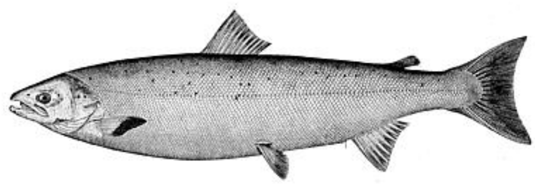
# STOCK STATUS OF ATLANTIC SALMON (*SALMO SALAR*) IN DFO GULF REGION (SALMON FISHING AREAS 15 TO 18)



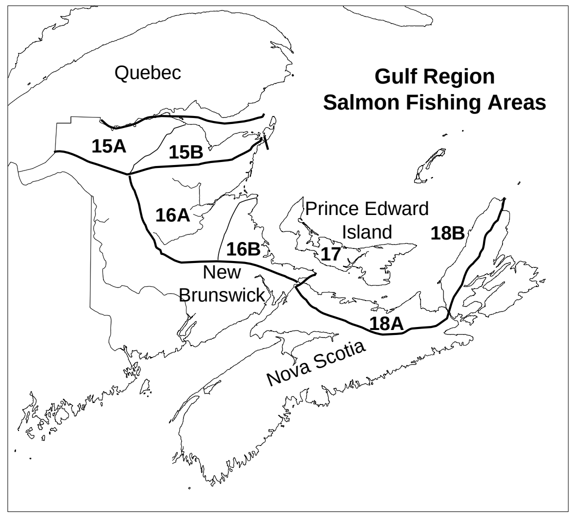



*Figure 1: Salmon fishing areas (SFA) in DFO Gulf Region.*

## Context :

*Atlantic salmon (*Salmo salar*) is broadly distributed in most rivers of the southern Gulf of St. Lawrence and is exploited by aboriginal communities and in recreational fisheries. The last assessments of stock status of Atlantic salmon were completed after the 2009 return year in support of the development of a status report for the species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Breau et al. 2009; Cairns et al. 2010; Cameron et al. 2009; Chaput et al. 2010). COSEWIC recently concluded that all the salmon populations from the southern Gulf of St. Lawrence and those in the Gaspé region of Québec (zones Q1 to Q3) were one designatable unit and assessed its status as "special concern" (COSEWIC 2010).*

*In support of the Gulf Region Integrated Fisheries Management Plan for Atlantic salmon, DFO Fisheries and Aquaculture Management (FAM) requested an assessment of the status of the Atlantic salmon stocks in DFO Gulf Region and an evaluation of the impacts of present and alternative fishery management measures for Atlantic salmon.*

*The assessments were reviewed and management advice developed during a regional advisory process meeting held in Moncton (N.B.) during March 12 to 14, 2012. Participants at the meeting included DFO Science, DFO Habitat Management, and DFO FAM from Gulf Region, DFO Science from Newfoundland and Labrador, Maritimes, and Central and Arctic regions, aboriginal communities, watershed associations, provincial governments, and conservation organizations.*

## SUMMARY


- Atlantic salmon in DFO Gulf Region are harvested in Aboriginal Food, Social and Ceremonial (FSC) fisheries and in recreational fisheries. All recreational fisheries for large (>= 63 cm fork length) salmon are mandatory catch-and-release.

- Atlantic salmon occupy 115 rivers (that empty into estuaries) in the southern Gulf of St. Lawrence (DFO Gulf Region). Sixty percent of these are small rivers with conservation egg requirements of less than 0.5 million eggs, equivalent to about 100 large salmon. Only four rivers are large and have conservation egg requirements that exceed 15 million eggs each.

- Returns of large salmon to Gulf Region overall in 2011 were estimated to be about 75,000 fish and at near maximum levels over the 1970 to 2011 time series. Large salmon spawners in 2011 were also estimated to be at record levels in Gulf Region and individual Salmon Fishing Areas (SFA).

- Small salmon (< 63 cm fork length) returns for Gulf Region in 2011 were estimated at about 73,000 fish and near the highest levels estimated since 1994 but were still low relative to the returns estimated during 1985 to 1993 (85,000 to 190,000 fish) and in several years during the 1970s.

- The high abundance of large salmon in 2011 was preceded by greatly improved returns of small salmon in 2010 in most areas. The improved returns in 2010 and 2011 were the result of improved marine survival of the 2009 smolt migration.

- Adult assessments are only conducted for the five largest rivers in Gulf Region: Restigouche River, Nepisiguit River, Northwest Miramichi River, Southwest Miramichi River, Margaree River.

- Conservation requirements, in terms of eggs from all size groups, were exceeded in all assessed rivers in 2011 including the Restigouche River (SFA 15A), Nepisiguit River (SFA 15B), the Northwest and Southwest Miramichi rivers (SAFA 16A), and the Margaree River (SFA 18B). The Northwest Miramichi River only achieved conservation requirements twice (2001 and 2011) during the 1998 to 2011 period.

- Removal rates on large salmon in Gulf Region overall are estimated to be in the range of 3% to 6% of total returns. Removal rates on small salmon are estimated to be in the range of 17% to 40% annually although in absence of reliable and complete harvest data these estimates are based on assumptions of catch rates and losses. Exploitation rates in individual rivers will vary from these depending upon the intensity of the aboriginal FSC and recreational fisheries.

- The drift surface gillnet fishery for mackerel which occurs in June in the southern Gulf of St. Lawrence likely has the greatest potential for salmon bycatch. This fishery would be expected to intercept salmon from rivers of Gulf Region and likely rivers in Quebec as well.

- The fishery at West Greenland exploits salmon from Gulf Region rivers with an estimated 3% to 10% of the total two-sea-winter salmon from Gulf Region rivers annually harvested in this fishery over the past five years.

- Because of undocumented harvests in aboriginal fisheries and incomplete or absent statistics on catches and harvests in the recreational fisheries, assessment of the effectiveness of management measures cannot be provided. Assumptions must be made to assess spawning escapements and compliance with conservation egg requirements.

- There are currently about 23 rivers out of 71 rivers historically in SFA 17 (PEI) with confirmed salmon populations. Salmon production in this area is constrained by sediment input from agricultural and other sources, fish kills due to pesticide inputs, water quality problems (low dissolved oxygen, high temperatures), competition with introduced rainbow trout, and habitat fragmentation due to artificial dams and improperly installed culverts.

- Proposed catch and release kelt fisheries are expected to have minimal impact on salmon conservation in rivers in SFA 18A (River Philip and West River Antigonish).

## INTRODUCTION

All rivers flowing into the southern Gulf of St. Lawrence are included in Fisheries and Oceans Canada (DFO) Gulf region (Fig. 1; Appendix Figure 1). Atlantic salmon (*Salmo salar*) management areas in DFO Gulf Region are defined by four salmon fishing areas (SFA 15 to 18) encompassing the three Maritime provinces (New Brunswick, Nova Scotia, and Prince Edward Island).

For management purposes, Atlantic salmon are categorized as small salmon (grilse; fish with a fork length less than 63 cm) and large salmon (fish with a fork length equal to or greater than 63 cm). When ages are determined, one-sea-winter (1SW) salmon refers to maiden fish which have spent one year at sea and two-sea-winter (2SW) salmon refers to maiden fish which have spent two years at sea. Repeat spawners are generally found in the large salmon group as repeat spawners grow after going to sea to recondition after spawning and usually return at lengths greater than 63 cm. The majority of salmon in small rivers return in the fall. Early (May to August) as well as fall runs are important in the larger rivers of the area, including Margaree, Miramichi and several rivers of Chaleur Bay (SFA 15; Nepisiguit, Jacquet) whereas runs to the Restigouche are essentially only early. Bright salmon refer to salmon returning to rivers to spawn during May to November. Kelt salmon (or black salmon) are post-spawned salmon, found in the river in the winter or returning to the ocean in the spring.

Anadromous Atlantic salmon populations in Gulf Region are comprised of important proportions of 1SW, 2SW, 3SW and repeat spawners. Small salmon, mostly 1SW fish, in SFAs 15 to 18 are the majority males (> 90%) with the exception of early run small salmon in parts of the Miramichi which can be comprised of larger percentages (up to 40%) of females. Large salmon, consisting mostly of 2SW, 3SW and repeat spawners, are predominantly female.

Juvenile salmon spend from two to four years in rivers before migrating to sea as smolts, a migration which takes place in May and June. Salmon from Gulf Region can undertake long seaward migrations, as far as Greenland and occasionally in the northeast Atlantic (east of Iceland) to feed.

# ANALYSIS

## Fisheries

All commercial fisheries for Atlantic salmon in Gulf Region have been closed since 1984. Since then, Atlantic salmon have been harvested by two user groups: Aboriginal peoples and recreational fishers. Since 1998, all salmon fisheries have been prohibited in southeast New Brunswick (SFA 16B; Fig. 2) but salmon are fished in all other Salmon Fishing Areas of Gulf Region.

### Aboriginal Food, Social and Ceremonial Fisheries

Aboriginal peoples are given first access to salmon, after conservation requirements, based on communal needs for food, social and ceremonial purposes. Aboriginal fisheries occur annually in the rivers of the southern Gulf of St. Lawrence that are open to salmon fisheries and generally in accordance with agreements and communal fishing licenses (Table 1). Many of the aboriginal fisheries take place in estuaries using gillnets and to a lesser extent trapnets. Salmon are also angled in rivers. In some communities, kelt salmon are allocated and harvested.

*Table 1. Allocations (number of fish) by size group of salmon specified within Aboriginal Fisheries Agreements for 2011 by Salmon Fishing Area and when appropriate by individual river.*

| | 2011 | |
|---|---|---|
| SFA (River[1]) | Small salmon | Large salmon |
| SFA 15A (Restigouche) | 530 | 610 |
| SFA 15B | 525 | 0 |
| SFA 16A (Miramichi and Tabusintac) | 11,832 | 1,304 |
| SFA 16B | Closed | Closed |
| SFA 17 | | 0 |
| - Mill, Trout (Coleman), Morell, and West rivers | 200 | |
| - Not specified | 250 | |
| SFA 18A[2] | 85 | 147 |
| SFA 18B[2] (Margaree) | 135 | 335 |
| SFA 18 (not specified)[3] | 1,820 | |

[1] when available, river specific allocations are provided
[2] kelt salmon allowed but numbers not specified
[3] Nova Scotia Native Council has access to 1,820 fish (small and large combined) throughout SFA 18 (no river-specific allocations)

### Recreational fisheries

All recreational fisheries for large salmon are mandatory catch-and-release. A provincial licence is required to fish for Atlantic salmon. Only fly fishing with artificial flies is permitted in the recreational salmon fishery. The angling season for salmon in the Gulf region varies among and within SFAs but generally begins in mid April for the kelt fishery and closes at the end of October in parts of SFA 18. All retained small salmon must be tagged with a single-use carcass tag which is provided with the purchase of a salmon angling licence.

Retention fisheries for small salmon are regulated by daily and seasonal bag limits (Fig. 2). There is a maximum daily catch and release limit of four fish of any size during the bright angling season and ten during the kelt angling season where this latter fishery is allowed. In New Brunswick, the season bag limit for small salmon is eight (including retained small salmon during the kelt fishery) with a daily retention limit of two or one in the case of the Miramichi River

(SFA 16A) and the Nepisiguit River (SFA 15B). The season retention limit for small salmon in SFA 18 (Gulf Nova Scotia) was reduced from eight to four in 2008 with a daily retention limit of two small salmon.

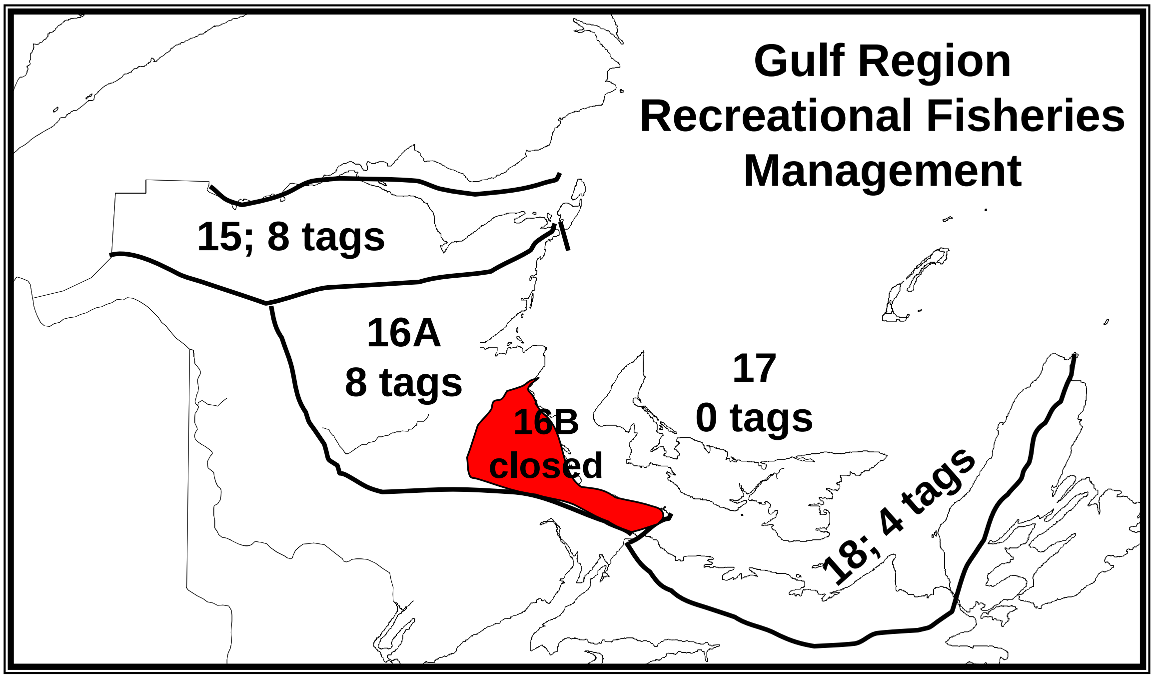



*Figure 2: Recreational fisheries management in Gulf Region in 2011 showing season retention limits for small salmon by Salmon Fishing Area.*

The largest number of salmon licences are issued in New Brunswick followed by Nova Scotia and Prince Edward Island (Table 2). In 2011, 23,317 licences were issued in New Brunswick and the total number of small salmon tags issued was just over 157,000. For Nova Scotia, 2,491 Atlantic salmon licences were issued in 2011 for a combined total retention tags of 9,964, about half the number of tags issued prior to 2008 (Table 2). Only 204 salmon licences were issued in Prince Edward Island in 2011, all were catch-and-release.

*Table 2. Number of recreational fishing licences and the total number of carcass tags issued by province for the retention of small salmon between 2007 and 2011. The number of tags per licence can vary by licence type for New Brunswick.*

| Province | | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|
| New Brunswick | Licences | 21,532 | 21,846 | 23,939 | 22,507 | 23,317 |
| | Tags | 143,268 | 147,452 | 164,038 | 153,352 | 157,002 |
| Nova Scotia | Licences | 2,310 | 2,200 | 2,394 | 1,938 | 2,491 |
| | Tags | 18,480 | 8,800 | 9,576 | 7,752 | 9,964 |
| Prince Edward Island | Licences | 258 | 223 | 129 | 143 | 204 |
| | Tags | 516 | 446 | 0 | 0 | 0 |

## Catches and harvests

A distinction is made between the terms catch and harvest. Harvest refers to salmon which are deliberately retained in fisheries and include small salmon retained in recreational fisheries and small salmon and large salmon retained in aboriginal fisheries. Catch includes retained fish and salmon which are caught and released in salmon recreational fisheries.

Harvests from aboriginal fisheries include only values reported by the aboriginal peoples to DFO. Reports in all SFAs are incomplete.

*Table 3. Reported harvests of small salmon and large salmon by SFA in aboriginal fisheries for food, social and ceremonial purposes.*

| Salmon Fishing Area | | 2007[1] | 2008[1] | 2009[1] | 2010[1] | 2011[1] |
|---|---|---|---|---|---|---|
| SFA 15 | Small | na | na | na | na | 113 |
| | Large | | | | | 513 |
| SFA 16 | Small | na | na | na | 2,895 | 2,130 |
| | Large | | | | 787 | 526 |
| SFA 17 | Small | 4 | 27 | 0 | 1 | 0[2] |
| | Large | 0 | 0 | 0 | 0 | 0[2] |
| SFA 18 | Small | na | na | na | na | na |
| | Large | na | na | na | na | 58 |

[1] Data are incomplete or not available
[2] Only one of two aboriginal groups reporting

For recreational fisheries, catch and harvest data are obtained using various methods. Angling catch data are available from the two largest rivers of SFA 15; the Restigouche River (SFA 15A) and the Nepisiguit River (SFA 15B). Catches in the Restigouche River are based on lodge catch reports compiled by DFO Science Branch and Crown Reserve angling catches compiled by the provinces of New Brunswick and Quebec and exclude catches from public water. There is limited public water in the Restigouche River but angling effort in the few public water stretches can be quite high in some years, including 2011. Angling data from the Nepisiguit River are compiled by the Nepisiguit Salmon Association through a creel survey and are adjusted based on observations from previous years for unsurveyed periods and sections of river.

For SFA 16, catch and effort data were available to 1995 (and in 1997) from a provincial post-season mail-out survey to a subset of licenced anglers. The last year of the survey was 1997 and since then, no complete recreational catch and effort data are available. The Miramichi is the largest river in SFA 16 and historically accounted for over 90% of the angling catch and effort in this SFA. For assessment purposes, catches for 1996 and the years after 1997 are estimated from average exploitation rates based on the 1991 to 1995 period and calculated as angling catches (retained, released by size group) divided by the estimated returns to the Miramichi River.

In Nova Scotia, anglers receive licence stubs with their licences. The anglers are required to keep track of days fished (effort) and fish captured (retained and released). At the end of the fishing season, anglers must return their licence stubs to the provincial authority but not all licence holders do so. Data are compiled by DFO Science Branch. The response rate in previous years has varied from 25% to 40% per year and higher return rates are achieved only with reminder letters. In 2011, 642 licence stubs (out of 2,491) were returned by anglers in Nova Scotia, a 26% response rate, before reminder notification. Estimates of total catches and harvests are obtained by raising the returned licence stub catch and effort values to total licence sales.

Estimated small salmon catch in the Restigouche River (NB) in 2011 increased from 2010 and the means of previous decades although the catch level was within the range (1,372 to 6,193) of values recorded during 1984 to 2011. The large salmon catch in 2011 was the highest value over the time series 1984 to 2011 during which the catches ranged from 1,173 to 4,894 fish. Estimated angling catch in 2011 of small salmon in the Nepisiguit River was the second highest since 1987 and the large salmon catch was the second highest since 1988 (Table 4).

Although the 2011 angling data are preliminary for SFA 18, the estimated catch of small and large salmon in 2011 was well above the mean values of previous decades. The estimated catch of small salmon in SFA 18A exceeded the range of past years (1984 - 2010: 60 to 857 fish) whereas the estimated catch in SFA 18B was within the range of values recorded over the same time period (179 to 1,259 fish). The estimated catch of large salmon was the highest of the time series (SFA 18A: 104 to 2,117 and SFA 18B: 334 to 2,702).

*Table 4. Catches (including retained and released fish) and effort by SFA during the bright salmon recreational fishery, 1984 to 2011. In the table, "na" refers to not available.*

| | | Mean (1984-1994) | Mean (1995-2004) | Mean (2005-2009) | 2010 | 2011 |
|---|---|---|---|---|---|---|
| SFA 15A Restigouche River [1] | Effort | 10,709 | 10,589 | 9,712 | 9,806 | 10,431 |
| | Small | 3,685 | 3,085 | 3,298 | 3,868 | 4,836 |
| | Large | 3,149 | 1,992 | 2,379 | 2,099 | 5,281 |
| SFA 15B Nepisiguit | Effort | na | na | na | na | na |
| | Small | 880 | 460 | 630 | 976 | 1,210 |
| | Large | 366 | 300 | 200 | 300 | 620 |
| SFA 16A (Miramichi) | Effort | 89,332 | na | na | na | na |
| | Small | 20,124 | na | na | na | na |
| | Large | 9,417 | na | na | na | na |
| SFA 16B | Effort Small Large | na | Closed since 1998 | Closed since 1998 | Closed since 1998 | Closed since 1998 |
| SFA 17 [2] | Effort | 5,674 | 4,611 | 2,721 | 1,065 | 2,067 |
| | Small | 1,312 | 523 | 159 | 72 | 68 |
| | Large | 197 | 118 | 61 | 32 | 68 |
| SFA 18A | Effort | 3,699 | 3,371 | 3,577 | 3,996 | 5,959 |
| | Small | 360 | 367 | 354 | 421 | 991 |
| | Large | 1,052 | 663 | 622 | 705 | 2,547 |
| SFA 18B | Effort | 12,556 | 8,766 | 8,874 | 7,361 | 10,098 |
| | Small | 675 | 451 | 420 | 444 | 707 |
| | Large | 1,655 | 1,220 | 1,175 | 1,264 | 2,924 |

[1] For border waters between New Brunswick and Quebec and waters within New Brunswick
[2] Estimates of catch in 2011 for SFA 17 based on angler card survey with 10% mail-in rate

The mortality associated with catch-and-release fishing varies among the SFAs. For SFA 15, a mortality rate of 6% is used. This value has been used since 1984 and is considered to account for a higher mortality rate than in other SFAs due to the prevalence of furunculosis (disease) which can contribute to mortalities. A 3% catch and release mortality value is used for released salmon in SFA 16 and SFA 17. A 5% catch and release mortality is applied to angling catches in rivers of Gulf Nova Scotia (SFA 18) because of the history of bacterial kidney disease in Atlantic salmon of the Margaree River.

Estimated losses of small salmon in the recreational fisheries are highest in SFA 16A whereas losses of large salmon are highest in SFA 15A (Table 5).

*Table 5. Losses (including retained catch and losses from incidental mortality in catch-and-release fisheries) by size group of salmon and by SFA during the bright salmon recreational fishery, 1984 to 2011.*

| | | Mean (1984-1994) | Mean (1995-2004) | Mean (2005-2009) | 2010 | 2011 |
|---|---|---|---|---|---|---|
| SFA 15A Restigouche River [1] | Small | 3,610 | 2,006 | 1,504 | 1,394 | 1,774 |
| | Large | 233 | 150 | 175 | 138 | 395 |
| SFA 15B Nepisiguit | Small | 663 | 295 | 347 | 517 | 730 |
| | Large | 22 | 16 | 12 | 18 | 37 |
| SFA 16A (Miramichi)[2] | Small | 20,124 | 7,970 | 6,451 | 13,183 | 11,470 |
| | Large | 282 | 174 | 163 | 162 | 307 |
| SFA 16B | Small | | Closed since 1998 | Closed since 1998 | Closed since 1998 | Closed since 1998 |
| | Large | | | | | |
| SFA 17 | Small | 599 | 301 | 67 | 2 | 2 |
| | Large | 0 | 4 | 2 | 1 | 2 |
| SFA 18A | Small | 263 | 204 | 107 | 144 | 252 |
| | Large | 53 | 33 | 31 | 35 | 127 |
| SFA 18B | Small | 538 | 212 | 222 | 198 | 273 |
| | Large | 83 | 61 | 59 | 63 | 146 |

[1] For border waters between New Brunswick and Quebec and waters within New Brunswick
[2] Estimated losses based on assumed exploitation rates (25% for small salmon, 30% for large salmon) and estimates of run size

## Conservation requirements

Conservation for Atlantic salmon is defined as an egg deposition rate of 240 eggs per 100 m² of wetted juvenile rearing habitat area (CAFSAC 1991a). This value is applied to all rivers in Gulf Region with the exception of the Restigouche River for which a value of 168 eggs per 100 m² of wetted area is used. The value for the Restigouche is based on a stock and recruitment analysis of index rivers in the province of Quebec and a reference spawning escapement that would result in the maximum surplus of fish.

Sixty percent of rivers in Gulf Region are small rivers with conservation egg requirements of less than 0.5 million eggs (Fig. 3). Only a few large rivers, Restigouche in SFA 15A, Southwest Miramichi, Northwest Miramichi and Little Southwest Miramichi in SFA 16A have conservation egg requirements that exceed 15 million eggs each (Appendix Table 1). At approximately 6,000 to 7,000 eggs per large salmon female and a sex ratio of about 80% female in the large salmon category, the conservation egg requirements would be met by about 100 large salmon in most of the small rivers.

Conservation requirements are considered to be equivalent to a limit reference point. Management of Atlantic salmon in eastern Canada and internationally has been based upon a fixed escapement strategy; all fish in excess of the conservation requirements are considered to be surplus and available for harvest (CAFSAC 1991b).

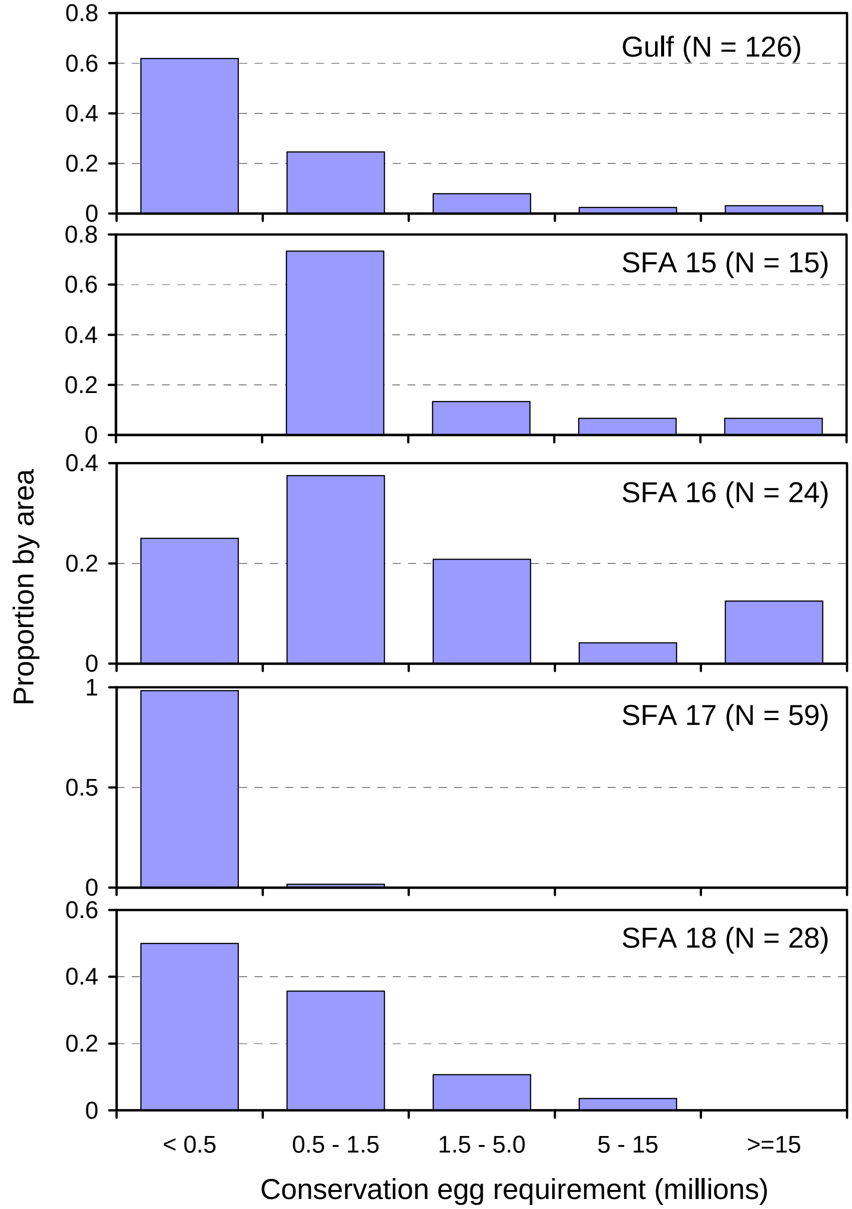



*Figure 3. Proportion of rivers within each SFA and for Gulf Region overall with defined conservation requirements by category of conservation egg requirements.*

## Abundance (returns and spawners) of adult salmon by SFA

### SFA 15A

Information on adult salmon abundance is available for the Restigouche River only and comes primarily from angling catches and effort as well as end of season spawner counts. Based on an assumed angling exploitation rate of 40%, returns to the Restigouche River (NB) were estimated at 13,500 large salmon and 12,100 small salmon (Fig. 4). After accounting for losses from fishing, the spawning escapement in 2011 was estimated at 12,900 large salmon spawners, 226% above the spawning requirement (5,700 for Restigouche NB). Based on an angling exploitation rate of 40%, the Restigouche NB has met spawner requirements in 6 of the last 11 years. This assumed angling exploitation rate is similar to that of the Matapedia which has averaged 41% over the past six years.

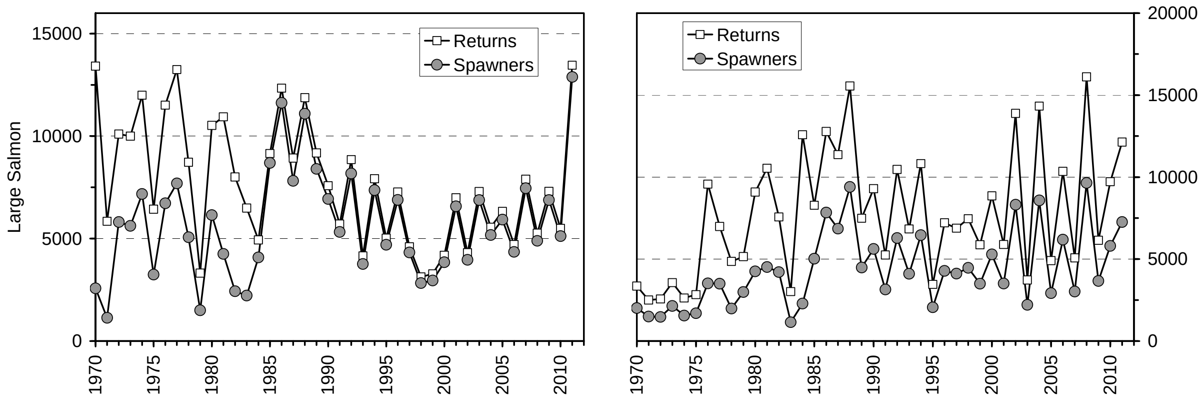



*Figure 4: Returns and spawners of large salmon (left) and small salmon (right) to Restigouche River (NB portion), 1970 to 2011, based on angling catches and an assumed exploitation rate of 40%.*

Assessments on the Restigouche River are also informed by spawner counts at the end of the season, after all fisheries and inriver losses. End of season spawner counts were conducted in 2011 on the Restigouche (NB) tributaries in late September to early October. Due to high water levels no counts were conducted on the mainstem Restigouche. Visibility was generally poor on the tributaries and counts derived from snorkelling should be considered a minimum estimate of spawners. When counts were conducted, spawners were already well distributed throughout the system due to the higher and cooler than normal water conditions. The total spawner counts were 1,570 small and 3,711 large salmon and break down as follows: Kedgwick counts were 228 small and 874 large salmon, Little Main Restigouche counts were 384 small and 1,219 large salmon and Upsalquitch counts were 861 small and 1,265 large salmon. Based on these, spawners were at or above conservation requirements for all three tributaries. The Kedgwick and Upsalquitch Rivers have been at or near conservation requirement in 7 of the last 13 years when spawner counts were completed whereas the Little Main Restigouche River has been at or near conservation requirement in only four years of the same time period.

Spawners in the Matapedia River (including Causapscal River) were 931 small and 3,063 large salmon, more than twice the conservation requirement. The spawners in the Matapedia system have exceeded the conservation requirement every year since 1993. Spawners in the Patapedia River (438 small and 985 large salmon) were over three times the conservation requirement for that tributary. The spawners in the Patapedia River have exceeded the conservation requirement every year since 1985.

## SFA 15B

For the Nepisiguit River, estimates of returns and escapements based on fence counts are generally incomplete. In recent years, estimates indicated that conservation requirements had been achieved in only 2 of 15 years when the stock was assessed (1982 to 1996).

A relationship between large salmon spawners and redds was derived from the years when complete counts of large salmon were obtained at the counting fence. Based on field studies specific to the Nepisiguit River, a general conversion rate of 2.5 redds per large female is used. Large salmon are assumed to average 71% female. The conservation requirement for the Nepisiguit River of 9.5 million eggs would be attained from 1,600 large salmon. Based on redd counts conducted in early November by the Nepisiguit Salmon Association, an escapement of

2,060 large salmon (127% of the egg conservation requirement) was estimated based on 3,653 redds observed. Estimates based on redd counts in late fall indicate that spawning escapement has been around the conservation requirement since 1994.

Counts of salmon at a protection barrier near the head of tide on the Jacquet River have frequently been incomplete due to washouts or late installations. Adult abundance in the Jacquet River exceeded the conservation requirement at the start of the time series (1994 to 1996) but in recent years, its status relative to conservation is unknown due to frequent washouts with partial counts have all been below the number of salmon required to meet conservation.

### SFA 16A

The Miramichi River is the largest river in SFA 16 and Gulf Region. Returns are estimated using catches and mark and recapture experiments at monitoring trapnets in tidal waters.

Estimated returns to the Miramichi River in 2011 were 34,090 large salmon (median; 95% confidence interval of 23,010 to 63,610) and 45,880 small salmon (95% C.I. 35,750 to 59,390) (Fig. 5). The large salmon return in 2011 was among the highest return estimated since 1970. Small salmon returns in 2011 were lower than in 2010 but equivalent to the highest estimates since 1994.

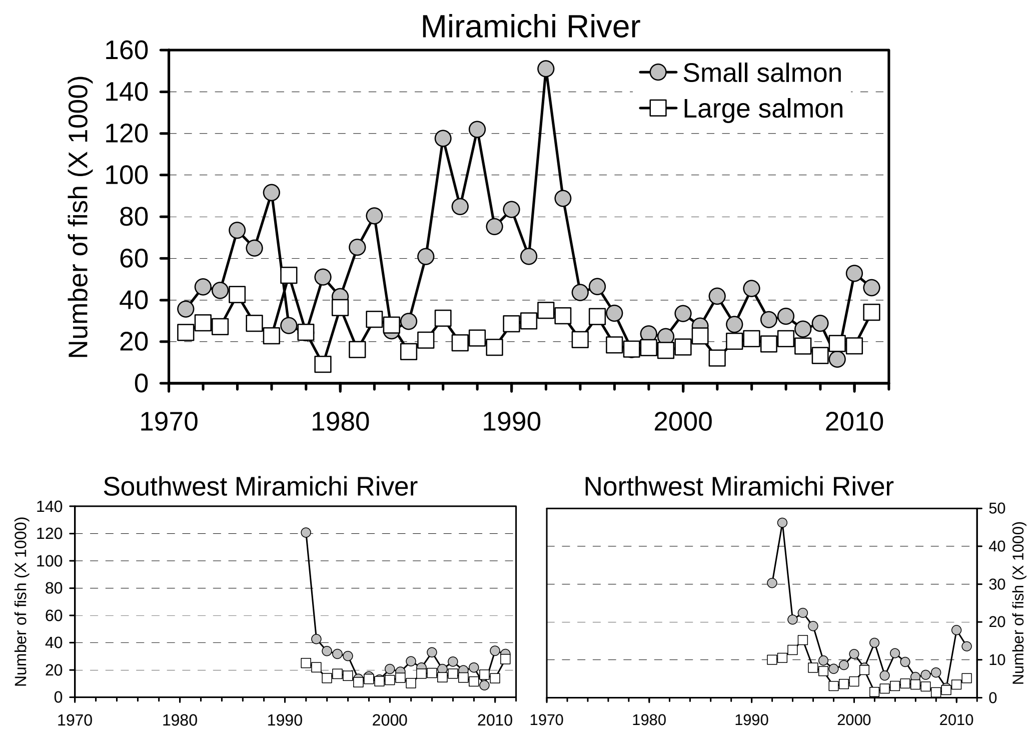



*Figure 5. Estimates (median) of large salmon and small salmon returns for the Miramichi River for 1970-2011 (upper panel), the Southwest Miramichi River 1992-2011 (lower left panel), and the Northwest Miramichi River 1992-2011 (lower right panel).*

Estimates for the two main branches of the Miramichi are available since 1992 (Fig. 5). The returns of large salmon to the Southwest Miramichi River in 2011 were estimated at 27,870 (95% C.I. 17,140-58,150) which was the highest since 1992. The return estimate of 31,710

(95% C.I. 22,360-45,890) small salmon to the Southwest Miramichi River was lower than in 2010 but equivalent to the highest return estimates since 1994. The returns of large salmon to the Northwest Miramichi River in 2011 were estimated at 5,147 (95% C.I. 3,180-8,813), an improvement over levels estimated during the preceding nine years but not as high as the 10 to 15 thousand large salmon estimated to have returned annually in the early 1990s. The estimated return of small salmon to the NW Miramichi River in 2011 was 13,550 (95% C.I. 9,976-18,680), down from 2010 but equivalent to highest levels estimated since 1997.

Considering the biological characteristics of salmon observed in 2011, total eggs in the returns of large salmon and small salmon were sufficient to attain 192% of the conservation requirement for the Miramichi River, 220% for the Southwest Miramichi River, and 132% for the Northwest Miramichi River (Fig. 6). After accounting for removals, the salmon escapement to the river was sufficient to meet 180% of the conservation requirement for the Miramichi River, 212% for the Southwest Miramichi River, and 109% for the Northwest Miramichi River (Fig. 6).

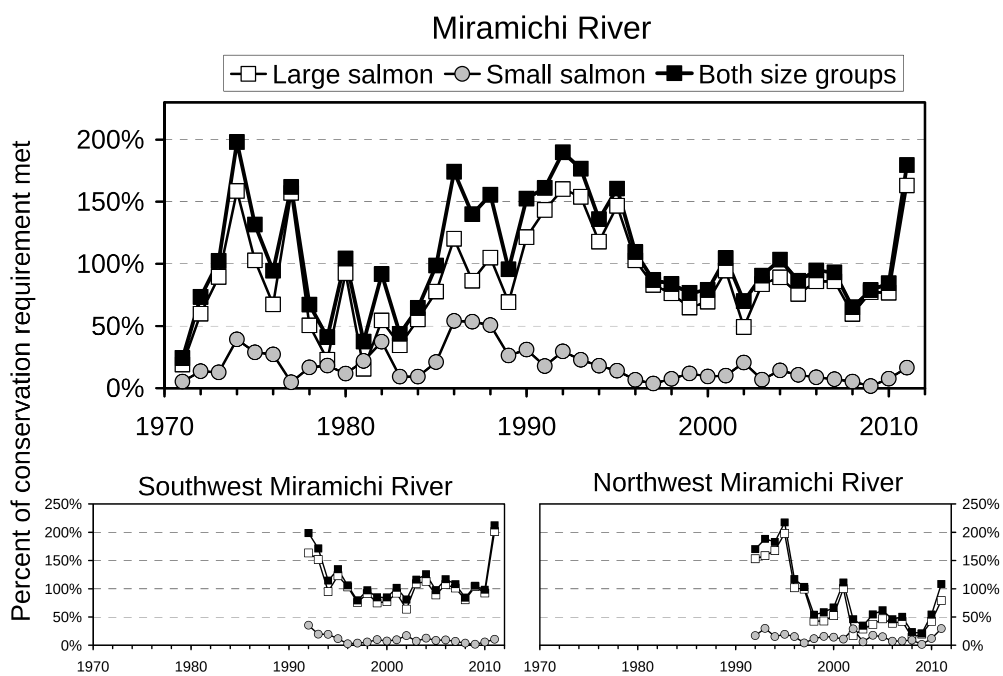



*Figure 6. Percentage of the conservation egg requirements achieved by large salmon spawners, small salmon spawners, and size groups combined for the Miramichi River overall (upper panel) and for the Southwest Miramichi (lower left panel) and the Northwest Miramichi (lower right panel).*

The escapement of salmon to the Miramichi River as a whole was sufficient to meet the egg deposition requirements repeatedly between 1992 and 1996 but only three times (2001, 2004, and 2011) during the period 1997 to 2011. The conservation requirement was attained on the Southwest Miramichi River between 1992 and 1996, and regularly (7 times and 3 marginal misses) between 1997 and 2011. The Northwest Miramichi River achieved conservation levels between 1992 and 1997 but only twice (2001 and 2011) during the 1998 to 2011 period.

A monitoring program for adult Atlantic salmon occurs in the Tabusintac River but this program has not evaluated the run size of Atlantic salmon since 1999. When last assessed, the Tabusintac River was exceeding its conservation requirement. Annual catches at the trapnets confirm that adult salmon return to spawn annually in this river.

### SFA 16B

Monitoring programs for adult Atlantic salmon have occurred in the Buctouche, Richibucto, and Kouchibouguacis rivers. These programs have not evaluated the run sizes of Atlantic salmon to these rivers since 2000 but trapnet catches confirm that adult salmon continue to migrate and spawn in these smaller rivers.

Stock status for these rivers is inferred from abundances of juvenile salmon which is described in the freshwater production section below.

### SFA 17

Salmon were widespread and abundant in the early historical period in SFA 17 and about 71 rivers are thought to have contained salmon. Salmon decreased in distribution and numbers after European settlement. Juvenile surveys conducted in 2000-2002 and in 2007-2008 found salmon in 28 and 22 rivers, respectively. With an additional river with salmon sampled in 2011, there are currently 23 rivers in SFA 17 with salmon presence confirmed.

Since 1990, redds have been counted in a large number of salmon rivers, either once or several times. Based on the most recent redd counts and a redd:female spawner ratio measured in the West River in 1990, female spawners are currently estimated at 662 and total spawners at 1,177 for all of SFA 17. With an estimated four mortalities due to fishing, total returns are estimated at 1,181 fish, size groups combined.

Estimated egg depositions are about 68% of conservation requirements for current salmon rivers, and 30% of conservation requirements for the 71 current and historic rivers. Six rivers are estimated to have exceeded their conservation requirements. Populations in several smaller rivers are very low and reproduction does not appear to occur every year, based on single year classes of juveniles in rivers. Salmon in these rivers are considered at risk of extirpation.

### SFA 18A

There are no direct counts of adult salmon in rivers of mainland Nova Scotia (SFA 18A) and catch per unit effort from the angling fishery is used as an index of abundance. Catch of large salmon and small salmon per rod day increased in River Philip and West River (Antigonish) during 2011 compared to the previous five-year average (2006-2010) (Fig. 7). Catch of large and small salmon per rod day on East River (Pictou) was similar to the previous five-year average. A snorkel count was conducted on Sutherland's River in November 2010. A total of 21 large and 18 small salmon were counted, close to the spawner requirement for this river of 25 large salmon.

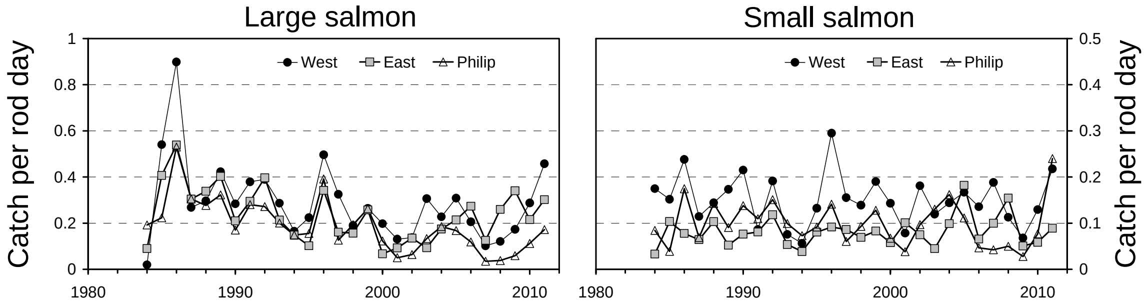



*Figure 7. Catch per rod day for large salmon (left panel) and small salmon (right panel) in three rivers of mainland Nova Scotia (SFA 18A).*

## SFA 18B

Angling catch of large salmon per rod day effort in the Margaree River in 2011 was the highest of the time series and the catch per rod day of small salmon was similar to the previous five-year average (Fig. 8). The returns of salmon to the Margaree River are assessed using an estimate of the catchability coefficient in the angling fishery based on years (1988 to 1996) when independent estimates of run size using mark and recapture experiments were available. The estimated return of large salmon to the Margaree River in 2011 was 5,200 large salmon (95% C.I. 4,300 – 6,200), the highest value over the period of assessment. The estimated return of small salmon to the Margaree River in 2011 was 1,120 fish (95% C.I. 850 – 1,480) and similar to levels throughout the time series. Large salmon returns and spawners to the Margaree River have exceeded the conservation requirement every year since 1985.

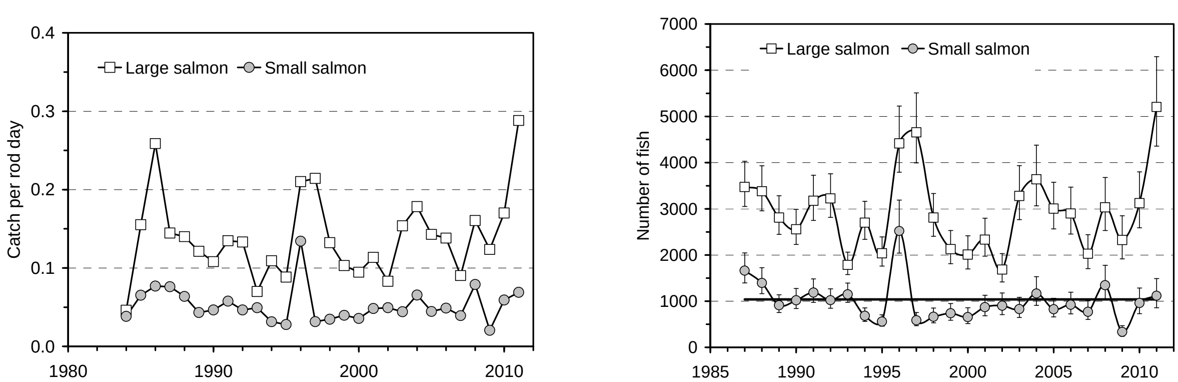



*Figure 8. Catch per rod day (left panel) and estimated returns (right panel) of large salmon and small salmon in the Margaree River (SFA 18B). The horizontal dark line in the right panel is the conservation requirement for the Margaree expressed as the number of large salmon (1,036 fish).*

## Gulf Region

Estimates of total returns and spawners of small salmon and large salmon are developed for each SFA and overall for Gulf Region. The estimates are derived from monitored rivers.

Return and spawner estimates for SFA 15 are based on angling catches from the Restigouche River and assumed exploitation rates of 30% to 50% (min. to max. values), with estuary catches added to the estimates of returns. The return and spawner estimates for SFA 15 are derived from the ratio of angling catch in all of SFA15 relative to angling catch in Restigouche River

(New Brunswick) (min = 1.117; max = 1.465). The most important Atlantic salmon river in SFA 16 is the Miramichi River which represents 91% of the total freshwater rearing area of SFA 16. Returns to the Miramichi are assessed annually. Returns to SFA 16 are Miramichi returns divided by 0.91. For SFA 17, estimates of returns of small salmon are calculated as retained catch of small salmon divided by exploitation rate. Angler exploitation rates of 0.264 to 0.347 were estimated during 1994 to 1996. Large salmon returns are calculated from small salmon returns and the proportion small as derived from sampled rivers. For 1995 and subsequently, spawners were estimated from redd counts. Returns and spawners to SFA 18 are derived from estimates of returns and spawners to the Margaree River, adjusted for the ratio of the SFA 18 angling catch to the Margaree River catch.

Returns of large salmon to Gulf Region in 2011 were estimated to be about 75,000 fish, at near maximum levels over the 1970 to 2011 time series (Fig. 9). The high returns in 2011 were estimated in all SFAs, over 15,000 in SFA 15, almost 50,000 in SFA 16, about 800 in SFA 17 and almost 10,000 in SFA 18 (Fig. 9). Large salmon spawners in 2011 were also estimated to be at record levels in Gulf Region and individual SFAs. Small salmon returns for Gulf Region in 2011 were estimated at about 73,000 fish and near the highest levels estimated since 1994 but were still low relative to the returns estimated during 1985 to 1993 (85,000 to 190,000 fish) and in several years during the 1970s (Fig. 9). Small salmon abundance remained low relative to levels observed in the 1980s and early 1990s for SFA 16 and for SFA 17, for the latter, the higher returns were the result of returns of hatchery-stocked smolts. Returns resulting from hatchery-stocked smolts were also important in SFA 18 in 1979 to 1982.

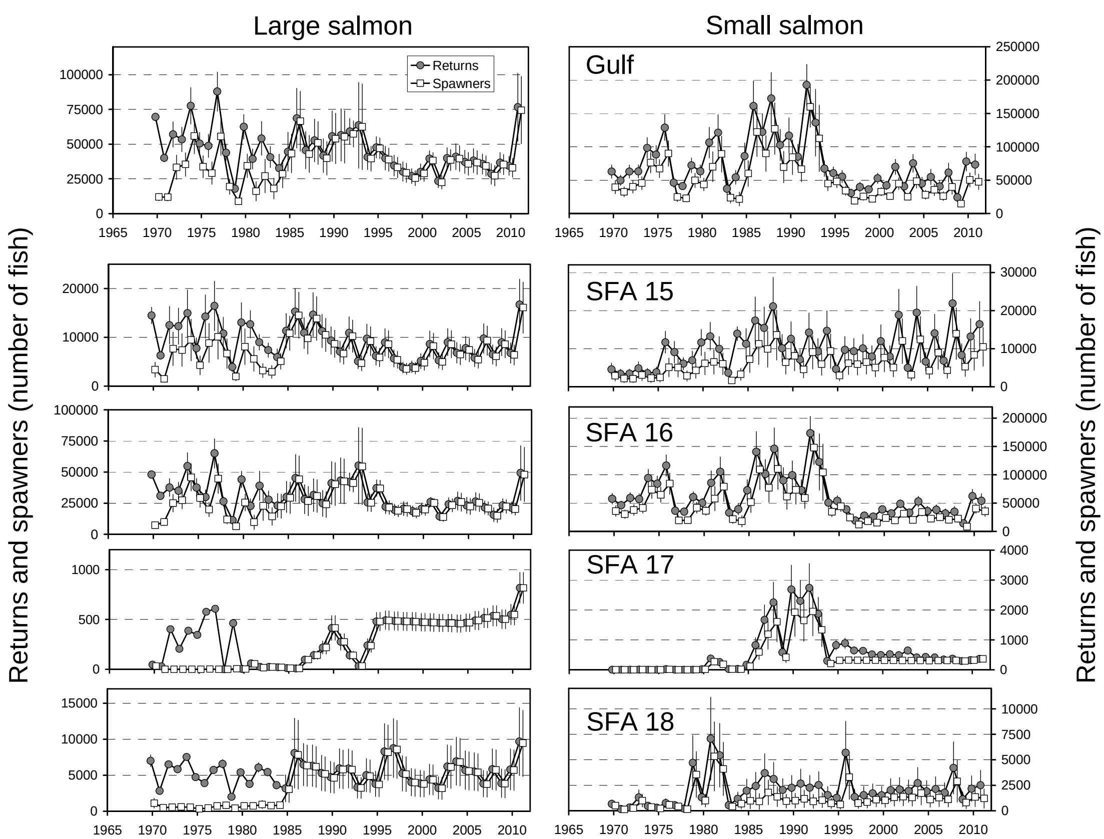



*Figure 9. Estimates (median, 95% Confidence Interval range) of total returns and spawners of large salmon (left panels) and small salmon (right panels) to each of SFA 15, 16, 17, and 18, and to Gulf Region 1970 to 2011.*

# Freshwater juvenile production

Indices of freshwater production are derived from electrofishing surveys of juvenile salmon and estimates of smolt production for index rivers. Fixed site sampling for juvenile salmon has been conducted since the 1950s in the Margaree River and most consistently since 1971 in the Miramichi and Restigouche rivers. Abundances at sites, in terms of number of fish per habitat area sampled by age or size group (densities), are obtained using successive removal sampling or by catch per unit effort sampling calibrated to densities. Sampling intensities vary among years and among rivers with more sites sampled in the larger rivers (Restigouche, Miramichi, Margaree). For rivers with long time series, densities are referenced for two time periods, prior to 1984 and post-1984 (or later depending upon the age group) corresponding to the year (1984) when commercial fisheries were closed and the introduction of mandatory catch-and-release for large salmon in the recreational fishery.

## SFA 15A (Restigouche)

Juvenile salmon are distributed throughout SFA 15A. In 2011 two to three cohorts (fry, small parr, large parr) were captured at most sampling sites indicating that there had been multiple years of spawning success. Juvenile abundance in the Restigouche River has been monitored annually since 1972. Densities of Atlantic salmon fry, small parr (mostly one-year old), and large parr (mostly two-year and older) all increased post-1984 and remain at relatively high levels (Fig. 10). Fry and small parr abundance since 1996 show a decrease whereas large parr show an increase in density (Fig. 10). Results from juvenile salmon surveys in 2008 and 2011, which showed decreased abundance of some age classes, could be biased due to difficult sampling conditions (extremely high water) rather than an indicator of actual lower abundance. All sites sampled have become and remain occupied by juveniles with the exception of some small streams which are prone to periodic blockages to spawners by beaver dams.

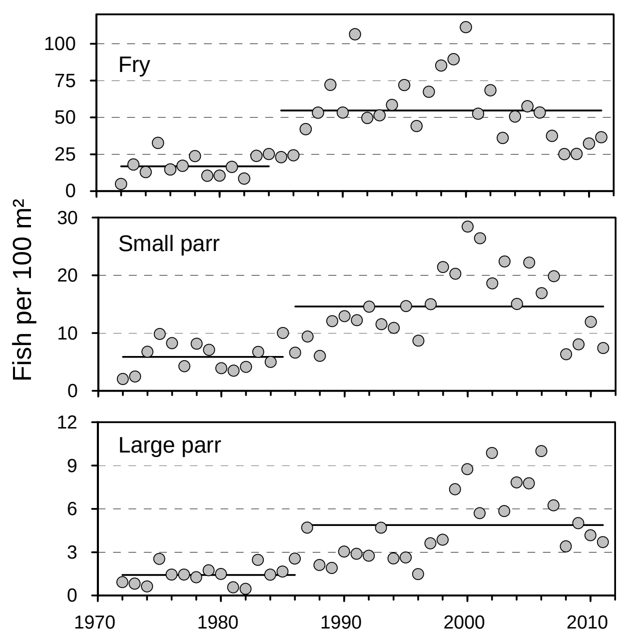



*Figure 10. Mean juvenile densities (fish per 100 m²) for fry (upper), small parr (middle) and large parr (lower) for the sites sampled in the Restigouche River (NB waters only, excluding Matapedia and Patapedia rivers).*

## SFA 15B

Juvenile abundance in the Nepisiguit River has been monitored annually since 1981 by the Nepisiguit Salmon Association (NSA). Salmon fry densities in the Nepisiguit River have increased since the 1980s whereas parr abundance has remained about the same (Fig. 11). In the exceptional high water years of 2008 and 2011, open site sampling was employed at some locations and resulted in possible underestimates of densities for these years.

Juvenile abundances in the Jacquet River, monitored since 1999, are higher than in the Nepisiguit River and at comparable levels to those of the Restigouche River (Fig. 11). Since 2007, juvenile salmon abundance levels on the Charlo River have been comparable to those of the Jacquet River and the Restigouche River (Fig. 11).

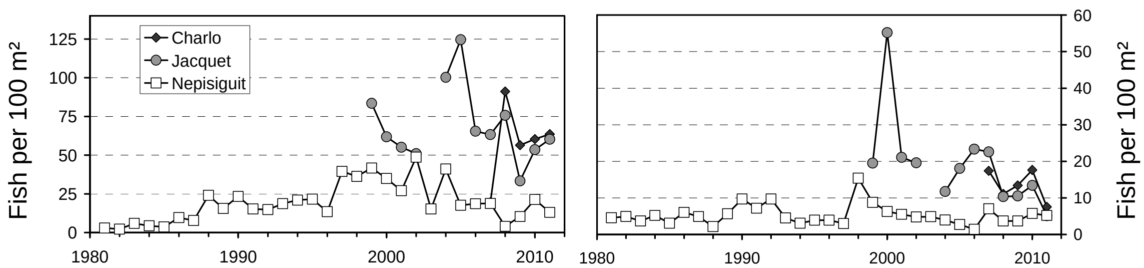



*Figure 11. Juvenile densities (fish per 100 m²) for fry (left) and parr (parr) for Nepisiguit, Jacquet and Charlo Rivers.*

The NSA also conducts juvenile abundance surveys of several other rivers of SFA 15B (Middle, Tetagouche, Bass, Milstream, Nigadoo and Elm Tree rivers). Juvenile abundance in these rivers has been comparable or superior to the Nepisiguit River.

## SFA 16A

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

Salmon fry were captured at all but one of the 49 sites surveyed in 2011 indicating that adult salmon continued to spawn throughout the Miramichi watershed. In 2011, average fry levels were similar in each of the four large rivers (ranged from 44 per 100m$^2$ on the LSW to 64 per 100m$^2$ on the SW) (Fig. 12). The trend in fry densities for each of the four major rivers is consistent with an increased spawning escapement after the implementation of significant management measures in 1984, followed by a gradual decrease to current levels which remain above those prior to 1984 (Fig. 12).

The abundance of small parr in all four major rivers of the Miramichi watershed increased after 1984 then decreased gradually to current levels (Fig. 12). The density of small parr is generally at or near the long term average density for small parr in their respective rivers between 1986 and 2011.

Average densities of large parr ranged from 4 per 100m$^2$ on the LSW to 7 per 100m$^2$ on the NW in 2011. The density of large parr in 2011 in the respective rivers was generally at or above the long term average density between 1987 and 2011. Since the early 1990s, the density of large parr has been trending up in all four major rivers of the Miramichi watershed (Fig. 12)

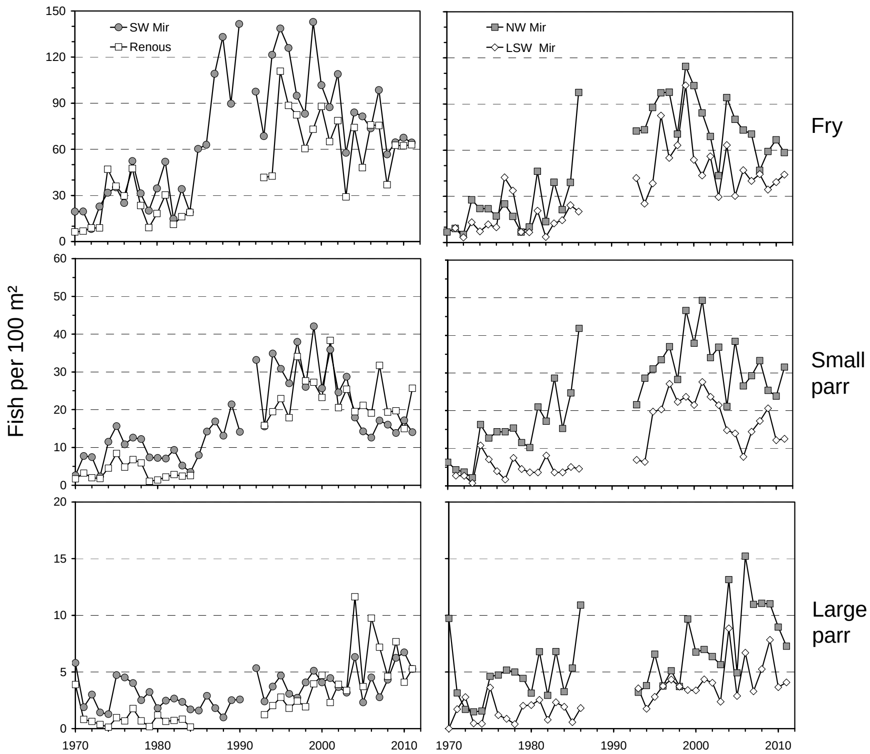



*Figure 12. Annual average densities, expressed as fish per 100 m² of sampled area, for fry (upper panels), small parr (middle panels), and large parr (lower panels) in the four major rivers of the Miramichi watershed.*

## SFA 16B

Surveys have been conducted consistently since the mid 1990s in four rivers of SFA16B. As in previous years, salmon fry were captured in the four surveyed rivers indicating that salmon continue to spawn in many of the smaller rivers of SFA 16B. In 2011, the highest fry densities were recorded in the Kouchibouguac River (37 per 100 $m^2$), while fry levels were consistent in the Richibucto, Buctouche, and Cocagne rivers at approximately 20 per 100 $m^2$ (Fig. 13). Similarly, average parr abundance was highest in the Kouchibouguac and Richibucto rivers at approximately 20 per 100 $m^2$ while parr levels on the Buctouche and Cocagne rivers were estimated to be about 10 per 100 $m^2$. While these levels of juvenile salmon are less than what were observed in the Miramichi River, direct comparisons of juvenile densities to other watersheds may not be appropriate given the notable differences in habitat between rivers. For example, many of the smaller rivers in SFA 16B have been characterized as low gradient with limited suitable spawning habitat.

Salmon fry densities of 40 per100 $m^2$ were observed in the Buctouche River in 2000 following an adult salmon assessment the previous year that determined that conservation had been met. Similar levels of fry were observed in the Buctouche and Cocagne rivers in 2005, suggesting that spawning requirements may have been achieved for those rivers in 2004. Densities of salmon fry on all southeastern New Brunswick rivers have been below 40 per 100$m^2$ since 2005; an indication that they have not likely met conservation requirements since that time.

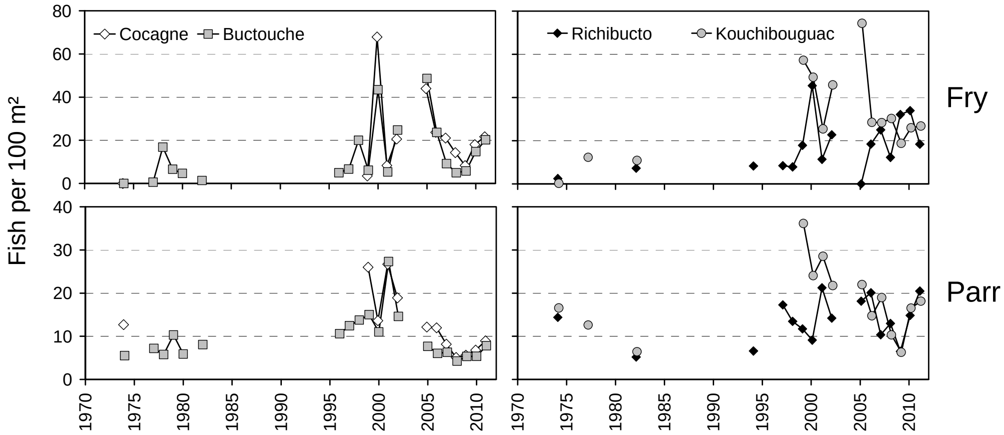



*Figure 13. Average densities, expressed as fish per 100 m² of sampled area, for fry (upper panels) and parr (size groups combined) (lower panels) in four rivers of southeast New Brunswick (SFA 16B). The 1978 value for fry density (116 fish per 100 m²) for the Kouchibouguac River is not shown.*

## SFA 17

No continuous series of juvenile abundance indices are available for SFA 17. Most surveys conducted since 2000 have been done by NGOs and the province of PEI, directed at determining the presence of salmon and helping identify habitat problems. Because of small sample sizes in recent years, these survey results are of limited value in assessing current trends in freshwater production. Juvenile surveys conducted in 2000-2002 and in 2007-2008 found salmon in 28 and 22 rivers, respectively. Surveys in 2011 sampled salmon in an additional river, the Clyde (Appendix Figure 1, Appendix Table 1). However, given the lack of comprehensive juvenile surveys in 2009-2011, it is possible that some rivers found to have salmon in 2007-2008 had lost their salmon populations by 2011.

## SFA 18A

Surveys for juvenile salmon have been conducted in the West River (Antigonish), Barney’s River, East River (Pictou), West River (Pictou), Wallace River and River Philip. The number of sites sampled per river is generally quite small (2 to 4).

Fry density in rivers of SFA 18A exceeded 40 fish per 100 m$^2$ in 2011, lower than densities observed in the 1990s (Fig. 14). However, parr densities are comparable to earlier years with more than 20 parr per 100 m$^2$ (15 and 16 parr per 100 m$^2$ in East River (Pictou) and Wallace River, respectively).

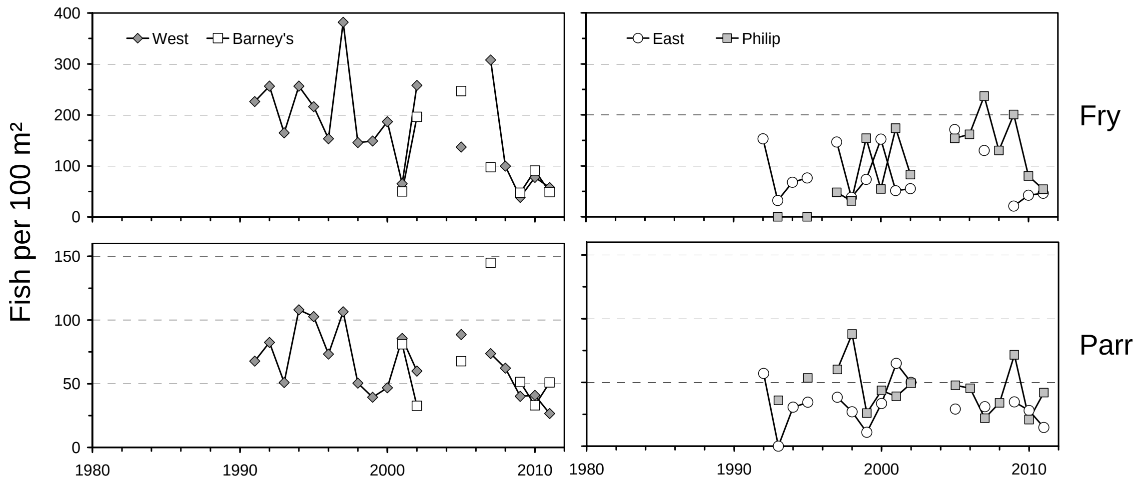



*Figure 14. Average annual densities, expressed as fish per 100 m² of sampled area, for fry (upper panels) and parr (size groups combined) (lower panels) in four rivers of mainland Nova Scotia (SFA 18A).*

## SFA 18B

Surveys for juvenile salmon have been conducted annually at 5 to 13 sites in the Margaree River since 1990. Juvenile densities in the Margaree River have been generally high but with important annual variation. Fry densities have declined from the peak abundances in 2004 and 2005 and were at the lowest abundance in 2011 and low relative to fry densities in other rivers of Gulf Nova Scotia and New Brunswick (Miramichi and Restigouche rivers) (Fig. 15). A 100-year flood occurred in the Margaree River in December 2010 and subsequently fry were absent at the three mainstem sites and present in only four of eight sampled tributary sites in the Margaree in 2011. A major flood had also occurred in March 2003 resulting in low fry abundance that year but in contrast to the situation observed in 2011, fry were present at all five sampled sites. Parr abundances have also declined from the peak value in 2005 (Fig. 15). In 2011, parr were found at all sites sampled indicating that the effect of the flood of December 2010 was most important on redds and egg survivals. The exceptional discharge conditions in December 2010 were restricted to the Cape Breton area.

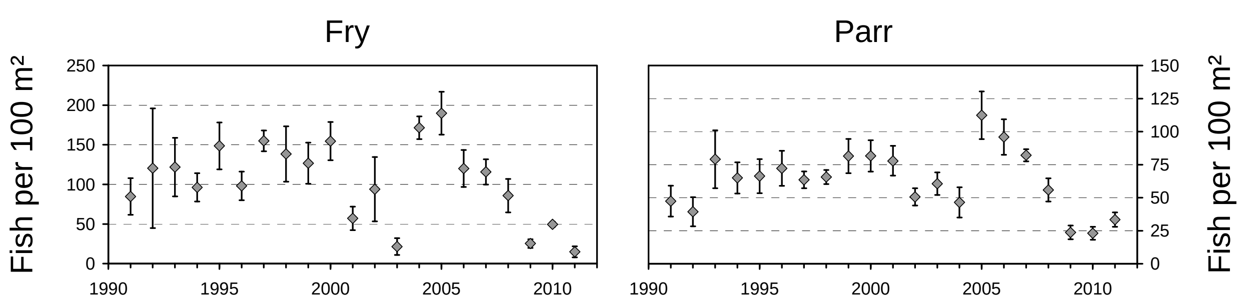



*Figure 15. Annual densities (mean, standard error bars), expressed as fish per 100 m² of sampled area, for fry (left panel) and parr (right panel) in the Margaree River (SFA 18B).*

## Smolt production estimates

Smolt monitoring programs have taken place in the past decade on the three major rivers of Gulf Region: Restigouche, Miramichi, and Margaree. All the assessments are based on mark and recapture experiments. Estimates are available for the Restigouche River overall and the

Kedgwick River (major tributary of the Restigouche), for the Southwest Miramichi and the Northwest Miramichi, and the Margaree River. Smolt production estimates are scaled to the unit of rearing habitat (smolts per 100 m²).

The highest smolt production rate has generally been estimated for the Margaree River with very high production rates estimated for the Southwest Miramichi in 2010 and for the Kedgwick River and the Northwest Miramichi in 2011 (Fig. 16). There has been a tendency for smolt production to have increased in all monitored rivers over the period of assessment. Smolt production of 3 to 5 smolts per 100 m² is expected for these rivers.

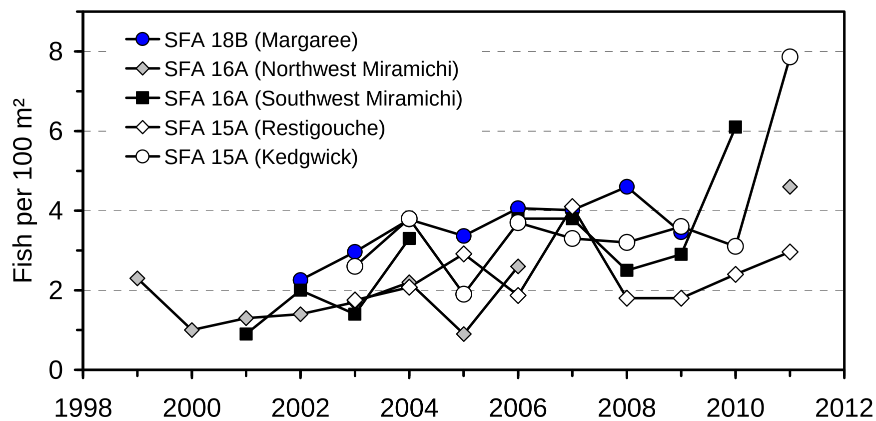



*Figure 16. Smolt production, expressed as fish per 100 m² of wetted habitat area, from monitored rivers in Gulf Region, 1999 to 2011. Smolt production from the Kedgwick River (SFA 15A) is included in the total smolt production from the Restigouche River.*

## Marine return rates

Return rates are calculated as the ratio of adult returns to the abundance of smolts, by year of smolt migration. These values are not marine survival rates but assuming that the probability of maturing as 1SW is constant for each river, the trends in return rates reflect trends in marine survival rates.

Return rates to small salmon are the lowest for the Margaree River and follow a similar trend to the return rates from the Southwest Miramichi and Northwest Miramichi rivers, a decline from 2002 to 2008 and a slight increase for the 2009 smolt cohort (Fig. 17). Return rates to the Miramichi River were highest in 2001 and 2003 smolt cohorts. Based on all the data, the average return rate of small salmon to the Margaree River was about 1%, about 3.4% for the Southwest Miramichi and 3.6% for the Northwest Miramichi.

Return rates to large salmon (for Margaree) or 2SW salmon (Miramichi) averaged 3.6% for Margaree and 1.5% and 0.7% for the Southwest Miramichi and Northwest Miramichi, respectively. Return rates for Margaree and the Southwest Miramichi declined over the time period of available data except for the 2009 smolt cohort for which return rates improved, as was noted for small salmon (Fig. 17). The differences in return rates by size group among the rivers reflects in part the different life history features of these rivers; in the Margaree River, large salmon are more abundant than small salmon hence the return rates of small salmon are lower than for large salmon. In contrast, small salmon are more abundant than large salmon in the Miramichi, hence the small salmon return rates are higher.

These return rates are in the high end of the rates for large salmon from other multi-sea-winter salmon stocks in Quebec and the Maritime provinces but small salmon return rates are in the low range of values for predominantly small salmon stocks of the island of Newfoundland.

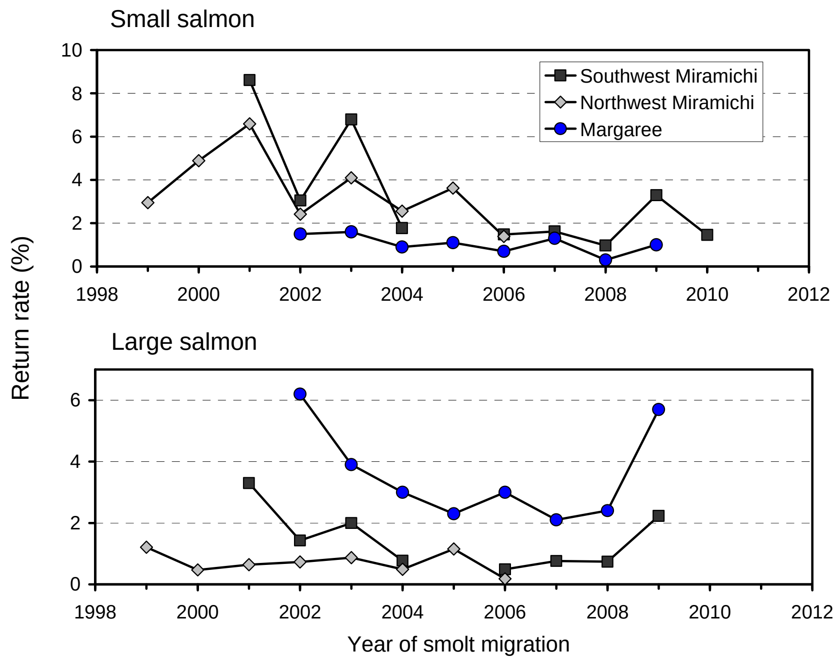



*Figure 17. Estimated return rates (%) to small salmon (upper panel) and large salmon (or 2SW for Miramichi; lower panel) by year of smolt migration for the Margaree River, Northwest Miramichi and Southwest Miramichi rivers, 1999 to 2009 smolt migration years.*

## Management Considerations

### Losses in directed salmon fisheries

Atlantic salmon are presently harvested in aboriginal FSC fisheries and in recreational fisheries.

Exploitation rates, expressed as losses (returns minus spawners) divided by returns, overall for Gulf Region declined sharply for large salmon in 1984 after closure of the homewater commercial fisheries and the mandatory catch–and-release of large salmon in the recreational fisheries (Fig 18). Exploitation rates on large salmon since 1985 have varied between 3% and 6% of total returns. Small salmon exploitation also declined after 1984 but has remained at levels between 17% and 40% of estimated total returns. The exploitation rate patterns after 1997 are determined in large part on the assumptions which are made on removal rates in the recreational fisheries for SFA 16 and on the assumed exploitation rates in the recreational fisheries which are used to estimate returns to SFA 15.

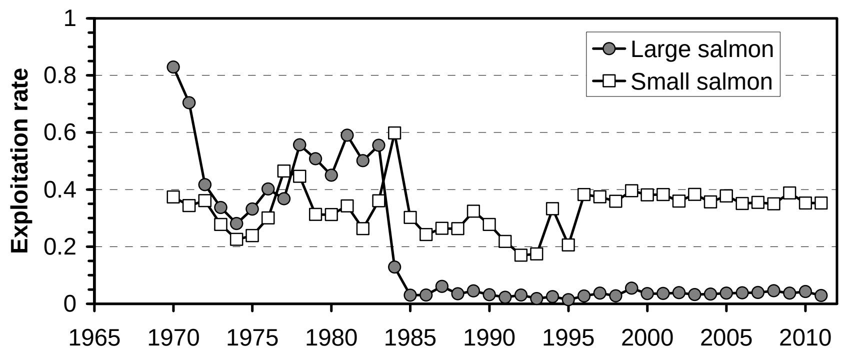



*Figure 18. Estimated exploitation rate (expressed as losses (returns – spawners) divided by returns) of large salmon and small salmon from all homewater salmon fisheries in Gulf Region, 1970 to 2011.*

*SFA 15 (Restigouche River)*

Aboriginal FSC harvest statistics are incomplete but large salmon tend to be targeted using gillnets in tidal and estuary waters of the Restigouche River. With the exception of the Matapedia River which is located entirely within the province of Quebec and the portion of the Patapedia River within the province of Quebec, only small salmon can be retained in the recreational fishery. Incidental mortality from catch-and-release fishing is estimated to be 6%. Catch-and-release is increasing in popularity; between 2001 and 2010, 56% to 93% of the small salmon catch of the Restigouche River (NB portion) was reported to have been released. Losses from catch-and-release for those years have ranged from about 50 to 200 small salmon annually and 75 to 150 large salmon annually. Total losses of small salmon in recreational fisheries (including retained and mortality from catch-and-release) have varied from 300 to over 1,200 small salmon annually during 2001 to 2010. Relative to the estimated returns to the river, the losses of small salmon have varied from 5% to 19% whereas the losses of large salmon have been just over 2% due to recreational fishing.

*SFA 16A (Miramichi)*

Harvest levels of small salmon and catch-and-release statistics for large salmon in the recreational fishery of the Miramichi River have not been available or unreliable since 1998. Similarly, harvest levels of small and large salmon are incomplete for aboriginal FSC gillnet fisheries but considered reliable from FSC trapnet fisheries in the Miramichi River. In the absence of fisheries' harvests statistics, assumptions about removals are made.

The harvest of large salmon in aboriginal FSC fisheries of the Miramichi River has been assumed to be 600 fish which is about 90% of allocations in fishery agreements. It is also assumed that 30% of the large salmon component is angled in the recreational fishery and that 3% of those die as a consequence of being caught and released. Harvest of small salmon in the recreational fishery is assumed to be 25% of the small salmon return estimate while 1,500 or about 20% of allocations is assumed to be removed in aboriginal FSC fisheries for years with incomplete harvest records. Based on these assumptions, the estimated losses were 760 large and 15,500 small salmon in 2010 and 900 large and 13,700 small salmon in 2011. The majority (85%) of small salmon losses occurred in the recreational fishery, while 90% of large salmon losses occurred in estuarine aboriginal FSC fisheries.

The aboriginal FSC fisheries take place mostly in the tidal waters of the Northwest Miramichi River and exploit a mixed stock of Southwest and Northwest Miramichi origin salmon. In previous assessments, the majority of harvested fish in aboriginal FSC fisheries were considered to have been taken from the returns to the Northwest Miramichi River. Recent assessment data suggest that there is an exchange of salmon between the branches of the Miramichi River, at least within the tidal water portions of the branches. Estimates of the extent of movement between branches are available from mark and recapture experiments and these movement rates were applied to the harvests of the FSC fisheries from the Northwest Miramichi and the Southwest Miramichi rivers.

The harvest of small salmon (all fisheries) generally accounts for the majority of the annual egg loss to the Miramichi River and its two branches (average of 60% for both the Miramichi and NW Miramichi, and 58% for the SW Miramichi between 1998-2011). In years of low small salmon returns, the proportion of eggs lost from the harvest of large salmon increases. The percentages of eggs lost in the returns of small salmon for the period 1998 to 2011 averaged 36% (30-60%) for the Miramichi River, 29% (27-34%) for the Southwest Miramichi River, and 44% (33-81%) for the Northwest Miramichi River (Fig. 19). Proportionally fewer eggs were lost in the returns of large salmon, averaging 4% (3-6%) for the Miramichi River, 2% (1-3%) for the SW Miramichi River, and 14% (6-27%) for the NW Miramichi River between 1998 and 2011 (Fig. 19).

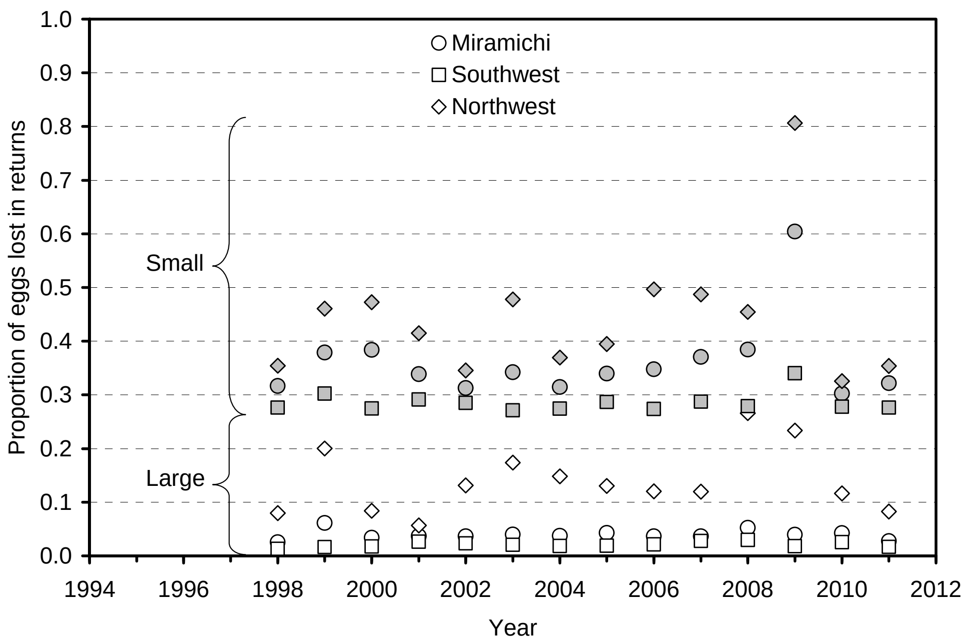



*Figure 19. Proportion of total eggs in the returns of small salmon and large salmon to the Miramichi River and its two main branches, which are lost due to fisheries for 1998-2011.*

*SFA 16B*

All directed fisheries for Atlantic salmon have been closed in the rivers of SFA 16B since 1998.

*SFA 17*

Fishery losses due to hook and release mortality are estimated as two small and two large salmon, for a total of four salmon, in 2011. One aboriginal community reported not harvesting any salmon in 2011 and no harvest report was provided by the other group. Losses attributed to fisheries in recent years have been very low (Table ).

*SFA 18*

Harvest levels from First Nations are incomplete. The total salmon allocations for FSC fisheries were 220 small salmon and 482 large salmon and the Nova Scotia Native Council has access to 1,820 adult salmon (small and large) with no river-specific allocations (Table 1).

Atlantic salmon are harvested and lost in recreational fisheries. For these rivers, it is assumed that the incidental mortality rate from catch-and-release fishing is 5%. In 2011, 240 small salmon were estimated to have been retained in the Margaree River. Mortality from catch–and-release was estimated at 22 small salmon and 143 large salmon. Total losses due to the recreational fishery represent 24% of the small salmon return and 3% of the large salmon return.

Overall in SFA 18, losses from catch and release mortality were estimated to be 62 small salmon and 274 large salmon in 2011; retained small salmon were 463 fish. The total losses due to the recreational fishery represent 21% of small salmon returns and 3% large salmon returns to SFA 18.

### Impacts of fisheries and fishery gear for salmon on other species and fish habitat

Regulations require anglers to use artificial flies when targeting Atlantic salmon in scheduled waters of the southern Gulf of St. Lawrence. Brook trout are susceptible to capture using this method and retention fisheries for this species are regulated by daily bag and size limits. Thousands of young salmonids are hooked and released on an annual basis while targeting adult salmon. The mortality associated with this activity is unknown but likely high and dependant on hook placement and care removing the hook. Other species such as striped bass, American shad, and white sucker are also regularly hooked when targeting Atlantic salmon but the mortality on these species is believed to be minimal.

The majority of salmon angling in the southern Gulf occurs by wading or from a boat. Wading causes disruption to the substrate which impacts habitat but this is not well documented and has not been quantified. The invasive freshwater algae *Didymosphenia geminata* (didymo) has a negative effect on salmonid habitat and is believed to be confined to freshwaters of SFA 15. The proper disinfection of wading boots, boats, and fishing gear after angling in didymo-infected waters are essential to limiting its spread to other watersheds.

Aboriginal FSC fisheries for Atlantic salmon mainly occur in the estuaries of the Gulf region and gillnets and trapnets are the most common gear types employed. The run-timing of salmon in the spring and/or fall overlap with migrations of other species which are intercepted while targeting salmon. Fish bycatch can be released alive from trapnets, whereas they are usually killed or injured in gillnets. Striped bass, American shad, and brook trout are the most common species intercepted in FSC fisheries targeting Atlantic salmon but only bycatch mortality for striped bass has been evaluated for this fishery in the Gulf region. The Allowable Harm Assessment for southern Gulf striped bass indicated that the FSC aboriginal gillnet fishery can intercept several thousand striped bass with corresponding high mortality on individual fish. First Nation estimates of current annual striped bass losses in FSC fisheries for Atlantic salmon were greater than 2,000 fish (DFO 2011).

Both trapnets and gillnets disrupt the substrate of the estuaries but the impacts to salmon habitat from these activities is considered to be minimal.

## Assessment of impacts of other fisheries on salmon and salmon habitat

Atlantic salmon of Gulf Region and other regions of eastern North America undertake long oceanic migrations and are harvested in the mixed-stock subsistence fishery at West Greenland. Tags applied to smolts and adult salmon in rivers of Gulf region have been returned consistently from the West Greenland fishery and were again in 2011. The fishery at West Greenland has reported catches of 9 to 43 t in the past ten years, with the second highest catch since 1997 reported for the 2010 fishery at 40 t (plus an estimated 10 t of unreported catch) (ICES 2011). The estimated catch of North American-origin salmon at West Greenland has varied between 2,300 and 10,000 fish, with 93% to 98% of the catch being 1SW non-maturing salmon; fish destined to have been 2SW or 3SW maiden salmon, had they not been captured and survived to return to home waters. The median estimate of salmon harvested at West Greenland over the last five fishing years (2006 to 2010) that were destined for home waters in Gulf region rivers (SFAs 15 to 18 in 2007 to 2011) was 1,703 potential 2SW fish (range 1,278-2,125). Relative to the estimated abundance of 2SW salmon in Gulf Region for the same time period (median = 22,800; range of 18,500 to 61,700 fish), the harvest at West Greenland has represented a removal rate of 3% to 10% of 2SW salmon, higher than the estimated losses of large salmon (which include 2SW fish) in the homewater fisheries.

Four non-salmon commercial fisheries occur in many estuaries of Gulf region and all have the potential of intercepting Atlantic salmon.

Gaspereau (alewife and blueback herring) are primarily fished with trapnets during May and June. The gaspereau catch is loaded alive and the unwanted bycatch can be quickly returned to the water. A qualitative assessment by DFO Conservation and Protection officers identified large quantities of salmon bycatch in the gaspereau fishery of the Miramichi and minimal levels in the East and Naufrage rivers of PEI, the Big Tracadie, Buctouche, Richibucto, and Kouchibouguacis rivers of NB, and rivers Philip, Pictou, and Pugwash of Gulf NS (Chiasson et al. 2002). The mortality of the salmon bycatch is unknown but likely highest in the Miramichi River.

American eels are typically fished in the spring or late summer-early fall with fyke nets in estuaries and shallow bays of the southern Gulf of St. Lawrence. The eel catch is loaded alive and the unwanted bycatch can be quickly returned to the water. DFO Conservation and Protection officers ranked the abundance of salmon bycatch in eel fisheries as high in the Miramichi and Tabusintac rivers, as moderate in Merigomish harbour and minimal in New Brunswick's Richibucto River, and Gulf Nova Scotia's Antigonish and Pomquet harbours (Chiasson et al. 2002). There are no estimates of mortality on salmon intercepted in the eel fisheries of the southern Gulf but it is considered to be low.

Minimal levels of Atlantic salmon bycatch were identified in the Atlantic silverside fishery of the East, West, Morell, and Pinette rivers of PEI (Chiasson et al. 2002). The silverside fishery occurs primarily in estuaries and bays of PEI, in the fall using small mesh boxnets and trapnets. The mortality of salmon in this fishery is believed to be low due to the low level of expected bycatch, the type of gear used and the colder water temperatures during the time of the fishery which would enhance post-release survival.

Rainbow smelt are typically targeted with box nets or gillnets in estuaries or bays of the southern Gulf of St. Lawrence during the November to March period. DFO conservation and Protection officers ranked the abundance of salmon bycatch in smelt fisheries as high in the Miramichi, Tabusintac, Tracadie, and Little Tracadie rivers of NB. Moderate levels of salmon bycatch were reported in the Buctouche, Richibucto, Kouchibouguacis, and Kouchibouguac rivers of NB, the East and West rivers of PEI, and the West River and Pugwash harbour of Gulf NS. Minimal levels of salmon bycatch were noted by the Bathurst/Kedgwick detachment but a river location was not identified (Chiasson et al. 2002). DFO Science has sampled the smelt fishery of the Miramichi River at Loggieville and Chatham on many occasions and occasionally in the Tabusintac River over many years with two observations of single salmon bycatch. Salmon mortality from this fishery is considered to be low.

The drift surface gillnet fishery for Atlantic mackerel in the southern Gulf of St. Lawrence can intercept adult Atlantic salmon. Salmon with net marks around their heads, consistent with entanglement in gillnets such as those used for the mackerel fishery, were observed in May and June 2011 at monitoring facilities in the Miramichi. The extent of the bycatch is unknown but reports from mackerel fishers suggest the bycatch was widespread that year. The bycatch and mortality of salmon from this fishery is likely proportional to the abundance of salmon and has the potential of being important in high salmon abundance years, as in 2011.

There is no indication that any of these fisheries pose a threat to Atlantic salmon habitat.

### Impacts of non-fishing related activities on Atlantic salmon and salmon habitat

In SFA 17, salmon production is constrained by sediment input from agricultural and other sources. Fish kills due to pesticide inputs, water quality problems (low dissolved oxygen, high temperatures), and competition with introduced rainbow trout also threaten salmon. Artificial dams that lack fishways, beaver dams, and improperly installed culverts prevent access to numerous small tributaries.

Land-use impacts in other areas of Gulf Region are less severe than in SFA 17 but inadequate fish passage and sedimentation are also an issue. A preliminary assessment of stream crossings in Gulf Nova Scotia (SFA 18) was conducted as part of the Habitat Protection programs to identify the extent of habitat fragmentation and impediments to fish passage. Based on an inventory of stream crossings within the first kilometre inland above the head of tide in Gulf Nova Scotia (SFA 18), there were impediments to fish passage noted at 47% of the sites (n = 669 sites). Not all these small streams would be used by salmon.

### Hatchery contributions

Prior to 1997, all salmonid enhancement activities were conducted by DFO. In 1997, the hatcheries were divested to the private sector and four of these continue to stock juvenile salmon at various stages in a limited number of rivers. All current enhancement activities have involved placing juvenile progeny back to rivers/tributaries from which the parents were collected. The scale of enhancement activities relative to wild production is small and generally Atlantic salmon adult runs to rivers are reliant on natural production.

### Kelt fisheries in SFA 18

Interest in a recreational fishery to catch and release kelts by angling with artificial flies in River Phillip and the West River (Antigonish) has prompted a request for science advice by DFO FAM. The River Philip and West River are relatively small rivers with spawner requirements of 358 and 353 large salmon, respectively. The adult returns to these two rivers, their age structure, and the contribution of eggs from repeat spawners have not been assessed.

Salmon in rivers of Gulf Region can spawn multiple times. Repeat spawning salmon occur in the Margaree River and in other rivers of SFA 18 however the return rates to a second spawning have not been estimated. In the Miramichi River, return rates to a second spawning have been as high as 20% for 2SW salmon in recent years but it is not known if survival and feeding conditions for kelts in rivers from SFA 18 are similar to those of the Miramichi River. Kelt fisheries in the Miramichi and Restigouche rivers have existed for decades with no discernable consequence on abundance of repeat spawners. Repeat spawner abundances in the Miramichi River have increased to the highest observed levels in the past decade.

Angling catch rates for kelts in the spring are generally higher than for bright salmon in the summer and fall, depending on water conditions. Studies on incidental mortalities from catch-and-release suggest that mortality is low at cold water temperatures (Brobbel et al. 1996).

Kelts are regularly caught by anglers targeting brook trout during the spring in many rivers and estuaries of SFA 18. Baited hooks, lures, and artificial flies are the usual terminal tackle used for trout angling. Artificial flies are believed to cause the least amount of injury to angled fish. Bycatch mortality of kelts in the current trout fisheries of SFA 18 are unknown but expected to be higher when salmon are caught on baited hooks or lures compared to artificial flies.

The likely small contribution of eggs in repeat spawners and their expected high catch and release survival with artificial flies in cool water during the spring suggests that a kelt fishery for River Philip and the West River (Antigonish) would have minimal impact on salmon conservation for these rivers.

## Environmental conditions affecting Atlantic salmon in freshwater and in the ocean.

Anadromous Atlantic salmon utilize both fresh and marine waters to complete their life cycle. Large scale climatic factors are hypothesized to be determinant of sea survival of salmon by changing the distribution and migration at sea and their consequent interactions with prey and predators. Variations in conditions at sea are expressed in terms of survival directly. Growth of salmon (based on size at age of returning adults) has increased in the Miramichi River whereas age at maturity (expressed as sex ratio by age group) shows no trend in any of the monitored rivers in Gulf Region. Causal factors of variations in marine survival remain speculative.

Adult Atlantic salmon return to rivers in eastern Canada over a broad range of river water temperatures with river migration seemingly favoured at water temperatures in the range of 14 to 20°C. The optimum temperature for growth of juvenile salmon is in the range of 16 to 20ºC (Elliott and Elliott, 2010).

When in freshwater, juvenile and adult salmon are subjected to large variations in water temperature and water levels, within and among seasons. High summer water temperatures together with low water and reduced flow conditions frequently occur in salmon rivers in the Maritimes: together they pose an environmental stress that can be particularly severe for early-run adult salmon. During July and August, water temperatures in rivers of the southern Gulf of St. Lawrence can exceed 25°C. Temperature-related stress in juvenile and adult Atlantic salmon has been associated with behavioural changes such as abandonment of feeding territories and aggregations at cool-water seeps (Breau et al. 2011).

A number of the hydrological indicators from index rivers in Gulf region, minimum daily discharge values, timing of peak runoff in the spring, and maximum daily discharges, are all characterized by important annual variations but without trend. Warm water temperature events in the Miramichi River, defined as days when the maximum temperature exceeded 23ºC, occur repeatedly but with the intensity varying annually (Fig. 20). Adult salmon mortalities associated with stressful environmental conditions have been recorded in some of these years, in particular

1995, 1999, 2001 and 2010. Mortality from catch-and-release angling increases at water temperatures above 20ºC (Dempson et al. 2002). Possible protocols for managing angling activities during these warmwater periods have recently been developed (DFO 2012).

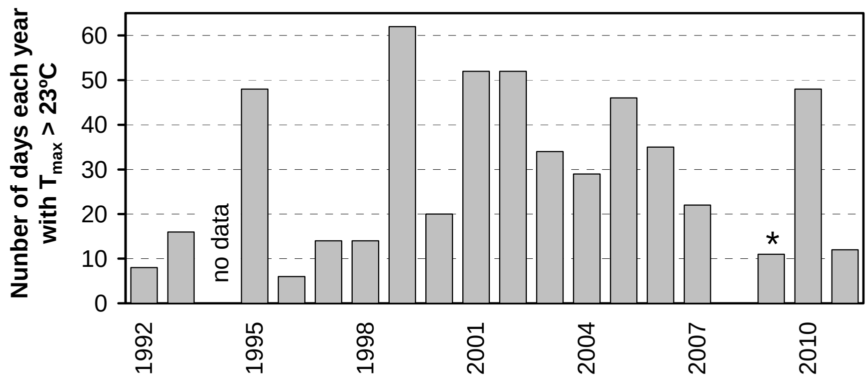



*Figure 20. Number of days each year when the daily maximum water temperature exceeded 23°C for the Little Southwest Miramichi River, 1992 to 2011 (* = incomplete year).*

Occasionally, excessive precipitation and/or snow melt can result in severe discharge conditions that modify streambed structure and which can lead to egg and juvenile salmon mortalities. Such an event occurred in December 2010 in the Margaree River. A 100-year flood event occurred which resulted in important changes in the river morphology and movement of the streambed. The absence of fry in the majority of the sites sampled in 2011 was interpreted as the consequence of destruction of eggs in redds due to the exceptional discharge event.

## Sources of Uncertainty

Catches and harvests from aboriginal fisheries and recreational fisheries are undocumented or incomplete. Undocumented harvests in aboriginal fisheries are particularly of concern as large salmon allocations are provided in agreements and licences. With the exception of the Restigouche River and the Nepisiguit River in SFA 15, there are no angling catch data for the other smaller rivers in SFA 15 nor for any rivers in SFA 16 including the Miramichi River. In SFA 17 (PEI) and SFA 18 (Gulf NS), angling catches are estimated from survey card reports but the return rate remains low (< 50%), even when prompted by reminder mailings. Adjustments for underreporting are applied but it is not known if this results in a bias due to differences in angling effort and success of reporting versus non-reporting anglers. Assumptions about harvest levels and catch and release mortality are required to assess spawning escapements and compliance with conservation objectives. Depending on the accuracy of the assumed levels of removals, the level of conservation attainment may be under or over estimated. Evaluation of the effectiveness of management measures, such as the benefits of catch and release measures in the Northwest Miramichi or of alternate management options such as season tag reductions, is consequently difficult.

Adult assessments are only conducted for the five largest rivers in Gulf Region. These assessments have differing levels of data needs and uncertainties. The assessment of the Margaree River depends upon annual angling catch and effort data to which a historical catch rate coefficient is assumed to still be appropriate. The assessment of the Restigouche River is based on angling catches and assumed exploitation rates unadjusted for changes in effort. Supplementary data from spawner counts in the fall in the main tributaries of the river, and generally excluding the main stem, are also used. The assessment of returns to the Nepisiquit

River is based on redd counts and a conversion factor from redds to adult fish that has not been verified in recent years. Adult returns to the Miramichi are assessed annually using mark and recapture experiments of varying quality depending upon the success of monitoring activities by two of the First Nations communities.

Status of Atlantic salmon in other rivers depends upon indices of angling catch and effort (SFA 18) and/or juvenile abundance indices, the latter being qualitative indicators of previous years' spawning escapement (SFA 15 to 18). Catch rates from angling data are difficult to compare among rivers due to differences in run timing of salmon, different sizes of runs and the absence of any measure of variations in catchability with river size. It is not possible to compare juvenile salmon abundance indices directly among rivers as there is no standardization of the indices for habitat characteristics (including habitat type, elevation, gradient, stream width, stream order, latitude, and water nutrients) which have been shown to be associated with carrying capacity of juveniles. Trends in juvenile abundance in individual rivers are considered relevant although small sample sizes for some rivers result in large intra- and inter- annual variations.

In SFA 17, adult returns and spawners are estimated from redd counts. The conversion of redd counts to spawners is based on data from a single river in a single year. Uncertainty in the ratio of redd counts to returns leads to uncertainty in return and spawner estimates. Since the 2000s, most electrofishing work has been directed at determining salmon status in smaller streams. There are no time-series which reliably track trends in juvenile salmon abundance.

The absence of adult assessment data in an index river in southeast New Brunswick (SFA 16B) and the fallback to using juvenile indices as an index of stock status relative to conservation makes it difficult to advise fisheries management on the option for and the size of fisheries options on salmon in these small rivers. Juvenile indices from the Buctouche River suggest that conservation may have been met in only a few years since monitoring began, but the level of harvestable surplus when it occurred is presumed to be small.

Periodic synoptic surveys as conducted in 2008 and 2009 show that salmon were found in over 115 rivers and streams in Gulf Region, the majority of these were small rivers that are not even intermittently monitored for juveniles or through catch statistics (Appendix Table 1; Appendix Figure 1).

The early run of salmon to the Miramichi River has progressively increased in the last decade while the late run component has decreased. Consequently, in-river catch rates and mortality may be higher, but this remains to be investigated further. The reason behind this shift is believed to be related to a change in salmon behaviour rather than the loss of a distinct fall run of salmon. Harassment of staging salmon in Miramichi Bay by grey seals is one hypothesis for the trend in the change in run timing.

## CONCLUSIONS AND ADVICE

Returns of large salmon to assessed rivers in Gulf Region in 2011 were among the highest on record since 1970. The high abundance of large salmon in 2011 was preceded by greatly improved returns of small salmon in 2010 in most areas relative to the previous fifteen years although higher returns of small salmon had been estimated historically. The improved returns in 2010 and 2011 reflected improved marine survival of the smolts that emigrated in 2009 relative to those of previous years. Small salmon returns in 2011 were variable relative to those of 2010 and were among the highest returns since 1994.

Catch and harvest data from all SFAs are incomplete or entirely lacking in some areas. Based on assumptions of removals, spawning escapements of large salmon were also improved in 2011 from previous years, and all assessed rivers (Restigouche, Nepisiguit, Northwest Miramichi, Southwest Miramichi, and Margaree) exceeded their conservation requirements. In 2011, it was estimated that several small rivers on the northeast tip of SFA 17 likely met or exceeded their conservation requirements however the majority of salmon bearing rivers in this SFA continue to be negatively impacted by sediment from erosion, pesticide runoff, competition with introduced rainbow trout, and habitat fragmentation due to inadequate fish passage.

Undocumented harvests in aboriginal fisheries and incomplete or absent statistics on catches and harvests in the recreational fisheries are particularly problematic. Assumptions about harvest levels and catch and release mortality are required to assess spawning escapements and compliance with conservation objectives. Depending on the accuracy of the assumed levels of removals, the level of conservation attainment may be under or over estimated. Evaluation of the effectiveness of management measures are also difficult to provide.

Exploitation rates (removal rates) on large salmon in Gulf Region overall are estimated to be quite low and in the range of 3% to 6% of total returns since the management measures introduced in 1984. Exploitation rates on small salmon are estimated to be in the range of 17% to 40% annually although these estimates are based on assumptions of catch rates and losses in absence of reliable and complete harvest data. Exploitation rates in individual rivers will vary from these depending upon the intensity of the aboriginal FSC and recreational fisheries.

Atlantic salmon occupy 115 rivers (that empty into estuaries) in Gulf Region and with exception of SFA 17, juvenile abundances are sustained at moderate to high levels. Smolt assessments in the three main rivers in Gulf Region indicate that the total production from freshwater has generally improved over the past decade and smolt production rates are within the range (3 to 5 smolts per 100 $m^2$) expected for salmon producing rivers in the Maritime provinces. Abundance of adult salmon is constrained by low marine survival, a phenomenon which is widespread for Atlantic salmon stocks from eastern North America.

Of the commercial fisheries for other species which occur in the Gulf of St. Lawrence, the drift surface gillnet fishery for mackerel which occurs in June likely has the greatest potential for salmon bycatch, particularly in years when abundance of salmon in the Gulf Region is high, as in 2011. There are no estimates of the number of salmon intercepted in this fishery but there were reports of dead salmon in fishing gear and net-marked salmon attributed to interactions with small mesh nets, as used in the mackerel fishery, were noted at the monitoring trapnets in the Miramichi River. This fishery would be expected to intercept salmon from rivers in SFA 15 and 16 and likely rivers in Quebec as well.

The fishery at West Greenland which occurs primarily on 1SW non-maturing salmon, fish which would most likely have returned as 2SW salmon, exploits salmon from Gulf Region rivers, as evidenced from recaptures of salmon originally tagged as smolts (from Restigouche, Miramichi, and Margaree rivers) and as reconditioning kelts (from Miramichi tag recoveries). The harvests at West Greenland since 2002, when the last commercial quotas were negotiated, have ranged from 9 to 40 t compared to harvests of 1,000 to 2,700 t during peak of the commercial fishery years (1971 to 1982). The estimated exploitation rate on Gulf Region salmon in the Greenland fishery in the past five years is higher (3% to 10%) than the estimated exploitation rate on large salmon in the homewater FSC and recreational fisheries (3% to 6%).

Catch and release kelt fisheries are expected to have minimal impact on salmon conservation in River Philip and West River (Antigonish) especially if managed using similar fishing rules as for the bright salmon fishery, i.e. fly fishing only with artificial flies.

## OTHER CONSIDERATIONS

Perceptions of abundance by user groups can be affected by the run timing of salmon to rivers. The run timing of Atlantic salmon to the Miramichi River has been previously characterized as bimodal, with the first mode occurring in the summer (prior to August 31) and the second in the fall (after August 31) (Saunders 1967). Early and late runs of salmon to the Miramichi River were obvious from index trapnet catches between the early 1950s and the mid 1990s but this pattern appears to recently have changed to a dominant summer mode. These changes in run timing have occurred for both large and small salmon and on both major branches of the Miramichi River. The percentage of salmon captured at index trapnets by August 31 has increased on the SW Miramichi River since 1994, attaining levels of 75-90% in recent years. A similar pattern was observed for salmon on the NW Miramichi River but the trend was less pronounced (Fig. 21).

The reduced late run of salmon to the Miramichi River is not believed to be related to the loss of the fall run but rather to a shift in behaviour where they enter the river during the summer and no longer stage in Miramichi Bay until autumn. Decreases in the late run component have generally corresponded with increases in the early run component since 2006. Single-day peak catches at index trapnets, particularly on the SW Miramichi River, have switched from occurring in the fall to July and are at levels higher than those experienced in the 1990s. These observations are consistent with the angling community’s perception of high salmon abundance in the river during the summer but low abundance during the fall.

Large and small salmon with significant non-typical wounds have been sampled at the index trapnets on both the NW and SW Miramichi rivers since 2009. In 2011, 4.3% of the large and 3.2% of the small salmon sampled at index trapnets in the Miramichi River had net marks or a severe wound. Nearly 100% of the fish observed with these wounds in 2011 occurred in the months of June and July. The wounds are specific to salmon and none of the other 10+ species captured at these facilities showed any signs of trauma. The non-typical wounds have been described as net marks and severe mid-body or caudal peduncle gashes or irregular shapes. Fish with net marks were typically small salmon with rings around their heads consistent with a small mesh (2-3 inch) gillnet. The wounds described as severe were deep lacerations that exposed the fishes’ flesh or body cavity. Different stages of healing were observed which suggests that the wounds were inflicted at various times during their migration to the rivers. The cause of the severe wounds and their associated mortality on the stock remains unclear.


*Figure 21. Proportion of total annual catches of large salmon and small salmon which were taken by August 31 at DFO Index trapnets at Millerton on the SW Miramichi River (left panel) and at Cassilis on the NW Miramichi River (right panel) for 1994 to 2011.*

## SOURCES OF INFORMATION

This Science Advisory Report is from the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, regional advisory process meeting of March 12-14, 2012 on the stock status of Atlantic salmon (*Salmo salar*) in DFO Gulf Region (Salmon Fishing Areas 15 to 18). Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

Breau, C., Cunjak, R.A., and Peake, S.J. 2011. Behaviour during elevated water temperatures: can physiology explain movement of juvenile Atlantic salmon to cool water? Journal of Animal Ecology. 80: 844-853.

Breau, C., Chaput, G., LeBlanc, P., and Mallet P. 2009. Information on Atlantic salmon (*Salmo salar*) from Salmon Fishing Area 18 (Gulf Nova Scotia) of relevance to the development of a COSEWIC status report. DFO Can. Sci. Advis. Secr. Res. Doc. 2009/076: iv + 53 p.

Brobbel, M.A., Wilkie, M.P., Davidson, K., Kieffer, J.D., Bielak, A.T., and Tufts, B.L. 1996. Physiological effects of catch and release angling in Atlantic salmon (*Salmo salar*) at different stages of freshwater migration. Can. J. Fish. Aquat. Sci. 53: 2036-2043.

CAFSAC. 1991a. Definition of conservation for Atlantic salmon. CAFSAC Adv. Doc. 91/15.

CAFSAC. 1991b. Quantification of conservation for Atlantic salmon. CAFSAC Adv. Doc. 91/16.

Cairns, D.K. (ed.) 2001. An evaluation of possible causes of the decline in pre-fishery abundance of North American Atlantic salmon. Can. Tech. Rep. Fish. Aquat. Sci. 2358: 67 p.

Cairns, D.K., Guignion, D.L., Dupuis, T., and MacFarlane, R.E. 2010. Stocking history, biological characteristics, and status of Atlantic salmon (*Salmo salar*) on Prince Edward Island. DFO Can. Sci. Advis. Secr. Res. Doc. 2010/104. iv + 50 p.

Cameron P., Chaput, G., and Mallet, P. 2009. Information on Atlantic salmon (*Salmo salar*) from Salmon Fishing Area 15 (Gulf New Brunswick) of relevance to the development of the COSEWIC Status report. DFO Can. Sci. Advis. Secr. Res. Doc. 2009/078. iv + 40 p.

Chaput, G., Moore, D., Hardie, P., and P. Mallet. 2010. Information on Atlantic salmon (*Salmo salar*) from Salmon Fishing Area 16 (Gulf New Brunswick) of relevance to the development of a COSEWIC status report. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/064. iv + 50 p.

Chiasson, G., Gallant, P.A., and Mallet, P. 2002. Traditional and local knowledge: estuarine fisheries by-catch in the southern Gulf of St. Lawrence; ecosystem based fisheries management considerations. Can. Manu. Rep. Fish. Aquat. Sci. No. 2613: vi + 45 p.

COSEWIC. 2010. COSEWIC assessment and status report on the Atlantic salmon *Salmo salar* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. Xlvii + 136 pp. (http://publications.gc.ca/collections/collection_2011/ec/CW69-14-167-2011-eng.pdf).

Dempson, J.B., Furey, G., and Bloom, M. 2002. Effects of catch and release angling on Atlantic salmon, *Salmo salar* L., of the Conne River, Newfoundland. Fisheries Management and Ecology 9: 139-147.

DFO. 2008. Atlantic salmon integrated management plan 2008-2012. Gulf Region. 45 p. (http://www.glf.dfo-mpo.gc.ca/Gulf/FAM/IMFP/2008-2012-Atlantic-Salmon-Gulf-Region).

DFO. 2011. Allowable harm assessment of Striped Bass (*Morone saxatilis*) in the southern Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/014: 17 p.

DFO. 2012. Temperature threshold to define management strategies for Atlantic salmon (*Salmo salar*) fisheries under environmentally stressful conditions. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/019. 18 p.

Elliott, J.M., and Elliott, J.A. 2010. Temperature requirements of Atlantic salmon *Salmo salar*, brown trout *Salmo trutta*, and artic charr *Salvelinus alpinus*: predicting the effects of climate change. Journal of Fish Biology 77: 1793-1817.

ICES 2011. Report of the Working Group on North Atlantic Salmon (WGNAS), 22-31 March 2011 Copenhagen, Denmark. ICES CM 2011/ACOM: 09. 286p. (http://www.ices.dk/workinggroups/ViewWorkingGroup.aspx?ID=35)

Saunders, R.L. 1967. Seasonal pattern of return of Atlantic salmon in Northwest Miramichi River New Brunswick. Journal of the Fisheries Research Board of Canada. 24: 21-32.

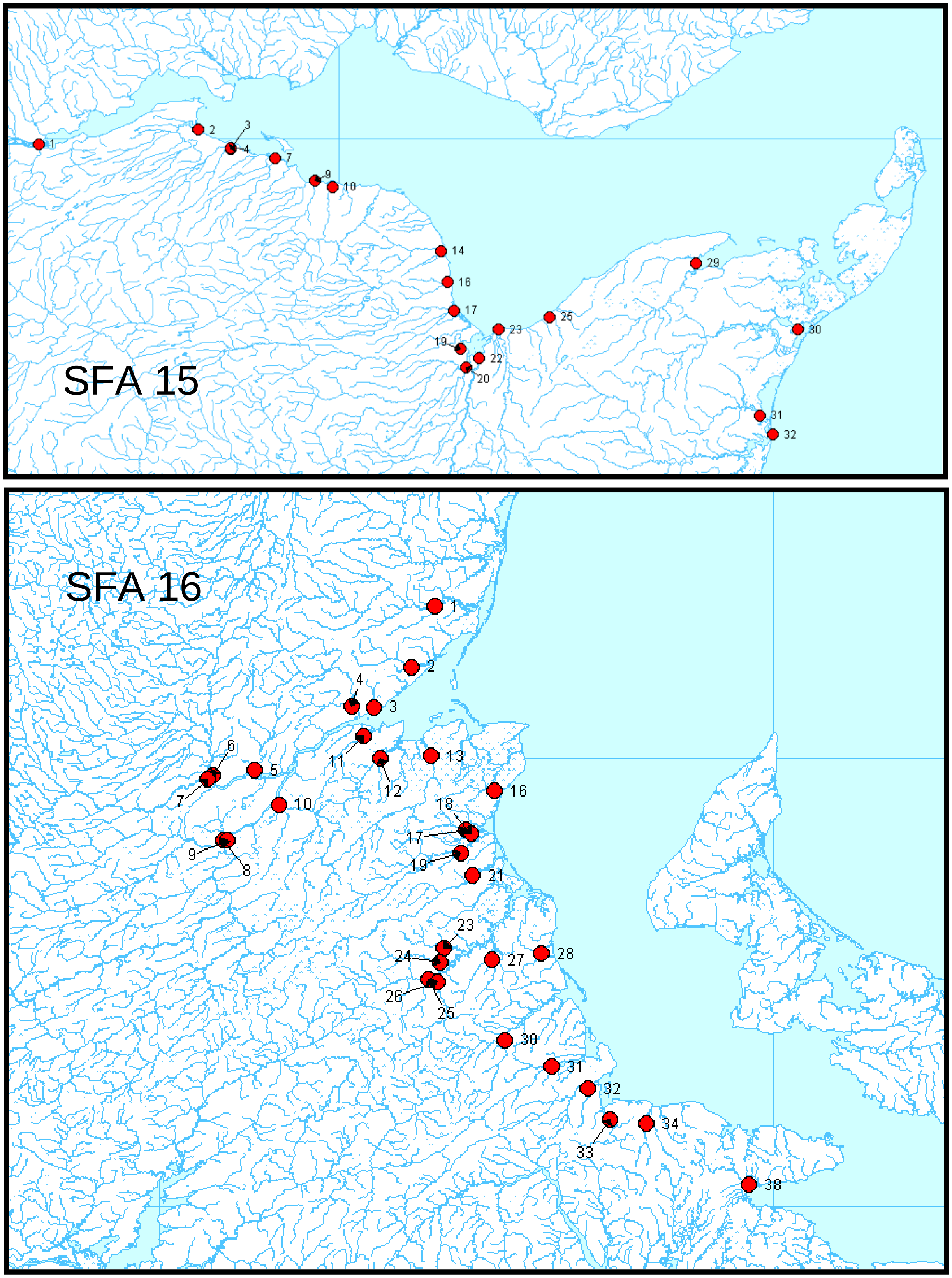
# APPENDICES

***Appendix Table 1.*** *List of rivers and their characteristics with confirmed Atlantic salmon presence by Salmon Fishing Area in DFO Gulf Region. Source of evidence of salmon presence include adults (Adult) either from angling, surveys or redd counts and from juvenile monitoring (Juvenile).*

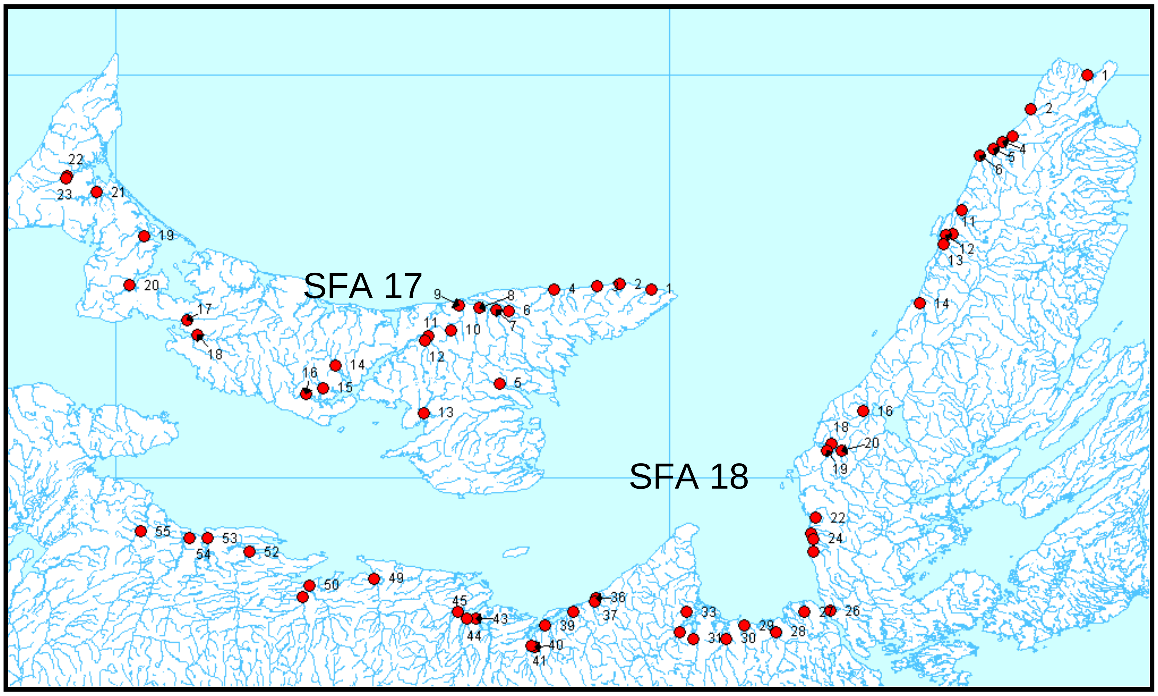
| Map index number | SFA | River name | Longitude (W) | Latitude (N) | Egg requirement (million) | Drainage area (km²) | Fluvial area (million m²) | Adult | Juve-nile |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 15 | Restigouche | -66.783 | 47.991 | 44.93 | 6,589 | 26.744 | X | X |
| 2 | 15 | Eel River | -66.367 | 48.017 | 1.01 | 116 | 0.422 | X | X |
| 3 | 15 | Charlo | -66.283 | 47.983 | 1.44 | 400 | 0.600 | X | X |
| 4 | 15 | South Charlo | -66.283 | 47.985 | | | | | X |
| 7 | 15 | Benjamin | -66.167 | 47.967 | 0.58 | 161 | 0.241 | X | X |
| 9 | 15 | Louison River | -66.063 | 47.927 | | | | | X |
| 10 | 15 | Jacquet | -66.017 | 47.917 | 2.72 | 510 | 1.135 | X | X |
| 14 | 15 | Elmtree | -65.732 | 47.805 | | | | | X |
| 16 | 15 | Nigadoo | -65.717 | 47.750 | 0.6 | 168 | 0.252 | X | X |
| 17 | 15 | Millstream | -65.700 | 47.700 | 0.83 | 229 | 0.344 | X | X |
| 19 | 15 | Tetagouche | -65.683 | 47.633 | 0.72 | 364 | 0.299 | X | X |
| 20 | 15 | Middle (Gloucester) | -65.667 | 47.600 | 2.28 | 401 | 0.950 | X | X |
| 22 | 15 | Nepisiguit | -65.633 | 47.617 | 9.54 | 2,312 | 3.973 | X | X |
| 23 | 15 | Bass (Gloucester) | -65.583 | 47.667 | 0.71 | 198 | 0.297 | X | X |
| 25 | 15 | Teagues Brook | -65.449 | 47.689 | | | | | X |
| 29 | 15 | Caraquet | -65.067 | 47.783 | 1.34 | 373 | 0.560 | X | X |
| 30 | 15 | Pokemouche | -64.800 | 47.667 | 0.60 | 481 | 0.248 | X | X |
| 31 | 15 | Little Tracadie | -64.900 | 47.517 | 0.69 | 192 | 0.289 | X | X |
| 32 | 15 | Tracadie | -64.867 | 47.483 | 1.44 | 527 | 0.601 | X | X |
| 1 | 16 | Tabusintac | -65.103 | 47.338 | 1.98 | 704 | 0.824 | X | X |
| 2 | 16 | Burnt Church | -65.179 | 47.204 | 0.72 | 135 | 0.299 | X | X |
| 3 | 16 | Oyster | -65.304 | 47.113 | | | | | X |
| 4 | 16 | Bartibog | -65.372 | 47.115 | 2.72 | 512 | 1.135 | X | X |
| 5 | 16 | Northwest Millstream | -65.692 | 46.974 | 1.20 | 210 | 0.479 | X | X |
| 6 | 16 | Northwest Miramichi | -65.826 | 46.963 | 20.10 | 2,307 | 8.230 | X | X |
| 7 | 16 | Little Southwest Miramichi | -65.845 | 46.953 | 19.70 | 1,345 | 8.070 | X | X |
| 8 | 16 | Renous | -65.792 | 46.816 | 14.00 | 1,429 | 5.820 | X | X |
| 9 | 16 | Southwest Miramichi | -65.781 | 46.816 | 70.90 | 5,840 | 29.530 | X | X |
| 10 | 16 | Barnaby | -65.611 | 46.896 | 3.10 | 490 | 1.304 | X | X |
| 11 | 16 | Napan | -65.337 | 47.050 | 0.28 | 115 | 0.115 | X | X |
| 12 | 16 | Black (Northum-berland) | -65.280 | 47.000 | 0.67 | 277 | 0.277 | X | X |
| 13 | 16 | Bay du Vin | -65.117 | 47.005 | 0.68 | 284 | 0.284 | X | X |
| 16 | 16 | Riviere au Portage | -64.910 | 46.928 | | | | | X |
| 17 | 16 | Black (Kent) | -65.004 | 46.840 | 0.82 | 343 | 0.343 | X | X |

| Map index number | SFA | River name | Longitude (W) | Latitude (N) | Egg requirement (million) | Drainage area (km²) | Fluvial area (million m²) | Adult | Juve-nile |
|---|---|---|---|---|---|---|---|---|---|
| 18 | 16 | Rankin Brook | -64.986 | 46.831 | | | | | X |
| 19 | 16 | Kouchibou-guac (Kent) | -65.020 | 46.790 | 1.41 | 389 | 0.588 | X | X |
| 21 | 16 | Kouchibou-guacis | -64.980 | 46.739 | 1.32 | 360 | 0.549 | X | X |
| 23 | 16 | Molus | -65.073 | 46.578 | | | | | X |
| 24 | 16 | Bass | -65.089 | 46.545 | | | | | X |
| 25 | 16 | Richibucto | -65.125 | 46.508 | 2.94 | 1,292 | 1.226 | X | X |
| 26 | 16 | Coal Branch | -65.093 | 46.502 | | | | | X |
| 27 | 16 | Saint Nicholas | -64.919 | 46.551 | | | | | X |
| 28 | 16 | Chockpish | -64.755 | 46.566 | 0.31 | 129 | 0.129 | X | |
| 30 | 16 | Buctouche | -64.874 | 46.373 | 1.59 | 628 | 0.661 | X | X |
| 31 | 16 | Cocagne | -64.724 | 46.314 | 0.68 | 333 | 0.283 | X | X |
| 32 | 16 | Shediac | -64.605 | 46.264 | 0.52 | 219 | 0.216 | X | X |
| 33 | 16 | Scoudouc | -64.532 | 46.194 | 0.35 | 159 | 0.146 | X | X |
| 34 | 16 | Aboujagane | -64.415 | 46.186 | 0.29 | 120 | 0.120 | X | X |
| 38 | 16 | Gaspereau (Westmorland) | -64.083 | 46.050 | 0.41 | 170 | 0.170 | | X |
| 1 | 17 | North Lake Creek | -62.068 | 46.468 | 0.15 | 48 | 0.062 | X | X |
| 2 | 17 | Priest Pond Creek | -62.179 | 46.481 | 0.08 | 25 | 0.033 | X | X |
| 3 | 17 | Cross Creek | -62.263 | 46.475 | 0.14 | 44 | 0.058 | X | X |
| 4 | 17 | Naufrage | -62.417 | 46.469 | 0.14 | 44 | 0.057 | X | X |
| 5 | 17 | Cardigan | -62.519 | 46.205 | 0.14 | 45 | 0.058 | | X |
| 6 | 17 | St. Peters | -62.581 | 46.415 | 0.14 | 45 | 0.058 | X | X |
| 7 | 17 | Midgell | -62.626 | 46.416 | 0.20 | 64 | 0.084 | X | X |
| 8 | 17 | Morell | -62.686 | 46.424 | 0.57 | 171 | 0.237 | X | X |
| 9 | 17 | Bristol (Berrigans) Creek | -62.759 | 46.427 | 0.13 | 41 | 0.054 | X | X |
| 10 | 17 | Head of Hillsborough | -62.788 | 46.368 | 0.17 | 53 | 0.070 | | X |
| 11 | 17 | Pisquid | -62.870 | 46.351 | 0.15 | 48 | 0.062 | X | X |
| 12 | 17 | Clarks Creek | -62.885 | 46.342 | 0.15 | 46 | 0.061 | | X |
| 13 | 17 | Vernon | -62.886 | 46.161 | 0.22 | 69 | 0.090 | | X |
| 14 | 17 | North | -63.151 | 46.226 | 0.31 | 99 | 0.130 | X | X |
| 15 | 17 | Clyde | -63.263 | 46.195 | 0.13 | 42 | 0.055 | | X |
| 16 | 17 | West | -63.471 | 46.209 | 0.14 | 43 | 0.185 | X | X |
| 17 | 17 | Wilmot | -63.741 | 46.391 | 0.26 | 83 | 0.109 | | X |
| 18 | 17 | Dunk | -63.778 | 46.369 | 0.46 | 166 | 0.193 | X | X |
| 19 | 17 | Trout (Tyne Valley) | -63.897 | 46.601 | 0.15 | 48 | 0.063 | X | X |
| 20 | 17 | Little Trout | -63.950 | 46.479 | 0.07 | 21 | 0.028 | X | X |
| 21 | 17 | Trout (Coleman) | -64.066 | 46.710 | 0.34 | 107 | 0.140 | X | X |
| 22 | 17 | Cains Brook (Mill River) | -64.172 | 46.749 | 0.05 | 31 | 0.023 | X | X |
| 23 | 17 | Carruthers Brook (Mill River) | -64.178 | 46.744 | 0.09 | 48 | 0.035 | X | X |
| 1 | 18 | Salmon | -60.494 | 47.000 | | | | | X |

| Map index number | SFA | River name | Longitude (W) | Latitude (N) | Egg requirement (million) | Drainage area (km²) | Fluvial area (million m²) | Adult | Juve-nile |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 18 | Blair | -60.699 | 46.917 | 0.23 | 58 | 0.097 | X | |
| 3 | 18 | Red | -60.766 | 46.850 | 0.14 | 35 | 0.059 | | X |
| 4 | 18 | Grande Anse | -60.799 | 46.833 | 0.20 | 51 | 0.085 | X | X |
| 5 | 18 | Mackenzies | -60.833 | 46.817 | 0.30 | 75 | 0.124 | X | X |
| 6 | 18 | Fishing Cove | -60.883 | 46.800 | 0.13 | 31 | 0.052 | X | |
| 10 | 18 | Chéticamp | -60.949 | 46.667 | 0.77 | 298 | 0.322 | X | X |
| 11 | 18 | Aucoin Brook | -60.981 | 46.607 | | | | | X |
| 12 | 18 | Fiset Brook | -61.005 | 46.603 | | | | | X |
| 13 | 18 | Farm Brook | -61.015 | 46.582 | | | | | X |
| 14 | 18 | Margaree | -61.099 | 46.433 | 6.71 | 1,100 | 2.798 | X | X |
| 16 | 18 | Broad Cove | -61.303 | 46.165 | | | | | X |
| 18 | 18 | Northeast Mabou | -61.416 | 46.083 | 1.02 | 254 | 0.424 | X | X |
| 19 | 18 | Southwest Mabou | -61.433 | 46.067 | 0.37 | 123 | 0.154 | X | X |
| 20 | 18 | Mabou | -61.383 | 46.067 | 0.56 | 188 | 0.235 | X | X |
| 22 | 18 | Judique Intervale Brook | -61.474 | 45.900 | 0.18 | 44 | 0.074 | X | X |
| 23 | 18 | Graham | -61.491 | 45.861 | | | | | X |
| 24 | 18 | Campbells Brook | -61.484 | 45.849 | | | | | X |
| 25 | 18 | Chisholm Brook | -61.483 | 45.817 | 0.07 | 17 | 0.028 | X | X |
| 26 | 18 | Mill Brook (Strait of Canso) | -61.422 | 45.669 | | | | | X |
| 27 | 18 | Wrights | -61.518 | 45.667 | | | | X | X |
| 28 | 18 | Tracadie | -61.616 | 45.617 | 0.13 | 120 | 0.053 | X | |
| 29 | 18 | Afton | -61.733 | 45.633 | 0.05 | 43 | 0.019 | X | X |
| 30 | 18 | Pomquet | -61.799 | 45.600 | 0.19 | 176 | 0.077 | X | X |
| 31 | 18 | South | -61.916 | 45.600 | 0.23 | 217 | 0.095 | X | X |
| 32 | 18 | West (Antigonish) | -61.966 | 45.617 | 1.15 | 353 | 0.480 | X | X |
| 33 | 18 | North | -61.939 | 45.666 | | | | | X |
| 36 | 18 | Vameys Brook | -62.269 | 45.701 | | | | | X |
| 37 | 18 | Baileys Brook | -62.270 | 45.692 | | | | | X |
| 38 | 18 | Barneys | -62.349 | 45.667 | 0.51 | 156 | 0.213 | X | X |
| 39 | 18 | French (Merigomish) | -62.449 | 45.633 | 0.42 | 128 | 0.174 | X | X |
| 40 | 18 | Russell Brook | -62.488 | 45.580 | | | | | X |
| 41 | 18 | Sutherlands | -62.499 | 45.583 | 0.16 | | 0.067 | X | X |
| 43 | 18 | East (Pictou) | -62.699 | 45.650 | 1.75 | 536 | 0.729 | X | X |
| 44 | 18 | Middle (Pictou) | -62.733 | 45.650 | 0.71 | 217 | 0.295 | X | X |
| 45 | 18 | West (Pictou) | -62.766 | 45.667 | 0.80 | 245 | 0.333 | X | X |
| 49 | 18 | River John | -63.066 | 45.750 | 0.95 | 292 | 0.397 | X | X |
| 50 | 18 | Waughs | -63.299 | 45.733 | 0.75 | 230 | 0.313 | X | X |
| 51 | 18 | French | -63.326 | 45.704 | | | | | X |
| 52 | 18 | Wallace | -63.516 | 45.817 | 1.50 | 458 | 0.623 | X | X |
| 53 | 18 | Pugwash | -63.666 | 45.850 | 0.59 | 182 | 0.247 | X | X |
| 54 | 18 | River Philip | -63.733 | 45.850 | 2.31 | 726 | 0.962 | X | X |
| 55 | 18 | Shinimicas | -63.909 | 45.866 | | | | | X |




***Appendix Figure 1.*** *Location of rivers with confirmed Atlantic salmon presence by SFA in DFO Gulf Region.*




***Appendix Figure 1*** *(continued).*

## FOR MORE INFORMATION

Contact: Marc Lanteigne
Aquatic Resources Division
Science Branch, Gulf Region
P.O. Box 5030
Moncton, NB
E1C 9B6

Tel: 506-851-6212
Fax: 506-851-2620
E-Mail: marc.lanteigne@dfo-mpo.gc.ca

This report is available from the:

Centre for Science Advice (CSA)
Gulf Region
Fisheries and Oceans Canada
P.O. Box 5030
Moncton, NB
E1C 9B6

Telephone: 506-851-6253
Fax: 506-851-2620
E-Mail: csas-sccs@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

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