Fisheries and Oceans Canada / Pêches et Océans Canada

Ecosystems and Oceans Science / Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat (CSAS)

Research Document 2023/008

Quebec Region

Information on the Atlantic Salmon (*Salmo salar*) in Quebec for the Preparation of the Second Status Report by the Committee on the Status of Endangered Wildlife in Canada

April, J., Bujold, V., Cauchon, V., Doucet-Caron, J., Gagnon, K., Guérard, M., Le Breton, S., Nadeau, V., Plourde-Lavoie, P. and Bujold, J.-N.

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May 2023

Canada

Foreword

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

Published by:

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

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

ISSN 1919-5044
ISBN 978-0-660-48049-7 Cat. No. Fs70-5/2023-008E-PDF

Correct citation for this publication:

April, J., Bujold, V., Cauchon, V., Doucet-Caron, J., Gagnon, K., Guérard, M., Le Breton, S., Nadeau, V., Plourde-Lavoie, P. and Bujold, J.-N. 2023. Information on the Atlantic Salmon (*Salmo salar*) in Quebec for the Preparation of the Second Status Report by the Committee on the Status of Endangered Wildlife in Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2023/008. v + 78 p.

Aussi disponible en français :

*April, J., Bujold, V., Cauchon, V., Doucet-Caron, J., Gagnon, K., Guérard, M., Le Breton, S., Nadeau, V., Plourde-Lavoie, P. et Bujold, J.-N. 2023. Information sur le saumon atlantique (*Salmo salar*) au Québec pour la préparation du deuxième rapport de situation du Comité sur la situation des espèces en péril au Canada. Secr. can. des avis sci. du MPO. Doc. de rech. 2023/008. v + 81 p.*

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ABSTRACT

This document presents an update of the information and analyses on the Atlantic Salmon in Quebec gathered since the first review conducted in 2010, and is intended to support the reassessment of the status of the Atlantic Salmon (*Salmo salar*) by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The information presented includes life history characteristics, habitat description, population abundance and threats to the species. A review of the data shows that the biological characteristics of the Atlantic Salmon and its freshwater habitats vary greatly among populations. Demographic trends also show high variability between populations. Although declines in salmon abundance were recorded in several rivers during the 1980s and 1990s, abundance levels have remained relatively stable over the past 20 years. In other rivers, abundance levels were fairly stable throughout the time series beginning in 1984. A few rivers remain in slow decline. However, no population appears to have become extinct, and the species' range has remained largely unchanged over time. The pressure exerted by various types of fishing, which is relatively well controlled and documented, has continued to decrease. Several other threats whose impacts are less well understood have a combined effect on Atlantic Salmon populations.

INTRODUCTION

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has reassessed the status of anadromous Atlantic Salmon populations in Canada. In 2010, the Atlantic Salmon (*Salmo salar*) was assessed by COSEWIC as comprising 16 designatable units (DUs), of which the Lake Ontario DU was assessed as extinct in Canada (COSEWIC 2010). For the remaining DUs, the status assigned by COSEWIC ranged from "Data Deficient" to "Endangered." Nearly 10 years later, the need to update the status of the DUs was identified in COSEWIC's call for bids in fall 2019.

The Government of Quebec, as the entity responsible for the management of freshwater, anadromous and catadromous fish in Quebec waters (tidal and non-tidal) and as the producer and archivist of data on these species, is required to provide COSEWIC with the best available data so that it can accurately assess the status of the species in question. The Ministère des Forêts, de la Faune et des Parcs (MFFP) was assigned responsibility for these fish species through a regulatory delegation under the *Fisheries Act*, which was formalized by the signing of an agreement in 1922.

The purpose of this document is to gather information from MFFP that COSEWIC can use to determine the status of the Atlantic Salmon populations in Quebec. Particular emphasis is placed on information acquired since the last COSEWIC assessment since much of the information prior to 2010 is already available in various documents (e.g., DFO and MRNF 2009; COSEWIC 2010). This document is not a review of the published scientific literature, but rather a review of information and data internal to the Government of Quebec. Contextual elements necessary for interpreting the data are also presented. The information contained in this report includes data on population characteristics, observed trends and threats to the species. The data and information held by MFFP up t and including 2019 were made available to the authors of the species status report, the co-chairs of the COSEWIC Fishes Specialist Subcommittee and COSEWIC.

ANADROMOUS ATLANTIC SALMON

LIFE HISTORY SUMMARY

Anadromous Atlantic Salmon are iteroparous salmonids that spawn in freshwater after undertaking a long marine migration (Aas et al. 2010). This document specifically deals with anadromous populations of this species, and for the remainder of this text, the term "salmon" will be used to refer exclusively to anadromous Atlantic Salmon. There are also populations of this species, *Salmo salar*, in which all individuals spend their entire lives in freshwater and are not anadromous (Hutchings et al. 2019). For the purposes of this document, the term "ouananiches" will be used to refer to these populations.

The first years of a salmon's life, typically between 2 and 5 years, are spent in rivers, (Aas et al. 2010). The salmon then leave the river as smolts and head for the sea. They return to their natal river as adults after a variable amount of time. Salmon returning from the sea are commonly classified by size and described as small or large salmon (MFFP 2016). Small salmon are less than 63 cm in fork length and are generally males that have spent one winter at sea. Large salmon have a fork length greater than or equal to 63 cm. They consist primarily of females returning to the river to spawn for the first time after spending two or more winters at sea. The Atlantic salmon (*Salmo salar*) is an iteroparous species with spawning populations consisting of first time maiden and repeat-spawning individuals. Precocious male parr, that mature before spending time at sea, also participate in egg fertilization.

RANGE

Atlantic Salmon have colonized a variety of habitats connected with the Atlantic Ocean (Aas et al. 2010). In North America, they range from Connecticut to Ungava Bay, and in Europe, they colonize rivers from Spain to northern Russia. They also can be found in the waters off Greenland. In Canada, salmon are found in the provinces of Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador.

In Quebec, 111 salmon rivers are defined in the *Quebec Fishery Regulations* (SOR/90-214). As some tributaries of these rivers are major watercourses and many of them host distinct salmon populations, the species is managed independently on 118 rivers (MFFP 2016, 2020). On the north shore of the St. Lawrence River, the species' range extends, eastward from the Jacques-Cartier River in the Quebec City region to the Brador-Est River, located near the Labrador border. On the south shore of the St. Lawrence, its range extends eastward from the Ouelle River in the Kamouraska region to the Restigouche River on the New Brunswick border, and includes the Gaspé Peninsula and Chaleur Bay. The species is also found in several rivers on Anticosti Island. Salmon are found in a few other rivers in Quebec as well, but since these rivers are very small (e.g., Brick, Tonnerre, Port-Daniel du Milieu, and Anse à la Barbe), they are not defined in the *Quebec Fishery Regulations.* These populations are marginal and are not harvested by recreational fishers.. The salmon rivers defined in the *Quebec Fishery Regulations* are shown in Figure 1.

The distribution of anadromous Atlantic Salmon in Quebec does not appear to have changed since the arrival of the first Europeans. The extensive historical accounts on salmon fishing activities indicates that the Jacques-Cartier River is the most upstream river in the St. Lawrence River system that has supported a population of anadromous salmon over the past several hundred years (Boucher 1664; Nettle 1857). Thermal conditions in the St. Lawrence River after postglacial colonization would have been a barrier to recurrent upstream migration of salmon (Legendre and Mongeau 1980). There are a few historical references to the presence of salmon upstream of the Jacques-Cartier River in the St. Lawrence River. However, analysis of these anecdotal records suggests confusion between species and locations, as well as possible observations of individuals exhibiting marginal behaviour during years with unusual environmental conditions (see Legendre and Mongeau 1980). According to the available information, no formally described Atlantic Salmon population has become extinct in Quebec. However, it is possible that a few small marginal populations may have existed and disappeared without being formally documented.

The co-occurrence of anadromous Atlantic Salmon and resident salmon (ouananiches) within a river section has been documented at a few locations in Quebec. This includes three rivers in the North Shore region, namely the Watshishou, Musquaro and Corneille rivers (Riley and Power 1987; Coté and Bernatchez 2013). On the Corneille and Musquaro rivers, genetic analyses have shown evidence of hybridization between ouananiches and anadromous salmon (Coté and Bernatchez 2013; Perrier et al. 2013).

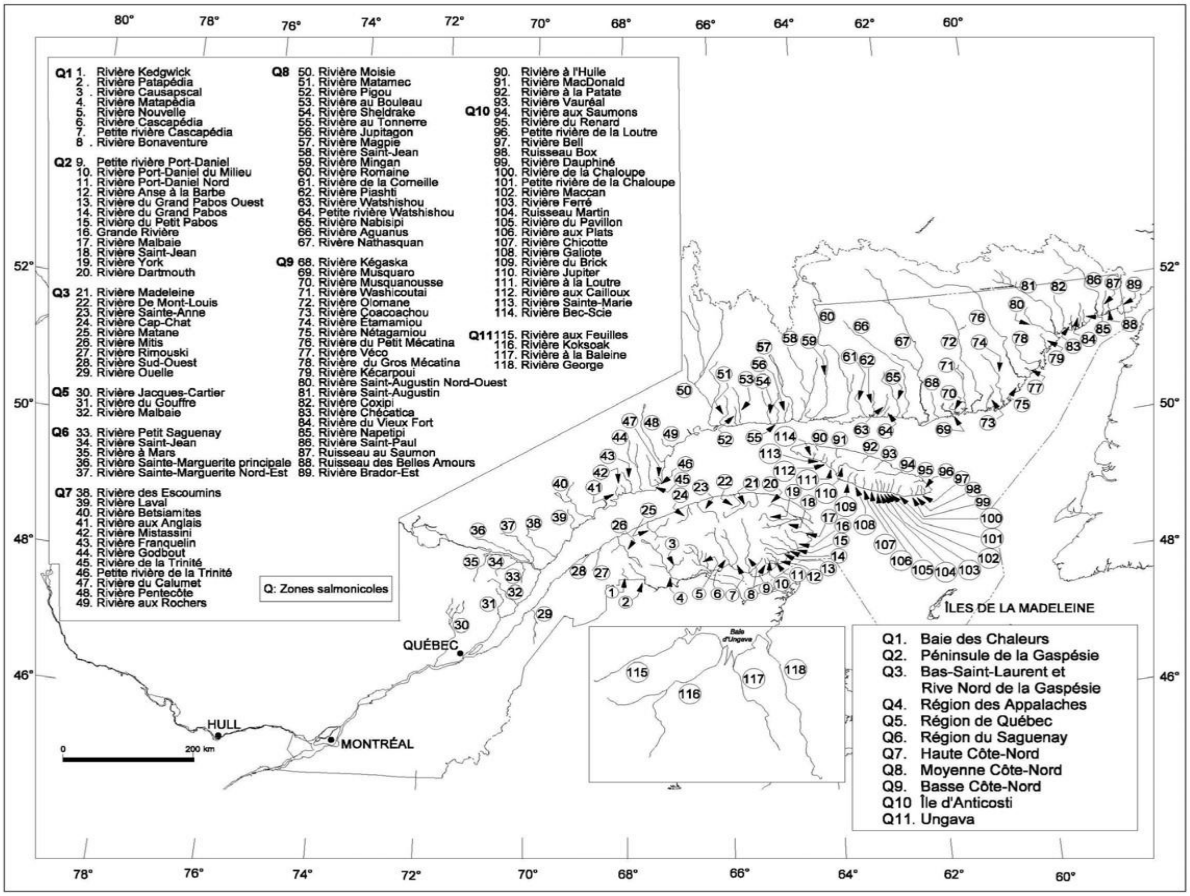


Figure 1. Quebec salmon rivers

The Nastapoka River, located on the east coast of Hudson Bay, does not seem to support a salmon population, as has sometimes been mentioned (Morin 1991), but rather a population of ouananiches (Legendre 1990). Although individuals of the species *Salmo salar* are present in the Nastapoka River estuary, it is unlikely that they can complete an anadromous life cycle there. This river has a 35-metre waterfall which is located 1.5 km upstream from its mouth on the Hudson Bay; the waterfall prevents salmon in this area from accessing sufficient suitable habitats to complete their life cycle. It seems more likely that ouananiches, which occupy the Nastapoka River upstream of this waterfall, are moving downstream and surviving in the estuary. This is consistent with the analysis of scales from specimens caught in the estuary, which show no clear signs of time spent at sea (Legendre 1990). In addition, the results of microchemical analyses of otoliths show that the concentration of strontium—an element that accumulates in otoliths and is relatively representative of environmental salinity—increases after a few years of life for most of the individuals captured around the river mouth, suggesting that these fish first lived in freshwater, upstream from the falls (preliminary data from Nunavik Parks and MFFP). In light of this information, the Nastapoka River population is not considered further in this document. Occasional captures are reported further north in Hudson Bay, but these events are marginal, and there are no data that would make it possible to determine whether they are anadromous individuals or ouananiches.

Some Ungava Bay salmon populations show migration patterns that are rarely or never documented elsewhere and are intermediate between those of anadromous salmon and ouananiches. This is the case in the large Koksoak River system, where four distinct migration patterns are encountered (Coté et al. 1984; Robitaille et al. 1984; Power et al. 1987). In addition to the known anadromous and resident (ouananiches) populations of Atlantic Salmon, some individuals, referred to as “estuarine”, remain in the brackish waters of the river after smoltification to continue their growth rather than migrating to the sea. Finally, some individuals in the Koksoak River, called “mixed-life-cycle” salmon, have a life cycle that combines periods of growth at sea and in the estuary. A recent analysis of scale samples from the three major tributaries accessible to Koksoak River salmon—the Aux Mélèzes, Du Gué and Delay rivers—indicates that estuarine salmon frequent all of these watercourses.

REVIEW OF DESIGNATABLE UNITS

Status assessments and conservation of biological diversity require that units below the species level be considered when appropriate. For example, where a single status designation does not reflect the extent of evolutionarily significant diversity within a species, COSEWIC may identify intraspecific DUs. These DUs should be discrete and evolutionarily significant units of the taxonomic species. More details on the definition of DUs are available on the COSEWIC website.

The structure of anadromous Atlantic Salmon DUs was reassessed at the Zonal Peer Review Meeting – Part 1: Review of designatable unit information from October 26 to 28, 2020. As such, some of the boundaries of these DUs were revised from COSEWIC’s 2010 assessment, and four new DUs have been created in Canada based on knowledge acquired in the intervening years. In order to present information in the manner most relevant to the COSEWIC review, several sections of this document are structured according to the DUs proposed in that review (Lehnert et al. 2023). A map of these DUs is presented in Figure 2. Given the biology of the species (e.g., fidelity to natal river), it is important to also assess the status of salmon at a lower hierarchical level than the DUs, that is, at the level of individual populations.

Quebec salmon populations are distributed within seven DUs proposed at the Zonal Peer Review Meeting – Part 1; descriptions of each of these DUs are provided below.

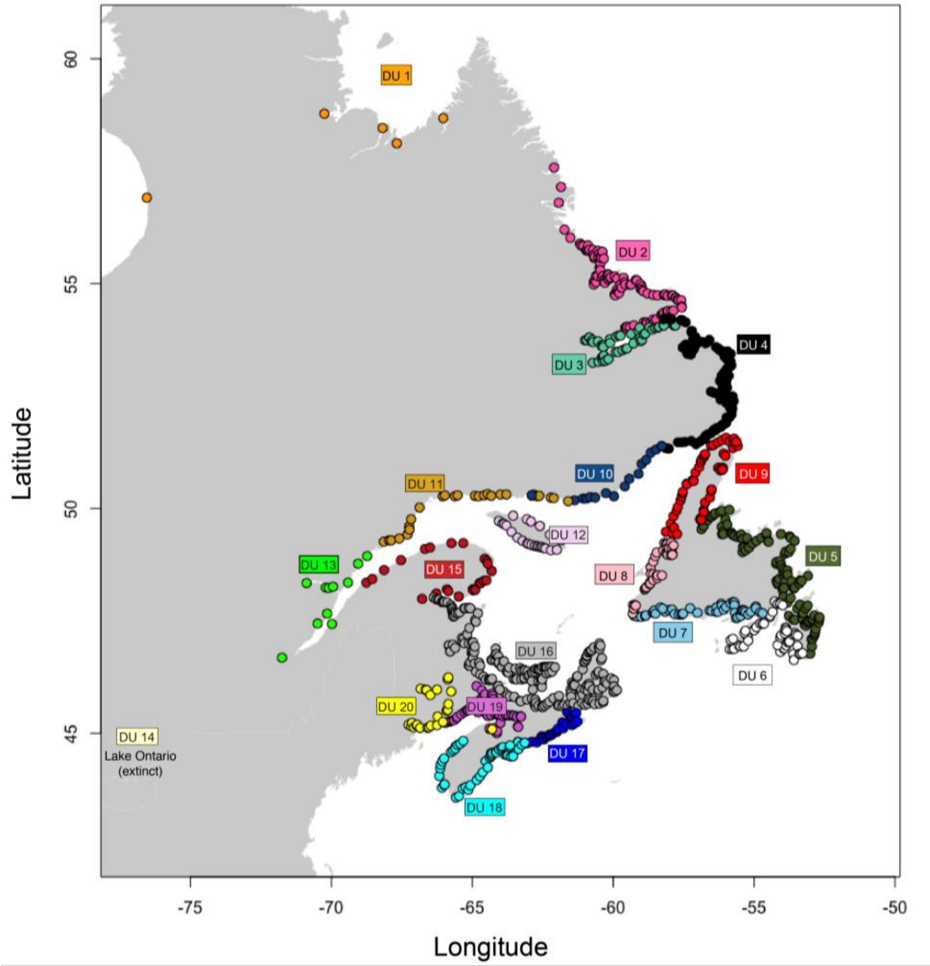


Figure 2. Map of proposed DUs from the Zonal Peer Review Meeting – Part 1: Review of designatable unit information from October 26 to 28, 2020. Figure taken from Lehnert et al. 2023.

DU 1 – NUNAVIK

This is the northernmost DU in the species' Canadian range. It is approximately 650 km from the nearest DU, that of Northern Labrador (DU 2). The Nunavik DU is characterized by four rivers that flow into Ungava Bay. From west to east, these are the Leaf, Koksoak, Baleine and George rivers. These are major rivers with long-distance salmon runs, most of which have large tributaries that are also inhabited by salmon. The salmon in this DU exhibit migration patterns that are atypical of southern rivers, and include individuals that limit their migration to estuarine areas before returning to the river to spawn.

This DU remains unchanged from COSEWIC's 2010 assessment.

DU 4 – SOUTHERN LABRADOR

The Southern Labrador DU straddles Labrador and Quebec. In Quebec, it covers the eastern north Shore of the St. Lawrence River and includes six rivers. These are, from east to west, the Brador Est, Belles Amours, Salmon Stream, Saint-Paul, Vieux-Fort and Napetipi rivers. In contrast to the general trends of salmon rivers in the province, these rivers are characterized by a series of lakes and rivers along the salmon's migratory route, as well as by a high proportion of individuals that have spent a single winter at sea (small salmon).

This DU was created by subdividing DU 2 (Labrador), which is defined in COSEWIC's 2010 report, because of the differences in genetics and life history characteristics that exist within the former DU 2.

DU 10 – QUEBEC EASTERN NORTH SHORE

This DU extends westward from the north shore of the St. Lawrence River—from the Chécatica River to the Kégaska River—and also includes the Corneille River, which is located east of the other rivers in this DU. The geographic coverage of this DU is therefore not contiguous (Figure 2). This situation is explained by the genetic characteristics of the Corneille River population, which are more closely associated with this population group than with its neighbouring populations. The genetic characteristics of the Corneille population cannot be explained by stocking, since this river has never been stocked, according to the MFFP database. The neighbouring rivers have also not been subject to a sustained stocking program. This DU includes 17 rivers characterized by a high proportion of individuals that have spent one year at sea, just like DU 4.

This DU corresponds to DU 7 described in COSEWIC's 2010 report and remains relatively unchanged except for the inclusion of the Corneille River.

DU 11 – QUEBEC WESTERN NORTH SHORE

This DU extends westward on the north shore of the St. Lawrence from the Natashquan River to the Aux Anglais River and includes 26 rivers spread over an area with more than 650 km of shoreline. Unlike the other DUs on the north shore of the St. Lawrence, this DU is characterized by a high abundance of salmon that have spent two or more winters at sea (multi-sea-winter; MSW).

This DU largely corresponds to DU 8 described in COSEWIC's 2010 report, except for a proposed boundary change to exclude three rivers, namely Escoumins, Laval and Betsiamites.

DU 12 – ANTICOSTI ISLAND

This DU includes all 25 rivers frequented by salmon on Anticosti Island. Many of these rivers are small, and some of them have marginal populations. The Chaloupe, Ferrée, Jupiter, À la Loutre and Aux Saumons rivers are the main rivers in this DU. The proportions of small and large salmon in this DU are close to the average proportions observed among Quebec populations, with a predominance of MSW salmon.

This DU remains unchanged from COSEWIC's 2010 assessment, except that it was identified as DU 9 in that report.

DU 13 – INNER ST. LAWRENCE

This DU extends westward from the north shore of the St. Lawrence—from the Betsiamites River to the Jacques-Cartier River—and includes the four salmon rivers that flow into the Saguenay River. It also includes the Ouelle River, located on the south shore of the St. Lawrence, for a total of 11 rivers. The proportions of small and large salmon in this DU are typical of Quebec populations.

This DU largely corresponds to DU 10 in COSEWIC's 2010 report, except for a boundary change proposed in order to include three rivers, namely Des Escoumins, Laval and Betsiamites, formerly included in DU 8.

DU 15 – GASPÉ

This DU extends eastward from the south shore of the St. Lawrence River—from the Sud-Ouest River to the Restigouche River (included), which is located partly in Quebec and partly in New Brunswick. It includes the rivers of the Gaspé Peninsula and Chaleur Bay, for a total of 25 rivers. The proportions of small and large salmon in this DU are typical of Quebec populations.

This DU is a proposed subdivision of DU 12 (Gaspé–Southern Gulf of St. Lawrence) from COSEWIC's 2010 report; this subdivision was proposed because of genetic differences with the new proposed DU for the Southern Gulf of St. Lawrence–Cape Breton (DU 16).

POPULATION INTEGRITY

Just over 150,928,000 salmon of all life stages were stocked in 29 Quebec rivers between 1881 and 2019. A few rivers stand out for their high level of historical stocking. For example, the following rivers have been stocked for more than 40 years since 1881: Petite-Cascapédia, Saint-Jean (Gaspé), Petit-Saguenay, Cap-Chat, Dartmouth, Sainte-Anne, Bonaventure, Jacques-Cartier, Port-Daniel, Saint-Jean (North Shore) and Rimouski. However, the number of salmon stocked and the number of rivers involved has been declining since the 1990s. Since 2012, stocking has been carried out in about four to six rivers annually, and stocking for fisheries enhancement purposes has been gradually abandoned in favour of conservation stocking, carried out using a local line, for populations whose abundance justifies a restocking effort.

Stocking methods have thus changed considerably in recent years. In addition, in order to maximize positive outcomes while minimizing negative impacts, new stocking guidelines were introduced in 2012 and stocking efforts are governed by the Atlantic Salmon Management Plan 2016-2026. Appendix 1 presents the main elements of the guidelines.

Temporal genetic monitoring of nine salmon populations has demonstrated that the decreases in genetic diversity regularly associated with stocking are relatively small in Quebec and appear to be diminishing over time (Perrier et al. 2016). Furthermore, none of the populations that have been stocked for more than 40 years and subjected to genetic structure analyses (nine out of eleven populations) have shown unusually low levels of genetic divergence compared to other salmon populations (e.g., Dionne et al. 2008). It seems unlikely that stocking has altered the genetic structure of populations enough to significantly affect the definition of the DUs put forward by Lehnert et al. 2023. The available information indicates that all documented salmon populations in Quebec should be considered wild.

Hybridization of wild salmon with escaped farmed salmon does not currently appear to be a major issue in Quebec. The few reports of escaped farmed salmon in rivers in the province remain unconfirmed. There are currently no commercial open-pen Atlantic Salmon farms in Quebec. However, such farms are present in the Atlantic provinces and could impact Quebec populations.

LIFE HISTORY CHARACTERISTICS

PORTRAIT OF POPULATIONS

Several life history traits, such as average age at smoltification and age at maturity, vary from one population to another. A portrait of Canadian populations is presented in Chaput et al. (2006). Spatial and temporal variation in the proportion of repeat spawners in the eastern Atlantic was recently described by Bordeleau et al. (2020).

The proportions of small and large salmon in Quebec populations are available from the return data presented in the *Bilan de l'exploitation du saumon au Québec* (MFFP 2020). The highest proportions of large salmon are observed in the Moisie (over 90% based on fishing statistics), Cascapedia (2014–2018 average returns = 93%) and Causapscal (2014–2018 average returns = 94%) rivers. The lowest proportion of large salmon recently documented is observed in the Rivière du Vieux-Fort (2014–2018 average returns = 7%).

The age at smoltification of salmon from 45 Quebec salmon rivers or tributaries is presented in Appendix 2. These numbers show that the average age at smoltification for salmon in the Jacques-Cartier River (DU 13) is as young as 2.00 years, while at the other end of the spectrum, salmon in the Georges River (DU 1) migrate to the sea for the first time at an average age of 5.49 years.

Mean generation times for Quebec salmon populations typically range from 5.5 to 6.0 years. Only the northern populations of Ungava Bay (DU 1) have average values of up to 7 years or more, due in part to an equally high age at smoltification.

The average weight of small and large salmon from 64 rivers is presented in Appendix 3. The data cover the period from 2015 to 2019. The weight of large salmon in some Gaspé rivers is particularly high, while the weight of small and large salmon is particularly low on Anticosti Island. Historical data show that these patterns are not recent and, despite annual fluctuations, do not appear to have changed over time.

Fecundity values representative of Quebec populations were updated by Leclerc in 2015. The fecundity of one-sea-winter (1SW) salmon is estimated at 2,025 eggs/kg. The fecundity of virgin MSW salmon is estimated at 1,757 eggs/kg, and that of previously spawned salmon is estimated at 1,410 eggs/kg. In a few cases, values more appropriate to the specific population situation are available in the MFFP databases.

The age frequencies of different population segments, the proportions of females in these population segments, and the average weight by age for 12 salmon populations are presented by Dionne et al. (2015). The age frequencies of these populations are presented in Table 1.

Table 1. Average age frequencies of different population segments for 12 Quebec salmon populations. Repeat spawners salmon are presented here separately from virgin MSW salmon.

River	1SW				MSW				Repeat spawners								
	3	4	5	6	4	5	6	7	4	5	6	7	8	9	10	11	12
York	0.06	0.56	0.37	0.02	0.02	0.47	0.38	0.13	-	0.04	0.15	0.25	0.25	0.24	0.06	0.01	-
Dartmouth	0.04	0.77	0.16	0.03	0.03	0.51	0.40	0.06	-	0.05	0.31	0.23	0.32	0.03	0.07	-	-
Bonaventure	0.05	0.64	0.30	0.01	0.05	0.58	0.33	0.03	0.01	0.05	0.14	0.40	0.25	0.08	0.04	0.02	0.01
Cascapédia	0.03	0.76	0.20	0.01	0.01	0.41	0.45	0.13	-	-	0.04	0.27	0.41	0.20	0.06	0.02	-
Grande-Rivière	0.06	0.57	0.35	0.01	0.06	0.59	0.31	0.05	-	-	0.04	0.53	0.30	0.13	-	-	-
Sainte-Anne	0.18	0.71	0.11	-	0.06	0.67	0.24	0.03	0.02	0.09	0.47	0.38	0.04	-	-	-	-
Madeleine	0.08	0.83	0.09	-	0.07	0.80	0.13	-	-	0.28	0.54	0.18	-	-	-	-	-
Matane	0.25	0.73	0.03	-	0.23	0.71	0.06	-	-	0.09	0.26	0.33	0.27	0.03	0.02	-	-
Jupiter	0.03	0.65	0.32	0.01	0.02	0.71	0.26	-	-	0.05	0.36	0.49	0.11	-	-	-	-
Chaloupe	0.10	0.75	0.14	0.01	0.13	0.77	0.10	-	-	-	0.62	0.38	-	-	-	-	-
Saint-Jean	0.06	0.67	0.26	0.01	0.07	0.65	0.27	0.01	-	0.03	0.26	0.43	0.20	0.07	0.01	-	-
Trinité	0.11	0.77	0.12	-	0.12	0.79	0.08	-	0.03	0.23	0.36	0.31	0.04	0.02	-	-	-

POPULATION DYNAMICS OF CONTROL RIVERS

The populations of the Saint-Jean River in Gaspé and the Trinité River on the North Shore have been monitored for over 40 years. This monitoring provides a better understanding of changes in the abundance, characteristics, in-river survival rates and sea return rates of these populations. It is carried out by counting adults and estimating the number of downstream-migrating smolts using the capture-mark-recapture method. Details of this monitoring are published in an annual report (e.g., Cauchon and April 2020).

Similar data have been collected over a few years in the Vieux-Fort River. Monitoring of adult salmon returns was conducted from 2010 to 2019 and allowed for comparison with data collected on the same river from 1996 to 1998. From 2014 to 2018, monitoring of smolt downstream migration was added to the project in order to characterize and assess the abundance of smolts, which had never been done in the region's rivers.

These three monitoring projects have revealed significant differences in population characteristics, four of which are presented in Table 2. The egg-to-smolt survival rate, calculated over four years, averages 1.01% in the Vieux-Fort River, which is lower than in the Saint-Jean River and Trinité River populations. This may be related to the greater time spent in the river on the Lower North Shore, which results in higher intraspecific competition. By contrast, the return rate of adult salmon from the Vieux-Fort River is much higher than that observed in the Saint-Jean and Trinité rivers, possibly due to the shorter marine migration and larger smolt size in the Vieux-Fort River.

Table 2. Difference in four characteristics of salmon populations in the Saint-Jean (Gaspé), Trinité and Vieux-Fort rivers.

River	Saint-Jean	Trinité	Vieux-Fort
Average total length of smolts from 2014 to 2018 (cm)	12.7	13.6	20.0
Average fork length of 1SW from 2010 to 2019 (cm)	55.0	53.9	56.7
Egg-to-smolt survival rate from 2010 to 2013 (%)	1.24	1.83	1.01
Smolt-to-adult return rate from 2014 to 2017 (%)	1.53	1.41	4.59

Long-term monitoring of salmon populations in the Saint-Jean and Trinité rivers provides a description of changes in marine and river survival rates (Figures 3 and 4). Using the longest time scale available, i.e., since 1980 for the Trinité River and since 1985 for the Saint-Jean River, the in-river egg-to-smolt survival rate shows a significant decrease over time in both control rivers (Saint-Jean: historical average = 2.28%; Trinité: historical average = 2.23%). For the marine life phase, a significant historical decrease in the smolt-to-adult return rate has been observed in the Trinité River, for which the longest data series is available (historical average = 2.12%). The Saint-Jean River population shows no significant trend in return rates, despite marked fluctuations over the years (historical mean = 1.39%).

An analysis of more recent population trends, based on the last 15 years for which data are available, reveals a different picture. The egg-to-smolt survival rate for the 1999 to 2013 cohorts shows no significant trend for the Trinité River population (mean = 2.19%). For the Saint-Jean River, however, the analysis of the same cohorts shows a significant downward trend in in-river survival (mean = 1.77%). For smolt-to-adult survival, data for the cohorts from 2002 to 2016 were used for the Saint-Jean River population (mean = 1.72%), and data for the cohorts from 2003 to 2017 were used for the Trinité River (mean = 1.52%), because of the difference in generation times between these populations. For both rivers, marine survival does not show a significant trend.

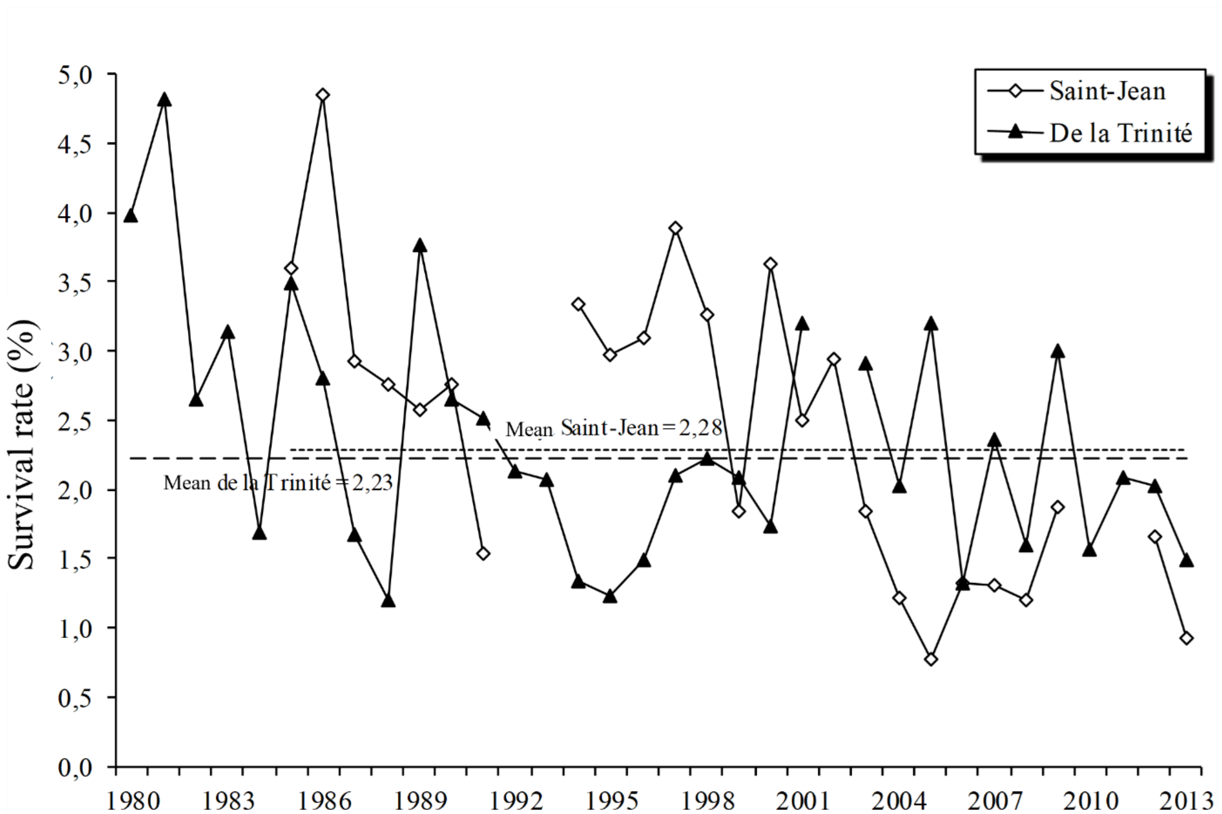


Figure 3. Egg-to-smolt survival rates for the Saint-Jean River (Gaspé) and Trinité River populations.

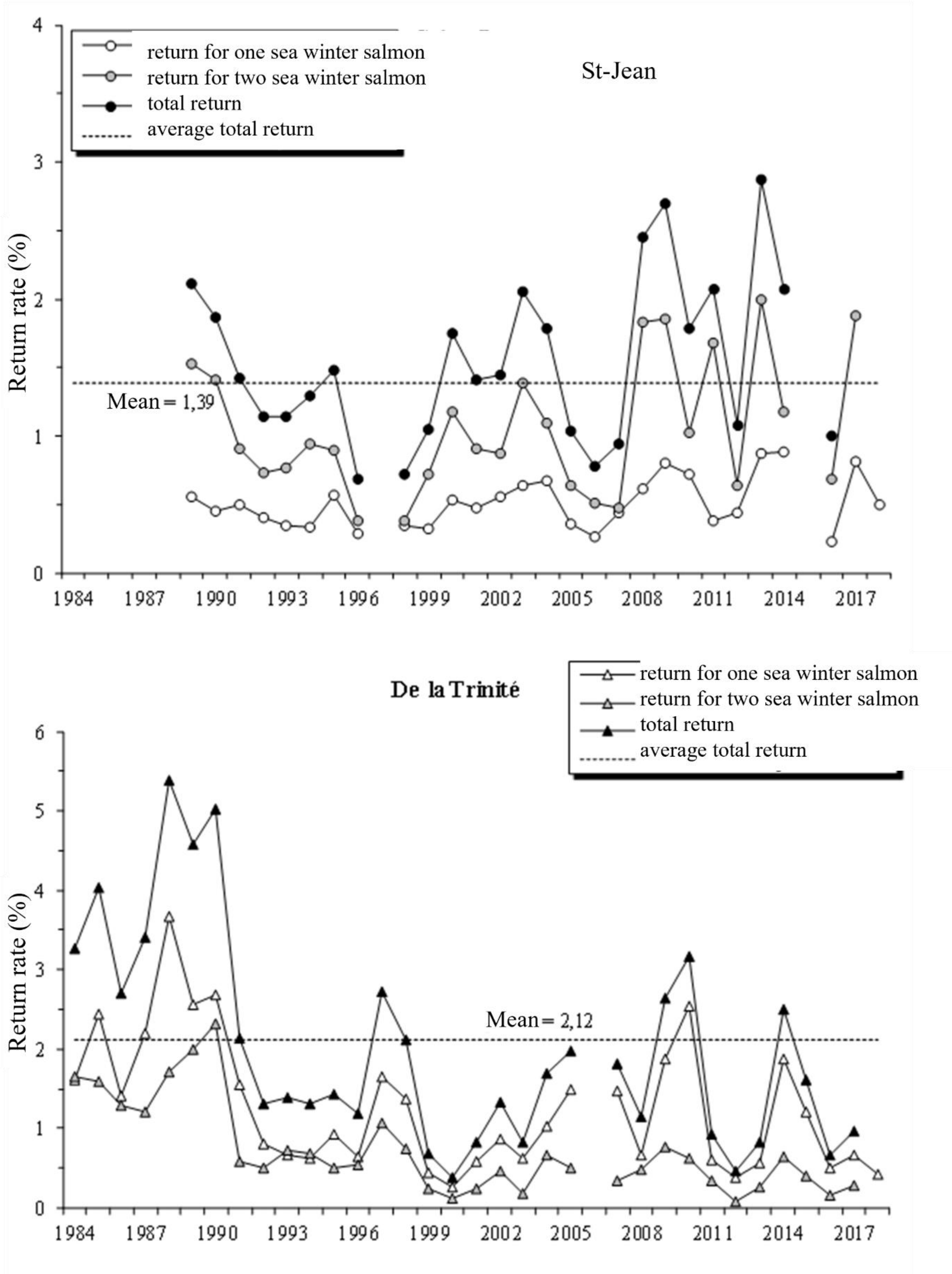


Figure 4. Smolt-to-adult sea return rates for the Saint-Jean River (Gaspé) and Trinité River populations.

SPECIES HABITAT CHARACTERISTICS

SPECIFIC HABITAT REQUIREMENTS AND IMPACT ON POPULATION DYNAMICS

In-river survival rates of juvenile salmon are strongly influenced by density-dependent factors. Fry disperse little, are territorial and compete not only with their own cohort but also with previous cohorts present in the river (Aas et al. 2010). This intraspecific competition is primarily related to territory defence and the limited food sources (Hilborn and Walters 1992; Peress 1996). An increase in the density of juveniles in the river decreases the chances of egg-to-smolt survival. At low densities, survival and growth increase. From a population dynamics perspective, this influences the relationship between the number of spawners and the number of recruits they produce. The availability of freshwater habitat is a limiting factor in the abundance of a salmon population.

The stock-recruitment (SR) relationship, that is, the relationship between the number of spawners and the number of recruits, is an important tool for managing Atlantic Salmon (Prevost and Chaput 2001). This relationship is used to define various biological reference points that are useful for fisheries management and conservation actions (Holt et al. 2009; DFO 2015).

A stock recruitment model with a hierarchical Bayesian approach was developed for Quebec rivers by Dionne et al. (2015). It incorporates data from 12 index rivers for the 1972–2005 cohorts. The model also incorporates a habitat covariate (production units) enabling the extrapolation of the SR relationship to rivers without biological data (discussed in more detail in the next section, entitled “Habitat Quality Index and Production Units”). Two biological reference points, considered as conservation thresholds and calculated on a river-by-river basis, were selected from this model for the Atlantic Salmon Management Plan 2016-2022. They are expressed as the number of eggs required per river.

The optimal conservation threshold represents the abundance level for which there is a 95% probability of being at or above the level that is necessary to maintain an optimal stock (MFFP 2016). The demographic conservation threshold is the abundance level at which there is a 75% certainty that at least 50% of the maximum recruitment will be produced (MFFP 2016). There is a third conservation threshold which is based on genetic considerations and remains fixed from one population to another. This is the genetic conservation threshold, which is set at 200 adult salmon per river. Under the terms of the 2016 Atlantic Salmon Management Plan, populations whose average abundance over the past 5 years exceeds the optimal conservation threshold are classified in the healthy zone. Populations whose average abundance level over the past 5 years is below the optimal conservation threshold but on average exceeds the demographic and genetic conservation thresholds over the same period are classified in the cautious zone. Populations that do not meet either the genetic conservation threshold or the demographic conservation threshold are classified in the critical zone.

HABITAT QUALITY INDEX AND PRODUCTION UNITS

The spatial distribution of freshwater salmon habitat in Quebec by DU is presented in Appendices 4 to 9. Appendix 10 presents the known accessible area of Quebec salmon rivers.

Quebec salmon rivers have a variety of aquatic habitats along their course, not all of which have the same production potential for salmon. Some parts of rivers are clearly less productive than others. The habitat quality index (HQI) makes it possible to divide rivers according to their level of productivity and to quantify the productive area of the rivers, in order to calculate a conservation threshold for the majority of rivers in Quebec.

The number of production units (PUs) is calculated by taking into account the characterization of rivers from the interpretation of aerial images and the HQI developed for salmon parr based on the relative abundance of parr sampled by electrofishing at 1,313 sampling stations. Rivers are segmented into homogeneous sections based on a classification of flow facies—an integrative element of water velocity and depth—according to five classes: rapids, riffles, meanders, channels and pools. For each homogeneous section, a particle size fraction and an average width were also estimated. A HQI was developed from parr habitat preference curves for the physical variables selected. In addition, to account for climate-related differences in productivity between southern and northern rivers, a relative growth index based on the calculation of the number of days per year when the air temperature is > 5.6°C was added to the HQI.

To estimate the production potential of a river, the number of PUs is calculated as the sum of the product of the wetted area and the HQI of each segment accessible to salmon. Thus, the more quality habitat a river has, the more PUs it has and the greater its production capacity. This approach makes it possible to properly estimate the real productivity potential of salmon rivers, so that it is no longer linked solely to the accessible area, but also to habitat quality. For more information on this subject, please refer to the following work: *Seuil de conservation et cible de gestion pour les rivières à saumon (*Salmo salar*) du Québec*, by Caron and Fontaine (1999a). Appendix 10 presents the known accessible area, number of PUs and average HQI of Quebec salmon rivers.

The HQI provides a good assessment of the theoretical potential production of rivers for global and inter-regional comparison purposes. In this regard, Table 3 presents the accessible area, number of PUs and average HQI by DU for Atlantic Salmon in Quebec rivers, excluding DU 1, which is the subject of a different approach discussed later in this section. The habitats of DUs 12 and 13, and especially DU 15, are generally of better quality for the parr stage than the habitats in the other DUs when the average HQI of the rivers is considered (Figure 5). In terms of habitat quantity, DUs 11, 13 and 15 account for 85% of the PUs in the province. The rivers in DUs 13 and 15 contain, on average, a greater number of PUs per river. However, some of the larger rivers in DUs 4 and 10, and particularly 11, have a very high number of PUs because of their large accessible area (Figure 6). A comparison the number of PUs with the accessible area for the various DUs (Appendix 11) shows the importance of considering habitat quality when estimating river productivity. The assessment of habitat suitability is likely to change somewhat in the coming decades, particularly because of climate change, which may modify the growth index of rivers, among other things. In addition, a project to update the HQI and the characterization of rivers is underway and could lead to changes in the assessment of current habitats. It involves the use of high-spatial-resolution digital image coverage and LIDAR data. The project, started in 2015 in collaboration with the Institut National de Recherche Scientifique (INRS), aims to update the river characterization data and improve the HQI by including in the model a new facies classification that divides the previously used facies, along with new knowledge on water temperature, stream slopes and distribution limits into smaller tributaries.

Table 3. Accessible area, number of PUs and average HQI by DU for Quebec salmon rivers. The % of accessible area and % of PUs refer to the proportion between the value for one DU and the value for all DUs.

DU	Accessible Area (m^2)	% Accessible Area	Production Units	% Production Units	Average HQI
4	17,423,059	5	3,646,296	4	0.38
10	63,643,320	18	6,396,879	7	0.32
11	194,399,127	55	41,639,775	44	0.44
12	7,376,108	2	4,068,942	4	0.58
13	26,276,215	7	11,524,866.59	12	0.59
15	42,669,187	12	27,203,717	29	0.71

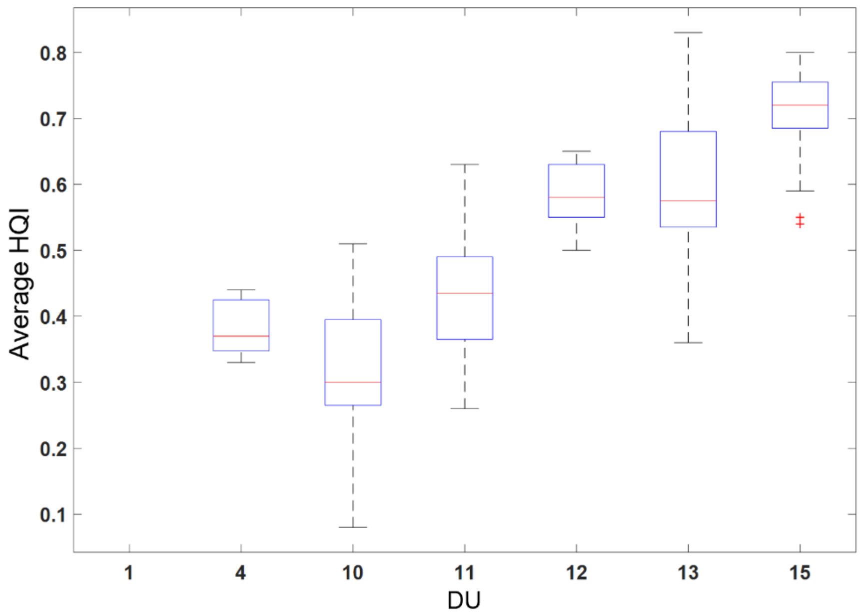


Figure 5. Average HQI for salmon rivers based on the different DUs. On each box, the line within the box is the median value, the box delineates the 25th and 75th percentiles, and the whiskers delineate minimum and maximum concentrations that are not considered outliers. Outliers are plotted individually in red.

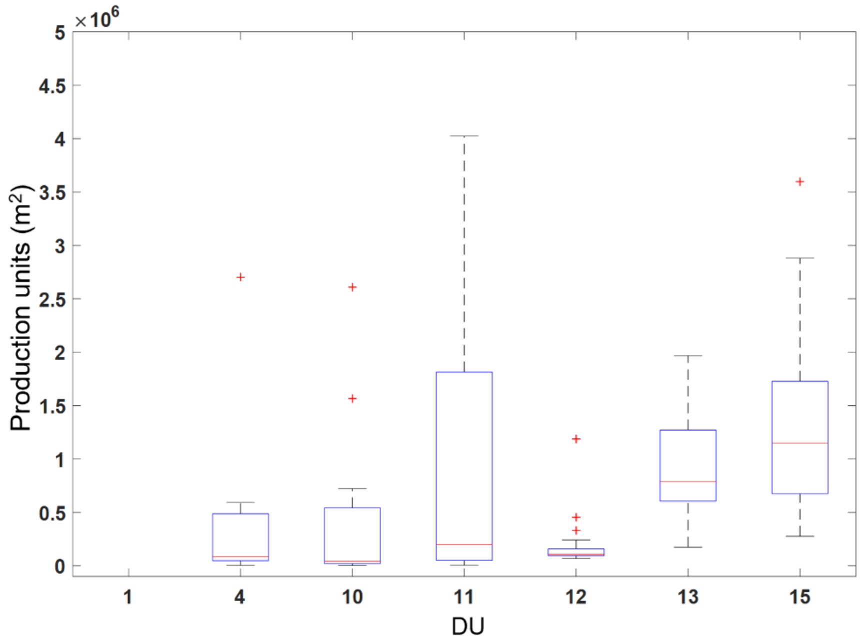


Figure 6. Number of salmon river PUs based on the different DUs. On each box, the line within the box is the median value, the box delineates the 25th and 75th percentiles, and the whiskers delineate minimum and maximum concentrations that are not considered outliers. Outliers are plotted individually in red. Some outliers are not shown because of their very high value. In this figure, "unitées de production" refer to "production units" and "UD" refer to "DU".

In the Ungava Bay region (DU 1), a project was carried out in recent years to estimate the number of PUs in the Koksoak River, the largest salmon river in Quebec. A complete preliminary estimate of the number of PUs was made using the available satellite images (Appendix 12). The total number of PUs was estimated to be 18,980,300 when the growth index, which that takes into account the river's nordicity, was included. By contrast, the total was estimated to be 55,348,800 when only the physical attributes of the river (flow facies and width) were assessed (Roy M., N. Bergeron, J.-N. Bujold and L. Beaupré 2015; MFFP, unpublished data). Since the resolution of the images used is not optimal, a new estimate will be calculated for this river in the near future using better-quality images.

POPULATION ABUNDANCE

DEMOGRAPHIC TRENDS

Individual counts of adult salmon are probably the most accurate method of assessing demographic trends for this species. These counts are typically done from a migration barrier using a capture cage, from a dam with a fishway, or through a visual count done by snorkeling or from a canoe when visibility conditions permit it. The number of spawners present annually in each of the rivers is also used to determine whether the various conservation thresholds established and presented above have been met, after converting the number of salmon into the number of eggs.

Adult salmon are counted individually on approximately 40 Quebec rivers annually (MFFP 2020). This monitoring is rigorous, since it is estimated that approximately 40% of all salmon in Quebec are counted and that these rivers support approximately 90% of the recreational fishing effort in Quebec. The rivers monitored in Quebec represent about 50% of the salmon rivers on which these counts are conducted in North America. The data are presented annually in the Bilan de l'exploitation du saumon au Québec (MFFP 2020). However, this publication, which is intended primarily for fishers, does not provide all the details required for a scientific and rigorous assessment of the situation in these rivers. It also includes some data from indirect indicators (i.e., from other rivers, other years and/or mid-season counts) and partial data (i.e., counting fence not operational for a significant period, snorkel counts conducted on only part of the sectors normally covered, inadequate snorkel observation conditions).

In order to provide the most accurate picture possible, indirect or partial data presented in this report were excluded from the analyses of changes in the number of spawners over time. This was done despite the fact that the use of objective and consistent estimates is still necessary in the absence of precise data on certain rivers, in order to present a picture of current overall abundance by DU (see section "Estimation of Total Abundance at the Designatable Unit Level"). Considering that any count has a certain level of uncertainty, data (possibly imperfect, but informative) obtained under the following conditions are included: non-ideal snorkeling conditions, counting fence operation time slightly shorter than usual, inventory conducted from the shore when visibility is adequate. This classification was made as objectively as possible on the basis of comments compiled in the MFFP database since 1984.

For the purposes of this document, the term "return" is used to refer to adult salmon returning from the sea and entering the river. The term "spawners" refers to adult salmon returning to the river and present at the time of spawning. The number of spawners is therefore obtained from the number of returns minus all catches and other removals. This number does not take into account precocious parr, which account for 22% to 65% of paternities (Garcia-Vazquez et al. 2001; Taggart et al. 2001; Saura et al. 2008; Weir et al. 2011; Bouchard et al. 2022). Other types of removals are limited in number and primarily include natural mortality, salmon caught for hatchery use, and subsistence fishing when it is carried out in rivers and data are available. A 7% mortality rate, based on the reported number of sport fishing releases, has been applied to calculations since 2016.

Changes in the number of spawners by year for rivers with at least one year of data between 2010 and 2019 are presented in Appendix 13.

When precise count data are not available, an analysis of the number of recreational catches per unit of effort is often the best available indicator of abundance. The adjusted fishing success corresponds to the average number of catches per fisher per day, including releases. Recording of retained recreational catches is mandatory, and attendance data are provided by the organizations to which MFFP has delegated the management of sport fishing activities. Fishing success data prior to 1997 did not include catch and release, but this practice was much less popular than it is today, and the much more permissive fishing conditions at the time resulted in fewer mandatory releases (MFFP 2020). Beginning in 1998, releases of salmon documented through voluntary recording of releases have been included in this analysis since, gradually over the years, fewer and fewer salmon have been retained, for regulatory or non-regulatory reasons. This situation is likely to influence the portrait. However, the use of fishing success to assess population trends without considering releases would be much less appropriate, since regulatory changes have directly reduced removals (MFFP 2020). Changes in adjusted fishing success for DU 1, DU 4, DU 10 and DU 11 are presented in Appendix 14.

ESTIMATE OF TOTAL ABUNDANCE AT THE DESIGNATABLE UNIT LEVEL

In order to estimate the total abundance of adult salmon in the different DUs, a combination of various approaches described by Caron and Fontaine (1999b) was used. Rivers were classified into six categories (C1–C6) based on the information available to estimate salmon returns, with C1 being the most reliable and C6 the least accurate. Category C1 is a river where the assessment of returns is based on a counting method that distinguishes between small and large salmon, determined using a counting fence or a fishway, or using a visual count obtained through snorkeling or from a canoe. Category C2 uses the same approach but does not distinguish between the number of small and large salmon, which is estimated from the proportions reported in sport fishing landings and, if necessary, from catch and release. Salmon returns to category C3 rivers are determined by multiple correlating factors, using catch numbers, fishing effort, season length, and river access distance (Guillouët 1993). When yields cannot be estimated using a category from C1 to C3 and when yield data from previous years are available, category C4 is used. This category assumes that inter-annual variations in salmon returns to the target river are approximately the same as the variations in other rivers in the corresponding region. Category C5 is based solely on sport fishing data, including catch and release. Salmon returns are estimated using the known regional average exploitation rate. Finally, virtually no data are available for some small rivers. Category C6 assumes that returns are related to available river salmon habitat and is estimated relative to rivers in the same area for which estimates of salmon returns and habitat area are known. Methods C3 to C6 involve estimates but provide the most representative approximate numbers available for estimating returns and broodstock in Quebec salmon rivers. The number of spawners is obtained using the approach described above.

The uncertainty assessment associated with the return estimates depends on the river category (Caron and Fontaine 1999b). For category C1 or C2 rivers, the correction factors for the minimum and maximum number of returns are + 5% and + 10%, respectively, for all rivers with fish ladders and for all other rivers in the Gaspé and Anticosti regions where the water is clear and conducive to visual counts. The correction factors for rivers with darker water in the Quebec City, Saguenay and North Shore regions are instead + 10% and + 30%. For the other categories, an uncertainty of ± 25% is associated with the estimates of salmon returns, except for category C3, for which the calculation depends on the method described by Guillouët (1993).

The average number of anadromous spawners per year during the 2015–2019 period, as estimated using this method (Caron and Fontaine 1999b), is provided in Table 4. The values are structured according to the DUs. These values exclude precocious parr that participate in spawning.

Table 4. Average number of anadromous spawners during the 2015–2019 period, as assessed using the method of Caron and Fontaine (1999b)

DU	Small Salmon Lower Limit	Small Salmon	Small Salmon Upper Limit	Large Salmon Lower Limit	Large Salmon	Large Salmon Upper Limit	Total
4	3,311	4,206	5,653	1,129	1,511	1,994	5,717
10	2,550	3,698	5,156	641	894	1,253	4,592
11	2,304	3,088	4,078	5,563	7,847	10,264	10,934
12	1,393	1,624	2,041	1,342	1,569	1,840	3,193
13	1,193	1,260	1,570	2,007	2,153	2,645	3,412
15	4,002	4,322	4,670	12,660	13,303	14,032	17,264

The Anticosti Island metapopulation of Atlantic Salmon (DU 12) was the subject of a modelling analysis performed by Brun and Prévost (2013). The results indicate an average size that fluctuated around 3,500 returning adults between 2006 and 2012. A Ricker model stock-recruitment relationship based on specific metapopulation data was used to estimate a reference point (S_{MSY}) equivalent to the level of stock that will achieve maximum sustainable yield (MSY). A recovery target equivalent to the 95th percentile of the S_{MSY} was established. The target is a population of 2 100 spawners and should allow both the survival of the metapopulation and maximum sustainable yield for sport fishing. This target is currently being met. According to the most realistic scenarios tested over a projected period of 15 years, the model shows that, if harvesting conditions remain unchanged, the probability that Anticosti salmon will maintain a level of abundance above this target is very high (over 80%) and the probability of extinction in the short term is zero (Brun and Prévost 2013).

SUMMARY DESCRIPTION OF SALMON FISHING IN QUEBEC

Management of Fishing in Quebec

The *Act respecting the conservation and development of wildlife* (/ACDW/LCMVF) stipulates that the fishery resource must be allocated according to the following order of priorities: (1) the reproductive stock; (2) fishing for food, ceremonial or social purposes; (3) sport fishing; and (4) commercial fishing. Due to the general decline in salmon stocks in North America, commercial salmon fishing was permanently banned in Quebec in 2000. The resource is now shared between two user groups: First Nations and recreational fishers.

The 2016 Atlantic Salmon Management Plan provides a framework for harvesting activities and certain conservation initiatives for salmon in Quebec (MFFP 2016). Considering that each river normally hosts a distinct salmon population, salmon management in Quebec is primarily supported by conditions adapted to the specific situation of each river, using a so-called "river-by-river" approach. To this end, conservation thresholds are used to classify salmon populations according to three categories: the critical zone, the cautious zone and the optimal zone (see section "Specific Habitat Requirements and Impact on Population Dynamics" for more details).

Recreational fishing rules are set for each river individually prior to the opening of the season. Release of large salmon is mandatory during the first half of the fishing season. Beginning in mid-summer, retention of large salmon may be allowed in rivers reported to have maintained the optimal conservation threshold over the past 5 years, on average, but only if run data for the current season indicate that these particular populations will exceed a management objective that is above the optimal conservation threshold by the end of the season. On average, between 6 and 12 rivers benefit annually from these more permissive arrangements. Release of large salmon is mandatory on rivers that do not reach, or are unlikely to reach, the optimal conservation threshold.

In addition, depending on abundance levels and the presence of a harvesting organization, conditions such as limited removal of 1SW, mandatory release of all salmon caught, or fishery closures may apply in rivers where salmon abundance is below the demographic or genetic thresholds. Some exceptions, described in the management plan, may be allowed (see MFFP 2016).

Three different fishing licenses are available. As of 2018, the seasonal licence allows a total removal of four salmon for the season, including one large salmon (subject to applicable regulations). The only exception is the four rivers in the Ungava Bay region (DU 1), where fishers may keep four salmon regardless of size. Prior to 2018, the annual limit per fisher was seven salmon, regardless of size. The second licence is a 3-day licence that allows the harvest of one small salmon. The third is a catch-and-release licence, which allows seasonal fishing with no salmon retention and no catch limit, provided that releases do not exceed three per day (with exceptions). The number of licences sold in 2019 for all categories was 16,832. This number has remained relatively stable over time, but has tended to increase since 2010. In 2019, salmon licence sales were the highest on record.

For most of the rivers used for sport fishing, MFFP delegates certain responsibilities related to fisheries management to wildlife territories structured under the terms of agreements. These territories include controlled harvesting zones (ZECs) for salmon fishing, wildlife reserves, outfitters with exclusive rights, organizations that are party to a memorandum of understanding for the purpose of managing wildlife and access to it on private land, and some agreements with national parks. On these rivers, non-profit organizations, companies or SEPAQ (Société des établissements de plein air du Québec) are responsible for overseeing the harvesting of the resource in accordance with the regulations in force. These entities are required to provide MFFP with harvesting data (e.g., attendance and catches), and some participate in salmon counts. They also provide a certain level of protection against poaching. In most of these areas, part of the revenue from fishing access rights is invested in hiring assistant wildlife protection officers.

In Quebec, it is mandatory to keep a record of all salmon retained by recreational fishers. This situation is unique in Canada. It provides accurate data. Weight and length data on the fish are recorded by the organizations responsible for managing structured wildlife territories and are transferred to MFFP for compilation at the end of the summer and sometimes during the season. These organizations also compile voluntary catch-and-release reports from fishers.

Indigenous fishing is practised for food, social or ceremonial purposes. There are nine Indigenous communities within DUs 4, 10, 11, 13 and 15 (Innu, Maliseet of Viger and Micmacs) that carry out salmon fishing in estuaries or rivers. These activities concern in particular the Mitis, Rimouski, York, Dartmouth, Saint-Jean, Restigouche, Romaine, Betsiamites, Mingan, Natashquan, Moisie, Saint-Augustin and Étamamiou rivers. Some of these communities have entered into agreements with the Government of Quebec under the ACDW (CQLR C-61.1) to better reconcile the needs of wildlife conservation and management with the fishing carried out by their members for food, social or ceremonial purposes. In addition, MFFP issues communal fishing licences annually under the *Aboriginal Communal Fishing Licences Regulations* (SOR/93-332) for the benefit of members of certain communities. Such licences generally specify the gear, season and catch limits. Catches made for food, ceremonial or social purposes under communal fishing licences must be reported collectively by each Indigenous community and, where applicable, must be within the quota specified for the licence. Some communal fishing licences authorize individual community members to carry out angling subject to certain conditions, including compliance with an individual quota. Some communities share information on their members' harvest data, while others do not track or do not wish to share this information, in which case harvest data are estimated from available information. Fishing for food, ceremonial and social purposes is also practised by the Inuit peoples who are beneficiaries of the James Bay and Northern Quebec Agreement (DU 1), for which catches are not reported. Consequently, MFFP must take these conditions into account and, where applicable, estimate the catches to the best of its knowledge and on the basis of the most reliable information available.

Level of Harvesting by Fisheries in Quebec

The number of salmon harvested from each river is presented annually in the Bilan annuel de l'exploitation du saumon au Québec (e.g., MFFP 2020). During the 2019 fishing season, for example, recreational fishers completed 69,086 fishing days and harvested 4,226 salmon (11,549 kg). The harvest consisted of 3,042 small salmon (5,517 kg) and 1,184 large salmon (6,032 kg). Also in 2019, a total of 12,686 salmon were released, which represented 75% of the total sport catch. Removals in fisheries carried out for food, ceremonial, or social purposes are estimated to be between 3,000 and 6,000 salmon annually. It is not possible to determine any upward or downward trends from the data collected on fishing for food, ceremonial or social purposes. Overall, the number of salmon harvested has been declining since the late 1980s, initially due to the closure of the commercial fishery and then due to regulatory restrictions on recreational fishing and the increasing popularity of catch and release (Figure 7).

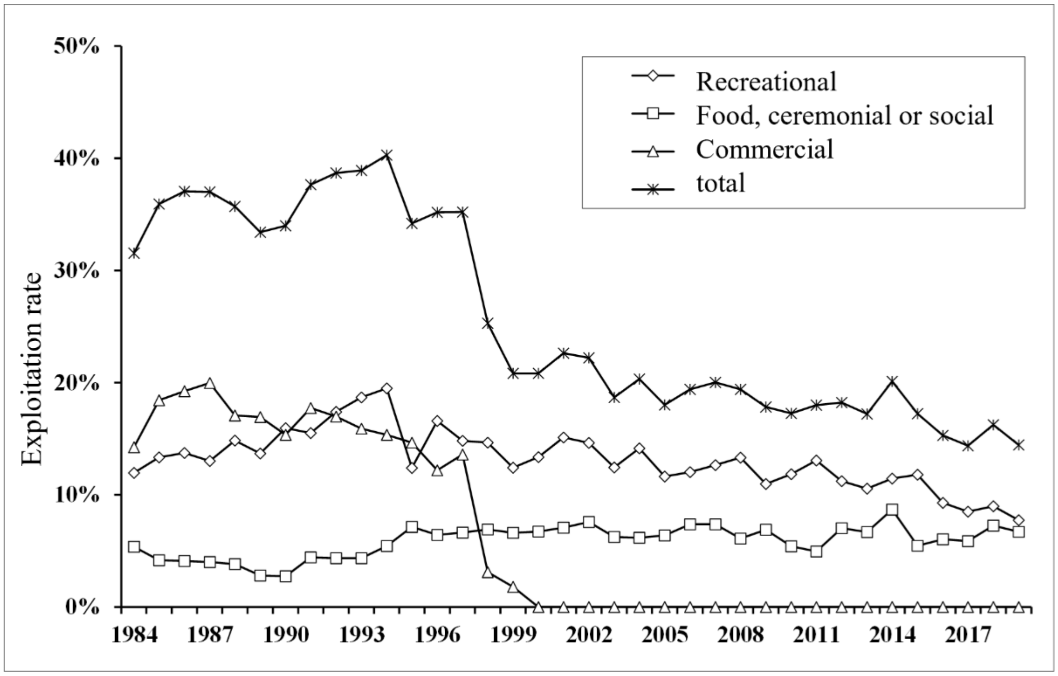


Figure 7. Changes in exploitation rates by recreational, food, ceremonial and social and commercial fisheries in Quebec.

Table 5 presents the average number of salmon caught in the recreational fishery by year and DU since the implementation of the 2016 Atlantic Salmon Management Plan. It shows that the majority of salmon are caught in DU 15.

Table 5. Average number of salmon harvested in Quebec by recreational fishers per year for each DU between 2016 and 2019. The minimum and maximum values recorded during this period are presented in parentheses.

DU	Small Salmon	Large Salmon	Total
1	254 (143–381)	312 (256–374)	566 (399–733)
4	466 (302–619)	0 (0–1)	467 (303–619)
10	395 (287–494)	124 (100–138)	519 (387–606)
11	408 (221–555)	556 (336–725)	964 (682–1,257)
12	345 (223–448)	0 (0–0)	345 (223–448)
13	225 (161–353)	0 (0–0)	225 (161–353)
15	1,965 (1,590–2,718)	469 (174–701)	2,434 (2,022–3,419)
Total	4,057 (3,043–5,261)	1,462 (1,083–1,879)	5,518 (4,269–7,074)

For Quebec as a whole, the total exploitation rate, which was estimated at 14% in 2019, has continued to follow a downward trend. The exploitation rate associated with sport fishing was estimated at 8% of total Quebec returns (14% for small salmon and 4% for large salmon). This represents a significant decrease in the exploitation rate for large salmon compared to previous years; the corresponding rate ranged from 11% to 18% between 1984 and 1999.

A comparison of data obtained since the implementation of the 2016 Atlantic Salmon Management Plan (2016 to 2019) with the average of the previous five years (2011 to 2015) reveals that the new fishing arrangements have reduced the removal of large salmon by 48% while increasing river use by fishers by more than 5%. This has helped to conserve populations while keeping citizens connected to the species.

Out-of-Province Capture of Quebec-Origin Salmon

Salmon originating from Quebec rivers may be caught in the marine environment during their migration outside provincial waters. Under the existing laws and regulations in these territories, fishers from Greenland, France (Saint-Pierre and Miquelon) and Labrador have the opportunity to capture salmon at sea using gillnets. Some of the salmon caught at these locations would normally have returned to spawn in their natal river in Quebec. Greenland's fisheries have by far the greatest impact in Quebec. Based on available catch data and the genetic assignment of these catches to their region of origin (ICES 2020), it is estimated that a few thousand salmon originating from Quebec are caught annually by the Greenland interception fisheries (Table 6). These salmon are individuals that normally spend more than one year at sea and therefore would have been considered large salmon upon their return to the river. Large salmon in DU 15 are thus about five times more affected by the Greenland fisheries than by in-river recreational fishing. The fisheries in Saint-Pierre and Miquelon are smaller than those in Greenland and, unlike Greenland, involve both small and large salmon. It is estimated that a few hundred salmon destined to return to Quebec rivers are intercepted by this fishery. Finally, non-Indigenous subsistence fishing in Labrador harvests the vast majority of salmon originating from Labrador rivers. Between a few dozen and a few hundred Quebec salmon may be affected by this fishery, which catches both small and large salmon.

Table 6. Estimated average number of Quebec-origin salmon caught in Greenland from 2016 to 2019. Data are arranged by DU. Minimum and maximum values observed during this period are presented in parentheses. These salmon would have been considered large salmon upon their return to the river. Because of the information available, catches associated with DUs 10 and 11 have been combined, and those from Quebec rivers in DU 4 have not been assessed.

DU	Average Number of Salmon Caught (Min–Max)
1	432 (383–515)
4	-
10 11	378 (255–594)
12	131 (53–378)
13	507 (125–1,607)
15	2,467 (1,112–3,915)
Total	3,915 (2,219–6,629)

ATTAINMENT OF CONSERVATION THRESHOLDS

The average attainment of the optimal and demographic conservation thresholds since 2016, the year when the 2016 Atlantic Salmon Management Plan came into effect, is presented in figures 8 and 9. The demographic conservation threshold is met or exceeded for 89% of the 44 populations with data. Only five rivers do not meet this threshold: Nouvelle, Ouelle, Petit-Saguenay, Jacques-Cartier and Huile. The optimal conservation threshold is met or exceeded for 23 of the 44 populations.

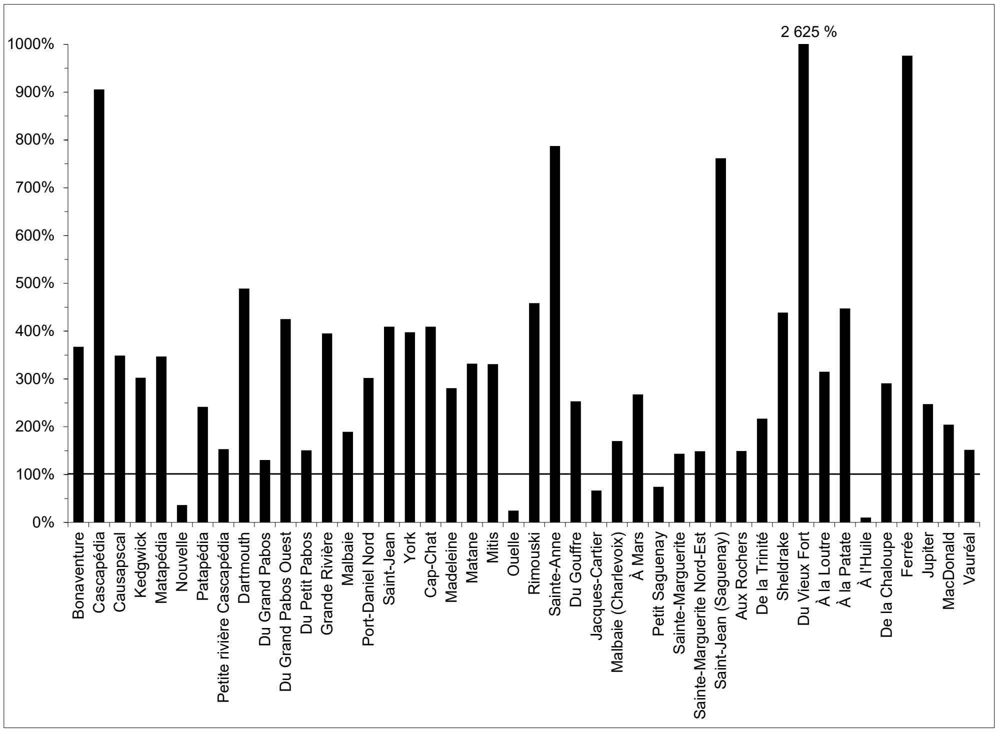


Figure 8. Average attainment of the demographic conservation threshold from 2016 to 2019, since the implementation of the 2016 Atlantic Salmon Management Plan

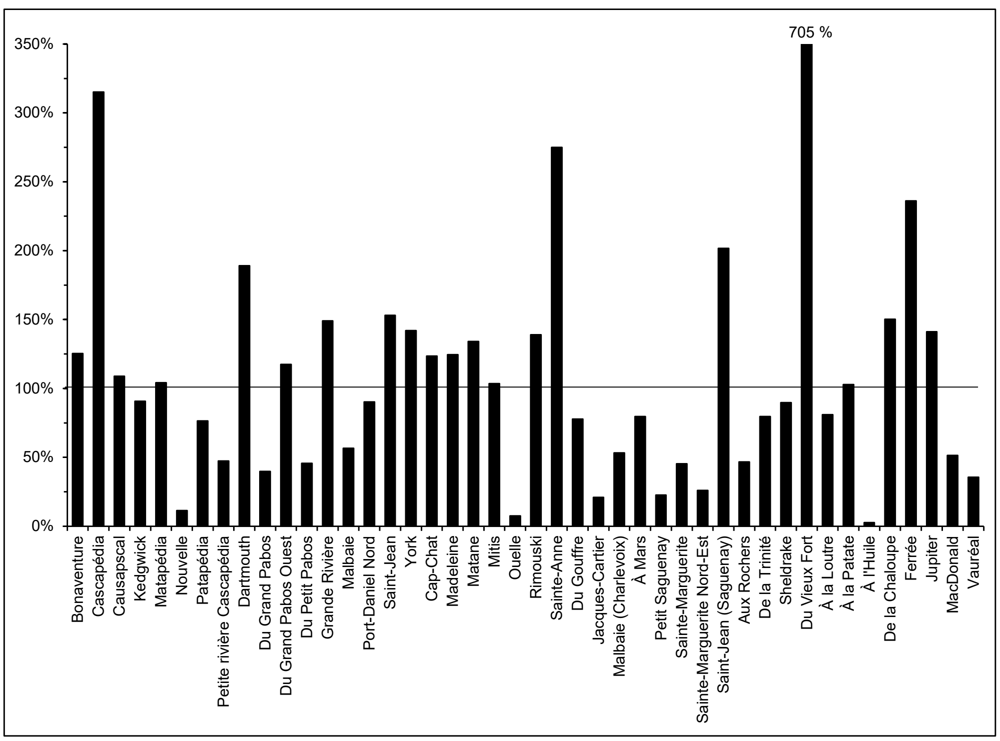


Figure 9. Average attainment of the optimal conservation threshold from 2016 to 2019, since the implementation of the 2016 Atlantic Salmon Management Plan

STATUS OF SALMON RIVERS IN RELATION TO CLIMATE CHANGE

In the coming decades, Quebec's salmon rivers, like those in the rest of Canada, will be increasingly affected by climate change. Climatic variations will affect the water temperature and flows of these rivers, among other things. Since 2014, MFFP has increased its efforts to acquire knowledge on water temperature and has implemented more exhaustive monitoring of this parameter on salmon rivers in Quebec. On average, more than 50 water temperature measurement stations were installed each year, for a total of 175 stations (Figure 10). More than 20 rivers per year had stations installed, including rivers in Ungava Bay. The data collected in this network are compiled and shared on the RivTemp platform, which is overseen by the INRS, among others. In addition, real-time water-temperature sensors have been installed at the gauging stations of 11 Quebec salmon rivers in partnership with the Ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC).

In collaboration with the INRS, various initiatives have been undertaken to increase knowledge of water temperatures in salmon rivers, including various data analyses. MFFP wishes to better understand the thermal regime of the various salmon rivers and their thermal sensitivity to climate. Despite all the efforts made in recent years, the time series on several rivers fitted with sensors are sometimes not long enough to assess the thermal regime and sensitivity of the rivers, because they do not represent all the possible annual climate classes for air temperature and precipitation (e.g., hot and humid, or cool and dry). However, for rivers with adequate data, the results obtained provide an initial approximation of the thermal regimes of Quebec salmon rivers. Some rivers, even some of the more northern ones, are already reaching high temperatures (Figure 11). The current data do not allow for an exhaustive portrait by DU. However, as can be seen, the stations with the most critical temperatures (i.e., average maximum temperatures between 18 and 24°C) are mostly found on the rivers of DU 13 (Figure 12).

Work is also underway to develop projections of water temperatures in salmon rivers under the RCP 4.5 (Representative Concentration Pathway; relatively optimistic) and RCP 8.5 (pessimistic) greenhouse gas concentration scenarios. These projections provide a better idea of the anticipated impacts of climate change on Quebec's salmon rivers. The results obtained to date tend to show an improvement in thermal conditions supporting optimal growth for certain rivers, while the opposite is true for other rivers (Figure 13). An increase in the number of days of primary thermal stress (Tavg > 20°C) is also projected for some rivers (Figure 14). The increase in the number of days of thermal stress implies that salmon survival and growth will be further compromised. In addition, the increase in average summer temperatures on tributaries may compromise the persistence of thermal refuges located at the confluence of these rivers and the main river.

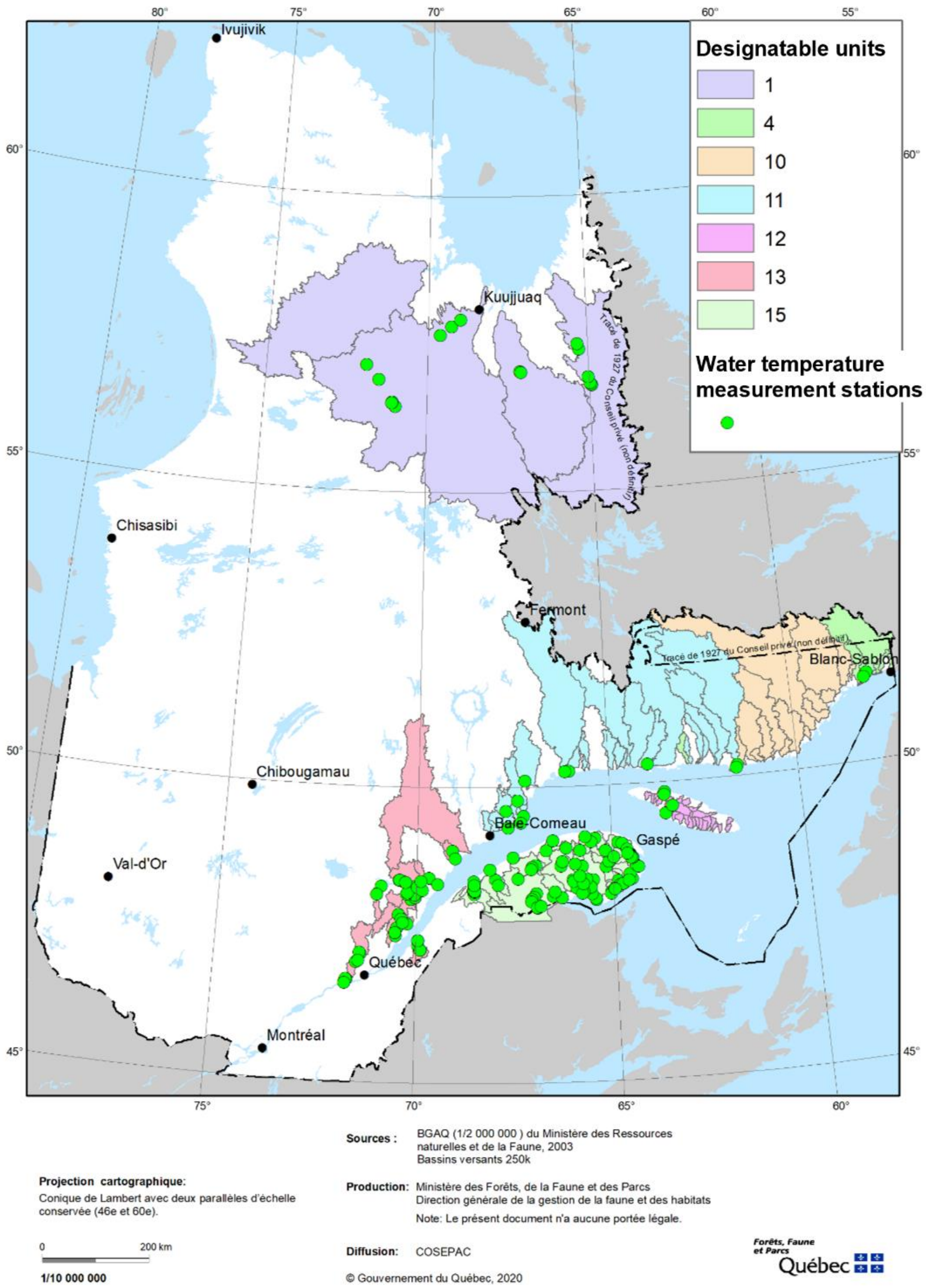


Figure 10. Map of water temperature measurement stations installed by MFFP on Quebec salmon rivers between 1985 and 2019.

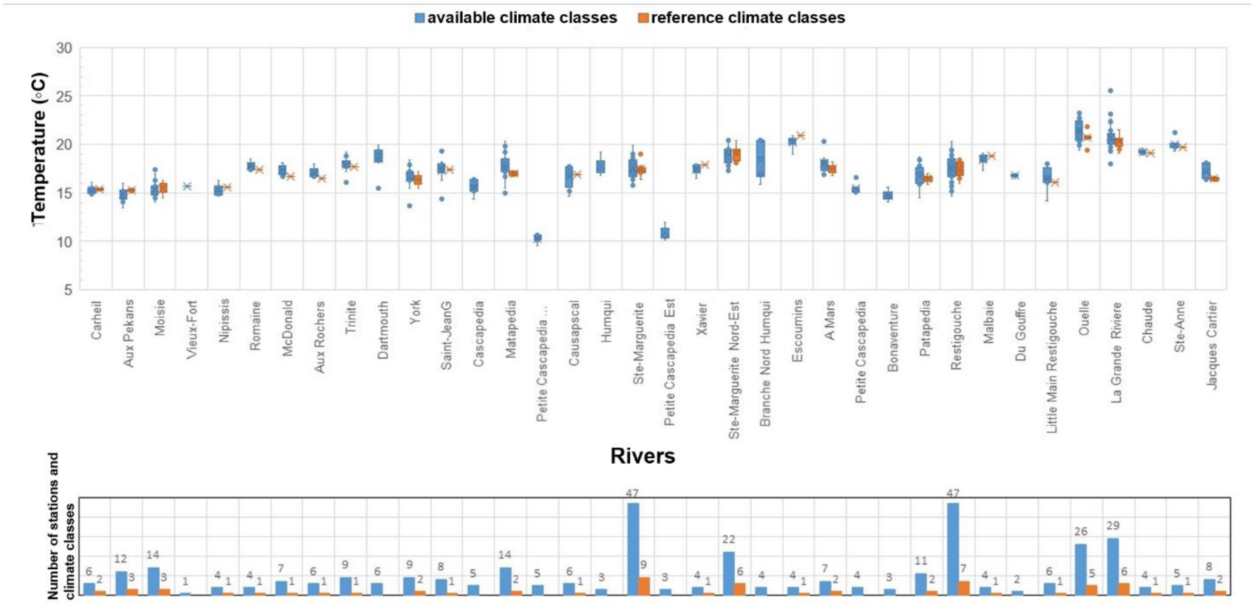


Figure 11. Average summer (July–September) maximum water temperatures (daily values) by river. The summer average of the temperatures recorded at the stations for the different climate classes is used to create the box and whiskers plot by river. The number of stations per river and the climate conditions measured differ from river to river. Only major rivers (excluding small tributaries) with at least 5 years of valid summer data were included in the graph. Rivers are organized by station latitude (northernmost stations/rivers are on the left side of the diagram). The reference climate class (orange symbols) is used to compare stations/rivers.

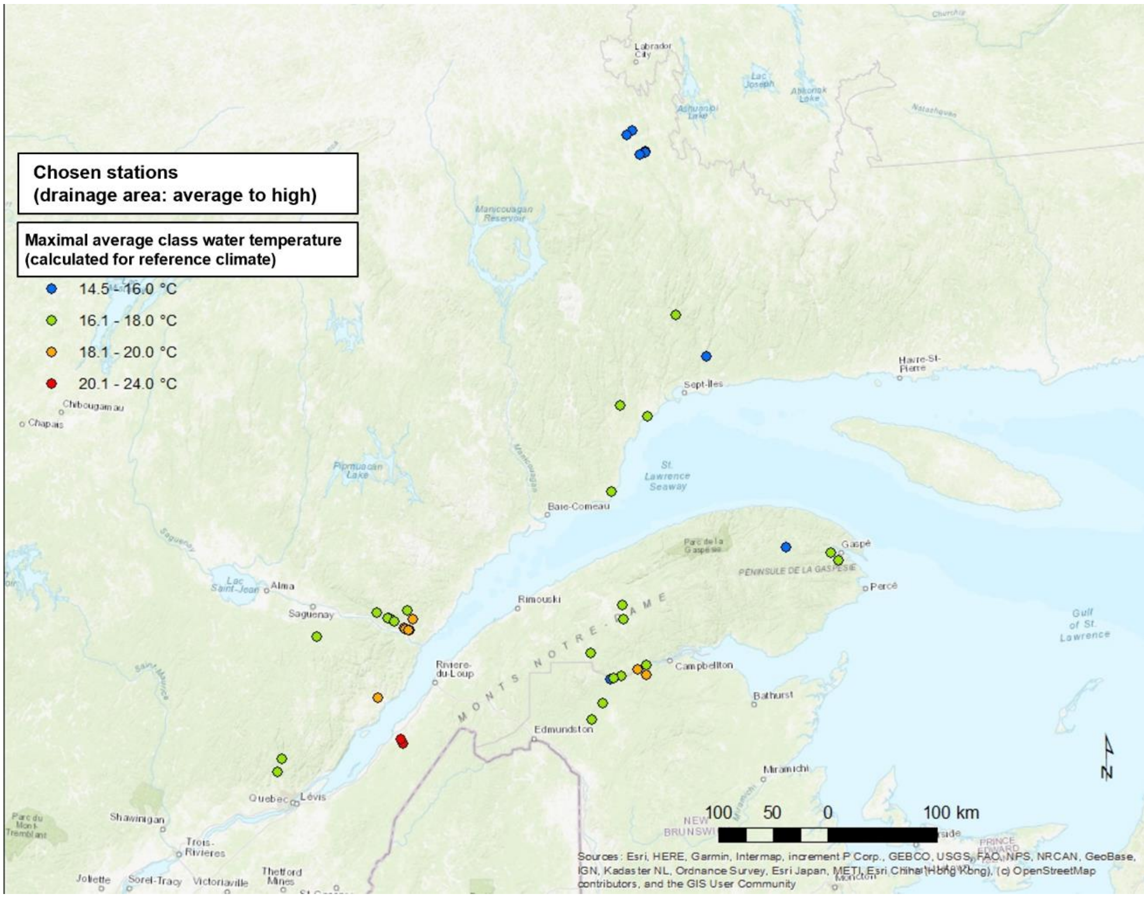


Figure 12. Map showing water-temperature measuring stations according to a classification based on the average maximum temperature for the summer period and for the normal–normal climate class. Only stations located on the main rivers (small tributaries excluded) with at least 5 years of valid data for the summer period and for the normal–normal climate class were included in the map.

The results obtained to date suggest that water temperature is an important element to consider in the management of the salmon fishery in the context of climate change. In addition, the results show the importance of continuing to monitor and analyze water temperature in salmon rivers to better understand changes in this parameter, the effects it will have on populations and the actions necessary to mitigate the negative impacts.

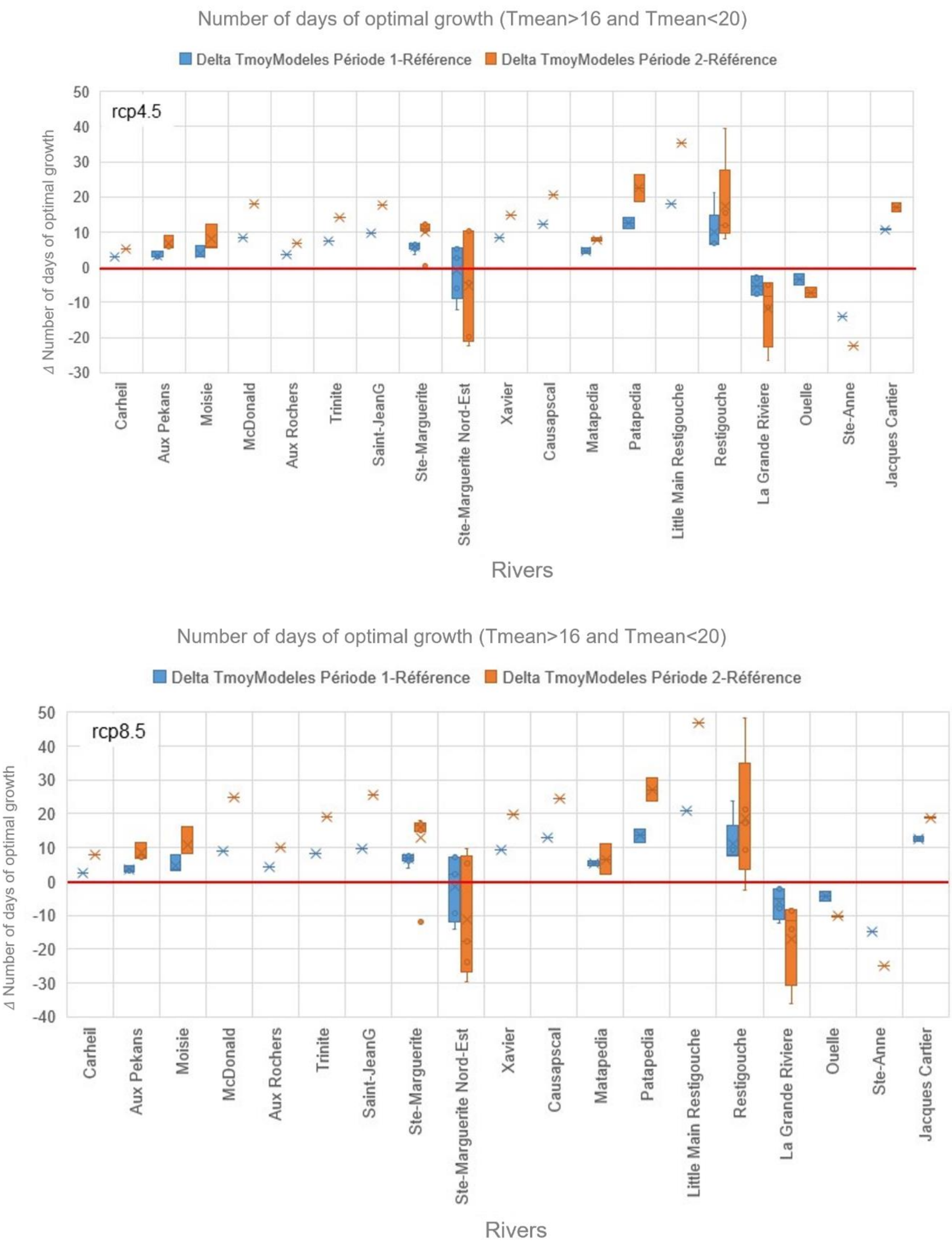
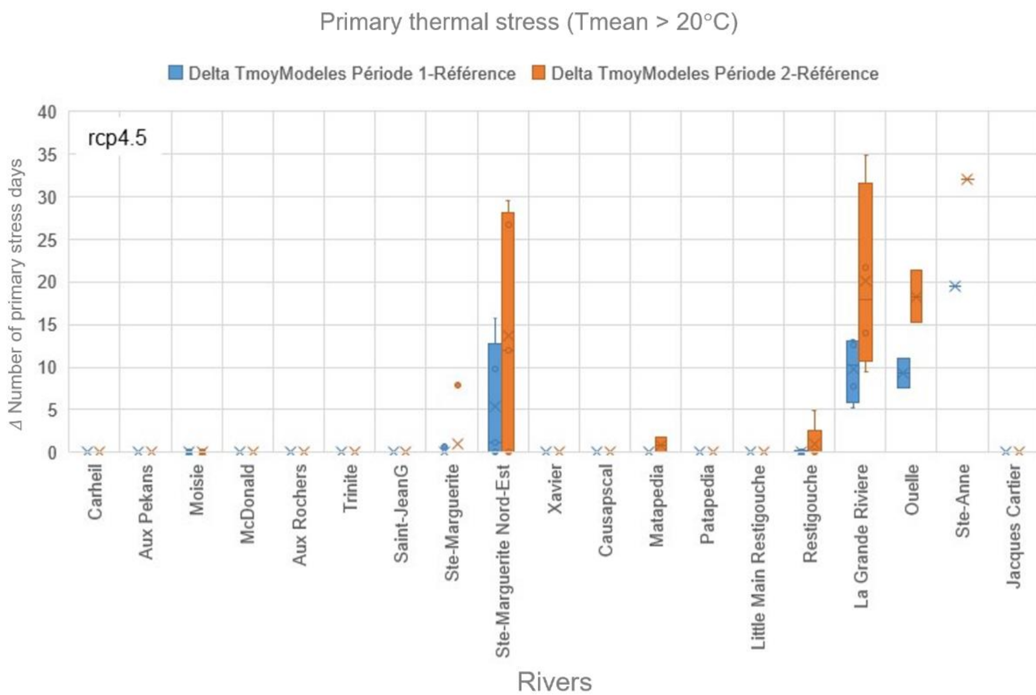


Figure 13. Average delta for an increase in the number of days of optimal growth for the 2011–2040 period and the 2041–2070 period by river. Results for the RCP 4.5 (relatively optimistic; top graph) and RCP 8.5 (pessimistic; bottom graph) concentration scenarios are shown. Rivers are organized by station latitude (northernmost stations/rivers are on the left side of the diagram).



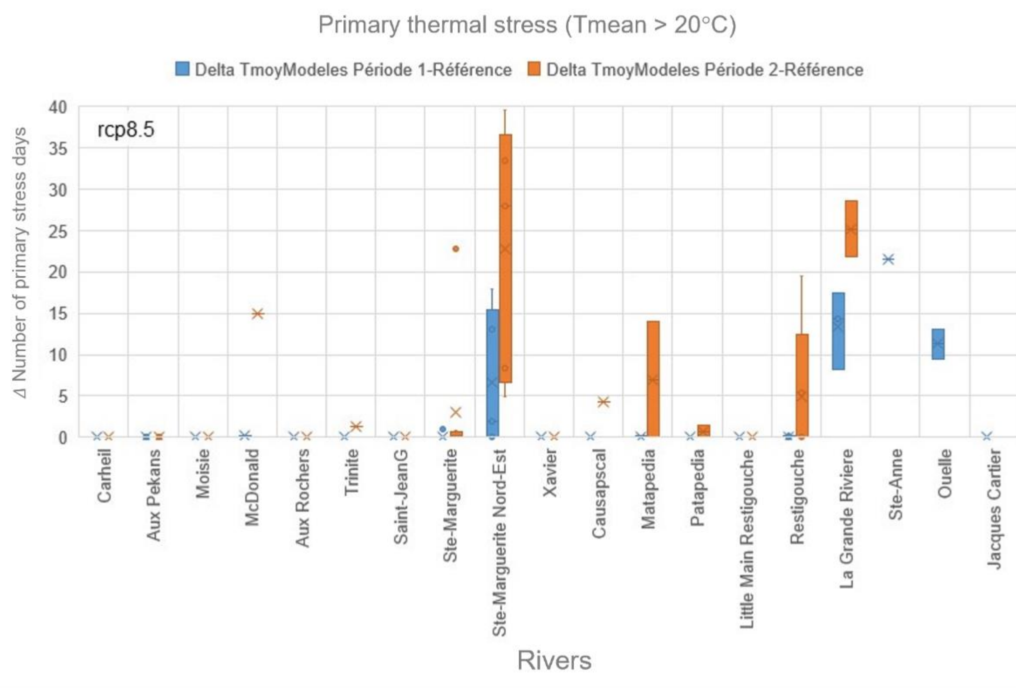


Figure 14. Average delta for an increase in the number of primary stress days (Tavg > 20°C) for the 2011–2040 period and the 2041–2070 period by river. Results for the RCP 4.5 (relatively optimistic; top graph) and RCP 8.5 (pessimistic; bottom graph) concentration scenarios are shown. Rivers are organized by station latitude (northernmost stations/rivers are on the left side of the diagram).

Climate change will also influence the flow of salmon rivers. The Hydroclimatic Atlas of Southern Québec, developed and published online by the MELCC, provides a better understanding of the anticipated flow changes in most of Quebec's salmon rivers, with the exception of the rivers on Anticosti Island and in Ungava Bay (Figure 15). According to the Atlas projections, despite the variability associated with the characteristics of the rivers and their location in the region, there will generally be a decrease in winter low flows, a decrease in the magnitude of spring floods, an increase in summer low flows, a decrease in summer-fall flows, an increase in the intensity of summer and fall floods, and higher flows in the northern part of the region. These changes in summer flood and low-flow regimes could affect the natural cycles, growth and survival of Atlantic Salmon in Quebec rivers. Combined with the increase in summer water temperatures, the increase in summer low flows could negatively impact Quebec salmon populations.

The magnitude of change in average annual low flows in summer, compared to the 1971–2000 reference period, was modelled for three indicators (Q7MIN2E: 7-day, 2-year recurrence; Q7MIN10E: 7-day, 10-year recurrence; Q30MIN5E: 30-day, 5-year recurrence) for the RCP 4.5 (relatively optimistic) and RCP 8.5 (pessimistic) concentration scenarios. The results show, for both RCP scenarios and the three indicators, a clear trend towards decreasing summer low flows (Figure 16). For the 2080 time horizon (2071–2100), median decreases of about 20% and over 40% are expected in the three indicators, for the RCP 4.5 and RCP 8.5 scenarios, respectively. In the RCP 4.5 scenario, some stabilization can be observed between the 2050 and 2080 time horizons, which is not the case for the RCP 8.5 scenario. The rivers in the different DUs are also likely to respond differently. In Figure 17, it can be seen that the rivers in DU 13 and DU 15 may be affected to a greater extent. Although there is uncertainty in these data, which is inherent in the climate and hydrological models and in the projection of low flows, the trends modelled at this time are relatively clear, and the magnitude of the anticipated decrease is considerable.

Taking into account the anticipated disruption of the water and thermal regimes of salmon rivers, MFFP is working to identify habitat management measures that could mitigate the impact of climate change on Atlantic Salmon populations and rivers in Quebec, such as the identification and protection of thermal and water refuges and the conservation of natural flows. An experimental project aimed at adapting salmon fishing methods to thermal conditions in rivers has also been in place since the summer of 2020.

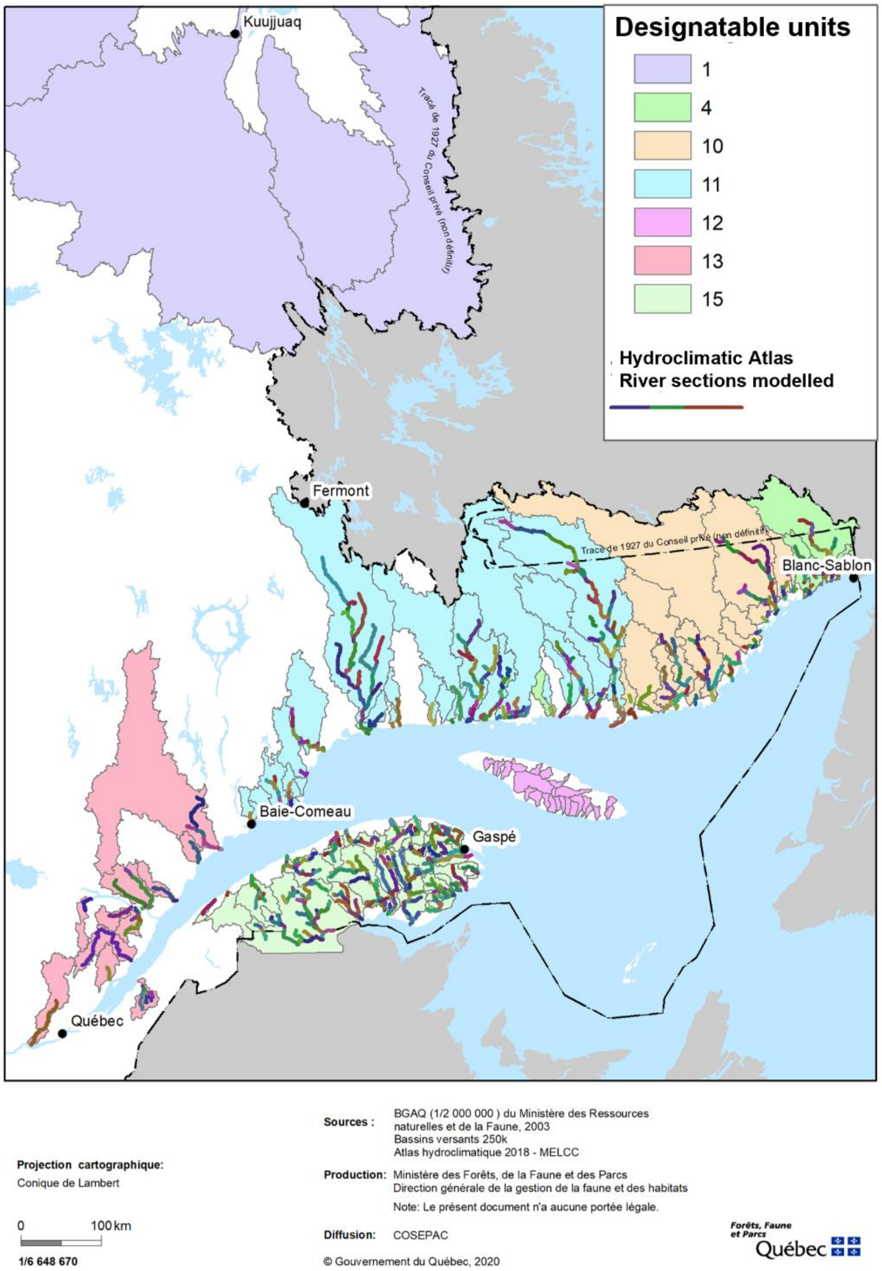


Figure 15. Map showing the sections of salmon rivers modelled in the Hydroclimatic Atlas of Southern Québec

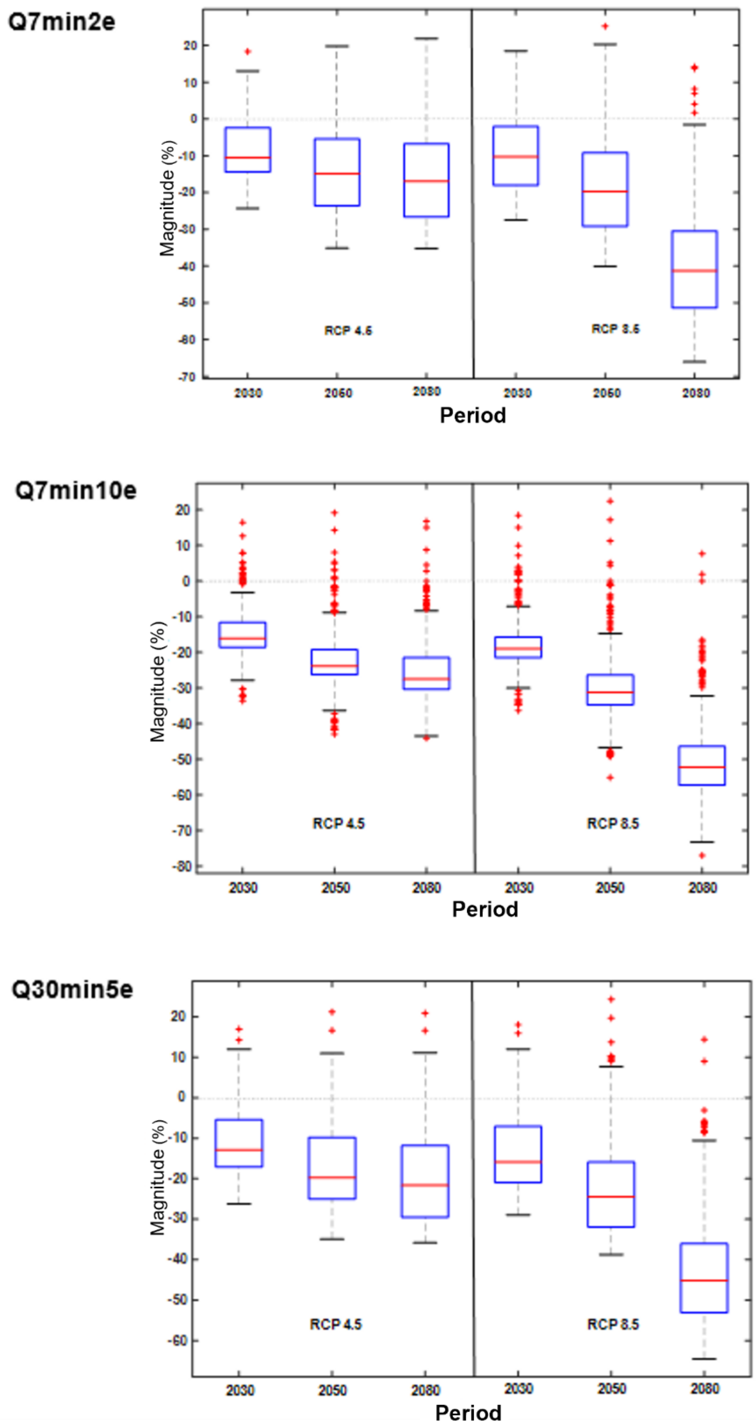


Figure 16. Magnitude of anticipated changes in the three summer low flow indicators (Q7MIN2E, Q7MIN10E, Q30MIN5E) for salmon rivers modelled for the 2030, 2050 and 2080 horizons for the two RCP scenarios. The magnitude indicates the percentage increase or decrease in the indicator. On each box, the line within the box is the median value, the box delineates the 25th and 75th percentiles, and the whiskers delineate minimum and maximum concentrations that are not considered outliers. Outliers are plotted individually.

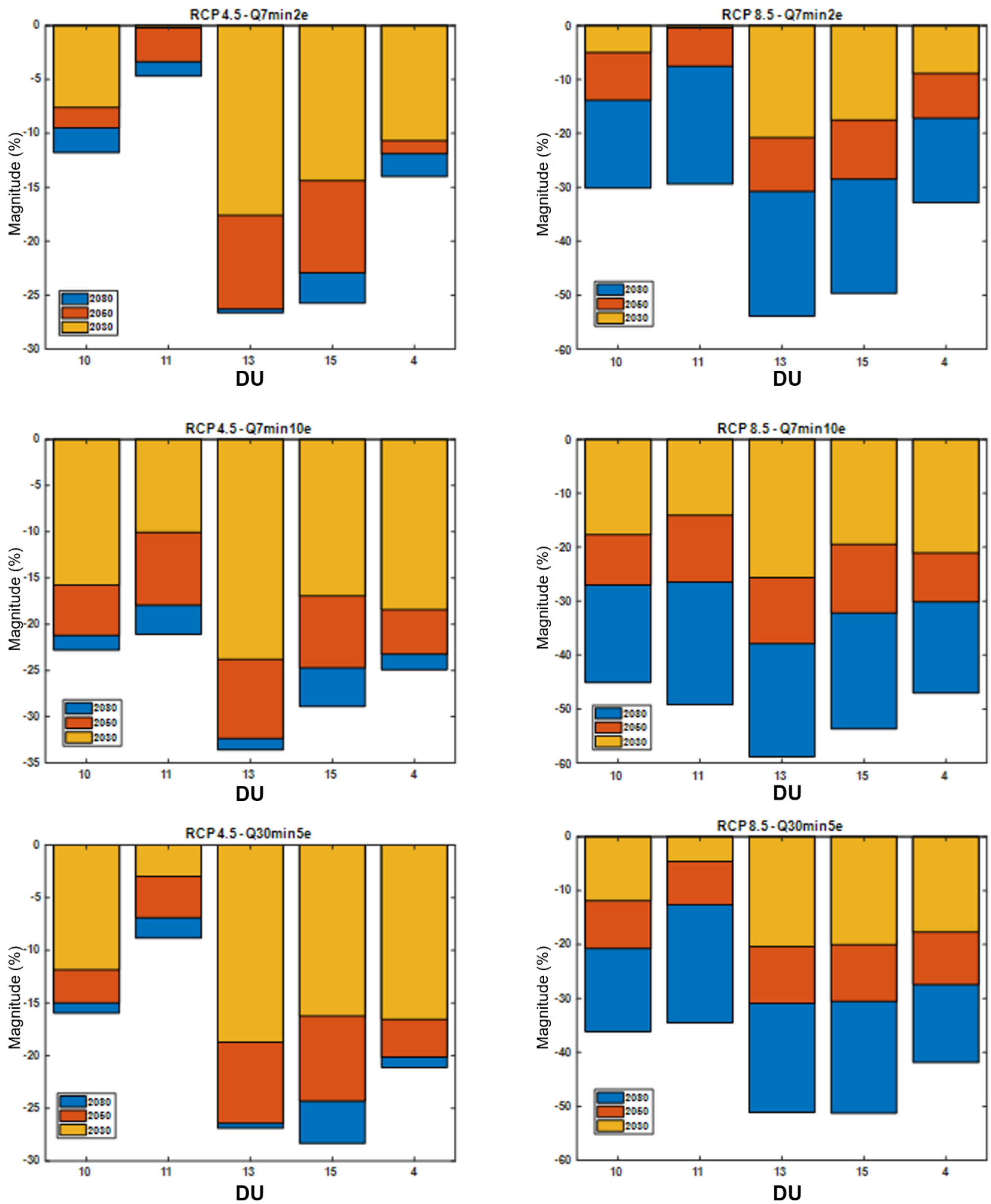


Figure 17. Average magnitude of expected changes by designatable unit for the three summer low flow indicators (Q7MIN2E, Q7MIN10E, Q30MIN5E) for salmon rivers modelled for the 2030, 2050 and 2080 horizons for the two RCP scenarios. The magnitude indicates the percentage increase or decrease in the indicator.

THREATS

This section provides a summary of threats to Atlantic Salmon in Quebec. It focuses on threats that were not addressed in the previous sections and for which up-to-date information is not readily available to the public. The information is presented according to the approach favoured by the International Union for Conservation of Nature (IUCN), COSEWIC and the *Centre de données sur le patrimoine naturel du Québec* (CDPNQ, see MFFP 2021). This approach differs slightly from the one used in a similar exercise conducted in 2009 (DFO and MRNF 2009).

AQUACULTURE

Marine salmon aquaculture can harm wild populations in a variety of ways. Caged salmon can transmit diseases (e.g., infectious salmon anemia) and significant sea lice loads to wild salmon (Ford and Myers 2008; Taranger 2015). Salmon that escape from cages can compromise the genetic integrity of wild populations (Bourret et al. 2013). This activity has the potential to alter the migratory behaviour of salmon and to attract a greater density of predators (Ford and Myers 2008). There are currently no commercial salmon farms at sea in Quebec, but Quebec salmon may pass close to salmon farms in the Maritime provinces during their migrations. Furthermore, salmon that have escaped from these cages could reach Quebec rivers.

RENEWABLE ENERGY

Hydroelectric facilities can have a considerable impact on migratory species. However, few hydroelectric dams are present on Quebec salmon rivers (e.g., Jacques-Cartier, Rimouski, Romaine, Mitis, Betsiamites and Sheldrake), and most were built at naturally impassable falls, which limits their impact. In some cases, these structures built at impassable barriers and equipped with fishways have enabled salmon to colonize new habitats that were previously inaccessible (Mitis, Rimouski and Sheldrake rivers). These interventions were accompanied by an increase in the size of the salmon populations in these rivers (MFFP 2020, Appendix 13). In these specific cases, the structures required the installation of devices to prevent downstream smolts from being sucked into the turbines.

ROADS AND RAILWAYS

Road construction can create barriers to Atlantic Salmon migration, and road development can affect river ecosystems (DFO and MRNF 2009). Road and rail density is strongly correlated with human density, which is generally low around the rivers supporting Atlantic Salmon populations in Quebec. However, some rivers are bordered by roads or railways. Some of this infrastructure is aging, and the work undertaken to repair these facilities will certainly impact salmon habitats. In some cases, the construction of road and railway infrastructure necessitated the straightening of watercourses.

In Quebec, one of the main components of the threat that roads pose to most DUs is the presence of forestry roads used to access logging areas. These roads are subject to washout, and when this occurs along watercourses, significant amounts of sediment may enter salmon habitat. They are also a potential source of bank erosion. The development of forestry roads requires the construction of several watercourse crossings, which leads to another significant impact, namely the presence of culverts (see *Dam and Water Management/Use*).

LOGGING AND WOOD HARVESTING

Logging and wood harvesting can affect salmon. In Quebec, specific measures governing logging are set out in the *Regulation respecting the sustainable development of forests in the domain of the State* (RSDF) (CQLR, A-18.1, r 0.01), which requires the preservation of a strip of woodland at least 60 m wide on both sides of a salmon river. In addition, specific measures for a maximum equivalent clearcut area of 50% apply at the watershed level. On private lands, some harvesting is done under protection plans, which include conditions to protect salmon rivers. However, smaller streams within salmon river watersheds generally do not benefit from the protection measures described above. Defoliation on the banks of these streams results in increased light penetration, which in turn increases the water temperature of the streams that feed the rivers. The temporary absence of vegetation can also increase washout events and contribute sediment to the rivers. In general, logging reduces the water retention capacity of soils, which contributes to the release of sediments into rivers. In addition, it increases the amount of water flowing into rivers, thus amplifying flooding, which is already increasing because of climate change.

DAM AND WATER MANAGEMENT/USE

Dams can affect Atlantic Salmon by acting as a barrier to migration. Passages constructed to bypass these structures show varying levels of effectiveness and increase the energy cost associated with adult migration (Fay et al. 2006). These crossings can delay or prevent smolt migration to the marine environment (DFO and MNRF 2009). In addition, dams can affect water conditions downstream. Dams can capture coarse sediments (gravel, pebbles), which can negatively impact sediment dynamics and consequently the quality of downstream habitats.

Water withdrawals for agriculture, industry, mining and municipalities can affect Atlantic Salmon spawning and rearing habitats.

Forestry roads result in the installation of numerous culverts and other stream crossings that can act as barriers to the free passage of juvenile fish. The impact of these structures can increase over time when the habitat changes (e.g., gap between the watercourse and the culvert, obstruction by vegetation) and when there are changes in the flow dynamics or when they become obsolete and are not maintained or replaced. In this regard, flow velocity, slope and distance between the culvert and the watercourse are the main characteristics that can hinder the free passage of fish.

OTHER ECOSYSTEM CHANGES

Some sections of a number of rivers in Quebec were straightened when roads or railways were built along them. This type of ecosystem modification is also characteristic of rivers in agricultural areas. Straightening increases flow velocity, thereby increasing bank erosion and leaching of the type of substrate preferred by salmon.

In addition, in human-modified environments, riprap is often used to stabilize slopes along roads or in residential, commercial or industrial areas. These habitat modifications have the same impact as straightening. A major flood occurred in 1996 in the Saguenay region (DU 13), during which some rivers burst their banks and caused extensive damage to the surrounding civil infrastructure. To prevent a recurrence of this situation, riprap was installed over long stretches of these rivers. These modifications now make it possible to document and demonstrate the effects of riprap on flow velocities and sediment leaching, which results in the deepening of the riverbed and the gradual deterioration of salmon habitat.

The changes described above also have the widespread effect of removing or reducing the vegetation along the banks of rivers, thereby reducing the soil’s water infiltration capacity and promoting the warming of water through increased exposure to the sun.

INVASIVE ALIEN PLANTS AND ANIMALS

Rainbow trout (*Oncorhynchus mykiss*) are currently present in a number of salmon rivers and can compete with salmon (Thibault and Dodson 2013). Brown trout (*Salmo truta*) are also present in some Quebec rivers. In addition, two pink salmon specimens were observed in the Ungava Bay region in 2019. One of these fish was caught in Kangirsuk, and the other in Kangiqsualujjuaq. Finally, emerging threats in the western part of the salmon range in Quebec, such as Tench (*Tinca tinca)* and certain Asian carp species, suggest that the impact of alien species is a threat to salmon that may become more significant in the future.

POTENTIALLY PROBLEMATIC NATIVE PLANTS AND ANIMALS

The successful reintroduction of Striped Bass (*Morone saxatilis*) into the St. Lawrence River has the potential to exert pressure on Atlantic Salmon populations through competition and predation.

Striped Bass can have an effect on aquatic food webs, as an increase in their abundance results in increased predation pressure on a wide variety of invertebrates and fish (Grout 2006). Because Striped Bass are opportunistic predators, anadromous species may be part of their diet when their respective migratory routes overlap (Grout 2006). Striped Bass predation may affect two life stages of Atlantic Salmon. First, smolts may be affected if striped bass are present at the river mouth during their migration to the sea. Second, parr may be affected when Striped Bass make incursions into the freshwater portion of rivers. From 2014 to 2019, MFFP documented interactions between striped bass and both life stages of Atlantic Salmon. The following information summarizes the knowledge published by Lapointe et al. (2021).

At the mouths of Quebec salmon rivers, the likelihood of interaction between smolts and Striped Bass is low, since the majority of smolts have already left the rivers by the time Striped Bass are observed there. Furthermore, no smolts were found in the stomach contents of 357 striped bass captured in 2014 and 2015 at the mouths of salmon rivers in the Gaspé Peninsula. The spatiotemporal mismatch in habitat use between the two species, as well as the apparent absence of smolts in the stomach contents analyzed, suggests that the potential for interaction between the two species is low in the estuaries of salmon rivers in southern Gaspé, even when Striped Bass are present. This situation is quite different from that observed in the Miramichi River, in New Brunswick, where the potential for interaction between the two species is higher. A large proportion of the Striped Bass population in the southern Gulf of St. Lawrence is concentrated in the downstream portion of this river at the same time as the smolts begin their migration to the sea.

Among Quebec salmon rivers, the Ouelle River in the Bas-Saint-Laurent region is the only one for which monitoring of Striped Bass movements by acoustic telemetry indicates a sustained presence at the mouth in the spring, when conditions are favourable for smolt migration. However, no smolts were found in the stomach contents of 184 Striped Bass captured in spring 2018 at the mouth of this river. Analysis of stomach contents indicates: (1) a 48% feeding incidence, (2) that fish accounted for 74% of prey counted and 81% of total prey volume, and (3) that there were no smolts among the prey (Lapointe et al. 2021). Although several prey could not be identified in the analysis, it is unlikely that smolts are an important prey item for Striped Bass, since the fish that were identified accounted for 54% of the number and 73% of the volume of prey and no salmonids were listed (Lapointe et al. 2021). However, the low abundance of Atlantic Salmon in the Ouelle River (MFFP 2020) could also explain their absence in the stomachs of Striped Bass captured at its mouth. The apparent absence of smolts in the stomach contents of Striped Bass despite a spatiotemporal overlap between the two species confirms the low risk of smolt predation by Striped Bass in Quebec.

The potential for interaction between Atlantic Salmon parr and Striped Bass in the freshwater portion of rivers is low, since they do not favour the same habitats. Parr prefer swift water, while Striped Bass are more likely to be observed in pools or calm water sectors. Nevertheless, MFFP, in collaboration with the *Fédération Québécoise pour le Saumon Atlantique*, conducted a study on the presence of Striped Bass in salmon rivers from 2017 to 2020 in order to assess their prevalence and potential impacts. Striped Bass were observed in the freshwater portions of 22 rivers in 2017, five rivers in 2018, six rivers in 2019 and five rivers in 2020 (Lapointe et al. 2021). Thus, this monitoring showed that only a fraction of Striped Bass make incursions into the freshwater portions of salmon rivers and that the extent of this phenomenon varies from one year to another. At the same time, MFFP carried out a Striped Bass sampling campaign in the freshwater portions of salmon rivers for stomach content analysis. During three years of this monitoring, the stomach contents of 87 striped bass captured in five rivers revealed: (1) a feeding incidence of 71% and (2) the presence of parr or undetermined salmonids in 23% of the Striped Bass captured (Lapointe et al. 2021).

Since 2014, the stomach contents of over 1,200 fish have been analyzed as part of the Striped Bass diet characterization projects conducted by MFFP. To date, for all stages combined, salmonids (Atlantic Salmon and anadromous brook trout) constitute less than 1% of the prey volume (Lapointe et al. 2021). Thus, despite the perceptions conveyed, the limited interactions between the two species and the low prevalence of salmon in the diet of Striped Bass allow us to conclude that Striped Bass do not constitute a major threat to the sustainability of Atlantic Salmon populations in Quebec.

HABITAT CHANGE AND TRANSFORMATION

Changes in the marine ecosystem are recognized as the main cause of the species' decline in the 1980s and 1990s (Chaput 2012; Mills et al. 2013). Since the late 1990s and early 2000s, marine mortality rates appear to have stabilized in Quebec populations, but at a higher level than in the past (MFFP 2020). Modification of the marine ecosystem remains a major threat, as it affects all migratory individuals.

ACKNOWLEDGEMENTS

We would like to thank Nicolas Gagné and Anne-Marie Pelletier for revising this report following the change of duties of Soazig Le Breton and Jérôme Doucet-Caron. We would also like to acknowledge the indirect contribution of numerous colleagues from the Ministère des Forêts, de la Faune et des Parcs who took part in the fieldwork and analyses, including William Cayer-Blais, Martin Laporte, Julien Mainguy and Isabel Thibault. Finally, we wish to thank Gérald Chaput and François Caron for their constructive comments, as well as Charley Cyr for coordinating the pre-COSEWIC review for Quebec salmon populations.

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APPENDICES

Appendix 1. Key elements of the Quebec salmon stocking guidelines

1. Stocking of Atlantic Salmon should be for conservation purposes only. Consequently, candidate populations for stocking should have an average egg deposition rate below the conservation threshold.
2. Atlantic Salmon stocking should not be carried out in very small populations, to minimize the risk of exacerbating the loss of genetic diversity. Therefore, it is recommended that populations with an effective population size (N_e) of less than 95 or, in the case of populations where effective size is unknown, with a spawner abundance of less than 200 not be stocked.
3. The number of spawners used and the number of juveniles stocked must be predefined so that the ratio of effective size following stocking to effective size without stocking is greater than 0.90 AND the ratio between adult abundance with and without stocking is greater than 1.15.
4. Offspring intended for stocking should always be produced from wild breeding stock taken from the target population.
5. The possibility of intra-river genetic structuring should be considered. Where possible, genetic analysis should be conducted to verify the existence of genetically differentiated populations within a river. In such a case, stocking should be done separately for each population identified in the river.
6. The number of spawners used for breeding at a fish farm must be greater than 30 for any population and must include an equal number of males and females.
7. The abundance of spawners in the target populations should not exceed 500 unless a high number of captive spawners can be captured and maintained in captivity, i.e., a minimum of 10% of the abundance of spawners in the river.
8. The removal of spawners in the wild should be spread out over the entire run and be representative of the phenotypic variation of each population, particularly the proportion of 1SW and MSW fish.
9. A partial factorial crossing design involving a minimum of three males and three females should be applied.
10. The annual replacement rate of spawners must be greater than 33%. A proportion of the spawners can therefore be reconditioned and used for more than one reproduction cycle without major consequences for the wild population being stocked.
11. The time spent in captivity by fish intended for stocking should be minimized in order to reduce the possibility of adaptation to the rearing environment and of genetic impacts on wild populations. It is therefore generally desirable to stock the youngest possible life stage.
12. The breeding plan should include stocking for the average duration of a generation, or 5 years, for each of the target populations.

Appendix 2. Age at smoltification of salmon from 45 Quebec rivers

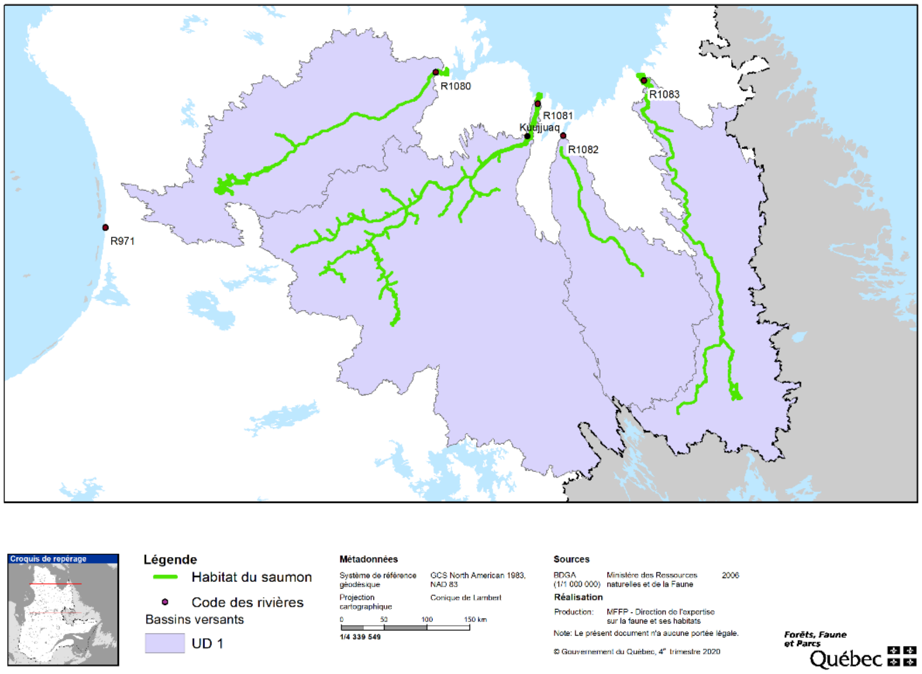
River	Average age at smoltification
Jacques-Cartier	2.00
Romaine	2.04
Betsiamite	2.10
Laval	2.36
Des Escoumins	2.42
Port-Daniel	2.56
Puyjalon (Romaine system)	2.73
Godbout	2.84
Matane	2.85
Maricourt (Koksoak system)	2.88
Cap-Chat	2.94
Rochers	2.94
Corneille	2.95
Madeleine	2.99
Chaloupe	3.00
Bec-Scie	3.01
Sainte-Anne	3.03
Petite Cascapédia	3.09
Trinité	3.10
Mingan	3.15
Grand-Pabos Ouest	3.18
Grand-Pabos	3.22
Watshishou	3.23
Saint-Jean (Saguenay region)	3.24
Saint-Jean (Gaspé region)	3.24
Cascapédia	3.25
Moisie	3.26
Frémin (Koksoak system)	3.28
Jupiter	3.30
Grande Rivière	3.31
Aguanus	3.36
Bonaventure	3.38
Watshishou	3.42
Dartmouth	3.50
Étamamiou	3.50
York	3.51
Natahquan	3.69
Vieux-Fort	3.99
Saint-Paul	4.20
Du Gué (Koksoak system)	4.29
Mélèzes (Koksoak system)	4.55
Koksoak	4.61
Leaf	4.64
Delay (Koksoak system)	4.68
Baleine	4.88
George	5.49

Appendix 3. Average weight of small salmon (less than 63 cm) and large salmon (63 cm and over) in 64 Quebec rivers

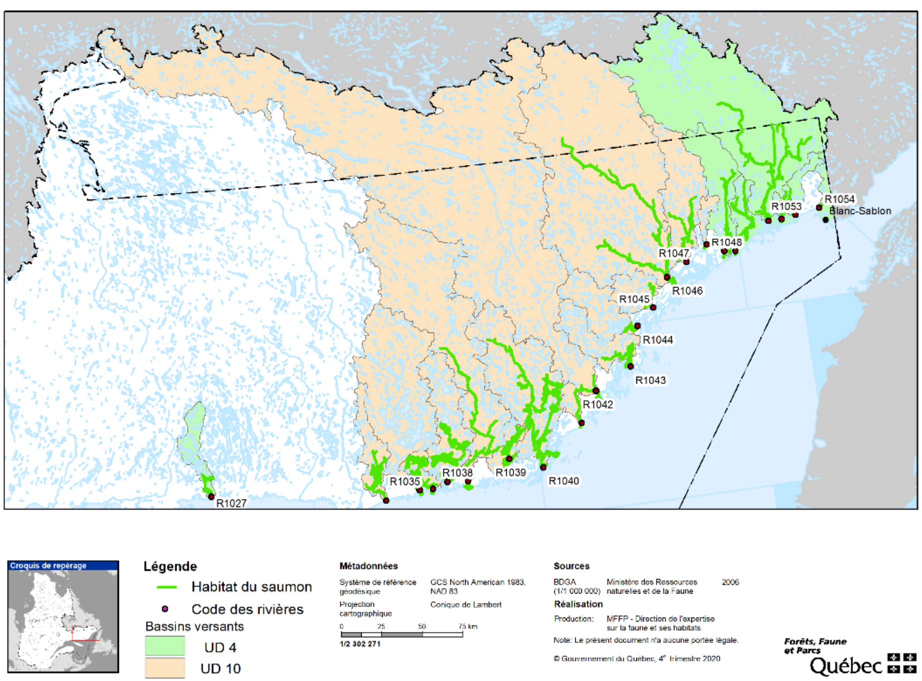
River	Average weight of small salmon (kg)	Average weight of large salmon (kg)
Bonaventure	1.51	-
Cascapédia	1.78	-
Causaspcal	1.82	7.65
Kedgwick	1.50	-
Matapédia	1.96	7.34
Nouvelle	1.61	-
Patapédia	1.88	7.00
Petite Cascapédia	1.59	-
Dartmouth	1.56	5.35
Grand Pabos	1.61	-
Grand Pabos Ouest	1.73	-
Grande-Rivière	1.69	-
Petit Pabos	1.62	-
Port-Daniel	1.42	-
Saint-Jean	1.54	4.52
York	1.64	5.20
Cap-Chat	1.67	5.02
Madeleine	1.64	4.42
Matane	1.70	5.19
Mitis	1.92	4.86
Ouelle	1.68	-
Rimouski	1.91	-
Sainte-Anne	1.75	5.08
Gouffre	1.90	6.50
Malbaie	1.90	-
Mars	2.20	-
Petit Saguenay	2.10	-
Sainte-Marguerite	2.08	-
Sainte-Marguerite Nord-Est	2.18	-
Saint-Jean (Saguenay)	2.05	-
Rochers	1.70	-
Trinité	1.62	-
Escoumins	1.86	-
Godbout	1.86	-
Pentecôte	1.68	-
Aguanus	1.80	-
Corneille	1.75	-

River	Average weight of small salmon (kg)	Average weight of large salmon (kg)
Mingan	1.92	4.86
Moisie	-	6.04
Nabisipi	1.62	-
Natashquan	1.99	4.48
Watshishou	1.65	-
Piashti	2.10	-
Saint-Jean (Côte-Nord)	1.83	5.38
Brador Est	1.91	-
Gros Mécatina	2.06	-
Vieux-Fort	1.79	-
Étamamiou	2.05	5.66
Kécarpoui	2.10	-
Kégaska	2.10	2.70
Musquanousse	2.11	-
Musquaro	1.87	-
Salmon Stream	1.86	-
Belles Amours	2.01	-
Saint-Paul	2.09	5.00
Washicoutai	2.06	5.10
Loutre	1.54	-
Salmon	1.47	1.80
Chaloupe	1.38	1.90
Ferrée	1.40	-
Jupiter	1.41	-
Leaf	2.00	4.58
Georges	2.31	5.13
Koksoak	1.81	3.58

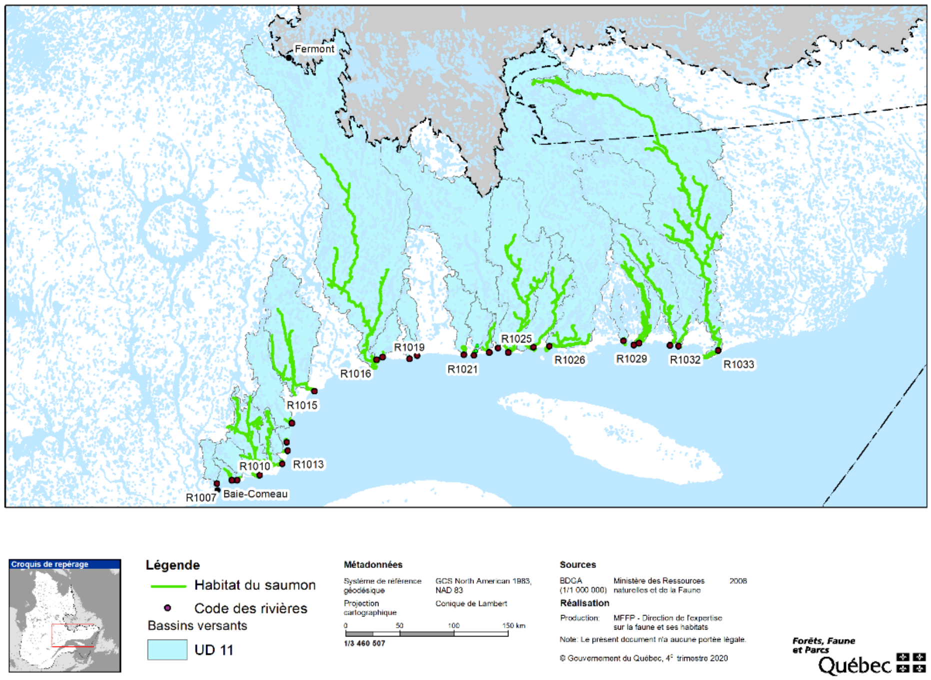
Appendix 4. Map of inventoried salmon habitat for rivers in DU 1



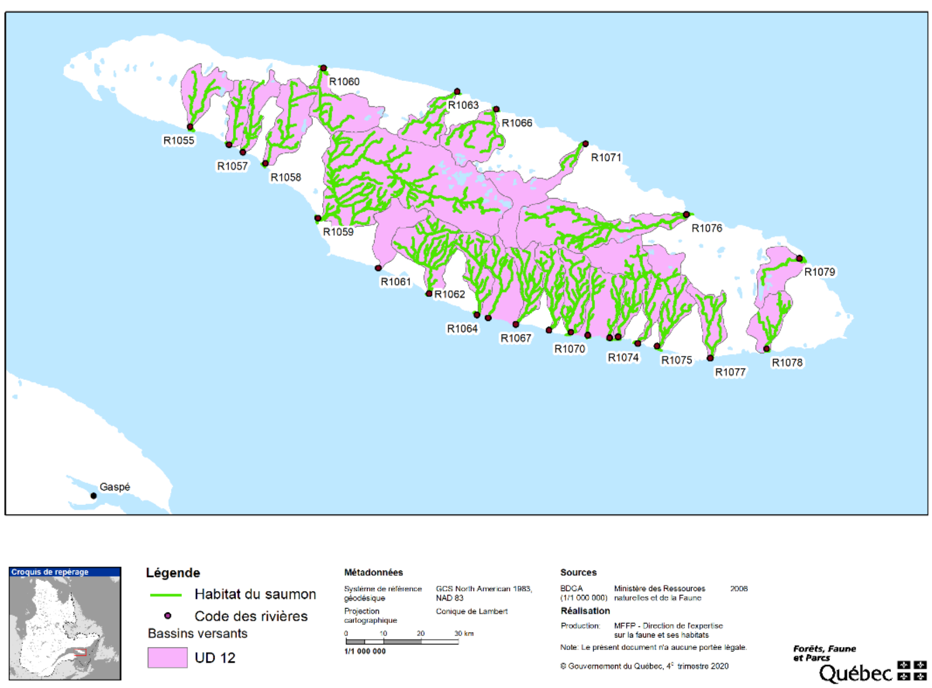
Appendix 5. Map of inventoried salmon habitat for rivers in DU 4 and DU 10



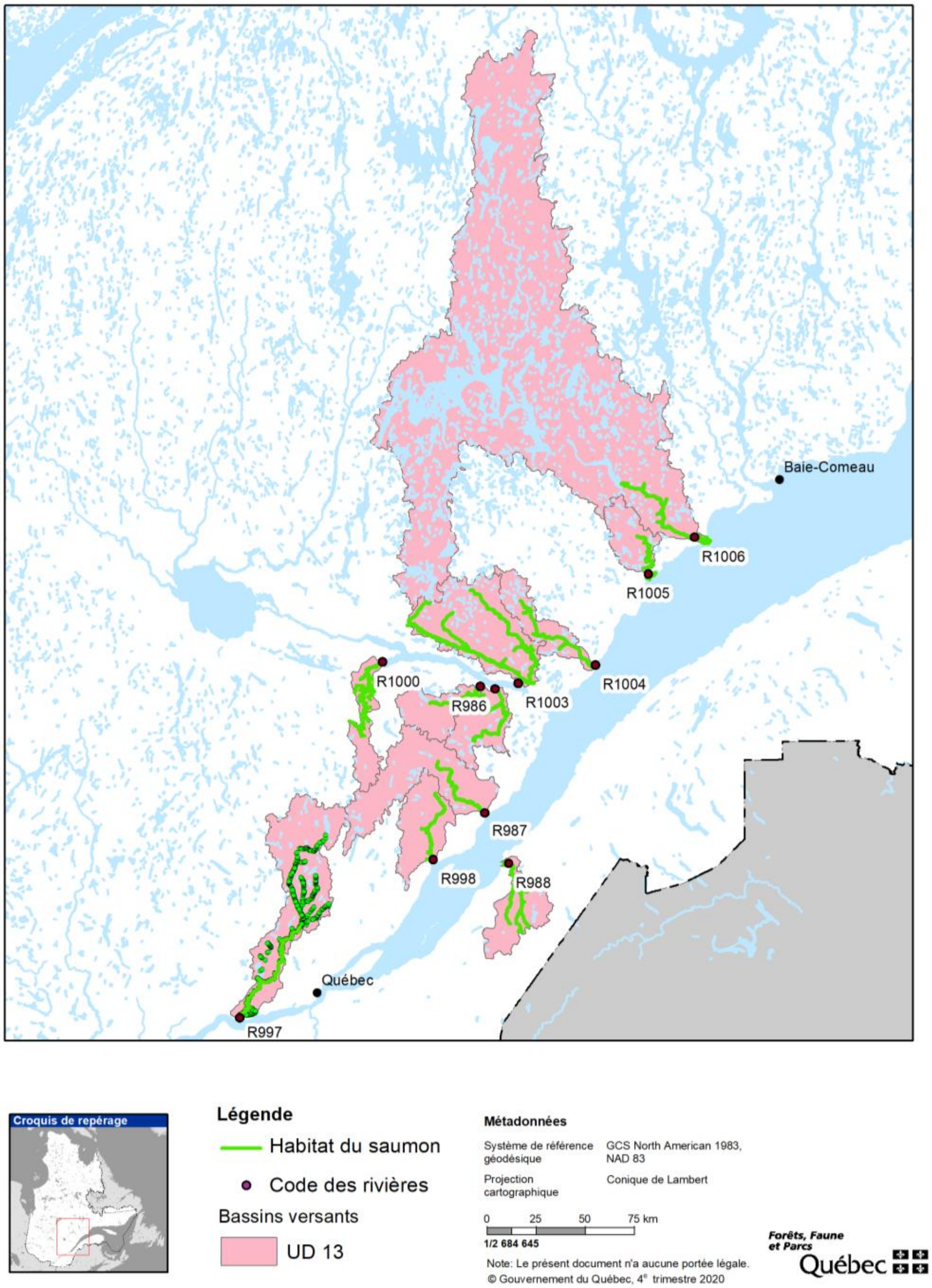
Appendix 6. Map of inventoried salmon habitat for rivers in DU 11



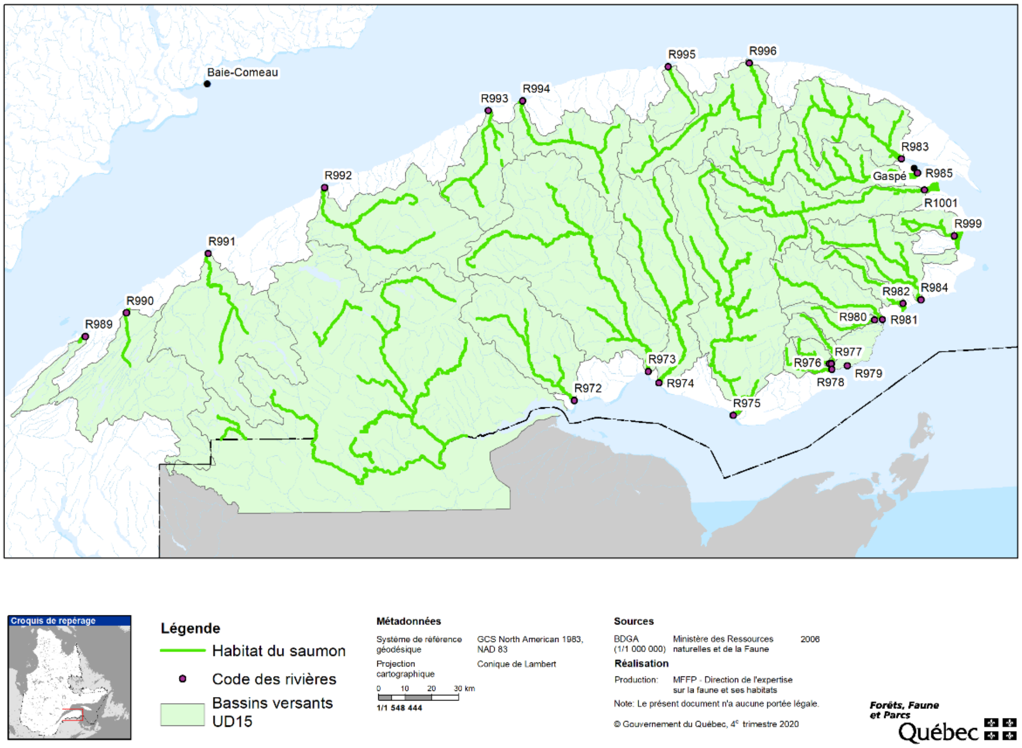
Appendix 7. Map of inventoried salmon habitat for rivers in DU 12



Appendix 8. Map of inventoried salmon habitat for rivers in DU 13



Appendix 9. Map of inventoried salmon habitat for rivers in DU 15



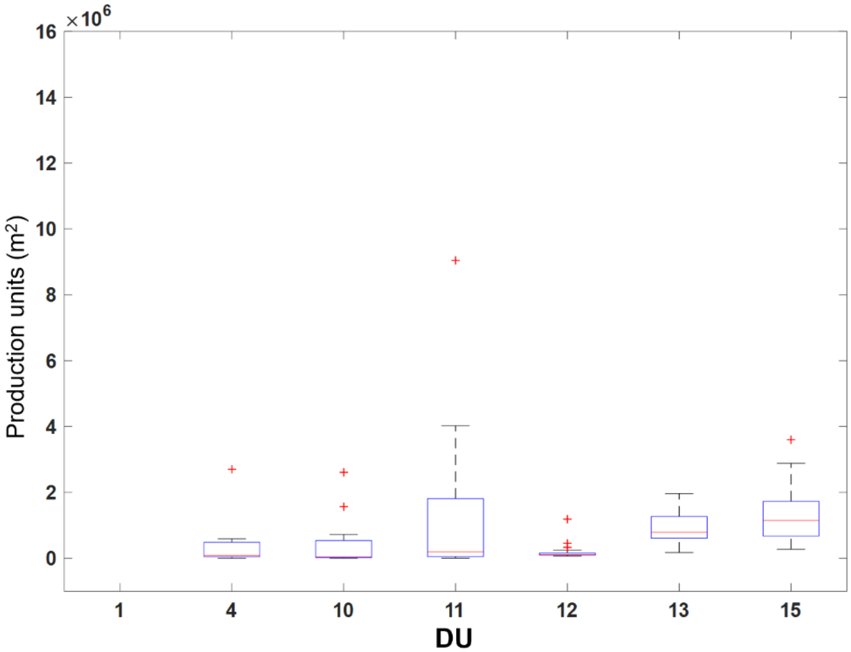
Appendix 10. Accessible area, number of production units and average HQI for Atlantic Salmon in Quebec rivers. Rivers are classified by DU. The administrative regions in which the rivers are located are also indicated.

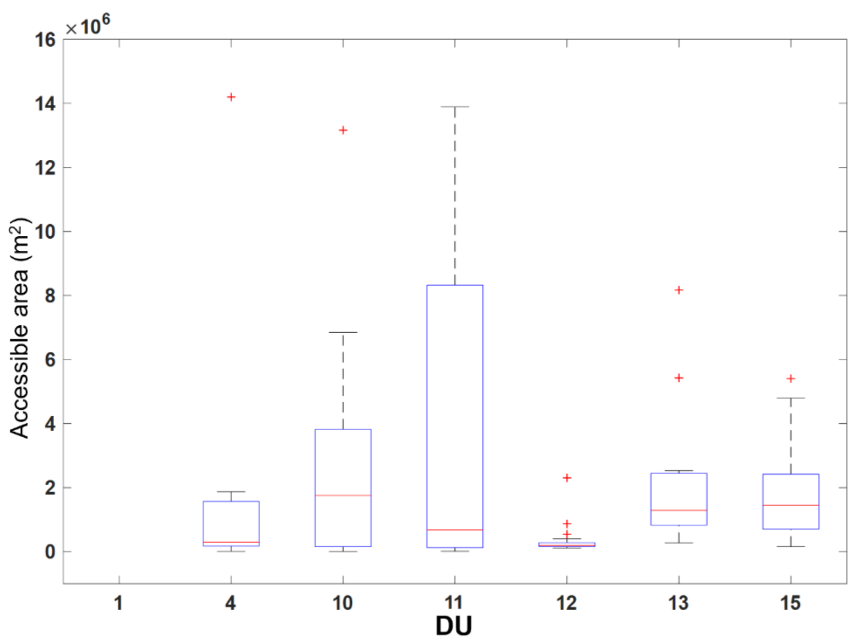
DU	Region	River	Accessible area (m^2)	Production unit (m^2)	Average HQI
1	10	Baleine	-	-	-
1	10	Leaf	-	-	-
1	10	George	-	-	-
1	10	Koksoak	-	-	-
4	9	Brador Est	156,034	49,312	0.41
4	9	Corneille	235,135	46,193	0.43
4	9	Vieux Fort	650,334	165,527	0.37
4	9	Napetipi	1,873,349	594,661	0.37
4	9	Salmon Stream	300,777	84,301	0.34
4	9	Belles Amours	7,269	3,174	0.44
4	9	Saint-Paul	14,200,161	2,703,128	0.33
10	9	Chécatica	4,032	2,379	0.49
10	9	Coacoachou	116,485	44,652	0.51
10	9	Coxipi	2,804,472	670,493	0.31
10	9	Gros Mécatina	918,627	41,086	0.25
10	9	Petit Mécatina	3,038,368	71,468	0.24
10	9	Étamamiou	6,847,078	1,565,697	0.41
10	9	Kécarpoui	90,913	32,732	0.38
10	9	Kégaska	3,075,674	139,841	0.38
10	9	Musquanousse	424,928	35,338	0.41
10	9	Musquaro	2,593,829	3,636	0.26
10	9	Nétagamiou	185,328	18,533	0.08
10	9	Olomane	13,163,865	721,318	0.35
10	9	Saint-Augustin	24,905,233	2,608,259	0.28
10	9	Saint-Augustin Nord-Ouest	4,560,685	413,203	0.29
10	9	Véco	792,125	7,004	0.28
10	9	Washicoutai	121,678	21,240	0.27
11	9	Aguanish	879,331	151,381	0.26
11	9	Bouleau	100,942	41,726	0.54
11	9	Anglais	45,785	27,693	0.46
11	9	Rochers	7,870,018	2,217,024	0.42
11	9	Calumet	49,267	31,393	0.34
11	9	Franquelin	143,663	73,789	0.49
11	9	Godbout	5,265,599	2,139,454	0.53
11	9	Jupitagon	437,001	196,088	0.47
11	9	Magpie	-	-	-
11	9	Matamec	566,248	231,728	0.36
11	9	Mingan	8,772,024	1,154,116	0.29
11	9	Mistassini	102,219	57,994	0.63
11	9	Moisie	39,343,869	9,044,427	0.39

DU	Region	River	Accessible area (m^2)	Production unit (m^2)	Average HQI
11	9	Nabisipi	9,639,269	1,487,005	0.36
11	9	Natashquan	86,892,854	16,017,361	0.41
11	9	Pentecôte	406,458	197,736	0.48
11	9	Trinité	106,416	74,110	0.62
11	9	Watshishou	795,529	105,245	0.4
11	9	Piashti	157,877	40,864	0.42
11	9	Pigou	12,511	5,551	0.49
11	9	Romaine	13,890,695	2,429,661	0.33
11	9	Saint-Jean (North Shore)	12,405,517	4,024,277	0.46
11	9	Sheldrake	147,825	37,110	0.45
11	9	Tonnerre	-	-	-
11	9	Trinité	1,916,081	987,058	0.52
11	9	Watshishou	4,452,129	866,984	0.37
12	9	Loutre	250,010	137,147	0.54
12	9	Patate	113,082	67,124	0.58
12	9	Huile	193,524	107,262	0.56
12	9	Cailloux	206,935	108,829	0.55
12	9	Plats	156,364	99,591	0.62
12	9	Salmon	868,196	453,875	0.55
12	9	Bec-Scie	164,569	82,495	0.53
12	9	Bell	192,314	119,414	0.63
12	9	Chaloupe	546,310	331,119	0.61
12	9	Chicotte	184,230	113,614	0.6
12	9	Dauphiné	372,334	242,728	0.65
12	9	Brick	-	-	-
12	9	Pavillon	115,943	68,722	0.58
12	9	Renard	236,819	117,570	0.58
12	9	Ferrée	153,351	92,933	0.64
12	9	Galiote	404,610	222,687	0.63
12	9	Jupiter	2,303,244	1,186,836	0.52
12	9	Maccan	-	-	-
12	9	McDonald	191,929	108,849	0.57
12	9	Chaloupe Stream	-	-	-
12	9	Loutre Stream	214,344	135,871	0.64
12	9	Box Creek	152,420	97,817	0.64
12	9	Martin Creek	-	-	-
12	9	Sainte-Marie	217,460	94,790	0.5
12	9	Vauréal	138,120	79,669	0.56
13	1	Ouelle	820,820	673,476	0.83
13	2	Mars	929,194	541,453	0.66
13	2	Sainte-Marguerite	2,367,800	1,373,593	0.58
13	2	Sainte-Marguerite Nord-Est	1,389,273	790,281	0.57
13	2	Saint-Jean (Saguenay)	270,549	174,554	0.73

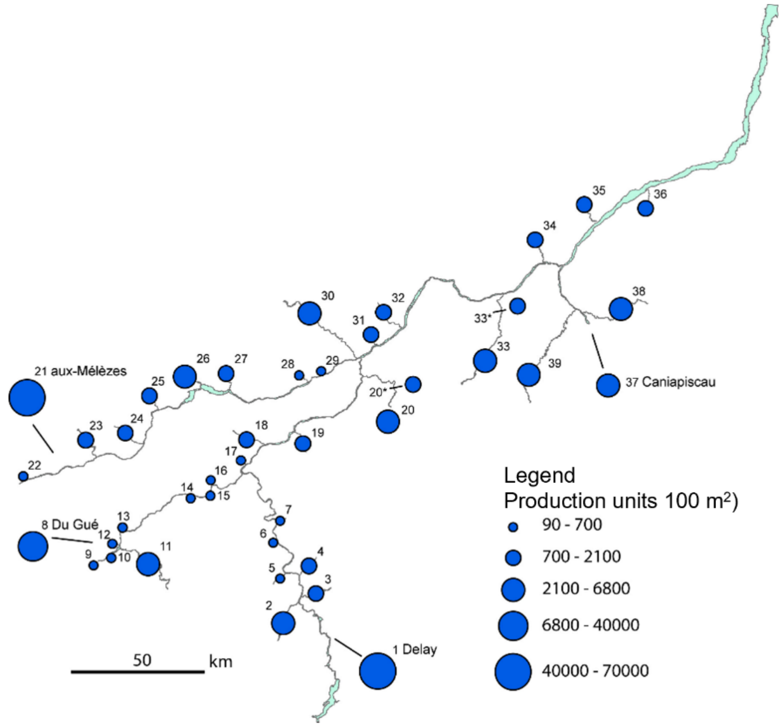
DU	Region	River	Accessible area (m^2)	Production unit (m^2)	Average HQI
13	3	Gouffre	1,541,005	787,890	0.53
13	3	Jacques-Cartier	5,427,920	1,962,947	0.36
13	3	Malbaie (Charlevoix)	2,530,640	1,168,606	0.46
13	3	Petit Saguenay	960,095	668,200	0.7
13	9	Betsiamites	8,169,276	1,967,504	0.54
13	9	Escoumins	1,190,232	1,017,899	0.55
13	9	Laval	779,411	398,463	0.61
15	1	Causapscal	1,407,786	990,434	0.72
15	1	Kedgwick	-	-	-
15	1	Matane	3,357,411	2,073,338	0.71
15	1	Matapédia	5,403,421	3,597,843	0.72
15	1	Mitis	1,817,256	1,233,206	0.77
15	1	Patapédia	1,486,590	1,153,622	0.74
15	1	Rimouski	973,450	592,415	0.69
15	1	Sud-Ouest	-	-	-
15	11	Bonaventure	4,361,239	2,766,182	0.7
15	11	Cap-Chat	913,281	490,942	0.54
15	11	Cascapédia	4,797,125	2,881,000	0.66
15	11	Dartmouth	1,758,200	1,081,688	0.71
15	11	Mont-Louis	155,689	-	-
15	11	Grand Pabos	719,975	539,126	0.8
15	11	Grand Pabos Ouest	359,100	275,648	0.72
15	11	Petit Pabos	682,425	532,724	0.78
15	11	Grande	1,143,660	857,203	0.78
15	11	Madeleine	2,813,595	1,556,853	0.59
15	11	Malbaie (Gaspé)	273,810	-	-
15	11	Nouvelle	1,574,073	1,145,008	0.74
15	11	Cascapédia Stream	1,996,260	1,224,913	0.68
15	11	Port-Daniel Stream	179,641	-	-
15	11	Port-Daniel Du Milieu	-	-	-
15	11	Port-Daniel North	321,429	-	-
15	11	Sainte-Anne	1,331,171	757,278	0.55
15	11	Saint-Jean (Gaspé)	2,251,410	1,610,502	0.74
15	11	York	2,591,190	1,843,792	0.79

Appendix 11. Number of production units (top) and accessible area (bottom) of salmon rivers by designatable unit. On each box, the line within the box is the median value, the box delineates the 25th and 75th percentiles, and the whiskers delineate minimum and maximum concentrations that are not considered outliers. Outliers are plotted individually. Some outliers are not shown because of their very high value.



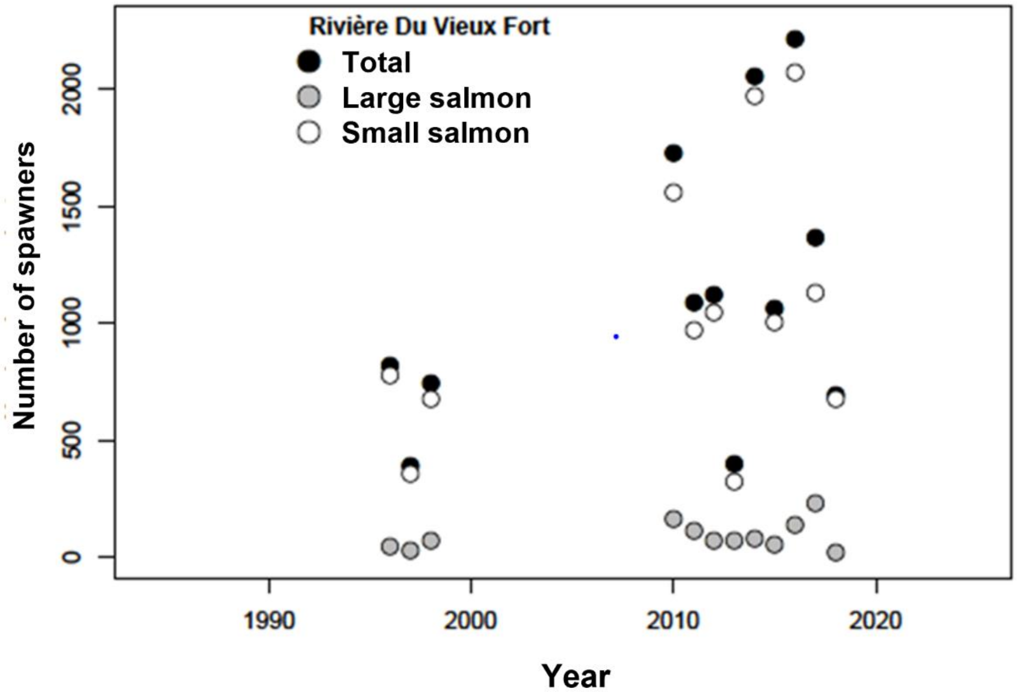


Appendix 12. Production units (PUs), expressed in hundreds, representing the total stream area weighted by the habitat quality index (HQI-Facies-Width-Growth) of watercourses in the Koksoak River system, located in DU 1.

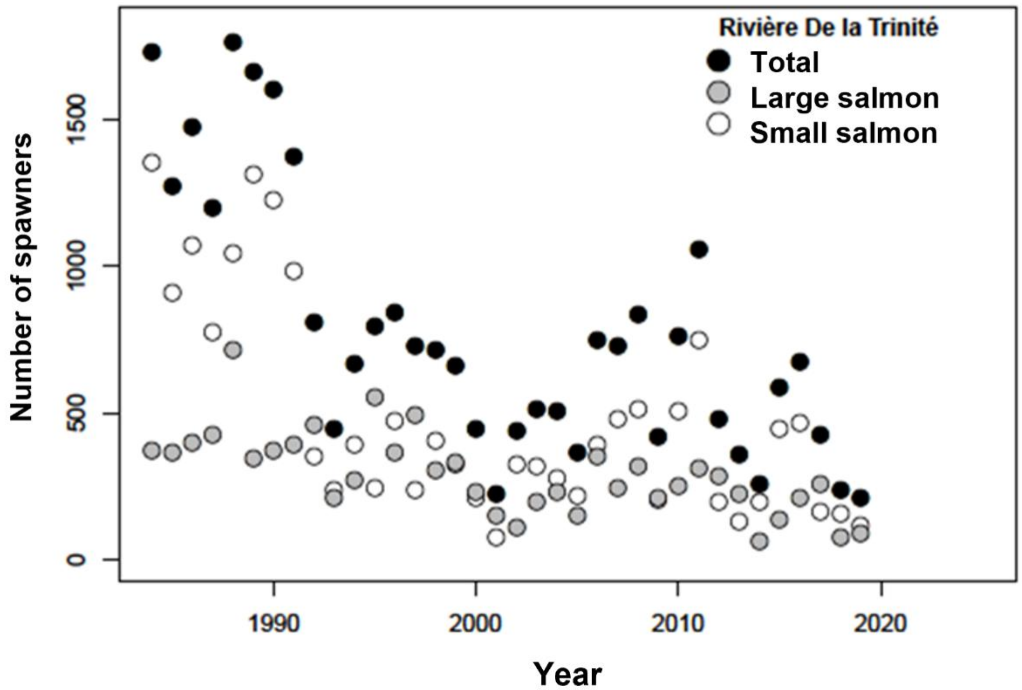


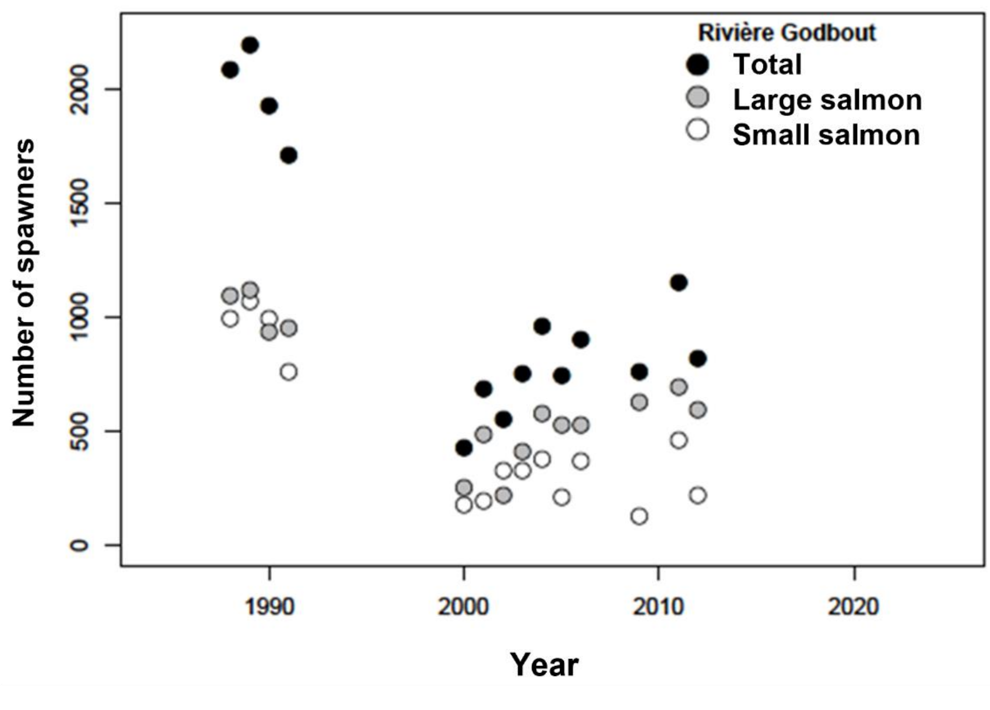
Appendix 13. Changes in number of spawners by year for rivers with at least one year of data between 2010 and 2019

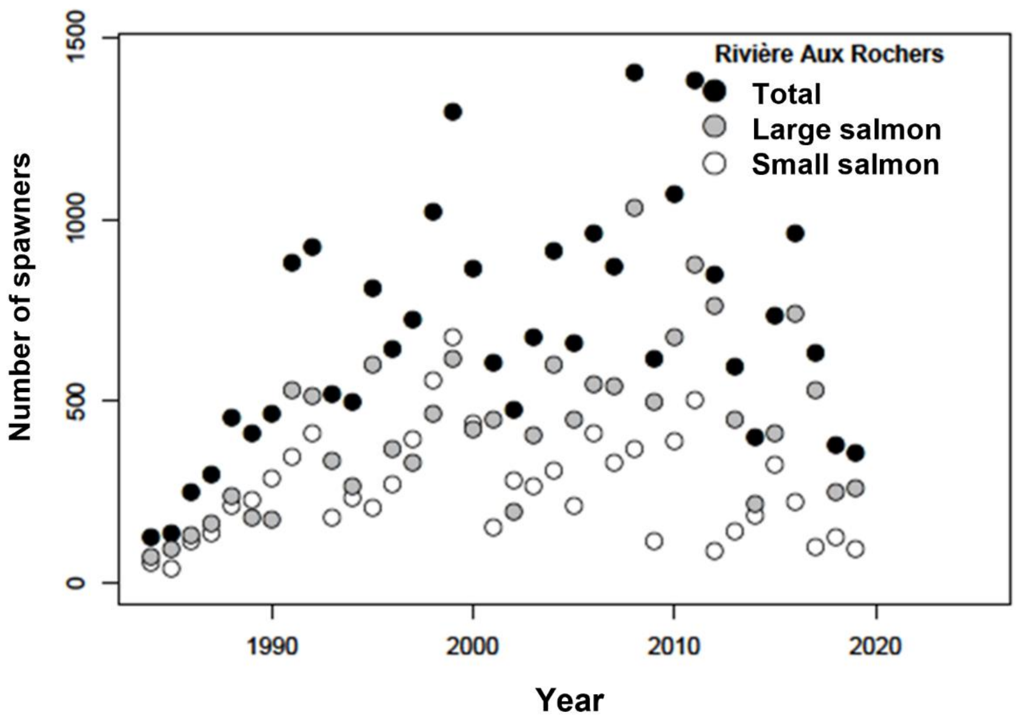
DU 4

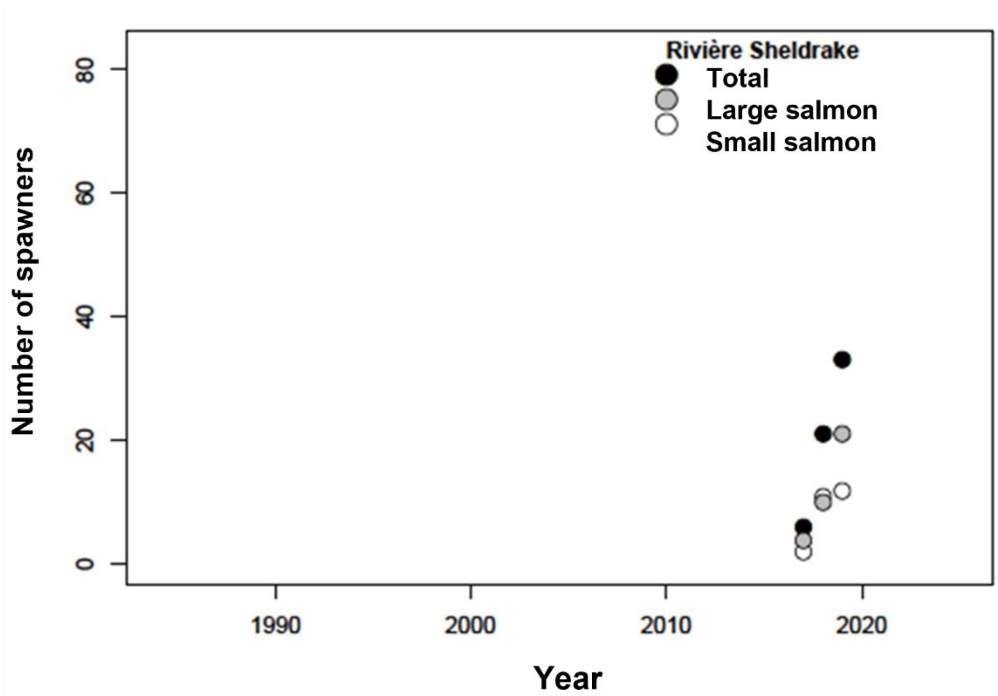


DU 11

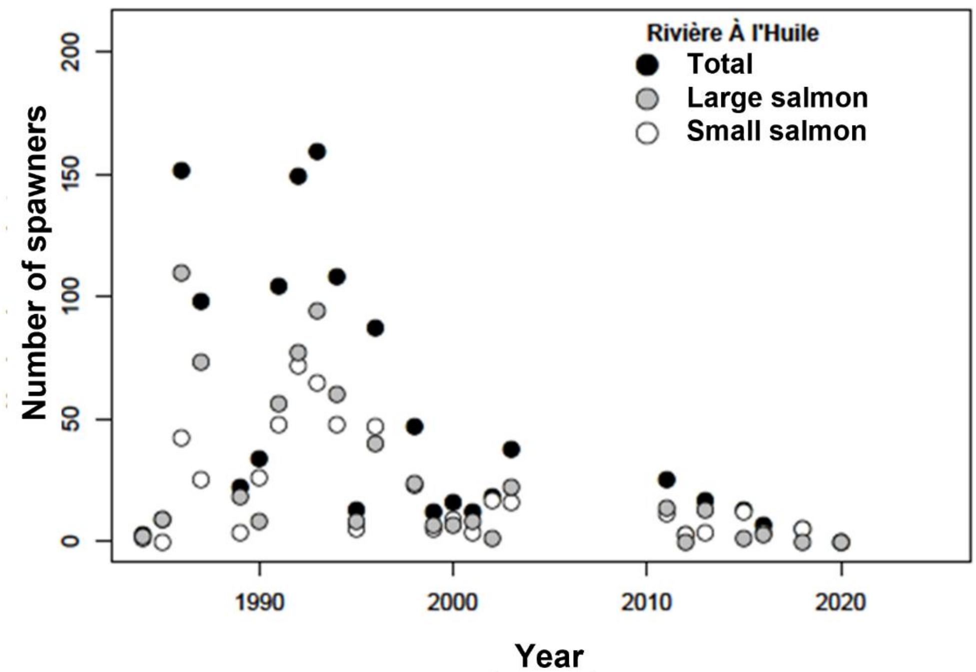

Rivière De la Trinité
Total
Large salmon
Small salmon
Number of spawners
0
500
1000
1500
1990
2000
2010
2020
Year


Rivière Godbout
Total
Large salmon
Small salmon
Number of spawners
0
500
1000
1500
2000
1990
2000
2010
2020
Year

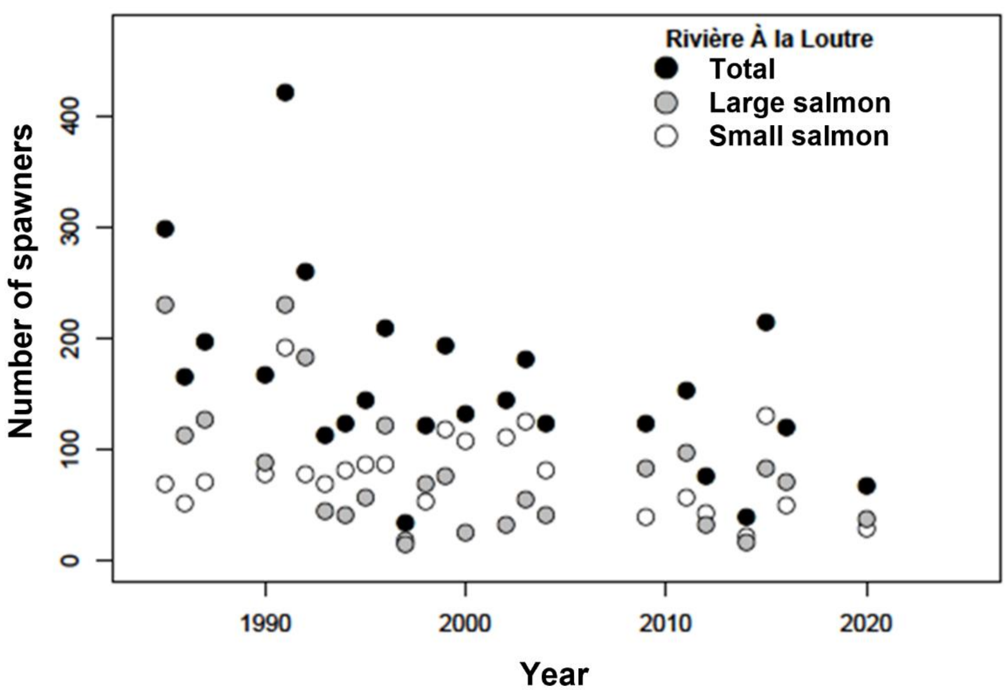

Rivière Aux Rochers
Total
Large salmon
Small salmon
Number of spawners
0
500
1000
1500
1990
2000
2010
2020
Year


Rivière Sheldrake
Total
Large salmon
Small salmon
Number of spawners
0
20
40
60
80
1990
2000
2010
2020
Year

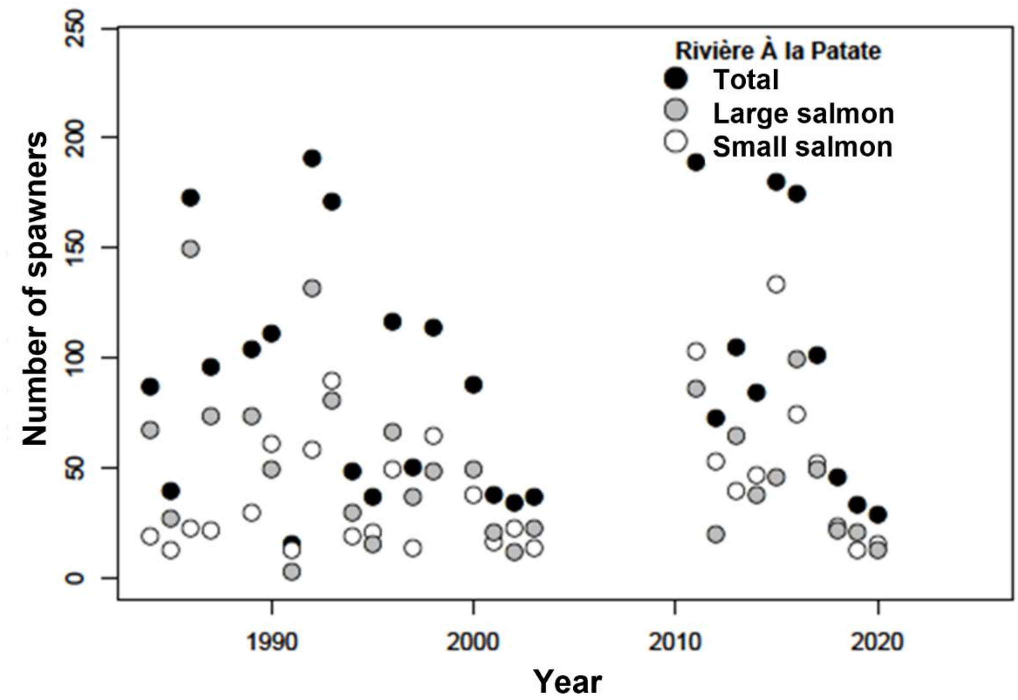
DU 12

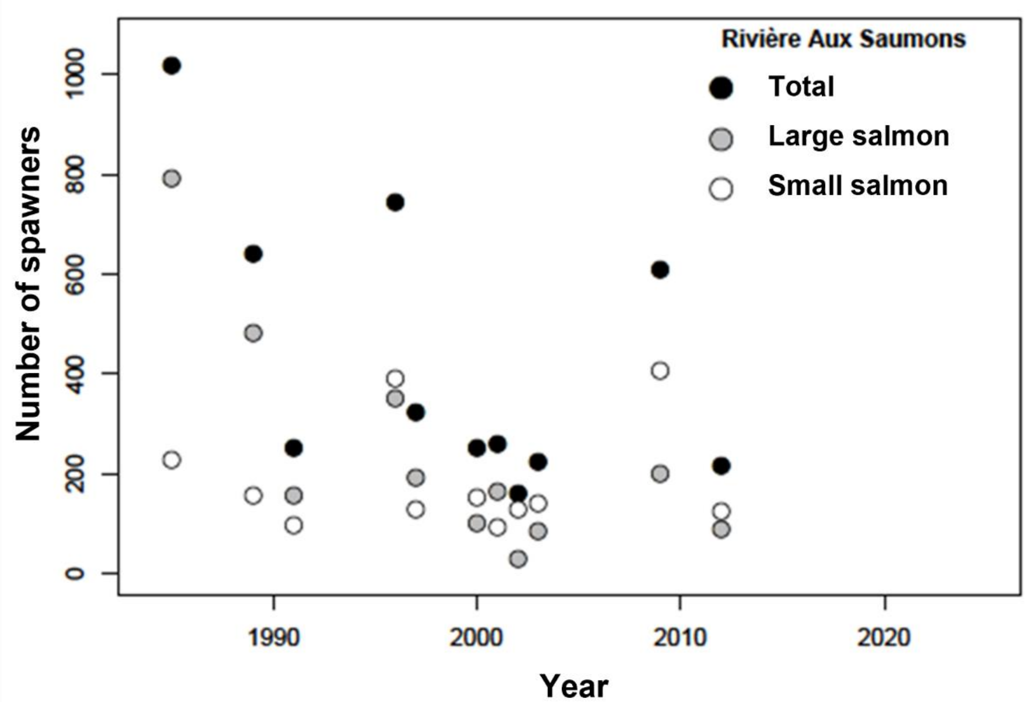


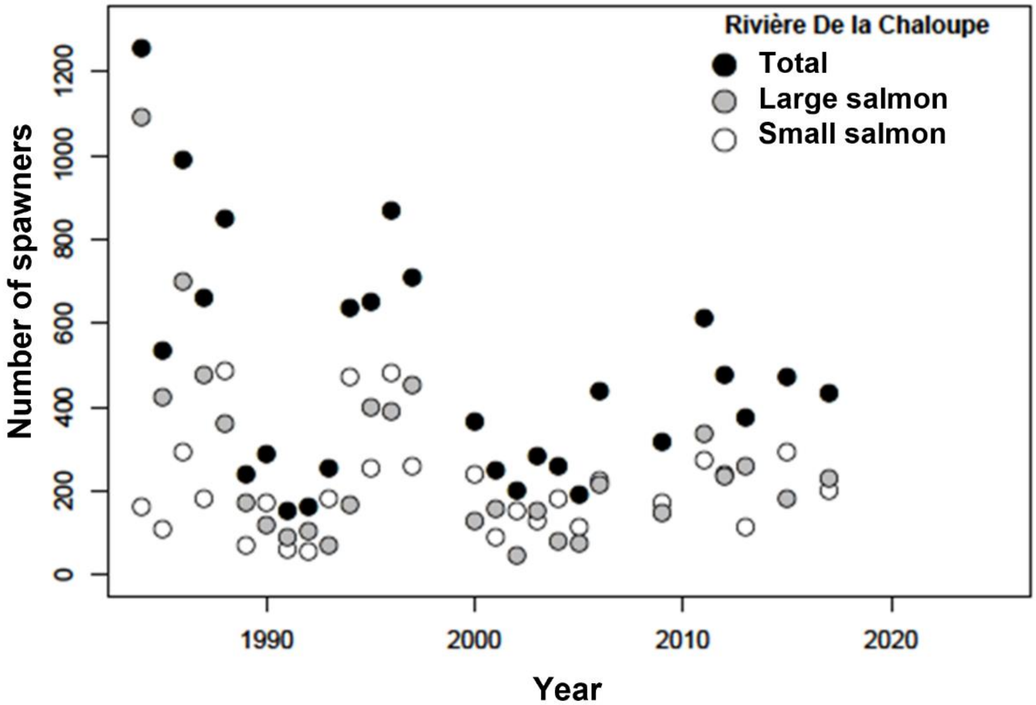
Rivière À l'Huile
Total
Large salmon
Small salmon
Number of spawners
0
50
100
150
200
1990
2000
2010
2020
Year

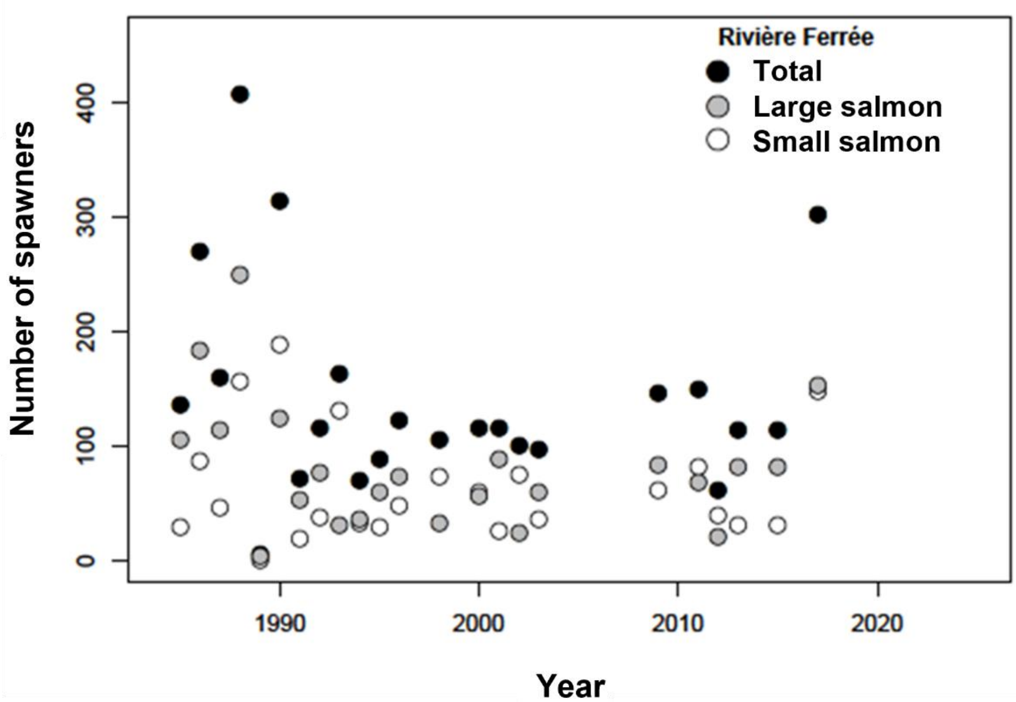


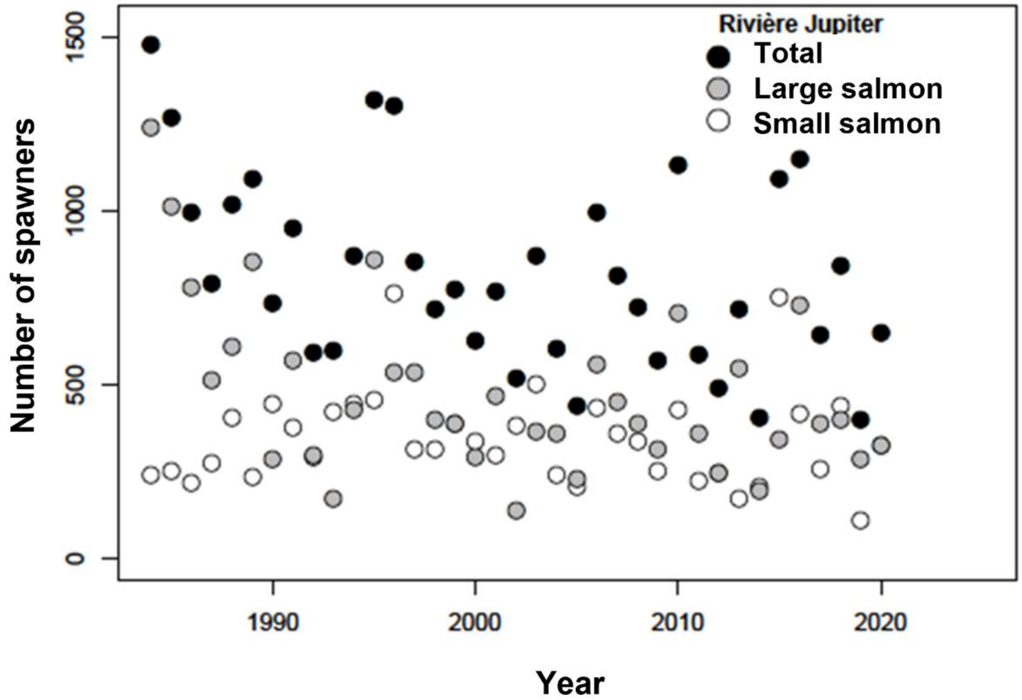
Rivière À la Loutre
Total
Large salmon
Small salmon
Number of spawners
0
100
200
300
400
1990
2000
2010
2020
Year

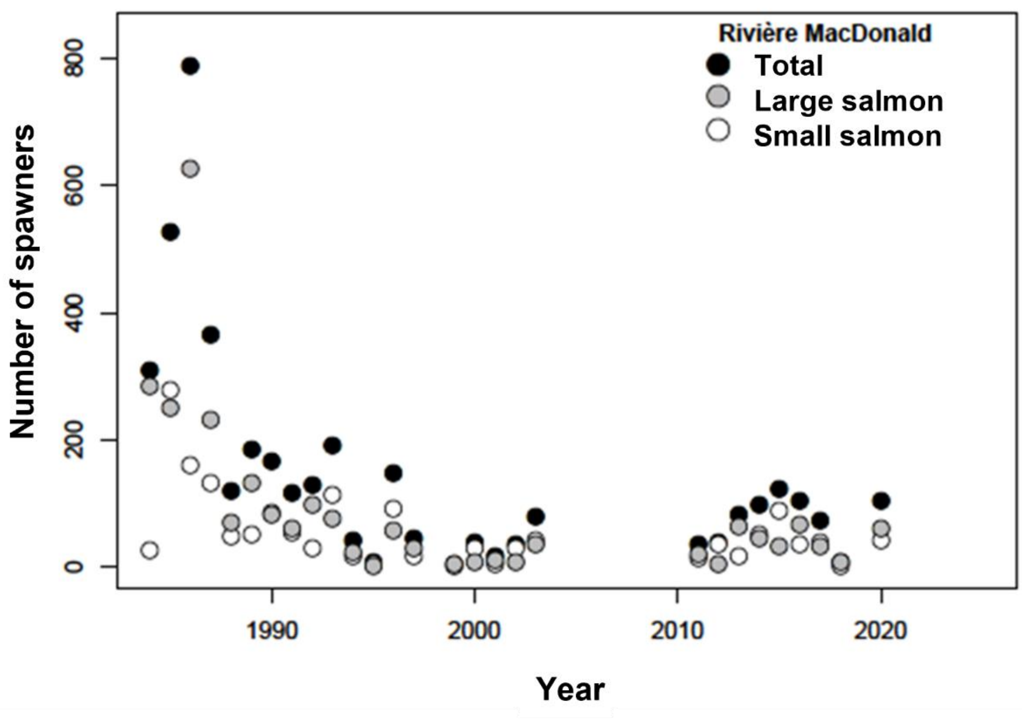

Rivière À la Patate
Total
Large salmon
Small salmon
Number of spawners
0
50
100
150
200
250
1990
2000
2010
2020
Year

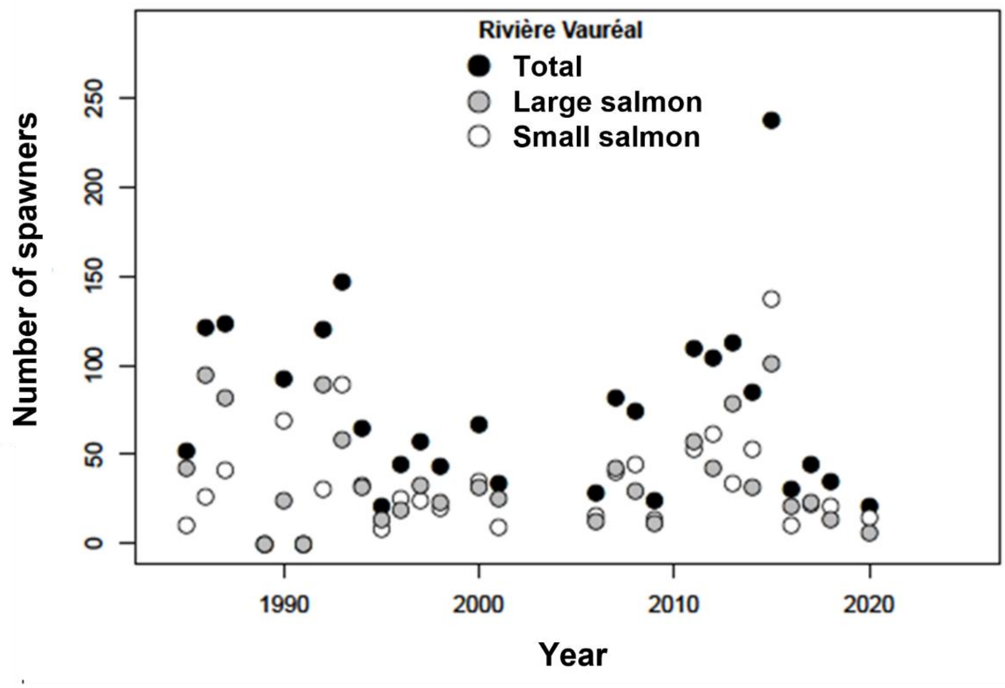

Rivière Aux Saumons
Total
Large salmon
Small salmon
Number of spawners
0
200
400
600
800
1000
1990
2000
2010
2020
Year


Rivière De la Chaloupe
Total
Large salmon
Small salmon
Number of spawners
0
200
400
600
800
1000
1200
1990
2000
2010
2020
Year

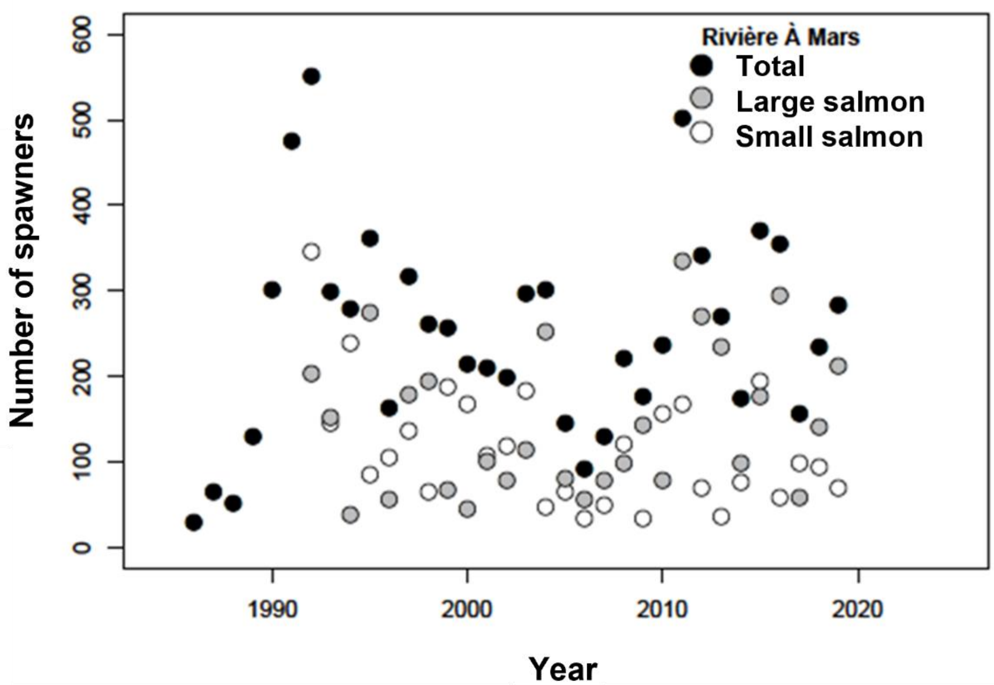

Rivière Ferrée
Total
Large salmon
Small salmon
Number of spawners
0
100
200
300
400
1990
2000
2010
2020
Year

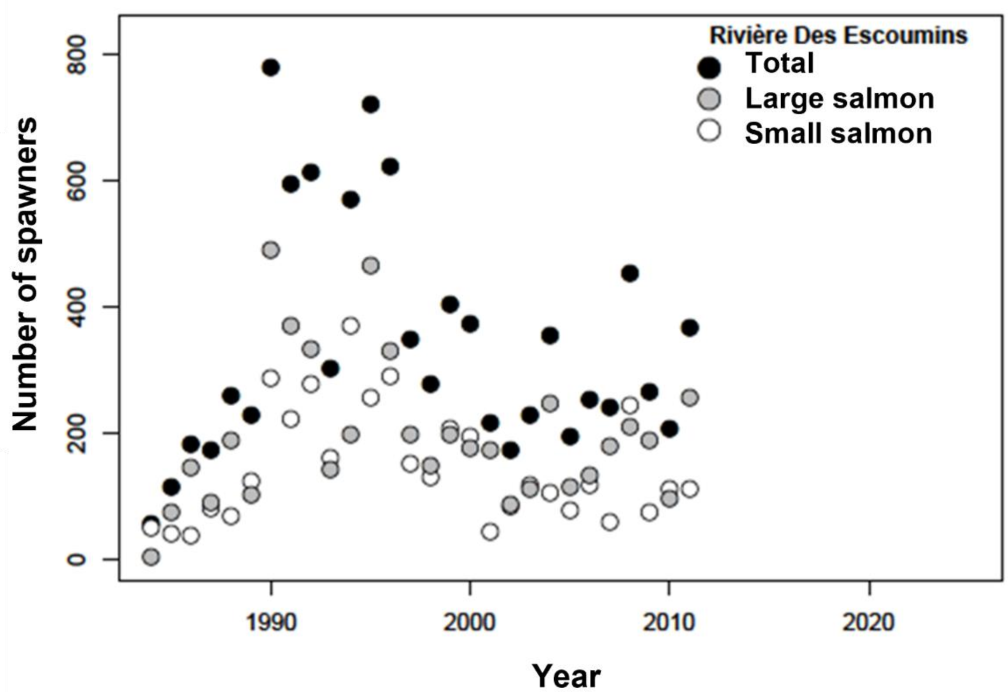

Rivière Jupiter
Total
Large salmon
Small salmon
Number of spawners
0
500
1000
1500
1990
2000
2010
2020
Year

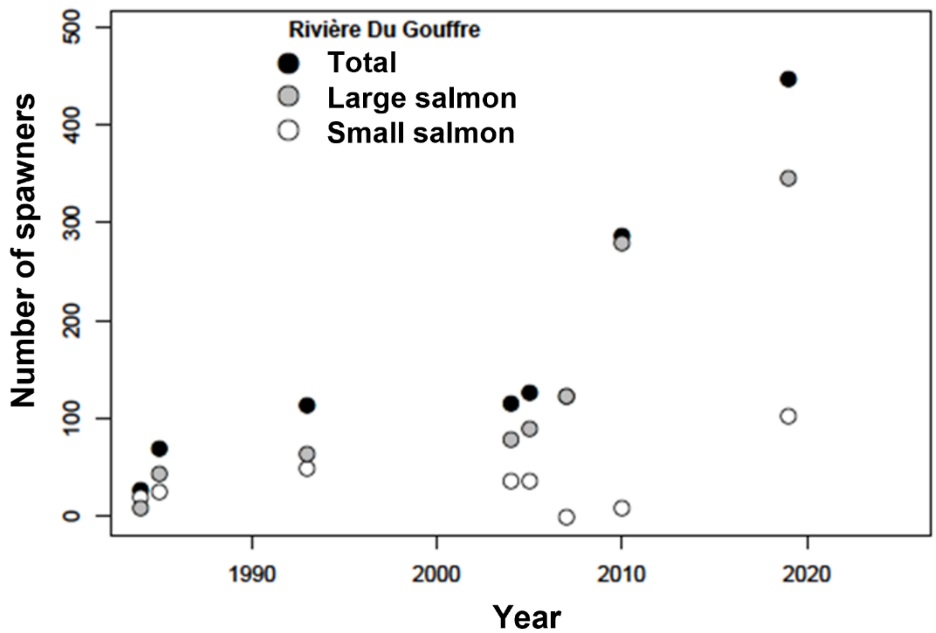

Rivière MacDonald
Total
Large salmon
Small salmon
Number of spawners
0
200
400
600
800
1990
2000
2010
2020
Year

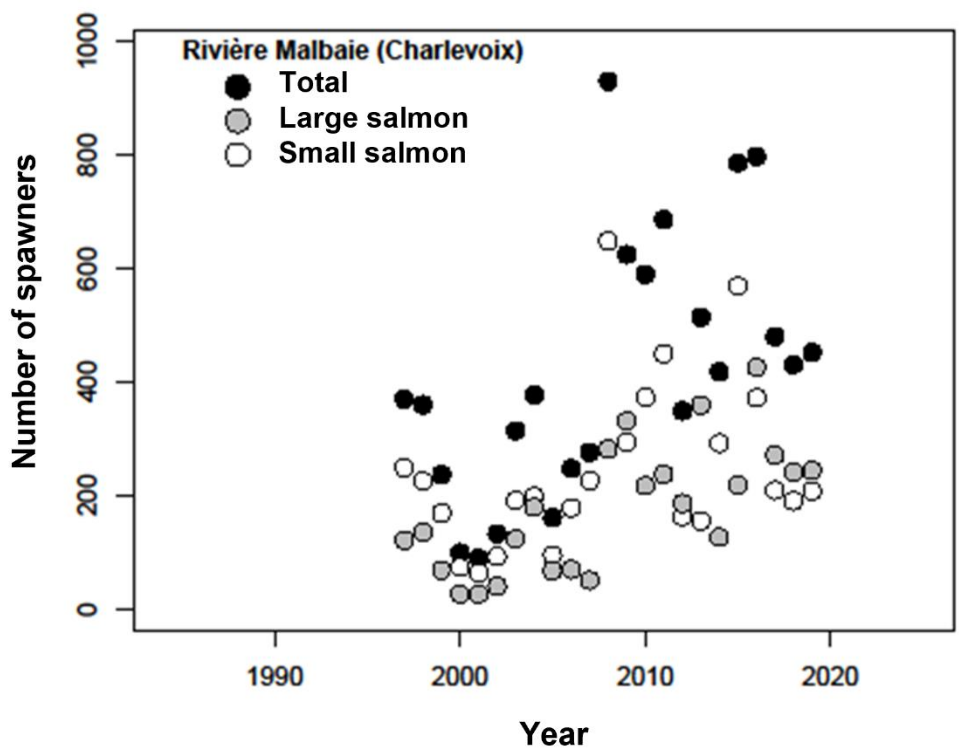

Rivière Vauréal
Total
Large salmon
Small salmon
Number of spawners
0
50
100
150
200
250
1990
2000
2010
2020
Year

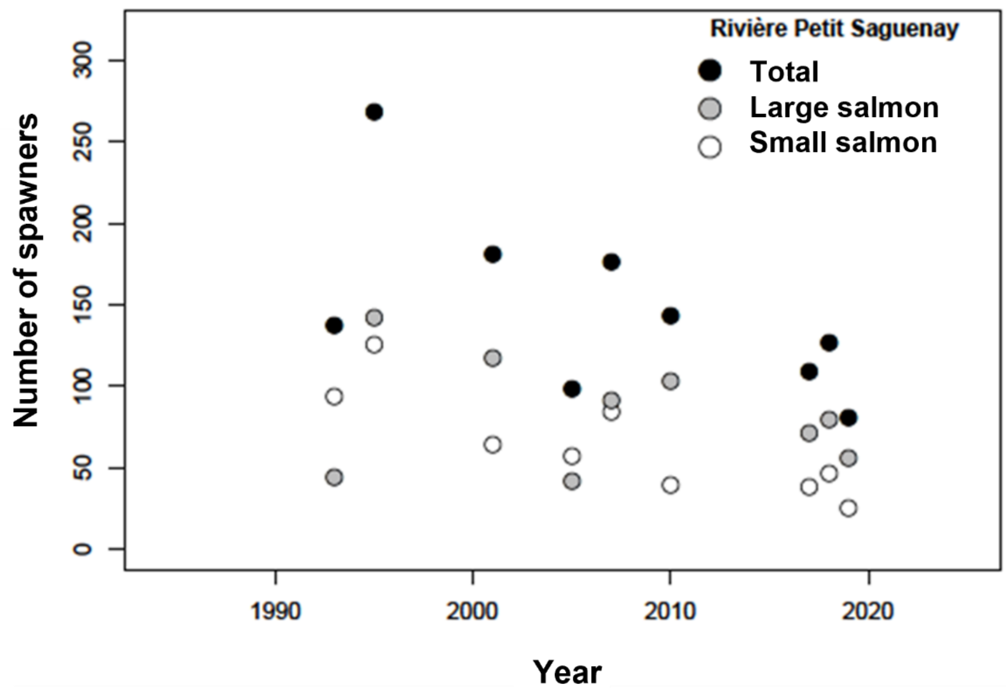
DU 13

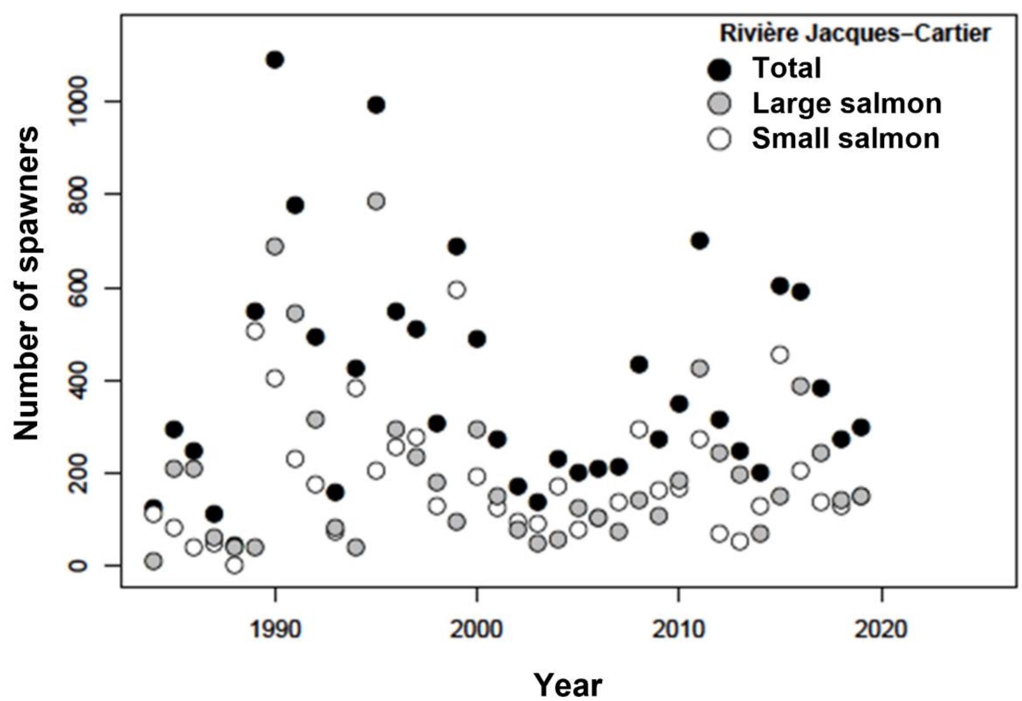

Rivière À Mars
Total
Large salmon
Small salmon
Number of spawners
0
100
200
300
400
500
600
1990
2000
2010
2020
Year

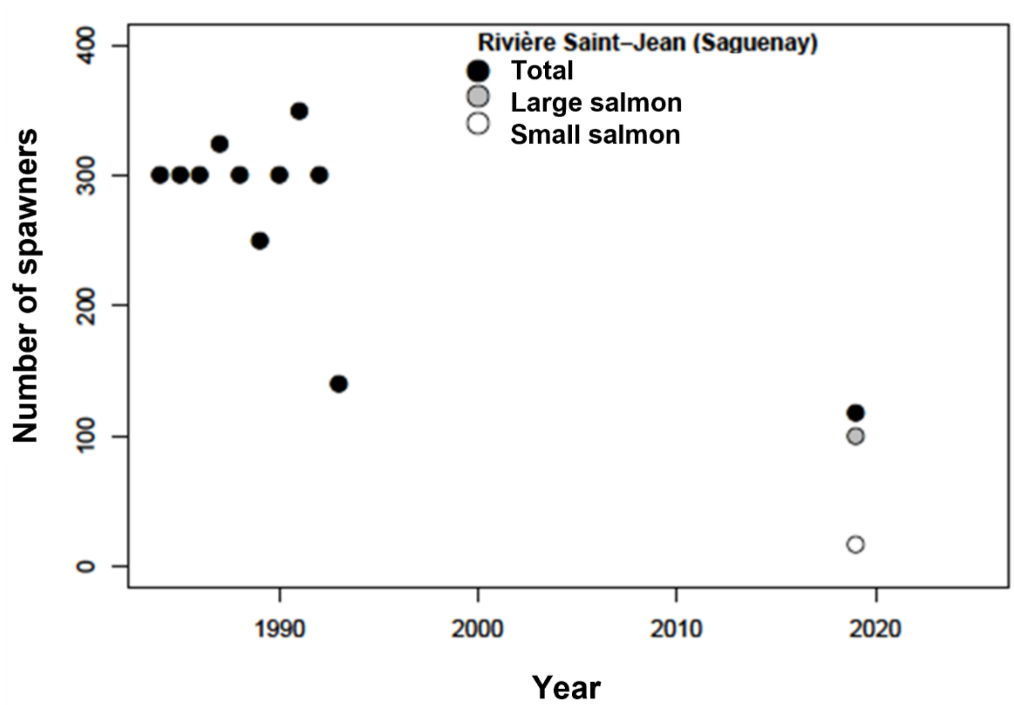

Rivière Des Escoumins
Total
Large salmon
Small salmon
Number of spawners
0
200
400
600
800
1990
2000
2010
2020
Year

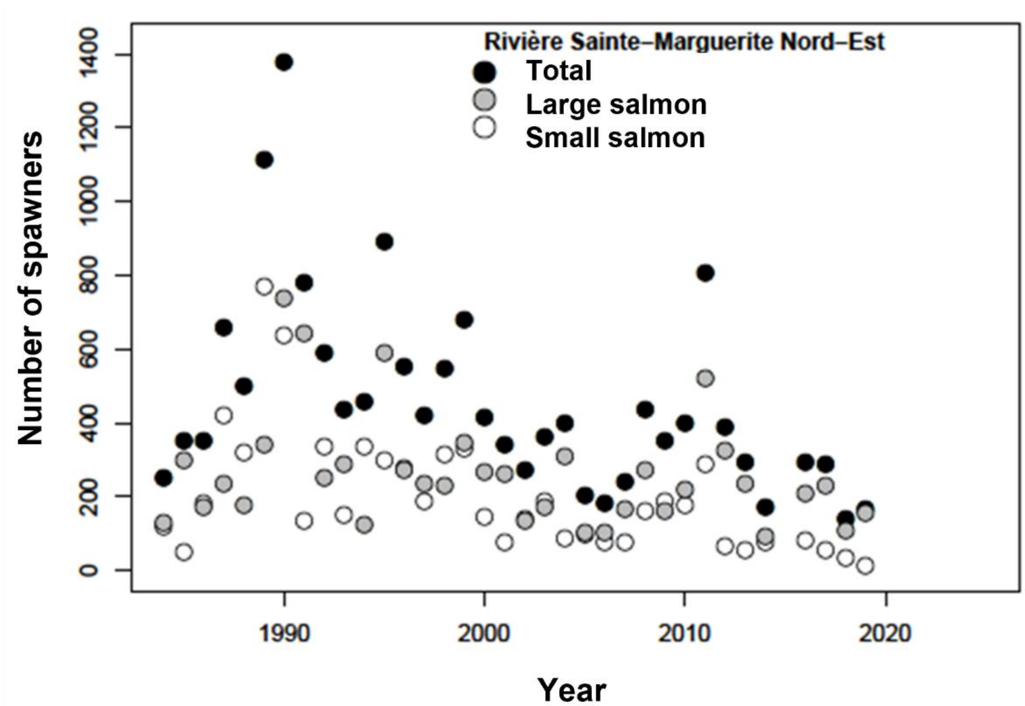

Rivière Du Gouffre
Total
Large salmon
Small salmon
Number of spawners
Year
0
100
200
300
400
500
1990
2000
2010
2020


Rivière Malbaie (Charlevoix)
Total
Large salmon
Small salmon
Number of spawners
Year
0
200
400
600
800
1000
1990
2000
2010
2020

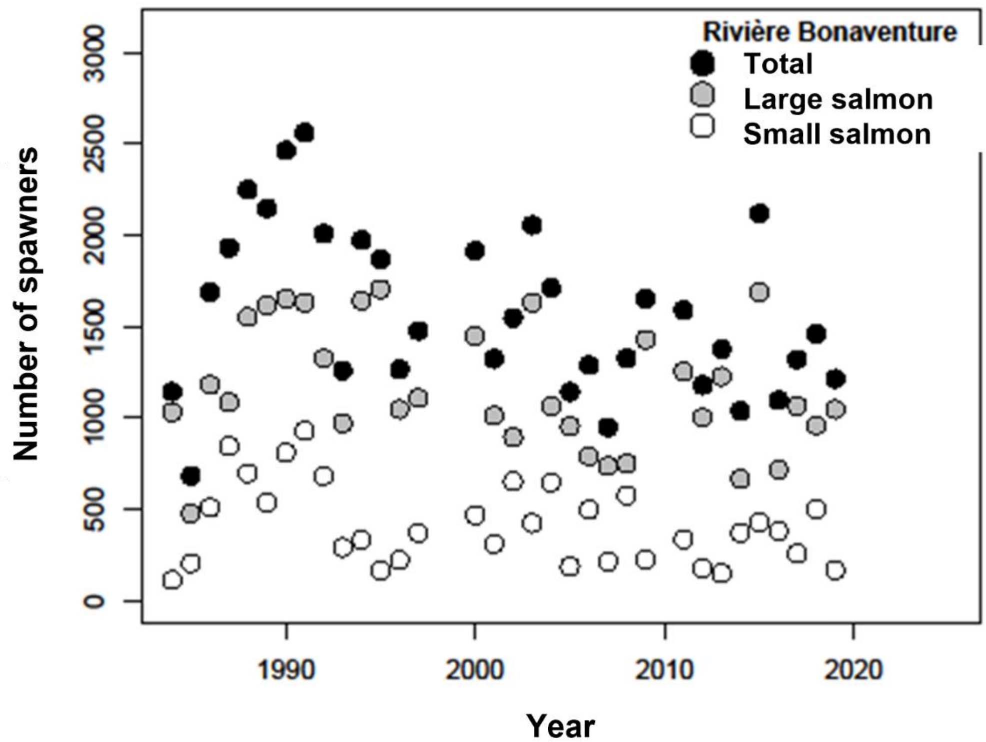

Rivière Petit Saguenay
Total
Large salmon
Small salmon
Number of spawners
0
50
100
150
200
250
300
1990
2000
2010
2020
Year

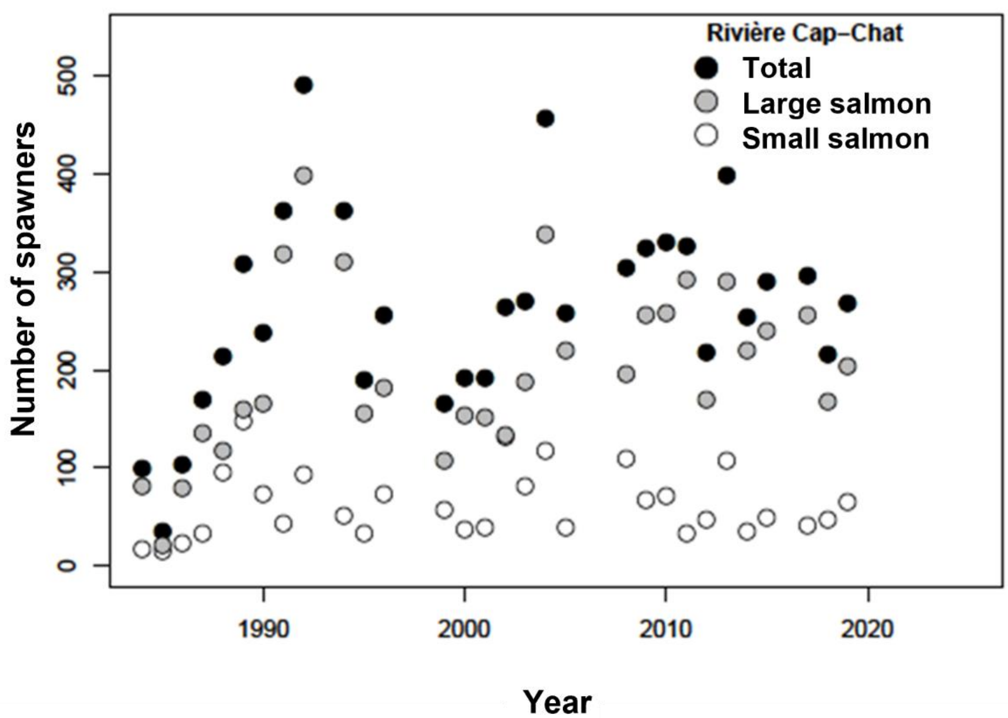

Rivière Jacques–Cartier
Total
Large salmon
Small salmon
Number of spawners
0
200
400
600
800
1000
1990
2000
2010
2020
Year

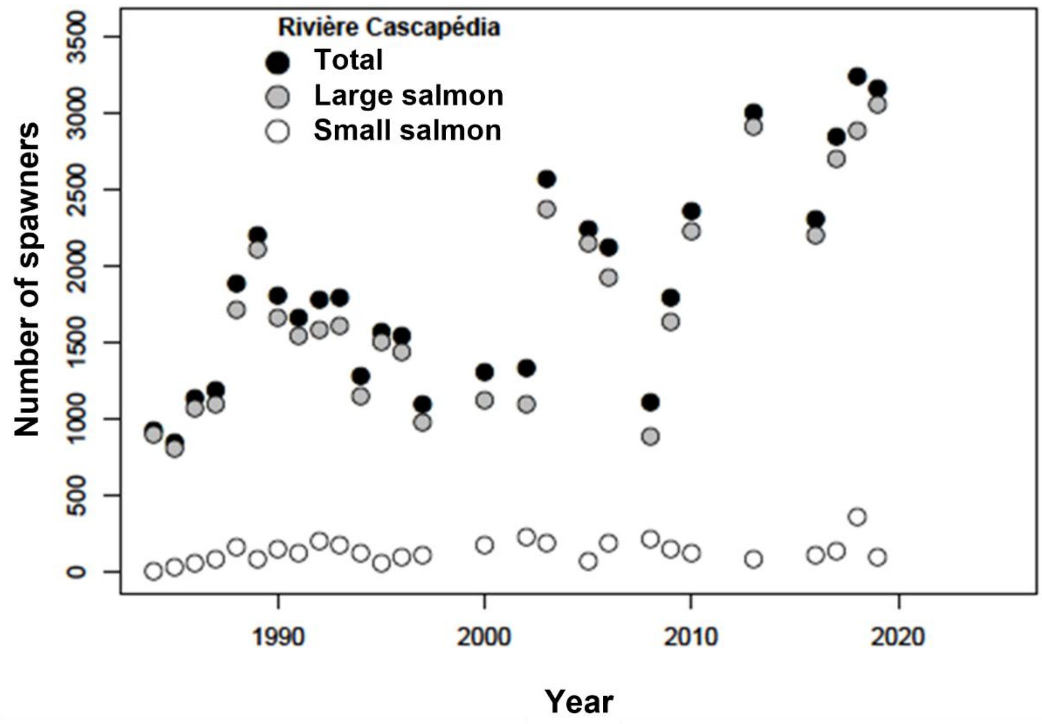

Rivière Saint–Jean (Saguenay)
Total
Large salmon
Small salmon
Number of spawners
0
100
200
300
400
1990
2000
2010
2020
Year


Rivière Sainte–Marguerite Nord–Est
Total
Large salmon
Small salmon
Number of spawners
0
200
400
600
800
1000
1200
1400
1990
2000
2010
2020
Year

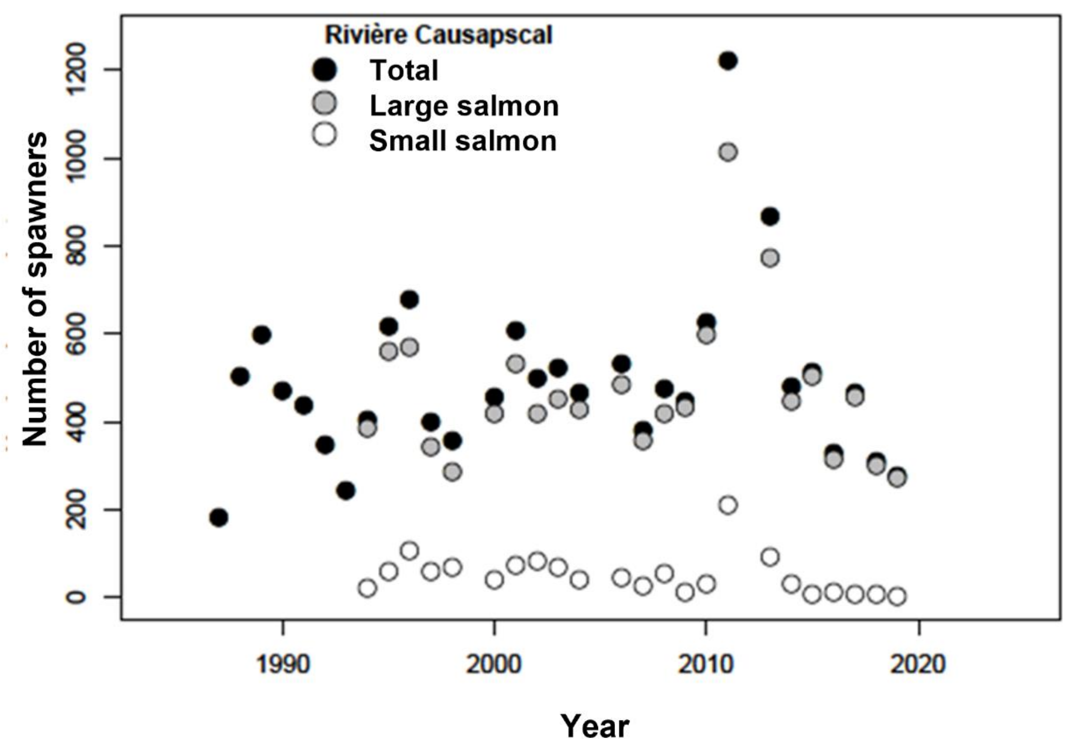
DU 15


Rivière Bonaventure
Total
Large salmon
Small salmon
Number of spawners
0
500
1000
1500
2000
2500
3000
1990
2000
2010
2020
Year

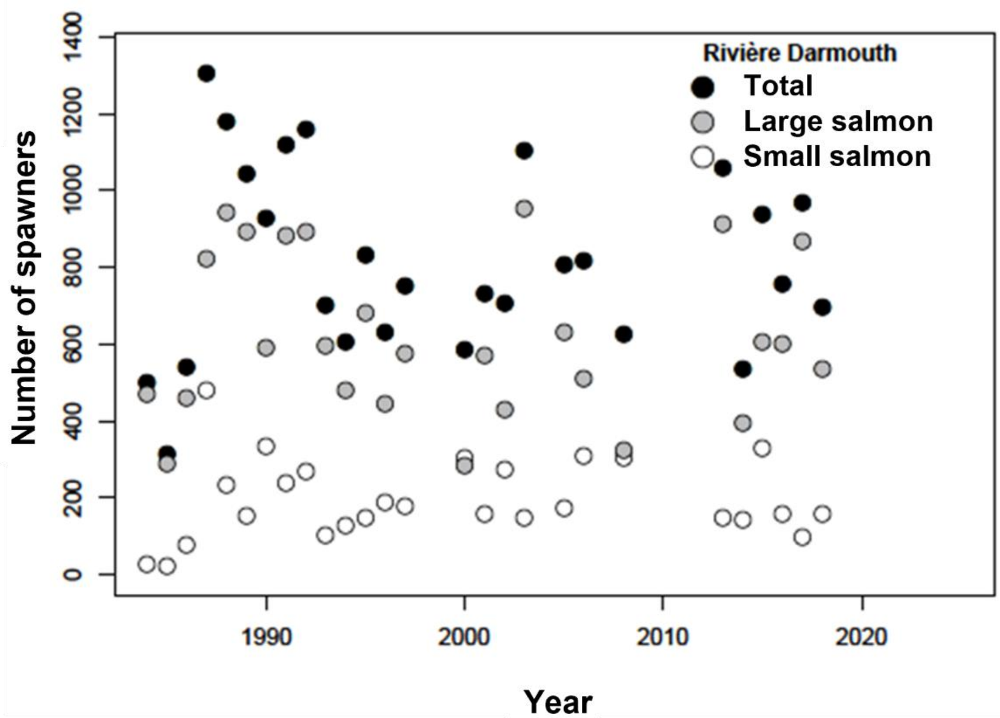

Rivière Cap–Chat
Total
Large salmon
Small salmon
Number of spawners
0
100
200
300
400
500
1990
2000
2010
2020
Year

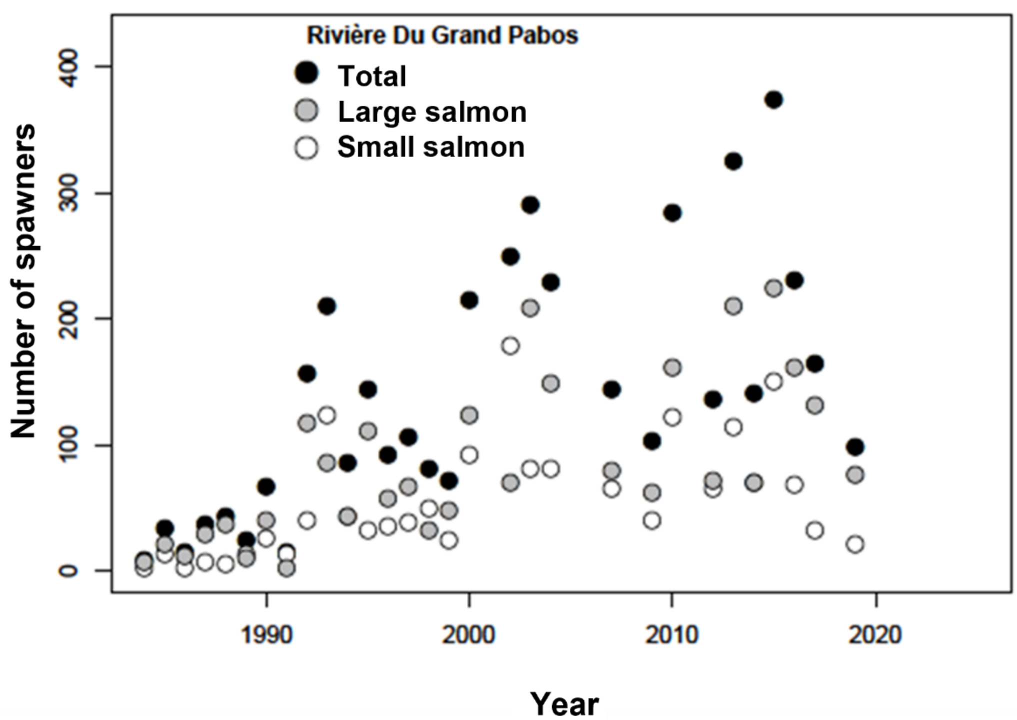


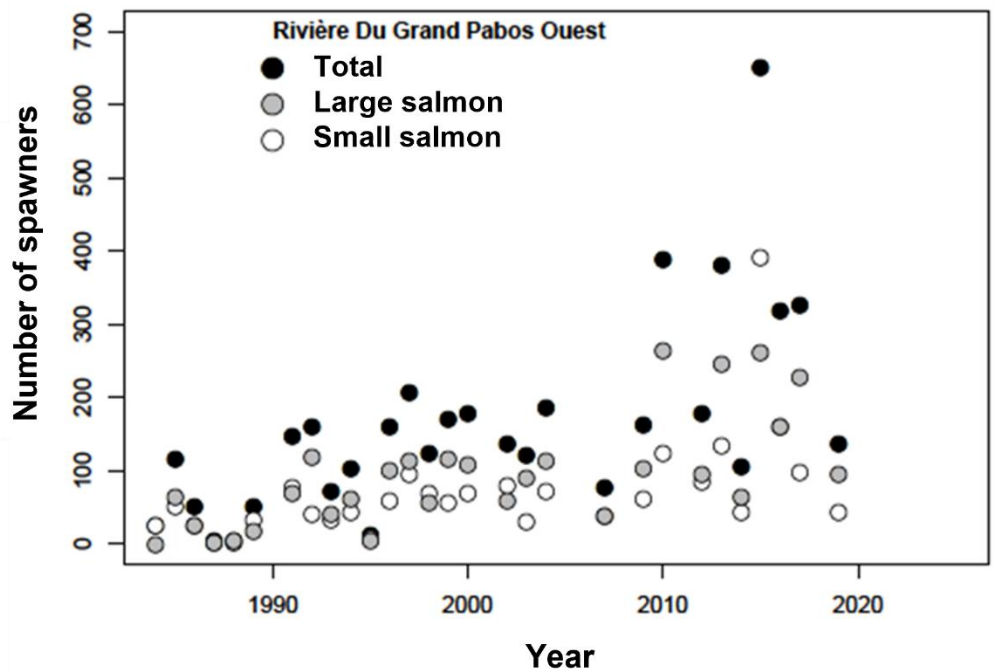
Rivière Cascapédia
Total
Large salmon
Small salmon
Number of spawners
0
500
1000
1500
2000
2500
3000
3500
1990
2000
2010
2020
Year

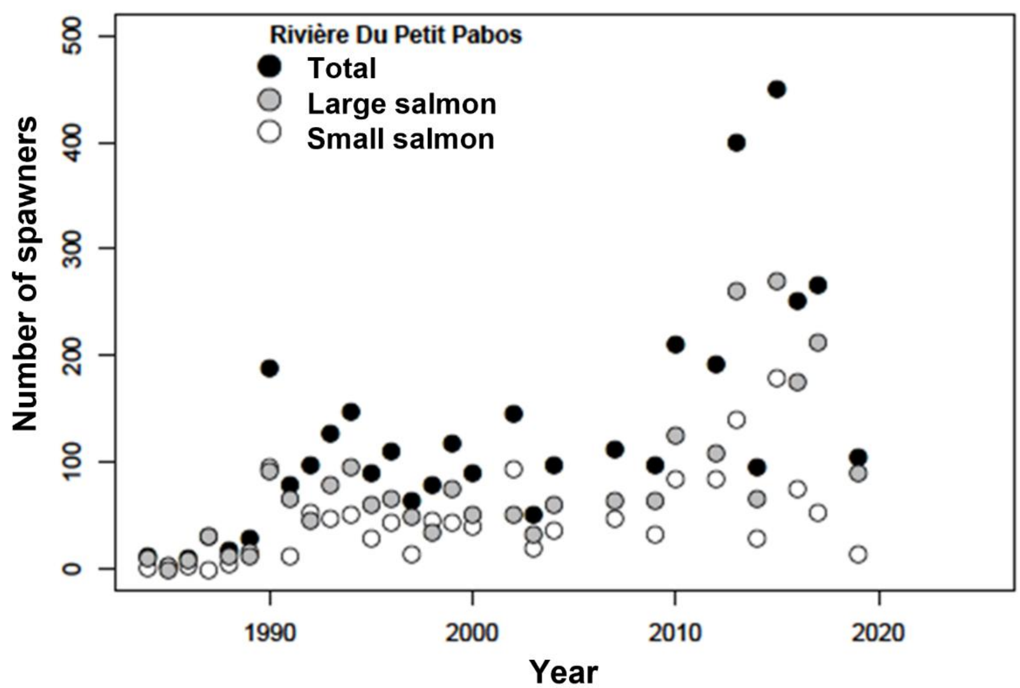


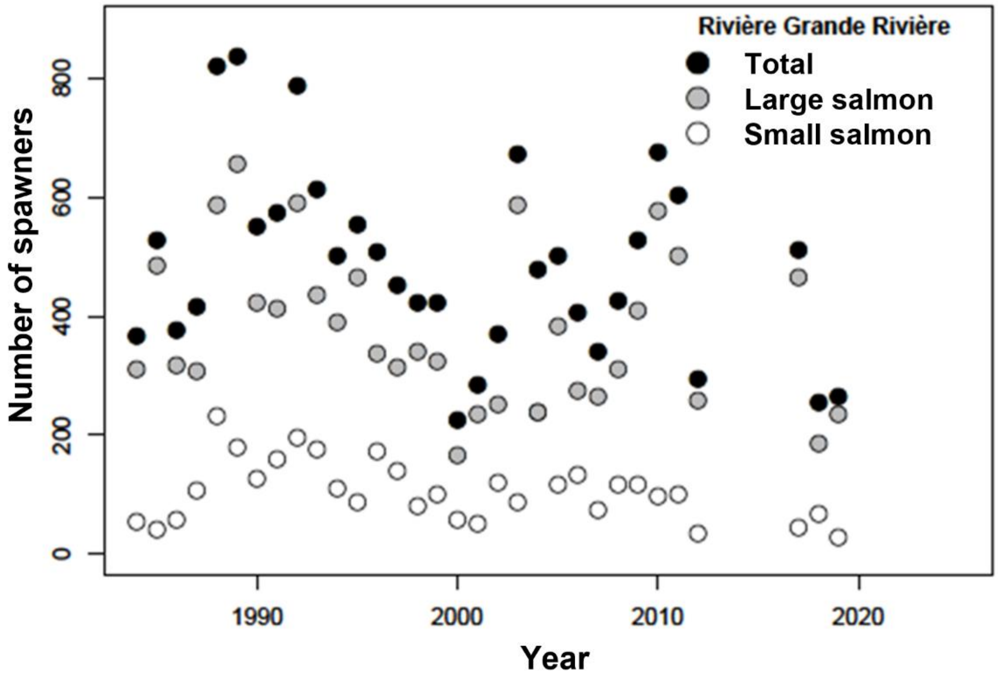
Rivière Causapscal
Total
Large salmon
Small salmon
Number of spawners
0
200
400
600
800
1000
1200
1990
2000
2010
2020
Year

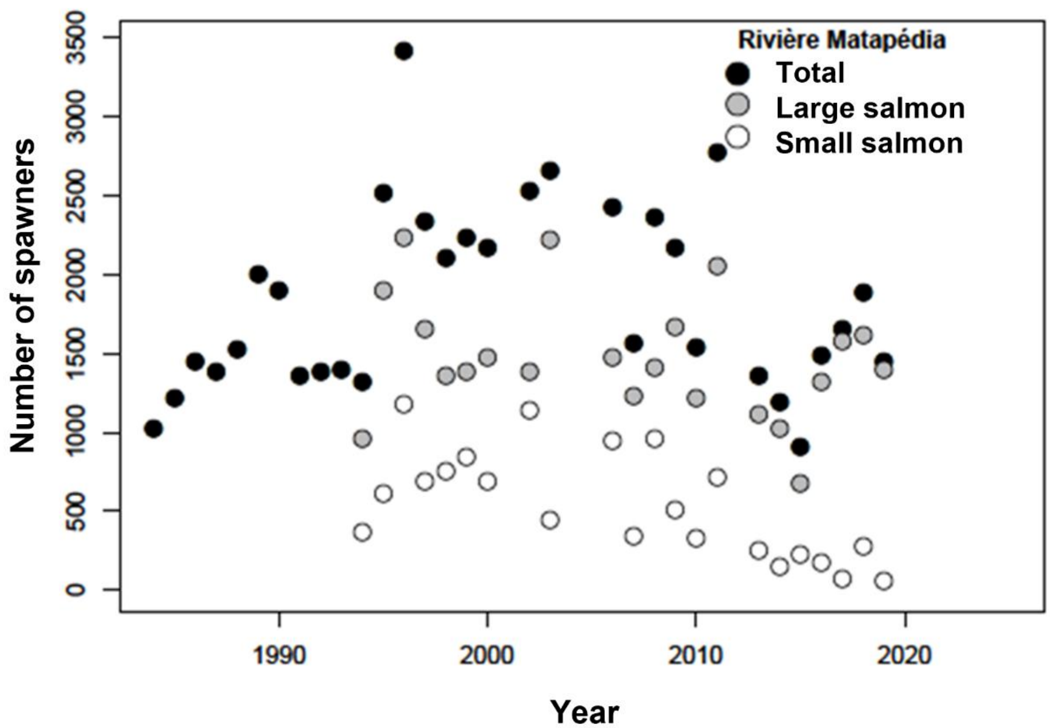

Rivière Darmouth
Total
Large salmon
Small salmon
Number of spawners
0
200
400
600
800
1000
1200
1400
1990
2000
2010
2020
Year

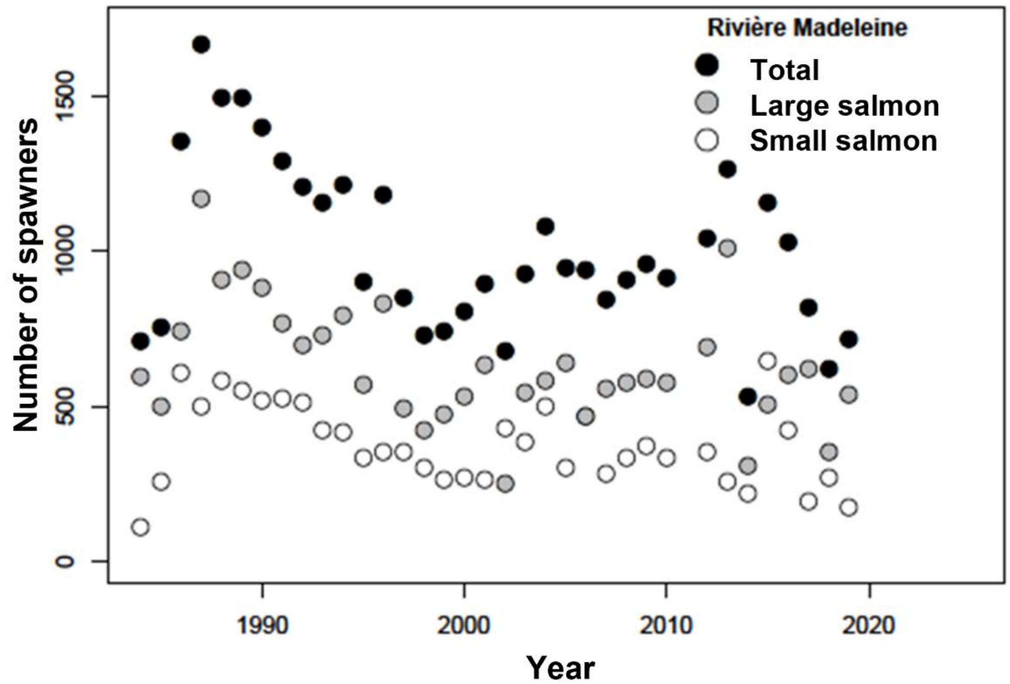

Rivière Du Grand Pabos
Total
Large salmon
Small salmon
Number of spawners
0
100
200
300
400
1990
2000
2010
2020
Year

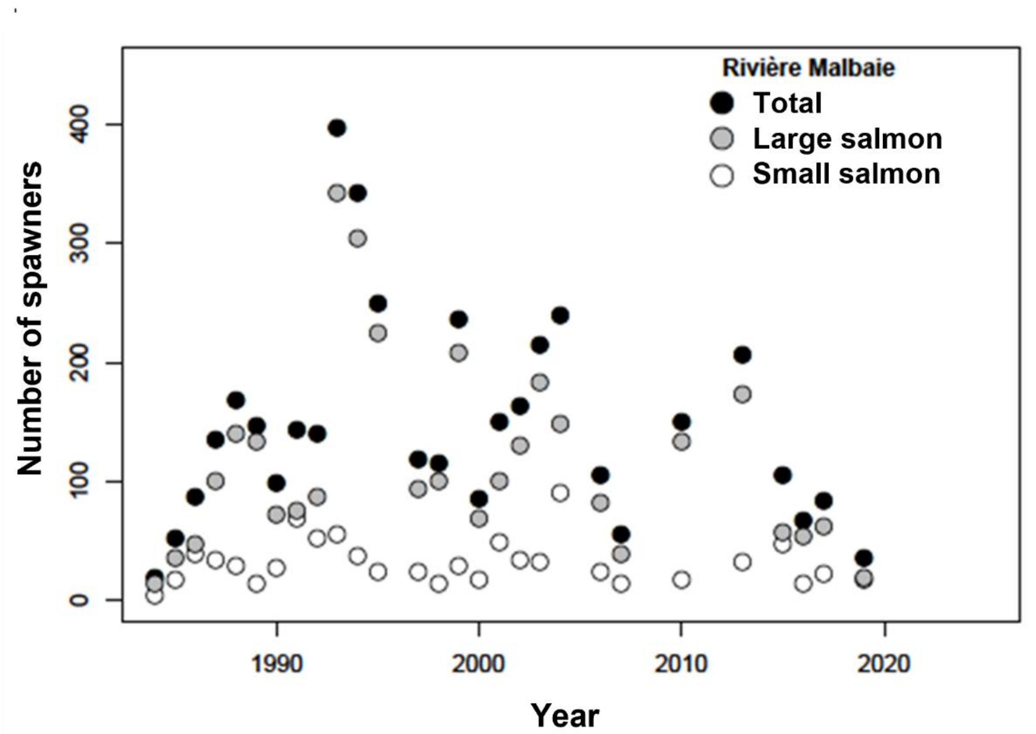

Rivière Du Grand Pabos Ouest
Total
Large salmon
Small salmon
Number of spawners
0
100
200
300
400
500
600
700
1990
2000
2010
2020
Year

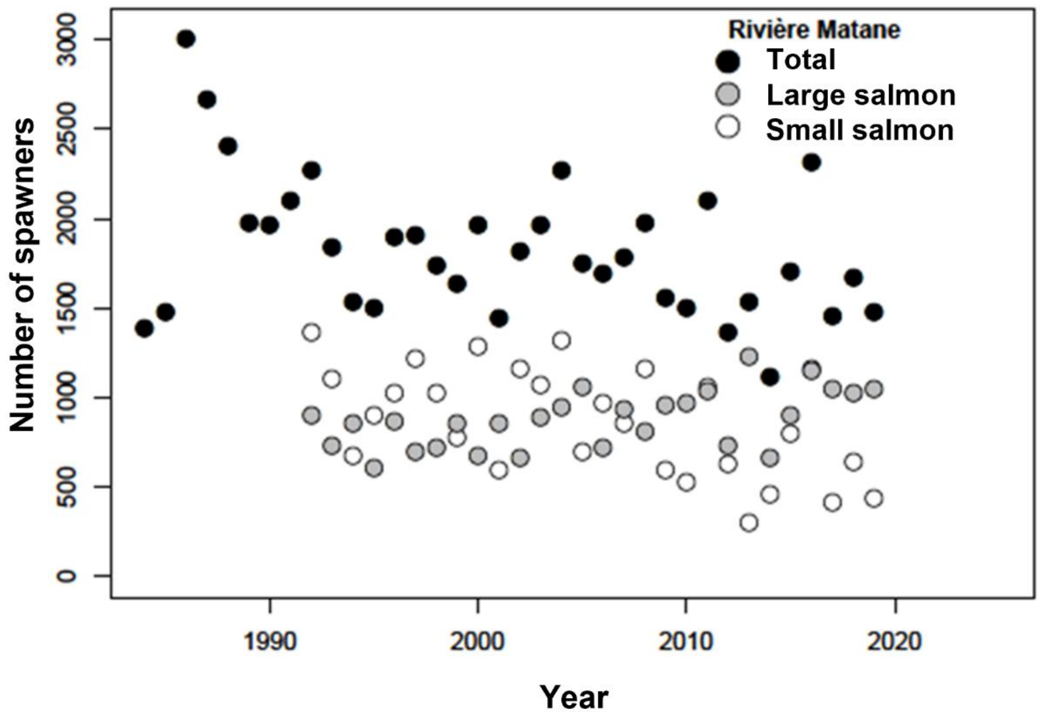

Rivière Du Petit Pabos
Total
Large salmon
Small salmon
Number of spawners
0
100
200
300
400
500
1990
2000
2010
2020
Year

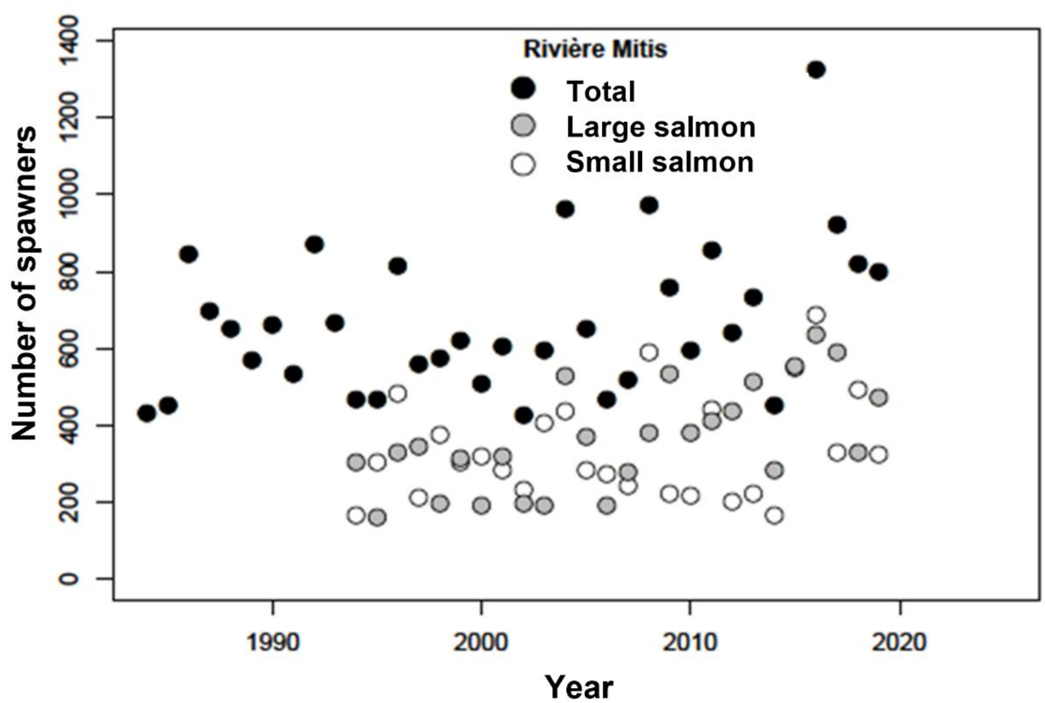

Rivière Grande Rivière
Total
Large salmon
Small salmon
Number of spawners
0
200
400
600
800
1990
2000
2010
2020
Year

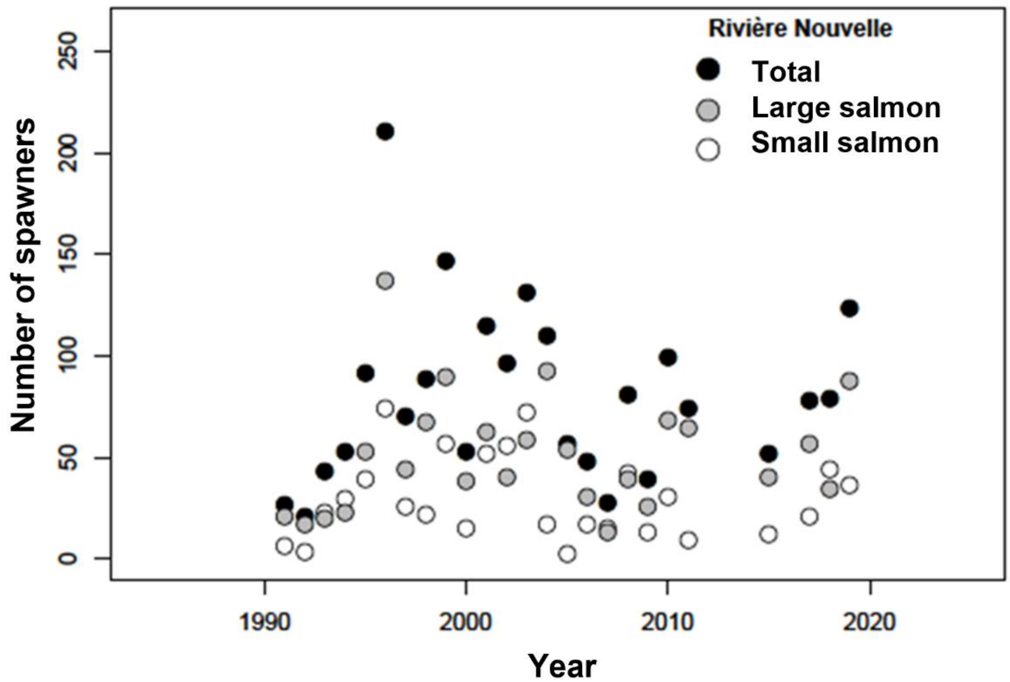

Rivière Matapédia
Total
Large salmon
Small salmon
Number of spawners
0
500
1000
1500
2000
2500
3000
3500
1990
2000
2010
2020
Year

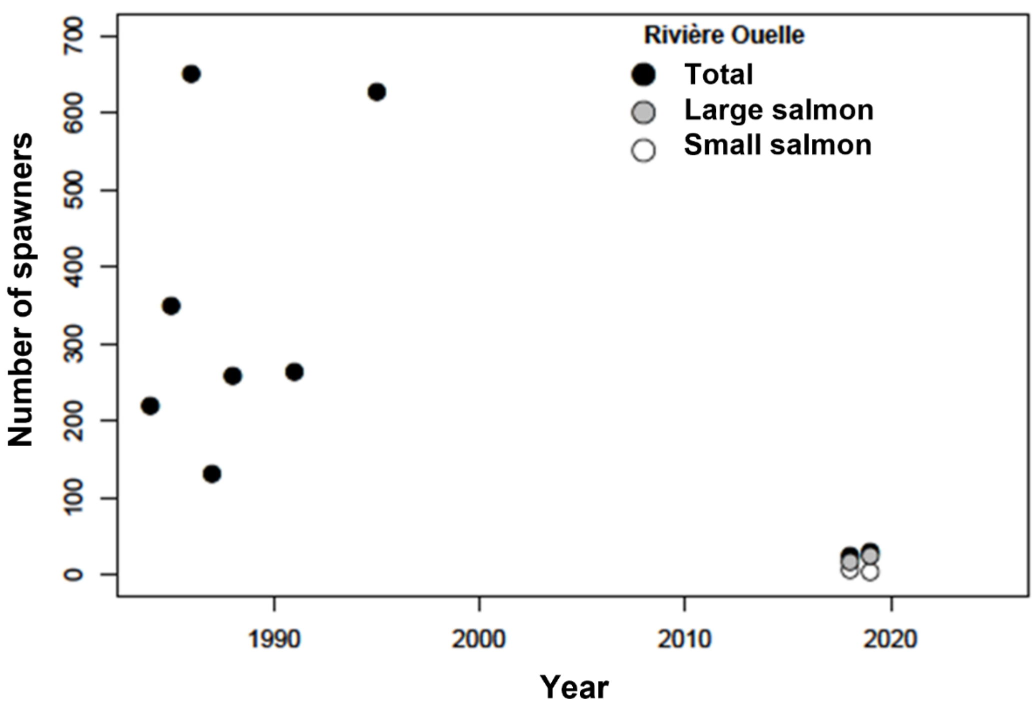

Rivière Madeleine
Total
Large salmon
Small salmon
Number of spawners
0
500
1000
1500
1990
2000
2010
2020
Year

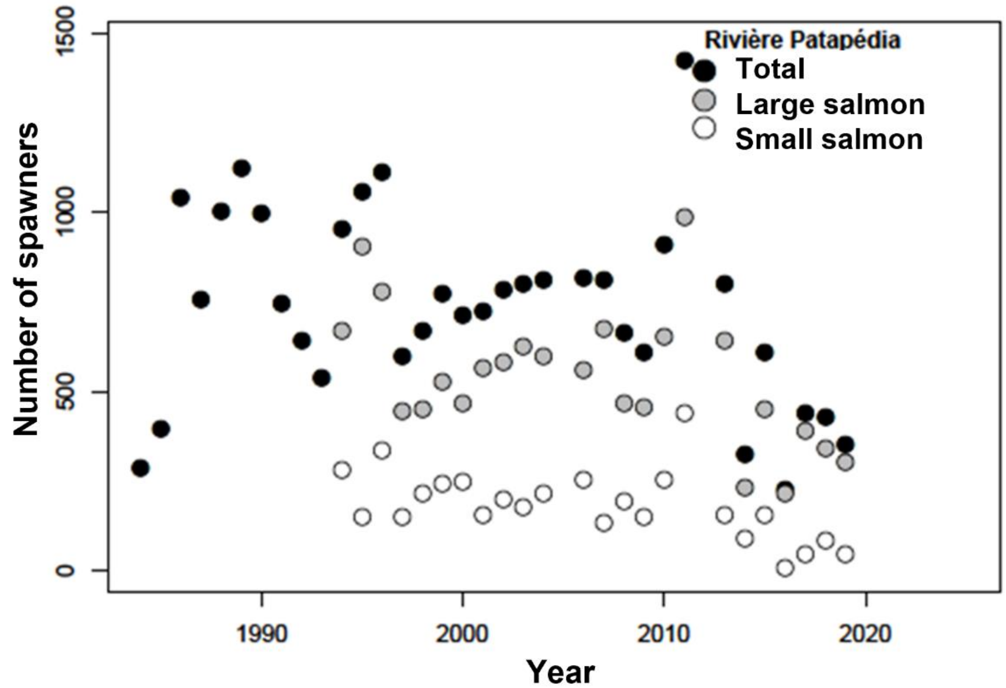

Rivière Malbaie
Total
Large salmon
Small salmon
Number of spawners
0
100
200
300
400
1990
2000
2010
2020
Year

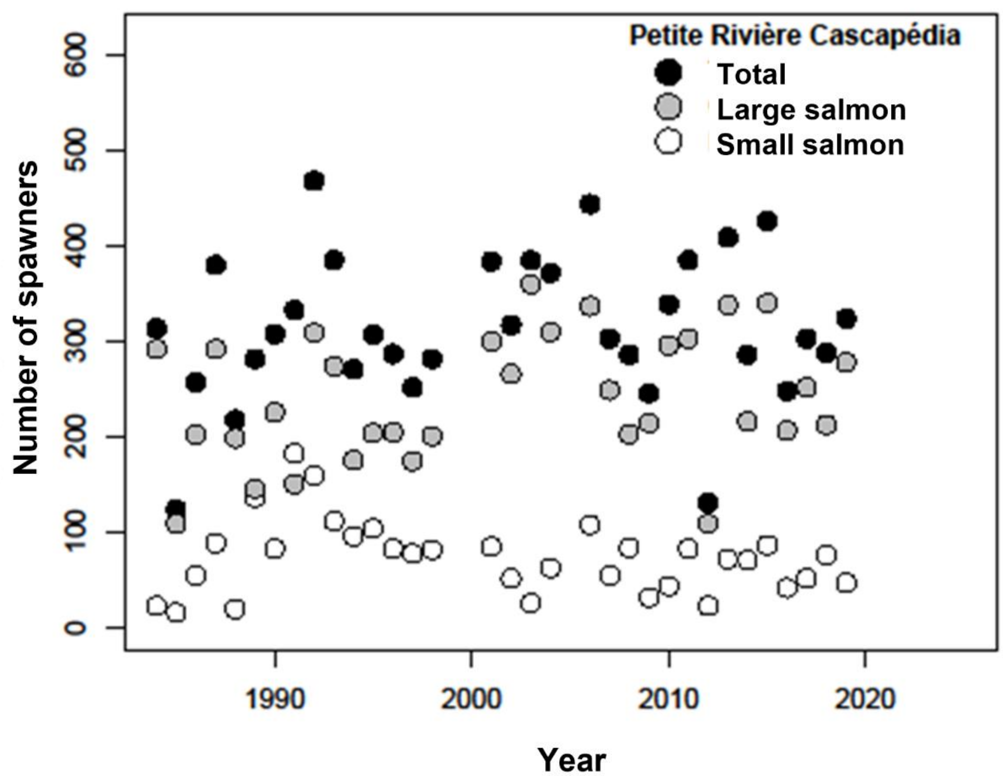

Rivière Matane
Total
Large salmon
Small salmon
Number of spawners
0
500
1000
1500
2000
2500
3000
1990
2000
2010
2020
Year

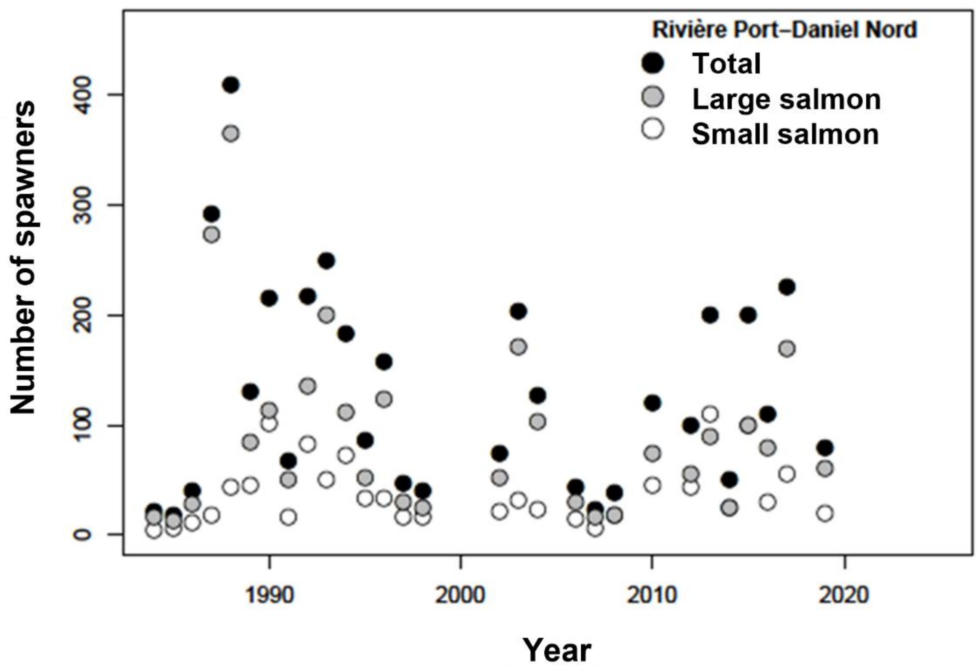

Rivière Mitis
Total
Large salmon
Small salmon
Number of spawners
0
200
400
600
800
1000
1200
1400
1990
2000
2010
2020
Year

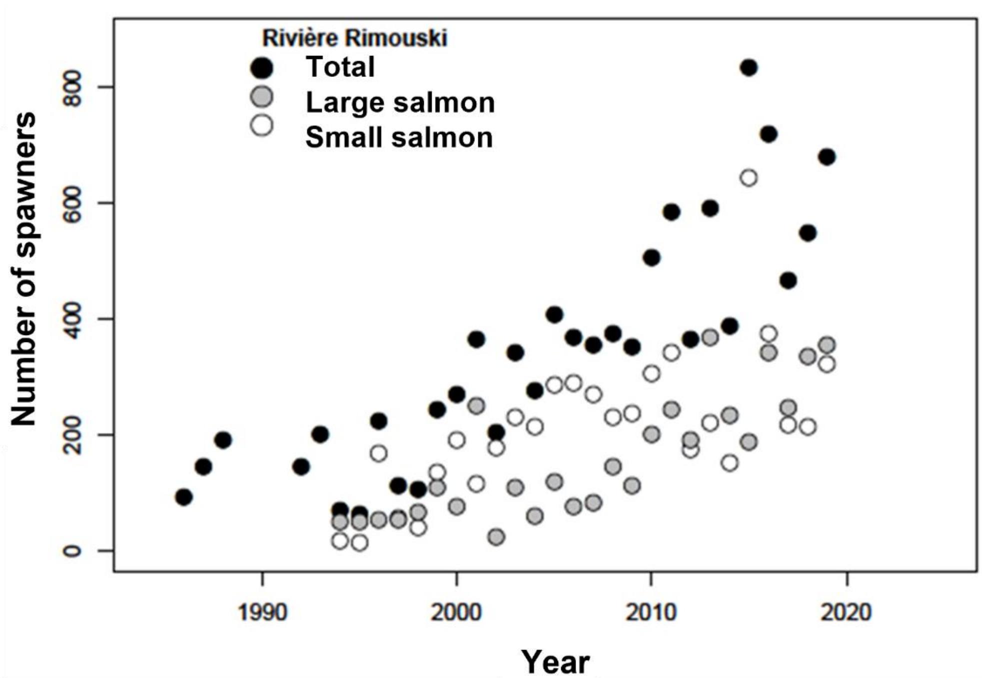

Rivière Nouvelle
Total
Large salmon
Small salmon
Number of spawners
0
50
100
150
200
250
1990
2000
2010
2020
Year

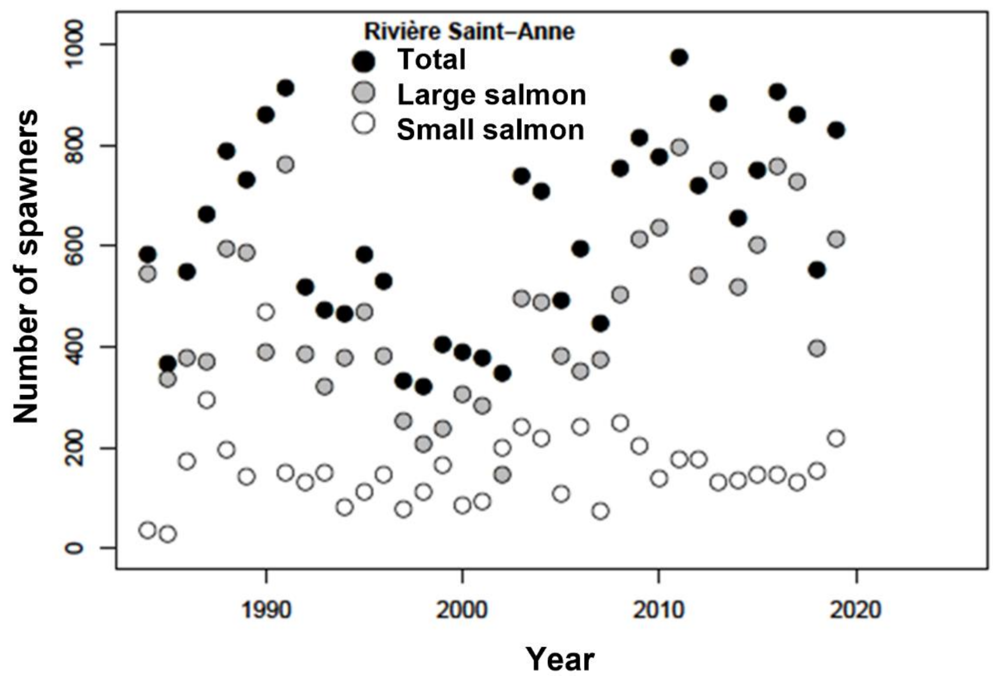

Rivière Ouelle
Total
Large salmon
Small salmon
Number of spawners
0
100
200
300
400
500
600
700
1990
2000
2010
2020
Year

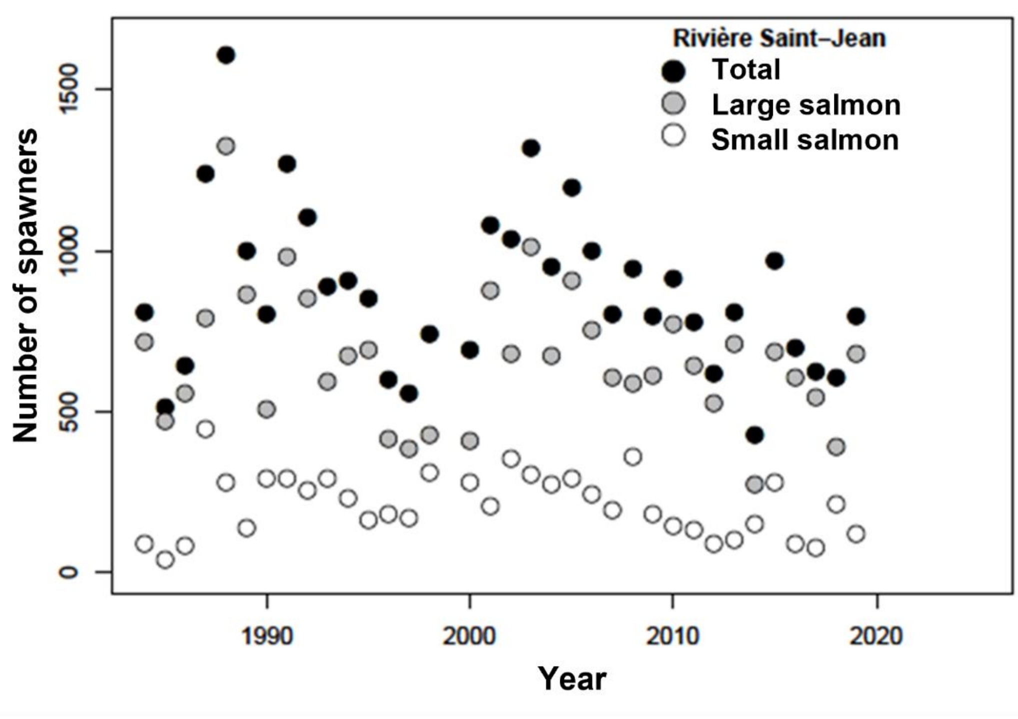

Rivière Patapédia
Total
Large salmon
Small salmon
Number of spawners
0
500
1000
1500
1990
2000
2010
2020
Year

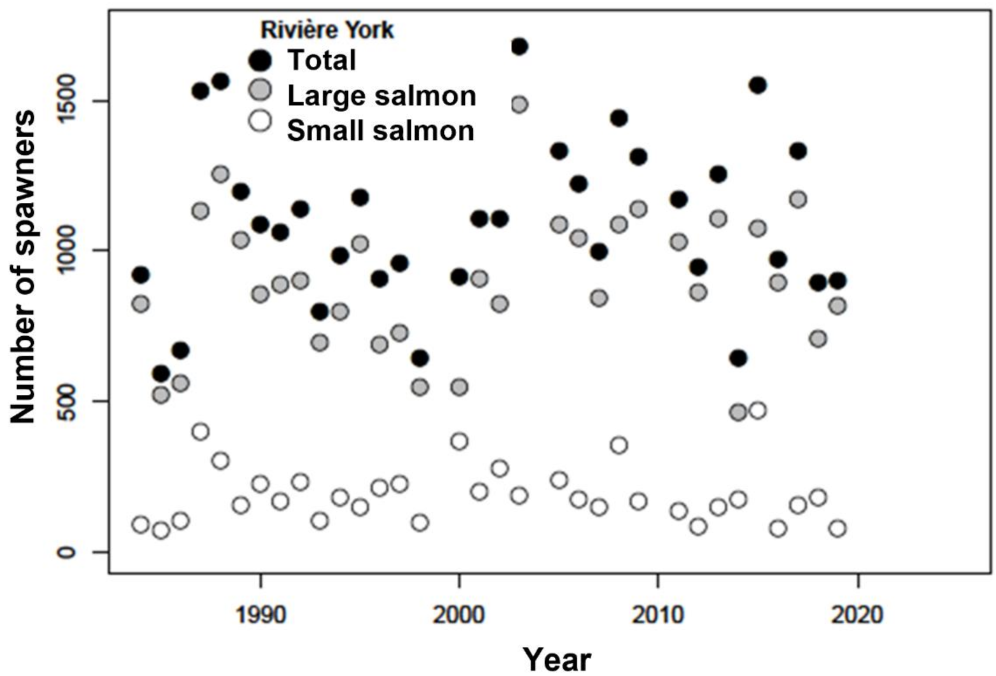

Petite Rivière Cascapédia
Total
Large salmon
Small salmon
Number of spawners
0
100
200
300
400
500
600
1990
2000
2010
2020
Year


Rivière Port–Daniel Nord
Total
Large salmon
Small salmon
Number of spawners
0
100
200
300
400
1990
2000
2010
2020
Year

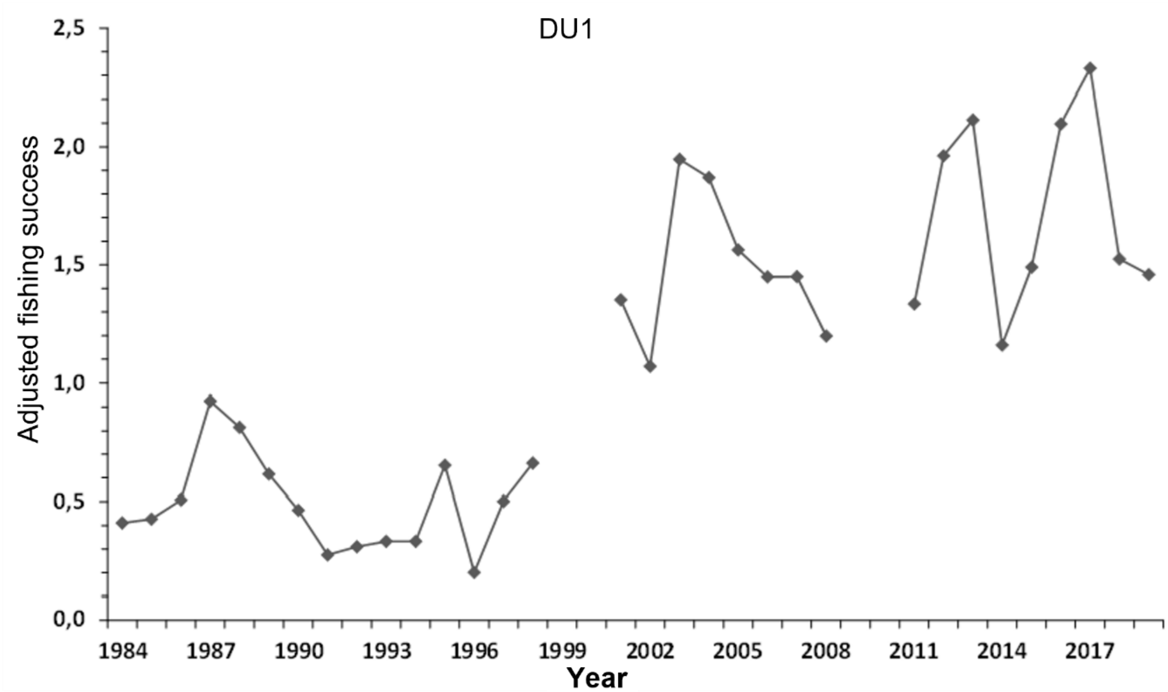

Rivière Rimouski
Total
Large salmon
Small salmon
Number of spawners
0
200
400
600
800
1990
2000
2010
2020
Year


Rivière Saint–Anne
Total
Large salmon
Small salmon
Number of spawners
0
200
400
600
800
1000
1990
2000
2010
2020
Year

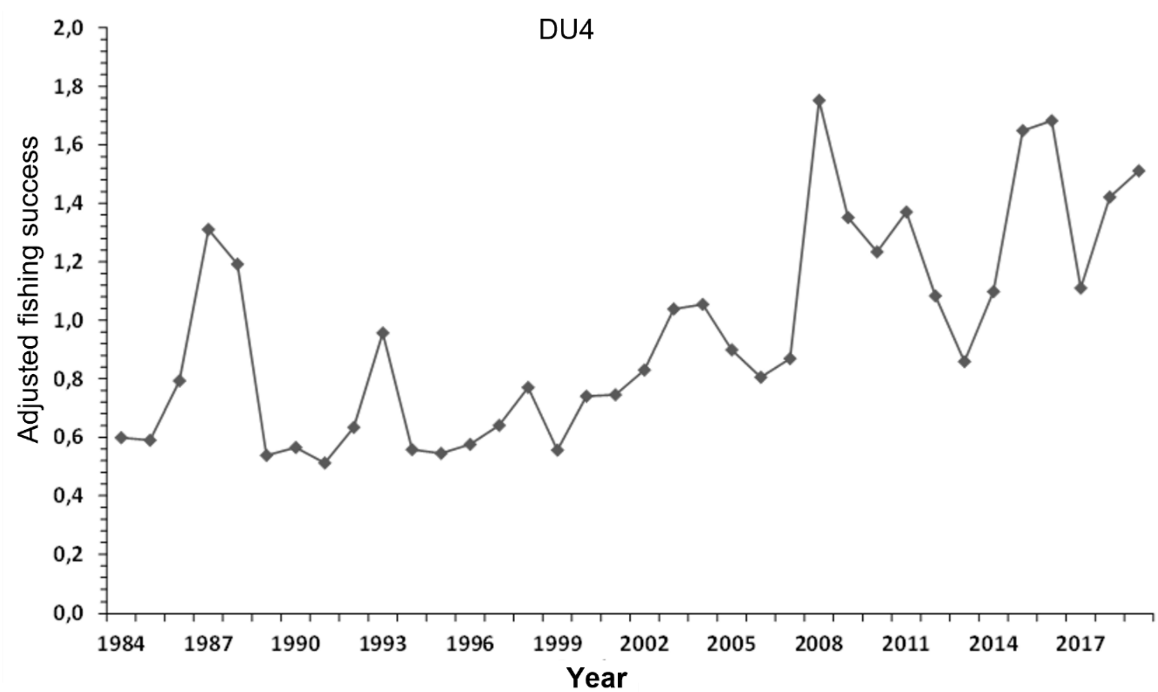

Rivière Saint–Jean
Total
Large salmon
Small salmon
Number of spawners
0
500
1000
1500
1990
2000
2010
2020
Year


Rivière York
Total
Large salmon
Small salmon
Number of spawners
0
500
1000
1500
1990
2000
2010
2020
Year

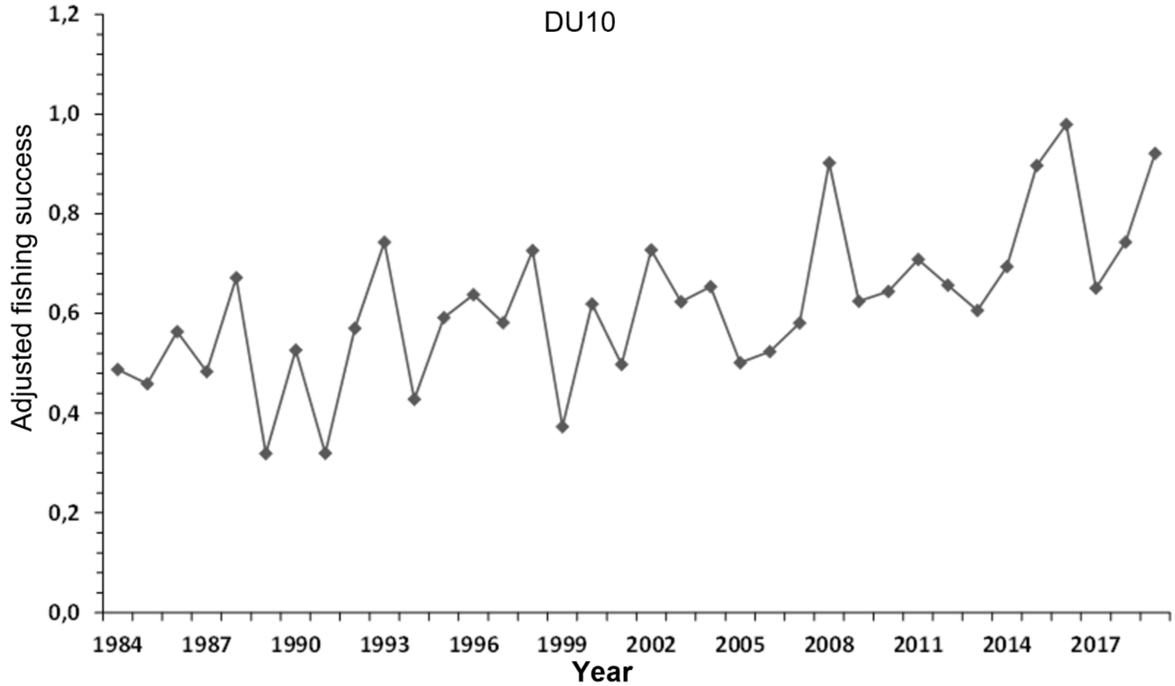
Appendix 14. Changes in adjusted fishing success for DUs 1, 4, 10 and 11. The adjusted fishing success corresponds to the average number of catches per fisher per day, including releases.



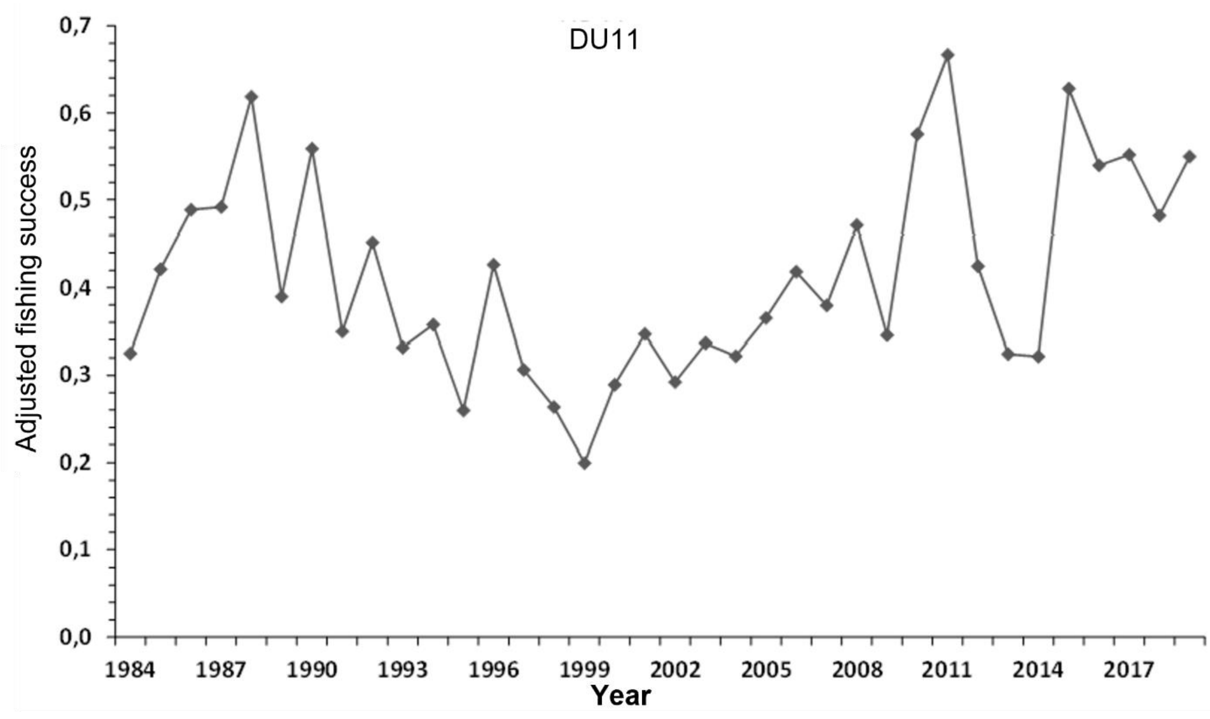
Appendix 14.1. Changes in adjusted fishing success for Ungava rivers (DU 1)



Appendix 14.2. Changes in adjusted fishing success for Quebec rivers included in the Southern Labrador DU (DU 4)



Appendix 14.3. Changes in adjusted fishing success for the rivers in the Quebec Eastern North Shore DU (DU 10)



Appendix 14.4. Changes in adjusted fishing success for the rivers in the Quebec Western North Shore DU (DU 11)