Fisheries and Oceans Canada
Pêches et Océans Canada

Ecosystems and Oceans Science
Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat (CSAS)

Research Document 2022/026

Maritimes Region

Summary of 2015, 2016, and 2017 Herring Acoustic Surveys in Northwest Atlantic Fisheries Organization (NAFO) Divisions 4VWX

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August 2022

Foreword

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

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1919-5044
ISBN 978-0-660-43251-9 Cat No. Fs70-5/2022-026E-PDF

Correct citation for this publication:

Singh, R. MacIntyre, A., Munden, J. Clay, A., Knox, D., and Melvin, G.D. 2022. Summary of the 2015, 2016, and 2017 Herring Acoustic Surveys in NAFO Divisions 4VWX. DFO Can. Sci. Advis. Sec. Res. Doc. 2022/026. iv + 197 p.

Aussi disponible en français :

Singh, R., MacIntyre, A., Munden, J., Clay A., Knox, D., et Melvin, G. 2022. Résumé des relevés acoustiques du hareng de 2015, de 2016 et de 2017 dans les divisions 4VWX de l'OPANO. Secr. can. des avis sci. du MPO, Doc. de rech. 2022/026. iv + 203 p.

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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 from industry vessel surveys and fishing excursions in the Bay of Fundy and coastal Nova Scotia area within Northwest Atlantic Fisheries Organization (NAFO) divisions 4VWX. During the years 2015 to 2017, regularly scheduled surveys at approximately 14 day intervals were again conducted on the main Herring spawning components, and the spawning stock biomass for each component was estimated by summing these results. Six structured surveys were conducted in Scots Bay in 2015, six in 2016, and eight in 2017. Five usable structured surveys were conducted on German Bank in both 2015 and 2016. There were four (plus two) surveys on German Bank in 2017. The September 17 survey was initially excluded because it was nine days after the previous one; however, this resulted in a 28-day gap before the next acceptable survey. Subesquently, at the 2018 assessment meeting, this survey was included. One acceptable structured survey was completed in the Trinity Ledge area in 2015, followed by three in 2016 and four in 2017. There were no structured surveys conducted in 2015 or 2016 for Spectacle Buoy; however, three fall surveys were completed in 2017. In most cases, these surveys provided good coverage of the spawning areas consistent with established protocols.

In 2015, the biomass estimate decreased to approximately 4% of the 2014 estimate for the combined survey areas of Scots Bay, Trinity Ledge, and German Bank (known as the Southwest Nova Scotia/Bay of Fundy [SWNS/BoF] [4X] stock). The 2016 estimate for the same overall areas decreased 29% of the 2015 estimate, while in 2017 the biomass increased (20%) above the 2016 estimate. The 2014 and 2015 estimates were above the long-term average since 1999, while the 2016 and 2017 biomass estimates are below the long-term average. These estimates provide mixed indications with regards to the SWNS/BoF stock. The German Bank spawning biomass estimate has decreased at an average annual rate of 9% since 2011. The Trinity Ledge 2017 spawning biomass has increased substantially to be above the long-term average; however, since 2006, the estimates have been well below the average. The recent large fluctuation in the SWNS/BoF spawning complex is occurring in the Scots Bay area; however, the long-term trend is upward.

Biomass estimates from surveys of the coastal Nova Scotia spawning components for the Little Hope/Port Mouton, Halifax/Eastern Shore, and Glace Bay areas were also examined. Four (2013), six (2014), and six (2017) surveys were completed for Little Hope, as well as, four (2015), seven (2016), and 10 (2017) surveys for Halifax/Eastern Shore. No surveys were completed in the Glace Bay area. In Little Hope, a substantial increase in the spawning biomass estimate to a historic high was observed in 2015 (145,395 t), a three-fold increase over the 2014 estimate. There was a 57% decrease in the estimate in 2016 (61,408 t) followed by an 8% increase in 2017 to 66,815 t. The estimate is above the long-term average of 38,659 t. The total spawning biomass estimate for the Halifax/Eastern Shore area demonstrated a seven-fold increase from 9.586 t (2014) to 68,564 t (2015). While the biomass decreased to 54,352 t (2015) and 58,681 t (2017), it is above the recent five-year average of 39,602 t, and above the long-term average since 1998 (33,606 t). No survey was completed in Glace Bay during the 2015–2017 period.

INTRODUCTION

Since 1997, the Spawning Stock Biomass (SSB) of Northwest Atlantic Fisheries Organization (NAFO) divisions 4WX Atlantic Herring has been estimated using acoustic surveys conducted by the fishing industry (Stephenson et al. 1998, Power and Melvin 2010). 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 estimates for individual spawning areas are summed, under specific assumptions about elapsed time between surveys, to provide an annual index of SSB for assessment processes. The development and implementation of the automatic acoustic systems represented 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 these are considered qualitative only (Melvin et al. 2002).

The use of commercial fishing vessels to survey and estimate SSB was initially developed to provide additional protection of individual spawning components within a global total allowable catch (TAC) during a period (1994–95) of declining biomass. The original qualitative approach, referred to as the “survey, assess, then fish” protocol, continues today, but it now uses a quantitative acoustic methodology with a standard survey design (DFO 1997, Melvin and Power 1999, Melvin et al. 2004, Power and Melvin 2010) to provide an index of spawning biomass. The present survey design allows for evaluation of the SSB index to provide information on the stock for the upcoming fishing year. Several major improvements to the approach have been made in survey design and in the 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, Power and Melvin 2010). The purpose of this document is to report and to summarize the NAFO divisions 4VWX Atlantic Herring stock assessment related survey data collected during the 2015, 2016, and 2017 fishing and survey seasons.

METHODS

Acoustic and mapping surveys using commercial fishing vessels have been employed to estimate SSB of individual components within the Herring 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 2010, Power et al. 2013, Singh et al. 2014).

Data from the 2015, 2016, and 2017 fishing seasons were obtained during regularly scheduled structured surveys. Structured surveys included mapping and/or acoustic surveys (Melvin et al. 2001); however, only acoustic surveys were used to determine the biomass estimates for the three reporting years (2015 to 2017). There were 21, 27, and 35 structured surveys completed in 2015, 2016, and 2017, respectively (Table 1). Any additional structured surveys that were conducted had to be excluded due to closeness in the number of days to another conducted survey (Table 1). The total number of survey boat nights (using acoustic recording systems) completed was 110 in 2015, 123 in 2016, and 131 in 2017, respectively. All surveys were undertaken with acoustic recording systems (Tables 2A, 2B and 2C).

Structured surveys were conducted in accordance with the protocol established by Melvin and Power (1999), and completed transects provided appropriate coverage of the defined spawning survey areas. A few exceptions to the normal protocols of survey design did take place. These are explained in more detail where they occur below.

DATA QUALITY ISSUES

Most of the previous issues with data quality, detailed in Power et al. (2013), have been resolved. Those issues included the following of surveying protocols, provision and verification of the raw data and editing, and issues of noise and interference. However, as mentioned previously in Singh et al. (2014, 2016), some issues continue to surface including not following survey protocols (i.e., doing a series of loops instead of parallel lines or not maintaining straight lines) when documenting fish aggregations. Data collections inconsistent with established protocols were given a low priority for analysis or were not incorporated into the SSB estimate.

Most of the task associated with processing the raw acoustic survey data files have been split between the Herring Science Council (HSC), Femto Electronics and Fisheries and Oceans Canada (DFO). At the framework assessment meeting held in January 2007, it was recommended that all raw data files should be made available on a regular basis for review prior to finalizing the acoustic biomass estimates (Power and Melvin 2008). In 2015, 2016, and 2017, as has been the case in previous years, all raw data files were received and the data was compared with the edited results before the final analysis was completed using Echoview software. The main reason for the 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 identified and resolved by re-editing the data for some vessels and for specific surveys. In a few cases, the bottom was not completely removed or some non-Herring species were apparent.

As a result of past testing, vessel noise/interference for each vessel outfitted with an acoustic recording system was addressed as part of the calibration process, and recommended speed or vessel revolutions per minute (RPM) levels were established. The resulting raw data collected continues to have less background noise and was useable from all survey vessels. However, the appearance of sonar noise did occur on a few recordings and this resulted in more editing requirements.

LENGTH/WEIGHT RELATIONSHIP

Prior to 2001, the fish weight variable in the Target Strength (TS) equation (Tables 3A, 3B, 3C) was estimated using a length/weight relationship developed from combined average monthly data for each area. TS was estimated using the generic clupeid equation from Foote (1987). A correction factor of 1.02 was also applied to each length measurement to account for the shrinkage of fish due to freezing, prior to calculating the length/weight relationship (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 been narrowed since 2001, to provide a more representative estimate of mean fish weight at the time of surveying.

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 nine-day window (four days prior to or after each of the surveys). These data are used to develop a weight/length relationship specific to each acoustic survey (Tables 3A, 3B, 3C). 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. When samples were not available, TS was estimated using values for an ‘average spawning fish’ at 28 cm in length with adjustment for sounder frequency as required.

CALIBRATION INTEGRATION FACTOR

As outlined in Melvin et al. (2004), a Calibration Integration Factor (CIF) was used to estimate backscatter in the acoustic data integration process. The inclusion of the CIF is deemed to provide a more accurate estimate of biomass, as a result all analyses utilize the CIF to calculate absolute biomass (Melvin et al. 2004). In Singh et al. (2014, 2016), the summary results were presented using calculations with only the CIF. All biomass estimates are presented using calculations with only the CIF including those from prior years (Melvin et al. 2014a).

ACOUSTIC SYSTEMS

As in previous years, acoustic data were collected using automated logging systems aboard commercial fishing vessels during structured surveys. The systems, which were activated whenever the captain wished to document observations, automatically saved all data to a hard drive. The data were downloaded at regular intervals prior to archiving, data editing, and analysis.

A total of 17 automated acoustic logging systems (i.e., Femto Model DE9320, Simrad Model ES60 or Simrad Model ES70) were deployed on commercial fishing vessels. Systems from Femto Electronics were installed and calibrated aboard one purse seine vessel and six gillnetters: *Tasha Marie, Emily & Aley, Miss Owls Head, Oralee, Trinity, Katrina and Kayla,* and *Double Don.* There were also five Simrad ES60 acoustic systems calibrated and used on the following purse seine vessels: *Silver Harvester*, *Margaret Elizabeth, Morning Star*, *Brunswick Provider*, and *Leroy & Barry II*. Five other purse seine vessels: *Dual Venture, Canada 100*, *Sealife II, Lady Janice II,* and *Lady Melissa* were equipped with Simrad Model ES70. Two Simrad ES60 acoustic systems were used on the inshore Herring gillnet vessels *Atlantic Star* and *Eagle 8* and one ES70 system on the vessel *Salt Water Hunter*.

STRUCTURED SURVEYS

Structured surveys play an important role in the understanding of the 4WX Herring stock. 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 two-week intervals. 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.

FISHING EXCURSIONS

Fishing nights are defined as those occasions when acoustic data are collected by fishing vessels equipped with automated acoustic logging systems during the search phase of a fishing excursion. Singh et al. (2014) provide more details on how and when data from fishing nights are used. No fishing night data were collected in 2015, 2016, and 2017.

RESULTS

The spawning biomass for individual components of the 4WX Herring stock complex in 2015, 2016, and 2017 was estimated from industry collected data using multiple structured acoustic surveys on major spawning grounds (Figure 1). These surveys, when summed, provide an index of SSB and form the foundation for evaluation of stock status. The following text provides a summary of the 2015, 2016, and 2017 observations and SSB estimates for each of the main spawning components within the stock complex. Detail acoustic data analyses from each survey are published in a separate Data Report (Singh et al. 2019).

SOUTHWEST NOVA SCOTIA/ BAY OF FUNDY (SWNS/BOF) 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 10–12 days (or less). Results of a study by Melvin et al. (2014b) indicate that between 13–19% of fish may remain on spawning grounds between surveys.

Sampling data for maturity supports the view of continuous spawning or waves with high proportions of ripe and running (Stage 6) fish observed over an extended period. The 10–14 day window between surveys 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.

The samples from the standard biological sampling program conducted by staff at the St. Andrews Biological Station (SABS) 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 and acoustic surveys, and from landings at various fish processing 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 fish processing plant classification system of maturity must not be confused with the standardized International Council for the Exploration of the Sea (ICES) 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 two methods. Analysis of the roe maturities was completed for the data available on an individual survey basis and is presented 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. Acoustic surveys are required to be separated by at least 10–14 days to allow for turnover and to prevent double counting (Power et al. 2002). 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 by Melvin et al. (2002, 2003, and 2004), Power et al. (2005, 2006, 2007, and 2008), and by Power and Melvin (2010), and were 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 (PRC/HSC), in partnership with DFO, tagged Herring on spawning grounds and on the major Nova Scotia over-wintering grounds. 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 returns) during the second week after tagging.

In response to a recommendation from the 2005 regional advisory process review, tags were applied to Herring on the spawning grounds of Scots Bay and German Bank (Clark 2006). 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 5–6 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 may 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 for 3 weeks or longer. However, these adjustments do not change the overall trends over time, but rather apply a scaling to the absolute amounts.

The 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.

Melvin et al. (2014b) updated the tagging study on German Bank during the spawning period that was completed in 2011. Approximately 23,000 spawning Herring were marked and released on German Bank during the 2009–2011 spawning season. These data were combined with data from previous Scots Bay and German Bank tagging studies for the analysis. Overall, 13% of tagged fish in Scots Bay and 19% on German Bank were recaptured after two weeks. Regression analysis indicates a strong relationship between the days at large and the proportion of fish remaining on the bank. Melvin et al. (2020) provides an update to the data presented in Melvin et al. (2014b) using the turnover biomass estimates. The incorporation of this method results in a downward adjustment to the limit reference point (LRP).

Acoustic Surveys[1]

Scots Bay

The Scots Bay Herring purse seine fishery has been an important component of the summer fishery with catches since 1987, ranging from 900 t to 24,400 t during the period of late June to late August-early September. Prior to 2015, the Scots Bay purse seine fishery was restricted to an industry imposed cap of 5,000 t. This cap was raised in the years that followed.

In 2015, purse seine landings in Scots Bay increased to 6,951 t (from 4,498 t in 2014), with landing dates from June 28 to September 13. Those numbers decreased in 2016 to 6,010 t, with landing dates from June 16 to August 17. In 2017, landings increased to 8,685 t, with landing dates from June 22 to September 27. Most of the catches were located within the defined survey box area.

Sampling was adequate in with samples from most landings allowing detailed description of the size and maturity of fish captured (Figures 2A, 2B, 2C, 3A, 3B, and 3C), however, there were no samples available for one survey each in 2016 and 2017. Samples for gonad maturity showed the majority as maturing/hard (Stage 5), as well as ripe and running (Stage 6) stages (Figures 3A, 3B, and 3C). Some immature juvenile fish were also picked up from research bottom trawl

[1] Acoustic biomass estimates from Scots Bay and German Bank in this document are not adjusted for turnover. See Melvin et al. (2020) for estimates adjusted for turnover as accepted at the 2018 assessment meeting.

samples collected in the area during the spring. Detailed acoustic data analyses from each survey are published in a separate Data Report (Singh et al. 2019).

2015 Scots Bay Acoustic Surveys

Six structured surveys were conducted between June 27 and September 8 during the 2015 spawning season in Scots Bay (Table 2A) similar to 2014. The surveys were separated by a minimum of 14 days and covered the survey area.

Scots Bay Acoustic Survey #1: June 27, 2015

- This survey was conducted by six vessels all with acoustic systems.
- Figure 4A shows the tracks of the vessels and the location of the fishery samples. Fifteen length–frequency and five detailed samples were processed giving a mean size of 27.1 cm and a mean weight of 167 g (Figure 4B).
- Maturity analyses showed that 82% of the fish were Stage 5 “maturing” condition and 12% of the fish were in the Stage 6 “ripe and running” condition (Figure 3A).
- The initial analysis resulted in a biomass of 83,600 t for the survey area of 728 km² using the standard TS.
- The biomass value was adjusted to 82,428 t after edits to the files and using sample generated TS.

Scots Bay Acoustic Survey #2: July 11, 2015

- Seven vessels participated in this survey, all with acoustic systems.
- Figure 5A shows the tracks of the vessels and the location of the fishery samples. Twenty-three length-frequency and five detailed samples plus samples from the CCGS *Alfred Needler* survey were used to generate the TS giving a mean size of 27.3 cm and a mean weight of 163 g (Figure 5B).
- Maturity analyses showed that 82% of the fish were Stage 5 “maturing” condition and 10% of the fish were in the Stage 6 “ripe and running” condition (Figure 3A).
- The initial analysis resulted in a biomass of 85,493 t for the survey area of 816 km² using the standard TS.
- The biomass value was adjusted to 81,673 t after edits to the files and using sample generated TS.

Scots Bay Acoustic Survey #3: July 25, 2015

- This survey was conducted by 8 acoustic survey vessels. Six boats ran two lines each within the pre-determined survey box, while one vessel ran four shorter lines in the upper eastern part of Scots Bay, while another boat ran four shorter lines to the north of the survey box. The vessels conducted a broad-scale systematic parallel transect survey.
- Figure 6A shows the tracks of the vessels and the location of the fishery samples. Thirteen length-frequency and four detailed samples were used to generate the TS giving a mean size of 28.2 cm and a mean weight of 187 g (Figure 6B).
- Maturity analyses showed that 85% of the fish were Stage 5 “maturing” condition and 5% of the fish were in the Stage 6 “ripe and running” condition (Figure 3A).
- The initial analysis resulted in a biomass of 40,116 t for the survey area of 880 km² using the standard TS.
- The biomass value was adjusted to 41,192 t after edits to the files and using the sample generated TS.

Scots Bay Acoustic Survey #4: August 8, 2015

- Eight vessels with acoustic systems participated in this survey. The vessel *Brunswick Provider* surveyed the north of the box while the vessel *Canada 100* surveyed the area east of the box.
- Figure 7A shows the tracks of the vessels and the location of the fishery samples.
- Twenty-four length-frequency and three detailed samples were used to generate the TS giving a mean size of 28.2 cm and a mean weight of 188 g (Figure 7B).
- Maturity analyses showed that 77% of the fish were Stage 5 “maturing” condition and 15% of the fish were in the Stage 6 “ripe and running” condition (Figure 3A).
- The initial analysis resulted in a biomass of 33,223 t using the standard TS for the survey area of 932 km².
- The biomass was adjusted to 34,234 t after edits to the files and using three detailed samples to generate the TS.

Scots Bay Acoustic Survey #5: August 22, 2015

- Five vessels with acoustic systems participated in this survey resulting in ten transects within the survey box.
- Figure 8A shows the tracks of the vessels and the location of the fishery samples.
- Fifteen length-frequency samples were available for the August 22 survey, and two detailed samples were available from August 23 and 24 (Figure 8B). The samples were used to generate the TS giving a mean size of 27.5 cm and a mean weight of 181 g.
- Maturity analyses showed that 81% of the fish were Stage 5 “maturing” condition and 12% of the fish were in the Stage 6 “ripe and running” condition (Figure 3A).
- The initial analysis resulted in a biomass of 28,242 t using the standard TS for the survey area of 654 km².
- The biomass was adjusted to 29,424 t after edits to the files and using the two detailed samples to generate the TS.

Scots Bay Acoustic Survey #6: September 8, 2015

- Three acoustic survey vessels participated resulting with six transects within the survey box.
- Figure 9A shows the tracks of the vessels and the location of the fishery samples. Ten length-frequency samples were available for the September 8 survey. Only one detailed sample was available for September 8 (Figure 9B), so the samples from August 23 and 24 were also used to generate the TS. The three detailed samples with a mean size of 26.9 cm and a mean weight of 166 g were used to generate the TS.
- Maturity analyses showed that 75.5% of the fish were Stage 5 “maturing” condition and 11.8% of the fish were in the Stage 6 “ripe and running” condition (Figure 3A).
- The initial analysis resulted in a biomass of 16,325 t using the standard TS for the survey area of 673 km².
- The biomass was adjusted to 16,245 t after edits to the files and using the three detailed samples to generate the TS.

2015 Scots Bay Acoustic Surveys Summary

The six structured surveys used in the biomass estimate were completed between June 27 and September 8, 2015. Biological sampling was available from survey catches to calculate the TS for use in estimating the total biomass. The 2015 Scots Bay acoustic survey SSB estimate from the six structured surveys within the survey box area (inbox) was 260,215 t. The total biomass estimate for areas surveyed outside of the standard survey box in the Scots Bay area was 24,979 t from surveys. The final 2015 Scots Bay acoustic survey estimate for all areas was 285,194 t (Table 4A).

2016 Scots Bay Acoustic Surveys

Six structured surveys were conducted between June 18 and August 27 during the 2016 spawning season in Scots Bay (Table 2B). The surveys were separated by a minimum of 14 days and covered the survey area.

Scots Bay Acoustic Survey #1: June 18, 2016

- This survey was conducted by five vessels all with acoustic systems. The acoustic recorder on the vessel *Margaret Elizabeth* was not turned on for the first transect, thus only one transect was recorded by this vessel. Figure 10A shows the tracks of the vessels.
- There was some confusion with regards to starting time. Three boats (*Margaret Elizabeth, Brunswick Provider* and *Canada 100*) started at 21:00 (UTC-3) and two boats (*Dual Venture* and *Leroy and Barry*) started at 22:30 (UTC-3). DFO agreed to treat this survey like any other, as it is unlikely the fish will move in the time between vessel start times.
- Twelve length-frequency and three detailed samples were processed giving a mean size of 27.2 cm and a mean weight of 162 g (Figure 10B).
- Maturity analyses showed that 68.2% of the fish were Stage 5 “maturing” condition and 13.7% of the fish were in the Stage 6 “ripe and running” condition (Figure 3B).
- The initial analysis resulted in a biomass of 25,178 t for the survey area of 665 km² using the standard TS.
- The biomass value was adjusted to 23,989 t after edits to the files and using sample generated TS.

Scots Bay Acoustic Survey #2: July 2, 2016

- This survey was conducted by seven vessels all with acoustic systems resulting in 14 transects. Figure 11A shows the tracks of the vessels and the locations of the fishery samples.
- Twenty length-frequency and six detailed samples were processed giving a mean size of 26.7 cm and a mean weight of 154 g (Figure 11B).
- Maturity analyses showed that 75% of the fish were Stage 5 “maturing” condition and 5% of the fish were in the Stage 6 “ripe and running” condition (Figure 3B).
- The initial analysis resulted in a biomass of 37,770 t for the survey area of 721 km² using the standard TS.
- The biomass value was adjusted to 41,094 t after edits to the files and using sample generated TS.

Scots Bay Acoustic Survey #3: July 16, 2016

- This survey was conducted by nine acoustic survey vessels. Seven boats conducted two transects each within the pre-determined survey box while one vessel did four shorter transects in the upper eastern part of Scots Bay. Another boat did four shorter transects to the north of the survey box. The vessels conducted a broad scale systematic parallel transect survey.
- Figure 12A shows the tracks of the vessels and the location of the fishery samples. Ten length-frequency and four detailed samples plus four samples from the CCGS *Alfred Needler* survey were used to generate the TS giving a mean size of 26.6 cm and a mean weight of 153 g (Figure 12B).
- Maturity analyses showed that 85% of the fish were Stage 5 “maturing” condition and 5% of the fish were in the Stage 6 “ripe and running” condition (Figure 3B).
- The initial analysis resulted in a biomass of 10,015 t for the survey area of 860 km² using the standard TS.
- The biomass value was adjusted to 9,423 t after edits to the files and using the sample generated TS.

Scots Bay Acoustic Survey #4: July 30, 2016

- This survey was conducted by nine acoustic survey vessels. Seven boats conducted two transects each within the pre-determined survey box, while one vessel did four shorter transects in the upper eastern part of Scots Bay. Another boat did four shorter transects to the north of the survey box. The vessels conducted a broad scale systematic parallel transect survey.
- Figure 13A shows the tracks of the vessels and the locations of the fishery samples. Twenty length-frequency and five detailed samples were used to generate the TS giving a mean size of 27.2 cm and a mean weight of 171 g (Figure 13B).
- Maturity analyses showed that 80% of the fish were Stage 5 “maturing” condition and 10% of the fish were in the Stage 6 “ripe and running” condition (Figure 3B).
- The initial analysis resulted in a biomass of 11,103 t using the standard TS for the survey area of 855 km^2.
- The biomass was adjusted to 11,165 t after edits to the files and using the samples to generate the TS.

Scots Bay Acoustic Survey #5: August 13, 2016

- This survey was conducted by eight acoustic survey vessels. Six boats conducted two transects each within the pre-determined survey box, while one vessel did four shorter transects in the upper eastern part of Scots Bay. Another boat did four shorter transects to the north of the survey box. The vessels conducted a broad scale systematic parallel transect survey.
- Figure 14A shows the tracks of the vessels and the locations of the fishery samples. Sixteen length-frequency and three detailed samples were used to generate the TS giving a mean size of 27.6 cm and a mean weight of 176 g (Figure 13B).
- Maturity analyses showed that 80% of the fish were Stage 5 “maturing” condition and 11% of the fish were in the Stage 6 “ripe and running” condition (Figure 3B).
- The initial analysis resulted in a biomass of 26,750 t using the standard TS for the survey area of 855 km^2.
- The biomass was adjusted to 26,097 t after edits to the files and using the detailed samples to generate the TS.

Scots Bay Acoustic Survey #6: August 27, 2016

- Six acoustic survey vessels participated, resulting with twelve transects within the survey box. Figure 15 shows the tracks of the vessels, but there were no fishery samples collected close to the survey date.
- The initial biomass estimate of 3,127 t over a survey area of 623 km^2 using the standard TS was adjusted to 3,047 t after edits to the files with the same standard TS since there were no samples.

2016 Scots Bay Acoustic Surveys Summary

The six structured surveys used in the biomass estimate were conducted between June 18 and August 27, 2016. There was sufficient biological sampling from the first five surveys to calculate the TS for use in estimating the total biomass. There were no samples collected close to the sixth survey, so the standard TS was used to estimate the biomass. The 2016 Scots Bay acoustic survey total SSB estimate from the six structured surveys within the survey box area (inbox) was 110,002 t. The total biomass estimate for areas surveyed outside of the standard survey box in the Scots Bay area was 5,667 t. The final 2016 Scots Bay acoustic survey estimate for all areas was 115,669 t (Table 4B).

2017 Scots Bay Acoustic Surveys

Eight structured surveys were conducted between June 21 and September 23 during the 2017 spawning season in Scots Bay (Table 2C). The surveys were separated by a minimum of 10 days and covered the survey area.

Scots Bay Acoustic Survey #1: June 21, 2017

- This survey was conducted by six vessels all with acoustic systems. The survey was planned for June 17th but was delayed due to poor weather conditions.
- The vessel *Margaret Elizabeth* conducted one plankton tow and two CTD casts after the survey. Figure 16A shows the tracks of the vessels and Herring sample locations.
- Fourteen length-frequency and four detailed samples were processed giving a mean size of 26.7 cm and a mean weight of 139 g (Figure 16B).
- Maturity analyses showed that 58.3% of the fish were Stage 5 "maturing" condition and 27.9% of the fish were in the Stage 6 "ripe and running" condition (Figure 3C).
- The initial analysis resulted in a biomass of 88,744 t for the survey area of 626.8 km² using the standard TS.
- The biomass value was adjusted to 75,364 t after edits to the files and using sample generated TS.

Scots Bay Acoustic Survey #2: July 1, 2017

- This survey was conducted by seven acoustic survey vessels. Six vessels conducted two transects each within the pre-determined survey box, while one vessel conducted four shorter transects to the north of the survey box. The vessels conducted a broad scale systematic parallel transect survey.
- Figure 17A shows the tracks of the vessels and the locations of the fishery samples. Eleven, length-frequency and five detailed samples were processed giving a mean size of 28.0 cm and a mean weight of 170 g (Figure 17B).
- Maturity analyses showed that 78% of the fish were Stage 5 "maturing" condition and 7% of the fish were in the Stage 6 "ripe and running" condition (Figure 3C).
- The initial analysis resulted in a biomass of 28,117 t for the survey area of 744 km² using the standard TS.
- The biomass value was adjusted to 26,669 t after edits to the files and using sample generated TS.

Scots Bay Acoustic Survey #3: July 15, 2017

- This survey was conducted by eight acoustic survey vessels. Seven vessels conducted two transects each within the pre-determined survey box, while one vessel did four shorter transects in the upper eastern part of Scots Bay. Another vessel conducted four shorter transects to the north of the survey box.
- Figure 18 shows the tracks of the vessels, but there were no fishery samples collected close to the survey date.
- The vessel *Margaret Elizabeth* conducted one plankton tow after the survey.
- The initial analysis resulted in a biomass of 24,981 t for the survey area of 858 km² using the standard TS.
- The biomass value was adjusted to 24,731 t after edits to the files and using the same standard TS since there were no samples.

Scots Bay Acoustic Survey #4: July 29, 2017

- This survey was conducted by seven acoustic survey vessels. Six vessels conducted two transects each within the pre-determined survey box, while one vessel did four shorter transects to the north of the survey box. The vessels conducted a broad scale systematic parallel transect survey.

- The vessel *Margaret Elizabeth* conducted one plankton tow and two CTD casts after the survey.
- Figure 19A shows the tracks of the vessels and the locations of the fishery samples. Nineteen length-frequency and four detailed samples were used to generate the TS giving a mean size of 27.2 cm and a mean weight of 155 g (Figure 19B).
- Maturity analyses showed that 76% of the fish were Stage 5 “maturing” condition and 9% of the fish were in the Stage 6 “ripe and running” condition (Figure 3C).
- The initial analysis resulted in a biomass of 6,889 t using the standard TS for the survey area of 739 km².
- The biomass was adjusted to 6,270 t after edits to the files and using the samples to generate the TS.

Scots Bay Acoustic Survey #5: August 12, 2017

- This survey was conducted by seven acoustic survey vessels. Six vessels conducted two transects each within the pre-determined survey box, while one vessel did four shorter transects to the north of the survey box. The vessels conducted a broad scale systematic parallel transect survey.
- Figure 20A shows the tracks of the vessels and the locations of the fishery samples.
- The vessel *Margaret Elizabeth* conducted one plankton tow and one CTD cast after the survey.
- Twenty-two length-frequency and five detailed samples were used to generate the TS giving a mean size of 25.9 cm and a mean weight of 128 g (Figure 20B).
- Maturity analyses showed that 72% of the fish were Stage 5 “maturing” condition and 5% of the fish were in the Stage 6 “ripe and running” condition (Figure 3C).
- The initial analysis resulted in a biomass of 21,597 t using the standard TS for the survey area of 729.7 km².
- The biomass was adjusted to 17,958 t after edits to the files and using the detailed samples to generate the TS.

Scots Bay Acoustic Survey #6: August 26, 2017

- This survey was conducted by eight acoustic survey vessels. Six vessles conducted two transects each within the pre-determined survey box, while one vessel did four shorter transects in the upper eastern part of Scots Bay. Another vessel conducted four shorter transects to the north of the survey box. The vessels conducted a broad scale systematic parallel transect survey.
- The vessel *Margaret Elizabeth* conducted one plankton tow after the survey.
- Figure 21A shows the tracks of the vessels and the locations of the fishery samples. Twenty-two length-frequency and three detailed samples were used to generate the TS giving a mean size of 26.2 cm and a mean weight of 135 g (Figure 21B).
- Maturity analyses showed that 58% of the fish were Stage 5 “maturing” condition and 29% of the fish were in the Stage 6 “ripe and running” condition (Figure 3C).
- The initial analysis resulted in a biomass of 13,854 t using the standard TS for the survey area of 854.3 km².
- The biomass was adjusted to 11,923 t after edits to the files and using the detailed samples to generate the TS.

Scots Bay Acoustic Survey #7: September 8, 2017

- Three acoustic survey vessels participated resulting with six transects within the survey box. Figure 22A shows the tracks of the vessels and the locations of the fishery samples.

- The vessel *Margaret Elizabeth* conducted one plankton tow after the survey.
- Six length-frequency and only one detailed sample was available to generate the TS giving a mean length of 25.4 cm and a mean weight of 117 g (Figure 22B).
- Maturity analyses showed that 67% of the fish were Stage 5 “maturing” condition and 3% of the fish were in the Stage 6 “ripe and running” condition (Figure 3C).
- The initial analysis resulted in a biomass of 10,356 t using the standard TS for the survey area of 346 km².
- The biomass was adjusted to 8,188 t after edits to the files and using the detailed sample to generate the TS.

Scots Bay Acoustic Survey #8: September 23, 2017

- Three acoustic survey vessels participated resulting with six transects within the survey box. Figure 23A shows the tracks of the vessels and the locations of the fishery samples.
- Twelve length-frequency and two detailed samples were available to generate the TS giving a mean length of 25.5 cm and a mean weight of 122 g (Figure 23B). Nearly 9% of fish in these samples were less than 23 cm.
- Maturity analyses showed that 66% of the fish were Stage 5 “maturing” condition and 0% of the fish were in the Stage 6 “ripe and running” condition (Figure 3C).
- The initial analysis resulted in a biomass of 2,137 t using the standard TS for the survey area of 343 km².
- The biomass was adjusted to 1,751 t after edits to the files and using the detailed samples to generate the TS.

2017 Scots Bay Acoustic Surveys Summary

The eight structured surveys used in the biomass estimate were conducted between June 21 and September 23, 2017. There was sufficient biological from all surveys with the exception of survey #3 on July 15, when no sampling occurred. The remaining surveys all had sufficient samples to generate a TS for use in estimating the total biomass. The standard TS was used to estimate the biomass when there was no sampling. The 2017 Scots Bay acoustic survey total SSB estimate from the eight structured surveys within the survey box area (inbox) was 160,330 t. The total biomass estimate for areas surveyed outside of the standard survey box in the Scots Bay area was 12,525 t. The final 2017 Scots Bay acoustic survey estimate for all areas was 172,855 t (Table 4C).

German Bank

The German Bank Herring purse seine fishery has been a major component of the summer fishery with catches since 1985, ranging from 3,000 t to 30,000 t during the overall fishery period of early May to late October. As in the recent years, catches of spawning Herring were occurring in localized groups seen in both the northern and southern portions of the standard survey area on German Bank.

In 2015, five valid (plus three) surveys covering the survey box on German Bank occurred between August 17 and October 12 (Table 2A). Three surveys were excluded from the biomass totals because they were within 10 days of a previous survey. The time interval between surveys ranged from 6 to 15 days (Table 2A). Five acoustic surveys were conducted on German Bank during the 2016 season between August 21 and October 7 (Table 2B). One additional survey also occurred on September 19 and was excluded from the biomass totals because it occurred within 10 days of another survey. The time interval between surveys ranged from 7 to 15 days (Table 2B). In 2017, four valid (plus two) surveys covering the survey box on German Bank occurred between August 21 and October 18 (Table 2C). The two excluded surveys were within 10 days of a previous survey and not included in the biomass estimates. The time interval between surveys ranged from 5 to 18 days (Table 2C). The September 17 survey was initially excluded because it was 9 days after the previous one; however, this resulted in a 28-day gap before the next acceptable survey. Subsequently, at the assessment meeting, it was decided that the September 17 survey was an exceptional case and the turnover estimate method proposed by Melvin et al. (2020) was applied to the biomass estimate so it could be included in the total biomass estimate for German Bank. The turnover biomass numbers are not reported in this document; however, the September 17 biomass was added to the 2017 estimates for German Bank.

In all 3 reporting years, fish samples for maturity indicated that mature spawning Herring (Stages 5-6) dominated samples collected (Figures 24A, 24B, and 24C). There were a few samples (for example, 10 August, 2016; 17 August, 2017) in which there were immature Herring (stages 1 and 2) present, but the majority of the samples had mature Herring. It is recognized that German Bank is both a feeding and spawning area and a mixture of juvenile and adult fish are available on the grounds on some occasions. Detail acoustic data analyses from each survey are published in a separate Data Report (Singh et al. 2019).

2015 German Bank Acoustic Surveys

Five structured surveys were conducted between August 17 and October 12 during the 2015 spawning season on German Bank (Table 3A). The surveys were separated by a minimum of 12 days and covered the survey area. Three additional "mini" surveys conducted on September 10, September 21 and October 5 were excluded from the biomass total because they were within 10 days of a previous survey.

German Bank Acoustic Survey #1: August 17, 2015

- Eight acoustic survey vessels participated in this survey resulting in 16 transects within the survey box. Figure 26A shows the tracks of the vessels and the locations of the fishery samples.
- Twenty length-frequency and three detailed samples were collected near the August 17 acoustic survey with a mean length of 28.4 cm and a mean weight of 190 g (Figure 26B) for calculation of the TS.
- Maturity analyses showed that 72% of the fish were Stage 5 "maturing" condition and 9% of the fish were in the Stage 6 "ripe and running" condition (Figure 24A).
- The initial estimate using the standard TS was 19,101 t for the entire survey area of 843 km². The final estimate was adjusted to 16,156 t after edits to the files and using sample generated TS.

German Bank Acoustic Survey #2: September 1, 2015

- This survey was conducted by seven acoustic vessels completing 14 transects. Figure 27A shows the tracks of the vessels and the locations of the fishery samples.
- There were 25 length-frequency samples available for this survey and three detailed samples giving a mean length of 27.8 cm and a mean weight of 172 g (Figure 27B).
- Maturity analyses showed that 80% of the fish were Stage 5 "maturing" condition and 13% of the fish were in the Stage 6 "ripe and running" condition (Figure 27B).
- Initial analysis resulted in an estimate of 72,641 t biomass for the entire survey area of 805 km² using standard TS.
- Analysis following edits and using the sample generated TS resulted in a total biomass of 64,219 t within the area surveyed.

German Bank "mini" Acoustic Survey #2a: September 10, 2015

- This "mini" survey was conducted by six acoustic vessels in the mid-northern area of the survey box covering only a small portion of the box.

- The initial estimate using the standard TS was 32,337 t over a survey area of 107 km^2. However, because this survey was conducted too close to the date of the next survey on September 13, it was excluded from the total biomass estimate for German Bank.

German Bank Acoustic Survey #3: September 13, 2015

- Seven acoustic survey vessels participated in this survey with 14 transects within the survey box. Figure 28A shows the tracks of the vessels and the locations of the fishery samples.
- Sixteen length frequencies and three detailed samples taken on September 14 and 15 were used to generate the TS with a mean length of 27.9 cm and a mean weight of 175 g (Figure 28B).
- Maturity analyses showed that 68% of the fish were Stage 5 “maturing” condition and 30% of the fish were in the Stage 6 “ripe and running” condition (Figure 24A).
- The initial estimate using the standard TS was 58,434 t for the entire survey area of 816 km². The final estimate was adjusted to 52,782 t after edits to the files and using sample generated TS.

German Bank Acoustic Survey #4: September 21, 2015

- Six acoustic survey vessels participated in this survey completing 12 transects within the survey box.
- The initial estimate using the standard TS was 19,650 t over a survey area of 814 km². However, because this survey was conducted too close to the date of the next survey on September 27, it was excluded from the total biomass estimate for German Bank.

German Bank Acoustic Survey #5: September 27, 2015

- Seven acoustic survey vessels participated in this survey completing 14 transects within the survey box. Figure 29A shows the tracks of the vessels.
- Since there were no available detail samples close to the survey date samples from September 14, 15, 18, 21 and 28, were utilized. The samples were used to generate the TS with a mean length of 26.7 cm and mean weight of 151 g (Figure 29B).
- Maturity analyses indicated that 68% of the fish were Stage 5 “maturing” condition and 30% of the fish were in the Stage 6 “ripe and running” condition (Figure 24A).
- The initial biomass estimate of 42,548 t using the standard TS for the entire survey area of 645 km². The final estimate was adjusted to 39,242 t after edits to the files using sample generated TS.

German Bank Acoustic Survey #6: October 5, 2015

- Six acoustic survey vessels participated in this survey completing 12 transects within the survey box. Figure 30A shows the tracks of the vessels and the locations of the fishery samples.
- Three length frequencies and one detailed samples taken on October 6 were used to generate the TS with a mean length of 26.8 cm and a mean weight of 148 g (Figure 30B).
- Maturity analyses indicated that 75% of the fish were Stage 5 “maturing” condition and 20% of the fish were in the Stage 6 “ripe and running” condition (Figure 24A).
- The initial estimate using the standard TS was 34,423 t over a survey area of 663 km². However, because this survey was conducted too close to the date of the previous one on September 27, it was excluded from the total biomass estimate for German Bank.

German Bank Acoustic Survey #7: October 12, 2015

- This survey was conducted by seven vessels all with acoustic systems. The acoustic recorder on the vessel *Lady Janice* was not turned on for the first transect, thus only one transect was recorded for this vessel.

- Figure 31 shows the tracks of the vessels, but there was no sampling close to the survey date.
- The initial analysis resulted in a biomass of 3,728 t for the survey area of 714 km² using the standard TS.
- The biomass value was adjusted to 3,990 t after edits to the files and using standard TS since there were no detail samples available close to the survey date.

2015 German Bank Acoustic Surveys Summary

Five structured surveys conducted between August 17 and October 12 were used to determine a spawning biomass estimate of 176,389 t within the survey box. The September 10, 21, and October 5 surveys were not included in the 2015 German Bank biomass estimates as there was an insufficient interval between survey dates.

<u>2016 German Bank Acoustic Surveys</u>

Six structured surveys were conducted between August 21 and October 7 during the 2016 spawning season on German Bank (Table 2B). The surveys were separated by a minimum of 11 days with the exception of survey #4, September 19, which was only seven days after the September 12 survey, and therefore, was not included in the overall biomass estimate.

German Bank Acoustic Survey #1: August 21, 2016

- Seven acoustic survey vessels participated in this survey completing 13 transects within the survey box. The *Lady Janice* was only able to conduct one transect because there was a problem with the auto pilot. Figure 32A shows the tracks of the vessels and the location of the fishery samples.
- Twelve length-frequency and four detailed samples were used to generate the TS with a mean length of 27.6 cm and a mean weight of 168 g (Figure 32B).
- Maturity analyses showed that 82% of the fish were Stage 5 “maturing” condition and 7% of the fish were in the Stage 6 “ripe and running” condition (Figure 24B).
- The initial analysis resulted in a biomass of 37,201 t using the standard TS for the survey area of 650 km².
- The biomass was adjusted to 35,565 t after edits to the files and using the sample generated TS.

German Bank Acoustic Survey #2: September 1, 2016

- This survey was conducted by six acoustic vessels completing 12 transects within the survey box. An additional east-west transect was run across the “tow area” (mid survey box) by each vessel. Figure 33A shows the tracks of the vessels and the locations of the fishery samples.
- Main box transects that intercepted the tow area were cut out and biomass was calculated by adding the result of the tow area (48 km²) to that of the main box with the cut outs (779 km²).
- There were eight length-frequency and two detail fishery samples available for September 1, survey giving a mean length of 27.5 cm and a mean weight of 166 g (Figure 33B).
- Maturity analyses showed that 89% of the fish were Stage 5 “maturing” condition and 3% of the fish were in the Stage 6 “ripe and running” condition (Figure 24B).
- Initial analysis resulted in an estimate of 28,170 t biomass for the entire survey area using standard TS.
- Analysis following edits and sample TS resulted in a total biomass of 26,914 t within the area surveyed.

German Bank Acoustic Survey #3: September 12, 2016

- This survey was conducted by eight acoustic vessels, but the *Tasha Marie* had problems with the acoustic recording and no analysis was completed for this boat.
- An additional east-west line was run across the "tow area" (mid survey box) by each vessel. Figure 34A shows the tracks of the vessels and the locations of the fishery samples.
- Main box transects that intercepted the tow area were cut out and biomass was calculated by adding the result of the tow area to that of the main box with the cut outs.
- There were fourteen length-frequency and two detail fishery samples available for this survey giving a mean length of 27.7 cm and a mean weight of 167 g (Figure 34B).
- Maturity analyses showed that 90% of the fish were Stage 5 "maturing" condition and 8% of the fish were in the Stage 6 "ripe and running" condition (Figure 24B).
- Initial analysis resulted in an estimate of 121,037 t biomass for the entire survey area using standard TS.
- The biomass was adjusted to 90,104 t after edits to the files and using the sample generated TS.

German Bank Acoustic Survey #4: September 19, 2016

- This survey was conducted by seven acoustic vessels completing 14 transects within the survey box. However, because this survey was conducted too close to the date of the previous one done on September 12, it was excluded from the total biomass estimate for German Bank.
- An additional east-west line was run across the "tow area" (mid survey box) by each vessel; however this tow box area was not included in the biomass estimate. Figure 35A shows the tracks of the vessels and the locations of the fishery samples.
- There were nine length-frequency and two detail fishery samples available for September 19, survey giving a mean length of 25.9 cm and a mean weight of 131 g (Figure 35B).
- Maturity analyses showed that 79% of the fish were Stage 5 "maturing" condition and 7% of the fish were in the Stage 6 "ripe and running" condition (Figure 24B).
- Initial analysis resulted in an estimate of 13,774 t biomass for the entire survey area using standard TS.
- The biomass was adjusted to 15,396 t after edits to the files and using the sample generated TS.

German Bank Acoustic Survey #5: September 26, 2016

- Seven acoustic survey vessels participated in this survey completing 14 transects within the survey box. Figure 36A shows the tracks of the vessels and the locations of the fishery length-frequency samples.
- Length-frequency samples gave a mean length of 26.7 cm; however, no detail samples were available close to the survey date to obtain a mean weight.
- The initial analysis resulted in a biomass of 55,287 t using the standard TS for the survey area of 701 km^2.
- The biomass was adjusted to 48,906 t after edits to the files using the standard TS as there were no detail samples collected close to the survey date.

German Bank Acoustic Survey #6: October 7, 2016

- Seven acoustic survey vessels participated in this survey completing 14 transects within the survey box.
- However, the *Leroy and Barry* conducted the same two transects as the *Silver Harvester* instead of the planned transects. With two vessels completing the same two transects, the vessel with the greatest biomass for that transect was used in the analysis. In this case, the

Leroy and Barry observed the greater biomass than the *Silver Harvester* for both transects, thus the *Silver Harvester* results were dropped.
- Figure 37 shows the tracks of the vessels, but no biological samples were available close to the survey date.
- The initial analysis resulted in a biomass of 10,455 t using the standard TS for the survey area of 727 km².
- The biomass was adjusted to 10,589 t after edits to the files using the standard TS as there were no samples collected close to the survey date.

2016 German Bank Acoustic Surveys Summary

In 2016, six structured surveys conducted between August 21 and October 7. One survey, conducted on September 19 was excluded from the overall biomass estimate as the interval between survey dates was insufficient. Two of the surveys included “mini surveys” within the survey box where higher biomass was noted and designated as “Tow-Box” areas. The biomass from these areas was included with the total biomass, after the biomass from that area was removed from the large survey box results. This provided a total spawning stock biomass estimate for German Bank of 212,078 t within the survey box for 2016.

2017 German Bank Acoustic Surveys

Six structured surveys were conducted between August 21 and October 18 during the 2017 spawning season in German Bank (Table 2C). Two surveys (September 17 and October 1) were excluded from the total estimate because there were less than 10 days separating them from another survey. As noted earlier, at the assessment meeting, it was decided that the September 17 survey was an exceptional case and the turnover estimate method proposed by Melvin et al. (2020) was applied to the biomass estimate so it could be included in the total biomass estimate for German Bank.

German Bank Acoustic Survey #1: August 21, 2017

- Nine acoustic survey vessels participated in this survey completing 18 transects within the survey area. Figure 38A shows the tracks of the vessels and the locations of the fishery samples.
- Start time was 20:30; however, the *Lady Janice* was 20 minutes late and the *Canada 100* was one hour late. Several of the vessels were surveying at speeds greater than the 8 knot protocol.
- One plankton tow and CTD cast were conducted from the *Lady Melissa* before the survey. The cod-end of the plankton net was overflowing with ctenophores.
- There were nineteen length-frequency and seven detail fishery samples available for August 21, survey giving a mean length of 26.2 cm and a mean weight of 132 g (Figure 38B). Juvenile Herring (< 23 cm) were present during this survey consisting up to 8.5% of the samples (Figures 24C, 25C, and 38B).
- Maturity analyses showed that 41% of the fish were Stage 5 “maturing” condition and 0% of the fish were in the Stage 6 “ripe and running” condition (Figure 24C).
- Initial analysis resulted in an estimate of 44,233 t biomass for a survey area of 820 km² using standard TS.
- The biomass was adjusted to 33,893 t after edits to the files and using the sample generated TS.

German Bank Acoustic Survey #2: September 8, 2017

- Eight acoustic survey vessels participated in this survey completing 16 transects within the survey area. The survey was planned for September 3, but was delayed 5 days due to severe winds. Figure 39A shows the tracks of the vessels and the locations of the fishery samples.

- One plankton tow and CTD cast were conducted from the *Lady Melissa* before the survey; however, upon recovery, it was discovered that the plankton net had been ripped completely down one side, resulting in a very small sample.
- There were twelve length-frequency and six detail fishery samples available for this survey giving a mean length of 26.4 cm and a mean weight of 133 g (Figure 39B).
- Maturity analyses showed that 60% of the fish were Stage 5 “maturing” condition and 9% of the fish were in the Stage 6 “ripe and running” condition (Figure 24C).
- Initial analysis resulted in an estimate of 84,439 t biomass for a survey area of 831 km² using standard TS.
- The biomass was adjusted to 65,393 t after edits to the files and using the sample generated TS.

German Bank Acoustic Survey #3: September 17, 2017

- Eight acoustic survey vessels participated in this survey completing 16 transects within the survey area. Figure 40A shows the tracks of the vessels and the locations of the fishery samples.
- The survey was planned for September 18, but due to impending weather forecasts of high winds into the following week, it was decided to get the survey in before the poor weather arrived.
- One plankton tow and CTD cast were conducted from the *Lady Melissa* before the survey.
- There were fourteen length-frequency and three detail fishery samples available for this survey giving a mean length of 25.9 cm and a mean weight of 125 g (Figure 40B).
- Maturity analyses showed that 64% of the fish were Stage 5 “maturing” condition and 10% of the fish were in the Stage 6 “ripe and running” condition (Figure 24C).
- Initial analysis resulted in an estimate of 82,359 t biomass for a survey area of 841 km², using standard TS.
- The biomass was adjusted to 62,935 t after edits to the files and using the sample generated TS.
- This survey was initially excluded from the biomass estimate as the survey interval was less than ten days; however, see 2017 German Bank summary.

German Bank Acoustic Survey #4: October 1, 2017

- Seven acoustic survey vessels participated in this survey completing 14 transects within the survey box. Figure 41 shows the tracks of the vessels but no biological samples were available close to the survey date.
- Due to poor weather conditions experienced during the second transect, no fishing occurred after the survey, thus no samples were taken.
- One plankton tow and CTD cast were conducted from the *Lady Melissa* before the survey.
- The initial analysis resulted in a biomass of 3,457 t using the standard TS for the survey area of 713 km².
- The biomass was adjusted to 3,014 t after edits to the files using the standard TS.
- This survey was excluded from the biomass estimate and the survey conducted on October 6th used instead.

German Bank Acoustic Survey #5: October 6, 2017

- Six acoustic survey vessels participated in this survey completing 11 transects within the survey area. The *Leroy and Barry* recorded one transect only. Figure 42A shows the tracks of the vessels and the locations of the fishery samples.
- There were four length-frequency and one detail fishery sample available for the October 6th survey giving a mean length of 28.8 cm and a mean weight of 166 g (Figure 42B).

- Maturity analyses showed that 36% of the fish were Stage 5 “maturing” condition and 0% of the fish were in the Stage 6 “ripe and running” condition (Figure 24C). However, there appear to be all adult fish with no juveniles recored in the samples.
- Initial analysis resulted in an estimate of 6,144 t biomass for a survey area of 822 km² using standard TS.
- The biomass was adjusted to 5,386 t after edits to the files and using the sample generated TS.

German Bank Acoustic Survey #6: October 18, 2017

- Six acoustic survey vessels participated in this survey completing 12 transects within the survey box. Figure 43 shows the tracks of the vessels but no biological samples were available close to the survey date.
- Due to poor weather conditions, no fishing occurred after the survey, thus no samples were taken.
- One plankton tow along with temperature and salinity were recorded, but no CTD cast was done due to instability on deck.
- The initial analysis resulted in a biomass of 32,742 t using the standard TS for the survey area of 830 km².
- The biomass was adjusted to 30,396 t after edits to the files using the standard TS.

2017 German Bank Acoustic Surveys Summary

In 2017, six structured surveys conducted between August 21 and October 18. Two surveys were excluded from the biomass estimates due to insufficient number of days between dates with other surveys. The 2017 surveys were plagued by unfortunate weather and resulted in irregular survey intervals. The exclusion of the September 17 and October 1 survey resulted in a gap of 28 days with no survey. As noted earlier, at the assessment meeting, it was decided that the September 17 survey was an exceptional case and it was included in the total biomass estimate for German Bank. The total spawning stock biomass for 2017 including the September 17 survey was 197,949 t.

Trinity Ledge

As pointed out in Power et al. (2007), acoustic surveys of spawning Herring on Trinity Ledge has been less than optimal, and it is unlikely that biomass estimates accurately reflect the abundance of fish in the area. Additionally, a major source of uncertainty in the total biomass estimate continues to be the assumption that the surveys are simply additive and a reduced biomass could be a reduced effort in surveying.

Maturity samples taken from the purse seine fishery outside the Trinity Ledge survey box indicated that there were mostly immature fish present during September in 2015 and 2016 (Figures 44A and 44B). In 2017, there were, mostly mature Stages 5 “maturing/hard” fish present, however, samples from August 28 and September 19 were composed of predominantly of Stage 1 and 2 “immature” fish (Figure 44C). In general, the length-frequency samples (Figures 45A, 45B, 45C, and 45D) are aligned with the maturity samples.

Trinity Ledge has been closed to fishing since 2015 and no catches have been reported from the gillnet fleet in the area during the reporting years 2015–2017 (Table 6). In 2015, the total overall survey biomass estimate was 657 t from one of the two surveys conducted on September 4 (49 t; see Figure 46A for transects; excluded from biomass estimate) and September 11 (657 t; see Figure 46B for transects). No multipanel samples were collected in 2015. In 2016, the total overall survey biomass estimate was 506 t from three acoustic surveys completed on August 12 (6 t; see Figure 47A for transects), August 29 (395 t; see Figure 47B for transects) and September 13 (105 t; see Figure 47C for transects). No multi-panel sample was collected in 2016. In 2017, the total overall survey biomass estimate was 13,866 t from four acoustic surveys completed on Trinity Ledge between August 12 and September 8, along with three multipanel samples. Surveys were completed on August 12 (547 t; see Figure 48 for transects; no samples), August 22 (401 t; see Figure 49A for transects, 49B for length-frequency), August 29 (8,513 t; see Figure 50A for transects, 50B for length-frequency), and September 8 (4,405 t; see Figures 51A for transects, 51B for length-frequency). All surveys were accepted because they were conducted in different areas and not on the same schools.

Tables 7A, 7B and 7C show details of the biomass estimates for the survey transects conducted in 2015, 2016, and 2017, respectively. Figure 53 shows the catches and the survey biomass estimates from 1998 to 2017 for Trinity Ledge. Detail acoustic data analyses from each survey are published in a separate Data Report (Singh et al. 2019).

2015 Trinity Ledge Acoustic Surveys

In 2015, there were two surveys on Trinity Ledge, one on September 4 and one on September 11. No multi-panel sample was collected.

Trinity Ledge Acoustic Survey #1: September 4, 2015

- One acoustic vessel, the *Kayla and Katrina*, completed this survey (Figure 46A). The survey was not considered optimal since the survey protocol was not followed. The vessel did not perform a grid survey; however, there were four somewhat parallel lines over one aggregation covering an area of 1.41 km². The initial biomass estimate was 49 t using the standard TS.
- Since no samples were available and this survey was followed 7 days later by another survey, no further analysis was done on the data. This survey was excluded from the final biomass estimates for Trinity Ledge.

Trinity Ledge Acoustic Survey #2: September 11, 2015

- One acoustic vessel, the *Kayla and Katrina*, completed this survey (Figure 46B). The survey was not considered optimal since the survey protocol was not followed. There were four parallel lines over one aggregation.
- An estimated biomass of 651 t using the standard TS was obtained. After review and edits the biomass was adjusted to 657 t using the standard TS since there was no multi-panel samples taken.

2016 Trinity Ledge Acoustic Surveys

In 2016, there were three acoustic surveys completed on Trinity Ledge, one on August 12, one on August 29 and the other on September 13. No multi-panel sample was collected.

Trinity Ledge Acoustic Survey #1: August 12, 2016

- One acoustic vessel, the *Kayla and Katrina*, completed this survey (Figure 47A). There were nine parallel lines over one aggregation covering an area of 0.84 km².
- The initial biomass estimate was 5 t using the standard TS. After edits to the files and using the standard TS the biomass was estimated to be 6 t.
- Since there were no multipanel samples, no TS adjustment to the biomass was possible.

Trinity Ledge Acoustic Survey #2: August 29, 2016

- This survey was conducted by one acoustic vessel, the *Kayla and Katrina* (Figure 47B).The vessel attempted to conducted parallel transect survey but the lines were poor, not parallel, and not evenly spaced.
- The initial biomass estimate was 445 t using the standard TS and covering an area of 0.56 km². Since surveys lines were poor, transects were further cut to avoid overlap and one

transect was dropped because it was too close another one. The resulting six transects covered an area of 0.52 km².

- After edits to the files and using the standard TS, the biomass was estimated to be 395 t.

Trinity Ledge Acoustic Survey #3: September 13, 2016

- This survey was conducted by one acoustic vessel, the *Kayla and Katrina* (Figure 47C).The vessel attempted to conduct a fine-scale systematic parallel transect survey. This survey could have been improved since the transects were not equally spaced and did not cover one end of the school to the other.
- The initial biomass estimate was 109 t using the standard TS on six transects covering an area of 0.49 km². After edits to the files and using the standard TS, the biomass was estimated to be 105 t.

2017 Trinity Ledge Acoustic Surveys

In 2017, there were four acoustic surveys completed on Trinity Ledge between August 12 and September 8. No multi-panel sample was collected for the first survey, but samples were collected for each of the last three surveys.

Trinity Ledge Acoustic Survey #1: August 12, 2017

- One acoustic vessel, the *Double Don*, completed this survey (Figure 48). The vessel conducted a fine-scale systematic parallel transect survey on three aggregations. The transects were poor, not evenly spaced, and did not cover the schools from end to end.
- Instead of the three areas initially created, five were used to generate separate estimates of five areas based on the layout of the transects.
- No multipanel sample was collected and, as a result, the standard TS was used. The initial biomass estimate was 451 t using the standard TS covering an area of 6.21 km².
- After edits to the files and using the standard TS, the biomass was estimated to be 547 t covering an area of 5.77 km² (Table 7C).

Trinity Ledge Acoustic Survey #2: August 22, 2017

- This survey was conducted by one acoustic vessel, the *Double Don*, on one dispersed aggregation (Figure 49A).
- The vessel attempted to conduct a parallel transect survey on a dispersed aggregation but the transects were poor, not parallel, and not evenly spaced.
- The initial biomass estimate was 473 t using the standard TS and covering an area of 1.79 km². Since survey transects were poor, there were some minor transect cuts to avoid overlap.
- One multi-panel gillnet sample was collected within the survey area by the *Double Don* on August 22. Maturity analyses showed that 80% of the fish were Stage 5 “maturing” condition and 8% of the fish were in the Stage 6 “ripe and running” condition (Figure 44C).
- The resulting sample generated TS with a weighted mean length of 25.6 cm and a mean weight of 128 g (Figure 49B) was used to estimate the biomass,
- After minor edits and using the sample generated TS, the biomass was estimated to be 401 t (Table 7C).

Trinity Ledge Acoustic Survey #3: August 29, 2017

- This survey was conducted by one acoustic vessel, the *Double Don,* on one aggregation (Figure 50A).
- The vessel conducted a fine-scale systematic parallel transect survey. Transects were satisfactory, except that the vessel started in the center of the school, did one side, and then the other. Without a confirmation transect down the center of the school, it is impossible to

know if the school was moving. For analytical purposes, it was assumed that the school was not moving.
- One multi-panel gillnet sample was collected within the survey area by the *Double Don* on August 30. Maturity analyses showed that 91% of the fish were Stage 5 “maturing” condition and 2% of the fish were in the Stage 6 “ripe and running” condition (Figure 44C).
- The resulting sample generated TS with a weighted mean length 26.1 cm and a mean weight of 138 g (Figure 50B) was used to estimate the biomass.
- The initial biomass estimate was 9,624 t using the standard TS and covering an area of 12.94 km².
- After minor edits to the files and using the sample generated TS, the biomass was estimated to be 8,513 t (Table 7C).

Trinity Ledge Acoustic Survey #4: September 8, 2017

- This survey was conducted by one acoustic vessel, the *Double Don,* on one aggregation (Figure 51A).
- The vessel conducted a fine-scale systematic parallel transect survey. Transects were satisfactory, except that the vessel started in the center of the school, did one side and then the other. Without a confirmation transect down the center of the school, it is impossible to know if the school was moving. For analytical purposes, it was assumed that the school was not moving.
- Some shorter transects that indicated fish were present were not usable. A doubling of the biomass estimate may have been possible, had the survey protocol been more closely followed.
- One multi-panel gillnet sample was collected within the survey area by the *Double Don* on September 9. Maturity analyses showed that 82% of the fish were Stage 5 “maturing” condition and 11% of the fish were in the Stage 6 “ripe and running” condition (Figure 44C).
- The resulting sample generated TS with a weighted mean length 25.8 cm and mean weight of 131 g (Figure 51B) was used to estimate the biomass.
- The initial biomass estimate was 5,131 t using the standard TS and covering an area of 15.79 km².
- After minor edits to the files and using the sample generated TS, the biomass was estimated to be 4,405 t (Table 7C).

Spectacle Buoy

The spring gillnet fishery for roe has usually occurred 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 previous years, Herring in this area were believed to have occurred in greater abundance in late May to early June, and it is assumed the surveys had missed the majority of fish. There have been no reported catches from this area since the spring of 2011. In addition to spring spawning, there is evidence of a fall spawning component. The last fall survey was in 2006 with an estimate 30 t biomass. Acoustic surveys were conducted during the fall of 2017 in the Spectacle Buoy area (Table 6).

2017 Spectacle Buoy Acoustic Surveys

In 2017, there were three acoustic surveys completed in the Spectacle Buoy area between August 25 and September 16. One multi-panel sample was collected on August 25 and another on September 16.

Spectacle Buoy Acoustic Survey #1: August 25, 2017

- One acoustic vessel, the *Double Don*, completed this survey. The vessel conducted a fine-scale systematic parallel transect survey on one aggregation. The transects were poor, because they were not equally spaced, not parallel, nor from one end of school to the other. (Figure 52A).

- One transect was cut because it was too close to another, and the area of the school was recalculated to 0.82 km².
- One multi-panel gillnet sample was collected within the survey area by the *Double Don* on August 25. Maturity analyses showed that 47% of the fish were Stage 4 “maturing/hard” condition and 47% of the fish were in the Stage 5 “maturing/hard” condition (Figure 44C).
- The resulting sample generated TS, with a weighted mean length of 25.2 cm and a mean weight of 118 g (Figure 52B), was used to estimate the biomass.
- The initial biomass estimate was 2,458 t using the standard TS and larger area.
- The length-frequency distribution indicated that about 11% of the fish present were < 23 cm (juveniles) (Figure 45D). After minor edits to the files and using the sample generated TS, a biomass of 1,466 t was obtained after adjusting for juveniles (Table 7D).

Spectacle Buoy Acoustic Survey #2: September 4, 2017

- One acoustic vessel, the *Double Don*, completed this survey. The vessel conducted a fine-scale systematic parallel transect survey on one aggregation. The transects were satisfactory, except that they did not start from one end of the school to the other end (Figure 53). A final verification transect up through the school would have improved the confidence in the estimate.
- Some of the targets were mid-water, while others were tight to bottom. The initial biomass estimate was 3,615 t using the standard TS.
- There was no multi-panel sample for this survey so the standard TS was used. The biomass estimate after minor edits to the files was 3,564 t (Table 7D). The lack of sample likely provides an over-estimate because juveniles were likely present in the upper water column.

Spectacle Buoy Acoustic Survey #3: September 16, 2017

- One acoustic vessel, the *Double Don*, completed this survey. The vessel conducted a fine-scale systematic parallel transect survey on one aggregation. The transects were done well, except that they only went through the school once and the verification transect was done at the beginning of the survey rather than at the end (Table 7D).
- As in the previous survey, some of the targets were mid-water, while others were tight to bottom. The initial biomass estimate was 5,378 t using the standard TS.
- One multi-panel gillnet sample was collected within the survey area by the *Double Don* on September 16. Maturity analyses showed that 60% of the fish were Stage 5 “maturing” condition and 13% of the fish were in the Stage 6 “ripe and running” condition (Figure 44C).
- The length-frequency distribution indicated that about 10% of the fish present were < 23 cm (juveniles) (Figure 45D). The resulting sample generated TS, with a weighted mean length 25.0 cm and a mean weight of 113 g (Figure 54B), was used to estimate the biomass.
- After minor edits to the files and using the sample generated TS, a biomass of 3,697 t was obtained after adjusting for juveniles (Table 7D).

2017 Spectacle Buoy Acoustic Surveys Summary

In 2017, three structured surveys conducted between August 25 and September 16. There is evidence that juvenile fish were present during two of the surveys. The total SSB estimated from the three surveys was 8,726 t.

Browns Bank

There was no survey activity on Browns Bank in 2015, 2016, or 2017. There was no reported fishery catches on Browns Bank during this reporting period. The last reported catches from this area was in 2012 (21 t).

Seal Island

Historically, the spawning areas around Seal Island made a significant contribution to the biomass of the Bay of Fundy/SWNS stock complex. 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 have been no surveys or reported caches in the Seal Island area during the reporting period (2015–2017). The last reported catches were in 2012 (161 t).

Bay of Fundy/Southwest Nova Scotia (SWNS) Summary

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 to rely on structured surveys scheduled at two-week intervals. Since 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 required a series of surveys that covered most of the spawning area on each of the spawning grounds during the defined spawning season.

The SSB estimates for the Bay of Fundy/SWNS component of the 4WX Herring stock complex during 2015–2017 were determined from industry based acoustic surveys of the three major spawning components: Scots Bay; Trinity Ledge; and German Bank. Historical timing of surveys and biomass estimates for Scots Bay and German Bank are presented in Figures 56A and 56B. The only structured surveys conducted outside these three major spawning areas in the Bay of Fundy/Southwest Nova Scotia component was in the fall in the Spectacle Buoy area in 2017. No fishing was reported in the Spectacle Buoy area; however, three acoustic surveys were done in 2017 with a biomass estimate of 8,726 t. Some juveniles were present in the Spectacle Buoy area during the survey season in the fall. There was no catches reported around Browns Bank and Seal Island; however, catches were reported for Gannet, Dry Ledge (10,240 t, 8,718 t, and 2,090 t, respectively for 2015, 2016, and 2017).

The acoustic results provide estimates 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 (multiple counting) was evaluated at DFO science peer review meetings in 2006/07 (DFO 2007), and the 10–14 day time period between surveys was considered reasonable at that time but required further investigations. The investigation into turn-over using tagging studies was presented by Maxner et al. (2010), which summarized the 2010 German Bank turn-over tagging experiment results. Melvin et al. (2014b) presented further data and analyses on these studies and more recent tagging studies. Corrections for the spawning biomass estimates for elapsed time reduced the biomass by 22.5%. An update to this study with updated biomass estimates to 2017 was presented at the April 2018 assessment meeting and were accepted. This resulted in adjustments to the reference points that utilize acoustic biomass estimates (see Melvin et al. 2020).

The SSB for Scots Bay showed a major decline in 2005 (Table 9, Figure 57), likely due, in part, to the excessive catches of 2004 and 2005 (Power et al. 2010). After the low in 2005, the Scots Bay SSB showed a slight improvement increasing from 21,200 t to 52,700 t in 2007. In 2008, there was a substantial decline with an area estimate of 23,400 t (Table 9). In 2009, the surveyed biomass increased to 87,700 t, but declined again in 2010 to 54,000 t. In 2011, there was a three-fold increase in the SSB to 140,700 t and a further increase to 184,800 t in 2012, taking the SSB to above the long-term average. In 2013, there was another substantial decline with a biomass estimate to less than half of the previous year, 76,200 t. The surveyed biomass, however, increased in 2014 to 226,100 t, followed by another increase in 2015 to 285,200 t, an all-time high. A substantial decline occurred in 2016 to 115,700 t followed by an increase to 172,900 t, in 2017 (Table 9, Figure 57).

The total German Bank biomass decreased to 176,400 t in 2015 from 233,000 in 2016. This was followed by an increased in 2016 to 212,100 t and a decrease to 198,000 t in 2017. Structured surveys used in the estimation covered the period from mid-August to mid-October (Table 5A, 5B and 5C). Since 2011, the German Bank spawning biomass estimate has decreased at an average annual rate of 9% (27,581 t; Table 9). There was an increase in 2016 over the 2015 estimate; however, the 2017 estimate is the lowest recorded (Figure 57). The September 17 survey was initially excluded because it was nine days after the previous one; however, this resulted in a 28-day gap before the next acceptable survey. Subsequently, at the 2018 assessment meeting, it was decided that the September 17 survey was an exceptional case and it was included in the total biomass estimate for German Bank. This adjustment is reflected in the numbers in this document.

The total spawning biomass observed on Trinity ledge decreased in 2015 and 2016 (from 4,772 t in 2014 to 657 t in 2015, to 506 t in 2016). There was a substantial increase in 2017 (13,866 t) to above the long-term average (1999–2017) of 6,234 t (Table 9). There was evidence in 2017 that juveniles were present in the area during the surveys. In all three years, one vessel conducted acoustic surveys; however, in 2015 and 2016 several trips to search for fish were conducted but no schools of significant amounts were located.

Trinity Ledge once supported a large spawning component and fishery within the 4WX stock complex. While there was a substantial improvement in the observed SSB in 2017, the fact that the prior two years documented low biomass and given the slow rate of recovery, consideration should also be given to keep the area closed until the observed increase can be proven for at least three years. Any fishing on Trinity Ledge should strictly adhere to the “survey, assess, and then fish” protocol during the upcoming spawning season.

Surveys around Spectacle Buoy are intermittent and only occur when Herring are found in the area. The last survey done in the area was in 2011 in the spring and 2006 in the fall. No surveys were done in 2015 and 2016. In 2017, three surveys were completed in the fall resulting in a biomass estimate of 8,726 t (Table 6). There was evidence that juveniles were present in the area during the surveys.

The lowest total SSB for the Bay of Fundy/SWNS spawning complex in the time series was estimated to be in 2008 (Table 9, Figure 57). Since 1999, the total SSB has fluctuated between 264,900 t and 576,700 t. A substantial decrease in the overall Bay of Fundy/SWNS stock area biomass estimate was observed in 2013 (341,694 t), with the estimate returning to slightly above the long-term average in 2014 (463,929 t). Since then, the estimate has decreased to 462,214 t (2015) and 328,253 t (2016), and increased to 393,396 t (2017). It is evident that the recent fluctuations in the Bay of Fundy/SWNS spawning complex are occurring on both of the main spawning areas. Continued caution should also be observed in the German Bank area as a result of a trending decline over the previous four years in the estimated biomass.

COASTAL NOVA SCOTIA 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 have been conducted in three areas of the Nova Scotia coastal stock component: Port Mouton/Little Hope; Halifax/Eastern Shore; and Glace Bay. Surveys of the spawning grounds were undertaken using the structured acoustic survey approach. No structured acoustic survey occurred in Glace Bay during 2015 to 2017.

The results for each spawning area presented below are calculated only with the CIF, which is considered to provide a more accurate representation of biomass. This method of calculation has been applied since 2003 and can now be used for the consistent calculation of five-year averages, which are used to establish beginning of year allocations for each area. Detail acoustic analyses from each survey are published in a separate Data Report (Singh et al. 2019).

Little Hope/Port Mouton Surveys

2015 Little Hope/Port Mouton Acoustic Surveys

The 2015 Herring gillnet fishery in Little Hope/Port Mouton area began on September 23 and extended to November 6. The total catch of 4,160 t in 2015 represents a slight increase from the 3,596 t in 2014 (Figure 58), with the majority of the catch occurring during mid-September and mid-October (Figure 59A). The catches occurred in two main areas: east of Port Mouton and northeast of Liverpool (Figure 60A). For the acoustic surveys, the transect lines were not predefined by a survey design, rather were conceived based on the best coverage of the aggregations using equally spaced parallel transects. Overall in 2015, four acoustics surveys were conducted in the Little Hope/Port Mouton area between September 24 and November 4 (Table 10A). All data were downloaded from the two boats with acoustic recorders and, after editing to remove the bottom and non-Herring targets, the acoustic files were cut into transects for each survey.

There was a multi-panel sample available for each survey, and only these samples were used to determine maturity and to generate the TS (Figures 61A and 62A). Industry is encouraged to deploy multi-panel gillnets to obtain samples whenever acoustic surveys are conducted.

Little Hope Acoustic Survey #1: September 24, 2015

- This survey was conducted by two acoustic survey vessels, the *Eagle 8* and the *Trinity,* on September 24 (Figure 63A). The vessels conducted a fine-scale systematic parallel transect survey on five schools. A biomass estimate of 7,217 t using the standard TS was initially determined.
- One multi-panel gillnet sample was taken on September 24. Maturity analyses showed that 86% of the fish were Stage 5 “maturing” condition and 8% of the fish were in the Stage 6 “ripe and running” condition (Figure 61A).
- The resulting sample with a weighted mean length of 28.1 cm and a mean weight of 182 g (Figure 63B) was used to generate the TS. The biomass estimate after minor edits and using the sample generated TS was 6,720 t.

Little Hope Acoustic Survey #2: October 7, 2015

- This survey was conducted by two acoustic survey vessels, the *Eagle 8* and the *Trinity,* on October 7 (Figure 64A). The vessels conducted a fine-scale systematic parallel transect survey of four schools. The schools were in close proximity to each other, but a careful investigation of the timing indicates they may be all separate schools except the third school surveyed by the *Trinity* may be part of the school surveyed by *Eagle 8*. Some aggregations were up in the water column, while others were tight to bottom.
- The initial biomass estimate using standard TS was 17,739 t.
- One multi-panel gillnet sample was taken on October 9. Maturity analyses showed that 80% of the fish were Stage 5 “maturing” condition and 16% of the fish were in the Stage 6 “ripe and running” condition (Figure 61A). The resulting sample with a weighted mean length

28.4 cm and a mean weight of 184 g (Figure 64B) was used to generate the TS. The biomass estimate after minor edits to the files and using the sample generated TS was 16,276 t.

Little Hope Acoustic Survey #3: October 18, 2015

- This survey was conducted by two acoustic survey vessels, the *Eagle 8* and the *Trinity* on October 18 (Figure 65A). The vessels conducted a fine-scale systematic parallel transect survey of four schools. Some aggregations were up in the water column, while others were tight to bottom.
- The resulting biomass estimate using the standard TS was 38,774 t.
- One multi-panel gillnet sample was taken on October 17. Maturity analyses showed that 82% of the fish were Stage 5 "maturing" condition and 17% of the fish were in the Stage 6 "ripe and running" condition (Figure 61A). Using the sample with a weighted mean length of 28.8 cm and a mean weight of 193 g (Figure 65B) to generate a TS resulted in the biomass estimate being adjusted to 32,168 t.

Little Hope Acoustic Survey #4 – November 4, 2015

- This survey was conducted by two acoustic survey vessels, the *Eagle 8* and the *Trinity,* on November 4 (Figure 65C). The vessels conducted a fine-scale systematic parallel transect survey of 8 aggregations. Both vessels did an excellent job of surveying the aggregations. The resulting biomass estimate using the standard TS was 101,250 t.
- One multi-panel gillnet sample was taken on November 5 with a mean weight of 166 g and mean length of 27.3 cm (Figure 65D). Maturity analyses showed that 87% of the fish were Stage 5 "maturing" condition and 13% of the fish were in the Stage 6 "ripe and running" condition (Figure 61A). Using the sample to generate the TS resulted in the biomass estimate being adjusted to 90,231 t.

2015 Little Hope Summary

In 2015, four 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 10–14 days between surveys was followed in order to avoid double counting fish that may have remained from the previous surveys. One multi-panel gillnet sample was available for each survey to better estimate the TS. The total spawning biomass for the Little Hope area for 2015 was taken as the sum of the four surveys (Table 10A). The total spawning biomass estimate was 145,396 t. This represented a substantial increase in the spawning biomass estimate over the low of 12,756 t in 2012 and a three-fold increase over 2014 (46,077 t) (Table 13B, Figure 77).

2016 Port Mouton/Little Hope Acoustic Surveys

The 2016 Herring gillnet fishery in Little Hope/Port Mouton area began on May 27 and extended to November 4. The total catch of 5,943 t in 2016 represents an increase from the 4,160 t in 2015 (Figure 58), with the majority of the catch occurring mid-September (Figure 59B). The catches occurred in three main areas: east of Port Mouton, east of Liverpool, and east of Port Medway. (Figure 60B). Overall in 2016, six acoustics surveys were conducted in the Little Hope/Port Mouton area between September 13 and November 14 (Table 10B). All data were downloaded from the two boats with acoustic recorders and, after editing to remove the bottom and non-Herring targets, the acoustic files were cut into transects for each survey.

There was a multi-panel sample available for each of the first five surveys and these samples were used to determine maturity and to generate the TS (Figures 61B and 62B). Survey #6 was not accompanied by a multi-panel sample so the standard TS was used. Industry is encouraged to deploy multi-panel gillnets to obtain samples whenever acoustic surveys are conducted.

Little Hope Acoustic Survey #1: September 13, 2016

- This survey was conducted by two acoustic survey vessels, the *Eagle 8* and the *Atlantic Star* on September 13 (Figure 66A). The vessels conducted a fine-scale systematic parallel transect survey of four light aggregations. The survey by both vessels covered the aggregations well, but it should be noted that the preferred number of lines in a school is 6 or greater but no more than 12. Some aggregations were up in the water column, while others were tight to bottom.
- One multi-panel gillnet sample was taken on September 14. Maturity analyses showed that 57% of the fish were Stage 5 “maturing” condition and 18% of the fish were in the Stage 6 “ripe and running” condition (Figure 61B). The resulting sample with a weighted mean length 28.0 cm and mean weight of 171 g was used to generate the TS (Figure 66B).
- A biomass estimate of 4,178 t using the standard TS was initially determined. The biomass estimate after minor edits to the files and using the sample generated TS was 3,572 t.

Little Hope Acoustic Survey #2: September 23, 2016

- This survey was conducted by two acoustic survey vessels, the *Eagle 8* and the *Atlantic Star* on September 23 (Figure 67A). The vessels conducted a fine-scale systematic parallel transect survey of seven aggregations. The survey by both vessels covered the aggregations well. Some aggregations were up in the water column, while others were tight to bottom.
- One multi-panel gillnet sample was taken on September 24. Maturity analyses showed that 70% of the fish were Stage 5 “maturing” condition and 21% of the fish were in the Stage 6 “ripe and running” condition (Figure 61B). The resulting sample with a weighted mean length of 27.4 cm and a mean weight of 163 g was used to generate the TS (Figure 67B).
- A biomass estimate of 21,750 t using the standard TS was initially determined. The biomass estimate after minor edits to the files and using the sample generated TS was 19,108 t.

Little Hope Acoustic Survey #3: October 4, 2016

- This survey was conducted by two acoustic survey vessels, the *Eagle 8* and the *Atlantic Star* on October 4 (Figure 68A). The vessels conducted a fine-scale systematic parallel transect survey of one aggregation. The *Eagle 8* did not find any aggregations. The *Atlantic Star*’s, ES60 was unknowingly set to maximum ping rate rather than one ping per second, which could have reduced the estimate slightly.
- One multi-panel gillnet sample was taken on October 5. Maturity analyses showed that 83% of the fish were Stage 5 “maturing” condition and 14% of the fish were in the Stage 6 “ripe and running” condition (Figure 61B). The resulting sample with a weighted mean length 27.6 cm and a mean weight of 164 g was used to generate the TS (Figure 68B).
- A biomass estimate of 981 t using the standard TS was initially determined. The biomass estimate after minor edits to the files and using the sample generated TS was 856 t.

Little Hope Acoustic Survey #4: October 17, 2016

- This survey was conducted by two acoustic survey vessels, the *Eagle 8* and the *Atlantic Star,* on October 17 (Figure 69A). The vessels conducted a fine-scale systematic parallel transect survey of six aggregations. The *Atlantic Star*’s ES60 was unknowingly set to maximum ping rate rather than one ping per second, which could have reduced the estimate slightly. This problem was corrected in time for the next survey.
- One multi-panel gillnet sample was taken on October 20. Maturity analyses showed that 85% of the fish were Stage 5 “maturing” condition and 9% of the fish were in the Stage 6 “ripe and running” condition (Figure 61B).

- The resulting biomass estimate using the standard TS was 19,821 t. Using the sample with a weighted mean length of 28.6 cm and mean weight of 184 g (Figure 69B) to generate a TS resulted in the biomass estimate being adjusted to 16,999 t.

Little Hope Acoustic Survey #5: November 1, 2016

- This survey was conducted by two acoustic survey vessels, the *Eagle 8* and the *Atlantic Star* on November 1 (Figure 70A). The vessels conducted a fine-scale systematic parallel transect survey of two aggregations.
- One multi-panel gillnet sample was taken on November 1. Maturity analyses showed that 87% of the fish were Stage 5 “maturing” condition and 13% of the fish were in the Stage 6 “ripe and running” condition (Figure 61B). The resulting sample with a weighted mean length 29.1 cm and a mean weight of 193 g was used to generate the TS (Figure 70B).
- A biomass estimate of 20,710 t using the standard TS was initially determined. The biomass estimate after minor edits to the files and using the sample generated TS was 19,858 t.

Little Hope Acoustic Survey #6: November 14, 2016

- This survey was conducted by one acoustic survey vessel, the *Eagle 8* on November 14 (Figure 71). The vessel conducted a fine-scale systematic parallel transect survey of two aggregations. Targets were primarily off bottom, with areas of dense concentration on bottom.
- A biomass estimate of 1,194 t using the standard TS was initially determined. There was no multi-panel sample for this survey, so the standard TS was used. The biomass estimate after minor edits to the files and using the standard TS was 1,015 t.

2016 Little Hope Summary

In 2016, six 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 10–14 days between surveys was followed in order to avoid double counting fish that may have remained from the previous surveys. One multi-panel gillnet sample was available for each survey of the first five surveys to determine the TS. The standard TS was used for the survey #6 to determine the biomass. The total spawning biomass for the Little Hope area for 2016 was taken as the sum of the six surveys (Table 10B). The total spawning biomass estimate was 61,408 t. This represents a substantial decrease (58%) from the previous year’s estimate of 145.396 t (Table 13B, Figure 77).

2017 Port Mouton/Little Hope Acoustic Surveys

The 2017 Herring gillnet fishery in Little Hope/Port Mouton area began on August 5 and extended to November 14. The total catch of 5,557 t in 2017 represents a slight decrease from the 5,939 t in 2016 (Figure 58), with the majority of the catch occurring early to mid-October. (Figure 59C). The catches occurred within the spawning box from southeast of Port Mouton to east of Port Medway (Figure 60C). Overall, in 2017, six acoustics surveys were conducted in the Little Hope/Port Mouton area between September 15 and November 7 (Table 10C). All data were downloaded from the three boats with acoustic recorders and, after editing to remove the bottom and non-Herring targets, the acoustic files were cut into transects for each survey.

A multi-panel sample was available for each of the first four surveys, and these samples were used to determine maturity and to generate the TS (Figures 61C and 62C). Surveys #5 and #6 did not have accompanying multi-panel samples and so the standard TS was used. Industry is encouraged to deploy multi-panel gillnets to obtain samples whenever acoustic surveys are conducted.

Little Hope Acoustic Survey #1: September 15, 2017

- This survey was conducted by three acoustic survey vessels, the *Eagle 8, Atlantic Star* and *Salt Water Harvester,* on September 15 (Figure 72A). The vessels conducted a fine-scale systematic parallel transect survey of seven aggregations. The survey by all vessels was good, but it should be noted that the preferred number of lines in a school is 6 or greater, but no more than 12. Some targets were up in the water column, while others were tight to bottom. It is possible that some of the targets were mackerel; however, no adjustment to the biomass was made due to lack of verification samples.
- One multi-panel gillnet sample was taken on September 16. Maturity analyses showed that 68% of the fish were Stage 5 “maturing” condition and 16% of the fish were in the Stage 6 “ripe and running” condition (Figure 61C). The sample with a weighted mean length of 25.3 cm and a mean weight of 119 g was used to generate the TS (Figure 72B).
- A biomass estimate of 41,833 t using the standard TS was initially determined. The biomass estimate after minor edits to the files and using the sample generated TS was 28,334 t.

Little Hope Acoustic Survey #2: September 26, 2017

- This survey was conducted by two acoustic survey vessels, the *Atlantic Star* and the *Salt Water Harvester,* on September 26 (Figure 73A). The vessels conducted a fine-scale systematic parallel transect survey of four aggregations. The *Eagle 8* had hardware problems and was unable to participate in the survey. Some targets were up in the water column, while others were tight to bottom. It is possible that some of the targets were mackerel; however, no adjustment to the biomass was made due to lack of verification samples.
- One multi-panel gillnet sample was taken on September 26. Maturity analyses showed that 69% of the fish were Stage 5 “maturing” condition and 25% of the fish were in the Stage 6 “ripe and running” condition (Figure 61C).
- A biomass estimate of 13,082 t using the standard TS was initially determined. The resulting sample with a weighted mean length 27.3 cm and a mean weight of 152 g was used to generate the TS (Figure 73B). The biomass estimate after minor edits to the files and using the sample generated TS was 11,953 t.

Little Hope Acoustic Survey #3: October 6, 2017

- This survey was conducted by three acoustic survey vessels, the *Eagle 8, Atlantic Star* and the *Salt Water Harvester* on October 6 (Figure 74A). The vessels conducted a fine-scale systematic parallel transect survey of four aggregations. Some targets were up in the water column, while others were tight to bottom.
- There is some concern that some of the targets may be ground fish moving in after the spawning event rather than Herring; however, no adjustments were made for this possibility.
- One multi-panel gillnet sample was taken on October 7. Maturity analyses showed that 78% of the fish were Stage 5 “maturing” condition and 14% of the fish were in the Stage 6 “ripe and running” condition (Figure 61C). The resulting sample with a weighted mean length of 27.3 cm and a mean weight of 155 g was used to generate the TS (Figure 74B).
- A biomass estimate of 5,329 t using the standard TS was initially determined. The biomass estimate after minor edits to the files and using the sample generated TS was 4,709 t.

Little Hope Acoustic Survey #4: October 17, 2017

- This survey was conducted by three acoustic survey vessels, the *Eagle 8, Atlantic Star,* and the *Salt Water Harvester,* on October 17 (Figure 75A). The *Eagle 8* experienced software configuration problems and was unable to collect data in survey mode, although it did participate in the survey. The vessels conducted a fine-scale systematic parallel transect survey of four aggregations. Some targets were up in the water column, while others were tight to bottom.

- There continued to be some concern that some of the targets may be ground fish moving in after the spawning event rather than Herring; however, no adjustments were made for this possibility.
- One multi-panel gillnet sample was taken on October 17. Maturity analyses showed that 75% of the fish were Stage 5 “maturing” condition and 18% of the fish were in the Stage 6 “ripe and running” condition (Figure 61C). The resulting sample with a weighted mean length of 28.0 cm and a mean weight of 162 g was used to generate the TS (Figure 75B).
- A biomass estimate of 4,614 t using the standard TS was initially determined. The biomass estimate after minor edits to the files and using the sample generated TS was 4,016 t.

Little Hope Acoustic Survey #5: October 28, 2017

- This survey was conducted by three acoustic survey vessels, the *Eagle 8, Atlantic Star,* and the *Salt Water Harvester,* on October 28 (Figure 76A). The *Eagle 8* experienced software configuration problems and lost some, but not a lot, of biomass. The vessel conducted a fine-scale systematic parallel transect survey of four aggregations. Some targets were up in the water column, while others were tight to bottom.
- There was some concern that some of the targets may be ground-fish feeding on the spawn rather than Herring, however, no adjustments were made for this possibility.
- There was no multi-panel sample for this survey and so the standard TS was used. A biomass estimate of 10,326 t using the standard TS was initially determined. The biomass estimate after minor edits to the files was 10,050 t.

Little Hope Acoustic Survey #6: November 7, 2017

- This survey was conducted by three acoustic survey vessels, the *Eagle 8, Atlantic Star* and the *Salt Water Harvester,* on November 7 (Figure 76B). The *Salt Water Harvester* did not find any aggregations to survey and the *Eagle 8* had hardware problems, but the data was recovered in time. The vessels conducted a fine-scale systematic parallel transect survey of three aggregations. The second grid conducted by *Atlantic Star* was not optimal since it had only two transects.
- There remains concern that some of the targets may be ground fish moving in after a spawning event, rather than Herring. Some targets were up in the water column, while others were tight to bottom. The targets surveyed by the *Eagle 8* were particularly close to bottom and difficult to edit.
- A biomass estimate of 7,868 t using the standard TS was initially determined. There was no multi-panel sample for this survey so the standard TS was used. The biomass estimate after minor edits to the files was 7,754 t.

2017 Little Hope Summary

In 2017, six 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 10–14 days between surveys was followed in order to avoid double counting fish that may have remained from the previous surveys. One multi-panel gillnet sample was available for each of the first 4 surveys. The standard TS was used for the survey #5 and #6 due to lack of samples. The total spawning biomass for the Little Hope area for 2017 was taken as the sum of the six surveys (Table 10C). The total spawning biomass estimate was 66,815 t. This represents a slight increase from the previous year’s estimate of 61,408 t, but the biomass is below the average of the last five years of 78,845 t (Table 13B, Figure 77).

Halifax/Eastern Shore Fishery and Surveys

2015 Eastern Shore Acoustic Surveys

The 2015 Herring gillnet fishery in the Eastern Shore fishing area began on October 6 and ended on November 23 with total landings of 1,001 t compared with 1,959 t in 2014 (Table 13A, Figures 78, 79A, and 80A). Most catches occurred between October 6 and October 17 (Figure 79A). Once again, this was primarily a Herring roe fishery with catches reported from two main cluster areas: one near Halifax Harbour approaches and one southwest of Jeddore Head (Figure 80A). In 2015, five surveys were completed between September 27 and October 27 (Table 11A).

For the acoustic surveys, the transect lines were not predefined by a survey design, rather were conceived based on the best coverage of the aggregations using equally spaced parallel transects. The data were downloaded from the survey vessels with acoustic recorders, *Emily & Aley*, *Miss Owl's Head,* and *Oralee*. There was no multi-panel sample available for the first survey, but there was one each for surveys #2 to #5. The maturity samples showed a high proportion of Stage 5 "maturing" condition (Figure 81A). Size distribution from the commercial fishery is shown in Figure 82A.

Halifax/Eastern Shore Acoustic Survey #1: September 27, 2015

- The first survey for the 2015 season was conducted by one acoustic survey vessel, the *Emily and Aley* (Figure 83). The vessel conducted fine-scale systematic parallel transect grids on two schools of targets. Both schools had little biomass but do indicate the presence of some Herring.
- A biomass estimate of 134 t using the standard TS was initially determined. There was no multi-panel sample for this survey so the standard TS was used. The biomass estimate after minor edits to the files and using the standard TS was 154 t.

Halifax/Eastern Shore Acoustic Survey #2: October 5, 2015

- This survey was conducted by three acoustic survey vessels, the *Emily & Aley*, *Miss Owl's Head*, and *Oralee,* on October 5 and 6. The vessels conducted fine-scale systematic parallel transect grids on five aggregations (Figure 84A). The *Miss Owl's Head* has significant noise caused by what may have been a ground loop. Also, the execution of the *Miss Owl's Head* survey was not optimal, so the analysis uses a non-standard selection of lines to produce an estimate.
- One multi-panel gillnet sample was taken on October 6. Maturity analyses showed that 70% of the fish were Stage 5 "maturing" condition and 30% of the fish were in the Stage 6 "ripe and running" condition (Figure 81A). The resulting sample with a weighted mean length of 29.1 cm and a mean weight of 195 g was used to generate the TS (Figure 84B).
- The September 27 (#1) and October 5 (#2) surveys were conducted on the same schools. Survey #2 had the higher biomass, but was too close to the October 10 (#3) survey, so September 27 (#1) estimate was used and October 5 (#2) survey was excluded.
- A biomass estimate of 7,778 t using the standard TS was initially determined for all the schools. The biomass estimate after minor edits to the files and using the sample generated TS was 6,635 t.

Halifax/Eastern Shore Acoustic Survey #3: October 10, 2015

- This survey was conducted by two acoustic survey vessels, the *Emily & Aley*, and *Oralee,* on October 10^{th}. The vessels conducted fine-scale systematic parallel transect grids on two aggregations (Figure 85A).

- The *Oralee* survey was not executed in the preferred manner, but, since the estimated biomass from the surveyed school was very small, it made little difference to the overall result.
- One multi-panel gillnet sample was taken on October 11. Maturity analyses showed that 79% of the fish were Stage 5 “maturing” condition and 21% of the fish were in the Stage 6 “ripe and running” condition (Figure 81A). The resulting sample with a weighted mean length of 28.8 cm and a mean weight of 188 g was used to generate the TS (Figure 85B).
- A biomass estimate of 53,494 t using the standard TS was initially determined. The biomass estimate after minor edits to the files and using the sample generated TS was 51,240 t. This survey biomass was the largest in recent years in the area.

Halifax/Eastern Shore Acoustic Survey #4: October 16, 2015

- This survey was conducted by two acoustic survey vessels, the *Emily & Aley* and *Oralee,* on October 16. The vessels conducted fine-scale systematic parallel transect grids on two aggregations (Figure 86A).
- One multi-panel gillnet sample was taken on October 16. Maturity analyses showed that 78% of the fish were Stage 5 “maturing” condition and 19% of the fish were in the Stage 6 “ripe and running” condition (Figure 81A). The resulting sample with a weighted mean length of 29.1 cm and mean weight of 197 g was used to generate the TS (Figure 86B).
- Since surveys #3 and #4 were only 6 days apart and surveyed some of the same schools, the AE01 aggregation from October 16 was the only school used for this survey’s estimate.
- A biomass estimate of 4,179 t using the standard TS was initially determined. The biomass estimate after minor edits to the files and using the sample generated TS was 4,050 t.

Halifax/Eastern Shore Acoustic Survey #5: October 27, 2015

- This survey was conducted by two acoustic survey vessels, the *Emily & Aley*, and *Oralee,* on October 27. The vessels conducted fine-scale systematic parallel transect grids on two aggregations (Figure 87A).
- Aggregation AE01 was not surveyed from one end to the other, as is the best practice, but rather in two sections. This is normally an indication that the aggregation was moving, lending itself to double counting. It was found; however, by looking at the verification line before and after the survey, that the school may have just been aggregating rather than moving.
- One multi-panel gillnet sample was taken on October 27. Maturity analyses showed that 87% of the fish were Stage 5 “maturing” condition and 13% of the fish were in the Stage 6 “ripe and running” condition (Figure 81A). The resulting sample with a weighted mean length of 28.0 cm and mean weight of 174 g was used to generate the TS (Figure 87B).
- A biomass estimate of 15,059 t using the standard TS was initially determined. The biomass estimate after minor edits to the files and using the sample generated TS was 13,118 t.

Halifax/Eastern Shore Acoustic Survey Summary for 2015

The total spawning biomass for the Eastern Shore area for 2015 was taken as the sum the surveys with at least a 10 day interval and schools that were sufficiently separated in space and time. Four of the five surveys were supported with multi-panel gillnet deployment to collect representative samples of Herring being surveyed to better estimate the TS. The total spawning biomass estimate was 68,561 t (Table 11A). This represents a substantial increase (seven-fold) from the 2014 estimate of 9,586 t.

2016 Eastern Shore Acoustic Surveys

The 2016 Herring gillnet fishery in the Eastern Shore fishing area began on May 29 and ended on October 20, with total landings of 1,837 t compared with 1,001 t in 2015 (Table 13A, Figures 78, 79B, and 80B). Most catches occurred between September 30 and October 8 (Figure 79B).

Once again, this was primarily a Herring roe fishery, with catches reported from the approaches to Halifax Harbour, up the coast to Jeddore Head (Figure 80B). In 2016, ten surveys were completed between September 13 and November 5 (Table 11B). The data were downloaded from the three survey vessels with acoustic recorders, *Emily & Aley*, *Miss Owl's Head,* and *Oralee*. There was a multi-panel sample available for all surveys, with the exception of the last survey on November 5. The maturity samples showed a high proportion of Stage 5 "maturing" condition (Figure 81B). Size distribution from the commercial fishery is shown in Figure 82B. Many of the Eastern Shore surveys had intervals of one to three days and so decisions had to be made on which dates and aggregations to include in the total biomass estimates.

Halifax/Eastern Shore Acoustic Survey #1: September 13, 2016

- This survey was conducted by one acoustic survey vessel, the *Emily & Aley* on September 13 (Figure 88A). The vessel conducted a fine-scale systematic parallel transect grid on one school of fish. It appears that the transects missed the densest part of the school as seen in the final verification line.
- Two multi-panel gillnet samples one each from September 13 and 30 were used to calculate the TS. The September 30 sample was included in the calculation to increase the number of details samples used to generate the weight-length relationship.
- Maturity analyses showed that 83% of the fish were in the Stage 5 "maturing" condition and 17% of the fish were in the Stage 6 "ripe and running" condition (Figure 81B). The resulting sample with a weighted mean length of 29.4 cm and a mean weight of 204 g was used to generate the TS (Figure 88B).
- The initial biomass estimate using the standard TS was 28 t. The biomass estimate after minor edits to the files and using the sample generated TS was 24 t.

Halifax/Eastern Shore Acoustic Survey #2: September 28, 2016

- This survey was conducted by one acoustic survey vessel, the *Emily & Aley,* on September 28. The survey lines overlapped and were not consistent with a good survey.
- The initial biomass estimate using the standard TS was 2,282 t.
- It was decided not to include this survey in the biomass estimate as the interval between surveys and separation of the aggregations was insufficient to reduce the possibility of double counting.

Halifax/Eastern Shore Acoustic Survey #3: September 30, 2016

- This survey was conducted by two acoustic survey vessels, the *Emily & Aley* and the *Miss Owl's Head,* on September 30 (Figure 89A). The vessels conducted fine-scale systematic parallel transect grids on three schools of fish. The *Miss Owl's Head* has a significant electrical noise problem that required removal from the data and a repair of the source.
- Only two schools, Ea01 and MoH02, were used because school MoH01 was the same as Ea02 surveyed on October 2.
- One multi-panel gillnet sample was collected on September 30. Maturity analyses showed that 71% of the fish were Stage 5 "maturing" condition and 19% of the fish were in the Stage 6 "ripe and running" condition (Figure 81B). The resulting sample with a weighted mean length of 29.3 cm and a mean weight of 195 g (Figure 89B) was used to generate the TS.
- The initial biomass estimate using the standard TS was 11,993 t. The biomass estimate after minor edits to the files and using the sample generated TS was 10,928 t.

Halifax/Eastern Shore Acoustic Survey #4: October 1, 2016

- This survey was conducted by one acoustic survey vessel, the *Emily & Aley,* on October 1. The vessel conducted a fine-scale systematic parallel transect grid on one aggregation. The

survey transects were not consistent with a good survey because they did not proceed from one end of the school to the other.
- The initial biomass estimate using the standard TS was 443 t.
- This survey was excluded because it surveyed the same school as the one conducted on September 30 (Ea01).

Halifax/Eastern Shore Acoustic Survey #5: October 2, 2016

- This survey was conducted by three acoustic survey vessels, the *Emily & Aley*, *Miss Owl's Head*, and *Oralee,* on October 2 (Figure 90A). The vessels conducted fine-scale systematic parallel transect grids on four aggregations. The survey lines of *Emily & Aley* and *Miss Owl's Head* were good, but those of the *Oralee* were not consistent with a good survey because they were not equally spaced, parallel, nor proceeded from one end of the school to the other.
- One multi-panel gillnet sample was collected on October 3. Maturity analyses showed that 71% of the fish were Stage 5 "maturing" condition and 19% of the fish were in the Stage 6 "ripe and running" condition (Figure 81B). The resulting sample with a weighted mean length of 29.3 cm and a mean weight of 196 g (Figure 90B) was used to generate the TS.
- The school surveyed by vessel *Emily & Aley* (Ea01) was not used in the biomass estimate because the same school was surveyed on September 30.
- The initial biomass estimate using the standard TS for the estimate was 7,450 t. The biomass estimate for the three schools after minor edits to the files and using the sample generated TS was 6,339 t.

Halifax/Eastern Shore Acoustic Survey #6: October 5, 2016

- This survey was conducted by two acoustic survey vessels, the *Emily & Aley* and the *Miss Owls Head,* on October 5 (Figure 91A). The vessels conducted fine-scale systematic parallel transect grids on four schools of targets.
- The school Ea03 was not used in the biomass calculations because the same school was also surveyed on September 30 (MoH02).
- One multi-panel gillnet sample was collected on October 5. Maturity analyses showed that 71% of the fish were Stage 5 "maturing" condition and 19% of the fish were in the Stage 6 "ripe and running" condition (Figure 81B). The resulting sample with a weighted mean length of 29.2 cm and a mean weight of 192 g (Figure 91B) was used to generate the TS.
- The initial biomass estimate using the standard TS was 2,679 t. The biomass estimate after minor edits to the files and using the sample generated TS was 2,245 t.

Halifax/Eastern Shore Acoustic Survey #7: October 12, 2016

- This survey was conducted by three acoustic survey vessels, the *Emily & Aley*, *Miss Owl's Head*, and *Oralee,* on October 12 (Figure 92A). The vessels conducted fine-scale systematic parallel transect survey grids on two aggregations of fish. The survey transects of the *Oralee* were not consistent with a good survey because they were not equally spaced, parallel, nor proceeded from one end of the school to the other. All three vessels surveyed one of the schools, while the other school was surveyed solely by the *Oralee*.
- Only the survey by *Emily & Aley* of the aggregation Ea01 was used for the biomass estimate. The survey by *Oralee* of aggregation Or02 was also included as the school was deemed to be far enough away to exclude double counting.
- Two multi-panel gillnet samples, one each from October 12 and 13, were used to calculate the TS and to increase the number of detailed samples used to generate the weight-length relationship.
- Maturity analyses showed that 66% of the fish were Stage 5 "maturing" condition and 30% of the fish were in the Stage 6 "ripe and running" condition (Figure 81B). The resulting

sample with a weighted mean length of 28.2 cm and a mean weight of 172 g was used to generate the TS (Figure 92B).
- A biomass estimate of 6,970 t using the standard TS was initially determined. The estimated biomass after minor edits to the files and using the sample generated TS was 5,532 t.

Halifax/Eastern Shore Acoustic Survey #8: October 19, 2016

- This survey was conducted by one acoustic survey vessel, the *Miss Owl's Head,* on October 19. The vessel conducted a fine-scale systematic parallel transect grid on one aggregation of fish. The vessel had a significant electrical noise problem that required removal from the data and a repair of the source.
- The initial biomass estimate using the standard TS was 10,764 t.
- This survey was excluded from the total biomass estimate because the October 25 survey of aggregation Ea01 was the same school.

Halifax/Eastern Shore Acoustic Survey #9: October 25, 2016

- This survey was conducted by one acoustic survey vessel, the *Emily & Aley,* on October 25 (Figure 93A). The vessel conducted a fine-scale systematic parallel transect grid on one aggregation of fish. This was a very dense aggregation, tight to bottom, leading to difficulty delineating the bottom of the school.
- This survey was included in the biomass estimate because it was 13 days from the October 12 survey on the same school.
- One multi-panel gillnet sample was taken on October 26. Maturity analyses showed that 67% of the fish were Stage 5 "maturing" condition and 30% of the fish were in the Stage 6 "ripe and running" condition (Figure 81B). The resulting sample with a weighted mean length of 28.0 cm and a mean weight of 169 g was used to generate the TS (Figure 93B).
- The initial biomass estimate using the standard TS was 33,279 t. The biomass estimate after minor edits to the files and using the sample generated TS was 29,035 t.

Halifax/Eastern Shore Acoustic Survey #10: November 5, 2016

- This survey was conducted by one acoustic survey vessel, the *Emily & Aley,* on November 5 (Figure 94). The vessel conducted a fine-scale systematic parallel transect grid on one aggregation of fish.
- There was no multi-panel sample for this survey, so the standard TS was used.
- The initial biomass estimate using the standard TS was 230 t. The biomass estimate after minor edits to the files was 207 t.

Halifax/Eastern Shore Acoustic Survey Summary for 2016

There were ten acoustic surveys in the Halifax/Eastern Shore area in 2016. Six multi-panel samples were available for all surveys, with the exception of the final, November 5 survey, when the standard TS was used. Not all surveys and aggregations were included in the biomass calculations, primarily because the survey intervals were insufficient to reduce the possibility of double counting. The estimated total spawning biomass decreased slightly from the 2015, eight-year high of 68,562 t to 54,312 t in 2016.

2017 Eastern Shore Acoustic Surveys

The 2017 Herring gillnet fishery in the Eastern Shore fishing area began on May 31 and ended on November 17, with total landings of 2,259 t compared with 1,837 t in 2016 (Table 13A, Figures 78, 79C and 80C). Most catches occurred between mid-September through late October, with sporadic catches into mid-November (Figure 79C). Once again, this was primarily a Herring roe fishery with catches reported from the approaches to Halifax Harbour, up the coast to Ship Harbour (Figure 80C). In 2017, ten surveys were completed between September 15 and November 12 (Table 11C).

For the acoustic surveys, the transect lines were not predefined by a survey design, rather they were conceived based on the best coverage of the aggregations using equally spaced parallel lines. The data were downloaded from the survey vessels with acoustic recorders*, Emily & Aley*, *Miss Owl's Head,* and *Oralee*. There was a multi-panel sample available for most of the surveys, but there were times, when the standard TS was used, as sometimes the multi-panel samples were collected too far away from the surveyed aggregations. The maturity samples showed a high proportion of Stage 5 "maturing" condition (Figure 81C). Size distribution from the commercial fishery is shown in Figure 82C. Since many of the Eastern Shore surveys had intervals of less than 10 days, some schools were excluded from the overall biomass estimates.

Halifax/Eastern Shore Acoustic Survey #1: September 15, 2017

- This survey was conducted by two acoustic survey vessels, the *Miss Owl's Head* and the *Emily & Aley*, on September 15 (Figure 95A). The vessels conducted fine-scale systematic parallel transect grids on two aggregations of fish. These were dense aggregations down to bottom, leading to difficulty delineating the bottom of the school.
- Two multi-panel gillnet samples, from September 15 and 16 were available for calculating the TS. One sample each was available to calculate a unique TS for each aggregation.
- The aggregation surveyed by *Miss Owl's Head* utilized the September 15 sample where the maturity analyses showed that 77% of the fish were in the Stage 5 "maturing" condition and 13% of the fish were in the Stage 6 "ripe and running" condition (Figure 81C). This sample had a weighted mean length of 28.6 cm and a mean weight of 181 g (Figure 95B).
- The initial biomass estimate for the *Miss Owl's Head* school was 7,446 t using the standard TS. The biomass estimate after minor edits to the files and using the sample generated TS was 7,160 t.
- The aggregation surveyed by *Emily & Aley* utilized the September 16 sample where the maturity analyses showed that 73% of the fish were in the Stage 5 "maturing" condition and 24% of the fish were in the Stage 6 "ripe and running" condition (Figure 79C). This sample had a weighted mean length of 28.4 cm and a mean weight of 179 g (Figure 95C).
- The initial biomass estimate was 580 t using the standard TS. The biomass estimate after minor edits to the files and using the sample generated TS was 555 t.
- The total biomass estimate for the September 15 survey was 7,716 t.

Halifax/Eastern Shore Acoustic Survey #2: September 26, 2017

- This survey was conducted by one acoustic survey vessel, the *Emily & Aley,* on September 26. The vessel conducted fine-scale systematic parallel transect grids on two aggregations of fish (Figure 96A). These were dense aggregations down to bottom, leading to difficulty delineating the bottom of the schools. The weather was quite poor, which also negatively affected the data.
- It was decided not to include aggregation Ea01 because this school was again surveyed on September 30. Aggregation Ea02 was used in the biomass estimate in place of the September 29 Ea02 school since they were the same school.
- A multi-panel sample was available for calculation of TS from September 30. Maturity analyses showed that 83% of the fish were Stage 5 "maturing" condition and 17% of the fish were in the Stage 6 "ripe and running" condition (Figure 81C). The sample with a weighted mean length of 30.5 cm and a mean weight of 229 g (Figure 96B) was used to generate the TS.
- The initial biomass estimate for the one school using the standard TS was 2,989 t. The biomass estimate after minor edits to the files and using the sample generated TS was 3,154 t for the one school.

Halifax/Eastern Shore Acoustic Survey #3: September 29, 2017

- This survey was conducted by two acoustic survey vessels, the *Oralee* and *Emily & Aley,* on September 29 (Figure 97). The vessels conducted fine-scale systematic parallel transect grids on three aggregations. The survey lines of Oralee were satisfactory but could have followed the protocol a bit better. These were dense aggregations down to bottom, leading to difficulty delineating the bottom of the school.
- Only one school (Or01) surveyed by *Oralee* was used for the biomass estimation. The schools surveyed by *Emily & Aley* were close in proximity and time to schools surveyed on September 30 and 26, so those surveys were included in place of the September 29 *Emily & Aley* schools.
- There was no multi-panel sample available for a TS calculation for the *Oralee* survey, as the September 30 sample was more than 25 km away from the survey area, so a standard TS was used.
- The initial biomass estimate using the standard TS was 280 t. The biomass estimate for aggregation OR01 after minor edits to the files was 241 t.

Halifax/Eastern Shore Acoustic Survey #4: September 30, 2017

- This survey was conducted by one acoustic survey vessel, the *Emily & Aley* on September 30. The vessel conducted a fine-scale systematic parallel transect grid on one aggregation of fish (Figure 98).
- This school was included over those from September 26 and 29, in keeping with an interval of 10 days or more between surveys.
- The September 30 multi-panel sample maturity analyses showed that 83% of the fish were Stage 5 “maturing” condition and 17% of the fish were in the Stage 6 “ripe and running” condition (Figure 81C). The sample with a weighted mean length of 30.5 cm and a mean weight of 229 g (Figure 96B) was used to generate the TS.
- The initial biomass estimate using the standard TS was 19,803 t. The biomass estimate after minor edits to the files and using the sample generated TS was 21,110 t for the one school.

Halifax/Eastern Shore Acoustic Survey #5: October 7, 2017

- This survey was conducted by two acoustic survey vessels, the *Oralee* and *Emily & Aley,* on October 7 (Figure 99A). The vessels conducted fine-scale systematic parallel transect grids on two aggregations of fish. As with earlier surveys in this area, these were dense aggregations down to bottom, leading to difficulty delineating the bottom of the schools.
- Both aggregations were used as they were separated by sufficient time and space from previous and future surveys, so the possibility of double counting was minimized.
- The October 8 multi-panel sample was utilized to calculate the TS for both surveys. Maturity analyses showed that 67% of the fish were Stage 5 “maturing” condition and 32% of the fish were in the Stage 6 “ripe and running” condition (Figure 81C). The sample had a weighted mean length of 29.6 cm and a mean weight of 197 g (Figure 99B).
- The initial biomass estimate using the standard TS was 7,187 t. The biomass estimate after minor edits to the files and using the sample generated TS for both schools was 6,888 t.

Halifax/Eastern Shore Acoustic Survey #6: October 16, 2017

- This survey was conducted by one acoustic survey vessel, the *Miss Owl’s Head,* on October 16. The vessel conducted a fine-scale systematic parallel transect grid on one aggregation (Figure 100A). This was a dense aggregation down to bottom, leading to difficulty delineating the bottom of the school.
- This aggregation was sufficiently separated by area from previous surveys, south of previous schools, and therefore was included in the overall biomass estimate.

- A multi-panel sample was available for calculation of TS from October 17 and was collected from the mid-survey area (Figure 100A). Maturity analyses showed that 66% of the fish were Stage 5 “maturing” condition and 23% of the fish were in the Stage 6 “ripe and running” condition (Figure 81C). The sample with a weighted mean length of 29.0 cm and mean weight of 176 g (Figure 100B) was used to generate the TS.
- The initial biomass estimate for this aggregation using the standard TS was 5,964 t.
- The biomass estimate after minor edits to the files and using the sample generated TS was 5,411 t for this school.

<u>Halifax/Eastern Shore Acoustic Survey #7: October 21, 2017</u>

- This survey was conducted by two acoustic survey vessels, the *Miss Owl’s Head* and *Emily & Aley,* on October 21 (Figure 101A). The vessels conducted fine-scale systematic parallel transect grids on two aggregations. As with earlier surveys in this area, these were dense aggregations down to bottom, leading to difficulty delineating the bottom of the school.
- Both of these schools were surveyed on consecutive days, and therefore the higher biomass estimate of each school was used in the overall estimate.
- Only one aggregation (Ea01) from this date was used since the second school was also surveyed on October 22.
- A multi-panel sample was available for calculation of TS from October 22 and was collected next to the area surveyed (Figure 101A). Maturity analyses showed that 69% of the fish were Stage 5 “maturing” condition and 16% of the fish were in the Stage 6 “ripe and running” condition (Figure 81C). The sample weighted mean length of 27.1 cm and mean weight of 147 g was used to generate the TS (Figure 101B).
- The initial biomass estimate using the standard TS for the one school was 2,462 t. The biomass estimate after minor edits to the files and using the sample generated TS was 2,067 t.

<u>Halifax/Eastern Shore Acoustic Survey #8: October 22, 2017</u>

- This survey was conducted by two acoustic survey vessels, the *Miss Owl’s Head* and *Emily & Aley,* on October 22 (Figure 102A). The vessels conducted fine-scale systematic parallel transect grids on two aggregations of fish. As with earlier surveys in this area, these were dense aggregations down to bottom, leading to delineating the bottom of the school.
- Since both these schools were surveyed on two consecutive days, the higher biomass estimate of each school was used in the overall estimate and only the aggregation surveyed by the *Miss Owl’s Head* was used from this date.
- A multi-panel sample was available for calculation of TS from October 23 and was collected next to the area surveyed by *Miss Owl’s Head* (Figure 102A). Maturity analyses showed that 67% of the fish were Stage 5 “maturing” condition and 28% of the fish were in the Stage 6 “ripe and running” condition (Figure 81C). The sample had a weighted mean length of 28.7 cm and a mean weight of 183 g (Figure 102B).
- The initial biomass estimate using the standard TS for the one school was 5,160 t. The biomass estimate after minor edits to the files and using the sample generated TS was 4,681 t.

<u>Halifax/Eastern Shore Acoustic Survey #9: November 11, 2017</u>

- This survey was conducted by two acoustic survey vessels, the *Oralee* and *Emily & Aley* on November 11 (Figure 103A). Both vessels conducted a fine-scale systematic parallel transect grid on one aggregation only, but at different times. The survey lines by the *Oralee* were satisfactory, but could have been straighter.

- During the *Oralee* grid (02:00), the targets were higher off bottom than when the *Emily & Aley* conducted the survey (05:00). For the *Emily & Aley* survey, there was some difficulty delineating the bottom of the school.
- After reviewing the two grids in some detail, one plausible conclusion is that, as the night progressed, the school increased in density, partially from recruitment from outside the original school, and moved to the bottom, perhaps for a spawning event.
- The survey by the *Emily and Aley* had the higher biomass of the two surveys and was used as the biomass estimate.
- A multi-panel sample was available for calculation of TS from November 11 and was collected within the survey area (Figure 103A). Maturity analyses showed that 77% of the fish were Stage 5 "maturing" condition and 20% of the fish were in the Stage 6 "ripe and running" condition (Figure 81C). The sample had weighted mean length of 29.1 cm and mean weight of 187 g (Figure 103B).
- The initial biomass estimate using the standard TS for this school was 7,016 t. The biomass estimate after minor edits to the files and using the sample generated was 6,556 t.

Halifax/Eastern Shore Acoustic Survey #10: November 12, 2017

- This survey was conducted by one acoustic survey vessel, the *Miss Owl's Head,* on November 12. The vessel conducted a fine-scale systematic parallel transect grid on one aggregation (Figure 104A). This was a relatively dense aggregation down to bottom, but not tight to bottom.
- This aggregation was sufficiently separated by a distance of 62 km, from the survey on November 11, and therefore was included in the overall biomass estimate.
- The November 11 multi-panel sample was too far away from this survey location, so the standard TS was used.
- The initial biomass estimate for this aggregation using the standard TS was 872 t. The biomass estimate after edits and using the standard TS was 857 t.

Halifax/Eastern Shore Acoustic Survey Summary for 2017

There were ten acoustic surveys in the Halifax/Eastern Shore area in 2017. There were eight multi-panel samples available from all surveys, but, in two cases, samples were deemed to be too distant to the survey area and the standard TS was used instead. Not all surveys and aggregations were included in the overall biomass estimate, primarily as the survey intervals or separation of schools was insufficient to reduce the possibility of double counting. The estimated total spawning biomass increased slightly from 2016 to 58,681 t, but was still less than the nine-year high of 68,562 t in 2015 (Figure 105).

A major concern or source of uncertainty is the assumption that the surveys are simply additive. If Herring do not move 'on to' and 'off of' the spawning grounds in waves, the estimate of total SSB will be significantly biased upward due to double counting. Another major issue, which was addressed at the 2007 Herring framework review (DFO 2007), is the use of these estimates as absolute measures of biomass due to the many uncertainties, especially with the TS.

Although no spawning surveys were conducted between Liverpool and Chebucto Head, commercial landings during the spawning seasons in 2015, 2016, and 2017 were reported from the area (Table 12, Figure 106). Further investigation of the area is required to determine if Herring are spawning in the area or just in transit to other spawning grounds.

Glace Bay Fishery and Surveys

2015–2017 Glace Bay Acoustic Surveys and Fishery

There was no acoustic survey conducted in the Glace Bay survey box during 2015 to 2017 and only 4 t landings was reported in 2015 with no landings being reported in 2015 and 2017. There has not been a significant fishery in the area since 2006 when the landings were 85 t (Table 13A, Figure 107).

Bras d’Or Lakes Fishery and Surveys

There has been no survey activity in the Bras d’Or Lakes area since 2001. There has been no fisheries catches since 2003 (Table 13A).

Overall Coastal Nova Scotia Spawning Component

Spawning biomass has fluctuated annually in the Little Hope/Port Mouton area since the beginning of the acoustic surveys in 1998. The spawning biomass estimate, which was at a five-year low in 2012 (12,756 t), increased substantially to a historic high in 2015 (145,395 t) and then decreased to 61,406 t in 2016. The biomass in 2017 increased to 66,815 t (Figure 77, Table 13B). The biomass estimate has climbed above the long-term average (1998–2017) of 38,659 t. The Halifax/Eastern Shore area has also shown variability in SSB, from an estimate for the area of below 10,000 t from 2011 to 2104 (Table 13B, Figure 105). Since 2015, there has been a substantial improvement in the SSB estimate, with estimates averaging over 50,000 t. The estimates over the last three years are well above the long-term average of 33,606 t. Landings have been much steadier, being close to the allocation limits in each of the last five years in the Little Hope/Port Mouton area, except in 2017 when there was still room for additional 1,247 t. Landings in the Halifax/Eastern Shore area have also recently (2014–2107) been closer to the allocation limits, which is an improvement because in prior years the landings were well below the allocation since 2010 (Table 13A). For the Glace Bay area, there have been essentially no landings since 2005, partly due to availability and partly due to markets. Annual surveys in the area could not find any significant aggregations of spawning Herring since about the same time (Figure 107, Tables 13A and 13B). Along the coast from Liverpool to Chebucto Head there were 7 t in 2015, 1 t in 2016 and 592 t in 2017 reported landings (Table 12, Figure 106). It is likely that some of the 2017 landings were actually caught in the Little Hope. Landings here were based on the reporting port and not on the actual fishing area.

2016 Mortality Event

During November and December 2016, a Herring mortality event occurred on the Nova Scotia side of the Bay of Fundy. Most of the event was concentrated in St. Mary’s Bay; however, dead Herring also washed up in Annapolis Basin and southwest Nova Scotia. The cause of the mortality event remains undetermined. Figures 108 and 109 show the length-frequency and maturity plots from the samples collected related to the mortality event. From an acoustic survey in St. Mary’s Bay, a biomass of over 11,700 t of Herring was estimated to be present in the area during the event (Table 8, Figure 110). The proportion of biomass actually affected is unknown but is likely small. The majority of the dead Herring were immature fish of ages 2 and 3. If the number of fish involved in the mortality event was small, the impact of this event on future SSB is expected to negligible.

Offshore Scotian Shelf Component

Fleet activity/catch in the spring/early summer fishery on the offshore banks of the Scotian Shelf has varied between 1,000–20,000 t since 1996 (Figure 111). In 2015, fishing occurred from May 18 to June 14 with a total catch of 1,763 t being reported. In 2016, fishing occurred from April 30 to June 2 with a total catch of 1,000 t being reported. In 2017, fishing occurred from May 9 to August 13 with a total catch of 3,945 t being reported. The total catch is still well below the long-term average, since 1996, of 6,343 t. Fishery samples during the years 2015–2017 showed that the majority of fish were either Stages 2 (immature), 3 or 4 “maturing/hard” fish (predominantly Stage 3, Figures 112A, 112B, and 112C). There were also a large percentage of Stage 8 “recovering” fish, and a small percentage of Stages 1 and 2 “immature” fish. Length-frequency samples also indicate that most of the fish were larger than 23 cm (Figures

113A, 113B, and 113C). No acoustic biomass estimates were available from the Scotian Shelf for the reporting years (2015–2017). There continues to be a need for Herring research on the Scotian Shelf in the fall.

ACKNOWLEDGEMENTS

The authors would like to thank the following for their invaluable contributions to the provision of survey data and other assistance in the preparation of this report: Atlantic Herring Co-Op; Comeau's Sea Foods Ltd.; Connors Bros. Ltd.; Eastern Shore Fishermen's Protective Association; Glace Bay Herring Gillnet Group; Little Hope Management Committee; Scotia Garden Seafood Inc.; Sea Crest Fisheries Ltd. and South-West Seiners.

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TABLES

Table 1. Summary of the number of surveys undertaken in 2015, 2016, and 2017, and the number of surveys examined in the estimation of spawning stock biomass (SSB) for the Atlantic Herring 4VWX stock and coastal component complexes. Numbers in brackets indicate numbers of excluded survey.

Spawning Grounds	Number of Surveys		
	2015	2016	2017
Offshore Banks	0	0	0
Scots Bay	6	6	8
German Bank	5 (+3)	5 (+1)	5 (+1)
Spectacle Buoy	0	0	3
Trinity Ledge	1 (+1)	3	4
Little Hope	4	6	6
Eastern Shore	4 (+1)	7 (+3)	10
Glace Bay	0	0	0
Total	21 (+4)	27 (+4)	36 (+1)

Table 2A. Summary of completed Herring acoustic surveys undertaken in 2015 with interval (days) between surveys on the same grounds, number of boats with acoustic systems.

No.	Survey Date	Location of Survey	Interval (days)	Acoustic Boats	Total No. Boats
1	27-Jun-15	Scots Bay #1	0	6	6
2	11-Jul-15	Scots Bay #2	14	7	7
3	25-Jul-15	Scots Bay #3	14	8	8
4	08-Aug-15	Scots Bay #4	14	8	8
5	22-Aug-15	Scots Bay #5	14	5	5
6	08-Sep-15	Scots Bay #6	17	3	3
7	04-Sep-15	Trinity Ledge #1*	0	1	1
8	11-Sep-15	Trinity Ledge #2	7	1	1
9	17-Aug-15	German Bank #1	0	8	8
10	01-Sep-15	German Bank #2	15	7	7
10a	10-Sep-15	German Bank #2a*	9	6	6
11	13-Sep-15	German Bank #3	12	7	7
12	21-Sep-15	German Bank #4*	8	6	6
13	27-Sep-15	German Bank #5	6	7	7
14	05-Oct-15	German Bank #6*	8	6	6
15	12-Oct-15	German Bank #7	7	7	7
1	24-Sep-15	Little Hope #1	0	2	2
2	07-Oct-15	Little Hope #2	13	2	2
3	18-Oct-15	Little Hope #3	11	2	2
4	04-Nov-15	Little Hope #4	17	2	2
1	27-Sep-15	Eastern Shore #1	0	1	1
2	05-Oct-15	Eastern Shore #2*	8	3	3
3	10-Oct-15	Eastern Shore #3	5	2	2
4	16-Oct-15	Eastern Shore #4	6	2	2
5	27-Oct-15	Eastern Shore #5	11	1	1
Total number of survey boat nights				110	110

* Excluded from analysis due to number of days between surveys.

Table 2B. Summary of completed Herring acoustic surveys undertaken in 2016 with interval (days) between surveys on the same grounds, number of boats with acoustic systems.

No.	Survey Date	Location of survey	Interval (days)	Acoustic Boats	Total No. Boats
1	18-Jun-16	Scots Bay #1	0	5	5
2	02-Jul-16	Scots Bay #2	14	7	7
3	16-Jul-16	Scots Bay #3	14	9	9
4	30-Jul-16	Scots Bay #4	14	9	9
5	13-Aug-16	Scots Bay #5	14	8	8
6	27-Aug-16	Scots Bay #6	14	6	6
7	12-Aug-16	Trinity Ledge #1	0	1	1
8	29-Aug-16	Trinity Ledge #2	17	1	1
9	13-Sep-16	Trinity Ledge #3	15	1	1
1	21-Aug-16	German Bank #1	0	7	7
2	01-Sep-16	German Bank #2	11	6	6
3	12-Sep-16	German Bank #3	11	8	8
4	19-Sep-16	German Bank #4*	7	7	7
5	26-Sep-16	German Bank #5	14	7	7
6	07-Oct-16	German Bank #6	11	7	7
1	13-Sep-16	Little Hope #1	0	2	2
2	23-Sep-16	Little Hope #2	10	2	2
3	04-Oct-16	Little Hope #3	11	2	2
4	17-Oct-16	Little Hope #4	13	2	2
5	01-Nov-16	Little Hope #5	15	2	2
6	14-Nov-16	Little Hope #6	13	1	1
1	13-Sep-16	Eastern Shore #1	0	1	1
2	28-Sep-16	Eastern Shore #2	15	1	1
3	30-Sep-16	Eastern Shore #3	2	2	2
4	01-Oct-16	Eastern Shore #4	1	1	1
5	02-Oct-16	Eastern Shore #5	1	3	3
6	05-Oct-16	Eastern Shore #6	3	2	2
7	12-Oct-16	Eastern Shore #7	7	3	3
8	19-Oct-16	Eastern Shore #8	7	1	1
9	25-Oct-16	Eastern Shore #9	6	1	1
10	05-Nov-16	Eastern Shore #10	11	1	1
Total number of survey boat nights				123	123

* Excluded from analysis due to number of days between surveys.

Table 2C. Summary of completed Herring acoustic surveys undertaken in 2017 with interval (days) between surveys on the same grounds, number of boats with acoustic systems.

No.	Survey Date	Location of survey	Interval (days)	Acoustic Boats	Total No. Boats
1	21-Jun-17	Scots Bay #1	0	6	5
2	01-Jul-17	Scots Bay #2	10	7	7
3	15-Jul-17	Scots Bay #3	14	8	8
4	29-Jul-17	Scots Bay #4	14	7	7
5	12-Aug-17	Scots Bay #5	14	7	7
6	26-Aug-17	Scots Bay #6	14	8	8
7	08-Sep-17	Scots Bay #7	13	3	3
8	23-Sep-17	Scots Bay #8	15	3	3
1	12-Aug-17	Trinity Ledge #1	0	1	1
2	22-Aug-17	Trinity Ledge #2	10	1	1
3	29-Aug-17	Trinity Ledge #3	7	1	1
4	08-Sep-17	Trinity Ledge #4	10	1	1
1	25-Aug-17	Spec Buoy #1	0	1	1
2	04-Sep-17	Spec Buoy #2	10	1	1
3	16-Sep-17	Spec Buoy #3	12	1	1
1	21-Aug-17	German Bank #1	0	9	9
2	08-Sep-17	German Bank #2	18	8	8
3	17-Sep-17	German Bank #3**	9	8	8
4	01-Oct-17	German Bank #4*	14	7	7
5	06-Oct-17	German Bank #5	5	6	6
6	18-Oct-17	German Bank #6	12	6	6
1	15-Sep-17	Little Hope #1	0	3	3
2	26-Sep-17	Little Hope #2	10	2	2
3	06-Oct-17	Little Hope #3	11	3	3
4	17-Oct-17	Little Hope #4	13	2	2
5	28-Oct-17	Little Hope #5	15	3	3
6	07-Nov-17	Little Hope #6	13	2	2
1	15-Sep-17	Eastern Shore #1	0	2	2
2	26-Sep-17	Eastern Shore #2	11	1	1
3	29-Sep-17	Eastern Shore #3	3	2	2
4	30-Sep-17	Eastern Shore #4	1	1	1
5	07-Oct-17	Eastern Shore #5	7	2	2
6	16-Oct-17	Eastern Shore #6	9	1	1
7	21-Oct-17	Eastern Shore #7	5	2	2
8	22-Oct-17	Eastern Shore #8	1	2	2
9	11-Nov-17	Eastern Shore #9	20	2	2
10	12-Nov-17	Eastern Shore #10	1	1	1
Total number of survey boat nights				131	131

* Excluded from analysis due to number of days between surveys.

**Initially excluded, subsequently included at assessment 2018 meeting (see Melvin et al. 2020).

Table 3A. Summary of 2015 fish sampled by survey date and location with Target Strength (TS) estimate from samples and TS estimate for a 28 cm Herring using the length/weight equation. A dash (-) indicates no data.

Date of Survey	Location of survey	Interval (days)	Number of Length Samples	Number of Fish Measured	Number Len/Wt Fish	Mean Length (mm)	Mean Weight (gm)	Target Strength dB/kg	Wt 28 cm Fish (gm)	TS 28 cm Fish dB/kg
27-Jun-15	Scots Bay #1	0	15	2,682	282	271	167	-35.449	185	-35.619
11-Jul-15	Scots Bay #2	14	23	4,435	251	273	163	-35.311	179	-35.495
25-Jul-15	Scots Bay #3	14	13	2,589	139	282	187	-35.625	183	-35.582
08-Aug-15	Scots Bay #4	14	24	4,586	170	282	188	-35.640	184	-35.599
22-Aug-15	Scots Bay #5	14	15	2,699	77	275	181	-35.688	193	-35.801
08-Sep-15	Scots Bay #6	17	10	1,960	102	269	166	-35.489	191	-35.757
11-Sep-15	Trinity Ledge #2	0	0	0	0	280*	180	-35.959	180	-35.959
17-Aug-15	German Bank #1	0	20	3,786	131	284	190	-35.612	179	-35.496
01-Sep-15	German Bank #2	15	25	4,598	127	278	172	-35.376	176	-35.419
10-Sep-15	German Bank #2a	9				Not Calculated				
13-Sep-15	German Bank #3	3	16	2,823	103	279	175	-35.415	177	-35.443
21-Sep-15	German Bank #4	8	-	-	-	-	-	-	-	-
27-Sep-15	German Bank #5	6	6	1,189	133	267	151	-35.159	178	-35.466
05-Oct-15	German Bank #6	8				Not Calculated				
12-Oct-15	German Bank #7	7	0	0	0	280*	180	-35.500	180	-35.510
24-Sep-15	Little Hope #1	0	1	146	146	281	182	-35.989	181	-35.989
07-Oct-15	Little Hope #2	13	1	159	159	284	184	-35.937	176	-35.937
18-Oct-15	Little Hope #3	11	1	161	161	288	193	-36.026	181	-36.026
04-Nov-15	Little Hope #4	17	1	62	62	272	166	-35.839	181	-35.839
27-Sep-15	Eastern Shore #1	0	1	0	0	280*	180	-35.959	180	-35.959
05-Oct-15	Eastern Shore #2	8	1	73	73	291	195	-35.988	176	-35.988
10-Oct-15	Eastern Shore #3	5	1	252	252	288	188	-35.902	174	-35.902
16-Oct-15	Eastern Shore #4	6	1	127	127	292	197	-35.998	178	-35.998
27-Oct-15	Eastern Shore #5	11	1	233	233	280	174	-35.823	175	-35.823

Note: values used for 50kHz system when no sampling was available. Further adjustments also made for frequency of systems used.
* Standard length, weight, target strength.

Table 3B. Summary of 2016 fish sampled by survey date and location with Target Strength (TS) estimate from samples and TS estimate for a 28 cm Herring using the length/weight equation.

Date of Survey	Location of survey	Interval (days)	Number of Length Samples	Number of Fish Measured	Number Len/Wt Fish	Mean Length (mm)	Mean Weight (gm)	Target Strength dB/kg	Wt 28 cm Fish (gm)	TS 28 cm Fish dB/kg
18-Jun-16	Scots Bay #1	0	12	2,263	151	272	162	-35.300	178	-35.467
02-Jul-16	Scots Bay #2	14	20	3,816	260	267	154	-35.255	183	-35.575
16-Jul-16	Scots Bay #3	14	10	1,898	205	266	153	-35.246	181	-35.536
30-Jul-16	Scots Bay #4	14	21	4,064	303	272	171	-35.534	188	-35.693
13-Aug-16	Scots Bay #5	14	16	2,983	144	276	176	-35.543	185	-35.625
27-Aug-16	Scots Bay #6	14	0	0	0	280**	180	-35.500	180	-35.500
12-Aug-16	Trinity Ledge #1	0	0	0	0	280*	180	-35.959	180	-35.959
29-Aug-16	Trinity Ledge #2	17	0	0	0	280*	180	-35.959	180	-35.959
13-Sep-16	Trinity Ledge #3	15	0	0	0	280*	180	-35.959	180	-35.959
21-Aug-16	German Bank #1	0	12	2,172	236	276	168	-35.315	175	-35.382
01-Sep-16	German Bank #2	11	8	1,491	95	275	166	-35.312	176	-35.408
12-Sep-16	German Bank #3	11	14	2,600	145	277	167	-35.295	173	-35.347
19-Sep-16	German Bank #4	7	9	1,783	98	259	131	-34.829	166	-35.147
26-Sep-16	German Bank #5	14	4	738	0	280**	180	-35.500	180	-35.500
07-Oct-16	German Bank #6	11	0	0	0	280**	180	-35.500	180	-35.500
13-Sep-16	Little Hope #1	0	1	93	93	280	171	-35.747	172	-35.761
23-Sep-16	Little Hope #2	10	1	132	132	274	163	-35.722	174	-35.987
04-Oct-16	Little Hope #3	11	1	130	130	276	164	-35.701	172	-35.903
17-Oct-16	Little Hope #4	13	1	108	108	286	184	-35.878	173	-35.609
01-Nov-16	Little Hope #5	15	1	172	172	291	193	-35.941	172	-35.446
14-Nov-16	Little Hope #6	13	0	0	0	280*	180	-35.959	180	-35.959
13-Sep-16	Eastern Shore #1	0	1	199	199	294	204	-36.085	183	-35.623
28-Sep-16	Eastern Shore #2	15				Not calculated				
30-Sep-16	Eastern Shore #3	2	1	321	321	293	195	-35.899	167	-35.240
01-Oct-16	Eastern Shore #4	1				Not calculated				
02-Oct-16	Eastern Shore #5	1	1	321	321	293	196	-35.905	167	-35.231
05-Oct-16	Eastern Shore #6	3	1	321	321	292	192	-35.870	167	-35.286
12-Oct-16	Eastern Shore #7	7	1	190	190	282	172	-35.683	167	-35.572
19-Oct-16	Eastern Shore #8	7				Not calculated				
25-Oct-16	Eastern Shore #9	6	1	183	183	281	169	-35.658	168	-35.630
05-Nov-16	Eastern Shore #10	11	0	0	0	280*	180	-35.959	180	-35.959

Note: values used for 50 kHz system when no sampling was available. Further adjustments also made for frequency of systems used.
* Standard length, weight, target strength. ** Standard length, weight, target strength for 38 kHz.

Table 3C. Summary of 2017 fish sampled by survey date and location with Target Strength (TS) estimate from samples and TS estimate for a 28 cm Herring using the length/weight equation.

Date of Survey	Location of survey	Interval (days)	Number of Length Samples	Number of Fish Measured	Number Len/Wt Fish	Mean Length (mm)	Mean Weight (gm)	Target Strength dB/kg	Wt 28 cm Fish (gm)	TS 28 cm Fish dB/kg
21-Jun-17	Scots Bay #1	0	14	2,694	143	266	138	-34.790	163	-35.074
01-Jul-17	Scots Bay #2	10	11	2,041	158	281	171	-35.270	170	-35.252
15-Jul-17	Scots Bay #3	14	0	0	0	280**	180	-35.500	180	-35.500
29-Jul-17	Scots Bay #4	14	19	4,053	119	271	153	-35.083	171	-35.281
12-Aug-17	Scots Bay #5	14	22	4,154	139	259	128	-34.699	164	-35.110
26-Aug-17	Scots Bay #6	14	22	4,158	85	262	135	-34.848	167	-35.172
08-Sep-17	Scots Bay #7	13	6	1,225	30	254	116	-34.480	159	-34.975
23-Sep-17	Scots Bay #8	15	12	2,114	58	255	122	-34.634	162	-35.050
12-Aug-17	Trinity Ledge #1	0	0	0	0	280*	180	-35.959	180	-35.959
22-Aug-17	Trinity Ledge #2	10	1	141	141	261	136	-34.915	173	-35.345
29-Aug-17	Trinity Ledge #3	7	1	190	190	263	140	-34.988	172	-35.311
08-Sep-17	Trinity Ledge #4	10	1	252	252	259	131	-34.820	168	-35.206
25-Aug-17	Spec Buoy #1	0	1	47	47	241	103	-34.369	165	-35.140
04-Sep-17	Spec Buoy #2	10	0	0	0	280*	180	-35.959	180	-35.959
16-Sep-17	Spec Buoy #3	12	1	193	192	252	115	-34.496	163	-35.071
21-Aug-17	German Bank #1	0	19	3,561	202	262	132	-34.714	164	-35.116
08-Sep-17	German Bank #2	18	12	2,159	152	264	133	-34.707	161	-35.030
17-Sep-17	German Bank #3	9	14	2,605	77	259	125	-34.593	159	-34.984
01-Oct-17	German Bank #4	14	0	0	0	280**	180	-35.500	180	-35.500
06-Oct-17	German Bank #5	5	4	745	181	288.01	166	-34.919	159	-34.794
18-Oct-17	German Bank #6	12	0	0	0	280**	180	-35.500	180	-35.500
15-Sep-17	Little Hope #1	0	1	93	93	280	171	-35.747	172	-35.761
26-Sep-17	Little Hope #2	10	1	132	132	274	163	-35.722	174	-35.987
06-Oct-17	Little Hope #3	11	1	130	130	276	164	-35.701	172	-35.903
17-Oct-17	Little Hope #4	13	1	108	108	286	184	-35.878	173	-35.609
28-Oct-17	Little Hope #5	15	1	172	172	291	193	-35.941	172	-35.446
07-Nov-17	Little Hope #6	13	0	0	0	280*	180	-35.959	180	-35.959
15-Sep-17	Eastern Shore #1	0	1	132	132	285	179	-35.792	170	-35.588
15-Sep-17	Eastern Shore #1	0	1	109	109	283	176	-35.798	170	-35.536
26-Sep-17	Eastern Shore #2	11	1	101	101	303	224	-36.245	185	-35.314
29-Sep-17	Eastern Shore #3	3	0	0	0	280*	180	-35.959	180	-35.959
30-Sep-17	Eastern Shore #4	1	1	101	101	303	224	-36.245	185	-35.314
07-Oct-17	Eastern Shore #5	7	1	110	110	294	193	-35.862	167	-35.132
16-Oct-17	Eastern Shore #6	9	1	94	94	289	173	-35.541	157	-35.057

Date of Survey	Location of survey	Interval (days)	Number of Length Samples	Number of Fish Measured	Number Len/Wt Fish	Mean Length (mm)	Mean Weight (gm)	Target Strength dB/kg	Wt 28 cm Fish (gm)	TS 28 cm Fish dB/kg
21-Oct-17	Eastern Shore #7	5	1	209	209	276	157	-35.363	163	-35.820
22-Oct-17	Eastern Shore #8	1	1	67	67	287	182	-35.807	175	-35.617
11-Nov-17	Eastern Shore #9	20	1	131	130	293	190	-35.780	165	-35.239
12-Nov-17	Eastern Shore #10	1	0	0	0	280*	180	-35.959	180	-35.959

Note: values used for 50 kHz system when no sampling was available. Further adjustments also made for frequency of systems used.
* Standard length, weight, target strength. ** Standard length, weight, target strength for 38 kHz.

Table 4A. Summary of the 2015 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).

Location/Type	Date	Target Strength (dB/kg)	Area (km²)	Weighted Sa (dB/m²)	Density (kg/m²)	Biomass (t)	Standard Error (t)	SE %
Scots Bay (inbox)	27-Jun-15	-35.449	728.00	-44.909	0.1164	82,428	24,799	30%
	11-Jul-15	-35.311	688.00	-45.722	0.0935	62,598	13,636	22%
	25-Jul-15	-35.625	693.00	-48.198	0.0595	38,318	10,381	27%
	08-Aug-15	-35.640	732.00	-49.343	0.0424	31,203	8,737	28%
	22-Aug-15	-35.688	654.00	-49.157	0.0435	29,424	11,893	40%
	08-Sep-15	-35.489	673.00	-51.662	0.0251	16,245	5,298	33%
Scots Bay total for standard survey area (inbox)						260,215	16,055	6%
Scots Bay (outbox)	11-Jul-15	-35.311	128.00	-43.579	0.1346	19,075	9,137	48%
	25-Jul-15	-35.625	112.00	-57.631	0.0060	706	243	34%
	25-Jul-15	-35.625	75.00	-51.016	0.0219	2,168	542	25%
	08-Aug-15	-35.640	121.00	-54.869	0.0091	1,586	842	58%
	08-Aug-15	-35.640	79.00	-52.613	0.0204	1,445	215	14%
Scots Bay total for non-standard survey area (outbox)						24,979	471	2%
Scots Bay overall total all survey areas						285,194	13,389	5%

Table 4B. Summary of the 2016 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).

Location/Type	Date	Target Strength (dB/kg)	Area (km²)	Weighted Sa (dB/m²)	Density (kg/m²)	Biomass (t)	Standard Error (t)	SE %
Scots Bay (inbox)	18-Jun-16	-35.300	665.16	-49.729	0.0381	23,989	14,461	60%
	02-Jul-16	-35.255	640.25	-47.294	0.0659	40,032	11,575	29%
	16-Jul-16	-35.246	640.55	-54.000	0.0135	8,534	2,140	25%
	30-Jul-16	-35.534	626.20	-53.618	0.0157	9,734	3,557	37%
	13-Aug-16	-35.543	642.71	-49.702	0.0360	24,666	17,600	71%
	27-Aug-16	-35.500	623.96	-58.612	0.0048	3,047	719	24%
Scots Bay total for standard survey area (inbox)						110,002	10,312	9%
Scots Bay (outbox)	02-Jul-16	-35.255	80.66	-54.062	0.0129	1,062	234	22%
	16-Jul-16	-35.246	82.35	-58.252	0.0049	412	48	12%
	16-Jul-16	-35.246	136.66	-59.814	0.0032	477	175	37%
	30-Jul-16	-35.534	89.00	-56.947	0.0072	643	66	10%
	30-Jul-16	-35.534	139.80	-58.021	0.0048	788	521	66%
	13-Aug-16	-35.543	78.43	-52.136	0.0215	1,719	410	24%
	13-Aug-16	-35.543	133.32	-59.258	0.0045	567	183	32%
Scots Bay total for non-standard survey area (outbox)						5,667	284	5%
Scots Bay overall total all survey areas						115,669	8,816	8%

Table 4C. Summary of the 2017 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).

Location/Type	Date	Target Strength (dB/kg)	Area (km²)	Weighted Sa (dB/m²)	Density (kg/m²)	Biomass (t)	Standard Error (t)	SE %
Scots Bay (inbox)	21-Jun-17	-34.790	626.84	-43.990	0.1159	75,364	28,362	38%
	01-Jul-17	-35.270	664.42	-49.702	0.0367	23,947	4,014	17%
	15-Jul-17	-35.500	646.61	-51.449	0.0239	16,433	8,310	51%
	29-Jul-17	-35.083	668.82	-55.580	0.0085	5,965	1,333	22%
	12-Aug-17	-34.699	643.38	-50.270	0.0273	17,838	11,217	63%
	26-Aug-17	-34.848	629.01	-52.483	0.0159	10,843	5,566	51%
	08-Sep-17	-34.480	346.21	-50.741	0.0248	8,188	4,960	61%
	23-Sep-17	-34.634	343.36	-57.559	0.0051	1,751	163	9%
Scots Bay total for standard survey area (inbox)						160,330	12,308	8%
Scots Bay (outbox)	01-Jul-17	-35.270	79.75	-49.939	0.0333	2,722	617	23%
	15-Jul-17	-35.500	80.31	-53.325	0.0161	1,325	417	31%
	15-Jul-17	-35.500	131.12	-48.242	0.0504	6,973	1522	22%
	29-Jul-17	-35.255	69.86	-58.858	0.0042	305	30	10%
	12-Aug-17	-34.699	86.36	-63.254	0.0014	120	37	31%
	26-Aug-17	-34.848	94.05	-55.904	0.0078	738	239	32%
	26-Aug-17	-34.848	131.19	-60.685	0.0023	342	258	75%
Scots Bay total for non-standard survey area (outbox)						12,525	654	5%
Scots Bay overall total all survey areas						172,855	10,664	6%

Table 5A. Summary of the 2015 German Bank spawning ground acoustic survey results and Spawning Stock Biomass (SSB) estimates for the standard survey box area (inbox) and for outside the survey box (outbox). A dash (-) indicates no data.

Location/Type	Date	Target Strength (dB/kg)	Area (km²)	Weighted Sa (dB/m²)	Density (kg/m²)	Biomass (t)	Standard Error (t)	SE %
German Bank (inbox)	17-Aug-15	-35.625	843.00	-57.661	0.0061	16,156	9,376	58%
	01-Sep-15	-35.376	805.00	-50.993	0.0282	64,219	27,219	42%
	13-Sep-15	-35.415	816.00	-47.307	0.0631	52,782	29,766	56%
	27-Sep-15	-35.159	645.00	-51.904	0.0229	39,242	17,880	46%
	12-Oct-15	-35.510	714.00	-58.037	0.0056	3,990	1,110	28%
German Bank inbox total (excluding Sept 10, Sept 21, Oct 5)						176,389	21,377	12%
German Bank (outbox) (not calculated)	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
-						-	-	-
German Bank overall						176,389	21,377	12%

Table 5B. Summary of the 2016 German Bank spawning ground acoustic survey results and Spawning Stock Biomass (SSB) estimates for the standard survey box area (inbox) and for outside the survey box (outbox).Note: Smaller survey areas on same dates were within the survey box. A dash (-) indicates no data.

Location/Type	Date	Target Strength (dB/kg)	Area (km²)	Weighted Sa (dB/m²)	Density (kg/m²)	Biomass (t)	Standard Error (t)	SE %
German Bank (inbox)	21-Aug-16	-35.315	650.42	-47.936	0.0551	35,565	8,856	25%
	01-Sep-16	-35.315	779.36	-53.432	0.0144	12,015	2,103	17%
	01-Sep-16	-35.315	47.80	-40.375	0.3146	14,899	5,959	40%
	12-Sep-16	-35.295	721.95	-47.887	0.0554	39,748	14,511	37%
	12-Sep-16	-35.295	45.09	-34.815	1.1087	50,356	33,013	66%
	19-Sep-16	-34.829	700.84	-51.411	0.0219	15,396	4,614	30%
	26-Sep-16	-35.515	701.33	-47.135	0.0700	48,906	32,038	66%
	07-Oct-16	-35.515	726.76	-57.989	0.0140	10,589	4,384	41%
German Bank inbox total (excluding Sept 19)						212,078	18,474	9%
German Bank (outbox) (not calculated)	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
-						-	-	-
German Bank overall						212,078	18,474	9%

Table 5C. Summary of the 2017 German Bank spawning ground acoustic survey results and Spawning Stock Biomass (SSB) estimates for the standard survey box area (inbox) and for outside the survey box (outbox).Note: Smaller survey areas on same dates were within the survey box. A dash (-) indicates no data.

Location/Type	Date	Target Strength (dB/kg)	Area (km²)	Weighted Sa (dB/m²)	Density (kg/m²)	Biomass (t)	Standard Error (t)	SE %
German Bank (inbox)	21-Aug-17	-34.726	819.58	-48.575	0.0414	33,839	10,175	30%
	08-Sep-17	-34.707	830.85	-45.785	0.0788	65,393	29,635	45%
	17-Sep-17	-34.607	841.28	-45.857	0.0749	62,935	33,366	53%
	01-Oct-17	-35.500	713.16	-59.240	0.0042	3,014	962	32%
	06-Oct-17	-35.315	822.33	-57.152	0.0066	5,386	1,885	35%
	18-Oct-17	-35.500	829.72	-49.861	0.0370	30,396	27,663	91%
German Bank inbox total (excluding Oct 1 only)						197,949	24256	12%
German Bank (outbox) (not calculated)	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
-						-	-	-
German Bank overall (includes September 17)						197,949	24256	12%

Table 6. Catch dates, catch, and acoustic survey biomass for the Spectacle Buoy and Trinity Ledge Herring fishery from 1998–2017. Survey biomass calculated with Calibration Integration Factor (CIF). 'n/s' indicates no survey and a dash (-) indicates data cannot be calculated.

Year	Spectacle. Buoy catches and surveys				Trinity Ledge Survey Box catches and surveys					Overall Stock Gillnet Catch(t)
	Start Day	End Day	Catch t	Survey SSB t*	Start Day	End Day	Catch t	Survey SSB t*	Exploitation Catch/SSB	
1998	10-May-98	30-Jun-98	484	n/s	24-Aug-98	21-Sep-98	1,668	n/s	n/s	2,153
1999	10-May-99	16-Jul-99	355	n/s	12-Aug-99	15-Sep-99	1,257	3,885	32%	1,612
2000	11-Jun-00	14-Jun-00	80	n/s	30-Aug-00	12-Sep-00	682	621	110%	814
2001	11-Jun-01	10-Jul-01	699	1,110	21-Aug-01	26-Sep-01	781	14,797	5%	1,576
2002	15-May-02	01-Jul-02	137	n/s	02-Sep-02	30-Sep-02	204	8,096	3%	378
2003	04-Jun-03	06-Jun-03	69	1,420	21-Aug-03	18-Sep-03	361	12,117	3%	439
2004	17-Jun-04	15-Jul-04	5	n/s	02-Sep-04	15-Sep-04	229	12,022	2%	229
2005	09-Jun-05	11-Jul-05	124	290	05-Sep-05	20-Sep-05	427	10,701	4%	570
2006	03-Jun-06	22-Jun-06	2	n/s	23-Aug-06	21-Sep-06	647	16,076	4%	719
2007	07-May-07	22-Jun-07	243	310	27-Aug-07	20-Sep-07	1,042	3,113	33%	1,334
2008	29-May-08	19-Jun-08	6	0	21-Aug-08	25-Sep-08	7	516	1%	15
2009	11-Jun-09	25-Jun-09	0.2	n/s	01-Sep-09	11-Sep-09	102	1,575	6%	117
2010	02-Jun-10	19-Jun-10	0	1,859	09-Aug-11	24-Sep-10	145	2,405	6%	204
2011	22-Jun-11	29-Jun-11	1	282	09-Aug-11	20-Sep-11	598	7,316	8%	638
2012	31-May-12	31-May-12	0	n/s	31-May-12	18-Sep-12	177	2,754	6%	471
2013	31-May-13	31-May-13	0	n/s	13-Aug-13	18-Sep-13	99	950	10%	1,270
2014	31-May-14	31-May-14	0	n/s	12-Aug-14	30-Sep-14	123	4,772	3%	1,661
2015	31-May-15	31-May-15	-	n/s	17-Aug-15	18-Sep-15	-	657	0%	1,634
2016	31-May-16	31-May-16	-	n/s	31-Jul-16	03-Oct-16	-	506	0%	1,661
2017	31-May-16	31-May-16	-	8,726	04-Jun-17	16-Sep-17	-	13,866	0%	2017
Spectacle Buoy Average			110	1,750	**Gillnet Average**		427	6,144	-	904

* Survey Spawning Stock Biomass (SSB) calculated with Calibration Integration Factor (CIF) after 2003 inclusive.

Table 7A. Biomass estimation for the 2015 Trinity Ledge acoustic surveys. Survey biomass was calculated with Calibration Integration Factor (CIF).

Location	Date	Mean Length (mm)	Target Strength (dB/kg)	Area (km²)	Weighted Sa (dB/m²)	Density (kg/m²)	Biomass (t)	Standard Error (t)	SE %
Trinity Ledge #1	04-Sep-15	280	-35.959	1.41	-50.32000	0.03489	49	18	36
Trinity Ledge #2	11-Sep-15	280	-35.959	0.67	-36.04248	1.06819	657	332	51%
Trinity Ledge total for 2015 (excluding Sept. 4)							657	332	51%

Table 7B. Biomass estimation for the 2016 Trinity Ledge acoustic surveys. Survey biomass was calculated with Calibration Integration Factor (CIF).

Location	Date	Mean Length (mm)	Target Strength (dB/kg)	Area (km²)	Weighted Sa (dB/m²)	Density (kg/m²)	Biomass (t)	Standard Error (t)	SE %
Trinity Ledge #1	12-Aug-16	280	-35.959	0.84	-57.74227	0.006152	6	1	24%
Trinity Ledge #2	29-Aug-16	280	-35.959	0.52	-37.14968	0.720972	395	86	22%
Trinity Ledge #3	13-Sep-16	280	-35.959	0.49	42.66221	0.238007	105	55	52%
Trinity Ledge total for 2016							506	54	11%

Table 7C. Biomass estimation for the 2017 Trinity Ledge acoustic surveys. Survey biomass was calculated with Calibration Integration Factor (CIF).

Location	Date	Mean Length (mm)	Target Strength (dB/kg)	Area (km²)	Weighted Sa (dB/m²)	Density (kg/m²)	Biomass (t)	Standard Error (t)	SE %
Trinity Ledge #1	12-Aug-17	280	-35.959	5.77	-46.21898	0.094189	547	47	9%
Trinity Ledge #2	22-Aug-17	256	-35.248	1.79	-41.74897	0.220927	401	113	28%
Trinity Ledge #3	29-Aug-17	261	-35.410	12.94	-37.22883	0.855269	8,513	4,076	48%
Trinity Ledge #4	08-Sep-17	258	-35.268	15.79	-40.81244	0.274232	4,405	1,860	42%
Trinity Ledge total for 2017							13,865	1,957	14%

Table 7D. Biomass estimation for the 2017 Spectacle Buoy acoustic surveys. Survey biomass was calculated with Calibration Integration Factor (CIF).

Location	Date	Mean Length (mm)	Target Strength (dB/kg)	Area (km²)	Weighted Sa (dB/m²)	Density (kg/m²)	Biomass (t)	Standard Error (t)	SE %
Spec #1	25-Aug-17	252	-35.050	0.82	-32.0213	2.190947	1,466	796	54%
Spec #2	04-Sep-17	280	-35.959	12.50	-41.8494	0.257610	3,564	1202	34%
Spec #3	16-Sep-17	250	-34.910	31.85	-43.8052	0.111578	3,697	3,171	86%
Spectacle Buoy total for 2017							8,726	2,044	23%

Table 8. Biomass estimation for the 2016 St. Mary's Bay acoustic surveys. Survey biomass was calculated with Calibration Integration Factor (CIF) and with sample Target Strength (TS).

Location	Date	Mean Length (mm)	Target Strength (dB/kg)	Area (km²)	Weighted Sa (dB/m²)	Density (kg/m²)	Biomass (t)	Standard Error (t)	SE %
St. Mary's Bay	29-Dec-16	280	-32.872	27.29	-36.54714	0.42784	11,707	8,662	74%
St. Mary's Bay total for 2016							11,707	8,662	74%

Biomass estimate using standard Target Strength (TS) was 21,493 t.

Table 9. Summary of the minimum observed Spawning Stock Biomass (SSB) for each of the surveyed spawning grounds in the SWNS/BoF component of the 4WX stock complex. Total SSB is rounded to nearest 100 t (except 2015, 2016 and 2017) (n/s = no survey). A dash (-) indicates no data. Shaded rows = sub-totals and totals. Note: Scots Bay 2014 data updated, Overall Standard Error (SE) (t and %) recalculated and updated for all years.

Location	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Average 2005 to 2010	Average 1999 to 2017
Scots Bay (inbox)	45,909	185,498	216,000	129,300	123,000	115,000	21,200	31,600	50,500	23,300	81,600	42,300	105,600	143,500	66,900	221,300	260,215	110,002	160,330	41,750	112,267
Scots Bay (outbox)	-	-	-	-	-	-	-	-	2,200	100	6,100	11,700	35,100	41,300	9,300	4,800	24,979	5,667	12,525	5,025	13,981
Scots Bay total	45,909	185,498	216,000	129,300	123,000	115,000	21,200	31,600	52,700	23,400	87,700	54,000	140,700	184,800	76,200	226,100	285,194	115,669	172,855	45,100	120,361
German Bank (inbox)	495,360	333,940	257,300	416,200	348,800	392,000	268,600	290,500	495,400	238,600	395,900	234,700	289,000	278,300	253,900	230,300	176,389	212,078	197,949	320,602	305,802
German Bank (outbox)	-	-	-	-	-	-	-	4,900	4,000	2,400	1,700	19,100	11,500	10,100	10,600	2,800	0	0	0	6,420	5,590
German Bank total	495,360	333,940	257,300	416,200	348,800	392,000	268,600	295,400	499,400	241,000	397,600	253,800	300,500	288,400	264,500	233,000	176,389	212,078	197,949	325,967	309,339
Trinity Ledge	4,061	1,336	14,800	8,900	12,100	12,000	10,700	16,100	3,100	500	1,600	2,400	7,300	2,800	900	4,800	657	506	13,866	5,733	6,234
Spec Buoy (spring)	-	-	1,100	-	1,200	n/s	600	n/s	300	0	-	1,900	300	n/s	n/s	n/s	n/s	n/s	n/s	700	771
Spec Buoy (fall)	-	-	87,500	-	-	-	-	30	-	-	-	-	-	-	-	-	-	-	8,726	30	32,085
Overall Stock Area	545,330	520,774	576,700	554,400	485,100	519,000	301,100	343,130	555,500	264,900	486,900	312,100	448,800	476,000	341,700	464,000	462,241	328,253	393,396	377,266	441,287
Seal Island	-	-	3,900	1,200	11,900	-	-	10,000	-	-	-	-	1,500	-	-	-	-	-	-	-	-
Browns Bank	-	-	45,100	-	-	-	-	7,700	-	-	-	-	-	-	-	-	-	-	-	-	-
Total All Areas	545,330	520,774	625,700	555,600	497,000	519,000	301,100	360,830	555,500	264,900	486,900	312,100	450,300	476,000	341,700	464,000	462,241	328,253	393,396	377,266	441,287
Overall SE (t)	24,488	22,715	5,961	25,406	24,646	25,199	35,843	16,876	38,290	24,758	29,039	11,609	25,339	11,664	17,214	22,640	17,044	13,705	14,352	-	-
Overall SE (%)	5%	4%	1%	5%	5%	5%	12%	5%	7%	9%	6%	4%	6%	2%	5%	5%	4%	4%	5%	-	-

Table 10A. The 2015 Herring acoustic surveys for Little Hope/Port Mouton with survey biomass and final total for the area (calculated with Calibration Integration Factor (CIF)).

Location	Date	Average TS (dB/kg)	Stratum Area (km²)	Weighted Mean Sa (dB/m²)	Biomass Density (kg/m²)	Strata Biomass (t)	Standard Error (t)	Standard Error %
Little Hope #1	24-Sep-15	-35.989	18.60	-34.516	1.4039	6,720	355	5%
Little Hope #2	07-Oct-15	-35.937	29.85	-37.467	0.7030	16,276	9,231	57%
Little Hope #3	18-Oct-15	-36.026	36.22	-36.728	0.8507	32,168	4,647	14%
Little Hope #4	04-Nov-15	-35.839	35.75	-32.102	2.3642	90,231	18,843	21%
Final 2015 Surveys		-35.948	120.42	-34.648	1.3489	145,396	11,282	8%

Table 10B. The 2016 Herring acoustic surveys for Little Hope/Port Mouton with survey biomass and final total for the area (calculated with Calibration Integration Factor (CIF)).

Location	Date	Average TS (dB/kg)	Stratum Area (km²)	Weighted Mean Sa (dB/m²)	Biomass Density (kg/m²)	Strata Biomass (t)	Standard Error (t)	Standard Error %
Little Hope #1	13-Sep-16	-35.747	18.95	-43.080	0.1848	3,572	495	14%
Little Hope #2	23-Sep-16	-35.722	30.96	-37.374	0.6837	19,108	5,363	28%
Little Hope #3	04-Oct-16	-35.701	1.74	-38.783	0.5159	856	422	49%
Little Hope #4	17-Oct-16	-35.878	7.00	-31.836	2.5362	16,999	3,968	23%
Little Hope #5	01-Nov-16	-35.941	3.45	-28.152	6.0106	19,858	4,765	24%
Little Hope #6	14-Nov-16	-35.959	3.48	-41.599	0.2729	1,015	198	19%
Final 2016 Surveys		-35.825	65.58	-35.8628	0.9913	61,408	3,965	6%

Table 10C. The 2017 Herring acoustic surveys for Little Hope/Port Mouton with survey biomass and final total for the area (calculated with Calibration Integration Factor (CIF)).

Location	Date	Average TS (dB/kg)	Stratum Area (km²)	Weighted Mean Sa (dB/m²)	Biomass Density (kg/m²)	Strata Biomass (t)	Standard Error (t)	Standard Error %
Little Hope #1	15-Sep-17	-35.023	35.31	-35.0208	1.0005	28,334	2,021	7%
Little Hope #2	26-Sep-17	-35.452	37.74	-41.2041	0.2659	11,953	815	7%
Little Hope #3	06-Oct-17	-35.528	16.66	-40.3148	0.3322	4,709	788	17%
Little Hope #4	17-Oct-17	-35.507	11.50	-39.4181	0.4064	4,016	686	17%
Little Hope #5	28-Oct-17	-35.959	13.65	-37.4388	0.7112	10,050	1,205	12%
Little Hope #6	07-Nov-17	-35.959	3.54	-32.5862	2.1741	7,754	1,146	15%
Final 2017 Surveys		-35.571	118.40	-37.6731	0.6164	66,815	1,491	2%

Table 11A. The 2015 Halifax/Eastern Shore Herring acoustic survey results with survey biomass and final total for the area (calculated with Calibration Integration Factor (CIF)).

Location	Date	Average TS (dB/kg)	Stratum Area (km²)	Weighted Mean Sa (dB/m²)	Biomass Density (kg/m²)	Strata Biomass (t)	Standard Error (t)	Standard Error %
Eastern Shore #1	27-Sep-15	-35.959	2.06	-24.879	0.0780	154	59	38%
Eastern Shore #2	05-Oct-15	-35.988	1.09	-28.468	5.6496	6,635	1,839	28%
Eastern Shore #3	10-Oct-15	-35.902	3.20	-24.270	14.5610	51,240	16,884	33%
Eastern Shore #4	16-Oct-15	-35.998	0.61	-27.777	5.1845	4,050	2,036	50%
Eastern Shore #5	27-Oct-15	-35.823	2.03	-28.011	6.0418	13,118	2,909	22%
Final all 2015 Surveys		-35.934	8.99	-27.125	7.6019	68,561	9,193	13%

Table 11B. The 2016 Halifax/Eastern Shore Herring acoustic survey results with survey biomass and final total for the area (calculated with Calibration Integration Factor (CIF)).

Location	Date	Average TS (dB/kg)	Stratum Area (km²)	Weighted Mean Sa (dB/m²)	Biomass Density (kg/m²)	Strata Biomass (t)	Standard Error (t)	Standard Error %
Eastern Shore #1	13-Sep-16	-36.085	0.22	-45.629	0.1010	24	15	62%
Eastern Shore #2	28-Sep-16	Excluded						
Eastern Shore #3	30-Sep-16	-35.899	1.61	-27.660	6.6673	10,928	3,089	28%
Eastern Shore #4	01-Oct-16	Excluded						
Eastern Shore #5	02-Oct-16	-35.905	1.19	-29.865	4.0173	6,339	1,726	27%
Eastern Shore #6	05-Oct-16	-35.870	0.41	-30.878	3.1568	2,245	594	26%
Eastern Shore #7	12-Oct-16	-35.683	1.11	-28.8623	4.8087	5,532	1,485	27%
Eastern Shore #8	19-Oct-16	Excluded						
Eastern Shore #9	25-Oct-16	-35.658	5.26	-28.239	5.7344	29,035	6,975	24%
Eastern Shore #10	05-Nov-16	-35.959	0.26	-36.943	0.6827	207	176	85%
Final all 2016 Surveys		-35.866	10.06	-28.6891	5.2197	54,312	2,993	6%

Table 11C. The 2017 Halifax/Eastern Shore Herring acoustic survey results with survey biomass and final total for the area (calculated with Calibration Integration Factor (CIF)).

Location	Date	Average TS (dB/kg)	Stratum Area (km²)	Weighted Mean Sa (dB/m²)	Biomass Density (kg/m²)	Strata Biomass (t)	Standard Error (t)	Standard Error %
Eastern Shore #1	15-Sep-17	-35.795	1.48	-28.9114	4.8793	7,716	1,198	15%
Eastern Shore #2	26-Sep-17	-36.245	0.58	-28.8902	5.3065	3,154	972	31%
Eastern Shore #3	29-Sep-17	-35.959	0.37	-37.8225	0.6568	241	77	32%
Eastern Shore #4	30-Sep-17	-36.245	2.13	-26.2839	9.1432	21,110	5,248	25%
Eastern Shore #5	07-Oct-17	-35.862	1.28	-28.5880	5.3389	6,888	1,150	17%
Eastern Shore #6	16-Oct-17	-35.541	0.81	-27.2933	6.2608	5,411	1,893	35%
Eastern Shore #7	21-Oct-17	-35.363	0.34	-27.5240	5.9960	2,067	1,061	51%
Eastern Shore #8	22-Oct-17	-35.807	0.60	-26.8848	7.7708	4,681	1,588	34%
Eastern Shore #9	11-Nov-17	-35.780	1.70	-29.9180	3.6801	6,556	2,319	35%
Eastern Shore #10	12-Nov-17	-35.959	0.94	-36.3600	0.8622	857	158	18%
Final all 2017 Surveys		-35.856	10.23	-28.4966	5.4438	58,681	2,311	4%

Table 12. The 2000–2017 Lunenburg Box area (Liverpool to Chebucto Head for statistical districts 22–26) catch and effort with start and end dates, total catch, number of sets, number of days with landings, and number of active vessels with landings in these districts. Note set data available from 2006 onwards only; from 2000–2005 (grey cells) only catch by day available.

Year	Min. Day	Max. Day	Day Range	Catch (t)	No. Sets	No. Days	No. Vessels
2000	01-May-00	14-Oct-00	167	27	46	34	11
2001	18-May-01	13-Oct-01	149	21	54	37	10
2002	05-May-02	12-Oct-02	161	29	84	48	15
2003	07-Jun-03	21-Oct-03	137	48	44	33	12
2004	13-Jun-04	30-Nov-04	171	32	34	22	12
2005	30-Jun-05	31-Oct-05	124	140	58	20	11
2006	03-May-06	30-Nov-06	212	64	134	53	18
2007	23-Jun-07	26-Nov-07	157	21	72	42	13
2008	04-May-08	06-Nov-08	187	47	106	44	14
2009	23-May-09	30-Nov-09	192	182	121	40	15
2010	30-Apr-10	12-Oct-10	166	164	80	31	15
2011	31-May-11	31-Oct-11	154	142	94	25	16
2012	24-May-12	31-Oct-12	161	34	52	22	9
2013	17-Aug-13	15-Oct-13	60	93	76	18	6
2014	15-Sep-14	31-Oct-14	47	39	24	12	7
2015	24-Sep-15	31-Oct-15	38	7	9	8	3
2016	20-Sep-16	31-Oct-16	42	1	19	12	4
2017	05-Aug-17	14-Nov-17	102	592	206	22	20
Average			135	93	73	29	12

Table 13A. Landings (t) by spawning area for coastal Nova Scotia from 1996–2017 with last 5-year (grey cells) and overall averages. '-' indicates not applicable.

Location	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Average Landings last 5 yrs.	Average Landings all Years
Little Hope/Port Mouton Catch	-	490	1,170	2,920	2,040	2,900	3,980	4,500	1,300	2,240	3,140	1,510	1,108	3,731	3,106	2,576	2,150	2,499	3,596	4,160	5,943	5,557	4,351	2,886
Little Hope/Port Mouton Allocation	-	-	-	-	1,495	1,170	1,410	2,248	3,028	3,162	3,952	4,008	2,944	2,172	2,454	2,094	2,188	2,387	3,577	3,772	6,151	6,803	-	-
Halifax/Eastern Shore Catch	1,280	1,520	1,100	1,630	1,350	1,900	3,330	2,700	4,200	3,450	3,350	3,720	2,348	5,885	2,302	908	771	1,390	1,163	1,001	1,837	2,259	1,530	2,245
Halifax/Eastern Shore Allocation	-	-	-	-	1,425	1,313	1,403	1,952	3,638	3,802	4,323	5,367	5,103	3,857	4,373	4,188	2,920	2,427	1,959	1,066	1,884	2,856	-	-
Glace Bay Catch	-	170	1,730	1,040	834	1,204	3,058	1,905	1,481	626	85	45	12	4	11	0	7	2	1	0	4	0	1	582
Bras d'Or Lakes Catch	170	160	120	31	56	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25
Total	1,450	1,450	2,340	4,120	5,621	7,200	8,487	13,181	13,309	13,647	13,280	14,850	14,650	11,515	15,649	12,246	9,766	8,036	8,577	5,161	7,784	7,816	5,882	5,738

Table 13B. Acoustic survey Spawning Stock Biomass (SSB) (t) by spawning area for coastal Nova Scotia from 1996–2017, with last 5-year (grey cells) and overall averages (with Calibration Integration Factor (CIF)). Note that no surveys were conducted prior to 1998. 'n/s' indicates no survey. Data from 1998–2002 without CIF. Cells with thick black borders includes mapping surveys which estimated biomass based on visual sounder estimates; cells with bolded values include mapping and acoustic surveys. Last, data prior to 2003 calculated with the CIF are not available. '-' indicates not applicable

Location	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	SSB Avg. last 5 yrs.	SSB Avg. all years
Little Hope/Port Mouton	14,100	15,800	5,200	21,300	56,000	53,100	22,500	44,700	24,100	2,800	14,500	36,600	26,700	28,796	12,756	74,532	46,077	145,395	61,408	66,815	78,845	38,659
Halifax/Eastern Shore	8,300	20,200	10,900	16,700	41,500	92,600	28,400	36,950	68,900	28,300	30,300	54,200	27,700	5,498	3,668	6,870	9,586	68,562	54,312	58,681	39,602	33,606
Glace Bay	-	2,000	-	21,200	7,700	31,500	n/s	3,180	n/s	240	500	100	8	51	n/s	50	n/s	n/s	n/s	n/s	50	6,048
Bras d'Or Lakes	-	530	70	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	300

Table 13C. Exploitation estimates (%) for coastal Nova Scotia spawning components from 1998–2017, with last 5-year and overall averages (with Calibration Integration Factor (CIF)). Exploitation estimates for Bras d'Or Lakes are not available. '-' indicates not applicable. Data from 1998 to 2002 without CIF. Cells with thick black borders includes mapping surveys which estimated biomass based on visual sounder estimates; cells with bolded values include mapping and acoustic surveys. Last, data prior to 2003 calculated with the CIF are not available and estimates of exploitation were made for these years based on the data without CIF.

Location	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Average Last 5 yrs.	Average All Years
Little Hope/Port Mouton	8%	18%	39%	14%	7%	**8%**	6%	5%	13%	54%	8%	10%	12%	9%	17%	3%	8%	3%	10%	8%	8%	13%
Halifax/Eastern Shore	13%	8%	12%	11%	8%	3%	15%	9%	5%	13%	8%	11%	8%	17%	21%	20%	12%	1%	3%	4%	10%	10%
Glace Bay	-	52%	-	6%	40%	6%	-	20%	-	19%	2%	4%	-	-	-	-	-	-	-	-	-	18%

FIGURES

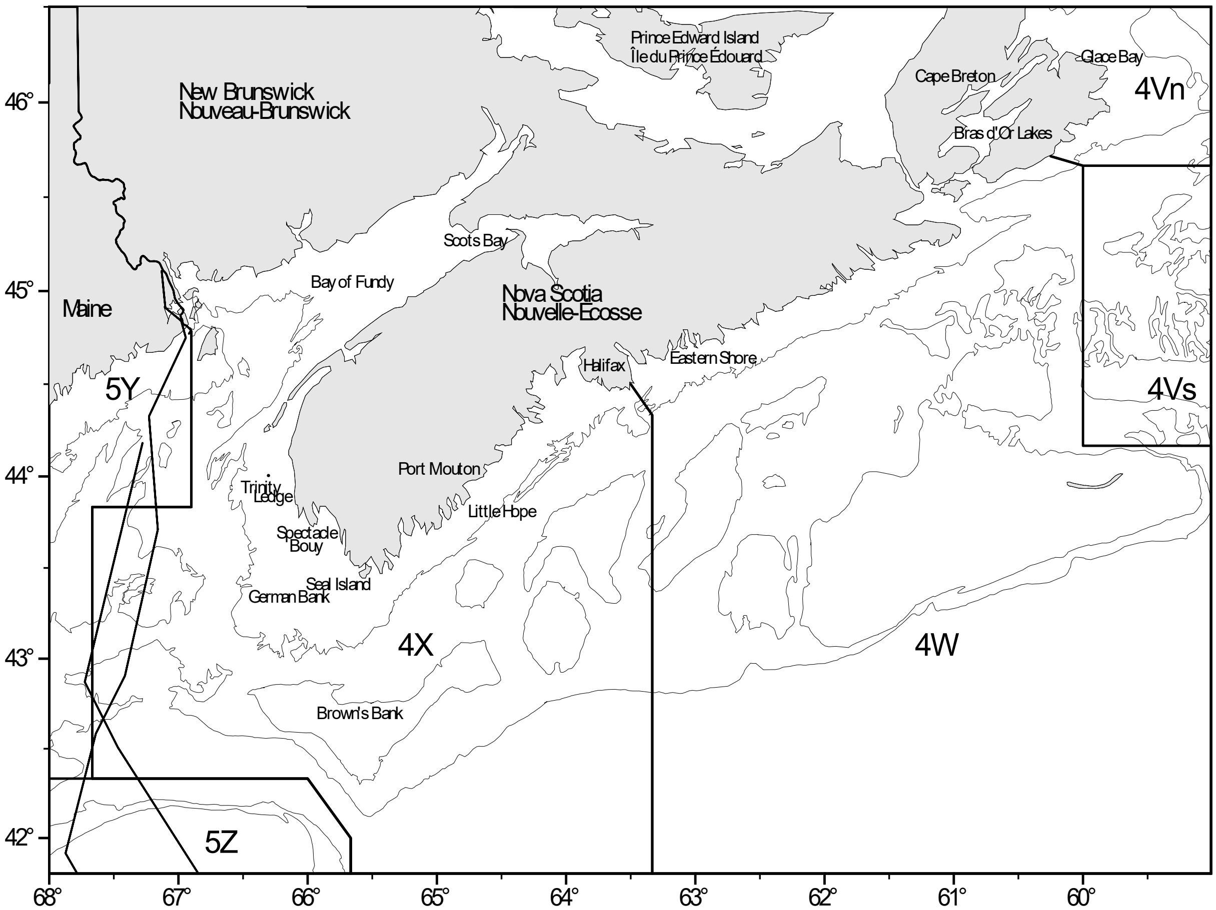

Figure 1. Map of the major spawning areas within 4WX Atlantic Herring stock complex.

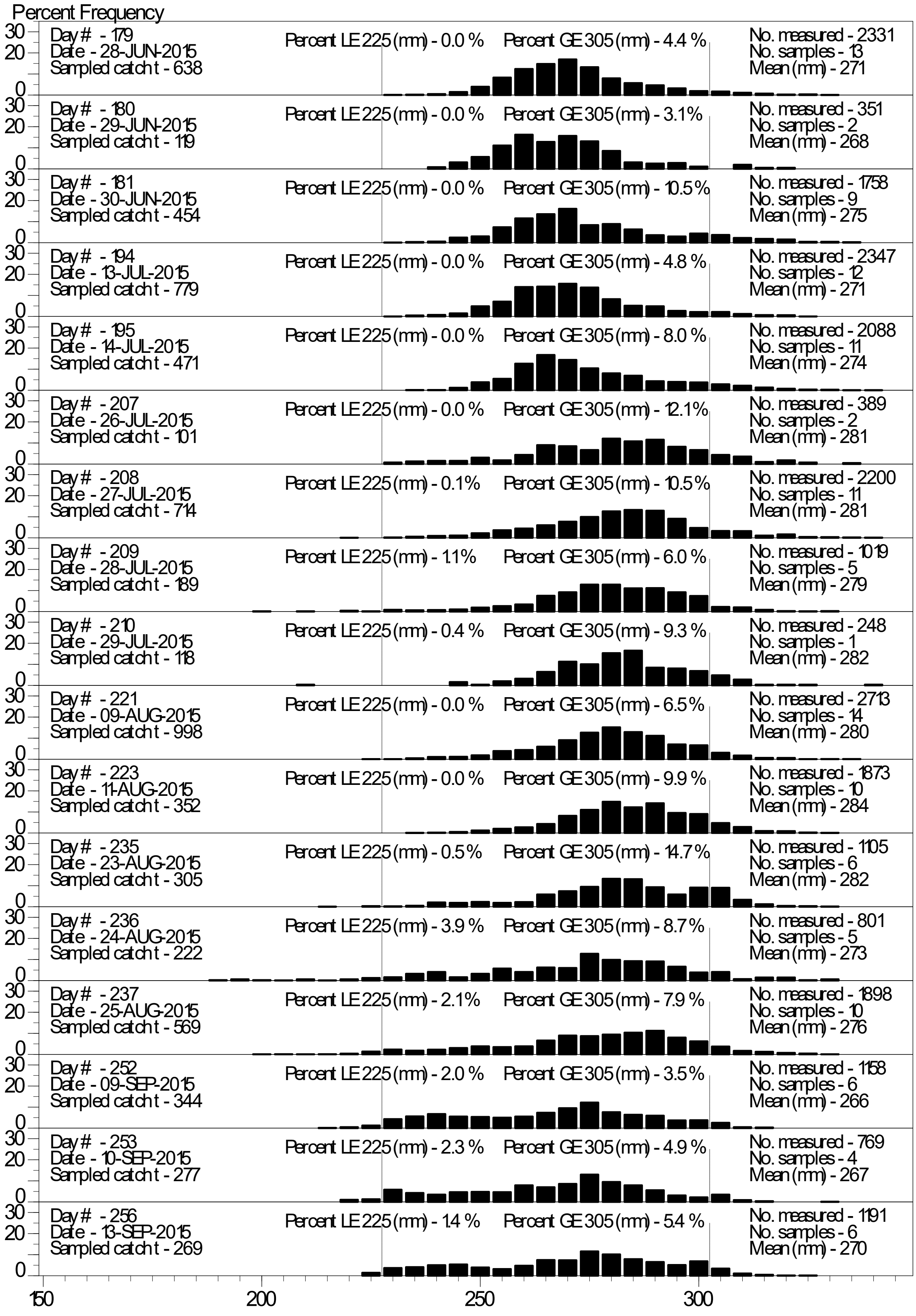

Figure 2A. Scots Bay daily Herring length-frequency samples collected from all landings in 2015, with proportions ≤ 225 mm and ≥ 305 mm. Length scale in millimetres with measurements grouped by half centimetre.

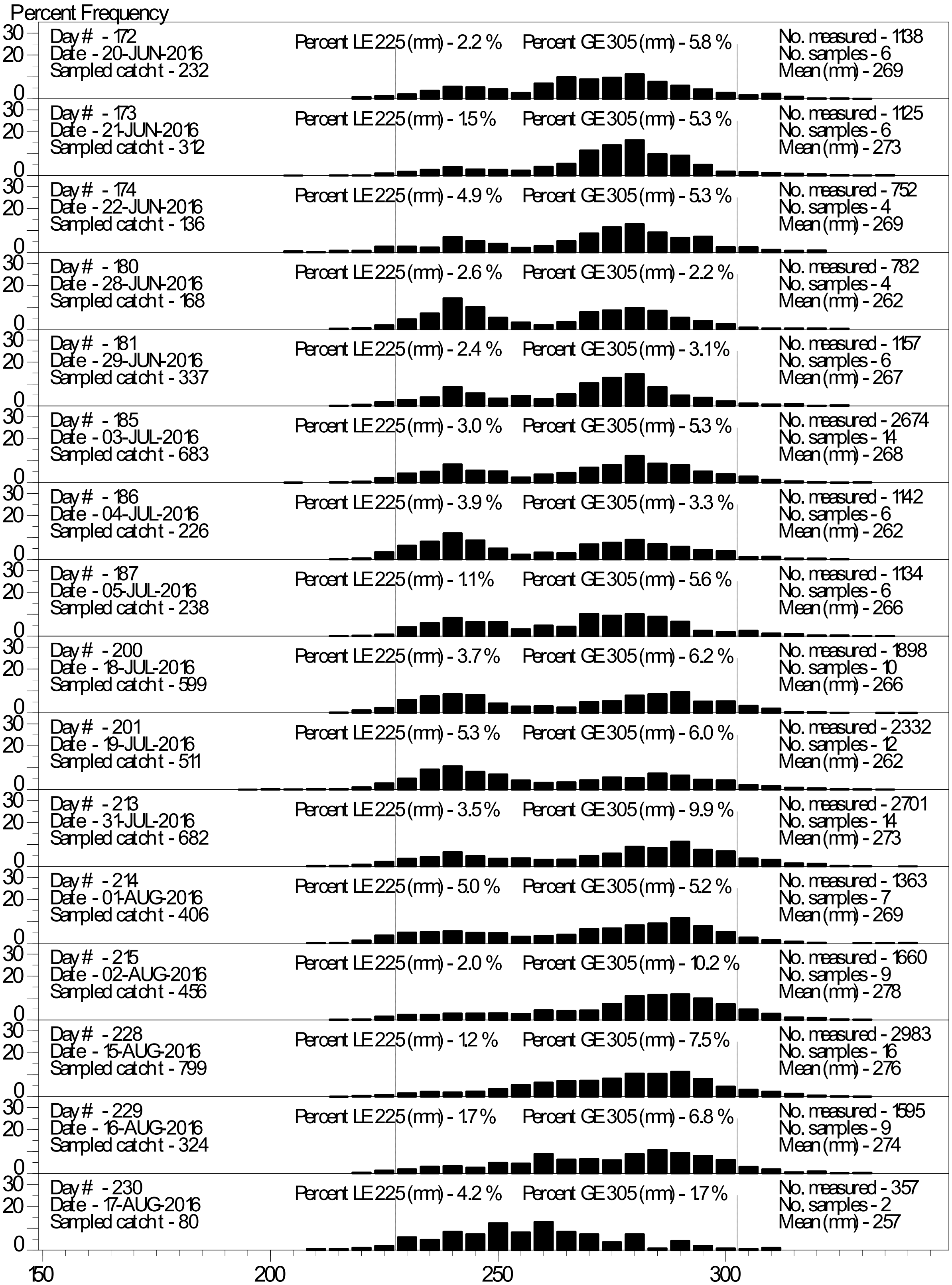

Figure 2B. Scots Bay daily Herring length-frequency samples collected from all landings in 2016, with proportions ≤ 225 mm and ≥ 305 mm. Length scale in millimetres with measurements grouped by half centimetre.

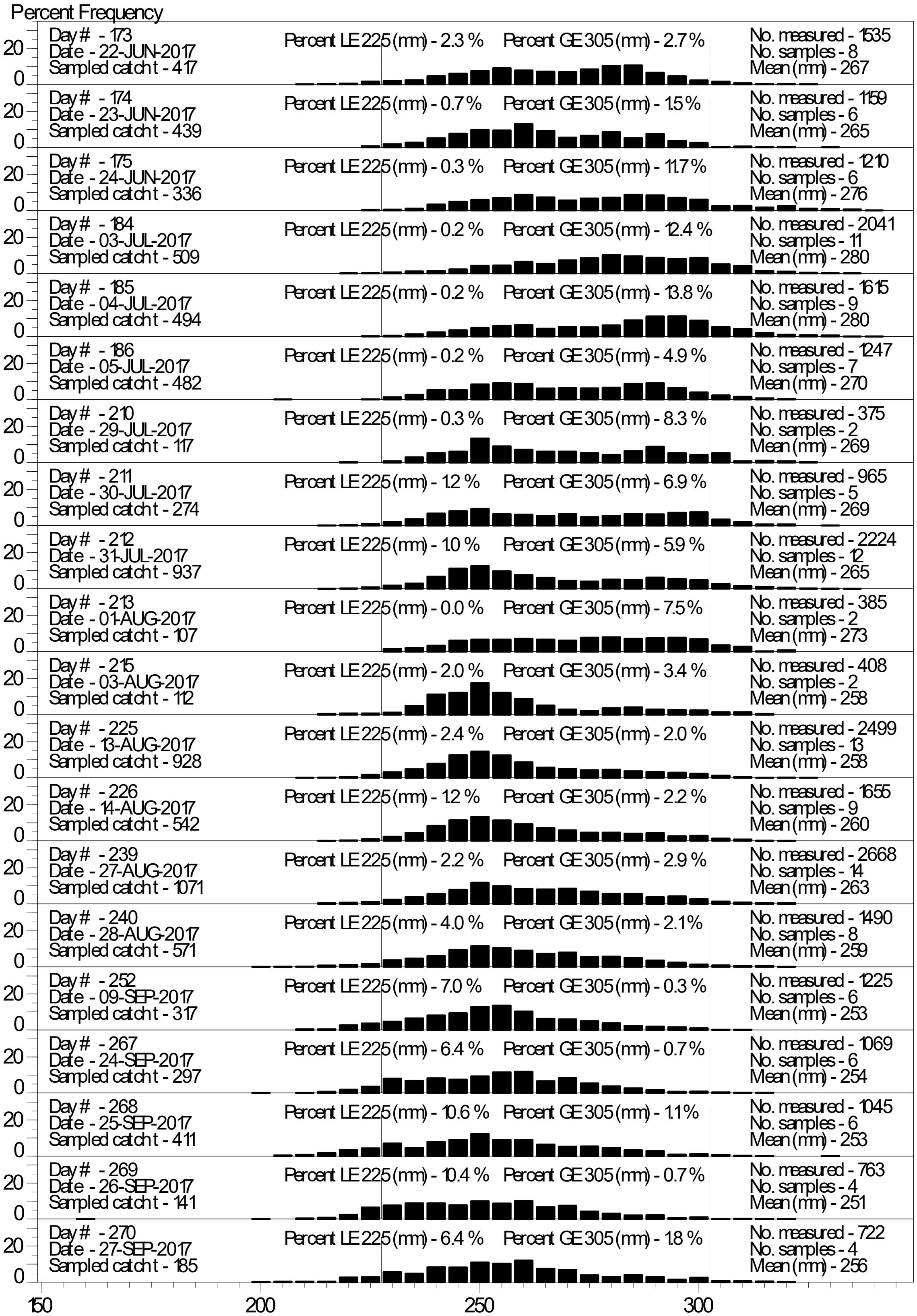

Figure 2C. Scots Bay daily Herring length-frequency samples collected from all landings in 2017, with proportions ≤ 225 mm and ≥ 305 mm. Length scale in millimetres with measurements grouped by half centimetre.

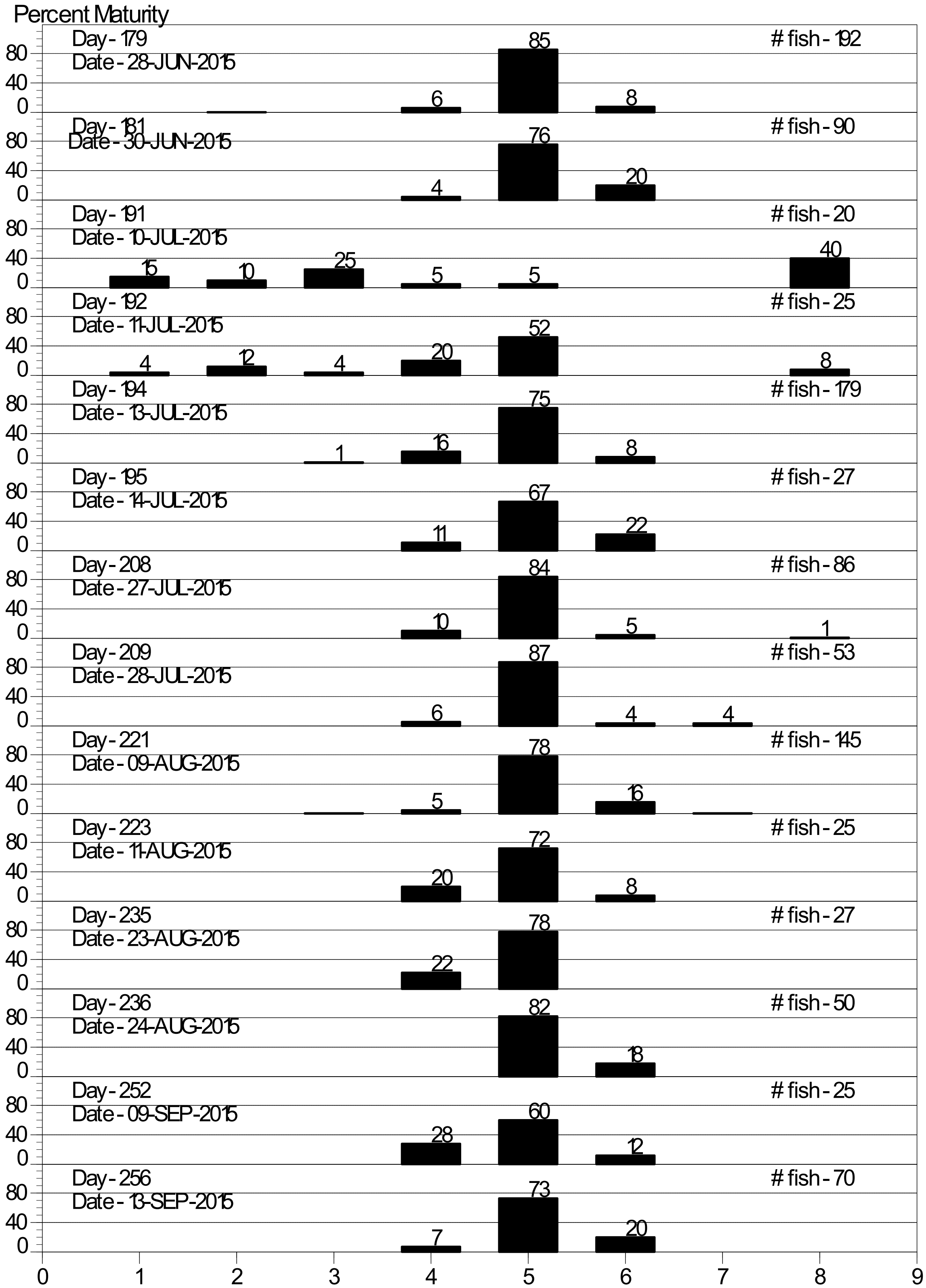

Figure 3A. Daily Herring maturity samples collected from Scots Bay landings in 2015. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; 8 = recovering.

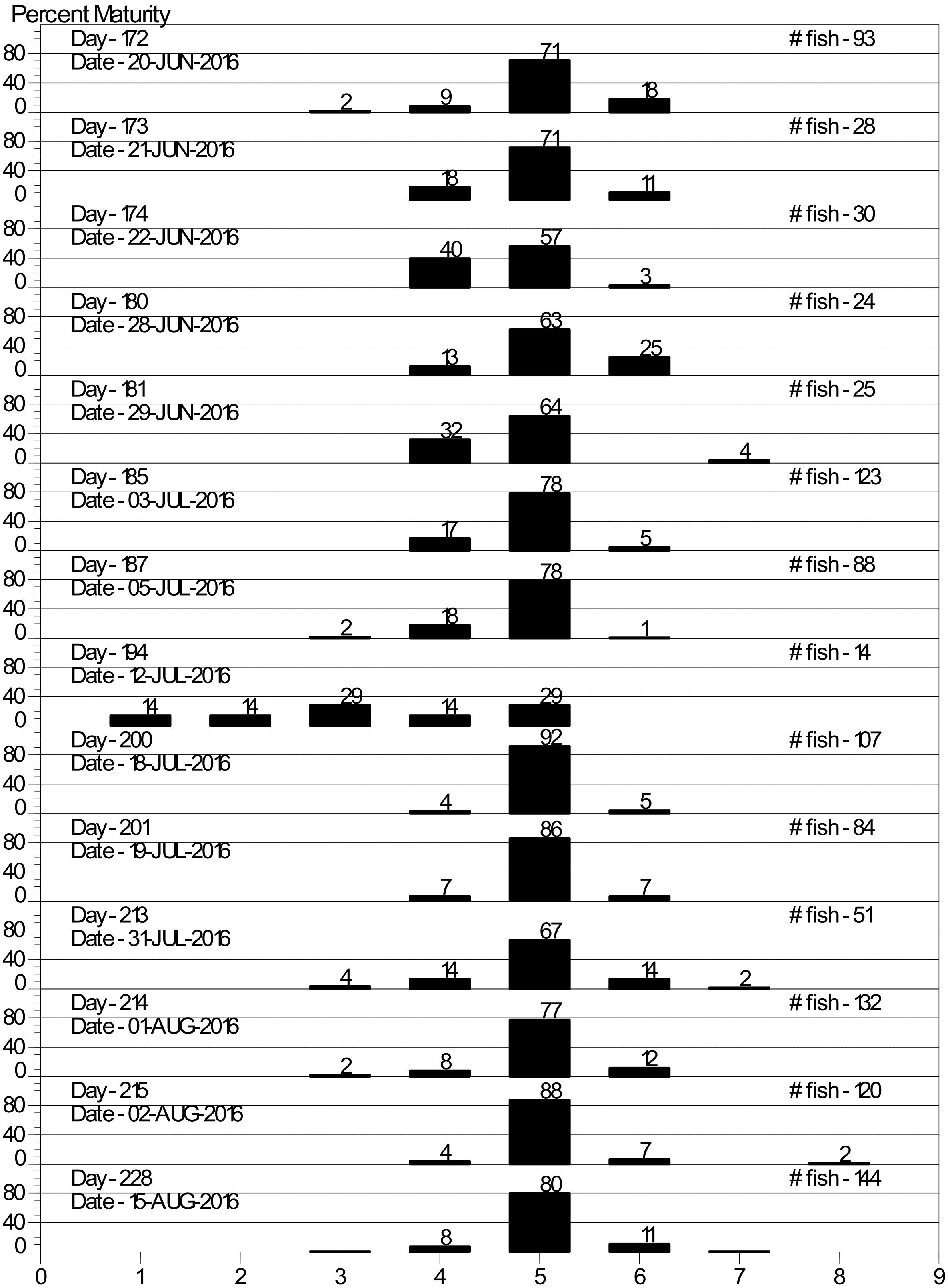

Figure 3B. Daily Herring maturity samples collected from Scots Bay landings in 2016. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; 8 = recovering.

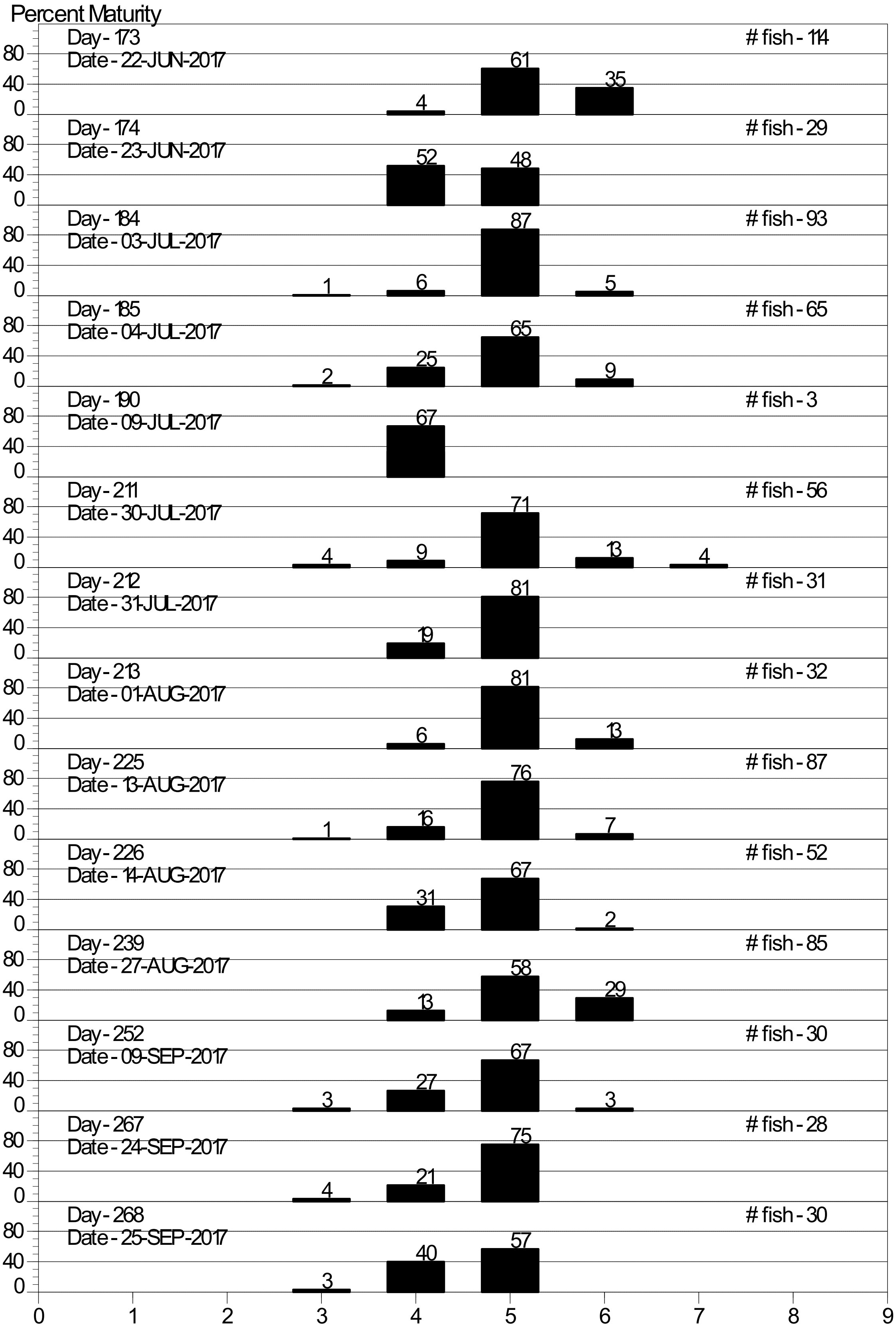

Figure 3C. Daily Herring maturity samples collected from Scots Bay landings in 2017. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; 8 = recovering.

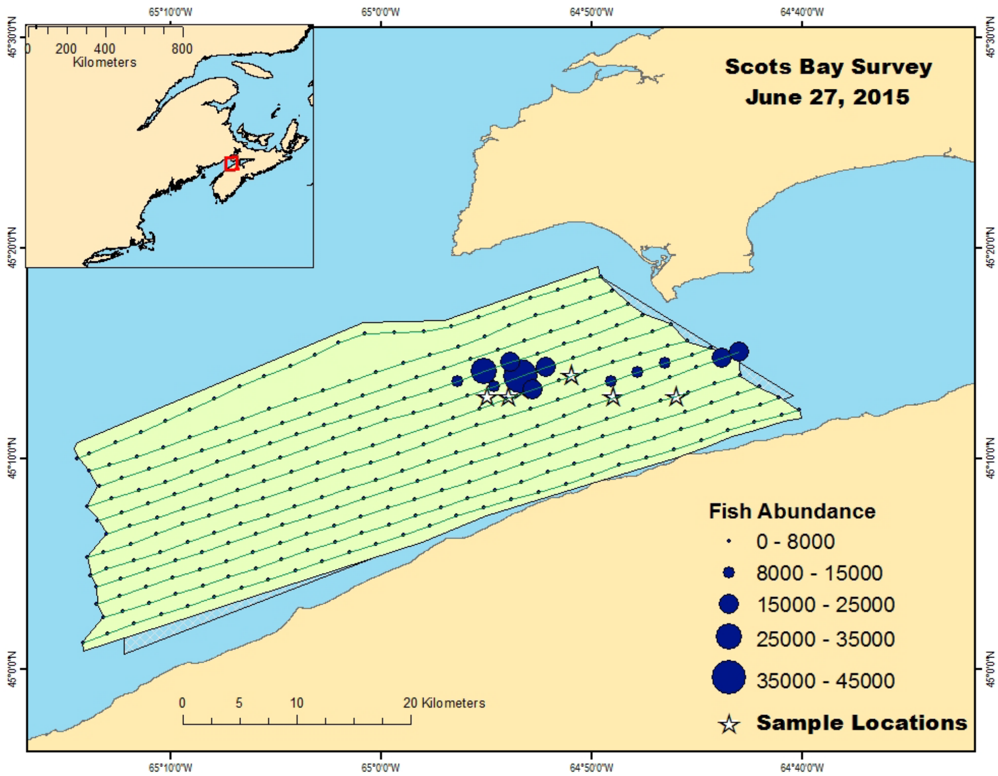

Figure 4A. Scots Bay acoustic survey (#1) on June 27, 2015 showing the main survey box and transects completed with backscatter (PRC-NASC) along with locations of fishery samples.

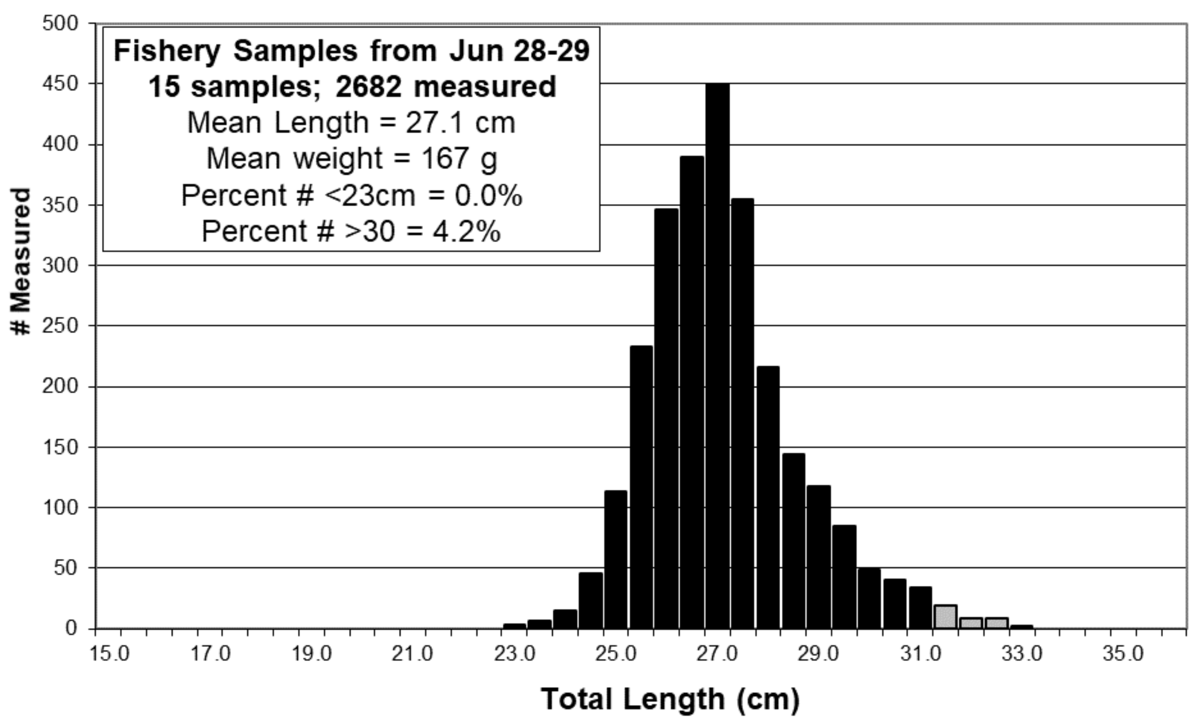

Figure 4B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#1) on June 27, 2015 from sampling on June 28–29, with proportions < 23 cm and > 30 cm shown as white and grey bars.

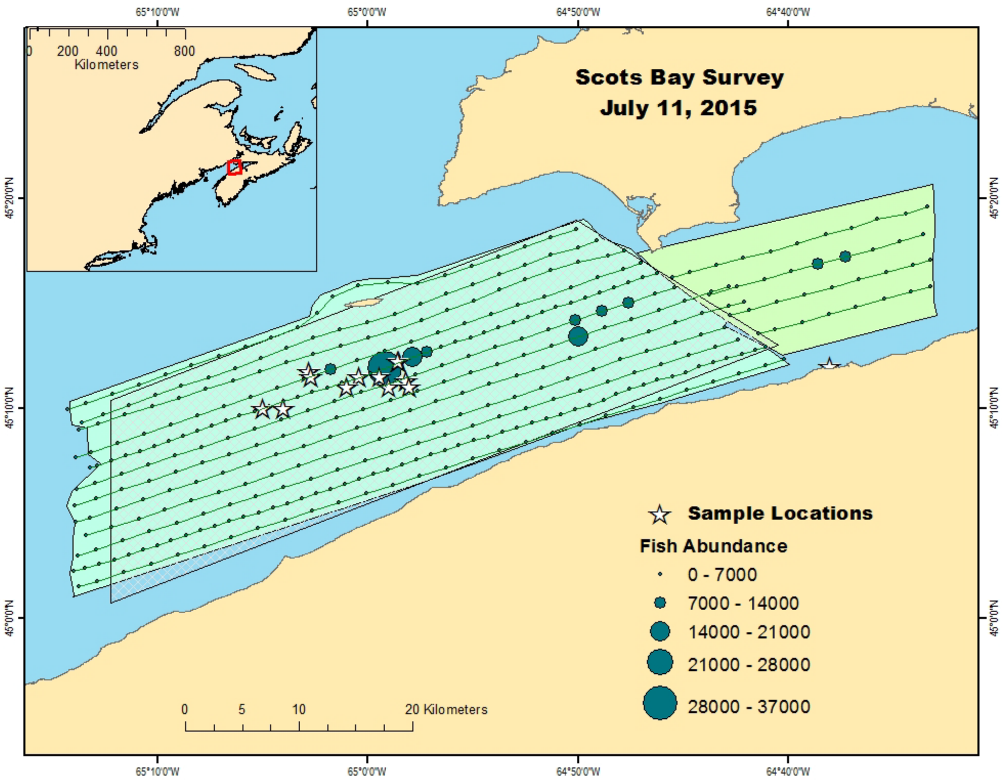

Figure 5A. Scots Bay acoustic survey (#2) on July 11, 2015 showing the main survey box and transects with backscatter (PRC-NASC) along with locations for fishery samples.

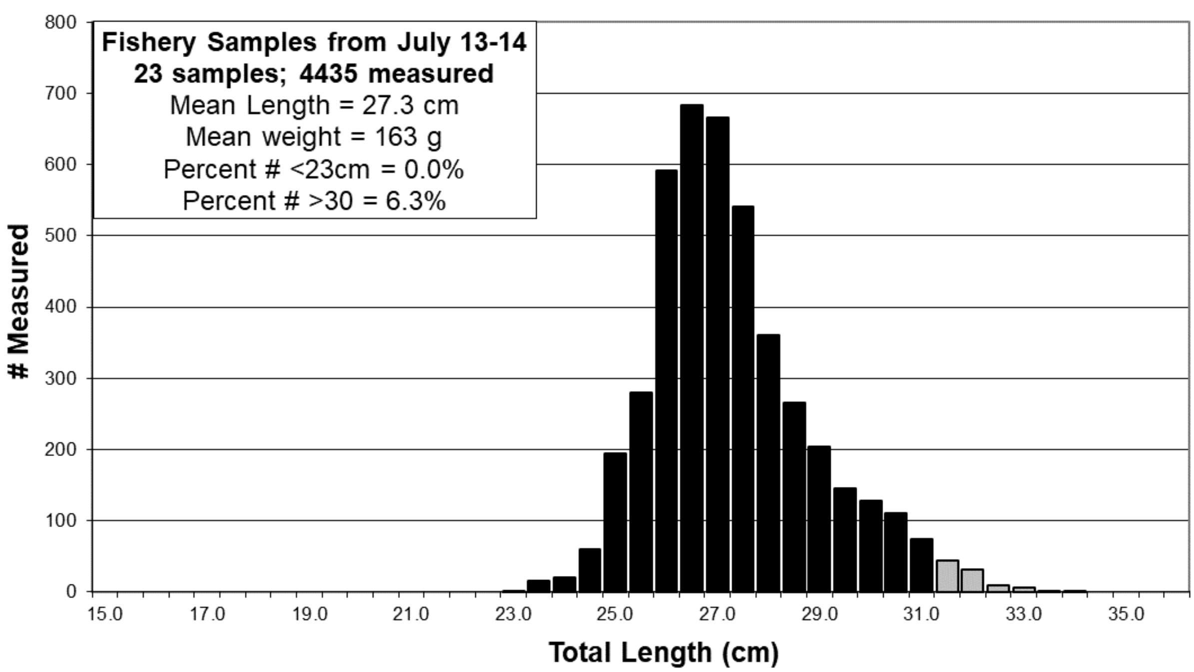

Figure 5B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#2) on July 11, 2015 from sampling on July 13–14, with proportions < 23 cm and > 30 cm shown as white and grey bars.

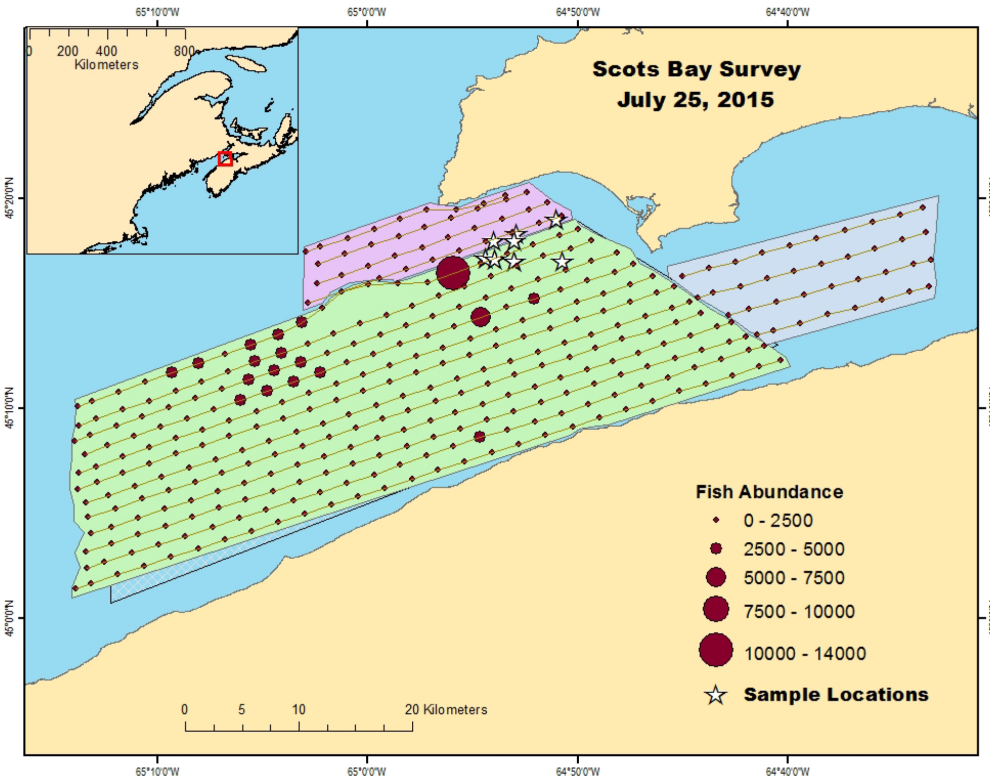

Figure 6A. Scots Bay acoustic survey (#3) on July 25, 2015 showing the main survey box and transects completed with backscatter (PRC-NASC) along with locations of fishery samples.

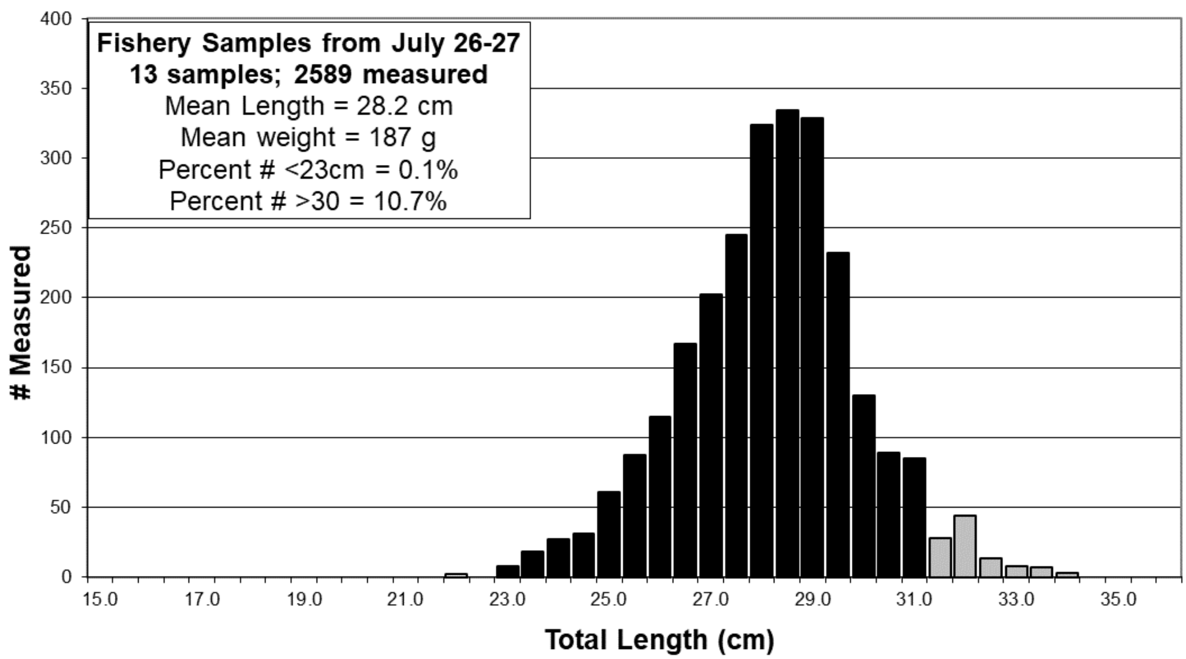

Figure 6B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#3) on July 25, 2015 from sampling on July 26–27, with proportions < 23 cm and > 30 cm shown as white and grey bars.

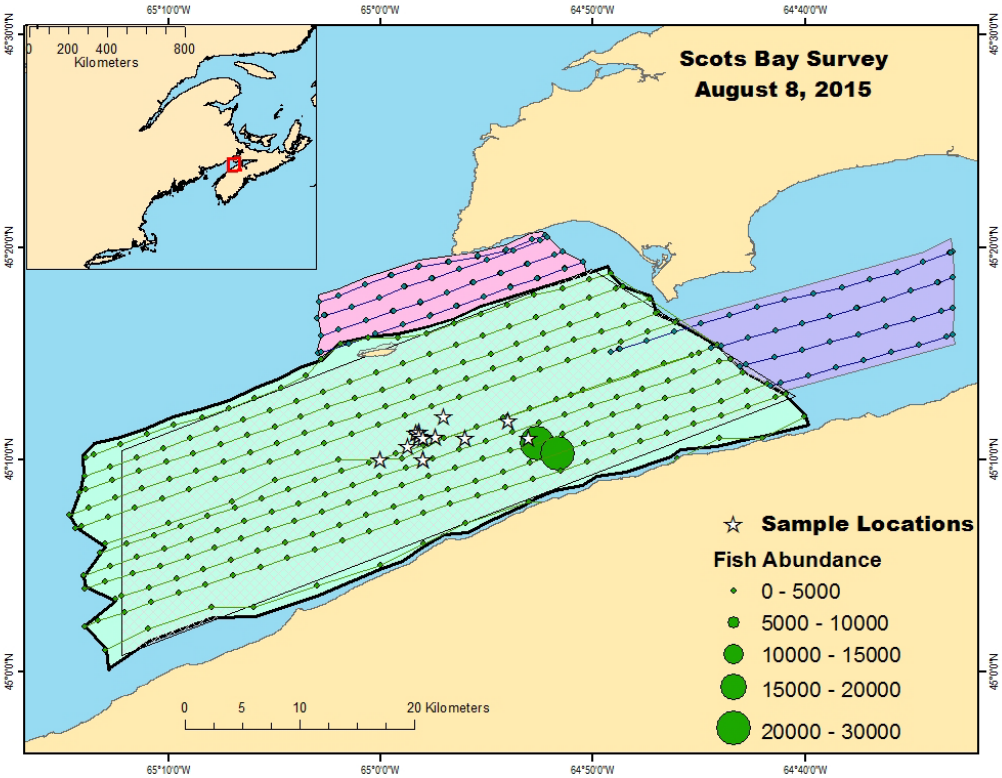

Figure 7A. Scots Bay acoustic survey (#4) on August 8, 2015 showing the main survey box and transects completed with backscatter (PRC-NASC) along with locations of fishery samples.

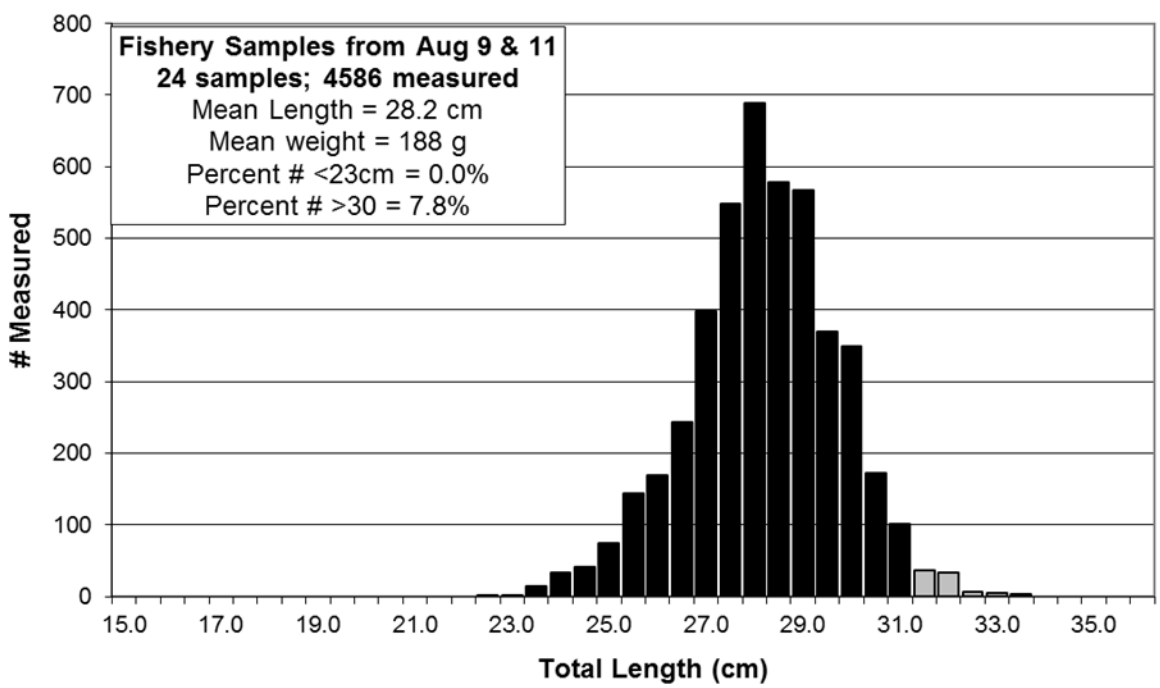

Figure 7B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#4) on August 8, 2015 from sampling on August 9–11, with proportions < 23 cm and > 30 cm shown as white and grey bars.

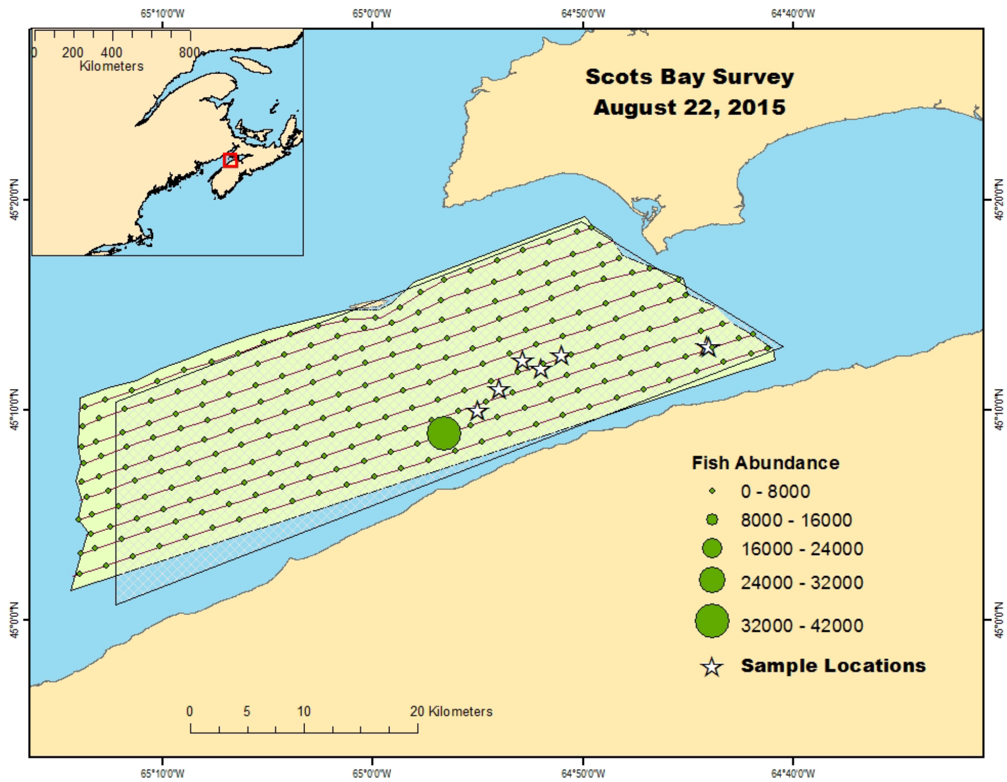

Figure 8A. Scots Bay acoustic survey (#5) on August 22, 2015 showing the main survey box and transects completed with backscatter (PRC-NASC) along with locations of fishery samples.

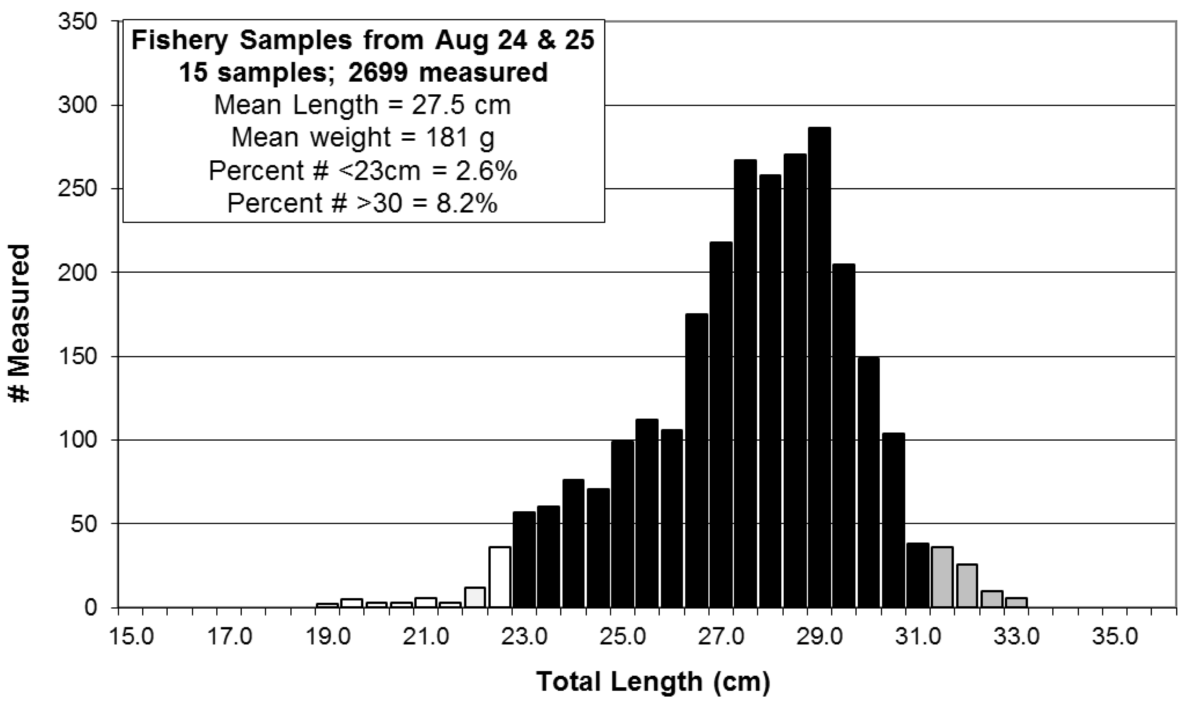

Figure 8B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#5) on August 22, 2015 from sampling on August 19, with proportions < 23 cm and > 30 cm shown as white and grey bars.

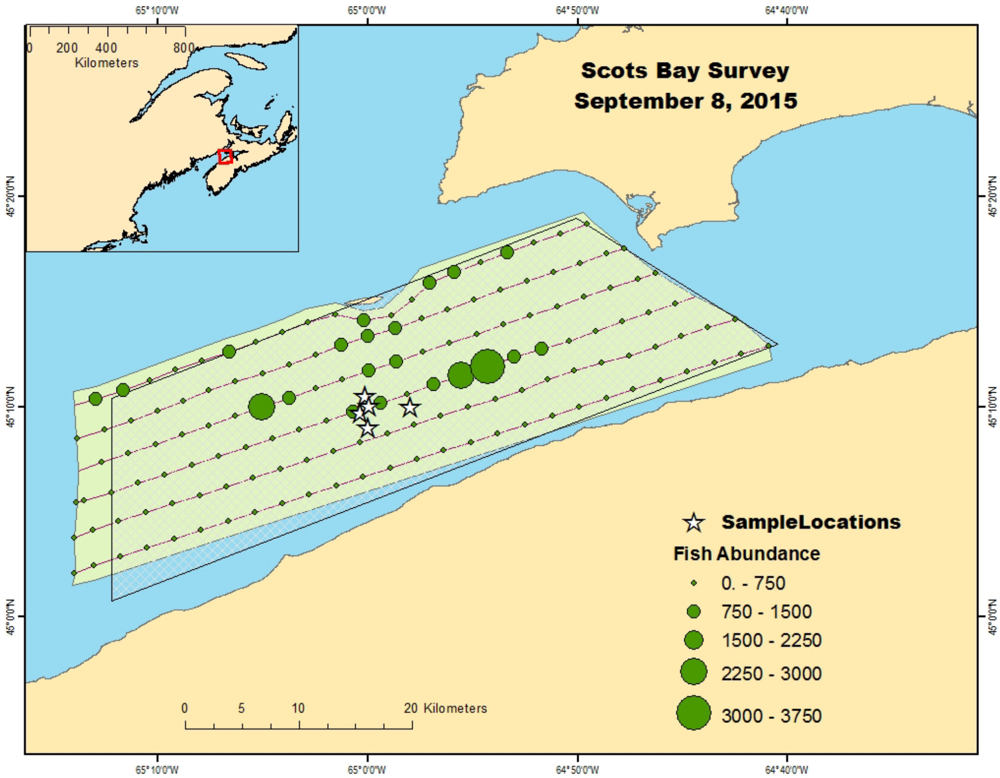

Figure 9A. Scots Bay acoustic survey (#6) on September 8, 2015 showing the main survey box and transects completed with backscatter (PRC-NASC) along with locations of fishery samples.

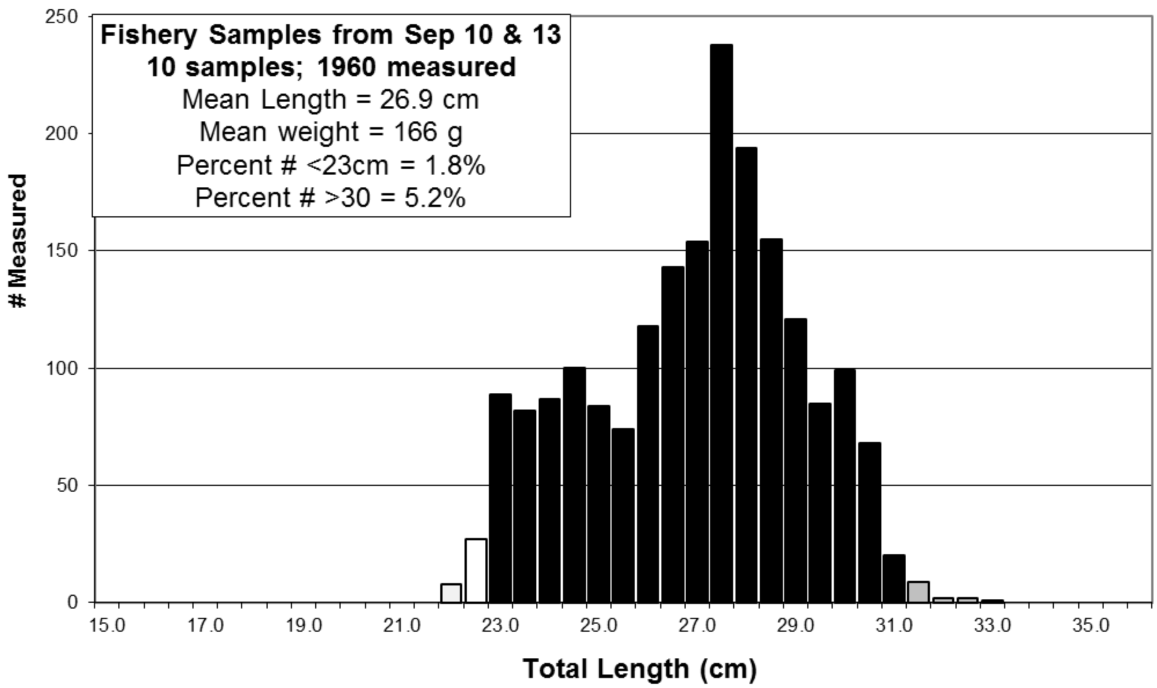

Figure 9B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#6) on September 8, 2015 from sampling on September 10 and 13, with proportions < 23 cm and > 30 cm shown as white and grey bars.

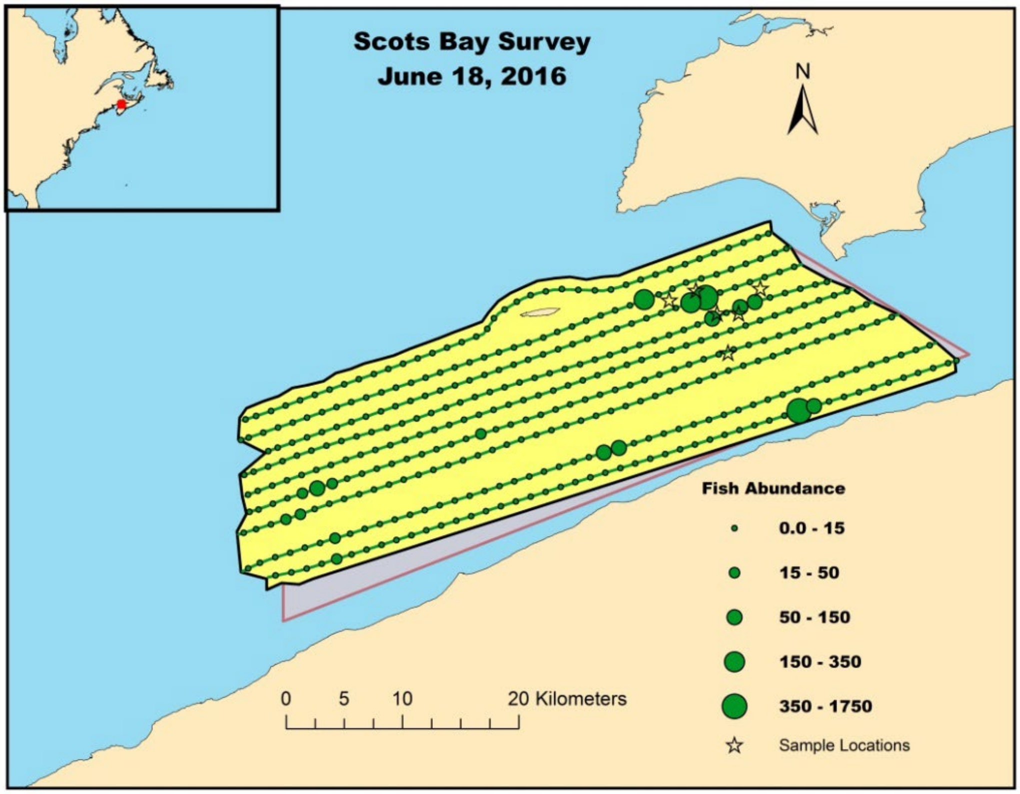

Figure 10A. Scots Bay acoustic survey (#1) on June 18, 2016 showing the main survey box and transects completed with backscatter (PRC_ABC) along with locations of fishery samples.

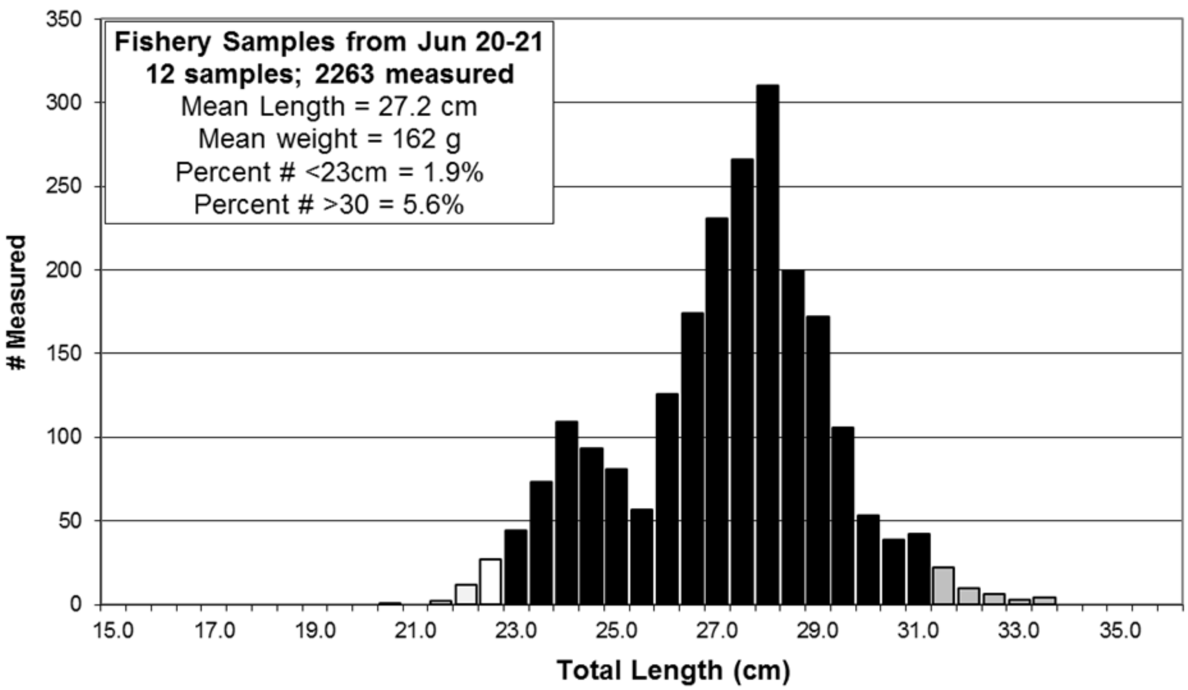

Figure 10B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#1) on June 18, 2016 from sampling on June 20–21, with proportions < 23 cm and > 30 cm shown as white and grey bars.

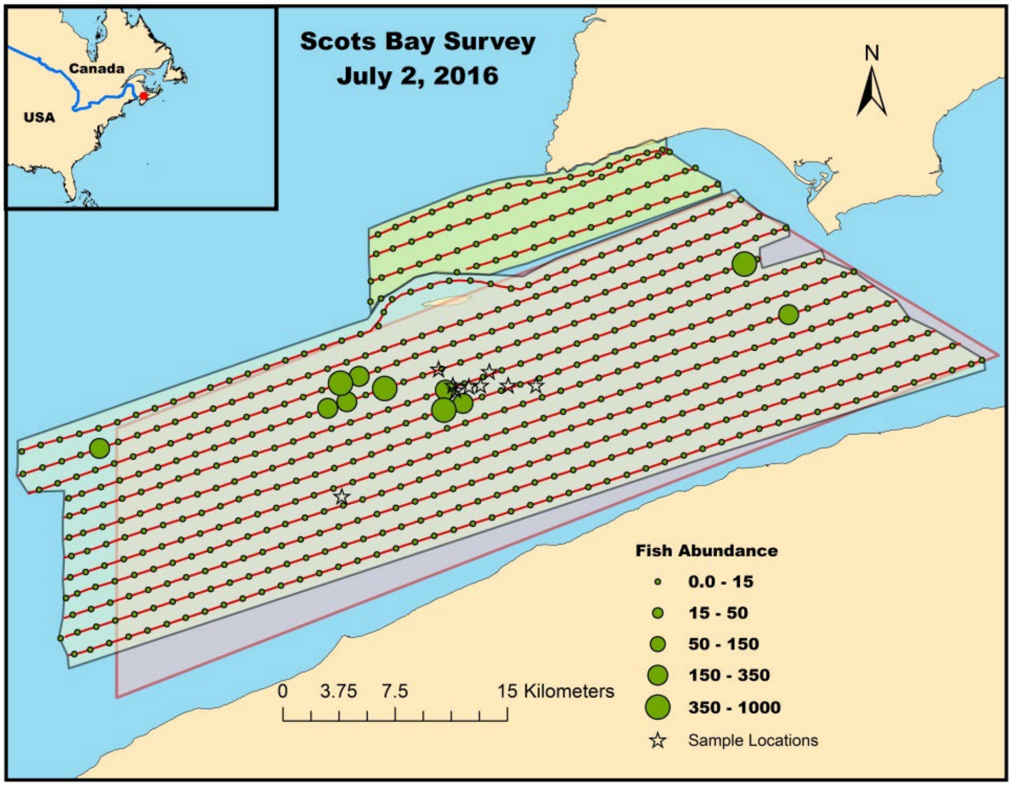

Figure 11A. Scots Bay acoustic survey (#2) on July 2, 2016 showing the main survey box and transects with backscatter (PRC_ABC) along with locations for fishery samples.

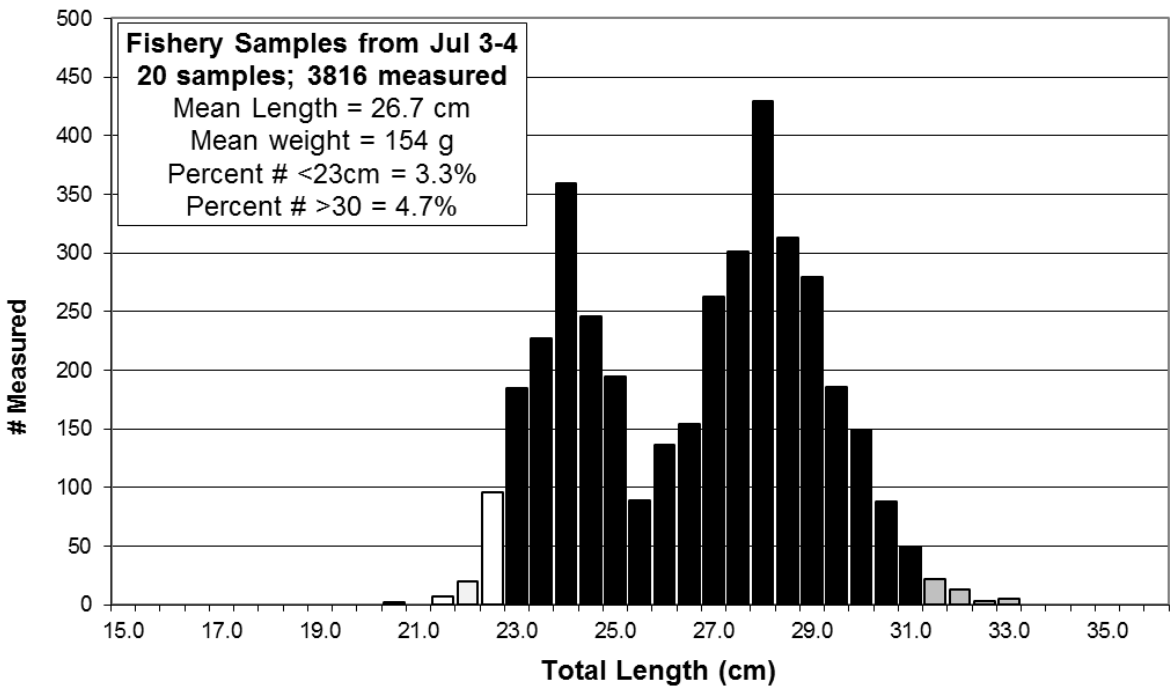

Figure 11B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#2) on July 2, 2016 from sampling on July 3–4, with proportions < 23 cm and > 30 cm shown as white and grey bars.

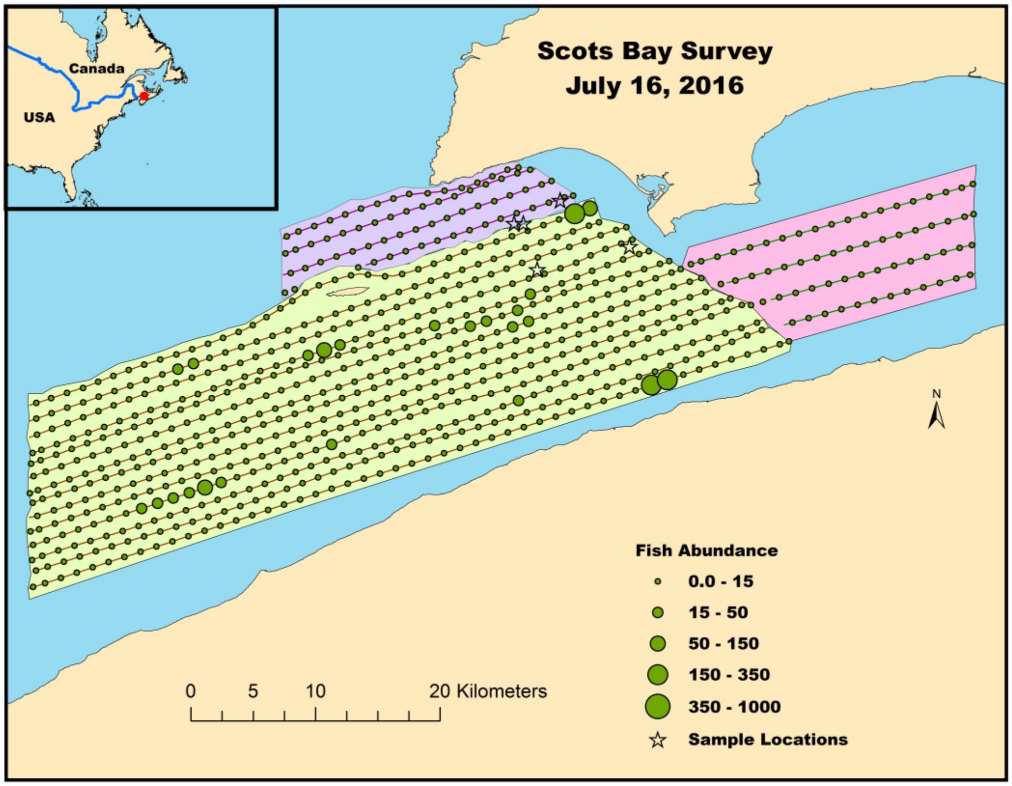

Figure 12A. Scots Bay acoustic survey (#3) on July 16, 2016 showing the main survey box and transects completed with backscatter (PRC_ABC) along with locations of fishery samples.

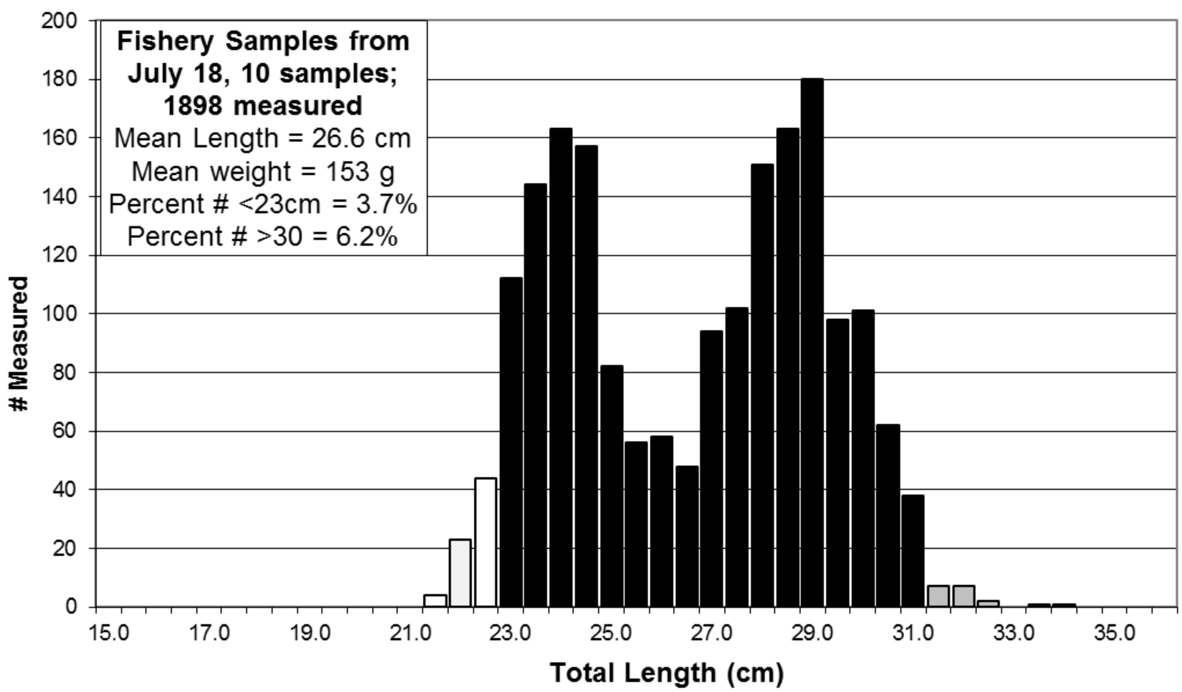

Figure 12B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#3) on July 16, 2016 from sampling on July 18, with proportions < 23 cm and > 30 cm shown as white and grey bars.

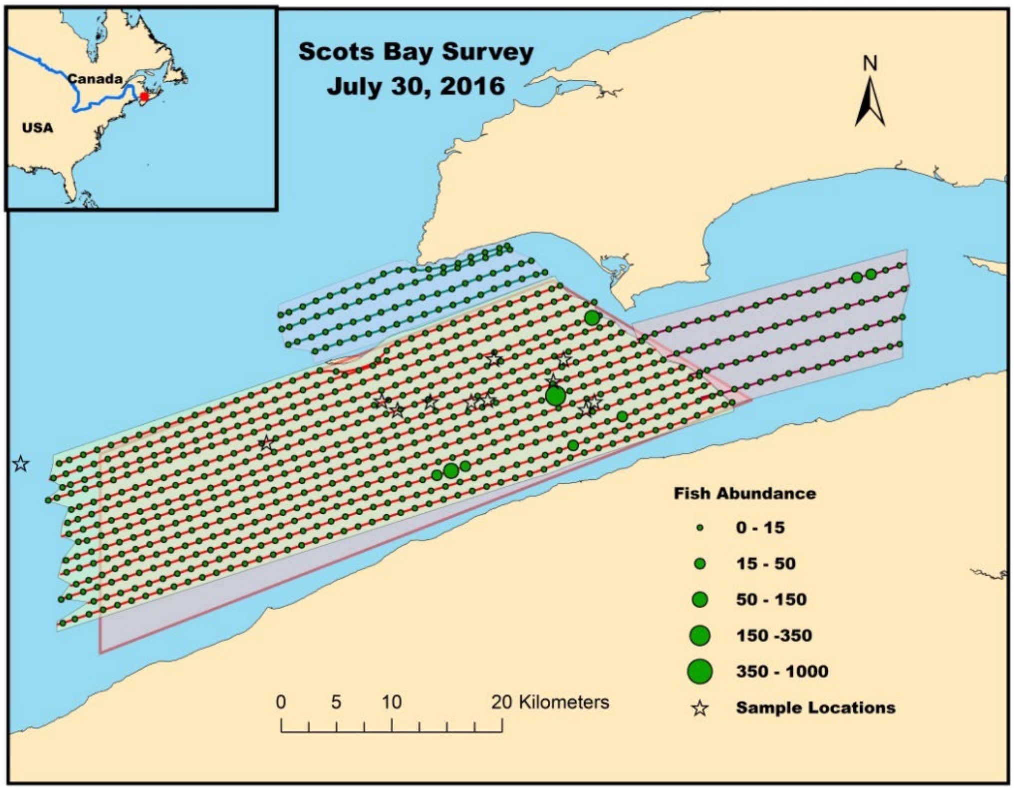

Figure 13A. Scots Bay acoustic survey (#4) on July 30, 2016 showing the main survey box and transects completed with backscatter (PRC_ABC) along with locations of fishery samples.

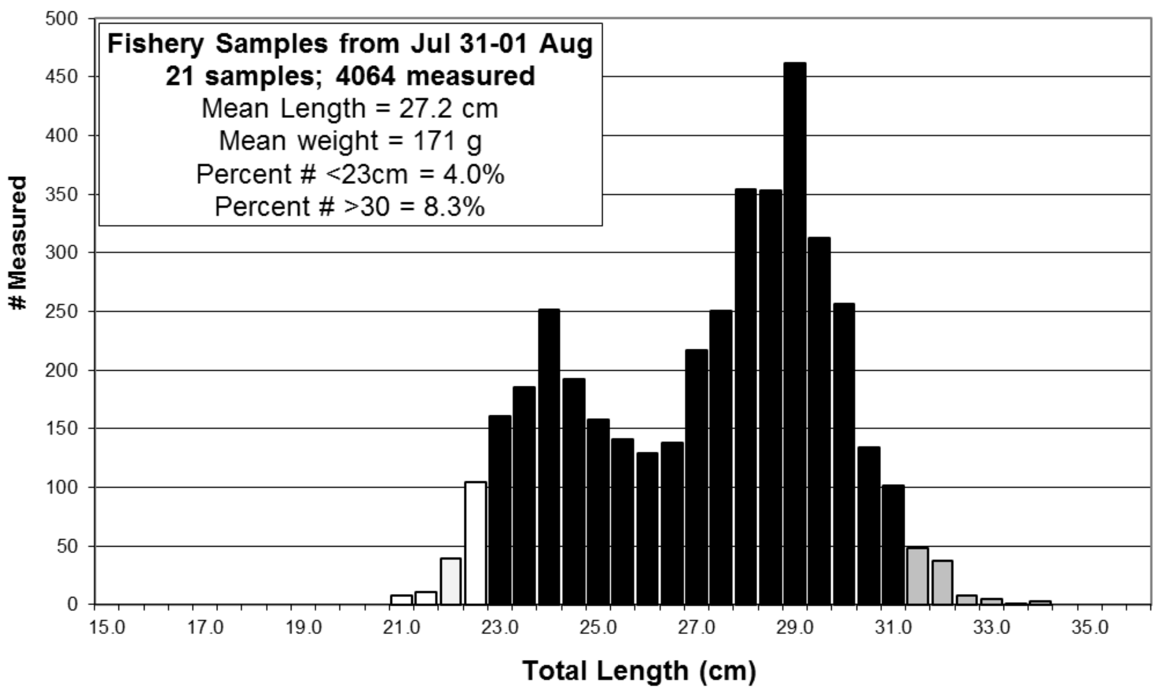

Figure 13B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#4) on July 30, 2016 from sampling on July 31–August 1, with proportions < 23 cm and > 30 cm shown as white and grey bars.

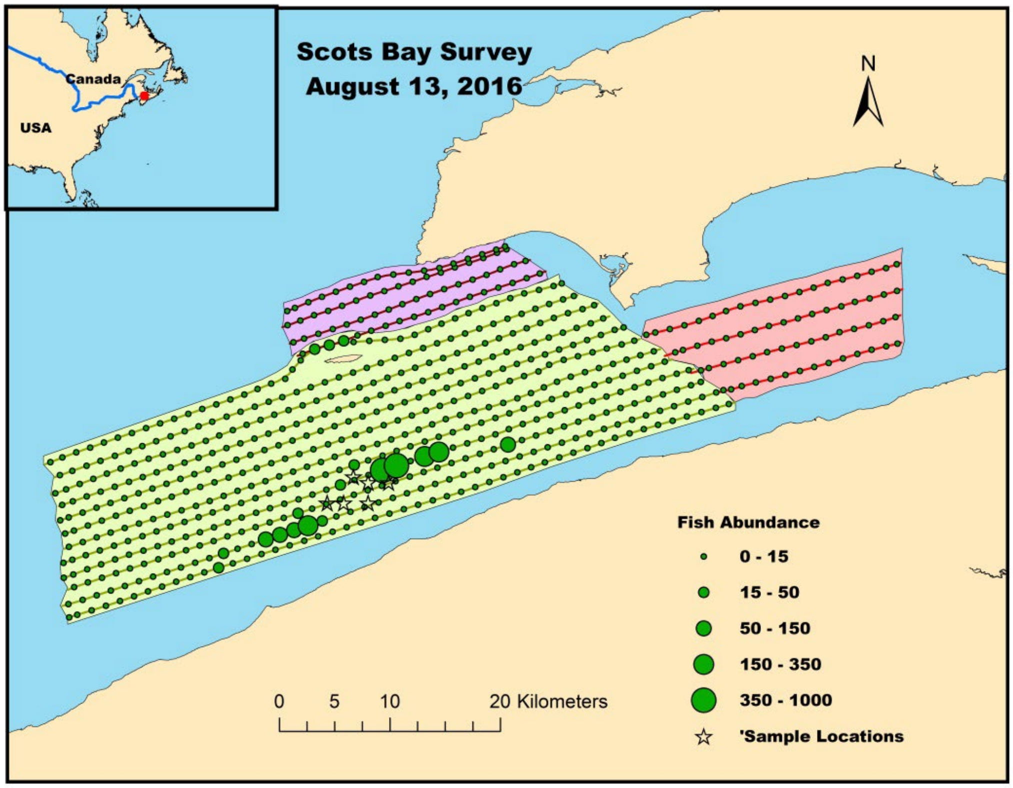

Figure 14A. Scots Bay acoustic survey (#5) on August 13, 2016 showing the main survey box and transects completed with backscatter (PRC_ABC) along with locations of fishery samples.

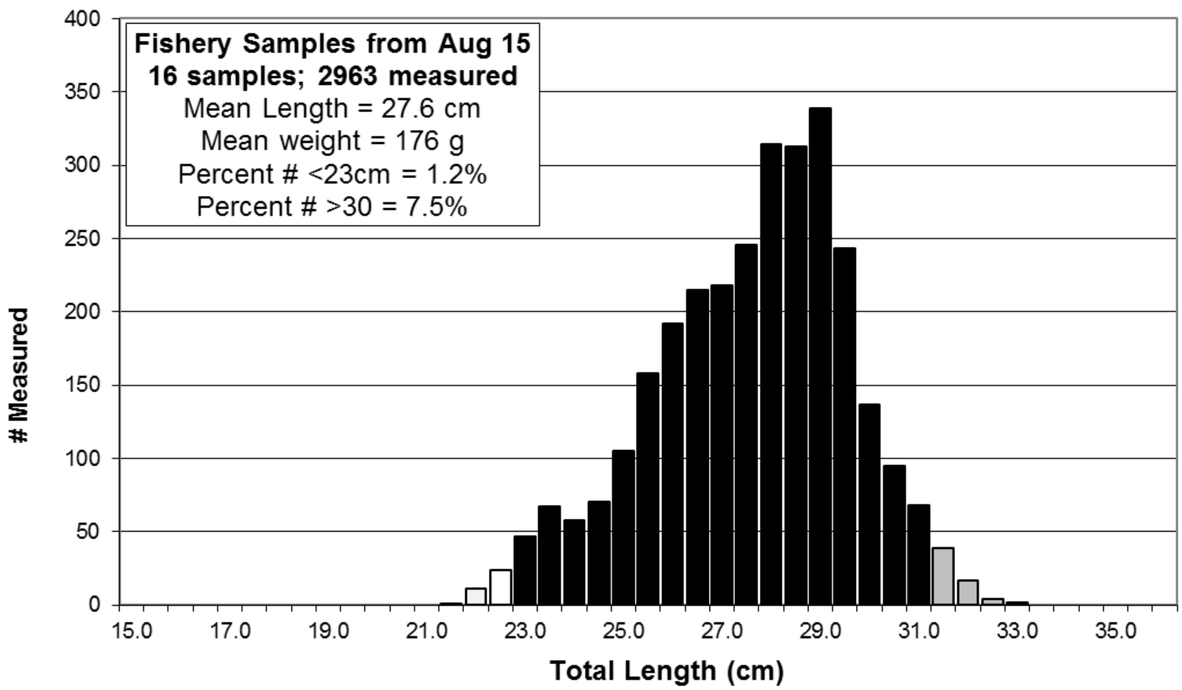

Figure 14B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#5) on August 13, 2016 from sampling on August 15, with proportions < 23 cm and > 30 cm shown as white and grey bars.

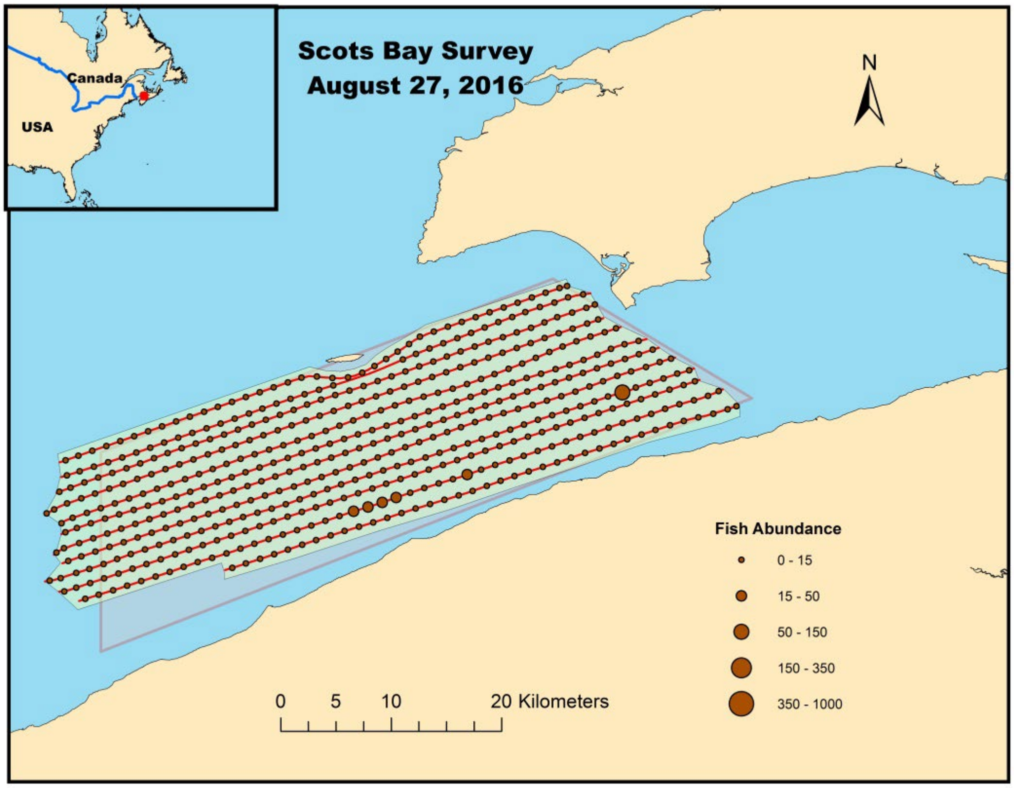

Figure 15. Scots Bay acoustic survey (#6) on August 27, 2016 showing the main survey box and transects completed with backscatter (PRC_ABC). No sample were collected close to the survey date. No length-frequency plot.

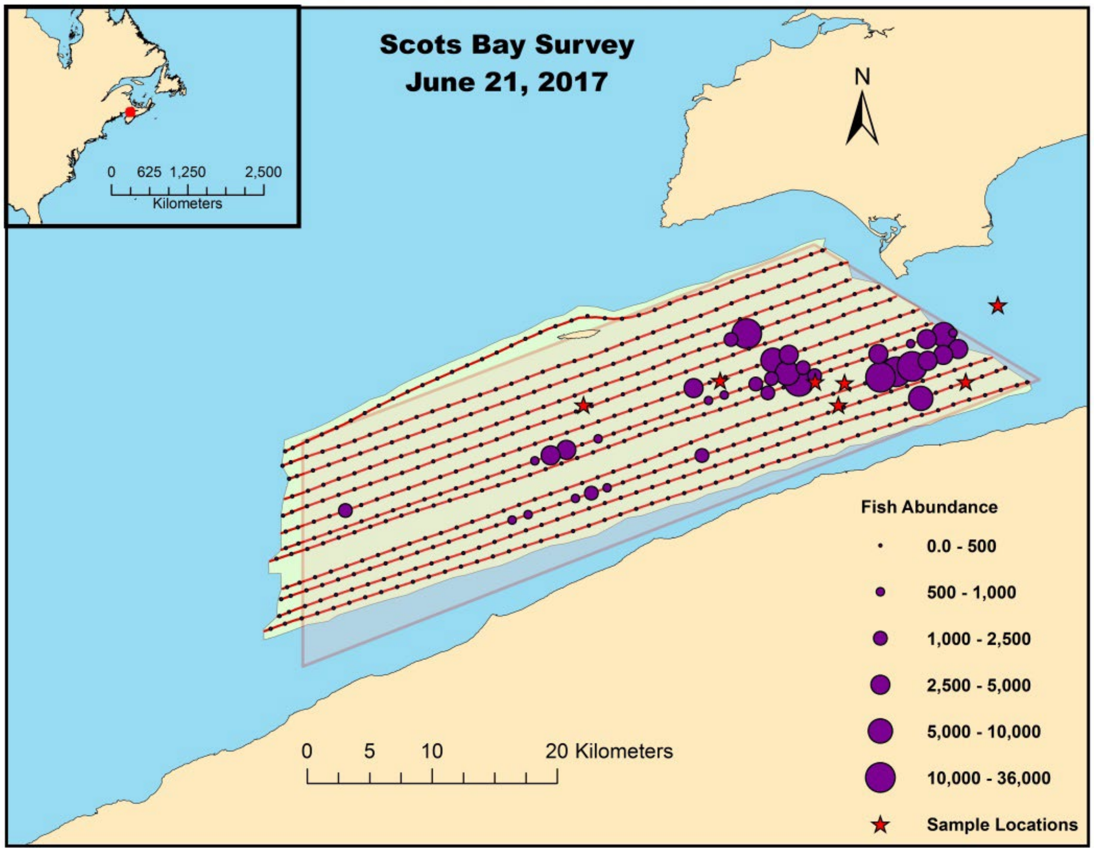

Figure 16A. Scots Bay acoustic survey (#1) on June 21, 2017 showing the main survey box and transects completed with backscatter (PRC_ABC) along with locations of fishery samples.

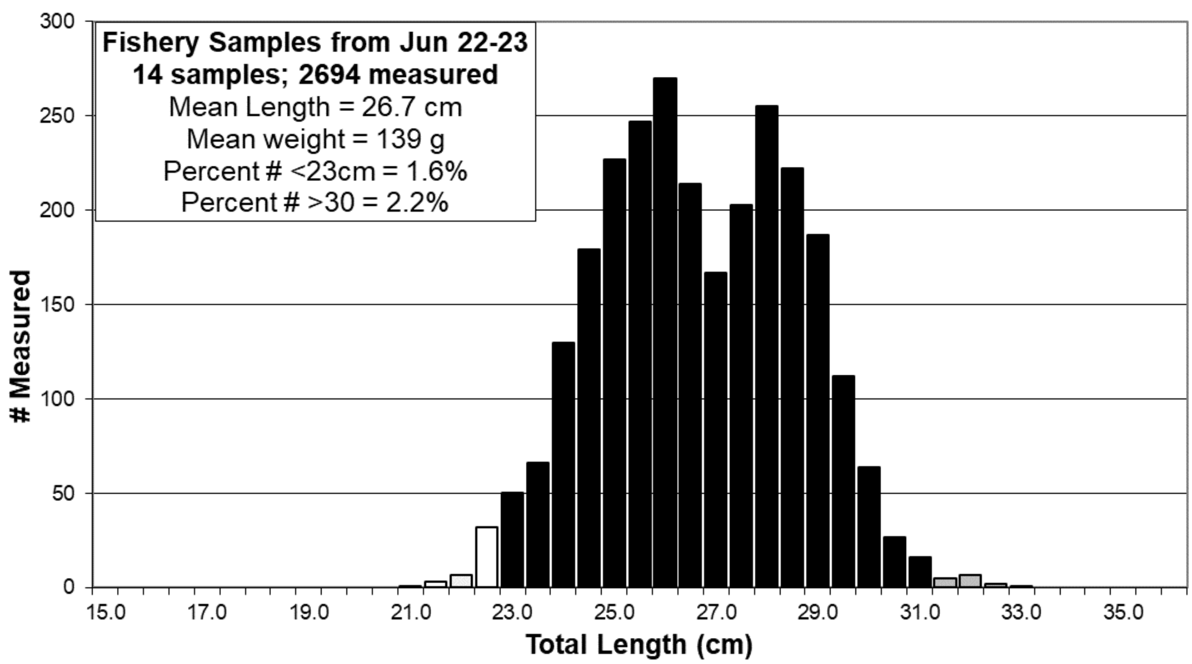

Figure 16B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#1) on June 21, 2017 from sampling on June 22-23, with proportions < 23 cm and > 30 cm shown as white and grey bars.

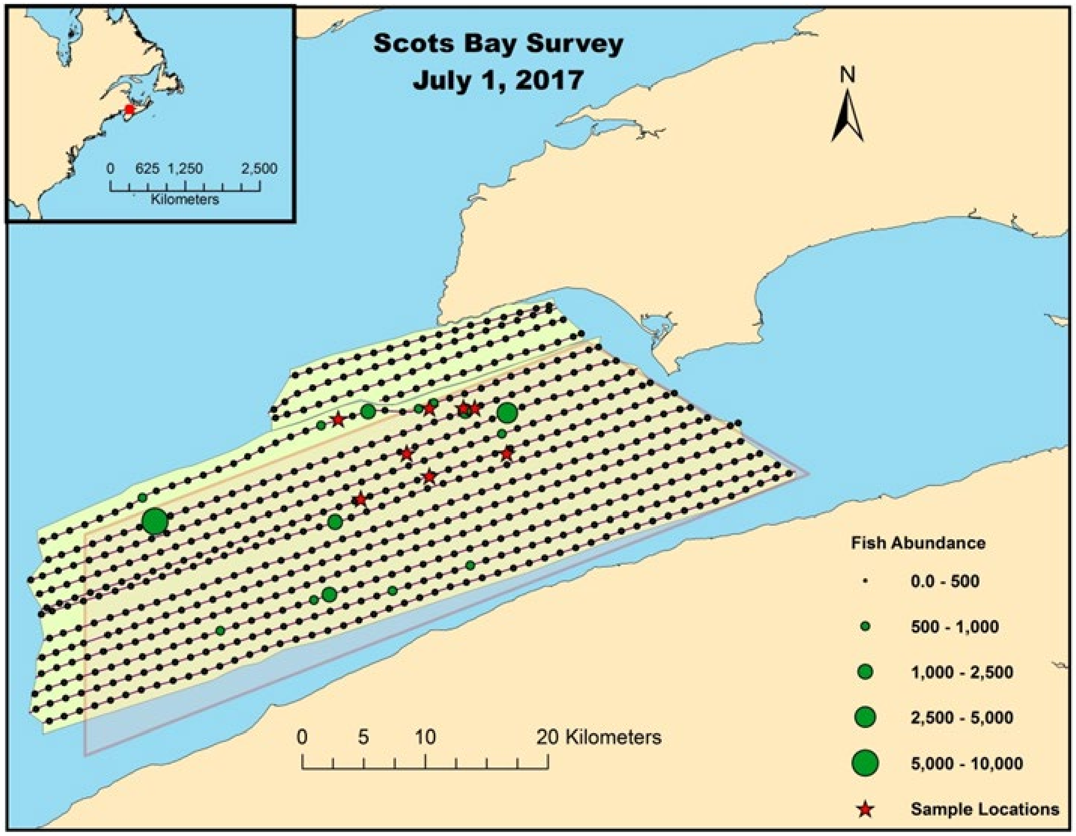

Figure 17A. Scots Bay acoustic survey (#2) on July 1, 2017 showing the main survey box and transects with backscatter (PRC_ABC) along with locations for fishery samples.

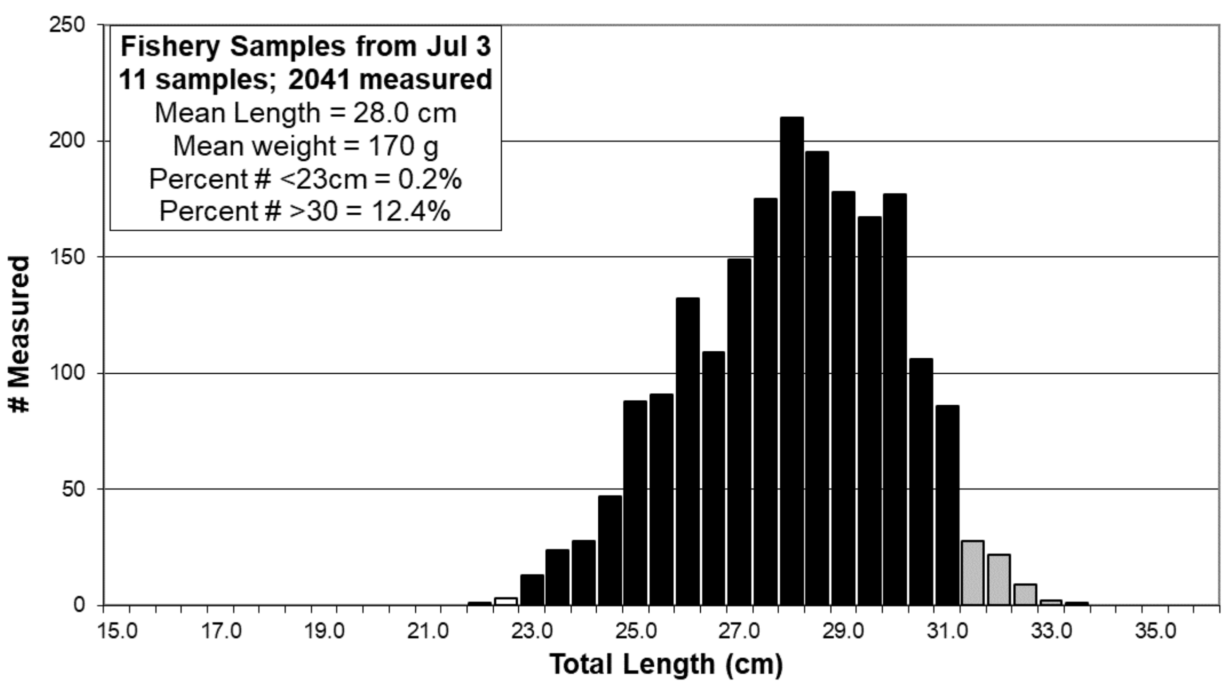

Figure 17B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#2) on July 1, 2017 from sampling on July 3, with proportions < 23 cm and > 30 cm shown as white and grey bars.

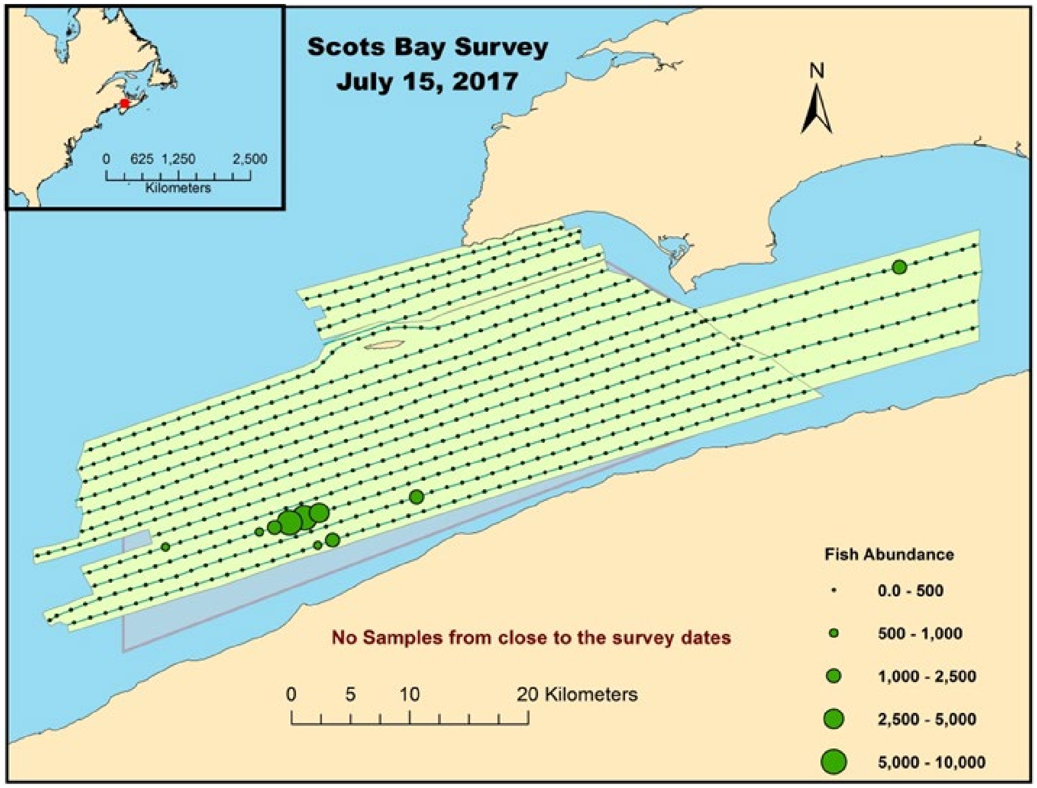

Figure 18. Scots Bay acoustic survey (#3) on July 15, 2017 showing the main survey box and transects completed with backscatter (PRC_ABC). No samples were collected close to the survey date so the standard was Target Strength (TS) used.

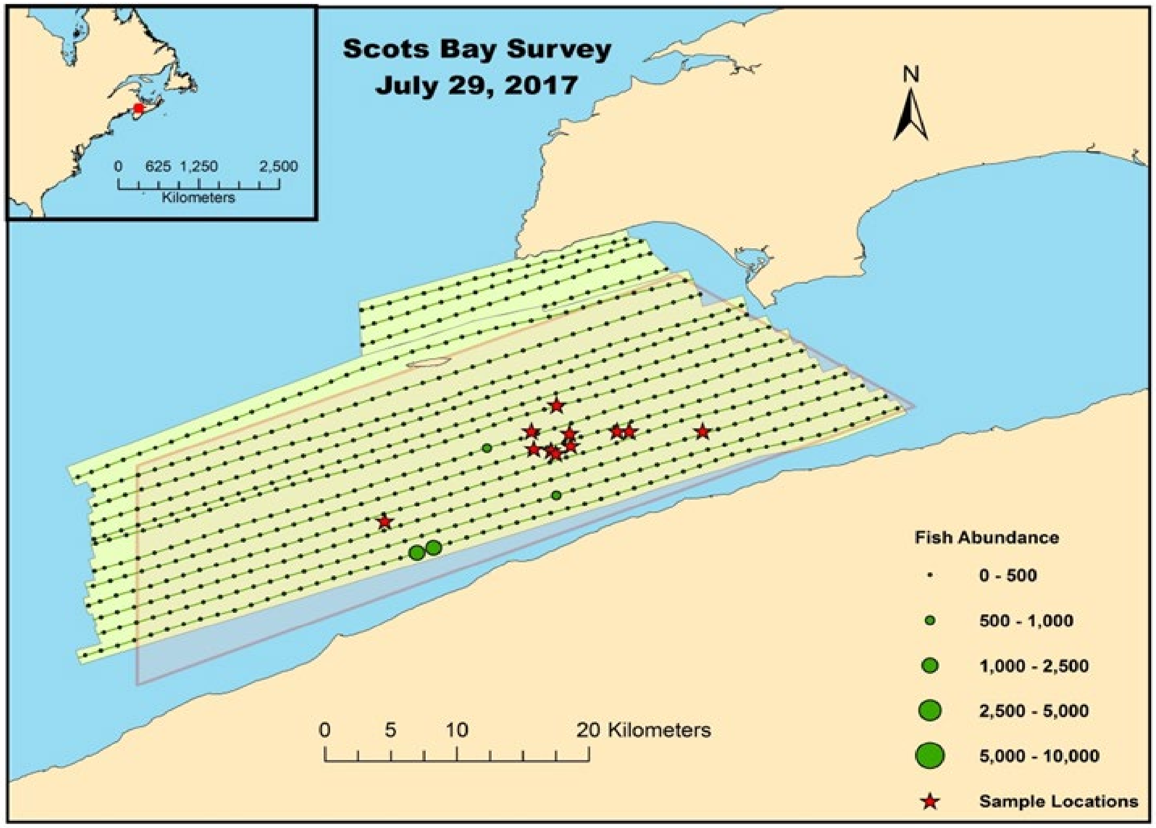

Figure 19A. Scots Bay acoustic survey (#4) on July 29, 2017 showing the main survey box and transects completed with backscatter (PRC_ABC) along with locations of fishery samples.

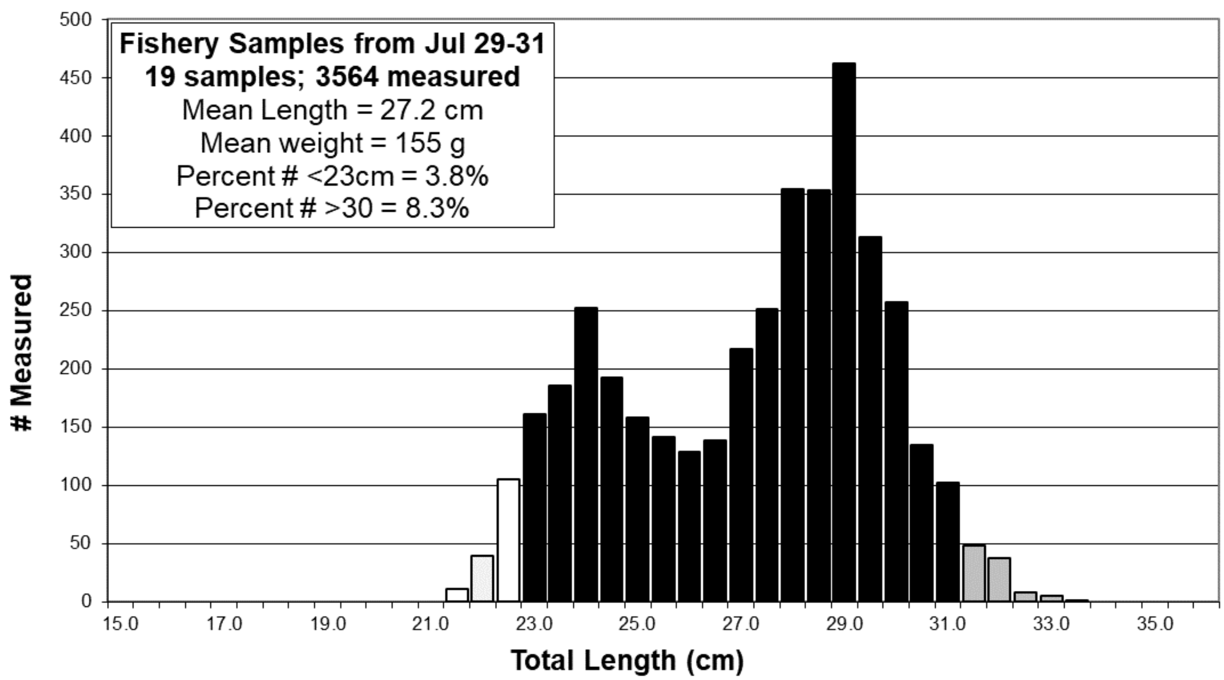

Figure 19B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#4) on July 29, 2017 from sampling on July 29–31, with proportions < 23 cm and > 30 cm shown as white and grey bars.

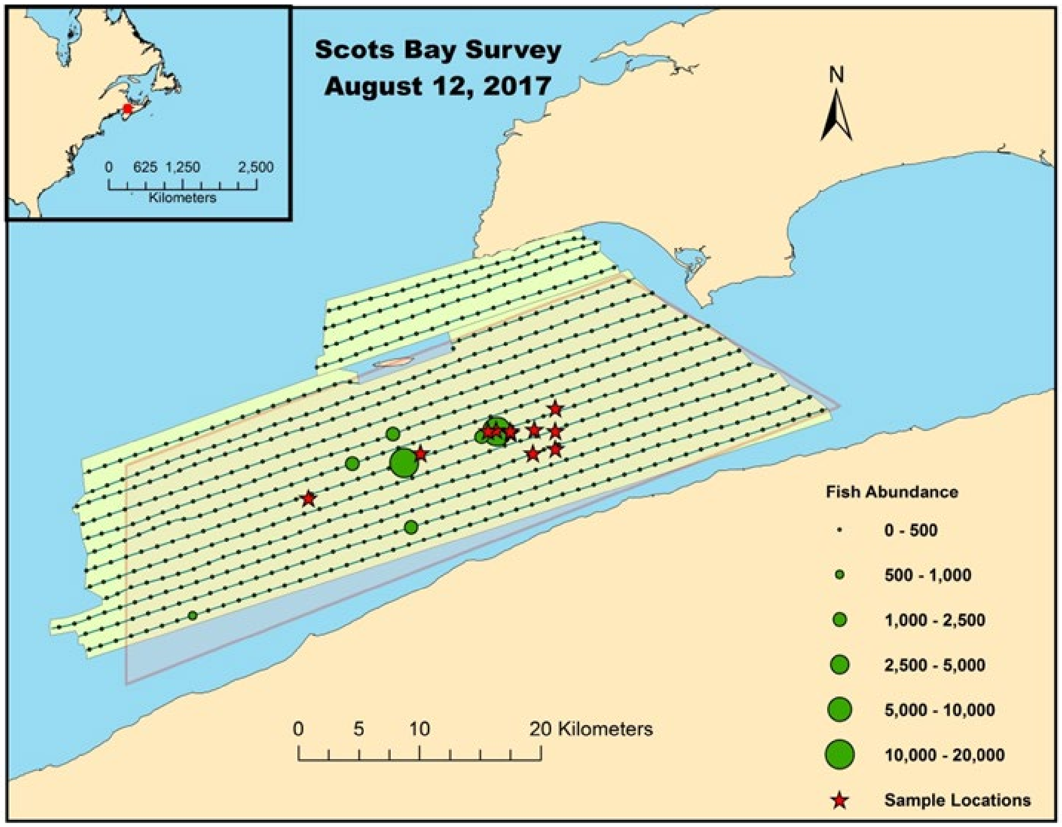

Figure 20A. Scots Bay acoustic survey (#5) on August 12, 2017, showing the main survey box and transects completed with backscatter (PRC_ABC) along with locations of fishery samples.

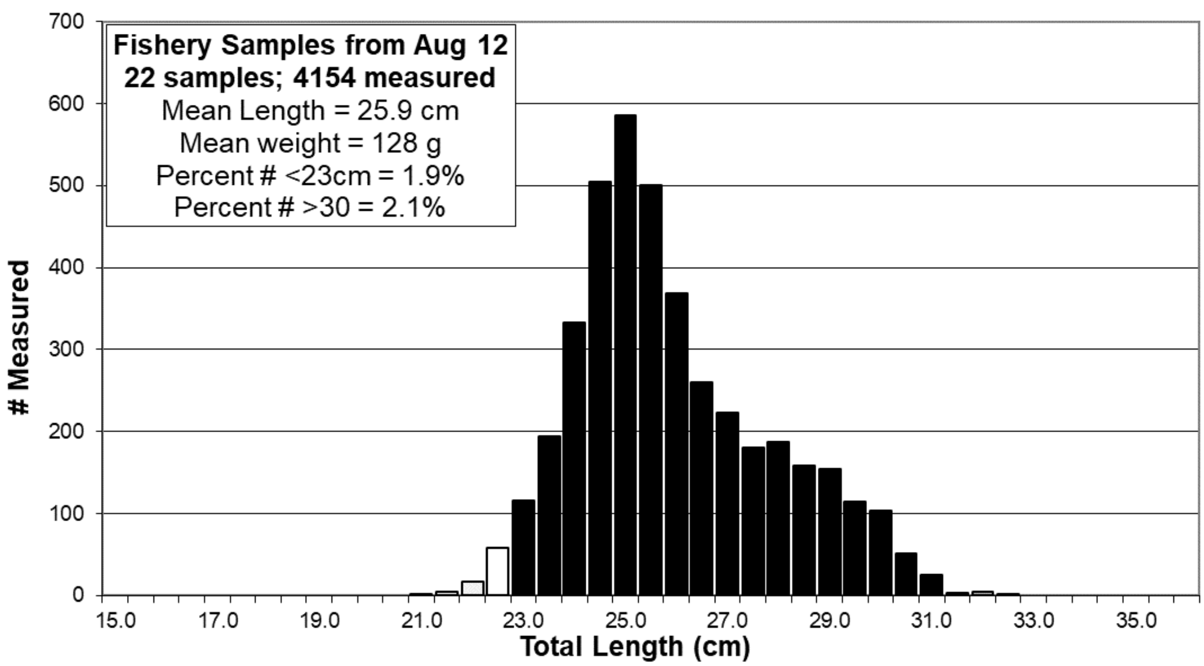

Figure 20B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#5) on August 12, 2017 from sampling on August 12, with proportions < 23 cm and > 30 cm shown as white and grey bars.

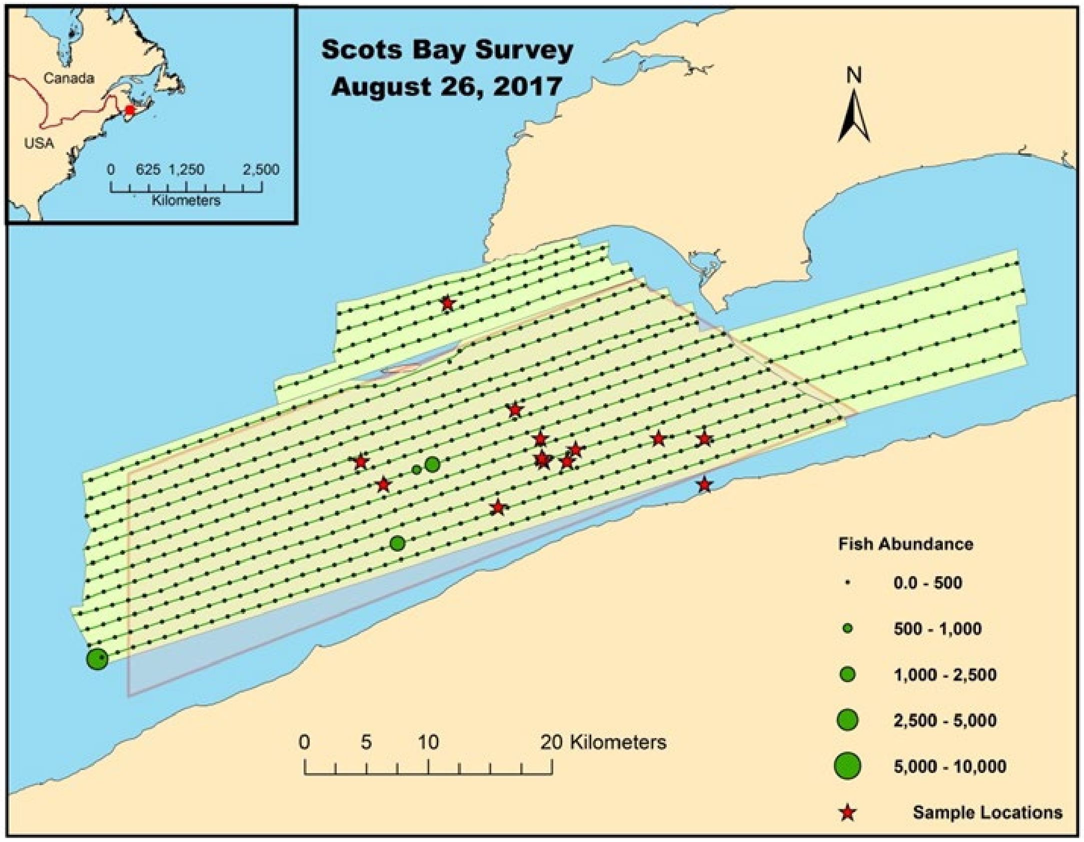

Figure 21A. Scots Bay acoustic survey (#6) on August 26, 2017 showing the main survey box and transects completed with backscatter (PRC_ABC) along with locations of fishery samples.

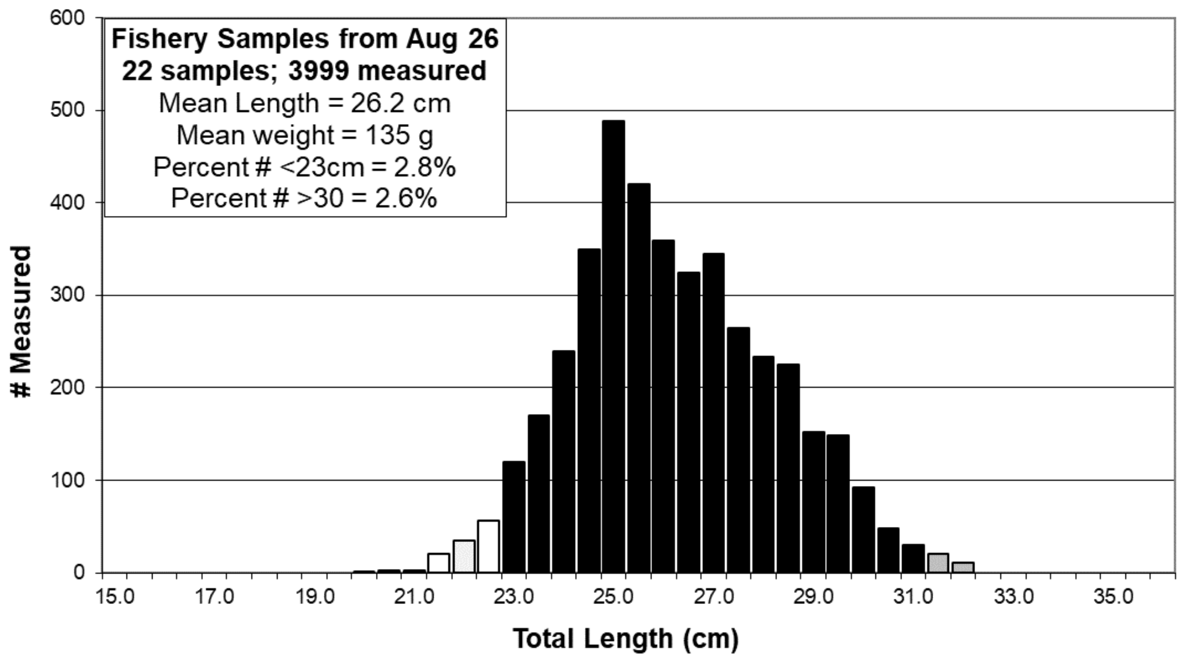

Figure 21B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#6) on August 29, 2017 from sampling on August 26, with proportions < 23 cm and > 30 cm shown as white and grey bars.

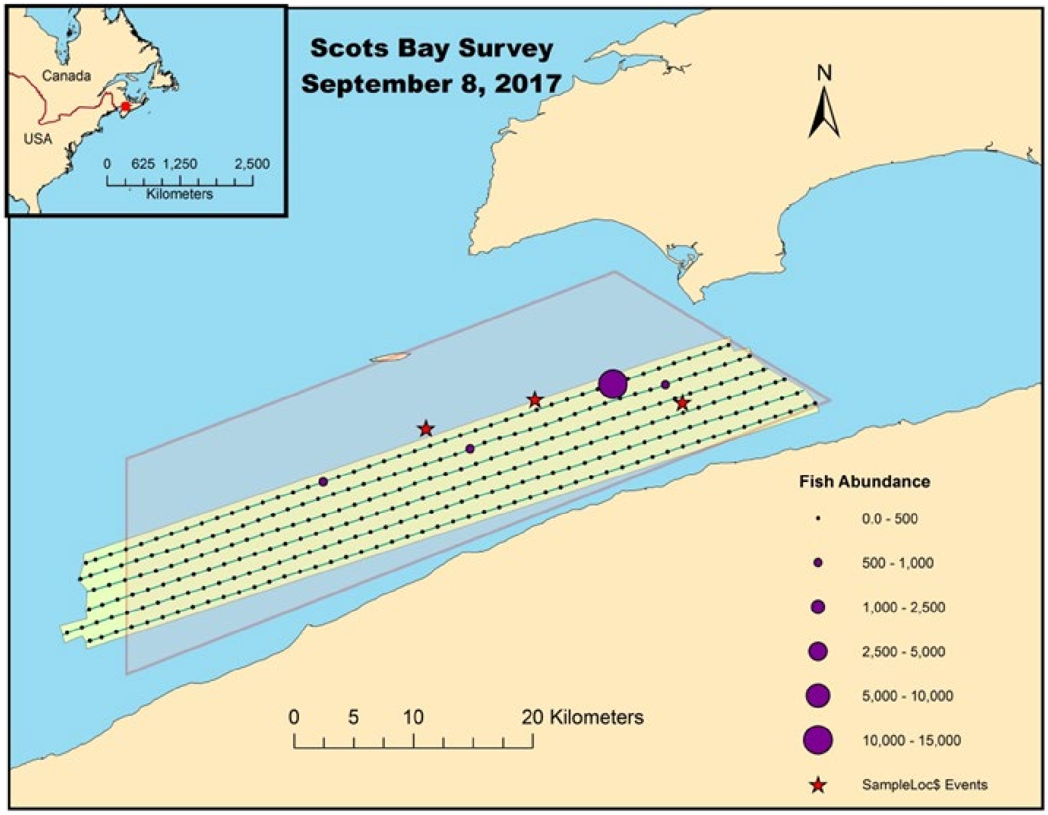

Figure 22A. Scots Bay acoustic survey (#7) on September 8, 2017 showing the main survey box and transects completed with backscatter (PRC_ABC) along with locations of fishery samples.

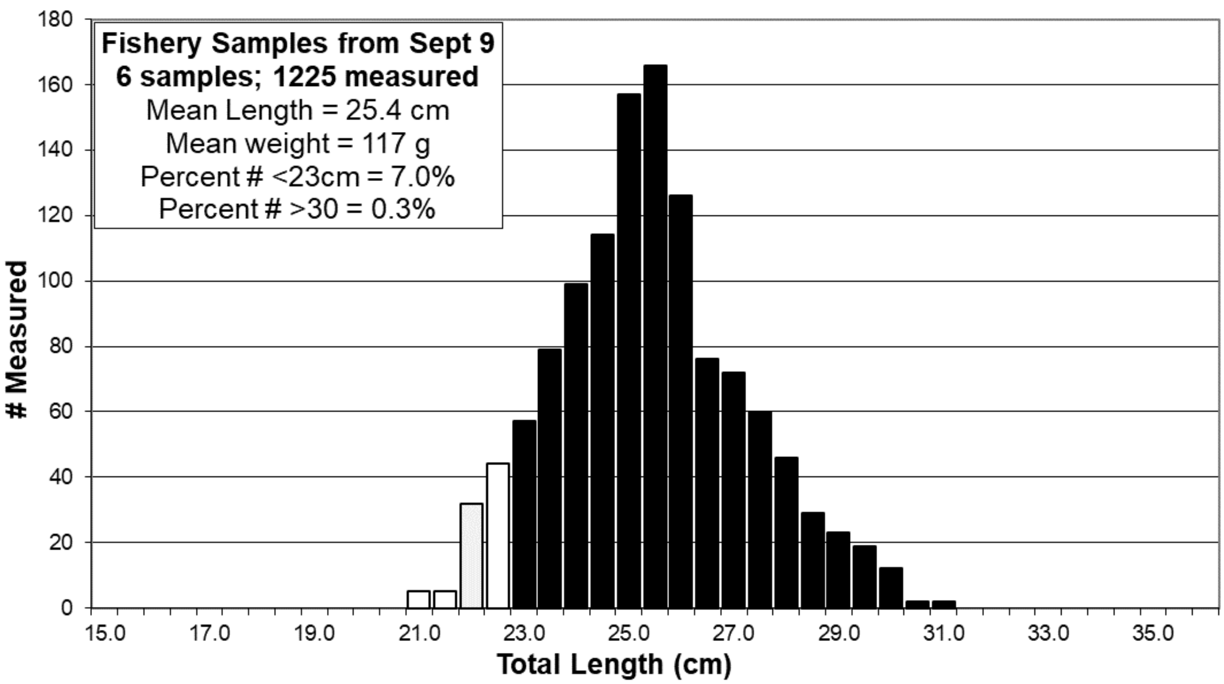

Figure 22B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#7) on September 8, 2017 from sampling on September 9, with proportions < 23 cm and > 30 cm shown as white and grey bars.

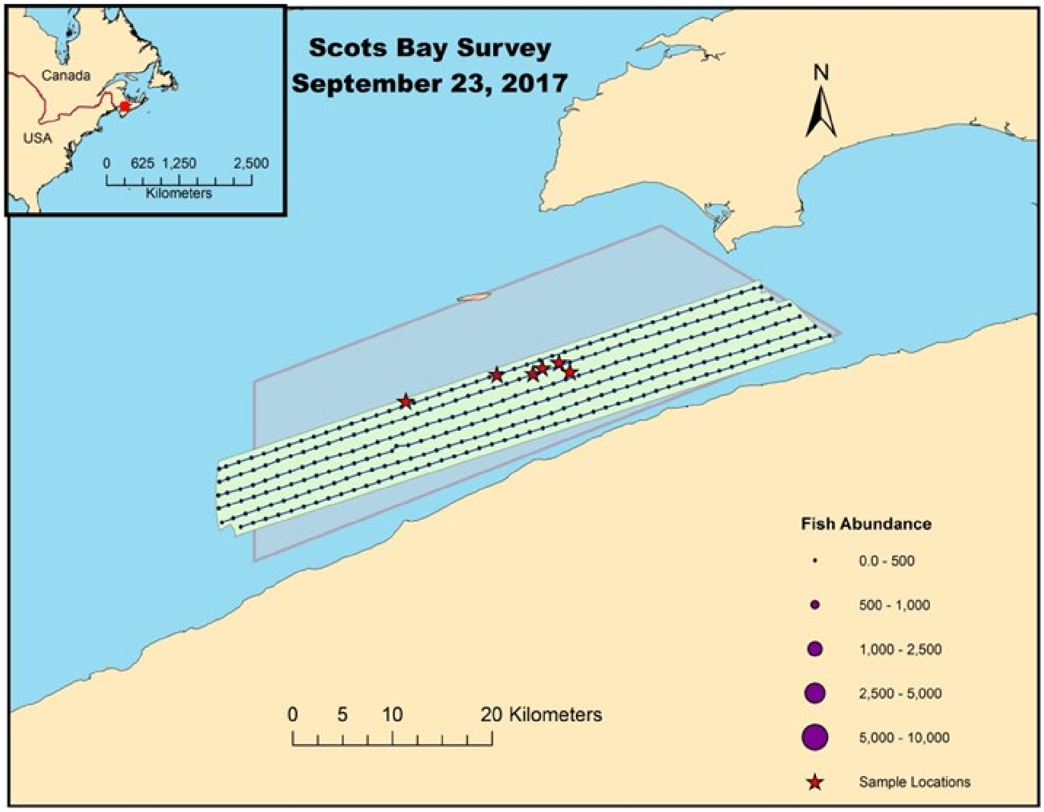

Figure 23A. Scots Bay acoustic survey (#8) on September 23, 2017 showing the main survey box and transects completed with backscatter (PRC_ABC) along with locations of fishery samples.

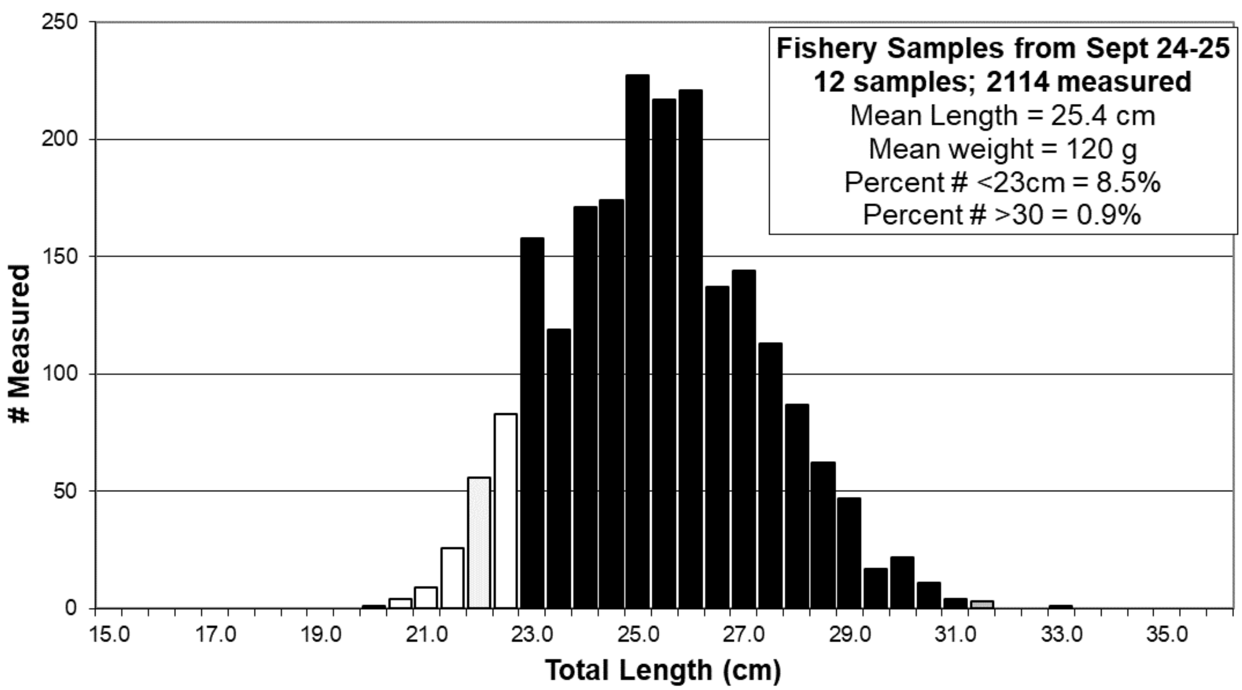

Figure 23B. Length distribution used for calculation of Target Strength (TS) for the Scots Bay acoustic survey (#8) on September 23, 2017 from sampling on September 24–25, with proportions < 23 cm and > 30 cm shown as white and grey bars.

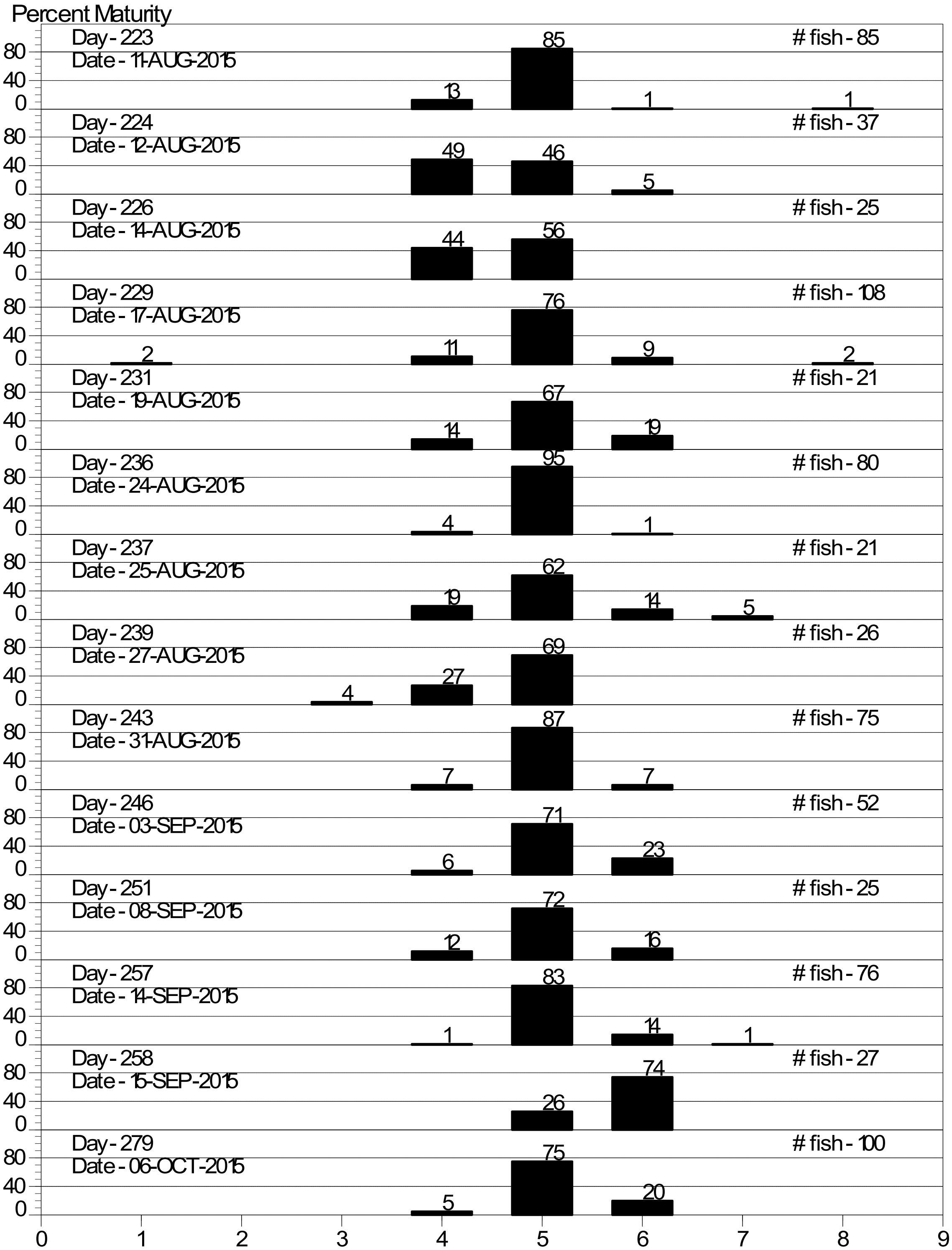

Figure 24A. Daily Herring maturity samples collected from German Bank survey box area in 2015 from August 11 to October 6. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; and 8 = recovering.

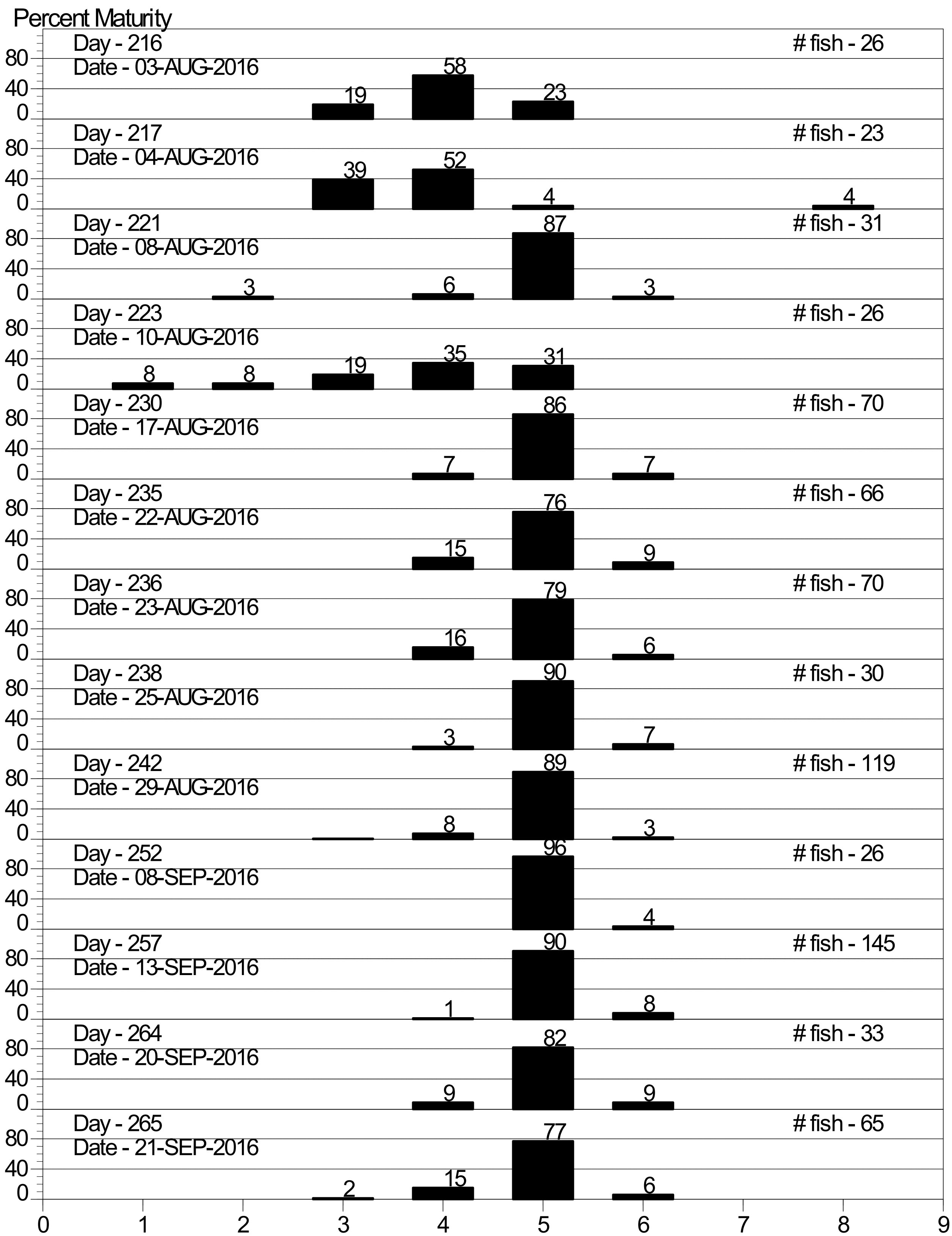

Figure 24B. Daily Herring maturity samples collected from German Bank survey box area in 2016 from August 13 to September 21. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; and 8 = recovering.

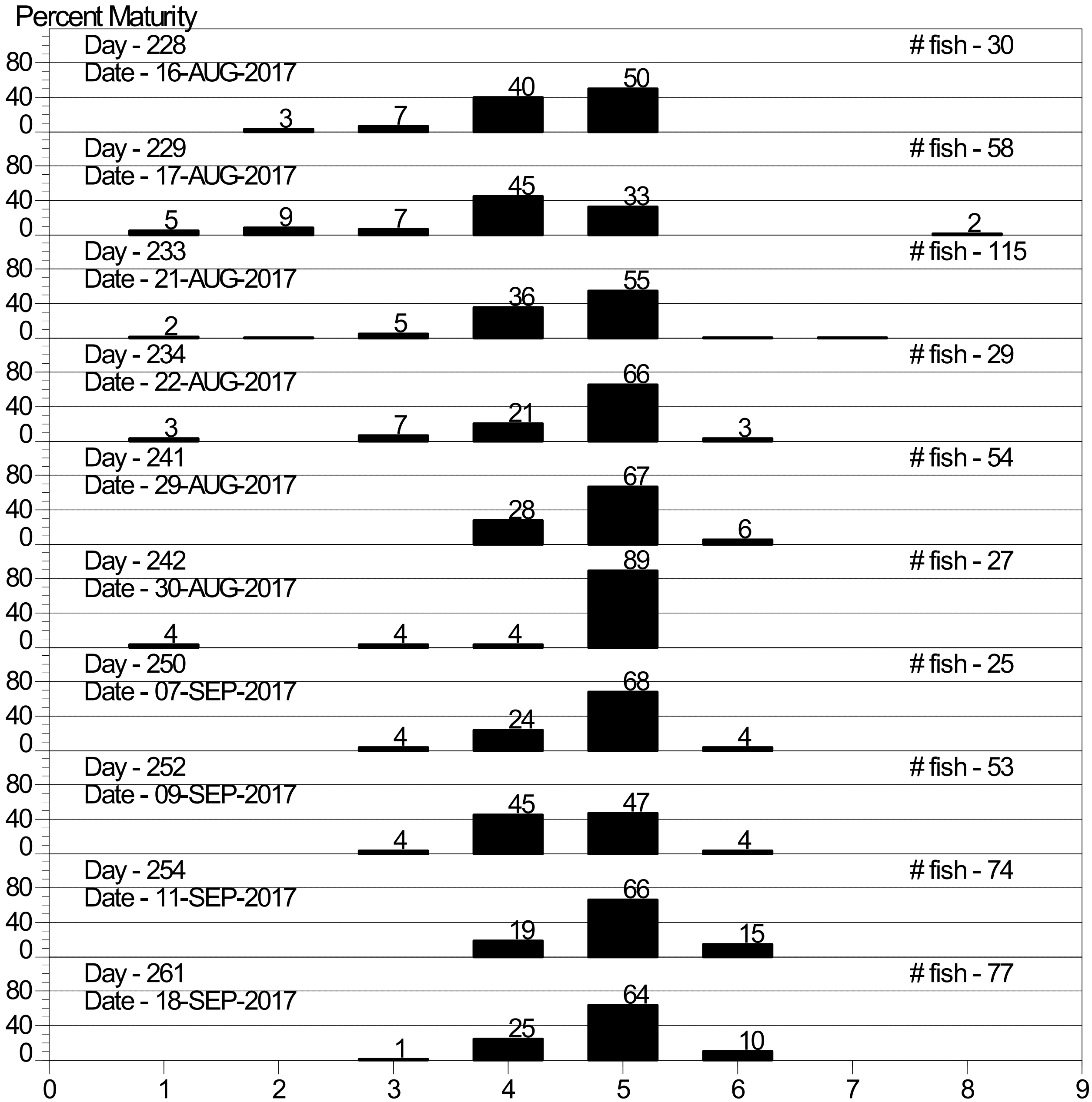

Figure 24C. Daily Herring maturity samples collected from German Bank survey box area in 2017 from August 16 to September 18. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; and 8 = recovering.

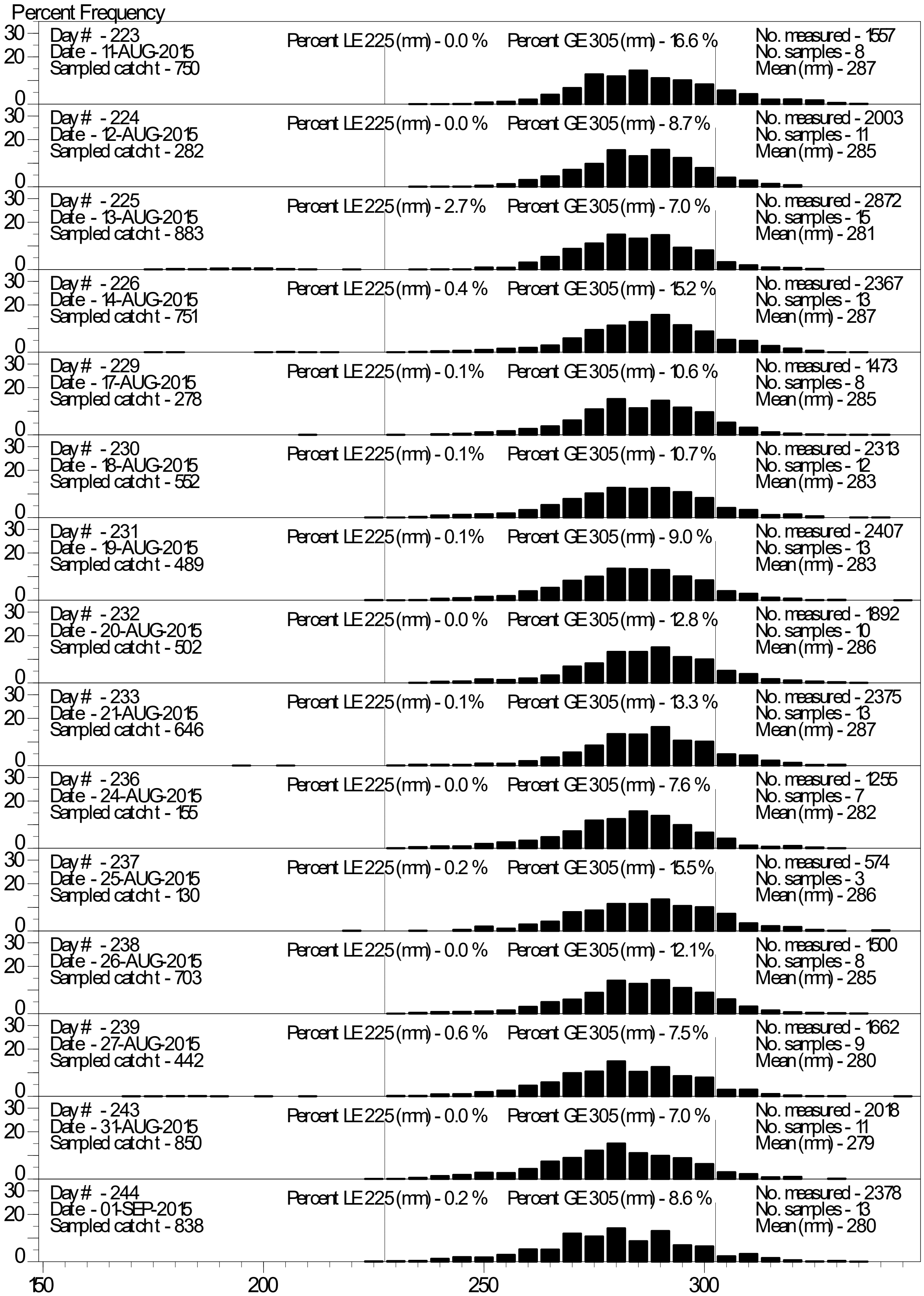

Figure 25A. Daily Herring length-frequency samples collected from 2015 German Bank survey box area for period from September 2 to October 6, with proportions < 23 cm and > 30 cm.

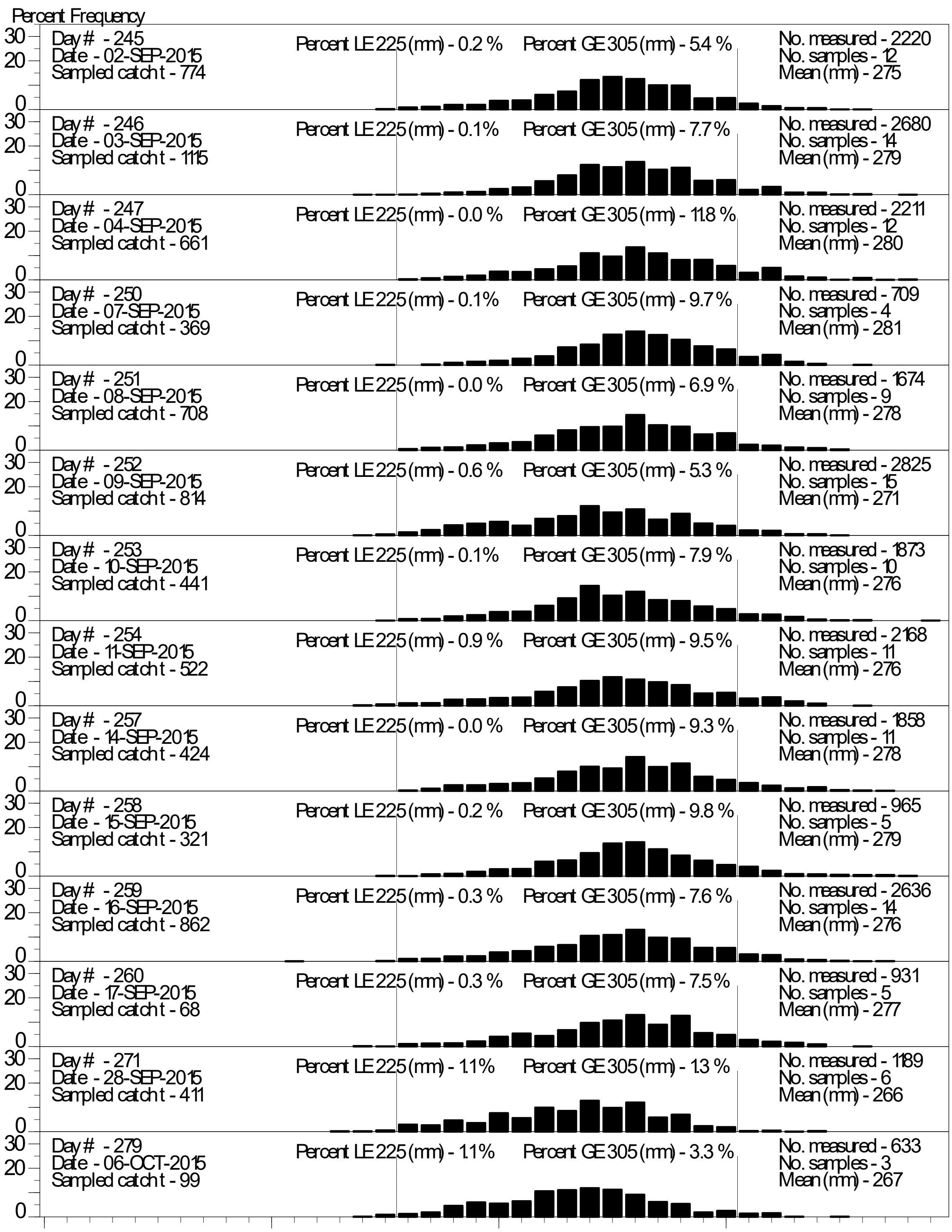

Figure 25A. (cont'd). Daily Herring length-frequency samples collected from 2015 German Bank survey box area for period from September 2 to October 6, with proportions < 23 cm and > 30 cm.

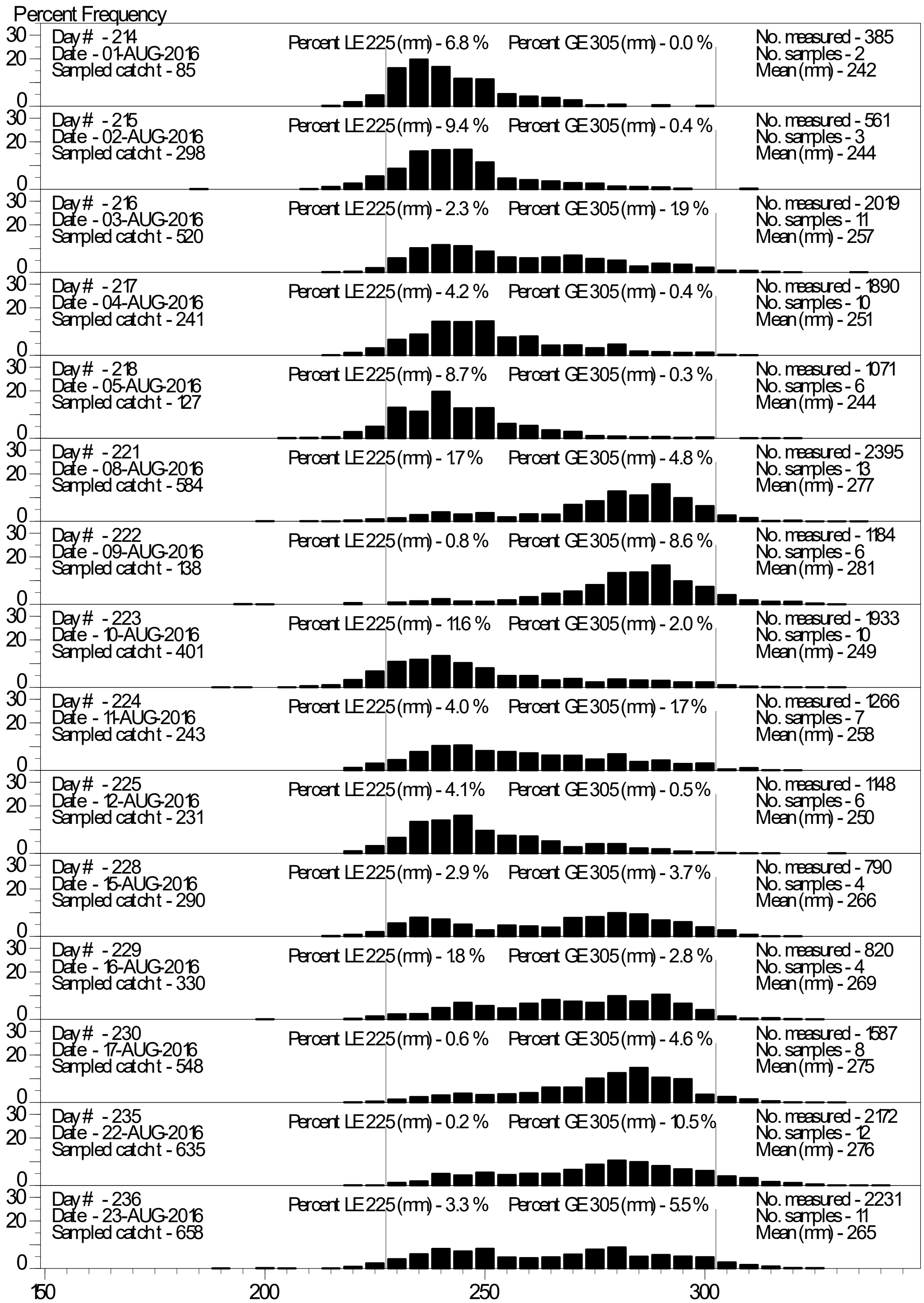

Figure 25B. Daily Herring length-frequency samples collected from 2016 German Bank survey box area for period from August 1 to August 23, with proportions < 23 cm and > 30 cm.

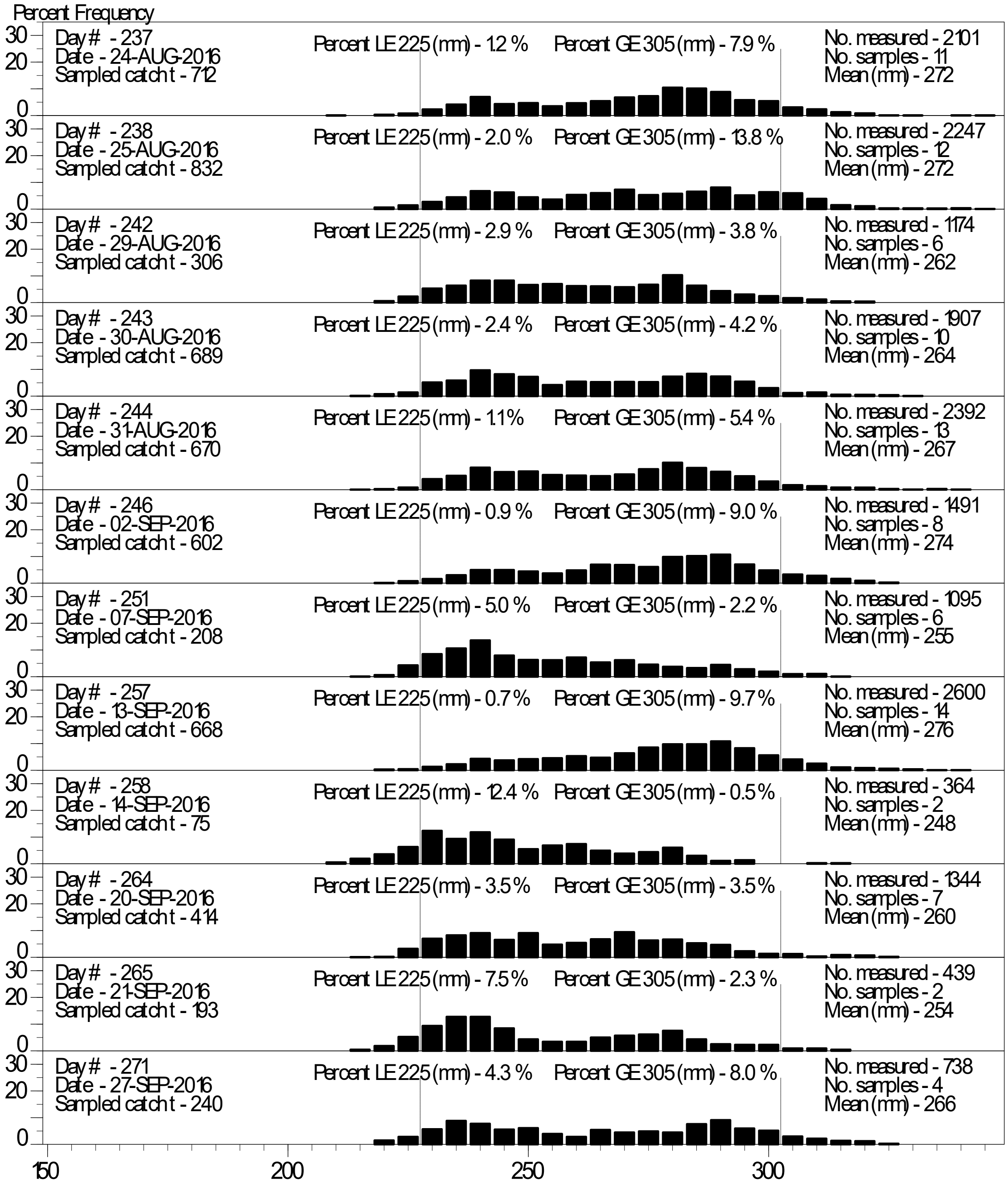

Figure 25B. (cont'd). Daily Herring length-frequency samples collected from 2016 German Bank survey box area for period from August 24 to September 27, with proportions < 23 cm and > 30 cm.

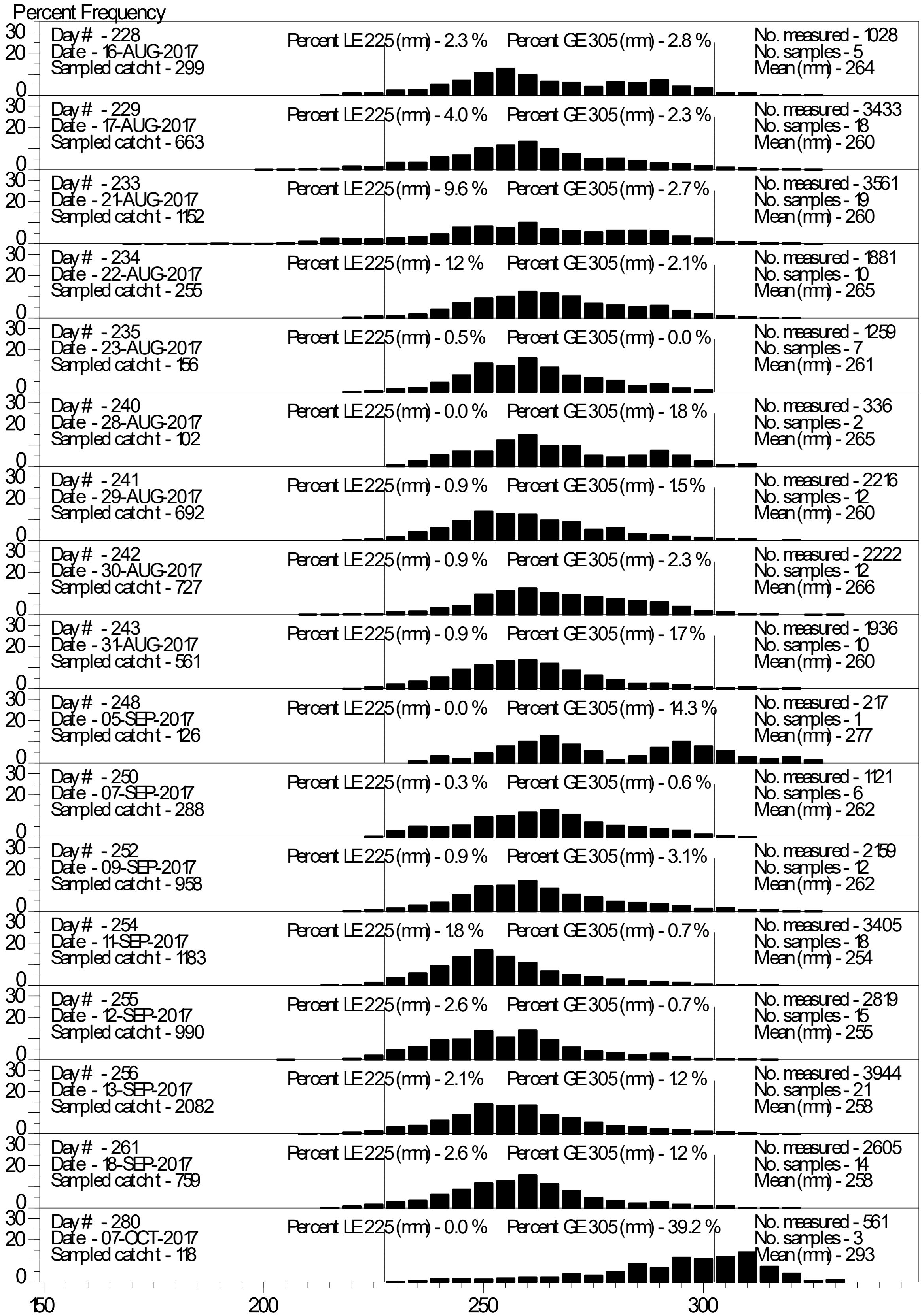

Figure 25C. Daily Herring length-frequency samples collected from 2017 German Bank survey box area for period from August 16 to October 7, with proportions < 23 cm and > 30 cm.

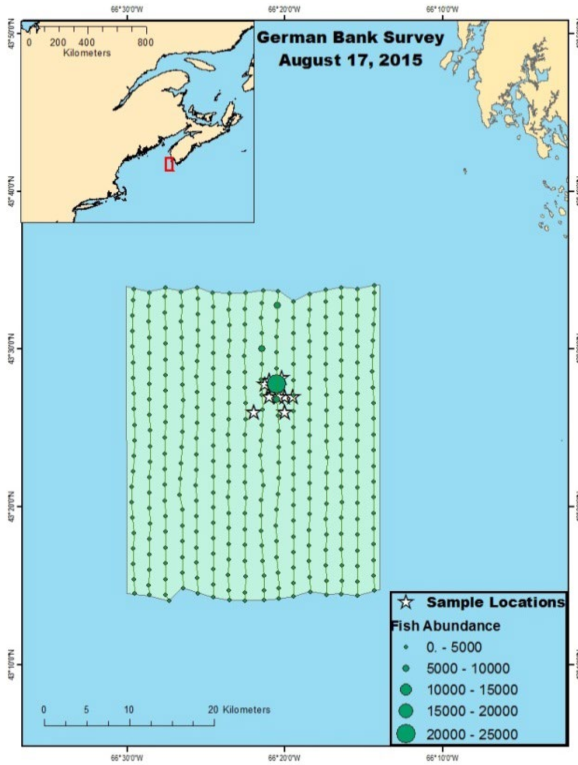

Figure 26A. German Bank acoustic survey (#1) on August 17, 2015 showing the transects with backscatter (PRC-NASC) along with the locations of fishery samples used in calculation of Target Strength (TS).

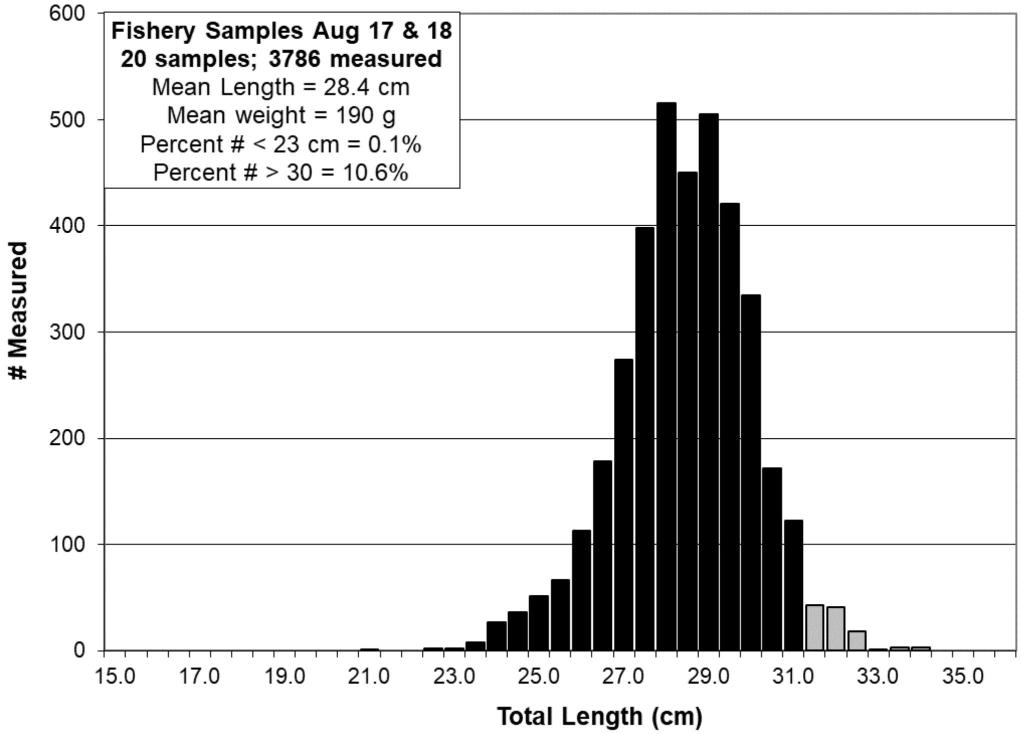

Figure 26B. Length distribution used for calculation of Target Strength (TS) for the German Bank acoustic survey (#1) on August 17, 2015, from sampling on August 17–18, with proportions < 23 cm and > 30 cm shown as white and grey bars.

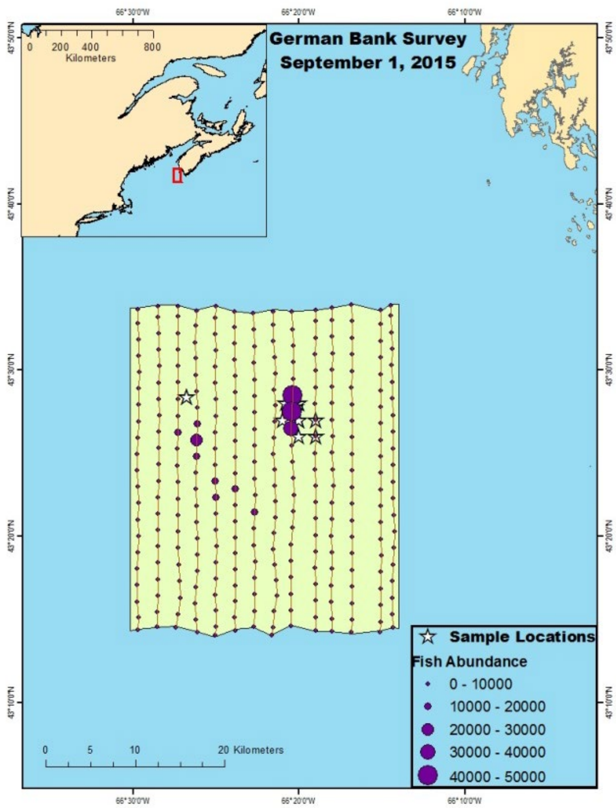

Figure 27A. German Bank acoustic survey (#2) on September 1, 2015 showing the transects with backscatter (PRC-NASC) along with the locations of fishery samples used in calculation of Target Strength (TS).

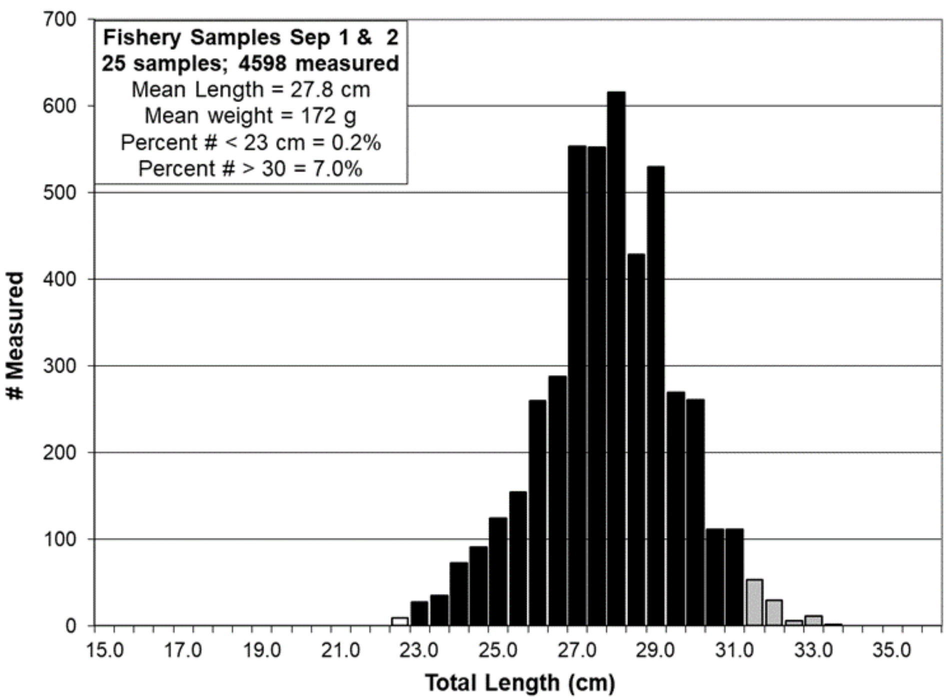

Figure 27B. Length distribution used for calculation of Target Strength (TS) for the German Bank acoustic survey (#2) on September 1, 2015 from sampling during on September 1–2, with proportions < 23 cm and > 30 cm shown as white and grey bars.

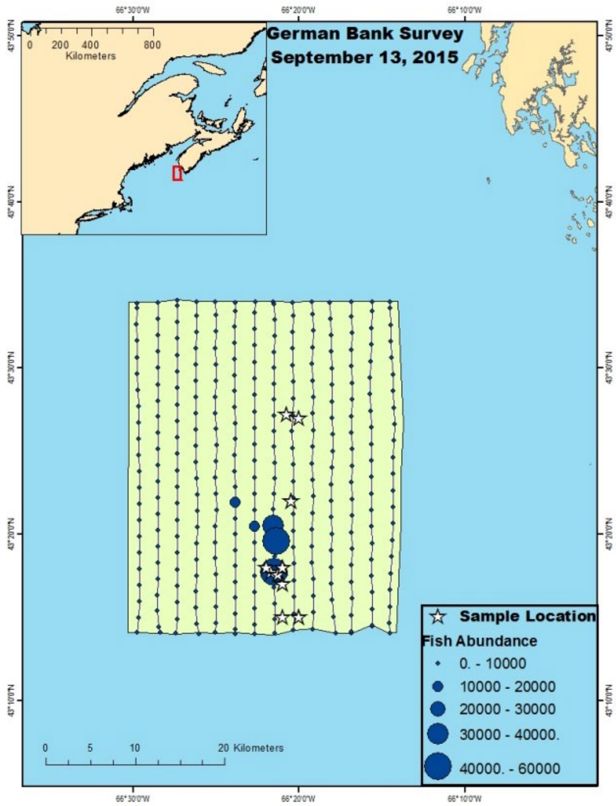

Figure 28A. German Bank acoustic survey (#3) on September 13, 2015 showing the transects with backscatter (PRC-NASC) along with the locations of fishery samples used in calculation of Target Strength (TS).

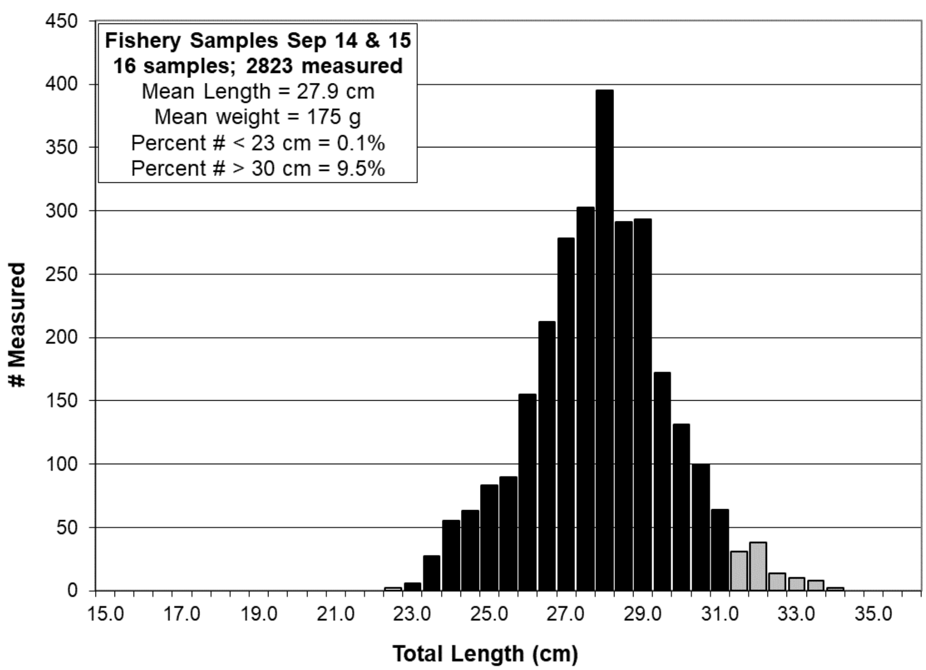

Figure 28B. Length distribution used for calculation of Target Strength (TS) for the German Bank acoustic survey (#3) on September 13, 2015 from sampling on September 14–15, with proportions < 23 cm and > 30 cm shown as white and grey bars.

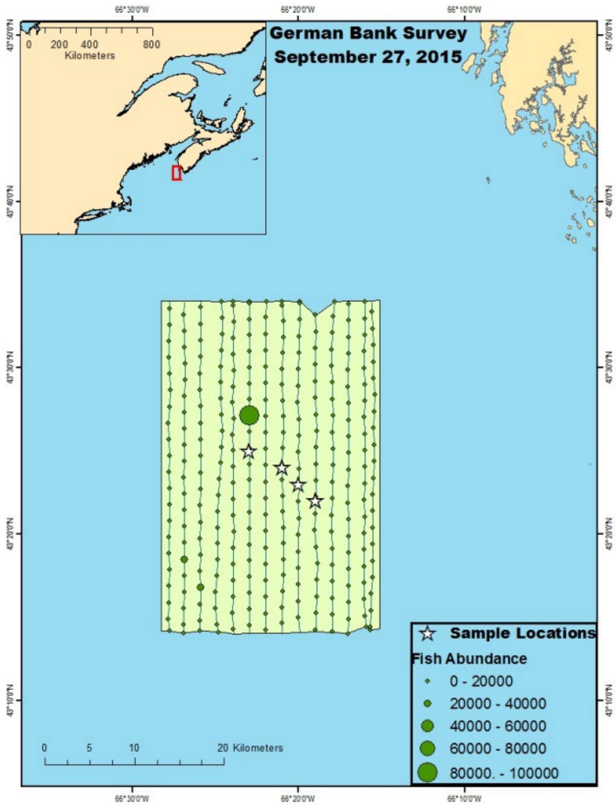

Figure 29A. German Bank acoustic survey (#5) on September 27, 2015 showing the transects with backscatter (PRC-NASC) along with the locations of fishery samples used in calculation of Target Strength (TS).

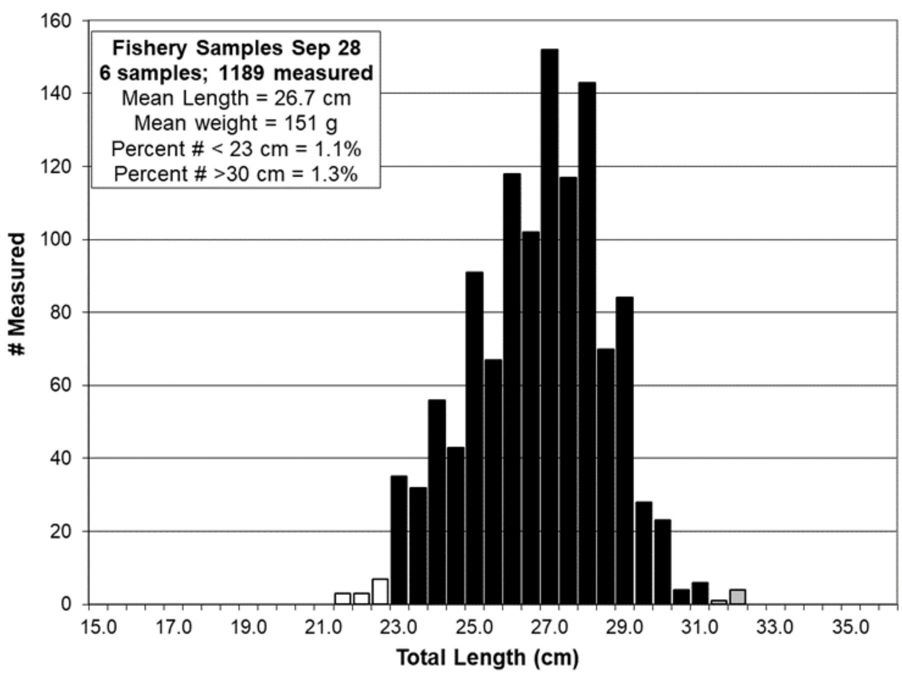

Figure 29B. Length distribution used for calculation of Target Strength (TS) for the German Bank acoustic survey (#5) on September 27, 2015 from sampling on September 28, with proportions < 23 cm and > 30 cm shown as white and grey bars.

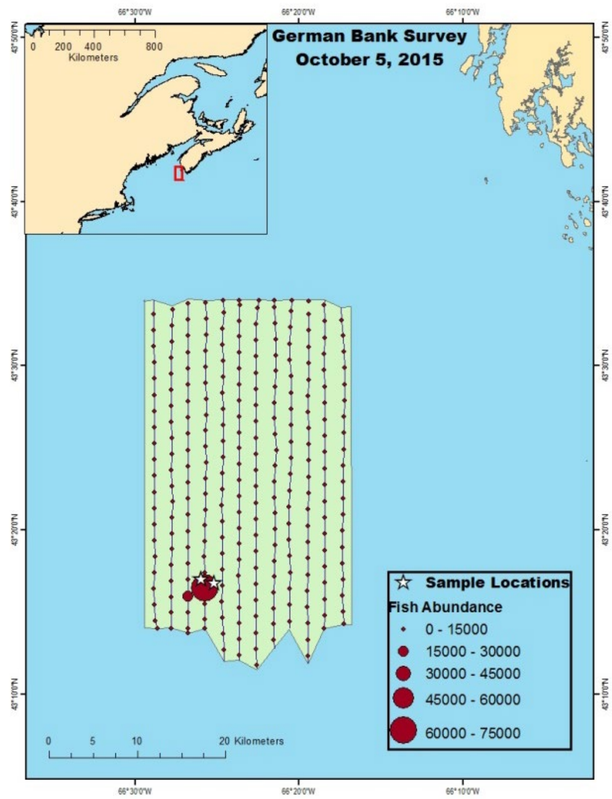

Figure 30A. German Bank acoustic survey (#6) on October 5, 2015 showing the transects with backscatter (PRC-NASC) along with the locations of fishery samples. This survey was excluded from the total biomass estimate because it was too close to the one done on September 13.

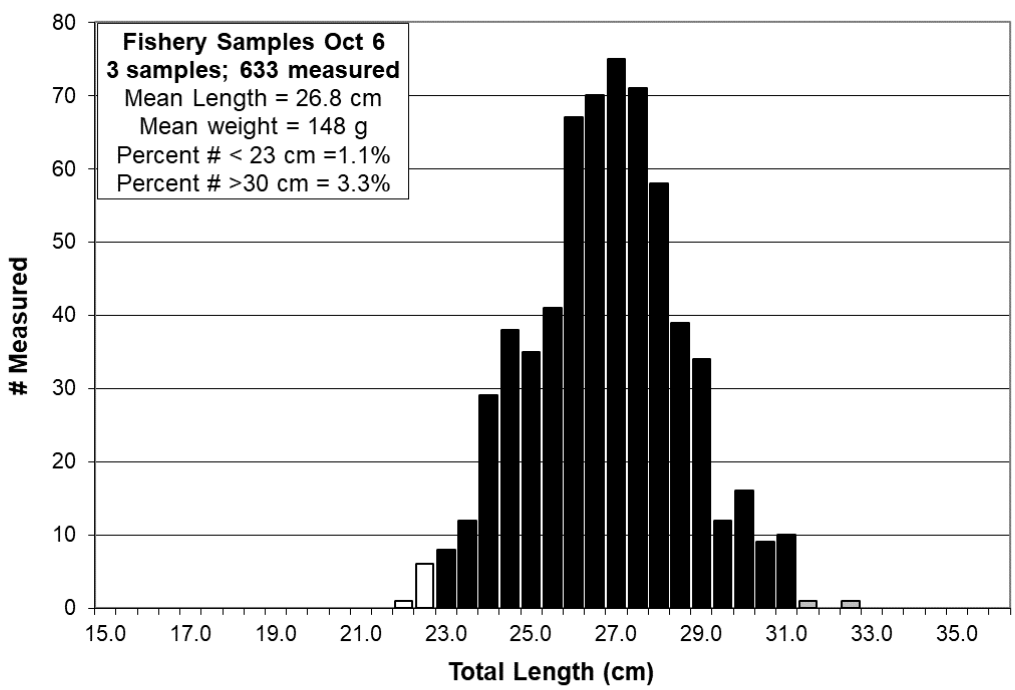

Figure 30B. Length distribution used for calculation of Target Strength (TS) for the German Bank acoustic survey (#6) on October 5, 2015, from sampling on October 6, with proportions < 23 cm and > 30 cm shown as white and grey bars.

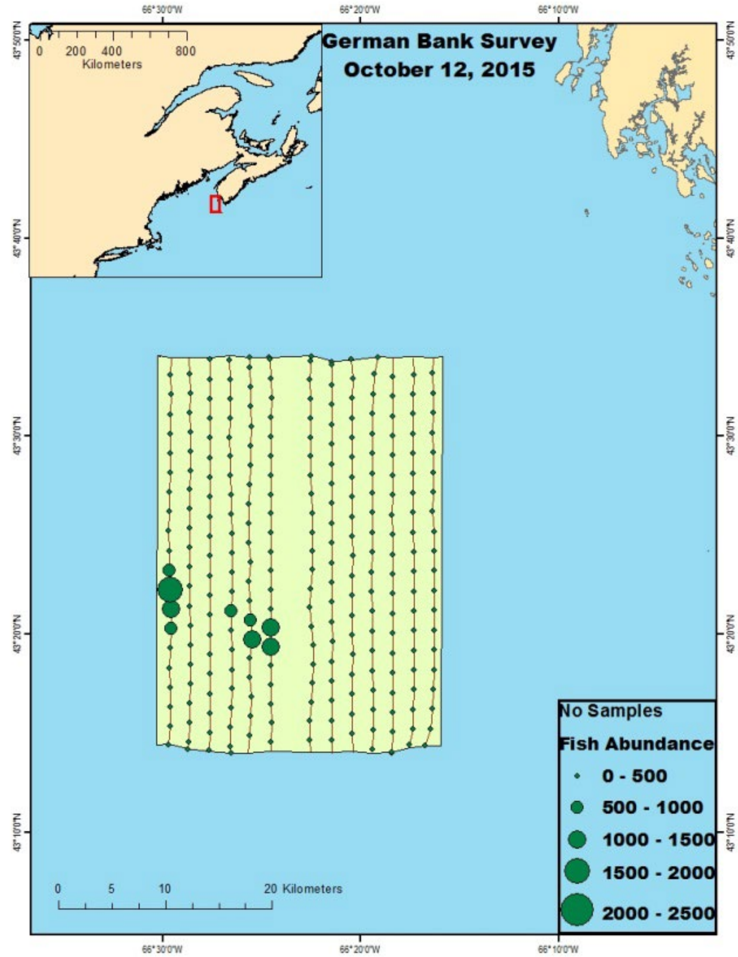

Figure 31. German Bank acoustic survey (#7) on October 12, 2015 showing the main survey box and transects with backscatter (PRC-NASC). No sample available for the German Bank acoustic survey (#7) on October 12, 2015. Standard Target Strength (TS) used.

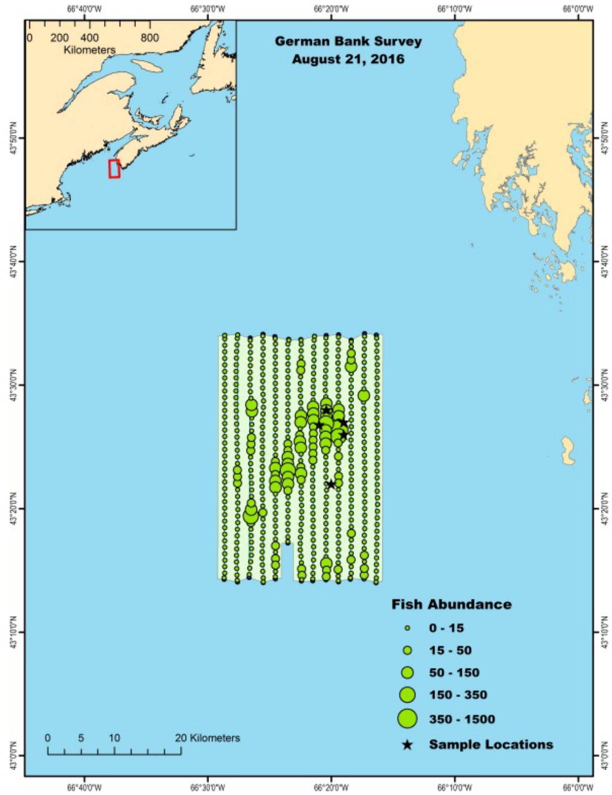

Figure 32A. German Bank acoustic survey (#1) on August 21, 2016 showing the transects with backscatter (PRC-NASC) along with the locations of fishery samples used in calculation of Target Strength (TS).

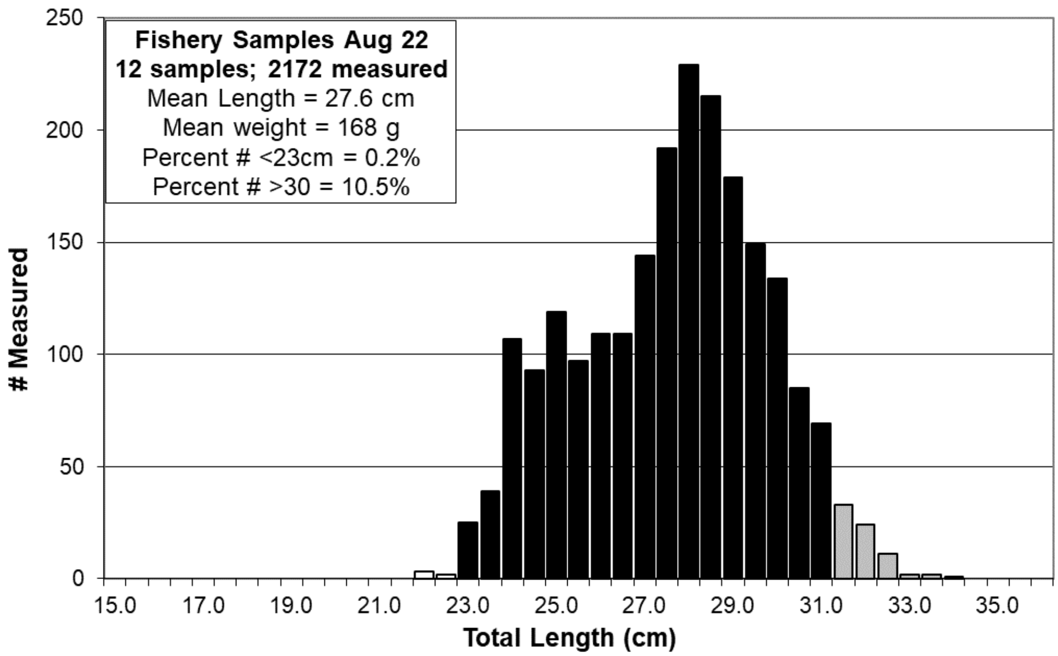

Figure 32B. Length distribution used for calculation of Target Strength (TS) for the German Bank acoustic survey (#1) on August 21, 2016 from sampling on August 22, with proportions < 23 cm and > 30 cm shown as white and grey bars.

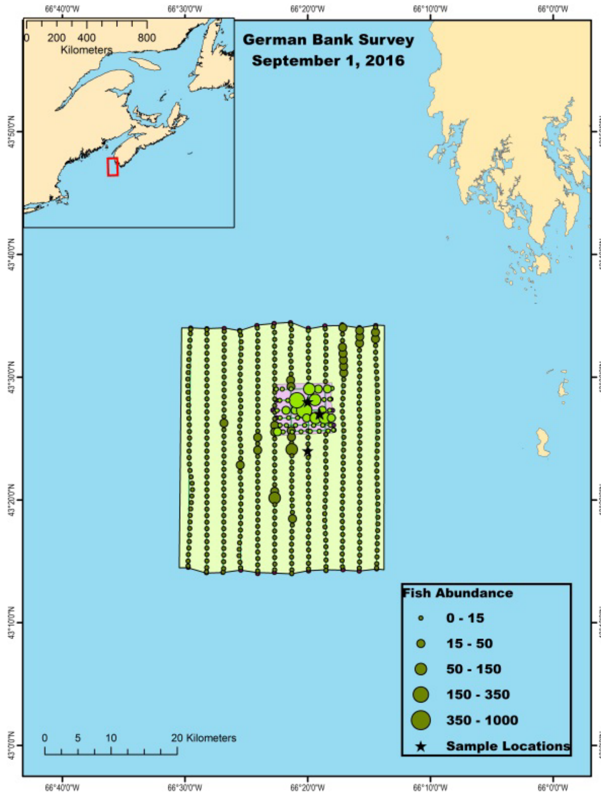

Figure 33A. German Bank acoustic survey (#2) on September 1, 2016 showing the transects with backscatter (PRC-NASC) along with the locations of fishery samples used in calculation of Target Strength (TS).

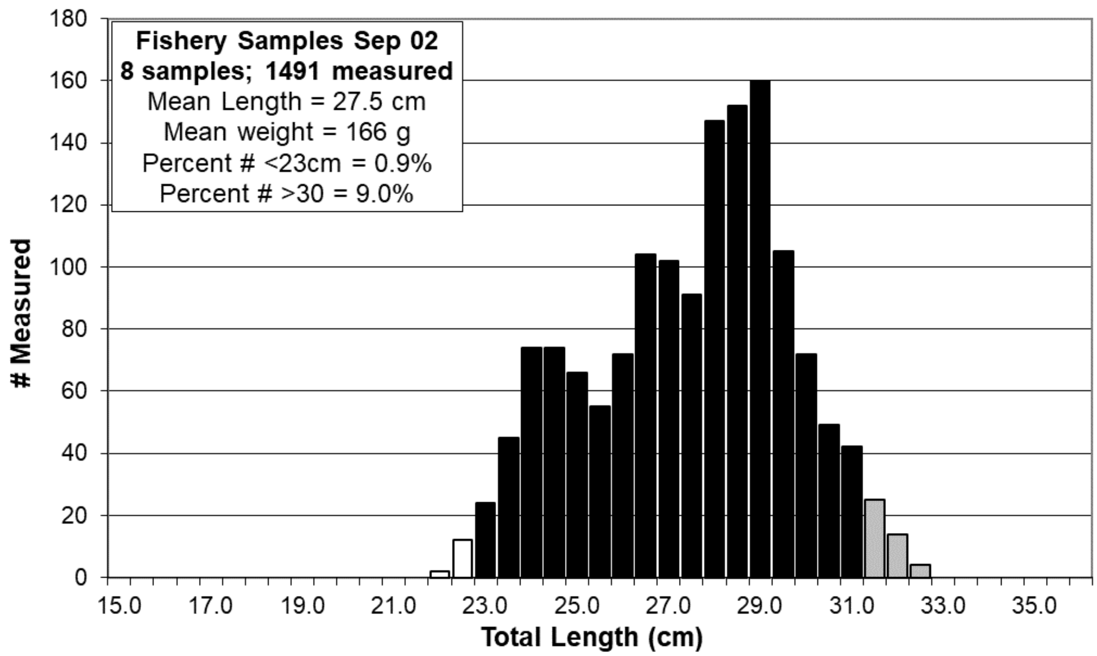

Figure 33B. Length distribution used for calculation of Target Strength (TS) for the German Bank acoustic survey (#2) on September 1, 2016 from sampling during on September 2, with proportions < 23 cm and > 30 cm shown as white and grey bars.

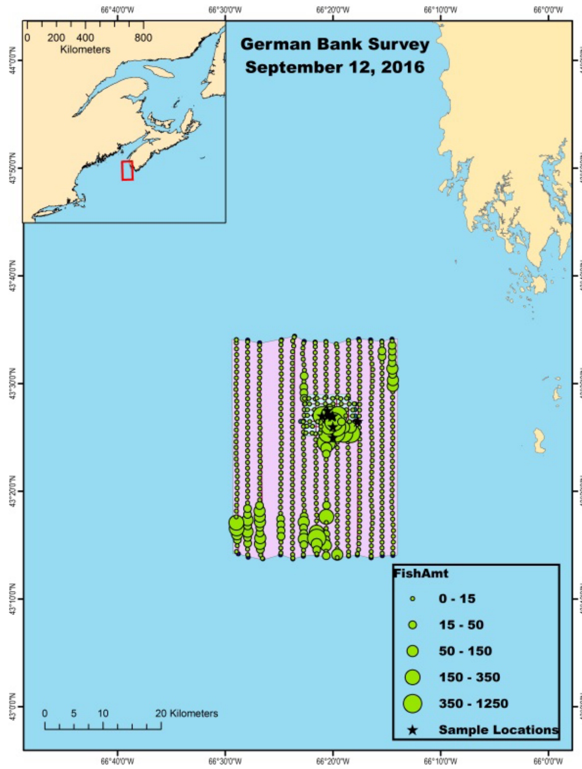

Figure 34A. German Bank acoustic survey (#3) on September 12, 2016 showing the transects with backscatter (PRC-NASC) along with the locations of fishery samples used in calculation of Target Strength (TS).

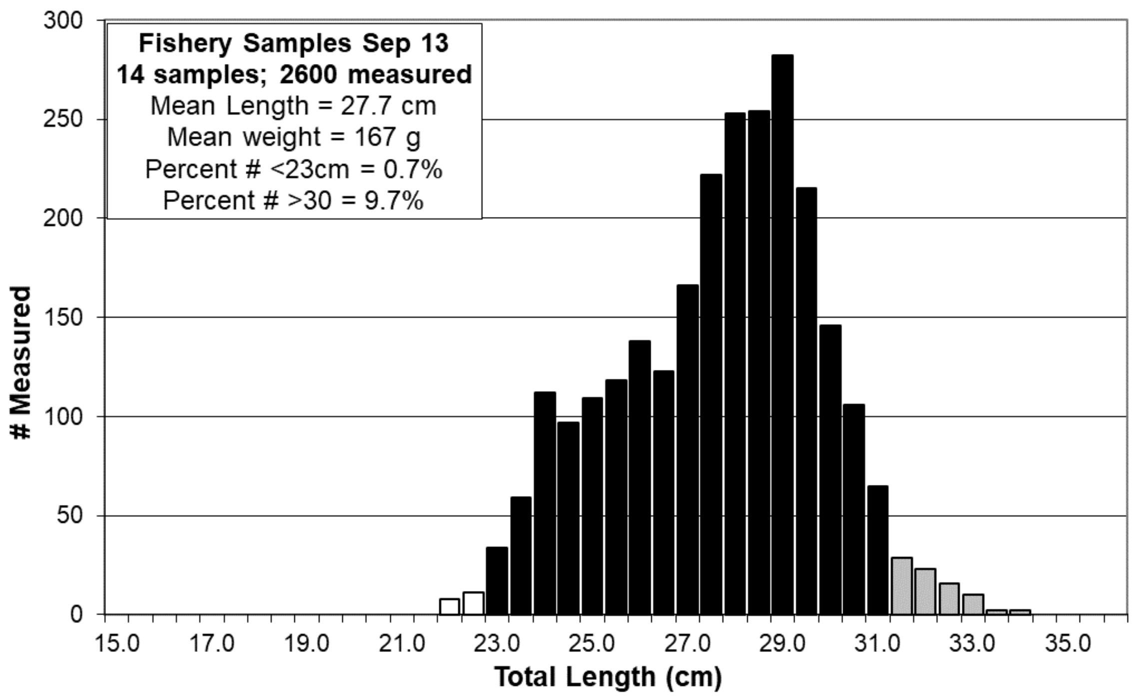

Figure 34B. Length distribution used for calculation of Target Strength (TS) for the German Bank acoustic survey (#3) on September 12, 2016 from sampling on September 13–14, with proportions < 23 cm and > 30 cm shown as white and grey bars.

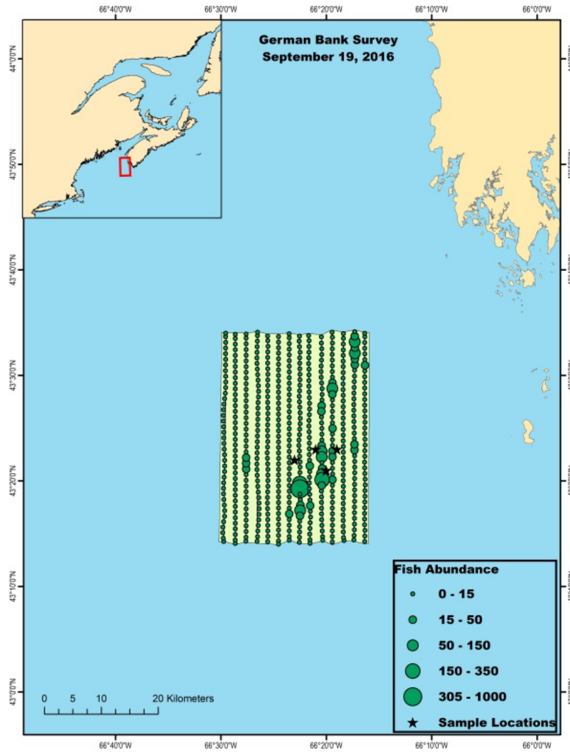

Figure 35A. German Bank acoustic survey (#4) on September 19, 2016 showing the transects with backscatter (PRC-NASC) along with the locations of fishery samples used in calculation of Target Strength (TS).

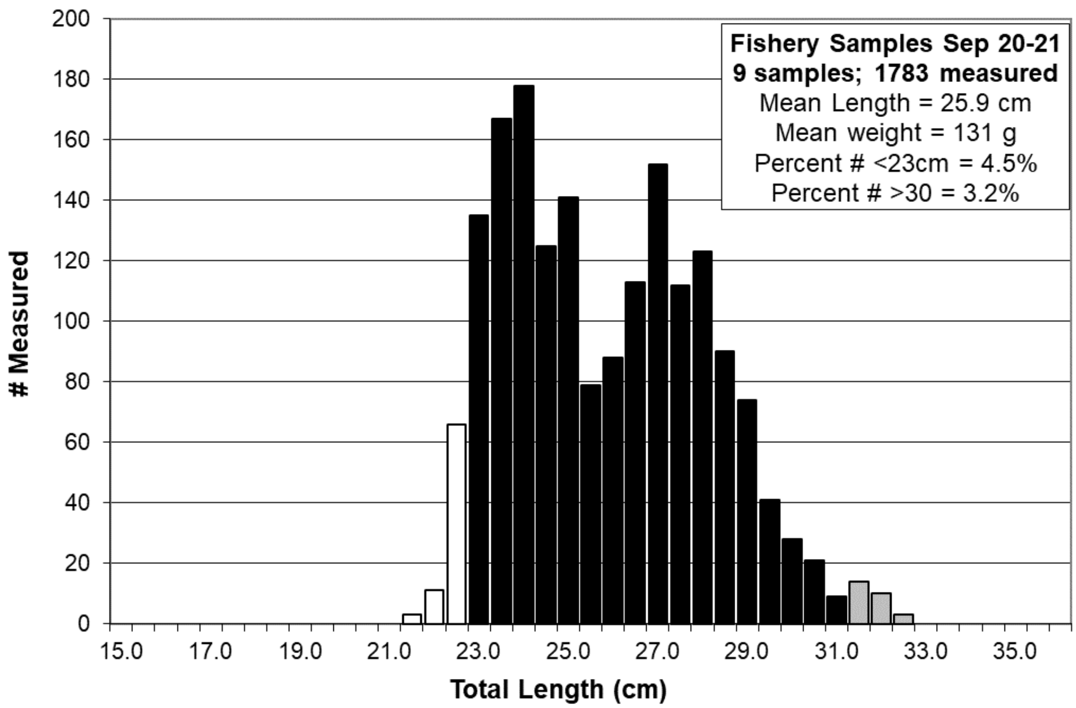

Figure 35B. Length distribution used for calculation of Target Strength (TS) for the German Bank acoustic survey (#4) on September 19, 2016 from sampling on September 21–22, with proportions < 23 cm and > 30 cm shown as white and grey bars.

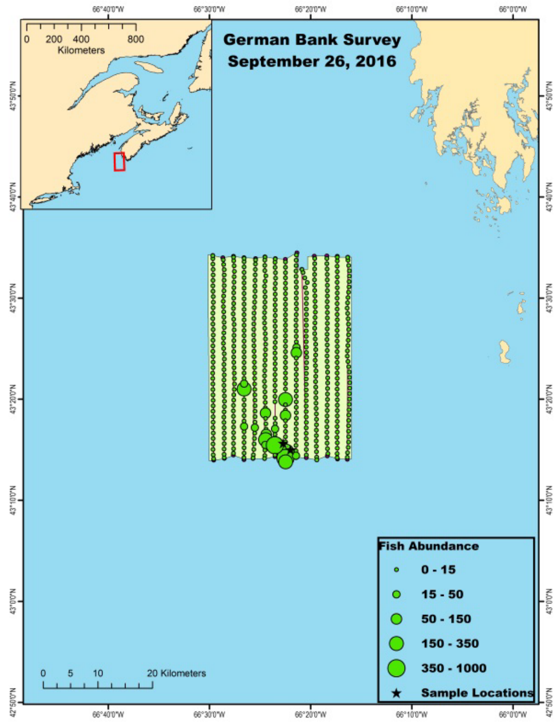

Figure 36A. German Bank acoustic survey (#5) on September 26, 2016 showing the transects with backscatter (PRC-NASC). No samples were collected close to the survey date. Standard Target Strength (TS) used.

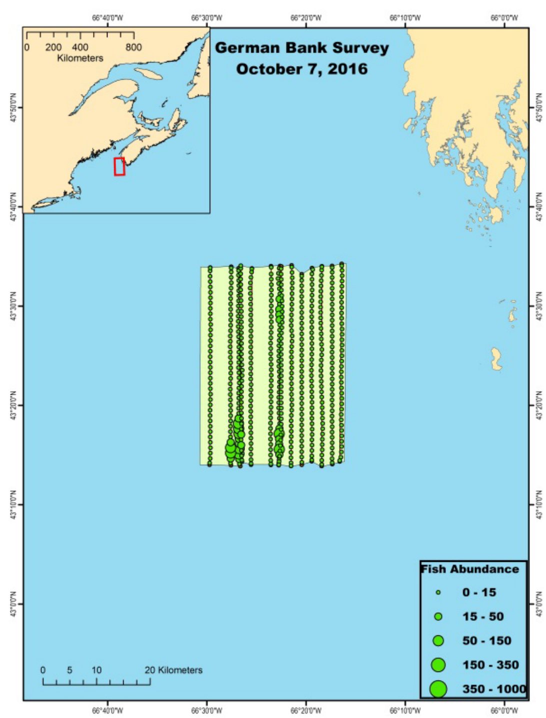

Figure 37. German Bank acoustic survey (#6) on October 7, 2016 showing the main survey box and transects with backscatter (PRC_NASC). No samples were collected close to the survey date. Standard Target Strength (TS) used.

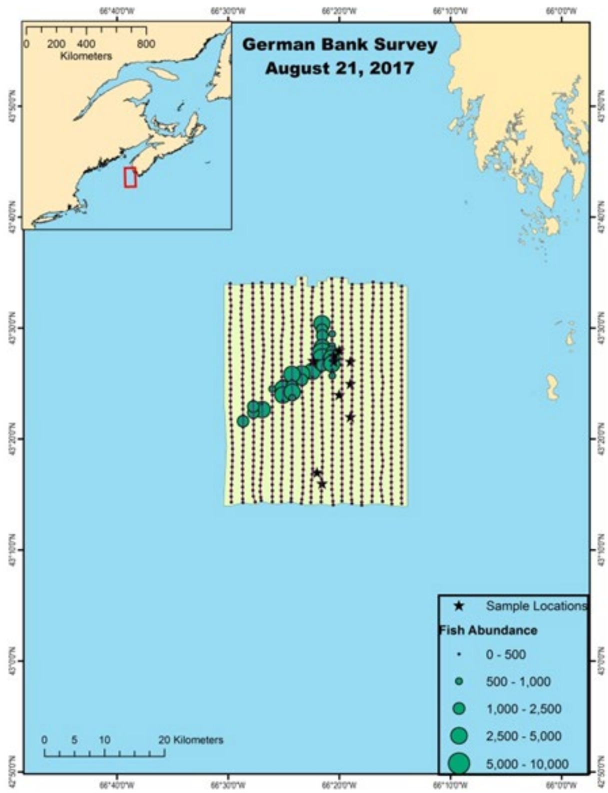

Figure 38A. German Bank acoustic survey (#1) on August 21, 2017 showing the transects with backscatter (PRC-NASC) along with the locations of fishery samples used in calculation of Target Strength (TS).

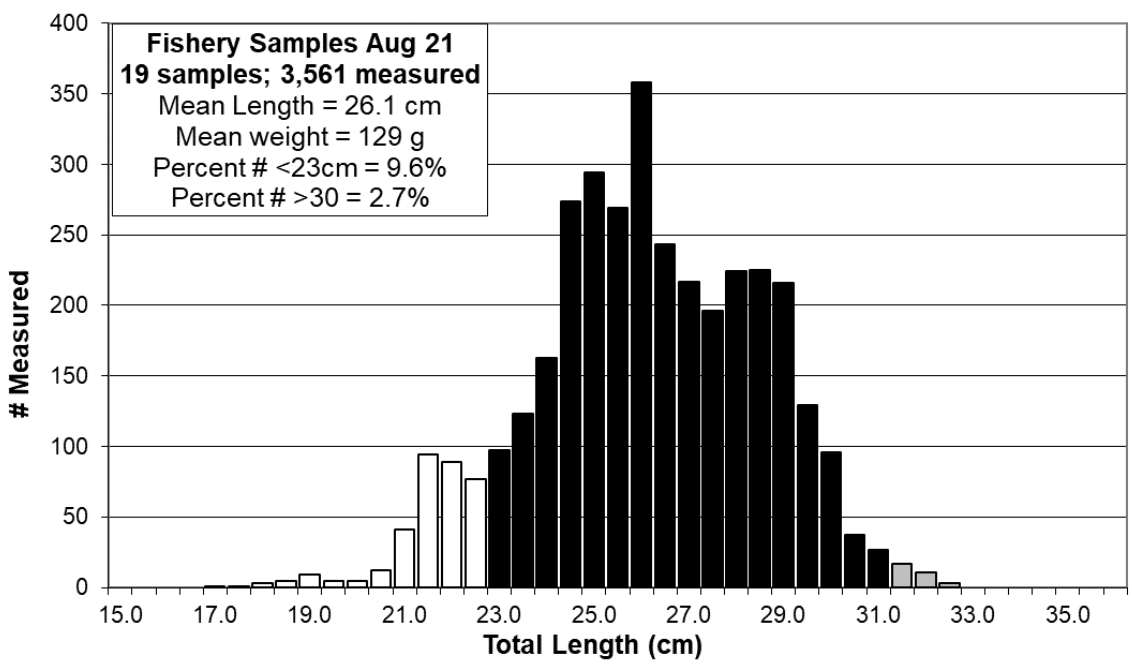

Figure 38B. Length distribution used for calculation of Target Strength (TS) for the German Bank acoustic survey (#1) on August 21, 2017 from sampling on August 21, with proportions < 23 cm and > 30 cm shown as white and grey bars.

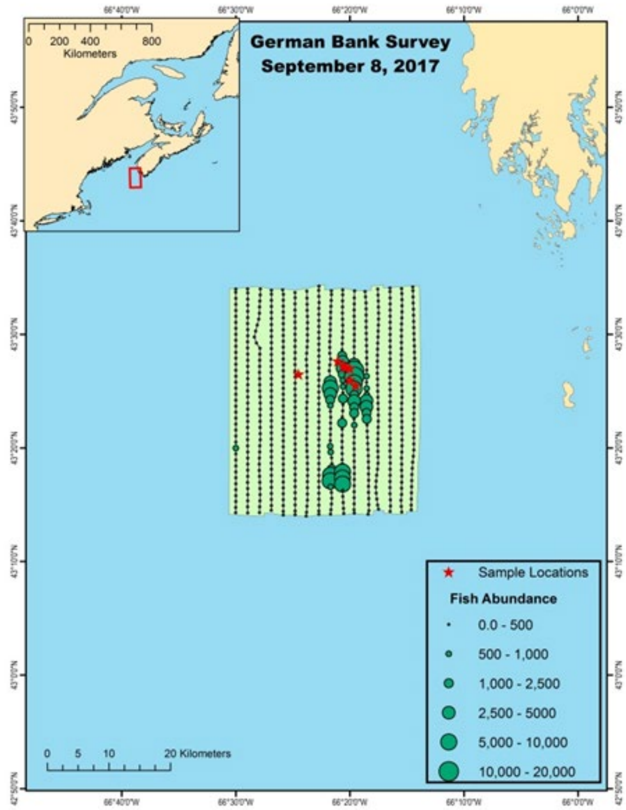

Figure 39A. German Bank acoustic survey (#2) on September 8, 2017 showing the transects with backscatter (PRC-NASC) along with the locations of fishery samples used in calculation of Target Strength (TS).

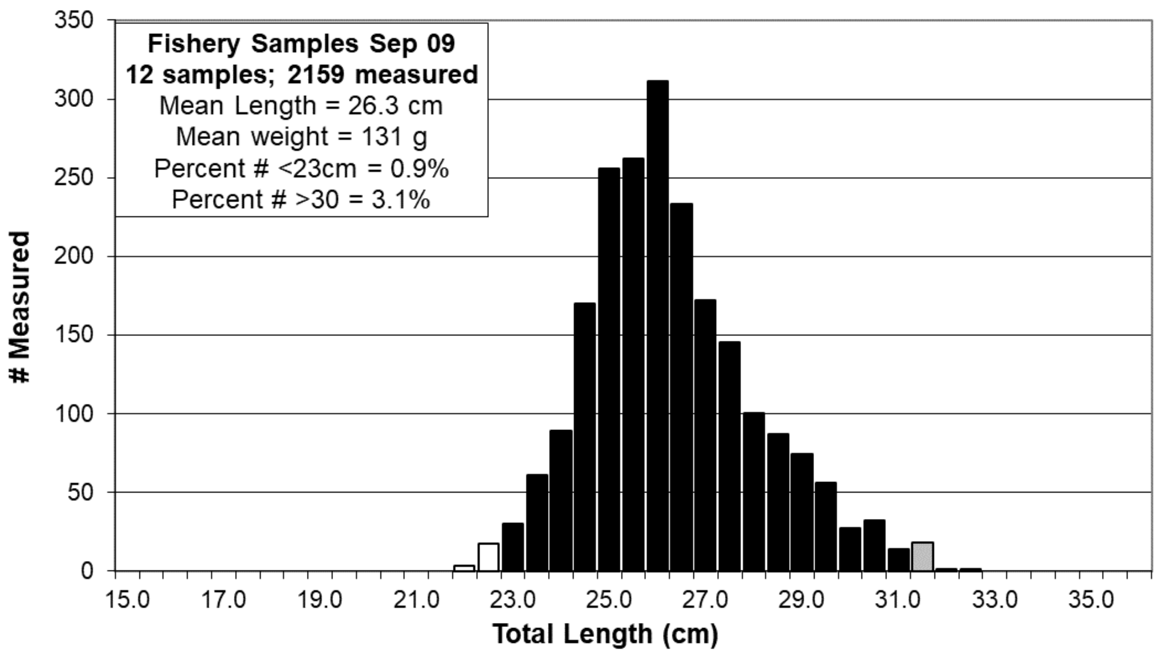

Figure 39B. Length distribution used for calculation of Target Strength (TS) for the German Bank acoustic survey (#2) on September 8, 2017 from sampling during on September 9, with proportions < 23 cm and > 30 cm shown as white and grey bars.

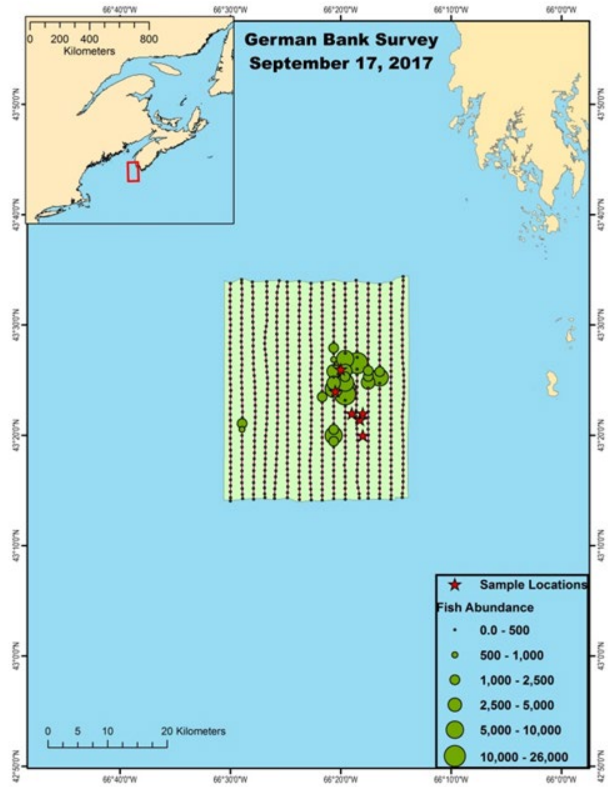

Figure 40A. German Bank acoustic survey (#3) on September 17, 2017 showing the transects with backscatter (PRC-NASC) along with the locations of fishery samples used in calculation of Target Strength (TS).

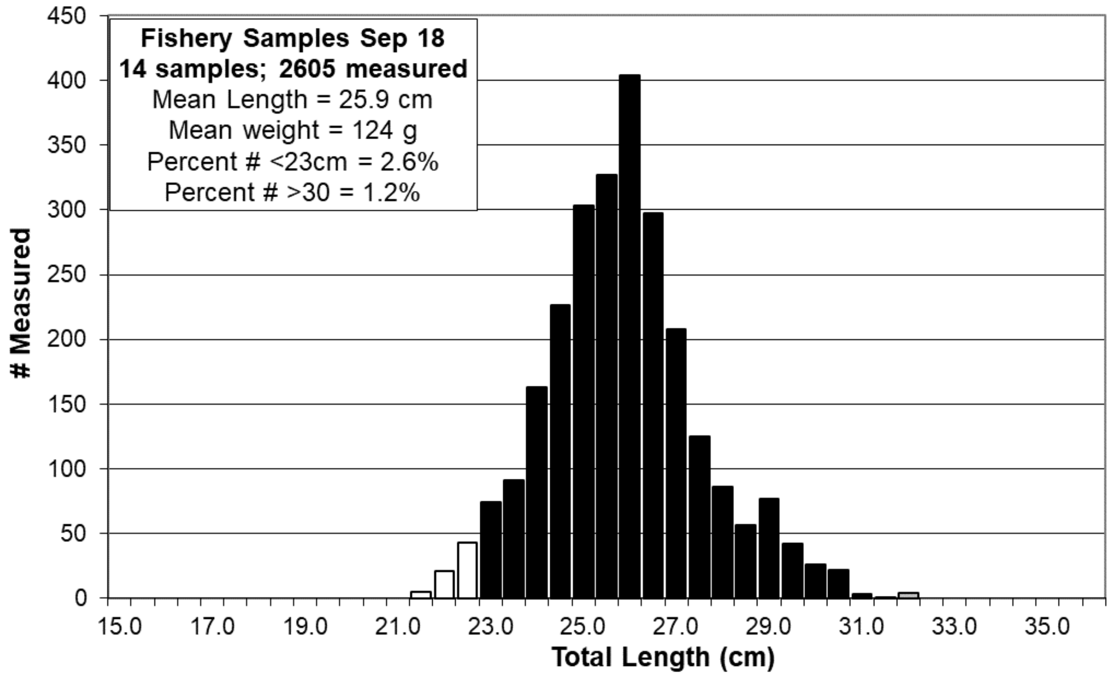

Figure 40B. Length distribution used for calculation of Target Strength (TS) for the German Bank acoustic survey (#3) on September 17, 2017 from sampling on September 18, with proportions < 23 cm and > 30 cm shown as white and grey bars.

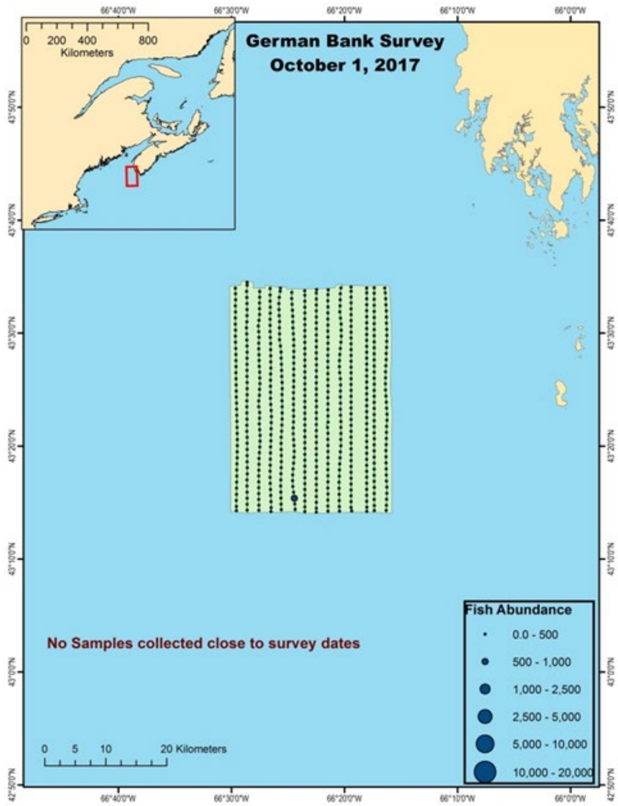

Figure 41. German Bank acoustic survey (#4) on October 1, 2017, showing the transects with backscatter (PRC_ABC). No samples were collected and the standard Target Strength (TS) was used, however, this survey was not used in the final biomass estimates.

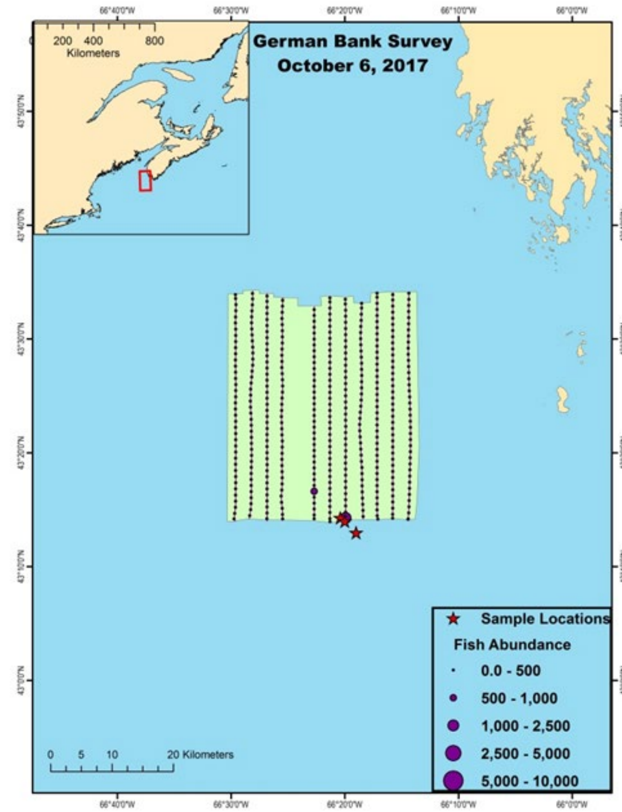

Figure 42A. German Bank acoustic survey (#5) on October 6, 2017 showing the transects with backscatter (PRC-NASC) along with the locations of fishery samples used in calculation of Target Strength (TS).

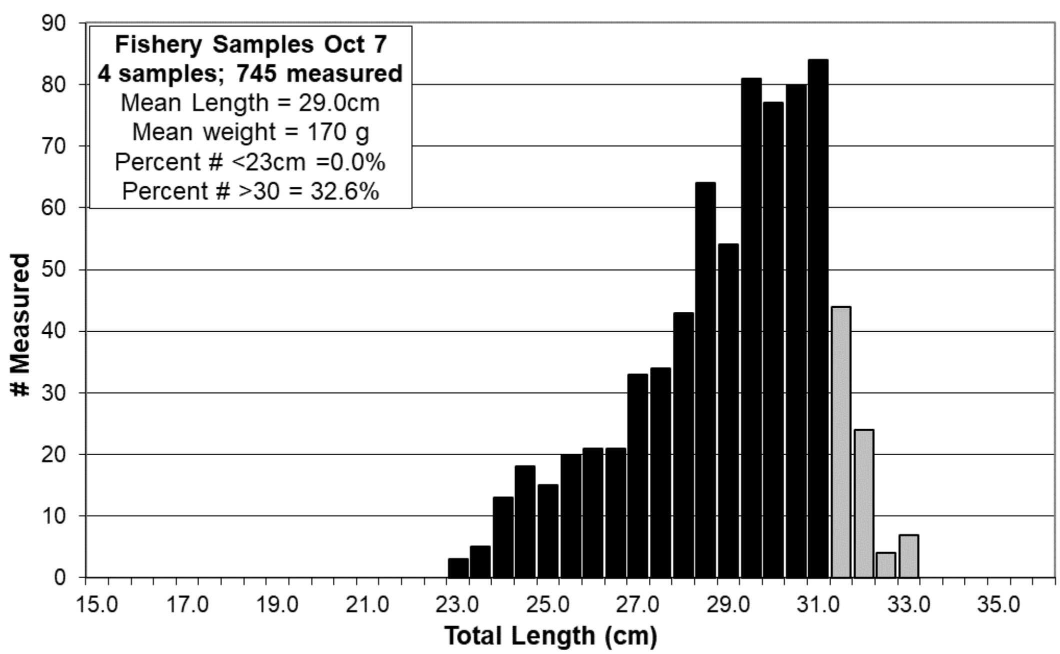

Figure 42B. Length distribution for the German Bank acoustic survey (#5) on October 6, 2017 from sampling on October 7, with proportions < 23 cm and > 30 cm shown as white and grey bars. Note that there were no detailed samples and the standard Target Strength (TS) was used in the biomass estimates.

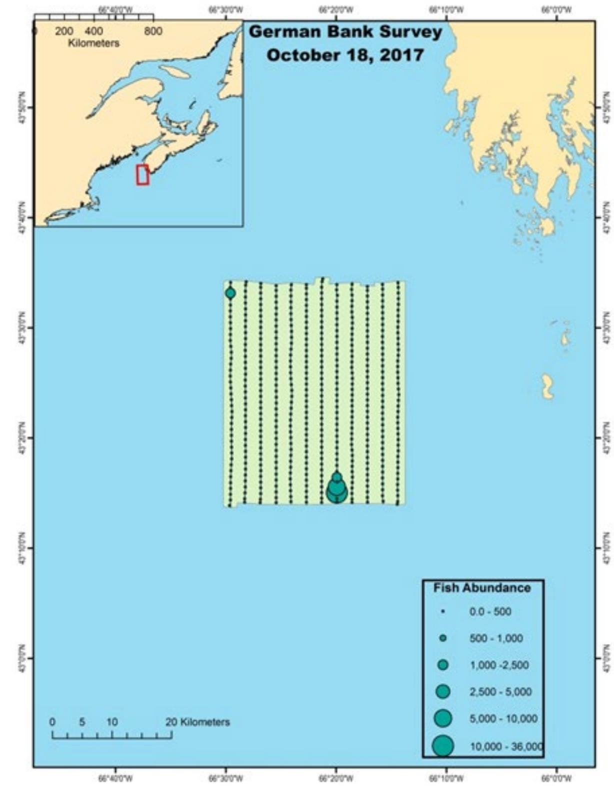

Figure 43. German Bank acoustic survey (#6) on October 18, 2017 showing the main survey box and transects with backscatter (PRC_ABC). No samples were collected close to the survey date so the standard Target Strength (TS) was used to estimates biomass.

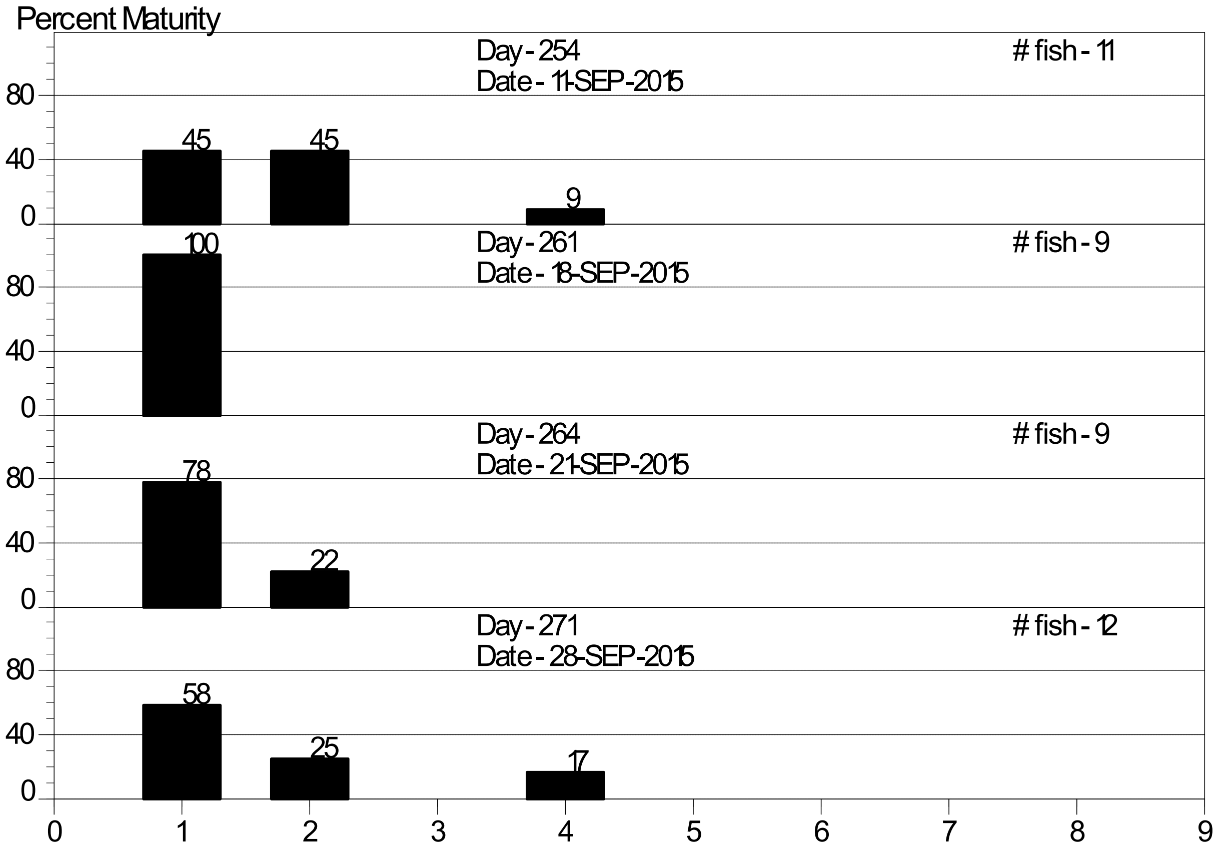

Figure 44A. Herring maturity samples collected from the Trinity Ledge area in 2015 between August 1 and September 30 . Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; and 8 = recovering.

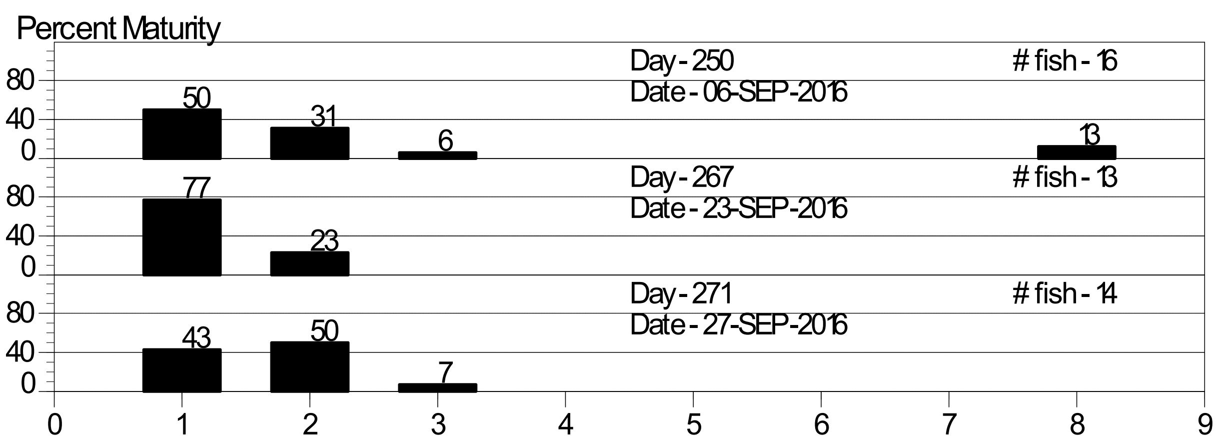

Figure 44B. Herring maturity samples collected from the Trinity Ledge area in 2016 between August 1 and September 30. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; and 8 = recovering.

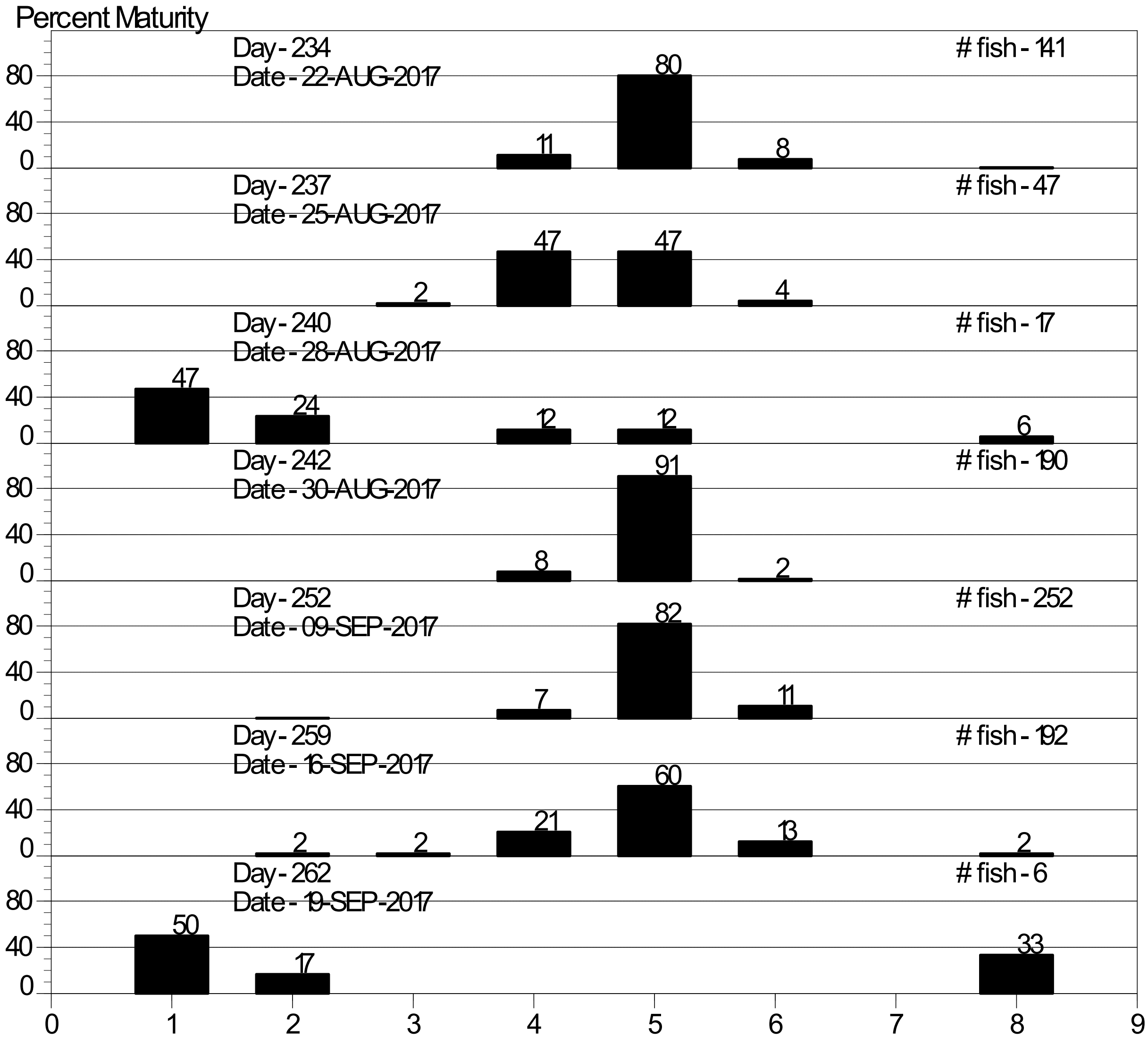

Figure 44C. Herring maturity samples collected from the Trinity Ledge area in 2017 between August 1 and September 30. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; and 8 = recovering.

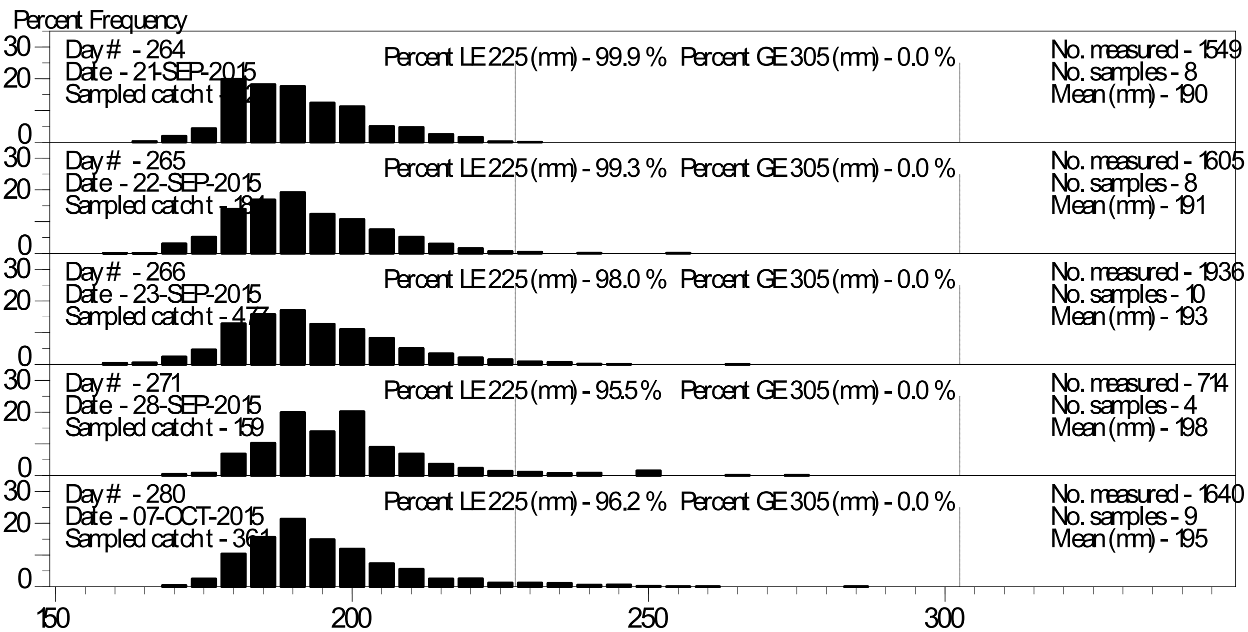

Figure 45A. Daily Herring length-frequency samples collected from the Trinity Ledge purse seine fishery in 2015, with proportions < 23 cm and > 30 cm.

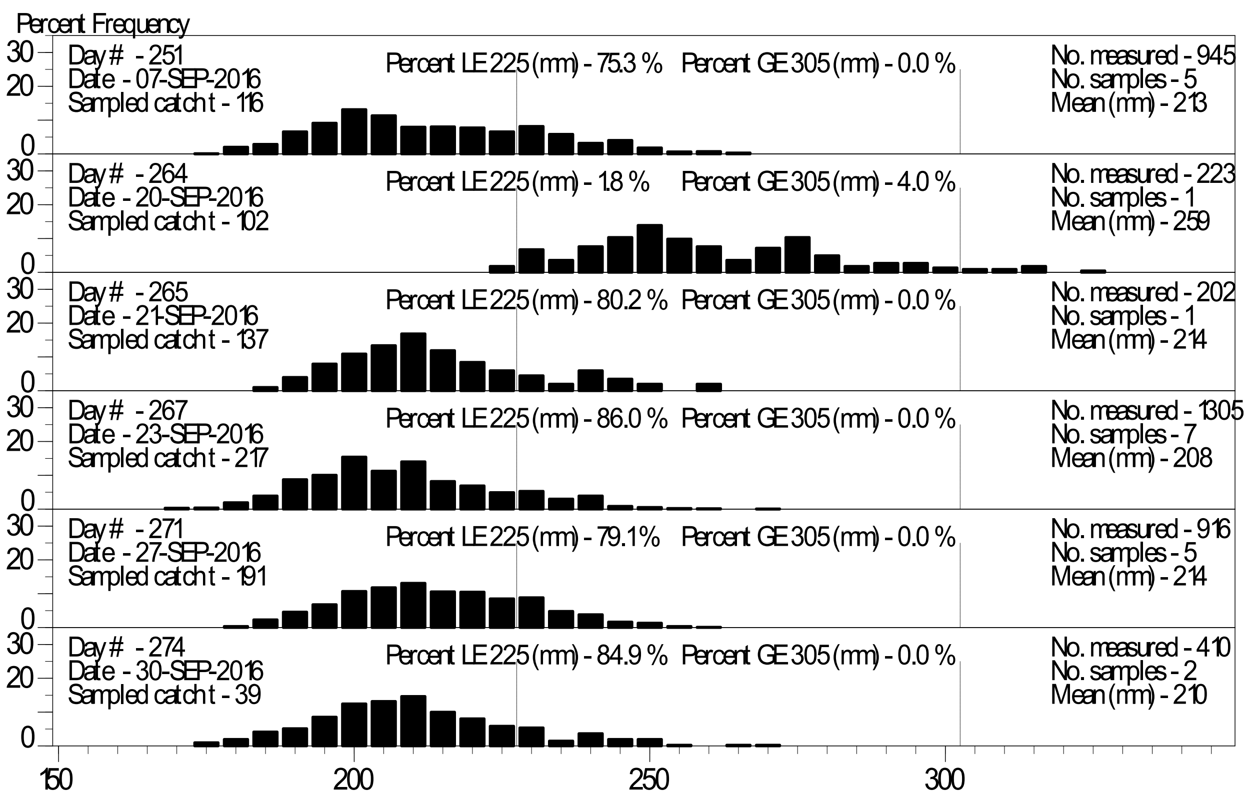

Figure 45B. Daily Herring length-frequency samples collected from the Trinity Ledge purse seine fishery in 2016, with proportions < 23 cm and > 30 cm.

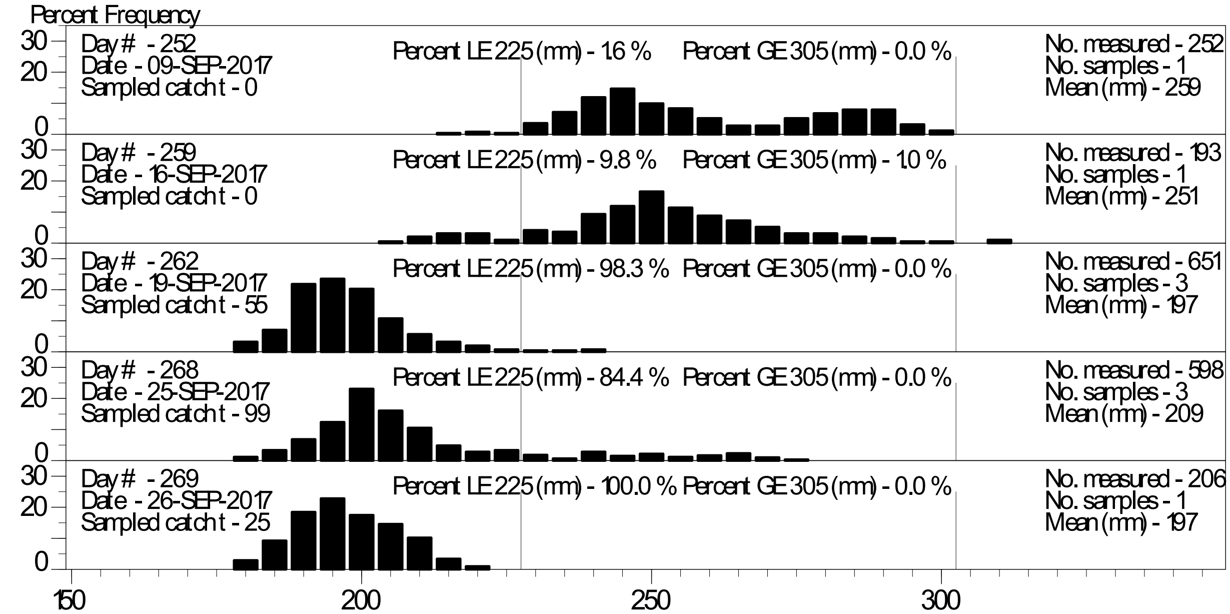

Figure 45C. Daily Herring length-frequency samples collected from the Trinity Ledge purse seine fishery in 2017, with proportions < 23 cm and > 30 cm.

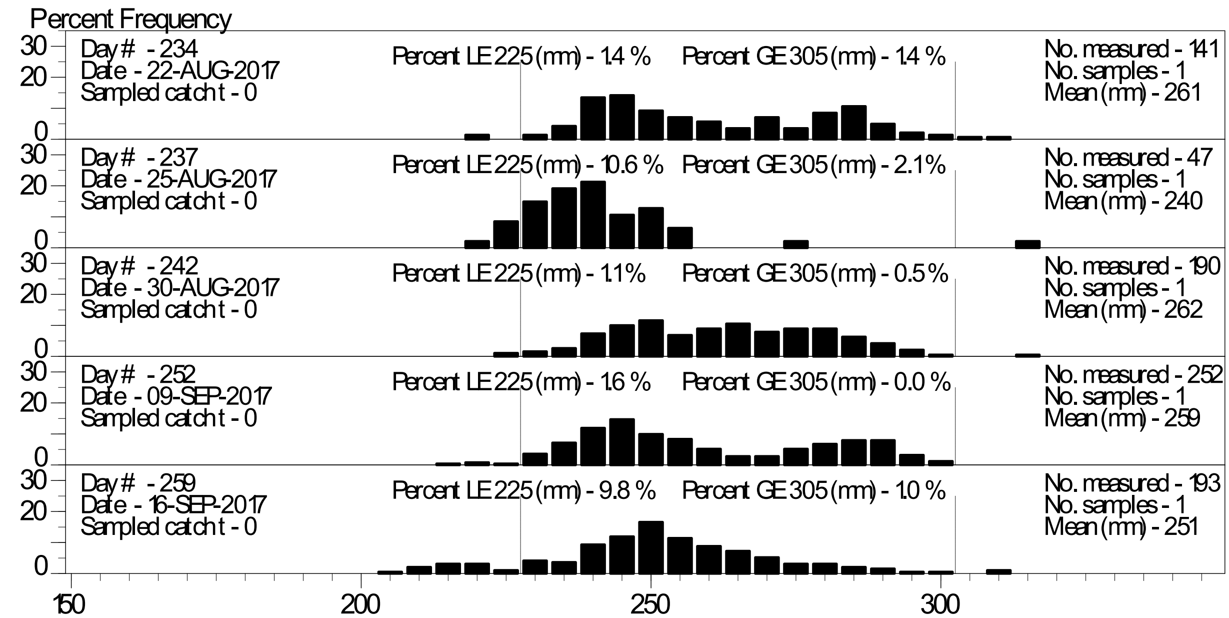

Figure 45D. Daily Herring length-frequency samples collected from the Trinity Ledge multipanel gillnet sampling in 2017, with proportions < 23 cm and > 30 cm.

Figure 46A. Trinity Ledge area Herring acoustic survey (#1) September 4, 2015 showing tracks conducted by the vessel <u>Katrina & Kayla</u>. No samples were available. Standard Target Strength (TS) used.

Figure 46B. Trinity Ledge area Herring acoustic survey (#3) on September 11, 2015 showing tracks conducted by the vessel <u>Katrina & Kayla</u>. No samples were available. Standard Target Strength (TS) used.

Figure 47A. Trinity Ledge area Herring acoustic survey (#1) August 12, 2016 showing tracks conducted by the vessel <u>Katrina & Kayla</u>. No samples were available. Standard Target Strength (TS) used.

Figure 47B. Trinity Ledge area Herring acoustic survey (#2) August 29, 2016 showing tracks conducted by the vessel <u>Katrina & Kayla</u>. No samples were available. Standard Target Strength (TS) used.

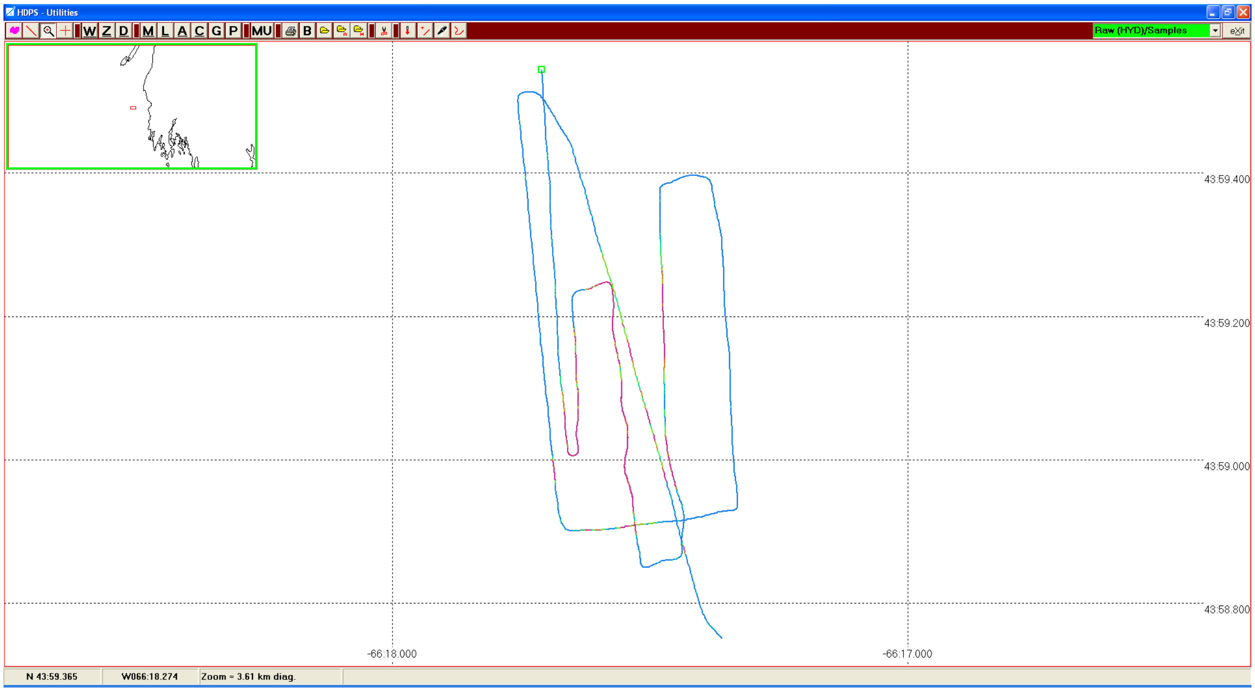

Figure 47C. Trinity Ledge area Herring acoustic survey (#3) September 13, 2016 showing tracks conducted by the vessel Katrina & Kayla. No samples were available. Standard Target Strength (TS) used.

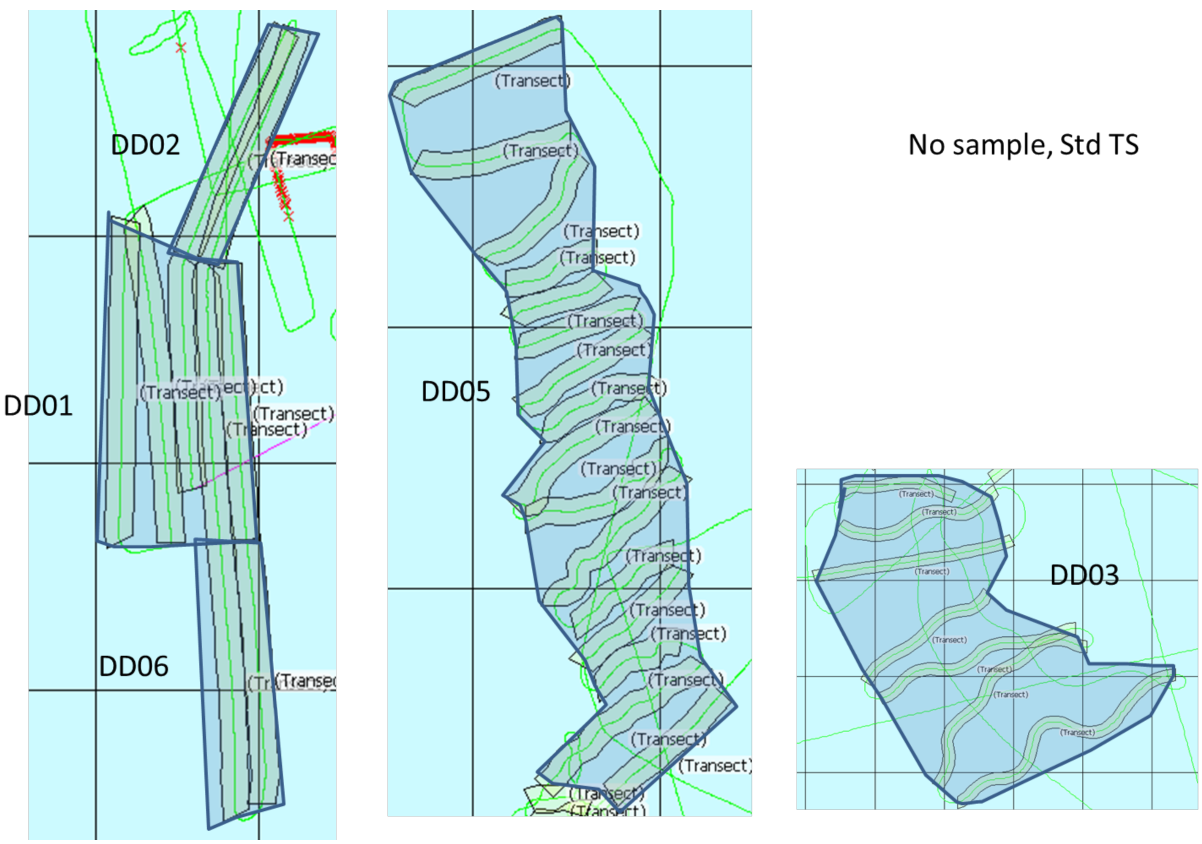

Figure 48. Trinity Ledge area Herring acoustic survey (#1) August 12, 2017, showing tracks conducted by the vessel Double Don. No samples were available. Standard Target Strength (TS) used.

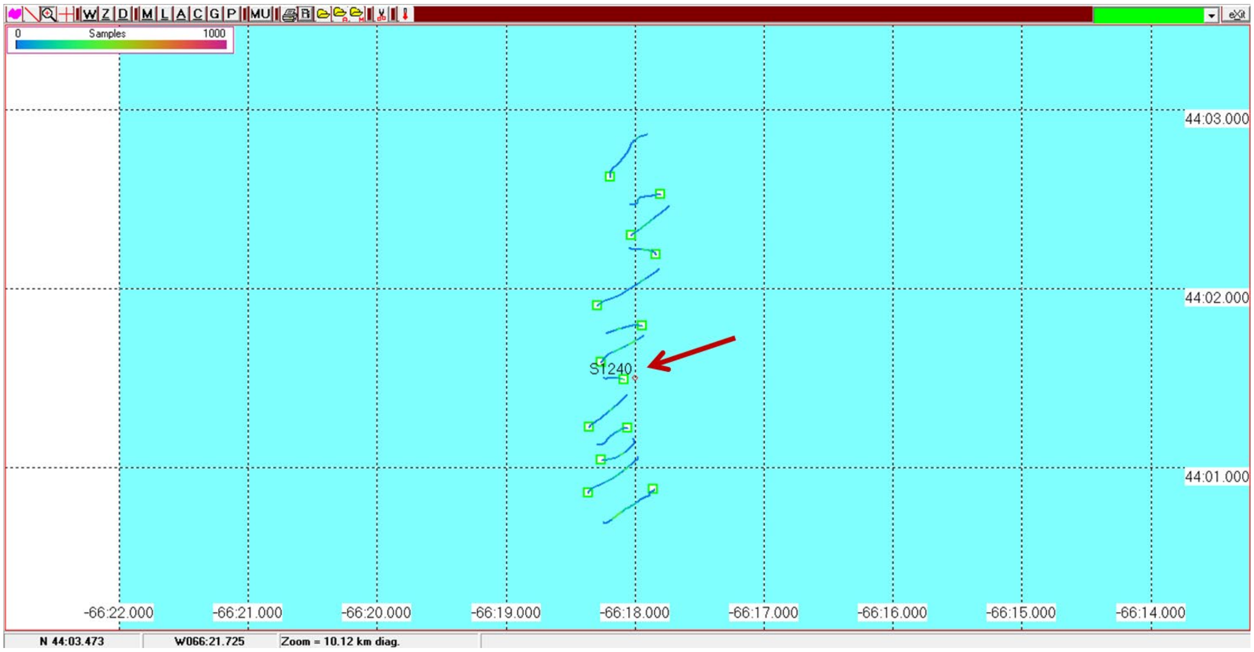

Figure 49A. Trinity Ledge area Herring acoustic survey (#2) August 22, 2017 showing tracks conducted by the vessel Double Don along with location (arrow) of multi-panel sample collected August 22, 2017.

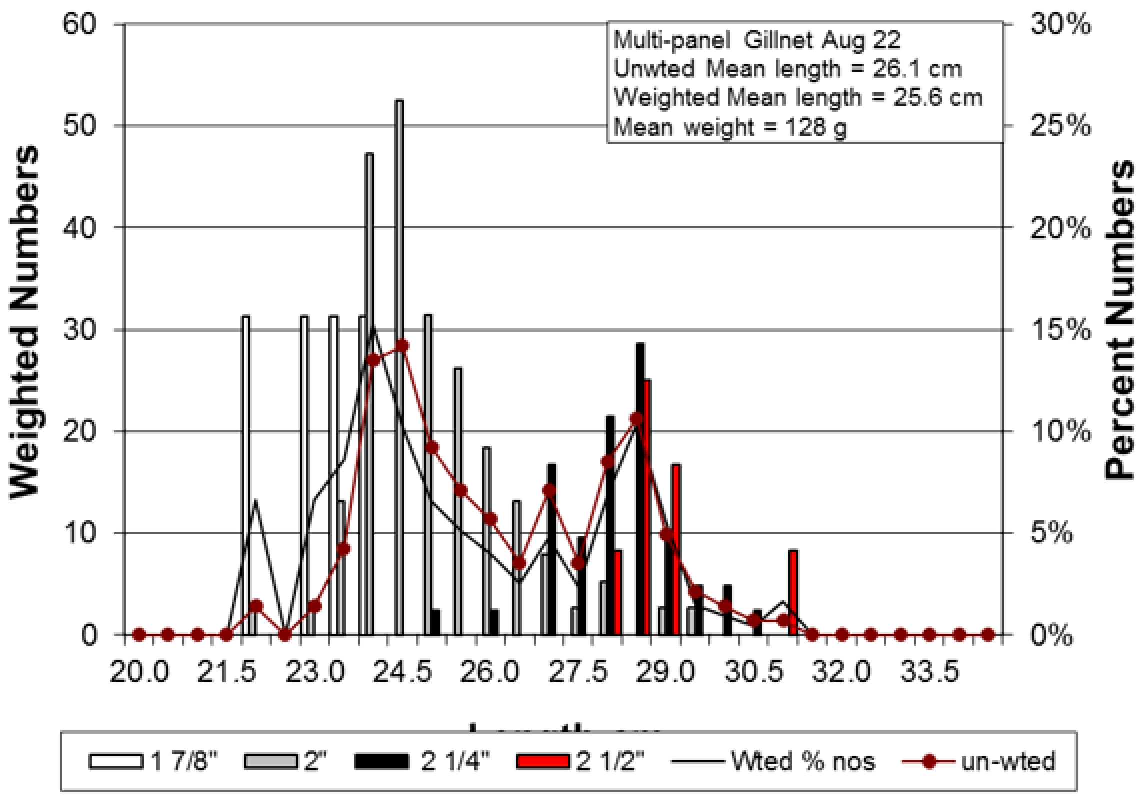

Figure 49B. Multi-panel Herring gillnet sample collected on August 22, 2017 by the vessel Double Don for the Trinity Ledge Herring acoustic survey (#2) on August 22.

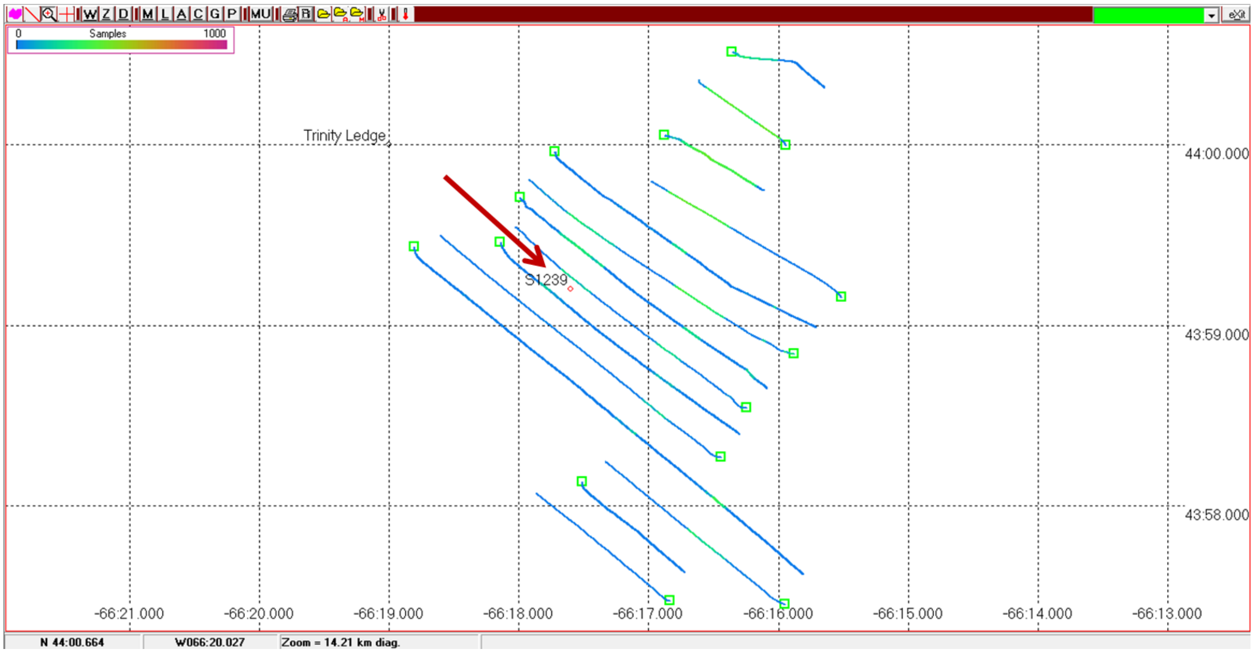

Figure 50A. Trinity Ledge area Herring acoustic survey (#3) August 29, 2017 showing tracks conducted by the vessel Double Don along with location (arrow) of multi-panel sample collected August 30.

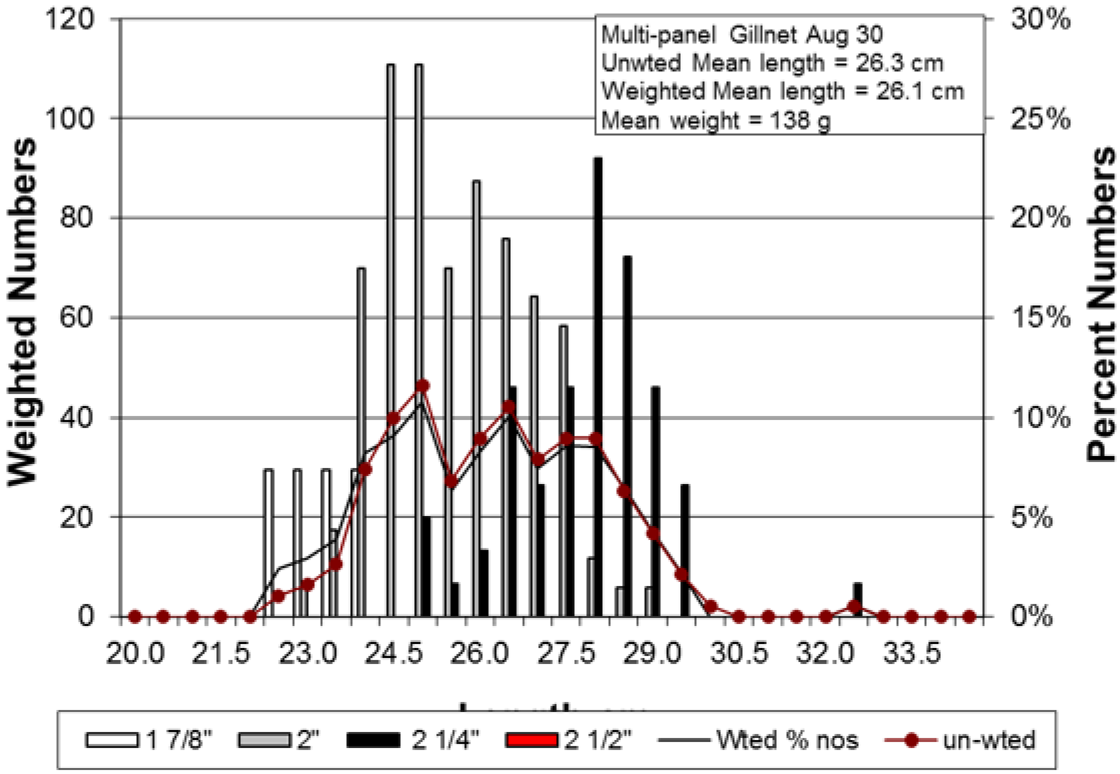

Figure 50B. Multi-panel Herring gillnet sample collected on August 30, 2017 by the vessel Double Don for the Trinity Ledge Herring acoustic survey (#3) on August 30.

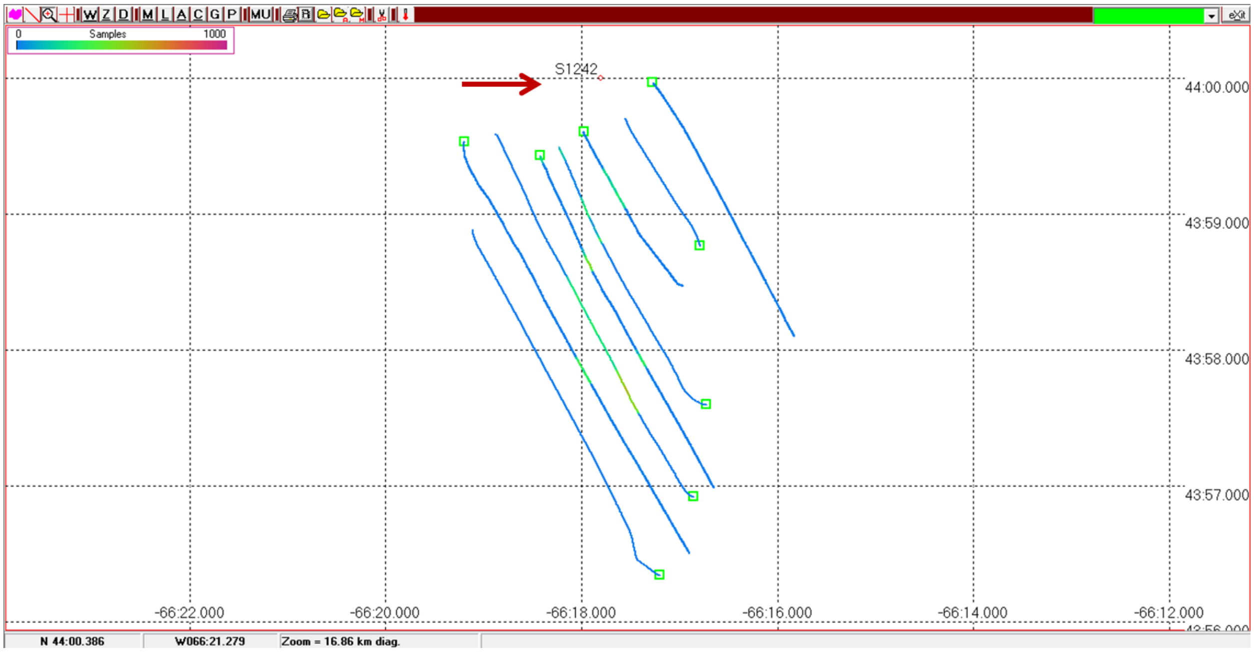

Figure 51A. Trinity Ledge area Herring acoustic survey (#4) September 8, 2017 showing tracks conducted by the vessel Double Don along with location (arrow) of multi-panel sample collected September 9.

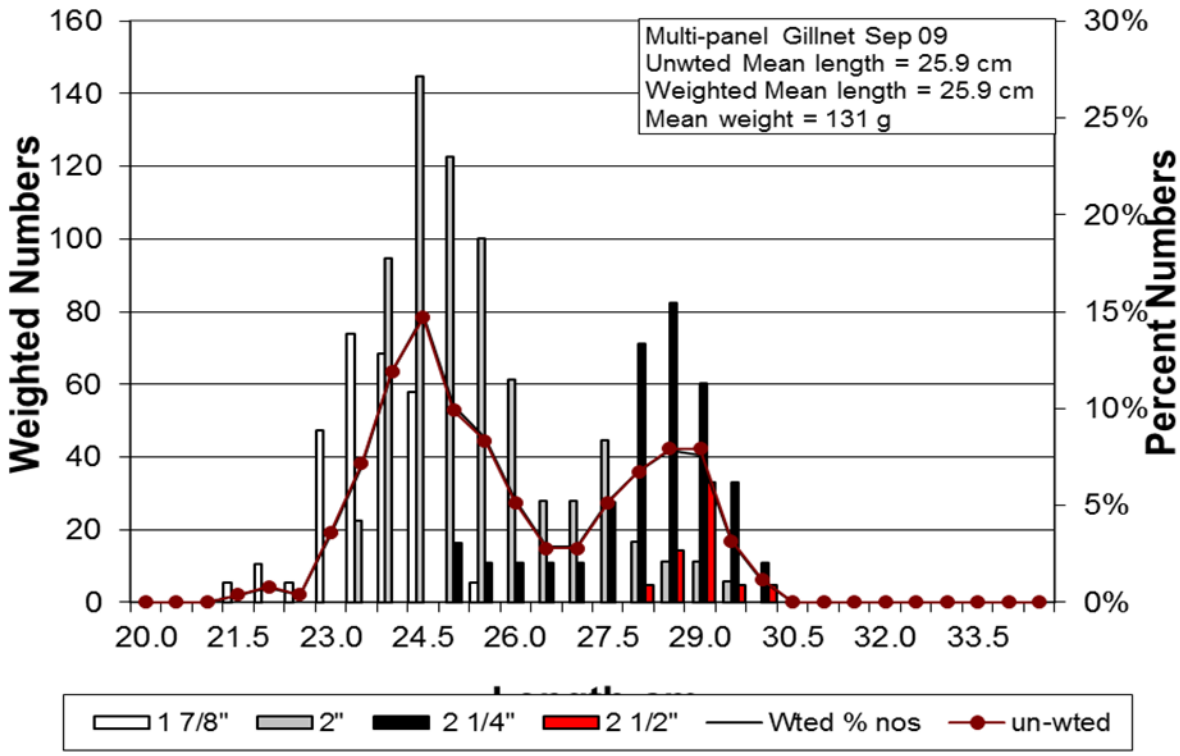

Figure 51B. Multi-panel Herring gillnet sample collected on September 9, 2017 by the vessel Double Don for the Trinity Ledge Herring acoustic survey (#4) on September 8.

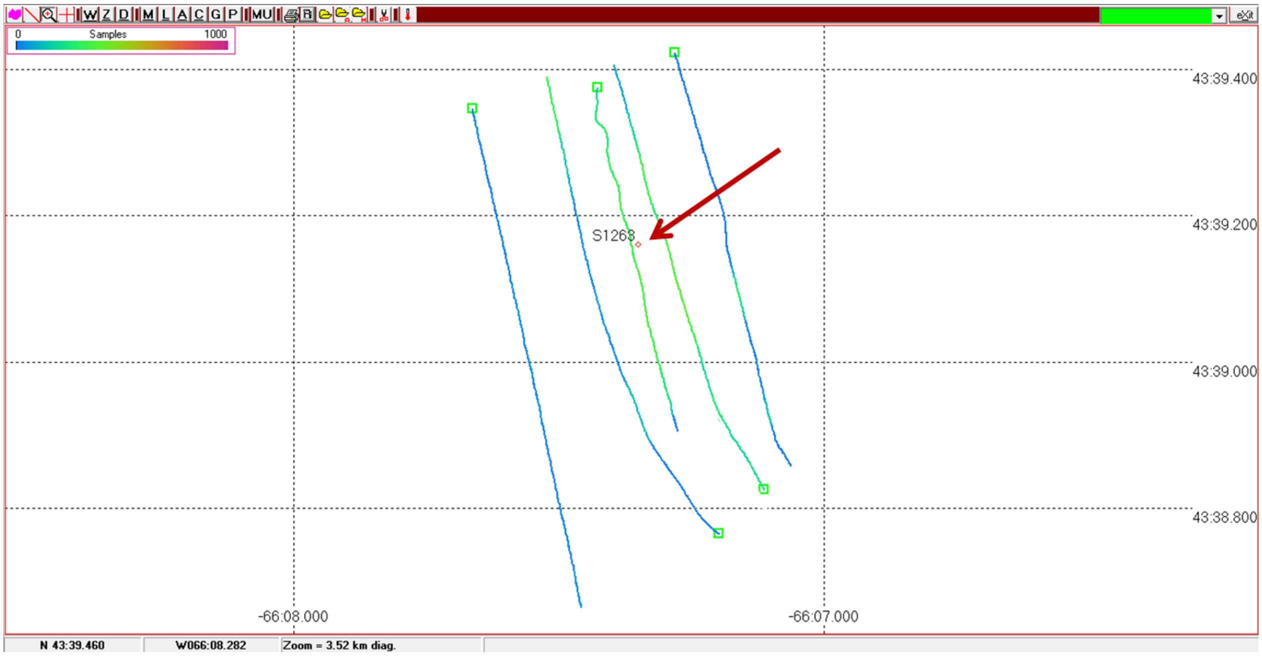

Figure 52A. Spectacle Buoy area Herring acoustic survey (#1) August 25, 2017 showing tracks conducted by the vessel Double Don along with location (arrow) of multi-panel sample collected August 25.

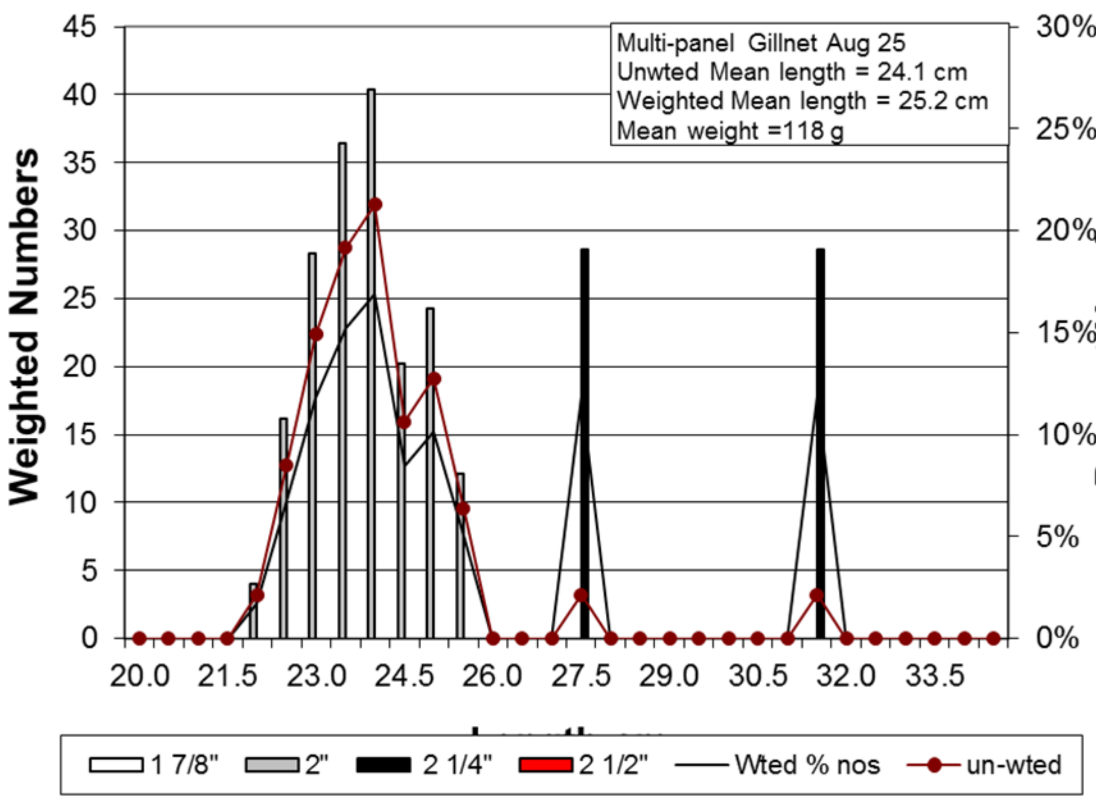

Figure 52B. Multi-panel Herring gillnet sample collected on August 25, 2017 by the vessel Double Don for the Spectacle Buoy Herring acoustic survey (#1) on August 25.

Figure 53. Spectacle Buoy area Herring acoustic survey (#2) September 4, 2017 showing tracks conducted by the vessel Double Don. No multipanel sample collected. Standard Target Strength (TS) used.

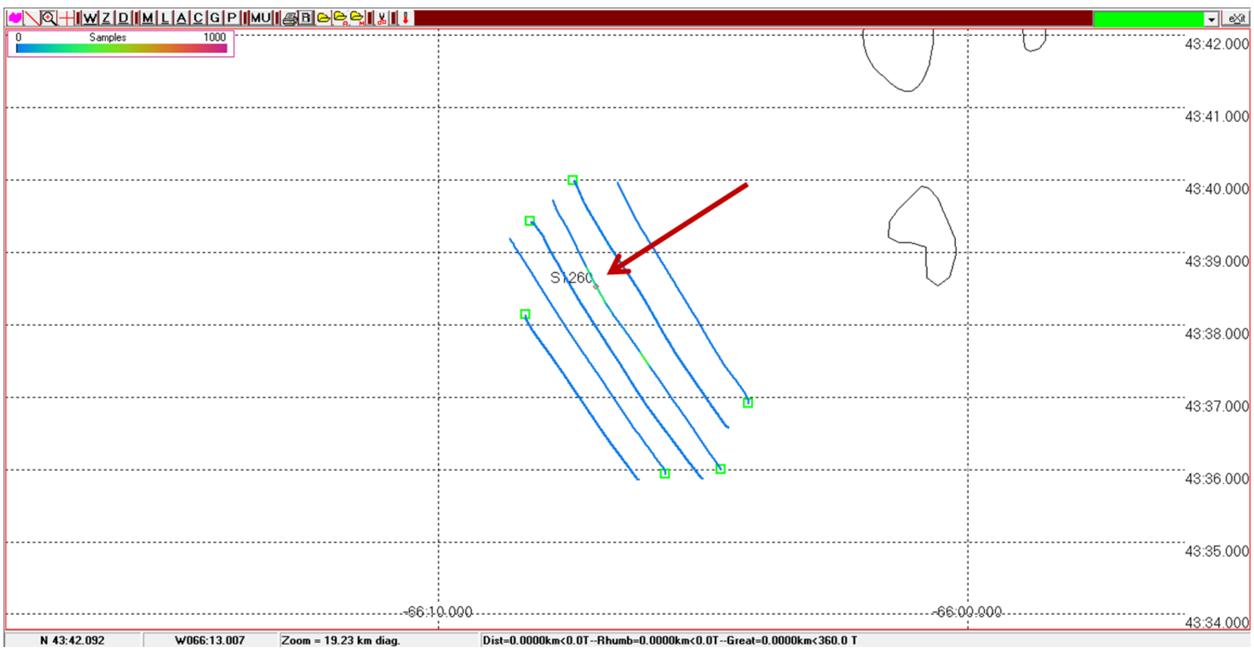

Figure 54A. Spectacle Buoy area Herring acoustic survey (#3) September 16, 2017 showing tracks conducted by the vessel Double Don along with location (arrow) of multi-panel sample collected September 16.

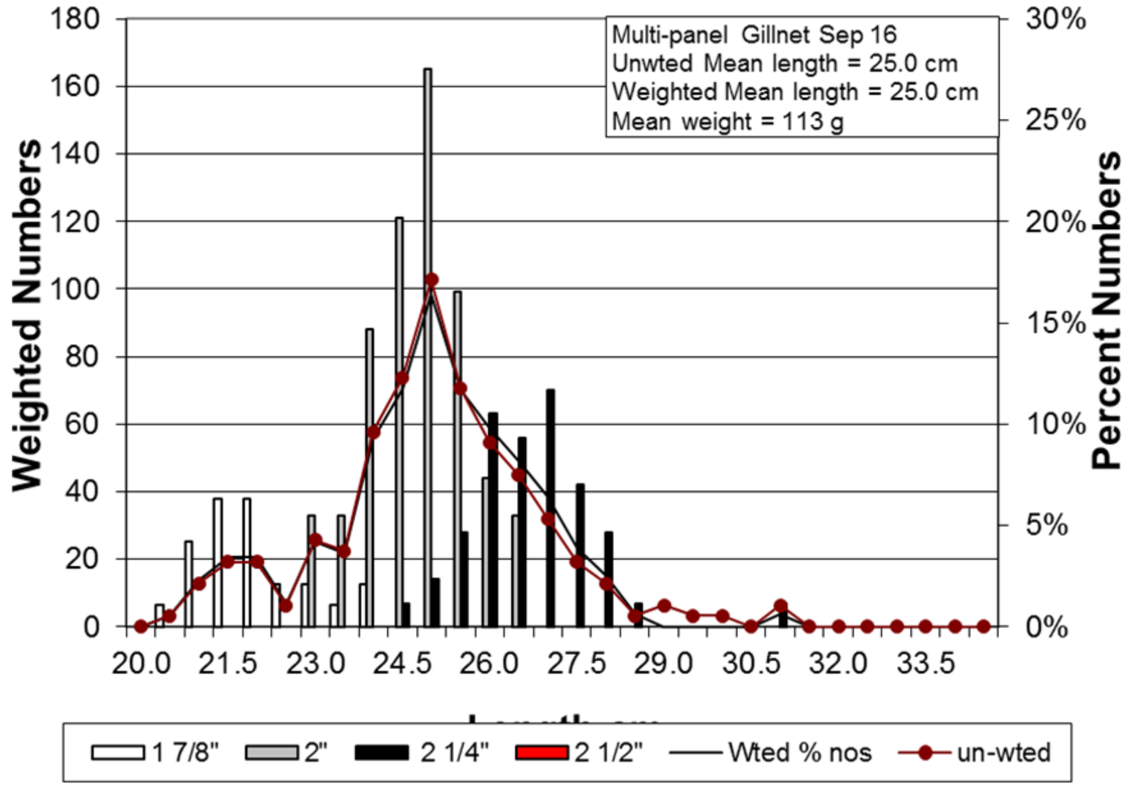

Figure 54B. Multi-panel Herring gillnet sample collected on September 16, 2017 by the vessel Double Don for the Spectacle Buoy Herring acoustic survey (#3) on September 16.

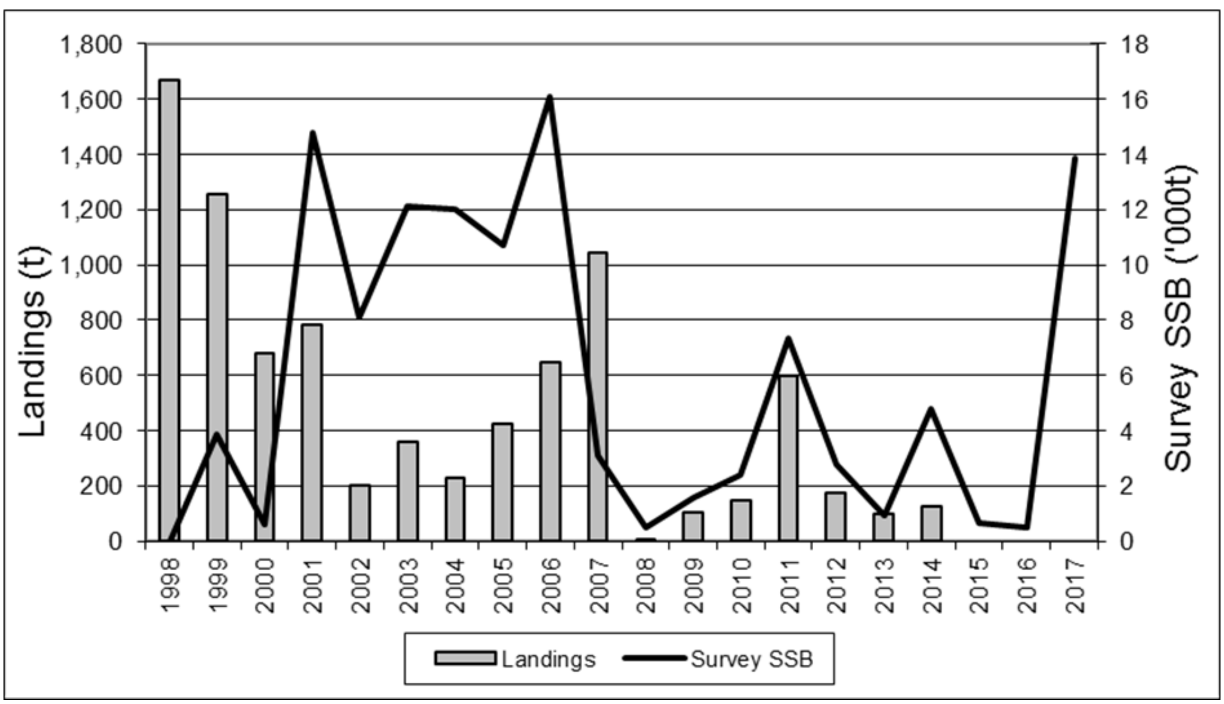

Figure 55. Trinity Ledge Herring landings and acoustic survey biomass estimates from 1998–2017. All acoustic estimates were calculated with the Calibration Integration Factor (CIF) except 1999–2002. Note landings scale is 10% of that of survey biomass.

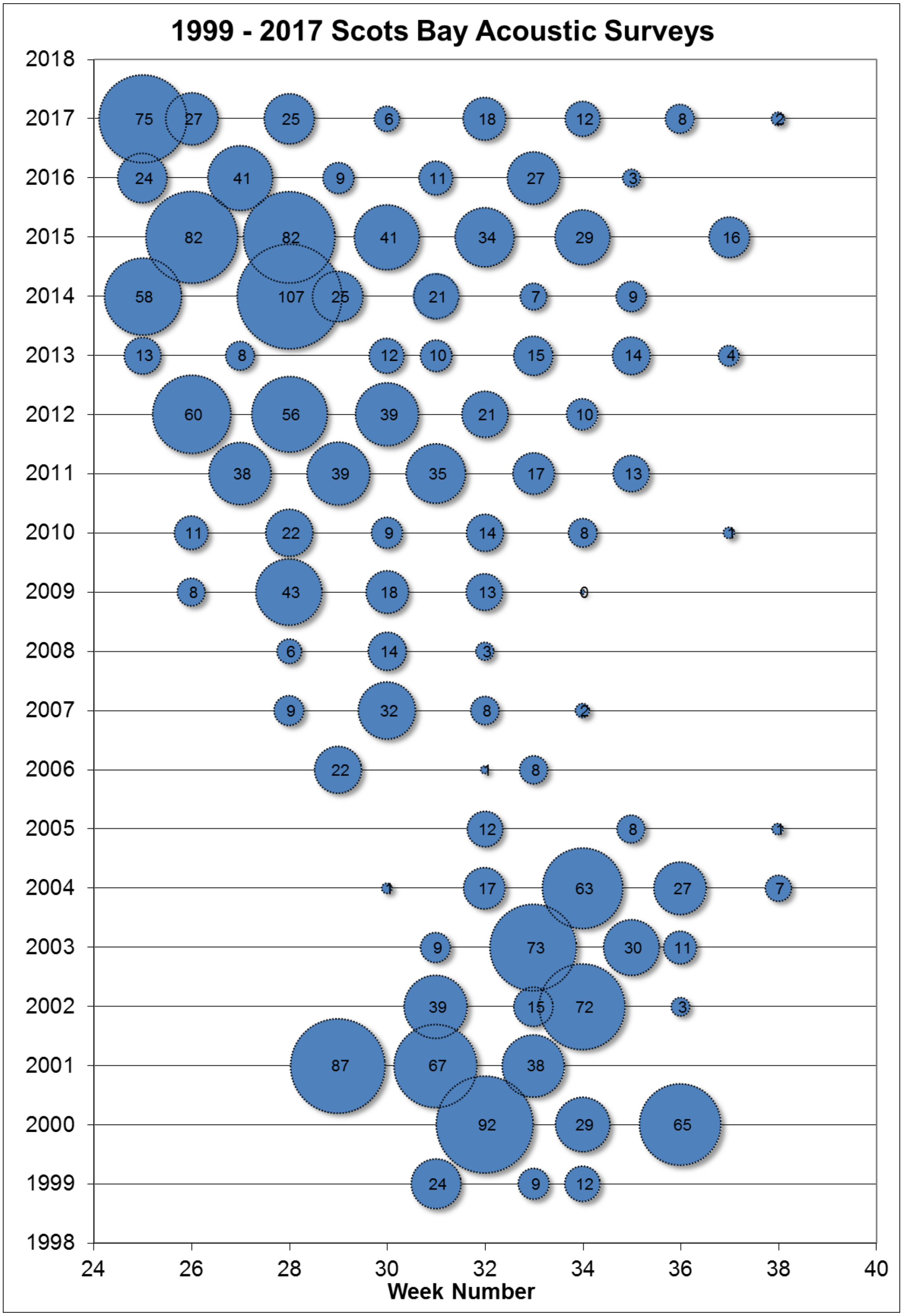

Figure 56A. History of Scots Bay Herring acoustic surveys from 1999–2017 by week number showing timing with bubble area representing biomass (in thousands) for each survey (calculated with)).

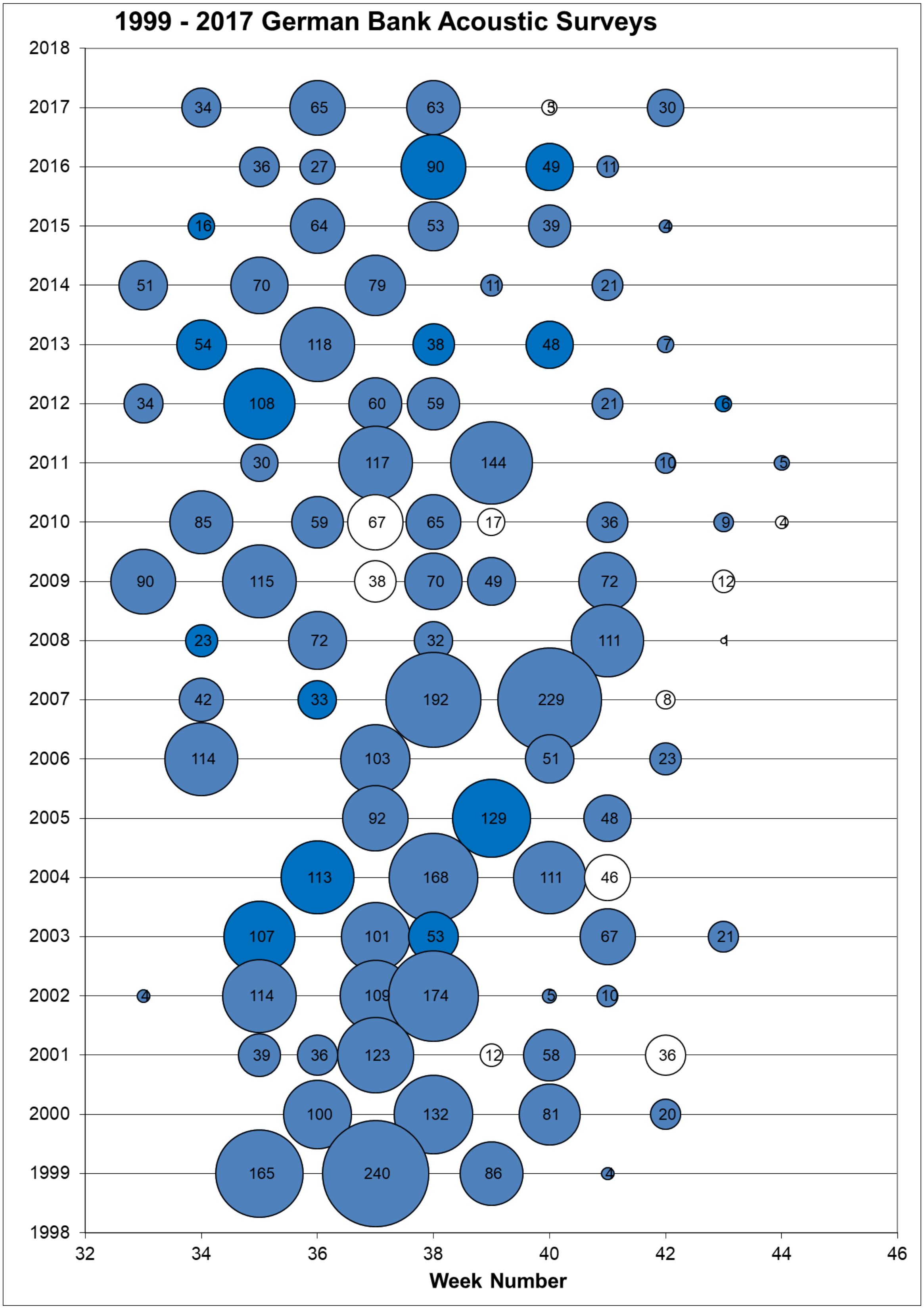

Figure 56B. History of German Bank Herring acoustic surveys from 1999–2017 by week number showing timing with bubble area representing biomass (in thousands) for each survey (calculated with Calibration Integration Factor (CIF)). White bubbles = surveys that were excluded.

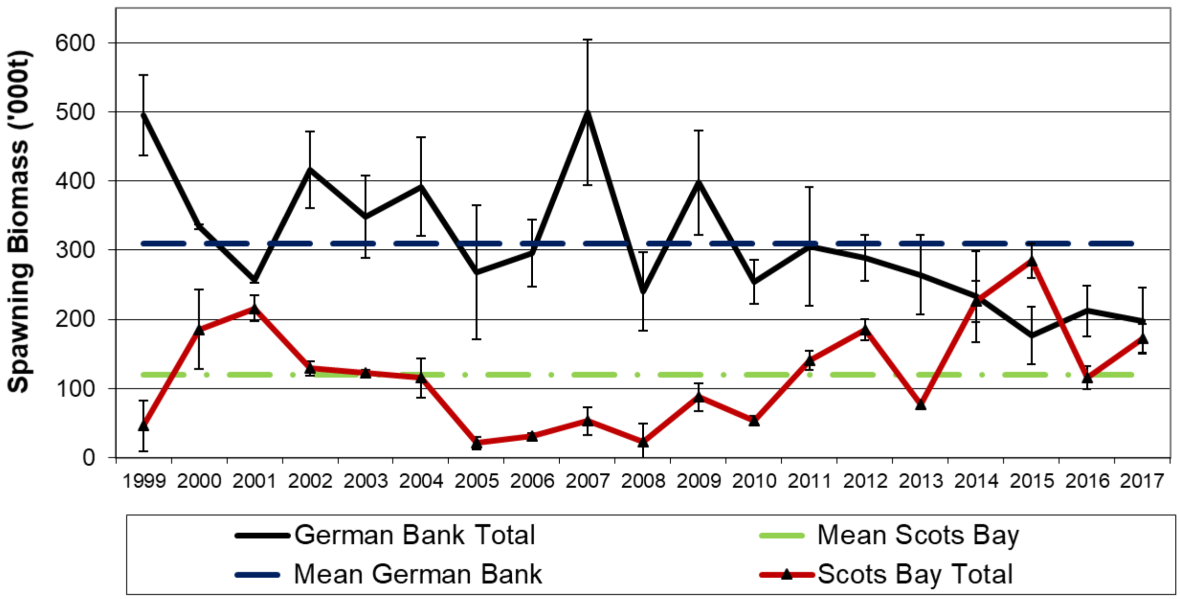

Figure 57A. Trends in Herring Spawning Stock Biomass (SSB) from acoustic surveys areas with 95% confidence intervals in Scots Bay and German Bank areas in relation to the 2005–2010 average. All estimates calculated with Calibration Integration Factor (CIF).

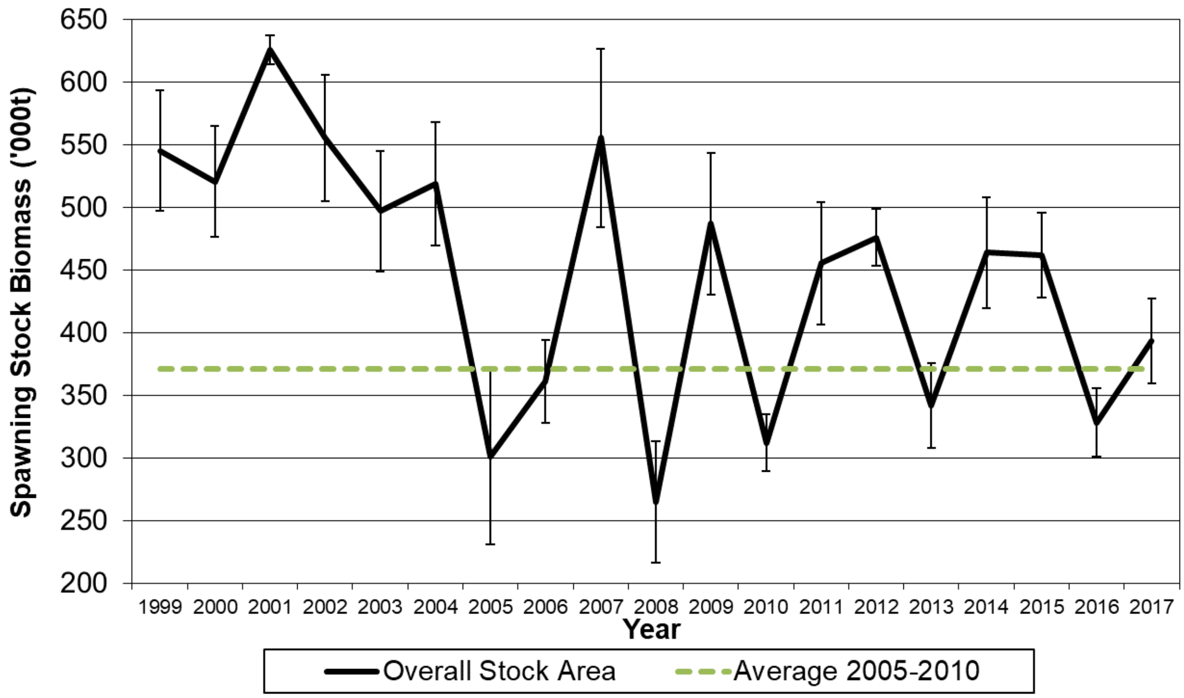

Figure 57B. Herring Spawning Stock Biomass (SSB) from acoustic surveys for the overall SWNS/BoF spawning component (along with the average from 2005–2010) with 95% confidence intervals (equivalent to two times Standard Error (SE)).

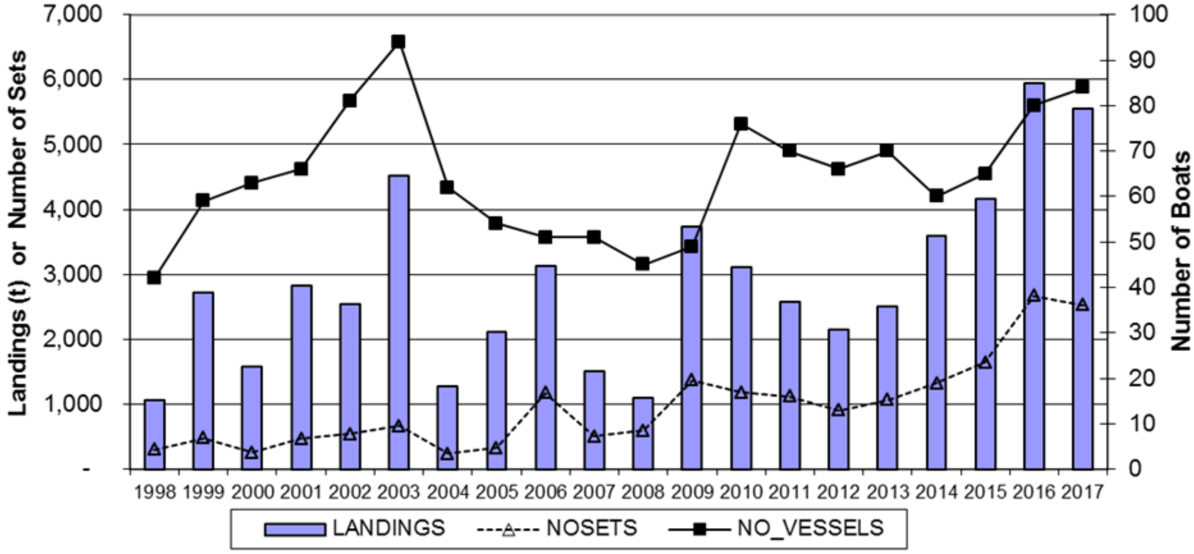

Figure 58. Herring gillnet total landings (t) and total effort in number of vessels and number of sets for the Little Hope/Port Mouton area for 1998–2017. Data for statistical districts 23, 25, 26–31 inclusive. Note overlap of district 26 with Liverpool area.

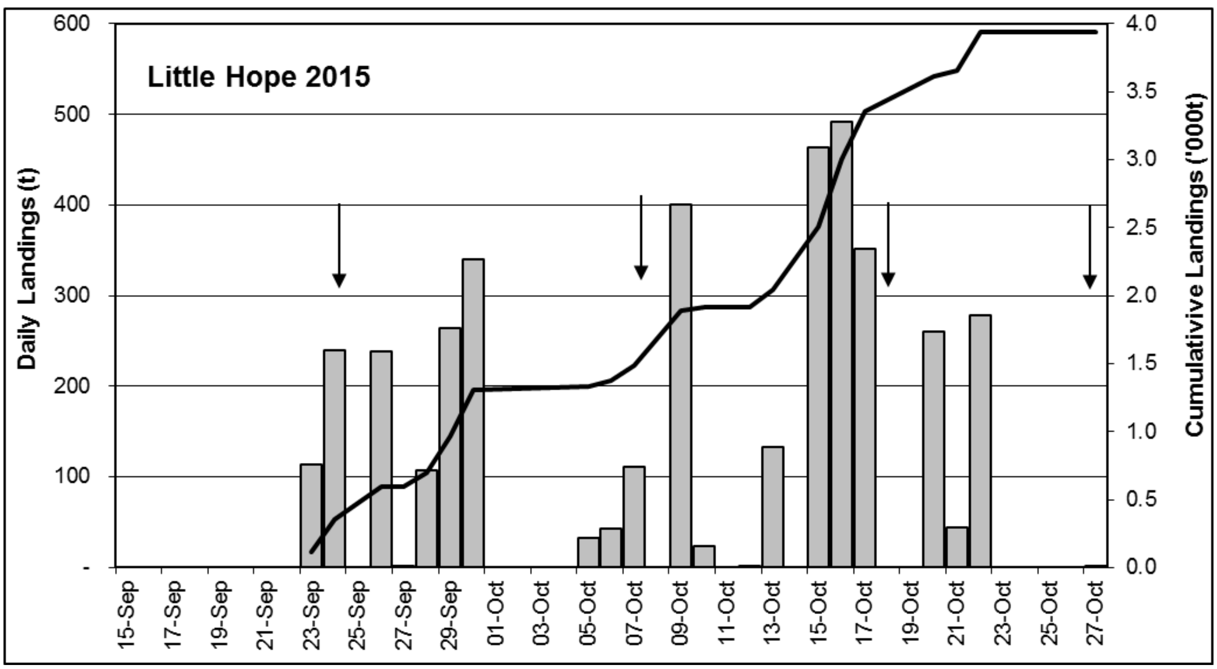

Figure 59A. Daily and cumulative catch for 2015 Little Hope/Port Mouton Herring gillnet fishery. Survey dates are identified with arrows indicating survey timing.

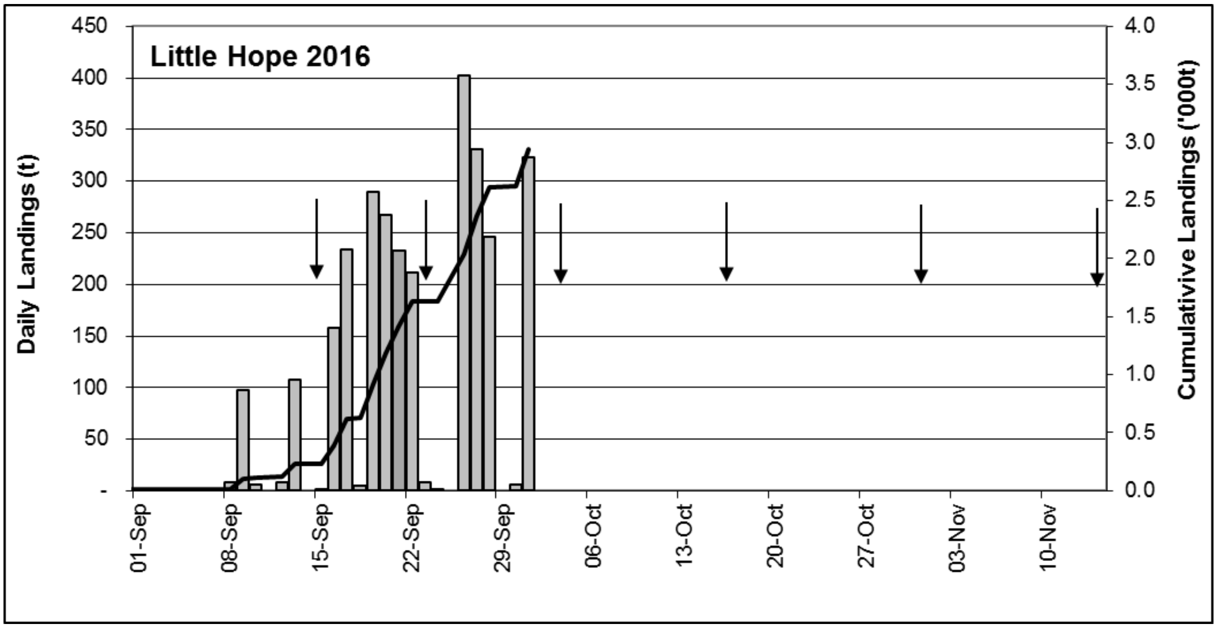

Figure 59B. Daily and cumulative catch for 2016 Little Hope/Port Mouton Herring gillnet fishery. Survey dates are identified with arrows indicating survey timing

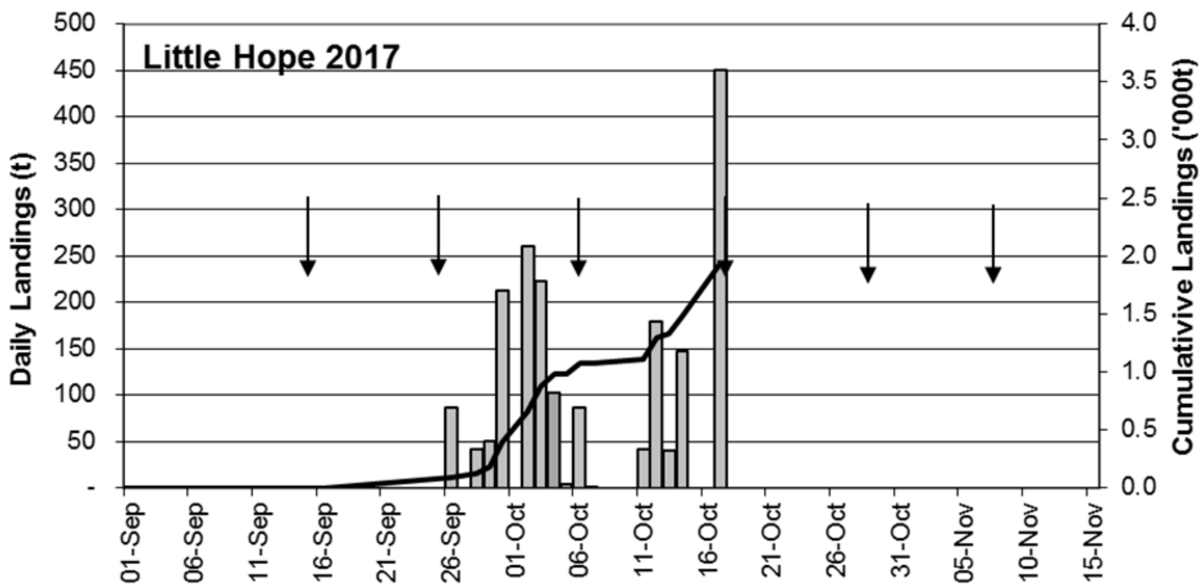

Figure 59C. Daily and cumulative catch for 2017 Little Hope/Port Mouton Herring gillnet fishery. Survey dates are identified with arrows indicating survey timing

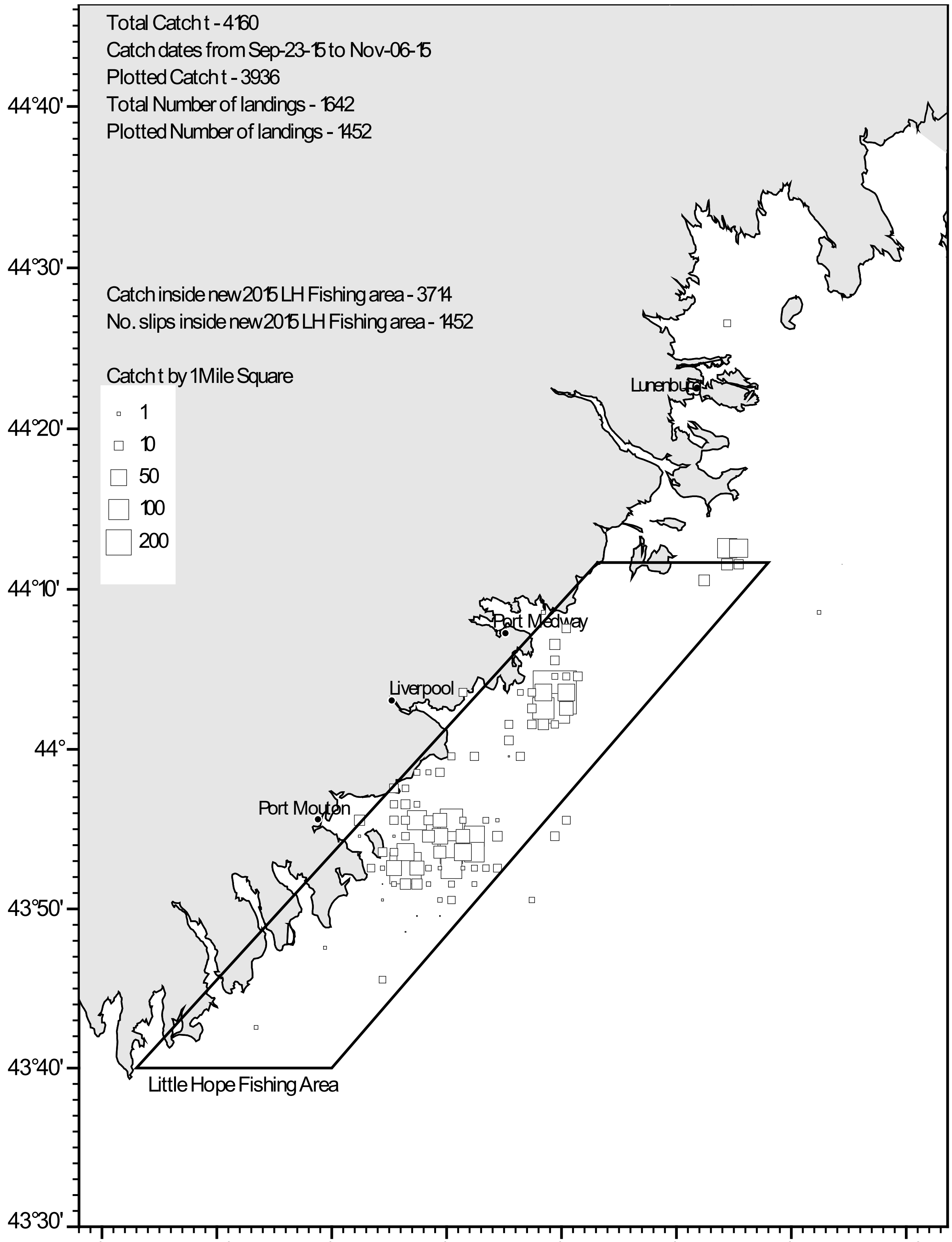

Figure 60A. Fishery Herring gillnet catch distribution for the Little Hope/Port Mouton area for 2015.

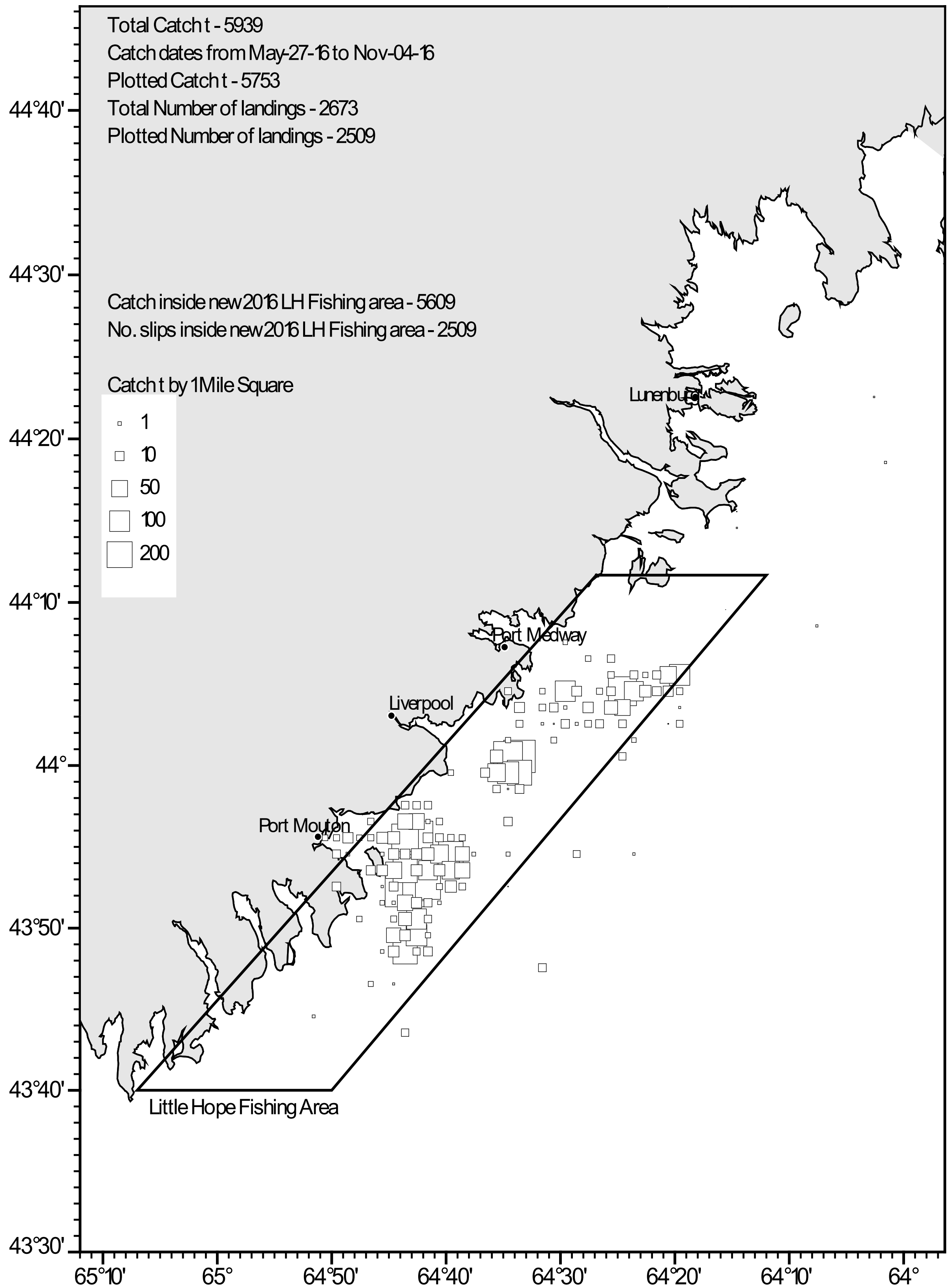

Figure 60B. Fishery Herring gillnet catch distribution for the Little Hope/Port Mouton area for 2016.

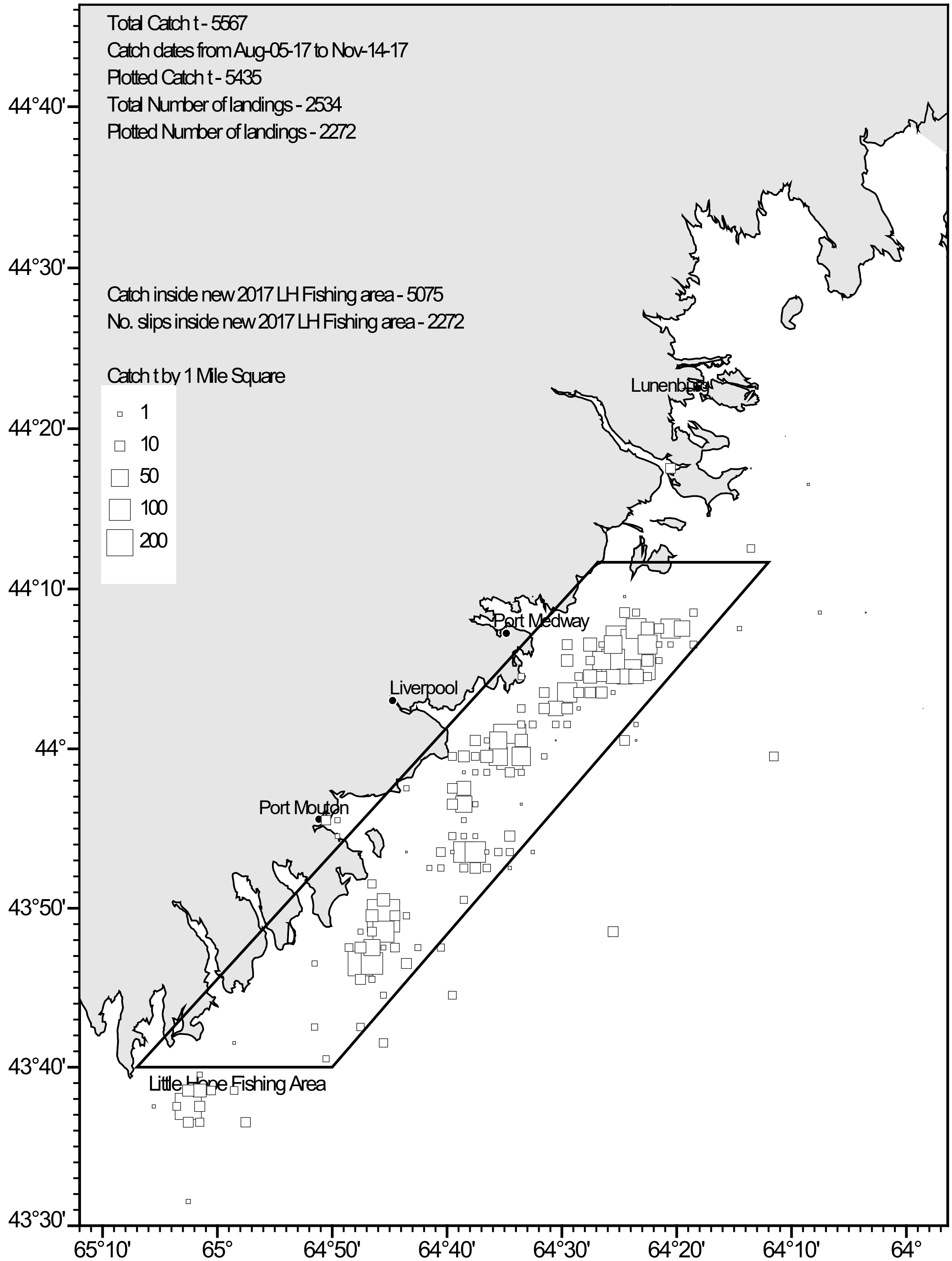

Figure 60C. Fishery Herring gillnet catch distribution for the Little Hope/Port Mouton area for 2017.

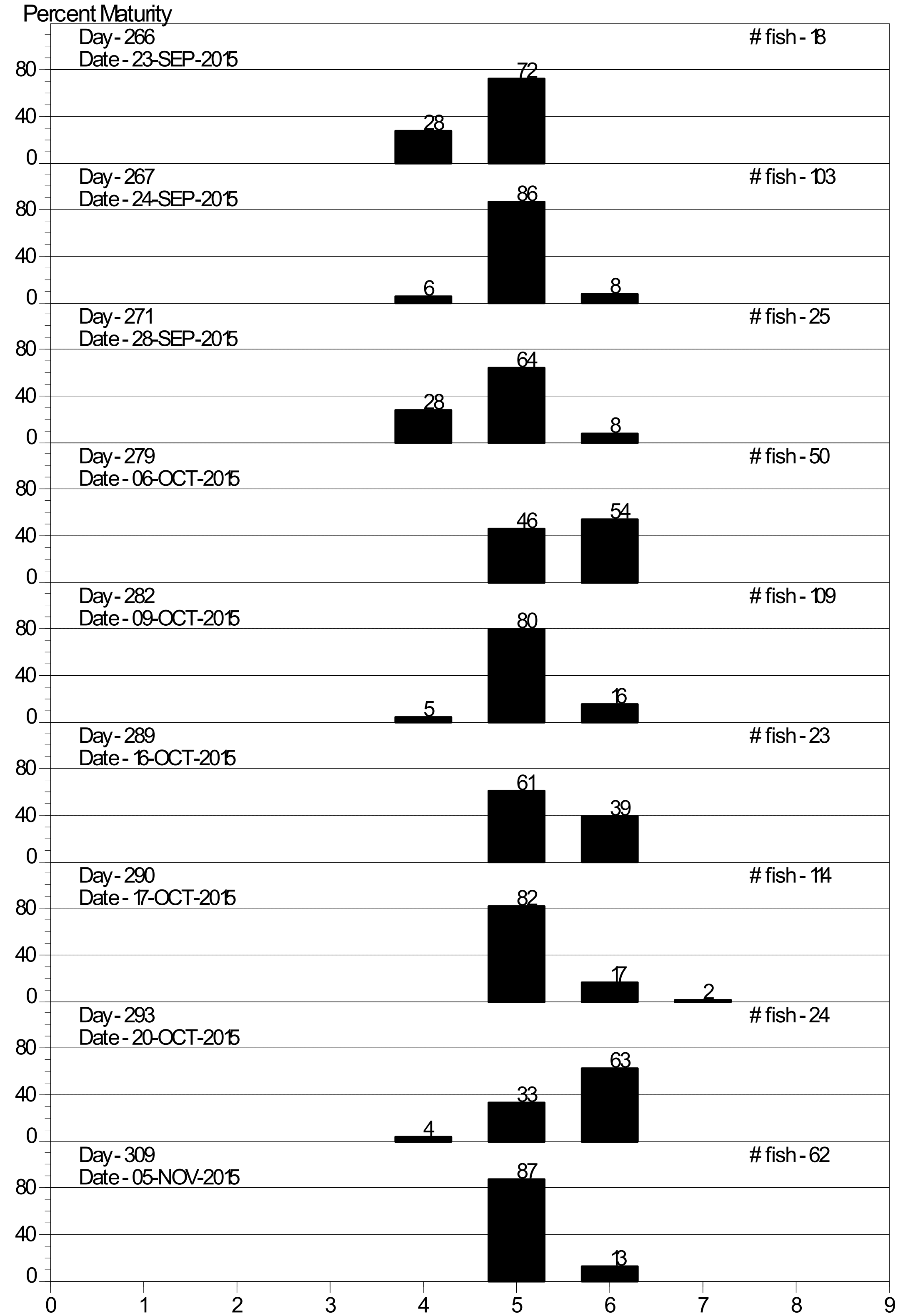

Figure 61A. Herring maturity samples collected from the Port Mouton/Little Hope area in 2015. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; and 8 = recovering.

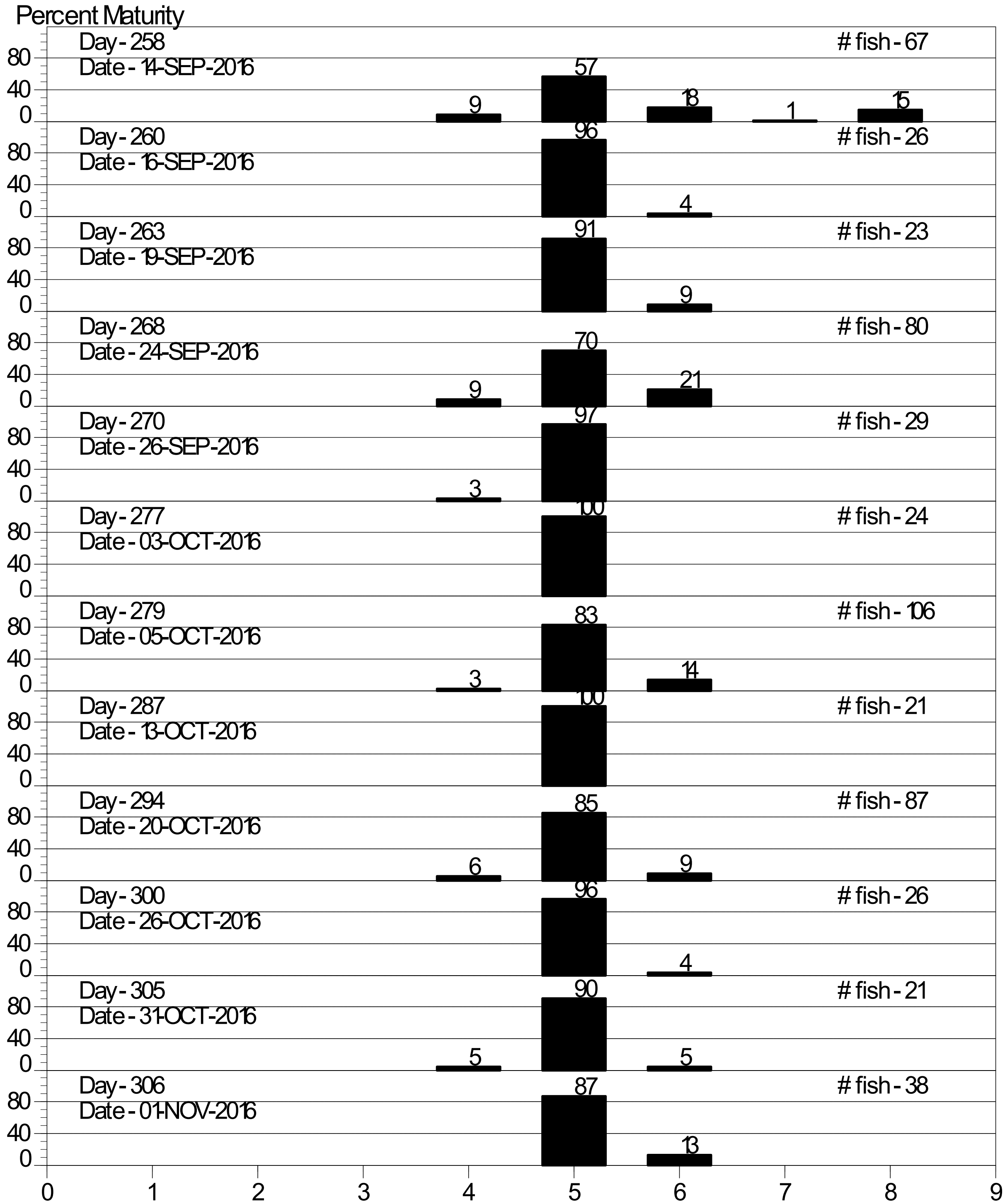

Figure 61B. Herring maturity samples collected from the Port Mouton/Little Hope area in 2016. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; and 8 = recovering.

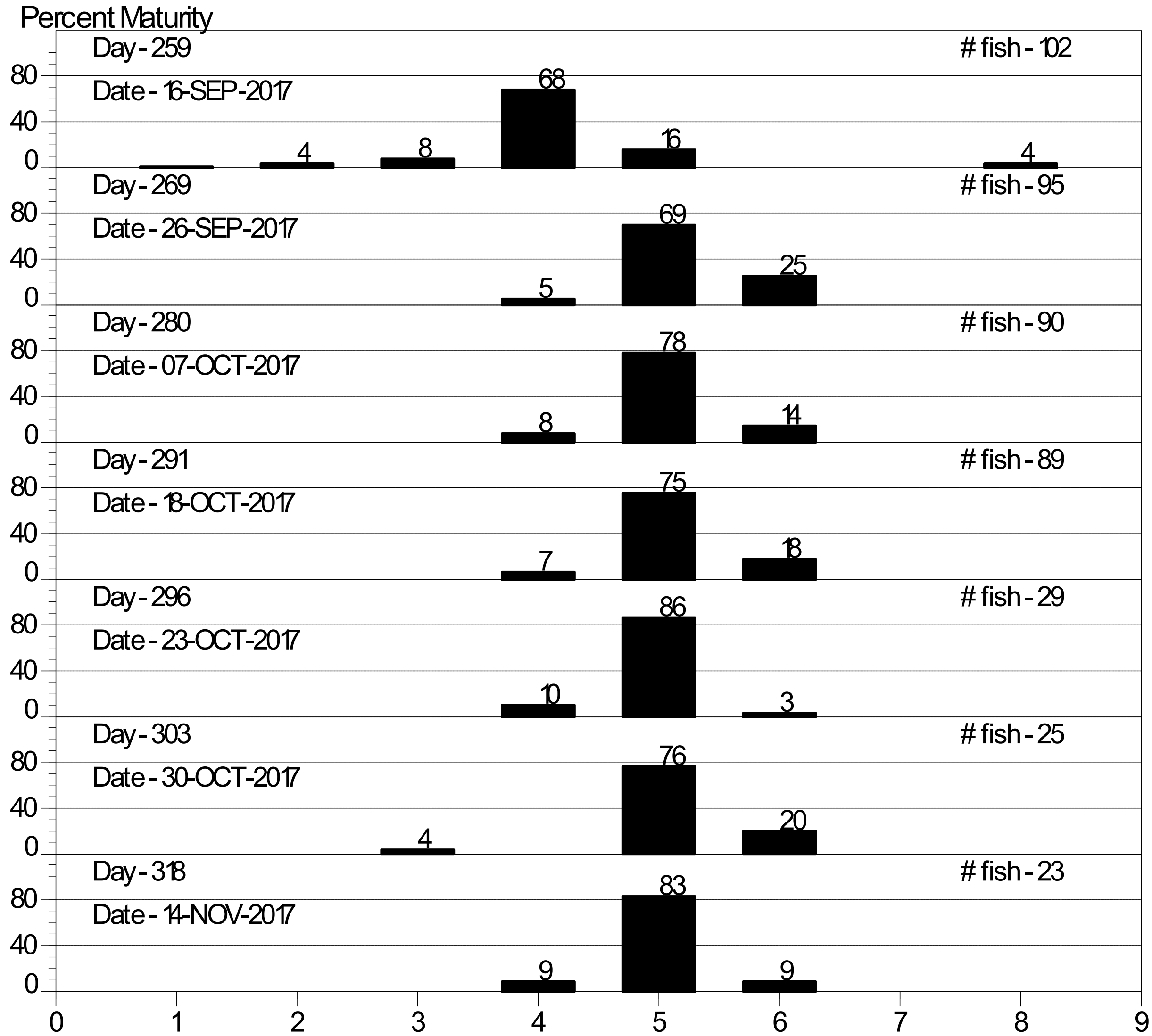

Figure 61C. Herring maturity samples collected from the Port Mouton/Little Hope area in 2017. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; and 8 = recovering.

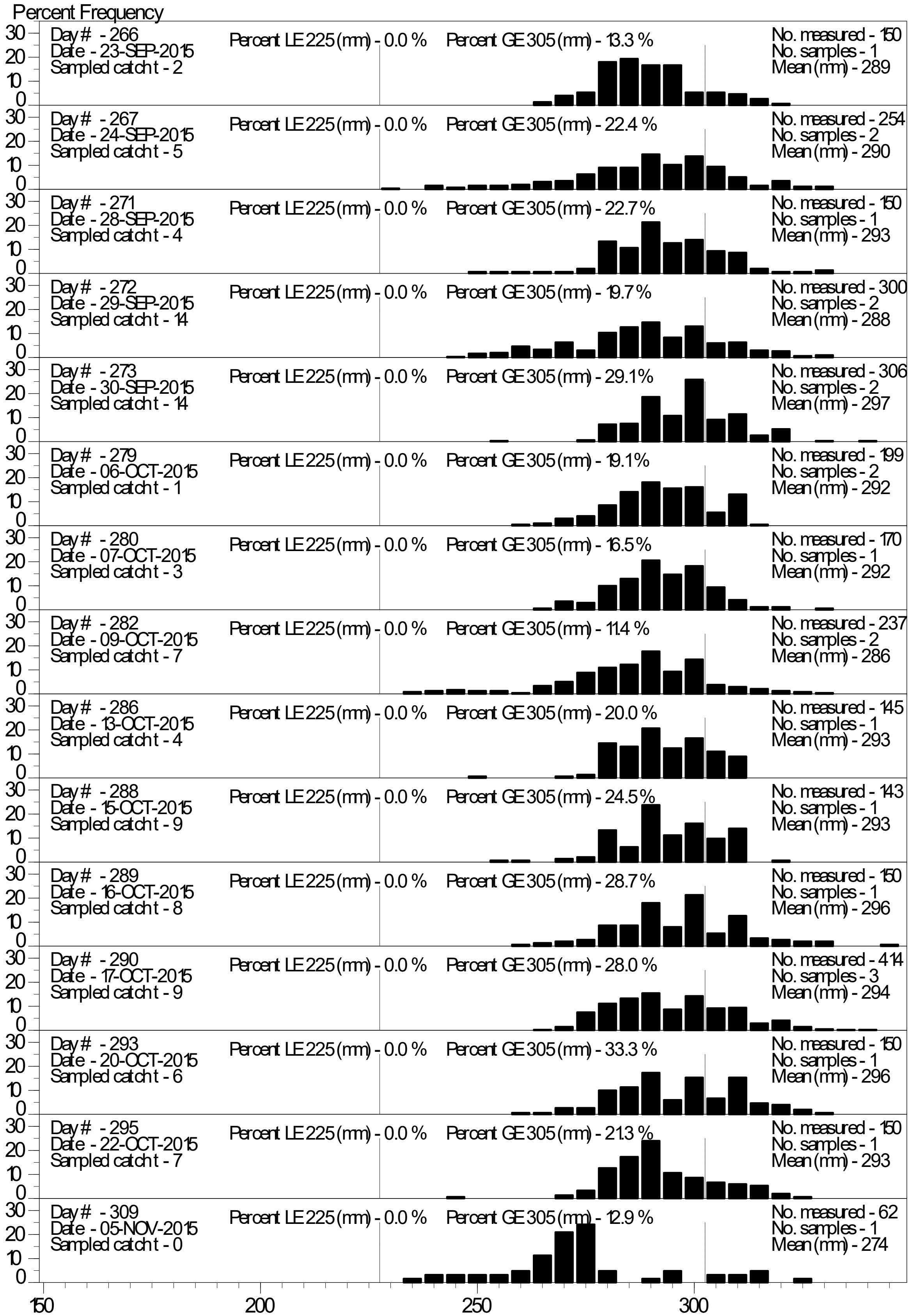

Figure 62A. Daily length-frequency samples collected from the Port Mouton/Little Hope area between September 23 and November 9, 2015 with proportions < 23 cm and > 30 cm.

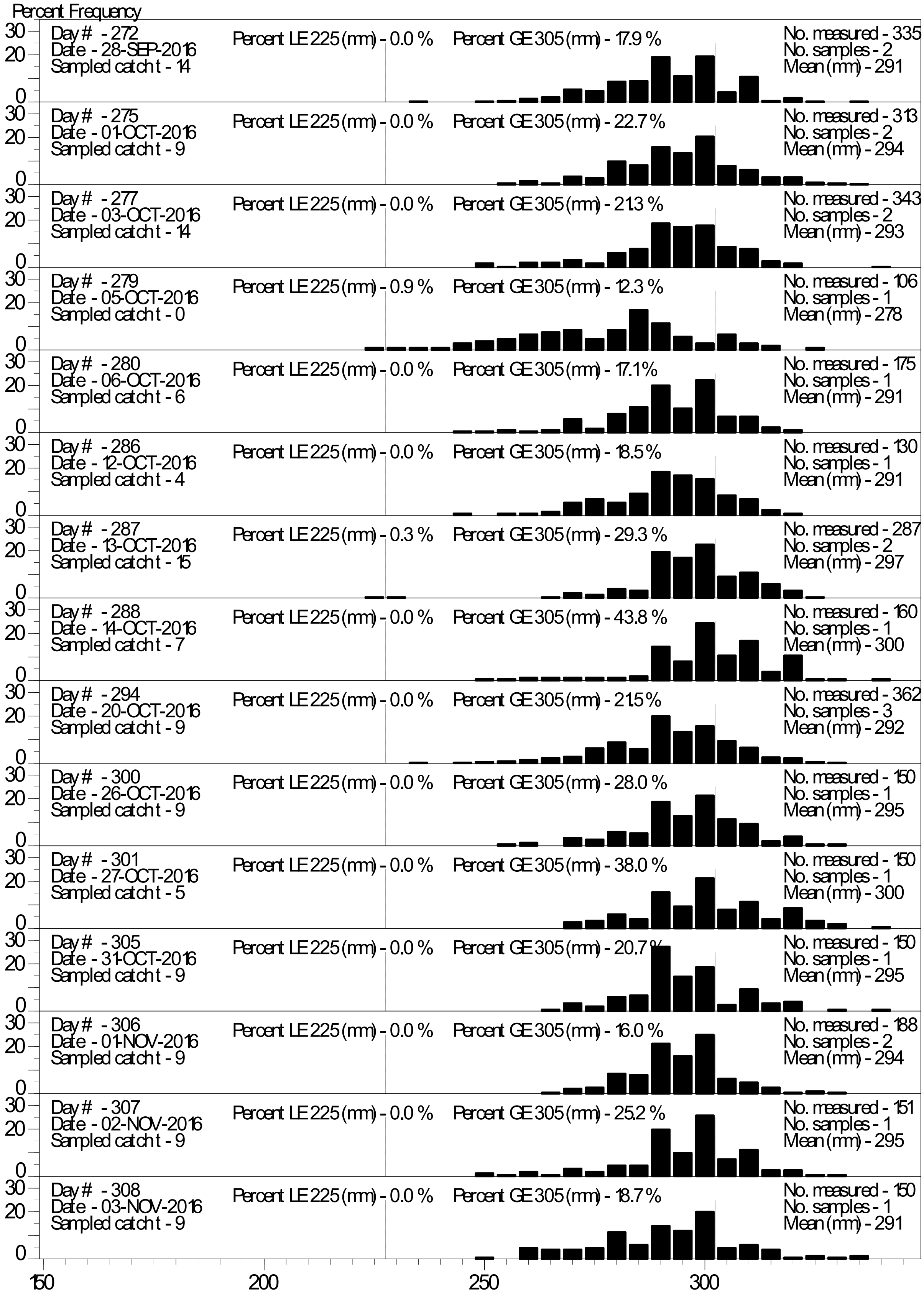

Figure 62B. Daily length-frequency samples collected from the Port Mouton/Little Hope area between September 28 and November 3, 2016 with proportions < 23 cm and > 30 cm.

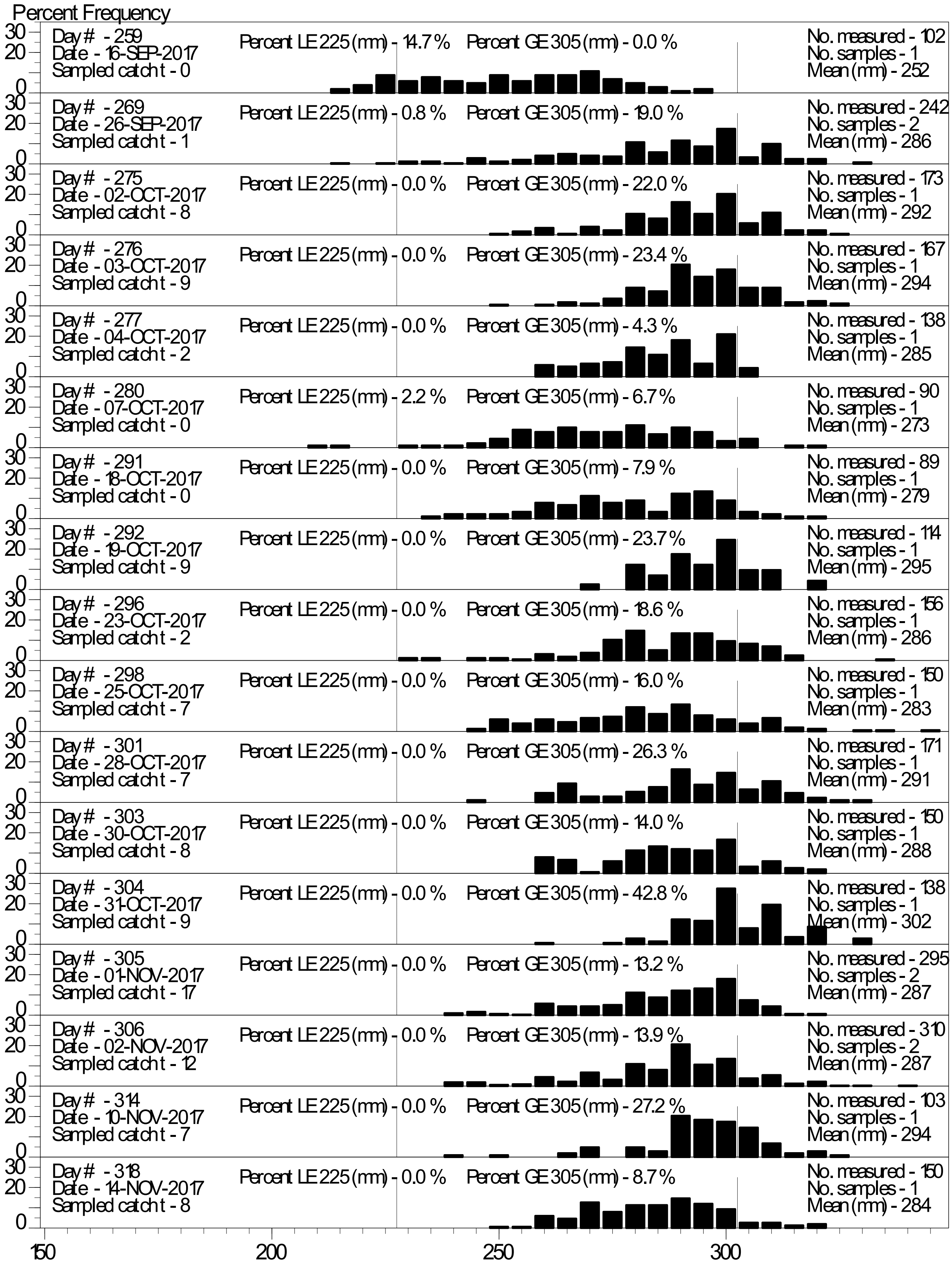

Figure 62C. Daily length-frequency samples collected from the Port Mouton/Little Hope area between September 15 and November 14, 2017 with proportions < 23 cm and > 30 cm.

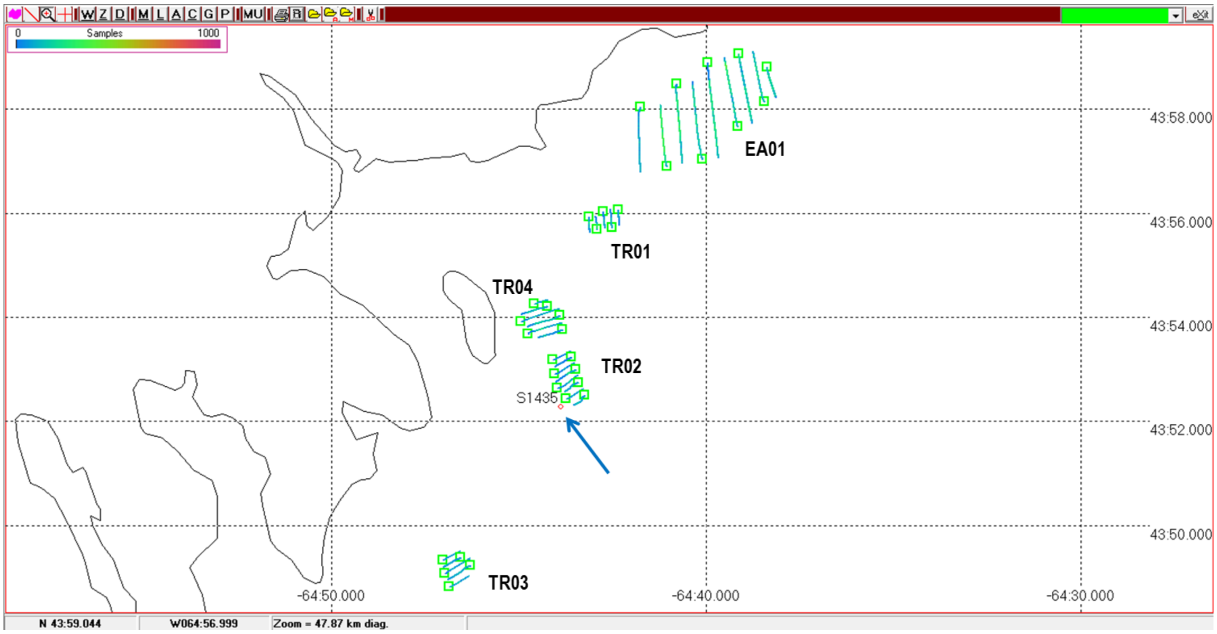

Figure 63A. Little Hope/Port Mouton acoustic survey (#1) on September 24, 2015 showing location (arrow) of multi-panel Herring gillnet samples collected on September 24.

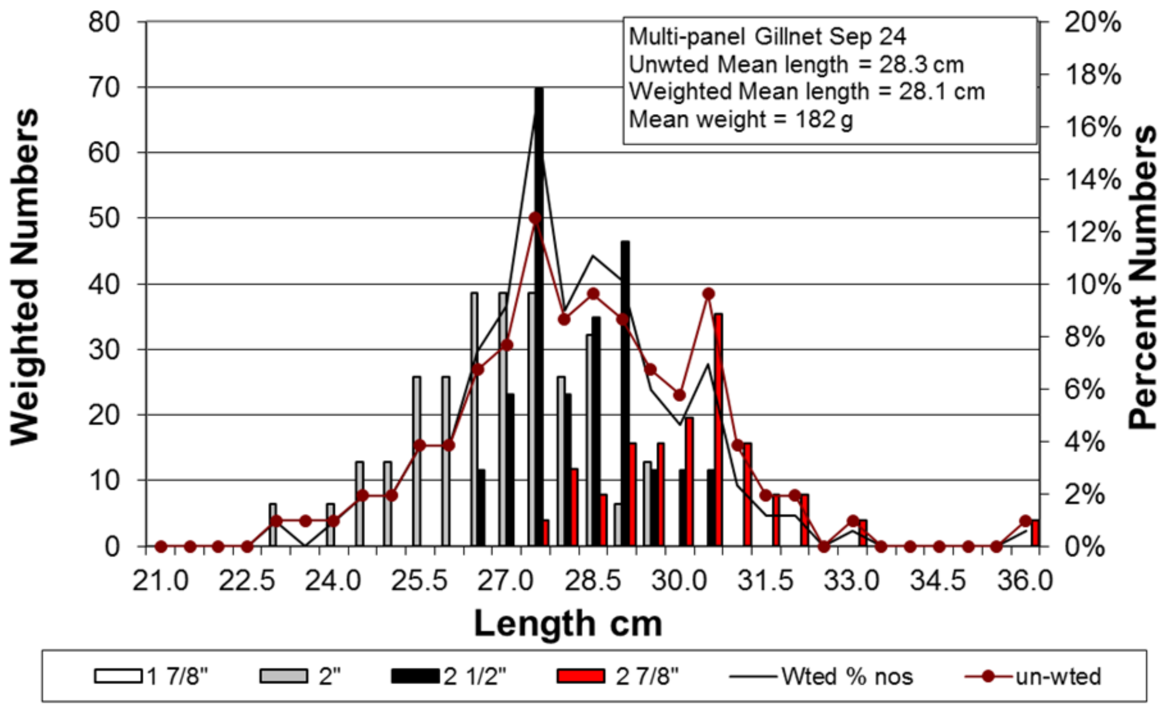

Figure 63B. Multi-panel Herring gillnet sample collected by <u>Jamie B II</u> on September 24, 2015 for the Little Hope Herring acoustic survey (#1) on September 24.

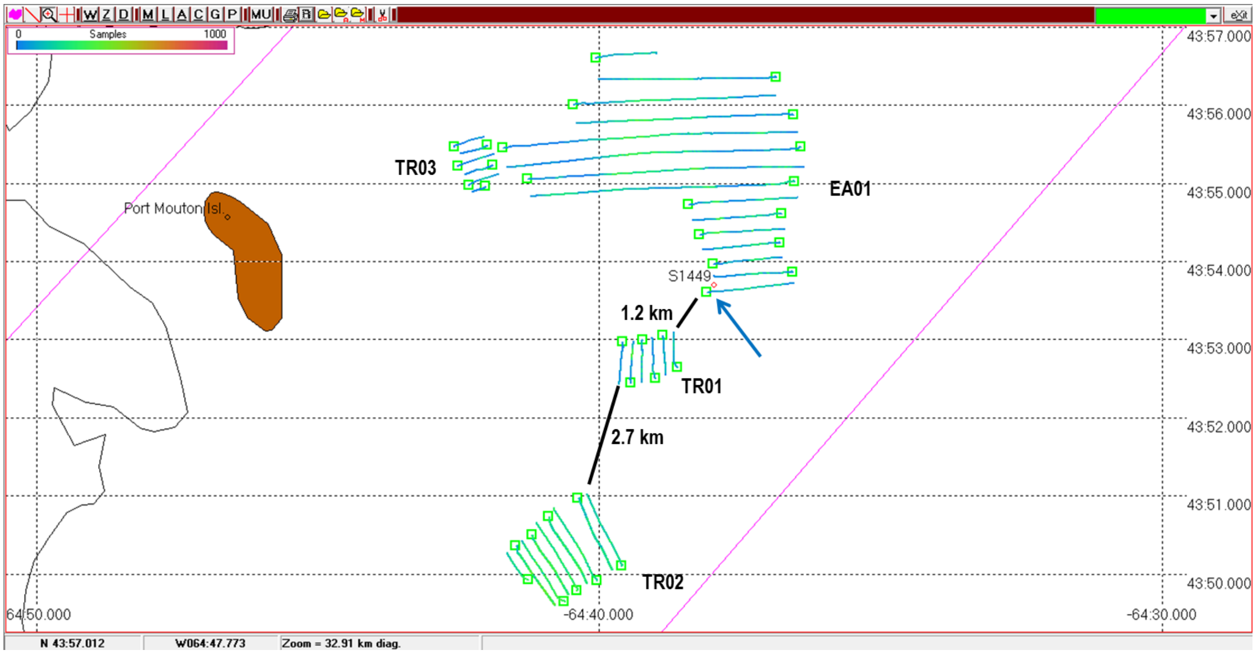

Figure 64A. Little Hope/Port Mouton acoustic survey (#2) on October 7, 2015 showing part of the main survey box (long straight lines), along with location (arrow) of multi-panel sample collected October 9.

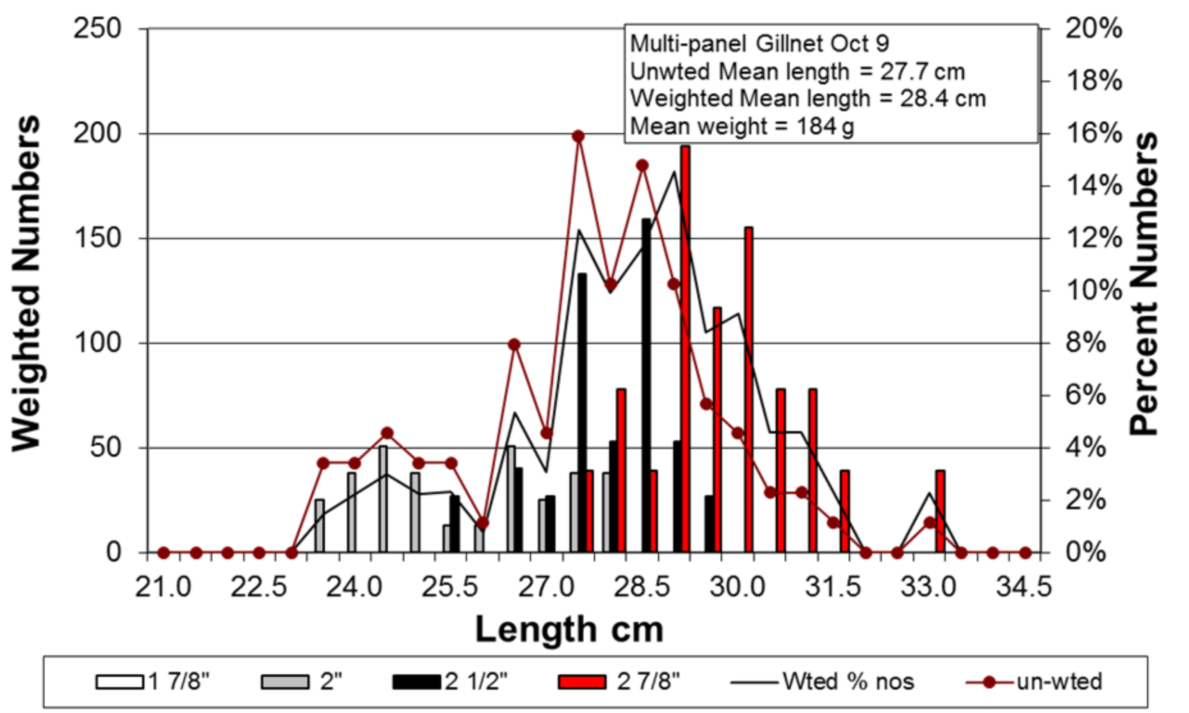

Figure 64B. Multi-panel Herring gillnet sample collected by Jamie B II on October 9, 2015 for the Little Hope Herring acoustic survey (#2) on October 7.

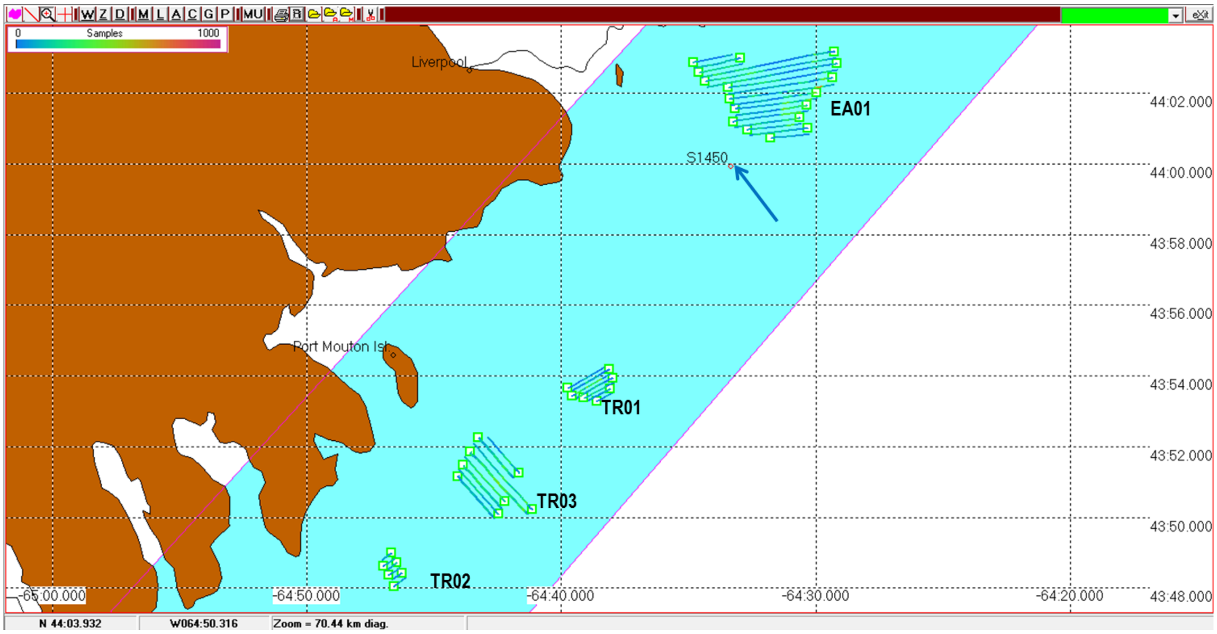

Figure 65A. Little Hope/Port Mouton acoustic survey (#3) on October 18, 2015 showing the main survey box (highlighted area), along with location (arrow) of multi-panel sample collected October 15.

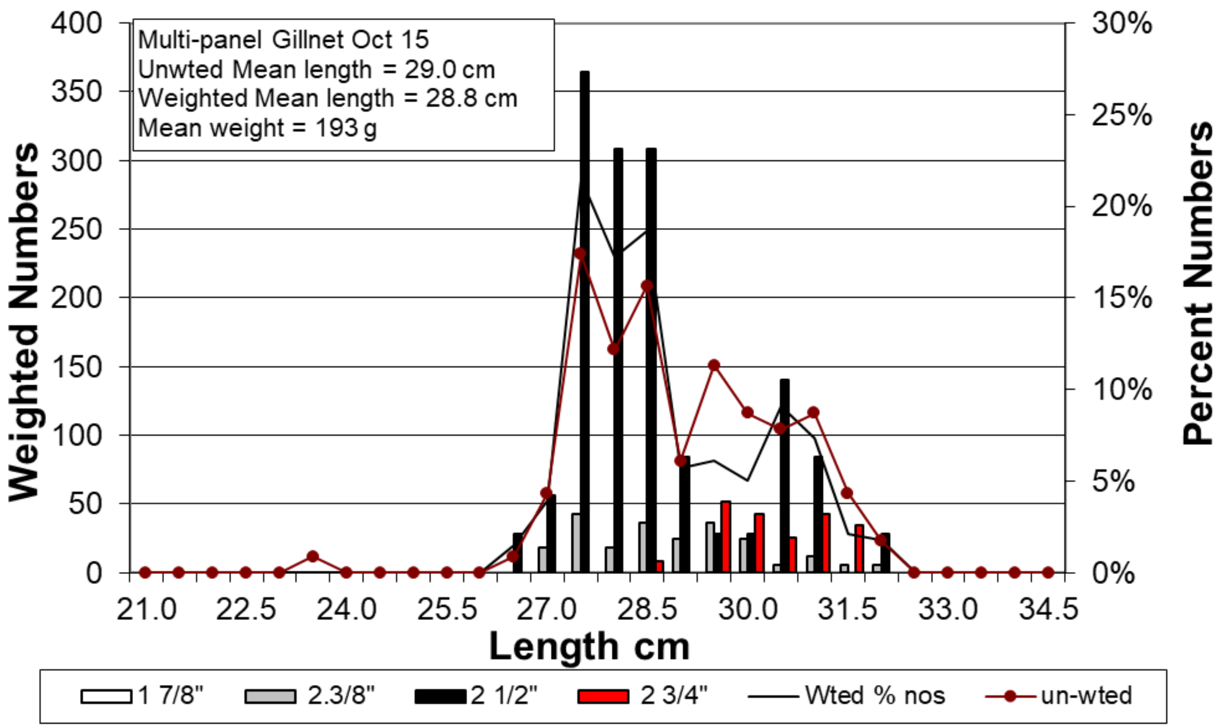

Figure 65B. Multi-panel Herring gillnet sample collected by <u>*Jamie B II*</u> *on October 15, 2015 for the Little Hope Herring acoustic survey (#3) on October 18.*

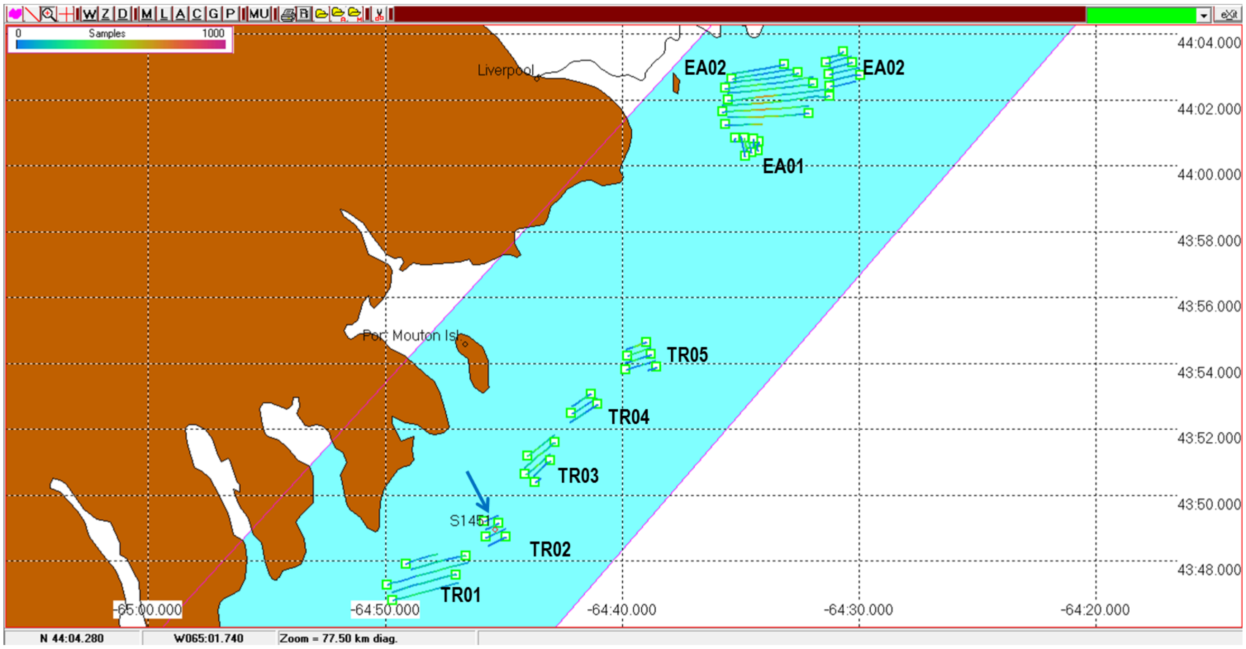

Figure 65C. Little Hope/Port Mouton acoustic survey (#4) on November 4, 2015 showing the main survey box (highlighted area), along with location (arrow) of multi-panel sample collected November 5.

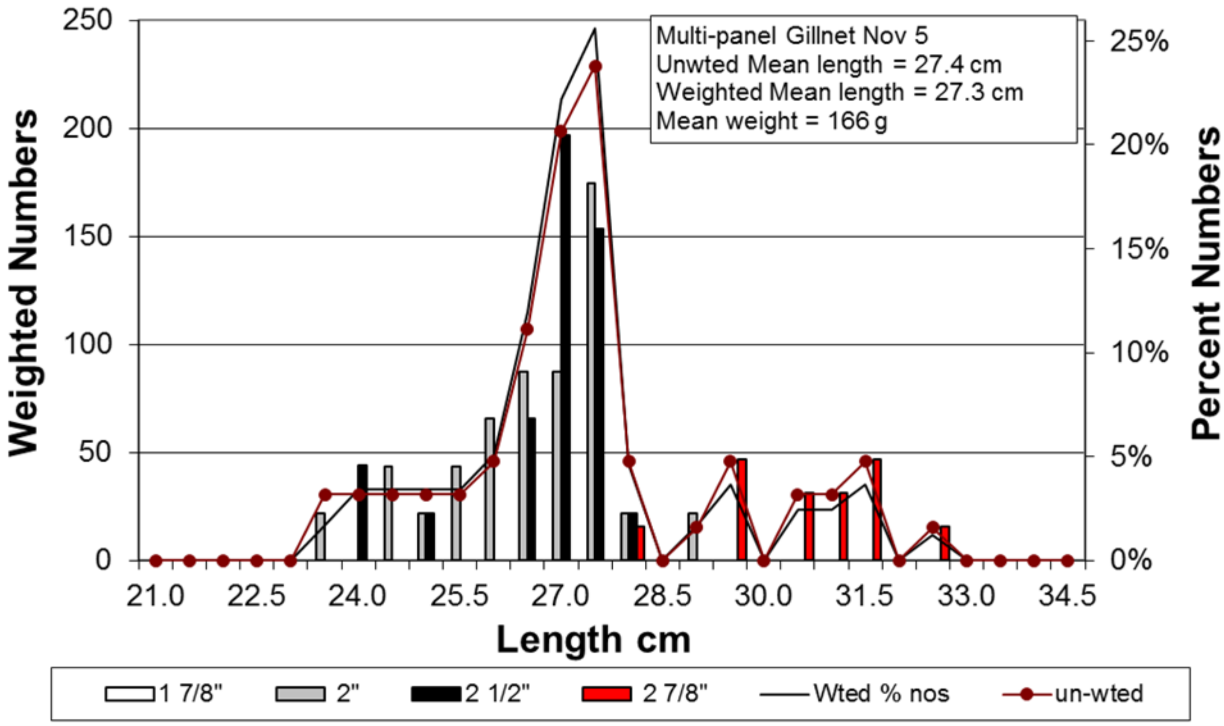

Figure 65D. Multi-panel Herring gillnet sample collected November 5, 2015 for the Little Hope Herring acoustic survey (#4) on November 4.

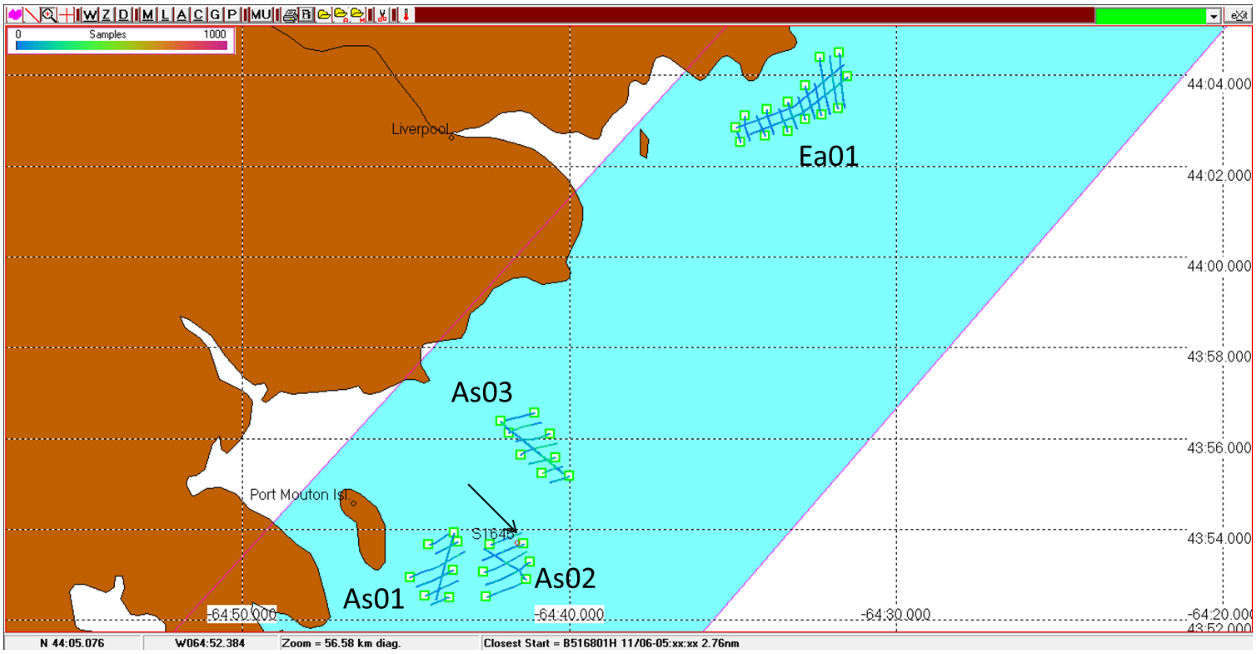

Figure 66A. Little Hope/Port Mouton acoustic survey (#1) on September 13, 2016 showing the main survey box (highlighted area), along with location (arrow) of multi-panel Herring gillnet samples collected on September 14.

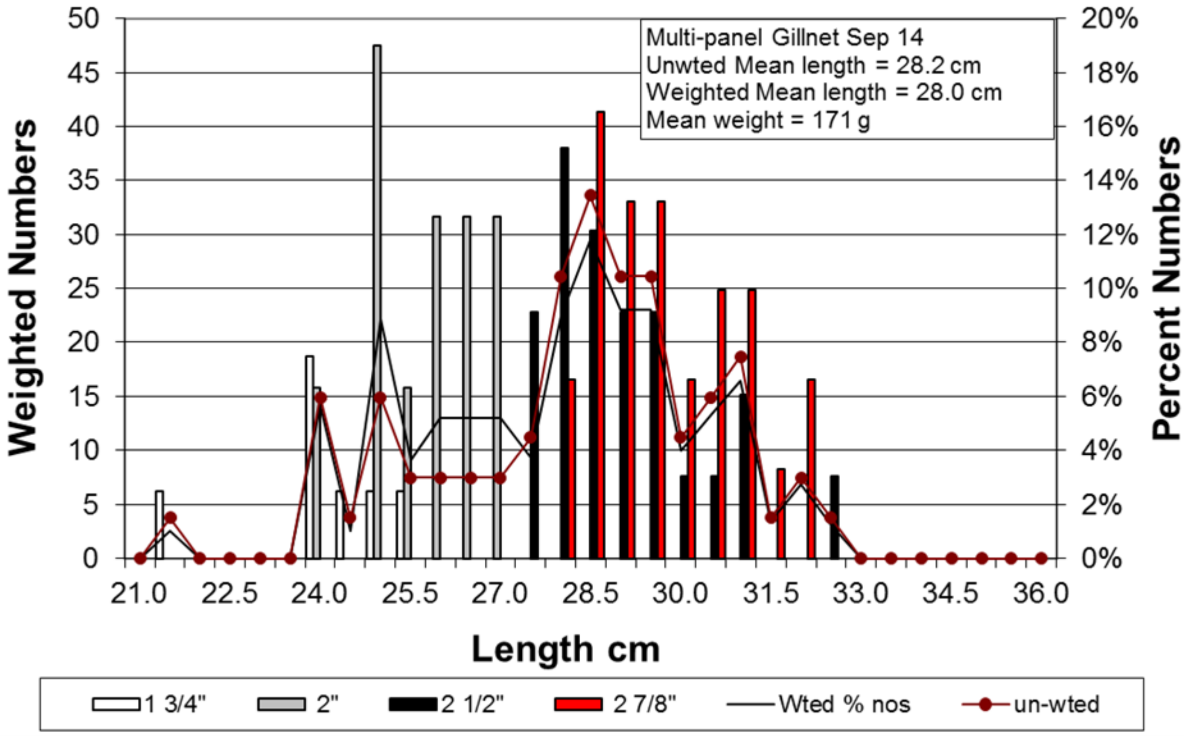

Figure 66B. Multi-panel Herring gillnet sample collected by <u>*Jamie B II*</u> *on September 14, 2016 for the Little Hope Herring acoustic survey (#1) on September 13.*

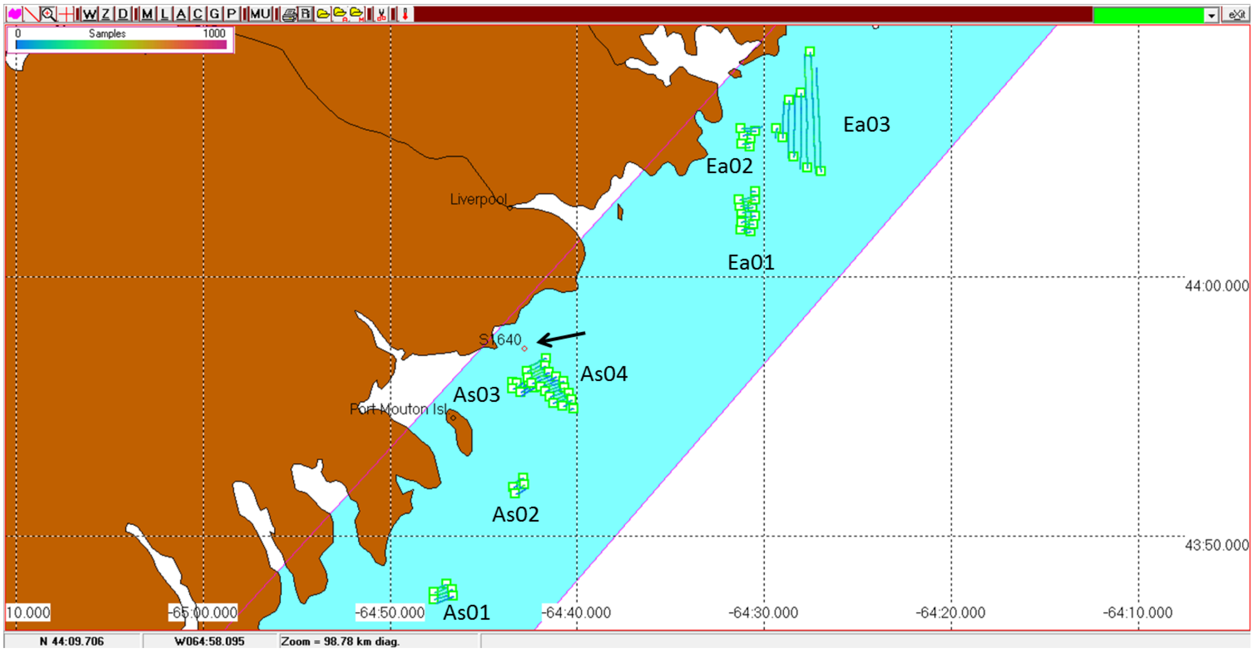

Figure 67A. Little Hope/Port Mouton acoustic survey (#2) on September 23, 2016 showing the main survey box (highlighted area), along with location (arrow) of multi-panel Herring gillnet samples collected on September 24.

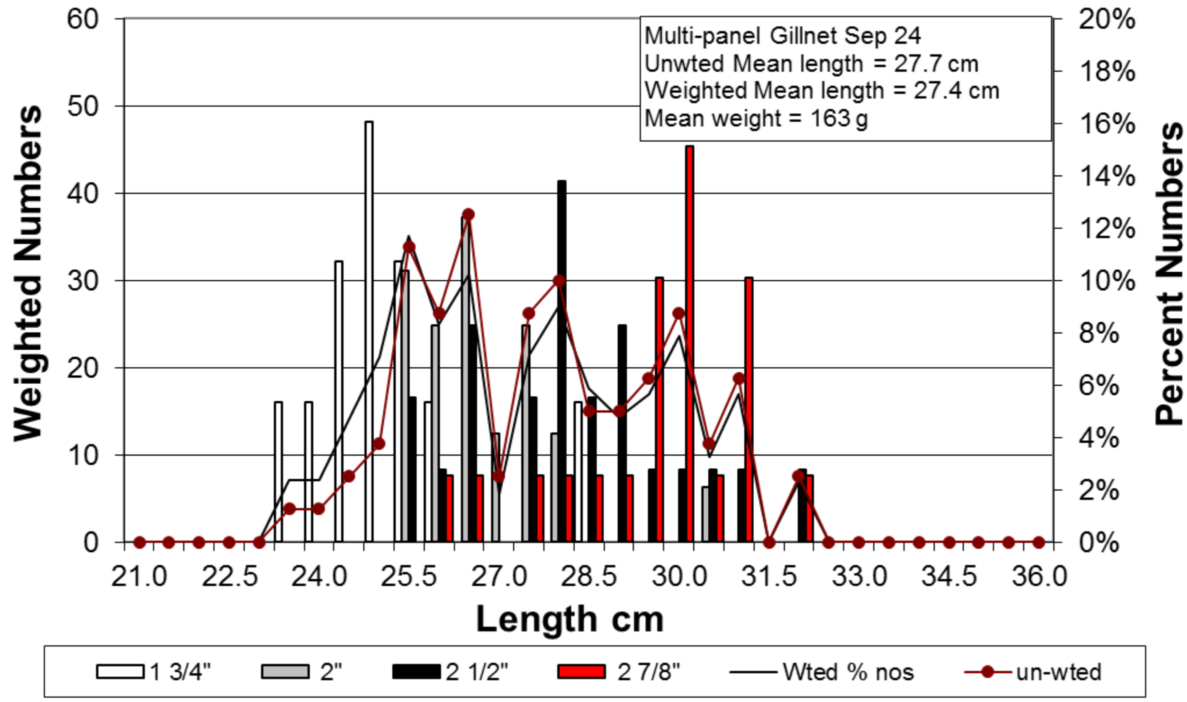

Figure 67B. Multi-panel Herring gillnet sample collected by Jamie B II on September 24, 2016 for the Little Hope Herring acoustic survey (#2) on September 23.

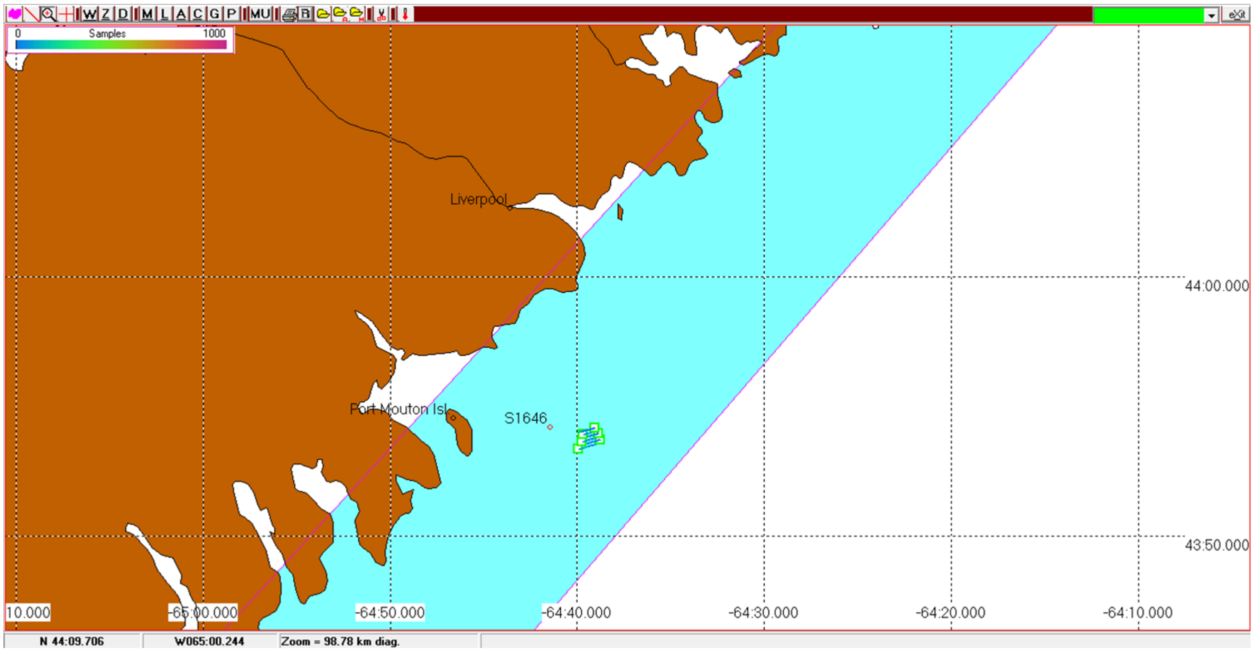

Figure 68A. Little Hope/Port Mouton acoustic survey (#3) on October 4, 2016 showing the main survey box (highlighted area), along with location (arrow) of multi-panel Herring gillnet samples collected on October 5.

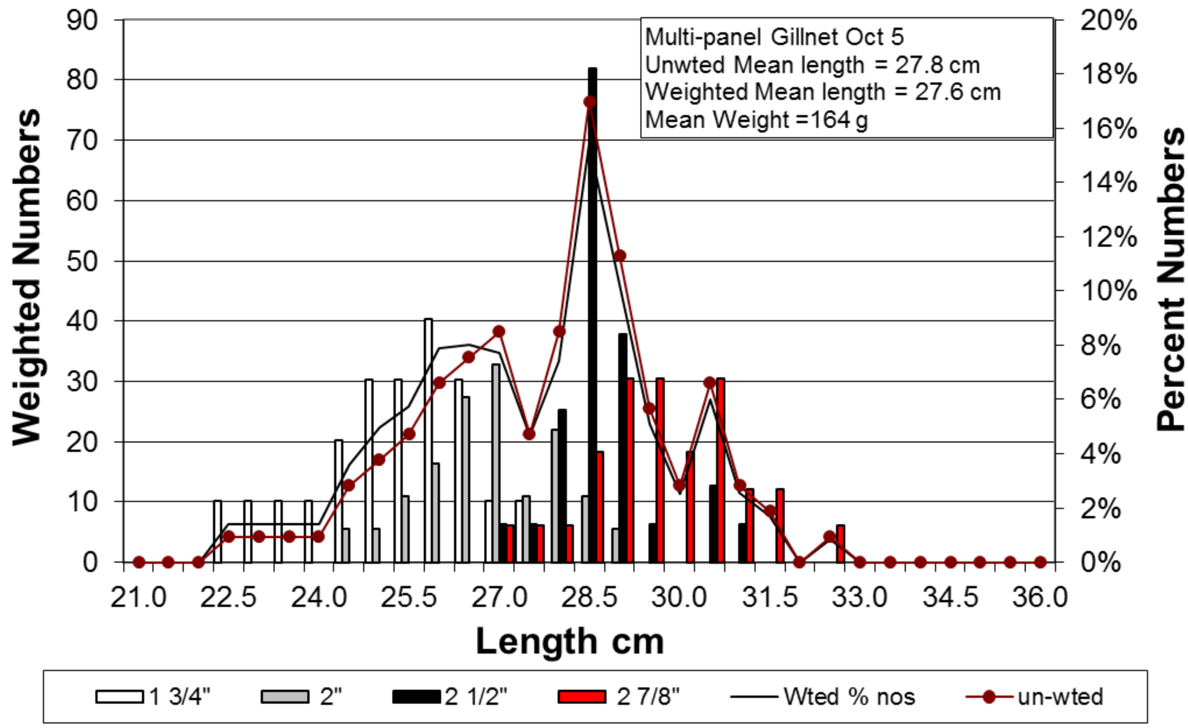

Figure 68B. Multi-panel Herring gillnet sample collected by Jamie B II on October 4, 2016 for the Little Hope Herring acoustic survey (#3) on October 4.

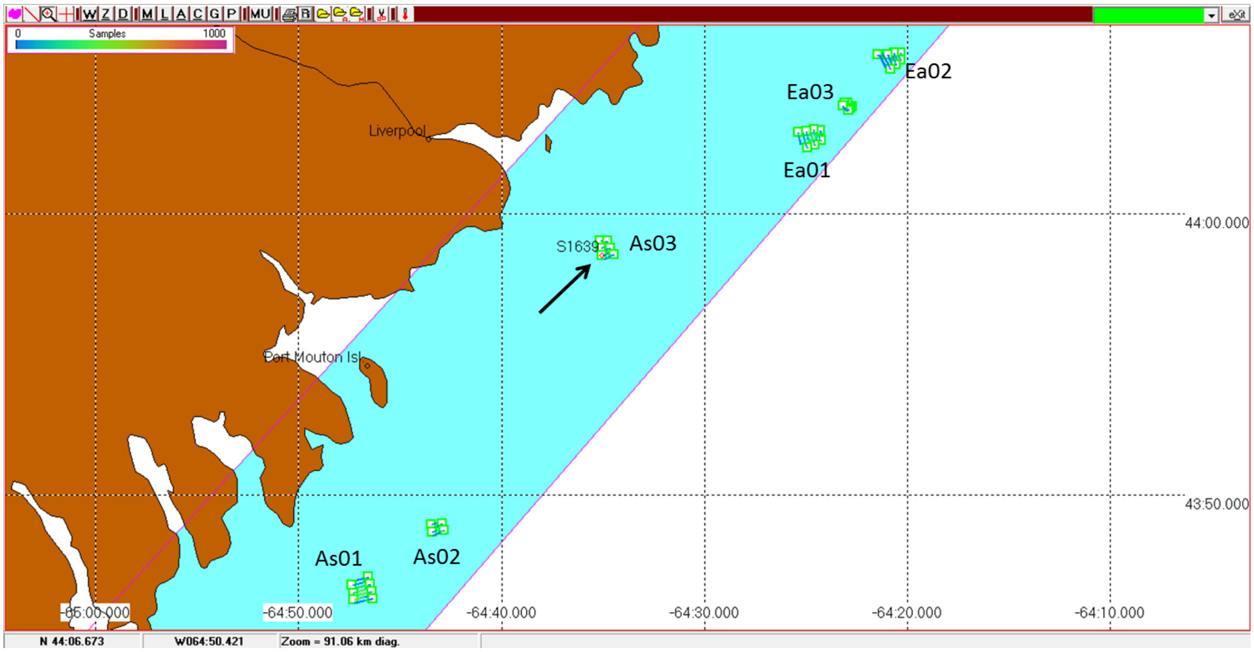

Figure 69A. Little Hope/Port Mouton acoustic survey (#4) on October 17, 2016 showing the main survey box (highlighted area), along with location (arrow) of multi-panel sample collected October 20.

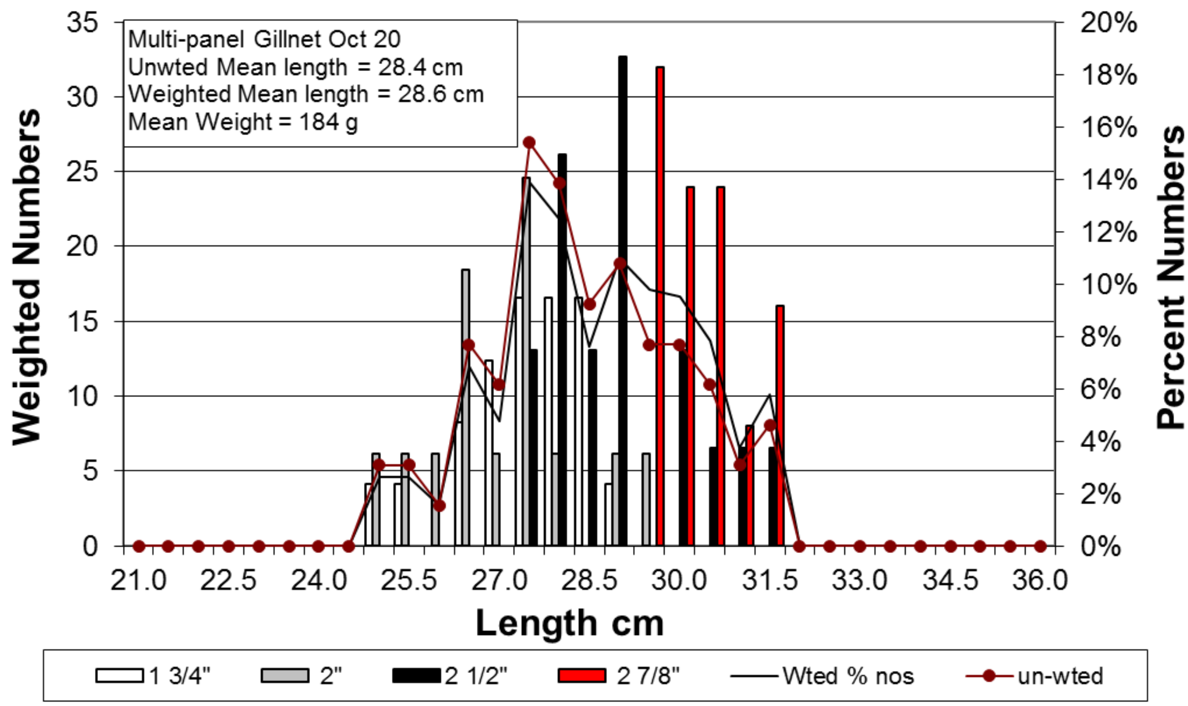

Figure 69B. Multi-panel Herring gillnet sample collected by Jamie B II on October 20, 2016 for the Little Hope Herring acoustic survey (#4) on October 17.

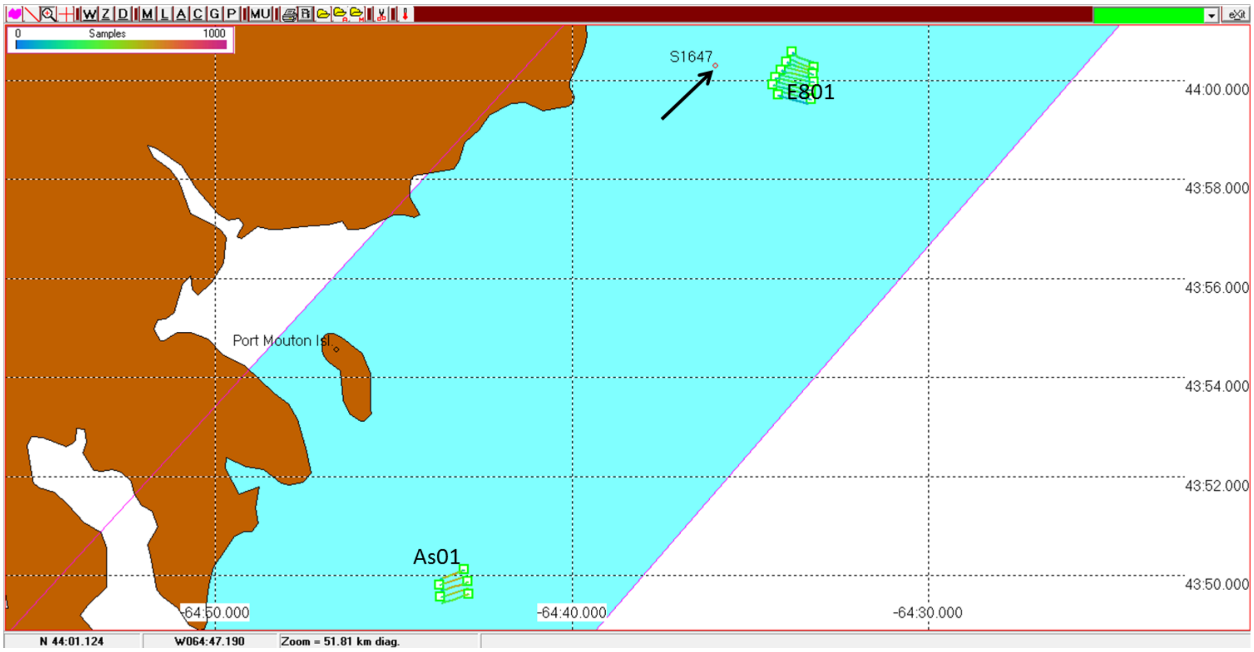

Figure 70A. Little Hope/Port Mouton acoustic survey (#5) on November 1, 2016 showing the main survey box (highlighted area), along with location (arrow) of multi-panel sample collected November 1.

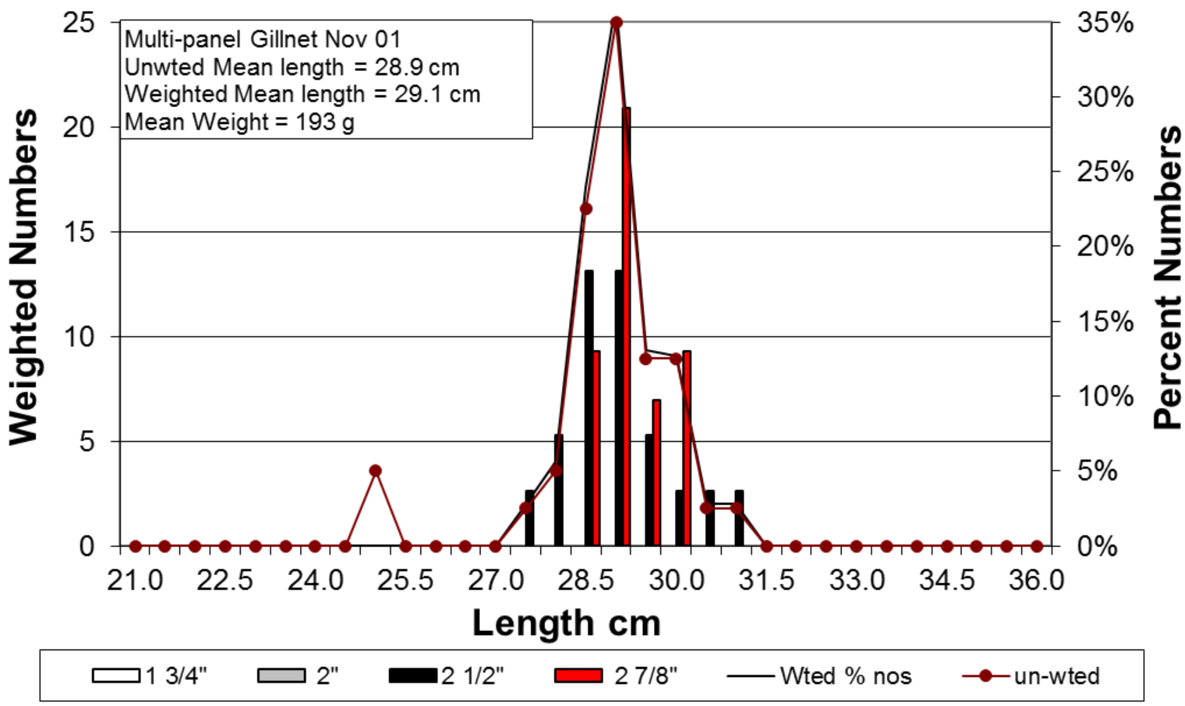

Figure 70B. Multi-panel Herring gillnet sample collected by Jamie B II on November 1, 2016 for the Little Hope Herring acoustic survey (#5) on November 1.

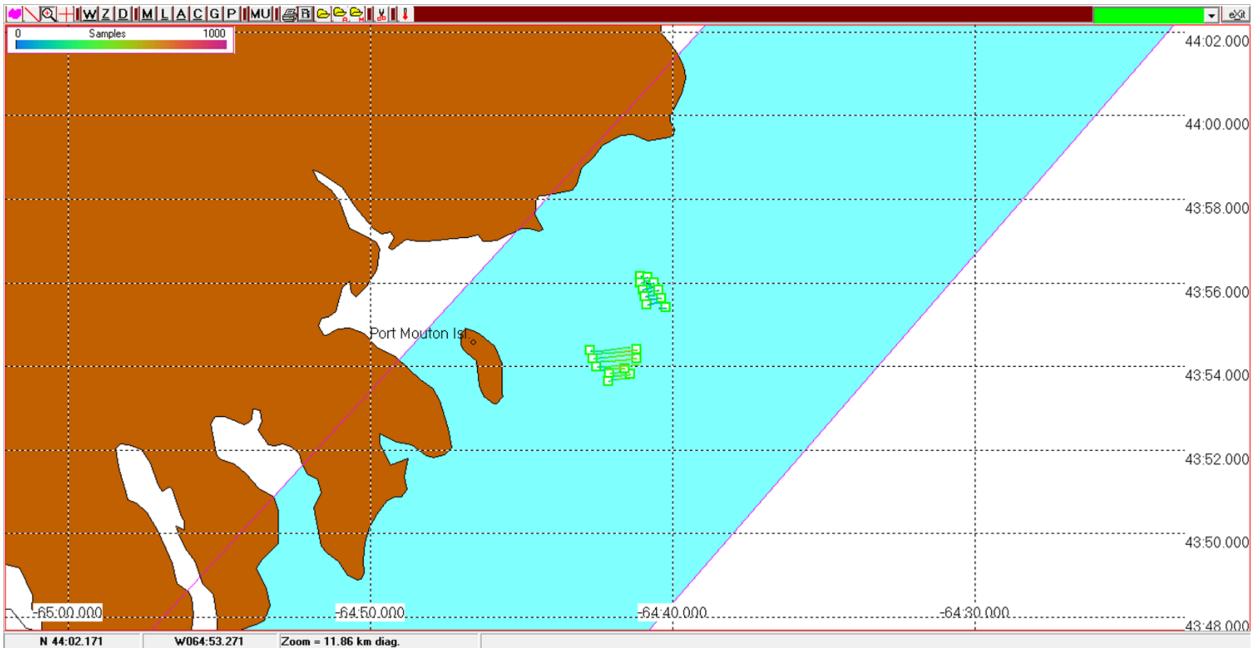

Figure 71. Little Hope/Port Mouton acoustic survey (#6) on November 14, 2016 showing the main survey box (highlighted area). No multi-panel sample was collected.

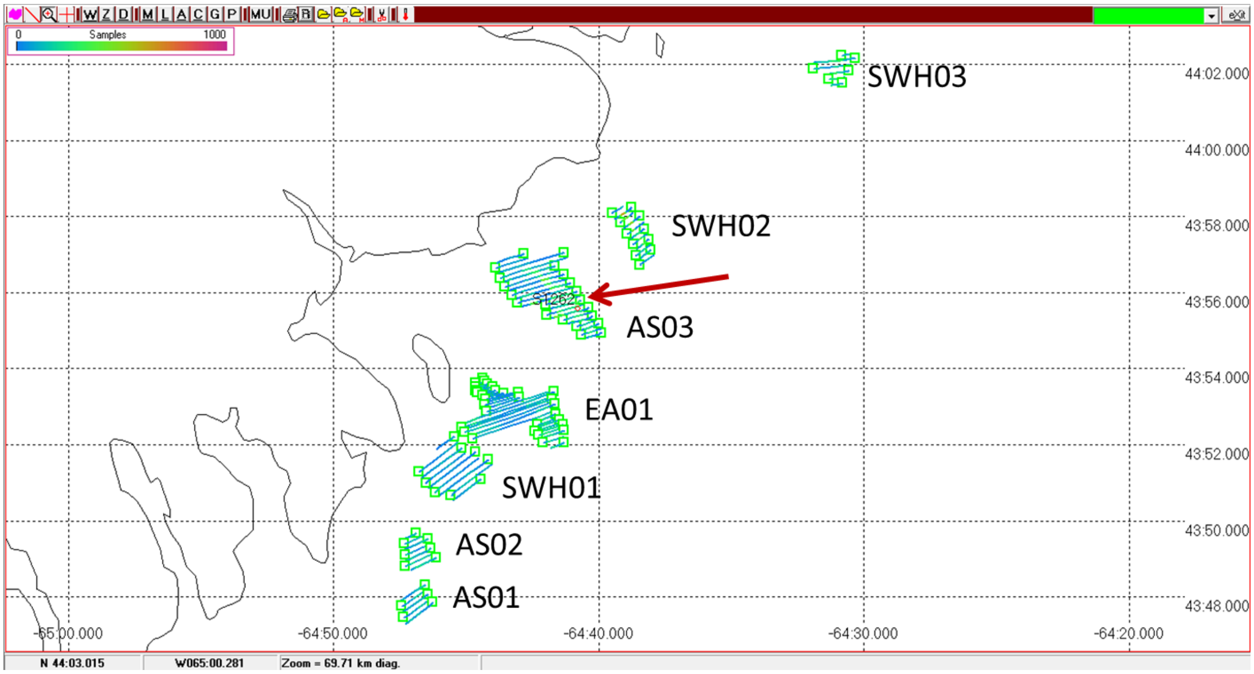

Figure 72A. Little Hope/Port Mouton acoustic survey (#1) on September 15, 2017 showing location (arrow) of multi-panel Herring gillnet samples collected on September 17.

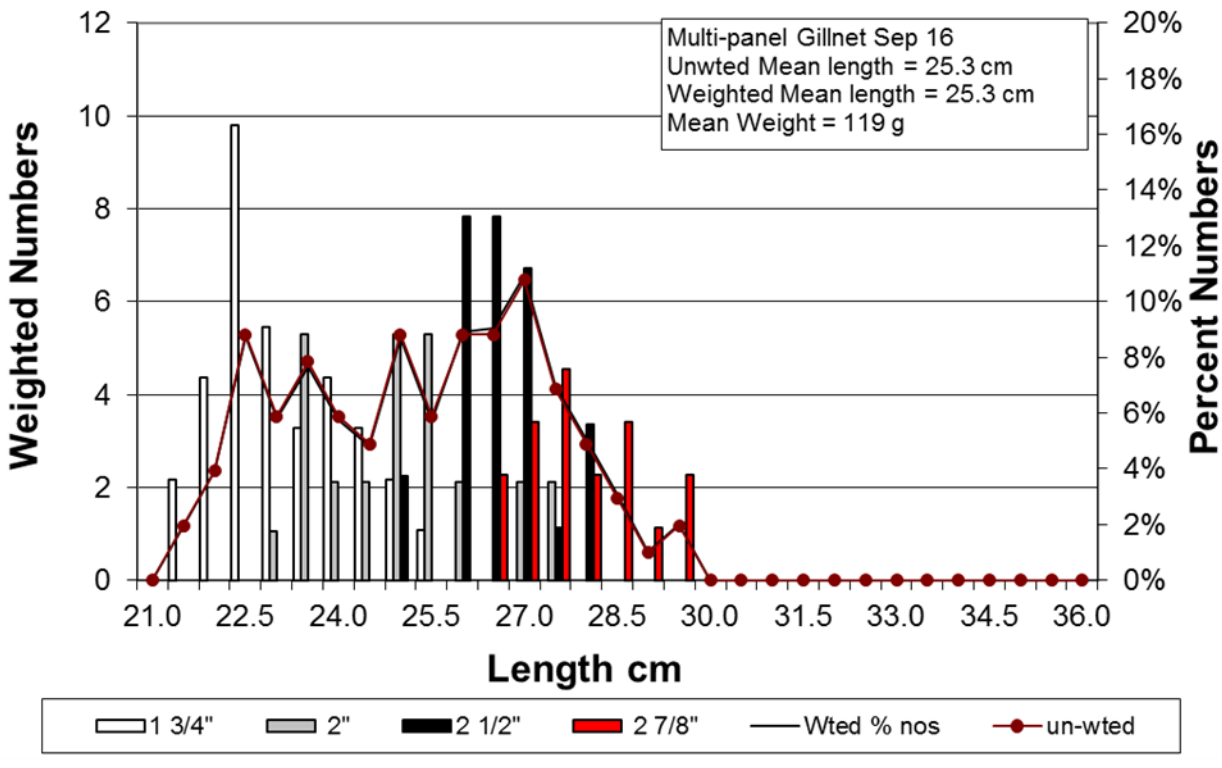

Figure 72B. Multi-panel Herring gillnet sample collected by <u>Jamie B II</u> on September 16, 2017 for the Little Hope Herring acoustic survey (#1) on September 15.

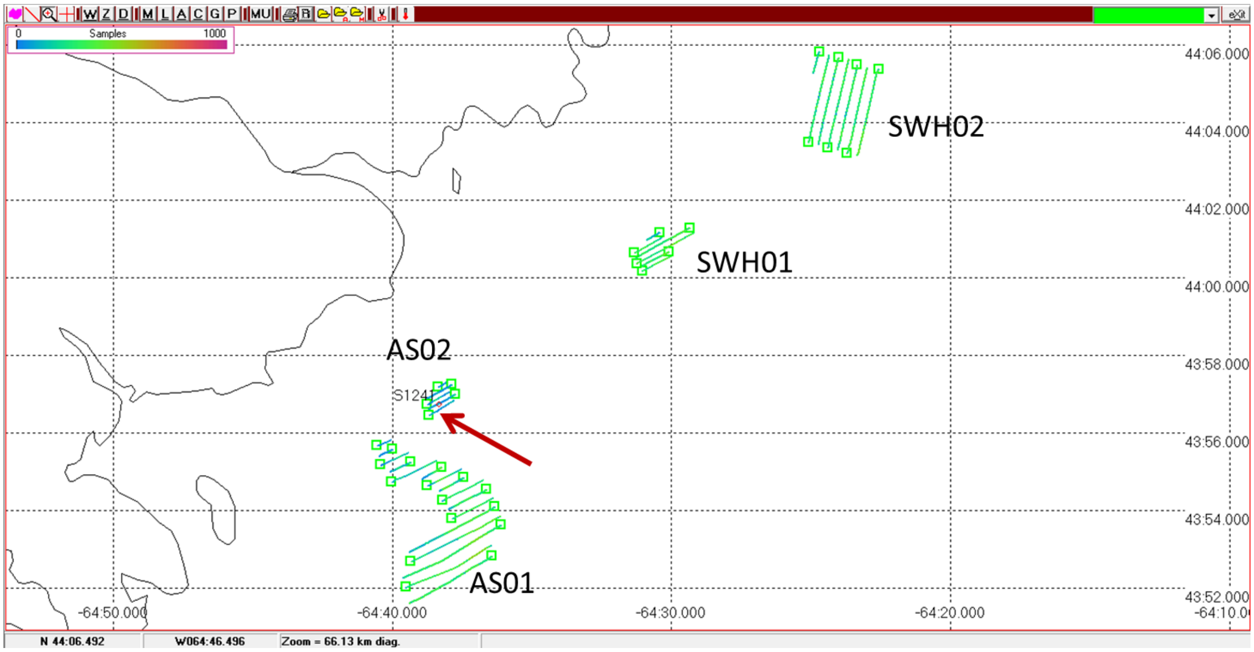

Figure 73A. Little Hope/Port Mouton acoustic survey (#2) on September 26, 2017 showing location (arrow) of multi-panel Herring gillnet samples collected on September 26.

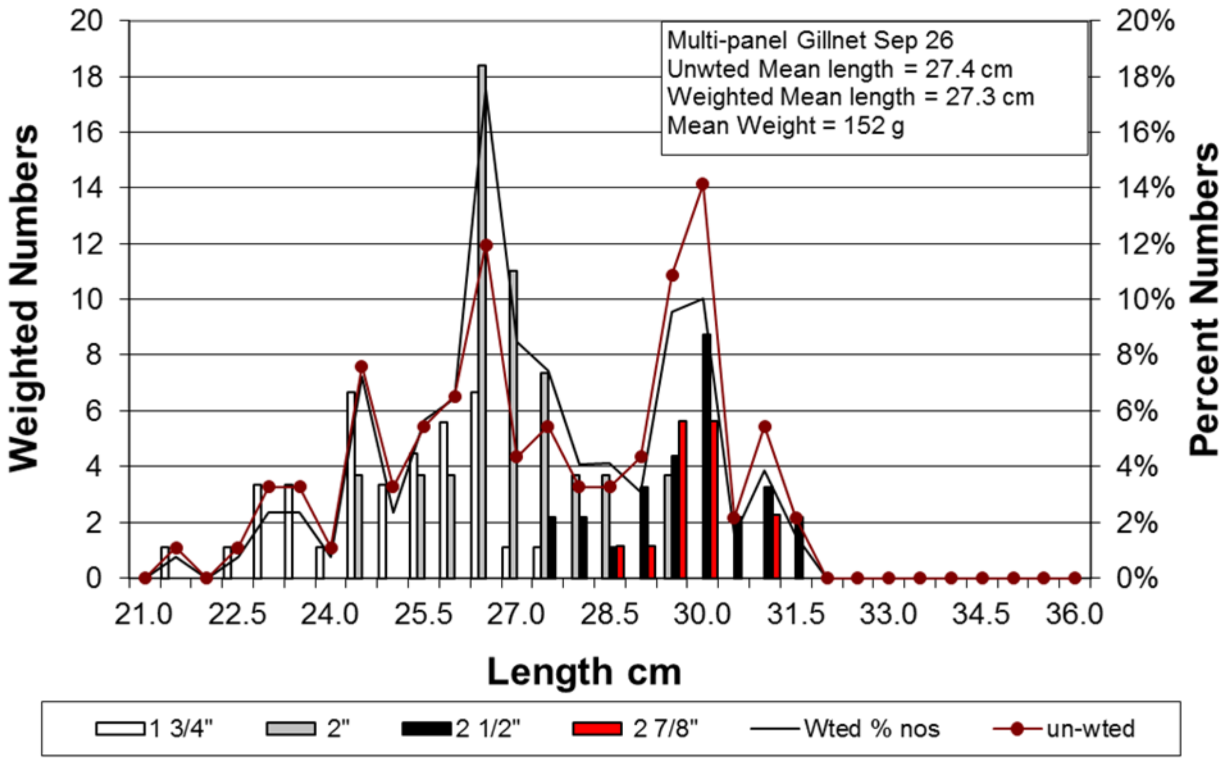

Figure 73B. Multi-panel Herring gillnet sample collected by Jamie B II on September 26, 2017 for the Little Hope Herring acoustic survey (#2) on September 26.

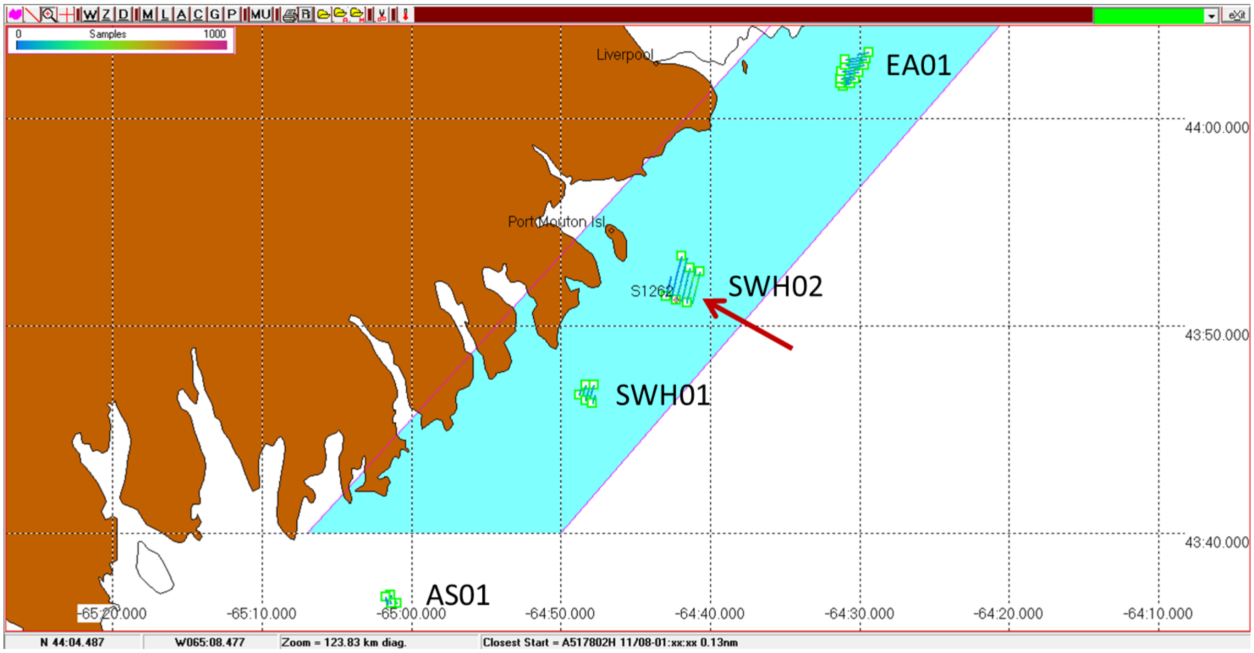

Figure 74A. Little Hope/Port Mouton acoustic survey (#3) on October 6, 2017 showing the main survey box (highlighted area), along with location (arrow) of multi-panel Herring gillnet samples collected on October 7.

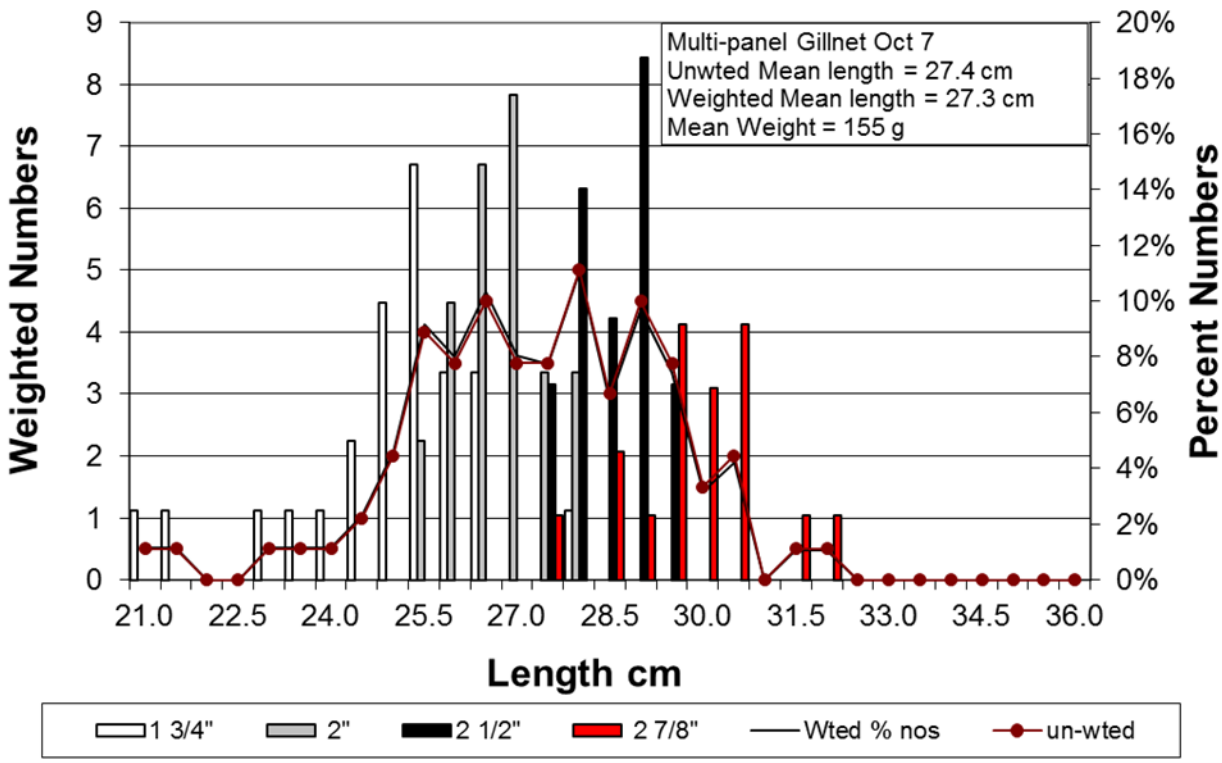

Figure 74B. Multi-panel Herring gillnet sample collected by Jamie B II on October 7, 2017 for the Little Hope Herring acoustic survey (#3) on October 6.

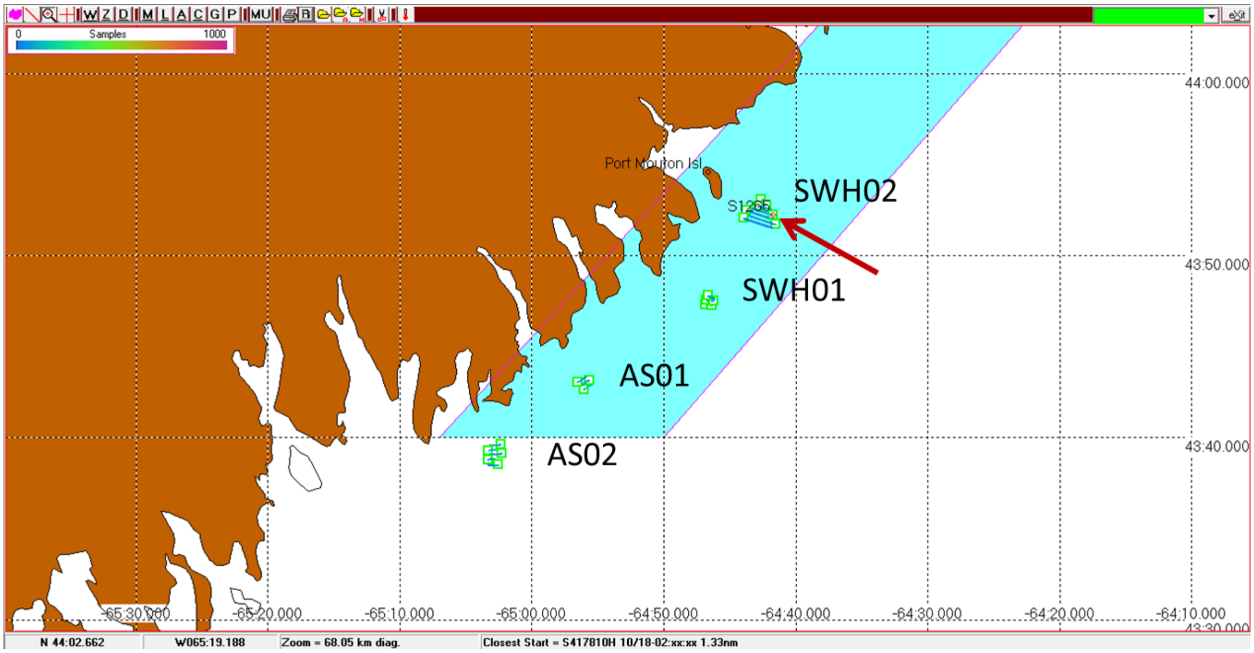

Figure 75A. Little Hope/Port Mouton acoustic survey (#4) on October 17, 2017 showing the main survey box (highlighted area), along with location (arrow) of multi-panel sample collected October 18.

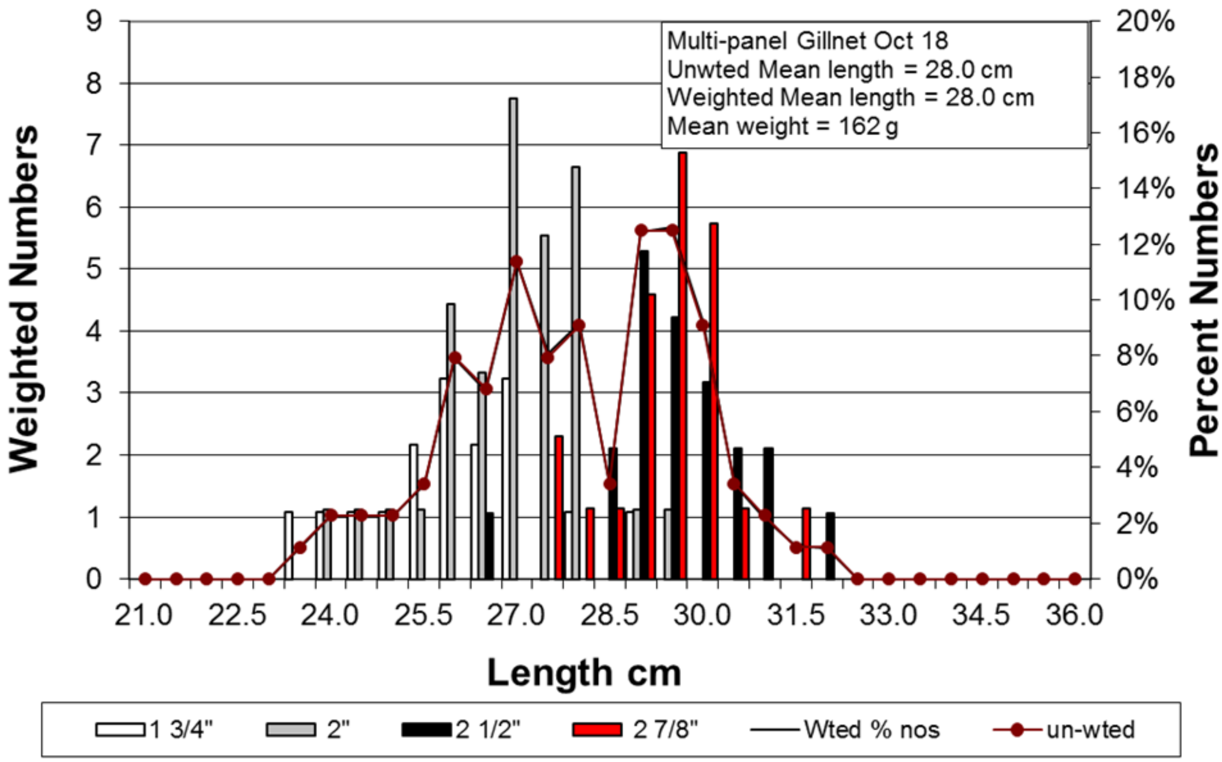

Figure 75B. Multi-panel Herring gillnet sample collected by <u>Jamie B II</u> on October 18, 2017 for the Little Hope Herring acoustic survey (#4) on October 17.

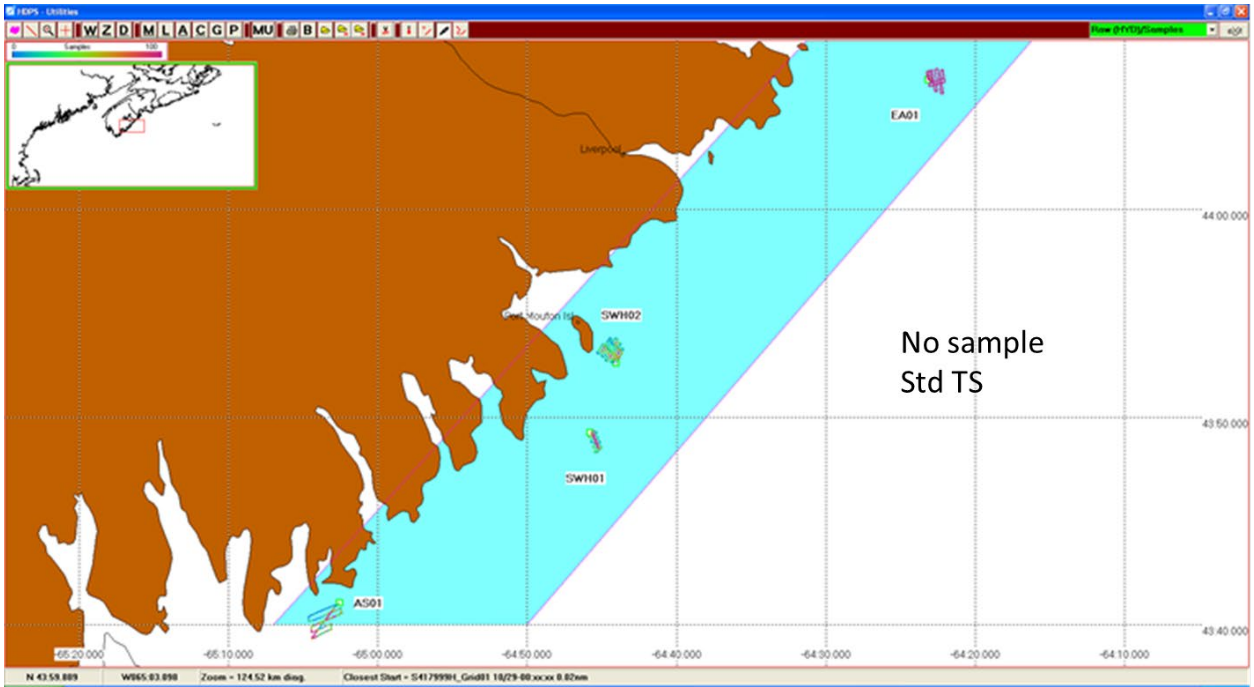

Figure 76A. Little Hope/Port Mouton acoustic survey (#5) on October 28, 2017 showing the main survey box (highlighted area). No multi-panel sample was collected. Standard Target Strength (TS) was used.

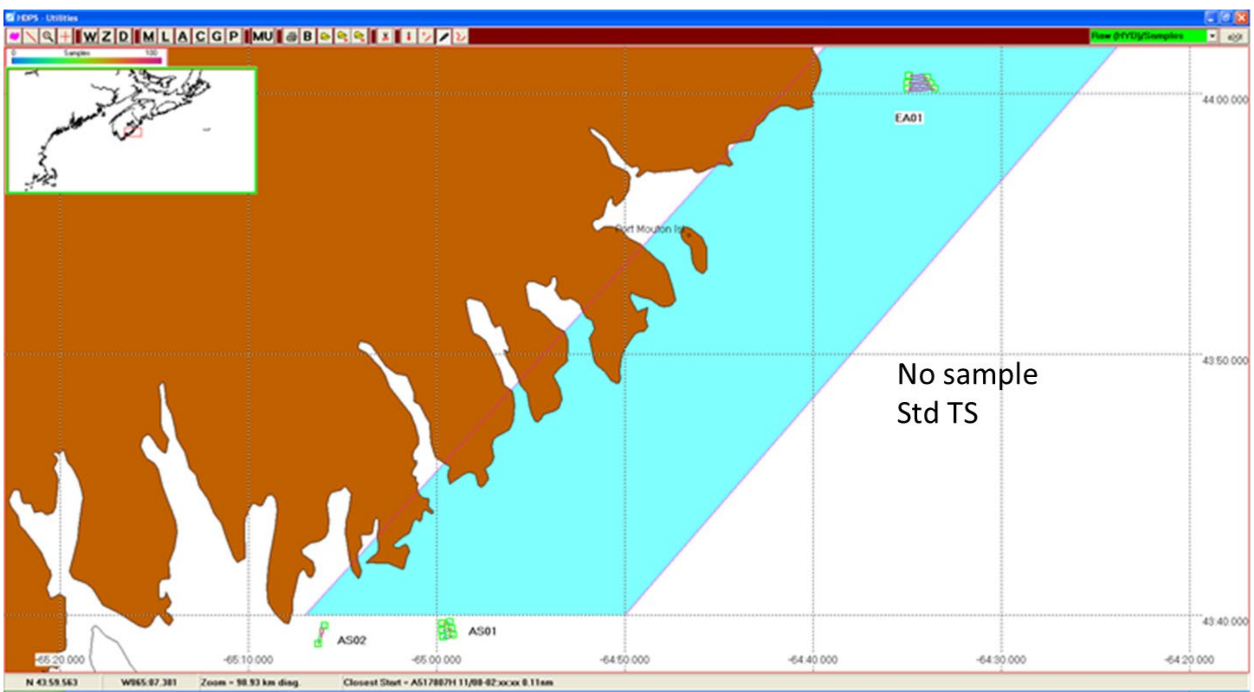

Figure 76B. Little Hope/Port Mouton acoustic survey (#6) on November 7, 2017 showing the main survey box (highlighted area). No multi-panel sample was collected. Standard Target Strength (TS) was used.

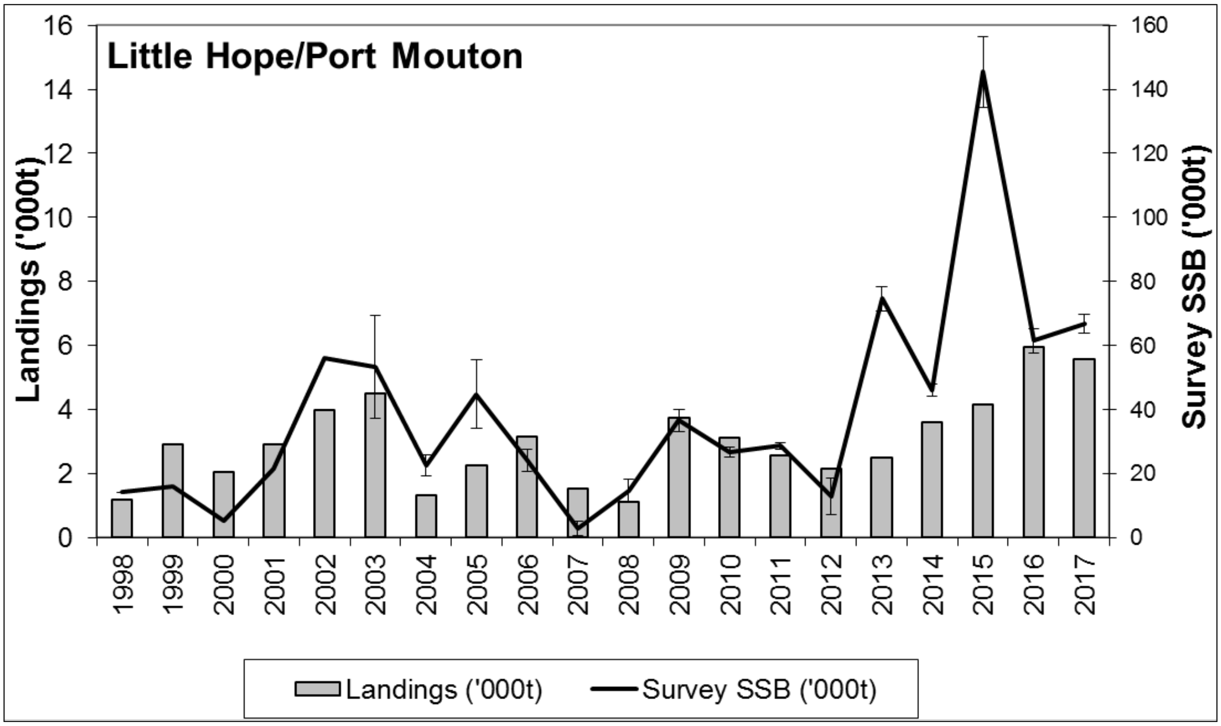

Figure 77. Herring landings and acoustic Spawning Stock Biomass (SSB) ('000 t) with 95% Confidence Interval (C.I.) for the Little Hope/Port Mouton gillnet fishery from 1997 to 2017. No C.I. could be calculated for years prior to 2004.

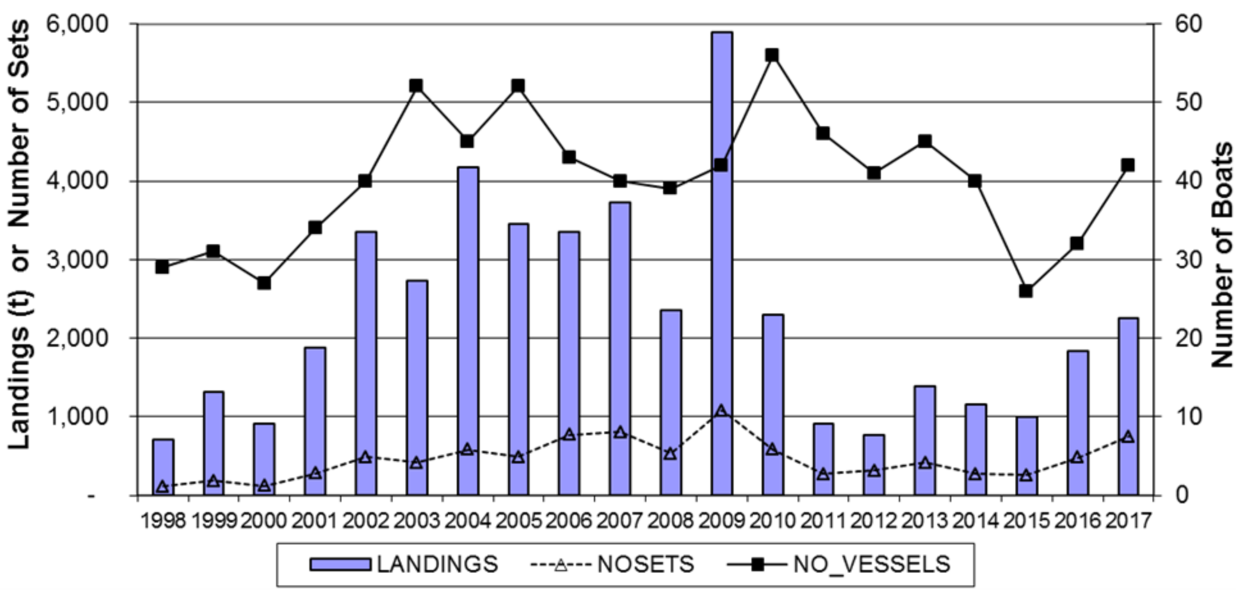

Figure 78. Herring gillnet total landings and total effort in number of vessels and number of sets for the Halifax/Eastern Shore area for 1998–2017. Data for statistical districts 18–22 inclusive.

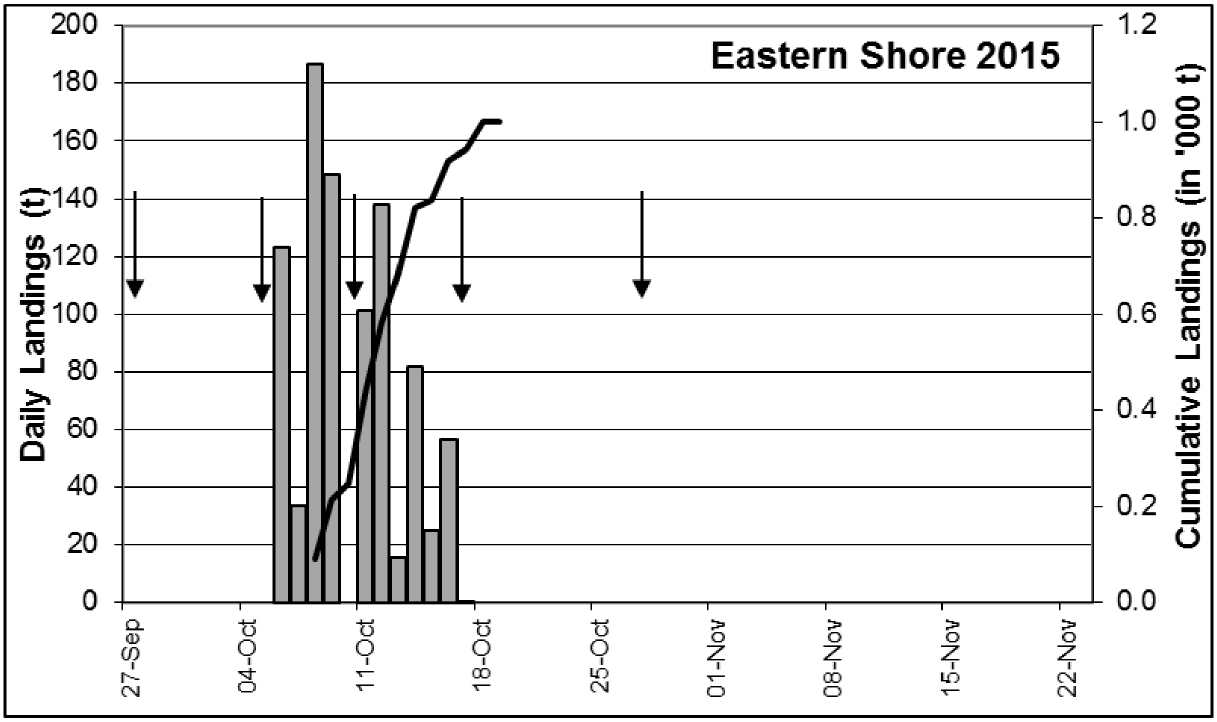

Figure 79A. Daily and cumulative catch for the 2015 Halifax/Eastern Shore Herring gillnet fishery. Survey dates are identified by arrows indicating survey timing.

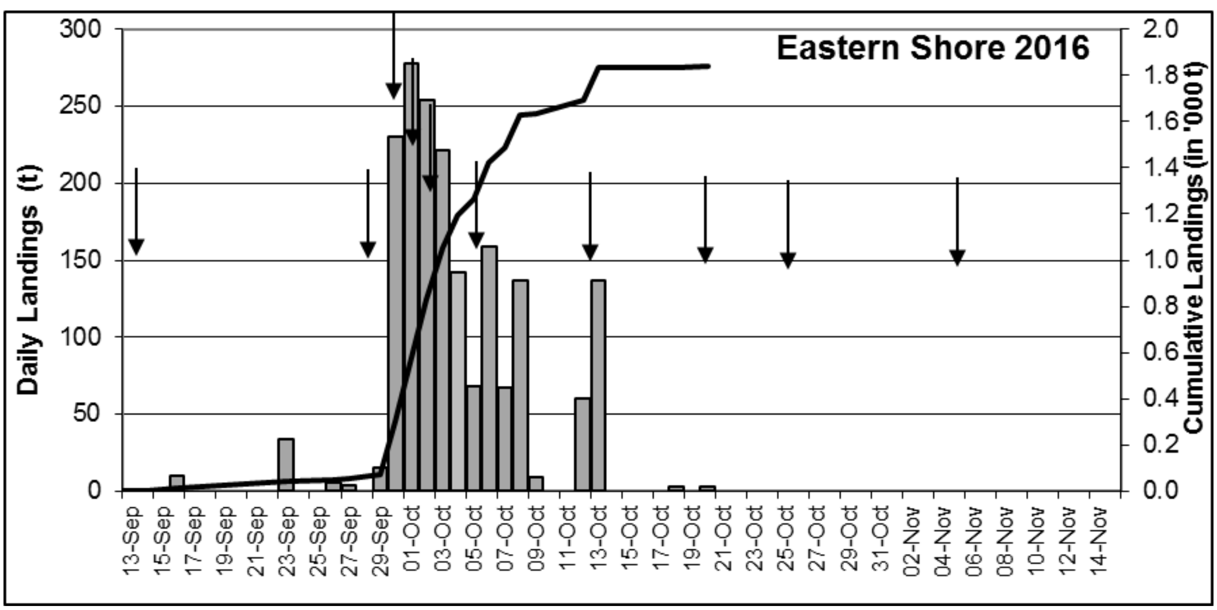

Figure 79B. Daily and cumulative catch for the 2016 Halifax/Eastern Shore Herring gillnet fishery. Survey dates are identified by arrows indicating survey timing.

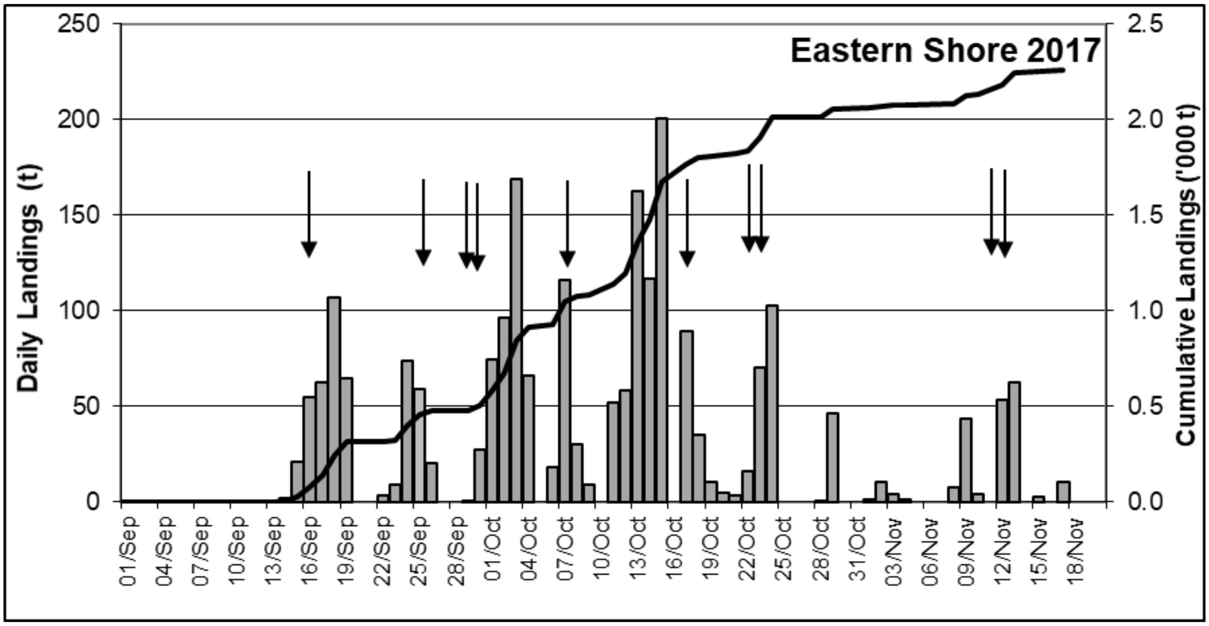

Figure 79C. Daily and cumulative catch for the 2017 Halifax/Eastern Shore Herring gillnet fishery. Survey dates are identified by arrows indicating survey timing.

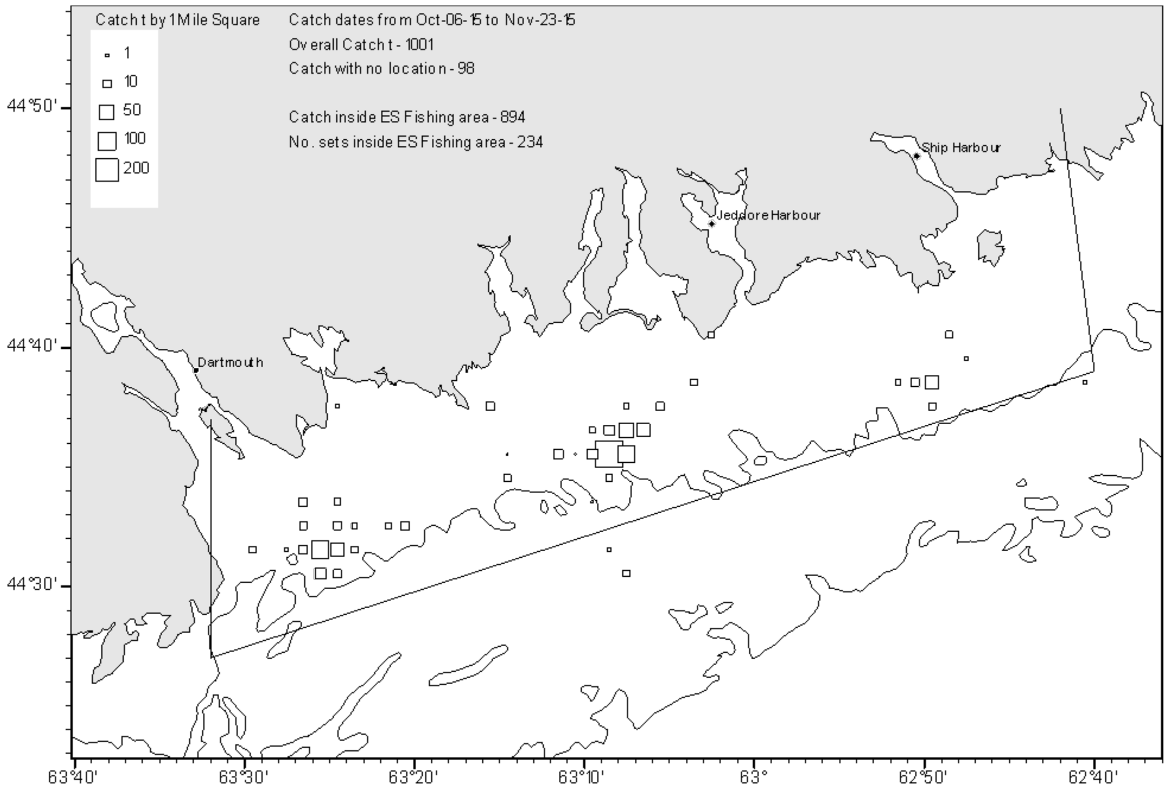

Figure 80A. Herring fishery gillnet catches for the Halifax/Eastern Shore area for 2015 (Districts 18–22).

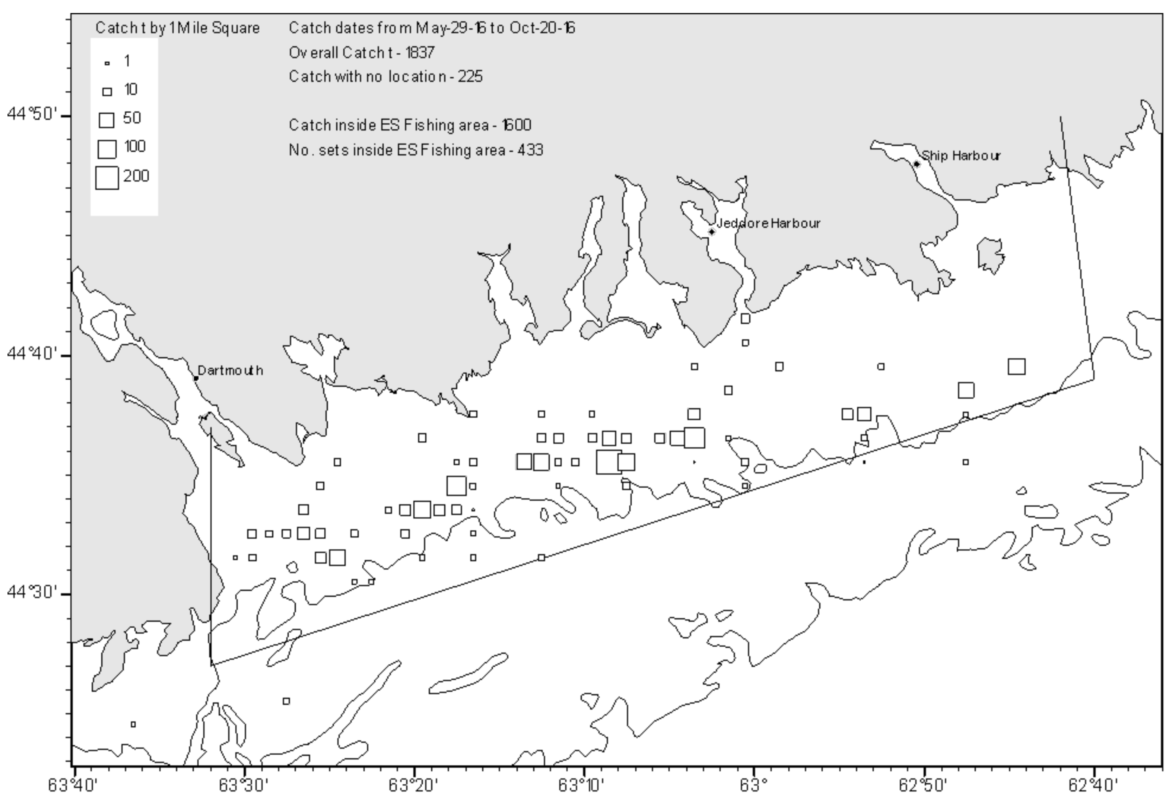

Figure 80B. Herring fishery gillnet catches for the Halifax/Eastern Shore area for 2016 (Districts 18–22).

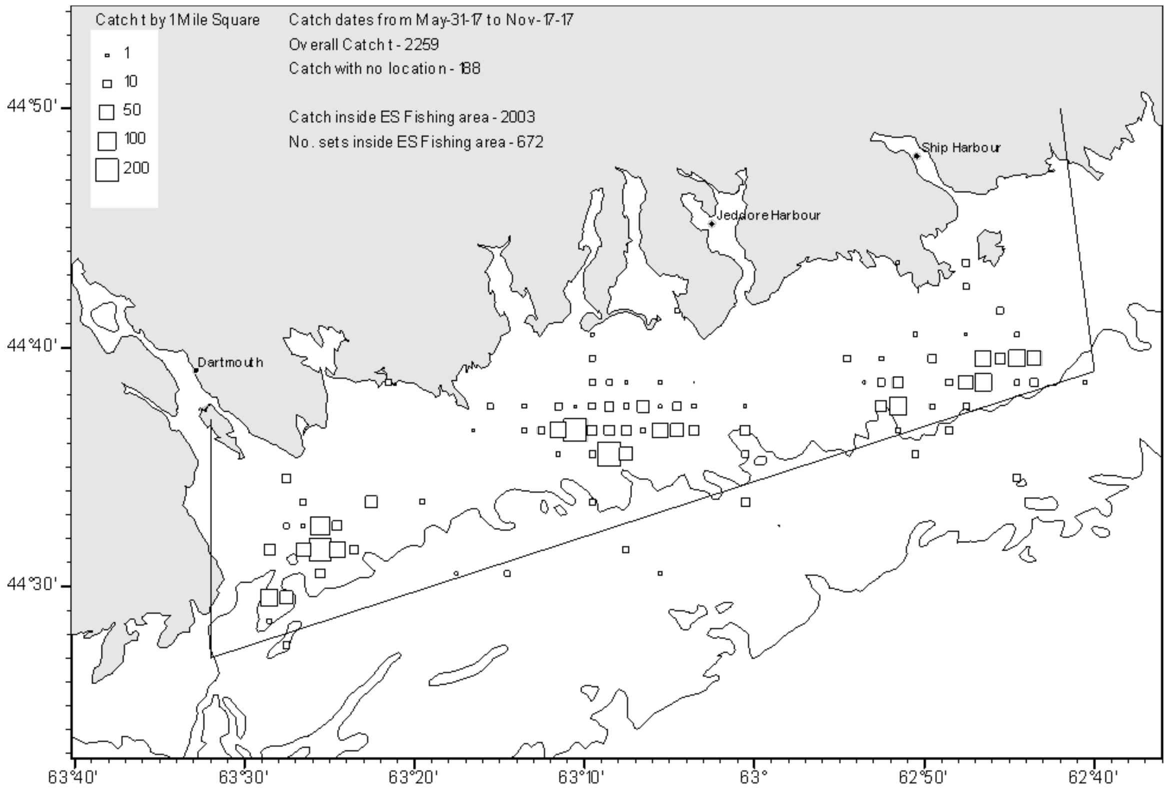

Figure 80C. Herring fishery gillnet catches for the Halifax/Eastern Shore area for 2017 (Districts 18–22).

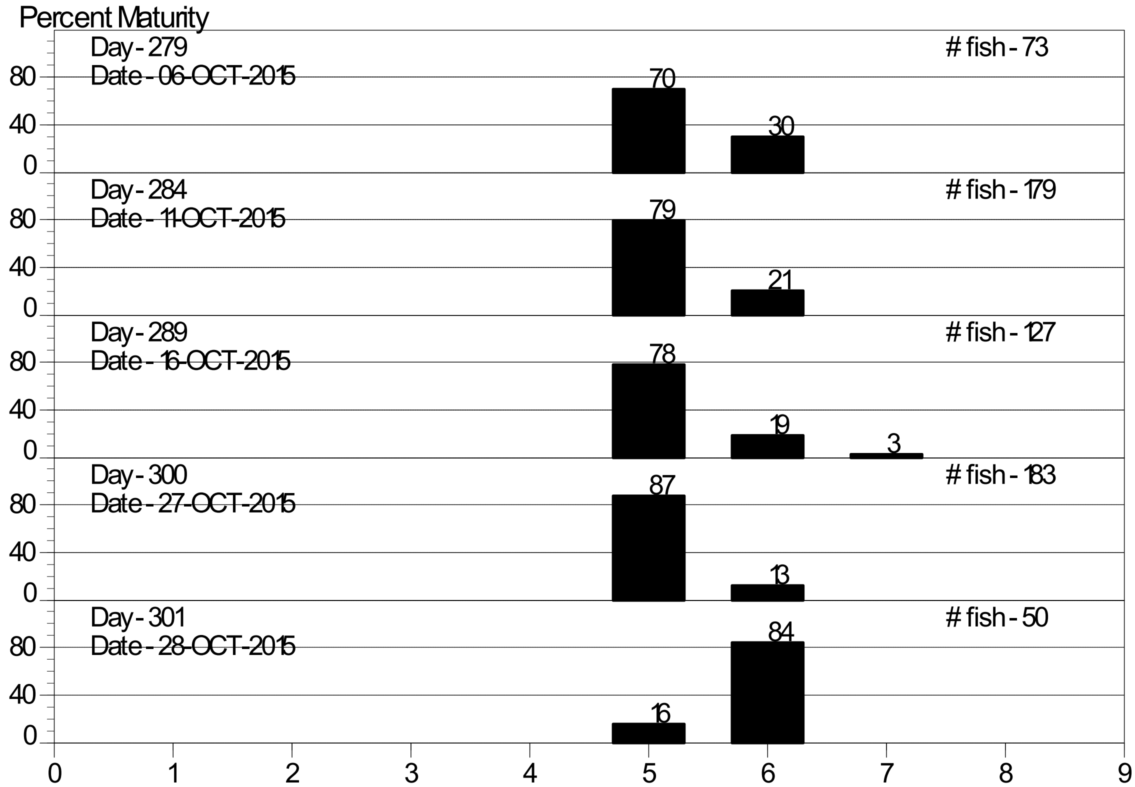

Figure 81A. Herring maturity samples collected from the Halifax/Eastern Shore area in 2015. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; and 8 = recovering.

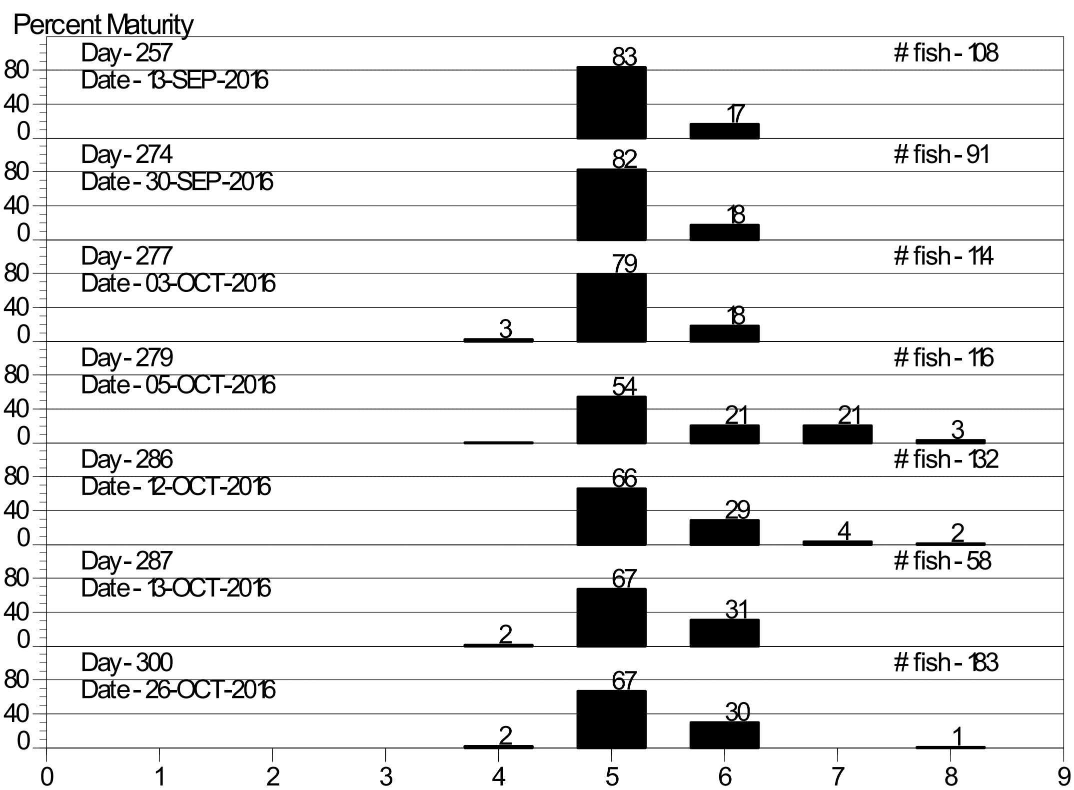

Figure 81B. Herring maturity samples collected from the Halifax/Eastern Shore area in 2016. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; and 8 = recovering.

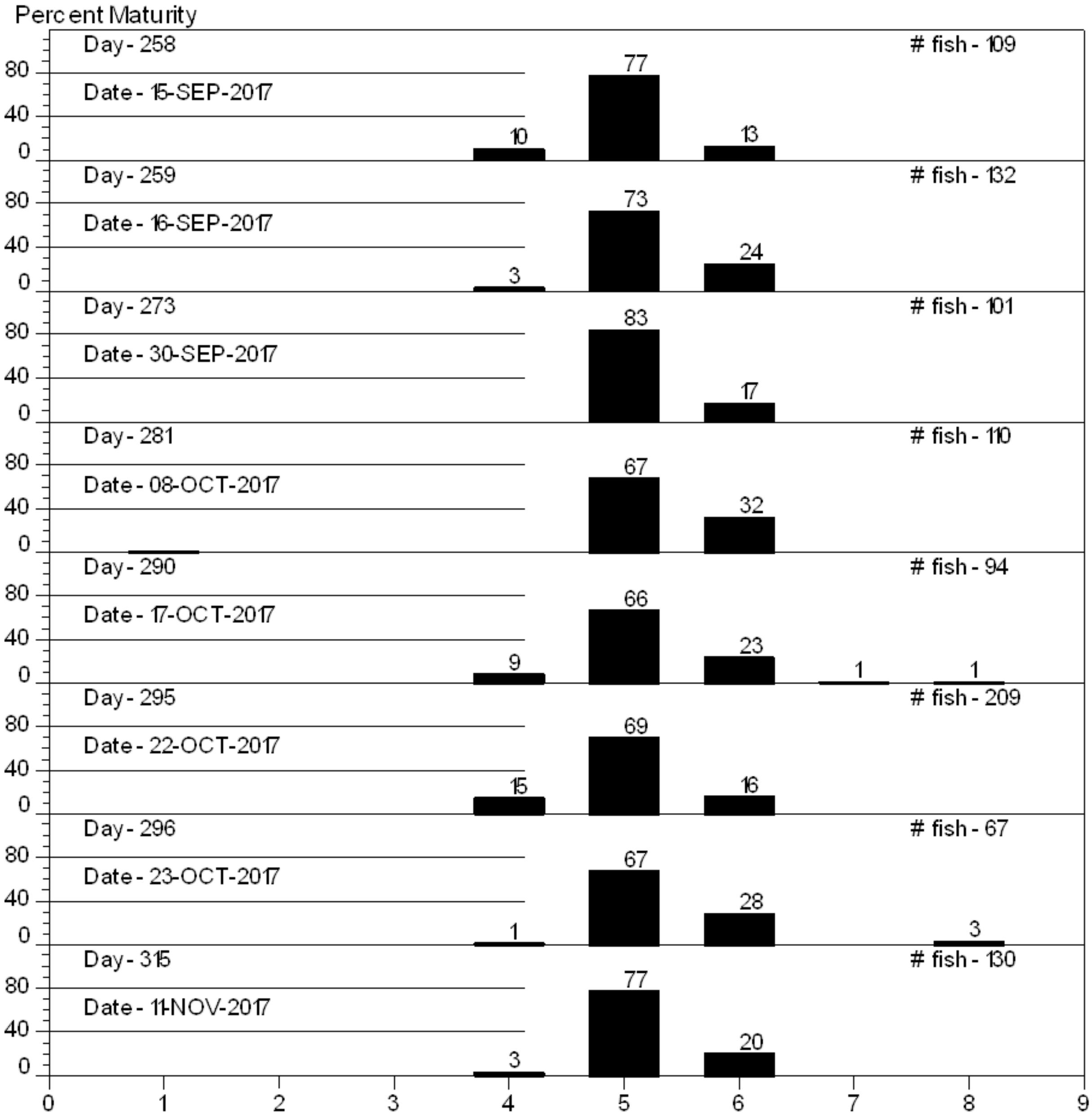

Figure 81C. Herring maturity samples collected from the Halifax/Eastern Shore area in 2017. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; and 8 = recovering.

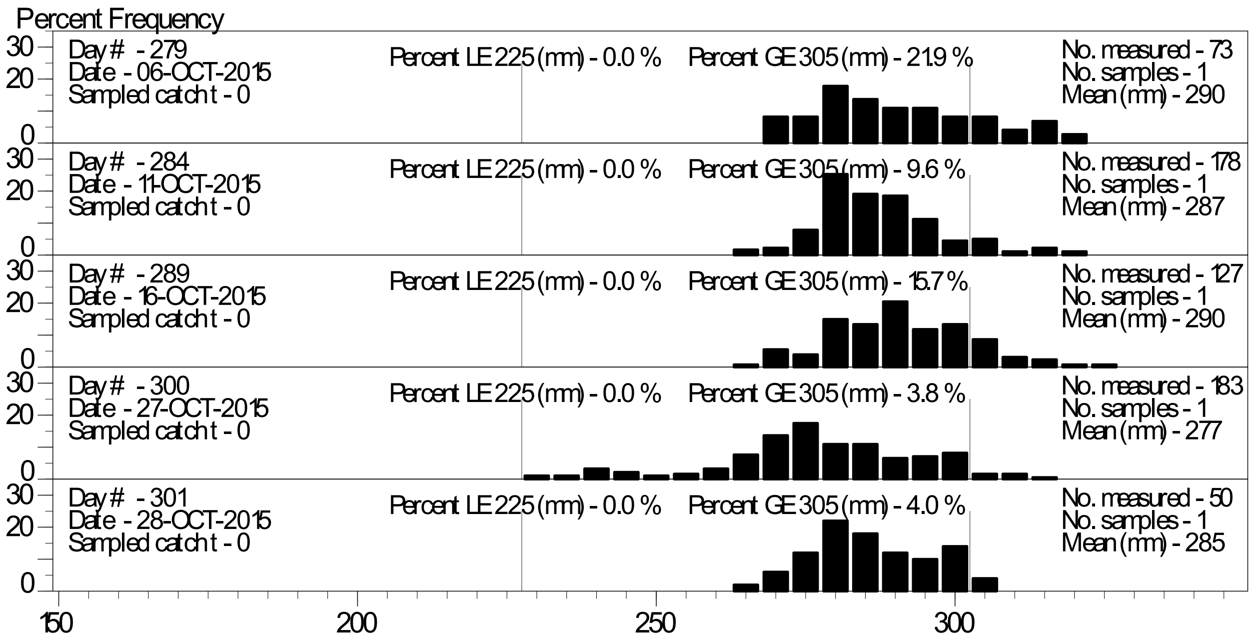

Figure 82A. Daily length-frequency sampling from the Halifax/Eastern Shore area in 2015, with proportions < 23 cm and > 30 cm.

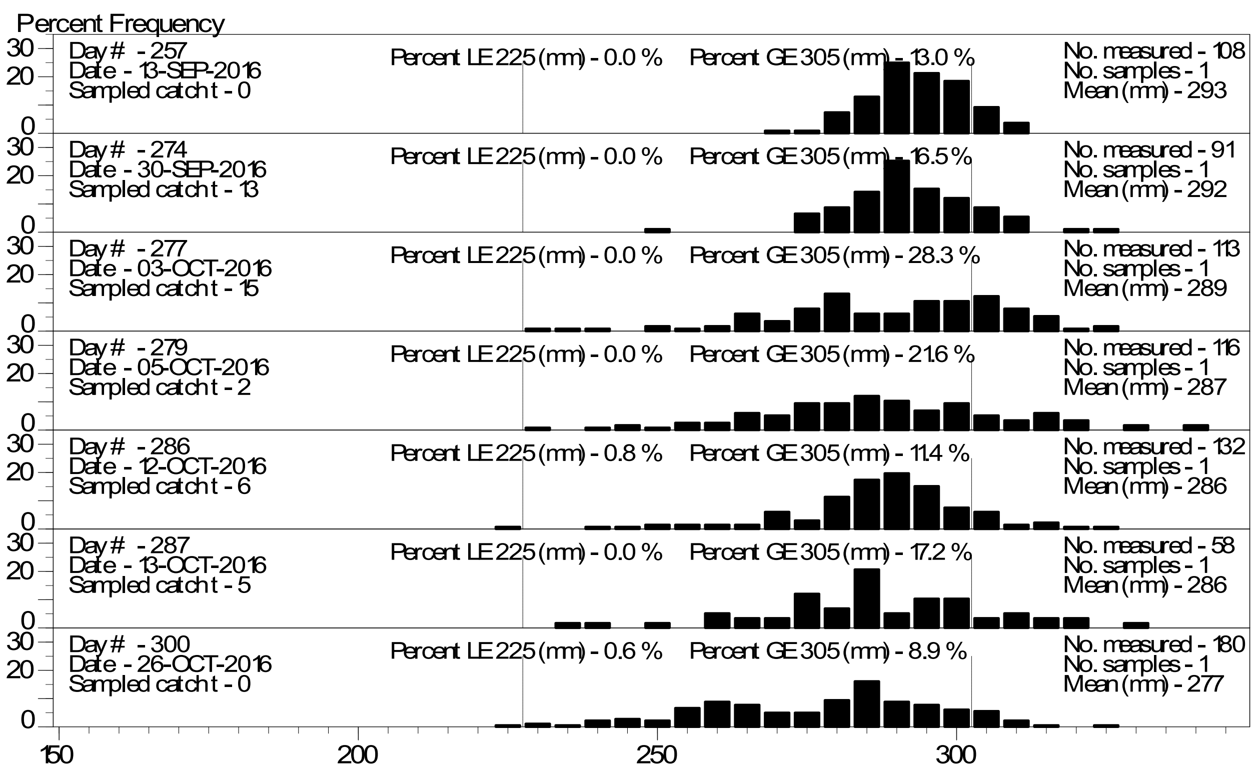

Figure 82B. Daily length-frequency sampling from the Halifax/Eastern Shore area in 2016, with proportions < 23 cm and > 30 cm.

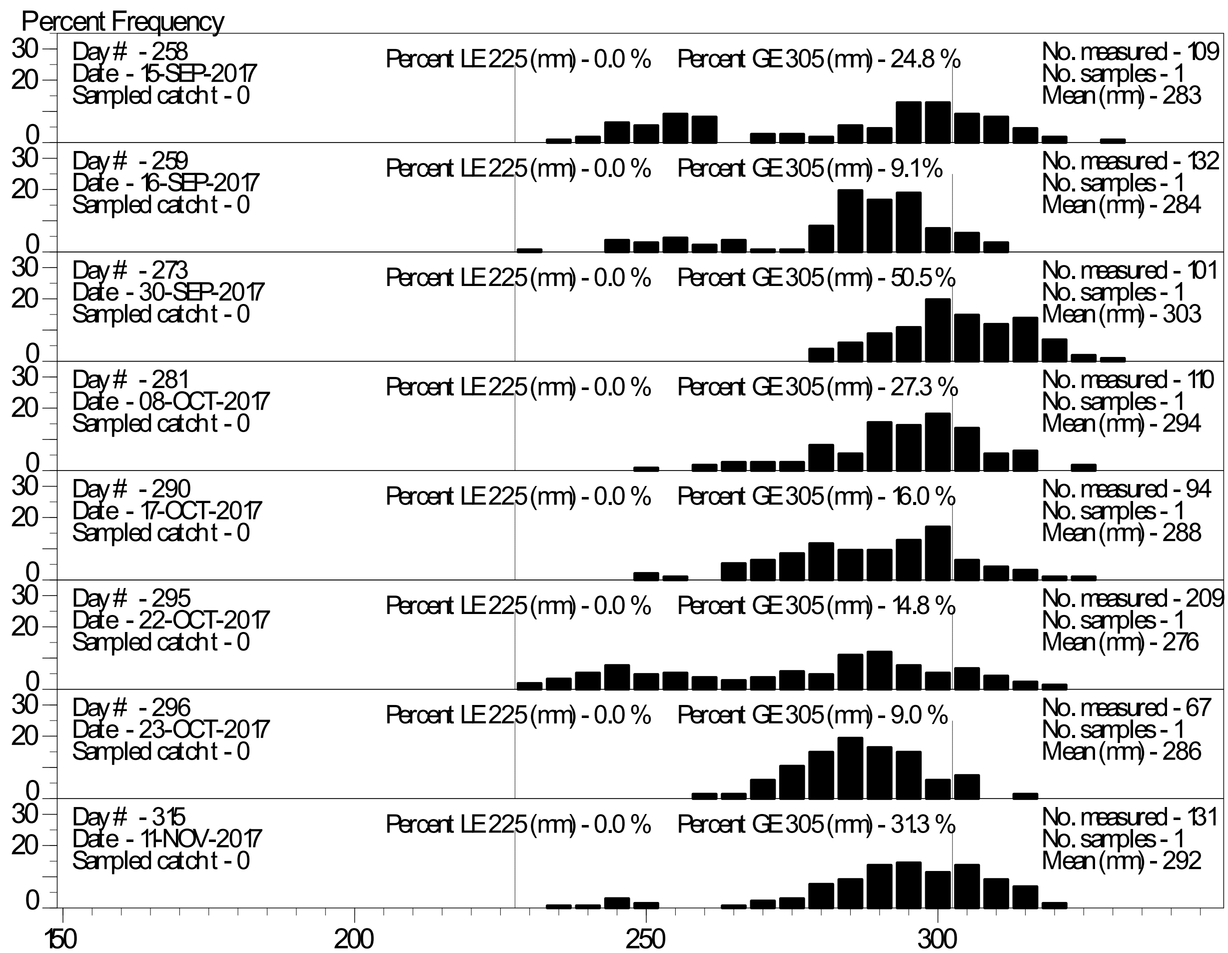

Figure 82C. Daily length-frequency sampling from the Halifax/Eastern Shore area in 2017, with proportions < 23 cm and > 30 cm.

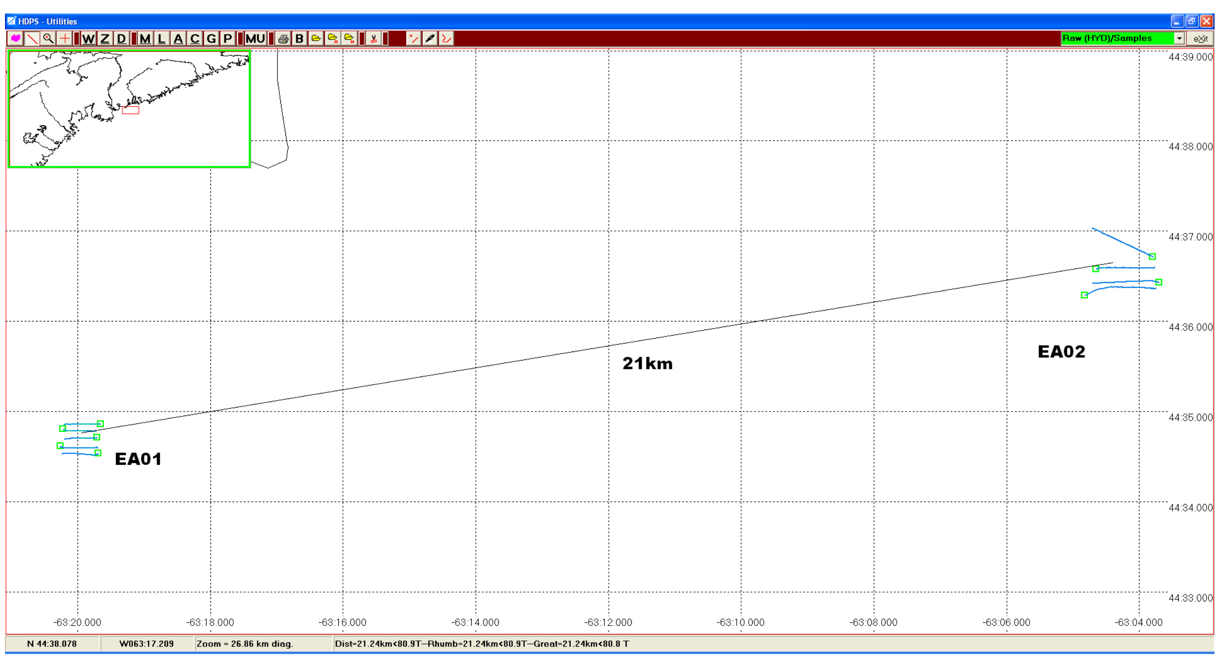

Figure 83. Halifax/Eastern Shore acoustic transects for September 27, 2015 survey (#1) conducted by one acoustic survey vessels, Emily & Aley. No sample was available. Standard Total Strength (TS) used.

Figure 84A. Halifax/Eastern Shore acoustic transects for October 5, 2015 survey (#2) conducted by three acoustic survey vessels, Emily & Aley, Oralee (replaced Crabs R Us) and Miss Owl's Head, along with the location (arrow) of multi-panel Herring gillnet sample collected on October 6.

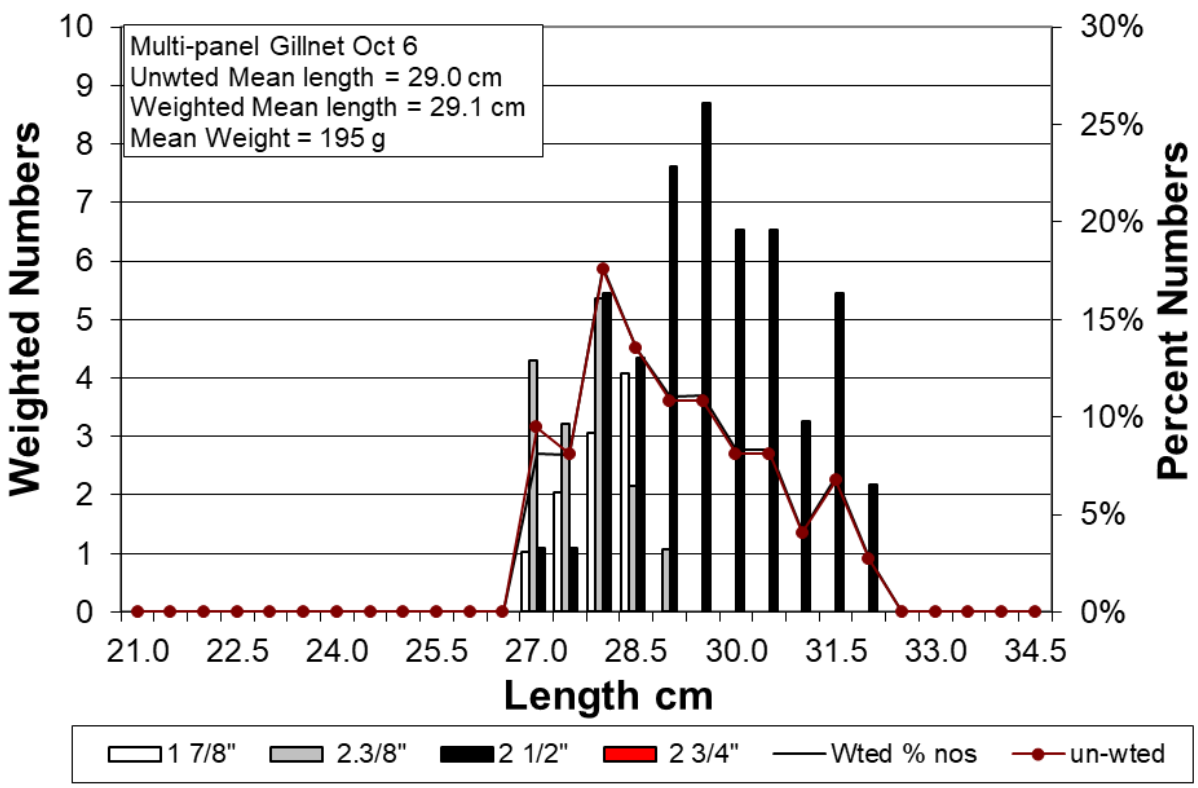

Figure 84B. Multi-panel Herring gillnet sample collected by Oralee on October 6, 2015 for the Halifax/Eastern Shore acoustic survey (#2) on October 5.

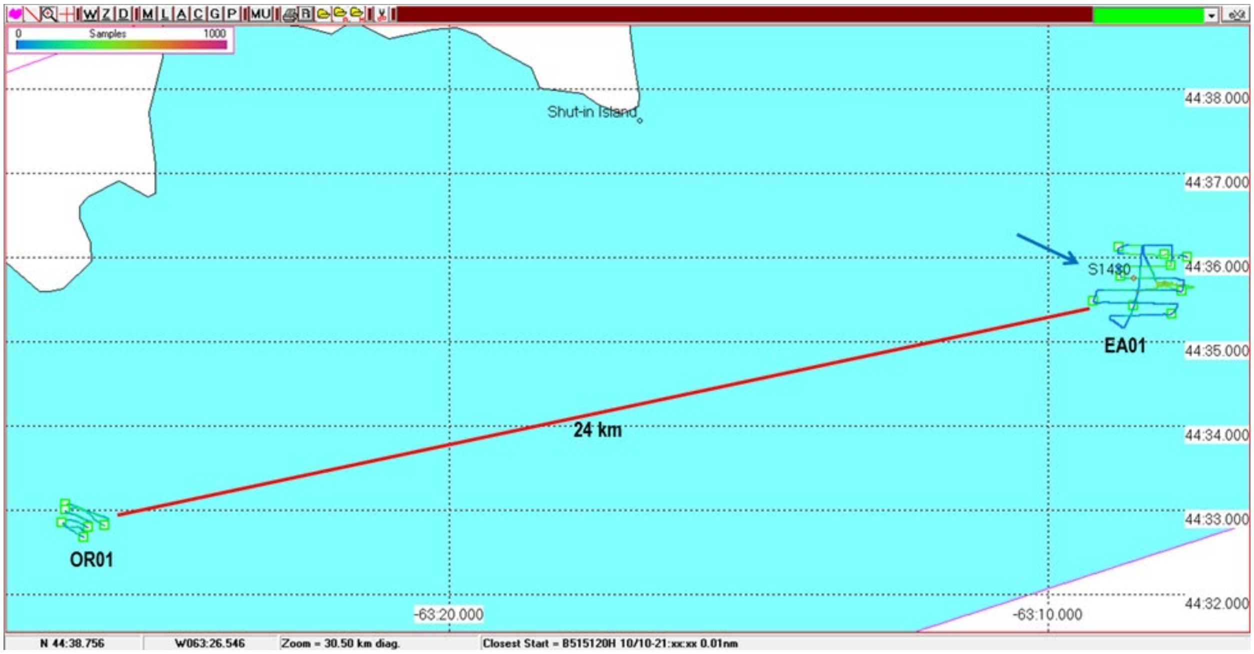

Figure 85A. Halifax/Eastern Shore acoustic transects for October 10, 2015 survey (#3) conducted by two acoustic survey vessels, Emily & Aley and Oralee along with the location (arrow) of multi-panel Herring gillnet sample collected on October 11.

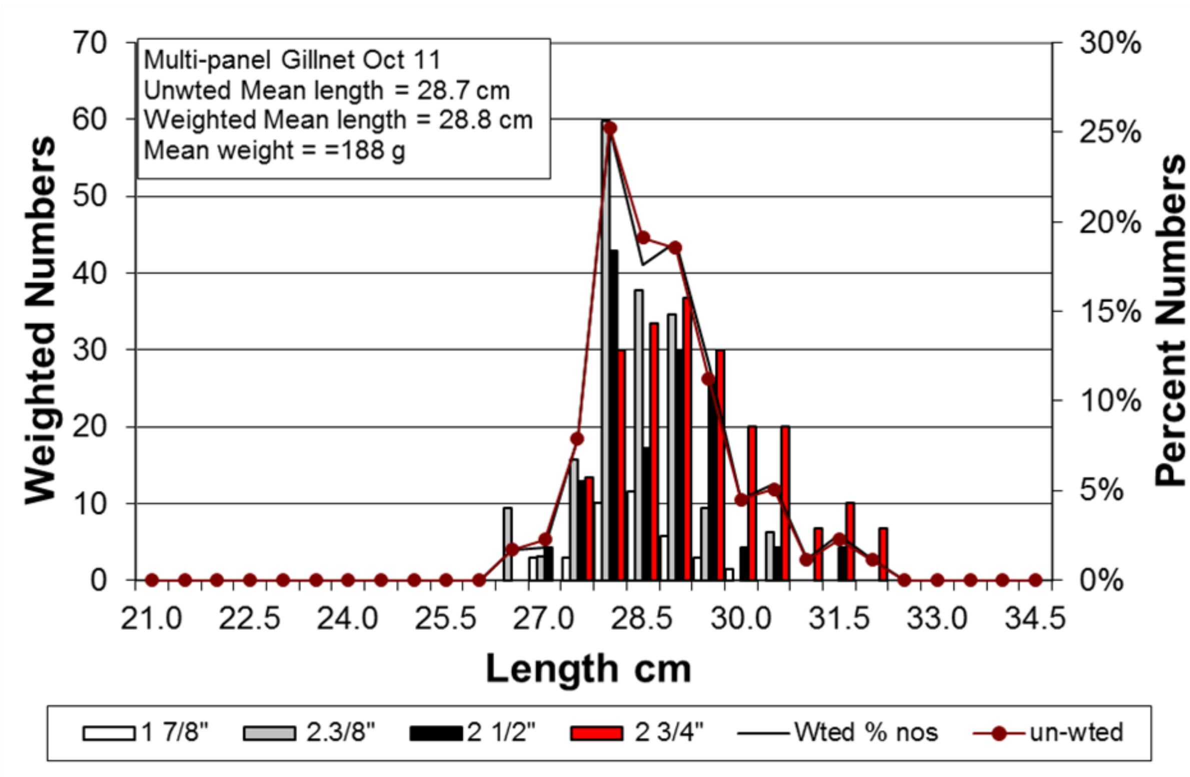

Figure 85B. Multi-panel Herring gillnet sample collected from the surveyed school of fish by Emily & Aley on October 11, 2015 for Halifax/Eastern Shore survey (#3) on October 10.

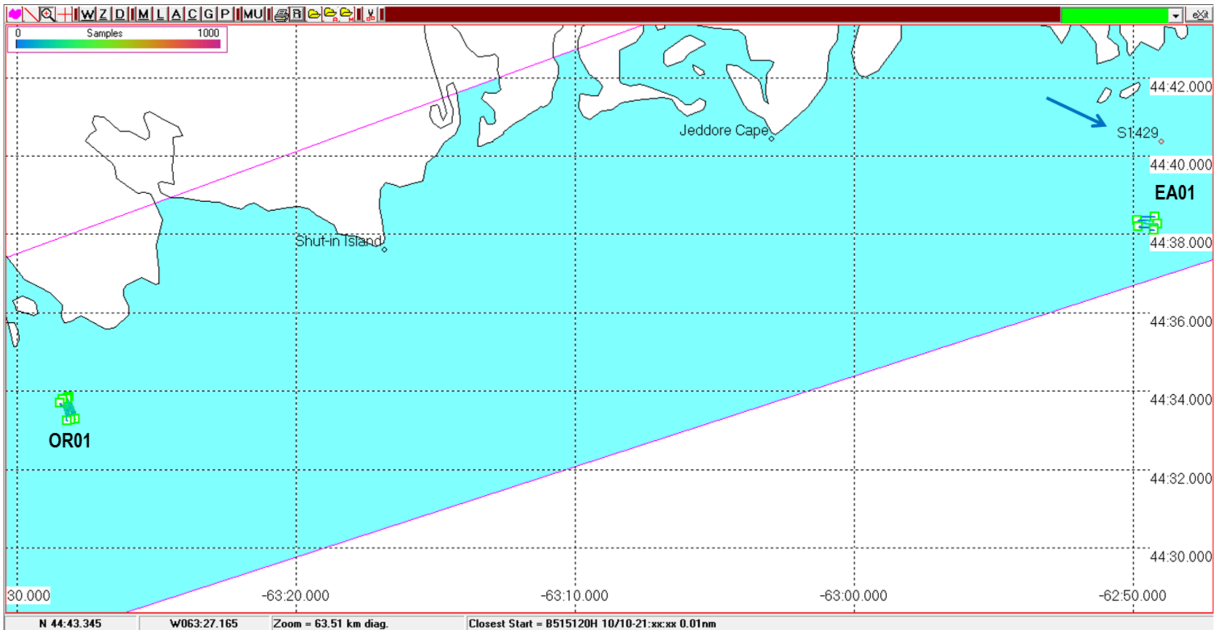

Figure 86A. Halifax/Eastern Shore acoustic transects for October 16, 2015 survey (#4) conducted by two acoustic survey vessel, Emily & Aley and Oralee along with the location (arrow) of multi-panel Herring gillnet sample collected on October 16.

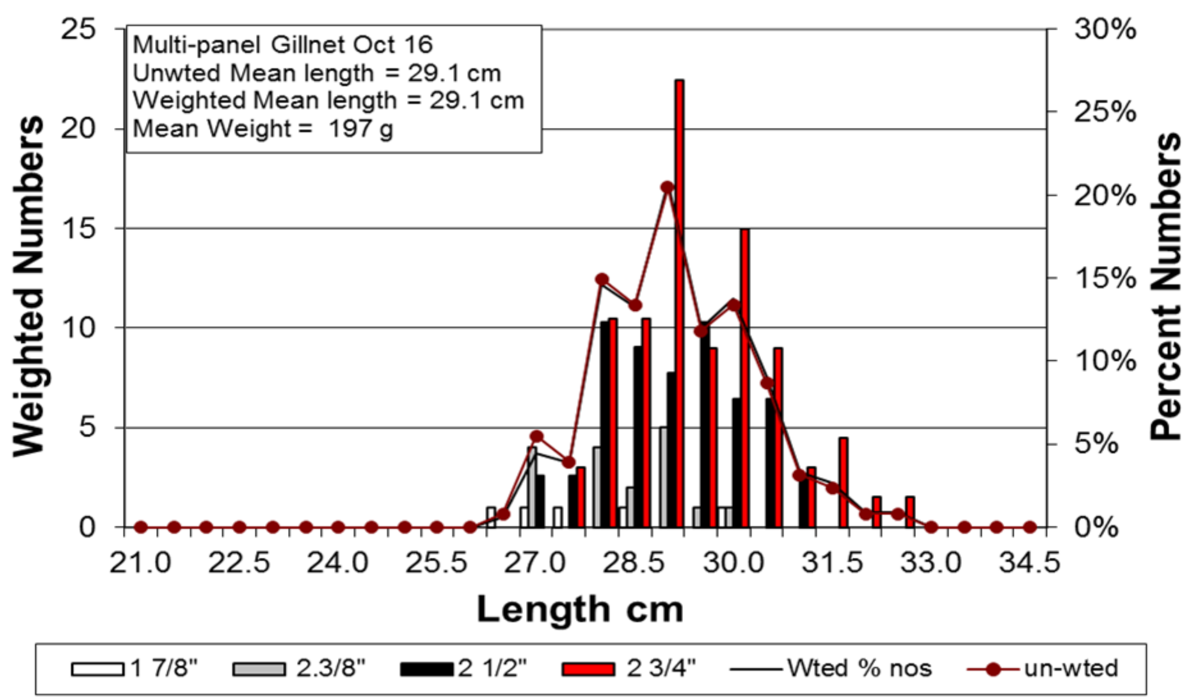

Figure 86B. Multi-panel Herring gillnet sample collected by Emily & Aley on October 16, 2015 for the Halifax/Eastern Shore acoustic survey (#4) on October 16.

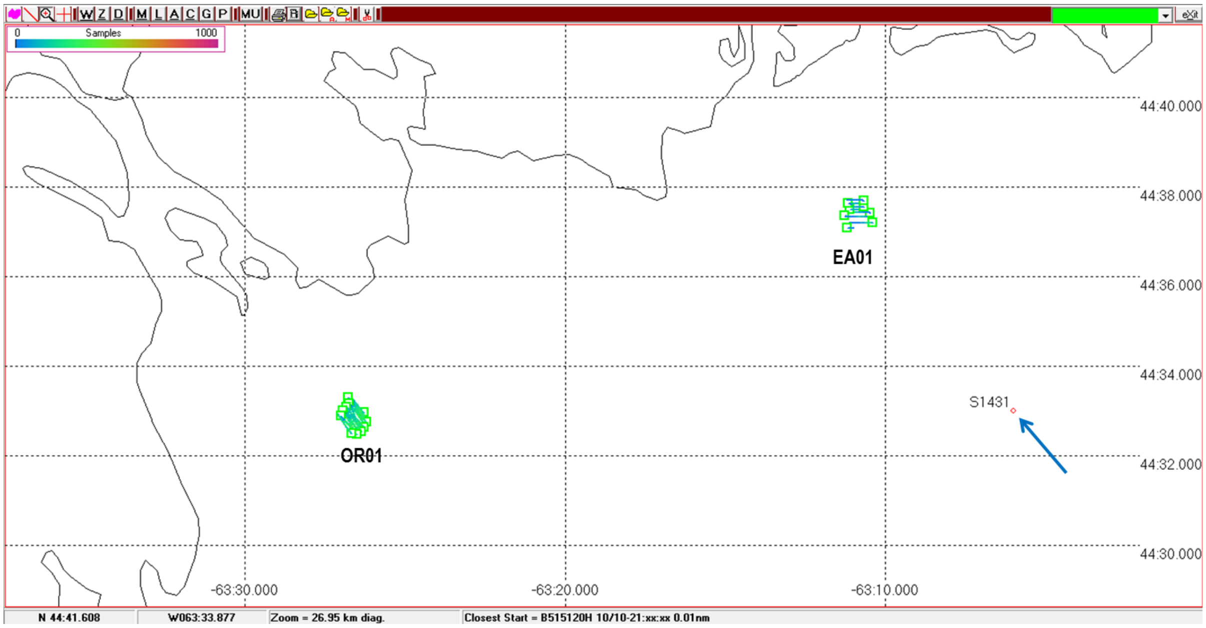

Figure 87A. Halifax/Eastern Shore acoustic transects for October 27, 2015 survey (#5) conducted by two acoustic survey vessel, Emily & Aley and Oralee along with the location (arrow) of multi-panel Herring gillnet sample collected on October 16.

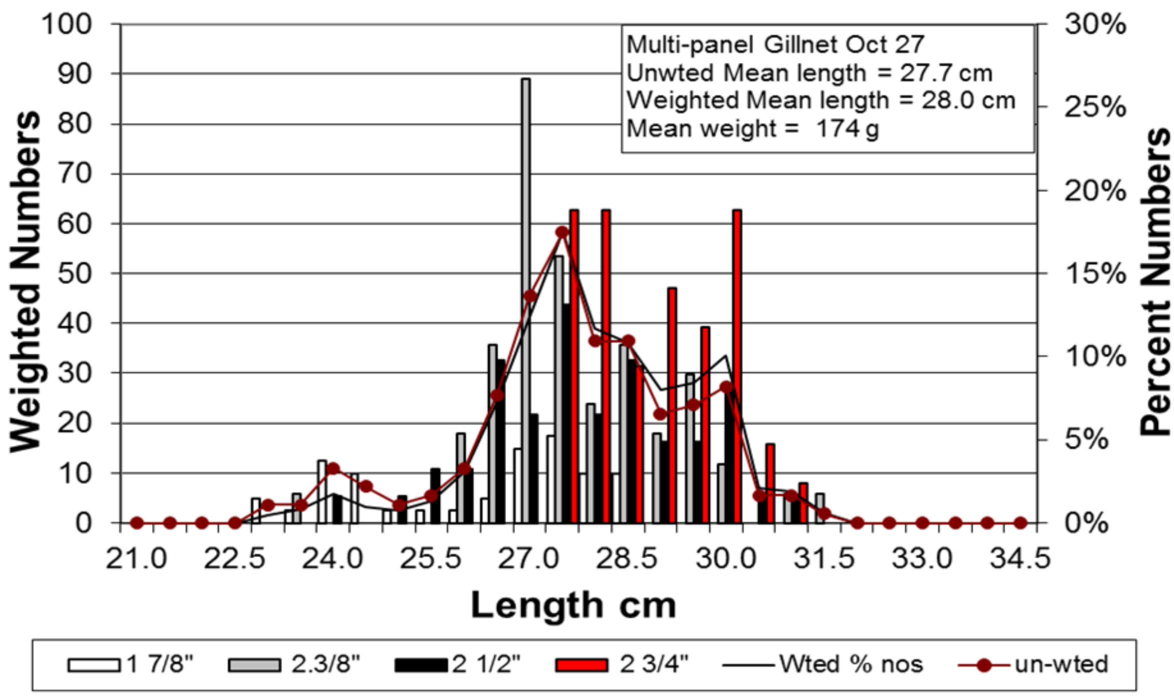

Figure 87B. Multi-panel Herring gillnet sample collected by Emily & Aley on October 27, 2015 for the Halifax/Eastern Shore acoustic survey (#5) on October 27.

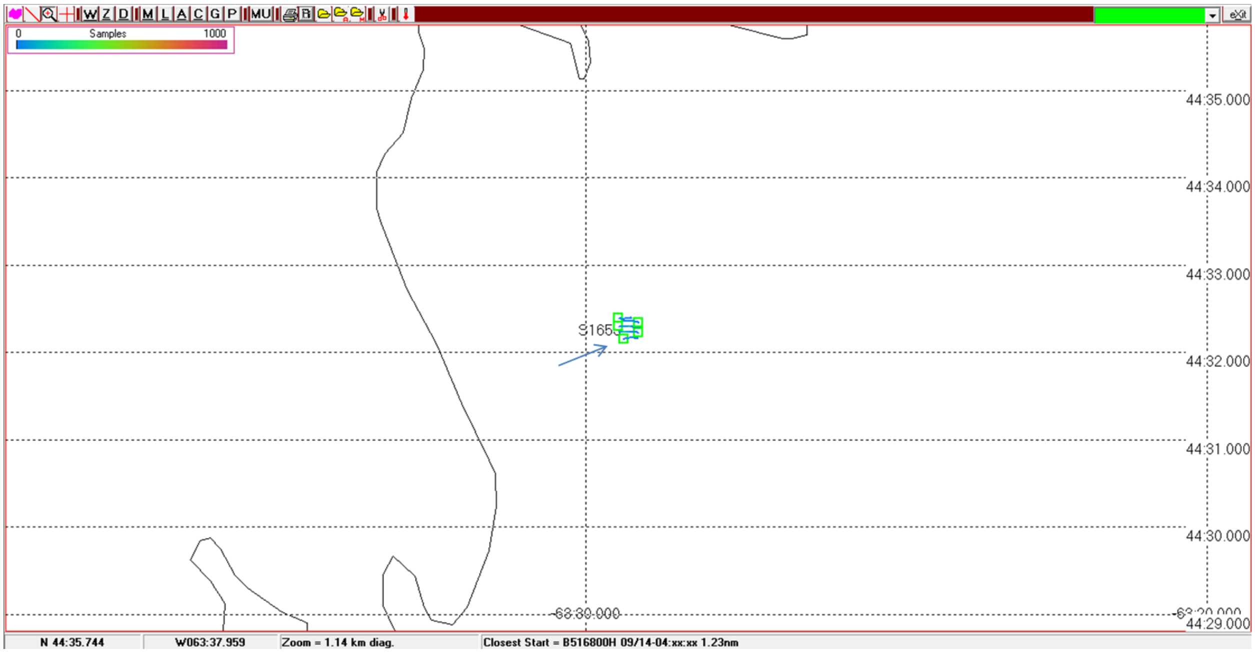

Figure 88A. Halifax/Eastern Shore acoustic transects for September 13, 2016 survey (#1) conducted by one acoustic survey vessel, Emily & Aley along with the location (arrow) of multi-panel Herring gillnet sample collected on for September 13.

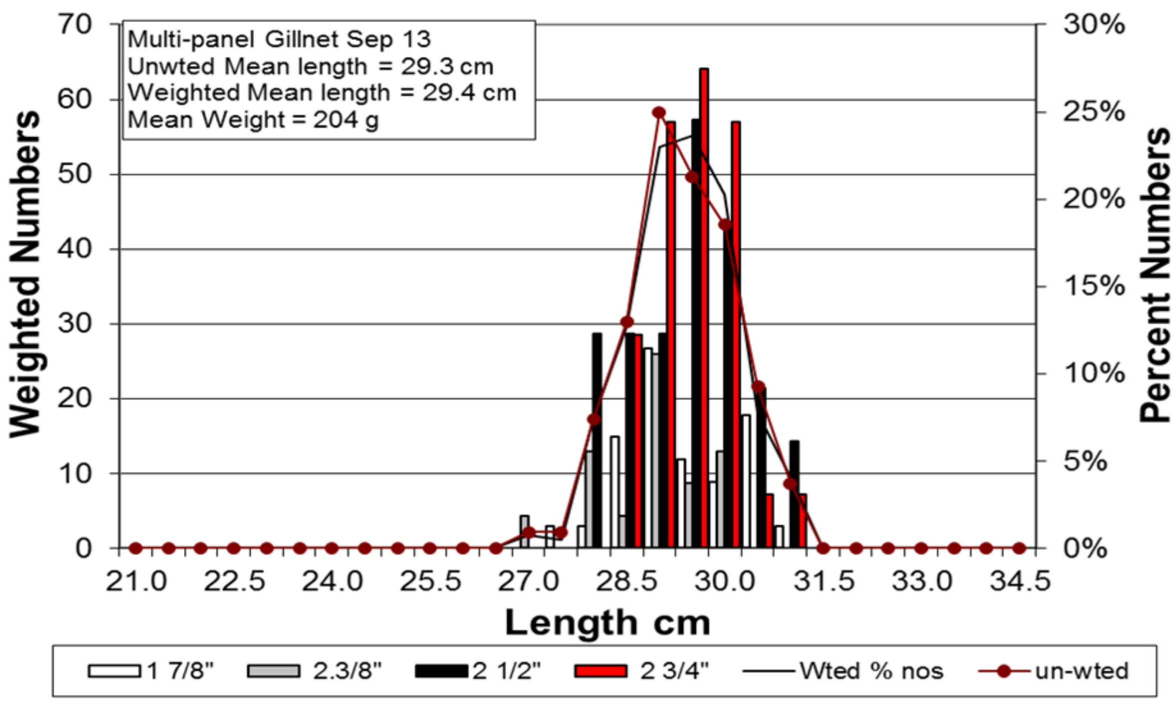

Figure 88B. Multi-panel Herring gillnet sample collected by Emily & Aley on September 13, 2016 for the Halifax/Eastern Shore acoustic survey (#1) on September 13.

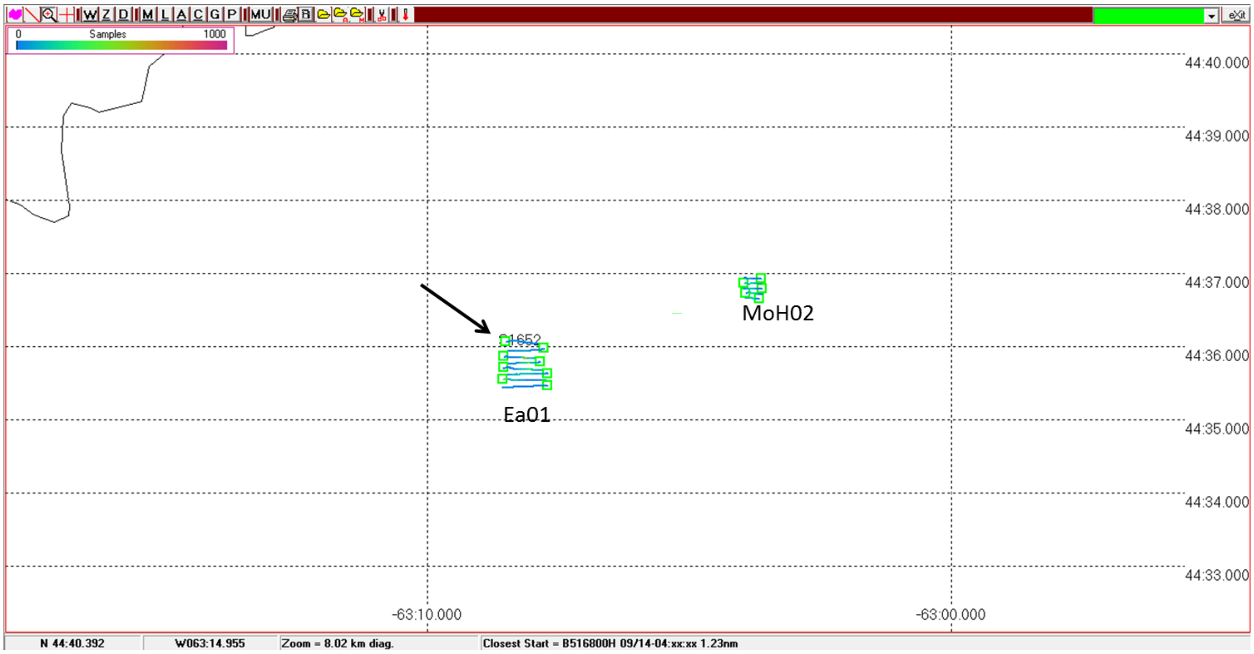

Figure 89A. Halifax/Eastern Shore acoustic transects for September 30, 2016 survey (#3) conducted by two acoustic survey vessels, Emily & Aley and Miss Owl's Head, along with the location (arrow) of multi-panel Herring gillnet sample collected on September 30.

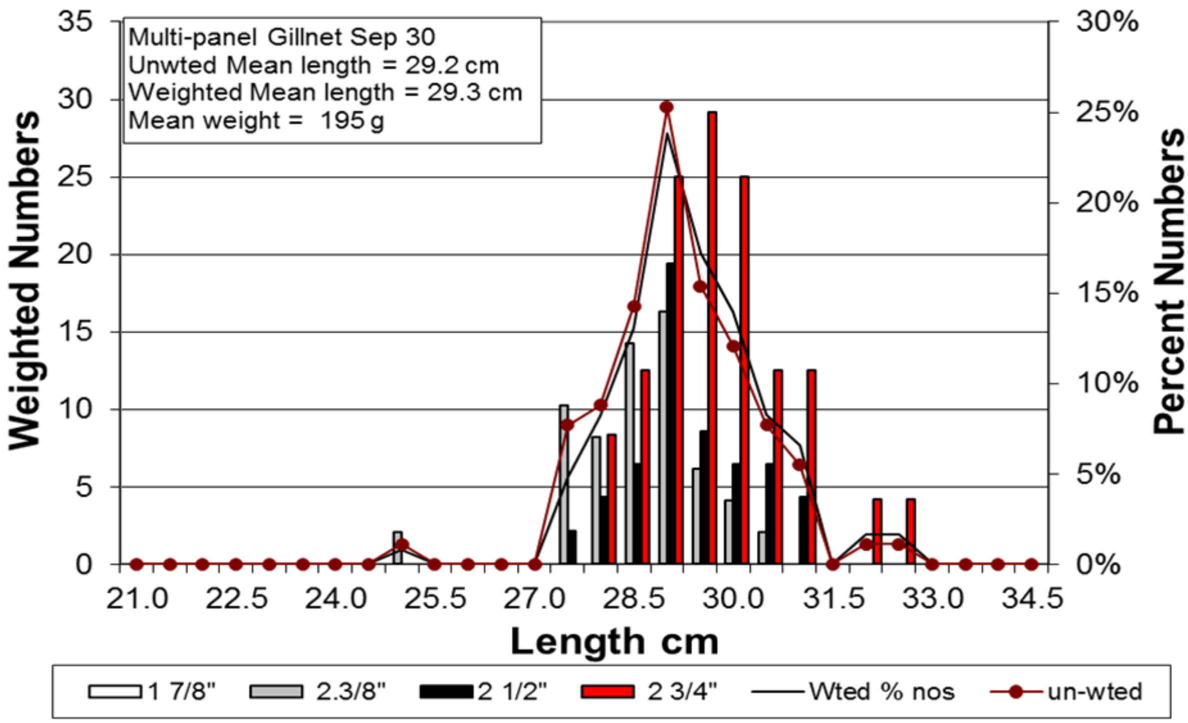

Figure 89B. Multi-panel Herring gillnet sample collected by Emily & Aley on September 30, 2016 for the Halifax/Eastern Shore acoustic survey (#3) on September 30.

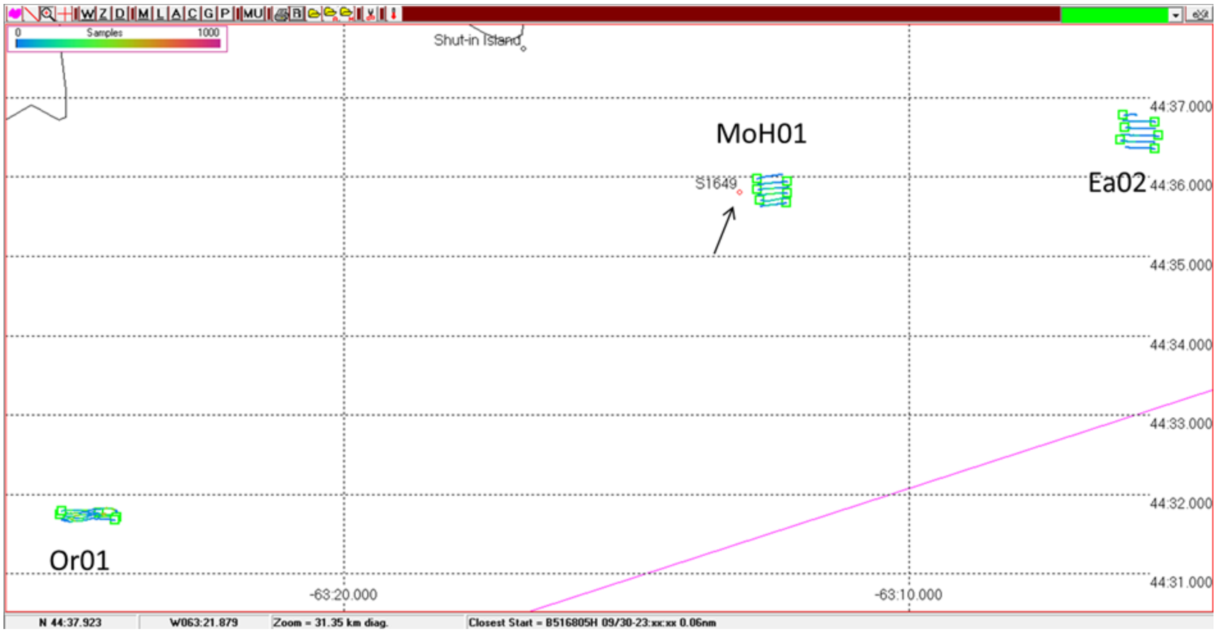

Figure 90A. Halifax/Eastern Shore acoustic transects for October 2, 2016 survey (#5) conducted by three acoustic survey vessels, Emily & Aley, Miss Owl's Head and Oralee, along with the location (arrow) of multi-panel Herring gillnet sample collected on October 3.

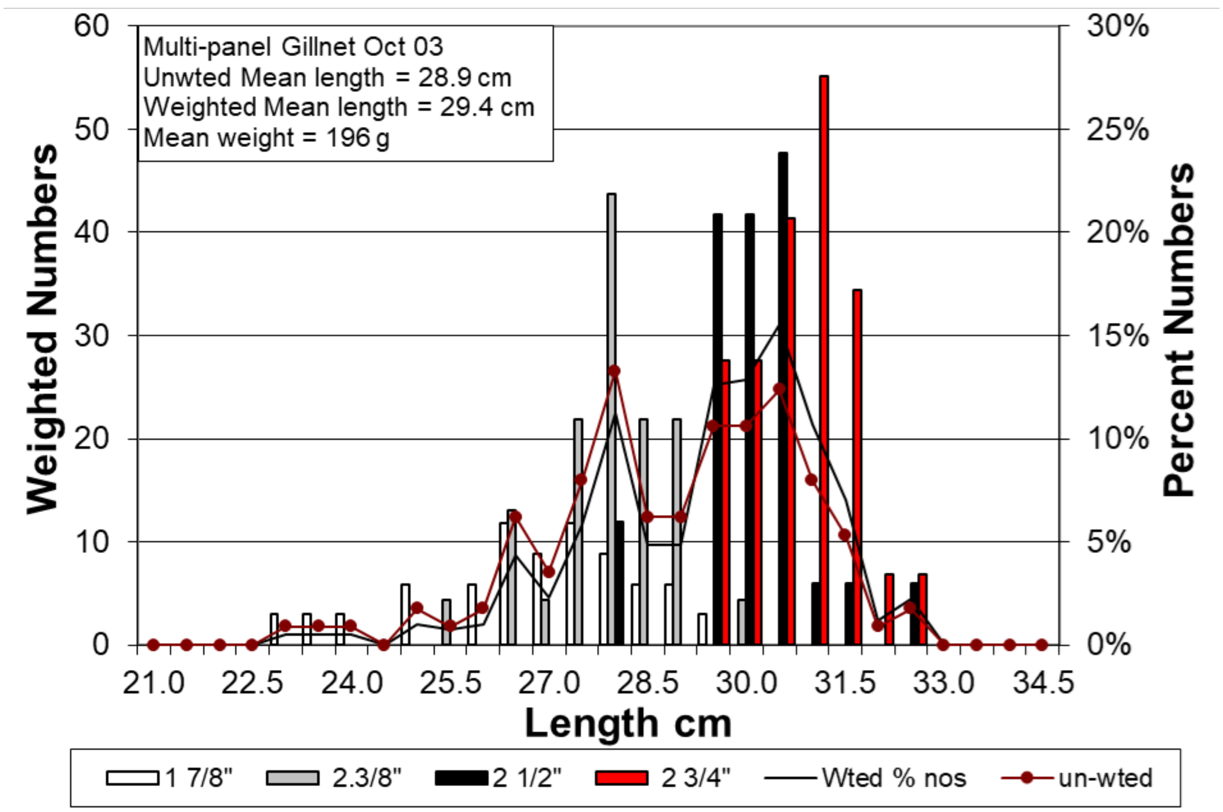

Figure 90B. Multi-panel Herring gillnet sample collected from the surveyed school of fish by Miss Owl's Head on October 3, 2016 for Halifax/Eastern Shore survey (#5) on October 2.

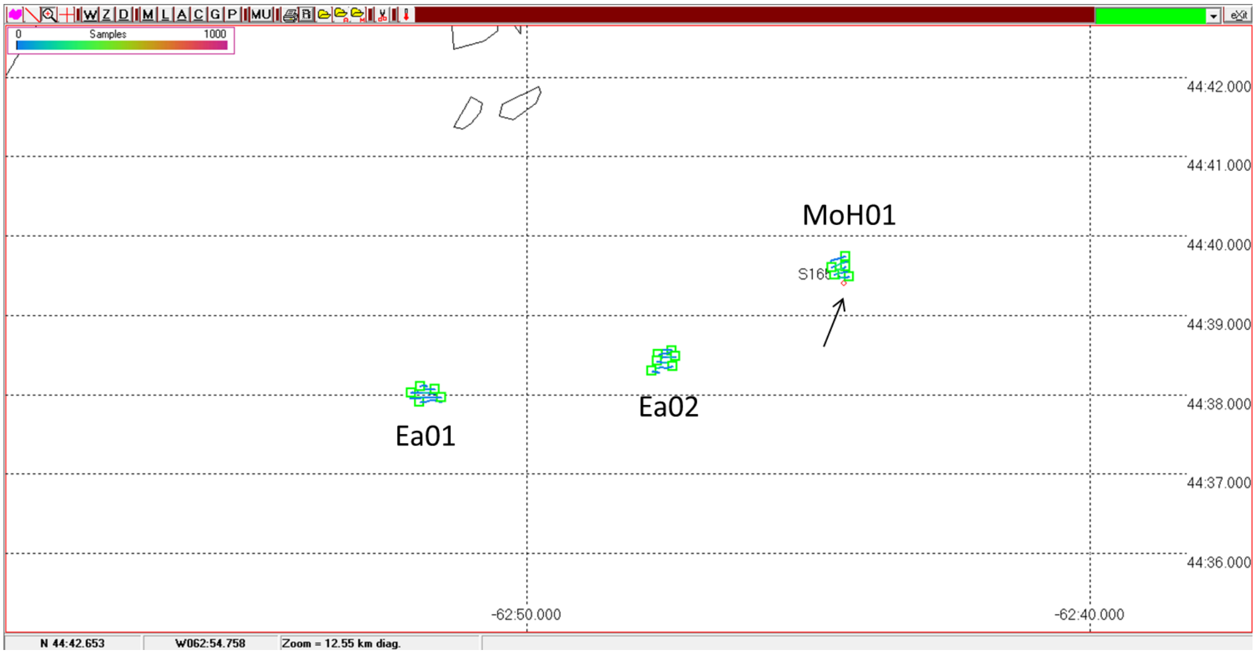

Figure 91A. Halifax/Eastern Shore acoustic transects for October 5, 2016 survey (#6) conducted by two acoustic survey vessels, Emily & Aley and Miss Owl's Head, along with the location (arrow) of multi-panel Herring gillnet sample collected on October 5.

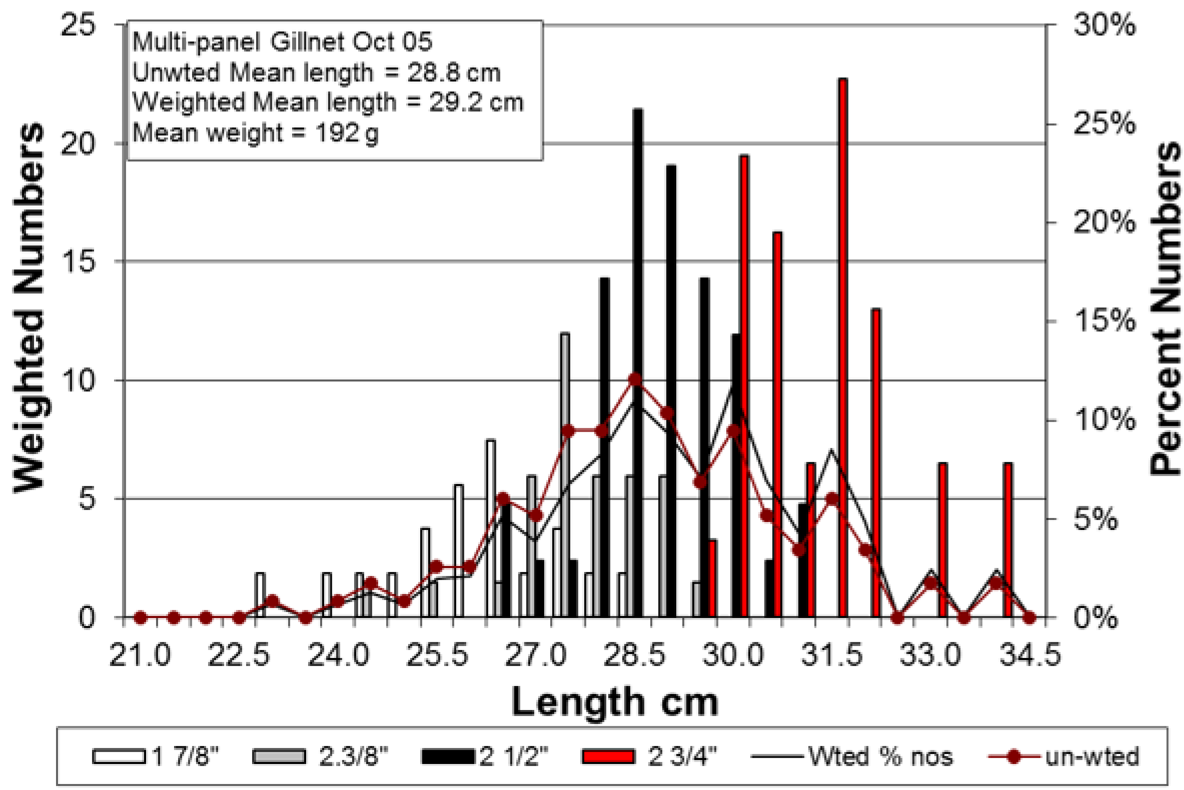

Figure 91B. Multi-panel Herring gillnet sample collected from the surveyed school of fish by Miss Owl's Head on October 5, 2016 for Halifax/Eastern Shore survey (#6) on October 5.

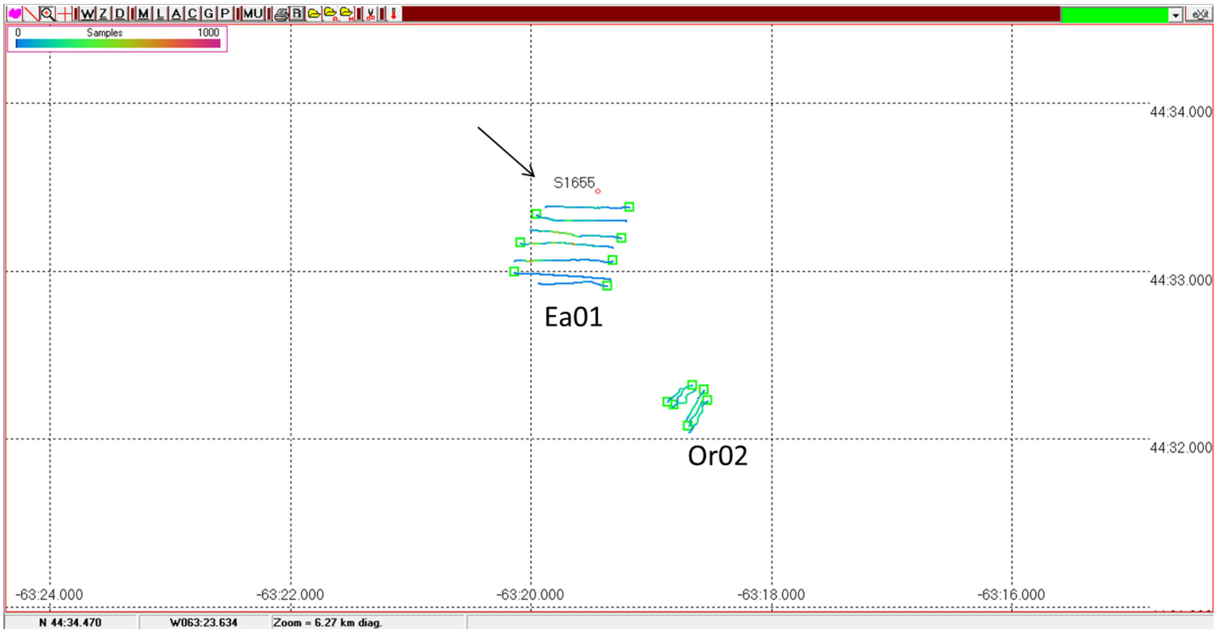

Figure 92A. Halifax/Eastern Shore acoustic transects for October 12, 2016 survey (#7) conducted by two acoustic survey vessels, Emily & Aley and Oralee, along with the location (arrow) of multi-panel Herring gillnet sample collected on October 13.

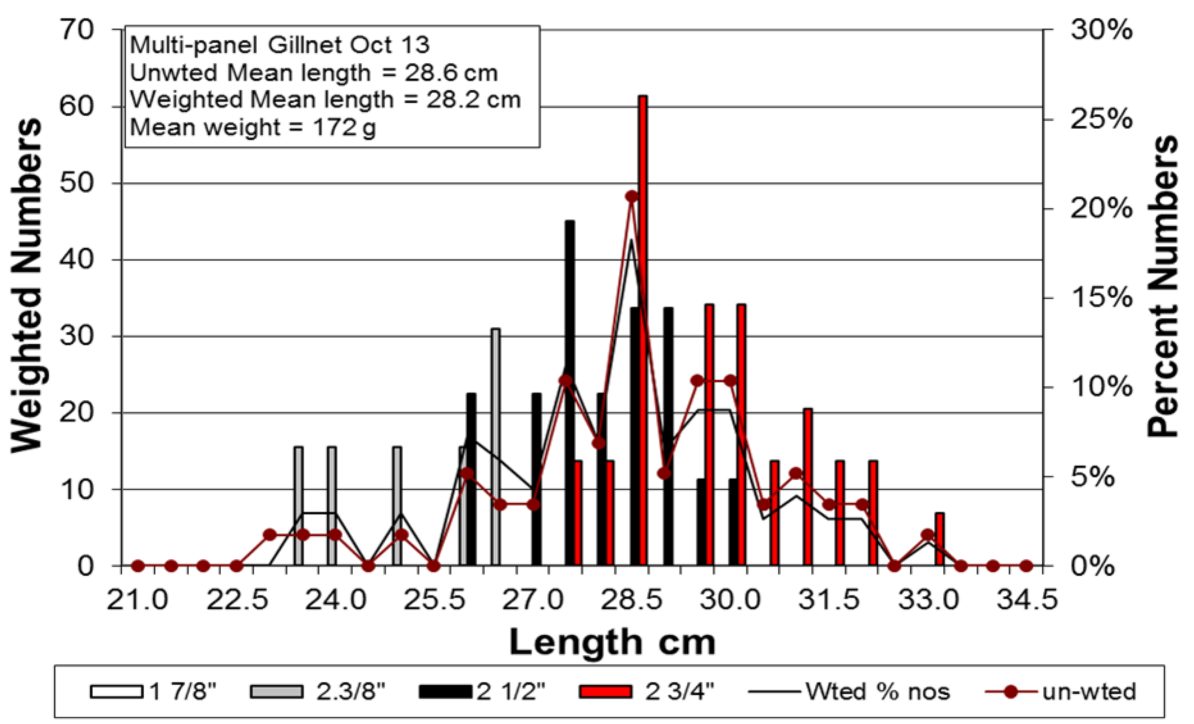

Figure 92B. Multi-panel Herring gillnet sample collected from the surveyed school of fish by Miss Owl's Head on October 12, 2016 for Halifax/Eastern Shore survey (#7) on October 13.

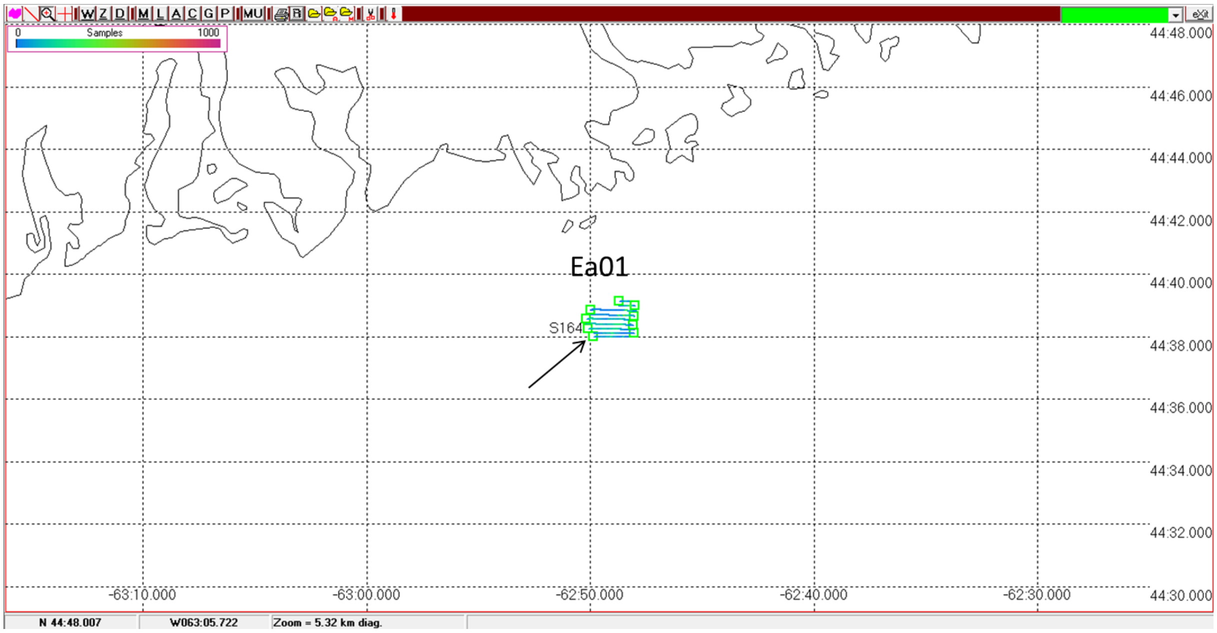

Figure 93A. Halifax/Eastern Shore acoustic transects for October 25, 2016 survey (#9) conducted by one acoustic survey vessels, Emily & Aley, along with the location (arrow) of multi-panel Herring gillnet sample collected on October 26.

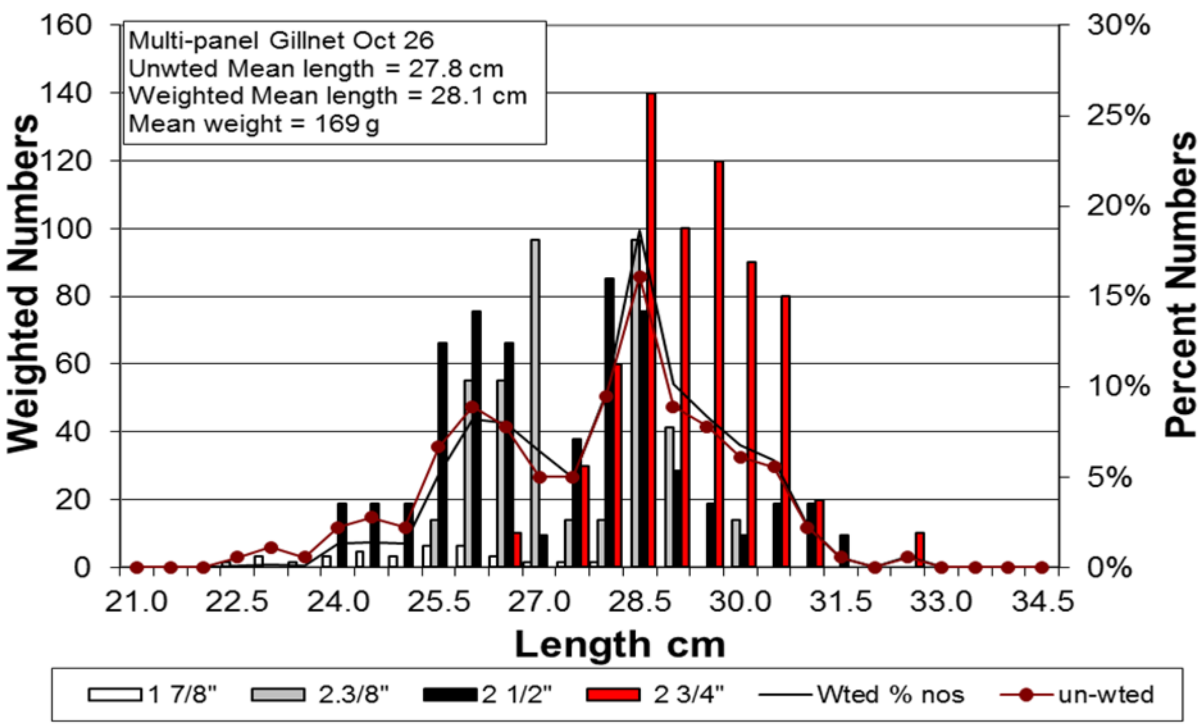

Figure 93B. Multi-panel Herring gillnet sample collected from the surveyed school of fish by Emily & Aley on October 26, 2016 for Halifax/Eastern Shore survey (#9) on October 25.

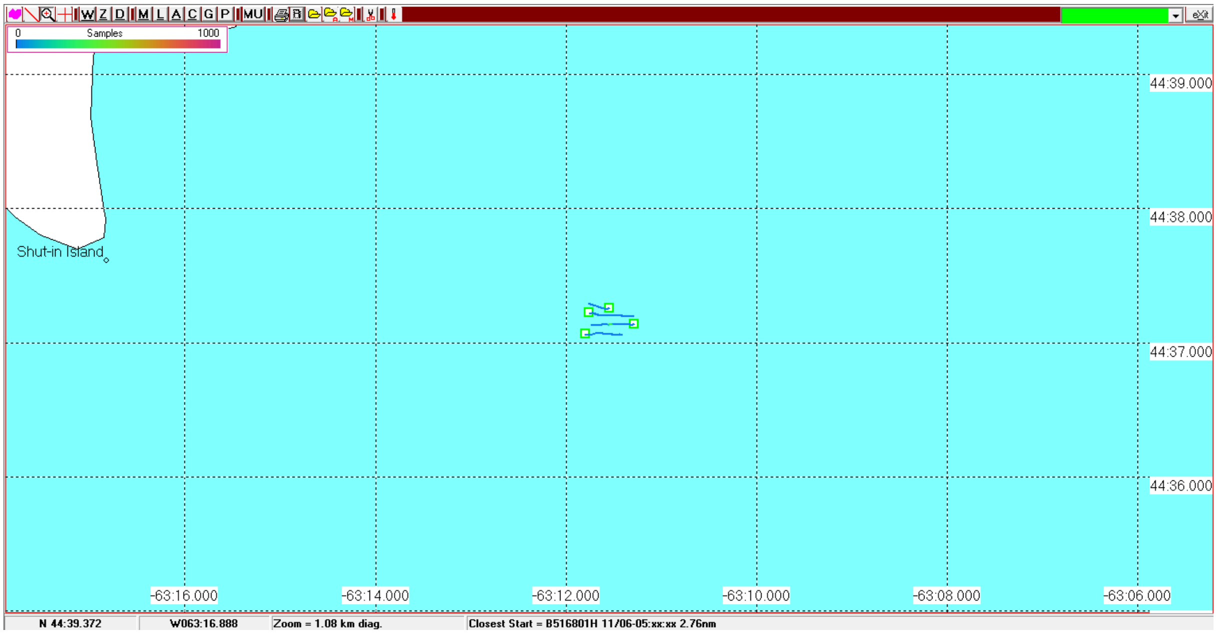

Figure 94. Halifax/Eastern Shore acoustic transects for November 5, 2016 survey (#10) conducted by the acoustic survey vessel, <u>Emily & Aley</u>. No multipanel sample was collected so the standard Target Strength (TS) was used.

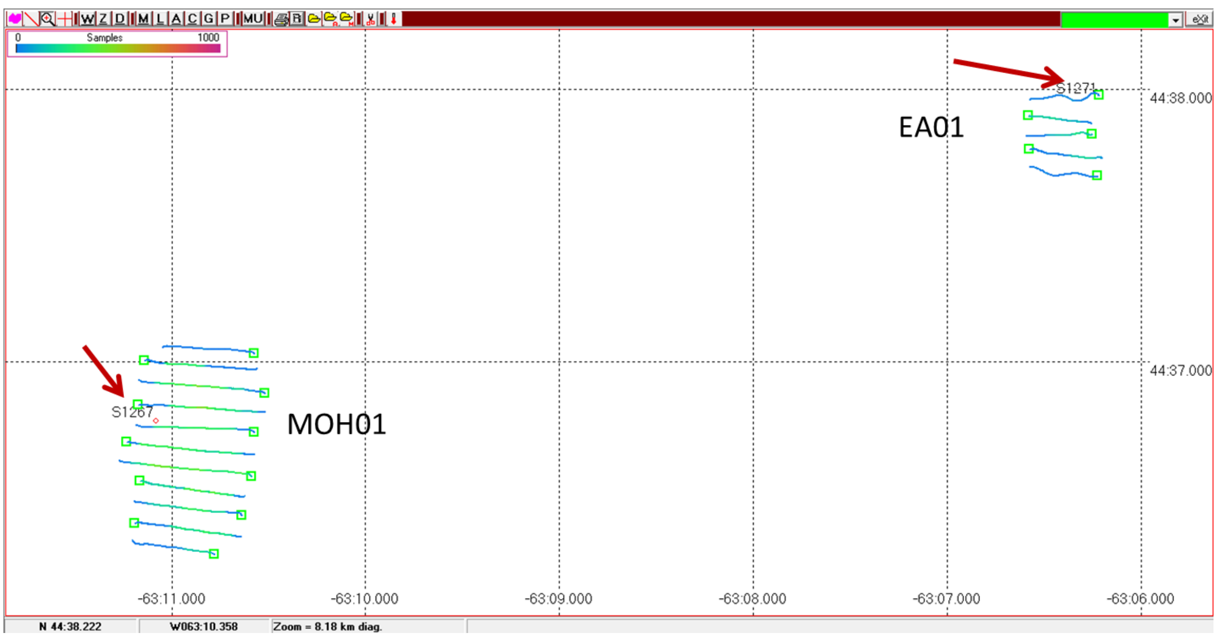

Figure 95A. Halifax/Eastern Shore acoustic transects for September 15, 2017 survey (#1) conducted by two acoustic survey vessels, <u>Emily & Aley</u> and <u>Miss Owl's Head</u>, along with the locations (arrows) of multi-panel Herring gillnet samples collected on for September 15 and 16.

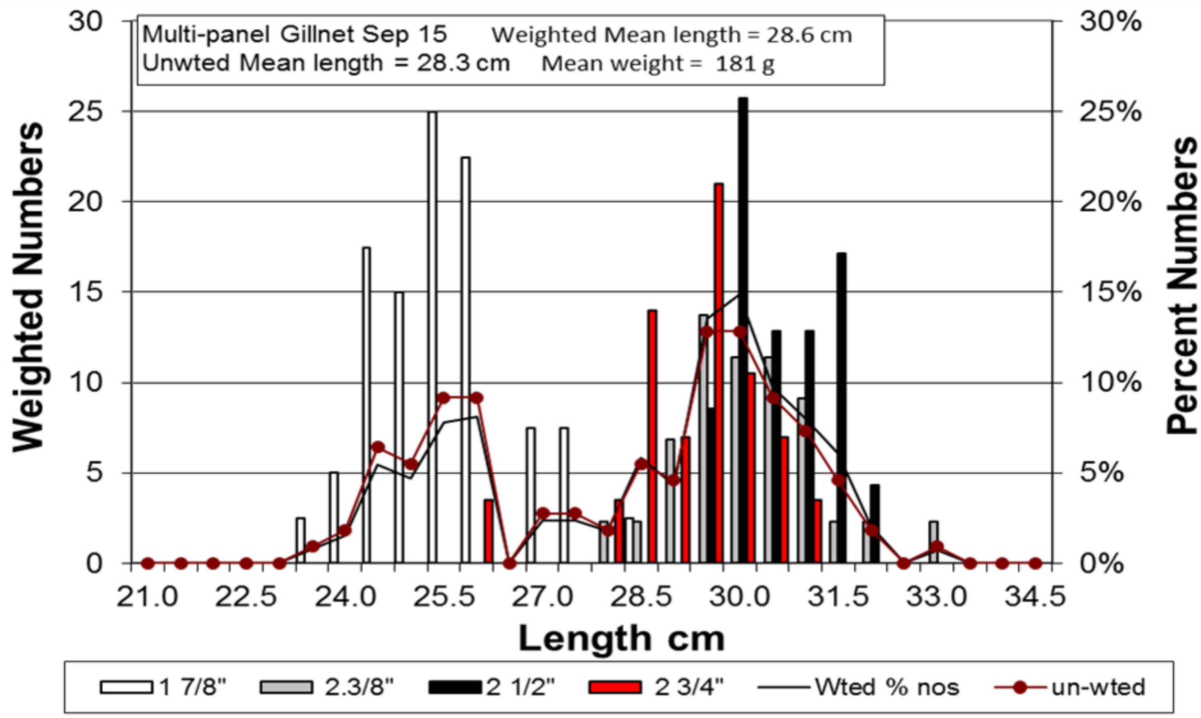

Figure 95B. Multi-panel Herring gillnet sample collected by Emily & Aley on September 15, 2017 for the Halifax/Eastern Shore acoustic survey (#1) on September 15.

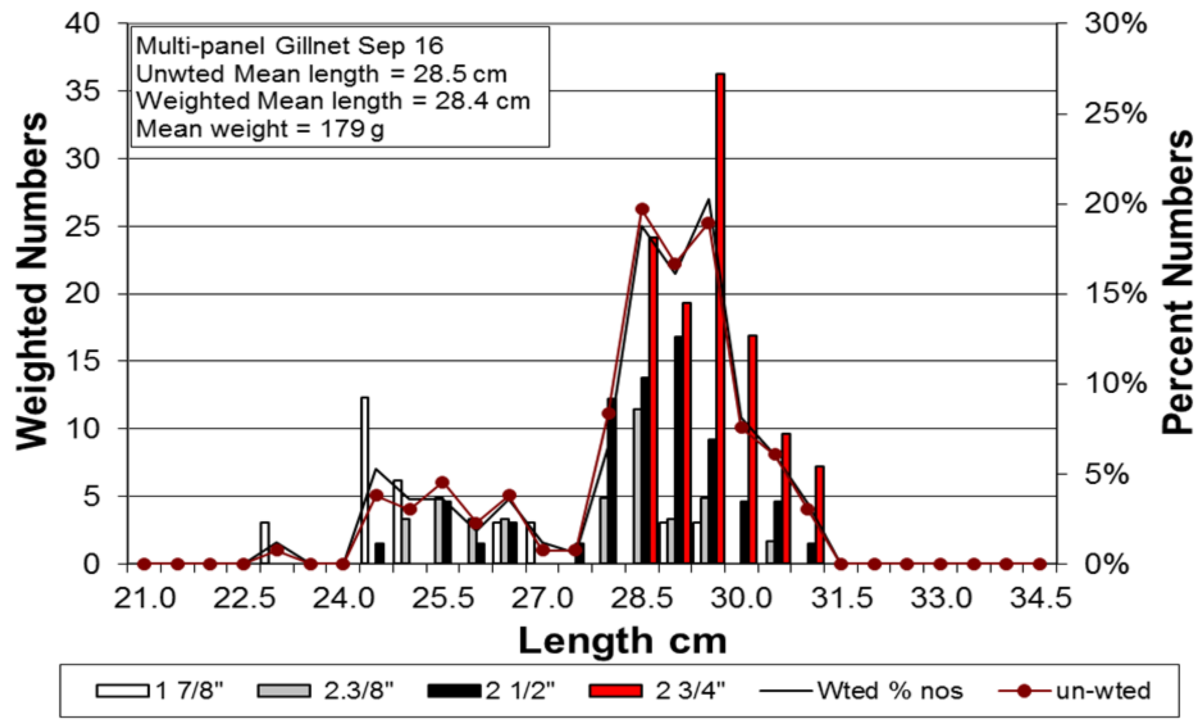

Figure 95C. Multi-panel Herring gillnet sample collected by Miss Owl's Head on September 16, 2017 for the Halifax/Eastern Shore acoustic survey (#1) on September 15.

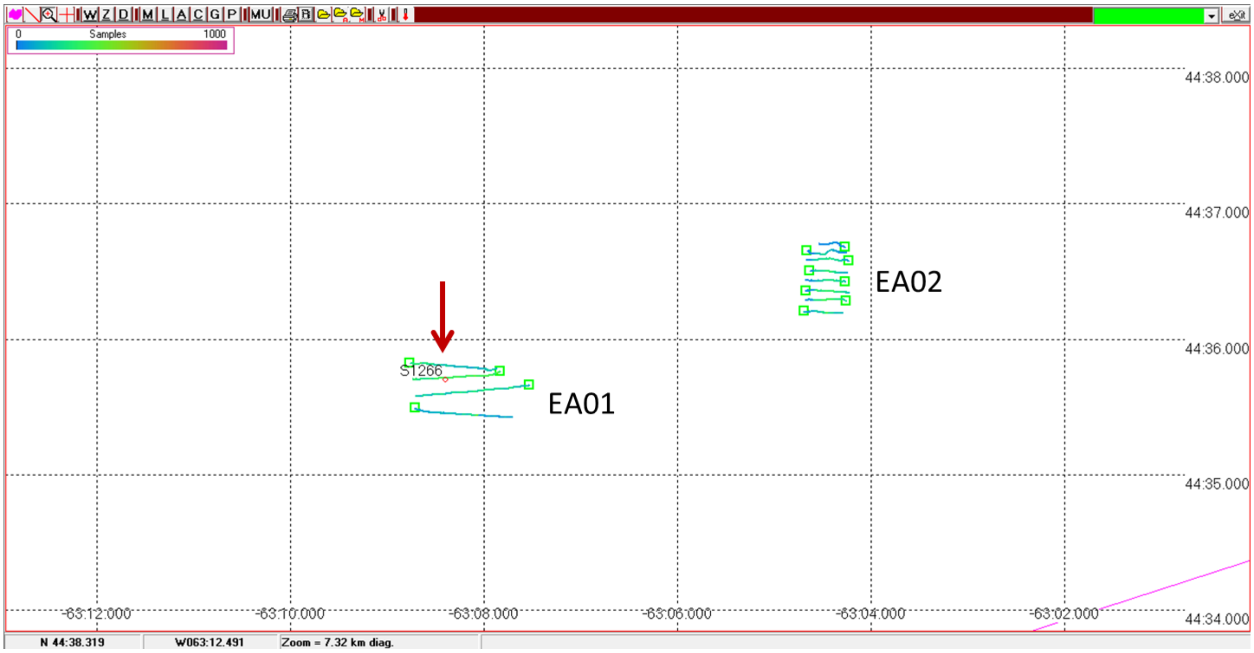

Figure 96A. Halifax/Eastern Shore acoustic transects for September 26, 2017 survey (#2) conducted by one acoustic survey vessel, Emily & Aley, along with the location (arrow) of multi-panel Herring gillnet sample collected on September 30.

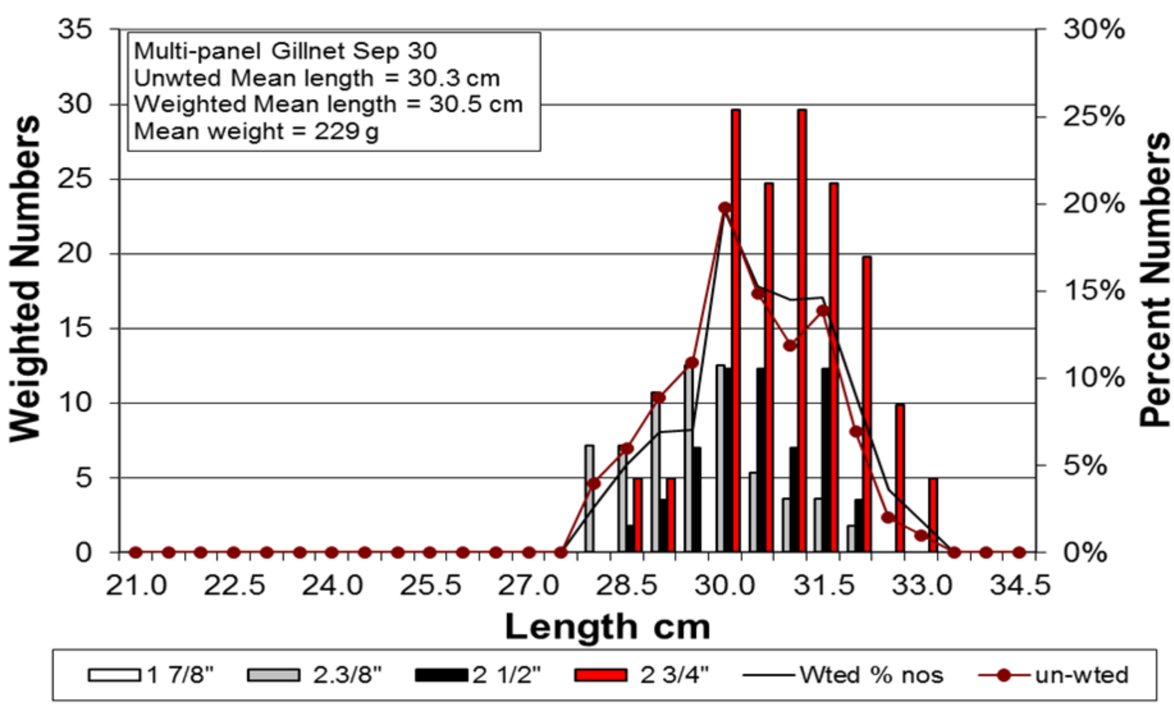

Figure 96B. Multi-panel Herring gillnet sample collected by Emily & Aley on September 30, 2017 for the Halifax/Eastern Shore acoustic surveys (#2), (#3) and (#4) on September 26, 29 and 30.

Figure 97. Halifax/Eastern Shore acoustic transects for September 29, 2017 survey (#3) conducted by two acoustic survey vessels, Emily & Aley and Oralee, along with the location (arrow) of multi-panel Herring gillnet sample collected on September 30. Only OR01 was used in the biomass estimate and the standard Target Strength (TS) was used because the September 30 sample was more them 25 km away.

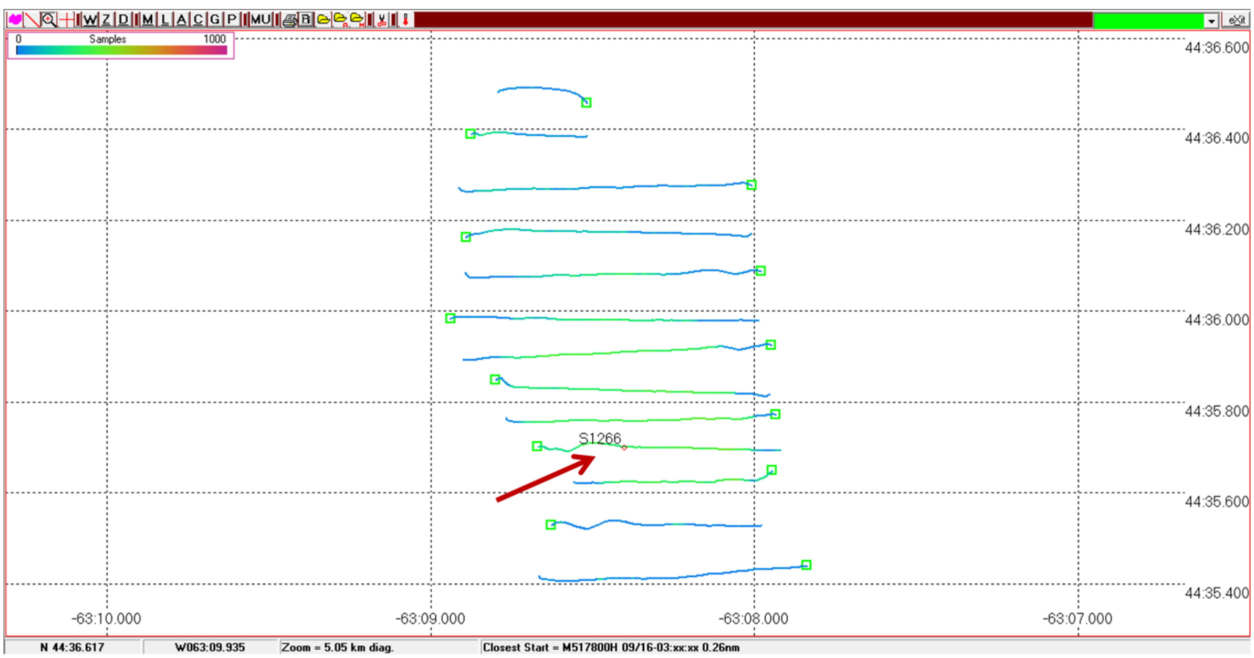

Figure 98. Halifax/Eastern Shore acoustic transects for September 30, 2017 survey (#4) conducted by one acoustic survey vessel, Emily & Aley along with the location (arrow) of multi-panel Herring gillnet sample collected on September 30 (see Figure 96B for details on the sample).

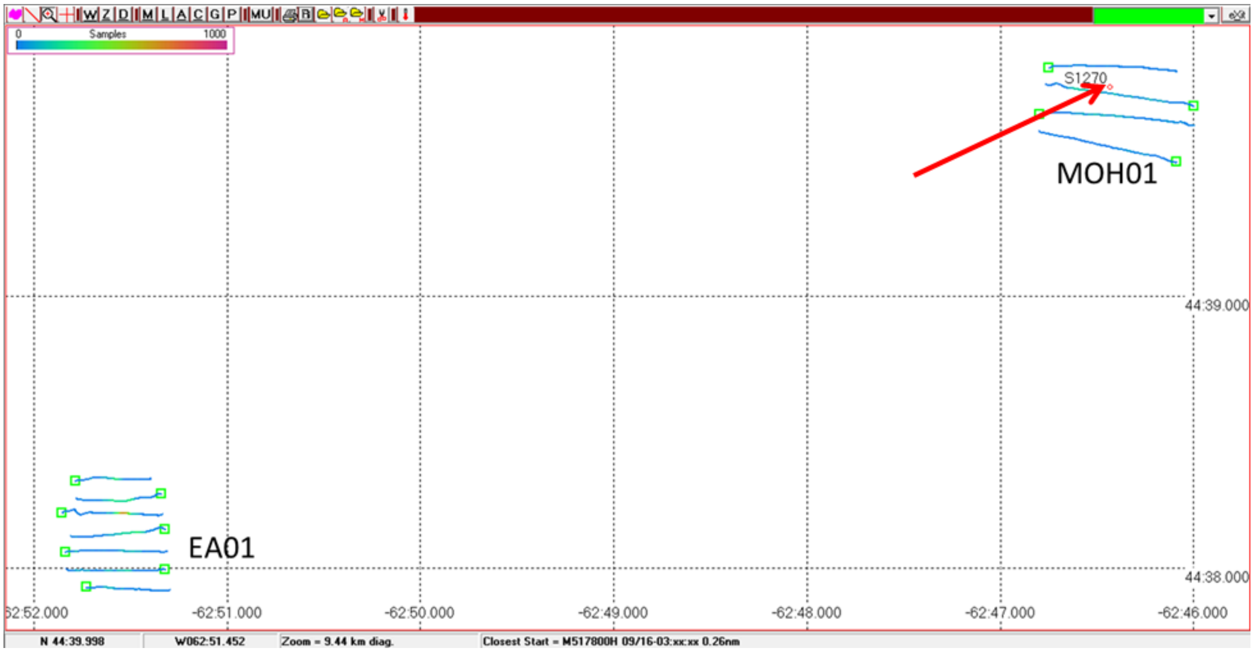

Figure 99A. Halifax/Eastern Shore acoustic transects for October 7, 2017 survey (#5) conducted by two acoustic survey vessels, Miss Owl's Head and Emily & Aley along with the location (arrow) of mult-panel Herring gillnet sample collected on October 8.

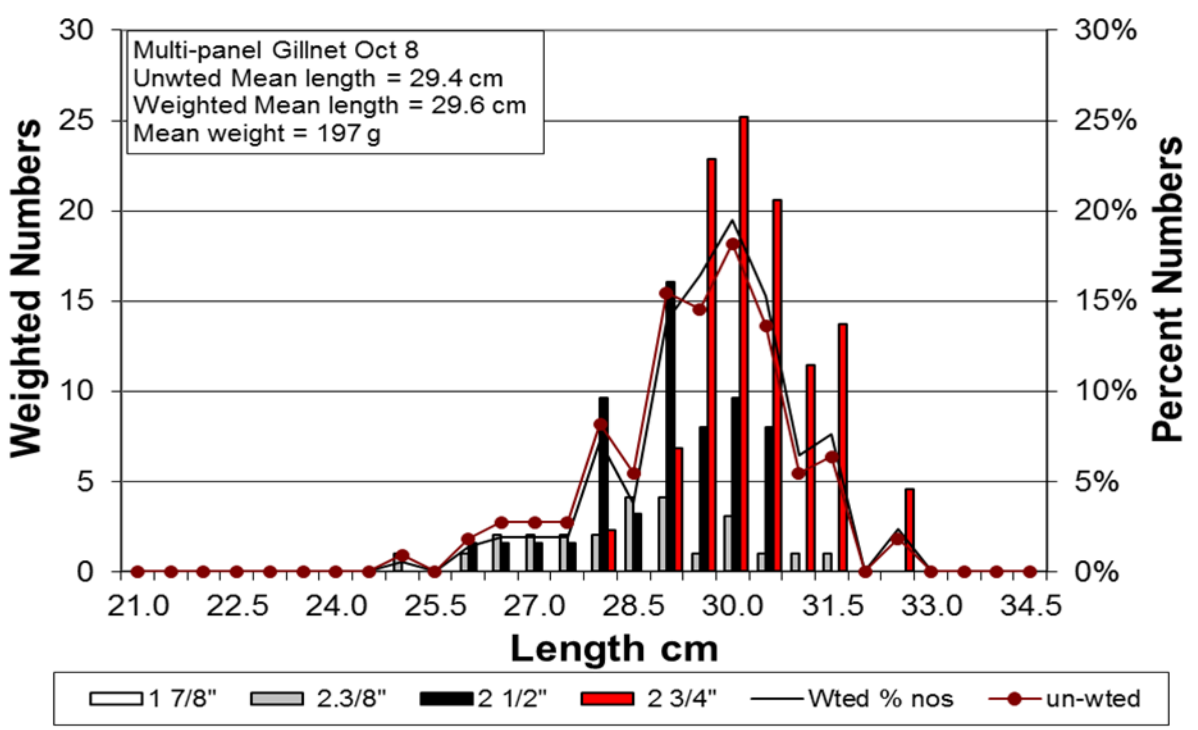

Figure 99B. Multi-panel Herring gillnet sample collected from the surveyed school of fish by Miss Owl's Head on October 8, 2017 for Halifax/Eastern Shore survey (#5) on October 7.

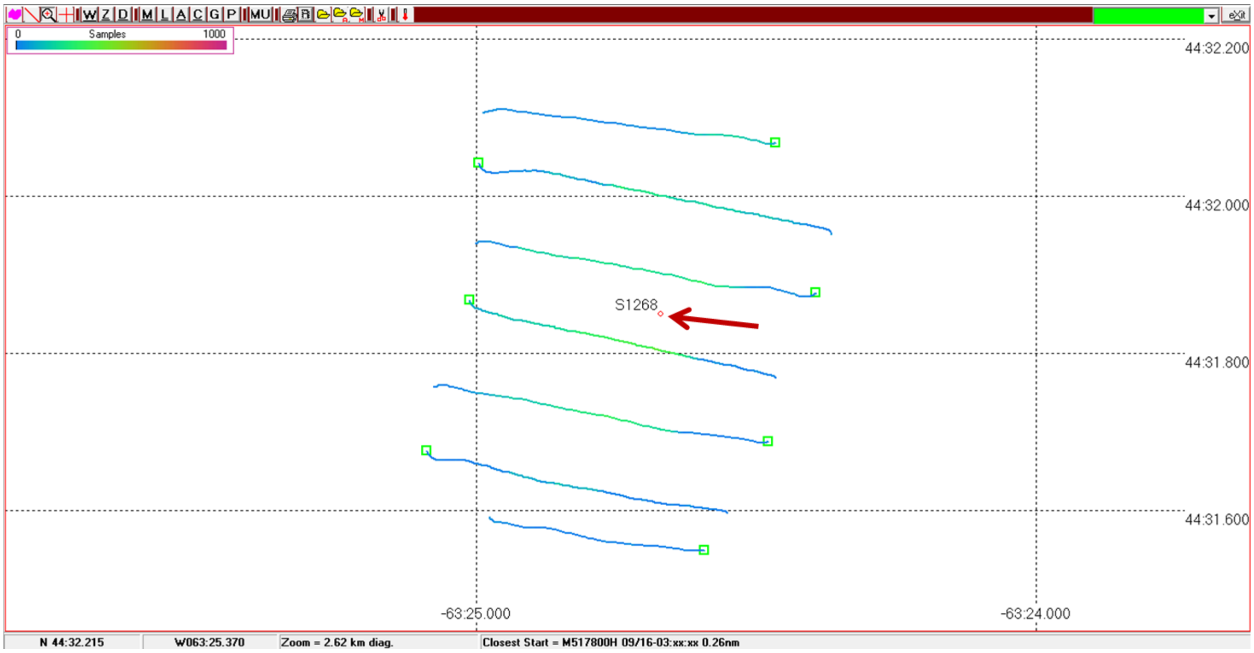

Figure 100A. Halifax/Eastern Shore acoustic transects for October 16, 2017 survey (#6) conducted by one acoustic survey vessel, Miss Owl's Head along with the location (arrow) of multi-panel Herring gillnet sample collected on October 17.

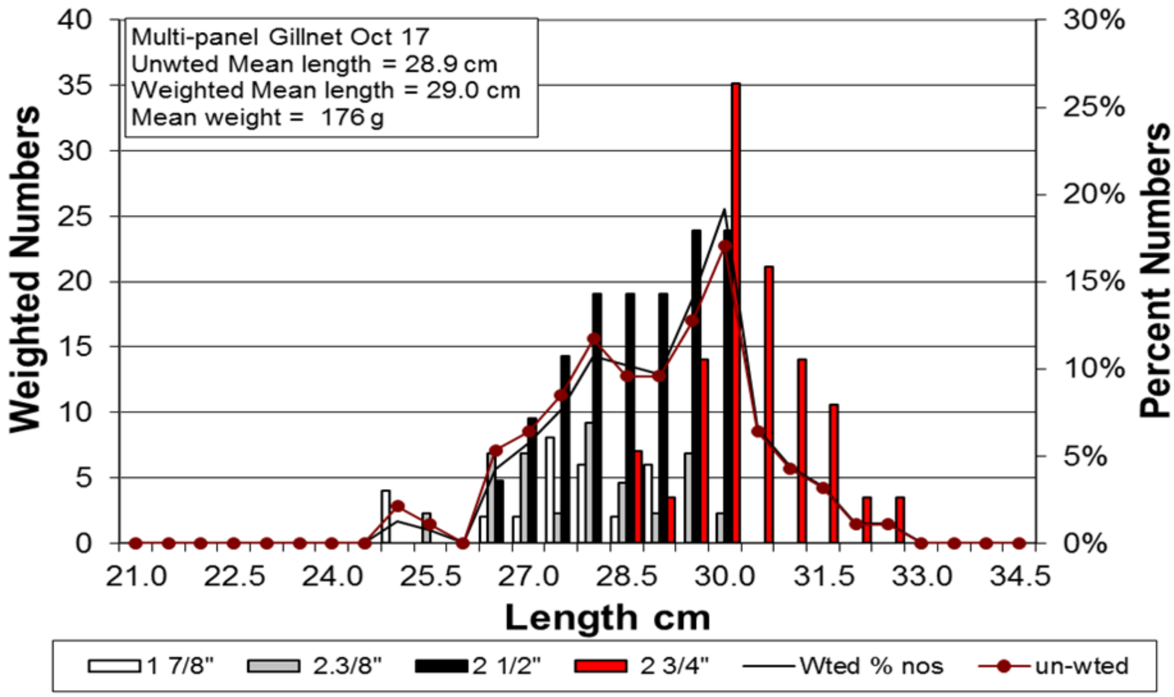

Figure 100B. Multi-panel Herring gillnet sample collected from the surveyed school of fish by Miss Owl's Head on October 17, 2017 for Halifax/Eastern Shore survey (#6) on October 16.

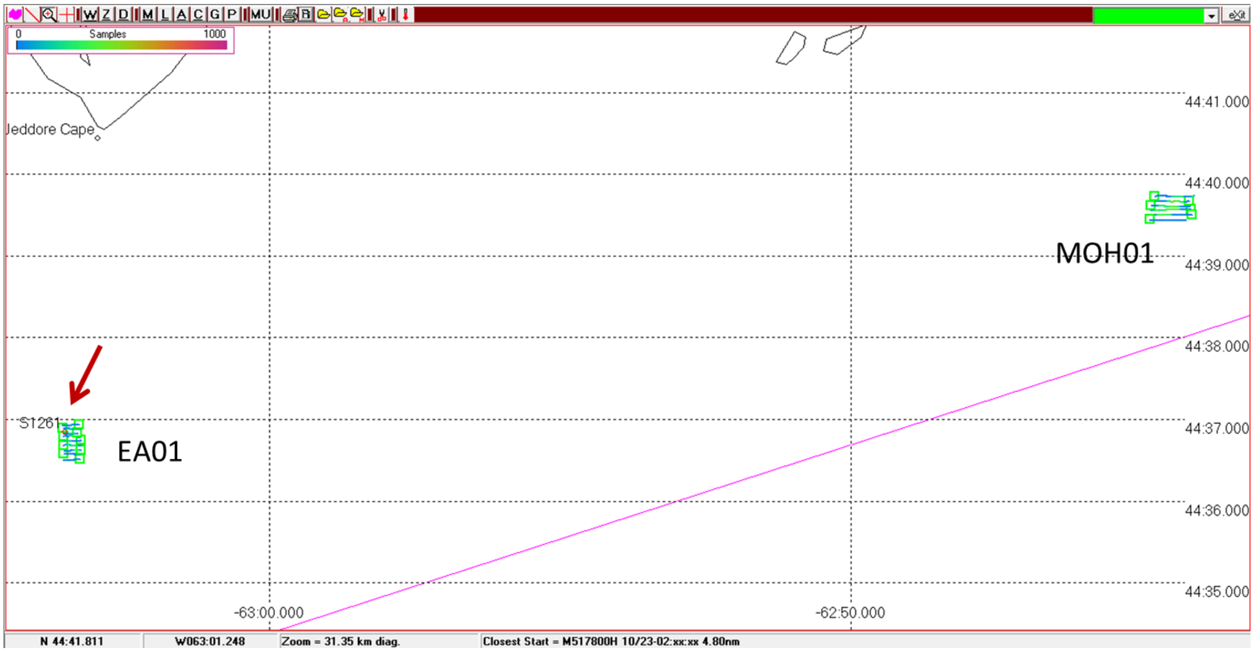

Figure 101A. Halifax/Eastern Shore acoustic transects for October 21, 2017 survey (#7) conducted by two acoustic survey vessels, Emily & Aley and Miss Owl's Head, along with the location (arrow) of multi-panel Herring gillnet sample collected on October 22.

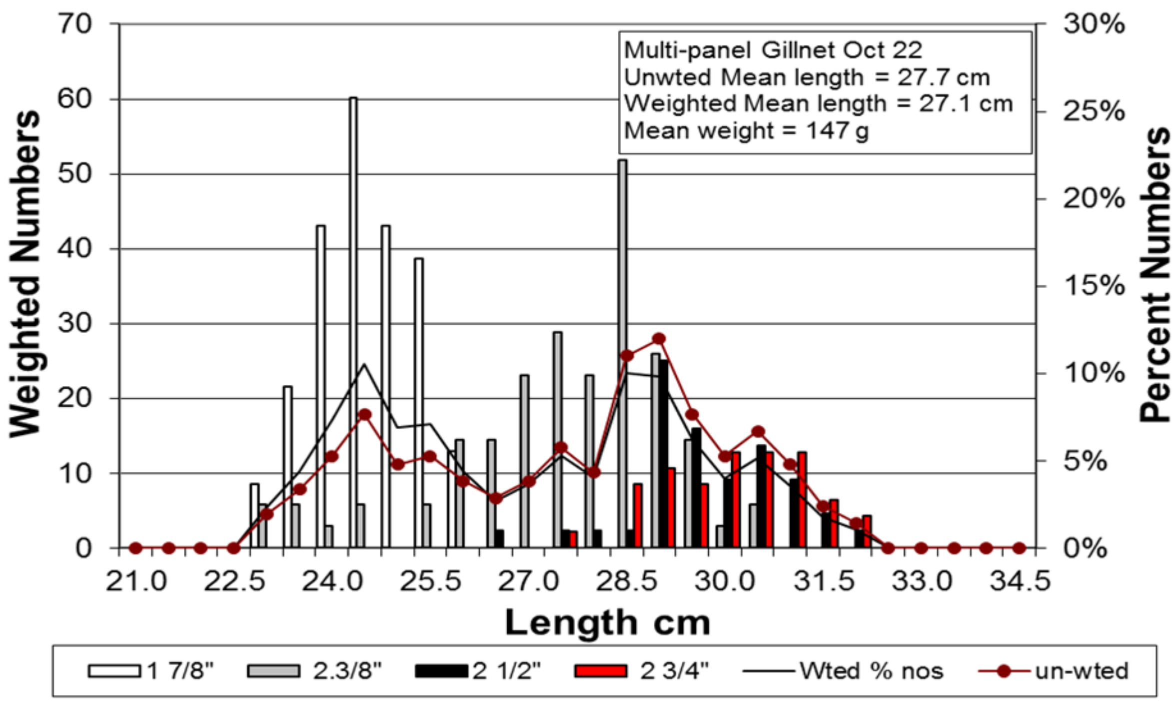

Figure 101B. Multi-panel Herring gillnet sample collected from the surveyed school of fish by Emily & Aley on October 22, 2017 for Halifax/Eastern Shore survey (#7) on October 21.

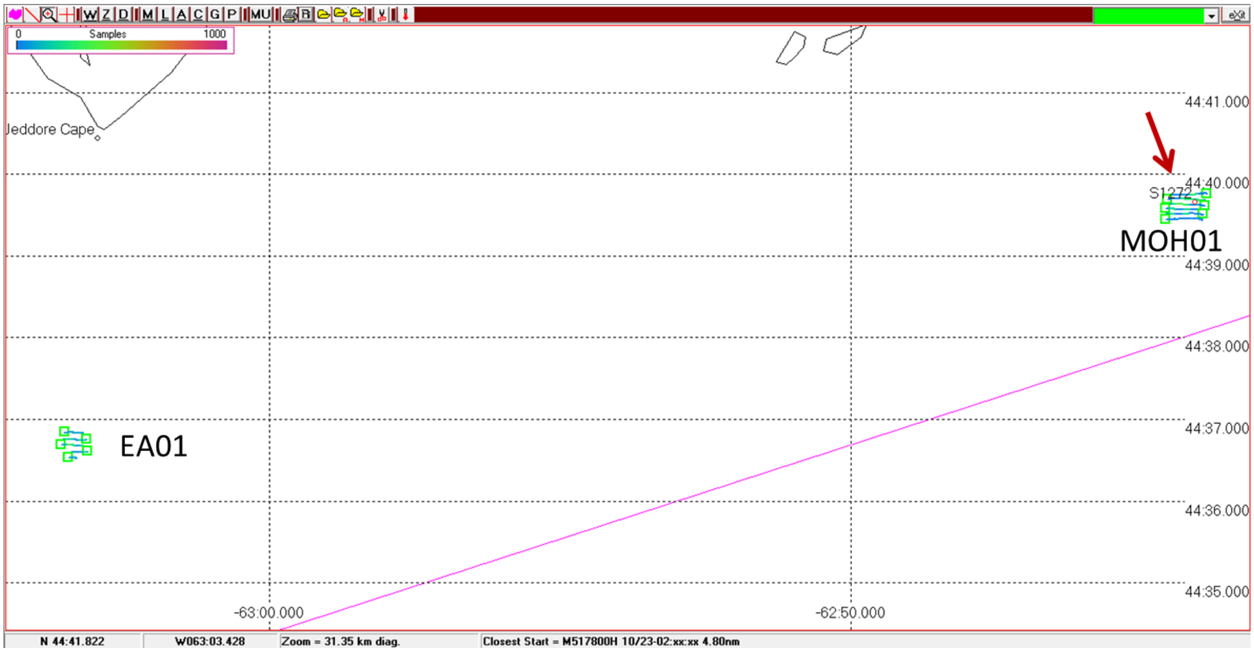

Figure 102A. Halifax/Eastern Shore acoustic transects for October 22, 2017 survey (#8) conducted by two acoustic survey vessels, Emily & Aley and Miss Owl's Head, along with the location (arrow) of multi-panel Herring gillnet sample collected on October 23.

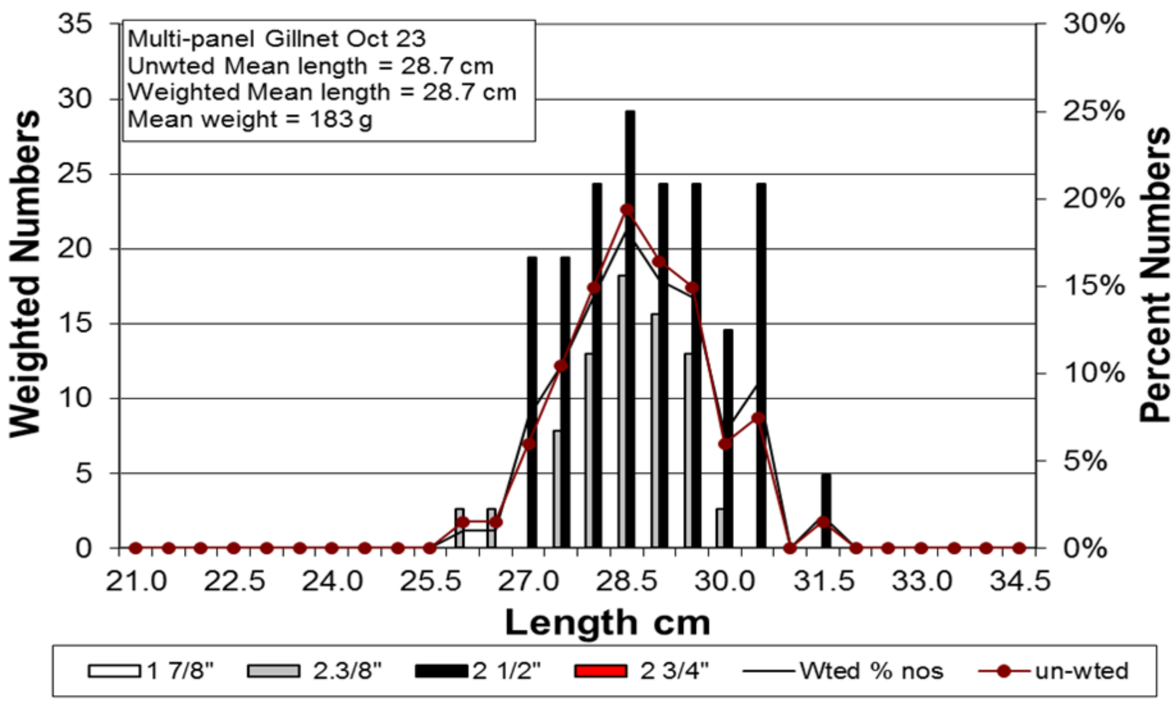

Figure 102B. Multi-panel Herring gillnet sample collected from the surveyed school of fish by Miss Owl's Head on October 23, 2017, for Halifax/Eastern Shore survey (#8) on October 22.

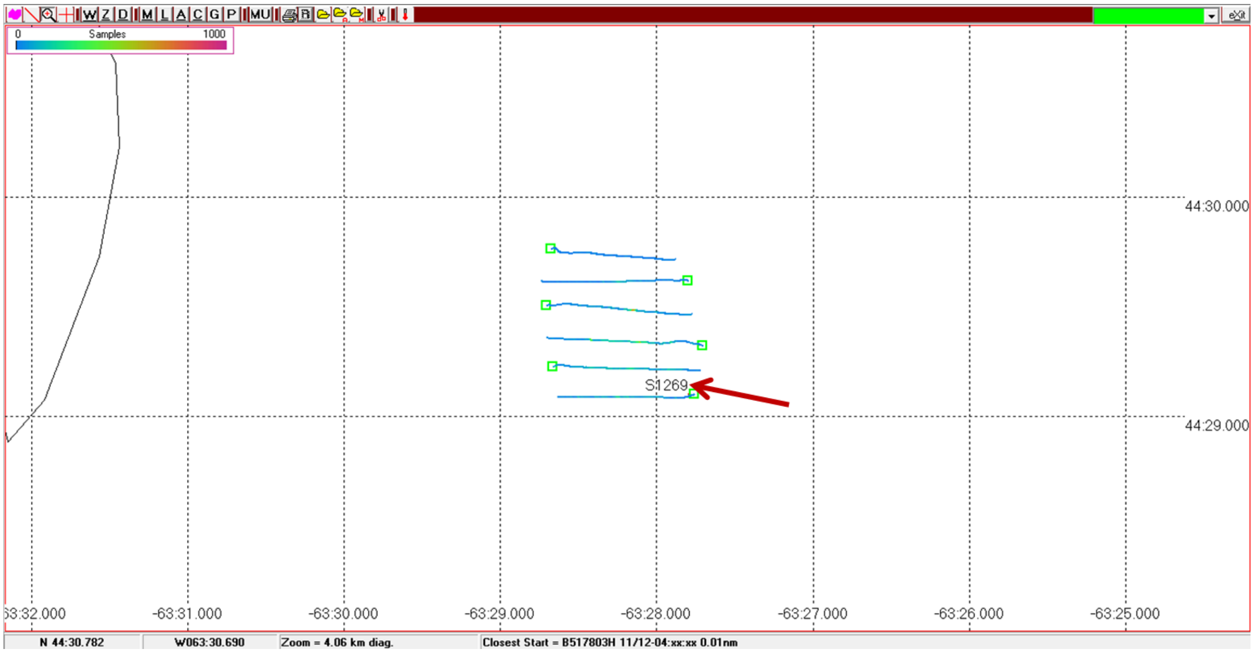

Figure 103A. Halifax/Eastern Shore acoustic transects for November 11, 2017 survey (#9) conducted by one acoustic survey vessel, Emily & Aley, along with the location (arrow) of multi-panel Herring gillnet sample collected on November 11.

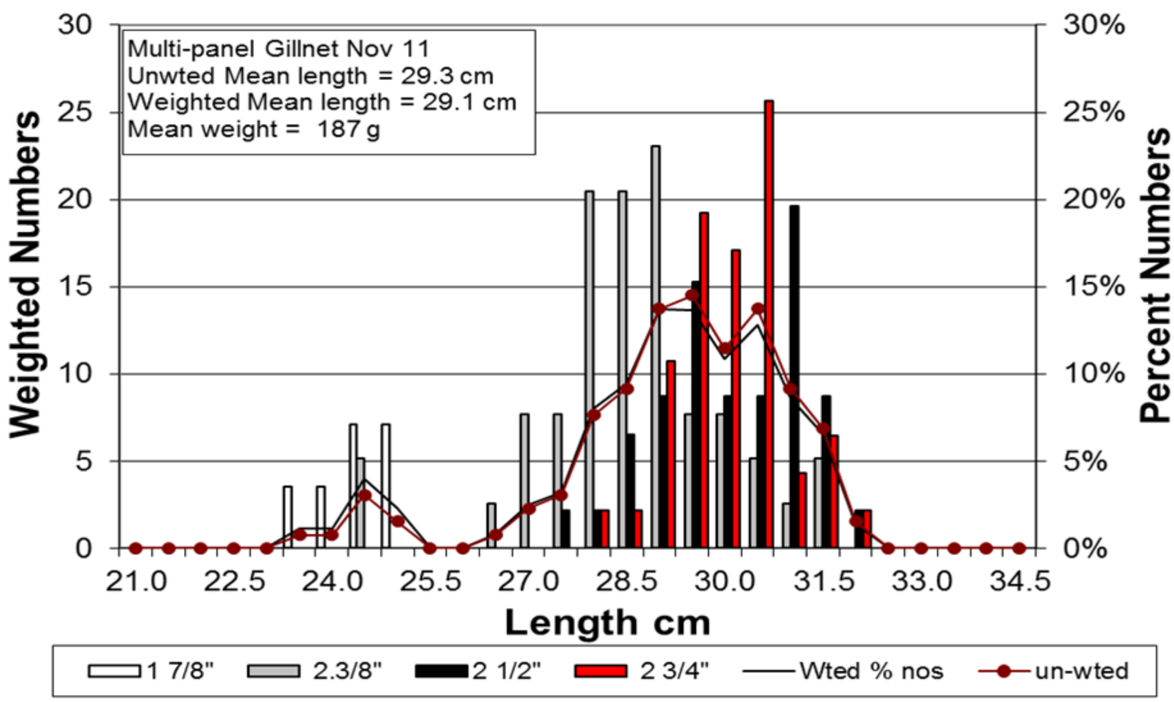

Figure 103B. Multi-panel Herring gillnet sample collected from the surveyed school of fish by Emily & Aley on November 11, 2017 for Halifax/Eastern Shore survey (#9) on November 11.

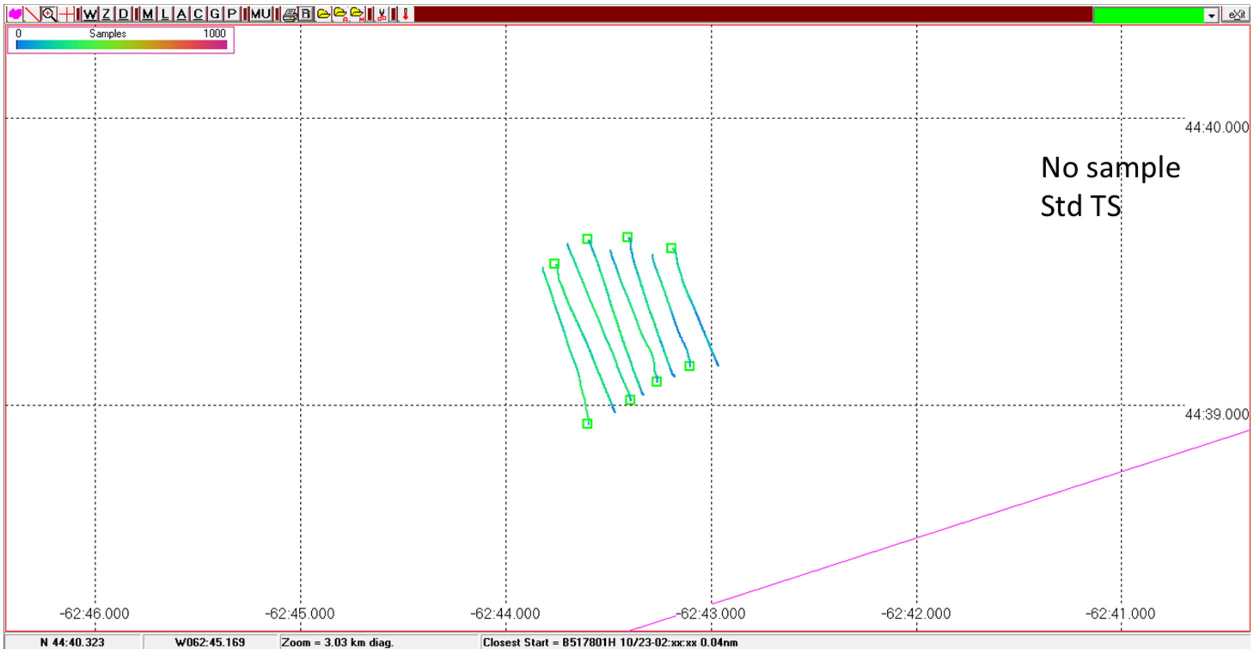

Figure 104. Halifax/Eastern Shore acoustic transects for November 12, 2017 survey (#10) conducted by one acoustic survey vessel, Miss Owl's Head. No multi-panel Herring gillnet sample was collected so the standard Target Strength (TS) was used.

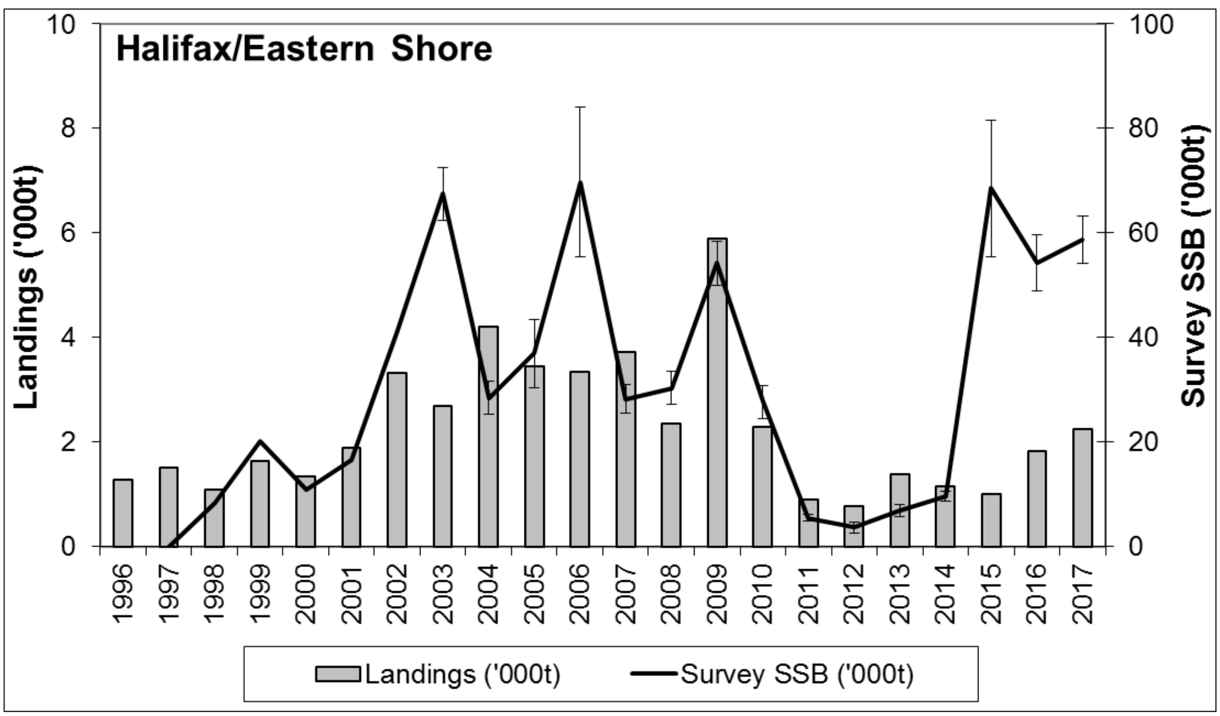

Figure 105. Herring landings and acoustic Spawning Stock Biomass (SSB) ('000 t) with 95% Confidence Intervals (C.I.) for the Halifax/Eastern Shore gillnet fishery from 1997–2017. No C.I. could be calculated for years prior to 2003.

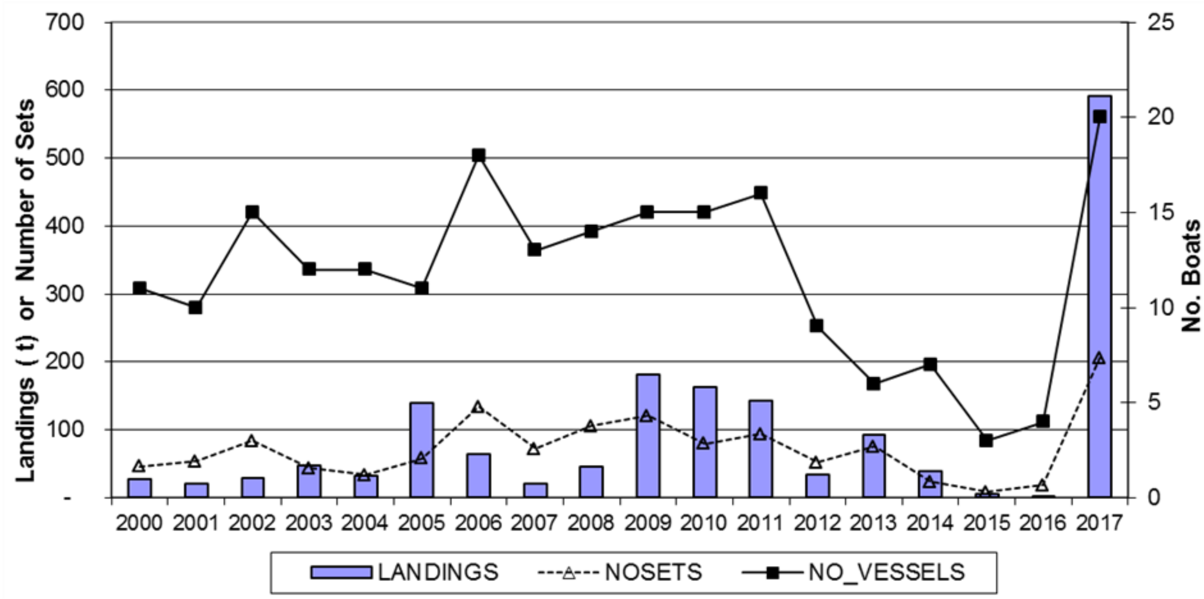

Figure 106. Herring gillnet total catch and total effort in number of vessels and number of sets for the Lunenburg Box area from Liverpool to Chebucto Head area (statistical districts 23–26) for 2000–2017. Note overlap of district 26 data with the Little Hope area used in Figure 58.

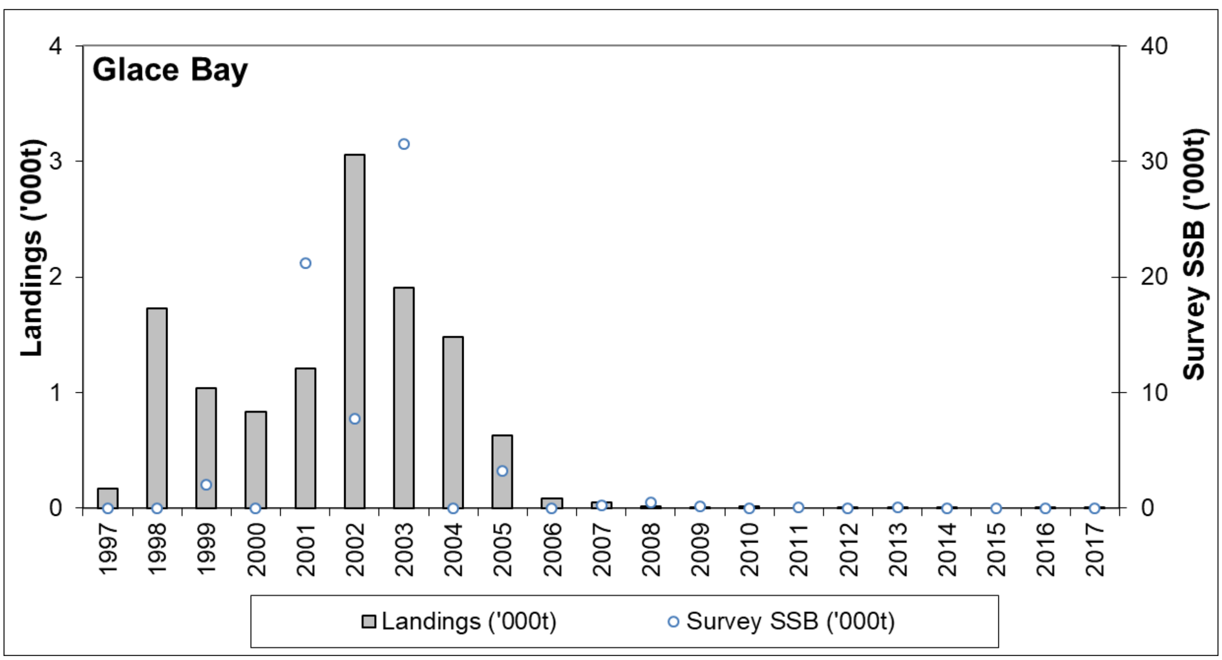

Figure 107. Glace Bay Herring catches and acoustic survey biomass estimates from 1997–2017. (Acoustic survey Spawning Stock Biomass (SSB) 1998–2002 'without' the Calibratiob Integration Factor (CIF); 2003–2012 with the CIF). No Confidence Intervals (C.I.) could be calculated due to limited number of surveys.

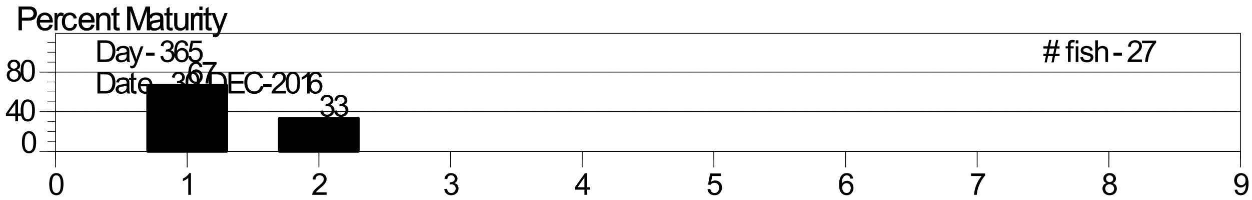

Figure 108. Herring maturity sample collected on December 30, 2016 from the Herring die-off event in St. Mary's Bay, Nova Scotia. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; and 8 = recovering.

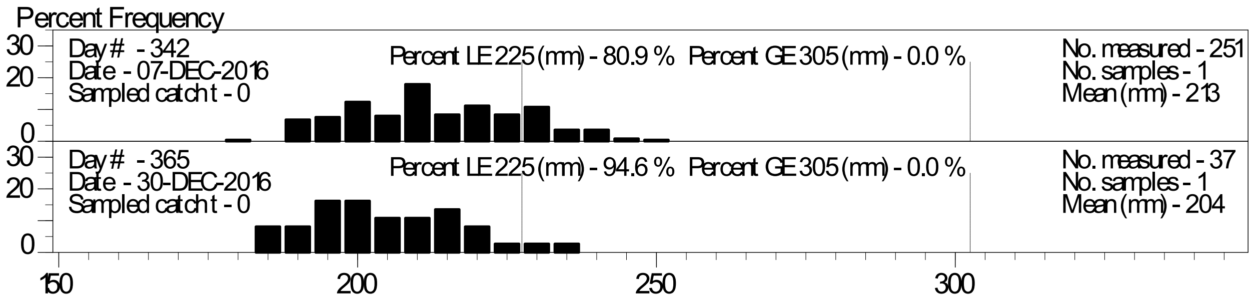

Figure 109. Length-frequency sampling collected on December 7, 2016 from Wedgeport, Nova Scotia and on December 30, 2016 from St. Mary's Bay, Nova Scotia during the Herring die-off event, with proportions < 23 cm and > 30 cm.

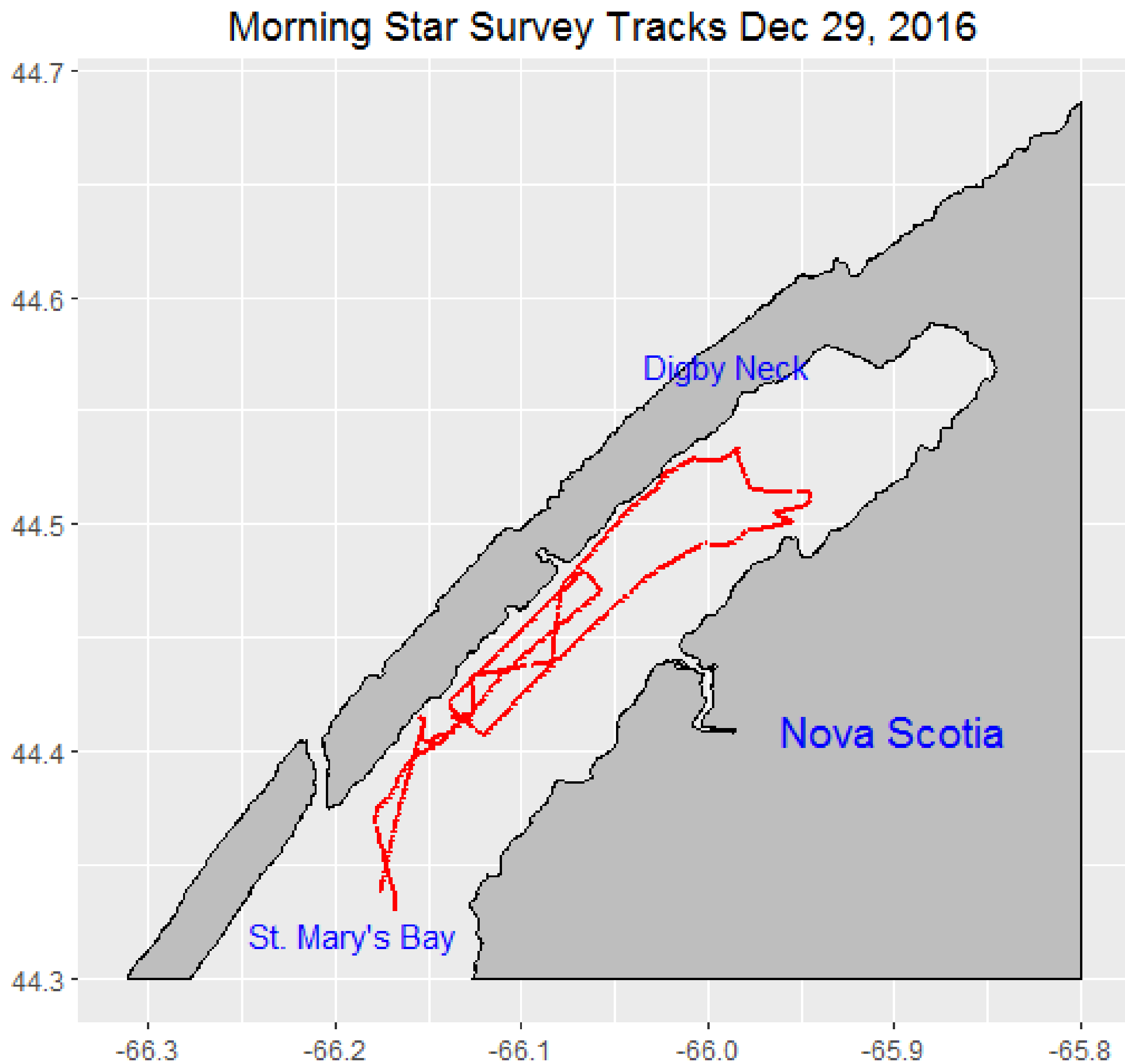

Figure 110. Acoustic transects of the Morning Star on December 29, 2016 in St. Mary's Bay, Nova Scotia during the Herring die-off event. The biomass estimate present in the area covered by the three parallel transects was calculated using both the standard and sample Target Strength (TS).

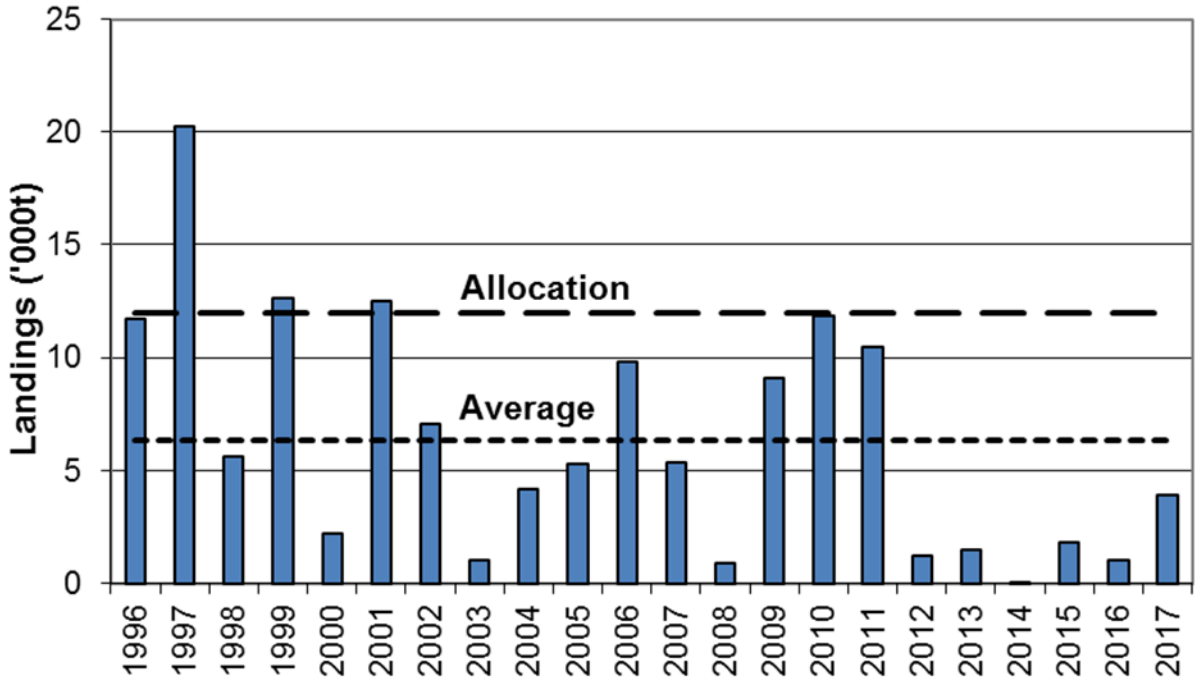

Figure 111. Offshore Scotian Shelf Component Herring landings (includes bycatch in other fisheries) from 1996–2017 with12,000 t allocation and the long term average.

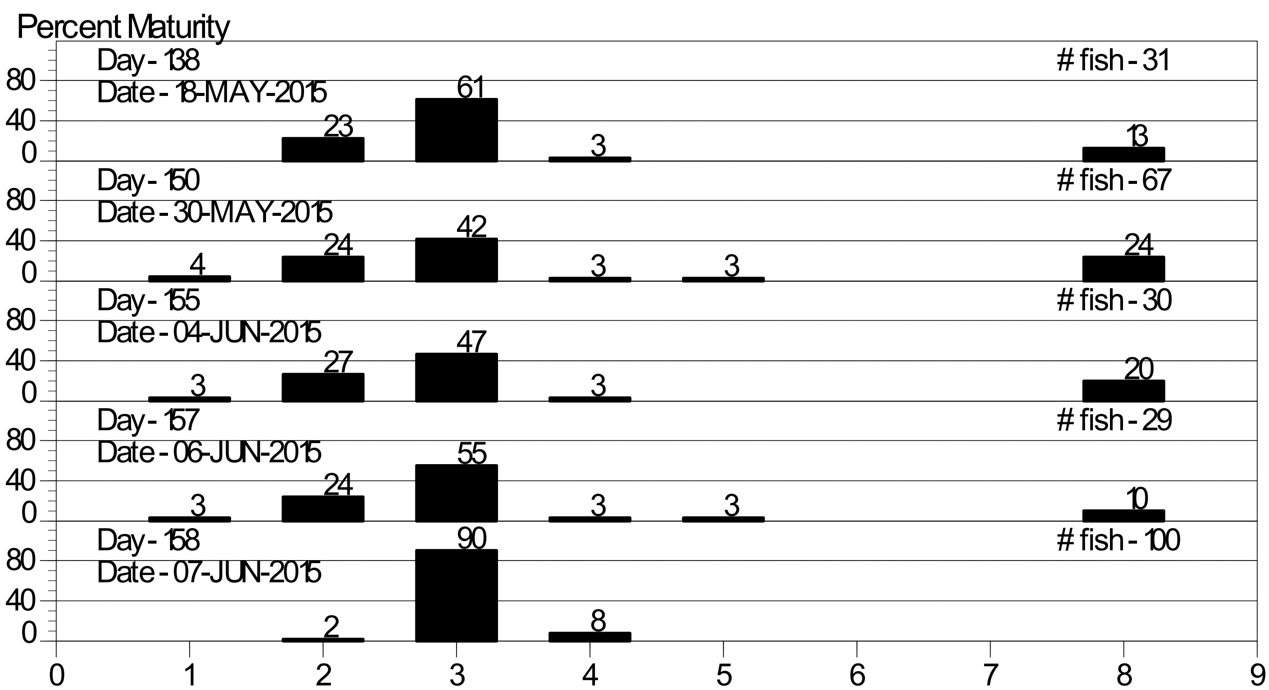

Figure 112A. Herring maturity samples collected from the Purse Seine Offshore Banks area in 2015. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; and 8 = recovering.

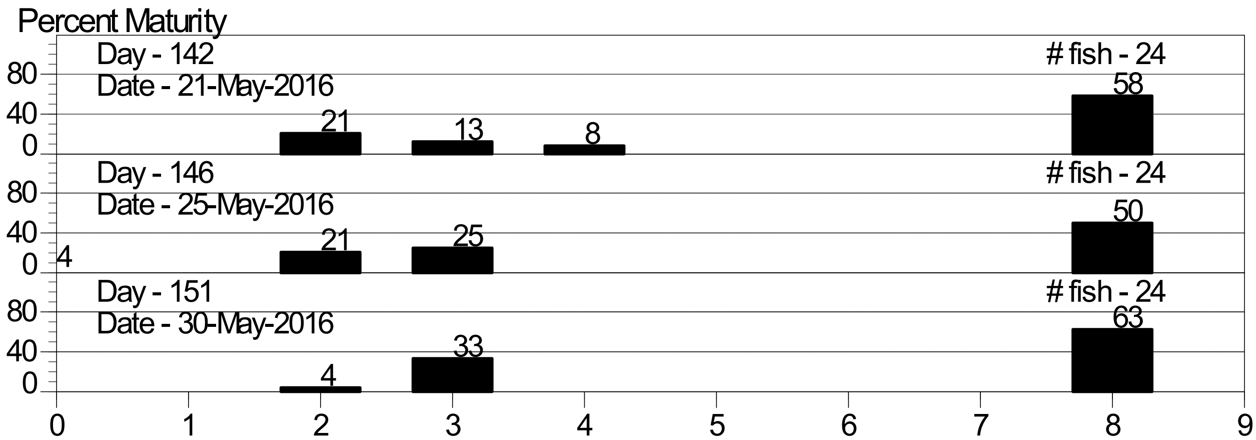

Figure 112B. Herring maturity samples collected from the Purse Seine Offshore Banks area in 2016. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; and 8 = recovering

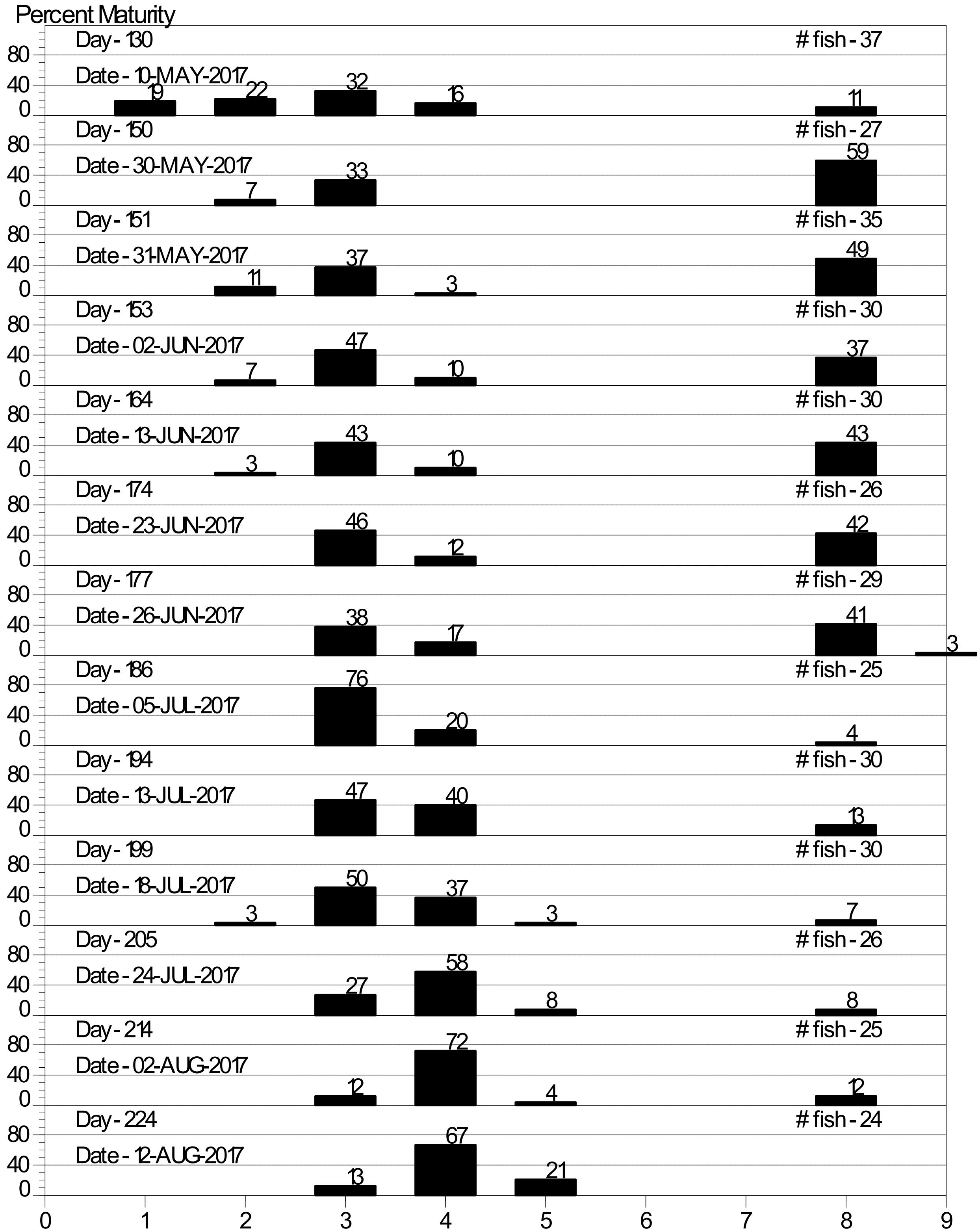

Figure 112C. Herring maturity samples collected from the Purse Seine Offshore Banks area in 2017. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; and 8 = recovering.

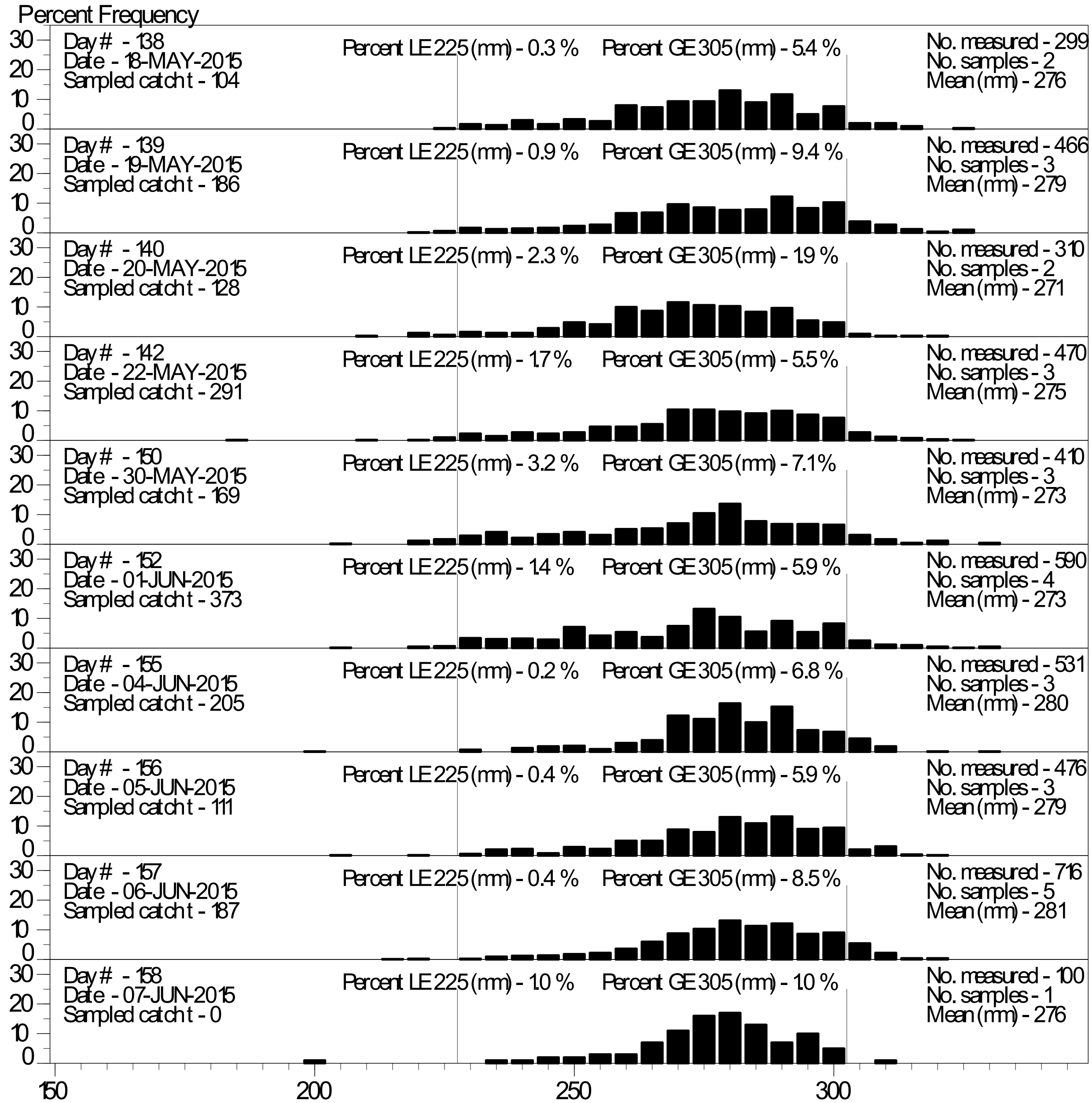

Figure 113A. Daily length-frequency sampling collected from the Purse Seine Offshore Banks area in 2015, with proportions < 23 cm and > 30 cm.

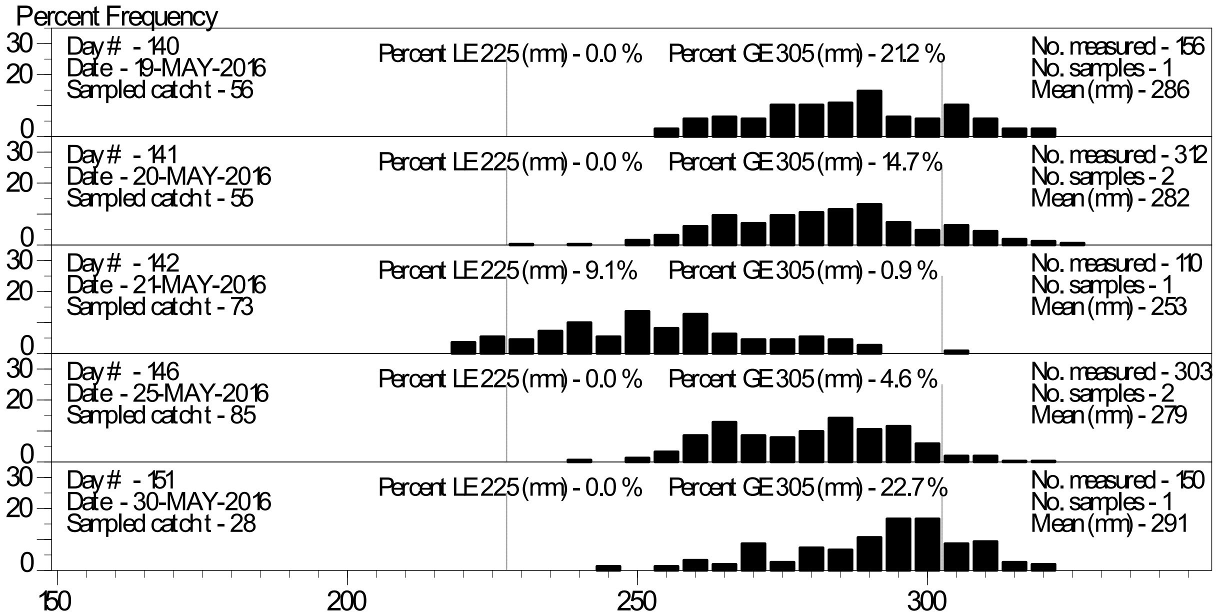

Figure 113B. Daily length-frequency sampling collected from the Purse Seine Offshore Banks area in 2016, with proportions < 23 cm and > 30 cm.

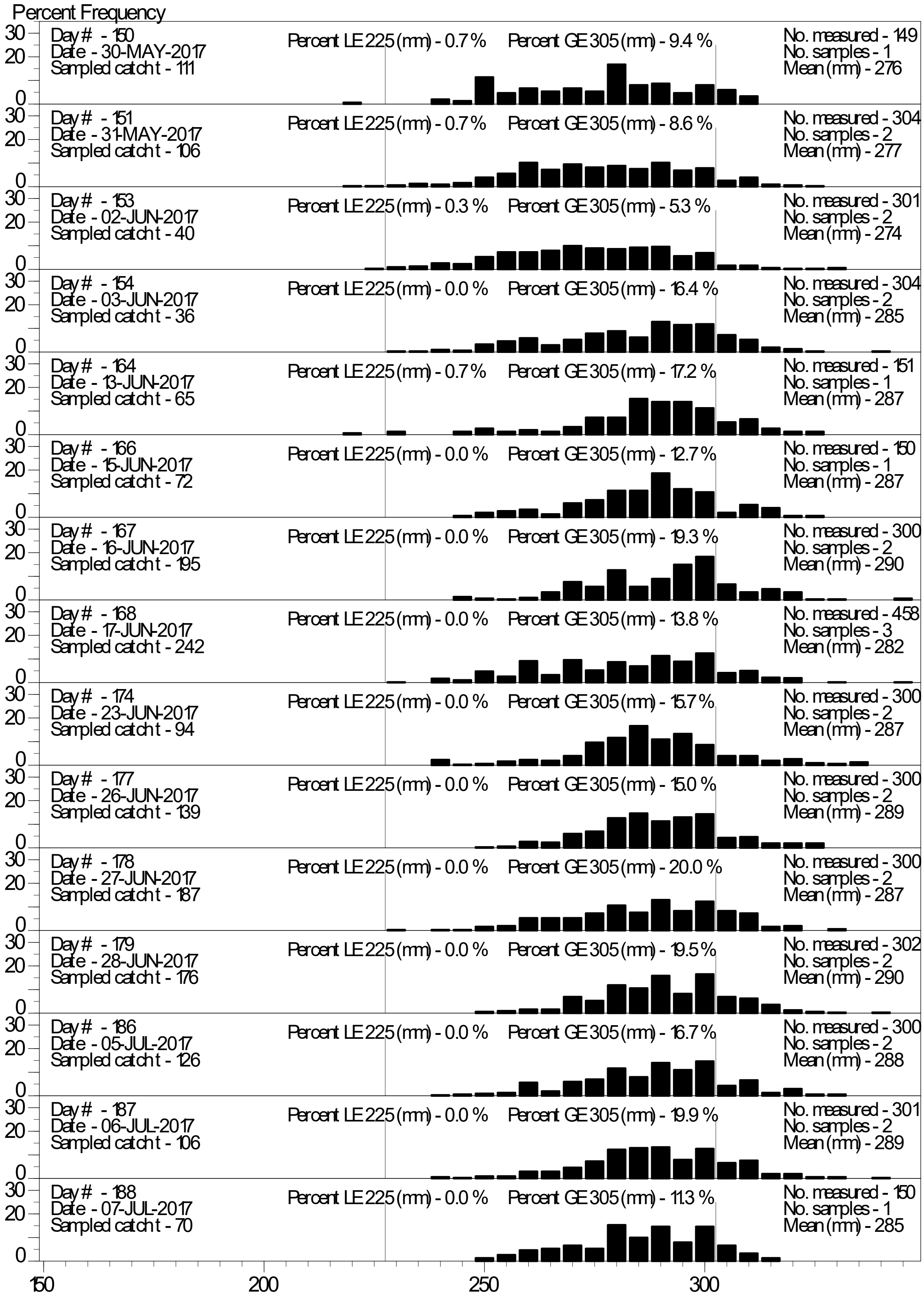

Figure 113C. Daily length-frequency sampling collected from the Purse Seine Offshore Banks area in 2017, with proportions < 23 cm and > 30 cm.

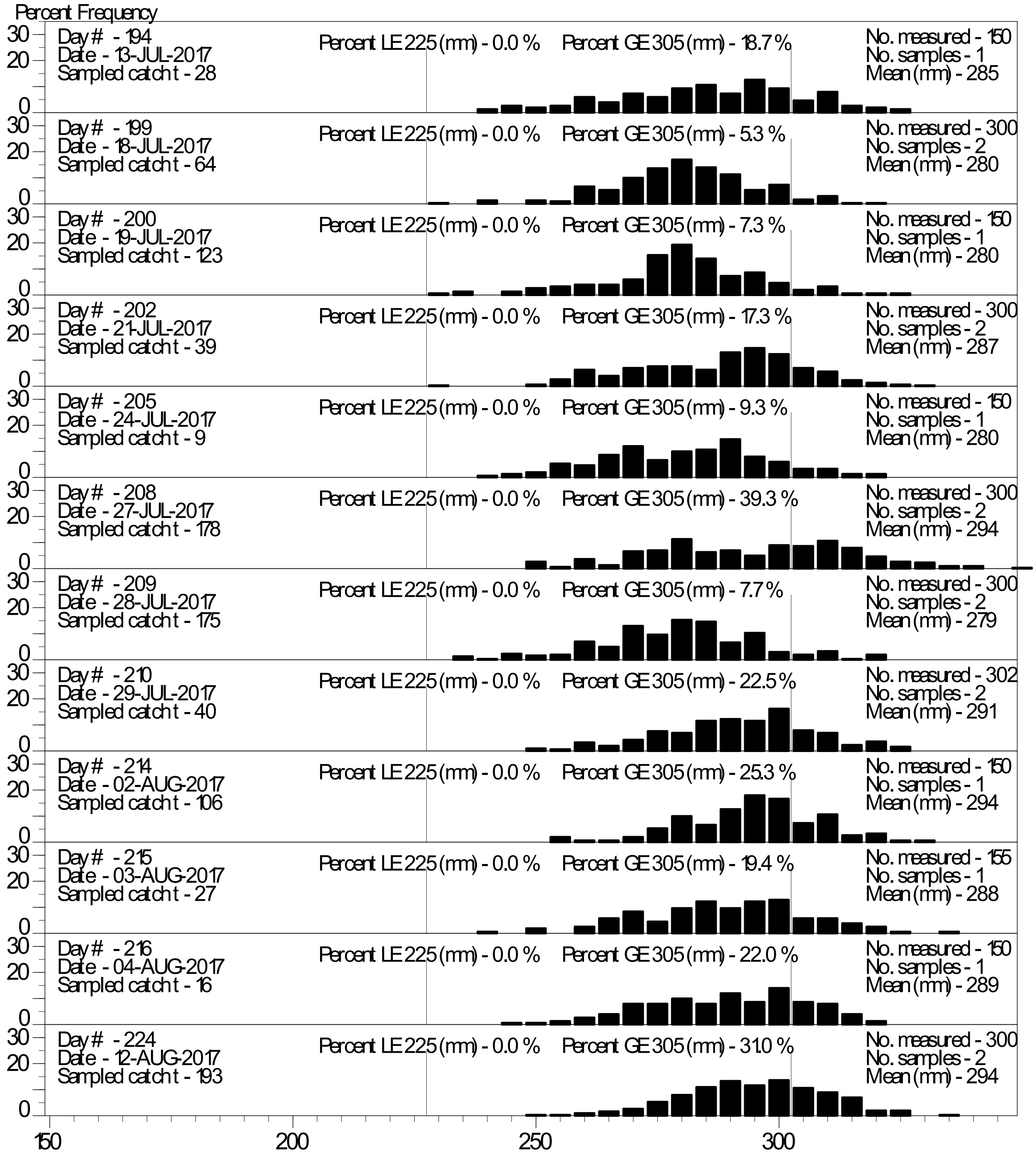

Figure 113C. (cont'd). Daily length-frequency sampling collected from the Purse Seine Offshore Banks area in 2017, with proportions < 23 cm and > 30 cm.

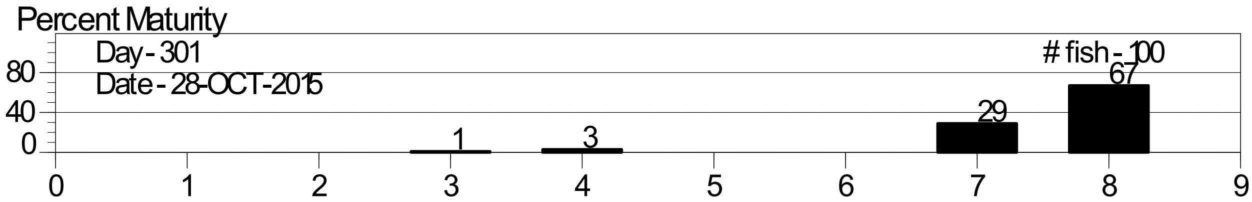

Figure 114 Herring maturity sample collected from the Commercial groundfish fishery Offshore Banks area in 2015 for DNA analysis. Staging codes are: 1-2 = immature; 3-4-5 = maturing/hard; 6 = ripe and running; 7 = spent; and 8 = recovering.

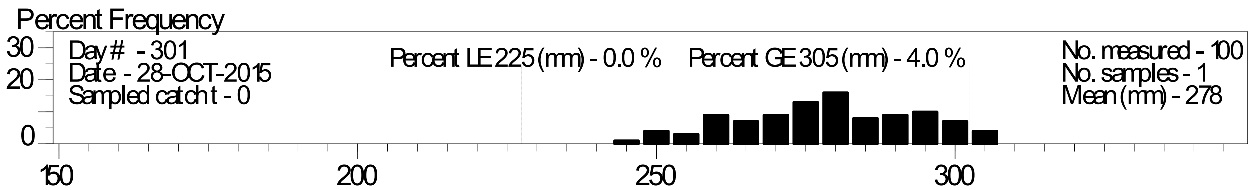

Figure 115. Daily length-frequency sampling collected from the Commercial groundfish fishery Offshore Banks area in 2015 for DNA analysis, with proportions < 23 cm and > 30 cm.