UPDATE OF INDICATORS OF ATLANTIC SALMON (*SALMO SALAR*) IN DFO GULF REGION SALMON FISHING AREAS 5 – 18 FOR 2020 AND 2021

Context

The last assessment of stock status of Atlantic Salmon for Fisheries and Oceans Canada (DFO) Gulf Region was completed after the 2013 return year (DFO 2014) and updates on stock status in 2014 to 2019 for each of the four Salmon Fishing Areas (SFA 15-18) were prepared (DFO 2015a; 2015b, 2016, 2017, 2018a, 2019, 2020). Ecosystems and Fisheries Management Branch (EFM) requested an update of the status of the Atlantic Salmon stocks in DFO Gulf Region for 2020 and 2021. Indicators for adult and juvenile Atlantic Salmon in SFAs 15 to 18 are provided in this report. This Science Response Report results from the Science Response Process of February 22, 2022 on the update of indicators of Atlantic Salmon to 2021 for Salmon Fishing Areas 15 to 18, DFO Gulf Region.

Background

All rivers flowing into the southern Gulf of St. Lawrence are included in DFO Gulf Region. Atlantic Salmon (*Salmo salar*) management areas in DFO Gulf Region are defined by four Salmon Fishing Areas (SFA 15 to 18) encompassing portions of the three Maritime provinces (New Brunswick, Nova Scotia, and Prince Edward Island; Figure 1).

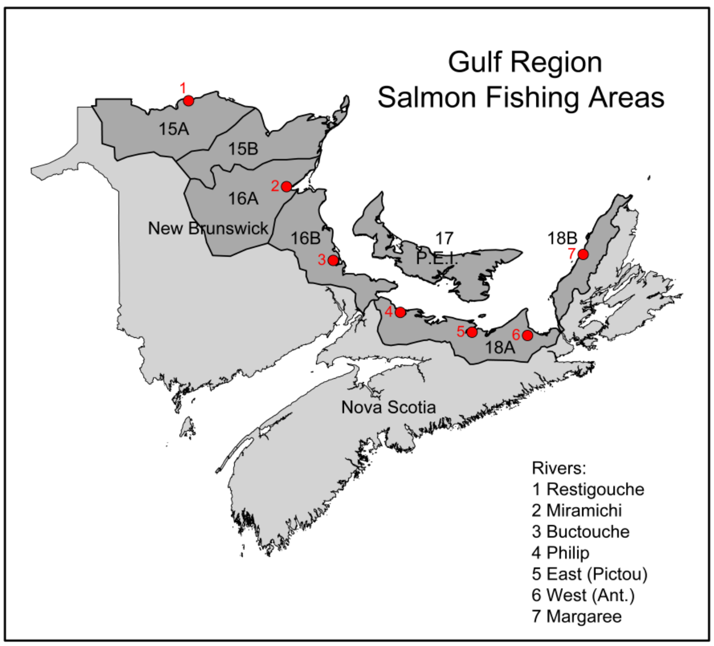

Figure 1: Salmon Fishing Areas in the DFO Gulf Region and locations of New Brunswick and Nova Scotia rivers mentioned in the report. Note the Buctouche data point represents the following southeastern New Brunswick rivers: Buctouche, Cocagne, Richibucto/Coal Branch, Kouchibouguacis and Kouchibouguac.

For management purposes, Atlantic Salmon are categorized as small salmon (grilse; fish with a fork length less than 63 cm) and large salmon (fish with a fork length equal to or greater than 63 cm).

This report presents indicators of abundance for adult salmon and juvenile life stages. To provide a perspective on recent trends, the changes (exponential regression of change) in the indicators over the recent 12 years, approximately two generations for Atlantic Salmon, are presented.

During 2015 to 2021, mandatory catch and release measures for the recreational fishery were in effect in all SFAs where recreational fisheries were authorized. This was a change from 2014 and previous years when retention of small salmon had been allowed in SFA 15, SFA 16A, and SFA 18. Since 1998, rivers in southeast New Brunswick (SFA 16B) have been closed to all directed salmon fishing. For Prince Edward Island (PEI), catch and release angling has been in effect since 2009 (DFO 2012). Current angling regulations on PEI do not permit retention of Atlantic Salmon and only two rivers (Mill (Carruthers and Cains) and Morell) have extended catch and release seasons for Atlantic Salmon angling.

In this report, status is assessed relative to a Limit Reference Point (LRP) consistent with the precautionary approach (PA; DFO 2009), as recently defined for Atlantic Salmon rivers in DFO Gulf Region (DFO 2018b). In conformity with the PA, the management objective is to have a low probability (5% or less) of the stock being below the LRP (i.e., in the critical zone).

Environmental Conditions in 2020 and 2021

Air temperature data collected from the Environment and Climate Change Canada meteorological station (station number 8100989) in Miramichi (NB) was used to characterize summer conditions in 2020 and 2021. Coincidentally, the mean air temperatures during the summer months (July and August) in 2020 and 2021 were both 19.6 °C, lower than the record high value of 21.4 °C recorded in 2018 (Figure 2). There is a statistically significant ($p < 0.001$) increasing trend over the time series with data from 1873 to 2021; the mean summer air temperature has increased by 1.05 °C over the past 100 years (Figure 2).

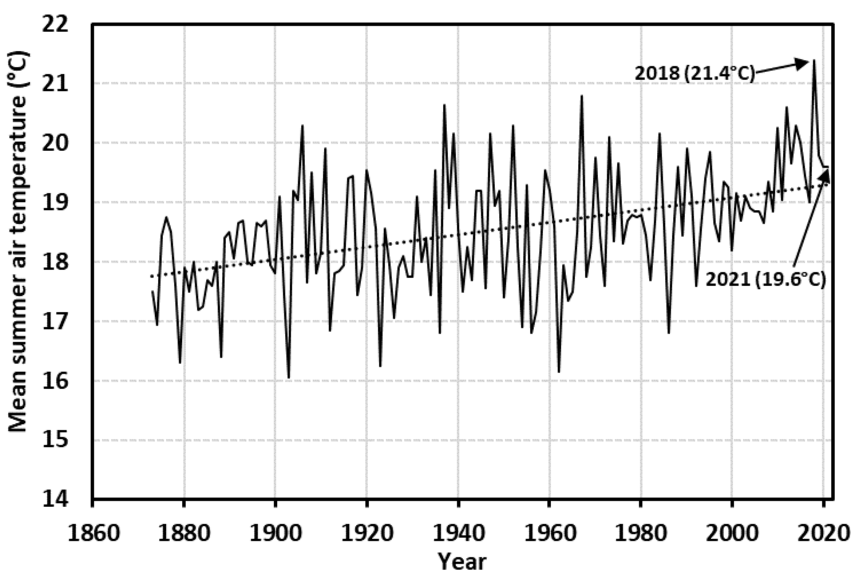

Figure 2: Mean annual summer (July and August) air temperatures and linear trend in mean temperature based on data from the Environment and Climate Change Canada meteorological station in Miramichi (station 8100989), 1873 to 2021.

High air temperatures in the Miramichi area during the summer of 2020 and 2021 resulted in high water temperature (> 23 °C; temperatures stressful for Atlantic Salmon) events in the Miramichi River. In 2020, high river temperatures (T_{max} > 23 °C) occurred between June 17 and September 4 at the monitoring station in the Little Southwest Miramichi River (above Catamaran Brook site). Mean daily temperatures during those dates ranged between 14.0 °C and 26.7 °C (Figure 3a). For 2021, the first day with T_{max} > 23 °C was June 7 and the last day was August 26. Mean daily temperatures during those dates ranged between 12.8° C and 26.2 °C (Figure 3b). The maximum water temperature recorded in 2020 was on August 11 at 29.6 °C and in 2021 it was on August 13 at 30.3 °C.

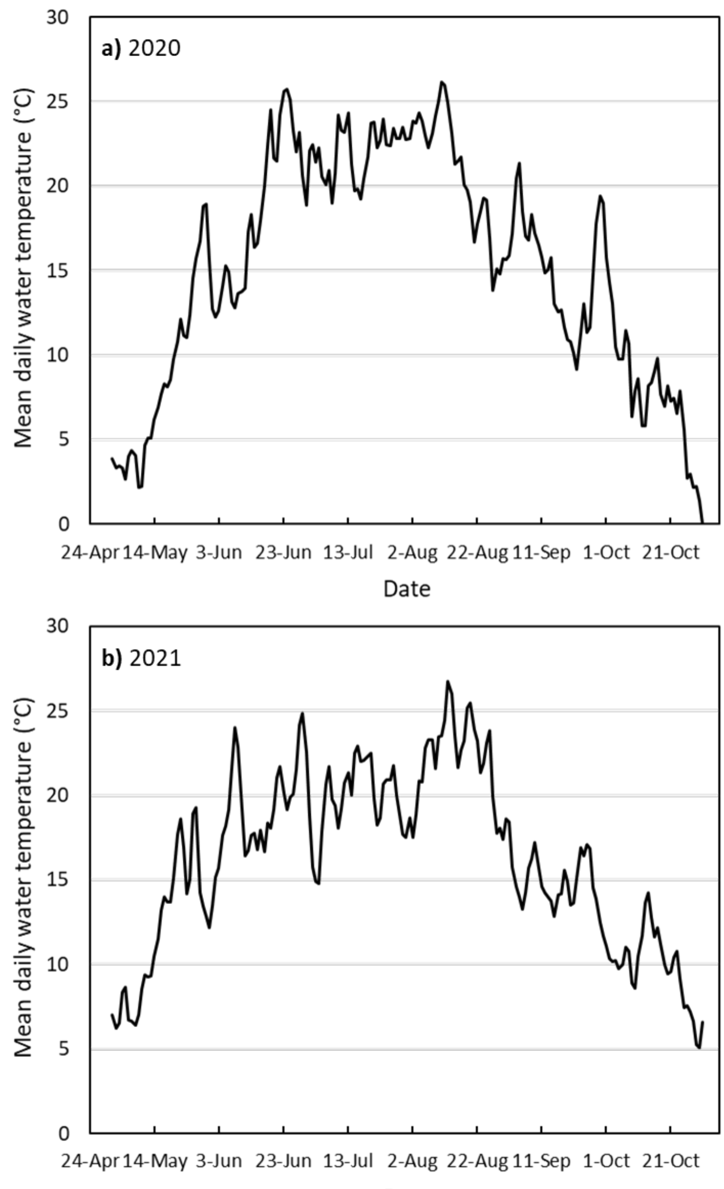

Figure 3: Mean daily water temperatures monitored in the Little Southwest Miramichi River (SFA 16) in a) 2020 (top panel) and b) 2021 (bottom panel), above the confluence of Catamaran Brook.

The daily maximum water temperature at the Little Southwest Miramichi River monitoring station exceeded 23 °C for 46 days in 2021, fewer days than in 2020 (59 days), 2018 (60 days) and 1999 (62 days; Figure 4). Water temperatures experienced at different locations in large rivers can be quite variable and generally water temperatures in the Miramichi River (SFA 16) are much warmer than those of the Restigouche (SFA 15) and Margaree (SFA 18) rivers.

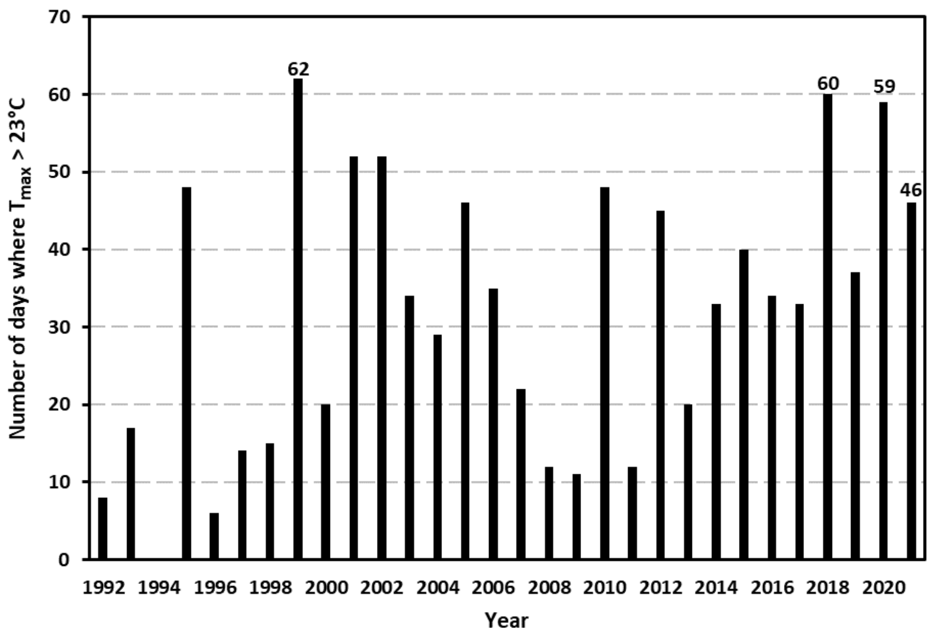

Figure 4: Number of days per year when the daily maximum water temperature exceeded 23 °C at monitoring stations in the Little Southwest Miramichi River (SFA 16) during 1992 to 2021. Data for 1992 to 2013 and 2018 to 2021 are from the DFO station above Catamaran Brook whereas for 2014 to 2017, the data are from the downstream Upper Oxbow site (Miramichi River Environmental Assessment Committee station).

In the Gulf Region, four rivers have warm water protocols: Restigouche, Nepisiguit, Miramichi and Margaree rivers. In 2020 and 2021, warm water angling restrictions were enacted on all four rivers, except for the Margaree River in 2021 (Appendix 1). High water temperatures on the Restigouche River prompted morning fishing only (6 am to 11 am) on two occasions in 2020 and on one occasion in 2021. Angling was restricted to morning fishing only on the Nepisiguit on four different occasions in 2020 and two occasions in 2021. A complete river closure on the Nepisiguit River was in effect for eight days in 2020 and 19 days in 2021 (Appendix 1). In 2020, high water temperatures prompted angling restrictions in the Miramichi River system to mornings only for five days (Aug 13-18) and the closure of cold water holding pools on three different occasions (Jun 23-Jul 8, Jul 10-17, and Jul 21-Aug 20), for a total of 52 days. Similarly in 2021, high water temperatures in the Miramichi River system resulted in angling restrictions to mornings only for three days (Aug 18-21) and the closure of the entire river system for seven days (Aug 21-28). Cold water holding pools were closed to angling on 18 days. In the Margaree River, a complete river closure to angling was in effect for 20 days in August 2020 whereas no restrictions were in place during 2021 (Appendix 1).

Monthly flow conditions in 2020 and 2021 and long-term average conditions for four index rivers in the Gulf Region are presented in Figure 5, where excessive flows (E) indicate months when the mean monthly flow was greater than the long-term average 75th percentile and deficient

flows (D) indicate months when the mean monthly flow was lower than the long-term 25th percentile. In 2020, there were few excessive flow months at the index rivers. The Southwest Miramichi River had excessive flows for the month of December and the Upsalquitch River had excessive flows during May and December. The Northeast Margaree River had excessive flows in May and June and the Wilmot River had no months with excessive flows (Figure 5).
For 2021,river flows in winter were excessive in January and March for both the Southwest Miramichi and Upsalquitch rivers, whereas, the Northeast Margaree and Wilmot rivers had normal flows in winter, except for the month of January in the Wilmot River which had deficient flows (Figure 5). Both the Upsalquitch and Northeast Margaree rivers had excessive flows in April and deficient flows in May. The Southwest Miramichi River also experienced deficient flows in May, potentially as a result of an earlier than average snow melt. In contrast, the Wilmot River had excessive flows from May to December, with the exception of June, where flows were normal. Additionally, September was a record month for the Wilmot River with an average monthly flow of 1.39 m^3 per second compared to the long-term average of 0.48 m^3 per second (Figure 5d).

Flows were relatively low in 2020, particularly during the summer months. The Southwest Miramichi and Wilmot rivers had deficient flows between June and November. Of those deficient flow months, there were record deficient months at the Southwest Miramichi River for August and September and at the Wilmot River for August. The Upsalquitch River had deficient flows between June and September and the Northeast Margaree River had deficient flows in March, April, August, September and November (Figure 5). Low flows during summer were not particularly severe in 2021, with normal and excessive flows during July and August at three of the four index rivers (Figure 5).The Upsalquitch River experienced deficient flows throughout the summer (Figure 5b), however, the lowest daily flow (5.1 m^3 per second; September 2) was only slightly lower than the 2-year low flow. Low flow conditions in 2021 were fewer than in 2020. All index rivers recorded higher monthly flows in 2021 for July, August and September, compared to 2020 (Figure 5).

Analysis and Response

Abundance indices of adult salmon

SFA 15A Restigouche River (NB)

Information on adult salmon abundance from the Restigouche River (NB), which excludes the Matapedia River that is entirely within the province of Quebec, comes primarily from angling catches as well as end of season spawner counts. For recreational fisheries, catches in the Restigouche River (NB) are based on lodge catch reports compiled by DFO Science and Crown Reserve angling catches compiled by the province of New Brunswick. Catches exclude those from public waters.

In 2020 and 2021, angling activities were impacted by Covid-19 related restrictions and weather conditions (i.e., low water conditions during the summer). In 2020, two lodges reported catch and effort and anecdotal information indicated that there was little angling at these lodges during the year. As of the date of this review, the catch data from lodges for 2021 were incomplete with information missing from 12 of 22 lodges. Similarly to previous years, catches from all lodges were estimated by assuming that the catch data from the missing lodges were of the same proportion of the total catch based on comparable time-period during the time series (2001-2019). In 2020, there was a decrease in the angling effort for Crown Reserve (CR) waters and more notably for lodges. In 2021, CR angling effort was similar to their last 5-year average (1,365 rod days in 2021 vs. 1,337 rod days on average over the 2016 to 2020 period) but, angling effort from lodges (based on partial reporting) does not seem to have followed the same rebound in effort in 2021.

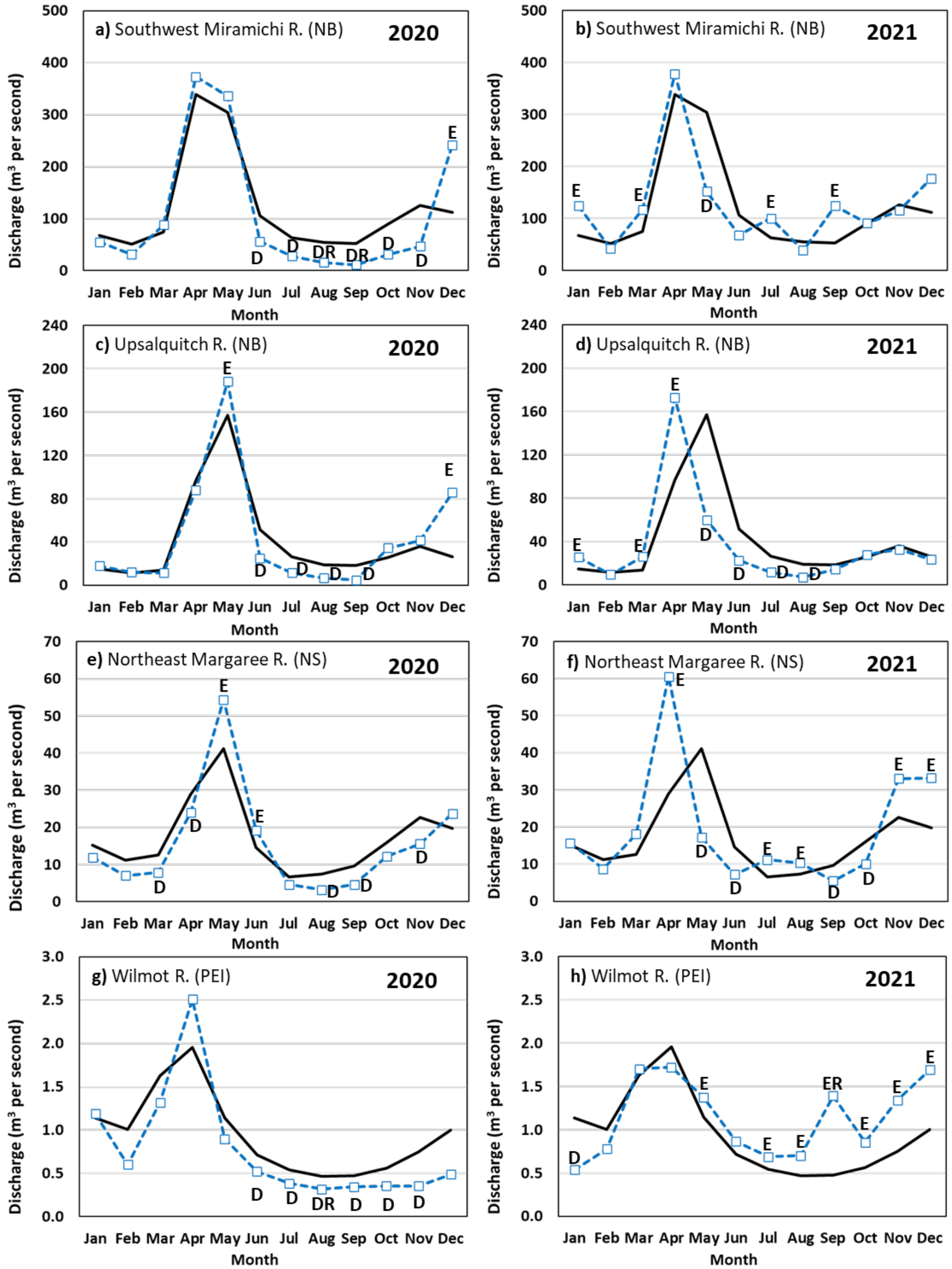

Figure 5: Monthly flow conditions in 2020 and 2021 (blue dashed line) and long-term monthly flow conditions (black line; 1919-2019) for Environment and Climate Change Canada index rivers within the DFO Gulf Region. In the graphs, E = excessive flow (above 75th percentile), ER = excessive and record flow, D = deficient flow (below the 25th percentile), and DR = deficient and record flow.

Angling effort from lodges and leases in 2020 could not be estimated due to the lack of reporting (only two lodges reported). In 2021, angling effort was estimated at 3,173 rod days, a 58% decrease in effort compared to the revised 2019 data (5,721 rod days). Since 2017, lodges have been reducing the extent of their fishing activity to certain pools or stretches in August and September because of low water levels.

Total parties registered in Crown Reserve waters in 2021 increased by 6% from 2020 (1,016 anglers in 2021 compared to 955 in 2020; for context there were 922 anglers in 2019). Of the registered parties, 60% had returned creel forms. Total Crown Reserve catches were estimated by raising the reported catches to all registered parties in 2020 and 2021. Combined, the provisional recreational fishery catches for 2020 were 758 large salmon and 1,037 small salmon from the Restigouche River (NB). In 2021, the provisional recreational fishery catches were 730 large salmon and 1,438 small salmon.

Similar to previous assessments, returns of small salmon and large salmon to the Restigouche River (NB) were estimated from an assumed angling exploitation rate of 40% to which were added the assumed Indigenous food social and ceremonial (FSC) fishery harvests from the NB side of Chaleur Bay (DFO 2014).

Based on the recreational angling data, returns to the Restigouche River (NB) in 2020 could not be estimated. In 2021, returns to the Restigouche River (NB) were estimated at 5,200 large salmon (median; 5^{th} to 95^{th} percentile: 4,200-6,900) and 3,600 small salmon (median; 5^{th} to 95^{th} percentile: 2,900-4,800; Figure 6).

Since 2017, unfavorable angling conditions have likely resulted in lower catches and a lower exploitation rate than the assumed value of 0.4. Additionally, restrictions associated with the Covid-19 pandemic have likely impacted the operations of lodges. Over the recent 12-year period (approximately two generations), based on angling data, the median annual abundance of small and large salmon has decreased by 56% and 54%, respectively (Figure 6).

Assessments on the Restigouche River (NB) are also informed by visual spawner counts at the end of the season, after all fisheries and in-river losses are complete. In September 2020 (14^{th} to 25^{th}), end of season visual spawner counts were conducted in the main stem of the Restigouche (NB) and four of its major tributaries (Kedgwick, Little Main Restigouche, Upsalquitch, and Patapedia; Figure 7). Water and weather conditions in 2020 were generally ideal for conducting visual spawner counts. In 2020,about 4,400 small salmon and 10,300 large salmon were counted (the highest count for large salmon of the time-series 1999-2021).

In 2021, weather conditions (i.e., rain and high discharge leading to turbid waters) did not allow for visual spawner counts to be conducted; therefore, no data are available for 2021.

Estimates of egg deposition relative to LRP

In 2021, the potential egg depositions from the combined returns of large and small salmon represented 74% of the LRP (Figure 8). The potential egg depositions from large and small spawners combined, based on the recreational fisheries model and accounting for in-river fishery losses (assumed Indigenous FSC fishery harvests and 6% catch and release mortality in the recreational fishery) represented 70% of the LRP in 2021 (Figure 8). In 2020, the potential egg depositions from large and small salmon spawners combined based on the end of season spawner counts represented 145% of the LRP (Figure 8).

Based on the recreational fisheries catches and an assumed angling exploitation rate of 40%, the egg depositions in the Restigouche River (NB) from returns and spawners have been below the LRP (in the critical zone) in nine of the last 11 years (no estimate in 2020). The eggs in the returns and spawners have declined by 54% and 55%, respectively over the same time period (Figure 8).

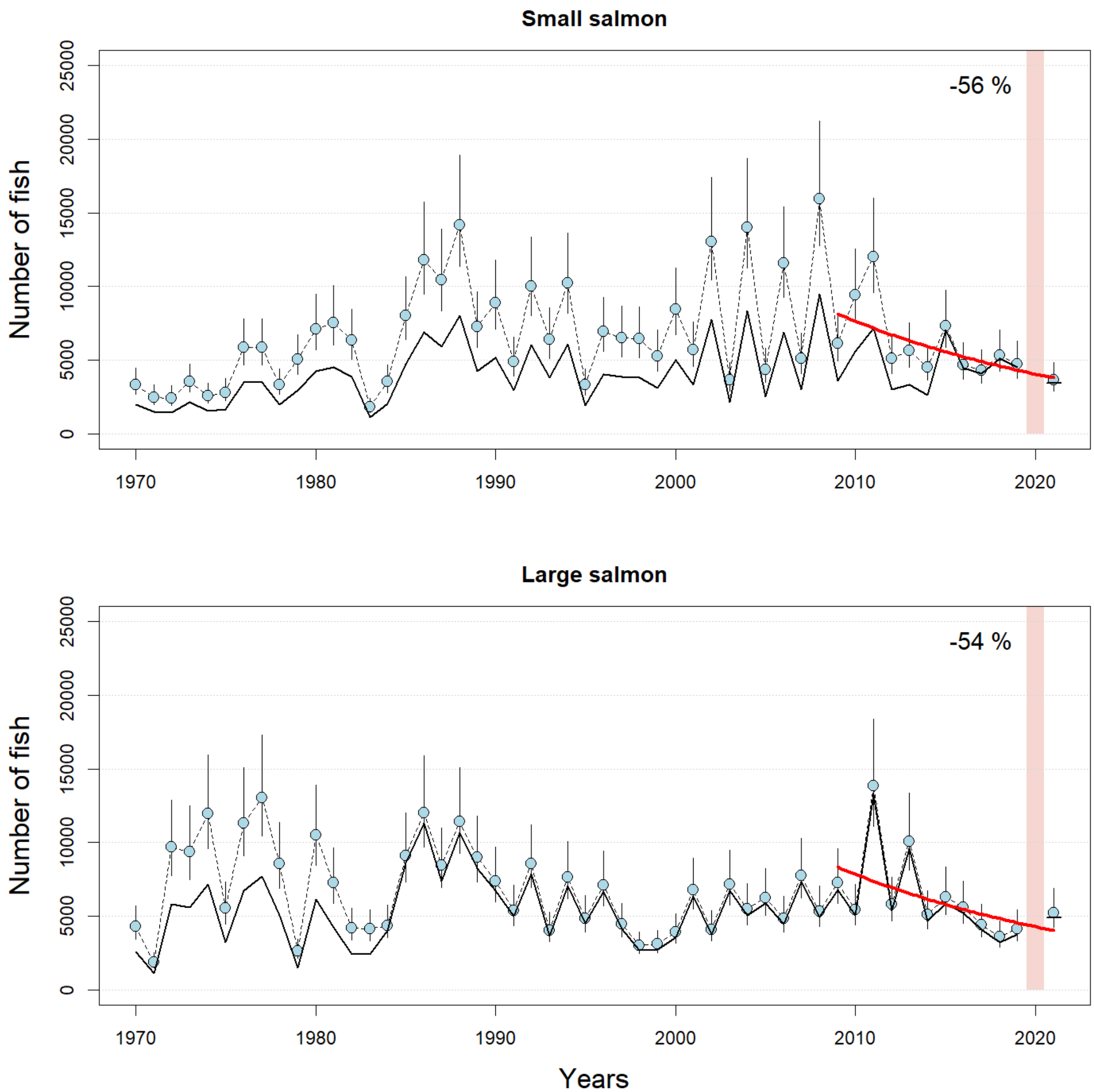

Figure 6: Estimated returns (grey circles and thin dashed solid line are for 40% catch rate and the vertical error bars show range based on catch rates of 30% to 50%) and spawners (thick solid line and no symbols, for 40% catch rate assumption) based on angling catches of small salmon (top panel) and large salmon (bottom panel) to the Restigouche River (NB), 1970 to 2021. The area shaded in light red indicates 2020, during which it was not possible to estimate returns and spawners based on angling data. The data for 2021 are preliminary. The trend line (exponential regression, red line) for returns over the previous twelve year time period (2009 to 2021) and the corresponding percent change over that period are shown in each panel.

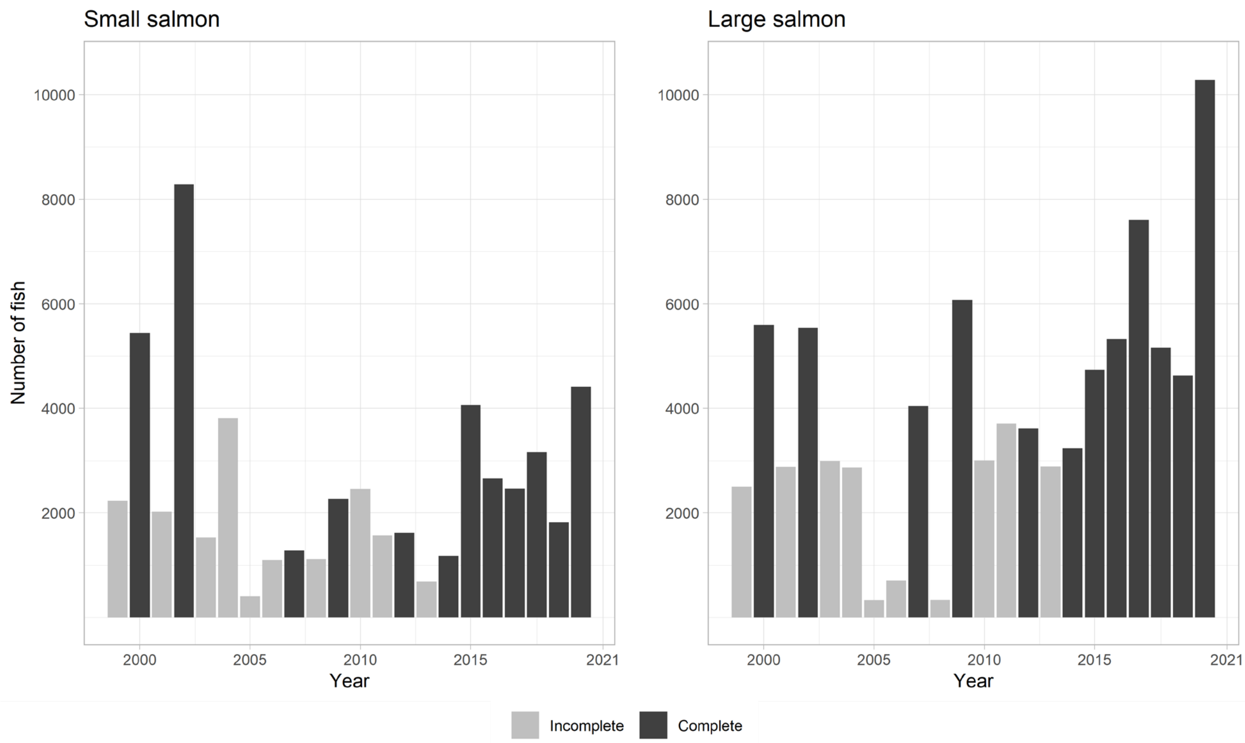

Figure 7: Total end of season visual spawner counts of Atlantic Salmon, by size group (small salmon left panel, large salmon right panel) from four tributaries and the main stem of the Restigouche River for 1999 to 2021 (no counts in 2021). Complete and incomplete (mainly due to high water conditions) visual spawner counts are indicated in dark and light grey, respectively.

SFA 16A Miramichi River

The Miramichi River is the largest watershed in SFA 16 and DFO Gulf Region. Returns of small and large salmon are estimated using mark and recapture experiments based on catches at various monitoring facilities throughout the watershed (DFO 2014).

Catches and counts of adult Atlantic Salmon, by size group, are available from trapnets operated in the estuary and from headwater barrier counting fences (Figure 9). The annual catches at these monitoring locations are not adjusted for periods when the counting facilities were not operating due to maintenance, high water conditions, or suspension of activities due to high water temperatures.

Catches of small and large salmon have been available from DFO index trapnets located in the Southwest Miramichi at Millerton since 1994 and in the Northwest Miramichi at Cassilis since 1998 (Figure 9). Index trapnets were not operated in 2020 because of field work restrictions. In 2021, the trapnet at Millerton operated between May 25 and October 29 while the trapnet at Cassilis operated between May 13 and October 27. The Millerton trapnet did not operate between September 11 and 20, 2021, because of a washout that was caused by heavy rain and high water levels associated with hurricane Larry.

The catches of large salmon at the Millerton (n = 305) and Cassilis (n = 168) trapnets in 2021 were improved over 2019 levels but remained below the long term average for this size group at both facilities (Figure 9). Similarly, small salmon catches were higher at the Millerton (n = 939) and Cassilis (n = 367) trapnets in 2021 compared to 2019 but remained below the long term average for this size group at both facilities (Figure 9).

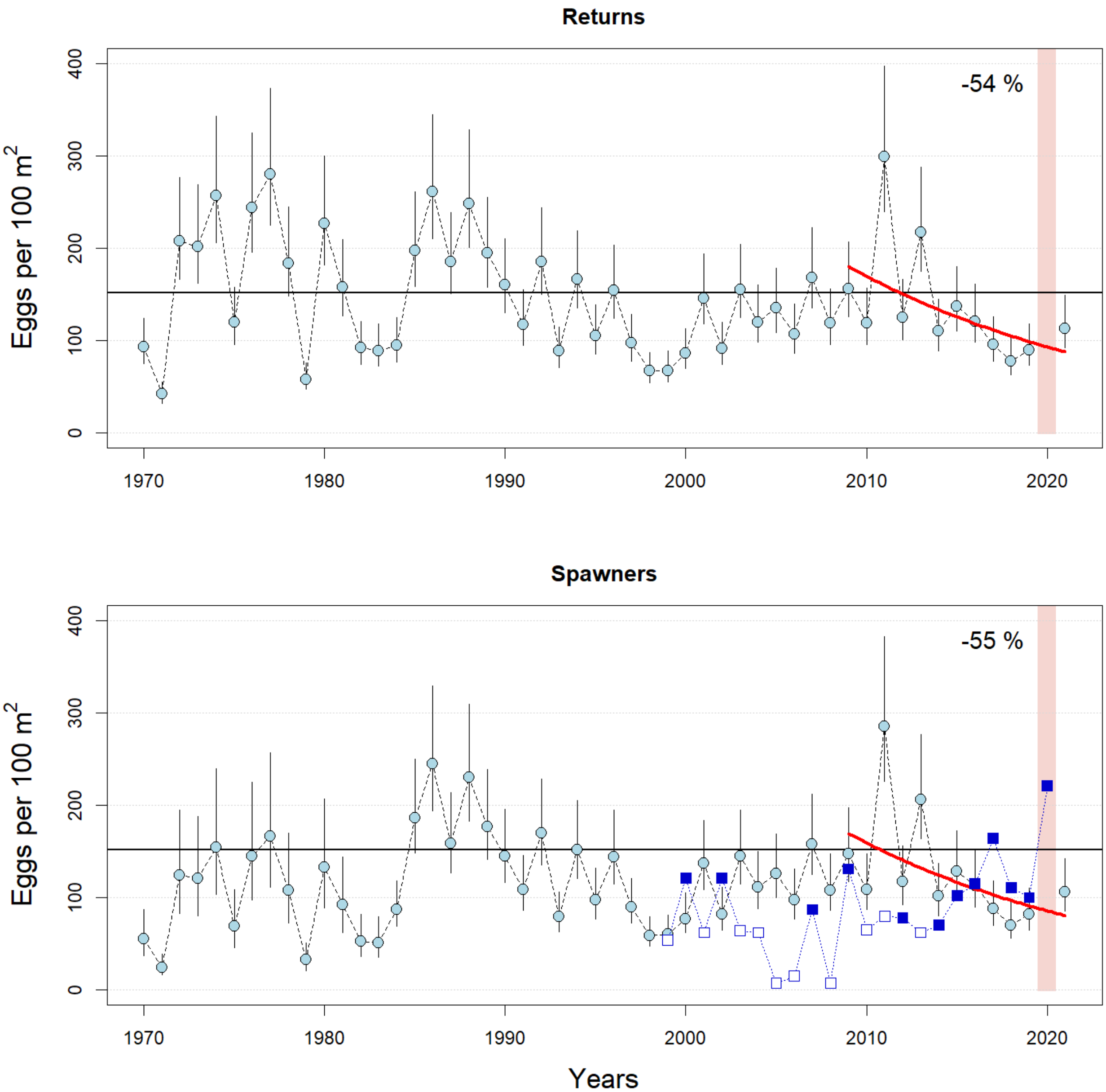

Figure 8: The potential eggs (expressed as eggs per 100 m² of wetted habitat area; total area of 26.39 million m²) by the combined small and large salmon returns (top panel) and spawners (bottom panel) in the Restigouche River (NB), 1970 to 2021. The area shaded in light red indicates the 2020-2021 time-period during which angling effort from the lodges has been greatly reduced. The estimates for 2021 are based on preliminary data. The solid horizontal line is the Limit Reference Point egg deposition rate of 152 eggs per 100 m² defined for the Restigouche River (NB; DFO 2018b). In the both panels, light blue circles are estimates based on an assumed catch rate of 40% and the vertical bars show the range for catch rates of 30% to 50%. In the right panel, the eggs in spawners based on the end of season spawner counts are shown as blue-filled square symbols for the years with complete coverage, years with incomplete coverage are indicate with empty blue squares. The trend line (exponential regression, solid and dashed red line when the slope is significantly different than 0 or not, respectively) for eggs in returns or eggs in spawners over the previous 12-year time period (2009 to 2021) and the corresponding percent change over that period are shown in each panel.

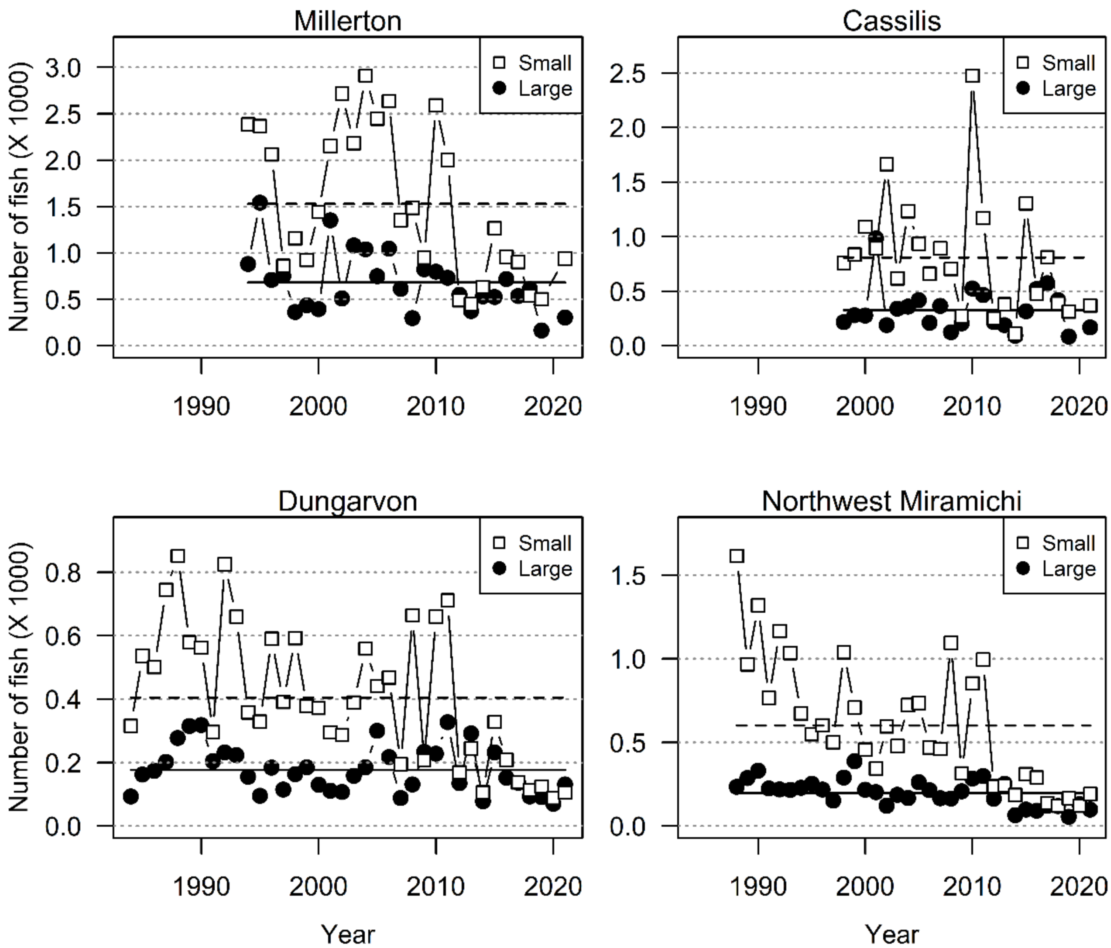

Figure 9: Catches of small salmon and large salmon at DFO index trapnets (top row) at Millerton on the Southwest Miramichi River (top left panel) and at Cassilis on the Northwest Miramichi River (top right panel) and at provincial headwater barriers (bottom row) in the Dungarvon River, tributary of the Southwest Miramichi River (bottom left panel) and the Northwest Miramichi River (bottom right panel) between 1984 and 2021.The horizontal solid and dashed lines represent the average catch or count of large and small salmon, respectively, for the time series of the facility depicted. DFO Index trapnets were not operated in 2020.

Annual counts of small and large salmon have been available from two headwater protection barriers operated by the NB Department of Natural Resources and Energy Development, and more recently on their behalf by the Miramichi Salmon Association and Miramichi Fisheries Management Inc. One protection barrier has operated on the Dungarvon River, tributary of the Renous and Southwest Miramichi rivers since 1984, and the other, on the Northwest Miramichi River since 1988. In 2020, both protection barriers operated continuously between June 17 and October 13. In 2021, the protection barriers on the Dungarvon and Northwest Miramichi rivers operated between June 10 and October 14. Due to high water which caused two washouts, the Dungarvon barrier was inoperable between September 10 and 14 and again between September 27 and October 4.

The count of large salmon (n = 131) and small salmon (n = 106) at the protection barrier on the Dungarvon River was improved over 2020 levels but remained below the long term average counts for large and small salmon at this facility (Figure 9). The count of large salmon (n = 98) at the Northwest Miramichi barrier decreased from levels observed in 2020, while counts of small salmon (n = 193) increased. Counts of both large and small salmon at the Northwest Miramichi barrier in 2021 were below the long term average for both size groups at this facility (Figure 9).

The estimated return of large salmon to the Miramichi River in 2021 was 8,500 fish (median; 5th to 95th percentile range 5,900 to 12,900) and represented an increase from levels estimated in 2019 (Figure 10). Small salmon returns to the Miramichi River in 2021 were estimated at 13,700 fish (median; 5th to 95th percentile range 10,800 to 18,300), higher than annual estimates of small salmon returns to the Miramichi River in 2018 and 2019 (Figure 10). Return estimates of both large and small salmon to the Miramichi River in 2021 were below the long term average for both size groups for the 1971 to 2019 time series (Figure 10).

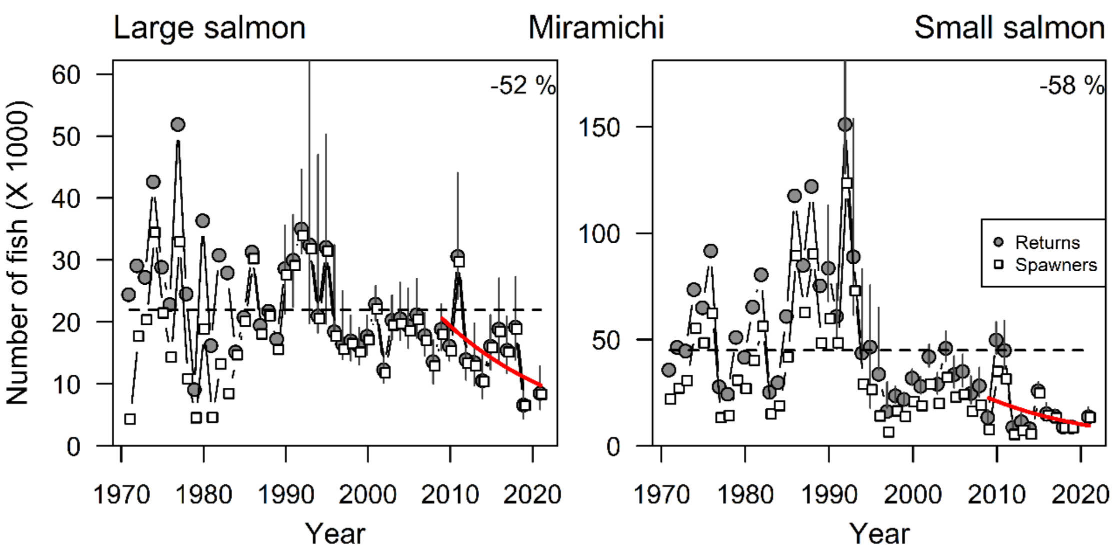

Figure 10: Estimated (median and 5th to 95th percentile range) returns and spawners of large salmon (left panel) and small salmon (right panel) for the Miramichi River for 1971 to 2021. Restrictions on field work in 2020 precluded the Miramichi assessment program and estimates of large and small salmon returns are unavailable for that year. The horizontal dashed line is the average of the median return estimates of large salmon or small salmon for the available time series. The trend line (exponential regression, red line) for returns over the previous 12-year time period (2009 to 2021) and the corresponding percent change over that period are shown in each panel.

Estimated returns for the two main branches of the Miramichi River are available since 1992 (Figure 11). The return of large salmon to the Southwest Miramichi River in 2021 was estimated at 6,600 fish (median; 5th to 95th percentile range 4,300 to 10,800) and represented an increase from the large salmon estimate of 2019 (Figure 11). Small salmon returns to the Southwest Miramichi in 2021 were estimated at 10,700 fish (median; 5th to 95th percentile range 7,900 to 15,400), and higher than annual estimates of small salmon returns since 2016 (Figure 11). Return estimates of both large and small salmon to the Southwest Miramichi River in 2021 were below the long term average for both size groups for the 1992 to 2019 time series (Figure 11).

The return of large salmon to the Northwest Miramichi River in 2021 was estimated at 1,700 fish (median; 5th to 95th percentile range 1,000 to 3,200) and represented an increase from the large salmon estimate of 2019 (Figure 11). Small salmon returns to the Northwest Miramichi in 2021 were estimated at 2,900 fish (median; 5th to 95th percentile range 2,000 to 4,200), nearly identical to the small salmon return estimates in 2018 and 2019 (Figure 11). Return estimates of both large and small salmon to the Northwest Miramichi River in 2021 were below the long term average for both size groups for the 1992 to 2019 time series (Figure 11).

Over the recent 12-year period, approximately two generations for Atlantic Salmon, the estimated returns of large salmon have declined 52% in the Miramichi River, 54% in the Southwest Miramichi River, and 47% in the Northwest Miramichi River (Figure 10 and Figure 11). Similarly, the estimated returns of small salmon over the last 12 years have declined in the Miramichi River (58%), the Southwest Miramichi River (56%) and Northwest Miramichi River (60%) (Figure 10 and Figure 11).

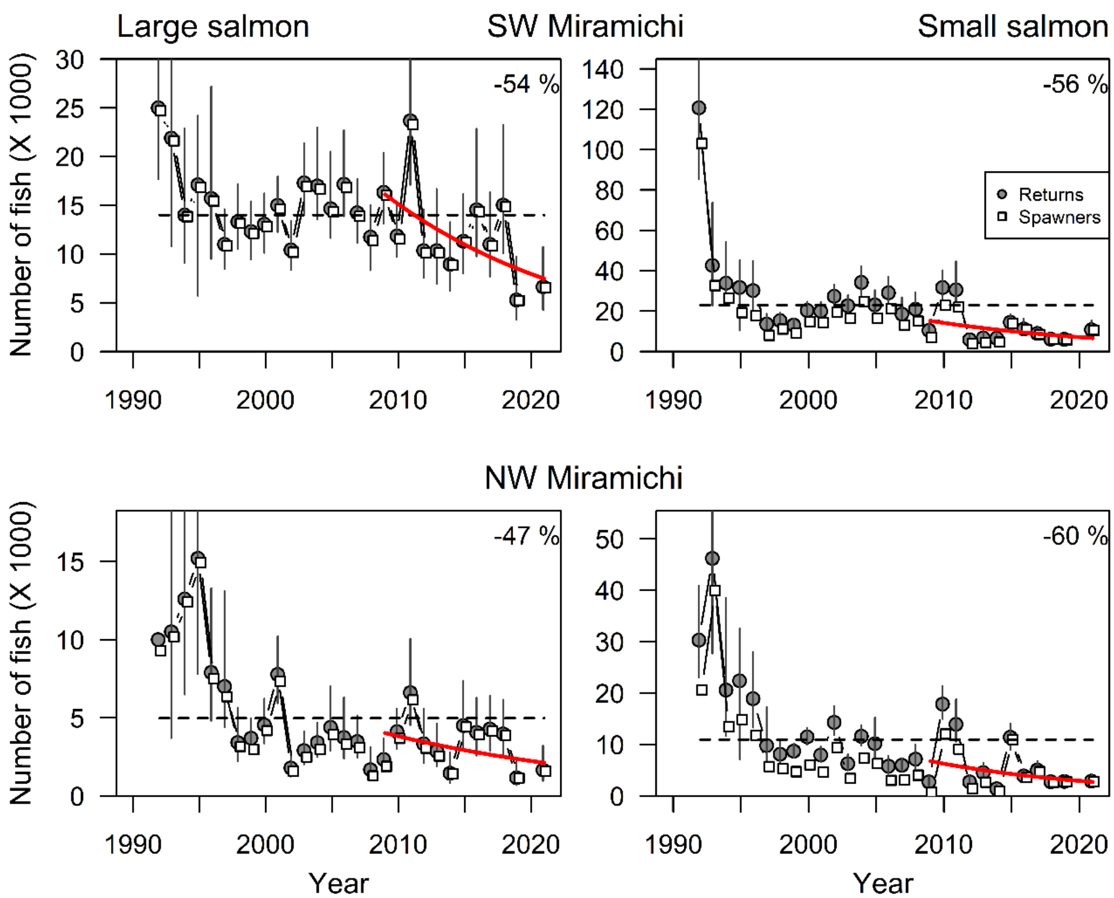

Figure 11: Estimated returns (median and 5th to 95th percentile range) and spawners (median) of large salmon (left panels) and small salmon (right panels) for the Southwest Miramichi River 1992 to 2021 (top row), and the Northwest Miramichi River 1992 to 2021 (bottom row).Restrictions on field work in 2020 precluded the Miramichi assessment program and estimates of large and small salmon returns are unavailable for that year. The horizontal dashed line is the average of the median return estimates of large salmon or small salmon for the available time series. The trend line (exponential regression, red line) for returns over the previous 12-year time period (2009 to 2021) and the corresponding percent change over that period are shown in each panel.

Estimates of egg depositions relative to LRPs

The Southwest Miramichi system, that includes the Barnaby River, Southwest Miramichi River, and the Renous River, has a LRP egg deposition rate value of 152 eggs per 100 m^2 (DFO 2018b). The Northwest Miramichi system, that includes the Northwest Millstream, Little

Southwest Miramichi River and the Northwest Miramichi River, has an LRP egg deposition rate value of 176 eggs per 100 m^2 (DFO 2018b). The LRP for the Miramichi River (Southwest Miramichi system and Northwest Miramichi system) is calculated as the habitat weighted average of the Southwest Miramichi system and Northwest Miramichi system LRP values, and is equivalent to 160 eggs per 100 m^2.

The eggs for small and large salmon returns and spawners for the Miramichi River and for the two main branches were determined using the 2021 biological characteristics (mean fork length, proportion female, eggs per fish). In 2021, the median egg deposition rates for returning small and large salmon combined were 113 eggs per 100 m^2 for the Miramichi River, 130 eggs per 100 m^2 for the Southwest Miramichi River, and 70 eggs per 100 m^2 for the Northwest Miramichi River (Table 1; Figure 12 and Figure 13).

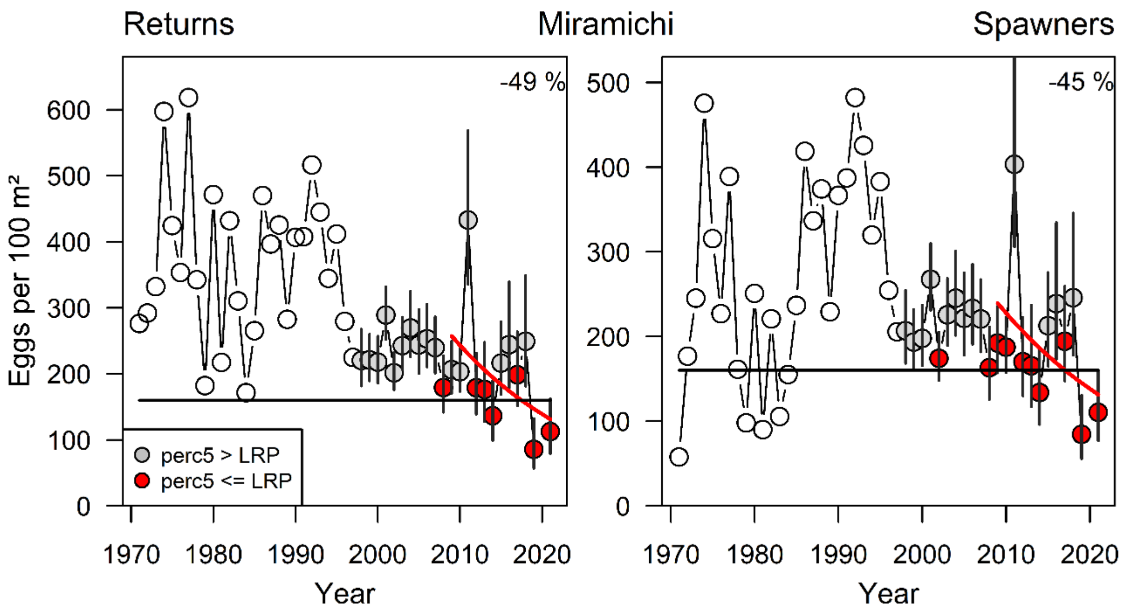

Figure 12: The estimated median N1971-2021) and 5th to 95th percentile range (1998-2021) of the number of eggs (expressed per 100 m² of habitat) from the returns (left panel) and spawners (right panel) of small and large salmon combined to the Miramichi River. The Limit Reference Point is shown as the solid horizontal line (Table 1; DFO 2018b). Grey symbols indicate when the 5th percentile of the number of eggs was above the LRP and red symbols indicate when the 5th percentile of the number of eggs was below the LRP. The white open circles are for years without estimates of uncertainties for egg depositions. The trend line (exponential regression, red line) in the number of eggs of large and small salmon combined over the previous 12-year time period (2009 to 2021) and the corresponding percent change over that period are shown in each panel.

These estimated egg deposition rates in 2021, translated into percentages of LRP attainment that ranged from 40% (median value) in the Northwest Miramichi River to 85% (median value) in the Southwest Miramichi River (Table 1).

Over the previous 12-year period, the estimated number of eggs in the returns of small and large salmon combined have declined 49% in the Miramichi River, 48% in the Southwest Miramichi River, and 50% in the Northwest Miramichi River (Figure 12 and Figure 13).

Spawners are calculated as returns minus losses from reported Indigenous FSC fisheries (based on data available to date) and from recreational fisheries. With the introduction of the mandatory release of small salmon in the recreational fishery, losses due to catch and release mortality were assumed to be 0.9% of the total returns (3% mortality of caught and released salmon, assuming 30% of the small salmon or large salmon return is caught and released), identical to the formula used for calculating large salmon losses in the recreational fishery since 1984.

After accounting for removals and losses from fisheries, the median egg deposition rate for large and small salmon combined in 2021, was 110 eggs per 100 m^2 for the Miramichi River, 128 eggs per 100 m^2 for the Southwest Miramichi River, and 67 eggs per 100 m^2 for the Northwest Miramichi River (Table 2; Figure 12 and Figure 13).

In 2021, the reported and estimated fisheries related losses were low. The percentages of the LRP attained by estimated eggs in the combined spawners of small salmon and large salmon ranged from 38% (median value) for the Northwest Miramichi to 84% (median value) for the Southwest Miramichi, similar to the percentages of LRP attainment in the returns (Table 1 and Table 2).

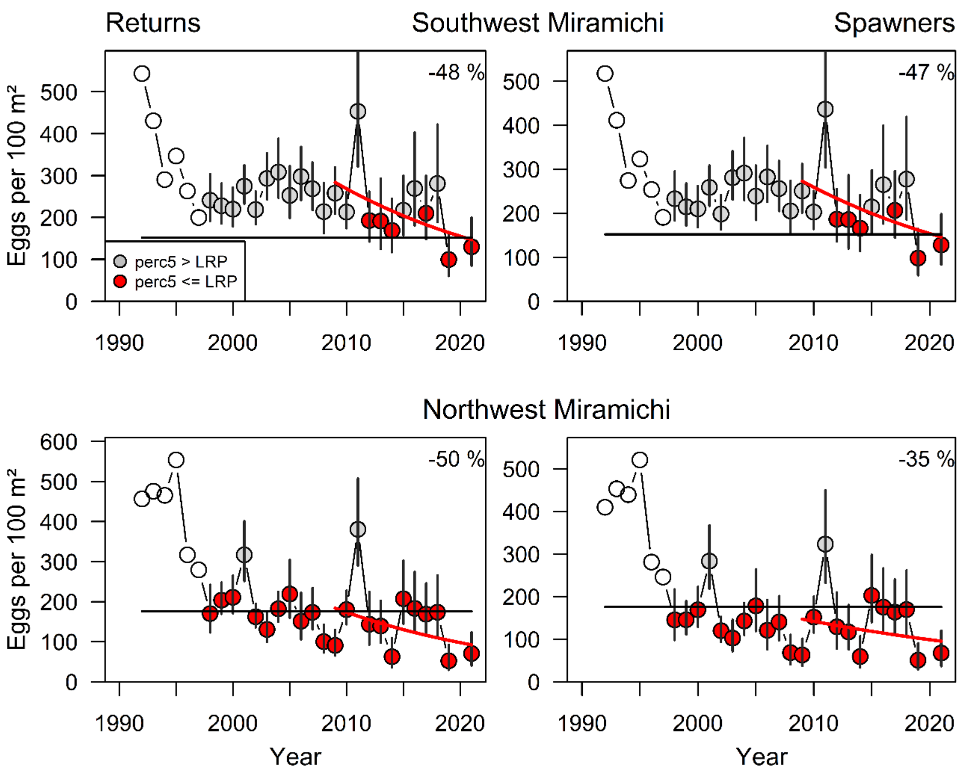

Figure 13: The estimated median (1992-2021) and 5th to 95th percentile range (1998-2021) of the number of eggs (expressed per 100 m² of habitat) from the returns (left panels) and spawners (right panels) of small and large salmon combined to the Southwest Miramichi River (top row) and the Northwest Miramichi River (bottom row). The Limit Reference Point is shown as the solid horizontal line (Table 1; DFO 2018b). Grey symbols indicate when the 5th percentile of the number of eggs was above the LRP and red symbols indicate when the 5th percentile of the number of eggs was below the LRP. The white open circles are for years without estimates of uncertainties for egg depositions. The trend line (exponential regression, red line) in the number of eggs of large and small salmon combined over the previous 12-year time period (2009 to 2021) and the corresponding percent change over that period are shown in each panel.

Table 1: Summary of estimated eggs per 100 m² in the combined returns of small salmon and large salmon by river / tributary in 2021, relative to the Limit Reference Point (LRP), and the probability of the eggs in the returns being less than the LRP.

River / tributary	Eggs in returns expressed as eggs per 100 m²; median (5^{th} to 95^{th} perc. range)	LRP (eggs per 100 m²)	Percentage of LRP attained; median (5^{th} to 95^{th} perc. range)	Prob. (%) of egg deposition rate being less than the LRP
Miramichi River	113 (79 to 163)	160	70% (49% to 102%)	94%
Southwest Miramichi	130 (85 to 200)	152	85% (56% to 131%)	73%
Northwest Miramichi	70 (40 to 124)	176	40% (23% to 70%)	> 99%

The probability of being below the LRP in 2021 was high for each river; 95% for the Miramichi River, 74% for the Southwest Miramichi River, and > 99% for the Northwest Miramichi River. All rivers were in the critical zone of the PA in 2021 (Table 1 and Table 2; Figure 12 and Figure 13).

The trends in the number of eggs from large and small salmon spawners combined show decreases over the last 12 years in the Miramichi River (-45%) the Southwest Miramichi River (-47%), and the Northwest Miramichi River (-35%) (Figure 12 and Figure 13).

Table 2: Summary of estimated eggs per 100 m² in the combined spawners (after removals and losses from fisheries) of small salmon and large salmon by river / tributary in 2021, relative to the Limit Reference Point (LRP), and the probability of the eggs in the returns being less than the LRP.

River / tributary	Eggs in spawners expressed as eggs per 100 m²; median (5^{th} to 95^{th} perc. range)	LRP (eggs per 100 m²)	Percentage of LRP attained; median (5^{th} to 95^{th} perc. range)	Prob. (%) of egg deposition rate being less than the LRP
Miramichi River	110 (77 to 160)	160	69% (48% to 100%)	95%
Southwest Miramichi	128 (83 to 198)	152	84% (55% to 130%)	74%
Northwest Miramichi	67 (37 to 120)	176	38% (21% to 68%)	> 99%

SFA 17

Salmon stock assessment on Prince Edward Island is currently based on redd counts which are conducted by local watershed groups. The method for converting redd counts to female salmon spawners is described in Cairns and MacFarlane (2015). The derivation of river-specific spawners corresponding to the LRPs is described in DFO (2018b).

There are 25 rivers in SFA 17 with current or recent Atlantic Salmon occupancy based on confirmed observations of redds or juveniles (Table 3; Figure 14). However, there are only 12 watersheds where they have been detected in all monitored years between 2000 and 2021. Local groups were able to conduct redd surveys on 18 watersheds in 2020, and 15 watersheds in 2021. In 2020 conditions were suitable and 95% of counts were complete, however high water conditions in 2021 meant only 50% of rivers surveyed had counts that were considered complete.

Environmental conditions continue to be a major determinant of the success of redd surveys for salmon stock assessment on PEI. In 2020, six of 18 surveyed rivers (33%) exceeded the Limit Reference Point (LRP) value, while only one (Carruthers Brook, Mill River) of 15 surveyed rivers exceeded its LRP value in 2021. Localized precipitation may have contributed to differences in groups' ability to execute surveys, in 2021 all seven rivers in the Northeast Cluster (from Cow River to North Lake Creek) had incomplete counts, all of which were below their LRP values. Alternately, the four south draining rivers (Vernon River, Clarks Creek, Head of Hillsborough River) surveyed by staff of Pisquid River Environmental Project, all had complete surveys, but these rivers ranged from 9%-22% of LRP values (Table 3).

Table 3: The percentage attainment of the Limit Reference Point (LRP) value for Atlantic Salmon monitored rivers in SFA 17, 2012 to 2021. A dash indicates no survey was performed. The spawner requirement is the estimated number of spawners, sexes and sea ages combined, corresponding to the LRP for the river (DFO 2018b). Status of rivers for previous years is available in Cairns and MacFarlane (2015).

River	Spawner req.	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Cains Brook	15	173	161	-	161[a]	186	316	96	-	215	-
Carruthers Brook	24	352	263[a]	-	277[a]	253	320	293	102[a]	247	358
Trout River, Coleman	94	-	41	25	25	31	29	22	17[a]	19	26
Trout River, Tyne Valley	26	-	0	0	-	-	7 [a]	-	-	-	-
Little Trout River	11	-	0	0	7	-	77	-	-	-	-
Bristol (Berrigans) Creek	22	12	19	0	0[a]	-	16	-	-	49	10[a]
Morell River	160	98[a]	132	157	58[a]	83	78	51	193[a]	174	21[a]
Midgell River	34	105	46[a]	97	181	-	135	-	-	-	-
St. Peters River	24	128	80	79	122	37	35	-	-	184	-
Cow River	12	4	182	43	245	204	139	48[a]	29	11	2[a]
Naufrage River	23	80	845	405	288	201	166	80[a]	138	71	0[a]
Bear River	9	-	74	14	60	164	33	5[a]	0	52	-
Hay River	14	9	140	49	117	133	49	13[a]	42	0	-
Cross Creek	24	153	496	357	440	315	355	109[a]	61	213	50[a]
Priest Pond Creek	13	70	506	433	462	234	503	13[a]	74	17	0[a]
North Lake Creek	26	180	568	311	447	428	364	68[a]	95	133	19[a]
Vernon River	37	9	12	0[a]	0	-	19	7[a]	11	14	21
Clarks Creek	25	0	5	-	0[a]	-	7	-	4[a]	-	21
Pisquid River	26	60	67	26[a]	81	49	47	28[a]	17	45	22
Head of Hillsborough R.	29	0	4	-	0	-	0	-	-	17	9
North River	53	-	18	-	-	-	7	-	-	0	12
Clyde River	22	-[b]	-[b]	-[b]	-[b]	-	0	-	-	-	-
West River	124	46	88	59	59	76	78	64[a]	59	53	20[a]
Dunk River	130	0[a]	-	-	-	-	39	-	-	-	-
Wilmot River	45	-	-	- [c]	- [c]	-	5	-	-	-	-

[a] Considered to be a minimum value due to poor counting conditions or incomplete survey coverage.
[b] Juveniles were found by electrofishing in 2012, but not in 2013, 2014, and 2015.
[c] Juveniles were found by electrofishing in 2014 and 2015.

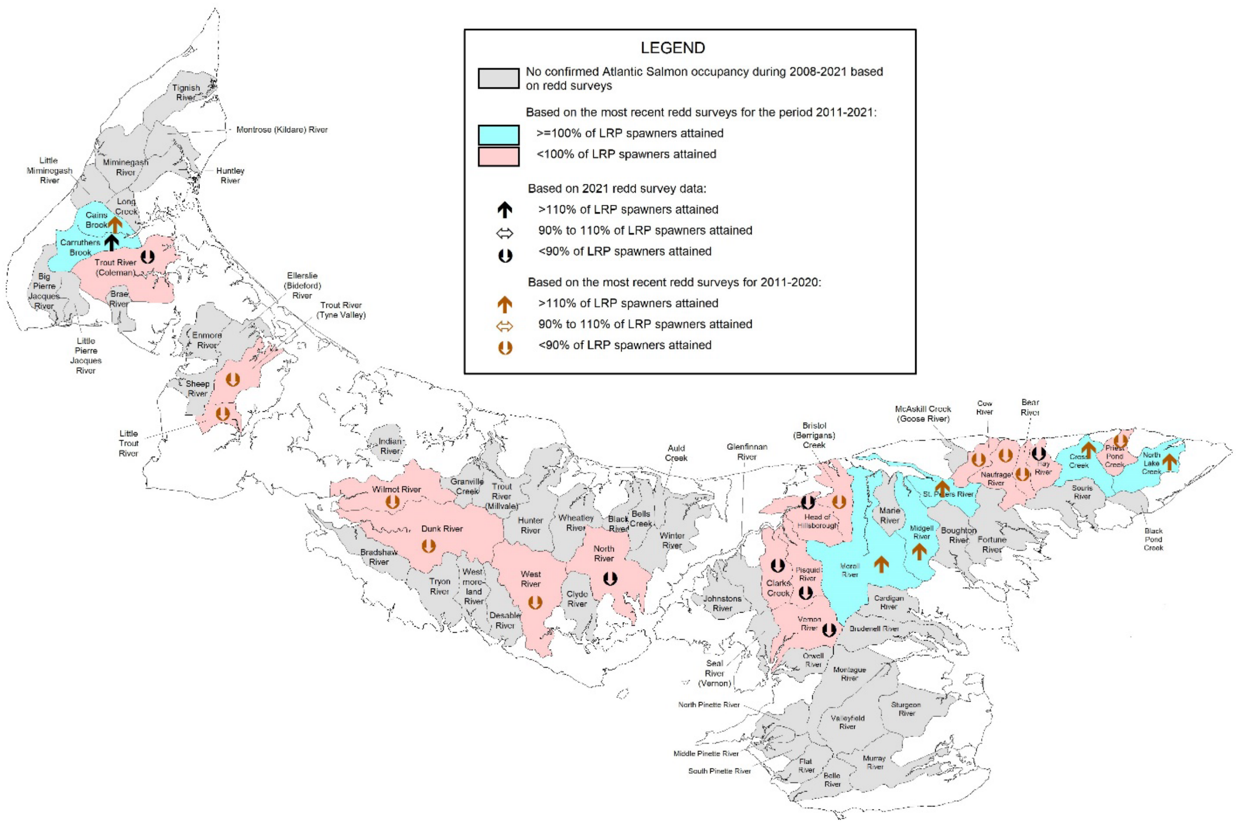

Figure 14: Location of SFA 17 watersheds with historic or current Atlantic Salmon occupancy and summary of their status relative to the percentage of the LRP attained in 2021 (Carruthers, and in 2020 or earlier (all other watersheds). Blue shading indicates watersheds which met or exceeded the LRP whereas pink shading indicates watersheds that are below the LRP. Grey shading indicates watersheds with no evidence of salmon redds since 2008. The symbols are as follows: ⇓ less than 90% of LRP attained, ⇔ between 90% and 110% of LRP, and ↑ greater than 110% of LRP.

SFA 18 Gulf Nova Scotia

Indices of abundance for the rivers in SFA 18 are derived from recreational fishery catch and effort data. The recreational fishery data for 2021 are preliminary and are based on extracts from the licence stub return database from February 4th, 2022 (277 licence stubs returned out of 2,187 licences sold in 2021; 13% return rate). Catch and effort from the returned licence stubs are raised by total licence sales to estimate total catch and effort. In 2020, the license stub return rate was 26% (509 licence stubs returned out of 1,954 licences sold in 2020).

SFA 18A Mainland Gulf Nova Scotia

In 2020 and 2021, there was a decrease in the catch of large salmon for West River (Antigonish) and River Philip, and an increase in large salmon catch for East River (Pictou) relative to 2019 (Figure 15). Values for all three rivers were lower than their respective long term averages (1984 to 2021;Figure 15). Catch for small salmon decreased slightly in West River (Antigonish) in 2020 and 2021, relative to 2019. East River (Pictou) and River Philip experienced little change in catch of small salmon from 2019 to 2020, but catch increased in 2021. Small salmon catch remained below their respective long term average for 2020. However, in 2021, East River (Pictou) and River Philip were above their long term average (1984 to 2021; Figure 15).

The catch rate (catch per rod day) of large salmon for West River (Antigonish) declined in 2020 and 2021 relative to 2019 (Figure 15). The catch rate (catch per rod day) of large salmon for East River (Pictou) increased in 2020, but declined in 2021. River Philip experienced minimal change between 2019 to 2020, but declined in 2021 (Figure 15). Over the recent 12-year period, the trend for catch rates of large salmon declined 31% in West River (Antigonish) and 21% in East River (Pictou). Catch rates of large salmon in River Philip increased 18% over the same time period (Figure 15).

In 2020 and 2021, catch rates of small salmon decreased in West River (Antigonish). Little change occurred in River Philip and East River (Pictou) from 2019 to 2020, but slight increases occurred between 2020 and 2021 (Figure 15). Over the recent 12-year period, the trend for catch rates of small salmon declined 15% for West River (Antigonish), increased 83% for East River (Pictou), and increased 56% for River Philip (Figure 15).

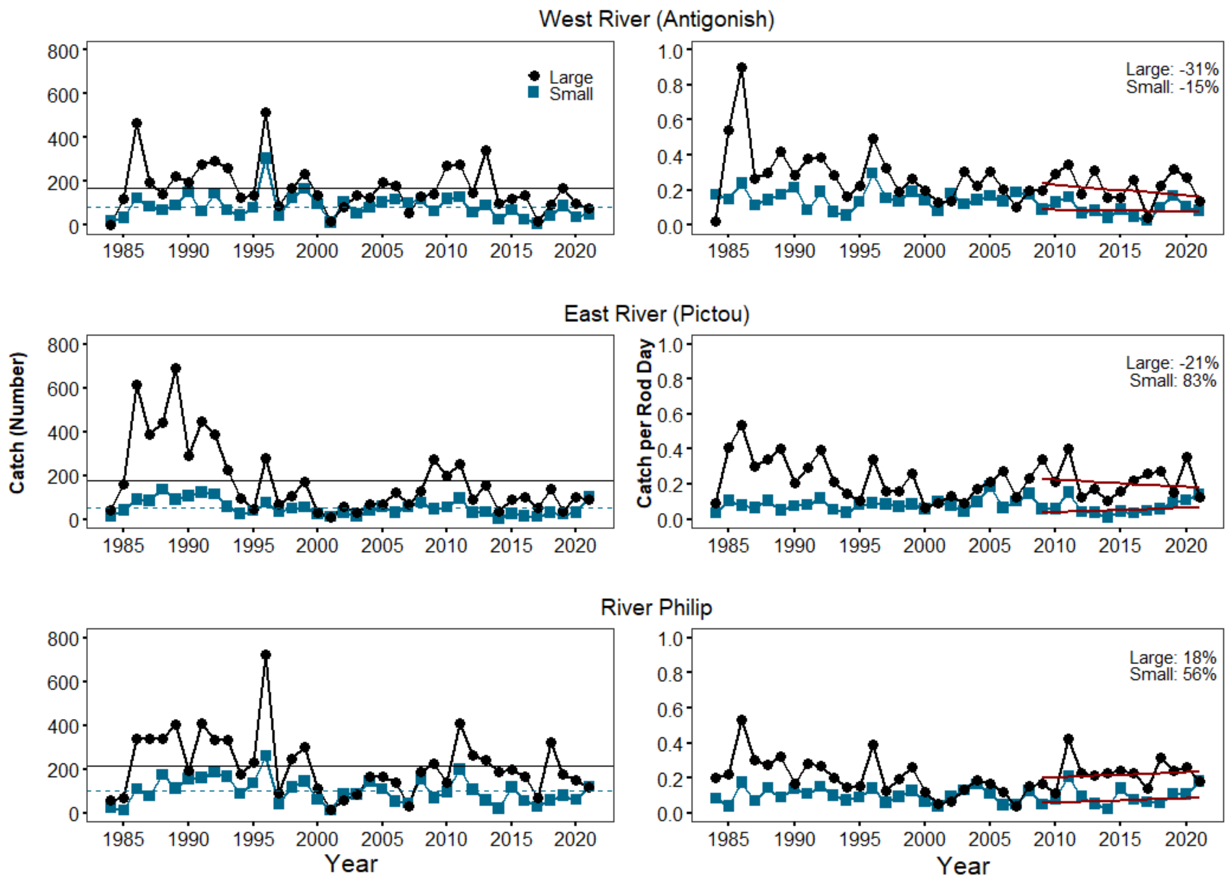

Figure 15: Estimated catches (left panels) and catch rates (catch per rod day; right panels) of large salmon and small salmon from the recreational fishery in the three largest rivers of SFA 18A, 1984 to 2021. In the left panels, the horizontal lines are the average catch for large salmon (solid) and for small salmon (dashed line) for the time series (1984 to 2021). In the right panels, the trend line (exponential regression, red line) in the median of the estimated catch rates over the previous 12-year time period (2009 to 2021) and the corresponding percent change over that period is shown.

SFA 18B Margaree River

The catches of large and small salmon for the Margaree River decreased in 2020 relative to 2019, but increased in 2021 relative to 2020 (Figure 16). Catches for large salmon were below the respective long term average, while catches for small salmon in 2021 were above the long term average (1984 to 2021;Figure 16). In 2020, the catches per rod day of large salmon on the Margaree River were higher than in 2019. However, in 2021 the catches per rod day declined relative to 2020. Catches per rod day of small salmon showed little change from 2019 to 2020, but increased from 2020 to 2021 (Figure 16). Trends in catch rates over the recent 12 years show an increase of 7% for large salmon and 42% for small salmon (Figure 16).

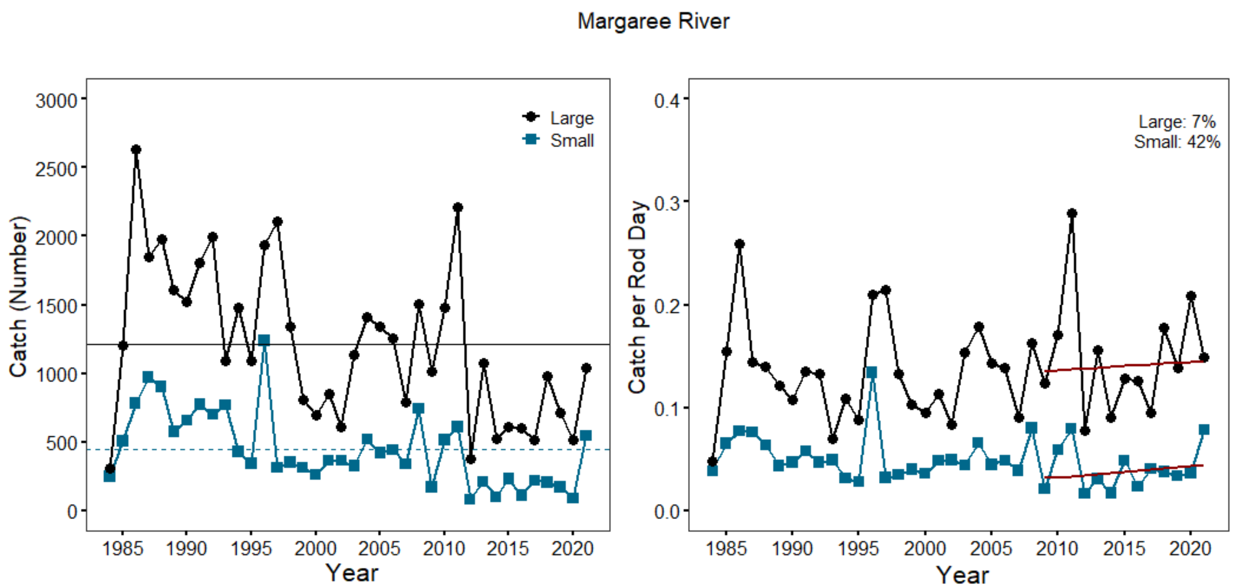

Figure 16: Estimated catches (left panel) and catch rates (catch per rod day; right panel) of large salmon and small salmon from the recreational fishery on the Margaree River (SFA 18B), 1984 to 2021. In the left panel, the horizontal lines are the average catch for large salmon (solid) and for small salmon (dashed line) for the time series (1984 to 2021). In the right panel, the trend line (exponential regression, red line) is the median of the estimated catch rates over the previous 12-year time period (2009 to 2021) and the corresponding percent change over that period is shown.

Adult salmon abundance for the Margaree River is derived by a model that estimates exploitation rates in the recreational fishery based on mark and recapture experiments conducted between 1988 and 1996 applied to the corresponding recreational fishery catch and effort data recorded in volunteer angler logbooks, and licence stub returns (Breau and Chaput 2012). Estimates for 2020 and 2021 are based on catch and effort data from volunteer angler logbook returns (n = 29) and licence stubs (for 2021, the results are preliminary and licence stubs were processed as of February 4, 2022).

The estimated returns of large salmon to the Margaree River in 2020 and 2021 were 3,600 fish (median; 5th to 95th percentile range of 2,900 to 4,600) and 2,500 fish (median; 5th to 95th percentile range of 1,900 to 3,100) respectively, which is above the long term average of 2,800 fish (1987 to 2021; Figure 17) for 2020, but below the long term average for 2021. The estimated returns of small salmon to the Margaree River in 2020 and 2021 were 500 fish (median; 5th to 95th percentile range of 350 to 720) and 1,100 fish (median; 5th to 95th percentile range of 760 to 1,400) respectively, which is above the long term average for 2021. For the Margaree River, trends in estimated returns over the recent 12-year period show an increase of

7% and 40% for large and small salmon, respectively. Caution should be taken when using abundance estimates in the Margaree River to inform management of the population status because of the reliance on fisheries-dependent information and the reduced effort from license sales (see Sources of Uncertainties section for more detail).

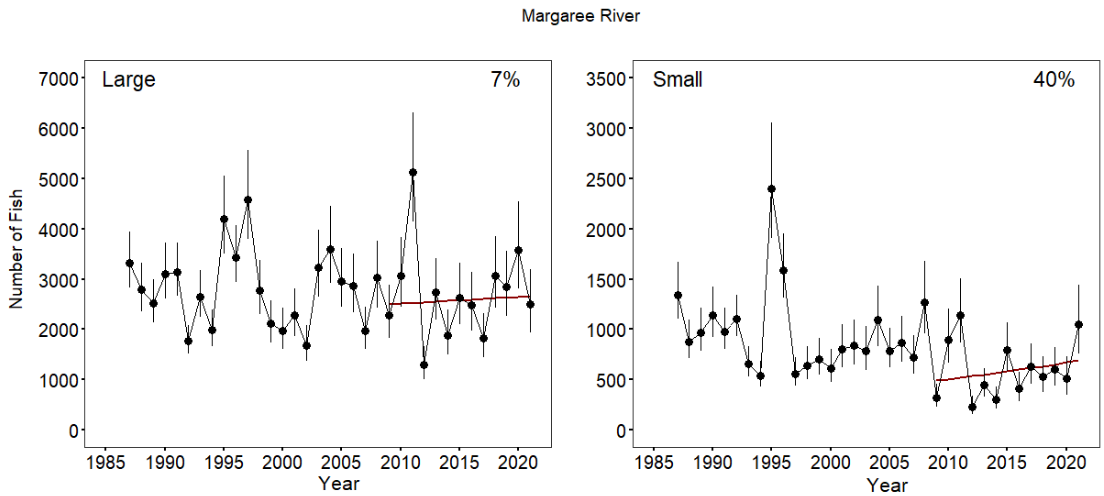

Figure 17: Posterior distributions (medians; 5th to 95th percentile range) of estimated returns of large salmon (left panel) and small salmon (right panel) to the Margaree River, 1987 to 2021. The trend line (exponential regression, red line) in the median estimated returns over the previous 12-year time period (2009 to 2021) and the corresponding percent change over that period are shown for each size group in each panel.

Estimates of egg depositions relative to LRP

The eggs in the returns and spawners of small salmon and large salmon combined are estimated using average biological characteristics of salmon in the Margaree River (DFO 2018b, 2019). In 2020, the estimated eggs in the returns of small salmon and large salmon combined were 846 eggs per 100 m² (median; 5th to 95th percentile range of 672 to 1,100 eggs per 100 m²), 5.5 times higher than the LRP value of 152 eggs per 100 m². In 2021, the estimated eggs in the returns of small salmon and large salmon combined were 596 eggs per 100 m² (median; 5th to 95th percentile range of 460 to 763 eggs per 100 m²), 3.9 times higher than the LRP value of 152 eggs per 100 m².The eggs in the combined returns of small and large salmon have exceeded the LRP value every year since 1987 (Figure 18).

The spawners are estimated after accounting for reported in-river fisheries losses (Indigenous FSC and recreational fisheries). For the recreational fishery, an assumed 5% catch and release mortality rate is applied to both large and small salmon released in the fishery (DFO 2014). In 2020, the estimated eggs in the spawners of small salmon and large salmon combined were 784 eggs per 100 m² (median; 5th to 95th percentile range of 616 to 992 eggs per 100 m²), 5.1 times the LRP value. In 2021, the estimated eggs in the spawners of small salmon and large salmon combined were 566 eggs per 100 m² (median; 5th to 95th percentile range of 437 to 725 eggs per 100 m²), 3.7 times the LRP value. The eggs in the combined spawners of small and large salmon have exceeded the LRP value every year since 1987 (Figure 18).

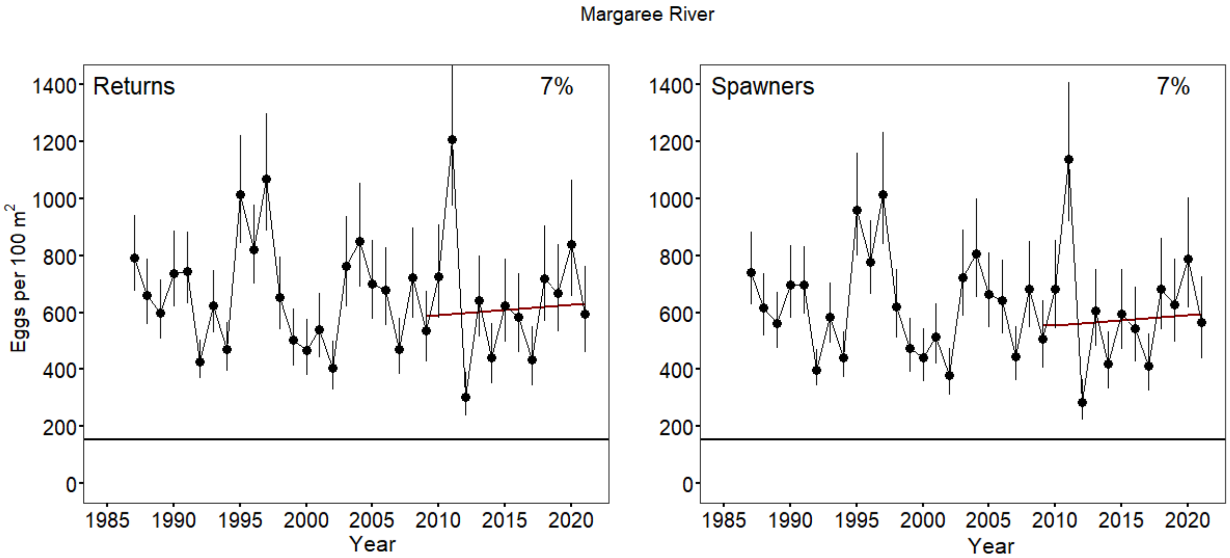

Figure 18: Median and 5th to 95th percentile range of the estimated number of eggs (expressed per 100 m² of habitat) in the returns (left panel) and spawners (right panel) of small and large salmon combined to the Margaree River, 1987 to 2021. The LRP value (152 eggs per 100 m²) is shown as the solid horizontal line. The trend line (exponential regression, red line) in the median of the estimated eggs for large salmon and small salmon combined over the previous 12-year time period (2009 to 2021) and the corresponding percent change over that period are shown in each panel.

Gulf Region

Estimates of total returns of small salmon and large salmon are developed for each SFA and overall for Gulf Region based on estimates from monitored rivers (DFO 2014). For SFA 15, from 2014 onwards, visual spawner counts in the Restigouche river are believed to be a better indicator of spawner abundance than the angling-based estimates and are therefore used to estimate adult returns in SFA 15 (ICES 2021-Annex 5).

Returns of large salmon to Gulf Region were estimated at 44,100 fish (5th to 95th percentile range of 37,200 to 50,800 fish) in 2020 and 23,300 fish (5th to 95th percentile range of 18,400 to 28,300 fish) in 2021; the medians estimates for 2020 and 2021 correspond to 188% and 100% of the 2019 estimate, and 110% and 58% of the long-term average (40,100 fish) of the 1970 to 2021 time series (Figure 19). Small salmon returns to Gulf Region were estimated at 26,400 fish (5th to 95th percentile range of 23,100 to 29,800 fish) in 2020 and 25,300 fish (5th to 95th percentile range of 20,700 to 29,900 fish) in 2021, higher than the 2019 return (16,000 fish) but, only 44% and 42% of the average abundance (59,800 fish) of the time series from 1970 to 2021 (Figure 19).

Over the recent 12 years, approximately two generations, the estimated abundances of large salmon have decreased in SFA 16 and 17 by 43% and 30%, respectively, while in SFA 15 and 18 the number of large salmon has increased by 2% and 11%, respectively (Figure 19). Overall in Gulf Region rivers, large salmon abundance has declined by 23% over the period 2009 to 2021. For small salmon, abundances have declined by 23% to 61% in SFA 15,16 and 17 while they have increased by 40% in SFA 18. Overall in the Gulf Region, the estimated small salmon abundance has declined by 51% (Figure 19).

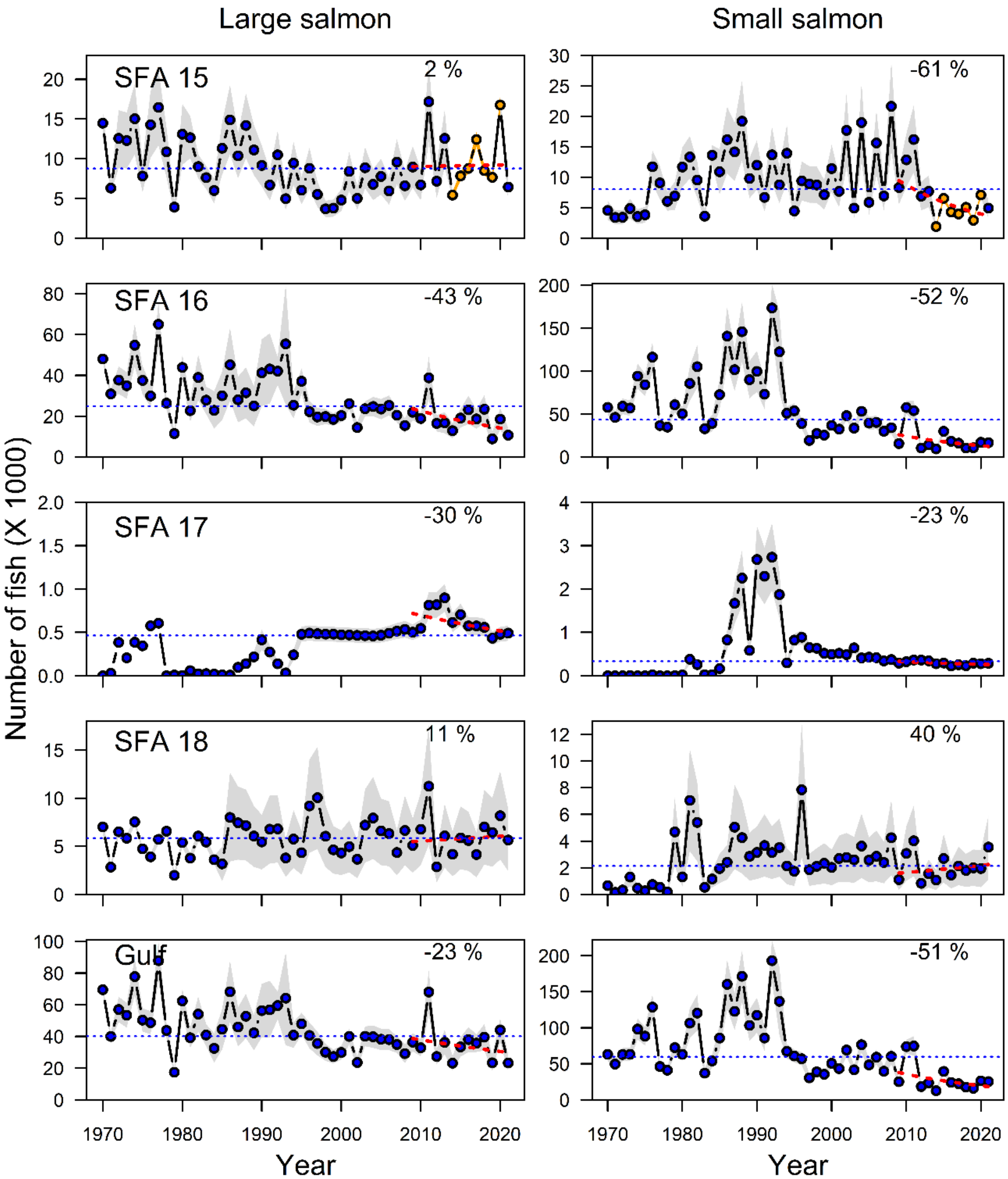

Figure 19: Estimates (medians are coloured symbols, shaded contours are the 5th to 95th percentile ranges) of total returns of large salmon (left panels) and small salmon (right panels) to each of SFA 15, 16, 17, and 18, and to Gulf Region rivers overall, 1970 to 2021. The trend line (exponential regression, solid and dashed red line when the slope is significantly different than 0 or not, respectively) in the median of the estimated returns over the previous 12-year time period (2007 to 2021) and the corresponding percent change over that period are shown in each panel. The light horizontal dashed line in each panel is the median abundance for the time series 1970 to 2021. Note: For SFA 15, from 2014 onwards, returns estimates are based on visual spawner counts when they are available, they are represented in orange (ICES 2021-Annex 5).

Abundance indices of juvenile salmon

Indices of freshwater production are derived from electrofishing surveys. Fixed site sampling for juvenile salmon has been conducted most consistently since the early 1970s in the Restigouche (SFA 15) and Miramichi (SFA 16) rivers, and since the mid-1980s for SFA 18 rivers. Juvenile salmon abundances at sites, in terms of number of fish per habitat area sampled by age or size group (densities), are obtained using successive removal sampling or catch per unit effort sampling calibrated to densities. Sampling intensities vary among years and among rivers. When information is available, annual densities are referenced to averages for two time periods, prior to 1984 and post-1984 (or later depending upon the age group) corresponding to the year (1984) when commercial fisheries were closed and mandatory catch-and-release for large salmon in the recreational fishery was introduced. Size groups of juveniles (fry, small parr, large parr) are used as proxies for cohorts.

SFA 15A Restigouche River (NB)

Juvenile densities are estimated and presented for four main tributaries of the Restigouche watershed (Main Restigouche, Upsalquitch, Little main Restigouche, and Kedgwick, Dauphin et al. 2019, 2021). In 2020 and 2021, one to three cohorts (fry, small parr, large parr) were captured at most sampling sites in the Restigouche River. In 2020, 59 sites were sampled (NB, sites excluding those of the Matapedia and Patapedia rivers), one site had no salmon juveniles, eight sites had no fry, eight sites had no small parr, and 22 sites had no large parr. In 2021, 63 sites were sampled (NB; n = 63 sites excluding those of the Matapedia and Patapedia Rivers), one site had no salmon juveniles, two sites had no fry, seven sites had no small parr, and 24 sites had no large parr.

These results indicate that there has been multiple years of spawning success throughout the watershed. Salmon juveniles are broadly distributed in the river with the exception of some small streams which are prone to periodic blockages to spawners by beaver dams.

Over the past 12 years, the abundances of salmon fry have not significantly changed except in the Upsalquitch River where they have increased by 255% (Figure 20). In 2021, the fry densities in all tributaries were the highest over the last 12 years, higher than the long-term average (about 27 fish/100 m^2 for all four tributaries between 1984 and 2021), and sometimes the highest for the complete time-series (1972-2021; Kedgwick and Little Main Restigouche). This may partly be explained by the large number of spawners observed during the end of season visual counts in 2020.

Similarly, the abundances of small parr over the last 12 years have not changed significantly except in the Kedgwick tributary where they have increased by about 140% (Figure 21). The abundance of large parr has not changed over the last 12 years in the main Restigouche and the Upsalquitch tributary while they have increased significantly in the Kedgwick and Little Main Restigouche tributaries (about 1200% an 800%, respectively, Figure 22). However, these large percentage changes have to be put in the context of very low densities (i.e., close to 0 fish/100 m^2 in the early 2010s and 5-10 fish/100 m^2 in recent years).

SFA 16A Miramichi River

Densities of Atlantic Salmon fry, small parr, and large parr in the Miramichi watershed are summarized according to the four major tributaries which drain into tidal waters (Southwest Miramichi [SW], Renous, Northwest Miramichi [NW], and Little Southwest Miramichi [LSW] rivers). Average juvenile densities were only calculated when four or more sites per major tributary were surveyed in a given year.

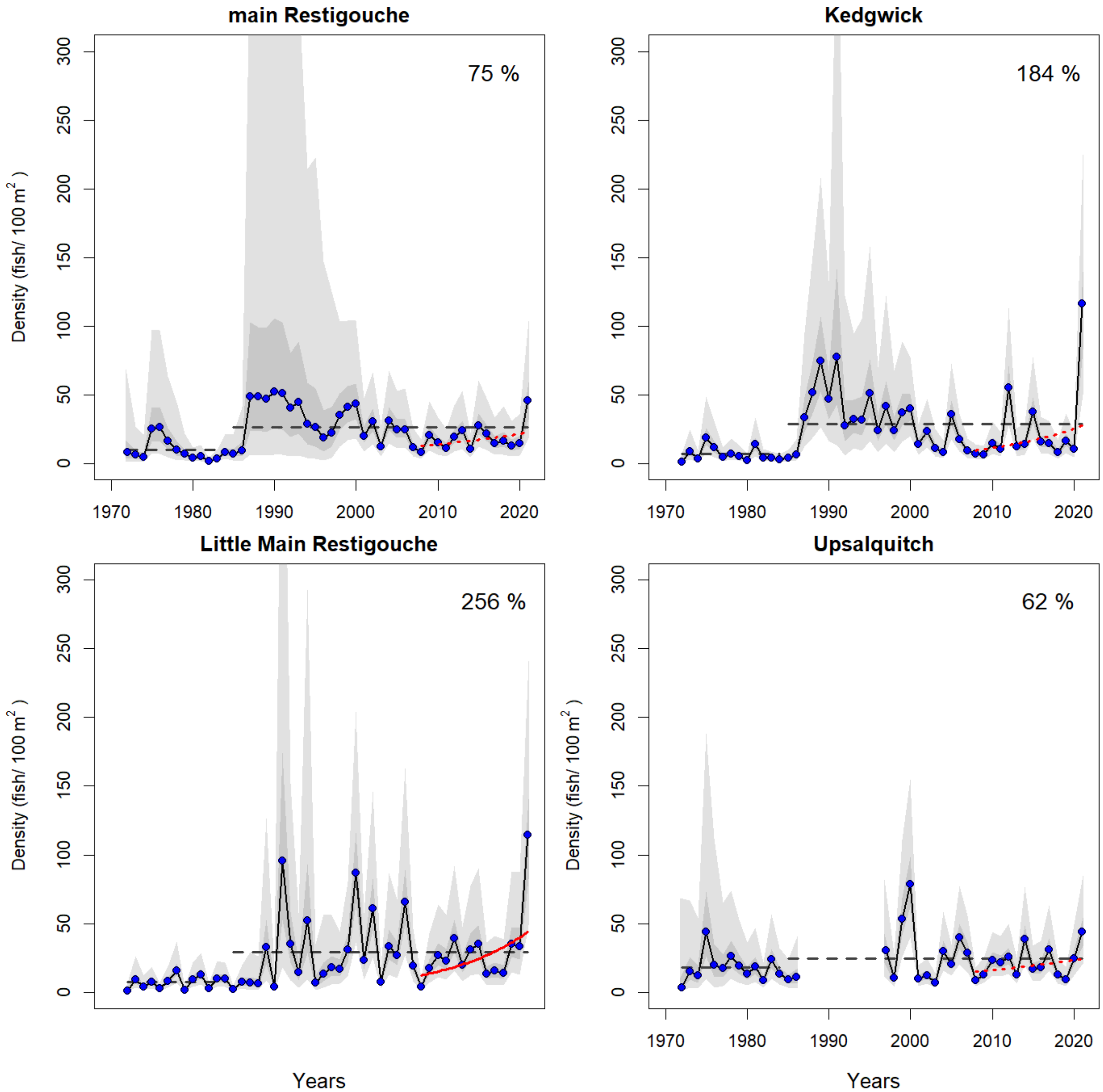

Figure 20: Mean juvenile densities (fish per 100 m²) for fry in the main Restigouche, Kedgwick, Little main Restigouche and Upsalquitch River, 1972 to 2021. Dots indicate the median of the posterior distribution, the light and dark shaded areas indicate the 2.5th-97.5th and 25th-75th percentile ranges, respectively. The horizontal dashed lines in each panel are the average densities corresponding to periods before and after the significant management changes that were implemented to the commercial and recreational salmon fisheries in 1984. The trend line (exponential regression, solid and dashed red line when the slope is significantly different than 0 or not, respectively) in the median of the estimated densities over the previous 12-year time period (2009 to 2021) and the corresponding percent change over that period are shown in each panel. Note: larger uncertainties are observed in the mid-1980s to mid-1990s time period due to a much lower number of sites sampled.

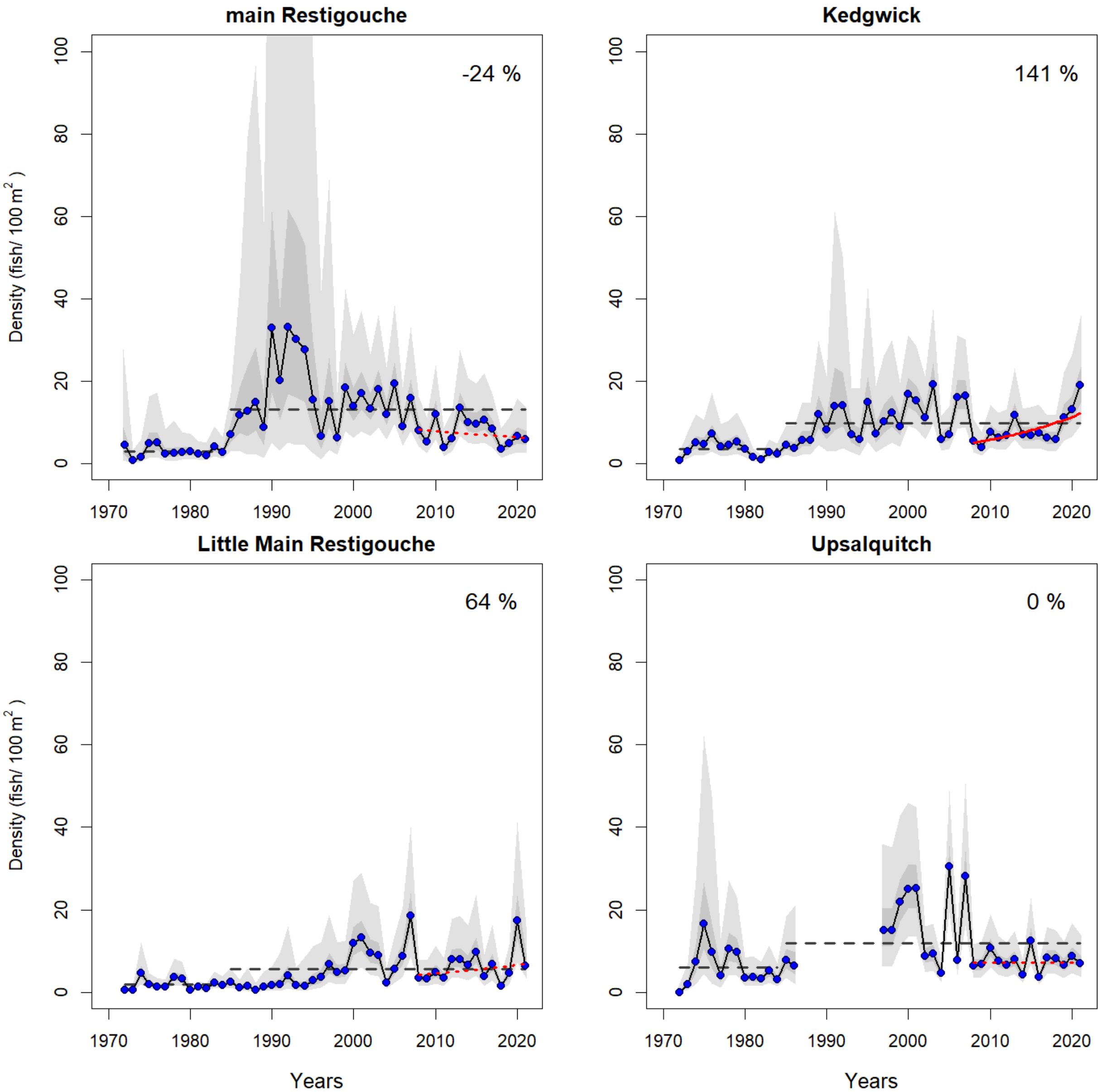

Figure 21: Mean juvenile densities (fish per 100 m²) for small parr in the main Restigouche, Kedgwick, Little main Restigouche and Upsalquitch River, 1972 to 2021. Dots indicate the median of the posterior distribution, the light and dark shaded areas indicate the 2.5th-97.5th and 25th-75th percentile ranges, respectively. The horizontal dashed lines in each panel are the average densities corresponding to periods before and after the significant management changes that were implemented to the commercial and recreational salmon fisheries in 1984. The trend line (exponential regression, solid and dashed red line when the slope is significantly different than 0 or not, respectively) in the median of the estimated densities over the previous 12-year time period (2009 to 2021) and the corresponding percent change over that period are shown in each panel. Note: larger uncertainties are observed in the mid-1980s to mid-1990s time period due to a much lower number of sites sampled.

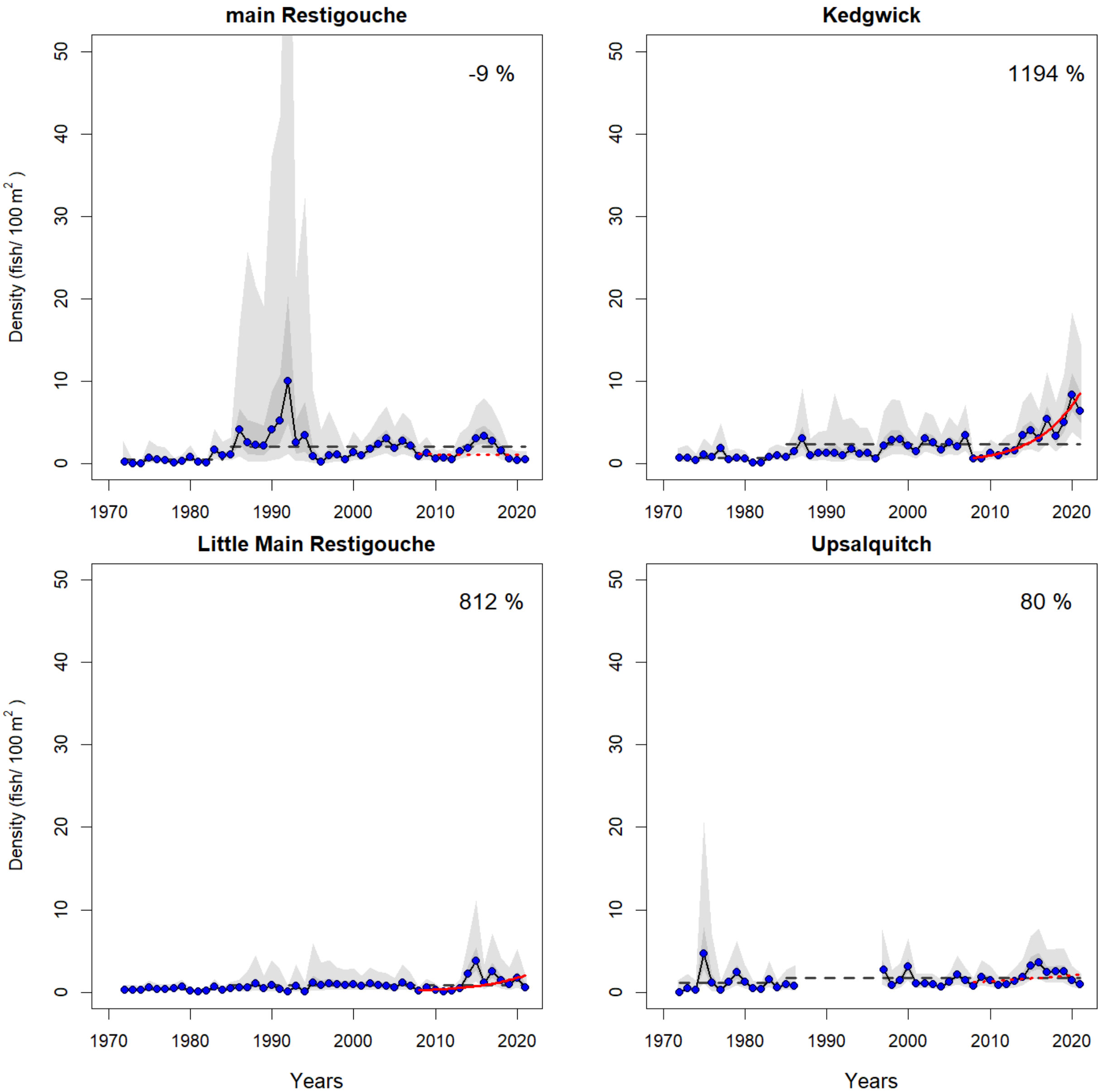

Figure 22: Mean juvenile densities (fish per 100 m²) for large parr in the main Restigouche, Kedgwick, Little main Restigouche and Upsalquitch River, 1972 to 2021. Dots indicate the median of the posterior distribution, the light and dark shaded areas indicate the 2.5th-97.5th and 25th-75th percentile ranges, respectively. The horizontal dashed lines in each panel are the average densities corresponding to periods before and after the significant management changes that were implemented to the commercial and recreational salmon fisheries in 1984. The trend line (exponential regression, solid and dashed red line when the slope is significantly different than 0 or not, respectively) in the median of the estimated densities over the previous 12-year time period (2009 to 2021) and the corresponding percent change over that period are shown in each panel. Note 1: larger uncertainties are observed in the mid-1980s to mid-1990s time period due to a much lower number of sites sampled. Note 2: When looking at percent change over the time period for this particular lifestage it is important to keep in mind the scale of the density i.e., virtually 0 in the early 2010s.

The electrofishing survey of the Miramichi watershed was not completed in 2020 due to restrictions on field work activities. In 2021, electrofishing surveys were carried out at seven sites in the LSW, at 18 sites in the NW, at six sites in the Renous and at 18 sites in the SW, for a total of 49 sites throughout the Miramichi watershed. High water conditions in September and October resulted in delays to complete the survey and may have impacted sampling efficiencies by electrofishing.

In 2021, salmon fry were captured at all but one site and salmon parr (small and large combined) at all but nine sites. No juvenile salmon were captured at one site on the Renous River.

Average fry densities in the four monitored rivers in 2021 ranged from 23 (Renous) to 49 (SW) fish per 100 m2. Fry densities in the SW and Renous rivers in 2021 were improved over 2019 levels but remained below the post-1984 average fry densities in those rivers (Figure 23). Average fry densities in the LSW and NW have remained unchanged at approximately 28 fish per 100 m2 since 2017 and below the post-1984 average fry densities in those rivers (Figure 23).

The average small parr densities in 2021 remained low and ranged from 3 (Renous) to 5 (SW) fish per 100 m2. Average small parr densities in 2021 represented the lowest values of the long term (1986 to 2019) average densities for this life stage in each river (Figure 23).

The average large parr density in 2021 was 3 fish per 100 m2 in the SW, LSW, and NW rivers and similar to large parr densities estimated for those rivers in 2019 (Figure 23). The average large parr density for the Renous River in 2021 was 1 fish per 100 m2 and represented one of the lowest values of the 1970 to 2019 period (Figure 23). The average large parr densities in 2021 were below the long term (1987 to 2019) average for this life stage in all monitored rivers (Figure 23).

The average density of all juvenile life stages has decreased in the four monitored rivers over the last 12 years (Figure 23). The decrease in average densities over the last 12 years has ranged from 35% (LSW) to 76% (Renous) for fry, from 69% (SW) to 85% (NW) for small parr, and from 51% (SW) to 71% (Renous) for large parr (Figure 23).

SFA 16B Southeast New Brunswick (NB)

Electrofishing surveys in five rivers (Buctouche, Cocagne, Richibucto/Coal Branch, Kouchibouguacis, and Kouchibouguac) of southeastern New Brunswick have been conducted intermittently since 1974 and most consistently since the late 1990s (Atkinson 2004). Densities of Atlantic salmon fry and parr (cohorts combined) were calculated when three or more sites per river were surveyed in a given year.

The electrofishing survey of southeastern NB rivers was not completed in 2020 due to restrictions on field work activities. In 2021, electrofishing surveys were carried out at eight sites in the Buctouche River, five sites in the Cocagne River, five sites in the Richibucto/Coal Branch rivers (combined), three sites in the Kouchibouguacis River, and five sites in the Kouchibouguac River, for a total of 26 sites sampled throughout southeastern NB. Water conditions in late September were considered favorable for the southeastern NB electrofishing survey in 2021.

In 2021, salmon fry were captured at all but three sites and salmon parr at all but four sites sampled throughout southeastern NB.

Average fry densities in the five monitored rivers in 2021 ranged from 18 (Kouchibouguacis) to 98 (Kouchibouguac) fish per 100 m^2 and all were higher than the average fry densities estimated in 2019 (Figure 24). Average fry densities in the five southeastern NB rivers were all above the long term (1999-2019) average of fry densities and among the highest values of the complete time series for each river (Figure 24).

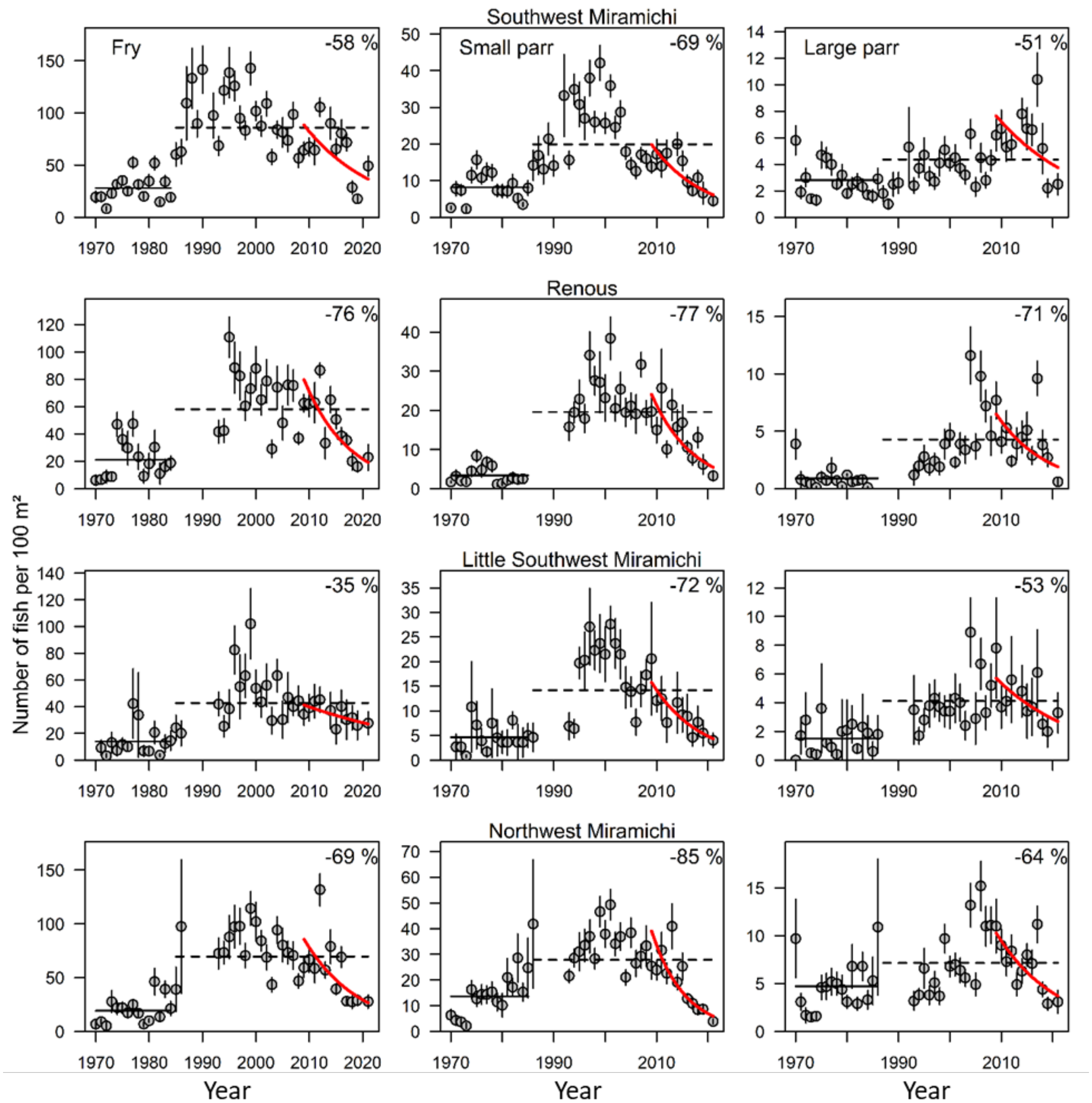

Figure 23: Annual average densities, expressed as fish per 100 m² of sampled area, for fry (left panels), small parr (middle panels), and large parr (right panels) at sampled sites in the four major rivers of the Miramichi watershed: Southwest Miramichi (upper row), Renous River (second row), Little Southwest Miramichi (third row), and Northwest Miramichi (bottom row) for 1970 to 2021. Restrictions on field work activities precluded the Miramichi electrofishing program in 2020. Vertical bars are one standard error. The horizontal solid and dashed lines in each panel are the average densities corresponding to periods before and after, respectively, significant management changes were implemented to the commercial and recreational salmon fisheries in 1984. The trend line (exponential regression, red line) is the median of the estimated densities over the previous 12-year time period (2009 to 2021) and the corresponding percent change over that period is shown in each panel.

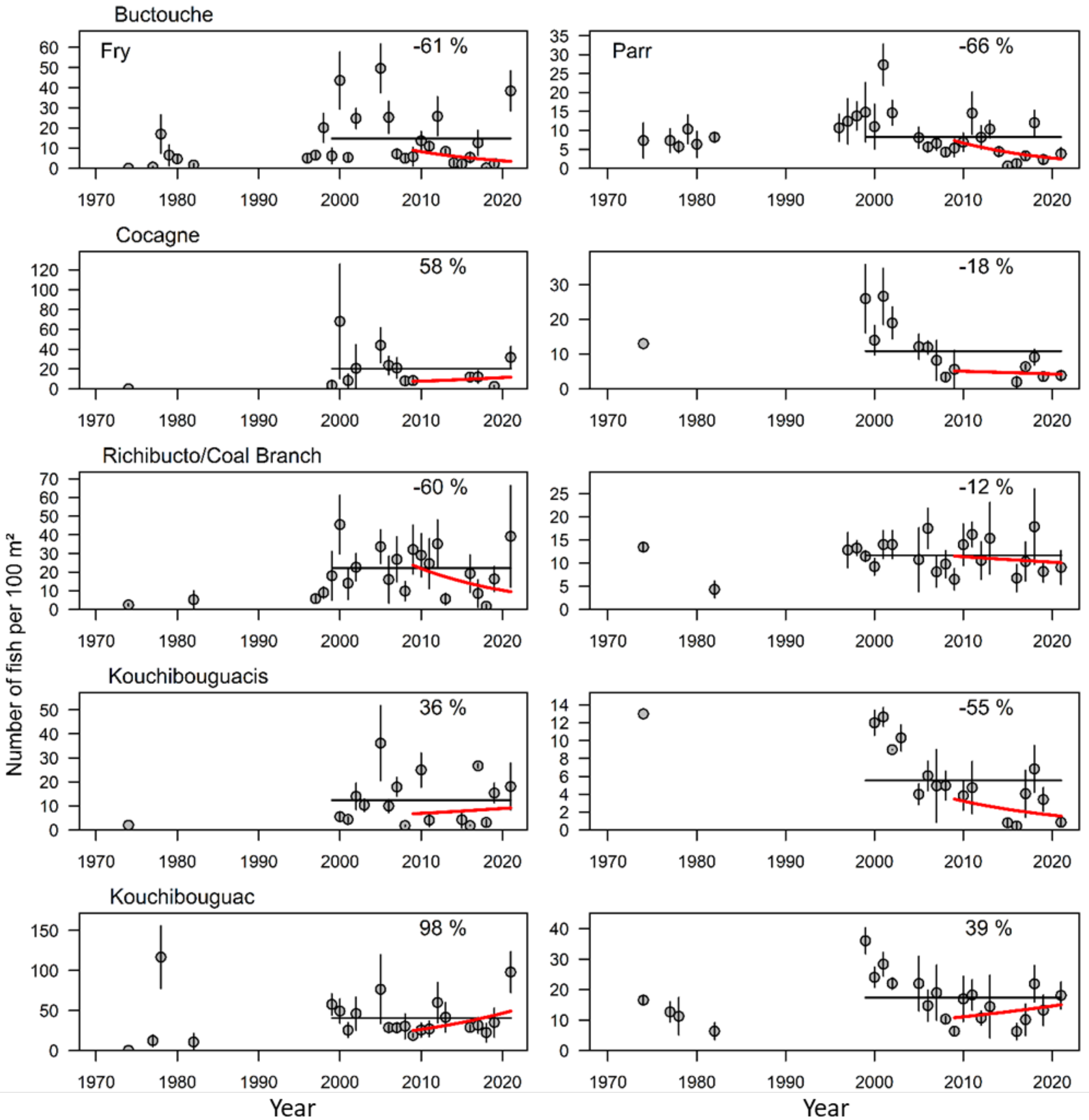

Figure 24: Annual average densities, expressed as fish per 100 m² of sampled area, for fry (left column) and parr (size groups combined, right column) from sampled sites in five major rivers of southeastern New Brunswick: Buctouche River (upper row), Cocagne River (second row), Richibucto/Coal Branch rivers (third row), Kouchibouguacis River (fourth row), and Kouchibouguac River (bottom row) for 1974 to 2021 sampling years. Vertical bars are one standard error when shown. The horizontal lines represent average fry and parr abundance for the years after the closure of the Indigenous and recreational fisheries in 1998. The trend line (exponential regression, red line) is the median of the estimated densities over the previous 12-year time period (2009 to 2021) and the corresponding percent change over that period is shown in each panel.

The average parr densities in the five monitored rivers in 2021 ranged from 1 (Kouchibouguacis) to 18 (Kouchibouguac) fish per 100 m^2. With the exception of the Kouchibouguacis River, average parr densities in 2021 were higher compared to densities in 2019 (Figure 24). Average parr densities in the five southeastern NB rivers were all below the long term (1999-2019) average of parr densities for each river (Figure 24).

Over the last 12 years, average fry densities have decreased by about 60% in the Buctouche and Richibucto/Coal Branch rivers but increased between 36% and 98% in the Kouchibouguacis and Kouchibouguac rivers, respectively. While the average density of parr in the Kouchibouguac River has increased (39%) over the last 12-year period, average parr densities have decreased between 12% (Richibucto/Coal Branch) and 66% (Buctouche) in the other four southeast NB rivers (Figure 24).

SFA 18A Mainland Gulf Nova Scotia

Juvenile salmon surveys have been conducted in three index rivers in SFA 18A: West River (Antigonish), East River (Pictou), and River Philip. Results are presented for years with at least three sites sampled per river. Since 2012, six sites per river have been sampled. All sites sampled in 2021 were occupied by juvenile salmon.

In 2021, fry abundance increased in all three rivers compared to 2020 (Figure 25). Over the past 12 years, fry abundances increased 153% in West River (Antigonish), 403% in East River (Pictou), and 11% in River Philip (Figure 25).

Parr abundances in 2021 were similar to 2020 in all three rivers with only slight decreases observed in each (Figure 25). The recent 12-year parr abundance trends show an increase of 25% in West River (Antigonish), an increase of 62% in East River (Pictou), and a decrease of 14% in River Philip (Figure 25).

SFA 18B Margaree River

Thirteen sites were surveyed in the Margaree River during 2021. Salmon fry were captured at twelve sites and parr were captured at all sampling sites. Mean fry abundance in 2021 was 122 fish per 100 m^2 compared to 50 fish per 100 m^2 in 2020 (Figure 26). The mean parr abundance in 2021 was 51 fish per 100 m^2, which is slightly greater than the 28 fish per 100 m^2 in 2020 (Figure 26). The recent 12-year fry abundance trend shows an increase of 147%, while the parr abundance trend shows an increase of 64% (Figure 26).

Sources of Uncertainty

A number of indicators of Atlantic Salmon adult abundance rely on fisheries-dependent data which could bias population estimates. While fisheries-dependent data are highly useful, they have the potential to bias estimates, especially in the absence of complimentary fisheries-independent data. The Restigouche River (NB) and SFA 18 rivers of mainland Gulf Nova Scotia are based on catches, and catch per unit effort data reported from the recreational fishery. The lack of reporting on angling effort can lead to inaccurate indicators. Conditions for recreational fishing are variable and success can be dependent upon factors such as water level and temperature. Covid-19 restrictions in 2020, and to a lesser extent in 2021, led to angling activities that potentially biased the indicators of Atlantic Salmon adult abundance.

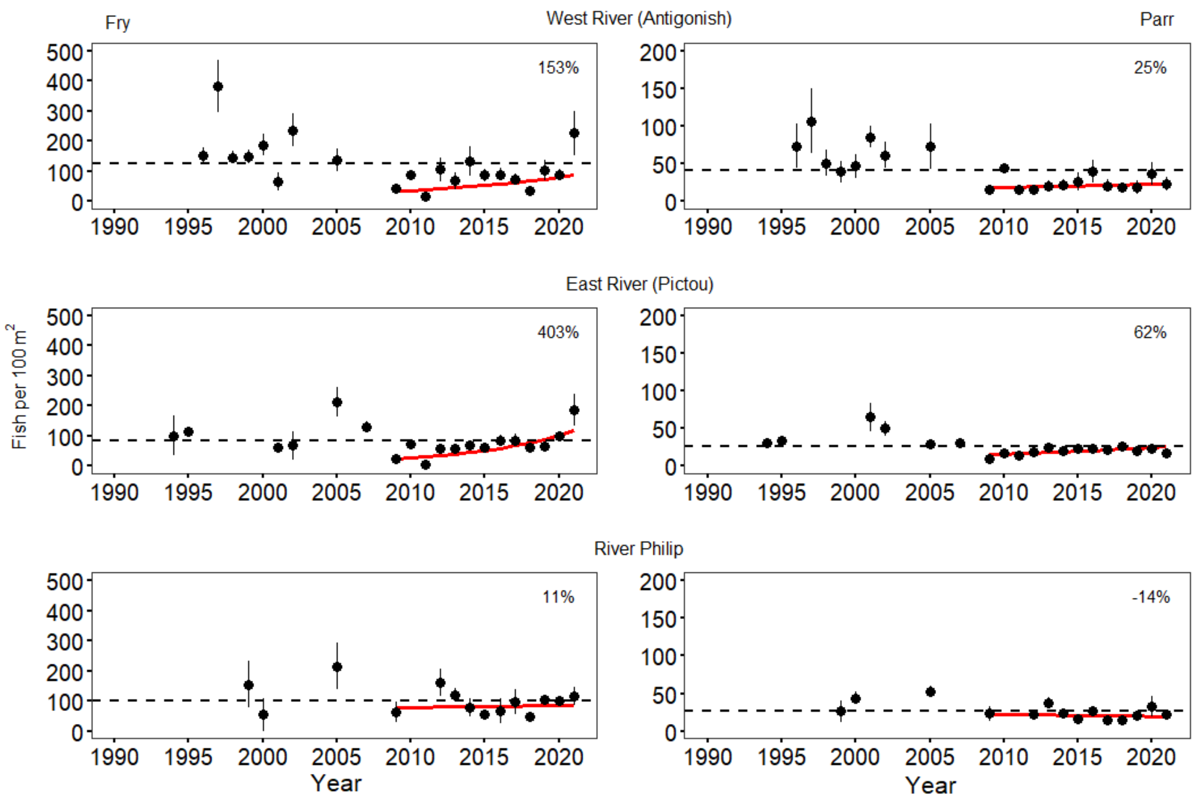

Figure 25: Mean juvenile Atlantic Salmon densities (fish per 100 m²) for fry (left panels) and parr (right panels; small and large size groups combined) for sites sampled in the West River (Antigonish; top row), East River (Pictou; middle row) and River Philip (bottom row), 1994 to 2021. Only years for which at least three sites per river were sampled are presented. Vertical bars are one standard error. The trend line (exponential regression, red line) is the median of the estimated densities over the previous 12-year time period (2009 to 2021) and the corresponding percent change over that period is shown in each panel. The dashed line in each panel is the average density throughout the timeseries. Note different range in y-axes for fry and parr.

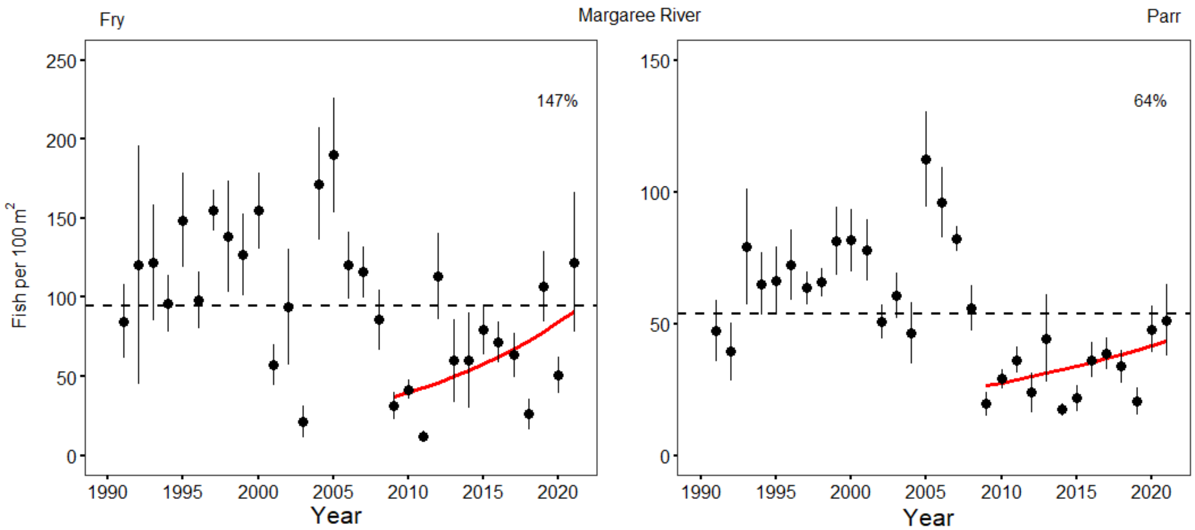

Figure 26: Juvenile densities (fish per 100 m²; mean ± one standard error) for fry (left panel) and parr (right panel) for all sites sampled each year in the Margaree River, 1991 to 2021. The trend line (exponential regression, red line) is the median of the estimated densities over the previous 12-year time period (2009 to 2021) and the corresponding percent change over that period is shown in each panel. The dashed line in each panel is the average density throughout the timeseries.

In the Margaree River assessment model, catch rates are estimated using a derived catchability value (per rod day) from the early 1990s to estimate returns. The applicability of this value in recent years is uncertain given the changes in fisheries management measures that have occurred over the past two decades, including the mandatory catch and release measures for all size groups since 2015. Caution should be taken when using salmon population estimates derived by the Margaree model to inform management decisions. Recreational angling effort from license stubs has decreased outside the range of values used during the years when the Margaree model was developed. The model was built from fisheries-independent data collected at a trap net from 1988 to 1996 in conjunction with effort from recreational license stub data. This relationship formed the basis of the Margaree model that is used annually to estimate returns of small and large salmon to the Margaree River. In 1997, the trap net program was cancelled, which resulted in the Margaree model having only fisheries-dependent data as input from that year onward. License stub effort for the Margaree River from 1988 to 1996 (9 years) ranged from 7,119 to 13,920 rod days, while effort in the most recent 9 years (2013 to 2021) ranged from 1,164 to 3,692 rod days. This represents a large decline in reported effort over the 33 years. In addition, the current effort is outside the range of effort for which the relationship between trap net catches and license stub effort was known. This means that the Margaree model is extrapolating outside of the established relationship to produce estimates of large and small salmon. Fisheries-independent adult salmon data from the Margaree River is required if the estimate of large and small salmon returns are to be verified.

For the Restigouche River (NB), the assessment model for estimating returns, the calculation of habitat areas, and the biological characteristics to be used for calculating the total egg depositions and the attainment of LRP are currently being refined. Depending on the refinements to the data inputs, the total egg requirement for the LRP and the status may change.

In 2021, and since 2017, high river temperatures and low water conditions during the summer and early fall have impacted the fishing effort in the Restigouche River (NB) and possibly the availability of salmon to the fishery.

For SFA 17, conditions for redd counting in 2021 were difficult leading to incomplete counts. Redd counts are converted to spawner numbers based on historical data obtained from a single river in a single year. A larger number of data points in these relationships (i.e., more years and/or rivers) would give a more reliable basis for estimating spawner numbers. There is ongoing uncertainty with respect to salmon occupancy status for a number of small rivers that are not consistently surveyed and in which spawning may be intermittent.

In all areas, adult Atlantic Salmon losses not accounted for in the estimation of spawners include those from incomplete reporting of fisheries catches, poaching, experimental manipulation, and broodstock collections. Losses due to natural factors including disease, mortalities from warm water, predation on adult salmon, and others are also not accounted for in the estimation of spawners. Consequently, the egg depositions are considered to be over-estimates of the realized egg depositions in any year.

Electrofishing surveys across the region occur from mid-July to early October depending upon the area. Sampling in SFA 15 occurs between July and early September whereas sampling in SFA 16 and SFA 18 occurs between late August and October. Catchability of juvenile Atlantic salmon may vary as a function of size, water temperature, stream size, water levels, visibility, etc. Some of the annual variations in juvenile indices may be associated with variations in sampling conditions that affect catchability and which are not accounted for in the current models to estimate juvenile abundance indices.

The freshwater life history dynamics of Atlantic Salmon in the Gulf Region rivers show variable patterns within and among rivers over time. The juvenile population dynamics linked with environmental variables such as summer water temperatures, water levels, and hydrological conditions during the winter need to be examined for their potential consequences on future adult recruitment and abundance.

Conclusions

Estimated returns of large salmon to Gulf Region rivers in 2020 and 2021 were 44,100 and 23,300 fish, respectively. The 2021 abundance was equivalent to the 2019 estimate (the last year since the indicators were updated), and 58% of the long-term average (40,100 fish) of the 1970 to 2021 time series. Small salmon returns to Gulf Region in 2020 and 2021 were estimated at 26,400 and 25,300 fish, respectively. The 2021 abundance was 34% higher than the 2019 estimated, and 42% of the average abundance (59,800 fish) of the time series.

Over the recent 12 years, approximately two generations for Atlantic Salmon, the estimated abundance of large salmon in Gulf Region rivers has declined by 23% whereas the small salmon abundance has declined by 51%. Among the four SFAs, small salmon abundance has declined by 23% to 61% in SFAs 15, 16 and 17 while it has increased by 40% in SFA 18 over the past 12 years. Over the same period, large salmon abundance has declined by 43% and 30% in SFA16 and 17, respectively while it has remained relatively stable in SFA 15 and 18 (+2% and +11%, respectively).

River specific stock status for Gulf Region rivers is summarized in Tables 4 and 5. The Restigouche, Northwest Miramichi, Southwest Miramichi and West rivers show declines (15% to 62%) in estimated abundances of small salmon over the recent 12 years, with the strongest decline in the Restigouche (SFA 15) and Southwest Miramichi rivers (Table 4). Small salmon abundances increased by 40% to 83% in the Margaree River, River Philip and East River

(Pictou), with the exception of West River which declined by 15% over the recent 12 years. Abundance in River Philip, East River and West River are based on catch rates in the recreational fishery. Large salmon abundances also declined by 21% to 76%, with the exception of the Margaree River and River Philip (abundance based on catch rates in the recreational fishery) which increased by 7% and 18%, respectively.

Table 4: Summary of trends over the recent 12 years of DFO Gulf Region river-specific Atlantic Salmon adult return and juvenile indicators to 2021. SFA is salmon fishing area.

	Trend in adult returns (12 years)		Trend in juvenile abundances (12 years)	
SFA - River	Small salmon	Large salmon	Fry [1]	Parr [1,2]
15 - Restigouche (NB)	-56%	-54%		
15 - main Restigouche			+75%	-24%
15 - Kedgwick			+184%	+141%
15 - Little Main Restigouche			+62%	+64%
15 - Upsalquitch			+256%	+0%
16A - Southwest Miramichi	-56%	-54%	-58%	-69%
16A - Renous			-76%	-77%
16A - Northwest Miramichi	-60%	-47%	-35%	-72%
16A - Little Southwest Miramichi			-69%	-85%
16B - Buctouche			-61%	-66%
16B - Cocagne			+58%	-18%
16B - Richibucto/Coal Branch			-60%	-12%
16B - Kouchibouguacis			+36%	-55%
16B - Kouchibouguac			+98%	+39%
18A[3] - River Philip	+56%	+18%	11%	-14%
18A[3] - East River	+83%	-21%	+403%	+62%
18A[3] - West River	-15%	-31%	+153%	+25%
18B - Margaree	+40%	+7%	+147%	+64%

[1] For the Restigouche, trends in juveniles are presented for the main Restigouche, Kedgwick, Little Main Restigouche, and Upsalquitch rivers, respectively. For the Northwest Miramichi, trends in juveniles are presented for Northwest Miramichi and Little Southwest, respectively. For the Southwest Miramichi, trends in juveniles are presented for the Southwest Miramichi and Renous, respectively.
[2] For the Restigouche, Southwest Miramichi, Renous, Northwest Miramichi, and Little Southwest Miramichi rivers, parr refers to small parr. For all others rivers, parr refers to small and large parr combined.
[3] For the trends in returns for the three rivers in SFA 18A, the catch rates (catch per rod day) in the recreational fishery were used.

In 2021, only the Margaree River (NS) and Carruther's Brook (PEI) population estimates were above the LRP of the PA. All other rivers where Atlantic Salmon populations were assessed were in the critical zone. The probability of being below the river-specific LRP for assessed rivers in Gulf New Brunswick was high in 2021: > 99% for the Northwest Miramichi River and 74% for the Southwest Miramichi River. Based on the recreational fisheries catch estimate, the Restigouche River (NB; SFA 15) was estimated to have been above the LRP in only two of the past 11 years (no estimate in 2020).

The eggs in the combined returns of small salmon and large salmon to the Miramichi River system in 2021 were improved over levels estimated in 2019 but remained below the respective LRPs for the Miramichi River, the Southwest Miramichi River, and the Northwest Miramichi River (Figure 12 and Figure 13). The median estimate of eggs in the combined small and large salmon spawners in the Northwest Miramichi River has only been above the LRP twice in the last 12 years of assessment. The median estimate of eggs in the small and large salmon spawners combined was below the LRP for the Southwest Miramichi River for the first time in 2019 and again in 2021.

For SFA 17, the assessments of status confirm the precarious status of salmon in several small rivers, especially those in which spawning appears to occur only in intermittent years. During the mid-2010s, the Northeastern rivers cluster was the salmon stronghold of SFA 17, with percentages of LRP attained commonly exceeding 300%. In 2021, only one of the 17 rivers in this SFA exceeded LRP (Carruther’s Brook, Mill River). Although, this could partly be due to incomplete redd surveys due to high water conditions.

The assessed river in Gulf Nova Scotia (SFA 18), the Margaree River, has been above the LRP every year of its time series (1987 to 2021). Caution is advised if used for management decisions (see section uncertainties).

Table 5: Summary of status in 2021 (median relative to the LRP) and the trends over the recent 12 years for Atlantic Salmon in DFO Gulf Region monitored rivers. SFA is salmon fishing area.

	Returns relative to LRP		Spawners relative to LRP	
SFA - River	In 2021 (prob. > LRP)	trend	In 2021 (prob. > LRP)	trend
15 - Restigouche (NB)	na [1]	-54%	na [1]	-55%
16A - Southwest Miramichi	85% (27%)	-48%	84% (26%)	-47%
16A - Northwest Miramichi	40% (< 1%)	-50%	38% (< 1%)	-35%
17[2] - PEI (18 rivers)	na	na	6 of 18; 0% to 247%	na
18B - Margaree	390% (100%)	+7%	370% (100%)	+7%

[1] For the Restigouche, the values represent the estimate relative to LRP based on the catches and a catch rate of 40% and based on the end of season spawner counts, respectively. The trend is based on catches and catch rate estimation model.
[2]Status is presented for eighteen rivers that had complete surveys in 2021. The number of rivers in which spawners exceeded the LRP in 2021 is shown along with the range of percent attainment for all surveyed rivers.

Although the juvenile indices in the rivers of SFA 15 and SFA 18 since 2010 are generally lower than during the previous decade, the trends over the past 12 years are either stable or increasing in these areas (Table 4). This contrasts with the trends for both fry and parr indices in the rivers of SFA 16 (Miramichi, southeast NB) which have been mostly declining over the same time period.

There were many days when warm water temperature and low flow events affected recreational fisheries access to Atlantic Salmon in DFO Gulf Region rivers in 2020 and 2021 (Appendix 1). Excessive flows in January and March 2021 were noted in DFO Gulf Region rivers. High winter and spring discharges may contribute to reduced survival of eggs and emergent fry and these conditions may further reduce future recruitment potential resultant of already low spawning escapements. The potential consequences of these flow and temperature events on future adult recruitment and abundance is unknown

For SFA 15, high water conditions during the fall of 2021 prevented visual spawner counts to be conducted on the Restigouche River and therefore no fishery independent indicators of spawner abundance is available for 2021.

Based on the trends in abundance of small salmon and large salmon and the generally declining or stable juvenile abundance indices, there is no expectation of increased abundance of salmon in rivers of DFO Gulf Region in 2022.

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Sources of Information

This Science Response Report results from the Science Response Process of February 22, 2022 on Update of indicators of Atlantic Salmon to 2021 for Salmon Fishing Areas 15 to 18, DFO Gulf Region. No additional publications from this process are anticipated.

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Appendix 1

Table A1: The timing and duration of recreational angling restrictions implemented under warm water protocols for the Restigouche, Nepisiguit, Miramichi, and Margaree rivers in 2020 and 2021. SFA is salmon fishing area.

			Cold water pools			Morning only			River			
Year	SFA	River	Start	Stop	Days	Start	Stop	Days	Start	Stop	Days	Variation order
2020	15	Restigouche	-	-	-	25-Jun 30-Jun	29-Jun 18-Aug	4 9	-	-	-	GVO-2020-071 GVO-2020-095 GVO-2020-106
2021	15	Restigouche	-	-	-	13-Aug	31-Aug	18	-	-	-	GVO-2021-088 GVO-2021-096
2020	15	Nepisiguit	-	-	-	26-Jun 14-Jul 22-Jul 18-Aug	30-Jun 17-Jul 10-Aug 22-Aug	4 3 19 4	10-Aug	18-Aug	8	GVO-2020-072 GVO-2020-077 GVO-2020-084 GVO-2020-085 GVO-2020-089 GVO-2020-098 GVO-2020-104 GVO-2020-106
2021	15	Nepisiguit	-	-	-	10-Jun 17-Jul	12-Jun 24-Jul	2 7	12-Aug	31-Aug	19	GVO-2021-054 GVO-2021-055 GVO-2021-078 GVO-2021-080 GVO-2021-086 GVO-2021-096
2020	16A	Miramichi	23-Jun 10-Jul 21-Jul	08-Jul 17-Jul 20-Aug	15 7 30	13-Aug	18-Aug	5	-	-	-	GVO-2020-064 GVO-2020-080 GVO-2020-086 GVO-2020-088 GVO-2020-100 GVO-2020-103 GVO-2020-105

			Cold water pools			Morning only			River			
Year	**SFA**	**River**	**Start**	**Stop**	**Days**	**Start**	**Stop**	**Days**	**Start**	**Stop**	**Days**	**Variation order**
2021	16A	Miramichi	13-Aug	31-Aug	18	18-Aug	21-Aug	3	21-Aug	28-Aug	7	GVO-2021-075 GVO-2021-087 GVO-2021-091 GVO-2021-092 GVO-2021-094 GVO-2021-095
2020	18	Margaree		-	-	-	-	-	8-Aug	28-Aug	20	*MAR-VAR-2020-095 *MAR-VAR-2020-105
2021	18	Margaree	-	-	-	-	-	-	-	-	-	NA

*Closure of sections 1 and 3 only.

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