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Summary of 2000 herring acoustic surveys in NAFO Divisions 4WX

Résumé des relevés acoustiques du hareng dans les divisions 4WX de l'OPANO en 2000

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Abstract

Atlantic herring distribution and abundance in NAFO Division 4WX was documented and estimated from data collected primarily by commercial fishing vessels with and without automated acoustic logging systems during structured, mapping and research surveys. In an improvement over the previous years all of the surveys for German Bank (n=4) and Scots Bay (n=3) were conducted according to established protocol and provided excellent coverage of the spawning area. As a result, the estimated biomass was considered representative of the spawning components. Surveying on Trinity Ledge was poor with only a single survey of the spawning component late in the season. The total biomass for each of the main spawning components was estimated by summing the results of surveys conducted at approximately two-week intervals. Biomass estimates for Scots Bay, Trinity Ledge and German Bank were approximately 106,000t, 621t, and 356,000t for a total stock complex minimum spawning biomass of 463,300t. Although the minimum spawning stock biomass (SSB) estimates of recent years do not directly reflect trends in stock abundance due to changes in coverage, the decline in observed biomass on German Bank and on Trinity Ledge is cause for some concern. Biomass estimates for coastal Nova Scotia and the offshore Scotian Shelf are presented and discussed.

Résumé

La distribution et l’abondance du hareng dans les divisions 4WX de l’OPANO ont été documentées et évaluées à partir de données recueillies principalement par des bateaux de pêche commerciale, munis ou non de systèmes automatisés d’enregistrement acoustique pendant des relevés structurés, cartographiques et de recherche. Comparativement aux années précédentes, tous les relevés pour le banc German (n=4) et pour Scots Bay (n=3) ont été effectués selon un protocole établi et ont assuré une excellente couverture de la frayère. Pour cette raison, on a considéré que la biomasse estimée était représentative des composantes de reproducteurs. La couverture de Trinity Ledge a été médiocre, un seul relevé de la composante de reproducteurs ayant été effectué tard dans la saison. On a estimé le total de la biomasse pour chacune des principales composantes de reproducteurs en additionnant les résultats des relevés effectués à peu près aux deux semaines. Les estimations de la biomasse pour Scots Bay, Trinity Ledge et le banc German avoisinaient respectivement 106 000, 621 et 356 000 t, pour un total de la biomasse féconde minimale du complexe de stock de 463 300 t. Bien que les estimations de la biomasse du stock reproducteur (BSR-SSB) minimale des dernières années ne traduisent pas exactement les tendances dans l’abondance du stock en raison de changements dans la couverture, le fléchissement de la biomasse observée sur le banc German et dans la zone de Trinity Ledge est préoccupant. Les estimations de la biomasse pour la Nouvelle-Écosse côtière et la Plate-forme Scotian sont présentées et examinées.

Introduction:

Industry based acoustic surveys continue to make a significant contribution to the evaluation of the 4WX herring stock. The first quantitative industry conducted survey to estimate the biomass of a herring spawning component was undertaken on German Bank in September of 1997. Data collected by automated acoustic logging systems installed aboard commercial fishing vessels during both regular fishing excursions and during DFO/industry structured surveys were first incorporated into the 1998 assessment process (Melvin *et al*. 1998, Stephenson *et al*. 1997). Prior to deployment of the automatic acoustic systems, biomass estimates from industry mapping surveys were qualitative and relied on the experience of the observer to estimate the amount of fish (Melvin *et. al*., 2000b).

The 4VWX herring fleet has undertaken numerous surveys of major and minor spawning grounds, provided direct input of their quantitative observations into the assessment process. During the 1995 and 1996 assessment serious concern was expressed about the declining biomass and potential erosion of individual spawning units as a result of increased fishing effort. To provide additional protection of individual spawning components within a global TAC, the herring industry initiated a “survey, assess, then fish” protocol, which continues today (Melvin *et al*., 1998, Melvin *et al.*, 2000a, Stephenson *et al*., 2000).

The number of acoustic systems deployed on herring vessels within 4WX has increased from 2 experimental units in 1997 to 6 (5 fixed and 1 portable) in 1999 and to 8 in 2000. Both the fishing industry and DFO have recognized the usefulness of these units, which are available to survey throughout the entire fishing season. Last year’s assessment of the 4WX stock status (assessment of the 1999 fishery reviewed in the spring of 2000) relied extensively on the biomass estimates of spawning components obtained from industry based surveys and data collected by commercial fishing vessels equipped with acoustic systems (Anon., 2000; Stephenson *et al*. 2000). Each year there are requests from different fishing sectors within the herring industry to increase the number of recording units or to make one available for surveying the smaller inshore spawning components. The main limiting factor, besides cost, with increasing the number of logging systems is having enough experienced personnel to collect, edit and analyze the vast amounts of data collected by these systems.

The incorporation of industry based surveys into the Regional Advisory Process (RAP) has resulted in several recommendations regarding the application of this technology and the need to move towards standardization of the survey design. The primary concern with our early approach was the inability to make inter-year comparisons of the results due to inconsistent survey coverage. Data from fishing excursions, where a standard survey protocol was not followed, reflect only the vessel’s search pattern for a given night. Therefore, detecting trends in abundance is problematic since the estimated biomass represents only the minimum biomass observed. In response to this concern a survey design based on catch statistics from several spawning seasons was developed, reviewed and recommended for implementation on the major spawning grounds (Melvin and Power, 1999). The design was partly implemented in 1999 and fully implemented in 2000. Concern was also expressed regarding the use of acoustic biomass estimates as absolute estimates of biomass. Several experiments were conducted on herring confined in weirs to obtain a level of confidence in the absolute biomass estimate (Melvin *et al*., 2000a). Additional research conducted during the summer of 2000 is reported in this document.

The purpose of this report is to describe and summarize the 4VWX stock assessment-related data collected by the acoustic logging systems during the 2000 fishing and survey season. In addition, a status report will be provided on the transition from *ad hoc* to formal structured surveys, quantification of absolute abundance estimates from herring weirs, and the results of a DFO research vessel acoustic survey on the eastern Scotian shelf.

Methods:

Data collected and used to estimate minimum observed spawning stock biomass during the 2000 fishing season are of two types, those collected during standard fishing operations and those obtained from structured (i.e. organized) surveys. Structured surveys were either acoustic or mapping surveys (Melvin *et. al.,* 2000b). The majority of information on the 2000 fishing season presented in this report originates from structured acoustic surveys in which data from the acoustic logging systems and mapping are combined to determine the survey area and biomass estimate.

Acoustic Systems:

Currently there are 8 automated acoustic logging systems available for deployment on commercial fishing vessels; the two original systems (FEMTO Electronics Inc., Model 9001), four new systems (FEMTO Electronics Inc., Model 9320) purchased by industry in 1998 and 2 purchased (1 borrowed) in 2000. Five of the systems are connected to hull mounted transducers on purse seine vessels and two are installed on smaller inshore gillnet fishing boats. Unfortunately, none of the 7 systems can be easily moved from one vessel to another as movement requires connection to the vessel's electronics and calibration of the ship's transducer. The eighth system is mounted in a towed body for portability. The portable unit is self-contained and can be deployed from almost any size of vessel with a winch capable of supporting 150 kg and a boom to deploy the towed body. All data are automatically logged to a hard drive within the system and the data are downloaded to either a removable hard-drive or tape prior to archiving and analysis.

During 2000, 7 hull fixed, and one portable, HDPS automated acoustic logging systems were deployed amongst the herring fleet to document the distribution and abundance of herring. Systems were installed and calibrated aboard the purse seining vessels *Margaret Elizabeth, Island Pride, Dual Venture, Leroy & Barry* and the *Secord* and on two inshore gillnet boats, the *Heather & Phyllis* and the *Attaboy*. The portable system, which uses a transducer mounted in a towed body and is virtually self-contained, was deployed from a number of fishing vessels during the fishing season. In 2000, acoustic data were collected by recording vessels during both standard fishing excursions and structured surveys.

Surveys:

<u>Mapping Surveys:</u>

In 2000, surveys that relied solely on the mapping approach used in the early years of industry based surveying were few. Most surveys included a combination of both mapping and acoustic data collections. Mapping data (log sheets) were collected on each survey by all vessels participating in the survey to establish the outer bounds and distribution of herring in the survey area. Biomass estimates were also made from the mapping type data to provide a quick approximation of fish numbers and used as input for the "survey, assess, then fish" protocol when uncertainty prevailed. The procedure involved recording information on fish abundance and distribution (depth, relative density) observed from the sounders and sonars of vessels without recording systems. Survey protocol required that parallel transects were run with vessel spacing varying from 1/8 mile to ½ mile, depending on the availability of sonar, to ensure that no large schools were missed. Observations were recorded every 5 to10 min on standardized data sheets. The observations were later categorized into the 3 density values (light, medium or heavy) and biomass estimated using the area and a relative density category (Melvin *et. al*, 2000b; Stephenson *et. al*, 1998). In most of the 2000 surveys at least one automated acoustic system was available to collect quantitative data.

Mapping data were contoured and plotted using the ACON Data Visualization package and the triangular contour method (Black, 2000). Blanking distance was set to the maximum distance between valid data recordings and varied between 1 and 3 miles depending on the survey. Interpolation between data points was undertaken using the inverse distance weighting gradient approach to compute the density at any given point. Once the area of the three contour levels was estimated, the areas (km^2) were multiplied by the appropriate fish density in accordance with the previously defined scale (Table 1) and summed to get the total biomass within the survey coverage area. However, final biomass estimates were based on acoustic density estimates whenever available.

Quantitative Surveys:

Industry based structured surveys were used throughout the 2000 spawning season to document the distribution and abundance of herring on individual spawning grounds. Standard operating procedure for surveying involved the presence of DFO scientific staff onboard one or more of the vessels to direct the activities, assign transects, determine coverage (with fishing captains), sample fish and download/collect the data upon completion of the survey. Typically, a series of randomly selected transects were provided to the participating vessels for the area of interest and a two-phase survey design (i.e. search then survey) implemented. The initial phase involved the search for fish on the spawning grounds along the pre-defined transects using vessels equipped with and without acoustic logging systems. Fishing vessels without a recording system would document their observations as if they were undertaking a mapping survey. Once the entire area was covered and the distribution of fish identified, each vessel involved in the survey was assigned a series of transects to execute in the area containing the higher concentration of fish. Biomass estimates were made using the procedure described below for fishing operations, except that transects were usually of similar length and selected at random within the pre-defined area of interest. Transect estimates were weighted for length (i.e. distance traveled) and the mean transect backscatter (converted to kg/m^2 using the Foote equation) extrapolated for the survey area to estimate the minimum observed biomass.

Prior to 1999, surveys were undertaken on an *ad hoc* basis and usually at the request of the fishing industry. This resulted in some uncertainty as to the turnover time between spawning waves and the potential for double counting of fish. In 1998 a procedure was established to estimate the percent of herring remaining on the spawning ground between surveys when the time between surveys was less than 10 days (Melvin et. al., 1999). However, to avoid potential problems associated with elapsed time of less than 10 days between surveys, a survey schedule was established for the main spawning area at approximately two week intervals for both 1999 and 2000. Of the 12 surveys scheduled for 2000, 9 were completed on or near the tentative dates. Table 2 summarizes the areas for which structured surveys were scheduled. Additional acoustic surveys were undertaken on the eastern Scotian shelf in October and off Chebucto Head (non-spawning aggregation) in January of 2001.

Analytical Procedures:

The computational procedures for analyzing data collected from standard fishing operations and structured surveys are similar. However, given that the vessel track from standard fishing operations does not follow any standardized survey design some assumptions have to be made about the area covered and the representative nature of the data. Unfortunately, there are some recording nights when the data were simply too convoluted, too sparse relative to the area covered or the area covered is too small to be incorporated into the SSB for the stock. In recent years fishing captains have attempted to put some structure to their ad hoc recordings by running parallel lines when documenting aggregations of fish as recommended (Melvin and Power, 1999). Furthermore, when the area covered in search of fish is of sufficient size and representative lines (equivalent to transects) can be extracted, an estimate of observed biomass can be obtained.

For structured surveys, transects were predefined and represent randomly distributed parallel lines within the survey area. Transects for fishing operations are extracted from the vessel track by dividing the track into a series of non-intersecting segments. Portions of the vessel track where the vessel looped back to take a second look at a group of fish were also removed to prevent over-weighting of areas of heavy fish concentrations.

Fish biomass is estimated by selecting segments of the vessel's track (transects), computing the distance weighted average area backscatter (Sa), estimating the mean weight of fish/m^2 under the vessel (target strength equation, Foote, 1987) and multiplying by the area covered. Target strength estimates are based on herring length frequency samples and associated weights collected from several commercial vessels fishing in the area of interest as follows:

$$\text{TS (target strength)} = (20\ \text{Log(length)} - 71.9) - 10\ \text{Log(weight)} \quad \text{in dB kg}^{-1}.$$

Length frequency data are normally obtained from the survey vessel or vessels fishing in the survey area for TS calculation and target verification. The weight component of the TS equation is computed from monthly historical data on the weight/length relationship for the mean size of fish observed. In the event length frequency data are unavailable a standard TS of –35.5 is used for calculating biomass. Such events occur when gillnet samples are collected (selective for larger size) or no fishing is undertaken. The standard target strength corresponds to the TS of a 28.5 cm herring in September. This represents the lower end of the observed mean spawning lengths and generally translates into smaller biomass estimate.

Backscatter (Sa) was initially computed by averaging the return signal for a specific navigational interval (usually 20 navigational fixes) along the transect and weighted by the distance traveled during that interval. The average Sa values, weighted for distance, were then used to compute the mean Sa (dB m^{-2}) for the transect. Biomass density per transect (sample unit) was computed from the estimated Sa and TS as follows:

$$\text{Biomass density/transect} = 10^{(\text{mean Sa - Target strength})/10} \quad \text{in kg m}^{-2}$$

Area covered by the vessel was determined by fitting a rectangle or polygon over the vessel track and estimating the area. When available, sonar data were used to determine the boundaries of the fish schools. The area was then multiplied by the biomass density/stratum to determine the biomass in the area covered by the fishing vessel. Standard Error (S.E.) was estimated from the standard deviation of the transect biomass density, where n is the number of transects. The area of coverage was then multiplied by standard error to determine the SE of the overall biomass estimate.

Data Collection:

Fishing Excursions:

As in previous years, vessels equipped with automated acoustic logging systems activated the units during the search phase of nightly fishing excursions. Several captains turned their system on when they reached the fishing ground and off once they deployed their fishing gear, while others activated the systems only when they believed there was something worth recording. Combining both approaches, this information formed by far the largest data set that had to be downloaded, archived, edited and analyzed. In 1999 the amount of fishing excursion data used in the assessment of the SSB was evaluated to examine how much of these data were used in determining the final stock status. Of the 146 nights of recordings examined in detail and for which a biomass estimate was computed, only one night's data actually made a contribution to the 1999 SSB (Melvin *et al*., 2000a). Consequently, in 2000 only fishing excursions that the captains identified as containing large quantities of fish were analyzed. This greatly reduced the level of effort required to analyze the data. However, all data were downloaded, archived and stored on CD for future analysis if required.

Structured Surveys:

Industry-based structured surveys played an important role in our understanding and perception of 4WX stock status for the 2000 fishing season. Automated acoustic logging systems aboard both commercial fishing vessels and DFO research vessels were used to document the distribution and abundance of herring on major spawning grounds and in areas of interest or uncertainty. Surveys were conducted on each of the major, and several of the minor, spawning grounds within 4WX, as well as several non-spawning areas (Figure 1). The data collected and the results are discussed below.

Results – Bay of Fundy/SWNS:

Scots Bay:

The first of 3 surveys in Scots Bay for 2000 was conducted on the night of August 1 and involved 8 commercial purse seiners (3 with logging systems). The vessels ran pre-defined northeast transects approximately 30km long up the bay from Margaretsville (Figure 2). Acoustic recordings from the three vessels with logging systems provided excellent coverage of the spawning area. When compared with the non-recording vessels the distribution and aggregations of herring were almost identical. A biomass estimate was made using the mean Sa (weighted for distance) from seven transects in an area of 377km^2. Estimates of biomass density (TS= - 35.65) from the transects ranged from 0 to 0.312 kg/m^2 of herring. Length frequency data used to estimate target strength indicated adult fish sizes only (Figure 3) and all samples contained ripe or ripe/running fish (Stage 5-6) consistent with fish about 1 week away from spawning. The total SSB in Scots Bay on the night of the survey was estimated to be 45,300t (Table 3). This is very similar to the estimate made from the mapping and contour approach (Figure 2).

The second industry based acoustic survey, undertaken on August 14, involved 11 vessels (4 with automated logging systems) and covered an area of 369 km^2 (Table 3). The vessels covered an almost equal amount of area at approximately the same location (Figure 4) as the first survey. Again comparison of the distribution of fish from the recording and non-recording vessels showed a similar pattern. The mean biomass density (weighted for distance) for 8 transects, ranging from 0.0 to 0.330 Kg/m^2, was used to estimate the SSB. Transect lengths ranged from 26.3 to 32.6 km. Length frequency distribution of samples collected from 3 boats on the survey night showed sizes consistent with predominantly adult fish (Figure 5), and gonad stages were 5-6 or ripe and running. The SSB in Scots Bay on the night of the August 14th was estimated to be 30,300t (Table 3).

A third survey was conducted in Scots Bay on August 29 with three fishing vessels and a single recording system (i.e. portable). Although the survey was less structured, overall the vessels covered a large area (300 km^2) while the boat with the logging concentrated its effort in a relatively small (24.50km^2) narrow band where the fish were located (Figure 6). Given the area of coverage the survey was considered representative of the area. The length distribution (24-32cm) of fish indicated adult herring (Figure 7). Examination of the gonads showed that greater than 90% of the herring were stage 5-6 with the remainder stage 4. The biomass estimated for August 29 was 30,700t (Table 3).

The minimum 2000 SSB for the Scots Bay spawning component was estimated to be 106,300t. This represents a survey series which provided excellent coverage of potential spawning areas in Scots Bay and can be considered to reflect the abundance of herring from this component. Continuation of surveys in the above way will lead to an estimate that can be compared on an inter-annual basis and to an index of abundance in future years.

Trinity Ledge:

Survey coverage on Trinity Ledge during the 2000 spawning season was extremely poor. Although three surveys were scheduled for 2000 (Table 2), only one was undertaken. On the night of September 12th the purse seiner the *Fundy Mistress* (equipped with the portable acoustic logging system) joined 11 gillnet vessels to survey Trinity Ledge. The Fundy Mistress proceeded about 9.25 km north of the ledge in search of fish while the gillnetters concentrated on the area (30.8km^2) known to contain herring from previous nights fishing (Figure 8). After observing no fish, the seiner then returned to cover an area suggested by the gillnetters. Herring were only located in an area of approximately 0.5 km^2. Several passes with the acoustic recording system provided data to estimate the SSB. The standard TS of –35.5 was used due to the absence of a sample and the biomass was estimated to be 620t (Table 4). It should also be noted that only three data sheets were obtained from vessels involved in the survey.

German Bank:

For 2000 the German Bank SSB was estimated from 3 structured surveys in August/September and records from a single fishing night in October. All surveys were separated by a minimum of 14 days to avoid the possibility of double counting (Table 5). While only 3 of the 4 scheduled surveys were actually conducted, the three surveys covered a significant portion of the German Bank spawning grounds and as such should be considered to represent the extent of spawning fish on the bank. All surveys utilized the two-phase approach (with random transects), initially covering a relatively large area during the first sweep before concentrating on the area where fish were observed. Surveys were conducted on August 29, September 12 and September 27. Data from one of the fishing vessels operating on the bank during this period were substituted for the mid-October survey which did not occur.

The first survey of German Bank was conducted on August 29 by 7 purse seining vessels, 3 with automated acoustic recorders. The vessels implemented the two phase approach where all boats ran north for approximately 38k covering an area of 366km^2 (Figure 9). A large aggregation of herring was observed in the northern portion of the survey area. The vessels then turned south to pass through the fish one more time on new transects before completing the survey. Herring sampled during in the survey area ranged in size from 24 to 35 cm (Figure 10). The data from this survey were analyzed two ways. The initial analysis utilized the 3 long transects for the entire survey area to estimate biomass. This resulted in an estimate of 74,808t (Table 5). The long transects were then cut to a distance approximately equal in length to the second, combined with the shorter lines and 6 transects used to estimate the SSB in the smaller area of 162km^2. The biomass estimate in this case was 72,513t. The slight difference in estimates can be accounted for by the occurrence of a small amount of fish observed outside the smaller survey area or random error. The adjusted SSB for German Bank on August 29 was 74,800t.

The second survey occurred on September 12, 2000 with 6 purse seine vessels, three of which had acoustic logging systems. Although the survey covered an area of 196 km^2 the herring and survey effort were concentrated in approximately 96 km^2 (Figure 11). The SSB was estimated using all transects within the reduced area and assumed to reflect the larger area as no fish were observed outside the bounds of the area of concentrated effort. A total of 7 transects with mean density ranging from 0.0 to 2.2 kg/m^2 were extracted from the acoustic recordings, weighted for length and used to estimate the biomass. TS was estimated from the length frequency of 867 fish with a mean length of 28.37cm (Figure 12). The SSB was estimated to be 121,783t and was considered representative of the spawning fish present on the bank on the night of the survey (Table 5).

The third and final structured survey on German Bank for 2000 was conducted on September 29 by 5 purse seine vessels, including 3 with automated acoustic recording systems. The survey covered an area of approximately 400 km^2 (Figure 13), however upon examination of the samples, fish in the northern portion of the survey were found to be juvenile herring (Figure 14). The data north of 43^o 31' was thus removed from the estimate of SSB and the area containing spawning fish reduced to 338km^2. Target strength was estimated for a mean length of 28.2 cm from six samples collected from sets made within the defined area of spawning fish (Table 4). The estimated biomass of 145,300t was made using 6 transects which ranged in mean biomass density from 0.0004 to1.61 kg/m^2. Approximately 21,000t of juvenile herring were observed in the northern portion of German Bank. As such, these fish were not included in the estimate of SSB.

The final survey on German Bank, which was scheduled to occur just prior to the closure of the fishing season on October 14, was not undertaken. Instead, data from fishing excursions on the bank for this time period were examined to estimate the distribution and abundance of spawning herring (Table 6). Analysis of these data indicate that the largest observed biomass occurred on the night of October 14. The estimated SSB was 14,508t of fish with a mean length 28.63 cm.

In summary the three scheduled surveys conducted on German Bank during the fall of 2000 were well implemented and provided excellent coverage of the potential spawning grounds on German Bank. Industry should be commended for their efforts and cooperation. The lack of a fourth survey in the latter part of the season may suggest an underestimate of total SSB, however incorporation of the fishing data from should account for most of the loss in the absence of a survey. The total SSB for 2000 on German Bank was estimated to be 356,879t (Table 7). This is the sum of the 3 scheduled surveys and the fishing recordings of October 14.

<u>Spectacle Buoy:</u>

The Spectacle Buoy spawning fish fishery was limited to a short period in June when about 80t of roe fish were landed. As in 1999, several surveys were scheduled for the area but did not occur. Consequently, no biomass estimate was available for this component in 2000.

Bay of Fundy/SW Nova (Summary):

Over the past 4 years the approach to estimating the minimum SSB has changed with respect to the survey design, implementation of scheduled surveys, and coverage area. Estimating the SSB has evolved from a heavy reliance on distribution and abundance estimates from fishing excursions with a 10 day minimum elapsed time, to structured surveys at two week intervals which follow accepted survey protocol within predefined areas. Unfortunately, because we have transformed and standardized the process for estimating SSB, the estimate for any given year cannot be directly compared annually, or be used as an index of abundance due to variation in coverage. In 2000 the surveys were enhanced to a point where they are believed to provide a representative estimate of the herring on each of the main spawning grounds. Assuming surveys are conducted in a manner similar to those of 2000, the future assessments will be able to track trends in the SSB from each of the surveyed spawning components. However, prior to 2000 (possibly 1999) the observed SSB provides only an estimate of the minimum biomass (Table 7).

Nova Scotia Coastal Spawning Component

Over the years there have been reports of spawning herring in the shallow inshore waters of the bays and inlets along the Atlantic coast of Nova Scotia. Our knowledge of these relatively small coastal populations is limited. Recently, in addition to the traditional bait fishery, roe fisheries have developed on several of these individual spawning grounds. In 2000, acoustic surveys and/or acoustic data were available for only two of the coastal spawning areas; near Little Hope and Eastern Passage. Both areas had access to a vessel (ie. gillnetter) with an automated acoustic logging system for the spawning season. The results from the systems for each area are discussed below.

Little Hope:

The 2000 fall spawning herring fishery near Little Hope/Port Mouton used an automated acoustic recorder to document the distribution of fish. Unfortunately, much of the data appear to have been collected in a relatively small area. On the night of October 2 what at first glance appeared to be a large aggregation of fish was actually fish confined to a very small area (0.3 km^2). The only night which had any significant amount of herring recorded was October 1 when 5,200t were observed in 1.61 km^2 (Table 8). The data indicate that the recording vessel did not cover a very large area and that most of the recording was being done while the nets were actually in the water. No mapping data sheets were provided for any night during the 2000 fall fishery. More time is needed to implement methodology for surveying fish with the acoustic gear. As no representative sampling (gillnet fish only) was undertaken in the area the standard target strength of –36.19 (120 kHz) was used for biomass estimation. The observed spawning biomass for 2000 was was estimated 5,200t (Table 8).

Eastern Passage:

In 2000, the Eastern Shore Fishermens Protective Association purchased automated acoustic logging system and installed it aboard the *Phyllis and Heather* to undertake survey work on the spawning aggregations of herring occurring in their area. Unfortunately, there was a problem with the physical positioning of the transducer. The system, which was installed on short notice, requires remounting of the transducer so that the acoustic axis is vertical. Currently, it is slightly off axis and signal returns are weak. This means any that biomass derived from this system is likely to be an underestimate. The system is also producing a shadow near bottom (again due to positioning of the transducer) which prevents the counting of fish closer than 2-3m from bottom, a serious concern in shallow water. The system operates on a frequency of 120kHz and TS adjustment are necessary to adjust for differences from the standard 50kHz units (Urick, 1983).

During the fall of 2000, 4 days (October 4,6,16,and 17) of acoustic logging were selected to estimate SSB. The standard TS of –36.19 was used to convert Sa to biomass given the selective nature of the fishing gear and the higher frequency. The vessel track for the 4 days combined are shown in Figure 15 to illustrate the variation in movement taken by the vessel to document the fish. Each aggregation of fish was considered as a separate unit, with Sa (area backscatter) and survey area estimated for each day. The results of these computations are presented in Table 9. A mapping survey involving 11 vessels was conducted on the night of October 17 and estimated 6,854t (Figure 16). The estimated SSB for Eastern Passage in 2000 was 10,865t (6,372t on October 6 and 4,493t on October 17).

Bras d'Or Lakes:

Several mapping surveys were conducted in the Bras d'Or Lakes by DFO, the Eskasoni Fish and Wildlife Commission, and local fishing representatives during the 2000 spring spawning (March/April). Table 10 summarizes the data obtained from these surveys which occurred on April 15, 18 and 28 in the southern areas of the lakes and April 18 and 19th. Biomass estimates are expressed in terms of less than a given value due to the subjective nature of the approach. Some surveys covered the same spawning area on two adjacent nights (April 18 &19) and it must be assumed that the same fish were observed (Figures 17-20). While the length frequency distribution of herring from April 15th shows large fish, those collected represent a mixture (Figure 21-22). It is also interesting to note that a large portion of the fish sampled were fall spawners (Table 10). Consequently the estimate of spring SSB must be adjusted to account for the dominance of fall fish of unknown origin. For the sake of simplicity it was assumed that 10% of the observed biomass from mapping surveys was spring spawning fish. The observed spring SSB for 2000 in the Bras d'Or Lakes was estimated to be less than 69 t.

Offshore Scotian Shelf Component:

Fleet activity in the spring/early summer fishery on the offshore banks of the Scotian Shelf was reduced in 2000 and only 2,095t of herring were landed (Power *et. al*., 2001). As such, the amount of acoustic data available from the area is limited. Preliminary examination of the data indicated that only two nights of recordings contained any substantial amounts of herring. On June 8 the *Leroy & Barry* documented 1,230t in 3.91km^2 on the Patch and the *Island Pride II* operating in approximately the same location observed 1,480t on June 19 (Table 11).

During the fall of 2000 the offshore banks on the eastern portion of the Scotian Shelf were surveyed as part of the fall survey program. (NED2000-58, Oct 20-28) Figure 23 displays the vessel track along coastal Nova Scotia and the survey grids and transects examined during the mission. Although herring were collected in every set, only 4 of 14 locations sampled contained more than 5 fish. The majority of herring were caught in the inshore waters off Country Harbour and in sets made around Chedabucto Bay. The other location where significant numbers of herring were caught was set 11 on Western Bank. These herring were stage 7 (i.e. recently spent), suggesting proximity to one of the offshore spawning grounds. The herring collected at this station were large (mean length 31.4cm) and characteristic of fish caught in the early years of the reactivated (1997) offshore fishery (Figure 24). Surveying on the Patch was cut short due to storm conditions and no fish samples were collected.

Acoustic biomass estimates for only the boxes which contained significant amounts of herring are presented in Table 11. The largest aggregation of herring (79,201) observed during the survey was in box 2 just off Chedabucto Bay. This was followed by 4,270t inside the bay and 2,200t on Western Bank near the slope.

Chebucto Head (January 2001):

Each year in January since 1999 DFO has undertaken an acoustic survey, in conjunction with the fishing industry, of a large aggregation of herring just off Chebucto Head, N.S.. The purpose of the program is to estimate the abundance of herring and to investigate the movement, using mark/recapture methods, of this aggregation of herring. Tagging returns during the 1999 and 2000 fishing season indicate that a portion of the fish originated from spawning areas in Southwest Nova, but the returns provided little information on the possible mixture with other components. This was primarily due to the fact that catches of herring in areas other than SW Nova, represented less than 1% of the SW Nova/Bay of Fundy landings. Maximum biomass estimates were 482,956 and 103,000 t in January of 1999 and 2000, respectively (Melvin *et al*. 1999, Melvin et. al. 2000a).

For 2001, it was again agreed that the seiner fleet would be allowed to survey the Chebucto Head area and to fish to collect herring for tagging. Compensation for their efforts was 100 t/night to a maximum of 1,000t. No fish could be retained unless 70,000 - 100,000t of herring were observed and a minimum 10,000 fish tagged. In addition, if more than 100,000t of fish were observed the seiner fleet could remove 1.5% of the estimated biomass to a maximum of 5,000t.

Between January 3rd and 5th three biomass estimates were obtained from acoustic data collected by the commercial purse seiner fleet (Table 13). The initial biomass estimate (70,700t) was made from data collected on the morning of January 3 as the vessels steamed into Halifax Harbour to await the survey/tagging team. The data represented a small area (4.07 km^2) examined by two of the participating vessels to determine if sufficient quantities of fish were present to warrant a full scale acoustic survey and tagging operation. On January 4th, *the Margaret Elizabeth* and the *Canada 100* undertook a survey of the waters between Chebucto Head and the Two Sisters, the former vessel concentrating her efforts near the head and the latter to the south in the vicinity of The Sisters. Thereafter, independent biomass estimates were made for each of the surveyed areas and summed to produce an estimate of 158,000t for the overall area (Table 13). The next day the *Margaret Elizabeth* was joined by the Island Pride (both vessels have automated acoustic logging systems) to undertake a synoptic survey of the area (Figure 25-26), while the *Canada 100* set its seine to collect fish for tagging. Combining transects from both vessels resulted in a biomass estimate of 150,700t in the 55.0 km^2 surveyed (Table 13). The turnover time from data collection to biomass estimate was approximately 48 hours. Based on the observed biomass of 158,000t, the fleet was allocated 2,370t of herring for removal from the area. However, only 700t were removed as the fish moved out of the area shortly after the survey.

Weir Study:

Whenever acoustic data are used to estimate absolute biomass, the issue of the precision of the biomass estimates arises. Computations for the Sa to biomass conversion rely upon the relationship of TS to length measured under a variety of conditions (Foote, 1987). During acoustic surveys users of this technology do not have the opportunity to survey a known quantity of fish. Biomass estimates are calculated from sample length-based TS equations. However, in Southwestern New Brunswick herring are contained for periods of several days in weirs before they are removed. In this situation it is possible to obtain a length sample and the weight determined (volumetric conversion) prior to transshipment for processing. As such, herring weirs provide an ideal experimental area to undertake acoustic estimates where the fish are alive and actively swimming in a school. Furthermore, the fish are later removed and weighed in the processing plant providing an estimate of absolute biomass.

In 1999 a single experiment was undertaken in a herring weir to estimate biomass before the fish were removed. The details of the experiment are discussed in

Melvin et al. 2000. Briefly summarized in an area of 1603 m^2 and a fish density of 52.69 kg/m^2 the acoustic estimate of biomass was 84.500t. The purchase slip tonnage was 78.75t, a 7.2% difference. The same experiment was repeated over three days in three different weirs during the 2000 fishing season. The first experiment was discarded because the data file could not be saved when the monitor failed. The second experiment involved the calibrated 50kHz single beam sounder to estimate fish density and the SM2000 multi-beam sonar to determine the boundaries of the fish. In essence, the sonar was used to determine the horizontal area (polygon) of the aggregation, then multiplied by the mean density at the time of recording. Two independent recordings were evaluated for September 21. In the first case the 12.8t of herring were observed in an area of 101.17 m^2 and in the second 13.4t in 131m^2 (Table 14) based on a mean length of 19.42cm (Figure 27). The actual tonnage reported removed from this weir was 11.81t. This represents a positive difference of 8.4% and 13.6% from the assumed actual amount. It is also interesting to note that all estimates to date are greater than the weight landed. Several possible factors could explain the difference,- reported weight is a volumetric conversion to tonnes, all fish ensonified may not have been captured during the seining operation and error in the TS equation. Further studies are proposed for 2001.

Discussion:

Industry based acoustic surveys were conducted on the major (Scots Bay and German Bank) and some minor 4WX spawning components in 2000 to provide an estimate of SSB for the stock complex. This is the fourth year of surveying. During most surveys in previous years there was some evidence that portions of the spawning component were missed. Reported fishing just outside the survey area on the night of the survey and the limited coverage supported this assumption. Other evidence stemmed from signal losses during surveys due to bad weather or technical problems with equipment were also cited. Therefore the estimated SSB was considered to represent a minimum.

Surveys of major spawning areas in the Bay of Fundy/ Southwest Nova Scotia in 2000 were well organized, regularly scheduled, contained several automated acoustic logging vessels, covered relatively large areas and followed established survey protocol. Most surveys were conducted extremely well and according to established protocol. One of the criticisms in the past concerned the time between surveys and whether or not the elapsed time was sufficient to allow turnover of a new wave of spawning fish. This year all surveys on a individual spawning ground were separated by a minimum of 14 days and no surveys were conducted during bad weather nights. While it is our working assumption that two weeks is sufficient to avoid double counting, the fishing industry feels that turnover time is variable and that we may be missing entire waves of spawning fish. It was strongly recommended that research effort be put into investigating turnover time of fish.

Trinity Ledge was the exception to what must be considered the best survey series to date. Insufficient effort was put into surveying this spawning component. The end result was a single survey which documented only 620t (Table 4). While it might be argued that the spawning fish were missed, there is only a single estimate upon which to evaluate the status of this component. Last year's research document suggested a "fish with caution" approach should be employed for Trinity Ledge when the minimum observed SSB dropped from 6,760t in 1998 to 3,890t (Table 7). Using the most recent information, the only conclusion that can be drawn is that the situation on Trinity Ledge has not improved since last year, and that the component appears to be continuing its downward trend. Strict adherence to the "Survey, assess then fish" protocol should be maintained if fishing is permitted during the spawning season on the ledge in 2001.

SSB in the Bay of Fundy/ SW Nova Scotia component of the 4WX stock complex appears from acoustic surveys to have decreased. Given the improvements, standardization's, and similarities of surveys in 1999 and 2000 it is reasonable to compare the two years in terms of scale. Assuming 2000 represents the most comprehensive set of surveys, and likely the best estimate of absolute SSB, then there has been a minimum decrease in overall abundance from 505,680t in 1999 to 463,300t or 8.4% in 2000. By far the greatest decline occurred on German Bank where a drop in the estimated SSB of more than 100,000t (22%) was observed. A significant decline on Trinity was also observed while in Scots Bay the SSB more than doubled from the previous year (Table 7).

This was the first year acoustic logging systems were available for the Little Hope and Eastern Passage fall roe fisheries. While the survey vessels made an honest attempt to document the fish in their area it is evident from the vessel tracks and operating practices that more effort is required in the area of survey design and on how and when to operate the systems. Attempts should also be made to reposition the transducer on the *Phyllis & Heather* to remove the shadow near bottom.

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Table 1. Summary of weightings for each category used in mapping surveys. The tonnes/set is based on the fishermen's estimate of their catch if they set on the school of fish, converted to km^2. The acoustic values are the range of tonnages estimated from acoustic recordings and categorized by the observers.

Category	Tonnes/Set	Tonnes/km^2	Acoustic (tonnes/km^2)
No Fish	0	0	0
Light	5	200	230 - 250
	10	400	
Moderate	25	1000	600 - 1300
	50	2,000	
Heavy	100	4,000	2,000 – 11,000
	200	8,000	
	250	10,000	
	500	21,000	

Table 2. Summary of 2000 scheduled and completed herring spawning ground surveys within the 4WX stock complex.

Area	Scheduled	Completed
Scots Bay	3	3
Trinity Ledge	3	1
German Bank	4	3
Eastern Passage	1*	1*
Port Mouton	1*	1*

* Each area had access to a vessel with an automated acoustic system. Data were collected on a regular basis.

Table 3. Summary of the 2000 Scots Bay spawning ground acoustic survey data and biomass estimates for scheduled surveys. The total SSB for the spawning component is obtained by summing the biomass estimates. Target strength was estimated using the Foote equation for samples collected from the area on the night of the survey.

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
Scots Bay								
	August 01	377.8	-45.231	0.1199	28.02	-35.65	45,284	15,400
	August 14	369.0	-46.523	0.0822	28.17	-35.68	30,322	14,331
	August 29	24.5	-34.809	1.2535	28.13	-35.79	30,710	14,762

Table 4. Summary of the 2000 Trinity Ledge acoustic survey results and SSB biomass estimate. The biomass estimate was made for only the small area which contained fish. Note no mapping survey results were undertaken due to incomplete submission of data sheets.

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
Trinity Ledge								
Acoustic	Sept 12	0.5	-34.567	1.240		-35.5	621	113

Table 5. Summary of the 2000 German Bank spawning ground acoustic survey results and SSB biomass estimates from structured surveys. The survey data for August 29 were analysed in two different ways (see text for explanation).

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
German Bank								
Acoustic	August 29	366	-42.426	0.204	28.12	-35.77	74,808	22,338
Acoustic	August 29	166	-38.910	0.425	28.12	-35.77	72,813	11,604
Acoustic	Sept 12	96	-32.401	1.269	28.37	-35.72	121,783	32,959
Acoustic	Sept 27	338	-38.531	0.430	28.20	-35.68	145,273	44,331

Table 6. Summary of SSB estimates from non-structured survey data (i.e. fishing excursions) from German Bank for 2000. Note that the number of fishing excursions examined was greatly reduced from 1999. For dates which were unlikely to affect the overall SSB the standard TS of –35.5 was used.

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
German Bank	Sept 4	0.73	-27.232	6.712		-35.5	4,900	
	Sept 5	0.26	-25.623	9.721		-35.5	2,508	
	Sep 10	2.78	-24.246	13.346		-35.5	37,103	20,495
Fishing	Oct 12	1.13	-29.115	4.351		-35.5	4,912	2,354
	Oct 13	0.86	-25.805	9.322		-35.5	7,890	
	Oct 14	2.70	-28.458	5.3731	28.63	-35.76	14,508	1,218

Table 7. Summary of the minimum observed spawning stock biomass for each of the surveyed spawning grounds in the Bay of Fundy/SW Nova component of the 4WX stock complex. Note that the biomass estimates represent annual observed values and cannot be directly compared from year to year due to variation in the coverage area.

Location	1997 Observed	1998 Observed	1999 Observed	2000 Observed
Scots Bay	160,168	72,473	40,972	106,316
Trinity Ledge	23,000	6,762	3,885	621
German Bank	370,400	440,704	460,823	356,372
Spectacle Buoy	15,000	1,329	0	0
Total	568,500	521,268	505,680	463,309

Table 8. Summary of the 1999 Little Hope/Port Mouton acoustic survey results and mapping SSB biomass estimates. Note the standard TS was corrected to account for a change in frequency from 50 khz to 120 kHz.

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
Little Hope								
Fishing	Oct 1	1.61	-30.403	3.4250		-36.19	5,224	824
Fishing	Oct 2	0.03	-29.26	4.932		-36.19	148	

Table 9. Summary of the 2000 Eastern Passage acoustic survey results and mapping SSB biomass estimates. The group number represents independent aggregations of herring on a given day. Total SSB for the day is obtained by adding the biomass estimates.

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
Eastern Shore								
Group 1	Oct 4	3.86	-47.874	0.058		-35.5	223	96
Group 2	Oct 4	2.47	-39.532	0.395		-35.5	977	
	Oct 6	0.50	-24.456	12.718		-35.5	6,372	
Group 1	Oct 16	0.41	-33.152	1.717		-35.5	706	54
Group 2	Oct 16	0.33	-25.803	9.326		-35.5	3,087	
Group 1	Oct 17	0.86	-30.925	2.868		-35.5	2,466	1003
Group 2	Oct 17	0.23	-26.125	8.661		-35.5	2,027	
Mapping	Oct 17	11.34					6,854	

Table 10. Summary of Bras d’Or Lakes spring 2000 mapping surveys, with biomass estimates and observed percent spring spawners.

Date	Area surveyed	Survey type	Estimate	Fish sample
April 15	Barra Strait to Fiddle Head and Eskasoni	mapping	<100 t	Yes 10.0% spring spawners
April 18	Western Bras d’Or Lake	mapping	<40t	No
April 18	Kellys Cove to Baddeck Bay	mapping	<500 t	Yes 3.1% spring spawners
April 19	Wycocomagh Bay to Kellys Cove	mapping	<500 t	Yes 8.6% spring spawners
April 28	Southern Bras d’Or Lake	mapping	<50t	No

Table 11. Summary of acoustic logging data collected during fishing excursions to the Patch in the spring of 2000. Only two nights of data were analyzed due to the small amount of fish observed.

Location	Date	Area (m2)	Mean Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
Patch								
Fishing	June 8	3.91	-40.535	0.3137		-33.52	1,225	
Fishing	June 19	3.05	-38.633	0.4861		-35.5	1,484	750

Table 12. Summary of the 2000 acoustic survey results by area from the *Alfred Needler* eastern Scotian Shelf Mission (NED2000-58, Nov 2- Nov12). Data are only presented for areas which contained herring (Figure 24).

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
Block Number								
Block 1	Oct 22	327	-51.932	0.013	19.08	-33.1	4,270	2,415
Block 2	Oct 22	442	--42.400	0.179	29.81	-34.9	79,201	42,065
Block 2b	Oct 23	17	-43.395	0.142	29.81	-34.9	2,457	474
Block 6	Oct 26	486	-58.581	0.005	31.46	-35.2	2,206	522

Table 13. Summary of the 2001 winter acoustic surveys conducted off Chebucto Head, N.S. between January 3 and January 5. Vessels involved included the *Margaret Elizabeth* (ME*), Canada 100* (PT) and *Island Pride* (IP).

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
Chebucto Head								
ME	3-Jan	4.09	-23.017	17.31	26.63	-35.35	70,727	26,020
ME	4-Jan	14.26	-27.488	6.18	26.63	-35.35	88,168	14,888
(PT)	4-Jan	8.36	-26.191	8.39	26.63	-35.35	69,842	22,346
ME & PT	4-Jan	23.62	-	6.70	26.80	-35.35	158,000	
ME & IP	5-Jan	55.00	-31.021	2.74	26.63	-35.40	153,743	46,268

Table 14. Summary of acoustic data, fish size and biomass estimates from a herring weir on September 21, 2000.

Location	Date	Area (m2)	Mean Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
Weir 1								
Try 1	Sept 21	101.17		127.43	19.42	-33.52	12.8	0.375
Try 2	Sept 21	131.87		102.04	19.42	-33.52	13.4	0.556

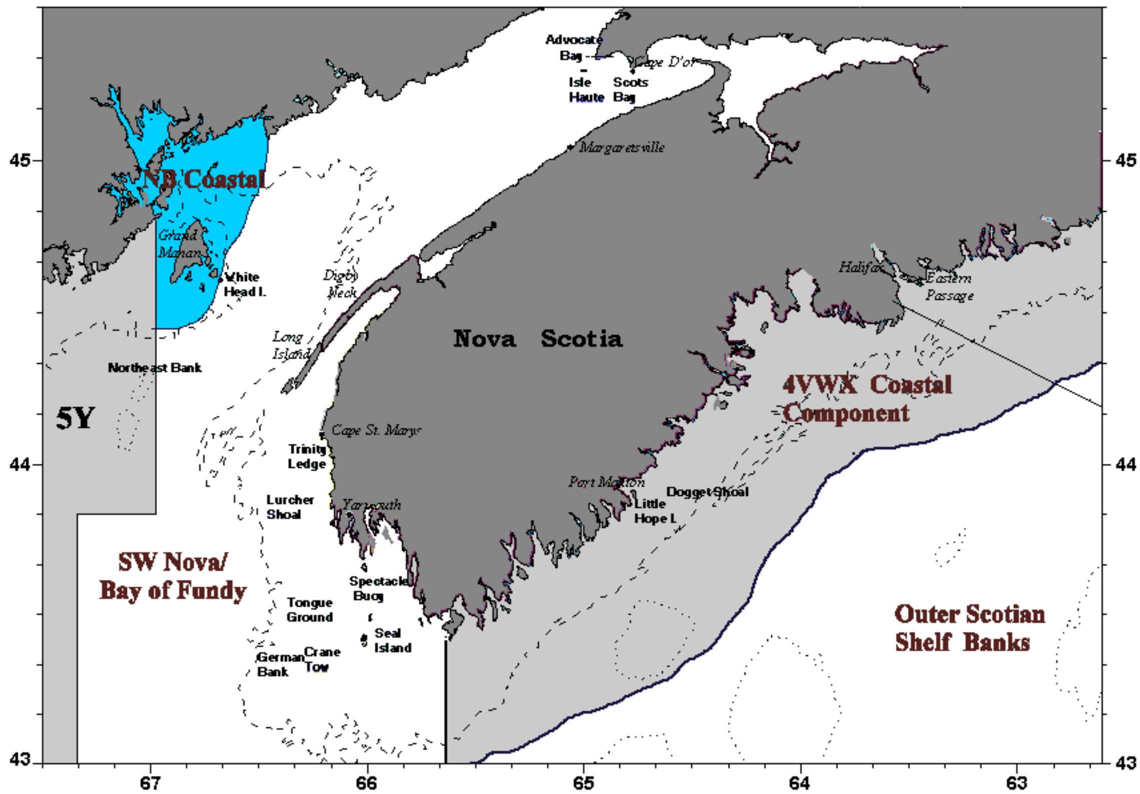

Figure 1. Map of the major spawning areas within the 4WX herring stock complex.

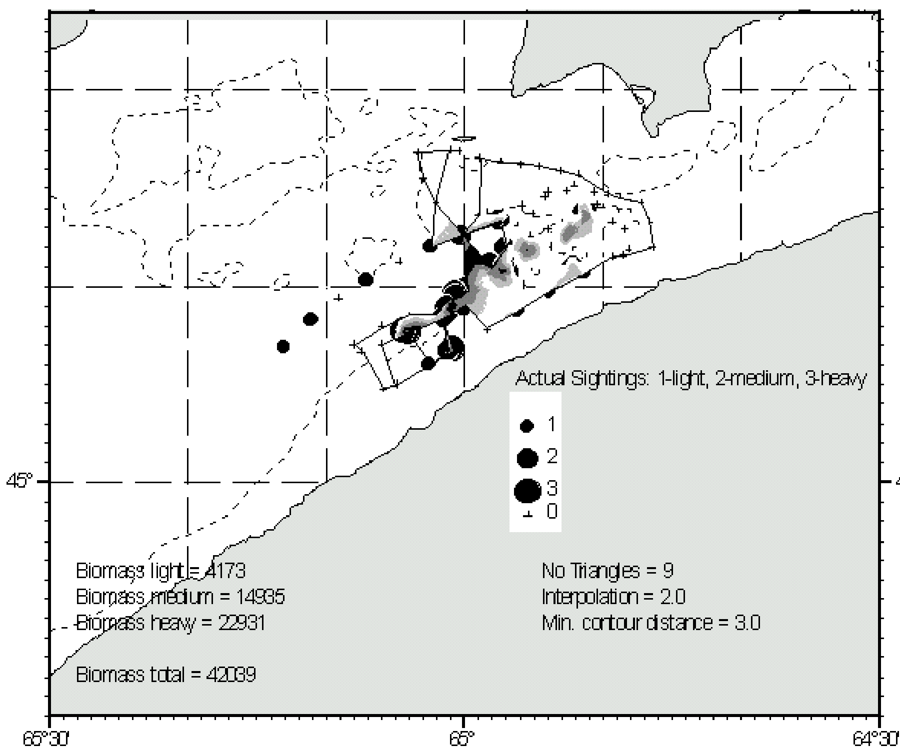

Figure 2. Vessel tracks and distribution of herring for the August 1, 2000 Scots Bay survey. Data for both recording and non-recording vessels are presented.

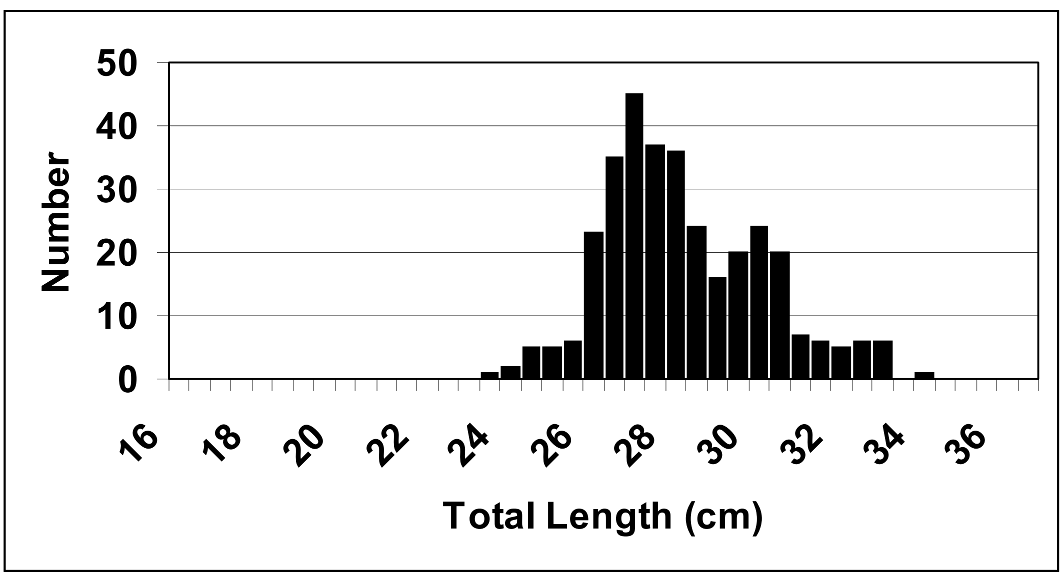

Figure 3. Length frequency distribution of herring sampled in Scots Bay on the night of August 1. Samples were collected from three fishing vessels.

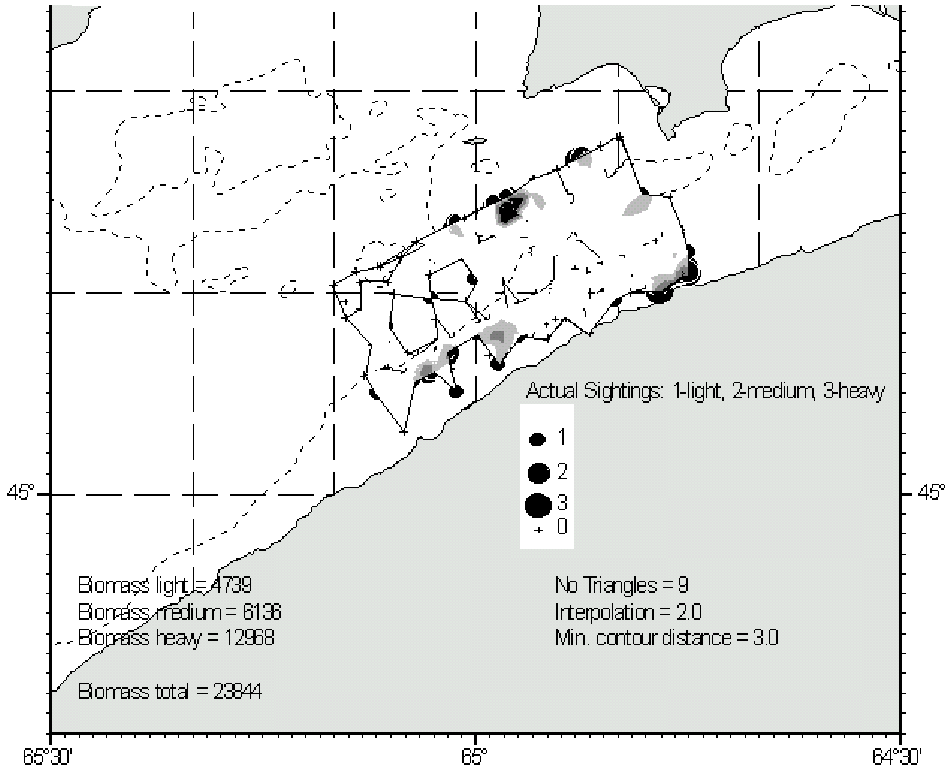

Figure 4. Vessel tracks and distribution of herring for the August 14, 2000 Scots Bay survey. Data for both recording and non-recording vessels are presented.

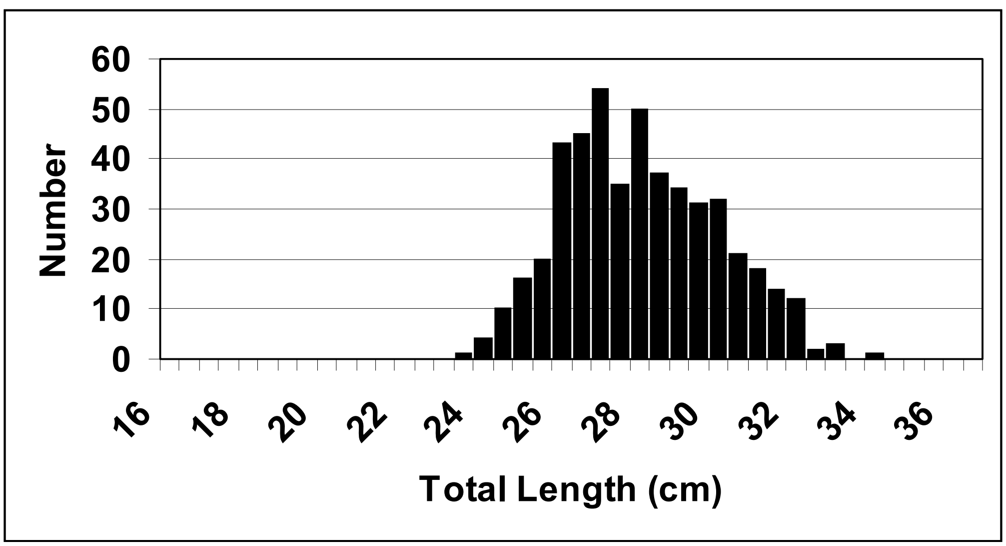

Figure 5. Length frequency distribution of herring sampled in Scots Bay on the night of August 14. Samples were collected from three fishing vessels.

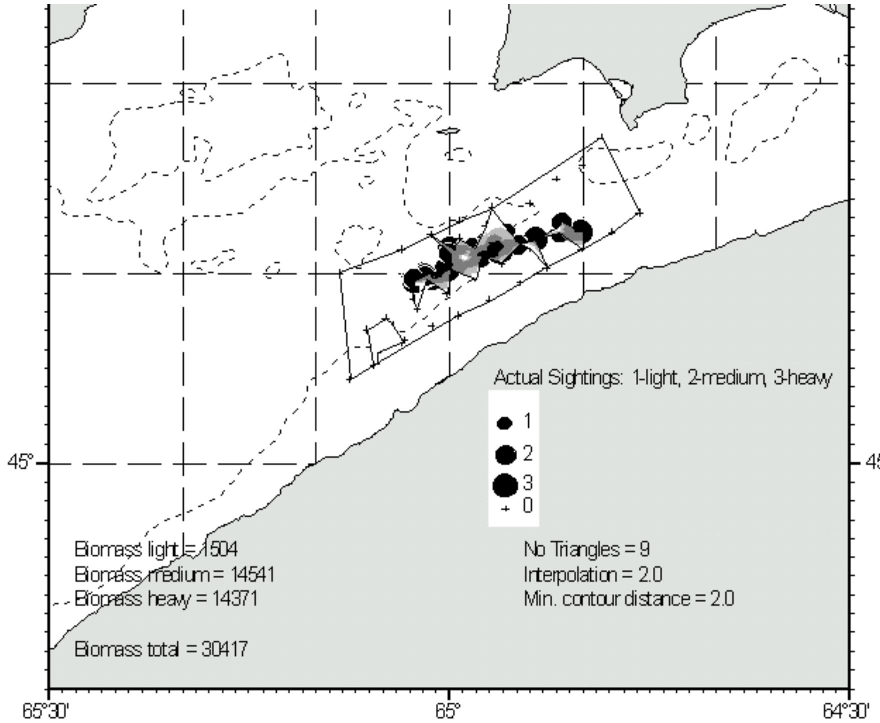

Figure 6. Vessel tracks and distribution of herring for the August 29, 2000 Scots Bay survey. Data for both recording and non-recording vessels are presented.

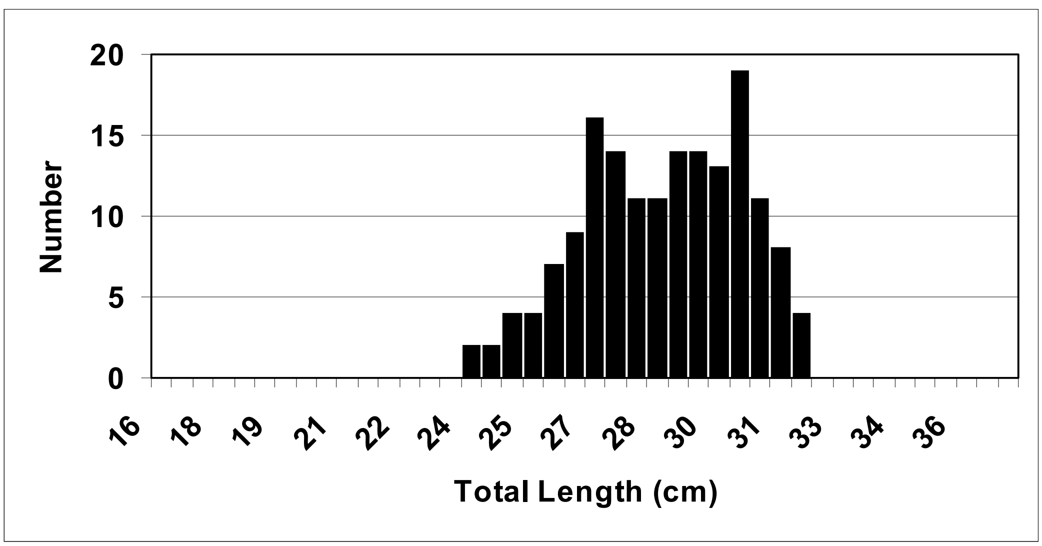

Figure 7. Length frequency distribution of herring sampled in Scots Bay on the night of August 29. Samples were collected from three fishing vessels.

Figure 8. Vessel track for the Trinity Ledge survey on September 12, 2000. Note only data sheets from three of 11 gillnetters and the purse seiner are presented.

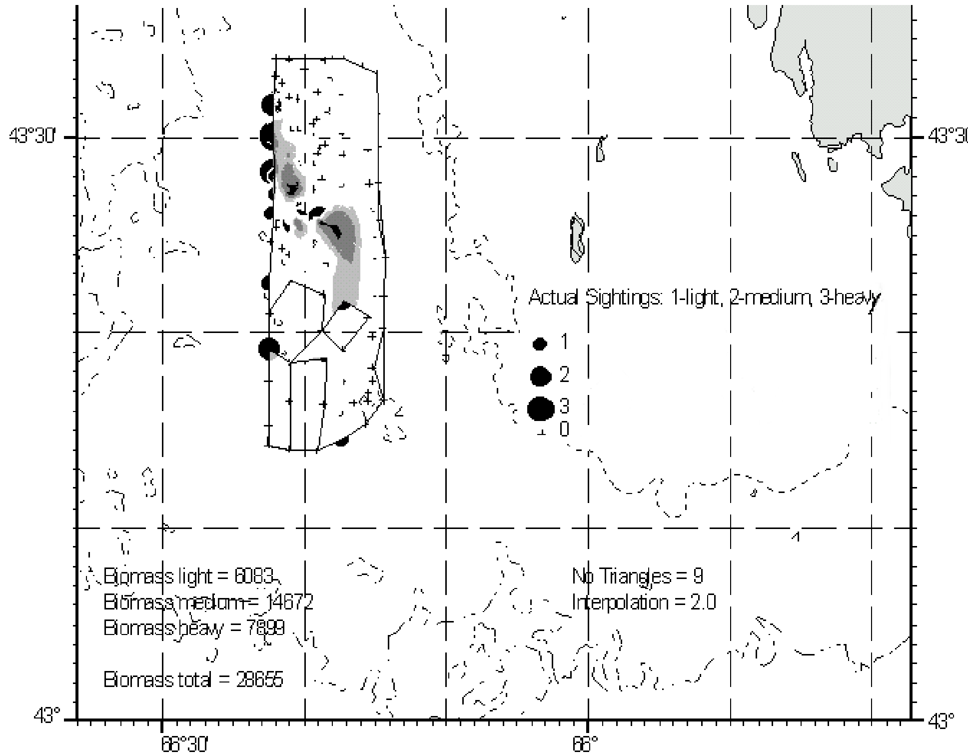

Figure 9. Vessel tracks and distribution of herring for the August 29, 2000 German Bank survey. Data for both recording and non-recording vessels are presented.

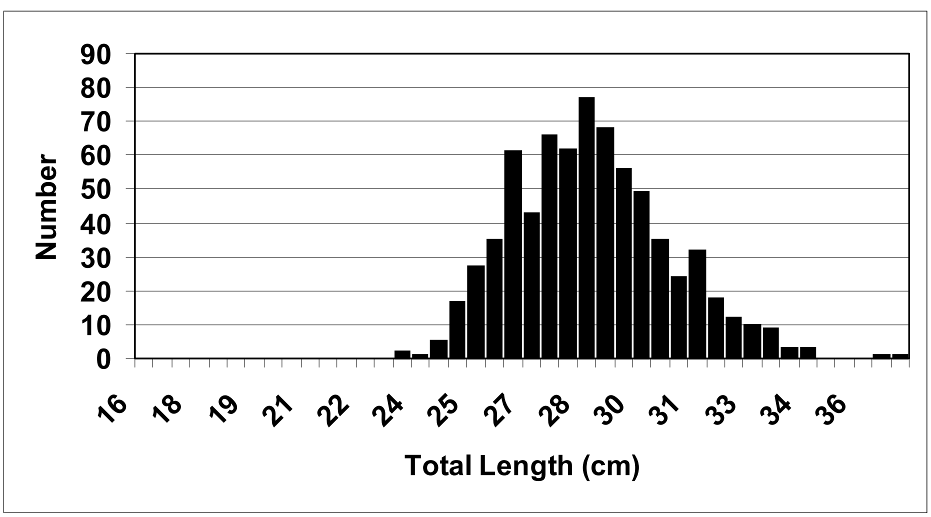

Figure 10. Length frequency distribution of herring sampled from German Bank on the night of August 29. Samples were collected from six fishing vessels.

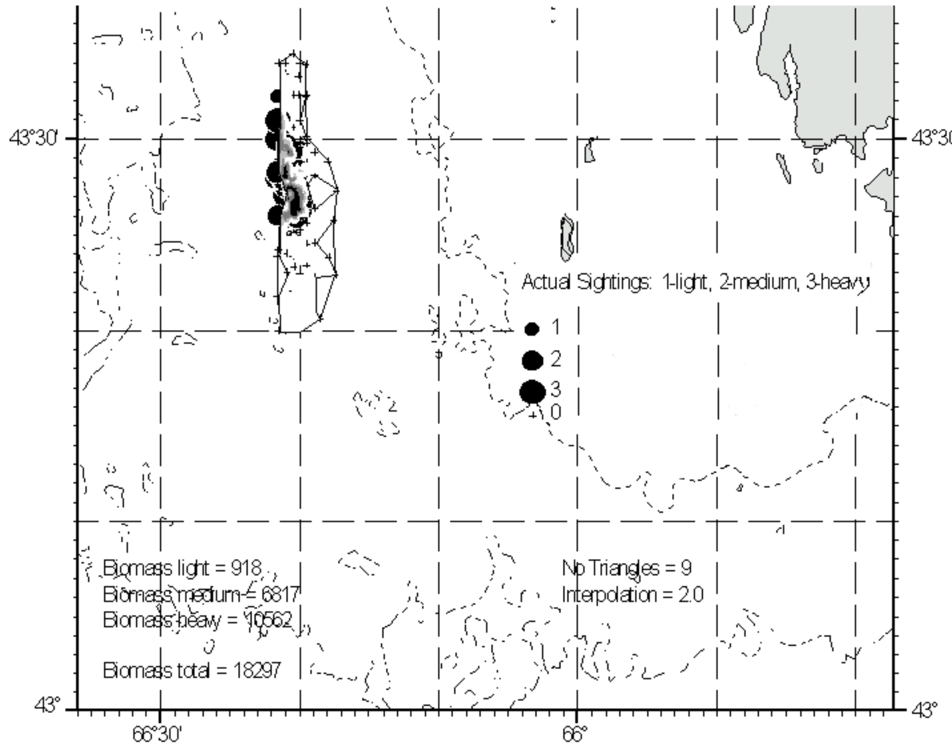

Figure 11. Vessel tracks and distribution of herring for the September 12, 2000 German Bank survey. Data for both recording and non-recording vessels are presented.

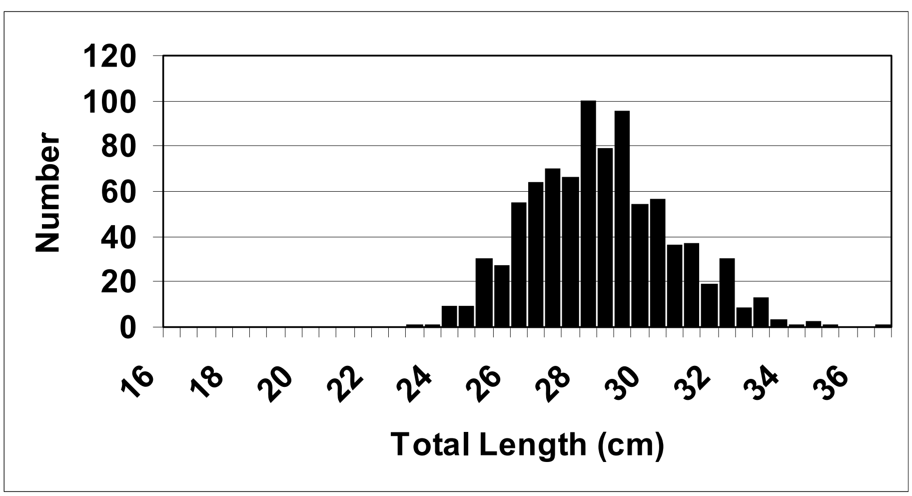

Figure 12. Length frequency distribution of herring sampled from German Bank on the night of September 12. Samples were collected from 2 fishing vessels.

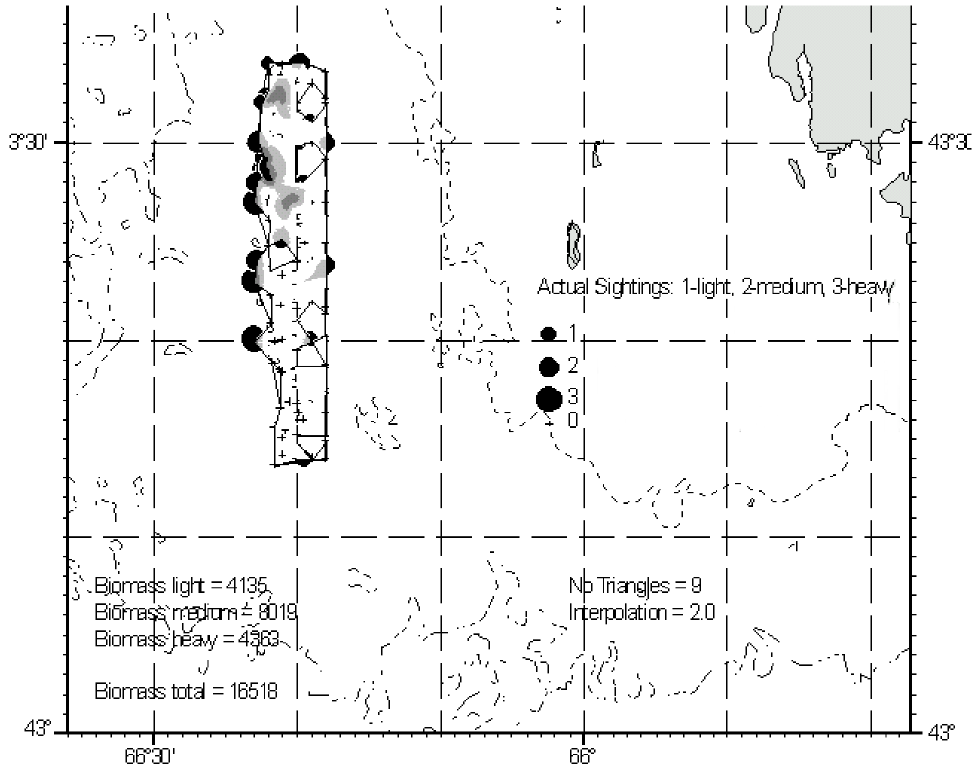

Figure 13. Vessel tracks and distribution of herring for the September 27, 2000 German Bank survey. Data for both recording and non-recording vessels are presented.

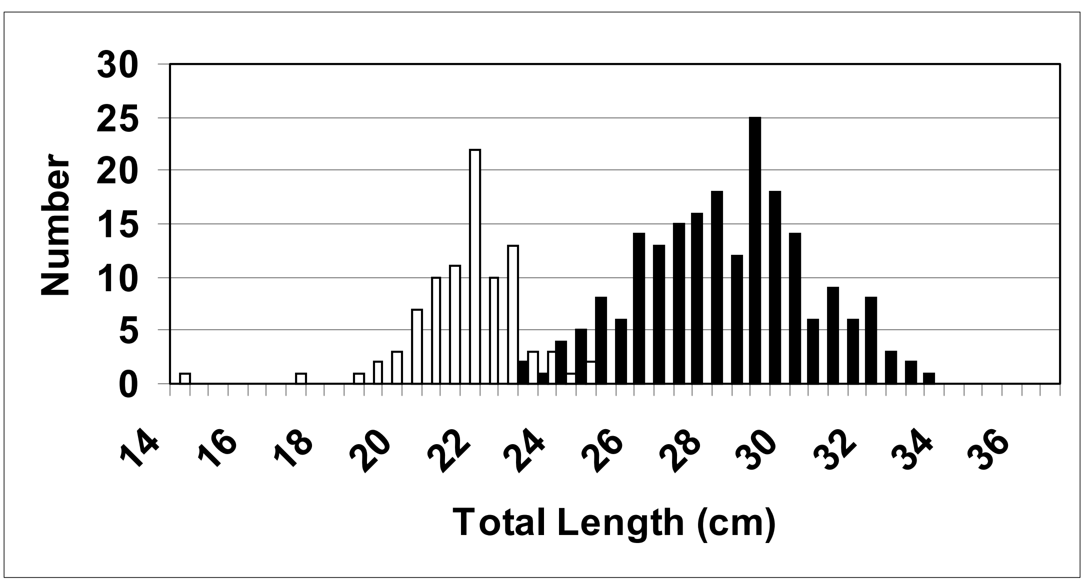

Figure 14. Length frequency distribution of herring sampled from German Bank on the night of September 12. Samples were collected from 7 fishing vessels. Open bars represent non-spawning herring length clases.

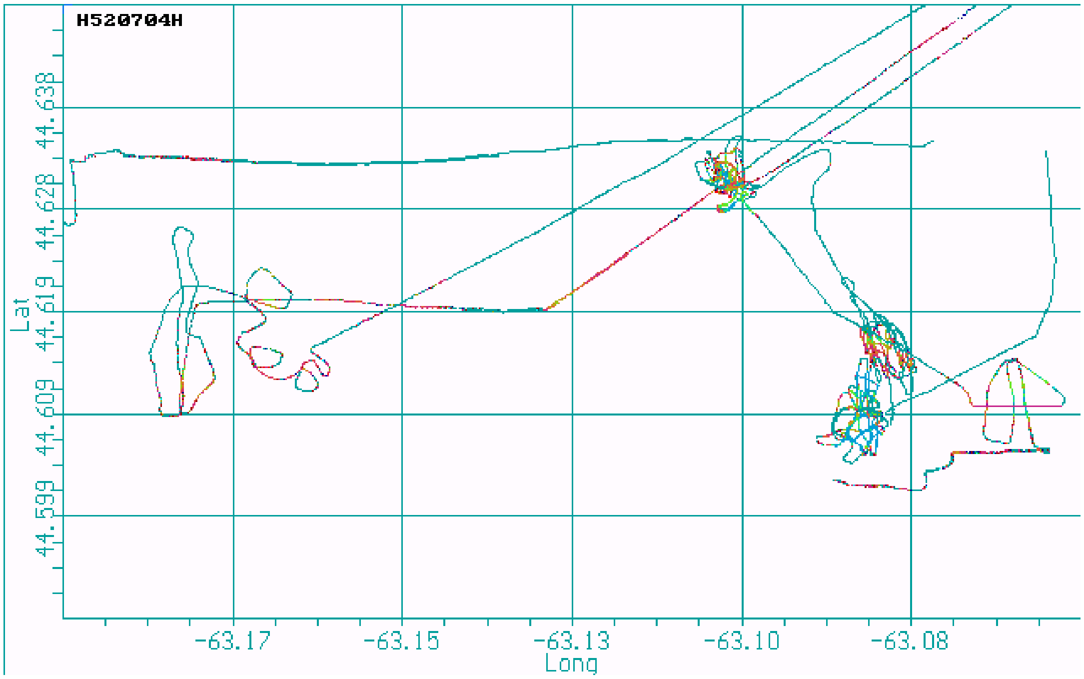

Figure 15. Vessel track of the *Phyllis and Heather* on the nights of October 4,6,16 and 17 combined.

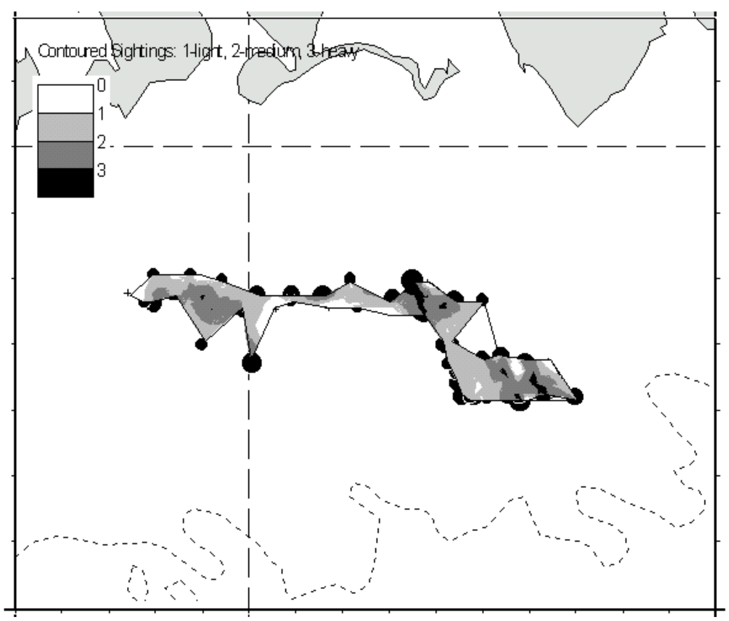

Figure 16. Distribution and abundance of herring observed on the October 17 mapping survey off Eastern Passage.

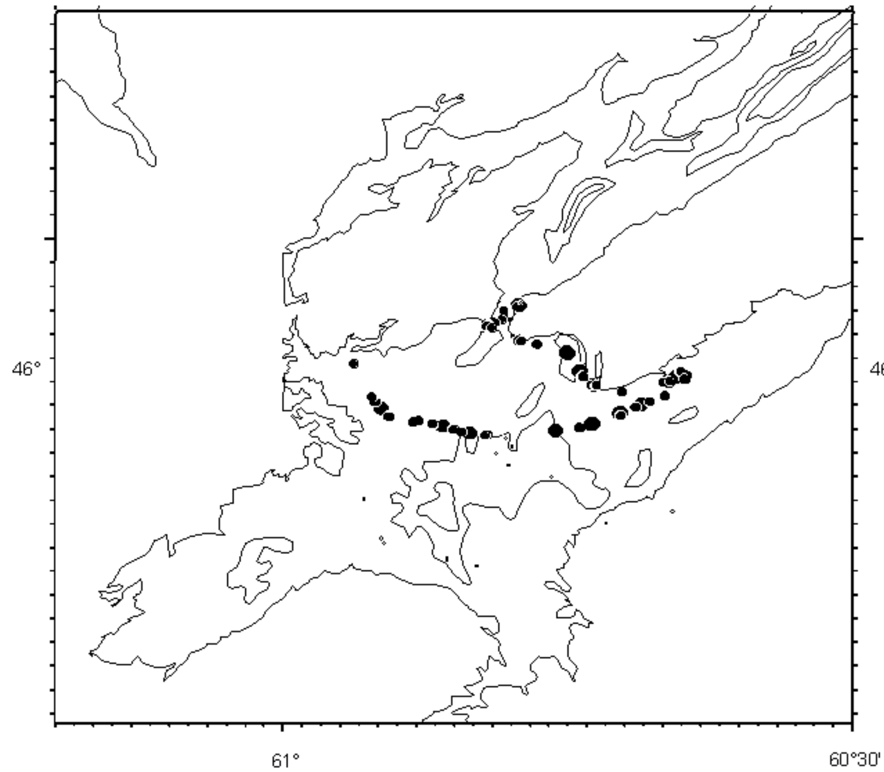

Figure 17. Bras d'Or lakes herring survey – April 15, 2000.

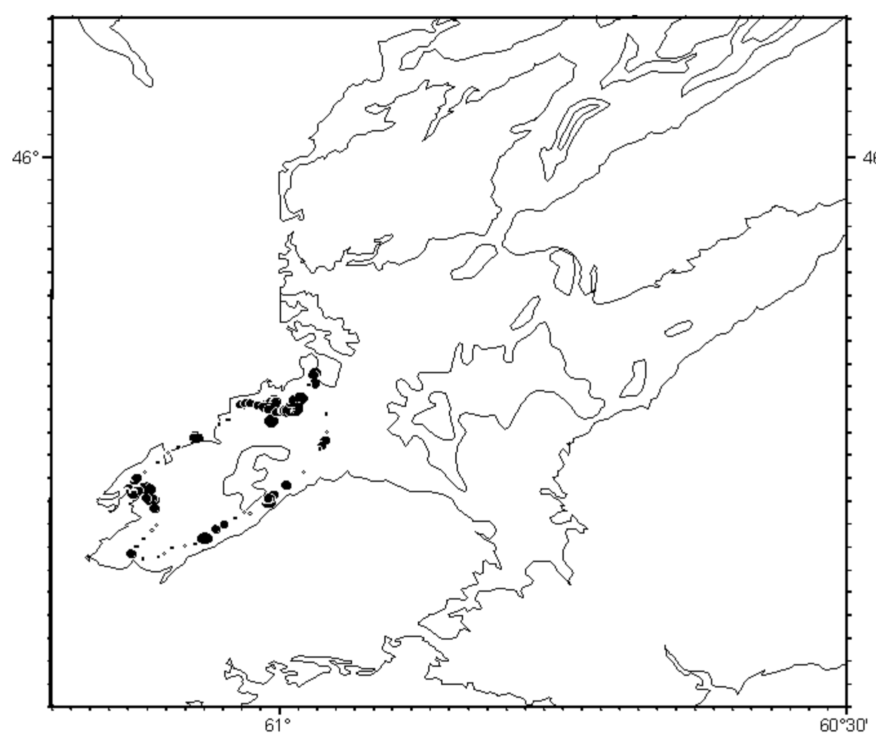

Figure 18. Bras d'Or lakes herring survey – April 18, 2000.

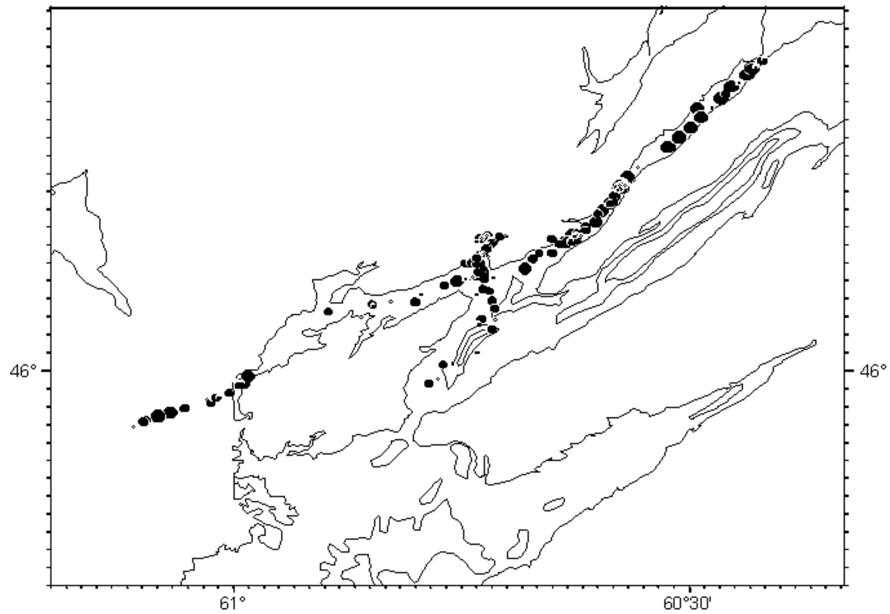

Figure 19. Bras d’Or lakes herring survey – April 18 &19, 2000

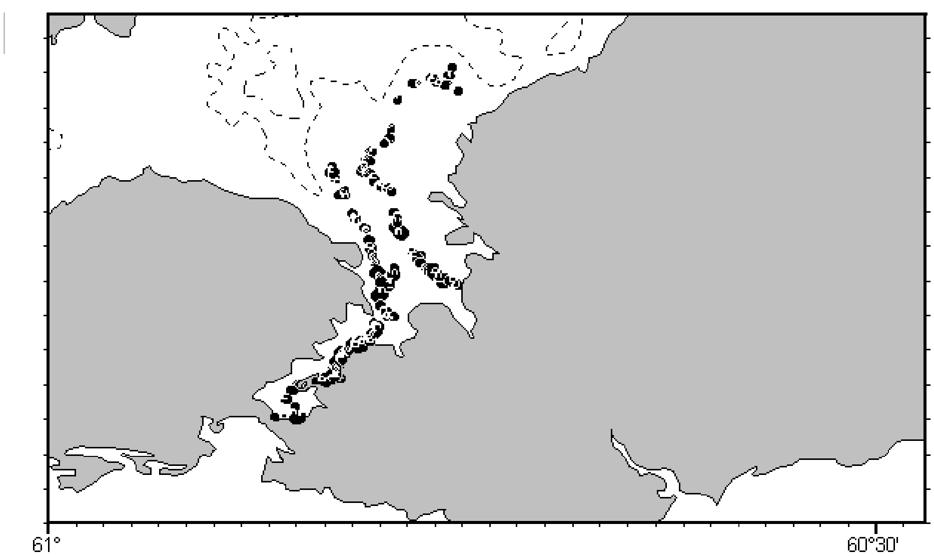

Figure 20. Bras d’Or lakes herring survey – April 28, 2000

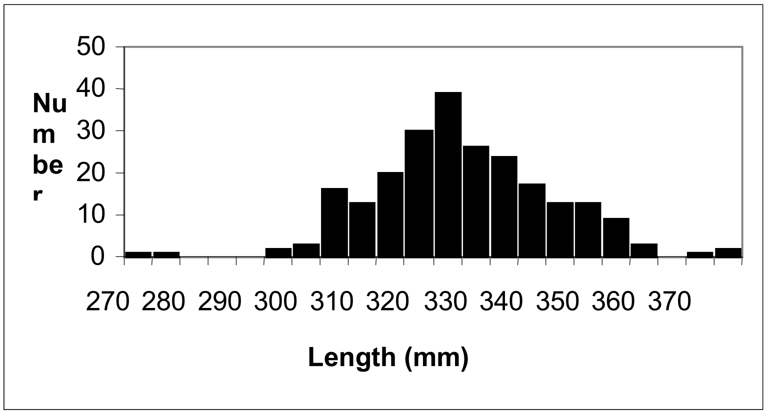

Figure 21. Length frequency of herring sampled from a gillnet on April 15, 2000.

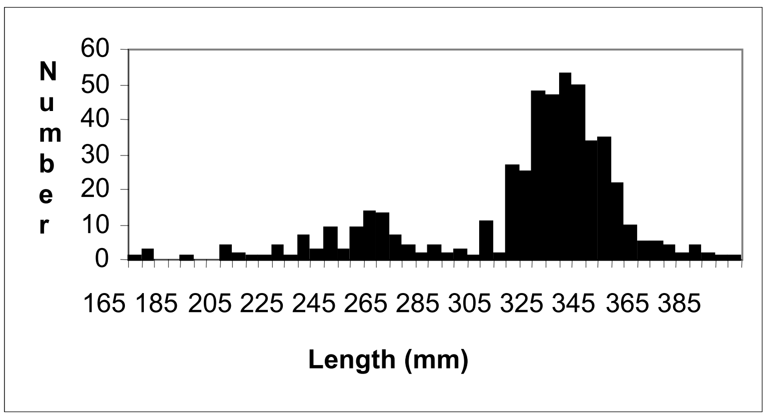

Figure 22. Length frequency of herring samples from a purse seine in the Bras d'Or lakes on April 18 &19th combined.

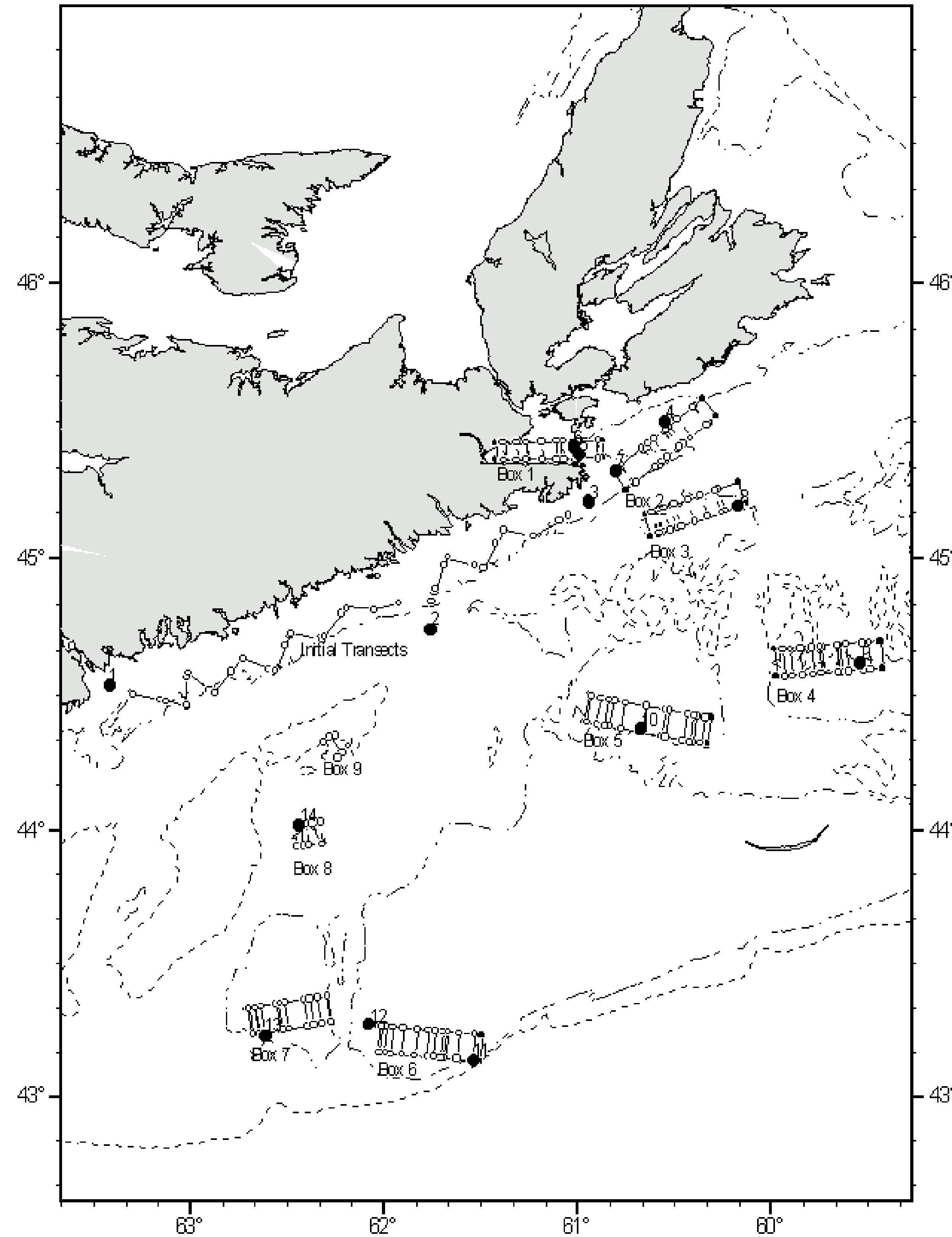

Figure 23. Eastern Scotian Shelf herring survey blocks, acoustic transects, and set locations for the Alfred Needler fall herring survey (Oct 18-29, 2000).

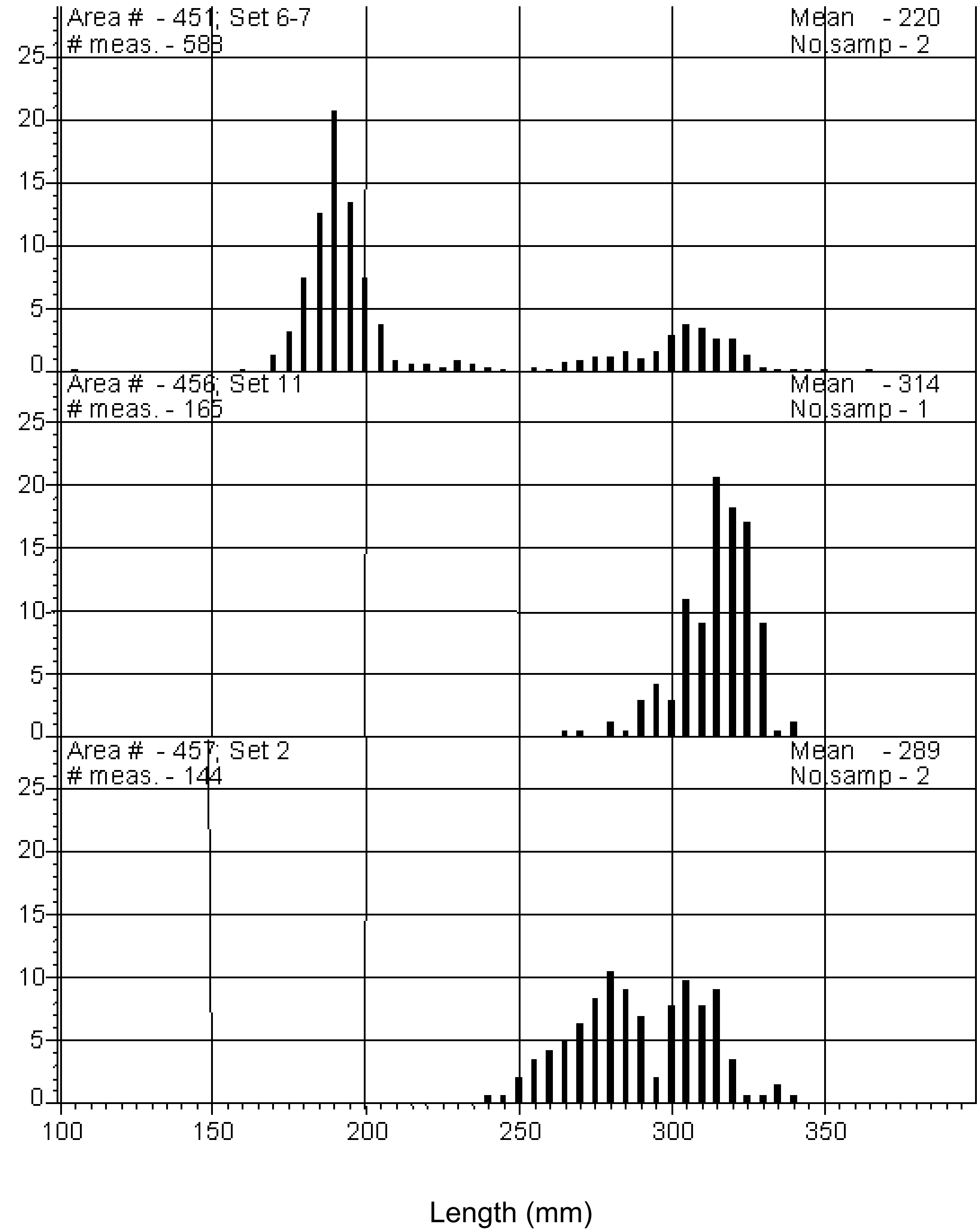

Figure 24. Herring length frequency samples from 4 sets, Country Harbour (set2), Chedabucto Bay (Sets 6-7) and Western Bank (Set 11), collected during the 2000 fall herring survey on the eastern Scotian Shelf.

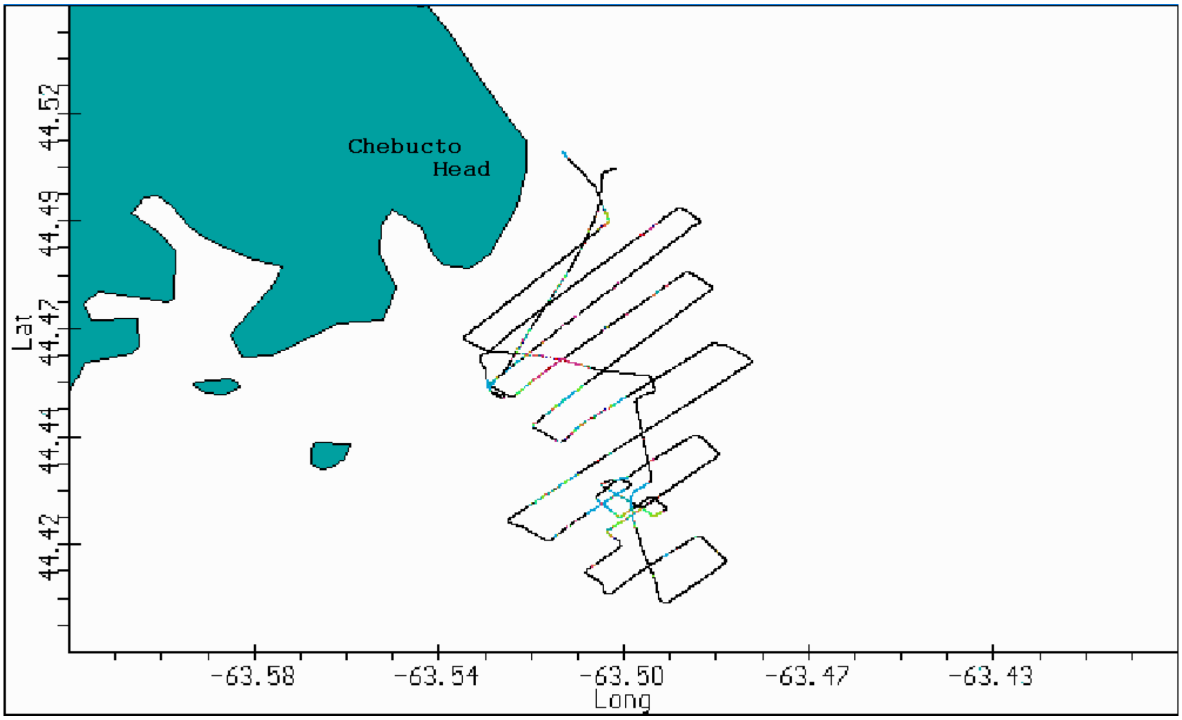

Figure 25. Vessel track of the *Margaret Elizabeth* off Chebucto Head on January 5, 2001.

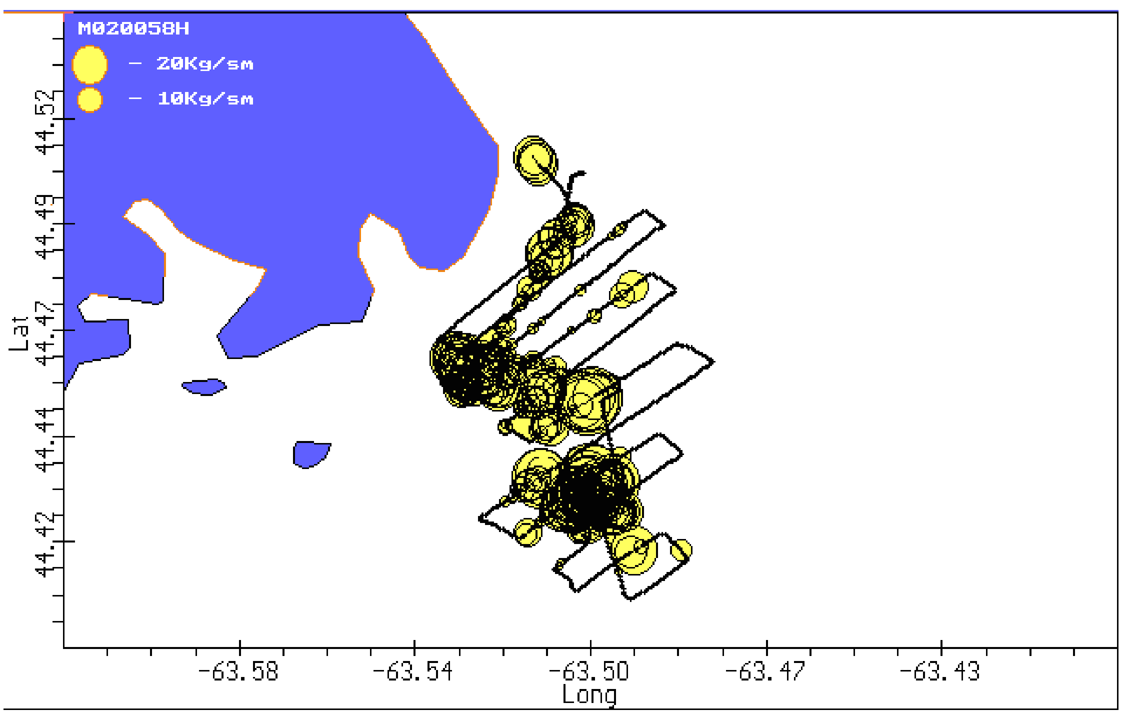

Figure 26. Fish distribution along the vessel track of the Margaret Elizabeth during the January 23, 2000 acoustic survey.

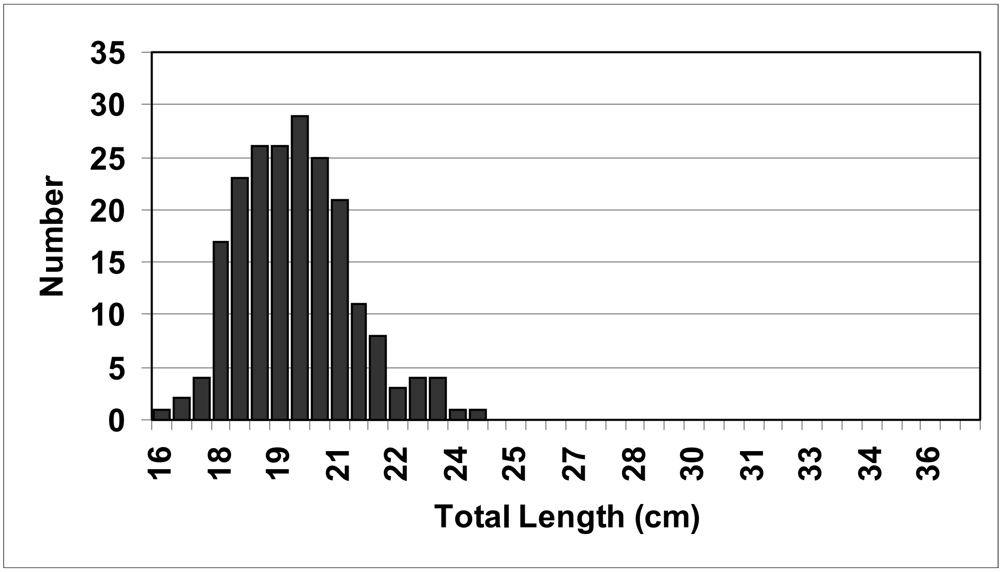

Figure 27. Length frequency of herring samples collected for a weir on Campobello Island during an acoustic experiment September 21, 2000.