STATUS OF ATLANTIC SALMON IN SALMON FISHING AREAS (SFAs) 19-21 AND 23

Context

Atlantic salmon populations of the Maritimes Region have experienced two or more decades of decline. Atlantic salmon commercial fisheries were closed by 1985. In-river closures of recreational fisheries began in 1990 in the inner Bay of Fundy and expanded to all outer Bay of Fundy (western part of Salmon Fishing Area, SFA 23) and many eastern and southern shore rivers (SFAs 20 and 21) by 1998. In addition, Aboriginal communities have either reduced or curtailed their fishing activity. There are thought to be four large groupings of salmon in the Maritimes Region: the outer Bay of Fundy, the Nova Scotia Southern Upland (SFAs 20 and 21), the inner Bay of Fundy (SFA 22 and eastern part of SFA 23), and eastern Cape Breton (SFA 19) areas. Many populations are extirpated, and inner Bay of Fundy salmon are listed as endangered under the Species at Risk Act. In November 2010, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the Outer Bay of Fundy, Nova Scotia Southern Upland and eastern Cape Breton population assemblages as endangered.

Science advice on the status of salmon in SFAs 19-21 and 23 was requested by Fisheries and Aquaculture Management on November 19, 2010. This advice is used to inform Aboriginal groups of the status of the salmon resource in advance of developing harvest agreements and to develop recreational fishing plans for 2011. Given that this advice consists of an update of previous advice using established methods, it was decided to provide this status report through the Science Special Response Process. A meeting was held by DFO Maritimes Science (February 17, 2011) to review the information in this document. This Science Response report is a product of that meeting.

Evaluation of the status of Atlantic salmon in the Maritime Provinces is based on a comparison of the abundance of salmon relative to a reference point known as the conservation spawner requirement (CSR). The CSR is generally a river-specific estimate of the number of salmon, based on the amount of fluvial (of suitable gradient) habitat, and biological characteristics of salmon, required to produce an egg deposition of 2.4 eggs/m^2 of habitat (O'Connell et al. 1997). The corresponding egg deposition is referred to as the conservation egg requirement. The CSR was originally adopted by the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) as the level below which CAFSAC would strongly advise that no fishing should occur. CAFSAC considered that this level provided a modest margin of safety but that the possibility of irreversible damage to the stock increased the further spawning escapement was, and the longer it remained, below the CSR, even at levels only slightly below (CAFSAC 1991).

Analyses and Responses

Eastern Cape Breton (SFA 19)

Salmon assessments in eastern Cape Breton is currently focused on four major river systems: **Middle, Baddeck, North, and Clyburn** (Appendix 1). Grand River was assessed annually in the past, but this assessment has been discontinued because neither fish counts nor

recreational catch data are available for this river. Dive survey counts in the North Aspy and Skye rivers were carried out in 2009 and a dive survey count in the Barachois River was attempted in 2010.

Assessments of salmon by DFO in SFA 19 are based on recreational catches, which are reported through a license-stub return program, as well as fishery-independent counts of adult salmon by dive surveys in Middle, Baddeck and North rivers. Parks Canada monitors adult abundance on the Clyburn River using similar dive surveys. Additional information about these assessments is provided in Gibson and Bowlby (2009).

Prior to 1998, recreational salmon fishing was open from June 1st to October 31st in eastern Cape Breton. Since 1998, with the exception of the North River, the season has been shortened with the implementation of a mid-season warm water closure (July 16th – August 31st). In 2009, all rivers within SFA 19 were closed to salmon fishing during the fall, with the exception of Middle, Baddeck and North rivers. In 2010, all rivers within SFA 19, with the exception of Middle, Baddeck, North and North Aspy rivers, were closed to salmon fishing all year. Middle and Baddeck rivers were open to catch-and-release salmon angling from September 11th to October 31st; North River (downstream from the area know as the "Benches") was open to catch-and-release salmon angling from June 1st to October 31st; and North Aspy River was open to catch-and-release salmon angling from June 1st to July 15th and from September 1st to October 31st (Appendix 2 and Appendix 3). In 2010, approximately 95% of the annual salmon recreational fishing effort within eastern Cape Breton took place on the Middle, Baddeck and North rivers (Appendix 4).

Catch-and-release angling has become more common for salmon management and conservation due to the widespread decline in salmon abundance in the North Atlantic. For populations that are below target levels, catch-and-release angling provides an intermediate management alternative between closing recreational fisheries and allowing retention fisheries. Catch-and-release angling has been practiced in some areas of Canada and the USA since 1984, and both regulated and voluntary catch-and-release angling has been practiced in many European countries in recent years (ICES 2010).

ICES (2009) evaluated the results of studies that estimate the levels of pre-spawning mortality of salmon caught and released by anglers and their implications for stock assessments. In most areas of North America, mortality resulting from catch-and-release angling is incorporated into assessments of spawning escapement and returns (ICES 2010). Highly variable rates of fish mortality associated with a fish being hooked and subsequently released have been reported (Dempson *et al*., 2002; Thorstad *et al*., 2003). Water temperature is cited as an important factor; angling at low temperatures (i.e., below 17-18^{o}C) generally results in lower mortalities than catch-and-release angling that occurs at higher water temperatures (ICES 2009). ICES (2009) provides a tabular summary of catch-and-release mortality studies on Atlantic salmon, which lists mortality rates and respective water temperatures. The mortality rates associated with catch-and-release angling at water temperatures less than 12°C are predominately $\leq$ 3 %, and five of five studies conducted at temperatures less than 10°C reported no mortality associated with catch-and release. In addition to temperature, fish mortality associated with catch-and-release angling is also believed to be affected by an angler's level of experience; fish mortality is believed to be lower for more experienced anglers than for less experienced anglers. These studies show low direct mortality associated with catch-and release recreational fisheries if conducted at low water temperatures. Although there is information available on the short-term physiological effects of angling, there is little information available about other effects of catch and release salmon fishing (e.g., potential effects on migration, reproduction, habitat

impacts, transfer of pathogens, etc.). As noted in the status sections below, an assumption of a 4% catch-and-release mortality is applied to rivers assessed in eastern Cape Breton.

Status

Data available for assessing the status of salmon in **Middle River** include annual recreational catch estimates from license stub returns and counts of adult salmon made during dive surveys, as well as intermittent electrofishing data. The conservation requirement for Middle River is 2.07 million eggs, calculated based on an estimated 864,600 m^2 of habitat and a target egg deposition density of 2.4 eggs/m^2. This egg deposition is expected from about 470 large and 80 small salmon.

Data from the recreational fishery have been collected from salmon license stub returns since 1983, with large salmon (63 cm or larger) and small salmon (less than 63 cm) being recorded separately. The data include the number of salmon caught and released, the number harvested and fishing effort in each year. Effort is estimated in rod days where any portion of a day fished by one angler is recorded as one rod day. Values are adjusted for non-returned stubs using a relationship based on the reported catch as a function of the number of reminder letters sent to licensed anglers. The preliminary estimates (Appendix 4) of the recreational catch in 2010 were 65 small and 199 large salmon with an estimated effort of 668 rod days. Although the effort was lower in 2010, the catch of both small and large salmon was higher in 2010 than in 2009. Analysis of the recreational fishing data series indicates that fishing effort on this river has shown an increasing trend over the last ten years.

The numbers of large and small salmon counted during dive surveys in Middle River from 1989 to 2010 provide an index of the spawning escapement for this population. These surveys typically take place during the last week of October, just prior to the end of the fishing season. During the dive survey in 2010, 10 small and 125 large salmon were counted. The number of small salmon counted in 2010 was lower than in 2009 (39), whereas the number of large salmon counted in 2010 was higher than in 2009 (97).

An abundance time series for Atlantic salmon in Middle River was derived using a model that combines the recreational catch, dive survey, adult mark-recapture and electrofishing data to estimate abundance using maximum likelihood (Gibson and Bowlby 2009). The resulting time series (Figure 1) shows that the spawner abundance has varied between 31 and 486 from 1983 to 2010. The spawning escapement in 2010 is estimated to be 312 large salmon and 53 small salmon, up from the 2009 estimates of 257 large and 18 small salmon.

Estimates of the percent of the conservation requirement met annually (Figure 1) show a similar pattern with very little chance that the population has met its conservation requirement at any time since 1983. An assumption of 4% catch-and-release mortality is used in the assessment model. Based on the preliminary recreational catch estimate, the number of mortalities resulting from the recreational fishery is estimated to be ten to eleven salmon.

In 2010, seven large salmon were removed from the population for use as broodstock. This stocking program was designed to offset anticipated future losses to the population from catch-and-release mortality. Approximately 12,000 fin-clipped age-0 fall parr, resulting from last year's broodstock collection, were released into Middle River in October 2010 as part of this program. Adult returns associated with this release are expected in three to seven years.

The percent of the conservation egg requirement met in 2010 is estimated to be 54%. Overall, the analyses indicate a more or less stable abundance trend with the population typically in the range of 24 to 74 % of its conservation requirement over the last 10 years.

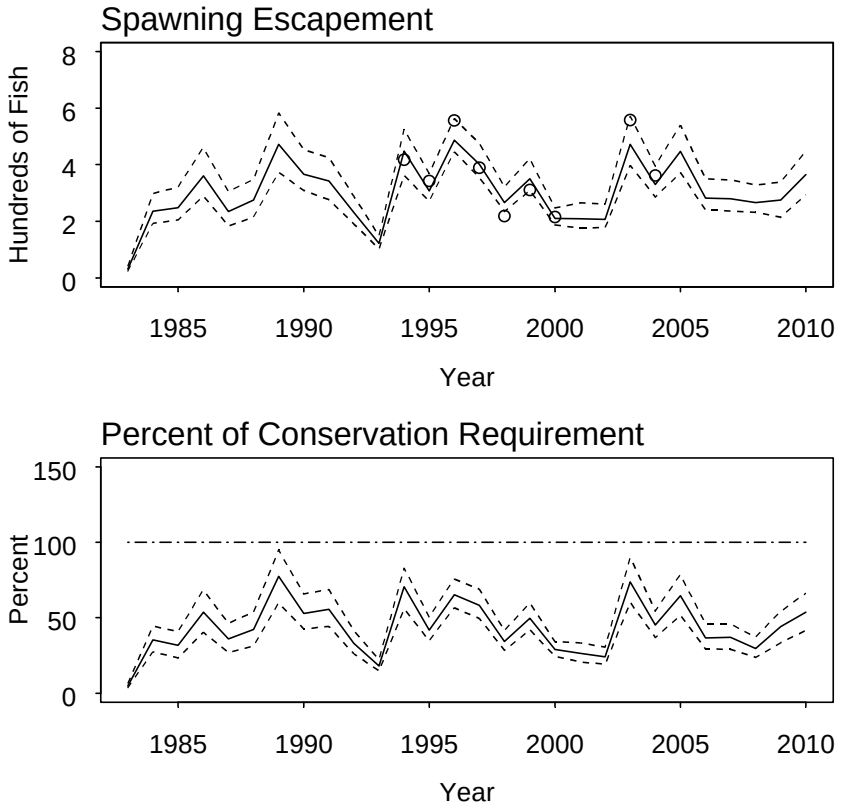

Figure 1. Estimated total number of spawners (top panel) and the percent of the conservation requirement attained (bottom panel) in Middle River, NS, from 1983 to 2010. The solid lines are the estimated values and the dashed lines are the 10th and 90th percentiles of the posterior probability densities for the estimates (indicative of the uncertainty of the estimates). The points in the upper panel are the population estimates obtained by mark recapture during the dive surveys. The horizontal dashed line in the bottom panel indicates 100% of the conservation requirement.

The assessment methods and data available for Atlantic salmon in **Baddeck River** are similar to those for Middle River. The conservation requirement for the Baddeck River is 2.0 million eggs, calculated based on an estimated 836,300 m^2 of habitat and a target egg deposition density of 2.4 eggs/m^2. This egg deposition is expected from about 450 large and 80 small salmon.

In 2010, the preliminary estimate (Appendix 4) of the recreational catch was 52 small salmon and 142 large salmon with an estimated effort of 333 rod days. Although the effort was lower in 2010, both the catch of small and large salmon was higher in 2010 than in 2009. Analysis of the recreational fishing data series indicates that fishing effort has shown an increasing trend over the last ten years.

The numbers of large and small salmon counted during dive surveys in Baddeck River from 1994 to 2010 provide an index of the spawning escapement for this population. These surveys typically take place during the last week of October, just prior to the end of the fishing season.

During the dive survey in 2010, 2 small and 40 large salmon were counted; both of these counts are lower than the dive survey counts for 2009 (i.e., 15 small and 67 large salmon).

Annual estimates of the salmon escapement after the recreational fishery (Figure 2) show that the spawner abundance has varied between 45 and 367 from 1983 to 2010. The spawning escapement in 2010 is estimated to be 190 large salmon and 31 small salmon, up from the 2009 estimates of 179 large and 21 small salmon.

Estimates of the percent of the conservation requirement met annually (Figure 2) show a similar pattern with very little chance that the population has met its conservation requirement since 1983. Based on the preliminary recreational catch estimate, the number of mortalities as a result of the recreational fishery in the Baddeck River (4% mortality rate assumed) is estimated to be seven to eight salmon.

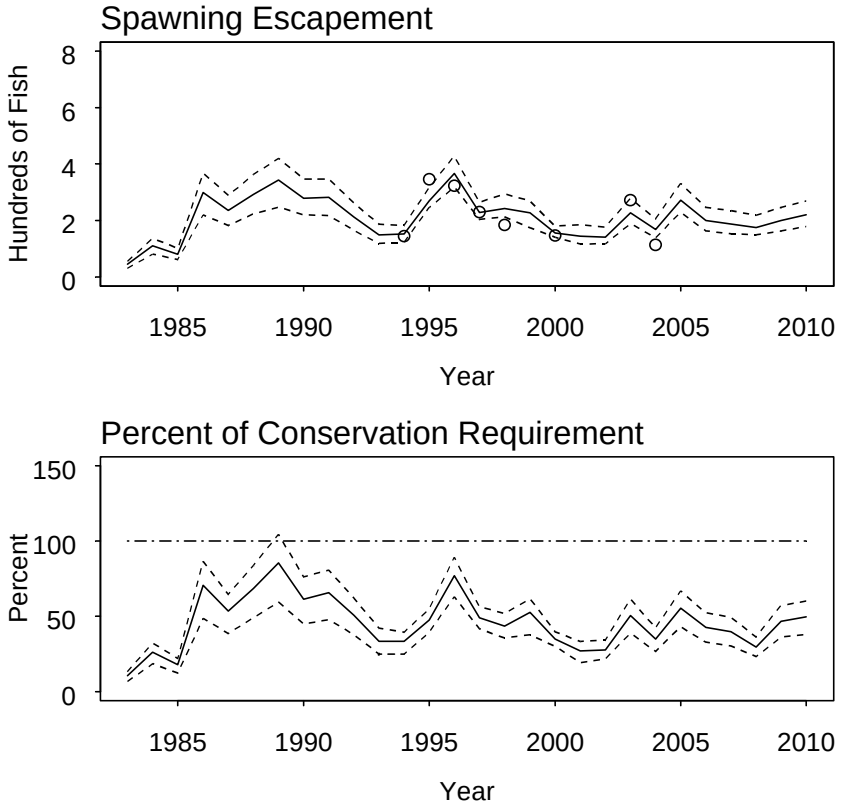

Figure 2. Estimated total number of spawners (top panel) and the percent of the conservation requirement attained (bottom panel) in Baddeck River, NS, from 1983 to 2010. The solid lines are the estimated values and the dashed lines are the 10th and 90th percentiles of the posterior probability densities for the estimates (indicative of the uncertainty of the estimates). The points in the upper panel are the population estimates obtained by mark recapture during the dive surveys. The horizontal dashed line in the bottom panel indicates 100% of the conservation requirement.

In 2010, seven salmon (two small and five large) were removed from the population for use as broodstock. This stocking program was designed to offset anticipated future losses to the population from catch-and-release mortality. Approximately 13,000 fry and 9,000 fin clipped age-0 fall parr, resulting from last year's broodstock collection, were released into the Baddeck River in 2010 as part of this program. Adult returns associated with these releases are expected in three to seven years.

The percent of the conservation egg requirement met in 2010 is estimated to be 50%. Overall, the analyses indicate a roughly stable total abundance trend with the population in the range of 27 to 55% of its conservation requirement over the last 10 years.

Clyburn Brook is found on the eastern side of Cape Breton Highlands National Park near Ingonish. The river runs over a length of 19.4 km and is estimated to contain 116,500 m^2 of habitat. Parks Canada has conducted annual dive surveys on this river from 1985 to 2010. The counts of large and small salmon are done at the end of the fishing season. The observation efficiency is not known; however, the time series provides a relatively consistent index of abundance for this river, yet in some years less area is covered during the survey than in others. Counts in this river were highest in 1987 at 175 salmon (Figure 3) and have only exceeded 20 salmon twice since 1999. Three small and five large salmon were counted during the annual dive survey in 2010.

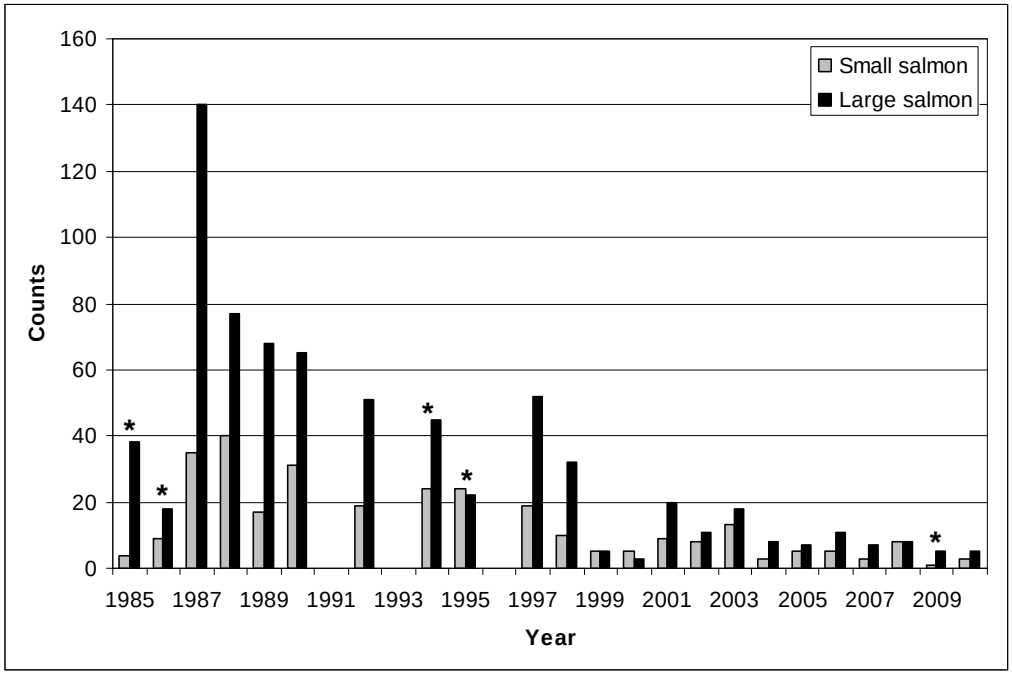

Figure 3. Counts of large and small salmon in Clyburn Brook, NS, from 1985 to 2010. Years in which only the lower section of the river was surveyed (partial counts) are identified with an asterisk (*****).

Similar to the Middle and Baddeck rivers, recreational catch estimates from license stub returns and counts of adult salmon made by divers are available for assessing the status of salmon in **North River**. The conservation requirement for the North River is based on an estimated 382,700 m^2 of habitat and a target egg deposition rate of 2.4 eggs/m^2. The requirement of 0.85 million eggs is expected from about 200 large and 30 small salmon.

In 2010, the preliminary estimate (Appendix 4) of the recreational catch in North River was 128 small salmon and 254 large salmon with an estimated effort of 529 rod days. Although the effort was lower in 2010, both the catch of small and large salmon was higher in 2010 than in 2009. Analysis of the recreational fishing data series indicates that fishing effort has shown an increasing trend over the last ten years.

Dive survey counts in North River are not conducted every year because of water conditions. Counts have been completed in six years since 2001 and have ranged from twelve to 117 salmon (size categories combined). Counts from 1994 to 1998 ranged from 167 to 335 salmon. A dive survey count was not conducted in 2010 due to water conditions. Returns to North River in 2010 were estimated using the preliminary recreational catch data and mean catch rates (ratio of the recreational catch to the estimated returns) for this river. Based on these rates (0.41 for large and 0.69 for small salmon), the estimated returns are 623 large and 186 small salmon. The 2010 large and small salmon estimates are both greater than those for 2009. Based on the preliminary estimated recreational catch, the number of mortalities as a result of the recreational fishery in North River (4% mortality rate assumed) is estimated to be 15 to 16 salmon. This population has shown a declining trend since the 1980s, but based on the recreational catch, it appears to be above its conservation requirement at present (Figure 4).

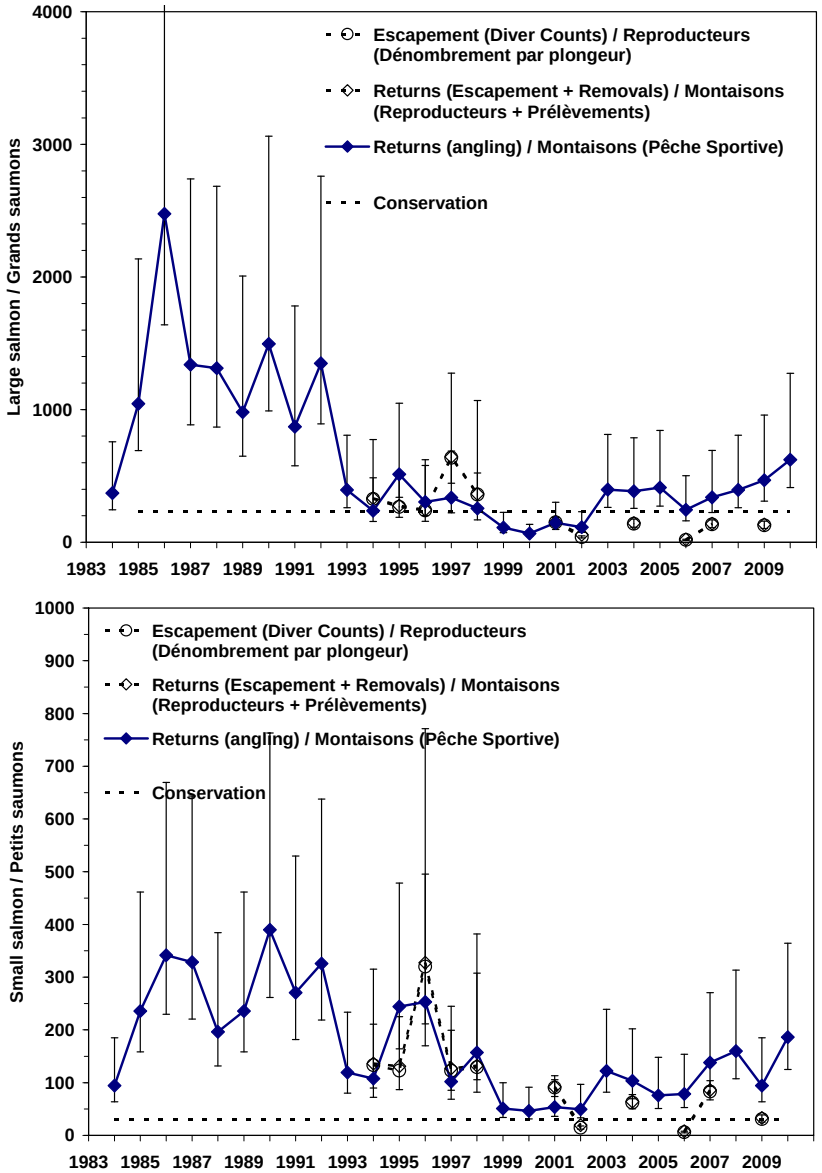

Figure 4. Estimates of the number of salmon returning to spawn and the spawning escapement for large and small salmon in the North River, NS, as derived from dive survey counts and from recreational catch data. The expected number of large or small salmon necessary to meet the conservation requirement is shown by the horizontal dashed line. Error bars are 90% confidence intervals.

The status of salmon in the **North Aspy River** was assessed by a dive survey for the first time in 2009, where 28 small and 126 large salmon were observed. A dive survey was not conducted in 2010 due to water conditions. The preliminary estimates (Appendix 4) of the recreational catch in 2010 were 14 small and 16 large salmon with an estimated effort of 82 rod days. Based on the preliminary recreational catch estimate, the number of mortalities as a result of the recreational fishery in North Aspy River (4% mortality rate assumed) is estimated to be one to two salmon. No recreational catch or effort data were reported for the North Aspy River in 2009. The 2009 salmon angling season for North Aspy River was June 1 to July 15, whereas the majority of the known reported recreational fishing effort has occurred in September and October on the North Aspy River over the last 10 years. Therefore, because the timing of the angling seasons differed, the 2009 and 2010 recreational catch information are not comparable.

A dive survey was performed in the **Barachois River** for the first time in 2010. Nine large and eight small salmon were counted, although water clarity was not favorable and the observation efficiency of the survey is not known. Therefore, the count could not be used to estimate adult abundance in the Barachois River and no inferences can be drawn from the results.

In 2010, a preliminary estimate (Appendix 4) of the number of salmon caught and released in SFA 19 was 870 fish. Assuming a 4% catch-and-release mortality rate, 34 to 35 salmon are estimated to have died as a result of the 2010 recreational fishery in SFA 19.

Southern Upland of Nova Scotia (SFAs 20 and 21)

The Southern Upland (SU) region of Nova Scotia includes all rivers on the Eastern Shore and Southwest Nova Scotia draining into the Atlantic Ocean. It has been divided into two SFAs for management purposes: SFA 20 (Eastern Shore) and SFA 21 (Southwest Nova Scotia) (Appendix 2). Within the previous century, 63 rivers in the Southern Upland are known to have supported anadromous Atlantic salmon populations. Based on pH samples collected in the early 1980s, at least 14 of these rivers were heavily acidified (pH < 4.7) and were no longer able to support salmon (DFO 2000). A further 20 rivers were partially acidified (pH ranges from 4.7 to 5.0) and were thought to support only remnant populations. A region-wide electrofishing survey conducted in 2000 found salmon in 28 of 52 rivers surveyed (54%). A similar survey conducted in 2008 and 2009 found salmon in only 21 of 54 rivers surveyed (39%).

Atlantic salmon assessment activities in the SU region are focused primarily on two populations: the St. Mary's River, the index population for SFA 20, and the LaHave River, the index population for SFA 21 (Appendix 1). Additional information about these assessments is provided in Gibson et al. (2009). In 2010, all rivers within SFA 20 and SFA 21 were closed to recreational fishing for Atlantic salmon (Appendix 2).

Status

The **St. Mary's River** is one of the major river systems in SFA 20 and consists of two main branches: the West and East. Assessment activities in the St. Mary's River are focused on the West Branch of the river, which contains 55% of the juvenile salmon habitat available in the watershed. The conservation requirement for the entire river is 7.4 million eggs, which is equivalent to approximately 3,155 adult salmon.

Escapement estimates (Table 1) for the river are based either on the recreational catches (1996 and earlier), on adult mark-recapture experiments (1997 to 2001, 2006 to 2008 and 2010) or on the ratio of escapement estimates for the West Branch of the St. Mary's relative to the LaHave

River above Morgan Falls (2009 and 2010). From 2002 to 2005, mark-recapture experiments were attempted but were unsuccessful, and escapement estimates in these years were derived using the mean catch rate for seining during years when the mark-recapture experiments were successful. Mark-recapture experiments in 2009 had to be cancelled due to high river water levels; therefore, the ratio of escapement estimates for the West Branch of the St. Mary's River relative to the LaHave River above Morgan Falls for 2004-2008 was used to estimate the 2009 escapement for the West Branch of the St. Mary's River. In 2010, escapement estimates resulting from the mark-recapture experiment and from the ratio of escapement estimates for the West Branch of the St. Mary's River relative to the LaHave River are reported.

In 2010, a total of 23 salmon were marked, 36 were captured and nine were recaptured, giving a corrected Petersen estimate of escapement of 89 salmon (95% C.I. = 57, 164). This estimate represents 5% of the conservation requirement for the West Branch of the St. Mary's River. Based on the scale samples taken from captured fish, 84% of the population was comprised of one-sea-winter salmon, 12% was comprised of two-sea-winter salmon and 4% was comprised of repeat spawners. Overall the results of the mark-recapture experiment show a decline in escapement from 2009.

As described below, adult salmon counts conducted at the Morgan Falls fishway on the LaHave River showed an increase in the number of one-sea-winter (1SW) salmon in 2010 (i.e., 300 1SW salmon counted in 2010 versus 168 1SW salmon counted in 2009), whereas the multi-sea-winter (MSW) salmon count of 53 fish was the same in 2010 and 2009. By comparing the St. Mary's to the LaHave, the ratios of escapement estimates for the West Branch of the St. Mary's relative to the LaHave River above Morgan Falls for 2004-2008 range from 0.40 – 0.64 with a mean of 0.52. Under the assumption that this ratio is the same in 2010, the 2010 adult escapement estimate for West Branch of the St. Mary's River is 183 adult salmon. Applying separate ratios for 1SW (almost all small salmon) and MSW (almost all large salmon) salmon yields a similar escapement estimate: 171 1SW and 15 MSW, respectively (Table 1). This estimate represents 11% of the conservation requirement for the West Branch of the St. Mary's River, which is slightly greater than the estimate for 2009.

Based on electrofishing data from 13 sites in 2010, estimated salmon densities (fish per 100 m^2) of age-0 (fry), age-1, and age-2 and older juvenile salmon were 7.7, 5.8 and 0.3 respectively for the entire St. Mary's River, which is lower than 2009 for fry (11.3) and higher than 2009 for age-1 (3.0) and age-2 and older parr (0.2). These values are low relative to densities observed in rivers where adult salmon abundance is above their conservation requirement.

In order to ensure that intervention programs, such as supportive rearing or live gene banking, remained as options in case of future population decline, DFO collected juvenile salmon (fry and parr) from the St. Mary's River in 2006 and 2007 for rearing at the Coldbrook Biodiversity facility. These collections were undertaken as an "insurance policy" to ensure that fish were collected while there was still sufficient genetic diversity in the event that an intervention would be necessary to slow population decline. In 2008, 201 of the collected juveniles reached maturity and were released at four sites on the St. Mary's River so they could spawn naturally. In 2009, a further 212 adult salmon that had reached maturity were released at eight sites along the West Branch and its tributaries. The final adult release from these collections occurred in 2010, where 114 adult salmon were released at five sites along the West Branch and its tributaries. These releases are expected to provide an increase in abundance considered necessary despite potential fitness consequences to the population.

Table 1. Estimated escapement, including assessment method, of one-sea-winter (1SW) and multi-sea-winter (MSW; including both two-sea-winter and repeat spawning salmon) Atlantic salmon relative to the conservation requirement in the West Branch of the St. Mary's River for the years 1995 to 2010.

Year	1SW	MSW	% Conservation Requirement	Assessment Method
1995	1,121	240	78	Recreational Catches
1996	844	325	67	Recreational Catches
1997	390	61	26	Adult Mark-Recapture Experiments
1998	1,059	41	63	Adult Mark-Recapture Experiments
1999	307	83	22	Adult Mark-Recapture Experiments
2000	315	25	20	Adult Mark-Recapture Experiments
2001	319	106	24	Adult Mark-Recapture Experiments
2002	220	16	14	Seining and Mean Mark-Recapture Catch Rate
2003	600	122	42	Seining and Mean Mark-Recapture Catch Rate
2004	464	23	28	Seining and Mean Mark-Recapture Catch Rate
2005	192	8	12	Seining and Mean Mark-Recapture Catch Rate
2006	222	18	14	Adult Mark-Recapture Experiments
2007	182	23	12	Adult Mark-Recapture Experiments
2008	361	36	23	Adult Mark-Recapture Experiments
2009	96	15	7	Ratio of Escapement of St. Mary's to LaHave
2010	75[a] / 171[b]	14[a] / 15[b]	5[a] / 11[b]	[a] Adult Mark-Recapture Experiments / [b]Ratio of Escapement of St. Mary's to LaHave

Assessment activities on the **LaHave River**, the index river for SFA 21, include counts of salmon ascending a fish ladder at Morgan Falls, smolt abundance estimates at Morgan Falls and juvenile densities obtained by electrofishing. The population above Morgan Falls increased as a result of improved fish passage with the construction of a fish ladder in the late 1960s. Salmon were stocked in the river above Morgan Falls to augment population growth, but stocking was terminated in 2005. The conservation requirement for the LaHave River above Morgan Falls is 1.96 million eggs, equivalent to roughly 1,320 salmon of typical characteristics for this run.

The total count of adult salmon at the Morgan Falls fishway on the LaHave River in 2010 was 353 (300 1SW and 53 MSW salmon), none of which were of hatchery origin (Figure 5). This represents an increase in total returns from 2009. The count of 1SW salmon ascending the Morgan Falls fishway in 2010 was 1.8 times greater than the count in 2009, whereas the MSW salmon count was the same in both years. Estimated egg deposition above Morgan Falls was 687,094 eggs in 2010, which represents 35% of the conservation requirement (Figure 6).

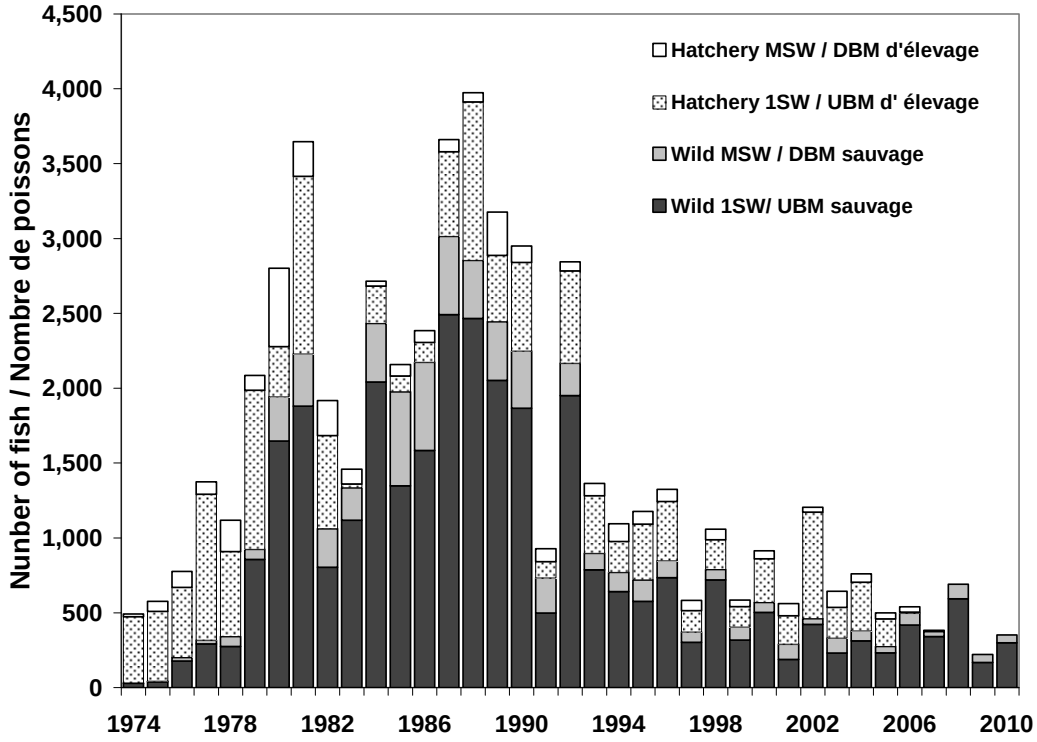

Figure 5. Counts of Atlantic salmon at Morgan Falls fishway on the LaHave River, NS, from 1974 to 2010 by wild-origin and hatchery-origin 1SW and MSW adults.

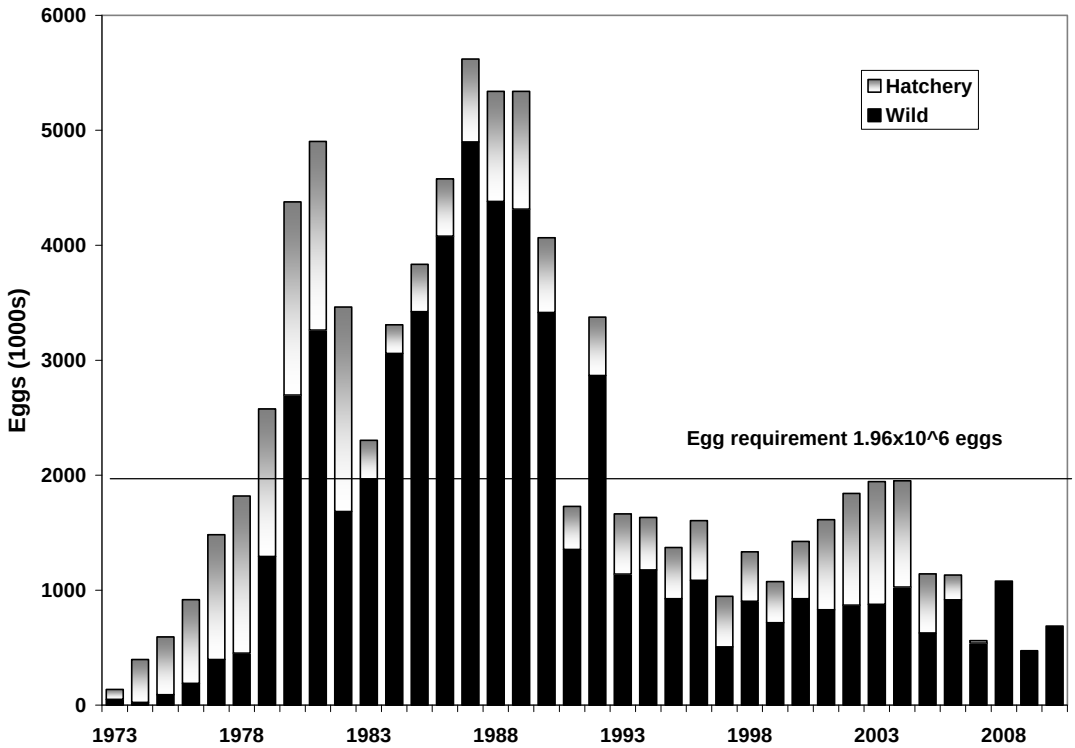

Figure 6. Estimated egg deposition (1000's) relative to the conservation egg requirement by wild and hatchery Atlantic salmon above Morgan Falls from 1973 to 2010.

In 2010, a total of 16,215 wild smolts (95% C.I. = 15160, 17270) were estimated to have emigrated from above Morgan Falls. This estimate is 1.9 times greater than the 2009 estimate (8,644) and greater than the 1996-2009 mean (15,869).

Based on electrofishing data from nine sites in 2010, estimated salmon densities (fish per 100 m^2) of age-0 (fry), age-1, and age-2 and older juvenile salmon were 17.0, 11.9 and 0.5, respectively for the entire LaHave River, which is lower than 2009 for fry (29.5) and age-2 and older parr (0.6), and higher than 2009 for age-1 (4.0) parr. These values are low relative to densities observed in rivers where adult salmon abundance is above their conservation requirement.

Outer Bay of Fundy (SFA 23)

The outer Bay of Fundy rivers in SFA 23 include those between the Saint John River and its tributaries and the St. Croix River, inclusively, and are bounded on the east by the endangered inner Bay of Fundy populations and on the west by salmon populations in Maine that are listed as endangered under United States legislation. The entire SFA 23 has been closed to commercial fishing for Atlantic salmon since 1984. Low abundance of salmon has resulted in the complete closures of the Aboriginal fisheries for food, social and ceremonial purposes, and the recreational fisheries since 1998. Assessment data in SFA 23 are collected for three index populations: the Saint John River upriver of Mactaquac Dam, the Nashwaak River and the Magaguadavic River. The Magaguadavic River data was provided by the Atlantic Salmon Federation. In the past, the St. Croix River was assessed annually, but the fishway has not been monitored since 2006. About 37% of the total accessible salmon habitat (wetted area) within SFA 23 is upriver of Mactaquac Dam. Further detail about these assessments is provided in Jones et al. (2010).

The Mactaquac Biodiversity Facility has been involved in the mitigation of salmon lost to hydroelectric projects on the Saint John River, primarily via smolt production. Historically, hatchery broodstock for the program has consisted of 200-300 wild sea-run adults each year. The program at the Mactaquac Biodiversity Facility has been re-focused to the singular objective of conserving and restoring a declining resource. Thus, discussion among DFO, with the Saint John River Management Advisory Committee and the Saint John Basin Board resulted in a program change in 2004. The new program replaces a large portion of the traditional smolt production with production of age-0 fall parr and furthermore, utilizes captive reared wild-origin juveniles that are used for broodstock and for release and natural spawning upriver of Mactaquac.

Status

The conservation requirement for salmon populations **upriver of Mactaquac Dam** is based on an accessible rearing area of 13,472,200 m^2. This does not include the Aroostook River, headponds, or the 21 million square meters of river with gradient <0.12%. Based on a required egg deposition of 2.4 eggs/m^2, the conservation requirement is 32.3 million eggs. The number of spawners necessary to obtain the conservation requirement is estimated to be 4,900 MSW and 4,900 1SW salmon.

Counts at Mactaquac Dam consist of fish captured at the fish collection facilities at the Mactaquac Dam and at the smolt migration channel at the Mactaquac Biodiversity Facility. During 2010, these facilities were operated from May 4 to October 29.

Total returns of 2,394 1SW and 460 MSW salmon destined for upriver of Mactaquac Dam on the Saint John River in 2010 were both well below returns observed in most years since 1970 (Figure 7). The 1SW returns (wild and hatchery combined) in 2010 were the highest since 2000, but remain well below the numbers observed from the 1970 to the early 1990s. The MSW returns were similar to the previous five-year mean and continue to be very low relative to past abundance. Wild-origin fish (which could include progeny from captive-reared adults released for natural spawning in 2004, 2005 and 2006) comprised 71% of 1SW and 68% of MSW fish.

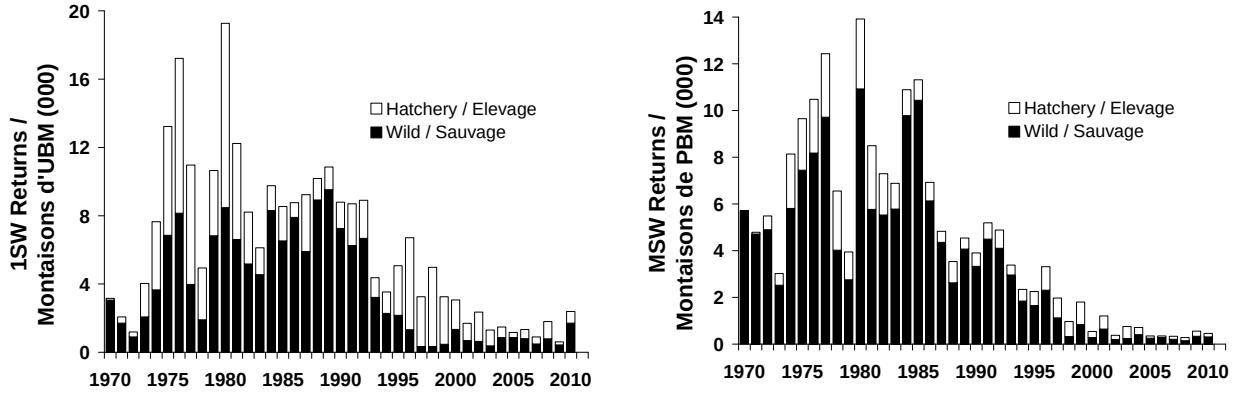

Figure 7. Estimated total returns of wild and hatchery 1SW and MSW salmon destined for upriver of Mactaquac Dam, Saint John River, 1970 - 2010.

Four repeat-spawning, captive-reared salmon and 26 1SW salmon suspected to be aquaculture escapes (based on fin condition and scale analysis) were also captured at the Mactaquac fishway in 2010. The number of aquaculture escapes counted in 2010 represents an increase from the total of five escapes that were captured in the past seven years.

Removals from the returns destined for production areas upriver of Mactaquac include: 1) the estimate of 1SW and MSW salmon ascribed to by-catch in the estuary, 2) salmon passed or trucked upriver of Tinker Dam on the Aroostook River, 3) salmon retained at Mactaquac as broodstock for conserving the Serpentine strain, 4) salmon estimated to have been lost to poaching activities, in particular those taken by illegal nets just below the Tobique and Mactaquac dams, and 5) known mortalities due to handling operations at Mactaquac, at fishways (Beechwood, Tobique and Tinker Dam) and at the Tobique Half Mile Barrier (Table 2).

Table 2. Estimated removals of 1SW and MSW salmon destined for upriver of Mactaquac Dam on the Saint John River, N.B., 2010.

	Estimated Removals		Percent of Total Returns	
Component	**1SW**	**MSW**	**1SW**	**MSW**
By-catch Estimates	24	10	1.0	2.2
Passed above Tinker Dam	22	10	0.9	2.2
Hatchery Broodstock	0	27	0.0	5.9
Poaching Estimates	3	58	0.1	12.6
Mortality at Mactaquac	2	8	0.1	1.7
Mortality at Beechwood	3	1	0.1	0.2
Mortality at Tobique	1	0	0.1	0.0
Mortality at Tinker	0	0	0.0	0.0
Mortality at Tobique Barrier	0	0	0.0	0.0
Total	55	114	2.3	24.8

The subsequent spawning escapement is estimated to be 2,339 1SW and 346 MSW salmon, 48% and 7% of the respective conservation requirements. The egg deposition estimate (72% from wild fish) was 8% of the requirement, a slight decrease from 2009 and similar to previous low estimates (< 10% of requirement) observed in the past five years (Figure 8). Captive-reared adults, with the potential to produce an additional 3.2 million eggs (or 10% of the requirement), were released in the Tobique River in 2010 (Figure 9).

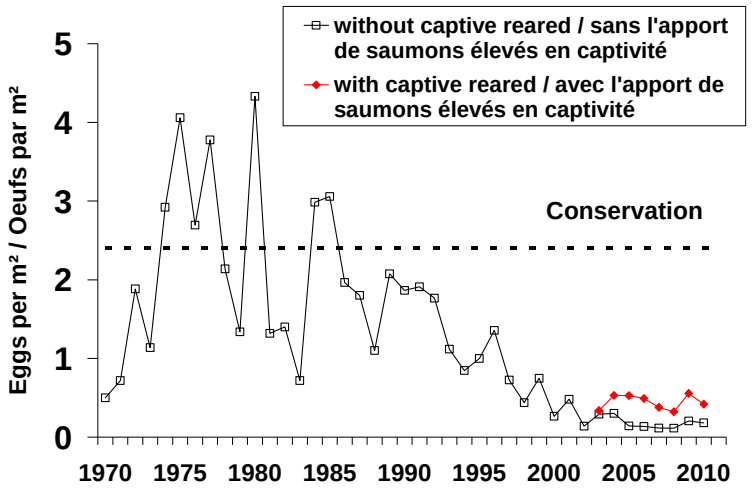

Figure 8. Estimated egg deposition (wild and hatchery combined, and captive reared) upriver of Mactaquac Dam, Saint John River, 1970 - 2010.

The **Nashwaak River** is the largest single salmon-producing tributary of the Saint John River downriver of Mactaquac Dam; it contains 28.5% of the total salmon production area in the Saint John River downriver of Mactaquac Dam. A salmon counting fence, located 23 km upriver from the confluence with the Saint John River, was operated by DFO in 1972, 1973 and 1975, and by DFO in cooperation with Kingsclear, Oromocto, St. Mary's, and Woodstock First Nations from 1993 - 2010. In 2010, the fence was jointly operated by Kingsclear and Oromocto First Nations. The salmon production area upriver of the fence is estimated to be 5.35 million square meters (90% of

the total river estimate) and the conservation requirement is 12.8 million eggs. The number of spawners necessary to obtain the conservation requirement is estimated at 2,040 MSW and 2,040 1SW salmon.

Counts of 854 1SW and 145 MSW salmon at the Nashwaak River fence, combined with seining of upriver holding pools, resulted in a mark-recapture estimate of 2,016 1SW and 197 MSW salmon (Figure 9) returning to this river. One-sea-winter returns in 2010 were the highest since monitoring resumed in 1993, whereas the MSW returns were lower than 2009 but were comparable to the mean value observed in the past decade. Wild-origin fish comprised 98% of 1SW and 98% of MSW fish. No aquaculture escapes were captured at the counting fence or during seining in 2010.

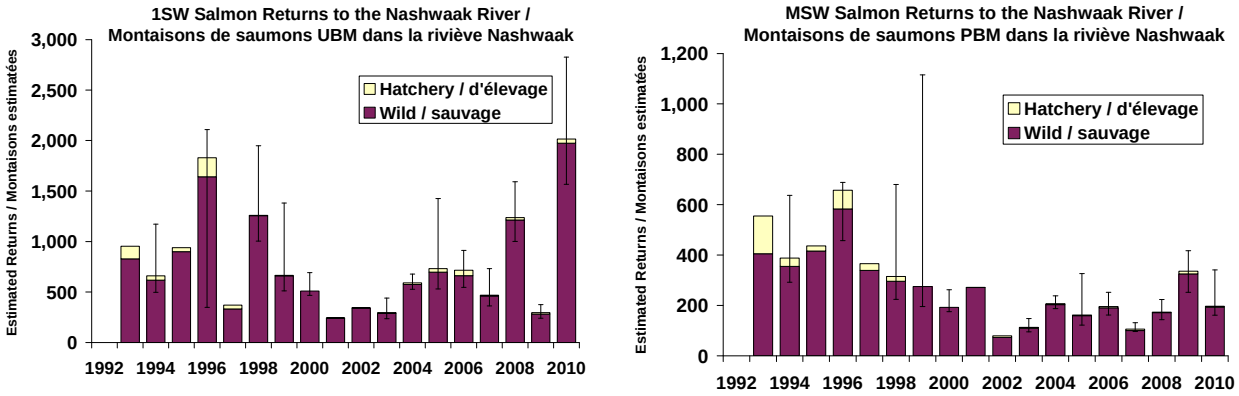

Figure 9. Estimated wild and hatchery 1SW and MSW salmon returns (and 2.5 and 97.5 percentiles) to the Nashwaak River, 1993-2010.

Spawning escapement is estimated by subtracting the known removals from the estimated returns. There were two 1SW and one MSW salmon mortalities observed while the counting fence was in operation in 2010. DFO fishery officers reported that seven salmon were known to have been removed by illegal fishing activities within the Nashwaak watershed. No 1SW or MSW salmon were removed from the fence trap for conservation initiatives by the Nashwaak Watershed Association Inc. in 2010. After removing the ten fish from the estimated returns, the estimated number of spawners was 2,008 1SW and 195 MSW. In 2010, the egg deposition estimate of 31% of the requirement was the highest value since 1996 (Figure 10). One-sea-winter females contributed 75% of the total egg deposition. Hatchery fish contributed 2% of the total egg deposition.

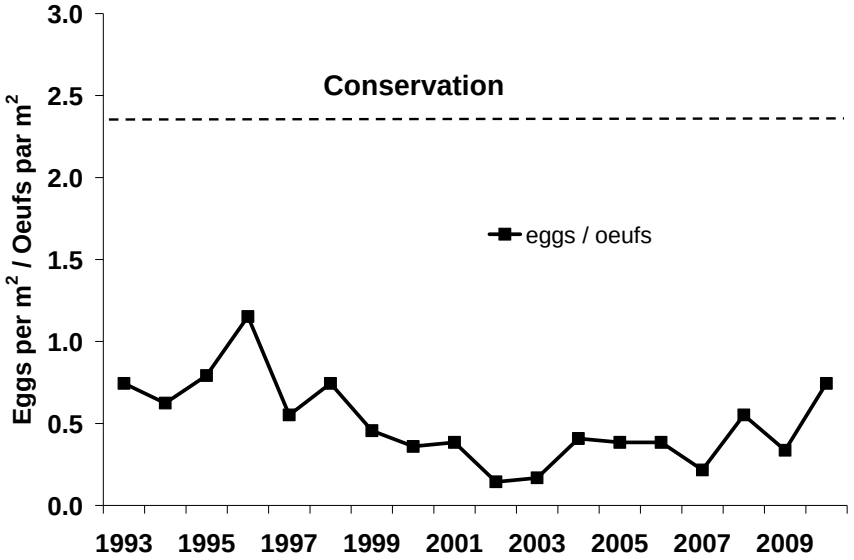

Figure 10. Estimated egg deposition upriver of the counting fence operated just below Durham Bridge, Nashwaak River, 1993 - 2010.

Wild smolt production in the Nashwaak River has been monitored since 1998. The number of wild smolts emigrating from upriver of the adult counting fence in 2010 was estimated to be 12,500 (95% C.I. = 9,940 to 16,740). The total number of wild smolts was below the 2009 value as well as the previous five-year mean.

Returns to the St. George fishway and trap located near the head of tide on the **Magaguadavic River** in 2010 were 12 1SW salmon. Aquaculture escapes captured at this facility in 2010 numbered four postsmolts and 23 1SW salmon. No MSW salmon of any origin were captured in 2010. The number of spawners necessary to obtain the conservation requirement is estimated to be 140 1SW and 230 MSW salmon.

Sources of Uncertainty

The assumed value of direct mortality associated with hook and release fisheries (4%) in Middle and Baddeck rivers is considered to be precautionary because the majority of salmon are caught during October when water temperatures are low. In North River, salmon enter the river throughout the summer and fall, and many are caught during the summer when water temperatures are higher. The use of the 4% value for hook-and-release mortality on this river is less precautionary than on rivers such as Middle and Baddeck where the majority of salmon enter the rivers during the fall.

The number of salmon harvested under Aboriginal fishing agreements in SFA 19 is not available at the time of this assessment. Removals resulting under these agreements are not thought to be substantial because allocations are low and harvests are typically below those allocations. There are no allocations of salmon for food, social and ceremonial fisheries in SFAs 20, 21, and 23.

Spawning escapement for Middle and Baddeck rivers is derived using a model that combines the recreational catch, dive survey, adult mark-recapture and electrofishing data to estimate abundance using maximum likelihood (Gibson and Bowlby 2009). When this model was

developed (using data to 2008), it fit both the recreational catch and dive count data very well. However, starting in 2009, and again in 2010, abundance estimates from the model based on the recreational catch are higher than those based on the dive surveys. This change in model performance occurred at the same time that most rivers in SFA 19 were closed to recreational salmon fishing and at a time when fishing efforts in Middle and Baddeck rivers were the highest since the early 1990's. As a result of the disparity between the recreational catch and the dive counts, the predicted recreational catch using the old model formulation did not track the observed recreational catch as well for 2009 and 2010, although fits to the dive surveys remained good. In 2010, to achieve a better fit to the recreational catch, the variance terms of the likelihood functions were adjusted giving more equivalent weightings to the recreational catch and dive counts. This resulted in abundance estimates from the model that are higher than if this adjustment had not been made.

In the past, several methods have been for estimating conservation requirements in rivers throughout Nova Scotia and New Brunswick. For most rivers, the values used are those reported in O'Connell et al. (1997) and are calculated as described in the Context section of this document. The conservation requirements being used for the LaHave and St. Mary's rivers are lower than those reported in O'Connell et al. (1997), values of 6.3 million eggs and 9.6 million eggs, respectively. If these values, which are calculated using methods that are consistent with the methods used for other rivers in the region, were used for these rivers, the resulting estimates of the percent of the conservation requirement achieved in 2010 would be lower for both rivers. On the St. Mary's River, the estimate would change from 5% to 4% of the conservation requirement attained on the West Branch of the River. On the LaHave River, the estimate would go from 35% to 11% of the conservation requirement attained above Morgan Falls.

The number of salmon caught and released within SFAs 19, 20 and 21 is estimated based on salmon license stub returns. It is known that salmon are being caught and released by anglers fishing with general recreational fishing licenses. Although the extent to which this is occurring is not known, the number of salmon caught and released each year in recreational fisheries, and hence mortality associated with the fishery, is likely underestimated. Under- or over-reporting may also affect population estimates based largely on angling data.

Incidents of illegal fishing are reported annually to DFO, but the number of removals associated with these activities and the resulting impact on the abundance of populations in the Maritimes Region cannot be quantified. However, removals of even small numbers of salmon can have substantial negative impacts on population growth or recovery due to the depressed state of populations throughout the region.

Conclusions

Overall, the information presented in this report does not outline a positive view of the status of Atlantic salmon in the eastern Cape Breton, Southern Upland or outer Bay of Fundy regions. The available data and analyses for Southern Upland (SFA 20 and 21) populations indicate that some populations are presently extirpated and that the healthiest populations are at levels well below their conservation requirements. In the absence of human intervention, the likelihood that populations in this region will extirpate is thought to be high. Actions that improve freshwater productivity or smolt-to-adult survival are expected to increase viability and reduce recovery times once conditions are favourable for recovery.

Within the outer Bay of Fundy (SFA 23), populations in the Saint John River upriver of Mactaquac Dam require supportive rearing to prevent extirpation. Actions that increase or improve freshwater productivity or survival from smolt to spawning are expected to increase viability, reduce the dependency on supportive rearing, and reduce recovery times once conditions are favourable for recovery. These include: reducing the poaching that is occurring in the system, in particular near the Mactaquac and Tobique Narrows dams, as well as increasing smolt survival by reducing turbine mortalities at each of the hydroelectric facilities affecting the upriver populations. The increased numbers of aquaculture escapes at Mactaquac in 2010 as well as their ongoing annual appearance on the Magaguadavic are indications that extra actions to improve containment of aquaculture salmon are necessary if their interaction with wild stocks is to be reduced.

Although the overall salmon population assemblage in eastern Cape Breton (SFA 19) is thought to be healthier than in the outer Bay of Fundy or Southern Upland regions, all but two populations in SFA 19 are below their conservation requirements. Middle and Baddeck rivers appear to be stable but at abundance levels below their conservation requirements. Some populations in this region have shown declines during the last 15 to 25 years. The small size of many rivers in this area makes their populations more vulnerable to the demographic and genetic effects of small population size. No dive survey was performed on the North and North Aspy rivers in 2010; however, both populations were assessed to be above their conservation requirements in 2009. Analysis of the recreational catch data for North River also showed an increase in the number of large and small salmon in 2010 compared to 2009.

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Sources of Information

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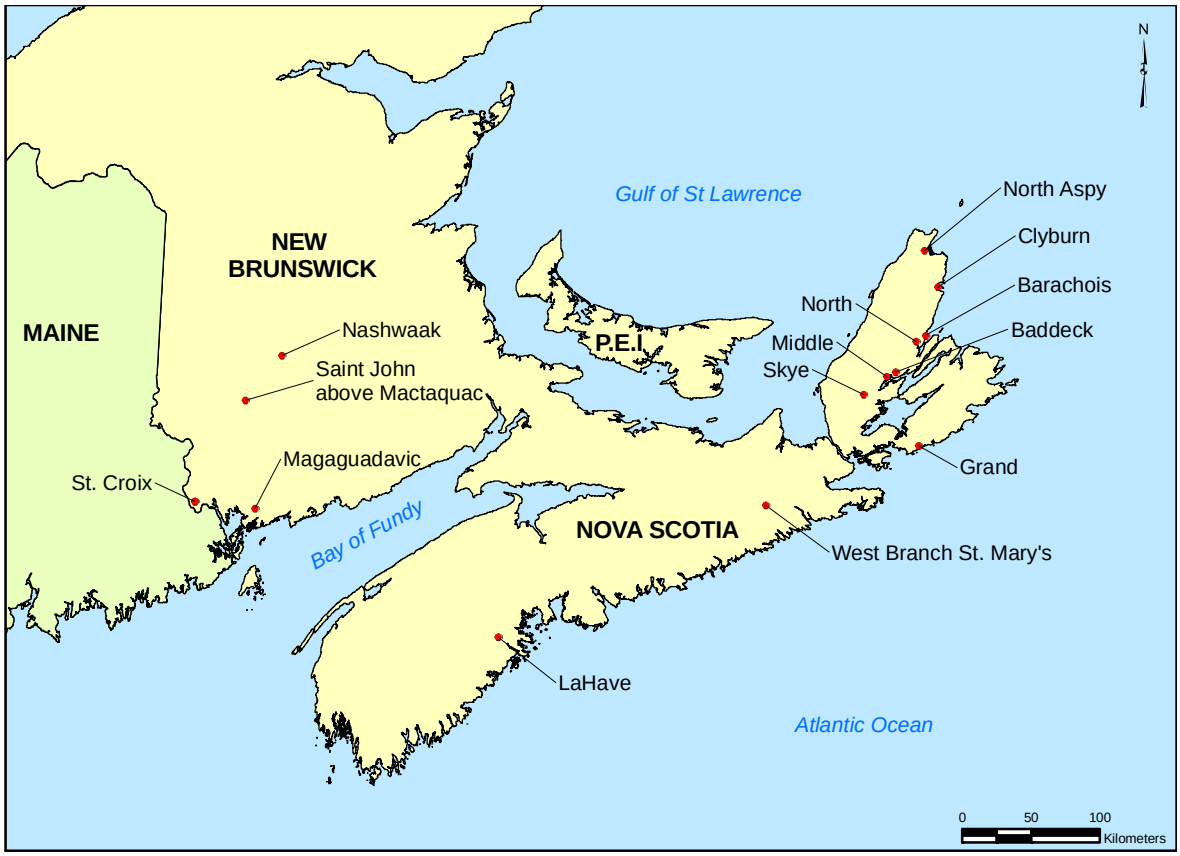
APPENDICES

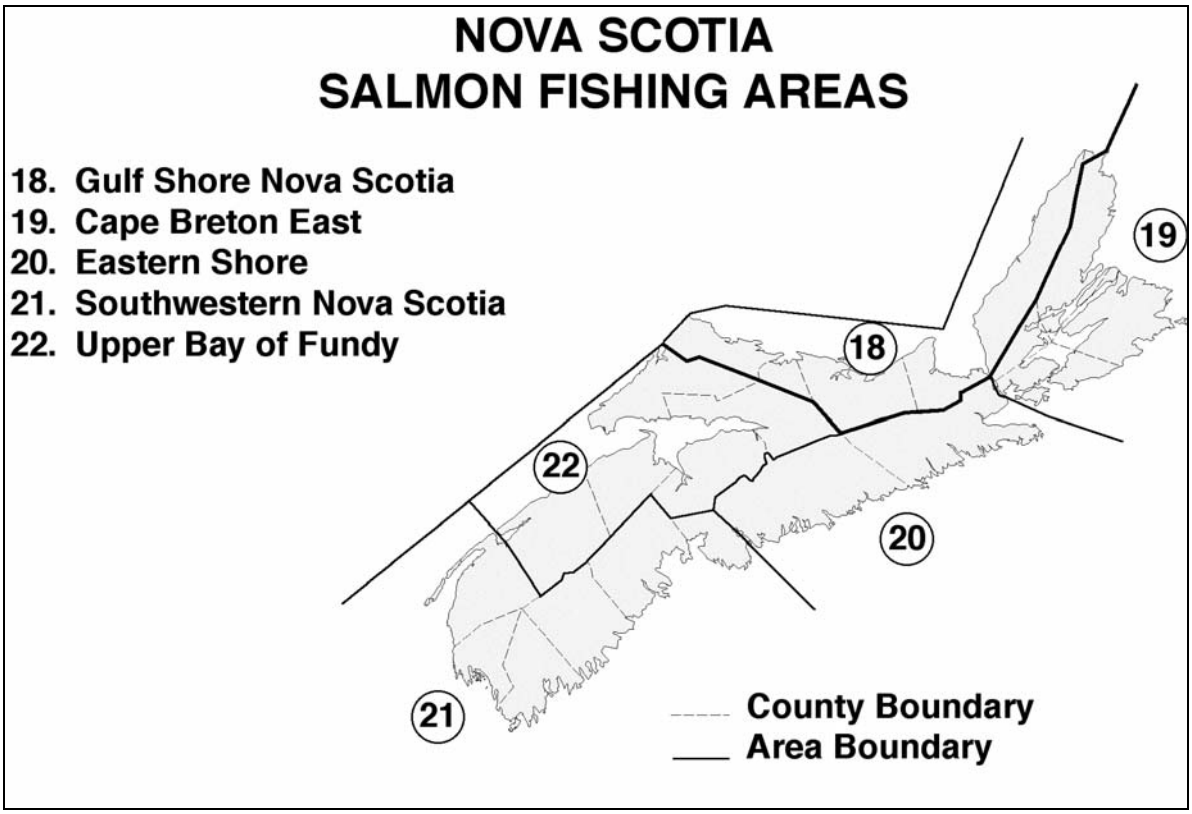
Appendix 1. Map showing the locations of Atlantic salmon rivers mentioned in this response.



Appendix 2: Fisheries and Oceans Canada Notice: 2010 Salmon Angling Seasons for Nova Scotia.

2010 SALMON ANGLING SEASONS

The Regional Director-General, Maritimes Region, Department of Fisheries and Oceans wishes to advise the public of the following changes to seasons and bag limits for Atlantic salmon in Nova Scotia.



1. (a) SALMON FISHING AREA 18 (Gulf Shore of Nova Scotia) and all waters of the Province flowing into that Area, except the waters referred to in paragraphs **(b)** to **(j)** ..... Sept. 1 to Oct. 31

(b) East River, Pictou County ..... Sept. 1 to Oct. 31

(c) West River, Pictou County ..... Sept. 1 to Oct. 31

(d) River Phillip ..... Sept. 1 to Oct. 31

(e) Wallace River ..... Sept. 1 to Oct. 31

(f) West River, Antigonish County ..... Sept. 1 to Oct. 31

(g) South River, Antigonish County ..... Sept. 1 to Oct. 31

(h) Margaree River, Northeast Margaree River, Southwest Margaree River and tributaries, except the waters referred to in paragraphs (i) and (j) ..... June 1 to Oct. 15

(i) Margaree River upstream from the highway bridges at East Margaree to the Big Intervale bridges on the Northeast Margaree River and upstream to the Scotsville highway bridge on the Southwest Margaree River, not including tributaries ..... June 1 to Oct. 31

(j) Northeast Margaree River and tributaries upstream from the Big Intervale Bridges .....**Closed all year**

NOTES FOR SALMON FISHING AREA 18

- **THE DAILY CATCH AND RETAIN LIMIT IS TWO GRILSE (SALMON LESS THAN 63 CM IN LENGTH).**
- **THE DAILY CATCH AND RELEASE LIMIT IS ANY COMBINATION OF GRILSE OR SALMON TOTALING FOUR.**
- **THE YEARLY CATCH AND RETAIN LIMIT IS FOUR GRILSE (SALMON LESS THAN 63 CM IN LENGTH).**
- **WHEN FISHING FOR SALMON, ONLY BARBLESS OR PINCHED BARB ARTIFICIAL FLIES ARE PERMITTED FROM OCTOBER 1 TO OCTOBER 31, INCLUSIVE.**

2. (a) SALMON FISHING AREA 19 (Cape Breton East) and all waters of the Province flowing into that Area, except the waters referred to in paragraphs **(b)** to **(f)** .....**Closed all year**

(b) Baddeck River.....(catch and release only) Sept. 1 to Oct. 31

(c) Middle River .....(catch and release only) Sept. 1 to Oct. 31

(d) North River downstream from the area known as "The Benches" as marked by a Fishery Officer..... (catch and release only) June 1 to Oct. 31

(e) North River upstream from the area known as "The enches" .....**Closed all year**

(f) North Aspy River..... (catch and release only) June 1 to July 15 .....and Sept. 1 to Oct. 31

NOTES FOR SALMON FISHING AREA 19

- **THE ANGLING SEASONS IN ITEMS (b), (c), (d) and (f) ARE OPEN TO CATCH AND RELEASE FISHING ONLY ON THE ABOVE SPECIFIED DATES AND ARE SUBJECT TO IN-SEASON ADJUSTMENTS.**
- **THE DAILY CATCH AND RELEASE LIMIT IS ANY COMBINATION OF GRILSE OR SALMON TOTALING TWO.**
- **WHEN FISHING FOR SALMON, ONLY BARBLESS OR PINCHED BARB ARTIFICIAL FLIES ARE PERMITTED.**

3. **SALMON FISHING AREA 20 (Eastern Shore)** and all waters of the Province flowing into that Area .....**Closed all year**

4. SALMON FISHING AREA 21 (Southwestern Nova Scotia) and all waters of the Province flowing into that Area .....**Closed all year**

5. SALMON FISHING AREA 22 (Upper Bay of Fundy) and all waters of the Province flowing into that Area .....**Closed all year**

REMINDERS

FOR 2010 ANGLERS ARE REMINDED THAT

- **FOR THOSE RIVERS ON WHICH RETENTION IS PERMITTED, THE YEARLY BAG LIMIT FOR ATLANTIC SALMON IS (4) GRILSE THAT MEASURE LESS THAN 63 CM FROM THE TIP OF THE NOSE TO THE FORK OF THE TAIL.**
- **SALMON FISHING IS ONLY PERMITTED USING ARTIFICIAL FLIES AND, IN CERTAIN LOCATIONS AT CERTAIN TIMES, ONLY WITH BARBLESS OR PINCHED BARB HOOKS.**
- **ALL SALMON 63 CM OR LONGER MUST BE RETURNED TO THE WATER IN A MANNER THAT CAUSES THE LEAST POSSIBLE HARM TO THAT FISH.**

SEASONS AND BAG LIMITS MAY CHANGE AT ANY TIME FOR CONSERVATION REASONS AND SUBJECT TO ABORIGINAL HARVEST AGREEMENTS.

FOR FURTHER INFORMATION CONTACT THE LOCAL FISHERY OFFICER AND REFER TO MARITIMES REGION VARIATION ORDERS 2010- 084, 2010-085 AND 2010- 086.

MIKE MURPHY
ACTING REGIONAL DIRECTOR-GENERAL FOR THE MARITIMES REGION

NOTE FOR SALMON FISHING AREA 19 (CAPE BRETON EAST):

- As per Maritimes Region Close Time Variation Order 2010-114 issued on August 20, 2010 (Appendix 3), the catch and release angling season on Middle and Baddeck rivers did not commence until September 11, 2010.

Appendix 3: Fisheries and Oceans Canada Order Varying the Close Times for Angling for Salmon in Nova Scotia

ORDER VARYING THE CLOSE TIMES FOR ANGLING FOR SALMON IN NOVA SCOTIA

Short Title

1. This Order may be cited as the Maritimes Region Close Time Variation Order 2010-114.

Variation

2. Items 90 and 101 of section 3 of the Maritimes Region Close Time Variation Order 2010-086 are hereby revoked.

3. The close times as fixed by section 61 of the ***Maritime Provinces Fishery Regulations*** for waters or portions of waters set out in items 90 and 101 of Schedule VII thereto are hereby varied so that no person shall angle for salmon in the waters of a river set out in the Schedule to this Order during the close time set out in the Schedule for that river.

SCHEDULE

Item	Column I Waters	Column II Close Time
	Salmon Fishing Area 19	
90.	Baddeck River	Nov. 1 to Sept. 10
101.	Middle River	Nov. 1 to Sept. 10

Coming Into Force

4. This Order shall come into force on August 30, 2010, and remain in force until December 31, 2010, unless otherwise revoked, at which time the close times shall revert to that set out in said Regulations.

Appendix 4. Reported recreational catch in SFAs 19 for 2010 (preliminary: January 26, 2011, database query), 2009, and the average catches for 2005-2009 time period. All salmon fisheries in SFA 20 to 23 were closed during this time period.

	2010 (Preliminary)				2009				5 Year Mean (2005 - 2009)							
	Grilse		Salmon	Effort	Grilse		Salmon	Effort	Grilse				Salmon		Mean Effort	
	Retained	Released	Released	Rod-days	Retained	Released	Released	Rod-days	Retained	95 % CI	Released	95 % CI	Released	95 % CI	Rod-days	95 % CI
SFA 19: EASTERN CAPE BRETON ISLAND																
ACONI BROOK		River Closed			0	0	0	0	0	0	0	0	0	0	0	0
BADDECK	0	52	142	333	0	14	135	488	0.3	0.9	23	13.1	88	45.5	346.5	119.4
BARACHOIS		River Closed			0	0	0	0	0	0	2.1	3.7	1.1	1.4	11.5	12.5
CATALONE		River Closed			0	0	0	0	0	0	0	0	0	0	0	0
CLYBURNE		River Closed			0	0	0	0	0	0	0	0	0	0	0	0
FRAMBOISE (GIANT LAKE		River Closed			0	0	0	0	0	0	0.6	1.7	0.2	0.6	5.3	8.3
FRENCHVALE BROOK		River Closed			0	0	0	0	0	0	0	0	0	0	0	0
GASPEREAUX: C. BRETON CO.		River Closed			0	0	0	0	0	0	0	0	0.3	0.8	1.2	2.6
GERRATT		River Closed			0	0	0	0	0	0	0	0	0	0	0	0
GRAND		River Closed			0	3	3	28	0	0	10.2	8.8	0.9	1.6	27	10.2
GRANTMIRE BROOK		River Closed			0	0	3	6	0	0	2	3.6	2.9	2.9	10	6.7
INDIAN BROOK		River Closed				River Closed			0	0	2.5	4.6	0	0	11	10.8
INGONISH		River Closed			0	0	0	0	0	0	0.3	0.7	0.3	0.7	1.7	3
INHABITANTS		River Closed			0	0	0	0	0	0	4.1	3.5	7.7	9.8	17.8	23.6
LITTLE LORRAINE		River Closed			0	0	0	0	0	0	0	0	0	0	0	0
LORRAINE BROOK		River Closed			0	0	0	0	0	0	0	0	0	0	0	0
MACASKILL'S BROOK		River Closed			0	0	0	0	0	0	0	0	0	0	0	0
MARIE JOSEPH		River Closed			0	0	0	0	0	0	0	0	0	0	1.4	1.1
MIDDLE: VICTORIA CO.	0	65	199	668	0	8	177	706	0	0	35.6	19.3	109.8	57.1	505	145.4
MIRA		River Closed			0	0	0	0	0	0	0.3	0.7	0	0	10.6	23.3
NORTH ASPY	0	14	16	82	0	0	0	0	0	0	4.9	8.7	9.6	10.3	36.1	43.1
NORTH: VICTORIA CO.	0	128	254	529	0	63	168	670	0.3	0.7	77.8	36.4	152.5	41	520.2	118.8
NORTHWEST BROOK (RIVER RYAN)		River Closed			0	0	0	0	0	0	0	0	0	0	0	0
RIVER BENNETT		River Closed			0	0	0	0	0	0	0	0	0	0	0	0
RIVER DENY'S		River Closed			0	0	0	0	0	0	0.3	0.8	0	0	0.9	2.5
RIVER TILLARD		River Closed			0	0	0	0	0	0	0.6	1.8	0.3	0.9	1.3	3.5
SAINT ESPRIT		River Closed			0	0	0	0	0	0	0	0	0	0	0	0
SALMON: CAPE BRETON CO.		River Closed			0	0	0	0	0	0	0.5	0.9	0.3	0.8	15	17.7
SKYE		River Closed			0	0	0	0	0	0	0	0	0	0	0	0
SYDNEY		River Closed			0	0	0	0	0	0	0	0	0	0	0	0
SFA TOTALS :	0	259	611	1612	0	88	485	1898	0.6	1	164.3	59.1	373.9	106.9	1520.2	270.1

This Report is Available from the:

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