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2024 STOCK STATUS UPDATE OF ATLANTIC SALMON IN NEWFOUNDLAND AND LABRADOR

CONTEXT

This Science Response Report presents results from the November 18-19, 2024, regional peer review regarding the Stock Status Update of Atlantic Salmon in Newfoundland and Labrador (NL), which includes Salmon Fishing Areas (SFAs) 1, 2, and 14B (Labrador) and 3 to 14A (Newfoundland) (Figure 1). Fisheries Management will use the advice from this SRP to inform Atlantic Salmon management plans in 2025 and beyond.

BACKGROUND

Species Biology

There are 15 Atlantic Salmon (*Salmo salar*) management areas, known as 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 (greater than 95% of samples taken since 2000) and four to five years in Labrador (greater than 83% of samples taken since 2000) prior to undergoing smoltification and migrating to sea as smolts (DFO 2020a). Spawning populations in NL consist of varying proportions of small (fork length [FL] less than 63 cm) and large (FL greater than or equal to 63 cm) adult salmon (DFO 2023a). For most rivers in Newfoundland (SFAs 3–12 and 14A), small adult salmon are mostly female (60–92% across sampled rivers) grilse (one-sea-winter [1SW] salmon), that have spent one year at sea before returning to spawn for the first time. Large adult salmon in Newfoundland rivers are composed mainly of repeat-spawning grilse that 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 components that contain maiden fish that have spent two (two-sea-winter [2SW] salmon) or more years (multi-sea-winter [MSW] salmon) at sea before returning to spawn.

Depending on the river location, Atlantic Salmon grilse migrate through the Gulf of St. Lawrence and Strait of Belle Isle, or along southern and eastern Newfoundland to the Labrador Sea, to overwinter (Reddin et al. 2006). Multi-sea-winter Atlantic Salmon typically migrate further north to West Greenland (Bradbury et al. 2016; Bradbury et al. 2021). During the early phase of their marine migration, post-smolts generally feed on krill (*Euphausiidae*), fish larvae, planktonic amphipods, and insects (Andreassen et al. 2001; Hellenbrecht et al. 2023). As post-smolts grow larger, their diet transitions to primarily fish, including capelin and sand lance (Lear 1972; Dutil and Coutu 1988; Rikardsen and Dempson 2010; Dixon et al. 2019; Power et al. 2023). The run timing for returning salmon in freshwater is influenced by climate conditions in the NL region, 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).

Atlantic Salmon Fisheries

In Newfoundland, the Miawpukek First Nation holds an Indigenous Food, Social, and Ceremonial (FSC) communal salmon fishing licence, but has chosen not to harvest salmon under this licence since 1997 due to conservation concerns. Indigenous FSC fisheries for Atlantic Salmon do occur in Labrador under communal licences. Labrador also has a resident fishery for Brook trout (*Salvelinus fontinalis*) and Arctic Charr (*Salvelinus alpinus*) that has a permitted retention of three salmon bycatch. Analysis of samples collected in this fishery consistently suggest that the salmon captured annually are predominantly from Labrador rivers (Bradbury et al. 2015; ICES 2024). Estimates of salmon harvest from the coastal Labrador fisheries in 2024 were unattainable at the time of the science response meeting, largely due to the shift in timing to the fall.

The 2024 recreational Atlantic Salmon angling season opened on June 15 and closed on September 15 for all Labrador rivers, while it opened on June 1 and closed on September 7 for all Newfoundland rivers. 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). Seasonal retention limits were set at one fish on Class 2 rivers and two fish on Class 4, 6, and unclassified rivers, with daily catch and release limits of three fish on all rivers. When water temperatures reach or exceed 20°C for two of three consecutive days, recreational angling restrictions may be implemented, allowing fishing only in the morning (from one hour before sunrise to 10 AM). This protocol is in place to reduce angling pressure on migrating salmon and to reduce the impact of warm water temperatures on health and survival (Van Leeuwen et al. 2020; Keefe et al. 2022; Van Leeuwen et al. 2023).

ANALYSIS AND RESPONSE

Reference Points

The Precautionary Approach (DFO 2006) identifies two reference points for managing fisheries stocks: Limit Reference Point (LRP) and Upper Stock Reference (USR). The statuses of NL Atlantic Salmon populations are assessed relative to these two reference points, defined by estimated egg depositions (DFO 2015). Conservation egg requirements for Atlantic Salmon were previously established for individual rivers in SFAs 1–2 in Labrador based on 1.9 eggs per m^2 of river rearing habitat; the Straits Area of NL (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 for Atlantic Salmon in the NL region are set at 100% and 150% of the previously defined, river-specific conservation egg deposition rate, respectively (DFO 2024).

Estimates of egg depositions by small and large salmon spawners on monitored rivers in 2024 were derived and compared to each river-specific LRP and USR to designate a stock status zone. Contemporary estimates of adult salmon sex ratio obtained from DNA samples are used when calculating egg depositions for rivers, where available (Robertson et al. 2024). Populations with estimated egg depositions below the river-specific LRP are in the Critical Zone, populations with estimated egg depositions above the USR are in the Healthy Zone, and those between the LRP and USR are in the Cautious Zone. Stock status could not be determined for Parkers River (SFA 14A) because there is no available estimate of fluvial rearing habitat area on this watershed; thus, no conservation egg requirement (nor LRP) can be established (Reddin et al. 2010). Stock status also could not be determined for Rattling Brook due to contemporary enhancement activities with salmon from Exploits River. In addition, counting facility washouts impacted three monitored rivers in 2024 to the extent that no stock status designation could be calculated: 1) Northwest River (SFA 5); 2) Northeast River, Placentia (SFA 10); and 3) Garnish River (SFA 11). Consequently, stock status zones were only designated for 17 of 22 monitored Atlantic Salmon populations in NL during 2024 (Table 1).

Methods

The 2024 status of Atlantic Salmon stocks within NL (SFAs 1–14B) was assessed using abundance data collected from 22 salmon monitoring facilities via fish counting fences and fishways (Figure 1) and an in-river snorkel survey for Harrys River (in SFA 13) in fall of 2024. There are no contemporary abundance data for Atlantic Salmon populations in SFAs 3, 6, 7, 8, 12, and 14B. River-specific estimates of recreational Atlantic Salmon catch and harvest (Veinott and Cochrane 2015) in 2024 were not available at the time of this assessment due to the short time interval between the end of the angling season and the assessment date. The average number of retained and released fish over the previous generation (2017–23 for Labrador rivers and 2018–23 for Newfoundland rivers) was used as a proxy when deriving estimates of spawners and egg depositions on monitored rivers in 2024. For rivers where estimates of harvest and catch downstream of the counting facility are available, these are added to the counts to estimate the total number of returning adults. If estimates of catch and harvest are available upstream of the counting fence, they are subtracted from the counts to estimate the number of adult Atlantic Salmon that escaped the recreational fishery and were available to spawn in fall 2024. DFO Science assumes a catch-and-release mortality rate of 10% when calculating estimates of total returns, total spawners, and egg depositions (Van Leeuwen et al. 2020; Keefe et al. 2022; DFO 2024; Van Leeuwen et al. 2024a). Egg depositions are derived from estimates of small and large salmon spawners, sex ratio, fecundity, and size, which are compared to the river-specific LRP and USR to designate a status each year.

The estimated number of returns on each river in 2024 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 20–22 years for Labrador rivers. Changes of less than 10% are considered to be non-significant and returns are reported as being similar to the comparative average. For rivers with sufficient data, time series of total returns were modelled over the previous three generations with a negative binomial generalized linear model (GLM) in R (R Core Team 2024; version 4.4.0) using the MASS package (Venables and Ripley 2002). In recent years, extreme environmental conditions caused counting fence washouts on a few rivers in Newfoundland. In some cases (see: DFO 2022; 2023a; 2024), washout timing and duration, along with historical daily Atlantic Salmon count data, are used to estimate the proportion of salmon (plus/minus 95% confidence intervals) via bootstrapping, with adjustments applied. These adjusted values represent salmon returns for these rivers in years affected by washouts and are used to estimate returns, spawner counts, and egg deposition, as well as in time series modeling.

Regional trends in adult Atlantic Salmon abundance on monitored rivers were assessed by modeling time series of total returns across monitored rivers using a negative binomial GLM with a log link function, considering year and river as factors (Dempson et al. 2004). The estimated marginal mean log abundance from this model serves as a Salmon Abundance Index to examine temporal patterns in the relative abundance of Atlantic Salmon on monitored rivers across the NL region. These estimates should not be used to infer actual Atlantic Salmon abundance in the NL region. Returns have been modelled separately for Newfoundland since

1992 and Labrador since 1998, which are the years when commercial moratoriums began in each area. The estimated marginal mean log abundances (plus/minus standard errors) were presented for each year for NL. The error bars represent variability in counts across monitored rivers, which typically differ by orders of magnitude (from 100s to 10,000s).

The abundance of out-migrating Atlantic Salmon smolts was monitored on six rivers in Newfoundland in 2024 (Table 2; Figure 1). In 2024, the Freshwater Alexander Bay Ecosystem Corporation and the Atlantic Salmon Federation derived a smolt abundance estimate for Terra Nova River (SFA 5), by deploying a rotary screw trap and using mark and recapture methods on smolts migrating downstream. Time series of smolt abundance on all rivers, except for Terra Nova River and Garnish River, were modelled over the previous three generations with a negative binomial GLM using the MASS package in R (Venables and Ripley, 2002). Estimates of marine survival in the adult return year are calculated for monitored rivers with smolt and adult counting facilities by dividing the small salmon return estimate in one year by the number of out-migrating smolts enumerated the year before, 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 here. Trends in marine survival over the previous three generations were modelled for each river with a beta GLM using the *betareg* package in R (Cribari-Neto and Zeileis 2010).

Total Returns

Total returns of adult Atlantic Salmon in 2024 were below the previous generation average on 12 of 15 (or 80%) monitored rivers with sufficient data for this comparison, seven of which (or 47%) declined by more than 30% (Table 1; Figures 2–5). Atlantic Salmon returns to Sand Hill River (SFA 2), Rattling Brook (SFA 4), and Conne River (SFA 11) were above the previous generation average (Table 1; Figure 2). Total returns to Campbellton River (SFA 4) and Rocky River (SFA 9) were at a record low in 2024 (Figures 4–5), the latter of which recorded just one large salmon, the first one recorded on Rocky River since 2021 (DFO 2024). Although counting facility washouts resulted in partial adult counts on Garnish River and Northeast River in Placentia, available data suggests that returns to both rivers in 2024 were likely below average.

Of 14 monitored rivers with sufficient data over the previous three generations, total returns in 2024 were below average on 13 of 14 rivers (or 93%), 11 of which (or 79%) declined by more than 30% (Table 1; Figure 2) and 7 (or 50%) by more than one standard deviation (Figure 6). Total returns to Sand Hill River were similar to the previous three generation average (or -4%) in 2024 (Figure 3).

Over the previous three generations, total Atlantic Salmon returns have declined significantly (GLM, $p<0.05$) on Southwest Brook (SFA 2) by 82% (95% Confidence Intervals, CIs: 64%; 95%), Rocky River (SFA 9) by 72% (95% CIs: 42%; 86%), Conne River (SFA 11) by 89% (95% CIs: 72%; 95%), and Western Arm Brook (SFA 14A) by 44% (95% CIs: 1%; 66%) (Figures 3–5).

Although returns to Conne River increased in 2024, they remain well below the previous three generation average (Figures 2–4), although represent a slight improvement following consistent declines in returns over the previous three decades (Figure 4: Dempson et al. 2024; DFO 2024). The cause of the declining trend in salmon returns to Rocky River (SFA 9) is poorly understood. Rocky River was not a historical salmon river due to a 8 m waterfall at the mouth of the river. The fishway at the waterfall was made operational in 1987, and salmon eggs, fry, and adults were transplanted from Little Salmonier River (SFA 9) between 1984 and 1996 (Mullins et al. 2003). Rocky River is the only monitored Atlantic Salmon population in SFA 9; thus, it is difficult to determine if neighboring wild populations in St. Mary's Bay, NL, are trending in a similar direction. For example, total returns have declined significantly over the past three generations on Southwest Brook in SFA 2 (Southern Labrador), but returns to the other two monitored rivers in that SFA have not (Figure 3). The declining trend on Western Arm Brook (SFA 14A) and well-below average returns on Torrent River and Harrys River in 2023 and 2024 reflect a larger pattern of declining trends in Atlantic Salmon returns to populations in SFAs 15, 16, and 17 (DFO 2023b), many of which also migrate through the Gulf of St. Lawrence on their way to the Labrador Sea (Chaput et al. 2019).

Total returns to English River (SFA 1) have increased by approximately 222% (95% CIs: 74%; 496%) over the previous three generations (2004–24) (Figure 3). This rate of increase is much lower than modeled parameter estimates reported in recent years for this river; however, adult salmon abundance reached record highs in 2022 and 2023 in this watershed (DFO 2024; DFO In Press[1]).

Salmon Abundance Index

Estimated salmon abundance in Newfoundland has declined since 2015 after a period of relative stability (Figure 7). This is representative of relatively poor returns observed on several monitored Atlantic Salmon rivers in Newfoundland in recent years (DFO 2020a; 2020b; 2022; 2023a; 2024). Returns to Newfoundland rivers in 2024 were similar to 2023, but were below average on more rivers and in many watersheds in 2024, and the magnitude of decline was larger. The estimated salmon abundance in both years are the lowest in the time series (Figure 7).

In Labrador, the estimated salmon abundance in 2024 was below that of 2020–23 and slightly higher than in 2019, when declines in returns were observed on English River, Sand Hill River, and Southwest Brook (DFO 2020a). The lower estimated abundance in 2024 for Labrador is a result of large declines in adult abundance observed at counting facilities on English River, Southwest Brook, and Muddy Bay Brook (Table 1; Figure 7). Arctic Charr dominate the fish composition of both the English River and Muddy Bay Brook. On the English River, Arctic Charr abundance shows a significant positive relationship with Atlantic Salmon abundance over the time series (GLM, $p<0.001$). In 2024, Arctic Charr counts were below the time series average in both rivers. This decline mirrors the trend observed in Atlantic Salmon abundance in 2024 across most monitored rivers in Labrador.

Indicators of the Stock Status (% LRP Achieved)

In 2024, the percentage LRP attained (based on egg depositions) and stock status zone was estimated for 17 of 22 monitored Atlantic Salmon populations. Estimated Atlantic Salmon egg depositions are in the Healthy Zone on two of 17 monitored rivers (or 12%): English River in Labrador and Torrent River in Newfoundland (Table 1; Figure 8). This is the lowest number of rivers in the Healthy Zone in the history of Atlantic Salmon assessments in the NL region. Estimated egg depositions were in the Cautious Zone on Muddy Bay Brook in Labrador and five Newfoundland rivers (Table 1; Figure 8). Estimated egg depositions were in the Critical Zone on two Labrador rivers and seven Newfoundland rivers (Table 1; Figure 8). Overall, 53% of all assessed rivers were below the LRP in 2024 (Table 1).

Egg depositions for Conne River in 2024 were estimated at 30% of the LRP, which is the highest since 2017, and is a two-to-four fold higher than estimates in 2020–23, but still

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[1] DFO. In press. Stock Assessment of Newfoundland and Labrador Atlantic Salmon in 2023 (SFA 1–14B). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep.

considered to be in the Critical Zone. Egg deposition estimates reached a record low on Rocky River in SFA 9 (9% of LRP) and tied the record low on Campbellton River in SFA 4 set in 2002 (138% of LRP).

Smolt Production and Marine Survival

In Terra Nova River, the rotary screw trap capture efficiency, estimated from the deployment of Passive Integrated Transponder (PIT), streamer, and acoustic tags, is estimated to be 4%, and smolt abundance is estimated at 27,727 (95% CIs: 20,468, 39,732) (Table 2; Figure 9). This abundance estimate may be an underestimate due to premature removal of the trap to fix equipment issues.

Smolt production in 2024 was below the river-specific, previous generation average on Conne River (57%), Campbellton River (30%), Rocky River (43%), and Western Arm Brook (16%), but was above average on Garnish River (30%). Smolt production in 2024 was below the river-specific three generation average for Conne River (14%), Campbellton River (38%), and Western Arm Brook (36%) (Figure 9), but was above average for Rocky River (23%). The three generation average for Garnish River is not available. All four rivers with sufficient data to compare 2024 smolt abundance to the previous three generation average had negative z-scores in 2024, three rivers by more than one standard deviation (Figure 6). Over the previous three generations (2006 or 2007–24), model estimates suggest that smolt abundance has declined significantly (GLM, $p<0.01$) for Western Arm Brook by 46% (95% CIs: 34%; 55%), Conne River by 72% (95% CIs: 61%; 80%), and Rocky River by 77% (95% CIs: 56%; 87%) (see Figure 9).

Marine survival is the primary driver of Atlantic Salmon returns (Chaput et al. 2012; Pardo et al. 2021). In contrast populations in other jurisdictions of North America (see: ICES Working Group on North Atlantic Salmon), Atlantic Salmon returns to Newfoundland rivers are dominated by 1SW grilse that are less than 63 cm in length (DFO 2024; ICES 2024). Estimates here represent survival of post-smolt salmon from 2023 to returning adult salmon in 2024. Due to a washout of the Campbellton River counting fence in 2023, the estimate shown for this river in 2024 (7.8%) is considered an overestimate. Marine survival for this population in 2024 is likely similar to short- and long-term averages (Table 2; Figure 10). In contrast, the 2024 estimate for Garnish River (1.2%) is considered an underestimate due to two adult counting fence washouts in 2024. Survival at sea for this population in 2024 is likely within the range observed in recent years (1–3%). The average marine survival in 2024 for Rocky River (SFA 9), Conne River (SFA 11), and Western Arm Brook (SFA 14A) is 3.6%. Estimates are below average for Rocky River (54%) and Western Arm Brook (46%) (Figure 10). Over the previous three generations (2007–24), estimated marine survival has declined significantly (GLM, $p<0.01$) for Conne River by approximately 52% (Figure 10). There are no significant trends in survival at sea among the other populations.

Contemporary Atlantic Salmon Returns to NL

After relatively strong returns to Newfoundland rivers from 2010–15, adult salmon returns to insular Newfoundland were below average from 2017–20 and 2022–24 (Figure 7). For the past Atlantic Salmon generations (6–7 years), stock assessments by DFO Science reported several rivers below average annually (DFO 2020a; 2020b; 2023a; 2024), with at least half of the rivers in the Critical Zone in most years. Since 2022, record low or near-record low returns have been observed at least once on monitored rivers in SFAs 2, 5, 9, 13, and 14A (DFO 2023a; DFO 2024; DFO In Press). In this time, estimated egg depositions on monitored rivers that typically exceed both the LRP and USR, such as English River (SFA 1), Middle Brook (SFA 5), Northeast River in Placentia (SFA 10), and Western Arm Brook (SFA 14A), had drastic declines in estimated egg depositions in 2023 and/or 2024, failing to exceed one or both reference points for the first time in over a generation or more.

Atlantic Salmon returns to NL rivers are thought to be largely influenced by survival at sea (Chaput et al. 2012, Pardo et al. 2021), which could be driven by a variety of physical and biological factors, such as temporal and spatial distribution of predators and prey (Strøm et al. 2019), sea surface temperatures (Reddin et al. 2006; Strøm et al. 2017), and for southern Newfoundland populations, anthropogenic impacts such as aquaculture (Bradbury et al. 2020a; Dempson et al. 2024). There are 407 known Atlantic salmon populations in the NL region spread across a wide spatial area. These populations vary from each other in the freshwater and marine environmental conditions they experience, as well as the degree of spatial and temporal overlap in their migrations (Chaput et al. 2012; Pardo et al. 2021). Consequently, the complex life history and migratory behavior of Atlantic Salmon make it very difficult to discern specific drivers behind declines in salmon abundance observed in recent years, including in 2024.

Atlantic Salmon metabolism, physiology, and behaviour are directly influenced by ambient water temperature (Breau et al. 2011; Bøe et al. 2019; Thorstad et al. 2021). Sea surface temperatures around NL from 2021–23 were the warmest on record (DFO 2023c; Cyr et al. 2024) and well above long-term averages, although the implications for Atlantic Salmon populations remain uncertain. Research on NL salmon populations suggests that the behaviour of smolts and kelts is influenced by thermal conditions in coastal habitats (Reddin et al. 1999; Bøe et al. 2019). Elevated marine temperatures could have negative impacts on growth of Atlantic Salmon post-smolts during the early phase of their migration (Friedland et al. 2003). However, warmer seas may benefit Atlantic Salmon metabolism and growth at sea (Friedland and Todd 2012; Strøm et al. 2023) and may primarily impact Atlantic Salmon through changes in the spatio-temporal distribution of predator and prey species (Strøm et al. 2023).

Water temperature is recorded and analyzed across five rivers in Labrador (i.e., Hunt River, Char Brook, Shinney's River, Eagle River, and Sand Hill River) and 43 rivers in Newfoundland in 2024 (Table 3). In Labrador, 18 ± 2.1 % of recorded hours had temperatures above 20°C in July 2024, compared to 64 ± 14% recorded hours in July 2023 and 5.6 ± 5.2% recorded hours in July 2022. In August 2024 in Labrador, 2.7 ± 1.8 % of hours were above 20°C compared to 6.8 ± 3.8 % hours in August 2023 and 11.2 ± 5.0% hours in August 2022. In 2023 in Labrador, 9.1 ± 5.7% of recorded hours in July 2023 were above 25°C, while only 0.2% of recorded hours were above 25°C in July 2024, and average maximum daily temperature was 18.1 ± 2.4°C in July and 17.6 ± 1.7°C in August.

Across Newfoundland rivers in June there were 19.2 ± 12.3% recorded hours with temperatures above 20°C , in July 57.1 ± 24.3% recorded hours with temperatures above 20°C and 9.5 ± 4.3% recorded hours with temperatures above 25°C , and in August 56.3 ± 10.4 % recorded hours with temperatures above 20°C and 5.3 ± 2.3% recorded hours with temperatures above 25°C. In contrast, percent time above 20°C in 2023 across Newfoundland rivers ranged from 14% in June to 75% in July, and percent time above 25°C ranged from 4.3% in June to 14.6% in July. Average maximum daily temperature in 2024 across Newfoundland rivers was 22.9 ± 2.0°C in July and 22.5 ± 1.4°C in August. Water temperatures were consistently high across the region except for the Avalon Peninsula, which was 1–3°C cooler than the rest of the Island (Table 3).

The hot and dry conditions during summer months in recent years (Cyr et al. 2024; Geissinger et al. 2024) could have negative consequences on freshwater survival of salmon in the NL region. 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). Water temperature and level influence the timing of phenological processes, egg and parr survival to smoltification, survival of returning adults to spawning, and access to spawning habitat (Linnansaari and Cunjak 2010; Breau 2013; Rooke et al. 2019; Van Leeuwen et al. 2020; Thorstad et al 2021; Gillis et al. 2023). Declines in smolt abundance have been observed over the previous three generations (17–18 years) on monitored rivers in southern Newfoundland (Rocky River in SFA 9 and Conne River in SFA 11). Smolt abundance on Campbellton River (SFA 4) has been well below previous one-generation and three-generation averages in 2022 and 2024 (Figure 9). Fewer smolts migrating to sea could impact the abundance of adults returning in subsequent years. However, with smolt counts available on only five Newfoundland rivers (and none in Labrador), combined with a lack of contemporary information on juvenile abundance and condition, it is difficult to determine with certainty the degree to which freshwater temperatures may have impacted juvenile and adult survival and abundance regionally. DFO Science is conducting research on the thermal tolerance of different populations in the province to improve its understanding of the degree of thermal stress that juvenile salmon are experiencing in the region, as well as to investigate the degree of variation in thermal tolerance among populations.

In the NL region, illegal harvesting activity in freshwater and/or predation by pinniped and piscivorous avian species on Atlantic Salmon while at sea are often the targets of public concern regarding the drivers of salmon declines. Van Leeuwen et al. (2024b) investigated temporal patterns of Atlantic Salmon angling violations in NL and indicated that violations have been low in the NL region in recent years relative to historical levels. Further, Atlantic Salmon have been infrequently observed in seal diet research (Hammill and Stenson 2000) and nowhere near the levels that would likely be required to cause declines over a large spatial area. Although both likely have negative impacts on some local Atlantic Salmon populations in the NL region, and in the case of illegal salmon harvest, likely have severe impacts to specific populations, it is unlikely that they are the cause of declines in adult Atlantic Salmon abundance observed on monitored rivers in recent years across the NL region.

Finfish aquaculture operations occur along southern Newfoundland from Placentia Bay to west of Bay d’Espoir. There were no reported containment issues in these regions in 2023 or 2024. However, ongoing research in southern Newfoundland (SFA 11) has documented extensive hybridization of wild salmon populations with aquaculture salmon 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; San Roman et al. 2023), and predicted negative impacts on wild population size at existing levels of finfish aquaculture production (Bradbury et al. 2020a). Eight years of escapee and genetic monitoring (2014–21) suggests that escapees were present preceding each year of the time series, with some smaller populations displaying evidence of significant genetic change (40–60% domestic ancestry) due to introgression with escapees (Holborn et al. 2022). This work suggests that the precocial maturation of male wild-farm hybrid parr likely fast-tracks introgression (i.e., transfer of genetic material from farmed escapees to wild populations) and subsequent genetic impacts (Holborn et al. 2022). This is against a backdrop of a declining wild salmon population that is currently designated as Threatened by COSEWIC (2010), although population status is being re-evaluated following further declines (DFO 2023a) whereby it now meets the criteria of Endangered under COSEWIC’s status classification system.

The recent detection of European ancestry in aquaculture salmon and escapees likely elevates the risk to wild populations in the southern Newfoundland region (Bradbury et al. 2022; Nugent et al. 2023). This work demonstrated that both contained and escaped farmed salmon sampled in Atlantic Canada had a portion of DNA attributable to recent interbreeding with European-origin, domestic salmon. In addition, in 2021, two escaped farmed salmon were detected in the marine environment with 100% European ancestry (Bradbury et al. 2022). Data suggest that these European genes are not from previous interbreeding events, as the two salmon were shown to be greater than 99% European based on admixture analysis using genome-wide markers. This indicates that the salmon were pure European salmon and not considered hybrids or backcrosses.

European genes were also detected in wild salmon sampled in areas around aquaculture sites (e.g., Conne River; see: Bradbury et al. 2022). In addition, analysis of samples of salmon that escaped from a Long Pond (net pen nursery) site in southern Newfoundland in 2021 indicated continued presence of significant European ancestry in farmed salmon. In the 2021 escape, 21% of the 189 fish analyzed displayed more than 10% European ancestry (naturally occurring background levels are less than 10% in the region). The results demonstrated that even though diploid European salmon have never been approved for use in Canada, individuals of full and partial European ancestry have been in use over the last decade, continue to be in use, and that some of these individuals have escaped and hybridized in the wild (Bradbury et al. 2022). European salmon have been shown to differ significantly from North American salmon across a variety of important genes and traits (Lehnert et al. 2020). This significantly elevates the risk to wild salmon populations if individuals escape and interbreed, as has been documented previously on the south coast of Newfoundland (Bradbury et al. 2022).

In addition to genetic interactions, aquaculture associated factors such as disease and/or parasite transfer, as well as ecological interactions (i.e., competition and/or predation), have been cited as contributing to declines of wild salmon populations in Norway, Scotland, and Ireland (Forseth et al. 2017; Bradbury et al. 2020b; Shephard and Gargan 2021; Gillson et al. 2022), as well as identified as a potential threat to the Conne River salmon population specifically (Dempson et al. 2024). Marine survival of monitored Atlantic Salmon populations in SFA 11 has been particularly poor in recent years (Figure 10). 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 NL region, and the residency of Atlantic Salmon post-smolts near aquaculture operations and/or sea lice infestations rates would improve the understanding of poor marine survival and declining abundance of returning Atlantic Salmon to rivers in that region in recent years.

Sources of Uncertainty

Given that this SRP occurred in Fall 2024, not all recreational angling logs have yet to be returned; thus, estimates of effort, catch, and harvest are unavailable for 2024. Calculations of total returns, spawners, and egg depositions on monitored rivers, where angling is permitted, are incorporated into the average catch estimates per river over the previous generation (2018–23 for Newfoundland rivers and 2017–23 for Labrador rivers). All estimates will be revised in Winter 2025 when 2024 recreational angling data has been received and processed. For almost all rivers, changes are typically negligible (i.e., 2% or less).

Returns of logs by recreational anglers have been low in recent years, averaging just over 14% from 2017–23. The relatively low return rate of angler logs in recent years adds uncertainty in estimates of retained and released salmon for monitored rivers where angling is permitted.

For all salmon fisheries, uncertainty exists where inaccurate and/or incomplete information is provided. Estimates of recreational catch and effort data, as well as the Indigenous FSC and resident trout/char harvest bycatch estimates in Labrador, are dependent on the quantity and accuracy of logbooks compiled and returned.

For several monitored rivers, estimates of fluvial and lacustrine juvenile salmon habitat area are based on surveys conducted more than 30 years ago. Contemporary information on the habitat structure of these watersheds and the amount of available rearing habitat in fluvial environments (available and used) would significantly improve accuracy of the LRP used in stock status calculations and thus would also improve the stock status zone estimates. Rivers like Exploits River and Terra Nova River have large areas in the upper watershed with available habitat, but the degree to which it is used by salmon remains unknown.

Incomplete accounting of losses when estimating spawners due to various activities, including illegal poaching activity in freshwater and coastal marine habitats, fish handling and sampling for scientific monitoring or research purposes, and impacts of extreme environmental conditions on freshwater survival. Extreme conditions refers to: 1) high temperature and low water periods in the summer months; 2) variable hydrological conditions through winter; and 3) storm events and their potential impacts on Atlantic Salmon habitat and egg survival.

Historical or estimated biological characteristic data (e.g., fecundity, sex ratio, and female size), and estimated catch data used in the assessment, add uncertainty to the estimates of egg depositions and percent LRP attained. Contemporary estimates of adult salmon sex ratio obtained from DNA samples are used for rivers, where available (Robertson et al. 2024).

No current assessments are 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 not be representative of all rivers in each SFA.

CONCLUSIONS

[Twenty-two populations of Atlantic Salmon were monitored in the NL region during 2024, with four rivers in Labrador and 18 rivers in Newfoundland. Atlantic Salmon smolt abundance was measured on five monitored rivers in Newfoundland during migration to sea.

A stock status zone was designated for 17 of 22 monitored populations in 2024. Estimated egg depositions are below the river-specific LRP (i.e., the Critical Zone) on two of four assessed rivers in Labrador and seven of the 13 (or 54%) assessed rivers in Newfoundland (Table 1; Figure 8). Estimated egg depositions exceeded the LRP, but are below the USR (i.e., the Cautious Zone) for six rivers in 2024; one in Labrador and five in Newfoundland (Figure 8). Only two rivers are in the Healthy Zone in 2024: English River in Labrador and Torrent River in Newfoundland (Table 1; Figure 8).

Of 15 monitored rivers with sufficient time series data, 12 (or 80%) show declines in total returns compared to the previous generation average, seven (or 47%) of which by more than 30%. Thirteen of 14 (93%) rivers with sufficient time series data show declines in 2024 total returns compared to the previous three generation average (16–20 years), 11 (or 79%) of which by more than 30% (Table 1; Figure 2). Above average returns are observed on Sand Hill River (SFA 2), Rattling Brook (SFA 4), and Conne River (SFA 11). All other monitored salmon rivers in NL with sufficient time series data have below average salmon returns in 2024, many of which by more than 50% (Table 1).

Marine survival is considered to be a major factor limiting the abundance of returning adult Atlantic Salmon in the NL Region. Survival of the 2023 smolt class to returning adult salmon in 2024 was below average on most rivers compared to previous generation averages where estimates were available. Marine survival on Conne River in 2024 (2.8%) was above the previous generation average; however, this remains low (less than 3%) relative to other regions of the province.

Smolt abundance is below average for four of five Newfoundland rivers, where they are counted during migration to sea. Modeling suggests that smolt abundance has declined over the previous three generations on Rocky River (SFA 9), Conne River (SFA 11), and Western Arm Brook (SFA 14A). Fewer smolts migrating to sea could have negative implications for the abundance of returning adult salmon in subsequent years.

High summer river temperatures in recent years, combined with declining trends in smolt abundance on most rivers where it is monitored, suggest that survival of juveniles in freshwater is becoming increasingly important. Smolt abundance is only monitored on six rivers in the region, making it difficult to ascertain the degree to which this is impacting NL populations spatially. Marine survival has often been identified as the factor driving adult Atlantic Salmon abundance on NL rivers (DFO 2023a, DFO 2024). Freshwater habitat and survival is becoming increasingly important to the status of NL Atlantic Salmon stocks. Improving the understanding of how contemporary and future freshwater conditions impact juvenile and adult survival of Atlantic Salmon would greatly inform the status of populations and the potential impacts of future environmental change in the NL region.

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APPENDIX I: TABLES

Table 1. Total, small (less than 63 cm), and large (greater than or equal to 63 cm) Atlantic Salmon returns to monitored NL rivers in 2024 in comparison to the average returns during the previous generation and previous three generations. One generation corresponds to six years in Newfoundland and seven years in Labrador. Three generations corresponds to 16–18 years in Newfoundland and 20–22 years in Labrador. Rivers where counts of returning salmon are considered incomplete in 2024, due to counting facility washouts, are bolded. SFA = Salmon Fishing Area.

River	SFA	2024 Total Salmon Returns	% Change 2024 vs Prev 1 Gen	% Change 2024 vs Prev 3 Gen	2024 Small Salmon Returns	% Change 2024 vs Prev 1 Gen	% Change 2024 vs Prev 3 Gen	2024 Large Salmon Returns	% Change 2024 vs Prev 1 Gen	% Change 2024 vs Prev 3 Gen	% of Limit Reference Point Achieved in 2024	Stock Status Zone in 2024
Exploits River	4	18,706	-25	-37	17,596	-24	-33	1,110	-41	-69	30	Critical
Campbellton River	4	1,464	-62	-62	1,287	-63	-63	177	-56	-58	136	Cautious
Salmon Brook	4	823	-18	-30	804	-12	-24	19	-78	-83	87	Critical
Rattling Brook	4	926	+62	NA	893	+64	NA	33	+27	NA	NA	NA
Middle Brook	5	1,365	-42	-46	1,196	-43	-47	169	-39	-36	146	Cautious
Terra Nova River	5	3,461	-19	-16	2,944	-25	-20	517	-42	-15	55	Critical
Northwest River	**5**	**100**	**NA**	**NA**	**84**	**NA**	**NA**	**16**	**NA**	**NA**	**NA**	**NA**
Rocky River	9	96	-69	-78	95	-69	-77	1	-70	-96	9	Critical
Northeast River	**10**	**205**	**NA**	**NA**	**189**	**NA**	**NA**	**16**	**NA**	**NA**	**NA**	**NA**
Come By Chance River	10	132	NA	NA	108	NA	NA	24	NA	NA	64	Critical
Bay de l’Eau River	10	428	NA	NA	417	NA	NA	11	NA	NA	137	Cautious
Garnish River	**11**	**160**	**NA**	**NA**	**150**	**NA**	**NA**	**10**	**NA**	**NA**	**NA**	**NA**
Conne River	11	659	+104	-52	626	+103	-52	33	-43	+120	30	Critical
Harry’s River	13	1,653	-28	-46	1,395	-27	-47	258	-30	-40	49	Critical
Deer Arm Brook	14A	277	NA	NA	234	NA	NA	40	NA	NA	149	NA
Torrent River	14A	2,314	-46	-50	2,288	-41	-40	26	-94	-97	265	Healthy
Western Arm Brook	14A	473	-54	-61	451	-54	-62	22	-47	-55	122	Cautious
Parkers River	14A	142	NA	NA	109	NA	NA	33	NA	NA	NA	NA
English River	1	527	-40	-22	383	-44	-28	144	-27	+4	162	Healthy
Southwest Brook	2	93	-39	-67	79	-38	-68	14	-45	-58	30	Critical
Muddy Bay Brook	2	236	-29	-34	211	-31	-37	25	-7	-1	102	Cautious
Sand Hill River	2	3,971	+11	-4	3,369	+17	-1	602	-13	-20	91	Critical

Table 2. Summary of Atlantic Salmon smolt production in 2024 compared to the previous generation average (2018–23) and previous three generation average for each river. The marine survival estimate for Campbellton River in 2024 is considered an overestimate due to an incomplete smolt count in 2023. The marine survival estimate for Garnish River in 2024 is considered an underestimate due to an incomplete returning adult count in 2024. SFA = Salmon Fishing Area; NA = estimates are not available

River Name	SFA	2024 Smolt Production	% Change vs Previous Generation Average	% Change vs Previous 3 Generation Average	Marine Survival (2023 smolt to 2024 returning adult)	% Change vs Previous Generation Average	% Change vs Previous 3 Generation Average
Campbellton River	4	23,530	-30	-38	7.8*	-7	-12
Terra Nova River	5	27,727 (20,468, 39,732)	NA	NA	NA	NA	NA
Rocky River	9	4,459	-43	+23	4.2	-54	+12
Conne River	11	19,989	-57	-14	2.8	+223	-2
Garnish River	11	17,986	+30	NA	1.2*	NA	NA
Western Arm Brook	14A	10,374	-16	-36	3.7	-49	-52

Table 3. Monthly average river water temperature in Labrador (Hunt River, Char Brook, Shinney's River, Eagle River, Sand Hill River) and Newfoundland (131 stations and 43 rivers) in June, July, August and September 2024. River temperature (°C) was recorded hourly and is expressed as a monthly average with standard deviation (SD).

Region	Month	Temperature (°C) ± SD
Labrador	June	11.1 ± 2.7
	July	16.6 ± 2.2
	August	16.2 ± 1.3
Newfoundland	June	16.6 ± 1.4
	July	20.7 ± 1.3
	August	20.4 ± 0.4
	September	17.0 ± 0.5

APPENDIX II: FIGURES

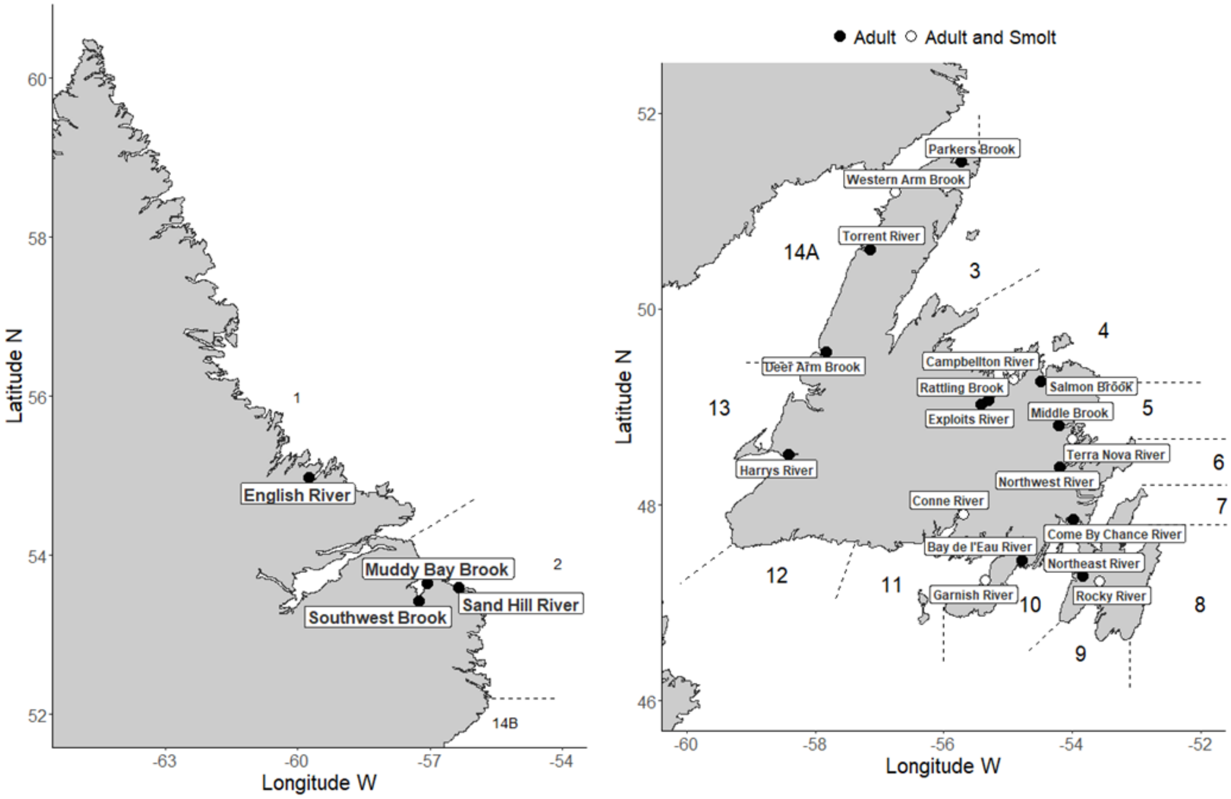


Figure 1. Map of the NL Region showing Salmon Fishing Areas (SFA) 1–14B and rivers where the number of out-migrating Atlantic Salmon smolts and/or returning adults were counted in 2024. Dashed lines indicate approximate SFA boundaries.

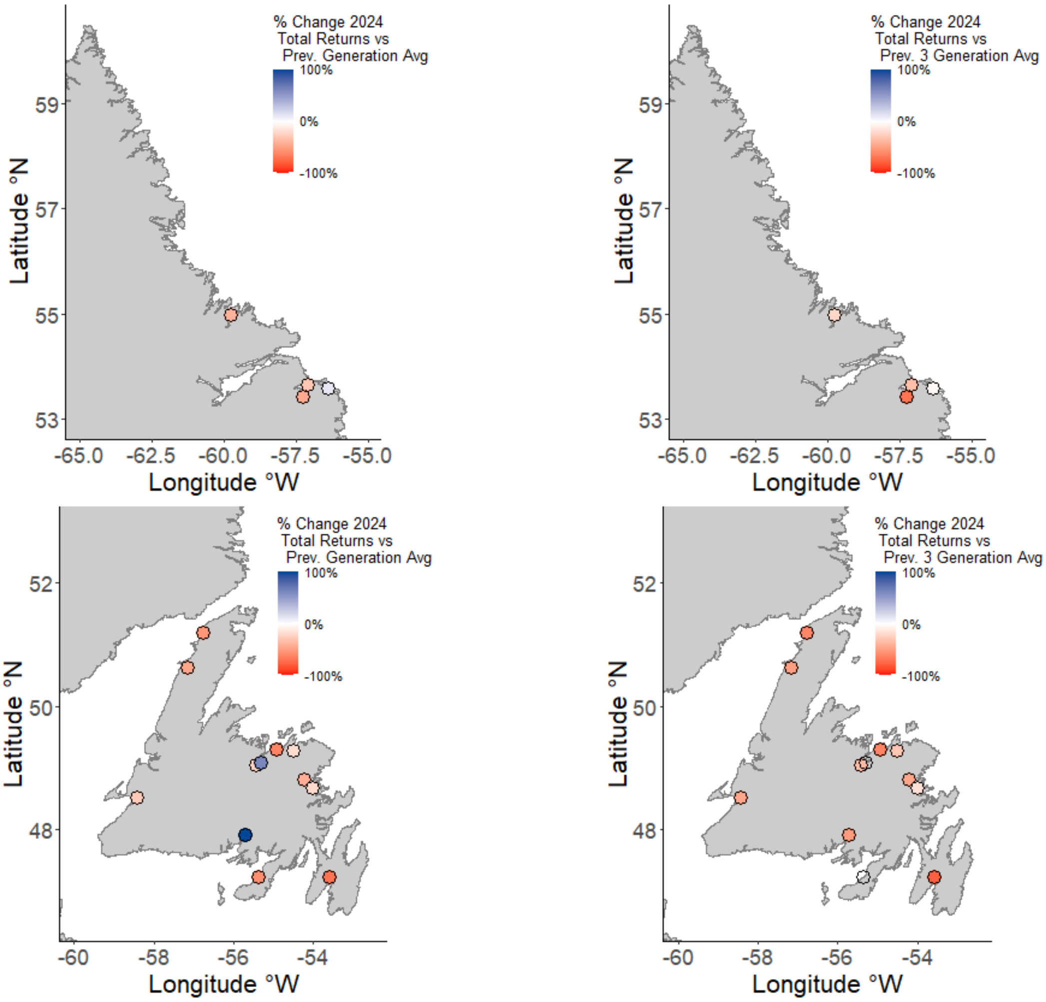


Figure 2. The percent change in 2024 total returns compared to the average returns over the previous generation (left panels) and previous three generation (right panels) for monitored Atlantic Salmon populations in Labrador (top panels) and Newfoundland (bottom panels). The previous generation time period is six years for most Newfoundland rivers and *seven years for Labrador rivers. The previous three generation time period is 16–18 years for Newfoundland rivers and 20–22 years for Labrador rivers. In cases where the magnitude of change is larger than 100%, values are scaled down to 100% for the figure. See Table 1 for actual percentages for each river.*

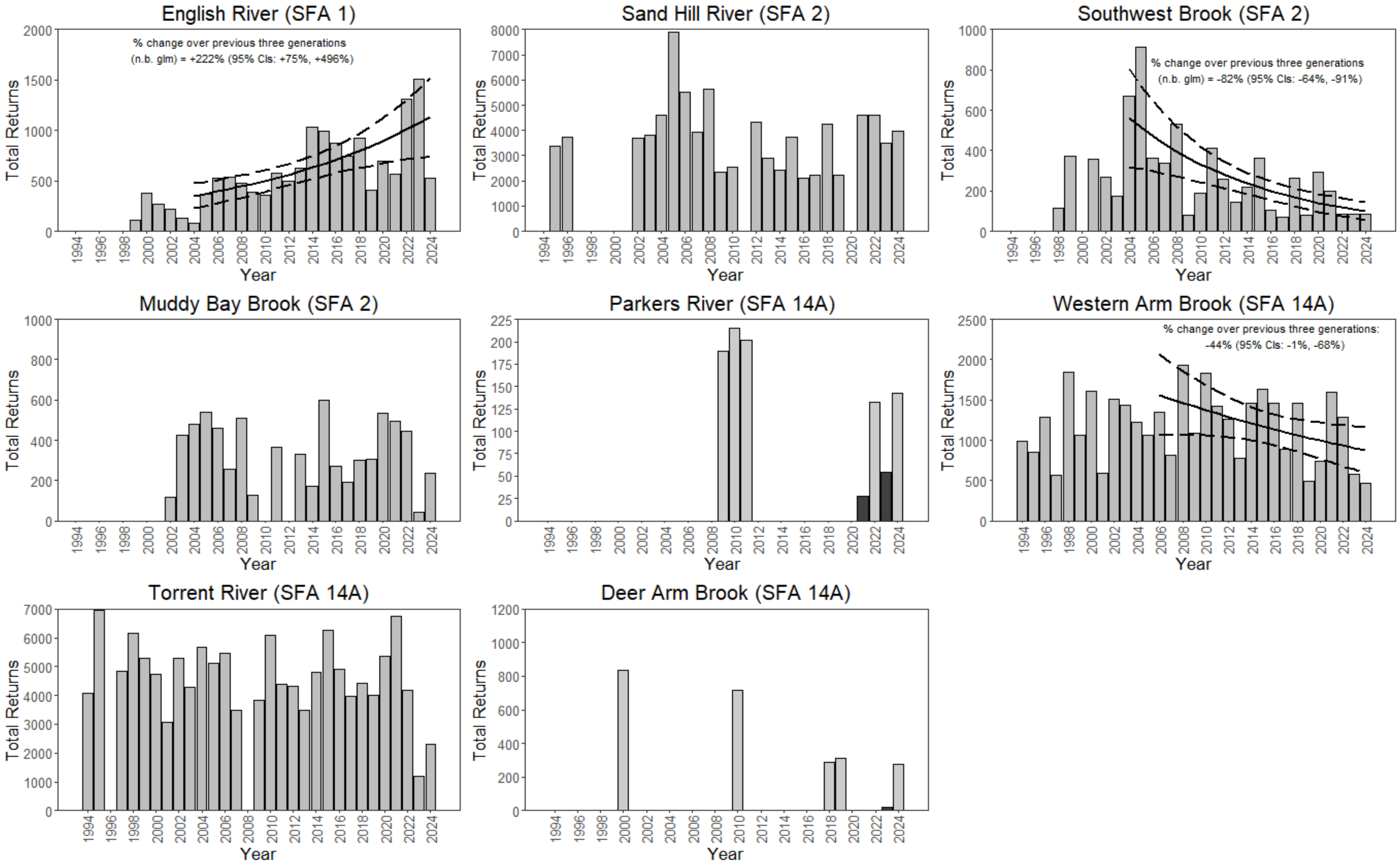


Figure 3. Time series of total Atlantic Salmon returns to rivers in Labrador (SFAs 1 and 2) and the northern peninsula of Newfoundland (SFA 14A) from 1994–2024. Black bars indicate years where salmon counts were significantly affected by environmental conditions and are therefore considered incomplete. Total returns to English River, Sand Hill River, Southwest Brook, Muddy Bay Brook, Western Am Brook, and Torrent River were modelled over the previous three generations (20–22 years in Labrador and 16–18 years in Newfoundland) using a generalized linear model with a negative binomial distribution. In the event of a significant effect of year on returns, the model estimates, 95% confidence intervals, and estimates of percent change in abundance over the time period are shown.

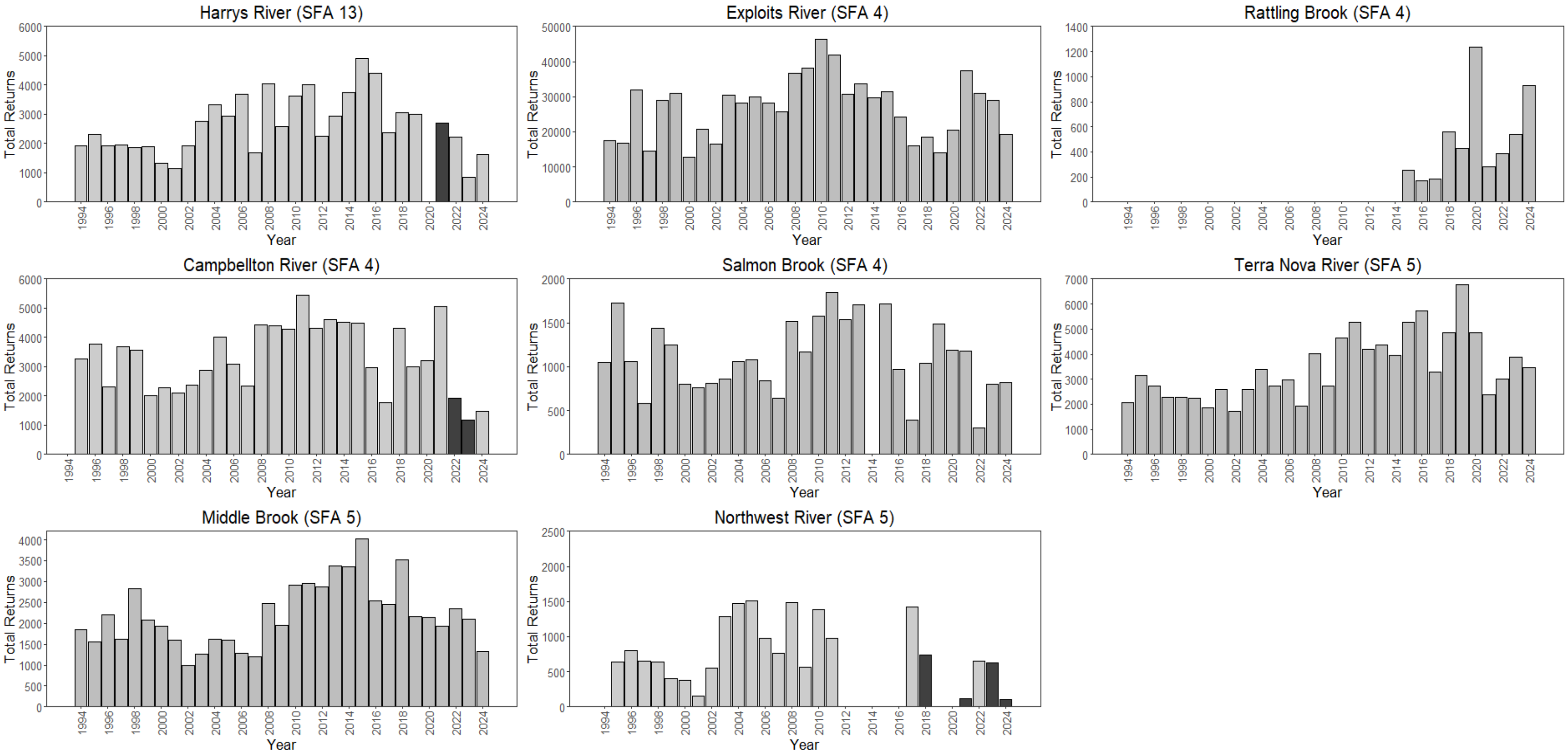


Figure 4. Time series of total Atlantic Salmon returns to rivers in western (SFA 13) and northeastern (SFAs 4 and 5) Newfoundland from 1994–2024. Black bars indicate years where salmon counts were significantly affected by environmental conditions and are therefore considered incomplete. Total returns to Harrys River, Exploits River, Campbellton River, Salmon Brook, Terra Nova River, and Middle Brook were modelled over the previous three generations (16–18 years in Newfoundland) using a generalized linear model with a negative binomial distribution. In the event of a significant effect of year on returns, the model estimates, 95% confidence intervals, and estimates of percent change in abundance over the time period are shown.

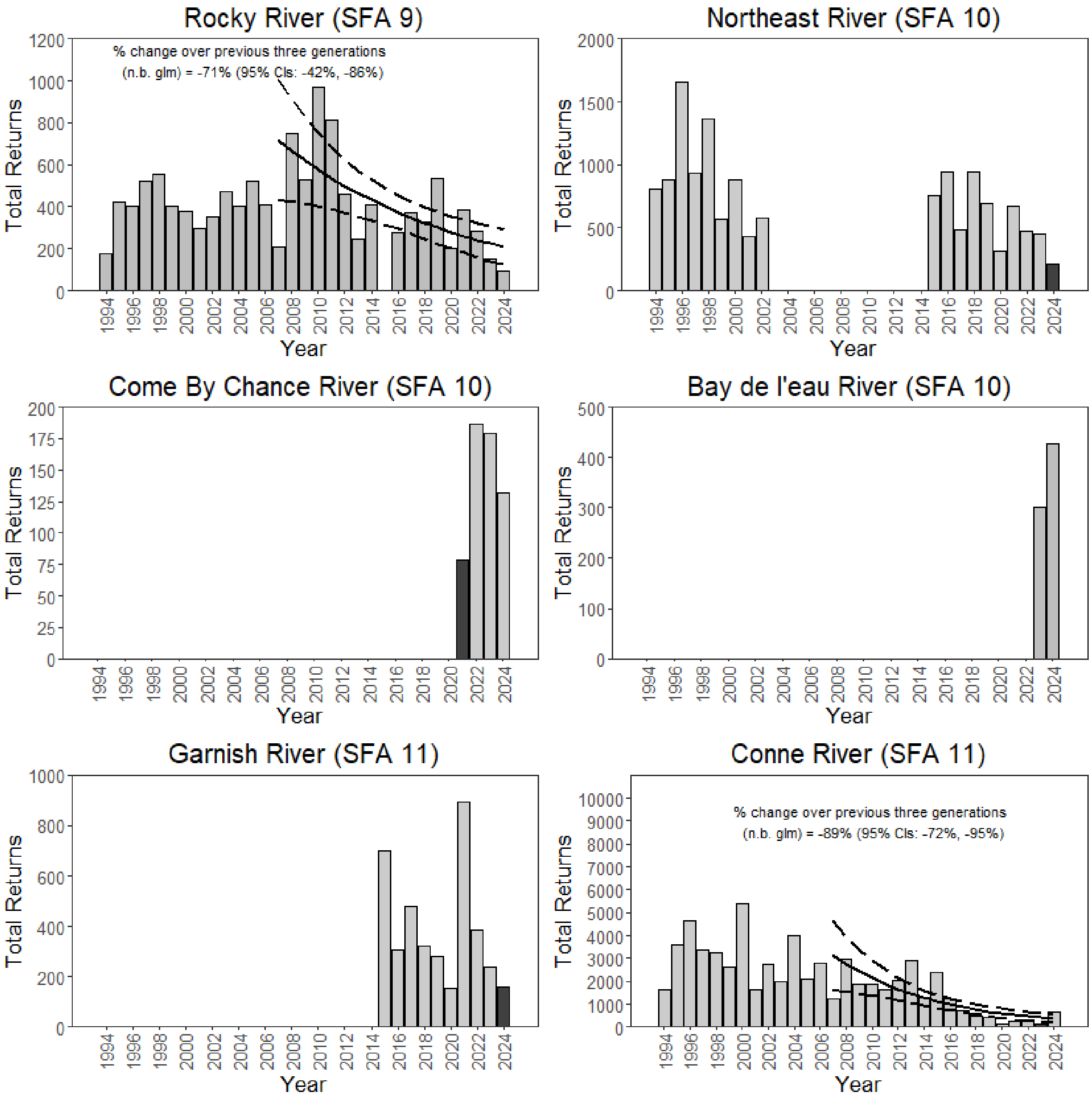


Figure 5. Time series of total Atlantic Salmon returns to rivers in southern Newfoundland (SFAs 9, 10, and 11) from 1994–2024. Black bars indicate years where salmon counts were significantly affected by environmental conditions and are therefore considered incomplete. Total returns to Rocky River and Conne River were modelled over the previous three generations (16–18 years in Newfoundland) using a generalized linear model with a negative binomial distribution. In the event of a significant effect of year on returns, the model estimates, 95% confidence intervals, and estimates of percent change in abundance over the time period are shown.

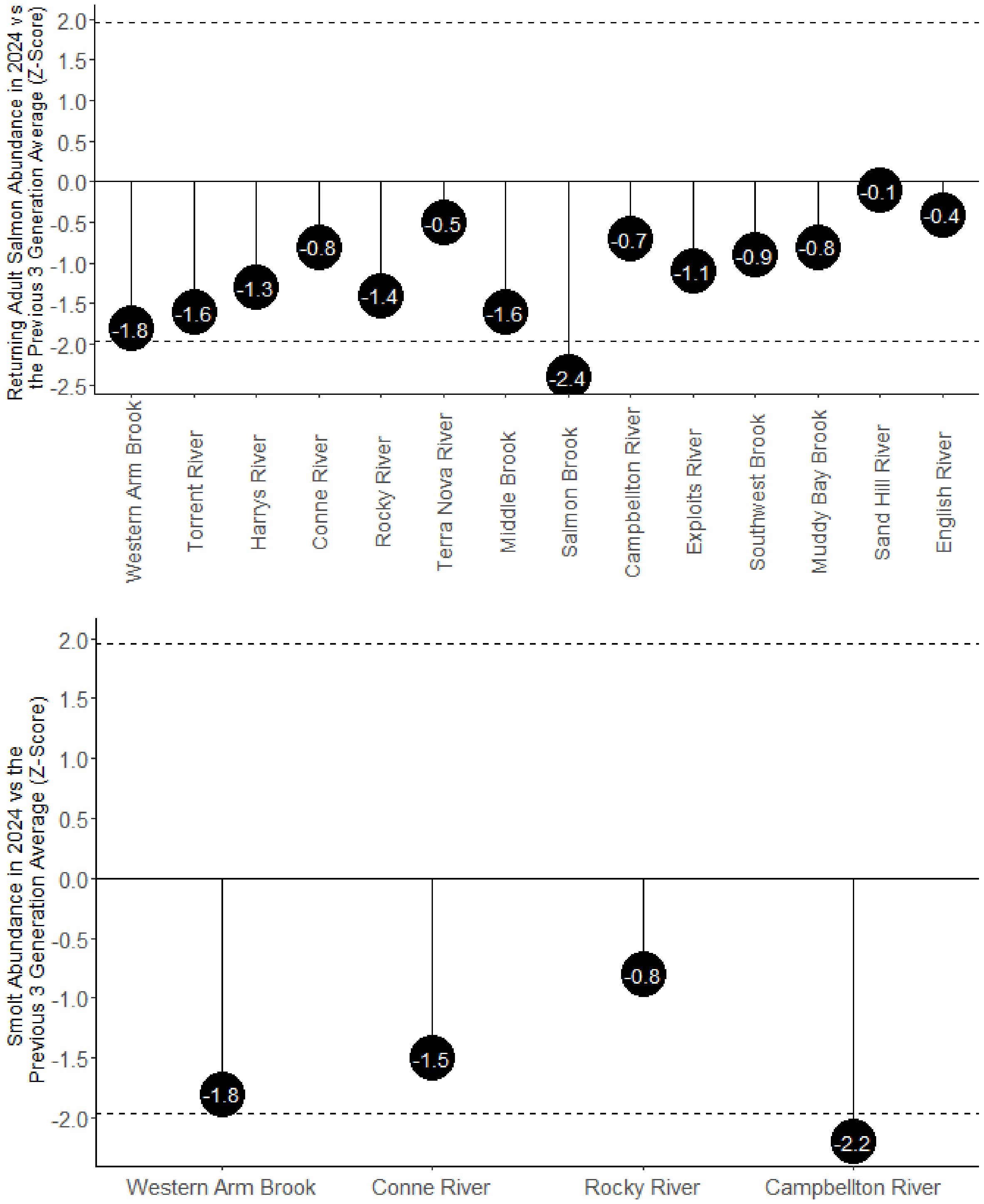
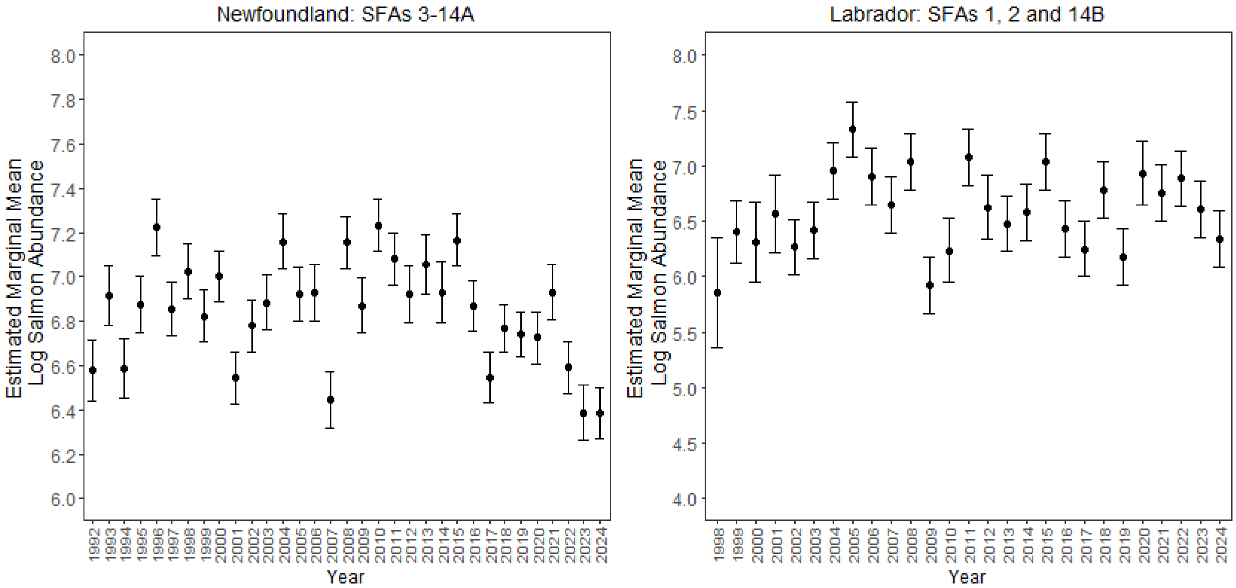


Figure 6. Z-scores of total Atlantic Salmon returns (top panel) and smolt abundance (bottom panel) on monitored rivers in 2024 compared to their river specific previous three generation average. The value shown for each river represents the number of standard deviations 2024 values are from the mean over the previous three generation time period. Horizontal dashed lines represent approximate 95% confidence intervals (plus/minus 1.96).



Newfoundland: SFAs 3-14A

Labrador: SFAs 1, 2 and 14B

Figure 7. Estimated marginal mean log Atlantic Salmon abundance from negative binomial generalized linear models (log link function and year as a factor) applied to data from monitored rivers in Newfoundland (left panel) and in Labrador (right panel). These estimates are of the relative abundance of returns across monitored rivers, and are ***not*** *an estimate of the total salmon returns to the NL region each year. Vertical lines represent plus/minus one standard error. Each model only includes data since the commercial moratorium (i.e., 1992 for Newfoundland and 1998 for Labrador).*

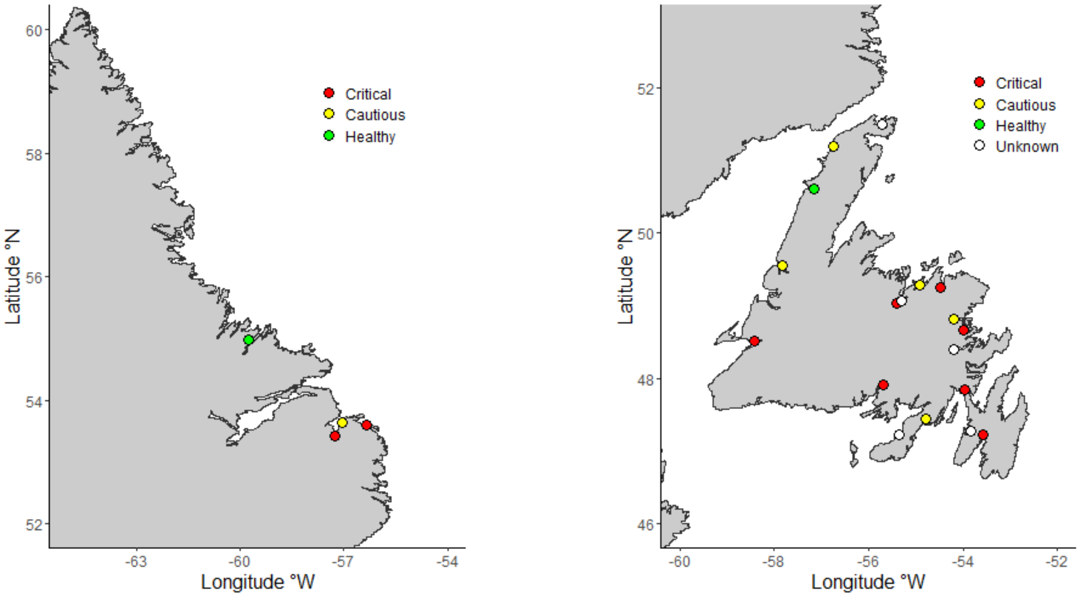


Figure 8. Map of monitored Atlantic Salmon rivers in Labrador (left panel) and Newfoundland (right panel) during 2024, coloured by their estimated stock status zone as per the Precautionary Approach (DFO 2015). Designation of a population within a stock status zone is based on comparing the estimated egg depositions in 2024 to the river-specific Limit Reference Point (LRP): Critical Zone (0–99% of LRP), Cautious Zone (100–149% of LRP), and Healthy Zone (greater than or equal to 150% of LRP). The LRP is equivalent to a river's conservation egg requirement.

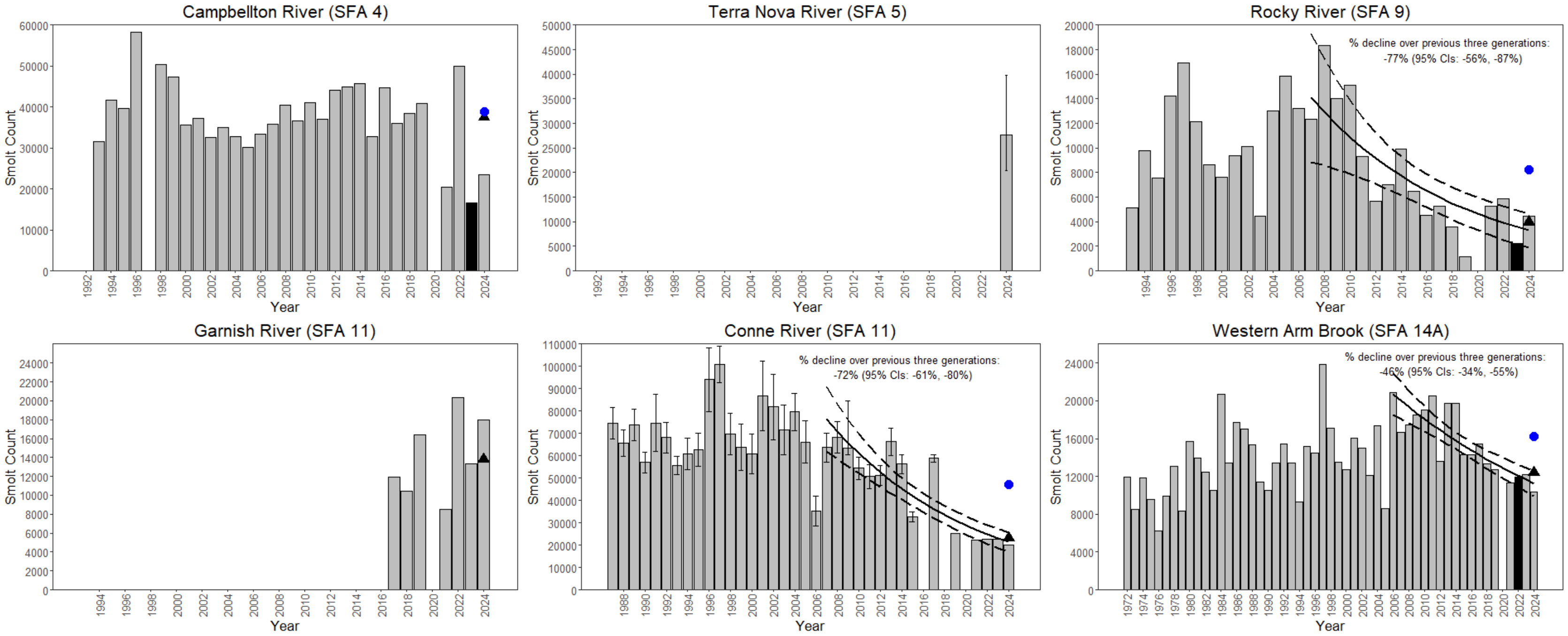


Figure 9. Time series of smolt production on monitored Newfoundland Atlantic Salmon rivers to 2024. The black triangles and blue circles represent the previous generation average (2018–23) and previous three generation average (16–18 years), respectively. Solid and dashed lines represent abundance estimates and 95% confidence intervals from a negative binomial generalized linear model. Black bars represent counts that were significantly impacted by counting fence washouts, which were excluded from modeling. Vertical error bars for Conne River (1987-2018) and Terra Nova River (2024) represent 95% confidence intervals around smolt abundance estimates derived from mark recapture methods.

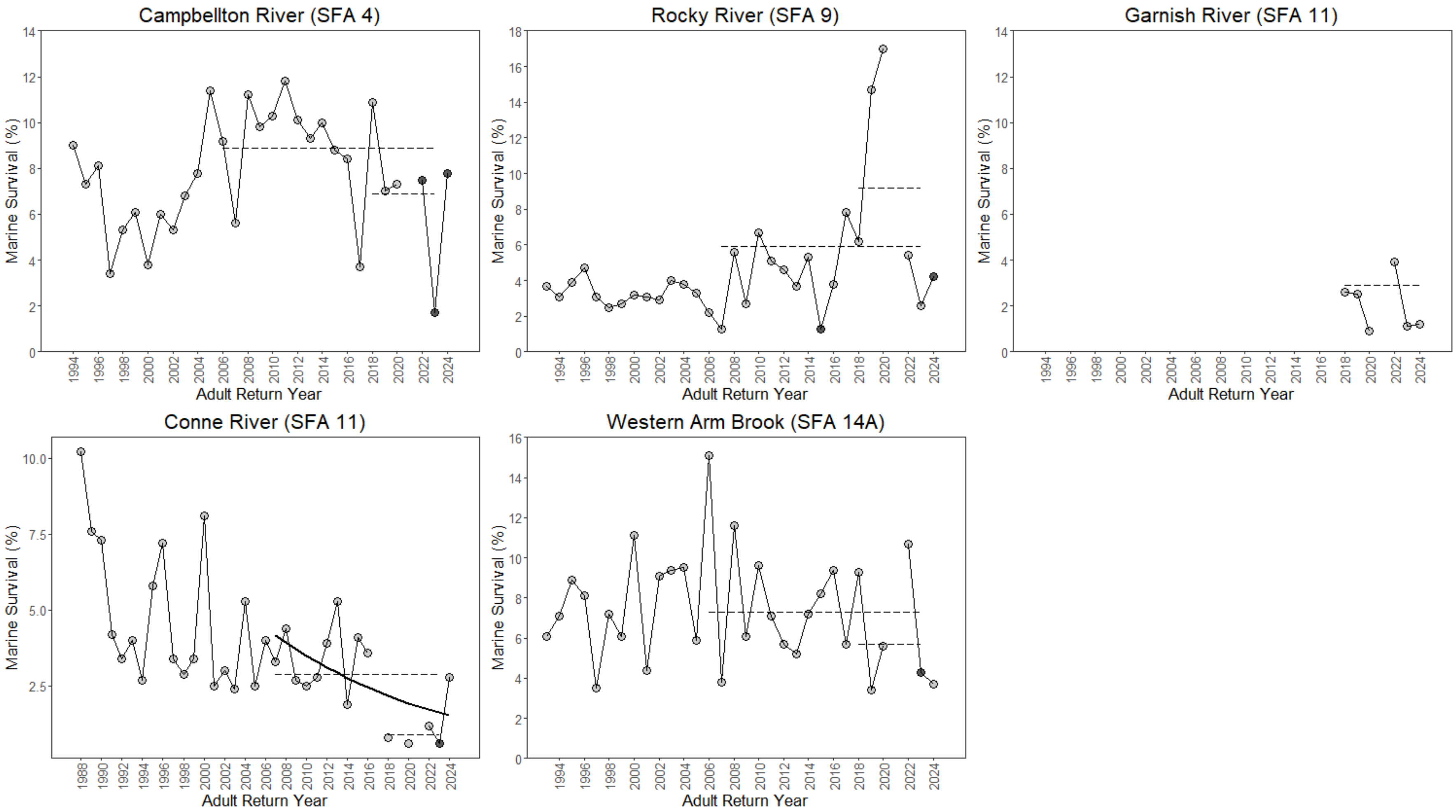


Figure 10. Marine survival rates of smolt to adult small salmon for monitored Newfoundland rivers. Survival rates have not been adjusted for marine exploitation during the commercial salmon fishery (prior to 1992); thus, values represent survival of salmon back to the river. Horizontal dashed lines illustrate the previous generation average (2018–23) and previous three generation average where sufficient data are available. Dark circles represent under- or over-estimates due to washouts in recent years on smolt and/or adult counting fences (see text for details in 2024).

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