Fisheries and Oceans Canada | Pêches et Océans Canada
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Canadian Science Advisory Secretariat (CSAS)

Research Document 2016/060

Gulf Region

Fishery performance and status indicators for the assessment of the NAFO Division 4T southern Gulf of St. Lawrence Atlantic herring (*Clupea harengus*) to 2014 and 2015

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September 2016

Canada

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.

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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

Correct citation for this publication:

McDermid, J.L., Mallet, A., and Surette, T. 2016. Fishery performance and status indicators for the assessment of the NAFO Division 4T southern Gulf of St. Lawrence Atlantic herring (*Clupea harengus*) to 2014 and 2015. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/060. ix + 62 p.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Atlantic herring in the southern Gulf of St. Lawrence (sGSL) consists of two spawning components, spring spawners (SS) and fall spawners (FS). This document presents the most recent information on trends in abundance, distribution, and harvest for the SS and FS herring components in NAFO Div. 4T of the southern Gulf of St. Lawrence (sGSL). This includes catch-at-age and catch-per-unit-effort (CPUE) indices, fisheries-independent acoustic indices, a catch rate index from the experimental gillnet survey, mesh selectivity indices, and catches in the multi-species bottom trawl survey of the sGSL. The data and indices are reported for the whole-area for the SS and regionally-disaggregated (North, Middle, and South regions) for the FS where applicable.

Preliminary landing data to 2015 for SS show continued declines despite maintaining a consistent total allowable catch (TAC). For FS, preliminary landings in 2014 and 2015 were lower than in previous years, however, the TAC was also lower for this time frame. Some indices suggest an improvement in the fishery in 2015. The CPUE index for both SS and FS increased in 2015. The catch rates from the experimental net index for FS increased in the North region, remained constant in the Middle region, and declined in the South region. These results corroborate the opinions of fish harvesters from the telephone survey. Nonetheless, the fishery-independent survey indices remained among the lowest values in the time series. These data and indices are incorporated into virtual population analysis (VPA) models and used to assess the herring stock in NAFO Div. 4T.

Indicateurs de performance et de l'état des pêches pour l'évaluation du hareng de l’Atlantique (*Clupea harengus*) dans la division 4T de l'OPANO au sud du golfe du Saint-Laurent pour 2014 et 2015

RÉSUMÉ

La population de hareng de l'Atlantique dans le sud du golfe du Saint-Laurent est constituée de deux composantes de reproducteurs : les reproducteurs de printemps (RP) et les reproducteurs d'automne (RA). Ce document présente les renseignements les plus récents sur les tendances en matière d'abondance, de répartition et de récolte pour les composantes RP et RA dans la division 4T de l'Organisation des pêches de l'Atlantique Nord-Ouest (OPANO) au sud du golfe du Saint-Laurent. Cela comprend les indices de prises selon l'âge et de captures par unité d'effort (CPUE), les indices des relevés acoustiques indépendants de la pêche, un indice du taux de prise provenant de l'étude à l'aide de filets maillants expérimentaux, les indices de sélectivité du maillage et les prises dans le cadre du relevé plurispécifique au chalut de fond dans le sud du golfe du Saint-Laurent. Les données et les indices relatifs aux RP sont déclarés pour l'ensemble de la région et ceux relatifs aux RA, répartis par région (nord, centre et sud), s'il y a lieu.

Les données préliminaires sur les débarquements de 2015 pour les RP montrent un déclin continu malgré le maintien d'un total autorisé des captures (TAC) uniforme. Pour ce qui est des RA, les données préliminaires sur les débarquements de 2014 et de 2015 étaient moins élevées que les années précédentes, mais le TAC était lui aussi inférieur pour cette période. Quelques indices donnent à penser qu'il y a eu une amélioration de la pêche en 2015. L'indice de CPUE a augmenté pour les RP comme pour les RA en 2015. Le taux de prises de RA dans le cadre de l'étude à l'aide de filets maillants expérimentaux a augmenté dans la région du nord, est demeuré constant dans la région du centre et a diminué dans la région du sud. Ces résultats corroborent les opinions exprimées par les pêcheurs lors du sondage téléphonique. Néanmoins, les indices du relevé indépendant de la pêche restent parmi les plus faibles de la série chronologique. Ces données et indices sont intégrés aux modèles d'analyse des populations virtuelles (APV) et sont utilisés pour évaluer le stock de hareng dans la division 4T de l'OPANO.

1. INTRODUCTION

Atlantic herring in the southern Gulf of St. Lawrence (sGSL) are found in the area extending from the north shore of the Gaspé Peninsula to the northern tip of Cape Breton Island, including the Magdalen Islands. Adults overwinter off the north and east coast of Cape Breton in the Northwest Atlantic Fisheries Organization (NAFO) divisions 4T and 4Vn (Claytor 2001; Simon and Stobo 1983; Fig. 1). Studies in the early 1970s indicated that southern Gulf herring also overwintered off the south coast of Newfoundland, but an exploratory fishery in 2006 did not detect any concentrations (Wheeler et al. 2006). Herring are a pelagic species that schools particularly during feeding, spawning periods, and annual migrations. Eggs are attached to the sea floor and large females can produce up to 360,000 eggs (Messieh 1988). Age at first spawning is typically four years of age.

Herring in the sGSL are managed across seven herring fishing areas (HFA) in area 16 (A-G; Fig. 1a). These herring fishing areas cover the same region as NAFO division 4T (Fig. 1). The herring population in the sGSL consists of two spawning components, as spring spawners (SS) and fall spawners (FS). Spring spawning occurs primarily in April-May but extends to June 30 at depths <10 m. Fall spawning occurs from mid-August to mid-October at depths of 5 to 20 m, but can occur as early as July 1. The SS and FS of 4T herring are considered distinct stocks which are assessed separately. Herring also show high spawning site fidelity (Wheeler and Winters 1984; McQuinn 1997; Brophy et al. 2006) and local stocks are targeted by the gillnet fishery which takes place on the spawning grounds. Herring in sGSL are therefore assessed using regionally-disaggregated assessment models (North, Middle, South regions; Fig. 1b).

The sGSL herring is harvested by a gillnet fleet (referred to as “fixed” gear fleet) and a purse seine fleet (“mobile” gear fleet). The mobile gear fleet consists of five large southern Gulf vessels (> 19.8m). Nonetheless, some “small seiners” (<19.8m) can also participate in the inshore fishery as part of the gillnet fleet. The fixed gear fishery is focused in NAFO Div. 4T, whereas the mobile gear fishery occurs in Div. 4T and occasionally in Div. 4Vn (Fig. 1). During the spring (F_S) and fall (F_F) fishing seasons, the mobile fleet are prohibited from fishing in areas set aside exclusively for the fixed gear fleet (Claytor et al. 1998). In the F_S, mobile gear fleets fish along the northern boundary of NAFO region 4Tf, referred to as the “Edge” fishery. Both SS and FS herring are harvested in the F_S and F_F fisheries and must therefore be separated into the appropriate groups.

Prior to 1967, sGSL herring was mainly exploited by fixed gear and average landings from 1935 to 1966 were 34,000 t. In the mid-1960s, a mobile gear fishery was introduced and average landings by both fleets were 166,000 t from 1967 to 1972. Since 1981, the fixed gear fleet has accounted for most of the catch of SS and FS (LeBlanc et al. 2015).

A global allocation or Total Allowable Catch (TAC) was introduced in 1972 at 166,000 t, and reduced to 40,000 t in 1973. Separate TAC for the SS and FS components began in 1985. The TAC were first allotted by fishing season (F_S and F_F) and later attributed to SS or FS landings based on biological samples taken during the fishery. The percentage of SS and FS in the catch varies according to season and gear type. As a result, landings during the F_S and F_F fisheries must be separated into the appropriate SS and FS groups to determine if the Total Allowable Catch (TAC) for these groups has been attained.

2. DATA SOURCES

The regionally-disaggregated models for the three regions (North, Middle, South) cover the entire 4T area (Fig. 1). The regions are defined on the basis of traditional herring spawning beds and fishing areas:

- North (Gaspé and Miscou; 4Tmnopq),
- Middle (Escuminac-Richibucto and west Prince Edward Island; 4Tkl), and
- South (east Prince Edward Island and Pictou; 4Tfghj) (Fig. 1).

The choice of three regions was dictated by geographic proximity of spawning beds and is the finest level of disaggregation that can presently be supported by the available data. The regionally-disaggregated models include inputs that are region-specific (e.g., catch-at-age, catch-per-unit-effort) and inputs that are common to the entire area (e.g., acoustic survey index, size-at-age).

When calculating region-specific catches-at-age, catches made by herring seiners during the fall were attributed to the region in which they were made, whereas catches made during the late spring and summer were attributed to the South region, which is most proximate to the location of capture. Catches made in NAFO Div. 4Vn during a winter fishery that took place prior to 1999 were attributed to the regional catches in proportion to those regional catches.

2.1 LANDINGS

Catch data were taken from purchase slips and ZIFF (zonal interchange file format) files collected by the Statistics Branch of Fisheries and Oceans Canada (DFO). Catch data to 1985 are available by fishery (fixed and mobile) and by fishing area. Beginning in 1986, the catch data are further reported by vessel and trip. The ZIFF files are based on information collected by the Dockside Monitoring Program (DMP). This program provides accurate, timely, and independent third-party verification of fish landings. Contracted companies are hired by the fishing industry to observe the offloading of fish and to record and report the landings information to DFO.

The fishery TAC for the spring and fall spawner components is set for the 4T stock unit. The 2014 TAC was distributed between the SS at 2,000 t and FS at 35,000 t for a total of 37,000 t (Table 1; Fig. 2). In 2015, the TAC was 2,000 t for SS and 40,000 for FS (Table 1; Fig. 2). Seventy-seven percent of the TAC was allocated to the fixed gear fleet with the remaining 23% for the mobile gear fleet (Table 1).

The preliminary estimated landings of SS herring in both the F_S and F_F fisheries were 1,250 t and 1,190 t for 2014 and 2015, respectively (Table 1; Fig. 3). Most of the SS herring were estimated to have been landed in the fixed gear fleet over the 1981 to 2015 period. In 2014 and 2015, the fixed gear fleet was estimated to have landed 61% and 49%, respectively, of the total harvests of SS herring (Table 1; Fig. 3). Generally more than 90% of the SS herring landed by the fixed gear fleet is landed during the spring fishing season, whereas most (> 75%) of the SS herring landed by the mobile fleet is landed in the fall season (Fig. 3).

The preliminary landings of FS in 2014 and 2015 were 29,214 t and 28,138 t respectively (Table 1; Fig. 3). The 2014 TAC was 35,000 t while in 2015, the TAC was 40,000 t. Over the 1978 to 2015 period, most of the FS herring have been landed in the fixed gear fleet. In 2014 and 2015, the fixed gear fleet was estimated to have landed 89% and 92%, respectively, of the total harvests of FS herring (Fig. 3). The majority (nearly 100%) of the FS herring captured in the fixed gear fishery are landed during the fall fishing season. The mobile fleet has landed varying amounts of FS herring in the fall, 32% to 44% during 2013 to 2015 (Fig. 3).

The mean percentages of the total catch caught by fixed gear during the recent period, 2010 to 2015, was 55% of the SS and 92% of the FS (Table 1). The majority of the 2014 to 2015 FS fixed gear catches occurred in herring areas 4Tm (North) and 4Th (South) (Table 2). Meanwhile, the majority of the 2014 to 2015 FF fixed gear catches occurred in herring area 4Tmn (North((Fig. 1; Table 2). The mobile gear (Edge) F_S landed 1,941 t and 1,433 t in 2014 and 2015, respectively. The F_F mobile gear catches in 2014 and 2015 were all from 4Tmn (North) (Fig. 1; Table 2).

In 2014, 62.5% of the SS TAC was attained. In 2015, 59.5% of the SS TAC was attained. For the FS component, 83.5% of the FS TAC was attained in 2014 and 70.3% of the FS TAC in 2015. Herring fishing area specific percentages of TAC attained can be found in Table 2.

A rebuilding plan was introduced for the SS in 2010 and renewed in subsequent years (DFO 2010, 2012, 2014). The plans included:

- fishing closures on some spawning areas in all HFA except 16A and 16F,
- weekly landing limits of 10,206 kg in all HFA except 16A, 16D, and 16F, where no restrictions applied, and
- no nets or herring allowed on board during a fishing trip between 18:00 and 04:00 (ADT) in 16C-G and between 22:00 and 03:00 (ADT) in 16A and 16B.

2.1.1 Spawning stock assignment

Three methods are used to assign herring samples to either SS or FS based on gonad maturity stages (Cleary et al. 1982).

- For immature herring of maturity stages 1 and 2 (juveniles), the season of hatching is based on the size at capture and visual examination of otolith characteristics (Messieh 1972). The spawning component assignment for juvenile herring is its hatching season (Cleary et al. 1982). Juveniles represent a small proportion of the commercial catch, but are a higher proportion in the research survey samples.
- Adult herring with ripe or spent gonads are assigned their maturity stage by macroscopic laboratory examination of the gonads. The fish are assumed to belong to the spawning component of the season in which they were caught. These represent over 90% of the gillnet catches and 75% of the total yearly landings.
- Adult herring with unripe gonads are assigned their maturity stage by using a gonadosomatic index (GSI) based on a discriminant function model. The GSI is based on the length of the fish and its gonad weight (McQuinn 1989). Once the maturity stage is determined by GSI, the spawning component is assigned by using a maturity schedule decision rule (a table cross-referencing maturity stage assigned by GSI and the date of capture to assign a spawning component) (Cleary et al. 1982).

For the month of June, the GSI and macroscopic examination methods resulted in different assignment of samples to spawning components. In particular, the 2012 and 2013 Cabot Strait Edge fishery samples were not well classified by the GSI method. The macroscopic examination identified at least 95% of the gonads as developing gonads therefore classifying them as FS. The GSI discriminant function reclassified at least 20% of these developing gonads as spent gonads resulting in a classification of SS. A change was made to the decision rules for the GSI method such that a “spent” gonad in June is classified as a FS.

2.2 TELEPHONE SURVEY

A telephone survey has been conducted annually since 1986 to collect information on the fixed gear fishery and opinions on abundance trends (details in LeBlanc and LeBlanc 1996). The sGSL was divided into eight telephone survey areas corresponding to the areas where the major fisheries occur (Fig. 1c). Active commercial licence holders were asked a series of questions concerning the number, dimensions, and mesh size of nets used, the frequency of fishing and how the abundance in the current year compared to the previous year, and the medium-term trend. A 2008 review of the consistency of the abundance relationship among years concluded that this index should not be used as an aggregated biomass index in the population model. The telephone survey responses do inform fishing effort which is related to the nets and fishing frequency.

The 2014 fixed gear telephone survey contacted 172 fishermen randomly selected out of approximately 665 active commercial licence holders in both seasons combined. Twenty-seven fishermen responded to the F_S survey and 124 F_F fishermen responded for a total of 151. The 2015 fixed gear telephone survey contacted 148 fishermen randomly selected out of approximately 493 active commercial licence holders in both seasons combined. Twenty-two fishermen responded to the F_S survey and 73 F_F fishermen responded for a total of 95. The distribution of respondents across the eight telephone survey areas, mean net hauls, net lengths, and trend in the abundance from the previous year are summarized in Table 3. Overall, fishermen felt that abundances in the 2015 F_S were lower than in 2014, whereas for the F_F there was an overall sense of increased abundance in the North and Middle regions and a decrease in the South (Table 3).

The gillnet data chosen for the abundance index were those with the greatest number of records in a given year (Table 3). In the F_S, mesh sizes of gillnets have been relatively constant at 2½". In the F_F, 2⅝" mesh is the most standard mesh size, however in 1992, many fishers started using bigger mesh sizes (2¾"). By 2002, the proportion of 2⅝" mesh reverted to pre-1992 numbers. The percentages of nets of 2⅝" mesh used in 2015 ranged from 92% to 100% (Table 3).

Patterns were noted in the 2015 DMP data indicating that the gillnet length information varied by several fathoms for a given fishermen from day-to-day. The differences seemed related to the DMP sampler. Discussions with the fishing industry confirmed that the same gear is used throughout the season therefore such differences should not exist. Examination of historical DMP records showed that this pattern has always existed. The mean number and length of gillnets were compared between DMP and telephone survey data and found to produce similar results (LeBlanc et al. 2015; Table 3).

2.3 FISHERY SAMPLING

Commercial fishery catches are sampled at dockside by DFO scientific personnel for the fixed and mobile fisheries, and at sea for the mobile fishery by fisheries observers. Sampling procedures are designed to obtain samples that are spatially and temporally representative of landings. The landings and samples by area used to calculate the catch-at-age are summarized in Table 2. The samples are used to determine the size, age, and spawning component (SS or FS) composition of the catch. Yearly age reading consistency tests are done in order to evaluate and ensure the consistency of age reading over time (Appendix A).

2.4 FISHERY-INDEPENDENT ACOUSTIC SURVEY

Since 1991, an annual fishery-independent acoustic survey of early fall (September-October) concentrations of herring in the sGSL has been conducted. The standard annual survey area

occurs in the 4Tmno areas where 4T herring aggregate in the fall. In some years, the acoustic survey also covered waters north of P.E.I. The survey uses a random stratified design of parallel transects within predefined strata. Surveys are conducted at night and employ two vessels: an acoustic vessel to quantify the biomass of fish schools using a hull-mounted 120 KHz single beam transducer, and a fishing vessel to sample aggregates of fish with a pelagic trawl (details in LeBlanc and Dale 1996 and LeBlanc et al. 2015). The acoustic survey in 2014 covered a total transect distance of 1,128 km within the 4Tmno areas and in 2015 the survey covered 886 km (Appendix Figure B1). Appendix Figure B1 shows the distribution of estimated herring schools during the 2014 survey. The samples are used to separate the observed biomass by spawning component and age, determine species composition, and the size distribution for the estimation of the target strength (methods described in LeBlanc and Dale 1996 and LeBlanc et al. 2015).

The 2014 acoustic biomass index of the 4Tmno areas for SS and FS combined was 67,378 t. The biomass was composed of 14% SS and 86% FS. A complete summary of the acoustic survey results is available in Appendix B.

2.5 EXPERIMENTAL GILLNETS

In this industry partnership project between DFO and the provincial fishery associations, experimental gillnets, consisting of multiple panels of varying mesh size, were deployed approximately weekly by fishermen during the F_F. These modified gillnets catch a wider range of fish sizes and provide information on the relative selectivity of various mesh sizes. Catches from the experimental nets project have been used to estimate the relative size-selectivity of gillnets of different mesh sizes and to produce age-disaggregated abundance indices (Surette et al. 2016a). Both are inputs to the revised FS assessment model.

Each experimental gillnet had five panels, each with a different mesh size, from a set of seven possible mesh sizes, ranging from 2" to 2¾" in ⅛" increments. All gillnets had panels with mesh sizes of 2½", 2⅝", and 2¾", plus two smaller mesh sizes that varied among fishermen. Harvesters in the F_F participated in the study on the following spawning grounds (Fig. 1a): Miscou Bank (North region; 16B), Gaspé (North; 16B), Escuminac (Middle; 16C), West PEI (Middle; 16E), Fisherman's Bank (South; 16G), and Pictou (South; 16F). The target fishing procedure was a one hour soak and nets were set during the commercial fishery on the fishing grounds. Data from Pictou prior to 2015 were corrected for gillnet depth as nets in this region were 5 m (17 feet) deep compared with the standard 2.4 m (8 feet) used on other spawning grounds. A correction factor of 8/17 (in feet) was applied to the Pictou nets to address the difference in net depth size.

2.6 SPAWNING GROUND ACOUSTIC SURVEYS

In 2015, a spawning ground acoustic survey project was initiated that follows the design of the fishery-independent acoustic survey (Section 2.4). The survey design uses random parallel transects within predefined strata that cover the same spawning grounds as the experimental nets (Section 2.5; Appendix C). The survey is an industry partnership between DFO and the provincial fishery associations. Surveys are conducted by fishermen according to protocols developed by DFO. The survey is conducted at night during the F_F weekend fishery closures except in herring fishing areas 16C and 16E (Middle; Fig. 1a). The Middle region does not have weekend closures, therefore the survey can only be conducted pre- and post-season. The spawning ground acoustic survey is meant to provide a nightly estimate of spawning biomass among regions. It is analyzed in the same manner as the acoustic survey (Section 2.4). The catches from the experimental nets (Section 2.5) are used to calibrate the target strength for the acoustics in order to obtain the nightly estimates of spawning biomass.

This pilot project was not directly incorporated into the assessment models. The results of the first year of data are available in Appendix C. The results highlight the importance of following protocol and weekly estimates in assessing local relative abundances. While the results are not used in this assessment, the goal is to include these results in later assessments when annual and consistent data is available.

2.7 MULTISPECIES BOTTOM-TRAWL SURVEY

The annual multi-species bottom trawl survey, conducted each September since 1971, provides information on the abundance and distribution of 4T herring throughout the sGSL in September (Benoît et al. 2009; Savoie 2014). Total catch weights and numbers, a representative length frequency, and representative individual length-weight data have been recorded for each fish species in each survey set since 1971. Since 1994, additional sampling of herring catches has been undertaken to disaggregate catches by spawner group and age. Additional details are provided in Hurlbut and Clay (1990). Herring aging data from the multispecies bottom-trawl survey catches was only available up to 2011 for this assessment.

Herring were primarily caught near shore in waters < 30 fathoms, mostly north and east of P.E.I., west of Cape Breton, as well as in the Northumberland Strait and St. Georges Bay (Appendix Figure D1). The number and weight of 19 to 26 cm herring per tow, the size-class representing herring not recruited to the fishery and of ages 2 to 3, increased slightly in 2014 and 2015 (Appendix Figure D2). The numbers and weights of herring large enough to be captured in the F_F (>26 cm) have also increased in 2014 and 2015.

3. INPUTS AND INDICES

3.1 CATCH-AT-AGE AND WEIGHT-AT-AGE MATRICES

Catch-at-age and weight-at-age matrices for 4T herring SS and FS include catches made by both fixed and mobile gear fleets. These were calculated using age-length keys and length-weight relationships for each spawning component, gear type, and fishing season (Table 2). When fewer than 30 fish were sampled for detailed analysis, the overall length-weight relationship and age-length key most similar and adjacent in gear, geography, and time were used to estimate the catch-at-age. Catch-at-age and weights-at-age are presented for fixed gear (SS: Tables 4 and 5; FS: Tables 6 and 7) and mobile gear (SS: Tables 8 and 9; FS: Tables 10 and 11). Region-specific catch-at-age and weights-at-age are reported for the FS fixed gear (Tables 6 and 7).

The dominant age in the 2014 SS catch was age 6 and in 2015 it was age 7 (Tables 4 and 8; Fig. 4). These both belong to the 2008 year-class. For FS, the dominant age was 8 in both 2014 and 2015 (Tables 6 and 10; Fig. 5), representing the 2006 and 2007 year-classes.

Beginning of year weights-at-age are calculated from the weight-at-age for fixed and mobile gear combined. These are calculated from the average of the weight-at-age and the weight-at-age for the following age-class. The 2015 beginning of year weights-at-age were averaged from the 2012 to 2015 commercial weights adjusted to the beginning of the year.

Mean weight-at-age of the SS caught in the mobile and fixed gears in the spring season have declined since the 1990s for mobile gear, and since the mid-1980s for the fixed gear (Tables 5 and 8; Fig. 6a). Mean weights-at-age of FS herring from fixed and mobile gears have declined almost continuously over the period 1978 to 2011 (Tables 7 and 11; Fig. 6b). The mean weights observed in recent years are declining for all ages (Tables 5, 7, 9, and 11; Fig. 6). Lower mean

weights are an indication of the status of the stock, and affect the stock biomass estimate when numbers are converted to weight.

3.2 CATCH-PER-UNIT EFFORT

The fixed gear fisheries occur on the spawning grounds and landings from this fishery account for approximately 60% of the SS and more than 90% of the FS catch. Fixed gear catch and effort data were used to construct age-disaggregated abundance indices for SS and FS herring, based on catch-per-unit-effort (CPUE). The fixed gear CPUE indices are defined as catches in kg per net-haul per day (or kg per net-haul per trip). Age-specific CPUE indices for ages 4 to 10 are used in the assessments of the stock.

Catch data were taken from the landings data. Fishing effort was calculated as the average number of gillnets deployed by season and area for the sGSL since 1978. From 1978 to 1985, the average number of nets used was obtained from questionnaires done on wharves and by mail (Clay and Chouinard 1986). Since 1986, the fishing effort was calculated as the number of trips (purchase slips) multiplied by the estimated number of standard net hauls, which were determined from the DMP records and the annual telephone survey depending on which has the most data (Table 3). F_F data on the number of nets set are available since 1978 and the number of hauls since 1986. F_S catch and effort DMP records are available since 1990. Nets are standardized to a length of 14 fathoms (25.6 m).

The percent of fixed gear fishing days with no catch has been recorded since 2006 based on responses to the telephone survey (Table 12). The percentage of days with no catch in 2014 and 2015 are the highest in the time series for the F_F fixed gear fishery. Since this information is available only for the most recent period, it is not presently included in the calculation of fishing effort. Furthermore, uncertainty about how the question is interpreted by respondents resulted in the question being revised for the 2015 telephone surveys.

A multiplicative model (GLM) is used to calculate the standardized indices, based on the following formulation:

$$\ln(CPUE_{ijk}) = \alpha + \beta_1 I + \beta_2 J + \beta_3 K + \epsilon$$

where i indexes year, j indexes telephone survey area , k indexes week, and ϵ is the residual error. For the SS, the model was applied to the data for the whole stock area. For the FS, models were run by region (North, Middle, and South) and did not include the area term. The SS analysis was limited to weeks 9 to 22, whereas the FS analysis was restricted to weeks 27 to 43.

The models explained over 40% of the variance in the data and the factors for year, week, and area were statistically significant (Table 13). Age-specific CPUE indices for ages 4 to 10 are used in the assessments for the SS and FS stock. The age-specific abundance index for ages 4 to 10 was derived by dividing the gillnet catch-at-age by the standardized effort (CPUE) from the multiplicative GLM model. The CPUE age-specific abundance index included the years 1986 to 2015. The indices presented in Tables 14 and 15 and Figures 7 and 8 account only for catch and effort, and do not account for possible changes in selectivity or catchability, which are addressed as part of the population modelling (Swain 2016). The CPUE index for SS and FS shows internal consistency as the abundance of cohorts is correlated between years (Figs. 7 and 8).

Decreases in the CPUE of younger fish and increases in the CPUE of older fish have been observed for both the SS and FS (Tables 14 and 15; Figs. 7 and 8), however for the FS, the declines in younger fish have been more pronounced in the South region (Fig. 8).

Fixed gear catches of SS in 2014 and 2015 were composed mostly of ages 6 to 8 (Table 14; Fig. 7). In the North region, catches of FS in 2014 were dominated by ages 7 and 8 (2006 and 2007 year-class) and in 2015 by age 6 (2009 year-classes). In the Middle region, catches of FS in 2014 were dominated by age 7 (2007 year-class) and in 2015 by ages 6 and 8 (2007 and 2009 year-classes) (Table 11; Fig. 8).

The overall CPUE was lower in 2014 than in 2015 for both the SS and FS, except for the FS in the South region where levels were very similar between years (Tables 14 and 15).

3.3 FISHERY-INDEPENDENT ACOUSTIC SURVEY INDEX

A second standardized abundance index is generated from the annual fishery-independent acoustic survey. This index includes catch-at age data from NAFO areas 4Tmno which have been surveyed yearly since 1994. The age-disaggregated acoustic abundance indices for ages 2 to 10 for SS and FS are presented in Table 16.

The SS assessment model uses the age-disaggregated abundances for ages 4 to 8 (Table 16). The acoustic survey estimated that catch rates (in numbers) of SS ages 4 to 8 increased in 2014 (Fig. 9). The 2014 4Tmno acoustic survey catches of the SS were dominated by age 2 herring and in 2015 by age 3 herring, the 2013 year-class in both years (Table 16; Fig. 9).

For the FS assessment model, the acoustic survey provides a useful abundance index of recruiting herring of ages 2 and 3 (LeBlanc et al. 2015). It is not thought to provide a useful abundance index for older ages given that the survey is limited to a restricted portion of the sGSL at a time when older FS herring are in areas throughout the sGSL spawning. This index suggests that the abundance of two year olds was relatively high in 2014. In contrast, the abundance of three year-olds was low (Fig. 9). The 2014 FS were also dominated by the 2013 year-class (age 2) (Table 16; Fig. 9).

3.4 EXPERIMENTAL NET INDICES

3.4.1 Catch-at-age of experimental nets

Region-specific age-disaggregated abundance indices are generated for the FS assessment from standardized experimental net data (Table 17). This index includes catch-at age data based on a one hour soak time. The experimental net index suggests an increase in young herring (ages 2 to 4) until 2009, after which the numbers decline, and no major trend over time are observed for older ages (Fig. 10). The indices suggest that there may have been an increase in herring abundance in the North, no strong trend in the Middle region, and an overall decline in the South region, particularly at younger ages (Fig. 10).

3.4.2 Relative selectivity index

A relative selectivity index was developed to account for variations in the proportions of 2⅝” and 2¾” meshes used by commercial fishermen, as well as changes in mean length-at-age which have generally decreased over time. Annual age-length keys were first derived from age samples collected from the commercial gillnet fishery from 1986 to 2015 and the experimental gillnet study from 2002 to 2015 during the months of August to October. Annual catch-at-length estimates for the commercial gillnet fishery from 1986 to 2015 were then calculated using length frequency samples gathered over the same months. The age-length keys and catch-at-length estimates were combined to yield catch-at-lengths by age and year. At this point, two selectivity-at-length curves, estimated from the gillnet selectivity study and assumed constant over time, were applied to these catch-at-lengths; one corresponding to the 2⅝” mesh size and the other to the 2¾” mesh size. Summing over lengths yields annual catch-at-age estimates for the

commercial fishery by mesh size. The ratio of the mesh size adjusted catches-at-age to the fishery catch-at-age yields selectivity-at-age proportions by mesh size and year. These selectivity-at-age proportions (Table 18; Fig. 11) were then applied to catch-at-age CPUEs for the 2⅝" and 2¾" mesh sizes. A weighted sum of these two CPUEs using the proportion of fishery catches from each of the two mesh sizes yielded an adjusted CPUE catch-at-age for the fall fishery.

3.5 Multispecies bottom-trawl index

Catches of herring in the multispecies bottom-trawl survey can be quite variable, even within areas where herring are common (Savoie, 2014). This age-disaggregated index was calculated using data from 1994 to 2011 for the FS only. Nonetheless, catch-at-age (mean number per tow) of FS herring in the multispecies trawl survey was estimated using a Bayesian estimation model (Surette et al. 2016b). Internal consistency was assessed and only ages 4 to 6 showed sufficiently strong correlations within cohorts to be considered an appropriate index (Benoît et al. 2016; Surette et al. 2016b). Since the ages of herring from surveys beyond 2011 were not available at the time of this assessment, only data for ages 4 to 6 from 1994 to 2011 were included in the FS assessment model (Surette et al. 2016b; Table 19; Fig. 12).

3.6 MATURITY OGIVE

For the purposes of the assessment, herring are assumed to follow a knife-edged maturity schedule, with 100% maturation occurring between the ages of 3 and 4.

4. SOURCES OF UNCERTAINTY

Fishery dependent indices, such as the commercial gillnet CPUE indices, may not be proportional to abundance due to changes in catchability over time. On one hand, catch rates can remain elevated despite decreases in abundance (increased catchability) due to contractions in stock distribution and targeting of aggregations by fishing fleets, and due to improved fishing technology and fishing practices. On the other hand, catch rates can be negatively affected by boat limits, saturation of nets at high abundance, and closure of prime fishing areas that redirect fishing effort to other locations. Catch rates calculated on the basis of realized landings and available fishing effort information would be subject to such effects. The estimation of time-varying catchabilities in the SS and FS assessments accounts for some of the effects listed above.

The commercial CPUE calculations are subject to uncertainty. The estimates are based on regional average seasonal values of fishing effort data (number of nets, number of hauls, and net length of gillnets) from the telephone survey and not trip-specific information. Trips with no catch are not documented prior to 2006 and therefore not incorporated in the effort data. No information is collected on the soak time of nets. There are also potential inconsistencies in the reporting of effort data within and among regions and seasons.

The weight-at-age of herring has declined and remains at near record low levels. The causes of these declines in weight-at-age and the consequences to recruitment rate are unknown.

Catches of herring in bait fisheries are presently not accounted for in the assessments of either spring or fall spawner components. Catches in these fisheries are meant to be recorded in harvester logbooks but compliance with the requirement to complete and return logbooks to DFO is low. Catches of herring in the bait fishery are expected to be much lower than landings in the commercial fishery, nonetheless this unaccounted fishing mortality constitutes a source of uncertainty in the total fishing mortality.

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TABLES

Table 1. Landings (in tons) of 4T herring in the spring (F_S) and fall (FF) fisheries by gear (fixed and mobile) and spawning group (SS=spring spawners and FS=fall spawners). TAC allocations are also provided. Total catches highlighted in red indicate years and stocks where the total catch exceeded the TAC.

		Catch 4T F_S		Catch 4T F_F			Annual	Total	
Year	Spawning group	Fixed	Mobile	Fixed	Mobile	Annual 4T catch	4Vn catch	catch 4TVn	TAC 4TVn
1981	SS	6,287	20	293	589	7,189	822		
	FS	1,212	1	10,932	2,599	14,744	2,594		
	Total	7,499	21	11,225	3,188	21,933	3,416	25,349	19,000
1982	SS	5,692	57	292	574	6,615	834		
	FS	230	5	12,691	2,003	14,929	2,674		
	Total	5,922	62	12,983	2,577	21,544	3,508	25,052	18,000
1983	SS	7,655	17	423	1,466	9,561	1,307		
	FS	865	2	13,415	2,023	16,305	2,672		
	Total	8,520	19	13,838	3,489	25,866	3,979	29,845	25,000
1984	SS	4,434	3	303	895	5,635	1,376		
	FS	847	1	15,672	1,384	17,904	2,549		
	Total	5,281	4	15,975	2,279	23,539	3,925	27,464	22,500
1985	SS	6,720	0	1,287	2,154	10,161	1,082		
	FS	498	0	22,420	4,867	27,785	2,388		
	Total	7,218	0	23,707	7,021	37,946	3,470	41,416	36,000
1986	SS	7,154	0	3,181	6,773	17,108	2,782		
	FS	1,397	0	36,710	4,143	42,250	1,568		
	Total	8,551	0	39,891	10,916	59,358	4,350	63,708	47,600
1987	SS	10,419	0	2,538	9,460	22,417	1,446		
	FS	1,340	0	49,585	4,273	55,198	917		
	Total	11,759	0	52,123	13,733	77,615	2,363	79,978	77,000
1988	SS	9,166	0	2,843	12,036	24,045	1,766		
	FS	3,719	0	38,367	5,496	47,582	806		
	Total	12,885	0	41,210	17,532	71,627	2,572	74,199	83,100
1989	SS	9,062	0	1,691	8,778	19,531	1,302		
	FS	2,032	0	32,157	5,492	39,681	815		
	Total	11,094	0	33,848	14,270	59,212	2,117	61,329	91,100
1990	SS	4,083	1	2,146	6,756	12,986	3,088		
	FS	818	0	59,138	3,551	63,507	1,623		
	Total	4,901	1	61,284	10,307	76,493	4,711	81,204	91,100
1991	SS	12,073	5	178	3,319	15,575	1,902	17,477	21,000
	FS	817	13	26,965	4,741	32,536	2,888	35,424	70,100
	Total	12,890	18	27,143	8,060	48,111	4,790	52,901	91,100
1992	SS	12,291	641	322	3,327	16,581	493	17,074	21,000
	FS	186	478	32,760	3,789	37,213	3,735	40,948	70,100
	Total	12,477	1,119	33,082	7,116	53,794	4,228	58,022	91,100
1993	SS	14,643	1,526	780	3,741	20,690	434	21,124	21,000
	FS	538	1,190	22,319	2,487	26,534	3,517	30,051	85,000
	Total	15,181	2,716	23,099	6,228	47,224	3,951	51,175	106,000
1994	SS	18,498	883	481	3,357	23,219	568	23,787	21,000
	FS	517	3,049	53,333	3,603	60,502	2,681	63,183	85,000
	Total	19,015	3,932	53,814	6,960	83,721	3,249	86,970	106,000
1995	SS	15,137	950	2,102	7,671	25,860	470	26,330	21,000
	FS	836	875	54,161	7,595	63,467	3,674	67,141	85,000
	Total	15,973	1,825	56,263	15,266	89,327	4,144	93,471	106,000
1996	SS	15,409	441	1,365	3,977	21,192	1,033	22,225	15,114
	FS	668	1,466	44,408	4,044	50,586	3,234	53,820	58,749
	Total	16,077	1,907	45,773	8,021	71,778	4,267	76,045	73,863
1997	SS	12,846	614	98	3,627	17,185	231	17,416	16,500

Year	Spawning group	Catch 4T F_S		Catch 4T F_F		Annual 4T catch	Annual 4Vn catch	Total catch 4TVn	TAC 4TVn
		Fixed	Mobile	Fixed	Mobile				
	FS	380	888	34,974	2,175	38,417	3,299	41,716	50,000
	Total	13,226	1,502	35,072	5,802	55,602	3,530	59,132	66,500
1998	SS	13,382	297	121	1,418	15,218	2	15,220	16,500
	FS	528	707	39,009	3,158	43,402	50	43,452	57,568
	Total	13,910	1,004	39,130	4,576	58,620	52	58,672	74,068
1999	SS	10,256	688	176	3,770	14,890	0	14,890	18,500
	FS	1,625	4,130	44,615	5,334	55,704	0	55,704	60,500
	Total	11,881	4,818	44,791	9,104	70,594	0	70,594	79,000
2000	SS	14,586	10	706	2,324	17,626	0	17,626	16,500
	FS	1,596	538	49,676	6,373	58,183	0	58,183	71,000
	Total	16,182	548	50,382	8,697	75,809	0	75,809	87,500
2001	SS	9,938	459	736	2,986	14,119	0	14,119	12,500
	FS	659	638	44,786	7,285	53,368	0	53,368	60,500
	Total	10,597	1,097	45,522	10,271	67,487	0	67,487	73,000
2002	SS	8,142	420	673	704	9,939	0	9,939	8,000
	FS	966	464	41,290	10,898	53,618	0	53,618	51,500
	Total	9,108	884	41,963	11,602	63,557	0	63,557	59,500
2003	SS	8,458	41	37	449	8,985	0	8,985	11,000
	FS	608	60	47,766	12,779	61,213	0	61,213	62,000
	Total	9,066	101	47,803	13,228	70,198	0	70,198	73,000
2004	SS	7,671	21	122	410	8,224	0	8,224	13,500
	FS	374	31	35,904	7,090	43,399	0	43,399	73,000
	Total	8,045	52	36,026	7,500	51,623	0	51,623	86,500
2005	SS	3,571	0	14	1,084	4,669	0	4,669	11,000
	FS	925	0	51,715	7,756	60,396	0	60,396	70,000
	Total	4,496	0	51,729	8,840	65,065	0	65,065	81,000
2006	SS	1,409	0	293	745	2,447	0	2,447	9,000
	FS	1,257	0	47,630	4,409	53,296	0	53,296	68,800
	Total	2,666	0	47,923	5,154	55,743	0	55,743	77,800
2007	SS	1,734	0	10	2,414	4,158	0	4,158	5,000
	FS	496	0	43,161	4,426	48,083	0	48,083	68,800
	Total	2,230	0	43,171	6,840	52,241	0	52,241	73,800
2008	SS	1,503	0	35	1,473	3,011	0	3,011	2,500
	FS	187	0	38,831	2,738	41,756	0	41,756	68,800
	Total	1,690	0	38,866	4,211	44,767	0	44,767	71,300
2009	SS	1,256	0	70	519	1,845	0	1,845	2,500
	FS	94	0	44,780	1,939	46,813	0	46,813	65,000
	Total	1,350	0	44,850	2,458	48,658	0	48,658	67,500
2010	SS	769	5	2	595	1,371	0	1,371	2,000
	FS	386	297	42,458	4,154	47,295	0	47,295	65,000
	Total	1,155	302	42,460	4,749	48,666	0	48,666	67,000
2011	SS	833	0	21	664	1,518	0	1,518	2,000
	FS	210	0	36,882	1,372	38,464	0	38,464	65,000
	Total	1,043	0	36,903	2,036	39,982	0	39,982	67,000
2012	SS	265	5	68	262	600	0	600	2,000
	FS	152	223	31,820	381	32,576	0	32,576	43,500
	Total	417	228	31,888	643	33,176	0	33,176	45,500
2013	SS	874	180	1	649	1,704	0	1,704	2,000
	FS	24	3,025	29,911	1,409	34,369	0	34,369	43,500
	Total	898	3,205	29,912	2,058	36,073	0	36,073	45,500
2014	SS	634	56	132	429	1,250	0	1,250	2,000
	FS	71	1,886	25,786	1,471	29,214	0	29,214	35,000
	Total	705	1,941	25,918	1,901	30,464	0	30,464	37,000
2015	SS	578	43	3	565	1,190	0	1,190	2,000
	FS	7	1,390	25,964	777	28,138	0	28,138	40,000
	Total	586	1,433	25,967	1,343	29,328	0	29,328	42,000

Table 2. Commercial fishery samples collected, number of fish processed (N), landings, and % TAC landed by zone in the spring (April 1 to June 30) and fall (July 1 to December 31) herring fisheries in the southern Gulf of St. Lawrence. These data are used to derive the 2014 and 2015 catch-at-age and weight-at-age matrices.

Gear and Region	Fishery	Zone	Samples	N	Landings (t)	% TAC landed
2014 Fixed gear - gillnets						
North	Gaspe (16A) fall	4Topq	1	29	2.6	12.9
North	Chaleur (16B) July – August 15	4Tmn	2	36	1,759.4	99.6
North	Chaleur (16B) August 16 - 22	4Tmn	3	55	4,232.4	111
North	Chaleur (16B) August 23 +	4Tmn	5	111	7,344.4	
Middle	Escuminac – West P.E.I. (16CE) July – August	4Tl	7	131	1,888.7	92.5
Middle	Escuminac – West P.E.I. (16CE) Sept. 1 - 5	4Tl	5	99	2,286	101.2
Middle	Escuminac – West P.E.I. (16CE) Sept. 6 +	4Tl	2	34	890.3	
South	Magdalene Islands (16D) fall	4Tf	1	26	158	12
South	Pictou (16F) fall	4Th	3	73	5,029.4	98.8
South	East P.E.I. (16G)) July – Sept. 19	4Tgj	3	70	1,135.2	100
South	East P.E.I. (16G) Sept. 20 +	4Tgj	6	149	1,322.5	49.8
2014 Fixed gear total		4T	33	813	25,910.0	97.7
2014 Mobile gear – purse seines						
South	Spring Edge fishery – June	4Tf	6	253	1,941	100
North	East of Grande-Anse (16B) Oct.	4Tmn	8	288	874.4	56
North	East of Grande-Anse (16B) Nov.	4Tmn	8	262	1,029.4	
2014 Mobile gear total		4T	21	803	3,844.8	52.2
2015 Fixed gear – gillnets						
North	Gaspe (16A) spring	4Tp	1	31	8.6	140.5
North	Chaleur (16B) April	4Tmn	2	54	102.6	92.9
North	Chaleur (16B) May – June	4Tmn	2	46	207.8	
North	Chaleur (16B) July – August	4Tmn	5	108	4,442.9	100
North	Chaleur (16B) September	4Tmn	6	123	8,817.3	
Middle	Escuminac – West P.E.I. (16CE) August	4Tl	2	46	2,404.1	99.3
Middle	Escuminac – West P.E.I. (16CE) September +	4Tl	8	153	3,722.2	107.4
South	Magdalene Islands (16D) fall	4Tf	2	68	9.6	4.9
South	Pictou (16F) fall	4Th	3	31	5,812.8	96.6
South	East P.E.I. (16G) spring	4Tgj	0	0	229.9	100
South	East P.E.I. (16G) fall	4Tgj	5	126	756.4	15
2015 Fixed gear total		4T	36	786	26,514.2	88
2015 Mobile gear – purse seines						
South	Spring Edge fishery – May - June	4Tf	4	150	1,433	100
North	East of Grande-Anse (16B) Nov	4Tmn	3	129	1342.6	18.4
2015 Mobile gear total		4T	7	279	2775.6	24.5

Table 3. Comparison of 2015 DMP and telephone survey results including number of respondents, mean net length (fathoms), numbers of nets set, percentage of nets of mesh size 2⅝ " in the fall fishery, and a comparative index of abundance from 2015 to 2014 [scale 1 (poor) to 10 (excellent)].

Region	Telephone survey area	Source	Number of respondents	Net length (fathom)	Number of nets set	Percent 2⅝" mesh size	Comparison to previous year
Spring fishery							
South	1 - Magdalen Islands	DMP	-	-	-	n/a	n/a
		Phone	1	17.0	12.1		1.0
North	2- Quebec	DMP	1	14.0	9.0	n/a	n/a
		Phone	9	14.1	16.4		5.8
	3- Acadian Peninsula	DMP	1	17.0	10.9	n/a	n/a
		Phone	-	-	-		-
Middle	4- Escuminac	DMP	2	13.0	21.4	n/a	n/a
		Phone	-	-	-		-
	5- South east NB	DMP	21	14.2	22.7	n/a	n/a
		Phone	5	14.6	21.8		4.4
South	6- Nova Scotia	DMP	-	-	-	n/a	n/a
		Phone	-	-	-		-
	7- East P.E.I.	DMP	2	15.5	13.2	n/a	n/a
		Phone	-	-	-		-
Middle	8- West P.E.I.	DMP	13	13.1	19.2	n/a	n/a
		Phone	3	13.2	17.5		2.3
Fall fishery							
South	1 - Magdalen Islands	DMP	-	-	-	-	n/a
		Phone	-	-	-	-	-
North	2- Quebec	DMP	-	-	-	-	n/a
		Phone	22	13.5	7.7	100	6.5
	3- Acadian Peninsula	DMP	13	14.1	6.4	100	n/a
		Phone	32	13.7	7.8	100	6.3
Middle	4- Escuminac	DMP	11	14.9	7.5	100	n/a
		Phone	8	13.5	8.6	93	7.0
	5- South east NB	DMP	2	15.0	7.3	100	n/a
		Phone	-	-	-	-	-
South	6- Nova Scotia	DMP	25	16.2	8.3	100	n/a
		Phone	23	15.5	6.6	92.5	4.4
	7- East P.E.I.	DMP	35	14.3	8.4	100	n/a
		Phone	4	14.0	9.0	100	1.0
Middle	8- West P.E.I.	DMP	53	12.5	8.7	100	n/a
		Phone	8	13.7	9.7	100	5.7

Table 4. Spring spawner (SS) catch-at-age (thousands) for fixed gear in the 4T herring fishery.

	Age (years)											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1978	0	44	6,026	25,253	1,042	2,123	660	243	370	1,561	752	38,072
1979	100	112	7,352	2,544	17,558	540	842	127	127	327	1,421	31,050
1980	0	217	9,420	6,744	2,378	9,068	1,424	807	612	442	720	31,832
1981	3	438	11,843	7,099	1,941	1,399	3,052	415	422	171	882	27,664
1982	11	216	23,577	4,191	988	421	299	315	143	88	618	30,868
1983	0	155	13,547	26,208	2,142	472	76	0	0	8	0	42,608
1984	16	39	3,377	12,083	7,529	409	59	14	7	4	0	23,538
1985	0	39	4,921	12,685	13,742	4,630	614	100	32	71	0	36,833
1986	0	11	2,712	13,905	12,357	10,348	2,783	391	20	233	349	43,109
1987	0	10	1,232	6,164	20,071	11,410	9,674	4,080	947	512	258	54,357
1988	60	549	3,536	6,298	9,353	14,600	6,944	5,246	935	68	269	47,858
1989	0	0	3,941	15,672	4,836	4,912	6,957	4,326	2,598	1,025	279	44,546
1990	0	128	1,925	7,387	4,109	2,178	2,532	3,928	1,827	733	306	25,053
1991	0	0	6,070	11,715	14,140	9,142	3,166	2,897	4,448	1,640	1,097	54,314
1992	0	0	2,160	30,046	11,543	7,579	3,460	1,593	1,956	1,423	2,263	62,023
1993	0	8	231	5,488	40,374	18,381	4,900	2,409	1,375	708	2,724	76,597
1994	0	0	2,061	5,847	24,642	48,553	9,048	3,595	1,221	438	1,032	96,438
1995	0	0	200	13,345	10,782	17,781	28,929	6,408	1,788	1,156	2,271	82,660
1996	0	0	416	1,682	48,104	9,123	14,154	9,414	3,102	590	1,087	87,672
1997	0	2	107	5,440	4,069	37,818	6,961	4,149	3,938	1,015	179	63,678
1998	0	0	785	7,744	15,786	2,264	29,871	3,421	2,449	1,966	875	65,159
1999	0	89	1,724	6,599	9,410	10,297	2,255	16,045	2,583	1,342	1,155	51,499
2000	0	12	2,141	11,977	15,975	15,248	7,568	4,457	11,675	2,912	1,756	73,722
2001	0	0	910	11,316	13,082	9,859	4,920	3,360	1,387	6,593	1,735	53,163
2002	0	1	2,509	7,044	18,352	7,626	3,608	2,075	1,152	1,052	1,214	44,633
2003	0	0	285	10,766	11,071	12,832	3,925	2,483	998	686	759	43,803
2004	0	21	1,607	2,606	15,101	5,400	8,500	3,223	1,164	413	1,005	39,040
2005	0	0	72	3,639	3,209	5,784	2,561	2,023	566	125	174	18,153
2006	0	1	720	1,299	4,653	1,652	528	285	387	28	73	9,626
2007	0	1	864	2,037	1,563	2,323	1,738	803	196	149	110	9,784
2008	0	71	177	2,812	3,111	1,139	1,261	269	52	23	12	8,928
2009	0	23	411	1,060	2,445	3,033	344	349	91	6	14	7,775
2010	0	0	144	1,107	860	1,559	766	366	358	4	13	5,177
2011	0	0	25	116	885	812	1,102	512	782	287	5	4,526
2012	0	0	153	400	400	609	671	340	225	186	84	3,068
2013	0	0	16	303	963	1,157	1,492	1,141	814	50	39	5,974
2014	0	0	1	17	454	773	868	1,080	561	222	67	4,041
2015	0	0	0	103	157	783	1,195	535	396	76	41	3,287

Table 5. Spring spawner (SS) weight-at-age (kg) for fixed gear in the 4T herring fishery. A dash indicates no samples were available from that age group.

	Age (years)										
Year	1	2	3	4	5	6	7	8	9	10	11+
1978	-	0.154	0.148	0.187	0.215	0.251	0.283	0.318	0.308	0.337	0.364
1979	0.020	0.161	0.163	0.197	0.226	0.243	0.313	0.335	0.352	0.326	0.360
1980	-	0.184	0.167	0.189	0.231	0.278	0.304	0.334	0.359	0.369	0.379
1981	0.027	0.156	0.178	0.232	0.267	0.318	0.343	0.350	0.374	0.411	0.419
1982	0.038	0.186	0.173	0.207	0.261	0.311	0.370	0.385	0.396	0.416	0.449
1983	-	0.170	0.148	0.206	0.236	0.258	0.343	-	-	0.361	-
1984	0.063	0.104	0.174	0.196	0.217	0.289	0.340	0.404	0.490	0.369	-
1985	-	0.213	0.169	0.198	0.229	0.266	0.315	0.315	0.329	0.432	-
1986	-	0.111	0.183	0.210	0.242	0.261	0.307	0.348	0.336	0.364	0.392
1987	-	0.091	0.192	0.196	0.218	0.249	0.267	0.280	0.317	0.310	0.377
1988	0.040	0.080	0.160	0.197	0.237	0.265	0.290	0.307	0.335	0.369	0.359
1989	-	-	0.165	0.202	0.229	0.257	0.291	0.301	0.314	0.328	0.300
1990	-	0.153	0.169	0.203	0.241	0.273	0.297	0.290	0.311	0.322	0.339
1991	-	-	0.146	0.182	0.219	0.246	0.260	0.292	0.303	0.320	0.319
1992	-	-	0.145	0.172	0.201	0.232	0.255	0.274	0.291	0.299	0.332
1993	-	0.135	0.127	0.164	0.186	0.207	0.244	0.252	0.268	0.294	0.292
1994	-	-	0.141	0.156	0.177	0.200	0.218	0.249	0.314	0.272	0.304
1995	-	0.116	0.182	0.160	0.179	0.202	0.222	0.245	0.271	0.301	0.322
1996	-	-	0.157	0.182	0.173	0.193	0.209	0.233	0.230	0.275	0.277
1997	-	0.133	0.131	0.162	0.183	0.200	0.213	0.233	0.246	0.246	0.303
1998	-	-	0.137	0.161	0.185	0.206	0.221	0.240	0.246	0.257	0.278
1999	-	0.121	0.120	0.149	0.176	0.204	0.220	0.230	0.244	0.254	0.269
2000	-	0.114	0.131	0.158	0.184	0.207	0.225	0.250	0.253	0.262	0.273
2001	-	-	0.135	0.158	0.182	0.198	0.223	0.236	0.257	0.260	0.270
2002	-	0.098	0.141	0.165	0.188	0.205	0.227	0.251	0.270	0.279	0.289
2003	-	-	0.143	0.160	0.184	0.202	0.223	0.233	0.253	0.260	0.280
2004	-	0.130	0.134	0.149	0.178	0.203	0.229	0.238	0.254	0.262	0.288
2005	-	0.075	0.134	0.152	0.172	0.201	0.221	0.252	0.253	0.269	0.308
2006	-	0.120	0.132	0.147	0.169	0.196	0.221	0.246	0.248	0.293	0.242
2007	-	0.108	0.139	0.152	0.169	0.185	0.194	0.212	0.253	0.246	0.234
2008	-	0.137	0.144	0.158	0.164	0.181	0.203	0.237	0.240	0.268	0.298
2009	-	0.118	0.144	0.155	0.165	0.173	0.205	0.209	0.253	0.223	0.206
2010	-	-	0.121	0.148	0.157	0.189	0.202	0.225	0.234	0.248	0.268
2011	-	-	0.112	0.144	0.170	0.179	0.199	0.217	0.229	0.250	0.233
2012	-	-	0.154	0.140	0.143	0.155	0.169	0.186	0.190	0.222	0.220
2013	-	-	0.119	0.134	0.147	0.160	0.181	0.187	0.203	0.217	0.224
2014	-	-	0.114	0.130	0.160	0.170	0.190	0.197	0.208	0.226	0.226
2015	-	-	0.094	0.133	0.144	0.164	0.176	0.188	0.208	0.188	0.231

Table 6a. Fall spawner (FS) catch-at-age (thousands) for fixed gear in the 4T herring fishery for the North region of the southern Gulf of St. Lawrence. A dash indicates no samples were available from that age group.

	Age (years)											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1978	0	0	216	3,414	2,450	510	432	2,709	50	81	1,189	11,049
1979	0	0	168	3,271	1,465	1,260	256	644	531	252	267	8,113
1980	0	26	3,056	1,471	1,648	233	1,154	129	110	147	0	7,974
1981	0	23	3,963	12,839	2,839	593	240	278	53	99	60	20,988
1982	0	0	1,726	5,625	11,797	1,746	331	202	64	40	62	21,593
1983	0	0	98	9,238	3,748	9,002	1,018	413	96	16	102	23,732
1984	0	0	453	7,434	6,808	3,462	3,133	556	113	108	71	22,139
1985	0	0	99	2,878	13,139	8,176	4,901	4,915	1,832	372	6	36,317
1986	0	0	617	9,919	9,734	21,934	15,361	7,286	3,326	447	770	69,394
1987	0	16	7,260	24,247	14,636	13,277	19,804	9,068	5,494	2,412	759	96,973
1988	0	0	152	14,470	24,858	9,543	8,464	7,752	4,121	1,998	1,953	73,312
1989	0	0	283	12,133	19,801	21,160	10,289	4,716	5,928	2,655	2,119	79,083
1990	0	14	2,351	13,755	12,557	19,491	20,685	7,816	5,478	5,759	4,141	92,048
1991	0	0	131	28,732	7,306	5,390	7,996	7,653	2,463	1,539	2,511	63,721
1992	0	0	11	6,153	37,342	10,677	6,225	6,775	5,960	2,872	5,423	81,438
1993	0	0	82	2,051	21,080	24,447	3,430	1,918	1,975	559	712	56,253
1994	0	0	0	6,553	10,534	31,558	47,627	9,076	7,049	3,229	5,405	121,030
1995	0	0	23	3,298	23,949	11,095	26,764	28,406	4,969	3,188	3,483	105,176
1996	0	0	0	12,767	15,443	20,775	4,565	8,681	9,465	1,341	1,561	74,599
1997	0	0	367	8,897	30,662	9,453	8,423	1,621	2,817	2,524	732	65,496
1998	0	0	37	8,752	23,986	22,898	5,734	5,461	787	1,272	2,305	71,232
1999	0	0	175	19,795	23,825	29,632	10,527	2,083	1,327	362	517	88,244
2000	0	0	266	17,183	56,056	14,915	6,279	3,445	668	493	224	99,529
2001	0	0	516	22,863	28,903	29,781	4,552	2,051	561	175	228	89,629
2002	0	1	212	21,279	23,278	16,324	8,777	2,292	683	471	187	73,503
2003	0	0	235	11,578	24,362	16,356	11,533	13,769	3,446	1,512	948	83,741
2004	0	0	1	23,785	17,748	8,619	5,219	4,049	2,776	638	433	63,267
2005	0	0	1	5,034	56,213	22,399	8,627	4,759	2,861	2,025	184	102,102
2006	0	0	5	6,092	37,842	36,714	5,458	1,549	2,922	1,127	602	92,312
2007	0	0	32	5,160	15,268	34,715	23,878	5,096	951	887	561	86,549
2008	0	0	403	18,423	11,717	18,718	15,180	14,670	1,778	598	865	82,352
2009	0	0	532	22,606	38,575	10,619	10,493	6,117	1,701	302	253	91,199
2010	0	0	0	3,120	26,685	23,029	7,969	5,320	4,186	1,708	199	72,217
2011	0	0	0	1,657	6,387	26,763	24,243	2,750	3,140	2,850	773	68,564
2012	0	0	8	156	8,609	17,648	26,305	11,769	2,342	2,749	954	70,540
2013	0	0	0	1,053	9,008	29,030	20,823	10,696	2,295	183	103	73,191
2014	0	0	0	91	4,454	9,817	24,496	11,276	7,629	100	60	57,924
2015	0	0	0	91	2,684	19,072	14,182	17,093	5,314	844	226	59,507

Table 6b. Fall spawner (FS) catch-at-age (thousands) for fixed gear in the 4T herring fishery for the Middle region of the southern Gulf of St. Lawrence. A dash indicates no samples were available from that age group.

	Age (years)											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1978	0	0	38	601	749	220	442	2,005	9	59	1,139	5,262
1979	0	0	144	3,673	2,048	831	205	100	209	18	161	7,389
1980	0	0	424	964	2,283	579	271	225	282	107	96	5,232
1981	0	0	974	6,224	1,910	1,150	460	629	31	83	238	11,699
1982	0	0	29	1,653	1,559	210	139	116	0	0	31	3,737
1983	0	0	255	3,998	1,482	1,578	351	130	0	0	0	7,794
1984	0	0	41	1,908	2,723	937	1,001	315	77	11	6	7,019
1985	0	0	11	235	1,370	1,010	562	536	200	41	1	3,964
1986	0	0	47	1,600	1,328	2,455	1,120	435	200	27	46	7,257
1987	0	0	298	934	1,761	1,532	3,059	289	267	298	19	8,457
1988	0	0	817	3,091	2,817	2,473	1,135	1,189	886	15	0	12,424
1989	0	0	16	772	1,431	1,274	694	428	378	171	139	5,303
1990	0	0	219	1,923	1,390	1,508	2,655	548	382	298	64	8,987
1991	0	0	17	5,973	1,617	1,332	1,749	2,066	1,271	585	1,335	15,945
1992	0	0	12	3,880	9,415	1,284	534	304	220	106	249	16,004
1993	0	0	0	350	6,612	8,298	1,417	597	415	470	716	18,875
1994	0	0	0	850	1,373	6,909	9,293	1,134	359	439	741	21,099
1995	0	0	0	214	10,009	3,408	12,249	10,646	1,363	243	4,272	42,403
1996	0	0	0	3,414	2,107	12,096	1,046	3,144	3,605	833	869	27,113
1997	0	0	285	4,835	10,979	1,980	4,125	782	938	1,026	639	25,588
1998	0	0	23	5,113	4,301	8,730	1,761	3,286	596	1,293	2,229	27,331
1999	0	0	0	9,710	12,903	5,104	3,222	1,303	2,854	278	1,330	36,703
2000	0	0	13	11,054	21,136	7,789	2,516	1,394	414	369	165	44,850
2001	0	0	383	5,519	13,582	9,633	2,919	630	208	0	293	33,167
2002	0	0	275	9,081	8,110	7,172	6,937	1,245	172	146	217	33,356
2003	0	0	123	5,648	11,842	5,541	3,737	3,739	839	110	156	31,735
2004	0	0	15	5,579	10,122	7,144	5,096	4,523	2,652	920	175	36,227
2005	0	0	0	2,355	14,518	11,757	3,536	3,046	2,099	895	66	38,273
2006	0	0	0	1,697	7,740	13,789	5,094	2,598	1,949	1,544	523	34,935
2007	0	0	193	1,197	3,429	9,509	9,811	3,736	1,509	733	454	30,572
2008	0	0	1,426	12,175	2,575	4,491	5,326	8,515	1,536	1,451	332	37,826
2009	0	0	101	8,185	14,543	3,368	7,438	3,578	1,245	530	245	39,232
2010	0	0	8	1,529	11,467	17,000	4,954	4,333	2,473	1,154	644	43,562
2011	0	0	0	405	2,089	12,157	15,610	2,973	2,237	2,101	631	38,202
2012	0	0	7	147	1,935	8,679	11,646	8,142	925	526	443	32,450
2013	0	0	7	590	1,125	7,042	10,527	6,451	2,488	201	43	28,474
2014	0	0	0	0	3,452	2,161	7,389	8,144	1,536	755	0	23,436
2015	0	0	0	165	1,052	10,058	4,474	7,592	2,987	1,060	0	27,388

Table 6c. Fall spawner (FS) catch-at-age (thousands) for fixed gear in the 4T herring fishery for the South region of the southern Gulf of St. Lawrence. A dash indicates no samples were available from that age group.

	Age (years)											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1978	0	41	1,988	1,390	632	154	75	119	22	0	13	4,434
1979	0	16	267	4,634	2,198	773	263	292	175	52	205	8,875
1980	0	38	4,404	1,939	2,352	294	923	129	164	154	77	10,473
1981	0	42	1,158	5,336	2,185	1,049	531	310	88	99	24	10,823
1982	0	0	353	7,029	3,634	3,226	2,345	819	332	81	37	17,856
1983	0	0	467	7,485	5,047	3,237	1,011	1,266	477	47	161	19,198
1984	0	0	397	15,010	5,562	4,586	2,288	703	381	110	23	29,060
1985	0	0	89	3,442	15,465	6,385	3,221	2,234	509	333	29	31,707
1986	0	383	871	20,436	5,745	12,065	3,350	1,635	487	106	164	45,244
1987	0	0	1,083	11,141	12,821	6,139	14,100	6,213	4,292	1,851	1,323	58,963
1988	0	0	377	4,361	16,703	9,665	4,750	6,641	3,036	985	665	47,183
1989	0	0	33	1,355	2,076	8,332	4,204	1,803	2,446	622	300	21,171
1990	0	0	875	6,772	6,732	7,712	36,015	9,853	4,322	4,591	2,472	79,345
1991	0	0	11	4,956	1,670	1,339	1,201	3,899	1,365	840	1,190	16,471
1992	0	0	0	1,335	7,461	1,081	631	1,510	3,338	1,241	1,316	17,913
1993	0	0	0	302	3,227	3,902	982	405	586	485	1,123	11,013
1994	0	0	0	1,463	310	10,000	13,800	1,873	2,460	5,256	8,730	43,892
1995	0	0	1	341	7,908	2,733	12,171	10,381	2,759	3,036	7,345	46,675
1996	0	0	4	3,477	2,082	13,644	4,899	11,411	10,891	2,781	8,448	57,637
1997	0	0	454	3,780	22,567	2,027	8,585	1,488	3,105	2,920	2,597	47,521
1998	0	0	0	9,390	4,415	15,711	3,964	8,891	1,751	3,429	4,223	51,773
1999	0	0	89	8,880	32,161	4,365	9,706	1,899	3,102	1,152	1,593	62,949
2000	0	0	77	8,101	31,645	18,887	3,076	3,685	715	1,148	717	68,050
2001	0	0	56	1,816	22,486	21,033	13,536	1,991	1,593	433	824	63,767
2002	0	0	0	17,708	7,514	16,987	14,117	4,249	1,072	926	547	63,120
2003	0	0	61	5,076	41,894	6,513	13,669	8,690	1,700	262	381	78,246
2004	0	0	0	4,823	11,135	24,502	4,842	4,452	2,175	600	312	52,840
2005	0	0	3	424	12,345	20,406	31,839	6,051	6,169	1,732	385	79,354
2006	0	0	51	2,825	7,738	20,291	20,875	15,511	5,119	2,721	760	75,890
2007	0	0	492	206	9,238	13,512	24,751	15,374	4,948	2,939	938	72,397
2008	0	0	292	4,858	1,774	6,585	12,063	15,009	6,873	3,646	2,818	53,919
2009	0	0	411	2,398	20,654	10,345	20,617	6,815	3,615	5,240	2,610	72,705
2010	0	0	0	2,080	8,754	32,103	8,352	10,398	6,809	3,819	2,439	74,754
2011	0	0	1	312	7,530	7,478	25,275	8,102	4,030	2,350	4,185	59,263
2012	0	0	0	24	1,199	12,938	14,639	15,613	1,662	476	1,603	48,156
2013	0	0	15	341	1,025	9,166	19,571	7,271	3,448	110	108	41,054
2014	0	0	0	173	2,842	2,276	8,971	15,942	3,504	1,700	58	35,466
2015	0	0	0	0	1,653	7,979	4,406	12,483	3,358	1,923	208	32,011

Table 7a. Fall spawner (FS) weight-at-age (kg) for fixed gear in the 4T herring fishery for the North region of the southern Gulf of St. Lawrence. A dash indicates no samples were available from that age group.

	Age (years)										
Year	1	2	3	4	5	6	7	8	9	10	11+
1978	-	-	0.200	0.259	0.296	0.339	0.347	0.379	0.416	0.396	0.447
1979	-	-	0.215	0.265	0.307	0.332	0.384	0.401	0.417	0.434	0.452
1980	-	0.212	0.205	0.239	0.296	0.308	0.289	0.319	0.362	0.376	-
1981	-	0.208	0.220	0.255	0.307	0.349	0.404	0.419	0.452	0.466	0.487
1982	-	-	0.226	0.271	0.304	0.344	0.384	0.425	0.425	0.439	0.447
1983	-	-	0.199	0.251	0.292	0.325	0.364	0.404	0.391	0.506	0.460
1984	-	-	0.232	0.255	0.295	0.340	0.356	0.398	0.434	0.391	0.507
1985	-	-	0.224	0.230	0.297	0.343	0.373	0.391	0.414	0.454	0.563
1986	-	-	0.216	0.265	0.303	0.333	0.376	0.396	0.407	0.446	0.452
1987	-	0.174	0.237	0.252	0.289	0.323	0.355	0.380	0.400	0.415	0.437
1988	-	-	0.212	0.260	0.285	0.311	0.341	0.367	0.393	0.389	0.421
1989	-	-	0.223	0.256	0.295	0.327	0.352	0.377	0.391	0.420	0.427
1990	-	0.148	0.198	0.248	0.287	0.325	0.350	0.368	0.389	0.408	0.435
1991	-	-	0.196	0.230	0.263	0.299	0.330	0.349	0.364	0.362	0.398
1992	-	-	0.200	0.229	0.258	0.283	0.312	0.345	0.355	0.363	0.409
1993	-	-	0.172	0.219	0.239	0.265	0.291	0.330	0.346	0.326	0.360
1994	-	-	-	0.209	0.237	0.258	0.288	0.315	0.348	0.353	0.400
1995	-	-	0.187	0.205	0.227	0.247	0.282	0.303	0.333	0.361	0.386
1996	-	-	-	0.221	0.244	0.258	0.281	0.306	0.329	0.376	0.426
1997	-	-	0.191	0.206	0.236	0.260	0.275	0.308	0.337	0.351	0.403
1998	-	-	0.149	0.209	0.232	0.258	0.286	0.293	0.330	0.355	0.362
1999	-	-	0.166	0.212	0.237	0.250	0.279	0.301	0.327	0.370	0.362
2000	-	-	0.177	0.214	0.235	0.260	0.275	0.304	0.317	0.334	0.387
2001	-	-	0.172	0.211	0.237	0.255	0.282	0.305	0.330	0.347	0.371
2002	-	0.031	0.181	0.220	0.240	0.264	0.282	0.296	0.326	0.332	0.362
2003	-	-	0.158	0.209	0.238	0.255	0.278	0.296	0.313	0.333	0.351
2004	-	-	0.149	0.200	0.218	0.252	0.263	0.285	0.308	0.329	0.349
2005	-	-	0.188	0.196	0.225	0.240	0.261	0.285	0.296	0.296	0.313
2006	-	-	0.158	0.202	0.220	0.241	0.258	0.285	0.300	0.303	0.323
2007	-	-	0.156	0.197	0.204	0.225	0.242	0.254	0.290	0.292	0.317
2008	-	-	0.159	0.190	0.214	0.228	0.244	0.259	0.264	0.294	0.319
2009	-	-	0.156	0.190	0.202	0.233	0.251	0.261	0.258	0.282	0.279
2010	-	-	-	0.179	0.206	0.217	0.238	0.250	0.261	0.279	0.295
2011	-	-	-	0.184	0.197	0.216	0.222	0.258	0.263	0.265	0.298
2012	-	-	0.126	0.158	0.183	0.204	0.214	0.225	0.250	0.250	0.290
2013	-	-	-	0.171	0.195	0.205	0.215	0.231	0.242	0.286	0.284
2014	-	0.114	-	0.202	0.213	0.220	0.230	0.241	0.243	0.292	0.301
2015	-	-	-	0.173	0.200	0.212	0.227	0.229	0.241	0.225	0.268

Table 7b. Fall spawner (FS) weight-at-age (kg) for fixed gear in the 4T herring fishery for the Middle region of the southern Gulf of St. Lawrence. A dash indicates no samples were available from that age group.

	Age (years)										
Year	1	2	3	4	5	6	7	8	9	10	11+
1978	-	-	0.200	0.259	0.261	0.305	0.279	0.363	0.416	0.313	0.410
1979	-	-	0.183	0.224	0.269	0.278	0.315	0.369	0.420	0.419	0.458
1980	-	-	0.244	0.249	0.353	0.384	0.354	0.390	0.546	0.504	0.510
1981	-	-	0.221	0.255	0.294	0.344	0.360	0.393	0.501	0.473	0.439
1982	-	-	0.247	0.270	0.305	0.330	0.424	0.449	-	-	0.499
1983	-	-	0.183	0.217	0.263	0.302	0.340	0.430	-	-	-
1984	-	-	0.225	0.227	0.253	0.301	0.344	0.397	0.433	0.484	0.540
1985	-	-	0.224	0.259	0.302	0.331	0.369	0.391	0.414	0.454	0.563
1986	-	-	0.194	0.209	0.244	0.276	0.347	0.397	0.407	0.446	0.453
1987	-	-	0.249	0.230	0.261	0.229	0.326	0.296	0.361	0.249	0.402
1988	-	-	0.234	0.281	0.305	0.357	0.362	0.413	0.439	0.366	0.420
1989	-	-	0.224	0.249	0.278	0.324	0.336	0.335	0.384	0.410	0.419
1990	-	-	0.194	0.236	0.284	0.324	0.342	0.355	0.365	0.404	0.431
1991	-	-	0.185	0.233	0.262	0.272	0.348	0.348	0.364	0.395	0.406
1992	-	-	0.199	0.219	0.242	0.269	0.285	0.328	0.348	0.358	0.412
1993	-	-	-	0.218	0.242	0.263	0.263	0.321	0.341	0.354	0.387
1994	-	-	-	0.213	0.243	0.270	0.294	0.309	0.328	0.399	0.427
1995	-	-	-	0.222	0.244	0.255	0.280	0.286	0.341	0.358	0.385
1996	-	-	-	0.226	0.250	0.261	0.304	0.310	0.318	0.393	0.432
1997	-	-	0.174	0.206	0.235	0.247	0.256	0.295	0.320	0.314	0.387
1998	-	-	0.176	0.219	0.234	0.265	0.286	0.279	0.336	0.343	0.388
1999	-	-	-	0.210	0.237	0.244	0.275	0.296	0.283	0.351	0.362
2000	-	-	0.111	0.214	0.234	0.260	0.273	0.300	0.318	0.311	0.366
2001	-	-	0.168	0.205	0.233	0.254	0.277	0.290	0.303	-	0.308
2002	-	-	0.191	0.219	0.244	0.257	0.288	0.293	0.327	0.327	0.311
2003	-	-	0.170	0.210	0.234	0.260	0.275	0.301	0.312	0.359	0.390
2004	-	-	0.146	0.208	0.229	0.248	0.268	0.286	0.310	0.305	0.362
2005	-	-	-	0.200	0.227	0.240	0.266	0.285	0.303	0.309	0.430
2006	-	-	-	0.197	0.224	0.245	0.260	0.279	0.297	0.310	0.317
2007	-	-	0.155	0.196	0.211	0.228	0.244	0.257	0.275	0.281	0.310
2008	-	-	0.120	0.169	0.206	0.220	0.237	0.242	0.252	0.272	0.300
2009	-	-	0.157	0.180	0.201	0.234	0.239	0.260	0.270	0.268	0.287
2010	-	-	0.139	0.176	0.202	0.213	0.228	0.246	0.255	0.274	0.269
2011	-	-	0.104	0.175	0.197	0.215	0.226	0.231	0.264	0.266	0.283
2012	-	-	0.115	0.153	0.181	0.199	0.212	0.218	0.241	0.262	0.280
2013	-	-	0.131	0.156	0.194	0.198	0.213	0.227	0.232	0.251	0.284
2014	-	-	-	-	0.189	0.209	0.212	0.228	0.231	0.242	0.244
2015	-	-	-	0.195	0.216	0.211	0.227	0.229	0.245	0.247	-

Table 7c. Fall spawner (FS) weight-at-age (kg) for fixed gear in the 4T herring fishery for the South region of the southern Gulf of St. Lawrence. A dash indicates no samples were available from that age group.

	Age (years)										
Year	1	2	3	4	5	6	7	8	9	10	11+
1978	-	0.077	0.133	0.192	0.228	0.236	0.295	0.318	0.331	-	0.338
1979	0.023	0.132	0.186	0.243	0.277	0.314	0.357	0.387	0.417	0.430	0.358
1980	-	0.212	0.205	0.245	0.297	0.315	0.324	0.340	0.358	0.396	0.351
1981	-	0.156	0.220	0.271	0.329	0.381	0.416	0.422	0.448	0.469	0.488
1982	-	-	0.210	0.263	0.297	0.330	0.371	0.360	0.391	0.357	0.404
1983	-	-	0.195	0.245	0.278	0.299	0.333	0.359	0.368	0.398	0.418
1984	-	-	0.212	0.242	0.282	0.304	0.339	0.400	0.405	0.406	0.496
1985	-	-	0.197	0.248	0.281	0.314	0.346	0.368	0.404	0.417	0.445
1986	-	0.175	0.189	0.240	0.277	0.311	0.343	0.361	0.385	0.427	0.348
1987	-	-	0.230	0.241	0.276	0.312	0.333	0.361	0.378	0.385	0.429
1988	-	-	0.226	0.246	0.287	0.322	0.352	0.381	0.403	0.416	0.446
1989	-	-	0.171	0.234	0.262	0.312	0.331	0.373	0.390	0.391	0.440
1990	-	-	0.192	0.240	0.277	0.325	0.347	0.372	0.398	0.410	0.428
1991	-	-	0.176	0.234	0.262	0.292	0.335	0.356	0.369	0.392	0.420
1992	-	-	-	0.215	0.252	0.280	0.287	0.338	0.344	0.368	0.388
1993	-	-	-	0.224	0.245	0.262	0.268	0.323	0.357	0.366	0.411
1994	-	-	-	0.213	0.222	0.258	0.284	0.322	0.331	0.360	0.376
1995	-	0.103	0.135	0.215	0.227	0.258	0.275	0.298	0.335	0.356	0.383
1996	-	-	0.172	0.217	0.244	0.254	0.278	0.306	0.322	0.347	0.386
1997	-	-	0.165	0.203	0.232	0.271	0.279	0.320	0.323	0.342	0.399
1998	-	-	-	0.211	0.237	0.257	0.283	0.296	0.319	0.331	0.369
1999	-	-	0.161	0.209	0.236	0.253	0.269	0.300	0.306	0.344	0.346
2000	-	-	0.150	0.203	0.227	0.256	0.281	0.300	0.326	0.329	0.360
2001	-	-	0.160	0.209	0.230	0.248	0.270	0.291	0.306	0.336	0.301
2002	-	-	-	0.216	0.233	0.249	0.271	0.288	0.306	0.308	0.337
2003	-	-	0.169	0.203	0.227	0.247	0.259	0.278	0.302	0.306	0.327
2004	-	-	-	0.206	0.224	0.237	0.254	0.282	0.282	0.303	0.308
2005	-	-	0.188	0.194	0.219	0.234	0.245	0.257	0.272	0.286	0.307
2006	-	-	0.169	0.190	0.215	0.231	0.249	0.257	0.276	0.279	0.299
2007	-	-	0.146	0.163	0.200	0.218	0.234	0.242	0.250	0.258	0.265
2008	-	0.093	0.138	0.160	0.206	0.214	0.227	0.237	0.248	0.257	0.271
2009	-	-	0.143	0.186	0.201	0.228	0.246	0.260	0.274	0.268	0.267
2010	-	-	0.107	0.161	0.205	0.214	0.241	0.257	0.264	0.281	0.296
2011	-	-	0.111	0.146	0.176	0.204	0.217	0.249	0.257	0.258	0.269
2012	-	-	-	0.150	0.170	0.193	0.216	0.221	0.239	0.270	0.265
2013	-	-	0.137	0.146	0.179	0.194	0.210	0.220	0.226	0.253	0.259
2014	-	-	-	0.157	0.175	0.200	0.201	0.213	0.237	0.231	0.272
2015	-	-	0.151	0.165	0.188	0.193	0.194	0.210	0.232	0.218	0.256

Table 8. Spring spawner (SS) catch-at-age (thousands) for mobile gear in the 4T herring fishery. A dash indicates no samples were available from that age group.

	Age (years)											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1978	1,390	14,933	3,664	24,366	3,053	4,619	1,293	734	565	2,877	599	58,093
1979	11,644	14,535	4,553	4,800	25,927	4,014	6,971	2,139	1,638	1,501	12,300	90,021
1980	737	11,101	10,404	1,790	1,878	11,154	8,852	4,207	2,229	751	286	53,389
1981	0	362	1,105	939	9	881	347	699	264	417	7	5,031
1982	0	2,343	3,816	400	53	10	89	165	210	2	19	7,109
1983	0	1,349	8,017	3,838	449	1	65	71	89	0	0	13,878
1984	0	619	1,831	4,190	2,901	291	0	71	41	0	0	9,943
1985	601	1,132	4,581	2,451	3,085	1,153	77	0	0	0	294	13,373
1986	0	4,194	3,982	9,551	7,647	7,410	3,070	212	514	0	60	36,640
1987	0	1,476	1,977	2,945	10,495	7,260	7,060	3,696	0	0	93	35,002
1988	2,710	6,291	2,125	1,546	2,730	11,772	9,514	5,399	2,434	0	2,155	46,676
1989	374	425	2,982	4,949	1,644	4,682	10,289	4,223	2,285	430	118	32,401
1990	46	5,182	6,250	7,301	4,236	2,645	1,504	5,841	2,964	737	318	37,024
1991	32	1,825	9,393	3,064	2,640	1,271	654	1,000	890	653	1,307	22,730
1992	5	860	2,808	7,350	3,461	2,489	707	448	790	527	453	19,896
1993	35	3,093	2,374	6,696	5,403	2,662	1,577	974	1,309	902	2,289	27,315
1994	0	52	4,057	2,255	3,477	5,930	2,435	1,349	647	166	1,251	21,620
1995	0	1,418	1,588	17,081	5,809	4,899	7,749	1,675	1,024	280	1,708	43,231
1996	6	385	2,942	919	11,291	3,589	2,107	1,965	370	388	138	24,100
1997	83	419	1,405	3,457	1,246	7,719	911	1,610	1,444	146	466	18,906
1998	5	298	796	1,930	1,524	213	1,767	461	337	374	254	7,959
1999	267	1,771	2,841	4,854	3,057	1,516	933	2,949	987	480	579	20,234
2000	294	1,314	3,254	3,739	1,485	891	354	305	491	70	92	12,290
2001	557	4,259	3,721	4,852	2,521	1,130	1,157	448	195	288	148	19,276
2002	55	744	3,135	1,060	729	195	554	109	42	7	42	6,670
2003	26	209	654	869	327	279	270	9	5	40	22	2,709
2004	103	487	825	433	360	135	234	17	10	1	17	2,621
2005	372	1,816	1,864	2,571	259	336	52	0	71	0	0	7,340
2006	61	236	898	521	1,825	620	138	24	6	5	0	4,333
2007	524	3,651	3,605	2,396	1,786	2,368	700	256	15	0	113	15,414
2008	268	3,474	1,888	765	1,209	587	774	137	93	16	28	9,239
2009	7	441	1,670	227	171	172	441	17	0	173	38	3,358
2010	0	116	406	941	506	713	634	74	8	0	1	3,398
2011	19	629	814	669	682	577	576	73	106	356	23	4,525
2012	0	17	404	454	279	237	169	9	33	0	21	1,624
2013	1	124	282	831	1,120	703	621	442	41	0	18	4,185
2014	0	489	191	714	309	656	372	213	0	37	82	3,063
2015	0	564	560	206	270	554	864	457	190	22	17	3,704

Table 9. Spring spawner (SS) weight-at-age (kg) from mobile gear in the 4T herring fishery. A dash indicates no samples were available from that age group.

	Age (years)										
Year	1	2	3	4	5	6	7	8	9	10	11+
1978	0.078	0.131	0.182	0.262	0.248	0.281	0.301	0.308	0.352	0.381	0.389
1979	0.107	0.173	0.193	0.212	0.261	0.259	0.303	0.305	0.340	0.342	0.364
1980	0.114	0.158	0.165	0.217	0.262	0.273	0.258	0.264	0.275	0.364	0.341
1981	0.027	0.158	0.203	0.274	0.272	0.425	0.306	0.284	0.290	0.316	0.417
1982	0.038	0.133	0.225	0.266	0.253	0.315	0.463	0.308	0.339	0.436	0.451
1983	-	0.145	0.188	0.231	0.278	0.270	0.315	0.243	0.411	-	-
1984	0.063	0.121	0.192	0.229	0.262	0.291	0.300	0.380	0.351	0.376	-
1985	0.083	0.137	0.221	0.244	0.297	0.313	0.384	-	-	-	0.384
1986	-	0.144	0.196	0.249	0.283	0.315	0.339	0.349	0.315	-	0.392
1987	-	0.156	0.189	0.251	0.304	0.332	0.358	0.375	-	-	0.527
1988	0.082	0.115	0.176	0.251	0.301	0.337	0.339	0.393	0.412	-	0.442
1989	0.090	0.142	0.212	0.258	0.270	0.313	0.343	0.363	0.385	0.411	0.466
1990	0.078	0.173	0.197	0.246	0.280	0.294	0.333	0.342	0.352	0.409	0.363
1991	0.082	0.143	0.181	0.215	0.248	0.264	0.322	0.334	0.357	0.349	0.401
1992	0.056	0.117	0.148	0.200	0.241	0.272	0.292	0.323	0.327	0.338	0.385
1993	0.070	0.109	0.152	0.179	0.195	0.235	0.252	0.290	0.281	0.311	0.347
1994	-	0.145	0.156	0.188	0.207	0.234	0.258	0.269	0.274	0.316	0.330
1995	-	0.105	0.146	0.182	0.202	0.226	0.247	0.278	0.303	0.314	0.315
1996	0.073	0.116	0.169	0.205	0.224	0.233	0.246	0.276	0.324	0.300	0.378
1997	0.068	0.124	0.155	0.192	0.209	0.249	0.271	0.287	0.308	0.329	0.326
1998	0.076	0.109	0.145	0.171	0.217	0.203	0.248	0.263	0.279	0.296	0.402
1999	0.063	0.118	0.156	0.187	0.232	0.265	0.277	0.294	0.309	0.317	0.319
2000	0.068	0.131	0.159	0.186	0.218	0.247	0.277	0.293	0.294	0.284	0.332
2001	0.062	0.118	0.149	0.190	0.209	0.242	0.256	0.296	0.327	0.330	0.323
2002	0.061	0.106	0.149	0.176	0.206	0.213	0.251	0.281	0.288	0.288	0.329
2003	0.078	0.099	0.141	0.177	0.199	0.238	0.251	0.282	0.291	0.296	0.330
2004	0.068	0.110	0.146	0.162	0.209	0.231	0.251	0.300	0.314	0.290	0.367
2005	0.079	0.120	0.145	0.163	0.188	0.210	0.197	-	0.261	-	-
2006	0.063	0.110	0.145	0.171	0.179	0.203	0.234	0.300	0.350	0.286	-
2007	0.060	0.118	0.145	0.177	0.181	0.197	0.191	0.213	0.300	-	0.198
2008	0.076	0.128	0.141	0.182	0.199	0.207	0.222	0.245	0.230	0.350	0.253
2009	0.033	0.116	0.139	0.191	0.195	0.210	0.172	0.236	-	0.201	0.212
2010	-	0.109	0.134	0.162	0.167	0.200	0.211	0.241	0.255	-	0.269
2011	0.058	0.083	0.122	0.124	0.174	0.169	0.199	0.210	0.191	0.164	0.192
2012	-	0.083	0.123	0.151	0.177	0.184	0.219	0.242	0.216	-	0.236
2013	0.060	0.100	0.127	0.149	0.170	0.183	0.206	0.209	0.227	-	0.287
2014	-	0.099	0.129	0.145	0.176	0.180	0.179	0.212	-	0.194	0.206
2015	-	0.105	0.116	0.140	0.158	0.183	0.194	0.188	0.249	0.268	0.281

Table 10a. Fall spawner (FS) catch-at-age (thousands) from mobile gear in the 4T herring fishery for the North region of the southern Gulf of St. Lawrence.

	Age (years)											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1978	0	78	3,951	11,698	15,776	2,708	2,739	9,720	993	507	17,790	65,961
1979	154	2,747	6,887	5,951	4,015	2,986	1,046	670	1,718	260	11,889	38,323
1980	139	2,020	16,038	4,433	1,825	654	674	268	228	216	1,850	28,344
1981	1	15	178	163	14	3	4	0	2	0	0	379
1982	0	176	4,698	1,441	2,520	321	58	69	55	19	263	9,618
1983	0	4	140	149	46	54	8	2	3	1	91	498
1984	0	31	290	1,854	1,801	843	507	109	23	2	39	5,500
1985	0	50	1,262	1,753	4,841	4,193	1,922	1,388	1,502	471	0	17,382
1986	0	85	692	1,354	2,328	4,745	2,730	1,206	1,227	163	218	14,747
1987	0	942	1,809	1,373	788	1,229	3,377	3,476	744	779	373	14,891
1988	84	3,401	2,151	2,381	2,797	1,342	2,788	2,429	925	1,207	1,629	21,135
1989	0	721	934	1,917	3,823	3,954	1,653	1,961	2,357	1,356	1,182	19,859
1990	0	49	3,063	2,304	2,507	1,386	1,360	1,063	1,430	678	296	14,137
1991	0	0	4,213	14,028	2,650	619	966	597	175	223	2,282	25,753
1992	0	44	571	4,049	9,726	1,270	647	337	274	285	4,868	22,070
1993	0	298	4,229	2,294	2,943	3,772	957	541	542	981	3,285	19,843
1994	0	0	29	6,854	2,913	8,070	10,362	1,177	1,202	468	1,112	32,188
1995	0	0	1,715	3,035	15,930	4,477	5,583	6,031	939	281	2,486	40,477
1996	0	44	1,257	5,034	1,628	6,605	1,615	1,210	862	191	1,082	19,528
1997	0	88	1,112	2,715	2,790	771	1,676	227	454	235	916	10,985
1998	0	51	1,467	2,759	2,785	1,681	464	1,778	108	455	1,268	12,817
1999	0	690	7,217	10,835	5,770	2,761	1,239	767	490	183	1,345	31,298
2000	0	793	4,875	8,784	10,216	2,650	1,369	582	223	272	254	30,017
2001	144	1,194	6,603	4,579	5,105	4,098	705	490	228	0	330	23,476
2002	0	76	1,363	7,505	6,378	4,178	4,009	975	321	346	394	25,545
2003	0	0	4,531	9,687	5,600	3,695	3,219	3,961	960	549	675	32,877
2004	0	71	2,533	8,511	3,204	1,537	741	344	333	40	333	17,647
2005	0	802	3,145	9,147	7,649	1,800	240	100	159	42	154	23,239
2006	0	800	1,966	3,218	7,747	5,366	1,417	493	315	239	54	21,616
2007	0	1,491	14,991	4,688	2,787	2,987	1,571	390	81	3	23	29,011
2008	0	1,385	8,080	5,566	1,678	834	607	771	3	24	0	18,948
2009	0	179	4,648	5,917	2,313	295	211	51	5	0	0	13,618
2010	11	6	1,811	6,112	10,088	6,857	1,258	684	203	90	1	27,120
2011	0	1,177	749	2,101	2,304	2,477	1,015	368	8	59	6	10,263
2012	0	42	379	314	931	641	410	9	0	9	7	2,742
2013	17	527	447	2,904	1,833	2,390	1,318	499	241	18	103	10,298
2014	0	36	1,780	596	2,685	1,301	1,582	942	455	94	0	9,470
2015	0	229	1,252	375	282	1,544	162	625	407	290	0	5,166

Table 10b. Fall spawner (FS) catch-at-age (thousands) from mobile gear in the 4T herring fishery for the Middle region of the southern Gulf of St. Lawrence.

	Age (years)											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1978	0	20	948	4,808	1,863	538	633	1,578	197	59	1,753	12,277
1979	0	0	0	0	0	3,097	745	2,065	1,754	1,313	7,202	17,887
1980	8	135	1,022	284	137	53	48	24	29	20	30	1,784
1981	0	5	44	52	5	1	2	0	1	0	0	110
1982	0	4	31	12	24	3	0	1	0	0	1	77
1983	0	207	5,327	6,407	2,466	3,865	672	156	209	28	85	19,422
1984	0	20	54	242	251	138	90	19	4	1	2	820
1985	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	2	3	2	1	1	3	4	1	1	0	18
1988	0	0	0	0	0	0	0	0	0	0	0	1
1989	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	3	24	369	127	122	102	121	70	23	30	956
1997	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	61	283	567	1,695	152	140	141	360	427	3,848
1999	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	320	464	288	464	190	64	0	0	3	1,795
2003	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	154	1,321	8,673	7,234	3,128	988	583	515	229	116	22,941
2006	0	1	28	192	574	85	30	15	0	0	0	926
2007	0	0	176	238	37	322	118	87	19	31	8	1,036
2008	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0

Table 10c. Fall spawner (FS) catch-at-age (thousands) from mobile gear in the 4T herring fishery for the South region of the southern Gulf of St. Lawrence.

	Age (years)											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1978	0	1,252	16,405	5,700	2,552	899	1,528	3,024	597	698	4,256	37,472
1979	1	31	84	597	780	1,071	215	489	313	83	2,055	6,239
1980	3	493	23,229	10,890	19,861	9,562	4,078	1,396	2,103	1,419	1,328	74,471
1981	17	1,081	9,675	11,391	1,040	287	432	30	181	0	0	24,134
1982	0	0	0	11	22	8	4	2	1	0	2	47
1983	0	5	139	167	64	101	18	4	5	1	2	506
1984	0	0	1	2	1	1	1	0	0	0	0	5
1985	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	74	426	135	6	7	5	1	0	0	0	366
1987	0	9	19	13	6	8	21	22	5	5	2	110
1988	1	50	32	35	42	20	41	36	14	18	21	310
1989	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	76	341	619	738	657	485	536	395	100	3,367
1993	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	13	2,188	1,578	5,388	7,248	775	1,388	962	2,032	21,042
1995	0	22	505	251	1,389	367	1,402	1,762	114	347	402	6,262
1996	0	28	6	2,463	3,060	2,247	1,637	1,285	578	369	649	12,636
1997	0	66	799	889	3,491	1,199	2,075	422	457	231	497	10,712
1998	0	0	3	16	113	349	116	490	91	273	697	2,177
1999	0	23	846	2,005	3,480	2,109	4,730	2,132	1,738	460	1,233	18,756
2000	0	236	1926	3,738	1,875	1,020	371	459	83	47	118	9,875
2001	2	831	6,223	2,837	4,609	4,693	1,956	1,337	836	250	310	23,885
2002	0	954	2,799	6,060	4,530	4,663	3,411	870	232	455	174	24,148
2003	0	201	4,034	5,966	6,382	3,697	4,609	3,633	1,543	303	357	30,726
2004	0	448	2,059	6,792	3,471	2,984	2,191	1,801	1,445	467	333	21,992
2005	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	240	360	260	420	381	129	10	15	3	0	1,817
2007	0	0	70	95	15	128	47	34	8	12	3	411
2008	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	64	928	516	342	38	21	5	0	1	1,914
2011	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	40	211	413	149	333	56	5	7	1,214
2013	0	18	0	1,502	2,107	3,489	5,125	2,162	1,870	202	98	16,575
2014	0	0	0	496	2,895	1,691	2,199	1,972	990	263	0	10,505
2015	0	0	61	359	554	3,343	1,306	1,279	724	176	53	7,856

Table 11. Fall spawner (FS) weight-at-age (kg) from mobile gear in the 4T herring fishery. A dash indicates no samples were available from that age group.

	Age (years)										
Year	1	2	3	4	5	6	7	8	9	10	11+
1978	-	0.100	0.149	0.214	0.253	0.278	0.293	0.331	0.332	0.316	0.388
1979	0.067	0.123	0.180	0.232	0.266	0.293	0.291	0.340	0.365	0.355	0.380
1980	0.033	0.108	0.139	0.174	0.224	0.245	0.290	0.338	0.379	0.388	0.423
1981	0.080	0.111	0.181	0.226	0.256	0.314	0.366	0.234	0.261	0.470	-
1982	-	0.095	0.168	0.221	0.259	0.279	0.374	0.334	0.355	0.455	0.434
1983	-	0.103	0.170	0.213	0.246	0.283	0.316	0.375	0.349	0.222	0.456
1984	-	0.095	0.146	0.208	0.248	0.279	0.305	0.329	0.373	0.392	0.433
1985	-	0.090	0.190	0.215	0.258	0.281	0.311	0.326	0.382	0.419	-
1986	-	0.116	0.158	0.207	0.252	0.276	0.306	0.328	0.335	0.362	0.404
1987	-	0.111	0.172	0.218	0.250	0.284	0.319	0.341	0.351	0.391	0.393
1988	0.074	0.095	0.157	0.220	0.261	0.307	0.327	0.341	0.342	0.414	0.382
1989	-	0.099	0.159	0.213	0.250	0.279	0.319	0.323	0.327	0.360	0.377
1990	-	0.105	0.171	0.213	0.236	0.288	0.310	0.323	0.329	0.338	0.386
1991	-	-	0.149	0.191	0.221	0.263	0.279	0.307	0.310	0.327	0.380
1992	-	0.072	0.128	0.171	0.211	0.237	0.261	0.282	0.290	0.301	0.335
1993	-	0.076	0.128	0.156	0.199	0.225	0.258	0.279	0.310	0.323	0.354
1994	-	0.086	0.134	0.159	0.174	0.204	0.222	0.262	0.274	0.302	0.336
1995	-	0.072	0.118	0.163	0.177	0.198	0.224	0.239	0.271	0.310	0.341
1996	-	0.089	0.133	0.165	0.183	0.209	0.222	0.248	0.269	0.291	0.331
1997	-	0.082	0.141	0.165	0.191	0.224	0.226	0.241	0.262	0.296	0.339
1998	-	0.076	0.126	0.165	0.187	0.224	0.248	0.244	0.303	0.300	0.387
1999	-	0.072	0.128	0.155	0.189	0.214	0.248	0.271	0.289	0.317	0.356
2000	-	0.077	0.131	0.162	0.185	0.208	0.231	0.262	0.263	0.275	0.318
2001	0.023	0.078	0.127	0.156	0.184	0.200	0.215	0.240	0.251	0.237	0.295
2002	-	0.084	0.148	0.188	0.222	0.245	0.272	0.290	0.321	0.329	0.360
2003	-	0.081	0.138	0.169	0.197	0.219	0.240	0.260	0.276	0.318	0.310
2004	-	0.080	0.131	0.160	0.181	0.204	0.224	0.248	0.265	0.278	0.290
2005	-	0.078	0.125	0.151	0.177	0.202	0.228	0.282	0.284	0.301	0.349
2006	-	0.079	0.132	0.164	0.181	0.206	0.215	0.228	0.264	0.301	0.345
2007	-	0.086	0.127	0.152	0.165	0.184	0.202	0.215	0.226	0.258	0.205
2008	-	0.093	0.133	0.153	0.159	0.179	0.184	0.197	0.210	0.218	-
2009	-	0.092	0.123	0.146	0.166	0.179	0.195	0.220	0.231	-	-
2010	0.044	0.094	0.118	0.137	0.155	0.166	0.176	0.198	0.194	0.205	0.309
2011	-	0.069	0.104	0.123	0.141	0.153	0.168	0.179	0.200	0.186	0.234
2012	-	0.076	0.107	0.125	0.142	0.162	0.163	0.206	0.228	0.219	0.245
2013	0.033	0.078	0.112	0.130	0.150	0.169	0.184	0.209	0.218	0.234	0.254
2014	-	0.065	0.109	0.134	0.150	0.167	0.182	0.200	0.222	0.224	-
2015	-	0.102	0.102	0.125	0.148	0.164	0.190	0.194	0.205	0.214	0.231

Table 12. Percent of fishing days with no gillnet catch, based on responses from the telephone survey for the main fishing areas in the spring (F_S) and fall (F_F) fisheries.

Year	F_S (%)	F_F (%)
2006	46.7	16.7
2007	40.0	28.8
2008	49.4	28.8
2009	23.2	17.5
2010	34.1	19.9
2011	26.2	27.3
2012	43.1	24.2
2013	36.3	22.8
2014	29.6	31.5
2015	16.2	40.9

Table 13. Results of the multiplicative general linear model applied to the fishery catch-per-unit-effort data for the spring spawner component (NAFO Div. 4T) and for the fall spawner component for each of the three regions of the southern Gulf of St. Lawrence.

Spawner component	Area	R^2	F_{year}	P_{year}	F_{week}	P_{week}	F_{area}	P_{area}
Spring (SS)	4T	0.42	22.9	<0.0001	17.6	<0.0001	53.3	<0.0001
Fall (FS)	North region	0.57	3.4	<0.0001	17.6	<0.0001	-	-
	Middle region	0.68	6.0	<0.0001	12.9	<0.0001	-	-
	South region	0.53	3.4	<0.0001	15	<0.0001	-	-

Table 14. Spring spawner (SS) fixed gear catch-per-unit-effort values (number per net-haul) of Atlantic herring for NAFO Div. 4T, 1990 to 2015.

	Age (years)							
Year	4	5	6	7	8	9	10	11
1990	125.0	69.5	36.9	42.8	66.5	30.9	12.4	5.2
1991	196.8	237.6	153.6	53.2	48.7	74.7	27.5	18.4
1992	576.2	221.4	145.3	66.4	30.6	37.5	27.3	43.4
1993	65.0	478.1	217.7	58.0	28.5	16.3	8.4	32.3
1994	48.8	205.6	405.1	75.5	30.0	10.2	3.7	8.6
1995	139.6	112.8	186.1	302.7	67.0	18.7	12.1	23.8
1996	15.7	449.1	85.2	132.1	87.9	29.0	5.5	10.2
1997	79.1	59.2	550.1	101.3	60.4	57.3	14.8	2.6
1998	79.3	161.6	23.2	305.8	35.0	25.1	20.1	9.0
1999	72.9	103.9	113.7	24.9	177.2	28.5	14.8	12.8
2000	103.2	137.6	131.3	65.2	38.4	100.6	25.1	15.1
2001	113.9	131.7	99.3	49.5	33.8	14.0	66.4	17.5
2002	71.9	187.4	77.9	36.9	21.2	11.8	10.7	12.4
2003	140.3	144.3	167.2	51.2	32.4	13.0	8.9	9.9
2004	25.9	150.2	53.7	84.5	32.0	11.6	4.1	10.0
2005	68.4	60.3	108.7	48.1	38.0	10.6	2.4	3.3
2006	58.1	208.2	73.9	23.6	12.8	17.3	1.3	3.3
2007	92.9	71.3	105.9	79.3	36.6	8.9	6.8	5.0
2008	155.1	171.6	62.8	69.5	14.8	2.9	1.3	0.7
2009	83.7	193.2	239.7	27.2	27.6	7.2	0.4	1.1
2010	54.0	41.9	76.0	37.4	17.8	17.5	0.2	0.6
2011	7.6	57.7	53.0	71.9	33.4	51.0	18.8	0.3
2012	46.2	46.2	70.3	77.6	39.3	26.0	21.5	9.7
2013	36.6	116.2	139.7	180.1	137.7	98.3	6.0	4.7
2014	2.6	68.6	116.9	131.2	163.2	84.8	33.5	10.2
2015	15.6	23.7	118.4	180.6	80.9	59.9	11.5	6.2

Table 15a. Fall spawner (FS) fixed gear catch-per-unit-effort values (number per net-haul) of Atlantic herring from the North region of the southern Gulf of St. Lawrence.

	Age (years)							
Year	4	5	6	7	8	9	10	11
1986	106.3	104.3	235.0	164.6	78.1	35.6	4.8	8.2
1987	187.2	113.0	102.5	152.9	70.0	42.4	18.6	5.9
1988	110.8	190.3	73.1	64.8	59.3	31.5	15.3	15.0
1989	182.0	296.9	317.3	154.3	70.7	88.9	39.8	31.8
1990	69.6	63.6	98.7	104.7	39.6	27.7	29.1	21.0
1991	490.1	124.6	91.9	136.4	130.5	42.0	26.3	42.8
1992	75.3	457.1	130.7	76.2	82.9	73.0	35.2	66.4
1993	30.7	316.0	366.5	51.4	28.8	29.6	8.4	10.7
1994	41.1	66.0	197.8	298.5	56.9	44.2	20.2	33.9
1995	18.0	130.6	60.5	146.0	154.9	27.1	17.4	19.0
1996	84.1	101.8	136.9	30.1	57.2	62.4	8.8	10.3
1997	92.2	317.7	97.9	87.3	16.8	29.2	26.1	7.6
1998	57.7	158.2	151.0	37.8	36.0	5.2	8.4	15.2
1999	124.8	150.2	186.8	66.4	13.1	8.4	2.3	3.3
2000	155.1	505.9	134.6	56.7	31.1	6.0	4.5	2.0
2001	147.3	186.2	191.9	29.3	13.2	3.6	1.1	1.5
2002	192.5	210.6	147.7	79.4	20.7	6.2	4.3	1.7
2003	82.8	174.2	117.0	82.5	98.5	24.6	10.8	6.8
2004	211.4	157.8	76.6	46.4	36.0	24.7	5.7	3.9
2005	47.6	531.4	211.8	81.6	45.0	27.0	19.1	1.7
2006	16.2	100.5	97.5	14.5	4.1	7.8	3.0	1.6
2007	35.2	104.1	236.8	162.9	34.8	6.5	6.1	3.8
2008	66.3	42.1	67.3	54.6	52.8	6.4	2.2	3.1
2009	118.1	201.5	55.5	54.8	31.9	8.9	1.6	1.3
2010	17.7	151.3	130.6	45.2	30.2	23.7	9.7	1.1
2011	8.0	31.0	129.9	117.7	13.4	15.2	13.8	3.8
2012	1.1	60.5	124.0	184.8	82.7	16.5	19.3	6.7
2013	9.1	77.6	250.1	179.4	92.1	19.8	1.6	0.9
2014	1.6	80.2	176.9	441.3	203.1	137.4	1.8	1.1
2015	2.4	69.6	494.6	367.8	443.3	137.8	21.9	5.8

Table 15b. Fall spawner (FS) fixed gear catch-per-unit-effort values (number per net-haul) of Atlantic herring from the Middle region of the southern Gulf of St. Lawrence.

	Age (years)							
Year	4	5	6	7	8	9	10	11
1986	144.2	119.7	221.4	101.0	39.2	18.1	2.4	4.2
1987	65.9	124.3	108.1	216.0	20.4	18.8	21.1	1.3
1988	69.6	63.5	55.7	25.6	26.8	20.0	0.3	0.0
1989	23.8	44.2	39.4	21.4	13.2	11.7	5.3	4.3
1990	47.7	34.5	37.4	65.9	13.6	9.5	7.4	1.6
1991	156.9	42.5	35.0	46.0	54.3	33.4	15.4	35.1
1992	105.2	255.3	34.8	14.5	8.2	6.0	2.9	6.8
1993	9.7	184.0	230.9	39.4	16.6	11.6	13.1	19.9
1994	14.4	23.2	116.7	157.0	19.2	6.1	7.4	12.5
1995	2.7	127.5	43.4	156.1	135.7	17.4	3.1	54.4
1996	61.9	38.2	219.3	19.0	57.0	65.4	15.1	15.8
1997	127.3	288.9	52.1	108.6	20.6	24.7	27.0	16.8
1998	54.3	45.7	92.8	18.7	34.9	6.3	13.7	23.7
1999	120.2	159.7	63.2	39.9	16.1	35.3	3.4	16.5
2000	202.6	387.5	142.8	46.1	25.6	7.6	6.8	3.0
2001	107.7	264.9	187.9	56.9	12.3	4.1	0.0	5.7
2002	147.0	131.3	116.1	112.3	20.2	2.8	2.4	3.5
2003	85.5	179.2	83.9	56.6	56.6	12.7	1.7	2.4
2004	127.5	231.3	163.2	116.4	103.4	60.6	21.0	4.0
2005	54.5	335.9	272.0	81.8	70.5	48.6	20.7	1.5
2006	48.0	218.8	389.9	144.0	73.4	55.1	43.7	14.8
2007	51.7	148.0	410.3	423.3	161.2	65.1	31.6	19.6
2008	322.1	68.1	118.8	140.9	225.3	40.6	38.4	8.8
2009	155.4	276.0	63.9	141.2	67.9	23.6	10.1	4.6
2010	12.9	97.0	143.7	41.9	36.6	20.9	9.8	5.4
2011	4.5	23.0	134.0	172.0	32.8	24.6	23.1	6.9
2012	2.4	31.0	139.2	186.8	130.6	14.8	8.4	7.1
2013	17.0	32.4	202.9	303.3	185.9	71.7	5.8	1.2
2014	0.0	48.2	30.2	103.2	113.7	21.4	10.5	0.0
2015	7.1	45.0	429.9	191.2	324.5	127.7	45.3	0.0

Table 15c. Fall spawner (FS) fixed gear catch-per-unit-effort values (number per net-haul) of Atlantic herring from the South region of the southern Gulf of St. Lawrence.

	Age (years)							
Year	4	5	6	7	8	9	10	11
1986	451.3	126.9	266.5	74.0	36.1	10.8	2.3	3.6
1987	126.4	145.5	69.7	160.0	70.5	48.7	21.0	15.0
1988	57.5	220.0	127.3	62.6	87.5	40.0	13.0	8.8
1989	101.9	156.2	626.7	316.2	135.7	184.0	46.8	22.6
1990	104.0	103.4	118.5	553.2	151.4	66.4	70.5	38.0
1991	334.5	112.7	90.3	81.1	263.2	92.1	56.7	80.3
1992	94.5	528.4	76.6	44.7	107.0	236.4	87.9	93.2
1993	28.6	305.4	369.3	93.0	38.3	55.5	45.9	106.3
1994	33.6	7.1	229.4	316.6	43.0	56.4	120.6	200.2
1995	3.9	90.6	31.3	139.4	118.9	31.6	34.8	84.1
1996	42.0	25.1	164.7	59.1	137.7	131.5	33.6	102.0
1997	118.6	707.9	63.6	269.3	46.7	97.4	91.6	81.5
1998	115.5	54.3	193.2	48.8	109.4	21.5	42.2	51.9
1999	143.5	519.6	70.5	156.8	30.7	50.1	18.6	25.7
2000	113.3	442.5	264.1	43.0	51.5	10.0	16.0	10.0
2001	36.8	455.9	426.4	274.4	40.4	32.3	8.8	16.7
2002	361.5	153.4	346.7	288.2	86.7	21.9	18.9	11.2
2003	94.9	783.0	121.7	255.5	162.4	31.8	4.9	7.1
2004	106.7	246.4	542.2	107.2	98.5	48.1	13.3	6.9
2005	9.4	273.2	451.6	704.7	133.9	136.5	38.3	8.5
2006	72.7	199.1	522.1	537.1	399.1	131.7	70.0	19.6
2007	7.6	340.9	498.5	913.2	567.2	182.6	108.5	34.6
2008	122.5	44.7	166.1	304.2	378.5	173.4	92.0	71.1
2009	51.4	443.0	221.9	442.2	146.2	77.5	112.4	56.0
2010	46.7	196.5	720.6	187.5	233.4	152.8	85.7	54.8
2011	7.1	170.3	169.1	571.7	183.2	91.1	53.2	94.7
2012	0.2	12.2	131.9	149.3	159.2	16.9	4.9	16.4
2013	8.6	26.0	232.2	495.7	184.2	87.3	2.8	2.7
2014	5.2	86.1	68.9	271.7	482.7	106.1	51.5	1.7
2015	0.0	57.5	277.7	153.4	434.4	116.9	66.9	7.2

Table 16. Spring spawner (SS) and fall spawner (FS) catch-at-age (thousands) from the fishery-independent acoustic survey of Atlantic herring in NAFO area 4Tmno.

	Age (years)								
Year	2	3	4	5	6	7	8	9	10
Spring spawner (SS)									
1994	2,548	231,972	100,087	109,649	104,274	28,059	6,389	7,213	1,020
1995	47,487	7,754	77,137	21,658	25,176	21,107	5,123	777	74
1996	329,625	141,573	16,362	184,895	48,108	28,881	30,565	7,998	3,685
1997	152,575	77,940	79,051	11,238	84,978	5,522	12,953	14,800	2,648
1998	156,808	30,320	31,992	19,716	5,616	38,121	6,423	5,438	3,585
1999	242,560	109,082	56,090	19,836	6,278	3,667	18,015	2,748	1,380
2000	22,189	31,065	25,435	9,748	8,553	1,647	10,009	2,155	448
2001	90,891	14,967	8,107	5,733	3,180	1,844	2,784	500	440
2002	93,282	27,633	8,130	11,464	3,494	5,132	1,684	271	123
2003	246,067	41,734	57,654	26,041	17,349	5,255	1,878	4,847	3,520
2004	234,180	62,439	9,350	10,956	556	0	0	0	0
2005	141,882	144,933	34,193	1,674	3,269	746	292	0	0
2006	100,680	39,313	24,601	26,314	2,909	885	572	257	338
2007	49,662	39,444	8,005	12,402	8,158	1,172	1,456	0	0
2008	71,227	25,129	7,599	9,225	5,760	3,091	2,294	532	0
2009	47,329	39,979	16,153	7,849	2,438	1,224	1,773	0	0
2010	37,884	67,713	73,493	8,786	8,469	8,824	2,433	1,517	0
2011	20,724	39,960	14,878	16,259	10,973	4,135	106	3,538	104
2012	14,686	114,169	29,857	9,938	7,663	2,494	1,243	260	379
2013	604	8,850	21,554	21,927	13,612	4,517	1,456	0	0
2014	23,417	17,322	13,489	7,512	6,430	7,003	666	0	872
Fall spawner (FS)									
1994	2,157	4,442	201,387	61,956	33,090	17,255	2,309	0	12
1995	13,032	23,475	12,114	53,149	11,242	20,081	27,312	2,836	1,218
1996	276,748	252,685	203,250	33,855	120,199	32,473	27,034	11,945	3,000
1997	234,294	383,392	238,795	115,422	16,301	45,770	15,375	14,487	6,536
1998	73,765	198,123	111,466	55,623	39,509	9,352	27,410	3,700	6,706
1999	60,387	324,854	231,521	103,094	69,001	82,058	34,684	30,955	11,048
2000	69,467	152,924	237,946	197,059	83,604	30,623	32,789	22,338	9,798
2001	130,503	430,404	119,003	55,365	38,311	11,522	14,404	10,217	3,448
2002	265,715	65,241	75,331	58,918	69,961	46,733	11,739	2,050	4,002
2003	57,267	418,553	236,960	221,303	85,138	135,135	133,900	56,418	21,343
2004	61,447	92,757	104,324	41,493	36,813	47,659	14,412	17,158	5,750
2005	41,546	148,749	357,945	187,039	69,267	14,900	5,769	5,923	2,600
2006	650,349	192,892	96,550	134,037	187,250	88,038	40,814	38,326	13,275
2007	146,879	306,699	71,436	34,344	42,814	34,105	3,974	1,952	1,419
2008	163,627	155,365	98,998	20,089	11,055	10,437	7,404	2,007	467
2009	102,976	169,918	96,964	50,109	6,429	2,552	1,186	421	160
2010	36,518	153,077	248,399	270,706	132,936	6,744	7,318	1,353	213
2011	29,046	42,618	88,110	68,688	51,739	22,620	4,808	2,908	1,077
2012	306	289,119	159,440	122,634	69,157	29,580	3,985	4,268	190
2013	4,292	19,527	173,674	70,662	99,164	41,757	10,859	7,683	11,321
2014	141,469	73,572	23,157	100,959	52,157	49,191	29,077	8,924	2,203

Table 17. Abundance indices of fall spawner Atlantic herring derived from the experimental gillnet catches, by age, year and region (a) North, b) Middle, and c) South) of the southern Gulf of St. Lawrence.

		Age								
Region	Year	2	3	4	5	6	7	8	9	10
a) North	2002	0.0	5.7	34.5	28.5	15.2	9.4	1.4	0.4	0.3
	2003	0.0	6.2	11.0	6.1	4.6	3.5	2.9	0.7	0.6
	2004	0.1	1.5	20.6	7.5	2.6	1.2	1.2	1.0	0.2
	2005	0.0	0.0	8.8	17.1	5.1	2.3	1.2	0.8	0.4
	2006	0.0	0.6	13.9	36.5	25.2	5.2	1.2	1.8	0.6
	2007	-	-	-	-	-	-	-	-	-
	2008	0.4	16.1	108.0	20.0	13.0	16.2	11.2	2.1	1.2
	2009	0.6	18.0	78.1	63.7	12.0	11.0	7.4	2.5	0.5
	2010	0.0	8.6	41.2	69.7	32.7	4.0	3.1	2.0	0.9
	2011	0.0	0.0	13.9	30.1	35.2	18.8	3.8	2.5	1.7
	2012	-	-	-	-	-	-	-	-	-
	2013	0.0	0.9	32.8	31.5	65.4	48.1	24.0	6.0	1.1
	2014	-	-	-	-	-	-	-	-	-
	2015	0.0	0.6	10.7	9.9	49.4	23.3	26.6	11.7	2.3
b) Middle	2002	-	-	-	-	-	-	-	-	-
	2003	1.0	26.1	70.7	53.2	21.0	22.8	15.3	2.9	1.0
	2004	0.0	11.2	66.8	44.3	16.6	7.2	6.6	3.5	1.0
	2005	0.4	8.7	45.9	67.1	34.8	12.0	7.3	5.9	2.1
	2006	0.1	3.9	20.7	39.9	53.2	23.1	9.8	6.2	5.0
	2007	0.2	10.9	8.5	13.9	20.8	21.7	8.5	2.9	2.0
	2008	1.0	15.6	100.1	15.4	13.1	12.9	12.7	3.2	1.8
	2009	0.1	45.9	155.8	140.4	24.6	28.2	16.1	5.8	2.0
	2010	0.0	0.1	1.4	3.9	5.7	1.2	1.5	1.9	0.9
	2011	0.0	0.8	18.5	25.3	44.5	41.7	9.2	7.0	5.6
	2012	0.5	10.9	7.6	24.7	31.2	37.5	24.1	2.1	1.1
	2013	0.3	5.5	82.8	18.4	56.2	49.6	30.9	10.6	0.6
	2014	0.0	0.0	0.7	16.3	8.5	17.8	12.8	3.8	0.8
	2015	0.3	2.5	14.2	15.7	101.7	23.7	28.8	11.1	3.1
c) South	2002	0.0	10.0	50.0	7.6	9.2	6.7	2.4	0.4	0.1
	2003	0.6	13.3	27.9	67.7	11.6	16.7	11.7	3.5	0.6
	2004	0.1	7.5	26.9	18.4	25.1	4.9	5.1	2.3	0.7
	2005	0.1	7.3	9.0	15.8	15.3	20.1	3.5	3.7	1.1
	2006	0.0	1.7	31.1	19.1	37.3	41.9	24.2	7.2	3.9
	2007	1.2	45.3	8.0	17.1	13.4	19.3	16.1	6.3	1.8
	2008	0.2	9.6	49.1	4.0	10.5	9.1	10.1	6.0	2.9
	2009	0.4	10.9	18.4	43.2	6.7	10.5	4.4	2.9	1.5
	2010	0.1	0.4	11.1	4.3	9.1	1.2	2.1	1.1	0.9
	2011	0.0	0.6	21.3	40.2	16.5	24.8	2.2	2.6	1.2
	2012	0.1	3.2	2.0	5.6	9.3	3.8	4.2	0.6	0.2
	2013	0.0	0.3	10.3	5.3	17.1	19.3	7.1	2.6	0.1
	2014	0.0	0.0	2.2	26.4	13.2	29.0	25.5	5.4	2.2
	2015	0.2	1.2	5.5	25.7	72.8	27.1	36.6	21.5	5.4

Table 18a. Relative selectivity-at-age, as proportions, for 2⅝" mesh gillnets calculated from the experimental netting survey and commercial gillnet fishery for fall spawner Atlantic herring from the southern Gulf of St. Lawrence.

	Age (years)								
Year	2	3	4	5	6	7	8	9	10
1985	0.393	0.328	0.620	0.859	0.951	0.922	0.875	0.799	0.732
1986	0.190	0.491	0.647	0.851	0.956	0.933	0.866	0.818	0.585
1987	0.107	0.583	0.653	0.848	0.945	0.936	0.863	0.802	0.764
1988	0.121	0.490	0.719	0.870	0.942	0.932	0.889	0.823	0.785
1989	0.120	0.569	0.724	0.927	0.969	0.944	0.866	0.822	0.745
1990	0.294	0.332	0.656	0.854	0.939	0.921	0.846	0.758	0.731
1991	0.133	0.432	0.554	0.777	0.933	0.938	0.899	0.815	0.735
1992	0.139	0.310	0.489	0.730	0.906	0.933	0.871	0.834	0.759
1993	0.146	0.217	0.521	0.677	0.856	0.927	0.886	0.841	0.798
1994	0.121	0.121	0.387	0.653	0.816	0.932	0.957	0.880	0.833
1995	0.159	0.465	0.384	0.554	0.721	0.867	0.946	0.897	0.831
1996	0.165	0.219	0.434	0.637	0.718	0.847	0.918	0.944	0.851
1997	0.048	0.145	0.330	0.580	0.779	0.868	0.955	0.949	0.932
1998	0.021	0.172	0.382	0.549	0.743	0.883	0.937	0.945	0.925
1999	0.365	0.092	0.337	0.563	0.656	0.829	0.924	0.947	0.918
2000	0.011	0.100	0.344	0.524	0.714	0.818	0.925	0.932	0.947
2001	0.006	0.075	0.328	0.516	0.670	0.814	0.909	0.967	0.935
2002	0.002	0.152	0.310	0.483	0.621	0.762	0.880	0.953	0.957
2003	0.057	0.231	0.310	0.462	0.621	0.757	0.851	0.922	0.931
2004	0.008	0.109	0.300	0.454	0.609	0.729	0.861	0.920	0.946
2005	0.001	0.065	0.259	0.458	0.568	0.671	0.820	0.889	0.922
2006	0.700	0.137	0.276	0.430	0.591	0.690	0.799	0.909	0.933
2007	0.030	0.057	0.286	0.412	0.572	0.702	0.778	0.849	0.919
2008	0.011	0.041	0.203	0.409	0.558	0.683	0.772	0.818	0.895
2009	0.027	0.089	0.233	0.343	0.542	0.680	0.781	0.851	0.874
2010	0.001	0.032	0.163	0.348	0.413	0.616	0.681	0.765	0.833
2011	0.625	0.036	0.116	0.285	0.449	0.489	0.694	0.752	0.829
2012	0.000	0.063	0.102	0.230	0.370	0.516	0.569	0.734	0.838
2013	0.927	0.042	0.108	0.271	0.377	0.477	0.580	0.633	0.774
2014	0.970	0.059	0.198	0.282	0.382	0.427	0.508	0.600	0.650
2015	0.009	0.076	0.162	0.326	0.363	0.490	0.544	0.634	0.692

Table 18b. Relative selectivity-at-age, as proportions, for 2¾" mesh gillnets calculated from the experimental netting survey and commercial gillnet fishery for fall spawner Atlantic herring from the southern Gulf of St. Lawrence.

	Age (years)								
Year	2	3	4	5	6	7	8	9	10
1985	0.205	0.167	0.380	0.642	0.848	0.941	0.964	0.948	0.922
1986	0.080	0.277	0.404	0.639	0.828	0.938	0.891	0.917	0.842
1987	0.016	0.351	0.411	0.623	0.826	0.919	0.955	0.943	0.928
1988	0.046	0.281	0.479	0.655	0.823	0.910	0.965	0.964	0.945
1989	0.041	0.332	0.493	0.768	0.867	0.948	0.958	0.946	0.922
1990	0.138	0.174	0.418	0.642	0.882	0.956	0.962	0.936	0.928
1991	0.066	0.232	0.322	0.541	0.786	0.919	0.963	0.951	0.922
1992	0.078	0.146	0.271	0.484	0.720	0.879	0.967	0.964	0.937
1993	0.090	0.094	0.300	0.429	0.632	0.789	0.902	0.957	0.931
1994	0.046	0.046	0.199	0.406	0.576	0.754	0.904	0.963	0.961
1995	0.115	0.249	0.197	0.321	0.480	0.666	0.801	0.907	0.945
1996	0.127	0.095	0.234	0.393	0.473	0.629	0.759	0.875	0.956
1997	0.016	0.059	0.164	0.347	0.539	0.649	0.831	0.870	0.933
1998	0.006	0.075	0.196	0.320	0.498	0.684	0.787	0.891	0.946
1999	0.640	0.034	0.168	0.330	0.416	0.604	0.753	0.840	0.925
2000	0.003	0.039	0.172	0.299	0.467	0.592	0.754	0.801	0.907
2001	0.002	0.028	0.162	0.292	0.423	0.581	0.713	0.841	0.889
2002	0.000	0.067	0.151	0.268	0.380	0.520	0.669	0.806	0.835
2003	0.019	0.112	0.152	0.253	0.380	0.513	0.632	0.749	0.839
2004	0.002	0.043	0.145	0.247	0.371	0.489	0.646	0.746	0.842
2005	0.000	0.024	0.123	0.250	0.337	0.428	0.597	0.697	0.764
2006	0.932	0.055	0.132	0.231	0.358	0.450	0.568	0.733	0.788
2007	0.010	0.020	0.137	0.217	0.341	0.460	0.543	0.644	0.756
2008	0.004	0.015	0.090	0.218	0.331	0.443	0.536	0.591	0.701
2009	0.009	0.035	0.107	0.173	0.321	0.444	0.548	0.648	0.671
2010	0.000	0.010	0.071	0.176	0.219	0.387	0.452	0.537	0.618
2011	0.824	0.022	0.047	0.141	0.247	0.276	0.467	0.526	0.619
2012	0.000	0.025	0.039	0.104	0.191	0.295	0.337	0.501	0.621
2013	0.997	0.014	0.044	0.129	0.195	0.264	0.342	0.388	0.537
2014	0.949	0.021	0.085	0.137	0.197	0.228	0.287	0.360	0.404
2015	0.002	0.028	0.067	0.162	0.184	0.276	0.315	0.391	0.446

Table 19. Multi-species trawl survey index (mean numbers per tow) at age for fall spawner (FS) herring from the southern Gulf of St. Lawrence. The values shown are the median from MCMC posterior distributions for each year and age.

	Age (years)										
Year	1	2	3	4	5	6	7	8	9	10	11+
1994	0.95	0.83	1.97	23.75	7.89	12.87	16.87	6.41	2.69	7.84	0.14
1995	0.72	1.80	8.04	6.09	21.07	5.9	6.26	7.14	0.76	1.65	1.62
1996	0.65	2.13	0.89	2.93	0.89	3.07	1.07	1.40	0.73	0.30	0.30
1997	4.01	18.52	17.6	7.73	17.72	5.54	11.14	3.00	3.29	2.25	0.88
1998	3.22	1.65	1.23	6.1	1.35	3.37	1.21	1.87	0.5	0.75	0.55
1999	5.09	11.42	3.56	5.16	2.77	1.18	1.76	0.98	0.79	0.37	0.13
2000	4.39	6.49	7.12	11.7	10.53	3.91	0.91	2.25	0.68	0.59	0.04
2001	4.30	24.29	16.27	8.78	9.21	10.57	4.73	2.15	1.15	0.75	0.56
2002	1.88	10.78	9.93	18.38	7.82	6.19	5.44	1.73	0.9	0.46	0.32
2003	9.19	0.72	7.35	21.4	19.19	9.06	5.35	5.47	0.84	0.62	0.34
2004	2.01	2.29	6.63	11.97	7.51	6.01	4.71	3.19	2.08	0.42	0.22
2005	0.69	3.00	10.79	61.36	95.06	21.79	12.37	10.07	5.27	4.14	1.09
2006	20.2	14.34	8.15	23.28	15.12	21.71	8.27	5.27	0.67	0.44	0.59
2007	3.27	23.33	54.96	9.67	16.44	12.76	16.22	4.81	4.04	1.74	0.83
2008	3.33	16.36	13.45	17.72	1.87	5.91	3.68	2.94	1.33	1.81	0.25
2009	2.56	19.52	30.87	30.55	19.87	4.64	4.46	3.03	2.88	0.1	0.06
2010	0.63	17.51	19.59	32.14	20.47	20.51	2.84	1.85	1.73	1.01	0.11
2011	0.53	34.96	10.64	35.60	40.34	25.05	12.48	5.39	1.82	2.66	0.03

FIGURES

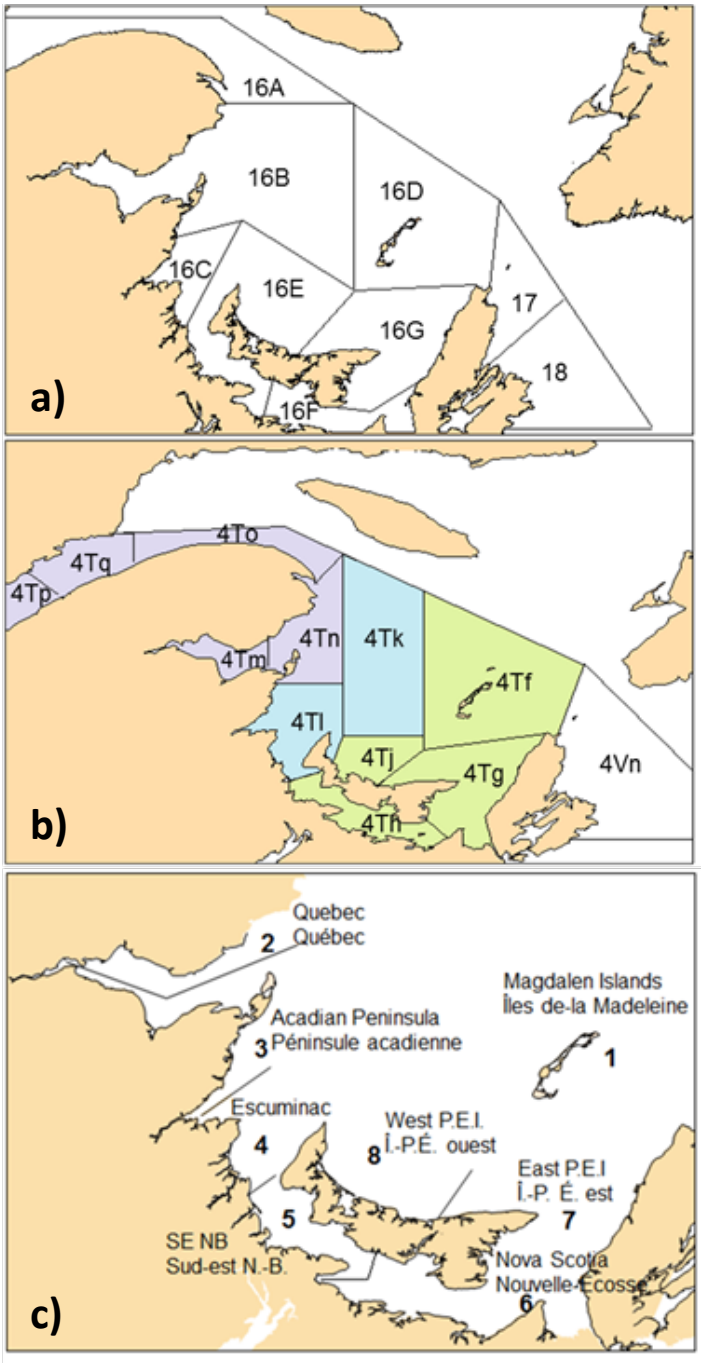


Figure 1. Southern Gulf of St. Lawrence herring fishery management zones (a) upper panel), Northwest Atlantic Fisheries Organization (NAFO) divisions 4T and 4Vn, where purple represents the North region, blue = Middle region, and green = South region (b) middle panel), and geographic areas used in the telephone survey of the herring gillnet fishery (c) lower panel).

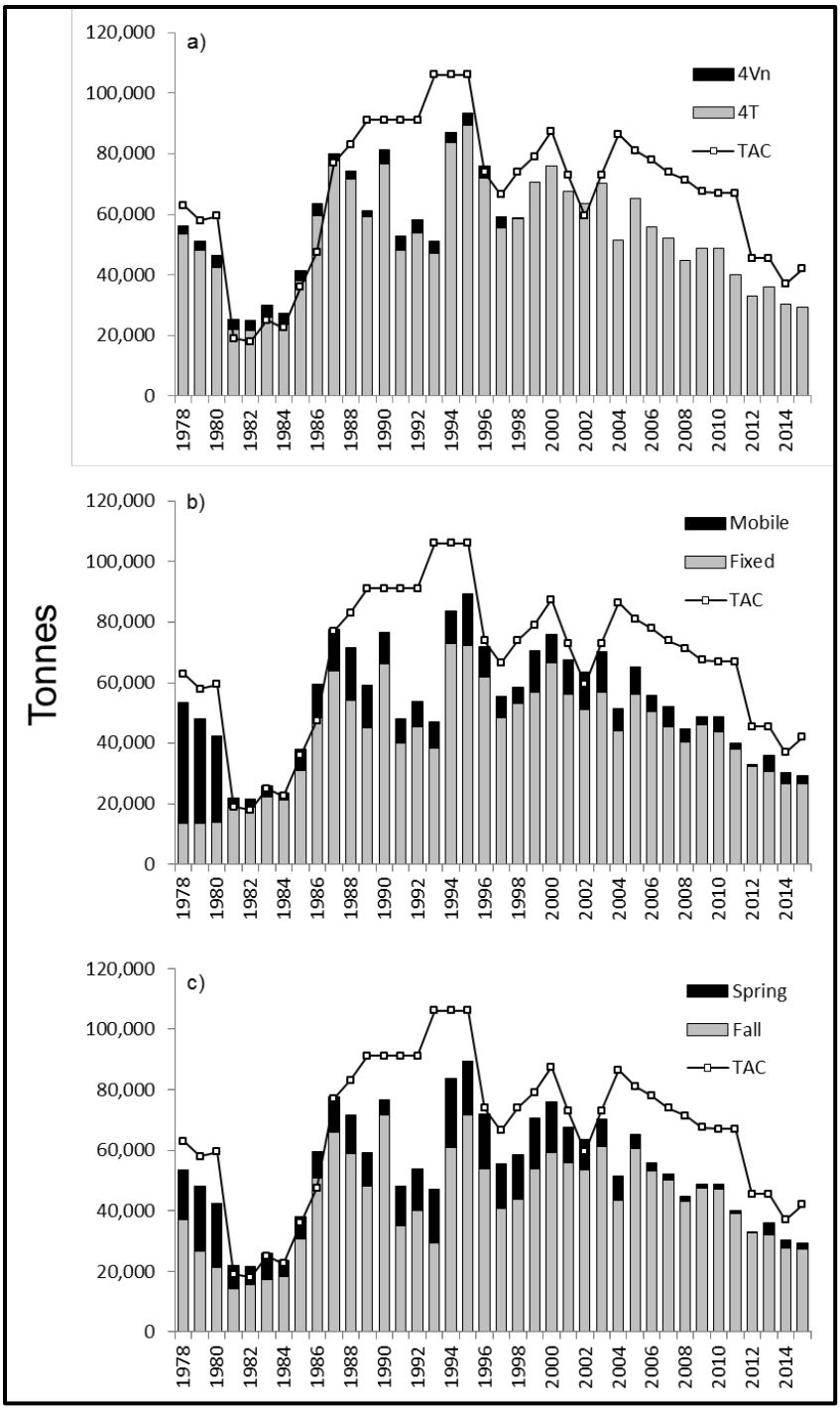


Figure 2. Reported landings (tonnes) of southern Gulf of St. Lawrence Atlantic herring (spring and fall spawners combined) by NAFO division (upper panel), by gear fleet (middle panel), and by fishing season (lower panel), 1978 to 2015. In all panels, the corresponding annual total allowable catch (TAC; tonnes) is shown. For landings by season, the landings in Div. 4Vn were attributed to the fall fishing season. Data for 2015 are preliminary.

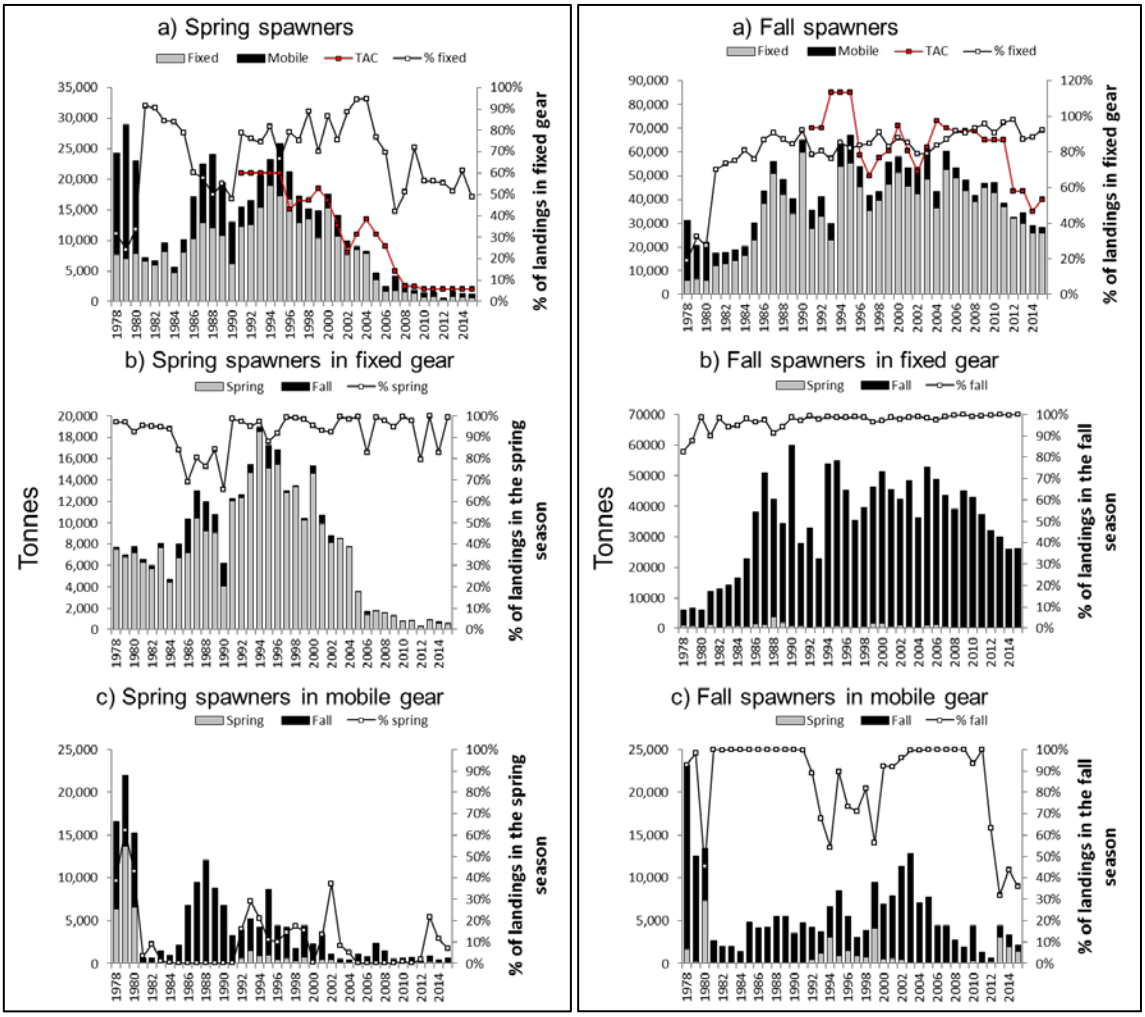


Figure 3. Estimated landings (tonnes) of the spring spawner component (SS) (left column) and fall spawner component (right panel) of Atlantic herring from the southern Gulf of St. Lawrence, 1978 to 2015. The upper panel shows the estimated landings by gear type and the proportion of the landings attributed to the fixed gear fleet. Also shown in the upper panel is the TAC for the spawner component (red symbols) for 1991 to 2015. The middle panel shows the estimated landings of herring in the fixed gear fleet that occurred in the spring fishery season and the fall fishery season as well as the proportion of herring landed in the matching fishing season. The lower panel shows the estimated landings of herring in the mobile gear fleet that occurred in the spring fishery season and the fall fishery season as well as the proportion of herring landed in the matching fishing season. For landings by season, the landings in NAFO Division 4Vn were attributed to the fall fishing season. Data for 2015 are preliminary.

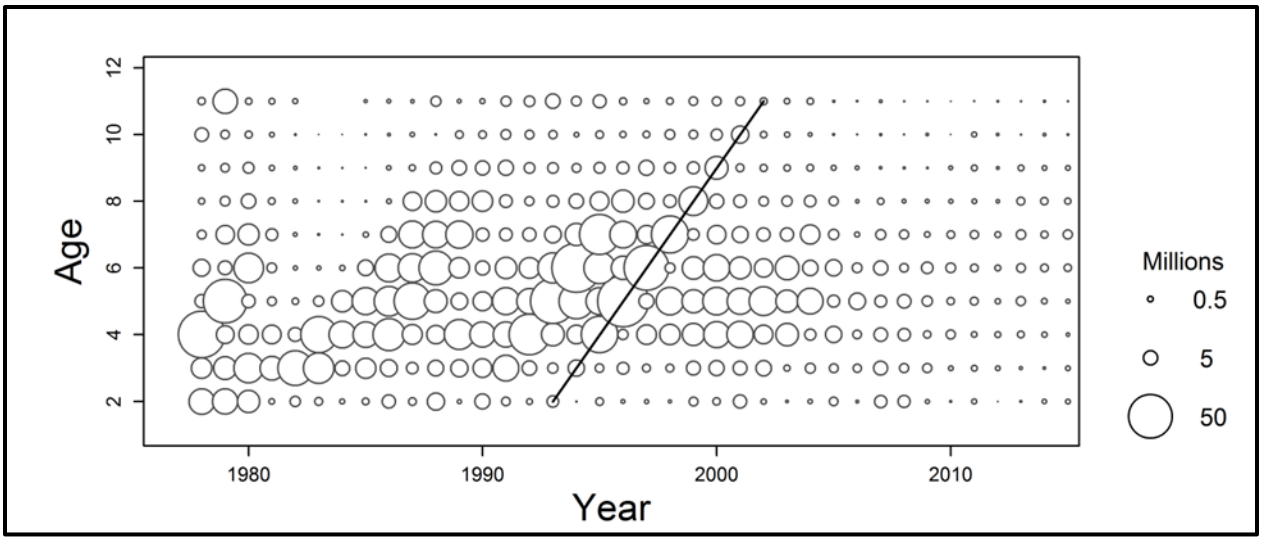


Figure 4. Catch-at-age of the spring spawner component of Atlantic herring from the southern Gulf of St. Lawrence, all gears combined, 1978 to 2015. Size of the bubble is proportional to the catch numbers by age and year. The diagonal line represents the most recent strong year-class (1991).

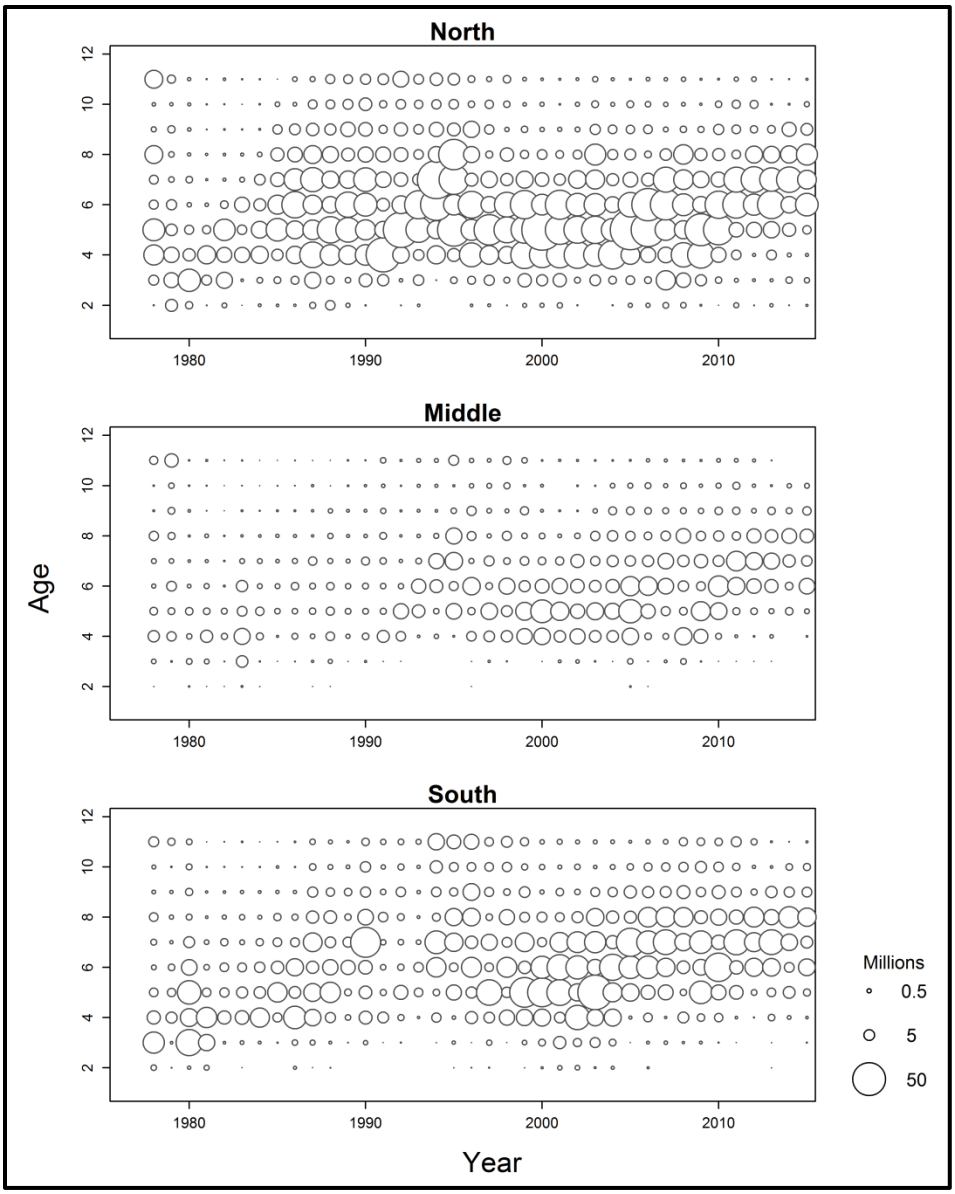


Figure 5. Bubble plots of fishery catch-at-age (number) of fall spawner Atlantic herring, for mobile and fixed gears combined, in three regions of the southern Gulf of St. Lawrence, 1978 to 2015. The size of the bubble is proportional to the number of fish in the catch by age and year. The values indicated at age 11 represent catches for ages 11 years and older.

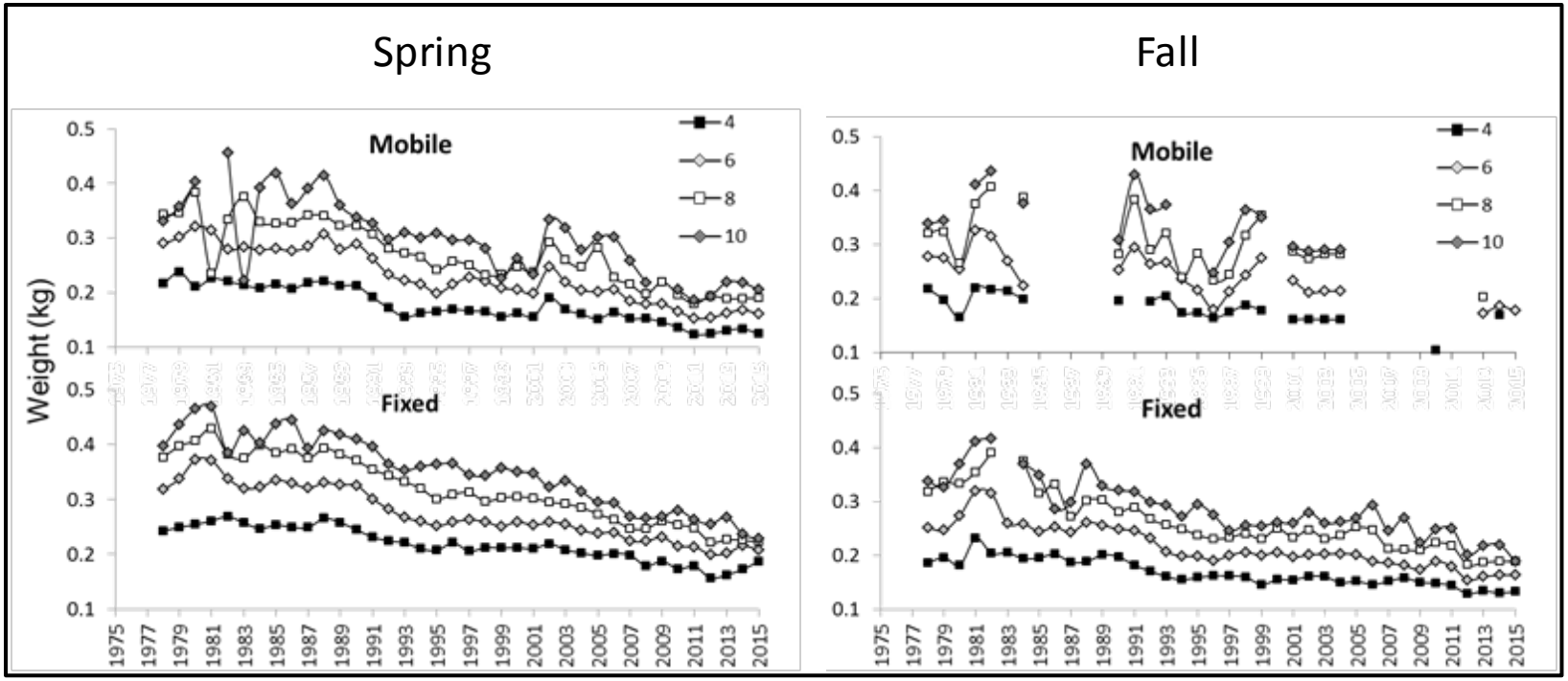


Figure 6. Mean weight-at-age for ages 4, 6, 8 and 10 of spring spawners (left panels) sampled from catches in the spring season and fall spawners (right panels) sampled from catches in the fall season from the mobile (upper panels) and fixed (lower panels) commercial gears, 1978 to 2015.

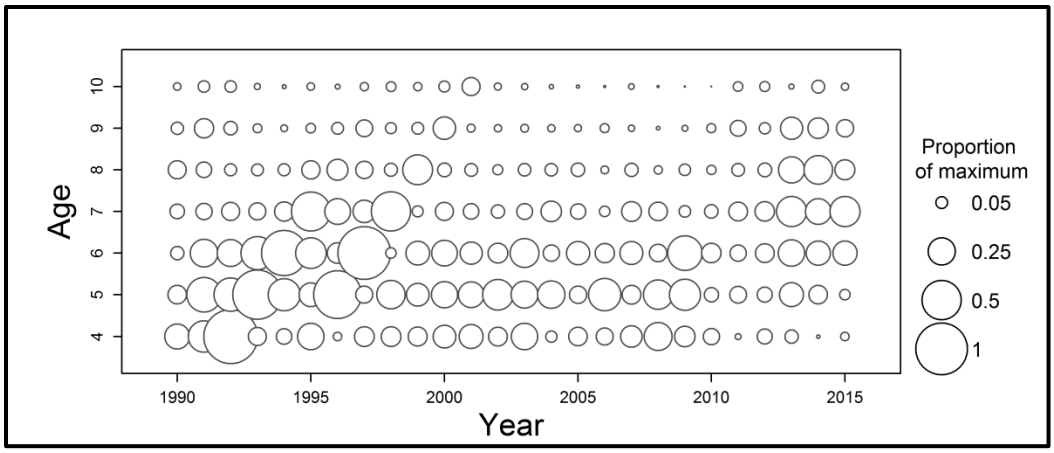


Figure 7. Bubble plot of spring spawner herring fixed gear catch-per-unit-effort values (number per net-haul per trip) at age, 1990 to 2015. The size of the bubble is proportional to the maximum CPUE index value.

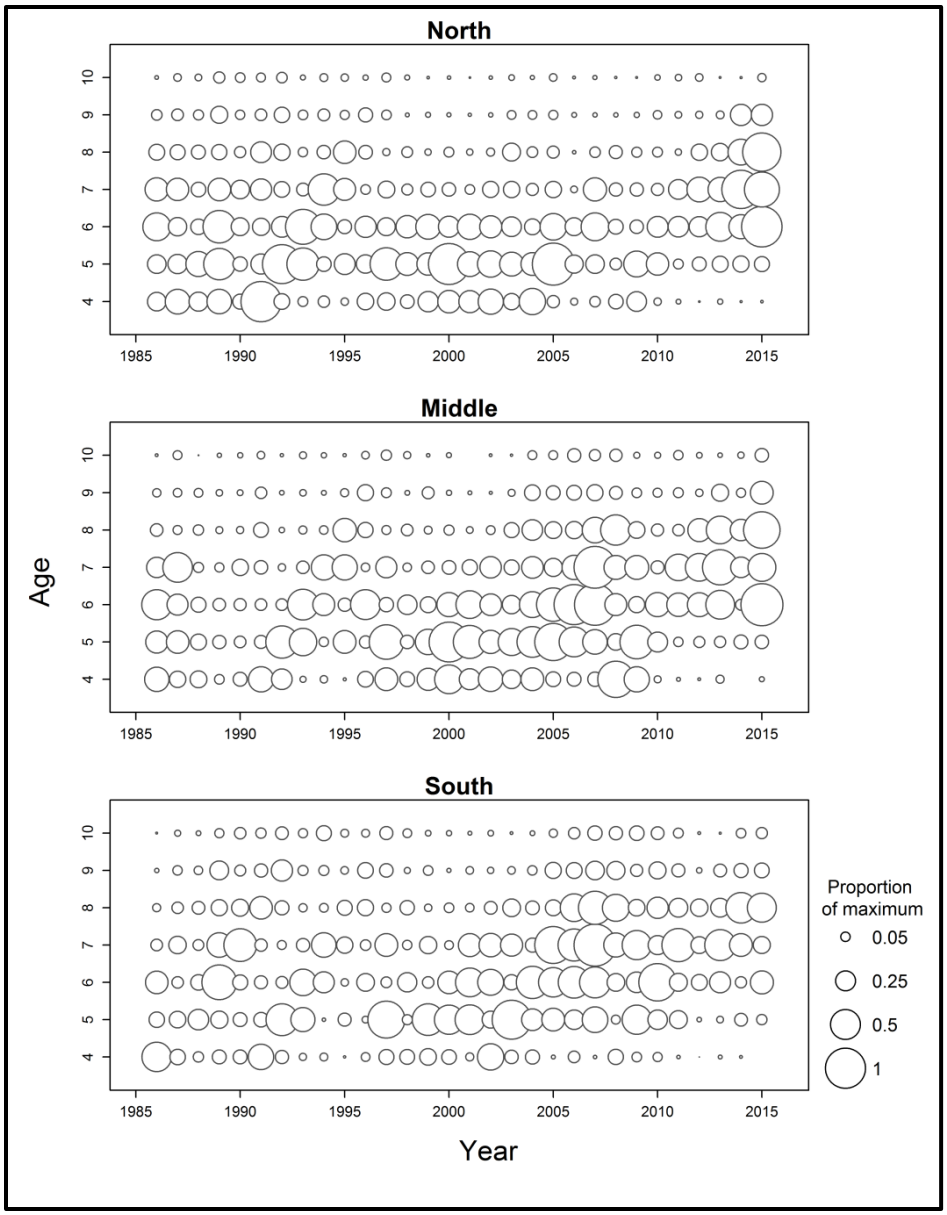


Figure 8. Fall spawner (FS) fixed gear age-disaggregated catch-per-unit-effort values (number per net-haul per trip) of Atlantic herring by region (upper panel North, middle panel Middle, and lower panel South) of the southern Gulf of St. Lawrence, 1986 to 2015. The size of the bubble is proportional to the CPUE index value.

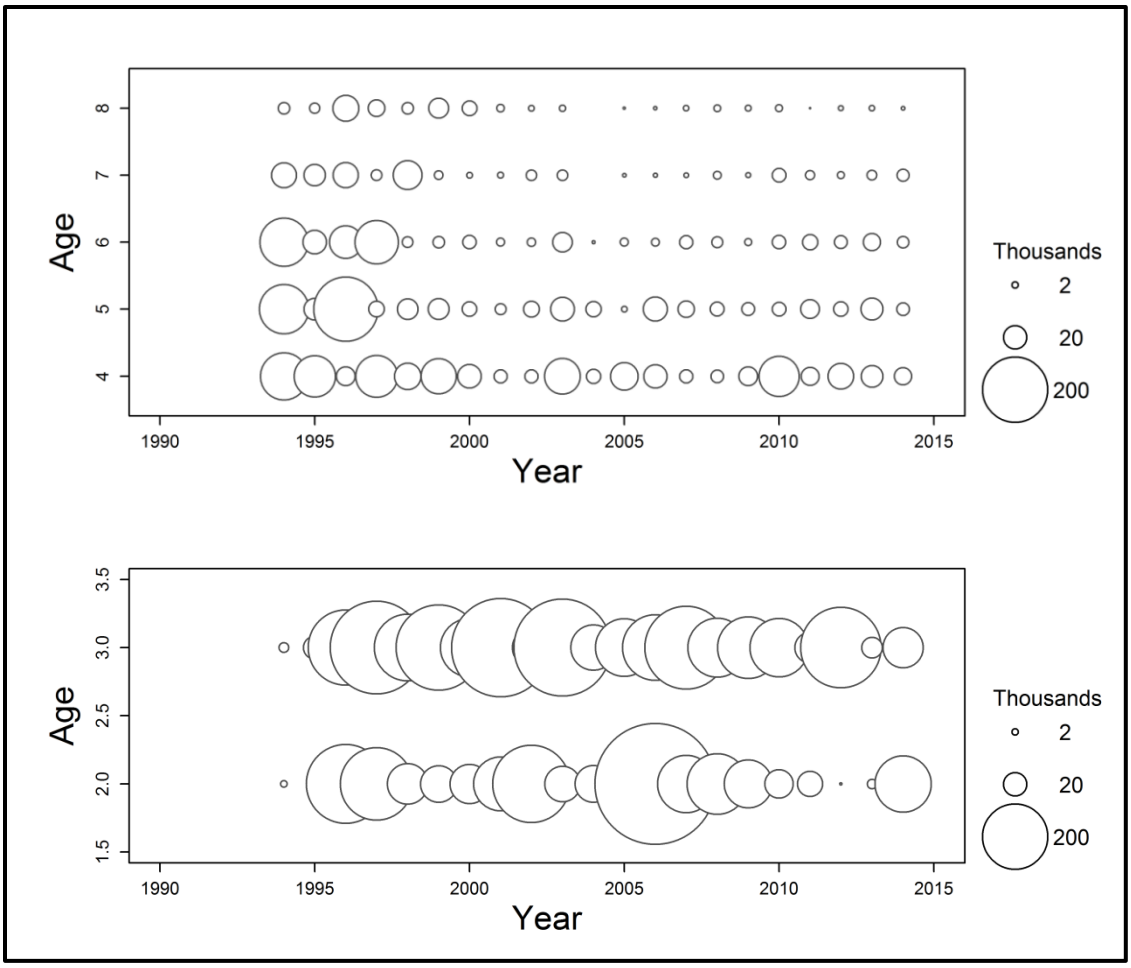


Figure 9. Bubble plot of abundance-at-age (number) from the fisheries-independent acoustic survey for spring spawners (upper panel; ages 4 to 8) and fall spawners (lower panel; ages 2 and 3) of the southern Gulf of St. Lawrence, 1994 to 2014.

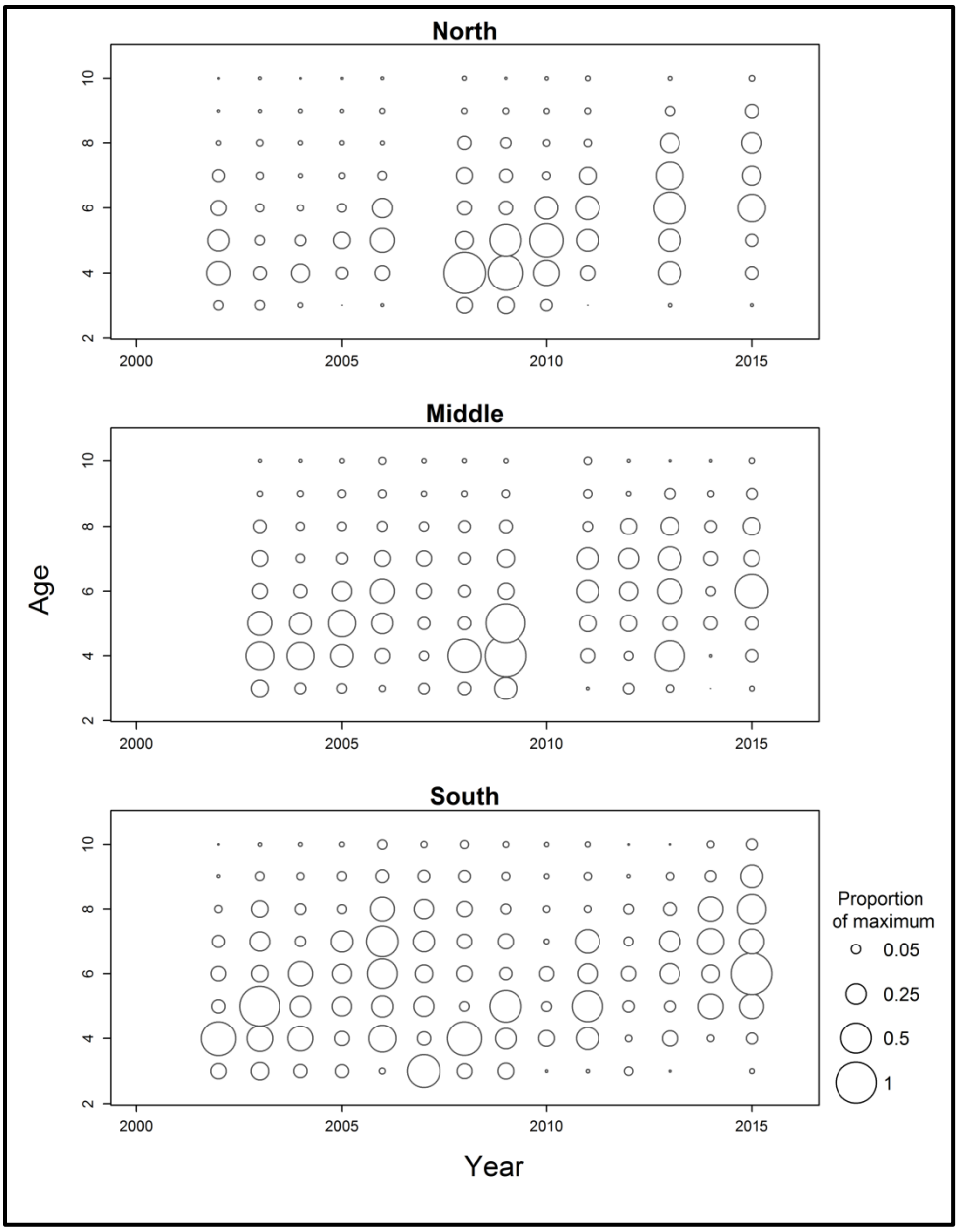


Figure 10. Bubble plots of catch-at-age indices (number) of fall spawner Atlantic herring from the experimental gillnetting survey by region (upper panel North, middle panel Middle, and lower panel South) of the southern Gulf of St. Lawrence, 2002 to 2015. The size of the bubble is proportional to the index value.

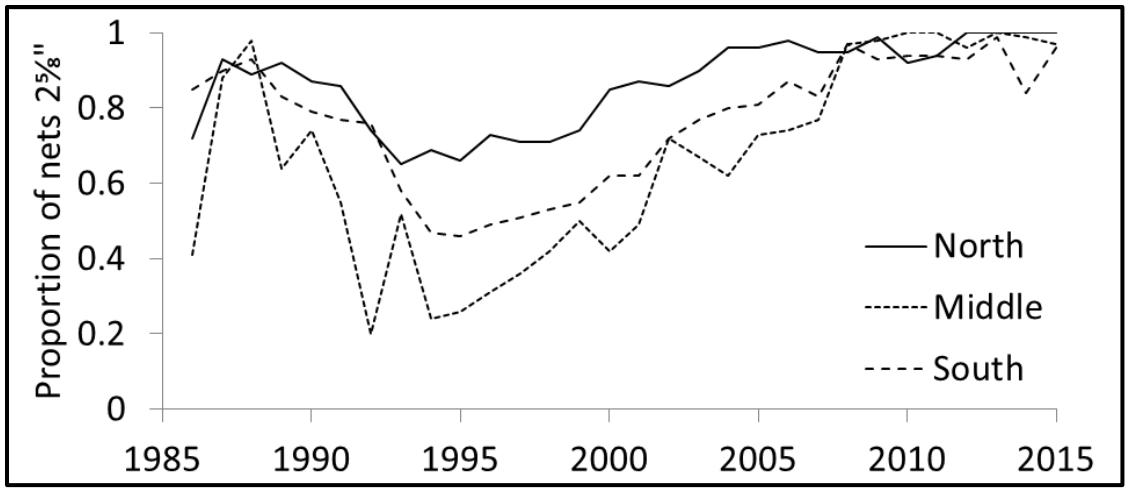


Figure 11. Variations in the proportions of gillnets with mesh sizes 2 $^{5}/_{8}$ inches by region used in the fall fishery of Atlantic herring of the southern Gulf of St. Lawrence, 1986 to 2015. It is assumed that all other nets used were of mesh size 2¾ inches.

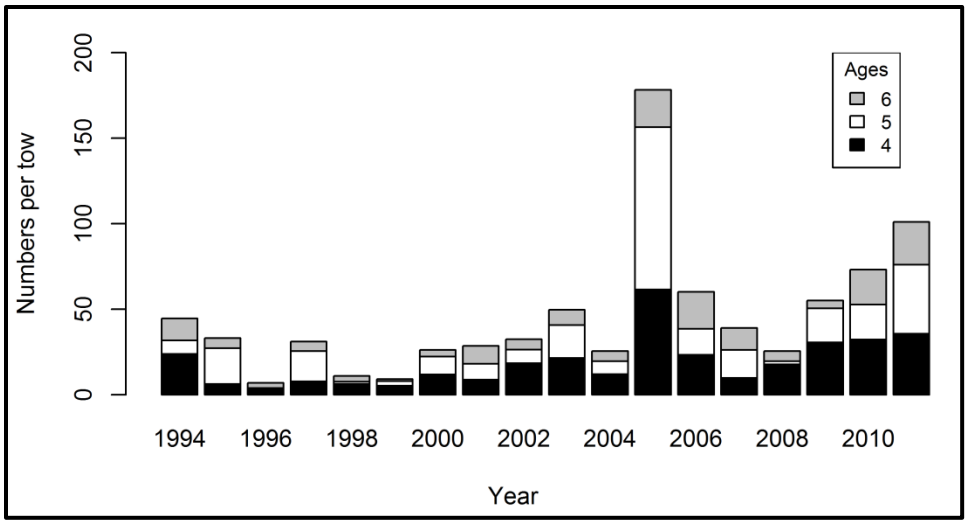


Figure 12. Multispecies bottom trawl survey abundance index (number of fish per standardized tow) of ages 4 to 6 year fall spawning herring from the southern Gulf of St. Lawrence, 1994 to 2011.

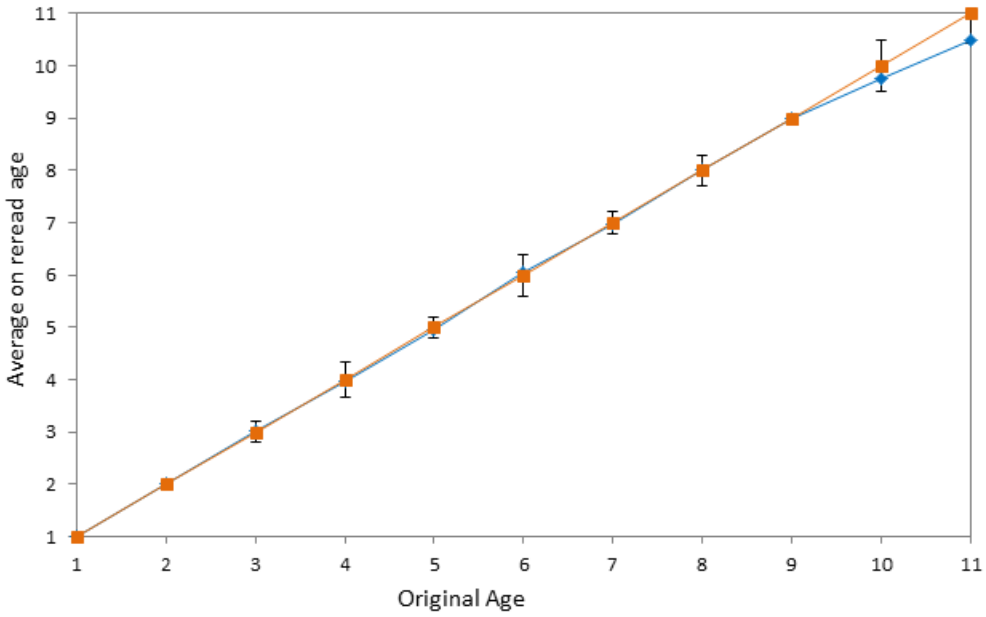
APPENDICES

APPENDIX A. AGE READING CONSISTENCY TEST

Starting in 2010, otolith age reading was done from digital photographs and read on a computer screen, as compared to previous aging done with a stereomicroscope. This new method enhanced the picture quality and made age reading more accurate. Also, a new reader was trained in 2010 to become the primary reader who aged the 2013 otoliths.

Yearly age reading consistency tests are done in order to evaluate and ensure the consistency of age reading over time. A sub-sample of pairs of herring otoliths from years 1993, 1994, 1996 and 2003 was re-aged, and the new ages were compared to the reference ages. Otolith samples were randomly selected for age-groups 1 to 11+ and from years between 1993 and 2003, gear types used and type of sample (commercial and research). In total, a final set of over 200 otoliths was used. Results are presented for the primary reader.

The results for the primary reader show an overall agreement of 93% and a coefficient of variation (CV) of 1.9%. (Fig. A1). The CV is considered to be a more robust measure of the precision of age determination (Campana et al. 1995). From the reading bias plot, there was no bias present, and age determination is more variable for older (9+) herring (Fig. A1).



Appendix Figure A1. Comparison of ages obtained during the validation test with the original ages assigned. Bars indicate 95% confidence intervals. Orange squares are original ages and blue diamonds are the average on reread ages.

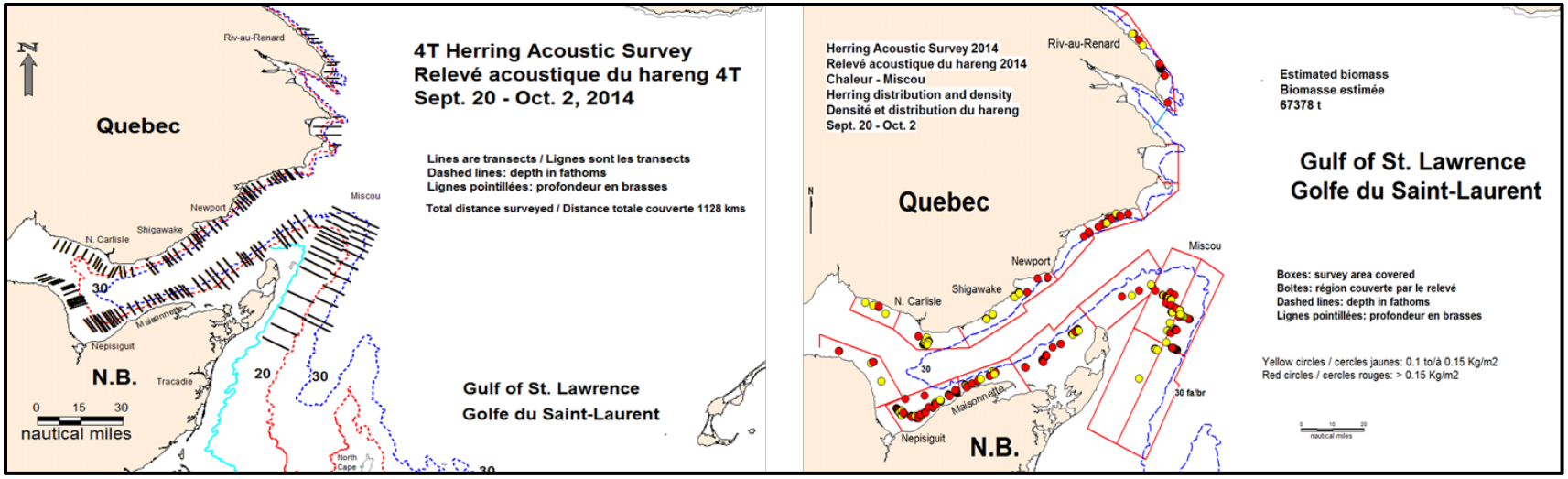
APPENDIX B. FISHERY-INDEPENDENT ACOUSTIC SURVEY RESULTS

The 2014 acoustic survey was carried out in the 4Tmno areas (i.e., Chaleurs-Miscou; Appendix Figure B1). The estimated biomass was 67,378 t. The distribution of herring in the area can also be seen in Appendix Figure B1 and Appendix Table B1. The 2014 acoustic biomass index of the Chaleurs-Miscou area for the combined spring (SS) and fall (FS) spawner groups has been similar in value since 2006, and is near the lowest value of the time series (Appendix Figure B2).

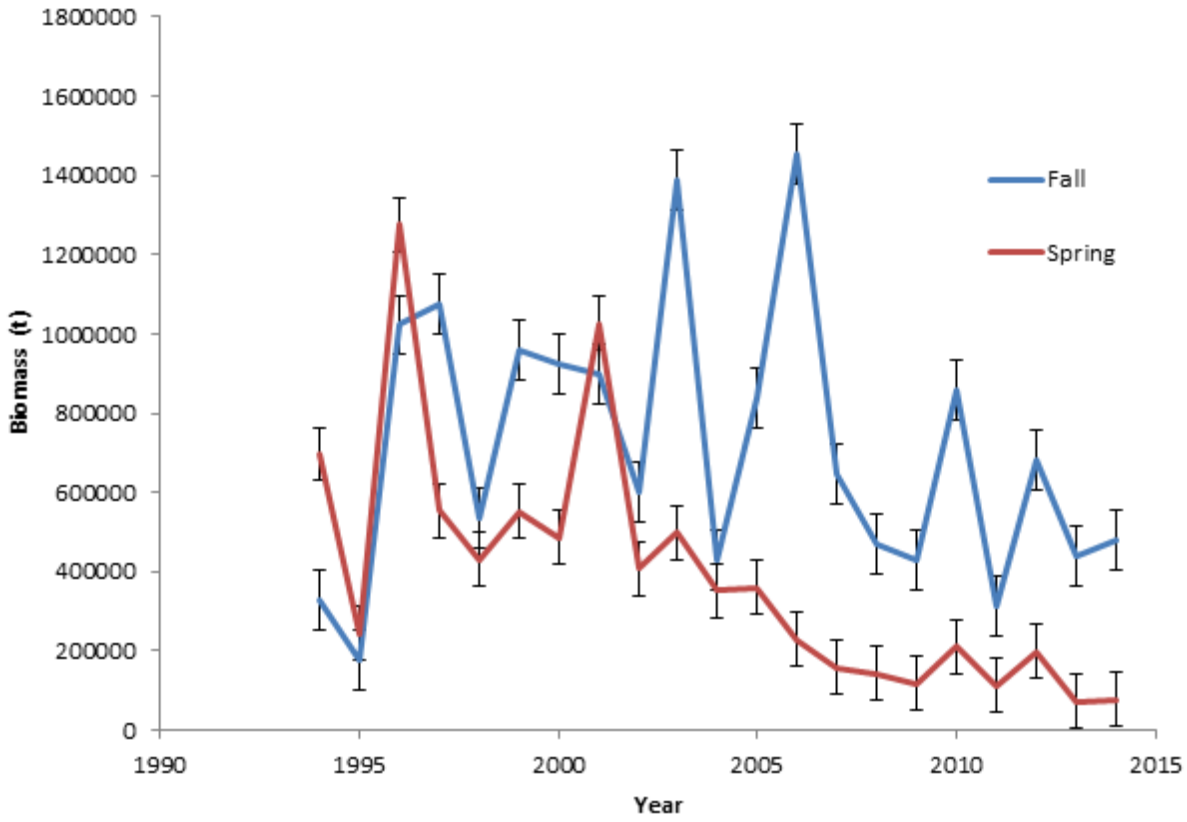
Midwater trawl samples were made where herring densities were greatest. The catch (length frequency) by set was weighted by the sum of acoustic herring densities recorded in the stratum or group of strata defined in the catch-at-age parameters as representing the biomass in that area. Using the herring densities recorded as the weighting factor is considered a better method as it does not depend on an estimated standardized amount of herring caught in a set of one nautical mile.

Appendix Table B1. Herring biomass densities and estimates by stratum and area from the fishery-independent acoustic surveys conducted in 2014.

Stratum	Average TS (dB/kg)	Stratum Area (km^2)	Mean Sa ($/m^2$)	Density (kg/m^2)	Biomass (tons)	SE (tons)	SE (%)
Gaspe							
Rivière au Renard	-34.66	124.6	-47.475	0.0523	6,517.8	8,849	136
Cap Bon Ami	-34.66	69	-47.274	0.0548	3,780.1	3,925	104
Malbaie	-34.66	95.6	-68.21	0.0004	42.2	59	139
Chaleur							
Grande Rivière	-34.66	106.4	-48.096	0.0453	4,823.9	1,381	29
Newport	-34.66	124.9	-55.797	0.0077	961.3	451	47
Shigawake	-33.55	265.6	-54.105	0.0088	2,335.2	540	23
New Carlisle	-33.55	169	-50.38	0.0207	3,502.9	1,443	41
New Richmond	-33.55	111.6	-53.391	0.0104	1,156.3	353	31
Belledune	-33.66	266	-54.003	0.0092	2,459.3	520	21
Nepisiguit	-34.25	211.3	-48.866	0.0345	7,297.2	2,001	27
Maisonnette	-34.51	145	-52.555	0.0157	2,273.5	636	28
Miscou							
West Miscou	-34.51	330.5	-52.115	0.0174	5,734.7	2,023	35
North Miscou	-34.51	295.7	-58.336	0.0041	1,224.9	574	47
Miscou NW	-34.90	444	-50.717	0.0262	1,1644.1	4,418	38
Miscou NE	-34.90	352.8	-51.957	0.0197	6,954.2	3,489	50
Miscou SW	-34.90	552.2	-56.489	0.0069	3,832.9	1,303	34
Miscou SE	-34.99	521.3	-57.632	0.0054	2,837.5	1,388	49
Total all areas					67,378		



Appendix Figure B1. Surveyed transects covered during the 2014 acoustic surveys (lines, left panel) and relative biomass values detected in the Chaleurs-Miscou area (circles, right panel) during the 2014 acoustic surveys.



Appendix Figure B2. Acoustic survey biomass index (t) of spring (red) and fall (blue) spawners of all strata from Chaleurs-Miscou (error bars ± S.E.).

APPENDIX C. SPAWNING GROUND ACOUSTIC SURVEY RESULTS

The pilot spawning ground acoustic survey was conducted in 2015 and followed a stratified random design, similar to the fishery-independent acoustic survey. Six spawning grounds were identified: Gaspe, Miscou, Escuminac/Richibucto, West PEI, East PEI (Fisherman's Bank/North Lake), and Pictou (Appendix Figure C1). Strata were identified on each spawning ground using the acoustic information collected in previous industry partnerships. Strata were designed to be large enough to encompass the historical spawning grounds in each region. Transects were randomly generated within strata at a minimum of 400m apart (Appendix Figure C2). Surveys were to be conducted at night, prior and following the fishing season and during the weekend fishing closure where possible. The fishing association selected one or two fish harvesters to conduct the acoustic surveys using a hull-mounted 120 KHz single beam transducer. Acoustic data from fishing vessels have been used to analyze school morphology characteristics, spatial patterns, relative changes in school density (Shen et al, 2008) and to develop estimates of abundance (Melvin et al. 2002; Honkalehto et al. 2011). In the sGSL, fishery acoustic data collected on Atlantic herring spawning aggregations can be used to obtain relative nightly biomass estimates (Claytor and Allard 2001; Claytor and Clay 2001).

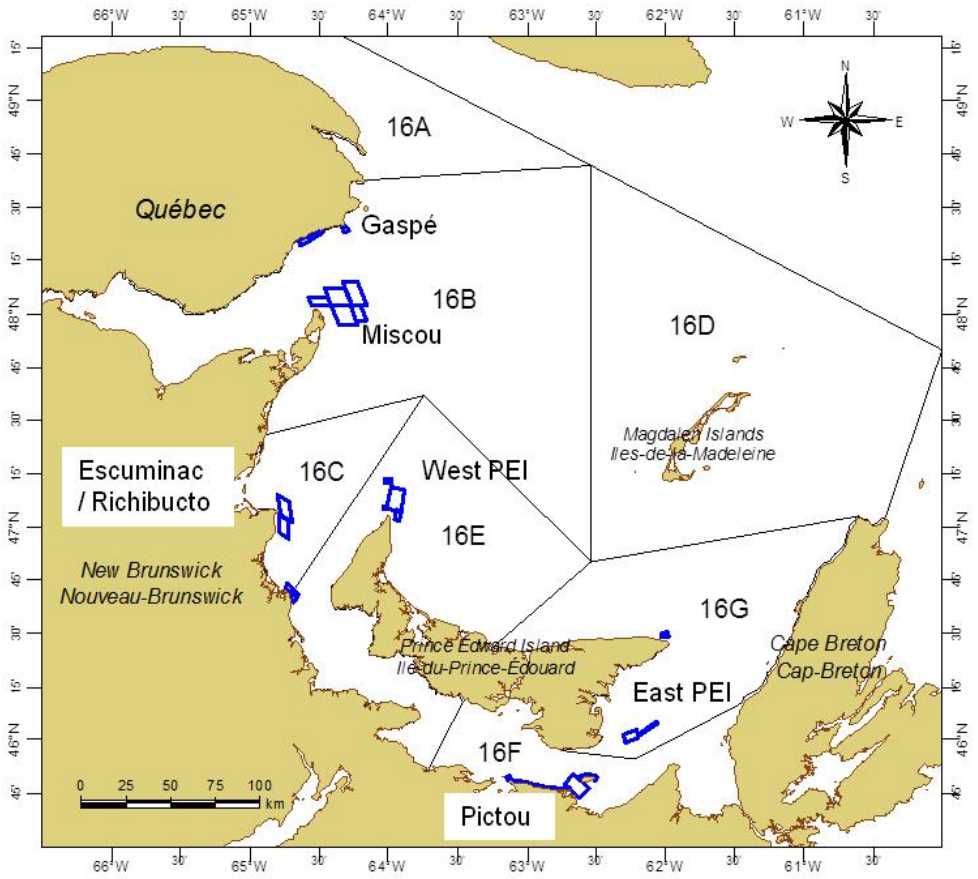
For each region, the goal of the analysis is to estimate the relative spawning biomass from a set of nightly acoustic observations. The acoustic data were obtained from one or two fishing vessels per night from each spawning ground. Size and age frequency data to convert the acoustic data into biomass estimates were obtained from the experimental gillnet surveys. Nightly acoustic data were processed and analyzed for each region in order to obtain a nightly biomass estimate, as described in Claytor and Clay (2001) (Appendix Table C1).

Ideally, the surveys would have been conducted daily or randomly within the potential spawning period of herring. Surveys by the fishing vessel were not conducted every day and were not randomly distributed within the season. There were some issues with acoustic surveys on the spawning grounds. The proportion of the strata covered and the frequency of survey coverage varied among regions from complete strata coverage on a weekly basis (Gaspe) to a complete absence of surveys in East PEI (Appendix Table C1). The surveys from Gaspe and Pictou highlight weekly differences in biomass throughout the fall fishing season. There is less information on relative biomass in Escuminac and West PEI as there are no acoustic surveys during the fall fishing season because there are no weekly fishing closures. Furthermore, both Escuminac and West PEI have incomplete surveys on one of the two evenings. Some surveys were also commenced prior to dusk and therefore before herring would be aggregated.

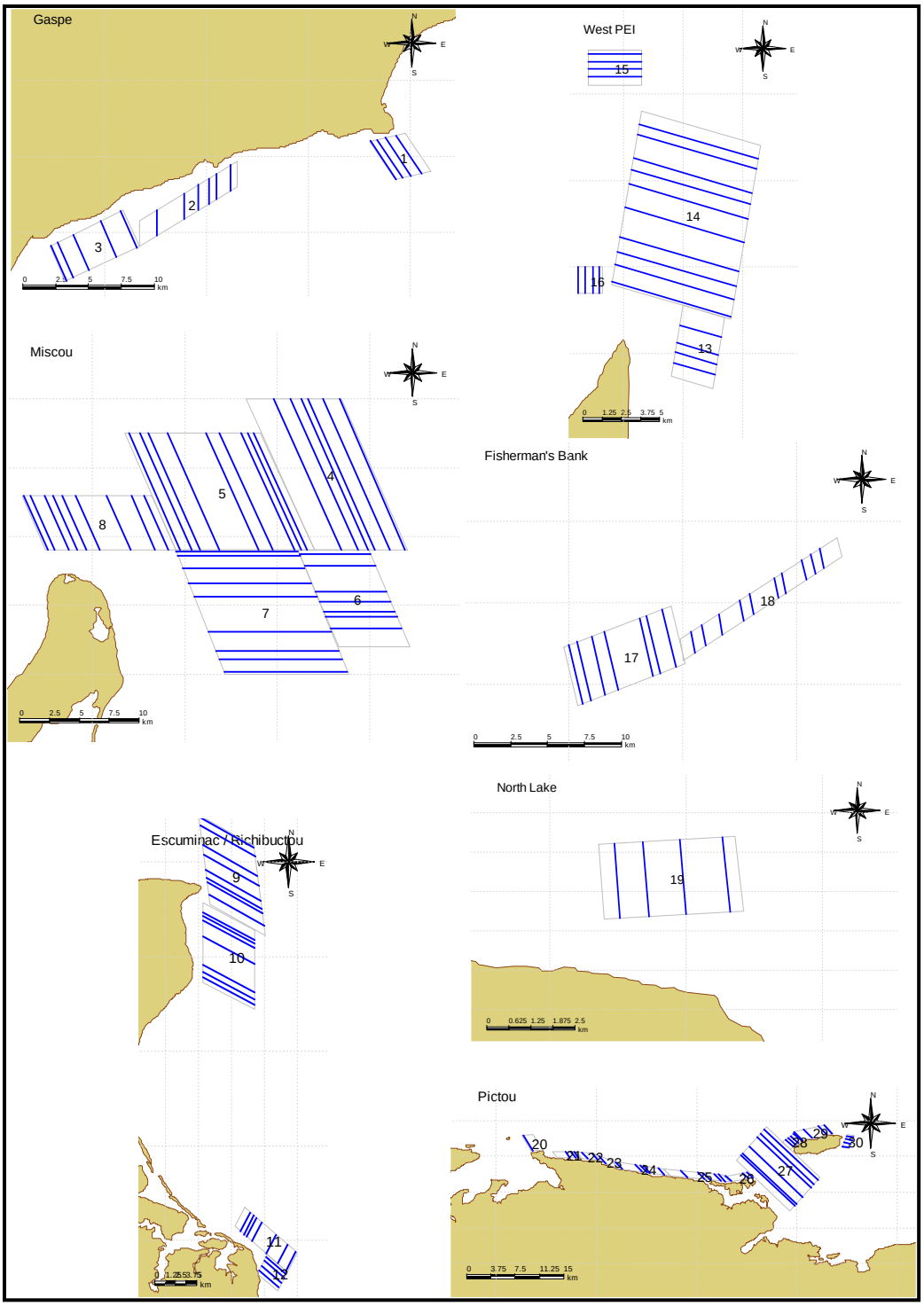
For this survey to be included in the assessment, surveys need to be consistent across regions and conscientiously carried out. From industry participant feedback, changes will be made to the design and implementation of this survey in 2016.

Appendix Table C1. Atlantic herring biomass densities estimates by spawning ground from the spawning ground acoustic surveys of the southern Gulf of St. Lawrence conducted in 2015.

Herring Fishing Area	Spawning Bed	Date	TS (dB/kg)	Area (km^2)	Sa ($/m^2$)	Biomass (kg/m^2)	Biomass (tons)	Std. Error (tons)
16B	Gaspe	15/Aug/15	-36.11	38.7	-56.55	1.25E-02	400	291
16B	Gaspe	22/Aug/15	-36.11	38.7	-51.20	1.48E-01	3,958	4,042
16B	Gaspe	29/Aug/15	-36.11	38.7	-60.00	1.77E-02	890	786
16B	Gaspe	5/Sep/15	-36.11	38.7	-55.03	5.84E-02	1,730	1,598
16B	Gaspe	12/Sep/15	-36.11	38.7	-54.04	2.50E-02	1,033	589
16B	Miscou	22/Aug/15	-36.32	386.9	-71.36	1.45E-03	302	207
16B	Miscou	29/Aug/15	-36.32	386.9	-57.27	8.14E-03	2,488	1,165
16B	Miscou	4/Sep/15	-36.32	386.9	-59.24	1.29E-02	2,403	702
16B	Miscou	11/Sep/15	-36.32	386.9	-58.22	9.11E-03	3,190	1,445
16C	Escuminac	20/Aug/15	-35.84	145.5	-39.24	1.49E-01	4,984	4,849
16C	Escuminac	9/Oct/15	-35.84	145.5	-62.66	4.29E-03	485	224
16E	West PEI	22/Aug/15	-35.97	111.3	-76.08	1.31E-04	20	7
16E	West PEI	21/Sep/15	-35.97	111.3	-58.86	8.22E-03	1,004	321
16F	Pictou	4/Sep/15	-35.67	127.3	-52.16	5.00E-01	6,860	5,920
16F	Pictou	11/Sep/15	-35.67	127.3	-58.74	5.47E-03	448	98
16F	Pictou	18/Sep/15	-35.67	127.3	-54.81	7.33E-02	2,080	1,110
16F	Pictou	25/Sep/15	-35.67	127.3	-61.89	6.18E-03	826	545
16F	Pictou	15/Oct/15	-35.67	127.3	-57.30	1.63E-02	2,912	1,349
16G	East PEI	na	na	na	na	na	na	na

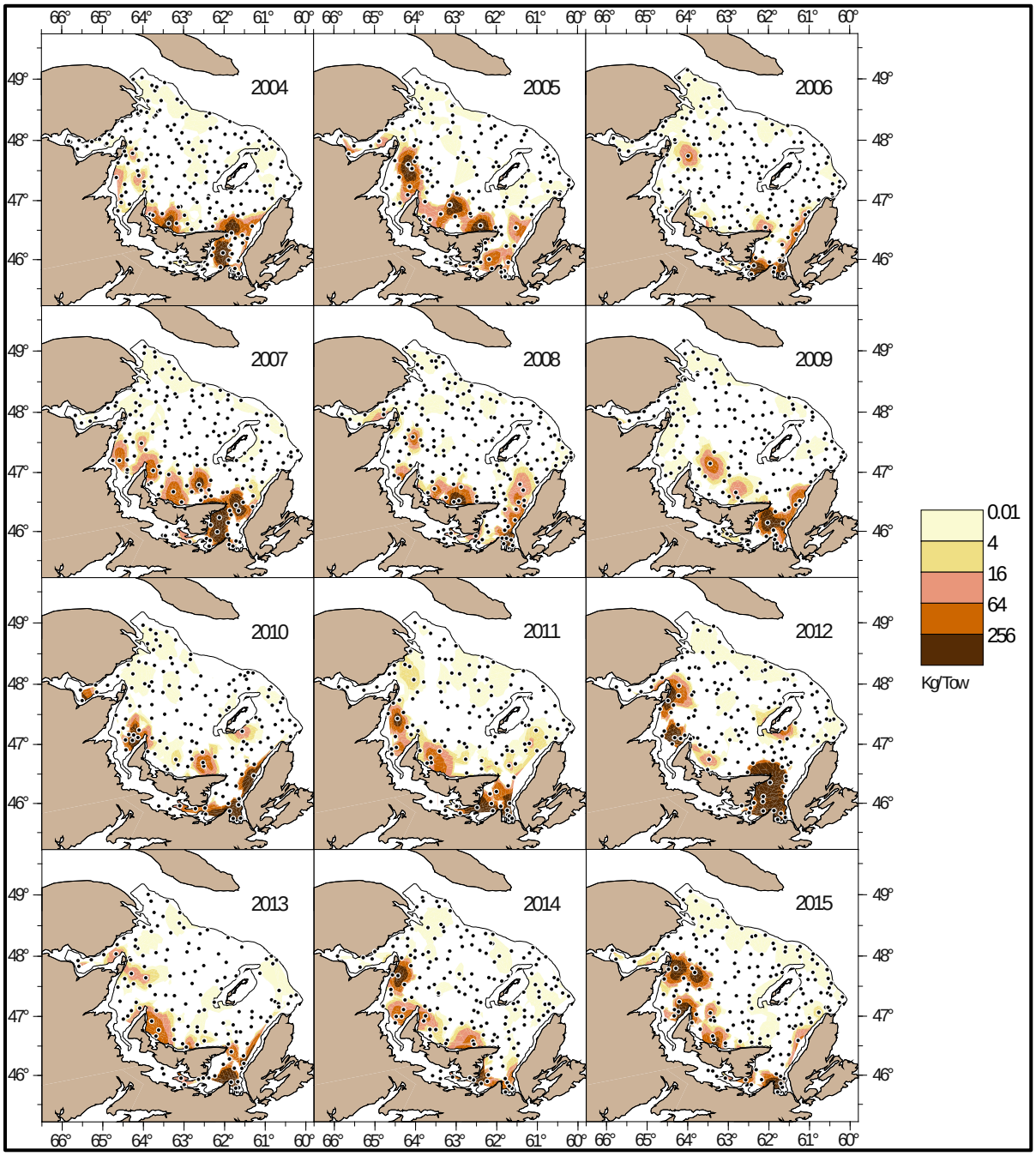


Appendix Figure C1. Spawning grounds surveyed during the 2015 spawning ground acoustic survey.

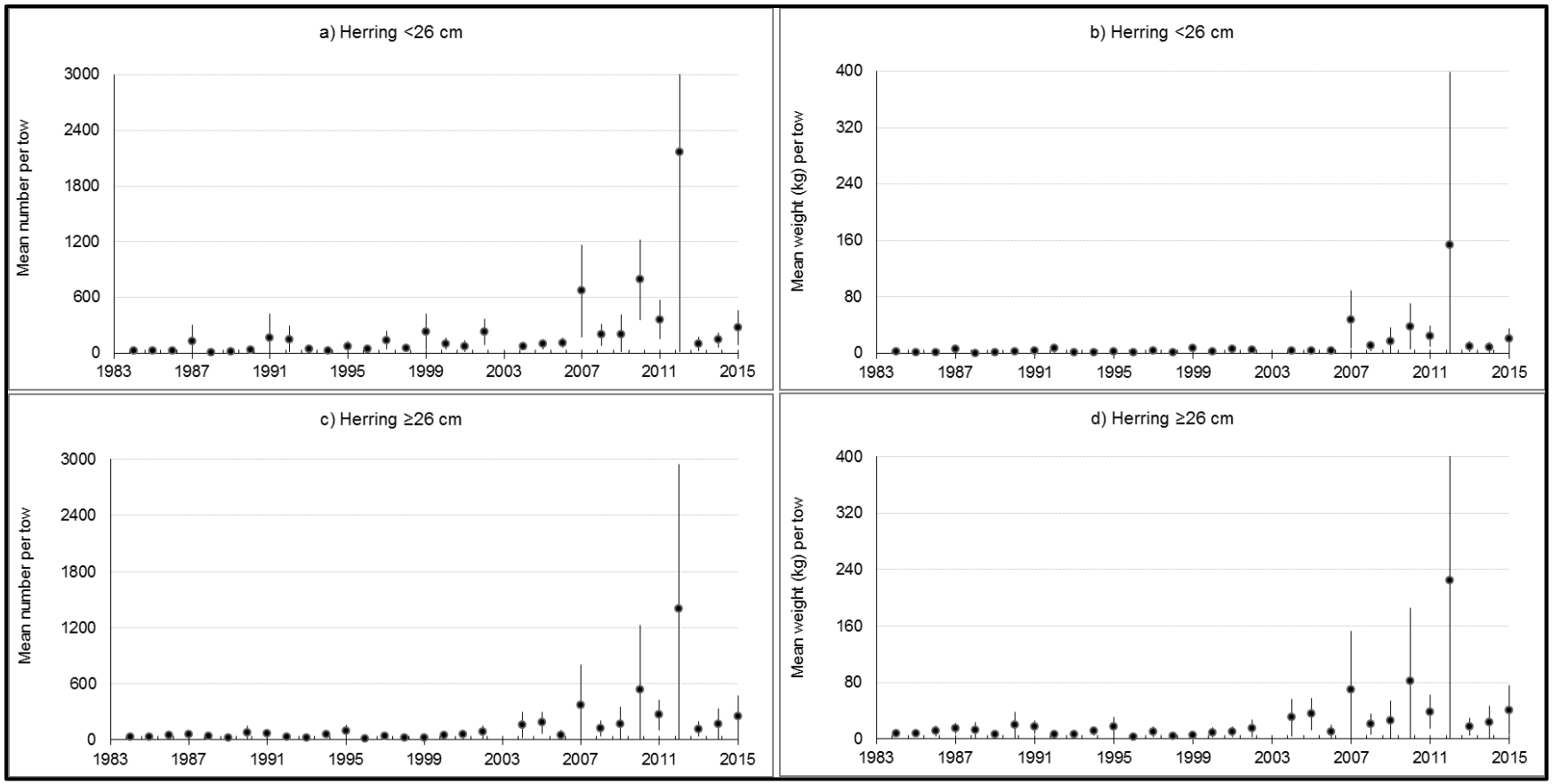


Appendix Figure C2. Surveyed transects covered during the 2015 spawning ground acoustic surveys (lines) of fall herring from the southern Gulf of St. Lawrence.

APPENDIX D. MULTISPECIES BOTTOM-TRAWL SURVEY RESULTS



Appendix Figure D1. Spatial distribution of herring catches over time in the southern Gulf of St. Lawrence from the multispecies bottom-trawl survey. The dots indicate the location of fishing sets.



Appendix Figure D2. Mean annual catch abundance (left column) and weight (right column) per tow of Atlantic herring <26 cm in length (top) and ≥ 26 cm (bottom) in the southern Gulf of St. Lawrence September bottom-trawl surveys. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).