REGIONAL ASSESSMENT
ST. LAWRENCE LOWER ESTUARY

Regional Assessment
St. Lawrence Lower Estuary

Priority Intervention Zone 18

Marc Gagnon

Edited by Marie-José Auclair
St. Lawrence Centre
Environment Canada–Quebec Region

February 1997

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 of Environment Canada, in conjunction with Fisheries and Oceans, Health Canada, the Ministere de la Sante et des Services Sociaux (MSSS) and its partners, and the Ministere de l'Environnement et de la Faune (MEF).

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Production Team

St. Lawrence Centre

Design and Writing	Marc Gagnon
Editing and Co-ordination	Marie-José Auclair
ZIP Writing Team	Alain Armellin
	Pierre Bergeron
	Jean-François Bibeault
	Guy Fortin
	Marc Gagnon
	Nathalie Gratton
	Anne Jourdain
	Pierre Mousseau
Cartographic Analysis and Illustrations	Marcel Houle
Copyediting	Patricia Potvin
Layout	Samim Esmail

Centre de Santé Publique de Québec	Josée Chartrand
	Jean-François Duchesne
	Denis Gauvin

Contributors

Ministere de l'Environnement et de la Faune Direction des Ecosystemes Aquatiques	Richard Berthiaume Denis Laliberté Yves Lefebvre Francine Richard Lucie Wilson
Direction Regionale Bas-Saint-Laurent	Guildo Lavoie
Direction Regionale Cote-Nord	André Lamoureux
Fisheries and Oceans Canada Fish Habitat Branch	Serge Villeneuve
Maurice Lamontagne Institute	Dominique Gascon Jean Piuze 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

Ministere de la Sante et des Services Sociaux du Quebec	Claire Laliberté (resource person)
Direction de la Sante Publique Cote-Nord	Jacques-François Cartier
Direction de la Sante Publique Bas-Saint-Laurent	Michel Laferrière
Biodiversity Assessment Team (SLV 2000)	Luce Chammard

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We would also like to take this opportunity to thank the people from the sectoral and regional offices of the departments 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 system 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.*

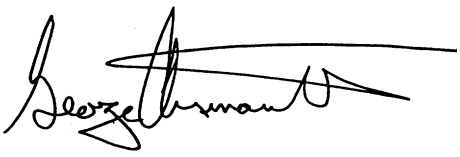
Through the ZIP Program, riverside communities are invited to play an active part in achieving the objectives aimed at restoring the St. Lawrence and Saguenay rivers.

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
Co-chair, St. Lawrence Vision 2000

Management Perspective

The Priority Intervention Zones (ZIP) Program is a federal-provincial initiative involving riverside communities in the implementation of remedial measures for the St. Lawrence and Saguenay rivers. The program is in three phases: production of a local-level assessment report on the St. Lawrence, consultations with riverside partners and setting priorities for action, and developing an Ecological Rehabilitation Action Plan (ERAP).

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

This process of gathering and analysing data on a local scale is a first for the St. Lawrence and Saguenay system. 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 work team remains nonetheless convinced that an enlightened and thoughtful overview of each study area can be presented without further delay. This first assessment, written for the riverside partners in each study area, is thus a starting point and discussion paper.

Perspective de gestion

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

Un bilan régional est établi à partir d'une synthèse des 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 fleuve Saint-Laurent et de la rivière Saguenay. Les rapports techniques vont plus loin encore, en proposant un bilan des connaissances sur l'état actuel d'un secteur à partir de critères de qualité connus.

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

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

Abstract

The Lower Estuary of the St. Lawrence River is more than 300 metres deep. Fresh surface water flows into it from the St. Lawrence River and the other major rivers of the Canadian Shield; at greater depths, icy salt water flows in from the Gulf of St. Lawrence. The mixing of these two water masses just off Tadoussac gives the Lower Estuary characteristics that distinguish it from other sections of the St. Lawrence River: surface waters that remain nutrient-rich all summer long and upwellings of cold, deep water that promote the formation of krill, food for baleen whales. The world's southernmost Beluga whale population is found here.

The coastal habitat and sea floors of the Lower Estuary support a diversity of riverine and marine plant and animal life. More than 800 species of benthic invertebrates are found here, along with over 80 species of fish, over 300 bird species, and 14 marine mammals, including the Beluga whale and Harbour seal. Area islands are used intensively as nesting sites by aquatic birds. Salt marshes, concentrated in the region of Ile Verte and in the estuary of the Aux Outardes River, are frequented by large numbers of migrating waterfowl and broods of ducks. Important economic activities are dependent on these different resources, including fishing (for shellfish, crustaceans and fish), hunting (birds, seals), eiderdown harvesting, and bird and whale watching. Although a number of protected areas do exist, some important wildlife sites are without protected status, particularly on the north shore.

The floor of the Lower Estuary acts as a sink for suspended matter transported by the St. Lawrence River and the deepwater layers of the Gulf. The toxic substances trapped in suspended matter are thus held in the sediments of the Lower Estuary. Since the beginning of the industrial era, however, none of the toxic substances studied has ever reached a very high level in the sediment. Contamination by mercury, lead and zinc is moderate, whereas contamination by other heavy metals and toxic organic substances (PCBs, DDT, PAHs, dioxins, furans) has been low. With the exception of zinc, contamination of recent sediments by all contaminants studied is lower than it was during the 1960s and 1970s.

The aquatic organisms of the Lower Estuary are contaminated by bioaccumulative toxic substances such as mercury, PCBs, and organochlorine pesticides. In general, concentrations are low in fish and invertebrates. However, through the process of biomagnification, worrisome concentrations of these substances have been found in species at the top of the food chain (sea birds, seals and Beluga whales). No net downward trend has yet been reported in the contamination of these species, despite major reductions in inputs of contaminants to the environment in recent years. The Beluga is the most contaminated species because it feeds on American eels from Lake Ontario, which are much more contaminated than resident or marine fish species. The Beluga population of the Lower Estuary is afflicted by diseases that are rarely seen in the other populations of marine mammals.

The few local sources of toxic substances have had their biggest impact on the marine environment of Baie des Anglais. Sediments there, highly contaminated by PCBs and PAHs from the wastewater discharges of an aluminum smelter, were dispersed throughout the bay when dredging work was done in the port, where the sediments had accumulated. Although inputs of contaminants into the bay have been virtually eliminated, its present level of contamination makes restrictions on the consumption of marine products caught in the region necessary.

The wastewater of 23% of the riverside population goes untreated. The bacterial pollution of the water in many areas limits shellfish harvesting. Other sources of environmental disruption include the harnessing of watercourses, fill and drainage activities in wetlands, disturbance of birds and marine mammals through human recreation or tourist activities, and overfishing.

Résumé

L'estuaire maritime du Saint-Laurent est un plan d'eau profond de plus de 300 mètres qui reçoit en surface les eaux douces du fleuve Saint-Laurent et des grandes rivières du bouclier canadien et, en profondeur, les eaux glaciales et salées du golfe du Saint-Laurent. Le mélange de ces deux masses d'eau au large de Tadoussac confère à l'estuaire maritime des caractéristiques qui le distinguent des autres tronçons du Saint-Laurent : des eaux de surface riches en éléments nutritifs pendant tout l'été et des remontées d'eaux profondes et froides favorisant la formation de bancs de krill exploités par les grandes baleines à fanons. On y rencontre la population de Bélugas la plus méridionale au monde.

Les habitats côtiers et les fonds marins de l'estuaire maritime supportent une flore et une faune riveraines et marines diversifiées. On y observe plus de 800 espèces d'invertébrés benthiques, plus de 80 espèces de poissons, plus de 300 espèces d'oiseaux et 14 espèces de mammifères marins, dont le Béluga et le Phoque commun. Les îles sont intensivement utilisées par les oiseaux aquatiques pour la nidification. Les marais salés sont concentrés dans la région de l'île Verte et de l'estuaire de la rivière aux Outardes et sont fréquentés en grands nombres par la sauvagine en migration et les couvées de canards. Ces différentes ressources supportent d'importantes activités économiques : pêche (mollusques, crustacés, poissons), chasse (oiseaux, phoques), récolte de duvet d'Eider et observation d'oiseaux et de mammifères marins. Malgré la présence de plusieurs territoires protégés, certains sites fauniques d'importance, particulièrement sur la rive nord, demeurent sans protection.

Le fond de l'estuaire maritime constitue une trappe pour les matières en suspension transportées par le fleuve Saint-Laurent et les couches d'eau profondes du golfe. Les substances toxiques associées aux matières en suspension sont ainsi retenues dans les sédiments de l'estuaire maritime. Cependant, depuis le début de l'ère industrielle, aucune des substances toxiques étudiées n'a atteint un niveau de pollution très élevé dans ces sédiments. La contamination par le mercure, le plomb et le zinc a atteint un niveau de pollution modéré tandis que la contamination

par les autres métaux lourds et les substances organiques toxiques (BPC, DDT, HAP, dioxines, furannes) a été faible. Pour l'ensemble des contaminants étudiés à l'exception du zinc, la contamination des sédiments récents est moins élevée qu'au cours des années 1960 et 1970.

Les organismes aquatiques de l'estuaire maritime sont contaminés par des substances toxiques bioaccumulables (mercure, BPC, pesticides organochlorés). En général, les teneurs demeurent faibles chez les invertébrés et les poissons, Toutefois, en raison du phénomène de bioamplification, la concentration de ces substances atteint des niveaux inquiétants chez les espèces au sommet de la chaîne alimentaire (oiseaux marins, phoques et Béluga). On ne décèle pas encore de tendance nette à la baisse de cette contamination malgré la réduction importante des apports dans l'environnement depuis plusieurs années. Le Béluga est L'espèce la plus contaminée. Ce niveau très élevé de contamination est attribuable au fait que le Béluga consomme des anguilles originaires du lac Ontario, beaucoup plus contaminées que les espèces de poissons résidentes et marines. La population de l'estuaire est affligée par des pathologies rares chez les autres populations de mammifères marins.

Les sources locales de substances toxiques sont peu nombreuses et n'ont eu des répercussions importantes sur le milieu marin que dans la baie des Anglais. Les sédiments de cette baie ont été fortement contaminés par les BPC et les HAP qui provenaient des eaux usées d'une aluminerie et qui ont été dispersés dans la baie par le dépôt de déblais du dragage de la zone portuaire où ils étaient accumulés. Malgré l'élimination presque complète des apports de contaminants dans la baie, le niveau actuel de contamination du milieu nécessite l'imposition de restrictions sur la consommation de produits marins prélevés dans cette région.

Les eaux usées de 23 p. 100 de la population riveraine ne sont pas traitées dans une station d'épuration. Dans plusieurs secteurs, la pollution bactérienne limite la récolte de mollusques. Le harnachement des cours d'eau, le remblayage et l'assèchement de milieux humides, les dérangements des oiseaux et des mammifères marins associés aux activités récréo-touristiques et la surexploitation des ressources halieutiques sont d'autres sources de perturbation du milieu.

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CHAPTER 1 The St. Lawrence, Then and Now

The name alone of the St. Lawrence River evokes in most Quebecers a sense of belonging to this land traversed by the river on its way from the Great Lakes to the sea. Images of a mighty river spring to mind, hugged on either side by fertile river-valley flatlands, shaded riverbanks and abundant wildlife.

This country was born on the banks of the St. Lawrence — as is still evident today in the division of land, a vestige of the seigneurial system. The St. Lawrence provided the colonists, still struggling with unreliable harvests, with a steady supply of fish and a means of linking the first settlements that grew up along its shores.

With time, forests gave way to farmland, and cities sprang up. Until then, the sparse population and the sheer size of the river meant that human use of the St. Lawrence had had virtually no impact on its resources. But things would soon change. The first significant threats seem to have come from forestry and the beginnings of industrialization in the nineteenth century. Logs began to be floated down the river, and dams and sawmills were built along its tributaries.

The pace of change accelerated in the twentieth century, as large dams were built on the river itself and its main tributaries. An increasing number of industrial plants were built near the cities, usually on the banks of the St. Lawrence. The river's proximity offered several advantages: it reduced the cost of transporting raw materials and acted as a ready dump for effluents and other wastes.

The St. Lawrence gradually succumbed to the accumulated abuse. A few well-informed observers noted that some animal species were becoming less abundant and suggested that the cause could be the disturbance of their habitats. Their warnings elicited little public interest, however.

The public suffered a rude awakening in the early 1970s, when they realized that mercury contamination of fish was not merely an abstract research topic, but indeed a very real risk to which some Native populations and many sport fishers were exposed. As the list of toxic

substances found in the river grew, the general public put the quality of the environment at the top of its list of concerns. The high level of contamination by toxic substances of the Beluga whale in the St. Lawrence estuary, detected in the early 1980s, showed that the problem was not limited to the river proper, but had repercussions in ecosystems far from the large industrial centres.

Today, there is virtually unanimous agreement that the comforts afforded by an industrial society have a drawback: the unbridled exploitation of resources and the growing quantity of contaminants will eventually threaten all forms of life, including human beings.

Most industrialized countries have now agreed to redirect their economic activities toward 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 provide for versatile use of resources and take into account quality of life for humankind and respect for biodiversity.

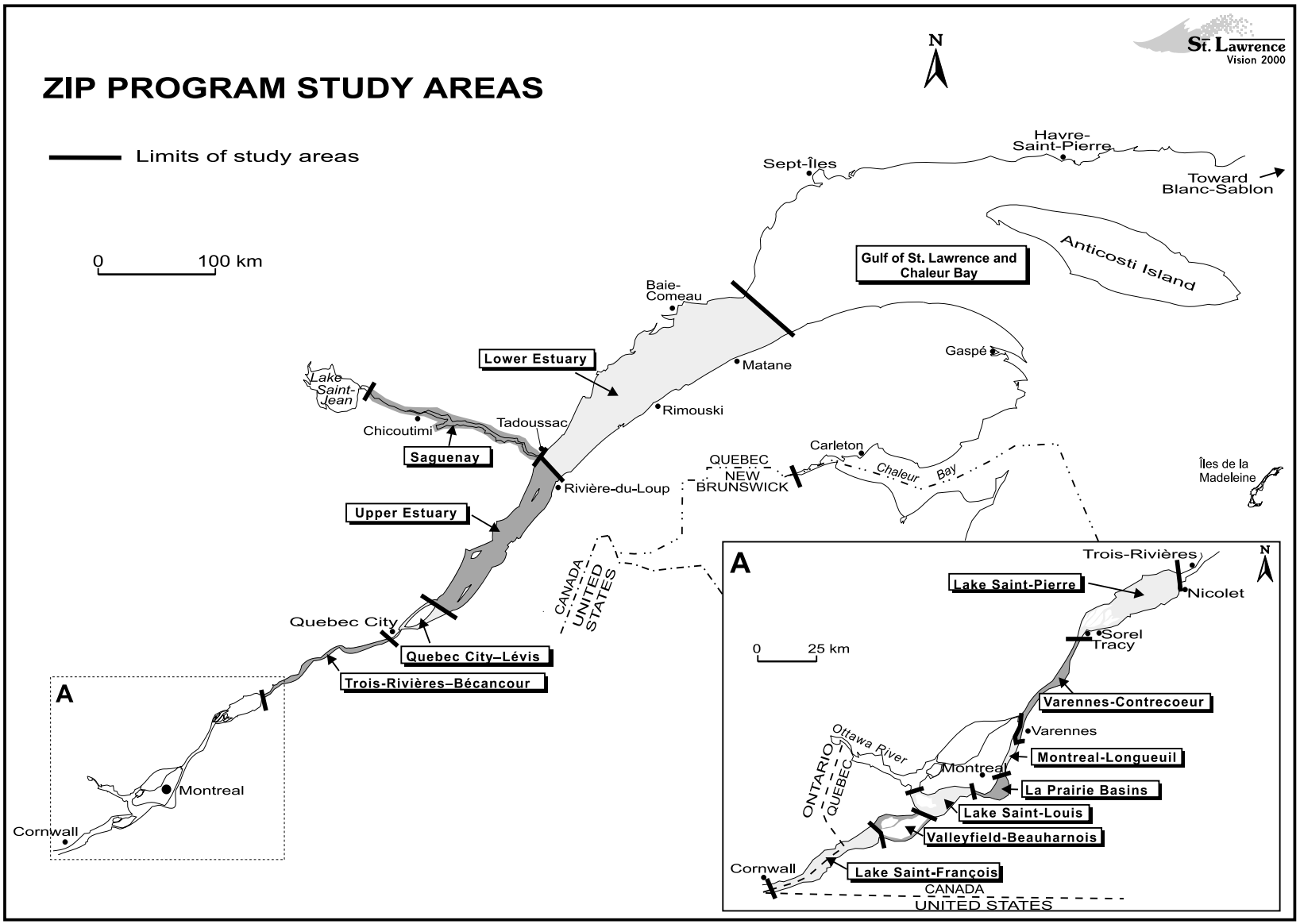
CHAPTER 2 Priority Intervention Zones (ZIP) Program

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 concrete, 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 Plans or RAPs). In 1988, Ontario, Quebec and the eight American states concerned signed an agreement to control toxic discharges into the Great Lakes basin and the Great Lakes Charter. In response to the poor quality of the waters of the St. Lawrence and its tributaries, the Quebec government launched its own 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). One of the objectives of this action plan is to do an environmental assessment to encourage local stakeholders to work together to restore and protect the St. Lawrence and co-ordinate the uses of this resource (Figure 1). As part of the groundwork for public consultations, SLV 2000 partners review and synthesize current knowledge about the state of the environment in each area.

This report presents the main points of the technical reports[1] and reviews current knowledge of the state of the resources and the present and potential uses of the St. Lawrence Lower Estuary (ZIP 18).

[1] One report deals with the physico-chemical aspects of the water and sediments (Fortin (ed.), 1996), another with biological communities (Mousseau and Armellin, 1996), another with relevant socio-economic aspects (Bibeault et al., 1996), and finally one with human health issues (Duchesne et al., 1996).



Source: Priority Intervention Zones (ZIP) Program – SLV 2000.

Figure 1 Priority Intervention Zones (ZIP) program study areas

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

CHAPTER 3 Characterization of the Lower Estuary Sector

The St. Lawrence Lower Estuary (ZIP 18), with a surface area of 9350 km^2, is 230 km long and stretches from Tadoussac and L'Isle-Verte at its landward limit, to Pointe-des-Monts and Les Méchins at its seaward end (Figure 2). It is connected in its upstream portion with the Upper Estuary and the Saguenay Fjord, and downstream with the Gulf of St. Lawrence.

3.1 Physical Environment

The bottom topography in the study area is dominated by the Laurentian Channel. This deep U-shaped trough begins off Tadoussac, crosses the Lower Estuary and the Gulf of St. Lawrence, and terminates at the shelf break southeast of Newfoundland. In the Lower Estuary, the channel reaches a maximum depth of 380 m.

Bordering the Laurentian Channel on either side is a relatively flat littoral shelf that is slightly inclined in an offshore direction. In the upstream portion, water exchanges with the Upper Estuary and the Saguenay Fjord are limited to passages less than 40 m deep, but the connection with the Gulf is much broader (50 km) and deeper (300 m).

The banks in the study area are fairly straight. Whereas the north shore of the estuary is generally steep and has a narrow intertidal zone, the south shore has a more gentle slope and the tides wash up on foreshore areas as wide as 2 km.

The region has semi-diurnal tides—that is, two high tides and two low tides each lunar day—and the mean tidal range increases in a landward direction, from 2.5 m at Pointe-des-Monts to 3.6 m at Tadoussac.

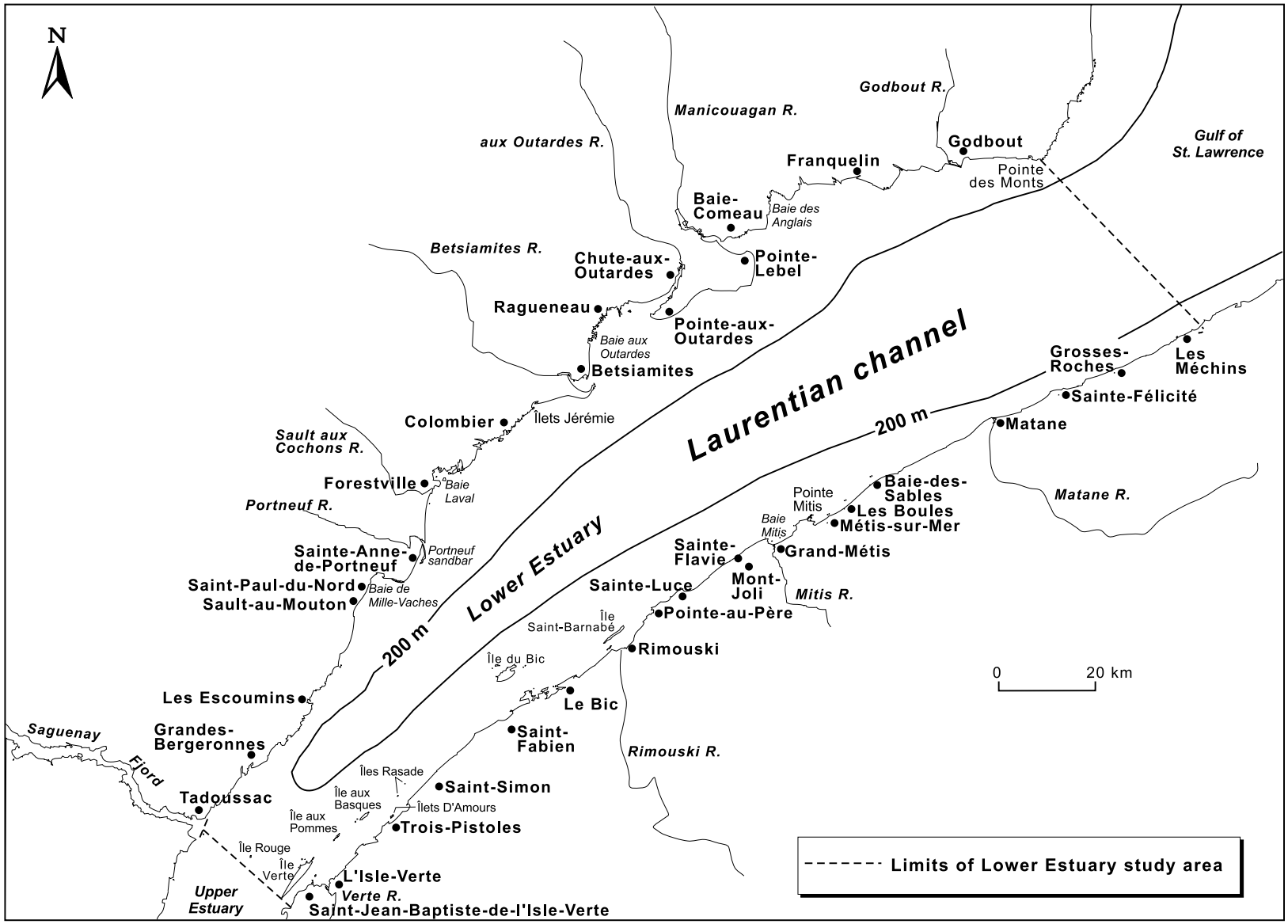


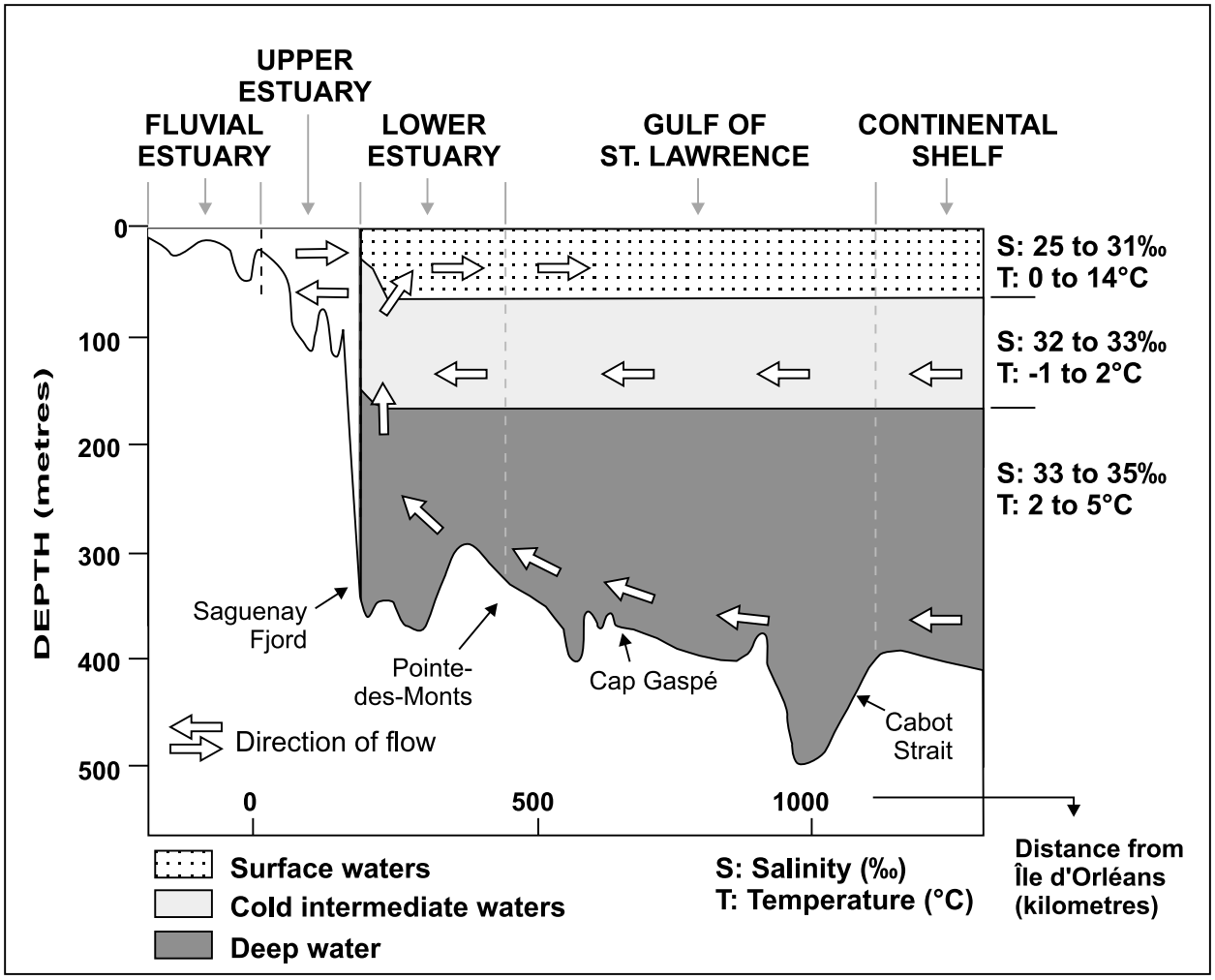
Figure 2 St. Lawrence Lower Estuary study area (ZIP 18)

The main sources of fresh water are the St. Lawrence River (12 000 m^3/s at the upstream boundary of the study area), the Saguenay River (2100 m^3/s off Tadoussac) and three large rivers on the north shore (Betsiamites, Aux Outardes and Manicouagan), which have a combined annual discharge of 1600 m^3/s. In the area of Pointe-des-Monts, high water occurs in May (23 640 m^3/s) and low water in February (13 282 m^3/s).

In the summer, three distinct water masses characterize the circulation pattern in the Lower Estuary and Gulf (Figure 3a). The *surface layer*, which is formed by mixing of fresh water with underlying salt water, is warmer, less salty, more turbid and less nutrient-rich than the lower layers. This water mass flows rapidly toward the Gulf and has a residence time of only 10 to 25 days in the study area. By contrast, the *intermediate layer***,** which forms in the Gulf during the winter, is a cold, relatively salty, clear, and nutrient-rich water mass that travels upstream to the head of the Laurentian Channel, where it undergoes intensive mixing with the surface waters. Water from the Atlantic Ocean makes up the *deep layer*, which is confined to the Laurentian Channel. This water mass, which is warmer and saltier than the intermediate layer, flows up the Laurentian Channel at a speed of only 150 to 200 km per year.

Only the surface layer displays widely fluctuating physico-chemical characteristics. In the winter, owing to the reduction in freshwater runoff and atmospheric cooling, the surface and intermediate layers become mixed, creating a two-layer circulation pattern with a cold surface layer and a warmer lower layer.

At the head of the Laurentian Channel, upwellings of deeper water occur; this water undergoes intensive mixing with surface waters. Upwellings occur during each high tide when the tidal wave moving up the estuary encounters the sudden rise in the seabed near Tadoussac. This phenomenon explains why the waters of the Lower Estuary are colder and more nutrient-enriched than those of the Gulf during the summer.



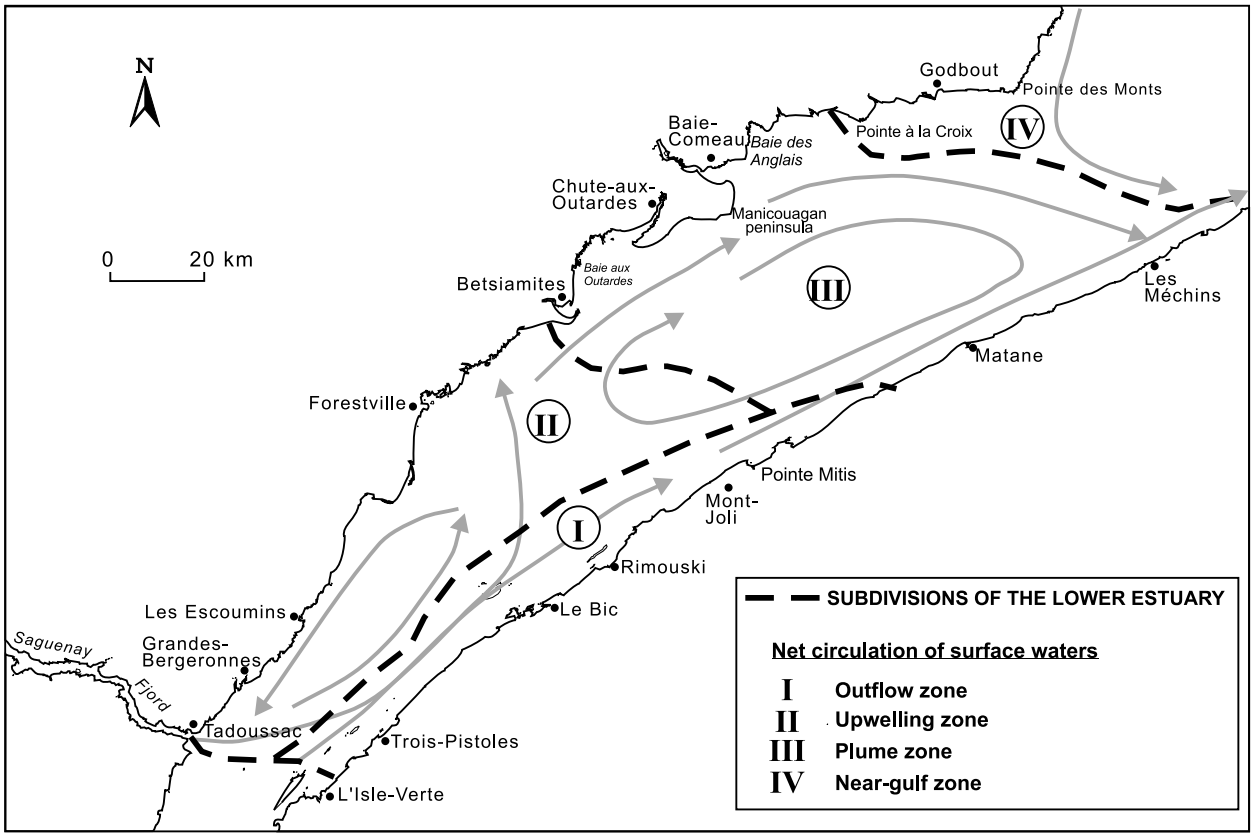
Source: St. Lawrence Centre and Laval University, 1991.

Figure 3a Summer distribution of water masses in a longitudinal section of the Lower Estuary and Gulf of St. Lawrence

Horizontally, the surface layer in the estuary can be subdivided into four distinct zones in the summer (Figure 3b). The *outflow zone* is characterized by warmer, less salty, more turbid and more nutrient-rich water than average. It is composed of waters discharging from the

Upper Estuary and the Saguenay, and which mix with the cold intermediate layer that flows rapidly seaward along the south shore.

In the *upwelling zone*, the water is colder, saltier, less turbid and more nutrient-rich than average. These surface waters form a cyclonic eddy.



Source: El Sabh, 1979; Therriault and Levasseur, 1985.

Figure 3b Division of the Lower Estuary into homogeneous zones based on temperature, salinity, nutrient content and residual circulation of surface waters, in summer

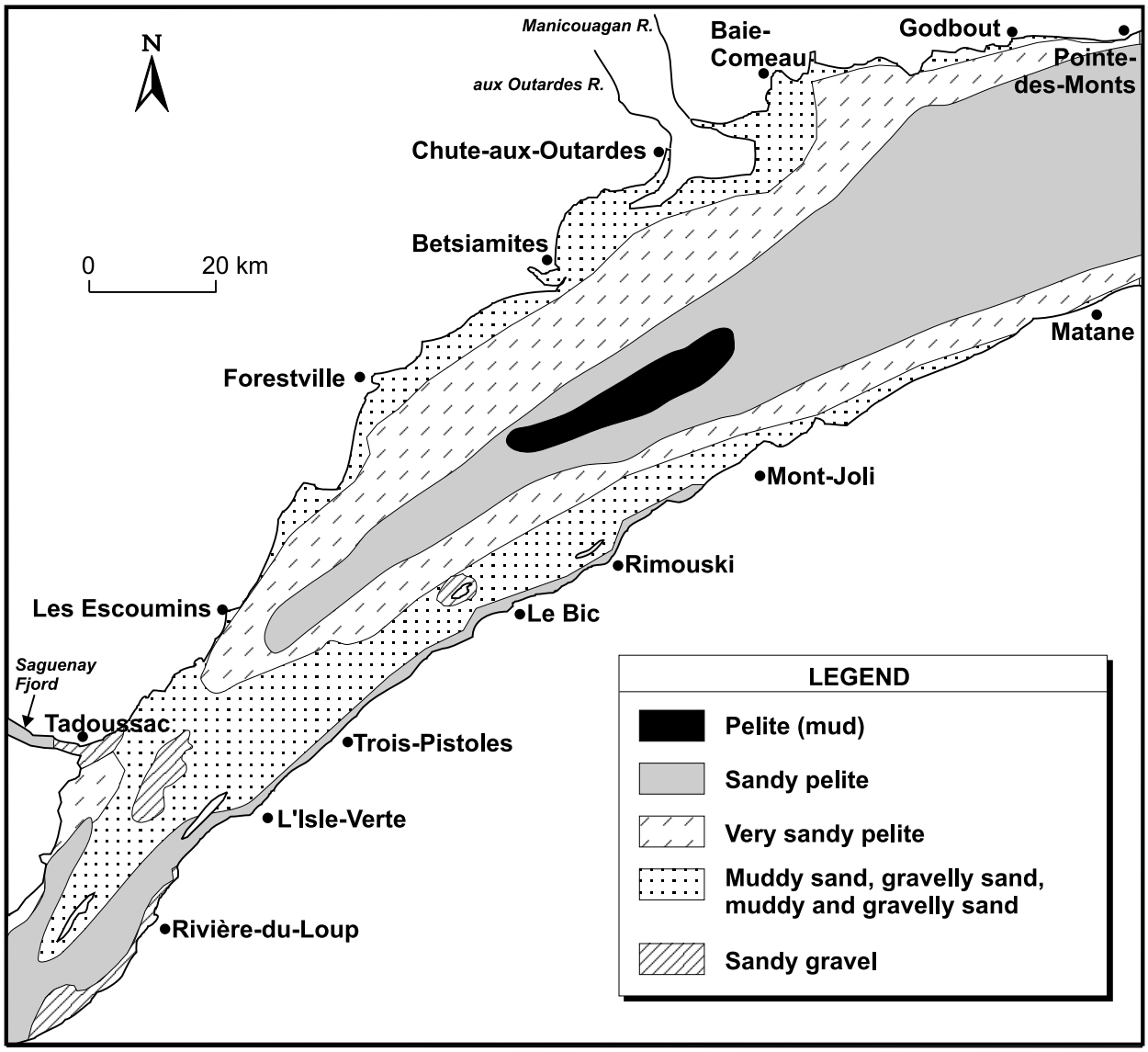
The *plume zone* consists of warmer, less salty, less turbid and less nutrient-rich waters than average. It is affected by the three major rivers on the Cote-Nord (North Shore) and an anticyclonic eddy that recirculates a portion of the surface waters within the estuary.

Lastly, the *near-Gulf zone* has characteristics similar to those of the Gulf waters: the water is warmer, saltier and less turbid and nutrient-rich than the waters farther upstream. At the seaward end of the Lower Estuary, a density front exists which marks the boundary between this water mass and the mass exiting the estuary (plume zone). The water moving downstream along the north shore of the estuary meets the water flowing south along the northwest shore of the Gulf at this front. These waters are then diverted toward the south shore, where they join with the discharge waters flowing out of the estuary and eventually form the Gaspé Current.

During an average winter, the Lower Estuary is frozen over from mid-December to mid-March. Ice cover is greater along the south shore because of the prevailing winds and the water circulation.

The St. Lawrence River transports more than 6.5 million tonnes of suspended solids (SS) into the Lower Estuary annually. Other tributaries and the Gulf are less important sources of suspended solids. The bulk of these sediments are permanently deposited on the bottom of the Laurentian Channel, within the study area. The mean sedimentation rate is about 2.5 mm per year in this part of the channel. Suspended solids of marine origin that are produced locally or transported from the Gulf in the deep water layers also settle in the channel. As a result, the organic fraction of the sediments is composed almost equally of terrigenous organic matter and marine organic matter.

Fine particles (silts and clays) can be deposited only in sheltered intertidal zones, or in very deep areas where the turbulence from the tides and storm surges is not intense enough to cause sediment resuspension. The grain-size distribution of sediments on the estuary floor is thus mainly a function of depth: mud or slightly sandy mud is found at depths greater than 200 m, very sandy mud between 100 and 200 m, and muddy sand to sandy gravel at depths of less than 100 m (Figure 4).

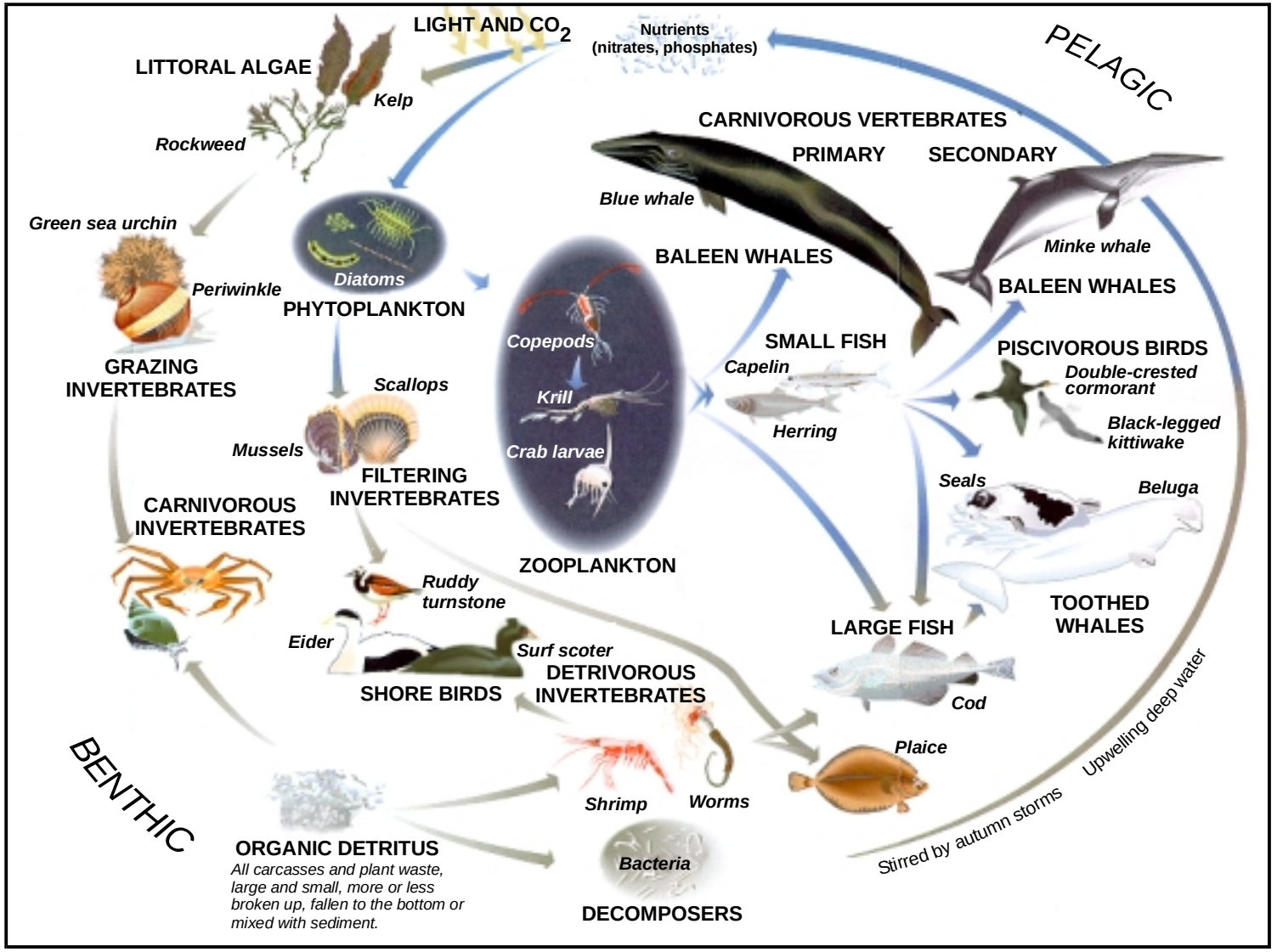


Source: Loring and Nota, 1973.

Figure 4 Distribution of bottom sediments in the Lower Estuary

3.2 Aquatic Habitats and Communities

The study sector contains a mosaic of aquatic habitats that reflect the many possible combinations of biophysical variables that determine the distribution and abundance of organisms (Figure 5). Habitats are generally divided into two broad categories: benthic and pelagic.

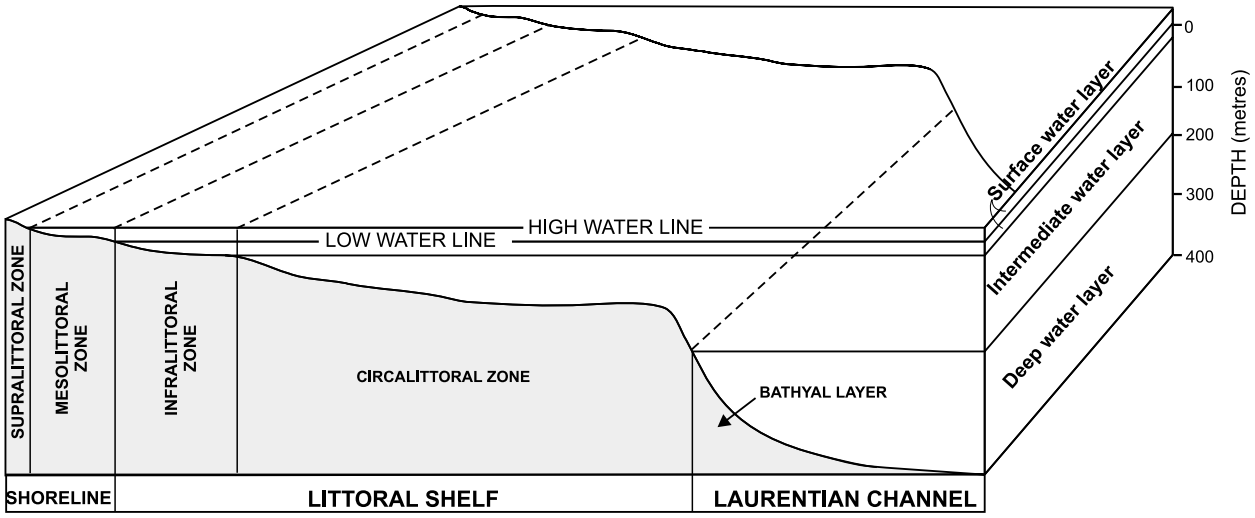


Source : Adapted from St. Lawrence Centre and Laval University, 1992.

Figure 5 Schematic representation of the food chain in the Lower Estuary

3.2.1 Benthic habitats

The benthic environment of the Lower Estuary is home to marine organisms that burrow into (endobenthos), attach themselves to or crawl on the water bottom (epibenthos), or swim near it (hyperbenthos and groundfish species). Many species of fish, birds and marine mammals use benthic habitats for reproduction or feeding purposes. The benthic environment is generally divided into four separate zones, based on tidal influence and the bathymetric layering of the water masses (Figure 6): the *mesolittoral zone* is covered and uncovered daily by the tides; the *infralittoral zone* is comprised of bottom areas beneath the surface water layer; the *circalittoral zone* is associated with the cold intermediate layer, and the *bathyal zone* consists of the bottom areas in the Laurentian Channel that lie under the deep layer of water.

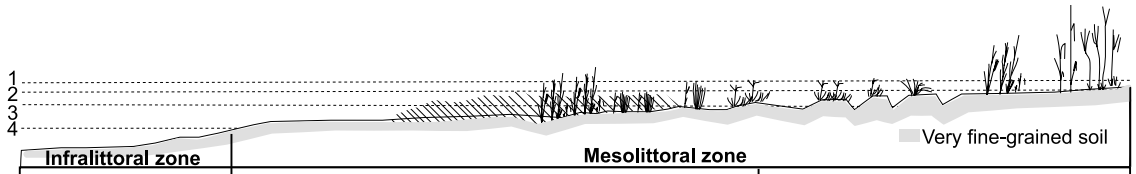


Source: Adapted from Brunel, 1991.

Figure 6 Benthic zones in the Lower Estuary, based on tides and water masses

Habitats of the mesolittoral zone. The mesolittoral zone is the part of the littoral area situated between the extreme low water and extreme high water levels (equinoctial tides). This zone experiences wide daily and seasonal fluctuations in physico-chemical conditions.

Gently sloping shores in well protected areas behind islands, around bays and in river mouths are areas conducive to the deposition of fine sediments and the development of salt marshes and eelgrass communities (mud flats). The typical vertical zonation of vegetation in salt marshes is illustrated in Figure 7a. Salt meadows, characterized by a wide variety of flora, occupy the band that is submerged only during equinoctial tides (twice a year). Salt-meadow marsh containing numerous salt pans occupies the strip that is inundated only by spring tides (twice a month). The upper part of the band is flooded during each tide and colonized by salt-water cord grass marsh; the lower part is denuded of vegetation but abundant in polychaetes and molluscs, fauna that burrow into the mud. Lastly, that part of the band that is uncovered only during low spring tides is sometimes colonized by eelgrass communities.



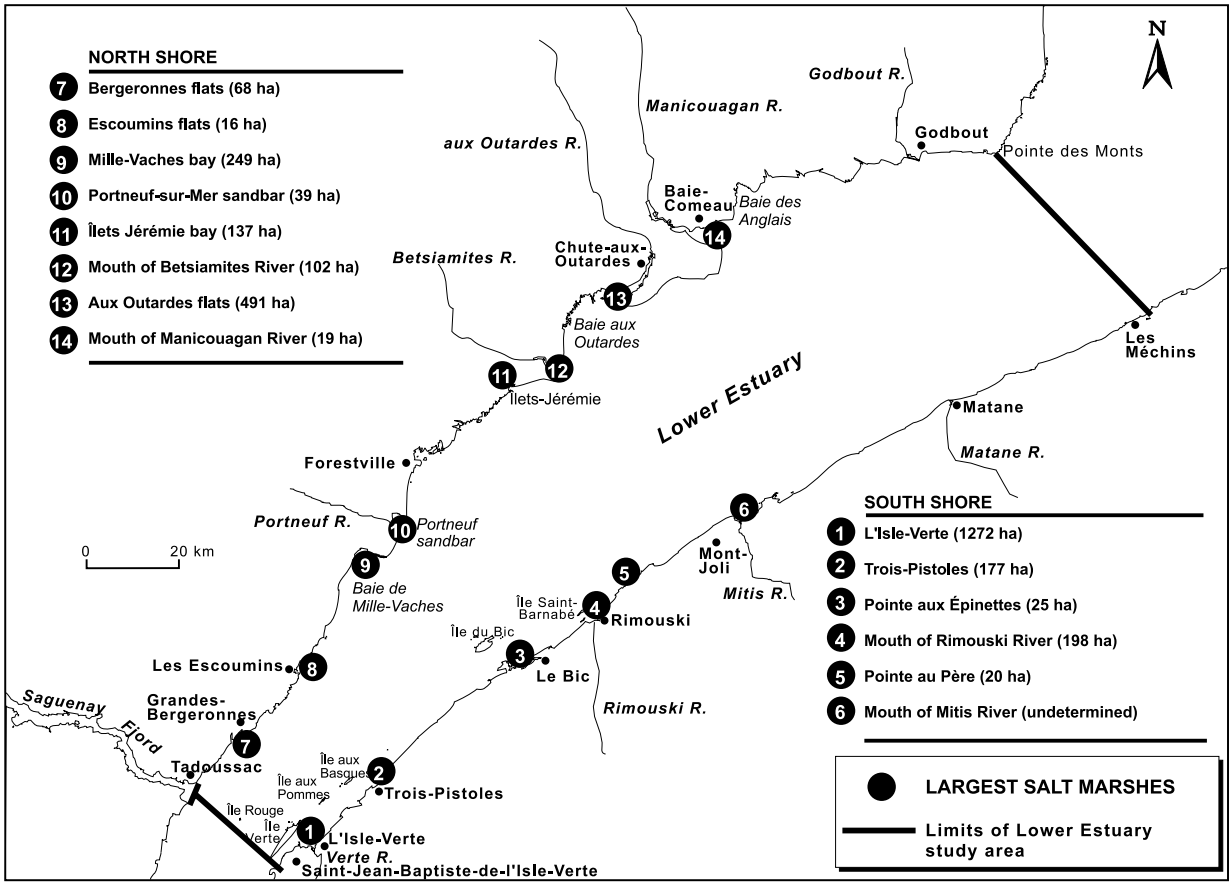
	Low marsh		Upland marsh	
	Partially denuded mud flat	Salt-water cord grass marsh with salt pans	Salt-meadow marsh with salt pans	Salt meadows
com.= community	*Fucus* sp. com Eelgrass com.	Salt-water cord grass com. Salt-water cord grass com. and Glasswort com.	Salt-meadow grass com. Seagrass com. *Plantago maritima* com. Glasswort com.	Red fescue and Chaffy sedge com. Fresh-water cord grass com. Canada reed grass and Canada burnet com.

1 = Equinoctial tide 2 = High water spring tide 3 = Mean high water 4 = Low water spring tide

Source: Adapted from Couillard and Grondin, 1986; Gratton and Dubreuil, 1990; Gratton, 1995; UQCN, 1993.

Figure 7a Vertical zonation of salt marshes in the Lower Estuary

In the Lower Estuary, there are 1072 hectares of salt meadows, 285 ha of salt-meadow marsh, 1487 ha of salt-water cord grass marsh and some 2300 ha of eelgrass beds. These habitats, which are mainly concentrated around L'Isle-Verte and in the Aux Outardes River estuary (Figure 7b), are the most productive areas in the sector. A number of fish species use them as breeding or feeding grounds. While salt meadows provide nesting sites for many dabbling duck species, salt-water cord grass marshes serve as a rearing area for ducks and as feeding grounds for migrating waterfowl. Eelgrass is the preferred food of the Brant and of many dabbling and diving ducks.



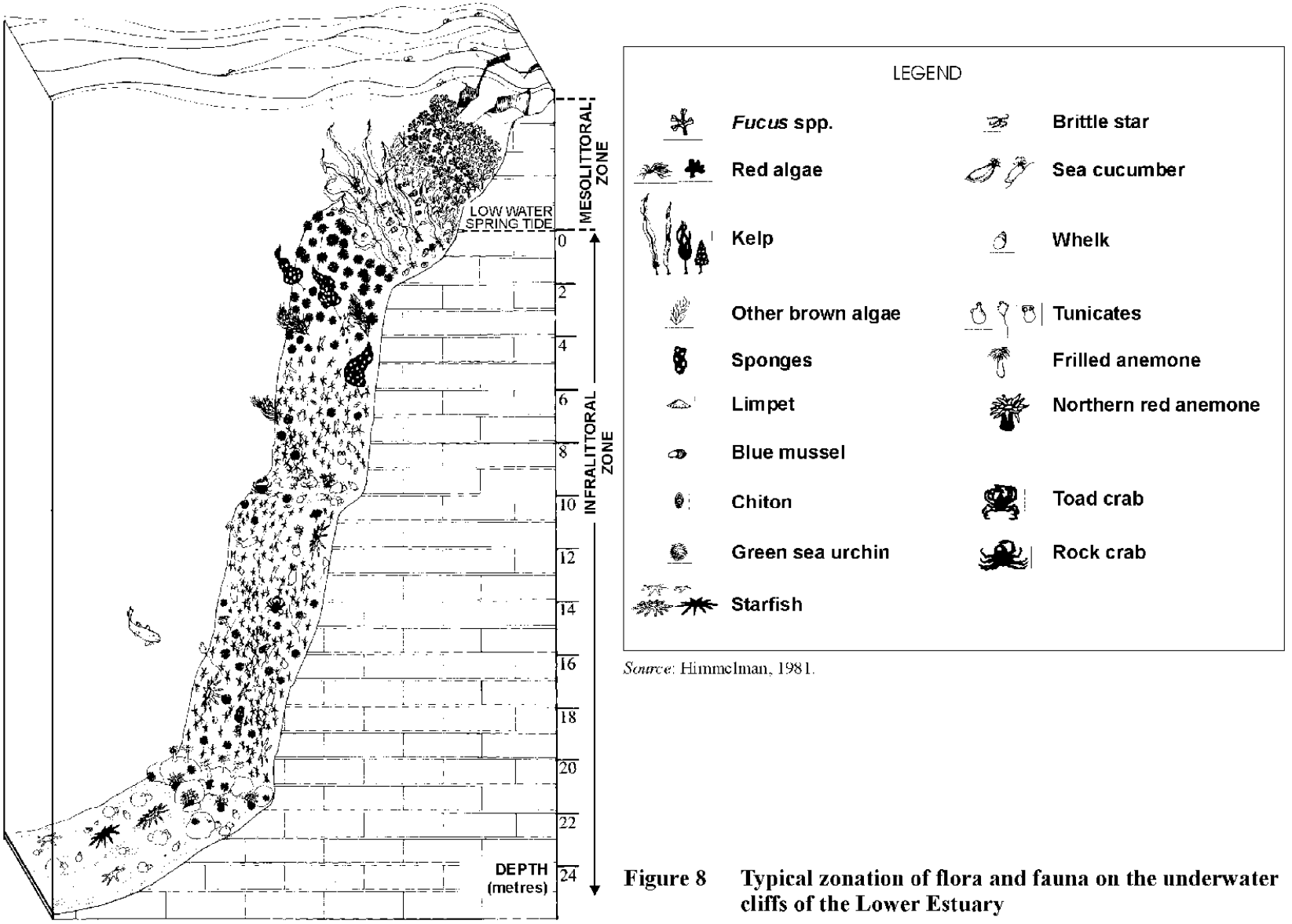
Source: Couillard and Grondin, 1986; UQCN, 1988; Dryade, 1980.

Figure 7b Distribution of the main salt marshes in the Lower Estuary

Rocky foreshores are ubiquitous on the north side of the estuary, on the fringes of islands and on the south side downstream from Ile Verte. These habitats are not very productive because they are subjected to ice scour during spring thaw. On rocky foreshores, the density and biomass of flora and fauna increase descending from the uppermost fringe. In the upper and middle portions of unprotected shore areas, organisms such as barnacles can survive only in ponds, crevices and sheltered rocky walls. By contrast, the lower fringe of the shore is occupied by brown algae (commonly called “rockweed”), which sometimes form a continuous mat inhabited by large numbers of periwinkles and gammarids. Beds of blue mussels are often present at the lower limit of the intertidal zone. Such habitats are used by various species; for example, Common eider broods feed there, and many invertebrate and fish species forage in the sector during high tide.

Sandy foreshores occupy large stretches of the north shore around Sainte-Anne-de-Portneuf and along the Manicouagan peninsula. This type of habitat is denuded of vegetation and, in areas subject to strong wave action, has a limited diversity of endobenthic fauna. Nonetheless, sandy foreshores are a popular site for shorebirds (sandpipers, plovers and other waders) and gulls, which feed on organisms and detritus washed up on the beach, and the capelin that come to spawn in nearby waters. In more sheltered spots, sand mixes with finer sediments. The ooze in sandy shores contains beds of soft-shell clams and marine worms, which are a preferred food of Winter flounder.

Habitats of the infralittoral zone. Unlike the intertidal zone, the infralittoral is never uncovered by the tides and so is basically protected from the destructive effects of ice. On rocky shores, the upper part of the infralittoral zone is often colonized by laminarian algae and blue mussels (Figure 8). Here, green sea urchins graze so heavily on the vegetation that they often wipe out the kelp. Sometimes all that remains are sparse patches or a denuded strip of vegetation around which the sea urchins cluster. At depths of between 5 and 25 m, the flora is dominated by encrusting red algae, whereas the fauna is diversified and includes a flourishing assemblage of



Source: Himmelman, 1981.

Figure 8 **Typical zonation of flora and fauna on the underwater cliffs of the Lower Estuary**

filter feeders (anemones, sponges, sea cucumbers, tunicates). Predation by starfish is so strong that it limits the abundance of blue mussels and barnacles in this habitat. Rocky infralittoral areas serve as spawning grounds for Atlantic herring.

Sandy infralittoral areas contain no vegetation. Fauna here is dominated by burrowers such as molluscs and polychaetes. Soft-shell clams, whelks and rock crab live in such habitats.

Habitats of the circalittoral and bathyal zones. Circalittoral and bathyal seabed areas in the Lower Estuary consist primarily of unconsolidated sediments (sand and/or mud). Not enough light penetrates into this zone to permit photosynthesis. The biological communities here are made up of organisms that feed on organic particles that settle on the bottom (detrivores) and carnivores. More than 800 different species of invertebrates have been identified in circalittoral and bathyal habitats within the study area. The endobenthic fauna is composed chiefly of polychaetes and molluscs, whereas the epibenthic fauna is dominated by echinoderms (brittle stars) and crustaceans (crabs, amphipods). On the bottom areas at the head of the Laurentian Channel, animal life is more abundant and diversified than farther downstream because the substrates are more heterogeneous and the rate of deposition of organic particles is higher. Whereas predominantly sandy areas in the circalittoral zone are populated by snow crab, muddy bathyal habitats have the largest concentrations of northern shrimp and Greenland halibut (turbot).

3.2.2 Pelagic habitats

The pelagic environment is populated by phytoplankton (plants) and zooplankton (animals), pelagic fish species, seabirds and cetaceans. The food chain is largely based on the production of microscopic algae (primary production) in the surface layer. Algae production in the Lower Estuary is lower than in the Gulf of St. Lawrence because of the strong advection of the water mass and the delay caused by spring runoff. Heavy algae production does not begin there until June, compared with late April in the Gulf.

The pelagic environment of the Lower Estuary is not homogeneous. Four broad zones can be differentiated on the basis of primary production in the surface layer (Figure 3b). In the

current that runs along the south shore of the Lower Estuary (outflow zone), primary production is greatly hampered by the high turbidity and short residence time of the water. This habitat is not productive. However, pelagic (herring, capelin), anadromous (American shad, salmon) and catadromous (American eel) fish species travel through the pelagic sector when migrating to their spawning grounds. The upstream part of the Laurentian Channel (upwelling zone) has higher primary and secondary production, and is used intensively by many marine mammals during the summer. Often ice-free in the winter, the sector also serves as an overwintering spot for some seabird species, and for Harp seals. Primary production in the plume zone is greater than farther upstream. In the near-Gulf zone, the seasonal pattern of primary production is similar to that in the Gulf, with strong production in early spring that tapers off in summer, as is the case farther upstream.

Zooplankton comprise numerous types of animals that drift passively with the currents. They include organisms that spend their whole lives in the pelagic zone, as well as the eggs and larvae of benthic organisms and fish. In the Lower Estuary, the zooplankton are not very diversified and resemble the community found in the High Arctic; the Lower Estuary zooplankton is 80–90% copepods, i.e. small crustaceans that spend their entire life cycle in the pelagic region. There is also an abundance of euphausiids (commonly called “krill”), which, under certain conditions, form large aggregations. Most zooplanktonic organisms make daily vertical migrations between the surface water layer, where they feed at night, and the deeper waters, where they can be safe from predators during the day.

In the water column above the northern continental slope and the upstream end of the Laurentian Channel, euphausiids form large aggregations that are exploited by cetaceans. At night these animals stay near the surface, whereas during the day euphausiids can be found at depths of between 40 and 150 metres. Krill accumulations in this area have been linked to the upwelling that occurs along the north shore and at the head of the Laurentian Channel. Euphausiids are transported seaward and toward the north shore by the currents at a depth of 40 m, which

corresponds to their light tolerance threshold. This is also the level at which they congregate during the day.

3.3 Fishery Resources

Only a handful of the hundred species of marine algae, thousands of invertebrate species and 80 fish species of the Lower Estuary are harvested. The main species targeted by commercial, sport and food fishermen in the study area are soft-shell clams, whelks, snow crab, northern shrimp, Rainbow smelt, Atlantic salmon, Atlantic herring, Atlantic cod and Greenland halibut. Secondary fishery resources include marine algae, Icelandic scallops, Stimpson's surf clams, blue mussels, Atlantic sturgeon, American eels, capelin, Canadian plaice, Atlantic halibut and Deepwater redfish. Lobster, a key fishery resource of the Gulf of St. Lawrence, do not inhabit the Lower Estuary.

Soft-shell clam. The study area contains some of the largest soft-shell clam beds in Eastern Canada, with landings making up about 75% of the total catch for Quebec. This bivalve mollusc is particularly abundant in the intertidal zone of the north shore, between Les Escoumins and Sainte-Anne-de-Portneuf and between Betsiamites and Baie-Comeau. Soft-shell clams and other filter-feeding molluscs may be contaminated by the toxic algae that cause paralytic shellfish poisoning in humans. Algal blooms occur sporadically in the area between Trois-Pistoles and Sainte-Flavie, and chronically in the area downstream from Sainte-Flavie and all along the north shore, thus effectively limiting where and when harvesting is permitted. Soft-shell clam beds on the north shore are intensively exploited; however, the state of the resource is not known.

Whelk. The whelk is a gastropod mollusc that abounds on sandy bottoms in the infralittoral zone. In Eastern Canada, the fishery for this species is centred primarily in the downstream part of the Lower Estuary and in the northwestern Gulf. Whelks are especially vulnerable to harvesting because many of them are caught before they have a chance to reproduce and because the larvae are not dispersed widely, as is the case for the other harvested

invertebrates. Although the current state of the resource is not known, in light of present fishing practices, the stocks may have difficulty rebuilding.

Snow crab. The snow crab is currently the main fishery resource in the Lower Estuary in terms of the volume and landed value of catches. This species is abundant on both sides of the estuary in the circalittoral zone, at depths of between 70 and 140 metres; however, snow crab densities are lower there than on the main fishing grounds in the Gulf of St. Lawrence. The fishery takes only male snow crab, and a large proportion of them (30–40%) never reach minimum legal size. The size of the snow crab population in the estuary is affected by major natural fluctuations occurring on a cycle of about 10 years. In the early 1990s, their numbers were substantial. Although their harvestable biomass has been declining since 1993, an upturn is expected to occur as of 1998.

Northern shrimp. The northern shrimp is a crustacean that stays near the bottom of the Laurentian Channel during the day, and migrates to the top of the water column at night. The shrimp in this area represent a distinct population that is much smaller than the other three populations harvested in the Gulf of St. Lawrence. The resource is concentrated primarily in the upstream part of the sector. Although the abundance of the large-sized shrimp (mostly females) targeted by the commercial fishery was relatively low in 1992–93, the stock is nonetheless considered to be stable.

Rainbow smelt. After spawning in several tributaries of the St. Lawrence in the spring, this anadromous species returns to the estuary, where it spends the rest of the year. The only known spawning ground in the study area is in Trois-Pistoles River. The smelt in the Lower Estuary may be from either of three separate populations: south shore of the St. Lawrence estuary, north shore of the Upper Estuary–Saguenay, or the Haute-Cote-Nord (Upper North Shore). Rainbow smelt numbers have dropped substantially since the 1960s, probably because of a deterioration in the quality of their spawning grounds.

Atlantic salmon. The main salmon rivers in the study area are the Escoumins, Laval, Betsiamites, Anglais, Mistassini and Godbout rivers on the north shore, and the Sud-Ouest,

Rimouski, Mitis and Matane rivers on the south shore. Although the data on salmon runs on Cote-Nord rivers are incomplete, fishing success is known to have declined markedly since the early 1990s. In south shore rivers, the number of returning salmon has fallen by roughly 15% since 1992. The decline in the resource, which is observed throughout Quebec, has been blamed on poor overwintering conditions in the Atlantic Ocean, which have caused mass mortalities. Two-sea-winter salmon are affected above all, because the proportion of one-sea-winter fish in runs has increased in step with the drop in the size of salmon runs. The large proportion of one-sea-winter salmon is worrisome since they are mainly males.

Atlantic herring. Herring is the primary pelagic species harvested in the study area. The main population migrates along the south shore of the estuary in the spring in order to spawn in the Rivière-du-Loup region, which is in the Upper Estuary. The population is thought to be stable at present. Several other populations exist which spawn in the estuary in the spring and fall.

Capelin. Capelin is a secondary fishery resource in the study area. Nonetheless, this species is very important from an ecological standpoint because it is a key prey species for many fish, birds and marine mammals. Capelin spawn in spring along the banks of the Upper and Lower estuaries, to which they travel in compact schools. The fish that survive the spawning period leave the estuary and spend the summer in the northwestern Gulf. A portion of the young-of-the-year stay near the mouth of the Saguenay River year-round. Although the condition of the population that frequents the estuary is not known, the species is considered to be abundant.

Atlantic cod. A small fraction of the cod population in the southern Gulf of St. Lawrence travels as far upstream as the Lower Estuary in the summer. During the 1960s and 1970s, this species was the most important fishery resource in the area. The population of the southern Gulf has been in decline since the mid-1980s, and fell to a record-low level in 1992–93. The moratorium imposed on cod fishing in 1993 has helped to halt the decline, but has not brought about a significant increase in the harvestable biomass, because of unfavourable oceanographic conditions that have hindered the survival and growth of cod (intermediate layer colder than normal).

Greenland halibut. A large part of the Greenland halibut (or turbot) population in the Gulf of St. Lawrence inhabits bottom areas in the Laurentian Channel, within the Lower Estuary. Turbot has been the main fish species landed in the sector since cod fishing was banned. The Gulf population is marked by wide fluctuations in abundance. Since the early 1990s, the biomass has been low but stable. There is no minimum legal size for the species, and a large proportion of catches is made up of immature turbot.

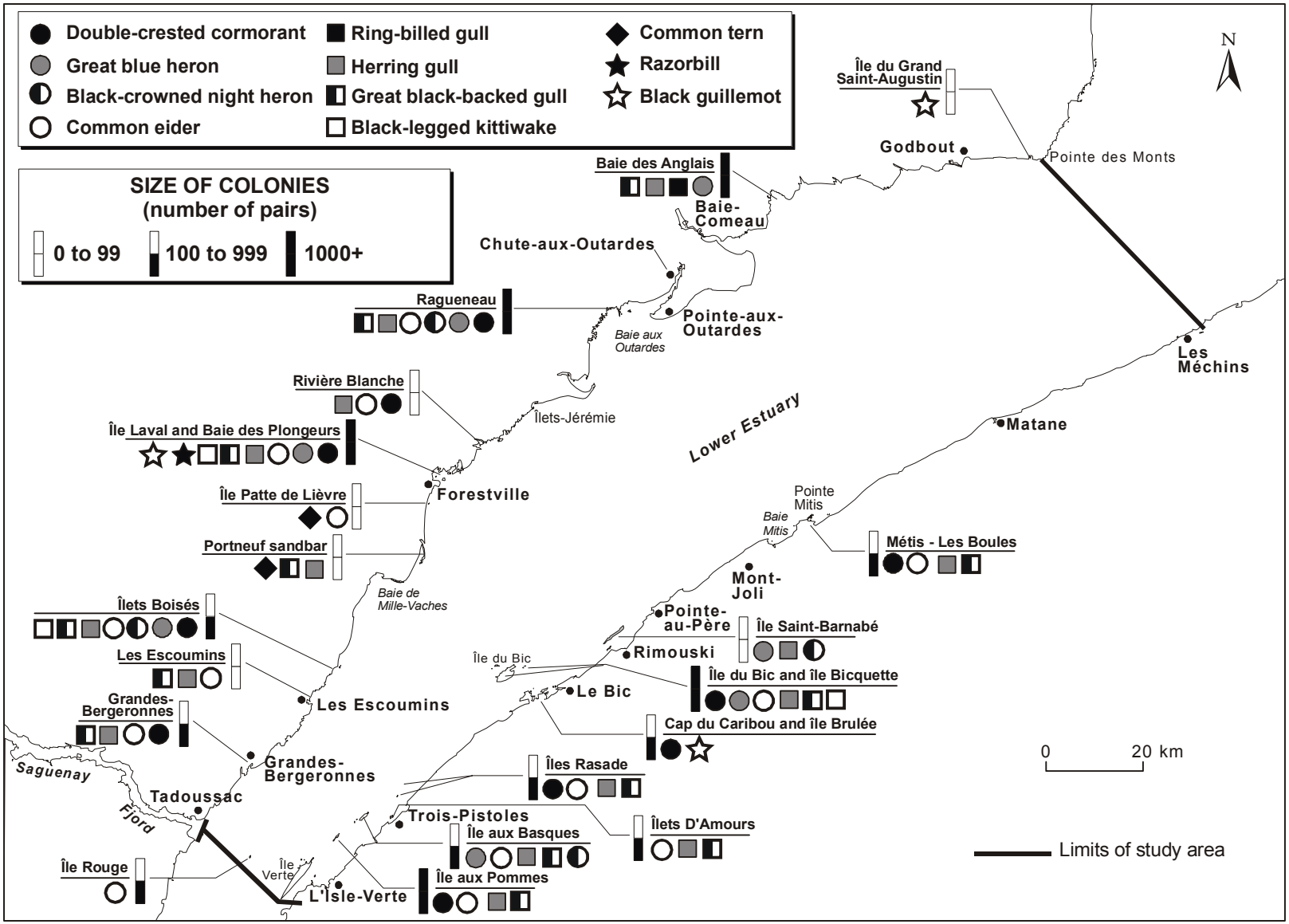
3.4 Birds

Over 300 species of birds have been observed in the shoreline municipalities in the study area. These birds come here to breed (156 species) and raise their young, to feed during spring or fall migration, to overwinter; others appear only occasionally or rarely.

3.4.1 Breeding

There are 75 breeding species directly associated with the study area's marine and coastal environments. The Lower Estuary is characterized by a wealth of seabird colonies. In the early 1990s, there were 129 colonies inhabited by 35 000 breeding pairs of 10 species (Figure 9). The main colonial species are, in descending order of number of pairs: Common eider, Herring gull, Double-crested cormorant and Ring-billed gull. These colonies are concentrated chiefly on Bic and Bicquette islands (16 colonies; 11 650 pairs), the Ragueneau islands (24 colonies; 5588 pairs), Ile aux Pommes (4 colonies; 5393 pairs) and Laval Island and Baie des Plongeurs (10 colonies; 4914 pairs).

The **Common eider** nests in May in 25 colonies located mainly on islands smaller than 20 ha in size. In 1995, there were 15 400 pairs in the study area, some 60% of the population of the entire St. Lawrence estuary. The two principal colonies, on Bicquette Island and Ile aux Pommes, on the south shore, account for about 70% of the total. The estuary's eider population is currently on the rise and is spreading upstream and to the north shore.



Source: Bédard and Nadeau, 1995 ; Bédard and Nadeau, 1994.

Figure 9 Distribution of bird colonies in the Lower Estuary

The **Herring gull** nests in 36 breeding colonies, and 8500 breeding pairs were counted in the early 1990s. The main colonies are on Ile aux Pommes and Bicquette Island on the south shore and Laval Island and Ile de la Mine (Ragueneau islands) on the north shore. This species' numbers in Quebec are currently declining, possibly because of reduced by-catch dumping at sea since the moratorium on cod fishing was introduced.

The **Double-crested cormorant** nests in 21 colonies totalling 5800 pairs (16% of the total estuary population). The principal colonies are on the north shore, on Laval Island and the Ragueneau islands. Between 1979 and 1990, the breeding population in the estuary rose from 12 000 to over 22 000 pairs. This spectacular expansion reduced the breeding habitat available to the Common eider. Eiders nest under tree cover, and the accumulated excrement of the cormorants nesting in the trees destroyed large areas of the islands' forest cover. In order to contain this destruction, the cormorant population was subjected to a control program between 1988 and 1993, and this brought the estuary's population down to 10 000 pairs.

The **Ring-billed gull** has only one breeding colony, on a wood waste dump in Baie-Comeau. The colony was discovered in 1973 and went from 1200 breeding pairs in 1978 to 2788 in 1993. It is now thought to have stabilized.

The Great blue heron (8 colonies), Black-crowned night heron (4 colonies), Great black-backed gull (31 colonies), Black-legged kittiwake (5 colonies), Common tern (2 colonies) and Razorbill (1 colony) are other colonial nesting species found in the study area.

There are other species that breed in large numbers along the shores of the Lower Estuary, but not in colonies. The **Black duck** is the most numerous of the 16 duck and goose species breeding in the area; it is found almost everywhere in southern Quebec, including the Bas-Saint-Laurent (Lower St. Lawrence) and the Haute-Cote-Nord (Upper North Shore). In the study area, the highest breeding densities are found around L'Isle-Verte. The Black duck nests mainly in tallgrass wetlands and in bogs.

3.4.2 Spring migration

In spring, some 75 000 ducks and geese gather in the study area. The main migratory species are the Greater snow goose, Scoter species, the Canada goose, the Common eider and the Brant.

The **Greater snow goose** crosses Quebec in a narrow north-south corridor on its spring migration to the Arctic. Its main staging areas are the bulrush marshes in the upstream part of the Upper Estuary. In the early 1960s, this species was rarely seen in the study area. The tremendous population increase that has occurred since then has occasioned an expansion of staging areas into the farmlands and salt-water cord grass marshes of the Upper Estuary and the south shore of the Lower Estuary (L'Isle-Verte, Trois-Pistoles, Bic, Rimouski and Métis-sur-Mer).

Surf scoters and **Black scoters** gather in spring along the north shore of the estuary, chiefly between Saint-Paul-du-Nord and Baie-Comeau. This distribution seems to be associated with herring spawning. In late May, these species gather in large flocks before leaving for their nesting grounds on the lakes of northern Quebec.

The **Brant** follows the Atlantic coast to Chaleur Bay, then crosses the Lower Estuary to its main staging areas around James Bay before heading for its Arctic breeding grounds. More than one-fifth of the birds on the St. Lawrence (estimated at 18 000 individuals in the mid-1970s) gather in the study area, mainly near eelgrass meadows. The Brant population was thought to be on the increase in the early 1980s.

3.4.3 Summertime use

After hatching, Common eider females and ducklings leave the colonies and form nurseries consisting of several broods; these then forage in sheltered bays of the shoreline and the larger islands in rocky intertidal areas and cordgrass marshes. The principal brood-rearing grounds in the study area are at Saint-Fabien-sur-Mer, Cap-à-l'Orignal, Ile aux Basques, Ile Saint-Barnabé, along the coast between Pointe-au-Père and the mouth of the Mitis River on the south shore, and along the Grandes-Bergeronnes section of the north shore. During the moulting period

(when old feathers are shed and new ones grow) in July and August, male and female eiders gather and feed in rocky shoals. In late September, the males leave the estuary for their overwintering grounds in the northern Gulf. They are joined in October by the females and that year's young.

The salt marshes are also used by locally breeding dabbling ducks (chiefly Black duck). Single individuals and broods are found mainly in the cord grass marshes and the diked brackish and freshwater marshes. Diving ducks and sea ducks, on the other hand, confine themselves almost entirely to the cord grass marshes.

Large groups of Surf scoters are seen in the study area in summer. The males head for the estuary after breeding (mid-July to mid-August), followed from late July to mid-August by those females that did not breed or bred unsuccessfully.

Of the shorebirds found in the Lower Estuary, only the Killdeer, Spotted sandpiper and Common snipe have been confirmed as breeding in the study area.

3.4.4 Fall migration

In the early 1990s, nearly 36 500 geese and ducks would gather in the Lower Estuary in fall. Over 90% were sea ducks or dabbling ducks, geese being much less abundant than in spring. In the mid-1970s, the study area hosted 11% of the migrating geese and ducks (50% of the sea ducks) on the St. Lawrence. The most common species along the north shore in the fall are the Black duck, Common eider and Surf scoter.

Thirty-eight shorebird species (plovers, sandpipers and other waders) use the study area chiefly on their fall migration, the great majority gathering along the north shore. The main sites are the Portneuf bank, Paradis Point, the Banc des Blancs and the mouth of the Petite Romaine River. On the south shore, the mouth of the Rimouski River and the Pointe-au-Père marsh are frequented by smaller numbers, but by a greater variety of species. The Semi-palmated sandpiper is generally the most abundant species at all sites.

Tadoussac is the most important staging point for Quebec birds of prey. In the 1993 fall migration, 615 hours of observation yielded a count of 17 891 birds of prey belonging to 13 species.

3.4.5 Overwintering

In the late 1970s, an estimated 36 000 ducks overwintered in the Lower Estuary, making it one of the main overwintering areas on the St. Lawrence after the Moyenne-Cote-Nord (Middle North Shore) and the Gaspé. Most ducks gather near the north shore, the main species being the Oldsquaw, Common goldeneye, Barrow's goldeneye, Black duck and Bufflehead. One of the main Oldsquaw haunts is the mouth of the Saguenay River, while Black ducks gather chiefly at the mouths of the Grandes-Bergeronnes and Petites Bergeronnes rivers. Goldeneyes are seen in small groups, principally between Tadoussac and Bon-Désir Bay and, in the case of Barrow's goldeneye, near Baie-Comeau.

3.5 Marine Mammals

Fourteen species of marine mammals can be seen in the Lower Estuary at various times of year, but only eight of them are frequent visitors. They are the Beluga whale, Harbour porpoise, Blue whale, Fin whale, Minke whale, Harbour seal, Grey seal and Harp seal. The Atlantic white-sided dolphin and the White-beaked dolphin, Killer whales, Atlantic pilot whales, Sperm whales and Humpback whales visit the Lower Estuary only occasionally or rarely.

Beluga. A population of Belugas lives permanently in the St. Lawrence estuary; it is the most southerly Beluga population in the world. During the ice-free period, Belugas stay in the downstream end of the Upper Estuary and the Saguenay Fjord, and in the upstream sector of the Lower Estuary. In the summertime, the main gathering place for Belugas is on the north shore between Tadoussac and Sainte-Anne-de-Portneuf (Figure 10). In winter, the whales leave the Upper Estuary and the Saguenay and congregate in the Lower Estuary and the northern Gulf where there are still areas of open water.

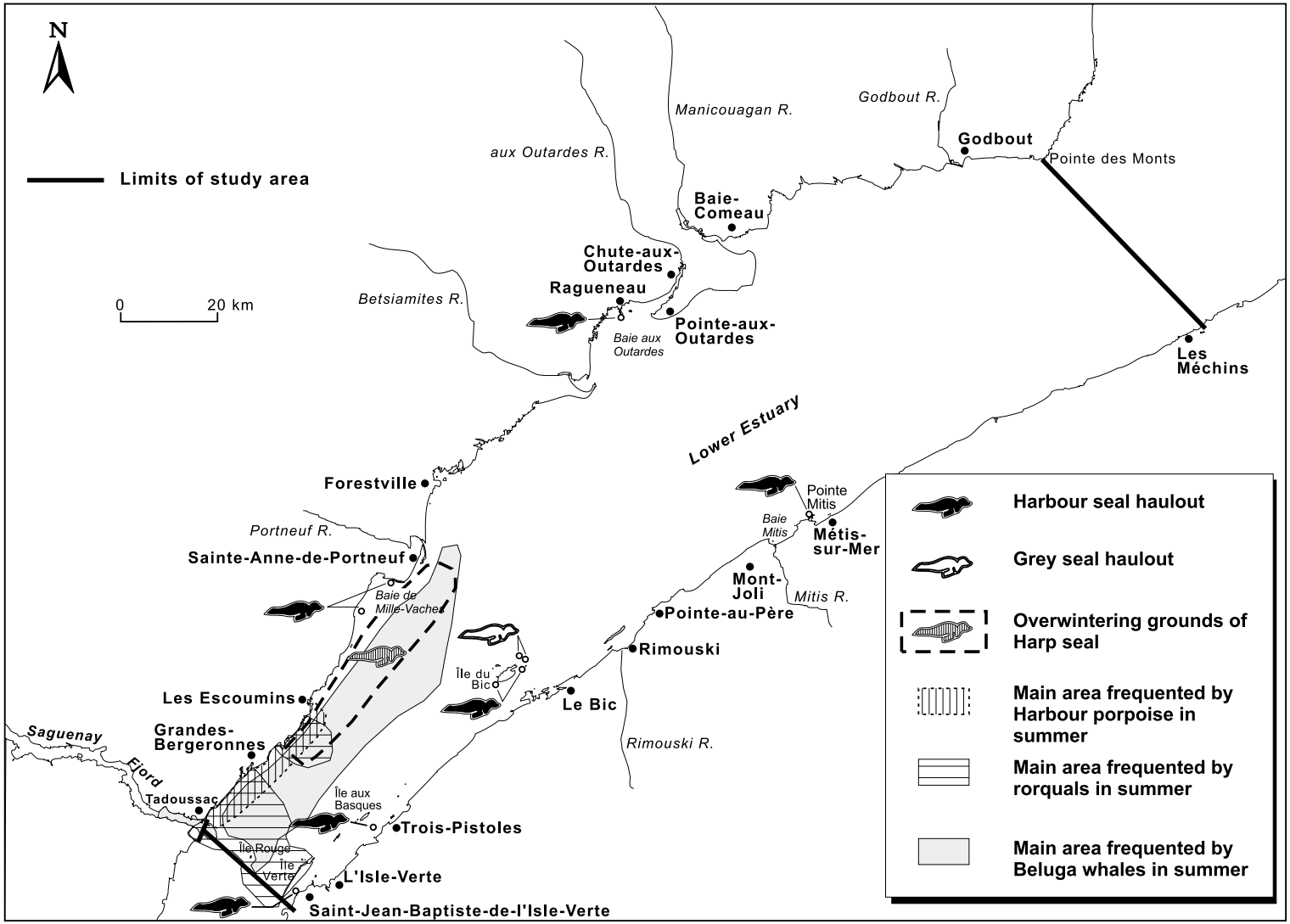
Little is known about the Beluga's diet. In the study area, they most likely eat prey species like Atlantic herring, Rainbow smelt, American eel, capelin and Sand lances.

The Beluga population in the estuary has declined drastically since the end of the 19th century, when it totalled about 5000. In 1960, there were some 1500 Belugas, in contrast with only about 500 today. This major decline is primarily attributable to overhunting. Although hunting has been banned since 1979, a number of other factors such as disturbances from ship traffic, habitat loss, contamination by toxic substances and competition for food still threaten the population (see Section 4). A low recruitment rate was noted in the 1980s. However, more recent observations suggest that the proportion of young Belugas is increasing and reaching a normal level for this mammal.

Harbour porpoise. Harbour porpoises can be found in the Lower Estuary from May to November, with maximum abundance in July. They travel in small pods of five to ten individuals that can frequently be sighted close to the north shore between Tadoussac and Les Escoumins (Figure 10). Although it is not known how many porpoises frequent the study area, they are probably quite numerous. A number of strandings have been reported. The species' diet consists primarily of herring and capelin.

Minke whale. The Minke whale is the smallest and most common of the four baleen whale species (rorquals) that occur in the Lower Estuary. This species can be sighted throughout almost the entire sector, especially in coastal zones along the north shore, between the mouth of the Saguenay River and Grandes-Bergeronnes, and between Bon-Désir Cape and Les Escoumins. Minke whales also occur in the middle of the estuary, between Ile Rouge and Ile Verte. They feed primarily on pelagic fish species, particularly capelin.

Fin whale. Fin whales begin to appear in the Lower Estuary in May; their number peaks in August and then declines when they leave the area in the autumn. It is estimated that more than 40 whales frequent the estuary at the same time. The species feeds on herring, capelin and euphausiids. The most heavily frequented area forms a triangle connecting Grandes-Bergeronnes, Baie-Sainte-Catherine and Ile Rouge (Figure 10).



Source: Adapted from Michaud, 1993; Lavigueur et al., Lavalin Environnement,1989; Lesage et al., 1995.

Note: There are no seal haulouts or areas used intensively by whales downstream of Pointe-aux-Outardes (north shore) or Métis-sur-Mer (south shore).

Figure 10 Distribution of marine mammals in the Lower Estuary

Blue whale. The Blue whale is rarely sighted before mid-July in the upstream stretch of the Lower Estuary. Although its abundance varies from year-to-year, the Blue whale is never a frequent visitor. The area visited most is situated along the north shore between Les Escoumins and Forestville. Euphausiids form the major part of the whales' diet.

Harbour seal. Harbour seals are permanent residents of the study area. Calving occurs in mid-June. The main haulouts are located in the Upper Estuary. In the upstream end of the Lower Estuary, 238 individuals were identified during an aerial census conducted in 1994. At the time, the main haulouts (> 20 individuals) were situated on the Mitis Point reefs, on Bic Island and the reefs on its southeastern coast (Figure 10). In 1973, an estimated 700 seals lived along the estuary between Ile aux Coudres and Pointe-des-Monts. In 1978, this figure fell to 400. The size of the current population is not known.

Grey seal. Part of the Grey seal population of Eastern Canada frequents the Lower Estuary from June to November. A population count done in August 1994 identified about 50 individuals in the study area. The principal haulouts are located on the reefs of the southeastern coast of Bic Island. The Grey seal population of Eastern Canada has been growing since the early 1960s. Capelin is the species' main food in the estuary.

Harp seal. A portion of the Harp seal population that reproduces in the Gulf of St. Lawrence late in the winter frequents the Lower Estuary from late autumn to early spring. These seals congregate in areas between Bon-Désir Cape and Sainte-Anne-de-Portneuf. At the end of the winter, most of the sexually mature females leave the estuary to go to the calving grounds in the Gulf. A small number of individuals stay in the estuary during the summer. The species' diet consists of capelin, groundfish and shrimp.

3.6 Species at Risk

There are 12 rare plant species, 7 fish, 1 reptile, 15 bird, 4 marine mammal and 1 land mammal in the study area that are listed as priority species in need of protection under the St. Lawrence Vision 2000 action plan (Appendix 1).

Two priority plant species—*Rosa rousseauorium, Rosa williamsii*—are endemic to the Lower Estuary and the Gulf of St. Lawrence, while Arrow grass (*Triglochin gaspense*) is endemic to northeastern North America. *Rosa rousseauorium* is found along the edge of marshes and river banks, while *R. williamsii* grows on cliffs and rocky shores. Arrow grass grows in salt marshes around ponds at the mean high water mark; it has been found around Trois-Pistoles, Rimouski and Grandes-Bergeronnes. A number of priority species have been reported recently in Bic Park.

The priority fish species are the Striped bass, American shad, Atlantic sturgeon, Rainbow smelt, Atlantic tomcod, Atlantic herring and American eel. The first five are anadromous, spawning in fresh water, with the larvae and young developing in the river, the Upper Estuary or their tributaries. The decline of these species is largely attributable to the degradation of spawning grounds. The causes of the sharp decline in the St. Lawrence American eel population over the last decade remain unknown. This species is found in most of the rivers emptying into the Lower Estuary, but these local populations are much less numerous than that of the St. Lawrence River and Great Lakes basin.

Of the 15 priority bird species, six—the Pintail, Blue-winged teal, Bald eagle, Peregrine falcon, Yellow rail and Le Conte's sparrow—are thought to nest in the study area. The two duck species have suffered a marked decline in numbers in Quebec over the past 30 years, the causes of which, in the case of the Pintail, remain unknown; the decline of the Blue-winged teal is likely due to loss of breeding habitat and overhunting in winter in Mexico. The other four species are rare in Quebec. The Bald eagle needs large, mature trees, fish-rich waters and freedom from disturbance to breed. It is a possible or probable breeder at Tadoussac, Grandes-Bergeronnes, Pointe-aux-Outardes and Franquelin. The Peregrine falcon nested successfully in Bic Park in 1994 and 1995 (one nest), and it may nest at Pointe-aux-Outardes. The Yellow rail has been seen only at Pointe-aux-Outardes in the breeding season. Le Conte's sparrow has probably nested around Saint-Paul-du-Nord; this is the only report of this species on the St. Lawrence east of Cap Tourmente, near Quebec City.

The four priority marine mammals in the study area are the Beluga whale, Harbour porpoise, Fin whale and Harbour seal. These species have already been covered in section 3.5.

3.7 Land Use

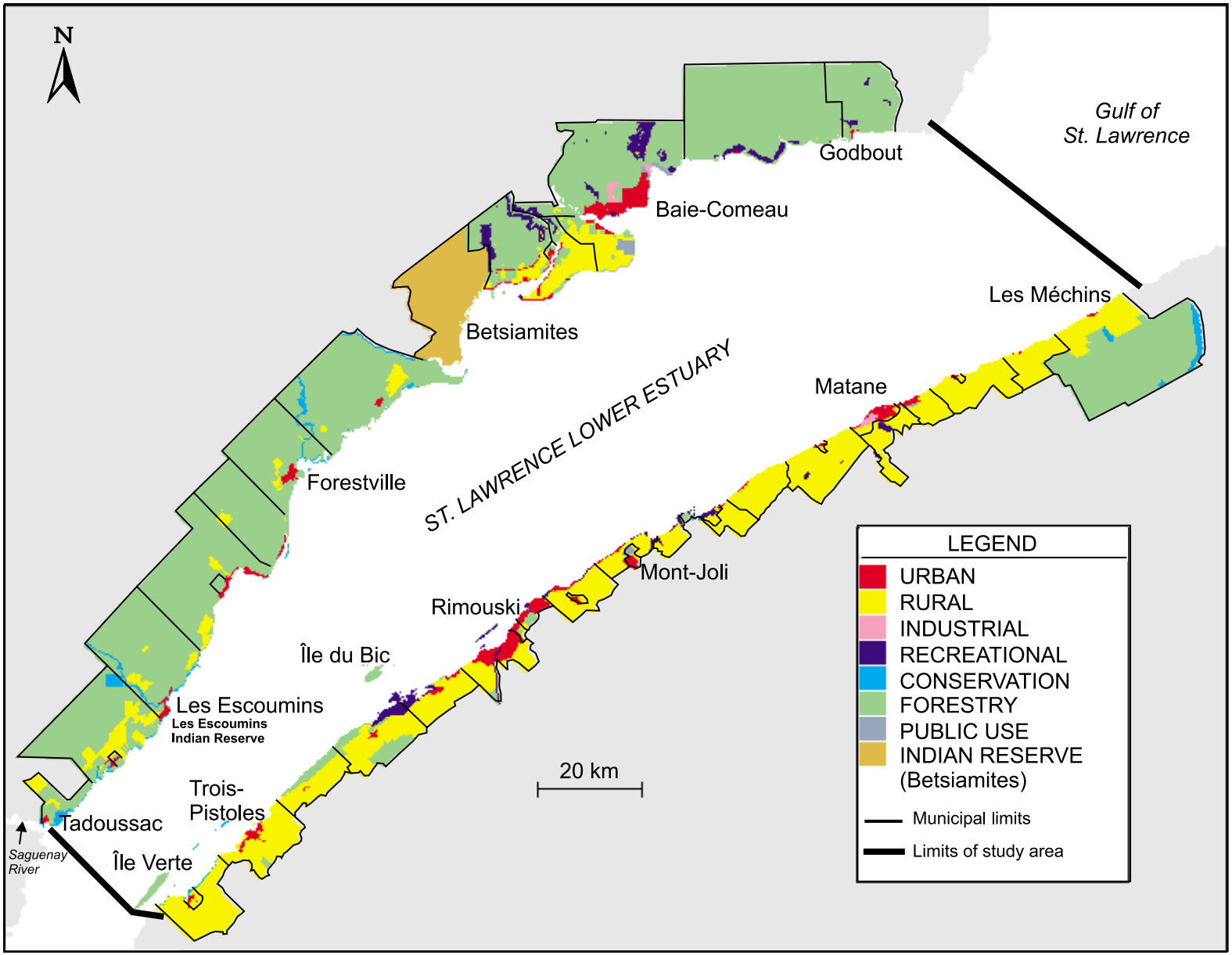
3.7.1 Land-use divisions

In 1991, almost 128 000 inhabitants lived along the Lower Estuary in 44 municipalities and two Native Indian reserves, which cover an area of 5204 km^2 (Figure 11). More than 50% of the population is concentrated in three urban centres: Rimouski and Matane on the south shore and Baie-Comeau on the north shore. Rimouski is mainly a service centre, while Matane and Baie-Comeau are industrial cities.

Most of the land in the riverside municipalities on the south shore is designated farmland, while most of the land on the north shore is set aside for forestry (Figure 11). The land along the 601 km of shoreline in the study area is designated as follows: forestry, 48%; urban: 22%; recreation and conservation: 18%; rural: 9%; and industrial: 3%.

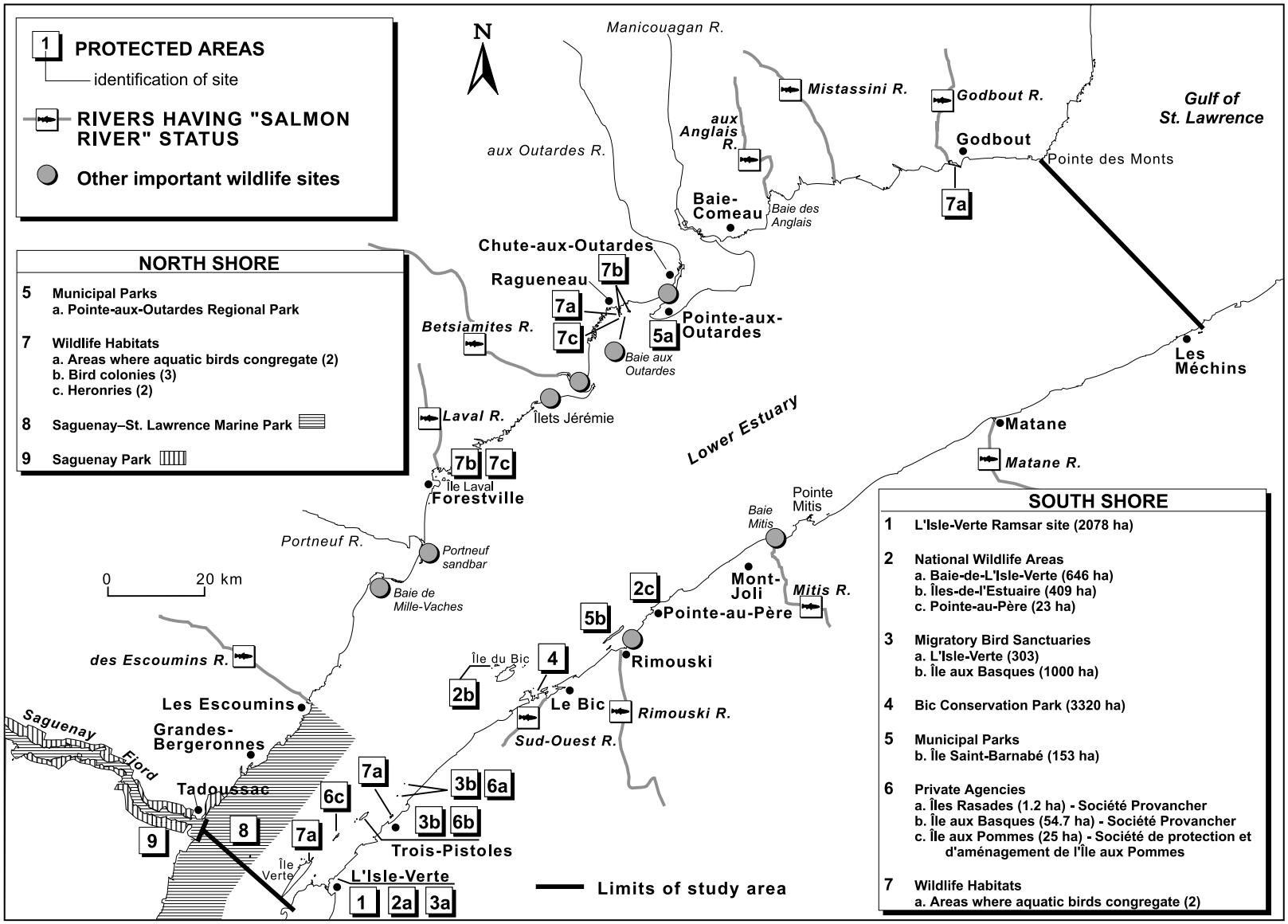
3.7.2 Protected areas

Saguenay–St. Lawrence Marine Park. The first steps in the creation of the Saguenay–St. Lawrence Marine Park have been completed under a federal-provincial agreement signed in 1990; the official announcement should be made soon. The park is 1138 km^2 in size and includes a large part of the marine environment of the Saguenay Fjord, part of the Upper Estuary and the upstream portion of the Lower Estuary along the north shore between Tadoussac and Les Escoumins (Figure 12). In creating the park, the two governments wanted to preserve biological diversity and ecosystem integrity while allowing low-intensity recreational activities based on the resources in the sector.



Source: Development plans of riverside RCMs: Rivière-du-Loup (1987), Les Basques (1987), Rimouski-Neigette (1987), La Mitis (1986), Matane (1992), La Haute-Côte-Nord (1989), Manicouagan (1988).

Figure 11 Main land-use divisions in riverside municipalities of the Lower Estuary



Source: Boucher, 1992; MLCP, 1993; Canadian Heritage, Parks Canada and Ministère de l'Environnement et de la Faune, 1994.

Figure 12 Protected areas and other important sites for wildlife in the Lower Estuary

Provincial parks. Two provincial parks protect portions of the Lower Estuary's shores. Created in 1983, the 284-km^2 Saguenay Park extends along either side of the Saguenay River and a shoreline strip of the Lower Estuary, which includes the Tadoussac dunes. Created in 1984, Bic Park is 33.2 km^2 in size, 45% of which is marine or intertidal habitat. The park's exceptional habitat is representative of the estuary's south shore. The objectives of the provincial parks are to maintain the natural status and development of ecosystems over the long term, maintain biological and genetic diversity, and preserve ecosystem stability in the face of human activity.

National Wildlife Areas. There are three national wildlife areas in the study sector. The 664-ha Baie de L'Isle-Verte National Wildlife Area protects part of a large *Spartina* marsh, which serves as the main breeding ground for the Black duck in North America and a major staging area for migratory birds. Since 1987, Baie de L'Isle-Verte (2078 ha) has also been protected under the International RAMSAR Convention. The Estuary Islands National Wildlife Area consists of 409 ha of islands along the south shore of the estuary between Kamouraska and Bic, including most of Biquette Island and the Rocher de l'Ouest within the limits of the study area. These sites are recognized as major staging grounds for sea ducks in the fall and important nesting grounds for the Common eider and other colonial nesting species. Finally, the Pointe-au-Père National Wildlife Area covers 23 ha of a marsh that is especially important for shore birds (including some 15 nesting birds). National wildlife area status implies full protection of migratory birds and their habitats, although hunting is permitted there.

Migratory Bird Sanctuaries. The study area includes two migratory bird sanctuaries managed by the Canadian Wildlife Service. The 303-ha Baie de L'Isle-Verte Migratory Bird Sanctuary is adjacent to the national wildlife area and includes a portion of Verte River. The Ile-aux-Basques Migratory Bird Sanctuary includes the island of the same name, the islands of Rasade Sud-Ouest and Rasade Sud-Est and a 500-m zone around each of the islands. Hunting and the harassment of migratory birds are prohibited in areas with migratory bird sanctuary status.

Wildlife Habitats. There are nine wildlife habitats managed by the Ministere de l'Environnement et de la Faune (MEF) along the shores of the Lower Estuary (Figure 12). These small areas protect water bird gathering areas, heronries and bird colonies.

Salmon Rivers. In order to be designated a *salmon river*, a river must have some protection from forestry operations, cottage development along the shores and projects affecting the bed of the watercourse. Ten rivers have salmon river status, six on the north shore and four on the south shore (Figure 12).

Other protected areas. Some sites not officially protected under provincial or federal legislation are protected under the charters of private organizations or as municipal or regional parks. Examples on the south shore are Ile aux Basques and the Rasade islands (both partly owned by the Provancher Society of Natural History of Canada), Ile aux Pommes (partly owned by the Société de protection et d'aménagement de l'Ile aux Pommes) and Ile Saint-Barnabé (a municipal recreational park). The Pointe-aux-Outardes Regional Park is on the north shore.

3.8 Developed Uses

3.8.1 Hydro-electric power generation and water supply

The Lower Estuary is one of Quebec's biggest electricity-generating regions. There are at present nearly 20 hydro-electric stations on the sector's tributaries (excluding the St. Lawrence and Saguenay rivers), with an overall generating capacity of more than 7500 megawatts. The harnessed tributaries are the Bergeronnes, Sault-aux-Cochons, Portneuf, Betsiamites, Aux Outardes and Manicouagan rivers on the north shore and the Mitis River on the south shore.

No municipalities, companies or farming enterprises in the sector draw water directly from the Lower Estuary because of its high salinity level. In 1989–90, the largest riverside municipalities drew approximately 24 million cubic metres of water annually from the tributaries, lakes and groundwater supplies. Companies in the sector drew 55 million m^3 of water in 1986. Three plants accounted for 97% of this amount: the Donohue paper mill and Canadian Reynolds

Metals Company (CRMC) in Baie-Comeau and the St. Laurent Paperboard mill in Matane. These firms have reduced their water use considerably since 1986.

3.8.2 Shipping and port activities

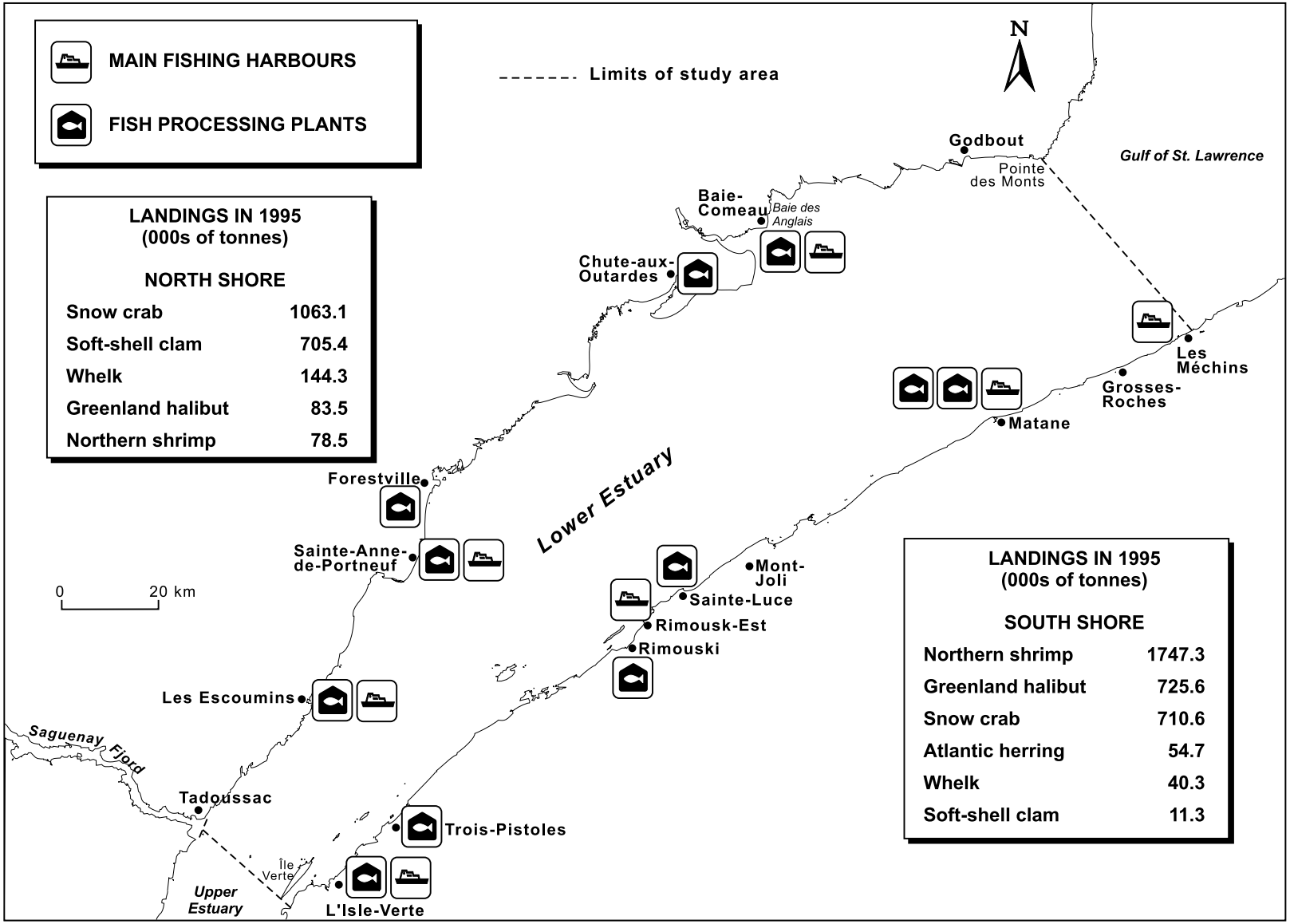
The Lower Estuary is a major national and international waterway. In the 1980s, approximately 8000 ship movements were recorded in the sector annually. In addition to this upstream-downstream shipping activity, there was regional shipping, which mainly links the estuary's two shores. This link is provided by three ferry lines (Trois Pistoles–Les Escoumins, Matane–Baie-Comeau and Matane–Godbout). The Matane–Baie-Comeau rail ferry is the only railway link between the Cote-Nord and the rest of Quebec.

Some of this national and international traffic is destined for the sector's four major commercial ports: Forestville and Baie-Comeau on the north shore and Matane and Rimouski East on the south shore. The port of Baie-Comeau is the biggest in the sector (and one of the biggest in Quebec), with 7 535 000 t of goods transshipped in 1995, consisting mainly of grain and dry bulk cargo. The port of Forestville was mainly used to transship forest products but has not been used in the past few years. The port of Rimouski is mainly used for transshipping petroleum products, while the goods transshipped in the port of Matane are more varied.

3.8.3 Harvesting biological resources for commercial or subsistence purposes

Commercial fishing. There is less commercial fishing in the study area than in the Gulf of St. Lawrence, but it is still one of the most important uses made of the St. Lawrence in the Lower Estuary. In 1994, there were some 134 fisher-owners, 348 fisher's helpers, 154 commercial fishing vessels, 7 fishing harbours and 11 fish processing plants in riverside municipalities (Figure 13).

The main species (in volume) landed and processed is the Northern shrimp (1825 t landed in 1995). However, most of the shrimp landed, mainly at Matane, are caught outside the



Source: Fisheries and Oceans, 1996, 1994a, 1994b.

Figure 13 Landings of main fishery resources on either shore of the Lower Estuary in 1995 and location of the main fishing harbours and fish processing plants

study sector in the northwest portion of the Gulf. That is not the case for the four other major species: snow crab (1774 t), Greenland halibut (809 t), soft-shell clam (717 t) and whelk (184 t). The snow crab is a very lucrative species that alone accounts for 67.5% of the value of all landings in the sector in 1995, which totalled $19.6 million.

Harvesting shore molluscs. Riverside communities along the Cote-Nord harvest large (but unrecorded) quantities of soft-shell clams for personal consumption. Although marginal from an economic point of view, this activity has major implications for public health.

Atlantic salmon food fishery. Native bands harvest salmon in the Escoumins and Betsiamites rivers for food. Annual catches of salmon are around 50 in the former river and between 100 and 300 in the latter.

Marine mammal hunting. Hunting marine mammals was a major activity in the study sector from the time it was first colonized until the middle of the 20th century. The cetacean hunt was particularly intense from 1870 to 1940, when it collapsed due to the drop in the price of whale oil and skins. Belugas continued to be hunted until 1972 in the Les Escoumins region and the Manicouagan peninsula. Cetacean hunting has been prohibited since 1979.

Seal hunts are still held today, almost exclusively along the north shore. They are limited to riverside dwellers who have licences to hunt seals for local consumption between October 1 and April 30. In 1994, 172 hunting licences were issued and 3895 Harp seals and 34 Grey seals were taken on the north shore.

Harvesting eiderdown. Harvesting the down of Common eider during the nesting period is a use specific to the St. Lawrence estuary. Harvesting takes place on several islands in the Upper and Lower estuaries, including Bicquette, Rasade, Rouge and Bic islands on the south shore and in the Ragueneau archipelago on the north shore. In 1994, a total of 806 kg of raw eiderdown was harvested, which is equal to approximately 130 kg of commercial down. The product’s value was around $400 per kilogram in 1993.

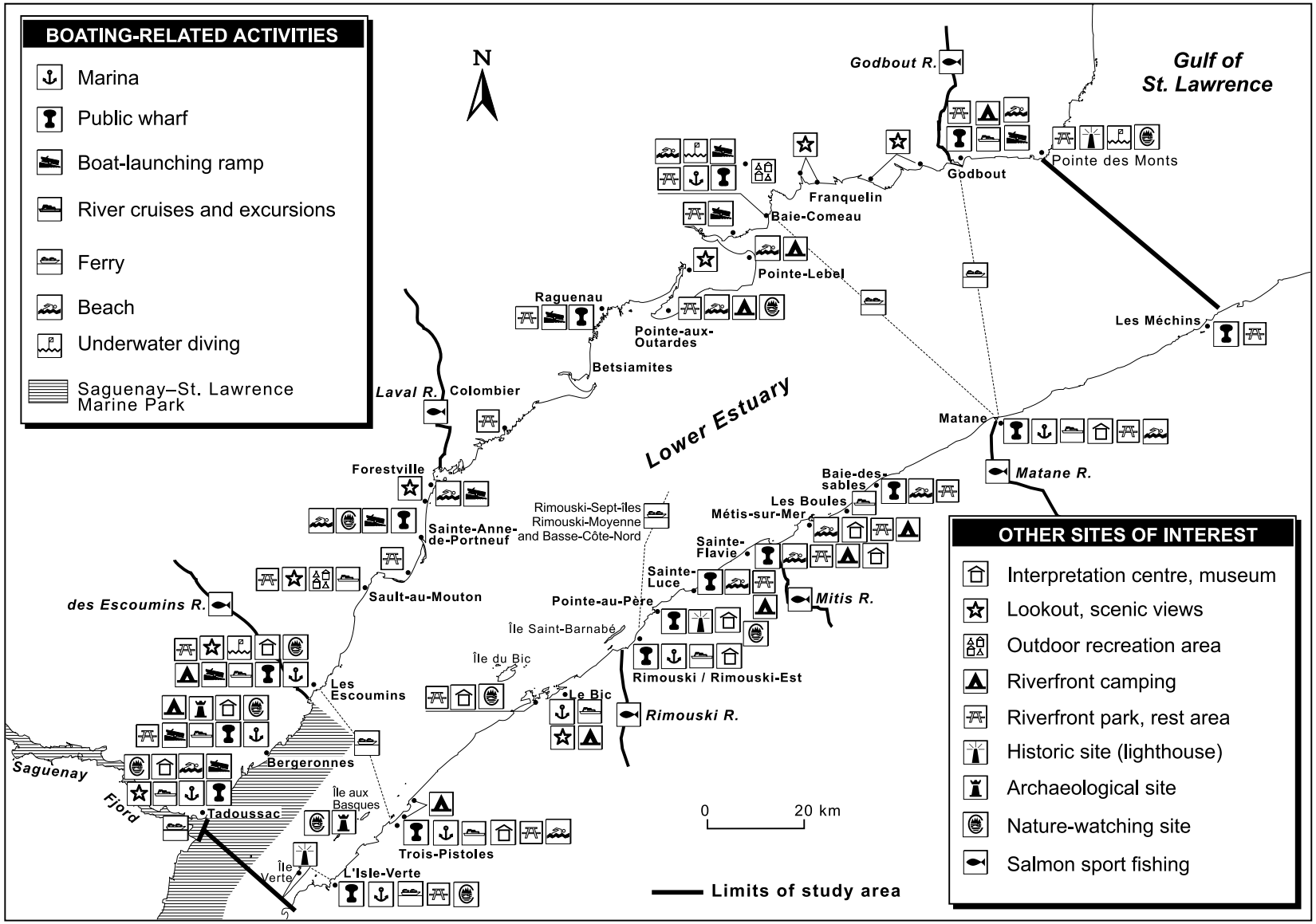
3.8.4 Recreational and tourism activities on the shoreline

Accommodation and resorts. In 1994, the total accommodation capacity in the study sector was 3238 rooms in establishments (hotels, motels, cabins and bed and breakfasts), 1619 camping sites and some 4000 secondary residences. Forty-seven per cent of the accommodation capacity of establishments is concentrated in the three main urban centres (Rimouski, Matane and Baie-Comeau). The main cottaging centres along the St. Lawrence are Trois-Pistoles and area and Métis-sur-Mer and area on the south shore, and Tadoussac and Pointe-aux-Outardes on the north shore.

Access to the shoreline. There are many access points to the shoreline on the south shore of the study area. The main road on the south shore (Highway 132) runs along the shoreline over long distances and is dotted with rest areas. There are also 16 public wharves on both shores. Hiking along the shore is permitted in the provincial parks (Saguenay Park and Bic Park), a regional park (Pointe-aux-Outardes Regional Park) and several municipal parks in the sector (Figure 14).

Marine environment and marine heritage interpretive facilities. Several sites in the study sector are devoted to interpreting the marine environment and marine heritage. There are the sand dune interpretation centre, marine mammals interpretation centre and maritime museum at Tadoussac, the Bon-Désir Cape interpretation and observation centre at Bergeronnes, the interpretation centre at Les Escoumins, the Baie de L'Isle-Verte National Wildlife Area at L'Isle-Verte, the Rimouski River and shoreline interpretive paths at Rimouski, the old lighthouse, maritime museum and Pointe-au-Père National Wildlife Area at Pointe-au-Père, the Atlantic salmon interpretation centre at Sainte-Flavie, and the Atlantic salmon fishway at Matane.

Swimming. Swimming is not a popular activity in the study sector because the water in the Lower Estuary remains very cold even in the middle of summer. However, there are roughly ten public beaches (Figure 14), for which there are no attendance data.



Source: ATR du Bas-Saint-Laurent, 1995; ATR de la Gaspésie, 1995; Regional tourism associations of Manicouagan and Duplessis, 1995; Association québecoise de l'industrie du nautisme inc., 1995.

Figure 14 Boating and recreational activities in the Lower Estuary

Sport fishing. Sport fishing from wharves is a very common activity. The most popular species fished is the Rainbow smelt. In 1991, the Rimouski wharf was the second most popular (11 200 hours of fishing) with the highest number of catches (a total of 48 900 smelt) along the south shore of the estuary after Cacouna (in the Upper Estuary).

Sport fishers fish six salmon rivers in the study area: the Escoumins, Laval and Godbout rivers on the north shore, and the Rimouski, Mitis and Matane rivers on the south shore. Total sport fishing catches in these rivers were 1703 salmon in 1994 and 971 salmon in 1995, compared to 1382 salmon in 1984. In terms of fishing frequency rates, in 1995 there were 5761 fishing days on the south shore (three rivers) and 2055 fishing days on the north shore (three rivers), with a success rate of 0.13 and 0.10 catches per fishing day, respectively.

Data on ice fishing of Rainbow smelt are limited. This activity takes place from December to March at the mouths of eight tributaries on the north shore: the Portneuf, Laval, Amédée, Betsiamites, Aux Rosiers, Aux Vases, Aux Outardes and Manicouagan rivers. On the south shore, this type of fishing is popular on L'Isle-Verte, with a fishing effort of 1140 fishing days and 46 400 smelt caught in winter 1991–92. This activity appears to be growing in the study area.

Waterfowl hunting. There is less migratory bird hunting in the area than along the St. Lawrence River corridor and in the Upper Estuary. An estimated 2000 people hunted waterfowl in the study area in 1989, with an average of 7.7 days per hunter. However, the hunt is not restricted to the estuary's shores. In the 1977–81 period, the harvest was estimated at close to 26 000 birds, mainly dabbling ducks (37.5%) and sea ducks (31.1%). The best hunting sectors are at L'Isle-Verte and in the Rimouski region.

Bird watching. There is a bird-watching club on either shore of the Lower Estuary. The best observation sites on the south shore are the Baie de L'Isle-Verte National Wildlife Area, Ile aux Basques and the Rasade islands, Bic Park, the Saint-Fabien rest area and the Rimouski and Pointe-au-Père marshes. The best sites on the north shore are the Bon-Désir, Escoumins and Mille-Vaches bays and Baie des Anglais, Portneuf sandbar, Anse à Norbert, Ragueneau

archipelago, the Aux Outardes, Manicouagan and Godbout river estuaries and Pointe-des-Monts. Ferries also make excellent vantage points for observing birdlife.

Festivals. Some festivals in the riverside municipalities have the St. Lawrence and its resources as their themes. Examples include the Bergeronnes Blue whale festival, the Matane shrimp festival and the sand sculpture contests in Tadoussac and Sainte-Luce.

3.8.5 Recreational and tourism activities at sea

Pleasure boating. Boating conditions in the Lower Estuary are difficult, but there is significant potential for pleasure boating. There are eight marinas (450 moorings) on its shores, 16 public wharves and several boat-launching ramps (Figure 14). There are no data on the extent of the activity in the study area.

Whale-watching cruises. There are twenty-odd companies—mainly on the north shore between Tadoussac and Les Escoumins—that offer whale-watching cruises in the upstream portion of the Lower Estuary where the whales are concentrated. In 1992, approximately 150 000 passengers took cruises, 4.5 times the number in 1985. Between 1984 and 1988, the number of cruises rose from 913 to 2052 and the number of passengers from 20 000 to 78 000. Direct and indirect gross income from this activity totalled $8 million in 1988.

Cruises to south shore islands. A few companies provide transportation to some of the islands on the south shore, such as Ile Verte, Ile aux Basques, the Bic islands and Ile Saint-Barnabé. The islands' main attractions are their special birdlife and plants.

Marine fishing. A few companies offer marine fishing cruises. The main species fished is the Atlantic cod. The Atlantic mackerel is also fished during its brief appearance in the estuary. There are no accurate data on the extent of this activity.

Diving and sea kayaking. The cold, clear waters of the Lower Estuary are home to rich underwater landscapes whose beauty can only be guessed at from the surface. Some of the most popular diving sites in Quebec are in this area, including Tadoussac, Baie-Comeau and especially Les Escoumins. In 1991, an estimated 1500 divers visited the Les Escoumins site,

spending an average of 2.5 days there. On the south shore, the wreck of the *Empress of Ireland* at Pointe-au-Père is one of the sites most often visited by divers in the Bas-Saint-Laurent region. Some ten companies offer introductory sea kayaking lessons and kayaking excursions in the estuary. There are no data on the popularity of this activity.

CHAPTER 4

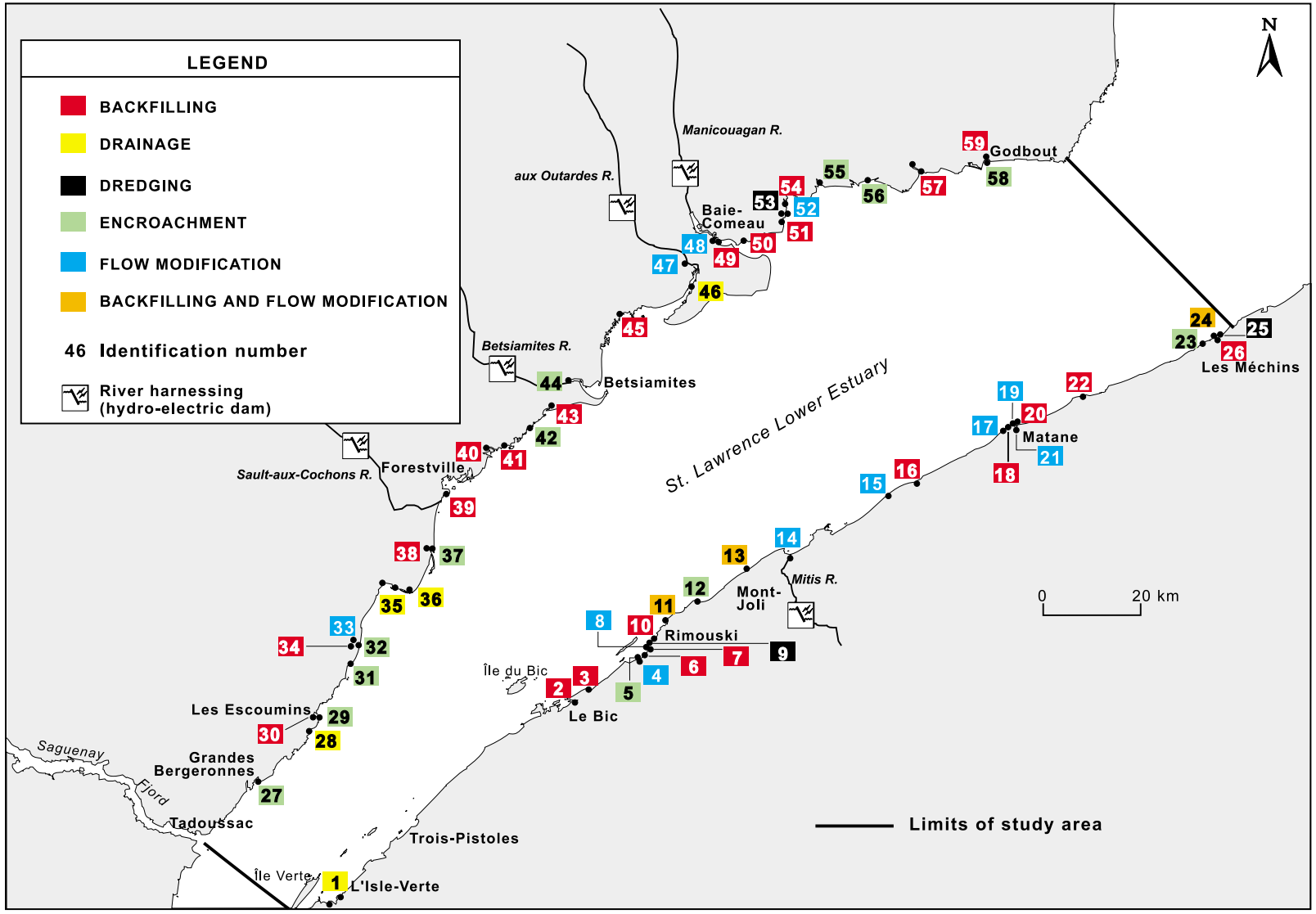
Human Activities and their Main Effects on the Environment

4.1 Physical Changes in the Environment

Harnessing of tributaries. The construction of hydro-electric dams on a number of tributaries has substantially reduced seasonal variations in freshwater inputs to the St. Lawrence Lower Estuary. It is estimated that, since 1970, the magnitude of seasonal fluctuations in this flow has been cut in half. At present, freshwater inflows from the Saguenay and rivers on the north shore occur principally in the form of short pulses that are completely dissociated from the natural annual cycle.

The effects of the change in inflows of fresh water are not known. Biological productivity may have declined owing to the decrease in the intensity of freshwater-driven estuarine circulation. This residual circulation helps to increase nutrient transport from deeper waters to the surface layer, thereby stimulating primary production. In the estuaries of the Manicouagan and Aux Outardes rivers, a new equilibrium has been achieved in the sediment regime, hydrodynamics, and among benthic communities since the watercourses were originally harnessed for hydro-electric production. The major changes in both rivers as a result of dam construction may be to blame for the near-disappearance of Atlantic sturgeon in the region. Furthermore, according to some researchers, the Beluga's abandonment of the Manicouagan banks is linked to the construction of hydro-electric dams in the 1960s. The dams also represent impenetrable barriers for anadromous fish.

Encroachment on the coastal environment. Between 1945 and 1988, 646 ha of coastal areas in the study area were altered by the construction of infrastructure (backfilling, draining, change in water flow and dredging) (Figure 15). Aquatic habitats destroyed or disturbed by these activities consist mainly of sandy, gravelly or rocky shores (41% of the surface area affected), river mouth areas (22%), and salt and freshwater marshes (22%). Encroachment has occurred primarily around three urban centres.



ORIGINAL HABITATS. Swamp: sites 35. **Salt marsh**: sites 2,11,18, 36, 43, 51. **Marsh**: sites 1, 46. **Aquatic plant community**: site 28. **Rocky foreshore**: sites 13, 15, 23, 27, 39, 41, 42, 52 to 56. **Sandy-gravelly foreshore**: sites 10, 12, 16, 17, 22, 24 to 26, 58, 59. **Muddy foreshore**: sites 6 to 9, 30. **River estuary**: sites 3 to 5, 14, 19 to 21, 29, 31 to 34, 37, 38, 40, 44, 45, 47 to 50, 57.

Source: Marquis et al., 1991; Robitaille et al., 1988.

Figure 15 Physical changes to aquatic and riparian habitats recorded in the Lower Estuary from 1945 to 1988

In the Rimouski region, the encroachment is associated with the construction of housing and port facilities, whereas around Matane, highway upgrading projects are the cause. In Baie-Comeau, 65 ha of rocky shoreline has been backfilled to make way for port facilities.

Between 1993 and 1995, 7.3 km of shoreline in the municipality of Ragueneau and along the Manicouagan peninsula was consolidated with riprap to counter the heavy erosion that occurred over many years. Finally, in the L'Isle-Verte region, some 200 ha of salt meadow was diked for farming purposes. Today, only vestiges of these dikes remain, and various projects have been carried out to restore the habitat affected.

4.2 Pollution

The terms "contamination" and "pollution" do not mean the same thing. When the concentration of a substance in water, sediments or living organisms is higher than the naturally occurring level, this constitutes contamination of the environment or aquatic organisms. Only when the concentration reaches a level where living organisms or developed uses are adversely affected is the term "pollution" used.

Some contaminants such as biodegradable organic matter, bacteria and nutrients (nitrates and phosphates) are not persistent, and environmental quality improves rapidly as one moves away from the contaminant source, as it does when discharges of those pollutants cease. However, other contaminants, which are persistent in the environment, are transported over great distances in the drainage system or the atmosphere and tend to accumulate in sediments and living organisms. These include polychlorinated biphenyls (PCBs), organochlorine pesticides (DDT, dieldrin and Mirex), polycyclic aromatic hydrocarbons (PAHs), dioxins, furans and mercury.

4.2.1 Sources of contamination

Sources of contamination can be divided into two broad categories: *distant sources***,** which input contaminants to the Lower Estuary through tributaries (Upper Estuary, Saguenay

Fjord and other rivers), the deep layers of water in the Gulf and atmospheric deposition; and *local sources***,** which are situated along the banks of the Lower Estuary or in the water (shipping).

4.2.1.1 *Distant sources*

On the whole, distant sources do not play a role in contamination of the Lower Estuary by biodegradable organic matter, nutrients and micro-organisms. However, they contribute most of the toxic substances found in the Lower Estuary.

Great Lakes. The Great Lakes basin is the most urbanized, industrialized and agricultural area drained by the Lower Estuary. However, the bulk of toxic substances discharged to water there is trapped in Great Lakes sediment. Mirex, an organochlorine pesticide, offers a good illustration of this situation. The only known source of Mirex in the St. Lawrence system is an industrial plant that has contaminated two tributaries of Lake Ontario. Between 1950 and 1990, only 13% of the Mirex that entered Lake Ontario was exported to the main course of the St. Lawrence; the rest is believed to have been buried in lake sediment or removed from the lake by various local phenomena. More than 17% of the Mirex entering the St. Lawrence River from Lake Ontario can be linked to the migration of American eels toward the Atlantic Ocean in autumn. The American eel population of Lake Ontario is heavily contaminated with Mirex and other bioaccumulative substances, and their migration to the Atlantic Ocean is believed to be the main vector by which Belugas in the estuary become contaminated with Mirex and, to a lesser extent, PCBs. The other hydrophobic toxic substances that are closely associated with suspended matter (mercury, organochlorine pesticides, PCBs, PAHs) are probably transported from the Great Lakes to the St. Lawrence River in the same way as Mirex. It is worth noting, however, that inputs of dissolved toxic substances from the Great Lakes, either bound to suspended solids or transported by migrating American eels, have declined substantially since the 1970s.

St. Lawrence River and Upper Estuary. Unlike the Great Lakes, only a small proportion of the toxic substances that reach the St. Lawrence River and the Upper Estuary are trapped in sediment; for example, 94% of the Mirex from Lake Ontario is exported to the Lower

Estuary, and merely passes through the fluvial corridor and the Upper Estuary. Since southern Quebec is a predominantly industrial, urban and agricultural region, it has undoubtedly been a primary source of most of the persistent toxic substances input to the study area.

Saguenay River. The Saguenay has contributed significantly to mercury contamination of the Lower Estuary. The main source of mercury in this basin was a chlor-alkali plant that operated in Jonquière from 1948 to 1976. While much of the mercury released into the aquatic environment by this plant was deposited in the sediments of the Saguenay Fjord, twelve tonnes of it reached the Lower Estuary. In the case of PAHs, the main sources of contamination along the Saguenay are two aluminum smelters that are using an outmoded electrolytic process. The bulk of PAHs discharged by these plants is trapped in the Saguenay Fjord, and it is not known whether this watercourse contributes a large quantity of this contaminant to the Lower Estuary. PAH releases to the water and atmosphere by the aluminum smelters have been declining steadily since the early 1980s.

Rivers of the Haute-Cote-Nord and Bas-Saint-Laurent. Distant sources of contaminants from the Haute-Cote-Nord and the Bas-Saint-Laurent—that is, those not located near the banks of the estuary—are much smaller than those in the upstream sections of the St. Lawrence and in the Saguenay. However, tributaries have probably contributed a large part of the DDT by-products found in the sediments of deep areas of the Laurentian Channel. The largest inputs of this pesticide occurred during the 1950s and 1960s, a period when intensive spraying was undertaken to protect forests against the spruce budworm. DDT has been banned in Canada since the early 1980s.

Atmospheric deposition and oceanic waters. The shores of the Gulf of St. Lawrence and the northwest Atlantic are characterized by limited urban, industrial and agricultural uses. Atmospheric deposition in Eastern Canada and the Atlantic Ocean is the main source of the contaminants that are transported from the Gulf to the Lower Estuary in deep waters, although the loads involved are not known. Inputs in the form of atmospheric releases of persistent toxic substances, particularly mercury, may be appreciable.

4.2.1.2 *Local sources*

Municipal wastewater. In 1996, 29 of the 44 riverside municipalities in the Lower Estuary had sewer systems, with 16 of them, serving 77% of the total population, channeling their wastewater to treatment plants. All the municipalities were using aerated ponds to treat effluents. The first plant started up in Luceville in 1984. The four main plants—that is, Matane, Rimouski, Baie-Comeau–Mingan and Baie-Comeau–Marquette—opened between 1985 and 1994. In 1992, the first three facilities were found to be in compliance with the requirements related to discharges of biodegradable organic matter (BOD_5), suspended solids (SS) and fecal coliforms. In terms of the criterion related to overflow facilities, only Matane has had problems during periods of dry weather. The largest municipalities not yet treating their wastewater are Chute-aux-Outardes, Les Escoumins and Les Méchins (Figure 16). The municipalities of L'Isle-Verte, Les Boules, Grosses-Roches, Les Méchins, Tadoussac (since 1982) and Les Escoumins have signed an agreement in principle to treat their effluents and are planning to build a treatment facility. Finally, some homes in a number of municipalities have septic tanks which, if not operating properly, can constitute local sources of contamination.

Industrial wastewater. Four industrial plants in the study area have been targeted for priority action under the provincial industrial effluent abatement program (PRRI) and the joint federal-provincial action plan, called SLV 2000, whose aim is to reduce industrial discharges (Table 1).

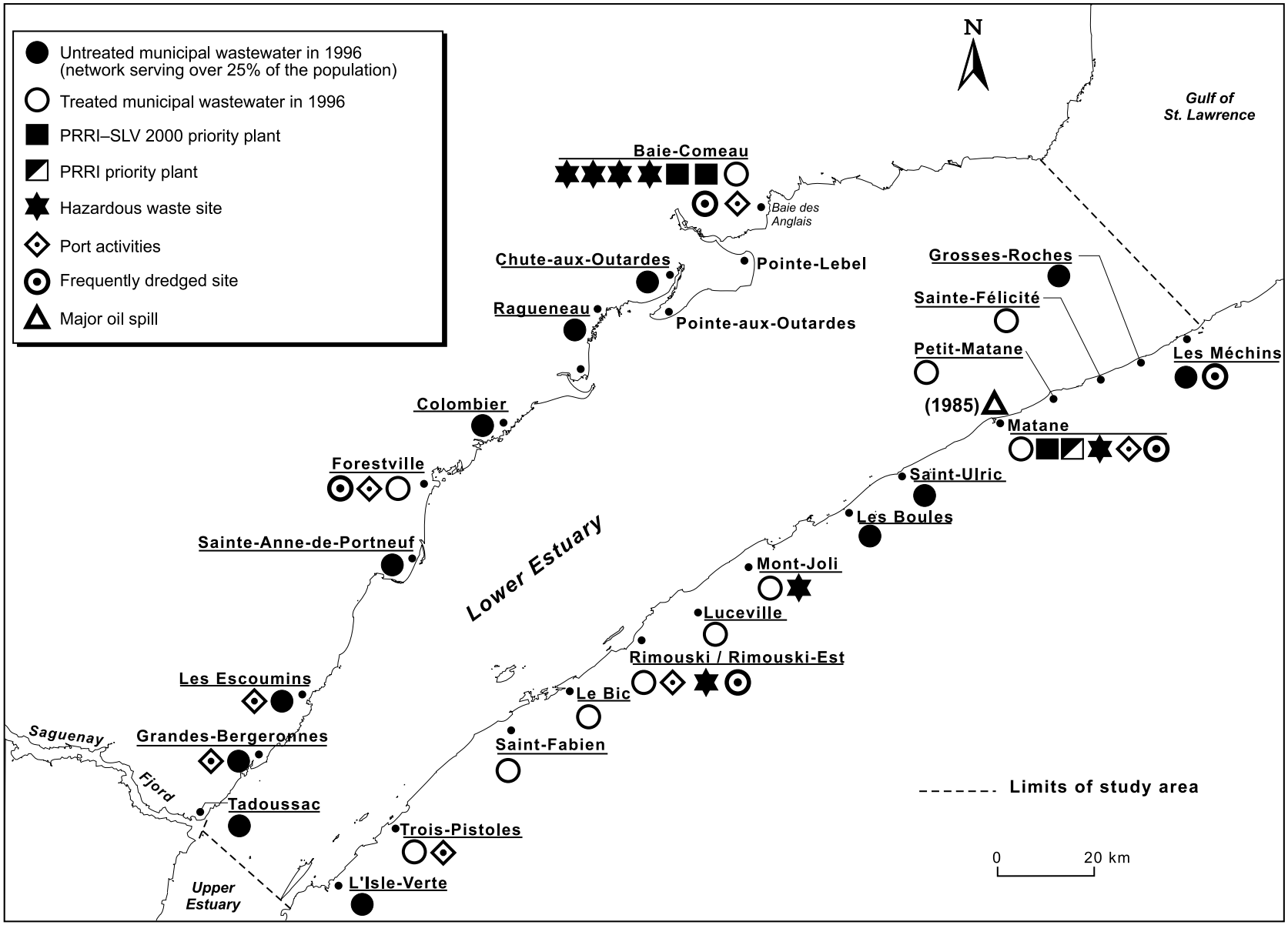
Table 1
Priority industrial plants along the Lower Estuary of the St. Lawrence

Plant	*Location*	*Sector*	*PRRI**	*SLV 2000***
QUNO Corporation	Baie-Comeau	Pulp and paper	X	X
Canadian Reynolds Metals Company Ltd.	Baie-Comeau	Aluminum smelter	X	X
St. Laurent Paperboard Inc.	Matane	Pulp and paper	X	X
Donohue Matane Inc.	Matane	Pulp and paper	X	

* Industrial effluent abatement program administered by the MEF.
** St. Lawrence Vision 2000.

QUNO Corporation of Baie-Comeau (recently acquired by Donohue) produces newsprint from thermomechanical pulp (using a process introduced in 1990), OPCO pulp and recycled pulp. From 1988 to 1995, effluents high in suspended solids (more than 100 mg/L) were treated by settling (primary treatment) and untreated effluents with a low suspended solids content were discharged into Comeau Creek, a small tributary that empties into Baie des Anglais. Sanitary wastewater has been and still is discharged into the municipal sewer system. In 1990, no bioaccumulative toxic substances were detected in the mill's effluent stream. Since late 1995, this facility has been using an activated sludge system (secondary treatment) to treat process water before discharging treated effluent into Baie des Anglais through a submerged outfall located near the federal wharf. This secondary treatment and other pollution control measures have helped to reduce BOD_5 by 99%, SS by 87%, and effluent toxicity by 99% since 1988.

The **St. Laurent Paperboard** mill in Matane manufactured corrugated board from a mixture of pulp using the neutral sulphite semichemical process up until 1993, when it switched over entirely to shredded recycled fibre. Between 1991 and 1995, the process water treated by screening and settling (primary treatment) was emptied into the estuary through a diffuser, whereas sanitary wastewater was, and still is today, discharged into the municipal sewer system.



Source: Fortin (ed.), 1996; Bibeault, Gratton and Jourdain, 1996.

Figure 16 Main local sources (current and historical) of contamination of the Lower Estuary

In 1991, no PAHs or PCBs were detected in the plant's effluents. Since 1995, only cooling water that has not been in direct contact with chemicals is released into the St. Lawrence. Contaminated water is recirculated to the process stream after primary treatment.

The **Donohue Matane Inc.** mill started up in 1991, but suspended its operations between September 1991 and April 1995. This facility uses a chemical-thermomechanical pulping process with bleaching. Its effluents are treated by settling (primary treatment) and then activated sludge (secondary treatment) before being released into the Lower Estuary. During the first eight months of 1991, mill discharges were found to comply with SS and BOD_5 standards. Effluent toxicity was not measured, however.

At the **Canadian Reynolds Metals Company Ltd.** plant in Baie-Comeau, which comprises an aluminum smelter, casting centre and anode plant, aluminum alloys are manufactured by two electrolytic processes. The first centres on the use of 542 vertical-stud Söderberg cells and the second consists of 480 prebaked-anode cells. Effluents from the plant are the primary source of PCB and PAH contamination in Baie des Anglais. Five treatment lines serve all the facilities, and process wastewater is emptied into the bay near Moulin Cove, whereas sanitary wastewater is discharged into the Baie-Comeau municipal sewer system. Between 1978 and 1980, the main source of PCB contamination—leakage from the hydraulic system in the pot rooms—was eliminated by introducing the use of PCB-free hydraulic oil. Subsequent remedial measures, implemented between 1984 and 1990, have to all intents and purposes removed the risk of PCB releases to the environment. Replacement of the wet scrubber system with a dry system in the pot rooms and the anode plant helped to decrease the PAH load in effluents by 65% between 1984 and 1988. Finally, between 1989 and 1992, facilities for treating the casting centre effluents and other treatment lines were brought on stream. Together, these abatement measures reduced the PCB load by about 75%, virtually eliminated PAHs and reduced effluent toxicity by 99% between 1988 and 1992, in spite of a 43% increase in production.

Hazardous waste sites. Five contaminated land-based sites were identified in the 1980s near the banks of the Lower Estuary during official inventories carried out by the provincial and federal governments (Table 2). Most of them have since been restored, although some require additional work. Overall, they now represent a lower risk of contamination for the estuary.

Two former dump sites in Baie-Comeau, which were used for domestic and industrial waste, including waste from the Reynolds aluminum smelter and the QUNO Corporation plant, represent a potential source of fluoride, cyanide, metal and hydrocarbon contamination for Baie des Anglais. The dump site section used for industrial waste between 1971 and 1983 was restored in 1994 and no longer poses a public health risk. No work has been done on the dump section used from 1955 to 1970, although characterization studies are planned.

The **dump behind the Norcast Corp. foundry** in Mont-Joli used to represent a potential source of phenol and heavy-metal contamination for a Mitis River tributary. After remedial measures were implemented at the site in 1992 and 1993, none of the contaminants identified at the dump were detected in the Mitis River. The foundry has not been storing waste behind the facility since 1991.

The **Matane dump site for contaminated soil** was used to store hydrocarbon-contaminated sand and gravel produced when the *Pointe Lévy* barge capsized in 1985. This site was restored in 1986, and groundwater quality has been monitored since then. The dump poses only a slight risk of groundwater contamination.

Table 2
Inventory of hazardous waste disposal sites in riverside municipalities of the Lower Estuary of the St. Lawrence

Location	*Description of site*	*Cat.*	*Contaminants identified*	*Impacts detected during the 1980s*	*Situation in 1995*
Provincial inventory					
Mont-Joli	Disposal site for sand and metal dust from the Norcast Corp. foundry.	II	None. Potential contaminants include phenols, copper, zinc and aluminum.	Contamination of groundwater and a creek that is a tributary of the Mitis River.	Dump partially restored in 1992 and 1993; monitoring is being carried out.
Matane	Storage site for sand and gravel residues collected after the barge *Pointe Lévy* capsized in 1985.	IIIR	Heavy oil (Bunker #6C).	Contamination of Petite Rivière Blanche and the water table.	Dump restored between 1986 and 1988; monitoring is being carried out.
Baie-Comeau	Former municipal dump of Baie-Comeau (municipal and industrial waste; 1971–83).	I	Fluoride, aluminum, cyanide, iron, manganese, magnesium and hydrocarbons.	Contamination of Anglais River.	Dump partially restored in 1995; characterization of groundwater slated for 1996.
	Former Baie-Comeau dump (1955–70); municipal and industrial waste.	II	None. Potential contaminants include fluoride, cyanide and heavy metals.	Contamination of Chasse River.	No change; action planned for 1996 or 1997.
Federal inventory					
Rimouski	Rimouski East Harbour.	C.1	Petroleum products.	Contamination of soil and surface waters of the estuary.	Restored in 1988.

Source: MENVIQ, 1991; Lefebvre, 1996; d'Aragon, Desbiens, Haldes et Associés Ltée and Roche Ltée, 1992.

Category I : Sites that present a potential risk for public health and/or a high environmental risk.

Category II : Sites that present an average potential risk for the environment and/or a low potential risk for public health.

Category III : Restored sites that are being monitored. Sites presenting a low potential environmental risk, but no risk for public health.

Priority C.1 : Facility known to be contaminated; action recommended in the short term.

In the **Rimouski East port area**, there is a land-based site that contains soil contaminated by gasoline leakage from the transshipment system for petroleum products. Work was carried out between 1988 and 1990 to recover some of the petroleum.

The **solid waste dumps at the Reynolds aluminum smelter** in Baie-Comeau formerly caused fluoride and cyanide contamination of Baie des Anglais through storm runoff. The sites were restored between 1984 and 1992, and have been removed from the provincial inventory.

The **Reynolds aluminum smelter lagoon** in Baie-Comeau once contained sediments that were heavily laced with PCBs. However, the lagoon was restored in 1986, and no PCBs were detected there in 1989 and 1990. The site was reclassified in 1991 owing to the low potential risk of environmental contamination; it was later removed from the provincial inventory.

PCB storage sites. At present, an estimated 3524 t of PCB-contaminated waste is stored on the north shore of the Lower Estuary, including 204 t at the Manic-2 site since 1989. The rest of the contaminated material, originating mainly from Hydro-Quebec operations and industrial plants in Baie-Comeau, is stored at four different sites in the municipality of Baie-Comeau. These storage sites do not pose a risk of contamination of the Lower Estuary.

Shipping and port activities. Shipping represents a potential source of pollution from marine incidents, ballast flushing and the discharging of hold contents directly into the sea, as well as goods transshipment and storage at ports. To date, there have been no catastrophic oil spills in the study area. The largest spill occurred in 1985 when the barge *Pointe Lévy* capsized off Matane and 200 to 300 t of oil was dispersed over 40 km of shoreline. Accidental spills are a much more frequent occurrence during transshipment operations at ports. For example, the area around the Reynolds aluminum smelter wharves in Baie-Comeau is contaminated with hard pitch and aluminum from spills during transshipment. In 1993, the smelter switched over to liquid pitch, and measures were adopted to bring about a substantial reduction in accidental spills.

Dredging. Maintenance dredging of ports, fishing harbours and marinas can contribute to contamination by causing the resuspension of toxic substances that would otherwise

remain isolated from the aquatic environment in deep sediment layers, or confined to sites separated from the general water circulation. The best documented case of this is Baie des Anglais, where the disposal of dredged material from the port has caused PCBs, PAHs and heavy metals to disperse throughout the bay.

Snow removal. In the three main urban centres (Rimouski, Matane and Baie-Comeau), the municipalities no longer dump snow directly into the estuary or its tributaries.

Atmospheric emissions. The Reynolds aluminum smelter in Baie-Comeau is a substantial local source of PAH emissions. Its emissions rose from 158 to 255 t a year between 1957 and 1984, and then dropped to about 45 t in 1990 after the facility upgraded its technology. In 1992, the company estimated that its emissions had fallen to 20 t/year. A portion of these PAH releases reached the Lower Estuary either directly or indirectly (through drainage basins). However, these inputs account for only a small fraction of the PAHs found in the sediments of Baie des Anglais, which has been mainly contaminated by wastewater from the smelter.

Agriculture. A large part of the land in riverside municipalities on the south shore is given over to farming. Agricultural activities can contaminate shoreline areas through runoff containing organic and toxic substances (pesticides), fertilizer, and bacterial contaminants. Between 1981 and 1991, the total area treated with chemical fertilizers in the study sector declined by 26%, whereas the total area treated with pesticides rose by 71%. During this period, organochlorine pesticides were gradually replaced by substances that are less persistent in the environment.

4.2.2 Impact of contaminants on resources and uses

The criteria and guidelines that can be used to determine to what extent contaminants found in the water, sediments and organisms pose a threat to aquatic organisms and human health, and also limit certain uses, are described in Appendix 2.

4.2.2.1 *Contamination of the water*

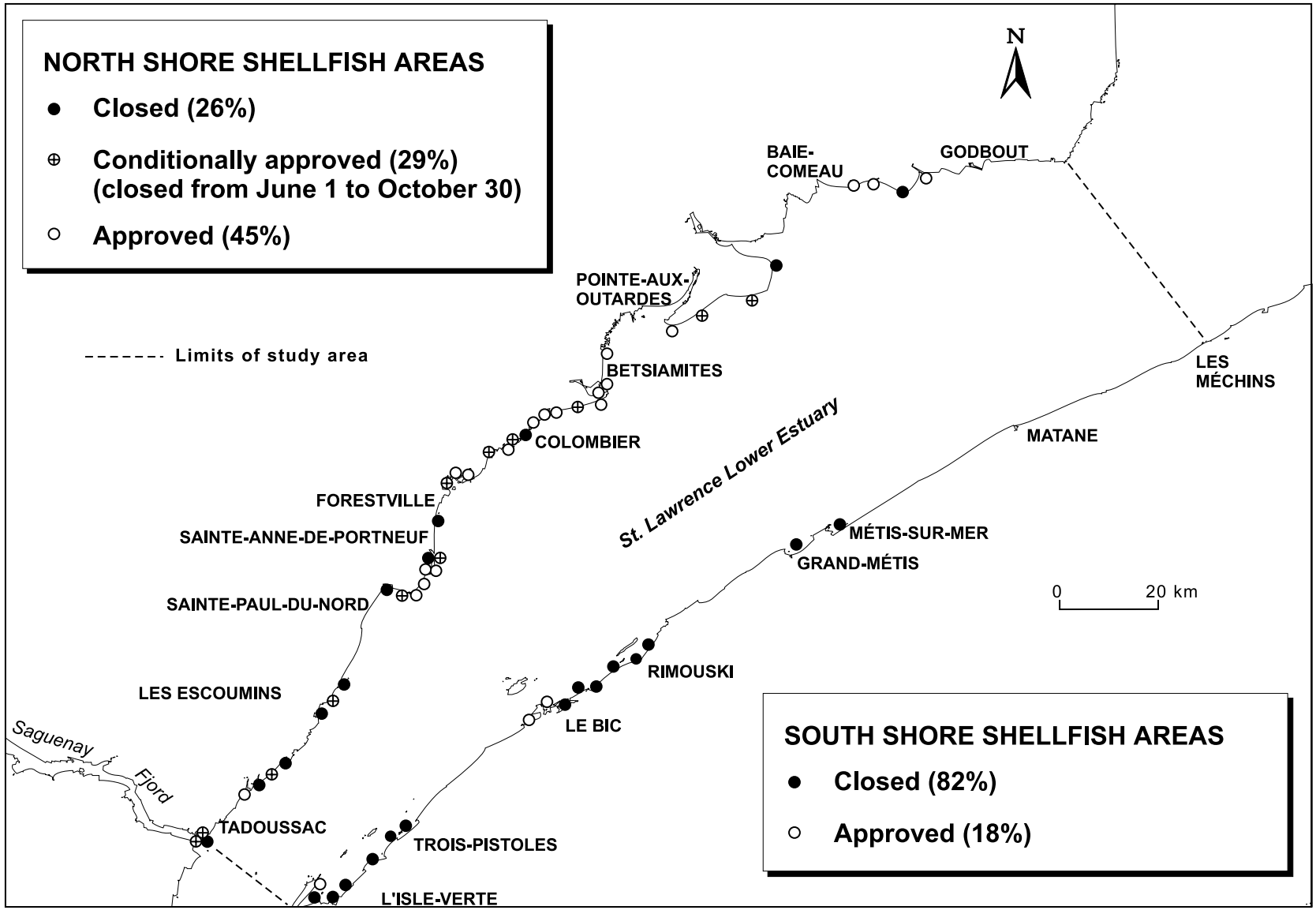
Available water quality data on the St. Lawrence Lower Estuary are very sketchy. Away from the shoreline, organic matter with a high BOD_5 content, nutrients, pathogens and toxic substances originating from various sources are substantially diluted by the mixing that occurs between fresh water and relatively uncontaminated salt water. The concentrations involved do not exceed the most stringent quality criteria established for all the substances.

Information on the bacteriological quality of the water along the banks is virtually non-existent, except for the data generated by Environment Canada's Shellfish Water Quality Program. In 1994, only 22 of the 59 shoreline sectors monitored under this program had a bacteriological water quality rating high enough to permit shellfish harvesting in the summer (Figure 17). Most of the harvesting areas are located on the north shore. The majority are contaminated by municipal effluents and runoff from septic tanks, agricultural uses and bird colonies.

4.2.2.2 *Contamination of sediments*

Sediments are considered contaminated when they contain heavy metals or certain organic compounds (PAHs, for example) in quantities exceeding the naturally occurring, pre-industrial levels of those substances. The concentrations become cause for concern when they are high enough to harm organisms living in or near sediments and that depend on them for their survival. This is the pollution danger point. To assist in evaluating sediment quality, three contamination thresholds have been established for the most worrisome substances: the no effect threshold (NET), the minimal effect threshold (MET) and the toxic effect threshold (TET) (Appendix 2). These thresholds can be used to classify sediments in four categories:

- Unpolluted: the concentrations are below NET
- Slightly polluted: the levels lie between NET and MET
- Moderately polluted: the levels are between MET and TET
- Heavily polluted: the concentrations are higher than TET.



Source: Environment Canada, 1994.

Figure 17 Classification of shellfish areas along the Lower Estuary, based on bacteriological water quality in 1994

Laurentian Channel. In the St. Lawrence River, a major proportion of most mineral contaminants (heavy metals) and toxic organic substances (PCBs, PAHs, DDT, Mirex, dioxins and furans) is transported with suspended particles. Most of the sediment load carried into the Lower Estuary is deposited in the Laurentian Channel. Toxic compounds originating from human activities in the St. Lawrence watershed, along with contaminants from Lake Ontario and the Saguenay Fjord, and part of the airborne pollutants that are deposited in the drainage basin and the ocean, end up largely in the Laurentian Trough where they remain bioavailable, sometimes for hundreds of years.

The peak concentrations of toxic substances measured in Laurentian Channel sediments have never reached the TET level, except mercury concentrations at the head of the channel, which hovered near this level in the 1960s. During the period of industrialization, the pollution level in Laurentian Trough sediments was low (> NET) in the case of cadmium, copper, nickel, and chromium, and moderate (> MET) for mercury, lead and zinc. As regards organic compounds (DDT, Mirex, PCBs, PAHs, dioxins and furans), the pollution level seems fairly low (> NET); however, recent studies have reported the presence of some of the most toxic compounds in the PCB family—that is, dioxins and furans.

The major historical trends in pollution that have been determined on the basis of sediment cores show that the early period of industrialization in the St. Lawrence watershed had an adverse impact on the quality of sediments in the Laurentian Trough. A number of profiles of chemical levels show maximum values for the 1960s and 1970s, when inputs of anthropogenic contaminants reached a peak at the head of the St. Lawrence River. Since then, the concentrations of most contaminants have declined (except zinc), as determined from the upper part of sediment cores, which provide evidence that inputs have decreased in recent years. This decline in the level of contamination is probably linked to measures implemented in the early 1980s to reduce industrial and urban effluent discharges into the drainage basin. Decreased lead inputs have been attributed to the gradual phase-out of leaded gasoline that began in the early 1970s.

Polluted coastal zones. Local sources of toxic substances are few in number, and, with the exception of Baie des Anglais and the Forestville harbour, coastal areas of the Lower Estuary have not been affected to a great extent by chemical contamination. Baie des Anglais is the worst case of coastal zone contamination by PCB and PAH releases in Eastern Canada. PCB- and PAH-laced effluents from the Reynolds aluminum smelter in Baie-Comeau have been identified as the main cause of the polluted sediment around the facility's wharves, which extends down four metres into the seabed. A portion of this contaminated sediment stems from maintenance dredging in Baie des Anglais, in the wharf area. PCB and PAH levels in the sediment are very high (> TET). Between 1985 and 1993, the Canadian Reynolds Metals Company implemented measures to reduce the sources of contamination, and today discharges of PCBs and PAHs to the environment from local sources are almost non-existent. In 1994, it was determined that a total of about 300 000 m^3 of heavily polluted sediments had been trapped in Moulin Cove or dumped in Baie des Anglais in the course of dredging operations around the wharves. Although PAH levels in sediments are high (> TET) in Forestville harbour, the volume of contaminated sediments (2250 m^3) is fairly low, and the heavily polluted zone does not extend beyond the periphery of the Hydro-Quebec wharf. The cause of the contamination is still not known.

4.2.2.3 *Contamination of the marine food chain*

Aquatic organisms tend to accumulate certain toxic substances in their body tissues at much higher concentrations than those found in ambient water and sediments; this is called *bioconcentration*. *Bioaccumulation* of a contaminant occurs when the rate of assimilation of the substance exceeds the rate of elimination. Hence, concentrations of the contaminant in an organism's body increase as it grows older. Since most aquatic organisms, except for shellfish, are able to regulate the concentrations of heavy metals in their bodies (except mercury) and can also quickly metabolize PAHs, they do not bioaccumulate these substances. However, most living organisms are unable to eliminate or quickly metabolize mercury and organochlorine compounds

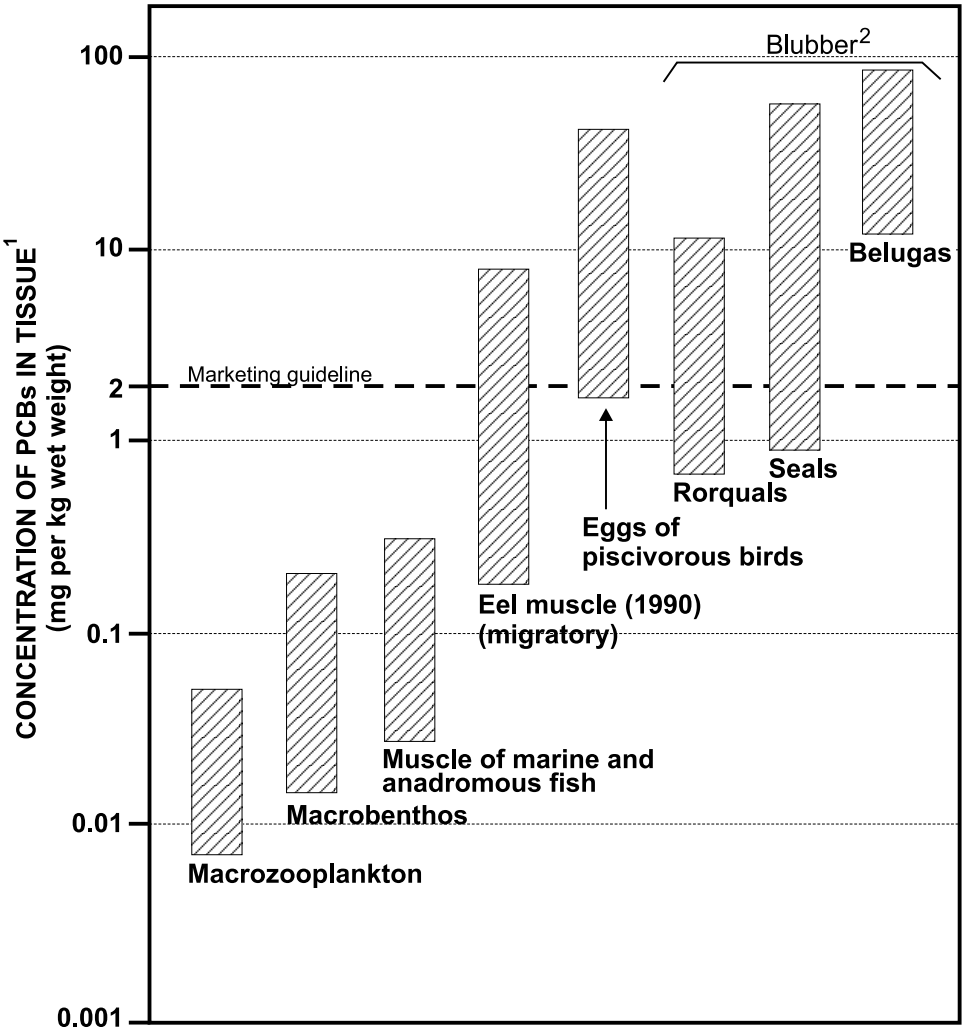
such as PCBs, DDT and Mirex. As a result, these substances become concentrated at all levels of the food chain and reach much higher levels in vertebrates than in invertebrates. This phenomenon, called *biomagnification***,** has been documented for the St. Lawrence estuary food chain with respect to PCBs, Mirex and mercury. For example, PCB levels are 100 to 1000 times higher in beluga blubber than they are in benthic and planktonic invertebrates (Figure 18). The extent to which organisms in the Lower Estuary are contaminated with biomagnified substances depends on their position in the food chain and their residence time in the estuary. For example, Finback whales are much less contaminated than Belugas because they feed primarily on herbivores (euphausiids) and they frequent the estuary only in summer, whereas Belugas eat mainly carnivorous organisms (fish) and live in the estuary year-round.

The sketchy data that are currently available indicate that, with the exception of American eels, invertebrates and fish in the study area do not contain toxic substance loads in excess of marketing guidelines for those species (Figure 18). However, fish-eating birds and marine mammals, particularly seals and toothed whales, are much more contaminated owing to the phenomenon of biomagnification.

Some of the American eels in the study area are heavily contaminated with PCBs, Mirex, dieldrin and mercury. These are the ones that migrate from the upper reaches of the St. Lawrence River and Lake Ontario to the sea. By contrast, contaminant levels are low in eels living in the estuary. Between 1982 and 1990, PCB and Mirex contamination of eels declined by 68% and 56%, respectively. In 1982, PCB levels in 80% of eels were above the marketing guideline, compared with only 36% in 1990. In the case of Mirex, dieldrin and mercury, the criterion was exceeded by 29%, 15.7% and 2.3%, respectively, in 1990.

The level of contamination in bird eggs in the estuary ranges in between levels reported in bird eggs from the Great Lakes and those on the Atlantic Coast of Canada. PCBs are the primary organochlorine contaminants found in the eggs. PCB, DDE, dieldrin, hexachlorobenzene, oxychlordane and Mirex concentrations in the eggs of Double-crested

cormorants in the estuary did not decline between 1972 and 1988. Present levels have no known harmful effects on cormorant populations.



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 concentrations measured in organisms of the Upper Estuary and Lower Estuary (excluding Baie des Anglais).

2. Concentration of PCBs in blubber is much higher than in muscle tissue.

Figure 18 Biomagnification of PCBs in the food chain in the Lower Estuary

For Belugas, the situation may be different. Concentrations of some organochlorine substances (PCBs, DDT and Mirex) in the Beluga population of the estuary are at least 10 times higher than in the Arctic populations. Mercury and lead levels are also higher than in Arctic Belugas. However, PAH, dioxin and furan concentrations in the estuary population are very low or undetectable. Belugas are thought to metabolize and hence not bioaccumulate these contaminants. However, a degradation by-product of benzo(a)pyrene—which is one of the PAH compounds generated by industrial plants—is more toxic than the original substance and is potentially carcinogenic. These by-products have been found at higher levels in the Belugas that inhabit the estuary than in the Arctic population.

No marked trend, either upward or downward, has so far been found in the Belugas' contamination status. The many pathologies identified in individuals that have washed up on shore (malignant or benign tumours, glandular lesions, infections signalling immune system impairment, periodontitis and tooth loss) may be linked to high levels of contamination.

Among marine mammals, seals rank second after Belugas in terms of contamination by toxic substances. PCBs, DDT and Mirex have been found in very high concentrations in the blubber of some Harbour seals and Grey seals, whereas Harp seals display much lower levels. While some Grey seals have high mercury levels in their livers, elevated concentrations of cadmium have been detected in the liver of Harbour seals and Harp seals.

Despite the high PCB and PAH concentrations in the sediments of Baie des Anglais at Baie-Comeau, the guideline for PCBs was only exceeded in mussels collected near Moulin Cove (whelks, herring and American eels were less contaminated). In the early 1990s, PAH levels in the flesh of cod were low and comparable to those found in specimens from the Atlantic Ocean. The PAH concentrations in the flesh of Greenland halibut were lower than those in specimens from the Saguenay Fjord. Finally, dioxin and furan concentrations in whelks, snow crab and shrimps were well below guideline levels.

4.3 Introduced or Expanding Species

Purple loosestrife. Purple loosestrife is a European plant that has invaded the freshwater marshes of the St. Lawrence River. It first appeared in the Lower Estuary around 1940 on the south shore and around 1960 on the north shore. The spread of this species was aided by abnormal water-level fluctuations, ice erosion, shoreline development and livestock grazing. Purple loosestrife is considered a nuisance plant in some parts of Canada and the United States because it reduces the diversity of marshland plant communities.

Exotic organisms in ship ballast. The ballast water carried by merchant ships may harbour large numbers of planktonic and benthic organisms, and ballast dumping is a potential vector for introducing exotic species into a marine environment. Some introduced species can have harmful effects on the ecosystem, as is the case with the freshwater Zebra mussel.

Double-crested cormorant. The rapid expansion of the Double-crested cormorant population in the St. Lawrence estuary during the 1980s led to the destruction of large portions of Common eider habitat. Between 1988 and 1993, this population was subjected to control measures to reduce its numbers. In the Lower Estuary, adults were destroyed in the colonies on the Rasade islands and the East Reef of Bicquette Island, and eggs and adults were destroyed in the colonies on the Ragueneau and Rasade islands, Ile aux Pommes, and the reefs of Bic Island, Grand Mitis Islet and the Les Boules islets.

4.4 Disturbance of Birds and Marine Mammals

Large-scale development of marine recreational and tourist activities in the study area has generated concern about the potential impact of the persistent presence of humans in habitats that had been, until recently, relatively inaccessible to the general public.

The Common eider, for example, is highly vulnerable to disturbance by pleasure craft during the brood-rearing season, and disruption caused by visitors can interfere with the nesting of eiders by facilitating predation of eggs and young in the colonies.

Disturbance due to the spectacular increase in marine traffic in the Tadoussac area, largely attributable to the rapid growth of whale watching, may be one of the factors contributing to the decline in the number of Belugas seen at the mouth of the Saguenay River in the early 1980s.

Marine mammals, the Beluga in particular, are sensitive to disturbance by boats, sea-doos, kayaks and low-flying aircraft. Such traffic may affect the Beluga's acoustic environment, interfering with its movements, disrupting its social behaviour and raising the risk of collisions. In order to contain such disturbance, the Department of Fisheries and Oceans has issued directives to pleasure craft and tour boat operators on how to conduct whale-watching activities.

4.5 Overfishing

Fishing always reduces the biomass of the populations harvested and the average size of the individual fish taken. These normal phenomena do not jeopardize stocks as long as their potential for renewal is maintained. The decline in the cod population in the southern Gulf of St. Lawrence in the late 1980s and early 1990s has been traced to the fact that the fishing effort was sustained at a time when environmental conditions were particularly unfavourable to renewal of the resource; this considerably diminished the reproductive potential of the population at that time. No significant increase in the groundfish biomass in general is expected over the next few years. Other major resources in the area, such as whelk and turbot, are currently highly vulnerable to overfishing, since a high proportion of the catch consists of individuals that have not yet reached sexual maturity.

CHAPTER 5 Human Health Risks

The technical health report offers the various users of the Lower Estuary and the riverside population more information on the health risks associated with the use of these waters.

5.1 Consumption of Fish, Crustaceans and Molluscs

This section looks at the constraints imposed by the chemical, bacteriological and toxic contamination of certain aquatic organisms in the Lower Estuary.

5.1.1 Chemical contamination

In general, fish, crustaceans and molluscs in the Lower Estuary (except for the American eel) are not very contaminated by anthropogenic chemicals. The vast majority of concentrations of the main contaminants studied and detected (mercury, PCBs, DDT, Mirex, dioxins and furans) are below the marketing limits for fish and seafood.

As a result, the health risks involved in eating fish, crustaceans and shellfish in the Lower Estuary are considered negligible compared to their health benefits. For the general public, eating fish provides not only a good dietary intake of proteins, vitamins and minerals, but also some protection against certain diseases, in particular cardiovascular disorders. Moreover, for pregnant and nursing women, eating marine species (which are generally less contaminated) is a good source of polyunsaturated fatty acids (particularly omega-3s) and nutrients needed for nervous system development in the fetus and the child in the first few months of life.

The American eel generally exhibits the highest levels of contamination among St. Lawrence species. The *Guide de consommation du poisson de pêche sportive en eau douce* (Guide to eating freshwater sport fish), published by the provincial ministries of Health and Social Services (MSSS) and of the Environment and Wildlife (MEF) (1995), recommends that

pregnant and nursing women and young children not eat this fish. It also suggests that other people limit the amount of American eel they eat.

Baie des Anglais (Baie-Comeau) is the most polluted region in the Lower Estuary. In 1984, the provincial ministries of Social Affairs and of the Environment, in co-operation with the Centre de Toxicologie du Québec (Quebec poison control centre), published a guide entitled *Contamination des produits de la pêche dans la région de Baie-Comeau* (Contamination of fish products in the Baie-Comeau region). It contains recommendations for eating fish, crustaceans and molluscs in the region. The purpose of the recommendations (see Table 3) is to limit the intake of contaminants (in particular PCBs) to levels below the allowable daily intake established by Health Canada, and thus decrease the health risks. Newborns and children of nursing mothers who eat a lot of fish, as well as fish eaters themselves, are the main risk groups targeted by the guide. These recommendations were still in effect in 1996 and will remain so until new data cause them to be revised.

5.1.2 Bacteriological contamination

Bacteriological contamination of molluscs is a major problem throughout the Lower Estuary. A large number of shellfish harvesting sites (62%) are either closed or conditionally approved (closed in summer). Contamination from municipal wastewater and nonpoint-source agricultural pollution appears to be the main cause.

Eating infected molluscs can cause digestive and intestinal problems. A few cases of bacterial poisoning have been reported in the past few years in the study sector, particularly on the Cote-Nord. However, the extent of the problem remains unknown because of under-reporting of intestinal problems, since most cases do not require a doctor’s visit or hospitalization.

Molluscs should only be harvested in sectors authorized by the Department of Fisheries and Oceans. Using data collected through Environment Canada’s Shellfish Water Quality Protection Program, the department advises harvesters on mollusc safety.

Table 3
Consumption guidelines for fish, crustaceans and shellfish from Baie des Anglais

		Target Public		
Species	*Sector*	*General public*	*Pregnant women*	*Nursing mothers*
Mussels	Southwest* Anse du Moulin Northeast	Avoid	Avoid	Avoid
Gutted whelks**	Anse du Moulin Northeast	Five meals/week	One meal/month	Avoid
Crab (meat only)	All sectors	Two meals/day	One meal/month	Avoid
Herring (meat only)		Five meals/week	Avoid	Avoid
Cod (meat only)		Two meals/day	One meal/week	One meal/month

NOTE: One meal is the equivalent of 230 g (8 ounces) of fish.

* Fishing is prohibited in the southwest sector as a result of bacterial (and not PCB) contamination.
** Ungutted whelks should not be eaten.

Source: Ministere des Affaires Sociales du Quebec, Ministere de l'Environnement du Quebec, in co-operation with the Centre de Toxicologie du Québec, 1984.

5.1.3 Contamination by toxic algae

The microscopic alga *Alexandrium excavatum* (the main species of toxic alga found in the Lower Estuary) produces a biotoxin that, when ingested by humans, can cause serious symptoms of poisoning, and even death. The toxin is transmitted to humans when they eat molluscs that feed on the alga, although the molluscs themselves are not affected by the toxin.

Some studies have detected the presence of toxins in mussel and clam meat at levels that exceed government standards in the study sector. Poisoning cases caused by eating infected molluscs have been reported in the study area.

The best way to avoid being contaminated by shellfish infected with toxic algae is to follow harvesting restrictions established by Fisheries and Oceans. Cooking does not destroy the toxin.

5.2 Seaweed Consumption

Both commercial and small-scale harvesting of seaweed is carried out in the Lower Estuary, although this activity is still marginal in Quebec as a whole. Analyses done in the study sector on the various kinds of edible seaweed detected the presence of several inorganic and organic contaminants. However, the levels observed were generally quite low and frequently undetectable. Organochlorine and mercury contamination of the seaweed was often comparable to levels in regions considered unpolluted. Only the presence of iodine and cadmium, which appeared in higher concentrations in some seaweed species than other chemical substances, could present a human health risk. However, there is only a risk if a large amount of seaweed is consumed.

5.3 Game Consumption

5.3.1 Waterfowl consumption

According to Health Canada analyses, the health risk of eating waterfowl meat is negligible. Chemical contamination of such game meat is not high enough to restrict its consumption. However, it is recommended that any lead shot visible in the flesh be removed as well as the skin and fat, particularly in the case of fish-eating birds.

5.3.2 Seal meat consumption

Seals in the St. Lawrence are highly contaminated with mercury, cadmium, PCBs, DDT and Mirex (analyses carried out on the liver and fat). As there are no specific recommendations regarding seals in the Lower Estuary, it would be preferable to follow the restrictions on Harp seal consumption applied by the provincial ministry of Agriculture, Fisheries and Food (MAPAQ).

MAPAQ has an analysis program to assess the safety of Harp seal meat in the Iles de la Madeleine. Following the analyses, MAPAQ recommends not eating seal livers and limiting

consumption of adult seal meat to one meal per week. There are no restrictions on eating the flesh of young seals.

5.4 Recreational and Commercial Activities

5.4.1 Contamination

Discharges of untreated municipal and household wastewater and nonpoint-source farm pollution increase the presence of germs that can cause health problems such as dermatitis, ear infections, conjunctivitis and gastroenteritis. These discharges may restrict recreational activities such as swimming, windsurfing, waterskiing and seadooing.

Swimming zones in the Lower Estuary are not part of the *Environnement-Plage* (beach environment) program of the MEF. Before practising an activity that brings you into contact with the water in a given sector, it is recommended you consult local authorities (municipalities, MEF, public health directorate) about water quality in the sector. Notices prohibiting shellfish harvesting are an indication of the possible presence of sources of bacteriological contamination near the site. Caution should be exercised when these signs are present.

5.4.2 Injuries

Recreational activities. In 1995, 54 accidents involving recreational vessels and requiring the assistance of the Canadian Coast Guard's Marine Rescue Centre occurred in the Haute-Cote-Nord and Bas-Saint-Laurent regions. Mechanical breakdowns and loss of control were the main reasons assistance was required. Motorboats were most frequently involved in accidents, followed by sailboats. In general, serious accidents are due to the lack of life jackets, alcohol consumption and the boaters' lack of training and knowledge, among other things.

The drownings, injuries, hypothermia and psychological problems resulting from an accident are the main risks related to boating on the St. Lawrence River. Four deaths have occurred in the study area since 1992, two of which were related to diving at Les Escoumins.

Commercial activities. In the Cote-Nord and Bas-Saint-Laurent regions, the Canadian Coast Guard's Marine Rescue Centre assisted 15 fishing boats in 1995. Mechanical breakdowns were the main types of incidents identified. Inadequate maintenance appears to be largely responsible for accidents.

5.5 Environmental Accidents

5.5.1 Natural accidents

Landslides and floods are uncommon on the shores of the St. Lawrence in the Lower Estuary. Most natural accidents in the study area over the past few decades have occurred on the periphery of St. Lawrence tributaries. One recent example is the major flooding that took place on July 20, 1996, causing serious material damage and loss of life. Although physical health problems do not necessarily occur during each of these events, the psychosocial impact of the material damage and evacuations they cause is far from negligible.

5.5.2 Technological accidents

Because large amounts of hazardous materials are transported through the study area, there is a risk of spills that could lead to public health problems. However, no such events have been reported in the area. The main ports in the study sector have strategies or response equipment to limit damage to health and the environment in the event of a technological accident.

The vast majority of spills occur at port facilities during transshipment. However, to date, these incidents have had little impact on health. No cases have been reported to any public health directorates.

CHAPTER 6 Toward Sustainable Development of the Lower Estuary

Sustainable development of the Lower Estuary involves reclaiming and preserving for future generations the biodiversity of plant and animal life, their manifold uses and the quality of life associated with them. Activities must ensure economic development while guaranteeing resource sustainability and environment quality. Among the means advocated to achieve sustainable development are:

- Reducing pollution
- Protecting and rehabilitating disturbed habitats and resources
- Improving access to the St. Lawrence
- Co-ordinating recreational and tourism development and environmental protection.

This exercise is an attempt to identify the main environmental issues in the sector and to describe some of the existing programs and activities that foster sustainable development (Table 4). This review is in no way exhaustive and only forms the basis for discussions by local stakeholders to establish local strategies and priorities for action as part of their Ecological Rehabilitation Action Plans (ERAPs).

6.1 Pollution Reduction

Restrictions on use because of pollution in the study area (swimming, shellfish harvesting, consumption of marine products and port development) are largely attributable to local sources of contamination. Since the mid-1980s, a great deal of effort has been devoted to reducing local industrial and municipal sources, but there is still room for improvement, particularly with regard to municipalities that do not yet treat their wastewater.

Uses that depend on the bacteriological quality of the water (harvesting mussels) can only be reclaimed if wastewater treatment equipment remains effective, sewer overflows during rainstorms are limited and farm runoff and other point sources of pollution are controlled.

Despite major efforts to reduce or eliminate sources of pollution, the Lower Estuary remains exposed and very vulnerable to the harmful effects of persistent, bioaccumulative toxic substances. It is a natural sink for contaminants transported over long distances in water and the atmosphere, as well as for toxic substances gradually released at contaminated land and water sites on the Great Lakes and the St. Lawrence River. In addition, the organisms most vulnerable to bioaccumulative toxic substances (fish-eating birds and marine mammals) frequently visit the zone where these substances are trapped. A better understanding of the interaction and effects of toxic substances on marine organisms is one of the major issues for the sector.

The Lower Estuary is also very vulnerable to a major oil spill, mainly because of the abundance of bird colonies, duck broods, seabird gathering areas, seal haulouts and the large number of marine mammals that visit the sector. An emergency response team and equipment and a bird cleaning centre have been set up on the north and south shores.

Eliminating the PCBs stored in the Baie-Comeau region is another major issue. Some of the PCBs were slated for incineration some time in 1996.

Table 4
The main issues of sustainable development of the St. Lawrence Lower Estuary

Issues	*Assessment of present state relative to sustainable development goals*	*Present actions for sustainable development*
Pollution Reduction		
• Treatment of municipal, household and agricultural wastewater.	Seventy-seven per cent of the area population's wastewater currently goes to treatment plants. However, several municipalities do not yet treat their wastewater. Bacteriological pollution restricts mollusc harvesting in several areas.	Uses related to the bacteriological quality of the water can only be reclaimed by treating wastewater (treatment plants or effective septic facilities), controlling overflows during rainstorms and controlling agricultural pollution.
• Treatment of paper mill effluents.	The three paper mills in the study area have significantly reduced BOD_5 and SS loads along with the toxicity of effluents discharged to the estuary. In 1995, two of the plants applied a secondary treatment to their effluent, while the third recycled its process water.	Effluents from paper mills are subject to regulatory monitoring.
• Treatment of effluents and reduction of atmospheric emissions from aluminum smelters.	The aluminum smelter in Baie-Comeau (Canadian Reynolds Metals Co.) was the main source of PCBs and PAHs found in Baie des Anglais. These toxic substances have been almost completely eliminated from discharges and PAH emissions have been reduced by 84% over the past decade.	No other measures are envisaged in the short term.
• Site restoration and elimination of hazardous waste.	The main hazardous waste disposal sites on the estuary's shores have been restored over the past decade and are subject to environmental monitoring.	Some sites have not been restored at all or require additional work.
• Persistent toxic substances in the environment.	Despite a considerable reduction in the various sources of contamination in the St. Lawrence watershed, aquatic organisms in the Lower Estuary remain exposed to toxic, bioaccumulative substances, in particular fish-eating birds and marine mammals. In general, contamination of fish products by chemical substances does not present any human health risks. However, consumption of American eels, seals and marine products harvested in Baie des Anglais is subject to restrictions.	A better understanding of the interaction and effects of these substances on marine organisms and human health is a major issue for the sector.

Issues	*Assessment of present state relative to sustainable development goals*	*Present actions for sustainable development*
Protecting and rehabilitating disturbed habitats and ressources		
• Baie des Anglais	Sediments in Baie des Anglais are highly contaminated by PCBs and PAHs.	Studies are being conducted to learn about the stability of contaminated sediments and the impact on aquatic organisms.
• Port of Forestville	The Forestville harbour is highly contaminated by PAHs.	An environmental study is under way to dismantle the wharf and restore the contaminated area.
• Manicouagan peninsula	Shore erosion is a serious problem in municipalities on the Manicouagan peninsula.	Data on the cause and scope of the phenomenon are limited.
• Sensitive habitats	Several major habitats for plant and animal life (salt marshes, bird colonies and seabird and marine mammal gathering areas) are protected. However, some important wildlife sites remain unprotected, especially on the north shore.	Several projects aimed at protecting sensitive habitats in the Lower Estuary are being studied.
• Belugas	The survival of the St. Lawrence Beluga is being threatened by toxic substances and disturbances from recreational and tourism activities.	An action plan to foster the Beluga's survival has been in effect since the late 1980s. The objective of the Saguenay-St. Lawrence Marine Park is to protect the environment of a large portion of the Beluga's critical habitats.
• Fishery resources	The Atlantic cod population that frequents the estuary reached its lowest historical level in the early 1990s because of overfishing and difficult oceanographic conditions. A moratorium on fishing of this species has been in effect since 1993. Current Greenland halibut and whelk fishing practices threaten the stocks' reproductive potential.	Recovery of the Atlantic cod population is very slow because of difficult oceanographic conditions; it is unknown when the fishery can be reopened. Establishing a minimum legal catch size for the Greenland halibut and whelk would help protect these species' reproductive potential.
• Atlantic salmon	The decline of the resource since the early 1990s is noted throughout Quebec and was apparently caused by bad winter conditions in the Atlantic Ocean that led to mass mortalities.	Since 1990, several of the sector's salmon rivers have undergone major improvements to increase the economic spin-offs of salmon fishing while ensuring the salmon's survival.

Issues	*Assessment of present state relative to sustainable development goals*	*Present actions for sustainable development*
• Atlantic sturgeon and Rainbow smelt	Atlantic sturgeon populations in the Aux Outardes and Manicouagan rivers have decreased while the status of the Rainbow smelt population on the north shore is unknown.	Increased knowledge of the biology of the Atlantic sturgeon and Rainbow smelt on the estuary's north shore is essential to the protection and rehabilitation of these populations.
• Shellfish sectors	Bacteriological pollution limits mollusc harvesting in several shellfish sectors, particularly on the south shore.	Control of various sources of bacteriological pollution (urban and household wastewater, agricultural discharges and bird colonies) is essential to maintaining the harvest.
• Black duck	The Black duck population has been in decline since the 1970s.	Projects are under way in the L'Isle-Verte region to improve the habitat of this species.
Access to the Lower Estuary		
• North shore	Access points to the shoreline and marine habitat have increased in the upstream portion of the north shore between Tadoussac and Les Escoumins, while they are limited downstream.	Several projects have been initiated to develop the shore for recreational and tourism purposes between Les Escoumins and Godbout in the last few years.
• South shore	There are many access points to the shoreline but access to the islands and the possibility of finding accommodation or eating places along the water are limited.	A few recent projects have improved the situation.
Co-ordination of recreational and tourism development and environmental protection		
	Recreational and tourism activities in a marine environment have grown considerably but some of them threatened seabirds and marine mammals.	The impact on resources of certain recreational and tourism projects is currently being studied.

6.2 Habitat and Resource Protection and Rehabilitation

Contamination of the sediments in Baie des Anglais limits development in the port of Baie-Comeau and imposes consumption restrictions on marine organisms harvested in the bay. Studies are being conducted to know more about the stability of these contaminated sediments and their impact on aquatic organisms.

Shore erosion is a major problem in municipalities on the Manicouagan peninsula. However, data on the nature and scope of the phenomenon are limited.

Several habitats important to the plant and animal life in the study area are already protected, but other equally important habitats are not. Sectors worthy of protection include the salt marshes in Baie aux Outardes and at the mouth of the Betsiamites River, the bay of the Jérémie islets, the Portneuf sandbar, Mille-Vaches Bay, Petite Boule Island and the Boulay reef (Ragueneau archipelago) on the north shore, and the marshes in the Rimouski and Mitis rivers and on Ile aux Pommes on the south shore. Currently being studied are projects to add a buffer zone around the Baie de L'Isle-Verte National Wildlife Area, enlarge the Pointe-au-Père National Wildlife Area, and acquire land to protect the marshes in Pointe-aux-Outardes and Mille-Vaches Bay. In addition, 52 new seabird gathering areas and five heronries on the north shore should be receiving wildlife habitat status in the near future.

The worrisome status of the Beluga population in the estuary has led to the implementation of several measures aimed at protecting the habitats used by the species and reducing pollution and disturbances. The Saguenay–St. Lawrence Marine Park was created to protect most of the areas frequented by the Beluga. Drawn up in 1995, the St. Lawrence Beluga Recovery Plan developed a series of strategies to increase sufficiently the population so that natural events and human activities would no longer threaten its survival. In July 1996, a plan was implemented under St. Lawrence Vision 2000 which combines all government activities and proposes new measures aimed at re-establishing the Beluga whale in the St. Lawrence River.

Among other things, the North American Waterfowl Management Plan is aimed at re-establishing Black duck populations to 1970 levels by the year 2000. In the L'Isle-Verte region, projects are currently under way to improve the species' habitat.

Large quantities of Atlantic sturgeon were caught in the 1940s at the mouths of the Aux Outardes and Manicouagan rivers, but the species has declined considerably in the region. The causes of the decline are unknown; major changes to the two rivers following hydro-electric development may be responsible.

The location of Rainbow smelt spawning grounds on the Haute-Cote-Nord is unknown, so it is impossible to protect this important resource at this time. The population on the estuary's south shore has for several years been the subject of a major recovery plan aimed primarily at rehabilitating the main spawning grounds in a tributary of the Upper Estuary.

A number of measures have been taken to re-establish the cod population in the southern part of the Gulf of St. Lawrence, some of which pass through the Lower Estuary. A moratorium on fishing has been in place since 1993 and will not be lifted until the population is sufficiently re-established. In addition, cod by-catches from other fisheries have been reduced through the improved selectivity of fishing gear. There are also plans to impose a minimum legal size for whelk and Greenland halibut to protect their stocks in the estuary and Gulf.

The objective of the Salmon Economic Development Plan (SEDP) is to increase economic spin-offs from Atlantic salmon while maintaining the resource's survival. Since 1990, several salmon rivers in the sector have undergone major changes under SEDP. Development plans are being implemented for the largest rivers, and, since 1984, they have been seeded each year with salmon eggs, fry, parr and smolt.

6.3 Access to Marine, Shore and Island Environments

For several years, tourism development based on the estuary's attractions and resources has grown, particularly on the north shore near the mouth of the Saguenay River. However, further downstream on the north shore, access to the St. Lawrence is limited because of

the land forms and the limited facilities and investment. However, in the past few years, several projects have been initiated to develop the shore for recreational and tourism purposes in the region (Verte Bay, Laval Bay, the Portneuf sandbar, the Pointe-aux-Outardes and Baie-Comeau municipal parks, and the Franquelin and Godbout recreational and tourism developments).

On the south shore, the Association Touristique du Bas-Saint-Laurent (Lower St. Lawrence tourism association) in 1988 pointed out problems experienced by tourists in gaining access to the islands and in finding accommodation or places to eat along the water. Several recent projects have increased access, such as the Rimouski River and shoreline paths, the Beauséjour Park in Rimouski and development of Ile Saint-Barnabé. The current process of retroceding federal ports to local stakeholders will help improve the situation.

6.4 Co-ordination of Recreational and Tourism Development and Environmental Protection

In the past few years, the Lower Estuary has experienced major growth in recreational and tourism activities on its shores and islands as well as in the sea. One of the major issues for the sector will be to ensure sustainable development by protecting wildlife resources and their habitats and the landscapes in which these activities take place. Among other things, it will be necessary to limit the disturbance of birds and marine mammals caused by the increasingly frequent presence of humans in habitats that, until quite recently, were not accessible to the general public.

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Appendices

1 St. Lawrence Vision 2000 Priority Species Found in the Lower Estuary

English or Latin name	*Type of distribution or local status*
Plants (12 of the 110 priority species)	
Arabis holboellii (var. Collins)	Disjunct
Arnica lonchophylla (ssp. *lonchophylla*)	Disjunct
Calamagrostis purpurascens (var. *purpurascens*)	Disjunct
Gilded draba	Disjunct
Poa secunda	Disjunct
Holly fern	Disjunct
Rosa rousseauorium	Endemic (Lower Estuary and Gulf of St. Lawrence)
Rosa williamsii	Endemic (Lower Estuary and Gulf of St. Lawrence)
Arrow grass	Endemic (northeastern North America)
Fleabane	Disjunct
Oregon woodsia	Disjunct
Rocky mountain woodsia	Disjunct
Reptiles (1 of the 6 priority species)	
Brown snake	Found on the south shore
Fish (7 of the 14 priority species)	
American shad	Migrates along south shore
American eel	Migrates along south shore and found in tributaries
Striped bass	Migratory
Rainbow smelt	Year-round resident; spawns in some tributaries
Atlantic sturgeon	Year-round resident
Atlantic herring	Migratory; spawns near coasts
Atlantic tomcod	Common in spring and summer; spawns in some tributaries

English or Latin name	*Type of distribution or local status*
Birds (15 of the 19 priority species	
Harlequin duck	Winter visitor on the north shore and migratory on the south shore
Le Conte's sparrow	Probable nester on the north shore
Pintail	Confirmed nester on both shores
Peregrine falcon	Confirmed nester on the south shore and possible nester on the north shore
Barrow's goldeneye	Migratory on both shores
Horned grebe	Migratory on both shores
Least bittern	Visitor to the south shore
Red-headed woodpecker	Visitor to both shores
Loggerhead shrike	Migratory on both shores
Piping plover	Visitor to the south shore
Common moorhen	Visitor to the south shore
Bald eagle	Probable nester on the north shore
Yellow rail	Possible nester on the north shore
Blue-winged teal	Confirmed nester on the south shore and possible nester on the north shore
Caspian tern	Visitor to the north shore and migratory on the south shore
Mammals (all 5 priority species)	
Beluga whale	Year-round resident
Harbour porpoise	Common in summer and fall
Pygmy shrew (land mammal)	Status unknown
Harbour seal	Year-round resident
Fin whale	Common in spring, summer and fall

2 Environmental Quality Criteria (for assessing loss of use)

Ecosystem component	*Reference criterion*	*Objective*
WATER	Raw water (taken directly from a body of water without treatment) (MENVIQ, 1990)	To protect the health of people who may both drink directly from a body of water and consume organisms taken from the body of water throughout their lives.
	Contamination of aquatic organisms (MENVIQ, 1990)	To protect human health from the threat posed by consumption of aquatic organisms.
	Aquatic life (chronic toxicity) (MENVIQ, 1990)	To protect aquatic organisms and their offspring and wildlife dependent on aquatic organisms.
	Recreational activities (primary contact) (MENVIQ, 1990)	To protect human health in the context of recreational activities in which the whole body is regularly in contact with the water, e.g. swimming, windsurfing.
SEDIMENTS	No effect threshold (NET) (SLC and MENVIQ, 1992)	Contaminant levels are below that at which any effects on benthic organisms are observed.
	Minimal 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	Fish marketing guidelines (Health and Welfare Canada, 1985)	Maximum acceptable contaminant levels in the tissues of fish, shellfish and crustaceans sold for consumption.
	Fish consumption guidelines (MENVIQ and MSSS, 1993)	To prevent harm to human health from eating contaminated fish, shellfish and crustaceans.

3 Glossary

Advection: The horizontal transport of a water mass.

Anadromous: Refers to fish which, in the course of their life cycle, return from the sea to fresh water to reproduce.

Benthos: All organisms living in contact with the bed of a watercourse, divided into phytobenthos (plants) and zoobenthos (animals).

Biomass: Total mass of living organisms, taken either globally or in systemic 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 with a salinity level in between that of fresh water (0.3 ‰) and that of salt water (35 ‰).

Carcinogenic: Refers to any factor apt to trigger or favour the appearance of a cancer.

Catadromous: Refers to fish that live in fresh or brackish water and migrate to the sea to reproduce.

Clay: The finest sediments, consisting of particles of less than 2 microns in diameter.

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

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 watersheds, as litres per second (L/s).

Disjunct distribution: Refers to plant species found in an area or areas remote from its main range.

Ecosystem productivity: Quantity of biomass produced annually and maintaining the equilibrium of animal and plant populations.

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

Effluent: General term for any fluid issuing from a source of pollution, whether a residential area (domestic outfall) or industrial plants (industrial outfall). Point-source effluents (sewers): outflow of liquid pollutants at a given place.

Endemic distribution: Refers to a plant species whose range is limited to a well defined area.

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

Estuarine circulation: Movement of water typical of estuaries, characterized by a downstream flow at the surface and an upstream flow on the bottom.

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

Foreshore: That part of the shore lying between the high and low water marks. (Synonyms: *mesolittoral, intertidal*).

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

Haulout: Stretch of shoreline where seals come out of the water to rest.

Hydrophobic: Refers to toxic substances that show little tendency to dissolve in water.

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

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

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

One-sea-winter salmon: Salmon returning to its native river to spawn after only one year at sea. Also called *Grilse*.

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

Primary production: Quantity of organic matter generated by autotrophic organisms in a given period.

Secondary production: Quantity of organic matter generated by heterotrophic organisms in a given period.

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

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

Silt: Sedimentary deposits of particles of intermediate size between clay and sand.

Spawning ground: Place where fish gather to breed.

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

Terrigenous: Refers to substances originating on dry land.

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

Tidal range: Vertical distance between high and low tides.

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).

Two-sea-winter salmon: Salmon that returns to its native river to spawn after at least two years at sea or one which has spawned before.

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

Waterfowl: Collective term for ducks and geese.

Watershed: The entire continental land area drained by a watercourse, that is the total precipitation catchment and drainage area. (Synonym: *drainage basin).*

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