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**Summary of the 2008 Herring  
Acoustic Surveys in NAFO Divisions  
4VWX**

**Résumé des relevés acoustiques sur  
le hareng effectués en 2008 dans les  
divisions 4VWX de l'OPANO**

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**ABSTRACT**

Automated acoustic recording systems deployed on commercial fishing vessels have been used since 1997 to document the distribution and relative abundance of Atlantic herring in the Bay of Fundy and coastal Nova Scotia. These areas are within the Northwest Atlantic Fisheries Organization (NAFO) divisions 4VWX. In 2008, regularly scheduled surveys, conducted by industry vessels at approximately 2-week intervals were focused on the main spawning components, and the spawning stock biomass for each component was then estimated by summing these results. Four structured surveys were conducted in Scots Bay, two on Trinity Ledge, two in the Spectacle Buoy area and five on German Bank. These surveys provided good coverage of the spawning areas consistent with established protocols in most cases. Additional data from fishing nights in various areas were also examined but were not applied to the overall spawning stock biomass (SSB).

In 2008 biomass estimates decreased for survey areas in Scots Bay, Trinity Ledge and German Bank to 223,100t. This is a 42% decrease from 2007 and is also the lowest recorded since acoustic surveys began in 1997. The overall estimate for 2008 also remains below the long term average, as it has since 2005.

Biomass estimates made from surveys of the coastal Nova Scotia spawning components for the Little Hope/Port Mouton, Eastern Shore and Glace Bay areas showed a large increase in the Port Mouton area and little change in other areas. No acoustic surveys were conducted in the Bras d'Or Lakes or the offshore Scotian Shelf in 2008.

## RÉSUMÉ

Des systèmes automatiques d'enregistrement acoustique installés sur des bateaux de pêche commerciale sont utilisés depuis 1997 pour documenter la répartition et l'abondance relative du hareng dans les eaux de la baie de Fundy et des côtes de la Nouvelle-Écosse. Ces eaux se trouvent dans les divisions 4VWX de l'Organisation des pêches de l'Atlantique Nord-Ouest (OPANO). En 2008, les relevés normaux prévus, effectués par des bateaux de l'industrie à environ 2 semaines d'intervalle, ont été axés sur les principales composantes de reproducteurs et les résultats de ces relevés ont permis d'estimer la biomasse du stock de reproducteurs de chaque composante. Quatre relevés structurés ont été effectués dans la baie Scots, deux sur le récif de la Trinité, deux aux alentours de la bouée Spectacle et cinq sur le banc German. Ces relevés ont permis de bien étudier les frayères, selon les protocoles établis dans la plupart des cas. D'autres données provenant d'opérations de pêche nocturne ont aussi été examinées, mais elles n'ont pas été appliquées à l'estimation globale de la biomasse du stock de reproducteurs (BSR).

En 2008, la biomasse estimée a diminué dans les zones de relevé de la baie Scots, du récif de la Trinité et du banc German, pour se chiffrer à 223 100 t. Cela représente un déclin de 42 % par rapport à 2007 et la plus faible valeur enregistrée depuis le début des relevés acoustiques, en 2007. L'estimation globale de 2008 reste également inférieure à la moyenne à long terme, comme toutes les autres depuis 2005.

Pour ce qui est des estimations de biomasse provenant des relevés réalisés parmi les composantes de reproducteurs des côtes de la Nouvelle-Écosse dans les secteurs de Little Hope/Port Mouton, de la côte est et de Glace Bay, on observait une forte augmentation dans le secteur de Port Mouton et peu de changement dans les autres secteurs. Aucun relevé acoustique n'a été effectué dans le lac Bras d'Or ou sur les bancs du large du plateau néo-écossais en 2008.

## INTRODUCTION

Acoustic surveys conducted by the fishing industry have been used to estimate spawning stock biomass (SSB) of NAFO divisions 4VWX herring since 1997 (Melvin et al. 1998; Stephenson et al. 1998). Each year, commercial fishing vessels equipped with calibrated acoustic logging systems undertake both scheduled and unscheduled surveys of herring aggregations on the spawning grounds. The data collected during these surveys serve two purposes. First, when necessary, the data can be analyzed in near real-time and used as input for the “survey, assess, and then fish” protocol, to apportion fishing effort on individual spawning grounds. Secondly, the estimates for individual spawning areas were summed and under specific assumptions about elapsed time between surveys, provided an annual index of the SSB for the assessment process. The development and implementation of the automatic acoustic systems represents a major improvement in quantifying fish biomass. Pre-1997 estimates relied on the experience of the observer to estimate the amount of fish from mapping surveys, and were considered qualitative only (Melvin et al. 2002a).

The use of commercial fishing vessels to survey and to estimate SSB was initially developed to provide additional protection for individual spawning components within the global total allowable catch (TAC), during the 1994-95 period of declining biomass. The original qualitative approach, commonly referred to as the “survey, assess, then fish” protocol, continues today, but now uses a quantitative acoustic methodology with a standard survey design (DFO 1997; Melvin and Power 1999; Melvin et al. 2004; Power and Melvin 2008) to provide an index of spawning biomass.

Several major improvements in our approach have been made in the areas of survey design and standardization of survey coverage, to a point where they can be considered comparable from year to year (Melvin and Power 1999; Melvin et al. 2003, 2004). The purpose of this document is to report and summarize the NAFO division 4VWX stock assessment, as it relates to survey data collected during the 2008 fishing and survey season.

## METHODS

Acoustic and mapping surveys using commercial fishing vessels have been employed to estimate the spawning stock biomass of individual components within the stock complex since 1999. The methods and procedures are well established and described in more detail in previous research documents (Melvin et al. 2004, Power and Melvin 2008).

Data from the 2008 fishing season was obtained during both standard fishing operations and regularly scheduled structured surveys. Structured surveys were either mapping and/or acoustic surveys (Melvin et al. 2001). In 2008, no major changes in established protocol from previous years were made to either acoustic or mapping surveys.

The 18 surveys scheduled for 2008 were completed on or near the dates planned, and an additional 9 fishing night recordings were examined in order to enhance coverage (Table 1). Additional surveys were conducted to either increase coverage or to ensure that newly observed groups of fish were recorded, bringing the total number of structured surveys to 25. The total number of survey boat nights was 112, with 66 from vessels with acoustic recording systems and 46 from ‘mapping’ vessels without recording systems (Table 2). In general, structured surveys were conducted in accordance with the protocol established in Melvin and Power (1999). When structured surveys were undertaken, participating vessels tended to follow standard protocol and there was usually good coverage of the defined spawning survey area.

A few exceptions to the normal protocols of survey design did take place and these are explained in more detail where they occur.

### **Data Quality Issues**

In the previous analysis, there were 3 main areas of concern with the data including surveying protocols, provision and verification of the raw data and editing, and issues of noise and interference (Power and Melvin 2008). In the 2008 season most of these issues were resolved, but some, like not following survey protocols (i.e. doing a series of loops instead of parallel lines) when documenting fish aggregations on non-survey nights, continued to be a problem.

There is a well defined survey protocol for structured surveys and fishing night school documentation, but these are not always followed and remain an issue. In cases of fishing night surveys by purse seine vessels, there was a very poor adherence to survey design, with vessel captains rarely establishing a series of parallel transects to document the fish. Rather, the data provided was usually an unorganized search pattern common in fishing operations and was very difficult to analyze. It is important to follow the protocol (of a series of stepped parallel lines) for surveying an aggregation or school of fish. Data collections inconsistent with established protocols were given a low priority for analysis, or were not processed.

A major portion of time is required to download, backup and edit the raw acoustic survey data files. In previous years, Department of Fisheries and Oceans (DFO) staff completed this task and received all 'original' raw data files (unedited). More recently, these tasks have been split between the Herring Science Council (HSC) and DFO with the complete raw data received at the end of the season. In the previous review, it was recommended that all raw data files be made available on a regular basis for review prior to finalizing the acoustic biomass estimates. In 2008, all raw data files were received and the data compared with the edited results before the final analysis was completed. The main reason for these comparisons is to check for target uncertainty, to distinguish fish from bottom and to examine interference/noise patterns. As a result of these examinations, some data problems were found and resolved for some vessels and specific surveys. In a few cases, the bottom was not completely removed and some non-herring species were detected.

In the previous year, vessel noise/interference was apparent in some of the raw data files examined. The solution for future analysis is to have raw data files made available and examined at regular intervals. At the first sign of problem the source would be determined and corrected if possible. In addition, the operational vessel speed should be determined for each vessel and surveying speed limited to this. In 2008, noise tests were again completed for each vessel as part of the calibration process, and a recommended speed, or vessel RPM level was made. As a result of these efforts, the resulting raw data collected was found to have less background noise and was useable from all survey vessels.

### **Length/Weight Relationship**

Prior to 2001, the fish weight variable in the target strength (TS) equation (Table 3) was estimated using a length/weight relationship developed from monthly data for each area. Prior to calculating the length/weight relationship, a correction factor of 1.02 was also applied to each length measurement to account for the shrinkage of fish due to freezing, (Hunt et al. 1986). This relationship was then used to estimate the weight of a fish for a given length. The time window used to select data appropriate for individual surveys has narrowed slightly since 2001, to provide a more representative estimate of mean fish weight. Recent initiatives and continued



collaboration with the processing plants have greatly improved sampling, such that it is now possible to obtain a significant number of detailed samples (length/weight data) within a 9-day window (4 days prior to or after each of the surveys). These data are used to develop a weight/length relationship specific to each acoustic survey (Table 3). The mean length of herring sampled during the night of the survey (or from landings of the previous night) and the calculated mean weight is then used to estimate TS specific to each survey period.

### **Integration Calibration Factor**

In 2003, an option to account for the non-square waveform observed in a ball calibration was incorporated into the HDPS software (Melvin, et al. 2004). This approach is used by several acoustic manufacturers when calibrating their echo sounders. The effect of including an integration calibration factor to estimate backscatter in the integration process varies depending on the vessel's acoustic hardware. The multiplier for the factor, which is applied to the standard calibration, typically lies between 0.4 and 1.6, with 1.0 equivalent to an ideal square wave and, thus require no adjustment.

Given that the inclusion of the integration calibration factor (ICF or CIF) is deemed to provide a more accurate estimate of biomass, it was recommended that all future analyses utilize the CIF to calculate absolute biomass (Melvin et al. 2004). However, when comparing observations from year to year, it is recommended that comparisons be made between biomass estimates that exclude the adjustment, until a time series has been established with the CIF included. After several years, only the biomass estimate with the CIF will be needed.

Recalculation of the estimates for the earlier years from 1999 to 2002 using the CIF has been partially completed for 2001 and 2002 and these results were presented by S. Osborne at the 2008 RAP meeting. Further analysis for the 1999 and 2000 data is ongoing at which point all future analysis will be processed and reported with the use of the CIF exclusively.

The following analysis presents results using both methods of calculation (with and without the CIF). Until the revision including the CIF for all years is completed comparisons between years are made only with data calculated without the CIF. Unless otherwise noted, only biomass estimates without the CIF will be referred to when summarizing the data results.

### **Acoustic Systems**

In 2008, as in previous years, acoustic data was collected using automated logging systems aboard commercial fishing vessels during both standard fishing excursions and structured surveys. The systems, which were activated whenever the captain wished to document observations, automatically saved all data to the system's hard drive. This data was then downloaded at regular intervals prior to archiving, data editing and summary analysis.

A total of 18 automated acoustic logging systems (model DE9320) were deployed on commercial fishing vessels in 2008. Systems from FEMTO Electronics were installed and calibrated aboard 9 purse seine vessels including, *Brunswick Provider*, *Canada 100*, *Dual Venture*, *Island Pride*, *Lady Janice*, *Lady Melissa*, *Leroy & Barry*, *Margaret Elizabeth* and *Secord*. There were also 2 SIMRAD ES-60 acoustic systems calibrated and used on the purse seine vessels *Morning Star* and *Leroy & Barry*. Note that the *Leroy & Barry* was the only vessel with both types of recording systems installed which gave it the capability of doing simultaneous comparison of data collections. There were also 7 FEMTO systems on the inshore herring gillnet vessels including the *Bradley K*, *Jessica & Trevor*, *Knot Paid For*, *Major Expense*, *Miss*

*Owl's Head, Natasha Lee* and the *Sea Quiz*. One system was moved and recalibrated mid-season from the *Sea Quiz* to the *Major Expense*.

### **Structured Surveys**

Structured surveys are defined as those surveys that follow the standard protocol described by Melvin and Power (1999). Under this protocol, commercial vessels follow a series of randomly selected transects within a pre-defined area. The number of transects depends upon the number of vessels involved. Acoustic recording vessels are distributed throughout the survey area to provide representative coverage. The surveys conducted periodically throughout the spawning season are generally scheduled at 2-week intervals. These surveys play an important role in the understanding and perception of the 4WX herring stock. Sufficient flexibility is built into the process to allow for schedule changes and for investigation of areas of interest or uncertainty. Structured surveys were conducted on each of the major, and several of the minor, spawning grounds within 4WX, and additional recordings were made of both spawning and non-spawning aggregations during fishing night operations.

### **Fishing Excursions**

Fishing nights are defined as those occasions when acoustic data is collected by fishing vessels equipped with automated acoustic logging systems during the search phase of a fishing excursion. This data, which often does not follow any formal survey design, provides information on the distribution and abundance of herring during non-survey nights. The data has also been used in the past to document large spawning aggregations not included in a survey and/or as a substitute for a survey, in the event that no other information is available. The approach to the activation of the systems has changed since the start of the program. During the early stages, fishing captains would turn their system on when they reached the fishing ground and off once they deployed their fishing gear. For the last few years, the majority of vessels have activated their systems only when they believed there was something worth recording. This has greatly reduced the amount of time required for archiving, editing and analyzing.

Analyses of acoustic data from non-survey nights was made possible in previous years (since 2002) by the provision of technical support from the Herring Science Council. Due to the reductions in recent years, data from fishing nights were examined only where sufficient aggregations were surveyed and where established survey protocols were followed. Any fishing night estimate found to be higher than the nearest survey estimate for that spawning area, and time period can be considered for the overall area estimates. In 2008 nine fishing nights were examined in detail but none were applied in the final analysis for the overall survey area since the fishing night estimates provided a smaller biomass estimate than the nearest structured survey night (Table 4).

## **RESULTS**

The spawning biomass for individual components of the 4WX herring stock complex in 2008 was estimated from industry collected data using multiple structured acoustic and mapping surveys on major spawning grounds (Figure 1). These surveys, when summed, provide an index of SSB and form the main foundation for evaluation of the stock status. The following text provides a summary of the 2008 observations and SSB estimates for each of the main spawning components within the stock complex.

## **Bay of Fundy/SWNS Spawning Component**

### **Biological Sampling for Maturity**

The timing of surveys in relation to the residence time of spawning groups on the spawning grounds continues to be an issue of major concern. The current hypothesis for surveys on individual spawning grounds assumes that there is constant spawning on each ground over the season with individual spawning groups or waves continuously arriving, spawning and then leaving within 10 to 12 days (or less).

Sampling data for maturity supports the view of continuous spawning or waves with high proportions of ripe and running (spawning/Stage 6) fish observed over an extended period. The 10 to 12 day window also assumes that there will be no double counting and that the maturing (hard/Stage 5), as well as the spawning (Stage 6) fish in the samples will also have spawned and left before the next survey.

In 2008, herring maturity data was again obtained from 2 primary sources: "Herring Roe Analysis Sheet" data from the Scotia Garden Seafood processing plant quality control group and samples from the standard biological sampling program conducted by staff at the St. Andrews Biological Station (SABS). The "Roe Analysis Sheets" from Industry were supplied as available, usually on a daily basis during the spawning period and often with multiple samples from different boats. These are random samples of 50 to 100 fish with the males and females separated, and the individual gonads weighed into categories for use by the processing plant. From these data, the overall percent weights of mature, immature and spent females, as well as percent weight of the male gonads were determined. In 2008 a total of 24 samples, all from the German Bank area were provided during the spawning season from Aug. 18 to Oct 5 (Figure 2).

The SABS biological samples provide data on individual fish for length, weight, sex, maturity stage, gonad weight and age. These samples are collected from various sources including research surveys, tagging trips, acoustic surveys, and from landings at various plants. For comparison with the industry categorization, a modification to the SABS lab procedure to weigh all gonad stages was implemented in 2003. SABS samples were combined for female fish by day and percent numbers and percent weight by the categories determined. The plant classification system of maturity must not be confused with the standardized ICES (International Council for the Exploration of the Sea) scientific scale of 1 to 8 (Parrish and Saville 1965), but the industry roe data can be compared with SABS data based on knowledge of the 2 methods. Analysis of the roe maturities was completed for the data available on an individual survey basis and is presented in the following sections along with the details for each survey area.

### **Spawning Ground Turnover Rates**

The current acoustic survey method on spawning grounds is dependent on the assumption of periodic turnover of spawning fish on the spawning grounds. Acoustic surveys are required to be separated by at least 10 to 14 days to allow for turnover and to prevent double counting (Power et al. 2010). This aspect of the assessment method was the subject of investigation in 2001 and of intensive sampling for maturity stage since that fishing season. The results and application to the acoustic surveys are summarized each year (i.e. Melvin et al. 2002b, 2003, 2004; Power and Melvin 2008), and are used to assist in the evaluation of turnover timing and the inclusion or exclusion of specific acoustic surveys.

From 1998 to 2002, the Pelagics Research Council/Herring Science Council, in partnership with DFO, tagged herring on spawning grounds and on the major Nova Scotia over-wintering grounds. Although this project has concluded, tags continue to be returned. The information on tags returned from this study has been summarized by Waters and Clark (2005). Evidence from tagging experiments conducted in 1998 of ripe and running (spawning) herring showed that the residence time for most returns on the same grounds was less than 7-10 days; however, 25% of returns were captured on the same grounds after more than 10 days at large (Paul 1999). In contrast, a similar experiment in September 2001 on German Bank showed no recaptures after 9 days on the same grounds during the same spawning season (Power et al. 2002). This latter result was complicated by a large decrease in fishing effort (and thus fewer returns) during the second week after tagging.

In response to a recommendation from the 2005 Regional Advisory Process (RAP), tags were applied to herring on the spawning grounds of Scots Bay and German Bank (Clark 2007). The results from the tag returns indicated that some tagged herring remained on the spawning grounds for at least 3 weeks after tagging and, in some cases, up to 5 to 6 weeks after tagging. Thus, acoustic surveys that were spaced at 2-week intervals were surveying some of the same fish twice or possibly even 3 times.

These results have serious implications in how the acoustic surveys are evaluated and used to determine stock status. Some preliminary analysis has been completed comparing 3 different approaches for the interpretation of the acoustic biomass estimates in an absolute sense (Power et al. 2006). The results showed that caution is warranted when employing the cumulative biomass estimates as absolute in any of the survey areas. The results also indicated that some proportion of herring remain in the survey area even 3 weeks or longer.

A framework assessment meeting in January 2007 determined that double counting does occur, but the extent has not been well determined (DFO 2007). However, it was still recommended to continue to do surveys at 10-14 day intervals to avoid double sampling. The timing/turnover issue was considered to be of highest importance for further study, which should include work on the duration of the maturation process, further tagging with more frequent intervals to estimate turnover rates and increased survey frequency to reflect maturity stage duration.

## **Acoustic Surveys**

### **Scots Bay**

The Scots Bay herring purse seine fishery has been an important component of the summer fishery with catches since 1987, ranging from 1,000 to 24,400t during the period of early July to late August-early September. The 2008 fishery was again restricted with a 5,000t cap due to the poor performance of the spawning component since 2005. Landings in 2008 were substantially reduced from 2007 with only 2,370t caught from July 14 to Aug. 27. Sampling was more than adequate with samples from virtually all landings allowing detailed description of the size and maturity of fish captured (Figure 3, 4). Most fish were of adult size with few fish smaller than 22.5cm (size at first maturity) with larger fish more prominent early in the season (Figure 3). Samples for gonad maturity showed mostly ripe and running (spawning) as well some maturing (stage 5) stages (Figure 4).

Four structured surveys were conducted during the 2008 spawning season in Scots Bay similar to previous years (Table 5). The surveys, which began about the same time as in recent years, were separated by a minimum of 13 days and provided good coverage of the survey area, albeit with some issues due to a reduced number of survey vessels available for surveying.

*Scots Bay Acoustic Survey #1: July 12, 2008*

The first acoustic survey of Scots Bay in 2008 had 3 vessels participating; *Canada 100*, *Brunswick Provider* and *Margaret Elizabeth*, all with acoustic recording systems. The survey was attended by J. Lugar of the HSC. The vessels met off Margaretsville at 2100hr near the southwest margin of the survey box, from which each vessel ran two lines within the survey box (Figure 5). The vessels also documented areas of fish which were missed by random lines, but seen to one side or other by SONAR. However, estimation of these adjacent schools was difficult because the vessel simply did a loop through the school of fish, rather than a series of 2 or 3 parallel transects (Figure 6). Additional surveying on the body of fish encountered between the transects was completed by the 2 vessels with working recorders on the day following the survey, but the school biomass was found to be less than that of the overall area and so this 'fishing night' estimate was not used in the overall total for Scots Bay (Table 4, Figure 7).

Three length frequency samples were collected from catches on the night after the survey. The mean size was 28.4cm with a range from 22 to 33cm (Figure 8). There was a very small proportion (0.3%) of the samples with size <23cm, which is the size at first maturity and is used to indicate immature fish. Most herring sampled were mature with ripe and running gonads (Figure 4). Biological samples provided sufficient numbers (145 fish) for the calculation of the length-weight regression used in the estimation of target strength. The resulting TS estimate of -35.66 was only slightly different from the standard TS of -35.5 for a 28cm herring, which is used when no samples are available (Table 3).

The data were downloaded from the 3 boats with acoustic recorders and the initial data editing was completed by A. Clay, FEMTO Electronics. Equipment problems with the recording system on the *Margaret Elizabeth* resulted in loss of all data and as a result only 4 transects were analyzed. Estimation of biomass for the school only was difficult due to problems of area estimation and the lack of multiple lines through the schools. In future, it would be beneficial if a grid pattern was completed on major schools with at least 3 lines through each school.

As recommended at the Herring Framework review, the standard survey box area of 636km<sup>2</sup> was used for comparability between years. Within the standard survey box, an adjustment was made for lines that were incomplete. The distance was extended to the length of the box and assessed as no fish where there were no observations. The biomass estimate from this survey for herring located within the standard survey box area (inbox) was 5,089t without the CIF and 5,912t with the CIF (Table 5). A total of 4 schools were also covered, with a total biomass estimate for the schools summed of 2,475t without the CIF and 2,813t with the CIF. These school estimates were not used since the schools were within the overall survey area and the overall estimate for the entire area was shown to be larger. An estimate was also made from fishing activities on the night following the survey (Table 4, Figure 7) which resulted in a biomass estimate of 5,700t when calculated with the CIF. This estimate is lower than that for the survey on July 12 and thus is not used to replace it in the overall total estimate for the season.

*Scots Bay Acoustic Survey #2: July 26, 2008*

The second acoustic survey of Scots Bay in 2008 took place on the evening of July 26 with D. Knox from DFO, SABS attending. Five vessels participated and all boats were equipped with acoustic recording gear including the *Canada 100*, *Brunswick Provider*, *Dual Venture*, *Lady Janice II* and *Margaret Elizabeth*. The vessels met off Margaretsville at 2100hr and the survey began around 2145hr. Each vessel ran 2 lines which had been pre-established by SABS staff with the exception of the outbound line for the *Brunswick Provider* which was moved to the

northwest side of Ile Haute before the survey began and the *Lady Janice II* was required to veer off the inbound line at various locations due to shallow water (Figure 9). No large schools of fish were encountered along any of the survey lines except for 2 small bunches about 10 fathoms deep and 10 fathoms wide observed on the *Margaret Elizabeth* outbound line which was resampled with a 2<sup>nd</sup> line (Figure 10). The other boats reported that they had not observed any large amounts of fish and only a scattering of fish at the start of the survey. The survey ended at 0415hr on July 27. It was decided by the fishing captains that there was insufficient amounts of herring in the area to warrant staying until the following night to fish. The captain of the *Margaret Elizabeth* observed some schools of fish outside the box to the southwest on the return to port.

Since there was no fishing on or after the night of the survey length frequency samples were used from the nearest fishing night which took place 6 days previously on July 21. The mean size was 28.0cm with a range from 22 to 33cm (Figure 11). There was a very small proportion (0.4%) of the samples with size <23cm, which is the size at first maturity and is used to indicate immature fish. Samples of herring collected the week before were a mixture of mature with ripe and running gonads (Figure 4). Biological samples and 67 detail fish were used in the calculation of the length-weight regression and the estimation of target strength. The resulting TS estimate of -35.58 was only slightly different from the standard TS of -35.5 for a 28cm herring, which is used when no samples are available (Table 3).

The data were downloaded from the 5 boats with acoustic recorders and the initial data editing was completed by A. Clay. Equipment problems with the recording system on the *Dual Venture* resulted in loss of all data and as a result only 8 of the 10 planned transects were analyzed (Figure 9). The biomass estimate from this survey for herring located within the standard survey box area (inbox) was 11,722t without the CIF and 14,238t with the CIF (Table 5). A single school was also covered within the survey box area with a total biomass of 1,670t without the CIF and 2,038t with the CIF. School estimates were not used as the schools were within the overall survey area and the overall estimate for the entire area was shown to be larger.

#### *Scots Bay Acoustic Survey #3: August 9, 2008*

The third survey was directed by J. Lugar from the HSC using transects supplied by SABS. Six purse seine vessels, all with acoustic recording equipment ran 12 equally spaced transects with deviations due to shallow water or to document schools close to or between the lines (Figure 12). Two additional transects were also completed northwest of the standard survey area near Ile Haute. Sampling data collected from fishing nights before and after the survey had bimodal size distribution with a smaller mean size than previous surveys at 26.4cm (Figure 13). Maturity samples had no immature roe but found a mixture of hard and spawning fish (stage 5-6) before the survey and a higher proportion of spawning fish in the days following the survey (Figure 4).

This was the best survey of the area in 2008 as far as the number of transects and survey coverage but there were very few herring seen along most transects. There were no equipment problems with the data downloaded from the six boats and initial data editing was performed by A. Clay. The biomass estimate from this survey for herring located within the standard survey box area (inbox) was 2,580t without the CIF and 3,144t with the CIF (Table 5).

Using the two transects northwest of Ile Haute the biomass estimate for herring located outside of the standard survey box area (outbox) was 59t without the CIF and 68t with the CIF (Table 5). Two schools were also covered within the survey box area with a total biomass of 692t without

the CIF and 844t with the CIF. These school estimates are smaller than the overall survey estimate and were not used further.

*Scots Bay searching activities: August 21 and August 26, 2008*

Additional searching of Scots Bay in 2008 took place on the evening of August 21 and 26-27<sup>th</sup>, with the vessel captains searching for herring (Figure 14, 15). Three purse seine vessels, all equipped with acoustic recording gear, participated in the surveying but there were no fish reported, no landings or samples from this area and no acoustic data was analyzed any further.

*Scots Bay summary*

In summary, the 2008 Scots Bay acoustic survey SSB estimate from the 4 structured surveys for the within survey box area (inbox) was 19,391t as calculated without the CIF and 23,294t with the CIF (Table 5). For 2008, the total biomass estimate for areas surveyed outside of the standard survey box in the Scots Bay area was 126t without the CIF and 148t with the CIF (Table 5).

German Bank

The German Bank herring purse seine fishery has been a major component of the summer fishery with catches since 1985, ranging from 9,000 to 36,000t during the overall fishery period of early May to late October (Power et al., 2010). In 2007 catches were widespread with two localized groups of spawning herring seen within the standard survey area on German Bank. Catches during the spawning period in 2008 were distributed quite differently from those of 2007 with only a single central area of catch concentration.

Five acoustic surveys were conducted on German Bank during the 2008 season between August 22 and October 21 covering the entire spawning period (Table 2). Only 4 surveys were counted in the total biomass estimate due to survey protocol problems in the final survey. The time interval between surveys ranged from 13 to 17 days, and a total of 39 vessel nights of surveying were completed. In addition to the acoustic recordings, visual observations from the sounder were recorded at 5 to 10 minute intervals on deck sheets for all vessels. Fish samples for maturity, while limited from industry sources, indicated that mature spawning herring dominated samples collected (Figure 2, 16). As in previous years, length sampling was very extensive for this fishery with fish sampled from within the survey box found to be mostly larger than 23cm, which is the approximate size of first spawning for this stock (Figure 17a, 17b).

Fishing night acoustic data for German Bank were examined for 8 nights between July 30<sup>th</sup> and October 21<sup>st</sup>, where sufficient data for estimation of biomass were collected (Table 4). Biomass estimates from these fishing nights ranged from 400 to 30,000t. All estimates were compared with adjacent survey nights within the 10 day spawning timing window and were found to be lower in total SSB than the structured surveys. Thus no fishing night data were used in the final overall SSB for German Bank.

*German Bank Acoustic Survey #1: August 24, 2008*

The first herring acoustic survey of the German Bank spawning area for 2008 took place on the evening of August 22-23 with Jay Lugar from the Herring Science Council attending and with the captains of the purse seine vessels managing the survey using pre-established lines received from SABS staff. Nine vessels participated, seven of which were equipped with acoustic recording gear. The vessels met at the northern boundary of the survey box at 2100hr

and each vessel ran at least two pre-assigned lines with additional surveying completed east of the survey box (Figure 18). The survey ended at 0230hr and no fishing took place on the survey night as per prior agreement.

Four samples collected from fishing on the night before the survey were used in the estimation of target strength (Figure 19). The mean size was 28.6cm with a range from 23 to 33.5cm. All fish sampled were larger than 23cm (the mean size at first maturity) and 25% were greater than 30cm (approximately 5-6 years old). Samples available for maturity showed herring caught near to the survey date were mature with ripe and running gonads (Figure 2, 16). Biological samples from both industry and SABS sources provided sufficient numbers (167 fish) for the calculation of the length-weight regression used in the estimation of target strength. The TS estimate calculated for a 38/50kHz frequency system of -35.598 differs by 0.1dB from the standard TS of -35.5 for a 28cm herring used when no samples are available (Table 3).

After the data was downloaded from the 6 boats with FEMTO acoustic recorders, the initial editing for this data was completed by A. Clay. Data for the SIMRAD ES-60 system was downloaded by R. Cunningham. These ES-60 data were then converted to HDPS format and also edited by A. Clay. The 7 vessels with recorders completed 13 approximately equally spaced lines within the survey box and 6 lines outside of the box (Figure 18). Biomass estimates were calculated using the line segments for each of these groups both with and without the CIF.

In previous years, herring observed outside of the survey box were often found to be primarily small juvenile fish and not considered to contribute to the SSB. There were no samples or catches from the eastern area but the fishery had reported spawning fish in the area. The biomass estimate for the area east of the survey box (outbox) was 1,700t without the CIF and 2,400t with the CIF (Table 6). As recommended at the Herring Framework review, the standard survey box area of 646km<sup>2</sup> was used for comparability between years. The final biomass estimate for the standard survey box area was 19,900t without the CIF and 23,100t with the CIF (Table 6).

#### *German Bank Acoustic Survey #2: September 5, 2008*

The second German Bank survey for 2009 was directed by J. Lugar from the HSC using equally spaced transects approximately 800m apart as supplied by SABS with fishing allowed after the survey was completed. Eleven purse seiners participated including 7 with recording equipment and 4 using paper records at 5 minute intervals. A total of 14 acoustic transects were recorded over a total distance of 520km (Figure 20)

Survey observations saw fish over more of the area than on the 1<sup>st</sup> survey. *Lady Janice* recorded 1.5 miles of 8-20 fathoms thick 'blood red' fish on the southern portion of the 66°21 line (below 'The Sock' or 'Boot') (Figure 21). The *Tasha Marie* also saw the same group but had no recorder. There was no large amount on the 'tow' area but the *Secord* saw a good bunch, 5-10 fathoms or so, for almost a mile just west of the 'tow', and it was still quite deep.

Sample data collected from fishing on the previous night was used for TS estimation with a mean size of 27.2cm about 1 cm smaller than the previous survey and with a smaller proportion of large fish greater than 30cm (Figure 22). Maturity samples had a higher proportion of spawning fish in the days before the survey and mixture of hard and spawning fish (stage 5-6) after the survey (Figure 2, 16). There were no equipment problems. The data were downloaded from all boats with initial data editing completed by A. Clay. The biomass estimate from this



survey for herring located within the standard survey box area (inbox) was 60,300t without the CIF and 72,300t with the CIF (Table 6).

*German Bank Acoustic Survey #3: September 21, 2008*

The third survey for German Bank in 2009 was organized by J. Lugar from the HSC using equally spaced transects as supplied by SABS with fishing allowed after the survey was completed. There were 9 seiners involved, including 7 with recording equipment and 2 using paper records at 5 minute intervals (Figure 23).

It is noteworthy that during the week previous to this survey there were general issues with poor catches due to herring being hard to catch and the seines not sinking well below 20-25ftm. The poor sinking was attributed to tides, currents and a layer of plankton in the water column. A sample of these 'eyeballs' or 'jellies' were later identified as the common Salp species, *Thalia democratica*. Blooms of this plankton species have previously been reported in the Gulf of Maine causing fishing nets to become clogged (COOA, 2006).

The survey started at the northern edge of the defined survey box at 2040hr with all 9 vessels steaming along their lines to the south. At the southern edge of the line 5 boats went to the west and 4 boats to the east in order to complete the 2<sup>nd</sup> set of lines towards the north. The survey ended around 0130 with very little fish of substance noted during the survey. The boats were then allowed to fish and most spent their effort in the Tongue Ground area (north middle area) with successful sets made late in the night just before dawn. Sample size was good with a range from 23-32.5 cm, a mean size of 27.6 cm and with 20% greater than 30cm (Figure 24). Maturity samples had a high proportion of spawning fish (>60% stage 6) in the days after the survey (Figure 2, 16).

There were no equipment problems and the data was downloaded from the 7 boats with initial data editing completed by A. Clay. Data from Simrad ES-60 systems was converted to HDPS formats and also edited by A. Clay. A total of 14 acoustic transects were recorded with a total distance of 520km (Figure 25). The biomass estimate from this survey for herring located within the standard survey box area (inbox) was 27,700t without the CIF and 32,200t with the CIF (Table 6).

*German Bank Acoustic Survey #4: October 5, 2008*

The fourth German Bank survey was organized by J. Lugar from the HSC using equally spaced transects as supplied by SABS with fishing allowed after the survey was completed. There were 6 seiners participating, all with recording equipment (Figure 26). The survey started at the northern edge of the defined survey box at 1930hr with 5 vessels steaming along their lines to the south and then to the north. The 6<sup>th</sup> vessel (Lady Noreen) was equipped with scientific EK-60 echo-sounder and conducted target strength work in the area of herring concentration under the direction of G. Melvin. The survey ended around 0130 with a good showing of fish along several lines.

Samples collected close to the survey night had a range from 22-33.5 cm, a mean size of 28.0 cm and with 28% greater than 30cm (Figure 27). Maturity samples had a high proportion of spawning fish (>90% stage 6) (Figure 2, 16). There were no equipment problems; the data were downloaded from the 5 boats with initial data editing completed by A. Clay. Data from the Simrad ES-60 system was converted to HDPS formats and also edited by A. Clay. A total of 10 acoustic transects were recorded with a total distance of 370km (Figure 25). The data from the EK-60 scientific sounder will be analyzed and reported separately by G. Melvin.

Additional survey lines were completed on the main area of fish located within the survey area with a separate estimate made for this school only of 10,500t with the CIF (Figure 28). This estimate is not used further because the school was within the overall survey area and was less than the total survey estimate. The overall biomass estimate from this survey for herring located within the standard survey box area (inbox) was 93,800t without the CIF and 111,050t with the CIF (Table 6).

#### *German Bank Acoustic Survey #5: October 17, 2008*

This final survey was organized by J. Lugar from the HSC with fishing allowed after the survey was completed. There were 2 seiners with recording equipment and one seiner dedicated for sampling. Since there were very little fish seen, no sets were made and no samples were collected close to the survey night with the last fishery sample available from Oct. 11. There were no equipment problems; the data were downloaded from the 2 boats with initial data editing completed by A. Clay. A total transect distance of 175km was recorded by the 2 boats over 9 hours of surveying (Figure 29). Additional survey lines with good standard survey protocol (multiple transects in 2 different directions) were completed on an area of thinly distributed fish in the central area (Figure 30). This school was estimated at about 100t and is not used further because the school was within the overall survey area and was less than the total survey estimate. The overall biomass estimate from this survey for herring located within the surveyed area was 790t without the CIF and 930t with the CIF (Table 6). Because of the lack of samples or fishery information to confirm size or maturity stage of these fish this survey is not included in the overall German Bank estimate.

#### *German Bank Summary*

In summary, the overall spawning stock biomass (without the integration factor) for German Bank in 2008 was estimated to be 201,700t from 4 structured surveys covering a period extending from August 22 to October 21, about 1 week longer than 2007 and about 3 weeks longer than the survey period in 2005 (Table 6). The elapsed time between all surveys was greater than or within the 10-14 day guideline, and in this analysis, the turnover of spawning fish was assumed to be 100%. The fifth survey of October 21 was not included in the total biomass estimate because of the lack of samples to confirm size or maturity stage.

As recommended at the RAP herring Framework meeting (January 2007), the use of a standard survey area was applied. This SSB estimate reflects only biomass estimated from within the survey box and may be used in inter-year comparisons for trends. There was an additional 1,700t surveyed in areas close to but outside of the German Bank standard survey area, which was not included in the overall estimate for German Bank (Table 6). No adjustments were made to account for possible double counting of fish documented by previously conducted surveys.

#### Spectacle Buoy

A spring gillnet fishery for herring roe has occurred in recent years for a short period in June in the vicinity of Spectacle Buoy located just southwest of Yarmouth, Nova Scotia. The fishery is dependent upon the availability of fish and to some extent, market conditions, and may or may not occur in any given year. In 2008, there was virtually no fishery with only one landing of 6t. Two acoustic surveys were undertaken; one on June 9 with one boat completing 3.5 hours/45km of searching and on June 16 with two boats one with a recorder (4.5hrs/45km) but very little fish was recorded (Figure 31). The data was not edited and analyzed but visual inspection showed only a small amount of fish on bottom. In previous years herring in this area

were believed to have occurred in greater abundance in late May early June, and it is assumed the surveys had missed the majority of fish. There were no other signs or reports of herring for this area in 2008.

### Trinity Ledge

In previous years, the surveying of spawning herring on Trinity Ledge has been considered to be less than optimal, and it is unlikely that biomass estimates accurately reflect the abundance of fish in this area (Power and Melvin 2008). Improvements to the survey approach and adherence to the design protocols were recommended if the data are to reflect trends in abundance.

In 2008, three acoustic surveys were undertaken near the Trinity Ledge area on Aug. 28, Sept. 22 and Sept. 24. In addition there was some scouting of the area on six separate nights from Aug. 21 to Sept. 23 by one or more vessels to check for herring in the area but there were no reports of major aggregations and only one night with landings (7t on Sept. 23) (Figure 32).

For each acoustic survey the single recording vessel documented small areas of herring near Trinity Ledge buoy with biomass estimates of less than 500t (with the CIF) (Table 7, Figure 33). There also were no samples for length frequency or biological sample for TS determination, thus standard values for herring TS were used (Table 3).

An acoustic survey was completed on Trinity Ledge on Sept. 22 by the *Jessica and Trevor* using a FEMTO recording system. A total of about 5 hours and 47km of survey lines were completed with most of the searching in a small area of about 0.3 km<sup>2</sup> located southeast of the Trinity Ledge buoy (Figure 33). The area of the school appeared to be very small and the fish were in small bands about 10 meters thick close to the bottom.

The standard protocol for surveys of spawning herring is to allow a minimum of 10 days between surveys in order to avoid double counting of fish that still remain from previous surveys. Summing the estimates for the two surveys, which were separated by a 21 days, results in an overall total for 2008 of 270t (calculated without the CIF) and 520t with the CIF (Table 7).

The total biomass of 270t (calculated without the CIF) is the lowest recorded since acoustic surveying began in 1998 (Table 8, Figure 34). Catches were minimal in 2008 but given the continued erosion of spawning biomass there remains cause for concern. Until biomass levels improve, very limited or no fishing should take place on the Trinity Ledge spawning ground to allow rebuilding of this spawning area. Surveys also need to be continued in order to monitor the status of this spawning area which once supported a major proportion of the overall stock catch.

### Browns Bank

There was no survey activity on Browns Bank in 2008.

### Seal Island

Historically, the spawning areas around Seal Island made a significant contribution to the biomass of the Bay of Fundy/SWNS stock complex. In recent years, the abundance of herring and the documentation of spawning fish in this area have been intermittent. In addition, little fishing has occurred in these shallow grounds, partly as a result of the deep purse seines that

are now being employed, which are unsuitable for fishing these areas. There was no survey activity in the vicinity of Seal Island in 2008.

### **Bay of Fundy/SWNS Summary**

The 2008 acoustic results are considered to provide a reasonable estimate of herring present at the time of surveying when conducted according to the survey design. A major source of uncertainty continues to be the assumption that the surveys are simply additive. If herring do not move on and off the spawning grounds in waves with a short period of time (days) between the waves, the estimate of total SSB will be significantly biased upward due to double counting. The issue of turn-over time and potential overlap (repeat counting) was evaluated at the RAP Framework review meetings in 2006-2007 (DFO 2007) and the 10-14 day time period between surveys was considered reasonable, but required further investigations.

Since 1997, biomass estimates determined from acoustic surveys have been used to evaluate the status of the Bay of Fundy/SWNS component of the 4WX herring stock complex. During this time, the approach for estimating SSB has evolved from a heavy reliance on distribution and abundance estimates from fishing excursions with a 10 day minimum elapsed time, to structured surveys scheduled at 2-week intervals. In 1999, spawning areas were defined and survey protocols were established to make the estimates more representative of the actual SSB rather than a minimum observed value. This was accomplished by undertaking a series of surveys that covered most of the spawning area on each of the spawning grounds during the defined spawning season.

In the absence of survey data, fishing excursion data may be substituted as appropriate. Regular monitoring of herring gonad development throughout the season, from both industry and DFO sampling, provides evidence that the fish surveyed were mature spawners, and that a turnover of spawning fish had occurred between each survey (and that at least 10 days had elapsed between surveys). The total observed biomass for the complex was obtained by summing the SSB estimate for each spawning ground. Given the changes in survey area that have occurred over time, the estimated SSB for 1998 and 1999 are not considered comparable with those reported since then.

The estimation of biomass from acoustic backscatter relies on the relationship of TS to length measured under a variety of conditions (Foote 1987). The size and weight of herring from appropriate sample data have been applied, but there can still be considerable variance. Studies in controlled conditions in herring weirs (Melvin et al. 2000, 2001) resulted in absolute differences of 7 to 12% between the acoustic estimate and the biomass removed from the weir by seining.

The spawning stock biomass for the Bay of Fundy/SWNS component of the 4WX herring stock complex in 2008 was determined from industry based acoustic surveys of the 3 major spawning components: Scots Bay, Trinity Ledge and German Bank. No structured surveys were conducted outside the main spawning areas, around Seal Island or in the vicinity of Browns Bank. Acoustic data from several fishing nights were analyzed and reviewed, but were not included in the biomass estimate for any spawning component. Fishing and survey activity in the Spectacle Buoy area was limited with few fish observed during the surveys and no biomass estimates were calculated.

This is the twelfth year of surveying in which biomass estimates from industry based surveys have played a significant role in the evaluation of the 4WX herring stock abundance. For 2008, the majority of acoustic surveys in the Bay of Fundy/SWNS areas were well organized and

provided good coverage of the spawning grounds. The elapsed time between all surveys was within the 10-14 day guideline and turnover of spawning herring was assumed to be 100% for this analysis. The survey vessels generally completed the assigned transects, and automated recording systems were distributed throughout the fleet on survey nights. The set of surveys for the overall areas are considered to be comparable to others in the series since 1999. Biomass estimates from 1997 and 1998 are not considered comparable due to variation in the coverage area.

The SSB for Scots Bay which had been as high as 163,900t in 2001 first showed a major decline in 2005, likely due in part to the excessive catches of 2004 and 2005 (Table 9, Figure 35). Recently, Scots Bay had shown an improvement increasing from 16,800 in 2005 to 45,700t in 2007 but was still well below the 1999-2007 year average of 87,200t. In 2008 there was a substantial decline with an overall estimate of 19,400. This is the lowest in the time series except for 2005. Thus the SSB remains very low and it is well below (80%) the 1999-2007 average of 87,200t.

In 2005, the total spawning stock biomass observed on German Bank was one of the lowest recorded for this area at 211,000t. This represented a decrease of 150,000t from 2004, and was well below the average (Table 9, Figure 35). The SSB in 2005 was based on estimates of biomass from only 3 structured surveys undertaken from September 7<sup>th</sup> to October 4<sup>th</sup> instead of the typical 4 surveys. In 2008, the overall spawning biomass for German Bank was 201,700t using 4 of the 5 structured surveys from Aug. 22 to Oct. 21 (similar to the survey period in 2007). In the previous assessment the 2007 biomass estimate for German Bank was 337,190t representing an 88,700t, or 36% increase, from that observed in 2006. This year's analysis for German Bank in 2008 showed a substantial (40%) decrease in biomass (of 135,500t) to levels similar to that of 2005 and near the lowest observed for this area over 12 years of acoustic surveying.

For the Trinity Ledge and Spectacle Buoy areas, even with restrictions on catches, there has been an observed decline and a small amount of biomass recorded with surveys. Coverage of Trinity Ledge in 2008 was limited with three surveys completed and a small amount of searching outside of the Ledge. The single recording vessel tended to concentrate on a relatively small area where the schools of fish were located, and searching of the entire spawning strata area of 100km<sup>2</sup> found no other aggregations. Trinity Ledge once supported a large spawning component and fishery within the 4WX stock complex. As such, given the fact that the observed biomass is still reduced, any fishing on Trinity Ledge must strictly adhere to the "survey, assess, then fish" protocol during the upcoming spawning season. This means that no fishing should occur until sufficient quantities of herring are observed to allow for removals. Alternatively, given the slow rate of recovery, consideration should also be given to complete closure until a significant increase in spawning biomass is observed.

In 2005, the total SSB for the Bay of Fundy/SWNS spawning complex was estimated to be 233,100t, the lowest level observed since acoustic surveys began in 1997 (Table 9). Since 2005, the total SSB had shown gradual increases with estimates of 286,700t in 2006 and 384,400t in 2007. However, in 2008 biomass estimates decreased for all survey areas, including Scots Bay, Trinity Ledge and German Bank, to 223,100t. This is a 42% decrease from 2007 and is also the lowest recorded since acoustic surveys began in 1997. The 2008 estimate for the overall area remains below the long term average as it has since 2005. (Table 9, Figure 36).

## Coastal Nova Scotia Coastal Spawning Component

The shallow inshore waters of the bays and inlets along the Atlantic coast of Nova Scotia support a number of herring spawning populations. Several documents describe reports of coastal spawning in 4VWX (Clark et al. 1999; Crawford 1979). Direct knowledge of these relatively small coastal populations is limited to a few areas, where there are active commercial fisheries for roe on spawning grounds. A traditional fishery for lobster bait occurs in the spring and summer of the year. In the fall, commercial roe fisheries were conducted in 3 areas of the Nova Scotia coastal stock component: Port Mouton/Little Hope, Jeddore/Eastern Shore and Glace Bay. Surveys of the spawning grounds were undertaken using both the mapping and the structured acoustic survey approach, depending upon the area and the availability of a recording vessel. The results for each spawning area are presented below.

### Little Hope/Port Mouton

The 2008 herring gillnet fishery in Little Hope/Port Mouton area began in mid-September and extended to October 15, 2009 (Figure 37). The total catch was down from 1,506t in 2007 to 1,100t with the majority of the catch occurring between October 6 and October 8. Three acoustics surveys were conducted in this area between September 25 and October 30. All surveys were considered independent and the biomass summed where the elapsed time between surveys was more than 10 days. All data were downloaded from the only boat with an acoustic recorder, the *Knot Paid For*, and after editing to remove the bottom and non-herring targets, the acoustic files were cut into transects for each survey. Given that the multi-panel gillnet was not used to sample the acoustic targets in 2008, the standard TS of -35.96 for a 120 kHz system was used for all surveys to estimate biomass from the backscatter (Table 3). Length frequency and biological sample from the commercial catch were used to confirm the size and maturity of herring in the area (Figure 38, 39).

#### *Little Hope Acoustic Survey #1 - September 26, 2008.*

The first survey in 2008 of the Little Hope spawning box was conducted overnight beginning on September 25 and continued into the early hours of September 26. The survey involved 9 vessels including one with an acoustic recording system. The overall survey covered a total area of approximately 45 km<sup>2</sup> off Port Mouton (Figure 40). Two schools of spawning herring were covered by the acoustic vessel, one just east of Port Mouton Island and the other about 6 km south of the island (Figure 41). No samples were collected using a multi-panel net and the length frequency from the commercial catch could not be used to estimate target strength as the commercial gillnet gear is considered biased for size. Biomass estimates for both schools are based on a standard target strength for a 28cm fish (-35.96 @ 120kHz). The total biomass from the two schools were estimated to be 6,918t with 380t from the southern school #1 and 6,538t from the eastern school #2 (Table 10). The size and their maturity of herring from the commercial fishery in the area confirmed the presence of spawning fish (Figure 38, 39).

#### *Little Hope Acoustic Survey #2 - October 6 and 8.*

The second Little Hope survey was conducted over a period of 2 nights, 12 days after the first survey. The same area surveyed east of Port Mouton Island was surveyed on October 6 while an area south of the island was surveyed on October 8 (Figure 42). Both aggregations of herring were surveyed following standard procedures and provided good coverage of the observed fish. The biomass estimate for October 6 was 5,780t and for October 8 was 1,277t (Table 10). Biomass estimates from the two nights were summed because the groups of fish were considered to be separated in space and appeared to be persistent in time. The total SSB

estimated was 7,057t for the two nights of October 6-8. Length frequency and biological samples from the commercial catch confirmed the presence of spawning fish (Figure 38, 39).

The third and final survey of the Little Hope/Port Mouton spawning area was conducted on October 30. Unfortunately the vessels did not observe any aggregations of herring during their search (Figure 43). However, herring-like targets were observed sporadically along the track. Three transects in an area of 25 km<sup>2</sup> were extracted from the track and used to estimate an observed biomass. Based on these transects the biomass was estimated to be 494t (Table 15). Unfortunately, there were no commercial or biological samples collected in the area during or near the survey date. Consequently it is uncertain if these observed fish were in spawning, spent, or feeding condition.

#### *Little Hope Summary:*

In 2008, three acoustic surveys were conducted in the Little Hope/Port Mouton spawning box over the traditional spawning period. The standard protocol for surveying spawning herring of allowing 2 weeks between surveys was followed in order to avoid double counting that may have remained from the previous surveys. Summing the biomass from all surveys/schools resulted in a total spawning biomass of 14,469t and approximately 14,000t if we exclude the last survey on Oct. 30, when there was uncertainty regarding the spawning state of the fish (Table 10). Although this represents a significant increase in biomass from 2007, the 2008 biomass is still the second lowest observed since 2001 and well below the 1999-2007 average of 27,300t. The spawning biomass in the Little Hope spawning box remains low and caution is warranted when setting catch levels.

#### Halifax/ Eastern Shore

The 2008 herring gillnet fishery in the Eastern Shore fishing area began on Sept. 21 and ended on Nov. 2 with total landings of 2,381t (Figure 44). There was a reduction in 2008 due in part to a quota allocation limit for the area of 2500t which was put in place due to the reduced biomass observed in the previous year. This herring roe fishery reported catches from three main areas; near Halifax Harbour approaches, southwest of Jeddore Head and south of Ship Harbour, N.S. The fishery duration was similar to 2006-2007 with most catches occurring between Sept. 20 and Oct. 20, but the daily amounts were more variable (Figure 44). In 2008 catches were low in early Oct. and didn't reach a peak until the end of the season for a one week period from Oct 12-18. Catches were well distributed in the area but were less concentrated in the area south of Jeddore Harbour compared to 2007 (Figure 45).

Surveys were completed in each of the primary fishing areas from Halifax Harbour to near Ship Harbour, N.S. on Sept. 23, Oct. 1, 6, 8, 15 and Nov. 6. The data were downloaded from the two boats with acoustic recorders, *Bradley K* and *Miss Owls Head*. Additional data were examined from deck sheet recordings on Sept. 23 and Oct. 16 with 11 and 8 vessels participating on the respective dates. Length frequency and biological samples from the commercial catch were used to confirm the size and maturity of herring in the area (Figure 46, 47).

#### *Eastern Shore Acoustic Survey #1 – September 23*

The first survey in 2008 of the Halifax/Eastern Shore area was conducted on Sept. 23. The survey involved 13 vessels including two with an acoustic recording system. The overall mapping survey covered a total area of approximately 50 km<sup>2</sup> east of Halifax Harbor and revealed scattered fish estimated at 3,234t (Figure 48). Three schools of spawning herring were also covered in detail by the acoustic vessels at the western edge of the surveyed area

(Figure 49). Biomass estimates for the schools were estimated to be 1,938t for an overall total survey biomass of 5,172t for Sept. 23 (Table 11). Biological sampling confirmed that the fish surveyed were large adults, mostly larger than 30cm which were mainly in ripe and running spawning condition (Figure 46, 47).

#### *Eastern Shore Acoustic Survey #2 - October 1*

The second survey in 2008 in the Halifax/Eastern Shore area was conducted 8 days after the first, in an area further to the east, near Jeddore. The survey involved a single vessel with an acoustic recording system which recorded four schools of spawning herring in detail (Figure 50). Biomass estimates for the schools combined was estimated to be 4,108t (with CIF) (Table 11). Biological sampling also confirmed that the fish surveyed were large adults, mostly larger than 30cm which were mainly in ripe and running spawning condition (Figure 46, 47).

#### *Eastern Shore Acoustic Survey #3 - October 6-8*

The third survey in 2008 in the Halifax/Eastern Shore area was conducted 7 days after the first in a new area west of the previous survey. The survey involved two vessels with acoustic recording systems which recorded two schools of spawning herring in detail on two separate nights (Figure 51). Biomass estimates for the individual schools were made and the larger estimate of 3,782t (with CIF) was used (Table 11).

#### *Eastern Shore Acoustic Survey #4 - October 15*

A fourth survey of the Halifax/Eastern Shore area conducted on Oct. 15 involved 10 vessels including two with an acoustic recording system. The overall mapping survey which covered a total area of approximately 170 km<sup>2</sup> east of Halifax Harbor had thinly scattered fish which was estimated at 4,459t (Figure 52). A single school of spawning herring was also covered in detail by the acoustic vessels at the eastern edge of the surveyed area (Figure 53). The biomass estimate for the school was 12,072t for an overall total survey biomass of 16,531t (Table 11). Biological sampling also confirmed that the fish surveyed were large adults, mostly larger than 30cm which were all (100%) in ripe and running spawning condition (Figure 46, 47).

#### *Eastern Shore Acoustic Survey #5 - November 6*

The final survey in 2008 in the Halifax/Eastern Shore area was conducted almost one month later by a single vessel which recorded one school of spawning herring in detail (Figure 54). The biomass estimate for the school was 737t (with CIF) (Table 11). Biological sampling also confirmed that these fish were large adults which were all (100%) in ripe and running spawning condition (Figure 46, 47).

#### *2008 Eastern Shore Acoustic Survey summary*

The total spawning biomass for the Eastern Shore area for 2008 was taken as the sum of the Sept. 23, Oct. 1, 8, 15 and Nov. 6 surveys. The overall estimates are 25,250t without the CIF and 30,330t with the CIF (Table 11).

#### Glance Bay Surveys

Acoustic recordings were completed in 2008 for the Glance Bay area by the *Natasha Lee* with 4 trips, a total of 20 hours of surveying and 237km in distance covered (Figure 55, 56). Very little



herring were encountered except in shallow water near Glace Bay in the final survey on Oct. 29 but this acoustic data was not processed.

#### Coastal Nova Scotia Coastal Spawning Component Summary

The landings in the gillnet fisheries along the coast of Nova Scotia declined from 5,240t in 2007 to 3,500t in 2008 (Table 12). Landings were slightly lower for Little Hope/Port Mouton area with a decrease from 1,506t to 1,108t, a large decrease for the Eastern Shore area from 3,727t to 2,381t, and landings were minimal for Glace Bay with only 12t recorded. The Bras d'Or Lakes area remained closed.

In the previous assessment (2007 fishing season) there was a reduction in surveyed acoustic biomass in the Halifax/Eastern Shore area of about 50%, while the Little Hope area saw an even larger decline of almost 90%. In 2008, there was an increase in surveyed acoustic biomass in the Little Hope/Port Mouton area to 11,800t from the low of 2,400t in the previous year, but biomass is still below average (Table 13-14, Figure 57). The surveyed biomass in the Halifax/Eastern shore area saw a slight increase from 24,000t to 25,200t and is close to the long term average SSB of 28,385t observed for this area (Table 13-14, Figure 58). Surveys were also completed near Glace Bay but there were very little spawning herring documented or catch reported (Table 13-14, Figure 59). No herring surveys have been conducted in the Bras d'Or Lakes since 2000.

As indicated for the SW Nova Scotia / Bay of Fundy component, summing of multiple surveys may result in overestimates of SSB due to double counting. However, the majority of surveys of the Coastal Nova Scotia spawning component were undertaken on spatially separated aggregations of fish.

#### Offshore Scotian Shelf Component

Fleet activity/catch in the spring/early summer fishery on the offshore banks of the Scotian Shelf has varied between 1,000 and 20,000t since 1996 with landings of 5,263t in 2005. Acoustic recorders were activated on a few occasions, but insufficient quantities of fish were observed to warrant analysis. Consequently, no acoustic biomass estimates were available from the Scotian Shelf. There was again no fall herring research survey on the Scotian Shelf using the research vessel *CCGS Alfred Needler*.

No acoustic surveys were undertaken on the outer Scotian Shelf banks in 2008.

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Table 1. Summary of the number of surveys scheduled and number undertaken in 2008 with the number of fishing nights examined in the estimation of spawning stock biomass in the 4VWX stock and coastal component complexes.

Spawning Ground	Surveys Scheduled	Surveys Completed	Fishing Nights
Scots Bay	4	4	1
German Bank	4	5	1
Spectacle Buoy	2	2	0
Trinity Ledge	2	2	0
Browns Bank	0	0	0
Seal Island	0	0	0
Little Hope	2	3	0
Eastern Shore	2	5	0
Glance Bay	2	4	0
Total	18	25	2

Table 2. Summary of completed herring acoustic surveys undertaken in 2008 with interval (days) between surveys on the same grounds, number of boats with acoustic systems and the number of mapping boats (without acoustic systems using deck sheets only).

Survey Date	Location of survey	Interval (days)	Acoustic Boats	Mapping Boats	Total No. Boats
12-Jul-08	Scots Bay #1	0	3	0	3
26-Jul-08	Scots Bay #2	14	5	0	5
09-Aug-08	Scots Bay #3	13	6	0	6
26-Aug-08	Scots Bay #4	17	3	0	3
22-Aug-08	German Bank #1	0	7	2	9
05-Sep-08	German Bank #2	13	7	4	11
19-Sep-08	German Bank #3	14	8	1	9
06-Oct-08	German Bank #4	17	6	1	7
21-Oct-08	German Bank #5	15	2	1	3
01-Jun-08	Spectacle Buoy #1	0	1	0	1
09-Jun-08	Spectacle Buoy #2	8	1	0	1
25-Aug-08	Trinity Ledge #1	0	1	0	1
22-Sep-08	Trinity Ledge #2	27	1	0	1
25-Sep-08	Little Hope #1	0	1	8	9
06-Oct-08	Little Hope #2	11	1	0	1
08-Oct-08	Little Hope #3	2	1	10	11
23-Sep-08	Eastern Shore #1	0	2	11	13
01-Oct-08	Eastern Shore #2	8	1	0	1
07-Oct-08	Eastern Shore #3	6	2	0	2
15-Oct-08	Eastern Shore #4	8	2	8	10
06-Nov-08	Eastern Shore #5	29	1	0	1
21-Sep-08	Glance Bay #1	0	1	0	1
12-Oct-08	Glance Bay #2	21	1	0	1
15-Oct-08	Glance Bay #3	3	1	0	1
29-Oct-08	Glance Bay #4	14	1	0	1
Total number of survey boat nights			66	46	112

Table 3. Summary of fish sampled by survey date and location with target strength estimate from samples, and target strength estimate for a 28cm herring using the length/weight equation.

Date of Survey	Location of survey	Interval (days)	Number Samples	Number	Number	Number	Mean	Mean	Target	Wt 28 cm	TS 28 cm
				Measured Fish	Len/Wt Fish	Length (mm)	Weight (gm)	Strength dB/kg <sup>1</sup>	Fish (gm)	Fish dB/kg <sup>1</sup>	
12-Jul-08	Scots Bay #1	0	3	345	145	284	192	-35.655	182	-35.558	
26-Jul-08	Scots Bay #2	14	2	251	67	280	183	-35.583	183	-35.576	
09-Aug-08	Scots Bay #3	13	5	627	100	264	151	-35.235	184	-35.594	
26-Aug-08	Scots Bay #4	17	0	0	0						
22-Aug-08	German Bank #1	0	4	454	167	286	192	-35.598	178	-35.472	
05-Sep-08	German Bank #2	13	4	496	220	272	164	-35.382	182	-35.564	
19-Sep-08	German Bank #3	14	3	358	151	276	168	-35.344	177	-35.435	
06-Oct-08	German Bank #4	17	4	458	208	280	177	-35.439	177	-35.440	
21-Oct-08	German Bank #5	15	0	0	0					-35.500	
01-Jun-08	Spectacle Buoy #1	0	0	0	0					-35.500	
09-Jun-08	Spectacle Buoy #2	8	0	0	0					-35.500	
25-Aug-08	Trinity Ledge #1	0	0	0	0					-35.500	
22-Sep-08	Trinity Ledge #2	27	0	0	0					-35.500	
25-Sep-08	Little Hope #1	0	0	0	0					-35.500	
06-Oct-08	Little Hope #2	11	0	0	0					-35.500	
08-Oct-08	Little Hope #3	2	0	0	0					-35.500	
23-Sep-08	Eastern Shore #1	0	2	145	42	312	257	-36.117	189	-35.726	
01-Oct-08	Eastern Shore #2	8	1	103	23	302	234	-35.999	189	-35.726	
07-Oct-08	Eastern Shore 3	6	0	0	0					-35.500	
15-Oct-08	Eastern Shore #4	8	1	94	21	305	241	-36.035	189	-35.726	
06-Nov-08	Eastern Shore #5	21	1	75	19	310	252	-36.094	189	-35.726	
21-Sep-08	Glace Bay #1	0	0	0	0					-35.500	
12-Oct-08	Glace Bay #2	21	0	0	0					-35.500	
15-Oct-08	Glace Bay #3	3	0	0	0					-35.500	
29-Oct-08	Glace Bay #4	14	0	0	0					-35.500	

<sup>1</sup> TS calculated for 38/50kHz system using Foote equation (adjustment of -0.26575 and -0.44946 dB for 75 and 120 kHz systems to account for frequency).

Table 4. Summary of the 2008 herring biomass estimates observed during fishing nights for various grounds off SWNS and the Bay of Fundy. Standard target strength and calculation without the CIF were used.

No	Date	Vessels	Ground	Target	Area (km <sup>2</sup> )	Weighted Sa (dB/m <sup>2</sup> )	Density (kg/m <sup>2</sup> )	Biomass (t)	Standard Error (t)	SE %	Allens estimate
				Strength							
1	13-Jul-08	BP, C100	Scots Bay	-35.92	8.8	-37.8070	0.648	5,700	1,804	32	5,974
2	30-Jul-08		German Bank								2,674
3	17-Aug-08		German Bank								2,023
4	18-Aug-08		German Bank								2,702
5	23-Aug-08		German Bank								0
6	19-Sep-08	Fishing lines	German Bank								18,080
7	19-Sep-08	Survey lines	German Bank								20,305
7	22-Sep-08		German Bank								30,005
8	23-Sep-08		German Bank								3,928
9	21-Oct-08		German Bank								410

Vessel names: BP - Brunswick Provider; C100 - Canada 100; IP - Island Pride; LJ - Lady Janice; L&B, Leroy & Barry; LM - Lady Melissa

Table 5. Summary of the 2008 Scots Bay spawning ground acoustic survey data and associated biomass estimates for the standard survey box area (inbox) and for outside the survey box (outbox). The total SSB for the spawning component was obtained for each grouping by summing the biomass estimates.

a - without calibration integration factor; as presented since 1997

Location/ Type	Date	Target Strength (dB/kg)	Area (km <sup>2</sup> )	Weighted Sa (dB/m <sup>2</sup> )	Density (kg/m <sup>2</sup> )	Biomass (t)	Standard Error (t)	SE %
Scots Bay (inbox)	12-Jul-08	-35.92	636	-56.89	0.008	5,089	5,135	101%
	26-Jul-08	-35.61	636	-52.95	0.018	11,722	18,634	159%
	09-Aug-08	-35.24	636	-59.16	0.004	2,580	2,056	80%
	26-Aug-08					0		
Scots Bay total for standard survey area (inbox)						19,391	19,438	100%
Scots Bay (outbox)	26-Jul-08	-35.62	60	-65.17	0.001	67	81	121%
	09-Aug-08	-35.24	75	-66.26	0.001	59	61	16%
Scots Bay total for non-standard survey area (outbox)						126	101	80%

b - with calibration integration factor as introduced in 2004 assessment

Location/ Type	Date	Target Strength (dB/kg)	Area (km <sup>2</sup> )	Weighted Sa (dB/m <sup>2</sup> )	Density (kg/m <sup>2</sup> )	Biomass (t)	Standard Error (t)	SE %
Scots Bay	12-Jul-08	-35.92	636	-56.24	0.009	5,912	5,972	101%
	26-Jul-08	-35.60	636	-52.10	0.022	14,238	22,746	160%
	09-Aug-08	-35.24	75	-65.68	0.001	3,144	2,510	80%
	26-Aug-08					0		
Scots Bay total for standard survey area (inbox)						23,294	23,650	102%
Scots Bay (outbox)	26-Jul-08	-35.62	60	-64.35	0.001	80	99	124%
	09-Aug-08	-35.24	75	-65.68	0.001	68	70	17%
Scots Bay total for non-standard survey area (outbox)						148	121	82%

Table 6. Summary of the 2008 German Bank spawning ground acoustic survey results and SSB biomass estimates. The shaded row represents survey data which was not included in the overall total.

a - without integration factor; as presented since 1997

Location/ Type	Date	Target Strength (dB/kg)	Area (km <sup>2</sup> )	Weighted Sa (dB/m <sup>2</sup> )	Density (kg/m <sup>2</sup> )	Biomass (t)	Standard Error (t)	SE %
German Bank (inbox)	22-Aug-08	-35.65	646	-50.77	0.031	19,883	6,104	31%
	05-Sep-08	-35.46	646	-45.76	0.093	60,302	19,661	33%
	19-Sep-08	-35.38	646	-49.06	0.043	27,694	16,031	58%
	06-Oct-08	-35.64	646	-44.02	0.145	93,801	51,686	
	21-Oct-08	-35.77	200	-59.81	0.004	788	503	64%
German Bank inbox total (excludes Oct. 21 survey)						201,680	26,092	13%
German Bank (outbox)	22-Aug-08	-35.60	80	-52.26	0.022	1,727	328	19%
German Bank outbox total						1,727	328	19%

b - with integration factor as introduced in 2003

Location/ Type	Date	Target Strength (dB/kg)	Area (km <sup>2</sup> )	Weighted Sa (dB/m <sup>2</sup> )	Density (kg/m <sup>2</sup> )	Biomass (t)	Standard Error (t)	SE %
German Bank	22-Aug-08	-35.65	646	-50.12	0.036	23,058	6,858	30%
	05-Sep-08	-35.46	646	-44.97	0.112	72,300	23,266	32%
	19-Sep-08	-35.38	646	-48.41	0.050	32,159	18,002	56%
	06-Oct-08	-35.63	646	-43.28	0.172	111,046	59,268	
	21-Oct-08	-35.77	200	-59.07	0.005	934	597	64%
German Bank inbox total (excludes Oct. 21 survey)						238,563	30,206	13%
German Bank (outbox)	22-Aug-08	-35.60	80	-50.85	0.030	2,387	454	19%
German Bank outbox total						2,387	454	19%

Table 7. Biomass estimation for the 2008 Trinity Ledge acoustic surveys. The non-shaded boxes represent the biomass estimates summed for the overall SSB based on the 10-14 day time window between surveys. The shaded rows describe the biomass estimates for surveys which were not used.

a - without integration factor; as presented since 1997

Location/ Type	Date	Mean Length (mm)	Target Strength (dB/kg)	Area (km <sup>2</sup> )	Weighted Sa (dB/m <sup>2</sup> )	Density (kg/m <sup>2</sup> )	Biomass (t)	Standard Error (t)	SE %
Trinity Ledge	28-Aug-08	280	-36.0	0.1	-32.2	2.368	237	67	28%
	22-Sep-08	280	-36.0	0.1	-48.4	0.057	6	3	50%
	24-Sep-08	280	-35.5	0.3	-44.7	0.134	36		0%
Trinity Ledge total (includes Aug. 22 and Sept. 24)							273	67	25%

b - with integration factor (as calculated since 2003)

Location/ Type	Date	Mean Length (mm)	Target Strength (dB/kg)	Area (km <sup>2</sup> )	Weighted Sa (dB/m <sup>2</sup> )	Density (kg/m <sup>2</sup> )	Biomass (t)	Standard Error (t)	SE %
Trinity Ledge	28-Aug-08	280	-36.0	0.1	-29.4	4.474	447	127	28%
	22-Sep-08	280	-36.0	0.1	-45.6	0.108	11	6	55%
	24-Sep-08	280	-35.5	0.3	-41.9	0.254	69	25	36%
Trinity Ledge total (includes Aug. 22 and Sept. 24)							516	129	25%

Table 8. Catches (t) and survey biomass estimates (with CIF) for the Trinity Ledge herring fishery from 1998 to 2008.

Fishery Start Day	Fishery End Day	Catch t	Survey Biomass t	Exploitation Catch/SSB
24-Aug-98	21-Sep-98	1,668		
12-Aug-99	15-Sep-99	1,257	3,885	32%
30-Aug-00	12-Sep-00	734	621	118%
21-Aug-01	26-Sep-01	1,012	14,797	7%
02-Sep-02	30-Sep-02	256	8,096	3%
21-Aug-03	18-Sep-03	369	14,512	3%
02-Sep-04	15-Sep-04	225	6,511	3%
05-Sep-05	20-Sep-05	447	5,071	9%
23-Aug-06	21-Sep-06	717	8,486	8%
27-Aug-07	20-Sep-07	1,091	1,357	80%
21-Aug-08	25-Sep-08	7	273	3%
Average		707	6,361	11%



Table 9. Summary of the minimum observed spawning stock biomass for each of the surveyed spawning grounds in the Bay of Fundy/SWNS component of the 4WX stock complex. Total SSB rounded to nearest 100t and all data calculated without the integration calibration factor.

Location/Year	1997*	1998*	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Average 1999- 2007
Scots Bay	160,200	72,500	41,000	106,300	163,900	141,000	133,900	107,600	16,800	28,600	45,700	19,400	87,200
Trinity Ledge	23,000	6,800	3,900	600	14,800	8,100	14,500	6,500	5,100	8,500	1,400	300	7,044
German Bank (inbox)	370,400	440,700	460,800	356,400	190,500	393,100	343,500	367,600	211,000	245,500	337,200	201,700	322,844
- German (outbox)										4,100	2,820	1,700	3,460
Spectacle Buoy													
- Spring	15,000	1,300	0	0	1,100		1,400	n/s	300	n/s	100	0	483
- Fall					87,500								87,500
Sub-Total	568,600	521,300	505,700	463,300	457,800	542,200	493,300	481,700	233,200	286,700	387,220	223,100	427,902
Seal Island					3,300	1,200	12,200			8,100			6,200
Browns Bank					45,800					6,100			25,950
Total	568,600	521,300	505,700	463,300	506,900	543,400	505,400	481,700	233,200	300,900	387,220	223,100	436,413
Overall SE t	n/a	n/a	94,600	64,900	50,800	49,500	86,100	74,200	64,900	47,251	94,255	94,255	69,612
Overall SE %	n/a	n/a	19	14	10	9	17	15	28	16	25	25	17

\*Biomass estimates for 1997 and 1998 are not considered comparable due to variation in the coverage area.

Table 10. Survey results for the 2008 Little Hope/Port Mouton area with biomass estimates calculated either with or without the use of the Calibration Integration Factor (CIF).

a - with integration factor (available since 2003)

Survey Date/School	Average TS (dB/kg)	Stratum Area (km <sup>2</sup> )	Weighted Mean Sa (/m <sup>2</sup> )	Biomass Density (kg/m <sup>2</sup> )	Strata Biomass (t)	Standard Error (t)	Standard Error %
Sept. 26 - School 1	-35.95	1.50	-41.92	0.25	380	112	29
Sept. 26 - School 2	-35.95	4.75	-34.56	1.38	6,538	3,310	51
Oct. 6 - School 2	-35.95	2.25	-31.85	2.57	5,780	1,274	22
Oct. 8 - School 1	-35.95	1.50	-36.65	0.85	1,277	371	29
Oct. 30 survey	-35.95	25.00	-52.99	0.02	494	333	67
Little Hope - overall 2008					14,469	3,583	25%

b - without integration factor (as presented since 1998)

Survey Date/School	Average TS (dB/kg)	Stratum Area (km <sup>2</sup> )	Weighted Mean Sa (/m <sup>2</sup> )	Biomass Density (kg/m <sup>2</sup> )	Strata Biomass (t)	Standard Error (t)	Standard Error %
Sept. 26 - School 1	-35.95	1.50	-42.80	0.21	310	91	29
Sept. 26 - School 2	-35.95	4.75	-35.45	1.12	5,334	2,701	51
Oct. 6 - School 2	-35.95	2.25	-32.74	2.10	4,716	1,039	22
Oct. 8 - School 1	-35.95	1.50	-37.53	0.69	1,042	303	29
Oct. 30 survey	-35.95	25.00	-54.17	0.02	377	285	76
Little Hope - overall 2008					11,779	2,925	25%

Table 11. Survey results for the 2008 Halifax/Eastern Shore area with biomass estimates calculated either with or without the use of the Calibration Integration Factor (CIF).

a - with integration factor (available since 2003)

Survey Date/Area	Average TS (dB/kg)	Stratum Area (km <sup>2</sup> )	Weighted Mean Sa (/m <sup>2</sup> )	Biomass Density (kg/m <sup>2</sup> )	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Sept. 23 - lines	-35.95	50.00	-47.84	0.06	3,234	249	8
Sept. 23 - school 1	-35.95	0.85	-35.33	1.15	980	301	31
Sept. 23 - school 2	-35.95	0.15	-28.18	5.99	898	467	52
Sept. 23 - school 3	-35.95	1.10	-48.61	0.05	60	12	21
Oct. 1 - school 1	-35.95	0.55	-30.18	3.77	2,075	478	2300%
Oct. 1 - school 2	-35.95	0.30	-31.56	2.75	825	476	5800%
Oct. 1 - school 3	-35.95	0.35	-32.43	2.25	788	171	2200%
Oct. 1 - school 4	-35.95	0.75	-38.47	0.56	420	296	7000%
Oct. 8 - NE school	-35.95	1.30	-31.31	2.91	3,782	2123	56
Oct. 15 - school	-35.95	2.30	-28.75	5.25	12,072	3,215	27
Oct. 15 - lines	-35.95	174.00	-51.86	0.03	4,459	1,548	35
Nov. 6 - school	-35.95	0.32	-32.32	2.30	737	564	77
Overall					30,330	4,002	13%

b - without integration factor (as presented since 1998)

Survey Date/Area	Average TS (dB/kg)	Stratum Area (km <sup>2</sup> )	Weighted Mean Sa (/m <sup>2</sup> )	Biomass Density (kg/m <sup>2</sup> )	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Sept. 23 - lines	-35.95	50.00	-48.58	0.05	2,729	266	10
Sept. 23 - school 1	-35.95	0.85	-36.17	0.95	808	248	31
Sept. 23 - school 2	-35.95	0.15	-29.01	4.94	741	385	52
Sept. 23 - school 3	-35.95	1.10	-49.27	0.05	51	11	21
Oct. 1 - school 1	-35.95	0.55	-31.02	3.11	1,711	394	23%
Oct. 1 - school 2	-35.95	0.30	-32.40	2.27	680	392	58%
Oct. 1 - school 3	-35.95	0.35	-33.09	1.93	677	147	22%
Oct. 1 - school 4	-35.95	0.75	-39.13	0.48	361	254	7%
Oct. 8 - NE school	-35.95	1.30	-32.15	2.40	3,118	1750	56
Oct. 15 - school	-35.95	2.30	-29.55	4.37	10,040	2,639	26
Oct. 15 - lines	-35.95	174.00	-52.64	0.02	3,725	1,229	33
Nov. 6 - school	-35.95	0.32	-33.16	1.90	608	465	77
Overall					25,249	3,295	13%

Table 12. Recorded herring landings (t) from gillnet fisheries in the coastal N.S. spawning component, 1996-2008.

Landings (t)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Average Catch Last 5 yr.	Average Catch All Years
Little Hope/Port Mouton		490	1,170	2,919	2,043	2,904	3,982	4,526	1,267	2,239	3,133	1,506	1,108	1,851	2,274
Halifax/Eastern Shore	1,280	1,520	1,100	1,628	1,350	1,898	3,334	2,727	4,176	3,446	3,348	3,727	2,381	3,416	2,455
Glace Bay		170	1,730	1,040	834	1,204	3,058	1,905	1,481	626	85	7	12	442	1,013
Bras d'Or Lakes	170	160	120	31	56	0	1	4	0	0	0	0	0	0	42
<b>Total</b>	<b>1,450</b>	<b>2,340</b>	<b>4,120</b>	<b>5,618</b>	<b>4,283</b>	<b>6,006</b>	<b>10,375</b>	<b>9,162</b>	<b>6,924</b>	<b>6,311</b>	<b>6,566</b>	<b>5,240</b>	<b>3,500</b>	<b>5,708</b>	<b>5,783</b>

Table 13. Summary of herring acoustic spawning biomass from gillnet surveys in the coastal N.S. spawning component from 1998-2008 as calculated without the calibration integration factor (CIF). Total SSB is rounded to nearest 100t.

Survey SSB (t) w/o CIF	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	10% SSB Average Last 5 yr	10% SSB Average All years
Little Hope/Port Mouton	14,100	15,800	5,200	21,300	56,000	<b>62,500</b>	15,600	39,500	21,700	2,400	11,800	1,820	2,417
Halifax/Eastern Shore	8,300	20,200	<b>10,900</b>	16,700	<b>41,500</b>	67,600	18,200	28,100	51,100	24,000	25,200	2,932	2,835
Glace Bay		2,000		21,200	7,700	31,500		2,200	n/s	100	500	93	931
Bras d'Or Lakes		530	70	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	30

Note: shaded cells include mapping surveys; bold cells include mapping and acoustic surveys.

Table 14. Summary of herring acoustic spawning biomass from gillnet surveys in the coastal N.S. spawning component from 1998-2008 as calculated with the calibration integration factor (CIF). Total SSB is rounded to nearest 100t.

Survey SSB (t) with CIF	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	10% SSB Average Last 5 yr	10% SSB Average All years
Little Hope/Port Mouton						<b>53,100</b>	22,500	44,700	24,100	2,800	14,500	2,172	2,695
Halifax/Eastern Shore						92,600	28,400	37,000	68,900	28,300	30,300	3,858	4,758
Glace Bay						31,500		3,180	n/s	240	500	131	886
Bras d'Or Lakes						n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/a

Note 1: shaded cells include mapping surveys; bold cells include mapping and acoustic surveys.

Note 2: data prior to 2003 calculated with the Calibration Integration Factor (CIF) are not available.

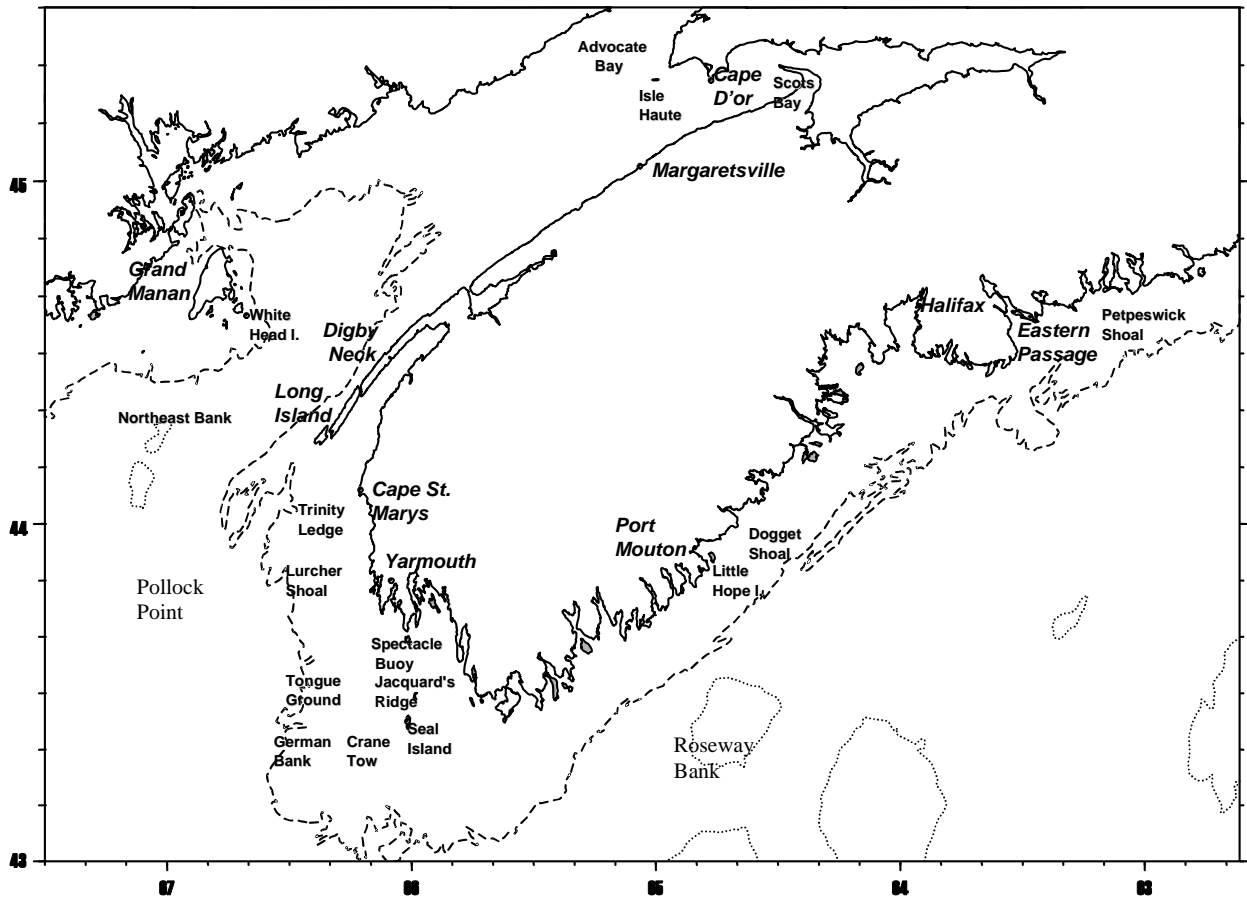


Figure 1. Map of the major spawning areas within the 4WX herring stock complex

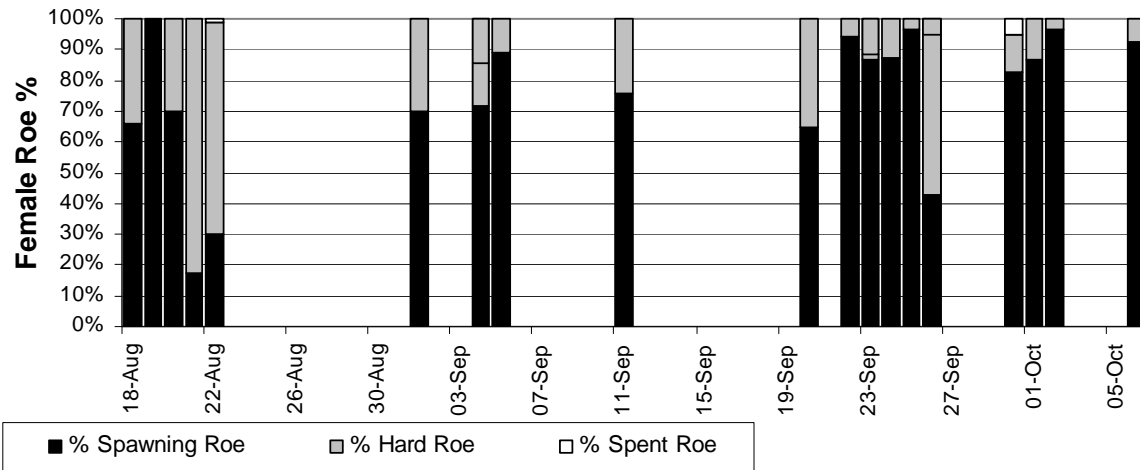


Figure 2. Daily female roe maturity proportions based on roe weight for German Bank in 2008 from industry supplied reports.

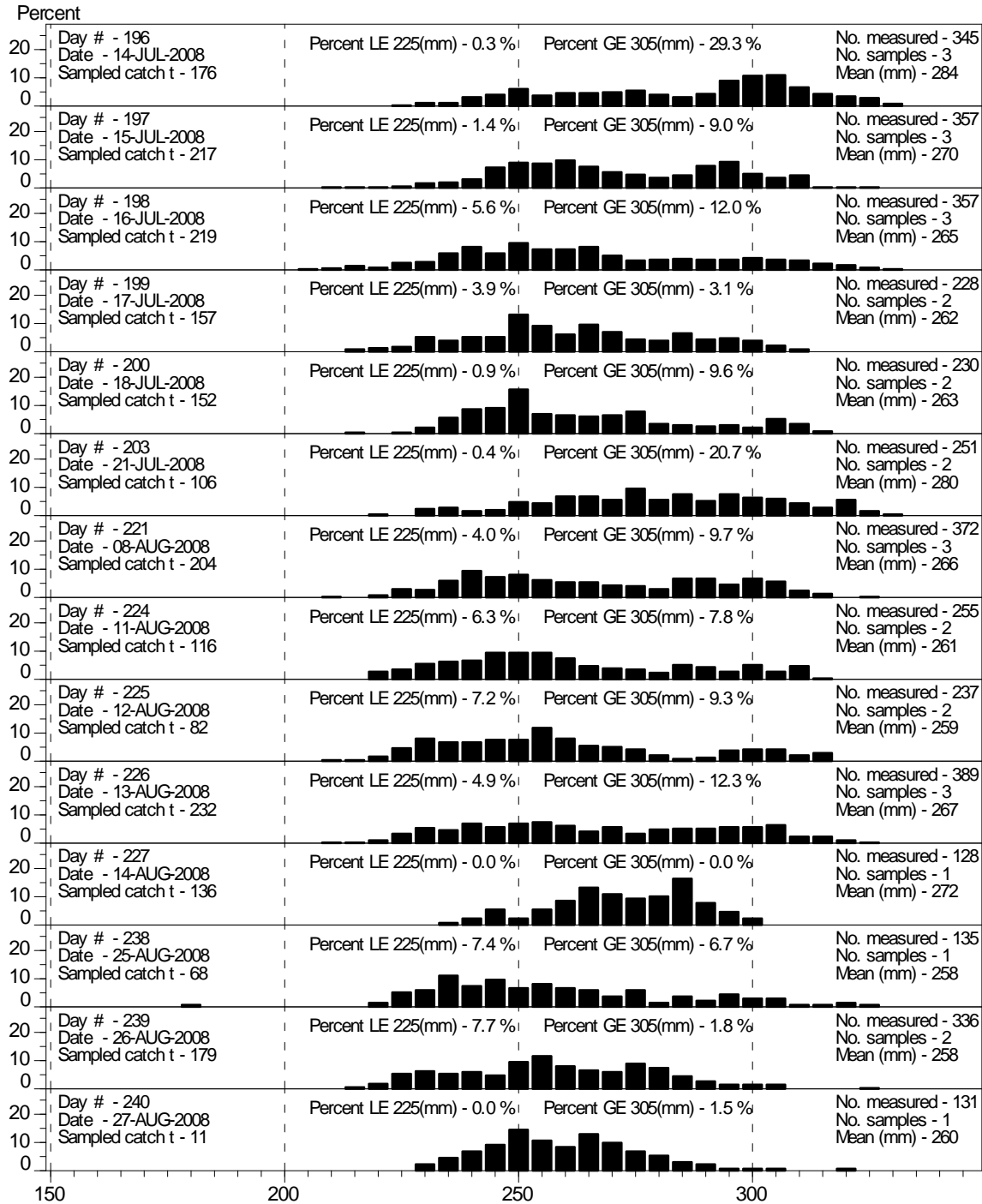


Figure 3. Daily herring length frequency samples collected from 2008 Scots Bay landings with proportions <23cm and >30cm.

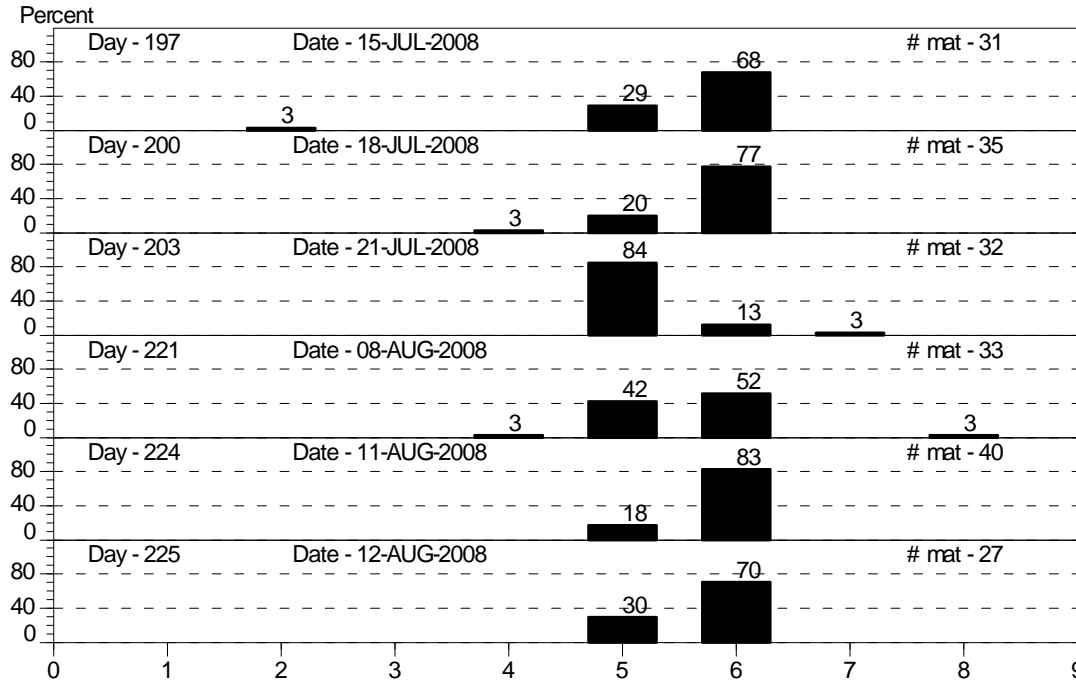


Figure 4. Daily herring maturity samples collected from Scots Bay landings in 2008. (Staging codes 2=immature; 4-5=maturing/hard; 6=ripe and running; 7=spent; 8=recovering).

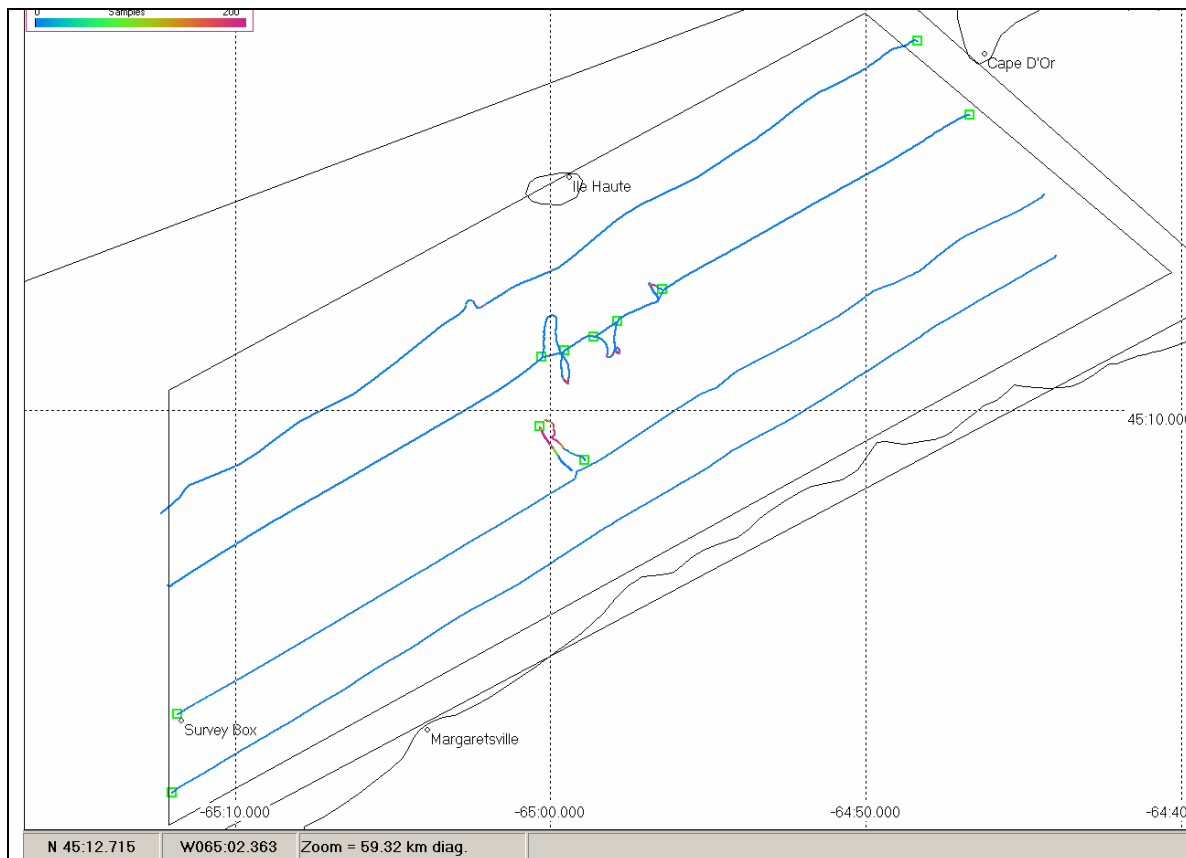


Figure 5. Scots Bay acoustic survey (#1) on July 12, 2008 showing transects within the standard survey area as well as deviations from the main survey lines to document fish between the lines.

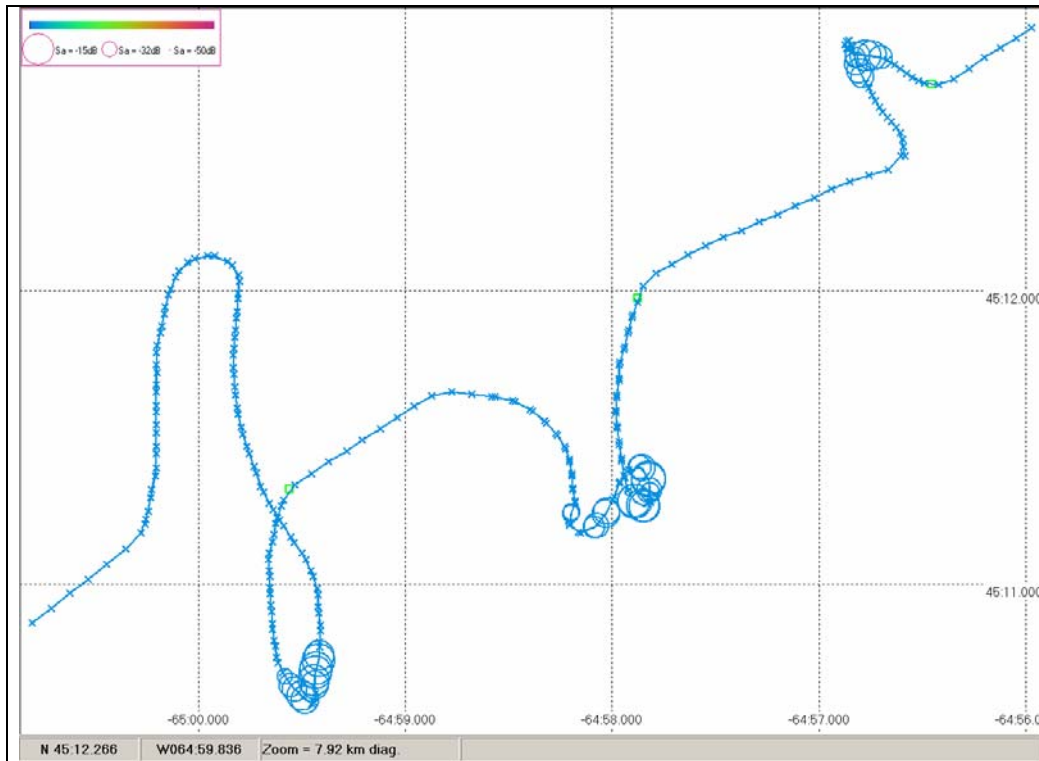


Figure 6. Closeup of vessel track for Scots Bay acoustic survey on July 12, 2008 showing deviations in track to document schools of fish adjacent to the designated transect.

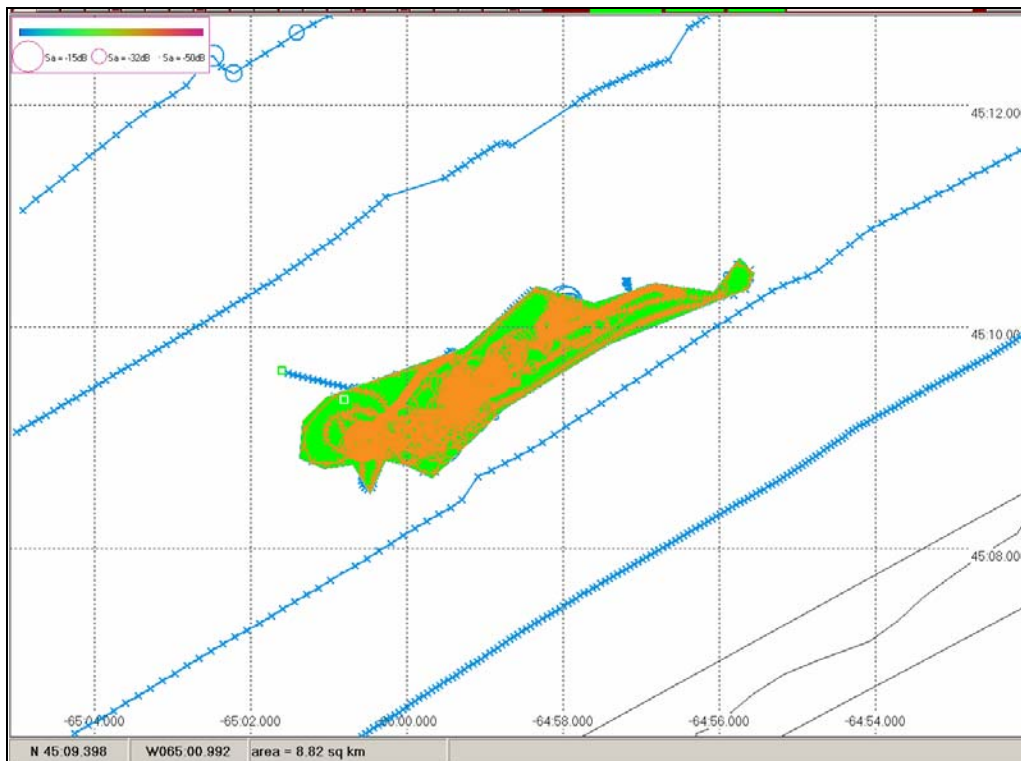


Figure 7. Vessel track of fishing activities in Scots Bay area on July 13, 2008 by purse seiners *Brunswick Provider* and *Canada 100* with main survey transects completed on the previous survey night also shown.



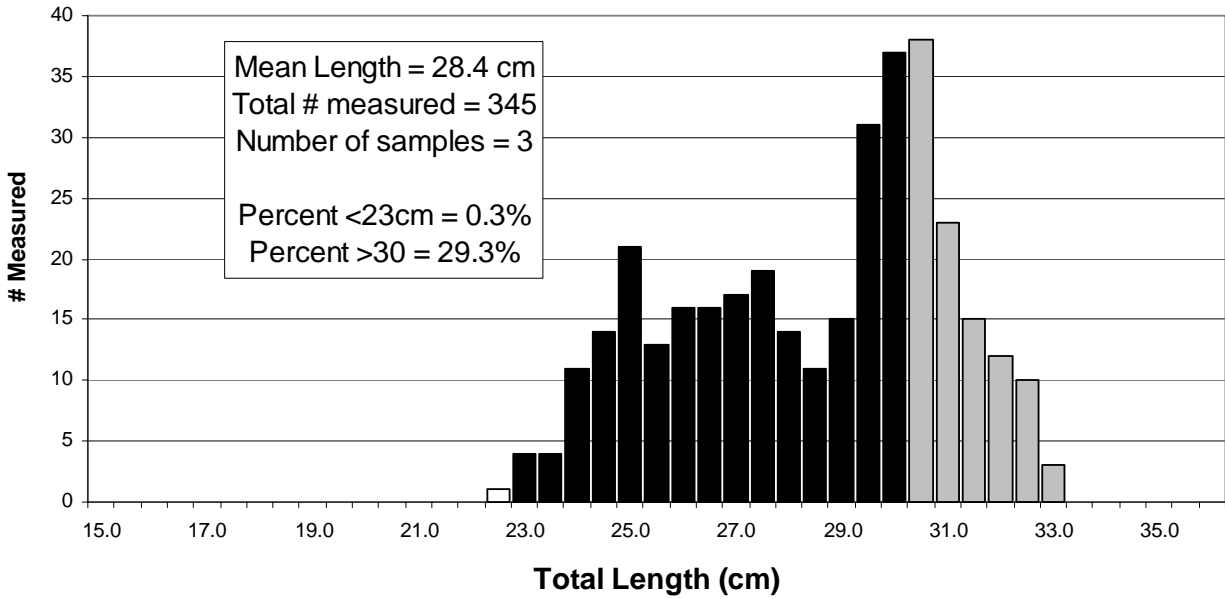


Figure 8. Length distribution for Scots Bay herring landings on July 14, 2008 using in the estimation of TS with proportions <23 and >30cm. Bars are shaded white for sizes less than 23cm and grey for sizes greater than 30cm.

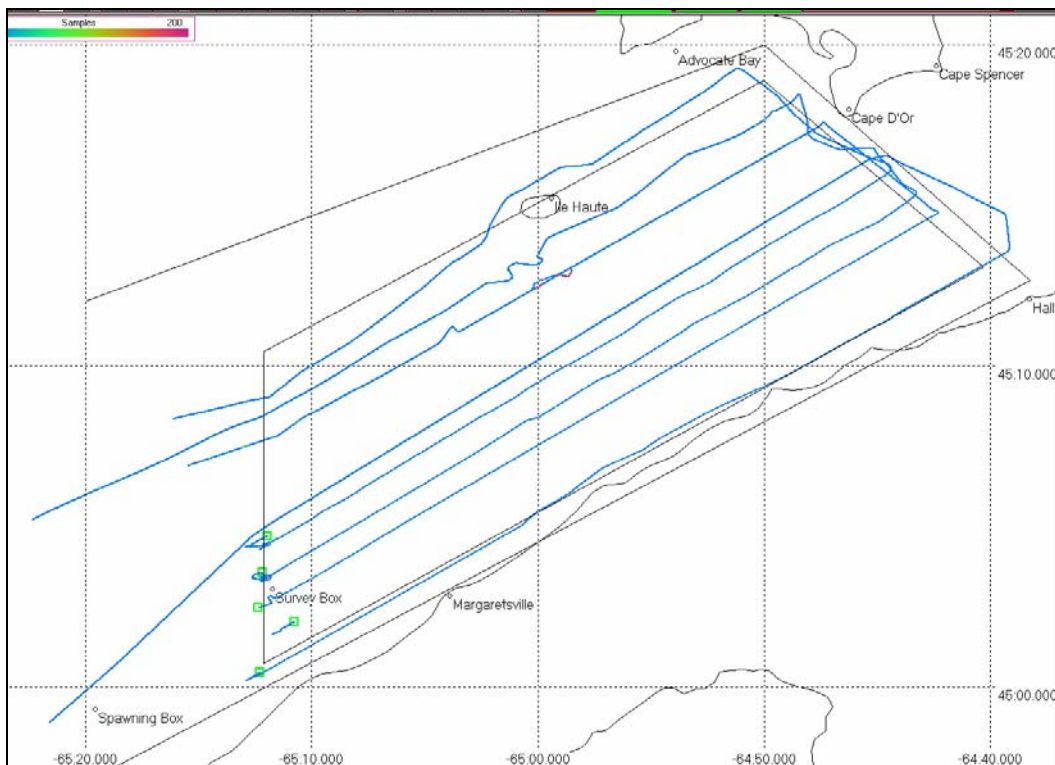


Figure 9. Scots Bay acoustic survey (#2) on July 26, 2008, showing tracks and the standard survey area as well as deviations from lines to document fish near the designated transects.

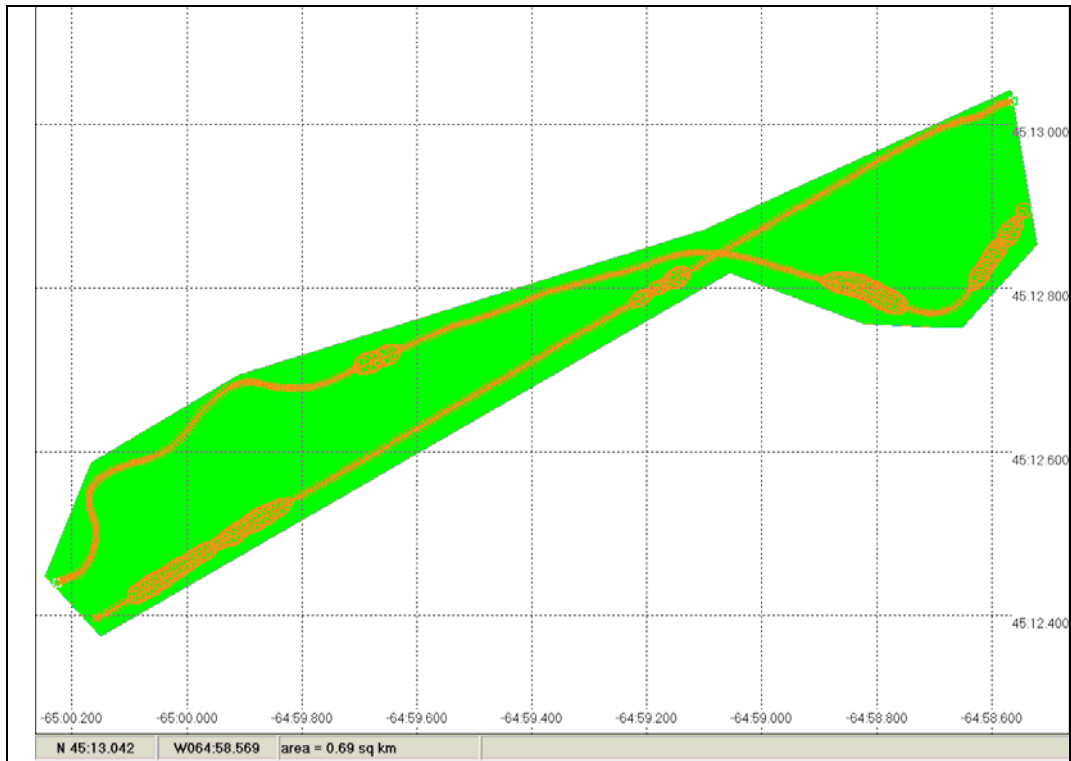


Figure 10. Vessel track by *Margaret Elizabeth* during Scots Bay acoustic survey on July 26, 2008 to document schools of fish adjacent to the designated transect.

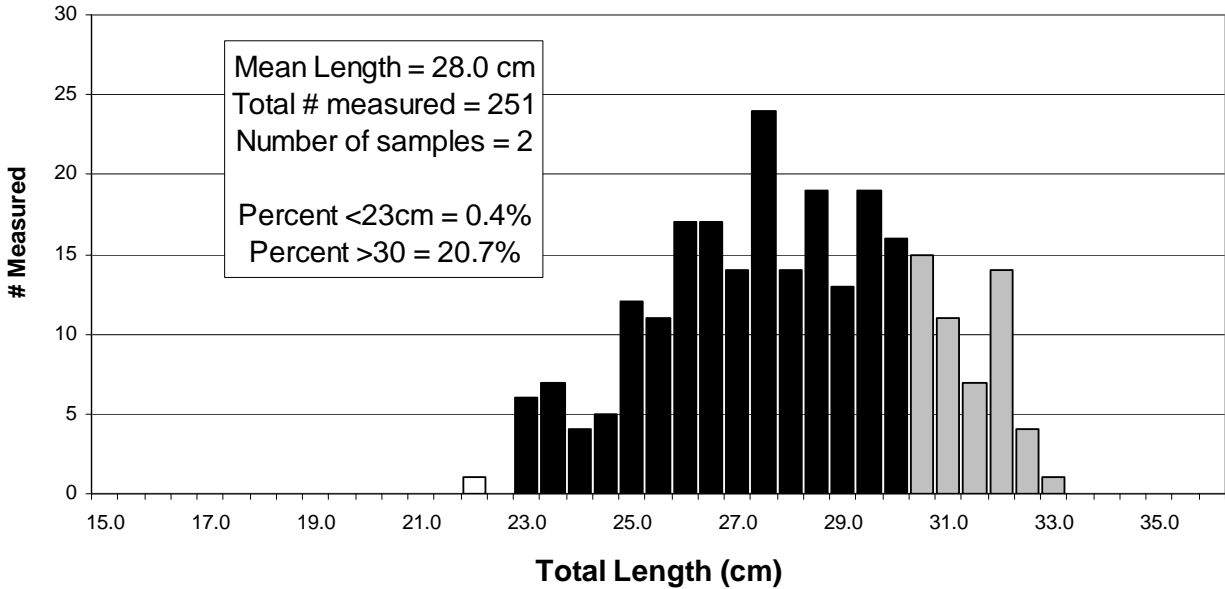


Figure 11. Length distribution for Scots Bay survey from landings on July 21 (nearest sample date to the survey) with proportions <23 and >30cm. Bars are shaded white for sizes less than 23cm and grey for sizes greater than 30cm.

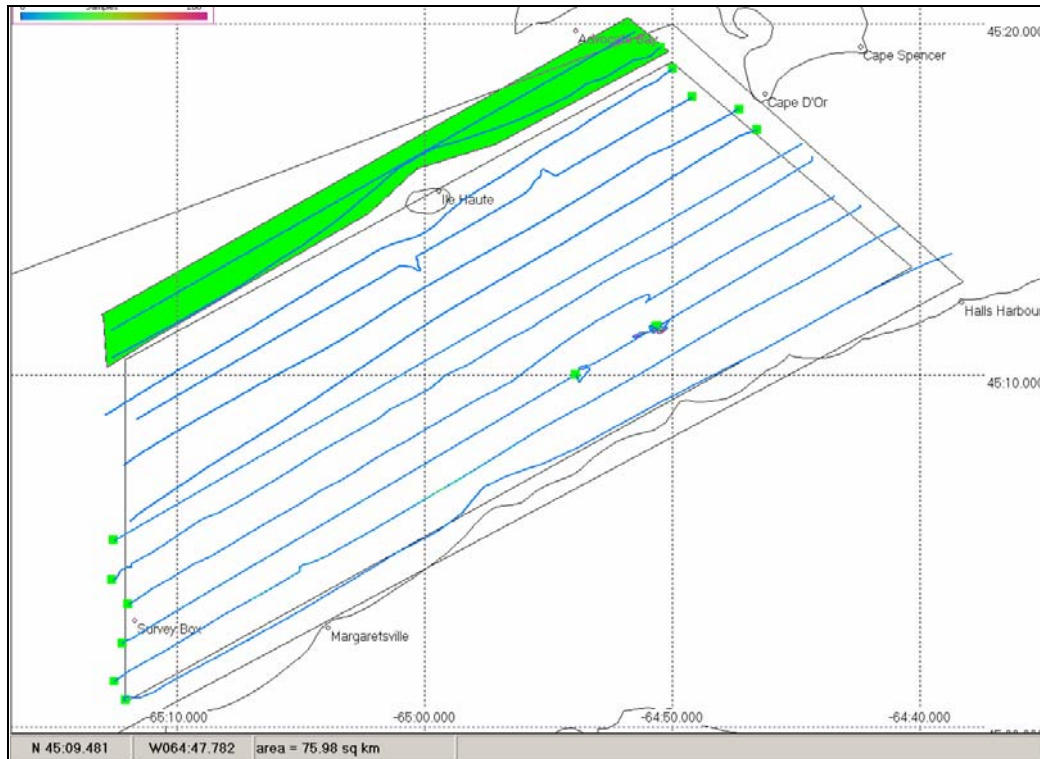


Figure 12. Scots Bay acoustic survey (#3) on Aug. 9, 2008, showing transects inside and outside the standard survey area as well as deviations from lines to document fish near the designated transects.

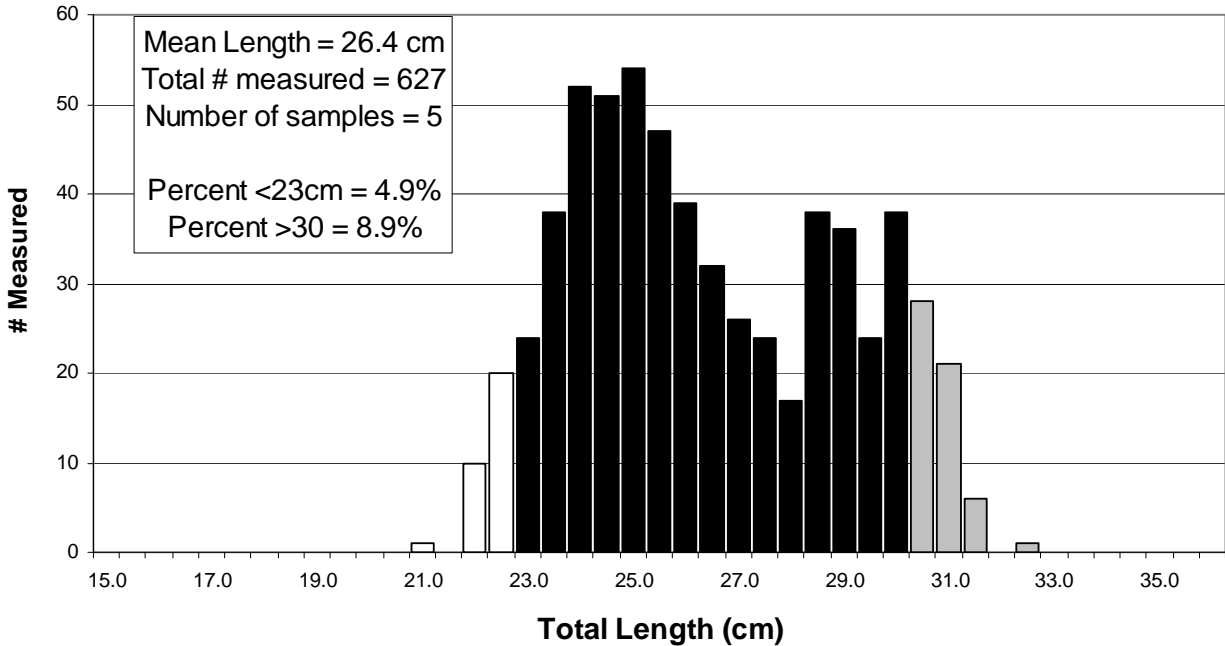


Figure 13. Length distribution for Scots Bay survey from herring landings on August 8-12<sup>th</sup> with proportions <23 and >30cm. Bars are shaded white for sizes less than 23cm and grey for sizes greater than 30cm.

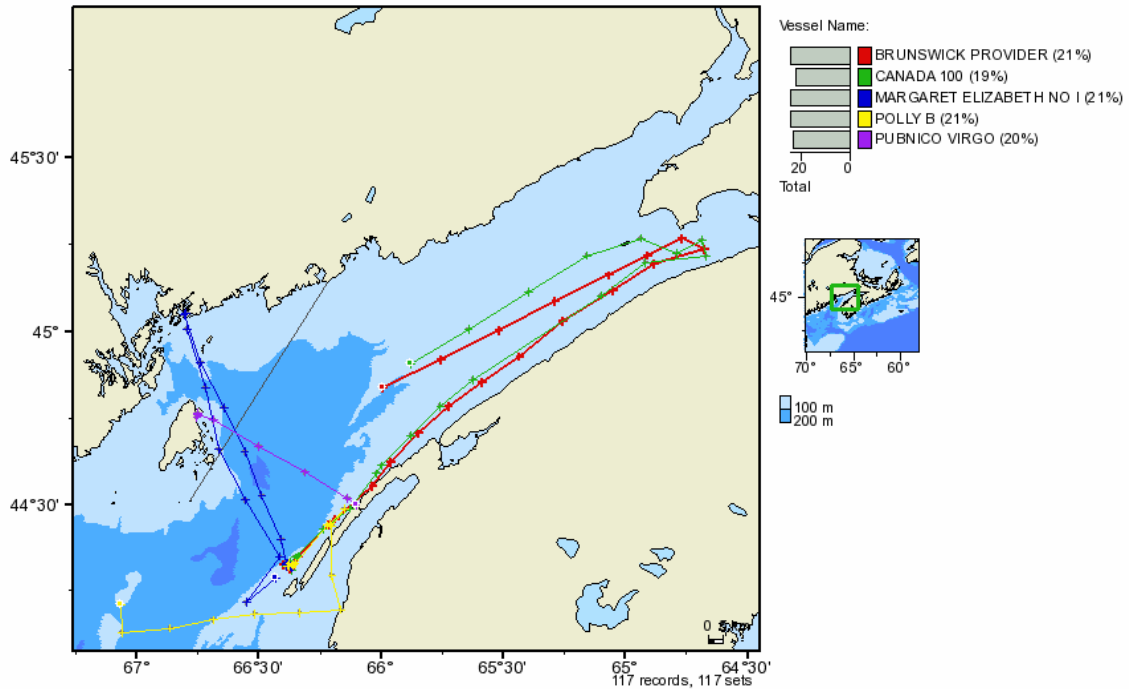


Figure 14. Herring purse seine vessel searching activity tracks for Scots Bay area on Aug. 21, 2008.

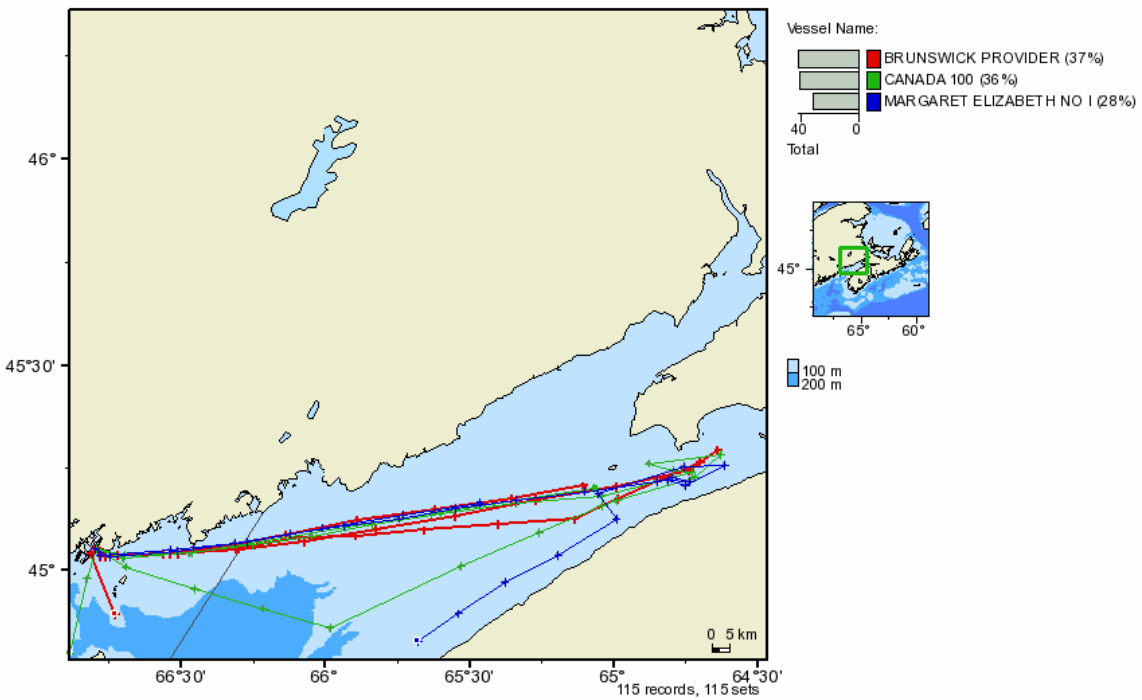


Figure 15. Herring purse seine vessel searching activity tracks for Scots Bay area on Aug. 26-27, 2008.

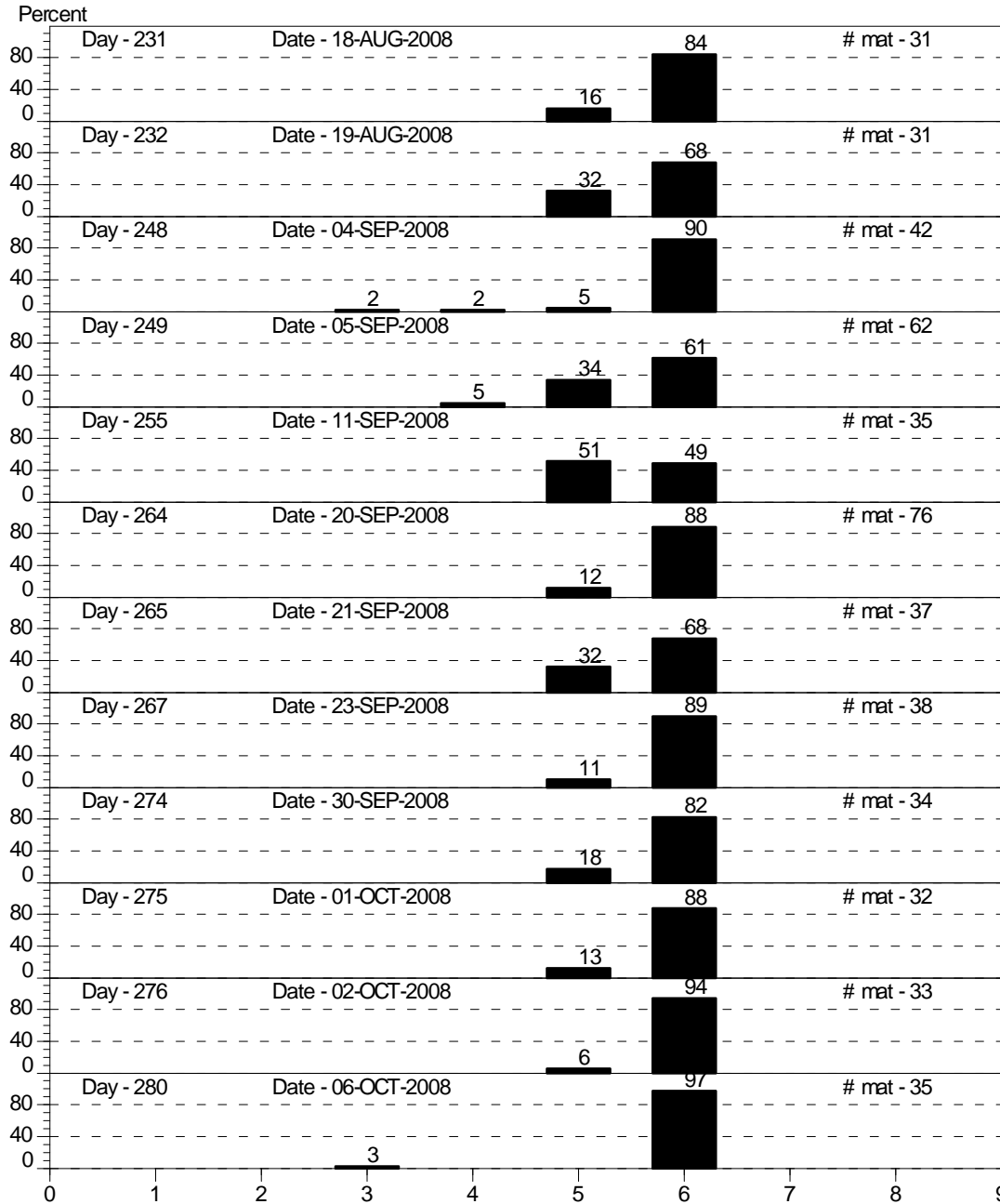


Figure 16. Daily herring maturity samples collected from German Bank survey box area in 2008. (Staging codes 1-2=immature; 3-4-5=maturing/hard; 6=ripe and running; 7=spent; 8=recovering).

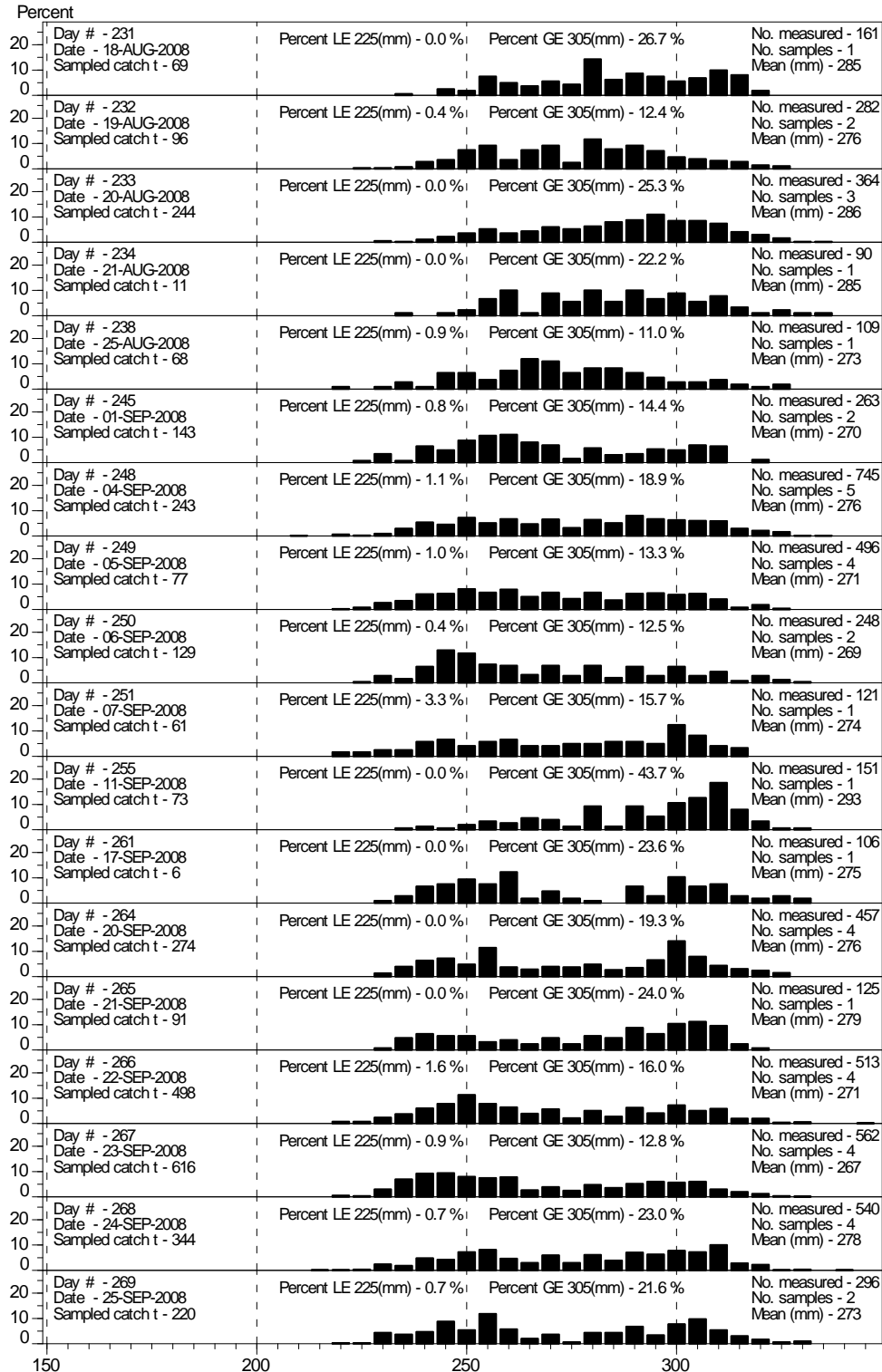


Figure 17a. Daily herring length frequency samples collected from 2008 German Bank survey box area for period from Aug. 18 to Sept. 25, 2008 with proportions <23cm and >30cm.

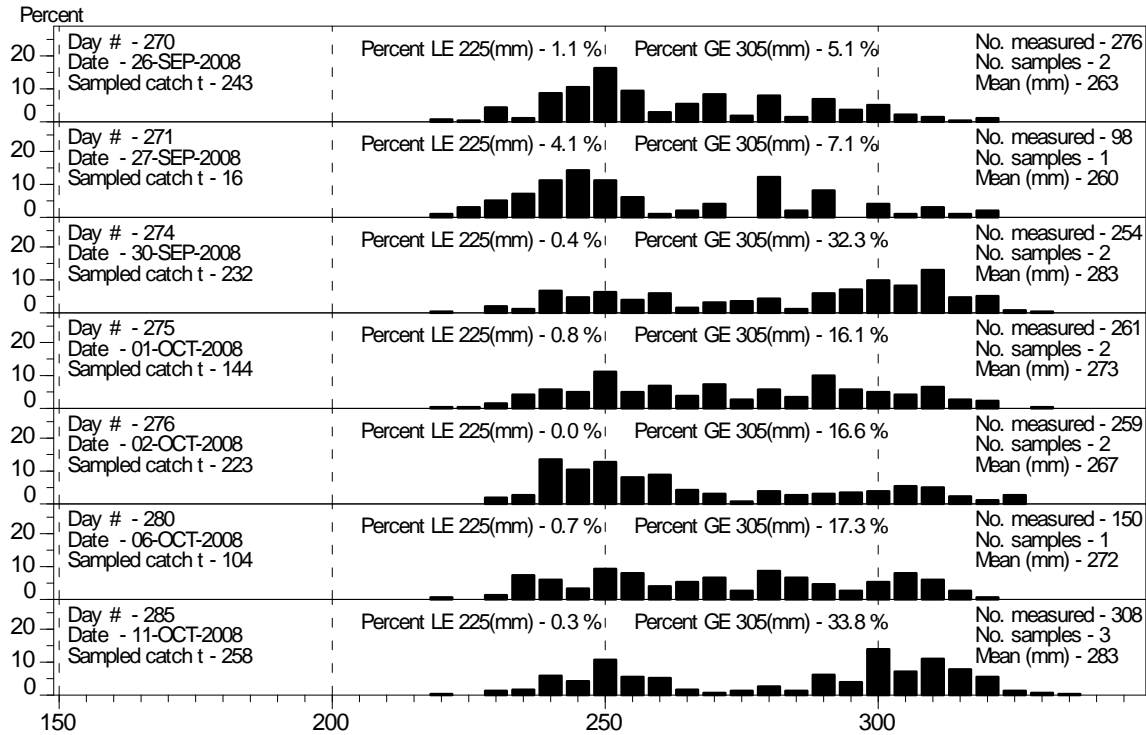


Figure 17b. Daily herring length frequency samples collected from 2008 German Bank survey box area for period from Sept. 26 to Oct. 11, 2008 with proportions <23cm and >30cm.

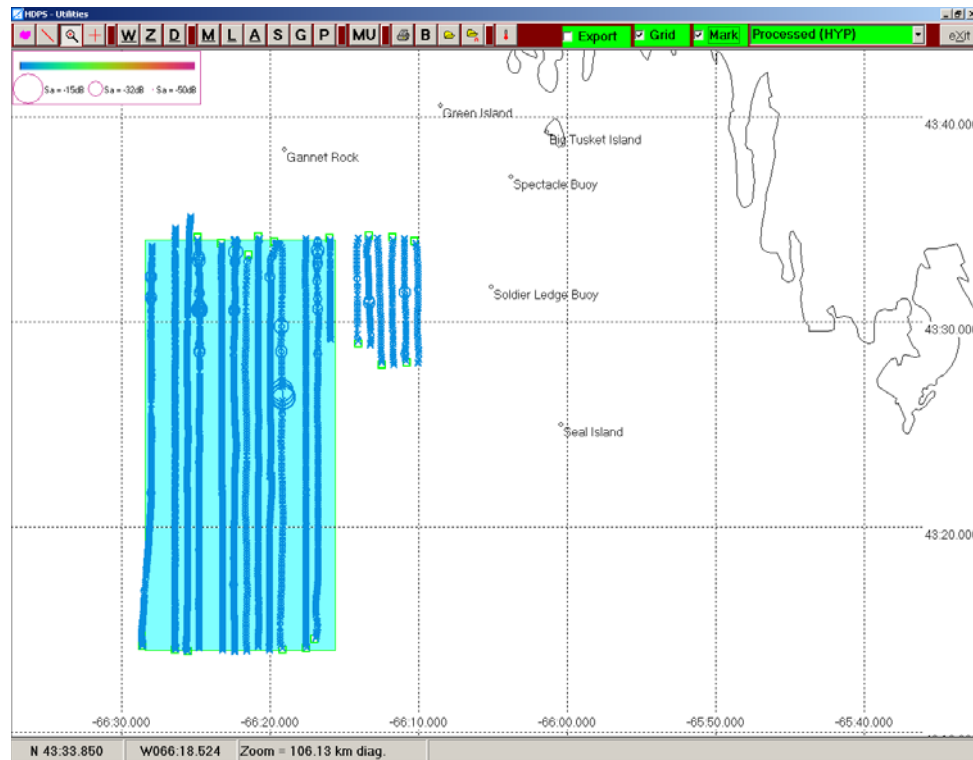


Figure 18. German Bank acoustic survey on August 22-23, 2008, with transects showing location and backscatter (Sa) both in the main survey box (highlighted area) and to the east of the survey box.

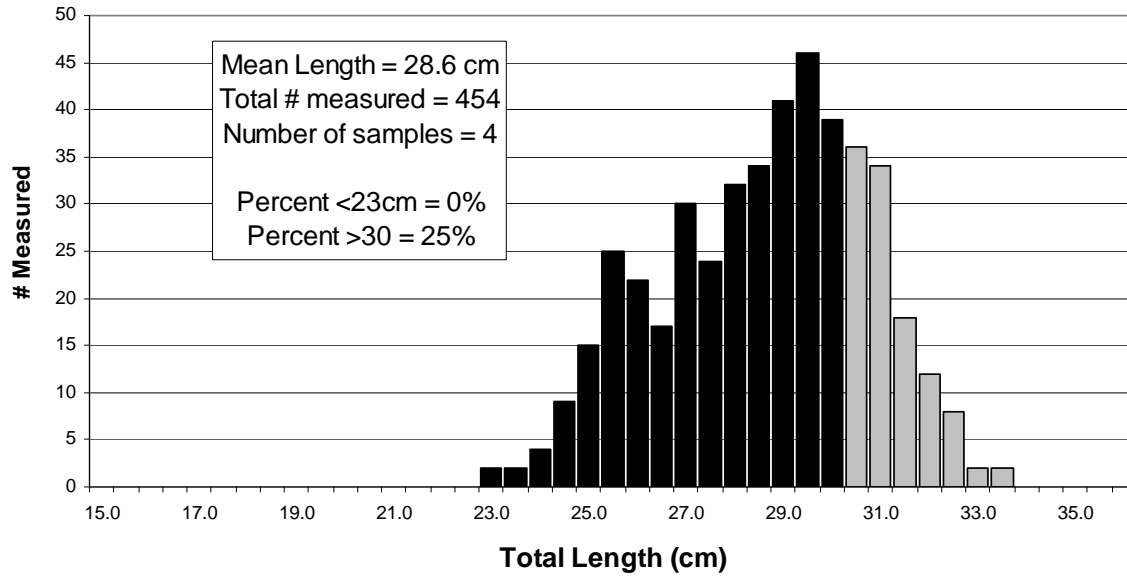


Figure 19. Length distribution used for calculation of target strength for the German Bank survey from herring landings on August 20-21 with proportions <23 and >30cm.

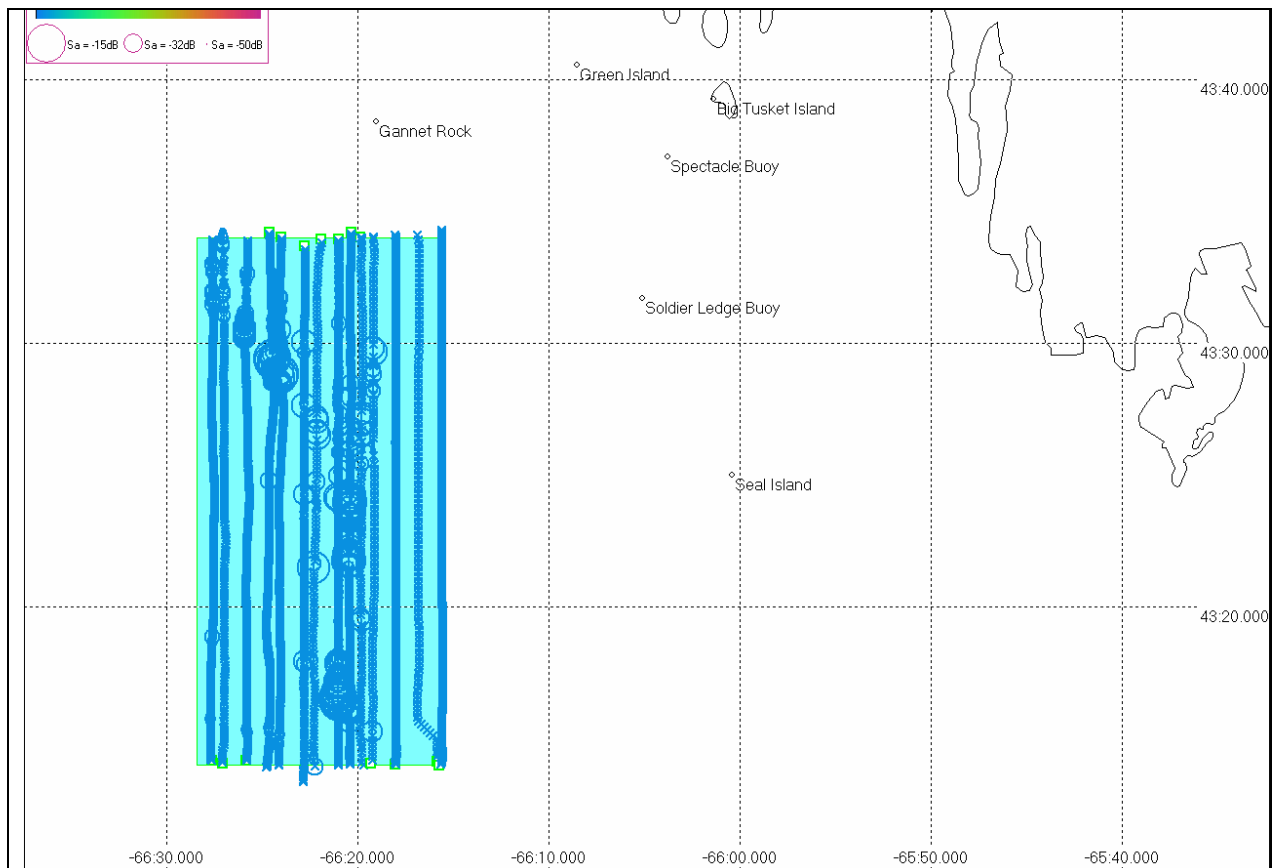


Figure 20. German Bank acoustic survey on September 5, 2008, showing location and backscatter (Sa) for transects in the survey box.



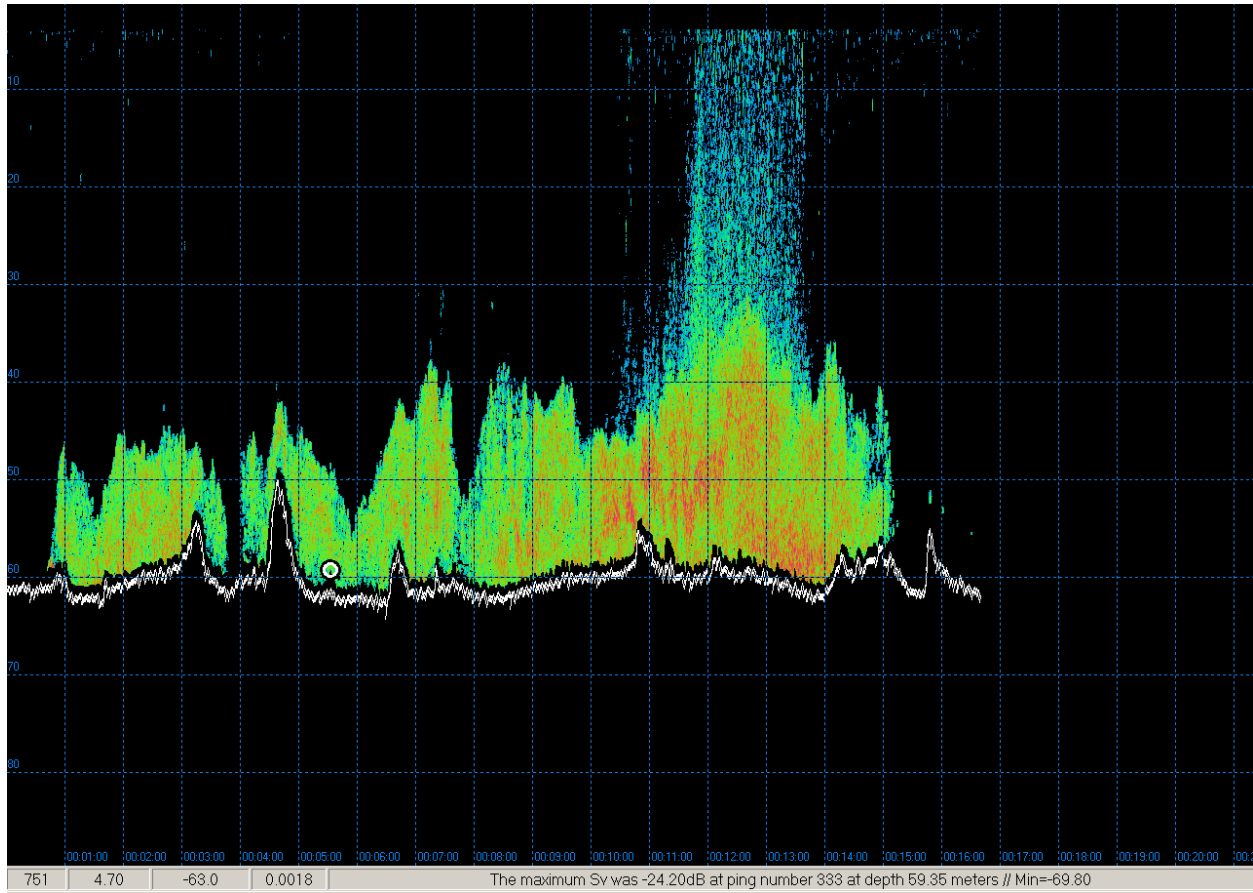


Figure 21. German Bank acoustic survey on September 5, 2008 showing sonar display for portion of transect recorded by the *Lady Janice II*. The bottom line is in white and the grid lines area at 1 minute time and 10 meter depth intervals. This section is 16 minutes long over 4.03 km with an average fish density of 3.4 kg per m<sup>2</sup>.

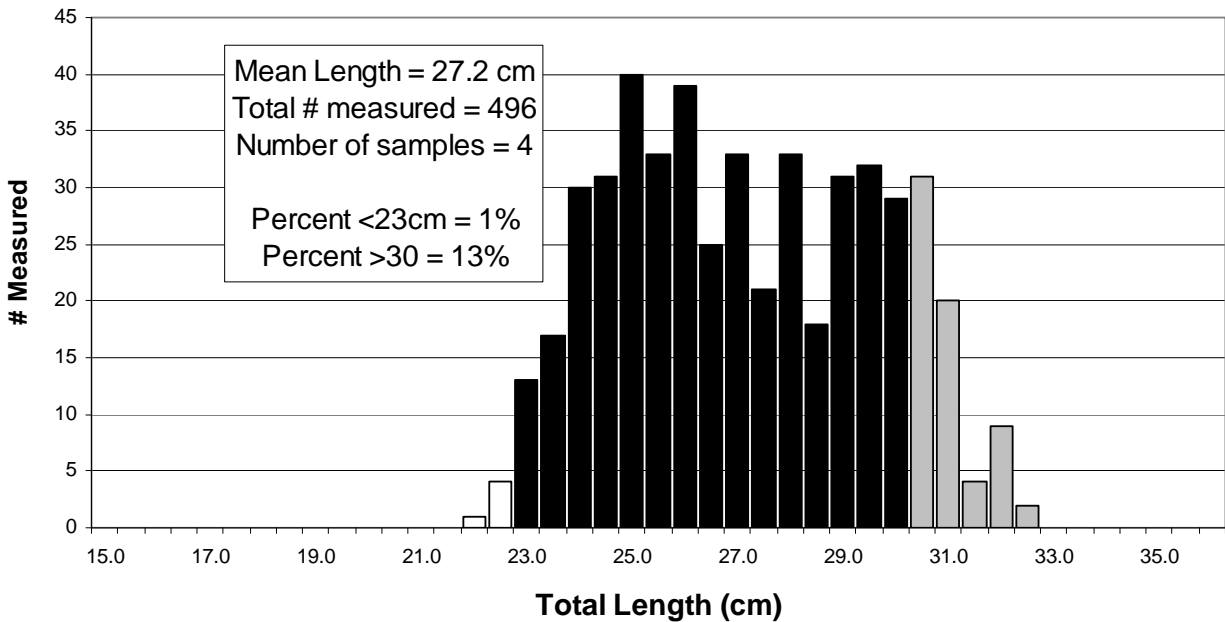


Figure 22. Length distribution used for calculation of target strength for the German Bank survey on September 5 from herring landings on the same day with proportions <23 and >30cm.

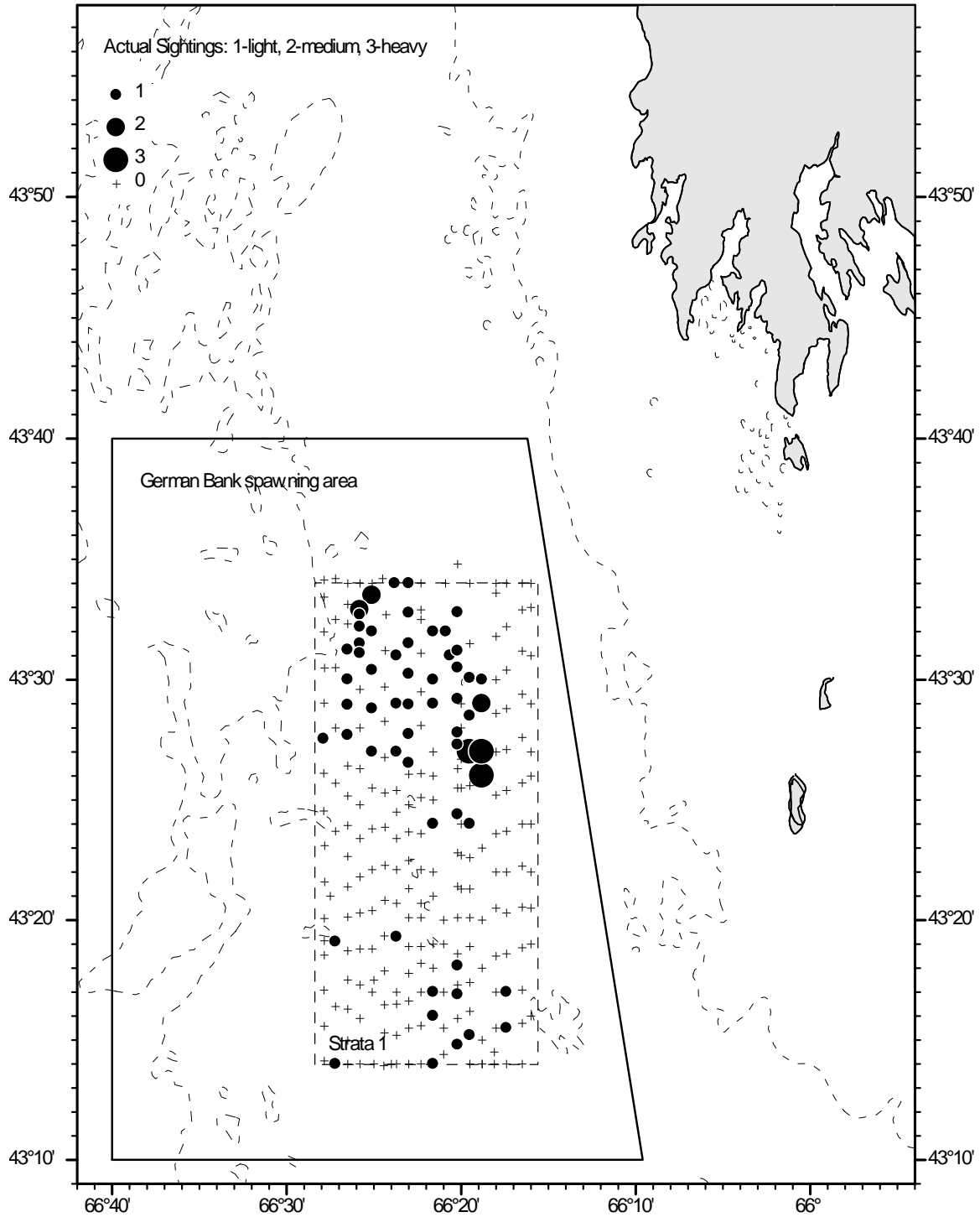


Figure 23. Deck sheet observations of herring sightings along transects for Sept. 19, 2008 survey on German Bank with overall defined spawning area (outer box) and standard survey area or Strata 1 (inner box).

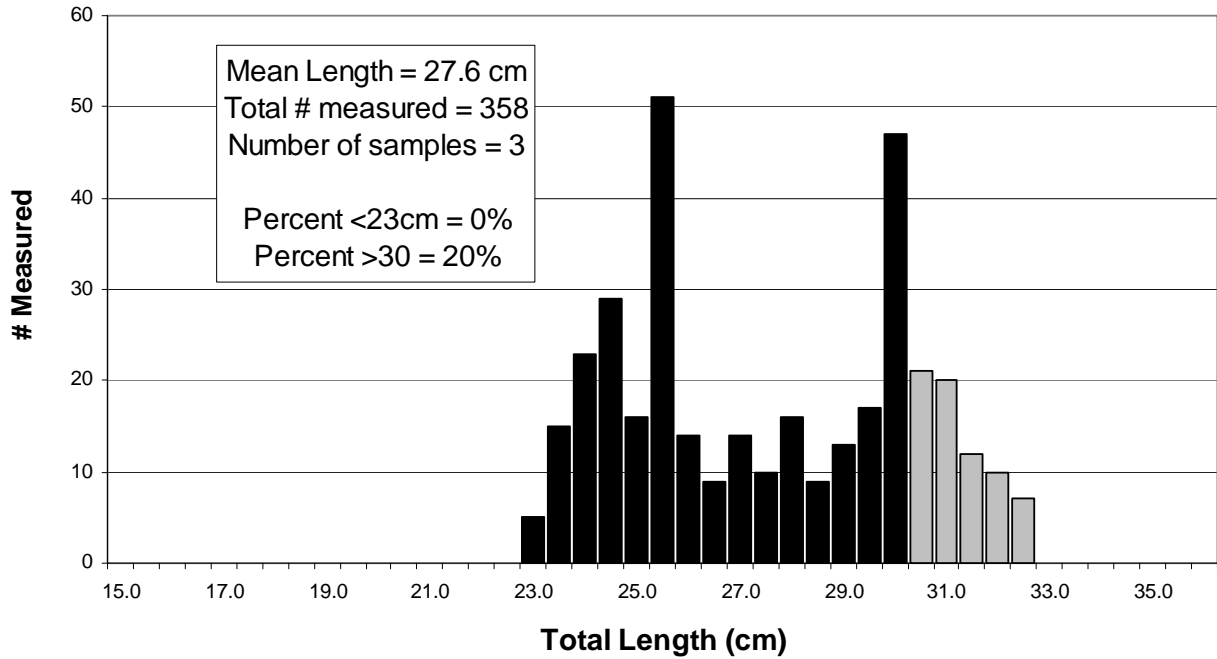


Figure 24. Length distribution used for calculation of target strength for the German Bank survey from herring landings on September 20 with proportions <23 and >30cm.

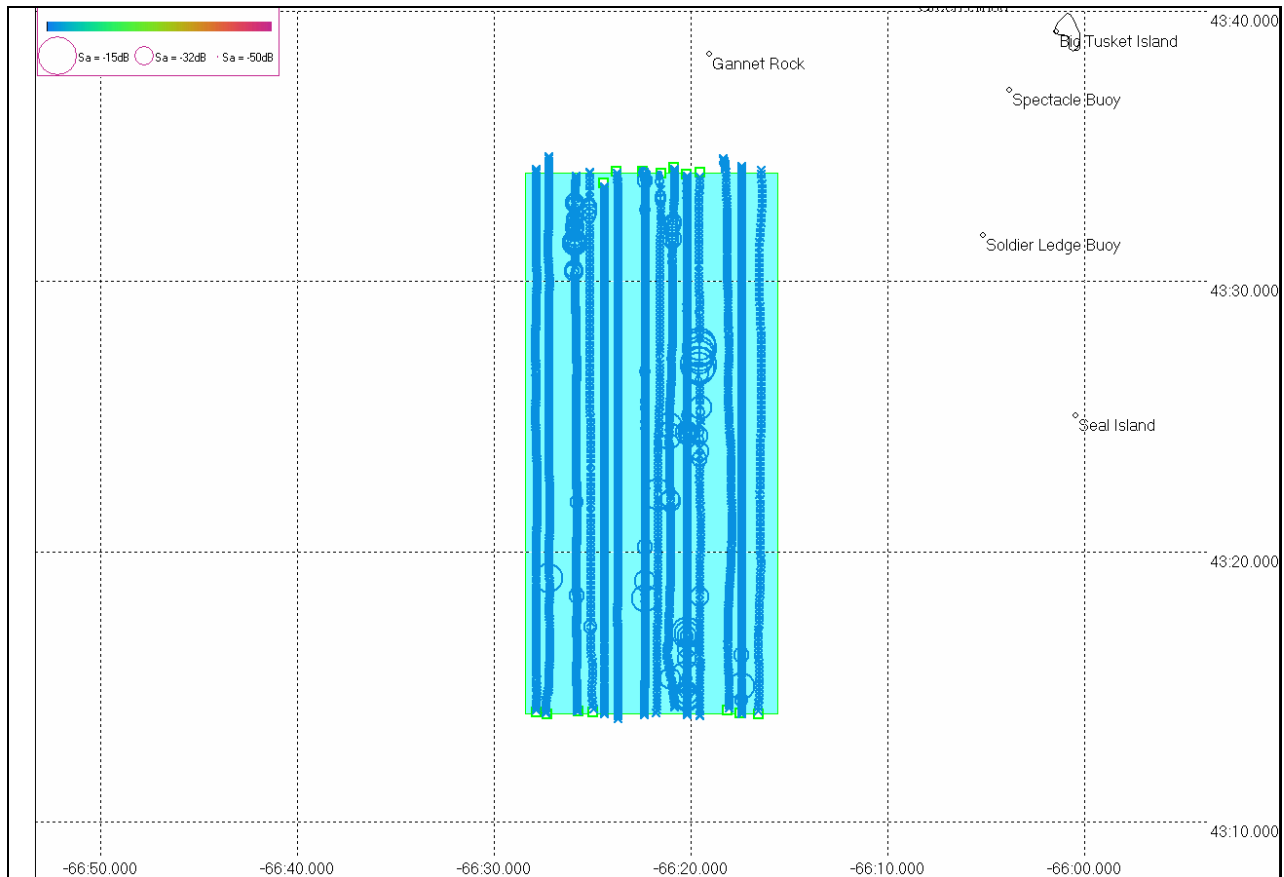


Figure 25. German Bank acoustic survey on September 19, 2008, showing location and backscatter (Sa) for transects in the survey box.

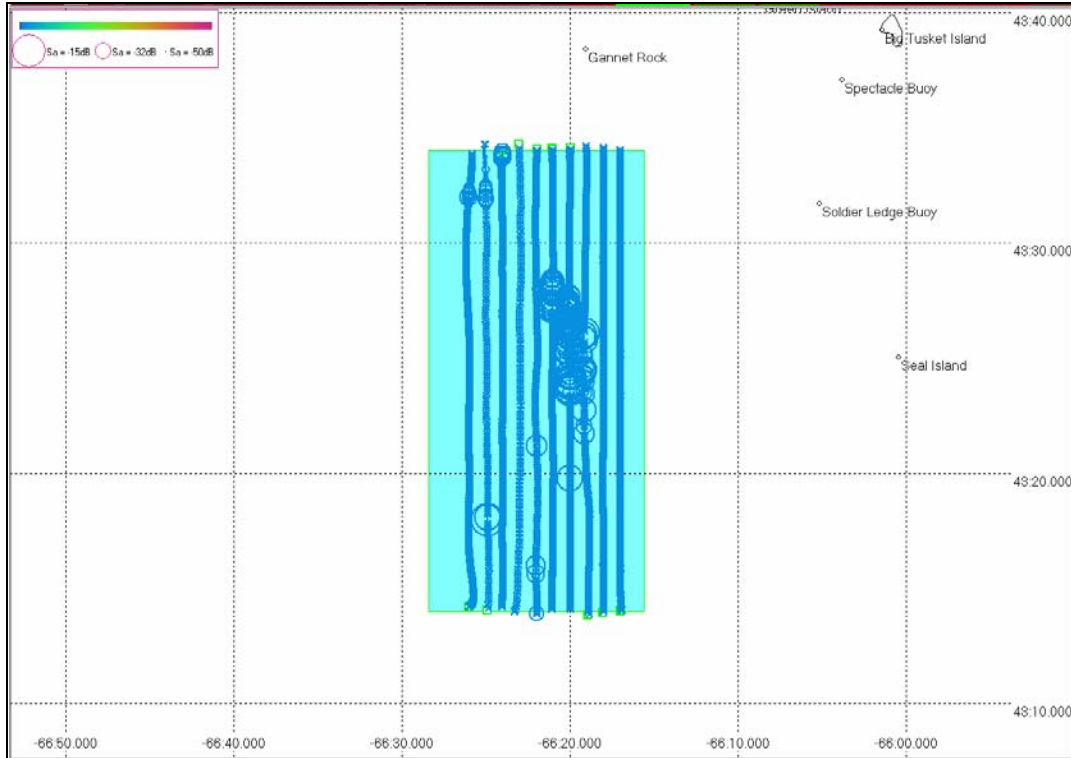


Figure 26. German Bank acoustic survey on October 6, 2008, showing location and backscatter (Sa) for transects in the survey box.

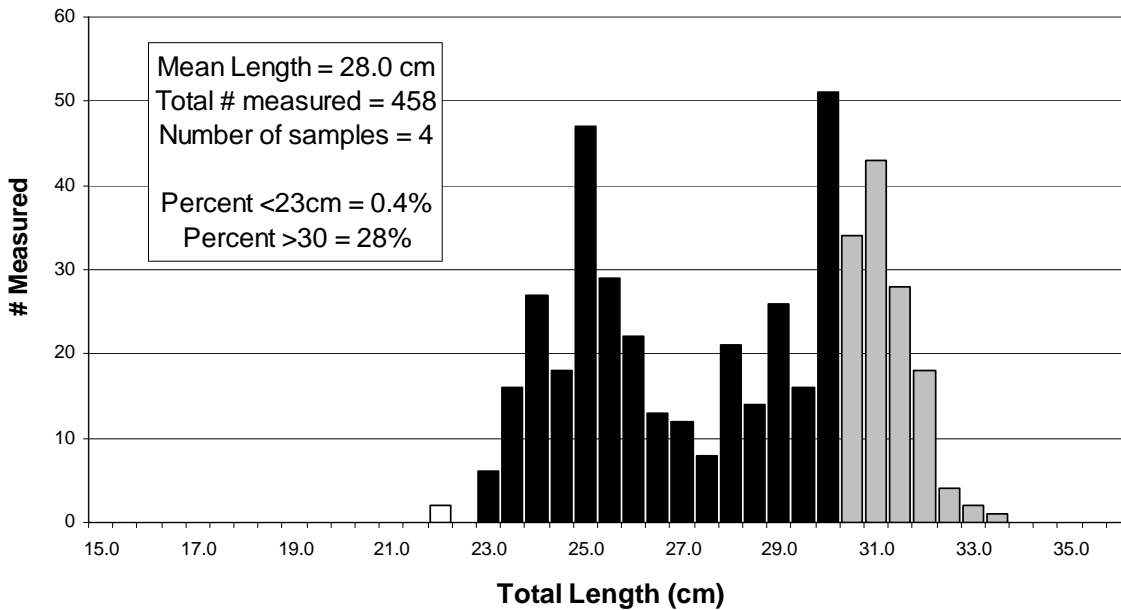


Figure 27. Length distribution used for calculation of target strength for the German Bank survey from herring landings on October 6<sup>th</sup> and 11<sup>th</sup> with proportions <23 and >30cm.

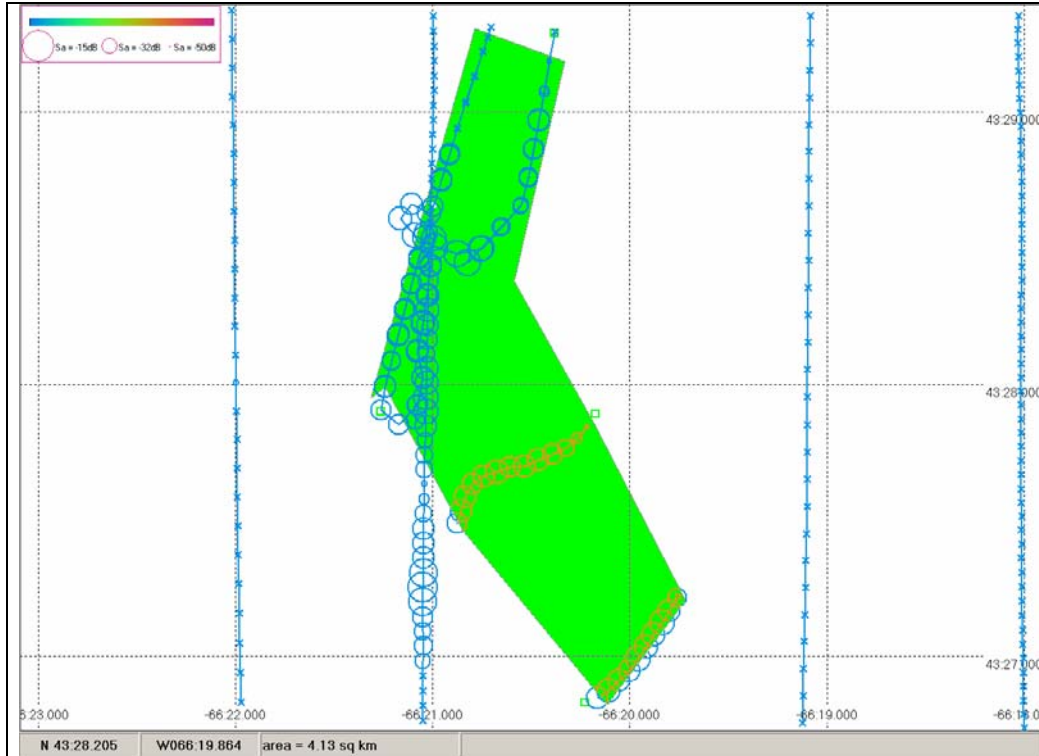


Figure 28. German Bank acoustic survey on October 6, 2008, showing location of fish school within the overall area as well as the main survey transects. Circle size represents average backscatter (Sa).

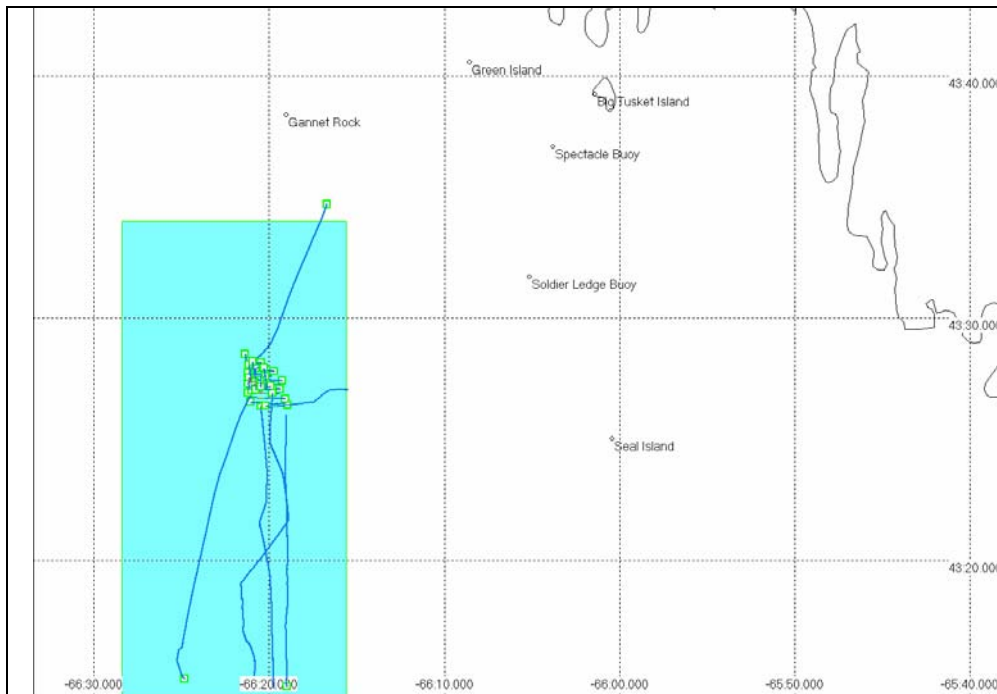


Figure 29. German Bank Oct 21 survey lines within overall strata area by the purse seine vessels *Lady Janice* and *Lady Melissa*.

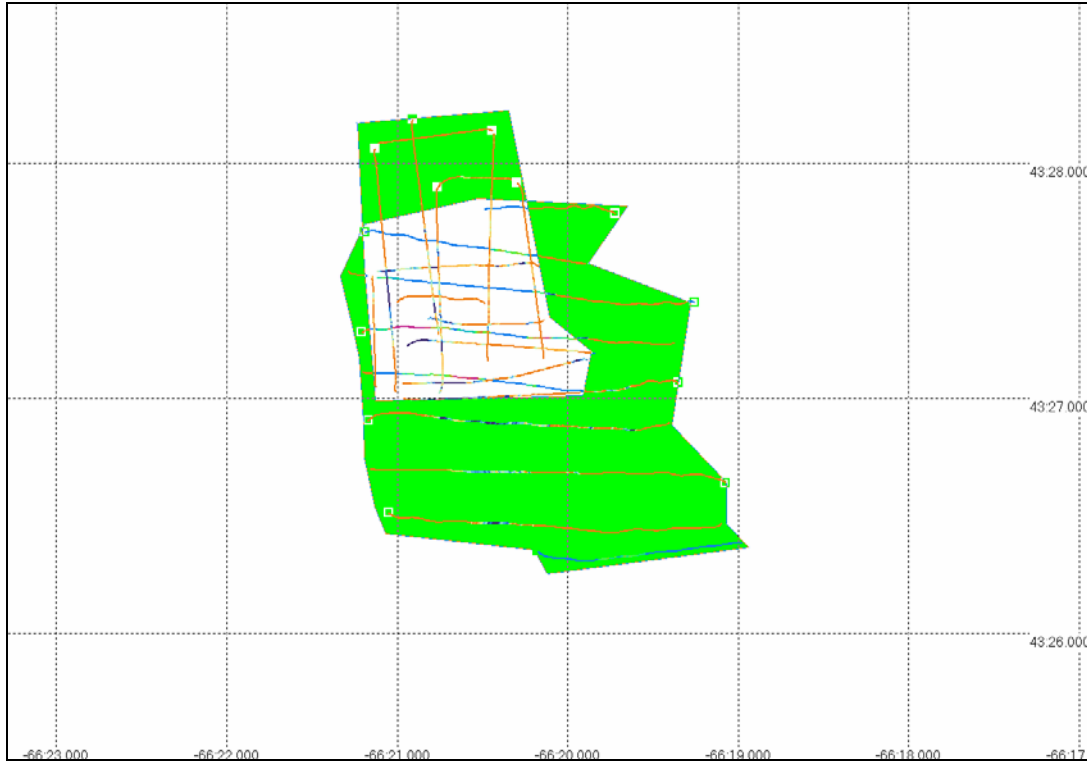


Figure 30. Detailed survey lines overlaid for the two purse seine vessels *Lady Janice* and *Lady Melissa* on a school of herring during the German Bank Oct. 21 survey.

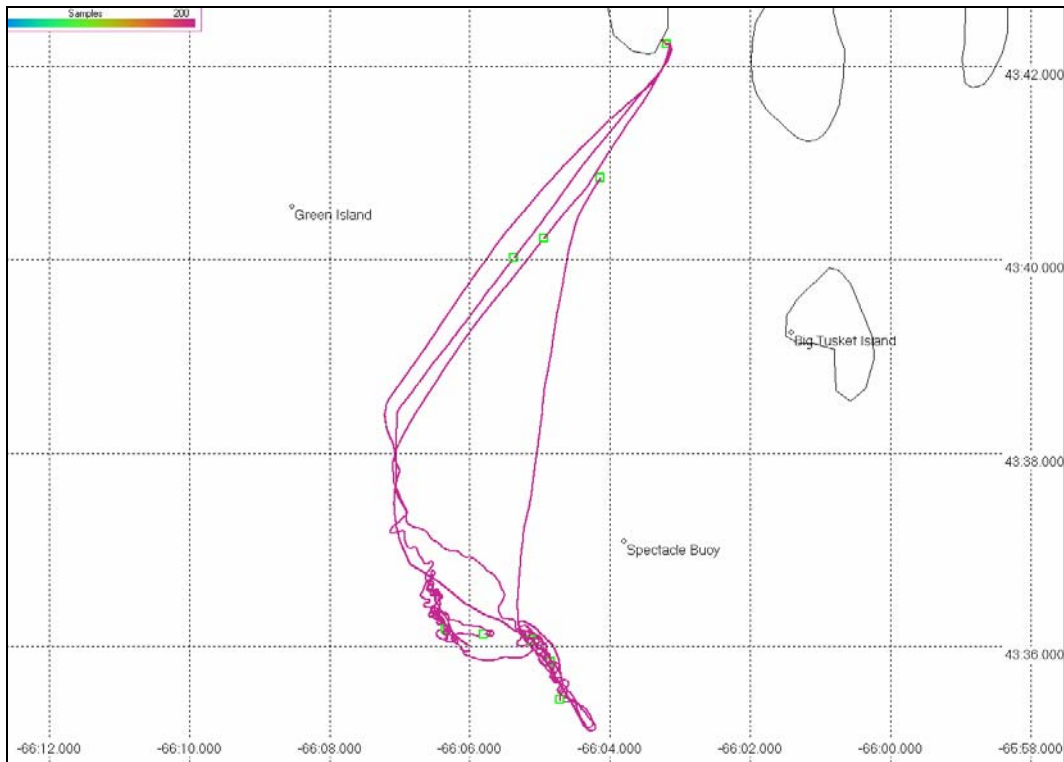


Figure 31. Spectacle Buoy area acoustic survey lines by *Jessica & Trevor* for June 9 and June 16 showing area covered.

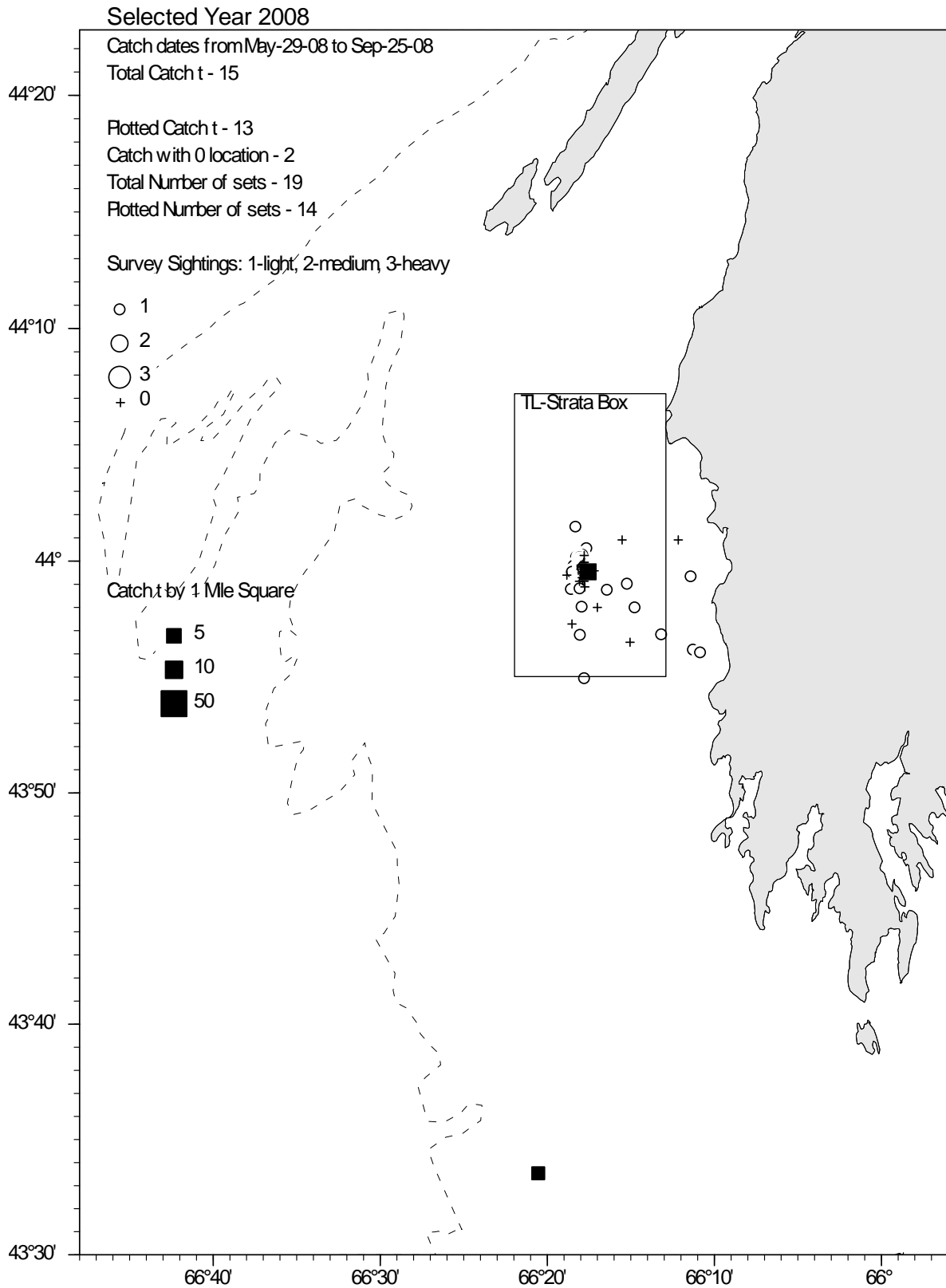


Figure 32. Location of 2008 herring catches and acoustic survey mapping/decksheet observations for the Spectacle Buoy and Trinity Ledge area.

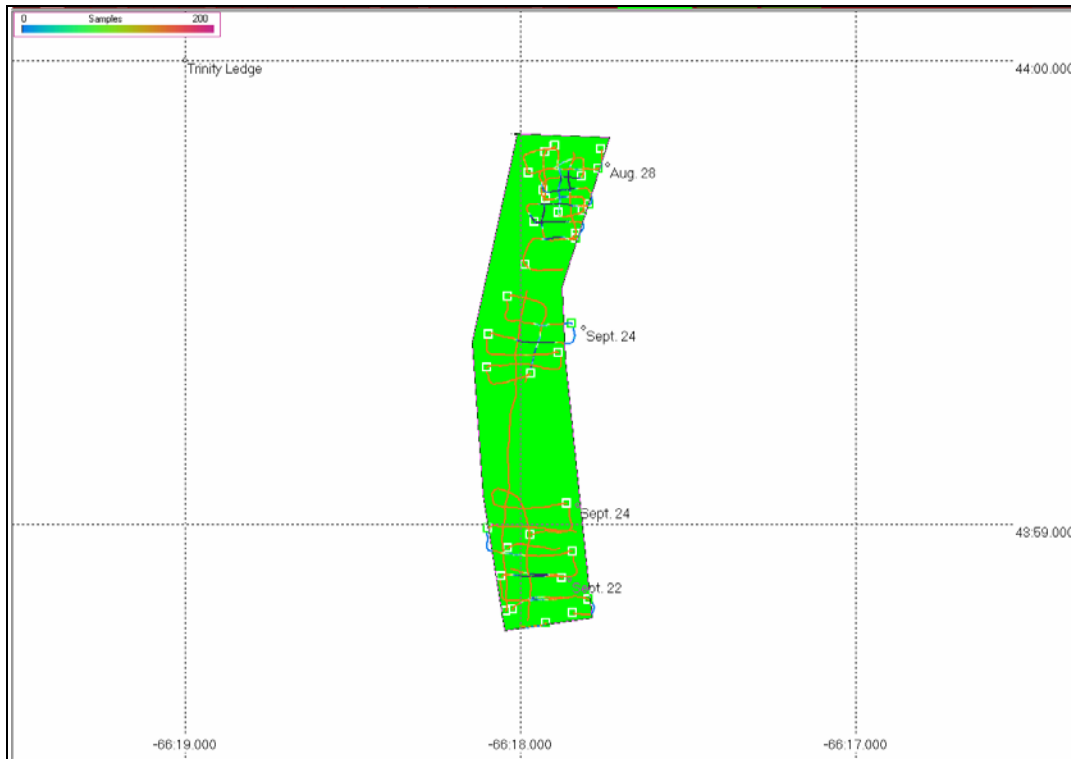


Figure 33. Trinity Ledge acoustic surveys on Aug. 28, Sept. 22 and Sept. 24, 2008 showing transects and an overall area of coverage of 1.0 km<sup>2</sup>.

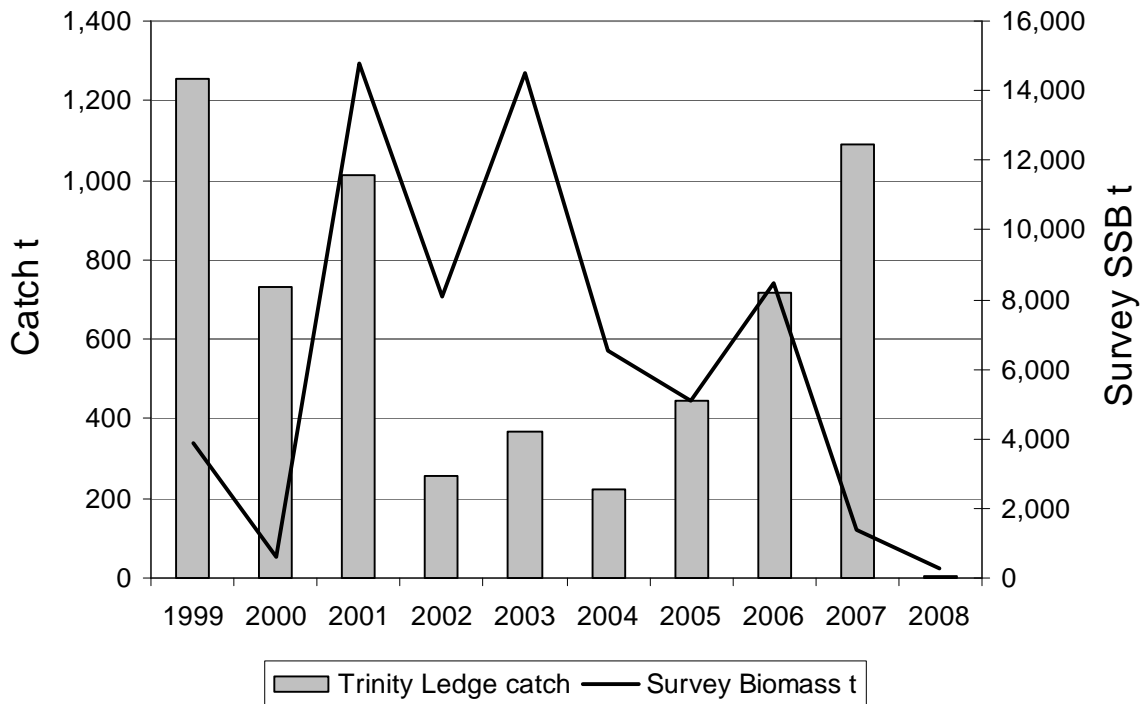


Figure 34. Trinity Ledge herring catches and acoustic survey biomass estimates from 1999 to 2008. All acoustic estimates were calculated without the CIF.



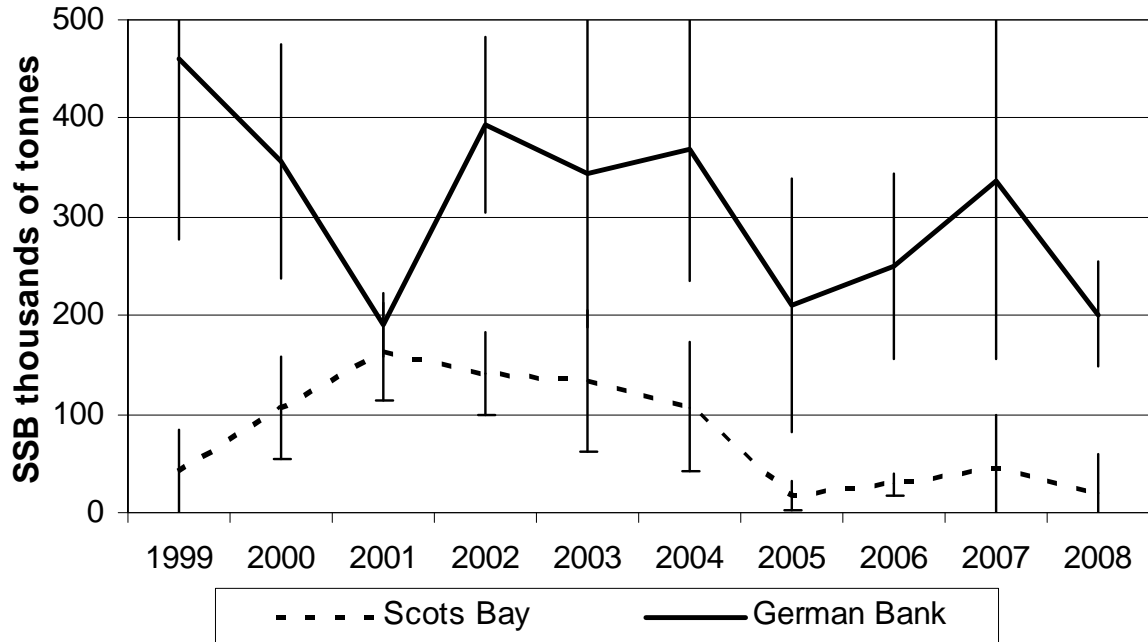


Figure 35. Trends in herring spawning stock biomass from acoustic surveys in Scots Bay and German Bank areas with 95% confidence intervals (equivalent to 2 times SE).

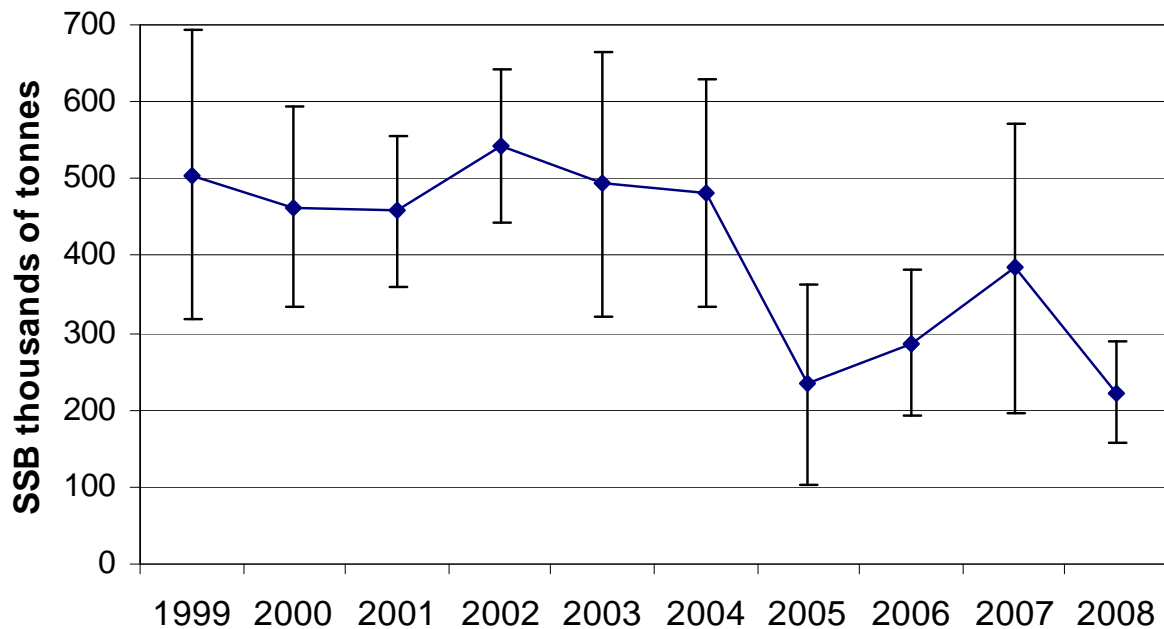


Figure 36. Trends in herring spawning stock biomass from acoustic surveys for the combined SWNS areas with 95% confidence intervals (equivalent to 2 times SE).

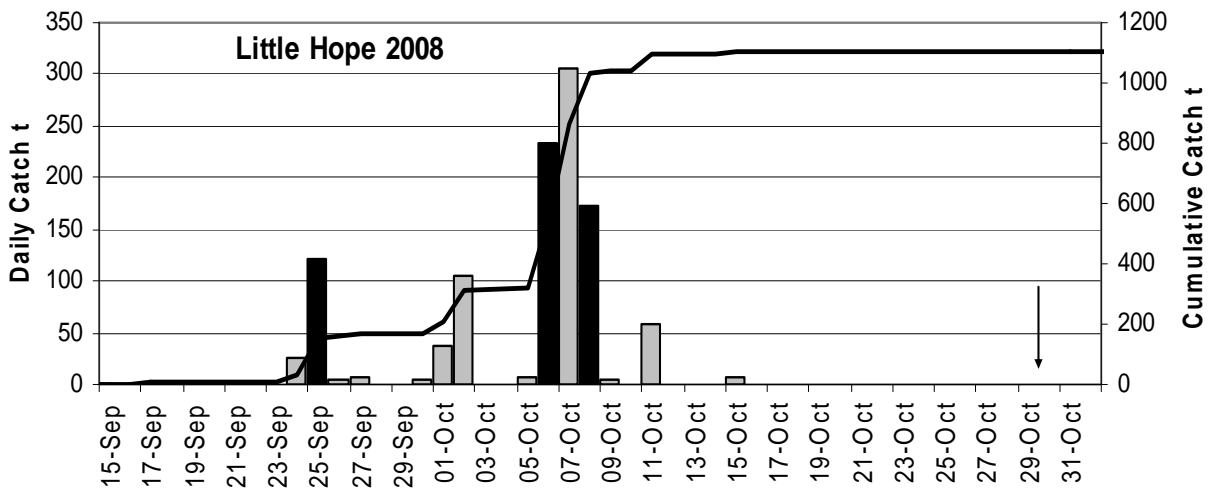


Figure 37. Daily and cumulative catch for the 2008 Little Hope/Port Mouton herring gillnet fishery. Survey dates are identified by black columns and arrow for final survey.

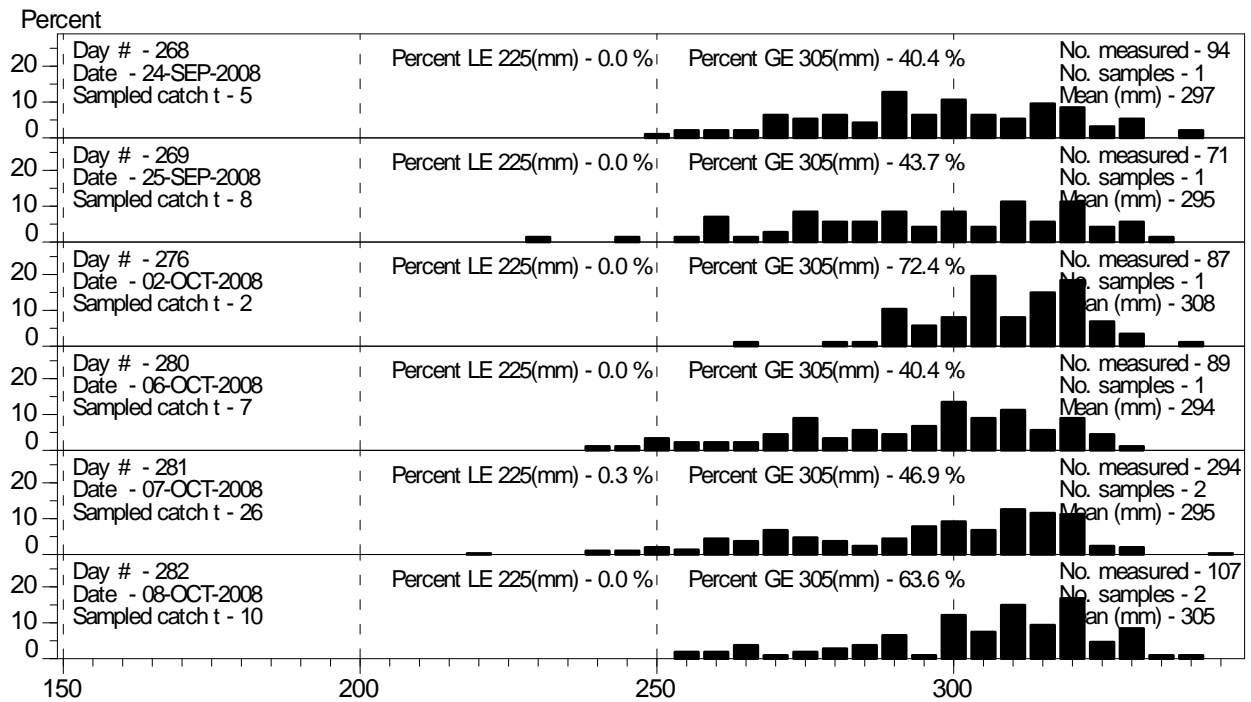


Figure 38. Daily length frequency sampling for the 2008 Little Hope/Port Mouton herring gillnet fishery.

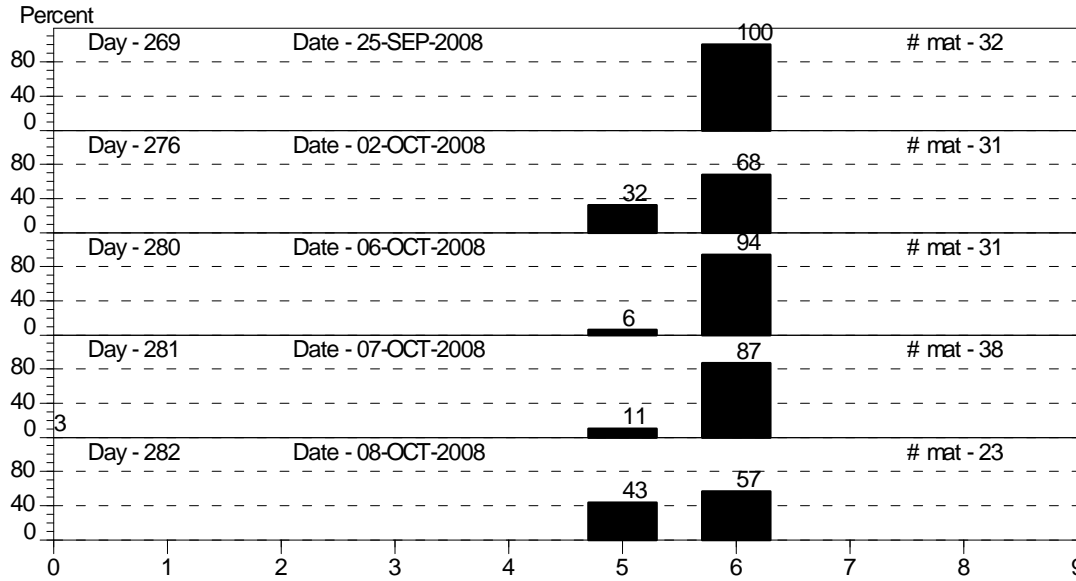


Figure 39. Daily maturity sampling for the 2008 Little Hope/Port Mouton herring gillnet fishery.

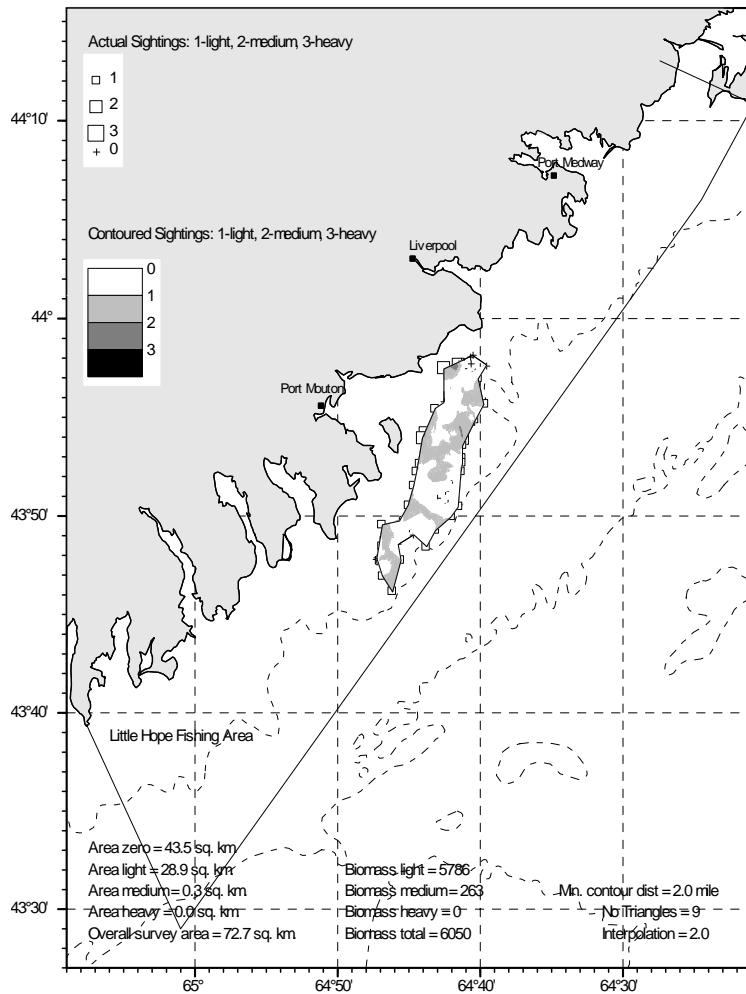


Figure 40. Herring mapping survey near Port Mouton for the night of Sept. 25-26, 2008 with an overall aerial coverage of 43.5 km<sup>2</sup>.

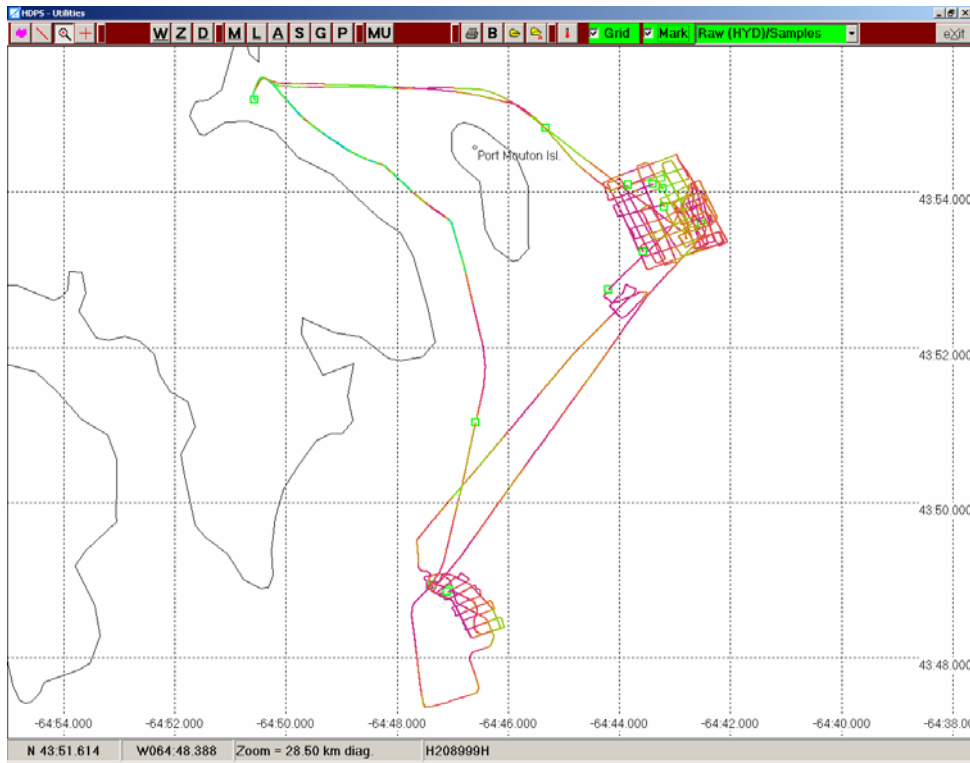


Figure 41. Acoustic survey track near Port Mouton for the night of Sept. 25/26, 2008 by fishing vessel *Knot Paid For*.

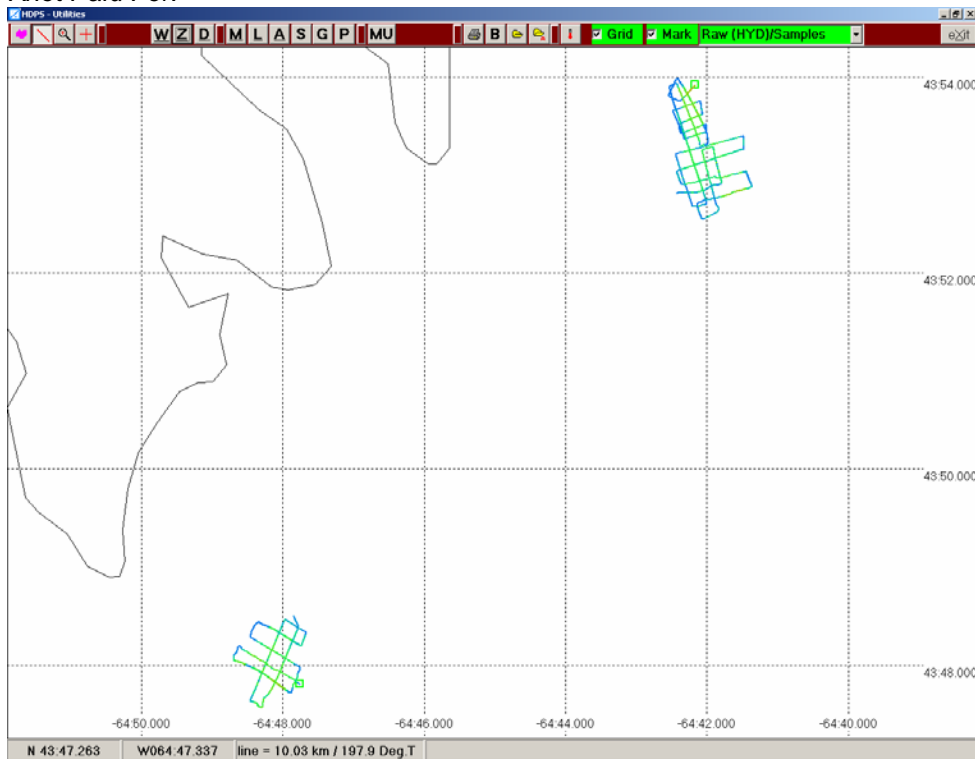


Figure 42. Little Hope/port Mouton surveys with overall lines of schools located about 5 km east (Oct.6) and 10km southwest (Oct. 8) of the island.

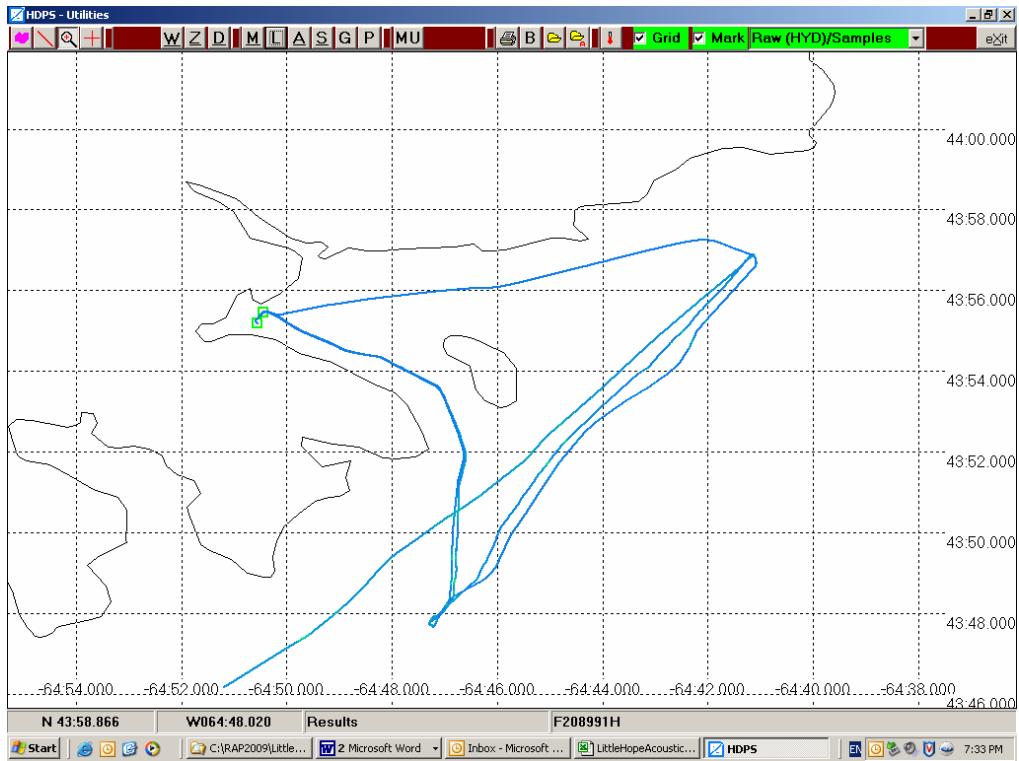


Figure 43. Vessel track off Port Mouton on October 30, 2008.

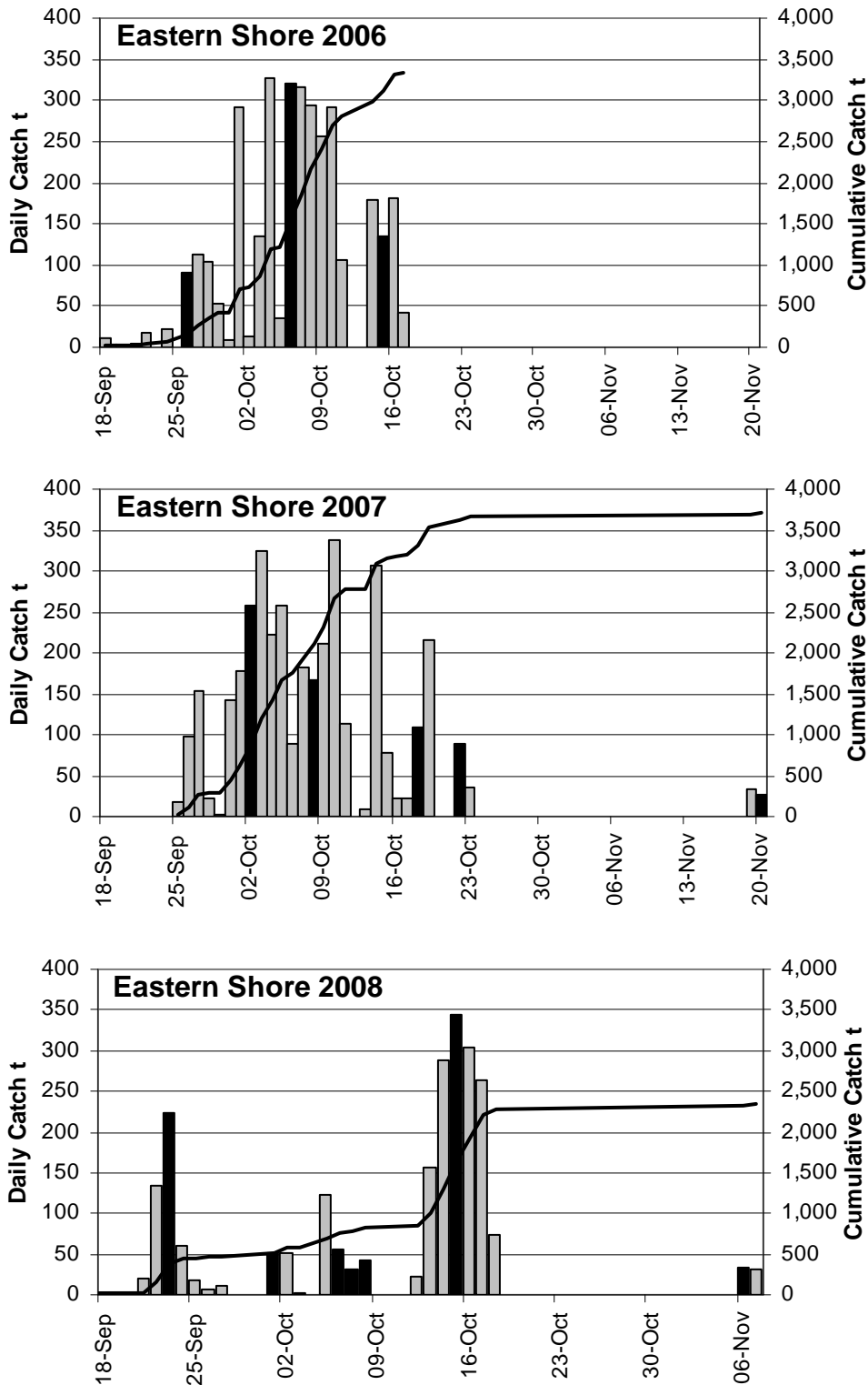


Figure 44. Daily catches for Halifax/Eastern Shore area from 2006-2008

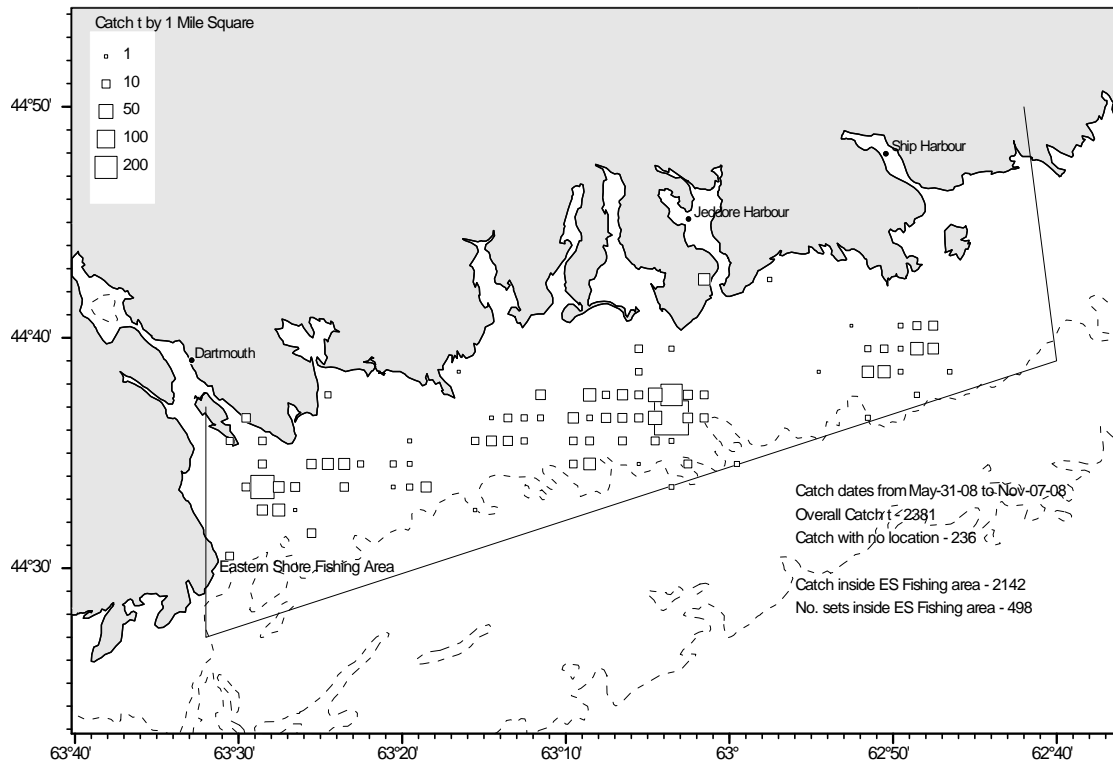


Figure 45. Gillnet herring catches for the 2008 fall fishery along the Eastern Shore Fishing Area (catches by 1 mile squares).

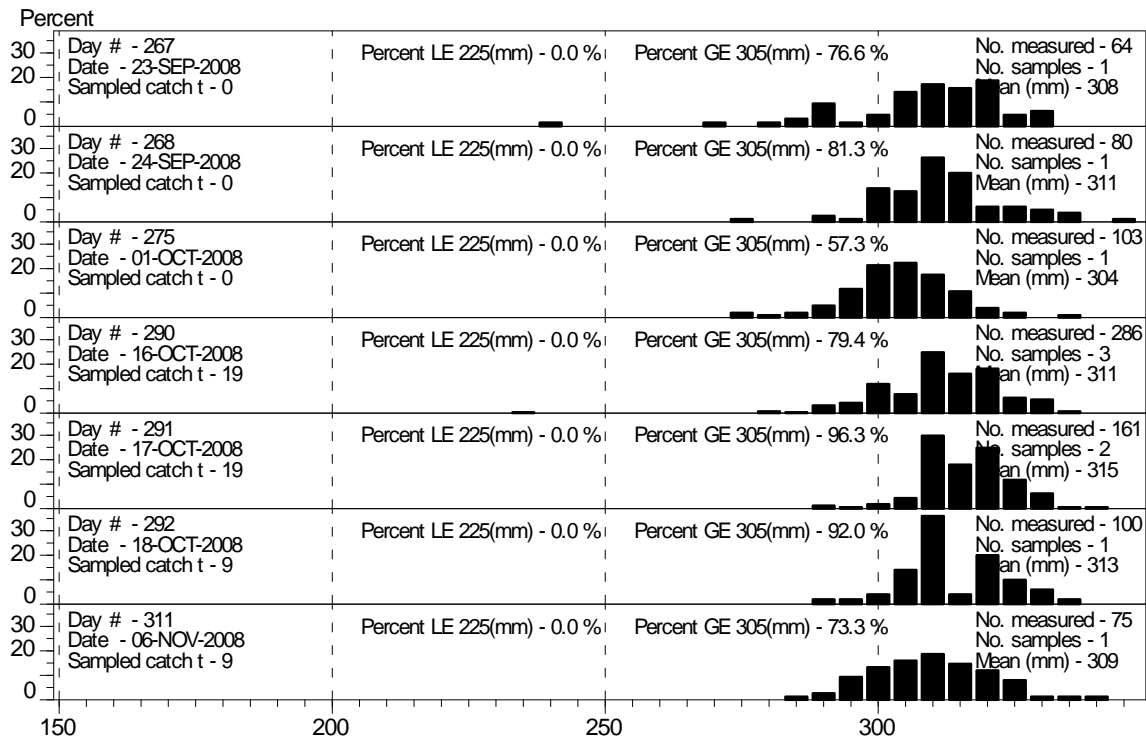


Figure 46. Daily length frequency sampling for the 2008 Halifax/Eastern Shore herring gillnet fishery.

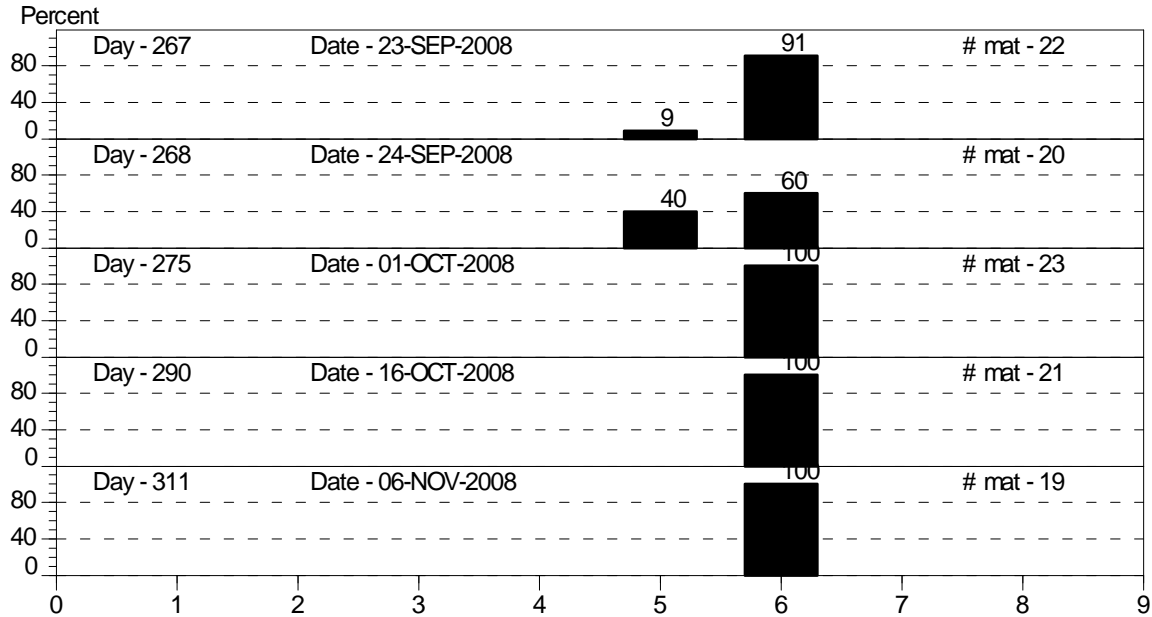


Figure 47. Daily maturity sampling for the 2008 Halifax/Eastern Shore herring gillnet fishery.

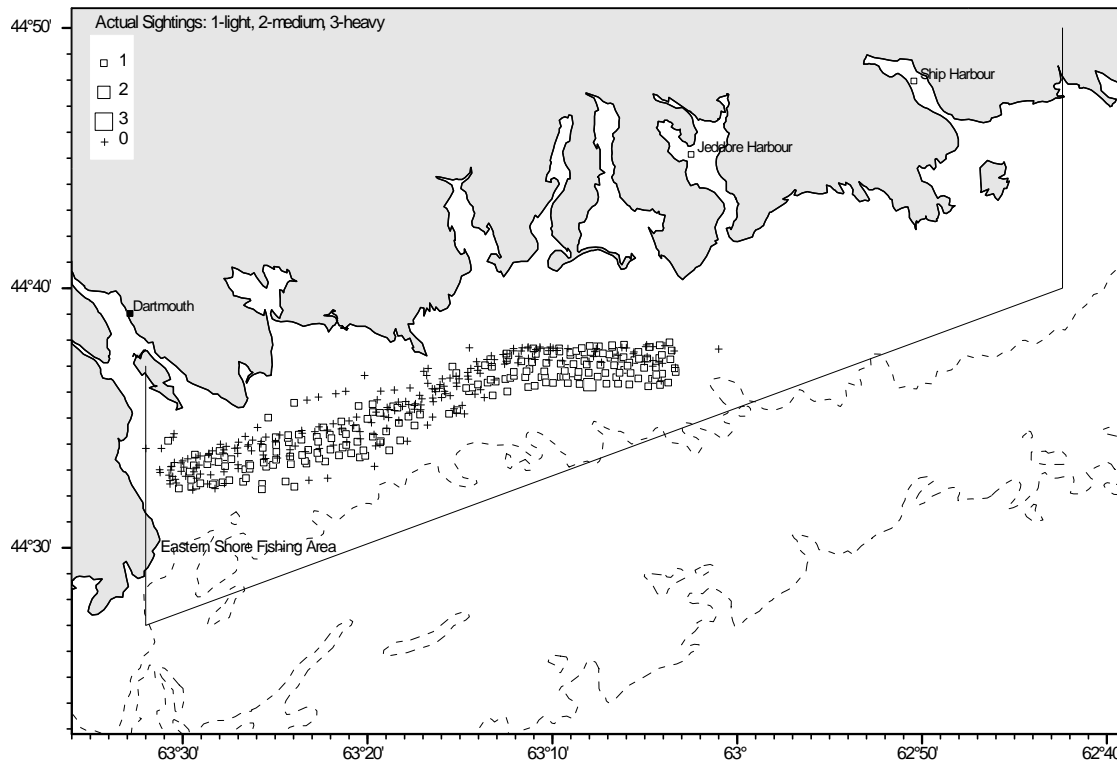


Figure 48. Survey track for mapping survey recorded on Sept. 23-24, 2008 along the Eastern Shore area.



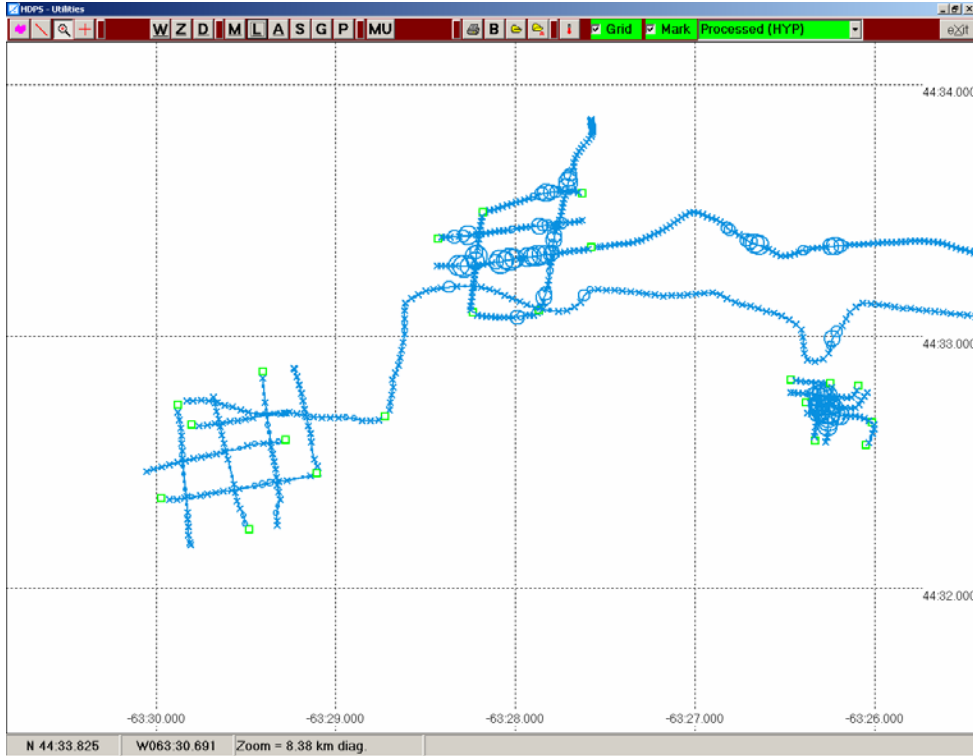


Figure 49. Survey track for the three schools surveyed by the Bradley K (B208) and Miss Owl's Head (M208) on Sept. 23-24, 2008 along the Eastern Shore area.

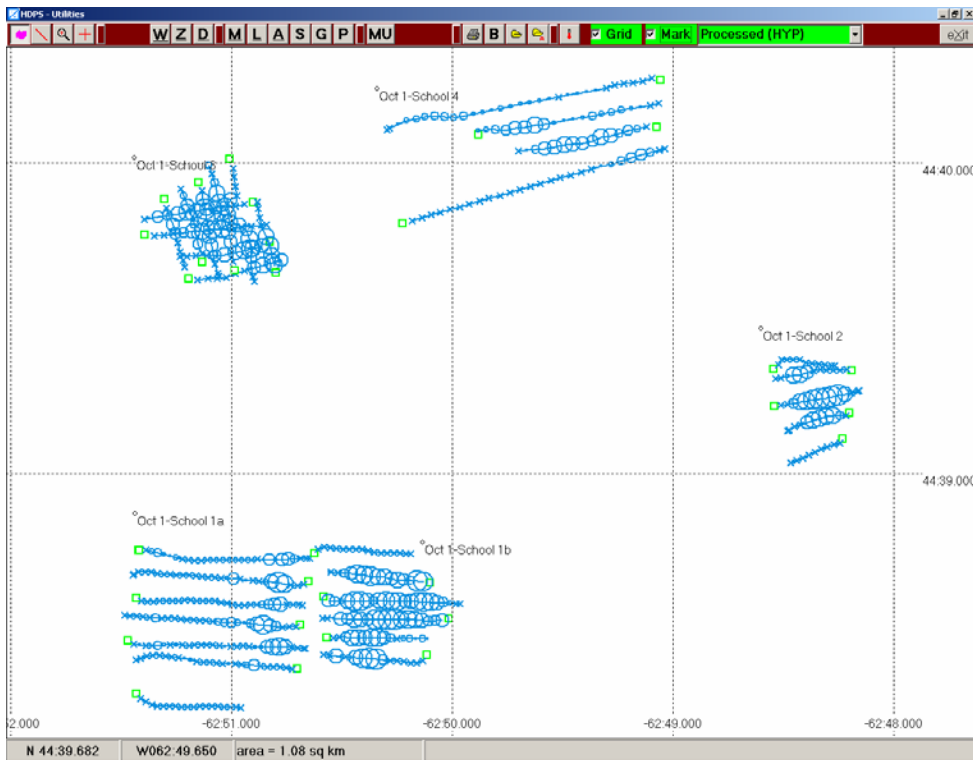


Figure 50. Survey pattern for schools surveyed near Jeddore on Oct. 1 by Bradley K and Miss Owls Head.

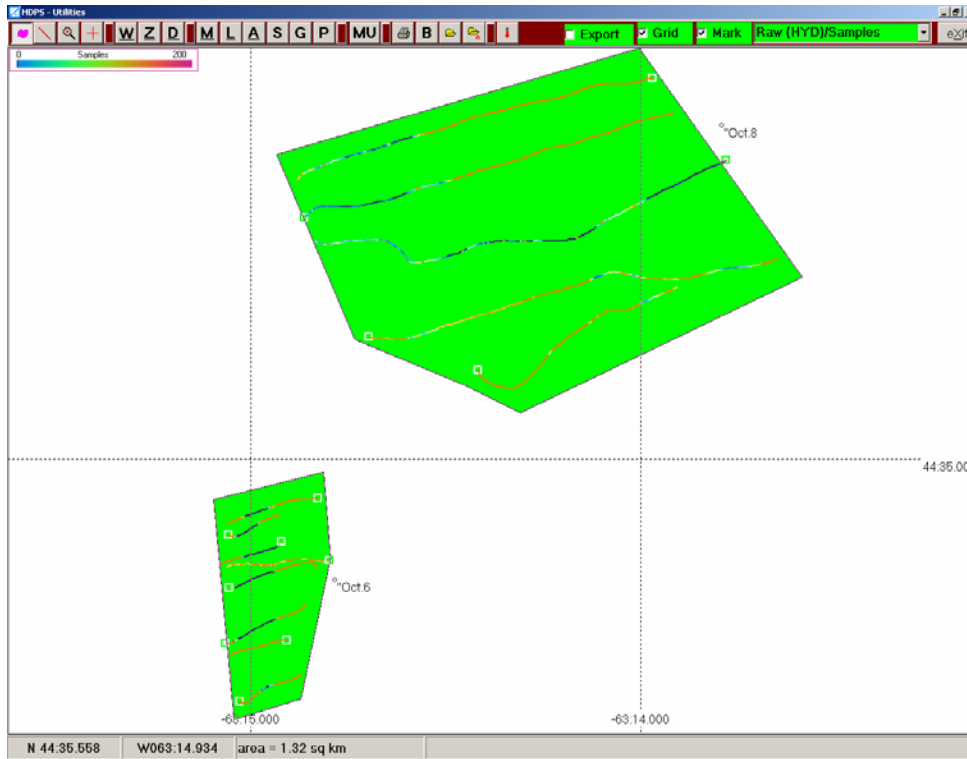


Figure 51. Survey pattern for schools surveyed near Jeddore on Oct. 6-8, 2008.

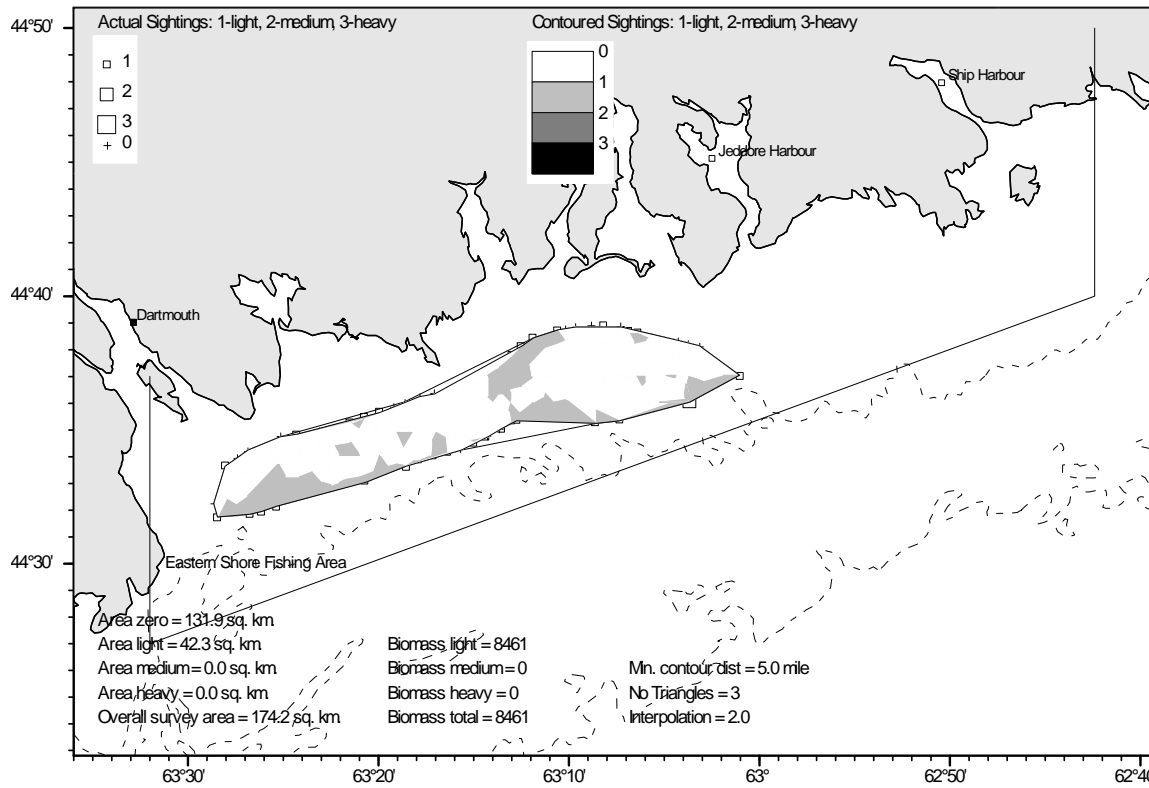


Figure 52. Survey coverage by mapping boats off the Eastern Shore on Oct 15-16, 2008 with an overall area of 174 sq. km.

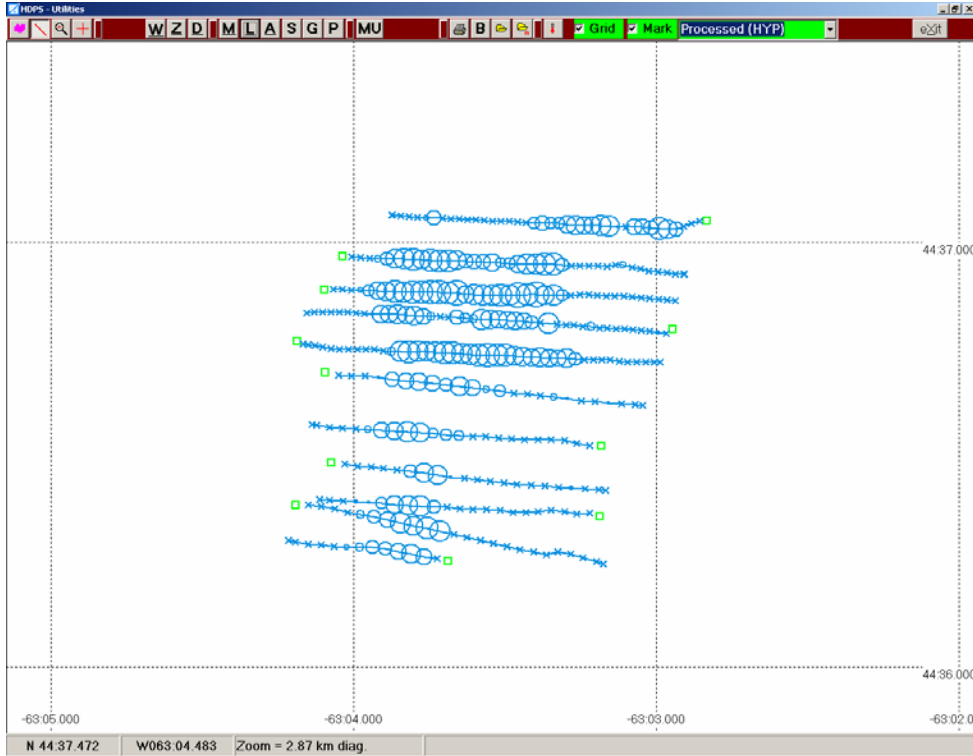


Figure 53. Eastern Shore survey on Oct. 15, 2008 for a spawning herring school located 6km south of Jeddore Cape.

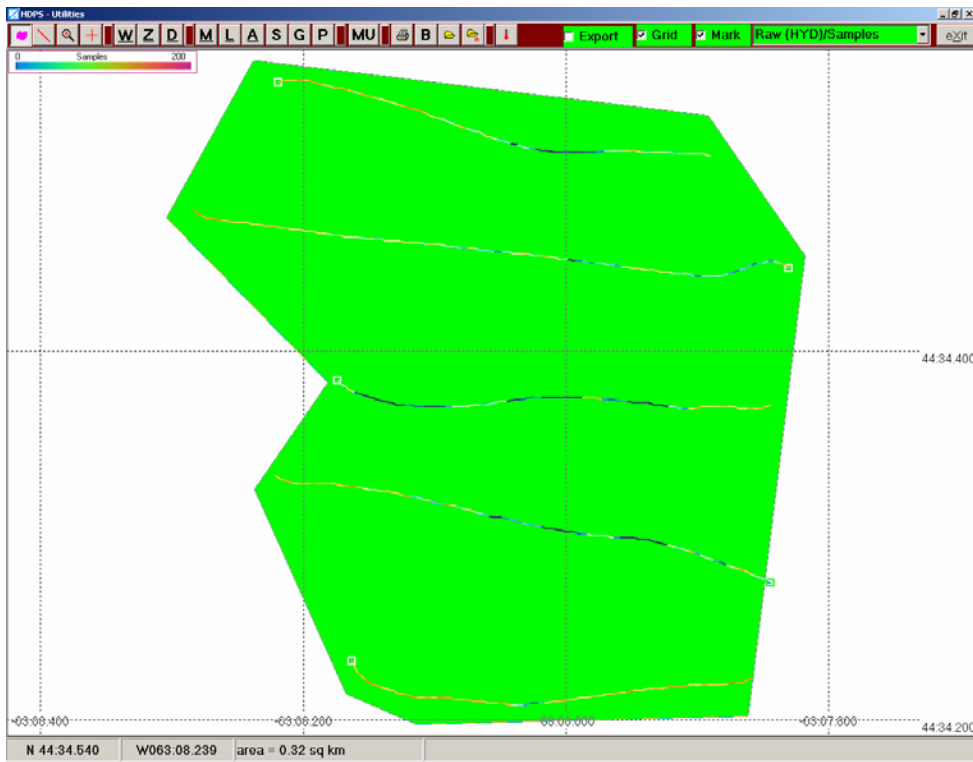


Figure 54. Eastern Shore survey on Nov. 6, 2008 on a spawning herring school.

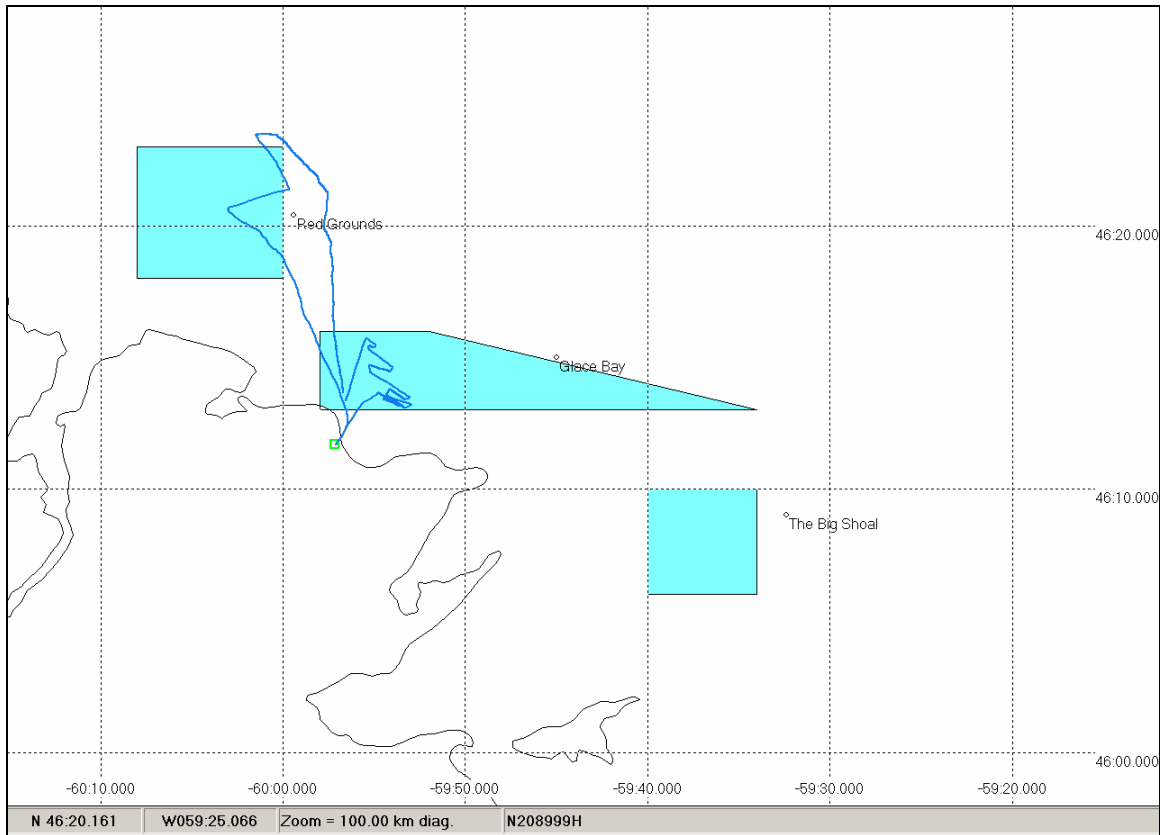


Figure 55. Survey tracks completed for Sept. 21 and Oct. 15, 2008 with defined fishing ground boxes shown as highlighted blue areas.

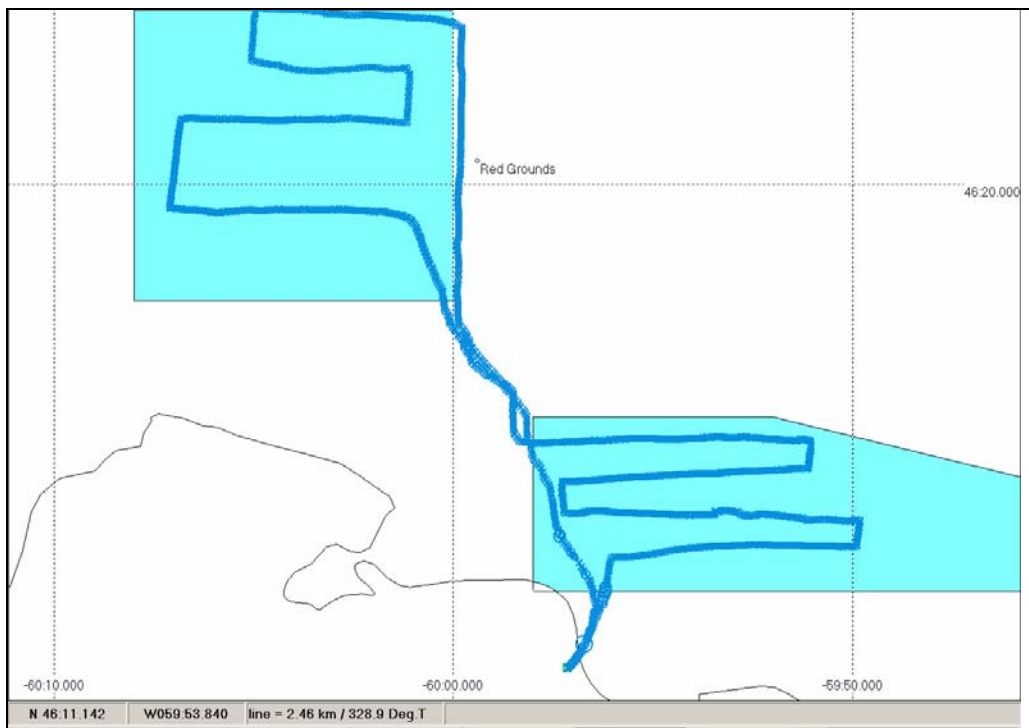


Figure 56. Survey backscatter for tracks completed on Oct. 29, 2008 with defined fishing ground boxes shown as highlighted blue areas.

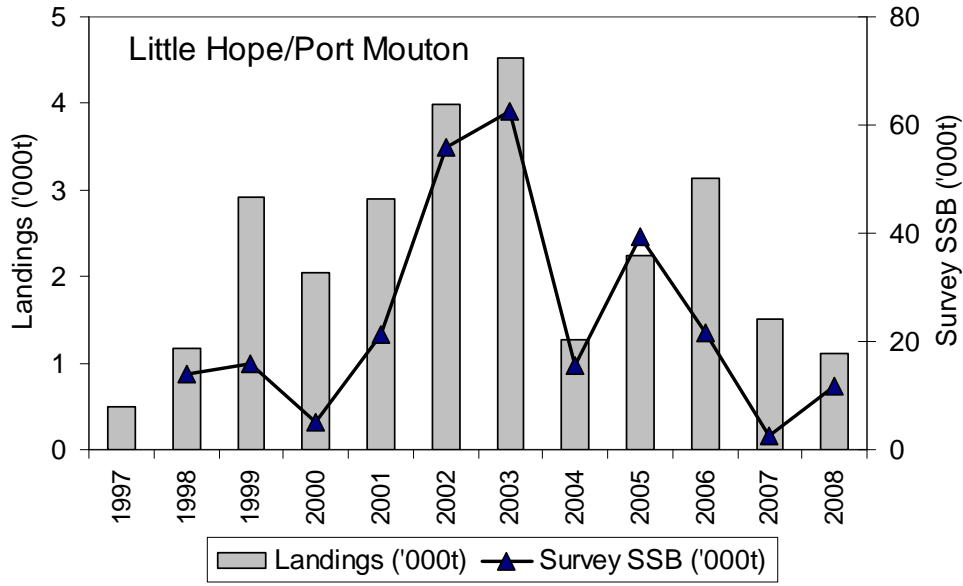


Figure 57. Herring landings and acoustic survey biomass ('000t) for the Little Hope/Port Mouton gillnet fishery from 1997-2008.

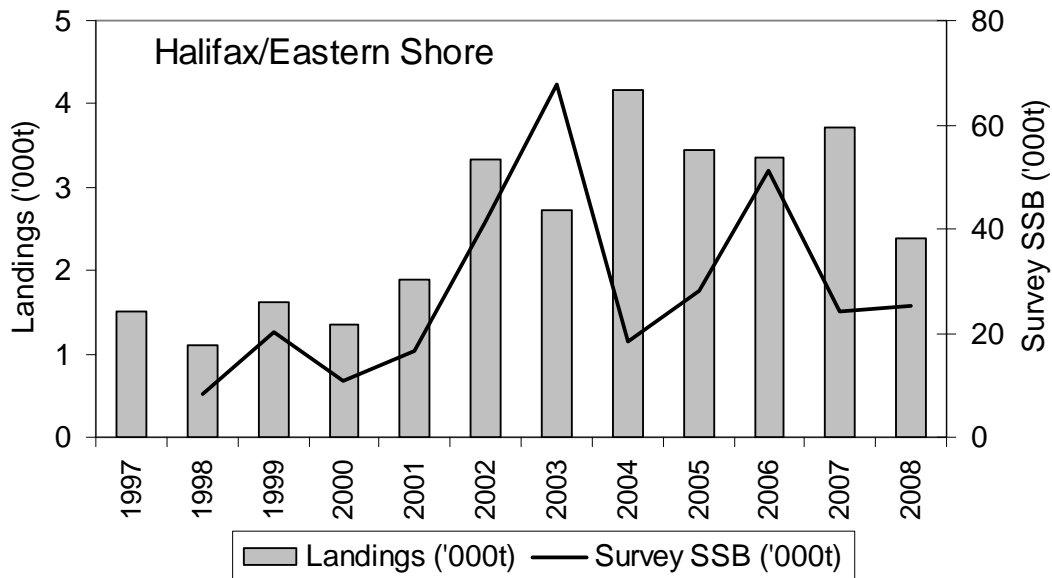


Figure 58. Herring landings and acoustic survey biomass ('000t) for the Halifax/Eastern Shore gillnet fishery from 1997-2008.

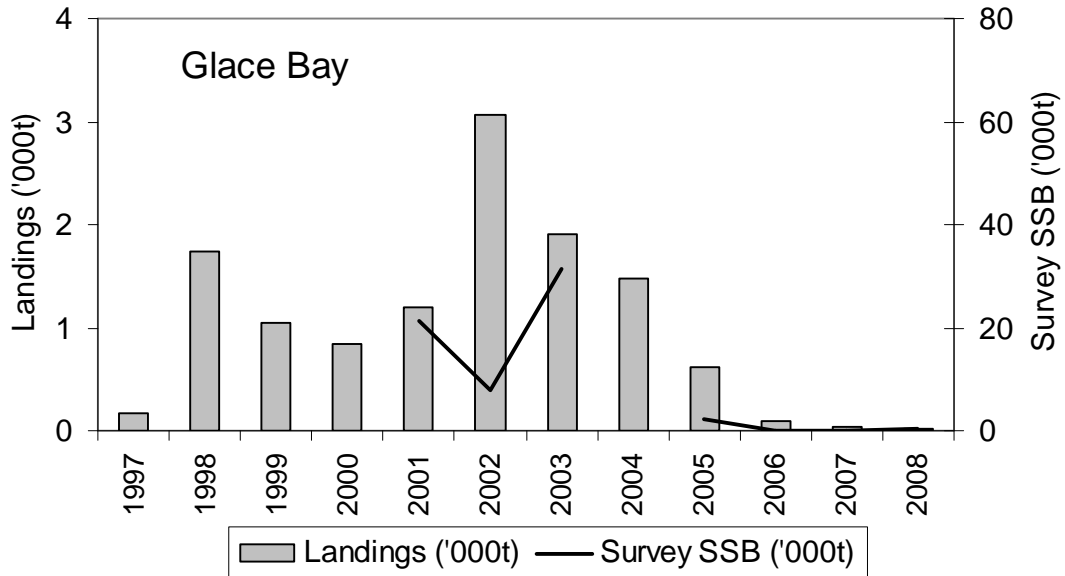


Figure 59. Herring landings and acoustic survey biomass ('000t) for the Glance Bay gillnet fishery from 1997-2008.