REGIONAL ASSESSMENT
NORTH SHORE OF THE ST. LAWRENCE
UPPER ESTUARY

Regional Assessment
North Shore of the St. Lawrence Upper Estuary

Priority Intervention Zones 15 and 16

Marc Gagnon

Edited by Jean Burton
St. Lawrence Centre
Environment Canada – Quebec Region

April 1998

NOTICE TO READERS

Reports on Priority Intervention Zones (ZIPs) are published as part of the St. Lawrence Vision 2000 Action Plan by the St. Lawrence Centre, Environment Canada, in conjunction with Fisheries and Oceans Canada, Health Canada, the Ministère de la Santé et des Services Sociaux and its partners, and the Ministère de l'Environnement et de la Faune.

Correct citation for this publication:
Gagnon, M. 1998. *Regional Assessment: North Shore of the St. Lawrence Upper Estuary. Priority Intervention Zones 15 and 16*. Environment Canada – Quebec Region, Environmental Conservation, St. Lawrence Centre. 67 pages.

Published by authority of the Minister of the Environment

Catalogue No. En40-216/55-1998E
ISBN 0-662-28706-1

Production Team

St. Lawrence Centre

Design and Writing	Marc Gagnon, Biorex Inc.
Editing and Co-ordination	Jean Burton, SLC
ZIP Writing Team	Pierre Bergeron, Biorex Inc. Jean-François Bibeault, SLC Marc Gagnon, Biorex Inc. Nathalie Gratton, SLC Judith Leblanc, MLI Pierre Mousseau, SLC Robert Siron, MLI
Cartographic Analysis and Illustrations	Marcel Houle, SLC
Linguistic Revision and Text Layout	Patricia Potvin, SLC
Quebec Public Health Centre	Josée Chartrand Jean-François Duchesne Denis Gauvin

Contributors

Ministère de l'Environnement et de la Faune du Québec	
Aquatic Ecosystems Branch	Gérard Croteau Yves Lefebvre
Lower St. Lawrence Regional Branch	Guildo Lavoie
North Shore Regional Branch	André Lamoureux
Fisheries and Oceans Canada	
Fish Habitat Branch	Serge Villeneuve
Maurice Lamontagne Institute	Dominique Gascon Jean Puize Jean-Claude Therriault Gordon Walsh
Canadian Heritage	
Parks Canada, Quebec Region	Suzan Dionne
Environment Canada	
Environmental Protection Branch	Élie Fédida Alain Latreille
Canadian Wildlife Service	Léo-Guy de Repentigny
Health Canada	Richard Carrier

Ministère de la Santé et des Services Sociaux	Claire Laliberté
Lower St. Lawrence Public Health Branch	Michel Laferrière
SLV 2000 Biodiversity Assessment Team	Luce Chamard

Acknowledgments

We wish to acknowledge the close working relationship that has developed among St. Lawrence Vision 2000 partners on the Community Involvement Consultation Committee, through the participation of Jean-Yves Roy, Lynn Cleary, Marc Hudon, Suzanne Bourget, Jean Burton, Raymonde Goupil, Claire Lachance, Claire Laliberté, Richard Larue, Daniel LeSauteur, Francine Richard, Claude Abel, Michel Provencher, and Yolaine St-Jacques.

We would also like to thank all those from the sectoral and regional offices of the departments and ministries concerned who were involved in reviewing this report.

Preface

In April 1994, the governments of Canada and Quebec agreed to carry on the work of the St. Lawrence Action Plan, approving a five-year program (SLV 2000) extended in 1998 until 2003.

The goal of St. Lawrence Vision 2000 (SLV 2000) is to conserve and protect the St. Lawrence River and the Saguenay River so that people living along their shores can reclaim use of these rivers in a manner compatible with sustainable development.

The Priority Intervention Zones program — better known by its French acronym ZIP (zones d'intervention prioritaire) *— is a major element of the Community Involvement component of the St. Lawrence Vision 2000 Action Plan.*

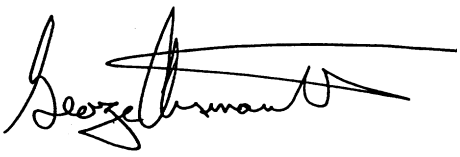
Through the ZIP program, riverside communities are invited to play an active part in achieving the objectives aimed at restoring the St. Lawrence and Saguenay rivers.

The program enables 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 report 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 SLV 2000.

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

Jean-Pierre Gauthier
Regional Director General
Quebec Region
Environment Canada
Co-chair, St. Lawrence Vision 2000



George Arsenault
Assistant Deputy Minister
Wildlife Resources and Parks
Ministère de l'Environnement et de la Faune
Co-chair, St. Lawrence Vision 2000

Management Perspective

The Priority Intervention Zones (ZIP) program is a federal-provincial initiative involving stakeholders and shoreline communities in implementing measures to restore the St. Lawrence River. The program has three phases: producing a regional assessment report on the state of a specific area of the St. Lawrence, consulting shoreline partners in setting priorities for action, and developing an ecological rehabilitation action plan (ERAP).

The regional assessment is a synthesis of four technical reports on the biological, physico-chemical, socio-economic and public health aspects of the study area, prepared by the federal and provincial partners of the St. Lawrence Vision 2000 Action Plan as part of its Community Involvement component.

The process of gathering and analysing data area by area has never before been undertaken for the entire St. Lawrence. The technical reports go a step further, assessing our knowledge of the current state of a given area based on known quality criteria.

The challenge, then, is to offer 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 team remains nonetheless convinced that an enlightened and thoughtful overview of each study area can be presented without further delay. This initial assessment is therefore intended as a discussion paper that will serve as a starting point for the shoreline partners in each study area.

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 œuvre des mesures de réhabilitation du Saint-Laurent. Ce programme comporte trois grandes étapes, soit l'élaboration d'un bilan environnemental sur l'état du Saint-Laurent 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 quatre rapports techniques portant sur les aspects biologiques, physico-chimiques, socio-économiques et sur la santé humaine 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 Saint-Laurent. 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 north shore of the St. Lawrence Upper Estuary encompasses the coastal and aquatic environments between Saint-Joachim and Baie-Sainte-Catherine. The study area is biophysically very different from areas upstream and downstream and from the south shore of the Upper Estuary, being characterized by abrupt rocky coasts, narrow foreshores, limited wetland areas, and few islands or islets. The physical and chemical conditions of the study area change rapidly as one moves downstream, with the salinity level and stratification of the water masses increasing and water temperature and turbidity dropping.

Aquatic plant and animal life in the upstream portion of the study area are dominated by freshwater species tolerant of the water's low salinity level and high turbidity. In the downstream portion, marine species that tolerate variations in the salinity level of the water are predominant. In the mid-section, flora and fauna are not very diversified and are dominated by a few typically estuarine species or by coastal marine species which have adapted well to the wide variations in salinity.

There are few islands in the area, so bird colonies and seal haulouts are rare. The small surface area of wetlands, flats or ice-free zones in winter also limits the number of migratory birds stopping over. Birds congregate mainly at either extremity of the area, on the Cap Tourmente flats (main staging grounds for migrating Greater snow geese in fall) or on the Alouette flats (important nursery grounds for the Common eider and for overwintering diving ducks and sea ducks). Beluga whales frequent the downstream portion of the area intensively from spring to fall, presumably for its abundance of capelin, herring, smelt and eel, the Beluga's main prey.

The study area constitutes a very important national and international shipping lane that requires heavy maintenance dredging every year in its upstream section. Port activities, commercial fishing and waterfowl hunting are relatively insignificant compared to tourism and cottaging, for many years the economic engines of the study area. Recreation and tourism activities are largely centred around the exceptional coastal scenery and on seabird- and marine-mammal-watching activities.

Most of the area's sensitive wildlife habitats are protected by law. This is also the case for the main intertidal marshes (with the exception of the marsh at Baie-Saint-Paul), bird colonies and seal haulouts. Moreover, the Saguenay–St. Lawrence Marine Park encompasses close to one-third of the entire surface area of the study area.

Since the 1970s, contaminants entering the area from remote and local pollution sources have declined considerably. Municipal and industrial cleanup efforts have taken place primarily in the last four years. In late 1998, the wastewater of 70% of riverside residents was being diverted to wastewater treatment plants before discharge, and today, no heavy industry in the area discharges toxic effluent into the aquatic environment.

The available data, though fragmentary, suggest that contamination by toxic substances (heavy metals, organochlorine pesticides, PCBs, PAHs, dioxins and furans) is low in water, sediment, plants, aquatic invertebrates and marine fishes in the study area, posing no significant risk to human health. The microbiological contamination of a few shellfish areas is high, however, and limits the shellfish harvest. Furthermore, some heavy metals and organochlorine substances attain elevated concentrations in Atlantic tomcod, Sauger, migratory eels coming from Lake Ontario, fish-eating aquatic birds, and marine mammals living year-round in the estuary. General trends indicate that this contamination is dropping, however. Fill work and marsh drainage cause minimal disturbance to the shores of the study area.

Résumé

Le secteur de la rive nord de l'estuaire moyen comprend les milieux côtiers et aquatiques situés entre Saint-Joachim et Baie-Sainte-Catherine. Les caractéristiques biophysiques de ce secteur sont très différentes de celles qu'on retrouve en amont et en aval du secteur ainsi que le long de la rive sud de l'estuaire moyen. Le secteur est caractérisé par des côtes rocheuses abruptes, des estrans étroits, une superficie limitée de milieux humides et un petit nombre d'îles et d'îlots. Les conditions physico-chimiques changent rapidement en progressant de l'amont vers l'aval avec une augmentation de la salinité et de stratification des masses d'eau et une diminution de la température et de la turbidité de l'eau.

La flore et la faune aquatiques dans la partie amont sont dominées par des espèces d'eau douce qui tolèrent les faibles salinités et la turbidité élevée alors que dans la partie aval, elles sont dominées par des espèces marines qui tolèrent les variations de salinité. Dans la portion centrale du secteur, la faune et la flore sont peu diversifiées et sont dominées par quelques espèces typiquement estuariennes ou par des espèces marines côtières bien adaptées aux variations importantes de salinité.

En raison du nombre limité de petites îles et d'îlots, les colonies d'oiseaux et les échoueries de phoques sont rares. La superficie restreinte de milieux humides, de battures et de surfaces libres de glace en hiver fait que le secteur est peu fréquenté par les oiseaux migrateurs. L'utilisation du milieu par les oiseaux se concentre principalement aux deux extrémités du secteur, soit sur les battures du cap Tourmente (principale halte migratoire automnale de l'unique population mondiale d'Oie des neiges) et sur la batture aux Alouettes (importante aire d'élevage de l'Eider à duvet et d'hivernage des canards plongeurs et des canards de mer). Le Béluga utilise intensivement la partie aval du secteur du printemps à l'automne présumément en raison de l'abondance de ses principales proies (capelan, hareng, éperlan et anguille).

Le secteur d'étude constitue une très importante voie de transport maritime national et international qui requiert d'importants dragages d'entretien annuels dans sa partie amont. Les activités portuaires, la pêche commerciale et la chasse à la sauvagine sont relativement peu importantes. Par contre, le tourisme et la villégiature constituent l'un des principaux moteurs

économiques du secteur depuis de nombreuses années. Les activités récréo-touristiques sont en grande partie basées sur les paysages exceptionnels de la côte et sur l'observation des oiseaux aquatiques et des mammifères marins.

La plupart des habitats fauniques sensibles du secteur jouissent d'une protection légale. Les principaux marais intertidaux (à l'exception de celui de Baie-Saint-Paul), les colonies d'oiseaux et les échoueries de phoques sont protégés. De plus, le parc marin du Saguenay–Saint-Laurent englobe près du tiers de la superficie totale du secteur.

On assiste depuis les années 1970 à une baisse importante des apports de contaminants en provenance des sources éloignées et locales de pollution. Les principaux efforts de dépollution des municipalités et industries riveraines ont été réalisés au cours des quatre dernières années. Aucune industrie lourde du secteur ne déverse des effluents toxiques dans le milieu aquatique et à la fin de 1998, les eaux usées de 70 p. 100 de la population riveraine seront traitées dans des stations d'épuration.

Les données très fragmentaires disponibles suggèrent que l'eau, les sédiments, les végétaux, les invertébrés aquatiques et les poissons marins du secteur sont peu contaminés par les substances toxiques (métaux lourds, pesticides organochlorés, BPC, HAP, dioxines et furannes) et ne présentent pas de risques significatifs pour la santé humaine. Par contre, la contamination microbiologique des quelques secteurs coquilliers du secteur est élevée et limite leur exploitation. De plus, certains métaux lourds et des substances organochlorées atteignent des concentrations élevées chez le Poulamon atlantique, le Doré noir, les Anguilles d'Amérique migratrices en provenance du lac Ontario, les oiseaux aquatiques piscivores et les mammifères marins qui résident à l'année dans l'estuaire. Cette contamination montre cependant une tendance générale à la baisse. Les rives du secteur d'étude sont peu perturbées par le remblayage et l'assèchement des marais.

Table of Contents

List of Figures

List of Tables

CHAPTER 1 The St. Lawrence, Then and Now

For the great majority of Quebecers, the mere mention of the St. Lawrence evokes a deep-rooted feeling of belonging to the land traversed by these waters on their way from the Great Lakes to the sea. The pictures that spring to mind are those of a mighty river, fertile plains on either side, shady banks, and rich wildlife.

The country was born on the banks of the river, as can still be seen today by the division of land — a vestige of the seigneurial system. In those days, people had to learn to live with the whims of the St. Lawrence, including spring flooding. In return, it provided the European settlers, still struggling with unreliable harvests, with a sure supply of fish and a crucial means of communication linking the first towns and villages that grew up along its banks.

With time, forests gave way to farmland, and then towns and cities sprang up. Until that point, the low population density and the very size of the St. Lawrence meant that human uses of the river had had virtually no impact on its resources. But things would soon change. The first major impact seems to have been caused by logging and the beginnings of industrialization, in the 19th century; this included the floating of timber down the Ottawa River and the St. Lawrence to Quebec City, the building of dams and sawmills along tributaries, and the construction and commissioning of the first hydro-electric power plants.

The pace of change accelerated in the 20th century, with the construction of major dams on the St. Lawrence, controlling its flow, shipping channels and then the St. Lawrence Seaway. More and more industries were established near towns, often right on the river. The proximity of the waterway offered several advantages: it reduced the cost of transporting raw materials, solved water supply problems and provided an easy way of getting rid of waste.

The St. Lawrence gradually succumbed to these numerous onslaughts. A few informed observers noted that some animal populations were declining and suggested that the reason was habitat degradation. Their warnings aroused little public interest, however.

Public awareness was sharply raised in the early 1970s with the realization that mercury contamination of fish was not just an abstract research topic, but a real risk to which some Native people and many sport fishers were exposed. As the list of toxic substances reported in the aquatic environment continued to grow, the general public changed its perception and put environmental quality at the top of its list of priorities. There is virtually unanimous agreement now that the comforts afforded by an industrial society have a drawback: unbridled exploitation of resources and increasing levels of contaminants will eventually threaten all forms of life, including human beings.

Most industrialized countries have now agreed to base their economies on sustainable development. The profit motive alone can no longer govern human activity. Given the fragile nature of our environment and the limitations of our planet, sustainable economic development must ensure that scarce resources are used for a variety of purposes; it must also take into account the quality of life of human beings and promote the maintenance of biological diversity.

CHAPTER 2 The ZIP Program

Starting in the 1960s, growing public awareness of the degradation of the Great Lakes and the St. Lawrence and Saguenay rivers, along with the urgency of the situation, prompted governments to take substantive joint action. This paved the way for the 1972 *Great Lakes Water Quality Agreement*. A 1987 amendment added a local use restoration program (Remedial Action Plan, RAP). In 1988, the eight American states concerned and the provinces of Ontario and Quebec signed the *Great Lakes Charter* and an agreement to control toxic discharges into the Great Lakes Basin. In response to the poor quality of the waters of the St. Lawrence and its tributaries, the Quebec government launched its wastewater treatment program (PAEQ) in 1978.

In 1989, the federal and Quebec governments decided to combine their efforts under the St. Lawrence Action Plan, which was renewed in 1994 as St. Lawrence Vision 2000 (SLV 2000). In 1998, the plan was extended until 2003 and renamed the *St. Lawrence Vision 2000 Action Plan, Phase III*. One of the objectives of this action plan is to prepare a comprehensive state of the environment report on the Quebec portion of the St. Lawrence River. Under the Priority Intervention Zones Program, the St. Lawrence has been subdivided into 23 sectors, or ZIPs, combined as necessary into study areas (Figure 1). The aim is to encourage community stakeholders to work together to restore and protect the St. Lawrence, and to harmonize use of the river.

As part of the groundwork for public consultation meetings, a state-of-the-environment review is conducted by the partners for each study area, and the findings are compiled in four technical reports.[1] This report summarizes these findings to provide an overall assessment of the resources, and present and potential uses, of the north shore of the St. Lawrence Upper Estuary.

[1] The technical reports deal with the physico-chemical aspects of the water and sediments (Gagnon et al., 1998), the biological communities (Mousseau et al., 1998), socio-economic aspects (Gratton and Bibeault, 1998), and human health issues (Duchesne et al., 1998).

The document is intended above all for stakeholders of this segment of the St. Lawrence, and summarizes the main points of the available scientific and technical literature with the aim of allowing them to participate actively in the discussions and the process of defining priorities for action.

The information presented here should provide the foundation for a common vision of the situation in the study area, thereby paving the way for concerted action by the partners.

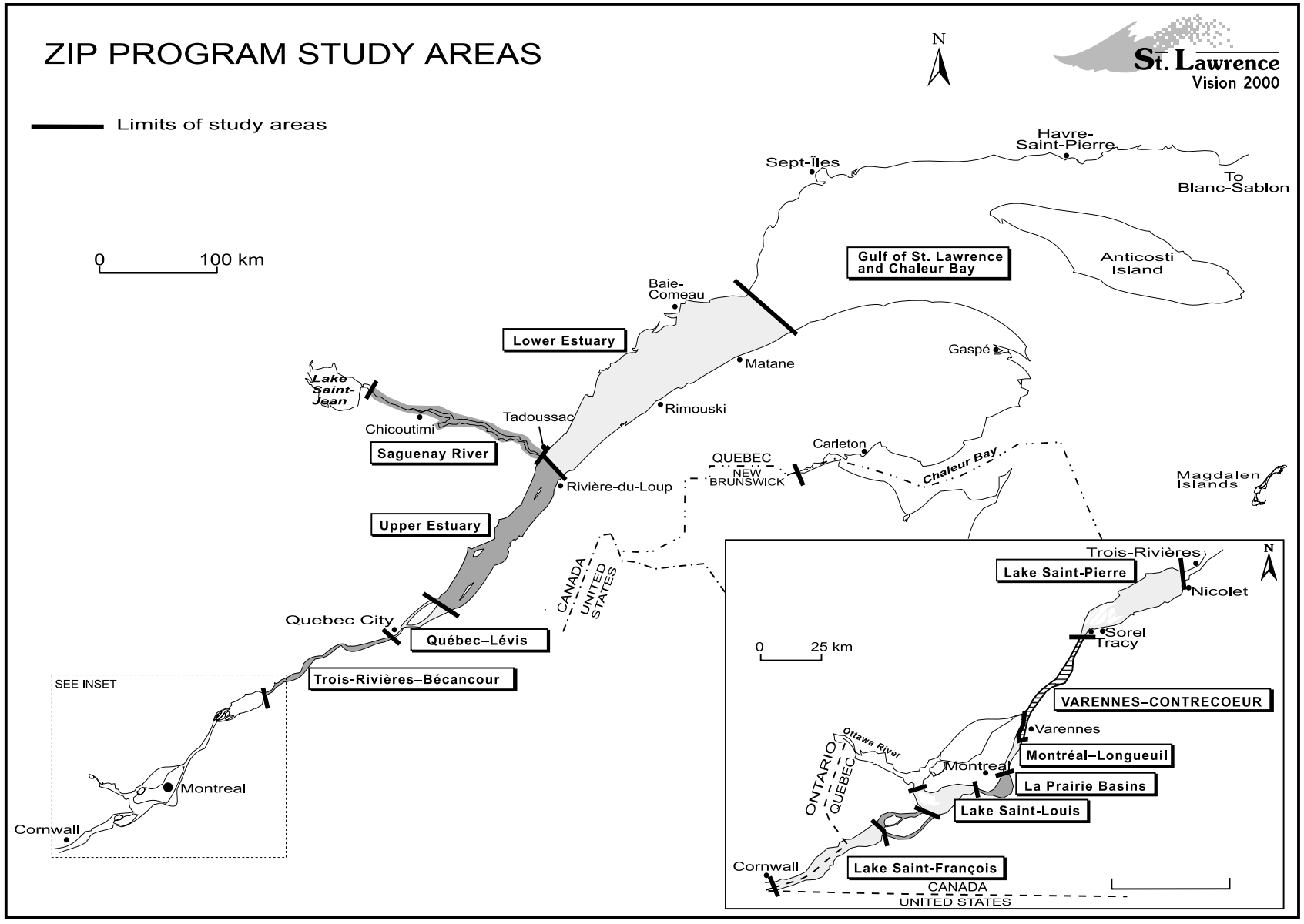


Figure 1 **ZIP Program study areas**

CHAPTER 3 Characterization of the Sector

The study area consists of that part of the Upper Estuary along the north shore of the St. Lawrence River from Saint-Joachim to Baie-Sainte-Catherine (Figure 2). Its western and eastern limits are the same as the upstream and downstream limits of the Upper Estuary, and it extends out to the midstream boundary between the north shore and south shore regional county municipalities (RCMs), or *municipalités régionales de comtés (MRCs).*

3.1 Physical Environment

The Upper Estuary is that part of the St. Lawrence where the fresh waters of the river mix with the salt water of the gulf. It is 150 km long, with an average width of 22 km and an area of 3470 km^2. It has a complex bottom topography, a wide tidal amplitude and highly variable local physical and chemical conditions.

Most of the northern shoreline of the Upper Estuary is cut right into the crystalline rocks of the Canadian Shield. Generally, the mountains plunge straight into the North Channel, and foreshores,where they exist, are narrow. The most extensive flats are at the upper and lower ends of the study area, at Saint-Joachim (Cap Tourmente flats) and Baie-Sainte-Catherine (Alouette flats). Except for Île aux Coudres, there are only a handful of islets and reefs.

The North Channel is wider and deeper than its southern counterpart, consisting of a series of basins whose depth increases heading downstream. The last of these basins is separated from the Lower Estuary (Laurentian Channel) by a sill less than 50 m below the surface off Île Rouge (Figure 3).

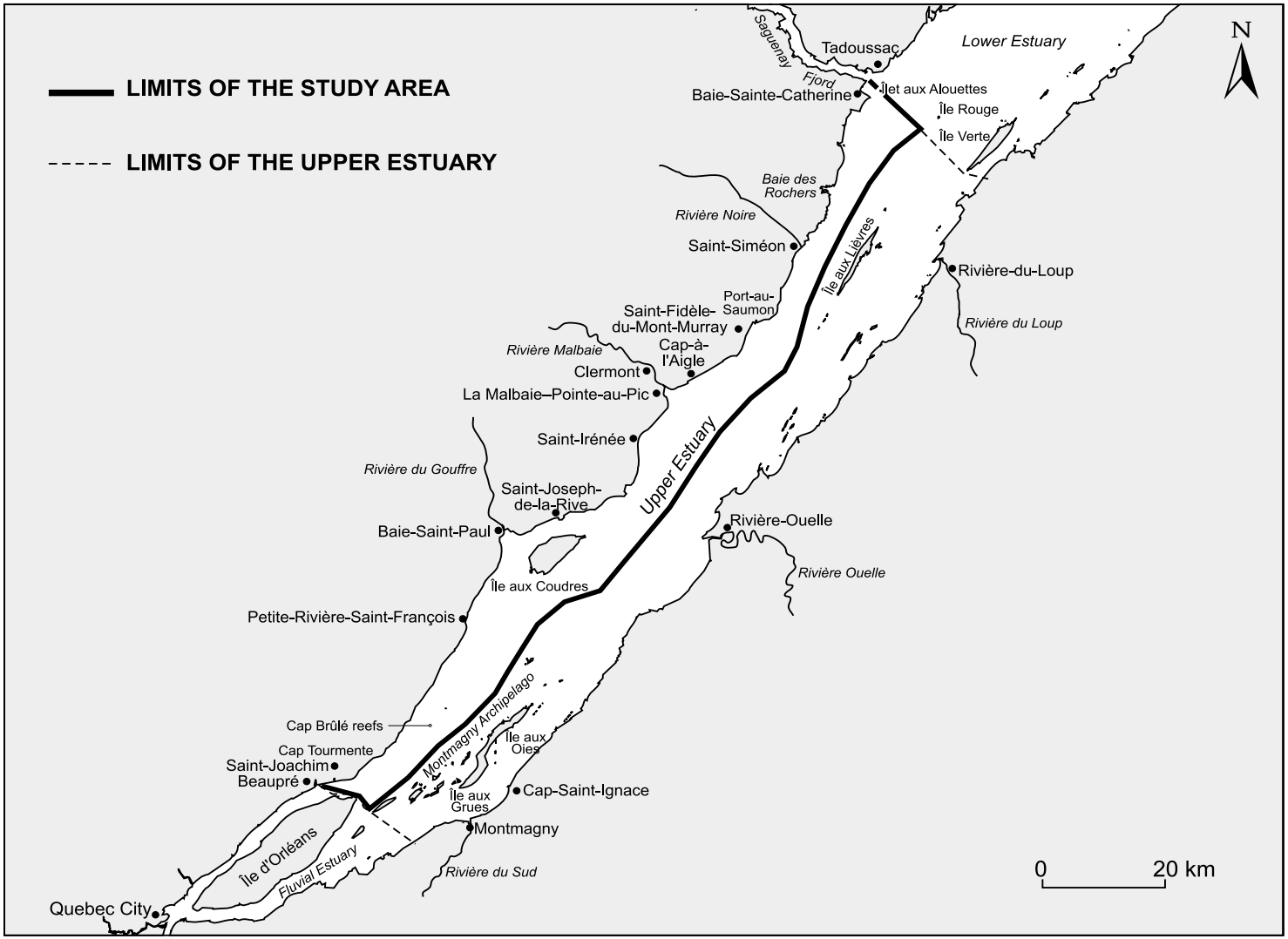
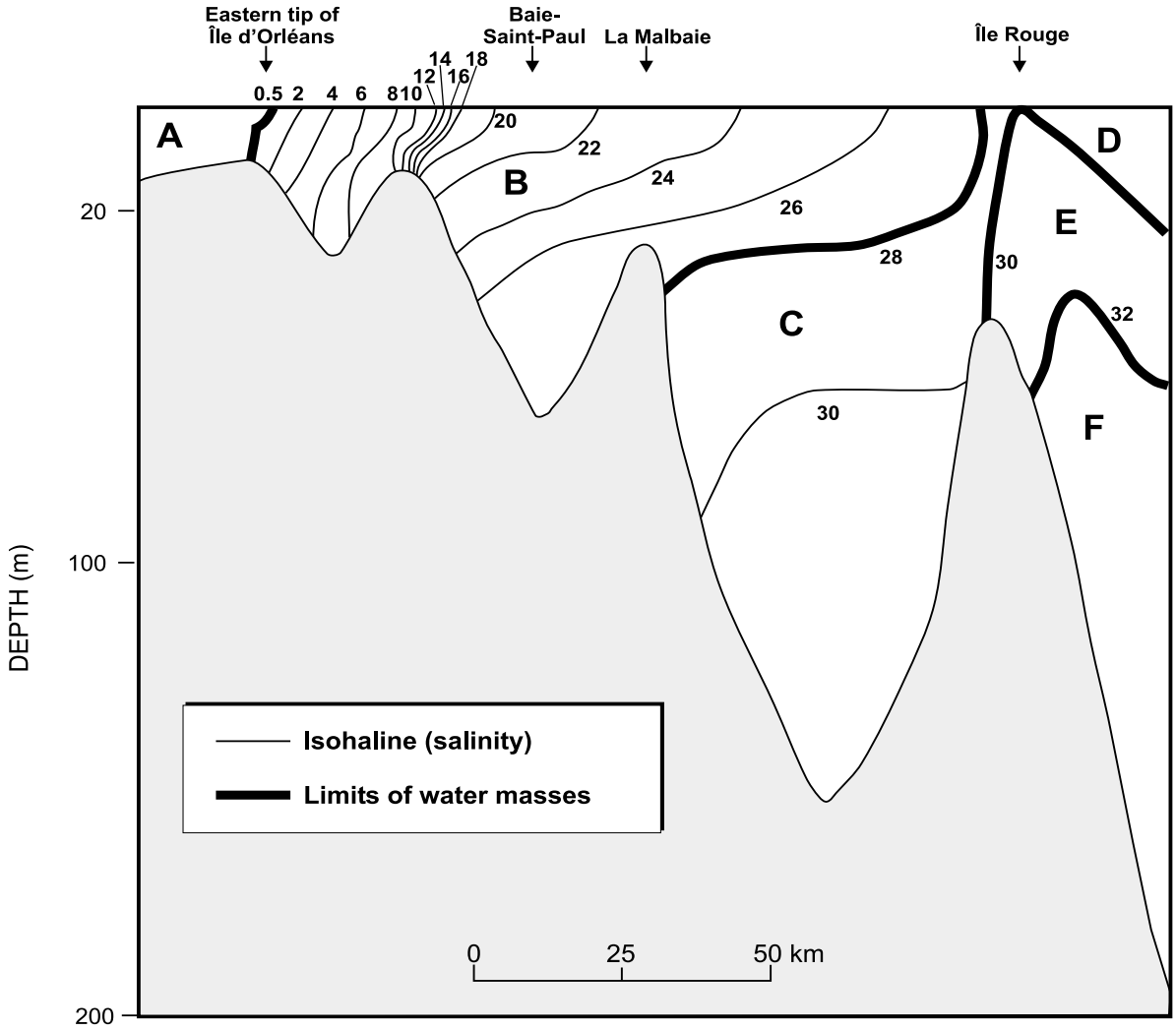


Figure 2 The north shore of the Upper Estuary



SECTOR	WATER MASSES	TEMPERATURE (°C)	SALINITY (‰)
Fluvial Estuary	**A** Fresh water	> 20	< 0.3
Upper Estuary	**B** Brackish water	5 to 20	0.3 to 28
	C Sea water	2 to 5	28 to 31
Lower Estuary	**D** Surficial layer	2 to 10	27 to 32
	E Icy intermediate layer	-1 to 2	32–33
	F Deepwater layer	2 to 6	33 to 35

Source: Adapted from Greisman and Ingram, 1977.

Figure 3 Breakdown of water masses and vertical salinity distribution in the St. Lawrence Estuary in summer (longitudinal section of the North Channel)

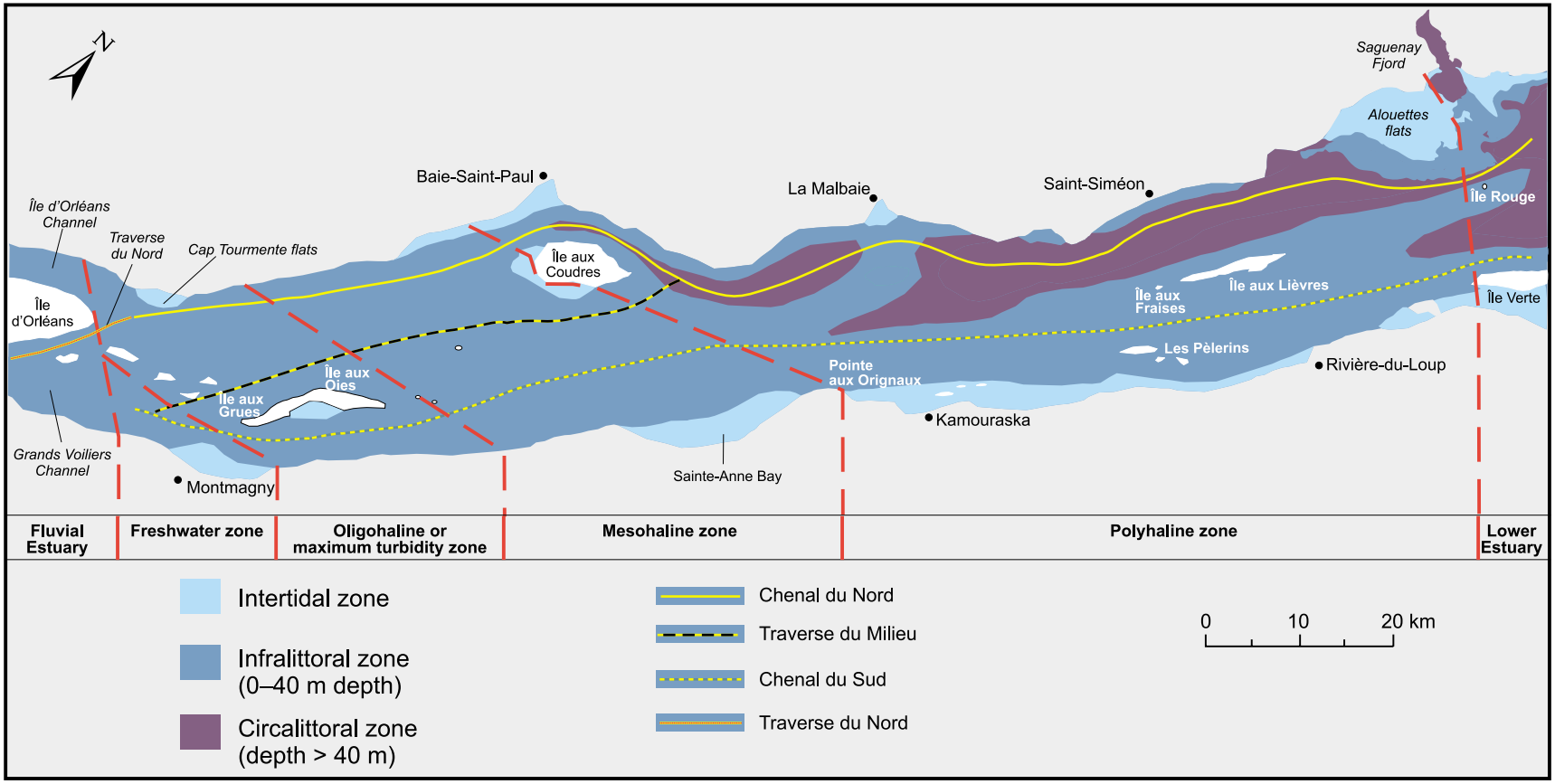
The average discharge of the St. Lawrence River at Quebec City over the year is about 11 000 m^3 per second, being fullest in April and lowest in January or February. Almost 90% of this flow enters the estuary through the Grands-Voiliers channel, while the rest flows through the Île d'Orléans channel (Figure 4). The rivers emptying directly into the Upper Estuary (chiefly the Du Gouffre, Malbaie, Du Sud, Ouelle and Du Loup) do not significantly increase the volume of fresh water.

The tide rises twice daily in the study area, with an amplitude varying over a two-week cycle (spring and neap tides). The average tidal range decreases downstream, from 4.6 m at the eastern end of Ile d'Orleans to 3.0 m at Pointe-au-Père (Lower Estuary).

Influenced by the strong tides, the fresh water from the river gradually mingles with the salt water and sweeps it downstream. Off Ile Rouge, the mixed surface waters emerging from the Upper Estuary are five times as voluminous as the fresh water entering the head of the estuary. The discharge of salt water at the surface is offset by an inward surge of salt water from the Lower Estuary at greater depths.

The limit of saltwater penetration into the estuary varies with the river's discharge and tidal amplitude. In summer, it is near the eastern end of Île d'Orléans and moves back and forth with the tide over a distance of some 20 kilometres. The waters washing the shores around Saint-Joachim, the Montmagny islands and Cap-Saint-Ignace are characterized by very high turbidity attributable to retention in summer of the suspended matter borne by the river. This stretch is known as the maximum turbidity zone (Figure 4).

Between the upstream limit of saltwater penetration and the western tip of Ile aux Coudres, the strong tides mix fresh and salt water from the surface to the bottom. The result is a very pronounced seaward gradient in physical and chemical conditions and vertical homogeneity in the water column. Downstream of Ile aux Coudres, depth increases, and mixing is less intense, so that the seaward gradient is less marked and salinity increases with depth (Figure 3).



Source: Adapted from SLC and Laval University, 1991.

Figure 4 Zonation of the Upper Estuary by bathymetry and seaward gradient of physical and chemical conditions

Though significant quantities of suspended matter are temporarily retained in the upstream part of the estuary in summer and settle on the shores of the maximum turbidity zone, this material is washed out of the Upper Estuary in fall and winter. There is thus no major zone of permanent sedimentation in the study area. The bed of the Upper Estuary is largely covered with sand, gravel and glacial and marine clays, eroded by the strong tides, while the foreshores and basins are subject to tidal and seasonal cycles of deposition and erosion of fine sediments.

The Upper Estuary starts to freeze up in early December, progressing downstream. In winter, there is less ice on the north shore than on the south. The break-up starts in late March, especially during spring tides, and proceeds upstream.

3.2 Aquatic Habitats and Communities

The distribution of flora and fauna in the study area is dependent on three main factors: *a)* position along the seaward gradient of physical and chemical conditions, *b)* depth or shoreline elevation relative to tide levels, and *c)* substrate type.

The study area can be divided into three distinct biogeographic zones: *1)* the oligohaline, *2)* the mesohaline, and *3)* the polyhaline zones (Figure 4).

Salinity in the **oligohaline** zone (also known as the maximum turbidity zone) varies from 0.1 to 5‰. The coastal flora and fauna of this zone are dominated by freshwater species tolerant of low salinity and high turbidity. Biological communities are less diversified than in the Fluvial Estuary. The zone is characterized by extensive brackish marshes along the muddy shores of the region of Saint-Joachim and by rocky shores practically denuded of plant or animal life. The pelagic environment in the oligohaline zone harbours a typically estuarine zooplankton community and constitutes a very important nursery area for anadromous fish (Rainbow smelt and Atlantic tomcod).

The **mesohaline** zone is the part of the estuary where salinity varies between 5 and 18‰. This zone is characterized by low biological diversity and productivity. Freshwater species generally reach the downstream limit of their range in the oligohaline zone, while marine species

reach their upstream limit in the polyhaline zone. In this zone, any brackish marshes are confined to the upper reaches of the foreshore and give way progressively to salt marshes. The zone's pelagic environment is characterized by a biomass that is relatively poor in plankton.

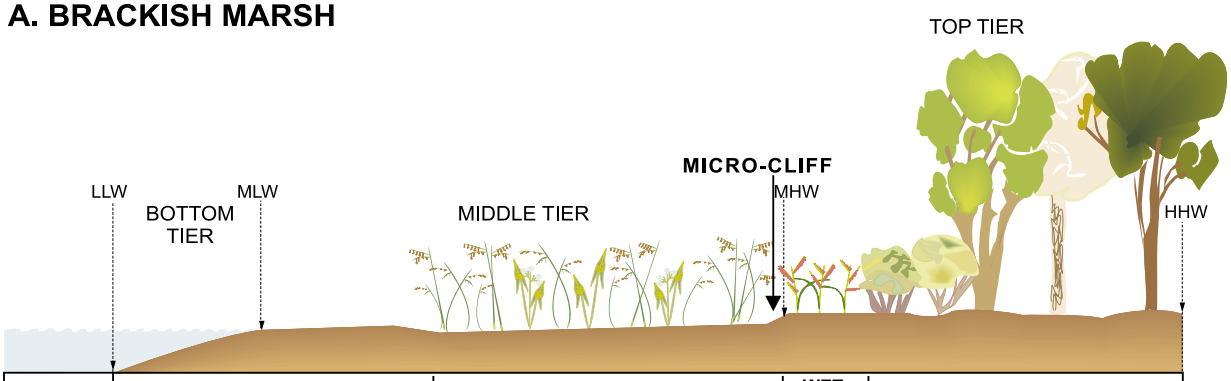
The **polyhaline** zone is that part of the estuary where surface salinity ranges between 18 and 28‰. Littoral flora and fauna in this zone are dominated by marine species tolerant of wide swings in salinity. Here, muddy foreshores, where present, are occupied by salt marshes, and rocky shores begin to take on the aspect of true sea coasts, with seaweed beds and a much more diversified benthic fauna than further upstream. Productivity in the polyhaline pelagic environment is higher than in the mesohaline zone, benefiting from a constant inflow of plankton from the Lower Estuary, which is even more productive.

Bathymetrically, the environment can be subdivided into four distinct levels: supralittoral, intertidal, infralittoral and circalittoral (Figure 4).

The main habitats for aquatic fauna in the **supralittoral** level are the small islands and islets distributed along the south shore and along the middle of the estuary. These are heavily used by seabirds for nesting and by seals for giving birth and resting. This type of habitat is rare in the study area, being limited to the reefs of Cap Brulé and Ilet aux Alouettes.

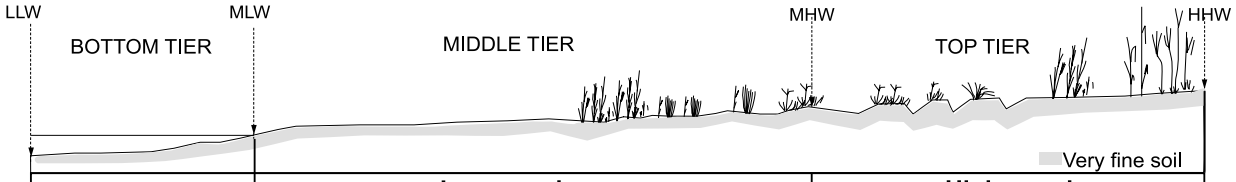
The **intertidal** level comprises that part of the shore between the extreme high and low tide marks. This is where brackish marshes develop (588 ha, occurring mostly in the area of Cap Tourmente and at the mouth of the Gouffre River), likewise salt marshes (320 ha, occurring mostly in the region of Baie-Saint-Paul and on the north shore of Ile aux Coudres). These two habitat types are characterized by successive bands of vegetation parallel to the shoreline and differing in their tolerance of immersion (Figure 5). The dominant species in the brackish marshes is American bulrush; in the salt marshes, it is Saltwater cord-grass. Plant diversity in these marshes increases inland. On the rocky shores of the polyhaline zone, diversity and abundance of fauna increase down the beach. The dominant plants at this level are brown algae (Knotted wrack and Bladder wrack), while the fauna is dominated by Blue mussels, winkles and Sand hoppers, which inhabit pools and fissures in the substrate and shelter under the seaweed.

A. BRACKISH MARSH



	DENUDED MUDFLAT	MARSH	WET MEADOW	SWAMP
		American bulrush c. Broadleaf arrowhead c. American bulrush and Sessilefruit arrowhead c. American bulrush and Arumleaf arrowhead c. American bulrush and wildrice c. American bulrush and Common spikerush c. American bulrush and Hemlock waterparsnip c. Great bulrush c. Broad-fruited bur-reed c.		Sweet gale c. Speckled alder c. Willow c. Crack willow c. Trembling aspen c.

B. SALT MARSH



	Low marsh		High marsh	
	Aquatic plant community	Saltwater cord-grass marsh with ice extraction pans	Salt-meadow grass with puddles	Saltwater herbaceous c.
	Marine benthic algae	Saltwater cord-grass marsh c. Glasswort c.	Salt-meadow grass c. Triangle orache c. Seaside plantain c. Glasswort c.	Foxtail barley c. Red fescue c. Prairie cord-grass c. Maritime bulrush c.

c. = community.

LLW : Lowest low water
MLW: Mean low water
MHW: Mean high water
HHW: Highest high water

Source: Adapted from Couillard and Grondin, 1986; Gratton and Dubreuil, 1990; Brind'Amour, 1988.

Figure 5 Typical profile of brackish and salt marshes of the Upper Estuary

The **infralittoral** level takes in the seabed between the extreme low water mark and a depth of 40 m. The flora and fauna of this level have been studied only in the polyhaline zone (Port-au-Saumon). Because of the variable salinity and the relatively high turbidity, oarweed and sea urchins are much less abundant than in the Lower Estuary, and vegetation disappears almost totally beyond a depth of 3 m. At depths of 0 to 2 m, beds of brown and red algae are found. From 2 to 3 m, seaweed declines sharply in quantity and sea urchins appear. Rocky bottoms more than 3 m deep are dominated by sponges and hydroids. At depths beyond 9 m, anemones and hydroids abound.

The unconsolidated bottoms in the infralittoral and **circalittoral** (greater than 40 m) levels are dominated by polychaetes and numerous species of molluscs and amphipods. The diversity of this benthic fauna increases with depth because physical and chemical conditions become increasingly stable.

3.3 Fishery Resources

None of the seaweed, invertebrate or marine mammal species in the study area is exploited, and only a few of the 61 fish species. This section details the status of the main fish populations of socio-economic importance found in the sector.

The **American eel** is one of the main fish resources of the study area. Almost all commercial catches are made in fall, as part of the Great Lakes and St. Lawrence population heads out through the study area to spawn in the Sargasso Sea. Since 1986, there has been a very serious decline in the numbers of elvers returning up the St. Lawrence.

The **Rainbow smelt** population of the north shore of the Upper Estuary spawns in spring in the Saguenay River basin and spends the rest of the year in the downstream part of the Upper Estuary and in the Lower Estuary. The larvae develop in the pelagic environment of the oligohaline zone, while the juveniles frequent either the pelagic oligohaline zone or the salt marshes, depending on the time of year. The condition of this population is satisfactory compared to that of the south shore population.

The current status of the Upper Estuary population of **Atlantic herring** is not known, but elsewhere in the Gulf of St. Lawrence the status of herring populations has improved markedly since the 1970s, when they were being overfished.

Part of the **Capelin** population of the northwestern Gulf comes up the estuary in spring to spawn on sand or gravel beaches in the polyhaline zone. Those adults that have spawned and survived soon leave the estuary, and the larvae drift downstream, some being trapped at the mouth of the Saguenay River, where concentrations of juveniles have been observed in summer. The species is abundant, and the population seems to be in good shape.

The estuarine population of **Atlantic tomcod** spawns in winter in the tributaries of the Fluvial Estuary between Trois-Rivières and Quebec City. Mature adults have also been taken in the Ouelle River (south shore of the Upper Estuary) in winter. In summer, this population feeds in the pelagic environment of the mesohaline and polyhaline zones. The larvae drift down with the break-up, and the juveniles develop in the pelagic waters of the oligohaline zone, drifting slowly downstream. Older juveniles swarm in salt marshes. The estuary population is in a precarious position, with a succession of good and bad recruitment years. Some individuals have histological deformities (hyperplasia, deformities of the scales, etc.), but it is not known whether this is a normal phenomenon or a pathology. However, another study showed that nearly 20% of adults taken had visible deformities.

There are two recognized **Atlantic salmon** rivers in the study area: the Du Gouffre and Malbaie rivers. The latter is the target of a restoration project.

3.4 Birds

Over 350 bird species frequent the Upper Estuary and adjoining lands at one time of the year or another. The Upper Estuary is characterized by the tremendous abundance of Greater snow geese during migration and by the fact that it marks the distribution limit for a number of continental and marine bird species.

3.4.1 Breeding

Of the 115 bird species that breed along the shores of the St. Lawrence 73 (confirmed or probable breeders) are found in the study area. This figure includes five colonial species, nine species of dabbling ducks, five of diving ducks, one sea duck, five shorebird species (plovers, waders, snipe, sandpipers and phalaropes) and six rare marshland species (Least bittern, Yellow rail, Common gallinule, Sedge wren, Marsh wren and Sharp-tailed sparrow).

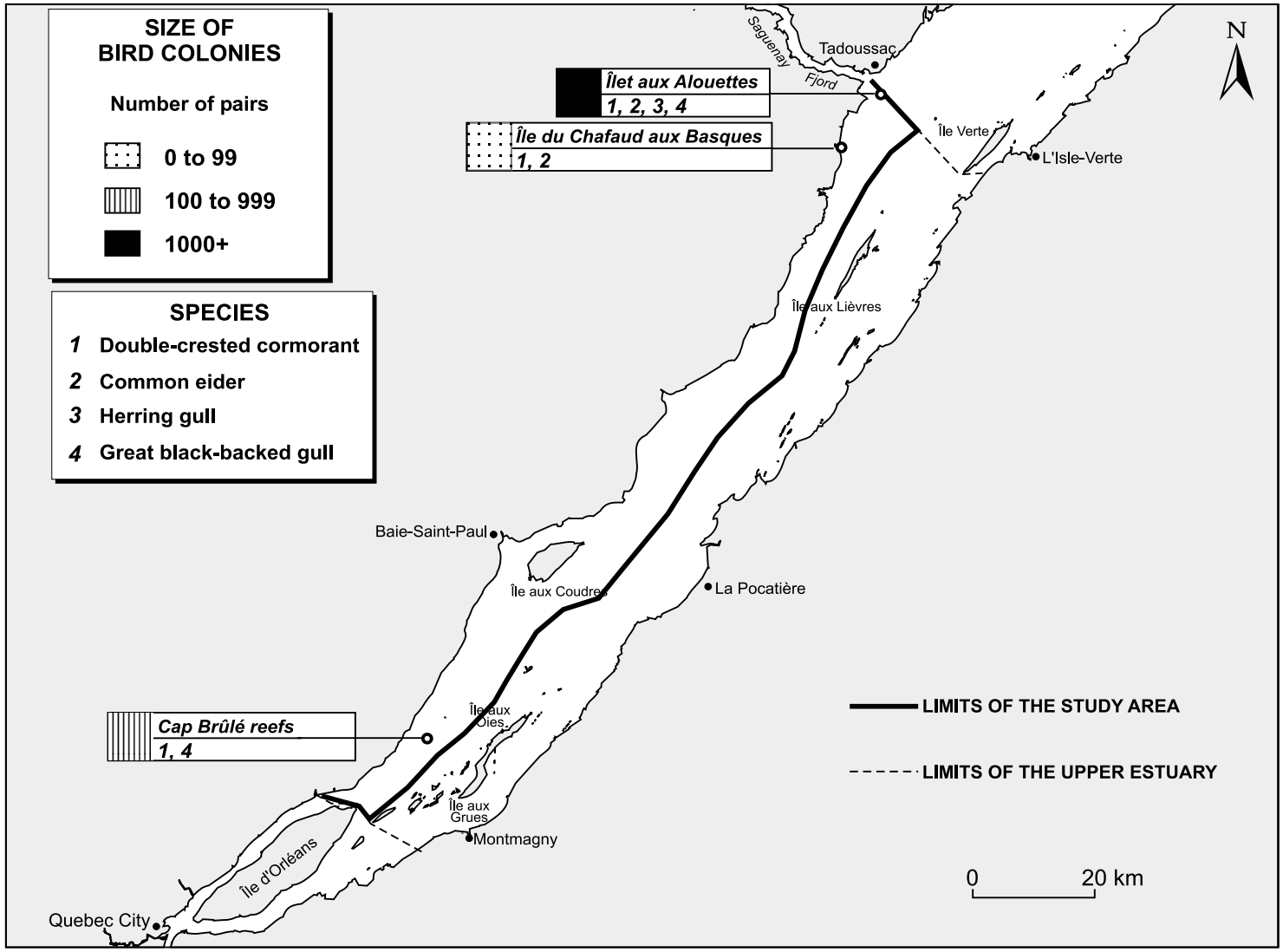
Only eight colonies on the north shore of the Upper Estuary have been inventoried (Figure 6). This number includes concentrations of Common eider nests (sea duck) and seabird colonies (Double-crested cormorant, Herring gull and Great black-backed gull). These colonies total some 2500 breeding pairs overall. The most abundant colonial species in the study area are the Double-crested Cormorant and the Common eider. The largest colony is that of the Double-crested cormorant on Îlet aux Alouettes (808 pairs).

Great black-backed gull numbers have risen since the 1970s, while those of the Herring gull are down. Double-crested cormorant numbers dropped sharply between 1988 and 1993 because their population was being culled (see Section 4.3).

The Black duck is the most common non-colonial species breeding in the Upper Estuary. It makes intensive use of the salt meadows for nesting. Other abundant species are the Mallard, Pintail, Blue-winged teal and Shoveler. Of the shorebirds breeding in the Upper Estuary, the Killdeer and the Spotted sandpiper are the most common.

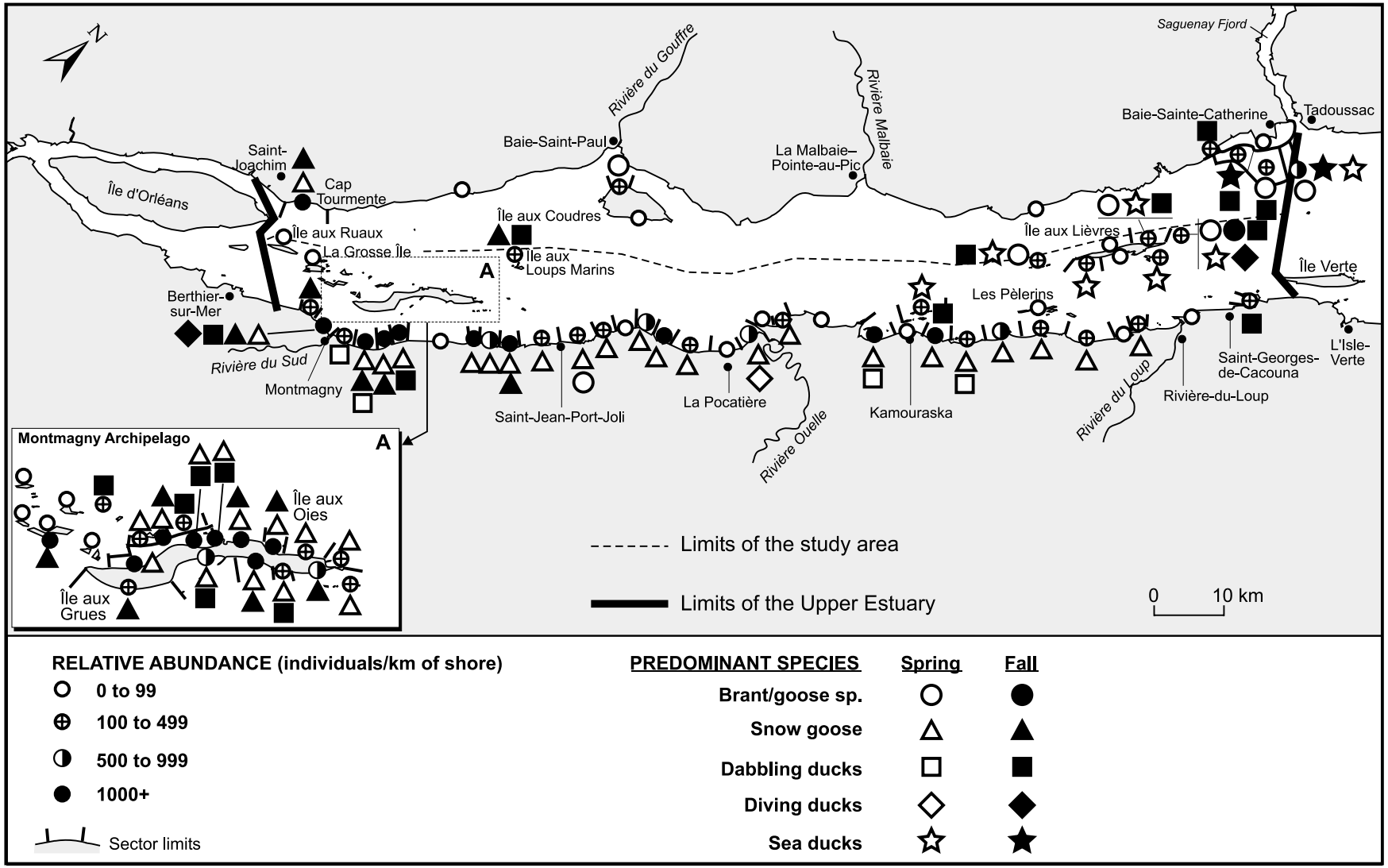
3.4.2 Spring migration

There are far fewer ducks and geese in the study area than on the south shore during spring migration (Figure 7). About ten thousand Greater snow geese flock to the flats of Cap Tourmente. There are few Canada geese, Brant or dabbling and diving ducks. The Canada goose is found mainly on the north shore of Île aux Coudres, and the Brant is often seen on the Alouette flats, where some gatherings of diving ducks (goldeneye) and many sea ducks (eider) have been reported.



Source: Adapted from Bédard and Nadeau, 1994; BIOMQ, 1997; DesGranges, 1997; Desrosiers, 1997.

Figure 6 Distribution of bird colonies on the north shore of the Upper Estuary



Source: Banville and St-Onge, 1990a and b; Verreault, 1997.

Figure 7 Main staging areas of migrating waterfowl in the Upper Estuary

3.4.3 Summering

After hatching, female Common eiders and their ducklings leave the colonies and form rafts consisting of several broods (nurseries) which feed in the sheltered coastal bays of the downstream reaches of the sector. The area around Baie-Sainte-Catherine is a major nursery for this species. During the moult, in July and August, many male and female eiders gather on the rocky shoals of the same area, where they can feed beyond the reach of predators.

3.4.4 Fall migration

In the fall, close to two-thirds of all the snow geese returning from the Arctic gather at Cap Tourmente. In 1997, the population was estimated at nearly 600 000 individuals. This area is the main fall stopover for the species on the St. Lawrence. The Canada goose and Brant are rare in fall, but dabbling ducks (Black duck and teal), diving ducks (goldeneye) and shorebirds (70% Semipalmated sandpiper) are much more abundant than in spring and gather on the Alouette flats.

3.4.5 Wintering

The Alouette flats are a major wintering ground for diving ducks (Common goldeneye, Barrow's goldeneye and Hooded merganser) and sea ducks (Oldsquaw).

3.5 Marine Mammals

There are eight marine mammals found in the Upper Estuary at one time of year or another. Three of these are toothed whales (Beluga, Harbour porpoise and Atlantic white-sided dolphin), two are baleen whales (Minke and Fin) and three are seals (Harbour, Grey and Harp seals). The Harbour porpoise, white-sided dolphin and Fin whale make only brief forays into the downstream reaches of the Upper Estuary.

Beluga. The St. Lawrence Estuary is home to a resident Beluga population, the southernmost in the world. Belugas frequent the downstream section of the Upper Estuary (below Île aux Coudres) in spring, summer and fall. In summer, over half the population is found

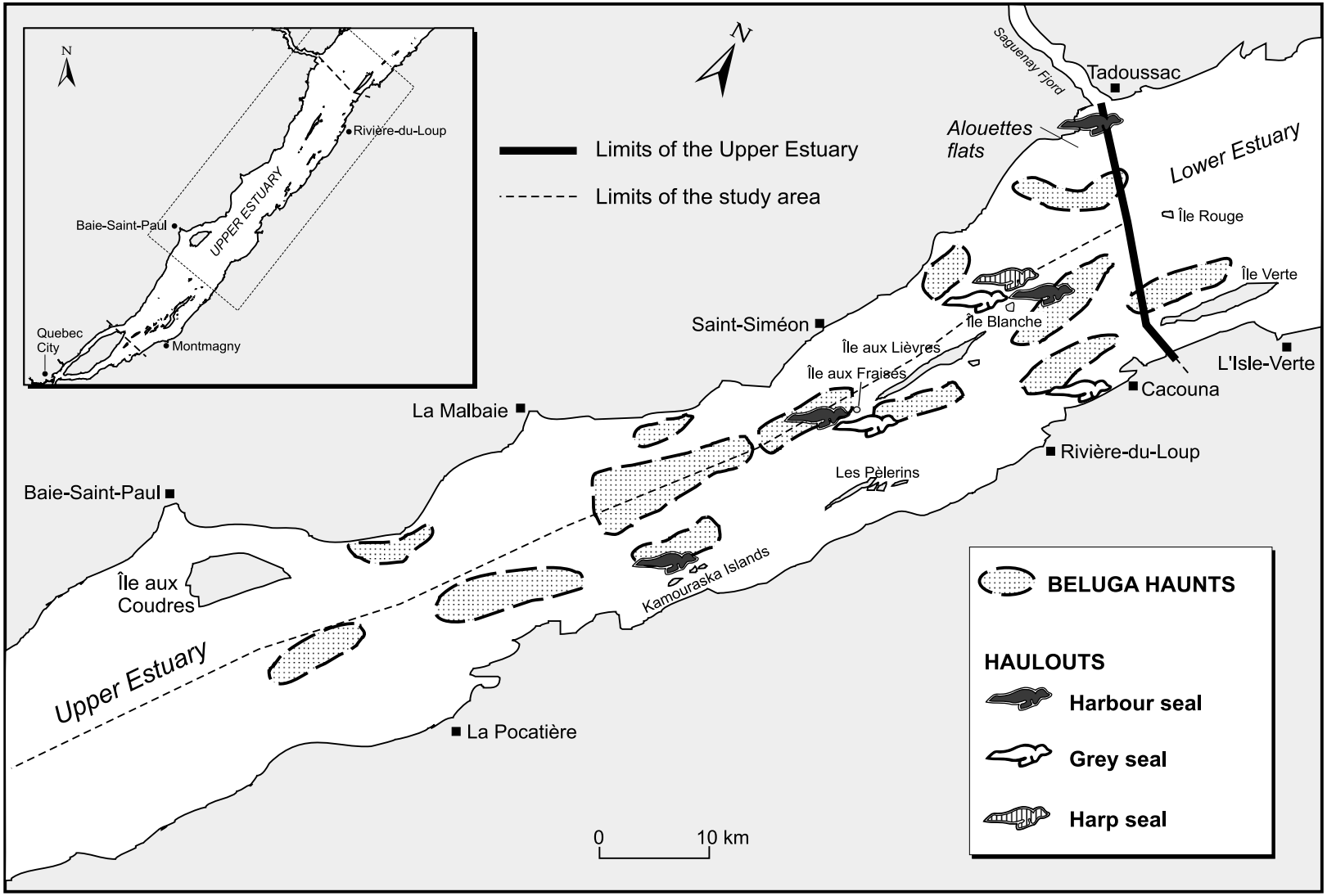
in this area. There are six areas along the north shore that are intensively used by pods of adults and young (Figure 8). It is not known what Belugas eat. The most likely prey species available in the study area are the Atlantic herring, Rainbow smelt, American eel and Capelin.

The Beluga population in the estuary numbered about 5000 in the late 19th century and has fallen sharply since then. In 1960, it was reduced to about 1500 individuals, and between 1973 and 1990 a mere 500 or so. It is thought that the population is now growing, and it was estimated at 700 in 1997. This serious decline is due chiefly to excessive hunting. Hunting was banned in 1979, but a number of other threats still loom, among them disturbance by marine traffic, habitat loss, contamination by toxic substances and competition for food. The recruitment rate was low during the 1980s, but recent observations suggest that the proportion of younger individuals is rising and that fertility rates have reached normal levels for the species.

Minke whale. In the estuary, the Minke whale is often seen from early spring until late fall. It is virtually a daily visitor to the mouth of the Saguenay and is frequently spotted off the Alouette flats. It rarely ventures further upstream than around Saint-Siméon. Unfortunately, there are no reliable estimates of the size or state of the population using the estuary.

Harbour seal. The Harbour seal is a permanent resident of the St. Lawrence Estuary. The pups are born in May and June. The main haulout in the study area is on the Alouette flats (Figure 8). In the course of an aerial survey conducted in August 1994, about 60 specimens were counted in the Upper Estuary. However, the main haulouts are on the south side of the river. Neither the total estuary population nor its fluctuations over time are known. Though the Harbour seal has not been hunted since 1977, numbers appear to have fallen substantially since the early 1970s.

Grey seal. Part of the Eastern Canadian Grey seal population comes into the Upper Estuary from June until November. In August 1994, no seals of this species showed up in an aerial survey of the study area, and only two individuals were reported from the Alouette flats from four boat surveys made that year. In 1992, 11 individuals were seen in the area. The Eastern Canadian population has been growing since the early 1960s. Capelin is the species' main prey.



Source: Adapted from Michaud, 1993; Lavigueur et al, 1993; Lesage et al., 1995.

Figure 8 Main Beluga haunts and seal haulouts in the Upper Estuary

Harp seal. Part of the Eastern Canadian Harp seal population uses the Lower Estuary from late fall to early spring. In the summer of 1991, a few individuals were spotted near the mouth of the Saguenay River (Figure 8).

3.6 Species at Risk

Eleven rare plants, seven fish species, eleven birds and four marine mammals listed for priority protection under the SLV 2000 Action Plan have been seen in the study area (Appendix 1).

Of the eleven rare plant species, five are endemic to the Fluvial Estuary, two to the St. Lawrence Estuary and Gulf (*Rosa rousseauiorum* and the Smooth rose) and one to northeastern North America (Gaspé Peninsula arrowgrass).

The priority fish species are the Striped bass, American shad, Atlantic sturgeon, Rainbow smelt, Atlantic tomcod, American eel and Atlantic herring. The first five are anadromous, spawning in fresh water, with the larvae and young developing in the Upper Estuary. The decline of these species is largely attributed to degradation of their spawning grounds. Why the St. Lawrence eel population has been in decline over the past decade remains unclear.

Of the eleven priority bird species in the Upper Estuary, seven are breeders. North American populations of Pintail and Blue-winged teal have been falling for the past thirty years. The reasons for the Pintail's decline are unknown, but in the case of the Blue-winged teal, it is likely due to loss of breeding habitat and excessive hunting pressure in Mexico in winter. The Peregrine falcon bred successfully at Cap Tourmente in 1995, a site it has used regularly since at least 1989. Between 1976 and 1992, young falcons were released here in the hope of re-establishing the population. Southern Quebec falcon populations are now well on the way to recovery. The Yellow rail has been spotted at Cap Tourmente in the breeding season, and the marshes in this area are among the few known Quebec breeding sites of the Least bittern and the Sedge wren, two species in decline throughout North America. The same marshes also mark the

limit of the Common gallinule's Quebec breeding range. Lastly, the Sharp-tailed sparrow, listed as a species likely to be designated as threatened or vulnerable, breeds at Cap Tourmente and may have bred at Baie-Saint-Paul.

The four priority marine mammal species are the Beluga, Harbour porpoise, Fin whale and Harbour seal. The difficulties faced by these species are covered in Section 3.5.

3.7 The Human Imprint

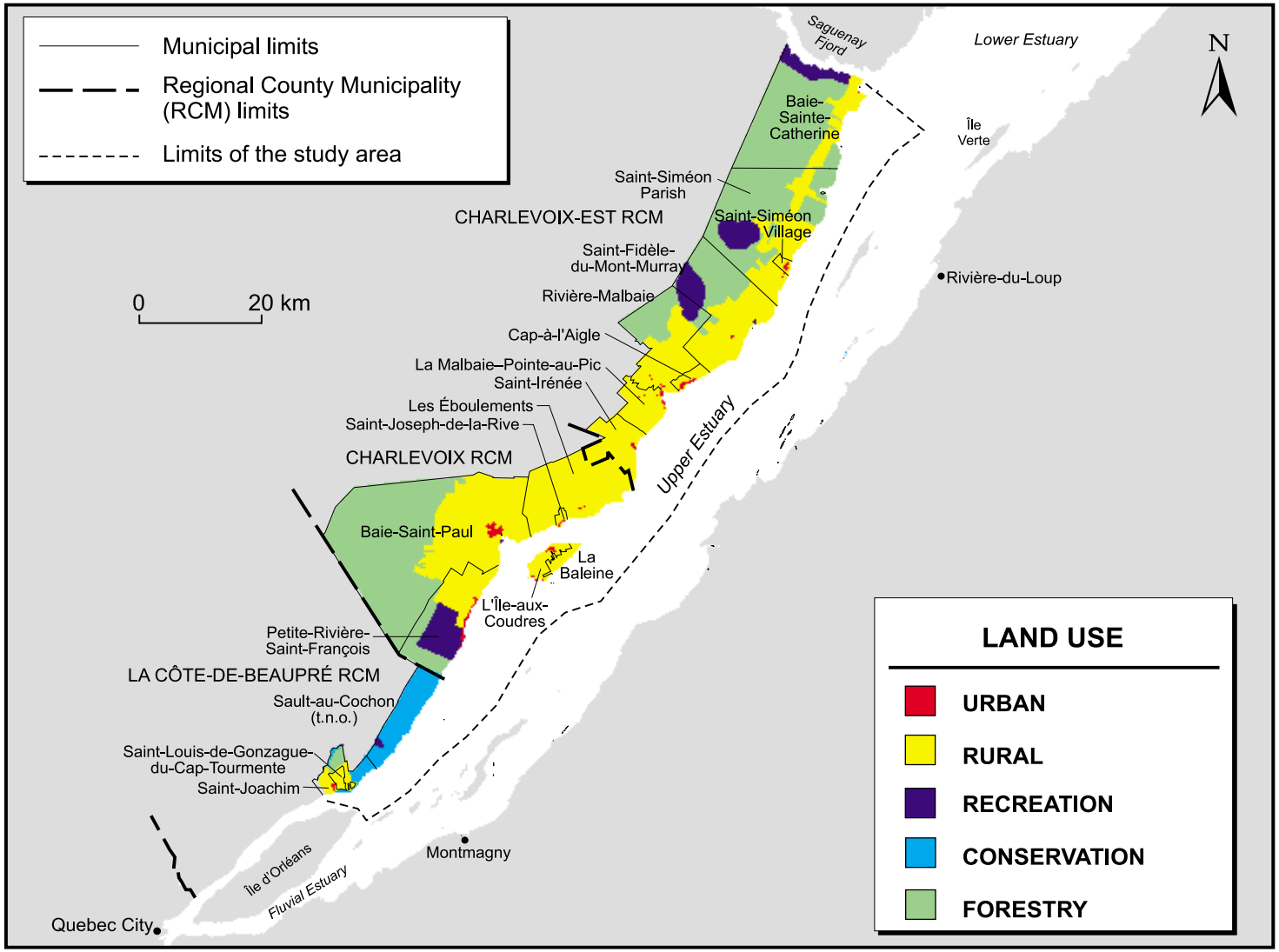
3.7.1 Shoreline land use

The 17 coastal municipalities on the north shore of the Upper Estuary have a combined area of 1959 km^2 and had 23 217 inhabitants in 1996 (Figure 9). They form part of the RCMs of Côte-de-Beaupré, Charlevoix and Charlevoix-Est. The chief urban and industrial centres are Baie-Saint-Paul and La Malbaie–Pointe-au-Pic–Clermont. Most of the land bordering the St. Lawrence is zoned rural, which includes both agricultural and cottaging use, accounting for 52% of the 236 km of shoreline. Urban development, forestry, recreation and conservation account for the remaining 113 km in nearly equal proportions. There are no industrial lands.

3.7.2 Protected lands

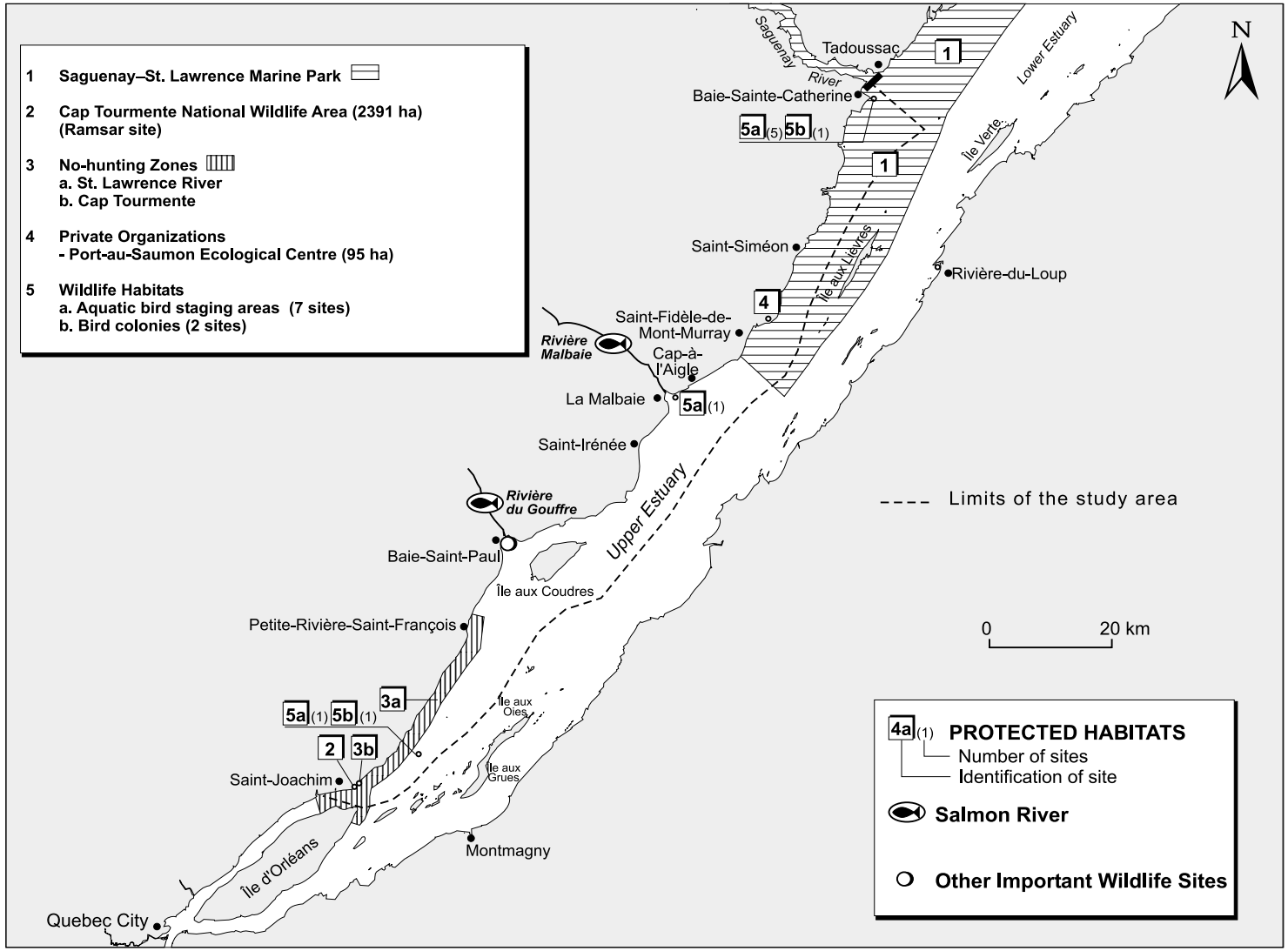
Land in the study area that is protected by provincial and federal legislation includes part of the Saguenay–St. Lawrence Marine Park, a National Wildlife Area, two no-hunting zones, nine wildlife habitats and two salmon rivers (Figure 10).

The **Saguenay–St. Lawrence Marine Park,** officially created in 1997, takes in part of the Saguenay Fjord and parts of the Upper and Lower Estuary of the St. Lawrence. It encompasses all of the study area below Cap- à-l'Aigle. The park, which covers the pelagic and benthic environments up to the high water mark and excludes islands, is jointly managed by the provincial and federal governments.



Source: Charlevoix RCM, 1988; Charlevoix-Est RCM, 1986; Cote-de-Beaupré RCM, 1987.

Figure 9 Land use patterns in the shoreline municipalities on the north shore of the Upper Estuary



Source: Mousseau et al., 1998.

Figure 10 Protected areas on the north shore of the Upper Estuary

The **Cap Tourmente National Wildlife Area** protects 2391 ha of brackish marshland and shoreline habitat. This reserve was established in 1978 and is the first Canadian site whose international significance was recognized under the RAMSAR Convention. It was created to protect the largest migratory stopover of the world's sole population of snow geese. Only a controlled waterfowl hunt is allowed.

The St. Lawrence River and Cap Tourmente **no-hunting zones** (known by their French acronym, *ZIC*) were created to provide waterfowl with staging areas where they can rest in safety during the hunting season. In the former ZIC, the restriction applies only to snow geese.

The nine **wildlife habitats** in the study area protect seven seabird staging areas and two colonies (Cap Brûlé reef and Îlet aux Alouettes) located on public land. Their status precludes any activity likely to alter any physical, chemical or biological component of the environment.

The Du Gouffre and Malbaie rivers also enjoy a form of protection not extended to other watercourses by virtue of their status as **salmon rivers**.

The protection of private land is in the hands of non-governmental agencies. The Port-au-Saumon Ecology Centre protects 95 ha of shoreline habitat. Other stretches of shoreline without legally protected status are recognized for their ecological importance by the RCMs (Figure 9). Zoning in these areas generally limits use and access. The Charlevoix region has been recognized as a **World Biosphere Reserve** since 1989 under a United Nations program.

3.8 Resource-based Activities

3.8.1 Hydro-electric production and water supply

None of the tributaries in the study area has been dammed for power generation, and there are no local municipalities, large-scale industries or farms taking water directly from the Upper Estuary. Water supplies come from watercourses, lakes or the water table. The main users are the municipalities of Baie-Saint-Paul (6001 m^3 per day) and La Malbaie–Pointe-au-Pic

(2650 m^3 per day in 1994), and the Donohue Forest Products paper mill in Clermont (37 200 m^3 per day in 1991).

3.8.2 Commercial shipping and port operations

More than 5000 vessels a year travel the Upper Estuary to or from the St. Lawrence River and Great Lakes ports. This traffic is almost wholly confined to the ship channel hugging the north shore of the estuary.

The sector's main ports are at Pointe-au-Pic and Cap-à-l'Aigle. The former port, run by Transport Canada, handled 149 000 tonnes of merchandise in 1996, most of which was newsprint produced by the local mill. As for the Cap-à-l'Aigle port, it is used mainly as a transshipment point for petroleum products, although there was no commercial activity there in 1995 or 1996. The docks at Saint-Joseph-de-la-Rive, Île aux Coudres and Saint-Siméon serve chiefly as ferry terminals for vehicles and passengers. In 1992, the Saint-Joseph–Île aux Coudres ferry carried 572 531 passengers, and the ferry between Saint-Siméon and Rivière-du-Loup on the south shore of the estuary carried 181 315 people.

3.8.3 Exploitation of biological resources

Commercial fishing. Commercial fishing is much less prominent in the study area than in the Lower Estuary and Gulf of St. Lawrence. In 1995, the total value of landings in the study area was a mere $40,000. There are only 14 commercial fishermen, and there are no processing plants. Targeted species are Capelin, herring, smelt and eel. Most catches are made with fixed intertidal gear.

Sport fishing. Rainbow smelt and Atlantic salmon are the main trophy species for sport fishers in the study area. In summer and fall, smelt are fished from the docks, especially at Pointe-au-Pic, which is a very popular site for this pursuit.

In 1996, 1140 fishing days on the Du Gouffre River yielded total catches of 127 salmon (success rate of 0.11 salmon per fishing day), representing a good year by comparison

with the annual average of 74 salmon over the period from 1989 to 1995 (success rate only 0.06). Data for the Malbaie River are not available; it was declared a salmon river only in 1997.

Other fisheries. The four shellfish beds in the sector, all near Baie-Sainte-Catherine, have been closed because of bacterial pollution. Though hunting of Grey and Harp seal is allowed in the estuary, none of either species has been taken in the study area in recent years. Beluga hunting, once a major activity on Île aux Coudres, ceased in 1972 and has been banned since 1979; hunting of Harbour seals has been banned since 1977. Seaweed is not harvested locally and has little real potential. There is no fish farming in the study area.

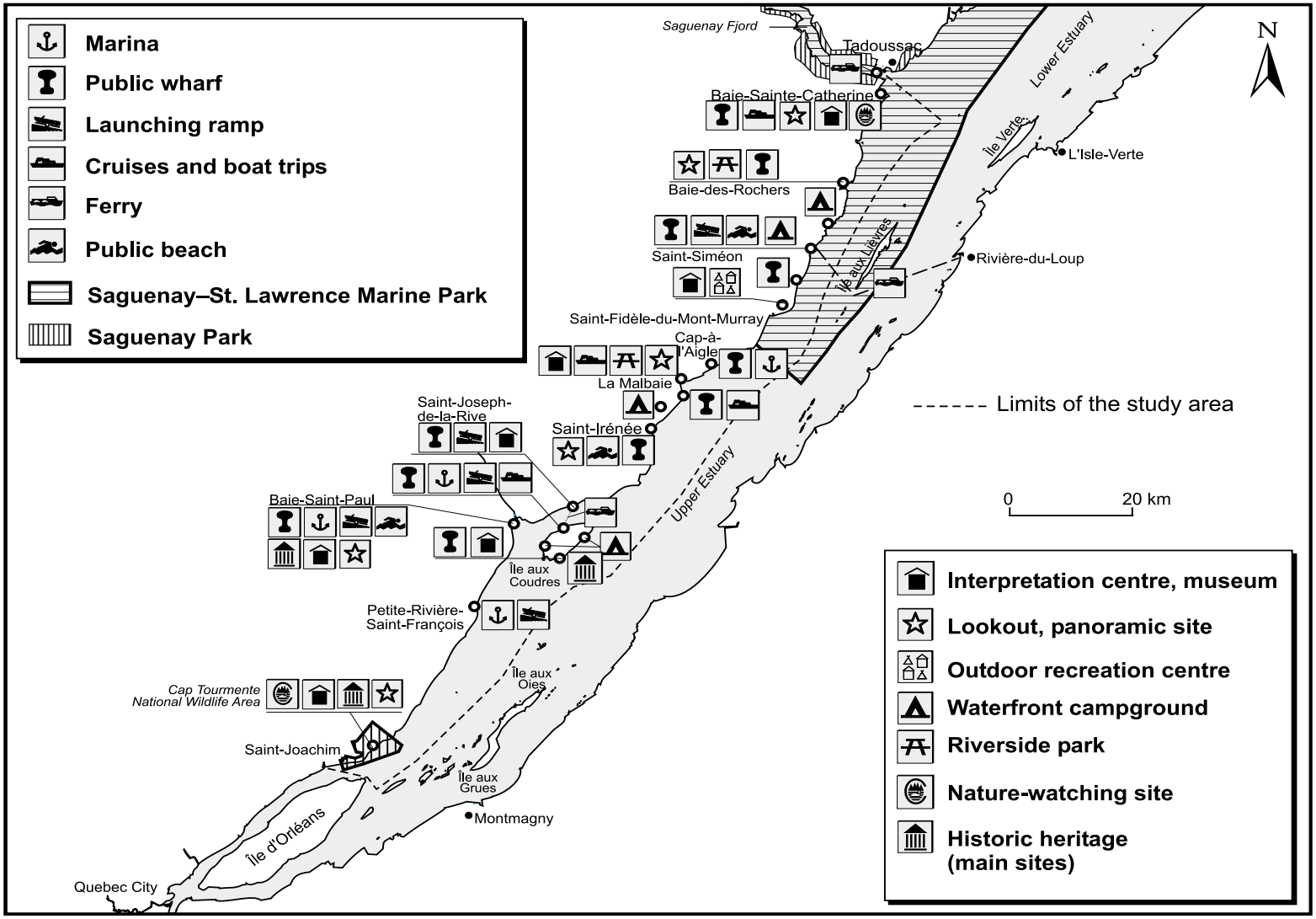
Harvesting of eider down. Gathering of eider down during the nesting season is an established custom on the St. Lawrence Estuary. Harvesting is done on several islands in the lower reaches of the Upper Estuary, including Îlet aux Alouettes, and in the Lower Estuary. In 1994, the total harvest in the estuary was 806 kg of raw down, or about 130 kg of commercial down.

Waterfowl hunting. Except around Saint-Joachim, where the snow goose hunt is very popular, waterfowl hunting is a secondary activity on the north shore of the Upper Estuary.

3.8.4 Non-exploitative recreation and tourism

Beach access. There is little access to the shore in the study area because of the rugged coastline, but there are some ten public docks, waterside parks at La Malbaie and Baie des Rochers, and look-outs at Saint-Joachim, Baie-Saint-Paul, Pointe-au-Pic, Baie des Rochers and Baie-Sainte-Catherine (Figure 11). Also, the rail line runs right along the shore between Cap Tourmente and La Malbaie, giving passengers an unrivalled view of the Charlevoix coastline.

Accommodations and cottages. The study area is characterized by relatively plentiful visitor accommodations and a significant tourism industry. In 1995–96, there were 147 private lodging establishments with a total capacity of 2583 rooms, and 15 campgrounds with 1712 places. There were also 1588 cottages (second homes).



Source: ATR de Charlevoix, 1996; OTCCUQ and MTQ, 1996; Quebec Yachting, 1995.

Figure 11 Recreation and tourism infrastructure on the north shore of the Upper Estuary

Swimming and scuba diving. There are no public beaches registered with the *Environnement-Plage* program in the study area. The beaches at the Saint-Irénée and Saint-Siméon docks were withdrawn from the program in the late 1980s, and the Cap-à-l'Aigle, Saint-Joseph-de-la-Rive and La Malbaie beaches were never a part of it. There are no figures for attendance at these beaches, but it is estimated that 3–12% of shoreline residents swam or indulged in other water-contact pursuits (water skiing, windsurfing, sea-dooing, etc.) at least once in 1995. Saint-Fidèle and Baie-Sainte-Catherine are the main locations for scuba diving.

Sailing. There are four marinas or sailing clubs in the study area with 113 berths (Petite-Rivière-Saint-François, Baie-Saint-Paul, Île-aux-Coudres and Cap-à-l'Aigle). There are also five launching ramps (Figure 11).

Access to the water. The water is accessible through two ferry services (Saint-Joseph–Îles-aux-Coudres and Saint-Siméon–Rivière-du-Loup) and sea cruises from Île-aux-Coudres, Pointe-au-Pic and Baie-Sainte-Catherine. There are five operations offering whale-watching cruises at the mouth of the Saguenay, two of which also offer cruises along the north shore of the Upper Estuary.

Marine and maritime heritage interpretation. The main centres for the interpretation of nature are at Saint-Joachim (Cap-Tourmente National Wildlife Area Interpretation Centre), Baie-Saint-Paul (Charlevoix natural history centre), Île aux Coudres (Île-aux-Coudres museum), Saint-Fidèle (Port-au-Saumon ecology centre) and Baie-Sainte-Catherine (Pointe-Noire interpretation centre). The best bird-watching sites are at Cap Tourmente and along the shores of Île aux Coudres.

The main centres for interpretation of the historical and seafaring heritage are the maritime exhibition/Economuseum (Saint-Joseph) and the observation and interpretation centre at the Musée Les Voitures d'Eaux (Île aux Coudres).

CHAPTER 4

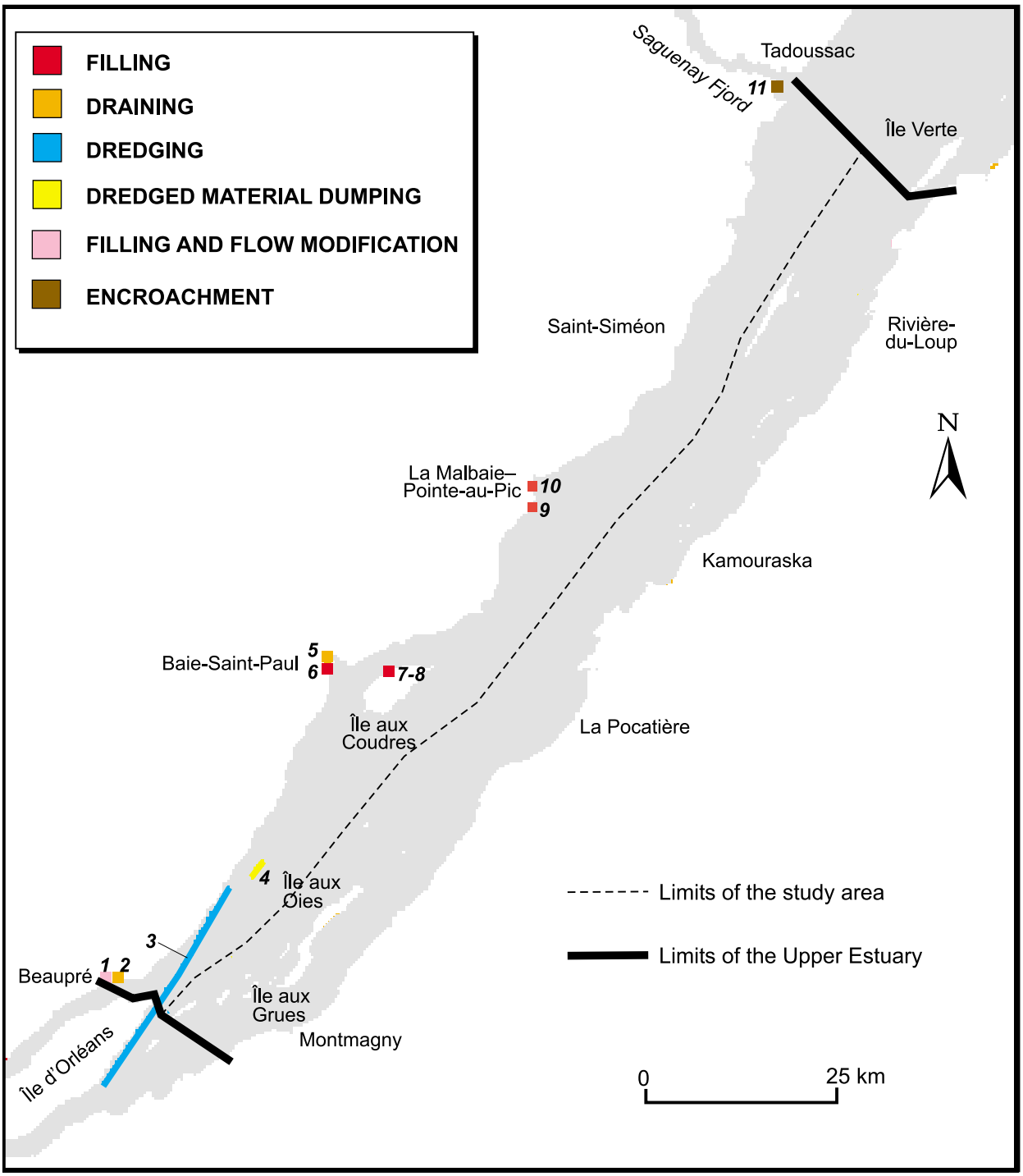
Human Activities and Their Main Effects on the Environment

4.1 Physical Modification of the Environment

Damming. The damming of many of the tributaries of the St. Lawrence for power generation has considerably reduced seasonal fluctuations in the flow of fresh water into the estuary. The amplitude of seasonal variations in discharge is estimated to have been halved since 1970. The impact of this change in freshwater flow on the study area is not known. One result may be diminished productivity because of the slackening of the estuarine circulation generated by this input of fresh water. This circulation boosts the upwelling of nutrient-rich deep water to the surface, thus promoting primary production. Dams are also an obstacle to migrating anadromous and catadromous fish species.

Shoreline encroachment. The study area is one of the sections of the St. Lawrence least affected by shoreline encroachment. Between 1945 and 1984, only 27 ha of intertidal environment was affected by filling, encroachment or drainage. Small areas of wetland have been lost at Saint-Joachim, Baie-Saint-Paul and La Malbaie (Figure 12).

Dredging. The upper reaches of the North Channel and the North Traverse have to be dredged each year to maintain a minimum draft of 12.4 m at low tide in the ship channel. About 90 280 m^3 of sandy sediment is dredged annually and dumped at designated points, two of which are located in the study area. The Île aux Coudres dock is dredged yearly (an average of 9400 m^3 from 1992 to 1996); the Saint-Joseph and Saint-Joachim docks are dredged less frequently, and the Cap-à-l'Aigle dock only occasionally. In all cases, dredged material is dumped off shore.



ORIGINAL HABITATS. **Swamp**: site 7. **Marsh and wet meadow**: sites 2, 5, 10. **Aquatic plant community**: sites 5–6. **Mudflat**: sites 1, 8. **Rocky foreshore**: site 11. **Deepwater**: sites 3–4, 9.

Source: Robitaille et al., 1988.

Figure 12 Physical modifications to habitat surveyed on the north shore of the Upper Estuary between 1945 and 1984

4.2 Pollution

4.2.1 Main sources of contamination

Some contaminants, such as readily degradable organic matter, bacteria and nutrients (nitrates and phosphates), have no lasting effects, and environmental quality improves rapidly once dumping ceases or as one moves away from the source of contamination. Other, persistent contaminants, on the other hand, are carried great distances in the water or atmosphere and tend to accumulate in sediments and living organisms. Among these are polychlorinated biphenyls (PCBs), organochlorine pesticides (DDT, dieldrin and mirex), polycyclic aromatic hydrocarbons (PAHs), dioxins, furans, and mercury.

On this basis, sources of contamination can be grouped into two major categories. There are **remote sources**, delivering persistent toxic substances to the study area in the waters of the St. Lawrence River, in the deep waters flowing into the Upper Estuary from the Lower Estuary, and through atmospheric deposition. The second category comprises **local sources** situated on the shores of the estuary or on the water itself (shipping), releasing both persistent and non-persistent contaminants.

4.2.1.1 *Remote sources*

The St. Lawrence River. The Fluvial Estuary of the St. Lawrence is the chief source of suspended matter in the Upper Estuary and thus is a vector for a number of contaminants with a tendency to bind to suspended particles; among these substances are mercury, PCBs, PAHs, organochlorines and others. In this way, pollutants from the industrial heartland around the Great Lakes and along the St. Lawrence reach the Upper Estuary. For example, it is estimated that 52% of the PAH load passing Quebec City comes from the Great Lakes, the St. Lawrence River and industrial effluents.

Atmospheric deposition and seawater. There is little industry, agriculture or urban development on the shores of the Gulf of St. Lawrence and the northwest Atlantic Ocean. Atmospheric deposition over Eastern Canada and the adjacent ocean is the leading source of

contaminants carried into the Upper Estuary from the Gulf in the deep waters, though the load is not known. This fallout may be quite a significant source of such toxic substances dumped into the atmosphere as mercury, lead, PCBs, PAHs, dioxins and furans. The Saguenay Fjord is heavily polluted with mercury and probably adds to the load of this heavy metal in the Upper Estuary.

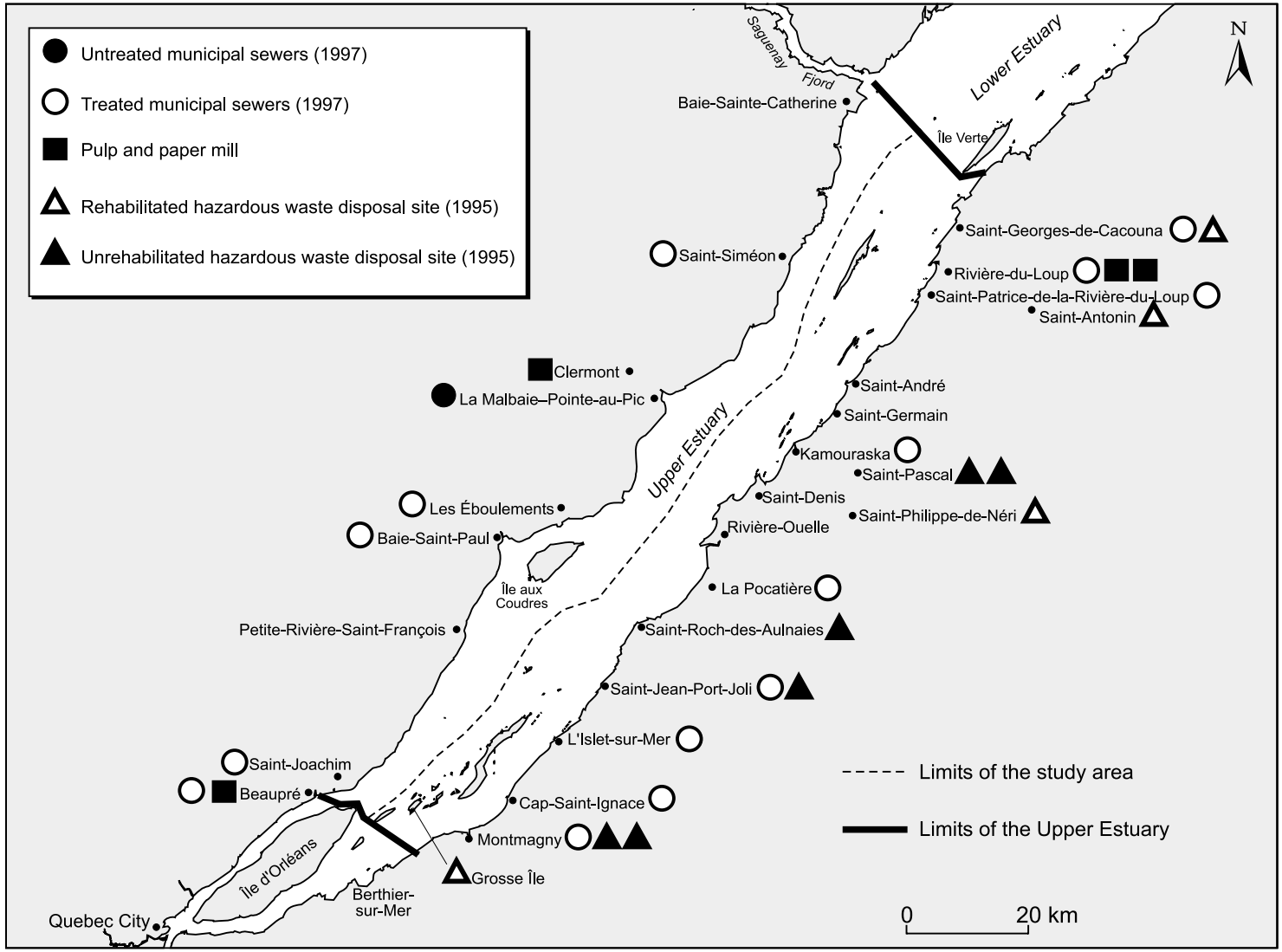
4.2.1.2 *Local sources*

Municipal wastewater. By the end of 1997, seven of the 17 shoreline municipalities in the study area (Saint-Joachim, Rivière-du-Gouffre, Baie-Saint-Paul (village and parish), Les Éboulements and Saint-Siméon (village and parish)) were channeling some or all of their wastewater to one of four treatment plants (Figure 13). These plants serve 30% of the population of the shoreline municipalities in the study area. The municipality of Saint-Joachim sends its wastewater to the Beaupré plant, outside the study area. The oldest of the plants (Baie-Saint-Paul) was inaugurated in 1989, and the other three have come into operation since 1993. The two plants operating in 1994 were certified as being compliant with wastewater standards.

A fifth treatment plant is expected to be operational in December 1998 in La Malbaie, serving three more municipalities. This will bring the proportion of the study area's population with wastewater treatment to nearly 61%.

The majority of the remaining seven municipalities have no sewer systems. Most household wastewater goes to individual septic systems, though in some cases it is dumped raw into the estuary or its tributaries.

Industrial effluents. A pulp and paper plant – Donohue Forest Products Inc. in Clermont – and a cable and metal strip plant – BICC Phillips Inc. in Rivière-Malbaie – both dump their wastewater into a tributary in the study area and are listed as priority plants under the SLV 2000 Action Plan.



Source: Gagnon et al., 1998; Gratton and Bibeault, 1998.

Figure 13 Main local sources of pollution in the Upper Estuary

The **Donohue** plant makes newsprint from wood chips and de-inked thermomechanical pulp. It has not used logs as raw material since 1993. The pulp is bleached with sodium hydrosulphite, and process wastewater is dumped into the Malbaie River about 10 km from its mouth, while domestic wastewater goes into the Clermont municipal sewer system and is treated in aerated ponds. Until 1995, process wastewater was only subject to primary treatment (settling) before being discharged. In that same year, a secondary activated-sludge treatment system was inaugurated, as was a primary and secondary sludge burner.

From 1988 to 1995, plant discharges of highly degradable organic matter were reduced by 96%; likewise discharges of suspended matter dropped by 77%. Effluent toxicity was reduced by 95%. In 1995, the effluent contained none of the 11 persistent bioaccumulating toxic substances targeted for virtual elimination under SLV 2000 (PCBs, DDT, dieldrin, toxaphene, dioxins, furans, mirex, mercury, lead, benzo(a)pyrene and hexachlorobenzene). Bioassays of the plant's effluent indicated that it was no longer toxic to aquatic life.

The **BICC Phillips** plant makes cables and metal strips from aluminum rods and steel wire. In 1995, it was operating at 70% of its nominal capacity (16 360 tonnes per year). No process wastewater is dumped into the aquatic environment; domestic wastewater and cooling water from heat exchangers and boilers go into a septic tank which empties into a ditch draining into the Malbaie River.

The reduction in effluent flow achieved between 1993 and 1995 had the effect of cutting the discharges of suspended matter, aluminum, iron, and oils and greases by 98%, 100%, 55% and 87%, respectively. In 1995, none of the 11 persistent bioaccumulating toxic substances targeted for virtual elimination under SLV 2000 and listed above were detected in the final effluent, which proved to be non-toxic to aquatic life in bioassays.

Hazardous waste dump sites. No hazardous waste disposal sites were reported in the study area in federal or provincial surveys conducted in the 1980s.

Snow dumping. We have no data on the volume of snow dumped either directly into the estuary or at sites immediately bordering the study area. Since November 18, 1997, the

provincial environment ministry has wielded a new regulation providing for retaliatory charges on any municipalities continuing to dump snow into watercourses starting in winter 1999–2000.

Agriculture. In 1995, there were reported to be 578 working farms in the municipalities along the shores of the Upper Estuary, occupying 58 964 hectares of land. Close to 25% of these operations were on the north shore. The main crops are forage and grain, and the chief livestock cattle and hogs. The total quantity of chemical fertilizer applied dropped by nearly 70% between 1981 and 1986, but the area treated with pesticides grew by 84% between 1981 and 1991. More than half the farms rotate crops to control erosion. From 1988 to 1996, 30 farmers in the study area took advantage of the assistance program for improving manure management to reduce the dumping of livestock excrement into the environment.

Logging. Hinterland forests are routinely sprayed with insecticide against the spruce budworm and other insect pests and with herbicides used to optimize the yield of pulpwood species. Until the mid-1970s, DDT was used; this is a chemical insecticide that remains in the environment for a very long time and whose toxic degradation byproduct, DDE, is still found in the tissues of estuary wildlife. Now a less stable chemical insecticide, fenitrothion, and a biological agent, *Bacillus thuringiensis*, are used instead.

Shipping and port operations. Shipping is a potential source of pollution in the event of marine accidents, dumping of swabbing or bilge water directly into the sea or during transshipment and cargo stowage in port. No major spills have afflicted the study area so far. Minor accidents during transshipment operations in port are more frequent, though we have no data on this subject. Such activities are marginal in the study area.

Dredging. Maintenance dredging in ports, fishing harbours and marinas is a source of pollution inasmuch as it stirs up toxic substances that would otherwise remain cut off from the aquatic environment in deep sediments or confined to isolated sites away from the general circulation.

Hunting (lead shot). Lead shot used by hunters can be a major source of contamination of sediments and bottom-feeding organisms, especially ducks. Cartridges with

non-toxic shot have been mandatory since 1996 in National Wildlife Areas, since 1997 within 200 m of open water or watercourses, and will be mandatory everywhere else beginning September 1, 1999.

4.2.2 Effects of contaminants on resources and uses

Appendix 2 lists the criteria and directives for evaluating the extent to which contaminants in water, sediments and organisms pose a risk to aquatic life and human health, thus inhibiting certain uses.

4.2.2.1 *Water contamination*

Up-to-date data on water quality in the study area are very sparse. Off shore, readily degradable biological matter, nutrients and pathogenic organisms from various sources of pollution are considerably diluted by the mixing of fresh and salt waters, and their concentrations do not exceed even the strictest quality criteria set for these parameters. Persistent toxic substances (heavy metals, organochlorines and hydrocarbons) gradually thin out seaward as a result of the progressive dilution of river water in sea water and the retention in the maximum turbidity zone of suspended matter, to which many toxic substances tend to bind. Maximum concentrations of toxic substances measured in the waters of the Upper Estuary since the early 1980s have not exceeded the criteria set for the protection of aquatic life, except in the case of total PCBs, which exceeded the criterion in the maximum turbidity zone in 1987. The data available also show a significant drop in oil residue concentrations in the estuary during the 1970s, but are too sketchy to follow the course of contamination by substances of concern in the sector since the mid-1980s.

Data on shoreline water quality are practically non-existent. The highly fragmentary data suggest that microbiological pollution near urban centres was significant in the 1980s. This situation has doubtless improved with the opening of municipal wastewater treatment plants starting in 1989.

4.2.2.2 *Sediment contamination*

Overall, heavy metal pollution of sediments was less severe in the Upper Estuary than in the St. Lawrence fluvial lakes, the Saguenay Fjord or the Lower Estuary in 1989–1990. This pattern is due to the progressive release of heavy metals bound to suspended matter with increasing salinity, dilution of sediments carried down the river by less contaminated sediments from tributaries or the bed of the Upper Estuary itself, and the greatly reduced local anthropic input. Mercury levels were moderate in the upstream and downstream parts of the sector and relatively low in the mesohaline zone, suggesting that the St. Lawrence and Saguenay rivers were the main sources of this metal. Chromium, nickel and zinc contamination diminishes seaward and is thought to come largely from the river; lead pollution was low everywhere.

Because sedimentation in the Upper Estuary is only temporary, sediment cores do not yield a chronology of contamination. A comparison of data gathered in 1989–1990 with those dating back to 1972–74 suggests that the sediments of the Upper Estuary are significantly less contaminated with heavy metals than they were.

Data from 1989–1990 on organic toxic substances indicate that the study area suffers little from contamination by PAHs or organochlorine pesticides. PCB levels exceeding those found in Lake Saint-Pierre and the Lower Estuary were measured in the sediments in the region of Cap Tourmente. PCBs carried down the river are thought to collect in the maximum turbidity zone, bound to suspended matter.

4.2.2.3 *Contamination of the food chain*

Aquatic organisms tend to accumulate toxic substances in their body tissues to higher levels than in the ambient water or sediment (**bioconcentration**). **Bioaccumulation** occurs when a contaminant is assimilated at a higher rate than it is eliminated, so that contamination increases as the organism ages. Most aquatic organisms, except molluscs, are able to regulate their body burdens of heavy metals (other than mercury) and to metabolize PAHs quickly, thereby not accumulating these substances. The majority of living organisms, however, are incapable of

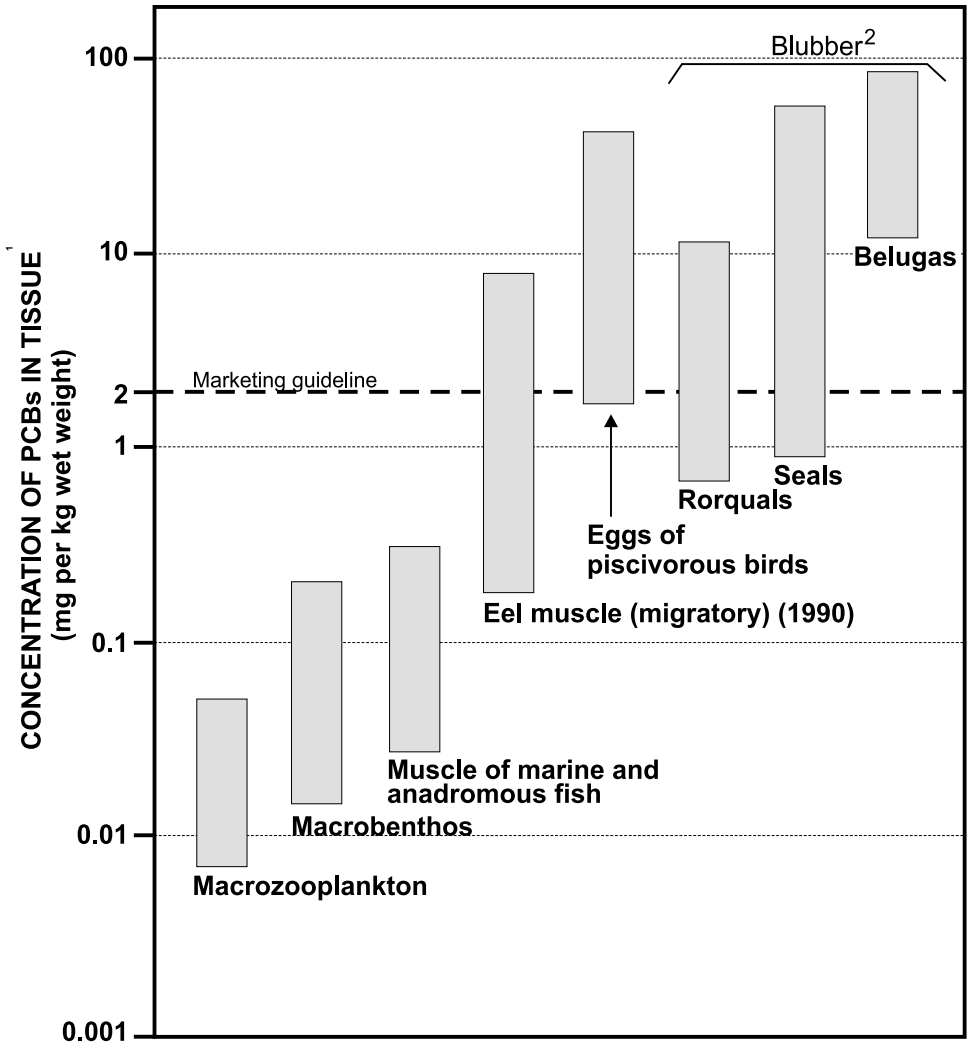
rapidly eliminating or metabolizing mercury or organochlorines such as PCBs, DDT or mirex. Toxic substances become more concentrated with each link in the food chain, and vertebrates have much higher levels than invertebrates. This phenomenon, **biomagnification**, has been well documented in the food chain in the St. Lawrence Estuary for PCBs (Figure 14), mirex and mercury. For example, PCB concentrations in the body fat of Belugas are one hundred to one thousand times higher than in benthic or planktonic invertebrates. Levels of biomagnified contaminants in estuarine organisms depend on the organism's place in the food chain and the time it spends in the estuary. Thus, Fin whales are much less contaminated than Belugas because their main prey species are herbivores (euphausids) and they come into the estuary only in summer, whereas the Beluga eats carnivorous prey (fish) and lives in the estuary year-round.

The very fragmentary data available indicate that seaweed and invertebrates in the study area are not highly contaminated with persistent toxic substances. Among fish, mercury, PCBs and two organochlorine pesticides (dieldrin and mirex) may reach problematic concentrations in Sauger, Atlantic tomcod and American eel.

In the early 1990s, mercury reached concentrations exceeding marketing limits in the flesh of some 2% of migratory eels from the Great Lakes and the fluvial stretch of the St. Lawrence River. Some Atlantic tomcod and Sauger were also over the limit. However, mercury contamination has dropped considerably since the 1970s and 1980s; in 1982, 8.6% of migratory eels were highly contaminated with mercury.

The eel is the only fish species in the study area in which PCB tissue concentrations exceeded marketing standards. Nearly 80% of migratory eels were heavily contaminated with PCBs in 1982, but the percentage had fallen to 36% by the early 1990s. In smelt and tomcod, concentrations are less problematic, but they are still seven to eight times higher than in the main prey species (zooplankton).

In the case of organochlorine pesticides, migratory eels again show disturbingly high levels of two of the many targeted substances, namely mirex and dieldrin. In 1990, mirex exceeded marketing standards in the flesh of 29% of migratory eels (52% in 1982), and dieldrin levels were exceeded in 15.7% of specimens.



Source: Béland et al., 1992; Gagnon and Dodson, 1990; Hodson et al., 1992; Hodson et al., 1994; Muir et al., 1990; Wagemann et al., 1990.

1. The figure shows the extent of findings in organisms of the Upper and Lower Estuary (excluding Baie des Anglais).
2. PCB concentrations are higher in the subcutaneous fat than in the muscles of the same individual.

Figure 14 Biomagnification of PCBs in the food chain of the St. Lawrence Estuary and Gulf

As a result of biomagnification, concentrations of persistent toxic substances in fish-eating (piscivorous) birds and marine mammals are much higher than in the fish themselves. Thus, mercury may reach very high concentrations in the liver of seals, Minke whales and Belugas in the estuary.

Organochlorines have a strong affinity for lipids and accumulate especially in the subcutaneous fat and breast milk of marine mammals and in the eggs of birds. Poultry egg marketing standards are widely exceeded for PCBs in the Double-crested cormorant, Great blue heron, Black-crowned night heron, Ring-billed gull and Razorbill in the Upper Estuary. Even higher PCB concentrations have been found in the subcutaneous fat of the Beluga, Grey seal and Harbour seal in the estuary.

Levels of organochlorine contamination in bird eggs in the estuary are mid-way between those of the Great Lakes and Canada's Atlantic coast. Levels have been falling since the 1970s, and, overall, present levels do not appear to be adversely affecting populations.

In the Beluga, the situation may be different. Concentrations of some organochlorines (PCBs, DDT and mirex) in the estuary population are at least ten times higher than in the Arctic population. Mercury and lead concentrations are also higher than in the Arctic. On the other hand, concentrations of PAHs, dioxins and furans in estuary Belugas are very low, even undetectable. These contaminants are likely to be metabolized rather than bioaccumulated. By contrast, one of the degradation byproducts of benzo(a)pyrene, a PAH of industrial origin, is more toxic than the parent substance and is a potential carcinogen. This derivative has been found in higher concentrations in the estuary population than in that of the Arctic.

No marked trend either way has shown up so far in Beluga contamination levels, but the many pathologies seen in beached specimens (tumours, both malignant and benign, glandular lesions, infections symptomatic of a defective immune system, dental periostitis and tooth loss) may be associated with high contamination levels.

After Belugas, seals are the marine organisms most heavily contaminated by toxic substances. PCBs, DDT and mirex have shown up in very high concentrations in the subcutaneous fat of Harbour and Grey seals and in much lower concentrations in Harp seals. The

livers of some Grey seals are heavily contaminated with mercury and those of some Harbour and Harp seals with cadmium.

4.3 Introduced or Expanding Species

Purple loosestrife. This is a European species which has invaded the freshwater marshes of the St. Lawrence. It is now well established and rapidly spreading in the Cap Tourmente National Wildlife Area. In ten years, the area it covers has tripled, from 10 to 30 hectares. Purple loosestrife is considered a real pest species in some parts of Canada and the United States because it saps the diversity of marshland plant communities.

Non-indigenous organisms carried in ship ballast. Ballast water in merchant ships may harbour great numbers of planktonic or benthic organisms, so that dumping of ballast is a potential vector by which exotic species can enter the marine environment. Some introduced species may adversely affect ecosystems, as is the case with the Zebra mussel and the Quagga mussel, introduced into the fresh waters of the Great Lakes in the 1980s. These two species reach the limit of their range in the oligohaline zone.

Double-crested cormorant. The rapid expansion of the Double-crested cormorant population in the St. Lawrence Estuary in the 1980s occasioned some destruction of Common eider breeding habitat. Between 1988 and 1993, their numbers in the study area were controlled by culling adults and destroying eggs in five colonies. In 1993, only about 10 000 pairs were counted, rather than the 25 000 that could have been expected without the control measures.

Greater snow goose. The spectacular growth of the Greater snow goose population in recent decades has seen the significant expansion of migratory stopovers into cord-grass marshes and farmland (pasture and cornfields) in spring. Grazing on harvest residues does little real damage, but this is not the case when sprouting forage crops are consumed. In 1992–94 the most seriously affected farmland was on the south shore of the Upper Estuary, in Kamouraska and Rivière-du-Loup RCMs. Crop loss estimates range from $210,000 to $905,000 for the period 1992–96, a much smaller amount than the economic benefits deriving from the snow goose

migration ($21 million per year). Various measures have been proposed for mitigating the impact of the snow goose population on crops: scare programs, setting aside of feeding areas, compensation to farmers, alternative farming practices, etc.

4.4 Disturbance of Birds and Marine Mammals

The massive development of marine recreational activities and tourism in the study area has raised concerns about the possible effects of sustained human presence in habitats that were relatively inaccessible to the general public until recently.

For example, the Common eider is very vulnerable to disturbance by pleasure craft when broods are being raised. Disturbance by visitors can also disrupt breeding in eider colonies by exacerbating predation of eggs and young.

Marine mammals, especially the Beluga, are sensitive to disturbance by boats, sea-doos, kayaks and low-flying aircraft. Such traffic may affect the whale's acoustic environment, hinder its movements, interfere with its social behaviour and occasion collision risks. To limit such disturbance, Fisheries and Oceans Canada has issued directives to operators of pleasure and excursion craft on how to proceed with whale watching.

4.5 Overfishing

One effect of fishing may be to reduce both the biomass of the populations harvested and the average size of their members. Such phenomena are normal and do not endanger populations as long as the stock can replenish itself, but the decline of some major resources in the study area may be partly due to overfishing of populations already rendered vulnerable by other, environmental factors.

CHAPTER 5 Risks to Human Health

This section on health provides users of the north shore of the Upper Estuary and shoreline residents with better knowledge of the health risks associated with using the waters of the St. Lawrence River.

5.1 Fish Consumption

5.1.1 Chemical contamination

Recent data on chemical contamination of fish in the study area are sparse, but it is known that mercury concentrations sometimes exceeding the administrative guidelines set by Health Canada for marketing fish products have been found in some Sauger and tomcod taken off Saint-Jean-Port-Joli (south shore). High concentrations (in excess of administrative guidelines) of mercury, PCBs, mirex and other pesticides have also been found in eel taken at several sites in the study area (Kamouraska, Cacouna and Saint-Irénée). The American eel is considered the most heavily contaminated species in the St. Lawrence. The sport fishing guide to consumption of Quebec freshwater fish (MEF and MSSS, 1995) recommends no more than two meals per month of Sauger and four of Atlantic tomcod taken in this sector. The guide recommends that pregnant women, nursing mothers and young children abstain completely from eating eel and advises other people to limit their consumption as much as possible.

Though the data available do not give a complete picture of the contamination status of other marine species of the Upper Estuary at present, the relatively low concentrations found in populations further downstream (Lower Estuary and Gulf) suggest that the fish in the study area are also largely clean. This means that nominally marine species can be eaten without restriction, especially since fish has certain benefits; as well as being a good source of proteins, vitamins and minerals, fish in the diet protects against certain disorders, in particular ischemic heart disease. Moreover, for pregnant women and nursing mothers, fish is an important source of

polyunsaturated fatty acids (especially omega-3) and the nutrients needed for development of the nervous system in the fetus and in the first few months of the infant's life.

Yet fish consumption is the chief source of exposure to the chemical contaminants of the St. Lawrence, and heavy and habitual consumption of the more contaminated species may provoke health problems over the long term. Compliance with the recommendations is therefore advisable to minimize health risks.

5.1.2 Microbiological and parasitic contamination

The presence of parasites or external abnormalities in fish from the St. Lawrence is sometimes striking. Fortunately, most fish parasites are no threat to human health. However, the following preventive measures are recommended: avoid eating the skin or entrails, and cook the flesh thoroughly; this will eliminate the risk of microbiological or parasitic contamination. Freezing also kills off most parasites. Lastly, as a precaution, avoid eating fish exhibiting visible abnormalities, such as ulcerous dermatitis, lumps on the skin, oral papilloma, and so forth.

5.2 Shellfish Consumption

5.2.1 Chemical contamination

In general, the molluscs of the St. Lawrence Lower and Upper Estuary and Gulf are quite free of contamination by chemical substances, and concentrations of the main contaminants for which testing is done (mercury, PCBs, DDT, mirex, dioxins and furans) are often well below fish and seafood marketing limits, so that as far as chemical contamination is concerned, the risks associated with eating shellfish are deemed negligible.

5.2.2 Bacteriological contamination

Municipal wastewater, diffuse agricultural pollution, cesspits and concentrations of seabirds may create bacteriological water pollution hazards in many parts of the study area, and this will affect the quality of edible shellfish, which should therefore be gathered only in places approved by the Department of Fisheries and Oceans Canada (DFO). This is the federal

government department responsible for using the data collected by Environment Canada under the *Canadian Shellfish Sanitation Program* to decide where shellfish can safely be harvested.

Bacteriological contamination of shellfish beds is a serious problem in the St. Lawrence, and the north shore of the Upper Estuary has not remained unaffected. In fact, there are currently no shellfish beds open for harvesting. It should be noted that the shellfish sold on the market is subject to inspection and poses no danger.

Eating bacteria-contaminated shellfish can provoke digestive and intestinal troubles. Along the north shore in the study area, no cases of food poisoning associated with shellfish have been reported to public health authorities, but given the under-reporting of intestinal upsets, most cases of which do not require medical attention or hospitalization, the scale of the problem remains unclear.

5.2.3 Contamination by toxic algae

The microscopic algae *Alexandrium* sp. (main type of toxic algae found in the St. Lawrence) produce a biotoxin which, once ingested by humans, can cause severe poisoning (called Paralytic Shellfish Poisoning, or PSP), even leading to death. This toxin reaches humans mostly through consumption of bivalves (clams and mussels) containing the algae. The shellfish themselves are not affected by the toxin.

The study area suffers little from shellfish toxicity, for the oceanographic conditions in the Upper Estuary (high turbidity, unstable water column) are such that the toxin levels measured to date in shellfish meat have always been within government standards.

Nonetheless, the safest way to avoid health problems is to abide by the shellfish gathering restrictions imposed by the DFO. The DFO is empowered to open and close shellfish beds on the recommendations of the Canadian Food Inspection Agency, which runs a detection program for various toxins in seafood products.

5.3 Seaweed Consumption

A study of seaweed samples taken from the St. Lawrence, including two stations on the north shore of the Upper Estuary (Ile aux Coudres and Baie-Sainte-Catherine) measured various inorganic and organic contaminants. The levels observed in seaweed are generally very low, often too low to detect. Only iodine and cadmium in some species could be a potential threat to human health if eaten in large quantities. Steeping and boiling in water should reduce the iodine content of seaweed.

5.4 Waterfowl Consumption

Following an analysis of data gathered nationwide on contamination in waterfowl, the Food Branch of Health Canada has declared that eating migratory birds is not hazardous to human health. In fact, concentrations of contaminants in samples were generally very low or below the detection threshold. Exposure to organochlorines can still be reduced to a minimum by using cooking methods that eliminate as much of the fat as possible, especially in the case of fish-eating birds.

As in the case of fish, duck parasites do not usually pose a threat to human health. To eliminate any risk of contamination, whether parasitic or microbiological, meat should be cooked thoroughly.

5.5 Recreational Activities

5.5.1 Risks associated with water quality

The health risks associated with water-contact recreational activities are essentially of microbiological origin. Dumping of household, industrial and agricultural wastewater boosts the count of microbes that can cause such health problems as gastro-enteritis and infections of the skin, eyes and ears. Windsurfers, sea-dooers and water skiers should remember that they are not immune to these infection risks. Given the low concentrations reported, health risks associated with chemical contamination of the water are deemed practically non-existent in the study area.

On the north shore of the estuary, there are no public beaches currently being monitored for microbiological water quality. Since up-to-date and regular tests are the only way to know whether a particular site is actually safe to use, swimming and other contact activities still represent a degree of risk. It is therefore important to check with local authorities (MEF, Public Health Branch, municipality) as to the safety of the water where such activities are planned. Signs banning shellfish gathering and proximity of sanitary or storm sewer outfalls are signs that local waters may be microbiologically contaminated. Caution is called for when these indicators are noticed.

5.5.2 Risks arising from physical hazards

In 1996, the Coast Guard's Marine Rescue Centre was called out to 109 incidents involving pleasure craft between Quebec City and Tadoussac. Mechanical failure and loss of control were the two leading causes of incidents reported. Sixty percent of cases involved motor boats. Generally speaking, serious accidents were attributable to lack of training and knowledge on the part of pleasure craft operators and to alcohol consumption. Many people still neglect to wear life jackets, which makes incidents more serious than they need be.

Drownings, injuries, hypothermia and psychological disturbances resulting from accidents are the most significant risks associated with nautical activities in the St. Lawrence. Since 1992, there have been three drowning deaths connected with recreational activities in the study area.

5.6 Environmental Accidents

5.6.1 Natural occurrences

The waterways in this region are subject to the influence of the St. Lawrence tides and wind direction. The movement of water in the St. Lawrence may cause ice jams at the mouths of rivers, leading to floods. On the north shore of the Upper Estuary, a number of watercourses have been designated as flood risks, among them the Du Gouffre, Bras-du-Nord and Malbaie rivers. In

1993, five homes in Baie-Saint-Paul were flooded. There are landslide risks in Petite-Rivière-Saint-François, Saint-Joseph-de-la-Rive, La Malbaie–Pointe-au-Pic and Rivière-Malbaie.

Physical health problems (generally due to unhygienic conditions) are among the hazards to which disaster victims are exposed, though they do not necessarily recur at every incident. The psychological and social impacts of property losses or evacuation, while hard to quantify, are quite probably significant.

5.6.2 Technological accidents

In recent decades, a number of environmental accidents involving hazardous cargoes have occurred in the Upper Estuary and the fluvial stretch of the river. The substances spilled were mainly hydrocarbons. However, none of these incidents has had any impact on the health of people living along the shores of the Upper Estuary. Yet the risk remains, given the volume of dangerous cargoes carried on the St. Lawrence, and challenging navigational conditions in the study area (strong tides, marine currents, narrow channels, etc.) magnify the accident risk.

.

CHAPTER 6 Strategies for Sustainable Development

Sustainable development of the Upper Estuary means restoring and preserving plant and animal biodiversity, a variety of uses and the quality of life associated with those uses for future generations. The action taken must provide for economic development while ensuring the survival of resources and maintenance of environmental quality. Some of the avenues for doing this are:

reducing pollution

protecting and rehabilitating disturbed habitats and resources

improving access to the St. Lawrence

reconciling recreation and tourism development with environmental protection.

Through this exercise, we seek to identify the main environmental issues in the sector and describe some of the programs and actions already taken to promote sustainable development (Table 1). This review is in no way exhaustive and constitutes only a basis for discussion among the local interests, who will have to establish their own approaches and priorities for action on a local scale in fulfilment of their Ecological Rehabilitation Action Plans (ERAPs).

6.1 Reducing Pollution

Pollution-related restrictions on uses in the study area (swimming, shellfish gathering) are largely the fault of local contamination sources. Since the mid-1990s, serious efforts have been made to attenuate these local sources of pollution, but there is still room for improvement, especially on the part of those municipalities that do not yet treat their wastewater. In any case, the recovery of uses constrained by bacteriological water quality can only be envisaged to the extent that wastewater treatment facilities remain reliable, sewer systems do not regularly overflow in heavy rain, and agricultural pollution and other diffuse sources are controlled.

Notwithstanding serious efforts to reduce or eliminate sources of pollution, both local and remote, the Upper Estuary remains exposed and very vulnerable to the adverse effects of

persistent and bioaccumulating toxic substances. Indeed, the Upper Estuary is a natural trap for contaminants carried long distances in the water and air and for toxic substances slowly leaching out of contaminated sites on land and in the water around the Great Lakes and along the St. Lawrence. Moreover, the organisms most vulnerable to bioaccumulating toxic substances (fish-eating birds and marine mammals) make intensive use of the Upper Estuary. A better understanding of the dynamics of toxic substances and their effects on organisms constitutes one of the major challenges in the study area.

The Upper Estuary is also very vulnerable to major oil spills, chiefly because of the abundance of bird colonies, duck broods, staging areas and seal haulouts and because of the resident Beluga population. Since 1990, regional oil and chemical spill prevention capability, emergency preparedness and ability to respond to spills and restore contaminated organisms and habitat have improved considerably. The region has acquired a new marine environmental action strategy, a warning system, a fully equipped response team (Quebec City–Lévis) and a bird cleaning centre at Cap Tourmente.

6.2 Protecting and Rehabilitating Disturbed Habitat and Resources

Some important plant and animal habitats in the study area are already protected, but others, equally important, are not. Sectors in need of protection include all brackish and salt marshes and unprotected islands and islets. Îlet aux Alouettes, already a designated wildlife habitat, is currently being studied for creation of a wildlife preserve under the provincial *Act respecting the conservation and enhancement of Quebec wildlife*. The marshes of Baie-Saint-Paul also deserve better protection.

The objective for species deemed a priority for protection under the SLV 2000 Action Plan is to draw up for each one a status report to see whether legal designation as threatened or vulnerable is warranted, to draft and implement a recovery plan for each threatened species, and

to monitor numbers over the long term. Recovery plans have already been drawn up for the Beluga, Rainbow smelt, Peregrine falcon, Yellow rail, Horned grebe, and Loggerhead shrike.

The worrying plight of the estuary Belugas has led to the enactment of many measures to protect habitat used by this species and to reduce pollution and disturbance. The creation of the Saguenay–St. Lawrence Marine Park was intended to protect most of the areas used by the Belugas. The St. Lawrence Beluga recovery plan, drafted in 1995, defined a set of strategies for bringing the population up to a number and condition where its survival is no longer jeopardized by natural calamities or human activities. The SLV 2000 implementation plan, launched in July 1996, embraces all government initiatives and proposes new measures for restoring the St. Lawrence Beluga population.

6.3 Accessibility of Marine, Coastal and Island Environments

Since the early 1980s, there have been many developments making the St. Lawrence more accessible, and tourism based on the estuary's attractions and resources is flourishing. Divestiture of federal harbours to local interests will open up further opportunities in this area. For example, the Pointe-au-Pic dock is now being revitalized, including rebuilding the wharf to accommodate ferries and pleasure craft, laying out of a pedestrian street, renovation of the buildings, redesign of the park, and installation of recreational and tourist facilities.

6.4 Reconciling Recreational and Tourism Development with Environmental Protection

In the last few years, development of recreation and tourism has burgeoned in the Upper Estuary, both on the shores and islands and on the water. One of the challenges facing this sector will be providing for sustainable development while protecting wildlife resources and their habitat, as well as the landscapes on which this development is based. Steps must be taken to limit disturbance of birds and marine mammals occasioned by the ever busier human traffic in places which were, until recently, beyond the reach of the general public.

Table 1
Main sustainable development issues on the north shore of the Upper Estuary

Issue	*Assessment of current situation in relation to sustainable development objectives*	*Current approach to sustainable development*
Reducing pollution		
• Treatment of municipal, household and agricultural wastewater	One wastewater plant currently treats the wastewater of 30% of the sector population. This figure will rise to 61% in late 1998. Bacterial pollution precludes the harvesting of shellfish and limits swimming in some places.	Restoration of uses dependent on bacteriological water quality can only be achieved when wastewater is treated (in treatment plants or effective septic systems) and when sewer overflows in heavy rain and agricultural pollution are controlled.
• Treatment of wastewater from pulp and paper mills	The only paper mill in the area has considerably cut its BOD_5 and suspended matter load, as well as the toxicity of the wastewater it dumps into the estuary. Its effluent has had secondary treatment since 1995.	Paper mill wastewater is subject to regulatory monitoring.
• Restoration of hazardous waste dump sites	In the 1980s, there were several sites posing a moderate threat to the marine environment. The most problematic of these have now been restored.	No action has been taken at certain sites; at others, further work is needed.
• Protection of the aquatic environment from spills	The Upper Estuary is a major shipping route. The environment is highly vulnerable to oil spills because of the many bird colonies, seabird staging areas, seal haulouts and whales. A spill response force is now in place.	A regional response team regularly conducts simulation exercises.
• Persistence of toxic substances in the environment	Though various contamination sources in the St. Lawrence drainage basin have been sharply reduced, the aquatic life of the Upper Estuary remains exposed to toxic bioaccumulating substances; this is especially true of fish-eating birds and marine mammals. In general, chemical contamination of fishery products poses no threat to human health, but consumption of eels and seal meat is subject to restrictions.	A better understanding of the dynamics of these substances and their effects on marine organisms and human health is a major challenge in this sector.

Issue	*Assessment of current situation in relation to sustainable development objectives*	*Current approach to sustainable development*
Protecting and rehabilitating disturbed habitat and resources		
• Sensitive habitat	Some important plant and animal habitats (salt marshes, bird colonies, bird and marine mammal staging areas) are protected, but some important wildlife sites, especially intertidal marshes and islands, remain without legal protection.	A number of projects to protect sensitive habitat in the sector are being studied.
• Belugas	The survival of the St. Lawrence Beluga is threatened by toxic substances and by disturbance created by recreational and tourist activities.	A Beluga survival action plan has been in force since the late 1980s. The Saguenay–St. Lawrence Marine Park is designed to protect a major segment of the Belugas' critical habitat.
Accessibility of the Upper Estuary		
South shore	Access to the shoreline is plentiful, but access to the islands and food services and accommodation near the water were limited in the late 1980s.	Many projects for developing shoreline tourism and recreation have been initiated in the study area.
Reconciling recreational and tourism development with environmental protection		
	Marine recreation and tourism operations have mushroomed, but some of these pose a threat to birds and marine mammals.	The impact of certain recreational and tourist activities on resources is currently under study.

References

ATR de Charlevoix – Association Touristique Régionale de Charlevoix. 1996. *Guide touristique édition 1996.*

Banville, D., and S. Saint-Onge. 1990a. *Inventaire aérien de la sauvagine sur le fleuve Saint-Laurent entre Grondine/Leclercville et Saint-Roch-des-Aulnaies/Baie-Sainte-Catherine à l'automne 1988.* Ministère du Loisir, de la Chasse et de la Pêche. Service de l'aménagement et de l'exploitation de la faune, région du Québec. 73 pp.

Banville, D., and S. Saint-Onge. 1990b. *Inventaire aérien de la sauvagine sur le fleuve Saint-Laurent entre Grondine/Leclercville et Saint-Roch-des-Aulnaies/Baie-Sainte-Catherine au printemps 1989.* Ministère du Loisir, de la Chasse et de la Pêche. Service de l'aménagement et de l'exploitation de la faune, région du Québec. 79 pp.

Bédard, J., and A. Nadeau. 1994. *L'Eider à duvet dans l'estuaire du Saint-Laurent : un plan de gestion (révisé: 1994).* Duvetnor Ltd. for Ducks Unlimited Canada.

Béland, P., S. DeGuise, and R. Plante. 1992. *Toxicologie et pathologie des mammifères marins du Saint-Laurent*. St. Lawrence National Institute of Ecotoxicology. World Wildlife Fund Wildlife Toxicology Fund.

BIOMQ – Banque Informatisée sur les Oiseaux Marins du Québec. 1977. Canadian Wildlife Service.

Brind'Amour, M. 1988. *Évaluation de la dynamique et de la productivité nette aérienne de la végétation vasculaire des marais intertidaux de la région de Kamouraska, Québec*. Master's thesis, Laval University. 113 pp.

Charlevoix RCM. 1988. *Schéma d'aménagement.*

Charlevoix-Est RCM. 1986. *Schéma d'aménagement.*

Cote-de-Beaupré RCM. 1987. *Schéma d'aménagement.*

Couillard, L., and P. Grondin. 1986. *La végétation des milieux humides du Québec*. Les Publications du Québec.

D'Aragon, Desbiens, Haldes Associates Ltd. and Roche Ltd. 1992. *Inventaire des terrains fédéraux potentiellement contaminés au Québec.* For Environment Canada.

DesGranges, J. L. 1997. Personal communication. Canadian Wildlife Service.

Desrosiers, A. 1997. Personal communication. Ministère de l'Environnement et de la Faune, Direction de la faune et des habitats.

Duchesne, J.-F., J. Chartrand, and D. Gauvin. 1998. *Synthèse des connaissances sur les risques à la santé reliés aux usages du fleuve Saint-Laurent dans le secteur d'étude Estuaire moyen. Rapport technique Zones d'intervention prioritaire 15, 16 et 17*. Centre de santé publique de Québec, Direction de santé publique Bas-Saint-Laurent, Direction de santé publique Chaudière-Appalaches, Ministère de la Santé et des Services sociaux du Québec and Health Canada.

Gagnon, M. M., and J. J. Dodson. 1990. Congener specific analysis of the accumulation of polychlorinated biphenyls (PCBs) by aquatic organisms in the maximum turbidity zone of the the St. Lawrence Estuary, Quebec, Canada. *The Science of the Total Environment* 97/98: 739–759.

Gagnon, M., P. Bergeron, J. Leblanc and R. Siron. 1998. *Synthèse des connaissances sur les aspects physiques et chimiques de l'eau et des sédiments de l'estuaire moyen. Rapport technique, Zones d'intervention prioritaire 15, 16 et 17*. St. Lawrence Centre, Environment Canada, Conservation Branch, Quebec Region.

Gratton, L. 1995. Personal communication. Consulting biologist.

Gratton, L., and C. Dubreuil. 1990. *Portrait de la végétation et de la flore du Saint-Laurent.* Ministère de l'Environnement du Québec, Direction de la conservation et du patrimoine écologique, and Environment Canada, Canadian Wildlife Service.

Gratton, N., and J. F. Bibeault. 1998. *Synthèse des connaissances sur les aspects socio-économiques du secteur d'étude Estuaire moyen*. *Rapport technique, Zones d'intervention prioritaire 15, 16 et 17*., Environment Canada, Conservation Branch, Quebec Region, St. Lawrence Centre, Montreal.

Greisman, P., and G. Ingram. 1977. Nutrient distribution in the St. Lawrence Estuary. *Journal of the Fisheries Research Board of Canada* 34: 2117–2123.

Hodson, P.V., C. Desjardins, É. Pelletier, M. Castonguay, R. McLeod, and C.M. Couillard. 1992. *Baisse de la contamination chimique des Anguilles d'Amérique (*Anguilla rostrata*) capturées dans l'estuaire du Saint-Laurent*. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1876.

Hodson, P.V., M. Castonguay, C. M. Couillard, C. Desjardins, E. Pelletier, and R. McLeod. 1994. Spatial and temporal variations in chemical contamination of American eel (*Anguilla rostrata*) captured in the estuary of the St. Lawrence River. *Canadian Journal of Fisheries and Aquatic Sciences* 51*:* 464–478.

Lavigueur, L., M. Hammill, and S. Asselin. 1993. *Distribution et biologie des phoques et autres mammifères marins dans la région du parc marin du Saguenay*. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2220.

Lesage, V., M. O. Hammill, and M. Kovacs. 1995. *Harbour seal (*Phoca vitulina*) and Grey seal (*Halichoerus grypus*) in the St. Lawrence Estuary*. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2307.

MEF and MSSS – Ministère de l'Environnement et de la Faune du Québec and Ministère de la Santé et des Services Sociaux. 1995. *Guide de consommation du poisson de pêche sportive en eau douce, 1995*. Government of Quebec.

MENVIQ – Ministère de l'Environnement du Québec. 1990 (rev. 1992). *Critères de qualité d'eau douce*. Direction de la qualité des cours d'eau, Service d'évaluation des rejets toxiques. Québec.

Michaud, R. 1993. *Distribution estivale du Béluga du Saint-Laurent : synthèse 1986 à 1992.* Canadian Technical Report of Fisheries and Aquatic Sciences No. 1906. Fisheries and Oceans Canada.

Mousseau, P., M. Gagnon, P. Bergeron, J. Leblanc, and R. Siron. 1998. *Synthèse des connaissances sur les communautés biologiques du secteur d'étude Estuaire moyen. Rapport technique. Zones d'intervention prioritaire 15, 16 et 17*. Environment Canada, Quebec Region, St. Lawrence Centre and MLI.

Muir, D. C. G., C. A. Ford, R. E. A. Stewart, T. G. Smith, R. F. Addison, M. E. Zinck, and P. Béland. 1990. "Organochlorine contaminants in Belugas, *Delphinapterus leucas*, from Canadian waters" *in* T. G. Smith, D. J. St. Aubin, and J. R. Geraci (eds.). *Advances in Research on the Beluga Whale,* Delphinapterus leucas. *Canadian Bulletin of Fisheries and Aquatic Sciences* 224: 165-190.

OTCCUQ and MTQ – Office du Tourisme et des Congrès de la Communauté Urbaine du Québec, and Ministère du Tourisme du Québec. 1996. *Guide Touristique 1996-1997*.

Québec Yachting. 1995. *Guide des marinas, Édition 1995*.

Robitaille, J. A., Y. Vigneault, G. Shooner, C. Pommerleau, and Y. Mailhot. 1988. *Modifications de l'habitatn du poisson dans le Saint-Laurent de 1945 à 1984 et effets sur les pêches commerciales*. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1608. 45 pp.

SLC and Laval University – St. Lawrence Centre and Université Laval. 1991. *A River, Estuaries and a Gulf: Broad Hydrographic Divisions of the St. Lawrence.* Environmental Atlas of the St. Lawrence, "St. Lawrence UPDATE" Series. Environment Canada, Conservation and Protection, Quebec Region.

SLC and MENVIQ – St. Lawrence Centre and Ministère de l'Environnement du Québec. 1992. *Interim Criteria for Quality Assessment of St. Lawrence Sediment.* Environment Canada and Ministère de l'Environnement du Québec.

Verreault, G. 1997. Personal communication. Ministère de l'Environnement et de la Faune, Direction régionale du Bas-Saint-Laurent.

Wagemann, R., R. E. A. Stewart, R. Béland, and C. Desjardins. 1990. Heavy metals and selenium in tissues of Beluga whale, *Delphinapterus leucas*, from the Canadian Arctic and the St. Lawrence Estuary. *Canadian Bulletin of Fisheries and Aquatic Sciences* 224*:* 191–206.

Appendices

1 St. Lawrence Vision 2000 (SLV 2000) Priority Species Found on the North Shore of the Upper Estuary

Name	*Type of distribution or status in the sector*
Plants (11 of 110 priority species)	
Annual wild rice	Endemic to Fluvial Estuary
Clammy hedge-hyssop	Endemic to Fluvial Estuary
Coast willowweed	Endemic to Fluvial Estuary
Dotted smartweed	Disjunct
Estuary pipewort	Disjunct
Gaspé Peninsula arrowgrass	Endemic to northeastern North America
Obedient plant	Disjunct
Rosa rousseauiorum	Endemic to the Estuary and Gulf
Smooth rose	Endemic to the Estuary and Gulf
Spotted water hemlock	Endemic to Fluvial Estuary
Victorin's fringed-gentian	Endemic to Fluvial Estuary
Fish (7 of 14 priority species)	
American eel	Migrant (fall)
American shad	Migrant (spring and summer)
Atlantic herring	Present
Atlantic sturgeon	Year-round resident
Atlantic tomcod	Resident (spring, summer and fall)
Rainbow smelt	Year-round resident; spawns in some tributaries
Striped bass	Resident (spring, summer and fall)
Amphibians and reptiles (1 of 7 priority species)	
Brown snake	Present
Birds (11 of 19 priority species)	
Bald eagle	Possible breeder
Barrow's goldeneye	Migrant
Blue-winged teal	Confirmed breeder
Common gallinule	Confirmed breeder
Horned grebe	Migrant
Least bittern	Confirmed breeder
Loggerhead shrike	Possible breeder
Peregrine falcon	Confirmed breeder
Pintail	Confirmed breeder
Sedge wren	Probable breeder
Yellow rail	Probable breeder
Name	*Type of distribution or status in the sector*

Mammals (5 of 5 priority species)	
Beluga	Resident (spring, summer and fall)
Fin whale	Casual in spring, summer and fall
Harbour porpoise	Casual in summer and fall
Harbour seal	Year-round resident
Pygmy shrew (land mammal)	Status unknown

2 **Environmental Quality Criteria** (for assessing loss of use)

Ecosystem Component	*Reference Criterion*	*Objective*
WATER	Raw water (untreated water taken directly from a body of water) (MENVIQ, 1990, rev. 1992)	Protect the health of persons who may both drink water directly from a body of water and eat aquatic organisms caught there throughout their lives.
	Contamination of aquatic organisms (MENVIQ, 1990, rev. 1992)	Protect human health from the risks associated with consumption of aquatic organisms.
	Aquatic life (chronic toxicity) (MENVIQ, 1990, rev. 1992)	Protect aquatic organisms and their offspring and wildlife that feed on such organisms.
	Recreational activities (direct contact) (MENVIQ, 1990, rev. 1992)	Protect human health in the context of recreational activities involving total body contact with the water (e.g. swimming and windsurfing).
SEDIMENTS	No effect threshold (NET) (SLC and MENVIQ, 1992)	Contaminant levels are below those at which any effects on benthic organisms are observed.
	Minor effect threshold (MET) (SLC and MENVIQ, 1992)	Contaminant levels exceed those at which minor but tolerable effects are observed in most benthic organisms.
	Toxic effect threshold (TET) (SLC and MENVIQ, 1992)	Contaminant levels exceed those at which harmful effects are observed in most benthic organisms.
AQUATIC ORGANISMS	Protection of aquatic life (IJC, 1987)	Protect the health of fish-eating aquatic organisms.
	Fish and poultry marketing guidelines (HWC, 1985)	Maximum acceptable contaminant levels in the tissues of fish, molluscs, crustaceans and poultry sold for consumption.
	Freshwater sport fish consumption guidelines (MSSS and MENVIQ, 1993)	Prevent harmful effects on human health from eating contaminated fish, molluscs and crustaceans.

3 Glossary

Anadromous: Refers to marine fish that enter fresh water at some time in their life cycle to breed.

Benthos: Community of organisms living on the bed of a body of water; divided into phytobenthos (plants) and zoobenthos (animals).

Biomass: Total mass of living organisms, taken either globally or in systematic groups by surface or volume unit, in a given biotope at a given moment (e.g. plant, insect, herbivore, carnivore biomass).

Brackish: Refers to water intermediate between fresh (0.3 psu units) and salt (35 psu units).

Carcinogen: Any factor that triggers or disposes to cancer.

Catadromous: Refers to fish species living in fresh or brackish waters that migrate to sea to breed.

Community: All the living organisms, both plant and animal, occupying the same biotope.

Diffuse pollution: Nonpoint-source discharge of pollutants into a given environment. Agricultural runoff is diffuse pollution, since fertilizers and pesticides are spread over large areas.

Discharge: Volume of water carried by a watercourse, conduit, etc. in a given unit of time, generally expressed in cubic metres per second (m^3/s) or, in small drainage basins, as litres per second (L/s).

Distribution – peripheral: Refers to a species that lives at the edge of its geographic range.

sporadic (or disjunct): Refers to species found in an area or areas remote from their main range.

endemic: Refers to a species that is confined to a particular area.

Drainage basin: The entire continental land area drained by a river system, that is, the total precipitation catchment and drainage area.

Ecosystem: An entire physical and chemical environment (biotope) and all the living organisms (biocenosis) living there and able continue doing so indefinitely by virtue of matter and energy inputs.

Effluent: Any liquid released from a source of pollution, whether a residential area (domestic outfall) or industrial plants (industrial outfall). Point-source effluents (sewers): liquid pollutants discharged at a given location.

Estuarine circulation: Water circulation typical of estuaries, with surface water moving downstream and deep water upstream.

Fjord: Scarp-sided glacial valley invaded by the sea.

Foreshore: That part of the shore between the high and low water marks.

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

Haulout: Place where seals come ashore to rest.

Herbaceous meadow: Plant community dominated by herbaceous species.

Hydrophobic: Refers to toxic substances that do not dissolve readily in water.

Minimum flow: Lowest level of water flowing in a watercourse.

Mudflat: Area of foreshore or seabed covered with mud.

Nutrient: Simple substance absorbed by plants and used in photosynthesis. Basic nutrients are nitrates, phosphates and silicates.

Plankton: Community of plants (phytoplankton) and animals (zooplankton) living suspended in the water column in either fresh or salt water.

Production – primary: Quantity of organic matter generated by autotrophic organisms in a given period.

Productivity (of ecosystem): Quantity of biomass produced annually and keeping animal and plant populations in equilibrium.

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

Spawning ground: Place where fish gather to breed.

Sporadic (or disjunct): Refers to species found in an area or areas remote from their main range.

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

Tidal range: Vertical distance between high and low tide.

Tributary: Watercourse that empties into a larger river, or into a lake.

Turbid: Refers to water containing a high concentration of suspended matter.

Turbidity: Cloudiness of a liquid due to the presence of fine suspended matter (clay, silt or micro-organisms).

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

Waterfowl: Collective term for ducks and geese.

References

Demayo, A., and E. Watt. 1993. *Glossary of Water Terms*. Published by the Canadian Water Resources Association jointly with Environment Canada.

Government of Quebec. 1981. *Dictionnaire de l'eau*. Association québécoise des techniques de l'eau. Cahiers de l'Office de la langue française. Éditeur officiel du Québec.

HWC – Health and Welfare Canada. 1985. *Fish Marketing Guidelines.*

IJC – International Joint Commission. 1987. *A Conceptual Approach for the Application of Biological Indicators of Ecosystem Quality in the Great Lakes Basin. A Joint Effort of the International Joint Commission and the Great Lakes Fishery Commission*. Report submitted to the Great Lakes Science Advisory Board.

MENVIQ – Ministère de l'Environnement du Québec. 1990 rev. 1992. *Critères de qualité de l'eau*. Service d'évaluation des rejets toxiques et Direction de la qualité des cours d'eau.

MSSS and MENVIQ – Ministère de la Santé et des Services Sociaux and Ministère de l'Environnement du Québec. 1993. *Guide de consommation du poisson de pêche sportive en eau douce*.

Parent, S. 1990. *Dictionnaire des sciences de l'environnement*. Éditions Broquet Inc., Ottawa.

Ramade, F. 1993. *Dictionnaire encyclopédique de l'écologie et des sciences de l'environnement.* Édiscience international, Paris.

Translation Bureau and Canadian Permanent Committee on Geographical Names. 1987. *Generic Terms in Canada's Geographical Names*. Terminology Bulletin 176. Canadian Government Publishing Centre.