UPDATE OF INDICATORS TO 2018 OF ADULT ATLANTIC SALMON FOR THE MIRAMICHI RIVER (NB), SALMON FISHING AREA 16, DFO GULF REGION

Context

The last assessment of stock status of Atlantic Salmon (*Salmo salar*) for Fisheries and Oceans Canada (DFO) Gulf Region was completed after the 2013 return year (DFO 2014) and updates on stock status for each of the four Salmon Fishing Areas (SFA 15-18) have been prepared annually since then (DFO 2015a; DFO 2015b; DFO 2016; DFO 2017; DFO 2018a). DFO Fisheries and Aquaculture Management requested an update of the status of the Atlantic Salmon stock in the Miramichi River for 2018. Indicators for adult Atlantic Salmon for the Miramichi River are provided in this report. This Science Response Report results from the Science Response peer review meeting held in Moncton (N.B.) on December 11, 2018. No other publications will be produced from this science response process.

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 New Brunswick, Nova Scotia, and all of Prince Edward Island (Fig.1). The Miramichi River is the largest river in SFA 16 and DFO Gulf Region.

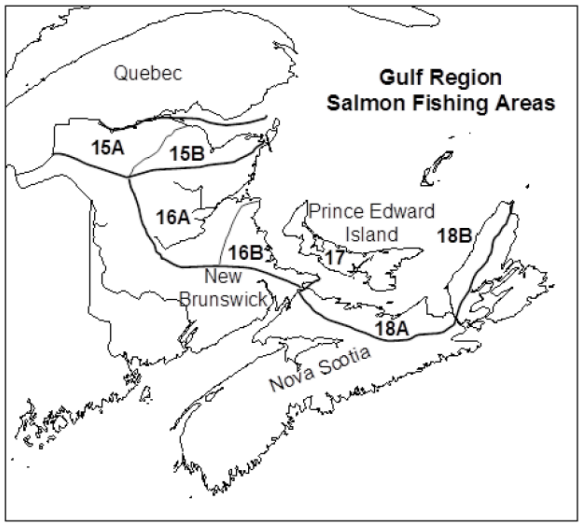

Figure 1. Salmon Fishing Areas in the DFO Gulf Region.

For management and assessment 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).

Mandatory catch and release measures in the recreational fishery have been in effect for both small salmon and large salmon in all Salmon Fishing Areas of DFO Gulf Region since 2015. This was a change from 2014 when retention of small salmon had been allowed in SFA 15, SFA 16A, and SFA 18.

Since 1998, rivers in south east New Brunswick (SFA 16B) have been closed to all directed salmon fishing.

The mean (27.6 °C) of the maximum air temperatures at Miramichi for July and August in 2018 were the highest of the time series beginning in 1873. The resulting high water temperatures prompted angling restrictions in the Miramichi system to mornings only (6 am to 11 am) for 18 days between 24 July and 11 August and the closure of cold water holding pools for 47 days between 5 July and 20 August (Gulf Variation Order (GVO) 2018-051, GVO 2018-062, GVO 2018-076, GVO 2018-081).

In previous assessments, status was assessed relative to a conservation requirement of 2.4 eggs per m^2. In this report, status is assessed relative to Limit Reference Points (LRP) consistent with the precautionary approach (PA) (DFO 2009), as recently defined for Atlantic Salmon rivers in DFO Gulf Region (DFO 2018b). For purposes of LRP definition, there are six rivers that enter in tidal waters within the Northwest and Southwest Miramichi systems. The Southwest Miramichi system includes the Barnaby River, Southwest Miramichi River, and the Renous River (Fig. 2) and has an LRP egg deposition rate value of 1.52 eggs m^{-2} (DFO 2018b). The Northwest Miramichi system includes the Northwest Millstream, Little Southwest Miramichi River and the Northwest Miramichi River and has an LRP egg deposition rate value of 1.76 eggs m^{-2} (DFO 2018b). The LRP for the Miramichi River (Southwest Miramichi system, Northwest Miramichi system) is calculated as the habitat weighted average of the Southwest Miramichi system and Northwest Miramichi system LRP values, equivalent to 1.60 eggs m^{-2}.

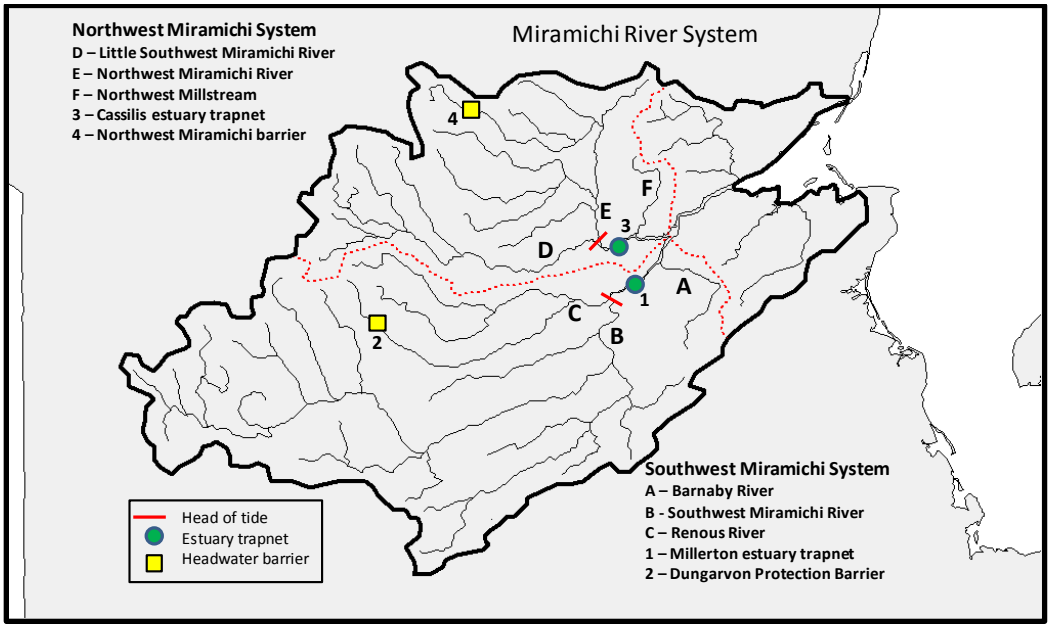

Figure 2. Rivers that make up the Miramichi River system and geographic locations of monitoring facilities in the Miramichi River, SFA 16. The dashed lines delineate the watershed boundaries of the Northwest Miramichi system and the Southwest Miramichi system.

For purposes of this update, returns, spawners and total egg depositions relative to the LRPs are presented for the two main branches for the years 1992 to 2018, and for the Miramichi River overall for the years 1971 to 2018. In cases when uncertainties in the return and spawner estimates are available, the probabilities of meeting or exceeding the LRP are also presented. In conformity with the PA, the objective is for a low probability of the stock being in the critical zone, i.e. below the LRP; low probability is interpreted to be 5% or less.

Analysis and Response

Abundance indices of adult salmon

Catches and counts of adult Atlantic Salmon, by size group, are available from trapnets operated in the estuary and from headwater barrier fences (Fig. 2). 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 temperature.

Season 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 (Fig. 2). In 2018, the trapnet at Millerton operated between 3 June and 26 October while the trapnet at Cassilis operated between 22 May and 26 October. Due to concerns associated with stress on fish from high water temperature, the trapnet at Millerton did not operate for 7 days between 10 July and 29 July and the trapnet at Cassilis did not operate for 5 days between 7 July and 17 July.

The catch of large salmon at the Millerton trapnet in 2018 increased relative to 2017, while the catch of small salmon in 2018 decreased. Catches of both small (n = 539) and large (n = 612) salmon at the Millerton trapnet in 2018 were lower than the long term averages for both size groups at that facility (Fig. 3). Catches of both small and large salmon at the Cassilis trapnet in 2018 were lower than levels observed in 2017. The catch of large salmon (n = 418) at the Cassilis trapnet in 2018 was above the long term average for this group at this facility while the catch of small salmon (n = 389) was below the long term average (Fig. 3).

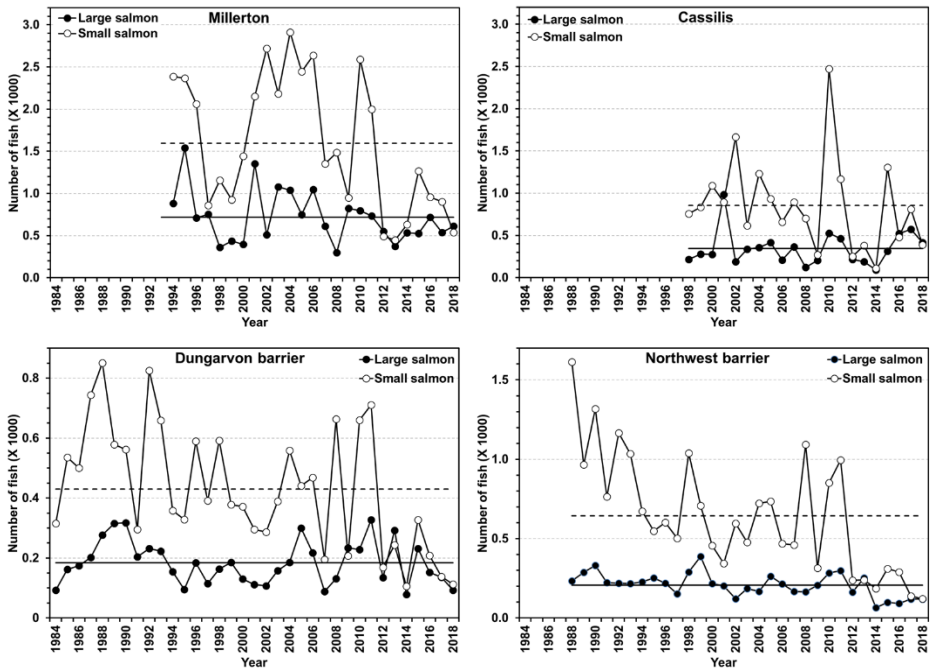

Figure 3. Catches of small salmon and large salmon at DFO index trapnets (top row) at Millerton on the Southwest Miramichi River (top left panel) and at Cassilis on the Northwest Miramichi River (top right panel) and at provincial headwater barriers (bottom row) in the Dungarvon River, tributary of the Southwest Miramichi River (bottom left panel) and the Northwest Miramichi River (bottom right panel) between 1984 and 2018.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.

Annual counts of small and large salmon have been available from two headwater protection barriers operated by the NB Department of Energy and Resource Development: one on the Dungarvon River, tributary of the Renous and Southwest Miramichi rivers since 1984, and the other, on the Northwest Miramichi River since 1988 (Fig. 2). In 2018, the barrier on the Dungarvon River operated continuously between 30 May and 16 October. The count of both large (n = 93) and small (n = 113) salmon at the Dungarvon Barrier in 2018 decreased from levels observed in 2017 and were below the long term average counts for both size groups at this facility (Fig. 3). The Northwest Miramichi Barrier operated continuously between 1 June and 19 October, 2018. The count of large salmon (n = 119) at the Northwest Miramichi Barrier in 2018 was similar to that of 2017 while the count of small salmon decreased; counts of both size groups were below their long term averages at this facility (Fig. 3).

Estimates of returns

Returns of small salmon and large salmon to the Miramichi River and to each of the Northwest Miramichi and Southwest Miramichi branches are estimated using mark and recapture experiments based on catches at various monitoring facilities throughout the watershed (Douglas et al. 2015). The estimated proportions of the returns of small salmon and large salmon in 2018 intercepted at the estuary trapnets decreased relative to 2017 and were within the range of values for the period 1998 to 2017 (Fig. 4).

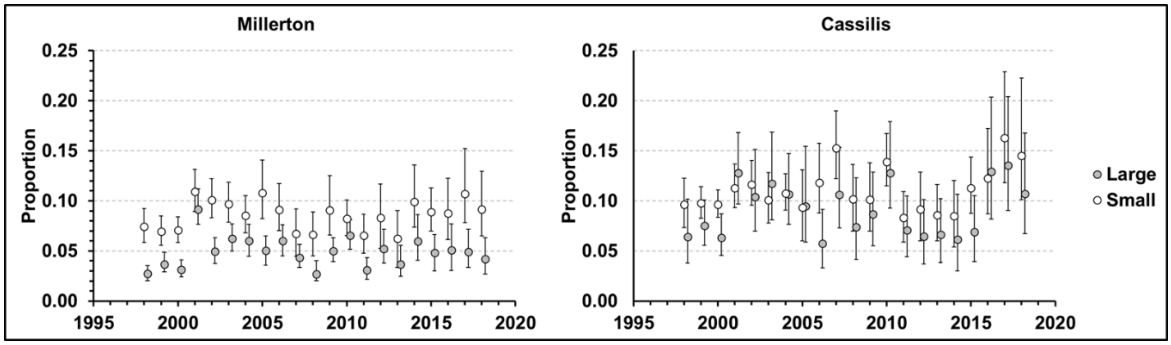

Figure 4. Estimated (median; 5th and 95th percentile error bars) proportions of the annual returns of small salmon and large salmon intercepted at the DFO index trapnets in the Southwest Miramichi at Millerton (left panel) and in the Northwest Miramichi at Cassilis (right panel) from 1998 to 2018.

The estimated returns of large salmon to the Miramichi River in 2018 were 18,800 fish (median; 5th to 95th percentile range 13,500 to 27,100). Small salmon returns were estimated at 8,600 fish (median; percentile range 6,600 to 11,300). Returns of both large salmon and small salmon to the Miramichi River in 2018 were below the average returns estimated for each size group over the time series 1971 to 2017 (Fig. 5).

Estimated returns for the two main branches of the Miramichi River are available since 1992 (Fig. 5). The returns of large salmon to the Southwest Miramichi River in 2018 were estimated at 14,700 fish (median; percentile range 9,800 to 22,800), whereas small salmon returns were estimated at 5,900 fish (median; percentile range 4,200 to 8,400) (Fig. 5). Returns of large salmon to the Southwest Miramichi River in 2018 were improved over 2017 levels and just above the average of the median returns over the 1992 to 2017 period (Fig. 5). Returns of small salmon to the Southwest Miramichi River in 2018 decreased from 2017 levels, and were equal to the lowest estimated return of small salmon (in 2012) of the time series, 1992 to 2018 (Fig. 5).

The returns of large salmon to the Northwest Miramichi River in 2018 were estimated at 3,900 fish (median; percentile range 2,500 to 6,300), whereas small salmon returns were estimated at 2,700 fish (median; percentile range 1,700 to 3,900) (Fig. 5). Relative to 2017 levels, the return estimates in 2018

represented a decrease in both large and small salmon. Both large salmon and small salmon return estimates in 2018 were below the average of the median return estimates for each size group over the period 1992 to 2018 (Fig. 5). For small salmon, the estimated return in 2018 was almost twice the record low return of 2014 but similar to the low returns estimated in 2009 and 2012.

Over the recent 12 year period, approximately two generations for Atlantic Salmon, the estimated returns of large salmon in the Miramichi River overall and the Southwest Miramichi have declined by 14% and 24%, respectively, while estimated returns of large salmon to the Northwest Miramichi have increased by 31% (Fig. 5). The estimated returns of small salmon have declined in the Miramichi River overall and in each of the main branches, particularly in the Southwest Miramichi River (74% decline) (Fig. 5).

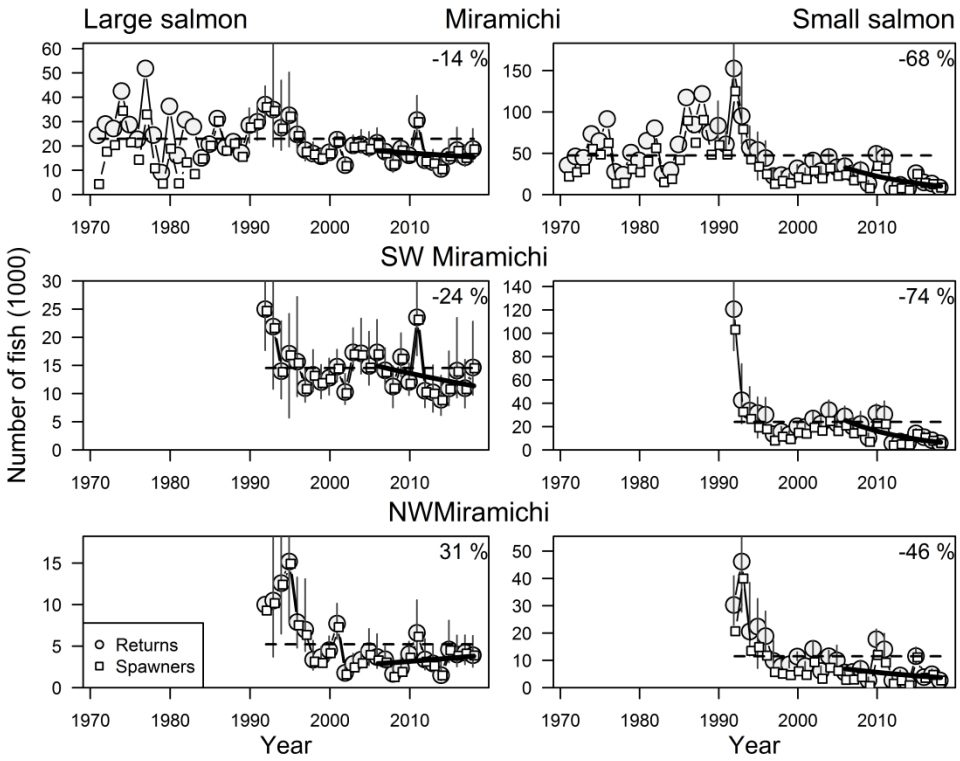

Figure 5. Estimated (median and 5th to 95th percentile range) returns and spawners of large salmon (left column) and small salmon (right column) for the Miramichi River for 1971 to 2018 (upper row), the Southwest Miramichi River 1992 to 2018 (middle row), and the Northwest Miramichi River 1992 to 2018 (bottom row).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) for returns over the previous twelve year time period (2006 to 2018) and the corresponding percent change is shown in the upper right corner of each panel.

Estimates of egg depositions relative to LRPs

Biological characteristics of adult Atlantic Salmon, including mean fork length, proportion female, and eggs per fish for small salmon and large salmon to 2018, are summarized in Figure 6.

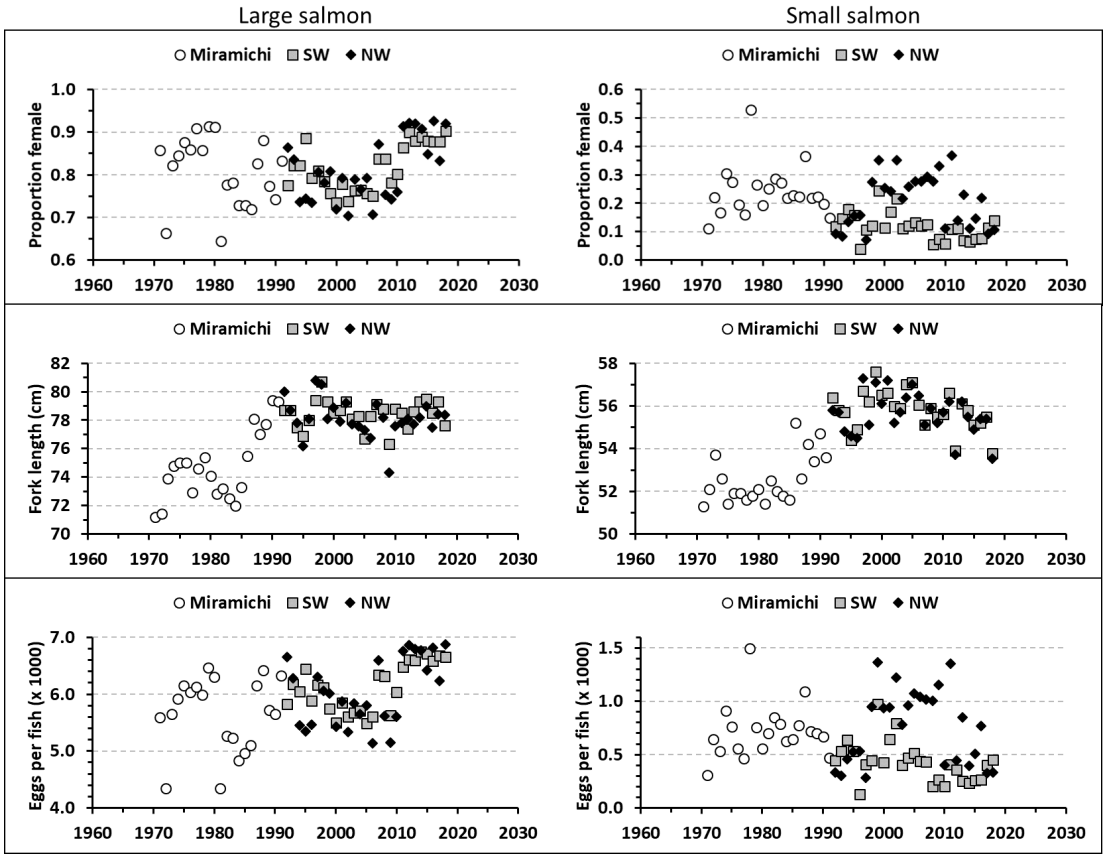

Figure 6. Biological characteristics of Atlantic Salmon by size group (large salmon left panels; small salmon right panels) including proportion female (upper panels), mean length (cm, middle panels), and eggs per fish (lower panels) from the Miramichi River overall (1971 to 1991) and the Southwest (SW) and Northwest (NW) Miramichi rivers, 1992 to 2018.

Considering these biological characteristics and the Limit Reference Points (LRP) developed for the Miramichi River and its two main branches (DFO 2018b), the estimated total eggs in the returns of large salmon and small salmon combined in 2018 exceeded the LRP for the Miramichi River overall (median of 2.43 eggs per m^{-2}; 5th to 95th percentile range of 1.75 to 3.40 eggs per m^{-2}) and the Southwest Miramichi River (2.75 eggs per m^{-2}; 1.83 to 4.11 eggs per m^{-2}). Eggs in the returns of large and small salmon to the Northwest Miramichi River were below the LRP in 2018 (1.67 eggs per m^{-2}; 1.09 to 2.60 eggs per m^{-2}) (Fig. 7).

Spawners are calculated as returns minus losses from 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 on catches equivalent to 30% of the small salmon return), identical to the formula used for calculating large salmon losses in the recreational fishery since 1984.

The number of adult Atlantic Salmon in the Miramichi system that died in river during the prolonged heat events of the summer in 2018 is unknown and unaccounted for in the estimates of spawners. Known losses and removals in 2018 not accounted for in the estimation of spawners, as in previous years, include broodstock collections, mortalities / removals of salmon associated with experimental activities, and incidental mortalities at monitoring facilities (DFO estuary trapnets and provincial headwater barriers) (Table 1).

Table 1. Summary of mortalities or reported removals of salmon in 2018 that are not accounted for in the estimation of spawning escapement.

River system	Source	Small salmon	Large salmon
Southwest Miramichi	DFO monitoring facilities (incidental mortalities)	4	3
	Headwater barriers (incidental mortalities)	0	0
	Broodstock removals	5	11
	Experimental activities [1]	9	9
Northwest Miramichi	DFO monitoring facilities (incidental mortalities)	4	0
	Headwater barriers (incidental mortalities)	0	0
	Broodstock removals	15	6
	Experimental activities [1]	3	10

[1] includes salmon removed (from Dungarvon headwater barrier for the Southwest Miramichi; DFO Cassilis trapnet for the Northwest Miramichi) and transferred to the experimental enclosure area of the Northwest Millstream.

There was greater than 95% chance of the estimated eggs from small and large salmon spawners combined exceeding the LRP for the Miramichi River overall (2.40 eggs per m^{-2}; 1.72 to 3.38 eggs per m^{-2}) and the Southwest Miramichi River (2.72 eggs per m^{-2}; 1.80 to 4.08 eggs per m^{-2}) in 2018 (Fig. 7). There was a greater than 50% chance that the eggs in small and large salmon spawners combined were below the LRP for the Northwest Miramichi River in 2018 (1.65 eggs per m^{-2}; 1.07 to 2.58 eggs per m^{-2}) (Fig. 7).

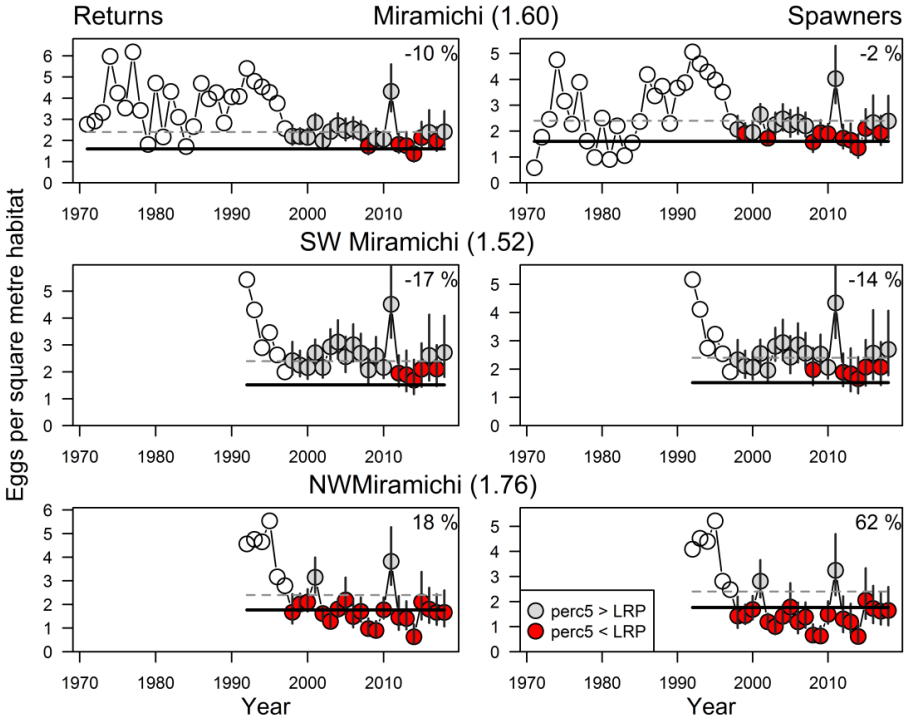

Figure 7. The estimated median (1970-2018) and 5th to 95th percentile range (1998-2018) of the number of eggs (expressed per square meter of habitat) from the returns (left panels) and spawners (right panels) of small and large salmon combined to the Miramichi River overall (top row), the Southwest Miramichi River (middle row) and the Northwest Miramichi River (bottom row) in relation to the Limit Reference Point for each river (solid horizontal line) (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 percent change in the number of eggs in the returns (left panels) and spawners (right panels) of large and small salmon combined over the previous twelve year period (2006-2018) is identified in the top right corner of each panel. For reference to previous assessments, the dashed horizontal line is the conservation level of 2.4 eggs m^{-2}.

For the Southwest Miramichi, there was greater than 95% chance of the egg depositions having been above the LRP in 15 of 21 years since 1998, and in all years, there was greater than 50% chance of having met or exceeded the LRP (Fig. 7). For the Northwest Miramichi, the estimated eggs in the spawners exceeded the LRP with greater than 95% chance in only 2 of 21 years since 1998. In 17 of 21 years, there was greater than 50% chance of the eggs being below the LRP for the Northwest Miramichi (Fig. 7).

Over the previous twelve year period, the estimated number of eggs in the returns of small and large salmon combined have declined in the Miramichi River overall (-10%) and the Southwest Miramichi River (-17%) but have increased in the Northwest Miramichi River (+18%) (Fig. 7). The trends in the number of eggs in spawners is similar with decreases over the last twelve years for the Miramichi River overall (-2%) and the Southwest Miramichi River (-14%) but an increase in the Northwest Miramichi River (+62%) (Fig. 7).

Conclusions

Returns of large salmon to the Miramichi River overall and the Southwest Miramichi River in 2018 were improved over 2017 but returns of large salmon to the Northwest Miramichi River decreased in 2018. With the exception of large salmon returns to the Southwest Miramichi River in 2018, returns remained below the average return estimates for the time series for each river.

Returns of small salmon were low in 2018. Small salmon returns in the Southwest Miramichi were equal to the lowest value (in 2012) over the 1992 to 2018 time period whereas returns of small salmon to the Northwest Miramichi were equal to the low values of 2009 and 2012, but above the lowest level in 2014.

In both the Northwest Miramichi and Southwest Miramichi, small salmon returns have declined more rapidly than large salmon. Large salmon in the Northwest Miramichi are increasing on average over the past twelve years although they remain substantially lower than values in the early 1990s.

The median and 5th percentile estimates of eggs in the returns as well as in spawners for the Miramichi River overall and the Southwest Miramichi River were above the river specific LRP in 2018. Salmon of the Southwest Miramichi have been below the LRP, based on the 5th percentile, in 6 of 21 years since 1998.

The median of the estimates of eggs in the returns and spawners to the Northwest Miramichi River were below the LRP in 2018. The status of salmon from the Northwest Miramichi has been in the critical zone (based on the 5th percentile) in 19 of 21 years since 1998.

While the median estimates of eggs in the returns and spawners to the Miramichi River overall and the Southwest Miramichi River have most often been at or above the LRP since 1998 (exception for the returns in 2014 and the spawners in 2008 and 2014), there is a decreasing trend over the last twelve years for both returns and spawners to the Miramichi (range -2% to -10%) and the Southwest Miramichi (-13% to -17%). The trends over the last twelve years in the number of eggs in the returns and spawners to the Northwest Miramichi River have both been increasing (+16% for returns and +60% for spawners) although the status of salmon from the Northwest Miramichi has been in the critical zone of the PA since 2012.

Based on the trends over the recent 12 years, there is no expectation of increased abundance of small salmon in either the Northwest Miramichi or the Southwest Miramichi in 2019. Large salmon abundance has declined in the Southwest Miramichi but has increased in the Northwest Miramichi although the salmon stock of the latter remains in the critical zone of the PA.

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Sources of Information

This Science Response Report results from the Science Response Process of December 11, 2018 on Update of indicators to 2018 of adult Atlantic Salmon for the Miramichi River (NB), Salmon Fishing Area 16, DFO Gulf Region. No additional publications from this process are anticipated.

DFO. 2009. A Fishery Decision-Making Framework Incorporating the Precautionary Approach.

DFO. 2014. Stock status of Atlantic salmon (*Salmo salar*) in DFO Gulf Region (Salmon Fishing Areas 15 to 18) to 2013. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/057.

DFO. 2015a. Update of stock status of Atlantic Salmon (*Salmo salar*) in DFO Gulf Region (New Brunswick Salmon Fishing Areas 15 and 16) for 2014. DFO Can. Sci. Advis. Sec. Sci. Resp. 2015/008.

DFO. 2015b. Indicators of Atlantic Salmon (*Salmo salar*) stock status for Prince Edward Island (SFA 17) and Gulf Nova Scotia (SFA 18) in DFO Gulf Region for 2014. DFO Can. Sci. Advis. Sec. Sci. Resp. 2015/016.

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DFO. 2018a. Update of stock status of Atlantic Salmon (*Salmo salar*) in DFO Gulf Region Salmon Fishing Areas 15 - 18 for 2017. DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/017.

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Douglas, S.G., Chaput, G., Hayward, J., and Sheasgreen, J. 2015. Assessment of Atlantic Salmon (*Salmo salar*) in Salmon Fishing Area 16 of the southern Gulf of St. Lawrence to 2013. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/049. v + 36 p.

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