Fisheries and Oceans Canada / Pêches et Océans Canada
Ecosystems and Oceans Science / Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat (CSAS)

Research Document 2024/049

Maritimes Region

Updated Information on Atlantic Salmon (*Salmo salar*) Eastern Cape Breton Populations (ECB; Salmon Fishing Area 19) of Relevance to the Development of a 2nd COSEWIC Status Report

A.D. Taylor[1], D. Raab[1], D.C. Hardie[1], E.B. Brunsdon[1]

Fisheries and Oceans Canada
Science Branch, Maritimes Region
[1]Bedford Institute of Oceanography
Dartmouth, NS, B2Y 4A2

August 2024

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1919-5044
ISBN 978-0-660-72330-3 Cat. No. Fs70-5/2024-049E-PDF

Correct citation for this publication:

Taylor, A.D., Raab, D., Hardie, D.C., and Brunsdon, E.B. 2024. Updated Information on Atlantic Salmon (*Salmo salar*) Eastern Cape Breton Populations (ECB; Salmon Fishing Area 19) of Relevance to the Development of a 2nd COSEWIC Status Report. DFO Can. Sci. Advis. Sec. Res. Doc. 2024/049. v + 69 p.

Aussi disponible en français :

*Taylor, A.D., Raab, D., Hardie, D.C., et Brunsdon, E.B. 2024. Information actualisée sur les populations de saumon atlantique (*Salmo salar*) de l'est du Cap-Breton (ECB; zone de pêche du saumon 19) pertinente pour l'élaboration d'un 2e rapport de situation du COSEPAC. Secr. can. des avis sci. du MPO. Doc. de rech. 2024/049. v + 77 p.*

TABLE OF CONTENTS

ABSTRACT

The purpose of this research document is to summarize and update the present status and recent trends of Atlantic Salmon populations in the Eastern Cape Breton (ECB) Designatable Unit (DU) of relevance to the development of the status report by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). There are 46 watersheds known to contain or have contained Atlantic Salmon in the DU, and additional smaller streams have been identified as likely to contain or historically contained Atlantic Salmon.

Atlantic Salmon population monitoring in ECB has focused on five river systems: Middle, Baddeck, North, Grand, and Clyburn. Assessments on these rivers have been based on fishery-independent counts by dive surveys or at a fish ladder and/or recreational catch reports. Of these five populations, two (Grand and Clyburn) show marked declines in adult abundance over the last 3-generations of available data. Two populations (Middle and Baddeck) have remained relatively stable at abundances below their conservation requirements and one population (North) is estimated to be near or above its conservation requirement in recent years. Recreational catch data for other rivers in the ECB DU suggests that Atlantic Salmon abundance is low throughout most of the DU. Intermittent electrofishing surveys also indicate that juvenile densities are below reference values at many locations throughout the ECB DU, although juvenile salmon are still widely distributed. A number of threats to Atlantic Salmon are identified in the freshwater and estuarine/marine environment of the ECB DU, including illegal fishing/poaching, salmonid aquaculture, marine ecosystem change, disease and parasites, and many others.

INTRODUCTION

This document presents information on the status of Atlantic Salmon (*Salmo salar*) populations in the Eastern Cape Breton (ECB) Designatable Unit (DU), prepared in support of a review of the conservation status of Atlantic Salmon in eastern Canada by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

The ECB DU of Atlantic Salmon consists of an assemblage of salmon populations that occupy rivers in a region of Nova Scotia extending from the northern tip of Cape Breton Island (approximately 47 02' N, 60 35' W) along the Atlantic coast to the Canso Causeway (approximately 45 39' N, 61 25' W; COSEWIC 2010). All populations inhabit rivers within Salmon Fishing Area (SFA) 19, which is a management area used by Fisheries and Oceans Canada (DFO) for salmon fisheries management and assessment purposes (DFO 2014). There are 46 watersheds known to contain or have contained Atlantic Salmon in the DU, and additional smaller streams have been identified as likely to contain or historically contained Atlantic Salmon (DFO 2014). The ECB DU was assessed as "Endangered" by COSEWIC in 2010 (COSEWIC 2010).

Salmon population monitoring in ECB is focused on five index river systems: Middle, Baddeck, North, Grand, and Clyburn. The assessments by DFO in SFA 19 are based on recreational catches reported through a license-stub return program, fishery-independent counts by dive surveys on Middle, Baddeck, and North rivers, and fishway counts on Grand River (ending in 2000). Clyburn Brook is monitored for adult abundance using similar dive survey techniques by Parks Canada. DFO assesses the abundance of Atlantic Salmon in ECB relative to a conservation egg requirement, which is estimated based on available river-specific spawning habitat and a target egg deposition of 2.4 egg/m^2 (O'Connell et al. 1997).

Additional information and previous assessments with regard to Atlantic Salmon populations can be obtained from the Canadian Science Advisory Secretariat (CSAS) published by DFO in Ottawa. The most recent documents with information on Eastern Cape Breton Atlantic Salmon populations are DFO (2020) and four research documents prepared in support of the Recovery Potential Assessment (RPA) for the ECB DU providing information on abundance, life history, and trends (Levy and Gibson 2014), genetic variation (O'Reilly et al. 2013), population dynamics and viability (Gibson and Levy 2014), and habitat use and threats to populations (Gibson et al. 2014).

1. LIFE HISTORY CHARACTERISTICS

There is little information available to summarize life history characteristics in Eastern Cape Breton (ECB) outside of recreational catch statistics on the size of catch. Analyses of these data indicate that with the exception of Indian Brook, all populations to the east of the Bras d'Or Lakes have a higher proportion of small salmon (that mature after one sea-winter (1SW)) than populations to the west of the lakes (Gibson and Bowlby 2009), which have a higher proportion of large salmon (that mature after two sea-winter (2SW), three sea-winter (3SW), or greater), collectively referred to as multi sea-winter (MSW). The higher proportion of small salmon coincides with a lower stream gradient in rivers to the east of the Bras d'Or Lakes (Robichaud-Leblanc and Amiro 2004).

Biological information is summarized below for index rivers with data in addition to recreational catch. The length-fecundity relationship is calculated for Middle, Baddeck, and North River (A; Marshall et al. 1999) and Grand River (B; Amiro and Longard 1990) as:

$$\text{A) Fecundity} = 340.83e^{0.039 * \text{Fork Length}}$$

$$B)\ Fecundity = 261.90e^{0.043*Fork\ Length}$$

The fecundity calculation is then used to estimate number of eggs per fish based on the proportion female in each population.

1.1. MIDDLE RIVER

Adult Atlantic Salmon returns to Middle River were historically comprised of a summer and fall component, however, the summer component has reportedly disappeared (Marshall et al. 1996). Analysis of adult scale samples collected from wild Atlantic Salmon over nine years during the 1995-2015 time period indicate that the majority of Atlantic Salmon from Middle River spend two to three years in fresh water prior to migrating to sea (Table 1). The majority of Atlantic Salmon then spend two winters at sea prior to returning to Middle River to spawn for the first time (Table 1). This is consistent with the results from the recreational catch data during the 1983-2019 time period, where an estimated 28% of the Atlantic Salmon population captured by anglers on Middle River were small adults, with no obvious trend observed in this proportion over the 37 year time period (Table 2). Adult salmon that returned to Middle River after one winter at sea were predominately males (Appendix 1 in Levy and Gibson 2014). Based on the scale samples, less than 5% of salmon spawned more than one time and very few maiden 3SW fish were observed. Additional details on specific life histories of repeat spawners is available in Levy and Gibson 2014.

Mean fork length of first time spawners was 56 cm for 1SW, 75 cm for 2SW, and 85 cm for 3SW and the proportion female was 0.04 for 1SW, 0.73 for 2SW, and 0.33 for 3SW (Table 3). The average generation time was calculated using the mean smolt age in addition to mean sea age for maiden spawners, with an additional year added to account for the year of egg deposition (COSEWIC 2010). For Middle River, the mean generation time is calculated as 5.4 years, resulting in a 17 year 3-generation time once rounded to the nearest integer.

1.2. BADDECK RIVER

Adult Atlantic Salmon predominately return to Baddeck River to spawn in the fall (Gibson and Bowlby 2009). Analysis of adult scale samples collected from wild Atlantic Salmon over eight years during the 1977–2004 time period shows that Atlantic Salmon from Baddeck River generally spend two to three years in fresh water prior to migrating to sea (Table 4). Atlantic Salmon then predominately spend two winters at sea prior to returning to Baddeck River to spawn for the first time (Table 4). This result is consistent with the results from the recreational catch data during the 1983–2019 time period, where an estimated 23% of salmon captured by anglers from Baddeck River were small adults, with no significant trend in this proportion over the 37 year time period (Table 5). Adults that return to the Baddeck River after 1SW are predominately males (Appendix 2 in Levy and Gibson 2014). Less than 5% of the samples indicated that the salmon had spawned previously and only two maiden 3SW fish were observed. Additional details on specific life histories of repeat spawners is available in Levy and Gibson 2014.

Mean fork length of first time spawners was 57 cm for 1SW, 75 cm for 2SW, and 85 cm for 3SW and the proportion female was 0.13 for 1SW, 0.84 for 2SW, and 0.5 for 3SW (Table 3). The average generation time was calculated using the mean smolt age in addition to mean sea age for maiden spawners, with an additional year added to account for the year of egg deposition (COSEWIC 2010). For Baddeck River, the mean generation time is calculated as 5.5 years, resulting in a 17 year 3-generation time once rounded to the nearest integer.

1.3. NORTH RIVER

Adult Atlantic Salmon return earlier to the North River than to Middle or Baddeck Rivers (Gibson and Bowlby 2009). Analysis of adult scale samples collected from wild Atlantic Salmon over seven years during the 1991–2016 time period indicates that Atlantic Salmon from North River generally spend two to three years in fresh water prior to migrating to sea (Table 6). Atlantic Salmon predominately spend two years at sea before returning to North River to spawn (Table 6). These results are consistent with the results from the recreational catch data during 1983–2019 time period, where an estimated 33% of the Atlantic Salmon population captured by anglers in North River are small (1SW) adults (Table 7). The recreational catch data series indicates that there were a few years (i.e., 1996, 1998 and 2000) where the proportion of small (1SW) salmon angled was greater than the large component. Scale samples indicated that 1SW returns were primarily male (30), with only four females recorded. Approximately 9% of scale samples indicated that salmon had spawned previously, a frequency of repeat spawners more than twice that of the Middle and Baddeck salmon populations. Additional details on specific life histories of repeat spawners is available in Levy and Gibson 2014.

Mean fork length of first time spawners was 52 cm for 1SW, 72 cm for 2SW, and 85 cm for 3SW and the proportion female was 0.07 for 1SW, 0.88 for 2SW, and the only 3SW observed was female (Table 3). The average generation time was calculated using the mean smolt age in addition to mean sea age for maiden spawners, with an additional year added to account for the year of egg deposition (COSEWIC 2010). For North River, the mean generation time is calculated as 5.3 years, resulting in a 16 year 3-generation time once rounded to the nearest integer.

1.4. GRAND RIVER

There is no new information on Grand River Atlantic Salmon since the recreational fishery closed in 2010. See Levy and Gibson (2014) for a detailed overview of the life history characteristics. In brief, adult salmon return to Grand River primarily as small (1SW) fish in June or July, and large salmon that return are primarily repeat-spawning 1SW fish (Marshall et al. 2000). Atlantic Salmon in Grand River spend two to four years in fresh water and return after one sea winter (Levy and Gibson 2014). There are more repeat spawners observed in Grand River (approximately 13%) than any other ECB Rivers with data available (Levy and Gibson 2014).

The average generation time was calculated using the mean smolt age in addition to mean sea age for maiden spawners, with an additional year added to account for the year of egg deposition (COSEWIC 2010). For Grand River, the mean generation time is calculated as 4.2 years, resulting in a 13 year 3-generation time once rounded to the nearest integer.

1.5. CLYBURN RIVER (BROOK)

Results from dive surveys conducted by Parks Canada indicate that the run of Atlantic Salmon in Clyburn Brook is predominately comprised of large salmon during most years (Table 8). However, results from these surveys indicate that there are some years where the percent composition of small salmon is equal to or greater than that of large salmon (Table 8). Reported recreational catch is low compared with rivers assessed by DFO (Appendix 5 in Levy and Gibson 2014) and has been closed to angling since 2010. Although there is limited data for Clyburn Brook, recreational catches were predominately comprised of large salmon in most years where catch was reported.

2. OVERVIEW OF DESIGNATABLE OVERVIEW OF DESIGNATABLE UNIT

The ECB DU of Atlantic Salmon consists of an assemblage of salmon populations that occupy rivers in a region of Nova Scotia extending from the northern tip of Cape Breton Island (approximately 47 02' N, 60 35' W) along the Atlantic coast to the Canso Causeway (approximately 45 39' N, 61 25' W; Figure 1; COSEWIC 2010). All populations inhabit rivers within Salmon Fishing Area (SFA) 19, which is a management area used by DFO for salmon fisheries management and assessment purposes (DFO 2014). There are 46 watersheds known to contain or have contained Atlantic Salmon in the DU, and additional smaller streams have been identified as likely to contain or historically contained Atlantic Salmon (DFO 2014). In COSEWIC 2010, it was concluded that some structuring exists within the DU, but limited genetic information exists to resolve the life history differences within the DU. The populations in this DU appear to be genetically distinct from its southern neighbour, DU 14 (Nova Scotia Southern Upland; Verspoor et al. 2005).

There is considerable life history and genetic diversity among Atlantic Salmon populations in ECB, the maintenance of which is considered important for the long term persistence of the DU (DFO 2014). This diversity likely originates from the diversity of ecosystem types and the relatively complex geography within the region that can lead to the isolation of populations on small spatial scales (DFO 2014). Within the ECB DU there are notable differences between rivers to the east and west of the Bras d'Or Lakes in the life history (proportion of fish maturing after one winter at sea (1SW)), and habitat (Levy and Gibson 2014, Gibson et al. 2014). The differences in river types and life history were the basis for the recommendation of separating the ECB DU into two conservation units to the east and west of the Bras d'Or Lakes (DFO and MNRF 2008) and further analysis by Gibson and Bowlby (2009) provided additional evidence of life history divergence between the east and west of the Bras d'Or Lakes.

An overview of the stocking history in the ECB DU is available below (See: Manipulated Populations) and extensive overviews of the Designatable Unit are available in COSEWIC (2010), Gibson et al. (2014) and DFO (2014).

3. TRENDS IN POPULATION INDICATORS

Evaluation of the status of Atlantic Salmon populations within the DFO Maritimes Region is based on a comparison of the estimated egg deposition to a reference point known as the conservation (egg) requirement. Conservation requirements have been developed for rivers within the DFO Maritimes Region using a target egg deposition of 2.4 eggs/m^2 and estimates of fluvial rearing habitat for juvenile Atlantic Salmon within each respective river (O'Connell et al. 1997).

River specific conservation requirements for all 46 rivers known to support or to have historically supported Atlantic Salmon populations in ECB were estimated in Gibson et al. (2014). The conservation requirement is considered to be consistent with a Limit Reference Point in the Precautionary Approach (PA) Framework (DFO 2012b, Gibson and Claytor 2012).

Population monitoring for Atlantic Salmon in ECB has been focused on five major river systems: Middle, Baddeck, North, Grand and Clyburn. Middle, Baddeck, North and Clyburn rivers originate in small headwater lakes in the Cape Breton Highlands and are characterized by relatively steep stream gradients and good water quality (Robichaud-LeBlanc and Amiro 2004, Gibson and Bowlby 2009). Grand River has the lowest mean stream gradient of the five major river systems assessed and its stream flow and water temperatures are influenced by mid-reach lakes (Robichaud-LeBlanc and Amiro 2004). No information on the status of Grand River is available since the recreational fishery closure in 2010, prior to the most recent status update in ECB (Levy and Gibson 2014).

Adult Atlantic Salmon assessments in ECB are based on recreational catches, which are reported through a license-stub return program, as well as fishery-independent counts via dive surveys in Middle, Baddeck, and North rivers. Intermittent data from electrofishing surveys is used where possible. Recently, smolt abundance and return rates were obtained using data from a rotary screw trap operated by the Unama'ki Institute of Natural Resources (UINR) on Middle River. Parks Canada monitors adult abundance in the Clyburn Brook using a similar dive survey approach. The status of adult Atlantic Salmon on Grand River was assessed via fishway counts prior to 2000 and through the use of recreational catch data from 2000-2009. In 2019, 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-and-release angling from October 1st to October 31st, and North River (downstream from the area known as "The Benches") was open to catch-and-release angling from June 1st to July 14th and September 1st to October 31st. Since the widespread fishery closure in 2010, no reliable estimates of Atlantic Salmon abundance are available in other rivers throughout the ECB DU, despite efforts to increase monitoring (Levy and Gibson 2014).

The following sections provide information on status and trends of Atlantic Salmon populations in ECB using data collected up to 2019 (where available), with an emphasis on the adult portion of the population. More detailed information on methods used to collect data and assess status and trends can be found in Gibson and Bowlby (2009).

Table 9 provides the abundance times series for adults on all index rivers and a log-linear regression model fit via least squares was conducted on the adult abundance for the most recent 3-generations in each index river (Table 10).

3.1. MIDDLE RIVER

The conservation requirement for Middle River is 2.07 million eggs (O'Connell et al. 1997). This was calculated based on an estimated 864,600 m^2 of available rearing habitat and a target egg deposition of 2.4 eggs/m^2 (Levy and Gibson 2014). This egg deposition is expected from approximately 470 large and 80 small salmon (O'Connell et al. 1997).

Data available for assessing the status and trends of Atlantic Salmon in Middle River include annual recreational catch estimates from a license stub return program (Table 2), counts of adult salmon made while snorkeling reaches of the river (termed dive counts; Table 11), and intermittent data from electrofishing surveys (Table 12). A detailed summary of the monitoring protocols is provided in Levy and Gibson (2014).

The status of Atlantic Salmon in Middle River is assessed by comparing the estimated egg deposition with the conservation requirement. Egg deposition is estimated using a statistical model that incorporates all of the assessment data series described above. A full description of the model is provided in Appendix 1 of Gibson and Bowlby (2009). A time series showing the maximum likelihood estimates (MLEs) of the number of salmon available to spawn after the recreational fishery (spawning escapement) and the percent of the conservation requirement attained is shown in Figure 2. The egg deposition was estimated to be at 57% of the conservation requirement in 2019, with only one year (2017) estimated to be above the requirement throughout the time series (beginning in 1983). Over the last three generations (17 years) the estimated egg deposition ranged from 22 (2014) to 103 (2017) percent of the conservation requirement and the total population has not changed significantly, but has shown an increasing trend (Table 10).

The Unama'ki Institute of Natural Resources (UINR) began monitoring smolts on Middle River in 2011 using a single trap mark-recapture experiment and smolt population is estimated in 2013–2016 and 2018 using the Adjusted Peterson Estimate (Ricker 1975; Table 13). Return rates for 1SW and 2SW adults were calculated based on the adult returns series. Return rates for 1SW adults were less than 1% of smolts and a maximum return rate of 2.15% for 2SW adults was observed in the four years with available data (Table 13).

3.2. BADDECK RIVER

The conservation requirement for Baddeck River is 2.01 million eggs (O'Connell et al. 1997). This was calculated based on an estimated 836,300 m^2 of available juvenile rearing habitat and a target egg deposition of 2.4 eggs/m^2 (Levy and Gibson 2014). This egg deposition is expected from approximately 450 large and 80 small salmon (O'Connell et al. 1997).

Data available for assessing the status and trends of Atlantic Salmon in Baddeck River include annual recreational catch estimates from a license stub return program (Table 5), counts of adult salmon made while snorkeling reaches of the river (termed dive counts; Table 14), and intermittent data from electrofishing surveys (Table 15). A detailed summary of the monitoring protocols is provided in Levy and Gibson (2014).

The status of Atlantic Salmon in Baddeck River is assessed by comparing the estimated egg deposition with the conservation requirement. Egg deposition is estimated using a statistical model that incorporates all of the assessment data series described above. A full description of the model is provided in Appendix 2 of Gibson and Bowlby (2009). A time series showing the MLE of the number of salmon available to spawn after the recreational fishery (spawning escapement) and the percent of the conservation requirement attained is shown in Figure 3. The egg deposition was estimated to be at 44% of the conservation requirement in 2019, with a low probability that the population has met its conservation requirement since 1983. Over the last three generations (17 years) the estimated egg deposition ranged from 19 (2014) to 70 (2011) percent of the conservation requirement and the total population has not changed significantly (Table 10).

3.3. NORTH RIVER

The conservation requirement for North River is 0.92 million eggs (O'Connell et al. 1997). This was calculated based on an estimated 382,700 m^2 of available spawning habitat and a target egg deposition of 2.4 eggs/m^2. This conservation requirement was first applied in Levy and Gibson (2014) and the explanation of the change is described within. This egg deposition is expected from approximately 215 large and 32 small salmon (O'Connell et al. 1997).

Data available for assessing the status and trends of Atlantic Salmon in North River include annual recreational catch estimates from a license stub return program (Table 7) and counts of adult salmon made during dive surveys (Table 16). Beginning in 2013, dive counts expanded on North River to include further upstream reaches (West Confluence Pool to McLeans Pool) than were surveyed from 2004–2012. The proportion of Atlantic Salmon observed in the added reach ranged from 6–52% of the total adult count. A scaling factor based on the mean observation in the additional reach (23.75%) was applied to all dive counts from 2004–2012. No scaling factor was applied for years prior to 2004, as the extent of the dive count survey is not well documented. Additional data for North River include summer dive counts conducted in 2001 and all years from 2014–2019 (Table 17). Summer dive counts are conducted by counting small and large adult Atlantic Salmon holding in pools throughout the reaches monitored in the fall dive counts. No mark-recapture experiments have been conducted for the summer pool counts, so observation efficiency is not available to provide an estimate of abundance from the summer counts.

It was not possible to assess the North River population using the same analytical methods as Middle and Baddeck rivers (Gibson and Bowlby 2009), so dive count escapement and recreational catch data are presented separately. Dive counts have been conducted in favorable conditions on North River over the past several years and successful dive counts have occurred in six of the last seven years (2013-2019; Table 16). Mark-recapture experiments have also been conducted four of those years and there has been a relatively stable observation efficiency through the time series (mean 0.48 ± 0.03 SE). The dive count estimate is considered the most accurate representation of adult abundance.

Due to challenges associated with completing dive counts in the past (prior to 2013), North River returns were estimated based on recreational catch with a catch rate scaling factor relative to estimated escapement from dive count surveys (DFO 2012a, Levy and Gibson 2014). The catch rate estimate used to scale recreational catch was assessed to include the recent dive count data and was found to be highly variable and unlikely to provide an accurate measure of abundance. In addition, reported recreational catch is closely related to effort and effort is variable (Figure 4). This relationship makes it difficult to interpret the data prior to a large change in fishing effort that occurred following the closure of the retention fishery in 1994, as effort decreased by > 70% and has remained relatively low since. Although precise estimates of abundance are not available from the recreation catch time series, the reported recreational catch in the 1980's is significantly higher than scaled abundance estimates from the most recent 3-generations, suggestive of large declines in total abundance since the 1980s.

Using the dive count data available, the 2019 egg deposition was estimated at 96% of the conservation egg requirement, and has been equal to or greater than 100% in three (2013, 2016, 2017) of the nine years sampled in the last 3-generations (2003–2019; Figure 5). The minimum egg deposition in the last 3-generations was recorded in 2014 at 36% of the conservation egg requirement. The recent abundance estimates (maximum of 116% of the conservation egg requirement) are a decline from abundance estimates observed in the 1990s, which had egg deposition estimates that ranged from 121–262% of the conservation requirement. Over the last 3-generations (16 years; 2003–2019), no significant change to the estimated escapement was observed (Table 10). With the exception of 2014, abundance estimates based on dive counts from the most recent years (2013–2019) have been at or near the conservation egg requirement.

3.4. GRAND RIVER

The conservation requirement for Grand River is 1.1 million eggs (O'Connell et al. 1997). This was calculated based on an estimated 461,800 m^2 of available rearing habitat and a target egg deposition of 2.4 eggs/m^2. This egg deposition is expected from a total of approximately 545 large and small salmon combined (O'Connell et al. 1997).

No new data is available for Grand River since the recreational fishery closure in 2010, prior to the previous status update (Table 18 reproduced from Levy and Gibson 2014). Data available for assessing the status of Atlantic Salmon in Grand River included recreational catch estimates until 2009 from the Atlantic Salmon license stub return program and counts of adult salmon ascending the fishway located at Grand River Falls until 1999 (Table 19 reproduced from Levy and Gibson 2014). Grand River has not met the conservation requirement upriver of the fishway since 1998, and the wild component of the stock has not met the conservation requirement since 1990 (Figure 6; Robichaud-Leblanc and Amiro 2004). When last assessed, Grand River Atlantic Salmon were well below the conservation requirement and had a decline 97% over the last 15 years (1994–2009, approximately 3-generations) of the time series (Levy and Gibson 2014; Table 10).

3.5. CLYBURN RIVER (BROOK)

The conservation requirement for Clyburn Brook is 0.28 million eggs (O'Connell et al. 1997). This was calculated based on an estimated 116,500 m^2 of available rearing habitat and a target egg deposition of 2.4 eggs/m^2. This egg deposition is expected from approximately 10 small and 65 large salmon (O'Connell et al. 1997).

Parks Canada has conducted annual dive surveys on Clyburn Brook from 1985 to 2019, with the exception of four years (1991, 1993, 1996, 2015). Counts of large and small salmon are recorded separately (Table 8). In some years, only the lower section of the river was surveyed. The observation efficiency of the dive counts is not known, but the time series provides a relatively consistent index of abundance. Counts in Clyburn Brook were highest in 1987 with a total count of 175 salmon (Table 8 and Figure 7), but total counts have only exceeded 20 salmon twice in the last 20 years (2001 and 2003). Significant declines were estimated in 2011 at 95% and 89% for 20 year (1991–2011) and 15 year (1996–2011) time periods, respectively (Levy and Gibson 2014). Surveyed numbers have remained low since the last update and declines were observed of 74% in the most recent 20 years (1999-2019) and 56% in the most recent 15 years (2004–2019; Table 10). The decrease in the updated decline rates in comparison to the decline rates reported in Levy and Gibson 2014 are not indicative of recovery, but are a result of the high abundance estimates in the 1990s no longer falling within the most recent 15 and 20 year time periods.

3.6. OTHER RIVERS

There is very little information available on other rivers in the ECB DU. Prior to 2010, recreational catch and effort data from the Atlantic Salmon recreational fishery's license stub return program was available for 31 rivers in ECB (Appendix 5 in Levy and Gibson 2014). An analysis of these data indicated that recreational catch and effort was greater in the 1980's and 1990's, and recreational catches declined by more than 75% from the 5-year mean from 1983–1987 to the most recent 5-year time period with data available (2005–2009) in all but four rivers (Baddeck, Middle, North, and North Aspy; Levy and Gibson 2014). North Aspy River was subsequently closed to recreational angling in 2013. At the time of the recreational fishery closure on all other rivers (2010), little to no fishing effort was reported on most rivers in SFA 19, suggesting that fishing effort contracted down to the few rivers within the SFA that contain an appreciable number of Atlantic salmon (Gibson and Bowlby 2009). Similarly, the year prior to the widespread angling closures, 98.3% of the 2009 recreational fishing effort and 98.6% of the recreational catch in SFA 19 occurred on Baddeck, Middle and North rivers (Levy and Gibson 2014). This shift in angling effort prior to closures also suggests abundance was low on other rivers, and anglers were switching to rivers with higher abundance (Levy and Gibson 2014).

3.7. SOURCES OF UNCERTAINTY

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.

Distribution of Atlantic Salmon within rivers is dependent on environmental factors (water level, flow, temperature) that vary temporally and are likely to impact occupancy. The consistency of dive count surveys can be impacted by these changes to occupancy. Similarly, angling success can be variable through time based on the distribution of Atlantic Salmon within the river.

Due to the limited number of populations assessed in ECB and inconsistent trends among populations where data exist, evaluating the status of Atlantic Salmon throughout the DU should be done cautiously. Recreational fishing effort was distributed over many rivers in the past, but prior to the widespread fishery closure catch and effort contracted to primarily the North, Baddeck, and Middle rivers suggesting abundance has declined throughout the DU, particularly for non-monitored populations.

4. TRENDS IN DISTRIBUTION

Limited data is available relating to the distribution of Atlantic Salmon in ECB. Recreational catch and effort estimates from the Atlantic Salmon recreational fishery's license stub return program are available prior to 2010 for 31 rivers in ECB (Appendix 5 in Levy and Gibson 2014). Catch and effort declined significantly from the 1980's and early 1990's (Gibson and Bowlby 2009), however, 20 of the rivers had catch reported since 2000.

Electrofishing surveys have been conducted to estimate juvenile densities with relatively limited spatial coverage in ECB. Levy and Gibson (2014) examined the results of previous electrofishing surveys from 2006–2007 (reported in Gibson and Bowlby 2009) and 1998–2002 (reported in Robichaud-Leblanc and Amiro 2004). Levy and Gibson (2014) summarized that at least one juvenile life stage (i.e., fry and/or parr) was captured from every river surveyed in ECB since 1996, however, abundance was generally low relative to reference values reported by Elson (1967).

The most recent electrofishing survey was conducted by DFO and UINR in 2016. The methods used in the 2016 electrofishing survey follow the protocols used in the 2006–2007 regional survey (Gibson and Bowlby 2009) as described by Chaput et al. (2005). All species captured were identified and measured for fork length (mm) and weight (grams). The total catch of Atlantic Salmon was summarized by age 0 (fry), and parr ages 1–3 at each site through scale aging. Juvenile density (number of fish per 100 m^2 of habitat area) was calculated using the catch-per-unit-effort (CPUE) method described by Chaput et al. (2005) for single-pass electrofishing at open sites, as was used by Gibson and Bowlby (2009).

During the 2016 electrofishing survey, 31 sites were fished on 11 rivers and Atlantic Salmon fry and/or parr were present at all sites (Table 20). Fry and parr densities were low relative to the indices of normal abundance (Elson 1967) of 29 fry per 100m^2 and 38 parr (age 1 and older combined) per 100m^2 at most sites sampled (Table 20). Only sites sampled on the Baddeck River, Indian Brook, and River Denys had fry densities above 29 fry per 100m^2 and sites on the Baddeck River, Skye River, and River Denys had parr (age 1 and 2 combined) densities greater than 38 parr per 100m^2 (Table 20). However, some rivers with fry and parr abundances above indices of normal abundance (Elson 1967) in the 2006 and 2007 survey were not revisited in 2016 (e.g., Middle, North, North Aspy River). Parr age 3 were only observed on the Grand River, River Tillard, River Denys, and Sydney River at low densities (maximum of nine fish per 100m^2; Table 20). Only three rivers had sites repeated in 2016 that were sampled in 2006 or 2007: Grand River (Grand003), Indian Brook (Ind001), River Denys (DEN001, DEN2002).

Parks Canada has conducted additional electrofishing on rivers in ECB that can provide information on distribution for rivers that DFO does not have data.

5. ESTIMATES OF TOTAL POPULATION SIZE

Sufficient data collection to estimate recent adult abundance in ECB exists for only four rivers. Only broad inferences about relative abundance based on historical recreational angling data can be suggested and changes to populations are not currently monitored through most of the DU. An estimate of the total population size for the DU is not available.

6. HABITAT CHARACTERISTICS

Seven ecodistricts were identified within the ECB DU (Levy and Gibson 2014) and extensive descriptions of the functional properties of Atlantic Salmon habitat, the spatial extent of areas in ECB having these properties, and the identified threats to habitat are available (Levy and Gibson 2014, Gibson et al. 2014). The DU contains at least 46 watersheds that are thought to support or have supported Atlantic Salmon (DFO 2014, Gibson et al. 2014; Figure 1). In addition, it is likely that salmon used or would have used a number of smaller or unassessed watersheds draining into the Atlantic Coast or to the Bras d'Or Lakes in ECB (Gibson et al. 2014). Rivers in ECB are generally considered to have better water quality and to be less impacted by human activities than other rivers along Nova Scotia's Atlantic coast (Amiro et al. 2006). Rivers that originate in the Cape Breton Highlands typically have steep stream gradients and relatively good water quality (Gibson and Bowlby 2009, Davis and Browne 1996) and are typically small, short rivers with few lakes in the upper reaches (Gibson et al. 2014). Rivers to the east of the Bras d'Or Lakes typically have a lower mean stream gradient, lower seasonal water flow and temperatures that are moderated by mid-reach lakes (Robichaud-LeBlanc and Amiro 2004).

Combining information from all 46 watersheds in ECB, there is an estimated 4,545 km^2 of drainage area containing an estimated 17,942,900 m^2 of rearing area for Atlantic Salmon (Gibson et al. 2014). More than half of the productive area for salmon (10,647,500 m^2) in the DU is found in the Mira, Inhabitants, Middle, Baddeck, and Framboise watersheds and 17 of the 46 watersheds have an estimated rearing area less than 100,000 m^2 (Gibson et al. 2014).

7. THREATS

In 2014, a Recovery Potential Assessment was performed for the ECB DU by Gibson et al. (2014) and provided a systematic review on current threats and their effect, or potential effect, on ECB populations. The following section summarizes and updates the threats from Gibson et al. (2014), however, the extent, occurrence, severity, causal certainty and level of concern assigned to each threat (Table A1 and A2) are based on the original assessment by Gibson et al. (2014). Threats have also been organized into International Union for Conservation of Nature (IUCN) Threat Calculator Categories and discussed in terms of their effects in freshwater and/or marine environments. Within the freshwater environment, threats assigned as a medium level of concern were: Altered hydrology, silt and sedimentation, non-native fish species, stocking for fisheries enhancement (Atlantic Salmon – using traditional methods), other salmonid stocking [Rainbow Trout (*Oncorhynchus mykiss*) – including the Bras d'Or Lakes, Brown Trout (*Salmo trutta*), and Brook Trout (*Salvelinus fontinalis*)], changes in predator/prey abundances, genetic effects of small population sizes, culverts, infrastructure, forestry and illegal targeting of salmon during recreational fishing (Table A1). Only illegal fishing/poaching of salmon was deemed a high level of concern in the freshwater environment. Within the estuary/marine environment, threats assigned a high level of concern were: salmonid aquaculture, marine ecosystem change, and disease and parasites (Table A2).

7.1. RESIDENTIAL AND COMMERCIAL DEVELOPMENT

7.1.1. Housing and Urban Areas

As of 2014, of the 46 watersheds that contain Atlantic Salmon, areas classified as urban accounted for < 1% (27 watersheds) and < 5% (2 watersheds) of total area (Gibson et al. 2014). However, Gibson et al. (2014) notes that these are likely underestimates as the land use data resolution was not sufficient to identify small cabins or cleared area, and furthermore, urban development has likely increased over the past six years since the last threat assessment in 2014. In 2014, this threat was assessed as a low level of concern (Gibson et al. 2014; Table A1).

7.1.2. Commercial and Industrial Areas

Only one watershed had > 5% of its area classified as industrial and 30 watersheds had < 1% in 2014 (Gibson et al. 2014).

7.1.3. Tourism and Recreation

No DFO data available.

7.2. AGRICULTURE AND AQUACULTURE

7.2.1. Annual & Perennial Non-Timber Crops

Overall, agriculture is low with 29 watersheds having < 1% of their area classified as agricultural (Gibson et al. 2014). Agricultural activity is mostly concentrated in three watersheds (Aconi Brook, McKinnons Brook and Skye River) where agricultural land use is between 6.07% and 10.56% of the total area (Gibson et al. 2014). In 2014, this threat was assessed as a low level of concern (Gibson et al. 2014; Table A1).

7.2.2. Livestock Farming and Ranching

No DFO data available.

7.2.3. Marine & Freshwater Aquaculture

Aquaculture within the ECB DU is more centered towards other salmonids and bivalves than Atlantic Salmon. In 2014, there were nine finfish leases within ECB licensed to grow Rainbow Trout, with eight of these also licensed for Atlantic Salmon, however, none were farming Atlantic Salmon (Gibson et al. 2014). Since the aquaculture threat was assessed in 2014 by Gibson et al. (2014), the aquaculture industry has only marginally grown. There are currently nine marine finfish leases within the ECB DU, with eight of these also licensed to grow out Atlantic Salmon and other finfish and one licensed to grow out only Rainbow Trout (experimental license). There is also an additional three proposed sites licensed to grow out Rainbow Trout with one being an apparent expansion of a currently active lease (Figure 8). Between 2010 and 2019, there have been two reported large scale escape events of Rainbow Trout within the ECB DU; estimated at less than 600 fish in 2017 and 29,000 fish in 2018. Within NS, there were an additional five escape events of Rainbow Trout in 2019 with two of these events consisting of 20 fish or less and the amount of escapees in the other three events have yet to be determined. Trout aquaculture production within Nova Scotia is much smaller in comparison to salmon, however, the majority of trout aquaculture sites occur within the ECB DU. Average trout aquaculture production for Nova Scotia between 2015 and 2019 was 412.8 tonnes and has substantially grown over the last decade (Figure 9). Since the aquaculture industry is less centered towards

Atlantic Salmon within the DU, negative effects are currently more likely to stem from habitat alterations, competition and predation, or disease/parasite transfer instead of genetic introgression. In 2014, aquaculture was assessed as a low to high level of concern depending on the environment it was taking place in (freshwater or marine) and the type of aquaculture/threat occurring (Table A1 and A2).

Although the negative effects of genetic introgression within the DU is considered minimal, escape events from other DUs, or should the industry resume Atlantic Salmon culture, the small population sizes within ECB could be significantly impacted (DFO 2014). In the past, significant amounts of aquaculture Atlantic Salmon escapes have been found within the rivers and bays of the ECB DU. Between 1994 and 2003, Morris et al. (2008) found that approximately 12.5% (580 of 4,624) of salmon sampled within four rivers and two bays were of aquaculture origin. Aquaculture salmon were also detected in the Bras d'Or Lakes but not counted.

Finfish aquaculture within the DU is predominantly focused towards Rainbow Trout. It was estimated that between 1974 and 1983 close to one million aquaculture Rainbow Trout have escaped into the lakes (Hurley Fisheries Consulting 1989). Rainbow Trout can outcompete Atlantic Salmon juveniles (Houde et al. 2017, Van Zwol et al. 2012) and Atlantic Salmon will alter behaviour in the presence of Rainbow Trout (Blanchet et al. 2006) which could increase likelihood of predation (Bowlby et al. 2014). However, the negative effects of aquaculture Rainbow Trout on wild Atlantic Salmon populations within the ECB DU are not thoroughly understood (Gibson et al. 2014). In 2014, salmonid aquaculture was considered a low and high level of concern within the freshwater and marine environment, respectively (Gibson et al. 2014; Table A1).

Bivalve aquaculture is much more prevalent throughout the DU in comparison to salmonids. The highest concentrations are within the estuaries of the North, Aspy, Denys and Middle Rivers (Gibson et al. 2014) and thus have the potential to negatively impact these populations. The potential negative effects of bivalve aquaculture pertain to habitat alterations and culminate in three ways; 1) material processes (filtering food and producing waste), 2) physical structure (anchoring physical structures for bivalve culture, and 3) pulse disturbances (harvesting and maintenance which can disturb the ecosystem community and environment) (Dumbauld et al. 2009). However, the causal certainty on the effects of bivalve aquaculture on Atlantic Salmon populations is low in general and low for the ECB DU. In 2014, other species aquaculture was considered a low level of concern (Gibson et al. 2014; Table A2).

7.3. ENERGY PRODUCTION AND MINING

7.3.1. Oil & Gas Drilling

No DFO data available.

7.3.2. Mining & Quarrying

Only abandoned mines were used in the review by Gibson et al. (2014). Of the 1,026 abandon mine openings used within the review, 892 were historic coal mines, predominantly within the southeast portion of the DU and did not occur within the watersheds within the review. Of the reviewed watersheds, the Mira Watershed, MacAskill Brook and Middle River had the highest amount of mine openings (Gibson et al. 2014). The vast majority of Middle River mines were abandoned gold mines (Gibson et al. 2014) which have the potential to cause skeletal deformities from increased metal concentrations (Silverstone and Hammell 2002). In 2014, mining was considered a low level of concern (Gibson et al. 2014; Table A1).

7.4. TRANSPORTATION AND SERVICE CORRIDORS

7.4.1. Roads and Railroads

Culverts were not assessed directly, and instead, road crossing network data was combined with flow data as a proxy for culverts (see Gibson et al. 2014). To enable between river comparisons, densities of road crossings per 10 km lengths of river were used. The mean and medium density of culverts was 2.8/10 km. McKinnons Brook had the highest density of culverts with 7.5/10 km along with several small watersheds having densities above 5/10 km (Gibson et al. 2014). Nine watersheds had road crossing densities below 1/10 km. Not surprisingly, the highest densities occurred in watersheds within more populated areas and where significant amounts of forestry and agriculture were occurring. In 2014, culverts were considered a medium level of concern (Gibson et al. 2014; Table A1). Gibson et al. (2014) also notes that there is a significant amount of more unpaved versus paved roads which have the potential to increase sedimentation and the rivers most likely affected by this are Indian Brook, Victoria County, Middle River and Framboise River. Road infrastructure was considered a medium level of concern in 2014 (Gibson et al. 2014; Table A1).

7.4.2. Utility and Service Lines

No DFO data available.

7.4.3. Shipping Lanes

Shipping vessel noise is thought to cause an avoidance behaviour in Atlantic Salmon and other species and has the potential to alter distributions and the ecology of near shore habitats (Bowlby et al. 2014). Ship traffic is heaviest exiting the Gulf of St Lawrence through the Cabot Strait and moving eastward along the southern coast of Newfoundland, and thus, has the potential to negatively impact immature and adult Atlantic Salmon within the ECB DU (Gibson et al. 2014). However, the impacts of shipping traffic on Atlantic Salmon is low in general and low for the ECB DU and was assigned a low level of concern in 2014 (Gibson et al. 2014; Table A1).

7.5. BIOLOGICAL RESOURCE USE

7.5.1. Logging & Wood Harvest

In comparison to agriculture, forestry activities encompass a much greater area for the majority of watersheds within ECB. Sixteen of the 46 rivers have between 10% and 30% of their area used for forestry practices (Gibson et al. 2014). Twenty rivers have between 5% and 10% of their area used for forestry. The remaining ten watersheds are within the boundaries of national parks and are therefore protected from forestry activities (Gibson et al. 2014). In 2014, forestry was assigned a medium level of concern (Table A1) but Gibson et al. (2014) notes that the data presented above is from a survey completed in 1995 and there is potential for substantial changes in land use that could have occurred in the proceeding 19 years since the threat was assessed.

7.5.2. Fishing & Harvesting Aquatic Resources

In 2011, there were three sources of directed Atlantic Salmon fisheries taking place in Canada; First nations food, social and ceremonial fisheries, residents of Labrador fishery and recreational fishermen (ICES 2012). Commercial fisheries for Atlantic Salmon within Canada have been closed since 2000 (ICES 2012). The following retention statistics from Gibson et al. (2014) are aggregates from both marine and freshwater fisheries. In 2014, Gibson et al. (2014)

assessed a low, low and high level of concern for Indigenous, recreational and illegal fisheries, respectively, in freshwater and a low, medium and low level of concern for subsistence (Labrador residents and Indigenous fisheries), international and local fisheries, respectively, in the estuary/marine environment (Table A1 and A2).

7.5.2.1. Indigenous and Labrador Residents Food Fishery

In 2010, three First Nations groups participated in the Labrador food fishery (Gibson et al. 2014) using gill nets within estuaries and bays (ICES 2012) and accounted for the majority of catches from all Indigenous fisheries (Bowlby et al. 2014). Reported catch statistics by these groups are thought to be over 85% (DFO and MRNF 2009). In 2010 and 2011, total harvest of all Indigenous fisheries was estimated at 59.3 and 70.4 metric tonnes, respectively (ICES 2012). Since 2011, total harvest has ranged between 52.5 t and 64.0 t with 54.0 t in 2019. As it is estimated that 95% of this harvest is from salmon destined for Labrador rivers, due to the fishery predominantly occurring in local river estuaries (ICES 2011), this fishery is expected to have little effect on ECB populations.

Non-First Nations residents within Labrador also participate in the food fishery with the same gear and reporting requirements (Gibson et al. 2014). In 2011, the estimated catch was 2.1 t with 37% of this catch consisting of large salmon (ICES 2012). Since 2011, the harvest has decreased to 1.6 t with 47% of the harvest comprising of large salmon in 2019 (ICES 2020). To minimize the amount of Atlantic Salmon intercepted from non-local populations, 95% of the fishery takes place within rivers and estuaries (ICES 2011) and therefore is expected to have minimal impact on ECB DU populations (Gibson et al. 2014).

7.5.2.2. Food, Social and Ceremonial Fisheries (within ECB DU)

Licenses are issued to individual groups for specific rivers that stipulate limits, gear and seasons for the Food, Social and Ceremonial fishery (Gibson et al. 2014). Restrictions have been imposed to limit the impact by regulating the size of salmon allowed to be harvested or forgone completely (Gibson et al. 2014). Historically, it was estimated that Indigenous salmon harvest was minimal in comparison to recreational fisheries (Gibson et al. 2014).

7.5.2.3. International Fisheries

France has a limited marine gillnet fishery off the island of St. Pierre et Miquelon near the southwestern coast of Newfoundland. In 2011, there were nine professional (three gillnets, each 360 m long) and 56 recreational (one gillnet of 180 m) licenses issued with a total harvest of 3.8 t (ICES 2012, Gibson et al. 2014). Genetic analyses indicated that approximately 96–98% of the harvest was of Canadian origin Atlantic Salmon. More recently, the amount of professional licenses issued is similar to 2011 with seven being issued in 2019, however, the amount of recreational licenses has steadily increased to 80 in 2019 (ICES 2020). Since 2011, the highest harvest amount occurred in 2013 at 5.3 t but has since decreased to 1.29 t in 2019 (ICES 2020). In 2017, 2018 and 2019, it was estimated that 1.6%, 0.1% and 0% of fish harvested were from Eastern Nova Scotia populations, respectively (ICES 2019, ICES 2020). Based on the proximity of the fishery and ECB population distribution patterns, it is likely to have a negative impact on ECB Populations (Gibson et al. 2014).

In 2010, the Greenland fishery factory landings was set at 0 t and only catches to be used for internal consumption were allowed (ICES 2019). The fishery is allowed to capture salmon via gillnets, driftnets and angling in six divisions along west Greenland and one division in east Greenland (Gibson et al. 2014). In 2010, total harvest was 40 t (ICES 2019). Compared to 2009, this represented an increase of 53% (Gibson et al. 2014). From 2012 to 2014, there was a decision to allow factory landings with a 30 t to 35 t quota which did not include commercial or private catches (ICES 2019). In 2015, a 45 t quota was set that included catches from all three sources (ICES 2019). Comparing seven years where factory landings have been allowed (2012-2018) to seven years where factory landings were set to 0 t (2005-2011), total harvest has increased to 290 t (2012–2018) from 182 t (2005–2011) marking a 59% increase. In 2019, it was estimated that approximately 29.8 t were landed with 0.4% (95% CI= 0.1%–0.9%) of total harvest in west Greenland being from Eastern Nova Scotia populations (ICES 2020) and thus it is likely that populations within the ECB DU are being negatively affected by the Greenland fishery.

7.5.2.4. Local Commercial Fisheries

Local commercial fisheries have a small ability to impact ECB populations as all commercial fisheries for Atlantic Salmon within Canada have been closed. Only coastal fisheries have potential to impact populations, however, due to the lack of data on tag returns it is difficult to estimate the amount of loss (Gibson et al. 2014).

7.5.2.5. Recreational Fishery

Recreational fishing for Atlantic Salmon has been shown to negatively impact Atlantic Salmon populations through direct mortality or reduced spawning success (DFO 2011). To reduce the impacts of recreational fisheries, multiple measurements have been put in place. In 1984, a mandatory release of large salmon (fork length of 63 cm or greater) and stub reporting system was implemented to better record catch data (O'Neil et al. 1987) and by 1998 mandatory release was extended for small salmon (fork length less than 63 cm). In 2010, all rivers within the ECB DU were closed to recreational fishing except for the Baddeck, North, Middle and North Aspy rivers (DFO 2012a). Following this closure, Gibson et al. (2014) notes that angling pressure in the closed rivers dropped dramatically and within the remaining open rivers, angling pressure remained relatively similar to before the closures. Since 2013, the North Aspy River has also been closed to recreational fishing, leaving only the Middle, Baddeck and North rivers open.

Although the majority of the ECB DU rivers have been closed to recreational Atlantic Salmon angling, there is still the potential for Atlantic Salmon within these closed rivers to be angled as bycatch while targeting other species. However, when using appropriate measures (using proper gear and tackle and targeting specific habitat types for specific species), recreational fishing is unlikely to result in the capture of adult Atlantic Salmon (Gibson et al. 2014). Atlantic Salmon juveniles are more likely to be captured when fishing for Brook Trout but bycatch is still assumed to be low, and given the abundance of this life stage, population level effects are likely minimal (Gibson et al. 2014). Mortality from hook and release angling for parr and smolt is poorly understood but has been shown to have negative effects on stress and survival in adult salmon. However, there have been multiple measures put in place to avoid bycatch and reduce stress on adult salmon by restricting fishing seasons and gear types used (DFO and MRNF 2009) and enforcing warm water protocols to close angling during high water temperatures.

There is also the potential for anglers to specifically target Atlantic Salmon within closed rivers under the guise of fishing for other species. There has been recent concern of fishing within closed river using Atlantic Salmon specific gear/flies and fishing pools known to hold Atlantic Salmon (DFO 2011). In other DUs, such as the SU DU, orders have been put in place to prohibit all angling within salmon pools but no such measurements have been put in place for the ECB DU (Gibson et al. 2014).

7.5.2.6. Illegal Fisheries

Quantifying the effects of poaching is difficult as the majority of reports on illegal fishing are anecdotal but there have been reports of poaching in ECB involving gillnets and recreational fishing gear (Gibson et al. 2014). As monitored ECB population sizes have been consistently below conservation requirement, any removal of adults from the population could have significant impacts.

7.5.2.7. Bycatch in Other Fisheries

There has not been any reported bycatch in freshwater Indigenous fisheries for other species and to limit incidental catches, fishing gears and seasons have been modified (DFO and MRNF 2009), therefore, it is thought to have extremely low impact on ECB populations (Bowlby et al. 2014). There has also been no reported bycatch in marine Indigenous fisheries except within Labrador, however, the likelihood of these fisheries capturing ECB salmon is low (Gibson et al. 2014) as 93% of Canadian salmon fisheries take place in rivers or estuaries (ICES 2020).

Retention of salmon bycatch in other fisheries is not permitted and although there are few estimates on the number of discards, the amount of bycatch is other fisheries is considered low (ICES 2020). A study by Reddin et al. (2002) estimated that bycatch within Newfoundland mackerel and herring bait fisheries was 0.3% of the catch. It is thought that the amount of ECB salmon caught as bycatch within other fisheries is low (Gibson et al. 2014).

There are concerns about unreported bycatch in offshore fisheries which operate outside regulatory monitoring systems (Gibson et al. 2014). Distribution of immature salmon, mackerel and herring do overlap, and it is possible that salmon could be an undetected component of these fisheries, however, no data exists to support these hypotheses (Gibson et al. 2014, DFO and MRNF 2009).

7.6. HUMAN INTRUSIONS AND DISTURBANCES

7.6.1. Recreational Activities

Mortality associated with scientific activities is thought to be low as activities attempt to minimize handling and stress as much as possible (DFO and MRNF 2009). Typical scientific activities within the ECB DU involve passive non-intrusive methods, although electrofishing has been carried out in the past (Gibson et al. 2014).

7.7. NATURAL SYSTEMS MODIFICATIONS

7.7.1. Fire & Fire Suppression

No DFO data available.

7.7.2. Dam & Water Management/use

When the last assessment of hydro power generation was completed by Gibson et al. (2014) there was only one major hydroelectric facility in operation. The facility included 14 dams/spillways and included water diversions in the Cheticamp and Ingonish rivers, Indian Brook and Wreck Cove Brook (Gibson et al. 2014). Gibson et al. (2014) noted that there did not appear to be any fish passage provided by the facilities but the majority of the dams were upstream of natural and impassable barriers for salmon except within Wreck Cove Brook. In terms of other physical barriers, only five of 20 barriers were considered to be passable by fish, however, only the Grand Lake dam in Northwest Brook and the Sydney River dam had significant impact on habitat availability (decreased available habitat by > 25%; Gibson et al. 2014). Gibson et al. (2014) also identified reservoirs and determined only nine of the 46 watersheds within the DU were affected. The most affected watershed was Indian Brook which had approximately 9.2 km^2 of reservoir, however the median affected area within the nine watersheds was only 0.97 km^2 (Gibson et al. 2014). Hydropower and other dams and reservoirs are all considered a low level of concern (Gibson et al. 2014; Table A1).

7.7.3. Other Ecosystem Modifications

No DFO data available.

7.8. NEGATIVE INTERACTIONS WITH OTHER SPECIES AND GENETIC INTERACTIONS

7.8.1. Invasive Non-Native/Alien Species

Invasive fish species found within the freshwater of ECB include Rainbow Trout, Brown Trout, Chain Pickerel (*Esox niger*), and Smallmouth Bass (*Micropterus dolomieu*). Smallmouth bass and chain pickerel distribution through the DU is limited, however, both species may have negative impacts on the Atlantic Salmon population (Gibson et al. 2014). As of 2014, both smallmouth bass and chain pickerel were only found within the Sydney River watershed (Gibson et al. 2014), thus their impact on Atlantic Salmon populations would be limited to this watershed. The effects of Brown Trout and Rainbow Trout are discussed below in the "Other salmonid stocking" section. Non-native fish species have a medium level of concern within ECB (Gibson et al. 2014; Table A1). Another non-fish non-native species found within the freshwater of the DU is the Spinycheek Crayfish (*Faxonius limosus*). This species was discovered in Freshwater Lake, and given its proximity to the Ingonish River estuary, has the potential to invade into the river (Gibson et al. 2014), alter the habitat, and prey upon salmonid eggs and juveniles (Reynolds 2011). However this threat is assessed as a low level of concern (Table A1).

Within the estuary and marine environments of the ECB DU, the Green Crab (*Carcinus maenus*), invasive tunicates (*Ciona intestinalis*, *Botrylloides violaceus*, and *Botryllus schlosseri*), Brown Algae (*Fucus serratus*) and Red Algae (*Neosiphonia harveyi*) have been found throughout the coast and within the Bras d'Or Lakes, and therefore, have the potential to alter marine habitats of ECB Atlantic Salmon (Gibson et al. 2014). However, this has not yet been linked to Atlantic Salmon (Bowlby et al. 2014). It is not expected that these species would directly affect Atlantic Salmon and their ability to indirectly impact ECB populations is not well understood and is considered a low level of concern (Gibson et al. 2014; Table A2).

7.8.2. Negative Interactions with Other Species

7.8.2.1. Diseases and Parasites

Due to an increased vulnerability, diseases and parasites are hypothesized to have greater effects on immature salmon survival to maturity as opposed to altering Adult spawning success (Harris et al. 2011). However, there is little information on disease and parasites in marine phases of Atlantic Salmon (Bowlby et al. 2014). Bacterial kidney disease has had considerable attention within the ECB DU in the past (1970s and 1980s) and has been detected within the North River (Amiro and Marshall 1990), Middle and Baddeck rivers, and St. Anns Bay (Paterson et al. 1979) with prevalence within samples ranging from 5.7% to 57.7% (Gibson et al. 2014). However, there have been no recent surveys of bacterial kidney disease within ECB, but if prevalence is still high and causing increased smolt mortality, the disease could be negatively affecting ECB populations.

Federally reportable diseases are reported for each year for each province. From 2015 to 2019, there were 79 total cases of Infectious salmon anaemia reported in NB (all strains= 55; disease strains= 18), NS (all strains= 5; disease strains= 2) and Newfoundland (all strains= 19; disease strains= 10). Infectious pancreatic necrosis was also reported in other finfish species (Brook Trout, Rainbow Trout and Arctic Char [*Salvelinus alpinus*]) from 2015 to 2019 with a total of 12 occurrences in NB (n= 3), NS (n= 7) and QC (n= 2).

Sea lice infestations have numerous negative effects on salmonids including reduced swimming performance, growth, immunity, and reproductive rates and can cause acute mortality (Finstad et al. 2011). It is generally accepted that Atlantic Salmon aquaculture net pens increases the likelihood of wild salmon becoming infested with sea lice. However, given the lower amounts of salmon aquaculture activity within the DU, the impact of sea lice on ECB populations is likely minimal (Gibson et al. 2014). As the aquaculture industry is similar in 2019 as it was when the original threat assessment was performed, this threat has likely not increased.

7.8.2.2. Predator and Prey Species

The quality and quantity of invertebrate prey within the freshwater ecosystem directly influences habitat quality, and land-use practices can have significant negative effects on the abundance of aquatic invertebrates (Quinn et al. 1997). There has not been any adverse effects of land-use practices on invertebrates presented within the ECB DU (Gibson et al. 2014).

Predators with the highest impact on Atlantic Salmon within the freshwater are likely avian predators and piscivorous fish (Gibson et al. 2014). Given Smallmouth Bass and Chain Pickerel are limited to the Sydney River watershed, their effects are localized. However, trout species are stocked and widely distributed throughout the DU, and their impact is limited to smaller/immature life stages (Gibson et al. 2014). Cormorant, merganser and kingfisher species have all been identified as predators of Atlantic Salmon within Nova Scotia (White 1936, Milton et al. 1995). However, avian predators are not widely surveyed in the ECB DU (Gibson et al. 2014). Predation by trout is likely offset via compensatory mechanisms (Gibson et al. 2014) due to the majority of predation occurring at early life stages when density-dependent survival would be simultaneously occurring. Avian predators and larger trout predation within the estuary may have a multiplicative effect due to reduced density-dependent effects during later life stages (Gibson et al. 2014).

7.8.2.3. Stocked Salmonids

The Nova Scotia Department of Fisheries and Aquaculture stocks Brook Trout, Brown Trout and Rainbow Trout each year in the ECB DU. Brown Trout are stocked in the fall while Brook Trout and Rainbow Trout are stocked in spring and fall. In 2011, Brown Trout were stocked in five locations throughout three watersheds, Rainbow Trout were stocked in ten locations within four watershed and the Bras d'Or Lakes, and Brook Trout were stocked into 46 locations within 12 watersheds (Gibson et al. 2014). Brown Trout releases only took place within watersheds where they have been established and consisted of adults and young-of-the-year, while Rainbow Trout releases have consisted of adults only and deployed techniques (all female or triploid releases) to reduce establishment into new areas. However, the use of Rainbow Trout management strategies have discontinued (Gibson et al. 2014). Brook Trout releases consist of multiple life stages and both sexes (Gibson et al. 2014).

Rainbow Trout have established themselves within the Bras d'Or lakes system with successful spawning occurring in the Skye and Baddeck watersheds (R. Madden, Fisheries Technician, NSDFA, pers. comm.). Scale analyses from adult recreational catches in 2008–2009 within the Bras d'Or Lakes also revealed that 71% and 29% of angled Rainbow Trout were of hatchery and wild (naturalized) origin, respectively (Madden et al. 2010, Gibson et al. 2014).

Trout stocking has the potential to impact Atlantic Salmon populations within the ECB DU through juvenile competition and predation alongside disease transfer between hatchery and wild fish, although no evidence of disease transfer has been documented within the ECB DU

(Gibson et al. 2014). In 2014, Trout stocking was considered a medium threat to ECB populations (Gibson et al. 2014) and since the stocking program has been similar in recent years, this level of threat is likely similar currently. Brown and Rainbow Trout are currently stocked in four and six locations, respectively.

7.8.3. Introduced Genetic Material

7.8.3.1. Traditional Stocking Methods

In the 1980s, the ECB DU received considerable stocking interventions throughout, however, the programs have since been terminated except for a few small operations and an enhancement program within the Middle and Baddeck rivers that use the release of reared parr and smolts from the capture of wild pre-spawn adults (Gibson et al. 2014). The goal of this program was to offset mortality from recreational angling (Levy and Gibson 2014). Ongoing genetic effects from traditional stocking programs are considered a medium level of concern (Gibson et al. 2014; Table A1).

Gibson et al. (2014) summarizes historical stocking (numbers released, life stage and broodstock origin) by decade between 1979 to 2012 and note that given the numbers of years a river was stocked within a given decade, total numbers stocked per decade are not directly comparable. Between 1979 and 2012, a total of 907,424 Atlantic Salmon were stocked in ECB rivers with 78.2% being stocked into the Grand River (32.3%), the Middle River (21.3%), Indian Brook (13.6%) and the Mira River (11.0%) (Gibson et al. 2014). Other rivers stocked included the North River, Baddeck River and River Inhabitants. Within each decade, total numbers stocked into all rivers were 9,458 salmon during the 1970s, 291,438 during the 1980s, 495,754 during the 1990s, 37,074 during the 2000s, and 73,700 during the 2010s. However, given each decade consisted of varying amounts of years rivers were stocked, these values are simply a summary and not comparable. Between 1979 to 2007, only the North, Grand, and Mira rivers were consistently stocked using juveniles from native broodstock (Gibson et al. 2014), however, there is evidence that the North River also used strains from several other rivers, including the Miramichi, Saint John, Margaree, Morell rivers, and various rivers from the Bay de Chaleur region (Amiro and Marshall 1990).

Rearing juveniles in captivity has been shown to significantly alter behavioural, morphological and physiological traits and relaxes selection for adaptation to wild conditions (Lynch and O'Hely 2001). Captive breeding can also leads to loss of genetic diversity, inbreeding depression, accumulation of deleterious alleles and adaptation to captive environments (Frankham 2008) which lead to reductions in fitness and fitness related traits compared to wild counterparts (Araki et al. 2007, Small et al. 2009, Williams and Hoffman 2009). If captive reared individuals survive to reproductive life-stages and interbreed with the wild population, over time, the entire population could suffer reductions in fitness (Fraser 2008). Although no formal analysis has been carried out on the degree of interbreeding within ECB populations, it is expected to have occurred and negatively affected populations and contributed to declines from the 1990s to present (Gibson et al. 2014). These effects would also likely be less severe for populations that used native broodstocks and released younger life stages (Fraser 2008).

7.8.3.2. Current Stocking Methods

Current federal and provincial (see Section 8) stocking programs have been in place since 2009 and involve the capture of juveniles and rearing them until maturity before release back into the river to spawn, alongside capturing adult broodstock for juvenile releases (Gibson et al. 2014). These programs took place within the Middle and Baddeck rivers to offset recreational fishing mortality and Indigenous Food, Social, Ceremonialharvests (Gibson et al. 2014). Considering the low reproductive success of parr removals and the low amount of adult removals to be restocked into these rivers, the negative genetic effects are likely negligible, however are also unknown (Gibson et al. 2014).

7.9. POLLUTION AND CONTAMINANTS

7.9.1. Household Sewage & Urban Wastewater

No DFO data available.

7.9.2. Industrial & Military Effluents

7.9.2.1. Chemical Contaminants

Of the Abandoned mine sites used in Gibson et al.'s (2014) assessment, 15.6% (164 of 1046 sites) occurred within 24 of the assessed watersheds. Mining within ECB was mostly focused in lowland watersheds with many draining into the Bras d'Or Lakes (Gibson et al. 2014). Abandon mine openings were most frequent throughout the Mira Watershed (n=48), Middle River (n=19) and MacAskill Brook (n=19) (Gibson et al. 2014). Mines were mostly centered towards coal but within the Mira Watershed there were also iron (n=3), lead (n=3), manganese (n=9) and shale oil (n=9) mines (Gibson et al. 2014). Middle River had significant amounts of gold mining (18 of 31 gold mines within the DU) (Gibson et al. 2014). As abandoned mines can be a source for metal accumulation within watersheds and poses risks to human and animal health, remediation processes have been undertaken by the Cape Breton Development Corporation (Gibson et al. 2014).

Sydney Harbour has become a heavily industrialized and populated area which has resulted in industrial and anthropogenic contamination (Stewart et al. 2001). The harbor is contaminated with a multitude of organic and metal contaminants, but most notably is polycyclic aromatic hydrocarbons (PAHs) which has resulted in the closure of the lobster fishery in certain areas of the inlet (Stewart et al. 2001).

Stewart et al. (2001) notes:

> "*The clean-up of the Sydney Tar Ponds and Muggah Creek into which much of the contaminants from the smelter and associated facilities flowed and accumulated (acknowledged to be the most hazardous toxic waste site in Canada), has been one of the most expensive, long-term, and controversial environmental undertakings in Canadian history-and one that is far from being over.*"

Stewart et al. (2001) concludes that the cumulative contamination of the harbor has resulted in biochemical changes in fish and altered the abundance and distribution of benthic animals. However, they also note that it does not appear that the contamination is extending past the harbour but more sampling would be required for firm conclusions.

Although heavy metal contamination within the Bras d'Or Lakes is not significant, there are localized areas where contamination may be having an effect (Gibson et al. 2014).

Information on Bras d'Or Lakes' contamination is described by Parker et al. (2007):

> "*Heavy metal contamination of the Bras d'Or's waters from the freshwater systems is not significant, although several hotspots have been noted and mapped (Young 1976). The freshwater runoff in the larger rivers is not sufficiently acidic to dissolve the naturally occurring heavy metals that are quite limited in the surficial geology (Kenchington and Carruthers 2001). Field surveys have confirmed heavy metal content of silt in the rivers flowing into Bras d'Or as being generally low, though somewhat higher in Baddeck and Middle rivers (Creamer et al. 1973, Young 1976). More recently, sediments in Denys Basin*

have been found to contain levels of cadmium, zinc, copper, and lead greater than threshold effects levels (but less than probable effects levels) (Yeats, pers. comm. 2005). An earlier study (Chou et al. 1999) reported that Denys Basin had the lowest ranking for metal concentrations in sediments of five basins evaluated in the Bras d'Or during 1997 over a wide range of metals examined. However, samples from this study were not corrected for grain size, likely resulting in an under reporting of metal concentrations in sediments. Limited sampling from East Bay sediment has shown localized copper and zinc above threshold effects levels and lead above probable effects levels (Yeats, pers. comm. 2005). Studies have shown some areas of the Bras d'Or as having high zinc in oysters (Young 1973) and in water (Strain et al. 2001). Most recently, in an as yet unreported study, zinc was found to be elevated in both oysters and water at the same location within the Bras d'Or (Yeats, pers. comm. 2005). Evaluation of the significance of these observations is ongoing."

7.9.2.2. Containment (spills)

DFO and the Fishermen and Scientists Research Society assessed a coastal area of 22 km from the shore from Cape Sable NS to Cape North in Cape Breton for potential euthrophication. The study found that while surface water maintained relatively stable in nutrient concentrations throughout the year, bottom waters near Sydney Harbour were subject to eutrophic conditions, however, there is no link to this contributing to population declines within the ECB DU (Gibson et al. 2014).

7.9.2.3. Pulp and Paper Mills

In 2014, Gibson et al. (2014) noted that there was only a single pulp mill at Point Tupper near Port Hawksbury within the ECB DU, however this area was not included within the assessed watersheds.

7.9.3. Agricultural & Forestry Effluents

No DFO data available.

7.9.4. Garbage & Solid Waste

No DFO data available.

7.9.5. Air-Borne Pollution

Although acid deposition is prevalent over the ECB DU, the geology of the region neutralizes acids thus preventing pH from significantly declining (Whitfield et al. 2007). In a recent study by MacMillan et al. (2008), pH measurements from the Middle, Baddeck and Denys rivers measured between 6.9 to 7.8. Therefore, acidification is not considered a threat for ECB DU Atlantic Salmon populations (Gibson et al. 2014).

7.9.6. Excess Energy

No DFO data available.

7.10. GEOLOGICAL EVENTS

7.10.1. Volcanoes

No DFO data available.

7.10.2. Earthquakes & Tsunamis

No DFO data available.

7.10.3. Avalanches & Landslides

No DFO data available.

7.11. CLIMATE CHANGE

7.11.1. Habitat Shifting & Alteration

7.11.1.1. Oceanographic Changes

As described by Gibson et al. (2014):

> "*Although there have been several negative winter North Atlantic Oscillation Index (NAOI) values in recent years (e.g., the winter of 2009/2010 was the lowest on record), the mean NAOI remains positive, and climatic models favor a shift in the mean state of atmospheric circulation towards positive NAOI conditions, likely due to anthropogenic impacts (Osborn 2011).*
>
> *Winter NAOI is strongly negatively correlated with sea-surface temperature (SST) and thus could influence Atlantic Salmon by; impacting the quantity of suitable ocean habitat, directly impacting growth rates, indirectly impacting growth by influencing marine productivity and prey abundance, altering the phenology of salmon migration and marine productivity blooms, shifting competitive advantages among species, altering predator fields and their relationship with salmon and changing migration patterns – all of which may influence salmon mortality rates at sea (Dickson and Turrell 2000, Jonsson and Jonsson 2004, Friedland et al. 2009a, 2009b).*
>
> *There is mounting evidence of a SST-growth-survival paradigm (i.e., bottom-up control) for the marine survival of European Atlantic Salmon postsmolts (e.g., Peyronnet et al. 2008, Friedland et al. 2009a). However, several directed studies did not identify a similar growth-survival relationship for North American postsmolt salmon (Friedland et al. 2005, 2009b, Hogan and Friedland 2010).*
>
> *There is evidence of climate-driven survival of repeat spawning salmon in North America. For example, partitioning marine mortality into that experienced predominantly in freshwater and near-shore environments (first year) and that experienced in more distant marine environments (second year) demonstrated a strong correlation between the NAOI and survival in the second year for alternate-spawning Atlantic Salmon from the LaHave River (Hubley and Gibson 2011). However, the mechanism of climate impacts remains unknown.*"

And

> "*If prey was limiting the marine survival of Atlantic Salmon, growth-mediated survival would be expected. However, as mentioned in the previous section, there is little evidence supporting this hypothesis for North American Atlantic Salmon postsmolts. However, there is emerging evidence for bottom-up control of survival to a second spawning event (i.e., postspawn kelts in the marine environment). Although they did not test for a growth-survival relationship, Chaput and Benoît (2012) used the time series of return rates to a second spawning for salmon kelts from the Miramichi River, New Brunswick, and an index of small-bodied fishes in the southern Gulf of St. Lawrence to*

show that survival was positively correlated with the abundance of small fishes, presumably representing prey availability.

The effect of predation was assessed by Friedland et al. (2012) who demonstrate that following the northeast Atlantic Ocean ecosystem regime shift, predator fields and ocean currents in the Gulf of Maine shifted, resulting in altered migration routes, increased predation and decreased survival of Atlantic Salmon postsmolts.

Given the mounting evidence of some interaction between climate, prey, predators and salmon, it is likely that the marine survival of salmon is impacted by changes in prey or predator fields. However, the magnitude of this impact, and the mechanism by which marine ecosystem regime shift has affected the marine ecology and survival of Atlantic Salmon from the ECB DU, remains unclear."

7.11.2. Droughts

No DFO data available.

7.11.3. Temperature Extremes

River temperature data within the ECB DU is limited, however, a study by MacMillan et al. (2005) reported temperatures throughout three watersheds. Warm water sites (mean summer temperatures > 18.9°C) were found in three of 11 sites within the Denys watershed, in one of 12 sites within the Baddeck River Watershed and in zero of ten sites within the Middle River watershed. Based on this extreme water temperatures may not be a significant issue for ECB rivers (Gibson et al. 2014), however, given sampling occurred in the early 2000s and the limited amount of sites, watersheds and years where sampling occurred, this may not be an accurate representation of the entire DU, conditions experienced by salmon currently, or over longer time periods.

7.11.4. Storms & Flooding

No DFO data available.

7.12. OTHER THREATS

7.12.1. Small Population Effects

It is unclear if any ECB populations are experiencing inbreeding depression, however, some populations (North and Clyburn rivers) have experienced declines in adult abundances (Gibson et al. 2014). There is evidence that population bottlenecks may be occurring in the North Aspy River, Indian Brook, Grand and Inhabitants (Gibson et al. 2014). O'Reilly et al. (2013) notes that, in comparison to reference collections, reductions in genetic variation were modest within the ECB DU. Many collections also exhibited multiple loci that deviated from Hardy-Weinberg expectations, and in combination with genetic variation reductions, these populations may have experienced bottlenecks. However, levels of within-population genetic variability were not significantly different from other Maritime populations (O'Reilly et al. 2013). Given the low abundance of Atlantic Salmon in comparison to historical population sizes, Allee effects have the potential to negatively affect ECB populations.

8. MANIPULATED POPULATIONS

A description of the history of stocking for fisheries enhancement in Atlantic Salmon populations in ECB is extensively reviewed in Gibson et al. 2014. An update to the decadal summary in

Gibson et al. 2014 is provided to include recent stocking activity in Middle and Baddeck River (Table 21).

The only current juvenile stocking in ECB was initiated by DFO's Fisheries and Aquaculture Management Branch and the NS Department of Fisheries and Aquaculture's Inland Fisheries Division in 2009 on Middle and Baddeck River as part of a program to offset catch-and-release mortality associated with recreational angling and to numerically offset Food, Social, and Ceremonial (FSC) allocations from Middle River (Levy and Gibson 2014). In addition, Adult stocking occurred in 2011 and 2012 with an aim to support FSC use (DFO 2012a, Levy and Gibson 2014). A summary of stocking related to these programs is provided for Middle River (Table 22) and Baddeck River (Table 23).

REFERENCES CITED

Amiro, P.G. and D.A. Longard. 1990. Status of Atlantic Salmon stocks of the Grand River, Richmond Co., N.S. 1988. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 90/3.

Amiro, P.G. and T.L. Marshall. 1990. The Atlantic Salmon resource of the North River, Victoria County, N.S. to 1984. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2075.

Amiro, P.G., A.J.F. Gibson, and H.D. Bowlby. 2006. Atlantic salmon (Salmo salar) overview for eastern Cape Breton, Eastern Shore, Southwest Nova Scotia and inner Bay of Fundy rivers (SFA 19 to 22) in 2005. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/024.

Araki, H., B. Cooper and M.S. Blouin. 2007. Genetic effects of captive breeding cause a rapid, cumulative fitness decline in the wild. Science 318: 100-103.

Chaput, G., and H.P. Benoit. 2012. Evidence for botton-up trophic effects on return rates to a second spawning for Atlantic Salmon (Salmo salar) from the Miramichi River, Canada. ICES Journal of Marine Science 69(9): 1656-1667.

Chaput, G., D. Moore, and D. Peterson. 2005. Predicting Atlantic Salmon (*Salmo salar*) juvenile densities using catch per unit effort open site electrofishing. Can. Tech. Rep. Fish. Aquat. Sci. 2600.

Chou, C.L., B.M. Zwicker, J.D. Moffatt and L. Paon. 1999. Elemental concentrations in the livers and kidneys of winter flounder (Pseudopleurectes americanus) and associated sediments from various locations in the Bras d'Or Lake, Nova Scotia, Canada. Canadian Technical Report of Fisheries and Aquatic Sciences 284.

COSEWIC. 2010. COSEWIC Assessment and status report on the Atlantic Salmon *Salmo salar* (Nunavik population, Labrador population, Northeast Newfoundland population, South Newfoundland population, Southwest Newfoundland population, Northwest Newfoundland population, Quebec Eastern North Shore population, Quebec Western North Shore population, Anticosti Island population, Inner St. Lawrence population, Lake Ontario population, Gaspe-Southern Gulf of St. Lawrence population, Eastern Cape Breton population, Nova Scotia Southern Upland population, Inner Bay of Fundy population Outer Bay of Fundy population) in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON. 136 p.

Creamer, R., M. Giles, J.H. MacDonald and J.C.O'C. Young. 1973. Metals contents of silt samples from Bras d'Or Lake and influent rivers found in silt, water, and miscellaneous molluscs. August 1973. SMU ESG Report 73-04.

Davis, D. and S. Browne. [eds.]. 1996. Natural history of Nova Scotia: Volume one, topics and habitats. Revised Edition. Nimbus Publishing, Nova Scotia.

DFO. 2011. Status of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2011/005.

DFO. 2012a. Status of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2012/014.

DFO. 2012b. Reference points consistent with the Precautionary Approach for a variety of stocks in the Maritimes Region. DFO Can. Sci. Advis. Sec. Sci. Rep. 2012/035.

DFO. 2014. Recovery Potential Assessment for Eastern Cape Breton Atlantic Salmon. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2013/072.

DFO. 2020. Stock Status Update of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19–21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2020/031.

DFO and MNRF. 2008. Conservation Status Report, Atlantic Salmon in Atlantic Canada and Quebec: PART I – Species Information. Can. Manuscr. Rep. Fish. Aquat. Sci. No. 2861.

DFO and MRNF. 2009. Conservation status report, Atlantic Salmon in Atlantic Canada and Quebec: PART II – Anthropogenic considerations. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2870.

Dickson, R.R., and W.R. Turrell. 2000. The NAO: The dominant atmospheric process affecting oceanic variability in home, middle and distant waters of European Atlantic Salmon; pp. 92-115. In The ocean life of Atlantic Salmon. Environmental and biological factors influencing survival. Edited by D. Mills. Fishing News Books, Oxford, UK.

Dumbauld, B.R., J.L. Ruesink and S.S. Rumrill. 2009. The ecological role of bivalve shellfish aquaculture in the estuarine environment: A review with application to oyster and clam culture in West Coast (USA) estuaries. Aquaculture 290: 196-223.

Elson, P.F. 1967. Effects on wild young salmon of spraying DDT over New Brunswick forests. J. Fish. Res. Bd. Can. 24: 731-767.

Finstad, B. P.A. Bjorn, C.D. Todd, F. Whoriskey, P.G. Gargan, G. Forde and C.W. Revie. 2011. The effect of sea lice on Atlantic Salmon and other salmonid species; pp. 253-276. In Atlantic Salmon Ecology. Edited by O. Aas, S. Einum, A. Klemetsen and J. Skurdal. Blackwell Publishing Limited, Oxford, UK.

Frankham, R. 2008. Genetic adaptation to captivity in species conservation programs. Molecular Ecology 17: 325-333.

Fraser, D.J. 2008. How well can captive breeding programs conserve biodiversity? A review of salmonids. Evolutionary Applications 1: 535-586.

Friedland, K.D., G. Chaput and J.C. MacLean. 2005. The emerging role of climate in post-smolt growth of Atlantic Salmon. ICES Journal of Marine Science 62: 1338-1349.

Friedland, K.D., J.C. MacLean, L.P Hansen, A.J. Peyronnet, L. Karlsson, D.G. Reddin, N.O. Maoileidigh and J.L. McCarthy. 2009a. The recruitment of Atlantic Salmon in Europe. ICES Journal of Marine Science 66: 289-304.

Friedland, K.D., J.P Manning, J.S. Link, J.R. Gilbert and A.F. O'Connell Jr. 2012. Variation in wind and piscivorous predator fields affecting the survival of Atlantic Salmon, Salmo salar, in the Gulf of Maine. Fisheries Management and Ecology 19: 22-35.

Friedland, K.D., D. Moore, and F. Hogan. 2009b. Retrospective growth analysis of Atlantic Salmon (Salmo salar) from the Miramichi River, Canada. Canadian Journal of Fisheries and Aquatic Sciences 66: 1294-1308.

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.

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.

Gibson, A.J.F., T.L. Horsman, J.S. Ford, and E.A. Halfyard. 2014. Recovery Potential Assessment for Eastern Cape Breton Atlantic Salmon (*Salmo salar*): Habitat requirements and availability, threats to populations, and feasibility of habitat restoration. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/071.

Harris, P.D., L. Bachmann, and T.A. Bakke. 2011. The parasites and pathogens of the Atlantic Salmon: lessons from Gyrodactylus salaris; pp. 221-254. In Atlantic Salmon Ecology. Edited by O. Aas, S. Einum, A. Klemetsen and J. Skurdal. Blackwell Publishing Limited, Oxford, UK.

Hogan, F., and K.D. Friedland. 2010. Retrospective growth analysis of Atlantic Salmon Salmo salar and implications for abundance trends. Journal of Fish Biology 76: 2502-2520.

Houde, A.L.S, C.C. Wilson, and B. Neff. 2017. Performance of four salmonid species in competition with Atlantic salmon. J of Great Lakes Res. 43: 211-215.

Hubley, P.B., and A.J.F. Gibson. 2011. A model for estimating mortality of Atlantic Salmon, Salmo salar, between spawning events. Canadian Journal of Fisheries and Aquatic Sciences 68: 1635-1650.

Hurley Fisheries Consulting. 1989. Enhancing the recreational salmonid fishery in the Bras d'Or Lakes: Feasibility study. Prepared for Bras d'Or Lakes Recreational Fisheries Ltd. Sydney, Nova Scotia.

ICES. 2011. Report of the working group on North Atlantic salmon (WGNAS). ICES Advisory Committee. ICES 2011/ACOM:09. 286 p.

ICES. 2012. Report of the working group on North Atlantic Salmon (WGNAS). ICES Advisory Committee. ICES 2012/ACOM:09.

ICES. 2019. Working Group on North Atlantic Salmon (WGNAS). ICES Scientific Reports. 1:16. 368 pp. http://doi.org/10.17895/ices.pub.4978

ICES. 2020. Working Group on North Atlantic Salmon (WGNAS). ICES Scientific Reports. 2:21. 358 pp. http://doi.org/10.17895/ices.pub.5973

Jonsson, B., and N. Jonsson. 2004. Size and age of maturity of Atlantic Salmon correlate with the North Atlantic Oscillation Index (NAOI). Journal of Fish Biology 64: 241-247.

Kenchington, T.J., and E. Carruthers. 2001. Unamapaqt – A description of the Bras d'Or Marine Environment. Version 0.2.2. Gadus Associates, Musquidoboit Harbour, NS. For the Unama'ki Environmental Committee of the Union of Nova Scotia Indians. 130 p.

Levy, A.L., and Gibson, A.J.F. 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.

Lynch, M., and M. O'Hely. 2001. Captive breeding and the genetic fitness of natural populations. Conservation Genetics 2: 363-378.

MacMillan, J.L., D. Caissie, J.E. LeBlanc and T.J. Crandlemere. 2005. Characterization of summer water temperatures for 312 selected sites in Nova Scotia. Canadian Technical Report of Fisheries and Aquatic Sciences 2582.

MacMillan, J.L., D. Caissie, T.J. Marshall and L. Hinks. 2008. Population indices of Brook Trout (Salvelinus fontinalis), Atlantic Salmon (Salmo salar), and salmonid competitors in relation to summer water temperature and habitat parameters in 100 streams in Nova Scotia. Canadian Technical Report of Fisheries and Aquatic Sciences 2819.

Madden, R.J., J.L. MacMillan and J. Apaloo. 2010. Examining the occurrence of wild Rainbow Trout in the Bras d'Or Lakes, Nova Scotia: Using scale pattern analysis to differentiate hatchery and wild populations; pp. 1-14. In Conserving wild Trout: Proceedings of the wild Trout X symposium. Edited by R.F. Carline and C. LoSapio. Trout Unlimited, Arlington, Virginia.

Marshall, T.L., R. Jones, P. LeBlanc, and L. Forsyth. 1996. Status of Atlantic Salmon stocks on the Margaree and other selected rivers of Cape Breton Island, 1995. DFO Atl. Fish. Res. Doc. 96/142.

Marshall, T.L., P.H. LeBlanc, K.A. Rutherford, and R.A. Jones. 2000. Assessments of Atlantic Salmon stocks in selected rivers of Cape Breton Island, 1999. DFO Can. Sci. Advis. Sec. Res. Doc. 2000/008.

Marshall, T.L., K. Rutherford, P. LeBlanc, and R. Jones. 1999. Follow-up to the assessment of Atlantic Salmon in selected rivers of Cape Breton Island, 1998. DFO Can. Stock Assess. Sec. Res. Doc. 99/108.

Milton, G.R., P.J. Austin-Smith and G.J. Farmer. 1995. Shouting at shags: a case study of cormorant management in Nova Scotia. Colonial Waterbirds 18: 91-98.

Morris, M.R.J., D. J. Fraser, A. J. Heggelin, F.G. Whoriskey, J.W. Carr, S.F. O'Neil and J.A. Hutchings. 2008. Prevalence and recurrence of escaped farmed Atlantic Salmon (Salmo salar) in eastern North American rivers. Canadian Journal of Fisheries and Aquatic Sciences 65: 2807-2826.

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. Sci. Advis. Sec. Res. Doc. 97/100.

O'Neil, S.F., M. Bernard, P. Gallop and R. Pickard. 1987. 1986 Atlantic Salmon sport catch statistics, Maritime Provinces. Canadian Data Report of Fisheries and Aquatic Sciences 663.

O'Reilly, P.T., S. Rafferty and A.J.F. Gibson. 2013. Within- and among-population genetic variation in Eastern Cape Breton Atlantic Salmon and the prioritization of populations for conservation (Salmo salar L.). DFO Can. Sci. Advis. Sec. Res. Doc. 2013/076.

Osborn, T.J. 2011. Variability and changes in the North Atlantic Oscillation Index. Advances in Global Change Research 46: 9-22.

Parker, M., M. Westhead, P. Doherty and J. Naug. 2007. Ecosystem Overview and Assessment Report for the Bras d'Or Lakes, Nova Scotia. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2789.

Paterson, W.D., C. Gallant, D. Desautels, and L. Marshall. 1979. Detection of bacterial kidney disease in wild salmonids in the Margaree River system and adjacent waters using an indirect fluorescent antibody technique. Journal of the Fisheries Research Board of Canada 36: 1464-1468.

Peyronnet, A., K.D. Friedland and N. O'Maoileidigh. 2008. Different ocean and climate factors control the marine survival of wild and hatchery Atlantic Salmon Salmo salar in the north-east Atlantic Ocean. Journal of Fish Biology 73: 945-962.

Quinn, J.M., A.B. Cooper, R.J. Davies-Colley, J.C. Rutherford and R.B. Williamson. 1997. Land use effects on habitat, water quality, periphyton, and benthic invertebrates in Waikato, New Zealand, hill-country streams. New Zealand journal of marine and freshwater research 31: 579-597.

Reddin, D.G., R. Johnson and P. Downton. 2002. A study of bycatches in herring bait nets in Newfoundland, 2001. DFO Can. Sci. Advis. Sec. Res. Doc. 2002/031.

Reynolds, J.D. 2011. A review of ecological interactions between crayfish and fish, indigenous and introduced. Knowledge and Management of Aquatic Ecosystems 401: 10.

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, 2003. DFO Can. Sci. Advis. Sec. Res. Doc. 2004/017.

Silverstone, A.M. and L. Hammell. 2002. Spinal deformities in farmed Atlantic Salmon. Canadian Veterinary Journal 43: 782-784.

Small, M.P., K. Currens, T.H. Johnson, A.E. Frye and J.F. Von Bargen. 2009. Impacts of supplementation: Genetic diversity in supplemented and unsupplemented populations of summer chub salmon (Oncorhynchus keta) in Puget Sound (Washington, USA). Canadian Journal of Fisheries and Aquatic Sciences 66: 1216-1229.

Stewart, A.R.J., T.G. Milligan, B.A. Law and D.H. Loring. 2001. Disaggregated inorganic grain size and trace metal analyses of surficial sediments in Sydney Harbour, N.S., 1999. Canadian Technical Report of Fisheries and Aquatic Sciences 2384.

Strain, P.M., G. Bugden, M. Brylinsky and S. Denny. 2001. Nutrient, dissolved oxygen, trace metal and related measurements in the Bras d'Or Lakes, 1995-1997. Canadian Data Report in Fisheries and Aquatic Sciences 1073.

Van Zwol, J.A., B.D. Neff, & C.C Wilson. 2012. The effect of competition among three salmonids on dominance and growth during the juvenile life stage. Ecology of Freshwater Fish 21: 533–540.

Verspoor, E., .M. O'Sullivan, A.L. Arnold, D. Knox, A. Curry, G. Lacroix and P. Amiro. 2005. The nature and distribution of genetic variation at the mitochondrial ND1 gene of the Atlantic salmon (Salmo salar L.) within and among rivers associated with the Bay of Fundy and Southern Upland of Nova Scotia. Fisheries Research

White, H.C. 1936. The food of kingfishers and mergansers on the Margaree River, Nova Scotia, Journal of the Biological Board of Canada 2: 299-309.

Whitfield, C.J., J. Aherne, P.J. Dillon and S.A. Watmough. 2007. Modelling acidification, recovery, and target loads for headwater catchments in Nova Scotia, Canada. Hydrology and Earth System Sciences 11: 951-963.

Williams, S.E., and E.A. Hoffman. 2009. Minimizing genetic adaptation in captive breeding programs: a review. Biological conservation 142: 2388-2400.

Young, J.C. O'C. 1973. Metal content of oysters found in Cape Breton Island waters; pp. 73-103. In Rocks, Phytoplankton and Oysters. Environmental Studies Group Report, St. Mary's University, Halifax, Nova Scotia.

Young, J.C. O'C. 1976. Aquaculture and chemistry of Bras d'Or; pp. 17-28. In The Proceedings of the Bras d'Or Lakes Aquaculture Conference, Sydney, Cape Breton. Edited by M.G. McKay. College of Cape Breton Press, Sydney, Nova Scotia.

TABLES

Table 1. Percent freshwater age composition and sea age composition of first time spawners as determined from scale samples of adult AtlanticSalmon collected from Middle River during the 1995–2019 time period. N=number of samples

Year	% Freshwater Age Comp. 1	% Freshwater Age Comp. 2	% Freshwater Age Comp. 3	% Freshwater Age Comp. 4	% Freshwater Age Comp. N	% Sea Age Comp. 1	% Sea Age Comp. 2	% Sea Age Comp. 3	% Sea Age Comp. N
1995	0%	17%	75%	8%	12	8%	92%	0%	12
1996	0%	0%	100%	0%	12	36%	64%	0%	14
1997	0%	36%	60%	5%	42	27%	73%	0%	48
1998	0%	6%	75%	19%	16	33%	56%	11%	18
2000		0%	100%	0%	3	25%	75%	0%	4
2003	0%	65%	35%	0%	20	29%	71%	0%	21
2004	0%	69%	31%	0%	16	25%	69%	6%	16
2014	0%	60%	40%	0%	5	29%	71%	0%	7

Table Notes:
"N" is the number of samples.

Table 2. Summary of the recreational fishery statistics for large and small Atlantic Salmon in Middle River, Victoria Co., from 1983–2019. The number of anglers is the number that reported fishing in Middle River. Other values are corrected for non-reporting. CPUE = catch per unit effort. Effort is the total number of rod-days.

Year	No. of Anglers	Small Kept	Small Released	Total Small	Large Kept	Large Released	Total Large	Effort	CPUE	% Large
1983	133	12	0	12	36	5	41	924	0.058	78.0
1984	83	23	10	33	1	74	75	506	0.202	69.5
1985	39	15	6	21	0	28	28	159	0.280	57.1
1986	76	36	8	45	0	108	108	385	0.410	70.9
1987	114	54	4	58	0	117	117	718	0.243	66.9
1988	131	35	12	47	0	136	136	722	0.276	74.2
1989	144	42	11	53	0	282	282	867	0.395	84.3
1990	153	76	26	102	0	187	187	1,005	0.313	64.7
1991	169	18	9	27	0	184	184	854	0.257	87.3
1992	66	8	4	12	0	32	32	218	0.198	72.7
1993	110	26	6	31	0	49	49	398	0.202	61.1
1994	122	0	24	24	0	167	167	504	0.393	87.6
1995	72	0	36	36	0	49	49	287	0.317	57.7
1996	125	3	62	64	0	147	147	512	0.415	69.5
1997	52	3	15	18	0	80	80	175	0.542	81.7
1998	99	5	26	31	0	60	60	312	0.303	66.2
1999	138	0	30	30	0	95	95	369	0.346	76.1
2000	92	0	20	20	0	67	67	311	0.297	76.7
2001	25	0	10	10	0	15	15	92	0.290	60.0
2002	60	1	27	28	0	35	35	231	0.284	56.0
2003	76	0	23	23	0	137	137	336	0.489	85.7
2004	45	0	22	22	0	44	44	185	0.382	66.7
2005	128	0	38	38	0	133	133	458	0.387	77.8
2006	78	0	44	44	0	87	87	416	0.327	66.3
2007	120	0	42	42	0	96	96	509	0.26	69.3
2008	57	0	48	48	0	61	61	466	0.235	55.8
2009	63	0	8	8	0	175	175	698	0.262	95.5
2010	72	0	87	87	0	262	262	888	0.394	75
2011	77	2	102	104	0	121	121	468	0.524	53.8
2012	118	2	18	20	0	158	158	657	0.315	88.8
2013	80	0	19	19	0	191	191	568	0.407	91.1
2014	66	0	21	21	0	51	51	363	0.182	71.4
2015	61	0	18	18	0	67	67	324	0.272	78.7
2016	56	0	21	21	0	52	52	242	0.248	71
2017	60	0	54	54	0	57	57	330	0.301	51
2018	66	0	36	36	0	150	150	425	0.367	80.6
2019	62	0	52	52	0	304	304	894	0.276	85.4

Table 3. Fork length (cm) and proportion female at age of first time spawners determined from scale samples of adult Atlantic Salmon collected from Middle, Baddeck, North, and Grand River. "-"= No information on sex is available for Grand River. N=total number

River	SW Age	Mean Length	Max Length	Prop Female	N
Middle	1	56	66	0.04	47
Middle	2	75	85	0.73	119
Middle	3	85	91	0.33	3
Baddeck	1	57	75	0.13	23
Baddeck	2	75	88	0.84	71
Baddeck	3	85	90	0.5	2
North	1	52	62	0.07	28
North	2	72	84	0.88	97
North	3	85	85	1.0	1
Grand	1	53	75	-	413
Grand	2	71	76	-	32

Table 4. Percent freshwater age composition, and sea age composition of first time spawners determined from scale samples of adult Atlantic Salmon collected from Baddeck River during the 1977–2004 time period (Source: Levy and Gibson 2014).

Year	% Freshwater Age Comp. 1	% Freshwater Age Comp. 2	% Freshwater Age Comp. 3	% Freshwater Age Comp. 4	% Freshwater Age Comp. N	% Sea Age Comp. 1	% Sea Age Comp. 2	% Sea Age Comp. 3	% Sea Age Comp. N
1977	-	60%	40%	-	5	-	100%	-	7
1978	-	100%	-	-	1	-	-	-	-
1995	-	10%	90%	-	21	-	-	-	21
1996	-	38%	62%	-	13	31%	63%	6%	16
1997	-	23%	77%	-	30	22%	78%	-	32
1998	10%	10%	70%	10%	10	11%	89%	-	9
2003	-	54%	46%	-	13	33%	67%	-	15
2004	-	50%	50%	-	2	-	100%	-	3

Table Notes:

"N" is the number of samples.

"-" = No sample observed within age category.

Table 5. Summary of the recreational fishery statistics for large and small Atlantic Salmon in Baddeck River, Victoria Co., from 1983–2019. The number of anglers is the number that reported fishing in Baddeck River. Other values are corrected for non-reporting. CPUE = catch per unit effort. Effort is the total number of rod-days.

Year	No. of Anglers	Small Kept	Small Released	Total Small	Large Kept	Large Released	Total Large	Effort	CPUE	% Large
1983	86	5	1	6	39	6	45	386	0.136	87.8
1984	60	4	2	7	2	44	46	273	0.189	87.5
1985	34	4	0	4	0	13	13	100	0.170	75.0
1986	67	19	6	26	0	126	126	287	0.540	83.1
1987	90	26	14	40	0	127	127	432	0.404	75.9
1988	86	18	17	35	0	168	168	447	0.492	82.8
1989	98	8	9	17	0	235	235	490	0.559	93.2
1990	103	40	30	69	0	178	178	584	0.446	72.0
1991	110	30	25	54	0	226	226	638	0.427	80.6
1992	129	50	6	56	0	162	162	704	0.327	74.4
1993	146	33	15	48	0	108	108	772	0.212	69.2
1994	74	1	14	15	0	56	56	308	0.265	79.4
1995	61	8	56	64	0	75	75	337	0.403	53.8
1996	70	0	47	47	0	169	169	380	0.580	78.2
1997	43	0	14	14	0	64	64	206	0.390	81.7
1998	87	0	57	57	0	81	81	335	0.442	58.6
1999	96	1	14	15	0	79	79	290	0.335	83.7
2000	54	1	11	12	0	55	55	212	0.363	82.0
2001	31	0	11	11	0	20	20	104	0.321	64.0
2002	59	0	19	19	0	38	38	204	0.303	66.0
2003	50	0	23	23	0	80	80	221	0.497	77.3
2004	40	2	14	15	0	53	53	185	0.392	77.5
2005	93	0	40	40	0	109	109	397	0.373	73.5
2006	57	0	21	21	0	88	88	316	0.425	81.2
2007	55	2	15	16	0	67	67	256	0.3	80.4
2008	36	0	31	31	0	46	46	301	0.254	60
2009	40	0	14	14	0	134	134	483	0.305	90.7
2010	45	0	70	70	0	192	192	462	0.567	73.1
2011	77	2	85	87	0	217	217	492	0.634	71.4
2012	81	0	4	4	0	134	134	461	0.391	97
2013	57	0	11	11	0	117	117	344	0.378	91.4
2014	45	0	6	6	0	27	27	212	0.25	82.1
2015	33	0	38	38	0	48	48	227	0.298	55.6
2016	42	0	17	17	0	39	39	196	0.287	69
2017	36	0	24	24	0	30	30	198	0.184	55.6
2018	53	0	19	19	0	159	159	379	0.423	89.2
2019	30	0	16	16	0	145	145	401	0.385	90

Table 6. Percent freshwater age composition, and sea age composition of first time spawners determined from scale samples of adult Atlantic Salmon collected from North River during the 1991–2016 time period. N=number of samples

Year	% Freshwater Age Comp. 1	% Freshwater Age Comp. 2	% Freshwater Age Comp. 3	% Freshwater Age Comp. 4	% Freshwater Age Comp. N	% Sea Age Comp. 1	% Sea Age Comp. 2	% Sea Age Comp. 3	% Sea Age Comp. N
1991	0%	100%	0%	0%	9	0%	100%	0%	8
1996	0%	67%	33%	0%	6	60%	40%	0%	5
1997	0%	10%	70%	20%	20	17%	83%	0%	23
1998	0%	8%	83%	8%	12	18%	82%	0%	11
2013	0%	25%	75%	0%	4	0%	90%	10%	10
2015	0%	50%	46%	4%	28	30%	70%	0%	23
2016	0%	59%	41%	0%	39	26%	74%	0%	46

Table Notes:

"N" is the number of samples.

Table 7. Summary of the recreational fishery statistics for large and small Atlantic Salmon in North River, from 1983–2019. The number of anglers is the number that reported fishing in North River. Other values are corrected for non-reporting. CPUE = catch per unit effort. Effort is the total number of rod-days.

Year	No. of Anglers	Small Kept	Small Released	Total Small	Large Kept	Large Released	Total Large	Effort	CPUE	% Large
1983	290	35	9	44	148	8	156	1,856	0.105	78.0
1984	162	56	9	65	94	57	152	1,174	0.183	70.0
1985	170	145	13	158	0	413	413	1,005	0.559	72.4
1986	297	186	50	237	0	1,017	1,017	2,035	0.640	81.1
1987	263	177	50	227	0	547	547	1,653	0.475	70.7
1988	202	119	17	136	0	539	539	1,593	0.438	79.9
1989	162	117	38	156	0	385	385	1,342	0.433	71.2
1990	219	207	67	274	0	625	625	1,845	0.491	69.5
1991	172	152	40	191	0	365	365	1,389	0.402	65.6
1992	205	194	42	236	0	580	580	1,858	0.433	71.1
1993	217	62	19	81	0	160	160	1,224	0.196	66.4
1994	73	0	78	78	0	102	102	411	0.435	56.5
1995	77	1	172	173	0	215	215	516	0.759	55.4
1996	81	0	165	165	0	118	118	592	0.525	41.7
1997	58	1	69	70	0	137	137	384	0.537	66.2
1998	84	0	108	108	0	104	104	448	0.497	49.1
1999	79	0	35	35	0	45	45	292	0.282	56.2
2000	49	0	32	32	0	27	27	261	0.232	45.8
2001	46	0	37	37	0	60	60	264	0.376	62.2
2002	44	0	34	34	0	45	45	269	0.341	57.1
2003	51	0	81	81	0	156	156	525	0.475	65.9
2004	37	0	70	70	0	152	152	505	0.468	68.5
2005	54	1	54	55	0	171	171	441	0.512	75.6
2006	51	0	56	56	0	104	104	444	0.445	64.8
2007	59	0	93	93	0	134	134	494	0.582	59.2
2008	45	0	133	133	0	196	196	602	0.547	59.7
2009	31	0	63	63	0	166	166	663	0.346	72.6
2010	37	0	180	180	0	352	352	758	0.703	66.1
2011	52	0	74	74	0	176	176	570	0.746	70.3
2012	45	0	10	10	0	36	36	296	0.277	78.3
2013	42	0	38	38	0	168	168	462	0.573	81.7
2014	38	0	21	21	0	56	56	340	0.389	72.9
2015	27	0	13	13	0	47	47	201	0.299	78.1
2016	25	0	12	12	0	42	42	225	0.466	77.8
2017	35	0	61	61	0	84	84	249	0.772	57.9
2018	22	0	63	63	0	138	138	321	0.689	68.6
2019	14	0	80	80	0	236	236	437	0.694	74.6

Table 8. Counts and percent size composition of small and large salmon from dive surveys conducted in Clyburn Brook, NS, from 1985–2019. (Source: Data provided courtesy of Parks Canada). "-" = no data.

Year	No. Small Salmon	No. Large Salmon	No. Total Salmon	% Small	% Large
1985*	4	38	42	9.52	90.48
1986*	9	18	27	33.33	66.67
1987	35	140	175	20.00	80.00
1988	40	77	117	34.19	65.81
1989	17	68	85	20.00	80.00
1990	31	65	96	32.29	67.71
1991	-	-	-	-	-
1992	19	51	70	27.14	72.86
1993	-	-	-	-	-
1994*	24	45	69	34.78	65.22
1995*	24	22	46	52.17	47.83
1996	-	-	-	-	-
1997	19	52	71	26.76	73.24
1998	10	32	42	23.81	76.19
1999	5	5	10	50.00	50.00
2000	5	3	8	62.50	37.50
2001	9	20	29	31.03	68.97
2002	8	11	19	42.11	57.89
2003	13	18	31	41.94	58.06
2004	3	8	11	27.27	72.73
2005	5	7	12	41.67	58.33
2006	5	11	16	31.25	68.75
2007	3	7	10	30.00	70.00
2008	8	8	16	50.00	50.00
2009*	1	5	6	16.67	83.33
2010	3	5	8	37.50	62.50
2011	2	0	2	100.00	0.00
2012	0	6	6	0.00	100.00
2013	0	3	3	0.00	100.00
2014*	0	0	0	-	-
2015	-	-	-	-	-
2016	3	9	12	25.00	75.00
2017	2	4	6	33.33	66.67
2018	5	9	14	35.71	64.29
2019	2	3	5	40.00	60.00

Table Notes:

*Only the lower section of the river was surveyed (partial counts).

Table 9. Adult Atlantic Salmon abundance time series for five rivers in Eastern Cape Breton. "-" = no data.

Year	Middle River[1] Small	Middle River Large	Baddeck River[1] Small	Baddeck River[1] Large	North River[1] Small	North River[1] Large	Grand River[1] Small+ Large	Clyburn Brook[2] Small	Clyburn Brook[2] Large
1983	2	27	4	39	-	-	-	-	-
1984	26	192	7	97	-	-	-	-	-
1985	57	169	12	64	-	-	-	4	38
1986	42	301	24	261	-	-	-	9	18
1987	20	206	29	200	-	-	-	35	140
1988	24	238	29	259	-	-	626	40	77
1989	19	485	14	343	-	-	453	17	68
1990	64	311	44	237	-	-	442	31	65
1991	20	345	34	288	-	-	348	-	-
1992	45	218	14	198	-	-	133	19	51
1993	10	86	20	127	-	-	97	-	-
1994	43	422	27	133	99	246	201	24	45
1995	53	240	90	185	118	256	281	24	22
1996	106	378	73	287	380	285	345	-	-
1997	59	328	45	180	112	580	147	19	52
1998	67	180	70	149	122	341	241	10	32
1999	60	279	24	194	-	-	93	5	5
2000	37	163	19	134	-	-	41	5	3
2001	50	137	41	96	-	-	2	9	20
2002	57	119	30	92	-	-	46	8	11
2003	36	380	25	162	-	-	37	13	18
2004	61	253	34	102	77	174	18	3	8
2005	72	349	60	202	-	-	39	5	7
2006	62	183	36	138	-	-	29	5	11
2007	60	195	38	135	102	169	16	3	7
2008	96	167	70	103	-	-	14	8	8
2009	23	199	19	134	38	158	12	1	5
2010	36	255	14	126	-	-	-	3	5
2011	155	311	88	264	-	-	-	2	0
2012	30	382	15	245	-	-	-	0	6
2013	32	452	19	182	36	228	-	0	3
2014	19	125	15	74	27	78	-	0	0
2015	40	196	48	129	63	171	-	-	-
2016	42	246	32	130	70	217	-	3	9
2017	162	594	71	118	167	238	-	2	4
2018	56	387	23	198	-	-	-	5	9
2019	39	331	21	167	25	215	-	2	3

Table Notes:

[1]Escapement Series;
[2]Index Series.

*Table 10. Summary of declines/increases in adult Atlantic Salmon abundance (large and small size categories combined) for five rivers in Eastern Cape Breton. The regression method is a log-linear model fit via least squares. *Slope is significant (p < 0.05).The standard errors and 95% confidence intervals are in brackets. A negative value in the decline columns indicates an increasing population size. The values reported for Grand River are calculated and reported in Levy and Gibson 2014.*

Population	Time Period	Number of Years	Slope (SE)	Regression1 year decline rate (%)	Regression Decline over time period (%)
Middle River	2002–2019	17	0.02 (0.02)	-2.3 (1.6 – -6.3)	-46.7 (23.6 – -181.9)
Baddeck River	2002–2019	17	0.008 (0.01)	-0.8 (2.2 – -3.9)	-14.3 (31.7 – -91.4)
North River	2003–2019	16	0.007 (0.03)	-0.7 (5.6 – -7.5)	-12.0 (60.4 – -216.6)
Grand River[a]	1989–2009	20	-0.19 (0.03)*	17.2 (22.2 – 11.8)	98.1 (99.5 – 92.9)
	1994–2009	15	-0.22 (0.05)*	19.6 (27.6 – 10.8)	97.0 (99.4 – 83.8)
	1999–2009	10	-0.08 (0.10)*	8.1 (24.2 – -11.4)	60.7 (95.3 – -226.2)
Clyburn Brook	1999–2019	20	-0.07 (0.03)*	6.6 (11.9 – 0.9)	74.4 (92.1 – 17.3)
	2004–2019	15	-0.06 (0.04)	5.3 (13.8 – -4.0)	56.0 (89.3 – -80.2)

Table 11. The number of large and small salmon counted during dive surveys in Middle River, Victoria Co., from 1994–2019. The number of salmon (size classes combined) that were marked and then observed during the dive count are shown for years when mark-recapture experiments were conducted. "-" = no data.

Year	Number Counted Small Salmon	Number Counted Large Salmon	Mark-Recapture No. Marked	Mark-Recapture No. of Observed Marks	Mark-Recapture Observation Efficiency
1994	35	289	17	13	0.76
1995	23	160	12	6	0.50
1996	75	284	16	10	0.63
1997	42	216	17	11	0.65
1998	52	96	18	12	0.67
1999	45	187	15	11	0.73
2000	22	102	23	13	0.57
2001	29	81	-	-	-
2002	30	61	-	-	-
2003	19	174	22	7	0.32
2004	31	149	17	8	0.47
2005	57	217	-	-	-
2006	34	95	-	-	-
2007	38	115	-	-	-
2008	83	134	-	-	-
2009	39	97	-	-	-
2010	10	125	-	-	-
2011*	100	221	-	-	-
2012	24	324	-	-	-
2013	25	340	-	-	-
2014	7	71	-	-	-
2015	31	119	-	-	-
2016	25	185	-	-	-
2017	105	386	-	-	-
2018	36	254	-	-	-
2019	34	292	-	-	-

Table Notes: *The mean dive count reported here (i.e., mean of surveys with and without new pools) was used in the assessment model.

Table 12. Means and standard deviations (s.d.) of age 0 and age 1+ densities (number/100m²) of juvenile Atlantic Salmon in the Middle River, Victoria Co., estimated during electrofishing surveys from 1985-2006. "N" is the number of sites electrofished in each year (Source: Gibson and Bowlby 2009).

Year	N	Age 0 mean	Age 0 s.d.	Age 1+ mean	Age 1+ s.d.
1985	2	48.1	29.6	58.2	13.8
1994	2	20.4	18.5	28.5	11.3
1995	3	129.8	38.4	42.8	29.7
1996	4	64.3	71.3	55.2	13.8
1997	4	34.1	27.0	68.9	41.1
1998	4	21.4	11.4	46.8	8.3
1999	4	55.3	25.7	43.8	10.0
2000	4	58.0	40.9	54.1	15.4
2001	4	9.4	6.6	41.9	12.8
2006	4	85.2	68.4	62.8	22.9

Table 13. Estimates of wild and hatchery Atlantic Salmon smolt abundance, production per unit area of habitat (smolts/100 m²), as well as one-sea-winter (1SW) and two-sea-winter (2SW) return rates for Middle River. "-" = no data.

Smolt Year (t)	Smolt Estimate*	95% Confidence Interval	Production Per Unit Area (smolts/100 m²)	Return Rate (%)**1SW (t+1)	Return Rate (%)**2SW (t+2)
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‡	-	-	-	-	-
2018***	9,554	1,265–17,842	1.23	0.41	-
2019‡	-	-	-	-	-

*Source: Smolt estimates provided by Unama'ki Institute of Natural Resources. For 2013–2016 and 2018, the smolt population was estimated using a single trap mark-recapture experiment and the Adjusted Peterson Estimate (Ricker 1975).

**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.

‡ *Smolt estimates were attempted in 2017 and 2019, but were not successful due to inoperable periods during high flow events.*

Table 14 The number of large and small salmon counted during dive surveys in Baddeck River, Victoria Co., from 1994–2019. The number of salmon (size classes combined) that were marked and then observed during the dive count are shown for years when mark-recapture experiments were conducted. "-" = no data.

Year	Number Counted Small Salmon	Number Counted Large Salmon	Mark-Recapture No. Marked	Mark-Recapture No. of Observed Marks	Mark-Recapture Observation Efficiency
1994	17	93	12	9	0.75
1995	42	112	28	12	0.43
1996	43	171	17	11	0.65
1997	35	103	32	19	0.59
1998	30	74	13	7	0.54
1999	-	-	-	-	-
2000	8	84	43	27	0.63
2001	-	-	-	-	-
2002	12	44	-	-	-
2003	7	60	15	3	0.20
2004	18	38	3	1	0.33
2005	34	121	-	-	-
2006	21	60	-	-	-
2007	27	64	-	-	-
2008	63	74	-	-	-
2009	15	67	-	-	-
2010	2	40	-	-	-
2011	39	121	-	-	-
2012	22	158	-	-	-
2013	11	87	-	-	-
2014	10	45	-	-	-
2015	17	78	-	-	-
2016	16	85	-	-	-
2017	52	93	-	-	-
2018	10	77	-	-	-
2019	14	89	-	-	-

Table 15. Means and standard deviations (s.d.) of age 0 and age 1+ densities (number/100 m^2) of juvenile Atlantic Salmon in the Baddeck River Victoria Co., NS, estimated during electrofishing surveys from 1996-2016. "N" is the number of sites electrofished in each year.

Year	N	Age 0 mean	Age 0 s.d.	Age 1+ mean	Age 1+ s.d.
1996	3	63.3	5.9	36.0	13.9
1997	3	113.4	64.5	38.7	12.0
1998	3	64.7	33.0	30.1	9.3
1999	3	95.2	77.3	32.6	16.0
2000	3	141.8	53.8	32.1	21.2
2001	3	47.5	27.3	27.0	18.2

Year	N	Age 0 mean	Age 0 s.d.	Age 1+ mean	Age 1+ s.d.
2016	2	73.3	23.2	41.5	4.4

Table 16. The number of large and small salmon counted during dive surveys in North River from 1983–2019. Values in brackets indicate the scaled count estimates. The number of salmon (size classes combined) that were marked and then observed during the dive count are shown for years when mark-recapture experiments were conducted. "-" = no data.

Year	Number Counted Small Salmon	Number Counted Large Salmon	Mark-Recapture No. Marked	Mark-Recapture No. of Observed Marks	Mark-Recapture Observation Efficiency
1994	68	167	22	8	0.36
1995	57	124	28	13	0.46
1996	184	138	14	8	0.57
1997	54	281	25	11	0.44
1998	59	165	13	6	0.46
1999	-	-	-	-	-
2000	-	-	-	-	-
2001	-	-	-	-	-
2002	-	-	-	-	-
2003	-	-	-	-	-
2004	30 (37.1)	68 (84.1)	-	-	-
2005	-	-	-	-	-
2006	-	-	-	-	-
2007	40 (49.5)	66 (81.7)	-	-	-
2008	-	-	-	-	-
2009	15 (18.6)	62 (76.7)	-	-	-
2010	-	-	-	-	-
2011	-	-	-	-	-
2012	-	-	-	-	-
2013a	21	115	11	6	0.55
2013b	14	106	11	3	0.27
2014	13	38	-	-	-
2015a	36	89	28	17	0.61
2015b	25	77	28	10	0.36
2016	34	105	26	13	0.5
2017	81	115	-	-	-
2018	-	-	-	-	-
2019	12	104	-	-	-

Table Notes:

Two counts were conducted in 2013 and 2015. The average of the two counts was used in calculating escapement.

Table 17. Summer counts on North River from 2001–2019. No observation efficiency available. "-" = no data.

Year	Number Counted Small Salmon	Number Counted Large Salmon
2001	24	93
2002	-	-
2003	-	-
2004	-	-
2005	-	-
2006	-	-
2007	-	-
2008	-	-
2009	-	-
2010	-	-
2011	-	-
2012	-	-
2013	-	-
2014	25	44
2015	18	85
2016	10	34
2017	47	85
2018	51	80
2019	11	106

Table 18. Summary of the recreational fishery statistics for large and small Atlantic Salmon in Grand River, from 1983–2011. The number of anglers is the number that reported fishing in Grand River. Other values are corrected for non-reporting (Source: Levy and Gibson 2014). CPUE = catch per unit effort. Effort is the total number of rod-days.

Year	No. of Anglers	Small Kept	Small Released	Total Small	Large Kept	Large Released	Total Large	Effort	CPUE	% Large
1983	371	194	34	228	31	39	69	4,212	0.069	23.3
1984	268	350	53	404	4	30	34	2,989	0.148	7.8
1985	312	471	71	542	0	132	132	3,073	0.224	19.6
1986	326	294	61	356	0	192	192	2,997	0.180	35.0
1987	262	301	33	334	0	104	104	2,059	0.208	23.8
1988	277	303	21	324	0	101	101	3,334	0.133	23.8
1989	247	311	23	334	0	80	80	2,709	0.148	19.4
1990	240	339	79	419	0	102	102	2,857	0.186	19.7
1991	178	115	13	128	0	18	18	1,981	0.076	12.3
1992	182	155	12	166	0	46	46	1,939	0.109	21.6
1993	183	115	21	136	0	24	24	1,469	0.105	15.2
1994	44	0	75	75	0	21	21	416	0.231	21.6
1995	4	0	6	6	0	16	16	49	0.368	71.4
1996	26	0	94	94	0	26	26	294	0.405	21.7
1997	20	3	28	31	0	6	6	173	0.202	15.4
1998	20	0	75	75	0	12	12	246	0.321	13.6
1999	7	0	17	17	0	3	3	47	0.429	16.7
2000	14	0	20	20	0	1	1	81	0.266	5.9
2001	6	0	1	1	0	0	0	9	0.143	0.0
2002	11	0	31	31	0	0	0	84	0.375	0.0
2003	8	0	16	16	0	3	3	63	0.302	15.4
2004	4	0	7	7	0	2	2	35	0.263	20.0
2005	6	0	20	20	0	0	0	13	1.500	0.0
2006	8	0	15	15	0	0	0	28	0.500	0.0
2007	5	0	6	6	0	2	2	34	0.174	25.0
2008	4	0	7	7	0	0	0	31	0.231	0.0
2009	2	0	3	3	0	3	3	27	0.200	50.0
2010	River closed	River closed	River closed	River closed	River closed	River closed	River closed	River closed	River closed	River closed
2011	River closed	River closed	River closed	River closed	River closed	River closed	River closed	River closed	River closed	River closed

Table 19. Returns of Atlantic Salmon above Grand River falls on the Grand River, NS, from 1988–2000 as estimated from fishway count data (Source: Gibson and Bowlby 2009). "-" = no data.

Year	Small and Large Fish Combined Returns	Small and Large Fish Combined Esc.	Small and Large Fish Combined% Hatch	Small and Large Fish Combined Wild Escapement	Small and Large Fish Combined Wild Returns	Small and Large Fish Combined% Requirement
1988	694	626	0	626	694	268
1989	607	453	0	453	607	194
1990	626	442	43	252	357	108
1991	442	348	45	191	243	82
1992	186	133	38	82	115	35
1993	132	97	45	53	73	23
1994	208	201	14	173	179	74
1995	281	281	32	191	191	82
1996	345	345	61	135	135	58
1997	152	147	31	101	105	43
1998	245	241	73	65	66	28
1999*	103	93	34	62	68	26
2000*	-	-	0	-	-	-

Table Notes:

*Only partial counts were conducted.

Table 20. Juvenile density by age of Atlantic Salmon at electrofishing sites in Eastern Cape Breton in 2016. Total catch at each site is standardized by shocking time and scaled up to density using the catch-per-unit-effort (CPUE) - density relationship for fry and parr developed by Chaput et al. (2005). The catchability of age 1, 2, and 3 parr is assumed to be equal.

River	Site ID	Method	Area (m^2)	Shocking Time (s)	catch Age 0	catch Age 1	catch Age 2	catch Age 3	CPUE (3 min.) Age 0	CPUE (3 min.) Age 1	CPUE (3 min.) Age 2	CPUE (3 min.) Age 3	Density (per $100m^2$) Age 0	Density (per $100m^2$) Age 1	Density (per $100m^2$) Age 2	Density (per $100m^2$) Age 3
Baddeck R.	BAD001	one-pass	407.4	1040	101	35	12	0	17	6	2	0	96	35	15	4
Baddeck R.	BAD002	one-pass	252	585	29	15	6	0	9	5	2	0	50	28	13	4
Benacadie R.	BEN002	one-pass	148	369	0	8	3	0	0	4	1	0	5	24	12	4
Benacadie R.	BEN003	one-pass	100	442	0	4	4	0	0	2	2	0	5	12	12	4
Breac Brook	BRE001	one-pass	443	601	13	9	1	0	4	3	0	0	24	18	6	4
Frambroise R.	FRM001	one-pass	309.7	665	0	0	0	0	0	0	0	0	5	5	5	4
Frambroise R.	FRM002	one-pass	447.2	922	18	13	3	0	4	3	1	0	22	17	7	4
Frambroise R.	FRM003	one-pass	285.2	865	5	1	0	0	1	0	0	0	10	5	5	4
Frambroise R.	FRM004	one-pass	314.4	782	0	1	0	0	0	0	0	0	5	6	5	4
Grand R.	Grand002.1	one-pass	867.4	1320	5	0	0	0	1	0	0	0	8	5	5	4
Grand R.	Grand005	one-pass	313.1	766	0	0	1	0	0	0	0	0	5	5	6	4
Grand R.	Grand006	one-pass	245	1068	0	0	0	0	0	0	0	0	5	5	5	4
Grand R.	Grand002.2	one-pass	787.4	1798	46	1	1	0	5	0	0	0	27	5	5	4
Grand R.	Grand007	one-pass	446.8	1721	0	0	0	3	0	0	0	0	5	5	5	6
Grand R.	Grand003	one-pass	515.8	1563	19	0	1	0	2	0	0	0	15	5	5	4
Grand R.	Grand004.1	one-pass	1344.8	1149	1	0	0	0	0	0	0	0	5	5	5	4
Grand R.	Grand008	one-pass	350.8	547	2	0	0	0	1	0	0	0	8	5	5	4
Grand R.	Grand008.1	one-pass	899.7	1330	0	0	0	0	0	0	0	0	5	5	5	4

River	Site ID	Method	Area (m^2)	Shocking Time (s)	catch Age 0	catch Age 1	catch Age 2	catch Age 3	CPUE (3 min.) Age 0	CPUE (3 min.) Age 1	CPUE (3 min.) Age 2	CPUE (3 min.) Age 3	Density (per $100m^2$) Age 0	Density (per $100m^2$) Age 1	Densit y (per $100m^2$) Age 2	Density (per $100m^2$) Age 3
Indian Brook	IND001	one-pass	192	349	10	8	4	0	5	4	2	0	30	25	15	4
River Denys	DEN001	one-pass	361.6	673	34	11	5	1	9	3	1	0	51	19	11	6
River Denys	DEN002	one-pass	114	422	16	15	6	0	7	6	3	0	39	37	17	4
River Inhabitants	INH003	one-pass	399.8	728	0	0	0	0	0	0	0	0	5	5	5	4
River Inhabitants	INH002.1	one-pass	540.96	1361	24	5	3	0	3	1	0	0	20	8	6	4
River Inhabitants	INH001	one-pass	1113.2	1969	2	33	23	0	0	3	2	0	5	19	15	4
River Tillard	TIL004	one-pass	541.1	1718	0	6	5	4	0	1	1	0	5	8	7	6
River Tillard	TIL001	one-pass	342.6	1122	0	0	3	0	0	0	0	0	5	5	7	4
River Tillard	TIL005	one-pass	508.8	1153	0	1	0	0	0	0	0	0	5	5	5	4
Skye R.	SKY001	mark-recap	353.8	1048	9	24	3	0	2	4	1	0	12	25	7	4
Skye R.	SKY001	mark-recap[1]	353.8	607	5	20	3	0	1	6	1	0	12	34	9	4
Skye R.	SKY002	one-pass	390.1	972	15	22	1	0	3	4	0	0	18	25	5	4
Skye R.	SYD003	one-pass	179	600	0	12	4	3	0	4	1	1	5	22	10	9
Sydney R.	SYD002	mark-recap	195	653	15	17	3	1	4	5	1	0	25	28	8	6
Sydney R.	SYD002	mark-recap[1]	195	655	10	11	0	0	3	3	0	0	18	19	5	4

Table Notes:

[1]Indicates recapture pass for site.

Table 21. Decadal summary of Atlantic Salmon stocking programs operated in rivers of the ECB DU from 1979 to 2012, including the total number of each life stage stocked and the broodstock origin. Native is defined as broodstock from the river of origin, local is broodstock from another river in the ECB DU and hybrid is a crossbreeding of two different populations (either native x local or local x local). Where broodstock came from outside of Eastern Cape Breton, the DU of origin is given.

Watershed Name	Decade	Total	Life Stage	Stock origin
North River	1980	21,432	Smolt	Native
North River	1990	55,062	Smolt/Parr	Native
Baddeck River	1970*	2,700	Smolt	Gulf DU
Baddeck River	1980	37,086	Parr	Local
Baddeck River	2010	158,568	Fry/Parr	Native
Baddeck River	2010	17	Adult	Native
Middle River	1970*	6,758	Smolt/Parr	Gulf DU
Middle River	1980	151,669	Smolt/Parr	Local / Gulf DU
Middle River	2010	172,904	Fry/Parr	Native
Middle River	2010	33	Adult	Native
River Inhabitants	1980	13,079	Smolt/Parr	Hybrid / Gulf DU / SU DU
River Inhabitants	1990	1,026	Parr	Gulf DU
Grand River	1980	56,658	Smolt/Parr	Native
Grand River	1990	236,278	Smolt/Parr	Native
Mira River	1980	11,514	Parr	Native
Mira River	1990	88,542	Smolt/Parr	Native
Indian Brook (CB Co.)	1990	86,659	Smolt/Parr	Hybrid / Local
Indian Brook (CB Co.)	2000	37,074	Smolt/Parr	Hybrid / Local
Other ECB watersheds	1990	28,387	Smolt	Local

Table Notes:

*Data from the 1970s only include releases from 1979.

Table 22.. Summary of adult and juvenile stocking of Atlantic Salmon aimed to numerically offset catch-and-release mortality, and adult stocking efforts aimed to support Food, Social, Ceremonial use on Middle River. "-" = no releases.

Year	Juvenile Stocking# Fry (Summer)	Juvenile Stocking # Age 0 Parr (October)	Adult Stocking # Large	Adult Stocking # Small
2009	-	-	-	-
2010	-	12,000	-	-
2011	12,600	10,400	14	-
2012	-	-	1	18
2013	-	13,000	-	-
2014	-	18,504	-	-
2015	-	15,000	-	-
2016	-	24,000	-	-
2017	-	21,000	-	-
2018	-	21,400	-	-
2019	-	25,000	-	-

Table 23. Summary of adult and juvenile stocking efforts of Atlantic Salmon aimed to numerically offset catch-and-release mortality, and parr removals and adult stocking efforts aimed to support FSC use on Baddeck River. "-" = no releases.

Year	Juvenile Stocking # Fry (Summer)	Juvenile Stocking # Age 0 Parr (October)	Adult Stocking # Large	Adult Stocking # Small
2009	-	-	-	-
2010	13,000	9,000	-	-
2011	6,000	10,700	2	-
2012	-	11,990	1	14
2013	-	-	-	-
2014	-	12,978	-	-
2015	-	23,700	-	-
2016	-	28,300	-	-
2017	-	20,400	-	-
2018	-	22,500	-	-
2019	-	-	-	-

FIGURES

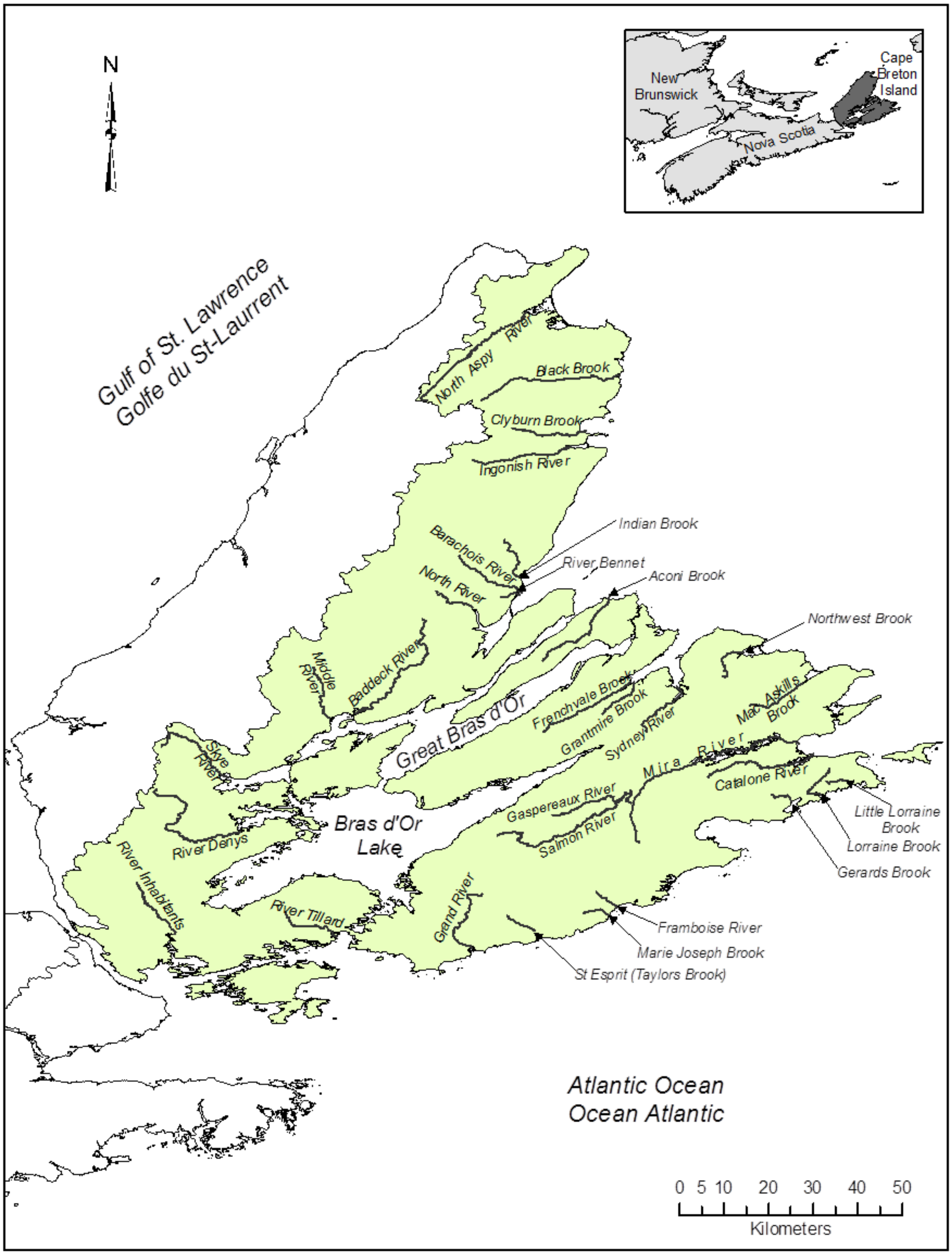

Figure 1. Rivers in the ECB DU with a reported recreational catch. The ECB DU is highlighted in green.

Middle River

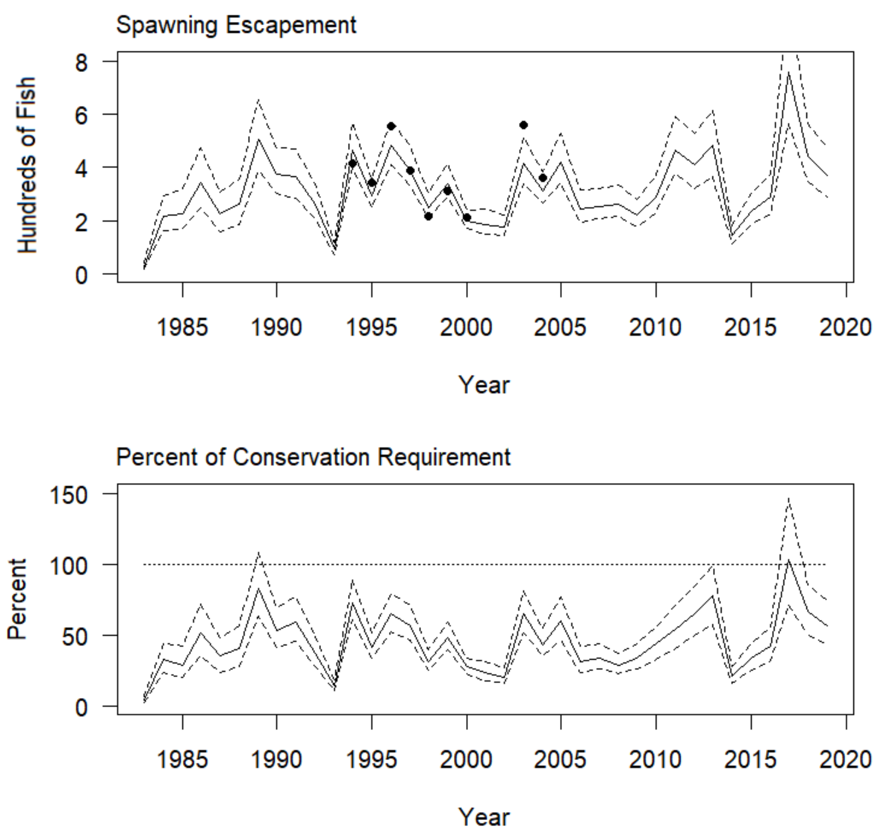

Figure 2. Estimated total number of spawners (top panel) and the percent of the conservation requirement attained (bottom panel) in Middle River, NS, from 1983–2019. The solid lines are the estimated values and the dashed lines are the 10th and 90th percentiles of the posterior probability densities for the estimates (indicative of the uncertainty of the estimates). The points in the upper panel are the population estimates obtained by mark-recapture during the dive surveys. The horizontal dashed line in the bottom panel indicates 100% of the conservation requirement.

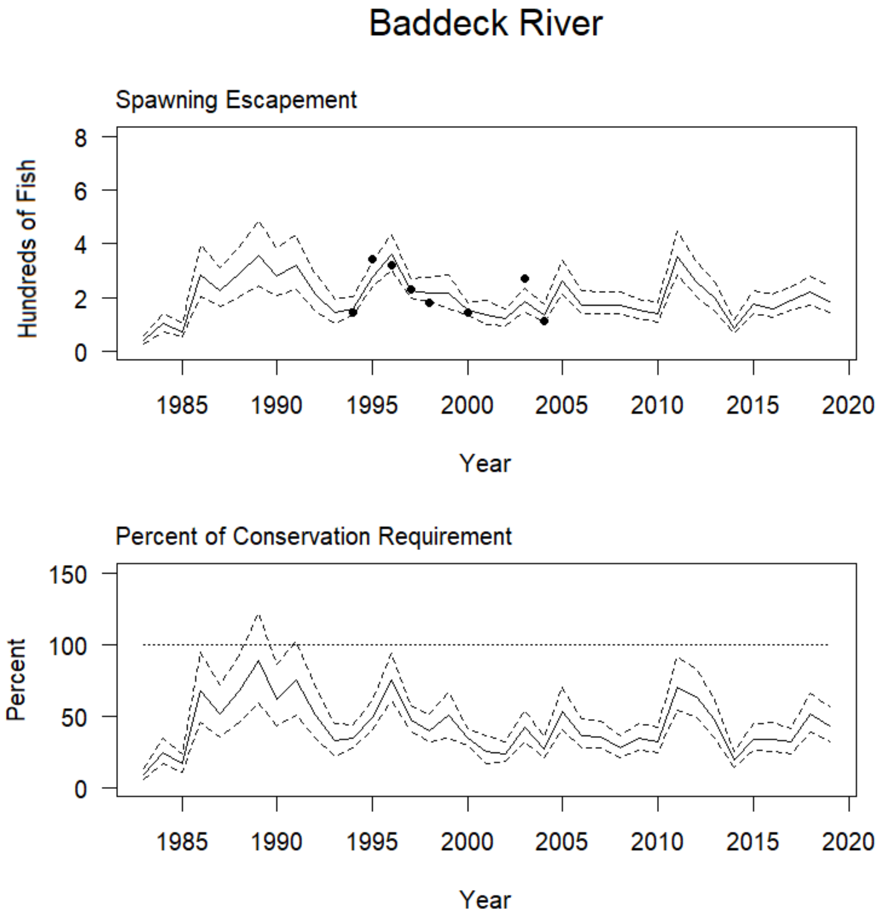

Figure 3. Estimated total number of spawners (top panel) and the percent of the conservation requirement attained (bottom panel) in Baddeck River, NS, from 1983–2019. The solid lines are the estimated values and the dashed lines are the 10th and 90th percentiles of the posterior probability densities for the estimates (indicative of the uncertainty of the estimates). The points in the upper panel are the population estimates obtained by mark-recapture during the dive surveys. The horizontal dashed line in the bottom panel indicates 100% of the conservation requirement.

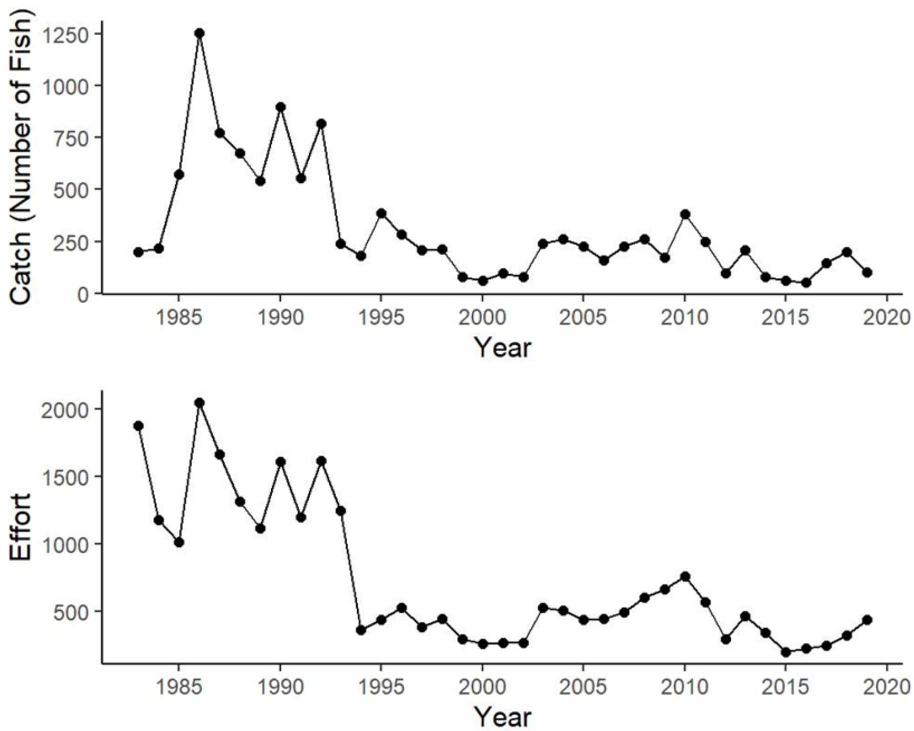

Figure 4. Estimated recreational catch (top panel) and fishing effort (bottom panel) of small and large Atlantic Salmon in North River, NS, from 1983–2019 (preliminary) based on salmon fishing license stub returns. Due to a change in management, retention of salmon has been prohibited since 1994.

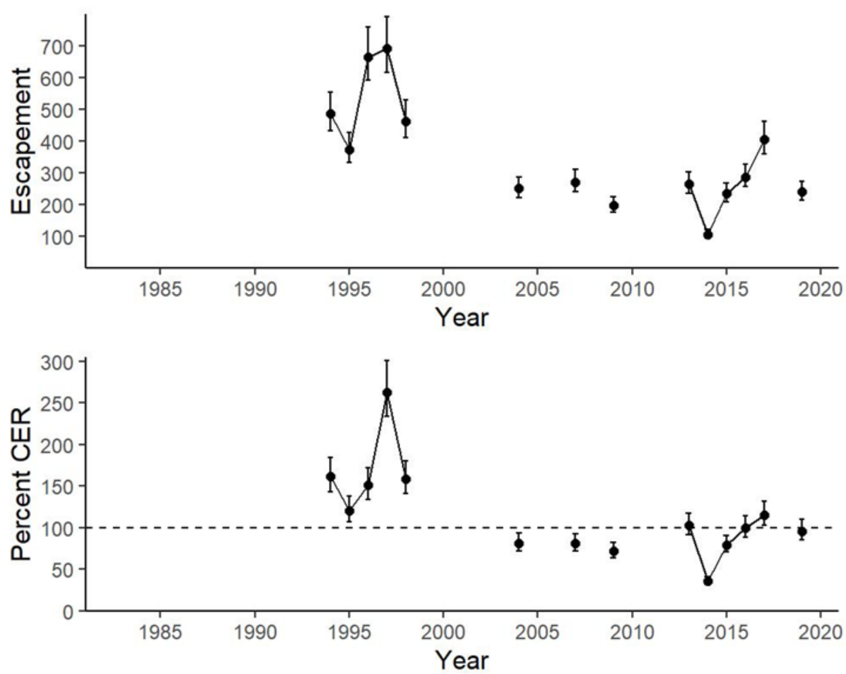

Figure 5 Estimated total escapement (top panel) and the percent of the conservation requirement attained (bottom panel) in North River, NS, from 1983–2019. Error bars represent the 95% confidence interval. The horizontal dashed line in the bottom panel indicates 100% of the conservation requirement.

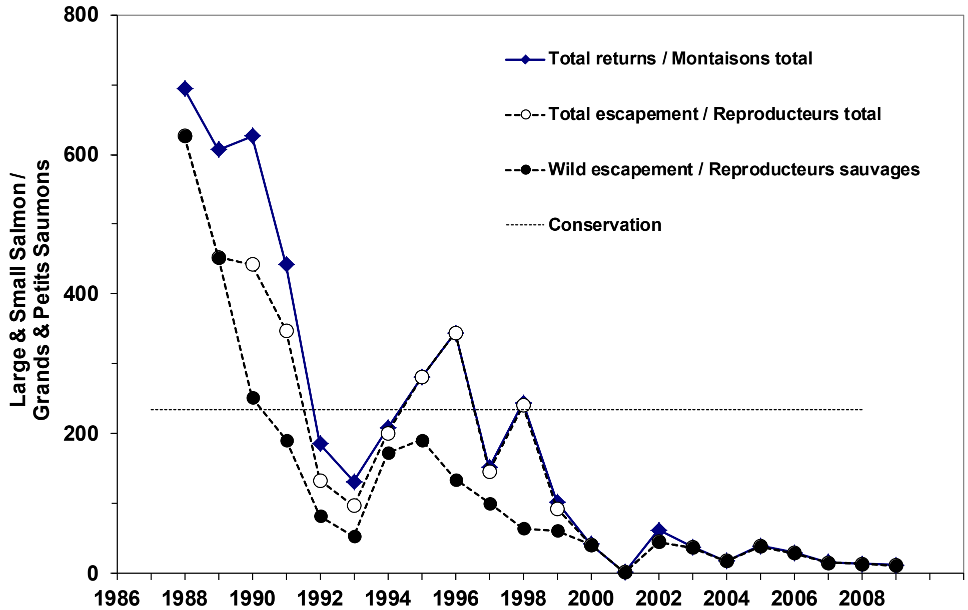

Figure 6. Total returns and escapement to the Grand River, NS, for large and small salmon from 1988–2009. Estimates derived from fishway counts and recreational catch data (pre-2000) and recreational catch data from 2000 onward. The approximate number of salmon (large and small combined) required to meet the conservation requirement is shown by the horizontal dashed line (Source: Levy and Gibson 2014).

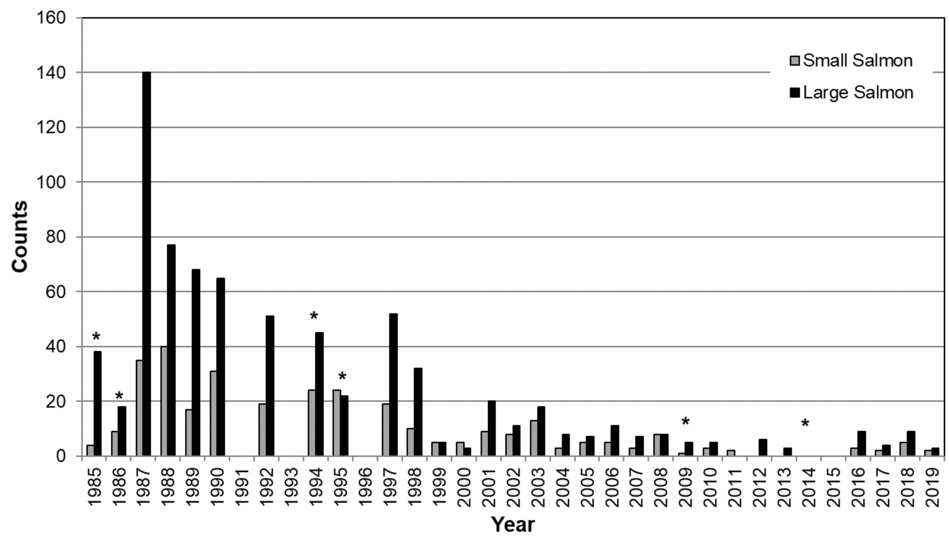

Figure 7. Counts of small (1SW) and large (2SW) Atlantic Salmon in Clyburn Brook, NS, from 1985 to 2019. Years where only the lower section of the river was surveyed (partial counts) are identified with an asterisk (*). No count was conducted in 1991, 1993, 1996, and 2015. Source: Parks Canada.

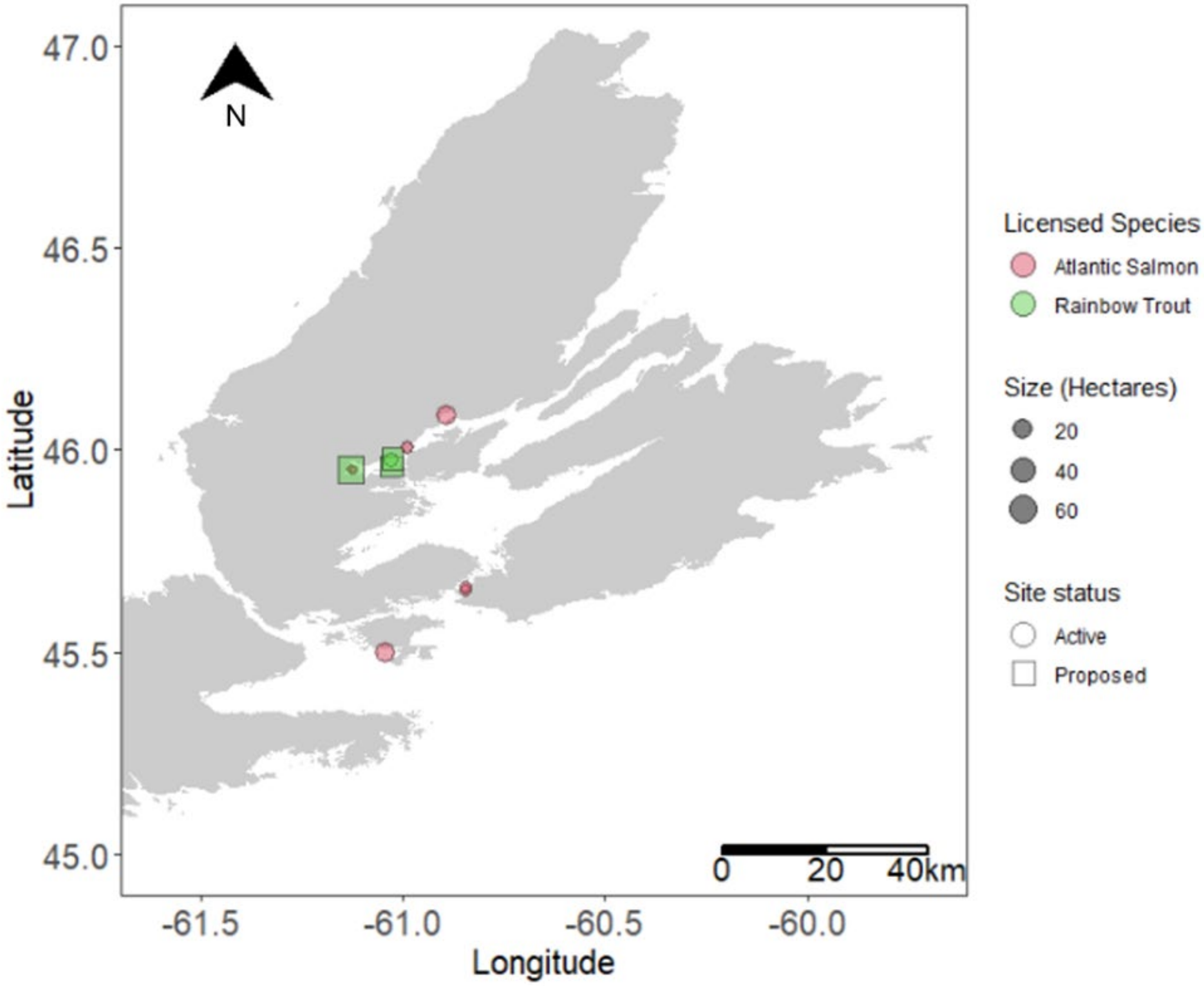

Figure 8. Locations, sizes, licensed species and site status of finfish aquaculture sites within the Eastern Cape Breton designatable unit. All sites licensed for Atlantic Salmon are also licensed for other trout species which are the predominant species of culture.

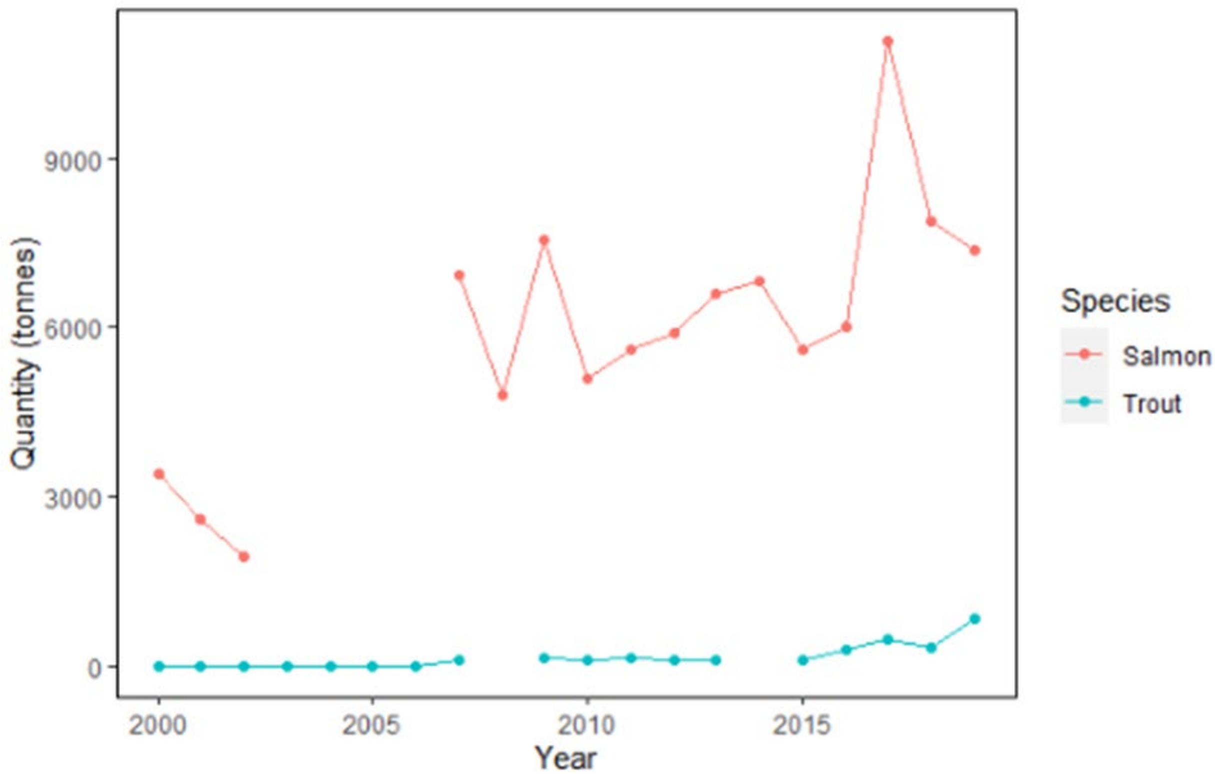

Figure 9. Aquaculture production of salmon and trout species for the province of Nova Scotia from 2000 to 2019.

APPENDIX

Table A1. Threats to Atlantic Salmon populations in the freshwater environment of the ECB DU (Gibson et al. 2014).

Threat Category	**Specific Threat**	**Level of Concern**	**Location or Extent‡**	**Occurrence and Frequency**	**Severity***	**Causal Certainty Evidence linking the threat to stresses in general**	**Causal Certainty Evidence for changes to viability of ECB salmon populations**
Freshwater Environment	Freshwater Environment	Freshwater Environment	Freshwater Environment	Freshwater Environment	Freshwater Environment	Freshwater Environment	Freshwater Environment
Water quality and quantity	Acidification	**Low**	Low	A (potential) Continuous	High	High	Low
Water quality and quantity	Extreme temperature events	**Low**	Low	H, C and A Seasonal	Low	High	Low
Water quality and quantity	Altered hydrology	**Medium**	Low (or unknown)	H, C and A Recurrent	Negligible to High (dependent upon timing and magnitude of alteration)	High	Low
Water quality and quantity	Water extraction	**Low**	Low	H, C and A Recurrent	Negligible to High (dependent upon timing and magnitude of	High	Low

Threat Category	Specific Threat	Level of Concern	Location or Extent‡	Occurrence and Frequency	Severity*	Causal Certainty Evidence linking the threat to stresses in general	Causal Certainty Evidence for changes to viability of ECB salmon populations
					extraction/alteration)		
Water quality and quantity	Chemical contaminants	**Low**	Low	H, C and A Seasonal	Negligible to High (dependent upon concentration (dose) and time of exposure (duration)	High	Low
Water quality and quantity	Silt and sediment	**Medium**	High	H and C Continuous	Negligible to High (dependent upon concentration (dose) and time of exposure (duration)	High	Low
Changes to biological communities	Non-native species (fish)	**Medium**	Medium (15% of assessed populations with invasive	H, C and A Continuous	Medium	High	Low

Threat Category	Specific Threat	Level of Concern	Location or Extent‡	Occurrence and Frequency	Severity*	Causal Certainty Evidence linking the threat to stresses in general	Causal Certainty Evidence for changes to viability of ECB salmon populations
			fish documented)				
Changes to biological communities	Non-native species (other)	**Low**	Low	A Continuous	Low to High	Medium	Very Low
Changes to biological communities	Stocking for fisheries enhancement (Atlantic Salmon – using traditional methods)	**Medium**	Medium (two rivers stocked by NSDFA in 2010 and 2011).	H and C Continuous	Low to Extreme (dependent upon number of fish stocked and length of period of stocking)	High (rate of fitness recovery after stocking ends is unknown)	Low
Changes to biological communities	Stocking (Atl. Salmon - current)	**Low**	Low (two rivers stocked by DFO in 2011)	C and A Continuous	Low to High	High	Low
Changes to biological communities	Other salmonid stocking (rainbow – including the Bras d'Or Lakes, brown,	**Medium**	Medium	H, C and A Continuous	Low to High (dependent upon number stocked and type of recipient waterbody	Medium	Low

Threat Category	Specific Threat	Level of Concern	Location or Extent‡	Occurrence and Frequency	Severity*	Causal Certainty Evidence linking the threat to stresses in general	Causal Certainty Evidence for changes to viability of ECB salmon populations
	and Brook Trout)				(lake versus. river)		
Changes to biological communities	Salmonid aquaculture (commercial hatcheries)	**Low**	Low	H, C and A Continuous	Medium	High	Low
-	Changes in predator or prey abundance	**Medium**	High	C and A Seasonal	Low to High	Medium	Low
-	Genetic effects of small population size	**Medium**	Medium	H, C and A Continuous	Negligible to High (dependent upon length of time at small population size, stocking history, and site specific conditions)	High	Low
-	Allee (small population size) effects	**Low**	Medium	H, C and A Continuous	High	Medium	Low

Threat Category	Specific Threat	Level of Concern	Location or Extent‡	Occurrence and Frequency	Severity*	Causal Certainty Evidence linking the threat to stresses in general	Causal Certainty Evidence for changes to viability of ECB salmon populations
-	Scientific Activities	**Low**	Low (Five Index Rivers and occasional surveys/ sampling of other rivers)	H, C, A Seasonal	Low	Low	Low
Physical obstructions	Dams, water diversions and permanent structures	**Low**	Low	H, C and A Continuous	Medium to Extreme (Dependent upon design of structure and location within watershed)	Very High	Low
Physical obstructions	Reservoirs	**Low**	Low	H, C and A Continuous	Low to High (Dependent upon size of individual reservoirs and number in series on a system)	High	Low
Physical obstructions	Culverts	**Medium**	Very High	H, C and A Seasonal	Low to High (dependent	High	Low

Threat Category	Specific Threat	Level of Concern	Location or Extent‡	Occurrence and Frequency	Severity*	Causal Certainty Evidence linking the threat to stresses in general	Causal Certainty Evidence for changes to viability of ECB salmon populations
					upon design and condition of culvert, and location in watershed)		
Habitat alteration	Infrastructure (roads, power lines, etc.)	**Medium**	Very High (all rivers)	H, C and A Continuous	Low to High (dependent upon road density within watershed or sub-watershed)	Medium	Low
Habitat alteration	Hydro power generation	**Low**	Low	H, C and A Continuous	Low to Extreme (dependent upon facility design and operating schedule)	High	High
Habitat alteration	Pulp and paper mills	**Low**	Low	H Continuous	Medium to High (Dependent upon process used and effluent	High	Low

Threat Category	**Specific Threat**	**Level of Concern**	**Location or Extent‡**	**Occurrence and Frequency**	**Severity***	**Causal Certainty Evidence linking the threat to stresses in general**	**Causal Certainty Evidence for changes to viability of ECB salmon populations**
					discharge quality)		
Habitat alteration	Urbanization	**Low**	Medium	H, C and A Continuous	Low to High (dependent upon density and infrastructure development)	High	Medium
Habitat alteration	Agriculture	**Low**	Medium	H, C and A Seasonal	Low to High (dependent upon extent within watershed and practices used)	Medium	Low
-	Forestry	**Medium**	High	H, C and A Continuous	Low to High (dependent upon extent within watershed and practices used)	Medium	Low
-	Mining	**Low**	Unknown	H, C and A Continuous	Low to High (dependent	Medium	Low

Threat Category	Specific Threat	Level of Concern	Location or Extent‡	Occurrence and Frequency	Severity*	Causal Certainty Evidence linking the threat to stresses in general	Causal Certainty Evidence for changes to viability of ECB salmon populations
					upon type of mine, processes used, and susceptibility to acid rock drainage)		
-	Habitat alterations from fishing activities	**Low**	High	H, C and A Seasonal	Low (for current fisheries and fishing gears)	Medium	Low
Directed salmon fishing (current)	Indigenous fishery	**Low**	Low (at current reported levels)	H, C and A Seasonal	Negligible to Very High	Very High	High
Directed salmon fishing (current)	Recreational fishery (angling)	**Low**	Low	H, C and A Seasonal	Negligible to High	Very High	High
Directed salmon fishing (current)	Illegal fishing / Poaching	**High**	Unknown (but potentially high)	H, C and A Seasonal	Low to Very High (dependent on number of salmon	Very High	Medium

Threat Category	**Specific Threat**	**Level of Concern**	**Location or Extent‡**	**Occurrence and Frequency**	**Severity***	**Causal Certainty Evidence linking the threat to stresses in general**	**Causal Certainty Evidence for changes to viability of ECB salmon populations**
					removed and size of impacted population)		
Bycatch in other fisheries	Indigenous or commercial fisheries	**Low**	High	H, C and A Seasonal	Low	High	Low
Bycatch in other fisheries	Recreational fisheries for other species	**Low**	High	H, C and A Seasonal	Low	High	Low
Bycatch in other fisheries	Recreational fishery: illegal targeting of Atlantic Salmon while fishing under a general license	**Medium**	High	H, C and A Seasonal	Low to High (dependent upon angling pressure)	High	Low

Table A2. Threats to Atlantic Salmon populations in the Estuarine environment of the ECB DU (Gibson et al. 2014).

Threat	**Specific Threat**	**Level of Concern**	**Location or Extent‡**	**Occurrence and Frequency**	**Severity ***	**Causal Certainty Evidence linking the threat to stresses in general**	**Causal Certainty Evidence for changes to viability of ECB salmon populations**
Estuarine Environment	Estuarine Environment	Estuarine Environment	Estuarine Environment	Estuarine Environment	Estuarine Environment	Estuarine Environment	Estuarine Environment
Changes to biological communities	Non-native species	**Low**	High	C and A Continuous	Low	Low	Low
Changes to biological communities	Salmonid aquaculture	**High**	Very High (because the spatial extent of potential impacts is very large, this can include salmon farms outside the DU)	H, C and A Continuous	Medium to High (dependent upon location of aquaculture facilities and operating practices)	High	Low
Changes to biological communities	Other species aquaculture	**Low**	Very High (all populations)	H, C and A Seasonal	Negligible to Medium (dependent upon species under culture, location of	Low	Low

Threat	Specific Threat	Level of Concern	Location or Extent‡	Occurrence and Frequency	Severity *	Causal Certainty Evidence linking the threat to stresses in general	Causal Certainty Evidence for changes to viability of ECB salmon populations
					facility, and operating practices)		
Changes to biological communities	Diseases and parasites	**High**	Very High (all populations)	H, C and A Continuous	Low to High (dependent upon irruptive behavior of disease/parasites resulting in outbreaks)	High	Low
Changes in oceanographic conditions	Marine ecosystem change (including shifts in oceano-graphic conditions and changes in predator/prey abundance)	**High**	Very High (all populations)	H, C and A Continuous	Low to Extreme (dependent upon magnitude of change and sensitivity of salmon to change)	High	Low

Threat	Specific Threat	Level of Concern	Location or Extent‡	Occurrence and Frequency	Severity *	Causal Certainty Evidence linking the threat to stresses in general	Causal Certainty Evidence for changes to viability of ECB salmon populations
Physical or abiotic change	Contaminants and spills (land- or water-based)	**Low**	Very High (all populations)	H, C, A Episodic	Low to Extreme (dependent upon identity and magnitude of contamination, and efficacy of cleanup)	Low	Low
Physical or abiotic change	Shipping, transport, noise, seismic activity	**Low**	Very High (all populations)	H, C and A Seasonal	Uncertain; likely Negligible to Low (dependent upon proximity to source of noise/activity)	Low	Low
Physical or abiotic change	Pulp and paper mills	**Low**	Very low (one mill, currently)	H and C Continuous	Medium to High (Dependent upon process used and effluent	High	Low

Threat	Specific Threat	Level of Concern	Location or Extent‡	Occurrence and Frequency	Severity *	Causal Certainty Evidence linking the threat to stresses in general	Causal Certainty Evidence for changes to viability of ECB salmon populations
					discharge quality)		
Directed salmon fisheries	Subsistence fisheries (Indigenous and Labrador residents)	**Low**	Low	H, C and A Seasonal	Negligible	High	High
Directed salmon fisheries	International fisheries (Greenland, St. Pierre – Miquelon)	**Medium**	Very High (all populations)	H, C and A Seasonal	Negligible to High	High	Medium
Directed salmon fisheries	Commercial fisheries (Local)	**Low**	Low	H and A Seasonal	Low	High	Low
Bycatch in other fisheries	Commercial fisheries	**Medium**	Very High (all populations)	H, C and A Seasonal	Low to High (dependent upon target species, gear and timing)	High	Low
Fisheries on prey species of salmon	Commercial Fisheries	**Low**	Very High (all populations)	H, C and A Seasonal	Low to High (dependent upon reduction of	Low	Low

Threat	Specific Threat	Level of Concern	Location or Extent[‡]	Occurrence and Frequency	Severity *	Causal Certainty Evidence linking the threat to stresses in general	Causal Certainty Evidence for changes to viability of ECB salmon populations
					prey species and availability of other forage species)		