REGIONAL ASSESSMENT
QUEBEC CITY–LÉVIS

Regional Assessment
Quebec City-Lévis Sector

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NOTE TO READERS

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

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Preface

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

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

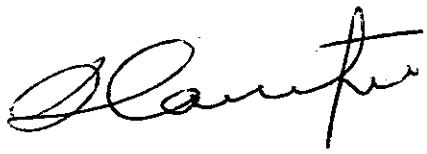
The Priority Intervention Zones Program – better known by its French acronym ZIP – is a major element of the Community Involvement component of the St. Lawrence Vision 2000 action plan.

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

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

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

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



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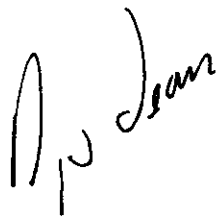

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Management Perspective

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

The regional assessment is based on a synthesis of three technical reports focusing on the biological, physico-chemical and socio-economic aspects of the study area. These reports are prepared by the ZIP team of the St. Lawrence Centre in co-operation with the federal and provincial partners of the St. Lawrence Vision 2000 action plan, of which the ZIP Program is a component.

The process of gathering and analysing data on a local scale has never before been undertaken for the St. Lawrence. The technical reports go even further, providing an assessment of the current state of a given area based on known quality criteria.

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

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

Perspective de gestion

Le programme des Zones d'intervention prioritaire (ZIP) relève le défi de la concertation entre les gouvernements fédéral et provincial et de l'implication des intervenants et des communautés riveraines, en vue de mettre en oeuvre des mesures de réhabilitation du Saint-Laurent. Ce programme comporte trois grandes étapes, soit l'élaboration d'un bilan régional sur l'état du Saint-Laurent, la consultation auprès de tous les partenaires riverains, avec l'identification de priorités d'intervention, et l'élaboration d'un plan d'action de réhabilitation du milieu naturel.

Le bilan régional est établi à partir d'une synthèse des trois rapports techniques portant sur les aspects biologiques, physico-chimiques et socio-économiques du secteur étudié. Ces rapports sont préparés par l'équipe ZIP du Centre Saint-Laurent en collaboration avec les partenaires fédéraux et provinciaux du plan d'action Saint-Laurent Vision 2000, dont le programme ZIP est un des volets.

La cueillette et l'analyse des données existantes à l'échelle locale est une première pour le 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 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

After Montreal-Longueuil, the Quebec City-Lévis sector (ZIP 14) is the most built-up section of the St. Lawrence River between Lake Ontario and the ocean. Vast tracts of wetlands, once prime wildlife habitats, have disappeared under backfill. Sport and commercial fishing have all but died out here following the catastrophic drop in anadromous fish populations.

The western half of the study area is primarily urban, while the other half, predominantly rural, suffers the onslaught of urban sprawl and high-density cottaging. Municipal and industrial cleanup efforts are only recent initiatives. Prior to 1992, wastewater of the Quebec Urban Community (QUC) was discharged untreated to the St. Lawrence and, under the effect of tidal action, degraded the bacteriological quality of the water over great distances, both upstream and downstream of outfalls. The situation has vastly improved with the start-up of treatment plants, but they are still in the break-in stage, so swimming and other water activities remain a health risk.

Port development in the sector has led to the creation of sediment traps, which have become contaminated with heavy metals and toxic organic compounds. In the outer part of Louise basin, opening onto the River, contaminated sediments are covered with more recent, less toxic sediment; in the Saint-Charles River estuary, local sources of pollution continue to contaminate sediments.

The study area is distinguished by the recreation and tourism opportunities afforded by Old Québec, a recognized world heritage site. The St. Lawrence landscapes, boating and river cruises are other attractions. Though the riverbanks have been largely inaccessible these past few decades, a trend toward their reclamation has recently begun. A few sites are under legal protection, but other shoreline areas of ecological importance remain unprotected.

Résumé

Le secteur Québec-Lévis (ZIP 14) est, après celui de Montréal-Longueuil, la portion du Saint-Laurent la plus artificialisée entre le lac Ontario et la mer. De grandes superficies de milieux humides, qui constituaient des habitats fauniques de première importance, ont disparu sous les remblais. La pêche sportive et commerciale ont presque complètement disparu dans ce tronçon du fleuve à la suite du déclin catastrophique des populations de poissons anadromes.

La moitié ouest du secteur est dominée par le milieu urbain alors que l'autre moitié, dominée par le milieu rural, subit les assauts constants de l'étalement urbain et de la villégiature à forte densité. Les efforts d'assainissement par les municipalités et les industries sont récents. Avant 1992, les eaux usées de la Communauté urbaine de Québec étaient rejetées sans traitement au milieu du fleuve et dégradaient la qualité bactériologique du fleuve sur de grandes distances en amont et en aval des émissaires sous l'effet du va-et-vient des marées. La situation s'est grandement améliorée depuis la mise en opération des stations d'épuration mais celles-ci sont encore en période de rodage et la baignade et la pratique d'autres activités récréatives dans le fleuve présentent encore des risques pour la santé humaine.

Les aménagements portuaires dans le secteur ont créé des trappes à sédiments qui ont été contaminés par des métaux lourds et des composés organiques toxiques. Dans la partie extérieure du bassin Louise, ouverte sur le fleuve, les sédiments contaminés sont recouverts de sédiments plus récents moins contaminés, alors que dans l'estuaire de la rivière Saint-Charles, des sources locales de pollution continuent de contaminer les sédiments.

Le secteur d'étude se distingue sur le plan récréo-touristique notamment par la présence du Vieux-Québec, joyau patrimonial mondialement reconnu. Le fleuve est aussi un attrait important pour les paysages, le nautisme et les activités de croisière. Si les abords du fleuve ont été peu accessibles ces dernières décennies, on observe depuis quelques années une tendance vers la mise en valeur et la réappropriation des rives. Quelques sites bénéficient d'un statut légal de protection mais certains rivages de grande valeur écologique ne sont pas protégés.

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CHAPTER 1 The St. Lawrence, Then and Now

The mere mention of the St. Lawrence evokes in most Quebecers a deep-rooted feeling of belonging to this land traversed by the river on its way from the Great Lakes to the sea. Images of a mighty river spring to mind, hugged on either side by fertile plains, shaded banks and rich wildlife.

This country was born on the banks of the river – as is still evident today in the division of land, a vestige of the seigneurial system. Back then, people had to learn to live with the spring flooding of the St. Lawrence. In return, the river provided the European settlers, still struggling with unreliable harvests, with a sure supply of fish and first-rate 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 use of the river had had virtually no impact on its resources. But things would soon change. The first major impact appears to have been caused by logging and the beginnings of industrialization in the nineteenth century; this included log drives from the Ottawa River 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 to control the flow of water, of ship channels and then the St. Lawrence Seaway. More and more industries were established near towns and cities, often right on the river. The proximity of the river 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 the accumulated abuse. A few informed observers noted that some animal species were becoming less abundant and suggested that this was the result of habitat disturbance. Their warnings elicited little public interest, however.

Then, in the early 1970s, public opinion was suddenly roused when it was realized that mercury contamination of fish was not just an abstract research topic but a real risk to which some Native peoples and many sport fishermen were exposed. As the list of toxic substances reported in the aquatic environment continued to grow, the general public changed its perception of the problem and put the quality of the environment at the top of its list of concerns. There is virtually unanimous agreement now that the comforts afforded by an industrial society have a drawback: unbridled exploitation of resources and the increasing quantity 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 dictate 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 Priority Intervention Zones (ZIP) Program

Beginning in the 1960s, the awakening of public opinion about the state of the environmental degradation of the Great Lakes and St. Lawrence River and the urgency of the situation prompted governments to undertake concrete joint action. This paved the way for the 1972 Canada-U.S. agreement to clean up the Great Lakes. An amendment was made in 1987 to include a program to restore use at the local level (Remedial Action Plans, or RAPs). In addition, an agreement to control the discharge of toxic waste into the Great Lakes system and the Great Lakes Charter were signed in 1988 by Ontario, Quebec and the eight U.S. states concerned. Out of concern for the poor quality of water in the river and its tributaries, the Quebec government launched its own wastewater treatment program in 1978.

In 1989, the federal and Quebec governments agreed to coordinate their efforts under the St. Lawrence Action Plan; in 1994, the plan was extended and renamed St. Lawrence Vision 2000 (SLV 2000). One of the plan's objectives is to draw up a comprehensive assessment of the state of the environment of the Quebec stretch of the river. Under the ZIP program, the St. Lawrence has been divided into 23 Priority Intervention Zones (better known as ZIPs) within which people and organizations will be encouraged on a local level to work together to restore and protect the river and coordinate its uses (Figure 1). As part of the groundwork for the consultations, government partners of SLV 2000 are reviewing and synthesizing current knowledge on the state of the environment in each study area.

This report summarizes the highlights of the technical reports[1] and assesses current knowledge on the state of resources and present and future uses of the Quebec City-Lévis sector (ZIP 14) and the associated constraints.

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

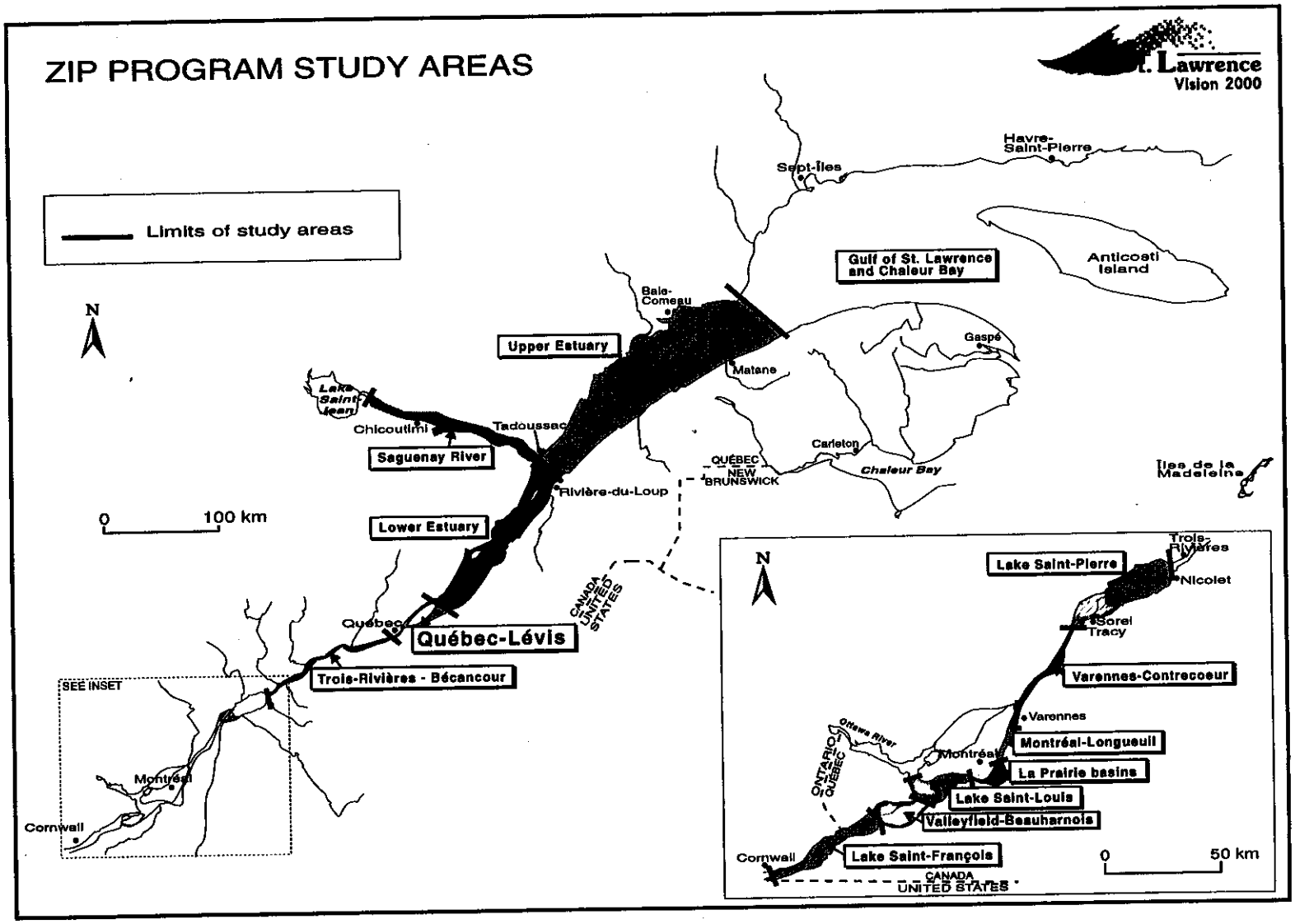


Figure 1 **ZIP Program study areas**

The purpose of this effort to review and synthesize our existing knowledge is to provide the various riverside stakeholders with accessible, objective scientific data so that they can define their priorities for action. They will then be able to draw up and implement action plans on a local and regional level, with each partner acting within its sphere of responsibility, but in coordination with the other partners.

CHAPTER 3 Characterization of Quebec City–Lévis

The Quebec City–Lévis study area (ZIP 14) stretches from Cap-Rouge to Beaupré on the north shore of the St. Lawrence and from Saint-Romuald to Berthier-sur-Mer on the south shore and includes Île d'Orléans (Figure 2). This section of the river is the downstream reach of the Fluvial Estuary characterized by tidal fresh water. It can be regarded as a microcosm of everything the St. Lawrence represents. This chapter describes the main biological and physical characteristics of the study area, as well as the resources and uses that have been developed and are still valued by the population.

3.1 Physical Environment

The study area is comprised of three distinct zones (Figure 2). Upriver from Quebec City, the St. Lawrence is narrow, fairly deep (up to 60 m) and bordered by cliffs on either bank. Downriver, it divides to encircle Île d'Orléans, flowing through the Grands Voiliers channel on the south side and the Île d'Orléans channel on the north side. The latter channel is narrow, shallow (maximum depth of 15 m) and bordered in places on either side by large foreshores. The Grands Voiliers channel is deeper (maximum depth of 33 m) and gradually broadens into the Upper Estuary, which is more than 10 km wide at the Montmagny archipelago.

At the western boundary of the study area, the mean annual discharge of the river is 12 600 cubic metres per second (m^3/s). This water originates in the Great Lakes (62%) and in tributaries of the St. Lawrence between the Great Lakes and Quebec City (38%). The tributaries, which carry a significant amount of atmospheric water and open onto the Quebec City–Lévis sector, only increase the discharge by about 2%. Downriver from Quebec City, 90% of the discharge flows through the Grands Voiliers channel, with the rest moving through the Île d'Orléans channel. The eastern boundary of the study area corresponds roughly to the point at which fresh water begins mixing with salt water. Water salinity at the eastern tip of Île d'Orléans rarely exceeds two parts per thousand in summer.

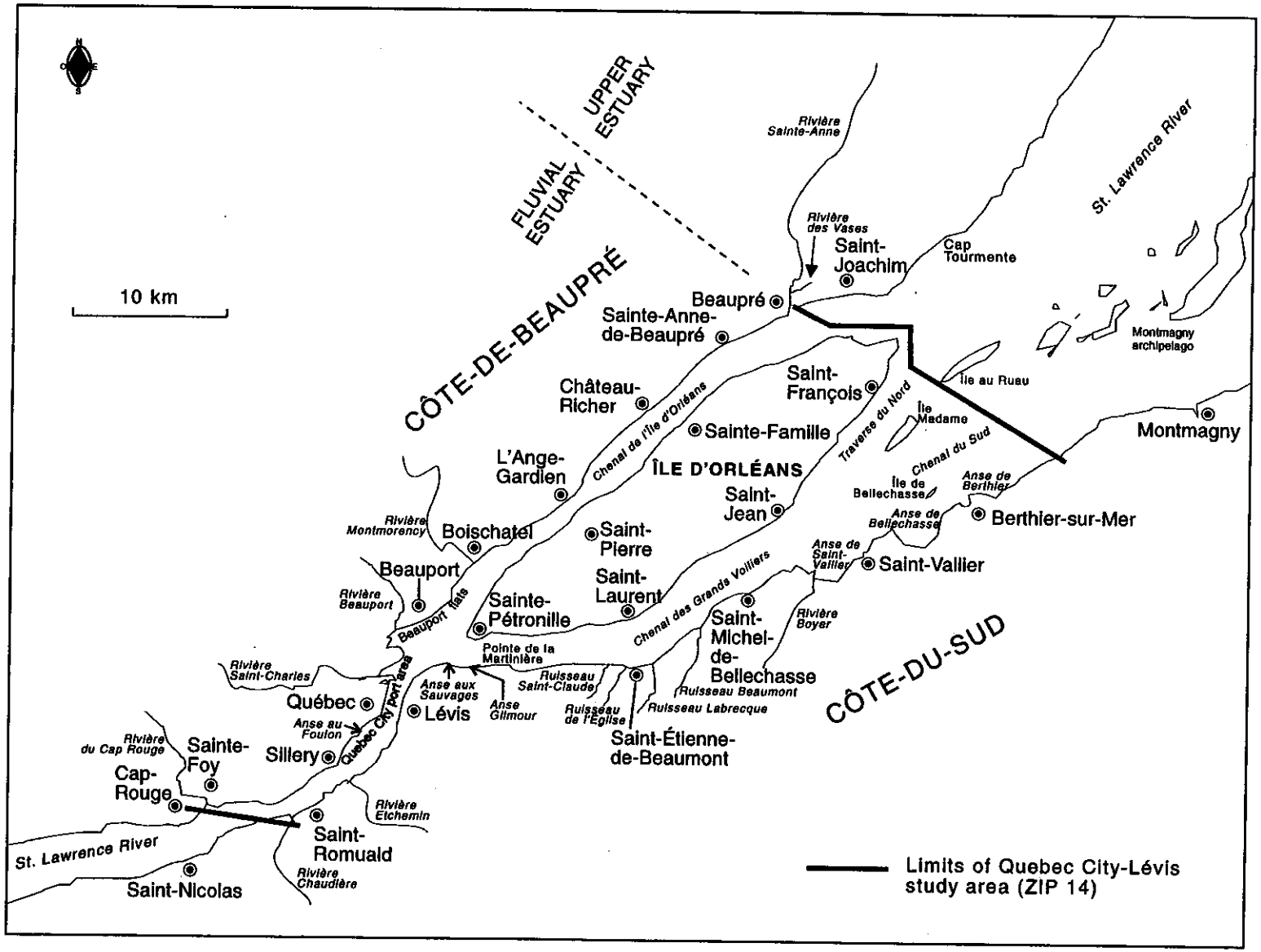


Figure 2 Quebec City–Lévis study area

Large tidal amplitude characterizes the Quebec City–Lévis sector, with the range increasing downriver to a maximum of 4.6 m at the eastern tip of Île d'Orléans. The tide progresses more freely on the south side of Île d'Orléans than on the north side, with the result that the maximum tidal range is smaller at Boischatel (3.7 m) than at Quebec City (4.2 m). The tides create strong turbulent flow, which in turn causes rapid mixing of the waters from the river, tributaries and municipal and industrial outfalls. Tidal action displaces the water mass twice daily over a distance of about 20 km, with currents which can reach more than 2 m/s. Flow at ebb tide is 4.5 times greater than the mean annual discharge of the river.

Each year, close to 6.5 million tonnes of suspended solids enter the river at the head of the Quebec City–Lévis sector, 70% of which occurs during spring floods. Strong turbulence along the main stem of the river, as well as upriver from Quebec City and in the Grands Voiliers channel prevents those solids from settling on the river floor or tidal flats. Downstream from Saint-Michel-de-Bellechasse, however, the currents weaken as the river widens, allowing sand to settle on the channel bed and silt and clay to settle in the partially isolated coves along the Côte-du-Sud.

Located at a distance from the main stem of the river, the flats of the Beauport and Île d'Orléans channels are where much of the river's sediment load settles on the foreshores in summer. Every year, a sediment layer 5 cm thick is deposited at Beauport, while a layer 20 cm thick is formed at Beaupré. These deposits are only seasonal, however, and are expelled from the study area in fall and the following spring. The only large zones of long-term sediment deposition in Quebec City–Lévis are located in rare sheltered spots, such as Louise Basin and the estuary of the Saint-Charles River.

3.2 Wildlife Habitats

The characteristics and distribution of wildlife habitats in the Quebec City–Lévis sector are largely determined by tidal patterns and sediment dynamics. The strongly sedimented foreshores of the Beauport flats, Île d'Orléans channel and Côte-du-Sud coves (Figure 3) support a dense plant life which has developed in strips parallel to the riverbank as a function of species tolerance to tidal submersion (Figure 4). Where the foreshore is only underwater during spring

and fall tides, one finds swampland dominated by trees and shrubs (mostly willow and alder). Here, cordgrass-dominated wet meadow occupies the tier that is covered only by spring tides (twice per month). A micro-cliff a few dozen centimetres high is found at the lower limit of this zone, at the mean high-water level. The foreshore between the cliff foot and the submerged area is occupied by an American bulrush marsh. The lower part of the intertidal zone is covered with barren mud.

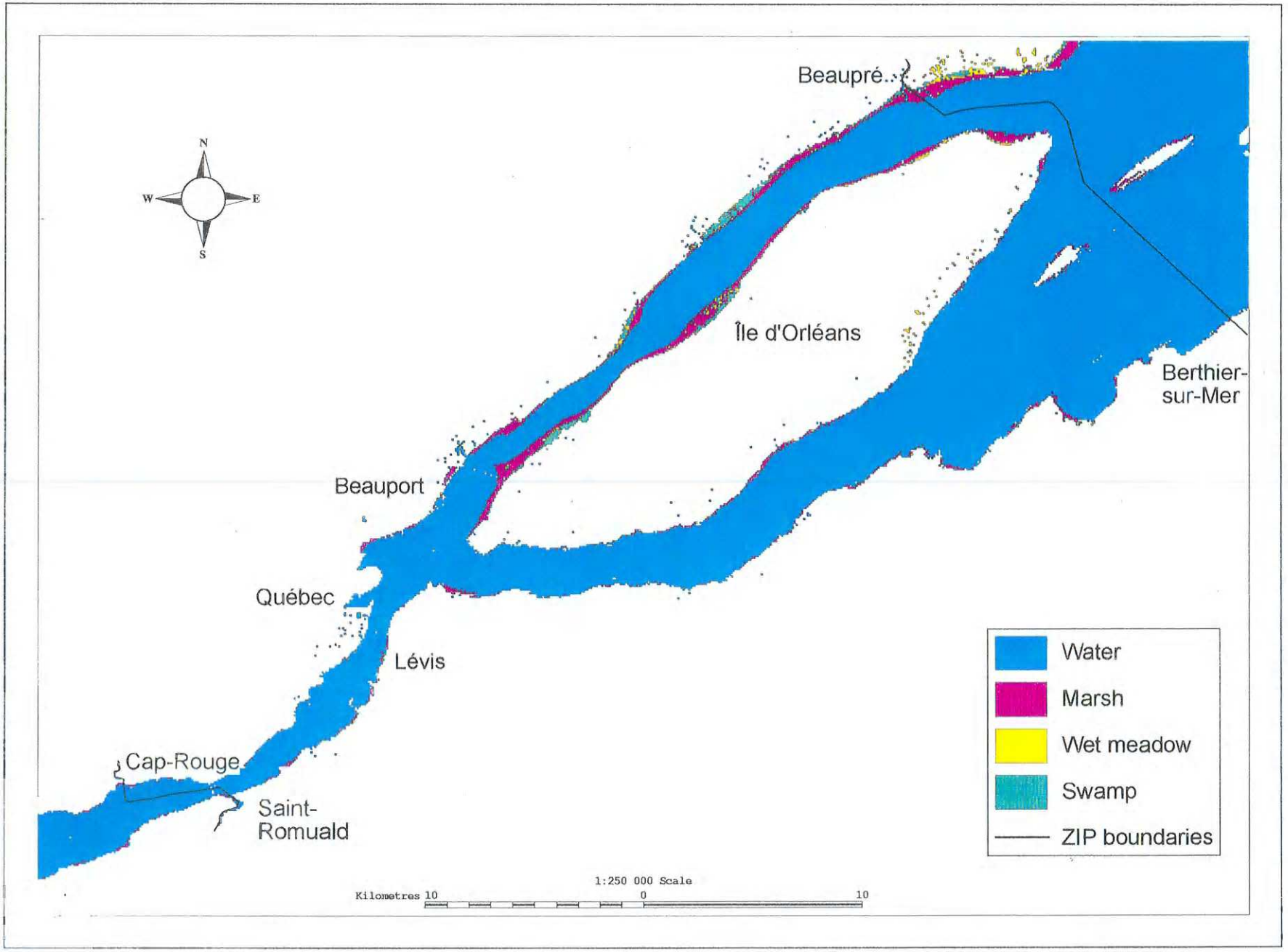
The *Scirpus* marshes are among the most productive ecological areas of the St. Lawrence system. They shelter abundant and diversified benthic and planktonic invertebrates and are used by large numbers of fish, birds and amphibians, as well as a few mammals. These habitats are critical as nursery areas for many species of fish, for the rearing of duck broods and for feeding by migrating waterfowl. The swamps and wet meadows are used as nesting grounds by dabbling ducks.

The Quebec City–Lévis sector provides habitat for a number of rare or threatened plants. A dwarf variety of wild rice (*Zizania aquatica*) is among the six species endemic to the Fluvial Estuary and one of the 12 priority species under the St. Lawrence Vision 2000 action plan found in Quebec City–Lévis (Appendix 1). This species is particularly abundant in the *Scirpus* marshes along the Beaupré coast.

On the lightly sedimented foreshores upriver from Quebec City, on the south bank of Île d'Orléans and the Côte-du-Sud, vegetation develops only along a thin layer of silt or in the shelter of rocky nooks. The foreshore in these sectors is often bare and generally unproductive.

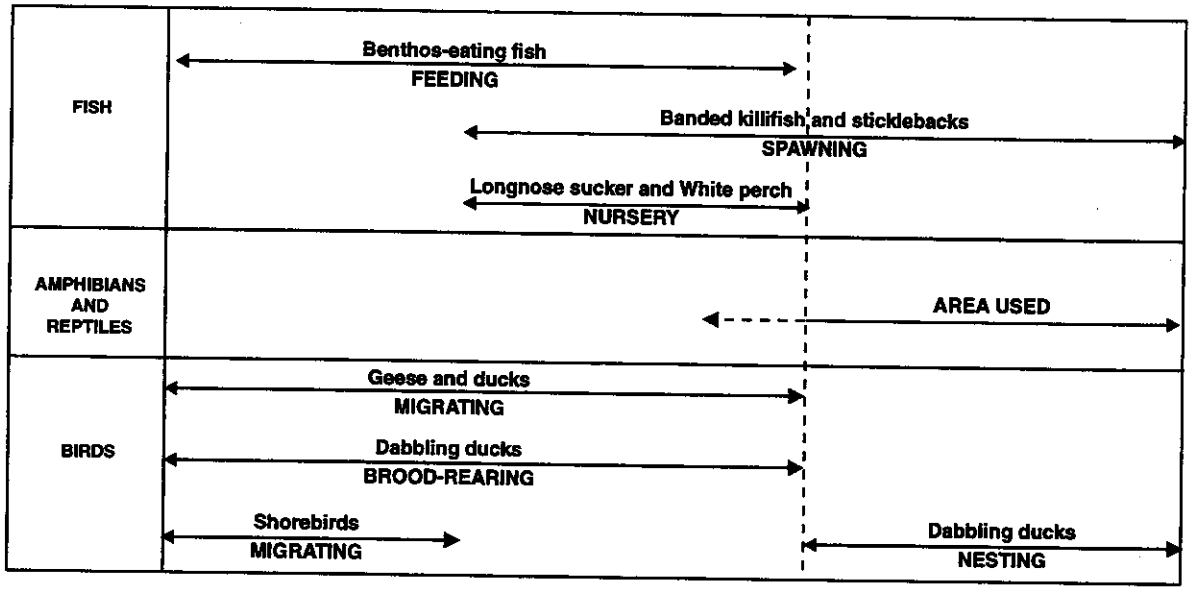
Beneath the low-water level, the riverbed consists almost entirely of rocky outcropping, gravel and coarse sand swept by strong currents, creating an environment unsuitable for the development of diverse populations of aquatic invertebrates.

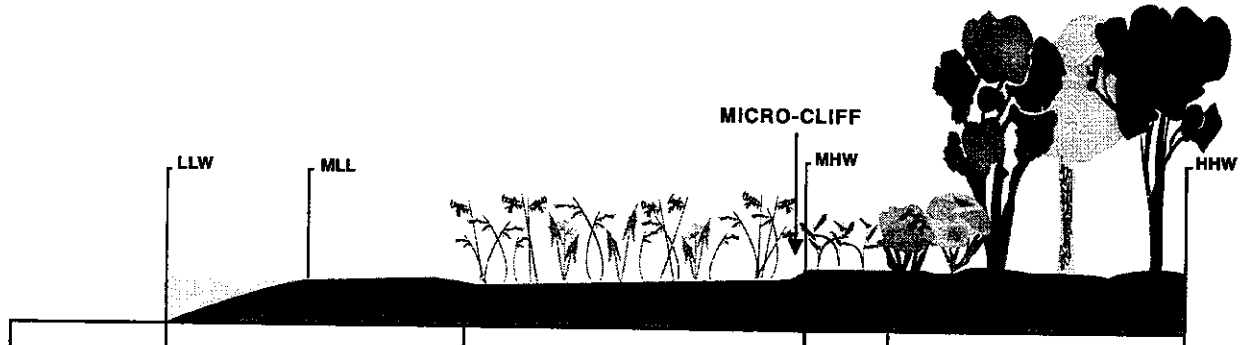
The water proper represents a habitat of about 3.5 km^3 characterized by an absence of stratification, strong turbulence, relatively high turbidity (two times greater than in the region of Montreal) and high concentrations of oxygen, nutrients and organic matter. This is a fairly



Source: Aménatech Inc. 1992. *Cartographie des marais, marécages et herbiers le long du fleuve Saint-Laurent de Trois-Rivières à Montmagny au moyen de la télédétection aéroportée*. Environment Canada, Quebec Region, Conservation and Protection, St. Lawrence Centre.

Figure 3 Distribution of wetlands in the Quebec City–Lévis sector





TIER	BARE MUDFLAT	MARSH	WET MEADOW	SWAMP
ASSOCIATION		American bulrush Giant bur-reed Narrow-leaved cattail	Cord grass	Erect willow Shining willow Pussy willow Speckled alder Crack willow Red ash

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

Source: Mousseau, P., and A. Armellin. 1995. *Synthèse des connaissances sur les communautés biologiques du secteur d'étude Québec-Lévis.* Technical report on ZIP 14. St. Lawrence Centre, Environment Canada - Quebec Region, Conservation Branch.

Figure 4 Typical vegetation on heavily sedimented foreshores in the Quebec City region

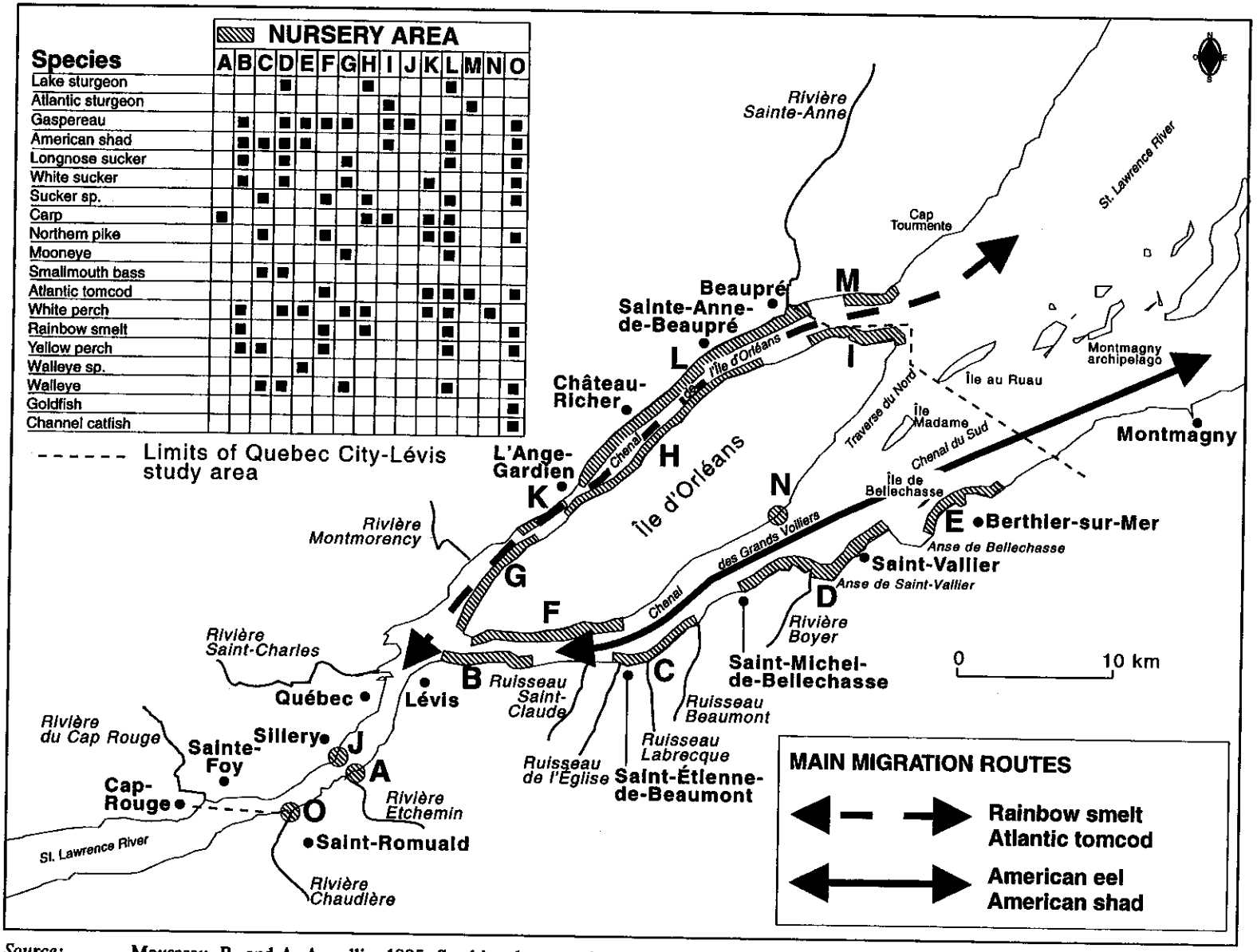
productive environment, particularly in the Île d'Orléans channel, where the water is less turbulent and shallower. But water residence time in the study area is only about three days, and plankton originating locally or upriver is constantly swept downstream to the saltwater intrusion limit, where special hydrodynamic conditions provide for zooplankton retention and accumulation.

Since the early 1950s, wildlife habitats in Quebec City–Lévis have been seriously disturbed by human activities: changes in hydrodynamic patterns, water pollution and sediment, backfilling and dredging, and the introduction of animal and plant species. These subjects are discussed in detail in Chapter 4.

3.3 Fish

Fifty of the 89 species of freshwater fish present in the St. Lawrence have been inventoried in the western part of the Quebec City–Lévis study area, 39 in the eastern part and only 9 in the brackish water on the downstream perimeter of the area. This drop in the number of freshwater species is largely attributable to harsher environmental conditions heading downstream. Indeed, owing to the large tidal range, the environment is unsuitable for species that frequent calm waters and those that spawn in riparian vegetation. Furthermore, several freshwater species cannot tolerate the salinity levels in the eastern part of the study area. Species in the Trois-Rivières area, such as Yellow perch, Brown bullhead, White sucker, Walleye and Lake sturgeon, are gradually replaced in the Quebec City area by species better adapted to faster currents and higher salinity, such as Channel catfish, Longnose sucker, Sauger and Atlantic sturgeon.

Both anadromous and catadromous migratory fish also occupy an important place in the ichthyofauna of the study area (Figure 5). Prior to 1960, some ten species favoured the Quebec City–Lévis sector as a migration corridor to spawning or nursery grounds. The Rainbow smelt, American shad, Atlantic sturgeon and Gaspereau (in spring), Atlantic salmon (in summer) and Striped bass, Lake whitefish and Atlantic tomcod (in fall) ascended the estuary and the River to their spawning grounds at the upstream boundary of the tidal waters (or even further upstream) in the river proper or the tributaries. The American eel descended the river in fall to breed in the



Source: Mousseau, P., and A. Armellin. 1995. *Synthèse des connaissances sur les communautés biologiques du secteur d'étude Québec-Lévis.* Technical report on ZIP 14. St. Lawrence Centre, Environment Canada - Quebec Region, Conservation Branch.

Figure 5 Nursery areas and main fish migration routes in the Quebec City–Lévis sector

Atlantic Ocean. The Quebec City–Lévis sector was also the site of large seasonal migrations, including smelt and Sauger in the fall.

Starting in the late 1950s, the main populations of anadromous fish in the study area suffered a catastrophic decline. Only the American shad and Atlantic salmon have evinced a few encouraging signs of recovery since that time, although they are still far less abundant than a few decades ago. By contrast, a decline is feared in the population of American eel in the next few years owing to very low recruitment in the 1980s. A decline in Atlantic tomcod has been observed since the 1970s, although it is still one of the most abundant species in the Quebec City–Lévis sector. The Atlantic tomcod, American shad, American eel, Striped bass, Rainbow smelt, Lake sturgeon and Atlantic sturgeon all appear on the list of SLV 2000 priority species (Appendix 1).

With the exception of the Banded killifish and sticklebacks, which spawn in *Scirpus* marshes, and the Longnose sucker, which spawns at the tributary mouths, it appears that few species breed in the stretch of river within the Quebec City–Lévis sector. Several species do still breed in St. Lawrence tributaries opening onto the study area. At present, the only known smelt spawning areas still active are in the streams around Saint-Étienne-de-Beaumont (de l'Église, Saint-Claude, Beaumont and Labrecque streams).

Several species rear their young in *Scirpus* marshes. Young Banded killifish, Longnose suckers and White perch strongly dominate the community in this environment. The larvae or fry of most anadromous species cross the study area on their descent to the brackish water of the Upper Estuary, where their main growth area is located. Smelt larvae tend, however, to ascend to Quebec City in the summer and congregate in fresh water.

Adult fish do not frequent the intertidal zone much, but are instead found in the channels. In the western part of Quebec City–Lévis, this environment is dominated today by Longnose sucker, Atlantic tomcod, Yellow perch and Walleye. The latter two species are much less abundant in the eastern sector and are gradually displaced by Lake whitefish and Sauger. Adult anadromous fish shy away from the warm waters of the river and congregate mainly in brackish or salt water.

Estuarine and marine species, with the exception of four species of stickleback, rarely enter fresh water. Smooth flounder, Winter flounder and Rock gunnel are occasionally caught at the downstream limit of Quebec City–Lévis.

3.4 Birds

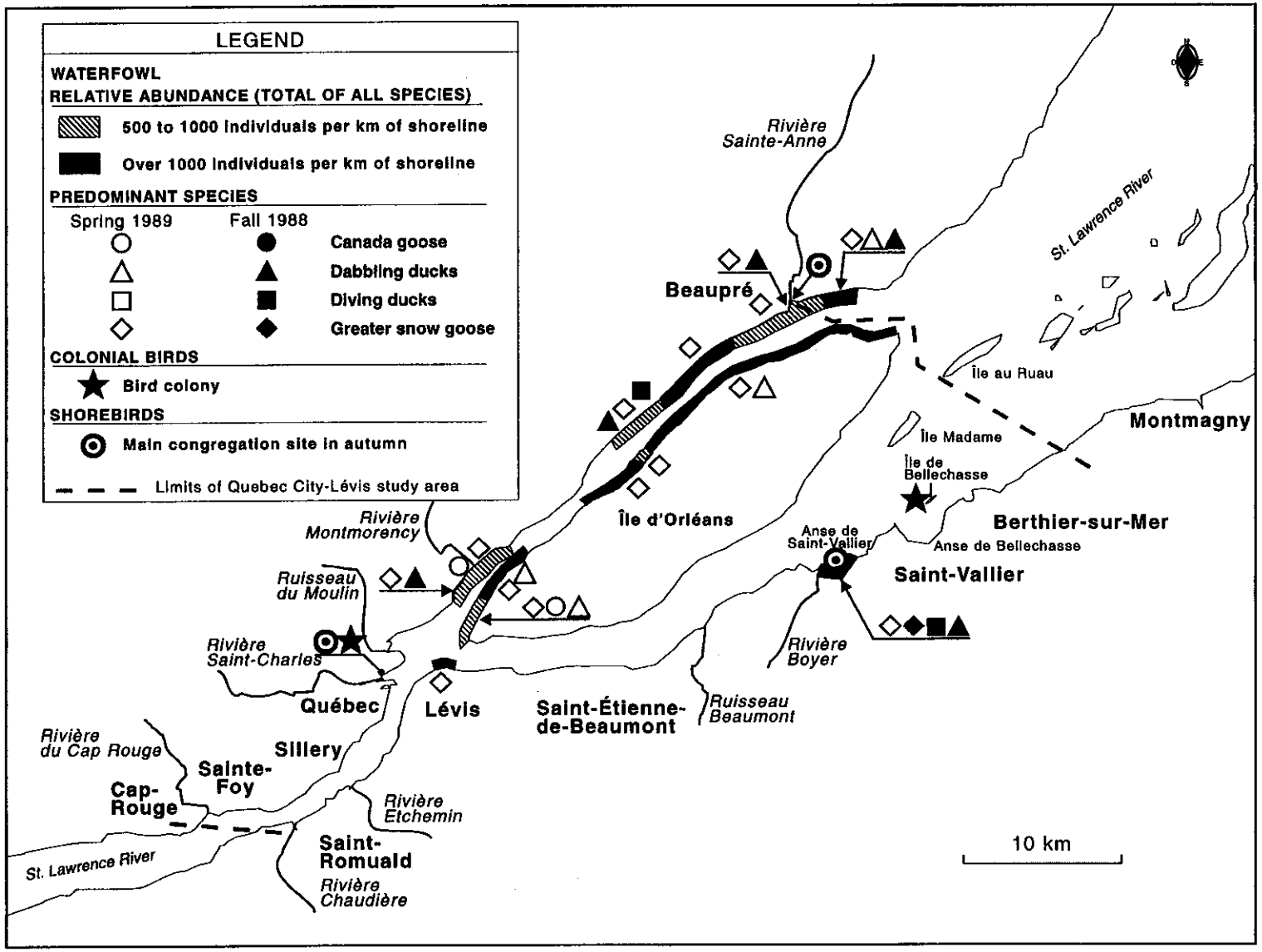
The Quebec City region has some of the richest bird life in the St. Lawrence, with species which frequent the river in southern Quebec now being joined by pelagic and estuarine species that frequent the Quebec City region.

Some 30 species of aquatic birds nest in the study area. Eight species of dabbling ducks nest on farmlands and in swamps and wet meadows, then rear their young in the *Scirpus* marshes.

There are only two colonies of birds in the Quebec City–Lévis sector (Figure 6). The Ring-billed gull largely dominates the Quebec City and Bellechasse Island colonies, where a few Herring gulls, Great black-backed gulls and Double-crested cormorants also nest. The study area, together with the Cap Tourmente marsh, forms the eastern limit of the nesting grounds for the Least bittern, Common moorhen, Marsh wren and Sedge wren. It is also the eastern limit of the Canvasback's fall migration corridor in Quebec.

In spring and fall, large numbers of migratory birds use the *Scirpus* marshes as feeding grounds. In spring 1989, an inventory put the number of geese and ducks in the study area at 45 600, including some 40 000 Greater snow geese, or 10% of the population present in the estuary at the time of the species' migration to its Arctic nesting grounds. The Greater snow goose uses mainly the flats in the downriver sector of the Île d'Orléans channel (Figure 6). Other abundant species in spring are the Canada goose, which frequents mostly the Beauport flats, the Black duck and the Northern pintail, particularly abundant on the north bank of Île d'Orléans.

In fall, Greater snow geese congregate in the Cap Tourmente National Wildlife Area on the periphery of the study area and are thus much less abundant in the area than in spring. Dabbling ducks too, but especially diving ducks return in greater number than in spring and congregate mostly on the Côte-du-Sud.



Taken from: Mousseau, P., and A. Armellin. 1995. *Synthèse des connaissances sur les communautés biologiques du secteur d'étude Québec-Lévis.* Technical report on ZIP 14. St. Lawrence Centre, Environment Canada - Quebec Region, Conservation Branch.

Figure 6 Main areas used by waterfowl, colonial birds and shorebirds in Quebec City–Lévis

Shorebirds, such as sandpipers, plovers and yellowlegs, are also more abundant in fall than in spring. The Semipalmated sandpiper is largely dominant among the group of birds which flock in great number to the mud flats at the mouth of the Sainte-Anne River and Saint-Vallier cove, as well as the Beauport beach and bay (Figure 6). The only aquatic species that overwinter in significant numbers in the study area are the Herring gull, Great black-backed gull, Iceland gull and Glaucous gull.

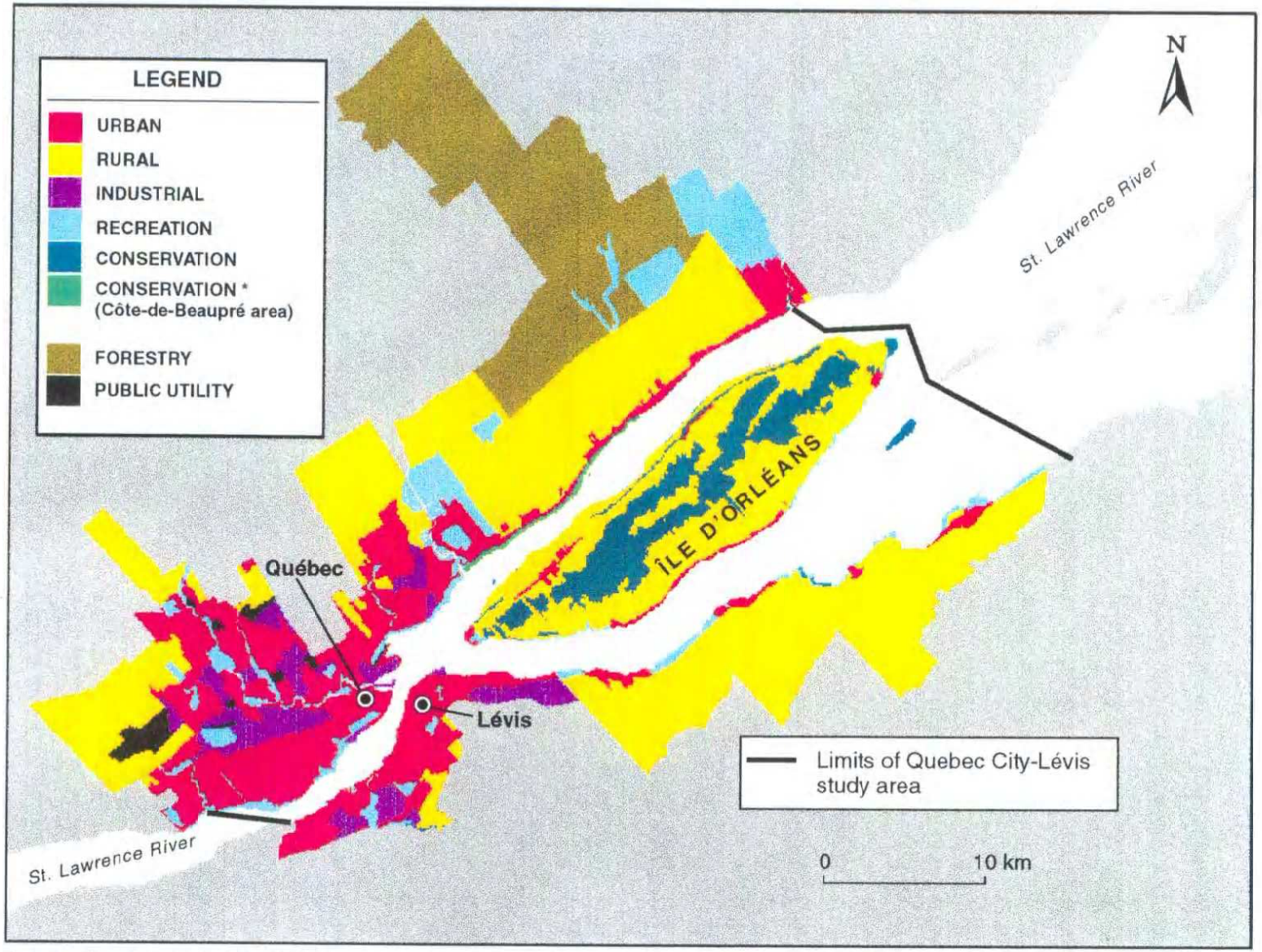
Populations of Canada goose, Black duck and Blue-winged teal, including some individuals which frequent the Quebec City–Lévis sector, are now in decline. In the case of the Canada goose population, which uses the Atlantic flyway, signs of decline first appeared in the mid-1980s; its present status is worrisome. In contrast, the Greater snow goose population has grown considerably in the twentieth century, soaring from a few thousand individuals in 1900 to almost 600 000 in 1994. Owing to this spectacular growth, the species has extended its feeding area to local farmlands, a situation that puts the birds in conflict with farmers during the spring migration.

The Quebec City colony of Ring-billed gulls has also posted spectacular growth, from 1400 pairs in 1983 to 18 771 in 1994. It is one of the largest colonies of this species in Quebec. The great abundance of Ring-billed gulls in the midst of the urban centre has raised questions about the possible threat to public health posed by this species.

Among the 15 species of SLV 2000 priority birds frequenting the Quebec City–Lévis sector (Appendix 1), the Peregrine falcon, Northern pintail and Blue-winged teal are the only confirmed nesters in the area. The latter two species show a marked decline in their numbers in North America. However, Quebec City–Lévis is critical only to the survival of the Peregrine falcon. The area does, however, have suitable habitats for several priority species.

3.5 Human Occupation

The Quebec City–Lévis sector encompasses 23 riverside municipalities occupying a total surface area of 1070 km^2 and with an overall population of 423 600 people. Land use in these municipalities breaks down as follows: 46% rural, 23% urban, 17% forest, 7% recreational and 7% conservation (Figure 7).



* As the Côte-de-Beauport RCM development plan has not taken effect and this conservation area is in dispute (see text), we decided to show it separately.

Taken from: Jourdain, A., and J.-F. Bibeault. 1995. *Synthèse des connaissances sur les aspects socio-économiques du secteur d'étude Québec-Lévis.* Technical report on ZIP 14. St. Lawrence Centre, Environment Canada - Quebec Region, Conservation Branch.

Figure 7 Land use patterns in riverside municipalities in Quebec City–Lévis

The study area comprises two large urban centres, Quebec City on the north shore and Lévis on the south shore. Its western end is highly urbanized; in addition to Quebec City's first suburbs of Sillery and Sainte-Foy, more suburbs have sprung up since the 1960s, including Cap-Rouge, Beauport and Beaupré on the north shore and Saint-Romuald on the south shore. Cottaging expanded considerably in Quebec City–Lévis from 1960 to 1975. With the exception of the north bank of Île d'Orléans, almost the entire non-urbanized shoreline is taken up by a continuous strip of cottages in riverside villages on either side.

3.6 Developed Uses

Up until the close of World War II, the St. Lawrence was the centre of economic development in the Quebec City region. Industrialization since that time appreciably altered everyday river-related uses in riverside communities.

Water supply. The St. Lawrence is the source of drinking water for just over 31% of the 423 600 inhabitants of the riverside municipalities in the study area. Close to 64% of them draw their water from one of the tributaries and 5% from groundwater sources. The municipalities of Cap-Rouge, Sainte-Foy, Saint-Romuald and Lévis are supplied directly from the river at the rate of some 85 000 m^3/day. In 1986, six industrial plants were drawing more than one million cubic metres of water annually from the river or one of its tributaries. Total consumption by area municipalities and industrial facilities, regardless of source of supply, amounted to close to 515 000 m^3/day in the 1980s.

Shipping. River navigation was long the most efficient means of transporting goods and people in the area. It dramatically lost ground to road transport beginning in the 1950s, and many village wharves are now dilapidated.

In the mid-nineteenth century, Quebec City was one of North America's leading seaports and shipbuilding centres. The decline of the Port of Quebec in favour of the ports of Montreal and the Great Lakes began in 1840 with the first phase of dredging of the ship channel between Quebec City and Montreal. It accelerated with the 1959 opening of the St. Lawrence Seaway between Montreal and the Great Lakes. Still, during the 1970s, the facilities of the Port

of Quebec underwent considerable expansion when part of the Beauport flats was backfilled to create new wharves and the North Crossing between Île d'Orléans and the Montmagny islands was dredged to give supertankers access to the Port of Quebec.

Today, the Port of Quebec includes a series of facilities on either shore between the Quebec Bridge and the western tip of Île d'Orléans. It ranks second in Quebec in terms of the value of goods handled, mainly crude oil, petroleum products and grain. On top of the 14 to 18 million tonnes of commodities handled in the port annually, more than 100 million t/year are transited through this river section.

Commercial fishing. The commercial fishery in the study area was an important activity up until the late 1960s. When the area was first settled, the division of land into narrow lots perpendicular to the river eased access to fish stocks. Weirs set up on the flats quickly became the most efficient fishing gear in this tidal environment. For centuries, the main species caught was the American eel, long a staple food for settlers. The actual commercial fishery peaked in the mid-1950s, when the study area had more than 200 fishermen with annual landings of more than 250 tonnes of eel, for the most part, but also large volumes of anadromous fish (Atlantic sturgeon, American shad, Lake whitefish, Striped bass, Atlantic salmon and Sea trout) and freshwater fish (Lake sturgeon and walleye species).

The disastrous decline in anadromous fish populations during the 1950s and 1960s, growing urbanization of the study area and toxic contamination of American eel and walleye led to the near-total collapse of this fishery. Today, some ten commercial fishermen are active in the Quebec City–Lévis sector, where there has been a seven-fold decline in landings since the 1950s. American eel, Atlantic sturgeon and walleye species are the main fish caught.

Sport fishing. Prior to the 1970s, Rainbow smelt and Striped bass were the main species of sport fish in Quebec City–Lévis. Smelt attracted hordes of fishermen to the mouth of the Boyer River in spring, during migration to their main spawning area in these waters. From September to mid-December, when smelt migrated from the Upper Estuary to the Fluvial Estuary, the Sillery, Quebec City and Lévis wharves were overrun by anglers. Today, smelt have abandoned the Boyer River spawning ground, degraded by agricultural, household and industrial

pollution, and the species no longer migrates upriver from Quebec City in fall. Sport fishing for smelt has become a marginal activity in the study area. A plan to rehabilitate the Boyer River was drawn up in 1992, primarily to restore the smelt spawning ground.

Sport fishing for Striped bass around Île d'Orléans and the Montmagny archipelago, on the margins of the Quebec City–Lévis sector, ceased in the mid-1960s at the same time as the Striped bass population vanished from the St. Lawrence. This species was fished in August from boats, and on Île au Ruau, one of the best bass fishing sites, annual fishing derbies attracted more than 2000 participants and over 200 craft. Today, Walleye and Atlantic tomcod are the main species caught by sport fishermen in the study area. Trout is fished at the foot of the Chaudière and Montmorency river falls, but the volume of activity is unknown.

Waterfowl hunting and bird-watching. The best sites for hunting waterfowl in Quebec are located in the area where Greater snow geese congregate in fall – the Saint-Joachim–Cap Tourmente area, the Montmagny islands and the Montmagny–Cap Saint-Ignace area bordering the study area. In the Quebec City–Lévis sector, waterfowl are hunted mainly along the Beaupré coast and on the Côte-du-Sud, near areas where Greater snow goose congregate. This species, along with the Black duck, Blue-winged teal, Northern pintail, Mallard and Lesser scaup are the main species harvested in Quebec City–Lévis.

Bird-watching is quite widespread in the study area. Bird-watchers favour the southern end of the Île d'Orléans bridge for geese and dabbling ducks in spring, and Beauport Bay for a wide variety of shorebirds and dabbling ducks in fall. The latter site was greatly altered by additional backfilling for the Port of Quebec in the 1960s and 1970s.

Swimming and windsurfing. The popularity of swimming in the St. Lawrence in Quebec City–Lévis peaked during the 1950s. In the 1930s, many resorts opened around the sandy coves of Île d'Orléans, the Côte-du-Sud and Saint-Romuald. This was also when Foulon beach was created at Sillery. These beaches and a number of other bathing spots attracted crowds in the mid-1960s before early bacteriological analyses showed that the water quality made all the beaches unsuitable for swimming. In 1994, none of the riverside beaches was officially open for swimming.

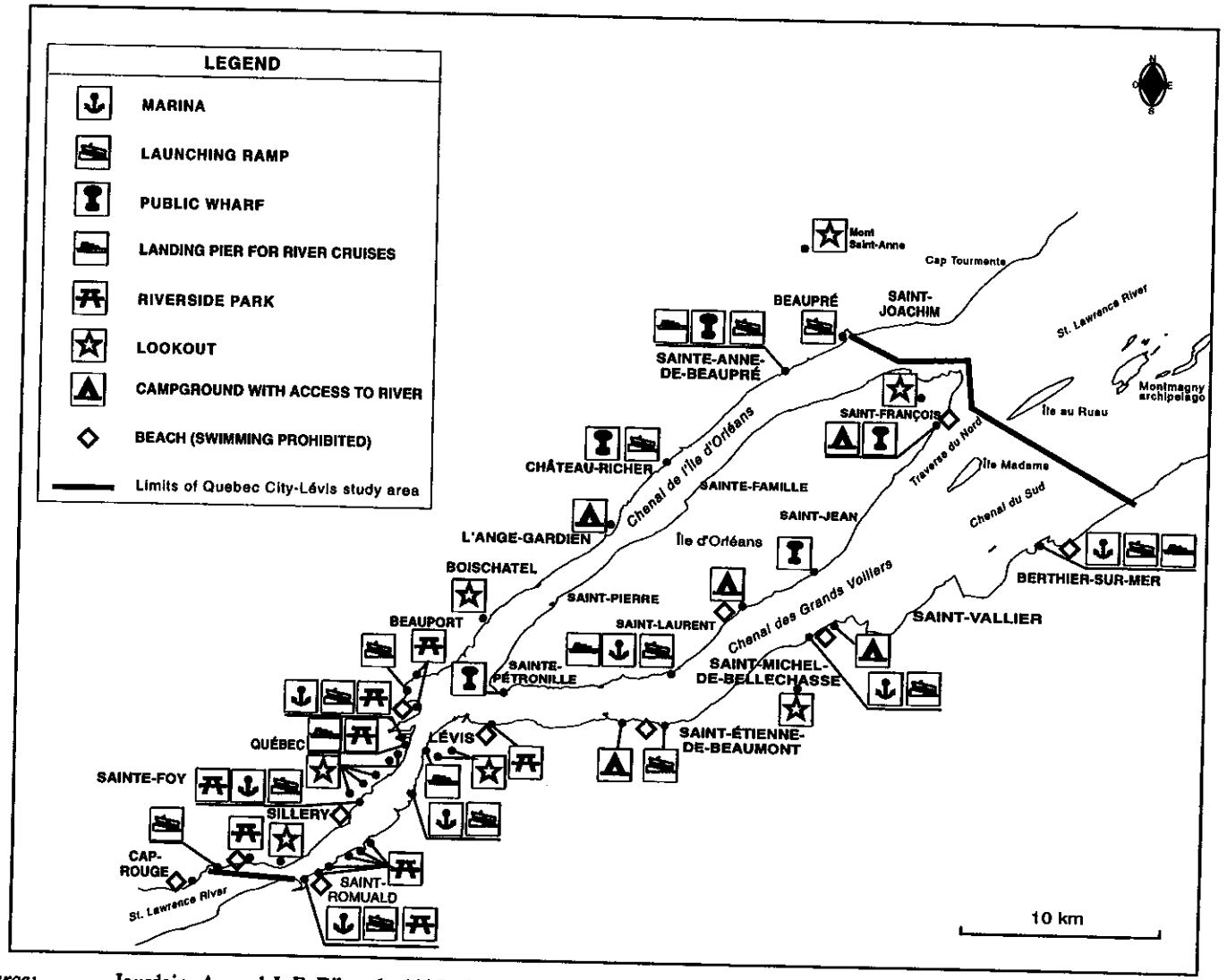
However, windsurfers have been drawn to a few of these once-crowded beaches, along with the new beach created on the Beauport flats.

Pleasure boating. Boating has been practised in the Quebec City area for more than 130 years. This activity grew considerably starting in the 1960s, but in 1972 there was still only one marina in the Quebec City–Lévis sector. The 1984 Tall Ships Festival in Quebec City gave a big boost to the development of boating infrastructures, and the study area now has seven marinas with a capacity of about 1200 boats, 13 boat-launching ramps, three federal wharves and two municipal wharves (Figure 8).

River cruises and excursions. In the first half of the twentieth century, Quebec City was an important stopover for Canada Steamship Lines' cruise ships, which carried vacationers to the cottage country of Charlevoix and the Lower St. Lawrence (Bas-Saint-Laurent). From 1965 to the early 1980s, the cruise and excursion industry went into a slump. Today, the Port of Quebec welcomes nearly 40 000 ocean-going cruise passengers annually and 4000 river cruise passengers. Quebec City is also the home port for six excursion ships (capacity slightly above 2000 passengers), sailing mainly to the outskirts of Quebec City and the Montmagny islands. A seventh boat makes excursions in the Montmagny archipelago from Berthier-sur-Mer. One of the largest ships in the area (1000-passenger capacity) saw business double from about 50 000 passengers in 1982 to more than 100 000 in 1990.

Recreation, tourism and the river. The Quebec City–Lévis sector is one of Quebec's hubs of recreation and tourism and a world-renowned destination. In 1988, the Quebec City tourist area attracted 3.74 million visitors and generated economic spinoffs of about $712 million. The Chaudière–Appalaches tourist area, on the south shore of the study area, attracted close to 500 000 visitors in 1990, with spinoffs totalling at least $35 million.

Old Quebec, a world heritage jewel recognized by UNESCO, with its hotels and restaurants, is the undisputed cornerstone of recreation and tourism. It is set in a landscape of exceptional beauty, where the St. Lawrence River is the centrepiece. Seen from the river, the Quebec City–Lévis sector appears urban here, rural there, but always captivating. The landscape



Source: Jourdain, A., and J.-F. Bibeault. 1995. *Synthèse des connaissances sur les aspects socio-économiques du secteur d'étude Québec-Lévis.* Technical report on ZIP 14. St. Lawrence Centre, Environment Canada - Quebec Region, Conservation Branch.

Figure 8 Main access points on the river in Quebec City–Lévis

is dominated just about everywhere by wooded cliffs. The many points of interest include Montmorency Falls and the Cap Diamant escarpment (92 m high), crowned by the Quebec Citadel.

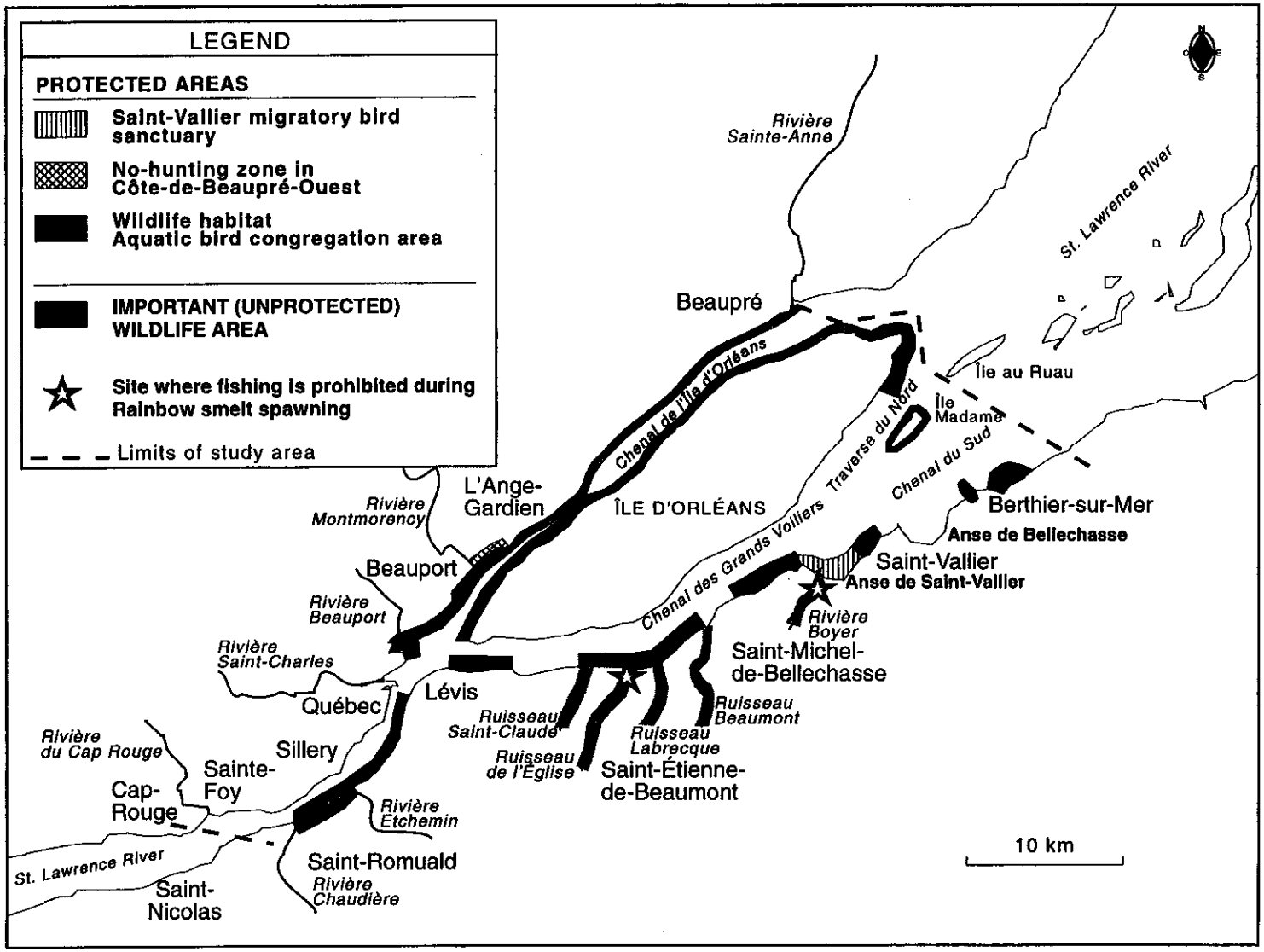
The top of the cliff offers many river vistas, from lookouts and urban parks, onto the main natural attractions: Quebec City, the countryside of Île d'Orléans and the Côte-du-Sud, and Mont Sainte-Anne, behind Beaupré.

The Quebec City–Lévis sector has many other attractions as well, including Île d'Orléans, established as a historic district for its great heritage value, the parks of Montmorency Falls and Mont Sainte-Anne, and the migratory bird sanctuary in the Saint-Vallier cove.

Its attractiveness for cottagers made the river an important influence in the development of recreation and tourism. Between 1930 and 1950 especially, waterfront resorts and cottage communities sprang up along the coves on the St. Lawrence and Saint-Jean coasts on the south bank of Île d'Orléans, and near Saint-Étienne-de-Beaumont, Saint-Michel-de-Bellechasse and Berthier-sur-Mer on the Côte-du-Sud. Today, cottaging persists, especially on Île d'Orléans, but the only resort areas left are the beaches of Berthier and the Beauport flats.

Although certain recreational activities have declined in the river in recent years – the most striking example being swimming – the St. Lawrence is still a major asset for recreation and tourism development. The growth of river cruises and interest in the Old Port of Quebec are proof of this. Moreover, a "back to the river" movement is taking shape, with emphasis on the redevelopment and enhancement of parks, beaches, itineraries and integrated riverside drives, especially along the shoreline of the Quebec Urban Community (QUC) and Saint-Romuald. The recreation function claims an estimated 38% of the riverbanks in the study area.

Conservation. Sites with protected status in Quebec City–Lévis, shown in Figure 9, are the migratory bird sanctuary in Saint-Vallier, the no-hunting area in Côte-de-Beaupré-Ouest, and waterfowl gathering areas that have enjoyed the status of wildlife habitat on public land since 1993. The status of sanctuary means that any activity likely to harm migratory birds is prohibited; hunting is prohibited in no-hunting zones; and the purpose of wildlife habitats is to prohibit any activity likely to alter habitat characteristics.



Source: Mousseau, P., and A. Armellin. 1995. *Synthèse des connaissances sur les communautés biologiques du secteur d'étude Québec-Lévis.* Technical report on ZIP 14. St. Lawrence Centre, Environment Canada - Quebec Region, Conservation Branch.

Figure 9 Protected areas and other important wildlife areas in the Quebec City–Lévis sector

The de l'Église, Saint-Claude, Beaumont and Labrecque streams, smelt spawning grounds all, have no protective status other than protection under federal fisheries policy applying to fish habitat. During the spawning period, smelt fishing is banned in the de l'Église stream and the Boyer River. Two areas are targeted for conservation under the St. Lawrence Vision 2000 action plan, one along the Beaupré coast and the other at Saint-Romuald.

As shown in Figure 7, conservation use predominates in development plans on Île d'Orléans, taking up about 50% of the land. This function also claims 14% of the riverside perimeter, especially on the north shore, where the Côte-de-Beaupré regional county municipality (RCM) has designated part of its shoreline for conservation. This should not be interpreted, however, as a measure to protect the intertidal zone, which has recognized ecological value. In fact, the Ministère de l'Environnement et de la Faune (MEF) and the Côte-de-Beaupré RCM have been locked in contention for several years over the boundaries and thus the future of the intertidal zone. The MEF is recommending increased protection, whereas several projects of the Côte-de-Beaupré RCM suggest uses, facilities and development of the shoreline zone that would jeopardize its ecological value.

Harvesting of riparian vegetation. Until the beginning of the twentieth century, the wet meadows on the north bank of Île d'Orléans were harvested in fall for cattle feed. Cordgrass was also cut in November to cover outbuilding roofs and to bundle grain at harvest time. Today, the wet meadows east of Sainte-Famille are still used to graze cattle, but harvesting is confined to smaller and smaller areas.

CHAPTER 4 Human Activities and Their Main Effects on the Environment

4.1 Physical Changes to the Environment

4.1.1 Changes in flow pattern

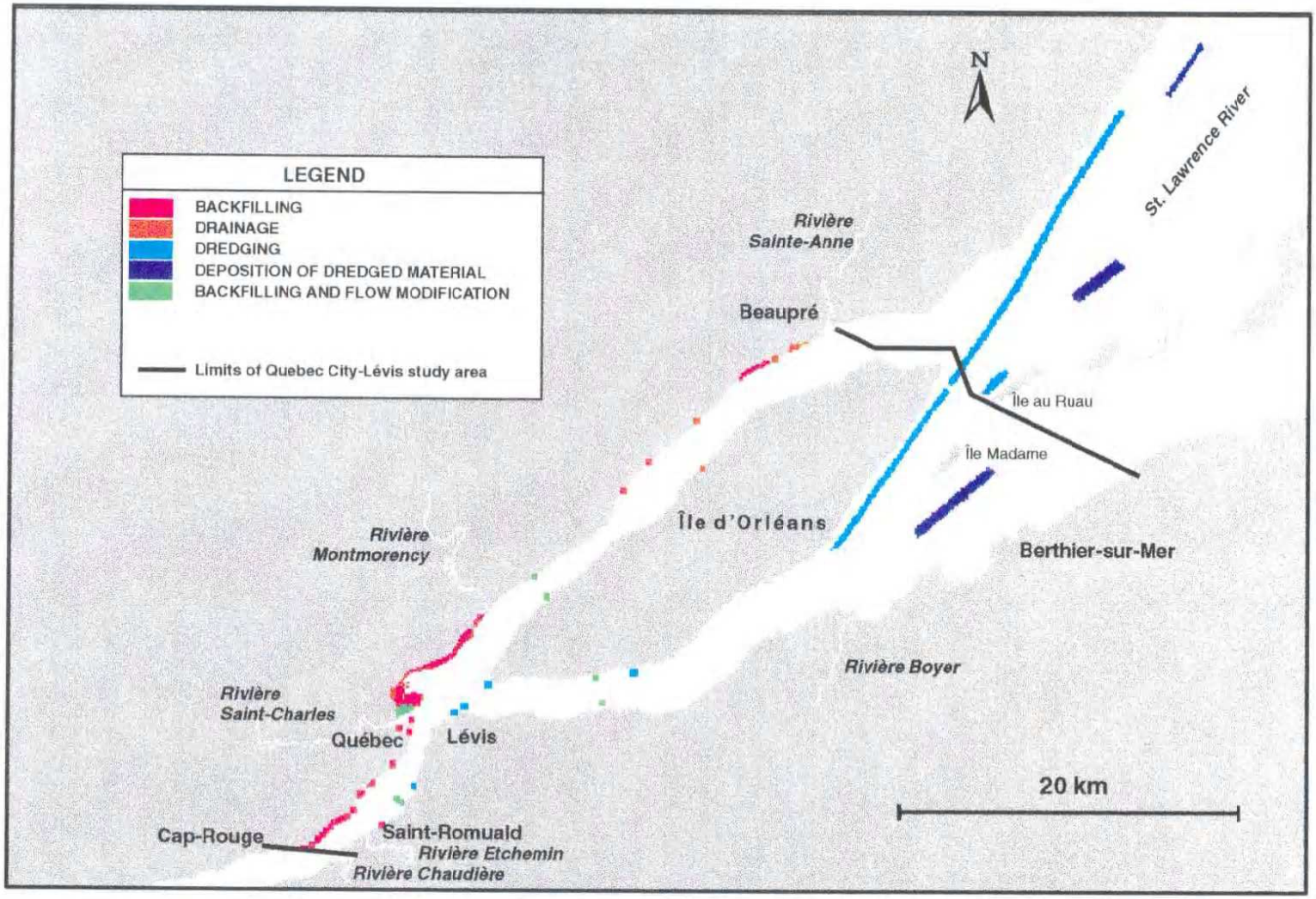
Water-level control in the Great Lakes, the many dams built on the main tributaries of the St. Lawrence upriver from Quebec City, excavation of the Seaway and the use of icebreakers between Montreal and Quebec City have altered the seasonal flow pattern of the river. Since 1958, spring flooding has occurred at more variable times, often earlier. The spates have been devastating for wetlands between Trois-Rivières and Quebec City owing to strong drift-ice erosion. There is, however, little documentation on changes in the Quebec City–Lévis sector since 1958. Strong erosion of the wet meadows in the Cap-Tourmente and Montmagny region in the 1970s and 1980s was ascribed to the rise in mean water level following years of strong runoff.

Dredging of the river between Quebec City and Montreal concentrated the river flow in the new channel, and the new flow pattern may affect the migration of certain fish species, Atlantic tomcod for one. The overall effect of streamflow changes has evidently been to promote undemanding species that find all the habitat they need for their life cycle in a limited area, suckers being an example, to the detriment of species that have to migrate, such as anadromous fish.

Facilities in Quebec City–Lévis that have had the greatest impact on river hydrodynamics are port installations (Saint-Charles River estuary, Louise Basin), which have created sediment traps, and dredging of the North Crossing (Figure 10).

4.1.2 Encroachment on riverbanks

According to riparian land-use designations, more than 66% of the riverfront in the study area is built up.



Source: Robitaille, J.-A., Y. Vigneault, G. Shooner, C. Pomerleau, and Y. Mailhot. 1988. *Modifications physiques de l'habitat du poisson dans le Saint-Laurent de 1945 à 1984 et effets sur les pêches commerciales.* Fisheries and Oceans, Fisheries Research Branch. Canadian Manuscript Report of Fisheries and Aquatic Sciences, No. 1608, and atlas.

Figure 10 Physical changes in aquatic and riparian habitats inventoried in Quebec City–Lévis between 1945 and 1984

Since 1945, an estimated 11% of the 2160 ha of *Scirpus* marshes and wet meadows and 13% of the 390 ha of treed or shrubby swampland in Quebec City–Lévis have been backfilled or diked. The 35 km along the north shore between the Quebec Bridge and Boischatel were completely backfilled or diked for Champlain Boulevard, port installations and the Dufferin-Montmorency Highway (Figure 10). Since 1861, an estimated 700 ha of river and riverbanks have been backfilled in the area. Expansion of the Port of Quebec and construction of the Dufferin-Montmorency Highway in the 1970s eliminated some 80 ha of *Scirpus* marshes and large expanses of mud flats on the Beauport flats.

Between 1964 and 1985, farther downriver on the north shore, the 27 km between Boischatel and Beaupré lost about 400 ha of wetlands that were backfilled in places to gain more land along Sainte-Anne Boulevard. The remaining 160 ha of swamp and wet meadow are a point of contention between the Côte-de-Beaupré RCM and the MEF over definition of the high-water level and use of the flood plain.

On the north bank of Île d'Orléans, farmland often encroaches on the swamp and wet meadow, whereas on the south bank and along the Côte-du-Sud, the many retaining walls keep high waters away from the encroachments made to expand the lawns of cottages and houses.

4.1.3 Dredging

The North Crossing sector of the St. Lawrence ranks first for annual volume of dredged sediment, with an average of 90 280 m^3 per year between 1984 and 1991. Part of the dredged material is dumped at a deep-water site south of Île Madame (Figure 10).

The discharge of dredged material into open water changes fish habitats in a way that may be deleterious for certain species. In the study area, these deposits have altered the particle size distribution on certain parts of the riverbed. Some muddy bottoms, favourable for Atlantic eel, are now covered with sand, a much less favourable substrate for this species. Unconsolidated bottoms provide habitat for benthic organisms on which several fish species feed. Coarser materials, such as sand, reduce the abundance and diversity of these benthic invertebrates and thus affect the availability of prey for the fish.

4.2 Pollution

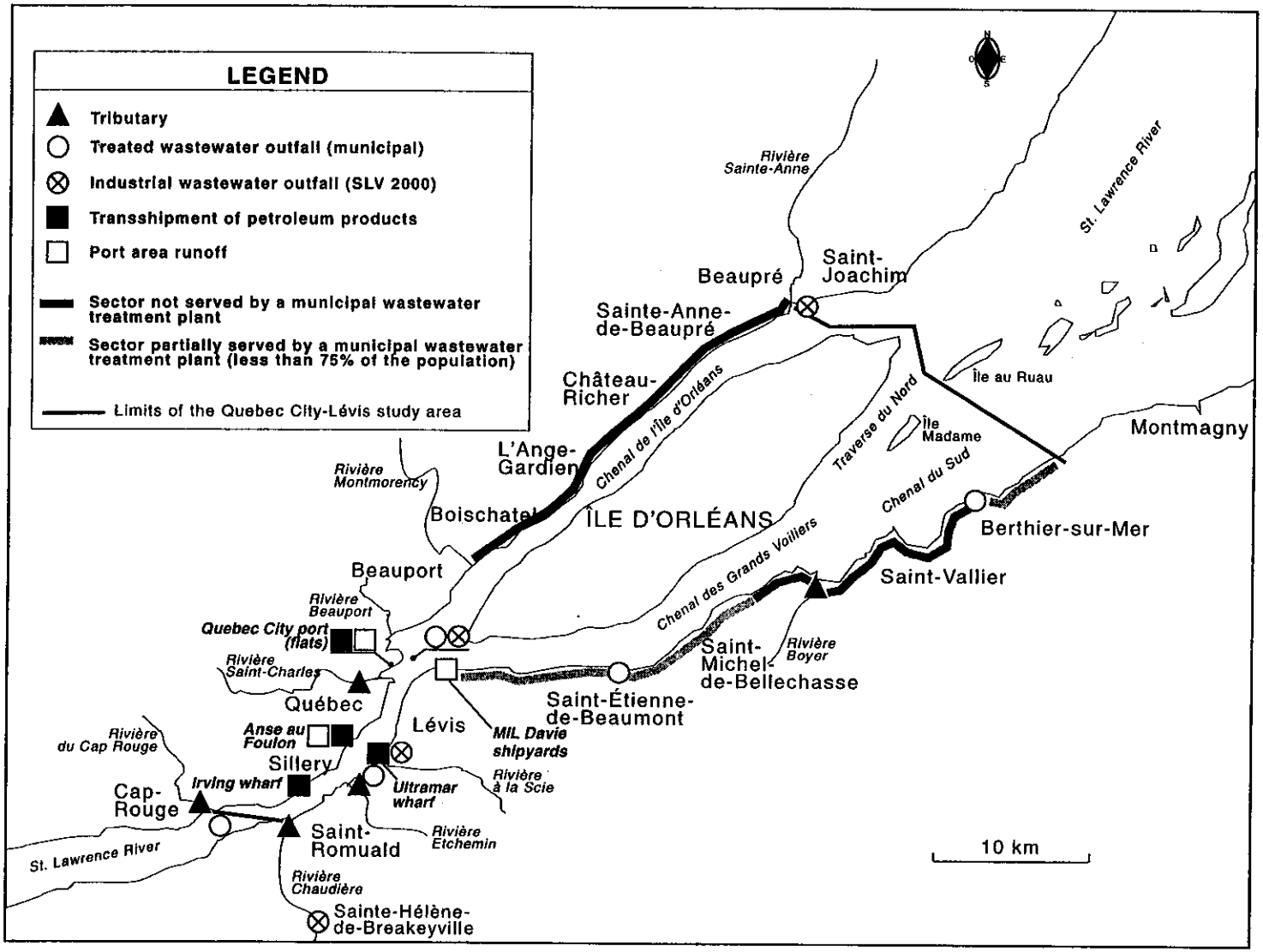
Human activities are at the origin of many types of pollution – organic, nutrient, bacterial, toxic and aesthetic. This section briefly describes the main sources of pollution; the second section describes how pollution has affected resources and entailed loss of use of the St. Lawrence. The risks to human health are described in the third section.

4.2.1 Sources of pollution

Apart from the river upstream, the main sources of pollution in the Quebec City–Lévis study area are the tributaries that empty into it, municipal and industrial outfalls, and runoff water from the port areas (Figure 11). Industrial establishments are generally the main sources of toxic substances; municipal effluent contains suspended solids, organics and nutrients, fecal coliforms and metals. Nonpoint-source atmospheric pollution reaches the river in large part through these varied sources. For example, the storm sewer overflow during heavy rainfall contains atmospheric pollutants deposited on impervious surfaces in the urban environment. The accidental spill of contaminants in the Seaway and dredging activities are potential sources of pollution.

St. Lawrence River. Owing to its strong flow, the river upstream of Quebec City–Lévis accounts for more than 90% of the total input of organic matter, nutrients (nitrogen, phosphorus) heavy metals (e.g. cadmium and lead) and toxic organic substances (e.g. pesticides, PCBs and hydrocarbons) in the area. It is noteworthy that the vast majority of the toxic organic matter is of anthropic origin (produced by human activities), whereas the heavy metals found in the water come from natural weathering of rocks as well as human activities in the drainage basin.

The still sketchy data on recent changes in water and sediment quality in the St. Lawrence upstream from Quebec City suggest that toxic inputs to the river have been significantly reduced since the early 1970s by such measures as the prohibition and decline in use of many substances, improvement of industrial processes, and urban and industrial cleanup



Sources: Jourdain, A., and J.-F. Bibeault. 1995. *Synthèse des connaissances sur les aspects socio-économiques du secteur d'étude Québec-Lévis.* Technical report on ZIP 14. St. Lawrence Centre, Environment Canada - Quebec Region, Conservation Branch.
Fortin, G., and M. Pelletier. 1995. *Synthèse des connaissances sur les aspects physiques et chimiques de l'eau et des sédiments du secteur d'étude Québec-Lévis.* Technical report on ZIP 14. St. Lawrence Centre, Environment Canada - Quebec Region, Conservation Branch.

Figure 11 Main sources of pollution in Quebec City–Lévis

programs in the Great Lakes–St. Lawrence system. But though a reduction has been noted since the early 1970s, certain substances that are largely insoluble in water and very persistent in the environment – such as DDT, PCBs and PAHs – still occur in worrisome concentrations in the river.

Tributaries. Although their combined flow is 50 times lower than the discharge of the river, almost all tributaries of the St. Lawrence within the Quebec City–Lévis sector are characterized by a high degree of degradation. South shore tributaries drain areas that are predominantly agricultural and that carry large quantities of organic matter, nutrients, pesticides and coliform bacteria, mainly from farmland erosion and runoff of animal waste.

On the north shore, the lower courses of all the large tributaries except for the Montmorency River are contaminated by storm sewers and the overflow from combined and sanitary sewers during rainfall. In addition, there are many industrial plants in the drainage basin of the tributaries within Quebec City–Lévis, including four targeted by SLV 2000, and nine hazardous waste sites.

The tributaries also contribute contaminants resulting from atmospheric fallout to the river, including lead, mercury, PCBs, polycyclic aromatic hydrocarbons (PAHs) and certain pesticides such as DDT.

Two tributaries in the area, the Chaudière and Boyer rivers, have been targeted by SLV 2000 for the reduction of agricultural pollution.

Municipal outfalls. Prior to 1991, virtually all municipal wastewater produced in the study area was discharged untreated to the river. Large numbers of municipal and industrial outfalls in the QUC emptied directly into the St. Lawrence or the Cap-Rouge, Saint-Charles and Beauport rivers. In the 1970s, they were interconnected to form two separate systems, each with a single outfall in mid-river at Sainte-Foy (western QUC) and the Beauport flats (eastern QUC). The numerous outfalls on the Lévis and Saint-Romuald side were not connected until the 1990s.

Today, the waters discharged to the river through the outfalls of the two QUC treatment plants are treated by biofiltration, boosted by disinfection in summer. These two plants serve 81% of the Quebec City–Lévis population, as well as many commercial and industrial

establishments subject to sewage discharge standards. Four other treatment plants on the south shore, including those at Lévis, Saint-Romuald, Saint-Étienne-de-Beaumont and Berthier-sur-Mer, complete the municipal cleanup picture. They serve 12% of the population in the study area and discharge water that has been biotreated in aerated lagoons without disinfection. In the eastern end of the study area, especially on the north shore, several outfalls discharge untreated wastewater from 4% of the population. A few years from now, that effluent will be routed to treatment facilities. Three per cent of the population uses septic installations, mostly on Île d'Orléans.

Since their inauguration in 1992, the QUC's two treatment plants have been plagued with problems with their biofiltration and disinfection processes. What is more, the overflow of the QUC sewer systems during heavy rains is discharged untreated through some 50 small outfalls along the tributaries (e.g. Saint-Charles River) and the St. Lawrence, particularly via the Sainte-Foy tunnel. The performance of the Lévis treatment plant, inaugurated in 1991, was deemed to be acceptable in 1993, despite problems of overflow.

Some municipalities (Sillery, Saint-Romuald and Lévis) are still dumping snow collected from city streets into the river. This practice is to be discontinued in 1996.

Industrial outfalls. Heavy industry is concentrated primarily in the industrial/port zone of Quebec City and the Lévis–Saint-Romuald sector on the south shore. Given the lack of precise discharge data for all the industrial plants in these areas, only recently characterized plants targeted by SLV 2000 are mentioned here.

The Quebec City–Lévis sector has three plants targeted by SLV 2000 discharging large amounts of wastewater that ends up in the St. Lawrence, and another plant along the Chaudière River. The Daishowa pulp and paper mill, at the mouth of the Saint-Charles River, discharges 107 500 m^3/day of process, cooling and sanitary wastewater which has undergone primary treatment and is channelled to the river through the east-QUC diffuser. In 1990, the substances of concern discharged to the river were organic matter with high biological oxygen demand (BOD_5), tannin and lignin, oils and greases, phosphorus, aluminum and many toxic organic substances, including PCBs. By being more selective in its supply of old paper and

improving quality control of the de-inking process, in 1992, PCB discharges were eliminated altogether, reducing effluent toxicity by 95%. In 1994, Daishowa undertook construction of a system for the secondary treatment of its discharges by activated sludge with pure oxygen. This should bring the company in line with new government requirements for organic discharges in 1995.

The Abitibi-Price pulp and paper mill in Beaupré dumps about 33 000 m^3/day of process, cooling and sanitary wastewater into the Vases River, which connects with the St. Lawrence. In 1988, this plant dumped large amounts of suspended solids (SS), biodegradable organic matter, heavy metals and toxic organic substances. A settling tank brought on line in 1989 has reduced the SS content of the effluent by 72% and its toxicity by 30%. In 1995, plans call for activated-sludge treatment that would further reduce the toxicity and organic loading of the effluent. Another measure contemplated is the diversion of sanitary wastewater to the municipal sewer system.

The Ultramar Canada refinery in Saint-Romuald dumps process water – cooling water for the most part – into the river. This effluent is pretreated in a settling tank, degreased, de-oiled and aerated before being discharged to the river, along with unpolluted rainwater, through a private outfall. The discharge amounts to 8800 m^3/day. The main pollutants dumped into the River are oils and greases, ammonia nitrogen, phenols and sulphides. The discharges do, however, comply with regulations, and no further pollution-control process is foreseen. Still, the company will review its wastewater treatment facilities in 1995. Ultramar Canada discharges several tonnes of pollutants into the atmosphere each year, including nearly 14 tonnes of benzene.

The Cascades de-inking plant in Sainte-Hélène-de-Breakeyville discharges some 900 m^3/day of wastewater into the Chaudière River. Problem areas are SS, BOD and the overall toxicity of the effluent, which occasionally exceeds provincial discharge standards.

Port areas. Runoff is a potential source of pollution in Quebec City's port area. The main sources are associated with ship maintenance and repair (MIL-Davie in Lévis); storage and handling of bulk metals (copper, iron), phosphorus, metallic waste, coal and salt (Saint-Charles

River estuary and Anse au Foulon); and the storage and use of petroleum products (Saint-Charles River estuary and Irving and Ultramar wharves).

Hazardous waste sites. According to provincial and federal inventories, there are nine hazardous waste sites in the study area, including the Port of Quebec. Owing to its location, Quebec City's incinerator dump on the Beauport flats is among the problem sites for river contamination. This ash dump, used from 1971 to 1975, is now partially covered by the Dufferin-Montmorency Highway. It contains construction and household waste, incinerator ashes and an undetermined amount of chemical and petroleum products. Part of the dump sits right in the river. While this site poses no danger to public health, it may be a source of local contamination. The other hazardous waste sites in Quebec City–Lévis pose fewer risks of direct contamination of the St. Lawrence.

Risks of accidental oil and chemical spills. Every year, about 60 oil tankers, some of them as large as 160 000 tonnes, make their way to the Port of Quebec; 200 smaller tankers travel between Quebec City and Montreal. The only recent accidental spill occurred in 1988, when 320 tonnes of crude oil poured from a ship moored at the Ultramar wharf and polluted 100 km of shoreline downriver to Île aux Grues. The narrow, shallow profile of the ship channel, strong currents, high tides, ice and the size of the ships make navigation very difficult in the Quebec City–Lévis sector and the risk of major oil spills is great.

Dredging. The largest quantities of sediment dredged in the St. Lawrence are dredged in the Quebec City region. Between 1984 and 1993, an average of 105 000 m^3/year of sediment was dredged there, including 69% in the North Crossing. Other sites are occasionally dredged; there was extensive dredging for the development of marinas (Lévis and Saint-Laurent in 1983, Berthier-sur-Mer in 1988) and approaches to the MIL-Davie shipyard in Lévis in 1988. In the latter case, some 15 000 m^3/year will be dredged in the area around the wharves over the next ten years.

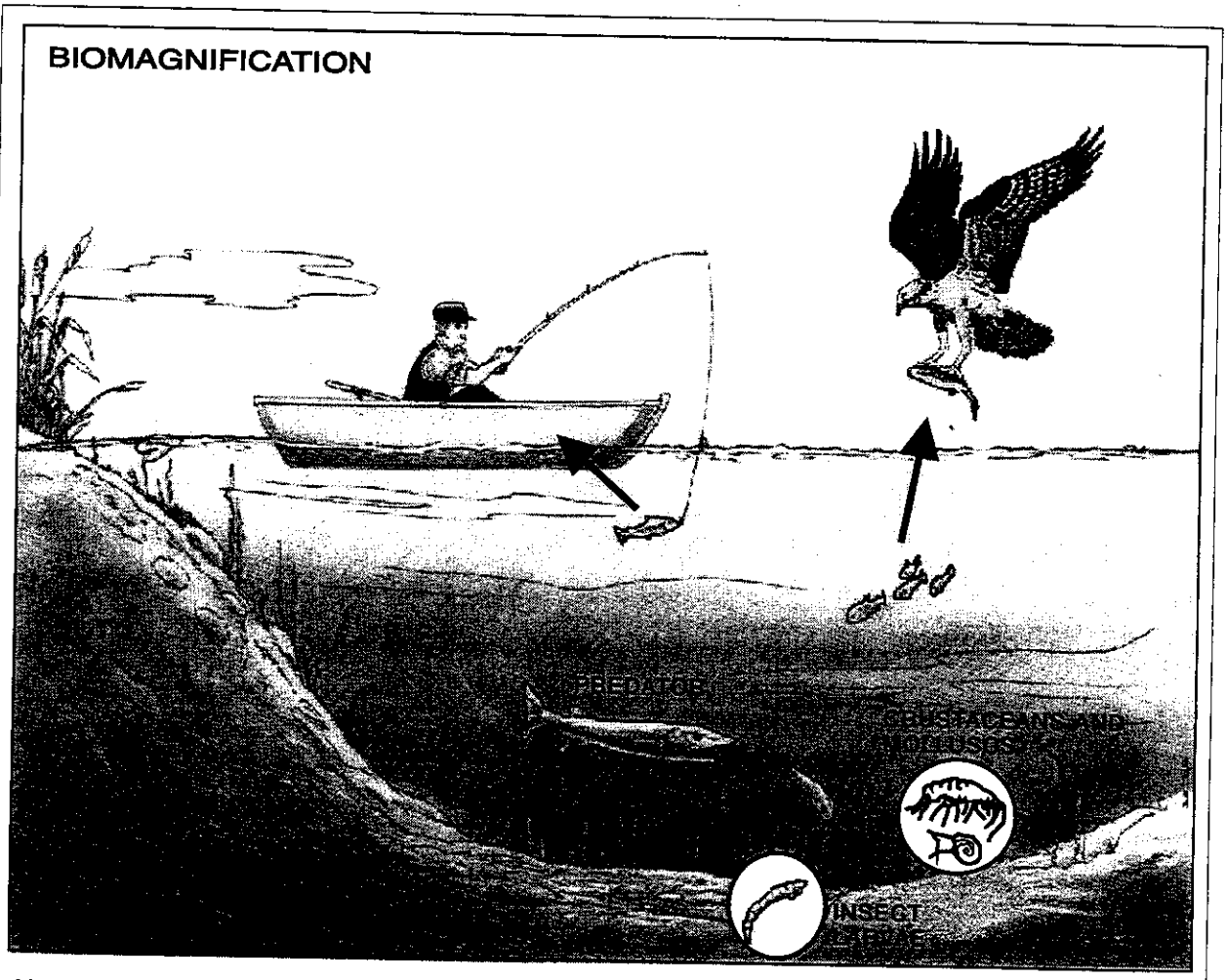
Dredging of contaminated sediment and its discharge into open water may result in the re-suspension of its toxic content. However, the impacts of this activity on the natural environment in Quebec City–Lévis are unknown.

4.2.2 Effects on resources and uses

Water pollution in Quebec City–Lévis as described below is based on data gathered between 1985 and 1994. The sediment pollution profile is based on data gathered in 1989 and 1991.

Whatever their origin, the pollutants found in the aquatic environment pose varying degrees of risk for the normal functioning of living organisms. Coliform bacteria, phosphorus and nitrogen have no lasting effects, and environmental quality quickly improves once discharges stop or as one moves away from the sources of pollution. However, pollutants such as mercury, PCBs and DDT tend to concentrate in sediments and organisms. Bivalve molluscs, for example, may accumulate such pollutants in concentrations several thousand times the concentrations in ambient water. In addition, these substances tend to concentrate as materials are passed up the food chain through the process known as biomagnification (Figure 12). In this case, the substances are gradually transferred to predators, which occupy the upper levels of the food pyramid, attaining high concentrations in these animals.

Water. Large quantities of pollutants reach Quebec City–Lévis mainly along the river upstream from Quebec City. As they are carried from the drainage basin to the estuary, most heavy metals of anthropic origin and toxic organic substances dissolved in the water are gradually adsorbed on suspended solids, the main vector of contamination, and thus become less bioavailable the farther one goes from the sources of pollution. Because of the input of solids between the Great Lakes and the estuary, the concentration of suspended particulate matter increases between the Great Lakes and Quebec City, and is twice as high in the Quebec City region as in the region of Montreal. Consequently, the particulate concentration of heavy metals and toxic organic matter in the waters around Quebec City is generally higher than in the Montreal area, but a large percentage of these substances are not bioavailable.



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

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

Figure 12 Risks of biomagnification

The reference criterion for raw water (not to be confused with the standard for drinking water quality) is the maximum allowable aqueous concentration of a substance in the environment in order to preserve the uses associated with drinking water supply and the consumption of aquatic organisms living in that water body (Appendix 2). This criterion is also aimed at keeping the aesthetic quality at an acceptable level for household uses (organoleptic and aesthetic quality).

Around the early 1980s, the parameters that often exceeded the raw water criterion in the study area were turbidity, iron, aluminum, arsenic and fecal coliforms. Partial results show that PCBs, PAHs and certain pesticides, including DDT and diazinon, also exceeded the reference criterion for raw water and for contamination of aquatic organisms. High turbidity will require more extensive chlorination of the water. Local concentrations of iron and aluminum appear to be naturally high. The iron criterion is strictly organoleptic and aesthetic (e.g. water taste and soiling of clothes), whereas the aluminum criterion is aesthetic (colour). The criterion for arsenic, PCBs, DDT, PAHs and diazinon takes account of bioaccumulation in fish and is thus much more stringent than the drinking water standard. Actually, this standard is not exceeded in raw water from the river in the case of arsenic, DDT and diazinon, while Quebec still has no standard for PCBs and PAHs. Measured arsenic values apparently represent concentrations that are widespread in the Great Lakes–St. Lawrence system. These substances are largely removed from the water by conventional filtration processes.

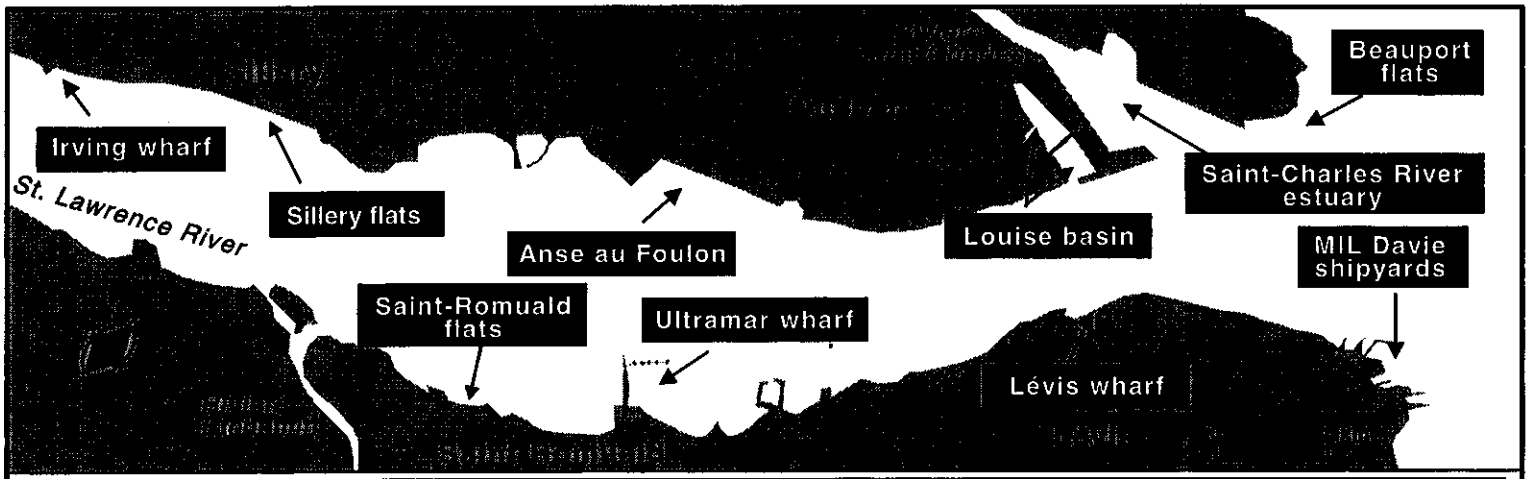
Based on 1985-1990 data, chromium and copper concentrations exceeded the chronic toxicity criterion for aquatic life in the waters of the Île d'Orléans and Grands Voiliers channels. Although a significant drop in phosphorus was observed between 1990 and 1994, concentrations measured in 1994 exceeded the criterion for the protection of aquatic life. Enrichment of water bodies with nutrients such as phosphorus may result in the proliferation of aquatic plant life where conditions are so conducive. Ensuing plant decomposition lowers the dissolved oxygen content of the water. These conditions are unfavourable for aquatic species and cause aesthetic problems and foul smells.

In summer, the coliform bacteria discharged to the river decay rapidly under the effects of solar radiation and predation by zooplankton. Nonpoint sources from upriver contribute to the degradation of bacteriological water quality, which would generally still be acceptable for all recreational uses if not for local inputs. Between 1990 and 1994, for example, bacteriological quality made the water unsuitable for swimming from Cap-Rouge to the downstream limit of the Île d'Orléans channel and up to Saint-Michel-de-Bellechasse on the south shore. Even in dry weather, the Beauport and Jacques-Cartier beaches were classified as "polluted" in 1994. This poor water quality was tied, in part, to discharges from the QUC, whose treatment plants were commissioned in 1992 but were not fully operational in dry weather. It was also related to sewage overflow in heavy rainfall. Moreover, although wastewater treatment in the QUC has improved bacteriological water quality in summer, the wastewater discharged in mid-river is quickly dispersed toward the banks due to the influence of tidal action on water circulation patterns. This affects water quality over several kilometres upriver and a few dozen kilometres downriver from these two main outfalls. Prior to 1992, the bacteriological quality criterion for raw water was occasionally exceeded at the Saint-Romuald, Lévis and Lauzon filtration plants. However, the water supply is not jeopardized in such cases, because disinfection ensures good-quality drinking water.

In the eastern sector of the study area, untreated wastewater from some small municipalities along the south shore and Côte-de-Beaupré may have a local impact on water quality.

Sediment. Between 1989 and 1991, most sites in the Quebec City port area were characterized by heavy-metal concentrations in excess of natural levels. But there were far fewer sites where concentrations reached a level potentially harmful for benthic fauna (above the toxic effect threshold for benthic organisms, Appendix 2). In fact, highly contaminated sediments are found at only two spots, Louise Basin and the Saint-Charles River estuary (Figure 13). These are also the only two large sediment deposition sites in the Quebec City–Lévis sector.

The Saint-Charles River estuary forms a reservoir containing nearly 4 000 000 m^3 of sediments highly contaminated by heavy metals (arsenic, cadmium, copper, lead, zinc), PCBs



SECTORS		INDEXES OF HEAVY-METAL CONTAMINATION* (arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc)	SUBSTANCES OF CONCERN ** exceeding the Minimal Effect Threshold (MET)	SUBSTANCES OF CONCERN ** exceeding the Toxic Effect Threshold (TET)
PORT AREA SECTORS	Saint-Charles River estuary	5.86	Arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, PAHs and PCBs	Arsenic, cadmium, copper, lead, zinc, PAHs and PCBs
	Louise basin	4.23	Arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, PAHs and PCBs	Cadmium, copper, lead, zinc and PAHs
	MIL Davie shipyards	1.99	Cadmium, chromium, copper, lead, mercury, nickel, zinc	None
	Lévis wharf	1.48	Copper	None
	Ultramar wharf	2.10	Cadmium, chromium, copper, lead, mercury, nickel, zinc	None
	Anse au Foulon	1.09	Copper, lead	None
	Irving wharf	0.90	None	None
	Beauport flats	1.40	Cadmium	None
OTHER SECTORS	Sillery flats and Saint-Romuald flats	2.11	Cadmium, copper	None
		* An index close to 1 indicates, on average, that heavy-metal concentrations in surface layers are near natural levels.	** In the whole sediment layer.	

Source: Fortin, G., and M. Pelletier. 1995. *Synthèse des connaissances sur les aspects physiques et chimiques de l'eau et des sédiments du secteur d'étude Québec-Lévis.* Technical report on ZIP 14. St. Lawrence Centre, Environment Canada - Quebec Region, Conservation Branch.

Figure 13 Sediment quality in Quebec City–Lévis

and PAHs. The sediment is contaminated from the surface to a depth reaching 14 m in some spots. This indicates that the Saint-Charles River, the outfalls emptying into it, storm sewers and port activities on the Beauport flats are still persistent sources of contamination. However, the mass of accumulated sediment is stable, and exchanges of pollutants with the river are very limited.

In the inner part of Louise Basin, isolated from the river by a lock, 30 900 m^3 of sediments are highly contaminated on the surface and at depth by cadmium, copper, lead, zinc and PAHs. But in the outer part opening onto the river, the recent sediment layer is basically unpolluted, and toxic concentrations of copper and zinc are found only in the northeast part of the basin and starting 75 cm below the surface of the sediment. This would suggest that toxic inputs from the St. Lawrence have considerably decreased since the 1970s, as in the sectors upriver.

No long-term sediment accumulation is observed at Quebec City's other port facilities along the main stem of the river, and the sediment is not heavily contaminated (Figure 13). The same is true for areas located in between the port facilities (Sillery and Saint-Romuald flats).

Available data for the Île d'Orléans and Grands Voiliers channels date from 1976 and are not representative of the present situation owing to very active sediment dynamics in these channels. At that time, the most heavily polluted sites were the tidal flats in the downstream portion of the Île d'Orléans channel.

Wildlife habitats. The effects of pollution on ecological productivity in the Quebec City–Lévis sector are unknown owing to a lack of data. Anthropic inputs of phosphorus, organic matter and bacteria may have increased overall productivity of the environment. However, relatively high turbidity and strong turbulence may be the main factors limiting that productivity.

Certain water quality criteria established for aquatic life (chronic toxicity level for aquatic organisms) are not met in the study area, examples being phosphorus, copper and chromium.

Sites of contaminated sediment accumulation are characterized by mostly undiversified benthic fauna largely dominated by tubificid worms, a group of highly pollution-resistant invertebrates.

Contamination levels of the planktonic or benthic organisms found in the study area are unknown. However, no organism is consumed by humans.

Fish. Although all fish populations frequenting the Quebec City region have declined appreciably since the late 1950s, pollution in Quebec City–Lévis is probably not the chief cause. Indeed, species that have experienced catastrophic declines are anadromous species, and the main spawning grounds and vital habitats of these fish are not usually located in the study area but rather upriver, downriver and in the tributaries. The only exception is Atlantic sturgeon, a species which may well have spawning grounds in the river estuary, though the exact location is not yet known.

Local fish populations present a low rate of malformation, tumours or other anomalies. This is characteristic of largely unpolluted environments. There are, however, high levels of parasitism that is probably attributable to reduced resistance to infection. Since 1989 – and perhaps before – a very large percentage of suckers, walleye and tomcod in the area have carried a tapeworm that burrows into the eye and renders the animals blind within a few months. Eel mortalities have been observed over the last few decades, and some authors have also referred to pollution-induced hormonal imbalance.

In the 1970s, the populations of fish residing in the area were all contaminated by mercury at levels exceeding the criterion for the protection of aquatic life and, in the case of Walleye and American eel, at a level exceeding fish marketing standards. Ten years later, it was observed that resident eels and those migrating downstream from the Great Lakes were less contaminated by mercury. In 1992 and 1993, mercury and PCB concentrations in most fish were lower than the fish marketing guidelines, although some specimens of American eel, Walleye and Smallmouth bass were found to contain mercury at levels exceeding these guidelines. Moreover, the criterion for the protection of aquatic life was exceeded in most fish species for mercury, and for PCBs in eels and Lake whitefish.

Birds. The data gathered (1991-1994) on contamination of eggs, young and adults of bird species frequenting the study area indicate generally low contamination by heavy metals and toxic organic substances, except for PCBs. The latter substances were found at concentrations above Canadian poultry marketing standards in certain duck species in migration, and in the eggs of the Ring-billed gull of the Quebec City colony.

The incidence of hunters' lead pellets in the gizzards of waterfowl and the lead content in the wing bones of ducks downed by hunters indicate that waterfowl are contaminated by this heavy metal from hunting activities. The risks of lead poisoning are high for waterfowl in the Quebec City–Lévis sector.

Recreational potential. Prior to 1992, the discharge of large quantities of wastewater in the western end of Quebec City–Lévis degraded the aesthetic value and recreational potential of the shoreline. With every high tide, an unsightly and foul-smelling layer of decaying organic matter was washed up. The situation has since improved, although bacteriological water quality is still unsuitable for swimming.

Recreational potential has also declined because of the loss of populations of smelt and Striped bass, which attracted sport fishermen.

Urban sprawl and expansion of the highway network, industrial and port development, and waterfront cottaging have altered the natural character of the landscape and reduced accessibility to the riverbanks and the river proper, especially since the 1950s. Shoreline modifications for such purposes often result in the irrevocable loss of potential river access and use for recreational pursuits.

4.2.3 Risks to human health

Water consumption. Four municipalities in the Quebec City–Lévis sector — Sainte-Foy, Cap-Rouge, Lévis and Saint-Romuald — draw their water supply directly from the St. Lawrence River. It is then treated in a filtration plant. Municipalities drawing their supply from a tributary have a filtration plant or chlorination station; those with groundwater sources have municipal wells or individual wells.

As a general rule, the river water is chemically acceptable as a supply source for drinking water treatment plants.

Fish and game consumption. Fish flesh contains contaminants that impose certain restrictions on consumption. Although the marketing standards mentioned earlier for certain species are exceeded, sport fishermen can nevertheless eat their catch. However, moderation is in order, especially where the largest predatory fish are concerned.

The recommendations on frequency of consumption by fish size and species and water body, issued by the MEF and the Ministère de la Santé et des Service Sociaux, are presented in the *Guide de consommation du poisson de pêche sportive en eau douce* (1993). In Quebec City–Lévis, the recommendations call for eating no more than eight fish portions (230 g each) per month, except for walleye, bass and small eels fished near the Quebec Bridge, in which cases the recommended limit is four meals per month.

Health Canada considers that consumption of the breast muscles of ducks hunted in Quebec poses no threat to human health. However, to limit exposure to chemical contaminants, consumers are advised to remove any visible lead shot from the flesh, skin and fat before eating.

Recreational activities. Swimming and windsurfing in Quebec City–Lévis pose threats to human health owing to the poor bacteriological quality of the water, which may cause dermatitis, conjunctivitis, otitis or gastroenteritis.

4.3 Species in Expansion

Purple loosestrife. Purple loosestrife is a herbaceous plant introduced to the North American continent around 1800. Today, it has spread throughout the fresh water along the St. Lawrence and is particularly abundant in Lake Saint-Pierre. Expansion of this species was favoured by the heavy erosion of wet meadows associated with the rising mean water level in the river during times of strong runoff in the 1970s and 1980s. This species, which is becoming dominant among the plant species composing wet meadows, may affect the quality of waterfowl habitat and lead to the disappearance of many rare plants associated with that environment.

Purple loosestrife is regarded as a nuisance in Quebec, Ontario and the U.S., but its magnitude in the sector of Quebec City–Lévis is still unknown.

Zebra and Quagga mussels. The Zebra mussel is a freshwater bivalve originally from the Caspian Sea and accidentally introduced into the Great Lakes in 1985 in ballast water. The species spread rapidly throughout the Great Lakes and, starting in 1990, entered the St. Lawrence up to the saltwater intrusion limit. In 1991, Zebra mussels were found attached to navigation buoys and the wharf at Lévis. In 1992, it was discovered that the wharves of Louise Basin were covered with mussels at densities of more than 30 000 individuals per square metre. The species was far less abundant at Île d'Orléans.

Zebra mussels are regarded as a nuisance in the Great Lakes, where they disturb the food chain, obstruct municipal and industrial intakes, clog outboard motors, alter fish habitats and clutter beaches with dead shells. They also risk contaminating wildlife resources, particularly certain waterfowl who eat them, because they accumulate toxic substances at concentrations several thousands times greater than found in the ambient environment.

The Quagga mussel, also originally from the Caspian Sea, was evidently introduced into the Great Lakes through ship ballast water about 1989. The species was first observed in 1992 throughout the St. Lawrence River, where it is 10 to 100 times less abundant than the Zebra mussel.

Ring-billed gull. The Ring-billed gull population in Quebec has been growing for the past 20 years as a result of propitious human activities (artificial islands, open-air dumps, outdoor fast-food restaurants). In Quebec City–Lévis, a large colony of gulls settled on the wastewood dump of Daishowa's pulp and paper mill at the mouth of the Saint-Charles River. When discovered in 1983, it consisted of 1400 pairs; by 1994, there were 18 771 pairs. This rapid expansion and the colony's location in the heart of an urban area raise concerns among company workers and users of local beaches.

In 1994, a program was undertaken that would gradually force the Ring-billed gull from the Daishowa site. The Canadian Wildlife Service (CWS) will continue monitoring this population to ascertain as soon as possible the colony's one or more new locations so as to

mitigate any associated inconvenience. In co-operation with the QUC and certain municipalities, CWS intends to pursue the public information campaign on the benefits of improved household waste management on the presence of gulls in the urban environment.

Greater snow goose. The spectacular growth of the Greater snow goose population has necessitated new feeding sites. In addition to the *Scirpus* marshes highly favoured by these birds, *Spartina* marshes and farmland have become new food habitats over the past 30 years and are used mostly in spring. In the Quebec City–Lévis study area, crop damage reported in 1993 accounted for only 7% of costs for all of Quebec. The geese mainly frequented local farmland in the municipalities of Saint-Pierre, on the north bank of Île d'Orléans, and Saint-Michel- de-Bellechasse and Saint-Vallier on the south shore of the river. To reduce crop damage caused by geese, CWS has put forward an action plan aimed at land development and changes in farming practices that would limit dispersal of the geese in spring and authorize outfitting activities, in an attempt to increase the benefits associated with the species' presence on farmland in fall.

CHAPTER 5 Issues of the Sustainable Development of the St. Lawrence

If sustainable development of the St. Lawrence is to become a reality, wildlife and plant biodiversity, multiple river uses and the quality of life associated with those uses must be restored and preserved for future generations. Environmental action must make provision for economic development, while at the same time guaranteeing the perpetuity of resources and a quality environment. Following are some of the means available to achieve sustainable development in the Quebec City–Lévis sector:

- Pollution reduction
- Protection and enhancement of shoreline ecosystems
- Restoration of disturbed wildlife resources and habitats
- Improved access to the river.

Pollution reduction. Pollution control measures for the St. Lawrence in the Quebec City region were late in coming compared with efforts carried out in the Great Lakes and along the upper course of the St. Lawrence. Though the points of entry of some pollutants lie upriver from the Quebec City–Lévis sector and despite recently-implemented cleanup efforts, many problems of water and sediment contamination are tied to local sources. Examples include municipal and industrial sewer outfalls, and activities in port areas.

The possibility of re-establishing recreational uses such as swimming and windsurfing will hinge on how effectively the Quebec City–Lévis treatment plants reduce bacterial contamination. In this regard, solving the problems experienced at the QUC's two treatment plants in dealing with overflows during heavy rainfall and the efficacy of treatment and disinfection processes are key issues.

In the estuary of the Saint-Charles River, sediment contaminated by local sources (Saint-Charles River, municipal overflow discharges, Daishowa's storm drains, wharf runoff) has been accumulating for some time. Although this sediment deposit is stable and does not appear to be a major source of river contamination at this time, it nevertheless carries long-term risks

of ecosystem contamination. One remediation scenario recommended by the Quebec Ports Corporation consists of dredging the contaminated sediment from the middle and downstream sections of the estuary and using the dredged material to expand the port facilities on the Beauport flats, while leaving the sediment upstream in place. But neither decontamination of the Saint-Charles River estuary nor port expansion is deemed to be urgent or essential at present. On another front, the sediment in Louise Basin has been highly contaminated by inputs from the St. Lawrence and from sewer systems. However, the recent sediment layer in the outer part opening onto the river is unpolluted for the most part, and contaminated sediment in the basin is isolated from the river by a lock – a situation which has lent itself to maintaining the status quo.

A third issue for the area is the risk of a major oil spill. Prior to 1990, there were no efficient means of intervention in the event of a major spill in the river. The Canadian Petroleum Products Institute has since opened an intervention centre in Lévis which covers the Montreal–Quebec City corridor. There is also a bird-cleaning centre at Cap-Tourmente, downriver from the study area. Lastly, the *Merchant Marine Act* should soon be amended to double Canada's capacity for intervention in case of accidental spills.

Persistent toxic organic substances are also a big threat to sustainable development. Despite all the pollution cleanup efforts to date, the presence of these substances, though on the decline in the river, threatens the aquatic environment. In Quebec City–Lévis, concentrations of certain metals (chromium and copper) in the water exceed the chronic toxicity level for aquatic organisms. Mercury concentrations in some species of fish exceed the criterion for the protection of aquatic life. Concentrations that may be harmful for benthic organisms are measured in sediment in Louise Basin and the Saint-Charles River estuary. The consumption of sport fish is also subject to restrictions in light of the frequency of contamination. The effects of these substances on the aquatic environment and human health are not fully known and require further study.

Protection and enhancement of shoreline ecosystems. St. Lawrence shorelines in Quebec City–Lévis have continued to suffer the effects of port development, urban sprawl and high-density cottaging. Some zones, such as the Beaupré coast and the eastern part of the north

bank of Île d'Orléans, which still have wetlands of significant ecological value, are unprotected. The Bureau d'Audiences Publiques sur l'Environnement (BAPE) was mandated to look into the ongoing dispute between the Côte-de-Beaupré RCM and the Ministère de l'Environnement et de la Faune (MEF) over the high-water limit along the Beaupré coast. BAPE concluded that the goals of sustainable development in that area could be achieved only through the joint effort of local and regional stakeholders. Indeed, the numerous statutes and regulations on shoreline protection have thus far proved unsuitable and ineffective in providing for environmental management of riverbanks already under strong development pressure.

The Quebec Ports Corporation still covets the Beauport flats with an eye to port expansion. A 440-ha expansion project put together in 1970 was cut to 42.5 ha in 1984, then temporarily shelved owing to stagnant port activity in the 1980s. New industrial projects and the possible return of a container terminal to Quebec City could reactivate matters.

Several municipalities in the sector of Quebec City–Lévis have projects for residential expansion in shoreline areas. They include Saint-Romuald (Saint-Télésphore sector), Lévis (Martinière point, Gilmour beach sector), Sillery (Puiseaux point) and Quebec City (Old Port). The many cottage development projects, on the south bank of Île d'Orléans and at Saint-Étienne-de-Beaumont for example, are additional opportunities for urban sprawl along the waterfront, both in the medium and long term.

Restoration of disturbed wildlife resources and habitats. Large expanses of wetlands in the Quebec City area were lost to the construction of wharves and highways and the backfilling of private land. The restoration of areas disrupted by pollution or encroachment and the protection of rare or at-risk plant and animal habitats can nonetheless aid in maintaining or increasing ecological biodiversity.

Anadromous fish are greatly disturbed by human activities. The restoration of commercial and sport fishing uses in the Quebec City area is basically dependent upon rehabilitation of this resource. The successful re-introduction of Atlantic salmon in the Jacques-Cartier River in the 1980s shows how joint action can produce conclusive results. The main thrust of a remedial plan drawn up since 1992 is to restore the Rainbow smelt spawning ground

in the Boyer River. The establishment of practical restoration programs is limited in the case of Striped bass and Atlantic sturgeon by the lack of knowledge of their biology and habitats. Before restoring Striped bass, predatory species such as Rainbow smelt, Atlantic tomcod and American shad should be re-introduced.

Improved access to the river. The St. Lawrence riverbanks in Quebec City–Lévis are largely inaccessible, owing mostly to the incompatibility of infrastructures with recreation and tourism. Until just recently, urban planning and development schemes generally overlooked the enhancement of shoreline recreational space. For example, controversy continues over the direction that local recreation and tourism development and enhancement plans should take in the Old Port of Quebec.

A trend has been witnessed in recent years toward reappropriation of the St. Lawrence shoreline to promote accessibility and enhancement. This trend is borne out by development projects in the sector of Jacques-Cartier beach (including the part completed in 1990 in Sainte-Foy), in the Old Port area and even at the mouths of tributaries like the Saint-Charles and Beauport rivers, on the north shore. On the south shore, the municipality of Saint-Romuald has an ambitious plan for shoreline recreational development, and thought is being given to creating a regional park on Martinière point at Lévis.

However, any such reappropriation of the river demands the involvement of many players working together.

Table 1
Main issues of sustainable development of the St. Lawrence in Quebec City–Lévis

Issues	*Assessment of present state relative to sustainable development goals*	*Present and future possibilities for sustainable development*
Pollution Reduction	By contaminating the environment, untreated effluent discharged to the river has a host of adverse effects on uses: reduced populations of many species and changes in habitat; restrictions on fish consumption; health risks associated with swimming and other water-related activities. Depending on the area, discharges of nutrients result in the proliferation of vegetation which is harmful to aquatic species and a nuisance to boaters, while causing aesthetic problems and bad smells.	The disruptive effects of pollution are reversible in the medium to long term, depending on the nature of the discharged substances, their time of residence in the environment and their effects on aquatic organisms. The most efficient means of limiting loss of use from pollution is reduction at source by all water users (industrial, household and commercial).
· Municipal and industrial wastewater treatment	Industrial and municipal cleanup programs have reduced the input of pollutants in the environment. However, during overflows and because of technical problems with filtration and disinfection processes, QUC wastewater is only partially treated, jeopardizing restoration of the river to full use.	Installing overflow control structures and improving the efficiency of treatment and disinfection processes are essential to environmental cleanup and restoration of recreational uses involving contact with the water, such as swimming and windsurfing.
· Sediment contamination in Saint-Charles River estuary and Louise Basin	The Saint-Charles River estuary and Louise Basin contain large amounts of highly contaminated sediment. Although this sediment deposit is stable, it is a potentially long-term source of river pollution.	Preferred interventions vary with the site: the status quo for Louise Basin and the section upstream from the Saint-Charles River estuary; dredging and on-shore containment for the central and downstream sections of the estuary.
· Risk of oil and chemical spills	The Quebec City–Lévis area lies on a river section where the risk of major oil spills is high.	Increased capacity for intervention and more rigorous safety measures reduce the risk of spills.

Issues	*Assessment of present status relative to sustainable development goals*	*Present and future possibilities for sustainable development*
· Persistent toxic substances in the environment	Despite a significant drop in toxic emissions, some of the substances involved still reach high concentrations in the environment. In the water and sediment in a few sectors, some metals and organic substances attain critical levels for aquatic organisms, and fish consumption is restricted. The effects of these substances on the aquatic environment and human health are not fully known.	A pesticide reduction program is under way for the Boyer and Chaudière rivers. Knowledge of the relationships between the river and the health of waterfront communities and resource users will round out this assessment.
Protection and Enhancement of Shoreline Ecosystems	Port infrastructure development and urban sprawl have occurred to the detriment of wildlife habitats and continue to threaten environments of high ecological value, particularly along the Beaupré coast.	The preservation of biodiversity and versatility of uses is possible only through local and regional joint action for development, protection and restoration of the riparian zone.
Restoration of Disturbed Wildlife Resources and Habitats	Many habitats disturbed by nonpoint-source pollution and encroachment are home to rare plants and at-risk wildlife species. Most species of anadromous fish are at risk; commercial fishing and sport fishing are two uses that have virtually disappeared from the Quebec City–Lévis area.	The safeguard of natural areas and restoration of disturbed habitats may aid in maintaining or improving ecological biodiversity. The restoration of anadromous fish populations requires restoration of the spawning grounds in the tributaries and, in some cases (Rainbow smelt), re-introduction of the species in the environment. The Boyer River is a special focus of attention.
Improved Access to the River	Until just recently, urban planning and development schemes overlooked enhancement of shoreline recreational space. As a result, there is very little access to the river.	Several municipalities are considering enhancing available spaces to improve access to the river. The facilities needed for river-centred leisure activities must be chosen wisely and located so as not degrade the natural and human environments.

Appendices

1 St. Lawrence Vision 2000 Action Plan (SLV 2000) Priority Species Found in the Quebec City–Lévis Sector

English name	*Latin name*	*Status of species in Quebec City–Lévis*
Plants (12 of the 110 species identified in SLV 2000 are present in the Quebec City–Lévis sector)		
Eaton's bur-marigold	*Bidens eatonii*	Several old references
Victorin's water-hemlock	*Cicuta maculata* var. *victorinii*	Endemic; a few old references
Bald willow-herb	*Epilobium ciliatum* var. *ecomosum*	Endemic; only one old reference
Philadelphia fleabane ssp. Provancher	*Erigeron philadelphicus spp. provancheri*	Endemic; one recent reference
Parker's pipewort	*Eriocaulon parkeri*	One recent reference
Victorin's gentian	*Gentianopsis victorinii*	Endemic; several recent references
St. Lawrence neglected hedge hyssop	*Gratiola neglecta* var. *glaberrima*	Endemic; one recent reference
Estuarine false pimpernel	*Lindernia dubia* var. *inundata*	A few old references
St. Lawrence American bugleweed	*Lycopus americanus* var. *laurentianus*	Endemic; a few old references
False dragonhead	*Physostegia virginiana* var. *granulosa*	Two old references
Small water knotweed	*Polygonum punctatum* var. *parvum*	A few old references
Dwarf wild rice	*Zizania aquatica* var. *brevis*	Endemic; abundant
Fish (7 of the 14 species identified in SLV 2000 are present in the Quebec City–Lévis area)		
Lake sturgeon	*Acipenser fluvescens*	Common in western end
Atlantic sturgeon	*Acipenser oxyrhinchus*	Common in eastern end
American eel	*Anguilla rostrata*	Common; abundant in fall
American shad	*Alosa sapidissima*	Common; fry abundant in late summer
Rainbow smelt	*Osmerus mordax*	Common in eastern end
Atlantic tomcod	*Microgadus tomcod*	Abundant; very abundant in fall
Striped bass	*Morone saxalitis*	Only one caught since 1971

English name	*Latin name*	*Status of species in Quebec City–Lévis*
Amphibians (none of the species identified in SLV 2000 is present in the Quebec City–Lévis sector)		
Reptiles (one species identified in SLV 2000 is present in the Quebec City–Lévis sector)		
Wood turtle	*Clemmys insculpta*	Unknown
Birds (15 of the 19 species identified in SLV 2000 are present in the Quebec City–Lévis sector)		
Horned grebe	*Podiceps auritus*	Migratory; common
Least bittern	*Ixobrychus exilis*	Nester outside study area; rare
Northern pintail	*Anas acuta*	Confirmed migratory nester; rare
Blue-winged Teal	*Anas discors*	Confirmed migratory nester; rare
Barrow's goldeneye	*Bucephala islandica*	Migratory; rare
Bald eagle	*Haliaeetus leucocephalus*	Nester outside Quebec City–Lévis
Peregrine falcon	*Falco peregrinus*	Confirmed migratory nester; rare
Yellow rail	*Coturnicop noveboracensis*	Nester outside sector; present in summer
Common moorhen	*Gallinula chloropus*	Nester outside sector; present in summer
Piping plover	*Charadrius melodus*	Visitor; exceptional
Caspian tern	*Sterna caspia*	Migratory; rare
Red-headed woodpecker	*Melanerpes erythrocephalus*	Observed in summer
Sedge wren	*Cistothorus platensis*	Nester outside sector
Loggerhead shrike	*Lanius ludovicianus*	Nester outside sector
Grasshopper sparrow	*Ammodramus savannarum*	Fall visitor
Mammals (none of the five species identified in SLV 2000 is present in the Quebec City–Lévis sector)		

2 Environmental Quality Criteria
(for assessing loss of use)

Ecosystem Components	Reference Criteria	Objectives
WATER	Raw water (untreated, taken directly from a body of water) (MENVIQ, 1990)	Protect the health of a person who may both drink water taken directly from a body of water and eat aquatic organisms caught there throughout his or her life.
	Contamination of aquatic organisms (MENVIQ, 1990)	Protect human health, which could be endangered by eating aquatic organisms.
	Aquatic life (chronic toxicity) (MENVIQ, 1990)	Protect aquatic organisms and their offspring, as well as wildlife that eat them.
	Recreational activities (primary contact) (MENVIQ, 1990)	Protect the health of humans engaging in a recreational activity in which the entire body is regularly in contact with water, such as swimming or windsurfing.
SEDIMENT	Minimal effect threshold (MET) (SLC and MENVIQ, 1992)	Contaminant levels above which minor but tolerable effects on most benthic organisms are seen.
	Toxic effect threshold (TET) (SLC and MENVIQ, 1992)	Contaminant levels above which effects harmful to most benthic organisms are observed.
AQUATIC ORGANISMS	Protection of aquatic life (IJC, 1987)	Protect health of fish-eating aquatic organisms.
	Fish marketing standards (Health and Welfare Canada, 1985)	Maximal contaminant levels in fish to protect human health.
	Poultry marketing standards (Canada, 1971)	Maximal contaminant levels in fowl to protect human health.
	Guide de consommation du poisson de pêche sportive en eau douce (MSSS and MENVIQ, 1993)	Rules on eating sport fish to prevent harmful effects of contaminants on human health.

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3 Glossary

Alkaline water: Water with a pH value greater than 7.

Anadromous: Pertaining to fish that ascend streams from the sea to spawn in fresh water.

Benthos: The plants (phytobenthos) and animals (zoobenthos) that inhabit the bottom of a body of water.

Biomass: The dry weight of living matter, altogether or by systematic group, expressed in terms of a given unit of surface area or volume of the habitat at a given time; examples are plant biomass, insect biomass, herbivorous biomass or carnivorous biomass.

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

Community: All plants and animals living in the same habitat.

Continental waters: Water table or natural or artificial watercourses, such as lakes, rivers, streams and irrigation, industrial or ship canals, reservoirs and impoundments in which water is in direct contact with the atmosphere. Also called *surface water*.

Drainage basin: The geographic catchment area from which the waters (originating as precipitation) of a particular watercourse or body of water are drawn. Also called *hydrographic basin* or *watershed*.

Ecosystem: Entire physico-chemical environment (biotope, or habitat) and the living beings in it (biocenosis, or community), which can perpetuate itself indefinitely with inputs of matter and energy.

Ecosystem productivity: Biomass produced each year to maintain balance between animal and plant populations.

Effluent: General term for any liquid discharge of a source of pollution, whether from inhabited areas (municipal effluent or sewage) or industrial facilities (industrial wastewater or effluent). Outfalls or sewers: places where liquid pollutants are discharged.

Flood plain: Flat alluvial expanse bordering a waterway that is only underwater during a spate.

Flow: Volume of water running in a water course, pipe, etc., in a given time. Usually expressed in m^3/s, but sometimes in L/s for small drainage basins.

Fry: Immature fish that have not yet attained adult form.

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

Hard water: Water containing a high level of mineral salts, especially calcium or magnesium (> 150 mg/L $CaCo_3$), liable to form scale.

Nonpoint-source pollution: Pollutants indirectly introduced into a given environment. Agricultural pollution is nonpoint-source pollution, since fertilizers and pesticides are spread over wide areas. Also called *area pollution*.

Sediment: Solid fragmental material formed by the weathering of rocks or other chemical or biological processes, which is transported or deposited by air, water or ice.

Sediment dynamics: All of the features of the flow of a water course influencing sediment transport, sedimentation and sediment erosion.

Spawning ground: Place where fish congregate to breed.

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

Thermal stratification: Presence of layers of different temperatures in bodies of water, with the warmer water above the cooler water.

Waterfowl: Collective name for geese and ducks.

Water mass: Volume of water having relatively homogeneous physical and chemical properties. Water from the Great Lakes is a distinct water mass, separate from that of the Ottawa River.

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