REGIONAL ASSESSMENT
SAGUENAY SECTOR

Regional Assessment
Saguenay Sector

Priority Intervention Zones 22 and 23

Marc Gagnon

Revised by Marie-José Auclair
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April 1996

NOTICE TO READERS

Reports on Priority Intervention Zones (known as ZIPs) are produced as part of the St. Lawrence Vision 2000 action plan by Environment Canada's St. Lawrence Centre, in conjunction with Fisheries and Oceans, Health Canada and the Ministère de l'Environnement et de la Faune du Québec.

Correct citation for this publication:
Gagnon, M. 1995. *Regional Assessment - Saguenay Sector. Priority Intervention Zones 22 and 23.* Environment Canada - Quebec Region, Environmental Conservation, St. Lawrence Centre. 66 pages.

Catalogue No.: En 40-216/16E
ISBN: 0-662-24480-X

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Acknowledgments

We wish to acknowledge the close working relationship that developed among St. Lawrence Vision 2000 partners on the Community Involvement Co-ordinating Committee, through the participation of Guy Boucher, Jean Burton, Sophie de Villers, Annie-France Gravel, Nicole Lavigne, Claire Laliberté, Francine Richard, Daniel Robitaille, Albin Tremblay and Yvan Vigneault.

We would also like to take this opportunity to express our appreciation to the staff of various sectoral and regional offices of the Ministère de l'Environnement et de la Faune who were involved in reviewing this report under the co-ordination of Paul Benoît.

Preface

In April, 1994, the governments of Canada and Québec approved a four-year action plan to carry on the work of the St. Lawrence Action Plan.

The goal of St. Lawrence Vision 2000 is to conserve and protect the St. Lawrence River and the Saguenay River so that the people who live along their shores can reclaim use of these rivers in the spirit of sustainable development.

The Priority Intervention Zones Program – better known by its French acronym ZIP – is a major element of the Community Involvement component of the St. Lawrence Vision 2000 action plan.

Through the ZIP Program, riverside communities are invited to play an active part in achieving the objectives aimed at restoring the St. Lawrence and Saguenay rivers.

The program urges various community partners, non-governmental organizations and citizens' committees to work together to identify common priorities for the conservation and restoration of the St. Lawrence River.

We are pleased to present this assessment, which reports on the uses, resources and main environmental problems specific to this area. It has been prepared using all the data available from the various federal departments and provincial ministries involved in St. Lawrence Vision 2000.

We hope it will prompt a more enlightened public debate based on information that is as objective as possible, and that the debate will help the various partners involved to develop and implement an action plan for restoration of the area in question.

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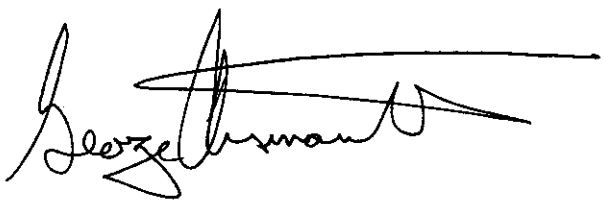

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Management Perspective

The Priority Intervention Zones (ZIP) Program is a federal–provincial initiative that seeks to involve stakeholders in riverside communities in implementing rehabilitation measures for the St. Lawrence River and the Saguenay River. The program has three broad phases: producing regional assessment reports on the state of the St. Lawrence, consulting riverside partners and setting priorities for action, and developing an ecological rehabilitation action plan (ERAP).

The regional assessment is a synthesis of three technical reports on the biological, physico-chemical and socio-economic aspects of the study area. These reports are prepared by the federal and provincial partners of the St. Lawrence Vision 2000 action plan, under its Community Involvement component.

This is the first time that data has been gathered and analysed on a local scale for the entire St. Lawrence River and the Saguenay River. The technical reports go even further, assessing the current state of a given area based on known quality criteria.

The challenge, then, is to formulate a scientific opinion based on the available information. The pitfalls are numerous: the data were collected for other purposes, the geographic and temporal coverage is less than ideal and the chemical analysis methods are not standardized, to name but a few.

The ZIP working group remains nonetheless convinced that an enlightened and thoughtful overview of each study area can be presented without further delay. This first assessment, written for the riverside partners in each study area, is therefore a starting point and discussion paper.

Perspective de gestion

Le programme des Zones d'intervention prioritaire (ZIP) relève le défi de la concertation entre les gouvernements fédéral et provincial et de l'implication communautaire des partenaires riverains, en vue de mettre en oeuvre des mesures de réhabilitation du Saint-Laurent et du Saguenay. Ce programme comporte trois grandes étapes, soit l'élaboration d'un bilan environnemental sur l'état du fleuve à l'échelle locale, la consultation de partenaires riverains, avec l'identification de priorités d'intervention, et l'élaboration d'un plan d'action et de réhabilitation écologique (PARE).

Un bilan régional est établi à partir d'une synthèse des trois rapports techniques portant sur les aspects biologiques, physico-chimiques et socio-économiques du secteur étudié. Ces rapports sont préparés par les partenaires fédéraux et provinciaux du plan d'action Saint-Laurent Vision 2000, dans le cadre du volet Implication communautaire.

La cueillette et l'analyse des données existantes à l'échelle locale constituent une première pour l'ensemble du fleuve Saint-Laurent et de la rivière Saguenay. Les rapports techniques vont plus loin encore, en proposant un bilan des connaissances sur l'état actuel d'un secteur à partir de critères de qualité connus.

Le défi consiste donc à poser un jugement scientifique fondé sur l'information disponible. Les embûches sont nombreuses : les données ont été recueillies à d'autres fins, la couverture spatiale ou temporelle n'est pas idéale, les méthodes d'analyses chimiques ne sont pas uniformes, etc.

L'équipe de travail ZIP demeure convaincue qu'il est possible de poser, sans plus attendre, un regard éclairé et prudent sur chaque secteur. Cette première évaluation constitue un point de départ et un document de base rédigé à l'intention des partenaires riverains de chaque secteur d'étude.

Abstract

The Saguenay region (ZIPs 22 and 23) is comprised of three distinct ecosystems: a fluvial ecosystem (Saguenay River), an estuary with an extensive sedimentation area on the tidal flats at Saint-Fulgence, and a marine ecosystem (Saguenay Fjord) characterized by the inflow of icy, oxygen-rich salt water teeming with marine life.

The rich biodiversity of the Saguenay is reflected in the more than 20 freshwater fish species, some 50 saltwater species and several anadromous species. The region is also home to over 400 species of invertebrates, including crustaceans and molluscs, and more than 250 species of riparian plants, including glasswort (*Salicornia europaea*) which, in the Saguenay–Lac-Saint-Jean region, is found only at Saint-Fulgence. Lastly, there are close to 300 species of birds, concentrated for the most part at Saint-Fulgence and La Baie, as well as marine mammals, including the Harbour seal and the Beluga whale.

The Saguenay is one of the sectors of the St. Lawrence River system most disturbed by human activity, along with the sectors of Montreal and Quebec City-Lévis. In the first half of the 20th century, the hydrodynamics of the Saguenay were greatly modified when the river was harnessed to generate hydroelectric power. This is also true of its upstream stretch, which was once similar to a large salmon river. The Saguenay has suffered the adverse effects of industrial development, particularly from aluminum smelters and pulp and paper mills.

The entire aquatic ecosystem of the Saguenay has been contaminated by mercury and polycyclic aromatic hydrocarbons (PAHs). While the main source of mercury was a chlor-alkali plant which operated in Jonquière from 1947 to 1976, the primary historical PAH sources have been two aluminum smelters, at Alma and Jonquière, both of which still employ the Söderberg process and continue to release PAHs into the atmosphere. An appreciable portion of these two contaminants settled in the sediment, primarily in the upstream portion of the fjord, between Saint-Fulgence and Cap à l'Est. By the end of the 1970s, the entire food chain of the Saguenay was highly contaminated by mercury.

PAH and mercury levels in the ecosystem have dropped steadily since the closure of the chlor-alkali plant in 1976 and the phase-out of the Söderberg process, begun in 1984,

because the contaminated sediment has slowly become buried beneath more recent, cleaner sediment. Nevertheless, contaminated sediment remains a potential source of pollution in the upstream part of the fjord.

In addition to this generalized contamination of the ecosystem, more localized areas have suffered repeated onslaughts from a variety of sources. These are the main ones, along with their respective sources of degradation: the La Petite Décharge River, issuing from Lake Saint-Jean (flow regulation, log drives and the outfalls of a paper mill and the municipality of Alma); the southern channel of Chute-à-Caron (outfalls of two paper mills and, during heavy rainfall, untreated wastewater from the town of Jonquière); and the shoreline of Ha! Ha! Bay (encroachment on the aquatic environment, log drives, paper mill effluent, accidental spills in ports).

The main sources of contamination in the study area have been reduced on the whole. Aluminum production using the obsolete Söderberg process is declining as facilities bring cleaner technologies on line. In 1995, the four pulp and paper mills in the region introduced secondary wastewater treatment systems and shut down certain polluting processes. The main hazardous waste disposal sites have been rehabilitated so as to eliminate losses to the environment. Today, 56% of residents in the riverside municipalities of the Saguenay are served by a wastewater treatment plant. That figure will approach 86% in 1997.

Much of the riparian and aquatic environments of the Saguenay, prized for their ecological, recreational and tourism value, are officially protected by virtue of Saguenay Park, the Saguenay–St. Lawrence Marine Park and the Saint-Fulgence municipal park. The boom in recreation and tourism in the Saguenay Fjord over the last decade is nonetheless exerting pressure on the environment, making the co-ordination of development and environmental protection an important local challenge.

Résumé

Le Saguenay (zones d'intervention prioritaire 22 et 23) présente trois écosystèmes bien distincts : un écosystème fluvial (la rivière Saguenay), un estuaire avec une vaste zone de sédimentation sur les battures de Saint-Fulgence et un écosystème marin (fjord du Saguenay) caractérisé par un apport d'eaux marines, glaciales et bien oxygénées, qui permettent le foisonnement d'une vie marine.

La grande diversité biologique du Saguenay s'illustre par la présence de plus de 20 espèces de poissons dulcicoles, une cinquantaine d'espèces marines et plusieurs espèces anadromes. Sont aussi présentes plus de 400 espèces d'invertébrés, dont des crustacés et des mollusques, plus de 250 espèces de plantes sur les rives, dont la Salicorne d'Europe qui, dans la région du Saguenay–Lac Saint-Jean, n'est connue qu'à Saint-Fulgence, près de 300 espèces d'oiseaux concentrées surtout à Saint-Fulgence et à La Baie, et des mammifères marins dont le Phoque commun et le Béluga.

Le Saguenay est, avec les secteurs de Montréal et de Québec-Lévis, l'un des secteurs du système du Saint-Laurent les plus perturbés par les activités humaines. Le harnachement de la rivière Saguenay pour la production hydroélectrique au cours de la première moitié du 20e siècle a considérablement modifié l'hydrodynamique du cours d'eau dont la partie amont s'apparentait jadis à une grande rivière à salmonidés. Le Saguenay a subi les contre-coups du développement industriel, notamment des alumineries et des fabriques de pâtes et papiers.

L'ensemble de l'écosystème aquatique du Saguenay a été contaminé par le mercure et les hydrocarbures aromatiques polycycliques (HAP). La principale source de mercure était une usine de chlore et de soude caustique située à Jonquière qui a été exploitée de 1947 à 1976, et les principales sources historiques de HAP sont deux alumineries, l'une située à Alma, l'autre à Jonquière, qui utilisent encore le procédé Söderberg à goujons horizontaux et qui émettent encore des HAP dans l'atmosphère. Une grande partie de ces deux contaminants s'est déposée dans les sédiments, principalement dans la partie amont du fjord, entre Saint-Fulgence et le cap

à l'Est. À la fin des années 1970, l'ensemble de la chaîne alimentaire du Saguenay était fortement contaminée par le mercure.

À la suite de la fermeture de l'usine de chlore et de soude caustique en 1976 et de l'abandon progressif du procédé Söderberg depuis 1984, on assiste à une diminution constante du niveau de contamination de l'écosystème par le mercure et les HAP, les sédiments contaminés étant progressivement enfouis sous des sédiments récents plus propres. Les sédiments contaminés sont toutefois une source potentielle de contamination dans la partie amont du fjord.

En plus de cette contamination globale de l'écosystème, certains secteurs plus localisés ont subi les atteintes répétées de sources diverses. Il s'agit principalement de la rivière La Petite Décharge du lac Saint-Jean (régularisation du débit, flottage du bois, émissaires d'eaux usées d'une papetière et de la ville d'Alma), du bras sud de Chute-à-Caron (émissaires d'eaux usées de deux papetières et lors de fortes pluies, des eaux usées non traitées de la ville de Jonquière) et le littoral de la baie des Ha! Ha! (empiètements sur le milieu aquatique, flottage du bois, eaux usées d'une papetière, déversements accidentels en zone portuaire).

Dans l'ensemble, les principales sources de contamination du secteur ont été réduites. La production d'aluminium au moyen d'une technologie vétuste (procédé Söderberg) a diminué au profit d'installations utilisant un procédé peu polluant. Les autres papetières du secteur ont entrepris en 1995 le traitement secondaire de leurs eaux usées et ont éliminé certains procédés polluants. Les principaux sites d'élimination de déchets dangereux ont été restaurés afin d'éliminer les pertes à l'environnement. Aujourd'hui, 56 p. 100 de la population des municipalités riveraines au Saguenay est desservie par une station d'épuration des eaux usées et on prévoit qu'en 1997, près de 86 p. 100 de la population le sera.

Une grande partie des milieux littoraux et aquatiques à forte valeur écologique et récréo-touristique du secteur jouissent d'une protection grâce au Parc du Saguenay, au Parc marin Saguenay–Saint-Laurent et au parc municipal de Saint-Fulgence. La croissance spectaculaire des activités récréo-touristiques dans le fjord du Saguenay au cours de la dernière décennie exerce toutefois des pressions sur l'environnement et l'harmonisation de ce développement avec la protection du milieu constitue un enjeu important pour le secteur.

Table of Contents

List of Figures

List of Tables

CHAPTER 1 The Saguenay, Then and Now

Development of the Saguenay–Lake-Saint-Jean region commenced in the mid-nineteenth century with the second wave of Quebec settlement. Migration to this new territory was prompted by congestion of the farmland allotments along the St. Lawrence River, easy access through the natural seaway formed by the Saguenay River, and the tremendous promise of its natural resources.

Beginning in the 19th century, harvesting of forest resources became the primary impetus for regional development and settlement, and the first villages sprang up near logging camps and sawmills. Then in the late 19th century, agriculture took over as the driving force for regional development, particularly in the lower Saguenay. The 20th century was marked by industrialization of the region, which centred on the aluminum and timber processing sectors. The proximity and accessibility of watercourses were crucial to the establishment of industry in the upper Saguenay in that they lowered the cost of transporting raw materials and provided a water supply and a means of disposal of industrial effluents and waste. The arrival of large industrial concerns in the region fostered the emergence of four large urban areas: Chicoutimi, Jonquière, La Baie and Alma. This had a decisive impact on regional planning and changes in uses linked to the Saguenay River, including shipping and hydroelectric power generation. The many hydroelectric dams built on the upper Saguenay and along certain tributaries bear this out.

The Saguenay River gradually succumbed to the many onslaughts of development, first from forestry, particularly log drives and sawmill operations along the tributaries, and then from industrialization, which harnessed the river's power-generating capacity and gave rise to discharges of toxic substances. As with the St. Lawrence, a few informed observers noted that the abundance of some animal populations was declining and suggested that the reason was habitat degradation. Their warnings aroused little public interest, however.

Then, in the early 1970s, public opinion was suddenly roused by the realization that mercury contamination of fish was not just an abstract research topic, but a very real risk to which many fishermen were exposed. As the list of toxic substances detected in the aquatic

environment grew longer, the general public eventually made environmental quality its primary concern. There is now near-unanimous agreement that the comforts afforded by an industrial society have their drawbacks, that unbridled exploitation of resources and pollution of the ecosystem pose a potential threat to all forms of life, including human beings.

Most industrialized nations have agreed to redirect their economies toward sustainable development. No longer can the profit motive be the sole force governing human activity. Given the fragile nature of our environment and the limitations of our planet, sustainable economic development must ensure that resources serve a variety of uses. It must also take account the quality of life of human beings and foster the preservation of biological diversity.

CHAPTER 2 Priority Intervention Zones (ZIP) Program

Starting in the 1960s, growing public awareness of the state of degradation of the Great Lakes and the St. Lawrence and Saguenay rivers and the urgency of the situation prompted governments to undertake joint action. That paved the way for the 1972 Canada-U.S. Great Lakes Water Quality Agreement. An amendment was made in 1987 to include a program to restore use at the local level (remedial action plans, or RAPs). In 1988, both an agreement to control toxic discharges into the Great Lakes basin and the Great Lakes Charter were signed by Quebec, Ontario and the eight U.S. states concerned. In 1978, concerned about the poor quality of the St. Lawrence and its tributaries, the Quebec government launched its own wastewater treatment program (PAEQ).

In 1989, the governments of Canada and Quebec agreed to co-ordinate their efforts under the St. Lawrence Action Plan, which was extended in 1994 and renamed St. Lawrence Vision 2000 (SLV 2000). The objectives of this action plan include producing an environmental assessment which will encourage local stakeholders to work together to restore and protect the St. Lawrence – as well as the Saguenay in this instance – and co-ordinate uses of this resource (Figure 1). As part of the groundwork for public consultations, the SLV 2000 partners are synthesizing and analysing the current state of knowledge of the environment in each study area.

This report presents the main points of the technical reports[1] and reviews current knowledge of the state of the resources, the present and potential uses of the Saguenay region (ZIPs 22 and 23) and the associated limitations.

This effort to synthesize and analyse existing knowledge is meant to provide riverside stakeholders with accessible, objective scientific data for use in establishing their priorities for action. This will make it possible to devise local and regional action plans wherein each partner will work within its particular sphere of responsibility, but in co-ordination with the other partners.

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1. One report deals with the physico-chemical aspects of the water and sediments (Fortin and Pelletier 1995), another with biological communities (Mousseau and Armellin 1995) and another with the socio-economic aspects (Jourdain et al. 1995).

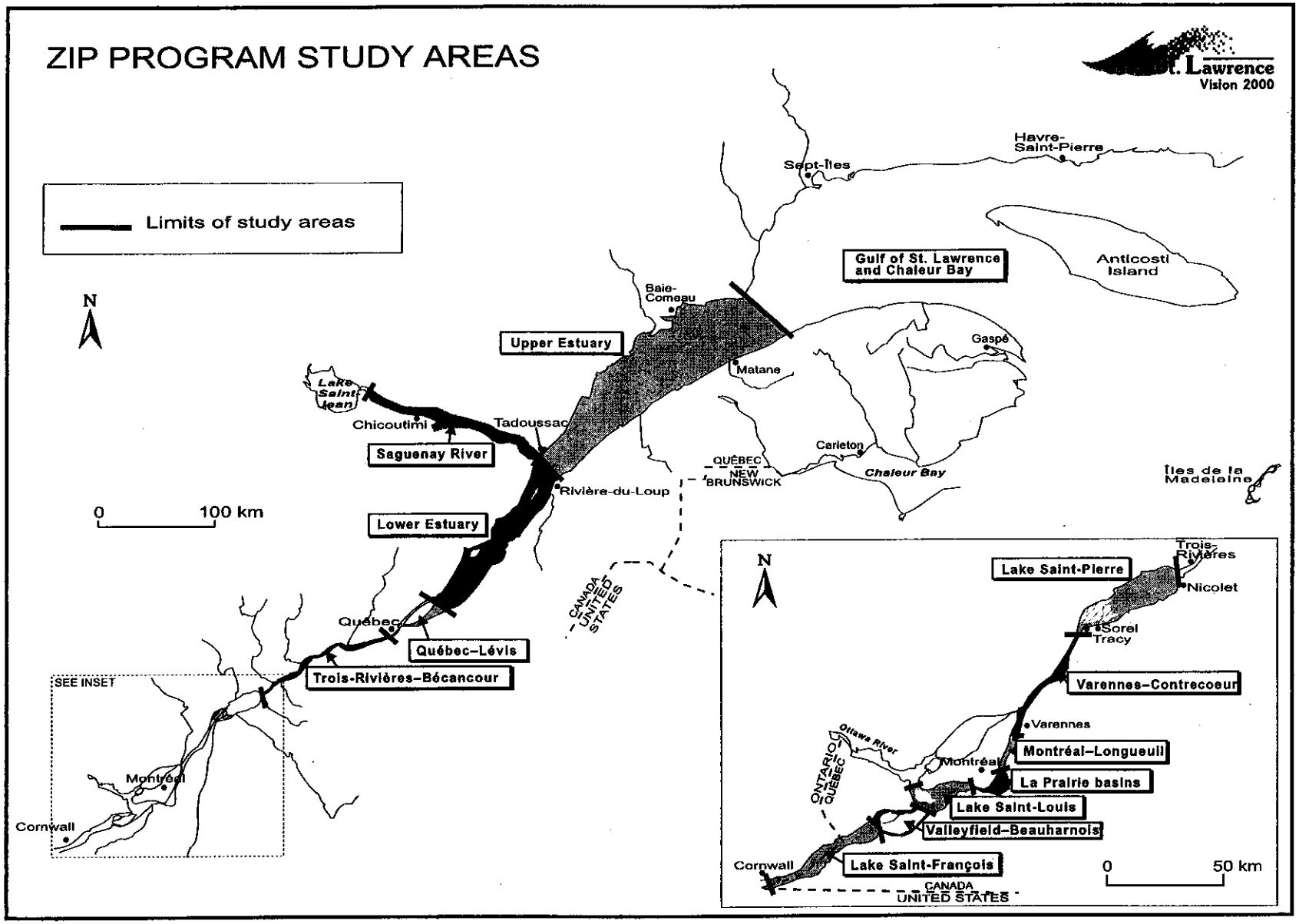


Figure 1 ZIP Program study areas

CHAPTER 3 Characterization of the Saguenay Region

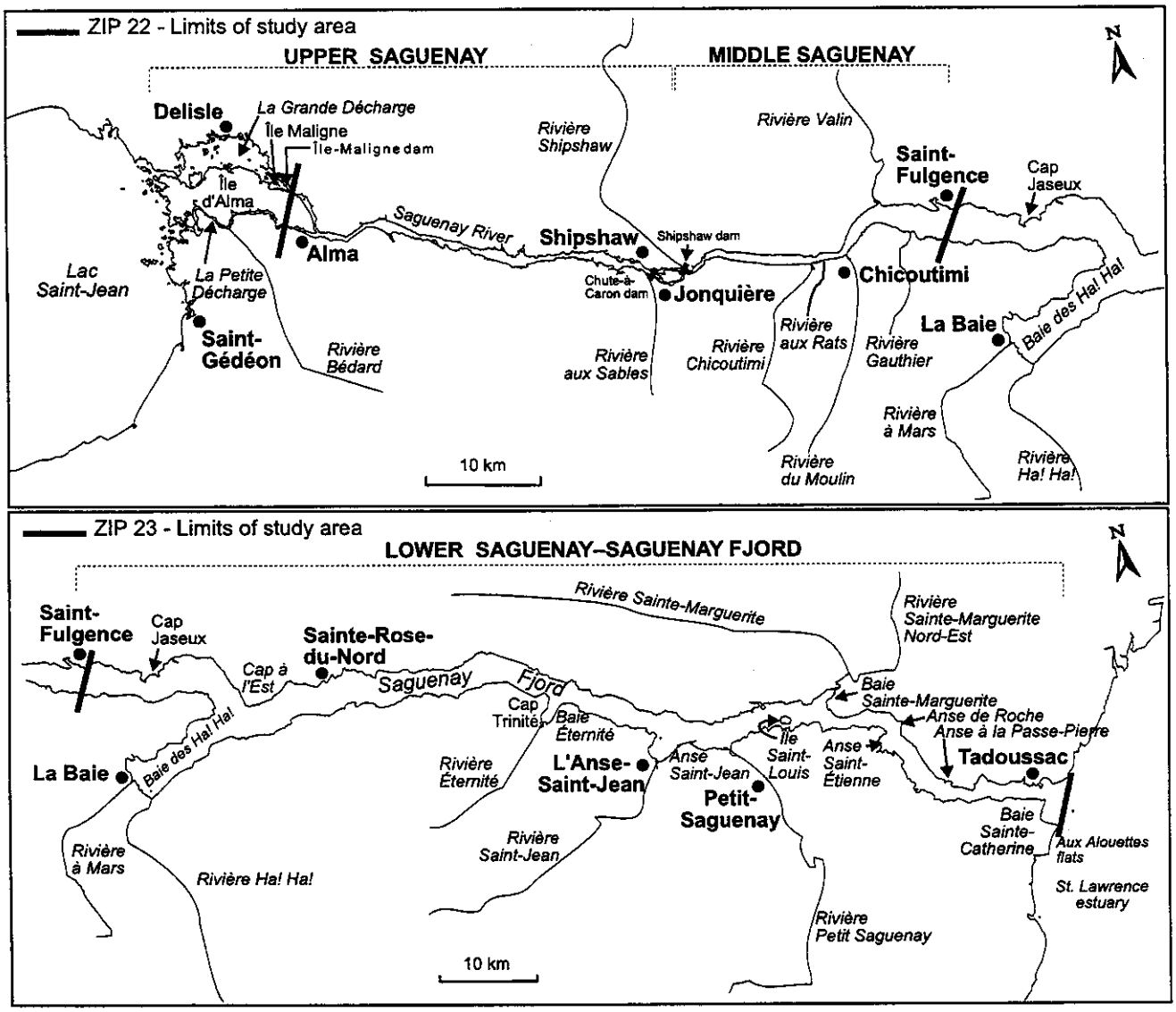
The Saguenay sector encompasses ZIPs 22 and 23, corresponding to the Saguenay river and fjord, respectively. There is a distance of almost 170 km from Lake Saint-Jean, the source of the Saguenay, to the St. Lawrence River, into which it empties. The upstream limit of the study area lies between the foot of Île-Maligne dam on the La Grande Décharge River (which flows out of Lake Saint-Jean), and at the town of Alma on the La Petite Décharge River. The downstream limit is situated at the confluence of the Saguenay River and the St. Lawrence estuary, off Tadoussac (Figure 2).

3.1 Physical Environment

The Saguenay River, set between Mont Valin to the north and the Laurentians to the south, occupies an ancient tectonic depression in which Lake Saint-Jean also lies. Glaciers carved this valley during the Quaternary period, widening it in places and overdeepening it in others. Based on its hydrodynamic and physico-chemical characteristics, the Saguenay River can be divided into three distinct sections: the upper Saguenay, between the Île-Maligne and Shipshaw dams, the middle Saguenay, between the Shipshaw dam and Saint-Fulgence, and the lower Saguenay, from Saint-Fulgence to the mouth of the Saguenay at Tadoussac (Figure 3).

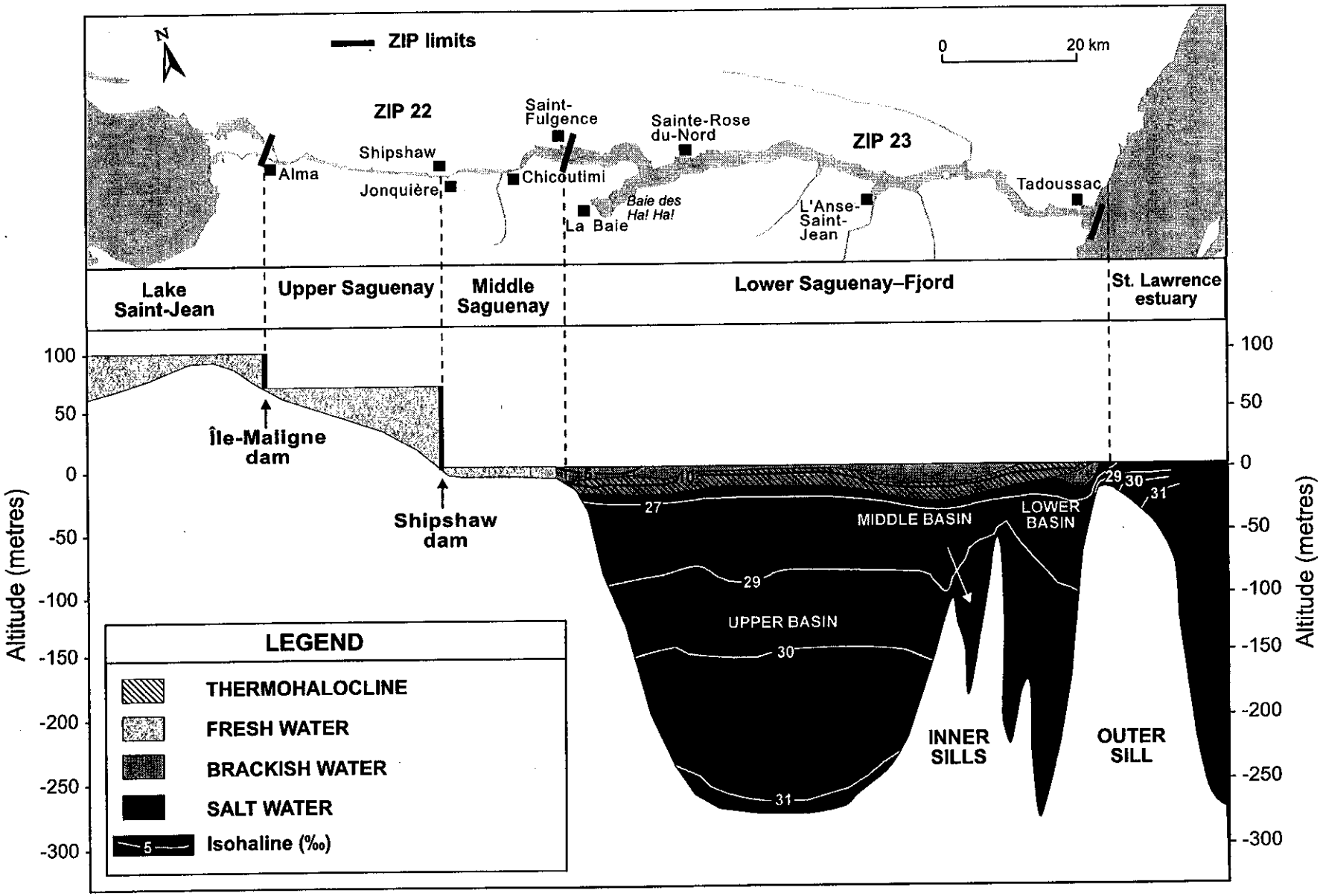
The upper Saguenay spans a distance of 40 km from the La Grande Décharge and La Petite Décharge rivers, both of which flow out of Lake Saint-Jean, to Shipshaw. Construction of the Chute-à-Caron dam in 1930 radically altered the aquatic environment of this river section, which once had the characteristics of a large salmon river. The upper Saguenay is now a deep, still body of water that lies between rocky scarps, except for a stretch of a few kilometres downstream of the dams on the La Grande Décharge and La Petite Décharge where the currents are swift.

The middle Saguenay stretches 25 km between Shipshaw and Saint-Fulgence and has the properties of a fluvial estuary. This part of the Saguenay River contains fresh water, but is also affected by the tides. The banks consist of rocky escarpments on the south side and clay terraces on the north shore.



Source: Mousseau, P., and A. Armellin. 1995. *Synthèse des connaissances sur les communautés biologiques du secteur d'étude Saguenay*. Technical report on Priority Intervention Zones 22 and 23. Environment Canada - Quebec Region, Environmental Conservation, St. Lawrence Centre.

Figure 2 Map of the study area



Source: Mousseau, P., and A. Armellin. 1995. *Synthèse des connaissances sur les communautés biologiques du secteur d'étude Saguenay*. Technical report on Priority Intervention Zones 22 and 23. Environment Canada - Quebec Region, Environmental Conservation, St. Lawrence Centre.

Figure 3 Saguenay River subdivisions and distribution of water masses

Brackish and salt waters flow between the scarped banks of an ancient glacial valley over the final 100 kilometres of the Saguenay, between Saint-Fulgence and Tadoussac. The upper portion of this section is Y-shaped, with Ha! Ha! Bay forming the southern arm and main stem of the river below Saint-Fulgence forming the northern arm. Morphologically, the lower Saguenay is a true fjord with deep basins (extending down 276 m) separated by sills (cross cliffs). The outer sill lies only 20 m below the water surface and does not cut the Saguenay Fjord off completely from the Lower Estuary of the St. Lawrence, as we will see later on. The banks of the fjord, which are steep-sided and largely inaccessible, create a landscape of exceptional beauty. This is the longest fjord in eastern Canada and the southernmost in eastern North America.

The Saguenay River is one of the two largest tributaries of the St. Lawrence (the other being the Ottawa River). Its annual flow leaving Lake Saint-Jean is approximately 1600 m^3/s, and the tributaries situated between Alma and Tadoussac increase this flow by only 25% (mean discharge of about 2100 m^3/s at Tadoussac). The construction of dams on the upper Saguenay regulated the flow from Lake Saint-Jean and the tributaries in this river section.

Starting at the mouth of the Shipshaw River, the waters are influenced by the coming and going of the tides. The tide entering the Saguenay from the St. Lawrence estuary has a mean amplitude of 3.6 m at Tadoussac. Tidal amplitude reaches a maximum of 4.6 m at Saint-Fulgence because of the sudden drop in depth there, then declines to 4.0 m at Chicoutimi and to zero a few kilometres below Shipshaw dam.

Beginning at Saint-Fulgence, the strong turbulence created by the tides in this shallow section causes mixing between the fresh water of the Saguenay and the salt water of the fjord. Farther downstream in the fjord, mixing is substantially reduced and the brackish water from the head of the fjord forms a thin surface layer which floats over the seawater, very slowly increasing in salinity from Saint-Fulgence to Tadoussac.

At the mouth of the Saguenay, the ebb tide draws the fresh water out of the fjord, along with a large volume of salt water, with which some mixing has occurred as of Saint-

Fulgence. This outflow of salty surface water (mixed with fresh water) is offset, at high tide, by an equal inflow of seawater to the Saguenay from the St. Lawrence estuary.

The Saguenay Fjord is an exceptional body of water, unlike any other of its kind in the world. Fjords with shallow outer sills are usually characterized by irregular renewal of the deep water, which is therefore anoxic (lacking dissolved oxygen) for several months of the year or even several years. However, such is not the case for the Saguenay, since despite its shallow outer sill, the deep water is continually replaced, making it well-oxygenated year-round and teeming with marine life. This characteristic, which is probably unique to the Saguenay Fjord, is explained by the upwellings of deep water that occur with each high tide in the St. Lawrence estuary precisely at the spot where the Saguenay emerges. Because of this physiographic peculiarity, the St. Lawrence water that is swept into the Saguenay with the rising tide, and which is denser than the deep water of the fjord, sinks to the bottom of the fjord's lower basin and then cascades into the upstream basins. In summer, therefore, the deep waters in the lower basin of the fjord are replaced in only a few days, whereas the waters of the fjord as a whole are renewed every six months or so. The renewal time may be even faster in winter.

In summer, the Saguenay Fjord thus contains two very different layers of water: a thin surface layer 10 to 15 m thick and composed of turbid, fairly warm, brackish water (> 10°C and 5-15‰ salinity), overlying a huge mass of clear, cold salt water (0 to 2°C and 29-31‰ salinity) which comprises 93% of the total water volume of the fjord (Figure 3). The boundary between these two masses of water is very sharp (thermohalocline): just 10 to 15 m below the surface layer, the water temperature plummets to less than 2°C and salinity goes from 10‰ to 25‰. The waters in the upper and lower basins of the fjord also differ in summer, when the icy water (< 1°C) occupying all of the basins in winter is gradually displaced to the upstream part of the upper basin by the slightly warmer water that begins entering the fjord.

The sediment regime of the Saguenay River is not as well understood as that of the St. Lawrence River. The annual load of suspended solids in the Saguenay River at Chicoutimi is estimated at 160 000 tonnes per year which, all things considered, is much less than the sediment load in the St. Lawrence at Quebec City.

Although the banks of the middle Saguenay and the fjord generally do not lend themselves to long-term accumulation of sediments, mud is deposited on some flats in summer. This seasonal sediment deposition on the flats is heavier in the zones where fresh and salt water mix, and suspended solids build up as a result of estuarine circulation. Conditions like these are encountered in the Saint-Fulgence area and at the mouth of the rivers that empty directly into the fjord.

In contrast with the banks, the floor of the upper basin of the Saguenay Fjord is an extensive area of long-term sedimentation. At the head of the fjord, between Saint-Fulgence and the mouth of Ha! Ha! Bay, the deposition rate is about 10 cm per year (sand and mud), and may reach one metre per year following natural disasters, such as the major landslides that occurred in the basin of the middle Saguenay (Kénogami in 1924, Saint-Jean-Vianney in 1971). The sedimentation rate in the fjord drops rapidly moving downstream. In the centre of the upper basin, it is a mere 0.1 to 0.2 cm per year. In the lower basin, near Tadoussac, strong currents prevent fine sediment from settling. The bottom in this area is covered with sand and gravel.

3.2 Aquatic Habitats and Communities

3.2.1 Upper Saguenay

The shore areas of the upper Saguenay, with their steep banks underlain by a rocky substrate, do not favour the development of wetlands. Very little is known about the benthos and plankton in this river section, making it impossible to characterize ecological productivity there.

With the construction of the Île-Maligne and Chute-à-Caron dams (in 1925 and 1930, respectively), anadromous fish could no longer swim upriver. The upper Saguenay now contains only freshwater species, six of which are anadromous and come from Lake Saint-Jean (Ouananiche; Rainbow smelt; Atlantic tomcod; and Threespine, Brook and Ninespine sticklebacks). This stretch of river has about 20 species of fish of boreal affinity characteristic of reservoir lakes, whose presence is explained by inflows of water from Lake Saint-Jean and the possible existence of local fish populations. The most abundant species are Yellow perch, Walleye, Emerald shiner, Longnose and White suckers, Northern pike, Spottail shiner and a species introduced by Lake Saint-Jean fishermen, the Brown bullhead. This stretch also contains

spawning grounds for Walleye, suckers, Northern pike and Yellow perch, as well as a possible Ouananiche spawning ground near Taché Island in the La Grande Décharge River.

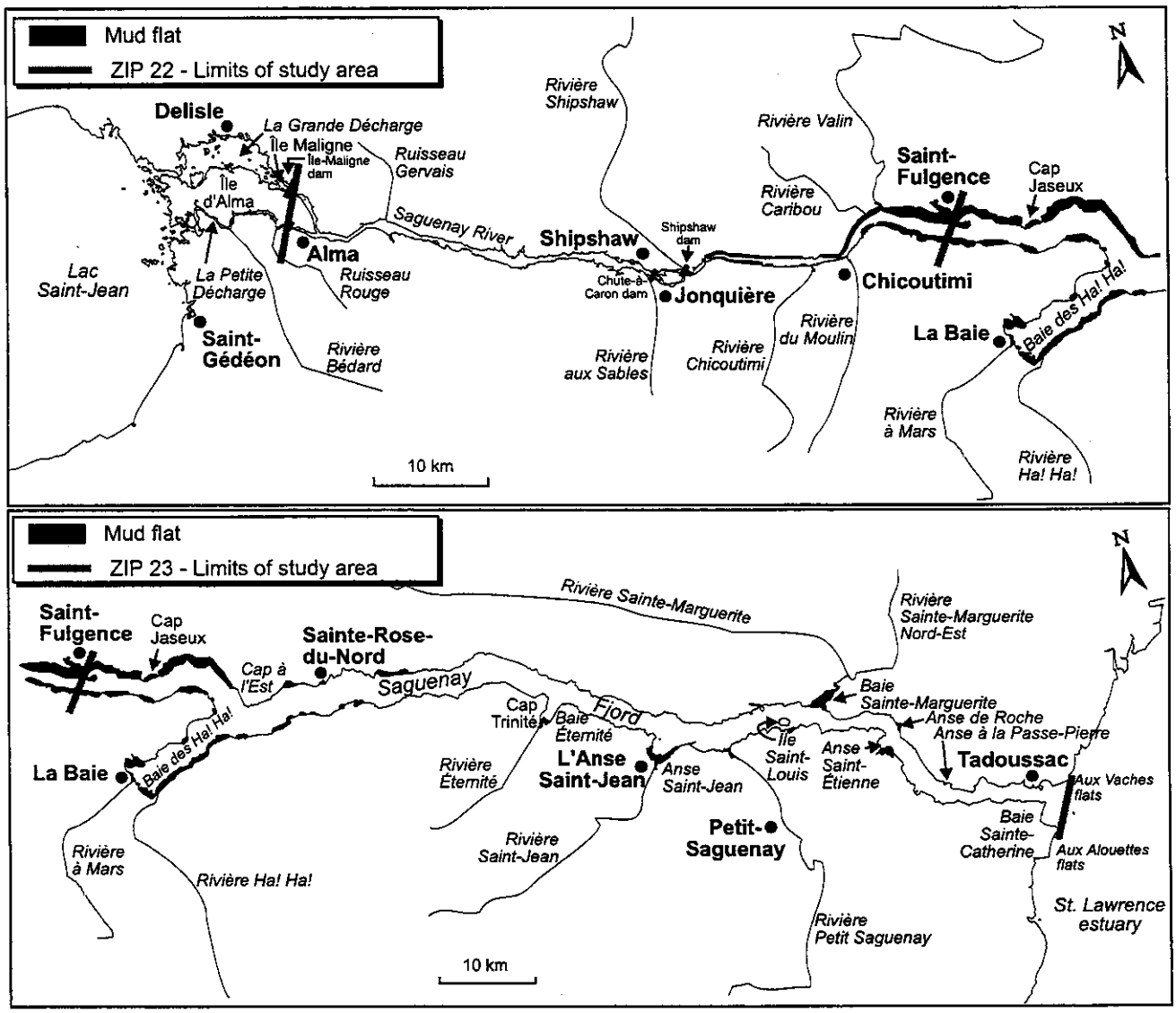
3.2.2 Middle Saguenay

The middle Saguenay has 1413 ha of mud flats suitable for the development of productive wetlands, including 880 ha in the immediate vicinity of Saint-Fulgence, at the boundary between the middle Saguenay and the fjord (Figure 4).

The flats of the 240-hectare Saint-Fulgence Flats Interpretation and Bird Rehabilitation Centre form the main wetlands in the study area. They include 160 ha of *Scirpus americanus* (American bulrush) marsh and 80 ha of wet meadow providing habitat for 70 of the 253 species of aquatic vegetation inventoried along the shores of the middle Saguenay and the fjord. The vegetation along the flats developed in a series of strips parallel to the riverbank according to the species' tolerance for tidal inundation (Figure 5). The bulrush marsh between mean low water and mean high water is a feeding ground for several species of fish and birds. The wet meadow, flooded only by spring tides, is a nesting area for several bird species. The Saint-Fulgence flats are the only place in the Saguenay–Lake Saint-Jean region where glasswort grows.

Not enough is known about the benthos and plankton of the middle Saguenay to characterize the productivity of those communities. The local sediment regime (deposition and mud flows) make this part of the fjord unsuitable for bottom-dwelling organisms.

The middle Saguenay fish community includes the same species as the upper Saguenay, several anadromous species (Rainbow smelt, Brook charr and Atlantic salmon) and one catadromous species (American eel). The principal fish habitats are found in the tributaries (Aux Sables, Shipshaw, Chicoutimi, Du Moulin and Valin rivers) and the upstream portion of the middle Saguenay, which still has all of the characteristics of a large salmon river and is a potential spawning ground.



Source: Mousseau, P., and A. Armellin. 1995. *Synthèse des connaissances sur les communautés biologiques du secteur d'étude Saguenay*. Technical report on Priority Intervention Zones 22 and 23. Environment Canada - Quebec Region, Environmental Conservation, St. Lawrence Centre.

Figure 4 Distribution of mud flats in the Saguenay study area

3.2.3 Saguenay Fjord (lower Saguenay)

The Saguenay Fjord comprises two superimposed ecological zones which are almost completely isolated from each other: the surface zone and the deep basins.

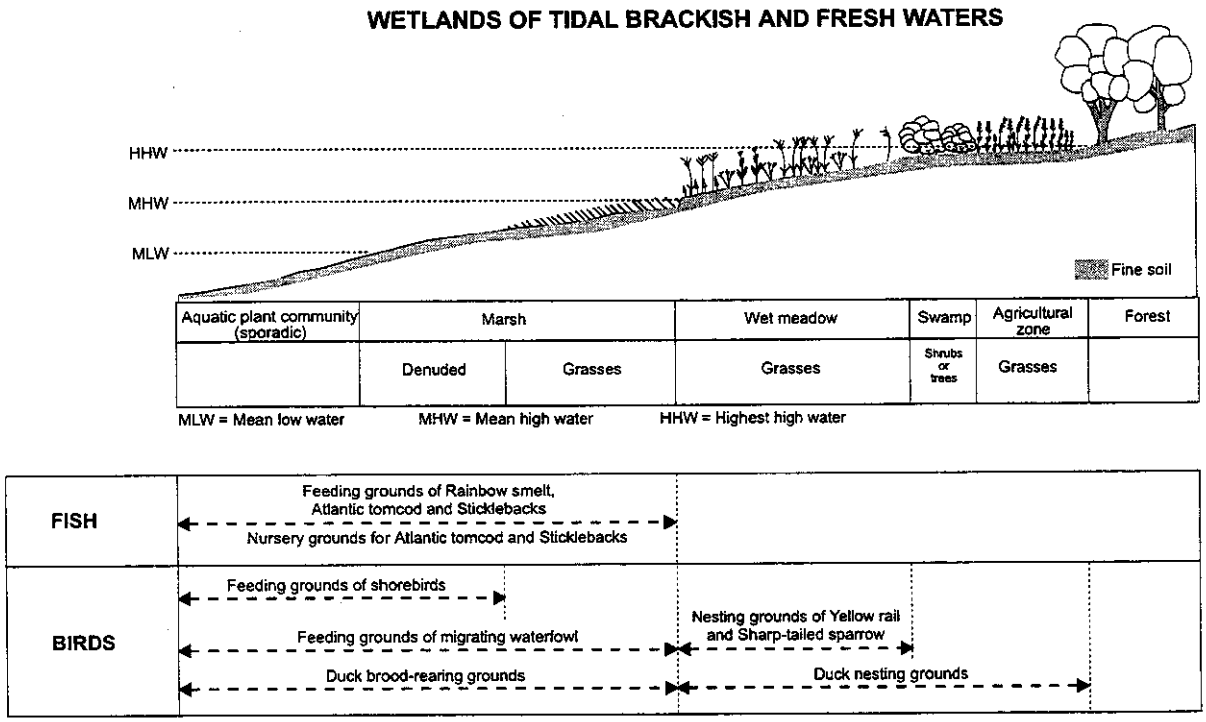
Surface zone. This zone of the fjord encompasses the layer of brackish surface water and the shores bathed by that water. It is characterized by steep rocky banks subjected to large tidal amplitudes and strong ice abrasion. The water is brackish, relatively warm, turbid and nutrient-poor. This water is affected by the great seasonal variability in physical and chemical conditions and rapid transport of the water to the St. Lawrence estuary (short residence time).

This environment is ill-suited for the development of wetlands. Most of the 1115 ha of mud flats here are at the head of the fjord, near Saint-Fulgence (165 ha), in Ha! Ha! Bay (359 ha) and at the mouths of the Saint-Jean and Sainte-Marguerite rivers (120 and 260 ha, respectively) (Figure 4). At both Saint-Fulgence and at the mouth of the Sainte-Marguerite river, the intertidal marshes are dominated by American bulrush. One strip of *Spartina alterniflora* (saltwater cord grass), the dominant species of the estuarine salt marshes of the St. Lawrence, managed to develop below the mean low water level (Figure 5).

The rocky walls that characterize most of the intertidal environment of the fjord are practically bare of vegetation and benthos owing to strong ice abrasion. On the flatter foreshores, the vegetation is mostly algae (rockweed and kelp). The benthos is dominated by Blue mussels and periwinkles (on hard bottoms) or Soft-shell clams (soft bottom).

Down 10 to 15 m below low water level, the rocky walls in the downstream part of the fjord are covered with bottom-dwelling animal and plant life characteristic of a marine environment, albeit far less diversified than the benthos in the Lower Estuary of the St. Lawrence.

The sharp gradient between the surface water and deep water (thermohalocline) prevents nutrients in the underlying salt water from being carried to the surface. This curbs the production of phytoplankton in the fjord, which can only occur in the surface layer which absorbs solar radiation. The small amount of biomass that is produced is quickly swept away to the St. Lawrence estuary by the current.



Source: Mousseau, P., and A. Armellin. 1995. *Synthèse des connaissances sur les communautés biologiques du secteur d'étude Saguenay*. Technical report on Priority Intervention Zones 22 and 23. Environment Canada - Quebec Region, Environmental Conservation, St. Lawrence Centre.

Figure 5 Zonation of vegetation in freshwater and brackish wetlands of the Saguenay river

The surface waters of the fjord provide habitat for fish species of boreal affinity that are able to withstand large variations in temperature and salinity. The zone is frequented by inshore marine species tolerant of low salinity (Atlantic herring and Smooth flounder), anadromous and catadromous species (e.g., Rainbow smelt, American shad, Atlantic salmon, Atlantic tomcod and American eel) and freshwater species amenable to low salinity (e.g., Northern pike, Lake whitefish, White and Longnose suckers, Walleye and Yellow perch).

Deep basins. The deep basins of the fjord are much more productive than the surface zone. This environment is characterized by icy, oxygen-rich salt water which remains in the fjord far longer than the surface water. The physico-chemical properties in these basins change very little.

The waters of the lower basin, off Tadoussac, are constantly replaced as estuarine waters enter with each rising tide. They are characterized in summer by high concentrations of dissolved oxygen, organic particulate matter, phytoplankton and zooplankton. During the slow upriver flow of these deep waters, dissolved oxygen and particulates diminish, the phytoplankton thins out and the zooplankton composition changes considerably. The dominant zooplankton species in the lower basin are the same as in the Lower Estuary of the St. Lawrence. The community in the upper basin is heavily dominated by small species typical of fjords. Zooplankton diversity, density and biomass are greater in the fjord than in the estuary owing to this coexistence of endogenous and exogenous populations.

The deep waters of the fjord provide habitat for invertebrate and fish species intolerant of large variations in temperature and salinity. Close to 80% of bottom-dwelling invertebrates in the fjord basins (410 species in all) are also found in the Lower Estuary of the St. Lawrence, where benthic organisms are far more diversified (800 species). This includes some 50 species of deep-water fish typical of the estuary and Gulf of St. Lawrence, the most common being Atlantic cod, Deepwater redfish and Greenland halibut. Contrary to widespread opinion, the marine fish communities in the fjord are not totally isolated from the estuary and Gulf communities because exchanges of eggs, larvae and immature individuals occur with the Lower Estuary. However, the adults of certain species, including Deepwater redfish and Greenland

halibut, are cut off from the Lower Estuary by the sill off Tadoussac. These fish spend much of their life cycle in the fjord and thus have their own particular characteristics, such as slower growth due to the low water temperature.

3.3 Fishery Resources

3.3.1 Invertebrates

Soft-shell clam. There are small beds of Soft-shell clams in most coves of the Saguenay Fjord. The main ones are in the Saint-Jean and Saint-Étienne coves and Tadoussac Bay (Figure 6). The largest Soft-shell clam beds in the study area are found in Sainte-Catherine Bay.

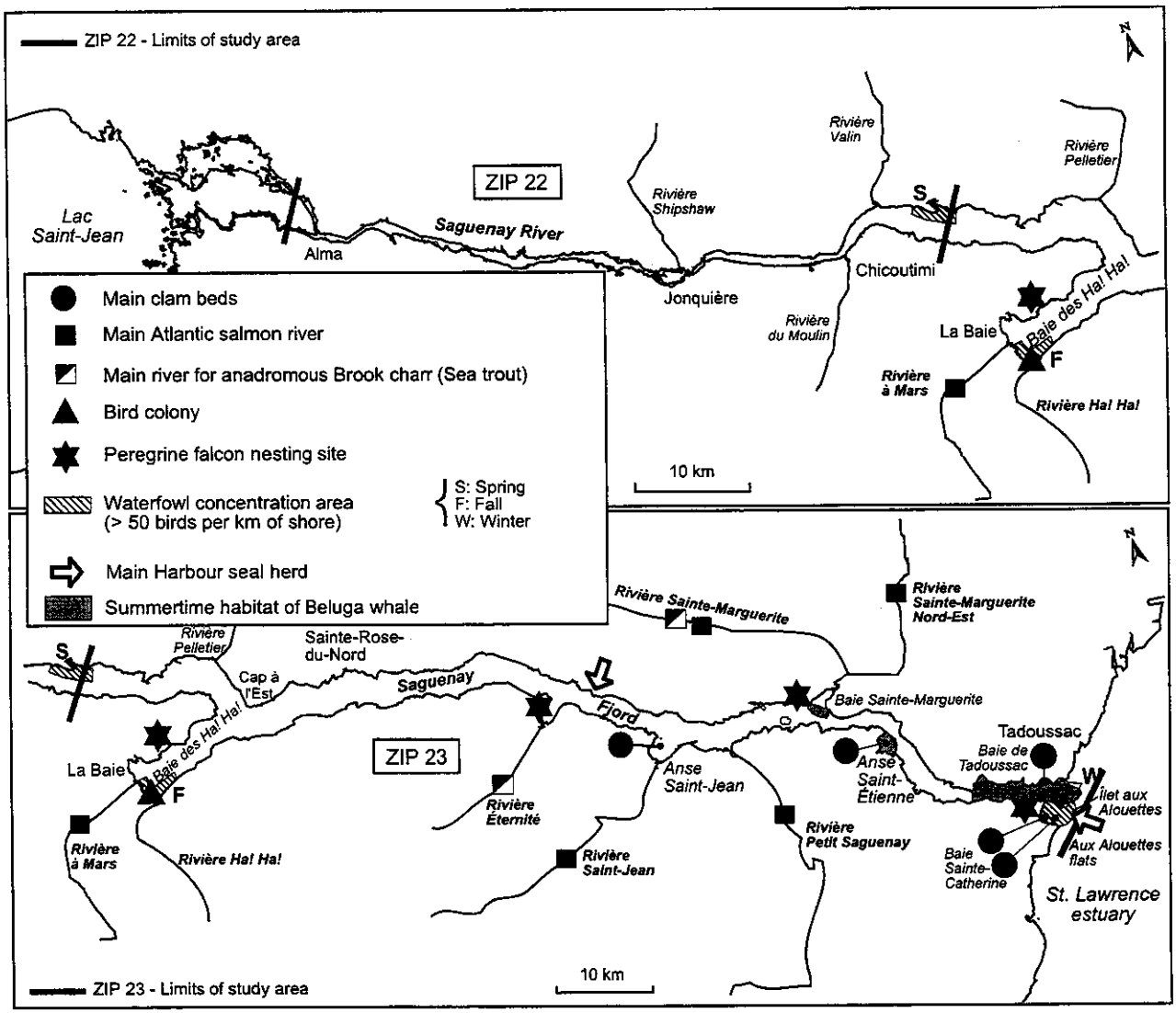
Snow crab. Snow crab are found from the mouth of the fjord up to Cap à l'Est, but not in Ha! Ha! Bay or the Saint-Fulgence area. This species is far less abundant in the fjord than in the commercial fishing areas of the estuary and Gulf of St. Lawrence. The fjord population also has a low reproduction rate, making it vulnerable to commercial harvesting.

Northern shrimp. Northern shrimp are also less abundant in the fjord than in the commercial fishing areas of the estuary and the Gulf. This species is found mainly in the upper basin, where it is characterized by slower growth than in the Gulf, low numbers of females and bi-annual spawning. These characteristics probably stem from the lower water temperature in the fjord (0 to 2°C) as compared with temperatures in the Northern shrimp concentration areas in the Gulf (4 to 6°C).

3.3.2 Fish

Freshwater species

The main freshwater fish species of interest for sport fishing in the study area are Walleye, Northern pike, Yellow perch and Ouananiche. The first three are abundant and reproduce in the upper Saguenay. Changing the upper Saguenay into a reservoir would have been favourable to the Walleye, but disadvantaged the Northern pike, which spawns in the flood plain. The presence of Ouananiche in the upper Saguenay can be explained by downstream migration from Lake Saint-Jean or the possible existence of a local population.



Source: Mousseau, P., and A. Armellin. 1995. *Synthèse des connaissances sur les communautés biologiques du secteur d'étude Saguenay*. Technical report on Priority Intervention Zones 22 and 23. Environment Canada - Quebec Region, Environmental Conservation, St. Lawrence Centre.

Figure 6 Habitat distribution for selected wildlife resources

Anadromous and catadromous species

Rainbow smelt. The anadromous rainbow smelt of the Saguenay River constitute one of the five Quebec populations of this species. The species' spawning grounds in the middle Saguenay have yet to be located; in summer the population scatters within the fjord and along the north shore of the St. Lawrence estuary between Quebec City and Tadoussac. This particular population is not growing as rapidly as the other Quebec populations. In winter, the Rainbow smelt is the main species caught in the ice fishery in the fjord.

Anadromous Brook charr (Sea trout). Sea trout spawn in several tributaries of the Saguenay, including the Sainte-Marguerite and Éternité rivers. The spawning run takes place from June to October. After spawning, the adults return to overwinter in the fjord; the young fish descend to the fjord the next spring and grow in the surface-water layer during the summer.

Atlantic salmon. Atlantic salmon spawn mostly in the À Mars, Saint-Jean, Sainte-Marguerite, Northeast Sainte-Marguerite and Petit Saguenay rivers. They also frequent and use, albeit marginally, the upper course of the middle Saguenay and the Shipshaw, Du Moulin, Valin, Ha! Ha!, Pelletier and Éternité rivers.

Stocking programs were introduced in the 1980s for four of the main salmon rivers: Petit Saguenay, À Mars, Sainte-Marguerite and Northeast Sainte-Marguerite. From 1983 to 1990, salmon stocks increased threefold in the tributaries of the Saguenay, then declined substantially from 1990 to 1993. This decline was observed throughout Quebec, and evidently resulted from harsh winter conditions in the Atlantic Ocean which caused mass mortalities. The upstream migration has improved since 1993 in some rivers, owing partly to the buyback of commercial fishing licences for Canadian Atlantic salmon.

American eel. American eel, a catadromous species, is abundant in the Éternité River, where it has been fished commercially in the past. It is probably present in other tributaries as well, such as the Petit Saguenay, where the spawning run of numerous juveniles has been observed in summer.

Other anadromous species. Very little is known about the ***Atlantic sturgeon***, ***American shad*** and ***Atlantic tomcod***. The first two species are scarce in the study area. Lake

Saint-Jean has a freshwater population of Atlantic tomcod; the individuals found in the upper Saguenay apparently swim down from the lake. There are also tomcod in the fjord, although no ice-fishing catches of this species have been reported.

Marine fish

Atlantic cod. This species frequents the estuary and Gulf of St. Lawrence in summer, then migrates to the Atlantic Ocean for the winter. One community of Atlantic cod does overwinter in the Saguenay Fjord, but it is not known whether it is distinct from the populations frequenting the estuary and the Gulf.

Deepwater redfish and Greenland halibut (turbot). Redfish and turbot are abundant in the estuary and Gulf of St. Lawrence below a depth of 150 m. Both species are found in the upper basin of the fjord. Because of the shallow depth of the sill at the mouth of the Saguenay, the adults in the fjord are isolated from those in the estuary. Genetic exchanges through eggs, larvae and juveniles are possible, however.

Capelin. Capelin spawn in the Tadoussac region in spring, but do not enter the upper basin of the fjord. In summer, large numbers of juveniles congregate in the lower basin. This species accounts for a large portion of the Beluga whale's diet.

3.4 Birds

The Saguenay River and surrounding terrestrial environment provide habitat for 289 species of birds. Reportedly, half of them (51%) are nesters (including 100 confirmed nesters), 19% are migrants, 5% are present in winter only and the remaining 25% are sporadic visitors to the area. The Saint-Fulgence and La Baie vicinities are among the Quebec sites with a particularly rich diversity of birds. Indeed, 75% of the species inventoried in the study area are present at Saint-Fulgence.

Of the 119 nesting species directly associated with the St. Lawrence wetlands, 103 of them, thus more than two-thirds (69 species), nest in the Saguenay area. Still, the study area as a whole is not a suitable waterfowl environment because of its generally steep banks. The Saint-Fulgence flats are the main nesting grounds for ducks and geese in the study area. Several

species of dabblers (Black duck, Mallard, Northern pintail, Blue-winged teal, Green-winged teal and Northern shoveler) and two species of divers (Common goldeneye and Common merganser) nest in the wet meadow and swampland, among other sites, and rear their young in the marsh. Canada geese sometimes nest in the Saint-Fulgence marsh. Large numbers of Common eiders frequent the Tadoussac area during the brood-rearing season.

There is only one bird colony on the Saguenay riverbanks at present, a colony of Ring-billed gulls in Ha! Ha! Bay (Figure 6). A colony of Black-crowned night-herons on the south shore of this bay was comprised of 80 nests in 1992, but was abandoned in 1994 for unknown reasons. The Ring-billed gull colony developed on Stone-Consolidated's land at the far end of Ha! Ha! Bay. In 1992, it included about 900 nests, a few of which may belong to Herring gulls and Great black-backed gulls. These last two species may also nest on other small islands or the cliffs of the fjord. In contrast to the situation observed elsewhere in Quebec, the Great blue heron and the Black-crowned night-heron populations appear to be at risk in the Saguenay–Lake Saint-Jean region. Since the late 1980s, several colonies have been deserted and the active colonies are shrinking. The causes of this decline are unknown.

During the spring migration, the main waterfowl congregation area (more than 50 individuals per kilometre of shore) in the study area is located at Saint-Fulgence (Figure 6). The Canada goose is the main waterfowl species using the marsh; some years, as many as 6000 individuals stopover there. Other flocks of several thousand geese have been observed on the La Grande Décharge River, which flows out of Lake Saint-Jean. Pointe des Américains, near Alma, is a major staging area for migrating Goldeneyes. In spring 1993, the main migratory species in the study area were the Canada goose (36% of observed individuals), Common merganser (24%), Black duck (10%) and Common goldeneye (7%).

During the 1990 fall migration, the only area heavily used by waterfowl (more than 50 individuals per kilometre of shore) was the south bank at the far end of Ha! Ha! Bay (Figure 6). The most abundant species in the study area in fall are the Black duck (48% of observed individuals), Common goldeneye (25%) and Canada goose (13%).

The Canada goose, Black duck and Blue-winged teal populations, some members of which frequent the Saguenay region, are currently declining. The Atlantic population of Canada geese has plummeted 75% since 1988. Hunting, growing numbers of predators on the northern nesting grounds and harsh weather appear to be the main reasons for this decline. Hunting of this species in most of Quebec, including the study area, was banned in 1995. From 1950 to the mid-1980s, Black duck numbers fell 50% in eastern North America, apparently owing to such factors as the disappearance of marshes and wet meadows, competition with the Mallard and overhunting. The sharp decline in Blue-winged teal populations over the past 30 years appears to be linked to loss of nesting habitat and wintertime overhunting in Mexico.

During their fall migration, shorebirds (e.g., plovers, sandpipers, yellowlegs) gather at the mouth of the À Mars and Ha! Ha! rivers and on the Saint-Fulgence flats. The Black-tailed godwit, Curlew sandpiper, American avocet and Long-billed dowitcher, all of them rare species, have been sighted on the flats over the years.

The Tadoussac area is Quebec's largest staging area for migrating birds of prey. In 1993, 13 species and 17 891 individuals were counted in 615 hours of observation during their flyby through the region from late August to mid-November. The main species are the Red-tailed hawk, Sharp-shinned hawk, American kestrel, Broad-winged hawk and Osprey.

In winter, large flocks of Common goldeneyes, Barrow's goldeneyes, Oldsquaws and Black ducks congregate at the mouth of the Saguenay. Farther upstream, the only large winter concentrations are observed at Saint-Fulgence. A few Common goldeneyes and Common mergansers winter at the far end of Ha! Ha! Bay and in the other unfrozen parts of the Saguenay.

3.5 Marine Mammals

The Harbour seal is the only seal species residing year-round in the Saguenay. It is occasionally spotted between the mouth of the fjord and Ha! Ha! Bay. Surveys conducted in 1991 and 1992 identified a herd of about 20 individuals on the north shore east of Éternité Bay and lone individuals at six different spots below Sainte-Rose-du-Nord. In 1994, only four lone individuals were spotted near sites where the species was observed in 1991 and 1992. The

calving sites for the Harbour seal are unknown. Grey seals rarely frequent the Saguenay River; only one individual was observed during 13 inventories taken in 1991, 1992 and 1994.

Part of the Beluga whale population of the St. Lawrence estuary uses the Saguenay Fjord. In summer, Belugas may occasionally be sighted right up to Saint-Fulgence (up to Chicoutimi before 1930). From 1980 to 1992, the number of individuals in the Saguenay River in summer ranged from 0 to 53, for an average of 24 individuals (4.1% of the St. Lawrence population). In spring and fall, Belugas swim upriver only as far as Sainte-Marguerite Bay; they do not frequent the Saguenay River in winter.

The main areas of the Saguenay frequented by Belugas are the mouth of the fjord, the last 3 km of the Saguenay heading downriver and Sainte-Marguerite Bay (Figure 6). Until the mid-1980s, Saint-Étienne Cove was also a popular spot for these whales. In summer, Sainte-Marguerite Bay is visited almost daily by groups of Belugas which stay for up to 16 hours. The reasons which lead them to frequent this site have yet to be determined; feeding and calving are two possible hypotheses.

During the summer season, the Belugas move continually between the Saguenay and St. Lawrence rivers. In 1987, 81% of the movements at the river mouth occurred less than 100 m from Pointe-Noire at Baie-Sainte-Catherine. Tadoussac Bay has also had regular Beluga visits in the past few years.

The only species of baleen whale using the Saguenay is the Minke whale, which is spotted almost daily at the river mouth. It regularly swims to within 3 km below Tadoussac and occasionally ventures as far as Sainte-Marguerite Bay. The Humpback whale was also a regular visitor to the fjord until 1960, but is now observed only occasionally in the St. Lawrence estuary off Tadoussac.

3.6 Rare and Threatened Species

Vegetation. None of the 110 plant species designated for priority protection by the St. Lawrence Vision 2000 action plan (SLV 2000) has been reported in the study area. This is probably an underestimation attributable to the limited data available for the region.

Fish. Six fish species that frequent the study area have priority status under SLV 2000 (Appendix 1). They are American shad, Atlantic sturgeon, Atlantic tomcod, Rainbow smelt, American eel and Atlantic herring. The first two species seem marginal in the Saguenay River. Sport fishing for smelt is regulated.

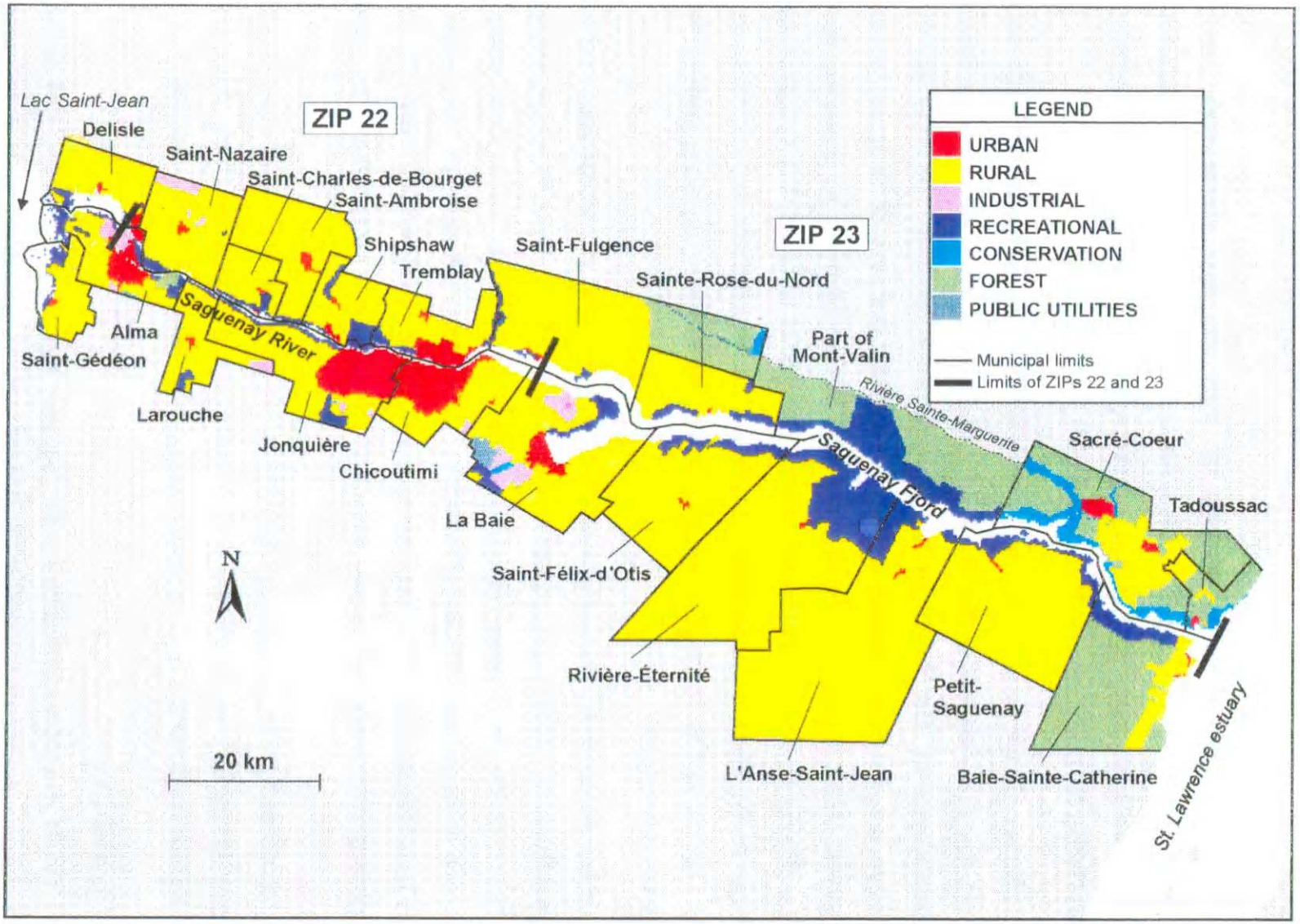
Birds. Of the seven SLV 2000 priority bird species present in the study area (Appendix 1), four are confirmed nesters (Northern pintail, Blue-winged teal, Peregrine falcon and Le Conte's sparrow). The Bald eagle is a probable nester (mouth of the fjord) and the Yellow rail has nested at Saint-Fulgence in the past. In 1994, four pairs of Peregrine falcons reportedly nested on the shores of the fjord, at La Baie, Rivière-Éternité, Cap Blanc and Ilets Rouges Cove (Figure 6). The Red-shouldered hawk, a rare species (designated as vulnerable by the Committee on the Status of Endangered Wildlife in Canada), regularly nests at Pointe des Américains near Alma. The Sharp-tailed sparrow, another rare species, regularly nests in the Saint-Fulgence wet meadow.

Marine mammals. The Beluga whale and the Harbour seal are two species of marine mammals designated for priority protection under SLV 2000. The St. Lawrence beluga population (part of which frequents the Saguenay River) numbered roughly 5000 in the late 19th century, but has declined to only about 500 today. Overhunting is the main explanation for this decline; hunting has been banned since 1979. This species is still at risk owing to many other adverse factors, including disturbance by vessels, habitat deterioration and contamination by toxic substances.

In the mid-1970s, an estimated 700 Harbour seals lived in the St. Lawrence estuary, including one hundred or so in the Saguenay Fjord. The population has since suffered a substantial decline owing to hunting, contamination and disturbance of the calving sites.

3.7 Land Use

The 21 riverside municipalities in the Saguenay region cover 4150 km^2 and had an aggregate population of 196 500 in 1991. There are four large urban centres: Alma, on the upper



Source: Jourdain, A., J.-F. Bibeault, and N. Gratton. 1995. *Synthèse des connaissances sur les aspects socio-économiques du secteur d'étude Saguenay*. Technical report on Priority Intervention Zones 22 and 23. Environment Canada - Quebec Region, Environmental Conservation, St. Lawrence Centre.

Figure 7 Land use patterns in Saguenay riverside municipalities

Saguenay, Jonquière and Chicoutimi on the middle Saguenay, and La Baie in the upstream portion of the fjord (Figure 7). Rural and urban uses predominate in the riverside municipalitiesof the upper and middle Saguenay and the upstream part of the fjord. In the riverside municipalities of the central and downriver parts of the fjord, much of the land along the river is reserved for Saguenay Park and therefore designated for conservation and recreation. The Saguenay area has about 470 km of shoreline; land use breaks down as follows: recreation 58%, rural 19%, conservation 11%, urban 10%, industrial 1% and forest 1%.

3.8 Developed Uses

Hydroelectric power generation. Twenty-two hydroelectric dams have been built on nine rivers in the Saguenay River watershed. These are private dams for the most part, with 99% of the hydroelectric power being supplied by works built between 1912 and 1960. The harnessed tributaries of Lake Saint-Jean and the Saguenay are the Péribonka, Aux Sables, Shipshaw, Chicoutimi, Saint-Jean and Belle-Rivière rivers. The dams on the Ha! Ha! and À Mars rivers have been decommissioned. On the main stem of the Saguenay, the Île-Maligne dam (336 000 kW) near Alma was commissioned in 1925; the Chute-à-Caron dam (180 000 kW) and Shipshaw dam (717 700 kW) near Jonquière were commissioned in 1930 and 1943, respectively. For the most part, these facilities supply power to the aluminum plants of Alcan Smelters and Chemicals and Abitibi-Price's pulp and paper mills.

Municipal and industrial water supplies. The only riverside municipalities which draw their water directly from the Saguenay are Alma (25 910 people served) and Delisle (2868 served), representing about 13% of the study area population. In 1989, these municipalities drew 15 000 to 16 000 m^3 of water directly from the La Grande Décharge River, on the outskirts of the study area. The other riverside municipalities accounted for combined daily withdrawals of 75 000 to 105 000 m^3 from the Saguenay tributaries and, in some cases, the groundwater and surface reservoirs.

In 1986, Abitibi-Price Ltd. in Alma was drawing 26 200 000 m^3 of water annually from the La Petite Décharge, while Alcan Smelters and Chemicals in Alma was taking

6 600 000 m^3 annually from the La Grande Décharge. The other industrial plants whose annual water withdrawals totalled over one million cubic metres in 1986 obtained their supplies from the Saguenay tributaries. In 1986, they drew almost 83 000 000 m^3 in all.

Commercial shipping and port activities. The section of the Saguenay River between Tadoussac and Chicoutimi is a large commercial waterway open year-round. Ice breakers keep a narrow shipping channel open in winter. Vessel traffic on the Saguenay represents just over 10% of vessel movements on the St. Lawrence. An average of 600 ships use this waterway each year.

The main port facilities in the study area are located on the south bank of the Saguenay, between Chicoutimi and the mouth of Ha! Ha! Bay (Port-Saguenay) and in Ha! Ha! Bay (Figure 8).

The port of Chicoutimi, located in the harbour zone of Port-Saguenay, was decommissioned in the late 1980s, and activities were transferred to Port-Saguenay's Grande-Anse area. Until 1994, petroleum products were transshipped at the Albert-Maltais wharf at Pointe-à-l'Islet. The operations were then transferred to the Grande-Anse wharf, which has been in service since 1985, mostly for handling forest products and bulk liquids and solids (coal, granite). An average of 403 800 t per year were handled at these two locations during the period 1983-1994.

Also from 1983 to 1994, an average of 3 672 250 t per year of bulk liquids and solids were handled at Alcan's two wharves and Stone-Consolidated's wharf in the port of Ha! Ha! Bay (Port-Alfred). The main products handled were bauxite, coke, alumina, chlor-alkali and aluminum fluoride (raw materials used in aluminum production by Alcan Smelters and Chemicals), as well as pulp and paper products and wood logs shipped to the Stone-Consolidated mill by barge.

Commercial and sport fishing. There has never been a large commercial fishery on the Saguenay. In late 1978, there were 43 commercial fishermen in all of the study area. In the past, intertidal fixed gear was the preferred commercial fishing equipment in the

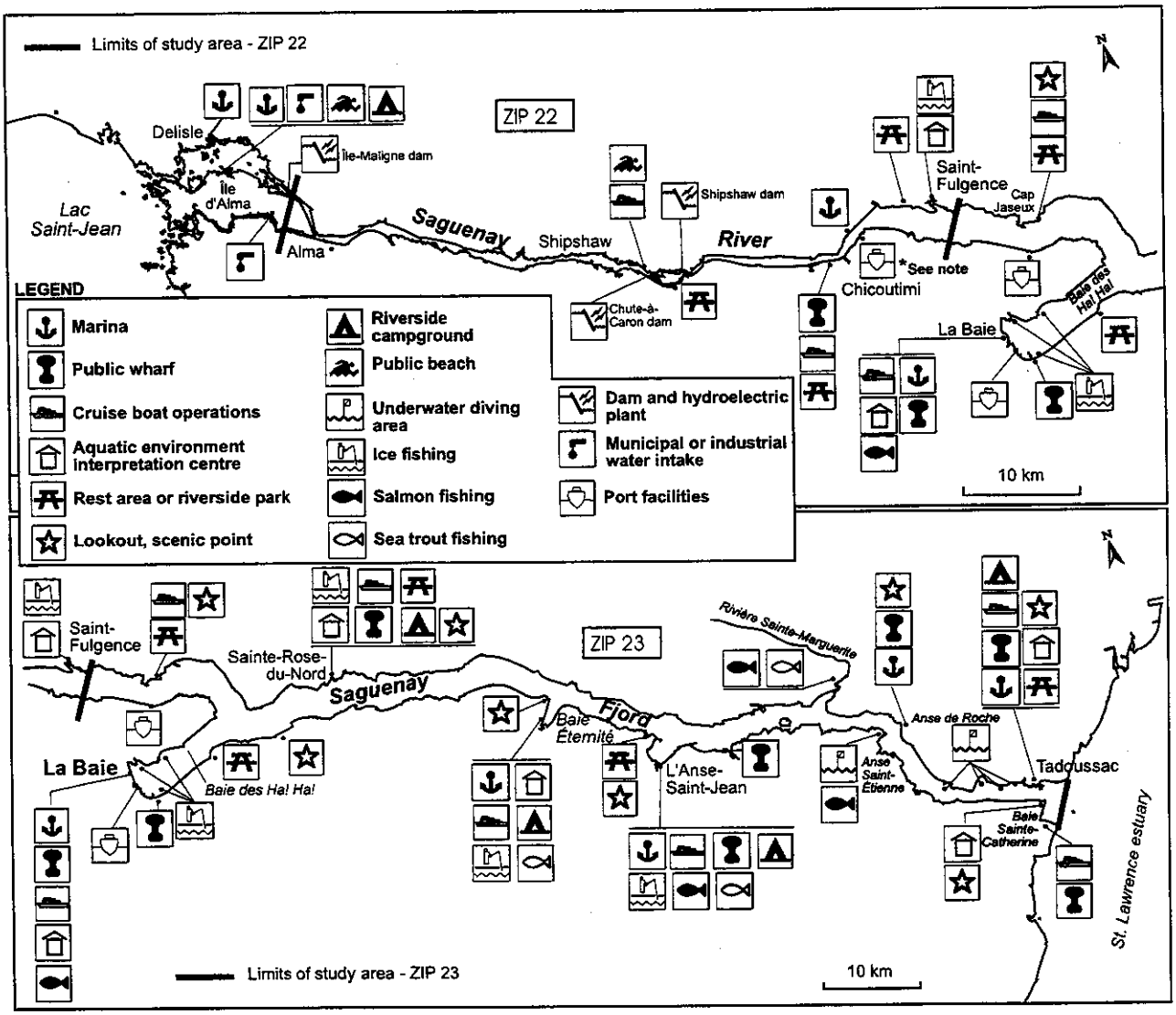
Chicoutimi–Saint-Fulgence area, at Ha! Ha! Bay and at the mouth of the rivers that drain into the fjord. The main fish species caught with fixed gear were Rainbow smelt, herring and Capelin. There was also an Atlantic salmon gillnet fishery in the Tadoussac area, and a small-scale Northern shrimp and Snow crab fishery in the fjord.

Commercial fishing underwent a rapid decline in the 1980s because of concerns about elevated levels of mercury, the moratorium on the issuance of fixed-gear fishing licences and the shortened fishing season, a measure introduced to prevent salmon and Sea trout by-catches. Harvesting of Northern shrimp was banned in 1971 owing to the high mercury levels found in this species.

Today, there are still a few intertidal fixed-gear fisheries at Saint-Fulgence and in Ha! Ha! Bay; however, commercial fishing is prohibited from May 16 to October 31. Although mercury levels in shrimp have dropped substantially since the 1970s, fishing is still banned in order to prevent resuspension of the contaminated sediments buried beneath more recent, less contaminated deposits.

Sport fishing on the Saguenay takes place both in winter and during ice-free periods. The main species sought between Alma and Chicoutimi are Walleye, Northern pike and Ouananiche. Rainbow smelt is fished from wharves along the middle Saguenay and the fjord. The area has many rivers suitable for salmon and Sea trout, which are major attractions (Figure 8). In 1993, salmon fishing in these rivers represented 3984 fisherman-days and 648 fish caught, less than the numbers recorded from 1988 to 1992. Although not directly linked to the Saguenay River, this recreational and tourist activity does promote regional economic activity that benefits riverside municipalities in the area.

Ice fishing in the fjord has increased appreciably in the last 15 years. The main ice-fishing spots are in Ha! Ha! and Éternité bays and at Saint-Fulgence, Sainte-Rose-du-Nord, and L'Anse-Saint-Jean (Figure 8). It is estimated that more than 200 000 people pour into these areas during the 11-week ice fishing season. The main species caught are Rainbow smelt, redfish, cod and Greenland halibut.



Source: Jourdain, A., J.-F. Bibeault, and N. Gratton. 1995. *Synthèse des connaissances sur les aspects socio-économiques du secteur d'étude Saguenay*. Technical report on Priority Intervention Zones 22 and 23. Environment Canada - Quebec Region, Environmental Conservation, St. Lawrence Centre.

* *Note*: The Port of Chicoutimi was decommissioned in the late 1980s.

Figure 8 Locations of main developed uses and access to the Saguenay River

Waterfowl hunting and bird watching. The Saguenay is not a favourable spot for hunting waterfowl, except for the Saint-Fulgence marsh, which comes under strong hunting pressure early in the season. Bird watching, on the other hand, is widespread in the area. There are two bird-watching clubs, one of which is active mainly around the mouth of the Saguenay. The three prime bird-watching sites are the Saint-Fulgence flats, Ha! Ha! Bay and the Tadoussac area. The first two sites attract large numbers of common and uncommon birds associated with wetlands; the Tadoussac sand dunes are an excellent spot for observing birds of prey during their fall migration. Saguenay Park and the Saguenay–St. Lawrence Marine Park are other spots suitable for bird watching.

Boating. In 1991, an estimated 5700 to 8200 boats sailed the Saguenay between Chicoutimi and Tadoussac, for a total of about 40 000 passengers. Boating facilities on the river consist of about 12 marinas, some 15 boat-launching ramps and four federal wharves (Figure 8). Sea kayaking and jet-skiing are two activities which have increased substantially in recent years.

Cruises in the fjord. Boat tours on the Saguenay set out from Tadoussac, Baie-Sainte-Catherine, L'Anse-Saint-Jean, Sainte-Rose-du-Nord, Rivière-Éternité, La Baie, Saint-Fulgence, Chicoutimi and Shipshaw. Local cruise ships have a total capacity of more than 2000 passengers. As with cruises on the St. Lawrence off Tadoussac, marine mammals are a major attraction. However, the primary appeal of fjord cruises is the majestic landscape.

The actual number of Saguenay cruise passengers is unknown. In 1995, an estimated 300 000 people took cruises in the Saguenay–St. Lawrence Marine Park, which includes the Saguenay Fjord and the areas where marine mammals congregate in the St. Lawrence estuary off Tadoussac. That number represents an increase of 900% over 1985.

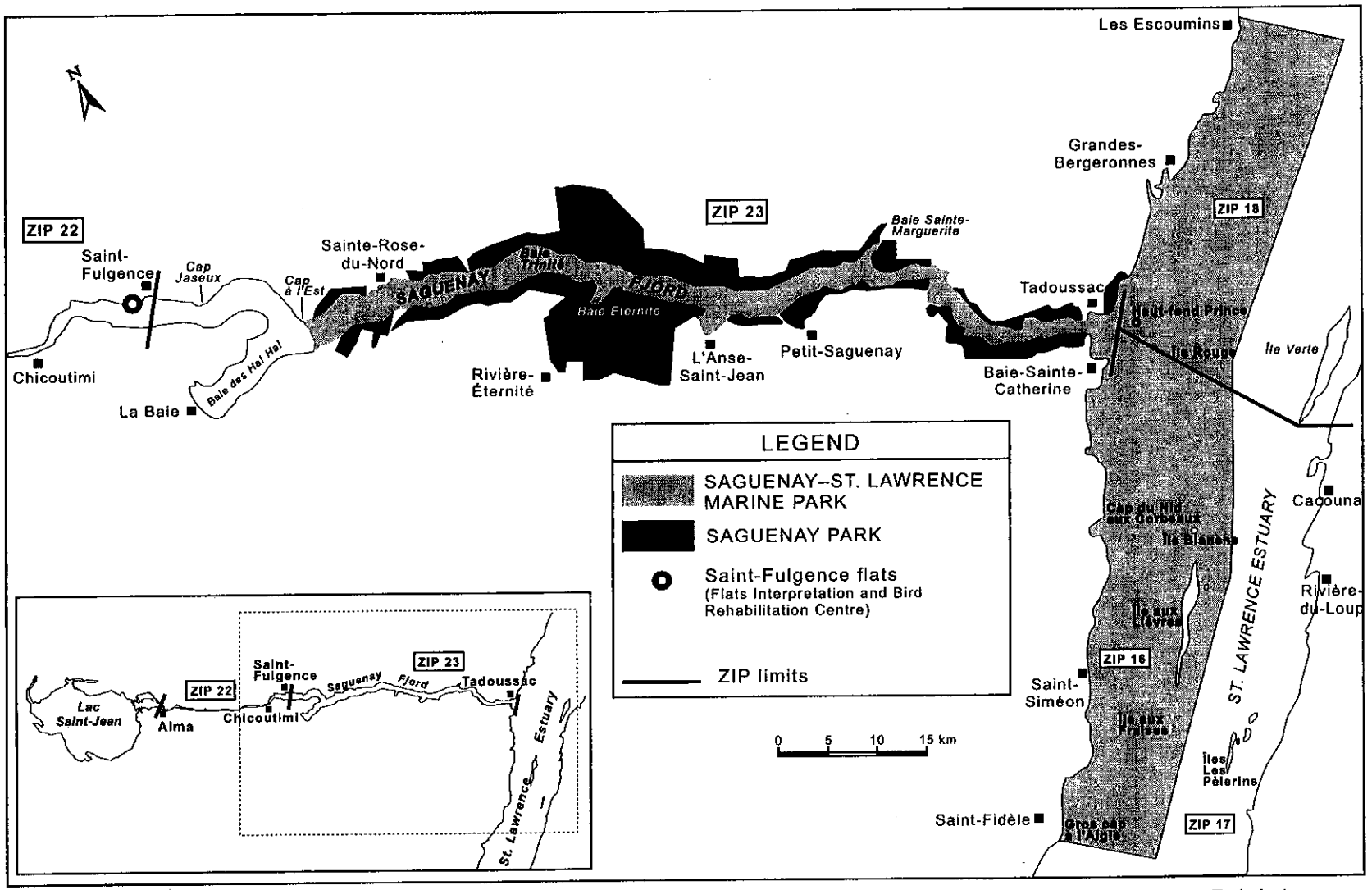
Swimming, windsurfing and diving. The Environnement-Plage beach program of the Ministère de l'Environnement et de la Faune (MEF) includes only one public beach in the Saguenay area: the Shipshaw beach, which also accommodates a windsurfing club. Windsurfing is also practised in Ha! Ha! Bay, at Saint-Fulgence, below the spit and in the upper Saguenay. Kayaking, jet-skiing and water skiing are other water sports in the study area. Some diving takes

place between Saint-Fulgence and Éternité Bay, and five spots in the downstream part of the fjord are used on a regular basis (Figure 8).

Cottaging. There are cottages along the Saguenay tributaries and the many lakes throughout the area. However, the steep banks along most of the river considerably limit the growth of cottaging there.

Tourism on the shores. The study area includes two large recreation and tourism centres: Saguenay Park, a provincial conservation park created in 1983, and the Saguenay–St. Lawrence Marine Park, soon to be officially established under a federal-provincial agreement (Figure 9). Many recreation and tourism infrastructures are concentrated at the mouth of the Saguenay. Baie-Sainte-Catherine is home to the Pointe-Noire Interpretation and Observation Centre, run by the Saguenay– St. Lawrence Marine Park. On the opposite side of the river mouth, Tadoussac is the main recreation and tourism spot in the area, with a marine mammal interpretation centre, a dune interpretation centre and a maritime museum. It is also the point from which numerous hiking trails fan out to the Tadoussac sand dunes, the lookout points at the mouth of the Saguenay and the north bank of the fjord up to Passe-Pierre Cove. A boat service operating out of this cove shuttles passengers across to the south shore, where the shoreline trails lead to the Saguenay Fjord Interpretation Centre at Baie-Éternité, run by Saguenay Park. More trails lead from there to the top of Cape Trinité, which is also accessible by boat. Farther upstream are hiking trails and an interpretation centre for the Saint-Fulgence tidal flats.

Conservation. Three sectors of the Saguenay River area are designated for protection (conservation): Saguenay Park, the Saguenay–St. Lawrence Marine Park and the Saint-Fulgence tidal flats (Figure 9). Saguenay Park, created in 1983, occupies 284 km^2 on either side of the Saguenay, from Sainte-Rose-du-Nord to Tadoussac, as well as the Tadoussac sand dunes along the approaches to the St. Lawrence estuary. The park's conservation goals are to preserve the natural state and evolution of the ecosystems while leaving free rein to natural processes, to maintain biological and genetic diversity and to ensure the stability of the ecosystems in the face of human activity so that they may serve as environmental witnesses.



Source: Jourdain, A., J.-F. Bibeault, and N. Gratton. 1995. *Synthèse des connaissances sur les aspects socio-économiques du secteur d'étude Saguenay.* Technical report on Priority Intervention Zones 22 and 23. Environment Canada - Quebec Region, Environmental Conservation, St. Lawrence Centre.

Figure 9 Protected areas in the Saguenay study area

The process of creating the Saguenay–St. Lawrence Marine Park began with the signing of a federal-provincial agreement in 1990. The establishment of the park should become official some time in 1996. With a surface area of 1138 km^2, it encompasses the entire marine environment of the fjord below Cap à l'Est and a large portion of the St. Lawrence estuary. In creating this park, the two levels of government are seeking to preserve for all time the biological diversity and ecological integrity of the area.

The 290-ha Saint-Fulgence tidal flats are protected under an agreement signed by the town of Saint-Fulgence and the Quebec Wildlife Foundation under the Eastern Habitat Joint Venture, designed to protect the rich biodiversity of this unique site. Designation of the flats as a wildlife preserve is being considered to further enhance their protection.

CHAPTER 4

Human Activities and Their Main Effects on the Environment and Uses

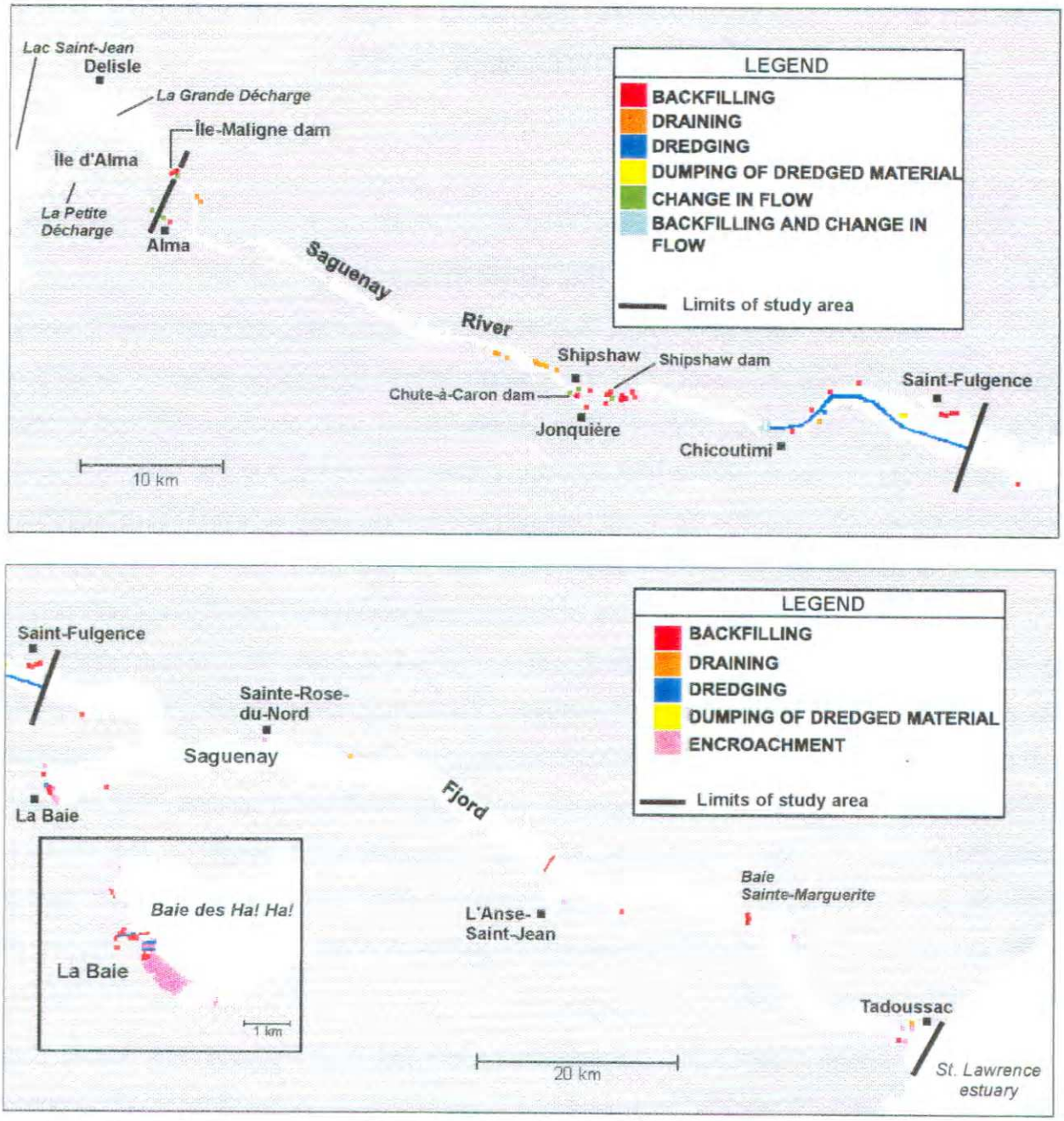
4.1 Physical Changes in the Environment

Harnessing the watercourses. Harnessing of the upper Saguenay and several middle Saguenay tributaries regulated about 90% of freshwater inflows to this river. Prior to construction of the Île-Maligne dam (1925) and the Chute-à-Caron dam (1930), the Saguenay had a mean monthly discharge of about 3900 m^3/s at high water (May) and 400 m^3/s at low water (January). Today, the mean monthly discharge in May has dropped to about 2600 m^3/s and the monthly low water flow in January has increased to about 1200 m^3/s.

Taming of the upper Saguenay radically altered this river section. Once characterized by steep drops in water level and the swift currents typical of a large salmon river, the upper Saguenay has become a fairly deep, still reservoir. The raising and controlling of water levels reduced the overall habitat suitable for salmon reproduction. Control structures and hydroelectric facilities constitute impassable barriers for fish, particularly anadromous species. They may also cause fish mortalities since individuals migrating downstream get caught in the turbines. Harnessing the river may also have affected the hydrodynamics and the mixing of water masses in the surface layer of the fjord. The nature and magnitude of these effects are unknown due to the lack of data prior to 1930.

Dredging. The channel between Chicoutimi and Saint-Fulgence was deepened to allow ships to pass (Figure 10). Such dredging concentrated the water flow in the dredged channel, and may therefore have affected the sediment regime of the flats, as well as fish movements in the area. Between 1945 and 1988, an estimated 215 ha of deep-water aquatic habitat was altered by dredging in the study area. Other localized dredging took place around the Ha! Ha! Bay port facilities on a fairly regular basis.

Shore backfilling and drainage. Between 1945 and 1988, some 168 ha of shoreline in the study area was backfilled or drained to make room for various infrastructures (roads,



Source: Mousseau, P., and A. Armellin. 1995. *Synthèse des connaissances sur les communautés biologiques du secteur d'étude Saguenay*. Technical report on Priority Intervention Zones 22 and 23. Environment Canada - Quebec Region, Environmental Conservation, St. Lawrence Centre.

Figure 10 Physical changes in the habitats inventoried in the Saguenay region between 1945-1988

housing) and for farm expansion (Figure 10). The main losses occurred at Saint-Fulgence, where the construction of Highway 172 and encroachment by housing developments and agriculture destroyed part of the wet meadow and marsh. About 20 ha of land was backfilled at La Baie to create port facilities and a road, and log drives encroached on another 55 hectares. Other habitats were backfilled at the mouth of the Chicoutimi River to build approaches to the bridge across the Saguenay.

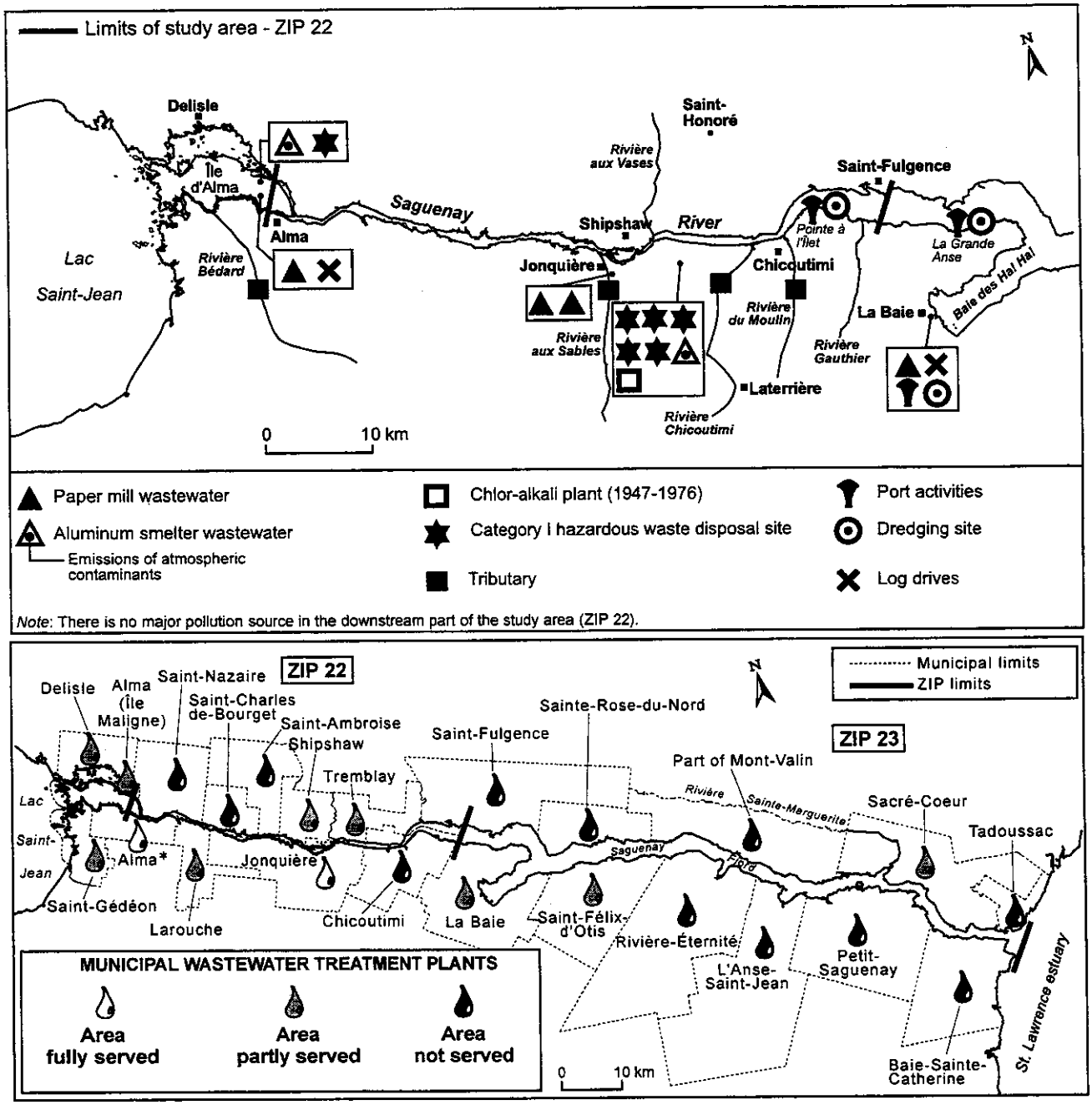
4.2 Pollution

Human activities give rise to many types of pollution: organic, fertilizer, bacterial, toxic and aesthetic. This section briefly describes the main pollution sources; the next section describes how pollution has adversely affected resource potential and caused the loss of some uses of the Saguenay River. Risks to human health are covered in the third section.

4.2.1 Sources of pollution

Lake Saint-Jean. About 75% of the fresh water at the mouth of the Saguenay originates in Lake Saint-Jean. This large expanse of water does not contribute many contaminants to the Saguenay River. In fact, the pollution sources are scattered. In 1992, 81% of people living within the Lake Saint-Jean watershed and connected to a sewer system were served by a wastewater treatment plant. Localized pollution may be heavy, but it is increasingly diluted as one moves away from the sources of contamination. Deposition of much of the suspended solids (the main carriers of pollutants) reduces the loads at the outlet.

Tributaries. The Saguenay tributaries as a whole account for only 25% of the flow at the river mouth but may nevertheless be important sources of contaminants. The Bédard River and a few others drain mostly farmlands, sources of suspended solids, fertilizing substances, coliform bacteria and pesticides (Figure 11). Added to this agricultural pollution are treated and untreated municipal wastewater, industrial wastewater and contaminants from cottage communities (faulty septic tanks). The tributaries also contribute to the Saguenay's load of toxic substances through inputs of atmospheric fallout. Log drives, once practised on many Saguenay tributaries, is now confined to the La Petite Décharge River.



Sources : Fortin, G., and M. Pelletier. 1995. *Synthèse des connaissances sur les aspects physiques et chimiques de l'eau et des sédiments du secteur d'étude Saguenay*. Technical report on Priority Intervention Zones 22 and 23. Environment Canada - Quebec Region, Environmental Conservation, St. Lawrence Centre.
Jourdain, A., J.-F. Bibeault, and N. Gratton. 1995. *Synthèse des connaissances sur les aspects socio-économiques du secteur d'étude Saguenay*. Technical report on Priority Intervention Zones 22 and 23. Environment Canada - Quebec Region, Environmental Conservation, St. Lawrence Centre.

* *Note*: Although the Alma treatment station is operational, most wastewater (more than 85%) is not channelled there because of pumping problems.

Figure 11 Main sources of present and past pollution of the Saguenay River

St. Lawrence estuary. The deep waters of the Saguenay Fjord come from the St. Lawrence estuary. When they enter the fjord at Tadoussac, they contain low levels of heavy metals and toxic organic substances and are thus a negligible source of pollution of the fjord.

Municipal outfalls. Prior to the mid-1980s, municipal outfalls emptying directly into the Saguenay or the lower course of its tributaries were a major source of organic and bacterial contamination. Today, 56% of the people living in riverside municipalities in the study area are served by a wastewater treatment plant, particularly in Alma, Jonquière and La Baie. Although the plant serving the south district of Alma (population of 22 759) has been operational since 1991, most wastewater (> 85%) has not been channelled there because of siltation problems at the Cascades pumping station. Corrective measures should be implemented some time in 1996. The effectiveness of treatment plants in the study area varies from year to year, but operating conditions for most of them have improved since 1990. In 1993, the majority of municipal treatment facilities in the Saguenay area were operating efficiently, with the reduction in biochemical oxygen demand (BOD_5) and suspended solids (SS) ranging from 71 to 97%. The municipality of La Baie uses an ultraviolet disinfection process which eliminates most fecal coliform bacteria before the treated wastewater is released into Ha! Ha! Bay.

The main present-day sources of contaminants associated with municipal wastewater are the municipality of Chicoutimi (population of 59 700), which will not start treating its wastewater until 1997 and continues to discharge untreated wastewater into the Chicoutimi, Du Moulin and Saguenay rivers; the municipality of Alma, which leaves 85% of its wastewater untreated; and the municipality of Jonquière, which releases untreated wastewater into the Saguenay River during heavy rains. Although they have signed an agreement in principle to set up treatment works, the municipalities of L'Anse-Saint-Jean (population of 1266), Saint-Charles-de-Bourget (711), Baie-Saint-Catherine (312) and Tadoussac (832) do not yet treat their wastewater. The houses of several small municipalities (Petit Saguenay, Rivière Éternité, Saint-Ambroise, Saint-Fulgence, Saint-Nazaire, Sainte-Rose-du-Nord and the unorganized territory of Mont-Valin) are equipped with septic tanks, some of which may be local sources of contamination.

Industrial wastewater outfalls. Table 1 lists the nine priority industrial plants in the Saguenay sector. Eight of them are covered by the Quebec industrial effluent abatement program (PRRI) and appear on the list of priority plants of the St. Lawrence Action Plan. The last one has been added to the list of plants targeted by SLV 2000.

Table 1
List of industrial plants targeted by SLV 2000 in the Saguenay study area

Company	*Location*	*Sector*	*PRRI*	*Action Plan*	*SLV 2000*
Abitibi-Price Ltd. Alma Business Unit	Alma	Pulp and paper	✓	✓	✓
Abitibi-Price Ltd. Kénogami Business Unit	Jonquière	Pulp and paper	✓	✓	✓
Cascades Inc.	Jonquière	Pulp and paper	✓	✓	✓
Stone-Consolidated Inc.	La Baie	Pulp and paper	✓	✓	✓
Alcan Smelters and Chemicals Isle-Maligne Works	Alma	Aluminum	✓	✓	✓
Alcan Smelters and Chemicals Vaudreuil and Arvida Works	Jonquière	Aluminum	✓	✓	✓
Alcan Smelters and Chemicals Grande-Baie Works	La Baie	Aluminum	✓	✓	✓
T.M.G. Inc., Niobec Mine	Saint-Honoré	Mining	✓	✓	✓
Alcan Smelters and Chemicals Laterrière Works	Laterrière	Aluminum	-	-	✓

Source: Jourdain, A., J.-F. Bibeault, and N. Gratton. 1995. *Synthèse des connaissances sur les aspects socio-économiques du secteur d'étude Saguenay*. Technical report on Priority Intervention Zones 22 and 23. Environment Canada - Quebec Region, Environmental Conservation, St. Lawrence Centre.

Characterization studies have been produced for eight industrial plants under the Action Plan: four pulp and paper complexes (Abitibi-Price's mills in Alma and Jonquière, Cascades' mill in Jonquière and Stone-Consolidated's mill in La Baie), three Alcan Smelters and Chemicals plants (Alma, Jonquière and La Baie) and Services T.M.G.'s niobium mine in Saint-Honoré.

Prior to recent wastewater treatment projects, these four paper mills contributed heavily to contamination of the Saguenay River. The main contaminants released in 1990 were suspended solids, high-BOD_5 organic matter, oil and grease, non-chlorinated and chlorinated phenols, resin acids and, in the case of the La Baie plant, PCBs.

After primary wastewater treatment systems (process water clarification and biological disks for sanitary sewage) were brought on line and production processes modified, overall SS discharges from the four paper mills were reduced by 46% during the period 1988-1994. To bring their operations into compliance with the new provincial and federal regulations taking effect in 1995, these mills introduced activated-sludge secondary treatment systems that same year; SS, BOD_5 and toxic loads should be reduced to levels consistent with the more stringent standards.

Alcan's three plants, which have undergone exhaustive characterization studies, are not major sources of suspended solids or high-BOD_5 organic matter. Their overall toxic load in 1994 was about four times lower than that of the four paper mills. The most polluting plant by far was the Jonquière works, although its aluminum production capacity was almost halved from 1987 to 1992 after the Laterrière plant came on stream. Aluminum and arsenic are the main contaminants of concern found in the effluent from the Jonquière plant. From 1988 to 1994, several large-scale projects affecting effluent quality reduced the toxic load by 75% at the Alma works and 55% at the Jonquière works. Other work slated for the Jonquière plant in 1995 should again cut effluent toxicity in half.

The Alma and Jonquière aluminum smelters employ the horizontal-stud Söderberg process, which releases polycyclic aromatic hydrocarbons (PAHs) into the atmosphere and effluents. By contrast, the recently built La Baie and Laterrière aluminum works use a new

process (prebaked anodes) that emits virtually no PAHs, and the generation of hazardous liquid and solid waste has been all but eliminated.

From 1947 to 1976, the chlor-alkali plant of Alcan's Jonquière complex released 200 tonnes or more of mercury into the Saguenay River, along with effluents, which contaminated the sediment. This plant was shut down and then the site was restored in 1978.

Les Services T.M.G. Inc. (Niobec Mine) exploits a niobium deposit. Seepage water from the underground mine is clarified in two settling tanks, then discharged into Cimon Creek, a tributary of the Aux Vases River, which is part of the Saguenay drainage basin. In 1994, the company built a new polishing pond to increase the removal of contaminants prior to releasing its effluent into the natural environment. The discharged effluent contains low levels of heavy metals and complies with federal regulations and provincial guidelines for mining companies; it does not appear to pose a threat to the Saguenay River.

Atmospheric fallout. Although many toxic substances (e.g., Hg, Pb, PCBs, PAHs, DDT) from North American industrial centres are known to reach the Saguenay by air, the actual loads remain unknown. On the other hand, atmospheric emissions of mercury and PAHs from local sources are major factors in the Saguenay's long-standing contamination problems. These substances, particularly PAH discharges to the atmosphere, have been monitored since 1983. From 1947 to 1976, the chlor-alkali plant in Jonquière released more than 34 t of mercury into the air. The Alma and Jonquière aluminum works using the horizontal-stud Söderberg process also emit PAHs, including benzo(a)pyrene, into the atmosphere.

In 1990, aluminum works were reportedly the main source of PAHs in Quebec, followed by the burning of heating wood, forest fires and transportation, in that order. It was estimated at the time that PAH emissions from Alcan's Jonquière plant (more than 300 t of total PAHs) accounted for 40% of total PAH emissions by aluminum smelters in Quebec. During 1984-1990, the shutdown of eight of the 14 Söderberg potrooms at that plant and measures to reduce at-source emissions cut PAH emissions by 67%. Additional measures have since been taken. In 1994, annual emissions of PAHs were estimated at 98 t (including 4.9 t of benzo(a)pyrene) at the Arvida plant in Jonquiere, and 86.6 t (including 4.3 t of benzo(a)pyrene)

at the Isle-Maligne plant in Alma. Some of the airborne PAH goes directly into the water or ground through dry or wet deposition and is then carried to the Saguenay by watercourses.

Hazardous waste disposal sites. Several hazardous waste disposal sites near the banks of the Saguenay River are potential sources of contamination of the river through creeks or groundwater. Fourteen sites are included in the provincial inventory of the Saguenay region (Table 2). The six sites which posed a potential risk to public health or a high potential risk to the environment in the early 1980s (Category I) all belong to Alcan Smelters and Chemicals: These consisted of dumps for spent cathode linings and other solid waste contaminated with fluorides, cyanides, phenol and PAHs, and ponds full of bauxite and fluorspar tailings contaminated with fluorides and cyanides. Beginning in 1985, but most especially since 1991, extensive work has been carried out to remediate the areas and eliminate losses to the environment. Work has been completed at most sites. In some cases, corrective measures are planned to solve problems uncovered during the monitoring program.

Apart from Alcan's red-mud pond at Laterrière (Category II), which is currently being restored, the inventoried sites pose few potential risks to the environment and no risk to public health (Category III). The two federal sites inventoried in the study area pose no direct threat to the Saguenay River.

Port activities. Port facilities are potential sources of pollution. The oil terminals of Port-Saguenay are located on the south shore of the river between Chicoutimi and Ha! Ha! Bay. The La Baie sector has two commercial wharves, a transit shed, storage areas for coke, coal, caustic soda, alumina and bauxite, and oil tanks. Dust and runoff from the piles of green coke, coal and bauxite stored on Alcan's wharves at La Baie may be a source of contamination of Ha! Ha! Bay. The company recently installed wind barriers, a watering system and a runoff-water treatment tank to cut down on losses to the environment.

Table 2
Inventory of hazardous waste disposal sites in the Saguenay watershed

Location	*Description of site*	*Cat.**	*Contam. identified*	*Impacts observed in 1983*	*Status in 1995*
Provincial Inventory					
Alma	· Alcan dump for dry materials and spent cathode linings	I	Fluorides, cyanides	Sectoral contamination of La Grande Décharge (Saguenay River)	Dump site reclaimed, monitoring in progress
	· Abitibi-Price solid waste yard	III		Sectoral contamination of La Petite Décharge (Saguenay River)	Monitoring in progress
Larouche	· Les Travaux Mécanisés G.L.B. dump	III		Sectoral contamination of Dorval River	
Jonquière	· Alcan solid waste dump	I	Fluorides, PAHs, phenol, cyanides	Contamination of two tributary creeks of Saguenay, groundwater and Saguenay River	Dump site reclaimed, monitoring scheduled for 1996
	· Alcan dumps for spent cathode linings on fluoride plant site and Drake St.	I	Ammonia, cyanides, fluorides	Contamination of tributary creeks of Saguenay, groundwater and Saguenay River	Fluoride plant dump: cathode linings removed, land reclaimed, monitoring in progress. Drake St. dump: linings removed, monitoring in progress.
	· Alcan gypsum dump	I	Fluorides, cyanides (acid pH)	Contamination of tributary creeks of Saguenay, groundwater and Saguenay River	Dump site restored, monitoring in progress
	· Alcan red-mud pond in Jonquière	I	Fluorides (highly alkaline pH)	Contamination of two tributary creeks of Saguenay, groundwater and Saguenay River	Monitoring in progress
	· Backfilled section on Alcan land in Jonquière (Arvida sector)	I	PAHs, fluorides, toluene, mineral oil and grease, heavy metals	Stagnant contamination of groundwater, sectoral contamination of surface waters; no direct threat to Saguenay River	No change

Location	*Description of site*	*Cat.**	*Contam. identified*	*Impacts observed in 1983*	*Status in 1995*
Jonquière (cont'd)	· Solid waste yards of Cascades paperboard mill	III		Sectoral contamination of Aux Sables River	Leachate biotreated along with process water
	· Abitibi-Price solid waste yards (Kénogami Business Unit)	III		Sectoral contamination of Aux Sables River	Monitoring in progress
Chicoutimi	· Elkem Metal Canada dump	III	Aluminum, arsenic, iron, lead, selenium, zinc	Contamination of Saguenay tributaries, including Chicoutimi River	No change
Saint-Honoré	· Disposal site of Fonderie Saguenay Ltée	III		Contamination of tributary creeks of Saguenay River	No change
	· Tailings pond of Niobec Mine	III	Radioactivity, suspended solids	Low contamination of immediate environment by natural radio-activity and of receiving environment by SS and chlorides	Effluent monitoring
Laterrière	· Alcan red-mud pond in Laterrière	II	Fluorides, cyanides (highly alkaline pH)	Contamination of groundwater, sectoral contamination of Jean-Dechêne Creek and a tributary creek of Chicoutimi River	Monitoring in progress
B. Federal Sites					
Jonquière	· Canadian National switchyard	2	Hydrocarbons	No direct threat to Saguenay River	
La Baie	· Canadian Forces Base Bagotville	2	Hydrocarbons	No direct threat to Ha! Ha! Bay	

Category I: Site posing potential risk to public health and/or high potential risk to the environment.
Category II: Site posing medium potential risk to the environment and/or low potential risk to public health.
Category III: Site posing small potential risk to the environment and no risk to public health.
Priority 2: Installation known to be contaminated; action recommended in the medium term.

Taken from: Fortin, G., and A. Pelletier. 1995. *Synthèse des connaissances sur les aspects physiques et chimiques de l'eau et des sédiments du Saguenay*. Technical report on Priority Intervention Zones 22 and 23. Environment Canada - Quebec Region, Environmental Conservation, St. Lawrence Centre.

During the period 1974-1989, there were 13 major spills of contaminants totalling almost 330 tonnes. Those spills resulted mostly from transshipping accidents. Indeed, the accident rate during such operations at the port facilities in Ha! Ha! Bay is estimated at one per 500 ships. On the river, the frequency of accidental spills is estimated at one per 8000 vessels. In 1992, 200 L of fuel oil was spilled at Port-Alfred, and a similar spill was recorded in 1993. The largest incident in recent years occurred at the Port of Chicoutimi in 1980, when 280 t of diesel escaped.

Tankers account for 25% of the vessel traffic on the Saguenay between Tadoussac and La Baie–Chicoutimi. Given the hydrodynamic profile of the Saguenay, a major spill at the head of the fjord would threaten the entire fjord all the way to the mouth. To guard against this eventuality, the area has an emergency response force complete with a 24-hour warning system and the necessary equipment; two specialized companies are prepared to intervene in the event of large spills in the Chicoutimi, Alma and Jonquière region. The La Baie region also has a response team. A contingency plan has been devised for the Grande-Anse and Port-Alfred facilities, and drills are held at regular intervals. An environmental emergency response plan has been drawn up for the Saguenay–St. Lawrence Marine Park, too. Mandatory pilotage by experienced mariners also helps to minimize the risk of spills.

Dredging. The federal government carries out maintenance dredging at certain spots in the Saguenay River area. The ship channel between Chicoutimi and Saint-Fulgence is dredged as needed. During three operations between 1978 and 1994, nearly 29 000 m^3 of sediments were dredged at the approaches to the Pointe-à-l'Islet port facilities (Port-Saguenay). Sediments from both sites were dumped at a deep-water disposal site. The transfer of activities to Grande-Anse will eliminate the need for dredging to accommodate vessel traffic.

About 200 000 m^3 of sediments were dredged between 1978 and 1988 at Port-Alfred in Ha! Ha! Bay. The dredged material was submerged a few hundred metres from the wharves. The redevelopment project for the mouth of the À Mars River sought to reduce the sediment load from that river. No dredging has been required since 1990. Before Stone-Consolidated stopped timber booming at its mill in 1990, it was necessary to dredge 80 000 to 100 000 m^3 a year of woody material that accumulated beneath the log lift. These residues were then discharged into deep water 1.5 km off the wharves.

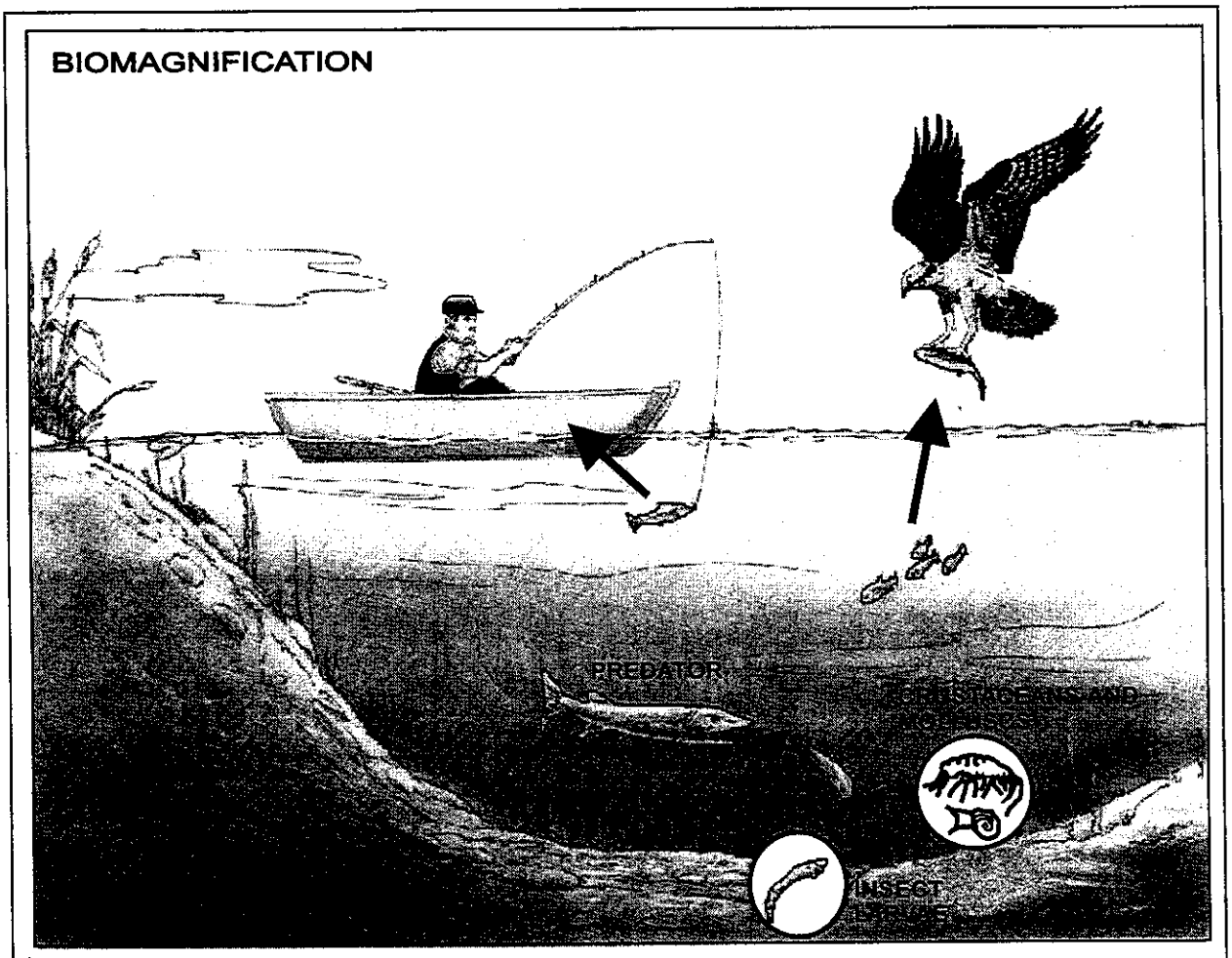
Extension of the Grande-Anse wharf on the middle Saguenay is currently being envisaged. An impact study on a proposed 50% increase in the size of the harbour terminal was carried out in 1991. This work would require the removal of 420 000 m^3 of unconsolidated earth and 50 000 m^3 of rock, which would be dumped into the upstream portion of the fjord.

Waste snow. The dumping of snow into watercourses is another source of pollution, particularly in urban areas. By 1996, all Quebec municipalities were required to introduce some alternative means of disposal.

4.2.2 Effects on resources and uses

This section overviews water pollution in the Saguenay River area using data gathered from 1979 to 1992 in the upper and middle Saguenay and throughout the 1970s and 1980s in the fjord; the situation for sediment pollution is based on data gathered between 1977 and 1992. These assessments take no account of improvements brought about in recent years by new municipal wastewater treatment plants in the region nor of the reduced toxicity of effluents discharged by the old aluminum smelters and paper mills under the St. Lawrence Vision 2000 action plan.

Regardless of origin, the contaminants present in the aquatic environment threaten the normal functioning of living organisms to varying degrees. Some of them, such as pathogenic bacteria and phosphorus, have no persistent effects; environmental quality quickly improves once the discharges stop or the sources of pollution become more remote. But other contaminants, including mercury, PCBs and DDT, tend to concentrate in the sediments and certain living organisms. Bivalve molluscs, for instance, may absorb such contaminants in concentrations several thousand times greater than the levels in ambient waters. In addition, certain toxic substances (mercury, for example) tend to become more concentrated as they are passed up the food chain. This is known as biomagnification (Figure 12). These substances are eventually ingested by predators, which occupy the upper levels of the food web, sometimes reaching very high concentrations in these animals.



Many invertebrates such as aquatic insect larvae, molluscs and crustaceans live on the bottom of waterways. They accumulate in their tissues the toxic substances attached to the sediments or adsorbed to suspended matter. They are then eaten by organisms that occupy a higher position in the food chain, such as Yellow perch, which are in turn eaten by larger predators such as Northern pike or Walleye, by fish-eating birds such as Osprey, or by humans. From one link to the next in the food chain, toxic substances accumulate in increasingly larger concentrations.

Adapted from: *Toxics in the St. Lawrence: An Invisible but Real Threat.* 1990. "St. Lawrence UPDATE" series. Environment Canada, Conservation and Protection, Quebec Region, St. Lawrence Centre.

Figure 12 Risks of biomagnification

Water. In the early 1990s, the waters from Lake Saint-Jean met all relevant quality criteria. However, in flowing through the La Grande Décharge River and, more especially, the La Petite Décharge, they became contaminated by several sources. Water quality remained good in the La Grande Décharge; treated effluents from Alcan's Isle-Maligne plant and the municipality of Alma (north district) apparently had no significant impact on its water quality. But a short distance from the confluence with the La Petite Décharge, untreated wastewater from part of Alma's south district (population of 4000) was discharged into the La Grande Décharge, and the bacteriological quality of its waters deteriorated there.

Water quality in the La Petite Décharge below Alma was poor. The quality criteria for the protection of aquatic life (chronic toxicity) and for swimming were often exceeded; the criterion for protection of the water body against eutrophication was regularly exceeded. Water quality in the La Petite Décharge was affected by the Bédard River, untreated wastewater from part of the south district of Alma (population of some 18 000), effluent from the Abitibi-Price paper mill, and log drives. Moreover, control of the water flow by Alcan promoted drainage of the waters to the La Grande Décharge, site of the Isle-Maligne hydroelectric power station, thus compounding the water quality problems.

Water quality between Alma and Shipshaw was good owing to strong dilution of the polluted waters from the La Petite Décharge by the far less contaminated waters from the La Grande Décharge and the absence of major contamination sources in that part of the upper Saguenay. At the downstream boundary of the upper Saguenay, above the Shipshaw and Chute-à-Caron dams, the quality criteria for the protection of aquatic life (chronic toxicity) and protection against eutrophication were only occasionally exceeded; the criterion for swimming was met.

Deterioration of water quality at the foot of Chute-à-Caron dam, in the southern arm where the Aux Sables River empties, was almost as severe as in the La Petite Décharge River owing to the industrial outfalls of the two paper mills at Jonquière and overflow of this municipality's sewers during heavy rain. The criteria for the protection of aquatic life and for swimming were frequently exceeded. Between Jonquière and Chicoutimi, the degraded waters are diluted by less contaminated water from the Shipshaw dam. But they then mix with the industrial effluent from Alcan's Jonquière plant. At Chicoutimi, water quality again worsens with

the massive inflow of untreated municipal wastewater. The criteria for the protection of aquatic organisms (chronic toxicity) and for swimming are often exceeded.

In general, water quality in the Saguenay River did improve from 1979 to 1992. Conductivity, turbidity, the different forms of phosphorus and iron content were reduced. This positive news appears to be linked to a decline in farming and to municipal and industrial wastewater treatment facilities upriver.

Ha! Ha! Bay receives wastewater from a pulp and paper mill. In the early 1980s, the water quality criteria were exceeded for certain heavy metals, and PAHs were detected in the deep waters near the wharves. Tannin and lignin reached very high levels in the surface waters near Stone-Consolidated's wharves, a zone affected by timber drives.

In August 1990, to determine whether the water was suitable for swimming, the municipality of La Baie monitored water quality at the beach north of the mouth of the À Mars River. The water met the bacteriological criteria for this use.

There was no significant heavy metal contamination of the fjord waters in the 1980s. But prior to 1976, these waters were highly contaminated by mercury. In 1979, three years after the closure of the chlor-alkali plant in Jonquière, the mercury was still present in the deep waters of the fjord, although by 1983 it had diminished considerably. In 1992, mercury levels were about three times lower than those measured 10 years earlier. It was also observed that mercury and several other heavy metals contained in the sediment layers deposited in the fjord prior to 1976 may later have been remobilized and entered the water column. As a result, the deep waters of the fjord may pick up heavy metals as they move slowly toward the upstream part of the fjord.

Sediments. Most data on sediment contamination levels in the upper and middle Saguenay are from the mid-1970s, when concentrations of contaminants in the upper Saguenay were fairly low. Chromium and mercury were the only metals which regularly exceeded the minimal effect threshold (MET, Appendix 2). However, the most heavily contaminated sector, in the La Petite Décharge River at Alma, contained copper, lead and chromium in excess of the MET. It is likely that most of the contaminated sediments were subsequently transported downstream during flooding (high water). Some data gathered in this zone in 1991 do in fact show a marked decline in contamination, with no heavy metals exceeding the MET. But the

sector remains seriously degraded by the large quantities of bark and wood fibre accumulated on the river bed.

In the mid-1970s, the highest contamination levels in the study area were recorded in the middle Saguenay, where mercury, zinc, lead and PAH concentrations frequently exceeded the toxic effect threshold (TET). The highest mercury, lead, zinc and copper concentrations were measured at the outfall of the Jonquière aluminum plant. In 1988, this area was also contaminated with PAHs. The lack of recent data precludes assessment of present pollution levels there.

In 1977, the northern arm of the Saguenay Fjord was heavily contaminated with mercury and, to a lesser extent, with lead, zinc and arsenic. In the mid-1980s, mercury and PAH concentrations in the sediments there were lower than in the 1970s. A time series of data on mercury and PAH inputs to that sector was constructed by examining the thick deposits in sediment cores. Mercury contamination commenced about 1947, when the chlor-alkali plant in Jonquière went into operation. The highest concentrations (up to 120 times the pre-industrial levels) are found in the sediments deposited prior to 1971. By contrast, the concentrations measured in surface sediments (1992) are close to pre-industrial levels; however, they are still three to six times higher than the earlier levels. Sediment cores show that PAH contamination started in the early 1930s, around the time the aluminum smelters in Arvida (1937) and Isle-Maligne (1943) started up. This contamination began dropping in the 1970s.

In 1977, the sediments in Ha! Ha! Bay were contaminated with mercury, lead and copper and heavily contaminated with arsenic. Data from 1986 also pointed up zinc contamination, which was not observed in 1977. The 1991 data showed a drop in mercury and zinc contamination. In addition, high aluminum levels were observed near Alcan's port facilities.

In 1986, the sediments in the upper basin of the fjord, below Cap à l'Est, were heavily contaminated with mercury in certain locations (Sainte-Rose-du-Nord), whereas mercury, zinc and chromium contamination was moderate on the whole. Sediment cores from this zone also show a marked drop in mercury and PAH contamination since the mid-1970s. Pollution has decreased by a factor of about four in an upstream to downstream direction in this basin.

Fishery resources. The Saguenay Fjord is one of the few places in Canada where fishing activities (Northern shrimp, Snow crab, Soft-shell clam) had to be banned as of 1970

because of contamination. The mercury pollution in the fjord was widely reported, both in Canada and abroad. The other most worrisome contaminants were organic substances such as PAHs, dioxins and furans, which have carcinogenic properties.

Fish in the upper and middle Saguenay were heavily contaminated by mercury in the early 1980s. The mercury levels in the flesh of Walleye and Longnose sucker often exceeded Health Canada's fish marketing standards. The permissible limits for other heavy metals, PCBs and DDT were never exceeded, while the limit for dieldrin, an agricultural pesticide, was occasionally exceeded in Walleye. Permissible mercury levels designed to protect birds and fish-eating mammals were systematically exceeded in all species analysed. In 1994, the mercury concentration in Walleye specimens continued to exceed the federal marketing standard.

As for fishery resources in the fjord, contamination data indicate that mercury is the only problem. The levels of other heavy metals, pesticides, PCBs, PAHs, dioxins and furans give no cause for concern. Although mercury levels in living organisms have been dropping since the 1970s, some species of cod, redfish and halibut, as well as Snow crab still have concentrations in excess of the Health Canada marketing standard. Northern shrimp no longer exceed the guideline for mercury content.

In 1994, the shellfish harvesting areas of Baie-Sainte-Catherine and Tadoussac were closed to harvesting because of contamination by coliform bacteria and the presence of toxic algae. Other shellfish areas in the fjord have been closed since the 1970s owing to chemical contamination.

Birds. There are no data on the toxic contamination of the eggs and flesh of Saguenay waterfowl, except in the case of lead, which has been monitored because of concern about possible contamination by lead shot from hunting rifles. The results show that Alma is the only area where this may be a problem.

Marine mammals. The Beluga whales of the St. Lawrence estuary are severely contaminated with mercury, selenium, lead, PCBs, DDT and mirex. It was estimated in the late 1980s that all of the mirex and half of the other organochlorine chemicals detected in the Belugas originates in the Lake Ontario eels the whales eat during their downriver movements. PAH levels

measured in the muscles, liver and kidneys of St. Lawrence belugas in 1988 and 1990 were very low. However, that does not necessarily indicate lack of exposure to these compounds because they degrade rapidly in fish and mammals. A number of PAH compounds have mutagenic properties. Benzo(a)pyrene, one type of PAH detected in St. Lawrence belugas, has been identified as a carcinogen. The dead Belugas that have washed up on the shores of the St. Lawrence are often riddled with serious chronic lesions, such as malignant tumours, lesions of the digestive system, mammary glands or glandular structures, immune system impairment or peridontitis.

The Harbour seal, another species of marine mammal that lives in the fjord and the St. Lawrence estuary year-round, is the second most contaminated species, after the Beluga.

4.2.3 Risks to human health

Water consumption. Two municipalities in the Saguenay region (Alma and Delisle) draw their water supplies directly from the Saguenay River, in the northern arm of the La Grande Décharge. This water is treated by a filtration system. Data indicate that pollution sources have no notable impact on the quality of water in the La Grande Décharge.

Mollusc consumption. The consumption of molluscs harvested along the fjord shoreline poses risks to human health because of chemical and bacterial contamination of the fjord and the presence of the toxin responsible for paralytic shellfish poisoning. Mollusc harvesting is therefore banned.

Consumption of fish, crustaceans and game. Because their flesh is contaminated (mainly with mercury), frequent consumption of fish and crustaceans caught in the Saguenay, as elsewhere in the St. Lawrence, represents another health risk. To reduce this risk, the provincial ministries of the environment (MEF) and of health and social services (MSSS) have together established restrictions for fish consumption (*Guide de consommation du poisson de pêche sportive en eau douce du Québec*, 1995). These guidelines were drawn up in light of mercury, PCB, DDT, mirex, dioxin and furan levels in fish by species, size and harvesting site. The most stringent restriction applies to eels caught in the middle Saguenay and recommends they be eaten only once a month (one portion of 230 g). Consumption of Walleye should be limited to not

more than eight meals a month for small fish and four meals a month for larger ones. The consumption recommendations for all the other freshwater and anadromous species varies from four to eight meals per month depending on size and harvesting site. For fish caught in the fjord, Chicoutimi Hospital's Community Health Department recommends not more than four meals (230 g) per month of Greenland halibut, cod, flounder and Snow crab, and eight meals per month of Rainbow smelt, redfish and shrimp.

As for game birds, Health Canada considers that consumption of breast meat from ducks harvested in Quebec is not hazardous to human health. To limit exposure to chemical contaminants, it is nevertheless recommended that visible lead shot in duck flesh, skin and fat be removed prior to consumption.

Recreation. On the whole, swimming and windsurfing in the Saguenay pose a risk to human health from bacterial pollution, which may cause skin, eye, ear and gastrointestinal problems (dermatitis, conjunctivitis, otitis and gastroenteritis). This situation should improve, particularly once the Chicoutimi treatment plant comes on stream in the late 1990s. In 1994, however, the only location that met the bacteriological water quality criteria for swimming was the Saguenay River beach which is covered by the beach action plan of the MEF. This beach is located at Shipshaw and is used by the Saguenay Windsurfing Club.

4.3 Introduction of Species

Vascular plants. Of the 253 vascular plant species inventoried in the intertidal zone of the middle Saguenay and the fjord, 43 are exotic species, making for a smaller percentage of exotic species than recorded for Quebec as a whole. The presence of foreign flora along the Saguenay coast has evidently not jeopardized the integrity of the plant communities, for no native species has been eradicated. Purple loosestrife, originally from Europe, is the exotic species most likely to cause damage, as is already the case in other parts of North America. It is found increasingly in the wetlands of southern Quebec, where it is usurping native wet meadow and marsh species to the detriment of nesting waterfowl.

Brown bullhead. The Brown bullhead has been introduced into Lake Saint-Jean. This fish, once confined to southwest Quebec, offers heavy competition to juvenile Brook charr (Sea trout) for food.

4.4 Disturbance of Marine Mammals

The disturbance caused by tremendous growth in vessel traffic at the mouth of the Saguenay, mainly as a result of the boom in marine mammal watching activities, could be one of the factors behind the decline in the number of Belugas observed at the river mouth in the early 1980s.

All marine mammals, but particularly Belugas, are sensitive to disturbance caused by boat traffic, jet-skiing, kayaking and low-flying aircraft. Vessel traffic may interfere with their acoustical environment, their movements and social behaviour, and also pose risks of collision. The cumulative effects of these many disturbances could have significant deleterious effects on the Beluga pods in the Saguenay.

The main potential causes of disturbance are pleasure craft and excursion boats because of the high sound frequencies produced by outboard motors and their great manoeuvrability.

To limit disturbance of the whales, the Department of Fisheries and Oceans has issued guidelines on marine mammal watching for pleasure boaters and tour vessels.

CHAPTER 5 Issues of Sustainable Development of the Saguenay

For sustainable development of the Saguenay to become a reality, animal and plant biodiversity, the many uses of the river and the quality of life associated with those uses must be restored and preserved for future generations. Environmental action must provide for economic development, at the same time guaranteeing the perpetuity of resources and a quality environment. Following are some of the means available to achieve sustainable development in the Saguenay region:

- Pollution reduction
- Protection and rehabilitation of disturbed habitats and resources
- Improved accessibility of the Saguenay River
- Harmonization of recreation and tourism development with environmental protection.

5.1 Pollution Reduction

Major efforts to reduce the sources of pollution of the Saguenay River were undertaken in the 1980s and 1990s. Once the Chicoutimi municipal wastewater treatment plant becomes operational in 1997, close to 86% of the residents of riverside municipalities will be served by such facilities. Still, the feasibility of reclaiming uses such as swimming will depend upon how well the treatment plants reduce bacterial pollution. The retention and treatment of wastewater from combined sewers during heavy rainfall and the effectiveness of treatment and disinfection processes are key issues in this respect.

The four paper mills in the area are subject to the new provincial and federal regulations for pulp and paper mills. In 1995, they set up secondary wastewater treatment systems using activated-sludge technology.

Log drives on the La Petite Décharge, which are the main source of localized organic pollution, should stop in 1997 once the Alma paper mill has switched to thermomechanical pulp.

The aluminum production process used at Alcan's two newest smelters (in La Baie and Laterrière) generates far less pollution than does the Söderberg technology used in the older smelters in Alma and Jonquière, which still discharge PAHs into the atmosphere. Treatment measures have reduced the toxicity of liquid discharges, however. An atmospheric emissions abatement program at the Jonquière works, indisputably the most polluting of the four smelters, achieved a substantial drop in PAH emissions between 1984 and 1994.

The main waste disposal sites posing a risk to human health and the environment have been rehabilitated to cut down on losses to the environment.

A major spill at the head of the fjord would pose a threat all the way to the river mouth. The area now has an emergency response force to handle such incidents.

Toxic substances continue to contaminate the ecosystem despite great effort in recent years to reduce inputs to the Saguenay River. Sediments in the Saguenay have been heavily contaminated by mercury and PAHs. Although buried beneath more recent, cleaner deposits, these sediments remain a possible contamination source in the upper part of the fjord. Many contaminants, including PAHs and mercury, are found in Belugas. Mercury contamination reaches high levels in several fish species, as well as the Blue mussel and the Snow crab. Fish and shellfish consumption is subject to restrictions, and mollusc harvesting is banned. The effects of these substances on the aquatic environment and human health are not fully known and warrant more attention.

5.2 Protection and Rehabilitation of Habitats and Resources

The aquatic ecosystems of the Saguenay River enjoy extensive protection. Saguenay Park and the Saguenay–St. Lawrence Marine Park protect much of the shoreline and marine environment of the Saguenay Fjord, including two important estuaries (those of the Éternité and Saint-Marguerite rivers). The Saguenay's chief wetlands, the Saint-Fulgence tidal flats, are already protected under the Eastern Habitat Joint Venture and are also being considered for designation as a wildlife preserve.

Other shorelines of great ecological value have suffered severe degradation as a result of human activities. One example is the area at the far end of Ha! Ha! Bay, which has become

a veritable desert bordering the port facilities of La Baie. As a result of the cessation of log drives in the early 1990s and the recent cutback in pollution sources at this same area, 55 ha of productive shoreline habitats can now be recovered, and a restoration program is already in progress under SLV 2000. Other localized measures to reclaim polluted environments could further aid in safeguarding or enhancing ecological biodiversity.

The Saguenay River provides suitable habitat for 15 vertebrate species included among the priority species of the St. Lawrence Vision 2000 action plan (Appendix 1). Since the late 1980s, the Beluga whale has been protected under an interdepartmental action plan to promote its survival. This plan seeks to reduce toxic substances in the St. Lawrence ecosystem that are harmful to the Beluga and is also designed to limit disturbance of the whales by human activities. In addition, the Saguenay–St. Lawrence Marine Park is designed to protect many critical Beluga habitats.

Although the state of the St. Lawrence Harbour seal population is cause for concern, no immediate measures are being contemplated to foster survival of the species. As for Rainbow smelt, the Saguenay population appears to be much better off than the one on the south shore of the St. Lawrence estuary. Knowledge of the other priority species (Atlantic tomcod, American shad, Atlantic sturgeon and American eel) is very limited.

The Rainbow smelt, anadromous Brook charr and groundfish species in the fjord are under strong pressure from recreational fishing and their populations may be vulnerable to harvesting. A federal-provincial program was recently initiated, in close co-operation with various local organizations (tourism and fishermen's associations), to monitor the status of the populations harvested by ice fishers.

Atlantic salmon stocking programs are under way in the Petit Saguenay, À Mars, Sainte-Marguerite and Northeast Sainte-Marguerite rivers.

The protected status of the Saint-Fulgence tidal flats and much of the fjord shoreline aids in protecting the priority bird species designated under SLV 2000 (Appendix 1), including the Peregrine falcon, for which the fjord is an important nesting ground.

5.3 Access to the Saguenay

Points of access to the fjord have increased with the creation of the Saguenay Park and the signing of an agreement to create the Saguenay–St. Lawrence Marine Park. Plans call for ongoing development of the network of hiking trails laid out along either bank, connection of the trails by shuttle boat service across the fjord and development of recreation and tourism opportunities in the municipalities bordering the park. Most shoreline areas in the upper and middle Saguenay are occupied by private property in the vicinity of urban areas or by industrial or harbour infrastructures that are incompatible with recreation and tourism uses, or the banks are inaccessible owing to steep escarpments. In recent years, however, there has been a marked change in prospects for providing access to the Saguenay within the urban environment. This includes redevelopment of the Port of Chicoutimi as a riverside park and projects to rehabilitate and enhance the shores of Ha! Ha! Bay in the Port-Alfred and Bagotville sectors.

With the recent growth in the Saguenay cruise boat industry, village wharves which stopped receiving vessel traffic in the 1980s are again becoming prime access points.

Several proposals for developing local salmon rivers were made in the early 1990s. They offer substantial economic spinoffs for the tourism industry in the study area.

5.4 Harmonization of Recreation and Tourism Development with Environmental Protection

In the past 10 years or so, the Saguenay region, and the fjord in particular, has witnessed a boom in recreation and tourism. One of the key challenges is to ensure sustainable development of these activities by protecting the wildlife resources, habitats and the exceptional landscapes which attract those activities. Studies are being conducted, for example, to determine how ice fishing affects fish populations.

The directions being taken, as mentioned here and in Table 3, stem from environmental programs and actions already undertaken in the study area. They provide a backdrop for discussion of desirable policies and actions for the sustainable development of the Saguenay River. Needless to say, these policies may be complemented and improved upon by local stakeholders responsible for defining local priorities for action under the ZIP program.

Table 3
Main issues of sustainable development of the Saguenay region

Issues	*Assessment of present state relative to sustainable development goals*	*Present actions for sustainable development*
Pollution Reduction		
· Treatment of municipal wastewater	Fifty-six percent of wastewater generated in the area is now being treated; some systems are subject to operating problems or overflows during heavy rains; bacterial pollution continues to limit uses (swimming, windsurfing, mollusc harvesting).	Overflow control, treatment and disinfection are essential to environmental clean-up and the restoration of recreational uses involving direct body contact with water, such as swimming and windsurfing. With the commissioning of the Chicoutimi treatment plant planned for 1997 and the new Sacré-Coeur plant in 1996, 86% of sewage will be treated. Wastewater treatment agreements have yet to be drawn up for Tadoussac, Baie-Sainte-Catherine and L'Anse-Saint-Jean.
· Treatment of paper mill effluents	Despite major efforts, paper mills were still a source of contamination in 1994.	To comply with new federal and provincial pulp and paper regulations, the four mills introduced secondary wastewater treatment systems in 1995. Effluent SS, BOD_5 and toxic load should be reduced.
· Treatment of effluents and reduction of atmospheric emissions from aluminum smelters	The two new aluminum smelters in the area employ a cleaner technology, but the two older ones continue to discharge PAHs and other toxic substances. Mercury pollution from liquid effluents was virtually eliminated in 1976.	Several projects to reduce discharges from the Jonquière plant are under way or have been completed. PAH emissions have declined substantially since 1984.
· Hazardous waste disposal sites	Several hazardous waste disposal sites which posed a high potential risk to public health and the environment have been redeveloped to mitigate their impacts.	The rehabilitated sites are being or will be monitored to verify the effectiveness of the measures taken.

Issues	*Assessment of present state relative to sustainable development goals*	*Present actions for sustainable development*
· Protection against spills in the aquatic environment	The Saguenay Fjord is very vulnerable to large spills of contaminants. The area has an emergency response force to handle any such incidents.	A regional emergency response team carries out regular drills.
· Persistent toxic substances in the environment	Despite pollution control efforts, high levels of some toxic substances occur in the ecosystem.	
	Sediments in the fjord have been heavily contaminated by mercury and PAHs. Contaminants are being found in molluscs, shellfish, fish and marine mammals.	Trends in contaminants in the ecosystem must be monitored.
	Fish and shellfish consumption is subject to restrictions; mollusc harvesting is banned.	Data on the health of riverside populations and resource users will round out this environmental assessment.
Protection and Rehabilitation of Disturbed Habitats and Resources		
· Protection of wetlands and landscapes	The coastal ecosystems and riverscapes of the Saguenay enjoy extensive protection. Three areas are designated protected: Saguenay Park, the Saguenay– St. Lawrence Marine Park and the Saint-Fulgence tidal flats. The zones around the port area of La Baie are degraded, however.	The possibility of additional protection is being considered for the Saint-Fulgence wetlands. The degraded areas of Ha! Ha! Bay are currently being restored.
· Survival of the Beluga and the Harbour seal	Survival of the St. Lawrence beluga and Harbour seal is threatened by toxic substances and disturbances occasioned by recreation and tourism activites.	An action plan to promote survival of the beluga has been in effect since the late 1980s. The Saguenay–St. Lawrence Marine Park is designed to protect many critical Beluga habitats.

Issues	*Assessment of present state relative to sustainable development goals*	*Present actions for sustainable development*
· Avifauna	Locally, the Great blue heron and the Black-crowned night-heron are at risk, for unknown reasons. Lead shot from hunting rifles is a potential source of lead poisoning. The status of certain SLV 2000 priority species is unknown.	In 1997, new regulations will ban the use of lead shot for hunting. Protection of the Saint-Fulgence tidal flats and the fjord shoreline aids in preserving bird species.
· Fish	Knowledge of the populations of several SLV 2000 priority fish species is limited.	Research on certain species is under way.
Accessibility of the Saguenay	The Saguenay Fjord has become much more accessible in the past 10 years following the creation of Saguenay Park. Until recently, the urban planning and land use process overlooked the matter of access to the upper and middle Saguenay.	Some municipalities are enhancing shoreline recreation spaces for better access to the upper and middle Saguenay, e.g., redevelopment of the Port of Chicoutimi as a riverside park and enhancement of the Ha! Ha! Bay shoreline. The facilities required for recreational activities in the Saguenay must be carefully chosen and sited so as not to degrade the environment and habitats.
Harmonization of Recreation and Tourism Development with Environmental Protection	Recreation and tourism are undergoing spectacular growth, but some activities threaten the very species, habitats and landscapes that underpin this success. Marine mammal watching is being monitored to limit disturbance of the animals.	The action plan for survival of the Beluga seeks to reduce disturbances from human activities. Present studies are examining how given recreation and tourism activities, such as ice fishing, affect resources.

Appendices

1 Priority Species of the St. Lawrence Vision 2000 Action Plan (SLV 2000) Present in the Saguenay Region

English Name	*Latin Name*	*Status in Sector*
Fish (6 of the 14 species of SLV 2000 are present in the area)		
American shad	*Alosa sapidissima*	Scarce
American eel	*Anguilla rostrata*	Abundant
Rainbow smelt	*Osmerus mordax*	Abundant
Atlantic sturgeon	*Acipenser oxyrhynchus*	Scarce
Atlantic herring	*Clupea harengus harengus*	Unknown
Atlantic tomcod	*Microgadus tomcod*	Unknown
Birds (7 of the 19 species of SLV 2000 are present in the area)		
Le Conte's sparrow	*Ammodramus leconteii*	Confirmed nester
Northern pintail	*Anas acuta*	Confirmed nester
Peregrine falcon	*Falco peregrinus*	Confirmed nester
Barrow's goldeneye	*Bucephala islandica*	Rare migrant
Bald eagle	*Haliaeetus leucocephalus*	Probable nester
Yellow rail	*Coturnicops noveboracensis*	Former nester
Blue-winged teal	*Anas discors*	Confirmed nester
Mammals (2 of the 5 species of SLV 2000 are present in the area)		
Beluga whale	*Delphinapterus leucas*	Frequent
Harbour seal	*Phoca vitulina*	Frequent

2 Environmental Quality Criteria

(for assessing losses of use)

Ecosystem Components	Reference Criteria	Objectives
WATER	Raw water (untreated, drawn directly from a water body) (MENVIQ, 1990)	Protect the health of humans who may throughout their lives both drink water drawn directly from a water body and eat aquatic organisms from that water.
	Contamination of aquatic organisms (MENVIQ, 1990)	Protect human health, which could be endangered by eating aquatic organisms.
	Aquatic life (chronic toxicity) (MENVIQ, 1990)	Protect aquatic organisms and their young, as well as the animals which feed on them.
	Recreational activities (primary contact) (MENVIQ, 1990)	Protect the health of humans engaging in a recreational pursuit in which the entire body is regularly in contact with water, e.g., swimming or windsurfing.
SEDIMENTS	Minimal effect threshold (MET) (SLC and MENVIQ, 1992)	Contaminant levels above which minor but tolerable effects on most benthic organisms are observed.
	Toxic effect threshold (TET) (SLC and MENVIQ, 1992)	Contaminant levels above which effects deleterious to most benthic organisms are observed.
AQUATIC ORGANISMS	Protection of aquatic life (IJC, 1987)	Protect the health of fish-eating aquatic organisms.
	Fish marketing standards (Health and Welfare Canada, 1985)	Prescribe maximum contaminant levels in fish flesh to protect human health.
	Poultry marketing standards (Government of Canada, 1971)	Prescribe maximum contaminant levels in fowl flesh to protect human health.
	Guide de consommation du poisson de pêche sportive en eau douce (MENVIQ and MSSS, 1993)	Prevent deleterious effects on human health from contaminants associated with eating sports fish.

3 Glossary

Anadromous: Refers to fish which live in salt water and migrate to fresh water to spawn.

Arctic (of arctic affinity): Refers to species living in the polar basin and adjacent seas whose waters come mainly from the polar basin.

Arctic - boreal: Refers to widely distributed species with subarctic and boreal characteristics.

Benthos: The organisms living on the bottom of a body of water. Divided into phytobenthos (plants) and zoobenthos (animals).

Biomass: The total mass of living organisms—as a whole or by formal grouping, surface unit or volume—existing within a biotope at a given time. This includes any biological material: plants, insects, herbivores, carnivores, and so forth.

Boreal (of boreal affinity): Refers to species distributed mainly in the waters of the Northern Hemisphere, where the influence of polar waters and tropical waters is negligible or altogether absent.

Brackish: Refers to water with a salinity between that of fresh water (0.3‰) and salt water (35‰).

Carcinogen: Refers to any factor likely to induce or promote cancer.

Catadromous: Refers to fish which live in fresh or brackish water and migrate to the sea to spawn in salt water.

Community: All the living organisms, both plants and animals, occupying the same biotope.

Discharge: Volume of water flowing into a stream, pipe, etc. for a specific time interval. Usually expressed in cubic metres per second (m^3/s) and sometimes in L/s for small areas. Also called *flow*.

Ecosystem: Entire physico-chemical environment (biotope) together with its living organisms (biocenosis), which is capable of perpetuating itself indefinitely given sufficient inputs of matter and energy.

Ecosystem productivity: Amount of biomass produced annually which maintains the equilibrium of animal and plant populations.

Effluent: Any liquid discharged by a pollution source, whether from a domestic source (main outfall) or an industrial source (industrial outfall). Point-source effluent: effluent discharged at a given location.

Endogenous: Refers to a population which spends most of its life cycle in the same place.

Estuarine circulation: Water circulation typical of estuaries where surface water is transported downstream and deep water moves upstream.

Exogenous: Refers to a population that sustains itself in a given environment through constant inputs from outside that environment.

Fjord: A steep-walled glacial valley invaded by the sea.

Flood plain: Flat alluvial land area bordering a waterway which is submerged only during flooding.

Habitat: Ecological framework in which an organism, species, population or group of species lives.

Mutagenic: Refers to a chemical or physical substance that has the ability to cause species mutation.

Non-point source pollution: Diffuse discharge of pollutants into a body of water. Agricultural runoff is non-point source pollution given that fertilizers and pesticides are spread over large areas.

Plankton: Animal (zooplankton) and plant (phytoplankton) organisms that live suspended in oceans or bodies of fresh water.

Sediment: Particles of soil and other solids formed by the weathering of rocks or other chemical or biological processes, which are transported or deposited by air, water or ice.

Sediment regime: Set of streamflow characteristics that influence sediment transport, deposition and erosion.

Sill: A ridge separating two structural basins.

Spawning ground: Place where fish congregate to breed.

Subarctic (of subarctic affinity): Refers to species which are intolerant of icy waters of strictly polar origin but which can nevertheless live in waters subject to the influence of polar waters.

Suspended solids: Small particles of solid matter (> 0.45 μm) floating in a liquid. Also called *suspended matter* (see Sediment).

Thermal stratification: Formation of layers of different temperatures in water bodies, with warmer water overlying the colder water.

Thermohalocline: Layer of water characterized by rapid drop in temperature and rapid rise in salinity with increasing depth.

Water mass: Volume of water having relatively homogeneous physical and chemical properties.

Waterfowl: Collective name for ducks and geese.

Watershed: Continental area comprising the hydrographic basin of a watercourse and encompassing the entire catchment and precipitation drainage area. Also called *hydrographic basin* or *drainage basin*.

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