Fisheries and Oceans Canada | Pêches et Océans Canada

Canadian Stock Assessment Secretariat
Research Document 99/180

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

Secrétariat canadien pour l'évaluation des stocks
Document de recherche 99/180

Ne pas citer sans
autorisation des auteurs[1]

Evaluation of the 1998 4WX Herring Acoustic Surveys

by

G.D. Melvin, T. Scheidl, F.J. Fife, M.J. Power,
S. Boates, K.J. Clark and R.L. Stephenson

Marine Fish Division
Maritimes Region, Science Branch
Biological Station
531 Brandy Cove Road
St. Andrews, New Brunswick, E5B 2L9

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

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

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

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

ISSN 1480-4883
Ottawa, 1999
Canada

Abstract:

Automated acoustic logging systems installed on commercial herring purse seine boats were used to document the distribution and abundance of herring in NAFO Division 4WX during the 1998 fishing season. As in previous years, data were collected during both fishing operations and structured (science-directed mapping/acoustic) surveys. The number of structured surveys in southwest Nova Scotia decreased from five in 1997 to three in 1998 and most biomass estimates were instead computed from fishing operations. The number of automated systems increased from two to six. Total biomass estimates for a spawning component was determined by summing the surveys and/or fishing estimates of greater than ten days intervals. Biomass estimates for German Bank, Scots Bay, Trinity Ledge and Spectacle Buoy were 440,700t, 72,500t, 6,800t and 1,300t respectively. Based on this approach the spawning stock biomass of 4WX herring stock complex was estimated to be 521,300t, down slightly from 568,500t in 1997.

Résumé:

Des systèmes d'enregistrement acoustiques automatisés installés à bord de bateaux de pêche commerciale à la senne coulissante ont été utilisés pour documenter la répartition et l'abondance du hareng dans les divisions 4WX de l'OPANO pendant la saison de pêche de 1998. Comme pour les années antérieures, des données ont été recueillies pendant les opérations de pêche et dans le cadre de relevés structurés (relevés scientifiques dirigés de cartographie et d'acoustique). Le nombre de relevés structurés effectués au sud-ouest de la Nouvelle-Écosse a été réduit de cinq, en 1997, à trois, en 1998, et la plupart des estimations de biomasse ont été faites à partir des données des opérations de pêche. Le nombre de systèmes automatisés a augmenté de deux à six. Les estimations de la biomasse totale d'une composante de géniteurs ont été déterminées en faisant la somme des estimations obtenues par relevés et/ou opérations de pêche à intervalles de plus de dix jours. Les estimations de biomasse obtenues pour le banc German, la baie Scots, Trinity Ledge et Spectacle Buoy étaient, respectivement, de 440 700 t, 72 500 t, 6 800 t et 1 300 t. Selon cette méthode, la biomasse estimée du stock de géniteurs du complexe de stocks de hareng de 4WX était de 521 300 t, soit légèrement inférieure à la valeur de 568 500 t déterminée en 1997.

Introduction:

In 1996 the first automated acoustic logging systems were installed aboard two commercial purse seiners of the 4WX purse seine herring fleet. The Hydroacoustic Data Processing System (HDPS) (supplied by FEMTO Electronics Inc.) was connected directly to the vessel's existing acoustic and navigational hardware (i.e. sounders, sonar and global positioning systems (GPS)). The captains were requested to turn on the system when they observed groups of herring they wished to record. Use and testing of the systems was voluntary. Data collected from several years of operating these systems clearly demonstrated that the equipment was dependable and could be used to document valuable information on fish distribution and abundance (Melvin et al. 1998a; Melvin et al., 1998b). The advantage HDPS was that it provided the two vessels "Margaret Elizabeth" and "Island Pride" with the means to record their observations on any night throughout the fishing season for later processing and quantitative estimates of fish biomass. These vessels could also be used to conduct structured surveys in the same manner as a research vessel. Furthermore, it demonstrated to DFO Science that the fishing fleet could make a valuable contribution to quantifying fish biomass for stock assessment purposes.

The data collected by these commercial vessels during fishing trips and during DFO structured surveys were first incorporated into the 1997 assessment of the 4WX herring stock (Melvin et al. 1998, Stephenson et al. 1997). Through the combined efforts of DFO, the fishing fleet and the two vessels, biomass estimates were made during the 1997 spawning period on German Bank. The first German Bank survey on October 3, under DFO supervision, documented 215,800t. The second survey conducted by "Island Pride" marks a milestone in the application of this technology. On the night of October 9th, while returning to port after fishing, the captain encountered a large aggregation of herring. The captain established a series of transects and undertook a survey on his own initiative. The biomass estimate from this survey was 194,100t. The combined spawning stock biomass estimate for German Bank, after discounting for possible double counting (Melvin et al. 1998), was 370,400t. A similar approach was used in Scots Bay where acoustic data from the commercial vessels was estimated at 160,200t (Melvin et al. 1998). Both values were taken into consideration in developing the 1998 advice and Stock Status Report (SSR) for the 1997/98 fishing season (Anon. 1998).

As a result of this initiative the herring fleet has had a mechanism for direct quantitative input of their observations into the assessment process since 1997. This sparked interest in increasing the number of 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). At the 1999 spring assessment the 4WX stock status was based primarily on the biomass estimates of spawning components from the vessel deployed acoustic

systems (Stephenson et al. 1999). The purpose of this report is to describe the results from the 1998 fishing and survey activities.

Methods:

***Acoustic Systems*:**

Currently there are six automated acoustic logging systems available for deployment on commercial fishing vessels, the two original systems (FEMTO Electronics Inc., Model 9001) and four new systems (FEMTO Electronics Inc., Model 9320) purchased by the PRC in 1998. Four of these systems are fixed to the hulls of purse seiner boats ("Margaret Elizabeth", "Island Pride", "Dual Venture" and the "Leroy & Barry") and cannot be moved easily. Movement requires connection to the vessel's electronics and calibration of the ship's transducer. Another system was fixed to an inshore boat ("Margaret Christie") for the summer of 1998 but was removed after the fishing season. The final system was mounted in a towed body for portability. The 'portable' system is self contained (i.e. complete with GPS and a generator) and can be deployed from almost any vessel with a winch capable of supporting 150 kg.

The difference between the two HDPS models is basically the hardware configuration of the systems. The 9001 connects to the vessel's existing hardware and utilizes the ships sounder as the transceiver, whereas the 9320 is a self-contained transceiver/digitizer and operates independently of the ships equipment. Both systems use the ship's navigation equipment and usually a hull mounted transducer. However, the 9320 can also be connected to the ships sounder if a transceiver is not available. Sonar logging capabilities available in Model 9001 are scheduled for implementation into the 9320 system for the spring of 1999. The advantage of the 9320 model is that it operates independently of the vessel's sounder and does not interfere with existing equipment, with the exception of another sounder of the same frequency. A schematic of the two models is presented in Figure 1. The portable system utilizes the 9320 with a commercial sounder as the transceiver. This particular sounder has not proven to be reliable and will be replaced in 1999.

Surveys:

Data collected and used to estimate minimum observed spawning stock biomass during the 1998 fishing season can be broken down into two types, those collected during standard fishing operation and those obtained from structured surveys. Structured surveys can be further subdivided into acoustic or mapping surveys.

Fishing Operations:

Data logging during a standard fishing operation do not follow any standardized survey design, although captain's are increasingly running parallel lines when documenting aggregations. When coverage of the search area was significant an estimate of observed biomass could be obtained 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 were based on herring sample lengths and associated weights collected from several commercial vessels fishing in the area of interest as follows:

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

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. This corresponds to a 28.0 cm herring.

To utilize the data from fishing operations the vessel track was divided into a series of non-intersecting transects. Portions of the vessel track where the vessel has looped back to take a second look at a group of fish were also removed to prevent over-weighting of areas of heavy 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:

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

In the case of fishing operations, where coverage area was generally small, all segments or transects are 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.

Area covered by the vessel was determined by fitting a rectangle or polygon over the vessel track and estimating the area. 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.

Structured Surveys:

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

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. 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).

The data were contoured using the ACON graphics package and the triangular contour method. Blanking distance was set to define 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 of 200, 1000 or 4000 t/km^2 and summed to get the total biomass survey coverage area.

The 1998 Season:

The most recent 4VWX Herring stock status report states that:

"Acoustic surveys have become critical to stock status evaluation. It is important that there be continued improvement in coverage and survey design, and attention to developing year-to-year consistency in these surveys." (Anon 1999).

In 1998 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 fewer structured surveys than had been recommended/planned for spawning areas in the Bay of Fundy and south west Nova Scotia and only one survey was conducted which involved more than a single vessel equipped with the automated logging system. All other surveys in the area were conducted using fishing vessels for mapping on an ad-hoc basis (Stephenson et al. 1998, Anon. 1999). Acoustic data were used to estimate the density of fish observed in the mapping surveys.

A survey schedule was developed for the 1998 fishing season, in conjunction with DFO, the fishing industry and the PRC to enhance coverage. However, the schedule was not adhered to for a variety of reasons. This resulted in greater reliance on estimates from fishing excursions, which do not cover a specific area and represent a minimum biomass estimate on any given night. When two or more vessels with logging systems were operating in the same area it was possible to combine their data. Yet, the biomass estimates from these vessels were not simply added together. If there was overlap, the area of overlap was taken into account so that double counting did not occur. Furthermore, no extrapolation between coverage areas was made unless the vessels were operating in close proximity (i.e. sonar data indicated or suggested that the fish were continuous between coverage areas).

There is usually insufficient coverage from these fishing excursions to permit year to year comparison. Biomass estimates for fishing excursions were determined using the approach described earlier and in Melvin et al. (1998a). Improvement in coverage, survey design, and year to year comparison is addressed in Melvin et al. (1999).

Results:

Scots Bay

The first survey of Scots Bay was conducted on the night of July 23rd and involved twelve herring seiners, including three vessels with automated logging systems. The survey began just off Margaretsville, N.S. with the vessels spread out between Isle Haute and mainland Nova Scotia. The vessels moved up the bay approximately parallel with the shore. Upon reaching the upper limits of the survey area, four vessels proceeded around the northern side of Isle Haute while the remainder of the fleet scouted the fish observed on the near shore.

Figure 2 shows the distribution of fish from the mapping of vessel data sheets completed by all vessels. The area of coverage is similar to that recorded by the vessels with acoustic logging systems (Figure 3).

The automated logging system was also activated by "Margaret Elizabeth" on August 26 and "Leroy & Barry" on August 30, 31 and September 1 while fishing in the area.

Biomass estimates for all acoustic data collected during the 1999 fishing season in Scots Bay are presented in Table 1 and Figure 4. For the night of July 23, three estimates of biomass were made; an initial visual estimate by those on the survey of 40-50,000t, a contour mapping estimate from vessel data sheets of 26,900t in an area of 250 km^2 and an acoustic estimate of 49,900t in 305 km^2. Converting the mapping estimate to the same area as the acoustic survey results in a biomass estimate of 32,900t and does not include the fish observed northeast of the Isle of Haute. A mapping survey undertaken on August 23 documented 22,600t (Table 2, Figure 5). No acoustic data are available for the period July 24th to August 22, which has traditionally been the peak spawning period for Scots Bay. Since no detailed sampling data are available for August 23rd or September 1 to partition the estimates (i.e. discounting, see Melvin et al. 1998) and no surveys were conducted during the peak spawning period the total observed spawning biomass for Scots Bay is 72,500t (49,900t + 22,600t).

Trinity Ledge:

Three surveys were conducted on Trinity Ledge during 1998 (Table 2) using the mapping approach and the portable acoustic system. Unfortunately, due to technical problems the only survey for which acoustic data are available is August 27. Even this survey had navigational errors and position had to be reconstructed from the paper recordings. The acoustic biomass estimate for August 27 was 1,900t in 2 km^2 using a standard TS. Given the technical problems associated with the portable system (see section on problems), the observed spawning stock component biomass was determined from the mapping data and estimated to be 6,800t for the 1998 spawning season (Figure 6,7,8)

German Bank:

The German Bank spawning grounds was the most active fishing area for both fishing and acoustic logging during 1998. In total, 47 individual vessel nights of acoustic recordings were made during the spawning season (Table 3, Figure 9). However, only two structured surveys occurred on the bank (Table 2) and only one (on August 23) involved a vessel with automated logging systems. Two

other recording vessels were operating in the area, but did not participate in the survey on that night.

The key factors in estimating the biomass of the spawning component are the identification of spawning waves to avoid double counting and the combining of estimates from more than one vessel (Melvin et al., 1998). As in previous years a minimum elapsed time of 10 days between surveys was established to separate spawning waves or groups. Biomass fluctuated over the course of the spawning season and fortunately, the majority of surveys, which were considered representative, were separated by approximately two weeks. In the case of the September 20th and 30th surveys the elapsed time was exactly 10 days, however the length frequencies during this period also suggested that a break point had occurred (Stephenson et al. 1999).

The 1998 biomass estimates for German Bank by day and vessel are presented in Table 4 and Figures 10-12. To determine the total SSB, specific nights were selected as providing a minimum biomass estimate for the bank. These nights correspond to peaks in abundance with declines in between dates, a minimum elapsed time (10 days), and evidence of possible changes in biological characteristics (Stephenson et al., 1999). The total observed spawning stock biomass estimate for German Bank in 1998 was 440,700t.

August 23	94,260t
September 7	199,060t
September 20	97,300t
September 30	23,470t
October 13	26,600t

Spectacle Buoy:

Fishing effort and the availability of spawning fish in the vicinity of Spectacle Buoy declined in 1998 compared with the previous two years. As such, survey activity was limited to the night of June 22 and involved 14 vessels (Table 2, Figure 13). No acoustic systems were deployed in this area during 1998. The single mapping survey produced a biomass estimate of 1,300t.

Little Hope:

Two surveys were conducted in the Little Hope area (Table 2, Figure 14,15). The first survey on October 6 involved 10 vessels and the portable acoustic logging system. The biomass estimates were 7,400t from mapping and 3,000t from the acoustic system. Unfortunately, the acoustic system was accidentally turned off and only collected data for a portion of the survey (Figure 16). Extrapolating the acoustic densities to the area where herring were observed on

the mapping logs produced an area of approximately 4 km^2 and resulted in a biomass estimate of 7,000t. On October 17, the mapping survey produced an estimate of 7,100t. The total 1998 observed spawning stock biomass for Little Hope was estimated to be 14,100t.

Eastern Passage:

A single mapping and acoustic survey was undertaken near Eastern Passage on the night of October 21, 1998. Three schools or groups of herring were observed (Figure 17). The vessel track of the portable acoustic system and the location of herring observed are shown in Figure 18. The total biomass of fish was estimated to be 8,300t in an area of 2.69 km^2 (mean Sa = -30.52dB). The standard TS of -35.5 was used in the estimation of biomass as the only length frequency data available were gillnet samples which are selective and are not considered representative of all the fish present. The contouring of the mapping data produced a biomass estimate of only 550t. This underestimate is considered to be due to infrequent recordings on the data sheets and a lack of detailed coverage in the areas recorded on the portable system.

Western Bank:

Between October 20 and 22 four purse seine vessels conducted an extensive survey (3086 km^2) on the Scotian Shelf near Western Bank (Figure 19). The automated logging systems aboard two of the vessels were operated continuously during the survey. The survey did not document any major aggregations of herring in the survey area and no sampling for target verification was undertaken due to high winds and rough seas. Assuming all targets were herring and using the standard TS of -35.5 dB the maximum observed tonnage would be 17,400t (Table 2). However, it is unlikely that the majority of targets observed were herring as they were unlike typical acoustic recordings of herring. Four weeks later a relatively large number of herring larvae were documented by a larval survey which covered the same area (Harris and Stephenson, 1999).

Chedabucto Bay:

Two vessels participated in the Chedabucto Bay winter fishery in November 1998 including "Margaret Elizabeth" which activated its automated logging system on six occasions during this fishery (Table 5). Observed biomass estimates ranged from 1,500t to 65,600t. These estimates apply to only the area covered by the vessel during its fishing activities.

St. Margarets Bay:

During the summer of 1998 an acoustic system was deployed aboard "Margaret Kristie", an inshore fishing vessel, to document the occurrence of mackerel and herring each day as the vessel tended its trapnet. The data presented in Table 6 depicts three peak periods of fish July 20th, August 3rd and August 15th on the vessel track. Unfortunately, no groundtruthing was undertaken, so the target species is unknown. Biomass estimates were determined using the standard TS for herring and ranged from 25t to 6,800t. However, if the targets were mackerel, as likely many were, then the estimates would be much higher. Mackerel, which have no swim bladders, have a TS in the order of -50dB.

Chebucto Head:

In January of 1999 a large aggregation of herring was reported in the vicinity of Chebucto Head, just off Halifax. Two purse seiners, "Leroy & Barry" and "Seacord", were recruited by the fishing industry to undertake several days of acoustic surveys and to tag herring in order to investigate the origin of these fish. Between January 21 and 23, three days of surveying were undertaken and a total of 10,300 herring were tagged. Because of the large quantity of fish observed both the portable system and the recording system on "Leroy & Barry" were re-calibrated to ensure accuracy. Unfortunately, at this time it was discovered that the portable system had a 4dB drift (i.e. a 2.5 times underestimate). Given the instability of the portable system it was decided to use only the Leroy & Barry's data since it had been shown to be stable between calibrations (i.e. 0.2dB or <5%). However, preliminary analysis of the Jan 21st data from the portable system when adjusted for a 4dB difference produced comparable numbers. Target strength was calculated from the mean length and weight of the fish sampled.

On the first survey day "Leroy & Barry" ran a series of transects from north to south and east to west. To examine the difference between directional transects the data were divided into three groups, all transects, North/South and East/West and the biomass estimated. The results of this analysis show that the estimates are relatively consistent regardless of which grouping was used (Table 7). Biomass estimates ranged from 314,900t to 330,100t.

Day 2 of the survey was broken into three time periods, transects undertaken before, during and after tagging. The vessel was sitting/drifting in a small area when the tagging operation was underway. Biomass estimates were made for the three periods and indicated the presence of 457,500t to 483,000t (Table 7). The densest group was located in the vicinity of the tagging operations where 445 kg/m^2 of fish were observed.

A short survey was conducted January 23 on a very dense aggregation with transects running from north to south. A few fish were recorded outside the Leroy & Barry's area of coverage by the portable system but could not be included in the estimate due to problems with the system. The biomass estimate was 233,400t.

On all three days it was obvious from the data that the fish were moving during the survey. The movement was northerly towards shore with the most activity occurring during daylight hours. Extreme care was taken in estimating the size of the schools from the echogram, not simply extrapolating the data from the transects. It should also be noted that on January 21 a large amount of fish very near shore could be seen on the sonar but could not be surveyed. It is therefore estimated that 400,000-500,000 t herring were surveyed off Chebucto Head during the survey. These fish were predominately age 3 and 4 year old (Stephenson et al. 1999)

Grand Manan

During the 1998 fishing season only a few nights of acoustic recordings were reported from off Grand Manan. All data were collected by "Dual Venture" during standard fishing operations. Biomass estimates from fishing areas off the island (i.e. northeast and northwest) ranged from 4,790t to 17,431t (Table 8). Note that fish observed after Oct. 15 are considered to contribute to the 1998/99 fishing quota year.

Discussion:

Accuracy/Precision:

At the 1997 Zonal Herring Assessment a number of questions were raised regarding factors that may affect the acoustic biomass estimates. While studies were not implemented to address these topics directly, it is possible to extract data from the fishing excursions and calibrations to address some of these concerns. It was suggested that water temperature might have an effect of the transducer and its calibration. Consequently the data for the Leroy & Barry's September and January calibrations were compared. After adjustment for a filter, there was a change of 0.2 dB or less than 5% difference between the warmest and coldest waters. The data also indicated that this system was relatively stable over time.

During 1998 there was only one night where two vessels with automated recorders surveyed the same body of fish: September 16 with "Island Pride" and "Dual Venture" on German Bank (Table 4). Although, these vessels were in the

same general area on the same body of fish their coverage was different. Biomass estimates were 74,600t and 74,800t, respectively.

During the January 21 survey off Chebucto Head biomass estimates were similar for transects run in different directions by the "Leroy & Barry" (Table 7). These results suggest that the systems used aboard commercial fishing vessels are comparable between and within vessels.

A study conducted on the Pacific west coast in January of 1999 compared the HDPS system with the Simrad EK500 and preliminary results indicate a strong correlation between the two data sets. The final results of this study will be available in the near future.

Precision of the acoustic systems is a major challenge and is affected by many physical, electrical and behavioral factors. The target strength of a fish is known to change according to swimming aspect, water depth, and even time of day. During 1998 the majority of herring were observed and recorded near the bottom on German Bank. Care was taken not to include any bottom in the echo-integration. Inevitably, some fish are removed from the estimate. Current values used to estimate biomass are published equations for the calculation of mean TS values, which allow correction for fish size. To obtain *in situ* TS estimates a dual or split beam transducer is usually required, available only in expensive scientific equipment although a procedure called deconvolution can be used in some cases with single beam technology. To overcome this problem it is proposed to evaluate the acoustic system further using fish confined in fishing gear (i.e. weir or seine) where the number and weight can be accurately obtained. The empirical data can then be used to evaluate the acoustic estimates.

Problems:

There were two categories of problems associated with the deployment of the HDPS logging system: those associated with the hardware and those associated data collection. Several minor system malfunctions occurred with the commercial fishing vessel deployments. In all cases the problems were identified as equipment failure, interference or a loose connection, and not a problem of the logging software. The purse seiner "Leroy & Barry" experienced several periods of severe and intermittent interference caused by an electric heater. The solution was to move the system away from the heater wiring. On another occasion the navigation was lost due to a loose connection. For the Margaret Elizabeth, which installed a new sounder, background noise and sounder hardware problems rendered the system inoperable for half of the fishing season. Smoothing of the propellers' leading edge and the replacement of the sounder eliminated the noise. A random computer failure also affected the

recording of data from "Margaret Elizabeth". This is one of the older systems that are scheduled for replacement in 1999. The other three systems deployed aboard commercial fishing vessels operated flawlessly throughout the fishing season.

By far the most serious problems occurred with the portable system which utilized a commercial sounder as a transceiver. The first problem arose with the transducer provided with the system. Upon detailed analysis of the transducer's beam pattern at the Defense Research Establishment Atlantic (DREA) acoustic barge it was discovered that the unit produced extremely large side-lobes which were inconsistent with the specifications (the likely source was a bad element). The transducer was replaced and the system re-calibrated. On several occasions the system was improperly connected and did not log any data. This was not discovered until several months later when the data were analyzed. Between the last survey in Eastern Passage (November 1998) and the Chebucto Head survey (Jan 1999) the transceiver developed a drift of more than 4 dB when calibrated in Jan of 1999. This could have resulted from a poor connection (unlikely) or the transceiver being bumped during shipment to the survey site.

Malfunctions such as those that occurred with the systems deployed aboard the commercial fishing vessels are to be expected given the amount of electronics involved. All in all the challenges which occurred in 1998 were overcome and were part of the learning curve associated with the deployment of six units. To prevent the loss of important data it is proposed that the data from each survey be downloaded and examined immediately after the survey to detect any problems associated with logging. A schedule of periodic checking should also be setup for the commercial vessels in 1999. The portable system is currently being reconfigured to remove the commercial sounder and replace it with the HDPS 9320 transceiver. In the future, more care should also be taken in handling the units when transporting, loading and off-loading.

The second challenge in 1998 developed from the vast amount of data collected by the acoustic logging systems. With only two systems and a few nights of recording it was possible to download the data using backup tapes in 1-2 hours per boat. With the increase in the amount of data and the number of systems this approach was not appropriate. For the new systems 3-4 hours were required to download the computers to tape due to the additional sonar data collected by these systems. On several occasions the vessels were not in port long enough for downloading to take place. In addition, the systems were left on for several days while the vessel(s) were in port. This generated numerous data files of the harbor bottom that had to be examined and edited prior to discarding. To overcome the downloading problem interchangeable hard drive units were purchased. Downloading time was reduced from 3-4 hours to 15-20 minutes.

Summary:

Acoustic surveys were undertaken on major spawning areas and some of the major fishing areas using the automated logging equipment deployed on commercial vessels. Sonars and sounders of the purse seine fleet, and sounders of the gillnet fleet were used to document the number, location and approximate size of herring schools. Five acoustic recording devices allowed the logging of quantitative data for later analysis from "structured surveys" and from many fishing trips. The number of quantitative surveys increased and mapping surveys decreased in 1998. Biomass estimates were made using standard target strength relationships.

Between 1998 and 1997 the number of structured surveys decreased for a variety of reasons but given the addition of four new logging systems the number of fishing nights for which data were available increased. Unfortunately, because of the decrease in structured surveys the data collected could only provide a minimum biomass estimate for the spawning component or area surveyed on the night recorded. The biomass estimates can not be used as an index of abundance for inter-year comparison, given the limited and variable coverage. The data do however provide a minimum biomass estimate for the survey area. Implementation of a new survey design (Melvin and Power, 1999) will over-come many of the difficulties encountered in 1998 and provide a mechanism for inter-year comparison. The survey protocol will form the basis for future spawning component surveys in Scot's Bay, on Trinity Ledge and on German Bank. Furthermore, it is assumed that a similar protocol will be established for other spawning areas and that the method remains flexible enough to be applied on non-spawning aggregations.

Although there was deterioration in 1998 (compared with 1996 and 1997) in the number of "structured survey" estimates made by the purse seine and gillnet fleets, there was better surveying of fish schools in association with fishing operations. Acoustic estimates from the spawning grounds documented 521,300t of spawning herring. As these surveys were separated by at least ten day periods, double counting was thought to have been avoided.

While the 1998 4WX total spawning stock biomass can not be directly compared with the 1997 estimate because of the nature of the surveys, it can be used as a minimum biomass estimate for the stock complex. As such, the minimum biomass estimate shows a slight decline in the amount of fish documented for 1998 (Table 9). This is assumed to be the result of a more than 50% reduction in observed biomass in Scot's Bay and is likely due to the fact that no surveying was undertaken during what has traditionally been considered the main spawning season (July 23 - August 23). Other decreases, such as those observed on Trinity Ledge, were the result of equipment failure. The reduction of fish in the Spectacle Buoy area was due to a limited fishery and survey period.

There was a 20% increase in observed biomass on German Bank where most of the information was collected.

References:

Anon. 1998. 4VWX Herring. DFO Science Stock Status Report, B3-03 (1998): 12p.

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

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

Melvin, G.D., Y. Li, L.A. Mayer and A. Clay. 1998b. The development of an automated sounder/sonar acoustic logging system for deployment on commercial fishing vessels. ICES, CM 1998/S: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 (in press).

Table 1. Summary of Scots Bay acoustic data and biomass estimates. Vessel abbreviations are IP = "Island Pride", DV = "Dual Venture", LB = "Leroy & Barry " and ME = "Margaret Elizabeth".

Vessel	Date	Area (km2)	Sa (db)	TS	Mean Length	Biomass (mt)
IP,DV,LB	23-Jul	305.00	-36.483	-35.8	28.51	49,904
ME	26-Aug	1.91	-26.537	-35.5	27.13	14,889
LB	30-Aug	6.01	-31.063	-35.4	27.00	16,418
LB	31-Aug	2.53	-32.208	-35.4	27.00	5,313
LB	1-Sep	5.90	-29.474	-35.2	26.02	22,104

Table 2. Summary of the 1998 mapping surveys conducted in 4WX. Biomass estimates from provided for initial, mapping and acoustics where available.

Location	Date	No. of Vessels Involved	Area (sq. km.)	Initial Estimate (t)	Paper record Estimate (t)	Acoustic record Estimate (t)
German Bank	23-Aug	14	158	N/A	10,544	18,348
German Bank	17-Sep	11	104	60,000	49,957	N/A
Scot's Bay	23-Jul	13	251	40,000-50,000	26,929	49,904
Scot's Bay	23-Aug	5	200	N/A	22,569	N/A
Trinity Ledge	27-Aug	9	14	10,000	2,142	N/A
Trinity Ledge	8-Sep	18	10	4,000	3,778	N/A
Trinity Ledge	20-Sep	10	10	2,000	842	N/A
Little Hope	6-Oct	10	26	8,500	7,438	2972* (6952 **)
Little Hope	17-Oct	9	16	10,000-15,000	7,089	N/A
Eastern Passage	21-Oct	8	4	N/A	550	8,259
Spectacle Buoy	22-Jun	14	18	N/A	1,329	N/A
Western Bank	20-Oct	4	1,310	N/A	8,862	17,445

* Machine turned off accidentally during survey.
** Extrapolated to mapping survey area.

Table 3. Summary of the 1998 German Bank nightly acoustic recordings and biomass estimates by vessel. Vessel abbreviations are ME="Margaret Elizabeth", IP="Island Pride", LB="Leroy & Barry" and DV="Dual Venture".

Vessel	Date	Area (km2)	Sa (db)	TS	Mean Length	Biomass (mt)
ME	22-Sep	2.00	-25.863	-35.9	29.17	11,718
IP	13-Aug	1.53	-24.312	-34.3	22.15	15,184
IP	18-Aug	0.97	-29.921	-34.5	23.00	2,784
IP	19-Aug	2.37	-28.06	-35.7	28.20	13,729
IP	20-Aug	4.58	-28.766	-35.6	27.69	22,092
IP	23-Aug	6.87	-34.145	-35.44	27.05	12,280
IP	27-Aug	1.88	-25.918	-35.8	28.51	18,028
IP	30-Aug	2.75	-23.092	-35.8	28.51	50,715
IP	2-Sep	3.66	-22.693	-35.8	28.81	78,996
IP	7-Sep	6.83	-23.168	-35.5	28.50	119,104
IP	8-Sep	1.80	-21.852	-35.5	28.50	41,668
IP	9-Sep	Very Few Fish For Analysis				
IP	10-Sep	Very Few Fish For Analysis				
IP	16-Sep	3.30	-23.677	-35.5	27.37	74,554
IP	18-Sep	3.20	-25.617	-35.86	29.06	28,647
IP	20-Sep	2.30	-19.436	-35.7	28.29	97,305
IP	22-Sep	Very Few Fish For Analysis				
IP	13-Oct	22.20	-39.768	-34.3	22.38	6,028
LB	23-Aug	11.70	-26.894	-35.12	25.60	18,348
LB	2-Sep	6.94	-29.476	-35.2	26.02	25,998
LB	3-Sep	9.33	-28.299	-35.9	29.32	45,482
LB	4-Sep	27.00	-39.82	-35.9	29.32	11,070
LB	7-Sep	7.63	-28.953	-35.7	28.20	36,079
LB	8-Sep	12.00	-28.743	-35.7	28.20	59,547
LB	9-Sep	Very Few Fish For Analysis				
LB	21-Sep	0.51	-29.407	-35.6	27.69	4,162
LB	22-Sep	0.78	-29.828	-35.7	28.20	3,865
LB	24-Sep	3.65	-33.992	-35.9	29.28	5,657
LB	28-Sep	1.00	-40.229	-35.9	29.28	369
LB	30-Sep	0.53	-24.806	-35.5	27.41	23,467
LB	1-Oct	0.40	-31.655	-35.5	28.20	2,424
LB	6-Oct	17.00	-45.325	-35.5	28.20	1,770
LB	12-Oct	1.30	-30.973	-35.4	26.79	3,603
LB	13-Oct	2.60	-44.87	-35.4	26.79	294
LB	20-Oct	Very Few Fish For Analysis				
DV	23-Aug	43.80	-37.021	-35.4	26.79	30,559
DV	2-Sep	7.17	-30.095	-35.9	29.40	49,026
DV	3-Sep	0.63	-25.042	-35.8	28.90	10,836
DV	7-Sep	7.16	-27.487	-35.7	28.10	43,878
DV	9-Sep	13.80	-31.004	-35.8	28.55	39,894
DV	10-Sep	Very Few Fish For Analysis				
DV	13-Sep	2.30	-37.31	-35.54	27.54	13,454
DV	14-Sep	Very Few Fish For Analysis				
DV	15-Sep	21.53	-30.503	-35.5	27.34	59,865
DV	16-Sep	10.72	-26.775	-35.4	26.84	74,845
DV	24-Sep	3.19	-26.573	-35.9	29.28	27,321
DV	25-Sep	Very Few Fish For Analysis				

Table 4. Summary of 1998 German Bank combined acoustic logging data and biomass estimates. The abbreviations for the vessels are as follows: ME="Margaret Elizabeth", IP="Island Pride", LB="Leroy & Barry", DV="Dual Venture".

Date	ME	IP	LB	DV	Total (mt)	Biomass (mt)
13-Aug	0	15,184	0	0	15,184	15,184
18-Aug	0	2,784	0	0	2,784	2,784
19-Aug	0	13,729	0	0	13,729	13,729
20-Aug	0	22,092	0	0	22,092	22,092
23-Aug	0	12,280	18,348	30,559	61,187	94,259 *1
27-Aug	0	18,028	0	0	18,028	18,028
30-Aug	0	50,715	0	0	50,715	50,715
2-Sep	0	78,996	25,998	49,026	154,020	
3-Sep	0	0	45,482	10,836	56,318	56,318
4-Sep	0	0	11,070	0	11,070	11,070
7-Sep	0	119,104	36,079	43,878	199,061	199,061 *2
8-Sep	0	41,668	59,547	0	101,215	101,215
9-Sep	0	0	0	39894	39894	39894
10-Sep	0	0	0	0	0	0
13-Sep	0	0	0	13,454	13,454	13,454
14-Sep	0	0	0	0	0	0
15-Sep	0	0	0	59,865	59,865	59,865
16-Sep	0	74,554	0	74,845	149,399	74845 *3
18-Sep	0	28,647	0	0	28,647	28,647
20-Sep	0	97,305	0	0	97,305	97,305
21-Sep	0	0	4,162	0	4,162	4,162
22-Sep	11,718	0	3,865	0	15,583	15,583
24-Sep	0	0	5,657	27,321	32,978	32,978
25-Sep	0	0	0	0	0	0
28-Sep	0	0	369	0	369	369
29-Sep	0	0	0	39,746	39,746	39,746
30-Sep	0	0	23,467	0	23,467	23,467
1-Oct	0	0	2,424	0	2,424	2,424
6-Oct	0	0	1,770	0	1,770	1,770
12-Oct	0	0	3,603	3,517	7,120	7,120
13-Oct	0	6,028	294	26,318	32,640	26,612 *4
20-Oct	0	0	0	0	0	0

*1 Data pooled, coverage area increased.
*2 No overlap, estimates summed.
*3 Same group of fish.
*4 "Island Pride", bait fish, west of German Bank.

Table 5. Summary of 1998 Chedabucto Bay acoustic data and biomass estimates. All data were collected by "Margaret Elizabeth".

Date	Area (krn2)	Sa (dB)	TS	Mean Length	Biomass (mt)
8-Nov	7.59	-26.503	-35.5	27.16	59,730
12-Nov	0.25	-22.619	-35.5	27.16	9,625
19-Nov	0.55	-19.111	-35.5	27.16	23,746
21-Nov	5.48	-26.868	-35.5	25.52	36,494
25-Nov	6.14	-25.298	-35.6	27.73	65,558
29-Nov	0.40	-29.621	-35.5	27.13	1,533

Table 6. Summary of 1998 St. Margaret's Bay acoustic loggings and biomass estimates. All data were collected by the fishing vessel "Margaret and Kristie".

Date	Area (krn2)	Sa (dB)	TS	Mean Length	Biomass (mt)
20-Jul	0.90	-34.113	-35.5	*	1376
21-Jul	1.50	-40.857	-35.5	*	437
22-Jul	9.50	-50.930	-35.5	*	544
23-Jul	0.85	-40.367	-35.5	*	326
25-Jul	0.50	-43.951	-35.5	*	71
28-Jul	0.70	-43.939	-35.5	*	100
31-Jul	1.00	-39.903	-35.5	*	363
3-Aug	1.86	-32.605	-35.5	*	3895
4-Aug	0.50	-32.014	-35.5	*	1,115
5-Aug	0.26	-41.353	-35.5	*	260
7-Aug	0.14	-24.210	-35.5	*	1,884
12-Aug	0.93	-41.898	-35.5	*	229
14-Aug	5.70	-46.260	-35.5	*	478
15-Aug	0.85	-27.145	-35.5	*	6848
17-Aug	0.20	-28.518	-35.5	*	998
18-Aug	4.02	-44.541	-35.5	*	499
19-Aug	1.00	-37.179	-35.5	*	679
20-Aug	0.60	-33.296	-35.5	*	997
21-Aug	0.30	-31.819	-35.5	*	700
24-Aug	3.70	-57.276	-35.5	*	25

* No length frequency data. Standard TS of -35.5 used to estimate biomass.

Table 7. Summary of Chebucto Head January 21-23, 1999 acoustic survey data and biomass estimates. See text for explanation of sub-groupings.

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	TS	Mean Length	Biomass (t)
Chebucto Head							
All transects	21-Jan	2.87	-12.785	113.377	-33.3	20.83	325,394
North transects	21-Jan	2.87	-12.928	109.710	-33.3	20.83	314,867
East transects	21-Jan	2.87	-12.723	115.006	-33.3	20.83	330,067
Chebucto Head							
Before tagging	22-Jan	1.13	-7.090	427.395	-33.39	21.17	482,956
During tagging	22-Jan	0.17	-6.917	444.737	-33.39	21.17	74,271
After tagging	22-Jan	1.36	-7.325	336.363	-33.39	21.17	457,454
Chebucto Head							
	23-Jan	0.53	-6.944	441.978	-33.39	21.17	233,365

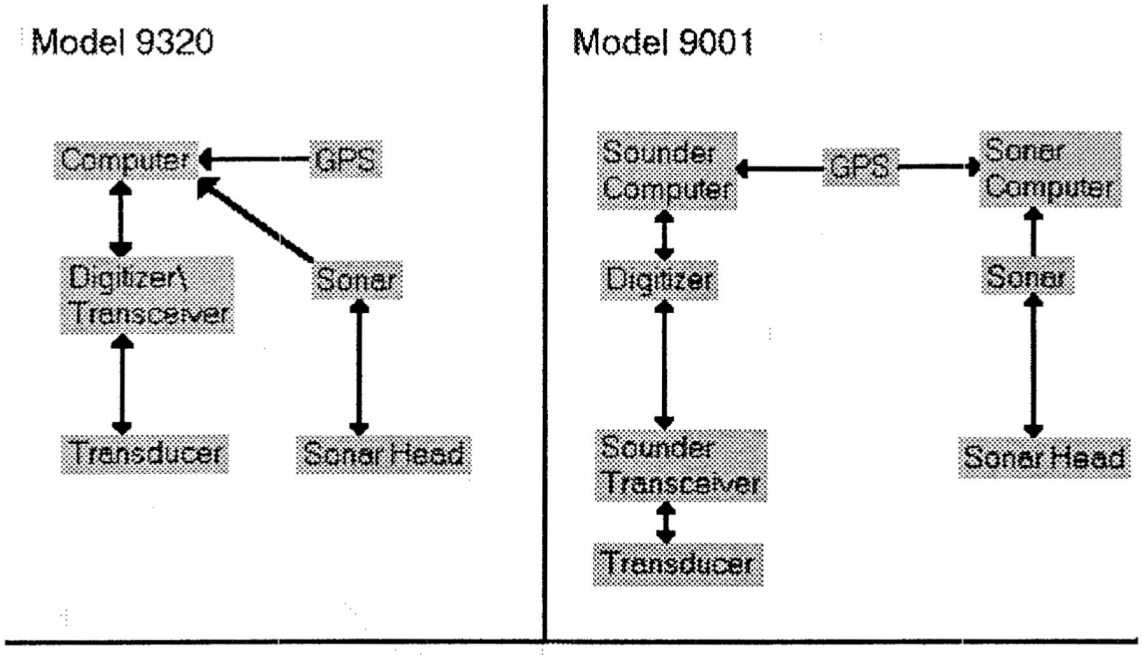
Table 8. Summary of 1998 Grand Manan acoustic data and biomass estimates. All data are from "Dual Venture".

Date	Area (km2)	Sa (dB)	TS	Mean Length	Biomass (mt)
6-Oct	8.60	-30.902	-34.0	20.99	17,431
20-Oct	2.23	-30.300	-33.6	19.78	4,790
21-Oct	8.90	-33.145	-33.6	19.79	8,958
4-Nov	3.70	-31.648	-33.6	32.62	5,840

Table 9. Comparison of the 1997 and 1998 acoustic and mapping biomass estimates for the spawning components surveyed in the 4WX stock complex.

Location	1997 Estimate	1998 Estimate
Scots Bay	160,168	72,473
Trinity Ledge	23,000	6,762
German Bank	370,400	440,704
Spectacle Buoy	15,000	1,329
Total	568,500	521,268

Figure 1. Schematic of acoustic systems currently being deployed aboard commercial fishing vessels.



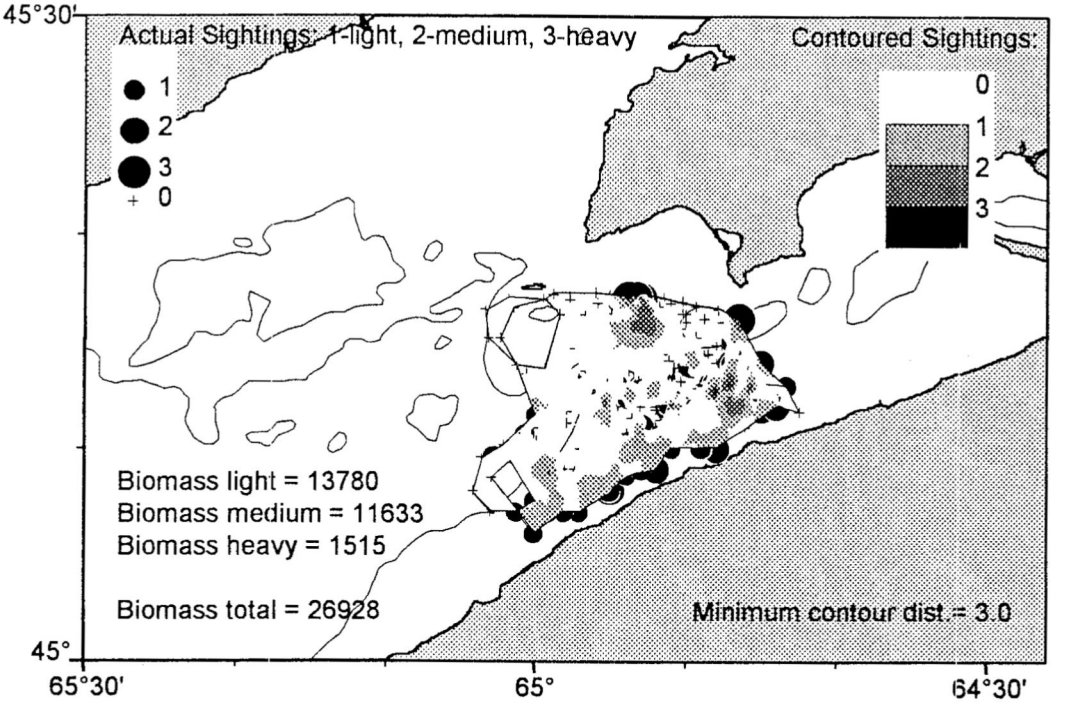


Figure 2. Scots Bay herring acoustic industry survey on July 23, 1998.

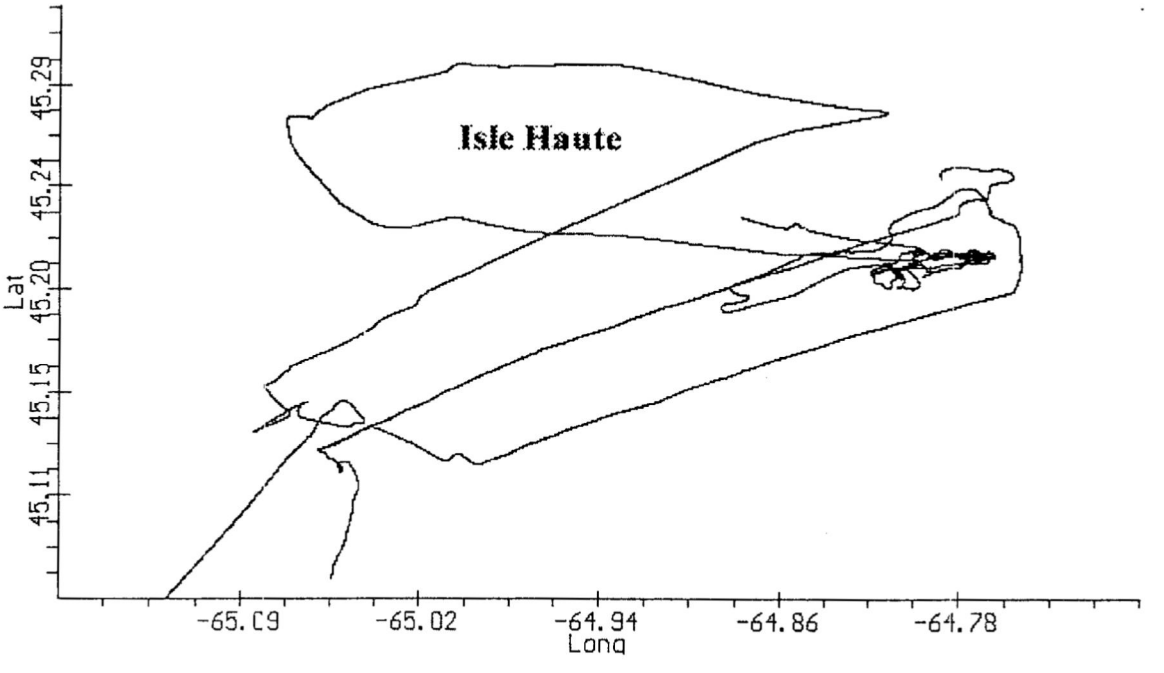


Figure 3. Vessel tracks undertaken by three herring purse seiners in the July 23, 1998 survey of Scots Bay. The three lines running from southwest to northeast were used to estimate biomass.

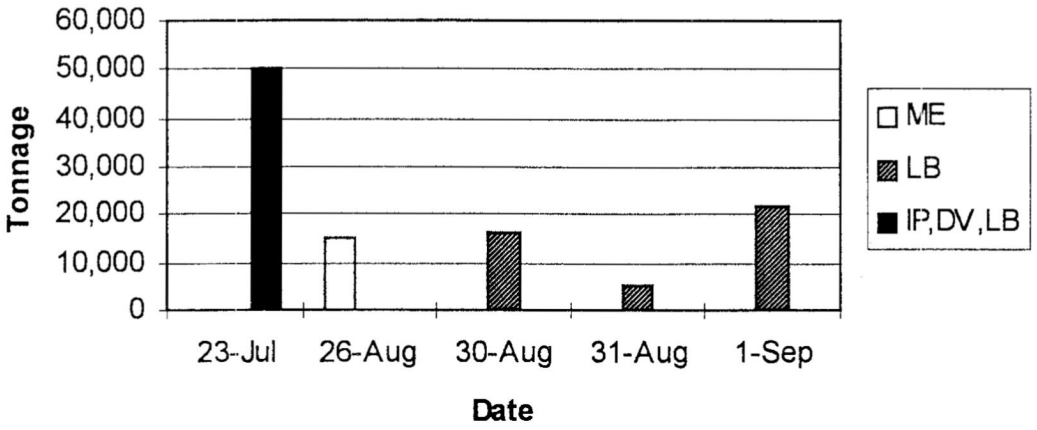


Figure 4. Biomass estimates from acoustic data records from the Scots Bay area for individual fishing nights. Vessel abbreviations are ME='Margaret Elizabeth", LB="Leroy & Barry", IP="Island Pride" and DV="Dual Venture".

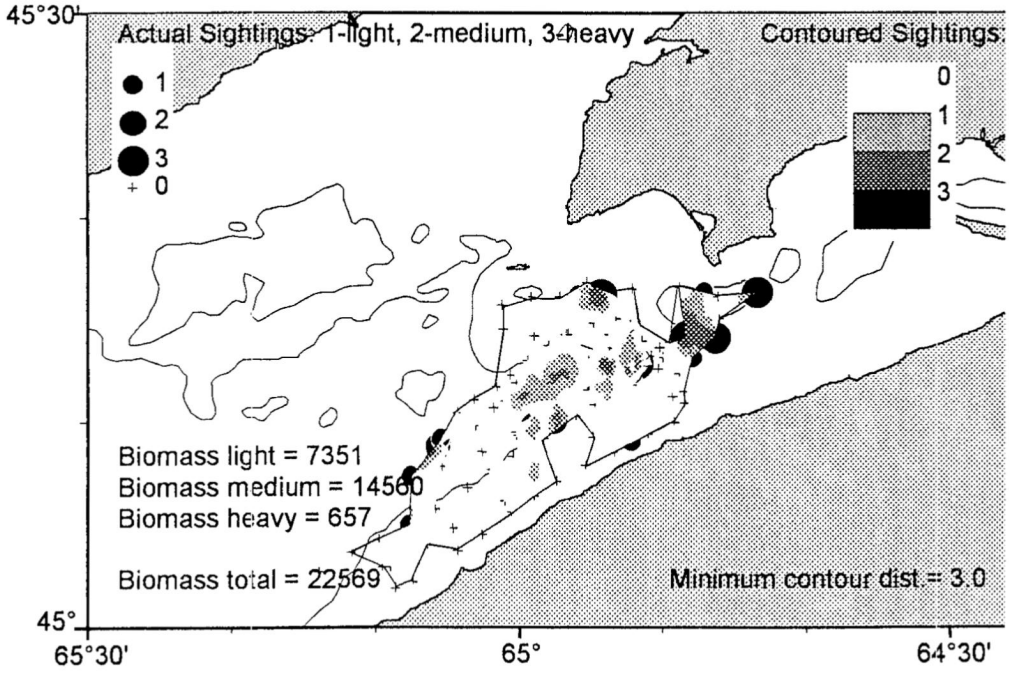


Figure 5. Scots Bay herring acoustic industry survey on August 23, 1998.

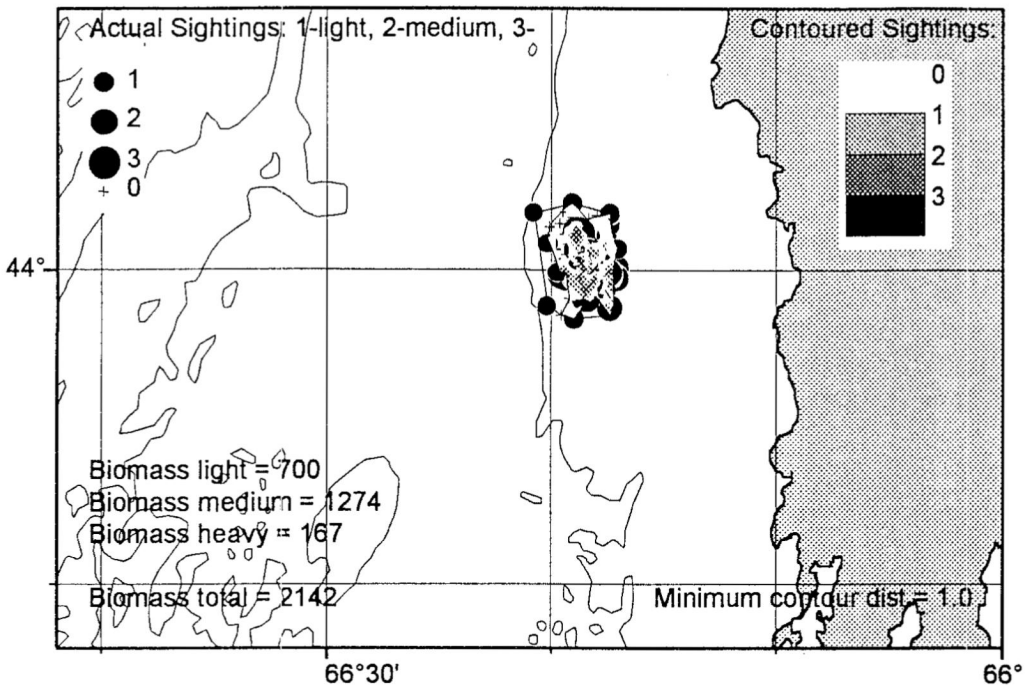


Figure 6. Trinity Ledge herring acoustic industry survey on August 27, 1998.

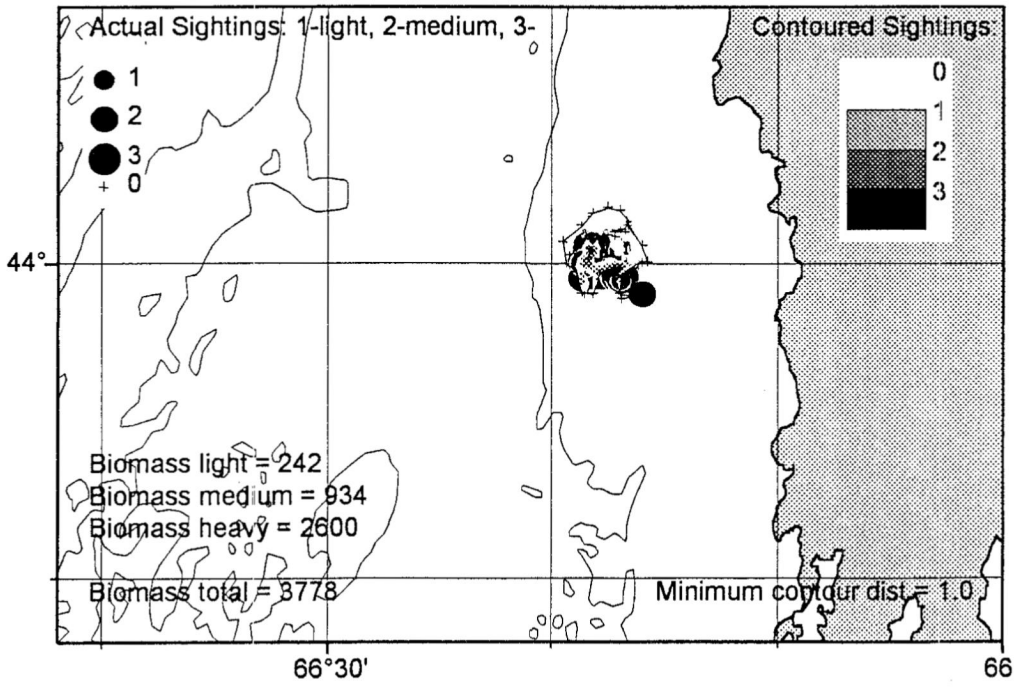


Figure 7. Trinity Ledge herring acoustic industry survey on Sept. 8, 1998.

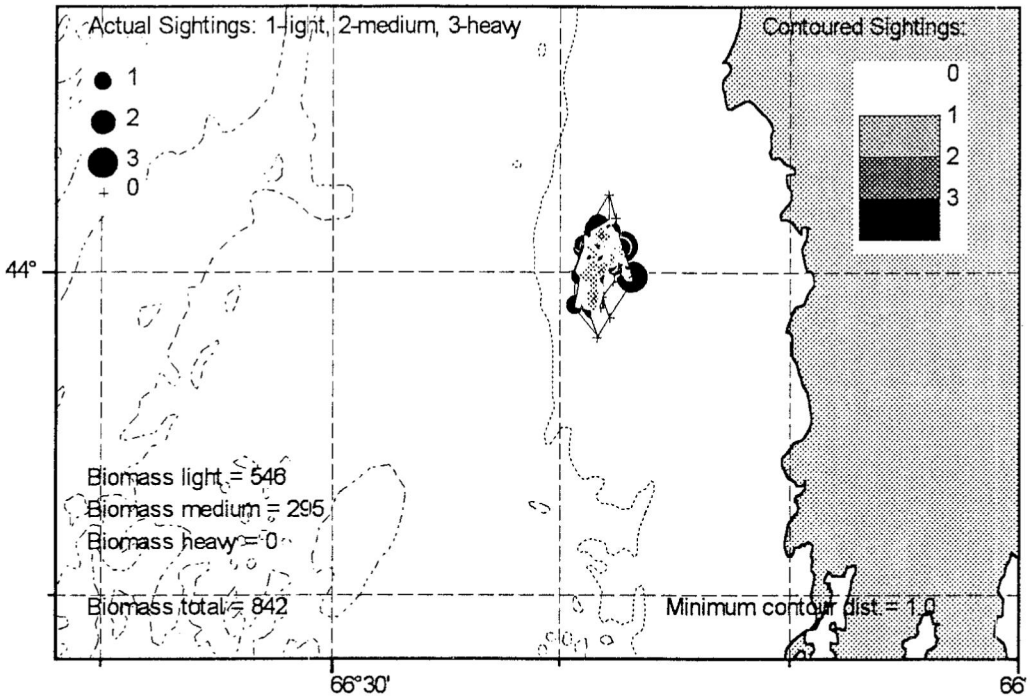


Figure 8. Trinity Ledge herring acoustic industry survey on Sept. 20, 1998.

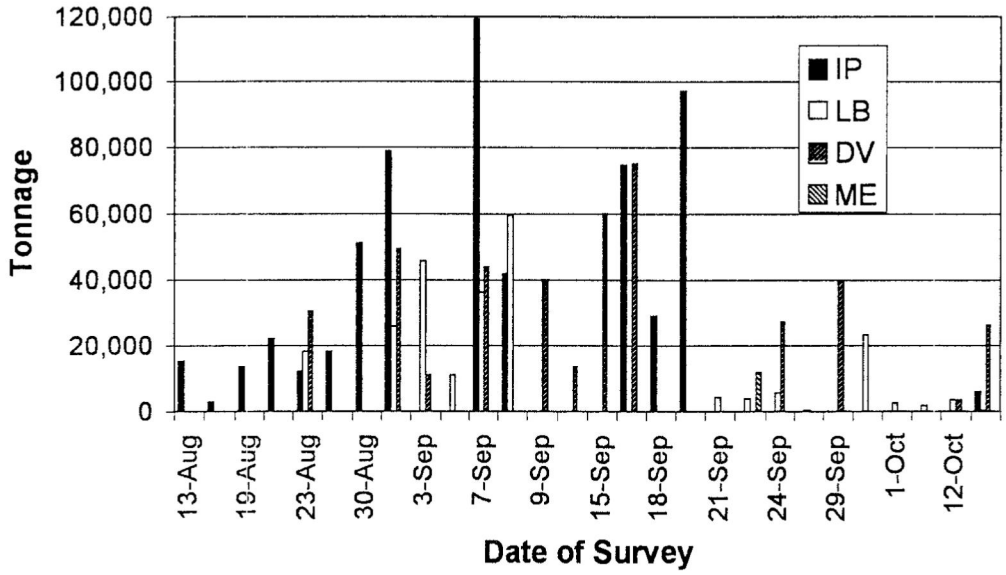


Figure 9. Summary of 1998 German Bank biomass estimates by individual survey vessel and date. Vessel abbreviations are IP="Island Pride", LB="Leroy & Barry", "DV="Dual Venture" and "ME='Margaret Elizabeth.

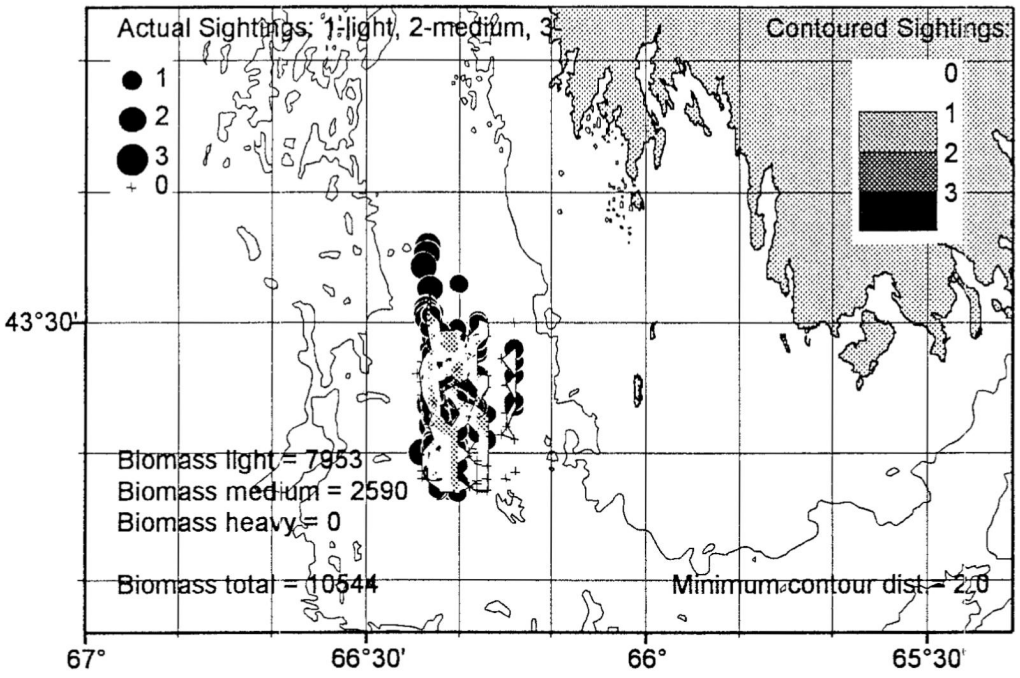


Figure 10. German Bank herring acoustic industry survey on Aug. 23, 1998.

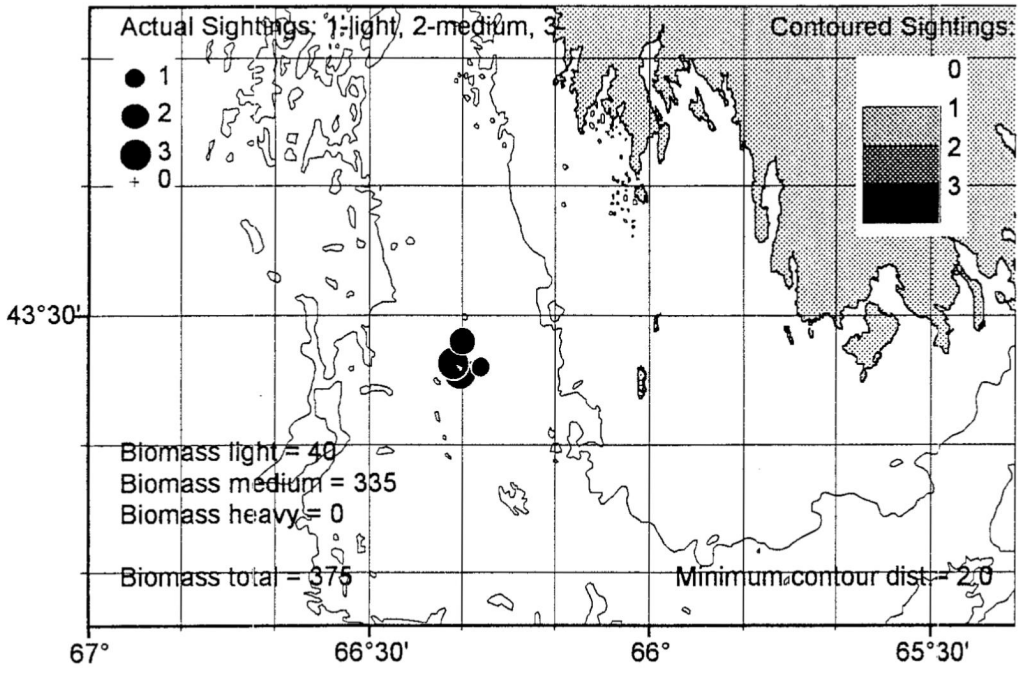


Figure 11. German Bank herring acoustic industry survey on Sept. 3, 1998.

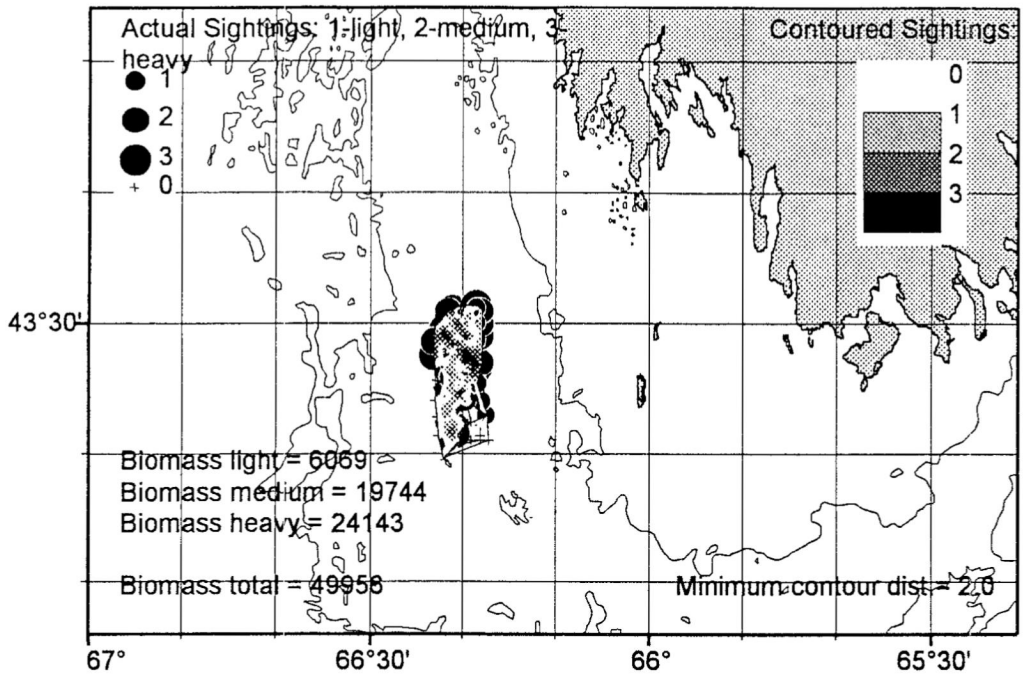


Figure 12. German Bank herring acoustic industry survey on Sept. 17, 1998.

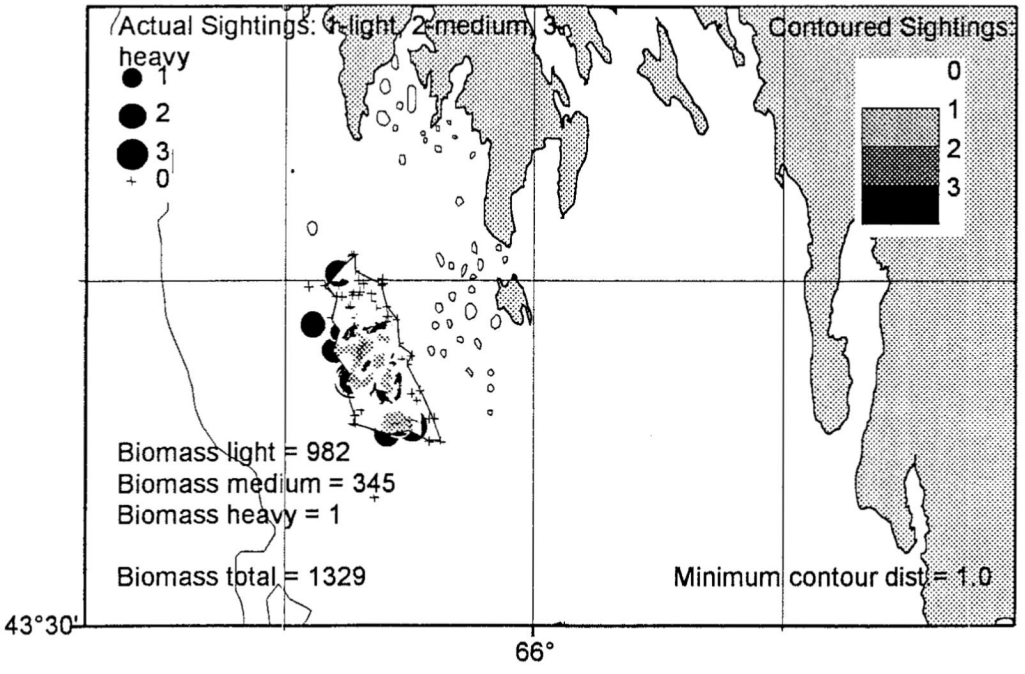


Figure 13. Spectacle Buoy herring acoustic industry survey on June 22, 1998.

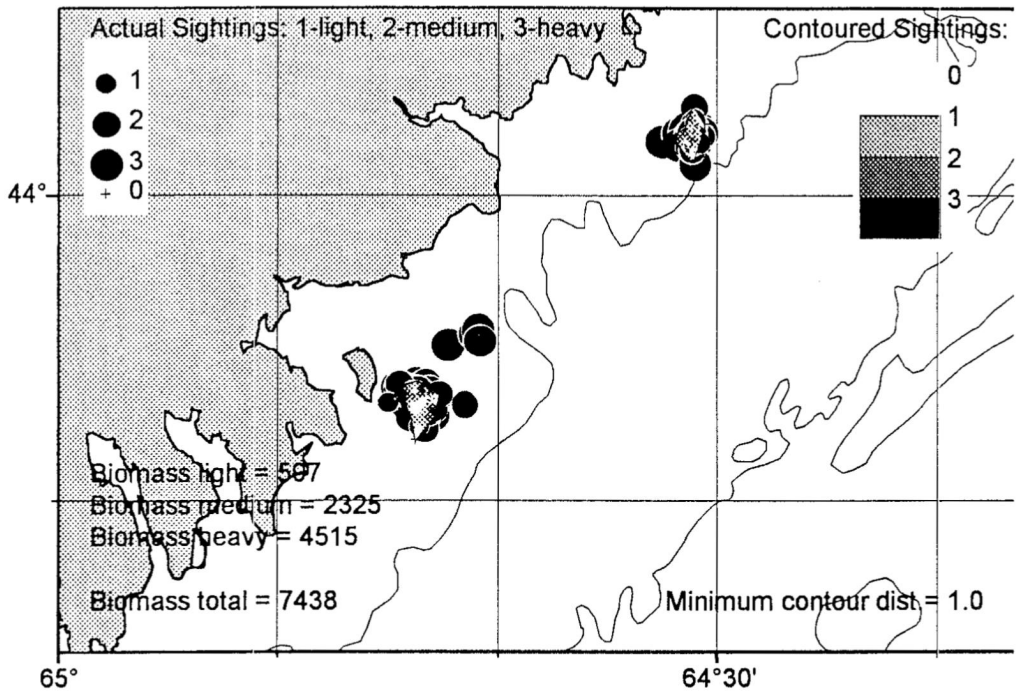


Figure 14. Little Hope herring acoustic industry survey on Oct. 6, 1998.

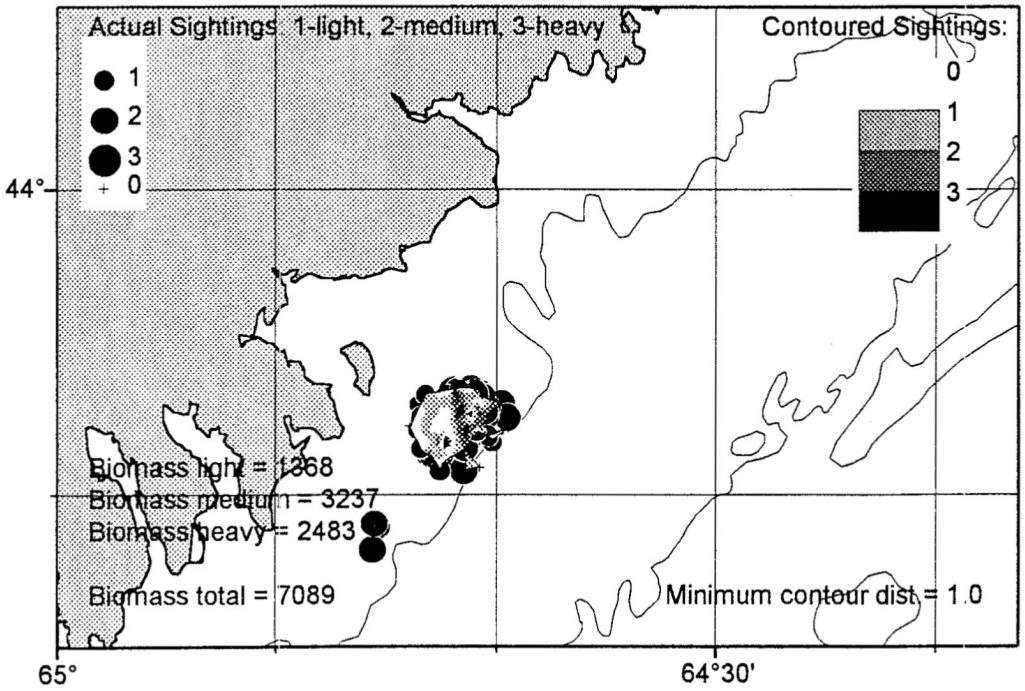


Figure 15. Little Hope herring acoustic industry survey on Oct. 17, 1998.

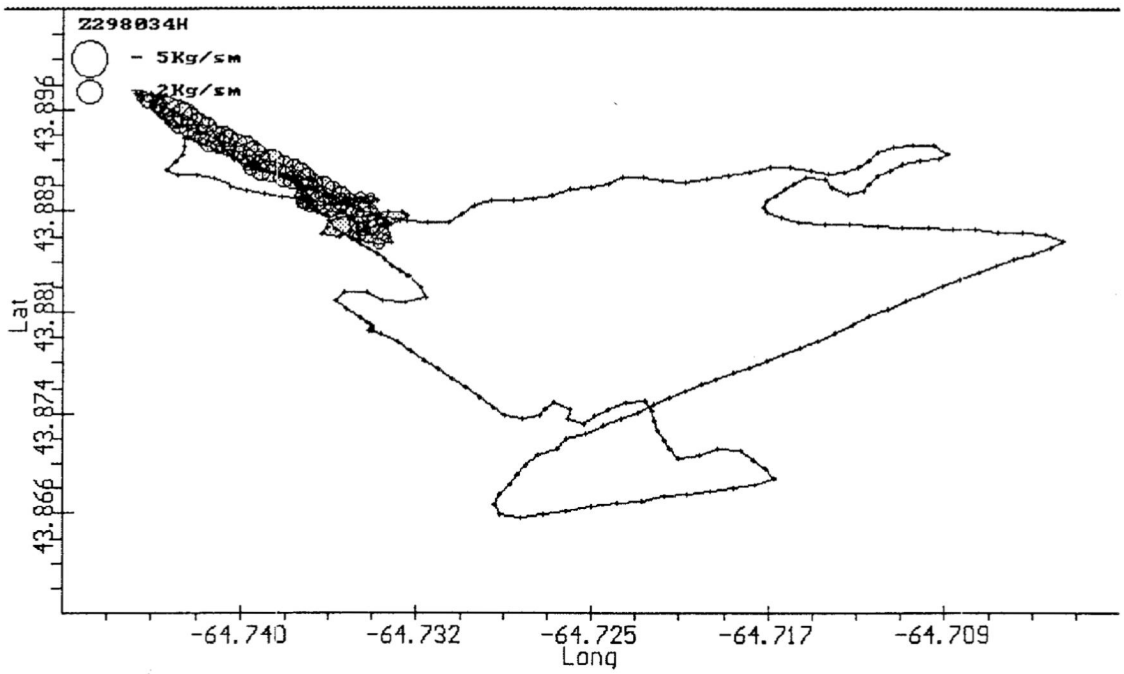


Figure 16. Vessel track of the portable acoustic system and the location of herring near Little Hope on the night of October 6 1998. Note the systems was turned off for most of the survey.

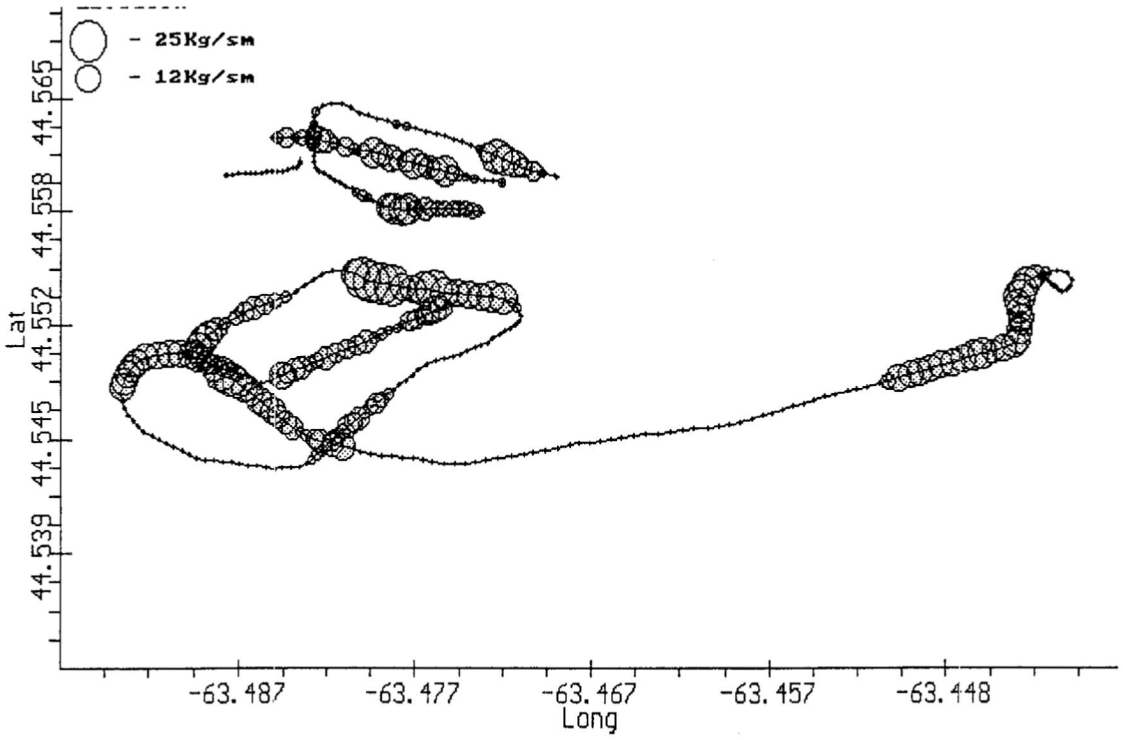


Figure 17. Vessel track of the portable acoustic system and the location of herring near Eastern Passage on the night of October 21, 1998.

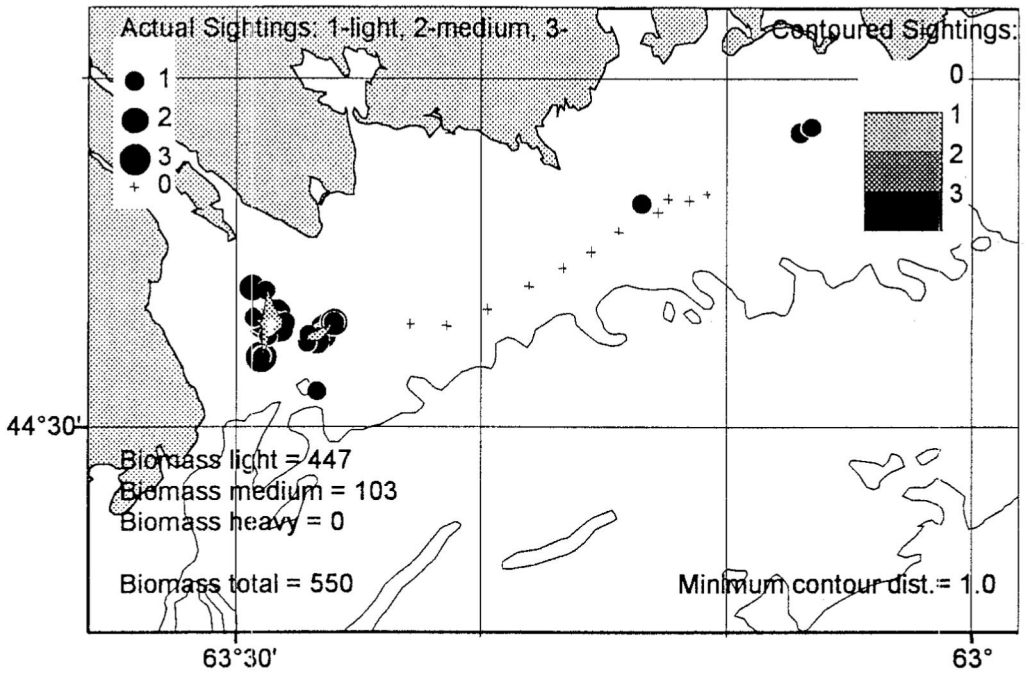


Figure 18. Eastern Passage herring acoustic industry survey on Oct. 21, 1998.

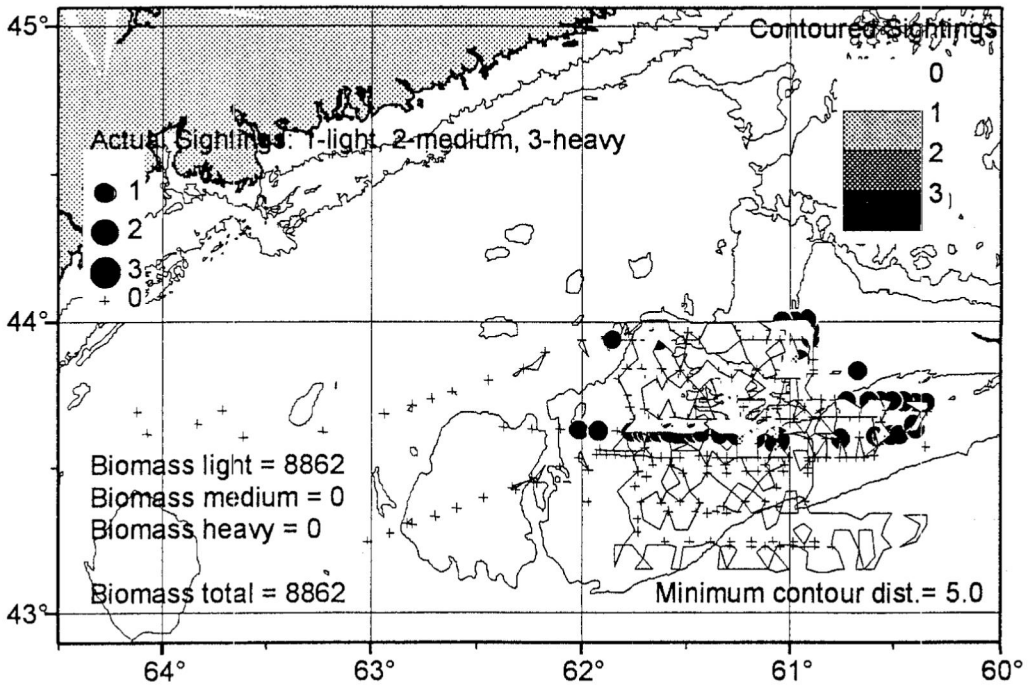


Figure 19. Western Bank herring acoustic industry survey on Oct. 20-22, 1998.