RECOVERY POTENTIAL ASSESSMENT FOR THE SOUTH NEWFOUNDLAND ATLANTIC SALMON (*SALMO SALAR*) DESIGNATABLE UNIT

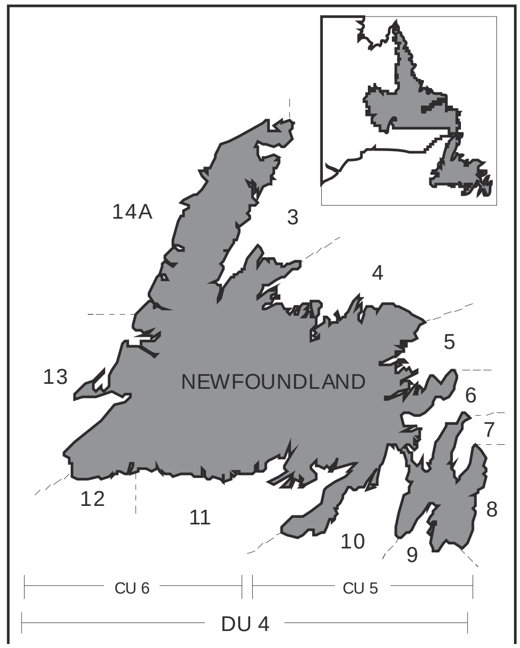

Figure 1. Salmon Fishing Areas (SFAs) 9–12 and Conservation Units (CUs) 5–6 that make up the South Newfoundland Designatable Unit (DU) 4.

Context

In 2010, South Newfoundland Atlantic salmon were designated Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2010) due to the significant decline in abundance over the last three generations.

A recovery potential assessment (RPA) was conducted by DFO Science to provide information and scientific advice required to meet various requirements of the Species at Risk Act (SARA). The advice in the RPA may be used to inform both scientific and socio-economic elements of the listing decision, in the development of a recovery strategy and action plan, and to support decision-making with regards to the issuance of permits, agreements and related conditions, as per relevant sections of SARA.

This Science Advisory Report (SAR) describes the status of Atlantic salmon populations in DFO Salmon Fishing Areas (SFAs) 9-12 that make up the South Newfoundland designatable unit (DU 4) and updates information presented in the COSEWIC Status Report. Historic population trajectories and projections are presented. This scientific advice also addresses the major threats to the survival and recovery of South Newfoundland Atlantic salmon and the limiting factors. This information was presented and reviewed at a regional science peer review meeting conducted February 14-17, 2012 in St. John's, NL.

SUMMARY

- The South Newfoundland Atlantic salmon (*Salmo salar* L.) DU 4 comprises Salmon Fishing Areas (SFAs) 9-12 and the population is estimated to have declined by 42.4% over the last three generations (1996-2010; small salmon 41.5% and large salmon 48.3%).

- The most substantial estimated decline occurred in SFA 11 which strongly influenced the total abundance for DU 4.

- Marine survival (smolts to adult) is variable in DU 4, averaging 4% (± 2%), and seems to have declined more in SFA 11 than in SFA 9, as evidenced by Conne River's (SFA 11) decline of 61.6% from 1987-2010; Northeast Brook's (SFA 9) 18% decline (1986-2010); and Rocky River's increase of 33.5% (1991-2010).

- Population projections over three generations (15 years) and under different recreational fishery management scenarios were undertaken for the South Newfoundland (DU 4) Atlantic salmon population to estimate the probabilities of: (1) maintaining current population levels, (2) achieving the Conservation Requirement, and (3) achieving the Pre-Decline Mean (1981-1995).

- According to these projections, under contemporary marine and angling mortality rates, there is a 50% chance that the DU 4 population will drop below its current size. There is a 23% chance of achieving the Conservation Requirement and 12% chance of achieving the Pre-decline mean.

- Under a "no-angling" scenario and a contemporary marine survival rate of 4% (± 2%), there is a 74% chance that the population will remain at or exceed its current size. There is a 52% chance of achieving the Conservation Requirement and 27% chance of achieving the Pre-decline mean.

- Under a "catch-and-release only" angling scenario and a contemporary marine survival rate of 4% (± 2%), there is a 70% chance that the population will remain at or exceed its current size. There is a 42% chance of achieving the Conservation Requirement and 26% chance of achieving the Pre-decline mean.

- According to these projections, over the next three generations (15 years) a minimum 5% average marine survival, at contemporary angling levels, would be required to have a 75% chance of maintaining or exceeding the current population size. To achieve the Conservation Requirement, marine survival would need to increase to an average of 6% and increase to an average of 7% to achieve the Pre-decline mean.

- Under a "no-angling" scenario, a minimum 5% average marine survival would be required to have a 75% chance of maintaining or exceeding the current population size. To achieve the Conservation Requirement, marine survival would need to be an average of 5% and increase to an average of 6% to achieve the Pre-decline mean.

- Under a "catch-and-release only" angling scenario, a minimum 5% average marine survival would be required to have a 75% chance of maintaining or exceeding the current population size. To achieve the Conservation Requirement marine survival would need to be an average of 5% and increase to an average of 6% to achieve the Pre-decline mean.

- Freshwater habitat quality and quantity are not thought to be limiting the production or recovery of DU 4 salmon.

- The greatest threat to the recovery of the South Newfoundland Atlantic salmon population is continued low marine survival. Factors influencing marine survival may include: illegal fisheries, mixed-stock marine fisheries and by-catch, ecological and genetic interactions with escaped domestic Atlantic salmon, and changes in marine ecosystems. The degree of influence of these factors is unknown and many have the potential to affect salmon in other DUs where populations have been stable or increasing.

- Understanding the possible unique factors that impact the biological condition of Atlantic salmon during the marine phase of their life-cycle and marine habitat quality within the DU 4 area are key knowledge gaps that need to be addressed.

BACKGROUND

Rationale for Assessment

South Newfoundland Atlantic salmon (*Salmo salar* L., 1758) were assessed to have declined by 37% for large salmon and 26% for small salmon from 1994 to 2007 and on this basis was designated Threatened in November 2010 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 2010). The COSEWIC report noted that there has been a significant historical decline in salmon beyond the last three generations and stated that extending the time series back one additional year would have produced decline rates of 52.5% and 50.1% for small and large salmon respectively.

As part of this "*post-COSEWIC*" process, scientific information is needed for the assessment of the social and economic cost and benefit of potential management scenarios for recovery, to support the listing decision of whether to add the species to Schedule 1 of the Species at Risk Act (SARA) and in the potential development of a recovery strategy and action plans.

Information contained in this recovery potential assessment (RPA) is primarily from the COSEWIC Report (COSEWIC 2010), recent peer-reviewed DFO Newfoundland and Labrador (NL) Regional assessments of Atlantic salmon in SFAs 9-12 and Conservation Status Reports for Atlantic salmon previously published by DFO (DFO and MRNF 2008, 2009). Information in this document regarding anthropogenic impacts on Atlantic salmon should be considered along with details found in the Conservation Status Report, Atlantic Salmon in Atlantic Canada and Québec: PART II – Anthropogenic Considerations (DFO and MRNF 2009).

Species Biology and Ecology

Anadromous Atlantic salmon are an iteroparous species (capable of spawning multiple times). A defining characteristic of anadromous salmonids is the ability to return, with a high degree of fidelity, to their natal river or tributary for spawning (homing). Such precision in homing has led to the formation and maintenance of local adaptations, resulting in much of the variability in genetic, life history, behavioural and other traits observed.

Depending on the population, spawners returning to rivers are comprised of varying proportions of 'maiden fish' (spawning for the first time) and 'repeat spawners'. Maiden salmon in South

Newfoundland populations are predominantly small salmon with a fork length less than 63 cm that return to spawn after one winter at sea (1SW, one-sea-winter; also known as 'grilse'), with a few larger fish returning after two winters at sea (2SW). The large salmon component (fork length ≥ 63 cm) of the South Newfoundland population consists mainly of repeat spawning grilse and 'multi-sea-winter' fish (MSW, two or more winters at sea). Repeat spawners from this population tend to spawn in consecutive years with a few 'alternate spawners' returning every second year.

Adult South Newfoundland Atlantic salmon return to their natal rivers from May to mid-July from feeding and staging areas in the sea. Spawning usually occurs in late October to early November in gravel-bottomed riffle areas of streams. Fertilization of eggs can involve both adult males and sexually mature juvenile males (precocious parr). Spawned-out or spent adult salmon (kelts) return to sea immediately after spawning or remain in freshwater until the following spring. Eggs incubate in the spawning nests (redds) over the winter months and hatching usually begins in April or May. The hatchlings (alevins) remain in the gravel for several weeks living off large yolk sacs. Upon emergence from the gravel in late May or early June, the yolk sac is absorbed and the free-swimming young fish (fry) begin active feeding. Juvenile salmon (parr) in the South Newfoundland population typically rear in fluvial (riverine) and lacustrine (standing water) habitats for three to four years before smolting (physiological change required to live in salt water) and migrating to sea in spring (April or May).

South Newfoundland Designatable Unit (DU 4; SFAs 9-12)

DU 4 includes salmon rivers in Salmon Fishing Areas (SFAs) 9-12. The South Newfoundland DU of Atlantic salmon includes freshwater populations found from the southeast tip of the Avalon Peninsula (defined by Mistaken Point) westward along the south coast to Cape Ray (Fig. 1). There are currently 104 known watersheds of which 58 rivers are scheduled for recreational salmon fishing. Scheduled rivers generally have abundant salmon populations and have historically had recreational fisheries. However, salmon may also be present in a number of un-scheduled rivers. There are no known extirpations of salmon in the South Newfoundland DU and one population has been introduced (Appendix 1). Anadromous Atlantic salmon were initially introduced to Rocky River following the construction of a fishway to allow access beyond an impassable waterfall at the river mouth. Enhancement initiatives occurred on Rocky River from 1984-96. Enhancement activities have also occurred, and continue to occur, on Little River in SFA 11 by the Miawpukek First Nation.

ASSESSMENT

Status and Trends

Total South Newfoundland DU 4 Spawning Escapement

The status of the South Newfoundland DU 4 Atlantic salmon population was assessed using monitoring facility data, recreational fishery data (1969-2010), and commercial catch data prior to the moratoria in 1992 (1969-1992). Monitoring facility data are available from four currently monitored rivers (Conne River, Little River, Northeast Brook and Rocky River). Angling exploitation rates were determined for rivers that have both a monitoring facility and angler catch rates derived from recreational fishery data (Licence Stub). These exploitation rates are applied, without adjustment, to south coast rivers that have angling data but where no counting facilities exist. The monitoring facility data from DU 4 are heavily biased to the eastern area of this DU (SFA 9-11) and may not be representative of the entire DU. Furthermore, rivers with no angling catch were not included in the abundance estimates provided. More detailed information regarding the method used to estimate salmon abundance in DU 4 (SFAs 9-12) can be found in Reddin and Veinott 2010.

Spawning escapement estimates (the number of fish available to spawn each year after all fisheries have taken place) were used for the overall DU 4 trend analysis. Escapement was chosen over pre-fishery abundance based on COSEWIC's criteria to use "*mature individuals who are capable of reproducing*". Within COSEWIC, definitions of mature individuals are further defined as follows: "*Mature individuals that will never produce new recruits should not be counted*".

The generation time, based on COSEWIC criteria to use the "*average age of parents of the current cohort (i.e. newborn individuals in the population)"*, for DU 4 salmon was calculated using a mean modal smolt age of 3.1 years, as in the COSEWIC report. However, in the COSEWIC report only 1 year was added for the marine phase of the life-cycle. This does not include the time from spawning to hatching or the time maturing adults spend in freshwater prior to spawning. The modal age of parents of the current age-0 cohort would be 5 years, spawning to spawning. Therefore, for the present assessment, trends during the last three generations were analyzed over 15 years (1996-2010).

Abundance trends were assessed with a general linear model using a negative binomial error distribution. Values for the calculation of percent change in abundance were taken from the predicted values of the general linear model (latest year and that from three generations previous, i.e., 2010 and 1996). The statistical significance of the estimates was assessed at the 95% confidence level.

The most recent estimate (2010) of adult abundance for DU 4 was 22,404 salmon (range 15,262-29,546 salmon), with 20,744 (range 14,065-27,423) small salmon and 1,660 (range 1,197-2,123) large salmon (Figure 2). The lowest abundance during the last three generations (1996-2010) was in 2001 with 18,572 salmon and the highest was in 1996 with 60,671 salmon. However, monitoring facility data and catch information suggest 2007 was the lowest year on record. Statistically significant declines ($P<0.05$) in abundance between 1996 and 2010 were determined for small salmon (41.5%), large salmon (48.3%) and total salmon (42.4%) (Fig. 2). The declines in DU 4 salmon abundance from 1996-2010 (15 years) are greater than those calculated for the 1995-2007 period (13 years) (small 37.3%, large 26.2%, and total abundance 36.0%) reported by COSEWIC (2010).

Adult abundance for DU 4 during the previous three generations (1996-2010) was compared to the Conservation Requirement achieved and the Pre-Decline Mean (1981-95). The conservation requirement for insular Newfoundland rivers in DU 4 has been defined as an egg deposition rate of 2.4 eggs/m^2 of fluvial rearing habitat and 368 eggs/hectare of lacustrine habitat. In terms of the approximate number of small salmon spawners needed to produce these egg deposition rates, the conservation requirement for DU 4 is 30,852 salmon. The pre-decline mean (1981-1995) total salmon abundance in DU 4 is 42,792 salmon. During the previous three generations (1996-2010) the total abundance of salmon in DU 4 met or exceeded the conservation requirement in 4 of the 15 years (27% of the time) (1996, 1997, 2000 and 2006) and only once in the past 10 years (Fig. 2). The total abundance of salmon in DU 4 met or exceeded the pre-decline mean in only two years during 1996-2010 (13% of the time) (Fig. 2).

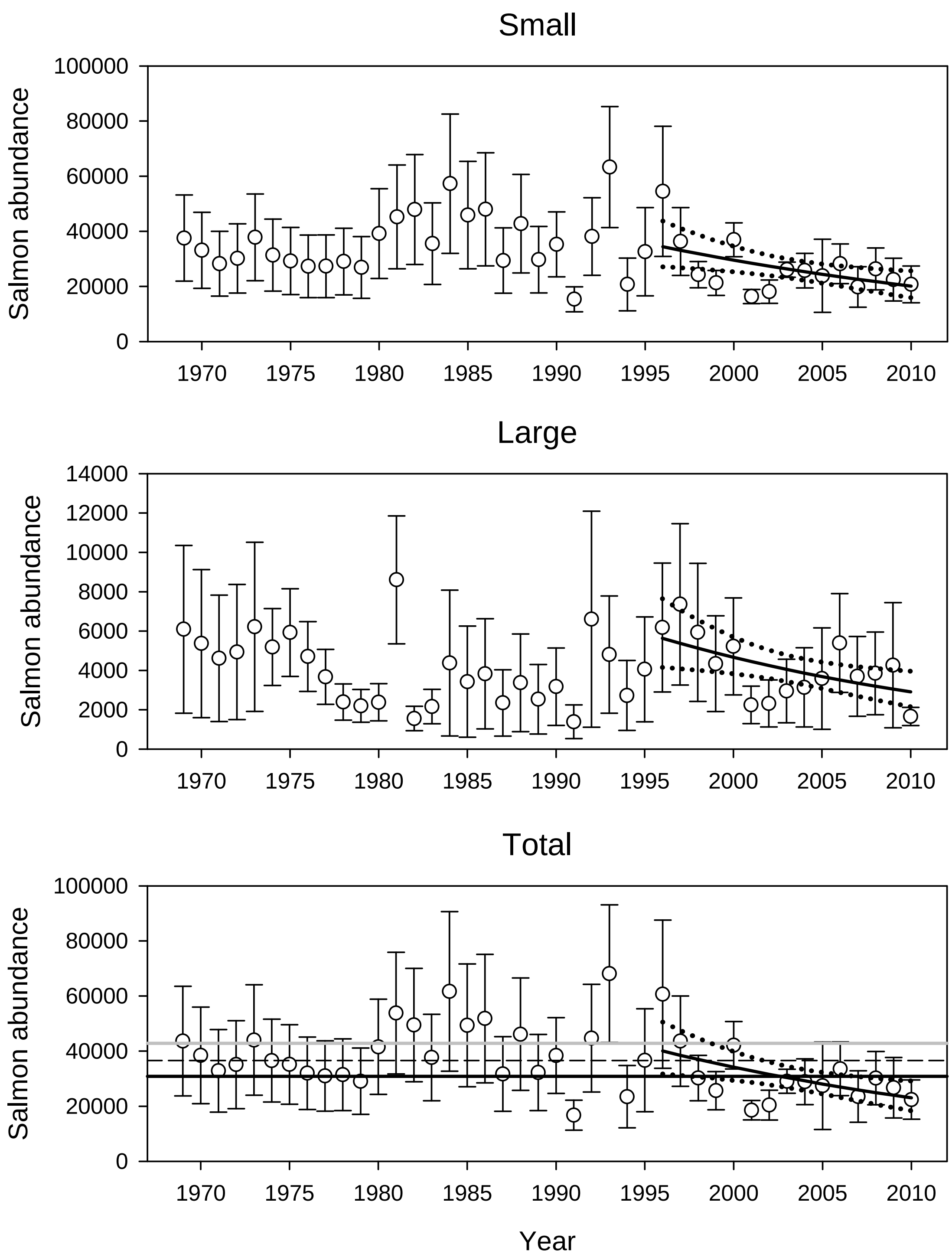

Figure 2. Atlantic salmon escapement (mean ± 2SE) (small: top panel; large: middle panel; total: bottom panel) for DU 4 (SFA 9-12) (1969-2010). Superimposed is the general linear model (± 2SE prediction intervals) used to determine trends in abundance over the past three generations (1996-2010). The three horizontal lines in the bottom panel represent the estimated conservation spawner requirement (solid black line), long-term mean (dashed black line), and abundance three generations prior to 1996 (1981-1995) (solid grey line).

South Newfoundland SFAs and River Specific Spawning Escapement

The trend analyses conducted for DU 4 were also applied to each individual SFA (9-12), the four currently monitored rivers, and the composite index of these four rivers. Results of these various abundance trend analyses are presented in Table 1 along with those from DU 4 for comparison.

As with DU 4 spawning escapement, declines over the previous three generations (1996-2010) occurred within each SFA. However, declines were greatest and statistically significant only in SFA 11 (Table 1). For individual rivers, Conne River and Little River in SFA 11 had statistically significant declines in both small (55.5% and 66.1% respectively) and large (64.8% and 95.3% respectively) salmon abundance since 1996, strongly influencing the trend in total abundance for DU 4. Small salmon abundance for Northeast Brook has remained relatively stable since 1996 but large salmon have declined by 81%. Rocky River is the only monitored river on the south coast where the abundance of small salmon has increased (+78.8%). However, large salmon abundance has declined on all monitored rivers, in each SFA and collectively in DU 4.

Table 1: Percent change (P-value) in Atlantic salmon escapement for DU 4 from 1995-2007 (COSEWIC Report) and 1996-2010 for DU 4 (SFAs 9-12), each SFA, South Coast Index, Conne River, Little River, Northeast Brook, and Rocky River. Statistically significant trends are bolded.

	Percent Change (P-value)		
Assessed Area	Small Salmon	Large Salmon	Total Salmon
DU COSEWIC Status Report 1995-2007	-37.3 (0.063)	-26.2 (0.293)	-36.0 (0.071)
DU 4 (SFAs 9-12)	**-41.5 (0.009)**	**-48.3 (0.012)**	**-42.4 (0.006)**
SFA 9	-33.1 (0.202)	-42.5 (0.152)	-34.4 (0.184)
SFA 10	-29.5 (0.147)	-41.3 (0.102)	-31.2 (0.126)
SFA 11	**-52.1 (0.002)**	**-56.1 (0.002)**	**-52.6 (0.001)**
SFA 12	-31.1 (0.277)	-36.8 (0.195)	-31.9 (0.253)
South Coast Index	-31.9 (0.091)	**-85.6 (<0.0001)**	**-40.1 (0.024)**
Conne River (SFA 11)	**-55.5 (0.002)**	**-64.8 (0.001)**	**-56.1 (0.001)**
Little River* (SFA 11)	**-66.1 (0.032)**	**-95.3 (<0.0001)**	**-71.0 (0.009)**
Northeast Brook (SFA 9)	-11.0 (0.620)	**-80.6 (<0.0001)**	-22.8 (0.271)
Rocky River (SFA 9)	+78.8 (0.055)	-53.0 (0.123)	+54.4 (0.084)

** Total returns of salmon minus known removals other than for brood stock were used for Little River. Brood stock removals and fry stocking occurred to 2001.*

Freshwater Production

Survival in freshwater can be approximated from estimates of numbers of eggs deposited and subsequent production of migrating smolts. Egg-to-smolt survival can vary substantially among rivers as well as within rivers over time. Egg-to-smolt survival averaged 1.3% (range 0.5-2.5%) for Conne River, 0.5% (range 0.3-1.1%) for Northeast Brook (Trepassey) and 0.9% (range 0.4-2.3%) for Rocky River (Fig. 3).

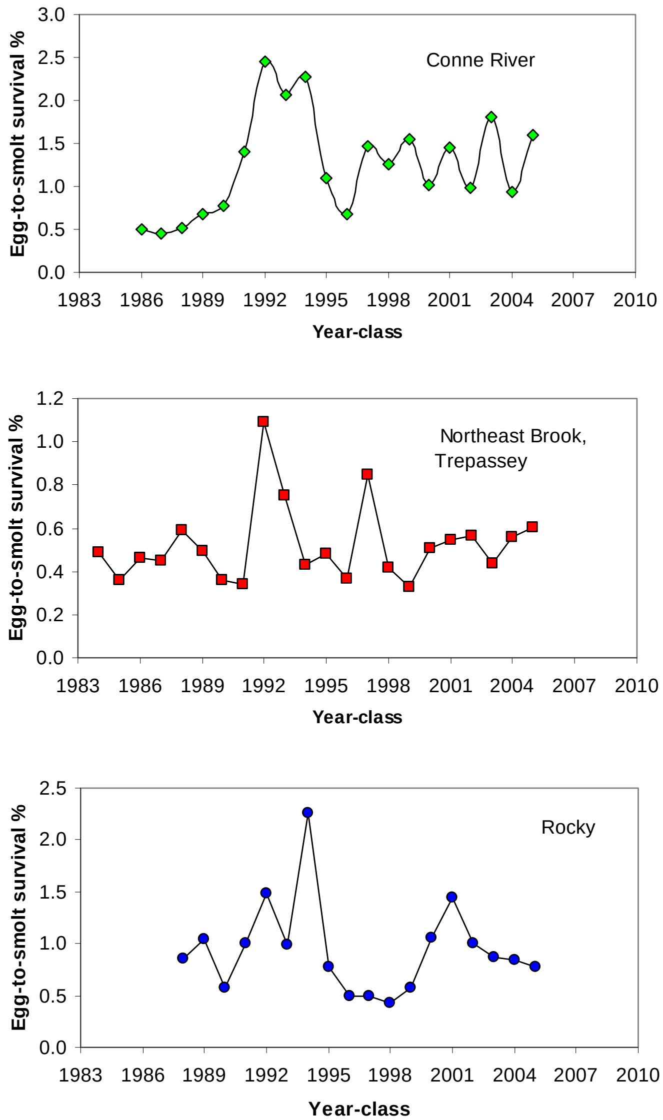

Figure 3. Freshwater survival, calculated as percent egg-to-smolt survival, of Atlantic salmon at Conne River, Northeast Brook (Trepassey), and Rocky River.

The number of smolts produced at monitored rivers appears to be constrained by certain carrying capacities (Fig. 4). Conne River normally produces between 55,000 and 75,000 smolts and Northeast Brook (Trepassey) appears to be a limited to about 2000-2500 smolts. Spawner numbers at Rocky River increased in 2008 and 2010, likely as a result of enhancement activities, and smolt production from these year classes will increase our knowledge regarding the capacity of this river.

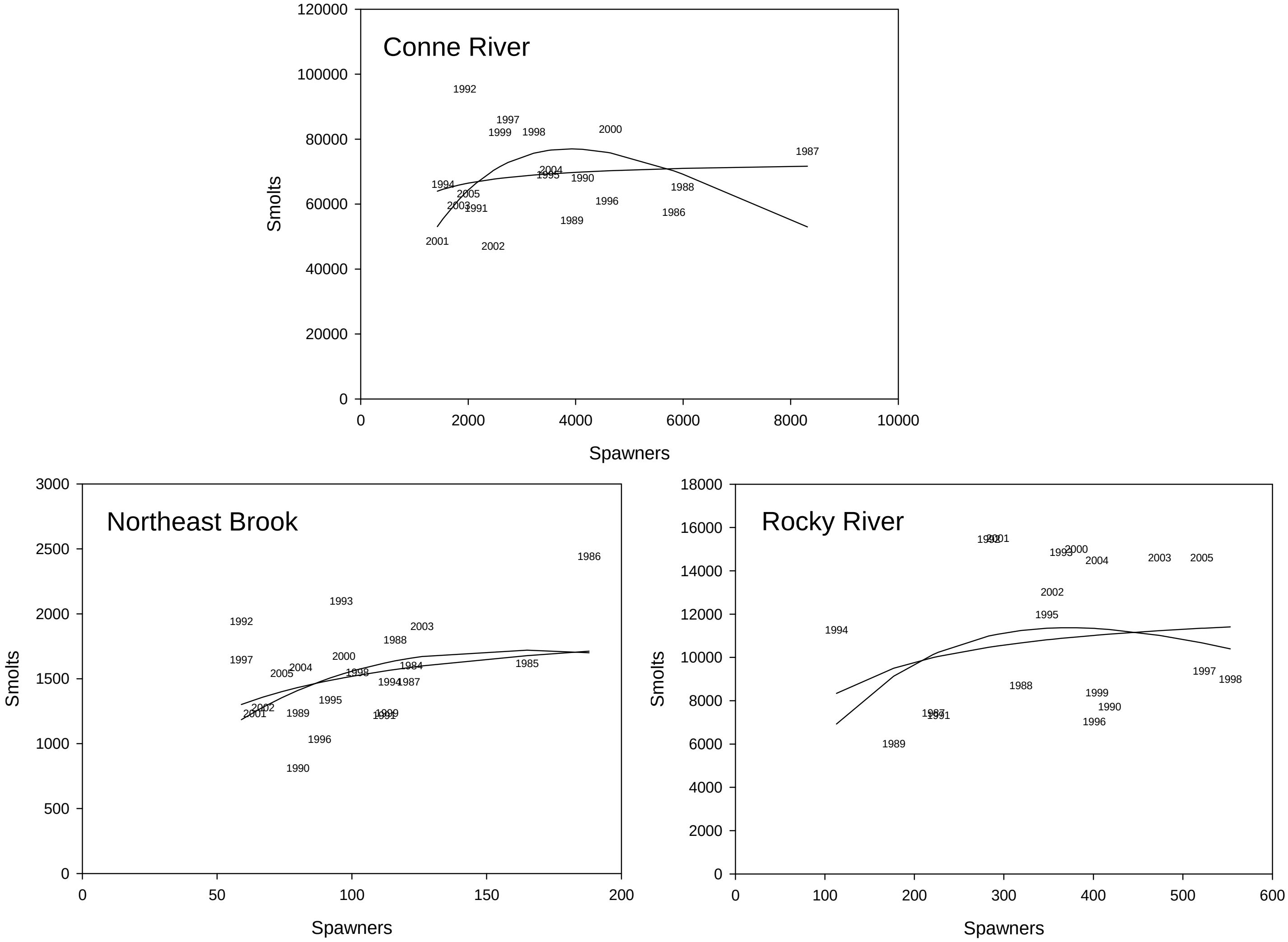

Figure 4. Atlantic salmon spawner and smolt recruitment data from Conne River, Northeast Brook (Trepassey) and Rocky River. Years indicate egg-year. Superimposed are the Beverton-Holt and Ricker stock recruitment models.

Marine Survival - Smolt to Adult Small Salmon

Marine return rates of smolt as adult salmon were calculated as a proxy for marine survival using the total return of small salmon in year x and the smolt counts in year x-1. Small salmon include a portion of repeat spawners, therefore, survival rates would be slightly lower for maiden 1-SW fish. Marine survival for the three monitored rivers in DU 4 varied widely (Fig. 5). Highest survivals for Conne River and Northeast Brook (Trepassey) occurred in the mid-1980s to mid-1990s, and for the year 2000 for Conne River. Survival rates on Rocky River were relatively low throughout the time series (record low in 2007) with the exception of two record high years in 2008 and 2010. Mean marine survival rates over the previous three generations are 3.8% for Conne River, 5.1% for Northeast Brook (Trepassey) and 3.5% for Rocky River (Fig. 5).

Marine survival trends were assessed with a general linear model using a binomial error distribution that allowed for over-dispersion. Values for the calculation of percent change in marine survival were taken from the predicted values of the general linear model (latest and earliest year in time series). The statistical significance of the trend was assessed at the 95% confidence level.

Marine survival of smolts to small salmon declined by 61.6% since 1988 (P = 0.0007) for Conne River and remained relatively stable on Northeast Brook (Trepassey) since 1987 (18% decline, P = 0.389) and Rocky River since 1991 (33.5% increase, P = 0.308) (Fig. 5). However, over the previous 15 years (1995 to 2009 smolts), there was a 35.3% decline for Conne River (P = 0.218), 12.0% decline on Northeast Brook (Trepassey) (P = 0.272) and a 44.3% increase on Rocky River (P = 0.362).

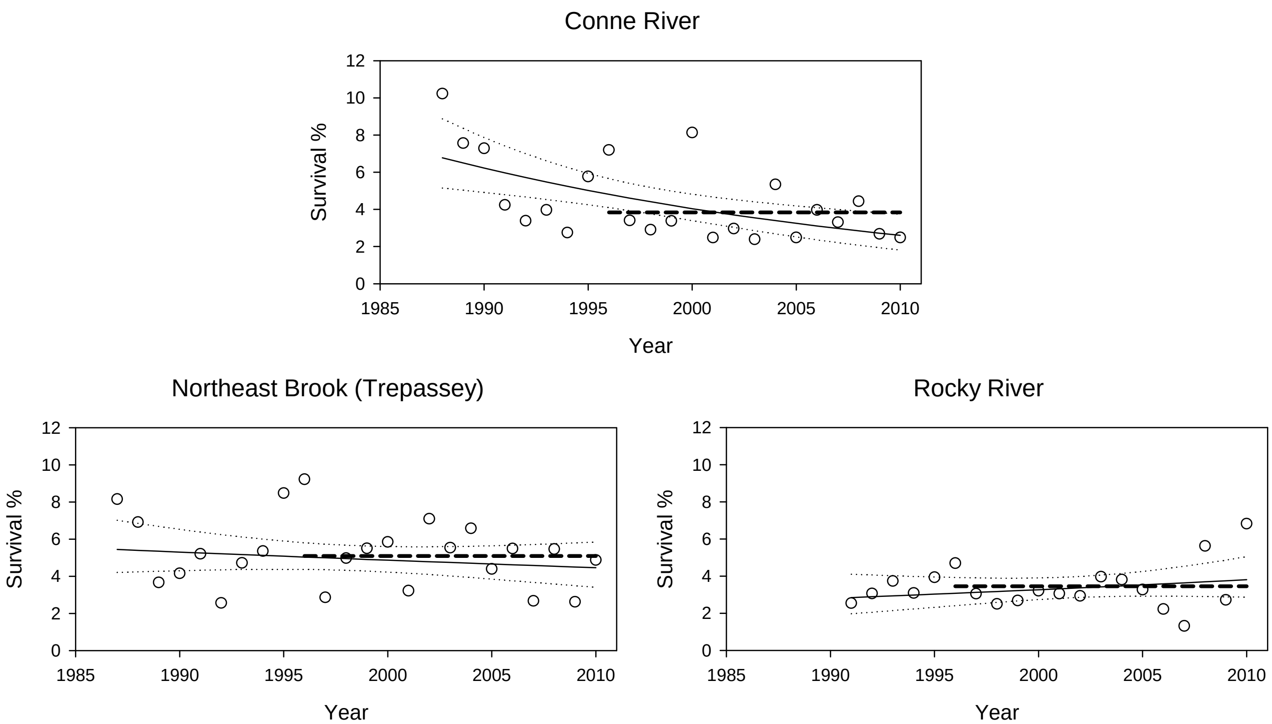

Figure 5. Atlantic salmon smolt to small salmon survival for Conne River (1988-2010), Northeast Brook (Trepassey) (1987-2010) and Rocky River (1991-2010). Superimposed is the general linear model (± 2SE prediction intervals) used to determine trends in survival over the time series. The horizontal dashed line represents the mean survival rate over the previous three generations.

Recreational Fishery

Recreational fishery data are reported for the period 1994-2010, based on the licence stub return system. Fishing effort is presented as rod days, defined as any day or part of a day on which each angler fishes. Catch per unit effort (CPUE) was calculated using all retained and released fish.

Trends in angling catches were analyzed by fitting a general linear model (GLM) separately to the retained catch, released catch, retained and released catch, and CPUE. Analyses were confined to small salmon only as they represent about 95% of the reported catch of both small and large fish. Angling data were $\log_e$ transformed. Adjusted means and standard errors were back-transformed to provide a trend in overall angling catch where the model accounts for both year and region (SFA) effects.

Retained catch from DU 4 declined significantly from 1994-2010 ($P < 0.01$), while the combined retained and released catch also trended downward but was not statistically significant ($P > 0.05$) (Fig. 6). Released catch and CPUE increased but were not statistically significant ($P > 0.05$) (Fig. 6). Collectively, the angling data provide mixed results from which to infer meaningful results regarding the status of these populations.

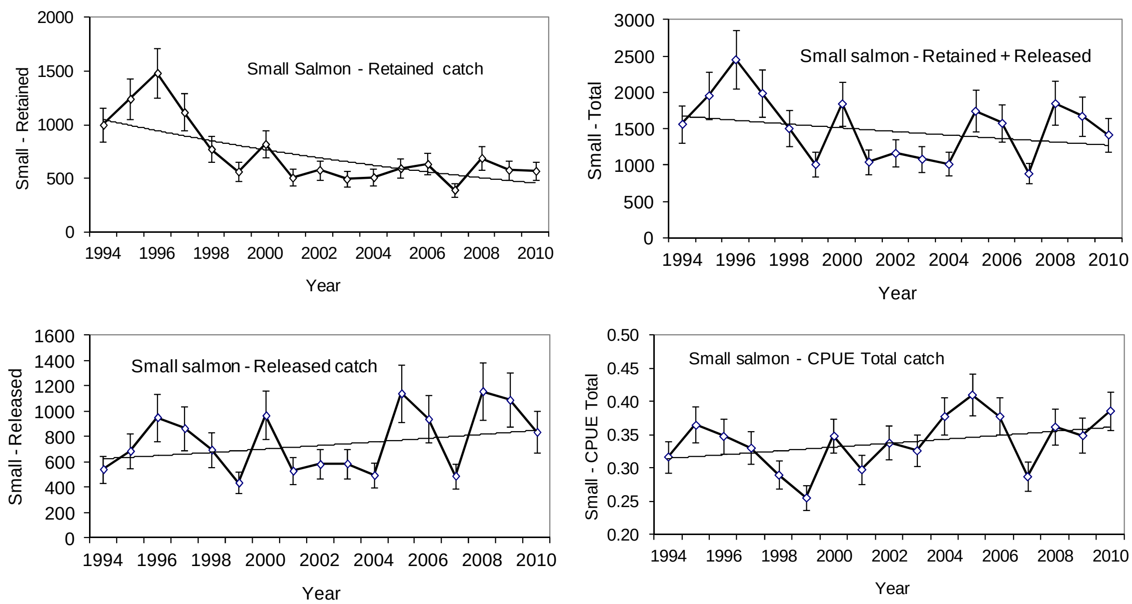

Figure 6. Trends in retained and released catches and catch per unit of effort (CPUE) for small salmon from DU 4 1994-2010. Vertical lines represent ±1 SE.

The declining catch may be related to an overall decrease in effort (rod days) that, in some years (1994, 1995, 1997, 1998, 2003, 2004), was likely associated with environmental river closures (i.e. due to low water levels or warm water temperatures) removing 25 to 34% of potential fishing days. River closures must be kept in mind when comparing yearly catch and effort information and is partially why rivers without a monitoring facility are not routinely assessed for population status.

Habitat Requirements

Residence Requirements

Residence is defined in SARA as a, "*dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating*".

Female Atlantic salmon excavate depressions and remove debris from gravels in the substrate to form redds (or nests). After spawning, females cover the eggs with substrate. These redds are essential for incubation of the eggs and for sheltering yolk-sac fry for an extended period of five months or more. If the physical structure of the redd is disturbed or destroyed, there would be very high to total mortality of eggs and yolk-sac fry. As a result, redds would meet the criteria of a residence as defined by SARA.

Habitat Properties

Information for this section has been abstracted and/or synthesized from a more comprehensive review and synthesis in DFO and MRNF 2008 and Amiro 2006; 2008.

Freshwater habitat utilization by Atlantic salmon is diverse and widely documented. Atlantic salmon may utilize several different freshwater habitats to complete a life cycle (fluvial, lacustrine, and estuarine) (see Appendix 2 from DFO and MRNF 2008 for summary). Various habitats are preferred for feeding, wintering, spawning, early life history nursery and rearing, and migration. Habitat quality is affected by: 1) seasonal temperatures, 2) stream discharge, 3) water chemistry (e.g., pH, nutrient levels, oxygen concentration), 4) turbidity, 5) invertebrate abundance and 6) physical perturbations (e.g., impoundments, deforestation), as well as many other factors. Connectivity among habitat types is an important determinant of growth, survival and lifetime reproductive success.

Atlantic salmon streams are generally clean, cool, and well oxygenated, and characterized by: moderately low (2 m/km) to moderately high (11.5 m/km) gradients; bottom substrates composed of assorted gravel, cobble and boulder; water with pH values greater than 5.5; and low (<0.02%) silt loads. Streams with about 70% riffle area appear to be optimum. Salmon prefer dynamically stable stream channels that develop natural riffles, rapids, pools and flats which are utilized during different life stages. Highest population densities and productivities are associated with rivers that have moderate summer temperatures (15º to 22°C) and moderate (25 cm/sec) flows.

The following are brief summaries regarding the habitat properties of various life stages of Atlantic salmon in Newfoundland.

Spawning and Larval Stage

Spawning of Atlantic salmon in South Newfoundland rivers involves two life stages; 1) adult salmon, and 2) precocious male parr. Habitat criteria for spawning sites of Atlantic salmon vary greatly with conditions present within a watershed. Generally Atlantic salmon spawn in relatively shallow, swift-velocity habitats where adequate spawning substrate (gravel 1-6 cm) is available with adequate intra-gravel flow. Atlantic salmon require fluvial habitat for spawning and have not been observed spawning in lacustrine habitat. The minimum oxygen concentration for successful incubation of eggs varies with developmental stage, and oxygen concentration may be reduced by deposited fine sediment. Habitat criteria for spawning sites are narrower than those for small juvenile rearing.

Juvenile

After emergence from the gravel, juvenile salmon establish and defend territories. The size of a territory is influenced by both biotic and abiotic factors including channel morphology, substrate, gradient, water quantity and quality, cover, food abundance, and predator and competitor abundance. Juvenile salmon parr in South Newfoundland rivers use fluvial and lacustrine habitat for rearing purposes. The widespread use of lacustrine habitat by parr in Newfoundland streams is believed to be due to the relative lack of predators and competitors. Growth of parr occupying lakes and ponds has been shown to be higher than for parr from fluvial habitats. In Newfoundland rivers, parr growth rates were higher in rivers dominated by lacustrine habitat compared to those comprised mainly of fluvial habitat. Parr growth occurs at temperatures above 7ºC and juveniles feed on invertebrates. Parr prefer stream gradients ranging from 0.5 to 1.5%. River utilized by juvenile Atlantic salmon are generally clear, cool and well oxygenated, and possessing bottom substrates of gravel, cobble and boulder. Thus, a diverse array of well connected habitat types is required, as well as migration corridors free from physical, chemical or biological barriers that prevent or impede in-river movements of parr or the downstream movements of parr and smolts to the estuary.

Adult

Within the freshwater environment, adult anadromous Atlantic salmon require habitat with a high degree of connectivity, to allow adults to enter, stage and migrate to spawning grounds. Additionally, many adult salmon remain in freshwater to overwinter after spawning. Marine habitat requirements for salmon are less well known than those for freshwater. This lack of information is due in part to the difficulty in collecting data and tracking salmon at sea.

Currently, the only indicator of marine habitat quality that is commonly applied to salmon is sea surface temperature. Based on research in the Labrador Sea, Atlantic salmon have been captured in marine water temperatures ranging from 1º to 13ºC, with highest catch rates in areas of water temperature between 4º and 10ºC. The diet of adult salmon is known to be quite variable and has been shown to include more than 40 different fish species or species groups and more than 10 taxonomic groups of invertebrates. Overall, the most important components of their diet include sand lance, capelin, herring, and cod along with planktonic amphipods.

Spatial Extent of Habitat

Freshwater Habitat

The South Newfoundland DU of Atlantic salmon includes rivers extending from the southeast tip of the Avalon Peninsula, Mistaken Point, and westward along the south coast to Cape Ray. There are currently 104 known watersheds of which 58 are scheduled Atlantic salmon rivers. There are no dams or man-made barriers that have removed naturally accessible freshwater habitat for Atlantic salmon. Previously inaccessible habitat on Rocky River (SFA 9) was made available to salmon by the construction of a fishway that opened 2300 ha of salmon habitat.

Marine Habitat

Marine habitat of Atlantic salmon smolts from DU 4 ranges from the coastal waters adjacent to the south coast of Newfoundland and northward through the Labrador Sea for 1SW salmon. Smolts maturing as 2SW salmon likely migrate as far north as West Greenland. Information from acoustic tracking of smolts and kelts from Conne River and Little River indicate that fish may remain in nearshore areas for four to eight weeks before migrating further to sea.

Anthropogenic Threats to Habitat

A semi-quantitative assessment, by regional fisheries scientists and managers, of the impact of habitat-related threats to salmon was provided in DFO and MRNF 2009. In that report the information for the South Newfoundland DU was provided for two areas comprising SFAs 9 and 10 (Conservation Unit, CU 5) and SFAs 11 and 12 (CU 6) (Fig. 1; Table 2; Appendix 2). The anthropogenic threats to habitat in DU 4 that have the potential to have significant impacts on Atlantic salmon habitat (significant defined as resulting in 5 to 30% of salmon affected or spawners lost) include air pollutants, agriculture/forestry/mining, hydroelectric power generation, transportation and infrastructure and aquaculture siting (Table 2; Appendix 2). Further details regarding these factors are provided below.

Table 2: Summary assessment of habitat alteration threats to Atlantic salmon (in terms of salmon affected; spawners lost) for the two areas of the South Newfoundland DU as described in DFO and MRNF (2009).

Atlantic salmon Conservation Unit	Salmon Affected : Spawners Lost												
	Regulated Habitat Alterations										Other		
	Municipal waste water	Industrial effluents	Hydroelectric & dams	Water extraction	Urbanization (hydrology)	Transportation Infrastructure	Aquaculture siting	Agriculture forestry mining	Dredging	**Cumulative**	Shipping transport	Air pollutants/acid rain	Ecosystem change
5. SE Coast	L:L	L:L	L:L	L:L	L:L	M:M	L:L	M:M	L:L	**U:U**	U:U	MU:MU	LU:LU
6. South Coast	L:L	- :L	M:M	L:L	L:L	L:L	M:M	L:L	L:L	**U:U**	- : -	MU:MU	LU:LU

Where ‘salmon affected’ symbol ‘L’ is < 5% of salmon affected; ‘M’ is 5-30% are affected, and ‘U’ is uncertain; ‘salmon lost’ symbol ‘L’ is < 5% of salmon spawners are lost; ‘M’ is 5-30% are lost, and ‘U’ is uncertain; N/A = Not Applicable and “-“ = Not Assessed.

Hydroelectric power generation

There are thirty-nine hydroelectric generating stations in insular Newfoundland (Appendix 3), eight of which are located on the south coast. The largest facility on the south coast is the Bay d’Espoir system that has three hydroelectric stations located at Bay d’Espoir (1967, 604 MW), Upper Salmon (1983, 84 MW) and Granite Canal (2003, 41 MW). Watersheds were altered in 1967 with dams to divert water to the Bay d’Espoir station, these included Salmon River, Grey River, White Bear River, and Victoria River. These diversions did not remove accessible habitat but did alter natural water flow. Fisheries compensation water releases occur in White Bear River, Grey River, Granite Canal, Upper Salmon and Hind's Lake for habitat protection and fish migration. The long term impact of the freshwater released into the head of Bay d’Espoir on Atlantic salmon is unknown.

Transportation and Infrastructure

As a migratory species, Atlantic salmon must be able to access spawning and rearing habitat and safely migrate back to the ocean in order to complete their life cycle. Man-made barriers associated with road construction can fragment Atlantic salmon habitat. Lack of habitat connectivity affects the abundance and distribution of Atlantic salmon populations.

To reduce costs, corrugated metal culverts are frequently installed at road crossings rather than bridges. Bridges with openings less than the natural high flow stream width increase velocities and create hydraulic conditions that can delay or block fish passage, as well as alter or disrupt habitat above and below an improperly designed and installed bridge. Improperly placed or designed culverts create barriers to fish passage through hanging outfalls, increased water velocities, or insufficient water velocity and depth within the culvert. Culverts can also degrade upstream and downstream habitat quality and food production as a result of damming, scouring, and deposition of sediments.

Aquaculture siting

Aquaculture sites have the potential to affect fish habitat predominantly though the accumulation of organic waste. There are 81 licensed salmonid aquaculture sites on the south coast of Newfoundland and approximately 52 of these are in the Bay D’Espoir area (SFA 11) (Appendix 4). However, not all sites are active in a given year and some sites have never been active. For example, from 2006 to 2010 between 10 and 23 sites were active in each year. The number of active sites is expected to rise and expand into other areas on the south coast.

Agriculture/Forestry/Mining

Pesticides used for agriculture, forestry, and other land use practices can have direct or indirect adverse effects on Atlantic salmon or their habitats. Direct effects occur when Atlantic salmon and the chemical come in direct contact. Indirect effects result from chemically induced modifications to habitat or non-target organisms (e.g., food sources). The effects of pesticides on salmonids may range from acute (leading to sudden mortality) to chronic (leading to increased cumulative mortality).

Many anthropogenic activities associated with or directly the result of forestry and agriculture can cause sedimentation. Clearing vegetation near watercourses or permitting livestock to enter streams and rivers can allow runoff to transport sediments into watercourses. Sedimentation may reduce the quality of spawning substrates and has been shown to reduce the survival of developing eggs and yolk-sac fry.

Mining impacts Atlantic salmon both directly and indirectly. Blasting can directly kill fish and destroy fish habitat. It can also disrupt groundwater patterns, which in turn influence groundwater fed water courses and their associated habitats. Effluents discharged from mines can impact salmon by altering water quality, for example, changing temperature, pH, increasing suspended particulate matter, and introducing heavy metals into the water. The flow of effluents can also indirectly alter downstream erosion patterns and alter hydrology. Another significant threat from mining is water extraction from either ground or surface water, the impacts of which are site specific.

Air Pollutants/Acid Rain

Sulphur-dioxide (SO2) emissions (from metal smelting, coal-fired electrical utilities) and nitrous oxide (NOx) emissions (combustion) are the principal acidifying pollutants transported over long distances and falling as acids in precipitation. Newfoundland watersheds do not appear to be as affected by acidification as those in other regions of eastern Canada. However, research has shown that two areas of Newfoundland have headwater lakes with relatively low pH values, and are likely more susceptible to potential acidification. One of these areas is the southwest portion of the south coast, in DU 4, and the other is the southeastern portion of the Northern Peninsula.

Impact of Potential Habitat Changes

Overall, the factor contributing to the decline and low abundance of Atlantic salmon in DU 4 is the reduced and low marine survival of 1 SW maiden salmon. Marine survival in monitored rivers in DU 4 have averaged between 4% and 5% over the past fifteen years. The extent to which habitat related factors modify marine survival rates are not clear.

Freshwater survival rates in monitored rivers of the south coast of Newfoundland are in the same range as those from other monitored rivers in Newfoundland. Egg-to-smolt survival fluctuates annually in response to variations in egg depositions and environmental variables such as water temperature and discharge, especially in winter.

Spatial Configuration Constraints

Spatial configuration constraints that affect connectivity, such as barriers to migration at various life stages, are not considered to be limiting factors for Atlantic salmon recovery in DU 4.

Amount of Suitable Habitat

There is no evidence to suggest that the quality and quantity of freshwater habitat is limited or has changed and contributed to the Atlantic salmon declines measured over the previous three generations in DU 4. Despite uncertainties in the role of marine habitat in modifying marine survival rates, it is assumed that there is sufficient suitable marine habitat to allow for recovery of salmon in DU 4.

Feasibility of Habitat Restoration

Given that freshwater habitat does not appear to be limited in DU 4, restoration activities are not likely to influence recovery. Not enough is known about marine habitat use by South Newfoundland Atlantic salmon to identify any habitat factors that may be limiting recovery.

Risks Associated with Habitat "*Allocation*" Decisions

The associated risks of habitat allocation decisions have not been evaluated for Atlantic salmon. There is no indication that the amount of suitable habitat is currently limiting the recovery of Atlantic salmon. However, this habitat should be maintained as the impact of reducing it is unknown.

The habitat requirements, in terms of discrete types (spawning and rearing habitats) within the freshwater environment for Atlantic salmon are relatively well known and understood. The degree to which a habitat can be defined as a discrete area with clear edges or a gradient of features in the marine environment has not been identified. Transitional areas between freshwater and marine habitats are known to be physiologically stressful to salmon. Additional stressors imposed on smolt or post-smolts in this transitional gradient have the potential to result in major impacts.

Impact of Threats on Quality and Quantity of Available Habitat

Habitat alteration, especially physical alteration in freshwater and coastal areas will reduce its value. Oceanographic changes in offshore marine areas and continued environmental impacts from climate change have the potential to significantly impact the distribution and production of Atlantic salmon in the Northwest Atlantic.

Scope for Management to Facilitate Recovery and Allowable Harm Assessment

Recovery Targets

Recovery targets within a SARA/COSEWIC framework should "reflect a population abundance that is sufficiently large to be secure and/or may meet some comparative standard with its historical size" and "the minimum estimate of the population size, allowing for uncertainties in estimation, should be substantially above the minimum size for a secure population" (DFO 2005). Three population targets were considered for South Newfoundland DU 4; 1) No further decline of the current level of 22,404 salmon, 2) the Conservation Requirement of 30,852 salmon, and 3) the Pre-Decline Mean (1981-1995) of 42,792 salmon.

As presently defined, the conservation objectives for Atlantic salmon are considered to be a limit reference point and as discussed by CAFSAC (1991): “the further the spawning escapement is below the biological reference level, and the longer this situation occurs even at rates only slightly below that level, the greater the possibility exists of incurring the following risks, some of which may cause irreversible damage to the stock.” The conservation requirement which has been used to manage fisheries access and exploitation is proposed as the recovery target for this DU. If the abundance of adult salmon in the DU meets or exceeds the conservation requirement consistently over time, then the DU could be considered recovered for the purposes of SARA.

Population Projections and Allowable Harm Assessment

Projections of adult abundance for DU 4 were determined by modeling the spawner to smolt production based on stock recruitment relationships and modeling the smolt to adult return dynamic as a simple proportional relationship. Population sizes were projected for fifteen years into the future based on current population parameters. Stochastic projections based on 2,000 simulations were conducted using freshwater productivity and ocean survival rates estimated for the entire DU from 1996-2010 based on data available for Conne River, Rocky River and Northeast Brook (Trepassey). An average ocean survival rate of 4% (± 2%) was used for the projections. Mortality due to retention of small salmon during 1996 to 2010 was estimated to average 12% for the entire DU, with additional catch-and-release mortality of 2% for small salmon and 1% for large salmon (assuming a 10% probability of mortality for salmon caught and released). Under the current management plan, fisheries losses include both retention and losses associated with mortality from catch-and-release angling. A five-year generation time is assumed and projections initiated using population estimates from 2006 to 2010. Three recreational fishery scenarios (allowable harm) were considered: current management plan (retention of small salmon only, catch-and-release of large salmon), no fishery (fishery closed) and catch-and-release fishing only for all sizes of salmon. Catch-and release only fisheries losses were calculated using the catch rates of the current management plan. It is likely that a catch-and-release only fishery will reduce current catch rates but this is difficult to quantify.

Population projections were evaluated relative to the probability of meeting or exceeding the three population targets: current abundance (2010) of 22,404 salmon or no decline, conservation requirement of 30,852 salmon and pre-decline mean (1981-1995) of 42,792 salmon. In addition, the mean ocean survival that would be required to attain a 75% chance of meeting or exceeding the three population targets within fifteen years for the three recreational fishery scenarios were also calculated.

Median population size after fifteen years based on an ocean survival rate of 4% (± 2%) with no angling was estimated at 32,000 salmon, with an 80% confidence interval range of 16,000 to 62,000 salmon (Fig. 7). Under this scenario, there was a 74% chance that population size would remain at or above current abundance. The probability of meeting or exceeding the conservation requirement and pre-decline mean were 52% and 27% respectively (Table 3).

Under the current fisheries management scenario, the median population size after fifteen years was 22,000 salmon (80% C.I. range of 11,000 to 46,000 salmon) and there was a 50% chance of the population size meeting or exceeding current abundance. The probability of meeting or exceeding the conservation requirement was 23% and the pre-decline mean was 12% (Table 3). Under a catch-and-release only fishery, the median population size after fifteen years was 30,000 salmon (80% C.I. range of 15,000 and 58,000 salmon) and there was a 70% chance of the population size meeting or exceeding current abundance. The probability of meeting or exceeding the conservation requirement was 42% and the pre-decline mean was 26% (Table 3).

Table 3: Probabilities of meeting or exceeding the population targets of no further decline in abundance of spawners, the conservation requirement, and the pre-decline mean under no angling, current angling management and catch-and-release angling only within fifteen years from current (2010) spawner abundance.

	Total removals		
Recovery objective	No angling	Current angling	Catch-and-release angling
No further decline	74%	50%	70%
Conservation requirement	52%	23%	42%
Pre-decline mean	27%	12%	26%

Estimates of average ocean survival required to meet each of the three population targets varied between 5% and 7% for the recreational fishery scenarios. Average ocean survival of 5% is required for a 75% chance of maintaining current population size under all three removal scenarios. Similarly, 5% average ocean survival would result in a 75% chance of meeting the conservation requirement under no angling and catch-and-release angling. A 75% chance of reaching the conservation requirement under current fishing would involve an increase in ocean survival to an average of 6%. This increase would also be required for a 75% chance to meet pre-decline mean abundance under no angling or catch-and-release scenarios. With current angling management, an average ocean survival of 7% would be required to have a 75% chance of reaching the pre-decline mean (Table 4).

Table 4: Mean ocean survival (± 2%) required for a 75% chance of meeting or exceeding the population targets of no further decline in abundance of spawners, the conservation requirement, and the pre-decline mean under no angling, current angling management, and catch-and-release angling only within fifteen years from current (2010) spawner abundance.

	Total removals		
Recovery objective	No angling	Current angling	Catch-and-release angling
No further decline	5%	5%	5%
Conservation requirement	5%	6%	5%
Pre-decline mean	6%	7%	6%

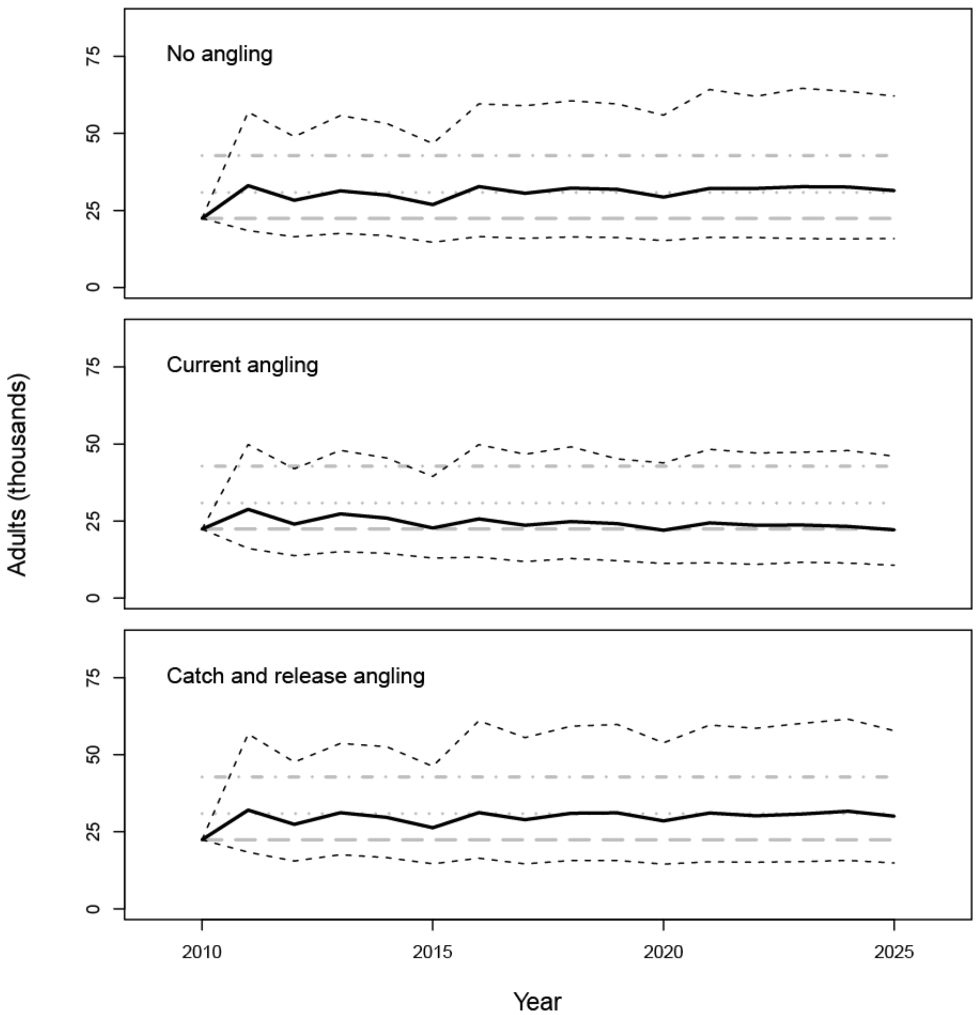

Figure 7. Population projections for the next fifteen years based on current population parameters for three recreational fishery scenarios: no angling (upper panel), current angling management (middle panel) and catch-and-release only angling (lower panel). Solid black lines represent median values of projected population size; dashed black lines represent the 10% and 90% percentile ranges of population size estimates. Grey lines represent three different population targets: dashed lines show current population abundance, dotted lines denote to the conservation requirement and dash-dot lines represent the pre-decline mean population abundance.

Major Potential Sources of Mortality

Major potential sources of mortality include recreational fisheries, illegal fisheries, mixed-stock marine fisheries and by-catch, ecological and genetic interactions with escaped domestic Atlantic salmon, and poorly understood changes in marine ecosystems. The degree of influence of many of these factors are not well understood, however, all factors with the exception of salmonid aquaculture have the potential to affect wild salmon in other DUs where salmon populations have been stable or increasing.

Management alternatives and mitigation are summarized in Appendix 2 for two areas of the South Newfoundland DU (DFO and MRNF 2009). Further details on fisheries and aquaculture are provided below.

Recreational Fisheries

The estimated catch of salmon in recreational fisheries in DU 4 for 2010 totalled 3053 retained small salmon and 5,045 small and 298 large released salmon. Assuming a 10% mortality rate for catch-and-release angling, the total mortality associated with recreational fisheries in 2010 was 3587 salmon (16% of total returns). The average mortality rate from recreational fisheries during the period from 1996 to 2010 was 12% (8-16%).

Non-Domestic Fisheries (St. Pierre et Miquelon)

Residents of the islands of St. Pierre et Miquelon, just off the south coast of Newfoundland, catch Atlantic salmon in a coastal marine gillnet fishery. There are no salmon producing rivers in the islands of St. Pierre et Miquelon. First reports of effort and catch from this fishery date to 1976 and annual reports begin in 1986. The maximum reported catch in the fishery is 3.54 t (in 2008) and annual reported catches have varied from 0.8 t to 3.5 t during 1992 to 2010. The fishery catches mostly small salmon (<63 cm fork length, about 2:1 small to large) and the estimated annual catch in number of fish is in the range of 300 to 1,500 fish during 1992 to 2010. Limited genetic analysis of samples from two years indicates that the majority of the fish (94%) are of Canadian origin but resolution to finer geographic scales has not been completed. Given the proximity of this fishery to the South Newfoundland DU, it is likely that a proportion of the catch of salmon originate from populations in this DU.

Aquaculture

As highlighted in the COSEWIC Status Report assessment summary for DU 4, "*the presence of salmon aquaculture in a small section of this area brings some risk of negative effects from interbreeding or adverse ecological interactions with escaped domestic salmon*." Scientific data are not currently available to assess the potential magnitude of these effects on wild salmon from this DU but escaped farmed salmonids have been reported in Conne River. Salmon from this and other Bay d'Espoir rivers migrate through an area where aquaculture occurs.

There are 81 licensed salmonid aquaculture sites on the south coast of Newfoundland and approximately 52 of these are in the Bay D'Espoir area (SFA 11) (Appendix 4). The production of salmon has increased dramatically since 1995 and is expected to continue to increase in the future and expand to other areas on the south coast (i.e. Fortune Bay) (Fig. 8).

Concerns over the potential impacts of aquaculture on local populations of salmonids have been raised both in Europe as well as in other areas of Canada. Concern is based on the potential for negative interactions that can result from inter-breeding and subsequent loss of fitness, competition for food and space, disruption of breeding behaviour, and transmission of disease and parasites. Even small numbers of escaped farmed salmon have the potential to negatively affect resident populations, either through demographic or genetic changes in stock characteristics. There have been many reviews and studies showing that the presence of farmed salmon results in reduced survival and fitness of wild Atlantic salmon, through competition, interbreeding and disease.

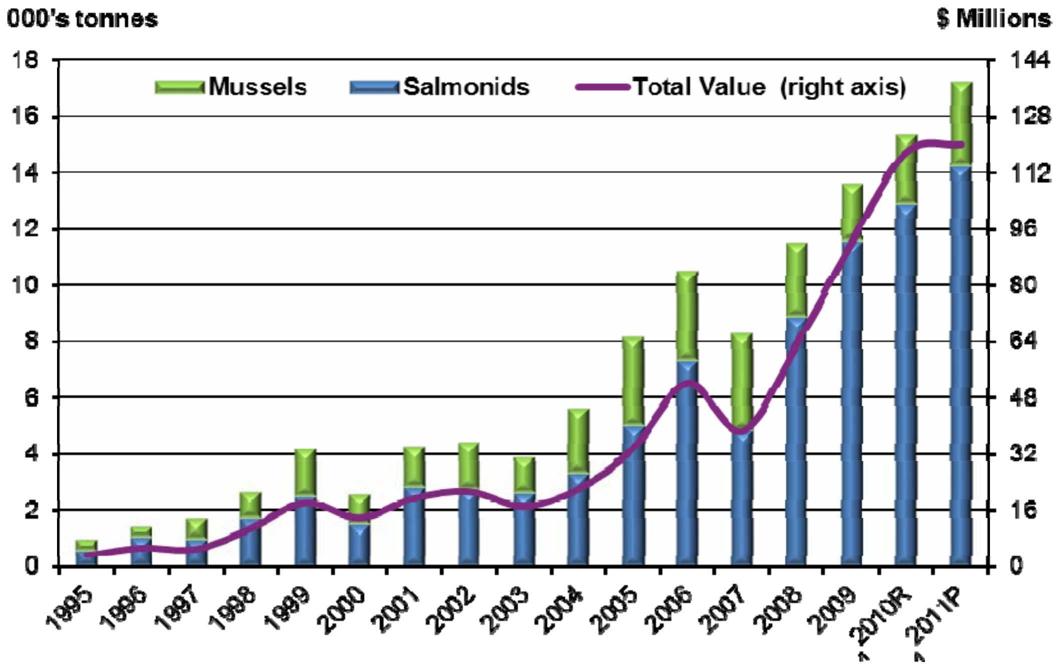

Figure 8. Annual reported salmonid (Atlantic salmon and rainbow trout) aquaculture production (t) and value summary from 1995-2011 (provided by the Provincial Department of Fisheries and Aquaculture) (R – revised, P – preliminary).

Habitat Quantity and Quality to Support Recovery

The quantity and quality of freshwater habitat in DU 4 is sufficient to allow Atlantic salmon populations to reach recovery. Not enough is known about marine habitat use by South Newfoundland Atlantic salmon to quantify the potential threats to habitat quantity and quality and its sufficiency for recovery. However, smolt from Conne River and Little river are known to spend an extensive period (~40 days) in the Bay d'Espoir fiord prior to migrating to sea. A growing salmonid aquaculture industry in this area may limit the quantity and quality of habitat within the bay but the magnitude of this impact is not known.

Scenarios for Mitigation and Alternatives to Activities

Management alternatives and mitigation for each potential source of mortality are listed in Appendix 2.

Although many threats exist, low at-sea survival is presently a major factor for the decline of salmon stocks in DU 4, the cause of which is unknown. While the mechanism(s) of marine mortality is uncertain, poor sea survival of salmon is occurring in parallel with many widespread changes in the North Atlantic ecosystem.

Sources of Uncertainty

There are 104 watersheds in DU 4. Angling data are available for most of the 58 scheduled Atlantic salmon rivers. The presence and status of Atlantic salmon in the un-scheduled rivers is unknown (Appendix 1).

There is a high degree of uncertainty regarding the utility of translating angling catches using measured exploitation rates from monitored rivers into estimates of total salmon abundance in DU 4. In particular, indices of abundance based on catch per unit effort in the angling fishery for Salmon Fishing Areas 9 to 12 indicate a lesser decline and even an increase in abundance which differs from trends of abundance based on angling catches. However, with the exception of Rocky River which is a colonization river, counts of salmon in the other three monitored rivers on the south coast all show a decline in returns of small salmon and large salmon.

Population projections were based on freshwater production models that use spawner to smolt data from the three monitored rivers scaled to the amount of fluvial habitat only. Lacustrine habitat was not included which is extensively used for rearing by juvenile salmon, particularly in Conne River and Rocky River. As a result, the global model that combined all three rivers was not a good fit to the observations; observed smolt production values for Conne River were greater than predicted whereas observed smolt production values for Northeast Brook (Trepassey), a river with limited lacustrine habitat were less than predicted. The amount of lacustrine production area in most rivers in this DU has not been quantified and this has consequences for the projection of abundance for the whole DU. Fixed and assumed parameters were also used for proportion maturing as 1SW and the survival rate to repeat-spawning.

Individually, most of the land-based activities that intersect salmon freshwater habitat may have minimal consequences on production and abundance but cumulative impacts of a wide range of land-based activities on Atlantic salmon have not been quantified.

SOURCES OF INFORMATION

This Science Advisory Report has resulted from a Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, Regional Advisory Meeting of February 14-16, 2012 on the Recovery Potential Assessment (RPA) of South Newfoundland Atlantic salmon DU. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

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Appendix 1: Watersheds in DU 4 with Atlantic salmon populations (* Scheduled). Accessible Habitat Units that are blank are unknown.

SFA	River	Longitude	Latitude	Drainage Area (km^2)	Accessible Habitat Units (km^2)
9	Biscay Bay River*	-53.28	46.78	239	239
9	Northeast Brook (Trepassey)*	-53.35	46.77	21	21
9	Northwest Brook (Trepassey)*	-53.39	46.76	178	178
9	St. Shotts River	-53.59	46.63	97	
9	Peter's River (Holyrood Bay)*	-53.61	46.76	144	144
9	Crossing Place River	-53.46	46.94	219	219
9	Salmonier River (St. Marys Bay)*	-53.45	47.17	257	257
9	Harricot River	-53.52	47.18	28	
9	Colinet River*	-53.55	47.22	158	158
9	Rocky River	-53.57	47.22	296	296
9	North Harbour River (St. Marys Bay)*	-53.62	47.19	73	73
9	Little Salmonier River (St. Marys Bay)*	-53.75	47.04	123	123
9	Big Barachois River (St. Marys Bay)*	-53.78	47.05	83	
9	Little Barachois River (St. Marys Bay)	-53.80	47.02	50	
9	Red Head River	-53.86	46.95	71	
9	Beckford River	-53.92	46.89	43	43
9	Branch River*	-53.95	46.88	118	118
9	Lance Brook	-53.00	46.00	53	
10	Cuslett Brook	-54.17	46.96	36	
10	Great Barasway Brook*	-54.07	47.13	68	
10	Lt. Barasway Bk.	-54.00	47.00	39	
10	Southeast River (Placentia)*	-53.91	47.22	140	140
10	Northeast River (Placentia)*	-53.84	47.27	94	94
10	Shalloway Pond Brook	-53.90	47.30	6	
10	Placentia Sound River	-53.87	47.31	34	
10	Ship Harbour Brook	-53.88	47.35	34	34
10	Come By Chance River*	-53.99	47.85	64	64
10	North Harbour River (Placentia)*	-54.07	47.88	96	96
10	Watsons Brook (Placentia)*	-54.08	47.88	9	
10	Black River (Placentia)*	-54.17	47.88	200	
10	Pipers Hole Brook*	-54.27	47.93	781	
10	Sandy Harbour River	-54.34	47.70	462	
10	Paradise River (Paradise Sound)	-54.43	47.62	490	
10	Black River (Paradise Sound)	-54.44	47.59	205	
10	Nonsuch River*	-54.65	47.44	30	30
10	Cape Roger Brook*	-54.70	47.43	93	
10	Bay de l'Eau River*	-54.78	47.44	152	
10	Rushoon River	-54.92	47.36	59	59

Appendix 1 con't: Watersheds in DU 4 with Atlantic salmon populations (* Scheduled). Accessible Habitat Units that are blank are unknown.

SFA	River	Longitude	Latitude	Drainage Area (km^2)	Accessible Habitat Units (km^2)
10	Northeast Branch (Red Harbour)*	-55.00	47.30	65	
10	Red Harbour River*	-55.00	47.29	73	
10	West Brook (Mortier Bay)	-55.25	47.17	85	
10	Tides Brook*	-55.23	47.14	179	
10	Big Salmonier Brook (Burin)*	-55.21	47.06	33	
10	Little St. Lawrence River*	-55.37	46.93	64	
10	Lawn River*	-55.48	46.93	38	
10	Little Lawn River	-55.54	46.95	67	
10	Taylor Bay Brook*	-55.71	46.88	70	70
10	Salmonier River (Lamaline)*	-55.77	46.87	115	115
10	Piercy's Brook*	-55.86	46.87	60	
11	Fortune Brook	-55.83	47.07	48	48
11	Grand Bank Brook*	-55.75	47.10	67	67
11	Garnish River*	-55.35	47.23	212	
11	Devil Brook	-55.31	47.28	68	
11	Terrenceville Brook	-54.70	47.67	115	
11	Grand le Pierre Brook	-54.78	47.69	46	
11	Southwest Brook (Long Harbour)	-54.94	47.78	162	
11	Long Harbour River*	-54.94	47.82	1002	
11	Mal Bay Brook	-55.12	47.70	47	
11	Recontre Brook	-55.21	47.64	195	
11	Belle Harbour River	-55.31	47.70	46	46
11	North East Brook (East Bay)	-55.36	47.73	142	142
11	North West Brook (East Bay)	-55.40	47.74	84	
11	Bay du Nord River*	-55.44	47.73	1171	
11	Salmon River (Cinq Island Bay)	-55.47	47.66	196	196
11	Simmions Brook*	-55.48	47.65	39	
11	South West Brook (Fortune Bay)*	-55.47	47.61	6	6
11	Old Brook*	-55.59	47.58	40	40
11	Taylor Bay Brook*	-55.64	47.56	31	
11	Salmonier Brook (Hermitage Bay)	-55.68	47.68	80	80
11	Little River	-55.70	47.85	183	
11	Conne River*	-55.70	47.91	602	602
11	Southeast Brook (Baie D'espoir)	-55.74	47.92	84	
11	North West Brook (Baie D'espoir)	-55.84	47.89	111	
11	Long Reach Brook*	-56.08	47.75	4	
11	Salmon River (Baie D'espoir)	-56.00	47.81	2708	
11	Hughes Brook (Baie D'espoir)	-56.15	47.84	24	
11	D'Espoir Brook*	-56.17	47.88	285	

Appendix 1 con't: Watersheds in DU 4 with Atlantic salmon populations (* Scheduled). Accessible Habitat Units that are blank are unknown.

SFA	River	Longitude	Latitude	Drainage Area (km^2)	Accessible Habitat Units (km^2)
11	Allan's Cove Brook*	-56.28	47.70	41	
11	Bottom Brook (Facheux Bay)*	-56.33	47.80	175	
11	Brent Cove Brook*	-56.35	47.70	44	
11	Morgan Brook*	-56.51	47.72	178	
11	Dolland Brook*	-56.58	47.73	688	
11	Grey River*	-57.01	47.68	2394	
11	White Bear River*	-57.27	47.78	2027	2027
11	Bay de Loup Brook*	-57.52	47.66	55	
11	Kelly Brook	-57.55	47.65	2	
11	Kings Harbour Brook*	-57.58	47.64	128	
11	Grandy Brook*	-57.67	47.64	264	264
11	Middle Brook	-57.83	47.65	8	
11	Connoire Brook	-57.91	47.75	311	
11	Couteau Brook	-58.03	47.74	132	
11	Cinq Cerf Brook*	-58.15	47.70	205	
12	East Bay Brook*	-58.25	47.77	57	
12	La Poile River*	-58.32	47.80	588	
12	Farmers Brook*	-58.50	47.66	89	89
12	Garia Brook*	-58.54	47.73	228	
12	Northwest Brook (Garcia Bay)*	-58.57	47.70	119	
12	Northwest Brook (Bay le Moine)	-58.60	47.68	52	
12	Grandys Brook*	-58.84	47.62	273	
12	Burnt Island River	-58.87	47.61	10	
12	Isle aux Morts River*	-59.01	47.59	214	
12	Grand Bay River*	-59.16	47.60	134	
12	Northwest Brook (Grand Bay)	-59.16	47.60	16	
12	Barachois River (Cape Ray Cove)	-59.27	47.62	49	

Appendix 2: Summary of threats to and rating of effects on recovery and/or persistence of Atlantic salmon in the southeast area (SFA 9-10) of the South Newfoundland DU.

Potential Sources of Mortality /Harm Permitted and Un-permitted Activities Conservation Unit 5	Source (with examples)	Proportion of Salmon Affected LOW < 5%, MEDIUM 5% to 30%, HIGH > 30%, UNCERTAIN	Cause/ Time Frame Historic (H) Current (C) Potential (P)	Effect on Population (LOW < 5% spawner loss, MEDIUM 5% to 30% spawner loss, HIGH > 30% spawner loss, UNCERTAIN)	Management Alternatives/ Mitigation (*relative to existing actions*)
Directed Salmon Fishing	Aboriginal: South Coast	Not applicable – no directed Aboriginal fisheries in this CU.			
	Recreational: retention and release	Medium (season open from June 1 to Sept. 7). Moderate effort on some rivers.	H C	Medium	Estimated at 12% for DU 4. Reductions in retention fisheries; increase use of catch-and-release; direct effort controls; season modifications; closures; environmental protocols.
	Commercial (domestic)	N/A – all commercial fisheries closed	H		
	Aboriginal: Labrador	Low	H C P	Low	
	International High-seas: West Greenland / St.Pierre – Miquelon	Low	C	Low	Reductions in internal use fisheries in those areas.

	Illegal (poaching)	Low	C	Low – increased enforcement; stewardship initiatives with local groups; change enforcement strategies for more targeted efforts.	Continued use of compliance monitors on selected watersheds, including Aboriginal guardians.
	Source (with examples)	**Proportion of Salmon Affected LOW < 5%, MEDIUM 5% to 30%, HIGH > 30%, UNCERTAIN**	**Cause/ Time Frame Historic (H) Current (C) Potential (P)**	**Effect on Population (LOW < 5% spawner loss, MEDIUM 5% to 30% spawner loss, HIGH > 30% spawner loss, UNCERTAIN)**	**Management Alternatives/ Mitigation (*relative to existing actions*)**
	Illegal (poaching)	Low	C	Low – increased enforcement in conjunction with DFO and Provincial enforcement officers; began stewardship initiatives with local groups; changed enforcement strategies for more targeted efforts.	Continued use of compliance monitors on selected watersheds, including Aboriginal guardians.
	CUMULATIVE EFFECT	Low – Medium	C	Low - Medium	New 5-year Integrated Fisheries Management Plan with major elements including river classification and adaptive management strategy.
Bycatch of Salmon in Fisheries for Other Species	Aboriginal				
	Resident – Labrador Trout Net Fishery	Low	C	Low	

	Recreational				– incidental catch prohibited
	Commercial near-shore	Uncertain			– incidental catch prohibited
	Commercial distant	Uncertain			
	Source (with examples)	**Proportion of Salmon Affected LOW < 5%, MEDIUM 5% to 30%, HIGH > 30%, UNCERTAIN**	**Cause/ Time Frame Historic (H) Current (C) Potential (P)**	**Effect on Population (LOW < 5% spawner loss, MEDIUM 5% to 30% spawner loss, HIGH > 30% spawner loss, UNCERTAIN)**	**Management Alternatives/ Mitigation (*relative to existing actions*)**
	Illegal (poaching)	Low		Low	
	CUMULATIVE EFFECT	Low - Uncertain		Low - Uncertain	
Salmon Fisheries Impacts on Salmon Habitat	Aboriginal	Not applicable - no directed Aboriginal fisheries in this CU.			
	Recreational	Uncertain		Uncertain - but expected to be Low.	
	Commercial				
	Illegal	Uncertain		Uncertain	
	CUMULATIVE EFFECT	Uncertain		Uncertain	
Mortality Associated with Water Use	Hydroelectric power generation at dams (turbine morts, entrainment, stranding)	Low	C	Low	A few small hydro dams. Harmful alterations, disruption and destruction (HADD) for new projects have to be mitigated or have compensation.

	Source (with examples)	Proportion of Salmon Affected LOW < 5%, MEDIUM 5% to 30%, HIGH > 30%, UNCERTAIN	Cause/ Time Frame Historic (H) Current (C) Potential (P)	Effect on Population (LOW < 5% spawner loss, MEDIUM 5% to 30% spawner loss, HIGH > 30% spawner loss, UNCERTAIN)	Management Alternatives/ Mitigation (*relative to existing actions*)
Habitat Alterations	Municipal waste water treatment facilities	Low – few communities	H C P	Low	Ensure current projects and future developments meet standards.
	Pulp and paper mills	Not applicable - no paper mills in this CU.			
	Hydroelectric power generation (dams & reservoirs, tidal power): altered behaviour & ecosystems	Low	H C P	Low	A few small hydro dams. HADDS for new projects have to be mitigated or have compensation.
	Water extractions	Low – some heavy industry	H C P	Low	Must meet regulations in place/ monitoring, develop regional guidelines.
	Urbanization (altered hydrology)	Low – only small communities	H C P	Low	Project redesign/ existing regulation – monitoring.
	Infrastructure (roads/culverts) (fish passage)	Medium	H C P	Medium – near shore heavy industry	Existing regulations – more monitoring/ enforcement.
	Aquaculture siting	Low – several mussel operations	P	Low	Choose locations carefully, monitor, follow guidelines and best practices.

	Source (with examples)	Proportion of Salmon Affected LOW < 5%, MEDIUM 5% to 30%, HIGH > 30%, UNCERTAIN	Cause/ Time Frame Historic (H) Current (C) Potential (P)	Effect on Population (LOW < 5% spawner loss, MEDIUM 5% to 30% spawner loss, HIGH > 30% spawner loss, UNCERTAIN)	Management Alternatives/ Mitigation (*relative to existing actions*)
	Agriculture/Forestry/ Mining, etc.	Medium	H C P	Medium – potential mineral processing, past mining/processing	Enforcement/ monitoring of existing suite of regulations, compensations where required.
	Municipal, Provincial & Federal dredging	Low	H C P	Low - some current work in relation to heavy industry	Follow regulations in place, mitigations and compensations as required, minimize amount of dredging.
	CUMULATIVE EFFECT	Uncertain		Uncertain	
Shipping, Transport and Noise	Municipal, Provincial, Federal & private transport activities (including land and water based contaminants/ spills)	Uncertain – potential for impacts owing to high shipping activities in Placentia Bay	C	Uncertain	Work with Placentia Bay integrated management planning committee.
Fisheries on Prey of Salmon (for ex. capelin, smelt, shrimp)	Commercial, Recreational, Aboriginal fisheries for prey species	Uncertain	C	Uncertain	

	Source (with examples)	Proportion of Salmon Affected LOW < 5%, MEDIUM 5% to 30%, HIGH > 30%, UNCERTAIN	Cause/ Time Frame Historic (H) Current (C) Potential (P)	Effect on Population (LOW < 5% spawner loss, MEDIUM 5% to 30% spawner loss, HIGH > 30% spawner loss, UNCERTAIN)	Management Alternatives/ Mitigation (*relative to existing actions*)
Aquaculture (Salmon and other species)	Escapes from freshwater, marine facilities, disease, parasites, competition, effects on behaviour and migration, genetic introgression.	Low – Uncertain – no directed salmonid aquaculture activities	C P	Low – Uncertain – low numbers farmed salmon in one river, low numbers of rainbow trout in some rivers; at least one established rainbow population (Shalloway Pond Brook)	
Fish culture / stocking (non-commercial, including private, NGO, government)	Impacts on effective population size, over representation of families, domestication.	Uncertain – no current stocking in this CU	H	Uncertain	
Scientific Research	Government, university, community and Aboriginal groups.	Low	C	Low – minimal removals for scientific purposes.	
Military Activities	Field operations, shooting ranges.				

Air Pollutants	Acid rain	Medium – Uncertain: historically, rivers in this area had moderately low mean alkalinities and were potentially sensitive to acidification; generally mean pH values 5.5 to 6.0.	H P	Medium – Uncertain – current information is lacking.	
Potential Sources of Mortality /Harm Permitted and Un-permitted Activities Conservation Unit 5	**Source (with examples)**	**Proportion of Salmon Affected LOW < 5%, MEDIUM 5% to 30%, HIGH > 30%, UNCERTAIN**	**Cause/ Time Frame Historic (H) Current (C) Potential (P)**	**Effect on Population (LOW < 5% spawner loss, MEDIUM 5% to 30% spawner loss, HIGH > 30% spawner loss, UNCERTAIN)**	**Management Alternatives/ Mitigation (*relative to existing actions*)**
UN-PERMITTED					
Introductions of non-native / invasive species	Smallmouth bass, chain pickerel, muskellunge, rainbow trout, inverts., plants, algae.				
International High Seas Targeted	Flags of convenience?				
Ecotourism and Recreation	Water crafts, swimming, etc. effects on salmon behaviour and survival.				

Ecosystem Change	Climate change, changes in relative predator and prey abundances, disease.	Low – Uncertain – some rivers in this area are moderately impacted by low water levels and warm water temperatures	C P	Low – Uncertain – affect on salmon populations is unknown, however, marine survival is a significant area of concern.	

Appendix 2 cont'd. Summary of threats to and rating of effects on recovery and/or persistence of Atlantic salmon in the southwest area (SFA 11-12) of the South Newfoundland DU.

Potential Sources of Mortality /Harm Permitted and Un-permitted Activities Conservation Unit 6	Source (with examples)	Proportion of Salmon Affected LOW < 5%, MEDIUM 5% to 30%, HIGH > 30%, UNCERTAIN	Cause/ Time Frame Historic (H) Current (C) Potential (P)	Effect on Population (LOW < 5% spawner loss, MEDIUM 5% to 30% spawner loss, HIGH > 30% spawner loss, UNCERTAIN)	Management Alternatives/ Mitigation (*relative to existing actions*)
Directed Salmon Fishing	Aboriginal				Aboriginal right to fish salmon has been set aside for over 20 years as a conservation measure.
	Recreational: retention & release	Medium (season open from June 1 to September 7 – except Conne River). Moderate effort on some rivers.	C	Medium	Estimated at 12% for DU 4. Reductions in retention fisheries, increase use of catch-and-release measures, direct effort controls, season modifications, closures, environmental protocols.
	Commercial (domestic)	N/A – all commercial fisheries closed			
	High Seas (West Greenland / St.Pierre – Miquelon)	Low		Low	Reductions in internal use fisheries in those areas.
	Illegal (poaching)	Low - Unknown		Low – Unknown increased enforcement; stewardship with local groups; changed enforcement strategies for more targeted efforts.	Continued use of compliance monitors on selected watersheds, including Aboriginal guardians.
	CUMULATIVE EFFECT	Low - Medium		Low – Medium – many initiatives in place in recent years	New 5-year Integrated Fisheries Management Plan with major elements including river classification and adaptive management strategy.

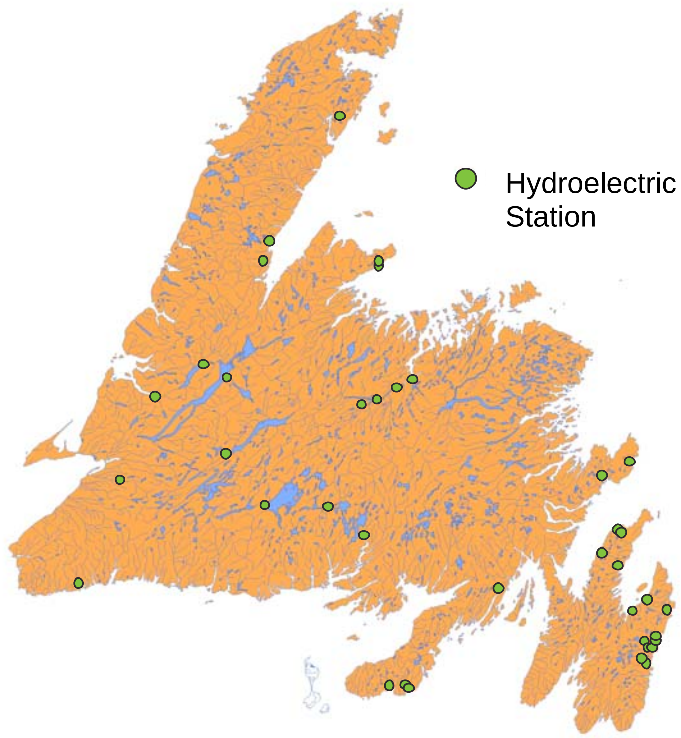
Potential Sources of Mortality /Harm Permitted and Un-permitted Activities Conservation Unit 6	Source (with examples)	Proportion of Salmon Affected LOW < 5%, MEDIUM 5% to 30%, HIGH > 30%, UNCERTAIN	Cause/ Time Frame Historic (H) Current (C) Potential (P)	Effect on Population (LOW < 5% spawner loss, MEDIUM 5% to 30% spawner loss, HIGH > 30% spawner loss, UNCERTAIN)	Management Alternatives/ Mitigation (*relative to existing actions*)
Bycatch of Salmon in Fisheries for Other Species	Aboriginal				
	Recreational				– incidental catch prohibited
	Commercial near-shore	Low (eel fishery)	C	Low	Eel Fishery – incidental catch prohibited.
	Commercial distant				
	CUMULATIVE EFFECT	Low		Low	
Salmon Fisheries Impacts on Salmon Habitat	Aboriginal				
	Recreational	Low		Low	
	Commercial				
	Illegal				
	CUMULATIVE EFFECT	Low		Low	
Mortality Associated with Water Use	Power generation at dams & tidal facilities (turbine morts, entrainment, stranding)	Low	C H P	Low	Fish Screen Guidelines; Section 32 enforcement; regional water withdrawal guideline development.
Habitat Alterations	Municipal waste water treatment facilities	Low	H C P	Low – few communities	Ensure current projects and future developments meet standards.
	Pulp & paper mills	Low	H C P (sawmills)	Low – Few operations	Current regulations and best management practices
	Hydroelectric power generation (dams & reservoirs, tidal power): altered behaviour & ecosystems.	Medium – one large project, some change to Bay characteristics.	H C P	Medium	HADDs for new projects have to be mitigated or have compensation; monitoring present mitigations; enforcement of present regulatory suite.

	Water extractions	Low – some light industry and communities.	H C P	Low	Must meet regulations in place; monitoring; develop regional guidelines.
	Source (with examples)	**Proportion of Salmon Affected LOW < 5%, MEDIUM 5% to 30%, HIGH > 30%, UNCERTAIN**	**Cause/ Time Frame Historic (H) Current (C) Potential (P)**	**Effect on Population (LOW < 5% spawner loss, MEDIUM 5% to 30% spawner loss, HIGH > 30% spawner loss, UNCERTAIN)**	**Management Alternatives/ Mitigation (*relative to existing actions*)**
	Urbanization (altered hydrology)	Low – only small communities	H C P	Low	Project redesign; existing regulation – monitoring.
	Infrastructure (roads/ culverts) (fish passage)	Low – few new roads or other projects	H C P	Low	Existing regulations – more monitoring/enforcement.
	Aquaculture siting	Medium – substantial finfish sites	H C P	Medium – Potential fouling of marine habitat. Water quality issues.	Choose locations carefully; active and continuing research; environmental effects monitoring; follow regulations and best practices, some are no longer active.
	Agriculture/forestry/ mining, etc.	Low	H C P	Low – extensive past forestry as well as some past mining.	Enforcement/monitoring of existing suite of regulations; compensations where required.
	Municipal, provincial & federal dredging	Low	P	Low	Follow regulations in place; mitigations and compensations as required; minimize amount of dredging.
	CUMULATIVE EFFECT	Uncertain		Uncertain	
Shipping, Transport and Noise	Municipal, Provincial, Federal & private transport activities (inc. land and water based contaminants/ spills)	Not Assessed	C H P	Not Assessed	Not applicable
Fisheries on					

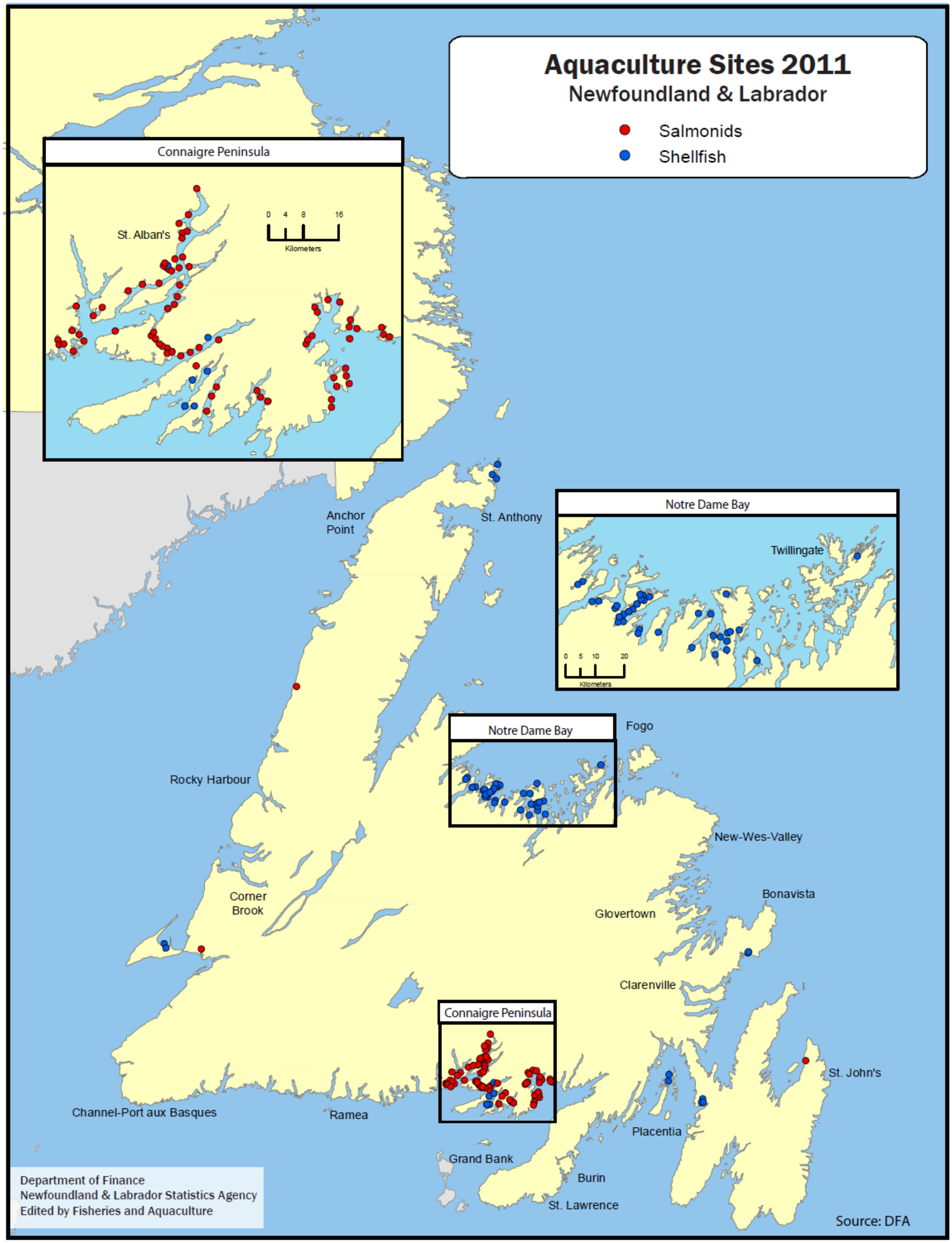
Prey of Salmon (capelin, smelt, shrimp)					
	Source (with examples)	**Proportion of Salmon Affected LOW < 5%, MEDIUM 5% to 30%, HIGH > 30%, UNCERTAIN**	**Cause/ Time Frame Historic (H) Current (C) Potential (P)**	**Effect on Population (LOW < 5% spawner loss, MEDIUM 5% to 30% spawner loss, HIGH > 30% spawner loss, UNCERTAIN)**	**Management Alternatives/ Mitigation (*relative to existing actions*)**
Aquaculture (Salmon and other species)	Escapes from freshwater, marine facilities, disease, parasites, competition, effects on behaviour and migration, genetic introgression.	Low - Uncertain – directed salmonid aquaculture activities occur in this CU; evidence of escaped farmed salmon have been documented in several rivers; higher numbers of escaped steelhead (rainbow) trout have been found.	C P	Medium – Uncertain – potential exists for greater interactions owing to substantive expansion of aquaculture industry into Fortune Bay.	
Fish culture / stocking (non-commercial, including private, NGO, government)	Impacts on effective population size, over representation of families, domestication.	Uncertain		Uncertain	
Scientific Research	Government, university, community and Aboriginal groups.	Low	C	Low – minimal removals for scientific purposes.	
Military Activities	Field operations, shooting ranges,				
Air Pollutants	Acid rain	Medium – Uncertain	H P	Medium – Uncertain: Historically, rivers in this area demonstrated low mean alkalinities with average pH values often < 5.5 and were among the most sensitive of all of	

				insular Newfoundland. Current information is lacking.	
	Source (with examples)	**Proportion of Salmon Affected LOW < 5%, MEDIUM 5% to 30%, HIGH > 30%, UNCERTAIN**	**Cause/ Time Frame Historic (H) Current (C) Potential (P)**	**Effect on Population (LOW < 5% spawner loss, MEDIUM 5% to 30% spawner loss, HIGH > 30% spawner loss, UNCERTAIN)**	**Management Alternatives/ Mitigation (*relative to existing actions*)**
UN-PERMITTED					
Introductions of non-native / invasive species	Smallmouth bass, chain pickerel, muskellunge, rainbow trout, invertebrates, plants, algae.				
International High Seas Targeted	Flags of convenience?				
Ecotourism and Recreation	Activities such as water crafts and swimming, can affect salmon behaviour and survival.				
Ecosystem change	Climate change, changes in relative predator and prey abundances, disease.	Low - Uncertain – -some rivers in this area are periodically impacted by low water levels and warm water temperatures.	C P	Low - Uncertain – affect on salmon populations is unknown.	

Appendix 3: Locations of hydroelectric generating stations in insular Newfoundland.



Appendix 4: Locations of Aquaculture Licences in Newfoundland.



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