2nd edition

St. Lawrence Freshwater Fish Communities

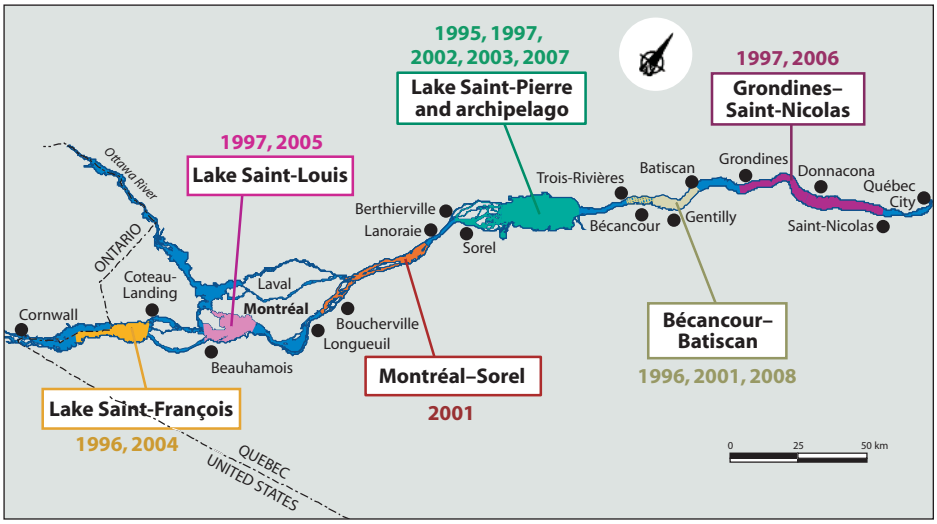
Background

While the initial impression of the St. Lawrence River is one of strength and stability, this highly dynamic environment is in fact constantly changing. This is why it must be closely monitored. Fish are excellent indicators of the health of the St. Lawrence, not only because they integrate spatial and temporal changes in the physical environment, but also because they are sensitive to most environmental pressures and stresses. Fish are easy to sample, useful for measuring the effects of toxic substances, and of interest to decision-makers and the general public because of their great heritage value and socio-economic importance.

Since 1995, the St. Lawrence Fish Monitoring Network (FMN) has been using a standardized and reproducible method to collect quantitative data on fish communities and the population dynamics of several fish species of interest. The goal is to assess the health of the Quebec portion of the freshwater St. Lawrence. Sectors fished during the 1995–97 campaign were sampled again during the second cycle (2001–2006). The study areas stretch from the Quebec–Ontario border, upstream, to Quebec City, downstream. The portion between Montréal and Sorel was added to the second sampling campaign (Figure 1).

Figure 1. St. Lawrence Fish Monitoring Network: Sampling years and site map for the first two sampling campaigns (1995–97 and 2001–2006)

The third campaign is under way.



Many concrete actions have been taken to better protect and manage the wildlife, plants and habitats of the St. Lawrence and reduce the sources of contamination (see http://www.planstlaurent.qc.ca/sl_obs/sesl/publications/fiches_indicateurs/fiches_e.html). However, the signs of an unbalanced ecosystem continue to abound and are, in many ways, symptomatic of the river's fragile health. Today, the river, which is already subject to several natural and anthropogenic pressures, is faced with new stresses whose effects are poorly understood, if at all. Specifically, a number of emergent contaminants are being found (and going untreated) in wastewater, including some that have estrogenic (feminizing) effects on the river's aquatic biota. Other threats to the ecological integrity of the St. Lawrence are: invasive species; climate change, which modifies the river's flow and water temperature; and the interactions among these new pressures (e.g. rising temperatures could facilitate the spread of invasive species). The FMN contributes to measuring these effects on the aquatic environment over time and space by providing the decision-support data necessary to minimize the stresses on the ecosystem.

Overview of the Situation

A Heterogeneous Environment

The St. Lawrence River is a complex ecosystem, comprised of fluvial lakes and narrow reaches with physiographic and hydrological characteristics that are highly variable over space and time. This natural heterogeneity greatly influences the river's habitats

Photo: Yves Mailhot, ministère des Ressources naturelles et de la Faune

Overview of the variety of aquatic habitats in the Nicolet area: from left to right, large grass beds, contrasting water masses, and deeper water.

Free movement of fish

The St. Lawrence fish communities include a great number of migratory species, and habitat fragmentation could have extremely negative effects on their development. In natural situations, fish frequent many and varied critical habitats during their various life stages, habitats that may be very far apart, such that the connections among these different habitats must be maintained to prevent the local extinction of some populations.

The free movement of fish is important all along the St. Lawrence and between the river and its tributaries, no matter their size. Observations of Lake Sturgeon, American Shad, Walleye, Atlantic Tomcod, Yellow Perch and Copper Redhorse, for example, further illustrate the important role the tributaries play in river-tributary dynamics, specifically in reproduction, as well as the importance of good water quality in the tributaries. Furthermore, fish often derive thermal benefits from frequenting smaller bodies of water that heat up faster, which has positive effects on the maturation of adults, the growth of the young and their food supply.

Sometimes, construction of fish ladders of various designs and sizes, like those that exist for the American Eel on the St. Lawrence and for other species on the Richelieu River and the Rivière aux Pins or the Ruisseau de Feu, may partially reduce the impacts of habitat fragmentation, without compensating for it.

and fish communities, which vary with the very different flow patterns of calm-water and fast-flowing areas. In addition, many tributary rivers and effluents discharge into the St. Lawrence, carrying with them their distinctive natural physical and chemical characteristics, including some that are highly degraded compared to the river. In fact, over a large part of its course, the river appears as the juxtapositioning of several rivers flowing side by side, each with its own "signature" that can be identified over a great distance: these we refer to as "water masses." Moreover, the river is artificially split in two by a ship channel that restricts the flow between the north and south banks, further concentrating water flow to the centre. This natural physical heterogeneity, along with many small- and large-scale anthropogenic disturbances, is the reason for the wide contrasts among the fish communities of the different sections of the river.

Diversified Fish Communities

The experimental fisheries conducted under the FMN for the sampling periods 1995–97 and 2001–2006 confirmed the tremendous diversity of St. Lawrence River fish communities (Figure 2). Overall, nearly one hundred freshwater and diadromous species are distributed throughout the river based on physical conditions and habitat preferences (Figure 3). This diversity is the result of the large geographic extent of the river, its position between the Great Lakes and the Atlantic Ocean, its connections with southern river systems such as the Mississippi via Lake Michigan and the Hudson River via Lake Champlain, the diversity of available aquatic habitats, and the introduction, over more than a century, of non-native species like carp, Tench and Round Goby.

Lake Saint-Louis and Lake Saint-Pierre and its archipelago are by far the richest in terms of species numbers and abundance—characteristics that can be associated with the free movement of fish, the large areas of available habitat and the varied physical conditions in these sections of the river. On the other hand, the potential of Lake Saint-François for use by fish seems to be greatly diminished by the dams that isolate it from the St. Lawrence system, cutting off access to migratory species, causing local losses of riparian and whitewater habitats, and creating highly stable water levels. Freshwater reaches, which are narrower and influenced by faster currents (Montréal–Sorel) and also by the tide (downstream from Trois-Rivières), shelter smaller areas of aquatic plant communities having a lower diversity of fish compared to the fluvial lakes.

Biotic Integrity Index

Although the available fish habitat has remained fundamentally unchanged since the overall assessment was published in 2003, several findings remain harsh and worrisome. Compared to 1995–97, most biotic integrity index (BII) values, developed to assess the health of the river's living communities, have remained within the limits considered low or average (Figure 4).

The BII comprises 12 descriptors combining species diversity, species abundance based on certain trophic levels (insectivore, omnivore, piscivore), the contribution of tolerant and intolerant species to some types of pollution, and the prevalence of external

Figure 2. Upstream-downstream trends in fish community diversity in the St. Lawrence

Lake Saint-Louis and Lake Saint-Pierre and its archipelago have the richest species diversity.

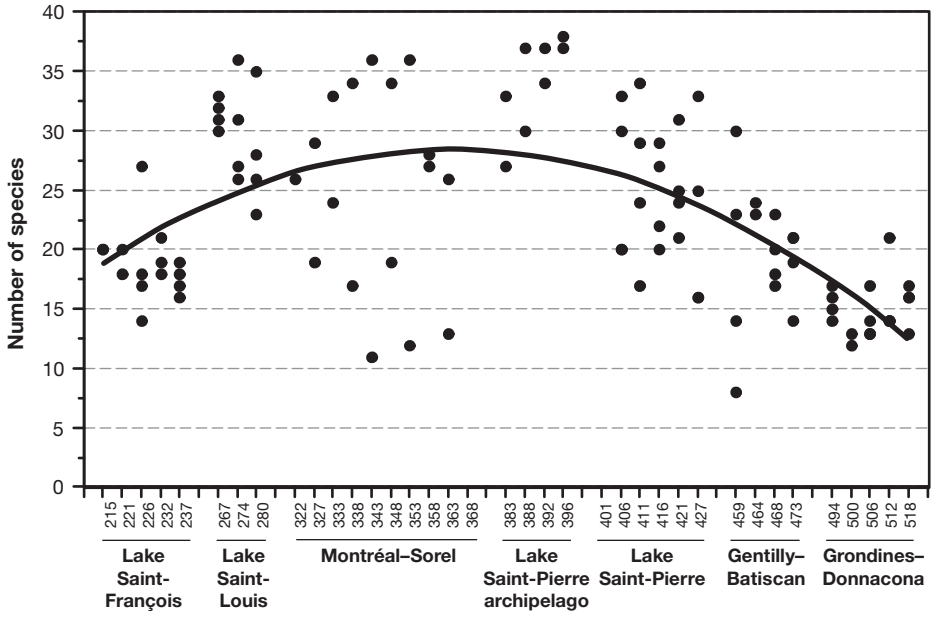
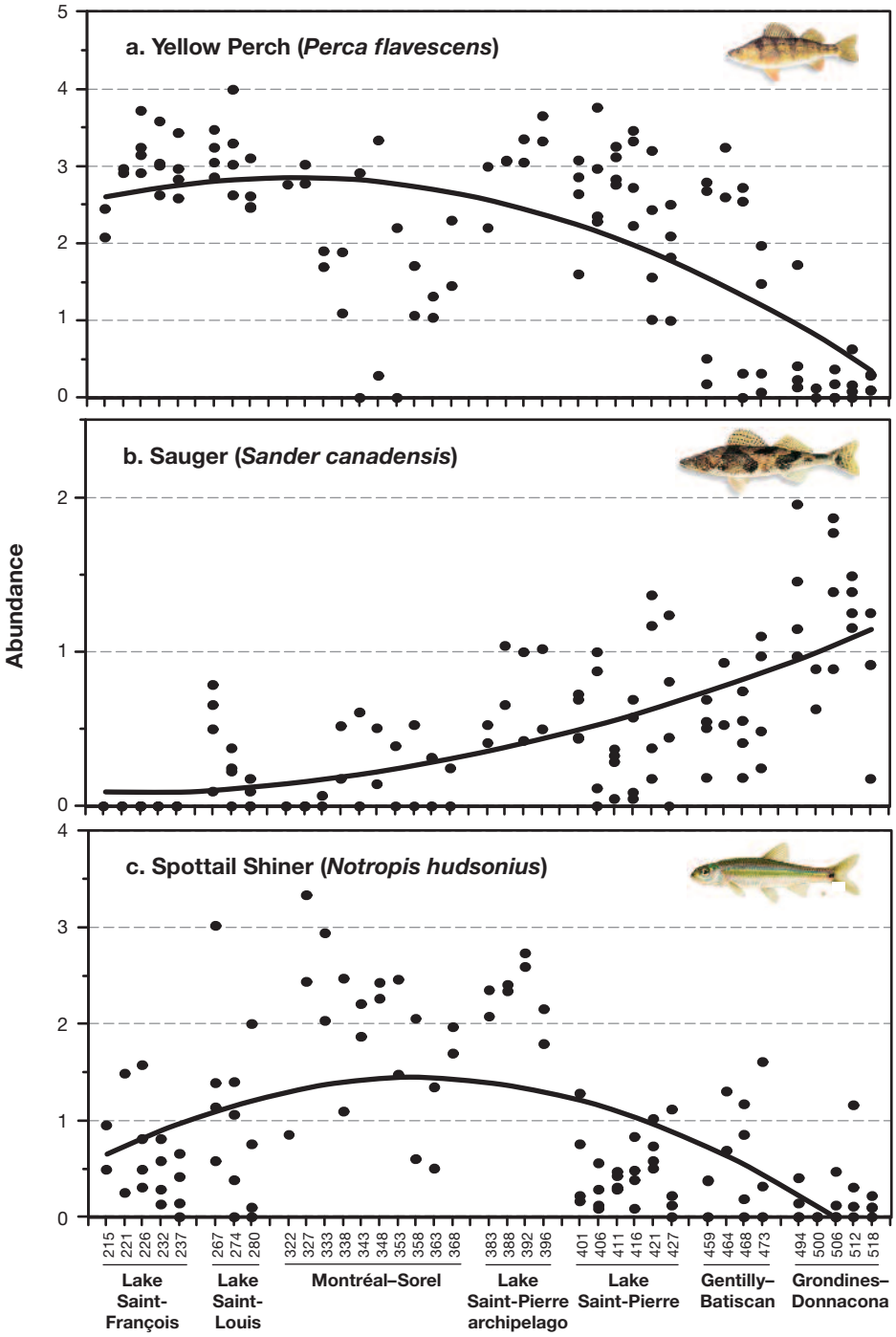


Figure 3. Average abundance of three dominant St. Lawrence River species

From Lake Saint-François to Bécancour–Batiscan, the Yellow Perch is the most abundant species sampled under the FMN. It is highly prized by fishers. Despite its great fecundity, it is in trouble in Lake Saint-Pierre. The Sauger, very sensitive to light, has disappeared from Lake Saint-François, but is progressively abundant from upstream towards downstream. This predator could play an important role in controlling invasive species such as the Round Goby. Spottail Shiner, an abundant, ubiquitous and sedentary forage fish, is used as a sentinel species to track the local effects of several contaminants, including mercury, and endocrine disruption in the Great Lakes–St. Lawrence system.



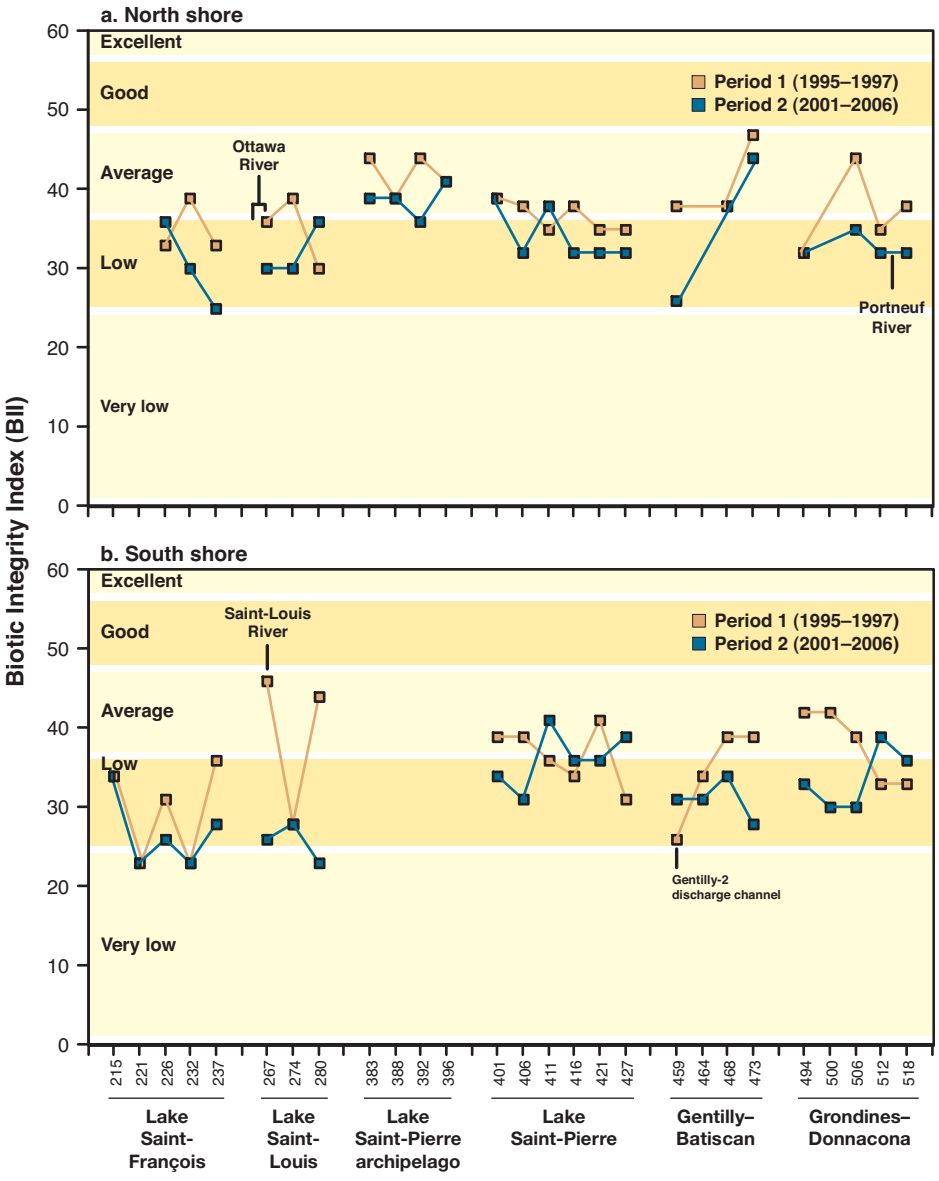
abnormalities (deformities, erosions, lesions, tumours). Several of these variables are influenced, to varying degrees, by both natural and anthropogenic changes observed in the living environment of the fish. Therefore, healthy sections of the St. Lawrence contain a high number of indigenous species, several of which are intolerant to pollution and have a low prevalence of external abnormalities. Due to the absence of data time-series of sufficient length, and without accurate historic references, BII values considered "excellent" represent the river's health at its potential best.

The BII developed for the St. Lawrence is a sensitive tool for identifying the overall, cumulative effects of habitat disruption and of certain pollution sources. It can be used to determine the quality of the aquatic environment based on the level of integrity of the communities inhabiting it. A preliminary report from the FMN's second sampling cycle shows clearly that there is still significant room for improvement of the aquatic environment. Some river sections have gotten better, some have gotten worse, and some cases point to the success of management plans to enhance the health of certain fish populations by reducing fishing and rehabilitating critical habitats.

The BII was not the sole indicator examined to assess the health of St. Lawrence fish. Highly informative data from the FMN have also been used to calculate the parameters of the population dynamics of several fish species: the results are presented below.

Figure 4. Upstream-downstream trends in the BII along the north and south shores for 1995–97 and 2001–2006

Each sequence of points corresponds to a river section. The south shore of the Lake Saint-Pierre islands could not be sampled due to the strength of the current and the proximity of the ship channel. Most BII values during the two sampling periods were within the range considered low or average (BII classes: 1–24: very low; 25–36: low; 37–47: average; 48–56: good; 57–60: excellent).



Fish Communities Destabilized by Numerous Pressures

The upstream portion of the fluvial section is still subject to the effects of environmental fragmentation and stabilization and the loss of vast areas of whitewater following the construction of dams at either end of Lake Saint-François. However, the portion of the river running nearly 350 km between Lake Saint-Louis and the freshwater limits still allows the free movement of migratory species and offers conditions conducive to the growth and maturation of these fish. The maintenance of populations is entirely dependent on the ability of the different life stages moving freely among critical habitats—habitats that are spread out over the entire river. This is the case of both the Atlantic Sturgeon and the Lake Sturgeon, whose future was still in doubt less than a decade ago. Today, thanks to careful planning and major initiatives to protect and enhance their habitats, both species support sustainable fisheries in the fresh and brackish waters of the St. Lawrence. Stocks of American Shad, another migratory species, return to the river to spawn each spring from the Bay of Fundy, with some travelling as far as upstream of Montréal. Reintroduction of the Striped Bass also seems to be progressing well: fish caught after the river was stocked indicate that habitats are of good quality, since there has been survival, growth and dispersion of the species over a wide area. Other migratory species, however, are more vulnerable: the recruitment of American Eel, historically important to the fluvial food web as well as being of economic value, fell two orders of magnitude in less than 25 years. On a smaller scale, the Rainbow Smelt population of the south shore of the estuary remains small, despite efforts invested toward its recovery.

The picture also varies for the typical freshwater species. Cut off from migratory routes and subject to conditions of increased water transparency with the introduction of the Zebra Mussel into the ecosystem, Sauger have disappeared from Lake Saint-François. Walleye in this lake are vulnerable for the same reasons, though

Lake Sturgeon spawn on the Outaouais River, a tributary of the St. Lawrence.

Photo: Daniel Hatin, ministère des Ressources naturelles et de la Faune

The endangered Copper Redhorse, a species that only exists in southwestern Quebec.

faring well in other areas. The Bridle Shiner is very vulnerable in the tributaries due to degradation of its habitats, but populations remain healthy in the river, specifically in Lake Saint-Pierre. The decline of the Yellow Perch population has continued in Lake Saint-Pierre, however and, at best, may only be reversed in the medium term despite the protective measures currently in place. The St. Lawrence River is home to the world's only population of Copper Redhorse, an endangered species. Its survival depends on the medium-term maintenance of the protection and restoration efforts of the past ten years. Among the fish present in the Quebec part of the St. Lawrence River today are one endangered species (Copper Redhorse), three vulnerable species (American Shad, Channel Darter and Rainbow Smelt in the southern estuary), and 14 species likely to be designated as threatened or vulnerable under Quebec law. Six of these species (Copper Redhorse and River Redhorse, Bridle Shiner, Channel Darter, Eastern Sand Darter and Grass Pickerel) are also protected under Canada's *Species At Risk Act*.

New types of pressures are being brought to bear on the ecosystem, with still unknown effects. The climatic changes under way may lead to major modification of the river's water regime, with, among other things, the probability of lower or earlier floods, lower low-water periods, and fish die-offs associated with abnormally high temperatures such as those seen in 2001, which are especially decimating for carp. Besides their effects on the dynamics of riparian and shoreline habitats, such environmental

Table 1. Partial list of pressures and disturbances on St. Lawrence fish and their habitats since the early twentieth century

Protection and conservation efforts must be adapted to new realities.

Pressures	Effects on fish
Dams, hydraulic and hydro-electric works, flow regulation	Habitat fragmentation, barriers impeding fish migration, direct mortality or serious injury during downstream migration, water-level stabilization, loss of habitat, modified flow
Waterways and dredging	Habitat fragmentation, limited movement between banks, habitat loss at sediment deposition sites, increased turbidity
Flow regulation	Water-level stabilization modifying plant succession, habitat loss, restricting of floods
Various types of pollution	Degraded water quality, habitat loss, fish die-offs
Various types of contamination	Acute or chronic diseases, mortality, reduced immunity
Overfishing	Direct mortality and decreased fishery production
Bank erosion	Habitat loss, increased turbidity
Encroachment, filling, etc.	Habitat loss, modified flow
Climate: more frequent extremes, lower water levels, modified flood signals	Habitat loss, mortality, lower immunity, modified recruitment and fishery production, modified flow, new biogeographical distribution
Numerous invasive animal and plant species: Zebra Mussel, Chinese Mitten Crab, Round Goby, Tench, Common Reed, etc.	Modified ecosystem and trophic network functions, habitat disruption, competition with indigenous species, positive effect of addition of forage fish
New diseases	Acute or chronic diseases, mortality, modified ecosystem functions
Partially-treated wastewater containing many emergent pollutants	**Endocrine disruption**: feminization of male fish, reproductive failure **Bromine**: little-known effects, possibly comparable to chlorine compounds

conditions make the task of reconciling the protection of biodiversity and the maintenance or development of shipping on the river even more complex. Inputs of nutrients via tributaries located in farming areas may also aggravate the harmful effects on the quality of the aquatic environment. The Round Goby's rapid colonization of the river is likely to modify, in a currently unforeseeable manner, energy transfer routes in the food web, as well as nutrients, contaminants and pathogens in the aquatic ecosystem.

Outlook

The Fish Monitoring Network (FMN) was formed in 1995 as part of the St. Lawrence Action Plan. This unique initiative has had many positive scientific and political benefits, and its outreach is international in scope. The knowledge acquired under the network has already contributed toward the production of more than 50 reports, scientific papers and brochures, and 40 far-reaching oral communications. It has been widely used in impact studies, legal assessments (fish habitat) and wildlife notices (legal authorizations, consultations, restoration projects, etc.) in the adjoining areas of the river. By availing itself of services such as those of the FMN, the Government of Quebec is respecting the commitments it made in 1992 in Rio de Janeiro and in 2002 in Johannesburg to preserve biodiversity.

The basic sampling data contained in the FMN are invaluable. They are being used in myriad ways to enlighten managers and contribute to research on the St. Lawrence ecosystem: fish health, impact of river flow regulation, management of fisheries stocks, monitoring Striped Bass reintroduction, status of rare or threatened species, contamination of fish tissue, monitoring the spread of invasive species, feminization by estrogenic or related substances, etc. The FMN has been so successful that it is being extended to cover the upper estuary of the St. Lawrence. Planning for this initiative began in 2006.

The choice of BII metrics will be fully reviewed and new ones developed in order to adapt the BII to the new realities of the St. Lawrence (global warming, invasive species, etc). BII values will also be associated with all the known sources of stress on the ecosystem, including the contaminants contained in the wastewater discharged by the City of Montréal.

KEY MEASURES

All fish population and community descriptors provide information on the overall health of the aquatic ecosystem by:

- characterizing fish population dynamics related to the various life stages, their needs and demographics; available habitat area, reproductive success, recruitment, growth and food supply are key measures to be monitored;
- measuring the main characteristics of fish communities such as biomass, diversity, number of species sensitive to pollution and the various types of abnormalities among them; this makes it possible to calculate a biotic integrity index or BII.

To Know More

LA VIOLETTE, N., D. FOURNIER, P. DUMONT, and Y. MAILHOT. 2003. *Caractérisation des communautés de poissons et développement d'un indice d'intégrité biotique pour le fleuve Saint-Laurent, 1995-1997.* Société de la faune et des parcs du Québec, Direction de la recherche sur la faune. 237 pp.

List of documents and research communications produced from data from the St. Lawrence Fish Monitoring Network (1994–2006). Direction de la recherche sur la faune – Direction de l'aménagement de la faune de Montréal, Laval and de la Montérégie – Direction de l'aménagement de la faune Mauricie-Centre-du-Québec – May 2006.

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State of the St. Lawrence Monitoring Program

Under the current Canada–Québec agreement, the St. Lawrence Plan for a Sustainable Development, six government partners—Environment Canada, the Ministère du Développement durable, de l'Environnement et des Parcs du Québec, Fisheries and Oceans Canada, the Ministère des Ressources naturelles et de la Faune du Québec, the Canadian Space Agency, and the Parks Canada Agency—together with Stratégies Saint-Laurent, a non-governmental organization that works actively with riverside communities, are pooling their expertise to provide Canadians with information on the state of the St. Lawrence River at regular intervals.

To obtain the fact sheets and additional information about the State of the St. Lawrence Monitoring Program, please visit our Web site at:

www.planstlaurent.qc.ca

Published by Authority of the Minister of the Environment

Published by Authority of the Ministre du Développement durable,
de l'Environnement et des Parcs du Québec

Catalogue No. En4-14/2002E
ISBN 0-662-33249-0
Envirodoq: ENV/2002/0343A
Legal deposit – National Library of Canada, 2008
Aussi disponible en français sous le titre : *Les communautés de poissons d'eau douce dans le Saint-Laurent*