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Summary of 1999 herring acoustic surveys in NAFO Divisions 4WX.

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Abstract:

The distribution and abundance of Atlantic herring in NAFO Division 4WX was documented and estimated from data collected by automated acoustic logging systems deployed on five purse seiners and research surveys. As in previous years, the data originated from fishing operations and structured (DFO- directed mapping and acoustic) surveys. The number of recording nights from both fishing excursions (92 to 184) and structured surveys (8 to 29) increased from 1998 to 1999. Adherence to the survey design for structured surveys proposed for the 1999 fishing season was mixed. Approximately 50% of the structured surveys were considered to have met the criteria for a successful/completed survey. Although survey coverage of the main spawning grounds improved, the coverage was not considered adequate for inter-year comparisons. The total biomass for each of the main spawning components was estimated by summing the results of surveys separated by more than 10 days during the spawning season. In 1999, the observed biomass was based almost exclusively on data collected during structured surveys. Biomass estimates for Scots Bay, Trinity Ledge and German Bank were 41,000t, 3,900t, and 460,800t. For the stock complex, the minimum spawning stock biomass estimate was estimated to be 505,700t. Although the minimum SSB's do not directly reflect trends in stock abundance, the decline in observed biomass in Scots Bay and on Trinity Ledge is cause for some concern, given the extent/increase of survey coverage.

Résumé:

La distribution et l'abondance du hareng de l'Atlantique dans les divisions 4WX de l'OPANO sont documentées et estimées d'après les données recueillies par des systèmes automatisés d'enregistrement acoustique installés à bord de cinq sennes coulissantes et navires de recherche. Comme par les années passées, les données ont été recueillies dans le cadre d'opérations de pêche et de relevés structurés (cartographiques et acoustiques dirigés par le MPO). Le nombre de nuits d'enregistrement pendant les sorties de pêche et les relevés structurés a augmenté en 1999 par rapport à 1998, passant de 92 à 184 et de 8 à 29, respectivement. Comme le modèle proposé pour effectuer les relevés structurés lors de la saison de pêche de 1999 n'a pas été appliqué uniformément, on considère qu'à peu près 50 % de ceux-ci satisfont aux critères d'un relevé fructueux/complété. Bien que la couverture des principales frayères soit meilleure, elle n'est pas considérée comme adéquate pour faire des comparaisons interannuelles. On a estimé la biomasse totale de chacun des principaux éléments reproducteurs par addition des résultats des relevés faits à intervalles de plus de 10 jours pendant la période de fraie. Pour 1999, la biomasse observée est basée presque exclusivement sur les données recueillies dans le cadre des relevés structurés. Selon les estimations, la biomasse dans Scots Bay, sur Trinity Ledge et German Bank se chiffrait à 41 000 t, 3 900 t et 460 800 t. Pour le complexe du stock, on estime que la biomasse du stock reproducteur minimale se chiffre à 505 700 t. Bien que celle-ci ne reflète pas directement les tendances dans l'abondance du stock, le déclin de la biomasse observée dans Scots Bay et Trinity Ledge préoccupe quelque peu, étant donné l'étendue et l'élargissement de la couverture des relevés.

Introduction:

Industry based acoustic surveys have become an important component in the 4WX herring stock assessment process over the past several years. Data collected by automated acoustic logging systems during fishing trips and during DFO structured surveys were first incorporated into the 1997 assessment (Melvin *et al*. 1998, Stephenson *et al*. 1997). Efforts by DFO, the fishing industry and two commercial purse seiners resulted in the first industry based spawning stock biomass estimate of German Bank during the fall of 1997. Since then, the herring fleet has undertaken numerous surveys of major and minor spawning grounds, implemented a “survey, assess, then fish” protocol, and had a mechanism for direct quantitative input of their observations into the assessment process. Fleet interest is reflected in the continuing request to increase the number of acoustic recording units on fishing vessels. During 1998 four new HDPS automated logging systems were made available to the fishing fleet through funding from the Pelagic Research Council (PRC). The 1999 spring assessment of the 4WX stock status was based primarily on the biomass estimates of spawning components obtained from the vessel deployed acoustic systems (Anon., 1999; Stephenson *et al*. 1999).

Several recommendations have been made at the Regional Assessment Process (RAP) meetings regarding the application of this technology and the need to move towards standardization of survey design. One of the primary concerns with the current approach is the inability to make inter-year comparisons of the results due to inconsistent survey coverage. Thus, detecting trends in abundance is currently problematic. The biomass estimate represents the minimum observed biomass. This problem was addressed at the 1999 RAP and a survey design which incorporated catch statistics was proposed to overcome this problem (Melvin and Power, 1999). The design was partly implemented in 1999.

The purpose of this report is to describe and summarize the data collected by the acoustic logging systems during the 1999 fishing and survey season. In addition, a status report will be provided on the transition from *ad hoc* to formal structured surveys.

Methods:

Acoustic Systems:

Currently there are six automated acoustic logging systems available for deployment on commercial fishing vessels, the two older systems (FEMTO Electronics Inc., Model 9001) and four new systems (FEMTO Electronics Inc., Model 9320) purchased by the PRC in 1998. Five of these systems are connected to hull mounted transducers on purse seining vessels (“Margaret Elizabeth”, “Island Pride”, “Dual Venture”, “Secord” and the “Leroy & Barry”) and cannot be easily moved. Movement requires connection to the vessel’s electronics and calibration of the ship's transducer. The final system was mounted in a towed body for portability. The portable unit is self contained (i.e. complete with GPS and a generator) and can be deployed from almost any size vessel with a winch capable of supporting 150 kg and a boom to deploy the torpedo.

Surveys:

Data collected and used to estimate minimum observed spawning stock biomass during the 1999 fishing season can be broken down into two types, those collected during standard fishing operations and those obtained from structured (i.e., organized) surveys. The structured surveys can be further subdivided into acoustic or mapping surveys (Melvin *et. al.,* 2000).

<u>Fishing Operations:</u>

The vessel track of standard fishing operations, from which acoustic data are collected, does not follow any standardized survey design, although the captains are increasingly running parallel lines when documenting aggregations of fish as recommended (Melvin and Power, 1999). However, when the area covered in search of fish is of sufficient size and representative lines can be extracted, an estimate of observed biomass can be obtained. This is accomplished by selecting segments of the vessel's track (transects), computing the 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. 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 28.0 cm herring. This represents the lower end of the observed mean spawning lengths and generally translates into smaller biomass estimate.

Transects were generated for fishing operations 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. The average Sa was then computed for a fixed navigation interval (usually 20 navigational fixes) 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 as follows:

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

In the case of fishing operations, where coverage area was generally small, all segments or transects were considered representative of a single stratum. The mean Sa for each transect was used to estimate the mean weighted area backscatter for the stratum, where the data are weighted for the length of the transect. Biomass density per stratum in kg m^{-2} was computed as above (Melvin *et al*., 1999).

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.

<u>Structured Surveys:</u>

Automated acoustic logging systems were used to undertake industry based structured surveys throughout the spawning season. The standard operating procedure for these surveys involved the presence of DFO scientific staff onboard one or more of the vessels to direct the activities. Typically, a random transect protocol was employed in the area of interest with a two-phase survey design (i.e. search then survey). Once an aggregation of fish was located each vessel involved in the survey was assigned a series of transects which they then executed. Biomass estimates were made using the procedure described above for standard fishing operations, except that transects were usually of similar length and selected at random within the pre-defined area of interest. Transect estimates were again weighted for the length of each transect.

In previous years, surveys were undertaken on an *ad hoc* basis and usually at the request of the fishing industry. To overcome this timing uncertainty and to avoid the potential problems associated with elapsed time (ie. >10 days) between surveys, a survey schedule was established through the PRC for the main areas of interest (Appendix 1). The schedule identified the survey area, tentative date and the number of vessels required, including those with automated acoustic recorders. Of the 18 surveys scheduled 16 were completed on or near the tentative dates. Some of the surveys were however undertaken by the using the

DFO research vessel “JL Hart”. In total, 12 scheduled surveys were delayed or canceled due to weather. Table 1 summarizes the areas for which structured surveys were scheduled in advance. Addition surveys were undertaken when required (e.g. Glace Bay, Bras d’Or Lake).

Mapping Surveys:

As in recent years, mapping information was used to define school size in acoustic surveys, and biomass estimated using the area and a relative density category (Table 2). The surveys were conducted from gillnet and purse seine vessels employing their sounders and sonars to document fish abundance and distribution. 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 5-10 min on data sheets which were later categorized into the 3 density values (light, medium or heavy) as in previous years (Melvin *et. al*, 2000; Stephenson *et. al*, 1998).

Table 1. Summary of scheduled and completed herring spawning ground surveys within the 4WX stock complex.

Area	Scheduled	Completed
Scots Bay	4	4
Trinity Ledge	4	2
German Bank	5	4
Eastern Passage	2	1
Port Mouton	1	2*

* One conducted from JLHart

Table 2. 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	

The data were contoured using the ACON graphics 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 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 were multiplied by the appropriate fish density in accordance with Table 2 and summed to get the total biomass survey coverage area.

Results:

During 1999 five hull fixed, and one portable, HDPS automated acoustic logging systems were deployed amongst the herring fleet. Systems were installed and calibrated aboard the fishing vessels *Margaret Elizabeth, Island Pride, Dual Venture, Leroy & Barry* and the *Secord*. The portable system, which uses a transducer mounted in a towed body and is virtually self-contained, was deployed from numerous fishing vessels during the fishing season. Again in 1999 acoustic data were collected from two types of activities, standard fishing excursions and structured surveys.

<u>Fishing Excursions:</u>

Data collected by the automated acoustic logging systems during fishing excursions made up the largest data set that had to be downloaded, archived, edited and analyzed (Figure 1). In 1999, the systems were activated for more than 180 individual fishing nights by the 5 vessels. This represents a doubling in activation nights from the 84 in 1998. Recording time ranged from a few minutes to greater than 10 hours on a given night. However, only 146 nights of recordings were examined in detail and a biomass estimate computed. Reasons for not examining data from the remaining nights include preliminary screening (i.e. no fish, recording of harbor), navigation absent (e.g. unplugged), and logging problems (e.g., interference, loose connection, etc.).

The biomass estimates obtained from each of the vessels by fishing or spawning area are summarized in Tables 3 through 6. Note that these data do not include the nights when the fishing vessels were involved with structured surveys. While the data represent an enormous analytical effort very little is applicable to assessing the stock components. In fact, only one individual night was considered in the overall 4WX minimum spawning stock biomass estimate. The reason is not due to the quality of the data, but due to the biomass, limited area covered by the vessels and overlap with the time period covered by structured surveys. Close examination of the biomass tables shows that the majority of the estimated biomass' are relatively small. More than 90% of recording nights produced biomass estimates from major fishing grounds of less than 25,000 t compared to 69% in 1998 (Figure 2). This is in part a function of the reduced coverage, 89% of all recordings had a coverage area of less than 10 km2 in 1999 compared with 79% in 1998 (Figure 3). It appears that the fish were either easier to catch in 1999 or that the fishing vessels located a group of fish and waited until they moved up in the water column. Biomass estimates from fishing excursions had little influence on the 1999 assessment of the 4WX stock status.

Structured Surveys:

Structured surveys were used to document the distribution and abundance of herring on major spawning grounds and areas of interest or uncertainty. As such these surveys played an important role in our understanding and perception of stock status. Each of the major and several of the minor spawning grounds within 4WX, as well as several non-spawning areas which were surveyed, will be discussed independently.

Scots Bay:

The first spawning ground survey of Scots Bay for 1999 was conducted from the research vessel "J.L. Hart" during the week of July 25. Over a 4 day period the area was surveyed following the proposed survey design with random transects in about one half of the predefined area (Melvin and Power, 1999) and on individual aggregations of fish. Coverage area was limited by the use of a single vessel (J.L. Hart) in the upper Bay of Fundy. Biomass estimates ranged from 22,307 t for the survey area to 175 t for a small aggregation in Advocate Bay (Table 9). The second survey, which occurred on August 10th, covered only a small portion of the pre-defined survey area (Figure 4). Survey effort concentrated on an aggregation of herring (4,800t) located just off Margaretsville. The same school of fish, plus three other schools, were surveyed on the 8th of August by the Secord. The biomass estimate was 8,284 t.

Two additional structured surveys were undertaken in Scots Bay. The first acoustically documented 10,381 t on August 20th, but did not provide complete coverage of the survey area. The second survey, which occurred on September 3 provided complete coverage of the survey area, but found no herring (Figure 5). The 1999 minimum biomass estimate for the Scots Bay spawning group was estimated to be 40,972t. This represents the sum of the July 25, August 20th and September 3rd surveys, plus August 8th fishing results. The latter replaced the August 10th survey because it was the largest of the observations and met the criteria for elapsed time. Further work is required on implementing the survey design before biomass estimates can be compared between years.

Trinity Ledge:

Two surveys were conducted on Trinity Ledge during the 1999 spawning season, one acoustic and one mapping (Table 10). The initial survey was undertaken by two purse seiners and covered the entire recommended survey area. Unfortunately, no fish were detected on the random transects. Sonar however revealed a small aggregation (0.4 km^2) which was passed over once and the mean Sa value of the single transect through the fish used to estimate biomass (1,875t). The second survey involved mapping coverage of the recommended survey area (Figure 6). Again the herring were found in a small area just north of the ledge. The September 9th biomass estimate was 2,010 t giving a total for 1999 of 3,885t.

German Bank:

The 1999 SSB estimate for German Bank was based on the results of five structured surveys, 4 acoustic and 1 mapping, separated by a minimum of 10 days (Table 11). The first survey of spawning fish on German was conducted on the night of August 27 and covered the primary stratum within the pre-defined survey area. Six vessels participated in the survey, 3 with logging equipment and 3 without. Transect data from the three recording vessels were combined to produce a biomass estimate of 191,496t for the bank (Table 11). This survey represents an example of how a survey should be undertaken and followed survey design protocol (Figure 7).

The second survey was conducted on September 10 and shows how the adherence to survey design slowly began to break down. Essentially what occurred was that while several of the vessels without automated acoustic logging systems completed their assigned transects, the recording vessels broke off their line as soon as the fish disappeared. This resulted in incomplete transects for the coverage area. Consequently, the biomass was estimated for only a fraction (198km2) of coverage area Table 11) and overlapped two strata (Figure 8). If it is assumed that the unlogged area contained no herring, confirmed from mapping data, then the biomass estimate could be considered representative of German

Bank and can be used in an annual comparison where Stratum 1 contained 159,564t and Stratum 3 contained 23,043t.

On September 25 another survey of German Bank was undertaken in weather that was too rough to fish. Echograms from the vessel were broken up and the estimated biomass estimate is considered low due to loss of signal. In addition, the vessels did not adhere to a survey plan. It appears from examination of the vessel's track that once they located the fish, the vessel with the acoustic logging equipment concentrated on the fish, not following a transect pattern. Furthermore, the vessel did not proceed far enough south to complete the transects. This resulted in the missing of fish documented by the other vessels. The biomass estimate of 82,789t was based only on the area where fish were observed by the acoustic recording vessel, plus 3.3 km^2, at mean the density observed by the recording vessel and known to have been missed by the recording vessels (Table11). These data are the poorest to date and cannot be reliably used for future comparisons.

The final two surveys of German Bank took place on October 2 for the structured survey and October 8 for the mapping survey (Table 11). Given that insufficient time had elapsed between the two surveys only one is considered valid. Therefore, the October mapping estimate of 3,900 was taken as an estimate for the part of the spawning season. The survey results are however not comparable with the other data in that the vessel concentrated on a single aggregation a small area (9.26km2).

Spectacle Buoy:

The early summer Spectacle Buoy spawning fish fishery is relatively new, commencing about 3 years ago with the reactivation of the gillnet fishing fleet. Effort declined in 1999 and although two surveys were scheduled, no surveys were undertaken during the fishing season. The first survey was canceled once due to bad weather (June 26) and the second due to the absence of fish (July 5). Consequently, no biomass estimate was available for the area.

Bay of Fundy/SW Nova (Summary):

Although the minimum spawning stock biomass, estimated for any given year, can not be directly compared with the estimate from another year, or used as an index of abundance due to variation in coverage, the estimates do provide an estimate of the minimum observed biomass on each of the surveyed spawning grounds (Table 12). In 1999, it was estimated that the SSB exceeded 500,000t, how much it exceeded this value is unknown. It is also apparent that the minimum observed SSB in Scots Bay and on Trinity Ledge has declined in the last three years. Given the extent of surveying in Scots Bay in 1999 this should raise some concern. Surveying on Trinity Ledge was limited.

Nova Scotia Coastal Spawning Component

Along the Atlantic coast of Nova Scotia there are, or have been, numerous reports of spawning in the shallow inshore waters of the bays and inlets. Our knowledge of these relatively small populations is limited. In recent years roe fisheries have developed on individual spawning grounds that have made it possible to survey a few of the spawning areas. In particular, surveys were undertaken near Little Hope, Eastern Passage, Glace Bay and in the Bras d'Or lakes. Survey results for each of these are discussed individually below.

<u>Little Hope:</u>

Two surveys were conducted near Little Hope/Port Mouton in 1999 (Table 13). The first survey was a mapping exercise and occurred on September 26. The area off Port Mouton was surveyed with approximately 20 gillnet vessels. The biomass estimate based on contour area of observed fish concentrations was 6,150t (Figure 9). Seven days later the JL Hart covered the same general area using a series of transects and the portable acoustic system (Figure 10). No sampling was undertaken in the area and the standard target strength of –35.5 was used for biomass estimation. The estimated biomass was15,834t (Table 13). Since insufficient time had elapsed between surveys only the latter biomass was considered to reflect the SSB for this area. The 1999 observed biomass was estimated to be 15,834t.

<u>Eastern Passage:</u>

The area around Eastern Passage has been surveyed over the last three years through the cooperation of the Eastern Passage Fishermens Association. This year three surveys were undertaken in area, one acoustic on October 4 and two mapping surveys on October 2 and October 10 (Table 14). Another survey was scheduled for October 22nd but was canceled due to poor weather and the absence of fish. The initial survey of October 4 (Figure 11 & 12) provided the largest biomass estimate and the widest fish distribution of the three surveys. The acoustic survey of October found herring in only a small area (0.3 km^2). Since the fishery used gillnets, which are known to be size selective, the biomass estimate was based on the standard TS of –35.5. and produced an estimate of 4,658t. On October 10 the mapping survey found that the fish were concentrated in two locations, one near Eastern Passage and the other off Jeddore (Figure13). All surveys fell within a 10 day window therefore the maximum observed spawning biomass of 20, 226t was assigned to the spawning group.

Glace Bay:

In September of 1999 a mapping survey was conducted in the vicinity of Glace Bay at the request of local fishers' association. The survey covered a small spawning group of herring estimated to contain 2,000t (Table 15, Figure 14). An acoustic survey was scheduled for October 12 was canceled due to bad weather.

Bras d'Or Lakes:

A number of surveys were conducted the in Bras d'Or Lakes during the 1999 spring spawning season (Table 16). Of the five surveys only one utilized the portable logging system and produced a quantitative acoustic survey. Biomass estimates ranged from 15 to 270 t depending on the night. The acoustic survey documented only 15t. Biomass estimates from the mapping surveys of April 8 and April 14 were combined, because they occurred in different areas of the lakes, to produce a total SSB of 530t (Figure 15).

Offshore Scotian Shelf Component:

Structured surveys on the Scotian were limited during the 1999 fishing season. On the night of June 10, seven vessels (3 with logging systems) undertook a survey of the Patch, the primary location of the spring offshore fishery (Figure 16). The data were then analyzed, with independent estimates of biomass, for a mapping survey and for a acoustic survey (Table 17). Comparison of these results shows similar biomass estimates (24,670 and 22,427t for the mapping and acoustic surveys, respectively).

The second set of data related to the offshore banks are the results of the Alfred Needler's fall survey during which a number of the potential spawning banks were examined. The results from the individual banks and some inshore grounds are summarized in Table 18 and graphically displayed in Figure 17. Biomass estimates for the surveyed offshore locations ranged from 0 t on Emerald Bank to 1,556t on the MacKenzie Spot. The largest biomass observed during the survey occurred just east of Canso in the vicinity of the traditional 4WX over-wintering area (Figure 17).

Chebucto Head (January 2000):

Over the past several years fishermen have reported the presence of large aggregations of herring off Chebucto Head during the winter months. A research program was implemented in January of 1999 to investigate the abundance and movement of this group of herring. During a three day period, more than 10,000 herring were tagged and a biomass of herring greater than 400,000t was observed. All surveying was conducted from two herring seiners, one with an automated acoustic logging system and the other equipped with the portable system.

Tagging returns during the 1999 fishing season found that some of the fish originated from spawning areas in Southwest Nova, but the returns did not provide any 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. For 2000, it was 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 at a rate of 100 t/night to a maximum of 1,000t. No fish could be retained until a minimum of 100,000t of herring had been observed and a minimum 10,000 fish had been tagged. In addition, if more than 100,000 t of fish were observed the seiner fleet could remove 1% to a maximum of 5,000 t.

Over a three week period in January of 2000 five estimates of fish biomass, which ranged from 25,000-103,000 t, were made (Table 18). Figure 18 displays the vessel track and the transects used to estimate biomass on the night of January 23rd. The turnover time from data collection to biomass estimate was 20-36 hours. Based on the observed biomass of 103,000t only 1,000 t of herring were removed from the area.

Weir Study:

Whenever acoustic results are used as estimates of absolute biomass, the question of how accurate are the acoustic biomass estimates arises. During acoustic surveys users of this technology do not have the opportunity to survey a known quantity of fish. Herring weirs however provide an ideal experimental area where the fish are alive and actively swimming in schools. Furthermore, the fish are later removed and weighed in the processing plant providing a true estimate of absolute biomass.

During the fall of 1999 we were provided with an opportunity to undertake an acoustic survey of herring confined in a weir. On September 14 an experiment setup to measure the acoustic backscatter of herring within a weir using the SM2000 multi-beam sonar and the single beam 50 kHz transducer normally contained within the towed body. The initial survey plan was to establish a series of transects to estimate fish biomass within the weir. Unfortunately, it soon became apparent that due to water clarity many fish simply moved away from the surface towed transducers. In addition, it was discovered that the GPS unit needed a receiver amplifier if transects were to be run across the entire width of the weir. Alternatively, the transducers were placed in a fixed position within the weir and the fish allowed to come to the unit. Herring characteristically swim in schools around and around in a weir. Therefore, logging acoustic data over time provided an estimate of mean backscatter or density of fish in the weir. The multi-beam sonar was used to determine when the fish were not obviously avoiding the floating unit. The HDPS logging was then activated for 20 minutes to record the fish as they passed under the transducer. Later the same evening the herring were seined from the weir and pumped aboard a carrier vessel. Biological samples were collected after the fish were transported to the processing plant (Figure 19) and the purchase slip weight, converted from hogshead to tonnes, used as the absolute biomass. Absolute biomass was unknown until the analysis was complete.

Unlike transect data where Sa estimates are weighted by distance, the mean area backscatter was computed from the individual pings (1/sec) over a 20 min time interval. The mean area backscatter was then converted to biomass using the Foote equation to estimate the target strength of herring sampled from the catch and the observed fish density (Table 20). Based on a measured area of 1603 m^2 and a density of 52.69 kg/m2 the acoustic estimate of biomass was 84.462 t. The purchase slip tonnage was 78.75t, a 7.2% difference. While the results of this experiment are encouraging they are based on a single event. Further work in this area is proposed for the 2000 fishing season.

Discussion:

Acoustic surveys were undertaken on the major and some minor 4WX spawning components to provide a minimum estimate of SSB for the stock complex as in 1998. The majority of the surveys were conducted from commercial fishing vessels using the automated acoustic logging systems deployed amongst the fleet. Unlike previous in years, more attention was paid to undertaking structured surveys on a regular schedule. On only one occasion was the estimate obtained from a nights fishing excursion considered in establishing the SSB. This occurred on the night of August 8 in Scots Bay. In addition, a survey design protocol was developed for three of the major spawning grounds and partially implemented during the 1999 season.

Adherence to the survey protocol established for each of the main spawning components depended upon the survey and ranged from very good to very poor. The primary problems resulted from not completing defined transects, or the concentration of the recording vessels on transects known to contain fish, or both.

In the first case no information was obtained about the area which was un-surveyed, thus the area of coverage was reduced. Concentrating recording vessels on only those areas where fish formed large aggregation provide no information on density estimates elsewhere. Again the coverage area was reduced.

In 1999 commercial fishing vessels collected acoustic data on herring abundance and distribution during fishing excursions and scheduled (i.e. structured) surveys. Over the year there were more structured surveys in the Bay of Fundy and southwest Nova Scotia due to the implementation of a survey schedule. However, the quality of the surveys in terms of following protocol, completing defined transects and surveying during reasonable weather declined. The main problem was that survey vessels would deviate from their assigned transects or the logging vessels would concentrate their effort on transects which contained fish, thereby not obtaining a representative sample of the strata. Overall, approximately 50% of the surveys met the criteria for a valid survey covering the predefined survey area. Improvement in survey implementation is required before the SSB, obtained from commercial fishing vessels can be used to investigate changes in abundance.

Vessels participating in the structured surveys were compensated at a return rate of 100t/vessel night in 1999. The 100t was initially removed from the individual boat quota and only returned for taking part in a survey. Unfortunately, this led to participation by vessels simply to get their 100 t returned. In several cases the objective was to get the survey over as quickly as possible and cover a minimum distance. As well, surveys were undertaken on nights when the weather conditions were less than desirable just to get the survey completed. This had several effects. First of all there was breakup of the acoustic signal from the sounders, thus reducing the observed biomass. Secondly, it was usually too rough to fish, and samples could not collected to estimate TS. Samples from another night (usually 1-2 days before or after) and from the same location had used to estimate size. Finally, the rough weather make many uncomfortable (i.e., both boat and scientific crew) thereby encouraging termination of the survey as soon as possible. It is recommended that future surveys use the rule of thumb that if it is too rough to fish it is too rough to survey. This will overcome many of the weather related problems.

In general, there has been an improvement in the overall approach to surveys. Prior to 1999 data collected during fishing excursion make a significant contribution to the SSB estimates. This year more effort was put into conducting of structured surveys following a specific survey design. The main problem was non-adherence to the protocol for one reason or another. In all about 50 % of the surveys can be used for inter-year comparisons. Improvements are required if we are to use the SSB's as an index of abundance in future years.

Unfortunately, the 1999 minimum SSB for the Bay of Fundy/Southwest Nova component of the 4WX stock complex cannot be compared directly with previous years due to variation in coverage. It does however provide a minimum estimate of the observed biomass on the spawning grounds surveyed. In this context, it is apparent that while the numbers on German Bank appear to be increasing, the biomass estimates for Scots Bay and Trinity Ledge have declined dramatically. In 1998, the reduction in observed biomass from Scots Bay was assumed to be due to the absence of surveys during the peak spawning period. In 1999 survey effort increased, yet the observed biomass decreased. Survey effort on Trinity Ledge was down from 1998. Given these observations a "fish with caution" during spawning season approach should be implemented for the 2000 fishing in Scots Bay and on Trinity Ledge.

References

Anon. 1999. 4VWX and 5Z Herring. DFO Science Stock Status Report, B3-05 (1999): 15p.

Black, G. 2000. ACON Data Visualization Software Version 8.29. Department of Fisheries and Oceans, Halifax, N.S. www.mar.dfo-mpo.gc.ca/science/acon

Foote, K.G. 1987. Fish target strengths for use in echo integrator surveys. J. Acoust. Soc. Am. 82: 981-987.

Harris, L.E., and R.L. Stephenson. 1999. Compilation of available information regarding the Scotian Shelf herring spawning component. DFO Canadian Stock Assessment Secretariat Res. Doc. 99/181: 30p.

Melvin, G.D., K.J. Clark, F.J. Fife, M.J. Power, S.D. Paul and R.L. Stephenson. 1998. Quantitative acoustic surveys of 4WX herring in 1997. Canadian Stock Assessment Secretariat Res. Doc. 98/81: 25p.

Melvin, G.D. and M.J. Power. 1999. A proposed acoustic survey design for the 4WX herring spawning components. DFO Canadian Stock Assessment Secretariat Res. Doc. 99/63: 15p.

Melvin, G.D., T. Scheidl, F.J. Fife, M.J. Power, S. Boates, K.J. Clark, and R.L. Stephenson. 1999. Evaluation of the 1998 4WX herring acoustic surveys. 1999. DFO Canadian Stock Assessment Secretariat Res. Doc. 99/180: 32p.

Melvin, G.D., R.L. Stephenson, M.J. Power, F.J. Fife, and K.J. Clark. 2000. Industry acoustic surveys as a basis for in-season decisions in a co-management regime. Proceedings of the Herring 2000 Symposium, Anchorage, Alaska. (In press): 14p.

Stephenson, R.L., M.J. Power, F.J. Fife, G.D. Melvin, and S.D. Paul. 1997. 1997 Evaluation of the stock status of 4WX herring. DFO Atlantic Fish. Res. Doc. 97/61: 28p.

Stephenson, R.L., M.J. Power, K.J. Clark, G.D. Melvin, F.J. Fife and S.D. Paul. 1998. 1998 evaluation of 4VWX herring. DFO Canadian Stock Assessment Secretariat Res. Doc. 98/52: 58p.

Stephenson, R.L., M.J. Power, K.J. Clark, G.D. Melvin, F.J. Fife, S.D. Paul, L.E. Harris, and S. Boates. 1999. 1999 evaluation of 4VWX herring. DFO Canadian Stock Assessment Secretariat Res. Doc. 99/64: 85p

Stephenson, R.L., M.J. Power, K.J. Clark, G.D. Melvin, F.J. Fife, T. Scheidl, C.L.Waters, S. Arsenault. 2000. 2000 evaluation of 4VWX herring. DFO Canadian Stock Assessment Secretariat Res. Doc. 2000/65: 115p

Table 3. Summary of Scot's Bay biomass estimates from fishing excursion acoustic recordings. August data are from the Secord and July from the portable acoustic system.

Date	Area (km2)	Sa (db)	TS(db/kg)	Mean Length(cm)	Biomass (mt)
7/25	73.38	-49.912	-35.5	unknown	1166
8/8	5.19	-33.681	-35.7	28.3	8282
8/10	11.96	-39.665	-35.7	28.3	4800

Table 4. Summary of Long Island Shore biomass estimates from fishing excursion acoustic recordings. The data were collected by the Dual Venture (DV), and the Margaret Elizabeth (ME).

Vessel	Date	Area (km2)	SA (db)	TS (db/kg)	Mean Length (cm)	Biomass (mt)
ME	7/6/99	16.56	-27.457	-34.40	22.73	80534
	7/20/99	5.87	-29.400	-35.00	25.06	21510
	7/25/99	0.87	-28.953	-34.80	24.37	3367
	7/26/99	0.20	-21.958	-34.50	22.89	3566
	8/8/99	0.71	-30.311	-35.00	25.17	2091
DV	10/2/99	2.52	-38.450	-34.43	22.72	999
	10/4/99	1.63	-36.300	-34.79	24.23	1151
	10/6/99	13.35	-49.886	-35.32	26.48	468
	10/9/99	0.56	-38.209	-34.29	22.18	227
	10/10/99	0.16	-39.238	-34.29	22.18	51
	10/13/99	1.05	-38.170	-34.29	22.18	430
	10/20/99	0.16	-41.915	-34.29	22.18	28

Table 5. Summary of Grand Manan biomass estimates from fishing excursion acoustic recordings. All data were collected with the portable acoustic system, except for 6/29/99, which was recorded by the Margaret Elizabeth.

Date	Area (km2)	Sa (db)	TS(db/kg)	Mean Length(cm)	Biomass (mt)
5/26	5.00	-53.992	-32.5	16.42	34
5/27	5.00	-68.518	-32.5	16.42	1
5/28	0.73	-63.794	-32.5	16.42	1
5/29	0.16	-32.643	-32.5	16.42	155
6/29	2.03	-27.703	-35.5	25.13	10702

Table 6. Summary of the 1999 German Bank biomass estimates from fishing excursion acoustic logging records. The abbreviations for vessels are as follows: Margaret Elizabeth (ME), Island Pride N0.1 (IP), Leroy and Barry(LB), Dual Venture (DV) and Secord (SC).

Date	ME	LB	IP	DV	SC	Biomass(mt)
4/17/99	0	6712	0	0	0	6712
4/20/99	0	4499	0	0	0	4499
4/23/99	0	2079	0	0	0	2079
4/26/99	0	425	0	0	0	425
4/30/99	0	4823	0	0	0	4823
5/4/99	0	442	0	0	0	442
5/19/99	0	64	0	0	0	64
5/23/99	0	2382	0	0	0	2382
6/16/99	0	0	0	421	0	421
6/20/99	0	0	0	126	0	126
6/21/99	0	0	0	231	0	231
6/22/99	0	0	0	1327	0	1327
6/24/99	0	0	0	264	0	264
6/27/99	0	0	0	312	0	312
7/5/99	0	0	0	0	1439	1439
7/6/99	0	619	695	0	428	1742
7/7/99	0	1960	0	0	0	1960
7/8/99	0	0	323	0	1831	2154
7/9/99	0	0	0	0	104	104
7/11/99	0	1425	0	0	0	1425
7/12/99	0	0	12407	0	0	12407
7/14/99	0	0	1915	0	1111	3026
7/15/99	0	0	31732	0	0	31732
7/19/99	0	0	1356	0	539	1895
7/20/99	0	0	1843	0	0	1843
7/21/99	0	0	37980	0	0	37980
8/2/99	0	27120	0	0	0	27120
8/4/99	0	1298	0	0	0	1298
8/5/99	0	7844	0	0	0	7844
8/10/99	0	1192	0	0	0	1192
8/11/99	0	21346	0	0	0	21346
8/12/99	0	3145	0	0	0	3145
8/16/99	0	3349	0	0	0	3349
8/18/99	0	2443	0	0	0	2443
8/19/99	0	2747	0	0	0	2747
8/20/99	0	33096	0	0	0	33096
8/22/99	0	37147	11484	0	0	48631
8/23/99	0	21107	13173	0	0	34280

8/24/99	0	10183	50011	0	0	60194
8/27/99	0	0	27222	0	0	27222
8/29/99	0	20878	11268	0	0	32146
8/30/99	0	18237	2071	0	5953	26261
8/31/99	0	2438	57886	0	770	61094
9/1/99	0	4650	30721	0	0	35371
9/2/99	0	10441	0	0	0	10441
9/3/99	0	6409	0	0	0	6409
9/5/99	0	9399	0	0	7475	16874
9/6/99	0	16957	23510	0	0	40467
9/7/99	0	6493	0	0	0	6493
9/8/99	0	0	110778	9767	0	120545
9/9/99	0	0	47809	489	0	48298
9/10/99	0	0	40991	0	0	40991
9/15/99	0	0	2894	0	0	2894
9/19/99	0	0	87585	0	0	87585
9/20/99	0	0	7993	0	0	7993
9/21/99	0	0	43218	0	0	43218
9/22/99	0	0	7312	0	0	7312
9/26/99	0	9090	0	2438	0	11528
9/27/99	0	0	0	731	0	731
9/29/99	0	0	0	1686	0	1686
10/1/99	0	4048	0	1413	0	5461

Table 7. Summary of Brown's Bank biomass estimates from fishing excursion acoustic recordings. All data were collected by the Leroy & Barry.

Date	Area (km2)	Sa (db)	TS	Mean Length (cm)	Biomass (mt)
4/19/99	4.28	-30.887	-35.50	28.10	12,381

Table 8. Summary of 1999 Scotian Shelf biomass estimates from fishing excursion acoustic logging records. The abbreviations for the vessels are as follows: Margaret Elizabeth (ME), Leroy and Barry (LB), Island Pride N0.1(IP), Dual Venture (DV).

Date	ME	LB	IP	DV	Biomass (mt)
5/24/99	0	19411	0	0	19411
5/26/99	0	0	9830	0	9830
5/27/99	4197	1733	0	0	5930
5/31/99	0	0	0	473	473
6/1/99	0	1130	0	368	1498
6/2/99	0	0	0	715	715
6/3/99	0	0	0	859	859
6/7/99	0	0	0	807	807
6/8/99	0	1541	0	889	2430
6/9/99	0	492	0	349	841
6/10/99	0	22347*	22347*	22347*	22347
6/11/99	0	0	1357	0	1357

* Combined survey biomass estimate.

Table 9. Summary of the 1999 Scots Bay spawning area acoustic survey data and biomass estimates for structured surveys and fishing excursions. The underlined biomass are those used to determine overall SSB for the spawning component.

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
Scots Bay								
Scheduled	25-Jul	312.31	-47.107	0.071	28.17	-35.65	<u>22,307</u>	19,630
Fishing	8-Aug	5.22	-33.680	1.587	28.3	-35.70	<u>8,284</u>	2,360
Scheduled	10-Aug	11.96	-39.665	0.401	28.3	-35.70	4,800	859
Scheduled	20-Aug	1.35	-32.170	2.151	28.3	-35.70	<u>10,381</u>	9,758
Scheduled	3-Sep	712					0	

Table 10. Summary of the 1999 Trinity Ledge acoustic survey results and mapping SSB biomass estimates. Note that the survey coverage on Aug 27th was 241 km^2 but herring were only observed in a 0.4 km^2 area and not along the pre-defined transects.

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
Trinity Ledge								
Acoustic	27-Aug	0.4*	-29.113	4.663	28.83	-35.80	1,875	
Mapping	9-Sep	241					2,010	

* Coverage is survey area, but fish not observed on transects.

Table 11. Summary of the 1999 German Bank spawning ground acoustic survey data and SSB biomass estimates for structured and mapping surveys. The underlined biomass are those used to determine overall SSB for the spawning component.

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
German Bank								
Acoustic	27-Aug	474	-39.070	0.404	28.51	-35.74	<u>191,496</u>	81,263
Acoustic	10-Sep	198	0.922	0.922	27.31	-35.49	<u>182,637</u>	22,497
Acoustic	25-Sep*	7.3	-25.164	11.313	28.34	-35.70	<u>82,790</u>	36,580
Acoustic	2-Oct	302	0.000	0.000			<u>0</u>	
Mapping	8-Oct	9.26	0.000	0.000			<u>3,900</u>	

* Includes 3.3 Km^2 of herring recorded by the non-logging vessel

Table 12. 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 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**
Scots Bay	160,168	72,473	40,972
Trinity Ledge	23,000	6,762	3,885
German Bank	370,400	440,704	460,823
Spectacle Buoy	15,000	1,329	0
Total	568,500	521,268	505,680

Table 13. Summary of the 1999 Little Hope/Port Mouton acoustic survey results and mapping SSB biomass estimates.

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
Little Hope								
Mapping	26-Sep						6,150	
Acoustic	3-Oct	65.2	-41.647	0.243		-35.50	15,834	13,206

Table 14. Summary of the 1999 Eastern Shore acoustic survey results and mapping SSB biomass estimates.

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strengt h	Biomass (t)	Standard Error
Eastern Shore								
Mapping	2-Oct						20,226	
Acoustic	4-Oct	0.3	-23.589	15.527		-35.50	4,658	3,084
Mapping	10-Oct						9,500	

Table 15. Summary of the 1999 Glace Bay mapping survey SSB biomass estimates.

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
Glace Bay								
Mapping	21-Sep						2,000	

Table 16. Summary of the 1999 Bras d'Or Lakes acoustic survey results and mapping SSB biomass estimates.

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
Bras d'Or								
Mapping	8-Apr						350	
Mapping	9-Apr						250	
Mapping	14-Apr						370*	
Acoustic	14-Apr	2.72	-58.969	0.0057	32.75	-36.5	15	
Mapping	15-Apr						20	

* Survey in Great Bras d'Or.

Table 17. Summary of the June 10 acoustic survey and mapping biomass estimates from the Patch. The table compares the biomass obtained from both the acoustic and mapping procedures.

Location	Date	Area (m2)	Mean Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strengt h	Biomass (t)	Standard Error
Patch								
Acoustic	10-Jun	104*	-42.672	0.216		-36.01	22,427	17,764

* Uses data from three vessels LB,IP,DV

Table 18. Summary of the acoustic survey results by area from the 1999 Alfred Needler Scotian Shelf survey (Nov 2- Nov12).

Location	Date	Area (m2)	Mean Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
Eastern Shore								
Acoustic	4-Nov	359.27	-55.086	0.0103	26.01	-35.2	3,688	24
Chedabucto Bay Inner								
Acoustic	5-Nov	333.74	-61.193	0.0025	26.01	-35.20	842	44
Chedabucto Bay Entrance outer								
Acoustic	5-Nov	416.6	-57.993	0.0053	26.01	-35.20	2,195	35
Chedabucto Bay Approaches								
Acoustic	6-Nov	274.25	-48.417	0.0478	26.01	-35.20	13,107	39
Chedabucto Bay Southern Approach								
Acoustic	7-Nov	200.31	-52.150	0.0202	26.01	-35.20	4,053	87
French Bank								
Acoustic	7-Nov	289.37	-75.051	0.0001	26.01	-35.20	30	70
Owl								
Acoustic	8-Nov	226.38	-62.253	0.0024	30.09	-36.00	540	87
Slipper								
Acoustic	8-Nov	158.4	-56.907	0.0082	30.09	-36.10	1,303	77
SW Western Bank								
Acoustic	9-Nov	275.96	-67.586	0.0007	29.97	-36.04	193	74
Patch								
Acoustic	11-Nov	258	-59.003	0.0053	31.25	-36.30	1,379	65
Chebucto Head								
Acoustic	11-Nov	234.7	-70.143	0.00032	26.01	-35.20	75	69
Emerald Bank								
Acoustic	10-Nov	218.64	-1031.017	0.000	31.25	-36.30	0	1
Mackenzie Spot								
Acoustic	11-Nov	136	-55.716	0.0114	31.25	-36.30	1,556	54

Table 19. Summary of the 2000 winter acoustic survey off Chebucto Head. Vessels involved included the Margaret Elizabeth, Secord and Island Pride.

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
Chebucto Head								
Acoustic	7-Jan	19.70	-28.195	5.25		-35.45	103,515	29,289
Acoustic	10-Jan	4.93	-28.212	5.23		-35.45	25,804	6,727
Acoustic	15-Jan	43.11	-32.890	1.78		-35.40	76,843	27,387
Acoustic	22-Jan	14.61	-28.593	4.79	27.11	-35.40	70,048	7,146
Acoustic	23-Jan	5.00	-24.242	13.08	27.11	-35.40	65,285	9,526

Table 20. Summary of acoustic data, fish size and biomass estimate from the Parkers Cove weir on September 14, 1999.

Location	Date	Area (m2)	Mean Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error
Parkers Cove Acoustic	14-Sep	1603.7	-16.877	52.690	21.46	-34.10	84.50	1.79

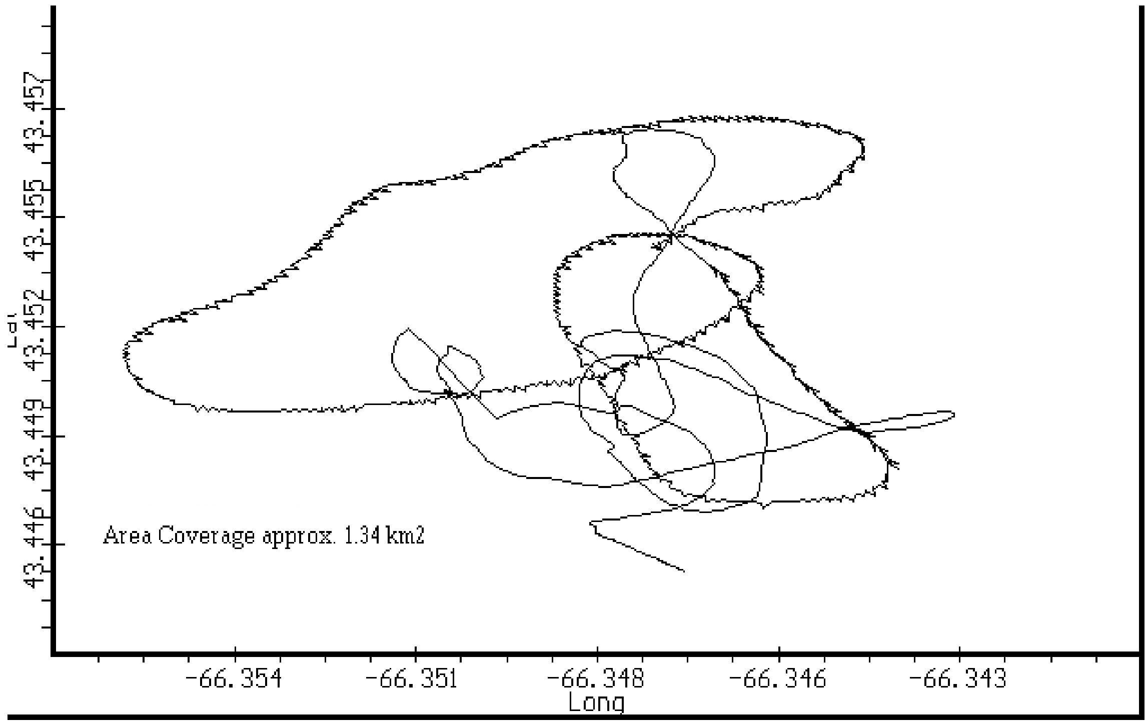

Figure 1. Example of the vessel track from a typical fishing excursion acoustic recording. This example is from the Leroy & Barry September 3, 1999 on German Bank.

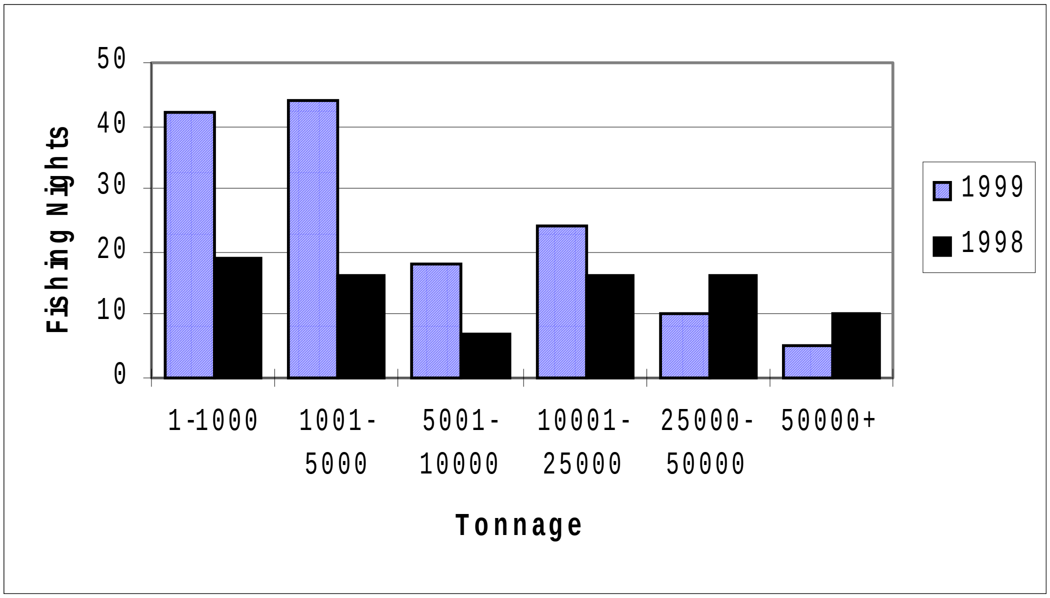

Figure 2a. Summary of the frequency in numbers of biomass estimates obtained from activation during fishing excursions for 1998 and 1999.

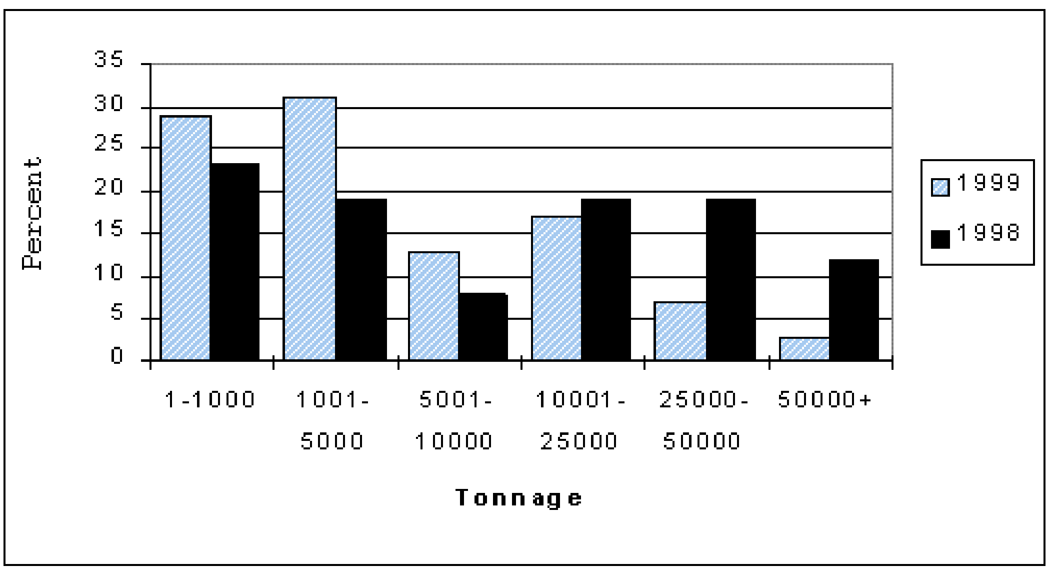

Figure 2b. Summary of the percent frequency of biomass estimates obtained from activation during fishing excursions for 1998 and 1999.

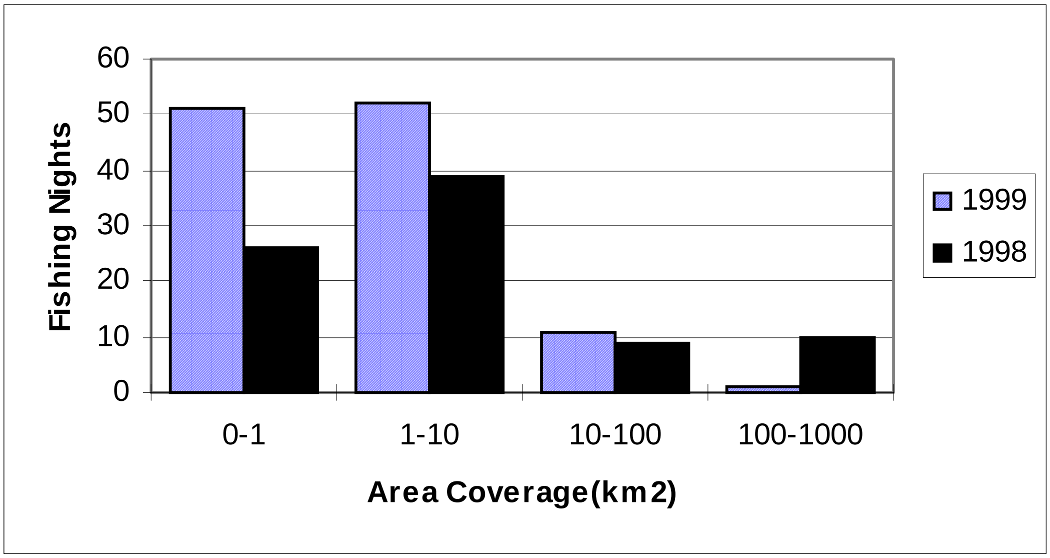

Figure 3a. Summary of the 1998 and 1999 nightly coverage area from fishing vessels equipped with automatic acoustic logging systems.

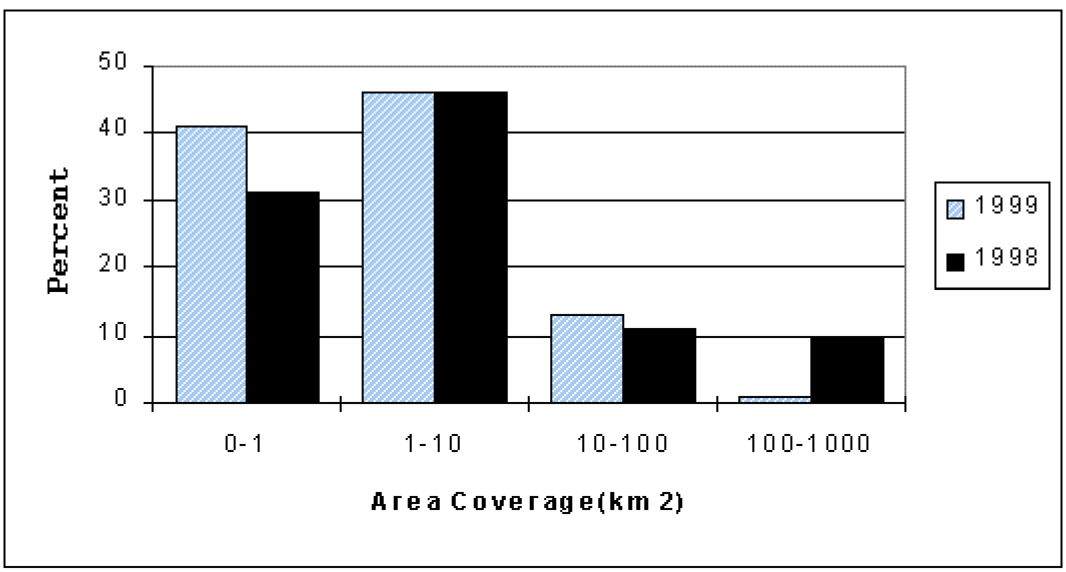

Figure 3b. Summary of the 1998 and 1999 relative frequency of nightly coverage area from fishing vessels equipped with automatic acoustic logging systems.

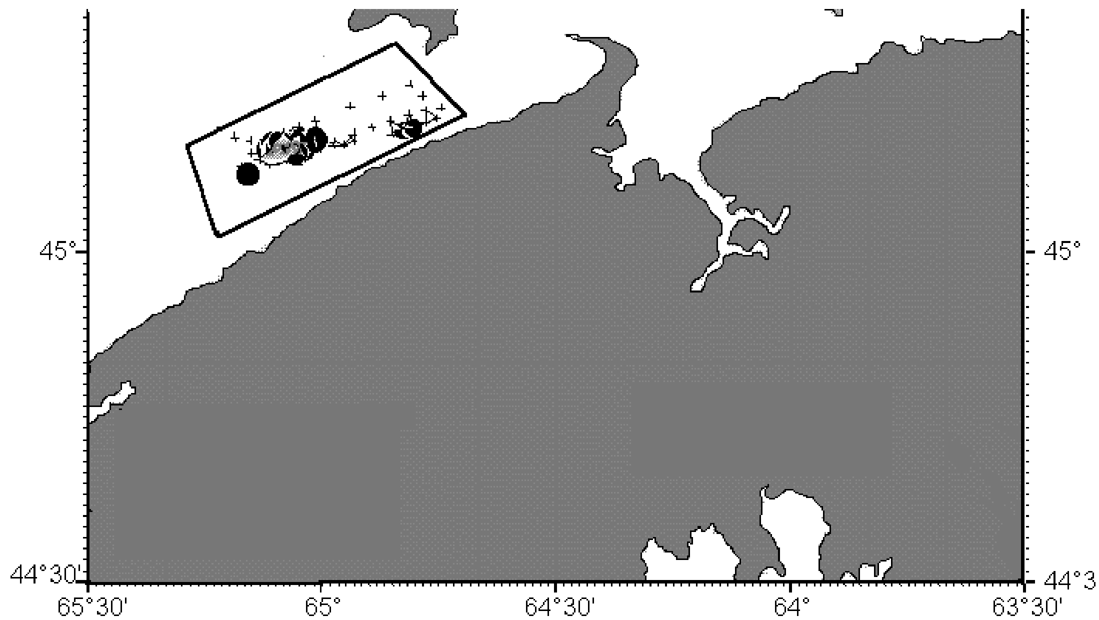

Figure 4. Summary of the August 10, 1999 Scots Bay mapping and acoustic survey. The box represents the proposed survey. The acoustic estimate is based on only a small area (12 km2) located where the fish are concentrated.

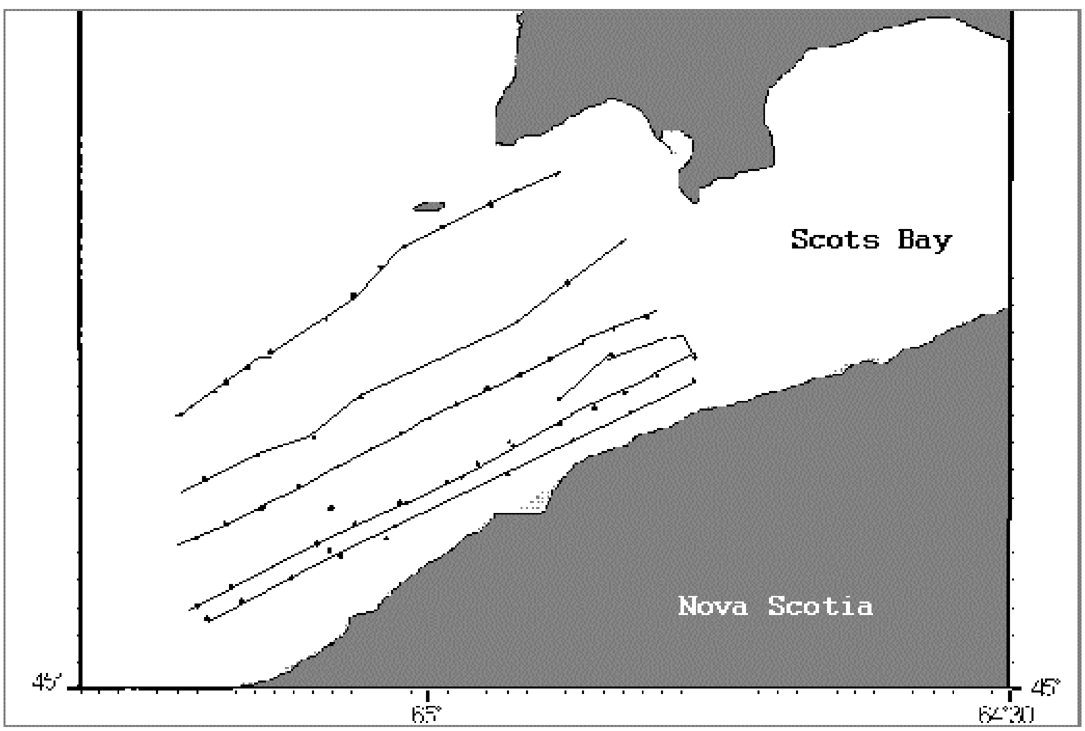

Figure 5. Vessel track and observation points from the five vessels involved in the September 3, 1999 Scots Bay mapping survey.

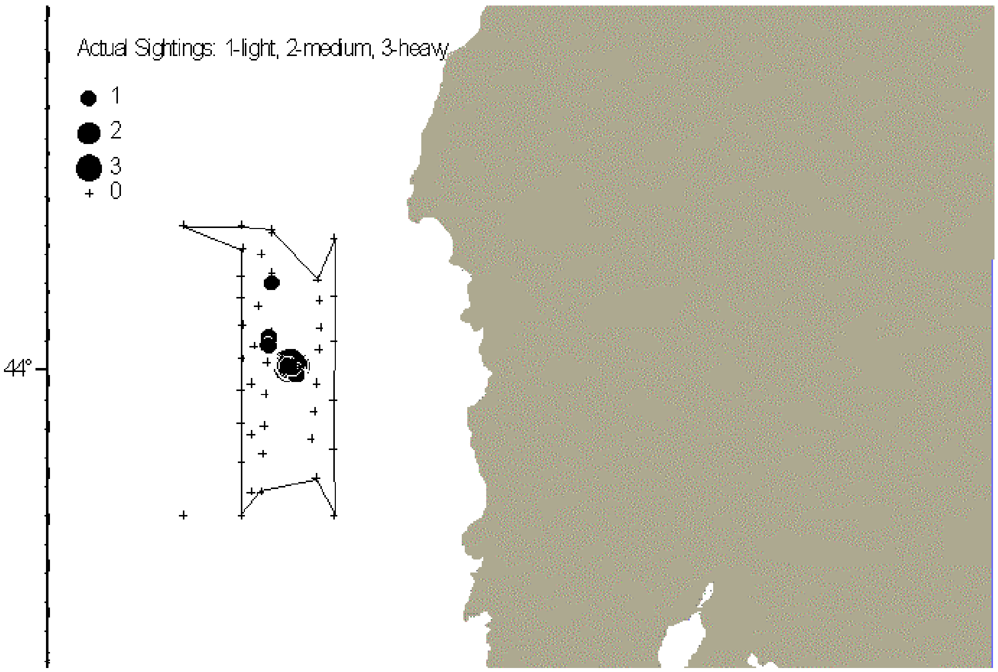

Figure 6. Summary of the vessel tracks, observation points and location of herring during the September 9, 1999 Trinity Ledge mapping survey. Nine gillnet vessels participated in the survey.

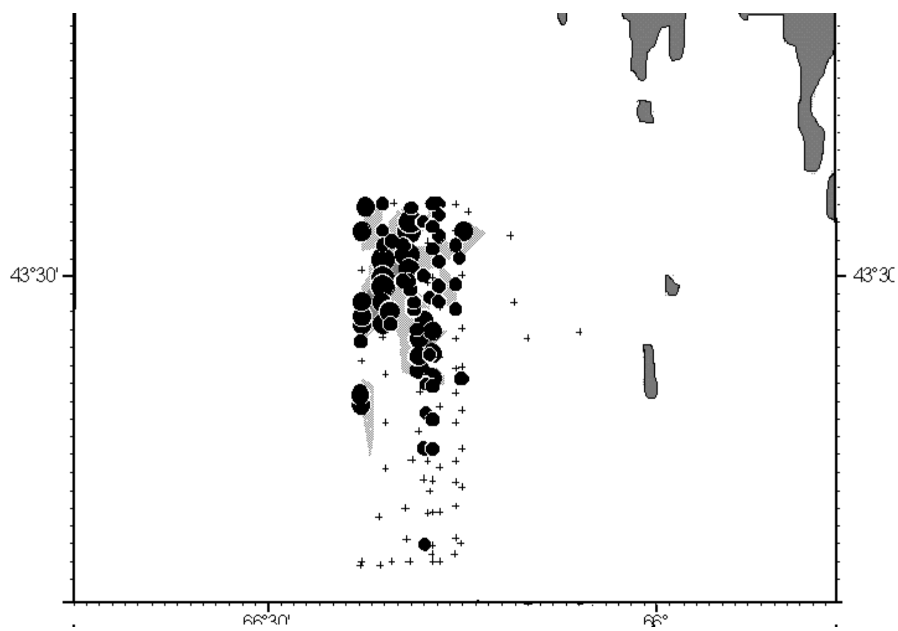

Figure 7. Observation points (+) and fish distribution on the August 27, 1999 German Bank mapping and acoustic survey.

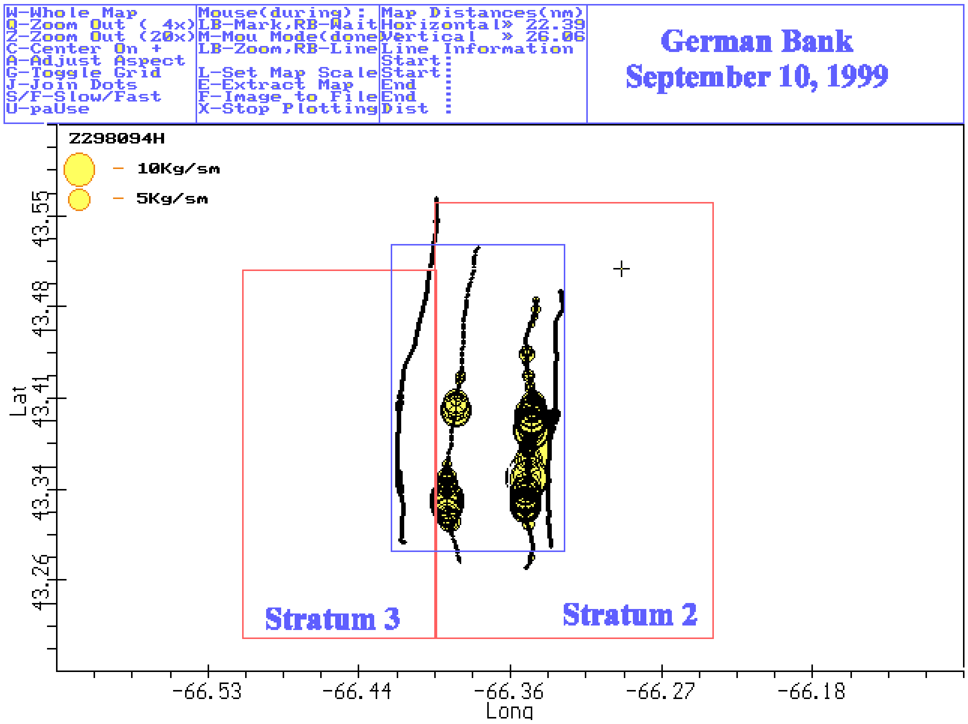

Figure 8. Vessel track and fish distribution on German Bank September 10, 1999. The large rectangles represent the survey strata and the smallest rectangle area covered by the vessels with acoustic logging systems.

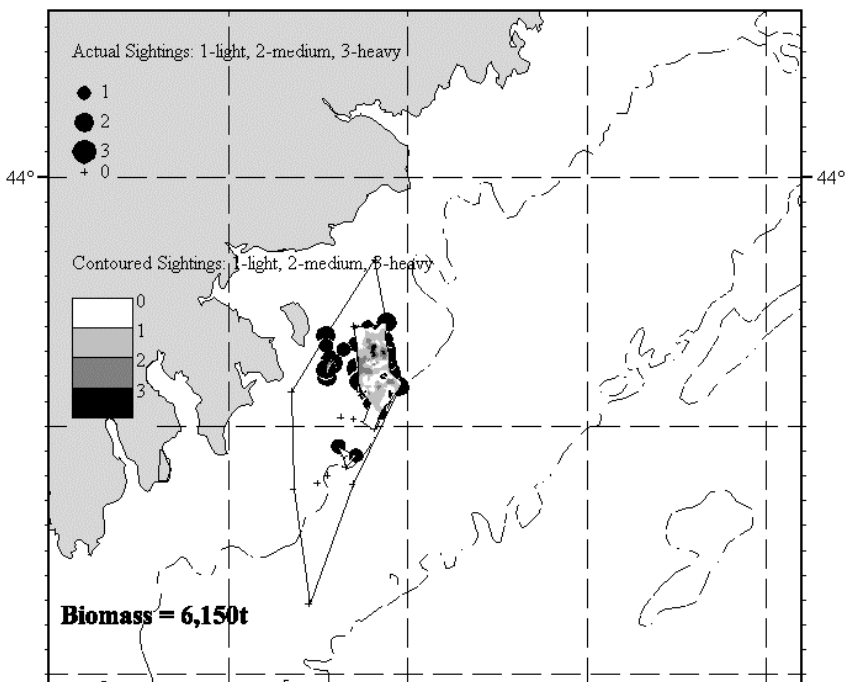

Figure 9. Survey area and fish locations for the mapping survey conducted near little Hope on September 26, 1999. Biomass estimated from contouring was 6,150t.

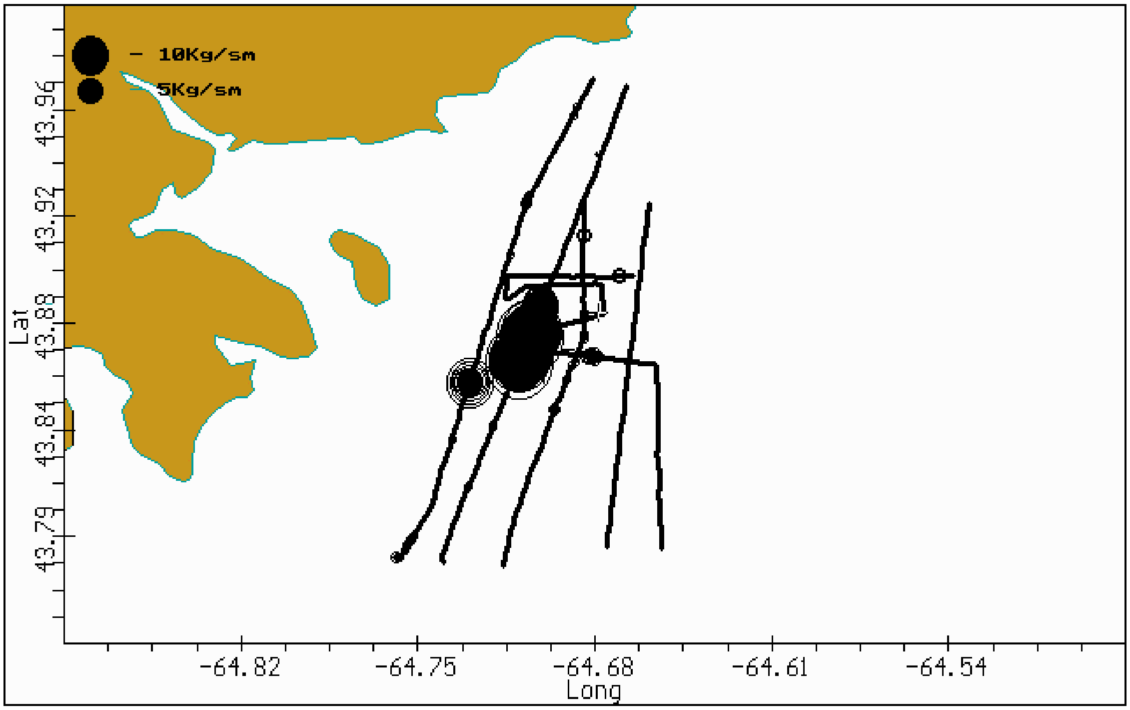

Figure 10. Survey transects and location of herring from an acoustic survey conducted near Little Hope on October 3, 1999. The estimated biomass was 15, 834t.

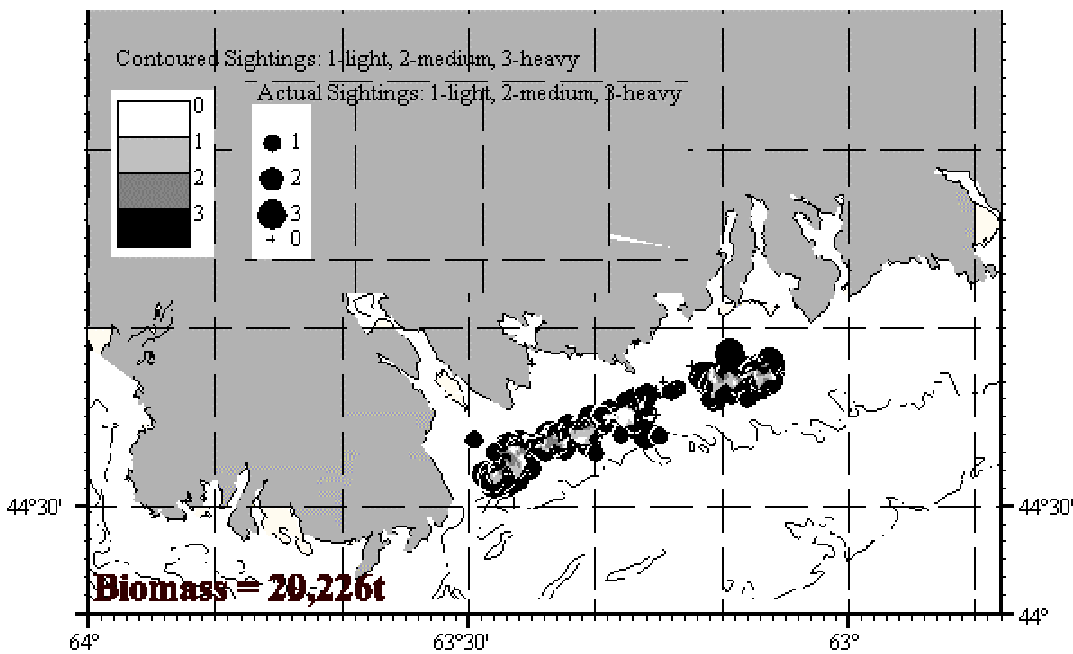

Figure 11. Summary of the Eastern Passage October 2 , 1999 mapping survey. The biomass estimate for this area was 20,226t.

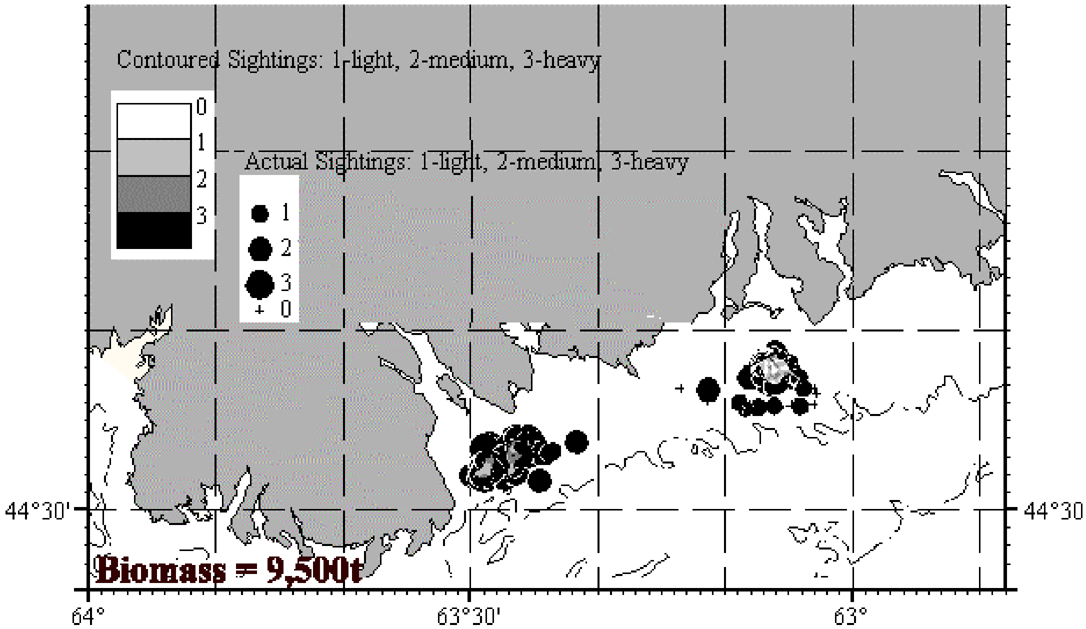

Figure 12. Summary of the Eastern Passage October 10 , 1999 mapping survey. The biomass estimate for this area was 9,500t.

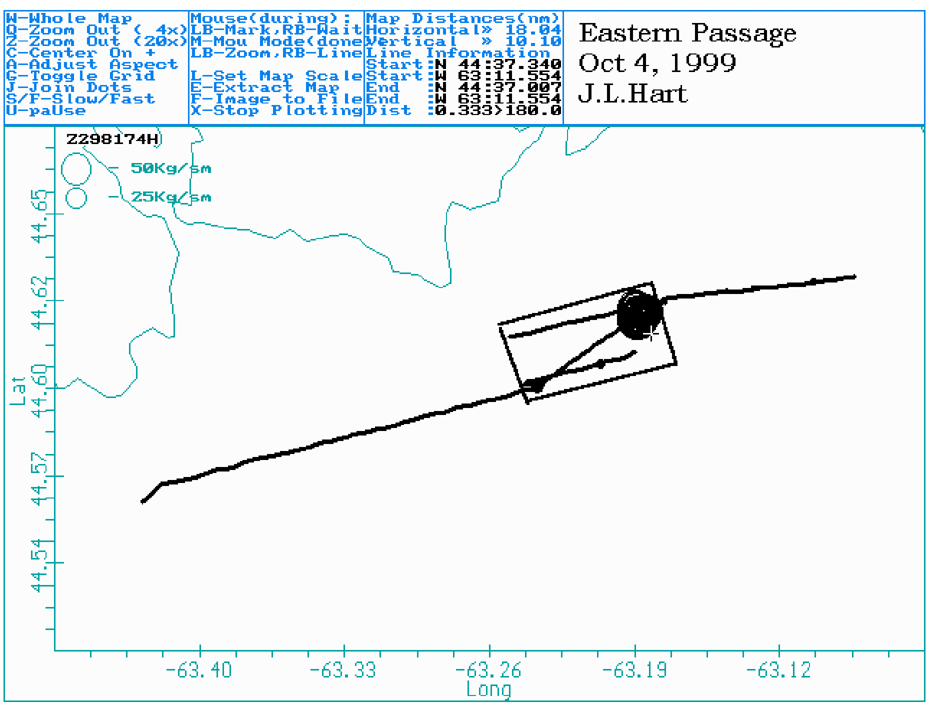

Figure 13 . Vessel track of the JL Hart and fish distribution on October 4, 1999 near Eastern Passage. Note that the box represents an area of 0.3km2 and the only place where herring were observed.

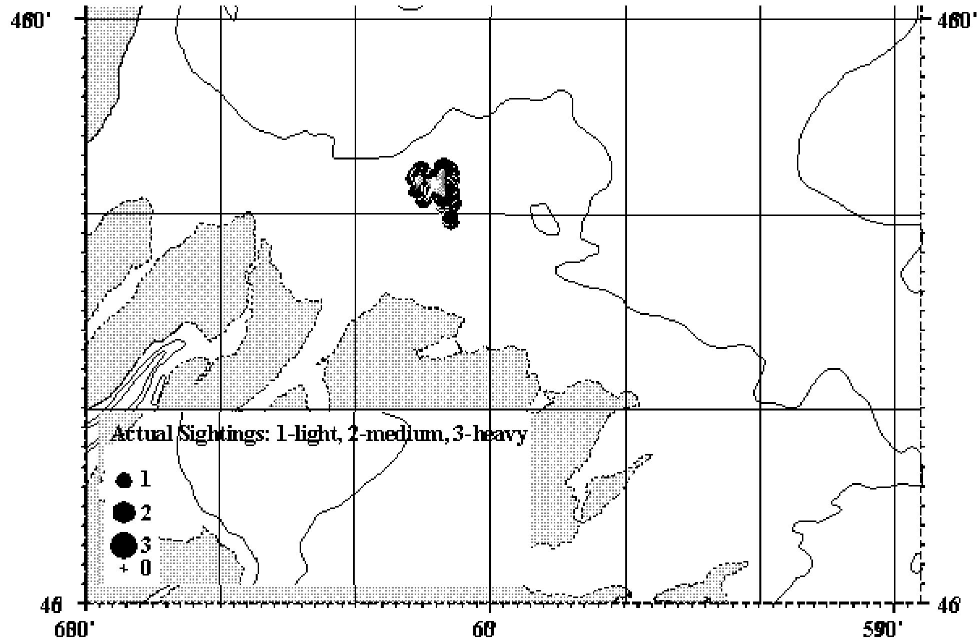

Figure 14. Summary of the Glace Bay September 21 , 1999 mapping survey. The biomass estimate for this area was 2,000t.

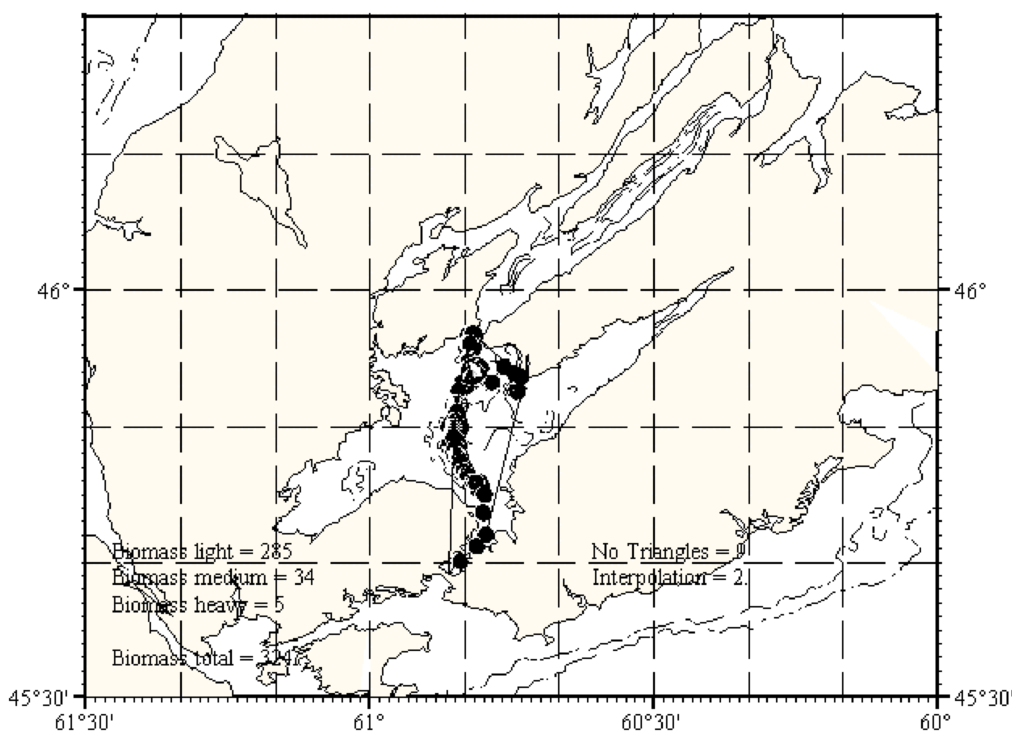

Figure 15a. Summary of the April 8, 1999 Bras d'Or Lakes mapping survey.

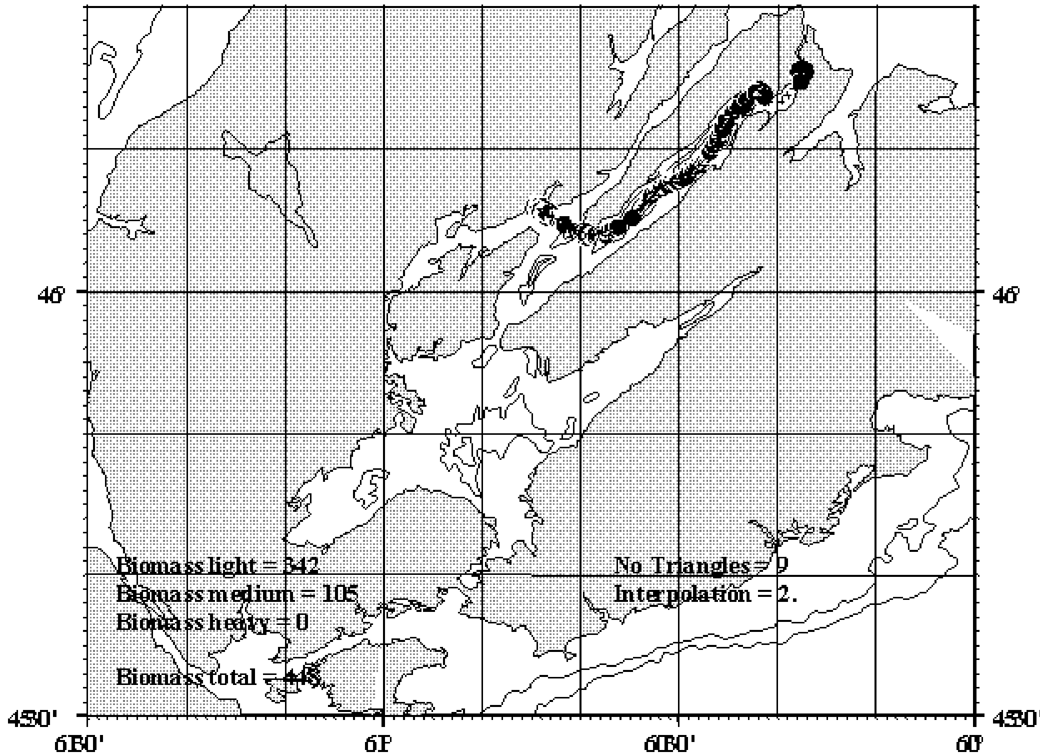

Figure 15b. Summary of the April 14, 1999 Bras d'Or Lakes mapping survey.

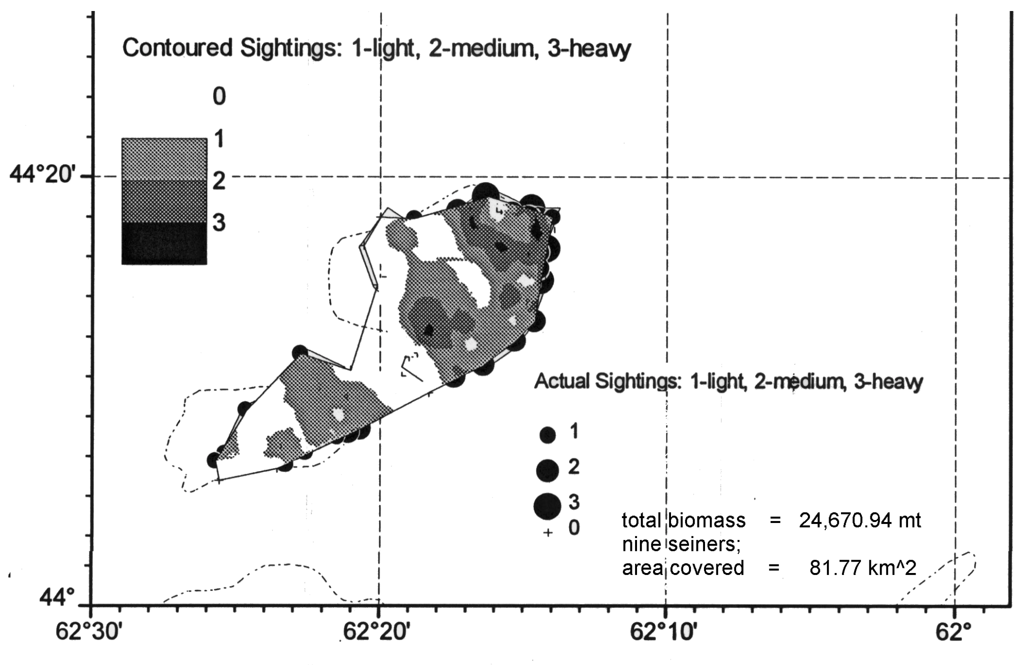

Figure 16. Summary of the mapping and acoustic survey undertaken on the Patch on June 10, 1999. Transects from three of the participating vessels were used to estimate the acoustic biomass.

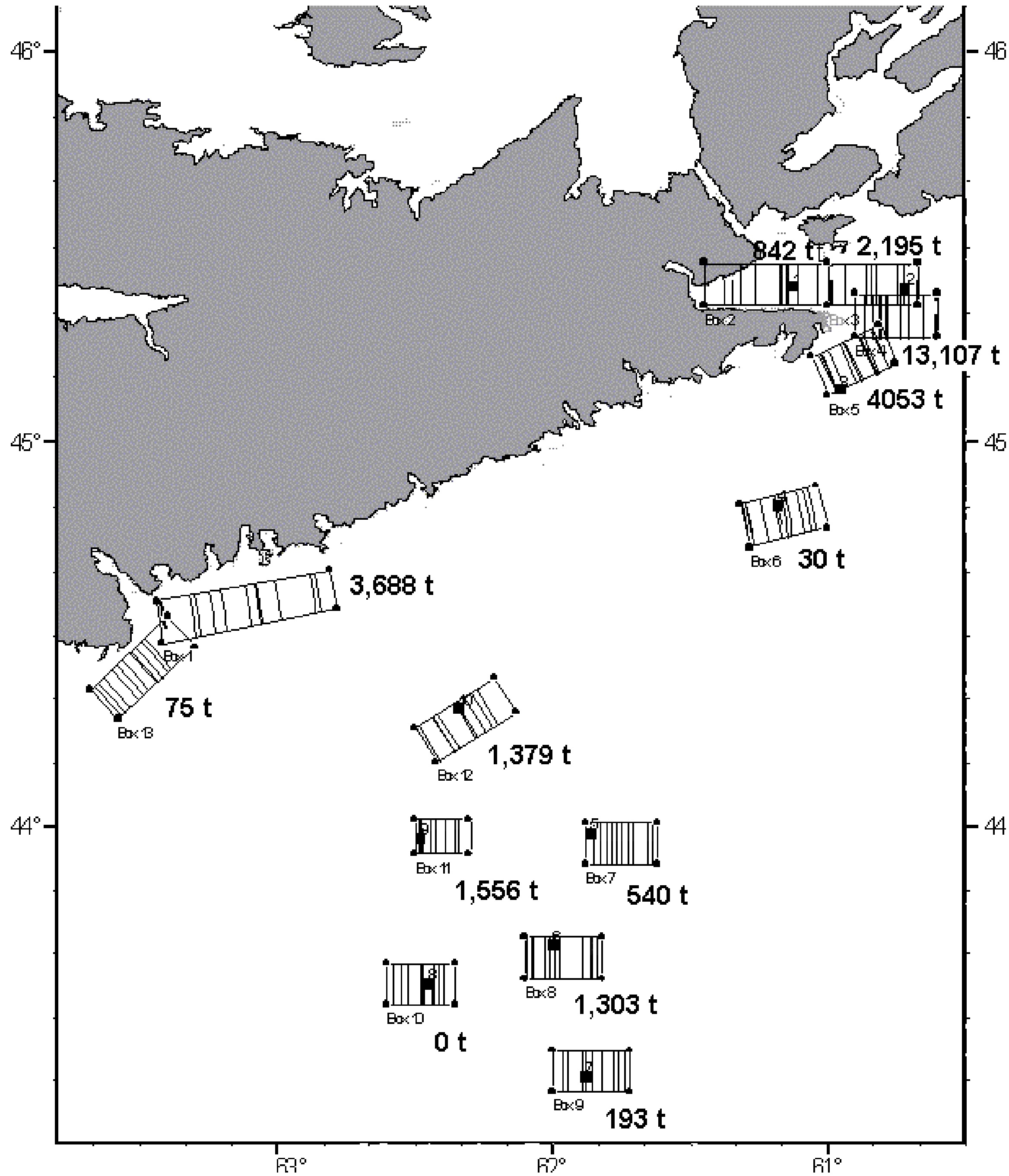

Figure 17. The 1999 Scotian Shelf herring acoustic survey grids, transect lines and set locations for the Alfred Needler 99-060 (Nov 2-12, 1999).

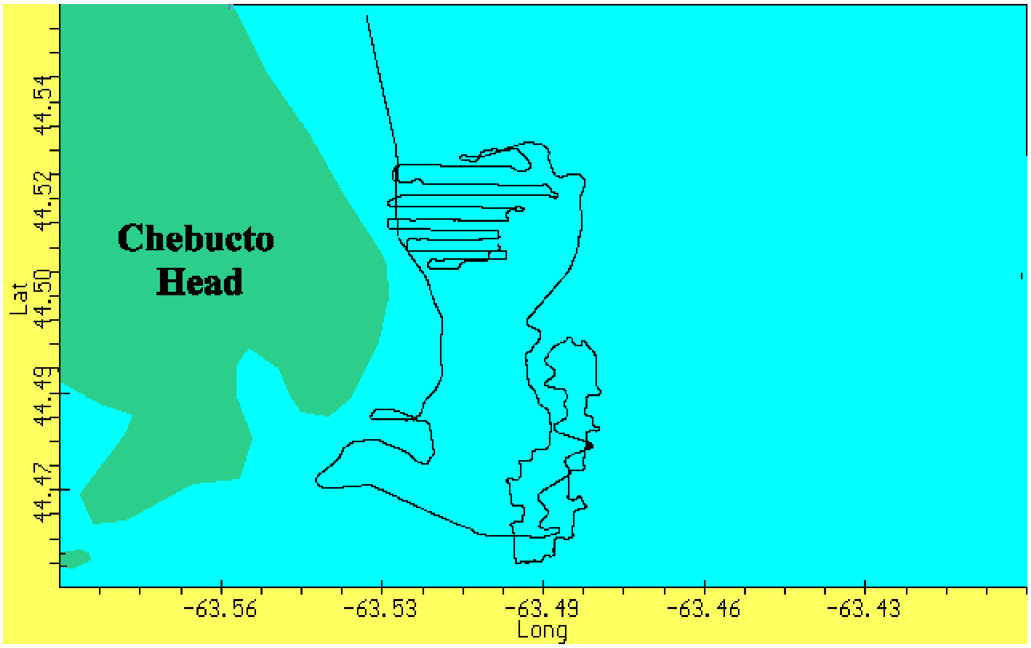

Figure 18a. Vessel track of the Margaret Elizabeth off Chebucto Head on January 23, 2000.

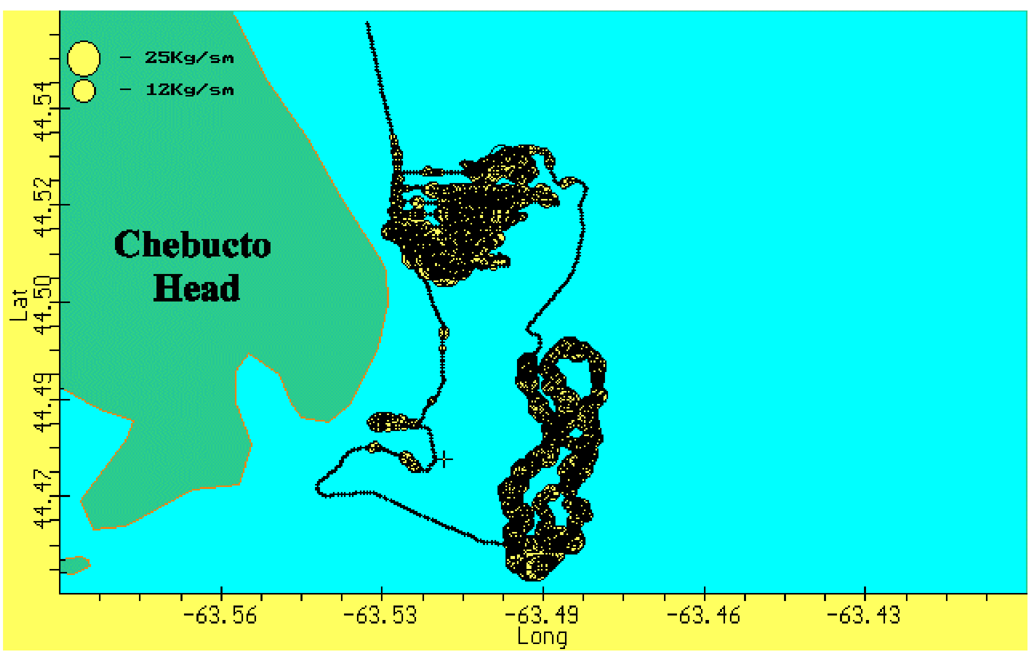

Figure 18b.Fish distribution along the vessel track of the Margaret Elizabeth during the January 23, 2000 acoustic survey.

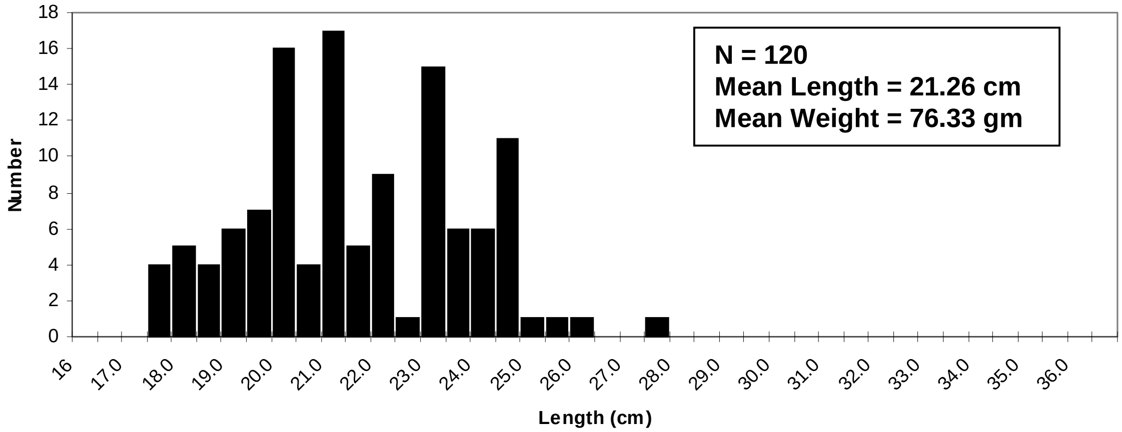

Figure 19. Length frequency distribution of herring sampled from the Parkers Cove weir on September 14, 1999.

Appendix 1. The 1999 proposed acoustic surveys schedule. The initials "GN" stands for gillnet vessel deployment.

PELAGICS RESEARCH COUNCIL
SURVEY PLAN 1999
25 August 1999

DATE	AREA	Vessels with HDPS acoustic Recording Systems	SM2000	Vessels without Recording Systems	
AUGUST 10	SCOT'S BAY	1	1	1	
AUGUST 20	SCOT'S BAY	1	1	2	
AUGUST 27	TRINITY	0	1	1	
AUGUST 27	GERMAN BANK	2	0	3	
SEPTEMBER 1	TRINITY		GN		
SEPTEMBER 3	SCOTS BAY	1	0	3	
SEPTEMBER 10	TRINITY	0	1	1	
SEPTEMBER 10	GERMAN BANK	1	1	3	
SEPTEMBER 13	TRINITY		GN		
SEPTEMBER 20	GLACE BAY		GN		
SEPTEMBER 24	TRINITY	0	1	1	
SEPTEMBER 24	GERMAN BANK	1	1	3	
SEPTEMBER 30	GLACE BAY		GN		
OCTOBER 8	GERMAN BANK	1	1	3	
OCTOBER 13	E. PASSAGE		GN		
OCTOBER 14	LITTLE HOPE		GN		
OCTOBER 20	GERMAN BANK	1	1	0	
OCTOBER 22	E. PASSAGE		GN		