REGIONAL ASSESSMENT
SOUTH SHORE OF THE ST. LAWRENCE
UPPER ESTUARY

Regional Assessment
South Shore of the St. Lawrence Upper Estuary

Priority Intervention Zones 15, 16 and 17

Marc Gagnon

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

April 1998

NOTICE TO READERS

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

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

Preface

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

The goal of St. Lawrence Vision 2000 (SLV 2000) is to conserve and protect the St. Lawrence River 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.

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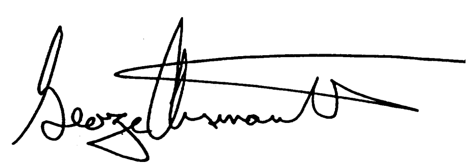

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Management Perspective

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

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

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

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

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

Perspective de gestion

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

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

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

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

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

Abstract

The south shore sector of the Upper Estuary comprises the coastal, aquatic and island habitats along the south shore of the St. Lawrence from Montmagny to Cacouna, Quebec. The sector's biophysical characteristics are very different from those found either further upstream or downstream or on the north shore of the Upper Estuary. The sector is characterized by low and even relief, a broad foreshore, extensive wetlands, and a wealth of islands and islets. Physical and chemical conditions change gradually seaward, with increasing salinity and water mass stratification and decreasing water temperature and turbidity.

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

Because of the large number of small islands and islets, there are many bird colonies and seal haulouts. Intertidal marshes are found everywhere and are heavily used by migrating and breeding birds. Beluga whales frequent the downstream portion of the area intensively from spring to fall, presumably for its abundance of capelin, herring, smelt and eel, the Beluga's main prey. The sector is little used by birds or marine mammals in winter because of the extensive ice cover.

There is only one commercially significant port in the sector, at Gros-Cacouna. Commercial fishing almost exclusively targets two at-risk species (Atlanic sturgeon and American eel), but waterfowl hunting, cottaging, recreation and tourism are very important.

Most of the sensitive wildlife habitat in the sector is protected by government legislation or regulation, but some of the islands and much of the wetland area remain without legal protection.

Since the beginning of the 20th century, close to 1000 hectares of wetland have been disturbed or simply wiped out. Disturbance is due mainly to diking of the upper parts of the intertidal marshes for farming.

Since the 1970s, there has been a significant drop in the contaminant input from both remote and local sources of pollution. Most of the cleanup effort on the part of local municipalities and industry has occurred in the 1990s. There are no heavy industries dumping toxic waste into the aquatic environment in the sector, and by late 1997 the wastewater of 70% of the sector's population was being piped to treatment plants.

The very fragmentary data available suggest that water, sediments, plants, aquatic invertebrates and marine fish (herring, capelin, flounder) in the sector are largely free of contamination by toxic substances (heavy metals, organochlorine pesticides, PCBs, PAHs, dioxins and furans) and pose no significant threat to human health. On the other hand, concentrations of heavy metals and organochlorines are high in certain freshwater or anadromous fish (Atlantic tomcod, Sauger and migratory eels from Lake Ontario), fish-eating birds and marine mammals that stay in the estuary year-round, though such concentrations are generally declining. Bacterial contamination of some shellfish beds is high and precludes harvesting.

Résumé

Le secteur de la rive sud de l'estuaire moyen comprend les milieux côtiers, aquatiques et insulaires situés le long de la rive sud du Saint-Laurent entre Montmagny et Cacouna. Les caractéristiques biophysiques de ce secteur sont très différentes de celles qu'on retrouve en amont et en aval du secteur de même que le long de la rive nord de l'estuaire moyen. Le secteur est caractérisé par des côtes au relief peu accidenté, de larges estrans, une grande superficie de milieux humides et de nombreuses îles et îlots. Les conditions physico-chimiques changent progressivement de l'amont vers l'aval avec une augmentation de la salinité et de la stratification des masses d'eau et une diminution de la température et de la turbiditéde l'eau.

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

En raison du grand nombre de petites îles et îlots, les colonies d'oiseaux et les échoueries de phoques sont nombreuses. Les marais intertidaux omniprésents le long de la côte sont utilisés intensivement par les oiseaux migrateurs et nicheurs. Le Béluga utilise intensivement la parties aval du secteur du printemps à l'automne présumemént en raison de l'abondance de ses principales proies (capelan, hareng, éperlan et anguille). Le secteur est peu utilisé par les oiseaux et mammifères marins en hiver à cause de la couverture glacielle importante.

Le secteur n'est doté que d'un seul port commercial d'importance, le port de Gros-Cacouna. La pêche commerciale est preseque uniquement axée sur deux espèces diadromes en situation précaire (l'Esturgeon noir et l'Anguille d'Amérique). Par contre, la chasse à la sauvagine, la villégiature et le récréo-touristique sont des activités très importantes.

Une grande partie des habitats fauniques sensibles du secteur sont l'objet d'une protection en vertu des lois et règlements gouvernementaux. Par contre, quelques îles et de grandes superficies de marais sont sans protection légale.

Depuis le début du 20e siècle, près de 1000 hectares de milieux humides ont été perturbés ou carrément éliminés le long des rives du secteur. Des perturbations proviennent surtout de l'endiguement à des fins agricoles de la partie supérieure des marais intertidaux.

On assiste depuis les années 1970 à une baisse importante des apports de contaminants en provenance des sources éloignées et locales de pollution. Les principaux efforts de dépollution des municipalités et industries riveraines ont été réalisés au cours des années 1990. Aucune industrie lourde du secteur ne déàverse des effluents toxiques dans le milieu aquatique et, à la fin de 1997, les eaux usées de 70 p. 100 de la population riveraine étaient traitées dans des stations d'épuration.

Les données très fragmentaires disponibles suggèrent que l'eau, les sédiments, les végétaux, les invertebrés aquatiques et les poissons marins (hareng, capelan, plies) du secteur sont peu contaminés par les substances toxiques (métaux lourds, pesticides organochlorés, BPC, HAP, dioxines et furannes), et ne présentent pas de risques significatifs pour la santé humaine. Par contre, certains métaux lourds et des substances organochlorées atteignent des concentrations élevées chez certains poissons d'eau douce et anadromes (Poulamon atlantique, Doré noir et anguilles migratrices en provenance du lac Ontario), les oiseaux aquatiques piscivores et les mammifères marins qui résident à l'année dans l'estuaire. Cette contamination montre cependant une tendance générale à la baisse. Enfin, la contamination bactérienne des quelques secteurs coquilliers est élevée et empêche leur exploitation.

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CHAPTER 1 The St. Lawrence, Then and Now

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

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

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

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

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

Public awareness was sharply raised in the early 1970s with the realization that mercury contamination of fish was not just an abstract research topic, but a real risk to which some Native people and many sport fishers were exposed. As the list of toxic substances reported in the aquatic environment continued to grow, the general public changed its perception and put environmental quality at the top of its list of priorities. The very high levels of contamination by toxic substances in Beluga whales in the St. Lawrence Estuary, first recognized in the early 1980s, demonstrated that the problem was not limited to the Fluvial Section of the St. Lawrence, and that its repercussions were also being felt in the distant ecosystems of large industrial centres.

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

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

CHAPTER 2 The ZIP Program

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

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

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

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

The document summarizes and analyses the main points of the available knowledge with the aim of providing local stakeholders with scientific data in an accessible and objective form, to assist them in defining their priorities for action. Action plans can then be developed and implemented locally and regionally, by stakeholders in their own areas of responsibility, but paving the way for concerted action by the partners.

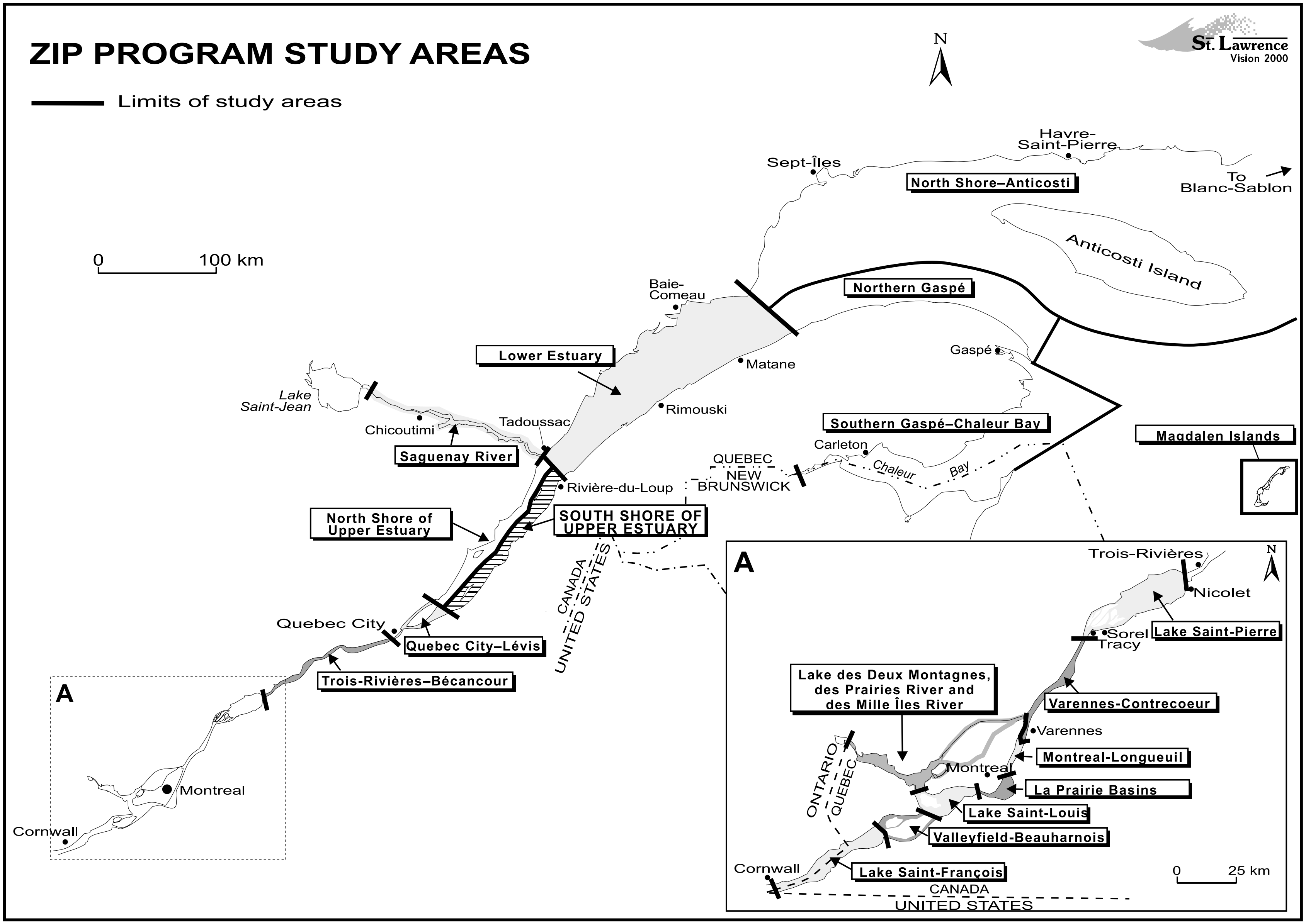


Figure 1 ZIP Program study areas

CHAPTER 3 Characterization of the Sector

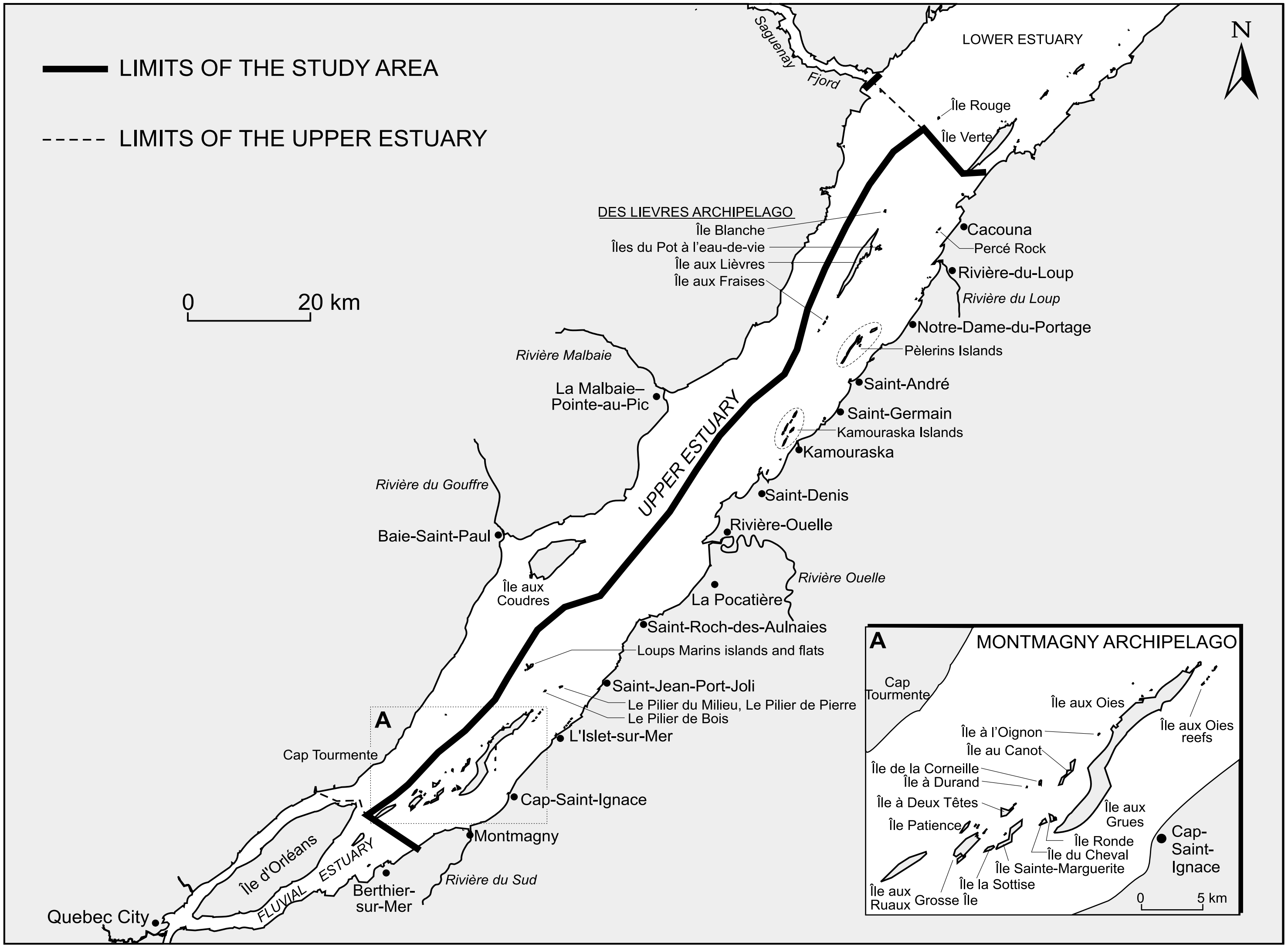
The study area consists of that part of the Upper Estuary along the south shore of the St. Lawrence River from Montmagny to Saint-Georges-de-Cacouna (Figure 2). Its western and eastern limits are the same as the upstream and downstream limits of the Upper Estuary, and it extends out to the midstream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

3.1 Physical Environment

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

The south shore of the Upper Estuary is cut into the sedimentary rocks of the Appalachian zone. This low and even coastline is bordered by a broad submerged shelf less than 10 m deep bearing some 30 islands and islets (Figure 3). The main islands in the sector (Île aux Grues, Île aux Oies and Île aux Lièvres) are separated from the south shore by a narrow channel (South Channel) generally no more than 20 m deep.

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



Note: Ile aux Ruaux is included in the study area, but is part of the municipality of Saint-Pierre-de-l'Ile-d'Orleans.

Figure 2 The south shore of the Upper Estuary

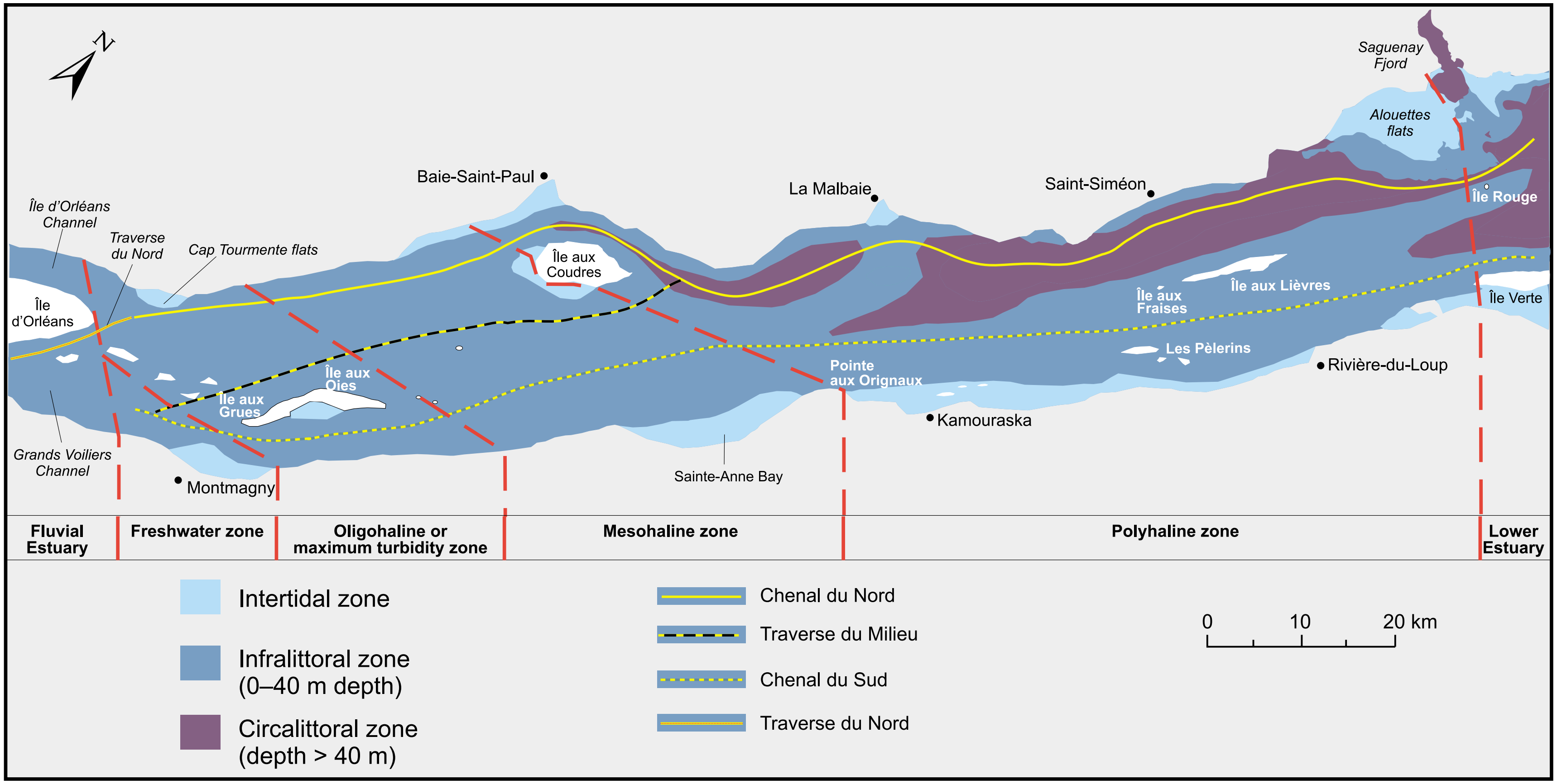
The tide rises twice daily in the study area, with an amplitude varying over a two-week cycle (spring and neap tides). The average tidal range decreases downstream, from 4.9 m in the Montmagny islands to 3.8 m at Rivière-du-Loup.

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

The limit of saltwater penetration into the estuary varies with the river's discharge and tidal amplitude. In summer, it is near the eastern end of Île d'Orléans and moves back and forth with the tide over a distance of some 20 kilometres. The waters washing the shores around Cap Tourmente, the Montmagny islands and the south shore between Montmagny and Cap Saint-Ignace are characterized by very high turbidity attributable to retention in summer of the suspended matter carried down by the river. This stretch is known as the maximum turbidity zone (Figure 3).

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

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



Source: Adapted from SLC and Laval University, 1991.

Figure 3 Zonation of the Upper Estuary by bathymetry and seaward gradient of physical and chemical conditions

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

3.2 Aquatic Habitats and Communities

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

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

The **freshwater** zone is situated between the upstream limit of the Upper Estuary and the limit of the saltwater penetration in summer (Montmagny archipelago). This zone has the same characteristics as water in the Fluvial Estuary: warmer and less turbid in the oligohaline zone, net transport of water in a downstream direction at all depths, relatively high concentration of phytoplankton, and freshwater flora and fauna that are more diversified than in the oligohaline zone.

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

The **mesohaline** zone is the part of the estuary where salinity varies between 5 and 18‰. This zone is characterized by low biological diversity and productivity. Freshwater species generally reach the downstream limit of their range in the oligohaline zone, while marine species reach their upstream limit in the polyhaline zone. In this zone, any brackish marshes are confined to the upper reaches of the foreshore and give way progressively to salt marshes. The zone's pelagic environment is characterized by a biomass that is relatively poor in plankton.

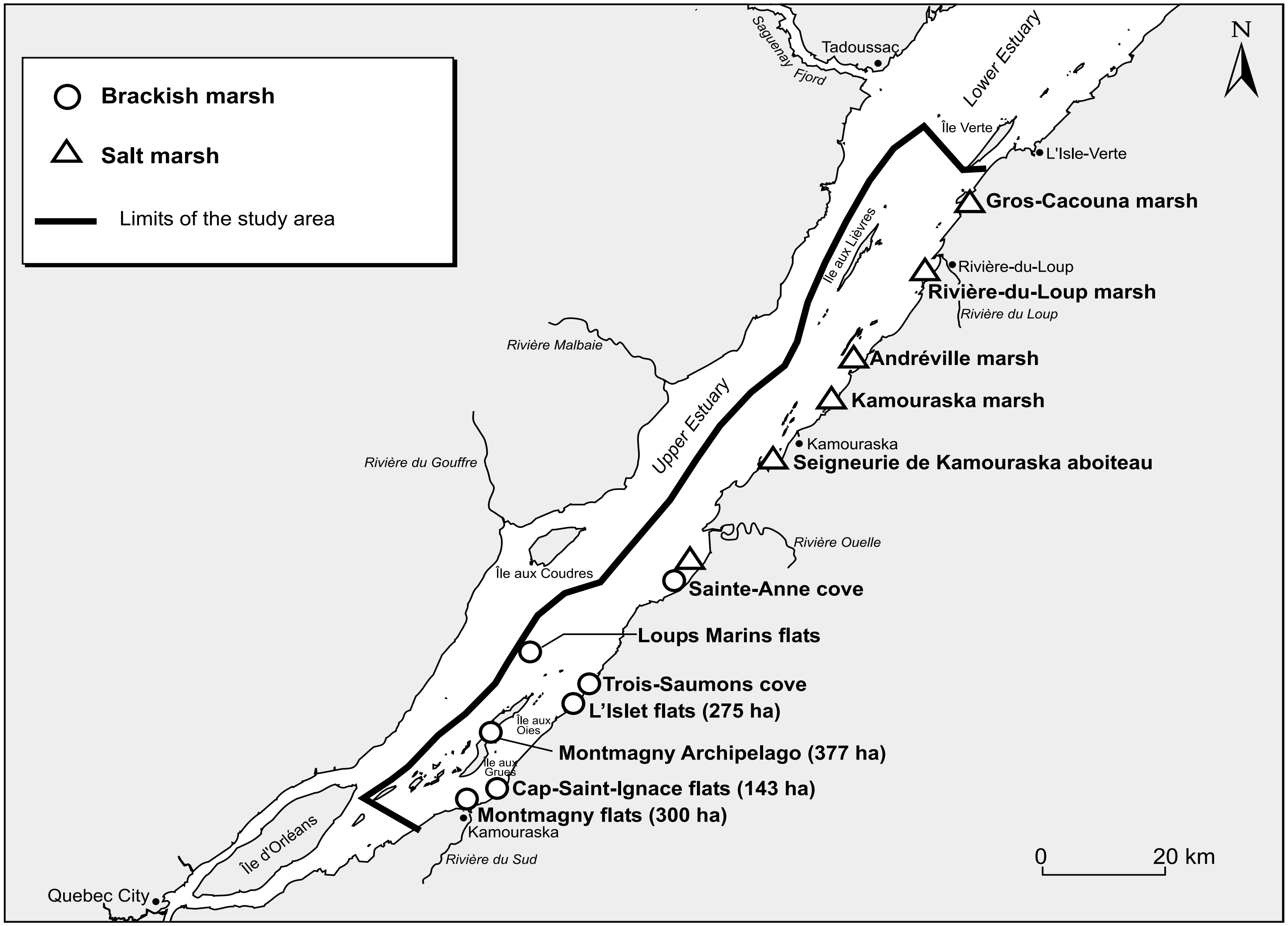
The **polyhaline** zone is that part of the estuary where surface salinity ranges between 18 and 26‰. Littoral flora and fauna in this zone are dominated by marine species tolerant of wide swings in salinity. Here, muddy foreshores are occupied by vast salt marshes, and rocky shores begin to take on the aspect of true sea coasts, with seaweed beds and a much more diversified benthic fauna than further upstream. Productivity in the polyhaline pelagic environment is higher than in the mesohaline zone, benefiting from a constant inflow of plankton from the Lower Estuary, which is even more productive.

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

The main habitats for aquatic fauna in the **supralittoral** level are the small islands and islets distributed along the south shore and along the middle of the estuary. These are heavily used by seabirds for nesting and by seals for giving birth and resting.

The **intertidal** level comprises that part of the shore between the extreme high and low tide marks. This is where brackish marshes develop (oligohaline zone), likewise salt marshes (polyhaline zone) (Figure 4). These two habitat types are characterized by successive bands of vegetation parallel to the shoreline differing in their tolerance of immersion (Figure 5).

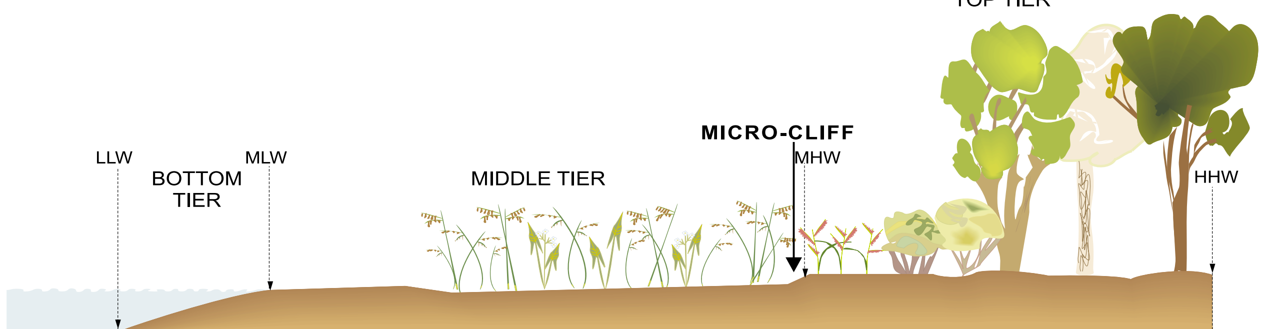
The dominant species in the brackish marshes is American bulrush; in the salt marshes, it is Saltwater cord grass. Plant diversity in these marshes increases inland. On the rocky shores of the polyhaline zone, diversity and abundance of fauna increase down the beach. The dominant plants at this level are brown algae (knotted wrack and bladder wrack), while the fauna is dominated by blue mussels, winkles and sand hoppers, which inhabit pools and fissures in the substrate and shelter under the seaweed.



Source: UQCN, 1993, 1988; Couillard and Grondin, 1986; Dryade; 1980.

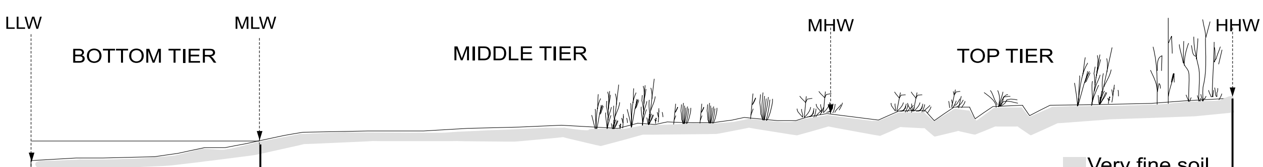
Figure 4 Distribution of main intertidal marshes on the south shore of the Upper Estuary

A. BRACKISH MARSH



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

B. SALT MARSH



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

c. = community.

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

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

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

The **infralittoral** level takes in the seabed between the extreme low water mark and a depth of 40 m. The flora and fauna of this level have been studied only in the polyhaline zone (Cacouna). Because of the variable salinity and the relatively high turbidity, oarweed and sea urchins are much less abundant than in the Lower Estuary, and vegetation disappears almost totally beyond a depth of 3 m. At depths of 0 to 2 m, beds of brown and red algae are found. From 2 to 3 m, seaweed declines sharply in quantity and sea urchins appear. Rocky bottoms more than 3 m deep are dominated by sponges and hydroids. At depths beyond 4 m, rocky substrates are rare. The unconsolidated bottoms in the infralittoral and **circalittoral** (greater than 40 m) levels are dominated by polychaetes and numerous species of molluscs and amphipods. The diversity of this benthic fauna increases with depth because physical and chemical conditions become increasingly stable.

3.3 Fishery Resources

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

The **American shad** passes through the study area to spawn in fresh water in spring and when returning to the Atlantic Ocean in summer. The seaward-bound juveniles from the river hit the estuary in August and head out to sea in October or November. The St. Lawrence population of this species has been in a tenuous position since the late 1950s because of the ever-greater number of obstacles to migration in the river, degradation of their spawning grounds, and heavy commercial and sports fishing pressure both within and outside the study area.

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

The **Rainbow smelt** population of the south shore of the Upper Estuary spawns in spring in a few south shore tributaries and spends the rest of the year in the downstream part of the Upper Estuary and in the Lower Estuary. The larvae develop in the pelagic environment of the oligohaline zone, while the juveniles frequent either the pelagic oligohaline zone or the salt marshes, depending on the time of year. This population has been at risk since the mid-1960s. Its decline is probably due to degradation of spawning grounds, mainly through farming operations. On the south shore, the smelt spawns in the Ouelle and Fouquette rivers and in Ruisseau de l'Église (Fluvial Estuary).

There are two **Atlantic herring** populations that come into the St. Lawrence Estuary to breed in the vicinity of Rivière-du-Loup. The first spawning takes place in June off the western end of Île aux Lièvres, and there is a second one in August and September in the same area. The larvae and juveniles of this population grow in the pelagic waters of the polyhaline zone. The current status of the population is not known, but elsewhere in the Gulf of St. Lawrence the status of Atlantic herring populations has improved markedly since the 1970s, at which time they were being overfished.

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

The Ouelle River is the only designated salmon run (**Atlantic salmon**) in the study area. It was restored after considerable lobbying. From 1984 to 1994, the upstream salmon run in this river fluctuated widely (400 to 1700 individuals), with no clear long-term trend.

3.4 Birds

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

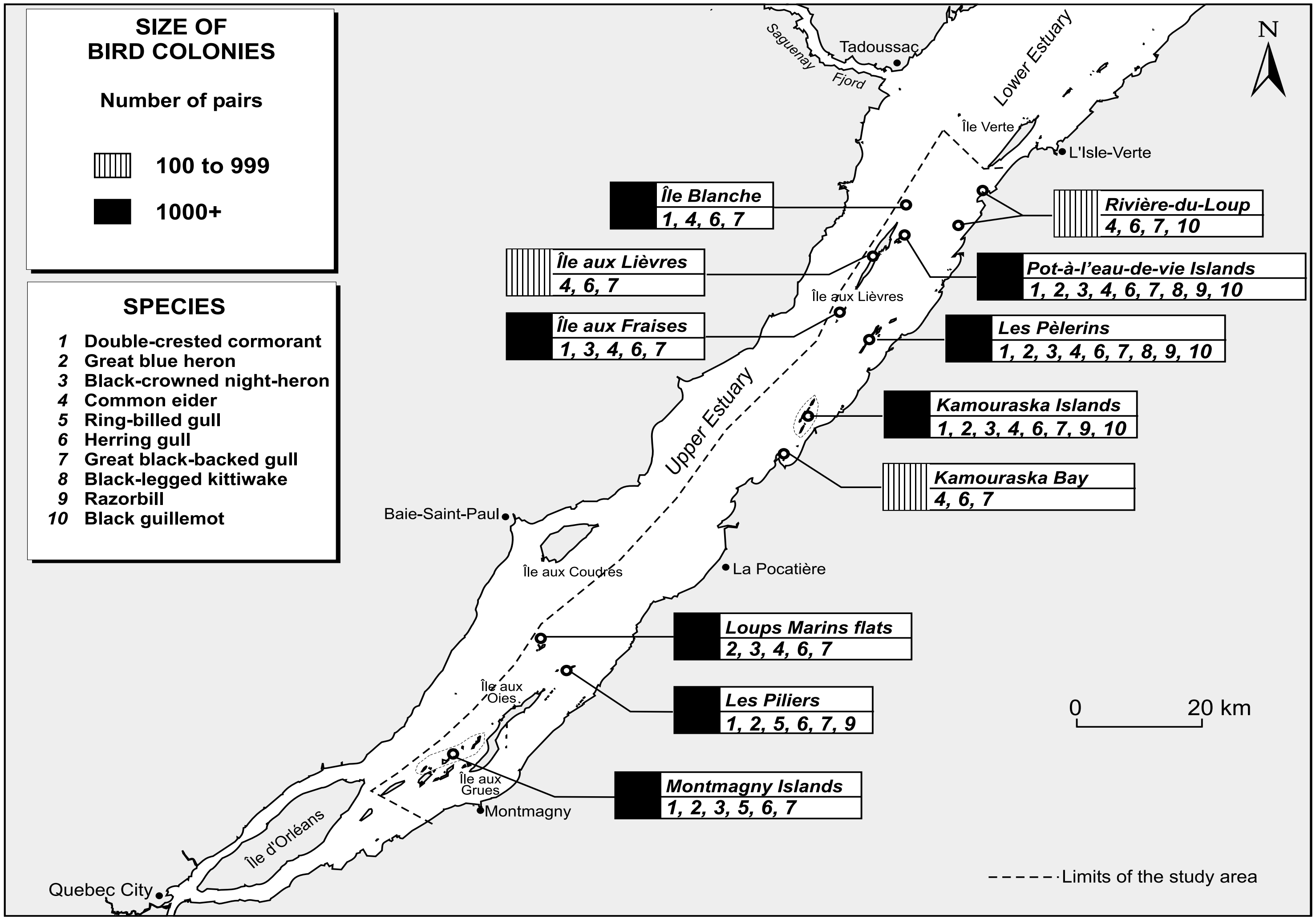
3.4.1 Breeding

Of the 115 bird species that breed along the shores of the St. Lawrence, 57 (confirmed or probable breeders) are found in the Upper Estuary. This number includes ten colonial species, nine species of dabbling ducks, five of diving ducks, one sea duck, four shorebird species (plovers, waders, snipe, sandpipers and phalaropes) and three rare marshland species (Yellow rail, Long-billed marsh wren and Sharp-tailed sparrow).

More than 120 bird colonies have been reported in the study area (Figure 6). This number includes concentrations of Common eider nests (sea duck), seabird colonies (Double-crested cormorant, Ring-billed gull, Herring gull, Great black-backed gull, Black guillemot, Black-legged kittiwake and Razorbill) and colonies of two inland species (Great blue heron and Black-crowned night heron). Together, these colonies have a total population of over 25 000 breeding pairs. The most abundant colonial species in the study area are the Common eider, Ring-billed gull, Herring gull and Double-crested cormorant The largest colony is that of the Ring-billed gull on Îlet du Pilier de Fer off L'Islet-sur-Mer (6799 pairs).

Numbers of the Ring-billed gull, Great black-backed gull, Kittiwake, Razorbill and Great blue heron have risen since the 1970s, while those of the Herring gull, Black guillemot and Black-crowned night heron have been falling. Double-crested cormorant numbers fell sharply between 1988 and 1993 because the population was being culled (see Section 4.3).

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



Source: Adapted from Bédard and Nadeau, 1994; BIOMQ, 1977; DesGranges, 1997; Desrosiers, 1997.

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

3.4.2 Spring migration

Hundreds of thousands of geese and ducks flock to the study area during the spring migration between their southern wintering range and their Arctic and northern Quebec breeding grounds. The vast majority of these anatids are snow geese, which gather chiefly on the shores of Île aux Grues and Île aux Oies and in the Kamouraska area (Figure 7). The Canada goose and Brant are much less abundant, the former gathering around Saint-Jean-Port-Joli and on Île aux Ruaux, and the latter frequenting mainly the eelgrass beds in the downstream part of the sector and the shores of Île aux Fraises and Île Blanche. Many thousands of dabbling ducks (teal, Black duck and Pintail) converge mainly on the Montmagny and Kamouraska areas, while sea ducks (eiders and scoters) and the less numerous diving ducks (goldeneye and mergansers) are found chiefly around Île aux Fraises, Île aux Lièvres and Île Blanche.

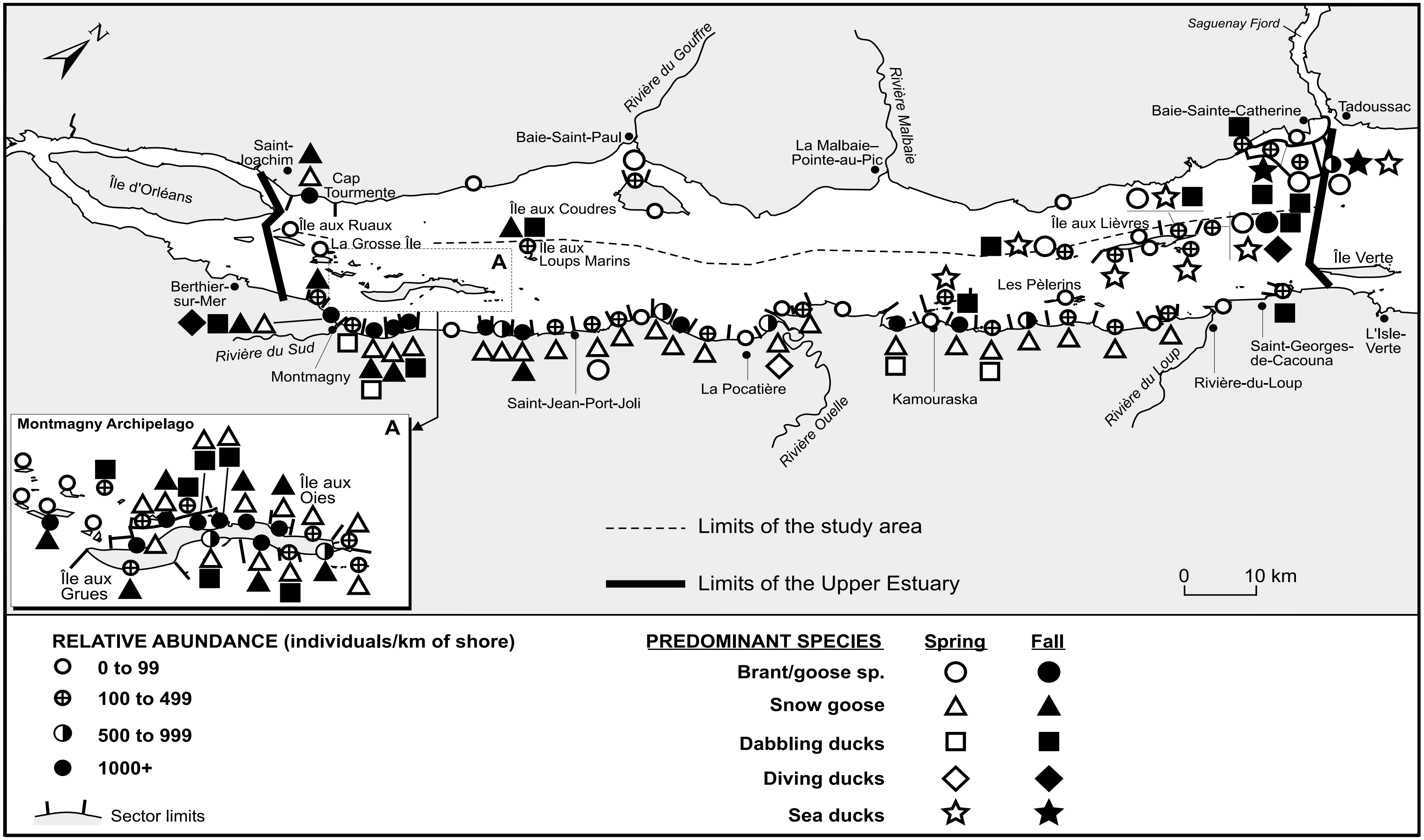
3.4.3 Summering

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

The salt marshes are used in summer by dabbling ducks (chiefly Black duck) and the Common eider. Isolated individual ducks and broods make use of the cord-grass marshes. Herons and Night herons make intensive use of the ice-extraction pans of the cord-grass marshes.

3.4.4 Fall migration

In the fall, snow geese returning from the Arctic gather at Cap Tourmente on the north shore of the estuary. In 1997, the population was estimated at nearly 660 000 individuals. On the south shore, they are much less abundant than in spring. They are found mainly in the Montmagny sanctuary and on Île aux Grues and Île aux Oies, where they feed on bulrush rhizomes (Figure 7).



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

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

There are few Canada geese or Brant in fall, the latter occurring mainly on Île Blanche at this time of year. By contrast, dabbling ducks (Black duck and teal) are much more abundant than in spring (running into tens of thousands). The Montmagny sanctuary, the Montmagny and Kamouraska islands, Île aux Lièvres and Île Blanche are the busiest sites. Many tens of thousands of shorebirds (plovers and sandpipers) start arriving from the north in July. Their main staging areas are in the upstream reaches of the sector: Montmagny Bay, Île aux Ruaux and the Loup Marin flats. The Semipalmated sandpiper is the commonest species (about 85% of the total) and feeds chiefly on the intertidal mudflats, whereas the plovers and other waders frequent both rocky and muddy shores.

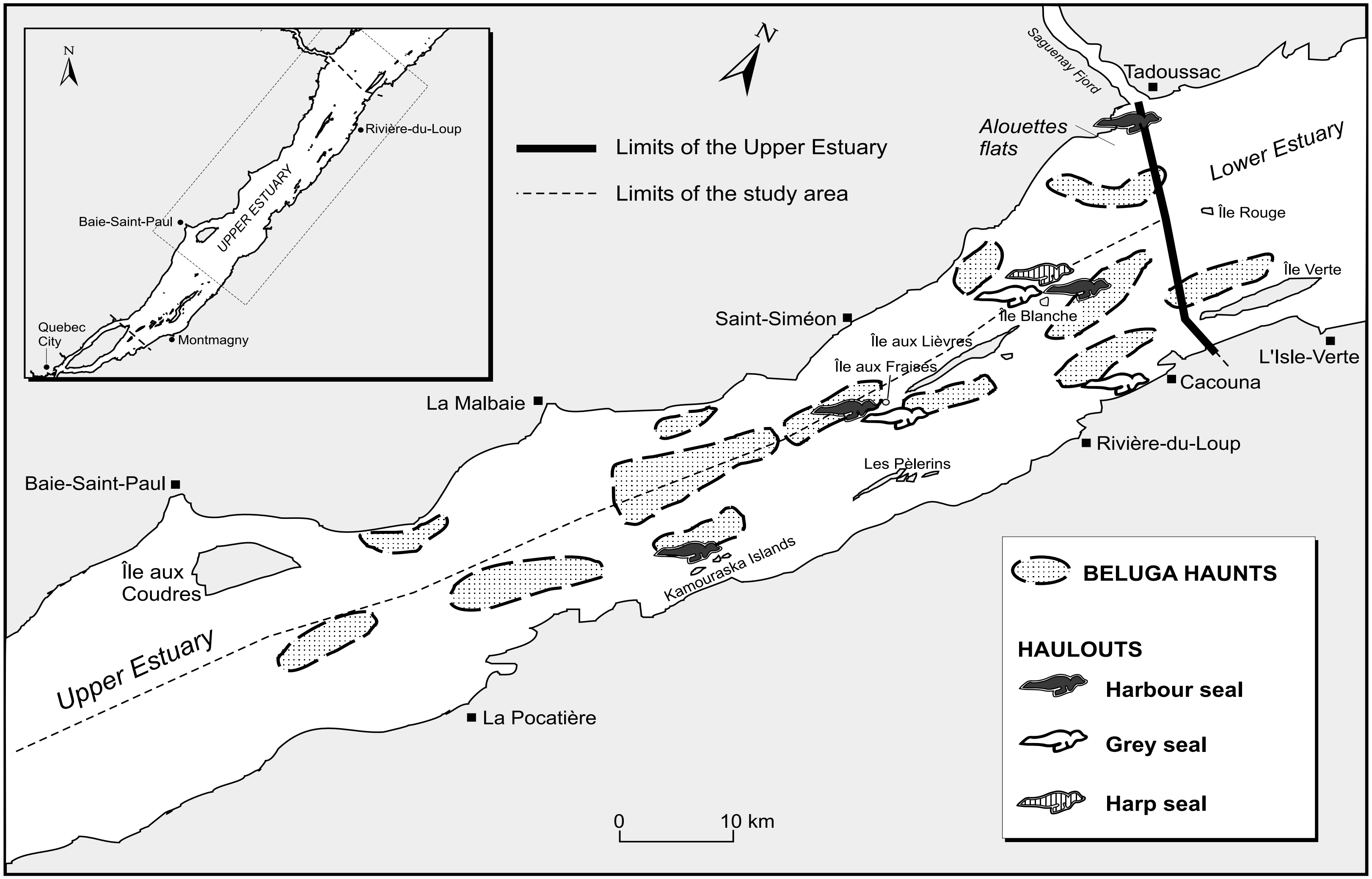
3.4.5 Wintering

The sector is not a major wintering ground for birds because so little of it is ice-free. Black guillemots are found around Île aux Fraises and Île Blanche.

3.5 Marine Mammals

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

Beluga. The St. Lawrence Estuary is home to a resident Beluga whale population, the southernmost in the world. Belugas frequent the downstream section of the Upper Estuary (below Île aux Coudres) in spring, summer and fall. In summer, over half the population is found in this area. There are seven areas along the north shore that are intensively used by pods of adults and young (Figure 8). It is not known what Belugas eat. The most likely prey species available in the study area are the Atlantic herring, Rainbow smelt, American eel and capelin.



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

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

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

Minke whale. In the estuary, the Minke whale is often seen from early spring until late fall. It typically ventures no further upstream than around Cacouna. Unfortunately, there are no reliable estimates of the size or state of the population in the estuary.

Harbour seal. The Harbour seal is a permanent resident of the St. Lawrence Estuary. The pups are born in May and June. The main haulouts in the study area are in the lower part of the Upper Estuary on Île aux Fraises and Île Blanche and at Kamouraska (Figure 8). In the course of an aerial survey conducted in 1994, about 60 specimens were counted in the Upper Estuary. However, neither the total estuary population nor its variations over time are known. Though the Harbour seal has not been hunted since 1977, numbers appear to have fallen substantially since the early 1970s.

Grey seal. Part of the Eastern Canadian Grey seal population comes into the Upper Estuary from June until November. In August 1994, 59 seals of this species showed up in an aerial survey of the study area. The main haulouts are on Île aux Fraises, Île Blanche and Percé Rock and off Cacouna (Figure 8). The Eastern Canadian population has been growing since the early 1960s. Capelin is the species' main prey.

Harp seal. Part of the Eastern Canadian Harp seal population uses the Lower Estuary from late fall to early spring. In the summers of 1991 and 1992, a few individuals were spotted near Île Blanche (Figure 8).

3.6 Species at Risk

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

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

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

Of the eight priority bird species in the Upper Estuary, four breed in the study area; they are the Pintail, Blue-winged teal, Peregrine falcon and Yellow rail. North American populations of Pintail and Blue-winged teal have been falling for the past thirty years. The reasons for the Pintail's decline are unknown, but in the case of the Blue-winged teal, it is likely due to loss of breeding habitat and excessive hunting pressure in Mexico in winter. The Peregrine falcon bred successfully at Saint-Germain from 1991 to 1994. Between 1976 and 1992, 32 young falcons were released at La Pocatière and Kamouraska in the hope of re-establishing the population. Falcon populations in southern Quebec are well on the way to recovery. The only known recent Quebec breeding sites (1984–1998) of the Yellow rail are on Île aux Grues, with four nests in 1994 and two in 1995, though the species has also been spotted around Cacouna in the breeding season. This species has been deprived of much of its breeding habitat by the draining of the upper intertidal marshes for farming. Lastly, the Sharp-tailed sparrow, listed as a species likely to be designated as threatened or vulnerable, probably breeds in the study area.

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

3.7 The Human Imprint

3.7.1 Shoreline land use

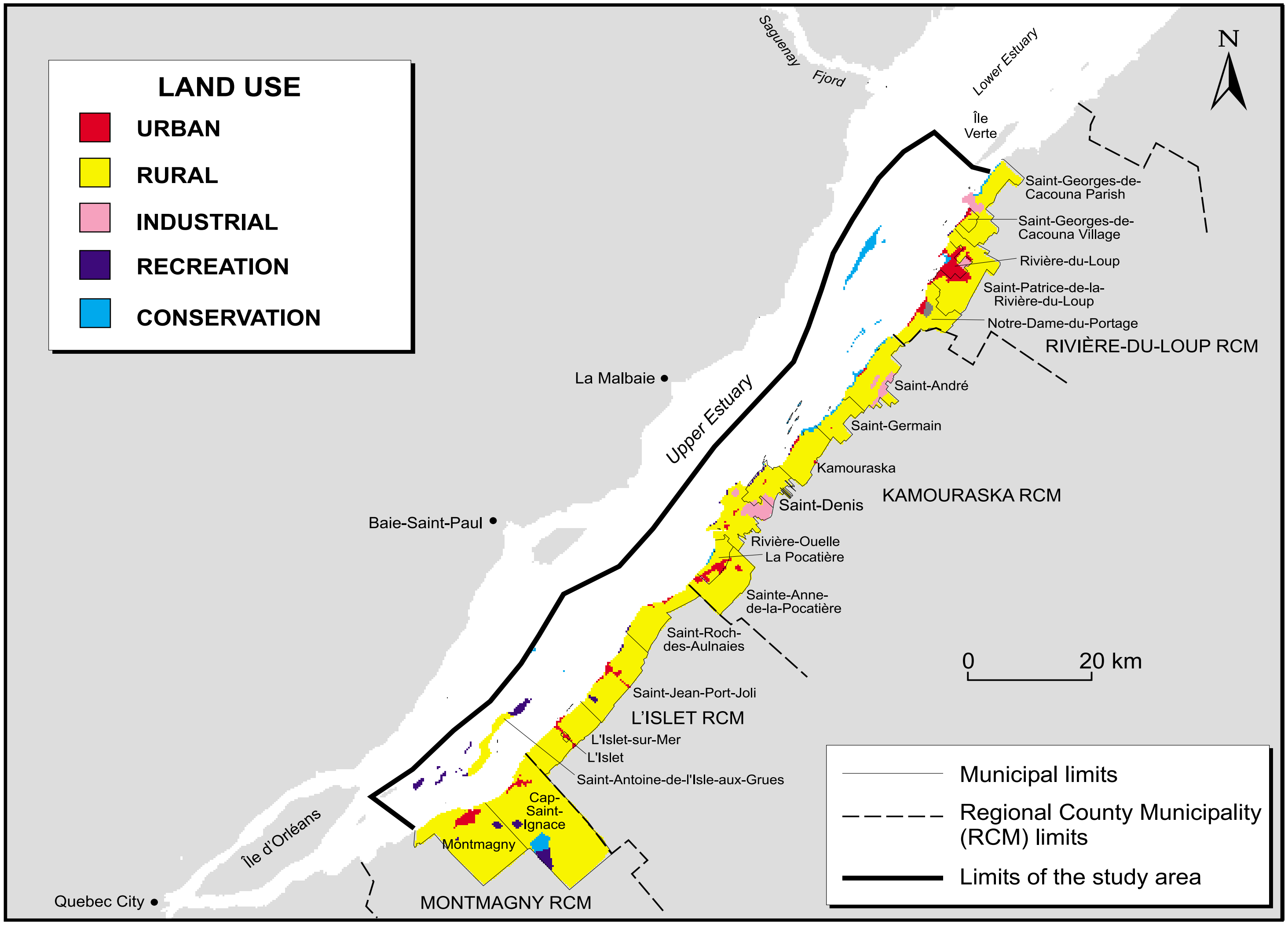
The 19 coastal municipalities on the south shore of the Upper Estuary have a combined area of 1040 km^2 and had 53 178 inhabitants in 1996 (Figure 9). They form part of the RCMs of Montmagny, L'Islet, Kamouraska and Rivière-du-Loup. The chief urban and industrial centres are Montmagny (11 885 ha), La Pocatière (4887 ha) and Rivière-du-Loup (14 721 ha).

Most of the land bordering the St. Lawrence is zoned rural, which includes both agricultural and cottaging use and accounts for 40% of the shoreline. The rest is largely zoned for conservation (36% of the shoreline, including the coastal and island habitats of Kamouraska RCM), urban development (both residential and commercial) (12%) and recreation (11%). Only 1% of the shoreline is zoned industrial.

3.7.2 Protected lands

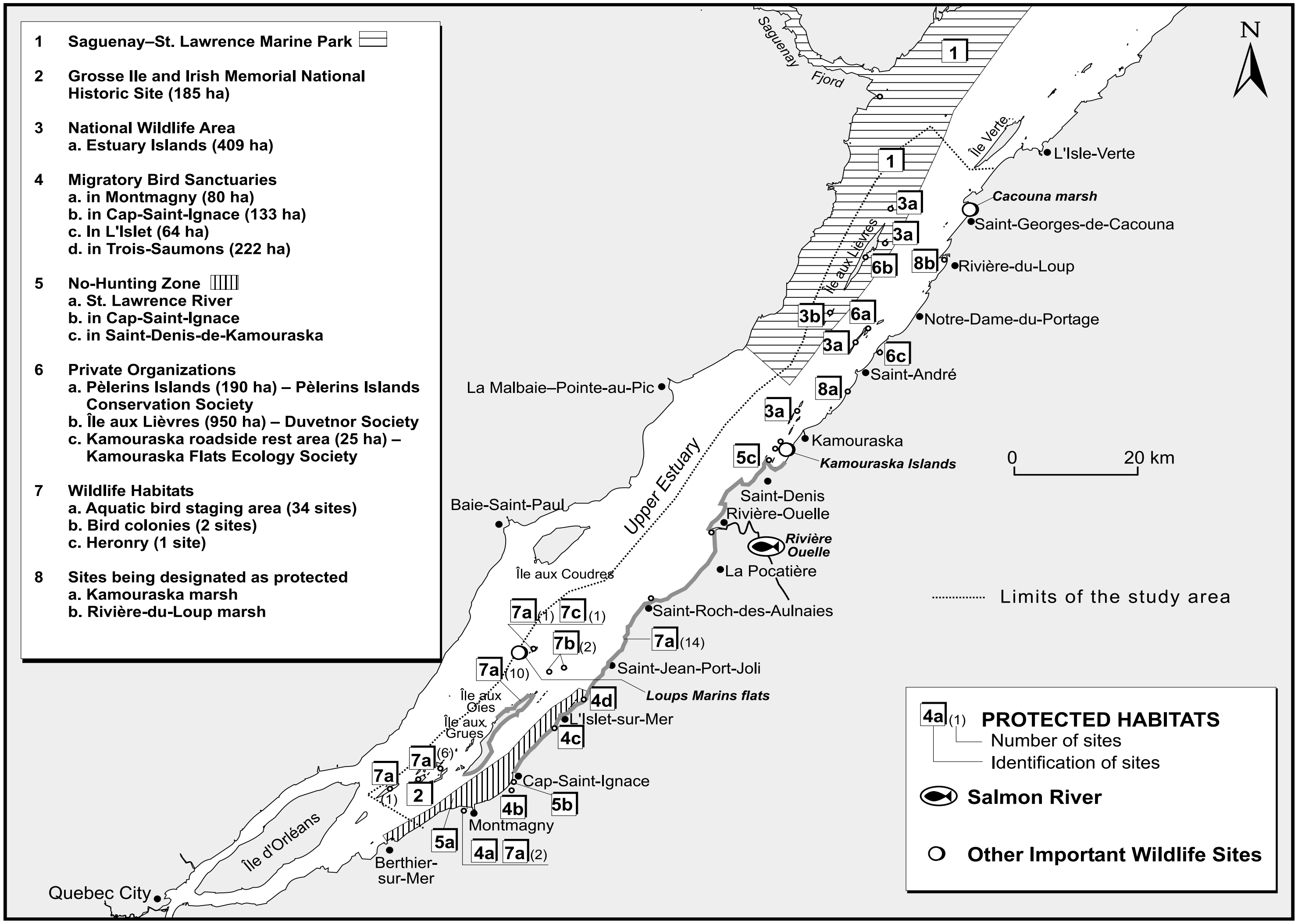
Land in the study area that is protected by provincial and federal legislation includes part of the Saguenay–St. Lawrence Marine Park, a National Historic Site, a National Wildlife Area, four migratory bird sanctuaries, three no-hunting zones, 37 wildlife habitats and one salmon river (Figure 10).

The **Saguenay–St. Lawrence Marine Park,** officially created in 1997, takes in part of the Saguenay Fjord and parts of the Upper and Lower Estuary of the St. Lawrence. Within the study area, it encompasses the waters around Île aux Fraises, Île aux Lièvres and Île Blanche, which are heavily used by seabirds, Belugas and seals. The park, which covers the pelagic and benthic environments up to the high water mark and excludes islands, is jointly managed by the provincial and federal governments.



Source: Kamouraska RCM, 1987; L'Islet RCM, 1987; Montmagny RCM, 1986; Rivière-du-Loup RCM, 1987.

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



Source: Mousseau et al., 1998.

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

The **Grosse Île and Irish Memorial National Historic Site** was established in 1988 to commemorate immigration to Canada and Grosse Île's history as an immigrant quarantine station. Parks Canada's principal mandate is to preserve the heritage resources of historic sites and national parks, and much effort is devoted to conserving and protecting the island's natural resources. A number of studies, mostly botanical, have been done. Grosse Île has an area of over 185 ha and is home to 600 species of vascular plants, including 21 rare, threatened or vulnerable ones. Most of these are found along the island's shores, so that Parks Canada has designated the shore as a special conservation zone, where few activities will be allowed. Another conservation priority is the island's recently discovered colonies of bats.

The **Estuary Islands National Wildlife Area** (409 ha) was created in 1986 by the Canadian Wildlife Service, chiefly to protect Common eider breeding habitat. This reserve encompasses five islands and islets in the Kamouraska archipelago, part of Le Long Pèlerin, Île aux Fraises and its reefs, Île le Pot du Phare, Île Blanche and other islands and islets along the south shore of the Lower Estuary. These islands are home to a number of seabird colonies and seal haulouts. Waterfowl hunting is banned.

In the Montmagny (80 ha), Cap-Saint-Ignace (133 ha), L'Islet (64 ha) and Trois-Saumons (222 ha) **migratory bird sanctuaries**, hunting and other forms of disturbance are banned to protect waterfowl.

The St. Lawrence River, Cap-Saint-Ignace and Saint-Denis-de-Kamouraska **no-hunting zones** (known by their French acronym, *ZIC*) were created to provide waterfowl with staging areas where they could rest in safety during the hunting season.

The 37 **wildlife habitats** in the study area protect 34 aquatic bird staging areas, two colonies and a heronry located on public land. Their status precludes any activity likely to alter any physical, chemical or biological component of the environment.

The Ouelle River also enjoys a form of protection not extended to other watercourses by virtue of its status as a **salmon river**.

The protection of private land is in the hands of non-governmental agencies. Île aux Lièvres and its flats, Île le Petit Pot and Île le Gros Pot (total area: 950 ha) are administered by Duvetnor Inc. and the Pèlerins islands by the Pèlerins Islands Conservation Society. The Kamouraska Flats Ecology Society operates the Kamouraska roadside rest area, and the Wildlife Foundation owns 32 ha of shoreline habitat on the Kamouraska flats. Other stretches of shoreline without legally protected status are recognized for their ecological importance by the RCMs (Figure 9). Zoning in these areas generally limits use and access.

3.8 Resource-based Activities

3.8.1 Hydro-electric production and water supply

Only one of the tributaries in the study area has been dammed for power generation, the Rivière du Sud, where a small-scale generating plant (1.8 to 2.4 megawatts) was built in 1995 and hooked up to the Hydro-Quebec grid.

There are no local municipalities, large-scale industries or farms taking water directly from the Upper Estuary. Water supplies come from watercourses, lakes or the water table. The main users are the municipalities of Rivière-du-Loup (11 000 m^3 per day) and Montmagny (6800 m^3 per day), and the F.F. Soucy Inc. (18 450 m^3 per day) and Mohawk Ltd. (5720 m^3 per day) paper mills, both located near Rivière-du-Loup.

3.8.2 Commercial shipping and port operations

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

The sector’s main ports are at Cacouna, Rivière-du-Loup, Île aux Grues and Montmagny. The port of Gros-Cacouna, administered by Transport Canada, handled 335 000 tonnes of cargo in 1996, most of it lumber and paper. There is little transshipment of petroleum products in the study area’s ports. The ports at Montmagny, Île aux Grues and Rivière-du-Loup serve mainly as docks for passenger and vehicle ferries. In 1992, 41 482 passengers took the Montmagny–Île aux Grues ferry, and 181 315 passengers sailed with the ferry linking Rivière-du-Loup with Saint-Siméon on the north shore of the estuary.

3.8.3 Exploitation of biological resources

Commercial fishing. Commercial fishing is much less important in the study area than in the Lower Estuary and Gulf of St. Lawrence. In 1995, the total value of landings in the study area was only $950,000. There are 58 commercial fishermen, and there are two processing plants, both in Montmagny. Only two species are fished: Atlantic sturgeon and American eel. Other species landed (tomcod, smelt, shad, Lake sturgeon and Sauger) are taken largely as bycatch. The sturgeon fishery is centred between Montmagny and Saint-Roch-des-Aulnaies and is active during the summer, using gill nets set in deep water. The eel fishery is based in and around Kamouraska, taking place in the fall using fixed intertidal gear. Both these species are at risk, to the point that restrictions have recently been imposed on the sturgeon fishery (minimum size and total catch limit).

Sport fishing. Rainbow smelt and Atlantic salmon are the main trophy species for sport fishers in the study area. The Striped bass was a much sought-after species until the estuary population crashed in the 1950s. In summer, smelt are fished from the docks. In 1991, sports catches of smelt along the south shore of the Upper Estuary were estimated at 6.6 tonnes, a mere fifth or sixth of catches prior to the 1960s.

In 1996, 926 fishing days on the sector’s only salmon river (Ouelle River) yielded total catches of 290 salmon (success rate of 0.31 salmon per fishing day), representing a very good year by comparison with the annual average of 134 salmon over the period from 1989 to 1995 (success rate only 0.11).

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

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

Waterfowl hunting. The stretch of the St. Lawrence between Quebec City and Saint-Roch-des-Aulnaies is the main waterfowl hunting area along the river. From 1977 to 1981, an annual average of 65 000 ducks and geese were taken, 20% of the St. Lawrence harvest. Nearly half of these were snow geese. Hunting is less intense further downstream in the study area, but is still significant, with an average annual cull of 20 000 ducks and geese between 1977 and 1981. Here, dabbling ducks (especially Black duck and Green-winged teal) are the main quarry. Hunting is less intense on the south side of the estuary than on the north.

3.8.4 Non-exploitative recreation and tourism

Beach access. Access to the shore is plentiful on the south shore. Highway 132 actually hugs the shore for considerable distances. There are about ten public wharfs in the sector, waterfront parks in the municipalities of Saint-André, Notre-Dame-du-Portage and Rivière-du-Loup, and lookouts at La Pocatière, Saint-André and Rivière-du-Loup (Figure 11).

Accommodations and cottages. In 1995–96, there were 73 private lodging establishments with a total guest capacity of 1722 rooms, 65% of which are located in the three main urban centres (Montmagny, La Pocatière and Rivière-du-Loup), and 11 campgrounds with a total of 1473 places. Most of these facilities are on the shore. There are also 1748 cottages (second homes), nearly one-third of them in and around Montmagny.

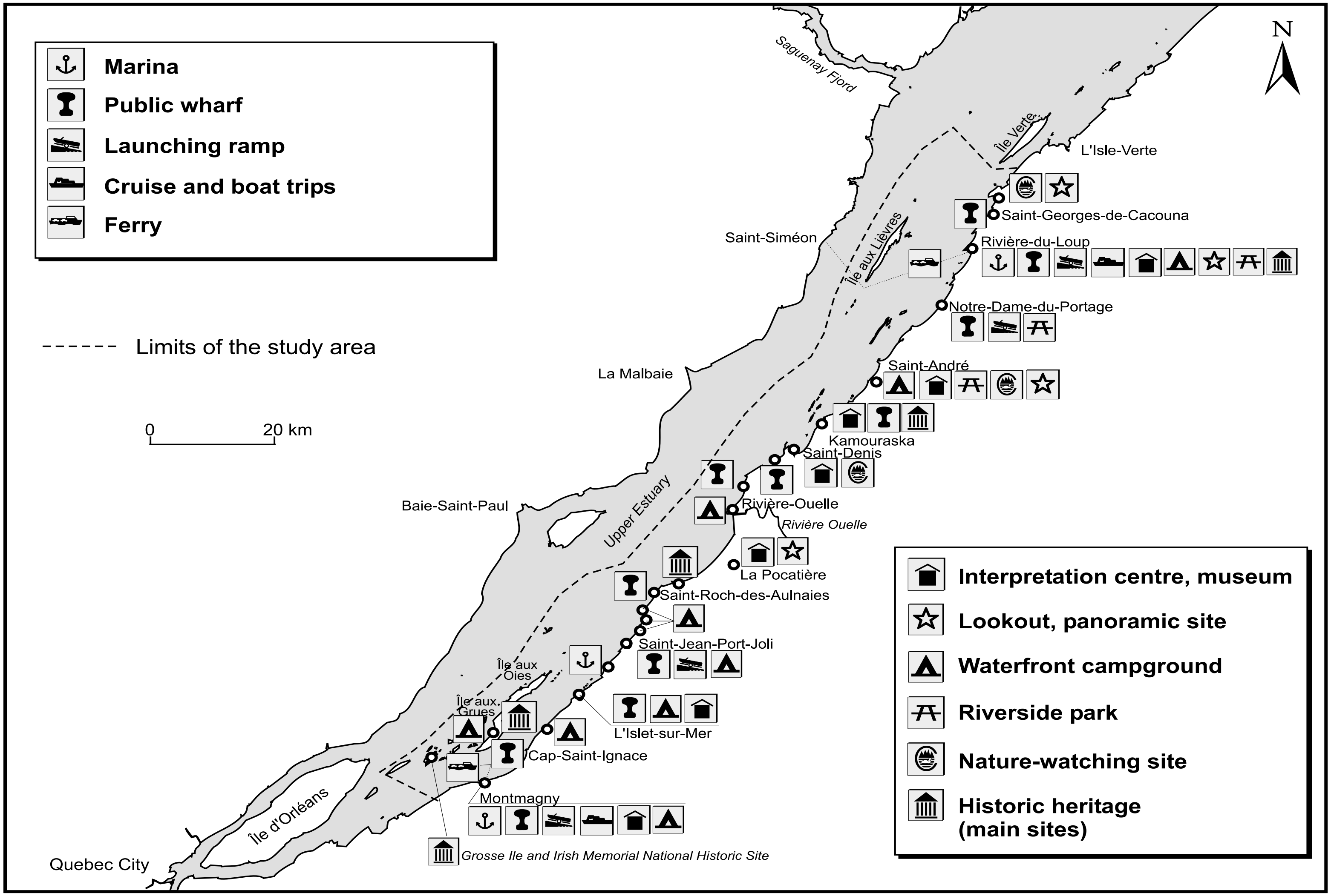
Swimming. There are no public beaches registered with the *Environnement-Plage* program in the study area. The beach at the Kamouraska dock and the municipal beach in Notre-

Dame-du-Portage were withdrawn from the program in the late 1980s. Other beaches in the sector, like those at Rivière-Ouelle, Saint-Denis, Rivière-du-Loup and Cacouna, were never in the program, and there is no information on how much they are used. A 1995 study estimated that 3–12% of the shoreline population swam or indulged in other water-contact pursuits (water skiing, windsurfing, sea-dooing, etc.).

Sailing. There are three marinas or sailing clubs in the sector with a total of 110 berths (Montmagny, Trois-Saumons and Rivière-du-Loup). There are also four launching ramps (Figure 11).

Access to the water and islands. Access to the water and islands is provided by two ferry services (Montmagny–Île aux Grues and Rivière-du-Loup–Saint-Siméon), shuttle services between Montmagny and Grosse Île, and cruises, some including the option of staying over on certain islands. The Pot à l’Eau-de-Vie islands, Île aux Lièvres, the Pèlerins and the Montmagny islands are served by three private companies, and there is a company running whale-watching cruises in the Lower Estuary which operates out of Rivière-du-Loup.

Marine and maritime heritage interpretation. The main centres for the interpretation of nature are at Montmagny (migration study centre), Saint-André (Kamouraska Flats Ecological Site), Kamouraska (Kamouraska Seigneurie Aboiteau and Eel Interpretation Centre), and Cacouna (Gros-Cacouna Marsh Birdwatching Site). Other good spots for birdwatching are the Rivière-Ouelle dock and the flats in Montmagny, La Pocatière and Kamouraska. The main centres for the interpretation of historical and seafaring heritage are the Grosse Île and Irish Memorial National Historic Site, the Bernier Maritime Museum (L’Islet-sur-Mer) and the François Pilote Museum (La Pocatière). In addition, there are a score of recognized or designated historic monuments and two historic sites: the Isle-aux-Grues Seigneurie and Domaine Fraser in Rivière-du-Loup.



Source: ATR du Bas-Saint-Laurent, 1996; ATR de Chaudière-Appalaches, 1996; Quebec Yachting, 1995.

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

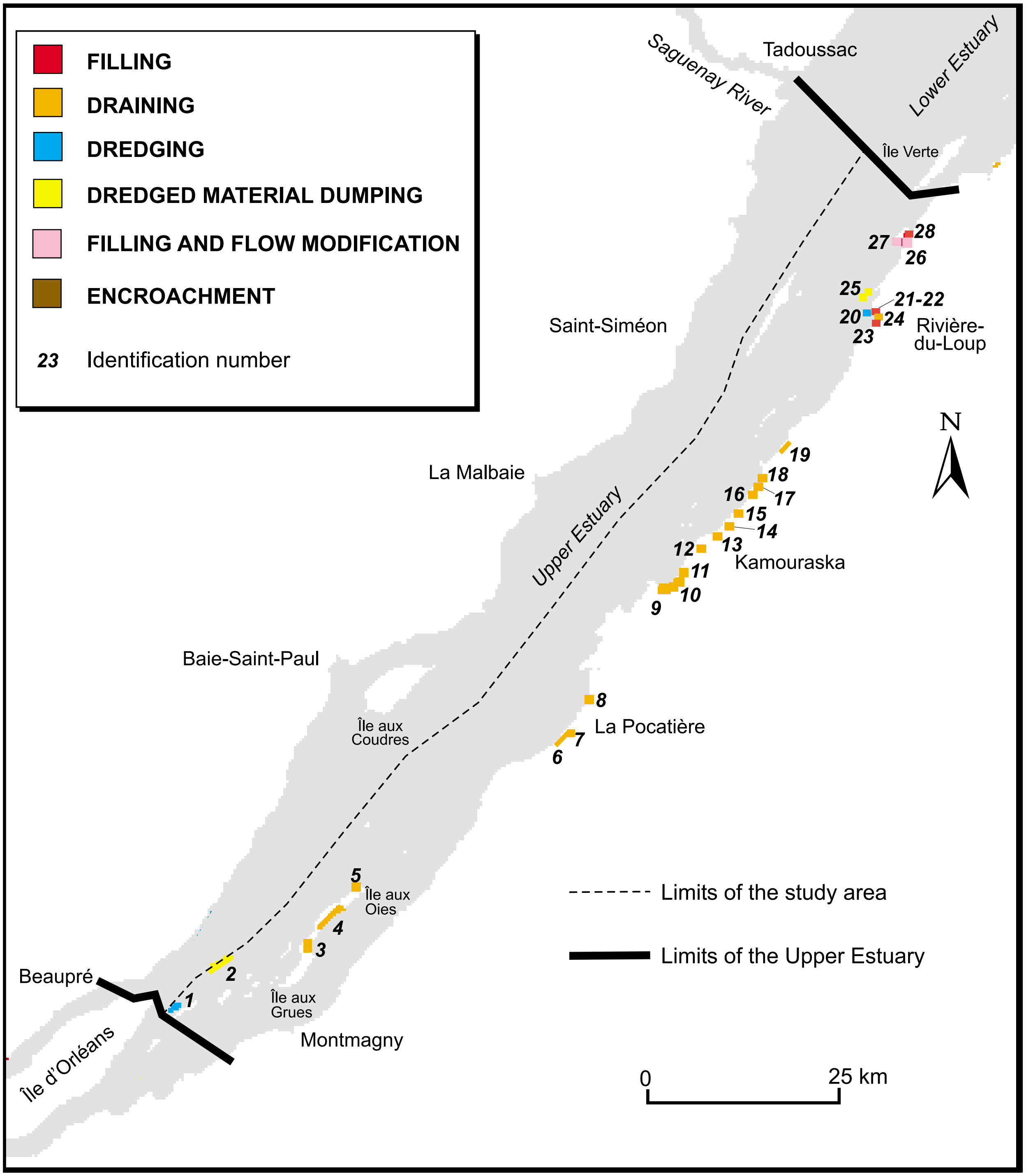
CHAPTER 4 Human Activities and Their Main Effects on the Environment

4.1 Physical Modification of the Environment

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

Shoreline encroachment. Between 1945 and 1984, 615 ha of the study area was affected by the construction of coastal infrastructure (Figure 12). The habitat type most seriously affected is the upper reaches of the brackish and salt marshlands (wet prairie, swamp, salt meadows), of which a total of 442 ha has been filled or drained for farming. These figures, however, do not take account of losses prior to 1945. In the Kamouraska area, for instance, 540 ha of salt marsh was diked for farming between 1930 and 1986. Similar large-scale diking took place in the marshes around La Pocatière (283 ha) and on Île aux Grues and Île aux Oies (225 ha). The building of the port in Gros-Cacouna cost 108 ha of salt marsh between 1965 and 1979.

Dredging. Maintenance dredging is done yearly in Rivière-du-Loup harbour (annual average of 34 000 m^3 of sediment dredged between 1985 and 1996) and at the Île aux Grues dock (5200 m^3). The Grosse Île dock and Gros-Cacouna harbour are dredged as needed. When the latter was built, 760 000 m^3 of sediment was dredged, and some of the spoil was dumped in the adjacent intertidal marshes.



ORIGINAL HABITATS. **Marsh and wet meadow**: sites 3–19, 23, 24, 28. **Mudflats**: sites 21, 26. **Deepwater:** sites 1, 2, 20, 22, 25 and 27.

Source: Robitaille et al., 1988.

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

4.2 Pollution

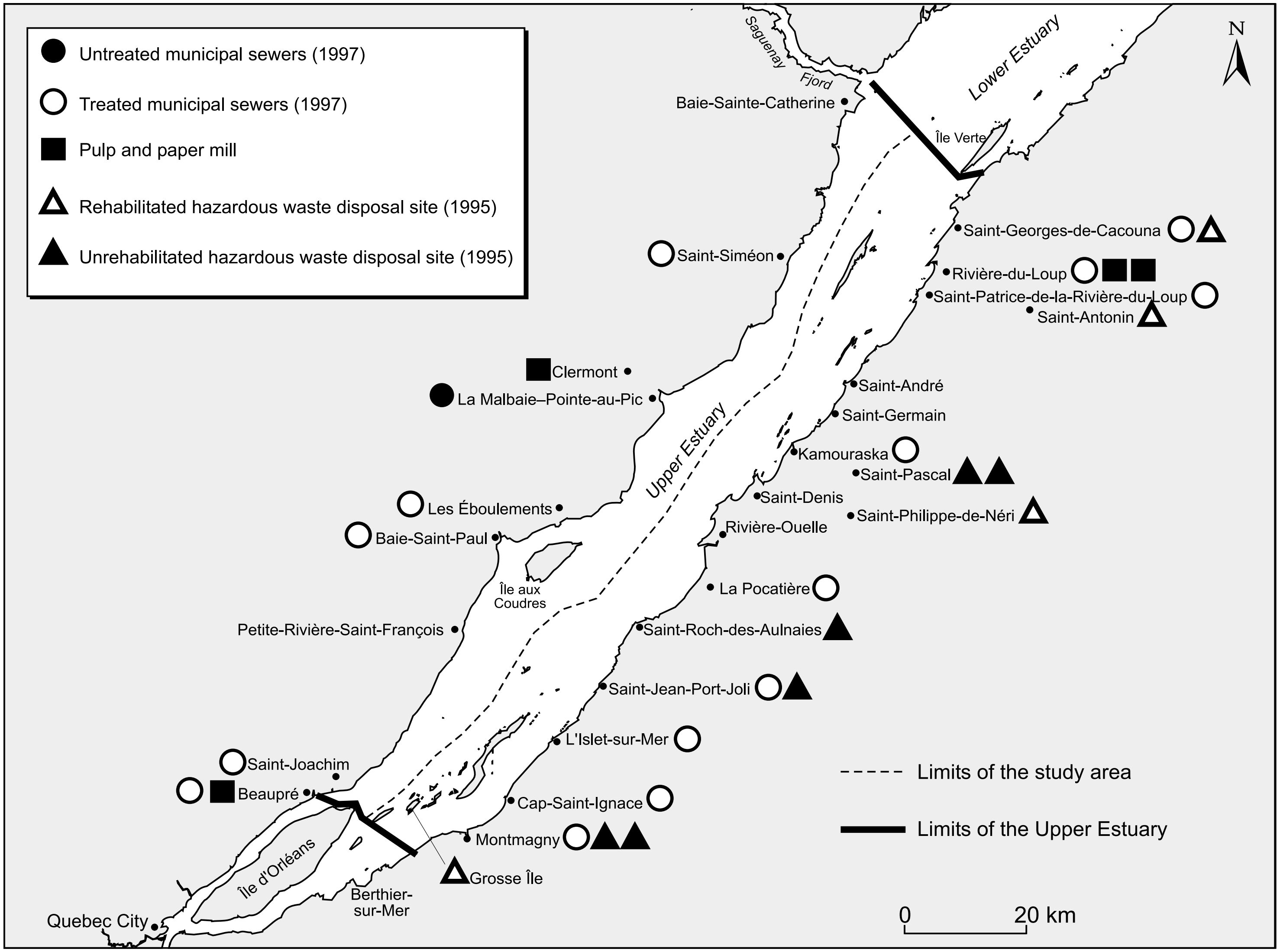
4.2.1 Main sources of contamination

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

On this basis, sources of contamination can be grouped into two major categories. There are **remote sources**, delivering persistent toxic substances to the study area in the waters of the St. Lawrence River, in the deep waters flowing into the Upper Estuary from the Lower Estuary, and through atmospheric deposition. The second category comprises **local sources** situated on the shores of the estuary or on the water itself (shipping), releasing both persistent and non-persistent contaminants (Figure 13).

4.2.1.1 *Remote sources*

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



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

Figure 13 Main local sources of pollution in the Upper Estuary

Atmospheric deposition and seawater. There is little industry, agriculture or urban development on the shores of the Gulf of St. Lawrence and the northwest Atlantic Ocean. Atmospheric fallout over Eastern Canada and the adjacent ocean is the leading source of contaminants carried into the Upper Estuary from the Gulf in the deep waters, though the load is not known. This fallout may be quite a significant source of such toxic substances dumped into the atmosphere as mercury, lead, PCBs, PAHs, dioxins and furans. The Saguenay Fjord is heavily polluted with mercury and probably adds to the load of this heavy metal in the Upper Estuary.

4.2.1.2 *Local sources*

Municipal wastewater. By the end of 1997, 11 of the 19 shoreline municipalities in the study area were putting some or all of their wastewater through one of eight treatment plants (Figure 13), serving close to 70% of these communities' population. Seven of these plants were inaugurated after 1991 and use aerated ponds. The plant in Cacouna was opened in 1986, independently of PAEQ (Quebec water cleanup program), and uses the activated sludge process.

The four plants which were operating in the study area in 1995 (Montmagny, Cap-Saint-Ignace, Saint-Jean-Port-Joli and La Pocatière) met wastewater standards. Aerated ponds reduce readily degradable organic matter and suspended particles by 85–90%.

The other eight shoreline municipalities (Saint-Antoine-de-l'Isle-aux-Grues, Saint-Roch-des-Aulnaies, Sainte-Anne-de-la-Pocatière, Rivière-Ouelle, Saint-Denis, Saint-Germain, Saint-André and Notre-Dame-du-Portage) do not have sewer systems. Most household wastewater goes through individual septic facilities, though in a few cases it is dumped directly into the estuary or a tributary.

Industrial effluents. There are two SLV 2000 priority pulp and paper plants dumping their wastewater into a tributary in the study area – F.F Soucy Inc. in Rivière-du-Loup and Mohawk Ltd. in Saint-Antonin.

The **F.F. Soucy** plant makes newsprint from logs and wood chips by a thermo-mechanical process and bleaches the pulp with sodium hydrosulfite and occasionally with hydrogen peroxide. In 1995, the plant was operating at 85% of its production capacity of 253 000 tonnes per year.

Process wastewater is dumped into the Du Loup River about 6.5 km from its mouth, and domestic wastewater is fed into the Rivière-du-Loup municipal sewer system. Until 1991, process water was given primary treatment only prior to dumping. Between 1991 and 1994, measures were implemented to reduce and recirculate wastewater, and in 1994–95 a secondary activated-sludge treatment system was inaugurated, as were a dryer and settling tank to reclaim sludge.

From 1988 to 1995, readily degradable organic matter in effluent was reduced by 95% and suspended matter by 77%. Effluent toxicity was reduced by 99%. In 1995, the effluent contained none of the 11 persistent and bioaccumulating toxic substances targeted for virtual elimination under SLV 2000 (PCBs, DDT, dieldrin, toxaphene, dioxins, furans, mirex, mercury, lead, benzo(a)pyrene and hexachlorobenzene). Bioassays of the plant's effluents revealed that is it is no longer toxic to aquatic life.

The **Mohawk** plant makes mechanical pulp by defibration of softwood logs. The pulp is condensed and compressed into blocks. In 1995, the plant was operating at 15% of its capacity of 50 000 tonnes per year.

Process wastewater is dumped into the Du Loup River some 20 km above its mouth, until 1995 without treatment. In that year, the plant installed filters and began recirculating part of the wastewater, reducing the volume of effluent dumped by 64%, readily degradable organic matter by 76% and suspended matter by 87%. Also in 1995, a domestic wastewater treatment system was installed. In 1994, effluent contained none of the 11 persistent bioaccumulating substances targeted for virtual elimination under SLV 2000 listed above. Bioassays of the plant's effluent revealed that it is only mildly toxic to aquatic life. The company is planning on installing a secondary treatment system to meet federal and provincial regulatory requirements for pulp and paper plants.

There are four other major industrial operations in the study area (Inglis, Consoltex and Montel in Montmagny, and Bombardier in La Pocatière) which feed their wastewater to municipal treatment plants.

Hazardous waste dump sites. Ten hazardous waste dump sites were recorded in the south shore municipalities of the Upper Estuary in federal and provincial government surveys conducted in the 1980s (Figure 12), none of which poses a serious threat to human health. There are four tannery sludge dumps (chromium and sulphur residues), three household and industrial dumps (heavy metals and phenols), and two landfill sites for ash from the F.F. Soucy paper mill (heavy metals). There were underground oil tanks on Grosse Île, but in 1995 both the tanks and oil-contaminated soil were removed and sent to disposal sites that met MEF standards.

Three dumps (two at Montmagny and one at Saint-Jean-Port-Joli) have been decommissioned, pose little threat to the environment and have not been targeted for study or action. The Saint-Antonin ash dump represented a high environmental risk, but it was rehabilitated in 1991 and has been monitored since. The ash dumped into the Rivière-du-Loup regional controlled outfall at Cacouna poses a slight risk to the environment. This site is equipped with a leachate capture system meeting provincial regulatory demands and is monitored. One of the four tannery sludge dumps is located on a controlled outfall fitted with a leachate capture system since 1990 and is expected to come into compliance with provincial regulations soon. The other three are currently under study.

Snow dumping. The volume of snow dumped either directly into the estuary or at sites immediately adjacent to the study area was at least 91 000 m^3 in 1996. Dumping was done at Rivière-du-Loup, Montmagny and Saint-Jean-Port-Joli. Since November 18, 1997, the provincial environment ministry has wielded a new regulation providing for retaliatory charges on any municipalities continuing to dump snow into watercourses beginning in winter 1999–2000.

Agriculture. In 1996, there were 433 working farms in the municipalities along the south shore of the Upper Estuary, occupying 44 223 ha. The main crops are forage and grain, and the chief livestock cattle and hogs. The total quantity of chemical fertilizer applied dropped by nearly 70% between 1981 and 1986, but the area treated with pesticides grew by 84% between

1981 and 1991. More than 60% of the farms on the south shore rotate crops to control erosion. From 1988 to 1996, 42 farmers in the study area took advantage of the assistance program for improving manure management to reduce the dumping of livestock excrement into the environment.

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

Shipping and port operations. Shipping is a potential source of pollution in the event of marine accidents, dumping of swabbing or bilge water directly into the sea or during transshipment and cargo stowage in port.

In 1988, the tanker *Czantoria* spilled 320 tonnes of light crude oil while docked at the port of Quebec City, the most serious spill recorded in the study area. Driven by tide and wind, the slick spread downstream, fouling the coastline as far as the Montmagny flats and Île aux Grues. Follow-up studies have shown the impact of the spill to be site-specific and relatively mild.

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

Hunting (lead shot). Lead shot used by hunters can be a major source of contamination of sediments and bottom-feeding organisms, especially ducks. Cartridges with non-toxic shot have been mandatory since 1996 in National Wildlife Areas, since 1997 within 200 m of open water or watercourses, and will be mandatory everywhere else starting in September 1, 1999.

4.2.2 Effects of contaminants on resources and uses

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

4.2.2.1 *Water contamination*

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

Data on shoreline water quality are practically non-existent. The highly fragmentary data suggest that microbiological pollution almost everywhere along the south shore was chronic in the 1980s. This situation has doubtless improved with the opening of municipal wastewater treatment plants starting in 1991.

4.2.2.2 *Sediment contamination*

Overall, heavy metal pollution of sediments was less severe in the Upper Estuary than in the St. Lawrence fluvial lakes, the Saguenay Fjord or the Lower Estuary in 1989–1990. This pattern is due to the progressive release of heavy metals bound to suspended matter with increasing salinity, dilution of sediments carried down by the river by less contaminated sediments from tributaries or the bed of the Upper Estuary itself, and the greatly reduced local anthropic input. The only parts of the study area seriously contaminated with heavy metals are around Rivière-du-Loup, where mercury levels in some samples reached concentrations harmful to most benthic organisms. Mercury levels outside these harbour areas were moderate in the upstream and downstream parts of the sector and relatively low in the mesohaline zone, suggesting that the St. Lawrence and Saguenay rivers were the main sources of this metal. Moderate copper contamination of sediments was found at many points along the south shore. Chromium, nickel and zinc contamination diminishes seaward and is thought to come largely from the river; lead pollution was low everywhere.

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

Data from 1989–1990 on organic toxic substances indicate that the study area suffers little from contamination by PAHs or organochlorine pesticides. PCB levels exceeding those found in Lake Saint-Pierre and the Lower Estuary were measured in the sediments in the maximum turbidity zone; PCBs carried down the river are thought to collect here, bound to suspended matter that settles temporarily in the flats. High PCB levels found in and around harbours (Notre-Dame-du-Portage dock and Gros-Cacouna port) may derive from local sources.

4.2.2.3 *Contamination of the food chain*

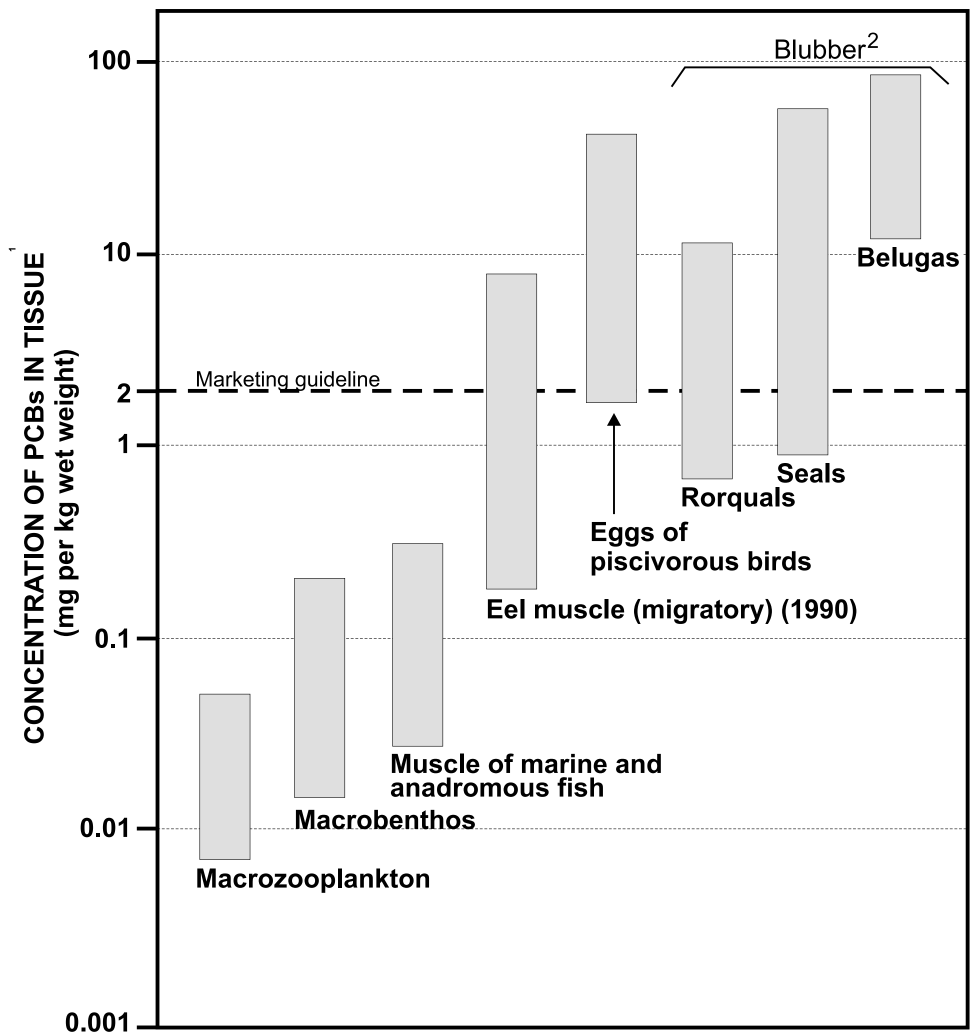
Aquatic organisms tend to accumulate toxic substances in their body tissues to higher levels than in the ambient water or sediment (**bioconcentration**). **Bioaccumulation** occurs when a contaminant is assimilated at a higher rate than it is eliminated, so that contamination increases as the organism ages. Most aquatic organisms, except molluscs, are able to regulate their body burdens of heavy metals (other than mercury) and to metabolize PAHs quickly, thereby not accumulating these substances. The majority of living organisms, however, are incapable of rapidly eliminating or metabolizing mercury or organochlorines such as PCBs, DDT or mirex. Toxic substances become more concentrated with each link in the food chain, and vertebrates have much higher levels than invertebrates. This phenomenon, **biomagnification**, has been well documented in the food chain in the St. Lawrence Estuary for PCBs (Figure 14), mirex and mercury. For example, PCB concentrations in the body fat of Belugas are one hundred to one thousand times higher than in benthic or planktonic invertebrates. Levels of biomagnified contaminants in estuarine organisms depend on the organism’s place in the food chain and the time it spends in the estuary. Thus, Fin whales are much less contaminated than Belugas because their main prey species are herbivores (euphausids) and they come into the estuary only in summer, whereas the Beluga eats carnivorous prey (fish) and lives in the estuary year-round.

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

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

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

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



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

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

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

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

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

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

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

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

Apart from Belugas, seals are the marine organisms most heavily contaminated by toxic substances. PCBs, DDT and mirex have shown up in very high concentrations in the subcutaneous fat of Harbour and Grey seals and in much lower concentrations in Harp seals. The liver of some Grey seals is heavily contaminated with mercury and that of some Harbour and Harp seals with cadmium.

4.3 Introduced or Expanding Species

Purple loosestrife. This is a European species which has invaded the freshwater marshes of the St. Lawrence. On the south shore of the Upper Estuary, it first appeared around 1940. Abnormal fluctuations in water levels, ice scouring, rebuilding of the banks and livestock grazing favoured its expansion. Purple loosestrife is considered a real pest species in some parts of Canada and the United States because it saps the diversity of marshland plant communities.

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

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

Greater snow goose. The spectacular growth of the snow goose population in recent decades has seen the significant expansion of migratory stopovers into cord-grass marshes and farmland (pasture and cornfields) in spring. Grazing on harvest residues does little real damage, but this is not the case when sprouting forage crops are consumed. The most seriously affected farmland in 1992–94 was in Kamouraska and Rivière-du-Loup RCMs. Various measures have been proposed for mitigating the impact of the snow goose population on crops: scare programs, setting aside of feeding areas, compensation to farmers, alternative farming practices, etc.

4.4 Disturbance of Birds and Marine Mammals

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

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

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

4.5 Overfishing

One effect of fishing may be to reduce both the biomass of the populations harvested and the average size of their members. Such phenomena are normal and do not endanger populations as long as the stock can replenish itself, but the decline of some major resources in the study area may be partly due to overfishing of populations already rendered vulnerable by other, environmental factors. Atlantic tomcod and Atlantic sturgeon populations are heavily fished, and controls on commercial harvesting have had to be imposed in recent years.

CHAPTER 5 Risks to Human Health

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

5.1 Fish Consumption

5.1.1 Chemical contamination

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

Though the data available do not give a complete picture of the contamination status of other marine species of the Upper Estuary at present, the relatively low concentrations found in populations further downstream (Lower Estuary and Gulf) suggest that the fish in the study area are also largely clean. This means that nominally marine species can be eaten without restriction, especially since fish has certain benefits; as well as being a good source of proteins, vitamins and minerals, fish in the diet protects against certain disorders, in particular ischemic heart disease. Moreover, for pregnant women and nursing mothers, fish is an important source of polyunsaturated fatty acids (especially omega-3) and of the nutrients needed for development of the nervous system in the fetus and in the first few months of the infant’s life.

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

5.1.2 Microbiological and parasitic contamination

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

5.2 Shellfish Consumption

5.2.1 Chemical contamination

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

5.2.2 Bacteriological contamination

Municipal wastewater, diffuse agricultural pollution, cesspits and concentrations of seabirds may create bacteriological water pollution hazards in many parts of the study area, and this will affect the quality of edible shellfish, which should therefore be gathered only in places approved by the Department of Fisheries and Oceans Canada (DFO). This is the federal government department responsible for using the data collected by Environment Canada under the *Canadian Shellfish Sanitation Program* to decide where shellfish can safely be harvested.

Bacteriological contamination of shellfish beds is a serious problem in the St. Lawrence, and the south shore of the Upper Estuary has been particularly hard hit. In fact, there are currently no shellfish beds open for harvesting. It should be noted that the shellfish sold on the market is subject to inspection and poses no danger.

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

5.2.3 Contamination by toxic algae

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

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

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

5.3 Seaweed Consumption

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

5.4 Waterfowl Consumption

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

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

5.5 Recreational Activities

5.5.1 Risks associated with water quality

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

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

5.5.2 Risks arising from physical hazards

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

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

5.6 Environmental Accidents

5.6.1 Natural occurrences

Since 1994, floods have struck the municipalities of Île aux Grues, Saint-André, Saint-Pacôme and Rivière-Ouelle. Saint-André also suffered a landslide. Some watercourses — the Tortue (L'Islet-sur-Mer), Du Sud and Bras-Saint-Nicolas (Montmagny) rivers — have been designated as flood risks. There are also landslide risk zones in the municipalities of Montmagny and Cap-Saint-Ignace.

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

5.6.2 Technological accidents

In recent decades, a number of environmental accidents involving hazardous cargoes have occurred in the Upper Estuary and the fluvial stretch of the river. The substances spilled were mainly hydrocarbons. However, none of these incidents has had any impact on the health of people living along the shores of the Upper Estuary. Yet the risk remains, given the volume of dangerous cargoes carried on the St. Lawrence.

CHAPTER 6 Strategies for Sustainable Development

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

reducing pollution

protecting and rehabilitating disturbed habitats and resources

improving access to the St. Lawrence

reconciling recreation and tourism development with environmental protection.

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

6.1 Reducing Pollution

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

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

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

6.2 Protecting and Rehabilitating Disturbed Habitat and Resources

Some important plant and animal habitats in the study area are already protected, but others, equally important, are not. Sectors in need of protection include all brackish and salt marshes and unprotected islands and islets. Among protection plans currently under study are the purchase of 83 ha of marshes in the Kamouraska area and the designation of the Rivière-du-Loup marshes under the Eastern Habitat Joint Venture.

The objective for species deemed a priority for protection under the SLV 2000 Action Plan is to draw up a status report for each one to see whether legal designation as threatened or vulnerable is warranted, to draft and implement a recovery plan for each threatened species, and to monitor numbers over the long term. Recovery plans have already been drawn up for the Beluga, Rainbow smelt, Peregrine falcon, Yellow rail, Horned grebe and Loggerhead shrike.

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

In order to re-establish the local Rainbow smelt population, work was begun in 1990 on restoring the Boyer River (Fluvial Estuary), where this population's main spawning grounds are located. Serious efforts have been made to reduce the adverse impact of farming on water quality and sediment in this watercourse, and a drive is now under way to pinpoint the spawning grounds of the Atlantic sturgeon in the Fluvial Estuary so that these too can be protected or restored.

Work has been done to improve Common eider nesting sites disrupted by cormorants on the Pèlerins islands, Île au Pot à l'Eau-de-Vie, Île aux Fraises and Île Blanche. Other projects for improving waterfowl production have been carried out or are in progress on Île aux Oies, and in Montmagny, Rivière-du-Loup and Cacouna.

6.3 Accessibility of Marine, Coastal and Island Environments

In 1988, the Lower St. Lawrence Tourism Association drew attention to the inaccessibility of the sector's islands to tourists and the limited accommodation and dining facilities along the shore. Since then a number of projects to improve access have been implemented, and tourism based on the estuary's attractions and resources is now booming. The divestiture of federal harbours to local interests will further improve matters.

6.4 Reconciling Recreational and Tourism Development with Environmental Protection

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

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

Issue	*Assessment of current situation in relation to sustainable development objectives*	*Current approach to sustainable development*
Reducing pollution		
• Treatment of municipal, household and agricultural wastewater	The wastewater of 70% of the sector's population is treated. Bacterial pollution precludes the harvesting of shellfish and limits swimming in some places.	Restoration of uses dependent on bacteriological water quality can only be achieved when wastewater is treated (in treatment plants or effective septic systems) and when sewer overflows in heavy rain and agricultural pollution are controlled.
• Treatment of wastewater from pulp and paper mills	The two paper mills in the area have considerably cut their BOD_5 and suspended matter load, as well as the toxicity of the wastewater they dump into the estuary. In 1997, both plants were using secondary treatment.	Paper mill wastewater is subject to regulatory monitoring.
• Restoration of hazardous waste dump sites	In the 1980s, there were several sites posing a moderate threat to the marine environment. The most problematic of these have now been restored.	No action has been taken at certain sites; at others, further work is needed.
• Protection of the aquatic environment from spills	The Upper Estuary is a major shipping route. The environment is highly vulnerable to oil spills because of the many bird colonies, seabird staging areas, seal haulouts and whales. A spill response force is now in place.	A regional response team regularly conducts simulation exercises.
• Persistence of toxic substances in the environment	Though various contamination sources in the St. Lawrence drainage basin have been sharply reduced, the aquatic life of the Upper Estuary remains exposed to toxic bioaccumulating substances; this is especially true of fish-eating birds and marine mammals. In general, chemical contamination of fishery products poses no threat to human health, but consumption of eels and seal meat is subject to restrictions.	A better understanding of the dynamics of these substances and their effects on marine organisms and human health is a major challenge in this sector.

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

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Appendices

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

Name	*Type of distribution or status in the sector*
Plants (15 of 110 priority species)	
American waterwillow	Northern periphery
Annual wild rice	Endemic to Fluvial Estuary
Canada garlic	Northern periphery
Clammy hedge-hyssop	Endemic to Fluvial Estuary
Coast willowweed	Endemic to Fluvial Estuary
Dotted smartweed	Disjunct
Estuary pipewort	Disjunct
False mermaidweed	Sporadic
Gaspé Peninsula arrowgrass	Endemic to northeastern North America
Obedient plant	Disjunct
Rosa rousseauiorum	Endemic to the Estuary and Gulf
Sandberg bluegrass	Disjunct
Smooth rose	Endemic to the Estuary and Gulf
Spotted water hemlock	Endemic to Fluvial Estuary
Victorin’s fringed-gentian	Endemic to Fluvial Estuary
Fish (8 of 14 priority species)	
American eel	Migrant (fall)
American shad	Migrant (spring and summer)
Atlantic herring	Present
Atlantic sturgeon	Year-round resident
Atlantic tomcod	Resident (spring, summer and fall)
Lake sturgeon	Casual
Rainbow smelt	Year-round resident; spawns in some tributaries
Striped bass	Resident (spring, summer and fall)
Amphibians and reptiles (2 of 7 priority species)	
Brown snake	Present
Wood turtle	Present

Name	*Type of distribution or status in the sector*
Birds (8 of 19 priority species)	
Bald eagle	Migrant
Barrow’s goldeneye	Migrant
Blue-winged teal	Confirmed breeder
Horned grebe	Migrant
Least bittern	Migrant
Peregrine falcon	Former breeder
Pintail	Confirmed breeder
Yellow rail	Probable breeder
Mammals (5 of 5 priority species)	
Beluga	Resident (spring, summer and fall)
Fin whale	Casual in spring, summer and fall
Harbour porpoise	Casual in summer and fall
Harbour seal	Year-round resident
Pygmy shrew (land mammal)	Status unknown

2 Environmental Quality Criteria (for assessing loss of use)

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

3 Glossary

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

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

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

Carcinogen: Any factor that triggers or disposes to cancer.

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

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

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

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

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

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

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

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

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

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

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

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

Haulout: Place where seals come ashore to rest.

Herbaceous meadow: Plant community dominated by herbaceous species.

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

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

Mudflat: Area of foreshore or seabed covered with mud.

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

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

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

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

Spawning ground: Place where fish gather to breed.

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

Tidal range: Vertical distance between high and low tide.

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).

Waterfowl: Collective term for ducks and geese.

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