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Recovery Potential Assessment for Eastern Cape Breton Atlantic Salmon (*Salmo salar*): Status, Past and Present Abundance, Life History, and Trends

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Foreword

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

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ABSTRACT

The purpose of this research document is to provide background information on the present abundance, status, life history, and recent trends for Atlantic Salmon populations in the Eastern Cape Breton Designatable Unit (ECB DU) and to provide information on recovery targets in support of recovery planning for this DU. Atlantic Salmon population monitoring in eastern Cape Breton has focused on five river systems: Middle; Baddeck; North; Grand; and Clyburn. Assessments on these rivers have been based on fishery-independent counts by dive surveys or at a fish ladder and/or recreational catches. Of these five populations, Grand and Clyburn have declined in adult abundance over the last 20-, 15-, and 10-year time periods. North River has declined over the last 20 years; however, the population appears to have increased during the last 10 years. Trends for Middle and Baddeck rivers are less evident; both populations appear to be relatively stable, but at abundance levels below their conservation requirements. North River was the only population estimated to be above its conservation requirement in 2011 (the most recent year available for assessment). Status of Atlantic Salmon in other rivers is based on recreational catch data and intermittent electrofishing surveys. Declining trends in recreational catch and effort are evident for many rivers across eastern Cape Breton. Low abundance observed in the recreational catch data is consistent with the results from the most recent electrofishing surveys, which indicated that juvenile Atlantic Salmon abundance was below reference values at many locations during 1996-2007 even though juveniles were widely distributed throughout eastern Cape Breton.

Recommended interim recovery targets for Atlantic Salmon populations in eastern Cape Breton have abundance and distribution components. Conservation (egg) requirements are proposed as abundance targets until the dynamics of recovered populations can be studied. Distribution targets are more difficult to quantify, but should encompass the range of variability among populations. There is the expectation that including a wider variety of populations in the distribution target will enhance short-term persistence and facilitate recovery in the long-term. Recovery targets will need to be revisited as information about the dynamics of the recovering population becomes available.

Évaluation du potentiel de rétablissement du saumon atlantique de l'est du Cap-Breton (*Salmo salar*) : Situation, abondance passée et présente, cycle biologique et tendances

RÉSUMÉ

L'objectif du présent document de recherche est de fournir des renseignements généraux sur l'abondance actuelle, la situation, le cycle biologique et les récentes tendances des populations de saumon atlantique de l'unité désignable (UD) de l'est du Cap-Breton et de fournir des renseignements sur les objectifs de rétablissement à l'appui de la planification du rétablissement pour cette UD. La surveillance des populations de saumon atlantique à l'est du Cap Breton a porté sur cinq réseaux fluviaux : Middle, Baddeck, North, Grand et Clyburn. Les évaluations de ces rivières se sont fondées sur des relevés indépendants des populations de saumon effectués par des plongeurs, ou à l'échelle à poisson ou selon les prises de pêche récréative. Sur ces cinq populations, celles de Grand et de Clyburn ont affiché une baisse de l'abondance des dernières périodes de 20, 15 et 10 ans. La population de la rivière North a baissé au cours des 20 dernières années; cependant, la population semble avoir augmenté au cours des 10 dernières années. Les tendances des populations des rivières Middle et Baddeck sont moins évidentes; les deux populations semblent être relativement stables, mais à des niveaux d'abondance inférieurs à leurs exigences de conservation. La population de la rivière North était la seule population que l'on estimait être au-dessus de ses exigences de conservation en 2011 (année disponible la plus récente pour l'évaluation). La situation du saumon atlantique dans d'autres rivières est basée sur les données sur les prises de pêche récréative et les relevés intermittents de la pêche à l'électricité. Les tendances à la baisse des prises et de l'effort de la pêche récréative sont évidentes pour un grand nombre de rivières dans tout l'est du Cap-Breton. La faible abondance observée dans les données sur les prises de pêche récréative correspond aux résultats des relevés les plus récents sur la pêche à l'électricité, qui indiquaient que l'abondance des saumons atlantiques juvéniles était inférieure aux valeurs de référence à plusieurs endroits au cours de la période de 1996 à 2007, même si les saumons juvéniles étaient répartis dans tout l'est du Cap-Breton.

Les objectifs de rétablissement provisoires recommandés pour les populations de saumon atlantique de de l'est du Cap-Breton comportent des composantes d'abondance et de répartition. Des exigences de conservation (ponte) sont proposées à titre d'objectifs d'abondance jusqu'à ce que la dynamique des populations rétablies puisse être étudiée. Les objectifs de répartition sont plus difficiles à quantifier, mais ils devraient englober l'intervalle de variabilité parmi les populations. En incluant une plus grande variété de populations dans les objectifs de répartition, on s'attend à améliorer la persistance à court terme et à faciliter le rétablissement à long terme. Les objectifs de rétablissement devront être revus au fur et à mesure que des renseignements sur la dynamique de la population en rétablissement seront disponibles.

1.0 INTRODUCTION

The range of Atlantic Salmon (*Salmo salar*) in Canada extends northward from the St. Croix River (at the border with Maine, United States of America) to the outer Ungava Bay and eastern Hudson Bay, Quebec (COSEWIC 2010). Canadian populations represent a significant proportion of the species' range. Recent estimates indicate that there are at least 700 rivers in Canada that either currently support or have supported Atlantic Salmon populations in the past (COSEWIC 2010, DFO and MNRF 2008). In 2001, the World Wildlife Fund (WWF) reported that Canadian populations of wild Atlantic Salmon had declined by more than 75% during the past three decades (WWF 2001). Populations in many rivers continue to decline despite management actions that include closures of commercial fisheries for Atlantic Salmon (in 1985, 1992, 1998, and 2000) and increasingly restrictive recreational fishing regulations since 1983 (DFO and MNRF 2009).

Canadian populations of Atlantic Salmon have been grouped into 16 Designatable Units (DUs) based on genetic information and broad patterns in life history variation, environmental variables, and geographic separation (COSEWIC 2010). DUs are intended to be discrete and evolutionarily significant units of a species, which are important to the evolutionary legacy of the species as a whole, and if lost would likely not be replaced through natural dispersion (COSEWIC 2012). The Eastern Cape Breton (ECB) DU includes rivers from the northern tip of Cape Breton Island (approximately 47^{o} 02' N, 60^{o} 35' W) along the Atlantic coast to the Canso Causeway (approximately 45^{o} 39' N, 61^{o} 25' W) (COSEWIC 2010). The ECB DU was assessed as "Endangered" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2010 (COSEWIC 2010).

The ECB DU includes all Atlantic Salmon populations found in rivers in eastern Cape Breton, which drain into the Bras d'Or Lakes and Atlantic Ocean south of the Salmon River: Victoria County watershed to the Canso Causeway (Figure 1 in Gibson et al. (2014)). All these rivers are contained within Salmon Fishing Area (SFA) 19, which is a management area used by Fisheries and Oceans Canada (DFO) for salmon fisheries management and assessment purposes. An analysis of the status and trends of Atlantic Salmon populations within eastern Cape Breton was completed to provide background information in support of the review of the status of Atlantic Salmon populations within eastern Canada (Gibson and Bowlby 2009). DFO's Science Branch has also recently completed a Recovery Potential Assessment (RPA) for Southern Upland (SU) Atlantic Salmon populations (i.e., nearest populations to the south), where abundance and distribution recovery targets were proposed for the recovery of those populations (DFO 2013).

This document contains an update of the status and trends of Atlantic Salmon populations within the ECB DU using monitoring data available during the 2008-2011 time period. It also includes information that can be used to develop abundance and distribution recovery targets based on DFO guidance documents (DFO 2005, 2010a), and which are consistent with recovery target recommendations for inner Bay of Fundy (iBoF; DFO 2008) and SU (DFO 2013) Atlantic Salmon populations. This is one of four research documents prepared in support of the RPA for the ECB DU of Atlantic Salmon. The other documents provide information about genetic diversity and population structuring (O'Reilly et al. 2013), population dynamics and viability (Gibson and Levy 2014), and habitat use and threats to populations (Gibson et al. 2014).

The objectives identified in the ECB DU RPA Terms of Reference (TOR) addressed in this document are:

- Evaluate present status for abundance and range and number of populations.
- Evaluate recent species trajectory for abundance (i.e., numbers and biomass focusing on mature individuals) and range and number of populations.

- Estimate, to the extent that information allows, the current or recent life-history parameters (total mortality, natural mortality, fecundity, maturity, recruitment, etc.) or reasonable surrogates; and associated uncertainties for all parameters. (In part; see also Gibson and Levy 2014).
- Estimate expected population and distribution targets for recovery, according to DFO guidelines (DFO 2005, 2010a).

Additional information and previous assessments with regard to Atlantic Salmon populations can be obtained from the Canadian Science Advisory Secretariat (CSAS) published by DFO in Ottawa. The most recent documents with information on eastern Cape Breton Atlantic Salmon populations are: DFO (2012a); Gibson and Bowlby (2009); and Robichaud-Leblanc and Amiro (2004).

2.0 OVERVIEW OF EASTERN CAPE BRETON POPULATIONS

In 2011, eastern Cape Breton contained the only remaining populations of Atlantic Salmon open to recreational fishing within the DFO Maritimes Region of Nova Scotia (NS) and New Brunswick. During the 1983–2011 time period, recreational catches of Atlantic Salmon have been reported for 31 rivers in eastern Cape Breton (Figure 2.1). A recent review of rivers that were thought to support or to have supported Atlantic Salmon (Gibson et al. 2014) identified a total of 46 rivers in eastern Cape Breton that met the criteria used. Gibson et al. (2014) indicate that there is no information to suggest that Atlantic Salmon did not utilize most or all accessible habitat in eastern Cape Breton at least intermittently in the past.

In a report summarizing the population structure, biology, abundance, status, potential for recovery, and scope for harm of Atlantic Salmon within Atlantic Canada and Quebec (DFO and MNRF 2008), two Conservation Units (CUs) for Atlantic Salmon populations in eastern Cape Breton (i.e., Cape Breton East Highlands and Cape Breton East Lowlands) were proposed. CUs were defined as "groups of individuals likely exhibiting unique adaptations that are largely reproductively isolated from other groups, and that may represent an important component of a species' biodiversity" (DFO and MNRF 2008). Evidence for separate CUs in eastern Cape Breton was largely based on differences in stream gradient (DFO and MNRF 2008), although additional biological evidence (i.e., a higher proportion of one sea-winter, or 1SW, salmon in populations east of the Bras d'Or Lakes) has since been presented, which further suggests that Atlantic Salmon populations east of the Bras d'Or Lakes are distinct from populations west of the Bras d'Or Lakes (Gibson and Bowlby 2009).

COSEWIC recognized that Atlantic Salmon populations in eastern Cape Breton appear to be genetically distinct from SU populations (i.e., nearest populations to the south) and noted that there is substantial life history variation in eastern Cape Breton between Atlantic coast rivers and rivers draining into the Bras d'Or Lakes (COSEWIC 2010). Although this life history variation, along with differences in freshwater habitat and divergent demographic trends, which further suggested some structuring within the ECB DU, were recognized by COSEWIC, the sparse genetic data available at the time was not sufficient to support a clear geographic pattern (COSEWIC 2010). Therefore, Atlantic Salmon populations within eastern Cape Breton were assessed as a single DU (COSEWIC 2010).

3.0 PRESENT STATUS, LIFE HISTORY, AND TRENDS

Evaluation of the status of Atlantic Salmon populations within the DFO Maritimes Region is based on a comparison of the estimated egg deposition to a reference point known as the conservation (egg) requirement. Conservation requirements have been developed for rivers within the DFO Maritimes Region using a target egg deposition of 2.4 eggs/m^2 and estimates of fluvial rearing habitat for juvenile Atlantic Salmon within each respective river (O'Connell et al. 1997). For North and Grand rivers, where recent assessments have been based primarily on recreational catch data and are thus considered to be less robust, adult status assessments have been based on comparing abundance estimates to the numbers of large and small salmon that were expected to meet the conservation (egg) requirement (O'Connell et al. 1997).

River specific conservation requirements were previously reported for 26 rivers in eastern Cape Breton (O'Connell et al. 1997). During this RPA, this list was expanded to provide a river specific conservation (egg) requirement estimate for all 46 rivers known to support or to have historically supported Atlantic Salmon populations (Gibson et al. 2014).

Within the DFO Maritimes Region, the conservation requirement is considered to be consistent with a Limit Reference Point in the Precautionary Approach (PA) Framework (DFO 2012b, Gibson and Claytor 2012). Limit Reference Points are defined by DFO (2006) as:

> "[text omitted] the stock level below which productivity is sufficiently impaired to cause serious harm but above the level where the risk of extinction becomes a concern. In this context, serious harm could be due to over-fishing, other human induced mortality, or changes in population dynamics not related to fishing."

Population monitoring for Atlantic Salmon in eastern Cape Breton has been focused on five major river systems: Middle, Baddeck, North, Grand and Clyburn. Middle, Baddeck, North and Clyburn rivers originate in small headwater lakes in the Cape Breton Highlands and are characterized by relatively steep stream gradients and good water quality (Robichaud-LeBlanc and Amiro 2004, Gibson and Bowlby 2009). Grand River has the lowest mean stream gradient of the five major river systems assessed and its stream flow and water temperatures are influenced by mid-reach lakes (Robichaud-LeBlanc and Amiro 2004).

Adult Atlantic Salmon assessments in eastern Cape Breton are based on recreational catches, which are reported through a license-stub return program, as well as fishery-independent counts via dive surveys in Middle, Baddeck, and North rivers. Parks Canada monitors adult abundance in the Clyburn River using a similar dive survey approach. The status of adult Atlantic Salmon on Grand River was assessed via fishway counts prior to 2000 and through the use of recreational catch data from 2000-2009. More detailed information on data used to assess status in these five rivers is provided in the following sections.

Recent attempts have also been made to assess adult status in other rivers in eastern Cape Breton using dive surveys. In 2009, attempts were made to assess adult status in North Aspy, Skye and Indian (a tributary to Skye River) rivers via dive surveys in late October. The dive survey on North Aspy River was successful in 2009; however, attempts in 2010, 2011, and 2012 were not successful due to high water levels and poor visibility. The representativeness of counts conducted on Skye and Indian rivers were questionable in 2009 due to the small river size, poor visibility, and the potential for salmon to hold in remote areas that were not surveyed; therefore, no inferences were drawn from the results (DFO 2010b). An attempt was also made to assess status in the Barachois River via a dive survey in 2010. However, the water clarity was not favourable and the observation efficiency of the survey was not known. Therefore, the count could not be used to estimate adult abundance and no inferences were drawn from the results (DFO 2011).

The following sections provide information on recent status and trends of Atlantic Salmon populations in eastern Cape Breton using data collected up to 2011 (where available), with an emphasis on the adult portion of the population. More detailed information on methods used to assess status and trends can be found in Gibson and Bowlby (2009).

3.1 MIDDLE RIVER

Habitat

The habitat of Middle River was summarized by Gibson and Bowlby (2009) as:

> "The main stem of the Middle River, Victoria County, arises in the Cape Breton Highlands, about 450 m above sea level [text omitted]. From there, it flows in a southward direction to its confluence with Nyanza Bay, in the St. Patrick's Channel of the Bras d'Or Lakes. Throughout its length, Middle River is unobstructed and is not impacted by acid precipitation, but is exposed to agricultural practices in the lower valley (Marshall et al. 2000)."

Biological Characteristics

Historically, adult Atlantic Salmon returns to Middle River were comprised of a summer and fall component (Marshall et al. 1996). However, the component that returned to the river during the summer has reportedly disappeared, and an effort to redevelop returns with summer-run stock from North River in the late 1980s was largely unsuccessful (Marshall et al. 1996).

Analysis of adult scale samples collected from wild Atlantic Salmon over seven years during the 1995-2004 time period indicate that Atlantic Salmon from Middle River generally spend two to four years in fresh water prior to migrating to sea (Table 3.1.1). Atlantic Salmon then predominately spend two winters at sea prior to returning to Middle River to spawn for the first time (Table 3.1.1). This result is consistent with the results from the recreational catch data during the 1983-2011 time period, where an estimated 29% of the Atlantic Salmon population captured by anglers on Middle River were small adults, with no obvious trend observed in this proportion over the 29 year time period (Table 3.1.2). Adult salmon that returned to Middle River after one winter at sea were predominately males (Appendix 1). Based on the scale samples, few salmon spawned more than one time (6 out of 138 samples). These fish include an alternate-year spawning 1SW salmon and consecutive- and alternate-year spawning two sea-winter (2SW) salmon (Appendix 1). There was also a low frequency of virgin three sea-winter (3SW) males and females in this population (Appendix 1).

Beginning in 2009, DFO's Fisheries and Aquaculture Management Branch and the NS Department of Fisheries and Aquaculture's Inland Fisheries Division initiated programs to numerically offset anticipated future losses to the population from catch-and-release mortality (assumed to be 4% of fish angled) and to numerically offset Aboriginal Food, Social, and Ceremonial (FSC) allocations from Middle River. In 2009, 40 parr were collected from Middle River and taken to the Coldbrook Biodiversity Facility to rear to adults (DFO 2010b). DFO began stocking adults from this collection in 2011 with an aim to support Aboriginal FSC use (DFO 2012a). During 2009-2011, adult salmon were also collected from Middle River by the NS Inland Fisheries Division on an annual basis for use as broodstock as part of a program to offset catch-and-release mortality associated with recreational angling (DFO 2010b, 2011, 2012a). Juvenile salmon stocked as part of this program commenced in 2010 and adult returns associated with these releases were expected three to seven years thereafter (DFO 2011). A summary of removals and stocking associated with these programs is provided in Table 3.1.3.

Assessment Data

Data available for assessing the status and trends of Atlantic Salmon in Middle River include annual recreational catch estimates from a license stub return program, counts of adult salmon made while snorkeling reaches of the river (termed dive counts), and intermittent data from electrofishing surveys. Following is a summary of each data series:

1. Recreational catch and effort (Table 3.1.2):

   License stub return data from the Atlantic Salmon recreational fishery are available for the years 1983-2011 and are used to provide estimates of catch and effort using consistent methods throughout this time period. Large salmon (fork length of 63 cm or larger) and small salmon (fork length less than 63 cm) are recorded separately. The data include river specific numbers of salmon caught and released, numbers harvested and fishing effort in each year, as estimated from license stub returns. Effort is estimated in rod days, where any portion of a day fished by one angler is recorded as one rod day. The data used are corrected for non-reporting.

2. Dive surveys (Table 3.1.4):

   The numbers of large and small salmon counted during dive surveys in Middle River from 1989 to 2011 are used to provide indices of spawning escapement for the population. Dive surveys typically take place during late October, just prior to the end of the fishing season. Details of the dive survey methods are described in Robichaud-LeBlanc and Amiro (2004) as follows:

   > "In brief, divers (snorkelers) swim down most of the river and count the number of large and small salmon observed during the survey. In years when conditions are favourable and abundance is sufficiently high, the dive surveys include a mark-recapture component. Several pools are seined prior to the counts and the captured fish are marked with a disk tag that is quite visible to the divers. During the subsequent swim, the divers record large and small counts, as well as the number of marked salmon observed (size classes combined) to obtain an estimate of the proportion of the population observed during the survey."

   Mark-recapture surveys were conducted during 1994-2000 and 2003-2004 for Middle River.

   During the 2011 dive survey, the main survey was conducted along the reach of the river and known holding pools that had been surveyed in previous years. However, after completing the survey, new pools (i.e., holding pools not known to exist before) were identified. Divers swam these pools on the following day and counted additional adults; however, it was unknown if these new pools contained salmon that had already been counted on the previous day (DFO 2012a). Here, the mean dive count in 2011 (i.e., mean of surveys with and without new pools) was used in the assessment model.

3. Juvenile abundance indices obtained by electrofishing (Table 3.1.5):

   Electrofishing surveys were conducted intermittently on Middle River over the 1985-2006 time period and provide 10 years of data for juvenile Atlantic Salmon. Juvenile data are used in the assessment model to provide indices of egg deposition. The use of the juvenile data in the assessment model has been summarized as:

   > "These data can be used as indices of egg deposition in previous years: the number of age 0 salmon in year *t* as an index of egg deposition in year *t*-1, and the number of age 1 and older salmon in year *t* as an index of egg deposition in year *t*-2. This latter assumption is made knowing that some parr are older than age 1, but aging data is not available for most of the electrofishing surveys." (Gibson and Bowlby 2009)

Conservation Requirement

The conservation requirement for Middle River is 2.07 million eggs (O'Connell et al. 1997). This was calculated based on an estimated 864,600 m^2 of available rearing habitat and a target egg deposition of 2.4 eggs/m^2.

Status

The status of Atlantic Salmon in Middle River is assessed by comparing the estimated egg deposition with the conservation requirement. Egg deposition is estimated using a statistical model that incorporates all of the assessment data series described above. A full description of the model is provided in Appendix 1 of Gibson and Bowlby (2009).

A time series showing the maximum likelihood estimates (MLEs) of the number of salmon available to spawn after the recreational fishery (spawning escapement) and the percent of the conservation requirement attained is shown in Figure 3.1.1. Upon review of the total spawning escapement in a given year relative to the previous year, the Atlantic Salmon population in Middle River has increased on 14 occasions and also decreased on 14 occasions since 1983. Overall, the series shows an increasing trend in spawning escapement until 1996, followed by a decrease to 2006, and an increase to 2011. Egg depositions show a similar pattern with low probability that the population has met its conservation requirement since 1983.

Five-year mean population sizes from the model were calculated over 20-, 15- and 10-year time periods. Estimated total spawning escapement averaged 350 fish during the 1987-1991 time period, 324 fish during the 1992-1996 time period, 276 fish during the 1997-2001 time period, and 312 fish during the 2007-2011 time period. The five-year mean population size is presently lower than it was 20 and 15 years ago, but appears to be higher than it was 10 years ago, indicating population declines over the past 20 and 15 years, but an increase over the past 10 years (Figure 3.1.2). Although the population size has likely increased over the last 10 years, the estimated egg deposition has remained below the conservation requirement and has ranged between 21% and 66% of the conservation requirement during this time (Figure 3.1.1).

3.2 BADDECK RIVER

Habitat

The habitat of Baddeck River was summarized by Gibson and Bowlby (2009) as:

> "The Baddeck River, Victoria County, lies in SFA 19 between the Middle and North rivers [text omitted]. The river arises in the Cape Breton Highlands at about 430 m elevation and flows in a south and westward direction to its confluence with Nyanza Bay, St. Patrick's Channel of the Bras d'Or Lakes at a point less than 4 km east of the mouth of Middle River. Of the area in the Baddeck River accessible to salmon, the average gradient profile is steeper than that of the neighbouring Middle River, but not as steep as that of the North River (Robichaud-LeBlanc and Amiro 2004)."

Biological Characteristics

Adult Atlantic Salmon predominately return to Baddeck River to spawn in the fall (Gibson and Bowlby 2009). Analysis of adult scale samples collected from wild Atlantic Salmon over eight years during the 1977-2004 time period shows that Atlantic Salmon from Baddeck River generally spend two to four years in fresh water prior to migrating to sea (Table 3.2.1). Atlantic Salmon then predominately spend two winters at sea prior to returning to Baddeck River to spawn for the first time (Table 3.2.1). This result is consistent with the results from the recreational catch data during the 1983-2011 time period, where an estimated 24% of salmon captured by anglers from Baddeck River were small adults, with no significant trend in this proportion over the 29 year time period (Table 3.2.2). Adults that return to the Baddeck River after 1SW are predominately males (Appendix 2). There were few samples (4 out of 106) which indicated that the salmon had spawned previously. Based on this limited number of samples, there were consecutive-year and alternate-year spawning 2SW salmon observed returning to Baddeck River (Appendix 2). One consecutive spawning female salmon spawned on three previous occasions before returning to spawn for a fourth time in 1995. One virgin 3SW male and one virgin 3SW female were also identified in the samples.

Beginning in 2009, DFO Fisheries and Aquaculture Management and the NS Inland Fisheries Division initiated stocking programs to numerically offset anticipated future losses to the population from catch-and-release mortality (assumed to be 4% of fish angled) and to offset Aboriginal FSC allocations from Baddeck River. In 2009, 40 parr were collected from Baddeck River and taken to the Coldbrook Biodiversity Facility to rear to adults. DFO began stocking adults from this collection in 2011, with an aim to support Aboriginal FSC use. During 2009-2011, adult salmon were also collected from Baddeck River by the NS Inland Fisheries Division on an annual basis for use as broodstock as part of a program to offset catch-and-release mortality associated with recreational angling. Juvenile salmon stocked as part of this program commenced in 2010 and adult returns associated with these releases were expected three to seven years thereafter (DFO 2011). A summary of removals and stocking associated with these programs are provided in Table 3.2.3.

Assessment Data

Data available for assessing the status and trends of Atlantic Salmon in Baddeck River include annual recreational catch estimates from a license stub return program, counts of adult salmon made while snorkeling reaches of the river (termed dive counts), and intermittent data from electrofishing surveys. Following is a summary of each data series:

1. Recreational catch and effort (Table 3.2.2):

   License stub return data from the Atlantic Salmon recreational fishery are available for the years 1983-2011 and are used to provide estimates of catch and effort using the same approach as described for Middle River.

2. Dive surveys (Table 3.2.4):

   Dive surveys for Baddeck River are conducted using the same approach as described for Middle River. The numbers of large and small salmon counted during dive surveys in Baddeck River for 16 years during the 1994-2011 time period are used to provide indices of spawning escapement for the population. Dive surveys typically take place during late October, just prior to the end of the fishing season. Mark-recapture surveys were conducted during 1994-1998, 2000 and 2003-2004 for Baddeck River. Additional details of the methods are described in Robichaud-LeBlanc and Amiro (2004).

3. Juvenile abundance indices obtained by electrofishing (Table 3.2.5):

   Electrofishing surveys were conducted intermittently on Baddeck River over the 1996-2001 time period. Six years of juvenile Atlantic Salmon data are available from these surveys and, as described for Middle River, these data are used in the assessment model to provide indices of egg deposition for the previous year.

Conservation Requirement

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

Status

The status of Atlantic Salmon in Baddeck River was assessed using the same approach as Middle River (i.e., using a model developed by Gibson and Bowlby (2009), which incorporates all of the information from the indices described above to estimate egg deposition). A full description of the model is provided in Appendix 2 of Gibson and Bowlby (2009).

A time series showing the MLE of the number of salmon available to spawn after the recreational fishery (spawning escapement) and the percent of the conservation requirement attained is shown in Figure 3.2.1. Based on year-to-year comparisons since 1983, abundance of salmon in Baddeck River has increased in 12 years relative to the previous year, and decreased in 16 years. Overall, the series shows an increasing trend in spawning escapement to 1996, followed by a decrease to 2002, and a stable to slightly increasing trend to 2010 with a more pronounced increase in 2011. Egg depositions show a similar pattern with low probability that the population has met its conservation requirement since 1983.

Five-year mean population sizes from the model were calculated and compared over 20-, 15- and 10-year time periods. Estimated total spawning escapement averaged 286 fish during the 1987-1991 time period, 232 fish during the 1992-1996 time period, 190 fish during the 1997-2001 time period, and 215 fish during the 2007-2011 time period. The five-year mean population size is presently lower than it was 15 and 20 years ago, but is higher than it was 10 years ago, indicating population declines over the past 20 and 15 years but an increase over the past 10 years (Figure 3.2.2). Although the population may have increased in size over the last 10 years, the estimated egg deposition has remained below the conservation requirement and has ranged between 25% and 72% of the conservation requirement during this time. The 2011 estimated egg deposition was the largest estimate (equivalent to 72% of the conservation requirement) since 1996 (Figure 3.2.1).

3.3 NORTH RIVER

Habitat

The habitat of North River was summarized by Gibson and Bowlby (2009) as:

> “The North River, Victoria County, lies on the eastern slope of the Cape Breton Highlands [text omitted]. The headwaters are at an elevation of approximately 475 m and the river flows 30 km to its outflow in St. Ann’s Harbour. Gradients are steep with many small falls and several barriers to upstream fish passage. Water quality is thought to be good (Amiro and Marshall 1990) as the North River is not impacted by acid precipitation or agriculture.”

Biological Characteristics

Gibson and Bowlby (2009) described the run timing and recent stocking history of Atlantic Salmon in North River as:

> “Adult salmon are thought to return earlier to the North River than to the Middle or Baddeck rivers. Stocking of hatchery fish of North River origin occurred in the late 1980’s and concluded in 1995 (Marshall et al. 1998). There is currently no stocking of hatchery-reared salmon in this system.”

Analysis of adult scale samples collected from wild Atlantic Salmon over four years during the 1991-1998 time period indicates that Atlantic Salmon from North River generally spend two to four years in fresh water prior to migrating to sea (Table 3.3.1). Recognizing that the number of samples is limited, it appears that Atlantic Salmon predominately spend two years at sea before returning to North River to spawn, although there may be years where the proportion of 1SW salmon is greater than the multi sea-winter (MSW) component (e.g., 1996 in Table 3.3.1). These results are consistent with the results from the recreational catch data during 1983-2011 time period, where an estimated 35% of the Atlantic Salmon population captured by anglers in North River are small (1SW) adults (Table 3.3.2). Moreover, the recreational catch data series also indicates that there were a few years (i.e., 1996, 1998 and 2000) where the proportion of small (1SW) salmon angled was greater than the large component. Samples from adults that returned to North River after one winter at sea were exclusively male salmon (Appendix 3).

There were few scale samples (5 out of 52) that indicated the salmon had spawned previously although, based on available samples, the frequency of repeat spawners is more than twice that of the Middle and Baddeck salmon populations. Alternate-year repeat spawning 1SW, and consecutive-year repeat spawning 2SW and 3SW salmon, were observed (Appendix 3) in the samples. The only repeat spawning 3SW salmon was a female, which had spawned on two occasions prior to returning to spawn for a third time in 1998.

Assessment Data

Data available for assessing the status and trends of Atlantic Salmon in North River include annual recreational catch estimates from a license stub return program and counts of adult salmon made during dive surveys. Following is a summary of each data series:

1. Recreational catch and effort (Table 3.3.2):

   License stub return data from the Atlantic Salmon recreational fishery are available for the years 1983-2011 and are used to provide estimates of catch and effort using the same approach as described for Middle River.

2. Dive surveys (Table 3.3.3):

   Dive surveys for North River are conducted using the same approach as described for Middle River. Dive survey counts are available for 11 years during 1994-2011. Dive surveys cannot be conducted every year on North River due to its higher gradient, particularly during years with higher streamflow conditions (Gibson and Bowlby 2009). When conditions are favourable, dive surveys typically take place during late October, just prior to the end of the fishing season, and the results provide an index of the numbers of large and small salmon available to spawn after the recreational fishery. Mark-recapture experiments associated with dive surveys are available for five consecutive years during 1994-1998. Further details of the methods used for dive surveys in North River are described in Robichaud-LeBlanc and Amiro (2004).

Conservation Requirement

The conservation requirement for North River is 0.92 million eggs (O’Connell et al. 1997). This was calculated based on an estimated 382,700 m^2 of available spawning habitat and a target egg deposition of 2.4 eggs/m^2. This egg deposition is expected from approximately 215 large and 32 small salmon (O’Connell et al. 1997). An alternative estimate for juvenile rearing area (and associated conservation requirement) has been reported (Amiro and Marshall 1990) and has been used for assessing the status of salmon in North River (most recently in DFO 2012a). Here, the conservation requirement reported in O’Connell et al. (1997) is used to assess status, as it is consistent with the orthophoto map gradients reported by Robichaud-Leblanc and Amiro (2004) and is also consistent with the values used to derive conservation requirements in other eastern Cape Breton rivers.

Status

An attempt to use the same modeling approach for assessing status on Middle and Baddeck rivers was made for North River, but was not successful (Gibson and Bowlby 2009). Gibson and Bowlby (2009) noted the following with respect to this approach when applied to North River:

> “We attempted to fit the same model used to estimate abundance for the Middle and Baddeck populations, but ran into an issue with the data from North River. There was a large reduction in recreational fishing effort starting in 1994, the same year that the dive surveys started [text omitted]. In the model, fishing effort is used to estimate the relationship between catch and abundance. When the recreational fishing effort is used to estimate catch rates, unrealistic estimates of salmon catchability prior to 1994 are necessary in order for the model to accurately capture the trends in

recreational catch. The model predicts catch rates of 1.0 for these earlier years. Given this issue, the model results are not presented."

Therefore, the assessment of status for North River presented here uses an escapement time series derived from dive survey results, and an estimate of the number of salmon returning to the river based on recreational catch estimates and mean catch rates derived for large (0.41) and small (0.69) salmon on this river. This approach has been used in recent status assessments for Atlantic Salmon in North River (e.g., DFO 2012a). Recreational catch data have been predominately used to assess status in recent years, due to difficulties with conducting dive surveys because of water conditions and low confidence in dive survey results associated with river characteristics. As the assessment on North River is predominately based on recreational catch data, it is considered to be less robust than the assessment conducted for Middle and Baddeck rivers.

Time series of the estimated returns and spawning escapement for large and small salmon in North River relative to the estimated number of large and small salmon required to achieve the conservation requirement is shown in Figure 3.3.1. In comparison with the previous year, abundance of salmon in North River has increased in 11 years and decreased in 16 years since 1984 (Table 3.6.1). Based on the analysis of total returns, the Atlantic Salmon population in North River has shown a declining trend since the mid-1980s with an increasing abundance trend since the early 2000s. Unlike other assessed rivers in eastern Cape Breton, North River appears to have been above its conservation requirement since 2003 (Figure 3.3.1).

3.4 GRAND RIVER

Habitat

Grand River has a lower stream gradient than the other three rivers assessed by DFO. Gibson and Bowlby (2009) summarized the habitat of Grand River as:

> "The Grand River, Richmond County, drains an area of 217 km^2 (Amiro and Longard 1990). The mainstem flows southerly for 15.7 km from Loch Lomond Lake to its outflow in the Atlantic. Grand River has a low average gradient and headwater elevation (~100 m). On average, the gradients of Grand River tributaries accessible to salmon are the lowest of the rivers assessed in this document. When river discharge rates are low, Grand River is obstructed to salmon passage by a falls located 10.2 km upstream of head-of-tide. About 45% of the total juvenile production potential is estimated to be upstream of the falls, while 55% is below the falls (Amiro and Longard 1990). A fishway at the falls is estimated to pass 57% of small and 43% of large salmon (Amiro and Longard 1990, 1995)."

Biological Characteristics

Unlike most Atlantic Salmon populations in Cape Breton, adult salmon return to Grand River in June or July (Marshall et al. 2000). Moreover, returning adults are predominately small (1SW) fish, and large salmon that return are mostly repeat-spawning 1SW fish (Marshall et al. 2000). Grand River was stocked during the late 1980s and 1990s; however, the stocking program ended in 1997 (Marshall et al. 1998). There have been no stocked fish contributing to returns to Grand River since 1999 (DFO 2001).

Analysis of adult scale samples collected from wild Atlantic Salmon over five consecutive years during the 1990-1994 time period indicate that Atlantic Salmon from Grand River predominately spend two years in fresh water prior to migrating to sea (Table 3.4.1). Atlantic Salmon then predominately spend one winter at sea prior to returning to spawn for the first time (Table 3.4.1). This result is consistent with the recreational catch data during the 1983-2009 time period, where an estimated 82% of the Atlantic Salmon population captured by anglers on Grand River were small adults, with no significant trend observed in this proportion (Table 3.4.2).

There are more samples from Grand River indicating that the salmon had previously spawned (67 out of 512) than for other rivers assessed in eastern Cape Breton, although the gender of the adult salmon that these scales were collected from is unknown (Appendix 4). Upon analysis of these samples, repeat spawning adults returning to Grand River are predominately consecutive-year spawning 1SW fish (i.e., 41 out of 67 samples). However, other life history strategies have been observed including, alternate-year spawning 1SW fish (n=12), as well as consecutive-year (n=7) and alternate-year (n=5) spawning 2SW fish. In addition, two fish returned as alternate-year spawning 1SW fish during the first two spawning events and then returned on a third occasion as a consecutive spawner (i.e., 4 sp 1,3).

Assessment Data

Data available for assessing the status of Atlantic Salmon in Grand River include recreational catch estimates from the Atlantic Salmon license stub return program and counts of adult salmon ascending the fishway located at Grand River Falls.

1. Recreational catch and effort (Table 3.4.2):

   License stub return data from the Atlantic Salmon recreational fishery are available for the years 1983-2009 (the recreational salmon fishery was closed during 2010 and 2011 on Grand River) and are used to provide estimates of catch and effort using the same approach as described for Middle River.

2. Fishway counts (Table 3.4.3):

   Salmon returns to Grand River were estimated from adult counts at the Grand River Falls fishway from 1988 to 1998 (Marshall et al. 1998) and from a partial fishway count in 1999 (Marshall et al. 2000). The total number of Atlantic Salmon returning to areas above the falls was estimated by assuming that 80% of the total run was counted and that 40% of small and 57% of large salmon by-passed the fishway in a given year (Marshall et al. 1998). Adult salmon ascending the Grand River fishway have not been monitored since 2000 (Robichaud-Leblanc and Amiro 2004).

Conservation Requirement

The conservation requirement for Grand River is 1.1 million eggs (O'Connell et al. 1997). This was calculated based on an estimated 461,800 m^2 of available rearing habitat and a target egg deposition of 2.4 eggs/m^2. This egg deposition is expected from a total of approximately 545 large and small salmon combined (O'Connell et al. 1997). Of this, 475,000 eggs or approximately 234 salmon are required upstream of the fishway to meet the conservation requirement (DFO 2001).

Status

As noted above, Atlantic Salmon returns were estimated from fishway counts during the 1988-1999 time period. Atlantic Salmon returns to Grand River during the 2000-2009 time period were then estimated from recreational catches with an assumed catch rate of 0.5, which was considered to be similar to that determined in other rivers (Robichaud-Leblanc and Amiro 2004). No estimates have been conducted since 2009, as recreational fisheries were closed on Grand River in 2010 and 2011.

Based on recreational license stub returns, the reported catch of Atlantic Salmon in 2009 was one small and one large salmon, yielding a total estimated return of five salmon (large and small sizes combined). This estimate is low relative to past abundance and well below the conservation requirement (Figure 3.4.1). As noted by Gibson and Bowlby (2009), abundance estimates from recreational catch data for Grand River are based on low sample sizes (Table 3.4.2). For example, in 2009, escapement was estimated from catch reported by two anglers who caught a total of two fish in 10 rod-days. Grand River has not met the conservation requirement upriver of the fishway since 1998, and the wild component of the stock has not met the conservation requirement since 1990 (Robichaud-Leblanc and Amiro 2004).

3.5 CLYBURN RIVER (BROOK)

Habitat

Clyburn Brook is located on the eastern side of Cape Breton Highlands National Park near Ingonish, NS. The river flows over 19.4 km before emptying into the Atlantic Ocean and is estimated to contain 116,500 m^2 of fluvial rearing habitat for Atlantic Salmon (O'Connell et al. 1997).

Biological Characteristics

Results from dive surveys conducted by Parks Canada indicate that the run of Atlantic Salmon in Clyburn Brook is predominately comprised of large salmon during most years (Table 3.5.1). However, results from these surveys indicate that there are some years where the percent composition of small salmon is equal to or greater than that of large salmon (Table 3.5.1). Reported recreational catch is low compared with rivers assessed by DFO (Appendix 5). Although there is limited data for Clyburn Brook, recreational catches were predominately comprised of large salmon in most years where catch was reported.

Conservation Requirement

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

Assessment Data and Status

Parks Canada has conducted annual dive surveys on Clyburn Brook from 1985 to 2011, with the exception of three years (1991, 1993, and 1996). Dive counts are conducted toward the end/after the fishing season, and counts of large and small salmon are recorded separately (Table 3.5.1). In some years, only the lower section of the river was surveyed. The observation efficiency of the dive counts is not known, but the time series provides a relatively consistent index of abundance. Counts in Clyburn Brook were highest in 1987 with a total count of 175 salmon (Table 3.5.1 and Figure 3.5.1), but total counts have only exceeded 20 salmon twice since 1999 (DFO 2012a).

3.6 ABUNDANCE TRENDS FOR INDEX POPULATIONS

Using the approach of Gibson and Bowlby (2009), abundance trends for Atlantic Salmon populations in the index rivers (i.e., Middle, Baddeck, North, Grand, and Clyburn) are analyzed over three time periods using two methods. Abundance estimates for large and small salmon (Table 3.6.1) were combined for the analysis.

The first approach uses a "log-linear model" to estimate trends:

$$N_t = N_0 e^{zt}$$

Here, N_0, the estimated population size at the start of the time series, and *z,* the instantaneous rate of change in abundance, are estimated parameters. This model was fit using least squares after transformation of the data to a log scale. For a given value of z, the percent change in population size over a given number of years, t, is calculated as (1-e^{zt})*100. Potential issues with this approach include the ideas that when log transformed, zero abundances are difficult to include (small values must be added). Additionally, if residuals are not appropriately distributed, depending on when and how abundance changes during the time period, some points can have either high leverage or little influence on the model fit.

The second approach used to estimate abundance trends in the index rivers was accomplished by calculating the extent of the decline/increase as the ratio of the population size at the start and the end of the time period. Gibson and Bowlby (2009) note the following with respect to this approach*:*

> "In order to dampen the effect of year-to-year variability when using this approach, we used the five-year average population size (missing values were dropped during the smoothing) when calculating the ratio. The five-year time period for smoothing was chosen to represent approximately one generation. Although this method is easy to implement, a drawback is that confidence intervals for parameter estimates cannot easily be calculated. We therefore re-parameterised the model into the form:
>
> $$N_t = \begin{pmatrix} N_1 & s_t = 1 \\ N_1 p & s_t = 2 \end{pmatrix},$$
>
> where *s* is a state variable that indicates whether a year is in the first or second time period. The parameters to be estimated are N_1, the average abundance during the first time period, and *p*, the change in abundance between the two time periods. This model, termed here the "ratio model", estimates the extent of decline and is not influenced by data between the time periods of interest. Confidence intervals were estimated using likelihood ratios. We used a lognormal distribution for the error structure when fitting this model."

Both of these models were fit to 10-year, 15-year and 20-year time periods, where the 15-year time period corresponds roughly to the three generation time period used by COSEWIC when evaluating conservation status. Widespread recreational fishery closures for Atlantic Salmon in eastern Cape Breton occurred in 2010, and Grand River was among one of the rivers closed. As noted in Section 3.4, total abundance estimates for Grand River were calculated using recreational catch data and a mean catch rate of 0.5 beginning in year 2000. Therefore, the time periods used to estimate declines for the Grand River population (i.e., data series ending in 2009) varies from other index rivers, where data were available up to and including 2011.

Results of the analyses are provided in Table 3.6.2 and Figure 3.6.1. Of the index river populations, Grand and Clyburn river populations show declining abundance trends irrespective of the time period and method used. Overall, the North River population has shown a declining trend in total abundance since the late 1980s, but appears to have been increasing since 2000; the change in trend (i.e., change from declining trend to increasing trend) that occurred around year 2000 should be considered when interpreting the results from the log-linear and ratio models for different time periods. Based on the model results, the North River population has shown a declining trend over the 20-year time period, but likely increased over the 10-year time period.

Trends in salmon abundance in the Middle and Baddeck rivers are not as evident. Trends for Middle River also vary depending upon the method used for the 20- and 15-year time periods (Table 3.6.2). Overall, the Middle River population appears to have been relatively stable (with considerable variability in abundance) compared to the other index populations over the 20- and 15-year time periods, and may have been increasing over the last 10 years. Salmon abundance in Baddeck River appears to have declined over the 20- and 15-year time period, but may have increased during the last 10 years. Confidence intervals on the rates of decline (or increase) are generally large for Middle, Baddeck and North populations.

3.7 OTHER RIVERS

Comparatively little data exist for Atlantic Salmon populations in other eastern Cape Breton rivers, other than the catch and effort data from the Atlantic Salmon recreational fishery's license stub return program. Recreational catch and effort estimates from these license stub returns are available for a total of 31 rivers in eastern Cape Breton, although catch and effort was only reported for Black Brook (Victoria County) in 2010 (Appendix 5).

Analysis of recreational catch and effort data for SFA 19 was recently conducted to provide background information on Atlantic Salmon populations in eastern Cape Breton (Gibson and Bowlby 2009) in support of the review of status of Atlantic Salmon populations in eastern Canada by COSEWIC. Here, the analysis conducted by Gibson and Bowlby (2009) has been updated to include data from 2008 to 2011. Gibson and Bowlby (2009) describe the data as:

> "Large salmon (63 cm or larger) and small salmon (less than 63 cm) are recorded separately, and the numbers harvested, as well as caught and released are estimated. Effort is estimated in rod days where any portion of a day fished by one angler was recorded as one rod day. Values are adjusted for non-reporting using a relationship based on the reported catch as a function of the number of reminder letters sent to licensed anglers."

Recreational Atlantic Salmon fishing seasons in eastern Cape Breton have been undergoing changes due to management actions since 1998. DFO (2012a) summarized these changes as follows:

> "Prior to 1998, recreational fishing was open from June 1st to October 31st in eastern Cape Breton. Since 1998, with the exception of the North River, there was a mid-season warm water closure from July 16th – August 31st. In 2010 and 2011, all rivers within SFA 19 with the exception of Middle, Baddeck, North, and North Aspy rivers were closed to fishing all year. In 2011, Middle and Baddeck rivers were open to catch-and-release angling from October 1st to October 31st; North River (downstream from the area known as the "Benches") was open to catch-and-release angling from June 1st to October 31st; and North Aspy River was open to catch-and-release angling from June 1st to July 15th and from September 1st to October 31st."

Upon analysis of recreational catches from 1983 to 2007, Gibson and Bowlby (2009) noted:

> "Although there are exceptions, recreational catches tended to be higher in the 1980's and early 1990's than at present [text omitted]. However, the fishing effort in these earlier years was also higher."

This pattern generally remains when the time series is extended to include data up to and including 2011 (Figure 3.7.1). A comparison of mean recreational catch estimates for the five-year time period ending in 1987 (i.e., the beginning of the data series) with the five-year time period ending in 2009 (i.e., the year prior to widespread recreational fisheries closures; Figure 3.7.2) indicates that recreational catches have declined by more than 75% in all but four rivers (Baddeck, Middle, North Aspy, and North). These four rivers are the ones that remained open to recreational angling after the most recent closures in 2010.

Recreational catch estimates for large and small salmon on Baddeck, Middle and North rivers exhibit variability over the time series. Although there are exceptions, larger recreational catches have been estimated for small and large salmon on Middle and Baddeck rivers during the 2009-2011 time period than estimated during the previous 10-year time period (Figure 3.7.1). Some of the higher recreational catch estimates in recent years are comparable to higher values estimated in the late 1980s and early 1990s. Recent recreational catches on North River are still well below peak values estimated in the mid-1980s and early 1990s and no obvious trends are evident when examining the estimates over the last 10-15 years. Catches on North Aspy also show variability, making the recent trend difficult to interpret. The most recent five-year mean of total catch (large and small combined) is slightly higher than the mean estimate during the 1983-1987 time period, but lower than five-year mean values estimated during the mid- to late 1980s and early 1990s.

Gibson and Bowlby (2009) also noted the following with respect to fishing effort:

> "The recreational catch tracks the estimated effort very closely [text omitted]. Fishing effort has also declined on most rivers in a pattern similar to the recreational catch [text omitted]. Little to no fishing effort is presently being reported on most rivers in SFA 19. While this issue makes interpreting the recreational catch statistics as an abundance index difficult, it does suggest that fishing effort has contracted down to those few rivers within the SFA that contain an appreciable number of Atlantic Salmon."

Again this interpretation generally holds when the data series was extended to include recreational catch and effort data up to and including 2011 (Figure 3.7.1). In 2009, prior to widespread recreational fisheries closures, 98.3% of the recreational fishing effort and 98.6% of the recreational catch in eastern Cape Breton occurred on Baddeck, Middle and North rivers. Despite declines in catch and effort for the majority of rivers in eastern Cape Breton, Baddeck, Middle, and North have shown increasing trends in angling effort over the last 10 years, although effort has not reached peak values estimated during the mid- to late 1980s to early 1990s. The increases in effort on Baddeck, Middle and North rivers after declines in effort on other rivers prior to their closure may suggest abundance is low on other rivers, and anglers are switching to fish rivers where Atlantic Salmon are more abundant.

3.8 ELECTROFISHING DATA

Electrofishing surveys, conducted intermittently with relatively limited spatial coverage, have been most recently performed by DFO in eastern Cape Breton during the 1996-2007 time period. A summary of these data was prepared in support of a review of the conservation status of Atlantic Salmon in eastern Canada by COSEWIC (Gibson and Bowlby 2009). DFO has not conducted any additional electrofishing surveys to estimate juvenile densities in eastern Cape Breton since those conducted in 2007. Therefore, a summary of results previously reported by Robichaud-LeBlanc and Amiro (2004) and Gibson and Bowlby (2009) are provided here. More detailed information on surveys conducted during 2002 and earlier can be found in Robichaud-LeBlanc and Amiro (2004), and more detailed information on surveys conducted during 2006 and 2007 can be found in Gibson and Bowlby (2009).

Results of surveys conducted during 2002 and earlier are provided in Figures 3.8.1 through 3.8.3. Gibson and Bowlby (2009) summarized these results as:

> "Robichaud-LeBlanc and Amiro (2004) provided a comparison of fry densities from 1998 to 2002 to the Elson (1967) norm of 29 fry per 100 m^2 for some rivers in SFA 19 [text omitted]. Fry densities estimated in the most recent years of sampling (2001 and 2002) were above the norm in only three of 21 rivers sampled. Similarly, parr (age 1 and older) densities have typically been below the Elson (1967) norm for age 1 and older parr (38 parr per 100 m^2) since 1998 [text omitted]."

Electrofishing surveys at a total of 27 sites were conducted during 2006 and 2007, and of these five sites were surveyed in both years (Table 3.8.1). These surveys included sites that had been surveyed since 1996, sites that had not been surveyed since the 1970s and 1980s, as well as new sites that had not been previously surveyed. Tables 3.8.2 and 3.8.3 provide the results of these surveys and Figure 3.8.3 shows a time series of juvenile densities in the Grand, Middle, North and Sydney rivers. Gibson and Bowlby (2009) summarized the results as follows:

> "Of the 32 sites fished [text omitted] half of them had been sampled since 1996, while the other half were either new or had last been electrofished in the 1970's and 80's. Atlantic Salmon were found in all but three of the sites visited: two upstream of a large barrier falls on the Clyburn River (Cly002 and Cly003) and one on the Sydney River (Sydney002) [text omitted]. Estimated densities of fry ranged from 157 individuals per 100 m^2 in the Middle River to 4 individuals per 100 m^2 in Black Brook [text omitted]. The highest age 1 parr density (112 individuals per 100 m^2) was obtained at a site on North River, but parr densities were less than 10 per 100 m^2 in River Denys, Grand River, Sydney River, Mira River, and Black Brook. Age 2 parr were absent from the sites sampled on River Denys, the Ingonish and Grand rivers in 2006, and in Sydney River in 2007. No individuals older than age 2 were found in any river.
>
> A time-series of juvenile densities for the Middle, Grand, North and Sydney rivers is shown [text omitted]. Based on mean annual density (1996 – 2002, 2006 and 2007), there were no trends obvious in the data. Density estimates for 2006 and 2007 were within the range of those sampled in the 1996-2002 period, except for parr (age 1 and age 2 combined) in the North River, which was more than double any previous estimate. However, given that the method used in the recent surveys differed from previous surveys, this result should be interpreted with caution.
>
> In general, fry and parr densities at most sites are low relative to the indices of normal abundance, developed by Elson (1967), of 29 individuals per 100m^2 for fry and 38 individuals per 100 m^2 for parr (age 1 and age 2 combined). However, the densities estimated for rivers in eastern Cape Breton tend to be above those observed in rivers along the Atlantic coast of mainland Nova Scotia."

Overall, results of the juvenile electrofishing surveys conducted since 1996 indicate that at least one juvenile life stage (i.e., fry and/or parr) was captured from every river surveyed in eastern Cape Breton since 1996. Although the presence of juveniles was widespread throughout eastern Cape Breton, abundance was generally low relative to reference values reported by Elson (1967). There is no regional juvenile abundance data available since the most recent surveys in 2006 and 2007, where 11 rivers were surveyed, to further describe the current distribution or abundance of Atlantic Salmon within eastern Cape Breton.

4.0 ABUNDANCE AND DISTRIBUTION TARGETS FOR POPULATION RECOVERY

DFO guidelines are available to help ensure that a consistent and defensible standard of conservation is being applied toward science advice on recovery targets while allowing for different kinds of information and indicators of status, as well as flexibility for differences in life histories found in aquatic species (DFO 2005, 2010a). Moreover, RPAs for Atlantic Salmon populations within the DFO Maritimes Region have been recently completed for the iBoF (DFO 2008) and SU (DFO 2013) populations that contain scientific advice for abundance and distribution targets for those DUs. Both the DFO guidelines and the RPAs for other Atlantic Salmon DUs were used as a basis for the recommendations for abundance and distribution targets for eastern Cape Breton Atlantic Salmon described below.

If listed, statements of population and distribution objectives will be required for the recovery plan of eastern Cape Breton Atlantic Salmon (DFO 2005). However, determining how many populations need to be recovered or how large populations must be to ensure recovery of Atlantic Salmon is difficult from a quantitative perspective, although existing information on abundance targets, as well as theoretical research on how species distribution relates to persistence or recovery can be used as a basis for decision-making to address this concern (Gibson et al. 2008, Bowlby et al. 2013). As was recommended for iBoF (DFO 2008) and SU

Atlantic Salmon (DFO 2013) populations, these targets will have to be revisited when recovery is underway and information about the dynamics of the recovering populations is obtained.

4.1 RECOVERY TARGETS FOR ABUNDANCE

As was the case with the SU Atlantic Salmon DU (DFO 2013), the use of river-specific conservation requirements are proposed as abundance recovery targets for individual salmon populations in eastern Cape Breton. The proposal for the abundance target for SU Atlantic Salmon was described by DFO (2013) as being:

> "Abundance targets for Southern Upland Atlantic salmon are proposed as the river-specific conservation egg requirements, which are based on the estimated amount of juvenile rearing area and an egg deposition rate of 2.4 eggs/m^2. Attaining the conservation requirement is consistent with attaining long-term population persistence, maintaining the ecological function of the watersheds in which salmon formerly resided, and increasing the potential for human benefits if populations were recovered in as many rivers as possible."

This description is also applicable to eastern Cape Breton Atlantic Salmon populations. As noted in Section 3, river-specific conservation requirements (based on a target egg deposition of 2.4 eggs/m^2 and estimates of fluvial rearing habitat for juvenile Atlantic Salmon) are currently used to assess the status of Atlantic Salmon populations within the DFO Maritimes Region, including populations in eastern Cape Breton. Advice on the status of salmon populations relative to the conservation requirement provides an indication of the relative health of the populations and informs management decisions, such as decisions on Aboriginal harvest allocations and recreational fishing opportunities for Atlantic Salmon.

The development of conservation requirements arose due to a need to formally define "conservation" for Atlantic Salmon. A subcommittee of CAFSAC based their formal translation of conservation for Atlantic Salmon on the potential productivity of rivers by adopting the egg deposition rate of 2.4 eggs/m^2 of fluvial rearing habitat as a biological reference point. It was assumed that this reference point provided a modest margin of safety and that the further the spawning escapement was below and the longer it remained below this reference point (even at levels only slightly below), the greater the possibility of incurring risks, of which some could lead to irreversible damage to the stock (CAFSAC 1991). Specific risks to stocks identified by CAFSAC (1991) include:

> "accentuation of annual fluctuations in run size and reduction in the long-term capability of the stock to sustain native food fisheries, recreational fisheries, or commercial fisheries;
>
> increased susceptibility to extinction from genetic, demographic, or environmental catastrophes and consequent decreases in productivity;
>
> permanent changes in demographic characteristics of the spawning population;
>
> replacement in the ecosystem by other competing fish species of potentially less social and economic value."

Within the DFO Maritimes Region, the conservation requirement is considered to be consistent with a Limit Reference Point in the PA Framework (DFO 2012a, Gibson and Claytor 2012). The PA Framework used for science advice on fisheries harvests has three zones, defined below, which have also been evaluated for use in the context of species at risk:

> "Critical: Zone where stock biomass is evaluated as being at or below a level where there is a high risk of serious or irreversible harm to stock productivity. When stock biomass is within this zone, exploitation rates should be as low as possible, with no

directed fisheries and practical bycatch reduction measures in place. Rebuilding of the stock should be the sole consideration in allocating surplus production.

Healthy: Zone where stock biomass is evaluated as being within the historical range of the stock when science advisors did not recommend that priority be given to rebuilding the stock. When stock biomass is in this zone, exploitation should be at rates which are sustainable in the long term, but social and economic considerations are the main factor in deciding what proportion of surplus production from the stock should be devoted to harvests.

Cautious: Zone between the Critical and Healthy Zones, which reflects uncertainty about the estimation of annual stock status and the biomasses at which stock productivity begins to decline and becomes at risk of serious or irreversible harm. Exploitation rate should decline progressively from sustainable in the long-term at the Healthy-Cautious Boundary to as near zero as possible at the Cautious-Critical Boundary, as the priority given to stock rebuilding grows and the priority given to social and economic uses of surplus production declines." (DFO 2005)

In the context of species at risk, this framework provides a starting point for determining the state of a species or population when it is "recovered" (DFO 2005). The use of the "critical-cautious boundary" and the "cautious-healthy boundary" has been reviewed to determine where recovery would lie within this framework (DFO 2005). Strengths and weaknesses were noted for both positions; however, it was concluded that "any reasonable description of "recovery" would be at least a stock healthier than either the critical-cautious boundary or the risk criteria of COSEWIC" (DFO 2005). As the conservation requirement is considered to be consistent with a Limit Reference Point (which occurs at the critical-cautious boundary) in the PA Framework, the use of the conservation requirement as the abundance recovery target is consistent with the reasonable description of "recovery" described by DFO (2005).

Conservation requirements have been reported for many Atlantic Salmon populations in Atlantic Canada, including 26 populations in eastern Cape Breton (O'Connell et al. 1997). Using a regression of fluvial habitat area on watershed area, conservation requirements have been estimated for all 46 rivers in eastern Cape Breton thought to either contain or to have historically contained Atlantic Salmon populations (Gibson et al. 2014) to facilitate their use as recovery targets.

When proposing abundance recovery targets for iBoF and SU Atlantic Salmon, it was noted that estimated population sizes of Atlantic Salmon for rivers in the DFO Maritimes Region have exceeded conservation requirements in the past based on available monitoring data. Specific examples within the region where this had been documented include the Stewiacke River and Big Salmon River populations in the iBoF DU (DFO 2008), and the St. Mary's River population in the SU DU (Bowlby et al. 2013). Within eastern Cape Breton, the population of Atlantic Salmon in North River appears to have been above the conservation requirement for the river prior to 1999 and from 2003 onward, the Grand River population was estimated to be above the conservation requirement for the river for four years where data was available prior to 1992, as well as during 1995, 1996, and 1998 (although the wild component of the stock has not met the conservation requirement since 1990; Robichaud-Leblanc and Amiro 2004), and dive counts of salmon in Clyburn Brook indicate that it was, at a minimum, in excess of the conservation requirement for the river during the 1987-1990 time period. The population in the North Aspy River was also likely above the conservation requirement for the river in 2009, as divers almost counted the number of small and large salmon estimated to achieve the conservation requirement while snorkeling the river (DFO 2010b). Although, abundance estimates for the Middle River and Baddeck River populations indicate that it is unlikely that these two rivers have met conservation requirements since 1983, these populations have attained estimated maximum values of 85% and 86%, respectively, of the conservation requirements for those rivers in 1989. The Baddeck population was also estimated to have attained 72% of the conservation requirement in 2011.

When taken into context of the PA Framework, historical abundance estimates in surrounding DUs, and current and historic population estimates from the ECB DU, the conservation requirement appears unlikely to be unduly large, and is appropriate as a recovery target for river-specific populations. River-specific conservation (egg) requirements for eastern Cape Breton populations are provided in Table 2 of Gibson et al. (2014).

4.2 RECOVERY TARGETS FOR DISTRIBUTION

The population-specific abundance target is one component of recovery targets for eastern Cape Breton Atlantic Salmon. As discussed in the following sections, the distribution of populations within eastern Cape Breton also has to be sufficient to ensure enough populations are recovered to maximize the probability of longer term population viability.

Identifying Environmental Variation

Information that could be used to establish distribution targets for SU Atlantic Salmon was provided during the RPA for that DU; specifically Bowlby et al. (2013) noted:

> "The initial steps in protecting biological diversity involve first identifying diversity, and then defining the units of diversity that require preservation (Wood 2001). Therefore, setting appropriate distribution targets for the recovery of Southern Upland Atlantic Salmon populations partially relies on knowing the extent of variation among populations. Environmental variation both within and among river systems, coupled with the natural homing ability of Atlantic Salmon, act in concert to promote and maintain the variability in life history characteristics found among Atlantic Salmon populations in the Southern Upland (Chaput et al. 2006). Such local adaptation (and consequently biological diversity) would be expected to be the largest among the most dissimilar watersheds, provided that gene flow was relatively restricted among them."

Similarly, understanding the extent of variation among populations is also important for the recovery of eastern Cape Breton Atlantic Salmon. Consideration of environmental variation among watersheds along with recognizing the natural homing ability of Atlantic Salmon and implications for gene flow when establishing distribution targets will help promote and maintain variability found among populations in eastern Cape Breton.

As described in Section 2, two separate CUs were identified in eastern Cape Breton based on environmental characteristics (i.e., stream gradient) coupled with variation in life history characteristics (i.e., proportion of 1SW salmon) quantified among populations (DFO and MNRF 2008, Gibson and Bowlby 2009). Individual CUs were intended to represent population groupings that were sufficiently reproductively isolated and adaptively diverged from other representatives of the species (DFO and MNRF 2008). In addition to variation in the proportion of 1SW salmon observed within the ECB DU (i.e., variation among populations east and west of the Bras d'Or Lakes), other biological variation has been observed in rivers assessed by DFO in the form of variation in the proportion of repeat spawning salmon, variation in size of large salmon among Middle and Baddeck rivers, and variation in run timing among nearby rivers.

Differences in the proportion of repeat spawning salmon among populations within the DU have been observed through scale sample analysis (Appendix 1 – 4, Table 4.2.2). The proportion of repeat spawning salmon is greater in North and Grand rivers than in Middle and Baddeck rivers (combined for the analysis). As noted earlier, Atlantic Salmon returning to Middle and Baddeck rivers are predominately 2SW fish, which return during the fall (Marshall et al. 1996, Gibson and Bowlby 2009), whereas returns to Grand River are predominately 1SW fish that return in June or July with a considerable component of the large salmon returns being comprised of repeat spawning 1SW individuals (Marshall et al. 2000, Appendix 4). Although samples are limited, scale samples from North River also indicate that returns are predominately 2SW salmon, but there may be years where the 1SW component is greater than the MSW component. The run timing on North River is comprised of an early run of salmon (compared to a fall run on Middle and Baddeck rivers) and a late run has also been suggested, but undocumented (Marshall et al. 1996).

Size-at-age and run timing are also known to vary among some populations in eastern Cape Breton. Fork length measurements collected from salmon in Middle and Baddeck rivers show that males from Baddeck River were larger (on average) than those from Middle River during two of the four years where measurements were obtained; however, differences were not statistically significant, which may be attributed to some extent to small sample sizes (Table 4.2.1). Fork length measurements collected from female salmon in these rivers show that females from Baddeck River were larger than those from Middle River during five of the six years where samples were collected, and were statistically significant during three of those years (Table 4.2.1). Again it is important to note that sample size was relatively small in some years. Middle and Baddeck rivers both drain into Nyanza Bay, in the St. Patrick's Channel of the Bras d'Or Lakes and the river mouths are only separated by approximately four kilometers. Moreover, a significant proportion of Atlantic Salmon in North River, located further to the north of Middle and Baddeck rivers (Figure 2.1), return earlier than those returning to Middle and Baddeck rivers (Robichaud-LeBlanc and Amiro 2004, Gibson and Bowlby 2009) and the North River population has a higher proportion of repeat spawners. Taken together, all this information suggests variation in life history strategies currently exist among rivers within the same CU, even at relatively small spatial scales.

As an initial step toward identifying biodiversity for SU Atlantic Salmon, Bowlby et al. (2013) first conducted an inventory of the physical and geological characteristics of rivers (considered to be indicative of variability in freshwater habitats), and then grouped watersheds into those of similar type using a hierarchical cluster analysis. The authors stressed that the clusters resulting from the analysis were completely dependent on the data inputs. The consideration of additional or alternative environmental variables or more/fewer feature classes within a variable, could have affected the composition of watershed groups (i.e., watershed groupings were not considered fixed in the sense that no other groupings were possible). Both genetic analysis (O'Reilly et al. 2012) and environmental cluster analysis of watershed characteristics (Bowlby et al. 2013) for SU Atlantic Salmon showed similarities in divides among populations analyzed within the SU DU. As a result, it was suggested that local adaptation to environmental characteristics may have contributed to the genetic structuring of populations in the SU (Bowlby et al. 2013).

The environmental cluster analysis (Bowlby et al. 2013) was considered to be a meaningful way of grouping landscape level patterns and demonstrated that all watersheds within the SU region could not be considered equivalent in terms of protecting the biological diversity of Atlantic Salmon populations (DFO 2013). However, it was also noted that the use of a lower level grouping within the cluster analysis (i.e., more clusters), or the use of the already developed ecodistrict classification for the region, would be alternative ways to characterize environmental diversity within the SU (DFO 2013).

Recognizing the potential importance of environmental variation on genetic structuring and local adaptation of Atlantic Salmon populations in eastern Cape Breton, an existing ecological land classification (ELC) for NS (Neily et al. 2003) is described with the intent that it be used to aid in the establishment of distribution targets for recovery of eastern Cape Breton Atlantic Salmon. The use of the existing ELC for NS captures the collaborative work that has been undertaken by a number of federal agencies, as well as provincial and territorial governments to establish hierarchical ecosystem frameworks within Canada and NS (Webb and Marshall 1999, Neily et al. 2003).

The current hierarchical ELC for NS is considered to provide common language for discussions concerning biodiversity, forest ecosystems, and resource management (Neily et al. 2003). This classification system is hierarchical in nature and uses abiotic and biotic environmental attributes to define ecosystems. The system is comprised of five levels, which are described by Neily et al. (2003) as:

> **"Ecozone**
>
> Ecosystems at this scale are usually described on a global/continental scale. In Canada it is representative of large and very generalized ecological units characterized by interactive and adjusting abiotic and biotic factors. Basically they are the broad mosaics formed by the interaction of macroclimate, human activity, vegetation, soils, geological and physiographic features of the country (Ecological Stratification Working Group, 1996). Usually the forest vegetation is a reflection of the macroclimatic elements such as solar radiation and heat totals. In Nova Scotia, the Acadian Forest, as described by Rowe (1972) is "a major geographic belt or zone, characterized vegetationally by a broad uniformity both in physiognomy and in the composition of the dominant tree species". This unit has been adopted as the Acadian Ecozone, and is the only ecozone within the province. It is called the Atlantic Maritime ecozone by the Ecological Stratification Working Group (1996).
>
> **Ecoregions**
>
> Ecoregions are subdivisions of the larger Acadian ecozone and express macroclimate as a distinctive ecological response to climate through soils and vegetation. Rowe (1972) defines ecoregions as representations of broad provincial climatic patterns as expressed by the macrofeatures of vegetation: the distribution and range of conspicuous tree species, their life-forms (broadleaved or needle-leaved), the physiognomy and relative areal extent of the communities in which they are associated, and the patterning of the total vegetation. In Nova Scotia climate is often conferred as a result of the proximity to the cool salt waters along the coast or by elevation. Therefore, at this scale, boundaries drawn on the basis of these criteria are often coincident with the major physiographic features and ecoregions can be delineated around topography that has distinct differences in climate and/or proximity to the ocean. Regardless, the delineation of climatic zones in the province is rendered difficult and the boundaries are fuzzy due to the often mixing effects of coastal proximity and elevation. Climatic factors that affect the variety of biodiversity on terrestrial ecosystems also includes some elements of weather data that are not always used when determining the typical climatic zone. Minimum winter temperatures and snowfall are two factors that were considered in the determination of ecoregional boundaries in Nova Scotia. Soil, water and fauna also mirror the interaction of climate and vegetation at this scale. Vegetation patterns are strongly correlated with these climatic influences and the terrestrial ecosystems of each region display distinctive characteristics. Nine ecoregions have been mapped for Nova Scotia [text omitted] ranging in size from 444 km^2 to 16,906 km^2.
>
> **Ecodistricts**
>
> Ecodistricts are subdivisions of the ecoregions and reflect macroelements of the physical and biological attributes of the ecosystems which will ultimately influence biodiversity. Ecodistricts are major landforms within an ecoregion with geology and soils distinct from adjacent ecodistricts. Matson and Power (1996) state that ecodistricts indicate the principal regulators of meso-scale climate influences and the supply of soil nutrients (and moisture) which together influences all terrestrial and aquatic ecosystems. These elements of the ecodistricts include microclimate, physiography, geology, geomorphology, soils and moisture. One dominant element can usually be selected as

the defining characteristic and is reflected in the biodiversity of the ecodistrict. In Nova Scotia physiographical features resulting from geological history can be used to separate the uplands and lowlands. Due to the diversity of landform caused by glacial activity many of the province's ecodistricts can also be identified by landforms and surficial geology. Variation at an ecodistrict level will also be recognized along the coastal areas of Nova Scotia due to the influence of warmer and colder off-shore currents. Other districts can be distinguished based on the underlying effects of bedrock geology as expressed through soil lithology.

Within ecodistricts there will be a variability of biodiversity expressed due to the complexity of the interactions between the physical and biological attributes of the ecodistrict. This often confuses the mapping effort at this scale but if a strict application of the delineating criteria is maintained a meaningful and manageable unit can be described. The benefits of a hierarchical classification can be utilized at this level as this detail and complexity can be mapped at lower levels of the ELC. Nonetheless, as more data is collected and analyzed boundaries of any ecological unit can be adjusted to reflect and capture the complexity. Thirty-eight ecodistricts have been mapped for Nova Scotia [text omitted] ranging in size from 126 km^2 to 6,481 km^2. [text omitted]

Ecosections

These are the smallest mapped units of this current version of the ELC and are repetitive subdivisions of the ecodistrict. As the building block for the ELC this unit describes the enduring physical features - topographic pattern, soil texture and soil drainage. At this level biological processes such as climax forest association and natural disturbance regime can be determined. Together the physical and biological attributes of the ecosection determine the ecological processes and structures affecting biodiversity. Each ecodistrict will have several dominant ecosections repeating across the landscape which may be unique to that ecodistrict. Ecodistricts within the same ecoregion are more than likely to share ecosections with perhaps no noticeable physiognomic differences. However, floristic variability and contrasting response to management inputs can be expected. Significant differences in both physiognomic and floristic components as well as response to management inputs will be expected between ecosections of different ecoregions. Ecosections have a natural disturbance regime that maintains or rejuvenates the forest ecosystem. The frequency of these natural disturbances is a function of the forest species that occur in the ecosection. Forest ecosystems unaffected by human disturbances such as tree harvesting or protection from fire and insect damage can be expected to reach a climax or steady state at which time the natural disturbance can be expected to occur as conditions (climatic or biological) dictate. Wetland ecosystems are classified as poorly drained ecosections of smooth topography, i.e., PCSM, PMSM and PFSM. In this classification these wetlands include areas which are forested and nonforested. A further classification of wetlands has been undertaken to describe such features regarding water and nutrient source, vegetation, etc. (NSDNR 2000).

Ecosites

As a subdivision of an ecosection, ecosites describe a suite of site conditions including elevation, slope, slope position, aspect, soil drainage and soil texture that can be used to predict forest communities, their species, successional development and productivity. These units are usually mapped at a scale of 1:10,000 to 1:50,000 but in Nova Scotia will most likely be at the finer scale in order to be compatible with currently used inventories such as the forest cover layer in the provincial GIS. Management applications for ecosites will include forest/landscape level planning, forest ecosystem

> management prescriptions (including habitat supply modeling), silviculture prescriptions and estimating wood supply."

The hierarchical nature of the ELC allows for the selection of an appropriate level of ecosystem information for use in planning and managing various elements of biodiversity (Neily et al. 2003). The importance of the ELC for NS has been recognized as a tool for forest ecosystem management (Neily et al. 2003). Although the ELC for NS appears to be focused toward terrestrial ecosystem management, it could also prove to be valuable for aquatic resource management as environmental heterogeneity at small and medium spatial scales accompanied with the nearly precise homing of Atlantic Salmon are likely to lead to variation in life history and other fitness related traits that may have a genetic basis (DFO and MNRF 2008, DFO 2013). Therefore, it is important to consider environmental variation, as documented by the ELC, when establishing distribution targets.

The ecodistrict level of the ELC appears to be the most appropriate level for recovery planning, as it is characterized by distinctive assemblages of relief, geology, landform, soils and vegetation (Neily et al. 2003), with a spatial scale that is likely more conducive to recovery planning than smaller levels (i.e., ecosections and ecosites). There are seven ecodistricts within the ECB DU (Figure 4.2.1) and the watersheds for the 46 rivers that contain/have historically contained Atlantic Salmon populations encompass all seven of these ecodistricts to varying degrees (Table 4.2.3).

Identifying and Grouping Genetic Variation

Analysis of seven Atlantic Salmon populations distributed throughout eastern Cape Breton was conducted to identify genetic variation and patterns of present-day genetic structuring within the ECB DU (refer to O'Reilly et al. 2013). One objective of this analysis was to prioritize populations for conservation measures based on genetic information. Examining patterns of genetic variation can be useful to help identify and prioritize remaining within-species biodiversity for conservation actions; more specifically:

> "[text omitted] analyses of mitochondrial DNA, can help identify major ancestral lineages not otherwise apparent (Utter et al., 1993; Verspoor et al., 2002). Additionally, analyses of patterns and extent of genetic structuring among samples from different locations can provide information on amounts of recent and ongoing gene flow. This information is important in inferring the potential for adaptive differences to have developed between salmon from different rivers or regions, since genetically based adaptive differentiation can only accrue in the absence of large amounts of gene flow (Waples, 1991). Assessments of levels of within-population genetic variation have also been used to prioritize populations for conservation efforts (Petit et al., 1998) with, all else being equal, more weight given to populations exhibiting higher levels of genetic variation. This increased importance of more genetically diverse populations reflects both a) potentially increased likelihood of persistence of a given population over more genetically depauperate populations (Saccheri et al., 1998) and, hence, the ability of a population to contribute demographically to the species through time, and b) the potential contribution to the adaptability of the species in the face of future environmental change." (O'Reilly et al. 2012)

As noted by O'Reilly et al. (2012), all salmon populations from a given region can potentially contribute genetically or demographically to the long-term persistence of a DU, and possibly to the species itself. Different approaches suggested for prioritizing species conservation applicable to Atlantic Salmon have been recently summarized by O'Reilly et al. (2012):

> "A number of different approaches have been suggested for prioritizing species for conservation, recently discussed in O'Reilly and Doyle (2007). Ultimately, decisions would ideally be based on many criteria, including a) molecular genetic and genetically

based phenotypic differences in quantitative traits (Crandall et al., 2000), and b) ecological and life history information (Utter et al., 1993). [text omitted]. Petit et al. (1998) suggest an approach that prioritizes populations based on within-population genetic variation (specifically, AR) and divergence among populations, and, hence, what each contributes most to the total diversity of a given group of populations."

It is recognized that the analysis of neutral molecular genetic data only represents part of the picture when prioritizing species conservation. As noted by O'Reilly et al. (2013), recommendations with regard to the prioritization and conservation of Atlantic Salmon populations in eastern Cape Breton would depend on many criteria, including the number of populations that could be conserved and the consideration of all relevant and available information, including phenotypic and ecological factors in addition to insight from molecular genetic data.

Even though the genetics analyses only included seven of the 46 rivers known to harbour, or have historically supported Atlantic Salmon populations in eastern Cape Breton, the results of the analyses identified four (and possibly five) "groupings" that could be prioritized for conservation based on levels of within and among (though primarily the latter) population genetic variation (refer O'Reilly et al. 2013). All pairwise estimates of F_{ST} (measure of genetic structuring among populations) between samples from eastern Cape Breton populations were significantly different from zero, consistent with the presence of genetic structuring within the DU. Samples from the Baddeck River and Middle River populations, which empty into a common bay, were the least differentiated and clustered closely together in both phylogenetic and factorial correspondence analyses. This pair of populations next clustered together with samples from the North Aspy population in the most obvious grouping of multiple eastern Cape Breton populations in the study, before joining the somewhat more divergent North River and the western Cape Breton Margaree population. The Indian Brook (Eskasoni) population was clearly divergent from the other populations included in the analysis, and constitutes a second major grouping of these populations. River Inhabitants and Grand River were moderately differentiated from each other and the other eastern Cape Breton populations that were analyzed, though the former grouped with Mabou from western Cape Breton and the latter with the St. Mary's River population of the neighbouring SU DU. If considering only eastern Cape Breton populations, River Inhabitants and Grand River can be considered sole representatives of two additional groupings in the seven populations analyzed. Possible indications of within-population structuring was observed in North River, suggesting the presence of a fifth group of eastern Cape Breton Atlantic Salmon, although additional analyses of further samples from this location are required to substantiate these latter findings. Although unknown, it is important to consider that sampling additional populations within eastern Cape Breton may provide additional evidence for a greater number of divergent populations or clusters within the ECB DU and may provide further insight into clustering within major drainage basins and bays of the Bras d'Or Lakes and along the Atlantic coast.

On the whole, the results may suggest that genetic variation has developed on small spatial scales in eastern Cape Breton, and that geography as partial barriers to gene flow may be important to consider when prioritizing populations for recovery of ECB DU Atlantic Salmon (see below).

Setting Recovery Targets for Distribution

As noted during the SU RPA (Bowlby et al. 2013), distribution targets are harder to quantitatively define than abundance targets because the amount of population-level variation and contribution from straying, necessary to ensure long-term persistence of Atlantic Salmon, have not been quantified. Recent scientific advice with regard to distribution targets for SU Atlantic Salmon stated:

> “The distribution target should encompass the range of genetic and phenotypic variability among populations and environmental variability among rivers, and should include rivers distributed throughout the DU to allow for gene flow between the rivers/populations. There is the expectation that including a wide variety of populations in the distribution target will enhance persistence as well as facilitate recovery in the longer term.” (DFO 2013)

This advice is also applicable to Atlantic Salmon populations in eastern Cape Breton. As shown in Figure 4.2.1, there are seven ecodistricts in eastern Cape Breton and watersheds known to contain/have historically contained Atlantic Salmon populations encompass all seven of these ecodistricts to varying degrees (Table 4.2.3). As environmental heterogeneity may lead to local adaptations among populations, all seven of these ecodistricts should be considered when establishing the distribution target for ECB DU Atlantic Salmon. In addition, gene flow in eastern Cape Breton salmon populations may also be limited by the connectivity among rivers and local adaptation within the region. Therefore, selecting populations in areas that are potentially "geographically isolated" is also an important consideration in addition to selecting populations with representative life histories and that represent all seven ecodistricts. "Groupings" identified in the genetics analysis appears to lend support to the importance of this isolation (e.g., close grouping of Middle and Baddeck rivers that both flow into Nyanza Bay, distinctiveness of Indian Brook (Eskasoni) which was the most geographically isolated population, lack of clustering among River Inhabitants and Grand River, which both drain into the Atlantic Ocean). Although there is limited genetic information to help partition the DU precisely and a greater degree of uncertainty in the distinctiveness of Grand River and River Inhabitants populations, consideration of geographic isolation when establishing distribution targets could include selecting representative populations of the major basins and bays of the Bras d’Or Lakes (Figure 4.3.1), populations representative of those found along each of the south, central and northern regions of the southeast Atlantic coast, and representation of Atlantic coast rivers flowing off the Cape Breton highlands. Although other schemes are possible, a proposed geographic grouping (Figure 4.3.1) includes: rivers flowing into the Atlantic Ocean between the Canso Causeway and St. Peters (group 1), rivers flowing southeast into the Atlantic that are northeast of St. Peters (group 2), rivers flowing northeast into the Atlantic to the east of the Great Bras d’Or (group 2.1), Highland rivers northwest of White Point (group 3), Highland rivers between White Point and the Great Bras d’Or (group 4), rivers flowing in the Bras d’Or Lakes via St. Patrick’s Channel (group 5), and other rivers flowing into the Bras d’Or Lakes (group 6). Other than direction of flow, there is no information for splitting between groups 2 and 2.1.

The six divisions of geographic isolation presented (Figure 4.3.1) take into consideration the major basins and bays within the DU and roughly correspond with ecodistricts (Section 4.2). Group 1 is comprised of the three watersheds that drain into Chedabucto Bay and St. Peters Bay within the Bras d’Or Lowlands and Cape Breton Hills ecodistrists. Group 2 is comprised of the six watersheds that drain south into the Atlantic Ocean, east of St. Peters Bay and are predominately within the Cape Breton Coastal and Bras D’Or Lowlands ecodistricts. Group 2.1 is comprised of eight watersheds (potentially a subset of group 2) predominantly within the Bras d’Or Lowlands and Cape Breton Hills ecodistricts that drain in a generally northeast direction to the Atlantic Ocean along the eastern coast of Cape Breton, north of Scaterie Island and southeast of the Great Bras d’Or Channel. Group 3 is comprised of four watersheds on the north tip of Cape Breton ranging in size from approximately 12 km^2 to 142 km^2. These watersheds drain into Aspy Bay and Bay St. Lawrence and are a combination of Cape Breton Taiga, Cape Breton Highlands, and Victoria Lowlands. Group 4 is comprised of six watersheds that drain into the Gulf of St. Lawrence and St. Ann’s Bay, ranging in size from approximately 23 km^2 to approximately 267 km^2. These watersheds are almost entirely within the Cape Breton Highlands ecodistrict with small portions of Cape Breton Taiga, and Victoria Lowlands and Bras D’Or Lowlands. Group 5 is comprised of eight watersheds ranging in size from approximately

13 km^2 to 349 km^2, with five of these being smaller than 50 km^2. Rivers in this group drain into the Great Bras d'Or, the northern basin of the Bras d'Or Lake and occupy areas primarily within the Cape Breton Highlands and Cape Breton Hills ecodistricts, and to a smaller extent the Bras d'Or Lowlands and the Inverness Lowlands. Group 6 is the largest grouping of watersheds in the designated unit with 11 small watersheds that drain into Bras d'Or Lake. River Denys at approximately 215 km^2 is the exception when it comes to the size, with all the other watersheds smaller than 75 km^2 and nine are less than 50 km^2. These watersheds are within the Cape Breton Hills and Bras d'Or Lowlands ecodistricts. These divisions are by no means definitive but do capture a variety of ecodistrict composition and representation of major geographic features leading to possible population isolation.

As population viability, ecological function, and human benefits are likely to increase with the recovery of as many populations as possible, it is recommended that the distribution target include as many of the 46 rivers that contain/were known to historically contain Atlantic Salmon populations, distributed using the criteria above, as possible. Moreover, having as many populations in the distribution target as possible is expected to increase the long-term persistence of the DU as a whole (DFO 2013) and having representation of more than one population from each ecodistrict is anticipated to help protect against catastrophic loss. Additionally, as noted for iBoF (DFO 2008) and SU (DFO 2013) Atlantic Salmon populations, the following criteria should also be used to help prioritize among rivers when setting distribution targets: current population size, complexity (in terms of population life history, local adaptation and genetic distinctiveness); connectivity with surrounding populations (metapopulation structure); and the number and location of source populations.

Watersheds with larger rearing areas for juvenile Atlantic Salmon (Table 2 and Figures 2 and 4 in Gibson et. al. 2014) are distributed throughout eastern Cape Breton. Some of the largest watersheds also provide representation of each of the seven ecodistricts (Figure 4.2.1) and include rivers with current Atlantic Salmon populations, which are suspected to be some of the largest within the DU (e.g., Baddeck, Middle, and North rivers). Thus, larger watersheds, especially those meeting other important attributes for recovery identified earlier, are good candidates for inclusion within the distribution target.

5.0 DISCUSSION AND CONCLUSIONS

Overall, the assessment data presented here does not provide a positive view of the status of Atlantic Salmon populations within eastern Cape Breton. Two (Grand and Clyburn) of the five populations for which adult time series data are available have shown marked declines in abundance over the last 10-, 15-, and 20-year time periods. Adult abundance trends on two other rivers, i.e., Middle and Baddeck, are less evident, which may indicate that these populations are relatively stable, but with considerable variability in abundance observed over the time series. Although populations in Middle and Baddeck rivers appear to have been relatively stable over the last 15 years, they have remained at levels below conservation requirements. North River is the only one of the five rivers that was assessed to be above its conservation requirement in 2011. North River has shown a considerable decline in adult salmon abundance since peak values observed in the mid-1980s, but analysis of the recreational catch data indicates that the abundance appears to have been increasing over the last 10 years. Recent assessment work on North Aspy River also indicates that it was likely above the conservation requirement in 2009, although repeated attempts to assess adult status during subsequent years have been unsuccessful.

Declining trends in recreational catch and effort are evident for many rivers across eastern Cape Breton. Although reported recreational fishing effort for Atlantic Salmon had been distributed over many rivers in the past, it had primarily contracted down to the North, Baddeck, and Middle rivers in 2009, prior to widespread recreational fisheries closures for Atlantic Salmon in eastern

Cape Breton. Declines in recreational catch and effort on most rivers coupled with increases in recreational fishing effort observed on Middle, Baddeck, and North rivers over the last 10 years, may indicate that abundance is low in other rivers and that anglers have focused toward fishing in rivers with higher abundance of Atlantic Salmon. Results from electrofishing surveys were positive in the sense that juvenile Atlantic Salmon were found in all rivers surveyed since 1996; however, juvenile salmon densities observed during these surveys were generally low relative to reference values used to evaluate juvenile salmon abundance within the DFO Maritimes Region. In general, the status of eastern Cape Breton salmon populations in rivers other than the index rivers is a major source of uncertainty in this RPA, particularly for those populations in rivers to the south and east of the Bras d'Or Lakes.

Recommended recovery targets for eastern Cape Breton Atlantic Salmon include abundance and distribution components. River specific conservation requirements have been proposed as the abundance target, which is consistent with recovery targets proposed for SU Atlantic Salmon populations, as well as their use as Limit Reference Points in the PA Framework. Distribution targets are more difficult to quantify and the exact number of populations required to recover eastern Cape Breton salmon is unknown. Attaining conservation requirements and recovering Atlantic Salmon in as many rivers as possible is likely to increase the probability of attaining long-term population persistence, to restore the ecological function of the watersheds in which salmon formerly resided, and to increase the potential for human benefits.

Population and genetic structuring has been identified within eastern Cape Breton, which means that all populations of Atlantic Salmon cannot be considered equivalent. Moreover, each population is important and has the potential to contribute genetically and/or demographically to the long term persistence of the ECB DU and possibly to the species itself. Preserving the maximum amount of genetic variation will maximize the evolutionary potential of eastern Cape Breton Atlantic Salmon, meaning that the DU as a whole will have the greatest ability to respond or adapt to environmental change, as well as the greatest chance of re-colonizing rivers that have been extirpated. Preserving populations with high genetic variation and populations with high genetic divergence will be important for recovery.

As the exact number of rivers/watersheds required to ensure long-term persistence of Atlantic Salmon within eastern Cape Breton is not known, it is recognized that management decisions will have to be made during recovery planning relative to the perceived degree of risk of how many rivers constitute an acceptable distribution target for recovery of eastern Cape Breton Atlantic Salmon. The following scientific criteria have been proposed to help prioritize among rivers when setting distribution targets: current population size; complexity (in terms of population life history, local adaptation and genetic distinctiveness); connectivity with surrounding populations (metapopulation structure); and the number and location of source populations. The use of ecodistricts, information on genetic structuring among populations presented in O'Reilly et al. (2013), and inferences of geographic isolation and the implications for gene flow will be valuable when prioritizing rivers for conservation. Both abundance and distribution recovery targets will need to be revisited as information about the dynamics of the recovering population becomes available.

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TABLES

Table 3.1.1. Percent freshwater age composition and sea age composition of first time spawners as determined from scale samples of adult Atlantic Salmon collected from Middle River during the 1995 – 2004 time period.

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

Table Notes:

"N" is the number of samples.

"-" = No sample observed within age category.

Table 3.1.2. Summary of the recreational fishery statistics for large and small Atlantic Salmon in Middle River, Victoria Co., from 1983-2011. The number of anglers is the number that reported fishing in Middle River. Other values are corrected for non-reporting. (Source: Updated from Gibson and Bowlby 2009). CPUE = catch per unit effort. Effort is the total number of rod-days.

Year	No. of Anglers	Small Kept	Small Released	Total Small	Large Kept	Large Released	Total Large	Effort	CPUE	% Large
1983	133	12	0	12	36	5	41	924	0.058	78.0
1984	83	23	10	33	1	74	75	506	0.202	69.5
1985	39	15	6	21	0	28	28	159	0.280	57.1
1986	76	36	8	45	0	108	108	385	0.410	70.9
1987	114	54	4	58	0	117	117	718	0.243	66.9
1988	131	35	12	47	0	136	136	722	0.276	74.2
1989	144	42	11	53	0	282	282	867	0.395	84.3
1990	153	76	26	102	0	187	187	1005	0.313	64.7
1991	169	18	9	27	0	184	184	854	0.257	87.3
1992	66	8	4	12	0	32	32	218	0.198	72.7
1993	110	26	6	31	0	49	49	398	0.202	61.1
1994	122	0	24	24	0	167	167	504	0.393	87.6
1995	72	0	36	36	0	49	49	287	0.317	57.7
1996	125	3	62	64	0	147	147	512	0.415	69.5
1997	52	3	15	18	0	80	80	175	0.542	81.7
1998	99	5	26	31	0	60	60	312	0.303	66.2
1999	138	0	30	30	0	95	95	369	0.346	76.1
2000	92	0	20	20	0	67	67	311	0.297	76.7
2001	25	0	10	10	0	15	15	92	0.290	60.0
2002	60	1	27	28	0	35	35	231	0.284	56.0
2003	76	0	23	23	0	137	137	336	0.489	85.7
2004	45	0	22	22	0	44	44	185	0.382	66.7
2005	128	0	38	38	0	133	133	458	0.387	77.8
2006	78	0	44	44	0	87	87	416	0.327	66.3
2007	120	0	42	42	0	95	95	506	0.260	69.3
2008	57	0	45	45	0	57	57	434	0.235	55.8
2009	63	0	8	8	0	176	176	704	0.262	95.5
2010	72	0	73	73	0	218	218	737	0.394	75.0
2011	77	2	100	102	0	119	119	459	0.524	53.8

Table 3.1.3. Summary of adult broodstock removals and juvenile stocking of Atlantic Salmon aimed to numerically offset catch-and-release mortality, and parr removals and adult stocking efforts aimed to support Aboriginal FSC use on Middle River. NA = Not Applicable.

Year	Adult Removals		Juvenile Stocking		Juvenile Removals # Parr	Adult Stocking
	# Large	# Small	# Fry (Summer)	# Age 0 Parr (October)		
2009	8	1	NA	NA	40	NA
2010	7	0	NA	12,000	NA	NA
2011	7	1	12,600	10,400	NA	14

Table 3.1.4. The number of large and small salmon counted during dive surveys in Middle River, Victoria Co., from 1994-2011. The number of salmon (size classes combined) that were marked and then observed during the dive count are shown for years when mark-recapture experiments were conducted. (Source: Updated from Gibson and Bowlby 2009).

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

Table Notes:

NA = Not Applicable.

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

Table 3.1.5. Means and standard deviations (s.d.) of age 0 and age 1+ densities (number/100m^2) of juvenile Atlantic Salmon in the Middle River, Victoria Co., estimated during electrofishing surveys from 1985-2006. "N" is the number of sites electrofished in each year (Source: Gibson and Bowlby 2009).

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

Table 3.2.1. Percent freshwater age composition, and sea age composition of first time spawners determined from scale samples of adult Atlantic Salmon collected from Baddeck River during the 1977–2004 time period.

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

Table Notes:

“N” is the number of samples.

NA = Not Applicable.

“-” = No sample observed within age category.

Table 3.2.2. Summary of the recreational fishery statistics for large and small Atlantic Salmon in Baddeck River, Victoria Co., from 1983-2011. The number of anglers is the number that reported fishing in Baddeck River. Other values are corrected for non-reporting. (Source: Updated from Gibson and Bowlby 2009). CPUE = catch per unit effort. Effort is the total number of rod-days.

Year	No. of Anglers	Small Kept	Small Released	Total Small	Large Kept	Large Released	Total Large	Effort	CPUE	% Large
1983	86	5	1	6	39	6	45	386	0.136	87.8
1984	60	4	2	7	2	44	46	273	0.189	87.5
1985	34	4	0	4	0	13	13	100	0.170	75.0
1986	67	19	6	26	0	126	126	287	0.540	83.1
1987	90	26	14	40	0	127	127	432	0.404	75.9
1988	86	18	17	35	0	168	168	447	0.492	82.8
1989	98	8	9	17	0	235	235	490	0.559	93.2
1990	103	40	30	69	0	178	178	584	0.446	72.0
1991	110	30	25	54	0	226	226	638	0.427	80.6
1992	129	50	6	56	0	162	162	704	0.327	74.4
1993	146	33	15	48	0	108	108	772	0.212	69.2
1994	74	1	14	15	0	56	56	308	0.265	79.4
1995	61	8	56	64	0	75	75	337	0.403	53.8
1996	70	0	47	47	0	169	169	380	0.580	78.2
1997	43	0	14	14	0	64	64	206	0.390	81.7
1998	87	0	57	57	0	81	81	335	0.442	58.6
1999	96	1	14	15	0	79	79	290	0.335	83.7
2000	54	1	11	12	0	55	55	212	0.363	82.0
2001	31	0	11	11	0	20	20	104	0.321	64.0
2002	59	0	19	19	0	38	38	204	0.303	66.0
2003	50	0	23	23	0	80	80	221	0.497	77.3
2004	40	2	14	15	0	53	53	185	0.392	77.5
2005	93	0	40	40	0	109	109	397	0.373	73.5
2006	57	0	21	21	0	88	88	316	0.425	81.2
2007	55	2	15	16	0	66	66	254	0.300	80.4
2008	36	0	28	28	0	43	43	280	0.254	60.0
2009	40	0	14	14	0	135	135	487	0.305	90.7
2010	45	0	59	59	0	159	159	384	0.567	73.1
2011	77	2	84	85	0	213	213	483	0.634	71.4

Table 3.2.3. Summary of adult broodstock removals and juvenile stocking efforts of Atlantic Salmon aimed to numerically offset catch-and-release mortality, and parr removals and adult stocking efforts aimed to support Aboriginal FSC use on Baddeck River. NA = Not Applicable.

Year	Adult Removals		Juvenile Stocking		Juvenile Removals # Parr	Adult Stocking
	# Large	# Small	# Fry (Summer)	# Age 0 Parr (October)		
2009	8	1	NA	NA	40	NA
2010	5	2	13,000	9,000	NA	NA
2011	7	1	6,000	10,700	NA	2

Table 3.2.4. The number of large and small salmon counted during dive surveys in Baddeck River, Victoria Co., from 1994-2011. The number of salmon (size classes combined) that were marked and then observed during the dive count are shown for years when mark-recapture experiments were conducted (Source: Updated from Gibson and Bowlby 2009). NA = Not Applicable.

Year	Number Counted		Mark-Recapture		
	Small Salmon	Large Salmon	No. Marked	No. of Observed Marks	Observation Efficiency
1994	17	93	12	9	0.75
1995	42	112	28	12	0.43
1996	43	171	17	11	0.65
1997	35	103	32	19	0.59
1998	30	74	13	7	0.54
1999	NA	NA	NA	NA	NA
2000	8	84	43	27	0.63
2001	NA	NA	NA	NA	NA
2002	12	44	NA	NA	NA
2003	7	60	15	3	0.20
2004	18	38	3	1	0.25
2005	34	121	NA	NA	NA
2006	21	60	NA	NA	NA
2007	27	64	NA	NA	NA
2008	63	74	NA	NA	NA
2009	15	67	NA	NA	NA
2010	2	40	NA	NA	NA
2011	39	121	NA	NA	NA

Table 3.2.5. Means and standard deviations (s.d.) of age 0 and age 1+ densities (number/100 m^2) of juvenile Atlantic Salmon in the Baddeck River Victoria Co., NS, estimated during electrofishing surveys from 1996-2001. "N" is the number of sites electrofished in each year (Source: Gibson and Bowlby 2009).

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

Table 3.3.1. Percent freshwater age composition, and sea age composition of first time spawners determined from scale samples of adult Atlantic Salmon collected from North River during the 1991–1998 time period.

Year	% Freshwater Age Composition					% Sea Age Composition			
	1	2	3	4	N	1	2	3	N
1991	-	100%	-	-	9	-	100%	-	8
1996	-	67%	33%	-	6	60%	40%	-	5
1997	-	10%	70%	20%	20	17%	83%	-	23
1998	-	8%	83%	8%	12	18%	82%	-	11

Table Notes:

"N" is the number of samples.

"-" = No sample observed within age category.

Table 3.3.2. Summary of the recreational fishery statistics for large and small Atlantic Salmon in North River, from 1983-2011. The number of anglers is the number that reported fishing in North River. Other values are corrected for non-reporting (Source: Updated from Gibson and Bowlby 2009). CPUE = catch per unit effort. Effort is the total number of rod-days.

Year	No. of Anglers	Small Kept	Small Released	Total Small	Large Kept	Large Released	Total Large	Effort	CPUE	% Large
1983	290	35	9	44	148	8	156	1856	0.105	78.0
1984	162	56	9	65	94	57	152	1174	0.183	70.0
1985	170	145	13	158	0	413	413	1005	0.559	72.4
1986	297	186	50	237	0	1017	1017	2035	0.640	81.1
1987	263	177	50	227	0	547	547	1653	0.475	70.7
1988	202	119	17	136	0	539	539	1593	0.438	79.9
1989	162	117	38	156	0	385	385	1342	0.433	71.2
1990	219	207	67	274	0	625	625	1845	0.491	69.5
1991	172	152	40	191	0	365	365	1389	0.402	65.6
1992	205	194	42	236	0	580	580	1858	0.433	71.1
1993	217	62	19	81	0	160	160	1224	0.196	66.4
1994	73	0	78	78	0	102	102	411	0.435	56.5
1995	77	1	172	173	0	215	215	516	0.759	55.4
1996	81	0	165	165	0	118	118	592	0.525	41.7
1997	58	1	69	70	0	137	137	384	0.537	66.2
1998	84	0	108	108	0	104	104	448	0.497	49.1
1999	79	0	35	35	0	45	45	292	0.282	56.2
2000	49	0	32	32	0	27	27	261	0.232	45.8
2001	46	0	37	37	0	60	60	264	0.376	62.2
2002	44	0	34	34	0	45	45	269	0.341	57.1
2003	51	0	81	81	0	156	156	525	0.475	65.9
2004	37	0	70	70	0	152	152	505	0.468	68.5
2005	54	1	54	55	0	171	171	441	0.512	75.6
2006	51	0	56	56	0	104	104	445	0.445	64.8
2007	59	0	92	92	0	134	134	491	0.582	59.2
2008	45	0	123	123	0	183	183	559	0.547	59.7
2009	31	0	63	63	0	168	168	668	0.346	72.6
2010	37	0	150	150	0	293	293	630	0.703	66.1
2011	52	0	74	74	0	175	175	559	0.746	70.3

Table 3.3.3. The number of large and small salmon counted during dive surveys in North River from 1983-2011. The number of salmon (size classes combined) that were marked and then observed during the dive count are shown for years when mark-recapture experiments were conducted (Source: Updated from Gibson and Bowlby 2009).

Year	Number Counted		Mark-Recapture		
	Small Salmon	Large Salmon	No. Marked	No. of Observed Marks	Observation Efficiency
1994	48	119	22	8	0.36
1995	57	124	28	13	0.46
1996	184	138	14	8	0.57
1997	54	281	25	11	0.44
1998	59	165	13	6	0.46
1999	NA	NA	NA	NA	NA
2000	NA	NA	NA	NA	NA
2001	44	73	NA	NA	NA
2002	7	19	NA	NA	NA
2003	NA	NA	NA	NA	NA
2004	30	68	NA	NA	NA
2005	NA	NA	NA	NA	NA
2006	3	9	NA	NA	NA
2007	40	66	NA	NA	NA
2008	NA	NA	NA	NA	NA
2009	15	62	NA	NA	NA
2010	NA	NA	NA	NA	NA
2011[a]	NA	NA	NA	NA	NA

Table Notes:

NA = Not Applicable.

[a]A dive survey was conducted in 2011 where 14 small and 37 large salmon were counted; however, the results were judged not to be useful for the estimation of abundance due to unsuitable water conditions (DFO 2012a).

Table 3.4.1. Percent freshwater age composition, and sea age composition of first time spawners determined from scale samples of adult Atlantic Salmon collected from Grand River during the 1990 – 1994 time period.

Year	% Freshwater Age Composition					% Sea Age Composition			
	1	2	3	4	N	1	2	3	N
1990	-	94%	6%	-	167	92%	8%	-	145
1991	1%	96%	2%	2%	130	95%	5%	-	118
1992	-	97%	3%	-	68	87%	13%	-	71
1993	-	93%	7%	-	41	95%	5%	-	57
1994	-	67%	33%	-	48	96%	4%	-	54

Table Notes:

"N" is the number of samples.

"-" = No sample observed within age category.

Table 3.4.2. Summary of the recreational fishery statistics for large and small Atlantic Salmon in Grand River, from 1983-2011. The number of anglers is the number that reported fishing in Grand River. Other values are corrected for non-reporting (Source: Updated from Gibson and Bowlby 2009). CPUE = catch per unit effort. Effort is the total number of rod-days.

Year	No. of Anglers	Small Kept	Small Released	Total Small	Large Kept	Large Released	Total Large	Effort	CPUE	% Large
1983	371	194	34	228	31	39	69	4212	0.069	23.3
1984	268	350	53	404	4	30	34	2989	0.148	7.8
1985	312	471	71	542	0	132	132	3073	0.224	19.6
1986	326	294	61	356	0	192	192	2997	0.180	35.0
1987	262	301	33	334	0	104	104	2059	0.208	23.8
1988	277	303	21	324	0	101	101	3334	0.133	23.8
1989	247	311	23	334	0	80	80	2709	0.148	19.4
1990	240	339	79	419	0	102	102	2857	0.186	19.7
1991	178	115	13	128	0	18	18	1981	0.076	12.3
1992	182	155	12	166	0	46	46	1939	0.109	21.6
1993	183	115	21	136	0	24	24	1469	0.105	15.2
1994	44	0	75	75	0	21	21	416	0.231	21.6
1995	4	0	6	6	0	16	16	49	0.368	71.4
1996	26	0	94	94	0	26	26	294	0.405	21.7
1997	20	3	28	31	0	6	6	173	0.202	15.4
1998	20	0	75	75	0	12	12	246	0.321	13.6
1999	7	0	17	17	0	3	3	47	0.429	16.7
2000	14	0	20	20	0	1	1	81	0.266	5.9
2001	6	0	1	1	0	0	0	9	0.143	0.0
2002	11	0	31	31	0	0	0	84	0.375	0.0
2003	8	0	16	16	0	3	3	63	0.302	15.4
2004	4	0	7	7	0	2	2	35	0.263	20.0
2005	6	0	20	20	0	0	0	13	1.500	0.0
2006	8	0	15	15	0	0	0	28	0.500	0.0
2007	5	0	6	6	0	2	2	34	0.174	25.0
2008	4	0	7	7	0	0	0	31	0.231	0.0
2009	2	0	3	3	0	3	3	27	0.200	50.0
2010					River closed					
2011					River closed					

Table 3.4.3. Returns of Atlantic Salmon above Grand River falls on the Grand River, NS, from 1988-2000 as estimated from fishway count data (Source: Gibson and Bowlby 2009).

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

Table Notes:

NA = Not Applicable.

*Only partial counts were conducted.

Table 3.5.1. Counts and percent size composition of small and large salmon from dive surveys conducted in Clyburn Brook, NS, from 1985-2011. (Source: Data provided courtesy of Parks Canada).

Year	Number Counted			Size Composition	
	Small Salmon	Large Salmon	Total Salmon	% Small	% Large
1985*	4	38	42	9.52	90.48
1986*	9	18	27	33.33	66.67
1987	35	140	175	20.00	80.00
1988	40	77	117	34.19	65.81
1989	17	68	85	20.00	80.00
1990	31	65	96	32.29	67.71
1991	NA	NA	NA	NA	NA
1992	19	51	70	27.14	72.86
1993	NA	NA	NA	NA	NA
1994*	24	45	69	34.78	65.22
1995*	24	22	46	52.17	47.83
1996	NA	NA	NA	NA	NA
1997	19	52	71	26.76	73.24
1998	10	32	42	23.81	76.19
1999	5	5	10	50.00	50.00
2000	5	3	8	62.50	37.50
2001	9	20	29	31.03	68.97
2002	8	11	19	42.11	57.89
2003	13	18	31	41.94	58.06
2004	3	8	11	27.27	72.73
2005	5	7	12	41.67	58.33
2006	5	11	16	31.25	68.75
2007	3	7	10	30.00	70.00
2008	8	8	16	50.00	50.00
2009*	1	5	6	16.67	83.33
2010	3	5	8	37.50	62.50
2011	2	0	2	100.00	0.00

Table Notes:

NA = Not Applicable.

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

Table 3.6.1. Adult Atlantic Salmon abundance time series for five rivers in eastern Cape Breton (Source: Updated from Gibson and Bowlby 2009).

Year	Middle River[1]		Baddeck River[1]		North River[2]		Grand River[1]	Clyburn River[3]	
	Small	Large	Small	Large	Small	Large	Small+ Large	Small	Large
1983	2	26	3	36	NA	NA	NA	NA	NA
1984	28	189	8	93	94	372	NA	NA	NA
1985	60	165	10	61	229	1011	NA	4	38
1986	46	296	24	251	343	2490	NA	9	18
1987	21	202	27	194	329	1339	NA	35	140
1988	25	235	27	251	197	1320	626	40	77
1989	20	494	13	334	226	943	453	17	68
1990	67	316	40	231	397	1530	442	31	65
1991	20	351	31	282	277	894	348	NA	NA
1992	48	221	12	194	342	1420	133	19	51
1993	10	87	19	125	117	392	97	NA	NA
1994	45	426	28	136	113	250	201	24	45
1995	55	242	91	188	251	526	281	24	22
1996	109	380	75	294	239	289	345	NA	NA
1997	62	330	45	183	101	335	147	19	52
1998	69	182	72	154	156	255	241	10	32
1999	63	281	23	190	51	110	93	5	5
2000	39	164	19	136	46	66	41	5	3
2001	52	139	38	91	54	147	2	9	20
2002	59	121	31	95	49	110	46	8	11
2003	38	383	26	166	117	382	37	13	18
2004	60	251	34	109	101	372	18	3	8
2005	75	354	62	210	80	419	39	5	7
2006	64	185	37	143	81	255	29	5	11
2007	62	198	38	138	133	328	16	3	7
2008	100	175	77	116	178	448	14	8	8
2009	25	215	23	159	91	411	12	1	5
2010	38	269	16	143	217	717	NA	3	5
2011	161	315	90	273	107	428	NA	2	0

Table Notes:

NA = Not Applicable.

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

Table 3.6.2. Summary of declines/increases in adult Atlantic Salmon abundance (large and small size categories combined) for five rivers in eastern Cape Breton. The regression method is a log-linear model fit via least squares. The step function is the change in the five-year mean population size ending on the years given in the time period column (the number of years differs between the methods). The standard errors and 95% confidence intervals are in brackets. Fifteen years corresponds to approximately three generations. A negative value in the decline columns indicates an increasing population size. Model fits for the 15-year time period are shown in Figure 3.6.1.

Population	Time Period	Number of Years	Slope (SE)	Regression		Step Function
				1 yr decline rate (%)	Decline over time period (%)	Decline over time period (%)
Middle River	1991 - 2011	20	0.01 (0.01)	-0.57 (2.24 – -3.46)	-12.65 (37.82 – -104.10)	9.94 (36.79 – -28.71)
	1996 - 2011	15	-0.00 (0.02)	0.10 (3.57 – -3.50)	1.54 (44.07 – -73.33)	-7.27 (41.00 – -94.82)
	2001 - 2011	10	0.04 (0.03)	-3.97 (1.85 – -10.14)	-53.49 (18.55 – -189.25)	-13.96 (19.37 – -61.77)
Baddeck River	1991 - 2011	20	-0.01 (0.01)	0.67 (2.90 – -1.61)	13.14 (46.10 – -39.96)	27.56 (46.41 – 1.34)
	1996 - 2011	15	-0.01 (0.02)	0.52 (3.94 – -3.03)	7.97 (47.48 – -61.25)	6.33 (38.60 – -43.74)
	2001 - 2011	10	0.06 (0.03)	-5.74 (-0.63 – -11.12)	-84.84 (-7.10 – -219.01)	-10.39 (21.77 – -56.36)
North River	1991 - 2011	20	-0.02 (0.02)	1.50 (6.05 – -3.27)	27.16 (73.01 – -96.61)	59.49 (69.85 – 45.81)
	1996 - 2011	15	0.06 (0.03)	-6.12 (-0.38 – -12.19)	-158.75 (-6.28 – -529.92)	11.44 (49.42 – -55.16)
	2001 - 2011	10	0.11 (0.03)	-12.03 (-4.99 – -19.54)	-248.82 (-70.82 – -612.27)	-156.83 (-47.95 – -200.00)
Grand River[a]	1989 - 2009	20	-0.19 (0.03)	17.19 (22.23 – 11.83)	98.10 (99.49 – 92.89)	96.31 (98.10 – 92.69)[b]
	1994 - 2009	15	-0.22 (0.05)	19.61 (27.59 – 10.76)	96.96 (99.43 – 83.83)	90.61 (95.09 – 81.27)
	1999 - 2009	10	-0.08 (0.10)	8.14 (24.22 – -11.35)	60.70 (95.27 – -226.21)	90.18 (94.49 – 81.87)
Clyburn River	1991 - 2011	20	-0.14 (0.02)	13.17 (17.18 – 8.97)	94.84 (98.09 – 86.09)	93.95 (96.89 – 87.28)[c]
	1996 - 2011	15	-0.14 (0.04)	13.07 (19.20 – 6.46)	89.36 (96.70 – 65.65)	88.65 (95.09 – 72.85)[d]
	2001 - 2011	10	-0.19 (0.04)	17.52 (24.24 – 10.20)	87.99 (95.28 – 69.39)	70.54 (89.08 – 18.16)

Table Notes:

[a]Abundance for Grand River has been estimated from recreational catch data and an assumed catch rate. The recreational fishery on Grand River was closed during 2010 and 2011; therefore, the most recent time period (i.e., up to and including 2009) was used for each series.

[b]Due to missing values, a two year mean is used for the 1985-1989 time period in the step function comparisons.

[c]Due to missing values a four-year mean is used for the 1987-1991 time period in the step function comparisons.

[d]Due to missing values a three-year mean is used for the 1992-1996 time period in the step function comparisons.

Table 3.8.1. Sites electrofished in rivers throughout eastern Cape Breton in 2006 and 2007 (Source: Adapted from Gibson and Bowlby 2009).

River	Site Name	Index River	Site #	Years Sampled	Map	Site location			
						Grid Ref	Datum	Latitude	Longitude
								(decimal degrees)	
Black Brook	Main channel	no	BlkB001	2007	11K16	016-826	NAD83	46.7666	60.3597
Clyburn	SP1	no	Cly001	2006	11K9	912-706	NAD83	46.6619	60.5009
	SP2	no	Cly002	2006	11K9	907-707	NAD83	46.6629	60.5070
	NA	no	Cly003	2006	11K9	904-708	NAD84	46.6639	60.5110
	Franny Brook	no	Cly004	2006	11K9	941-699	NAD83	46.6554	60.4637
	Main channel	no	Cly005	2006-2007	11K9	700-977	NAD83	46.6545	60.4159
River Denys	Glen 27	no	Denys001	2006	11F14	345-822	NAD83	45.8822	61.2652
	Glen 8	no	Denys002	2006	11F14	350-819	NAD83	45.8796	61.2577
Grand	Mud Hole (above falls)	yes	Grand001	1996-2000, 2006	11F10	843-665	NAD83	45.7279	60.6309
	Fishway (above falls)	yes	Grand002	1996-2000, 2006	11F10	847-647	NAD83	45.7114	60.6267
	Crib Pool (below falls)	yes	Grand003	1996-2000, 2006	11F10	844-613	NAD83	45.6815	60.6319
	Frank MacDonald Rd. (below falls)	yes	Grand004	1996-2000, 2006	11F10	824-589	NAD83	45.6604	60.6583
Indian Bk (Eskazoni)	NA	no	Indian001	2002, 2006-2007	11K2	858-918	NAD83	45.1232	60.1012
Ingonish	NA	no	Ingon001	2001, 2006	11K9	956-664	NAD83	46.6230	60.4448
Middle	MacKenzie Bk	yes	Mid001	1996-2001, 2006	11K2	575-107	NAD83	46.1323	60.9599
	Finlayson	yes	Mid002	1996-2001, 2006	11K2	603-232	NAD83	46.2436	60.9195
	Twin Churches	yes	Mid003	1996-2001, 2006	11K2	601-134	NAD83	46.1559	60.9265
	MacLeods Bk	yes	Mid004	1996-1998, 2006	11K2	600-140	NAD83	46.1612	60.9265
Mira River	Gaspereaux River	no	Mira001	2007	11F16	073-884	NAD83	45.9181	60.3274
North Aspy	South branch	no	NAspe001	2006-2007	11K15	810-871	NAD83	46.8129	60.6275
	NA	no	NAspe002	2007	11K15	800-864	NAD83	46.8072	60.6400
North	Karr's	yes	NorCB001	1998-2001, 2006	11K7	829-312	NAD83	46.3100	60.6245
	MacLeans	yes	NorCB002	1997-2001, 2006	11K7	779-337	NAD83	46.3338	60.6882
	Narrows	yes	NorCB003	1999-2001, 2006	11K7	812-320	NAD83	46.3178	60.6460
	Benches	yes	NorCB004	1996, 1998-2000, 2006	11K7	774-343	NAD83	46.3397	60.6940
Sydney	Meadows Brook	no	Sydney001	1996-2000, 2006-2007	11K1	105-028	NAD83	46.0333	60.2792
	Woodbine Brook	no	Sydney002	2002, 2006-2007	11K1	084-995	NAD83	46.0210	60.1353

Table 3.8.2. Number of fish captured by species while electrofishing in rivers in eastern Cape Breton during 2006 and 2007. (Source: Adapted from Gibson and Bowlby 2009).

River	Crew[a]	Site ID	Number Captured by Species[b]										TOTAL
			Alosa unidentified	American eel	Atlantic Salmon	Brook trout	Brown trout	Chub unidentified	Mummichog	Rainbow trout	Sea lamprey	Threespine stickleback	
2006													
Clyburn	Parks, ARD, PED	Cly001	-	10	22	1	-	-	-	-	-	-	33
		Cly002	-	-	-	5	-	-	-	-	-	-	5
		Cly003	-	-	-	-	-	-	-	-	-	-	0
		Cly004	-	1	14	-	-	-	-	-	-	-	15
		Cly005	-	15	52	1	-	-	-	-	-	-	68
River Denys	FN, ARD, PED	Denys001	-	-	28	4	-	-	-	-	-	-	32
		Denys002	-	-	1	3	-	-	-	-	-	-	4
Grand	FN, ARD, PED	Grand001	6	10	14	-	-	-	3	-	-	-	33
		Grand002	-	8	16	-	-	-	-	-	-	-	24
		Grand003	1	15	23	-	-	-	-	-	-	-	39
		Grand004	-	-	9	-	-	1	-	-	-	-	10
Indian Brook	FN, PED	Indian001	-	-	20	4	2	-	-	6	-	-	32
Ingonish	Parks, ARD, PED	Ingon001	-	2	22	-	-	-	-	-	-	-	24
Middle	FN, ARD, PED	Mid001	-	-	37	15	-	-	-	-	-	-	52
		Mid002	-	-	101	5	-	-	-	-	-	-	106
		Mid003	-	-	100	1	-	-	-	-	-	-	101
		Mid004	-	-	164	5	-	-	-	-	-	-	169
North Aspy	Parks, ARD, PED	NAspe001	-	12	152	6	-	-	-	-	-	-	170
North	Parks, ARD, PED	NorCB001	-	9	84	2	-	-	-	-	-	-	95
		NorCB002	-	-	69	-	-	-	-	-	-	-	69
		NorCB003	-	4	76	-	-	-	-	-	-	-	80
		NorCB004	-	-	38	4	-	-	-	-	-	-	42
Sydney	FN, PED	Sydney001	-	-	29	2	-	-	-	-	-	-	31
		Sydney002	-	-	-	32	-	-	-	-	-	-	32
2007													
Black Brook	Parks, PED	BlkB001	-	1	2	3	-	-	-	-	-	-	6
Clyburn River	Parks, PED	Cly005	-	14	31	-	-	-	-	-	-	-	45
Indian Brook	FN, PED	Indian001	-	-	42	6	-	-	-	5	-	-	53
Mira River	FN, PED	Mira001	-	8	83	2	4	1	-	-	1	-	99
North Aspy	Parks, PED	NAspe001	-	1	43	4	-	-	-	-	-	-	48
		NAspe002	-	1	45	-	-	-	-	-	-	-	46
Sydney	FN, PED	Sydney001	-	1	11	2	-	-	-	-	-	1	15
		Sydney002	-	-	-	46	-	-	-	-	-	-	46

Table Notes: [a]Contributions to data collection came from First Nations (FN), Parks Canada (Parks) and the Department of Fisheries and Oceans, including the Aquatic Resources Division (ARD) at the Gulf Fisheries Centre, and the Population Ecology Division (PED) at the Bedford Institute of Oceanography.
[b]Alosa and chub were not identified to the species level.
"-" = Species not captured.

Table 3.8.3. Juvenile density by age of Atlantic Salmon at electrofishing sites in eastern Cape Breton in 2006 and 2007. Total catch at each site is standardized by shocking time and scaled up to density using the catch-per-unit-effort (CPUE) - density relationship for fry and parr developed by Chaput et al. (2005). The catchability of age 1 and age 2 parr is assumed to be equal (Source: Gibson and Bowlby 2009).

River	Site ID	Method	No. of Sweeps	Area (m^2)	Shocking Time (s)	Catch			CPUE (3 min.)			Density (per 100m^2)		
						Age 0	Age 1	Age 2	Age 0	Age 1	Age 2	Age 0	Age 1	Age 2
2006														
Clyburn	Cly001	one-pass	1	93.28	300	0	17	5	0	10	3	4	57	19
	Cly004	one-pass	1	201.08	385	3	4	7	1	2	3	11	14	21
	Cly005	one-pass	1	178.41	-	40	9	3	-	-	-	-	-	-
River Denys	Denys001	one-pass	1	69.27	301	28	0	0	17	0	0	92	4	4
	Denys002	one-pass	1	55.61	281	0	1	0	0	1	0	4	8	4
Grand	Grand001	one-pass	1	249.73	967	11	3	0	2	1	0	14	7	4
	Grand002	one-pass	1	257.04	889	13	3	0	3	1	0	17	7	4
	Grand003	one-pass	1	372.49	1400	20	3	0	3	0	0	17	6	4
	Grand004	one-pass	1	199.81	567	5	4	0	2	1	0	12	11	4
Indian Brook	Indian001	one-pass	1	223.44	534	5	6	9	2	2	3	13	14	19
Ingonish	Ingon001	one-pass	1	222.07	545	7	15	0	2	5	0	16	29	4
Middle	Mid001	one-pass	1	91.57	535	0	21	16	0	7	5	4	40	31
	Mid002	one-pass	1	230.15	723	40	49	12	10	12	3	56	68	19
	Mid003	one-pass	1	138.82	470	74	25	1	28	10	0	157	54	6
	Mid004	one-pass	1	214.37	1083	135	24	5	22	4	1	124	24	8
North Aspy	NAspe001	Removal	4	352.63	735,743, 748,1056*	23,19, 10,10*	45,10, 11,0*	7,5, 9,3*	6	11	2	33	61	13
North	NorCB001	one-pass	1	174.72	560	12	63	9	4	20	3	24	112	19
	NorCB002	one-pass	1	153.61	453	3	33	33	1	13	13	10	73	73
	NorCB003	one-pass	1	169.03	673	6	65	5	2	17	1	12	96	11
	NorCB004	one-pass	1	142.07	504	25	11	2	9	4	1	50	24	8
Sydney	Sydney001	one-pass	1	192.27	434	25	3	1	10	1	0	58	10	6
2007														
Clyburn	Cly005	one-pass	1	276	539	22	7	0	7	2	0	42	16	4
Indian Brook	Indian001	one-pass	1	384	855	10	25	5	2	5	1	15	31	10
North Aspy	NAspe001	one-pass	1	242	573	24	16	1	8	5	0	43	30	6
	NAspe002	one-pass	1	235	531	15	27	3	5	9	1	30	51	9
Sydney	Sydney001	one-pass	1	251	629	9	2	0	3	1	0	17	7	4
Mira River	Mira001	one-pass	1	449	786	72	2	1	16	0	0	91	7	6
Black Brook	BlkB001	one-pass	1	357	517	0	0	2	0	0	1	4	4	4

Table Notes:

*Numbers correspond to the shocking time and catch on each of the four passes.

Table 4.2.1. Mean, standard deviation, and p-value resulting from linear model when comparing fork lengths (mm) of virgin 2SW Atlantic Salmon in Middle and Baddeck rivers. "N" represents number of samples. NA = Not Applicable.

Year	Males					Females				
	Middle		Baddeck		p-value	Middle		Baddeck		p-value
	Mean (sd)	N	Mean (sd)	N		Mean (sd)	N	Mean (sd)	N	
1995	732.5 (46.0)	2	777.5 (81.3)	2	0.57	695.8 (31.2)	9	742.8 (32.9)	13	0.00
1996	763.8 (22.1)	4	NA	NA	NA	727 (19.6)	5	750 (35.7)	9	0.21
1997	766.5 (40.6)	13	782.4 (32.9)	5	0.45	750.4 (22.5)	20	738.2 (25.5)	20	0.12
1998	750.3 (5.5)	3	658.5 (142.1)	2	0.31	724.4 (12.8)	7	740.3 (34.3)	6	0.28
2003	800.8 (42.3)	4	755.0 (46.7)	2	0.29	732.6 (16.3)	11	775.9 (50.4)	8	0.02
2004	763.5 (37.5)	2	NA	NA	NA	728.9 (31.8)	9	778.3 (23.3)	3	0.03
Total	766.6 (37.5)	28	754.0 (75.3)	11	0.49	731.0 (28.8)	61	748.4 (35.2)	59	0.00

Table 4.2.2. Mean and standard deviation of the proportion of repeat spawning salmon in North, Grand, and Middle and Baddeck (combined) rivers. The "No. Years" represents the number of years with information on repeat spawning salmon for each river.

Middle & Baddeck (combined)		North		Grand	
Mean (s.d.)	No. Years	Mean (s.d.)	No. Years	Mean (s.d.)	No. Years
0.04 (0.05)	13	0.13 (0.04)	4	0.10 (0.07)	5

Table 4.2.3. Proportions of the seven eastern Cape Breton ecodistricts within each of the 46 watersheds thought to support or to have supported Atlantic Salmon within eastern Cape Breton. Percentages are based on the total area of each ecodistrict found in this set of 46 watersheds. A "-" represents 0%.

River No.	River Name	CB Taiga	CB Highlands	Victoria Lowlands	CB Hills	Inverness Lowlands	Bras D'Or Lowlands	CB Coastal
1	Salmon R. (Vic Co)	-	3.6%	-	-	-	-	-
2	Wilkie Bk.	-	0.8%	2.0%	-	-	-	-
3	North Aspy R.	39.1%	5.0%	43.1%	-	-	-	-
4	Middle, South Aspy R.	29.4%	0.8%	39.0%	-	-	-	-
5	Clyburn Bk.	10.5%	4.0%	6.1%	-	-	-	-
6	Ingonish R.	7.0%	6.1%	1.9%	-	-	-	-
7	Indian Bk. (Vic Co)	14.0%	18.4%	1.6%	-	-	-	-
8	Barachois R.	-	8.0%	1.6%	-	-	0.3%	-
9	River Bennett	-	1.5%	4.8%	-	-	0.0%	-
10	North R.	-	15.0%	-	0.6%	-	1.1%	-
11	Baddeck R.	-	10.8%	-	6.6%	-	3.8%	-
12	Middle R.	-	22.0%	-	-	77.8%	0.4%	-
13	Hume R.	-	3.6%	-	-	-	-	-
14	MacPhersons (Lewis) Bk.	-	0.4%	-	0.8%	-	-	-
15	Skye R.	-	-	-	10.1%	22.2%	0.2%	-
16	Blues Bk.	-	-	-	1.7%	-	0.3%	-
17	Washabuck R.	-	-	-	1.5%	-	0.6%	-
18	McKinnons Bk.	-	-	-	0.6%	-	0.4%	-
19	River Denys	-	-	-	14.3%	-	4.8%	-
20	Scott Bk.	-	-	-	0.6%	-	1.3%	-
21	River Tillard	-	-	-	2.5%	-	2.7%	0.4%
22	False Bay Bk.	-	-	-	0.5%	-	1.0%	0.1%
23	Black R.	-	-	-	0.6%	-	2.7%	-
24	River Inhabitants	-	-	-	19.3%	-	10.1%	0.1%
25	Grand R.	-	-	-	3.2%	-	10.0%	12.4%
26	St. Esprit (Taylors) Bk.	-	-	-	-	-	0.3%	2.3%
27	Marie Joseph Bk.	-	-	-	-	-	1.4%	9.9%
28	Framboise R.	-	-	-	-	-	4.5%	17.3%
29	Gerratt Bk./Lorraine Bk.	-	-	-	-	-	-	18.4%
30	Little Lorraine Bk.	-	-	-	-	-	-	9.8%
31	Catalone R.	-	-	-	-	-	3.1%	11.5%
32	Mira R.	-	-	-	7.4%	-	28.8%	17.9%
33	MacAskills Bk.	-	-	-	-	-	3.4%	-
34	Northwest Bk.	-	-	-	-	-	3.4%	-
35	Sydney R.	-	-	-	5.5%	-	8.2%	-
36	Grantmire Bk.	-	-	-	1.2%	-	0.7%	-
37	Frenchvale Bk.	-	-	-	3.4%	-	1.1%	-
38	Georges R.	-	-	-	1.0%	-	0.5%	-
39	Aconi Bk.	-	-	-	-	-	2.8%	-
40	Benacadie Bk.	-	-	-	3.7%	-	0.5%	-
41	Indian Bk. (CB Co)	-	-	-	4.4%	-	-	-
42	MacIntosh Bk.	-	-	-	3.3%	-	-	-
43	Gillies Bk.	-	-	-	3.0%	-	-	-
44	Breac Bk.	-	-	-	3.5%	-	-	-
45	River Tom	-	-	-	0.8%	-	0.8%	-
46	MacNabs Bk.	-	-	-	-	-	0.9%	-
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

FIGURES

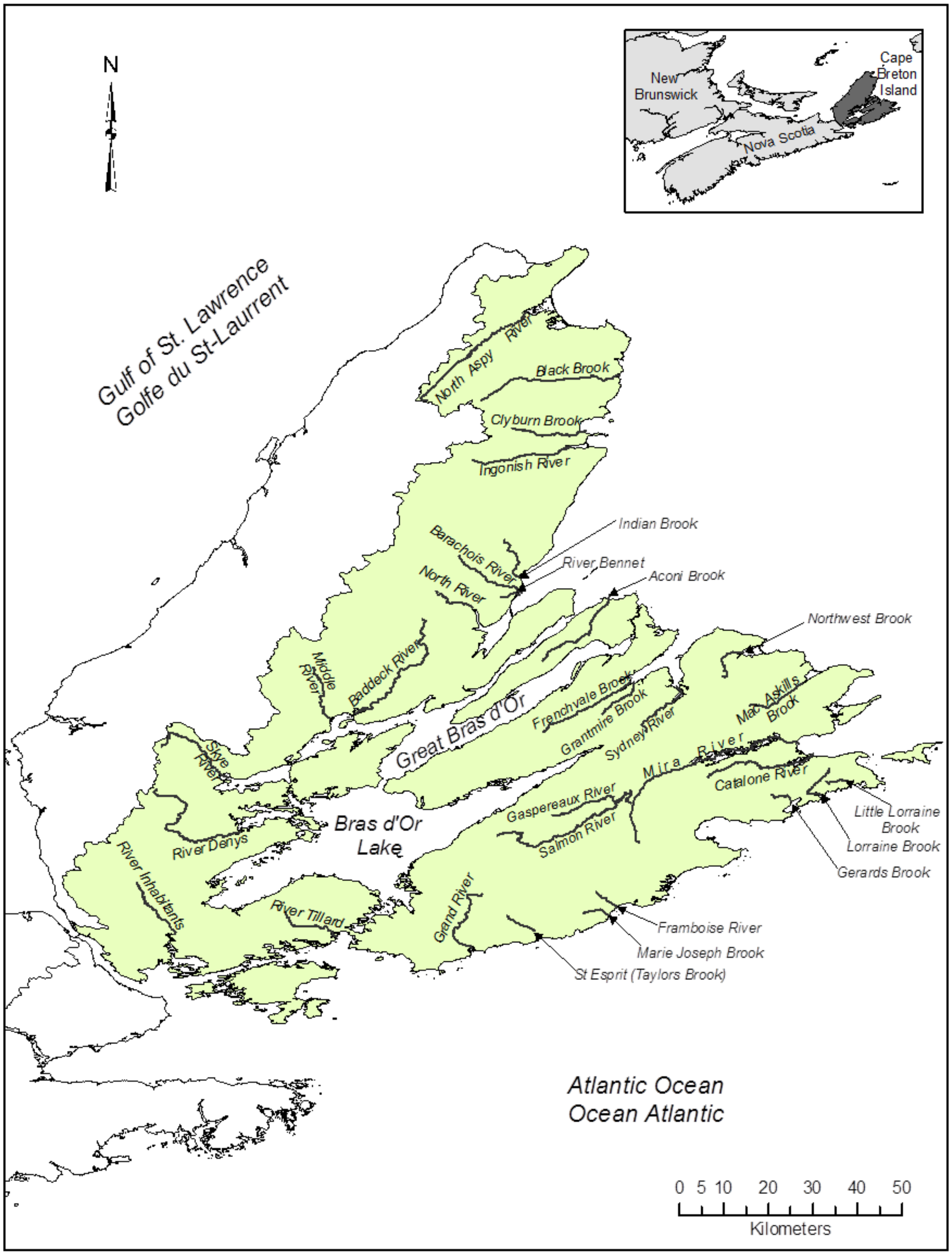


Figure 2.1. Rivers in the ECB DU with a reported recreational catch. The ECB DU is highlighted in green.

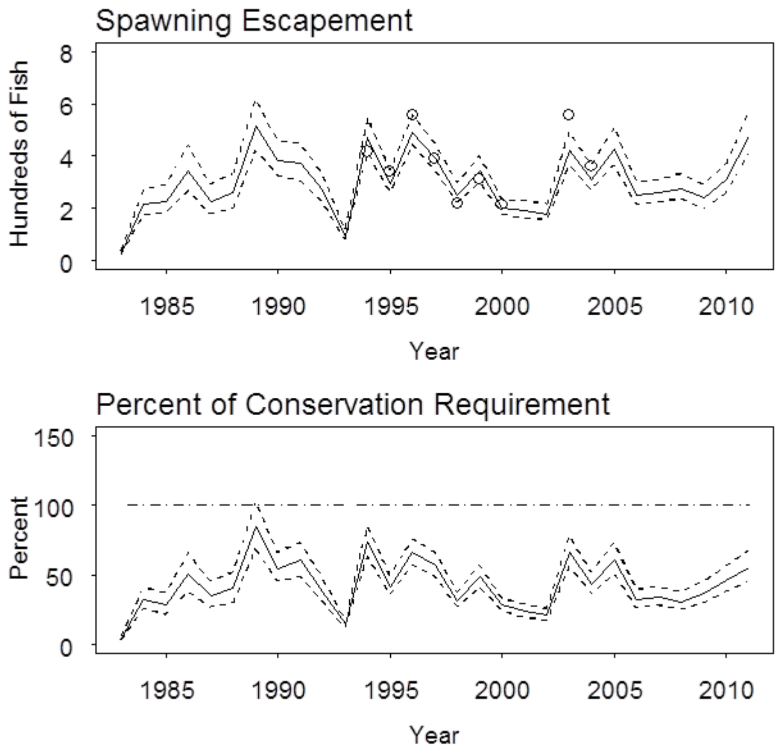


Figure 3.1.1. Estimated total number of spawners (top panel) and the percent of the conservation requirement attained (bottom panel) in Middle River, NS, from 1983-2011. The solid lines are the estimated values and the dashed lines are the 10th and 90th percentiles of the posterior probability densities for the estimates (indicative of the uncertainty of the estimates). The points in the upper panel are the population estimates obtained by mark-recapture during the dive surveys. The horizontal dashed line in the bottom panel indicates 100% of the conservation requirement.

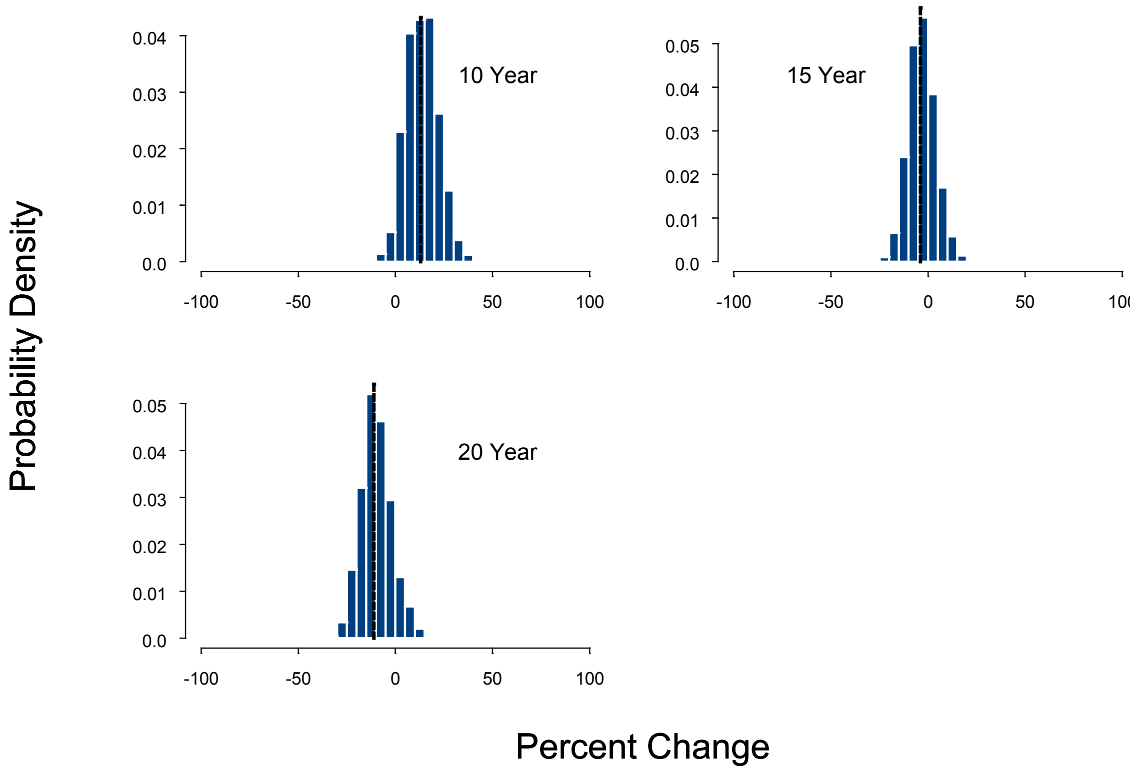


Figure 3.1.2. Posterior probability densities for the percent decline in the Atlantic Salmon escapement in Middle River, NS over 10-, 15- and 20-year time periods. Percent decline was calculated by comparing the mean number of returning salmon for the 2007-2011 time period to means for the 1997-2001 time period (10-year comparison), the 1992-1996 time period (15-year comparison), and the 1987-1991 time period (20-year comparison). The dashed lines show the maximum likelihood estimates for the percent change in population size. See Appendix 1 in Gibson and Bowlby (2009) for the derivation of this figure.

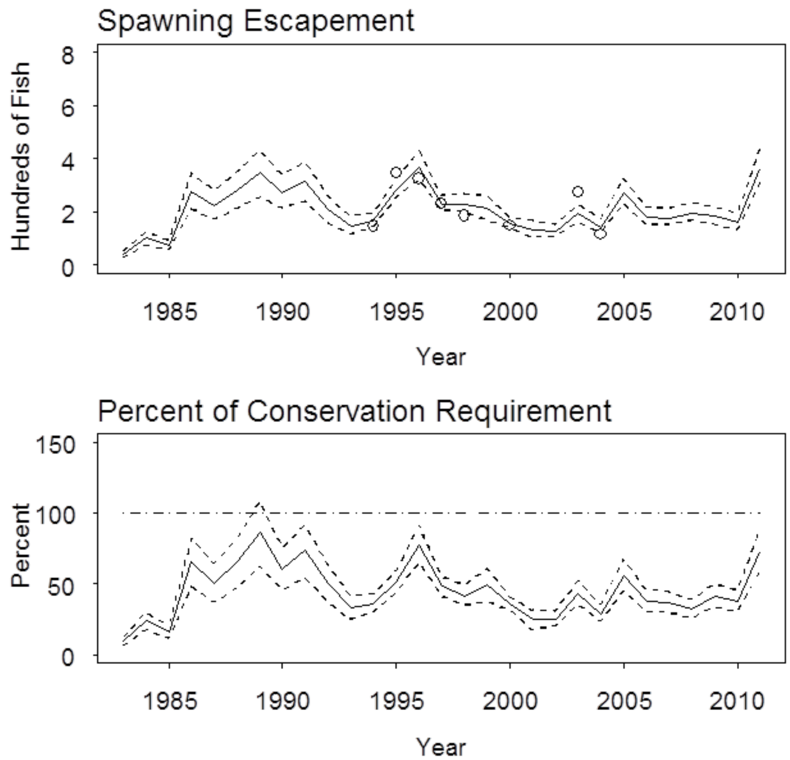


Figure 3.2.1. Estimated total number of spawners (top panel) and the percent of the conservation requirement attained (bottom panel) in Baddeck River, NS, from 1983 -2011. The solid lines are the estimated values and the dashed lines are the 10th and 90th percentiles of the posterior probability densities for the estimates (indicative of the uncertainty of the estimates). The points in the upper panel are the population estimates obtained by mark-recapture during the dive surveys. The horizontal dashed line in the bottom panel indicates 100% of the conservation requirement.

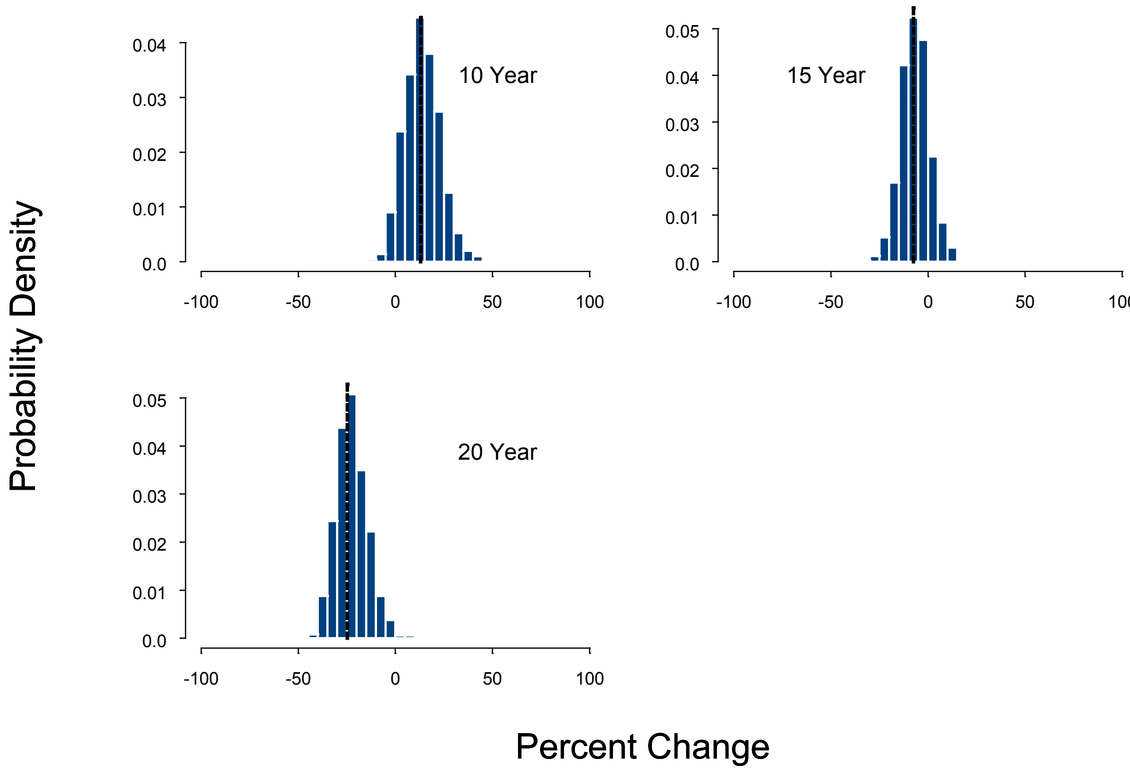


Figure 3.2.2. Posterior probability densities for the percent decline in Atlantic Salmon escapement in Baddeck River, NS, over 10-, 15- and 20-year time periods. Percent decline was calculated by comparing the mean number of returning salmon for the 2007-2011 time period to means for the 1997-2001 time period (10-year comparison), the 1992-1996 time period (15-year comparison), and the 1987-1991 time period (20-year comparison). The dashed lines show the maximum likelihood estimates for the percent change in population size. See Appendix 2 in Gibson and Bowlby (2009) for the derivation of this figure.

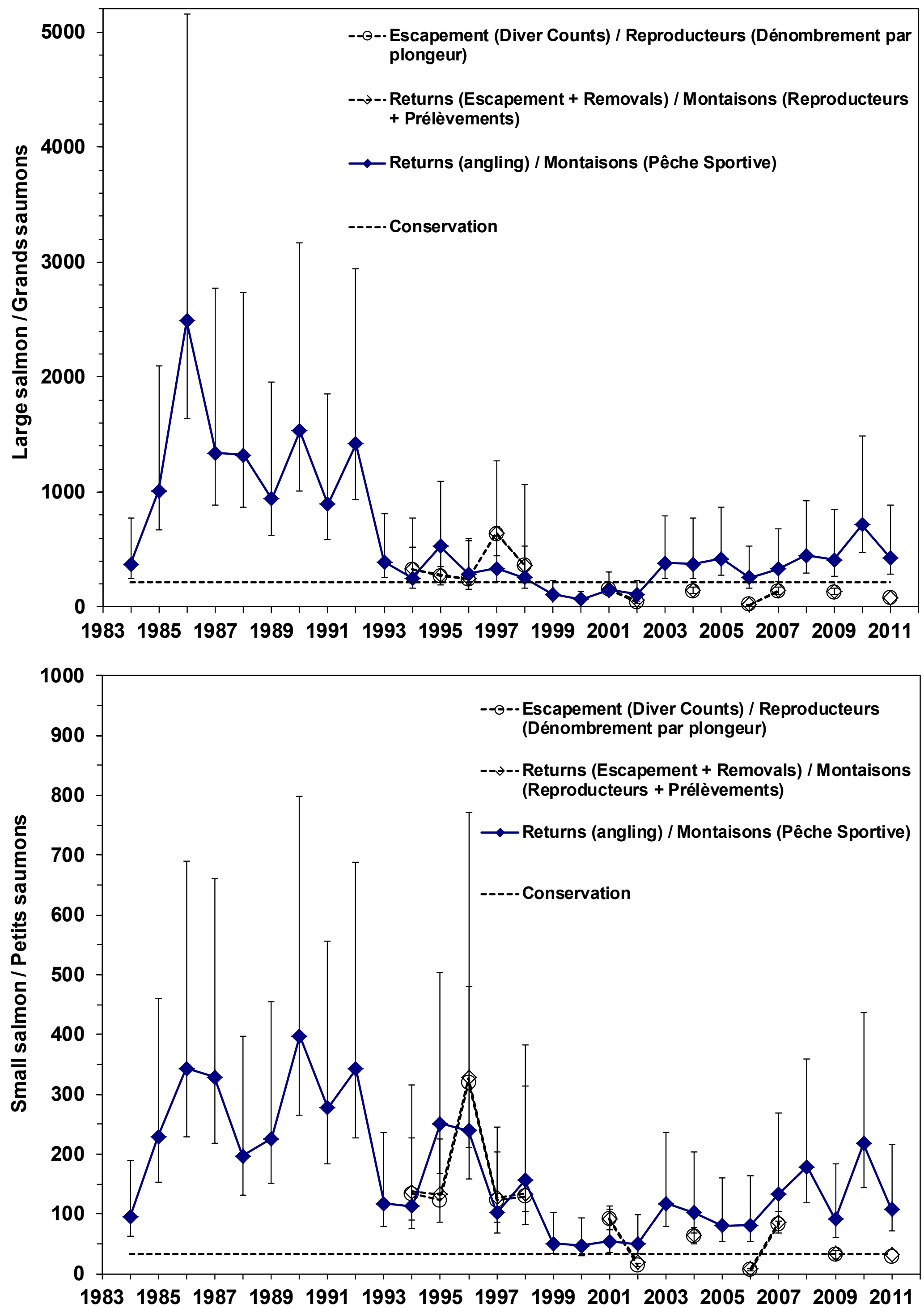


Figure 3.3.1. Estimates of the number of salmon returning to spawn and the spawning escapement for large and small salmon in the North River, NS, from 1984-2011, as derived from dive survey counts and from recreational catch data. The approximate number of large or small salmon required to meet the Conservation Requirement is shown by the horizontal dashed line.

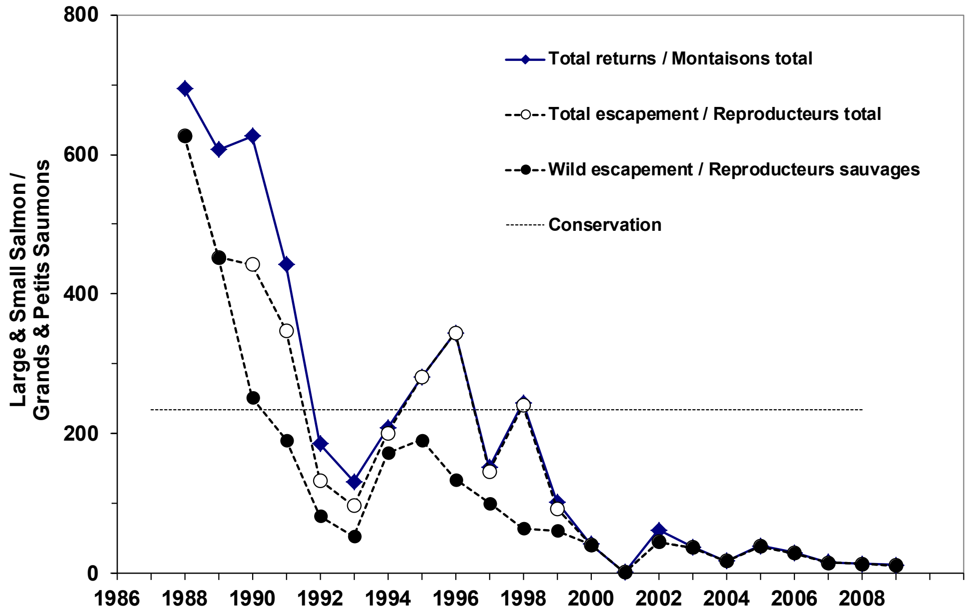


Figure 3.4.1. Total returns and escapement to the Grand River, NS, for large and small salmon from 1988-2009. Estimates derived from fishway counts and recreational catch data (pre-2000) and recreational catch data from 2000 onward. The approximate number of salmon (large and small combined) required to meet the conservation requirement is shown by the horizontal dashed line.

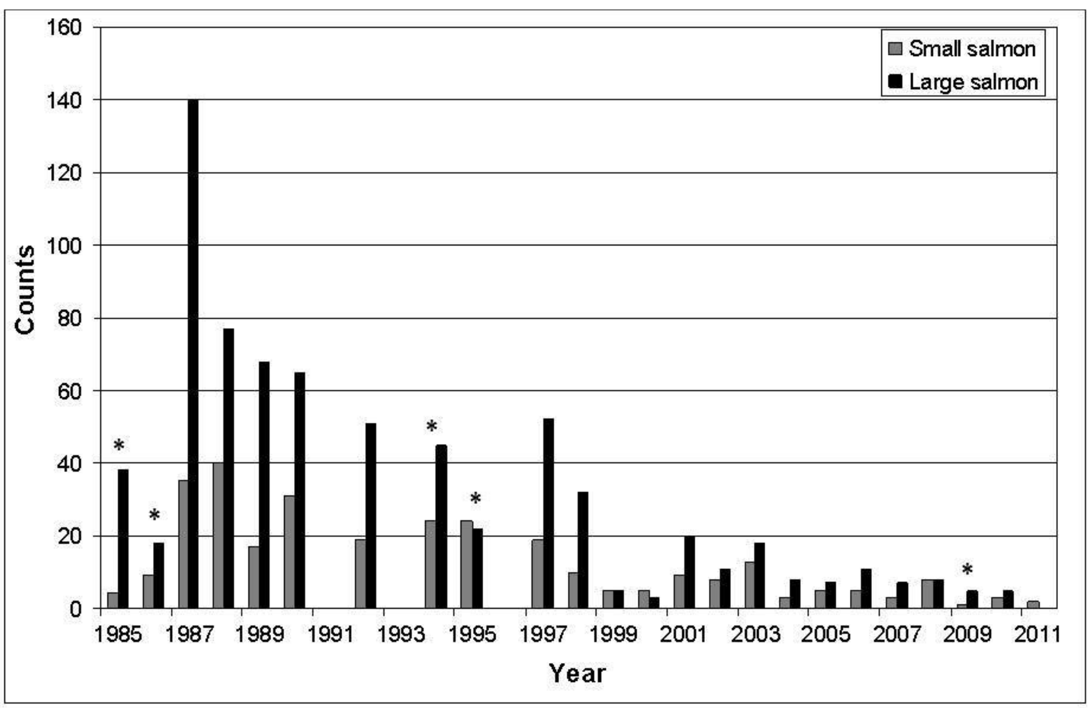


Figure 3.5.1. Counts of large and small salmon during dive surveys in Clyburn River, NS, from 1985-2011. Years in which only the lower section of the river was surveyed (partial counts) are identified with an asterisk (;1985, 1986, 1994, 1995 and 2009). (Source: Data provided courtesy of Parks Canada).*

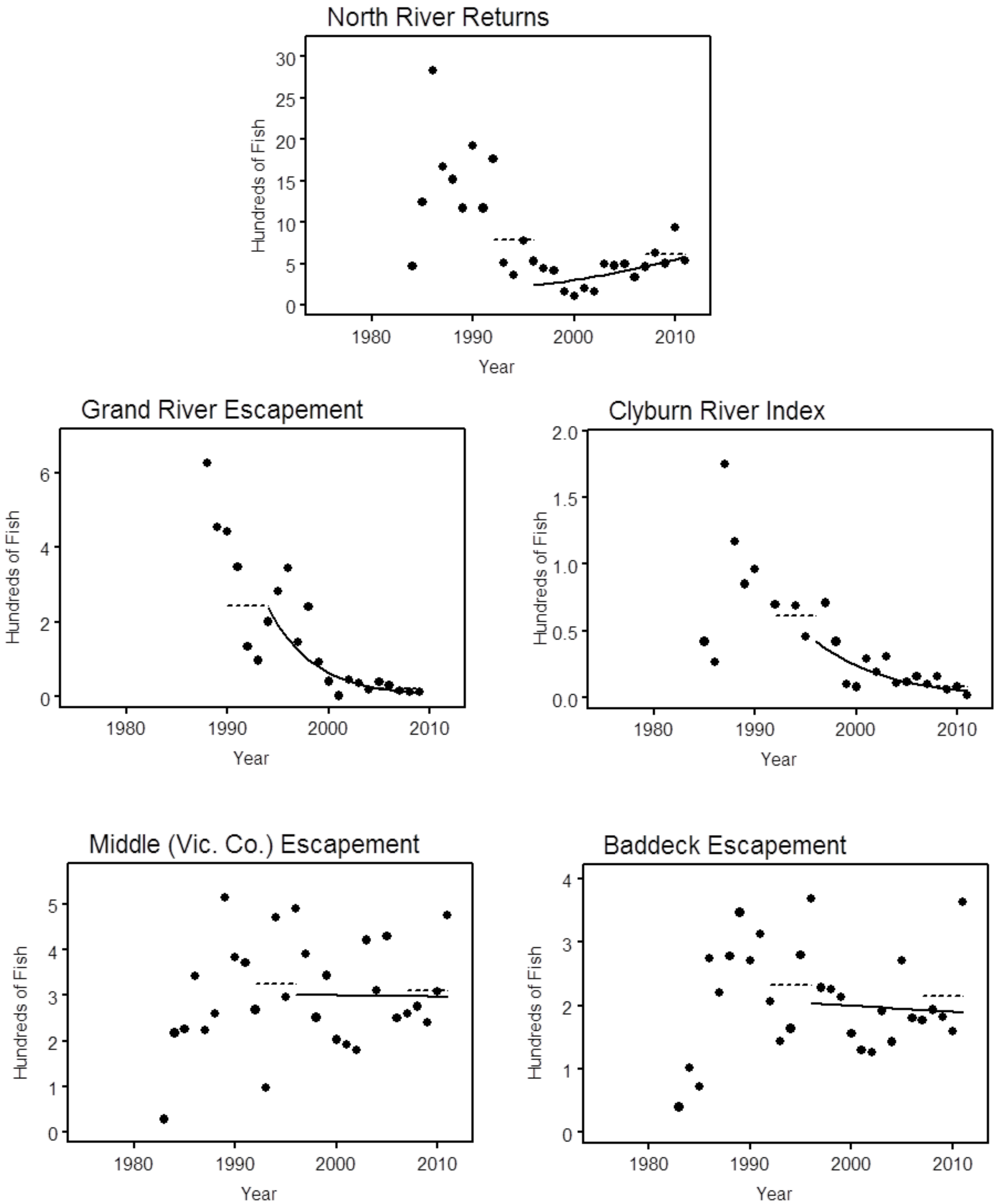


Figure 3.6.1. Trends in abundance of adult Atlantic Salmon (size categories combined) in five eastern Cape Breton rivers during the last 15 years. The solid line is the predicted abundance from a log-linear model fit by least squares. The dashed line shows the five-year mean abundance for two time periods separated by 10 years. The points are the estimated abundance (size categories combined). Model coefficients are provided in Table 3.6.2.

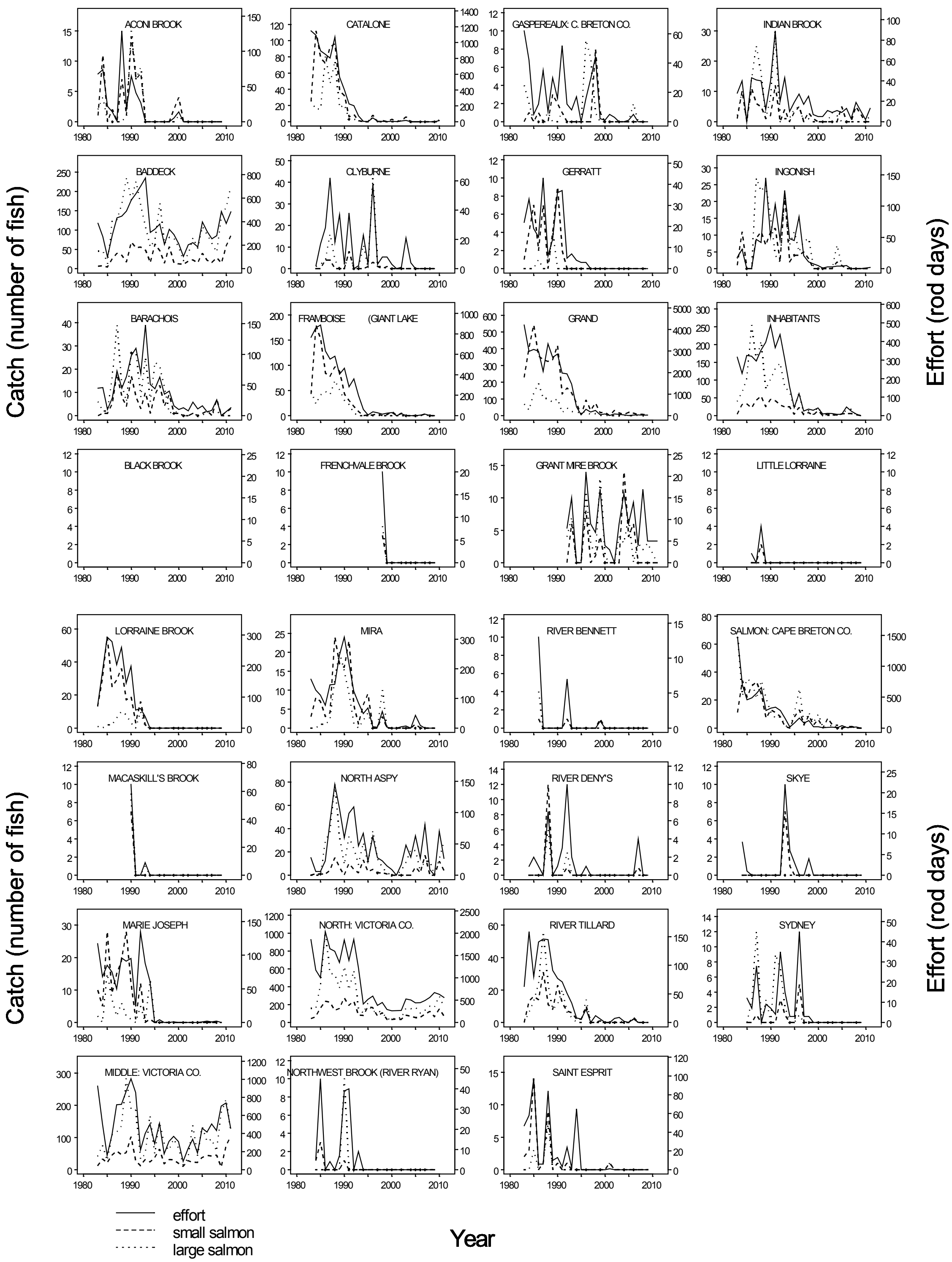


Figure 3.7.1. Estimated recreational catch of small and large Atlantic Salmon and fishing effort for eastern Cape Breton rivers (SFA 19) from 1983-2011 based on salmon fishing license stub returns.

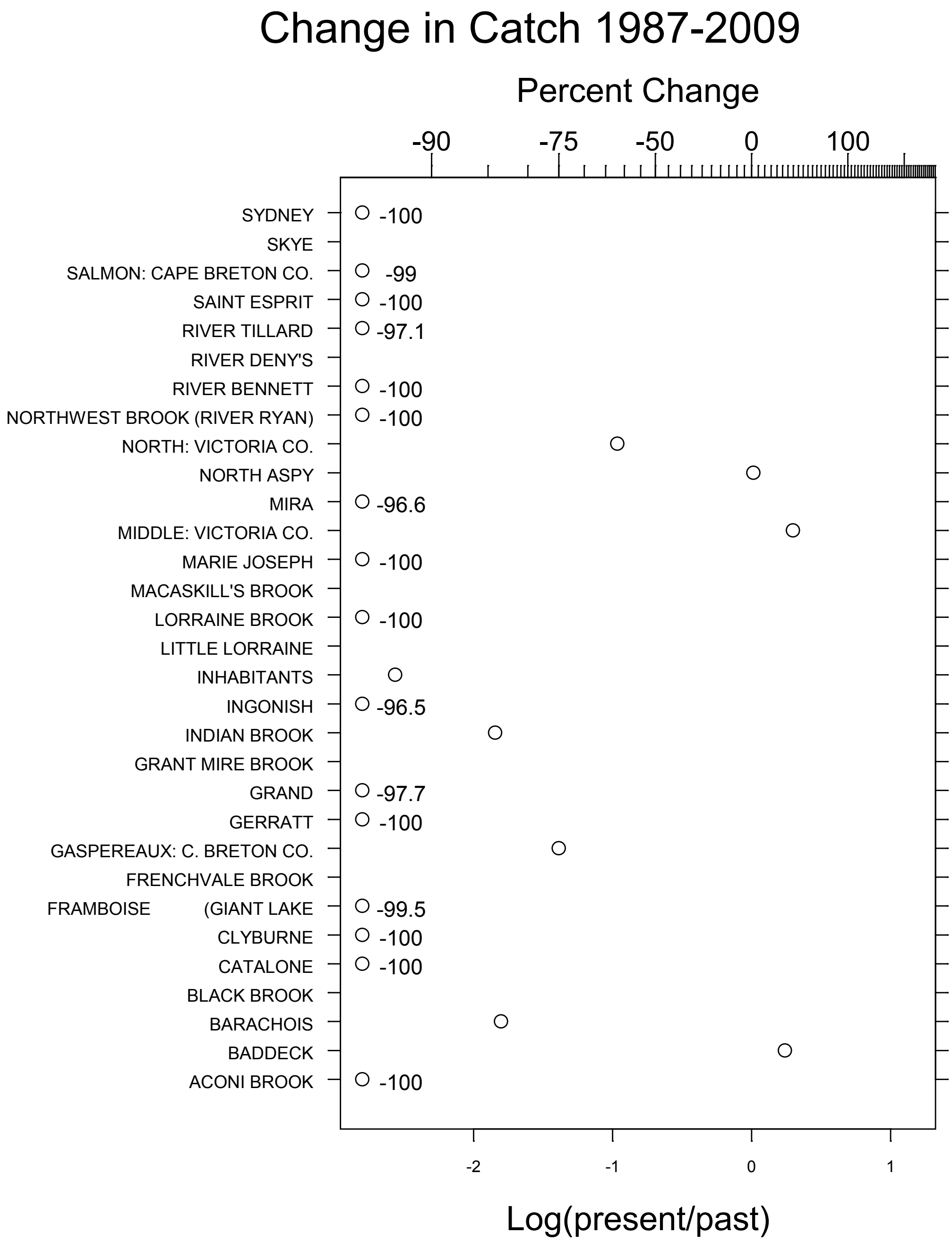
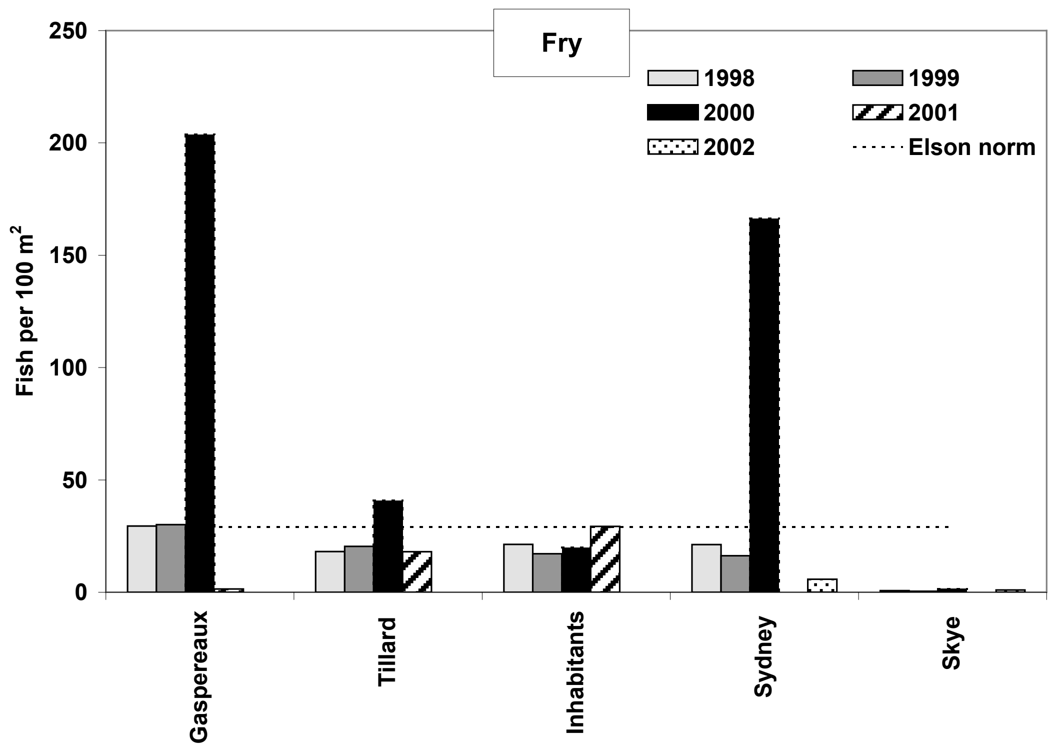


Figure 3.7.2. Change in the average estimated reported catch, of large and small salmon combined, between the five-year time periods ending in 1987 (years: 1983-1987; "past") and 2009 (years: 2005-2009; "present"). Points with value labels are outside the range of the graph. When extended to include data up to and including 2011, the percent change in catch for five-year time periods (i.e., 1983-1987 vs. 2007-2011) for Baddeck, Middle, North and North Aspy rivers are 85.9%,73.8%,-51.8%, and 37.0%, respectively.



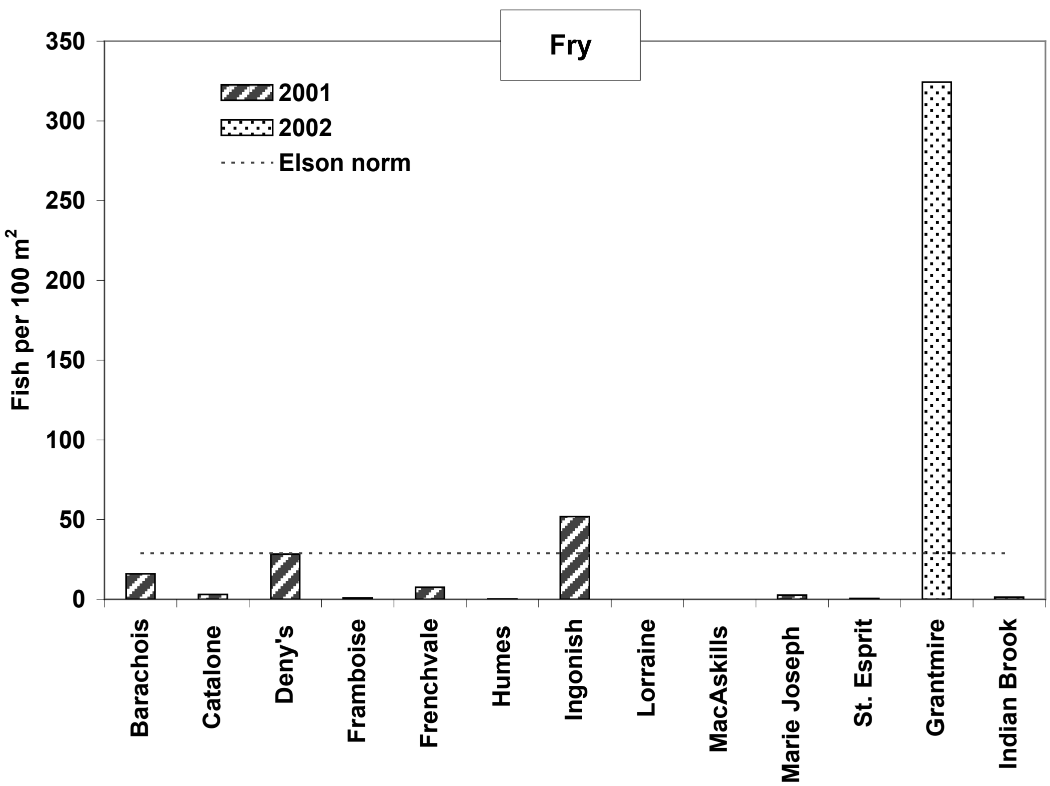


Figure 3.8.1. Mean densities of age 0 juvenile Atlantic Salmon (fry) sampled at a single site on 'other' ECB rivers from 1998-2002 (Source: Robichaud-LeBlanc and Amiro 2004).

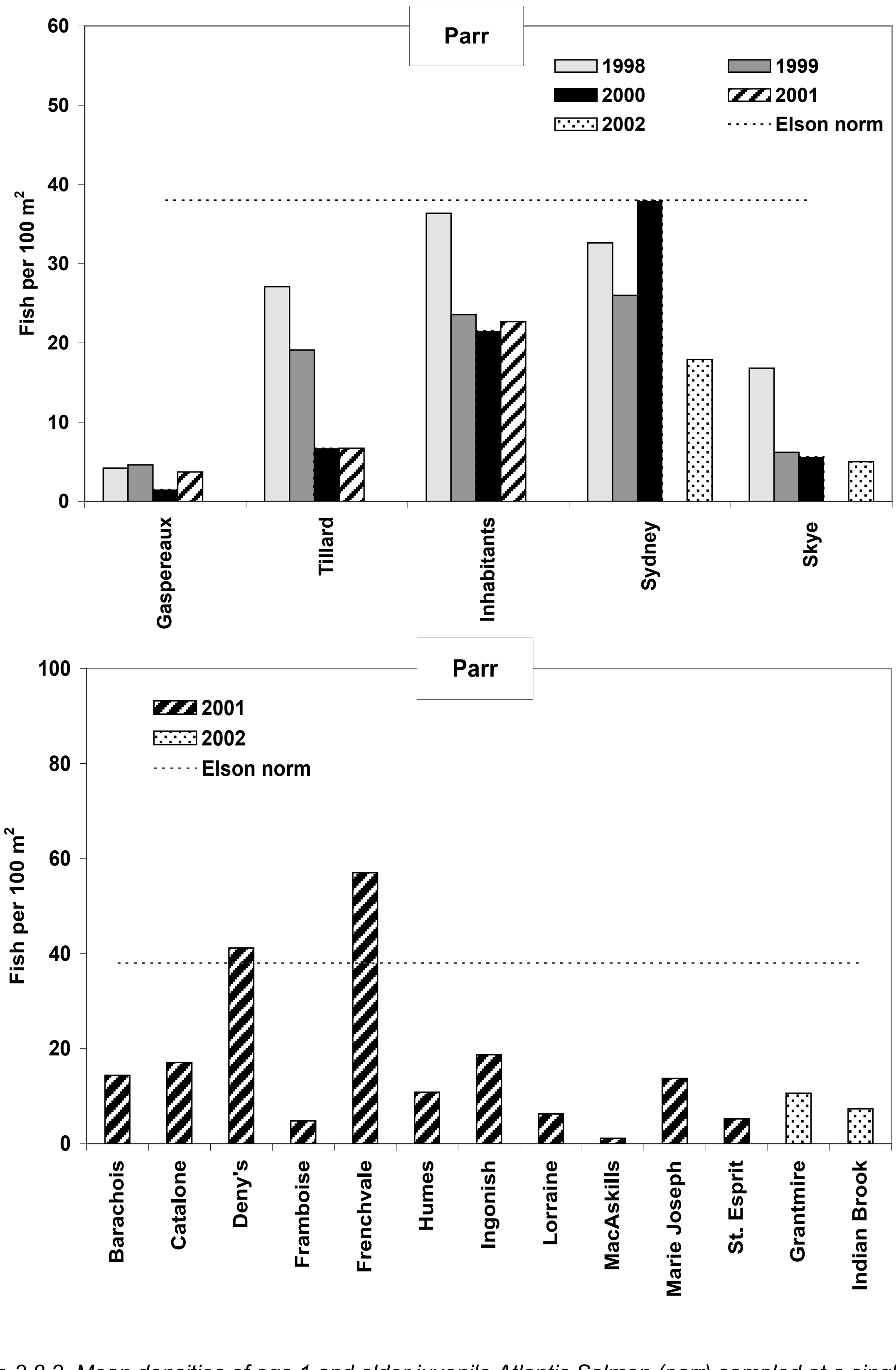
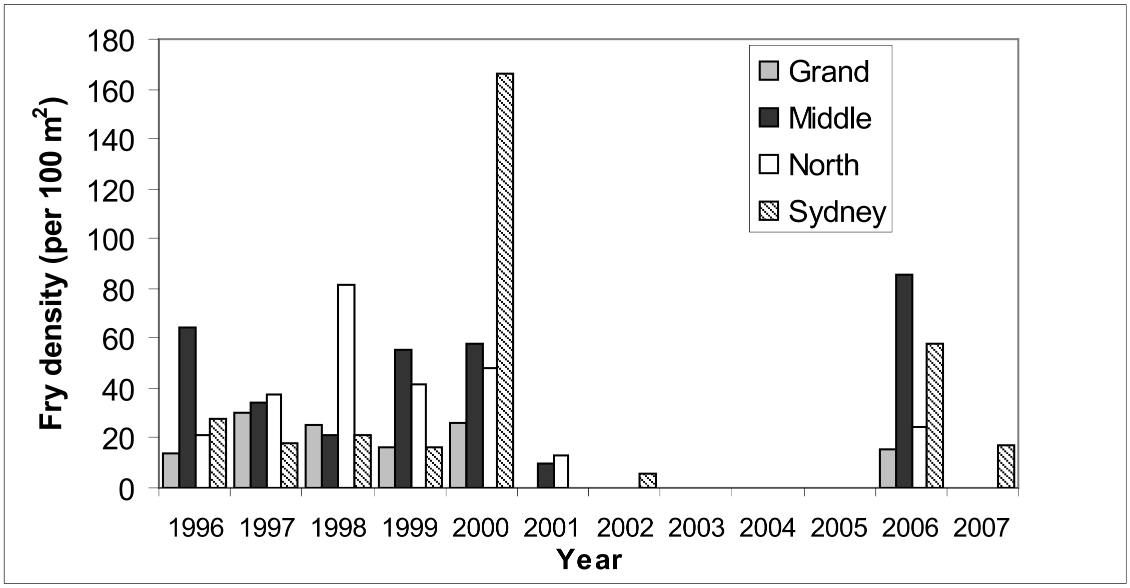


Figure 3.8.2. Mean densities of age 1 and older juvenile Atlantic Salmon (parr) sampled at a single site on 'other' ECB rivers from 1998-2002 (Source: Robichaud-LeBlanc and Amiro 2004).



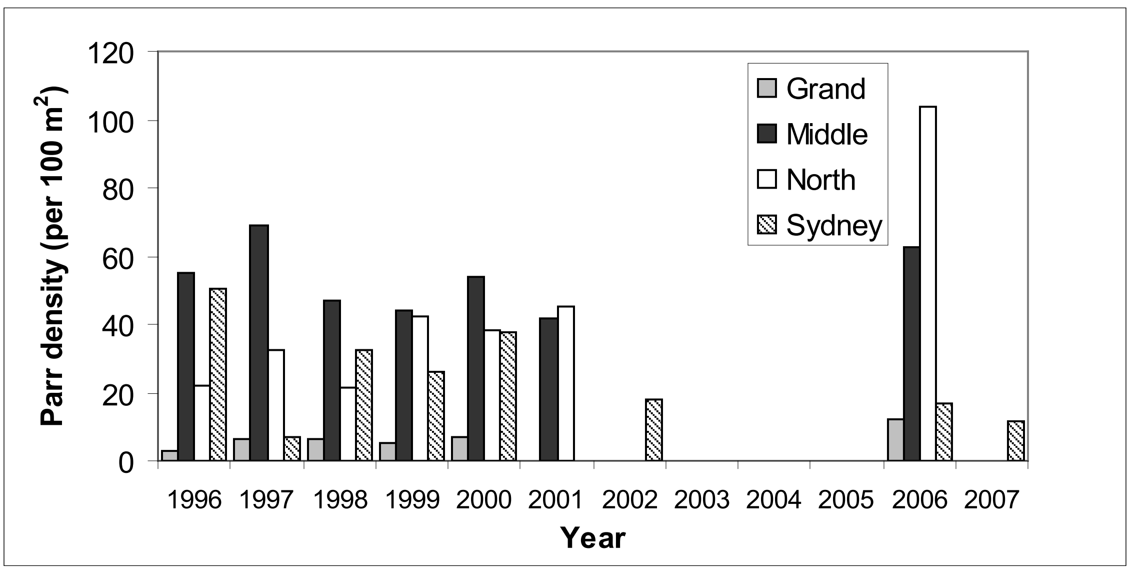
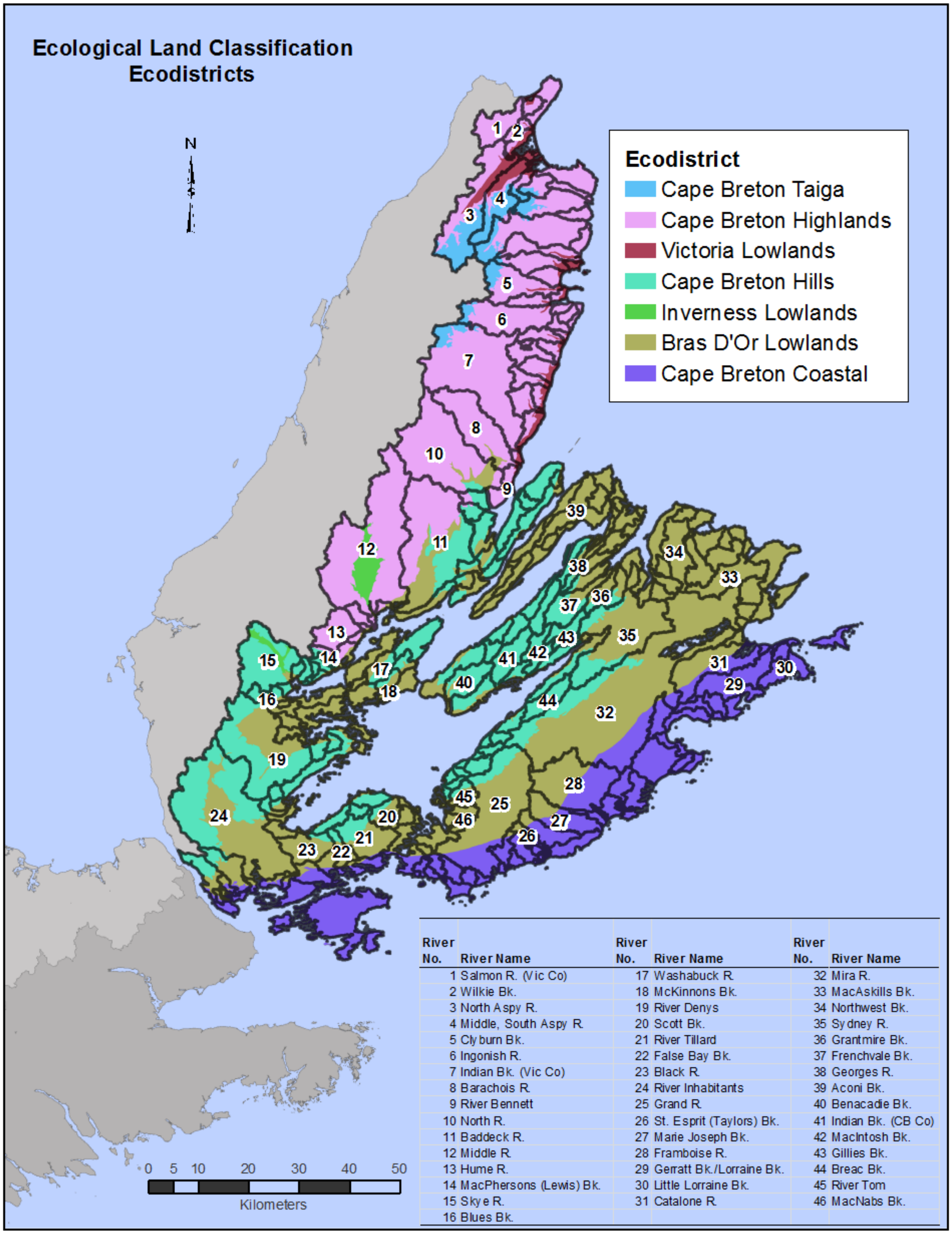


Figure 3.8.3. Mean fry (age 0) and parr (age 1 and age 2 combined) density in the Grand, Middle, North and Sydney rivers from 1996-2001, 2002, 2006 and 2007. (Source: Gibson and Bowlby 2009).



River No.	River Name	River No.	River Name	River No.	River Name
1	Salmon R. (Vic Co)	17	Washabuck R.	32	Mira R.
2	Wilkie Bk.	18	McKinnons Bk.	33	MacAskills Bk.
3	North Aspy R.	19	River Denys	34	Northwest Bk.
4	Middle, South Aspy R.	20	Scott Bk.	35	Sydney R.
5	Clyburn Bk.	21	River Tillard	36	Grantmire Bk.
6	Ingonish R.	22	False Bay Bk.	37	Frenchvale Bk.
7	Indian Bk. (Vic Co)	23	Black R.	38	Georges R.
8	Barachois R.	24	River Inhabitants	39	Aconi Bk.
9	River Bennett	25	Grand R.	40	Benacadie Bk.
10	North R.	26	St. Esprit (Taylors) Bk.	41	Indian Bk. (CB Co)
11	Baddeck R.	27	Marie Joseph Bk.	42	MacIntosh Bk.
12	Middle R.	28	Framboise R.	43	Gillies Bk.
13	Hume R.	29	Gerratt Bk./Lorraine Bk.	44	Breac Bk.
14	MacPhersons (Lewis) Bk.	30	Little Lorraine Bk.	45	River Tom
15	Skye R.	31	Catalone R.	46	MacNabs Bk.
16	Blues Bk.				

Figure 4.2.1. Map of ecodistricts and the major watersheds associated with known Atlantic Salmon rivers in eastern Cape Breton.

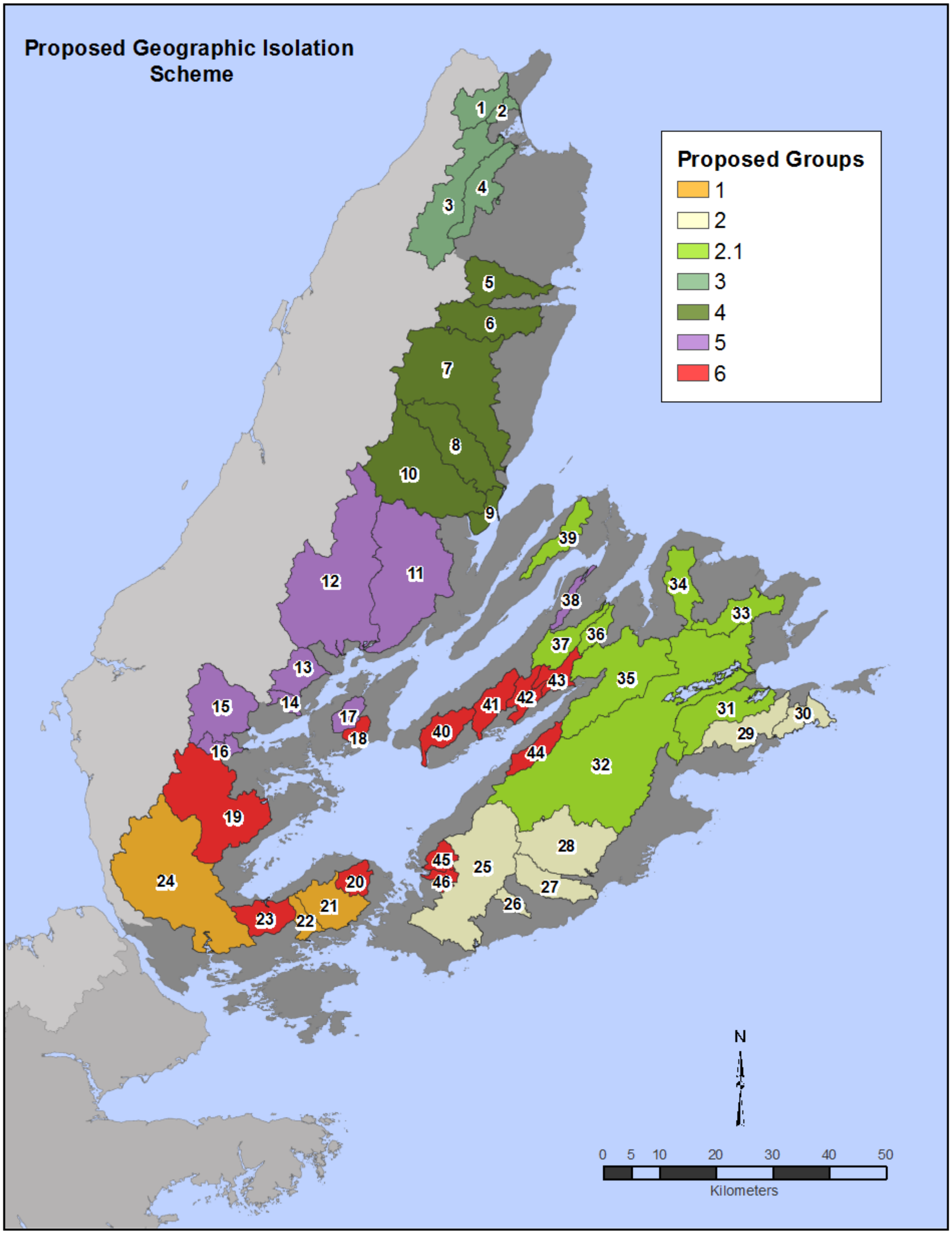


Figure 4.3.1. Map of proposed divisions of geographic isolation for major watersheds associated with known Atlantic Salmon rivers in eastern Cape Breton. Watershed numbers (in white) correspond with Figure 4.2.1.

APPENDICES

Appendix 1. Sea age (including spawning history), number of samples, and fork length (cm) of wild male and female adult Atlantic Salmon collected from Middle River during the 1995–2004 time period. The 'Sea Age' designation gives the sea-age of salmon, followed by the sea-age at previous spawning events (sp).NA = Not Applicable.

Sea Age	Number		Fork Length (cm)					
			Mean		Maximum		Minimum	
	Males	Females	Males	Females	Males	Females	Males	Females
1995:								
1	1	NA	54.0	NA	54.0	NA	54.0	NA
2	2	9	73.2	69.6	76.5	74.0	70.0	64.0
4 sp 2	1	NA	87.5	NA	87.5	NA	87.5	NA
1996:								
1	4	1	54.5	56.5	57.0	56.5	53.0	56.5
2	4	5	76.4	72.7	78.5	75.0	74.0	70.5
3 sp 1	1	NA	86.0	NA	86.0	NA	86.0	NA
1997:								
1	13	NA	55.9	NA	61.7	NA	50.2	NA
2*	13	20	76.7	75.0	84.8	79.0	70.0	71.2
3 sp 2	1	1	74.7	88.4	74.7	88.4	74.7	88.4
* 1 unknown sex (not included in table) with Fork Length = 74.5 cm.								
1998:								
1	6	NA	53.1	NA	56.0	NA	49.1	NA
2	3	7	75.0	72.4	75.6	74.5	74.5	70.9
3	2	NA	84.0	NA	91.3	NA	76.8	NA
2000:								
1	1	NA	55.5	NA	55.5	NA	55.5	NA
2	NA	3		75.5		75.8		75.0
2003:								
1	6	NA	54.6	NA	57.0	NA	52.4	NA
2	4	11	80.1	73.3	85.2	76.5	75.2	70.8
4 sp 2	NA	1	NA	89.0		89.0	NA	89.0
2004:								
1	4	NA	56.9	NA	59.9	NA	54.3	NA
2	2	9	76.4	72.9	79.0	77.0	73.7	67.2
3 sp 2	1	NA	71.7	NA	71.7	NA	71.7	NA
3	NA	1	NA	87.0	NA	87.0	NA	87.0

Appendix 2. Sea age (including spawning history), number of samples, and fork length (cm) of wild male and female adult Atlantic Salmon collected from Baddeck River during the 1977-2004 time period. The 'Sea Age' designation gives the sea-age of salmon, followed by the sea-age at previous spawning events (sp).NA = Not Applicable.

Sea Age	Number		Fork Length (cm)					
			Mean		Maximum		Minimum	
	Males	Females	Males	Females	Males	Females	Males	Females
1977:								
2	3	4	NA	NA	NA	NA	NA	NA
1978:								
4 sp 2	NA	1	NA	NA	NA	NA	NA	NA
1995:								
1	5	NA	53.8		56.8	NA	51.6	
2	2	13	77.8	74.3	83.5	79.0	72.0	69.5
3	1	NA	90.0	NA	90.0	NA	90.0	NA
5 sp 2,3,4	NA	1	NA	100.0	NA	100.0	NA	100.0
1996:								
1	3	2	61.0	61.8	75.0	72.0	50.5	51.5
2*	NA	9	NA	75.0	NA	79.0	NA	70.5
3	NA	1	NA	79.0	NA	79.0	NA	79.0
*1 unknown sex (not included in table) fork length = 72.0 cm.								
1997:								
1	7	NA	55.7	NA	60.2	NA	53.2	NA
2	5	20	78.2	73.8	81.5	78.5	74.6	67.5
1998:								
1	1	NA	56.0	NA	56.0	NA	56.0	NA
2	2	6	65.8	74.0	75.9	79.3	55.8	69.4
3 sp 2	NA	1	NA	81.5	NA	81.5	NA	81.5
4 sp 2	NA	1	NA	94.0	NA	94.0	NA	94.0
2003:								
1	4	1	55.6	61.0	56.6	61.0	54.0	61.0
2	2	8	75.5	77.6	78.8	88.3	72.2	72.9
2004:								
2	NA	3	NA	77.8	NA	80.5	NA	76.2

Appendix 3. Sea age (including spawning history), number of samples, and fork length (cm) of adult Atlantic Salmon collected from North River during the 1991-1998 time period. The 'Sea Age' designation gives the sea-age of salmon, followed by the sea-age at previous spawning events (sp). NA = Not Applicable.

Sea Age	Number		Fork Length (cm)					
			Mean		Maximum		Minimum	
	Males	Females	Males	Females	Males	Females	Males	Females
1991:								
2	1	7	72	68.3	72	71	72	63
3 sp 1	1	NA	76	NA	76	NA	76	NA
1996:								
1	3	NA	50	NA	51	NA	49	NA
2	NA	2	NA	71.1	NA	71.7	NA	70.5
3 sp 2	NA	1	NA	86	NA	86	NA	86
1997:								
1	4	NA	56.5	NA	61.9	NA	52.3	NA
2	5	14	77.3	70.6	80	74.4	74.5	66.3
3 sp 1	1	NA	77.6	NA	77.6	NA	77.6	NA
1998:								
1	2	NA	54.6	NA	54.8	NA	54.4	NA
2	NA	9	NA	71.1	NA	76	NA	68.5
3 sp 1	1	NA	75.6	NA	75.6	NA	75.6	NA
5 sp 3,4	NA	1	NA	85.8	NA	85.8	NA	85.8

Appendix 4. Sea age, spawning history, and fork length of adult Atlantic Salmon collected from Grand River during the 1990-1994 time period. The 'Sea Age' designation gives the sea-age of salmon, followed by the sea-age at previous spawning events (sp).

Sea Age	Number	Fork Length (cm)		
		Mean	Maximum	Minimum
1990:				
1	133	53.3	62.0	45.0
2	12	71.7	76.0	65.0
2 sp 1	20	59.8	67.0	53.0
3 sp 1	4	68.4	73.0	56.0
3 sp 1,2	7	67.9	73.0	60.0
3 sp 2	4	69.2	75.0	65.0
1991:				
1	112	53.1	75.0	46.0
2	6	69.4	72.5	67.0
2 sp 1	6	59.6	67.5	54.0
3 sp 1	5	73.5	76.0	72.0
3 sp 2	2	70.0	70.0	70.0
4 sp 1,3	1	74.0	74.0	74.0
4 sp 2	5	80.4	99.0	73.0
1992:				
1	62	53.0	60.0	49.0
2	9	72.0	74.0	70.0
2 sp 1	7	57.7	63.0	53.0
4 sp 1,3	1	76.0	76.0	76.0
5 sp 1,3	1	83.0	83.0	83.0
1993:				
1	54	52.9	58.0	48.0
2	3	68.3	73.0	61.0
2 sp 1	1	58.0	58.0	58.0
3 sp 1	2	72.0	74.0	72.0
1994:				
1	52	53.2	60.0	48.0
2	2	73.5	75.0	72.0
3 sp 2	1	74.0	74.0	74.0

Appendix 5. Estimated recreational catch and effort data for eastern Cape Breton (SFA 19). Note that "-" indicates fishing closures. CS is Catch Small, CL is Catch Large, RS is Retained Small, RL is Retained Large and Effort is in rod-days.

River	Catch Description	Years																												
		1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
ACONI BROOK	C S	1	11	0	2	0	7	1	14	7	8	0	0	0	0	0	0	2	4	0	0	0	0	0	0	0	0	0	-	-
	C L	2	4	0	0	0	0	1	15	7	9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	-	-
	R S	0	11	0	2	0	7	1	13	7	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	68	74	22	14	1	129	19	65	41	27	0	0	0	0	0	0	5	14	0	0	0	0	0	0	0	0	0	-	-
BADDECK	C S	6	7	4	26	40	35	17	69	54	56	48	15	64	47	14	57	15	12	11	19	23	15	40	21	16	28	14	59	85
	C L	45	46	13	126	127	168	235	178	226	162	108	56	75	169	64	81	79	55	20	38	80	53	109	88	66	43	135	159	213
	R S	5	4	4	19	26	18	8	40	30	50	33	1	8	0	0	0	1	1	0	0	0	2	0	0	2	0	0	0	2
	R L	39	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Effort	386	273	100	287	432	447	490	584	638	704	772	308	337	380	206	335	290	212	104	204	221	185	397	316	254	280	487	384	483
BARACHOIS	C S	0	1	1	5	18	8	4	17	8	3	10	1	9	13	4	9	1	1	0	0	1	0	1	2	0	7	0	-	3
	C L	6	2	2	17	39	13	6	27	27	8	25	6	23	21	12	1	2	1	0	0	1	0	0	2	1	2	0	-	0
	R S	0	1	1	4	12	5	3	8	5	3	8	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	-	0
	R L	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0
	Effort	45	46	10	29	73	45	64	98	110	69	148	51	44	63	35	40	16	10	13	8	22	11	16	6	9	26	0	-	13
BLACK BROOK	C S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
	C L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
	R S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-
	R L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-
	Effort	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21	-
CATALONE	C S	25	112	78	72	92	96	38	32	6	9	1	0	0	8	0	1	0	3	0	1	6	0	0	0	0	0	0	0	-
	C L	26	15	16	81	47	75	17	21	3	3	1	0	0	6	0	0	0	0	0	3	4	0	0	0	0	0	0	2	-
	R S	23	100	74	64	82	93	36	30	5	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
	R L	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
	Effort	1147	1093	894	852	804	1068	565	403	225	203	72	5	1	48	7	3	1	3	1	9	15	0	0	0	0	0	0	14	-
CLYBURNE	C S	-	0	0	4	4	0	0	0	8	0	0	0	1	3	1	0	1	0	0	0	0	0	0	0	0	0	0	-	-
	C L	-	1	2	4	16	4	0	0	8	0	0	11	0	42	1	1	0	0	0	0	0	0	0	0	0	0	0	-	-
	R S	-	0	0	1	4	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	-	2	17	28	62	18	37	3	38	0	2	23	3	58	3	8	8	3	0	1	21	4	0	0	0	0	0	-	-
FRAMBOISE (GIANT LAKE)	C S	43	180	152	84	78	97	88	43	30	18	8	0	1	1	4	0	2	8	0	5	0	0	0	0	3	0	0	-	-
	C L	48	23	41	48	42	70	51	30	22	5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	-	-
	R S	39	154	143	84	72	89	82	34	24	16	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	44	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	767	860	887	632	554	581	405	464	283	360	198	60	8	38	29	16	25	30	0	20	3	0	1	6	16	2	0	-	-
FRENCHVALE BROOK	C S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0	0	0	0	0	0	0	0	0	0	-	-
	C L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0	0	0	0	0	0	0	0	0	0	0	-	-
	R S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	0	0	0	0	0	0	0	0	0	0	0	-	-

River	Catch Description	Years																												
		1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
GASPEREAUX: C. BRETON CO.	C S	0	1	0	1	0	0	3	2	1	0	0	0	0	0	0	8	1	0	0	0	0	0	0	0	0	0	0	-	-
	C L	4	2	0	0	0	1	0	0	1	0	0	0	0	9	7	1	0	0	0	0	0	0	0	2	0	0	0	-	-
	R S	0	1	0	1	0	0	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	62	42	5	12	35	7	30	16	52	12	8	17	0	16	29	44	2	1	5	3	0	0	1	5	0	0	0	-	-
GERRATT	C S	1	4	7	2	7	0	4	9	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	C L	0	0	0	1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R S	1	2	4	0	3	0	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	22	33	19	15	43	6	14	36	37	5	7	4	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
GRAND	C S	228	404	542	356	334	324	334	419	128	166	136	75	6	94	31	75	17	20	1	31	16	7	20	15	6	7	3	-	-
	C L	69	34	132	192	104	101	80	102	18	46	24	21	16	26	6	12	3	1	0	0	3	2	0	0	2	0	3	-	-
	R S	194	350	471	294	301	303	311	339	115	155	115	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	31	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	4212	2989	3073	2997	2059	3334	2709	2857	1981	1939	1469	416	49	294	173	246	47	81	9	84	63	35	13	28	34	31	27	-	-
GRANT MIRE BROOK	C S	-	-	-	-	-	-	-	-	-	0	6	0	0	8	0	1	4	0	0	0	0	14	4	6	0	0	0	-	0
	C L	-	-	-	-	-	-	-	-	-	4	7	0	0	11	3	1	13	1	0	0	4	3	7	0	3	2	3	-	0
	R S	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0
	R L	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0
	Effort	-	-	-	-	-	-	-	-	-	8	15	0	0	21	9	7	17	4	3	0	9	16	9	14	4	17	5	-	5
INDIAN BROOK	C S	1	10	0	11	6	5	1	2	12	0	4	0	3	5	0	3	1	0	0	0	0	0	5	0	0	5	-	0	0
	C L	2	10	0	14	25	16	1	8	30	0	1	1	4	5	0	1	0	0	0	0	3	2	0	0	0	0	-	0	2
	R S	0	9	0	6	4	2	1	1	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0
	R L	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0
	Effort	28	40	0	43	41	40	12	40	89	20	43	10	19	27	17	25	7	5	5	11	9	11	9	13	3	19	-	2	13
INGONISH	C S	1	11	0	0	9	11	7	11	12	2	22	2	4	4	5	3	0	0	0	0	0	2	1	0	0	0	0	-	0
	C L	3	6	0	0	27	23	25	15	4	2	22	7	11	5	8	9	1	0	0	0	0	7	1	0	0	0	0	-	0
	R S	1	6	0	0	5	5	7	11	10	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0
	R L	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0
	Effort	18	31	0	0	47	42	145	51	103	46	125	48	45	83	21	11	8	5	1	3	3	4	4	5	0	0	0	-	2
INHABITANTS	C S	4	31	33	22	43	55	25	46	42	30	25	25	4	23	3	9	1	14	0	4	2	2	5	6	6	2	0	-	-
	C L	40	66	104	255	155	209	74	102	131	148	79	68	19	65	5	14	4	24	0	1	1	2	4	15	18	2	0	-	-
	R S	4	27	28	21	41	45	24	36	36	30	25	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	315	228	325	321	295	354	396	489	366	437	305	157	44	119	25	36	29	42	9	13	12	7	7	47	25	9	0	-	-
LITTLE LORRAINE	C S	-	-	-	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	C L	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R S	-	-	-	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	-	-	-	1	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
LORRAINE BROOK	C S	13	30	55	25	29	36	17	19	3	16	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	C L	1	0	2	2	6	10	8	3	0	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R S	10	30	53	24	28	35	14	17	0	13	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	72	183	293	279	204	260	145	199	58	63	37	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	-	-

River	Catch Description	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
		Years																												
MACASKILL'S BROOK	C S	-	-	-	-	-	-	-	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	C L	-	-	-	-	-	-	-	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R S	-	-	-	-	-	-	-	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	-	-	-	-	-	-	-	65	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
MARIE JOSEPH	C S	10	5	28	9	15	19	28	12	1	12	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	C L	2	0	15	7	2	6	2	1	0	5	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R S	5	5	19	9	12	15	28	12	1	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	117	68	85	75	50	96	91	95	24	135	88	61	0	4	0	0	1	0	0	0	0	0	1	2	1	2	0	-	-
MIDDLE: VICTORIA CO.	C S	12	33	21	45	58	47	53	102	27	12	31	24	36	64	18	31	30	20	10	28	23	22	38	44	42	45	8	73	102
	C L	41	75	28	108	117	136	282	187	184	32	49	167	49	147	80	60	95	67	15	35	137	44	133	87	95	57	176	218	119
	R S	12	23	15	36	54	35	42	76	18	8	26	0	0	3	3	5	0	0	0	1	0	0	0	0	0	0	0	0	2
	R L	36	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Effort	924	506	159	385	718	722	867	1005	854	218	398	504	287	512	175	312	369	311	92	231	336	185	458	416	506	434	704	737	459
MIRA	C S	3	8	7	3	4	24	17	16	23	6	1	6	9	0	0	3	0	0	0	0	0	0	1	0	0	0	0	-	-
	C L	0	0	1	1	2	13	20	15	9	1	0	2	4	0	0	10	0	0	0	0	0	0	0	0	0	0	0	-	-
	R S	3	6	6	3	3	23	17	16	21	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	165	128	111	77	146	148	246	307	218	124	85	49	68	4	3	56	3	0	0	4	7	0	43	9	0	0	0	-	-
NORTH ASPY	C S	0	1	1	1	4	15	7	0	10	5	2	13	3	5	2	2	1	0	0	0	0	0	7	2	17	0	0	12	4
	C L	0	0	0	29	37	78	33	9	33	23	9	28	9	38	14	7	2	0	0	4	11	22	21	3	12	12	0	14	29
	R S	0	1	1	1	3	11	5	0	8	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	R L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Effort	28	6	6	23	85	145	107	60	99	109	47	67	22	62	28	23	15	9	0	17	48	29	63	27	81	9	0	70	27
NORTH: VICTORIA CO.	C S	44	65	158	237	227	136	156	274	191	236	81	78	173	165	70	108	35	32	37	34	81	70	55	56	92	123	63	150	74
	C L	156	152	413	1017	547	539	385	625	365	580	160	102	215	118	137	104	45	27	60	45	156	152	171	104	134	183	168	293	175
	R S	35	56	145	186	177	119	117	207	152	194	62	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	R L	148	94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Effort	1856	1174	1005	2035	1653	1593	1342	1845	1389	1858	1224	411	516	592	384	448	292	261	264	269	525	505	441	445	491	559	668	630	559
NORTHWEST BROOK (RIVER RYAN)	C S	-	1	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	C L	-	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R S	-	1	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	-	5	45	0	4	0	7	39	40	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
RIVER BENNETT	C S	-	-	-	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	-	-
	C L	-	-	-	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R S	-	-	-	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	-	-	-	13	0	0	0	0	0	7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	-	-
RIVER DENY'S	C S	-	0	0	0	0	12	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	-	-
	C L	-	0	0	0	0	6	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R S	-	0	0	0	0	10	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	-	1	2	1	0	7	0	1	3	10	2	0	0	1	0	0	0	0	0	0	0	0	0	0	4	0	0	-	-

River	Catch Description	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
RIVER TILLARD	C S	0	13	16	14	31	11	8	23	12	7	6	2	2	10	0	0	1	0	0	0	0	0	0	3	0	0	0	-	-
	C L	0	6	13	24	56	23	8	11	20	6	3	0	0	14	0	0	0	0	0	0	1	0	0	2	0	0	0	-	-
	R S	0	13	16	14	24	10	8	20	7	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	63	159	80	141	146	145	91	77	71	51	34	8	6	23	0	12	6	0	0	7	9	2	0	6	0	0	0	-	-
SAINT ESPRIT	C S	2	3	14	0	1	9	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	-	-
	C L	0	0	3	0	1	7	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	-	-
	R S	2	3	14	0	1	9	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	47	58	97	6	6	84	10	13	3	24	2	65	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	-	-
SALMON: CAPE BRETON CO.	C S	11	34	22	30	33	24	7	13	11	8	1	0	8	13	2	9	2	6	0	7	2	0	0	1	1	0	0	-	-
	C L	65	23	35	33	21	34	21	11	7	8	2	0	11	28	2	11	4	10	0	1	2	2	0	0	1	0	0	-	-
	R S	10	32	18	30	31	20	7	11	6	7	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	61	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	1470	698	458	487	562	656	284	321	338	284	159	18	85	163	79	120	20	20	4	11	15	5	38	9	10	17	0	-	-
SKYE	C S	-	0	0	0	0	0	0	0	0	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	C L	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R S	-	0	0	0	0	0	0	0	0	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	-	8	1	0	0	0	0	0	0	0	22	6	3	0	0	4	0	0	0	0	0	0	0	0	0	0	0	-	-
SYDNEY	C S	-	-	0	0	1	0	0	0	0	3	1	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	C L	-	-	0	3	12	0	3	0	9	7	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R S	-	-	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	R L	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Effort	-	-	12	7	28	0	9	7	4	35	15	3	3	45	3	3	0	0	0	0	0	0	0	0	0	0	0	-	-