STOCK ASSESSMENT OF NEWFOUNDLAND AND LABRADOR ATLANTIC SALMON IN 2022 (SFA 1–14B)

*Image: Atlantic Salmon (*Salmo salar*).*

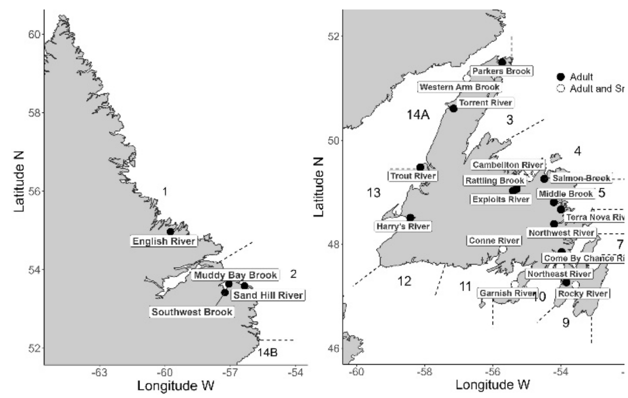

Figure 1. Map of Atlantic Salmon rivers monitored in the Newfoundland and Labrador (NL) Region in 2022 and approximate boundaries of Salmon Fishing Areas (SFAs) 1–14B.

Context:

*In Newfoundland and Labrador (NL), there are 15 Atlantic Salmon (*Salmo salar*) management areas, known as Salmon Fishing Areas (SFAs) 1–14B (Fig. 1). Within these areas there are 407 rivers known to contain wild Atlantic Salmon populations that are characterized by differences in life history traits, including freshwater residence time, timing of return migration, age at first spawning, and the extent of ocean migration.*

The Fishery Decision-Making Framework Incorporating the Precautionary Approach (Fisheries and Oceans Canada [DFO] 2015) identifies two reference points for managing fisheries stocks, the Limit Reference Point (LRP) and Upper Stock Reference Point (USR). As per the Precautionary Approach (PA) Framework, Atlantic Salmon stock status is assessed based on the proportion of the river-specific LRP and USR achieved. Conservation egg requirements for Atlantic Salmon were previously established for individual rivers in Newfoundland and Labrador (SFAs 1–14B). Conservation egg requirements are considered to be equivalent to a LRP. The USR is considered to be 150% of the LRP.

Status is also described in terms of trends in salmon returns (abundance prior to in-river exploitation), smolt production, and marine survival rates.

Annual comparisons are generally made to:

1. the previous generation average which corresponds to six years for most Newfoundland rivers and seven years for most Labrador rivers, and

2. the previous three generation average (16–18 years for most Newfoundland rivers and 19–22 years for most Labrador rivers).

This Science Advisory Report is from the February 28-March 2, 2023, Regional Peer Review Process on the Stock Assessment of Atlantic Salmon in Newfoundland and Labrador in 2022. This report provides information regarding the status of Atlantic Salmon stocks in 2022 for SFAs 1, 2, and 14B (Labrador), and SFAs 3 to 14A (Newfoundland) (Figs. 1 and 2)

SUMMARY

- Twenty-one populations of Atlantic Salmon (*Salmo salar*) were monitored in 2022. Returning adult salmon were counted on 20 rivers using monitoring fences or fishways, and returns were estimated on one river using a combination of a fish counting fence and snorkel survey. Stock status was estimated for 19 of 21 monitored populations.
- In 2022, 16 rivers had sufficient time series data to compare adult returns to the previous generation. Of these 16, nine (one in Labrador and eight in Newfoundland) showed declines in total returns with five having declines over 30%. Thirteen rivers had sufficient time series data to compare adult returns to the previous three generations. Of these 13, seven (one in Labrador and six in Newfoundland) showed declines in total returns with five having declines over 30%.
- Marine survival is considered a major factor limiting the abundance of Atlantic Salmon in Newfoundland and Labrador (NL), with adult returns in any given year determined primarily by marine survival rather than smolt production. In 2022, estimated marine survival on monitored rivers ranged from 5.4% to 10.7% excluding rivers in Salmon Fishing Area (SFA) 11, where survival rates were lower (1.2%–3.9%).
- In 2022, estimated spawning escapements (eggs) on Labrador rivers were in the Critical Zone on Southwest Brook, the Cautious Zone on Sand Hill River, and the Healthy Zone on English River and Muddy Bay Brook. Of the 15 assessed rivers in Newfoundland, nine were in the Critical Zone, one was in the Cautious Zone, and five were in the Healthy Zone.
- Preliminary estimates of harvest in the 2022 Labrador Indigenous and subsistence fisheries were inferred from logbooks and were similar to the previous generation average. Preliminary estimates of catch in the 2022 recreational Atlantic Salmon fishery were inferred from angler log returns. Estimates of retained salmon were similar to the previous generation average in Newfoundland and lower in Labrador. Estimates of released salmon were lower than the previous generation average in both Newfoundland and Labrador.
- In 2022, record high sea surface temperatures during ice-free months were observed on the Newfoundland shelf. Water temperatures from an inshore thermograph network on the island of Newfoundland also suggested that 2021 and 2022 were the two warmest years on record since 1989. However, the effects of higher marine temperatures on Atlantic Salmon are uncertain.
- In 2022, hourly water temperatures across 12 Newfoundland rivers were above 20°C for 58.9% of August and above 24°C for 7.5% of August, with higher temperatures in the Avalon and Central regions. In Labrador, temperatures were above 20°C for 1.2% of August across three rivers. Temperatures exceeding 20°C can have negative impacts on Atlantic Salmon physiology and behaviour.
- Overall conditions of the past three years are indicative of improved productivity at lower trophic levels along the NL bioregion (2HJ3KLNOPs). This includes earlier phytoplankton blooms, higher chlorophyll concentrations, and increased zooplankton biomass with a higher abundance of larger, more energy-rich *Calanus* copepods.
- Marine ecosystem conditions indicated overall limited productivity of the fish community. Total biomass of the entire fish community remained below pre-collapse levels with minor recovery up to the early 2010s, followed by subsequent declines. In recent years (2019–21), ecosystem indicators have suggested that conditions could be improving from the lows in

the mid-late 2010s. However, the lack of offshore multi-species surveys in 2022 prevented an updated evaluation of these trends.

- Aquaculture associated genetic impacts (i.e., hybridization and introgression) continued to be documented in southern Newfoundland wild salmon populations, with probable impacts on wild population size and persistence. Recent detection of unauthorized European ancestry in aquaculture salmon and escapees in the region elevates the uncertainty and potential magnitude of these impacts. In addition to genetic interactions, there remains significant uncertainty as to the role of aquaculture associated disease or parasite transfer and ecological interactions (i.e., competition or predation) on wild populations in the region.

BACKGROUND

Species Biology

There are 15 Atlantic Salmon (Salmo salar) management areas, known as Salmon Fishing Areas (SFAs) 1–14B, in Newfoundland and Labrador (NL) (Figs. 1 and 2). Within these areas there are 407 rivers known to contain wild Atlantic Salmon populations that are characterized by differences in life history traits, including freshwater residence time, timing of return migration, age at first spawning, and the extent of ocean migration. Juvenile Atlantic Salmon predominantly remain in freshwater habitats for three to four years in Newfoundland (>95% of samples taken since 2000) and four to five years in Labrador (>83% of samples taken since 2000) prior to undergoing smoltification and migrating to sea as smolts (DFO 2020a). Spawning populations in NL consist of varying proportions of small (fork length [FL] <63 cm) and large (FL ≥63 cm) adult salmon (Fig. 3). For the majority of rivers in Newfoundland (SFAs 3–12 and 14A), the small adult salmon population is predominantly grilse (one-sea-winter [1SW] salmon), that have spent one year at sea before returning to spawn for the first time. For most monitored rivers in NL, small salmon are predominantly female (range of 60–92% across rivers). The large adult salmon population in Newfoundland rivers is composed mainly of repeat-spawning grilse which are either a consecutive or alternate spawning fish. In contrast, populations in Labrador (SFAs 1, 2, and 14B) and southwestern Newfoundland (SFA 13) consist of important large salmon components that contain maiden fish that have spent two (two-sea-winter [2SW]) or more years (multi-sea-winter [MSW]) at sea before returning to spawn. Run timing for returning salmon is influenced by climate conditions on the NL shelf, occurring earlier in warmer years and later in colder years that have low water temperatures and high amounts of inshore sea ice (Dempson et al. 2017).

Atlantic Salmon Fisheries

Indigenous Food, Social, and Ceremonial (FSC) fisheries for Atlantic Salmon occur in Labrador under communal licences. Labrador also has a resident fishery for Brook trout (*Salvelinus fontinalis*) and Arctic char (*Salvelinus alpinus*) with a permitted retention of three salmon bycatch. In Newfoundland, Miawpukek First Nation (MFN) holds a FSC communal salmon fishing licence, but has chosen not to harvest salmon under this licence since 1997 due to conservation concerns.

The recreational Atlantic Salmon fishery is managed according to a river classification system, which is used to establish retention levels based on the health of individual salmon populations without jeopardizing conservation goals (Veinott et al. 2013). Consistent with the previous three years, the 2022 recreational angling season involved a seasonal retention limit of one fish on Class 2 rivers and two fish on Class 4, 6, and unclassified rivers, and daily catch-and-release limits of three fish on Class 2, 4, 6, and unclassified rivers.

ASSESSMENT

Reference Points

The Precautionary Approach (DFO 2015) identifies two reference points for managing fisheries stocks, the Limit Reference Point (LRP) and the Upper Stock Reference Point (USR). Populations below the LRP are in the Critical Zone, so management actions should promote stock growth and fisheries-related mortality should be kept to the lowest level possible. Populations above the USR are considered to be in the Healthy Zone and are therefore available for exploitation at some predetermined maximum exploitation rate. Populations with a status between the LRP and USR are situated in the Cautious Zone, so management actions should promote stock rebuilding to the Healthy Zone.

Conservation egg requirements for Atlantic Salmon were previously established for individual rivers in Newfoundland and (O’Connell and Dempson 1995; O’Connell et al. 1997; Reddin et al. 2006). The LRP and USR are set at 100% and 150% of the previously defined river-specific conservation egg deposition rate, respectively.

Methods

The 2022 status of Atlantic Salmon stocks within NL (SFAs 1–14B) was assessed using abundance data collected from 21 salmon monitoring facilities (counting fences and fishways; Fig. 2), an in-river snorkel survey (Harrys River in SFA 13), and preliminary catch and effort estimates from the recreational fishery. The Licence Stub Return System (O’Connell et al. 1996, 1998; Dempson et al. 2012; Veinott and Cochrane 2015) provides recreational catch and effort estimates for rivers in SFAs 2–14B, except for Eagle River and Sand Hill River in SFA 2 where private fishing camps’ data are used. DFO Science assumes a catch-and-release mortality rate of 10% when calculating estimates of total returns, total spawners, and egg depositions on monitored rivers where angling is permitted. This was consistent with low to average mortality estimates from a review of several catch-and-release studies on Atlantic Salmon (Van Leeuwen et al. 2020) and similar to the mean mortality probability observed in a study on Western Arm Brook (SFA 14A; Keefe et al. 2022). Recreational angling estimates used in calculations for this report are considered preliminary and will be updated upon the completion of a phone survey of nonrespondent anglers (i.e., anglers that have not voluntarily submitted their fishing logs). The total returns of small (<63 cm FL) and large (≥63 cm FL) adult Atlantic Salmon to monitored rivers in 2022 were reported and include estimates of fishery removals downstream of the monitoring facilities where available. Total return estimates for Sand Hill River were adjusted to account for fish that migrated upstream prior to the fence installation. These estimates are based on a nonparametric bootstrap procedure applied to the proportion of the small and large salmon run counted on Sand Hill River prior to July 2 over the previous three generations (2002–21). For each river, total spawner estimates were converted to estimates of egg deposition and compared to the river-specific LRP and USR to designate a stock status zone. Estimates of salmon returns, egg depositions, and marine survival reported for 2022 are considered preliminary and will be updated upon the completion of an angler phone survey, although most changes are typically negligible. No current abundance data were available for salmon populations in SFAs 3, 6, 7, 8, 12, and 14B, or in the Lake Melville area of SFA 1.

The abundance of out-migrating Atlantic Salmon smolts was monitored on five rivers in Newfoundland in 2022 (Fig. 2). For these rivers, reported estimates of marine survival in the adult return year are calculated by dividing the small salmon return estimate in $year_i$ by smolt abundance in $year_{i-1}$ and multiplying by 100%. As returns of small salmon include a portion of repeat spawners, estimates of marine survival from smolt to maiden 1SW salmon will be slightly less than the numbers reported in this report.

The estimated number of returns on each river in 2022 were compared to the average returns over the previous generation and three generation time periods. One generation is equivalent to approximately six years for populations in Newfoundland and seven years for populations in Labrador. Three generations correspond to 16–18 years for most Newfoundland rivers and 19–22 years for Labrador rivers. For all comparisons, changes of <10% are considered to be non-significant, and returns are reported as being similar to the comparative average.

Regional trends in adult Atlantic Salmon abundance on monitored rivers were assessed by combining and modelling time series of total returns across monitored rivers using a negative binomial generalized linear model (GLM) with a log link function, with year and river as factors (Dempson et al. 2004). The estimated marginal mean log abundance from this model is used as a Salmon Abundance Index, to examine temporal patterns in the relative abundance of Atlantic Salmon on monitored rivers simultaneously within the NL Region. Estimates from this model should not be used to infer actual Atlantic Salmon abundance in the NL Region. Returns were modelled separately for Newfoundland since 1992 and Labrador since 1998, the years that commercial moratoriums began in each area. The estimated marginal mean log abundances (+/- standard errors) were presented for each year for NL. The error bars represent variability in counts across monitored rivers which differed by orders of magnitude.

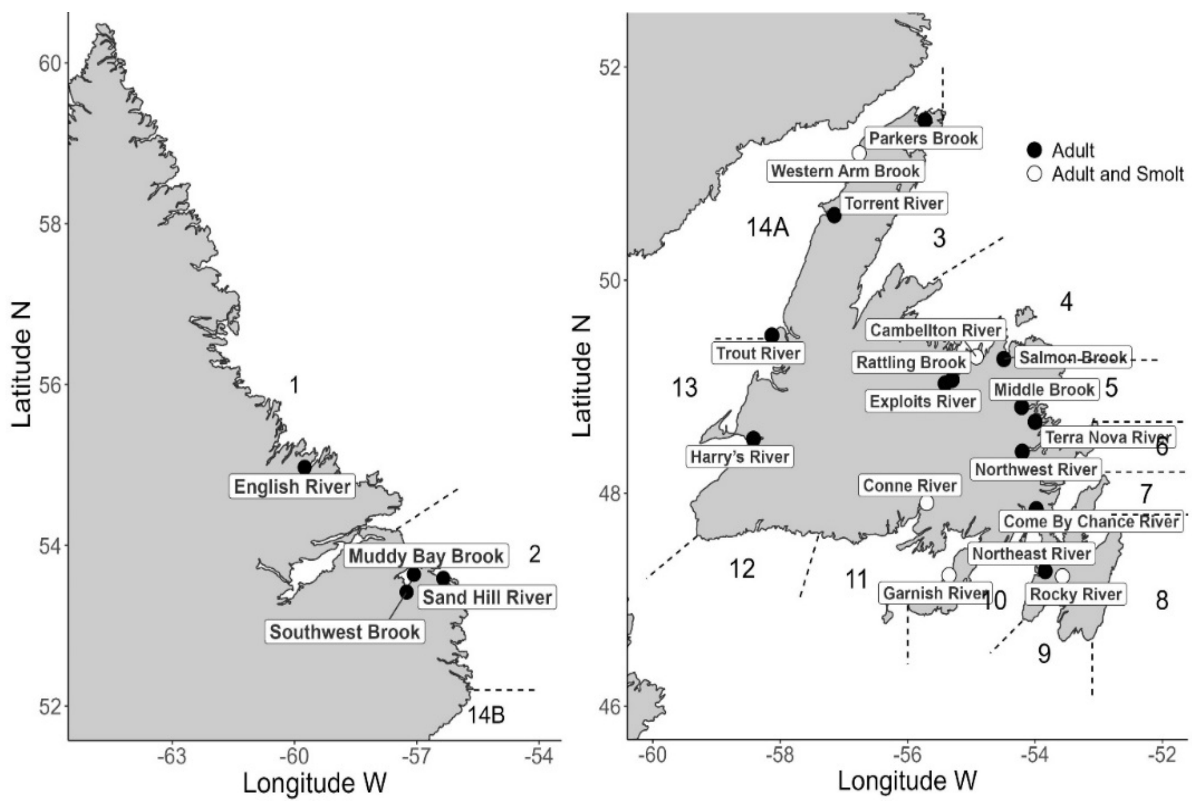

Figure 2. Map of the NL Region showing SFAs 1–14B and rivers where the number of out-migrating Atlantic Salmon smolts and/or returning adults were counted in 2022. Dashed lines indicate approximate SFA boundaries.

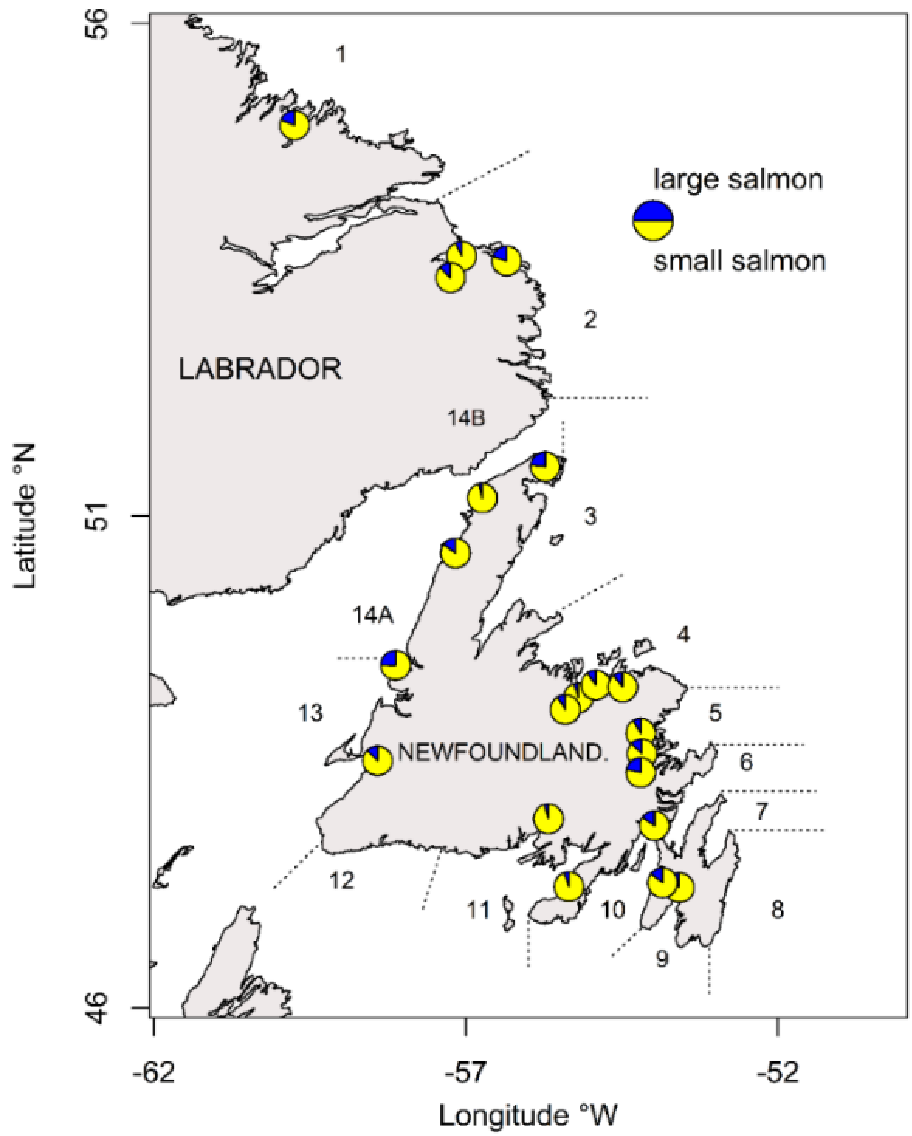

Figure 3. Average proportion of small (fork length <63 cm) and large (fork length ≥63 cm) Atlantic Salmon observed from 1992–2022 on Newfoundland and Labrador rivers monitored in 2022. The approximate boundary of each SFA is indicated by dotted lines.

RESULTS AND DISCUSSION

Indigenous and Subsistence Fishery Data

Labrador FSC and subsistence fisheries harvests were inferred from logbook returns (65% return rate) and were estimated at 14,165 salmon in 2022 (9,130 small, 5,035 large), which was 5% higher than the previous generation average (2015–21) of 13,441 salmon and 11% higher than the previous three generation average (2002–22) (Table 1, Fig. 4). Large salmon represented 36% of the catch by number.

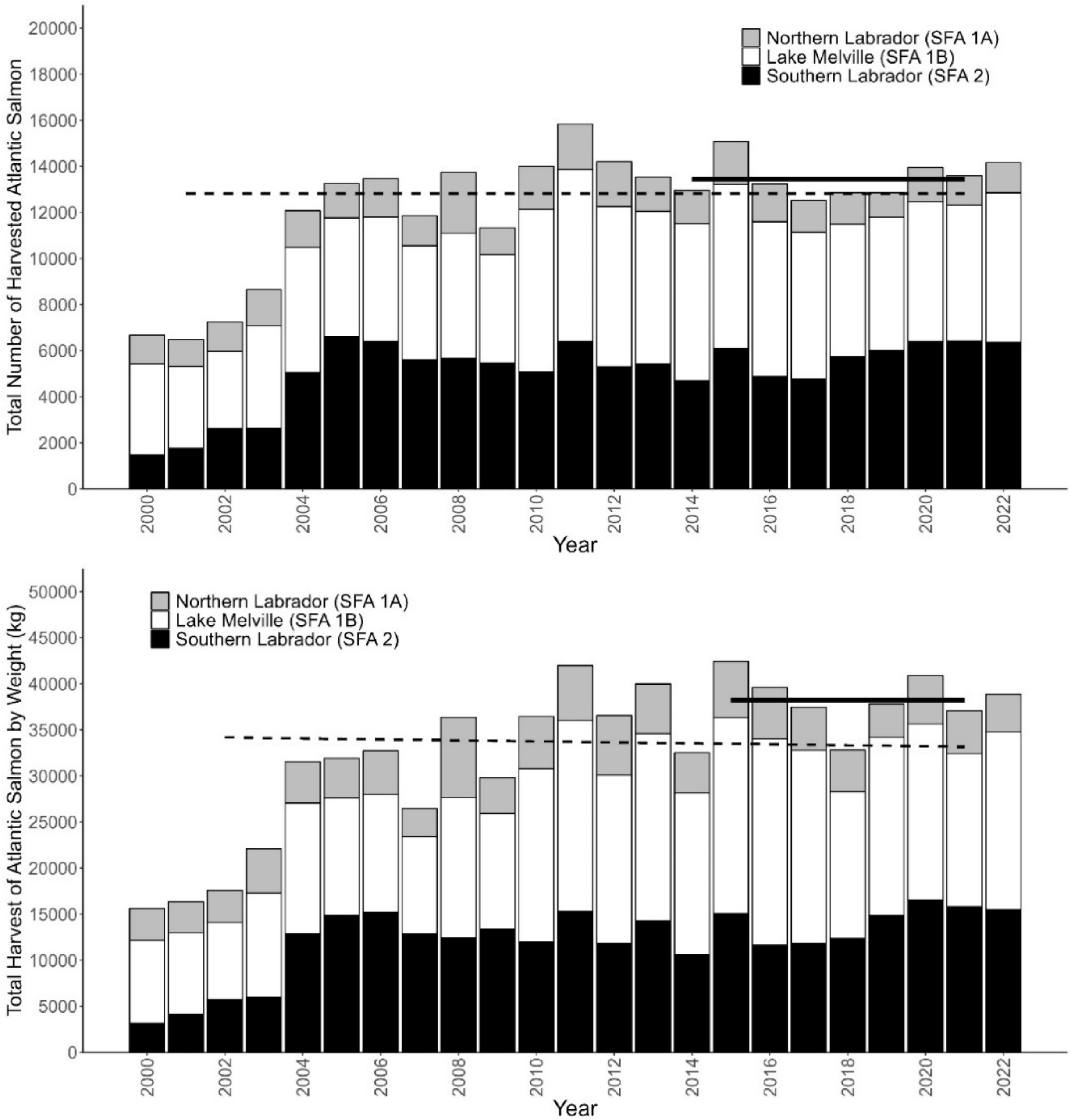

Figure 4. Estimated number (top panel) and weight (bottom panel) of Atlantic Salmon harvested in Labrador Indigenous and subsistence fisheries in SFAs 1A, 1B and 2 from 2000–22. Horizontal solid line represents the previous generation average (2015–21). Horizontal dashed line represents the previous three generation average (2002–21). Harvest estimates for 2022 are preliminary and will be updated upon the receipt and analysis of additional logbooks.

Recreational Fishery Data

Labrador (SFAs 1, 2 and 14B)

The 2022 recreational salmon fishery opened June 15 and closed September 15 for all Labrador rivers. The preliminary estimate of total small salmon retained in 2022 in Labrador is 952 salmon (Table 2, Fig. 5), 12% below the previous generation average (2015–21). The estimated number of released small salmon in 2022 in Labrador was 3,628 salmon, 12% below the previous generation average. In 2022, an estimated 1,686 large salmon were released in the Labrador recreational fishery, a 21% decrease compared to the previous generation average. Effort in the 2022 Labrador fishery was estimated at 6,883 rod days, a 24% increase compared to the previous generation average (Table 2, Fig. 5).

Newfoundland (SFAs 3–14A)

The 2022 recreational salmon fishery opened June 1 and closed September 7 for all Newfoundland rivers. The preliminary estimate of total small salmon retained in the 2022 recreational fishery is 17,078 fish (Table 3, Fig. 6), which is similar to (-2%) the previous generation average (2016–21). The preliminary estimate of total small salmon released in 2022 was 18,416 fish, which is 26% below the previous generation average. In 2022, an estimated 3,219 large salmon were released across Newfoundland, 41% below the previous generation average (Fig. 6). Estimated angler effort in 2022 (90,412 rod days) was 25% higher than the previous generation average.

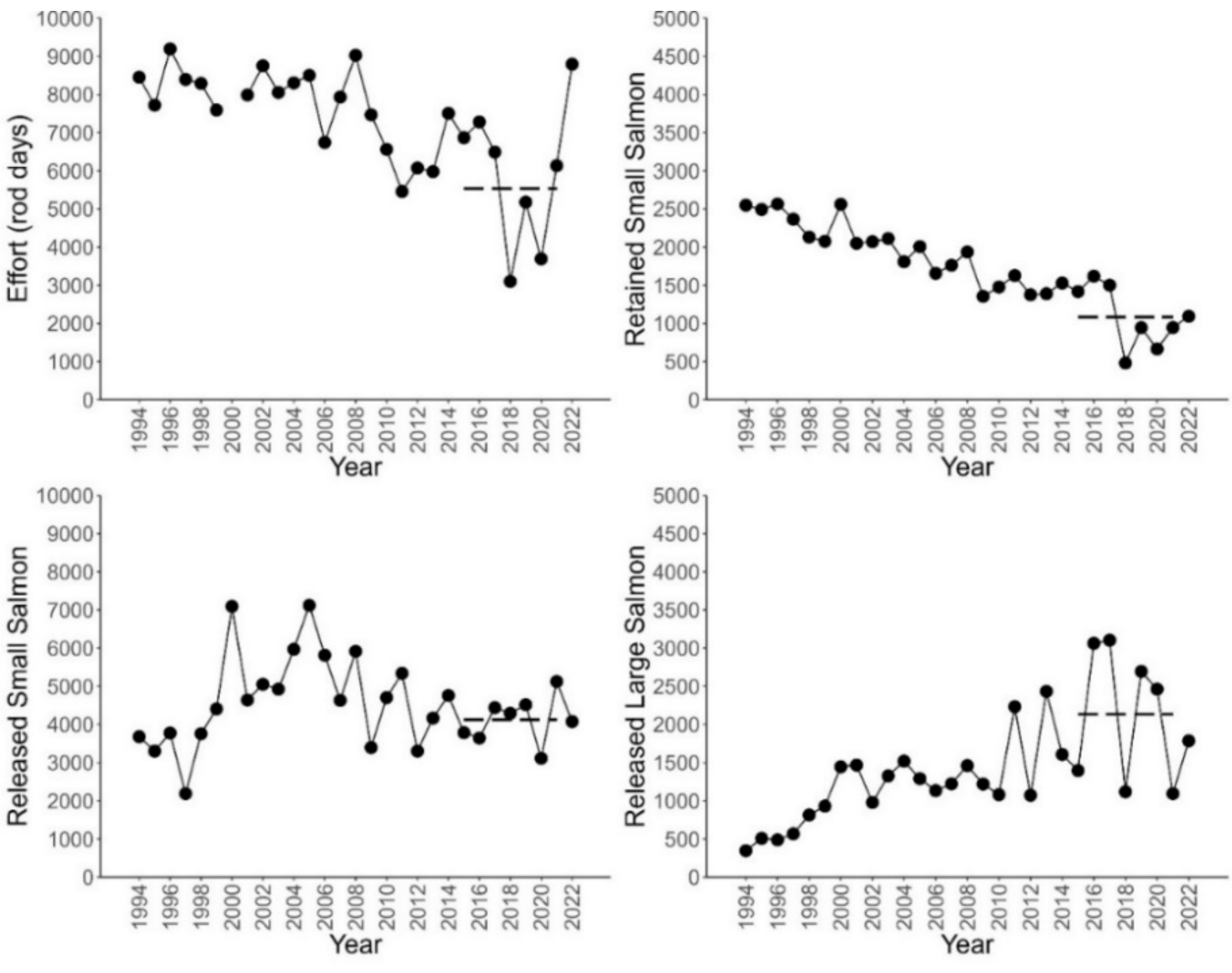

Figure 5. Recreational catch of small and large Atlantic Salmon and angling effort (rod days) in Labrador from 1994–2022. Horizontal dashed lines represent the previous generation average (2015–21). Estimates for 2022 are preliminary and will be updated upon the completion of a phone survey of anglers who have not returned their logs.

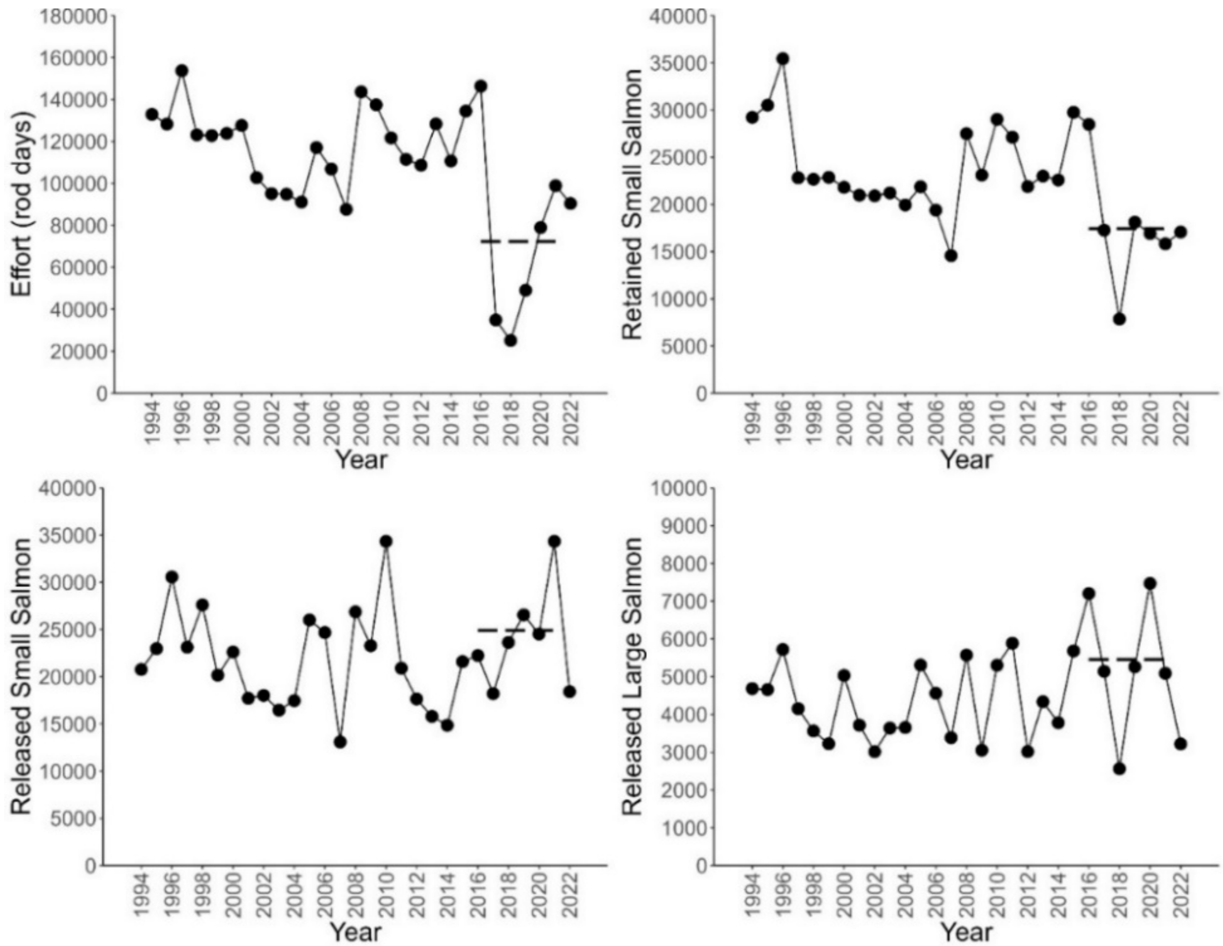

Figure 6. Recreational catch of small and large Atlantic Salmon and angling effort (rod days) in Newfoundland from 1994–2022. Horizontal dashed lines represent the previous generation average (2016–21). Estimates for 2022 are preliminary and will be updated upon the completion of a phone survey of anglers who have not returned their logs.

Resource Status – Adult Salmon

Labrador

Four Atlantic Salmon rivers in Labrador were monitored in 2022 (Fig. 2). Total returns to three of these rivers (English River, Sand Hill River, and Muddy Bay Brook) were higher than the previous generation average (2015–21) and previous three generation average (2002–21) (Table 4, Fig. 7). Atlantic Salmon returns to English River set a record high since monitoring began in 1999 and were 2.8 standard deviations above the average return over the previous three generations including 2022 (Fig. 8). Atlantic Salmon returns to Southwest Brook (SFA 2) were well below average in 2022 (Table 4, Figs. 7 and 8).

In 2022, estimated egg depositions exceeded the USR (Healthy Zone) on English River (373%) in SFA 1 and Muddy Bay Brook (193%) in SFA 2 (Table 5, Fig. 9). Egg depositions on Sand Hill River (109%) exceeded the LRP but were below the USR (Cautious Zone). Southwest Brook was in the Critical Zone at only 28% of the river-specific LRP (Table 5, Fig. 9).

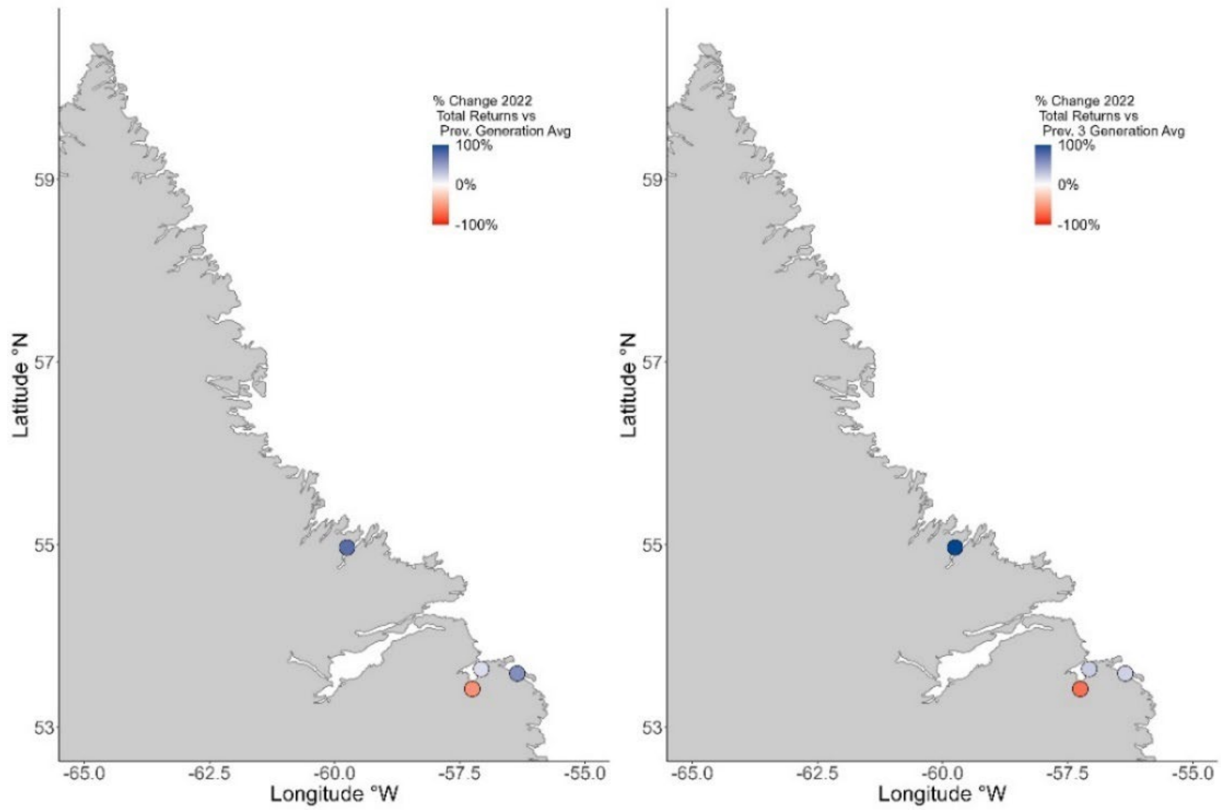

Figure 7. The percent change in 2022 total returns compared to the average returns over the previous generation (left panel) and previous three generations (right panel) for four monitored Atlantic Salmon populations in Labrador. The previous generation time period is seven years for Labrador rivers. The previous three generation time period is specific to each river (19–22 years for Labrador rivers). In cases where the magnitude of change is larger than 100%, values are scaled down to 100% for the figure. See Table 4 for actual percentages for each river.

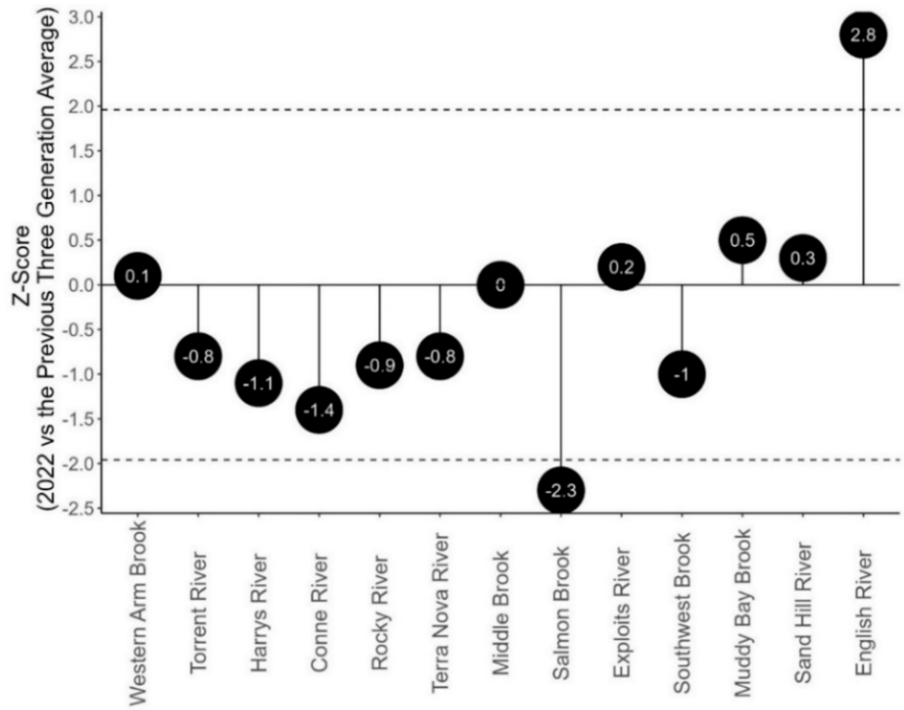

Figure 8. Z-scores of total Atlantic Salmon returns on monitored rivers in 2022 compared to their river-specific previous three generation average. The value shown for each river represents the number of standard deviations 2022 returns are from the mean over the previous three generation time period. Campbellton River was not included due to an incomplete count in 2022. Horizontal dashed lines represent approximate 95% confidence intervals (± 1.96).

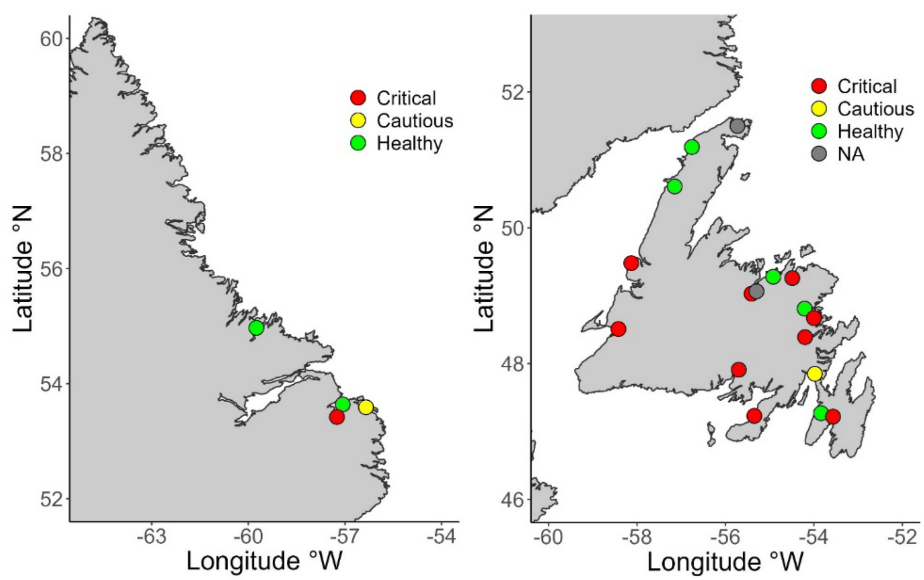

Figure 9. Map of monitored Atlantic Salmon rivers in Labrador (left) and Newfoundland (right) in 2022 coloured by their estimated stock status zone as per the Precautionary Approach (DFO 2015). Designation of a population within a stock status zone is based on comparing the estimated egg depositions in 2022 to the river-specific Limit Reference Point (LRP): Critical Zone (0–99% of LRP), Cautious Zone (100–149% of LRP), and Healthy Zone (≥150% of LRP). The LRP is equivalent to a river's conservation egg requirement.

Newfoundland

Seventeen Atlantic Salmon rivers in Newfoundland were monitored in 2022 (Fig. 2). The count of returning adult Atlantic Salmon to Campbellton River in 2022 is considered a partial count. In the fall after the counting fence was removed there were reports of returning salmon congregating at the river mouth unable to enter the river due to persistent low water conditions. DFO Science were unsuccessful in attempts to quantify the number of migrating salmon using DIDSON sonar technology, however, it did confirm that hundreds of salmon (at minimum) were moving into the watershed in the fall. Total returns to eight of 12 monitored rivers in Newfoundland with sufficient time series data were below the previous generation average (2016–21) in 2022 (Table 4, Fig. 10). In Newfoundland, only Exploits River and Western Arm Brook exhibited above-average returns in 2022 compared to the previous generation average and no monitored river had returns greater than the previous three generation average (Table 4, Fig. 10).

Estimates of stock status zone were unavailable for two monitored rivers in Newfoundland, Rattling Brook (SFA 4) and Parkers River (SFA 14A), in 2022. Of the remaining 15 monitored rivers in Newfoundland, estimated egg depositions exceeded the USR (Healthy Zone) on five rivers (Table 5, Fig. 9); egg depositions on Come By Chance River exceeded the LRP (103%) but were below the USR (Cautious Zone); and nine monitored rivers in Newfoundland were in the Critical Zone with estimated egg depositions below their river-specific LRPs (Table 5, Fig. 9). Estimated egg depositions on Conne River met only 14% of the river-specific LRP in 2022.

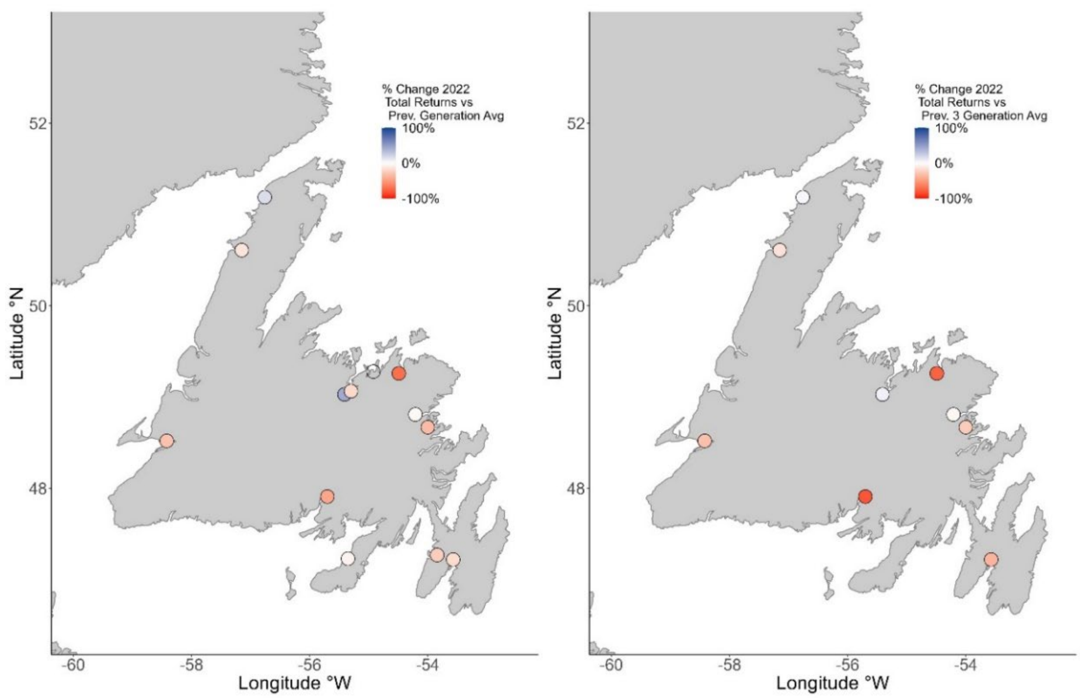

Figure 10. The percent change in 2022 total returns compared to the average returns over the previous generation (left panel) and previous three generations (right panel) for four monitored Atlantic Salmon populations in Newfoundland. The previous generation time period is six years for Newfoundland rivers. The previous three generation time period is specific to each river (16–18 years for most Newfoundland rivers). In cases where the magnitude of change is larger than 100%, values are scaled down to 100% for the figure. See Table 4 for actual percentages for each river.

Salmon Abundance Index

In Newfoundland, estimated marginal mean log salmon abundance declined after 2015, reflective of relatively poor returns observed on several monitored Atlantic Salmon rivers in recent years, particularly 2017–19 (DFO 2020a, 2020b). Estimated abundance improved in 2021 after strong returns were observed on several monitored rivers (DFO 2023a). However, below average Atlantic Salmon returns were recorded on the majority of monitored rivers in Newfoundland in 2022 (Fig. 10) resulting in the lowest estimated marginal mean log salmon abundance since 2017 (Fig. 11).

In Labrador, the estimated marginal mean log salmon abundance in 2022 was slightly higher than 2021 and similar to 2020 (Fig. 11). The estimate for 2022 is on par with some of the highest years over the previous generation (2015–21) and is largely driven by above average Atlantic Salmon returns observed on English River, Sand Hill River, and Muddy Bay Brook.

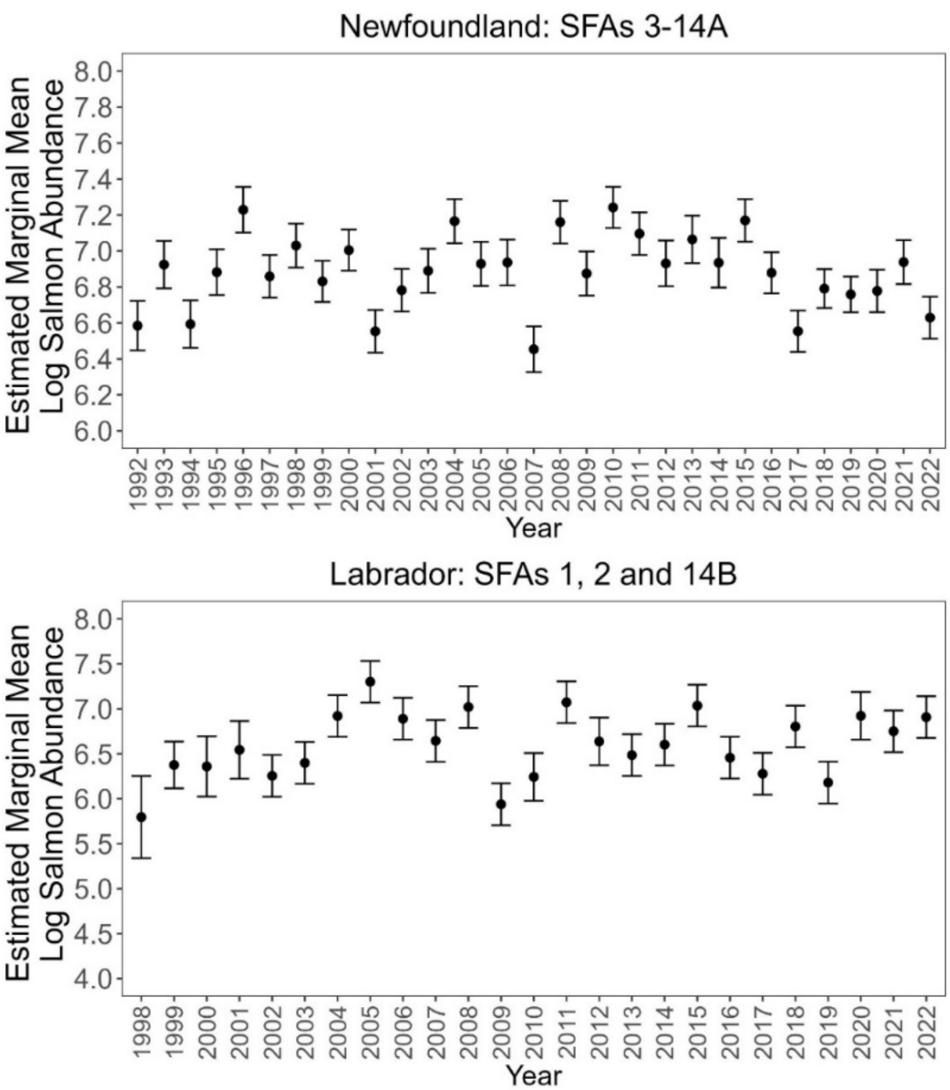

Figure 11. Estimated marginal mean log Atlantic Salmon abundance from negative binomial GLMs (log link function and year as a factor) applied to data from monitored rivers in Newfoundland (above) and in Labrador (below). Vertical lines represent ± one standard error. Each model only includes data since the commercial moratorium (1992 for Newfoundland and 1998 for Labrador).

Smolt Production and Marine Survival

Atlantic Salmon smolt abundance is typically monitored each year during the downstream migration on five rivers in Newfoundland (Figs. 2 and 12). Smolt production in 2022 was above the previous generation average on Campbellton River (+39%), Rocky River (+49%), and Garnish River (+73%), and below the previous generation average on Conne River (-36%) and Western Arm Brook (-11%) (Table 6, Fig. 12). However, the counting fence on Western Arm Brook was installed late in 2022 due to high water conditions and did not begin operation until June 1. A nonparametric bootstrap (10,000 iterations) was applied to the proportion of the smolt run counted prior to June 1 over the previous three generations (2004–21). This procedure suggested that, on average, 17.8% (95% Confidence Intervals [CIs]: 7.8%, 28.3%) of the smolt run is counted by that date, and that approximately 14,509 (95% CIs: 12,991, 16,774) smolt left Western Arm Brook in 2022, which would be similar to the previous generation average (+8%, 95% CIs: -3%, +25%).

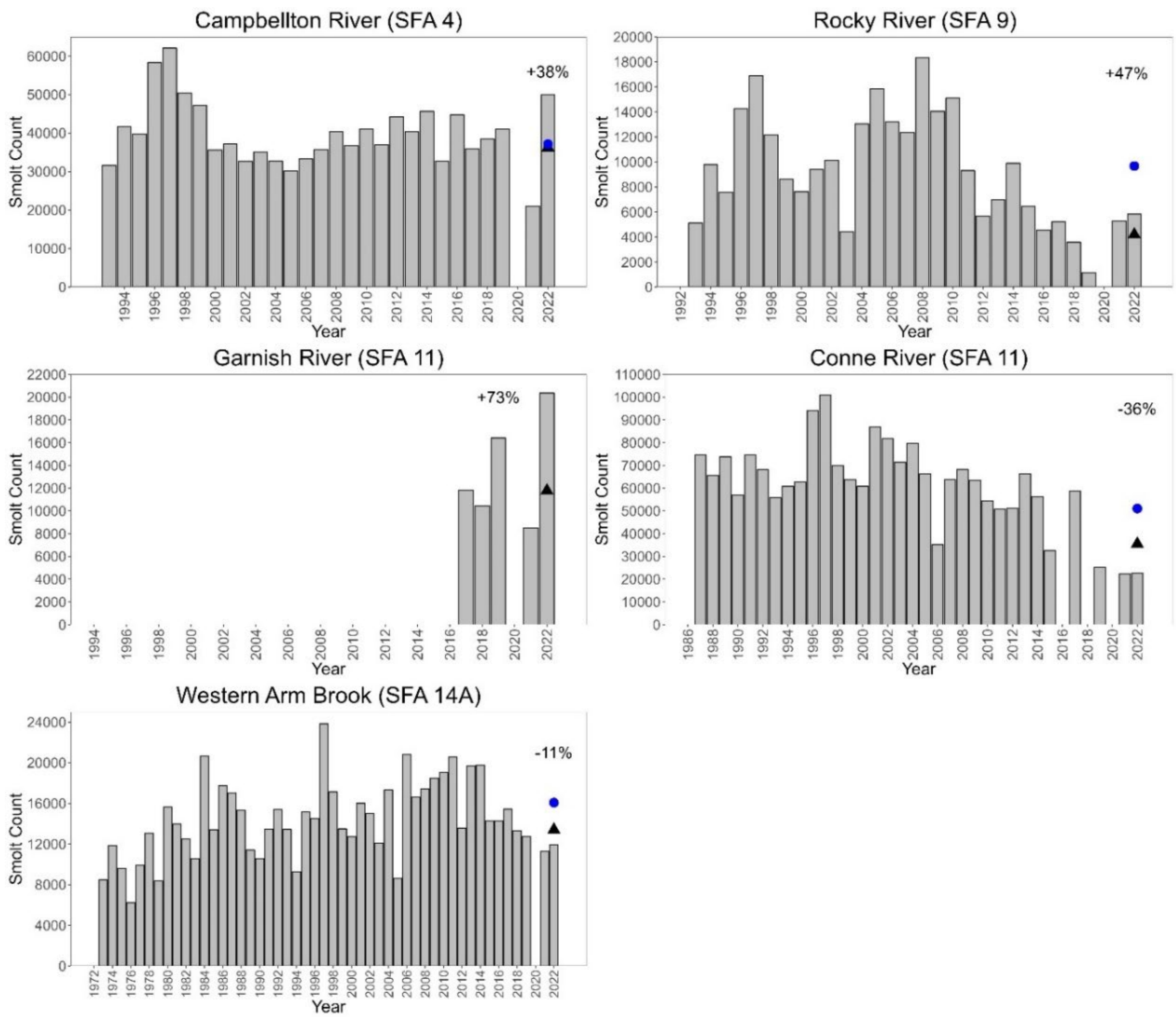

Figure 12. Smolt production on monitored Newfoundland Atlantic Salmon rivers in 2022. The black triangles and blue circles represent the previous generation average (2016–21) and previous three generation average (16–18 years), respectively. Smolt counts are not available for 2020 due to COVID-19 impacts on field operations. Percent change values (inset) reflect comparisons of 2022 smolt abundance to the previous generation average. For comparisons to previous three generation averages, see Table 6.

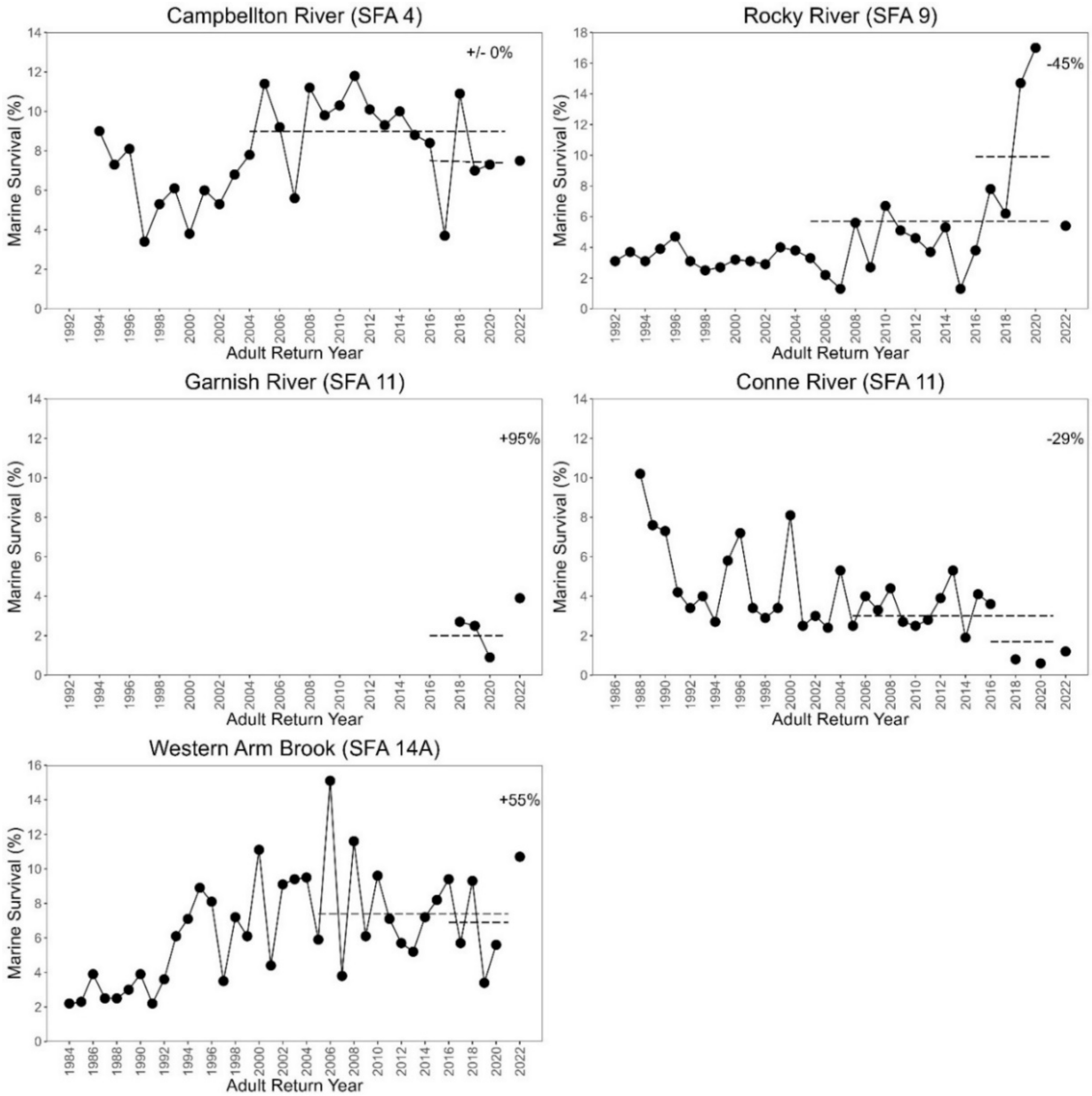

Figure 13. Marine survival rates of smolt to adult small salmon for monitored Newfoundland rivers. Survival rates have not been adjusted for marine exploitation during the commercial salmon fishery (prior to 1992) thus values represent survival of salmon back to the river. Horizontal dashed lines illustrate the previous generation average (2016–21) and previous three generation average where sufficient data are available. The marine survival estimate for Campbellton River is considered a minimum estimate because the count of returning small salmon is considered incomplete.

Marine survival estimates for 2022 are based on 2021 smolt migrations and corresponding 2022 small salmon returns. In 2022, marine survival estimates ranged from 1.2% at Conne River to 10.7% at Western Arm Brook (Table 7). Marine survival estimates in 2022 were below the previous generation average on Rocky River (-45%) and Conne River (-29%), and above average on Garnish River (+95%) and Western Arm Brook (+55%) (Table 7, Fig. 13). The marine survival estimate of 7.5% for Campbellton River is a minimum estimate due to the incomplete count of returning adult Atlantic Salmon on that river in 2022. However, it is likely that the actual survival rate in 2022 was above the previous generation average (2016–21). In recent years, marine survival rates on SFA 11 rivers have been poor relative to other monitored rivers in Newfoundland. The marine survival estimate on Garnish River (3.9%) in 2022 exceeded 3% for the first time since smolt monitoring began on this river in 2017 (Fig. 13). On Conne River, estimated marine survival fell below 1% in 2018 and 2020, and increased slightly to 1.2% in 2022.

Ecosystem Considerations

Sea ice extent is positively related to adult run timing (date) for Atlantic Salmon (Dempson et al. 2017). In 2022, sea ice extent and season duration were similar to the 1991–2020 average (DFO 2023b). However, sea surface temperatures during ice-free months were much warmer than normal on the NL shelf, establishing numerous new records. Water temperatures from an inshore thermograph network on the island of Newfoundland also suggested that 2021 and 2022 were the two warmest years on record in the coastal area since the time series began in 1989. Marine temperature impacts migrating salmon through a complex combination of direct (i.e., physiological) and indirect processes (i.e., altering the temporal and spatial distribution of prey). As a result, the effects of marine climate on Atlantic Salmon growth and survival from year to year are poorly understood. In the marine environment, Atlantic Salmon spend most of their time at temperatures ranging from 4–10°C and depths less than 10 m (Reddin 2006; Strøm et al. 2017; Strøm et al. 2018; Rikardsen et al. 2021), and occasionally make deeper dives that are potentially associated with foraging behaviour (Reddin et al. 2011; Hedger et al. 2017). Bøe et al. (2019) showed that the behaviour of migrating kelts and smolts from Campbellton River and Conne River was influenced by thermal conditions in the early phase of their migration. Comparisons of sea surface temperature with growth and survival of North American Atlantic Salmon stocks have reported positive (Friedland 1998; Friedland et al. 2000) and negative (Friedland et al. 2003) correlations. Ocean climate variability during the first few months at sea (Friedland et al. 2003; Friedland et al. 2014) and in the overwintering habitat (Reddin and Friedland 1993) appears to be important to the survival of North American populations.

Water temperature was recorded and analyzed across 3 rivers in Labrador (Char Brook, Hunt River, Shinney's River) and 12 rivers in Newfoundland (20 stations and 12 rivers) in 2022 (Table 8). In Labrador, 1.2 ± 0.9% of recorded hours had temperatures above 20°C. Across Newfoundland rivers there were 18.9 ± 12.8% recorded hours with temperatures above 20°C and 7.4 ± 2.1% recorded hours with temperatures above 24°C in June, 38.5 ± 14.2% recorded hours with temperatures above 20°C and 7.1 ± 5.3% recorded hours with temperatures above 24°C in July, and 58.9 ± 18.1% recorded hours with temperatures above 20°C and 7.5 ± 6.0% recorded hours with temperatures above 24°C in August. Water temperatures on the Avalon peninsula and Central region were higher than the Western region in Newfoundland. Prolonged exposure to temperatures above 20–22°C can negatively impact Atlantic Salmon metabolism (Breau et al. 2011; Breau 2013) and growth (Jonsson and Jonsson 2009) and can become lethal at temperatures exceeding 27°C (Elliot 1991; Corey et al. 2017; Debes et al. 2021).

Overall conditions of the past three years are indicative of improved productivity at the lower trophic levels along the NL bioregion. This includes earlier phytoplankton blooms, higher chlorophyll concentrations, and increased zooplankton biomass with a higher abundance of larger, more energy-rich Calanus copepods.

Marine ecosystem conditions in the NL bioregion remained indicative of overall limited productivity of the fish community and is likely driven by bottom-up processes (e.g., food availability). Total biomass of the entire fish community across the bioregion remained much lower than prior to the collapse in the early-1990s. It showed some recovery up to the early to mid-2010s, followed by some declines. Some ecosystem indicators in the most recent years with available data (2019–21) suggest that conditions could be improving from the lows in the mid-late 2010s, but the lack of surveys in 2022 prevented the evaluation of these trends in the current assessment, beyond what was observed in 2021.

Aquaculture Impacts

In southern Newfoundland (SFA 11), recent work has documented extensive hybridization with aquaculture escapees (Keyser et al. 2018, Sylvester et al. 2018, Wringe et al. 2018), reduced survival of the hybrid offspring (Sylvester et al. 2019; Crowley et al. 2022), and predicted negative impacts on wild population size at existing levels of aquaculture production (Bradbury et al. 2020a). In southern Newfoundland, the precocial maturation of male wild-farm hybrid parr has also been documented, likely fast-tracking introgression (i.e., transfer of genetic material from farmed escapees to wild populations) and subsequent genetic impacts (Holborn et al. 2022). Recent detection of European ancestry in aquaculture salmon and escapees in the region likely elevates this risk to wild populations (Bradbury et al. 2022). Genomic analysis of samples collected from wild juveniles from south coast Newfoundland rivers (Conne River and Long Harbour River) exhibited significant (>10%) levels of European ancestry (Bradbury et al. 2022), indicating that aquaculture escapees with elevated European ancestry have hybridized with wild salmon in the region. The resultant impacts likely exceed those of Canadian origin farmed salmon as significant trans-Atlantic genetic differences have been associated with developmental, immune, metabolic, and neural processes (Lehnert et al. 2020). In addition to genetic interactions, aquaculture associated factors such as disease and/or parasite transfer and ecological interactions (i.e., competition or predation) have been implicated as contributing to declines of wild salmon populations in Norway, Scotland, and Ireland (Bradbury et al. 2020b). Marine survival of monitored Atlantic Salmon populations in SFA 11 has been particularly poor in recent years (Fig. 13). Updated information on the presence of escapees and genetic interactions, disease and parasite transfer to wild populations from aquaculture salmon, predation of wild salmon in the region, and the residency of Atlantic Salmon post-smolts near aquaculture operations and/or sea lice infestations rates would improve our understanding of poor marine survival and declining abundance of returning Atlantic Salmon to rivers in that region in recent years.

Conne River Threat Assessment

Given the extreme decline (~90%) in Conne River Atlantic Salmon abundance, a comprehensive review was carried out to identify factors that were most likely responsible. The method considered both quantitative and qualitative data and used three approaches:

1. An examination of trends in survival and abundance of Atlantic Salmon from the long-term (37 year) monitoring program at Conne River and other rivers across Newfoundland,
2. A literature review of factors known or suspected to have impacted populations elsewhere and those that are potentially relevant in the Conne River region.
3. A semi-quantitative two-dimensional classification system based on expert opinion to rank factors most likely to have contributed to the extreme decline in Conne River Atlantic Salmon abundance. The approach of using expert opinion has been broadly accepted as a means by which various threats, judgements, or perceived status of populations are used to inform on conservation and rebuilding of at-risk or endangered fish populations (e.g., Forseth et al. 2017; Olusanya and van Zyll de Jong 2018; Stokes et al. 2021; Lennox et al. 2021; Gillson et al. 2022; Marine Scotland and Fisheries Management Scotland 2023).

Scoring of factors was conducted independently by 13 biologists and research scientists with experience working with Atlantic Salmon in NL or who regularly participate in the stock assessment process. In Fig. 14, the severity axis pertains to the pervasiveness of the factor (e.g., widespread, scattered, local), the potential of the factor to contribute to declines in survival and/or abundance, and whether any mitigation measures have been introduced (e.g., fishery closures). The projected magnitude axis considers whether any additional mitigation measures are being planned, as well as the likelihood of the factor to continue to have negative impacts on the Conne River Atlantic Salmon population.

Results from the quantitative analysis examining trends in abundance and survival using data collected from the counting fence program, suggests that something related to or occurring in the marine environment is the main contributor to the 90% decline in recent return rates (smolt to returning adult salmon) to below 2%. Factors influencing the decline are likely localized (Tirronen et al. 2022) as declines of this magnitude are only found at Conne River and neighbouring Little River.

The literature review suggested that factors associated with predation (in freshwater and marine habitats), climate change, and salmon aquaculture could not be dismissed as contributors to the extreme decline in abundance and survival of Conne River Atlantic Salmon.

Finally, of the 16 factors considered from the semi-quantitative classification system (Fig. 14), based on expert opinion, ten were considered stabilized risk factors: recreational fishery, FSC fishery, commercial fishery, stocking, pollution, habitat alteration, introduced species, hydropower influences, bycatch/poaching, and freshwater acidification. One factor was considered an expanding minor decline factor (low severity and little to no mitigation measures in place): natural predation. Five factors were identified as expanding major decline factors (high severity and little to no mitigation measures in place): escaped farm salmon, amplification of salmon lice (*Lepeophtheirus salmonis*) due to fish farming, amplification of infectious diseases related to fish farming, additional predation due to predator attraction to fish farms, and climate change. Based on the pattern of standard errors among participants, there was strong agreement among scores in relation to the severity axis, with more variability associated with the projected magnitude axis. Additional studies are required to investigate how Conne River salmon will respond to the challenges of climate change, along with focused studies to examine impacts of salmon lice and disease.

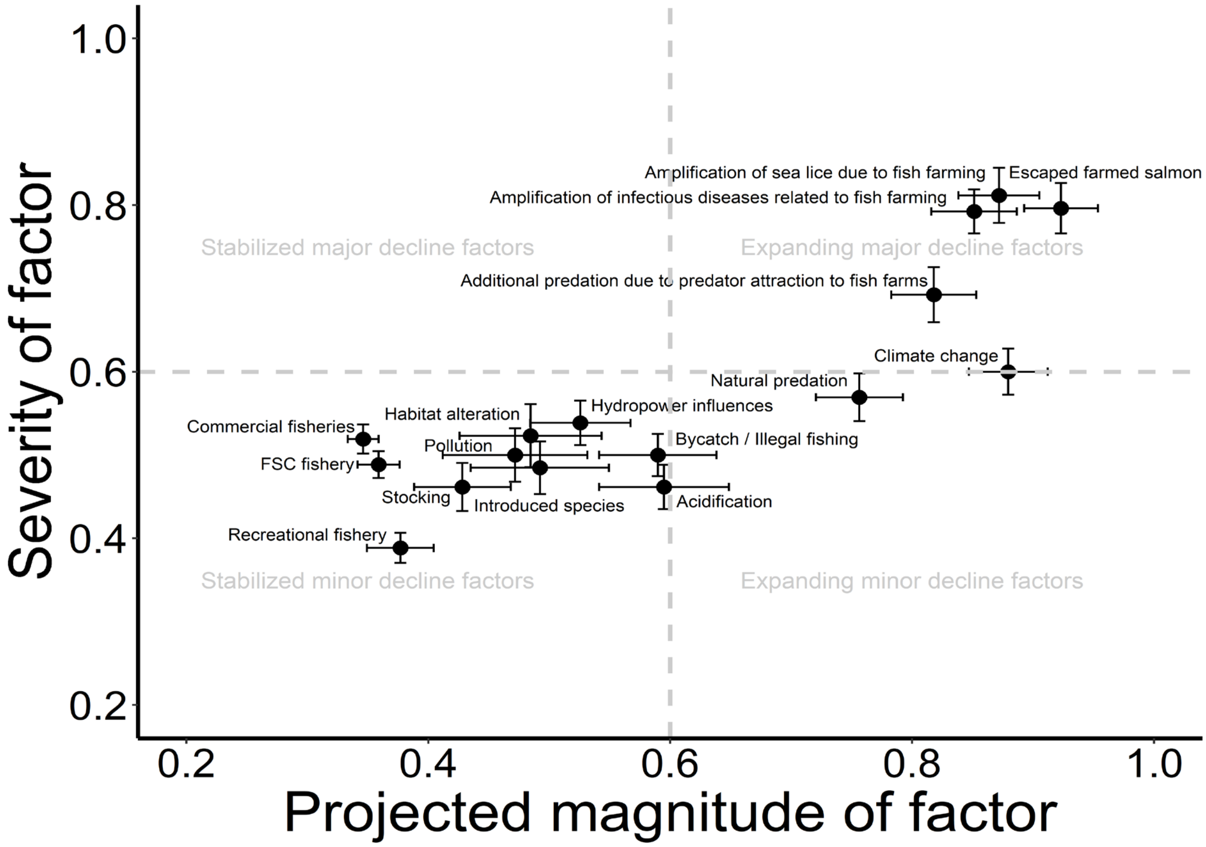

Figure 14. Ranking of potential decline factors to the Conne River Atlantic Salmon population as scored by expert survey respondents. Solid circles represent the mean score ± standard error for each factor. Plot quadrats (separated by dashed lines) represent the four categories of potential threats. In order of increasing research priority these include stabilized minor decline factors, stabilized major decline factors, expanding minor decline factors and expanding major decline factors. Scoring was conducted independently by thirteen Biologists/Research Scientists who ranged in experience from 4 to 30+ years (mean = 16 years).

Sources of Uncertainty

Calculations of 2022 total returns, spawners, and egg depositions on monitored rivers where angling was permitted included preliminary estimates of recreational harvest and catch-and-release mortality using recreational angling logs returned by anglers as of two weeks before the stock assessment meeting. During winter 2023, a phone survey was conducted to collect data from nonrespondent anglers (i.e., anglers that have not voluntarily submitted their fishing logs). River-specific estimates of recreational angling effort and catch will be finalized upon the completion of this survey, and estimates of returns, spawners, and egg depositions presented in this report will be updated. Therefore, some values herein may change slightly once data are finalized, although changes are typically negligible.

Returns of angling logs by recreational anglers have been low in recent years, averaging just over 15% from 2016–21. The relatively low return rate of angler logs in recent years will add uncertainty in estimates of retained and released salmon for rivers where angling is permitted.

Estimates of recreational catch and effort were dependent on the quantity and accuracy of angler licence stubs that were completed and returned. Similarly, the Indigenous FSC and resident trout/char harvest bycatch estimates in Labrador were dependent on the quantity and accuracy of logbooks completed and returned. For all salmon fisheries, uncertainty existed where inaccurate and/or incomplete information was provided.

Historical or estimated biological characteristic data (e.g., fecundity, sex ratio, female size) and estimated catch data used in the assessment added uncertainty to the estimates of egg depositions and %LRP attained.

No current assessments were available for salmon populations in SFAs 3, 6, 7, 8, 12, and 14B, or in the Lake Melville area of SFA 1.

Salmon populations in assessed rivers may have not been representative of all rivers in a SFA.

CONCLUSIONS AND ADVICE

Twenty-one populations of Atlantic Salmon were monitored in 2022. Adult salmon were enumerated at monitoring facilities (counting fences and fishways) on four rivers in Labrador and 17 rivers in Newfoundland. Atlantic Salmon abundance was estimated on Harrys River (SFA 13) with a counting fence near Gallants, NL and a late summer snorkel survey below the fence. Atlantic Salmon smolt abundance was counted on five monitored rivers in Newfoundland during their migration to sea.

In 2022, nine of 16 monitored rivers with sufficient time series data showed declines in total returns compared to the previous generation average (Table 4, Fig. 7 and 10), five of which by >30%. Seven of 13 rivers with sufficient time series data exhibited declines in 2022 total returns compared to the previous three generation average, four of which by >30% (Table 4, Fig. 7 and 10). Above average returns were observed on Exploits River and Western Arm Brook in Newfoundland, and on three of four monitored rivers in Labrador (Fig. 7 and 10). Returns to English River set a record high and were far above average (Fig. 8). In contrast, several monitored rivers in Newfoundland had below average returns in 2022, particularly Conne River and Salmon Brook (Figs. 8 and 10).

A stock status zone was designated for 19 of 21 monitored populations in 2022. Just over 50% of the assessed populations across the province were in the Critical Zone. Estimated egg depositions were below the river-specific LRP (Critical Zone) on one of four assessed rivers in Labrador (Table 5, Fig. 12) and nine of the 15 (60%) assessed rivers in Newfoundland (Table 5, Fig. 9). Two of 19 rivers (one in Newfoundland and one in Labrador) were in the Cautious Zone, and seven rivers were in the Healthy Zone (two in Labrador and five in Newfoundland).

Marine survival is considered to be a major factor limiting the abundance of returning adult Atlantic Salmon within the NL Region. Smolt to adult survival of the 2021 smolt class ranged from 1.2% for Conne River to 10.7% for Western Arm Brook.

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SOURCES OF INFORMATION

This Science Advisory Report is from the Regional Peer Review Process on the Stock Assessment of Atlantic Salmon in Newfoundland and Labrador on February 28-March 2, 2023. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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APPENDIX – TABLES

Table 1. Harvests of Atlantic Salmon in the subsistence and FSC Fisheries in Labrador (SFA 1 and 2 combined), 1999–2022. Estimates for 2022 are compared to the previous generation average (2015–21) and previous three generation average (2002–21). Estimates for 2022 are preliminary (p).

Year	Small salmon Number	Small salmon Weight (kg)	Large salmon Number	Large salmon Weight (kg)	Total Number	Total Weight (kg)
1999	2,739	5,580	1,084	4,220	3,824	9,800
2000	5,323	10,353	1,352	5,262	6,675	15,613
2001	4,789	9,789	1,673	6,499	6,478	16,288
2002	5,806	11,581	1,437	5,990	7,243	17,572
2003	6,477	13,196	2,175	8,912	8,653	22,108
2004	8,385	17,379	3,696	14,167	12,081	31,546
2005	10,436	21,038	2,817	10,876	13,253	31,914
2006	10,377	21,198	3,090	11,523	13,467	32,721
2007	9,208	17,070	2,652	9,386	11,860	26,456
2008	9,838	19,396	3,905	16,944	13,743	36,340
2009	7,988	16,130	3,344	13,681	11,332	29,810
2010	10,156	20,945	3,840	15,511	13,996	36,456
2011	11,301	23,439	4,535	18,541	15,834	41,979
2012	9,977	18,738	4,228	17,821	14,204	36,560
2013	7,164	14,674	6,374	25,299	13,539	39,973
2014	8,960	17,663	4,000	14,876	12,959	32,539
2015	8,923	17,500	6,146	24,935	15,069	42,435
2016	7,645	14,579	5,595	25,022	13,240	39,601
2017	6,701	12,952	5,818	24,523	12,518	37,475
2018	8,780	16,536	4,077	16,270	12,858	32,807
2019	7,062	13,249	5,793	24,543	12,855	37,791
2020	7,607	14,366	6,345	26,529	13,952	40,895
2021	9,377	19,500	4,217	16,978	13,594	36,478
2022p	9,130	18,889	5,035	19,983	14,165	38,871
2015–21 mean	8,014	15,526	5,427	22,686	13,441	38,212
% Change	+14	+22	-7	-12	+5	+2
2002–21 mean	8,608	17,056	4,204	17,117	12,813	34,173
% Change	+6	+11	+20	+17	+11	+14

Table 2. Estimates of angling effort and the number of Atlantic Salmon retained and released in the 2022 recreational fishery in Labrador (SFAs 1, 2 and 14B), 1994–2022. Estimates for 2022 are preliminary (p) and will be updated upon the completion of a phone survey of anglers that have not submitted logs. Effort is measured in rod days; any day or part of a day fished by an angler.

Year	Effort (rod days)	Small Salmon Retained	Small Salmon Released	Large Salmon Retained	Large Salmon Released	Total Retained	Total Released
1994	8,449	2,549	3,681	377	347	2,926	4,028
1995	7,719	2,493	3,302	326	508	2,819	3,810
1996	9,193	2,565	3,776	260	489	2,825	4,265
1997	8,394	2,365	2,187	158	566	2,523	2,753
1998	8,288	2,131	3,758	231	814	2,362	4,572
1999	7,592	2,076	4,407	320	931	2,396	5,338
2000	10,645	2,561	7,095	262	1,446	2,823	8,541
2001	7,986	2,049	4,640	338	1,468	2,387	6,108
2002	8,751	2,071	5,052	207	978	2,278	6,030
2003	8,053	2,112	4,924	222	1,326	2,334	6,250
2004	8,302	1,808	5,968	259	1,519	2,067	7,487
2005	8,499	2,007	7,120	285	1,290	2,292	8,410
2006	6,743	1,656	5,815	227	1,133	1,883	6,948
2007	7,930	1,762	4,631	235	1,222	1,997	5,853
2008	9,025	1,936	5,917	200	1,461	2,136	7,378
2009	7,466	1,355	3,396	216	1,219	1,571	4,615
2010	6,560	1,477	4,704	197	1,080	1,674	5,784
2011	5,457	1,628	5,340	NA	2,233	1,628	7,573
2012	6,071	1,376	3,302	NA	1,072	1,376	4,374
2013	5,978	1,389	4,167	NA	2,433	1,389	6,600
2014	7,504	1,529	4,760	NA	1,607	1,529	6,367
2015	6,865	1,417	3,785	NA	1,396	1,417	5,181
2016	7,280	1,619	3,644	NA	3,063	1,619	6,707
2017	6,491	1,501	4,441	NA	3,104	1,501	7,545
2018	3,100	481	4,293	NA	1,118	481	5,411
2019	5,178	945	4,518	NA	2,695	945	7,213
2020	3,692	665	3,114	NA	2,462	665	5,576
2021	6,133	946	5,124	NA	1,094	946	6,218
2022p	6,883	952	3,628	NA	1,686	952	5,314
Previous Generation Average (2015–21)	5,534	1,082	4,131	NA	2,133	1,082	6,264
% Change	+24	-12	-12	NA	-21	-12	-15

Table 3. Estimates of angling effort and the number of Atlantic Salmon retained and released in the 2022 recreational fishery in Newfoundland (SFAs 3-14A), 1994–2022. Estimates for 2022 are preliminary (p) and will be updated upon the completion of a phone survey of anglers that have not submitted logs. Effort is measured in rod days; any day or part of a day fished by an angler.

Year	Effort (rod days)	Small Salmon Retained	Small Salmon Released	Large Salmon Retained	Large Salmon Released	Total Retained	Total Released
1994	132,935	29,225	20,761	NA	4,685	29,225	25,446
1995	128,309	30,512	22,971	NA	4,658	30,512	27,629
1996	153,759	35,440	30,566	NA	5,720	35,440	36,286
1997	123,165	22,819	23,129	NA	4,154	22,819	27,283
1998	122,848	22,668	27,610	NA	3,561	22,668	31,171
1999	123,840	22,870	20,160	NA	3,222	22,870	23,382
2000	127,639	21,808	22,610	NA	5,033	21,808	27,643
2001	102,768	20,977	17,708	NA	3,716	20,977	21,424
2002	95,143	20,913	18,019	NA	3,014	20,913	21,033
2003	94,862	21,226	16,455	NA	3,639	21,226	20,094
2004	91,151	19,946	17,462	NA	3,653	19,946	21,115
2005	117,114	21,869	26,009	NA	5,308	21,869	31,317
2006	106,900	19,394	24,676	NA	4,561	19,394	29,237
2007	87,655	14,577	13,088	NA	3,385	14,577	16,473
2008	143,674	27,497	26,870	NA	5,573	27,497	32,443
2009	137,465	23,103	23,285	NA	3,053	23,103	26,338
2010	121,705	29,018	34,342	NA	5,303	29,018	39,645
2011	111,494	27,116	20,900	NA	5,886	27,116	26,786
2012	108,701	21,893	17,638	NA	3,017	21,893	20,655
2013	128,370	23,004	15,795	NA	4,337	23,004	20,132
2014	110,718	22,591	14,853	NA	3,781	22,591	18,634
2015	134,515	29,756	21,597	NA	5,683	29,756	27,280
2016	146,383	28,478	22,240	NA	7,203	28,478	29,443
2017	34,944	17,275	18,207	NA	5,143	17,275	23,350
2018	25,132	7,858	23,629	NA	2,562	7,858	26,191
2019	49,070	18,117	26,546	NA	5,262	18,117	31,808
2020	78,974	16,920	24,523	NA	7,470	16,920	31,993
2021	98,931	15,830	34,341	NA	5,089	15,830	39,430
2022p	90,412	17,078	18,416	NA	3,219	17,078	21,635
Previous Generation Average (2016–21)	72,239	17,413	24,914	NA	5,455	17,413	30,369
% Change	+25	-2	-26	NA	-41	-2	-29

Table 4. Total returns (small (<63 cm) and large (≥63 cm) size groups combined) of Atlantic Salmon to monitored NL rivers in 2022 in comparison to the average returns (and percent change) during the previous generation and previous three generations. One generation corresponds to six years in Newfoundland and seven years in Labrador. Percent change of <10% is considered no change. Rivers where counts of returning salmon are considered incomplete in 2022 are in bold type. Values in italics for Sand Hill River represent estimated returns and percent change if the bootstrapped estimates (and 95% CIs) of salmon returns prior to the 2022 fence installation are added to the counting fence data (see text for details).

River Name	SFA	2022 Total Returns	Previous Generation Average	Percent Change Vs Previous Generation	Previous 3 Generation Average	Percent Change Vs Previous 3 Generations
English River	1	1,305	742	+76	550	+137
Southwest Brook	2	86	195	-56	296	-71
Muddy Bay Brook	2	447	386	+16	361	+24
Sand Hill River	2	4,577 *5,009 (4,783, 5,359)*	3,189	+44 *+57 (+50, +68)*	4,121	+11 *+22 (+16, +30)*
Exploits River	4	30,999	21,764	+42	29,606	+5
Campbellton River	**4**	**1,930**	**3,384**	**NA**	**3,840**	**NA**
Salmon Brook	4	298	1,044	-71	1,232	-76
Rattling Brook	4	385	476	-19	NA	NA
Middle Brook	5	2,382	2,459	-3	2,464	-3
Terra Nova River	5	3,034	4,647	-35	4,077	-26
Northwest River	5	657	NA	NA	NA	NA
Rocky River	9	286	350	-18	463	-38
Northeast River	10	506	677	-25	NA	NA
Come By Chance River	10	187	NA	NA	NA	NA
Garnish River	11	386	374	+3	NA	NA
Conne River	11	297	544	-45	1,550	-81
Harry’s River	13	2,222	3,202	-31	3,283	-32
Torrent River	14A	4,244	4,905	-13	4,932	-14
Western Arm Brook	14A	1,281	1,105	+16	1,249	+3
Trout River	14A	51	NA	NA	NA	NA
Parkers River	14A	132	NA	NA	NA	NA
SUMMARY		N = 21	N = 16	Declines ≥30% 5/16 (31%)	N = 13	Declines ≥30% 5/13 (38%)

Table 5. Summary of Atlantic Salmon stock status in Newfoundland and Labrador (SFAs 1–14B). The Limit Reference Point (LRP) and Upper Stock Reference point (USR) correspond to 100% and 150% of the previously defined conservation egg requirement, respectively. One generation corresponds to five to six years in Newfoundland and seven years in Labrador. Asterisks indicate rivers that have undergone enhancement activities. Values for Campbellton River (bold type) in 2022 are based on an incomplete count and are considered as minimum estimates.

River Name	SFA	Limit Reference Point (LRP) Achieved (%)	2022 Status	Previous Generation Average	% Change Vs Previous Generation	Previous 3 Generation Average	% Change Vs Previous 3 Generations
English River	1	373	Healthy	215	+73	150	+149
Southwest Brook	2	28	Critical	62	-55	91	-69
Muddy Bay Brook	2	193	Healthy	155	+24	136	+42
Sand Hill River	2	109	Cautious	76	+44	93	+17
* Exploits River	4	52	Critical	34	+53	48	+8
Campbellton River	**4**	**210**	Healthy	**309**	**-32**	**337**	**-38**
Salmon Brook	4	28	Critical	118	-76	138	-80
Middle Brook	5	264	Healthy	269	-2	253	+5
* Terra Nova River	5	45	Critical	70	-35	62	-27
Northwest River	5	54	Critical	NA	NA	NA	NA
* Rocky River	9	28	Critical	35	-19	47	-40
Northeast River	10	229	Healthy	302	-24	NA	NA
Come By Chance River	10	103	Cautious	NA	NA	NA	NA
Garnish River	11	39	Critical	37	+6	NA	NA
* Conne River	11	14	Critical	25	-43	63	-76
Harry's River	13	70	Critical	96	-27	100	-30
Torrent River	14A	547	Healthy	737	-26	787	-30
Western Arm Brook	14A	351	Healthy	296	+37	381	+6
Trout River	14A	24	Critical	NA	NA	NA	NA
SUMMARY		Rivers with estimated stock status: N = 19	7 Healthy 2 Cautious 10 Critical	-	Declines ≥30% 3/16 (19%)	-	Declines ≥30% 2/13 (15%)

Table 6. Summary of Atlantic Salmon smolt production in 2021 compared to the previous generation average (2016–21) and previous three generation average for each river. Smolt abundance on Western Arm Brook is an underestimate due to a delayed installation of the counting fence as a result of environmental conditions. Values in italics for Western Arm Brook represent estimated smolt abundance and percent change if the bootstrapped estimates (and 95% CIs) of the historical proportion of the smolt run prior to July 2 to account for a late counting fence installation in 2022 (see text for details).

River Name	SFA	2022 Smolt Production	Previous Generation Average	% Change Previous Generation Average	Previous 3 Generation Average	% Change Previous 3 Generation Average
Campbellton River	4	50,024	36,107	+39	37,364	+34
Rocky River	9	5,880	3,958	+49	9,187	-36
Conne River	11	22,695	35,402	-36	51,028	-56
Garnish River	11	20,368	11,807	+73	NA	NA
Western Arm Brook	14A	11,926 *14,509* *(12,991, 16,774)*	13,406	-11 *+8 (-3, +25)*	16,074	-26 *-10 (-19, +4)*

Table 7. Summary of Atlantic Salmon marine survival in 2022 (adult return year) compared to the previous generation average (2016–21) and previous three generation average for each river. Marome survival estimates for Campbellton River (bold type) are considered minimum estimates. The adult count in 2022 is considered to be incomplete.

River Name	SFA	2022 Smolt Production	Previous Generation Average	% Change Previous Generation Average	Previous 3 Generation Average	% Change Previous 3 Generation Average
Campbellton River	**4**	**7.5**	**7.5**	**0**	**9.0**	**-17**
Rocky River	9	5.4	9.9	-45	5.7	-4
Conne River	11	1.2	1.7	-29	3.0	-60
Garnish River	11	3.9	2.0	+95	NA	NA
Western Arm Brook	14A	10.7	6.9	+55	7.4	+45

Table 8. Monthly average river water temperature in Labrador (Char Brook, Hunt River, Shinney's River) and Newfoundland (20 stations and 12 rivers) in June, July, and August 2022. River temperature (°C) was recorded hourly and is expressed as a monthly average with standard deviation (SD).

Region	Month	Temperature (°C) ± SD
Labrador	June	7.6 ± 2.6
	July	13.7 ± 1.6
	August	16.8 ± 1.2
Newfoundland	June	16.1 ± 4.2
	July	19.6 ± 2.6
	August	21.3 ± 2.2

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