



SOUTHERN GULF OF ST. LAWRENCE ATLANTIC SILVERSIDE (*MENIDIA MENIDIA*) STOCK REVIEW IN 2023

Context

This Science Response Report results from the regional peer review on March 26, 2024 on Southern Gulf of St. Lawrence Atlantic Silverside (*Menidia menidia*) Stock Review in 2023. The purpose of this report is to review the available information on Silverside and its fishery. This information will help guide Fishery and Oceans Canada's Fisheries and Harbour Management Sector in developing management measures to ensure a sustainable population.

Background

The Atlantic Silverside (*Menidia menidia*; hereafter "Silverside"), is a small-bodied (≤ 12 cm), short-lived (≤ 2 years) fish distributed along shorelines in brackish and salt waters (Cairns 1996). Silverside range along the Atlantic coast from Newfoundland to Florida (Scott and Scott 1988, Sargent et al. 2008). Silverside spawn in schools in the intertidal zone (DFO 2010; Barrett et al. 2015). In Atlantic Canada, spawning occurs over an approximately 6 week period during June and July (Barrett et al. 2015). Silverside feed on small plankton and benthic organisms, then migrate to deeper offshore water in winter. Most Silverside die the first winter following spawning (age-1; Jessop and Morantz 1982). In the southern Gulf of St. Lawrence (sGSL) in Northwest Atlantic Fisheries Organization (NAFO) Division 4T, Silverside are most common in estuaries and coastal ponds. While some Silverside migrate to deeper waters to overwinter, in the sGSL, at least some also overwinter under the ice in bays and estuaries (DFO 2010). No evidence of age-2 have been recorded in PEI (DFO 2010), which makes up the largest Silverside fishery in the sGSL. The last Science Advisory Process conducted on Silverside was held in 2009 (DFO 2010). The report identified Silverside as a forage fish species in the sGSL, and as prey for fish-eating birds and fish in estuaries and coastal waters. The report concluded that any new commercial fisheries for Silverside would not meet the conservation objectives described in the *Policy on New Fisheries on Forage Species* (DFO 2009), which aim to maintain the focal species as well as any other species and ecological relationships associated with the focal species. One of the driving factors was the lack of scientific information and reliable fisheries data to inform on reference points, abundance and ecosystem interactions.

Description of the fishery

Silverside were commercially harvested on Prince Edward Island (PEI) in the 1940s (Jessop and Morantz 1982). In 1973 beach seines were introduced, but captures were deemed too high, thus in 1974 traps/box nets were introduced and remain the principal gear used in this fishery (Cairns 1996; DFO 2009). The fishery is authorized to take place between October 1 and December 31. In 1994 individual quota per licence were eliminated, therefore the fishery is only controlled by the number of issued licences. The individual licences (held by one person per licence) differ in the number of trap nets authorized, which varies from 1 to 4 trap nets by

individual, however some licences include 1 dip net in addition to their trap nets. Each licence includes geographic information to indicate specifically where traps are permitted.

The last published Integrated [Fisheries Management Plan for Atlantic Silverside on PEI](#) covers the period 2000-2004. The fishery is predominately a PEI fishery, with an average of 79 licences in the past 15 years, versus 2 licences in Nova Scotia, and zero in New Brunswick (Table 1). There were no licences issued, and no landings reported for Quebec in NAFO 4T between 1985 and 2023. The modern day Silverside fishery primarily supplies bait in the commercial sGSL lobster fishery. However, the fishery also includes bait deemed for personal use (i.e., not sold), and unlike commercial bait, these data have not always been reported. Mandatory reporting in daily logbooks since 2022 for PEI and since 2001 for Nova Scotia are intended to capture data about Silverside caught for personal use. Only commercial landings data were used in this report, as these data are regularly collected and maintained by DFO regional offices.

Table 1: Number of Atlantic Silverside licences in the southern Gulf of St. Lawrence (NAFO Division 4T) by province.

Year	New Brunswick	Nova Scotia	Prince Edward Island
1985	0	0	29
1986	0	0	34
1987	0	0	36
1988	0	0	36
1989	0	0	36
1991	0	0	43
1992	0	0	44
1993	0	0	45
1994	0	1	105
1995	0	1	103
1996	0	2	103
1997	0	2	103
1998	0	2	105
1999	1	2	88
2000	3	2	84
2001	1	2	86
2002	1	2	83
2003	0	2	87
2004	0	2	78
2005	0	2	84
2006	0	2	83
2007	0	2	83
2008	0	2	81
2009	0	2	81
2010	0	2	81
2011	0	2	81
2012	0	2	80
2013	0	2	79
2014	0	2	79
2015	0	2	79
2016	0	2	79
2017	0	2	79
2018	0	2	79
2019	0	2	78
2020	0	2	78
2021	0	2	77
2022	0	2	76
2023	0	2	76

Analysis and Response

Fishery-dependent landings

Fisheries-dependent landings data are collected each year by DFO regional offices, and maintained by the Statistical Services Unit. These data are organized by species-groups (e.g., species caught), rather than by fishing event. Each record includes the landed weight of a species, along with associated meta-data that typically includes the commercial fishing vessel identification number, main species sought, date caught, date landed, gear used, and geographic coordinates. Individual records may have missing information, and often require quality control processing that can include verification, correction, or omission/deletion of erroneous or incomplete records. For Silverside, available landings data do not contain geographic coordinates or licence details, making it difficult to link catches with specific locations or to individual fishing trips. The port landed can be linked to Silverside fishery statistical districts (Figure A1), but this does not necessarily reflect locations where the catches occurred in the coastal fishery.

We used the `read.ziff` function from the `gulf` package (Surette et al. 2021) in **R** (R Core Team 2022) to access landings records. We accessed fisheries landings records for years 1985 to 2022 for NAFO Division 4T, where the main species sought was Atlantic Silverside, or where Atlantic Silverside were caught. We interpret the “main species sought” column as the targeted fishery. Data for 2023 were not yet available.

The reported landings are minimum removals, as landings for personal bait were not recorded prior to 2022 for PEI and prior to 2001 for Nova Scotia. Commercial landings may be indicative of abundance, but are also sensitive to changes in effort and changes in reporting. From 1985 to 2002, there were no records where the main species sought was Atlantic Silverside, therefore we assumed that all landings of Silverside were targeted. As a result, it is impossible to know if Silverside were captured in fisheries targeting other species. From 2003 onward, all records where Silverside were captured had a consistently filled out main species sought. The vast majority (99.9%) of Silverside were captured in the directed Silverside fishery from 1985 to 2022. Silverside were captured in six fishing events that were targeting Northern Sand Lance (*Ammodytes dubius*) with trap nets in 2004, 2005, 2006, and 2014. The total landed quantity of Silverside in the Northern Sand Lance fishery was 2,852 kg which represents 0.02% of total landings. Silverside were also caught in 15 fishing events that targeted Rainbow Smelt (*Osmerus mordax*) with trap nets in 2004, 2005, 2006, 2007, 2010, 2019, 2020, and 2021. The total landed quantity of Silverside in this fishery was 3,146 kg which also represents 0.02% of total landings. Despite the authorization of the fishery to only take place between October 1 and December 31, landings from 1985 to 2022 have occasionally occurred in other months (Figure 1) for unknown reasons. Silverside are licenced to be caught by trap/box nets and dip nets, however other fishing gear has occasionally been used (Figure 1).

The majority of the fishery occurred in PEI, however in recent years (from 2009 to 2016, 2021, and 2022) harvest in Nova Scotia has made an important contribution to removals (Figures 1 to 3). The majority of the fishery occurs in Kings County (districts 87 and 88) in eastern PEI (Figures 2 and 3). In Nova Scotia, landings predominately come from around St. Georges Bay (Figures 2 and 3). From 1985 to 1993, landings were at the lowest levels with an average of 38 licences issued. Landings increased as number of licences increased. Landings were consistently higher from 1999 to 2014 reaching a peak in 2010 (average 85 licences). Since 2014, landings have been declining steadily despite a consistent number of licences (average 80 licences; Figure 4).

For Silverside, the available landings data do not provide sufficient information to link landings to the licence, and therefore the licence conditions, nor is gear (number of trap nets or dip nets) or geographic location completed in the logbooks. We also do not have information on the number of licences that are active within a given year. Consequently, it is extremely difficult to determine how variation in landings was influenced by effort. Crude calculation of catch-per-unit-effort (CPUE) were calculated as total landings by number of licences, and total landings by number of days landed (Figure 4). These measures of CPUE show a declining trend to stable levels from 2016 to 2022. The large interannual variation observed in the landings and CPUE in the early time series is virtually absent after 2015.

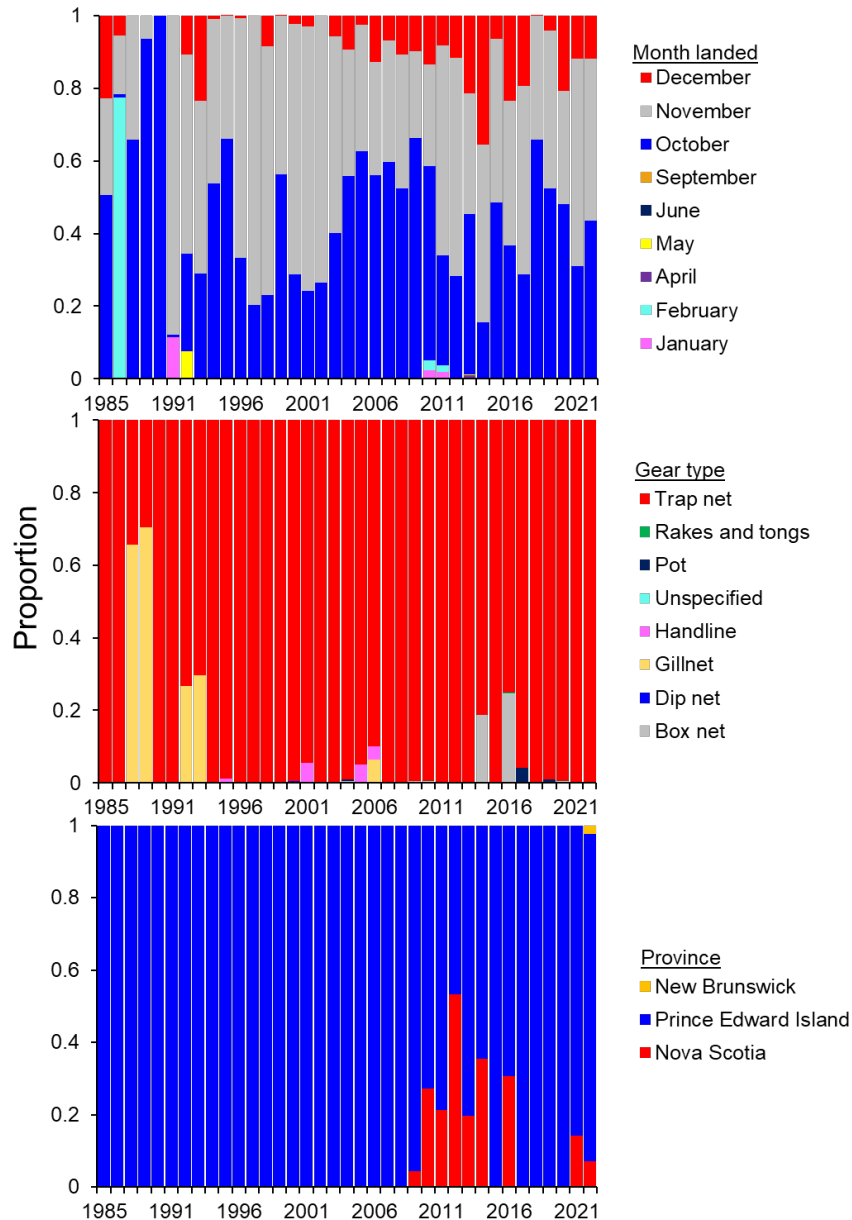


Figure 1: Proportion of annual Atlantic Silverside landings in the southern Gulf of St. Lawrence (NAFO Division 4T) by month (top panel), by type of fishing gear (middle panel), and by province (bottom panel) from 1985 to 2022.

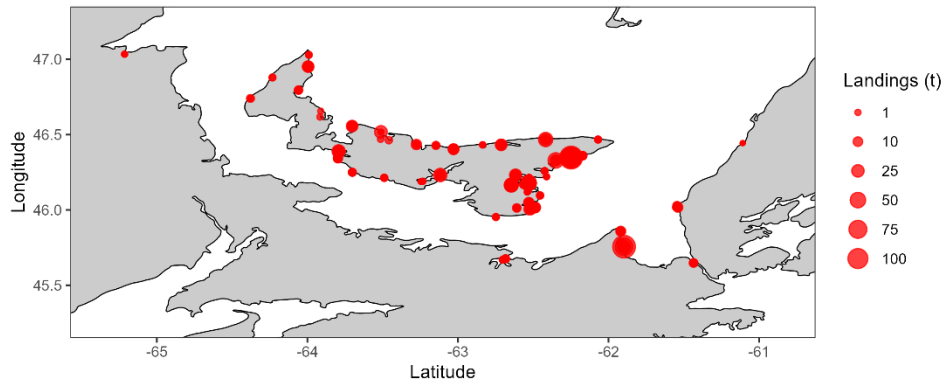


Figure 2: Reported landings (tonnes; t) of Atlantic Silverside in the southern Gulf of St. Lawrence from 1995 to 2022.

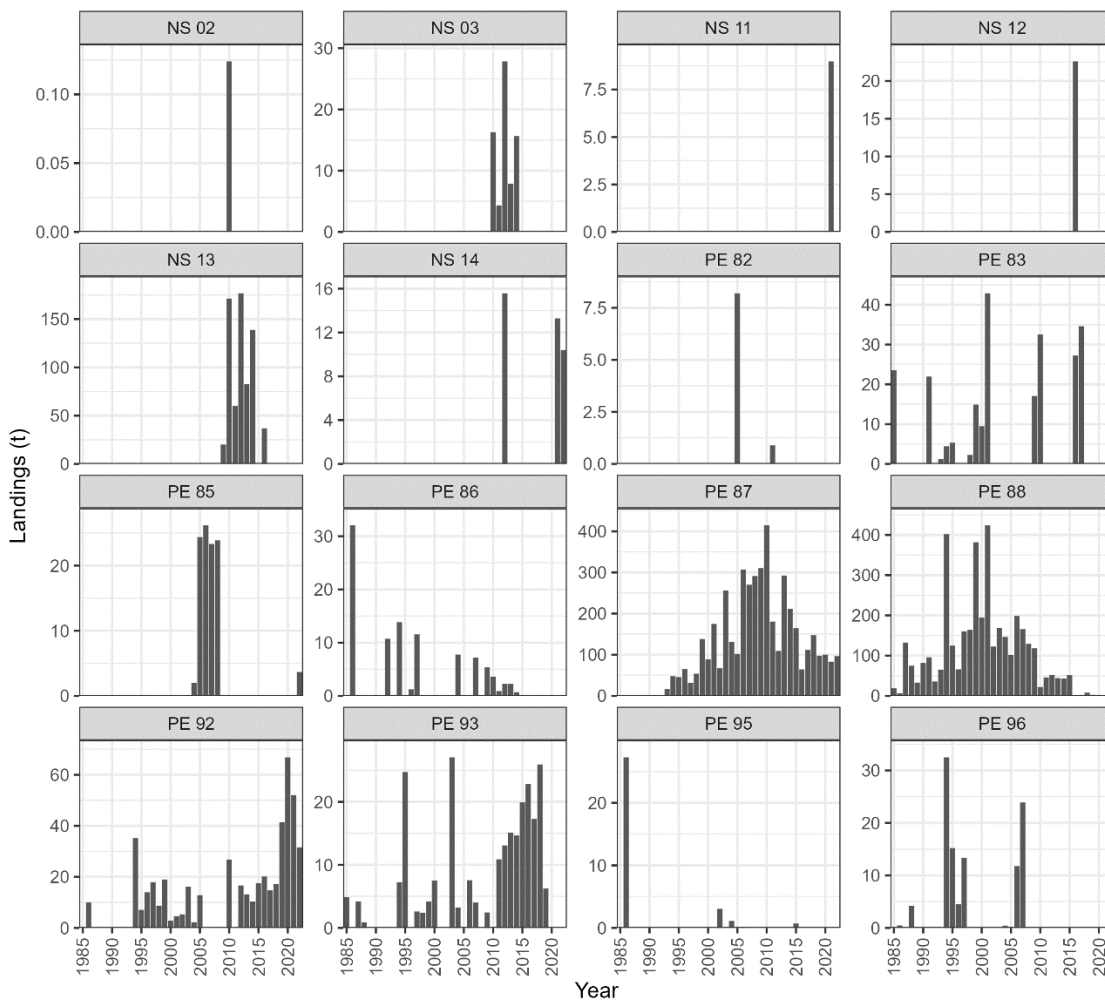


Figure 3: Reported landings (tonnes; t) of Atlantic Silverside by district and year for the provinces of Nova Scotia, and Prince Edward Island. Panel labels indicate the province and district number. Note that the y-axis was allowed to vary by panel. Total landings for New Brunswick (not plotted) were 3.447 tonnes, all from district 73 in year 2022.

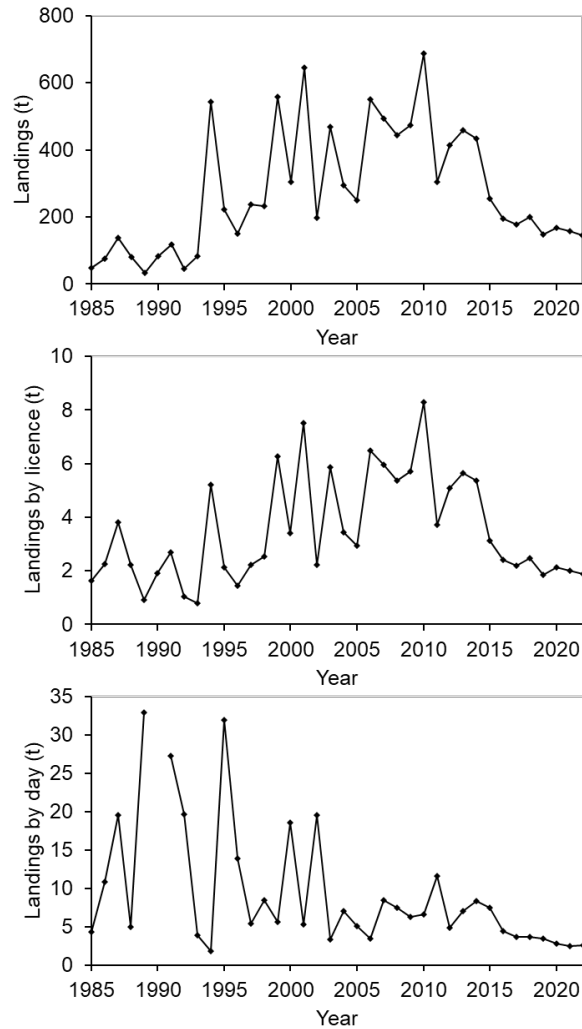


Figure 4: Reported landings (tonnes; t) of Atlantic Silverside from 1985 to 2022 (top panel) and catch per effort variable: catch per number of licences (middle panel), and catch per fishing day (bottom panel). Note: The number of days fished was not recorded in 1990 in the DFO statistical landing records.

Bycatch in the Atlantic Silverside fishery

Silverside traps also capture other species as bycatch. Among the species reported were Tomcod (*Microgadus tomcod*), Trout (c.f. *Oncorhynchus/Salvelinus*), White Hake (*Urophycis tenuis*), Rainbow Smelts (*Osmerus mordax*), Sand Lance (*Ammodytidae sp.*), Striped Bass (*Morone saxatilis*), and Atlantic Mackerel (*Scomber scombrus*), with a regulatory requirement that they be released alive (DFO 2010). The extent of the bycatch and the survival of fish released has not been measured.

Throughout the time series (1985 to 2022), there were recorded landings of the following bycatch in the targeted Silverside fishery: Snake Eel (8 kg), Alewife (1,406 kg), Arctic Char (1,746 kg), Northern Sand Lance (22,312 kg), and Rainbow Smelt (31,787 kg).

The earlier publications on sGSL Silverside identify bycatch of sticklebacks as a concern in this fishery that historically led to fish harvesters changing the location of their gear or resulting in the early closure of the fishery (Cairns 1996, DFO 2010). The available landings data lack any information on stickleback as bycatch, therefore we could not examine whether this continues to

occur. Nevertheless, Silverside and various stickleback species do co-occur throughout the sGSL (see Community Aquatic Monitoring Program (CAMP) section below).

Fishery-independent data

Northumberland Strait survey

The DFO Northumberland Strait Research Vessel (RV) multispecies bottom trawl survey (Northumberland Strait survey) has been conducted annually since 1999 to collect fishery-independent data (Hanson 2001; Asselin et al. 2021). The survey generally takes place from July through early August. Nearly 3,500 bottom trawls were conducted in the Northumberland Strait and there were zero records of Silverside captured.

Autumn research vessel survey

DFO Gulf Region conducts an annual scientific bottom-trawl survey in the southern Gulf of St. Lawrence (hereafter sGSL Autumn RV survey, Figure A1). The multi-species, standardized survey follows a stratified random sampling design that spans the majority of the sGSL, and is conducted each autumn, usually in September (Hurlbut and Clay 1990; Benoît 2006). We obtained Silverside catch numbers (number per tow) and catch densities (kg/tow) for survey years 1971 to 2023 and strata 401 to 439. In total, we examined 7,596 tows that were completed from 6 vessels, the CCGS E.E. Prince (1971 to 1985), CCGS Lady Hammond (1985 to 1991), Wilfred Templeman (2003), the CCGS Alfred Needler (1992 to 2002 and 2004 to 2005), CCGS Wilfred Templeman (2003), the CCGS Teleost (2004 to 2022), and the CCGS Jacques Cartier (2021 to 2023) (Table A1).

Silverside were not recorded before 1985, and were only recorded in 59 (0.78%) tows. The total number of Silverside sampled was 374, and their total catch weight was 1.01 kg. Silverside were mainly observed within inshore strata, especially 402, 432, and 433 (Figure 5). Prior to 1984, stratum 402 was not surveyed, and strata 432 and 433 had only 2 to 3 tows per year, which would partly account for no records of Silverside. It is also likely that Silverside were either captured but not being recorded, or were misidentified in the first fourteen years of the survey.

The number of Silverside caught varied by year and by vessel. The number of Silverside caught per year was generally low (median = 4), and only 5 years (1985, 1997, 2003, 2004, and 2022) caught greater than 10 Silverside. Aside from 2003, these years do not correspond with pulse years in landings (Figures 4 and 6). The greatest number of Silverside caught in a single year was 136 individuals over 3 tows in 2004, of which 135 were captured by the vessel the CCGS Alfred Needler, which was operating alongside the CCGS Teleost (Table A2, Figures 5 to 7). The second largest catch was 36 Silverside in 2022, of which 25 were caught by the CCGS Jacques Cartier, also operating alongside the CCGS Teleost. 2022 was also the year in which the CCGS Teleost captured its largest number of Silverside, with a total of 11 individuals. Zero Silverside were captured in the most recent survey year, 2023, during which 127 tows were conducted from the CCGS Jacques Cartier. Across all years, the majority (86%) of Silverside caught were 7 to 9 centimeters in length (Figure 6).

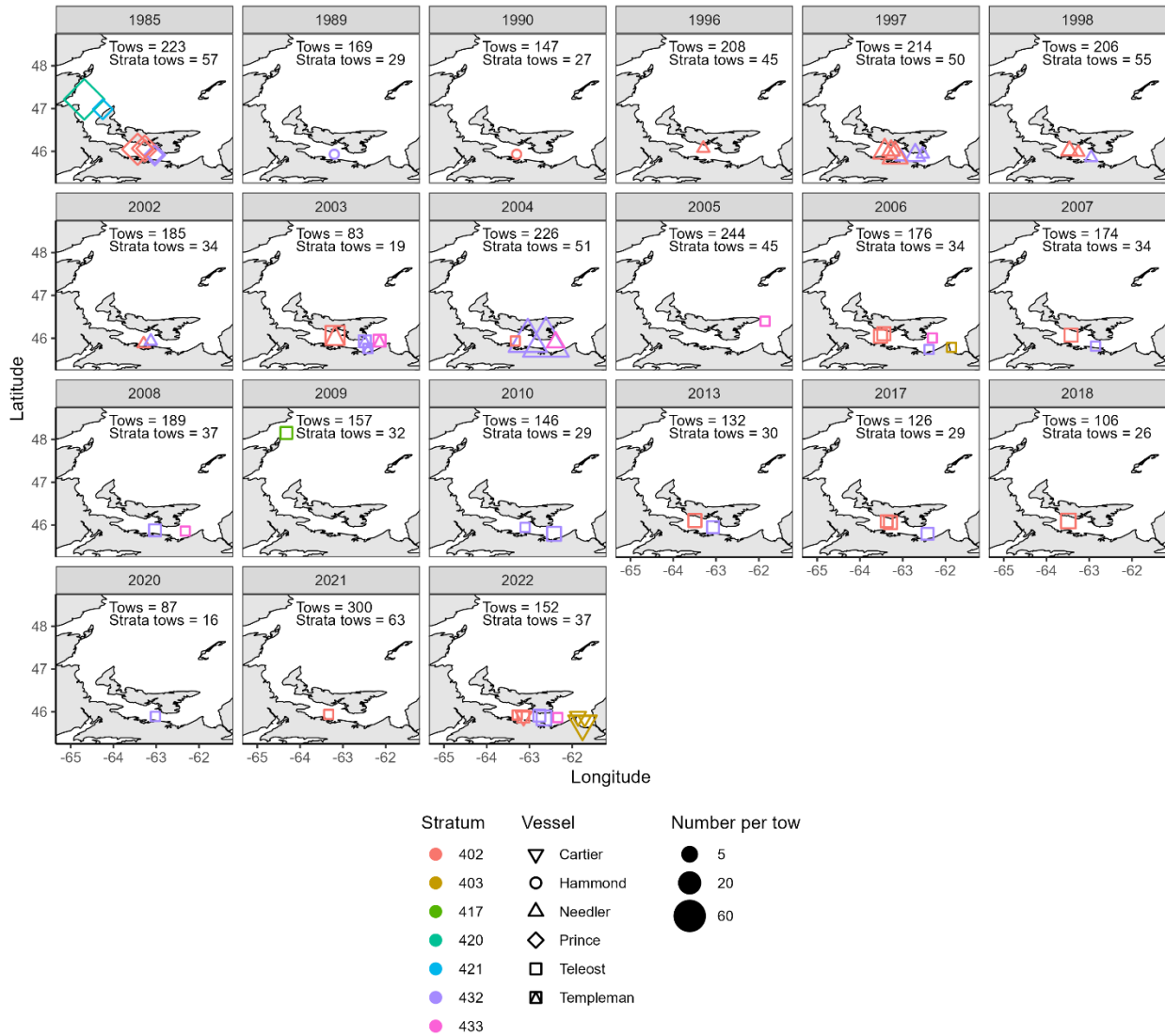


Figure 5: Number of Atlantic Silverside per tow in the southern Gulf of St. Lawrence Autumn Research Vessel survey from 1971 to 2023 in survey strata 401 to 439. The only years shown are those in which Atlantic Silverside were caught. “Tows” refers to the total number of sGSL Autumn Research Vessel tows conducted across survey strata 401 to 439. “Strata tows” refers to the number of tows conducted within the only survey strata in which Atlantic Silverside were caught, 402, 403, 417, 420, 421, 432, and 433.

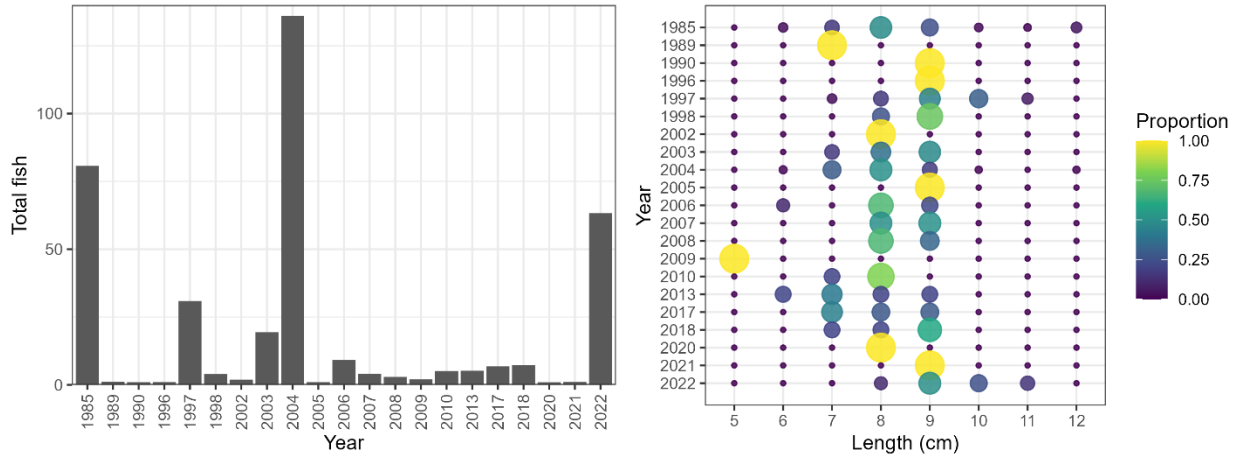


Figure 6: Number (left) and length frequencies (right) of Atlantic Silverside in southern Gulf of St. Lawrence Autumn Research Vessel surveys from 2003 to 2023 in survey strata 401 to 439. Only years in which Atlantic Silverside were caught are shown.

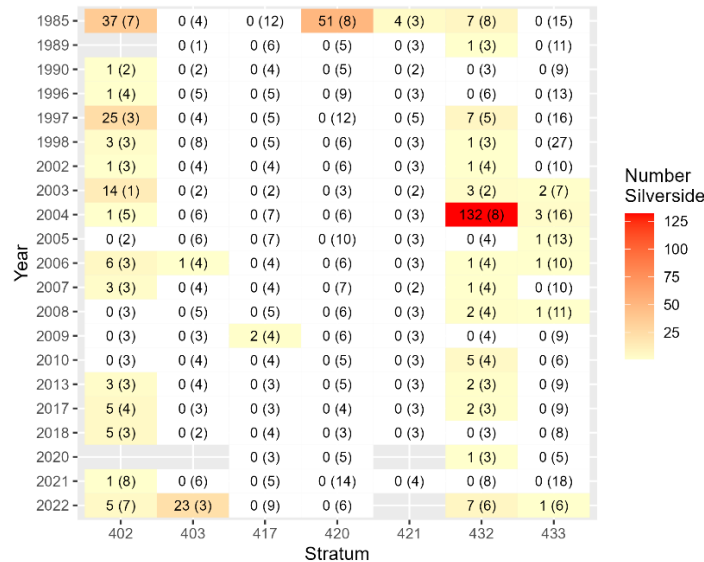


Figure 7: Heatmap of the total number of Atlantic Silverside caught (outside parentheses) and total number of tows (inside parentheses) in sGSL Research Vessel survey strata 402, 403, 417, 420, 421, 432, 433 from 1971 to 2023. Only years in which Atlantic Silverside were caught are shown.

Community Aquatic Monitoring Program (CAMP)

We used data from CAMP to assess the distribution of Silverside in bays and estuaries along the sGSL, as well as to identify species commonly associated with Silverside. CAMP began in 2003 as an outreach program for DFO to work more closely with community groups (DFO 2011), and used beach seines to sample the fish community. Following preliminary sampling in 2003, data were regularly collected by environmental community groups and staff each summer from 2004 to 2019. Seining was conducted from May through September for years 2004 through 2014, then from June through August. In 2018, no seining was done in July. In 2018 and 2019, the seining was conducted just once in each estuary. Over the full time series, seines were conducted across 41 sites, at 6 to 7 stations per site, for a total of 252 seining locations (109 in New Brunswick, 43 in Nova Scotia, and 100 in PEI) (Figure 8).

However, there are some issues with locational information, as some stations were dropped over the time series due to accumulation of algae, and were replaced with new locations but coded with the same identification as the original locations (DFO 2011).

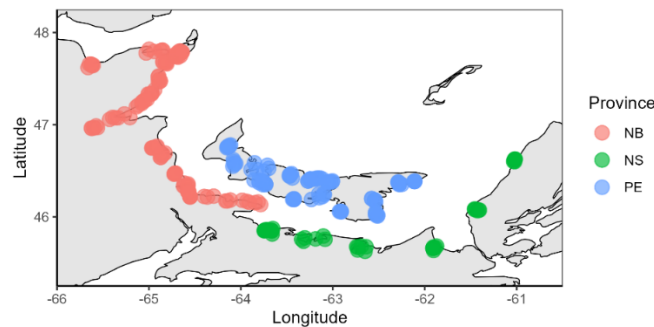


Figure 8: Locations of the 252 Community Aquatic Monitoring Program (CAMP) seining locations.

A total of 10,029 seines were completed over 118 different sampling days. Silverside were recorded in 7,293 (72.7%) seining events from 248 (98.4%) locations over 113 (95.8%) sampling days. There was little change in the number of Silverside recorded per seine across provinces, or months, however, there was a decrease in years 2018 and 2019 (Figures 9 to 11, A3). We standardized for effort by calculating the average abundance per beach seine haul. The decreased abundance in 2018 and 2019 does not seem to solely reflect the reduced sampling effort in those years (Figure 11).

The ten species that were most commonly recorded with Atlantic Silverside were Sand Shrimp (*Crangon septemspinosa*, co-occurred with Silverside in 6,484 seines), Mummichog (*Fundulus heteroclitus*, co-occurred in 6,449 seines), Fourspine Stickleback (*Apeltes quadracus*, co-occurred in 5,002 seines), Green Algae (*Chlorophyta*, co-occurred in 3,952 seines), Threespine Stickleback (*Gasterosteus aculeatus*, co-occurred in 3,844 seines), Smooth Flounder (*Pleuronectes putnami*, co-occurred in 3,589 seines), Grass Shrimp (*Palaemon*, co-occurred in 3,436 seines), Blackspotted Stickleback (*Gasterosteus wheatlandi*, co-occurred in 3,396 seines), eelgrass (*Zostera*, co-occurred in 2,528 seines), and Ninespine Stickleback (*Pungitius pungitius*, co-occurred in 2,489 seines).

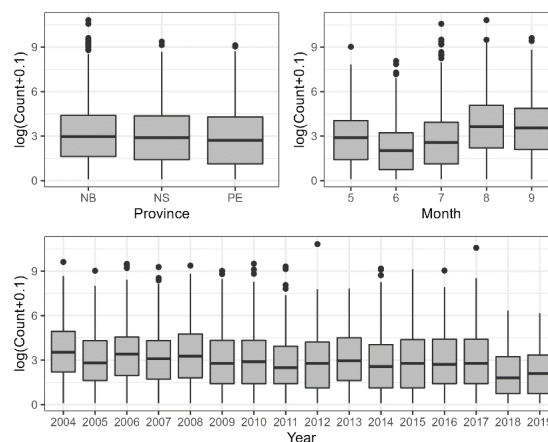


Figure 9: The distribution of the number of Atlantic Silverside per sampling event by Province (top left), month (top right), and year (bottom). Counts were log-transformed after adding 0.1. Two outliers with > 30,000 Atlantic Silverside were removed prior to plotting. Grey boxes indicate interquartile ranges, whiskers extend to $\pm 1.5 \times$ the interquartile range, datapoints beyond $\pm 1.5 \times$ the interquartile range are indicated by filled circles. Horizontal lines indicate medians.

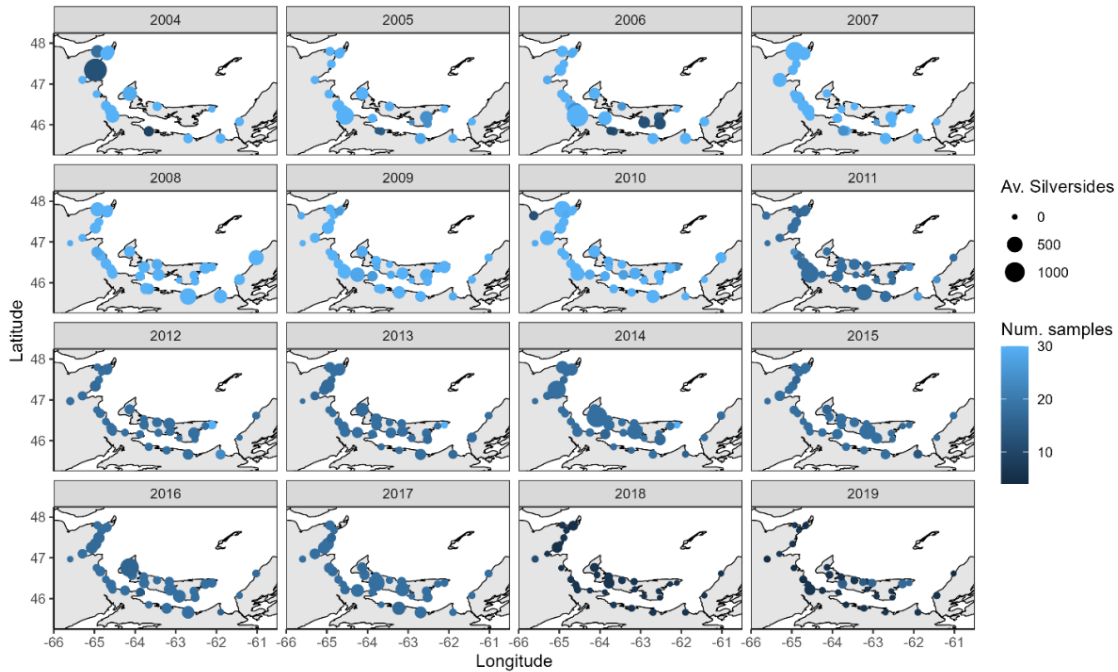


Figure 10: The average number of Atlantic Silverside sampled through the Community Aquatic Monitoring Program (CAMP) across the 41 sites per year. Two outliers with > 30,000 Silverside in 2012 and 2017 were removed prior to mapping.

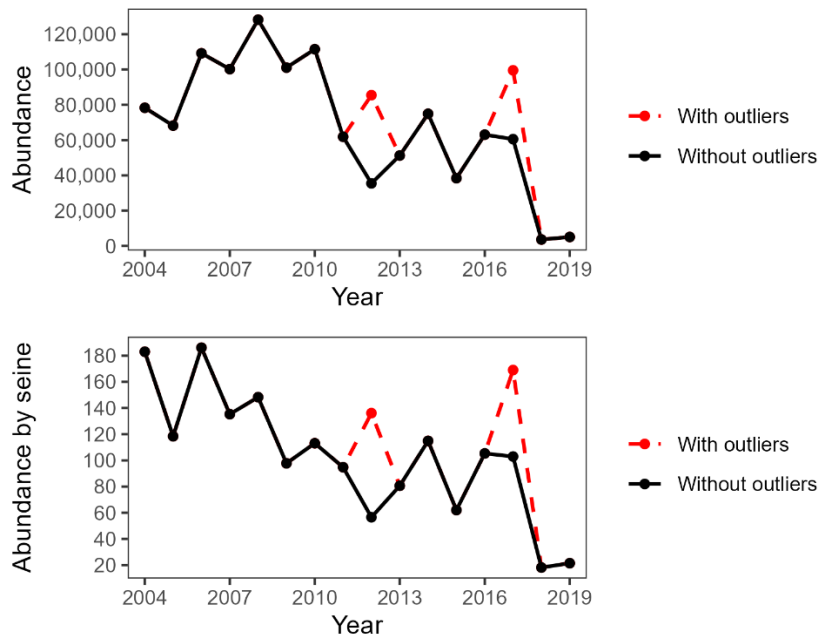


Figure 11: Total number (abundance) of Atlantic Silverside captured through the Community Aquatic Monitoring Program (top panel) and abundance by beach seine haul (bottom panel) from 2004 to 2019. The black solid lines indicate the trends without two outliers data points in 2012 and 2017 that each had > 30,000 Silverside; the red dashed lines include the two outlier data points.

Indicators of the stock status

Consistent with the last Science Advisory Process (DFO 2010), there are no validated indices of abundance of Silverside in the sGSL. The best available data to assess the stock are the fishery-dependent landings and the CAMP data, however, there are a number of issues with these data, as described above. Most importantly, the landings data do not include landings in the bait fishery that are kept for personal use, which is the primary fishery targeting Silverside. Furthermore, the data as collated do not allow one to examine the effort in this fishery or the number of active licences. The most important issue for the CAMP data is the cessation of this program in 2019. This is the only fisheries-independent data that consistently sampled the habitat in which Silverside occur.

Based on available data, it appears that the abundance of Silverside may be declining in the sGSL. This decline is inferred from a recent decline in landings despite a consistent number of licences since 2016 plus a sharp decline in average daily landings. This decline in landings also coincides with apparent increasing demand for bait in the sGSL. It is, however, difficult to determine if the observed declines could be due to changes in reporting behaviour of Silverside harvesters. It is also notable that since 2015 we see less interannual variation in the landings and CPUE. This large variation is characteristic of forage fish species as they are short lived, exhibit irregular recruitment dynamics, and are influenced by various climate and ecosystem drivers (Bakun 2006). The CAMP data also shows an overall declining trend in abundance of Silverside from 2008 to 2019, with the exception of a peak in 2017 that was attributed to a single catch of over 30,000. The abundance in 2018 and 2019 were the poorest observed in the time series across the sampled range, even when we standardized for effort per beach seine haul.

Sources of uncertainty

Sources of uncertainty on the status of Silverside in the sGSL are many, and include:

- Absence of complete information about the bait fishery prior to 2022, which is the primary fishery targeting Silverside. Since 2022, daily logbooks have been put in place in all active regions, in effort to address this issue going forward.
- Inconsistent reporting, and missing information in the available landings data, which makes it difficult to calculate CPUE, or to link captures to specific geographic locations or licences.
- Absence of winter data, when Silverside might undergo offshore migration (Cairns 1997).
- Low catchability in DFO surveys, possibly due to timing and/or location of these surveys.
- Reduced effort in the latter years of the CAMP data, and conclusion of the program in 2019. Additional issues with these data include changes in the location of stations over years, and changes in sampling frequency (DFO 2011).

Conclusions

In the sGSL, Atlantic Silverside is a forage fish species that is a source of prey for fishing-eating birds, fish, and seals (DFO 2010, Hammill and Stenson 2000, Hanson 2020). Harvest data for Silverside fisheries in the sGSL are incomplete, because it is primarily captured for bait, and this information was often not reported. Additionally, Silverside are not frequently caught in DFO sGSL Autumn or Northumberland Strait RV surveys. Silverside were also not identified in a study of sGSL Atlantic Bluefin Tuna (*Thunnus thynnus*) diet variability, despite the presence of other forage fish including Atlantic Saury (*Scomberesox saurus*) (Turcotte et al. 2023). Silverside were regularly encountered in CAMP surveys from 2004 to 2019, however, sampling effort declined, as did the months sampled, in the latter years of the program. Additionally, this

program ended after the 2019 season, leaving a gap in the data available for this nearshore coastal ecosystem. The largest source of data on sGSL Atlantic Silverside comes from commercial fishery on PEI, which is sensitive to changes in effort and reporting. It would be crucial to link the time series of fishery landing information to effort, in order to better utilize this information.

Available landings data suggest that the abundance of Silverside in the sGSL may be in steady decline since approximately 2016. Given that the gear used in this fishery is non size-selective, overexploitation of young of the year could lead to stock collapse due to lack of spawners (i.e., recruitment overfishing), and it is possible that the declines observed in the available landings reflect this (Cairns 1996). However, without a method to validate harvester data, it is possible that observed declines could be due to changes in reporting behaviour. Daily logbook reporting in all active regions from 2022 onward may help address this issue in future.

As a forage species, Silverside presumably provide a substantial proportion of the annual food for other species, and thus fisheries targeting Silverside are meant to be managed such that they are conducted in ways which are compatible with conservation of the full ecosystem (DFO 2009). As with the last Science Advisory Process, the lack of reliable fisheries data suggests that new commercial fisheries for Silverside would not meet the conservation objectives described in the *Policy on New Fisheries on Forage Species* (DFO 2009). The major data gap that would need to be addressed to fully assess the status of Silverside in the sGSL is complete landings information. Other important gaps in data include information on stock structure and seasonal migrations. At the present time, available data are not sufficient to provide a stock status.

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Appendix

Table A1: The number of sGSL Autumn RV survey tows conducted by vessel per year across survey strata 401 to 439. Asterisks indicate years in which multiple vessels were used.

Year	Cartier	Hammond	Needler	Prince	Teleost	Templeman
1971	.	.	.	66	.	.
1972	.	.	.	70	.	.
1973	.	.	.	71	.	.
1974	.	.	.	64	.	.
1975	.	.	.	67	.	.
1976	.	.	.	66	.	.
1977	.	.	.	66	.	.
1978	.	.	.	63	.	.
1979	.	.	.	74	.	.
1980	.	.	.	70	.	.
1981	.	.	.	70	.	.
1982	.	.	.	65	.	.
1983	.	.	.	67	.	.
1984	.	.	.	108	.	.
*1985	.	139	.	84	.	.
1986	.	173	.	.	.	.
1987	.	162	.	.	.	.
1988	.	154	.	.	.	.
1989	.	169	.	.	.	.
1990	.	147	.	.	.	.
1991	.	192	.	.	.	.
1992	.	.	169	.	.	.
1993	.	.	189	.	.	.
1994	.	.	160	.	.	.
1995	.	.	182	.	.	.
1996	.	.	208	.	.	.
1997	.	.	214	.	.	.
1998	.	.	206	.	.	.
1999	.	.	193	.	.	.
2000	.	.	198	.	.	.
2001	.	.	149	.	.	.
2002	.	.	185	.	.	.
2003	83
*2004	.	.	51	.	175	.
*2005	.	.	117	.	127	.
2006	176	.
2007	174	.
2008	189	.
2009	157	.
2010	146	.
2011	136	.
2012	153	.
2013	132	.
2014	166	.
2015	171	.
2016	162	.
2017	126	.
2018	106	.
2019	123	.
2020	87	.
*2021	134	.	.	.	166	.
*2022	75	.	.	.	77	.

Year	Cartier	Hammond	Needler	Prince	Teleost	Templeman
2023	127	.	.	.	.	.

Table A2: The number of Atlantic Silverside caught in sGSL Autumn RV survey tows by year and vessel from 1971 to 2023. "Tows Silv." is the number of tows that caught Silverside. "Num. Silv." is the total number of Atlantic Silverside caught.

Year	Vessel	Tows. Silv	Num. Silv
1985	Prince	7	99
1989	Hammond	1	1
1990	Hammond	1	1
1996	Needler	1	1
1997	Needler	6	32
1998	Needler	3	4
2002	Needler	2	2
2003	Templeman	4	19
2004	Needler	3	135
2004	Teleost	1	1
2005	Teleost	1	1
2006	Teleost	5	9
2007	Teleost	2	4
2008	Teleost	2	3
2009	Teleost	1	2
2010	Teleost	2	5
2013	Teleost	2	5
2017	Teleost	3	7
2018	Teleost	1	5
2020	Teleost	1	1
2021	Teleost	1	1
2022	Cartier	4	25
2022	Teleost	5	11

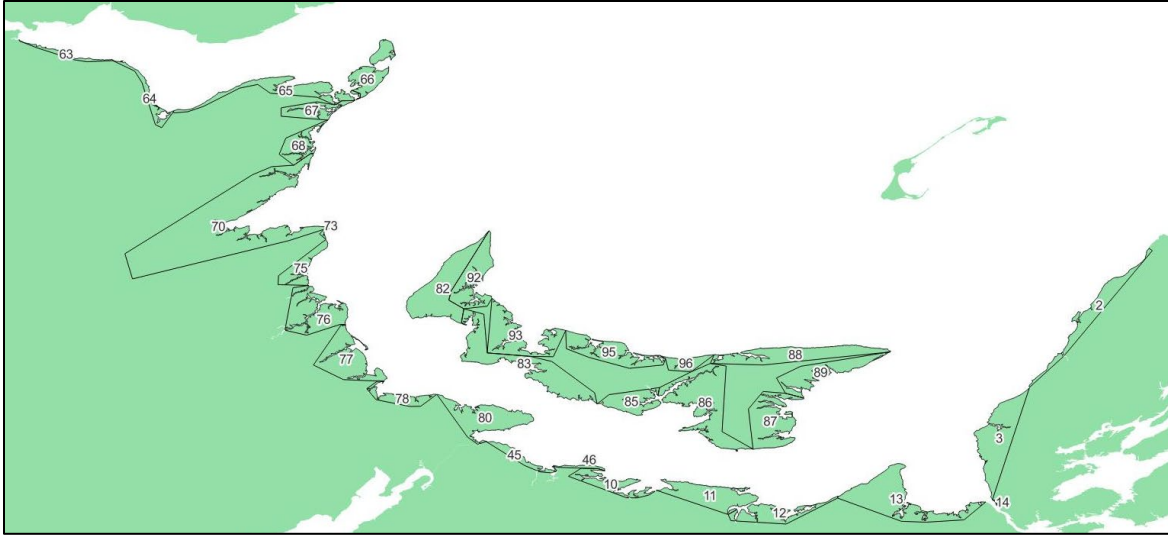


Figure A1: Locations of statistical districts pertaining to the Atlantic Silverside fishery.

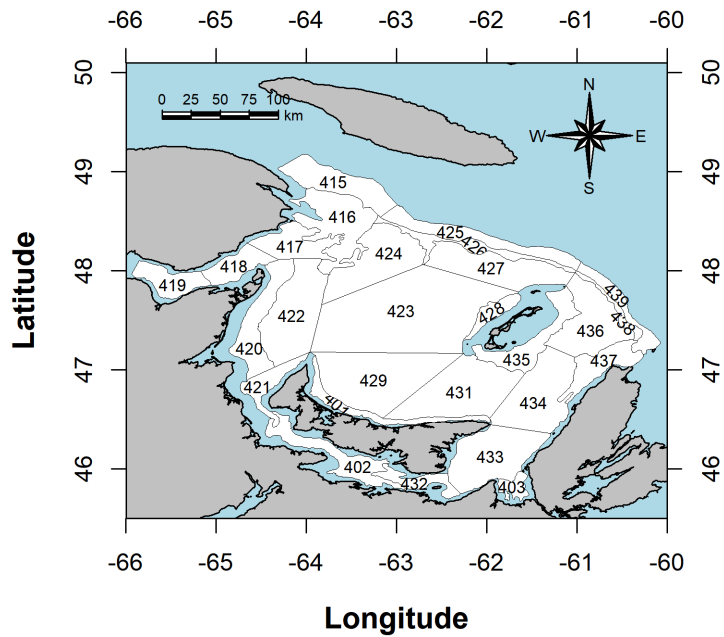


Figure A2: Map of the southern Gulf of St. Lawrence Autumn Research Vessel survey strata.

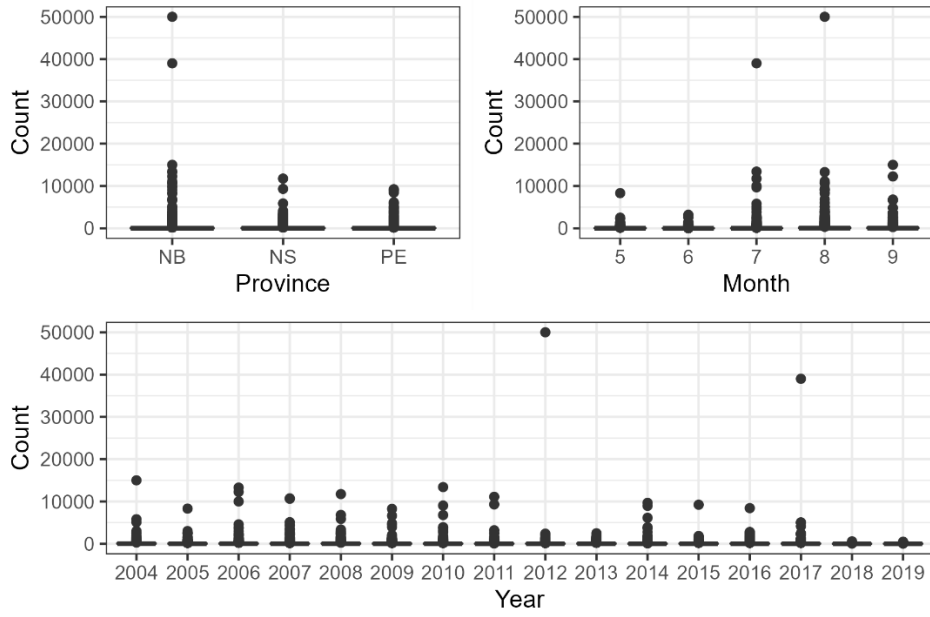


Figure A3: The distribution of the untransformed number of Atlantic Silverside per sampling event by Province (top left), month (top right), and year (bottom). Two outliers with > 30,000 Atlantic Silverside were removed prior to plotting. Datapoints beyond $\pm 1.5 \times$ the interquartile range are indicated by filled circles.

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