# STOCK STATUS UPDATE OF ATLANTIC SALMON (SALMO SALAR) IN SALMON FISHING AREAS (SFAs) 19-21 AND 23 

## Context

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) identified four large groups of Atlantic Salmon (Salmo salar), referred to as Designatable Units (DUs), in the Maritimes Region: Eastern Cape Breton (ECB; corresponding to Salmon Fishing Area (SFA) 19), Nova Scotia Southern Upland (SU; SFAs 20, 21 and part of 22), Outer Bay of Fundy (OBoF; corresponding to the western part of SFA 23), and Inner Bay of Fundy (IBoF; part of SFAs 22 and 23) (see Appendix).
Abundance of Atlantic Salmon in the Maritimes Region has been in decline for more than two decades. Populations in many rivers are extirpated and IBoF salmon are listed as Endangered under the Species at Risk Act (SARA). In November 2010, COSEWIC assessed the ECB, SU and OBoF population assemblages as Endangered. Fisheries and Oceans Canada (DFO) has completed Recovery Potential Assessments, Socio-Economic Analyses, and public consultations for these DUs to inform the decision on whether or not they will be listed under SARA.

Science advice on the status of Atlantic Salmon in SFAs 19-21 and 23 for 2018 was requested by Fisheries and Aquaculture Management. This advice is used to inform Aboriginal communities, clients, and the provinces of Nova Scotia and New Brunswick of the status of the Salmon resource in advance of developing harvest agreements and recreational fishing plans for 2019. The objectives of the request were to assess the status of Atlantic Salmon stocks in SFAs 19, 20, 21 and 23 up to the end of 2018 using the following indicators:

- adult abundance relative to reference levels;
- juveniles densities; and
- smolt production estimates.

Given that this request is for an update of previous advice using established methods (DFO 2014, DFO 2015, DFO 2016, DFO 2017, DFO 2018, and references therein), the Science Response Process was used.
This Science Response Report results from the Science Response Process of March 13, 2019, on the Stock Status Update of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23.

## Analysis and Response

## Methods

Evaluation of the status of Atlantic Salmon in the Maritimes Region is based on abundance monitoring for a number of index populations. For most index populations, status is evaluated using a comparison of the estimated egg deposition (calculated from the estimated abundance and biological characteristics of Salmon stocks) relative to a reference point known as the
conservation egg requirement. The river-specific conservation egg requirement is based on an egg deposition of $2.4 \mathrm{eggs} / \mathrm{m}^{2}$ multiplied by the amount of accessible fluvial rearing habitat that is of suitable gradient. An egg deposition of $2.4 \mathrm{eggs} / \mathrm{m}^{2}$ is considered to be a Limit Reference Point in the context of DFO's Precautionary Approach Framework (DFO 2009, DFO 2012, Gibson and Claytor 2012) for DFO's Maritimes Region. Conservation requirements for many of the rivers in the Maritimes Region are reported in O'Connell et al. (1997).

In this report, Salmon less than 63 cm in fork length are referred to as small, which are typically one-sea-winter (1SW) Salmon that return to spawn following a single winter at sea (also termed Grilse); Salmon greater than or equal to 63 cm in fork length are referred to as large, which are typically multi-sea-winter (MSW) Salmon that return following two or more winters at sea and repeat spawners. Juvenile Salmon abundance determined from electrofishing surveys is compared to Elson's norm values of 29 fry $/ 100 \mathrm{~m}^{2}$ and 38 parr/ $100 \mathrm{~m}^{2}$ (Elson 1967). A smolt production estimate of 3.8 smolt/100 $\mathrm{m}^{2}$ (Symons 1979) is sometimes used as a general reference value for rivers at or near the egg conservation requirement, and is provided here to allow for a comparison of smolt production estimates.

## Eastern Cape Breton (SFA 19)

Salmon population monitoring by DFO in ECB is currently focused on three river systems: the Middle, Baddeck, and North rivers (Table 1). Parks Canada (PC) monitors adult Salmon abundance on Clyburn Brook (Table 1) using dive surveys similar to those conducted by DFO. The Unama'ki Institute of Natural Resources (UINR) began monitoring smolts on Middle River in 2011, and smolt population estimates are available for 2013-2016, and 2018 (Table 2). Details on the assessment methods for ECB Salmon populations are provided in Levy and Gibson (2014), DFO (2013), Gibson and Bowlby (2009), and Robichaud-LeBlanc and Amiro (2004).

In 2018, all rivers within SFA 19, with the exception of the Middle, Baddeck, and North rivers, were closed to Salmon fishing all year. The Middle and Baddeck rivers were open to catch-andrelease angling from October $1^{\text {st }}$ to October $31^{\text {st }}$, and the North River (downstream from the area known as "The Benches") was open to catch-and-release angling from June $1^{\text {st }}$ to July $14^{\text {th }}$ and September $1^{\text {st }}$ to October $31^{\text {st }}$ (Table 1). A Provincial stocking program exists on the Middle and Baddeck rivers, which aims to numerically offset anticipated catch and release mortalities on these rivers (DFO 2010). Food, Social and Ceremonial (FSC) allocations were available to First Nations on these three rivers in 2018, and 3 large Salmon were harvested from North River (2 females and 1 male).

## Indicators of Stock Status

In 2018, all index populations in ECB were assessed to be below conservation egg requirements (Table 1), with estimated values of 60,43 , and 40 percent of the requirements for the Middle, Baddeck, and North rivers, respectively. The Salmon abundance in Clyburn Brook also continues to remain low, with 14 Salmon counted in 2018. The smolt abundance estimate for Middle River was 9,554 , within the range of the lowest estimates over the past 5 years, and the corresponding smolt production estimate is below the reference value of 3.8 smolts $/ 100 \mathrm{~m}^{2}$ (Symons 1979); however, the low number of recaptures resulted in high uncertainty of the markrecapture estimate (Table 2). A summary of the 2018 assessment results is provided in Tables 1, and 2 and a time series showing the status of adult Salmon populations for the Middle and Baddeck, North, and Clyburn rivers are provided in Figures 1, 2, and 3, respectively.

Table 1. Atlantic Salmon assessment information for index rivers in SFA 19 during 2018, including catch-and-release angling seasons, conservation egg requirements, preliminary recreational catch and effort estimates, catch and release mortality estimates, dive count results, escapement estimates, percent conservation egg requirement attained, and Provincial stocking information.

|  | Middle River | Baddeck River | North River | Clyburn Brook |
| :---: | :---: | :---: | :---: | :---: |
| 2018 Angling Season | October $1^{\text {st }}-31^{\text {st }}$ | October $1^{\text {st }}-31^{\text {st }}$ | June $1^{\text {st }}-$ July $14^{\text {th }}$; September $1^{\text {st }}$ October $31^{\text {st }}$ | Closed |
| Assessment Information | - Recreational Catch Estimates <br> - Dive Counts <br> - Mark Recapture Data (historical) <br> - Electrofishing Data (historical) | - Recreational Catch Estimates <br> - Dive Counts <br> - Mark Recapture Data (historical) <br> - Electrofishing Data (historical) | - Recreational Catch Estimates <br> - Mark Recapture Data (historical) | - Dive Counts |
| Conservation Egg Requirement (millions of eggs) | 2.07 | 2.01 | 0.92 | 0.28 |
| Preliminary Recreational Catch Estimates:* |  |  |  |  |
| Small Salmon | 17 | 10 | 24 | Not Applicable |
| Large Salmon | 92 | 71 | 37 | Not Applicable |
| Effort (rod-days) | 307 | 196 | 153 | Not Applicable |
| Total Catch and Release Mortality Estimates** | 4 | 3 | 2 | Not Applicable |
| Dive Counts:*** |  |  |  |  |
| Small Salmon | 36 | 10 | Not Applicable | 5 |
| Large Salmon | 254 | 77 | Not Applicable | 9 |
| Marks / Recaptures | Not Applicable | Not Applicable | Not Applicable | Not Applicable |
| Estimated Escapement: |  |  |  |  |
| Small Salmon | 43 | 20 | $35^{\ddagger}$ | Not Applicable |
| Large Salmon | 346 | 165 | 91 ${ }^{\ddagger}$ | Not Applicable |
| \% Conservation Egg <br> Requirement (Bayesian <br> 90\% credible interval) | $\begin{gathered} 60 \\ (46-79) \end{gathered}$ | $\begin{gathered} 43 \\ (32-57) \end{gathered}$ | $40^{\ddagger}$ | Not Applicable |
| Provincial Stocking: |  |  |  |  |
| Broodstock Collections | 4 large, 2 small (October) | Not Applicable | Not Applicable | Not Applicable |
| Juvenile Releases | $\begin{aligned} & \text { ~21,400 fin } \\ & \text { clipped } \\ & \text { 0+ parr } \\ & \text { (October) } \end{aligned}$ | $\begin{aligned} & \text { ~22,500 fin } \\ & \text { clipped } \\ & \text { 0+ parr } \\ & \text { (October) } \end{aligned}$ | Not Applicable | Not Applicable |

*Salmo-NS Database queried on Feb. 28, 2019. River specific mean scaling factors for small Salmon, large Salmon, and effort were used to estimate catch and effort in 2018 (see Sources of Uncertainty).
${ }^{* *}$ An assumed 4\% mortality rate is applied to estimate catch-and-release mortalities (DFO 2013).
${ }^{* * *}$ Middle River dive count was conducted November 1, 2018. Baddeck River dive count was conducted November 2, 2018. For North River, a Fall dive count was not possible in 2018 due to river conditions (see Sources of Uncertainty). Parks Canada conducted the dive count on Clyburn Brook on Nov. 1, 2018.
${ }^{\ddagger}$ North River escapement and \% Conservation Egg Requirement were based on preliminary Recreational Catch Estimates (see Sources of Uncertainty).

## Maritimes Region

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Table 2. Estimates of wild and hatchery Atlantic Salmon smolt abundance, production per unit area of habitat (smolts/100 m²), and one-sea-winter (1SW) and two-sea-winter (2SW) return rates for Middle River.

| Smolt <br> Year (t) | Smolt Estimate* | 95\% Confidence Interval | Production Per Unit Area (smolts/100 m${ }^{2}$ ) | Return Rate (\%)** |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | $\begin{aligned} & \text { 1SW } \\ & (t+1) \end{aligned}$ | $\begin{aligned} & \text { 2SW } \\ & (\mathrm{t}+2) \end{aligned}$ |
| 2013 | 11,103 | 6,848-15,359 | 1.43 | 0.20 | 1.68 |
| 2014*** | 11,907 | 2,471-21,343 | 1.53 | 0.37 | 1.52 |
| 2015 | 24,110 | 12,057-36,164 | 3.10 | 0.15 | 1.96 |
| 2016 | 14,848 | 8,451-21,244 | 1.91 | 0.90 | 2.15 |
| 2017 | Not Applicable | Not Applicable | Not Applicable | Not Applicable | Not Applicable |
| 2018*** | 9,554 | 1,265-17,842 | 1.23 | Not Applicable | Not Applicable |

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Figure 1. Estimated total number of spawners (top graph) and the percent of the conservation egg requirement attained (bottom graph) for Middle River (left panel) and Baddeck River (right panel), NS, from 1983 to 2018. Model fits derived from two methods are shown. The solid lines show the maximum likelihood estimates of annual abundance. The dashed lines show the Bayesian 90\% credible interval for the annual abundance estimates. The points in the top graphs are the population estimates obtained by mark recapture during the dive surveys. The horizontal dashed line in the bottom graphs indicates 100\% of the conservation egg requirement for each river.


Figure 2. Estimates of the number of Salmon returning to spawn and the spawning escapement for small and large Salmon in North River, NS, as derived from dive survey counts and from recreational catch data. The expected number of small or large Salmon necessary to meet the egg conservation requirement is shown by the horizontal dashed line. Error bars represent $90 \%$ confidence intervals. Note: A dive count was not conducted in 2018 due to river conditions.


Figure 3. Counts of small and large Salmon in Clyburn Brook, NS, from 1985 to 2018. Years in which only the lower section of the river was surveyed (partial counts) are identified with an asterisk (*). No count was conducted in 1991, 1993, 1996, and 2015. Source: Parks Canada.

## Southern Upland of Nova Scotia (SFAs 20, 21 and Part of SFA 22)

Atlantic Salmon assessment activities in the SU region are currently focused on two populations: the St. Mary's River, the index population for SFA 20, and the LaHave River, the index population for SFA 21. Beginning in 2010, all rivers within SFA 20 and SFA 21 were closed to recreational fishing for Atlantic Salmon and there were no FSC allocations. Details on the assessment methods for SU Salmon populations are provided in DFO (2013) and Gibson et al. (2009).

## Indicators of Stock Status

In 2018, the LaHave River Salmon population above Morgan Falls remained below the conservation egg requirement with an estimated egg deposition of $4 \%$ of the requirement (Table 3, Figure 4). Fry and total parr (age one and older) densities (Table 3) on the St. Mary's and LaHave rivers were also low and, with the exception of fry density on the St. Mary's River, remain below Elson's norm values. Smolt assessments were not completed on the LaHave River or St. Mary's River in 2018 due to collections for an interim captive rearing pilot (see Sources of Uncertainty). Smolt-to-adult return rates (a proxy for marine survival) for 1SW Salmon on the LaHave River have declined to values less than 1\% from 2013 to 2016 (Table 4, Figure 5). A summary of the 2018 assessment results is provided in Table 3, time series showing adult returns and estimated egg depositions in the LaHave River above Morgan Falls are provided in Figure 4, and a time series showing smolt-to-adult Salmon return rates is provided in Figure 5.

Table 3. Atlantic Salmon assessment information for index rivers in SFAs 20 and 21 during 2018, including angling seasons, conservation egg requirements, fishway counts, percent conservation egg requirement attained, juvenile assessment results, and Live Gene Bank broodstock collections.

|  | St. Mary's River | LaHave River |
| :---: | :---: | :---: |
| 2018 Angling Season | Closed | Closed |
| Assessment Information | - Juvenile Electrofishing Surveys | - Juvenile Electrofishing <br> Surveys (above and below Morgan Falls) <br> - Fishway Count (above Morgan Falls) |
| Conservation Egg Requirement (millions of eggs) | 9.56 | 6.22* |
| Fishway Count:** |  |  |
| Small Salmon | Not Applicable | 37 |
| Large Salmon | Not Applicable | 58 |
| \% Conservation Egg Requirement: | Not Applicable | 4*** |
| Number of Sites Surveyed and Electrofishing Densities (fish/100 m²): |  |  |
| Number of Sites | 6 | 7 |
| Age-0 Parr (Fry) | 24.3 | $4.9 \ddagger$ |
| Total Age-1 and Older Parr | 4.9 | $3.1{ }^{\ddagger}$ |
| Interim Captive Rearing Pilot: $\ddagger$ |  |  |
| Broodstock Collections (smolts) | $\begin{gathered} 388 \\ \text { (April-May) } \end{gathered}$ | $\begin{gathered} 35 \\ \text { (April-May) } \end{gathered}$ |
| Broodstock Collections (adults) | Not Applicable | 22 Large, 36 Small (May-October) |

*The conservation egg requirement reported by O'Connell et al. (1997) has been scaled according to the proportion of habitat area above Morgan Falls (i.e., 51\%).
${ }^{* *}$ Corrected for observed fallbacks (i.e., Salmon are marked when they ascend the fishway for the first time, and they are not included in the count if they ascend the fishway again).
***Corrected for broodstock removals by interim captive rearing pilot (see Sources of Uncertainty).
$\ddagger$ LaHave River average electrofishing densities were heavily influenced by a single site on the West Branch LaHave River (see Sources of Uncertainty).
$\ddagger \ddagger$ Smolts and adult Salmon were collected for an interim captive rearing pilot targeting genetic diversity of the Southern Upland DU. Adult collection numbers do not include Salmon released back to the river pre-spawn (see Sources of Uncertainty).

Table 4. Estimates of wild-origin Atlantic Salmon smolt abundance (and 95\% confidence interval), production per unit area of habitat (smolts/100 $\mathrm{m}^{2}$ ) and the smolt-to-adult return rates for the LaHave River.

| Smolt Year (t) | Wild Smolt Estimate | 95\% Confidence Interval | Production Per Unit Area (smolts/100 m²) | Return Rate (\%) |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | $\begin{aligned} & \text { 1SW } \\ & (t+1) \end{aligned}$ | $\begin{aligned} & \text { 2SW } \\ & (t+2) \end{aligned}$ |
| 1996 | 20,511 | 19,886-21,086 | 0.79 | 1.47 | 0.23 |
| 1997 | 16,550 | 16,000-17,100 | 0.63 | 4.33 | 0.43 |
| 1998 | 15,600 | 14,675-16,600 | 0.60 | 2.04 | 0.34 |
| 1999 | 10,420 | 9,760-11,060 | 0.40 | 4.82 | 0.86 |
| 2000 | 16,300 | 15,950-16,700 | 0.63 | 1.16 | 0.11 |
| 2001 | 15,700 | 15,230-16,070 | 0.60 | 2.70 | 0.59 |
| 2002 | 11,860 | 11,510-12,210 | 0.46 | 1.95 | 0.45 |
| 2003 | 17,845 | 8,821-26,870 | 0.68 | 1.75 | 0.17 |
| 2004 | 20,613 | 19,613-21,513 | 0.79 | 1.13 | 0.33 |
| 2005 | 5,270 | 4,670-5,920 | 0.20 | 7.95 | 0.54 |
| 2006 | 22,971 | 20,166-26,271 | 0.88 | 1.48 | 0.40 |
| 2007 | 24,430 | 23,000-28,460 | 0.98 | 2.33 | 0.16 |
| 2008 | 14,450 | 13,500-15,500 | 0.55 | 1.16 | 0.30 |
| 2009 | 8,644 | 7,763-9,659 | 0.33 | 3.47 | 0.88 |
| 2010 | 16,215 | 15,160-17,270 | 0.62 | 1.81 | 0.19 |
| 2011* | Not Applicable | Not Applicable | Not Applicable | Not Applicable | Not Applicable |
| 2012* | Not Applicable | Not Applicable | Not Applicable | Not Applicable | Not Applicable |
| 2013 | 7,159 | 5,237-10,259 | 0.27 | 0.60 | 0.24 |
| 2014 | 29,175 | 23,387-37,419 | 1.12 | 0.55 | 0.15 |
| 2015 | 6,664 | 6,011-7,413 | 0.26 | 0.35 | 0.35 |
| 2016 | 25,849 | 23,311-28,750 | 0.99 | 0.74 | 0.20 |
| 2017* | Not Applicable | Not Applicable | Not Applicable | Not Applicable | Not Applicable |
| 2018** | Not Applicable | Not Applicable | Not Applicable | Not Applicable | Not Applicable |

[^1]

Figure 4. Counts of small and large adult Atlantic Salmon (left panel) and estimated egg deposition (1000's) relative to the conservation egg requirement (right panel) by wild-origin and hatchery-origin Salmon at the Morgan Falls fishway on the LaHave River, NS, from 1973 to 2018. The horizontal dashed line in the right panel indicates the conservation egg requirement above Morgan Falls. Hatchery-origin smolts were no longer introduced after 2005. Genetic sex determination was used when available (2012 2017) to estimate egg deposition, and visual external sex identification was used in all other years.


Figure 5. Estimated smolt-to-adult return rates for maiden one-sea-winter (1SW) and two-sea-winter (2SW) Salmon on the LaHave River (above Morgan Falls).

## Outer Bay of Fundy (Outer Portion of SFA 23)

Atlantic Salmon assessment activities led by DFO in the OBoF region are currently focused on two river systems: Saint John River (upriver of Mactaquac Dam, which includes the Tobique tributary) and Nashwaak River (tributary of Saint John River downriver of Mactaquac Dam). The Atlantic Salmon Federation monitors adult and juvenile Salmon abundance on the Magaguadavic River. A detailed assessment to update status until 2012 for the OBoF
population was completed for the Recovery Potential Assessment of this DU (Jones et al. 2014).

All commercial fisheries for Atlantic Salmon in SFA 23 have been closed since 1984. Low abundance of Salmon has resulted in no FSC allocations and no recreational fisheries since 1998. In 2018, all rivers within SFA 23 remained closed to Salmon fishing all year.

The Mactaquac Biodiversity Facility (MBF) was constructed to numerically offset the effects of hydroelectric development on Salmon populations in the Saint John River, primarily by producing smolts from sea-run broodstock captured at fish collection facilities at Mactaquac Dam. Based on an agreement within the 'Saint John River Management Advisory Committee' in 2002, the Salmon supplementation program at the MBF was modified to focus on conserving and restoring a declining resource utilizing captive-reared adults, originally collected from the wild as juveniles, for both broodstock and adult releases to naturally spawn upriver of Mactaquac Dam (Jones et al. 2004). About 90 broodstock matings per year are still carried out at the MBF for the production of smolts to release downriver of Mactaquac Dam and unfed fry to release in the Tobique River. Unfed fry were also released into the Nackawic River in 2018.

## Indicators of Stock Status

Egg depositions from spawners in 2018 were estimated to be less than $8 \%$ of the conservation egg requirements for each of the three index rivers (Table 5) for the seventh consecutive year; the lowest to date at 1\%, 2\%, and 0\% for the Saint John (above Mactaquac Dam), Nashwaak, and Magaguadavic rivers, respectively. Assuming the captive-reared adults spawn successfully, spawners released upriver of Mactaquac Dam in 2018 potentially increased the estimated egg depositions to $6 \%$ of the requirement on that section of the Saint John River. In 2018, fry and total parr (age one and older) densities (Table 5) on the Tobique, Nashwaak and Magaguadavic rivers remain low at $<4$ fish $/ 100 \mathrm{~m}^{2}$, below Elson's norm values. The Rotary Screw Traps (RSTs) on the Nashwaak were operated in 2018, but a smolt abundance estimate was not possible for the second year in a row; due to high water levels, the RSTs could not be safely operated for a period of time during the peak emigration period. The pre-smolt (Tobique) abundance estimate in 2018 was less than 0.1 fish $/ 100 \mathrm{~m}^{2}$ of productive habitat, which is very low in comparison to the reference value of 3.8 smolts $/ 100 \mathrm{~m}^{2}$ (Symons 1979). The smolt-to1SW Salmon return rate in 2018 was not possible to calculate, while the smolt-to-2SW Salmon return rate in 2018 ( 0.41 ) was below the long-term mean (smolt years; 1998-2015; 1.08), remaining low, with the exception of 2017, for the last six years (Table 6). A summary of the 2018 assessment results is provided in Table 5. A time series showing the status of Salmon populations for the Saint John (upriver of Mactaquac Dam) and Nashwaak rivers are provided in Figures 6-9, and a time series showing smolt-to-adult Salmon return rates is provided in Figure 10.

Table 5. Atlantic Salmon assessment information for index rivers in SFA 23 during 2018, including angling seasons, conservation egg requirements, fish collection facilities/fishway/fence counts, estimated returns, percentage of conservation egg requirements attained, captive-reared adult and juvenile releases, and juvenile and smolt assessment results.

|  | Saint John River (Above Mactaquac Dam) | Nashwaak River (Above Durham Bridge) | Magaguadavic River |
| :---: | :---: | :---: | :---: |
| Angling Season (2018) | Closed | Closed | Closed |
| Assessment Information | - Fish Collection Facilities Count <br> - Juvenile Electrofishing Surveys <br> - Pre-smolt Assessment | - Counting Fence (Mark Recapture) <br> - Juvenile Electrofishing Surveys (above and below Counting Fence) <br> - Smolt Assessment (Mark Recapture) | - Fishway Count <br> - Juvenile Electrofishing Surveys |
| Conservation Egg Requirement (millions of eggs) | 32.30 | 5.35* | 1.35 |
| Fishway or Fence Count: |  |  |  |
| 1SW Salmon | 446 | 89 | 1 |
| MSW Salmon | 63 | 31 | 0 |
| Marks (M) / Recaptures (R) / Captures (C) | Not Applicable | $\mathrm{M}=33 / \mathrm{R}=15 / \mathrm{C}=38$ | Not Applicable |
| Estimated Returns: |  |  |  |
| 1SW Salmon | 451 | 89 | 0 |
| MSW Salmon | 65 | 31 | 0 |
| \% Conservation Egg Requirement: |  |  |  |
| Without Captive-Reared | 1 | 2 | 0 |
| Including Captive-Reared | 6 | Not Applicable | Not Applicable |
| Captive-reared Adult Releases | 744*** | Not Applicable | Not Applicable |
| Juvenile Releases: |  |  |  |
| Age-1 Smolt (below Dam) | 6,575 (May) | 41 (Research) | 30 (Research) |
| Age-1 Smolt (Tobique) | 500 (May) | Not Applicable | Not Applicable |
| Unfed Fry (Tobique) | 21,401 (June) | Not Applicable | Not Applicable |
| Unfed Fry (Nackawic) | 112,035 (June) | Not Applicable | Not Applicable |
| Age-0 Parr (Tobique) | 0 (Sept./Oct.) | Not Applicable | Not Applicable |
| Number of Sites Surveyed and Electrofishing Densities (fish/100 m²): |  |  |  |
| Number of Sites | 16** | 10 | 3 |
| Age-0 Parr (Fry) | 2.8** | 1.1 | 0 |
| Total Age-1 and Older Parr | 2.9** | 3.4 | 1.3 |
| Wild-Origin Pre-Smolt or Smolt Estimate (2.5 and 97.5 percentiles) | $\begin{gathered} 6,525^{\star *} \\ (5,400-8,250) \end{gathered}$ | No <br> Assessment | Not Applicable |
| Pre-Smolt or Smolt (fish/100 m${ }^{2}$ ) | 0.08** | Not Applicable | Not Applicable |

[^2]Table 6. Estimates of wild-origin Atlantic Salmon smolt abundance from upriver of Durham Bridge (and 2.5 and $97.5 \%$ percentiles), production per unit area of habitat (smolts/ $100 \mathrm{~m}^{2}$ ), and the smolt-to-adult return rates for the Nashwaak River, 1998-2018.

| Smolt Year <br> (t) | Wild Smolt Estimate | 95\% Confidence Interval | Production Per Unit Area (smolts/100 m²) | Return Rate (\%) |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | $\begin{aligned} & \text { 1SW } \\ & (t+1) \end{aligned}$ | $\begin{aligned} & \text { 2SW } \\ & (t+2) \end{aligned}$ |
| 1998 | 22,750 | 17,900-32,850 | 0.43 | 2.91 | 0.67 |
| 1999 | 28,500 | 25,300-33,200 | 0.54 | 1.79 | 0.84 |
| 2000 | 15,800 | 13,400-19,700 | 0.30 | 1.53 | 0.28 |
| 2001 | 11,000 | 8,100-17,400 | 0.21 | 3.11 | 0.90 |
| 2002 | 15,000 | 12,300-19,000 | 0.28 | 1.91 | 1.26 |
| 2003 | 9,000 | 6,800-13,200 | 0.17 | 6.38 | 1.58 |
| 2004 | 13,600 | 10,060-20,800 | 0.26 | 5.13 | 1.28 |
| 2005 | 5,200 | 3,200-12,600 | 0.10 | 12.73 | 1.52 |
| 2006 | 25,400 | 21,950-30,100 | 0.48 | 1.81 | 0.62 |
| 2007 | 21,550 | 16,675-30,175 | 0.41 | 5.63 | 1.26 |
| 2008 | 7,300 | 5,500-11,200 | 0.14 | 3.86 | 2.05 |
| 2009 | 15,900 | 12,150-22,850 | 0.30 | 12.41 | 3.31 |
| 2010 | 12,500 | 9,940-16,740 | 0.24 | 7.86 | 0.35 |
| 2011 | 8,750 | 7,130-11,300 | 0.17 | 0.33 | 0.98 |
| 2012 | 11,060 | 8,030-17,745 | 0.21 | 1.63 | 0.29 |
| 2013 | 10,120 | 8,840-11,800 | 0.19 | 1.61 | 0.45 |
| 2014 | 11,100 | 8,150-17,200 | 0.21 | 2.86 | 0.60 |
| 2015 | 7,900 | 6,520-9,980 | 0.15 | 5.04 | 1.18 |
| 2016 | 7,150 | 5,575-9,925 | 0.13 | 2.84 | 0.41 |
| 2017* | Not Applicable | Not Applicable | Not Applicable | Not Applicable | Not Applicable |
| 2018* | Not Applicable | Not Applicable | Not Applicable | Not Applicable | Not Applicable |

*A smolt estimate was attempted but was not successful due to a high flow event that prevented operation of the RST during the full smolt migration period.



Figure 6. Estimated wild and hatchery-origin one-sea-winter (1SW) and multi-sea-winter (MSW) returns destined for upriver of Mactaquac Dam, Saint John River, 1970-2018.


Figure 7. Estimated egg deposition per m² (wild and hatchery combined, and captive-reared) upriver of Mactaquac Dam, Saint John River, 1970-2018. The horizontal dashed line is the conservation egg requirement (2.4 eggs per m²).


Figure 8. Estimated wild and hatchery-origin one-sea-winter (1SW) and multi-sea-winter (MSW) Atlantic Salmon returns (and 2.5 and 97.5 percentiles) to the Nashwaak River, 1993-2018. No hatchery-origin releases since 2010.


Figure 9. Estimated egg deposition per $m^{2}$ upriver of the counting fence operated just below Durham Bridge, Nashwaak River, 1993-2018. The horizontal dashed line is the conservation egg requirement (2.4 eggs per $m^{2}$ ).


Figure 10. Estimated smolt-to-adult return rates for maiden one-sea-winter (1SW) and two-sea-winter (2SW) Salmon on the Nashwaak River (above Durham Bridge).

## Sources of Uncertainty

There are on-going informal reports of illegal fishing activities (e.g., fishing in closed areas and poaching), but the combined contribution of these activities to the depressed status of populations is not known.

Further details on the uncertainty associated with these assessment methods can be found in DFO (2013).

## Eastern Cape Breton

The number of small and large Salmon caught and released, fishing effort, and catch and release mortality within SFA 19 are estimated from license stub returns from the recreational Salmon fishery. Catch and effort values are adjusted for non-returned stubs using a relationship based on the reported catch as a function of the number of reminder letters sent to licensed anglers. For recreational catch data, under- or over-reporting of numbers of Salmon caught and fishing effort would impact assessment results based on these data. Estimates for 2018 are considered to be preliminary at the time of this status update since license sale information and license stubs are still being returned. In recent years, catch and effort estimates prior to sending reminder letters to anglers have generally been systematically higher than catch and effort estimates after reminder letters have been sent. In an attempt to reduce this bias in years where reminder letters were not sent to anglers (i.e., 2004, 2008-2010, and 2018), individual river mean scaling factors (i.e., estimate after reminder letter information divided by reported value prior to reminder letter information) for small Salmon, large Salmon and effort have been applied to reported values to estimate catch and effort.

A dive count was attempted for North River on October 31, 2018; however, water clarity was poor and water levels were unsuitable to complete the survey. As a result, the North River returns estimate was available only from recreational catch data in 2018. North River recreational fishing effort for 2018 was the lowest on record since 1983, and North River Salmon abundance estimated from the recreational catch data does not track consistently with dive count abundance estimates (Figure 2). In light of the potential unsuitability of North River recreational catch data for estimating returns, and low fishing effort in 2018, the Percent Conservation Egg Requirement value for North River should be carefully interpreted as it may be an underestimate.

A pool count of Salmon returns was conducted on North River on August 14, 2018, where 80 large and 51 small Salmon were counted. Water levels were very low and the visibility was considered to be good during this count, but the observation efficiency was unknown, so it was not used for population assessment purposes.

In 2017, the variance terms of the likelihood functions for dive count and recreational catch data in the escapement model for Middle River were adjusted giving more weight to the dive counts than to the recreational catch data (DFO 2018). This adjustment was not done for 2018 data, where dive counts and recreational catch data were weighted equally; however, the 2017 recreational catch values were omitted from the 2018 model to better reflect the model output for 2017 escapement estimates.
Although some populations in ECB have been closer to their conservation egg requirements than those in the OBoF and SU regions, substantial declines are evident in other ECB populations (e.g., Grand River and Clyburn Brook). There is uncertainty in the status of populations in non-index rivers, which has been inferred from recreational catch data and limited electrofishing data (Levy and Gibson 2014).

## Southern Upland

LaHave River electrofishing fry and parr densities were low at six of seven survey sites in 2018; while the average densities reported were similar to recent years data, the values were heavily influenced by a single site on the West Branch LaHave River. When this site was excluded from analyses, juvenile Salmon densities for the remaining six sites were the lowest on record since 1999 ( 0.6 fry per $100 \mathrm{~m}^{2}, 0.7$ parr per $100 \mathrm{~m}^{2}$ ). There is uncertainty as to the effect of drought
conditions on LaHave River in 2016 on juvenile Atlantic Salmon, but low juvenile densities in 2018 may be reflective of mortality due to this event.
Concerns over the possible extirpation of Southern Upland Atlantic Salmon within SFA 20 and 21, as well as potential population-bottleneck effects at low abundances, led to collection of wild-origin Salmon from the St. Mary's and LaHave rivers beginning with smolt collections in 2016. In 2018, smolts from the St. Mary's River, and smolts and adult Salmon from the LaHave River, were collected for an interim captive rearing pilot at the Coldbrook Biodiversity Facility (CBF; Table 3), with the primary objective to conserve genetic diversity representative of the Southern Upland DU. Some adult Salmon from 2018 collections were returned to the LaHave River on October $22^{\text {nd }}$ and October $25^{\text {th }}$ ( 25 total), and these were not recorded as broodstock collections as they had the potential to spawn in 2018. However, due to the potential behavioural effects of capture, temporary holding at CBF, and release immediately pre-spawn, there is uncertainty as to whether these individuals would spawn successfully.

## Conclusions

All Atlantic Salmon index populations within DFO's Maritimes Region were assessed to be below conservation egg requirements in 2018. SU and OBoF Atlantic Salmon populations remain critically low. Adult Salmon returns to the LaHave River (SU), the Saint John River upriver of Mactaquac Dam, and the Nashwaak River (OBoF) remain among the lowest returns on record with estimated egg depositions ranging between 1-4\% of conservation egg requirements in 2018; the lowest on record for the OBoF region. Moreover, recent smolt-toadult return rates (a proxy for marine survival) for 1SW and 2SW Salmon on the LaHave River were estimated to be the lowest on record with values less than 1\% from 2013-2016, the most recent years for which data are available. Smolt-to-adult return rates on the Nashwaak River were low and below the long-term mean for 2SW returns and not available for 1SW returns for the first time since 1999 because no smolt assessment was possible in 2017. Some populations in the ECB region have been closer to conservation egg requirements than those in the OBoF and SU regions, although egg depositions for ECB index populations remained below conservation egg requirements with values ranging between $40-60 \%$ of these requirements in 2018.

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## Sources of Information

DFO. 2009. A Fishery Decision-Making Framework Incorporating the Precautionary Approach. (Accessed July 2014)
DFO. 2010. Status of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2010/002. 25 p.
DFO. 2012. Reference Points Consistent with the Precautionary Approach for a Variety of Stocks in the Maritimes Region. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/035. 35 p.

DFO. 2013. Status of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2013/013. 29 p.

DFO. 2014. Status of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2014/037. 14 p.
DFO. 2015. Status of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2015/021. 14 p.
DFO. 2016. Stock Status Update of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2016/029.

DFO. 2017. Stock Status Update of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2017/020.

DFO. 2018. Stock Status Update of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/038.

Elson, P.F. 1967. Effects on Wild Young Salmon of Spraying DDT over New Brunswick Forests. J. Fish. Res. Board. Can. 24: 731-767.

Gibson, A.J.F., and H.D. Bowlby. 2009. Review of DFO Science Information for Atlantic Salmon (Salmo salar) Populations in the Eastern Cape Breton Region of Nova Scotia. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/080. vi +79 p.
Gibson, A.J.F., H.D. Bowlby, D.L. Sam, and P.G. Amiro. 2009. Review of DFO Science Information for Atlantic Salmon (Salmo salar) Populations in the Southern Upland Region of Nova Scotia. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/081. vi + 83 p.
Gibson, A.J.F., and R.R. Claytor. 2012. What is 2.4? Placing Atlantic Salmon Conservation Requirements in the Context of the Precautionary Approach to Fisheries Management in the Maritimes Region. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/043. iv + 21 p.
Jones, R.A., L. Anderson, and T. Goff. 2004. Assessments of Atlantic Salmon Stocks in Southwest New Brunswick, an Update to 2003. Can. Sci. Advis. Sec. Res. Doc. 2004/019: $\mathrm{ii}+70 \mathrm{p}$.

Jones, R.A., L. Anderson, and C.N. Clarke. 2014. Assessment of the Recovery Potential for the Outer Bay of Fundy Population of Atlantic Salmon (Salmo salar): Status, Trends, Distribution, Life History Characteristics, and Recovery Targets. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/008. vi + 94 p.
Levy, A.L., and A.J.F. Gibson. 2014. Recovery Potential Assessment for Eastern Cape Breton Atlantic Salmon (Salmo salar): Status, Past and Present Abundance, Life History, and Trends. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/099. v + 72 p.
Marshall, T.L., R.A. Jones, and T. Pettigrew. 1997. Status of Atlantic Salmon Stocks of Southwest New Brunswick, 1996. DFO Can. Stock Assess. Sec. Res. Doc. 97/27: iii + 67 p.
O'Connell, M.F., D.G. Reddin, P.G. Amiro, F. Caron, T.L. Marshall, G. Chaput, C.C. Mullins, A. Locke, S.F. O'Neil, and D.K. Cairns. 1997. Estimates of Conservation Spawner Requirements for Atlantic Salmon (Salmo salar L.) for Canada. DFO Can. Stock Assess. Sec. Res. Doc. 97/100. 58 p.

Ricker, W.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Bull. Fish. Res. Board Can. 191.

Robichaud-LeBlanc, K.A., and P.G. Amiro. 2004. Assessments of Atlantic Salmon Stocks in Selected Rivers of Eastern Cape Breton, SFA 19, to 2003. Can. Sci. Advis. Sec. Res. Doc. 2004/017. ii + 66 p.
Symons, P.E.K. 1979. Estimated Escapement of Atlantic Salmon (Salmo salar L.) for Maximum Smolt Production in Rivers of Different Productivity. J. Fish. Res. Board Can. 36: 132-140.

## Appendix



Figure A1. Map showing the locations of Atlantic Salmon rivers where monitoring predominately occurred, Salmon Fishing Areas (SFAs), and Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Designatable Units (DUs) mentioned in this update. SFA numbers are labeled inside the white circles. Data Source for DUs derived from NS Secondary Watershed Layer (NS Dept. of Environment) and NB Watershed Level 1 Layer (NB Dept. of Natural Resources).

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MPO. 2020. Mise à jour de l'état du stock des populations de saumon de l'Atlantique (Salmo salar) des ZPS 19 à 21 et 23. Secr. can. de consult. sci. du MPO, Rép. des Sci. 2020/002.


[^0]:    *Source: Smolt estimates provided by UINR. For 2013-2016 and 2018, the smolt population was estimated using a single trap markrecapture experiment and the Adjusted Peterson Estimate (Ricker 1975). A smolt estimate was attempted in 2017 but was not successful due to a high flow event that prevented operation of the Rotary Screw Trap (RST) during the full smolt migration period. **Ninety percent of large Salmon were assumed to be maiden 2SW Salmon based on the aging of scale samples collected from adult Salmon on Middle River during 1995-1998, 2003, and 2004. All small Salmon were assumed to be 1SW Salmon for these return rate calculations.
    ***The number of recaptures were low in 2014 (207 marked smolts, 276 captured smolts, and 4 recaptured smolts) and 2018 (193 marked smolts, 196 captured smolts, and 3 recaptured smolts ), resulting in greater uncertainty associated with these estimates.

[^1]:    *Smolt assessments were not conducted on the LaHave River in 2011, 2012, 2017, and 2018.
    ${ }^{* *}$ Smolts were captured for an interim captive rearing pilot in 2018 and a mark-recapture assessment was not possible (see Sources of Uncertainty).

[^2]:    *The conservation egg requirement reported by Marshall et al. (1997) is calculated based on the habitat area above the counting fence (above Durham Bridge) on the Nashwaak River (i.e., $90 \%$ ).
    **Electrofishing and pre-smolt results are for the Tobique River (index tributary and represents $54.4 \%$ of the accessible rearing habitat upriver of Mactaquac Dam within Canadian boundaries).
    ***561 captive reared adults were released into the Tobique River, while 183 adults (originally collected from the Beechwood Hydroelectric Facility) were released into the main Saint John River below Perth-Andover and allowed free swim throughout the upper part of the system.

