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Status of Atlantic Salmon (*Salmo salar* L.) Stocks within the Newfoundland and Labrador Region (Salmon Fishing Areas 1–14B) in 2022

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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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ABSTRACT

Twenty-one populations of Atlantic Salmon were monitored in 2022. Adult salmon were enumerated at monitoring facilities (fish counting fences and fishways) on four rivers in Labrador and seventeen rivers in Newfoundland. Atlantic Salmon abundance was estimated on Harry's River (Salmon Fishing Area [SFA] 13) with a counting fence near Gallants, Newfoundland and Labrador (NL) and a late summer snorkel survey below the fence. Atlantic Salmon smolt abundance was obtained at 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, five of which declined 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 decreased by >30%. Above average returns were observed on Exploits River and Western Arm Brook in Newfoundland, and on three of four monitored rivers in Labrador. Returns to English River set a record high and were far above average. In contrast, several monitored rivers in Newfoundland had below average returns in 2022, particularly Conne River and Salmon Brook. 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 Limit Reference Point (LRP) (Critical Zone) on one of four assessed rivers in Labrador and nine of the 15 (60%) assessed rivers in Newfoundland. 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 averaged over 5% across five monitored rivers in Newfoundland, but ranged from 1.2% for Conne River to 10.7% for Western Arm Brook.

INTRODUCTION

In 2023, Fisheries and Oceans Canada (DFO) started a new two-year stock assessment cycle for Atlantic Salmon (*Salmo salar*) in the Newfoundland and Labrador (NL) Region. This report summarizes information from the February 28–March 2, 2023 Regional Peer Review Process on the Assessment of NL Atlantic Salmon populations in 2022.

There are 15 Atlantic Salmon (*Salmo salar*) management areas, known as Salmon Fishing Areas (SFAs); 1-14B, in NL (Figure 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. 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 <63 cm) and large (fork length ≥63 cm) adult salmon (Figure 2). For the majority of rivers in Newfoundland (SFAs 3–12 and 14A), small adult salmon are 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). Large adult salmon in Newfoundland rivers are 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 with low water temperatures and high amounts of inshore sea ice (Dempson et al. 2017).

There has been no commercial salmon fishing in Newfoundland (SFAs 3–14A) since 1992, in the Straits area of Labrador (SFA 14B) since 1997, and in the remainder of Labrador (SFAs 1–2) since 1998.

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 Charr (*Salvelinus alpinus*) with a permitted retention of three salmon bycatch. In Newfoundland, the 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.

METHODS

The 2022 status of Atlantic Salmon stocks within NL (SFAs 1–14B) was assessed using abundance data collected from 21 salmon monitoring facilities (fish counting fences and fishways; Figure 2), an in-river snorkel survey (Harry’s 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. Recreational salmon catch estimates (retained and released) were combined with counts of returning adults derived at counting facilities to estimate the total returns to the river (where estimates of downstream removals were available) and total spawners that escaped the recreational fishery. DFO Science assumes a catch-and-release mortality rate of 10% when calculating estimates of total returns, total spawners and egg depositions. 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) in late February and early March 2023. Consequently, estimates of total returns, spawners and egg depositions on monitored rivers where recreational angling is permitted in 2022 are also preliminary in this report. When estimates of returns, spawners and egg depositions are updated annually with final angling estimates, changes are typically negligible (<2% for most rivers).

Total return and spawner estimates for Sand Hill River in 2022 were adjusted to account for fish that migrated upstream prior to the counting fence installation which was delayed due to environmental conditions. 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).

The Precautionary Approach (DFO 2015) identifies two reference points for managing fisheries stocks, the lower Limit Reference Point (LRP) and 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 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.

The status of NL Atlantic Salmon populations are assessed relative to these two reference points, defined on the basis of estimated egg depositions. Conservation egg requirements for Atlantic Salmon were previously established for individual rivers in Labrador (SFAs 1–2) based on 1.9 eggs per m^2 of river rearing habitat; the Straits Area of Labrador (SFAs 14A–14B) based on 2.4 eggs per m^2 of river rearing habitat and 105 eggs per hectare of lake habitat; and Newfoundland (SFAs 3–13) based on 2.4 eggs per m^2 of river rearing habitat and 368 eggs per hectare of lake habitat (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. Estimates of egg depositions by small and large salmon spawners on monitored rivers in 2022 were derived and compared to each river-specific LRP and USR to designate a stock status zone for 19 of 21 monitored rivers. Although returns of small and large salmon are reported for Rattling Brook (SFA 4), no stock status is designated for 2022 due to recent enhancement activities. No stock status could be designated for Parkers River (SFA 14A) because there is no conservation egg requirement established for this watershed (Reddin et al. 2010), and thus no LRP or USR to compare to 2022 estimated egg depositions.

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 modeling 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 (Table 4).

The abundance of out-migrating Atlantic Salmon smolts was monitored on five rivers in Newfoundland in 2022 (Figure 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.

Estimates of retained small salmon as well as the number of small and large salmon caught and released are presented separately for Newfoundland and Labrador. Recreational angling effort is presented as rod days, defined as any full or partial day during which an angler fished. Exploitation rates in the recreational Atlantic Salmon fishery are calculated for specific rivers by dividing estimates of retained salmon by the total returns each year and multiplying by 100%.

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% more than the previous generation average (2015–21) of 13,441 salmon and 11% higher than the previous three generation average (2002–22) (Table 1, Figure 3). Large salmon represented 36% of the catch by number.

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, Figure 4), 12% below the previous generation average (2015–21). The estimated number of small salmon retained has declined by 66% since 1994 (negative binomial glm, $p < 0.001$, 95% Confidence Intervals (CIs): 57%, 73%). The estimated number of released small salmon in 2022 in Labrador was 3,628 salmon, 12% below the previous generation average. Retention of large Atlantic Salmon in the recreational fishery has been prohibited since 2011. In 2022, there was an estimated 1,686 large salmon released in the Labrador recreational fishery, a 21% decrease compared to the previous generation average. Since 1994, the estimated number of released large salmon in Labrador has increased by 284% (negative binomial glm, p <0.001, 95% CIs: 142%, 501%). Effort in the 2022 Labrador fishery was estimated at 6,883 rod days, a 24% increase compared to the previous generation average (Table 2, Figure 4).

Newfoundland (SFAs 3–14A)

The 2022 recreational salmon fishery opened on 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, Figure 5), 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. Retention of large salmon has not been permitted in Newfoundland over the entire time series. In 2022, 3,219 large salmon were released across Newfoundland (SFAs 3–14A), which is 41% below the previous generation average (Figure 5). Estimated angler effort in 2022 (90,412 rod days) was 25% higher than the previous generation average.

Recreational exploitation rates are relatively stable on most monitored rivers where estimates are available (Figure 6), typically varying between 5–15% in most years on most rivers. In the 2022 recreational fishery, the average exploitation rate on monitored rivers in Newfoundland was 10.4% (range: 0.8%–19.8%) (Figure 6). Relatively low exploitation rates on Campbellton River (0.8%), Middle Brook (4.3%), Terra Nova River (3.7%) and Garnish River (5.7%) may be partially explained by persistent low water and high temperature conditions throughout much of the 2022 angling season.

TOTAL RETURNS AND EGG DEPOSITIONS ON MONITORED RIVERS

Northern Labrador (SFA 1)

Total Returns

There are nine scheduled salmon rivers in SFA 1. Only English River was monitored in Northern Labrador in 2022. Total returns to English River in 2022 set a record high (1999–2022) and were well above the previous generation average (2015–21, +76%) and the previous three generation average (2002–21, +137%) (Table 4). Above average returns were observed in both small and large salmon size groups (Table 5 and 6, Figure 7).

Percent % LRP Achieved

English River achieved 373% of its conservation egg requirement in 2022 and has exceeded the LRP for twelve consecutive years and the USR for three consecutive years (Table 7, Figure 8).

Southern Labrador (SFA 2 and 14B)

Total Returns

There are sixteen scheduled salmon rivers in SFA 2. Three rivers were assessed in 2022: Sand Hill River, Muddy Bay Brook (Dykes River) and Southwest Brook (Figure 1). Total returns of adult salmon in 2022 were higher than the previous generation average (2015–21) on Sand Hill River (+44%) and Muddy Bay Brook (+16%), and below the previous generation average on Southwest Brook (-56%) (Table 4, Figure 7). Above average returns on Muddy Bay Brook and Sand Hill River were observed in both small and large salmon size groups. Compared to the average total returns recorded over the previous three generations (2002–21), 2022 total returns were 11% higher on Sand Hill River, 24% higher on Muddy Bay Brook and 71% lower on Southwest Brook (Figure 7).

Returns reported for Sand Hill River in 2022 are likely an underestimate. The counting fence was installed once environmental conditions allowed and began operation July 2, 2022. Higher than expected numbers of salmon were counted each day during the first week of operation (range = 39–285 per day), suggesting that the salmon migration began before the fence was installed. To quantify the uncertainty around the number of fish that may have migrated prior to the fence installation in 2022, a nonparametric bootstrap (10,000 iterations) was applied to the number of small and large salmon that were counted prior to July 2 over the previous three generations (2002–21). Years where the fence was installed later than July 2 (2010, 2017–21) were excluded. The nonparametric bootstrap procedure estimated that 5.8% (95% CIs: 2.7%, 9.5%) of the small salmon and 19.3% (95% CIs: 10.0%, 29.8%) of the large salmon have been counted prior to July 2 since 2002. Applying these estimates to the observed counts on Sand Hill River in 2022 suggests that approximately 229 small salmon (95% CIs: 103, 390) and 207 large salmon (95% CIs: 96, 367) potentially migrated upstream prior to the counting fence installation in 2022. Combining these estimates with total returns from the counting fence suggests that total returns to Sand Hill River in 2022 could have reached approximately 5,013 salmon (95% CIs: 4,776, 5,334).

Percent % LRP Achieved

Estimated egg depositions on Southwest Brook achieved only 28% of the river-specific LRP in 2022, designating this population in the Critical Zone for the seventh consecutive year (Table 7, Figure 8). In contrast, estimating egg depositions on both Sand Hill River and Muddy Bay Brook exceeded their LRPs in 2022, with Sand Hill River in the Cautious Zone (109% of LRP) and Muddy Bay Brook in the Healthy Zone (193% of LRP) (Figure 8). Applying estimates of the number of salmon that potentially migrated upriver prior to July 2 on Sand Hill River suggests that egg depositions may have reached 123% (95% CIs: 116%, 133%) of the LRP, thus it is highly likely that this population was in the Cautious Zone in 2022. Atlantic salmon returns to Muddy Bay Brook have exceeded the LRP for five consecutive years and USR for three consecutive years. Returns to Sand Hill River have exceeded the LRP for the second consecutive year (Figure 8).

Northeast Newfoundland (SFAs 3–8)

Total Returns

There are 60 scheduled salmon rivers in SFAs 3–8. Seven rivers were monitored in 2022: Exploits River, Rattling Brook, Campbellton River and Salmon Brook (tributary of Gander River) in SFA 4, and Middle Brook, Terra Nova River and Northwest River (Port Blandford) in SFA 5. No rivers were assessed in SFAs 3, 6, 7 and 8 during 2022 (Figure 1).

An estimated 30,999 Atlantic Salmon returned to Exploits River in 2022 (Table 4, Figure 9), 42% above the previous generation average (2016–21) and similar to (+5%) previous three generation average (2005–21) (Figure 9). After salmon returns exceeded 46,000 salmon in 2010, annual returns to Exploits River declined to 13,977 salmon in 2019. However, returns to this river have now exceeded 30,000 salmon in 2021 and 2022 (Figure 9).

A total of 1,930 salmon were counted on Campbellton River in 2022, 43% below the previous generation average (2016–21) and 48% below the previous three generation average (2004–21). Water levels were low for the majority of the season on this river, preventing salmon from entering the river for prolonged periods in the summer. In September 2022 after the counting fence was removed, DFO Science and Enforcement staff received reports of salmon holding up near the river mouth unable to enter due to low water conditions. DFO Science staff attempted to install DIDSON sonar equipment to estimate the number of salmon migrating from mid-September to early November. Unfortunately, a combination of poor image quality, fish behavior and the time-consuming process of analyzing sonar imagery, prevented an estimate of the 2022 fall salmon run on Campbellton River. The values reported here for Campbellton River are a partial count of salmon abundance in 2022 (Table 4, Figure 9).

Total returns to Salmon Brook (Gander River) in 2022 were 71% below the previous generation average (2016–21) and 76% below the previous three generation average (2004–21). Similar to Campbellton River, water levels on Salmon Brook were low for much of the summer season, preventing salmon from entering the tributary for prolonged periods. The count obtained in 2022 is the lowest since 1991 (Figure 9).

Total returns to Rattling Brook in 2022 were 19% below the previous generation average (2016–21) (Table 4, Figure 9). Monitoring began on this river in 2013 following the restoration of fish passage in 2010 after a 52 year period were fish were obstructed due to a hydroelectric facility.

In SFA 5, Atlantic Salmon returns to Middle Brook in 2022 were similar to (-3%) the previous generation average (2016–21) and previous three generation average (2004–21) (Table 4, Figure 10). Total returns to Terra Nova River were 35% below the previous generation average (2016–21) and 26% below the previous three generation average (2004–21) (Figure 10). Persistent low water levels were observed on both of these rivers for much of the 2022 summer season, similar to what was observed on monitored rivers in SFA 4. The counting fence on Northwest River operated by Parks Canada counted 657 salmon in 2022 (369 small and 288 large). There is no previous generation average to compare the 2022 Northwest River salmon count due to partial counts in 2018 and 2021 and no counts available for 2016 and 2020.

Percent % LRP Achieved

Estimated egg depositions on Exploits River suggest that this population achieved 52% (Table 7, Figure 11) of the river-specific LRP in 2022 (Critical Zone). Using the partial count of returning small and large salmon on Campbellton River in 2022 suggests that this population achieved at least 210% of the river-specific LRP, and is in the Healthy Zone for the twentieth consecutive year (Figure 11). Estimated egg depositions on Salmon Brook achieved only 28% of the river-specific LRP in 2022 (Critical Zone). Although total returns were reported for Rattling Brook (SFA 4), no stock status was designated for this population due to recent enhancement activities.

Estimated egg depositions on Middle Brook were in the Healthy Zone in 2022 at 264% of the river-specific LRP. In contrast, Terra Nova River and Northwest River were in the Critical Zone in 2022 at only 45% and 54% of their river-specific LRP, respectively (Figure 11).

It is important to note that large areas of rearing habitat were made accessible in the upper areas of Exploits River (above Beothuk Lake Dam, 1989) and Terra Nova River (above Mollyguajeck Falls, 1985) which have not been fully colonized and therefore have consequences on the proportion of the total river egg deposition achieved. For Exploits River, adult salmon are counted at three locations: Bishop’s Falls (closest to the mouth of the river), Grand Falls, and Beothuk Lake dam. However, if you exclude the habitat above the Beothuk Lake dam, estimated egg depositions on Exploits River in 2022 would still remain in the Critical Zone (62% of LRP).

South Coast Newfoundland (SFAs 9–11)

Total Returns

There are 48 scheduled salmon rivers in SFAs 9–11. Information on total returns of small and large salmon in 2022 was available for five South Coast rivers: Rocky River (SFA 9), Northeast River (Placentia Bay) (SFA 10), Come By Chance River (SFA 10), Conne River (SFA 11) and Garnish River (SFA 11).

Total returns of Atlantic Salmon to Rocky River in 2022 were 18% below the previous generation average (2016–21) and 38% below the previous three generation average (2005–21). From 2018–21, large salmon have contributed only 0.6–2.1% of annual salmon returns to Rocky River, and zero large salmon returned to this river in 2022 (Figure 12).

Atlantic Salmon returns to Northeast River (Placentia Bay) in 2022, were 25% below the previous generation average (2016–21). Below average returns were observed in both small (-21%) and large (-60%) size groups (Table 5 and 6, Figure 12). The salmon counting facility on Northeast River did not operate from 2003–14, thus there is no previous three generation average to compare to 2022 returns.

Atlantic Salmon monitoring on Come By Chance River began in 2021. In the first year of operation 78 total salmon (57 small, 21 large) were counted. However, the counting fence was partially removed to assist migrating salmon to move upstream during persistent low water conditions July 15–19, 2021 resulting in a partial count for the year. In 2022, 187 total salmon returned to Come By Chance River (158 small and 29 large).

Returning adult Atlantic Salmon abundance has been monitored on Garnish River since 2015. Total returns reached a record high in 2021 (DFO 2023a). In 2022, 386 salmon returned to Garnish River, similar to (+3%) the previous generation average (2016–21) (Table 4, Figure 13). Small salmon abundance in 2022 was similar to (-6%) the previous generation average; however, large salmon abundance was 152% higher than the previous generation average and was the highest recorded since monitoring began in 2015. Historical angling data suggest that returns to this river in recent years are significantly lower than in the 1970s (Moores et al., 1978). Estimates of returns, spawners and egg depositions for Garnish River in 2022 are a slight underestimate. The counting fence on Garnish River washed out July 21 and was not fully repaired until July 23, 2022. In the two days prior to the washout, 95 salmon migrated through the counting fence. While it is likely that additional salmon that were downstream prior to the washout migrated through when the counting fence was not operational, it is difficult to ascertain an accurate number that may have moved through uncounted.

Total Atlantic salmon returns to Conne River have been monitored since 1986. Salmon returns ranged from 8,047–10,671 salmon in the first three years of operation, but declined continually over the following three decades and reached a record low of 157 salmon in 2020. Returns in 2021 and 2022 improved slightly over 2020 but still represent the second and third lowest returns in the time series. Total returns to Conne River in 2022 were 45% below the previous generation average and 81% below the previous three generation average (Table 4, Figure 13). Over the previous three generations (2005–22), total Atlantic Salmon returns to Conne River have declined by 91% (negative binomial GLM, $p < 0.001$, 95% CIs: 77%, 96%). Total returns to Conne River have not exceeded 500 salmon since 2017 and 300 salmon since 2020. Consecutive years of reduced spawner abundance from 2018–22 could have a progressive negative impact on smolt production in subsequent years (2023–27). Conne River smolts are predominantly age 3 and 4 (average 64% and 33%, respectively, over the previous three generations). In 2024, age 3 smolts which comprise the bulk of the smolt migration on Conne River will be offspring from the first spawning cohort of fewer than 300 individuals (2020).

Marine survival rates on Conne River have been below 1.5% in recent years, so any decline in smolt abundance could have further detrimental impacts on future adult spawner abundance.

Percent % LRP Achieved

Estimated egg depositions on Rocky River achieved only 28% of the river-specific LRP in 2022 (Figure 14). This population has been in the Critical Zone in every year it has been assessed (since 1983). Applying estimates of fecundity, sex ratio and female weight historically used to assess the Northeast River salmon population to Come By Chance River salmon returns suggests that this population achieved 103% of the river-specific LRP in 2022 (Cautious Zone). Atlantic salmon returns to Northeast River achieved 229% of the LRP in 2022 (Healthy Zone) and have exceeded the USR in every year since 1984 except for 2020 (Figure 14).

Conne River achieved 14% of the LRP in 2022, which is the third lowest record since 1986 (Figure 15). A population viability analysis (Robertson et al. 2013) noted that under current conditions there was a low probability (<30%) that Atlantic Salmon populations in southern Newfoundland would meet or exceed conservation spawning requirements over the next 15 years. To date, management measures remain the same with no additional measures taken to rebuild these populations. Garnish River only achieved 39% of the LRP in 2022 and has been categorized within the Critical Zone every year since counts began in 2015 (Figure 15).

Southwest Coast Newfoundland (SFAs 12–13)

Total Returns

There are ten scheduled salmon rivers in SFA 12, however, no rivers were assessed in this SFA during 2022. There are eighteen scheduled salmon rivers in SFA 13. Information on total returns of small and large salmon in 2022 was available for Harry's River (SFA 13).

Returns to Harry's River were estimated using a variety of methods from 1992–2010 (Veinott and Caines 2016). From 2011–21, annual returns were enumerated using DIDSON sonar equipment and a partial counting fence deployed near the mouth of the river each year. Due to repeated washout events in recent years, the location of this counting facility was changed in 2022. A full counting fence was installed near the community of Gallants, NL at the same location (lat: 48.70, long: -58.23) where salmon were monitored from 2005–10 (Veinott and Caines 2016). A total of 987 salmon were counted at this location throughout the 2022 season (733 small, 254 large). This location is approximately 28 km up river from where the DIDSON sonar equipment were deployed from 2011–21. To account for returning Atlantic Salmon that were below the counting fence location, DFO Science conducted a snorkel survey from August 30–31, 2022, right before removing the counting fence. Approximately 28 km of Harry's River and 7.5 km of North Brook (a large tributary) counted 986 salmon (829 small, 157 large). Estimates of total returns on Harry's River, including estimates of retained and released fish from the 2022 recreational fishery, suggest that 2,222 salmon returned to Harry's River in 2022 (Table 4, Figure 13), 31% below the previous generation average (2016–21) and 32% below the previous three generation average (2005–21).

Percent % LRP Achieved

Combining the returning salmon abundance data from the counting fence and snorkel survey with estimated removals in the recreational fishery suggests that Harry's River achieved approximately 70% of its LRP in 2022 and was in the Critical Zone (Figure 15).

Northwest Coast Newfoundland (SFA 14A)

Total Returns

There are twenty-two scheduled salmon rivers in SFA 14A. Information on total returns of small and large salmon in 2022 was available for four Northwest Coast rivers (SFA 14A): Torrent River, Western Arm Brook, Trout River (Gros Morne National Park, monitored by Parks Canada) and Parkers River.

Total returns to Torrent River exceeded 6700 salmon in 2021, reaching a record high (DFO, 2023a). In 2022, 4,244 salmon returned to Torrent River (Table 4, Figure 16), 13% below the previous generation average (2016–21) and 14% below the previous three generation average (2005–21). Below average returns to this river in 2022 were primarily driven by declines in returning large salmon abundance (Table 6, Figure 16).

Total Atlantic Salmon returns to Western Arm Brook in 2022 were 16% higher than the previous generation average (2016–21) and similar to (+3%) the previous three generation average (2004–21) (Figure 16).

A counting fence on Trout River was installed and operated by Parks Canada in 2022. Total returns reached 51 salmon in 2022 (42 small and 9 large). This is the highest total of small salmon on record (Figure 16) and highest total returns to this river since 2002.

In 2021 and 2022, a counting fence was installed on Parkers River to monitor the abundance of returning adult Atlantic Salmon, Arctic Charr and Brook Trout. A washout event in 2021 resulted in a partial count of Atlantic Salmon (27 total, 19 small and 8 large). A total of 132 Atlantic Salmon returned to this river in 2022 (132 total – 101 small, 31 large) (Figure 16).

Percent % LRP Achieved

Torrent River (547%) and Western Arm Brook (351%) exceeded the LRP and USR in 2022 (Table 7). Both of these rivers have exceeded the USR every year since 1992 (Figure 17). Trout River was in the Critical Zone in 2022 having met only 24% of the river-specific LRP (Table 7, Figure 17). There is no conservation egg requirement established for Parkers River (Reddin et al. 2010), therefore, the stock status for this population in 2022 is unknown.

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 (Table 4) resulting in the lowest estimated marginal mean log salmon abundance since 2017 (Figure 18).

In Labrador, the estimated marginal mean log salmon abundance in 2022 was slightly higher than 2021 and similar to 2020 (Figure 18). 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.

SMOLT PRODUCTION AND MARINE SURVIVAL

Atlantic Salmon smolt abundance is monitored each year during the downstream migration on five rivers in Newfoundland (Figure 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 8, Figure 19). 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% 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%).

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 9). 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 9, Figure 20). 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 (Figure 20). On Conne River, estimated marine survival fell below 1% in 2018 and 2020, and increased slightly to 1.2% in 2022. As returns of small salmon include a portion of repeat spawners, marine survival of smolt to maiden 1SW salmon will be slightly less than the numbers reported here.

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 1991–20 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 10). 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

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 (Figure 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 in the abundance of Conne River Atlantic Salmon (~90%) 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 and comparison of trends in survival and abundance of Atlantic Salmon from the long-term (37 year) monitoring program at Conne River and other rivers from 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. Factors included: exploitation (commercial, recreational, subsistence/FSC) and associated bycatch and illegal removals (poaching), habitat issues, pollution/acidification, enhancement, introduced species, hydropower regulation, predation, aquaculture (ecological and genetic impacts), and climate change (freshwater, marine).
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 thirteen biologists and research scientists with experience working with Atlantic Salmon in NL or who regularly participate in the stock assessment process. In Figure 21, 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 sixteen factors considered from the semi-quantitative classification system (Figure 21), 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.

SUMMARY AND CONCLUSIONS

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 seventeen rivers in Newfoundland. Atlantic Salmon abundance was estimated on Harry's 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, Figure 22 and 23), 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, Figure 22 and 23). Above average returns were observed on Exploits River and Western Arm Brook in Newfoundland, and on three of four monitored rivers in Labrador (Figure 24). Returns to English River set a record high and were far above average. In contrast, several monitored rivers in Newfoundland had below average returns in 2022, particularly Conne River and Salmon Brook (Figure 24).

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, Figure 25) and nine of the 15 (60%) assessed rivers in Newfoundland (Table 5, Figure 26). 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.

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 will be 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 monitored rivers where angling is permitted.

Estimates of recreational catch and effort data 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 given SFA.

REFERENCES CITED

Bøe, K., Power, M., Robertson, M.J., Morris, C.J., Dempson, J.B., Pennell, C.J., and Fleming, I.A. 2019. The influence of temperature and life stage in shaping migratory patterns during the early marine phase of two Newfoundland (Canada) Atlantic salmon (*Salmo salar*) populations. Can. J. Fish. Aquat. Sci. 76(12): 2364–2376.

Bradbury, I.R., Duffy, S., Lehnert, S.J., Jóhannsson, R., Fridriksson, J.H., Castellani, M., Burgetz, I., Sylvester, E., Messmer, A., Layton, K., Kelly, N., Dempson, J.B., and Fleming, I.A. 2020a. Model-based evaluation of the genetic impacts of farm-escaped Atlantic salmon on wild populations. Aquacult. Environ. Interact. 12: 45–49.

Bradbury, I.R., Burgetz, I., Coulson, M.W., Verspoor, E., Gilbey, J., Lehnert, S.J., Kess, T., Cross, T.F., Vasemägi, A., Solberg, M.F., Fleming, I.A., and McGinnity, P. 2020b. Beyond hybridization: the genetic impacts of nonreproductive ecological interactions of salmon aquaculture on wild populations. Aquacult. Environ. Interact. 12: 429–445.

Bradbury, I.R., Lehnert, S.J., Kess, T., Wyngaarden, M.V., Duffy, S., Messmer, A.M., Wringe, B., Karoliussen, S., Dempson, J.B., Fleming, I.A., Xolberg, M.F., Glover, K.A., and Bentzen, P. 2022. Genomic evidence of recent European introgression into North American farmed and wild Atlantic salmon. Evol. Appl. 15(9): 1436–1448.

Breau, C., Cunjak, R.A., and Peake, S.J. 2011. Behaviour during elevated water temperatures: can physiology explain movement of juvenile Atlantic salmon to cool water? J. Anim. Ecol. 80(4): 844–854.

Breau, C. 2013. Knowledge of fish physiology used to set water temperature thresholds for in-season closures of Atlantic salmon (*Salmo salar*) recreational fisheries. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/163. iii + 24 p.

Corey, E., Linnansaari, T., Cunjak, R.A., and Currie, S. 2017. Physiological effects of environmentally relevant multi-day thermal stress on wild juvenile Atlantic salmon (*Salmo salar*). Conserv. Physiol. 5(1): 1–13.

Crowley, S.E., Bradbury, I.R., Messmer, A.M., Duffy, S.J., Islam, S.S., and Fleming, I.A. 2022. Common-garden comparison of relative survival and fitness-related traits of wild, farm, and hybrid Atlantic salmon *Salmo salar* parr in nature. Aquacult. Environ. Interact. 14: 45–59.

Debes, P.V., Solberg, M.F., Matre, I.H., Dyrhovden, L., and Glover, K.A. 2021. Genetic variation for upper thermal tolerance diminishes with and between populations with increasing acclimation temperature in Atlantic salmon. Heredity. 127: 455–466.

Dempson, J.B., O'Connell, M.F., and Schwarz, C.J. 2004. Spatial and temporal trends in abundance of Atlantic salmon, *Salmo salar*, in Newfoundland with emphasis on impacts of the 1992 closure of the commercial fishery. Fisheries Manage. Ecol. 11(6): 387–402.

Dempson, J.B., Robertson, M.J., Cochrane, N.M., O'Connell, M.F., and Porter, G. 2012. Changes in angler participation and demographics: analysis of a 17-year license stub return system for Atlantic Salmon. Fisheries Manage. Ecol. 19(4): 333–343.

Dempson, J.B., Schwarz, C.J., Bradbury, I.R., Robertson, M.J., Veinott, G., Poole, R., and Colbourne, E. 2017. Influence of climate and abundance on migration timing of adult Atlantic Salmon (*Salmo salar*) among rivers in Newfoundland and Labrador. Ecol. Freshw. Fish. 26(2): 247–259.

DFO. 2015. Development of reference points for Atlantic Salmon (*Salmo salar*) that conform to the Precautionary Approach. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/058.

DFO. 2020a. 2019 Stock Status Update for Atlantic Salmon in Newfoundland and Labrador. DFO Can. Sci. Advis. Sec. Sci. Resp. 2020/045.

DFO. 2020b. Stock Assessment of Newfoundland and Labrador Atlantic Salmon in 2018. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/038.

DFO. 2023a. 2021 Stock Status Update of Atlantic Salmon in Newfoundland and Labrador. DFO Can. Sci. Advis. Sec. Sci. Resp. 2023/036.

DFO. 2023b. Oceanographic Conditions in the Atlantic Zone in 2022. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2023/019.

Elliot, J.M. 1991. Tolerance and resistance to thermal stress in juvenile Atlantic salmon, *Salmo salar*. Freshwater Biol. 25(1): 61–70.

Forseth, T., Barlaup, B.T., Finstad, B., Fiske, P., Gjøsæter, H., Falkegård, M., Hindar, A., Mo, T.A., Rikardsen, A.H., Thorstad, E.B., Vøllestad, L.A., and Wennevik, V. 2017. The major threats to Atlantic salmon in Norway. ICES J. Mar. Sci. 74(6): 1496–1513.

Friedland, K.D. 1998. Ocean climate influences on critical Atlantic salmon (*Salmo salar*) life history events. Can. J. Fish. Aquat. Sci. 55: 119–130.

Friedland, K.D., Hansen, L.P., Dunkley, D.A., and MacLean, J.C. 2000. Linkage between ocean climate, post-smolt growth, and survival of Atlantic salmon (*Salmo salar* L.) in the North Sea area. ICES J. Mar. Sci. 57: 419–429.

Friedland, K.D., Reddin, D.G., and Castonguay, M. 2003. Ocean thermal conditions in the post-smolt nursery of North American Atlantic salmon. ICES J. Mar. Sci. 60(2): 343–355.

Friedland, K.D., Shank, B.V., Todd, C.D., McGinnity, P., and Nye, J.A. 2014. Differential response of continental stock complexes of Atlantic salmon (*Salmo salar*) to the Atlantic Multidecadal Oscillation. J. Mar. Syst. 133: 77–87.

Gillson, J.P., Basic, T., Davison, P.I., Riley, W.D., Talks, L., Walker, A., and Russell, I.C. 2022. A review of marine stressors impacting Atlantic salmon *Salmo salar*, with an assessment of the major threats to English stocks. Rev. Fish Biol. Fish. 32: 879–919.

Hedger, R.D., Rikardsen, A.H., Strøm, J.F., Righton, D.A., Thorstad, E.B., and Næsje, T.F. 2017. Diving behaviour of Atlantic salmon at sea: effects of light regimes and temperature stratification. Mar. Ecol. Prog. Ser. 574: 127-140.

Holborn, M.K., Crowley, S.E., Duffy, S.J., Messmer, A.M., Kess, T., Dempson, J.B., Wringe, B.F., Fleming, I.A., Bentzen, P., and Bradbury, I.R. 2022. Precocial male maturation contributes to the introgression of farmed Atlantic salmon into wild populations. Aquacult Environ Interact. 14: 205–218.

Jonsson, B., and Jonsson, N. 2009. A review of the likely effects of climate change on anadromous Atlantic salmon *Salmo salar* and brown trout *Salmo trutta*, with particular reference to water temperature and flow. J. Fish. Biol. 75(10): 2381–2447.

Keefe, D., Young, M., Van Leeuwen, T.E., and Adams, B. 2022. Long-term survival of Atlantic salmon following catch and release: Considerations for anglers, scientists and resource managers. Fish. Manag. Ecol. 29(3): 286–297.

Keyser, F., Wringe, B.F., Jeffery, N.W., Dempson, J.B., Duffy, S., and Bradbury, I.R. 2018. Predicting the impacts of escaped farmed Atlantic salmon on wild populations. Can. J. Fish. Aquat. Sci. 75(4): 506–512.

Lehnert, S.J., Kess, T., Bentzen, P., Clement, M., and Bradbury, I.R. 2020. Divergent and linked selection shape patterns of genomic differentiation between European and North American Atlantic salmon (*Salmo salar*). Marin. Ecol. 29(12): 2160–2175.

Lennox, R.J., Alexandre, C.M., Almeida, P.R., Bailey, K.M., Barlaup, B.T., Bøe, K., Breukelaar, A., Erkinaro, J., Forseth, T., Gabrielsen, S.-E., Halfyard, E., Hanssen, E.M., Karlsson, S., Koch, S., Koed, A., Langåker, R.M., Lo, H., Lucas, M.C., Mahlum, S., Perrier, C., Pulg, U., Sheehan, T., Skoglund, H., Svenning, M., Thorstad, E.B., Velle, G., Whoriskey, F.G., and Vollset, K.W. 2021. The quest for successful Atlantic salmon restoration: perspectives, priorities, and maxims. ICES J. Mar. Sci. 78(10): 3479–3497.

Marine Scotland and Fisheries Management Scotland. 2023. Regional and national assessment of the pressures acting on Atlantic salmon in Scotland, 2021. Scott. Mar. Freshwater Sci. Vol 14(4): 23 p.

Moores, R.B., Penney, R.W., and Tucker, R.J. 1978. Atlantic salmon angled catch and effort data, Newfoundland and Labrador, 1953–77. Fish. And Mar. Serv. Data Rep. No. 84.

O’Connell, M.F., and Dempson, J.B. 1995. Target spawning requirements for Atlantic Salmon, *Salmo salar* L., in Newfoundland rivers. Fish. Manage. Ecol. 2: 161–170.

O’Connell, M.F., Cochrane, N.M., and Mullins, C.C. 1996. Preliminary Results of the License Stub Return System in The Newfoundland Region, 1994. DFO Can. Sci. Advis. Sec. Res. Doc. 1996/130. 34 p.

O’Connell, M.F., Reddin, D.G., Amiro, P.G. Caron, F., Marshall, T.L., Chaput, G., Mullins, C.C., Locke, A., O’Neil, S.F., and Cairns, D.K. 1997. Estimates of Conservation Spawner Requirements for Atlantic Salmon (*Salmo salar* L.) for Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 1997/100. 58 p.

O'Connell, M.F. Cochrane, N.M., and Mullins, C.C. 1998. An Analysis of the Results of the License Stub Return System in the Newfoundland Region, 1994-97. DFO Can. Sci. Advis. Sec. Res. Doc. 1998/111. 67 p.

Olusanya, H.O., and van Zyll de Jong, M. 2018. Assessing the vulnerability of freshwater fishes to climate change in Newfoundland and Labrador. PLoS One. 13(12): e0208182.

Reddin, D.G. 2006. Perspectives on the marine ecology of Atlantic salmon (*Salmo salar*) in the Northwest Atlantic. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/018. iv + 45 p.

Reddin, D.G., and Friedland, K.D. 1993. Marine environmental factors influencing the movement and survival of Atlantic Salmon. *In*: Salmon in the Sea. Fourth International Atlantic Salmon Symposium, St. Andrews, Canada. Edited by D. Mills. Fishing New Books, London, UK. pp. 79–103.

Reddin, D.G., Dempson, J.B., and Amiro, P.G. 2006. Conservation Requirements for Atlantic Salmon (*Salmo salar* L.) in Labrador rivers. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/071. ii + 29 p.

Reddin, D.G., Poole, R.J., Clarke, G., and Cochrane, N. 2010. Salmon rivers of Newfoundland and Labrador. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/046. iv + 24 p.

Rikardsen, A.H., Righton, D., Strøm, J.F., Thorstad, E.B., Gargan, P., Sheehan, T., Okland, F., Chittenden, C.M., Hedger, R.D., Naesje, T.F., Renkawitz, M., Sturlaugsson, J., Caballero, P., Baktoft, H., Davidsen, J.G., Halttunen, E., Wright, S., Finstad, B., and Aarestrup, K. 2021. Redefining the oceanic distribution of Atlantic salmon. Sci. Rep. 11: 12266.

Robertson, M.J., Weir, L.K., and Dempson J.B. 2013. Population viability analysis for the South Newfoundland Atlantic Salmon (*Salmo salar*) designatable unit. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/090. vii + 26 p.

Stokes, G.L., Lynch, A.J., Funge-Smith, S., Valbo-Jørgensen, J., Beard Jr., T.D., Lowe, B.S., Wong, J.P., and Smidt, S.J. 2021. A global dataset of inland fisheries expert knowledge. Nat. Sci. Data. 8: 182.

Strøm, J.F., Thorstad, E.B., Chafe, G., Sørbye, S.H., Righton, D., Rikardsen, A.H., and Carr, J. 2017. Ocean migration of pop-up satellite archival tagged Atlantic salmon from the Miramichi River in Canada. ICES J. Mar. Sci. 74(5): 1356–1370.

Strøm, J.F., Thorstad, E.B., Hedger, R.D., and Rikardsen A.H. 2018. Revealing the full ocean migration of individual Atlantic salmon. Anim. Biotelem. 6(2).

Sylvester, E.V.A., Wringe, B.F., Duffy, S.J., Hamilton, L.C., Fleming, I.A., Bradbury, I.R. 2018. Migration effort and wild population size influence the prevalence of hybridization between escaped farmed and wild Atlantic salmon. Aquacult. Environ. Interact. 10: 401–411.

Sylvester, E.V.A., Wringe, B.F., Duffy, S.J., Hamilton, L.C., Fleming, I.A., Castellani, M., Bentzen, P., and Bradbury, I.R. 2019. Estimating the relative fitness of escaped farmed salmon offspring in the wild and modelling the consequences of invasion for wild populations. Evolutionary Applications. 12(4): 705–717.

Tirronen, M., Hutchings, J.A., Pardo, S.A., and Kuparinen, A. 2022. Atlantic salmon survival at sea: temporal changes that lack regional synchrony. Can. J. Fish. Aquat. Sci. 79(10): 1697–1711.

Van Leeuwen, T.E., Dempson, J.B., Burke, C.M., Kelly, N.I., Robertson, M.J., Lennox, R.J., Havn, T.B., Svenning, M., Hinks, R., Guzzo, M.M., Thorstad, E.B., Purchase, C.F., and Bates, A.E. 2020. Mortality of Atlantic salmon after catch and release angling: assessment of a recreational Atlantic salmon fishery in a changing climate. Can. J. Fish. Aquat. Sci. 77(9): 1518–1528.

Veinott, G., Cochrane, N., and Dempson, J.B. 2013. Evaluation of a river classification system as a conservation measure in the management of Atlantic salmon in Insular Newfoundland. Fish. Manage. Ecol. 20(5): 454–459.

Veinott, G., and N. Cochrane. 2015. Accuracy and Utility of the Atlantic Salmon Licence Stub (Angler Log) Return Program in Newfoundland and Labrador. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/035. v+ 14 p.

Veinott, G. and Caines, D. 2016. Estimating Proportion of Large Salmon on Harry's River, Newfoundland Using a DIDSON Acoustic Camera. Can. Manuscr. Rep. Fish. Aquat. Sci. 3100: iii + 11 p.

Wringe, B.F., Jeffery, N.W., Stanley, R.R.E., Hamilton, L.C., Anderson, E.C., Fleming, I.A., Grant, C., Dempson, J.B., Veinott, G., Duffy, S.J., and I.R. Bradbury. 2018. Extensive hybridization following a large escape of domesticated Atlantic salmon in the Northwest Atlantic. Commun. Biol. 1(108).

APPENDIX I – TABLES AND FIGURES

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.

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 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 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 bolded. Values in italics for Sand Hill River represent estimated returns and percent change if the boostrapped 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 *5,013* *(4,776, 5,334)*	3,189	+44 *+57 (+50, +67)*	4,121	+11 *+22 (+16, +29)*
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% 4/13 (31%)

Table 5. Total returns of small (<63 cm) 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 bolded. 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 Small Returns	Previous Generation Average	Percent Change Vs Previous Generation	Previous 3 Generation Average	Percent Change Vs Previous 3 Generations
English River	1	1,012	570	+78	441	+129
Southwest Brook	2	73	167	-56	263	-72
Muddy Bay Brook	2	401	358	+12	336	+19
Sand Hill River	2	3,712 *3,941* *(3,815, 4,102)*	2,487	+49 *+58 (+53, +65)*	3,408	+9 *+16 (+12, +20)*
Exploits River	4	28,495	20,020	+42	25,992	+10
Campbellton River	**4**	**1,535**	**3,054**	**NA**	**3,442**	**NA**
Salmon Brook	4	261	915	-71	1,112	-77
Rattling Brook	4	368	454	-19	NA	NA
Middle Brook	5	2,123	2,182	-3	2,224	-5
Terra Nova River	5	2,817	4,237	-34	3,685	-24
Northwest River	5	369	NA	NA	NA	NA
Rocky River	9	286	337	-15	431	-34
Northeast River	10	506	602	-21	NA	NA
Come By Chance River	10	158	NA	NA	NA	NA
Garnish River	11	333	353	-6	NA	NA
Conne River	11	264	523	-50	1,480	-82
Harry's River	13	1,804	2,749	-34	2,816	-36
Torrent River	14A	3,971	4,274	-7	4,018	-1
Western Arm Brook	14A	1,204	1,053	+14	1,201	0%
Trout River	14A	42	NA	NA	NA	NA
Parkers River	14A	101	NA	NA	NA	NA
Summary		N = 21	N = 16	Declines ≥ 30% 5/16 (31%)	N = 13	Declines ≥ 30% 5/13 (38%)

Table 6. Total returns of large (≥63 cm) 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 bolded. 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 Large Returns	Previous Generation Average	Percent Change Vs Previous Generation	Previous 3 Generation Average	Percent Change Vs Previous 3 Generations
English River	1	293	172	+70	109	+169
Southwest Brook	2	13	29	-55	33	-61
Muddy Bay Brook	2	46	28	+64	24	+92
Sand Hill River	2	865 *1,072* *(961, 1,232)*	702	+23 *+53 (+37, +75)*	713	+21 *+50 (+35, +73)*
Exploits River	4	2,504	1,744	+44	3,614	-31
Campbellton River	4	395	330	NA	398	NA
Salmon Brook	4	37	130	-72	120	-69
Rattling Brook	4	17	22	-23	NA	NA
Middle Brook	5	259	277	-6	240	+8
Terra Nova River	5	253	410	-39	419	-40
Northwest River	5	288	NA	NA	NA	NA
Rocky River	9	0	12	-100	33	-100
Northeast River	10	30	75	-60	NA	NA
Come By Chance River	10	29	NA	NA	NA	NA
Garnish River	11	53	21	+152	NA	NA
Conne River	11	33	22	+50	69	-52
Harry's River	13	418	438	-5	461	-9
Torrent River	14A	273	633	-57	915	-70
Western Arm Brook	14A	77	50	+54	48	+60
Trout River	14A	9	NA	NA	NA	NA
Parkers River	14A	31	NA	NA	NA	NA
Summary		N = 21	N = 16	Declines ≥ 30% 6/16 (38%)	N = 13	Declines ≥ 30% 7/13 (54%)

Table 7. 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. The 2022 value for Campbellton River (bolded) in 2022 are based on an incomplete count and is considered to be a minimum estimate.

River Name	SFA	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	NA	337	NA
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% 4/16 (25%)	-	Declines ≥ 30% 4/13 (31%)

Table 8. Summary of Atlantic Salmon smolt production in 2022 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 are added to the count data (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 9. 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. Marine survival estimates for Campbellton River (bolded) are considered minimum estimates. The adult count in 2022 is considered to be incomplete.

River Name	SFA	2022 Marine Survival (%)	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 10. 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

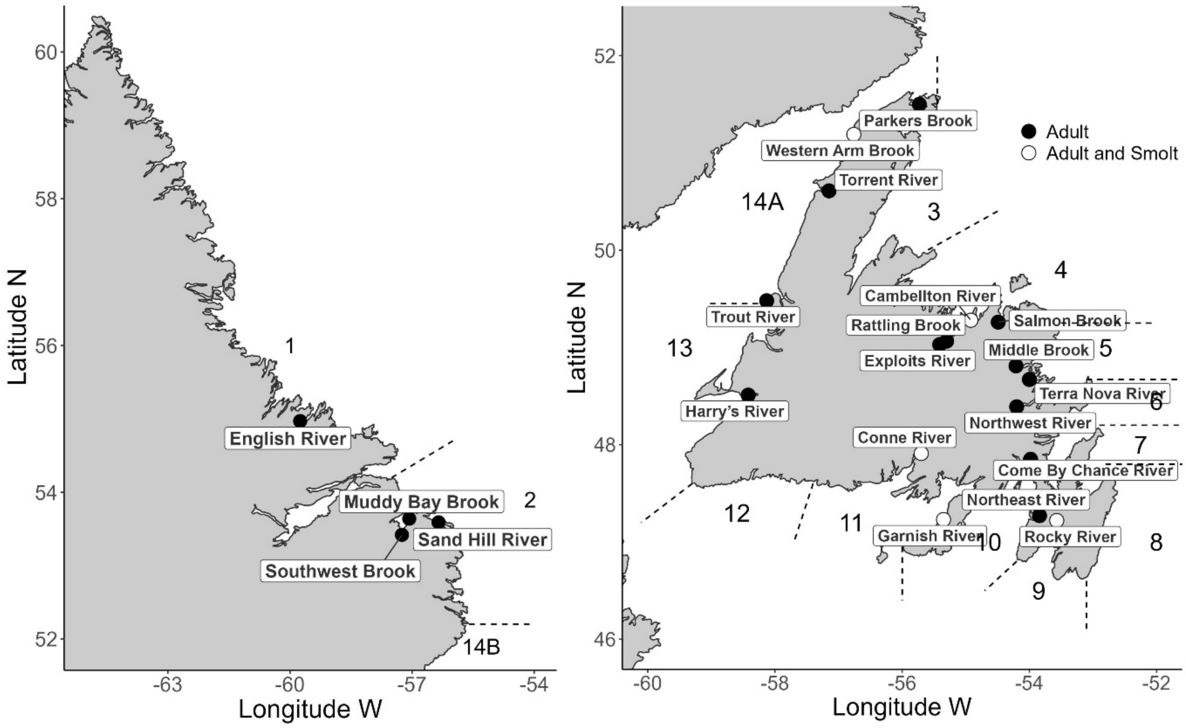


Figure 1. Map of the NL Region showing SFAs 1–14B and rivers where the number of out-migrating Atlantic Salmon smolts and/or returning adults were counted in 2022. Dashed lines indicate approximate SFA boundaries.

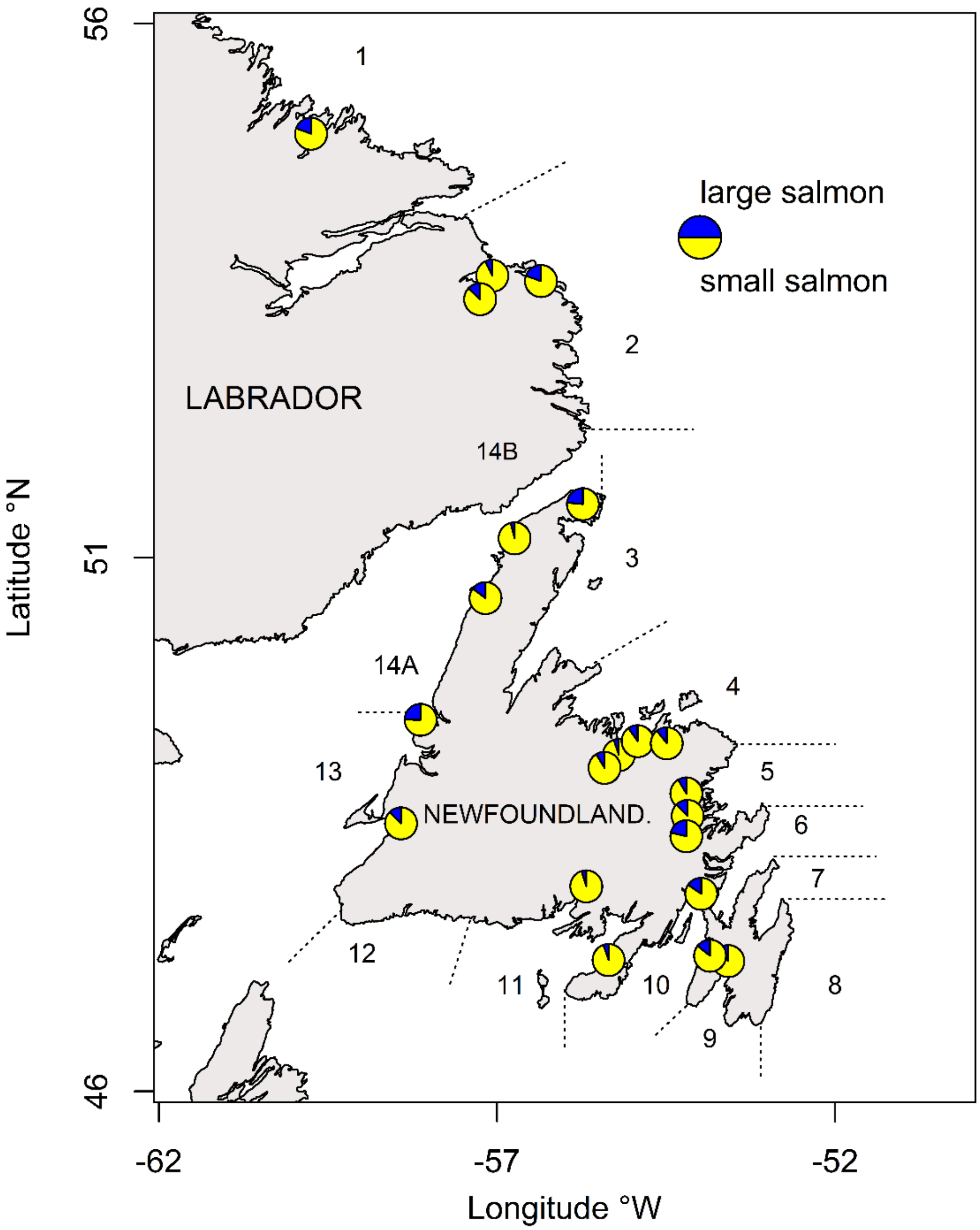


Figure 2. Average proportion of small (fork length <63 cm) and large (fork length ≥63 cm) Atlantic Salmon observed from 1992–2022 on Newfoundland and Labrador rivers monitored in 2022. The approximate boundary of each SFA is indicated by dotted lines.

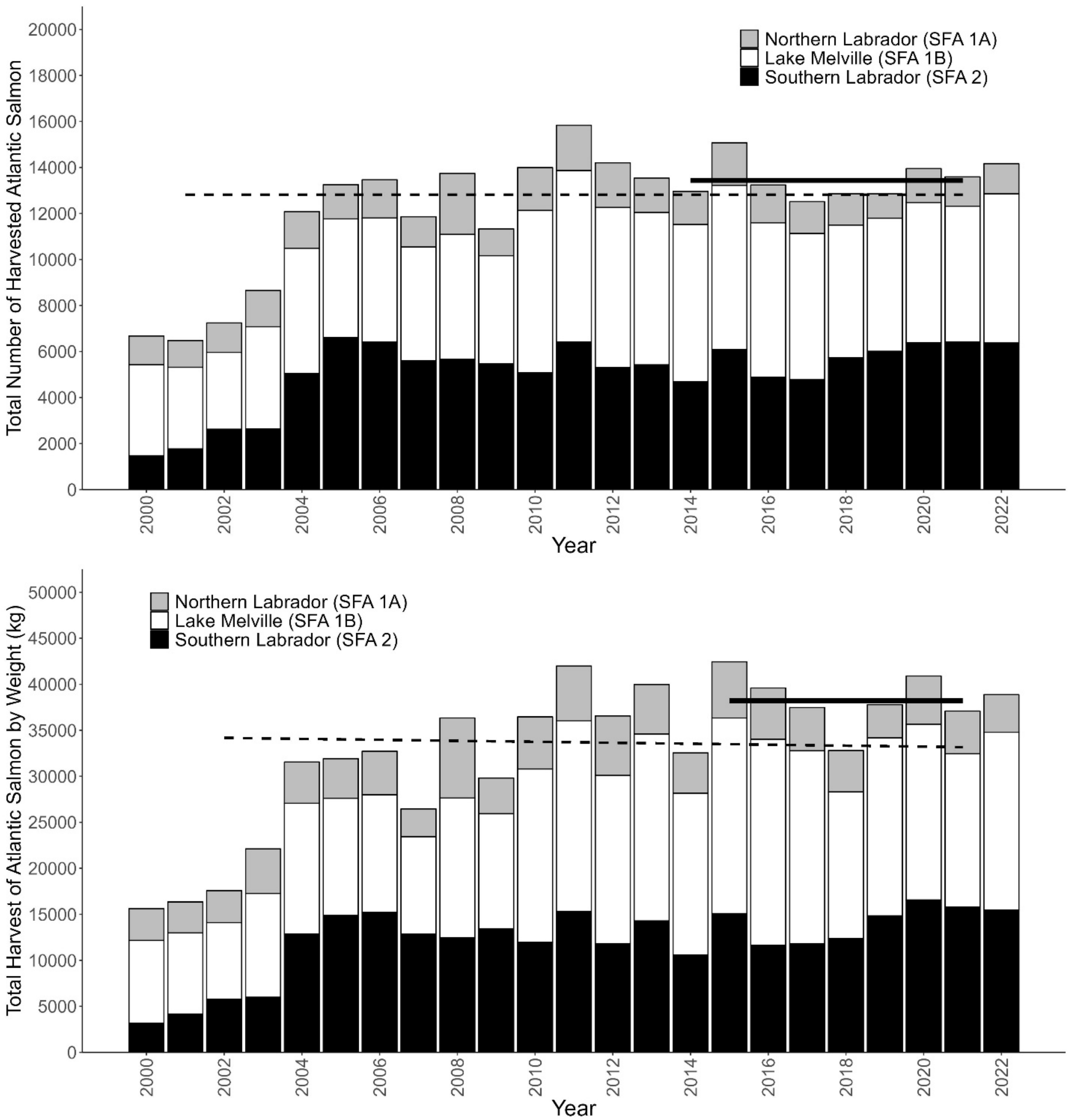


Figure 3. Estimated number (top panel) and weight (bottom panel) of Atlantic Salmon harvested in Labrador Indigenous and subsistence fisheries in SFAs 1A, 1B and 2 from 2000–22. Horizontal solid line represents the previous generation average (2015–21). Horizontal dashed line represents the previous three generation average (2002–21). Harvest estimates for 2022 are preliminary and will be updated upon the receipt and analysis of additional logbooks.

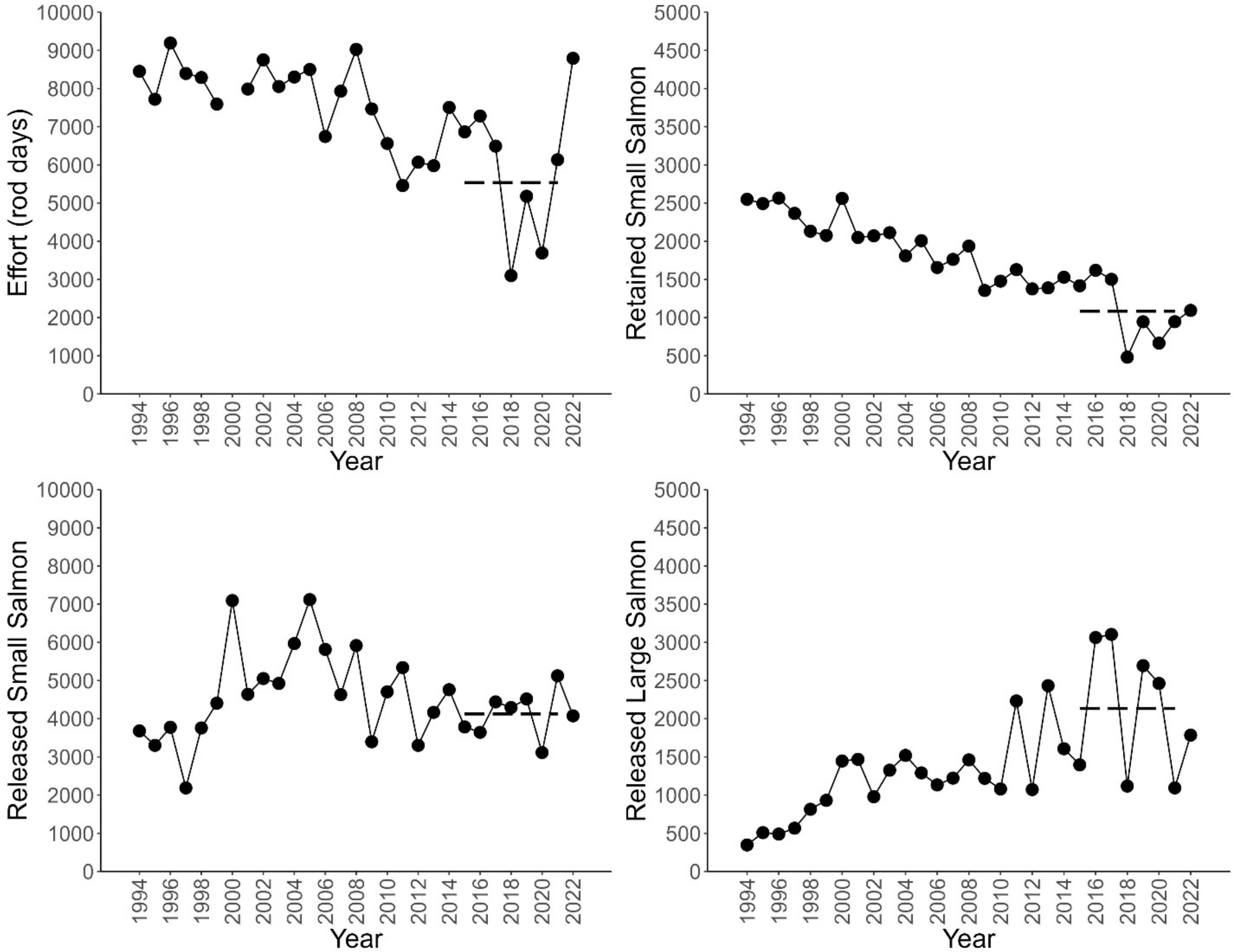


Figure 4. Recreational catch of small and large Atlantic Salmon and angling effort (rod days) in Labrador from 1994–2022. Horizontal dashed lines represent the previous generation average (2015–21 for Labrador rivers). Estimates for 2022 are preliminary and will be updated upon the completion of a phone survey of anglers who have not returned their logs.

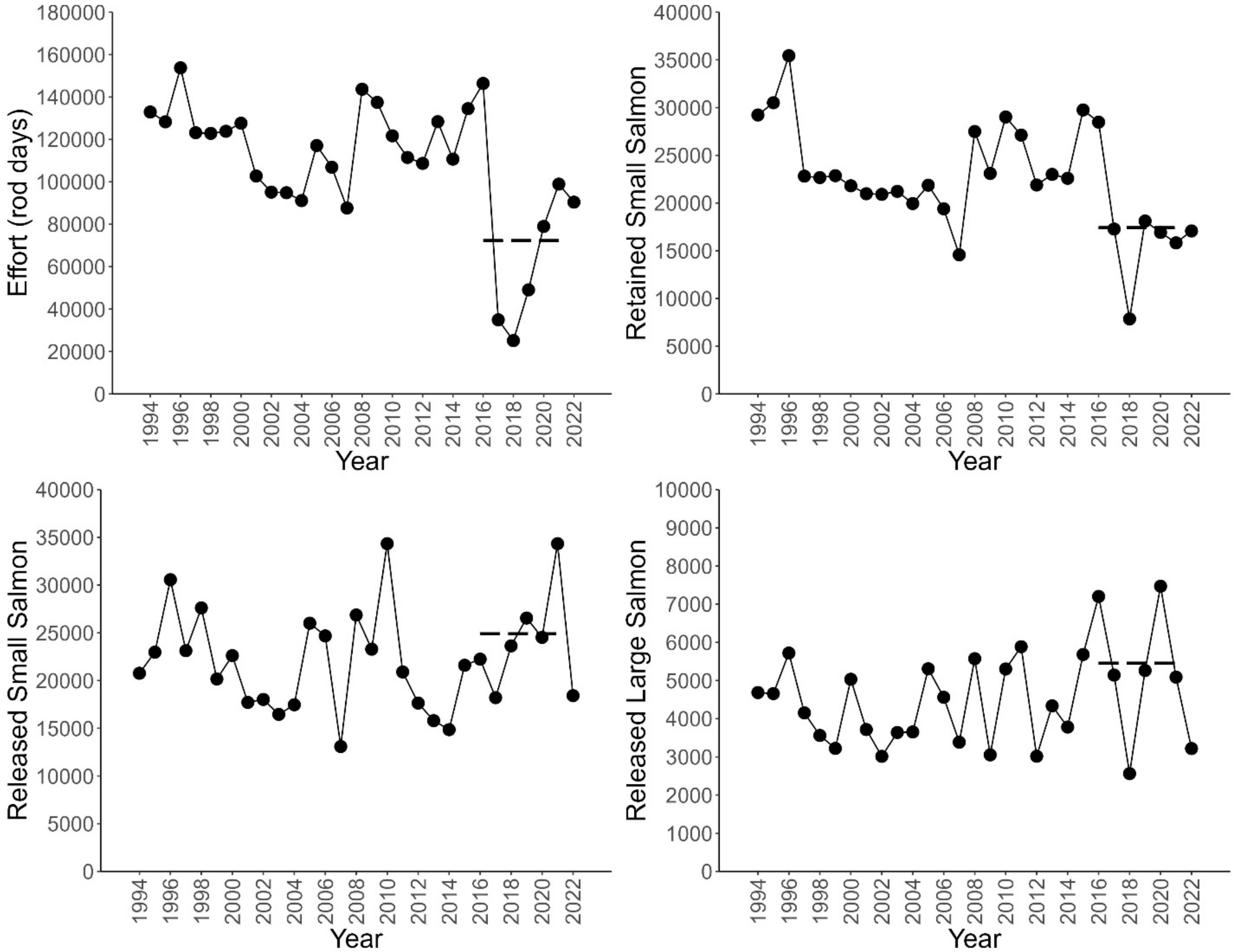


Figure 5. Recreational catch of small and large Atlantic Salmon and angling effort (rod days) in Newfoundland from 1994–2022. Horizontal dashed lines represent the previous generation average (2016–21 for Newfoundland rivers). Estimates for 2022 are preliminary and will be updated upon the completion of a phone survey of anglers who have not returned their logs.

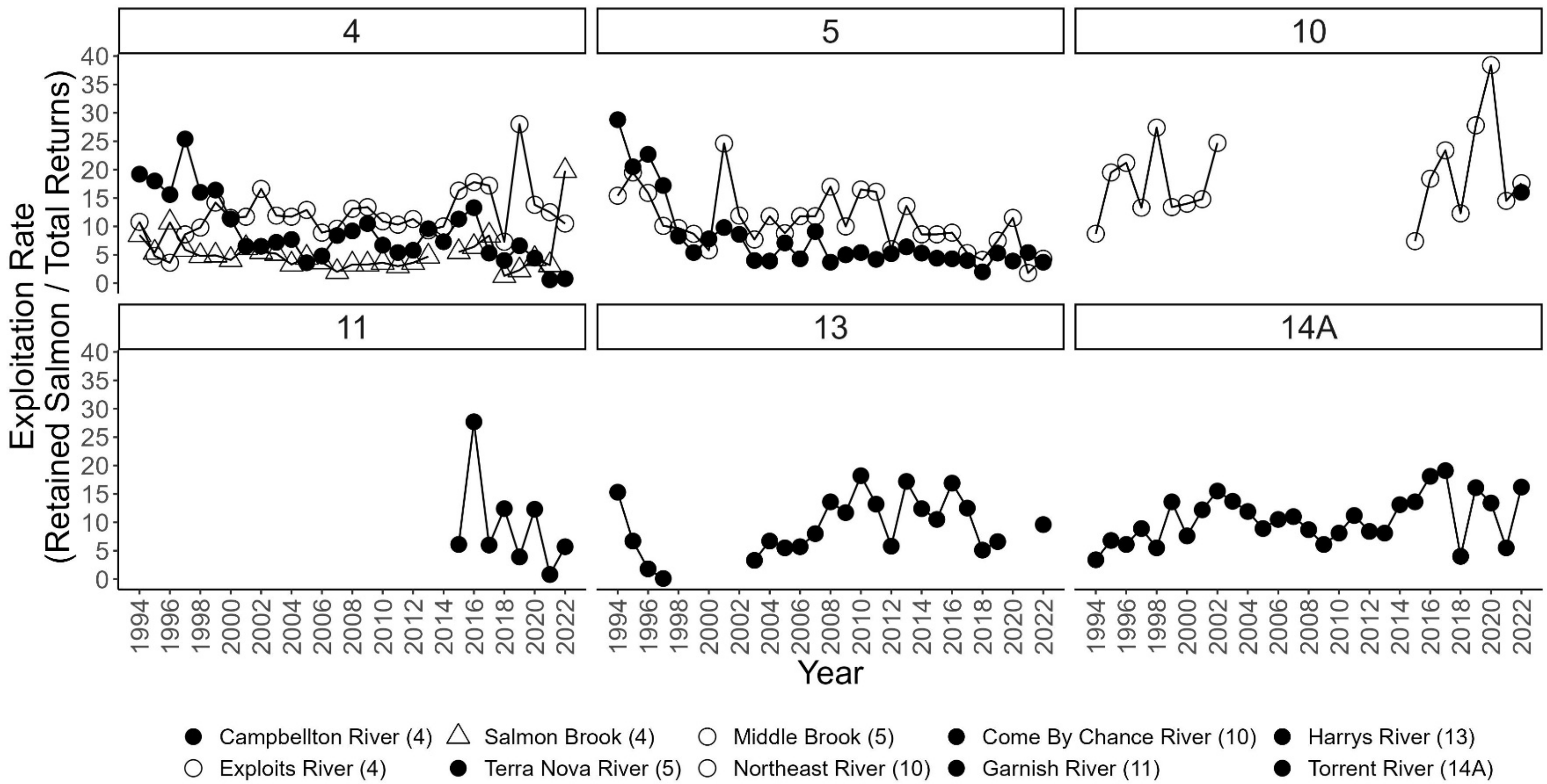


Figure 6. Estimated exploitation rate in the recreational Atlantic Salmon fishery from monitored rivers in Newfoundland, 1994–2022. Exploitation rate is calculated by dividing the estimate of retained salmon by the total returns and multiplying by 100%. Estimates for 2022 are preliminary and will be revised upon the completion of an angler phone survey and finalization of river-specific angling estimates. Number at the top of each panel and numbers in parentheses near each river name in the legend key represent the SFA.

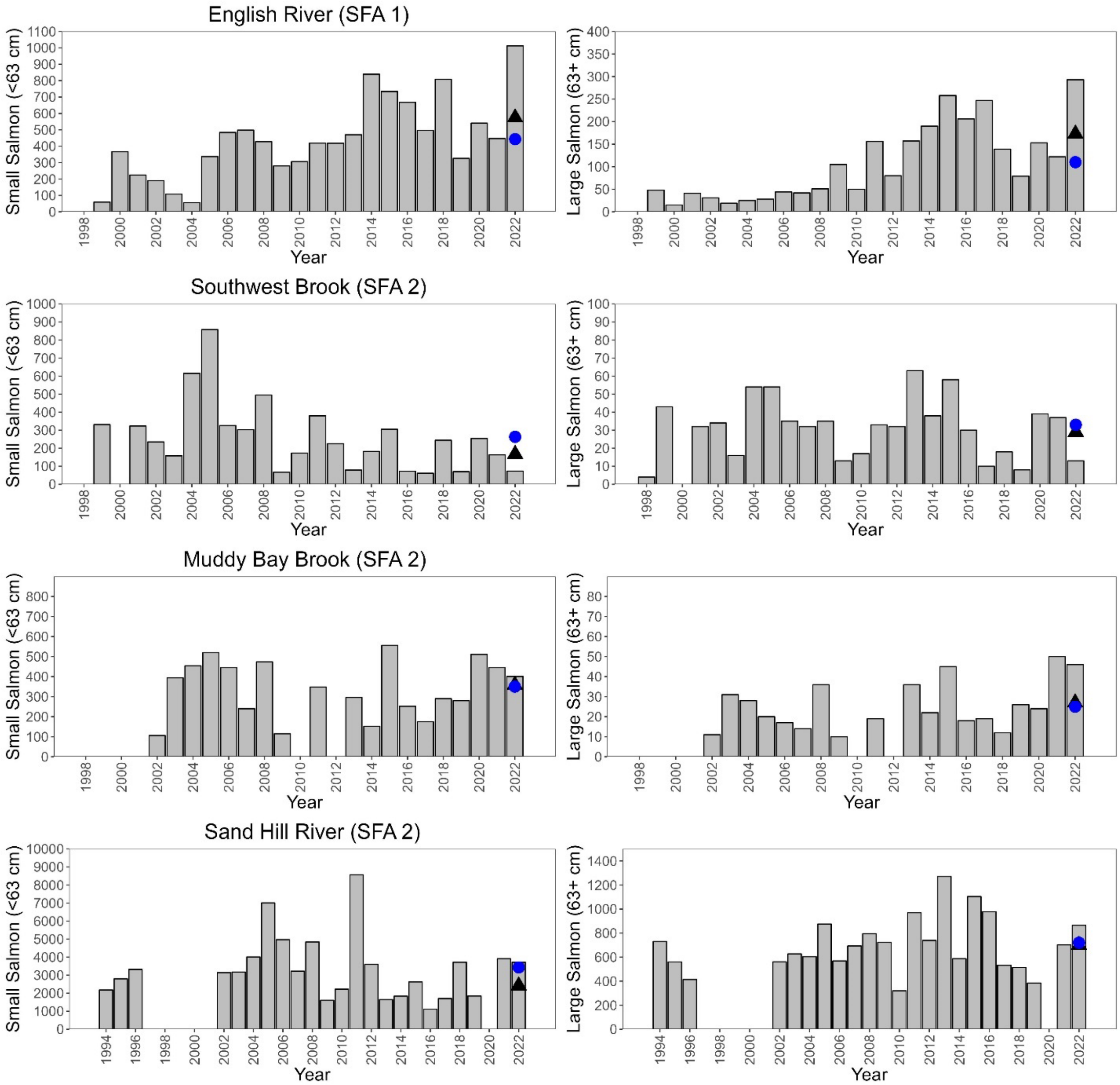


Figure 7. Total returns of small and large salmon to monitored rivers in Labrador: English River (SFA 1) and Southwest Brook, Muddy Bay Brook, and Sand Hill River (SFA 2), 1994–2022. The black triangles and blue circles represent the previous generation average (2015–21) and previous three generation average, respectively. For comparisons of 2022 values to previous generation or previous three generation averages, see Tables 4–6.

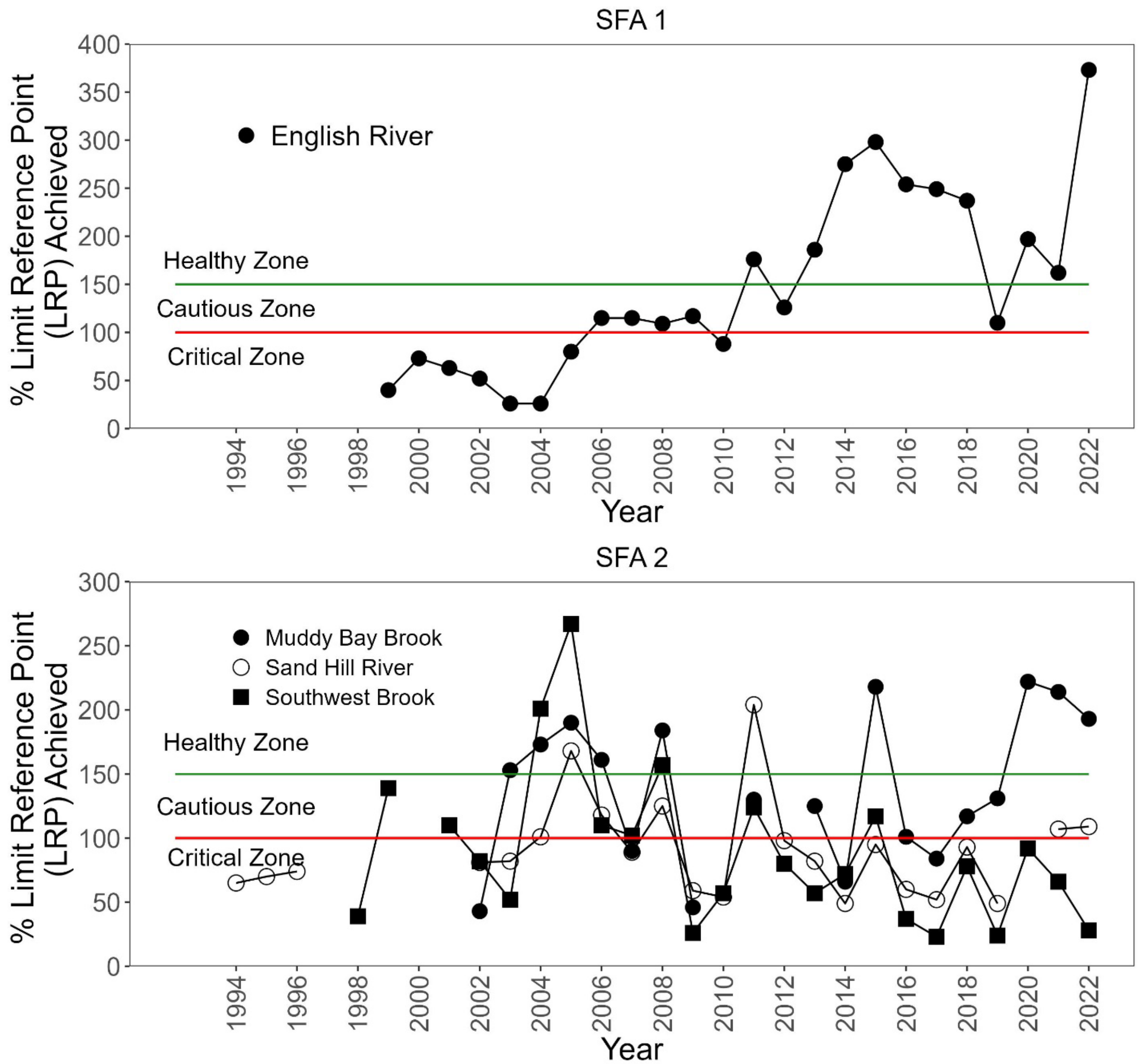


Figure 8. Percent limit reference point achieved on monitored rivers in SFA 1 (top panel) and SFA 2 (bottom panel) from 1994–2022. Estimates for 2022 are preliminary. Calculations are based on estimated egg depositions in each year compared to the LRP (red line) and upper stock reference point (USR; green line). The LRP and USR are equivalent to the 100% and 150% of the conservation egg requirement for each river, respectively.

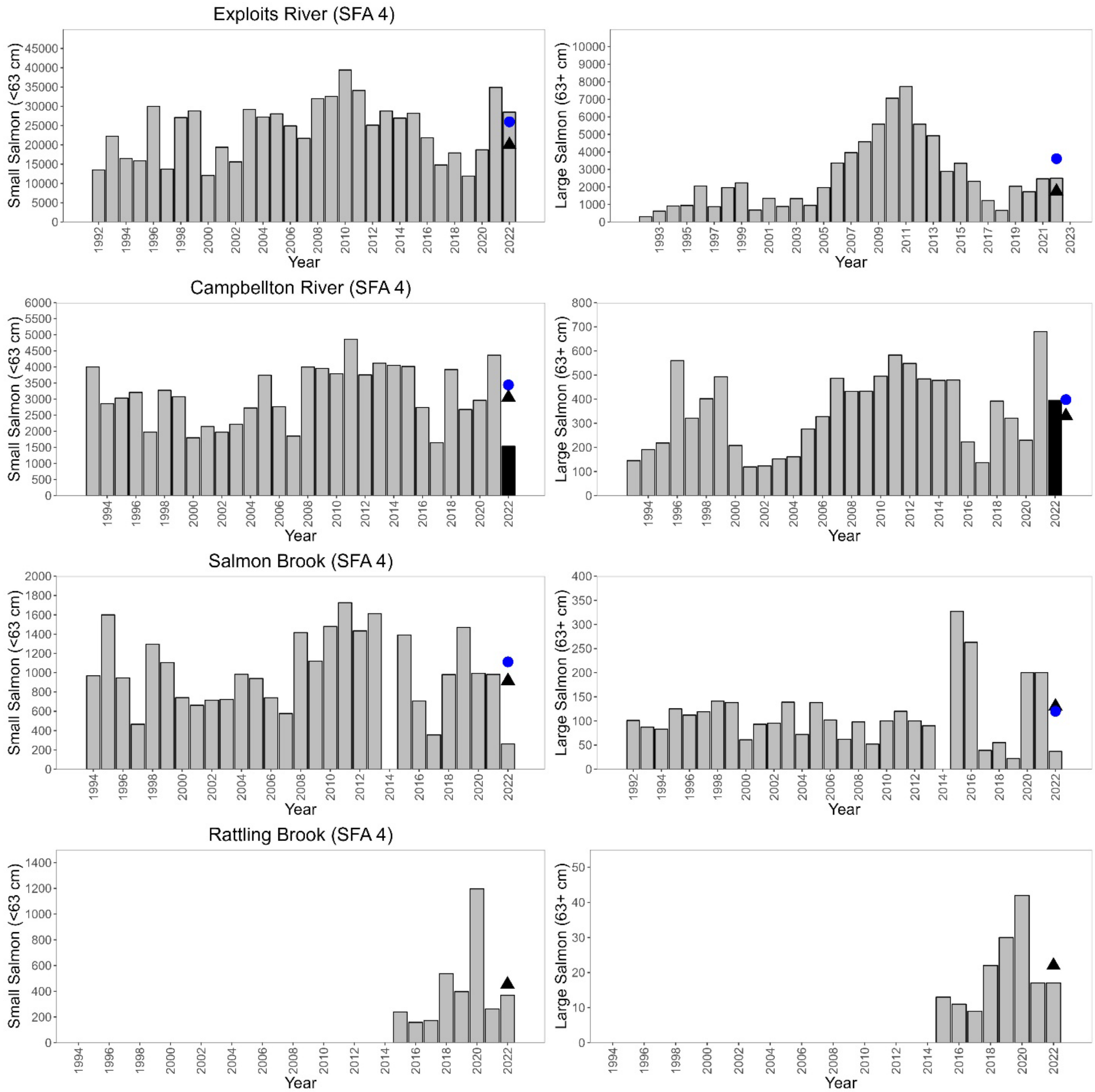


Figure 9. Total returns of small and large salmon to monitored rivers in SFA 4, 1994–2022. The black triangles and blue circles represent the previous generation average (2016–21) and previous three generation average, respectively. Black bars represent incomplete counts (not used in averages). For comparisons of 2022 values to previous generation or previous three generation averages, see Tables 4–6.

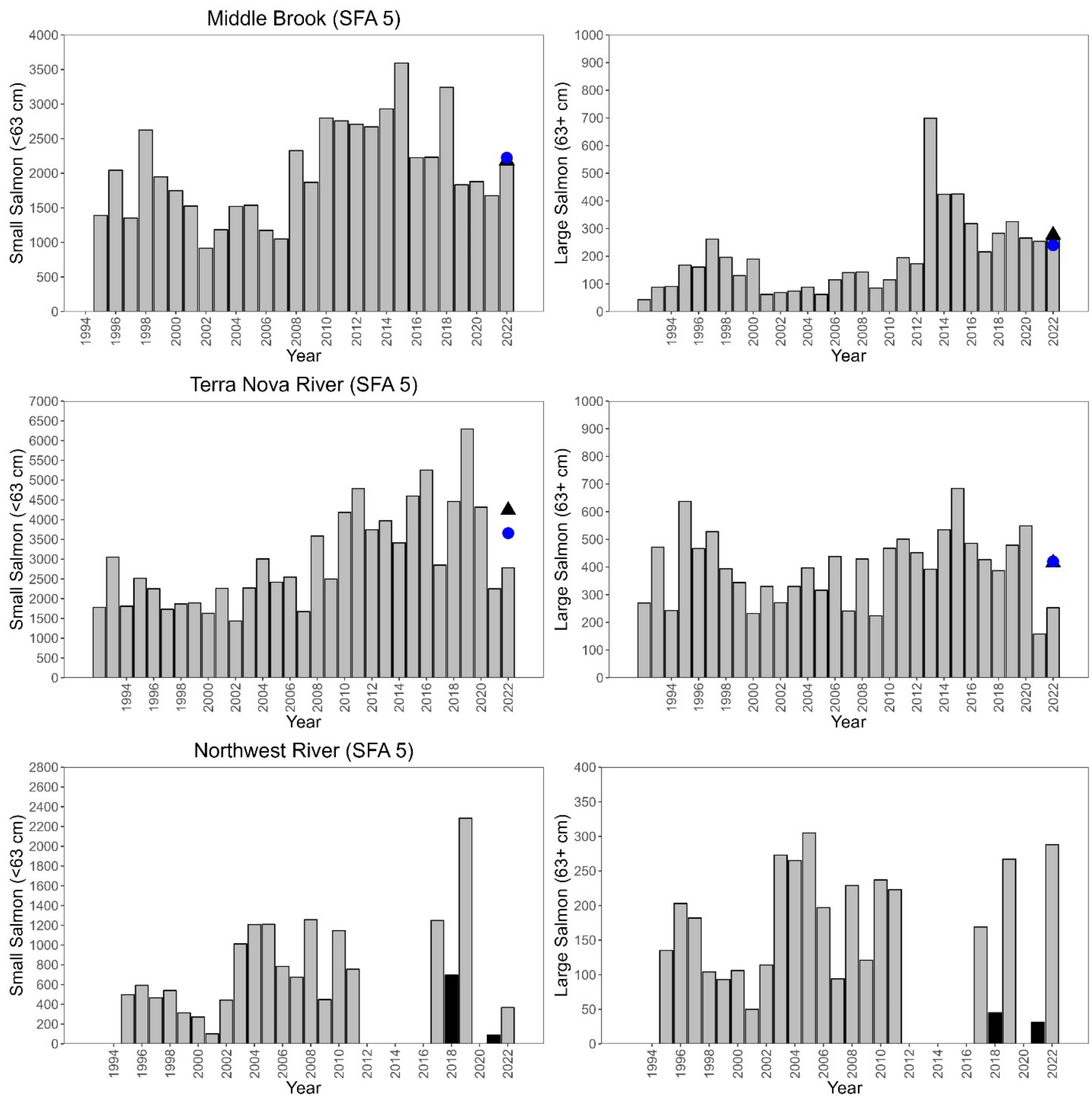
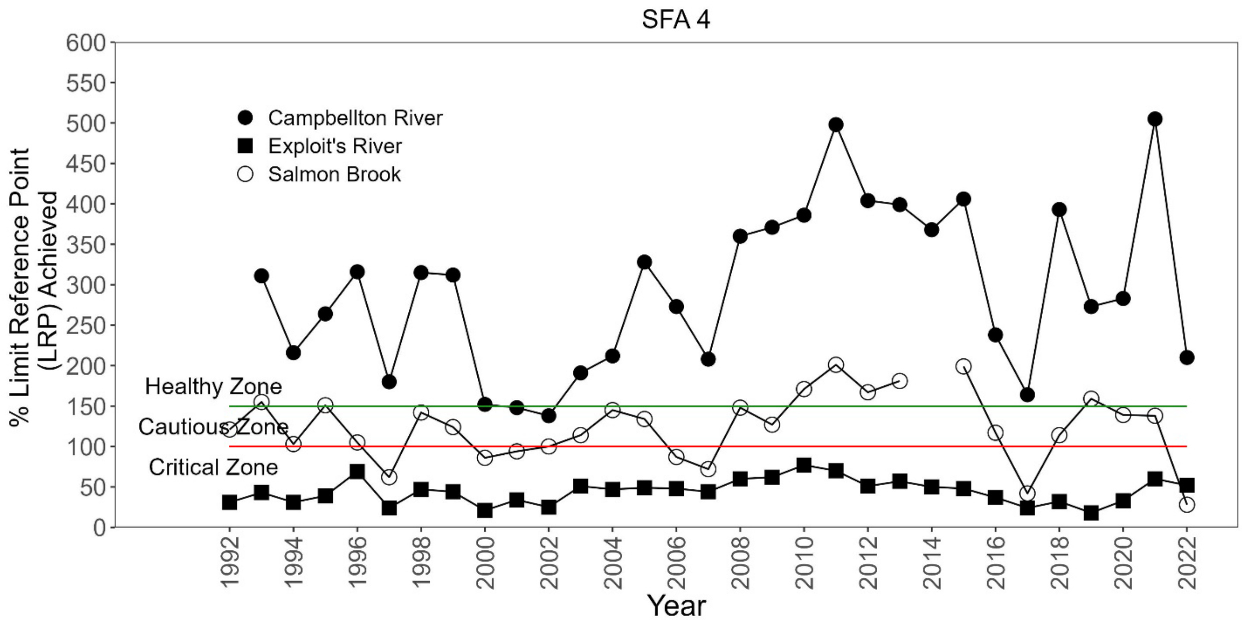


Figure 10. Total returns of small and large salmon to monitored rivers in SFA 5, 1994–2022. The black triangles and blue circles represent the previous generation average (2016–21) and previous three generation average, respectively. Black bars represent incomplete counts (not used in averages). For comparisons of 2022 values to previous generation or previous three generation averages, see Tables 4–6.



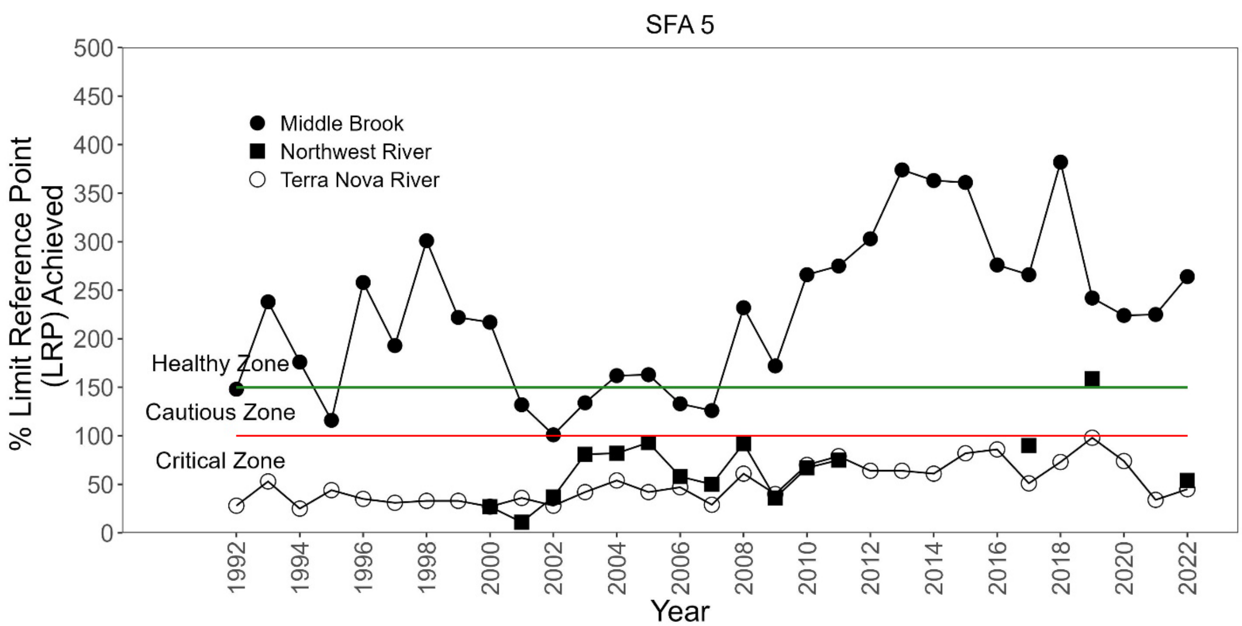


Figure 11. Percent limit reference point achieved on monitored rivers in SFA 4 (top panel) and SFA 5 (bottom panel) from 1992–2022. Estimates for 2022 are preliminary. Calculations are based on estimated egg depositions in each year compared to the LRP (red line) and upper stock reference point (USR; green line). The LRP and USR are equivalent to the 100% and 150% of the conservation egg requirement for each river, respectively.

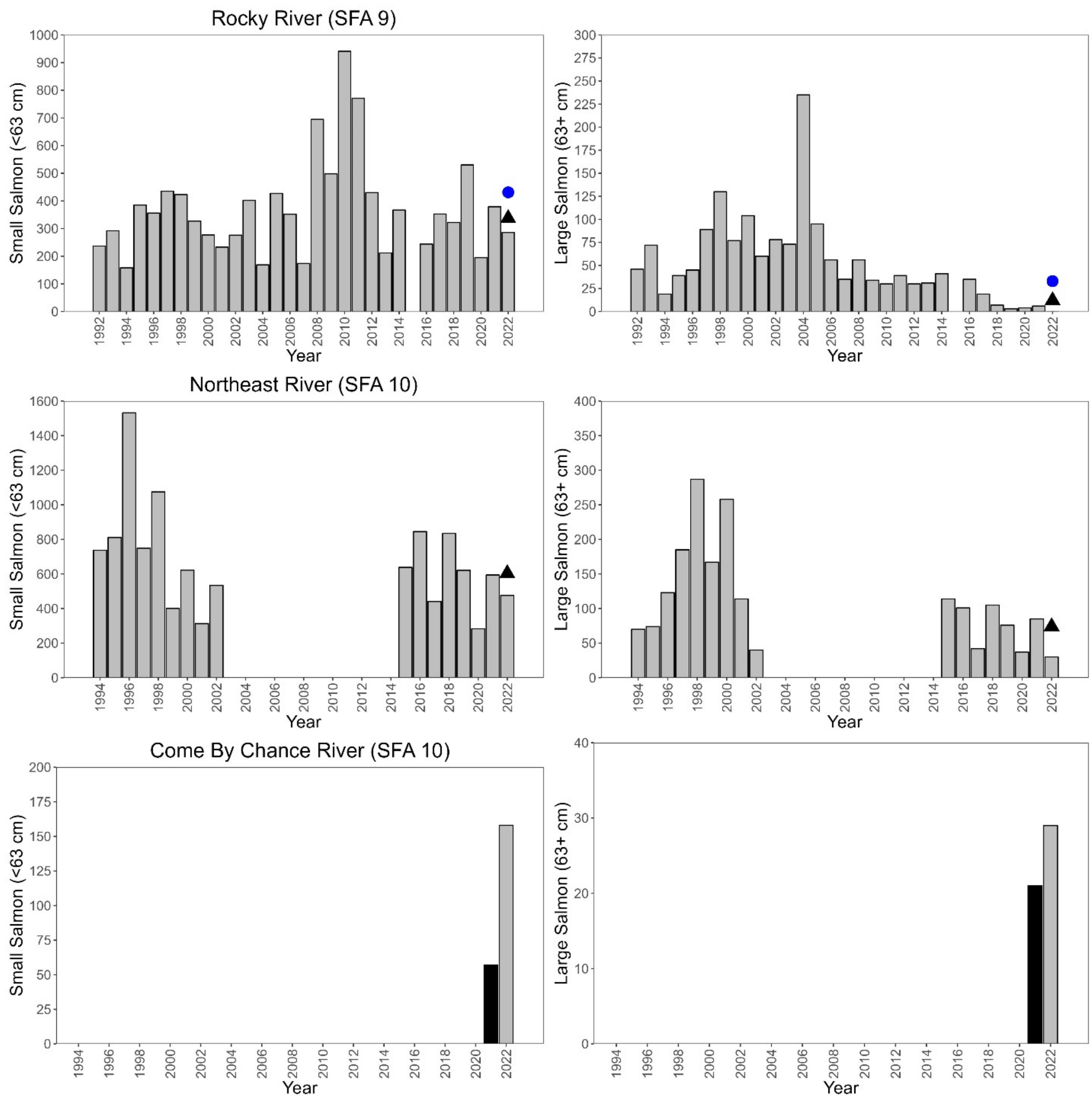


Figure 12. Total returns of small and large salmon to monitored rivers in SFA 9 and 10, 1994–2022. The black triangles and blue circles represent the previous generation average (2016–21) and previous three generation average, respectively. Black bars represent incomplete counts (not used in averages). For comparisons of 2022 values to previous generation or previous three generation averages, see Tables 4–6.

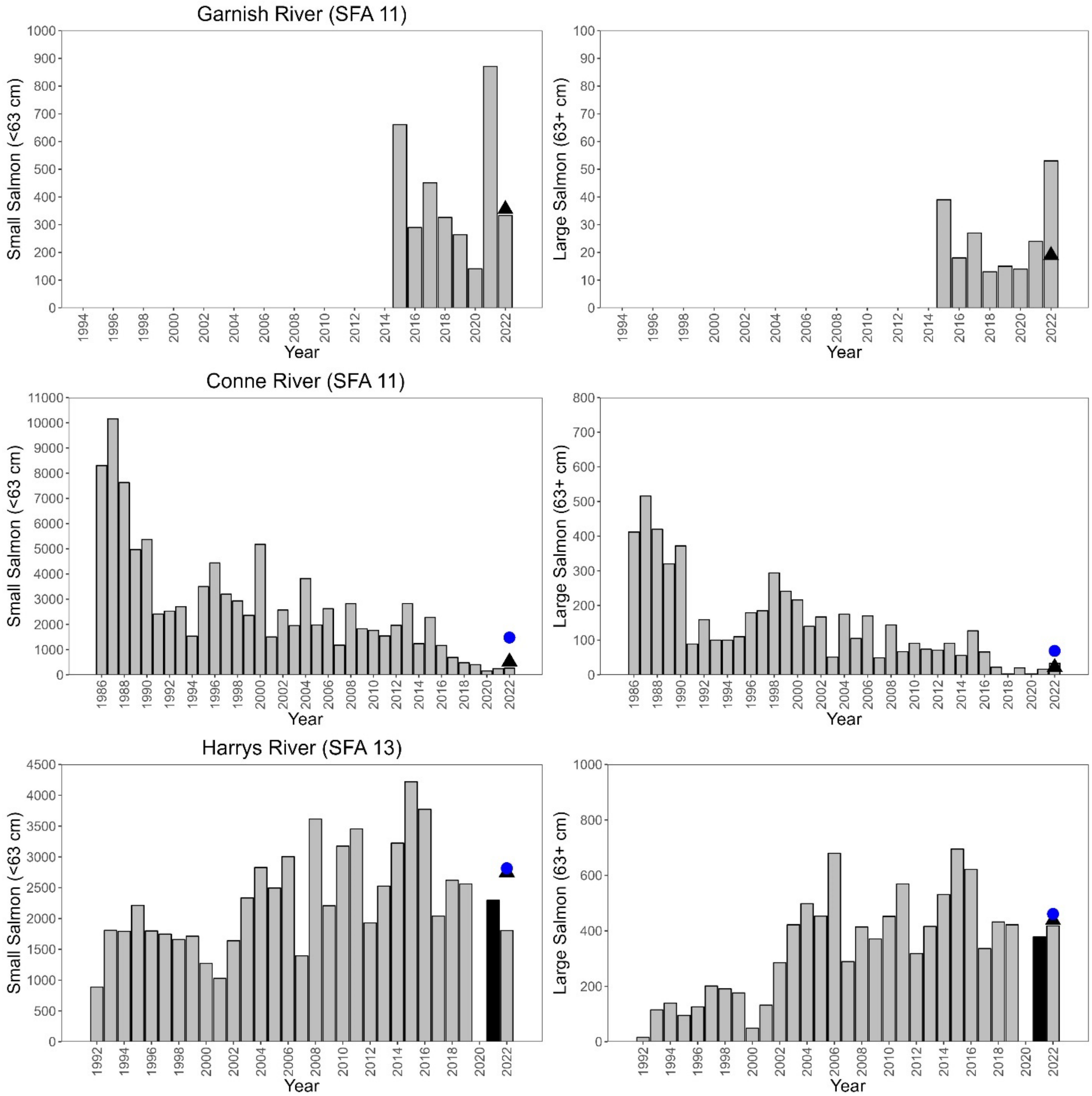


Figure 13. Total returns of small and large salmon to monitored rivers in SFA 11 and 13, 1994–2022. The black triangles and blue circles represent the previous generation average (2016–21) and previous three generation average, respectively. Black bars represent incomplete counts (not used in averages). For comparisons of 2022 values to previous generation or previous three generation averages, see Tables 4–6.

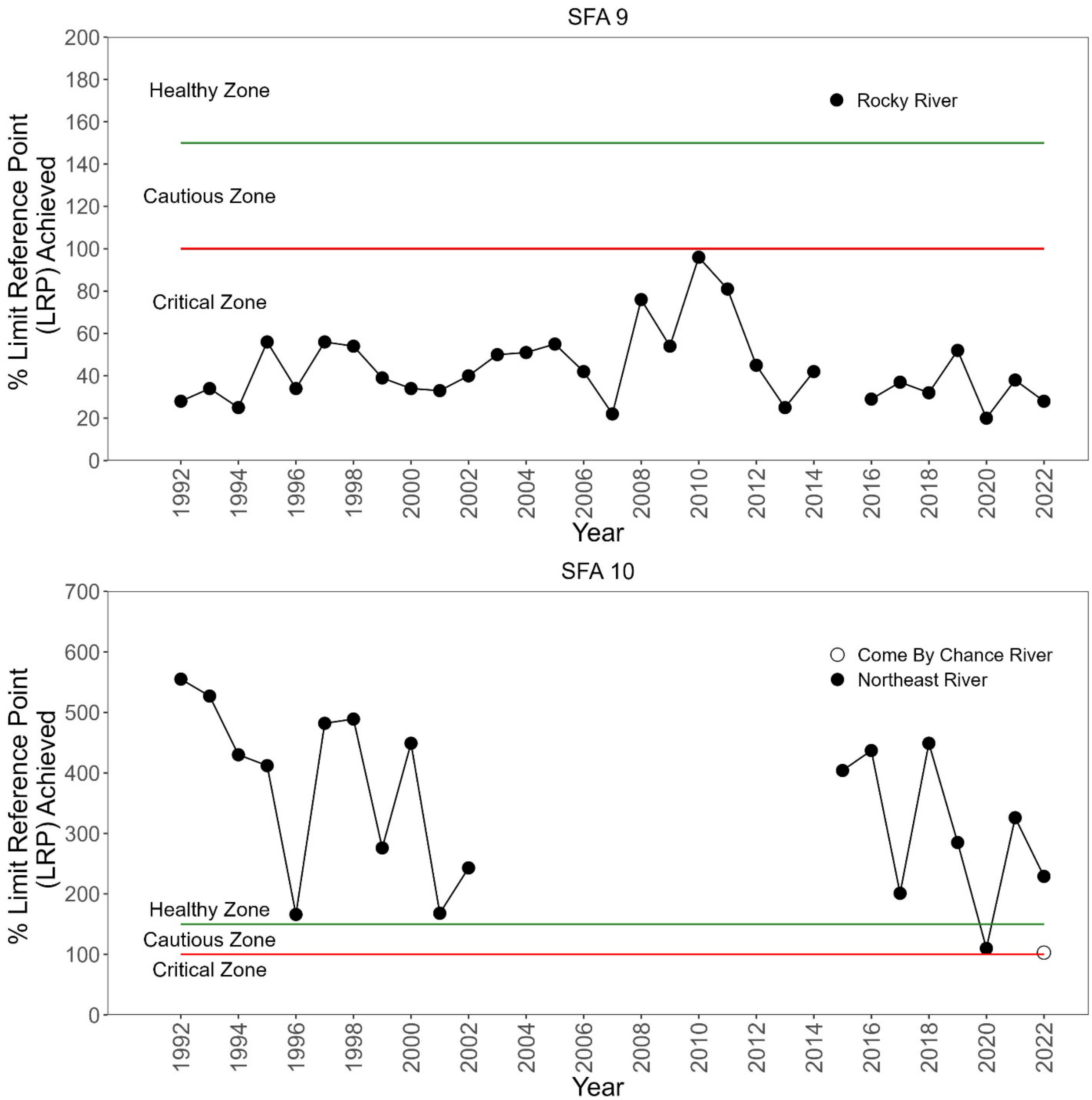


Figure 14. Percent limit reference point achieved on monitored rivers in SFA 9 (top panel) and SFA 10 (bottom panel) from 1992–2022. Estimates for 2022 are preliminary. Calculations are based on estimated egg depositions in each year compared to the LRP (red line) and upper stock reference point (USR; green line). The LRP and USR are equivalent to the 100% and 150% of the conservation egg requirement for each river, respectively.

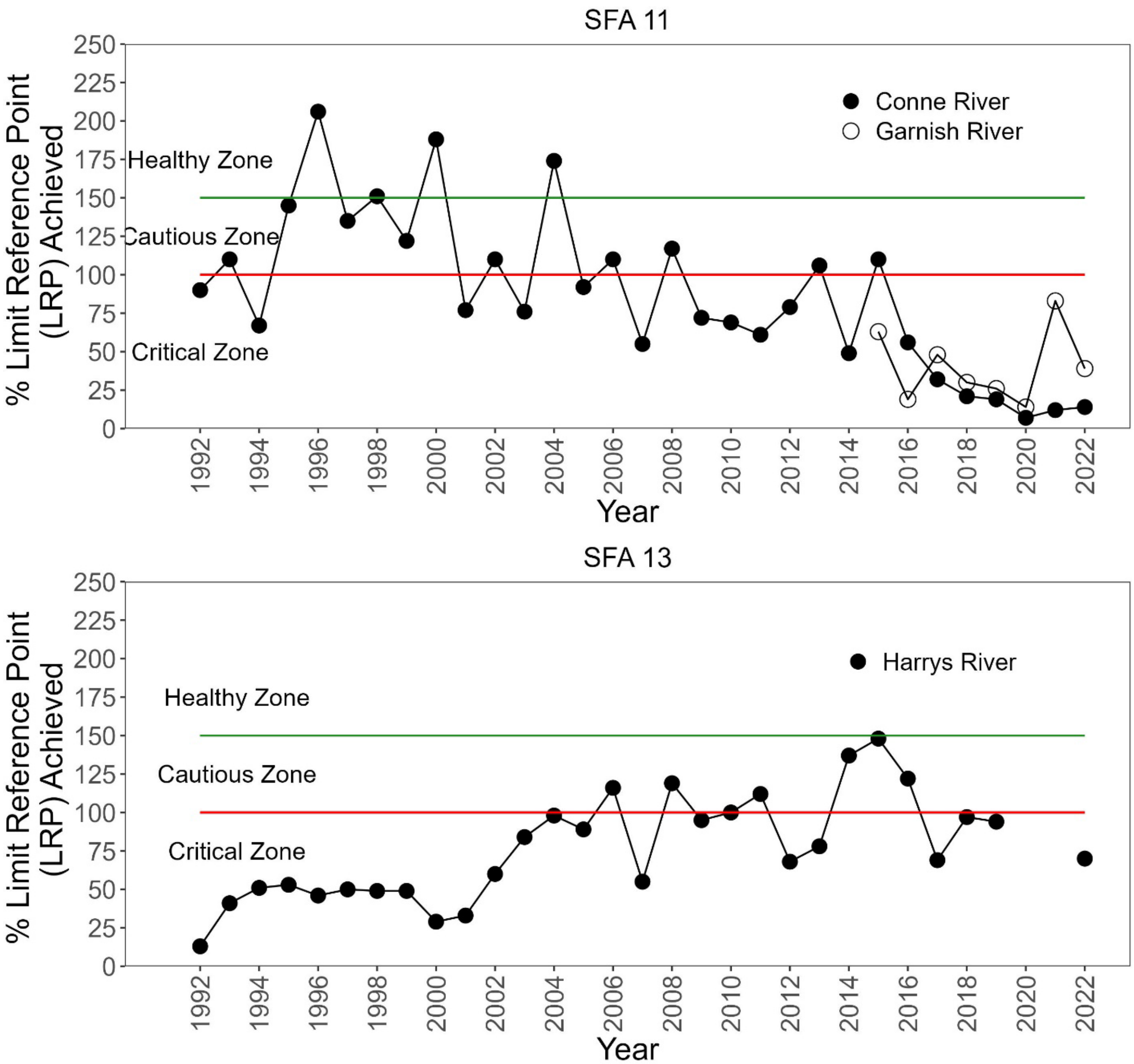


Figure 15. Percent limit reference point achieved on monitored rivers in SFA 11 (top panel) and SFA 13 (bottom panel) from 1992–2022. Estimates for 2022 are preliminary. Calculations are based on estimated egg depositions in each year compared to the LRP (red line) and upper stock reference point (USR; green line). The LRP and USR are equivalent to the 100% and 150% of the conservation egg requirement for each river, respectively.

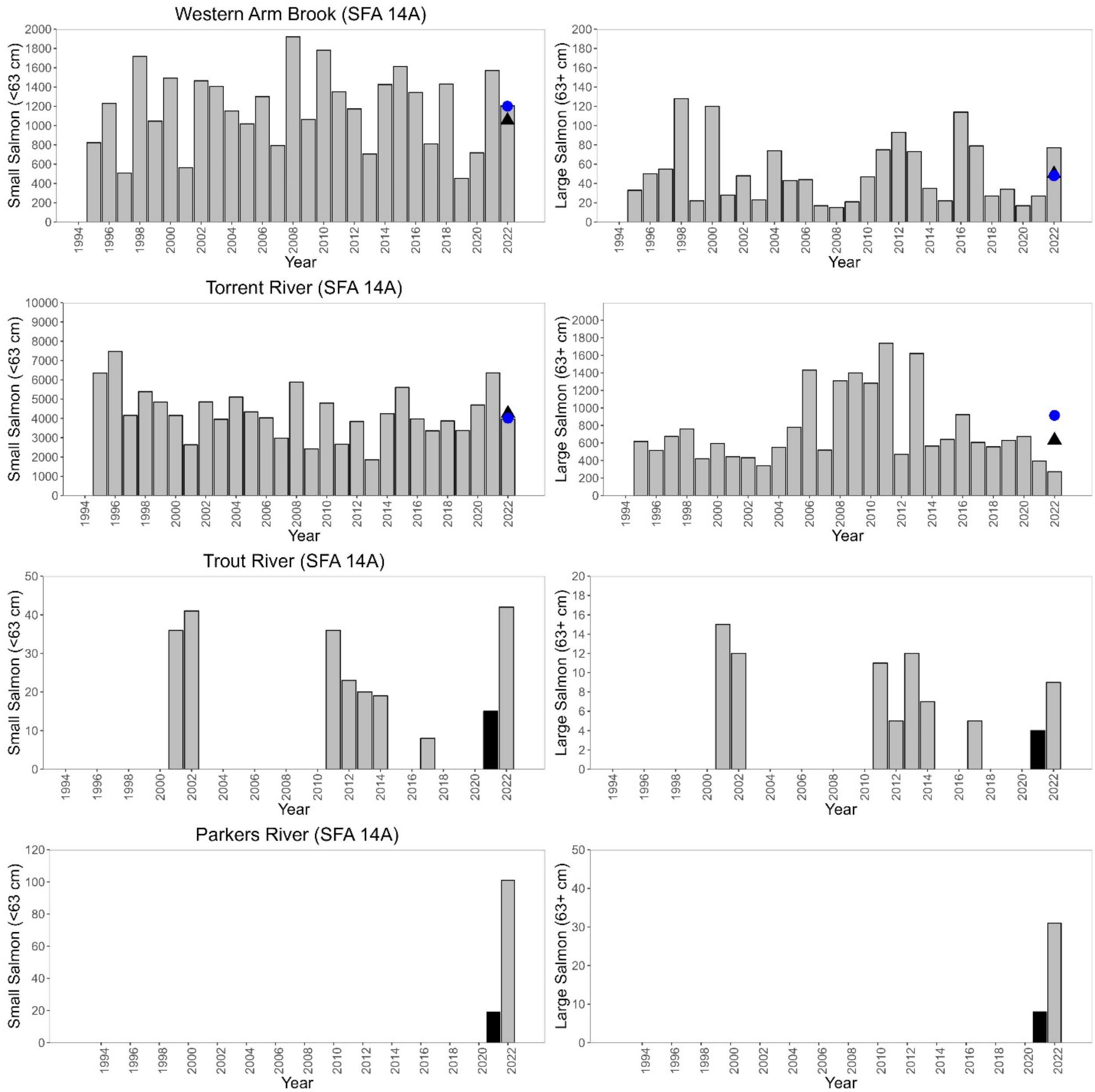


Figure 16. Total returns of small and large salmon to monitored rivers in SFA 14A, 1994–2022. The black triangles and blue circles represent the previous generation average (2016–21) and previous three generation average, respectively. Black bars represent incomplete counts (not used in averages). For comparisons of 2022 values to previous generation or previous three generation averages, see Tables 4–6.

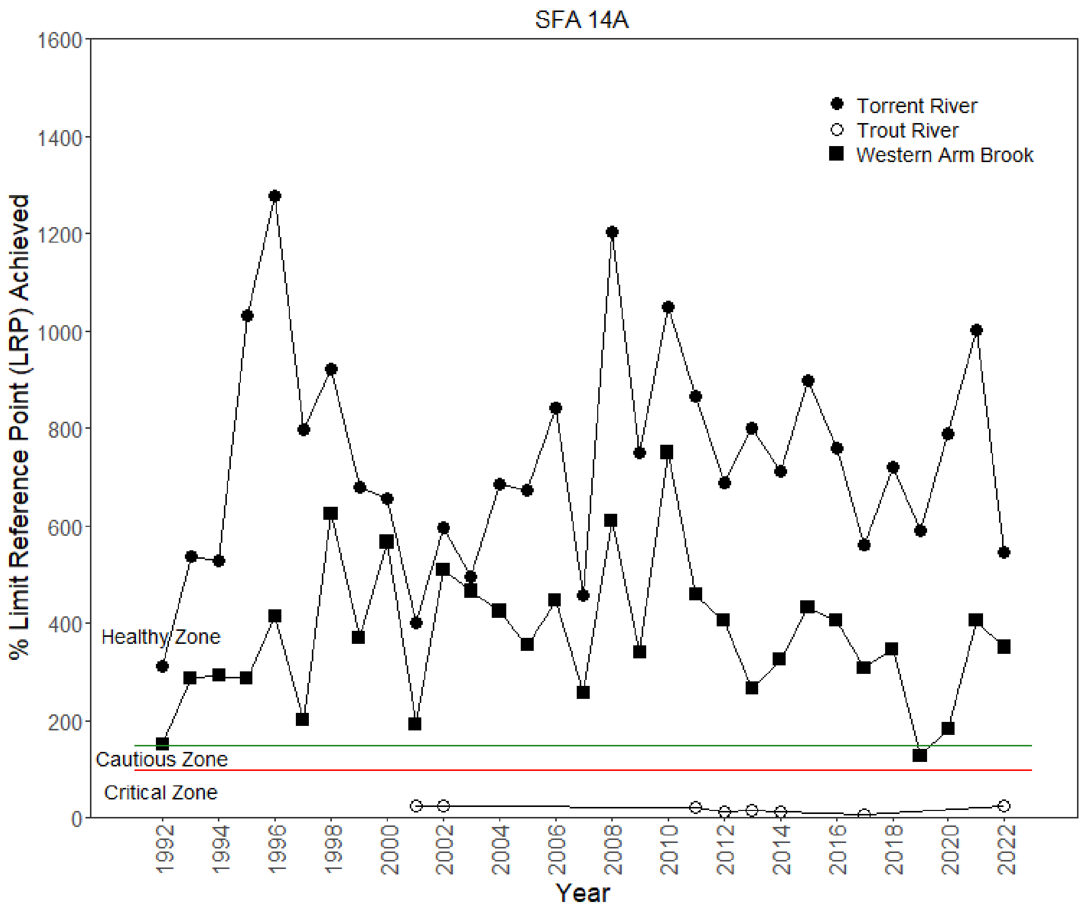


Figure 17. Percent limit reference point achieved on monitored rivers in SFA 14A from 1992–2022. Estimates for 2022 are preliminary. Calculations are based on estimated egg depositions in each year compared to the LRP (red line) and upper stock reference point (USR; green line). The LRP and USR are equivalent to the 100% and 150% of the conservation egg requirement for each river, respectively.

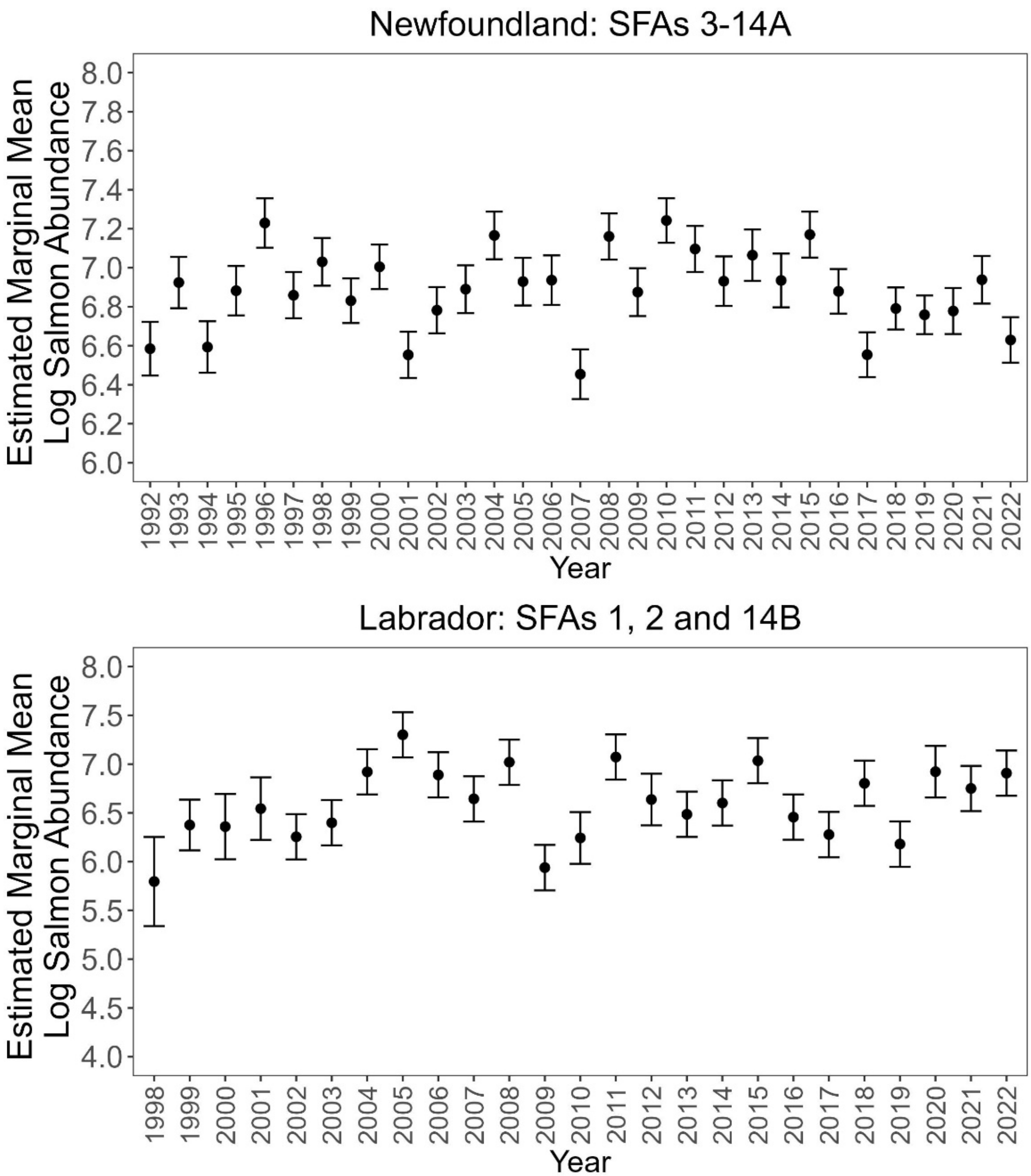


Figure 18. Estimated marginal mean log Atlantic Salmon abundance from negative binomial GLMs (log link function and year as a factor) applied to data from monitored rivers in Newfoundland (top) and in Labrador (bottom). Vertical lines represent ± one standard error. Each model only includes data since the commercial moratorium (1992 for Newfoundland and 1998 for Labrador).

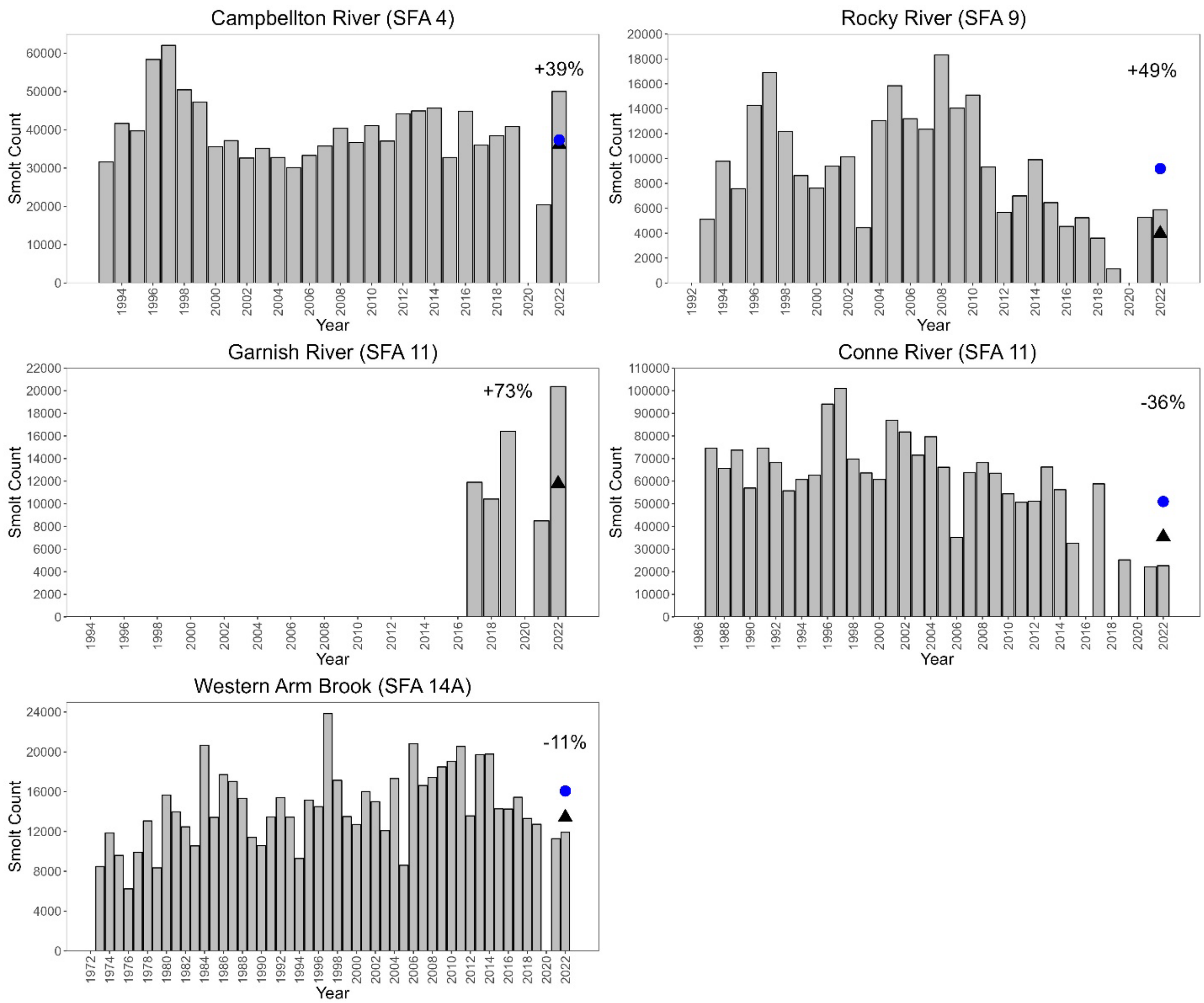


Figure 19. Smolt production on monitored Newfoundland Atlantic Salmon rivers in 2022. The black triangles and blue circles represent the previous generation average (2016–21) and previous three generation average, respectively. Smolt counts are not available for 2020 due to COVID-19 impacts on field 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 8.

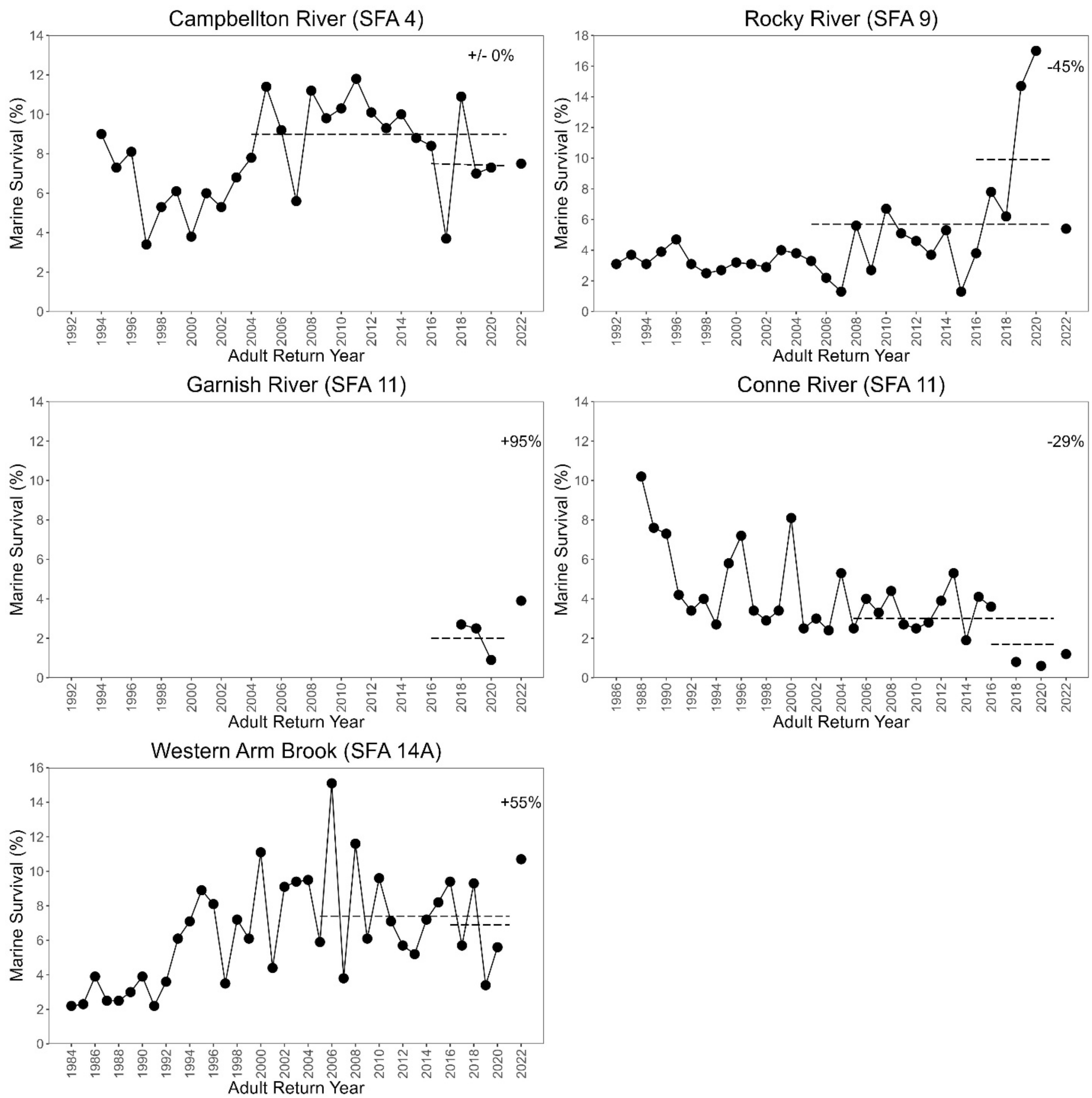


Figure 20. Marine survival rates of smolt to adult small salmon for monitored Newfoundland rivers. Survival rates have not been adjusted for marine exploitation during the commercial salmon fishery (prior to 1992) thus values represent survival of salmon back to the river. Horizontal dashed lines illustrate the previous generation average (2016–21) and previous three generation average where sufficient data are available. Percent change values (inset) reflect comparisons of 2022 smolt abundance to the previous generation average. For comparisons to previous three generation averages, see Table 9. The marine survival estimate for Campbellton River is considered a minimum estimate because the count of returning small salmon is considered incomplete (see text for details).

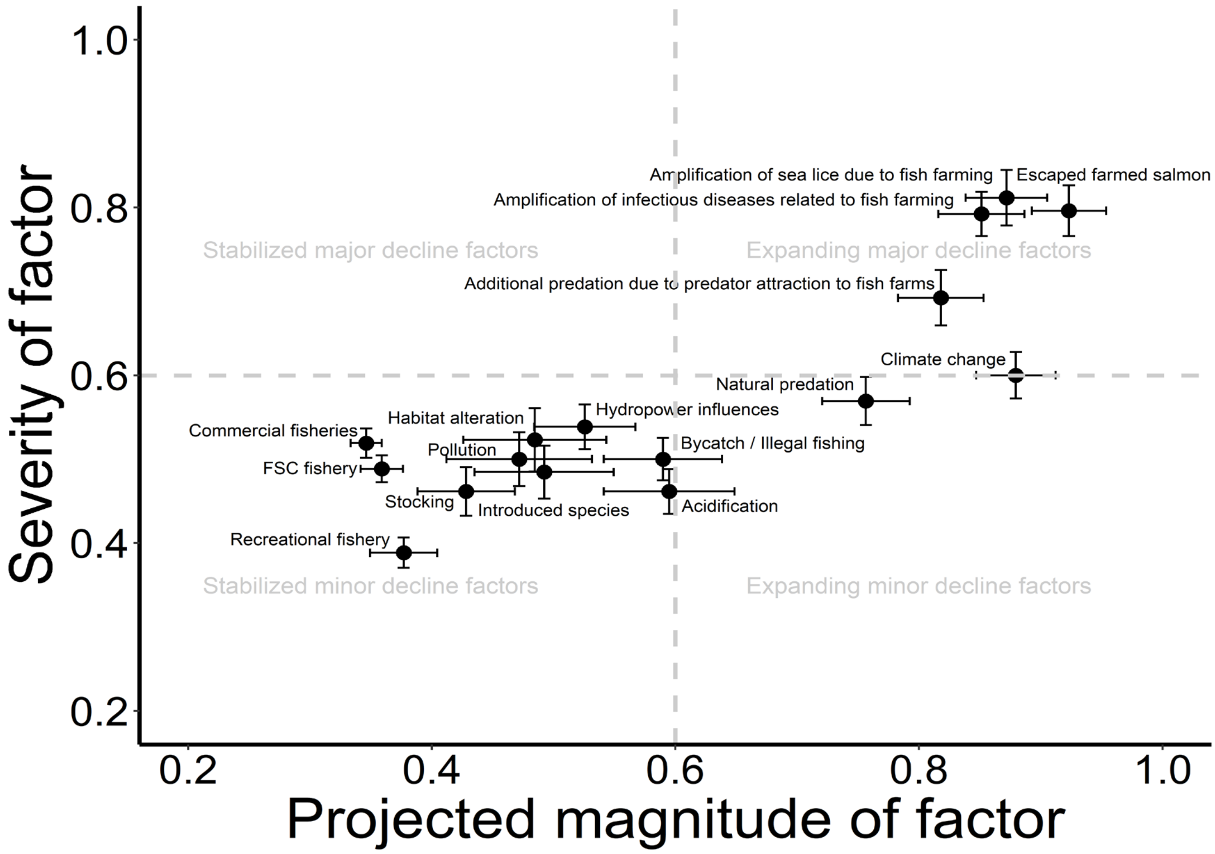


Figure 21. Ranking of potential decline factors to the Conne River Atlantic Salmon population as scored by expert survey respondents. Solid circles represent the mean score ± standard error for each factor. Plot quadrats (separated by dashed lines) represent the four categories of potential threats. 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).

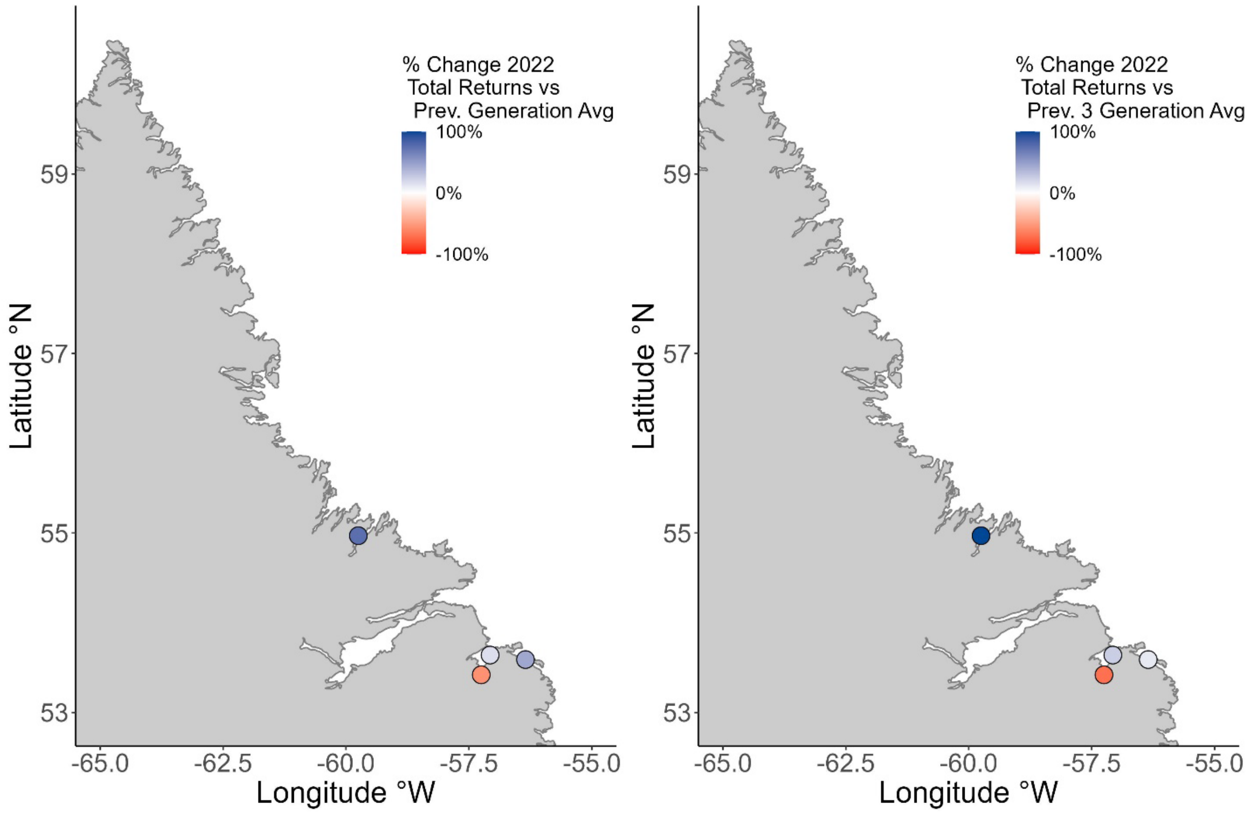


Figure 22. The percent change in 2022 total returns compared to the average returns over the previous generation (left panel) and previous three generations (right panel) for four monitored Atlantic Salmon populations in Labrador. The previous generation time period is seven years for Labrador rivers. The previous three generation time period is specific to each river (19–20 years for most 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.

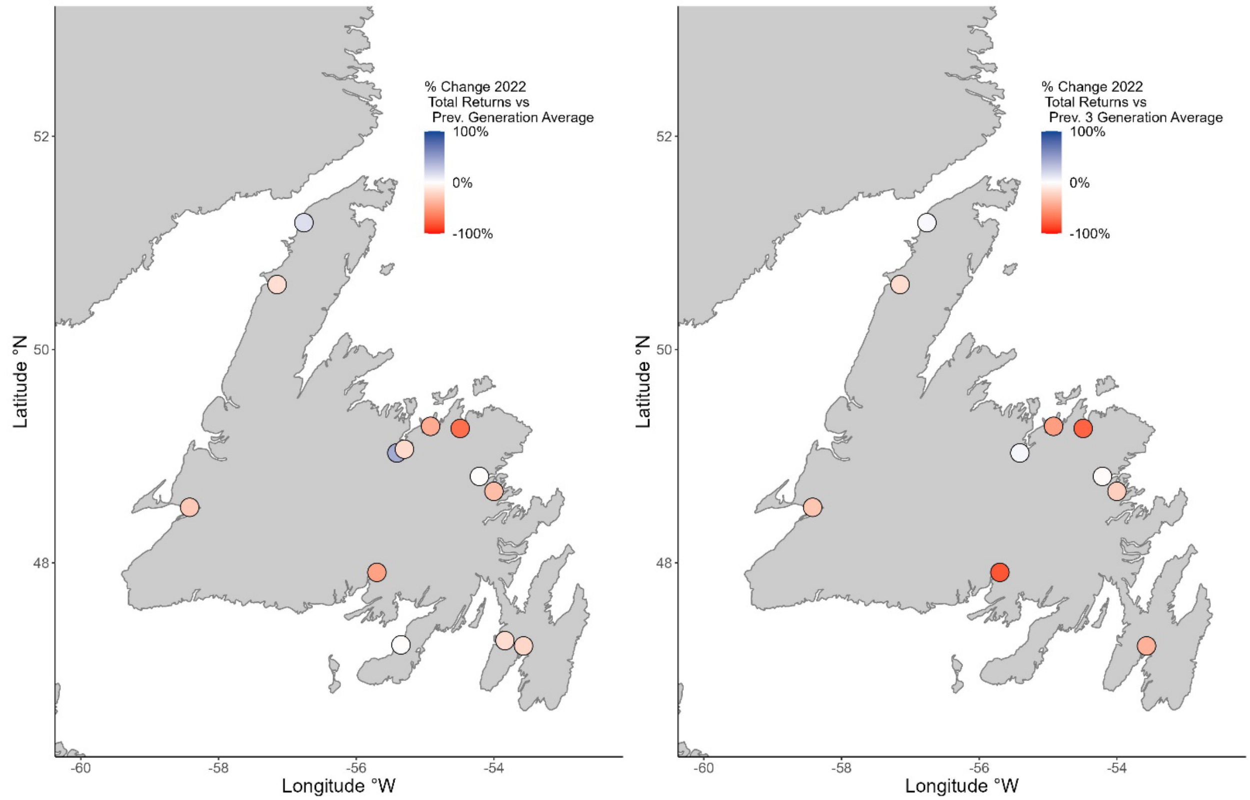


Figure 23. The percent change in 2022 total returns compared to the average returns over the previous generation (left panel) and previous three generations (right panel) for four monitored Atlantic Salmon populations in Newfoundland. The previous generation time period is six years for Newfoundland. The previous three generation time period is specific to each river (16–18 years for most Newfoundland). 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.

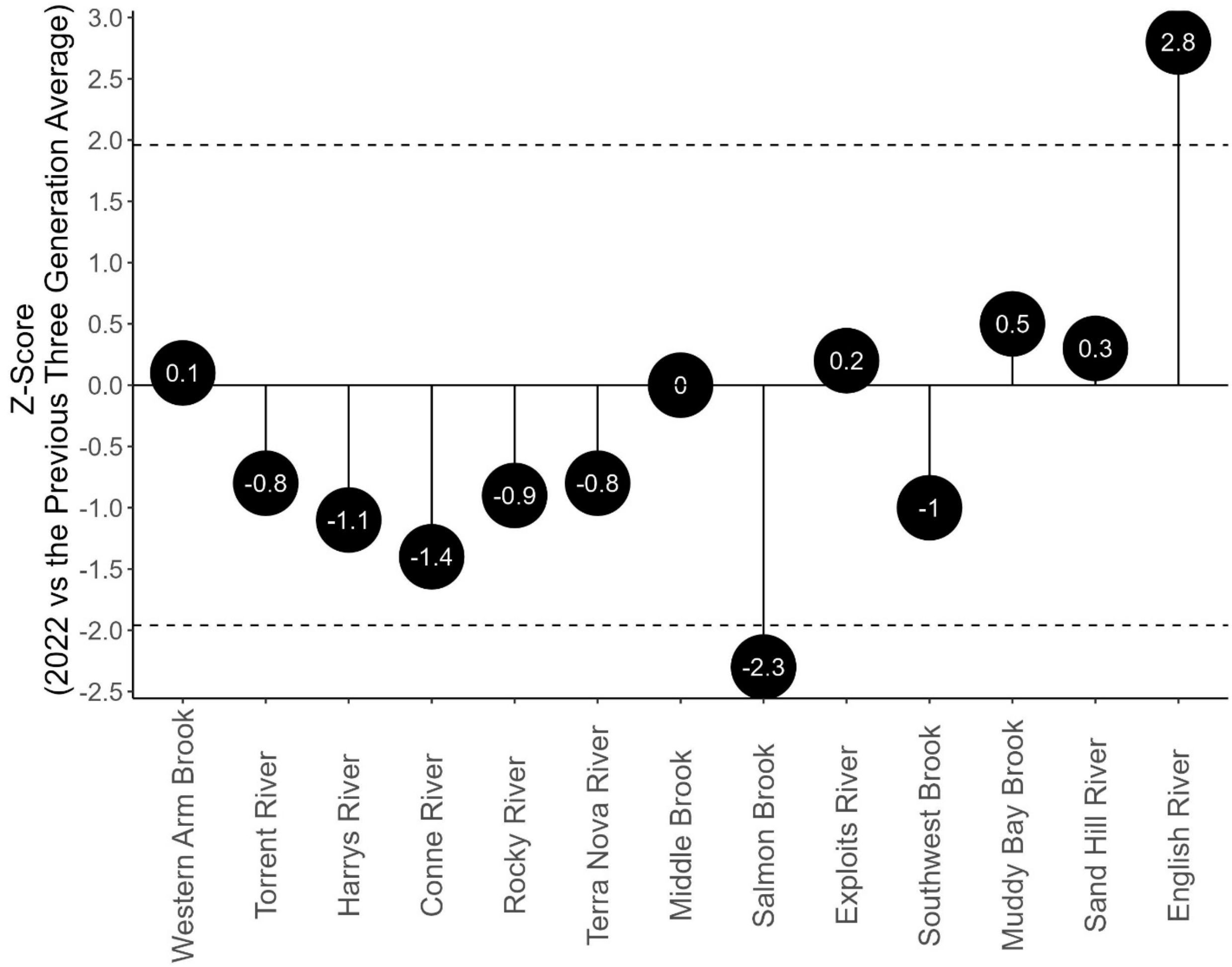


Figure 24. Z-scores of total Atlantic Salmon returns on monitored rivers in 2022 compared to their river-specific previous three generation average. The value shown for each river represents the number of standard deviations 2022 returns are from the mean over the previous three generation time period. Campbellton River was not included due to an incomplete count in 2022. Horizontal dashed lines represent approximate 95% confidence intervals (±1.96).

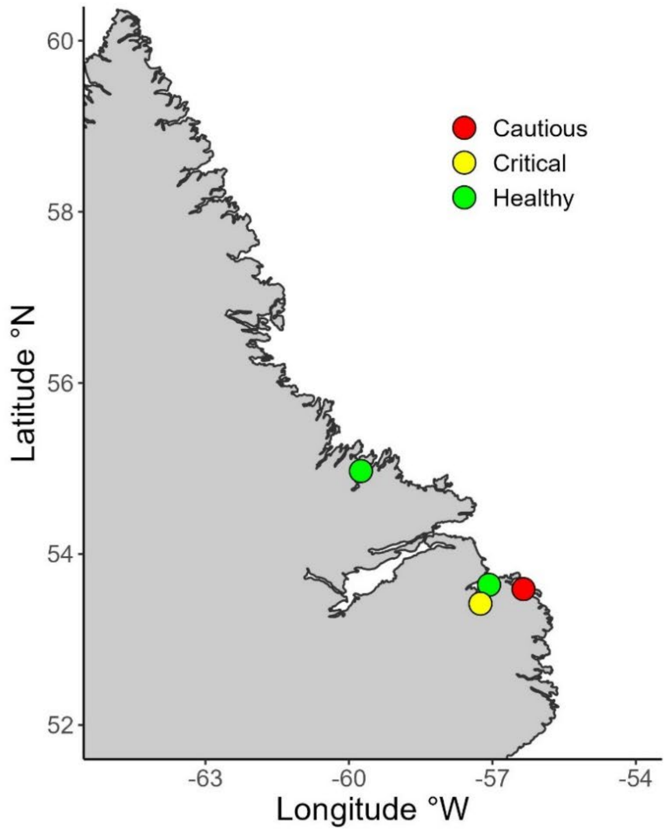


Figure 25. Map of monitored Atlantic Salmon rivers in Labrador during 2022 coloured by their estimated stock status zone as per the Precautionary Approach (DF0 2015). Designation of a population within a stock status zone is based on comparing the estimated egg depositions in 2022 to the river-specific 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.

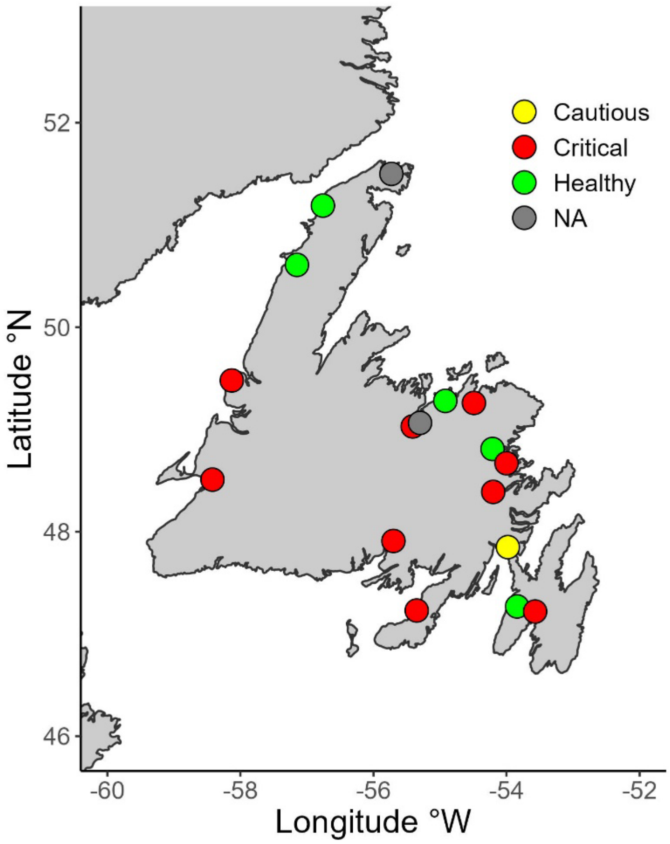


Figure 26. Map of monitored Atlantic Salmon rivers in Newfoundland during 2022 coloured by their estimated stock status zone as per the Precautionary Approach (DF0 2015). Designation of a population within a stock status zone is based on comparing the estimated egg depositions in 2022 to the river-specific 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. The status of Parkers River in 2022 is unknown because there is no available LRP for this population. No stock status zone is designated for Rattling Brook due to its recent enhancement activities.