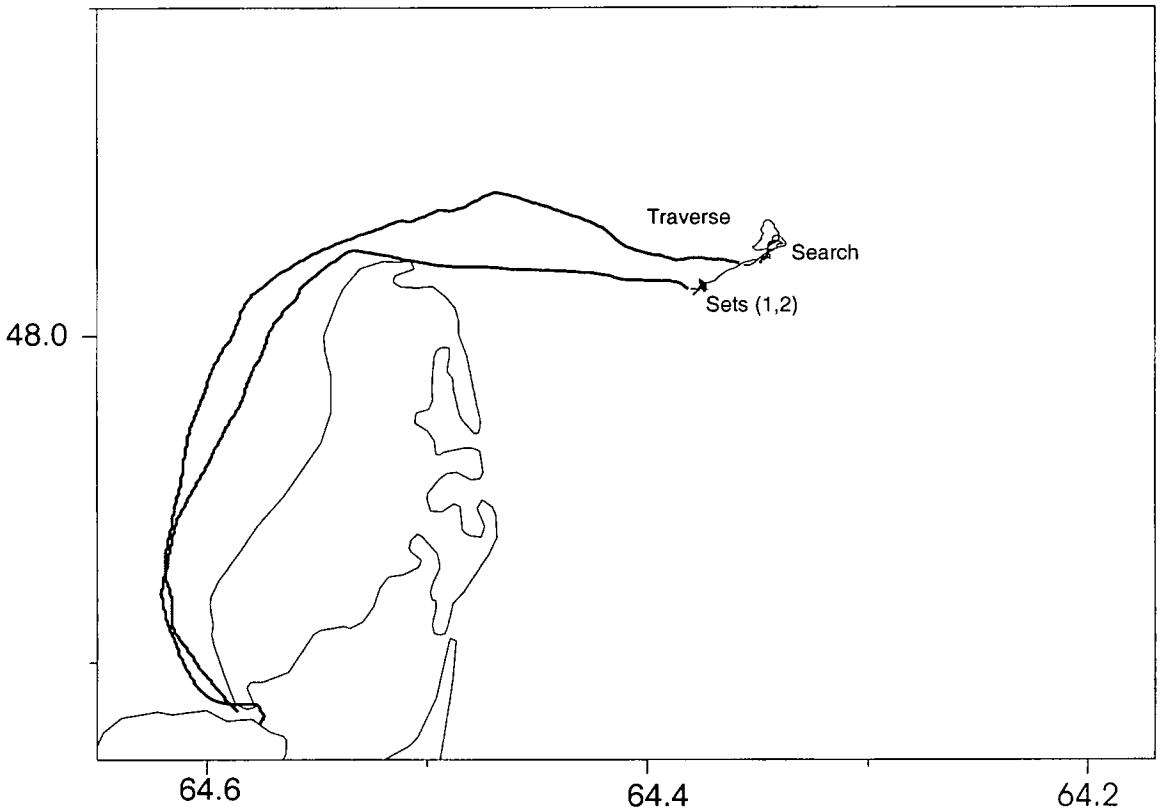


Fig. 13 . Fishing track and acitivities for gillnetter, Gilbert G, Sep 8-9, 1996.

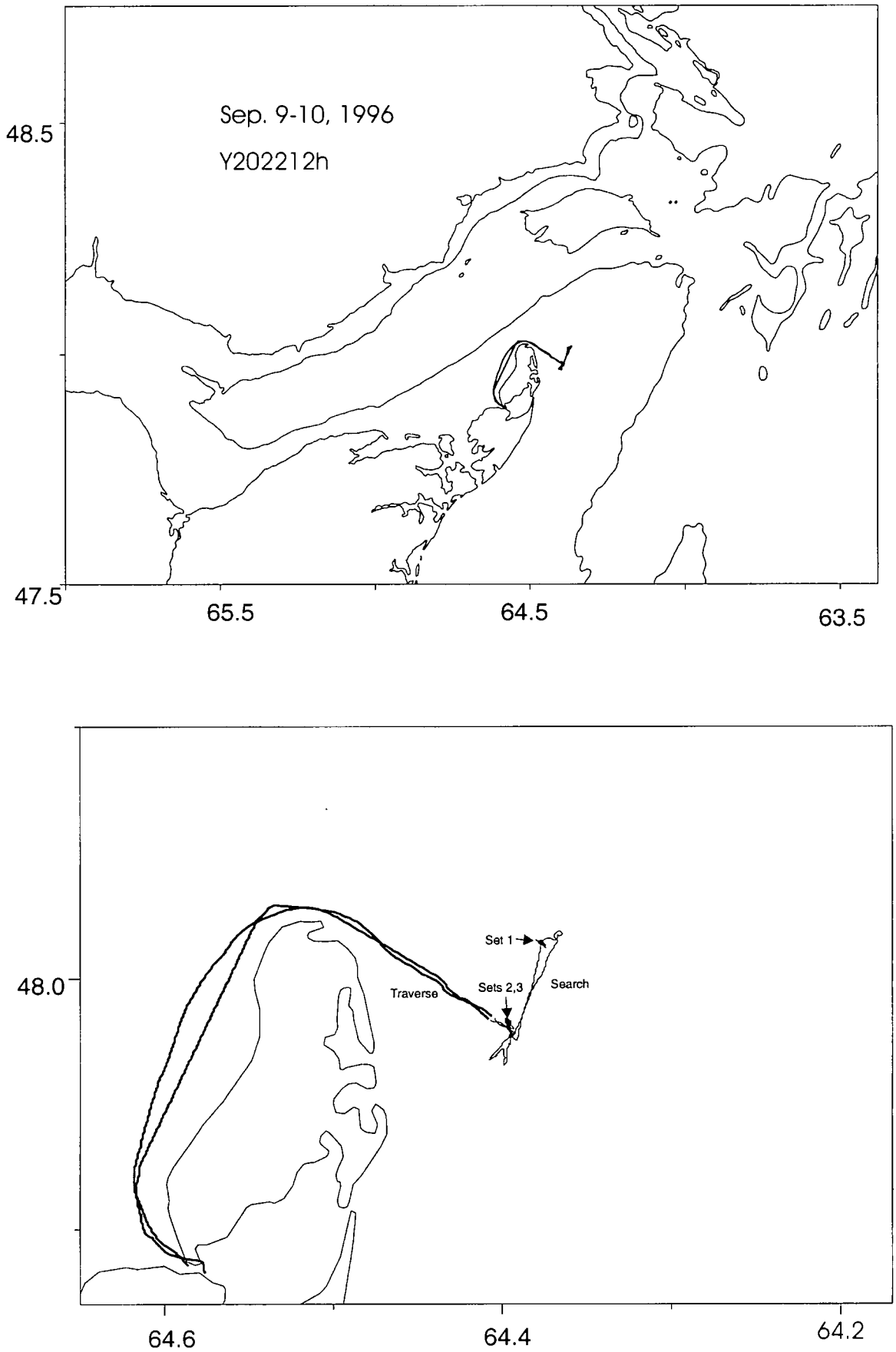


Fig. 14 . Fishing track and activities for gillnetter, Gilbert G, Sep 9-10, 1996.

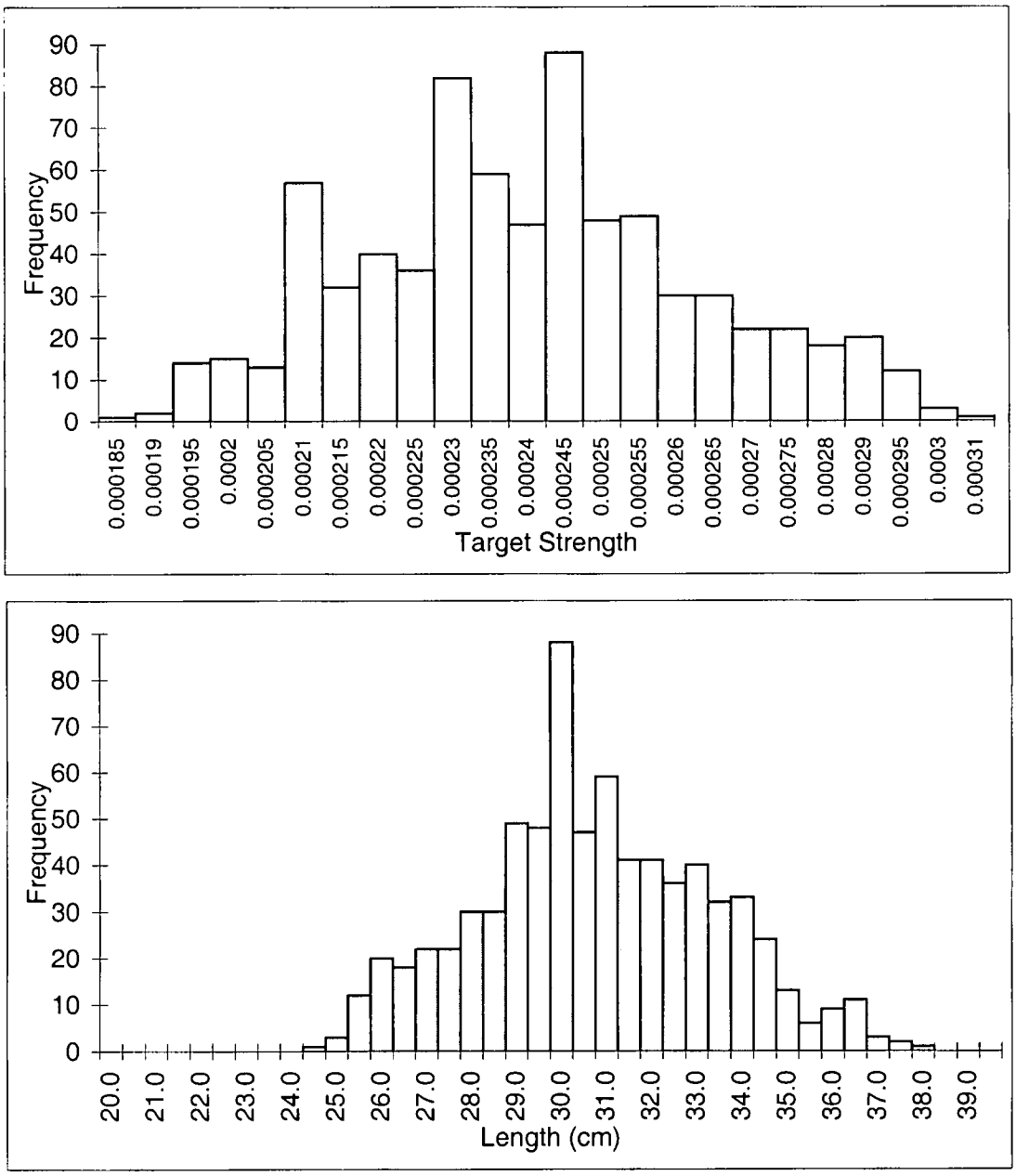
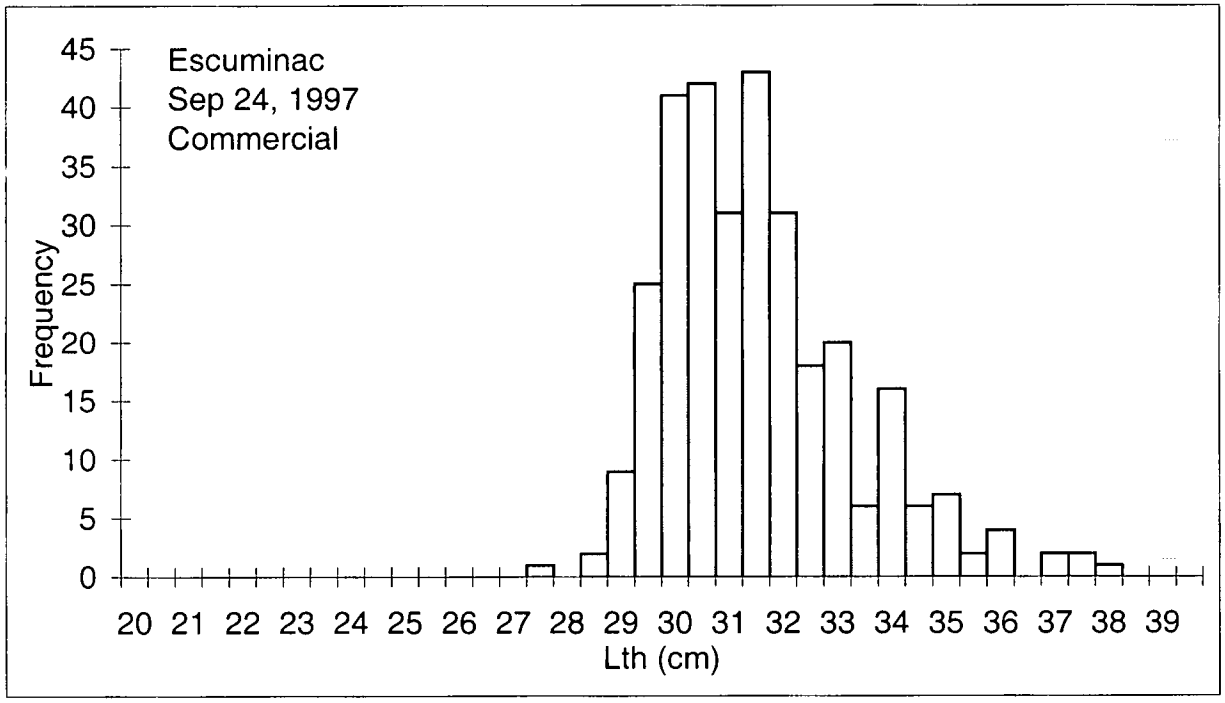


Fig. 15. Length frequency and target strength distributions from experimental net sampling in Gulf Nova Scotia, September 18, 1997.



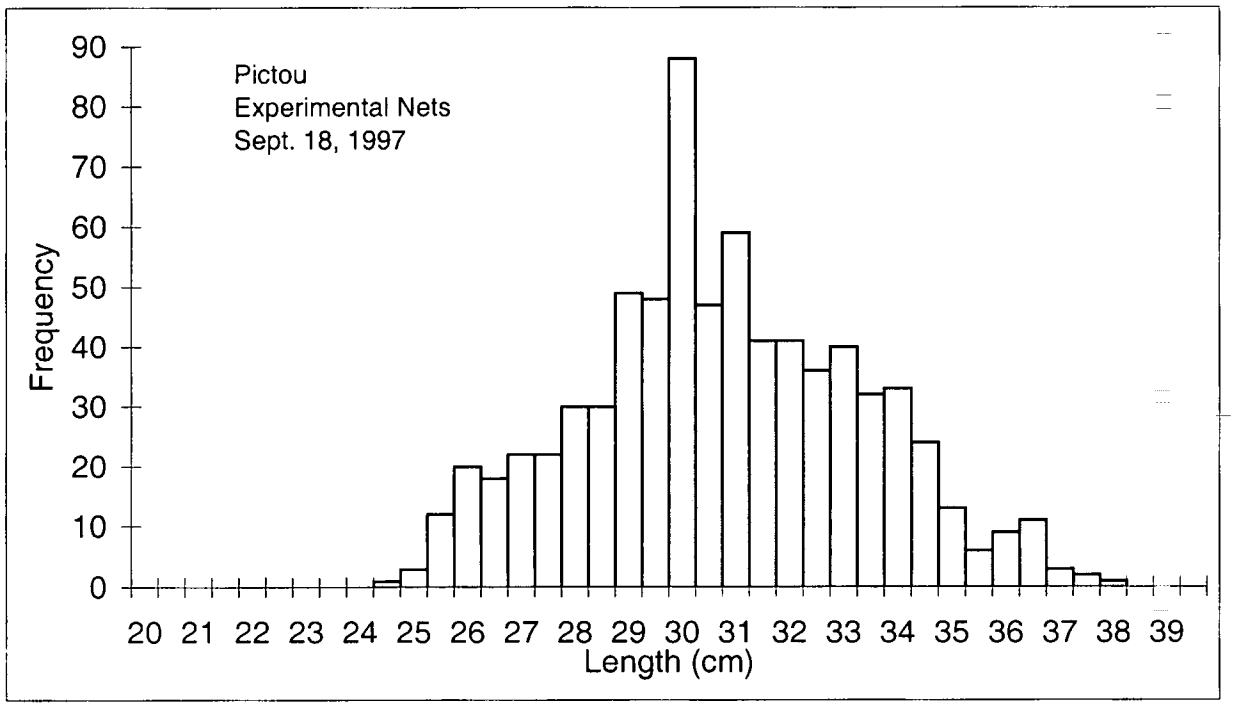
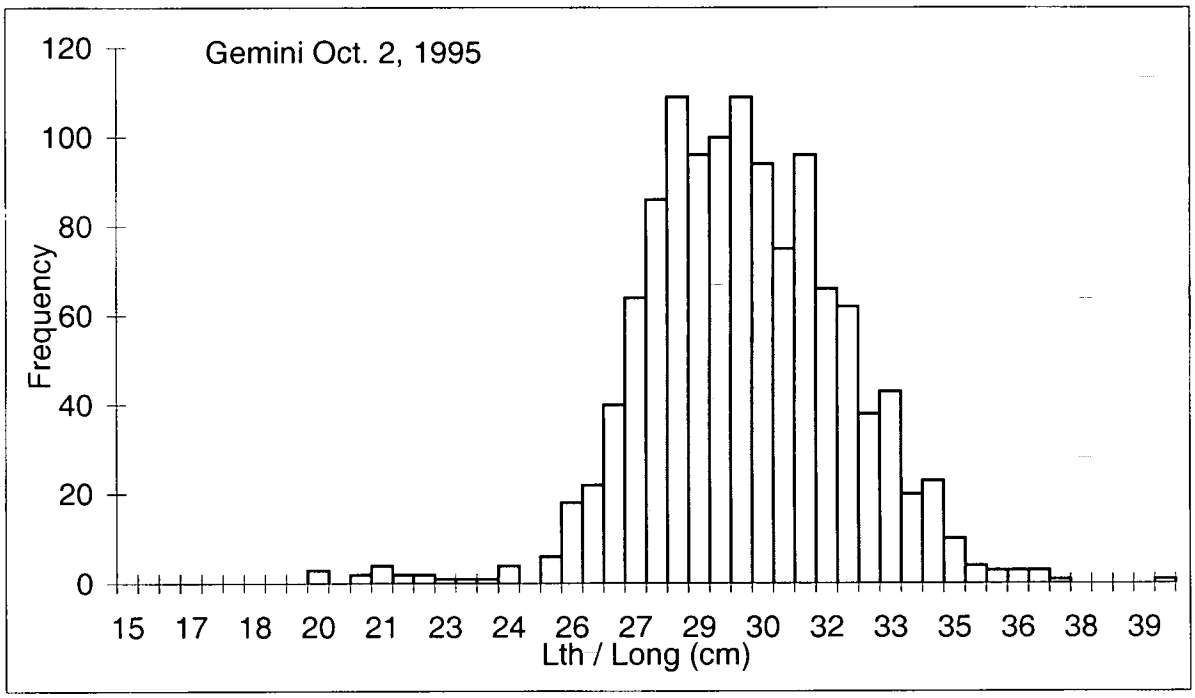


Fig. 16. Comparison of length frequencies from experimental nets in Gulf Nova Scotia and commercial nets in Escuminac, NB.



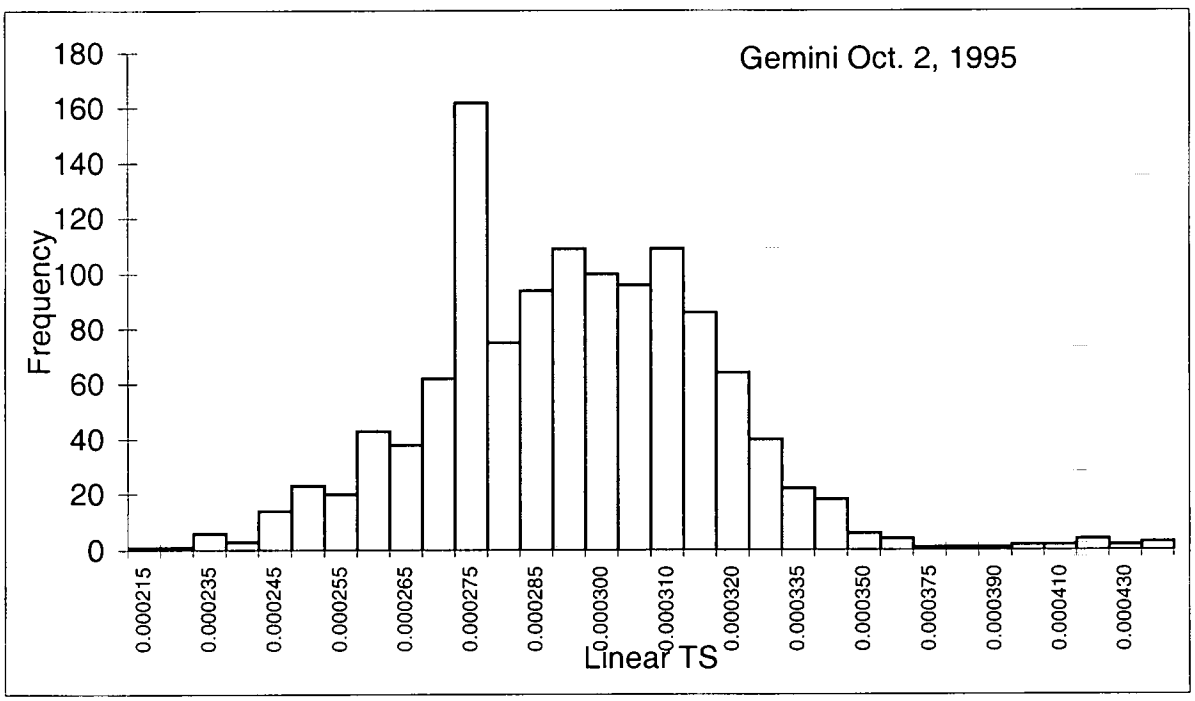


Fig. 17. Length frequency and target strength distributions from purse seiner on Oct. 2, 1995.

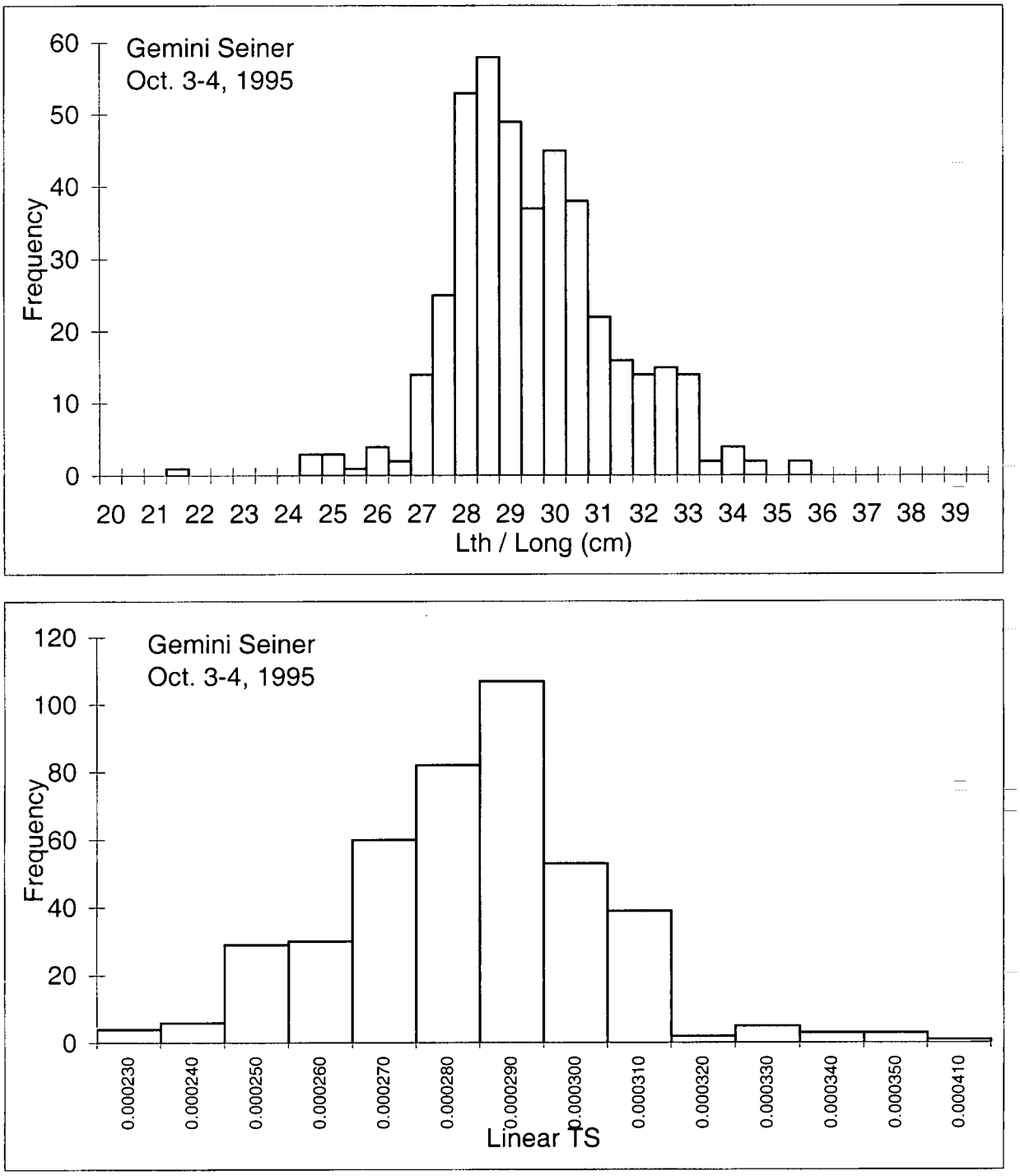


Fig. 18. Length frequency and target strength distributions from Gemini Oct. 3-4, 1995.

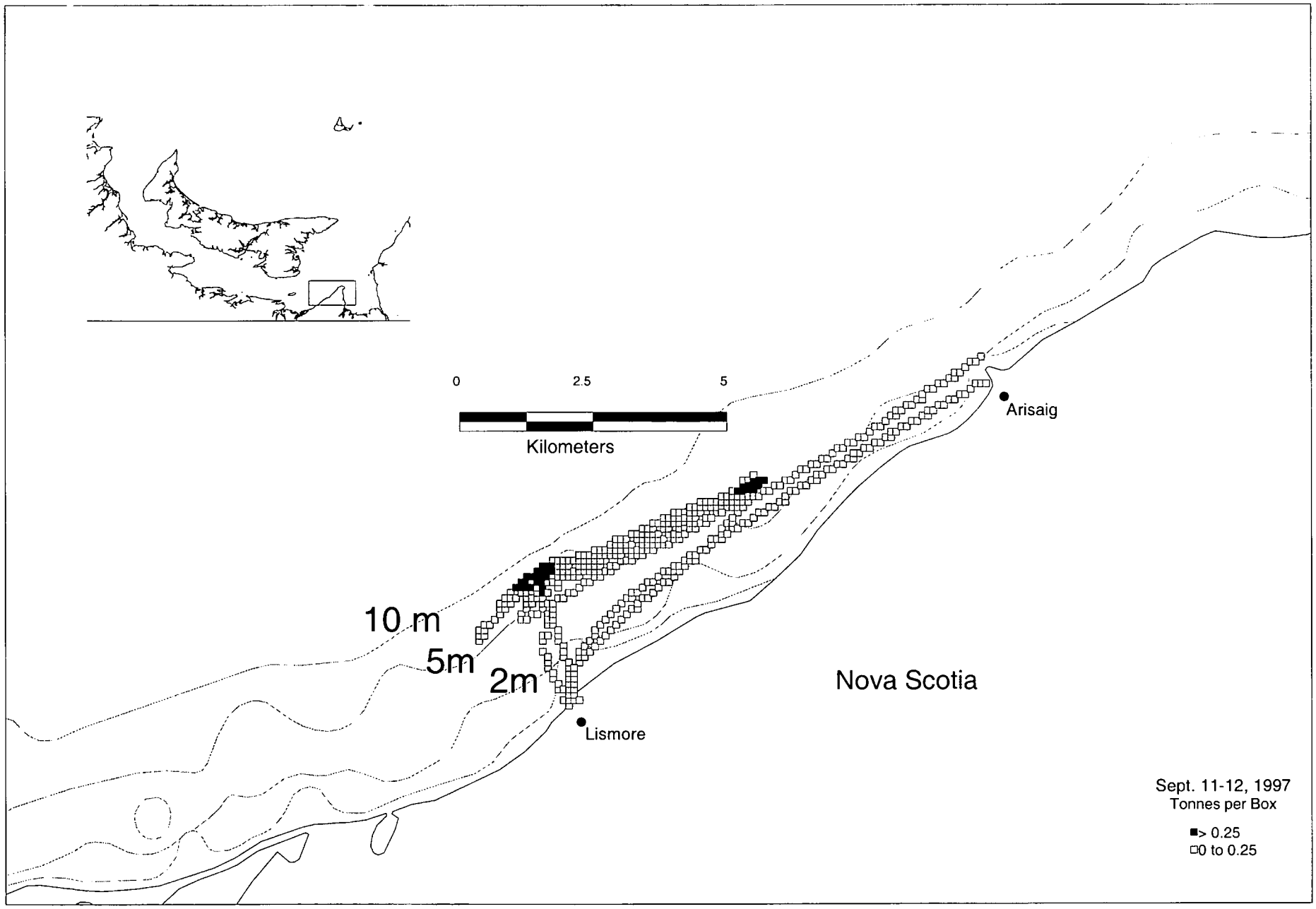


Fig. 19. Tonnes per 100m square box for Sept. 11-12, 1997 in Gulf Nova Scotia herring fishery.

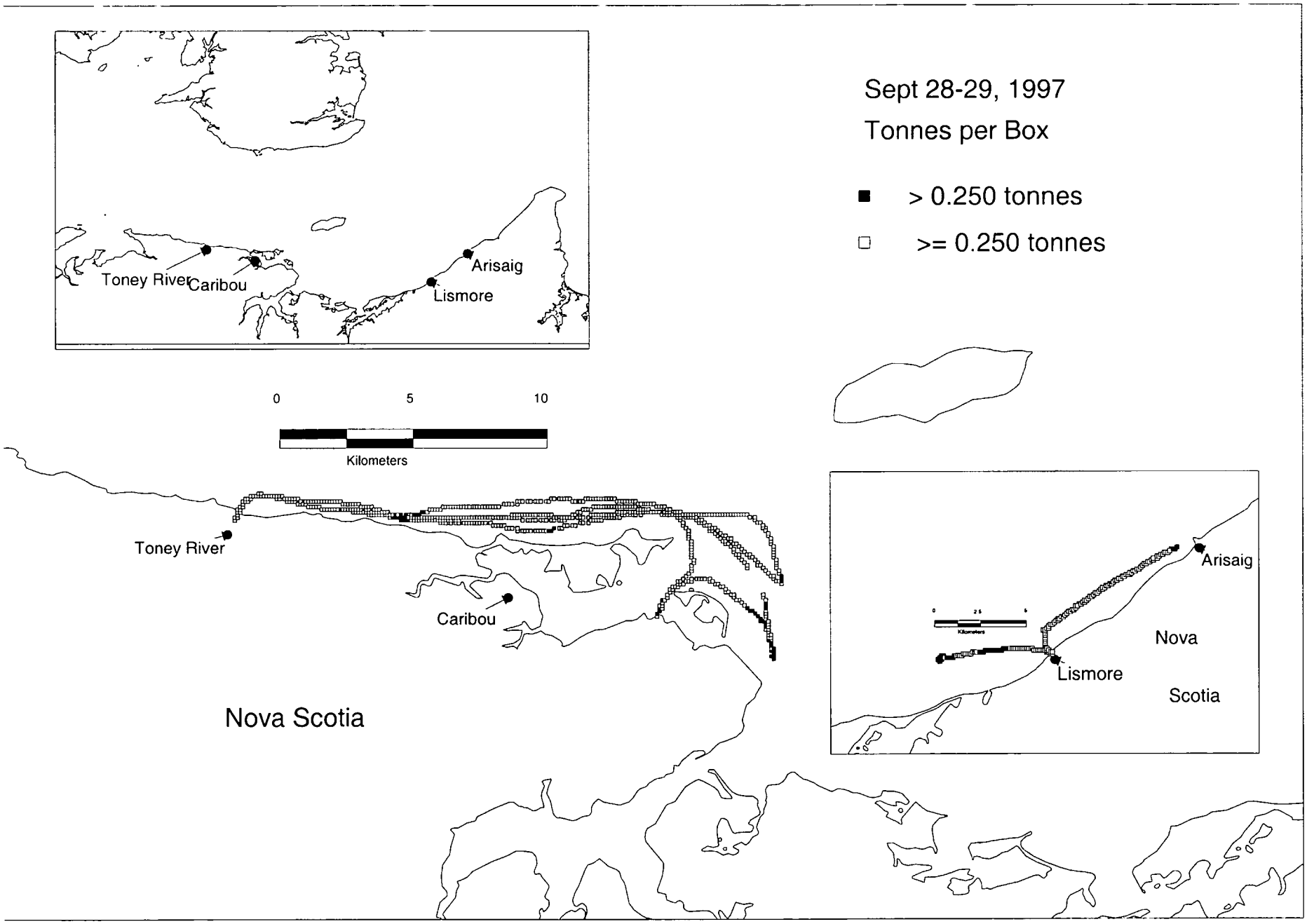


Fig. 20. Tonnes per 100m square box for Sept. 28-29, 1997 in Gulf Nova Scotia herring fishery (16F).

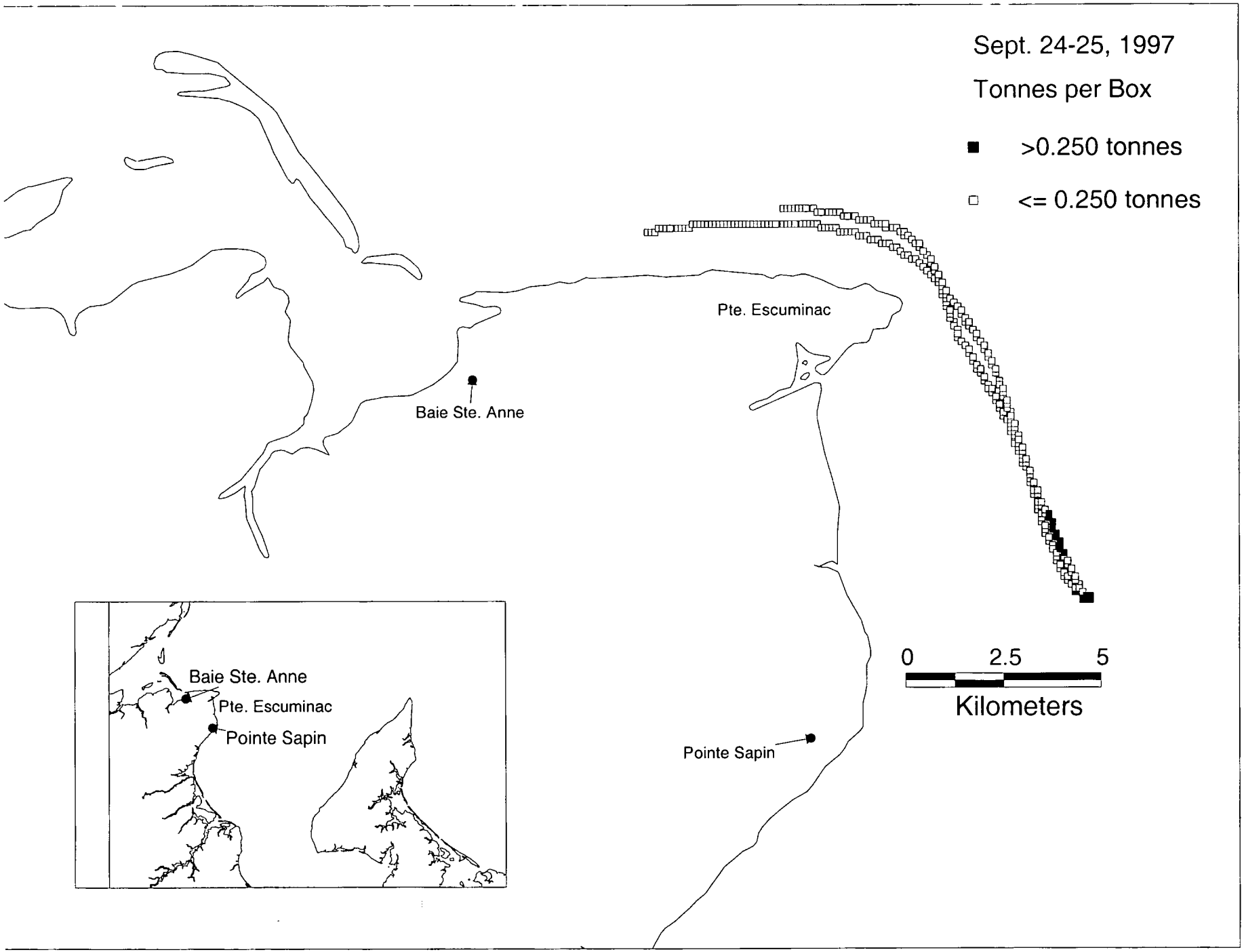


Fig. 21. Tonnes per 100 square metre box in Escuminac fishery Sept. 24-25, 1997 (16C).

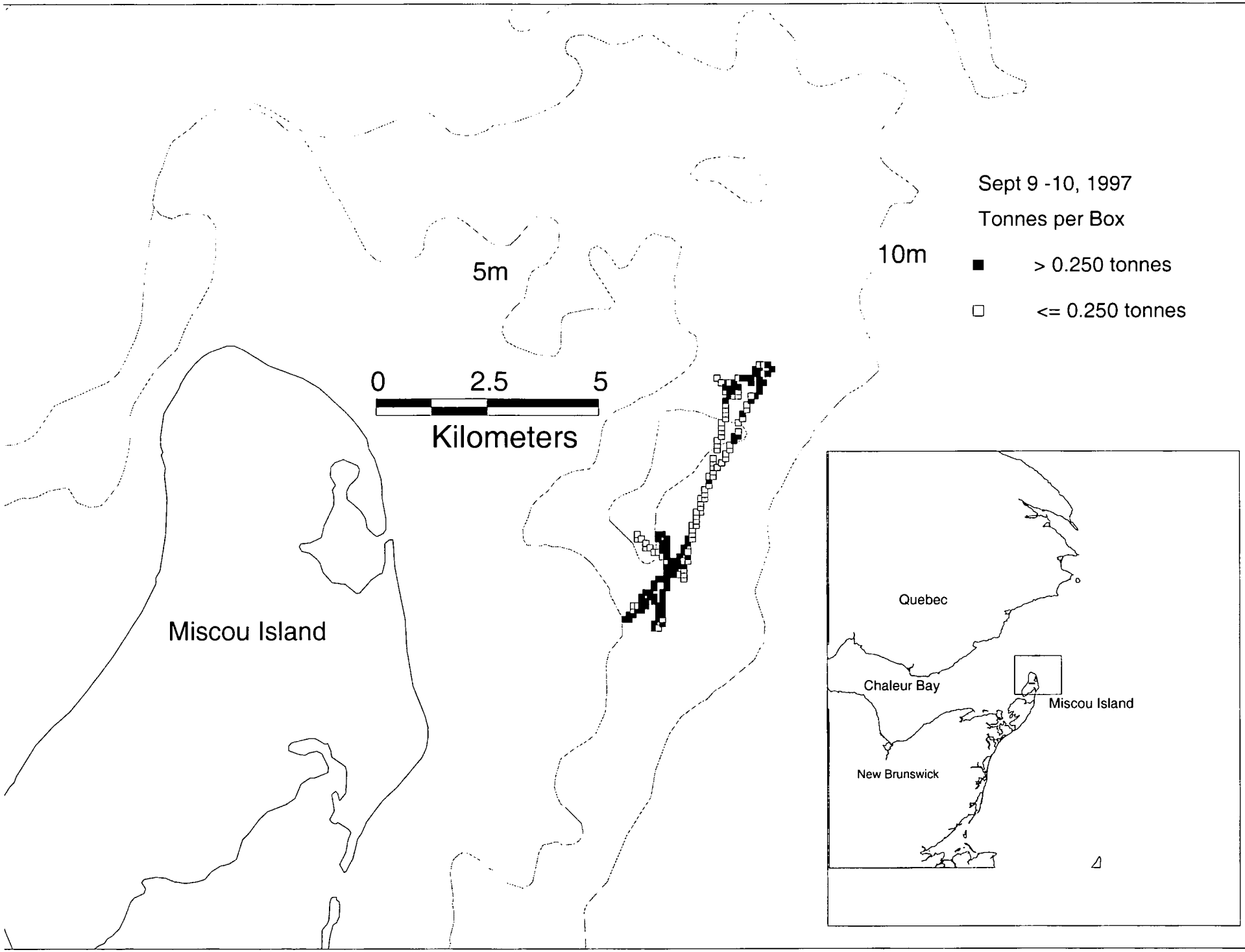


Fig. 22. Tonnes per 100 square metre box in Miscou fishery, Sept. 9-10, 1997 (16B).

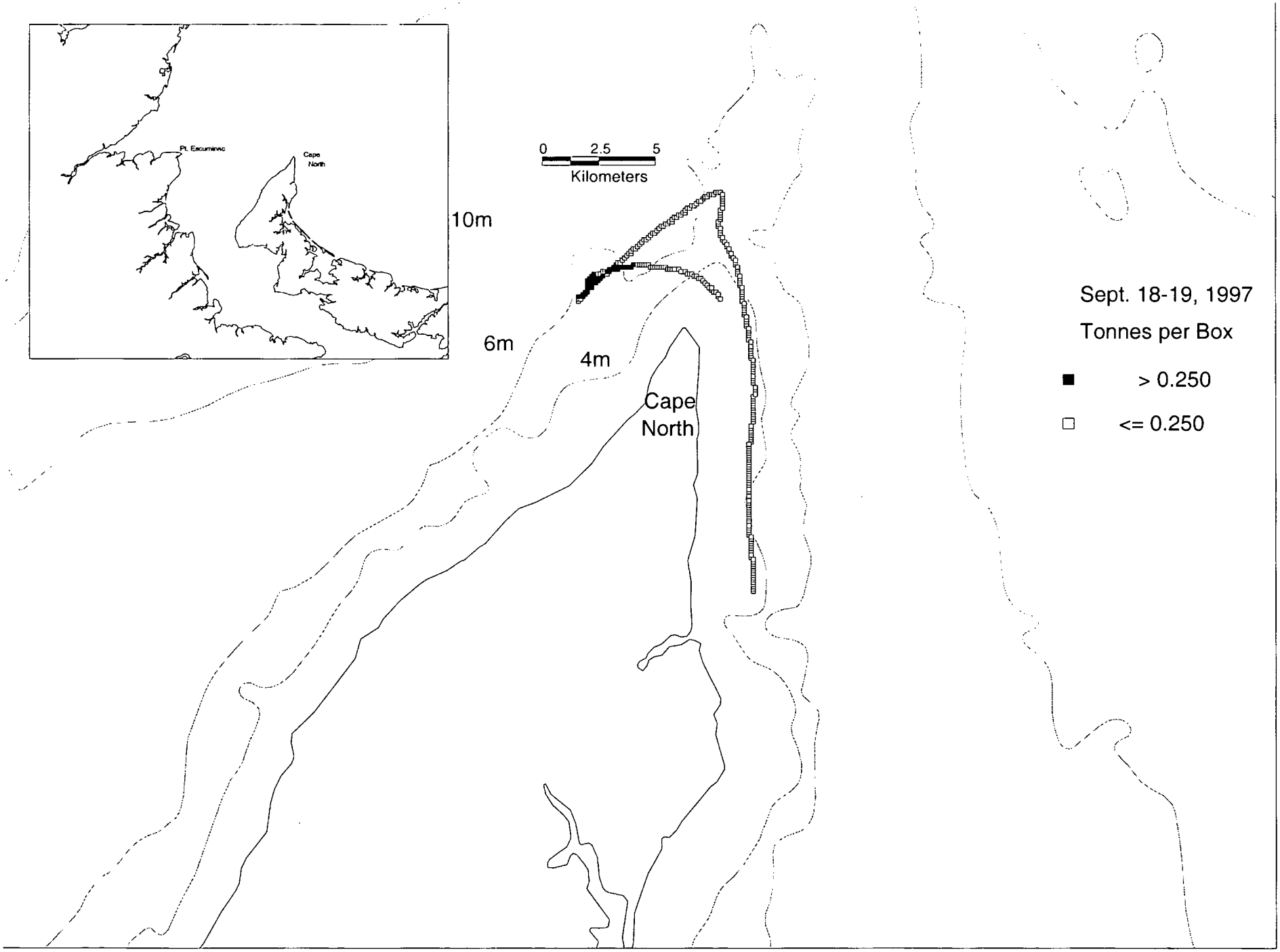


Fig. 23. Tonnes per 100 square metre box in West Prince Edward Island fishery (16E), September 18-19, 1997.

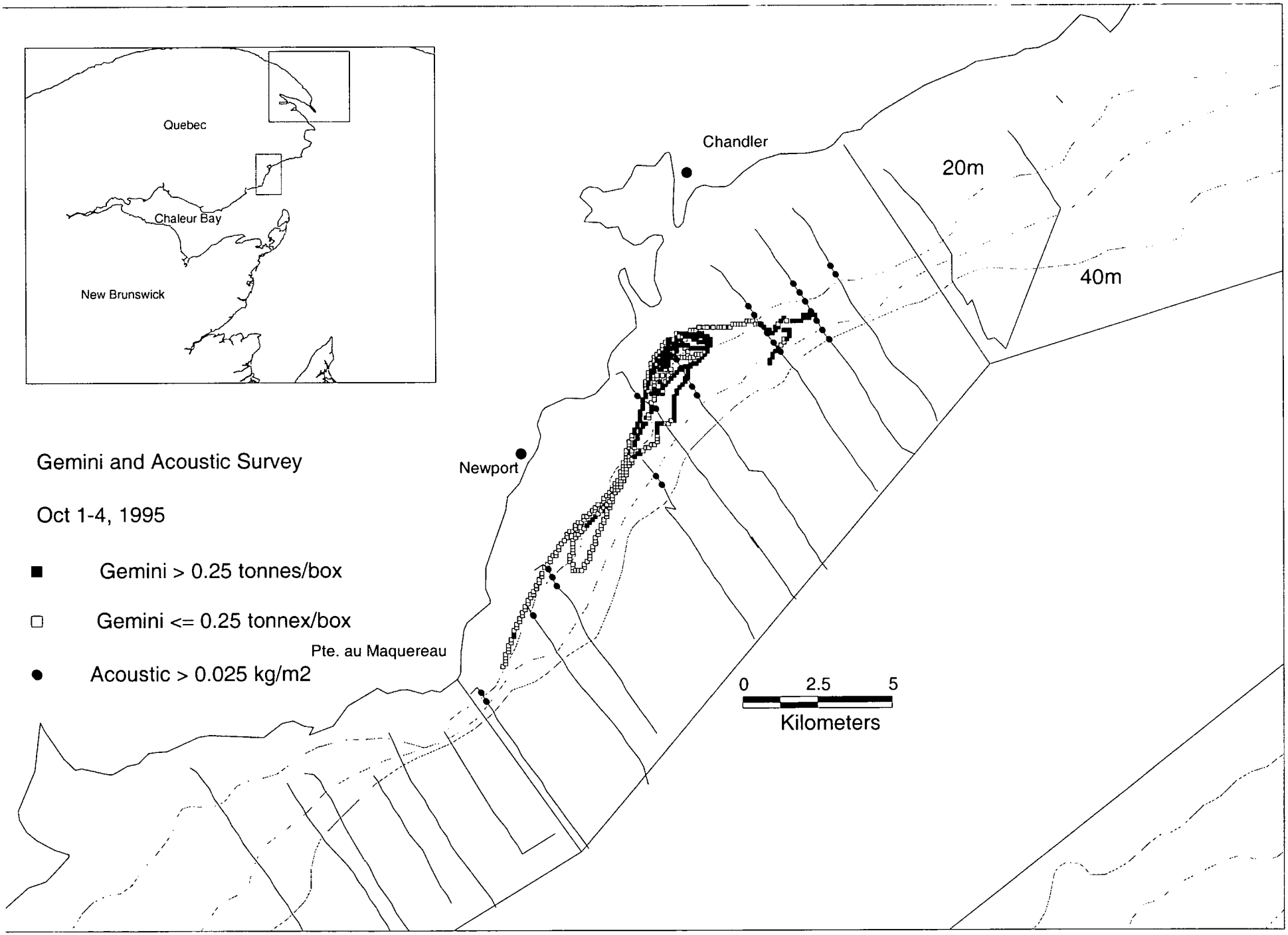


Fig. 24. Comparison of herring densities observed by Gemini while fishing (Oct. 3-4, 1995) and acoustic survey (Oct. 1-2, 1995).

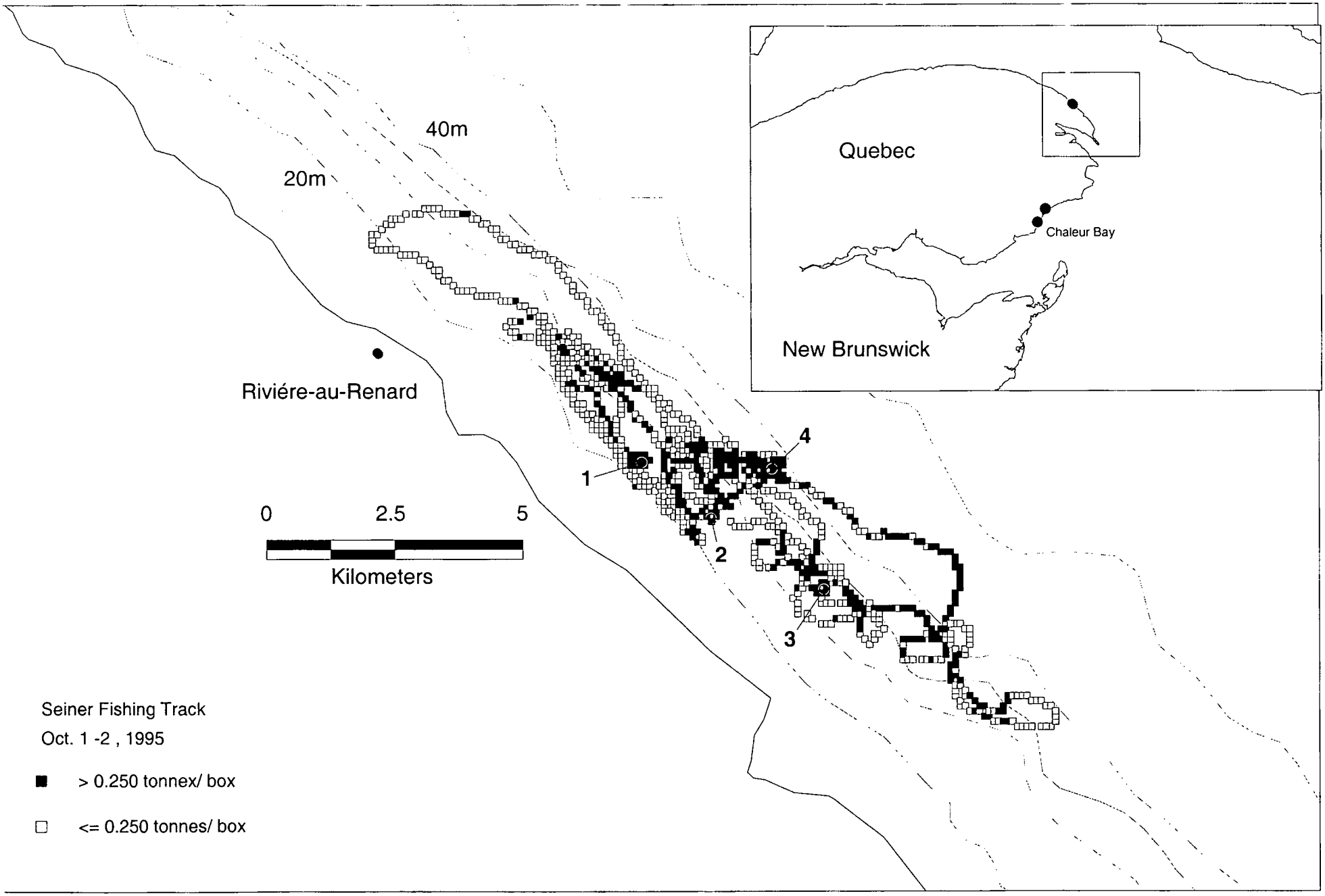


Fig. 25. Tonnes per 100 metre square box during fishery on Oct. 1-2, 1995 (16A). Numbers indicate set locations.

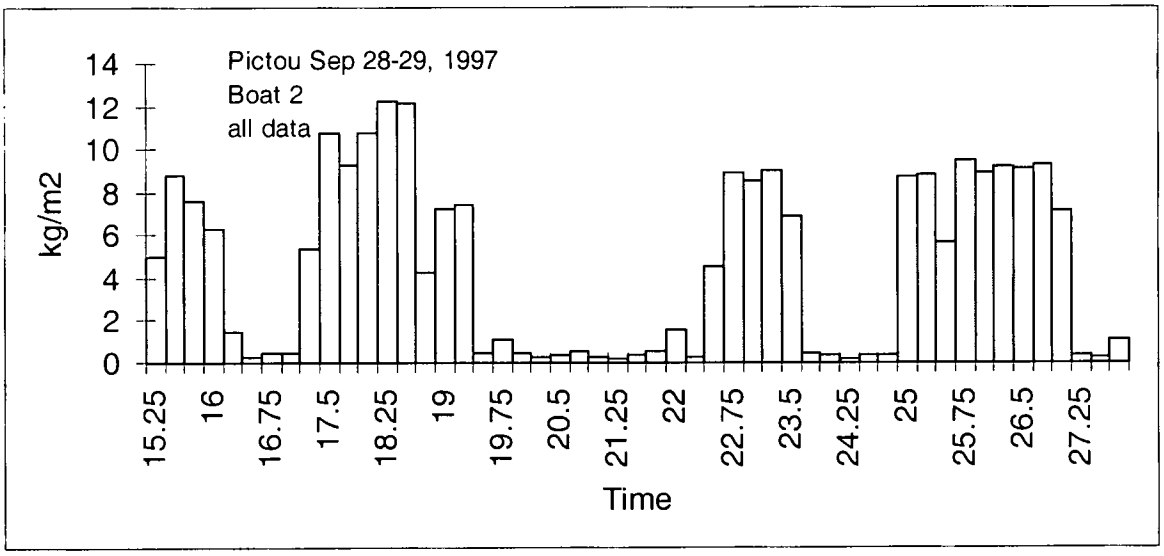


Fig. 26. Density from gillnetter over time for Sept. 28-29, 1997 from Toney River - Caribou location (Fig. 20).

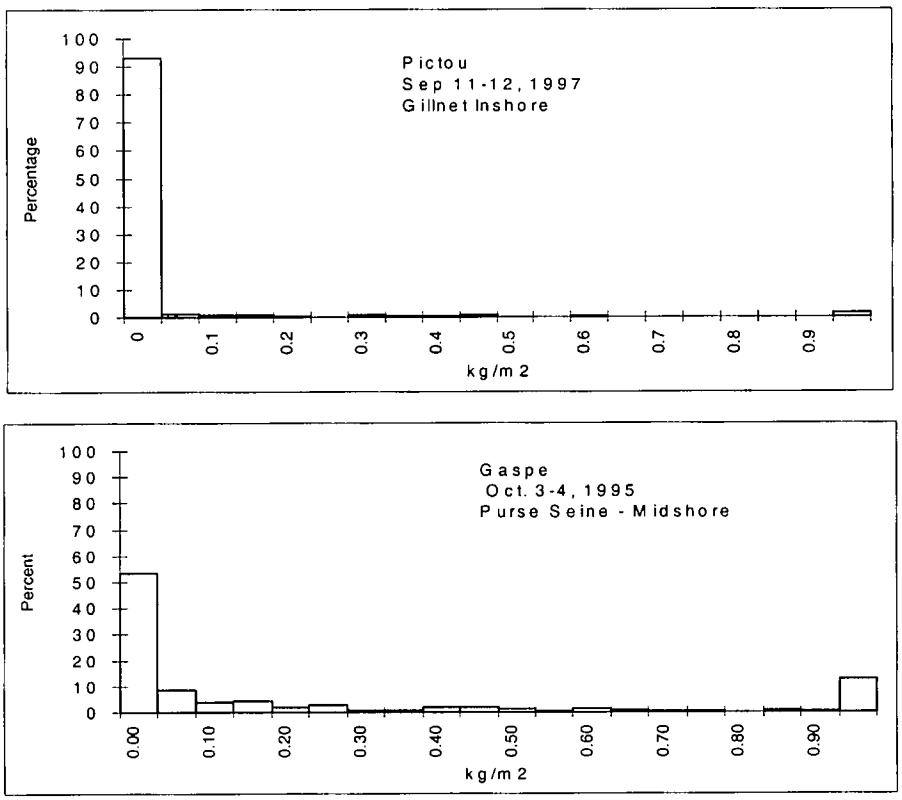


Fig. 27. Distribution of density for indicated fishing nights and locations shown in Fig. 19 ro Pictou and Fig. 24 for Purse Seiner.

Set Estimates Purse Seine Oct. 1-2, 1995

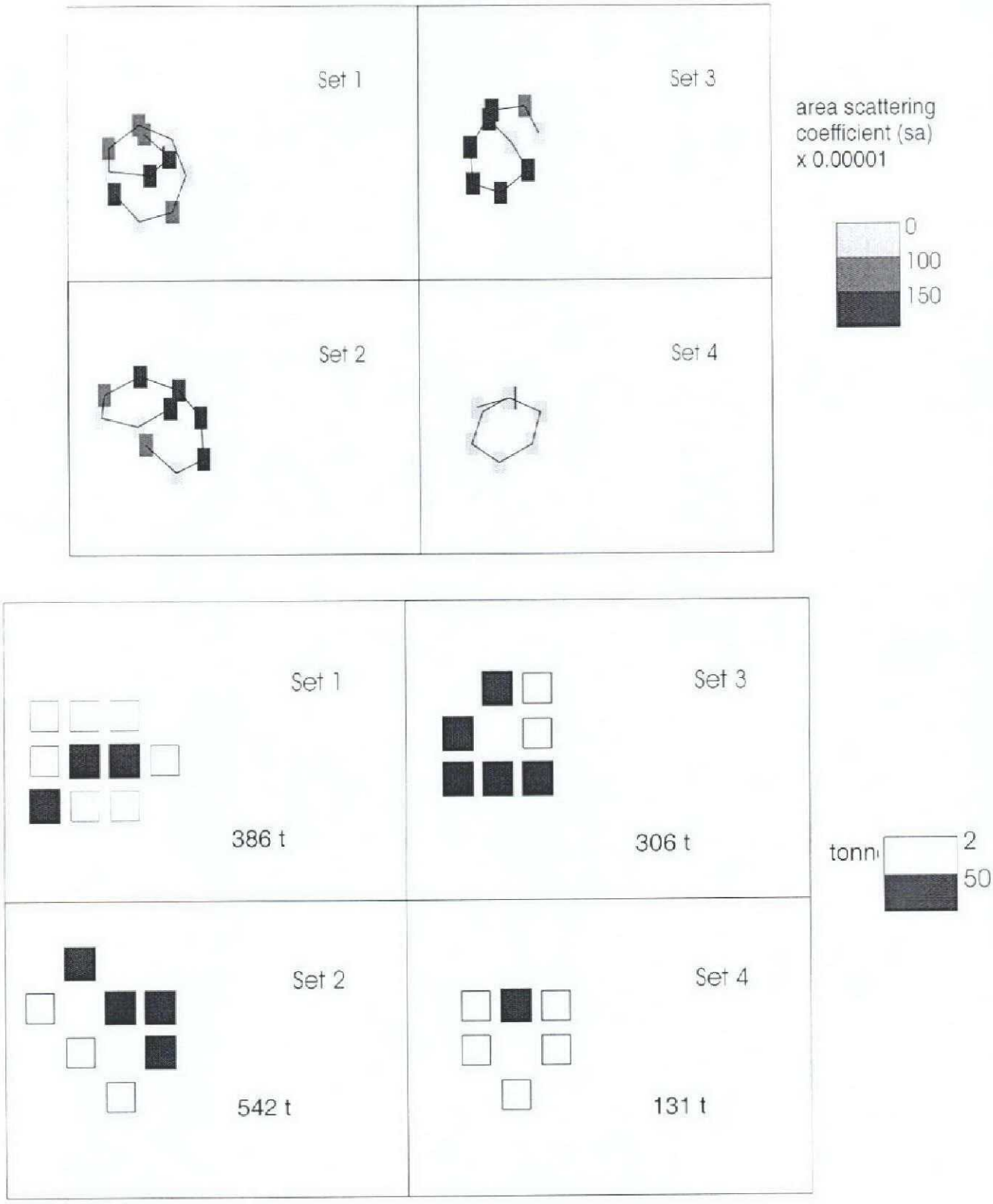


Fig. 28. Backscatter distribution and tonnes in 100 square metre boxes for four sets made by seiner on Oct. 1 -2, 1995 as shown in Fig. 25.

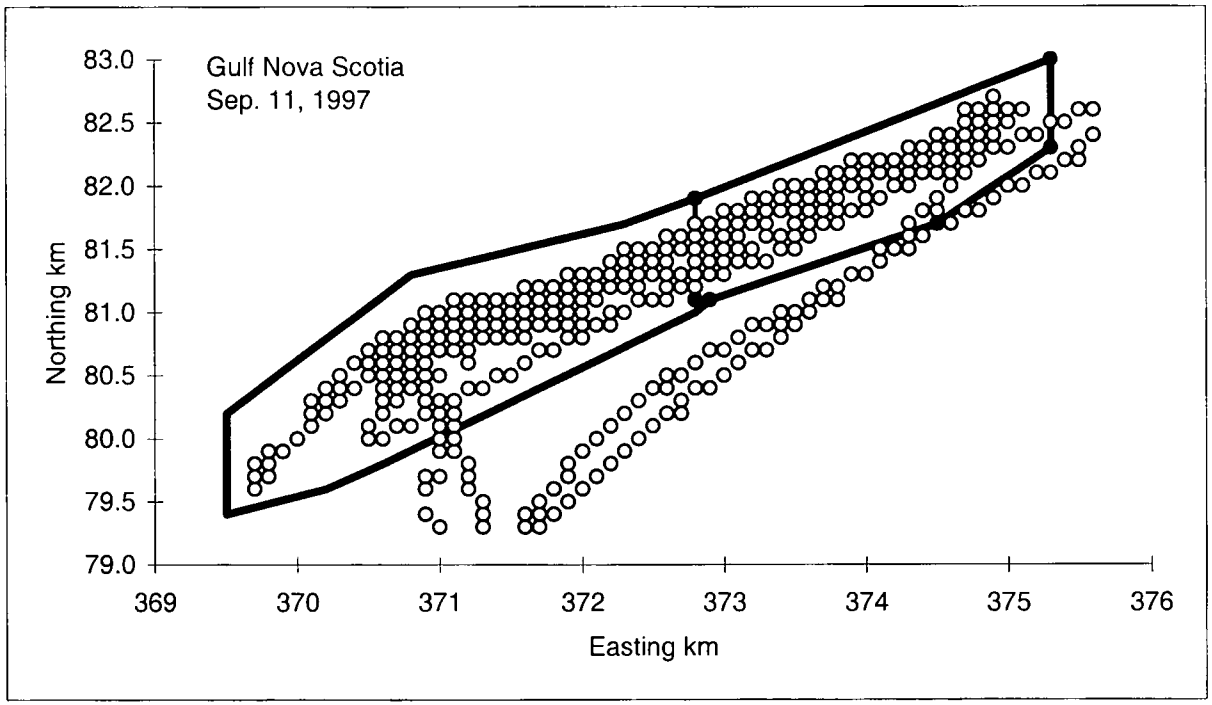


Fig. 29. Polygons for block kriging data from Gulf Nova Scotia Sept. 11-12, 1997.

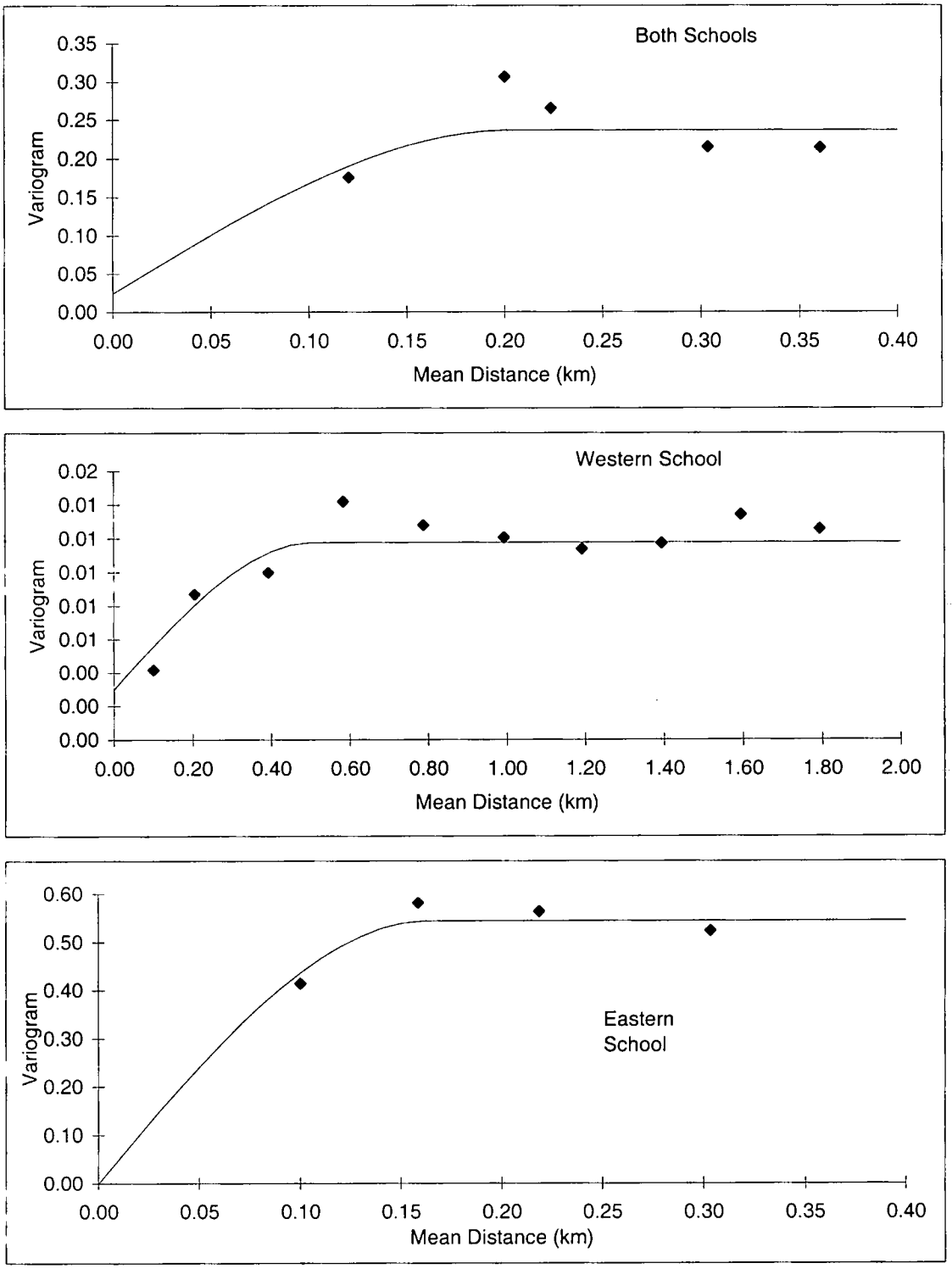


Fig. 30. Variograms for schools observed at Gulf Nova Scotia, Sept. 11-12, 1997.

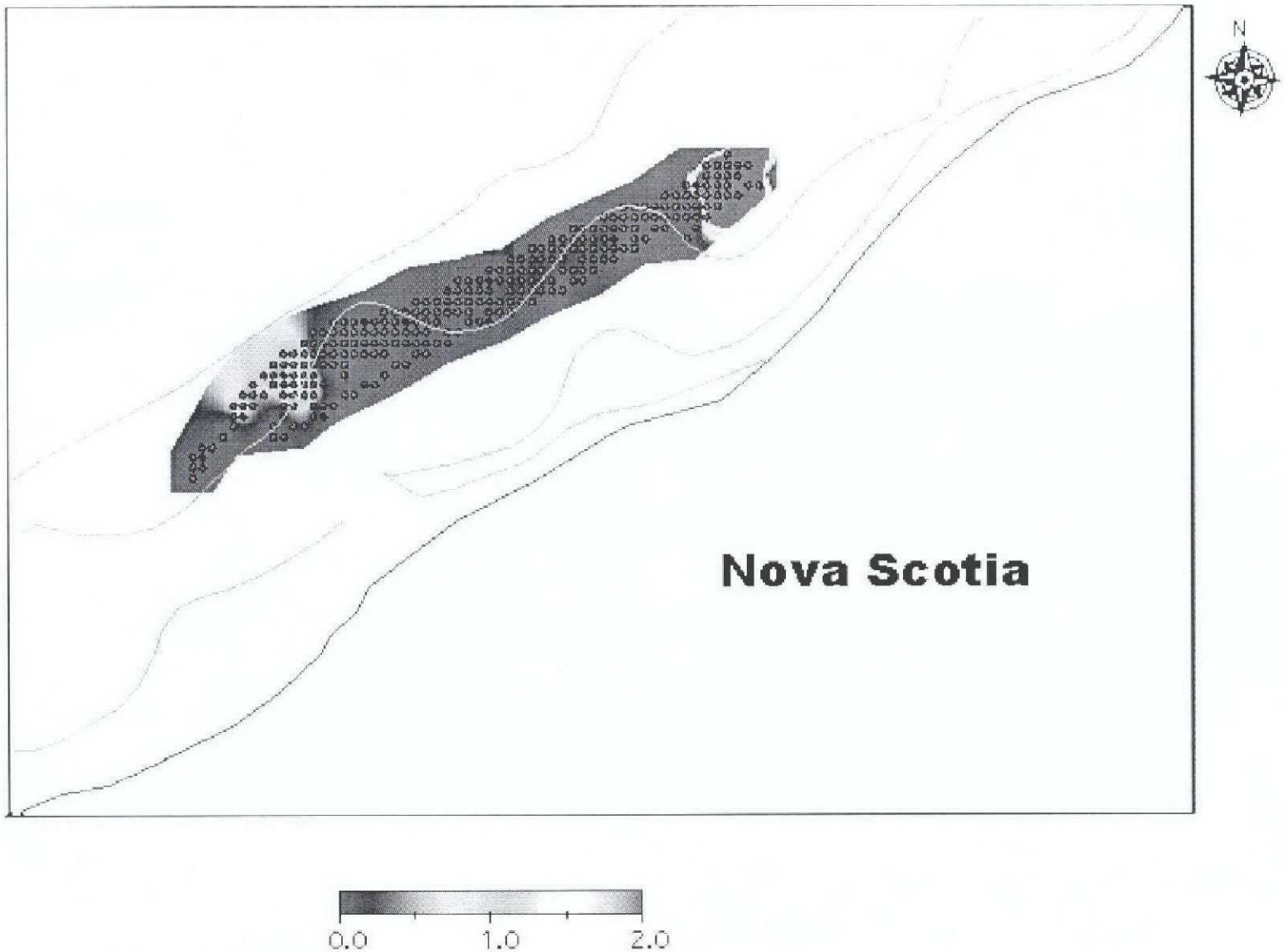


Fig. 31. Relative contoured densities (kg/m^2) from point kriging for gillnetter data from Gulf Nova Scotia, Sep. 11-12, 1997. Raw data are shown in Fig. 19.

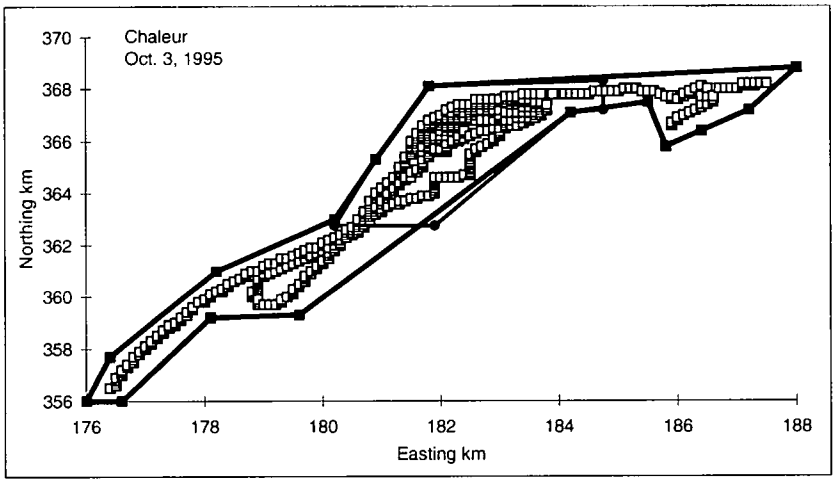
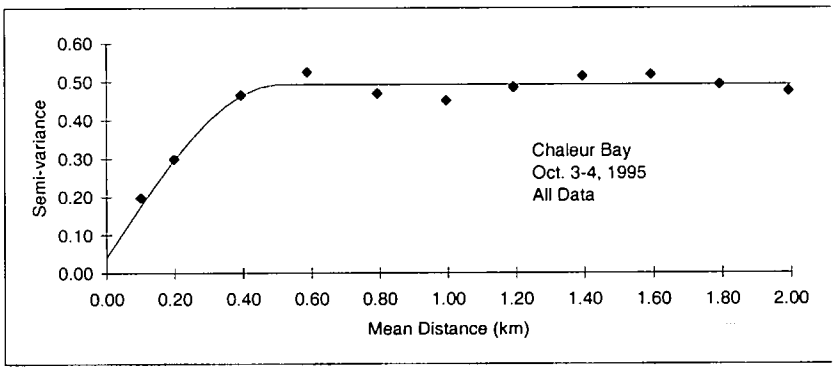


Fig. 32. Polygons for block kriging for seiner data collected Oct. 3-4, 1995 (Fig. 24).



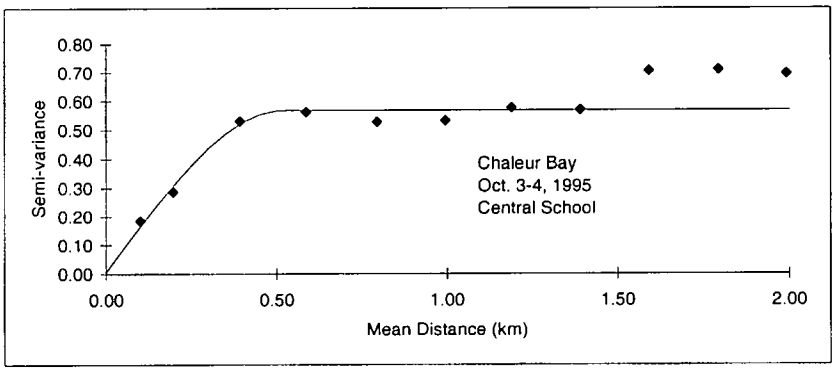


Fig. 33. Variograms for Chaleur Bay analysis, Oct. 3-4, 1995. Data are shown in Figs. 24 and 32.

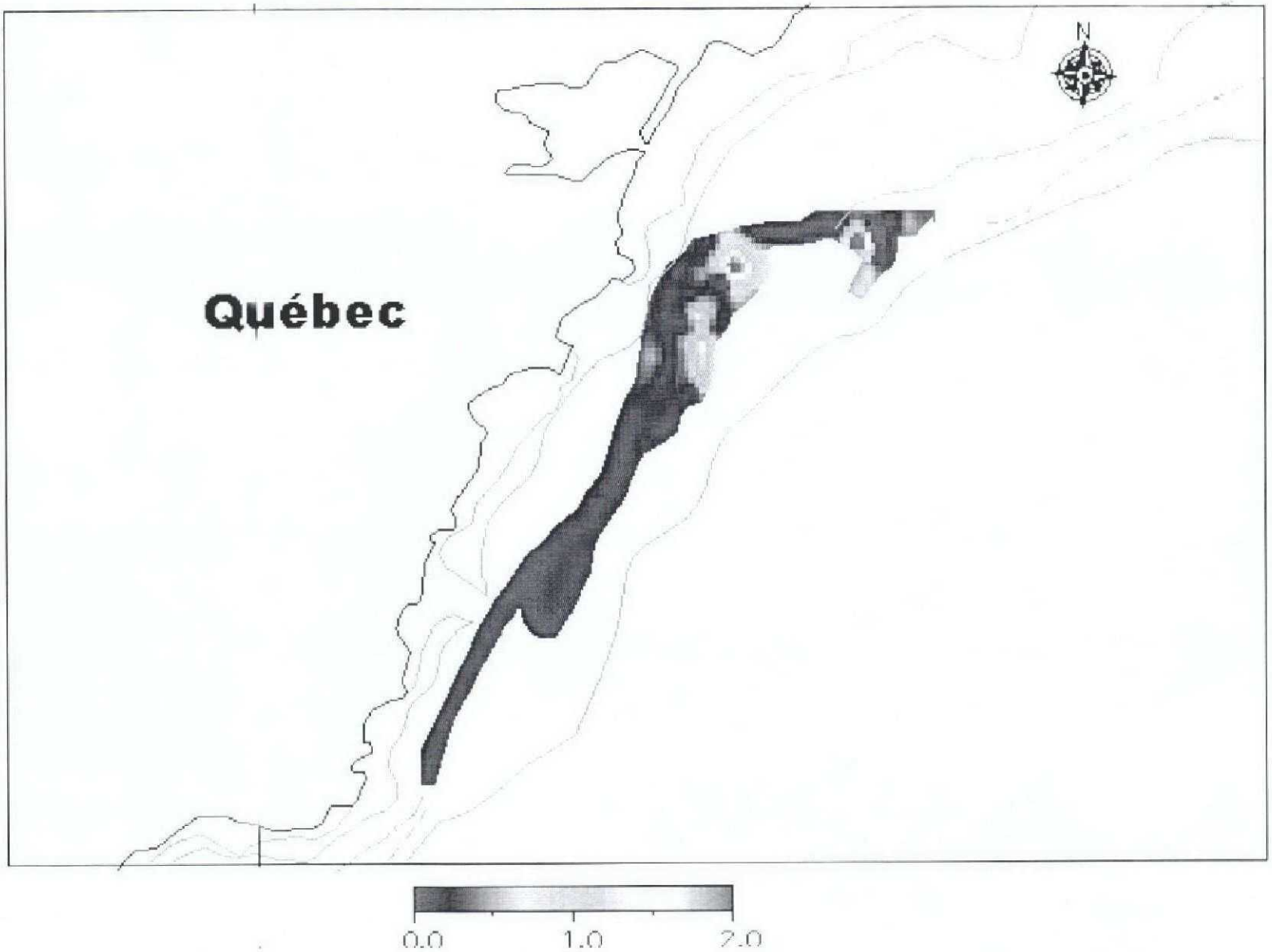


Fig. 34. Relative contoured densities (kg/m^2) from point driging for Chaleur Bay Oct. 3-4, 1995. Raw data are shown in Fig. 24.

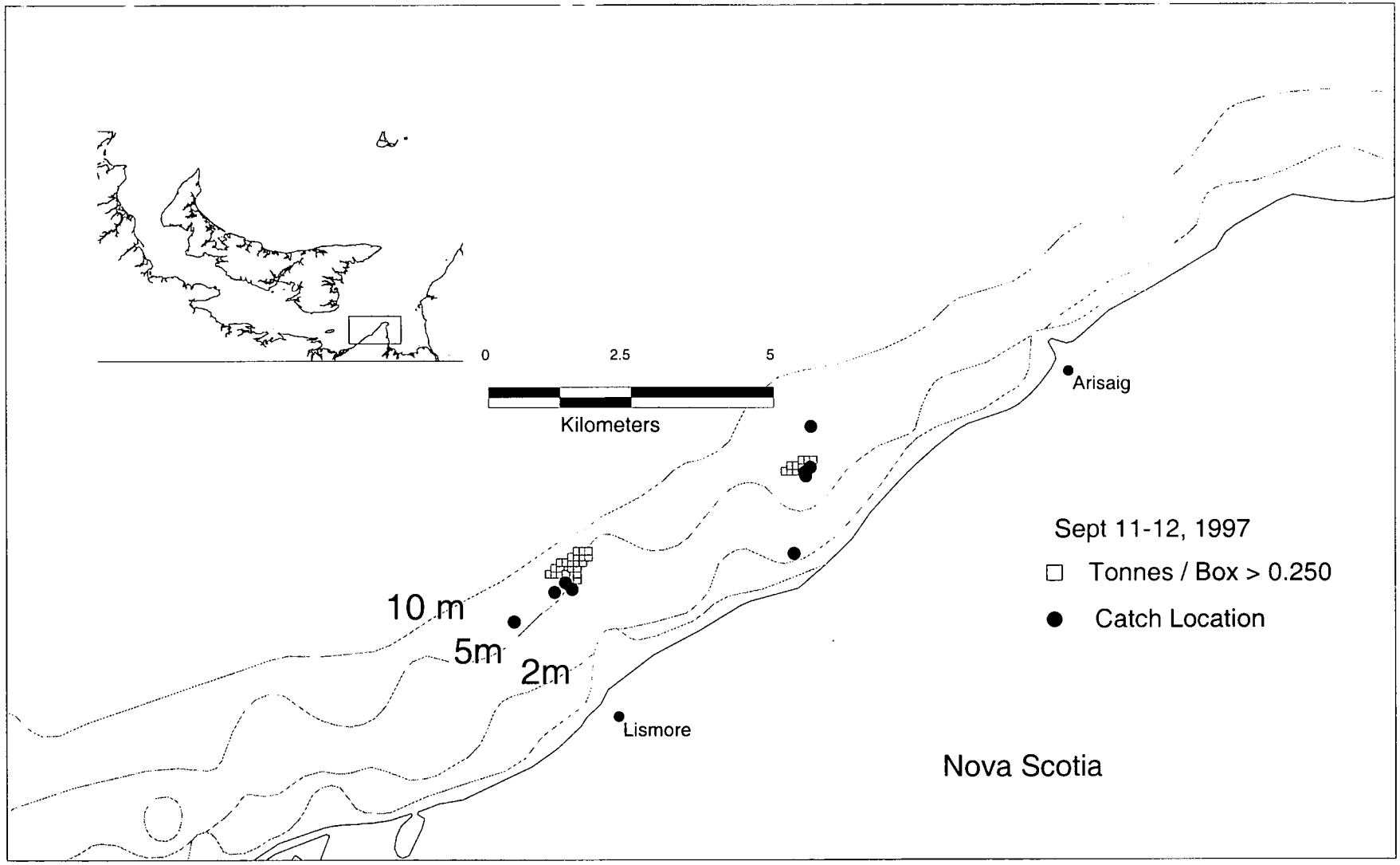


Fig. 35. Catch locations as reported by dockside monitoring and index logbooks compared to locations where acoustic estimates were 0.250 tonnes or greater per 100 square metre box for Sept. 11-12, 1997 in Gulf Nova Scotia herring fishery.

See Fig. 19 for complete fishing track.

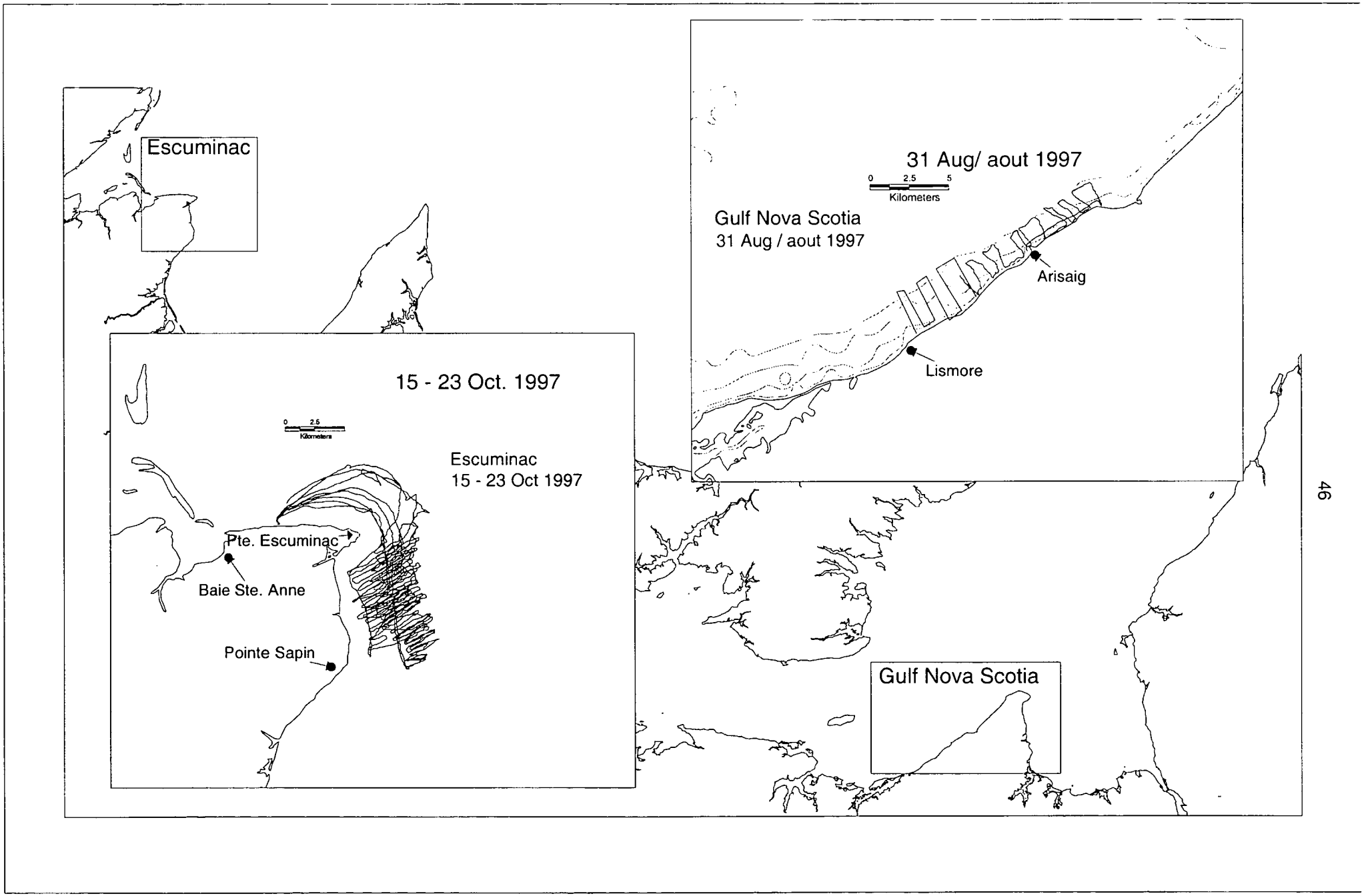


Fig. 36. Survey tracks in Escuminac, NB and Gulf Nova Scotia herring fishing areas for indicatd dataes.

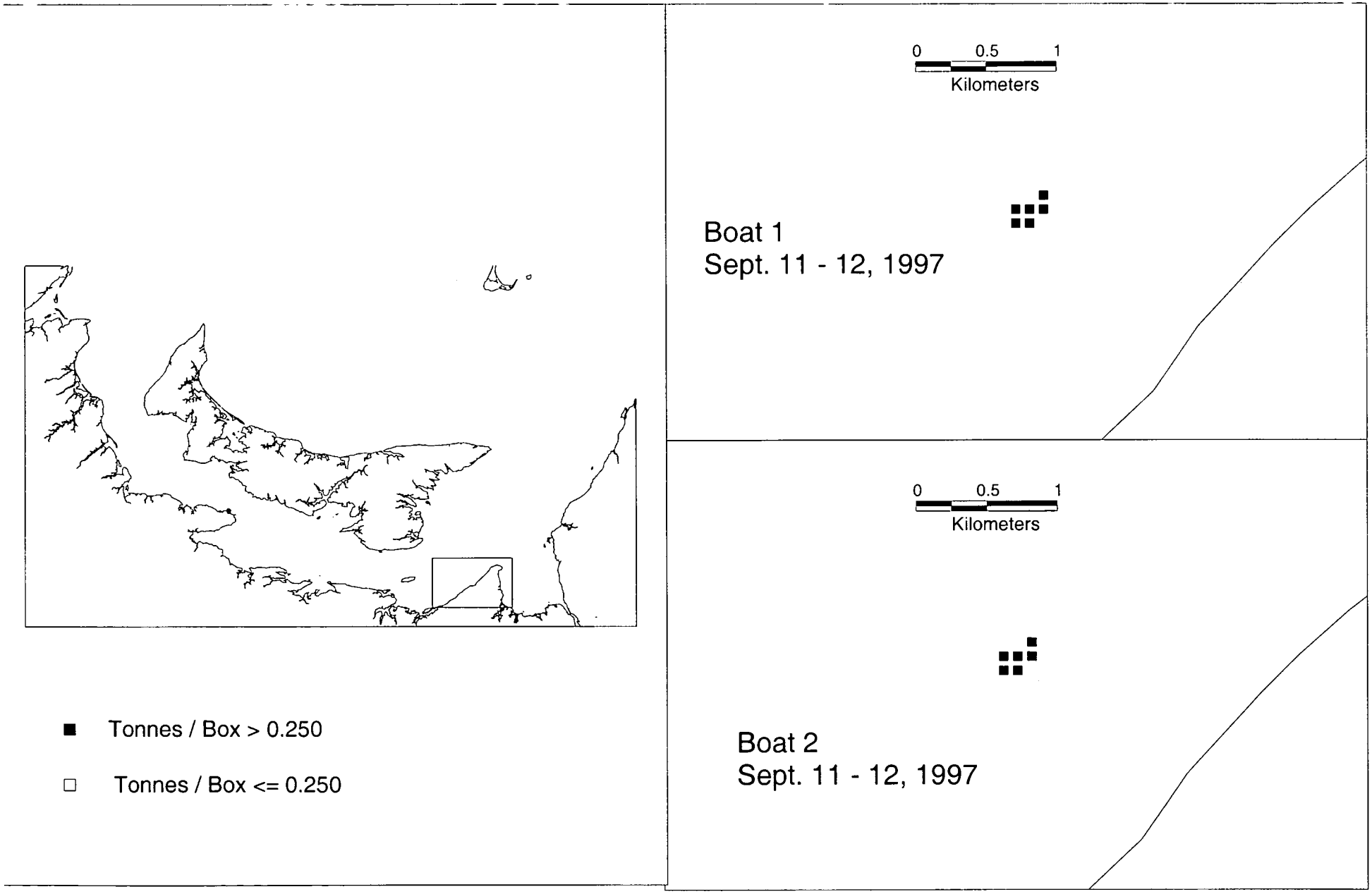


Fig. 37. Comparison of tonnes per box for two gillnetters collecting data in Gulf Nova Scotia area at similar times, Sept. 11 -12 ,1997.

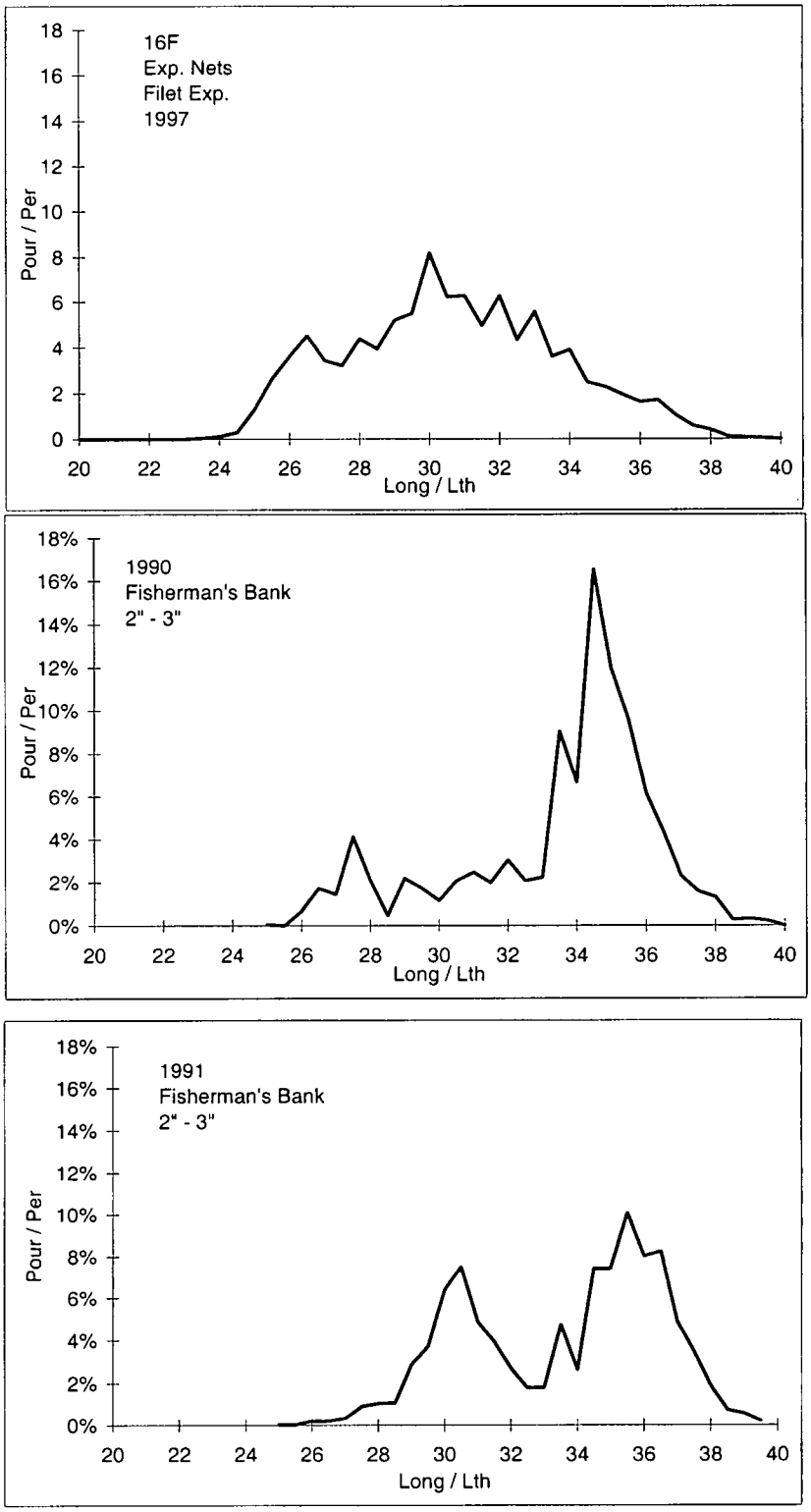


Fig. 38. Comparison of percentages at length for experimental nets fished in Pictou, 1997 and Fisherman's Bank 1990 and 1991.

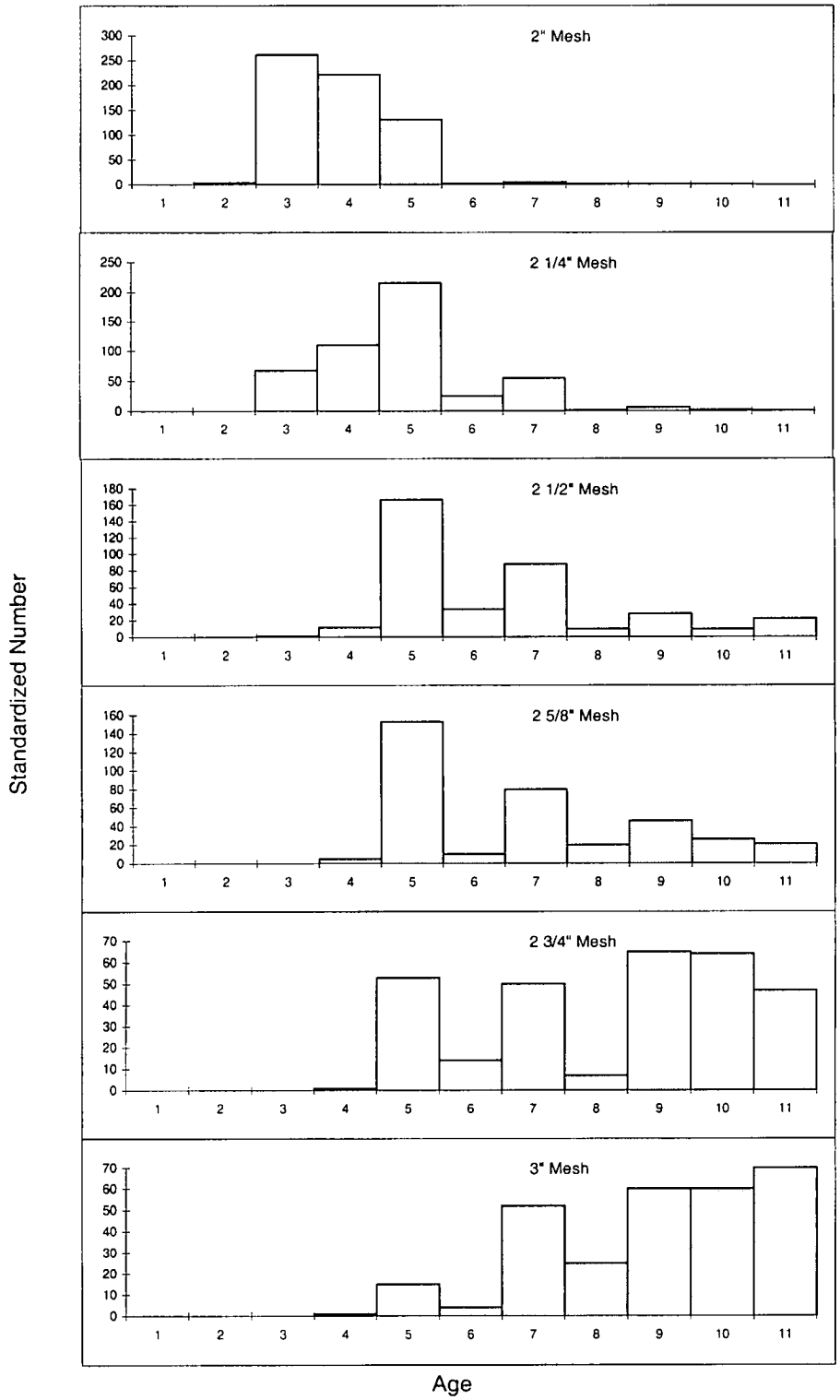


Fig. 39. Standardized number at age in experimental nets at indicated mesh size from Pictou experiment, 1997.

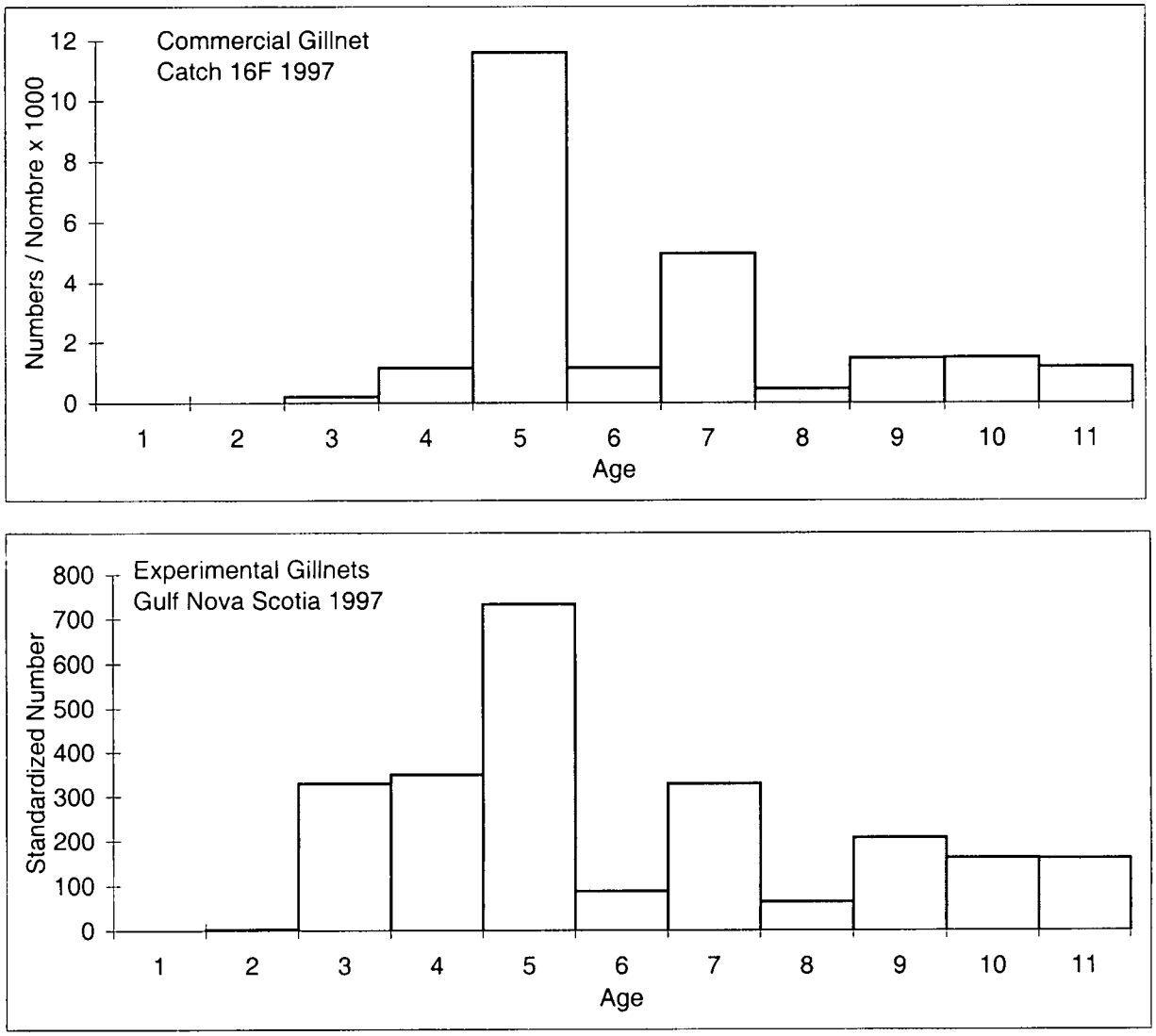


Fig. 40. Comparison of ages in commercial gillnet catch in Gulf Nova Scotia, 1997 to total numbers at age for all experimental nets combined.

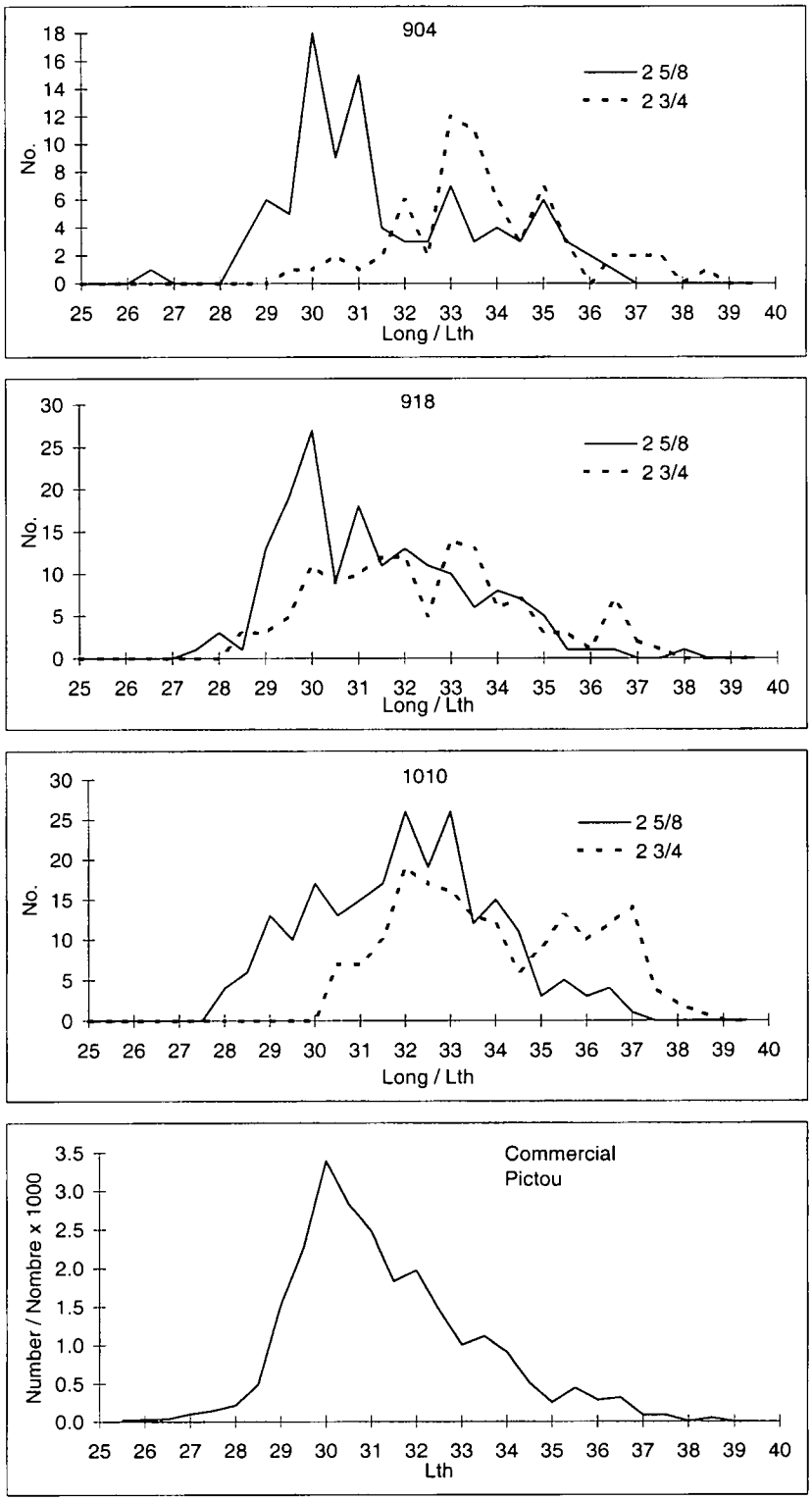


Fig. 41. Comparison of lengths caught by 2 5/8" and 2 3/4" mesh before, during, and after the gillnet fishery in the Gulf Nova Scotia experimental gillnets and the commercial fishery, 1997.

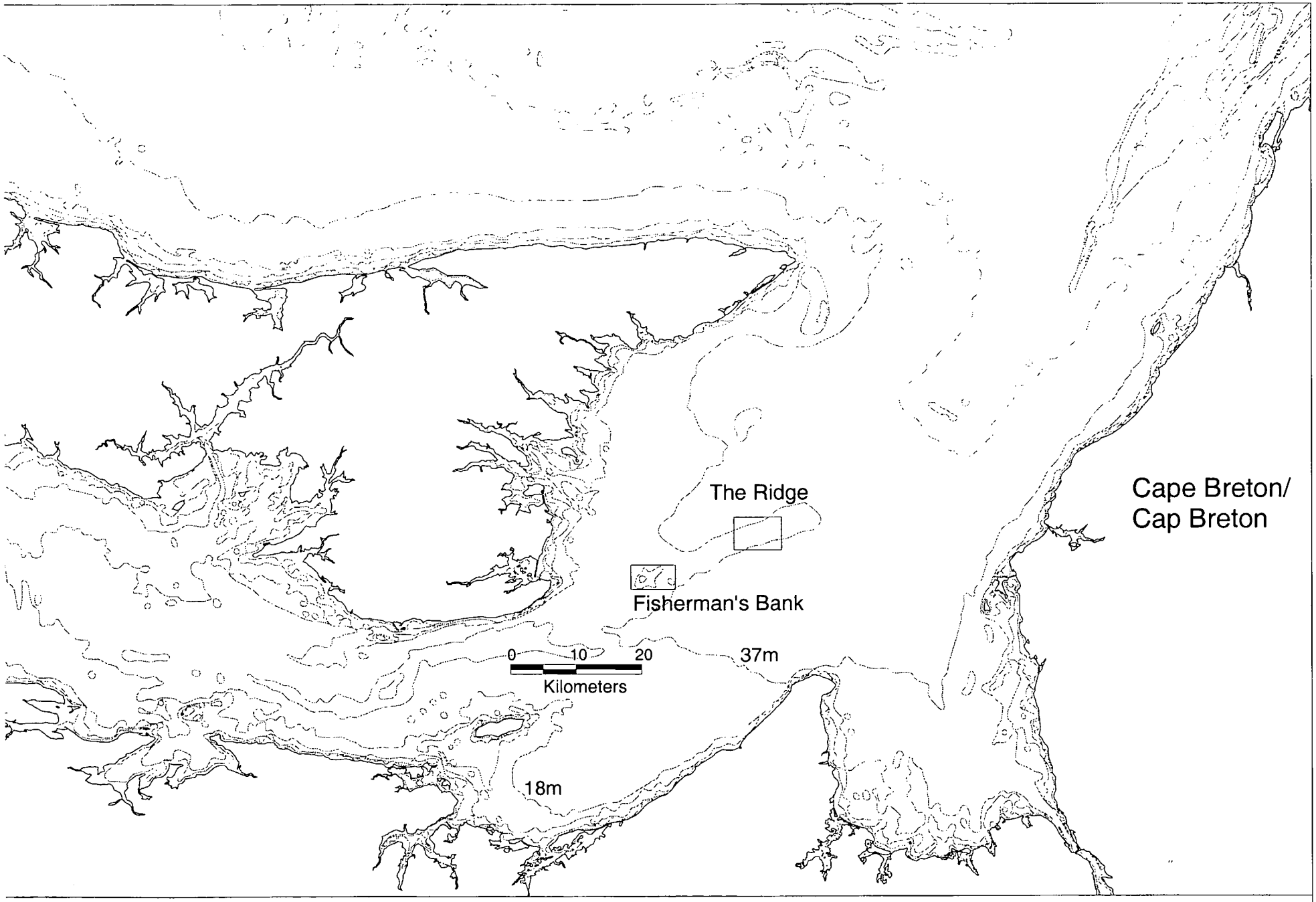


Fig. 42. Locaton of survey areas for Fisherman's Bank and The Ridge spawning bed surveys.

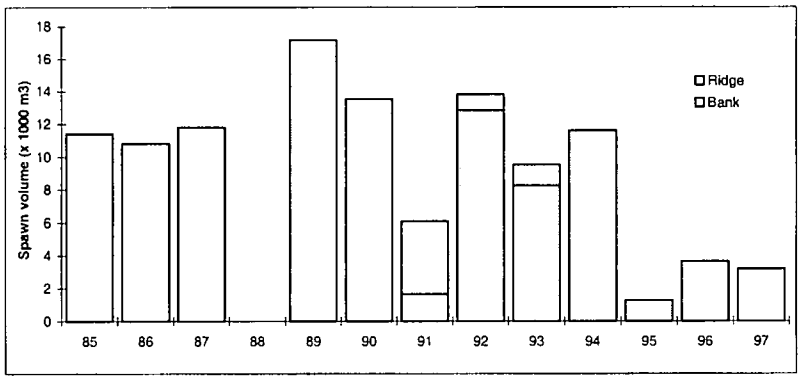


Fig. 43. Egg deposition estimated from spawning bed survey, 1985-1997.

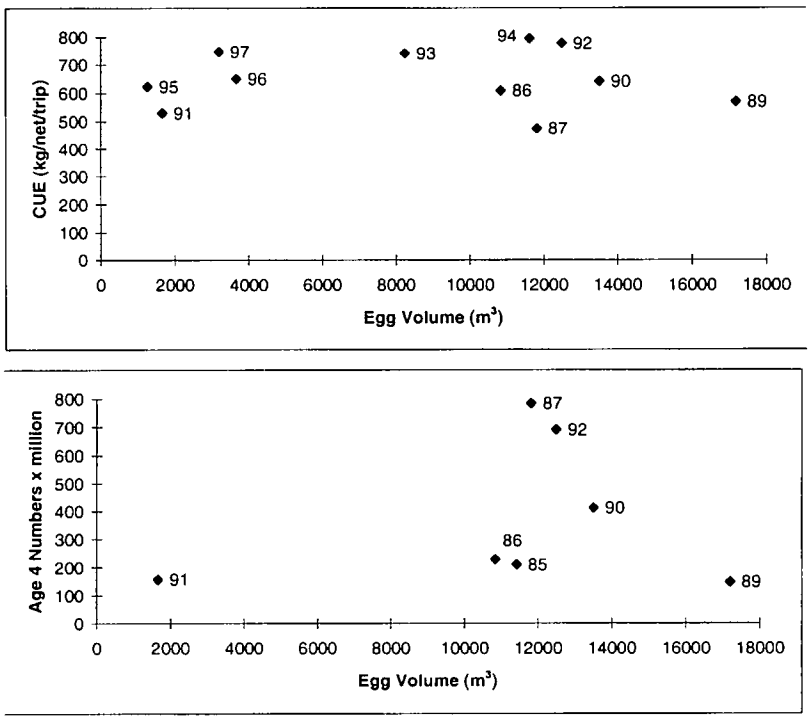


Fig. 44. Scatter plot of catch rates (kg/net/trip) (top) and age 4 numbers from the assessment (bottom) against egg deposition estimated at Fisherman's Bank.

Table 1. Catch-at-age for 4T herring fall spawners from 4Tmnopq, 1978-1997. Numbers are in thousands of fish.

Fixed Gear

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	51	316	0	0	0	0	0	15	0	0	12	0	0	0	0	0	0	0
3	174	206	6356	4154	1773	7514	465	477	612	6652	144	266	2734	129	69	78	0	53	0	198
4	3421	3386	2151	12990	6040	11226	7388	3916	10839	25007	13441	11894	14849	28509	6044	2000	6671	2955	12726	9052
5	2392	1368	2004	2735	11775	3995	6306	8758	10233	14716	22754	19054	12627	7159	37239	21146	10589	21690	15703	30568
6	495	1605	3186	608	1643	8854	3264	7914	21638	13854	7813	20563	19767	5343	11045	24660	31682	10721	20865	9442
7	414	281	852	285	283	920	3030	5641	15446	19049	7549	9916	20067	7945	6149	3741	47512	25709	4518	8384
8	2627	635	159	146	186	382	615	2712	6322	8677	6330	5192	7888	7622	7191	1968	9532	25449	9213	1609
9	57	541	185	73	71	103	78	693	3936	4922	3328	6244	5163	2398	5853	1730	7100	4317	9579	2829
10	77	194	100	49	28	67	73	273	207	2471	1755	2673	5779	1123	3145	522	3194	2473	1366	2506
11+	1205	230	0	37	53	73	56	108	496	639	1176	2232	3603	2177	5106	784	5264	2915	1630	681
	10862	8446	15044	21393	21852	33134	21275	30492	69729	96002	64290	78034	92489	62405	81841	56629	121544	96283	75601	65269

Mobile Gear

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0	239	0	0	0	0	0	0	0	0	64	0	0	0	0	0	0	0	0	0
2	96	2533	0	3	199	6	32	253	134	47	3790	726	43	0	61	16	0	0	71	57
3	3914	9020	0	157	5005	148	315	2037	860	906	2614	840	3426	4343	545	1899	30	2449	1323	1045
4	16052	6394	0	155	2486	206	2333	4303	2155	1604	2885	3184	3211	17311	4424	2292	6396	3918	4989	3483
5	20196	4508	0	21	2455	91	2762	5103	6324	2600	2716	5829	5909	3595	12412	3873	2368	22149	1898	4031
6	3517	7102	0	3	321	46	1531	4897	6699	8242	3229	5054	2989	1189	2685	6129	4658	7189	7062	1733
7	3936	1651	0	11	110	8	536	1950	6331	7500	8709	4023	2287	1091	1336	1870	6359	5599	1967	5333
8	9137	1373	0	3	95	2	92	1760	2858	6219	7392	6706	1762	698	727	1152	1163	6579	1483	641
9	1294	1931	0	9	102	1	31	601	1106	2146	4098	4308	3577	479	306	293	584	957	1091	1035
10	225	329	0	4	38	1	13	449	435	287	1217	2284	1848	456	676	1800	433	389	352	664
11+	10609	3296	0	2	121	1	1	372	210	60	2330	1366	297	536	1084	2678	928	537	160	377
	68976	38376	0	368	10932	510	7646	21725	27112	29611	39044	34320	25349	29698	24256	22002	22919	49767	20396	18399

All Gears

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0	239	0	0	0	0	0	0	0	0	64	0	0	0	0	0	0	0	0	0
2	96	2533	51	319	199	6	32	253	134	62	3790	726	55	0	61	16	0	0	71	57
3	4088	9226	6356	4311	6778	7662	780	2514	1472	7558	2758	1106	6160	4472	614	1977	30	2502	1323	1243
4	19473	9780	2151	13145	8526	11432	9721	8219	12994	26611	16326	15078	18060	45820	10468	4292	13067	6873	17715	12535
5	22588	5876	2004	2756	14230	4086	9068	13861	16557	17316	25470	24883	18536	10754	49651	25019	12957	43840	17601	34599
6	4012	8707	3186	611	1964	8900	4795	12811	28337	22096	11042	25617	22756	6532	13730	30789	36340	17910	27926	11175
7	4350	1932	852	296	393	928	3566	7591	21777	26549	16258	13939	22354	9036	7485	5611	53871	31309	6486	13717
8	11764	2008	159	149	281	384	707	4472	9180	14896	13722	11898	9650	8320	7918	3120	10695	32028	10696	2250
9	1351	2472	185	82	173	104	109	1294	5042	7068	7426	10552	8740	2877	6159	2023	7684	5274	10670	3863
10	302	523	100	53	66	68	86	722	642	2758	2972	4957	7627	1579	3821	2322	3627	2862	1719	3171
11+	11814	3526	0	39	174	74	57	480	706	699	3506	3598	3900	2713	6190	3462	6192	3452	1790	1058
	79838	46822	15044	21761	32784	33644	28921	52217	96841	125613	103334	112354	117838	92103	106097	78631	144463	146050	95997	83669

Table 2. Catch-at-age for 4T herring fall spawners from 4TI, 1978-1997. Numbers are in thousands of fish.

Fixed Gear

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	29	70	288	1650	30	235	100	68	39	204	723	17	201	17	0	0	0	0	0	288
4	628	2212	1342	4362	1689	3406	1602	467	733	1184	2701	759	1899	5946	5026	325	931	158	3650	4841
5	520	1553	2103	1752	1475	1173	1755	1231	676	1669	2923	1348	1377	1386	9319	6654	1369	8512	2099	10992
6	156	604	635	839	211	1373	789	1098	1455	335	2832	1326	1766	751	0	8626	7000	1993	12052	1577
7	253	306	350	286	120	344	638	781	1050	2511	1092	646	2787	1637	595	1459	8657	10465	1042	3148
8	1165	151	148	183	120	0	126	385	430	148	1159	332	630	1743	260	556	920	6617	3013	731
9	10	186	71	52	0	0	16	99	268	399	582	386	372	1208	122	362	269	1138	3284	923
10	81	35	54	118	0	0	15	39	14	204	29	172	363	517	215	504	437	494	860	879
11+	694	266	81	52	0	0	15	15	34	55	0	142	58	1210	237	681	707	2795	826	551
	3536	5383	5072	9294	3645	6531	5056	4183	4699	6709	12041	5128	9453	14415	15774	19167	20290	32172	26825	23931

Mobile Gear

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	1	118	2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1665	231	284	24	17	3114	16	0	0	1	0	0	0	0	0	0	0	0	5	0
4	6494	1267	702	24	8	4368	122	0	0	2	0	0	0	0	0	0	0	0	249	0
5	1963	1917	744	3	8	1937	146	0	0	3	0	0	0	0	0	0	0	0	58	0
6	256	3262	661	1	1	974	81	0	0	8	0	0	0	0	0	0	0	0	132	0
7	0	863	115	2	0	170	28	0	0	7	0	0	0	0	0	0	0	0	68	0
8	727	851	70	0	0	42	5	0	0	6	0	0	0	0	0	0	0	0	60	0
9	0	2396	144	1	0	23	2	0	0	2	0	0	0	0	0	0	0	0	26	0
10	315	580	59	1	0	28	1	0	0	0	0	0	0	0	0	0	0	0	8	0
11+	92	5667	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	5	0
	11512	17034	2779	56	35	10792	403	0	0	29	0	0	0	0	0	0	0	0	610	0

All Gears

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	1	118	2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1694	301	572	1674	47	3349	116	68	39	205	723	17	201	17	0	0	0	0	5	288
4	7122	3479	2044	4386	1697	7774	1724	467	733	1186	2701	759	1899	5946	5026	325	931	158	3898	4841
5	2483	3470	2847	1755	1483	3110	1901	1231	676	1672	2923	1348	1377	1386	9319	6654	1369	8512	2157	10992
6	412	3866	1296	840	212	2347	870	1098	1455	343	2832	1326	1766	751	0	8626	7000	1993	12184	1577
7	253	1169	465	288	120	514	666	781	1050	2518	1092	646	2787	1637	595	1459	8657	10465	1110	3148
8	1892	1002	218	183	120	42	131	385	430	154	1159	332	630	1743	260	556	920	6617	3073	731
9	10	2582	215	53	0	23	18	99	268	401	582	386	372	1208	122	362	269	1138	3310	923
10	396	615	113	119	0	28	16	39	14	204	29	172	363	517	215	504	437	494	868	879
11+	786	5933	81	52	0	18	15	15	34	55	0	142	58	1210	237	681	707	2795	831	551
	15048	22417	7851	9350	3680	17323	5459	4183	4699	6738	12041	5128	9453	14415	15774	19167	20290	32172	27436	23931

Table 3. Catch-at-age for 4T herring fall spawners from 4Tjkfgh, 1978-1997. Numbers are in thousands of fish.

Fixed Gear

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0	904	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	82	8	38	6	0	0	0	0	253	0	0	0	0	0	0	0	0	0	0	0
3	3389	198	4534	595	352	394	399	572	976	1154	299	11	771	11	0	0	0	0	9	460
4	1500	4388	2296	6479	7256	7897	15893	4433	21298	12014	4291	1460	5824	5004	1297	115	1555	370	3470	3782
5	573	2211	2363	1732	3633	4705	5384	14452	5587	13864	16267	1654	5812	1690	7469	1904	307	7953	1943	22600
6	165	715	218	832	3068	2998	4253	5848	11335	6523	9609	7784	6681	1214	1106	3196	9730	1786	12357	2031
7	78	278	821	395	2120	904	2310	3075	2755	14777	4599	3495	31371	1202	596	835	13621	11141	4550	8602
8	118	279	136	267	744	1250	594	1398	1461	6693	6778	1609	8484	3932	1492	644	1772	10039	11535	1452
9	51	153	96	133	299	384	362	420	462	4061	3043	2391	3629	1233	3372	1570	2288	2531	11584	3144
10	0	48	151	72	89	57	112	415	120	1887	954	479	3816	769	1195	923	6009	2676	3064	2988
11+	3	49	14	13	9	86	20	36	163	1184	447	219	1743	1152	1362	1319	8144	8345	8670	2493
	5959	9231	10667	10524	17570	18675	29327	30649	44410	62157	46287	19102	68131	16207	17889	10506	43426	44840	57181	47552

Mobile Gear

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0	1	140	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
2	1326	195	2342	75	0	3	0	0	23	0	52	0	0	0	0	6	0	0	3	0
3	15859	4032	36489	4337	0	81	1	0	114	6	36	0	0	0	0	8	0	391	7	0
4	4897	13005	14346	4281	0	114	1	0	83	10	40	0	0	0	162	62	804	55	681	1
5	936	10331	11347	598	0	50	6	0	11	16	37	0	0	0	133	346	308	256	613	0
6	287	6322	6590	104	0	25	0	0	5	50	44	0	0	0	146	84	873	121	628	0
7	383	1896	7340	304	0	4	0	0	1	46	119	0	0	0	99	110	1491	434	720	0
8	663	1478	5462	88	0	1	0	0	3	38	101	0	0	0	36	113	338	784	390	0
9	155	950	3184	257	0	1	0	0	1	13	56	0	0	0	39	115	154	0	87	39
10	197	340	1562	111	0	1	0	0	0	2	17	0	0	0	49	207	127	117	145	2
11+	1080	1501	896	62	0	0	0	0	0	0	32	0	0	0	16	474	334	66	90	0
	25783	40051	89698	10217	0	280	8	0	241	181	535	0	0	0	680	1525	4429	2224	3364	43

All Gears

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0	905	140	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
2	1408	203	2380	81	0	3	0	0	276	0	52	0	0	0	0	6	0	0	3	0
3	19248	4230	41023	4932	352	475	400	572	1090	1160	335	11	771	11	0	8	0	391	16	687
4	6397	17393	16642	10760	7256	8011	15894	4433	21381	12024	4331	1460	5824	5004	1459	177	2359	425	4151	4100
5	1509	12542	13710	2330	3633	4755	5390	14452	5598	13880	16304	1654	5812	1690	7602	2250	615	8209	2555	23491
6	452	7037	6808	936	3068	3023	4253	5848	11340	6573	9653	7784	6681	1214	1252	3280	10603	1907	12985	2072
7	461	2174	8161	699	2120	908	2310	3075	2756	14823	4718	3495	31371	1202	695	945	15112	11575	5271	8717
8	781	1757	5598	355	744	1251	594	1398	1464	6731	6879	1609	8484	3932	1528	757	2110	10823	11925	1461
9	206	1103	3280	390	299	385	362	420	463	4074	3099	2391	3629	1233	3411	1685	2442	2531	11670	3245
10	197	388	1713	183	89	58	112	415	120	1889	971	479	3816	769	1244	1130	6136	2792	3208	3028
11+	1083	1550	910	75	9	86	20	36	163	1184	479	219	1743	1152	1378	1793	8478	8411	8759	2524
	31742	49282	100365	20741	17570	18955	29335	30649	44651	62338	46822	19102	68131	16207	18569	12031	47855	47064	60544	49326

Table 4. Weights-at-age (kg) for 4T herring fall spawners from 4Tmnopq, 1978-1997.

Fixed Gear

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.1766	0.1305	0.0000	0.0000	0.0000	0.0000	0.0000	0.1328	0.0000	0.0000	0.1492	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.2026	0.2065	0.1838	0.2047	0.2239	0.1355	0.2425	0.2799	0.2214	0.2354	0.2113	0.2257	0.2165	0.1991	0.2267	0.1596	0.0000	0.1247	0.0000	0.1785
4	0.2598	0.2640	0.2374	0.2565	0.2692	0.2486	0.2581	0.2551	0.2631	0.2512	0.2611	0.2609	0.2540	0.2330	0.2285	0.2122	0.2080	0.2004	0.2209	0.2068
5	0.2954	0.3081	0.2908	0.3091	0.3000	0.2870	0.2983	0.3051	0.2939	0.2869	0.2870	0.2973	0.2891	0.2667	0.2576	0.2332	0.2328	0.2254	0.2441	0.2364
6	0.3349	0.3277	0.2618	0.3622	0.3408	0.3222	0.3407	0.3479	0.3304	0.3217	0.3178	0.3277	0.3245	0.3021	0.2826	0.2610	0.2554	0.2468	0.2577	0.2593
7	0.3446	0.3738	0.3279	0.4279	0.3748	0.3567	0.3553	0.3664	0.3700	0.3553	0.3486	0.3539	0.3492	0.3325	0.3095	0.2884	0.2844	0.2821	0.2828	0.2745
8	0.3773	0.3969	0.3230	0.4634	0.4133	0.3939	0.3961	0.3795	0.3903	0.3804	0.3762	0.3716	0.3657	0.3527	0.3435	0.3348	0.3111	0.3018	0.3038	0.3077
9	0.4221	0.4114	0.3694	0.4586	0.4194	0.3993	0.4537	0.4210	0.4031	0.3929	0.4069	0.3848	0.3828	0.3713	0.3535	0.3552	0.3470	0.3324	0.3280	0.3387
10	0.3920	0.4280	0.4360	0.5027	0.4208	0.4965	0.3612	0.4377	0.4511	0.4085	0.4123	0.4062	0.4010	0.3832	0.3619	0.3265	0.3520	0.3709	0.3774	0.3492
11+	0.4447	0.4363	0.0000	0.5208	0.4782	0.4527	0.4895	0.5081	0.4562	0.4387	0.4333	0.4042	0.4331	0.4078	0.4035	0.3687	0.3983	0.3882	0.4165	0.4016
	0.3241	0.3134	0.2358	0.2597	0.2913	0.2533	0.3019	0.3319	0.3332	0.3106	0.3135	0.3254	0.3263	0.2841	0.2902	0.2581	0.2806	0.2758	0.2703	0.2526

Mobile Gear

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0.0000	0.0692	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0753	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.1957	0.1257	0.0000	0.1154	0.0960	0.1079	0.1109	0.1023	0.1053	0.1422	0.0959	0.1049	0.1081	0.0000	0.0661	0.0849	0.0000	0.0000	0.1390	0.0693
3	0.1954	0.1853	0.0000	0.1789	0.1709	0.1734	0.1621	0.1886	0.1609	0.2033	0.1651	0.1585	0.1773	0.1541	0.1277	0.1432	0.1180	0.1275	0.1818	0.1469
4	0.2322	0.2455	0.0000	0.2256	0.2109	0.2079	0.2116	0.2142	0.2161	0.2427	0.2250	0.2159	0.2088	0.1893	0.1733	0.1639	0.1644	0.1673	0.2084	0.1717
5	0.2567	0.2854	0.0000	0.2498	0.2607	0.2345	0.2369	0.2556	0.2515	0.2683	0.2603	0.2490	0.2410	0.2178	0.2119	0.1961	0.1809	0.1755	0.2197	0.2025
6	0.2780	0.2799	0.0000	0.2863	0.2817	0.2854	0.2594	0.2829	0.2767	0.2890	0.3050	0.2832	0.2834	0.2520	0.2245	0.2214	0.2180	0.1968	0.2451	0.2249
7	0.2936	0.2691	0.0000	0.3408	0.3748	0.3185	0.3032	0.3170	0.2943	0.3148	0.3328	0.2946	0.3000	0.2784	0.2584	0.2318	0.2284	0.2181	0.2645	0.2425
8	0.3413	0.2974	0.0000	0.2547	0.3549	0.3675	0.3313	0.3370	0.3224	0.3352	0.3240	0.3082	0.3278	0.3093	0.2841	0.2116	0.2432	0.2315	0.2887	0.2519
9	0.3400	0.3621	0.0000	0.2603	0.3079	0.3648	0.3701	0.3754	0.3451	0.3435	0.3800	0.3297	0.3273	0.2955	0.3089	0.3457	0.2851	0.2699	0.3028	0.2852
10	0.3268	0.3477	0.0000	0.2620	0.4223	0.2639	0.3278	0.4055	0.3288	0.4071	0.4042	0.3609	0.3388	0.3166	0.3030	0.2539	0.2565	0.3078	0.2903	0.3111
11+	0.3942	0.4044	0.0000	0.2566	0.4439	0.4579	0.4236	0.4365	0.4098	0.4446	0.4108	0.3838	0.4150	0.3539	0.3443	0.2972	0.3173	0.3257	0.2349	0.2834
	0.2848	0.2567	0.0000	0.2117	0.2109	0.2117	0.2366	0.2671	0.2751	0.3035	0.2930	0.2856	0.2658	0.2028	0.2184	0.2180	0.2097	0.1922	0.2163	0.2187

All Gears

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0.0000	0.0692	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0753	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.1957	0.1257	0.1766	0.1304	0.0960	0.1079	0.1109	0.1023	0.1053	0.1399	0.0959	0.1049	0.1171	0.0000	0.0661	0.0849	0.0000	0.0000	0.1390	0.0693
3	0.1957	0.1858	0.1838	0.2038	0.1848	0.1362	0.2100	0.2059	0.1861	0.2316	0.1675	0.1747	0.1947	0.1554	0.1388	0.1438	0.1180	0.1275	0.1818	0.1519
4	0.2370	0.2519	0.2374	0.2561	0.2522	0.2479	0.2469	0.2337	0.2553	0.2507	0.2547	0.2514	0.2460	0.2165	0.2052	0.1864	0.1867	0.1815	0.2174	0.1971
5	0.2608	0.2907	0.2908	0.3086	0.2932	0.2858	0.2796	0.2869	0.2777	0.2841	0.2842	0.2860	0.2738	0.2504	0.2462	0.2275	0.2233	0.2002	0.2415	0.2325
6	0.2850	0.2887	0.2618	0.3618	0.3311	0.3220	0.3147	0.3231	0.3177	0.3095	0.3141	0.3189	0.3191	0.2930	0.2712	0.2531	0.2506	0.2267	0.2545	0.2540
7	0.2985	0.2843	0.3279	0.4247	0.3748	0.3564	0.3475	0.3537	0.3480	0.3439	0.3401	0.3368	0.3442	0.3260	0.3004	0.2695	0.2778	0.2707	0.2773	0.2620
8	0.3493	0.3289	0.3230	0.4592	0.3936	0.3938	0.3877	0.3628	0.3692	0.3615	0.3481	0.3359	0.3588	0.3491	0.3380	0.2893	0.3037	0.2874	0.3017	0.2918
9	0.3435	0.3729	0.3694	0.4368	0.3537	0.3990	0.4299	0.3998	0.3904	0.3779	0.3921	0.3623	0.3601	0.3587	0.3513	0.3538	0.3423	0.3211	0.3254	0.3244
10	0.3434	0.3775	0.4360	0.4845	0.4217	0.4931	0.3562	0.4177	0.3682	0.4084	0.4090	0.3853	0.3859	0.3640	0.3515	0.2702	0.3406	0.3623	0.3595	0.3412
11+	0.3994	0.4065	0.0000	0.5073	0.4543	0.4528	0.4883	0.4526	0.4424	0.4392	0.4183	0.3965	0.4317	0.3972	0.3931	0.3134	0.3862	0.3785	0.4003	0.3595
	0.2901	0.2669	0.2358	0.2589	0.2645	0.2527	0.2846	0.3049	0.3169	0.3089	0.3057	0.3133	0.3133	0.2579	0.2738	0.2469	0.2694	0.2473	0.2588	0.2451

Table 5. Weights-at-age (kg) for 4T herring fall spawners from 4TI, 1978-1997.

Fixed Gear

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.2026	0.2395	0.2217	0.2233	0.2446	0.1805	0.2422	0.2806	0.2250	0.2480	0.2334	0.2257	0.1917	0.1864	0.0000	0.0000	0.0000	0.0000	0.0000	0.1744
4	0.2567	0.2602	0.2802	0.2503	0.2721	0.2242	0.2557	0.2743	0.2635	0.2327	0.2768	0.2589	0.2380	0.2363	0.2178	0.2157	0.2084	0.2152	0.2245	0.2064
5	0.2970	0.2966	0.3378	0.3133	0.3071	0.2789	0.2729	0.3068	0.2960	0.2617	0.3047	0.2919	0.2877	0.2781	0.2494	0.2413	0.2443	0.2440	0.2508	0.2349
6	0.3148	0.2952	0.3768	0.3621	0.3706	0.3103	0.3250	0.3517	0.3313	0.3109	0.3566	0.3268	0.3252	0.3122	0.0000	0.2602	0.2693	0.2659	0.2608	0.2663
7	0.2935	0.3305	0.3845	0.3970	0.4464	0.3690	0.3518	0.3699	0.3701	0.3338	0.3920	0.3524	0.3425	0.3540	0.2805	0.2657	0.3016	0.2854	0.3038	0.2779
8	0.3587	0.3958	0.4093	0.4141	0.4464	0.0000	0.3952	0.3798	0.3903	0.3330	0.3957	0.3736	0.3685	0.3602	0.3398	0.3265	0.3345	0.2936	0.3136	0.2994
9	0.4221	0.4242	0.4658	0.4984	0.0000	0.0000	0.4513	0.4210	0.4031	0.3654	0.4569	0.3890	0.3753	0.3741	0.3241	0.3407	0.3690	0.3652	0.3279	0.3222
10	0.3060	0.3989	0.4453	0.4616	0.0000	0.0000	0.3602	0.4377	0.4511	0.2480	0.4008	0.4114	0.3992	0.4115	0.3892	0.3603	0.3934	0.3683	0.3916	0.3358
11+	0.4111	0.4331	0.4429	0.5420	0.0000	0.0000	0.4947	0.5081	0.4562	0.4058	0.0000	0.4045	0.4152	0.4157	0.3983	0.3849	0.4284	0.3823	0.4335	0.3958
	0.3329	0.2973	0.3308	0.2809	0.3032	0.2582	0.2895	0.3377	0.3342	0.2941	0.3306	0.3232	0.3127	0.3055	0.2467	0.2638	0.2911	0.2871	0.2804	0.2489

Mobile Gear

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0753	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0609	0.1154	0.0960	0.1079	0.1109	0.0000	0.0000	0.1422	0.0959	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.1799	0.2010	0.1916	0.1789	0.1709	0.1734	0.1621	0.0000	0.0000	0.2033	0.1651	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1698	0.0000
4	0.2233	0.2473	0.1991	0.2256	0.2120	0.2077	0.2115	0.0000	0.0000	0.2427	0.2250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1878	0.0000
5	0.2593	0.2729	0.2698	0.2498	0.2610	0.2343	0.2364	0.0000	0.0000	0.2683	0.2603	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2249	0.0000
6	0.2854	0.2895	0.2570	0.2863	0.2827	0.2850	0.2593	0.0000	0.0000	0.2890	0.3050	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2333	0.0000
7	0.0000	0.3134	0.3040	0.3408	0.3862	0.3185	0.3031	0.0000	0.0000	0.3148	0.3328	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2680	0.0000
8	0.3419	0.3231	0.3366	0.2547	0.3559	0.3675	0.3313	0.0000	0.0000	0.3352	0.3240	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2726	0.0000
9	0.0000	0.3352	0.3672	0.2603	0.3062	0.3648	0.3701	0.0000	0.0000	0.3435	0.3800	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3215	0.0000
10	0.3225	0.3195	0.4002	0.2620	0.4239	0.2639	0.3278	0.0000	0.0000	0.4071	0.4042	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3431	0.0000
11+	0.3981	0.3698	0.3915	0.2566	0.4461	0.4579	0.4236	0.0000	0.0000	0.4446	0.4108	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4860	0.0000
	0.2361	0.3203	0.2518	0.2134	0.2019	0.2117	0.2366	0.0000	0.0000	0.3003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2286	0.0000

All Gears

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0960	0.1079	0.1109	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.1803	0.2100	0.2068	0.2227	0.2179	0.1739	0.2312	0.2806	0.2250	0.2478	0.2334	0.2257	0.1917	0.1864	0.0000	0.0000	0.0000	0.0000	0.1698	0.1744
4	0.2262	0.2555	0.2523	0.2502	0.2718	0.2149	0.2526	0.2743	0.2635	0.2327	0.2768	0.2589	0.2380	0.2363	0.2178	0.2157	0.2084	0.2152	0.2222	0.2064
5	0.2672	0.2835	0.3200	0.3132	0.3069	0.2511	0.2701	0.3068	0.2960	0.2617	0.3047	0.2919	0.2877	0.2781	0.2494	0.2413	0.2443	0.2440	0.2501	0.2349
6	0.2965	0.2904	0.3157	0.3620	0.3702	0.2998	0.3189	0.3517	0.3313	0.3104	0.3566	0.3268	0.3252	0.3122	0.0000	0.2602	0.2693	0.2659	0.2605	0.2663
7	0.2935	0.3179	0.3646	0.3966	0.4464	0.3523	0.3498	0.3699	0.3701	0.3337	0.3920	0.3524	0.3425	0.3540	0.2805	0.2657	0.3016	0.2854	0.3016	0.2779
8	0.3522	0.3341	0.3860	0.4141	0.4464	0.3675	0.3928	0.3798	0.3903	0.3331	0.3957	0.3736	0.3685	0.3602	0.3398	0.3265	0.3345	0.2936	0.3128	0.2994
9	0.4221	0.3416	0.3998	0.4939	0.0000	0.3648	0.4423	0.4210	0.4031	0.3653	0.4569	0.3890	0.3753	0.3741	0.3241	0.3407	0.3690	0.3652	0.3279	0.3222
10	0.3191	0.3240	0.4218	0.4599	0.0000	0.2639	0.3582	0.4377	0.4511	0.2480	0.4008	0.4114	0.3992	0.4115	0.3892	0.3603	0.3934	0.3683	0.3912	0.3358
11+	0.4096	0.3726	0.4429	0.5420	0.0000	0.4579	0.4947	0.5081	0.4562	0.4058	0.0000	0.4045	0.4152	0.4157	0.3983	0.3849	0.4284	0.3823	0.4338	0.3958
	0.2589	0.3148	0.3028	0.2805	0.3023	0.2292	0.2856	0.3377	0.3342	0.2941	0.3306	0.3232	0.3127	0.3055	0.2467	0.2638	0.2911	0.2871	0.2792	0.2489

Table 6. Weights-at-age (kg) for 4T herring fall spawners from 4Tjkfgh, 1978-1997.

Fixed Gear

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
2	0.079	0.107	0.212	0.035	0.000	0.000	0.000	0.000	0.179	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
3	0.130	0.183	0.206	0.195	0.210	0.000	0.227	0.236	0.179	0.228	0.234	0.233	0.193	0.174	0.000	0.000	0.000	0.000	0.000	0.1658
4	0.177	0.246	0.250	0.226	0.262	0.194	0.243	0.251	0.241	0.240	0.267	0.255	0.243	0.236	0.220	0.214	0.211	0.212	0.217	0.2036
5	0.214	0.282	0.298	0.325	0.300	0.251	0.277	0.282	0.281	0.273	0.292	0.278	0.277	0.262	0.253	0.232	0.227	0.226	0.251	0.2323
6	0.218	0.324	0.324	0.383	0.333	0.283	0.307	0.315	0.313	0.305	0.322	0.319	0.325	0.298	0.279	0.251	0.260	0.252	0.254	0.2704
7	0.267	0.364	0.340	0.380	0.370	0.304	0.337	0.349	0.350	0.330	0.353	0.352	0.347	0.334	0.289	0.284	0.285	0.270	0.278	0.2781
8	0.277	0.402	0.339	0.400	0.365	0.334	0.399	0.362	0.360	0.351	0.380	0.378	0.371	0.356	0.337	0.318	0.326	0.295	0.305	0.3216
9	0.305	0.429	0.374	0.443	0.386	0.356	0.402	0.390	0.385	0.370	0.398	0.384	0.396	0.376	0.342	0.351	0.326	0.321	0.323	0.3221
10	0.000	0.446	0.432	0.467	0.354	0.395	0.394	0.381	0.396	0.370	0.405	0.404	0.408	0.391	0.365	0.357	0.360	0.356	0.348	0.3425
11+	0.409	0.457	0.364	0.435	0.400	0.410	0.486	0.458	0.361	0.420	0.451	0.431	0.430	0.414	0.381	0.390	0.370	0.376	0.388	0.3948
	0.158	0.251	0.255	0.268	0.301	0.238	0.272	0.297	0.276	0.303	0.325	0.333	0.340	0.310	0.295	0.296	0.307	0.294	0.303	0.2634

Mobile Gear

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0.000	0.069	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
2	0.093	0.033	0.103	0.114	0.000	0.108	0.000	0.000	0.114	0.142	0.096	0.000	0.000	0.000	0.000	0.066	0.000	0.000	0.032	0.0000
3	0.135	0.073	0.141	0.179	0.000	0.173	0.131	0.000	0.138	0.203	0.165	0.000	0.000	0.000	0.000	0.138	0.000	0.072	0.076	0.1372
4	0.168	0.150	0.167	0.226	0.000	0.208	0.167	0.000	0.169	0.243	0.225	0.000	0.000	0.000	0.148	0.205	0.150	0.113	0.124	0.1471
5	0.215	0.182	0.224	0.250	0.000	0.235	0.195	0.000	0.193	0.268	0.260	0.000	0.000	0.000	0.208	0.269	0.166	0.147	0.159	0.2170
6	0.228	0.200	0.236	0.287	0.000	0.285	0.250	0.000	0.245	0.289	0.305	0.000	0.000	0.000	0.272	0.285	0.190	0.199	0.187	0.1807
7	0.286	0.225	0.263	0.341	0.000	0.319	0.281	0.000	0.276	0.315	0.333	0.000	0.000	0.000	0.292	0.334	0.234	0.229	0.181	0.2266
8	0.314	0.280	0.250	0.257	0.000	0.368	0.000	0.000	0.289	0.335	0.324	0.000	0.000	0.000	0.326	0.375	0.222	0.230	0.219	0.2574
9	0.295	0.329	0.274	0.261	0.000	0.365	0.396	0.000	0.276	0.344	0.380	0.000	0.000	0.000	0.322	0.392	0.251	0.000	0.270	0.2653
10	0.315	0.346	0.283	0.262	0.000	0.264	0.000	0.000	0.000	0.407	0.404	0.000	0.000	0.000	0.302	0.401	0.335	0.342	0.257	0.2827
11+	0.364	0.381	0.359	0.263	0.000	0.458	0.000	0.000	0.000	0.445	0.411	0.000	0.000	0.000	0.382	0.427	0.327	0.300	0.309	0.4128
	0.162	0.181	0.187	0.212	0.000	0.211	0.183	0.000	0.154	0.303	0.293	0.000	0.000	0.000	0.243	0.355	0.215	0.196	0.180	0.2019

All Gears

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0.000	0.023	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
2	0.092	0.036	0.105	0.109	0.000	0.108	0.000	0.000	0.174	0.000	0.096	0.000	0.000	0.000	0.000	0.066	0.000	0.000	0.032	0.0000
3	0.134	0.078	0.148	0.181	0.210	0.030	0.227	0.236	0.174	0.228	0.227	0.233	0.193	0.174	0.000	0.138	0.000	0.072	0.035	0.1564
4	0.170	0.174	0.178	0.226	0.262	0.195	0.243	0.251	0.240	0.240	0.267	0.255	0.243	0.236	0.212	0.211	0.190	0.199	0.201	0.1992
5	0.214	0.200	0.236	0.306	0.300	0.251	0.277	0.282	0.281	0.273	0.292	0.278	0.277	0.262	0.252	0.238	0.196	0.223	0.229	0.2317
6	0.224	0.212	0.239	0.373	0.333	0.283	0.307	0.315	0.313	0.305	0.322	0.319	0.325	0.298	0.279	0.252	0.254	0.248	0.250	0.2686
7	0.282	0.243	0.271	0.363	0.370	0.304	0.337	0.349	0.350	0.330	0.353	0.352	0.347	0.334	0.289	0.290	0.280	0.268	0.265	0.2775
8	0.309	0.300	0.252	0.365	0.365	0.334	0.399	0.362	0.360	0.351	0.379	0.378	0.371	0.356	0.337	0.327	0.309	0.290	0.302	0.3212
9	0.297	0.343	0.276	0.323	0.386	0.356	0.402	0.390	0.385	0.370	0.398	0.384	0.396	0.376	0.342	0.354	0.321	0.321	0.322	0.3203
10	0.315	0.359	0.296	0.343	0.354	0.392	0.394	0.381	0.396	0.370	0.405	0.404	0.408	0.391	0.363	0.365	0.360	0.355	0.344	0.3417
11+	0.364	0.384	0.359	0.292	0.400	0.410	0.486	0.458	0.361	0.420	0.448	0.431	0.430	0.414	0.381	0.400	0.369	0.375	0.387	0.3950
	0.161	0.194	0.194	0.240	0.301	0.238	0.272	0.297	0.275	0.303	0.325	0.333	0.340	0.310	0.293	0.303	0.298	0.290	0.296	0.2612

Table 7. Correlations among areas for weight at age 5 and age 7 in inshore catches.

Age 5

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 12

	NORTH	MID	SOUTH
NORTH	1.00000 0.0	0.89328 0.0001	0.96389 0.0001
MID	0.89328 0.0001	1.00000 0.0	0.92675 0.0001
SOUTH	0.96389 0.0001	0.92675 0.0001	1.00000 0.0

Age 7

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 12

	NORTH	MID	SOUTH
NORTH	1.00000 0.0	0.85852 0.0004	0.95696 0.0001
MID	0.85852 0.0004	1.00000 0.0	0.92341 0.0001
SOUTH	0.95696 0.0001	0.92341 0.0001	1.00000 0.0

Table 8. Pearson correlation coefficients for catch rates among the major fall 4T inshore fishing areas.

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / Number of Observations

	CHCUE	ECCUE	WPCUE	FBCUE	PCUE	MGCUE
CHCUE	1.00000 0.0 12	0.59437 0.0538 11	0.16590 0.6063 12	0.09430 0.7707 12	0.41203 0.1832 12	-0.10987 0.8604 5
ECCUE	0.59437 0.0538 11	1.00000 0.0 11	0.63489 0.0358 11	-0.17238 0.6123 11	0.21285 0.5298 11	0.33461 0.5820 5
WPCUE	0.16590 0.6063 12	0.63489 0.0358 11	1.00000 0.0 12	-0.03886 0.9046 12	0.17267 0.5915 12	0.49816 0.3930 5
FBCUE	0.09430 0.7707 12	-0.17238 0.6123 11	-0.03886 0.9046 12	1.00000 0.0 12	0.57863 0.0487 12	0.10610 0.8652 5
PCUE	0.41203 0.1832 12	0.21285 0.5298 11	0.17267 0.5915 12	0.57863 0.0487 12	1.00000 0.0 12	0.53015 0.3581 5
MGCUE	-0.10987 0.8604 5	0.33461 0.5820 5	0.49816 0.3930 5	0.10610 0.8652 5	0.53015 0.3581 5	1.00000 0.0 5

Table 9. Pearson correlation coefficients between day when 50% of catch is made in each area.

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / Number of Observations

	CHT	ECT	WPT	FBT	PT	MGT
CHT	1.00000 0.0 12	0.10585 0.7434 12	0.30794 0.3302 12	0.22218 0.4877 12	-0.17006 0.5972 12	0.15562 0.7129 8
ECT	0.10585 0.7434 12	1.00000 0.0 12	0.27182 0.3927 12	0.30173 0.3405 12	0.63829 0.0255 12	0.28915 0.4873 8
WPT	0.30794 0.3302 12	0.27182 0.3927 12	1.00000 0.0 12	0.19400 0.5457 12	0.25262 0.4283 12	0.41702 0.3040 8
FBT	0.22218 0.4877 12	0.30173 0.3405 12	0.19400 0.5457 12	1.00000 0.0 12	0.46449 0.1282 12	0.31697 0.4443 8
PT	-0.17006 0.5972 12	0.63829 0.0255 12	0.25262 0.4283 12	0.46449 0.1282 12	1.00000 0.0 12	0.20742 0.6221 8
MGT	0.15562 0.7129 8	0.28915 0.4873 8	0.41702 0.3040 8	0.31697 0.4443 8	0.20742 0.6221 8	1.00000 0.0 8

Table 10. Distance traveled to fishing grounds (traverse), traveled searching for fishable sized schools (search), setting the net (fishing), and pumping the catch on board (pumping) for seiners during three example fishing days in 1995 and 1996. Catch per distance and time searched fpr the monitored boat and catch per boat for all boats fishing in the indicated location are compared.

Seiners

Area	Date	Traverse	Search	Fish	Pump	Catch(t)	Catch/ Search	Catch/ Boat
Distance (km)								
Gaspé	Oct 1-2/95		115	4	5	40	0.35	67
Chaleur	Sep 9-10/96	117	64	1	2	15	0.23	20
Aspy Bay	Nov 22-23/96	120	45	4	7	290	6.44	172
Time (minutes)								
Gaspé	Oct 1-2/95		537	29	227	40	0.07	67
Chaleur	Sep 9-10/96	377	306	11	71	15	0.05	20
Aspy Bay	Nov 22-23/96	390	205	30	377	290	1.41	172

Table 11. Distance traveled to fishing grounds (traverse), traveled searching for fishable sized schools (search), and setting the net, waiting for catch, and hauling (fishing), for inshore gillnetters during three example fishing days in 1995 and 1996. Catch per distance and time searched fpr the monitored boat and catch rate for the boat in units of kg/net/trip, the same as in the abundance index for the assessment, for the monitored boat are compared..

Inshore

Area	Date	Traverse	Search	Fish	Catch(t)	Catch/ Search	CUE
Distance (km)							
Miscou	Sep 5-6/96	99	57	1	4.6	0.08	629
Miscou	Sep 8-9/96	66	16	1	9.8	0.61	1535
Miscou	Sep 9-10/96	61	29	2	8.5	0.29	1413
Time (minutes)							
Miscou	Sep 5-6/96	322	449	123	4.6	0.01	629
Miscou	Sep 8-9/96	128	118	202	9.8	0.08	1535
Miscou	Sep 9-10/96	199	308	76	8.5	0.03	1413

Table 12. Mean lengths and target strengths used to estimate density in selected inshore and purse seiner data sets.

Area	Date Landed	Mean Length Fishery	Mean Length Exp. Nets	Target Strength Log	Linear
Inshore					
Pictou	Sep 12 /97		30.73	-36.19	0.00024
Pictou	Sep 29/97		30.73	-36.19	0.00024
West PEI	Sep 19/97		30.73	-36.19	0.00024
Escuminac	Sep 25/97		30.73	-36.19	0.00024
Miscou	Sep 10/97		30.73	-36.19	0.00024
Seiners					
Gaspé	Oct 2/95	29.54		-35.35	0.000292
Chaleur	Oct 4/95	29.48		-35.48	0.000283

Table 13. Abundance indices calculated by adding up tonnes per 100 square metre box, catch, and relative F calculated by dividing catch by index for example inshore and seiner fall fishing nights.

Area	Date Landed	Index (t)	Catch (t)	Relative F
Inshore				
Pictou	Sep 12/ 97	303	101	0.33
Pictou	Sep 29/ 97	3629	761	0.21
West Prince Edward Island	Sep 19/ 97	1638	515	0.31
Escuminac	Sep 25/ 97	267	206	0.77
Miscou	Sep 10/ 97	3109	2559	0.85
Purse Seiners				
Gaspé	Oct 2/95	11085	309	0.03
Chaleur	Oct 4/95	1653	392	0.24

Table 14. Abundance indices calculated by adding up tonnes per 100 square metre box, catch, and relative fishing mortality calculated by dviding catch by the index for individual sets made by seiner on Oct. 2, 1995

Purse Seine Set Indices - Oct. 2/95

Set	Biomass Index(t)	Catch(t)	Relative Fishing Mortality
1	386	15	0.04
2	306	10	0.03
3	542	10	0.02
4	131	5	0.04

Table 15. Biomass and density estimates using arithmetic averaging of tonnes per box applied to the area indicated (Arith), using block kriging (Geo), and summing the tonnes per box (Box). ci; confidence interval 2 times standard deviation and Percent is percent variation around the estimate.

		kg/m^2		tonnes			Arithmetic		Geostatistics	
Date and Location	Area km2	Arith	Geo	Arith	Geo	Box	+-ci	Percent	+-ci	Percent
Pictou Fig. 19										
11-12 Sep 1997										
Western School	3.30	0.03	0.04	109	118		50	57.42	70	56.93
Eastern School	2.00	0.24	0.36	471	713		370	98.49	370	52.09
SubTotal	5.30	0.11	0.16	580	831					
Total Area	**5.30**	**0.11**	**0.18**	**606**	**943**	**300**	**420**	**72.15**	**470**	**44.60**
	5.86	**0.11**	**0.18**	**670**	**1043**	**300**	**420**	**72.15**	**470**	**44.60**
Chaleur Fig. 24										
3-4 Oct 1995										
Central School	11.76	0.39	0.39	4634	4623		940	25.11	1600	34.60
Excluding Central School	16.07	0.30	0.23	4816	3656					
Total Area	**27.83**	**0.34**	**0.30**	**9451**	**8279**	**1600**	**932**	**31.42**	**2990**	**36.08**