Proceedings from a Scientific Workshop on Marine Mammals, their Habitats and Food Resources, held in Mont-Joli (Quebec) from April 3 to 7, 2000, within the context of the St. Lawrence Estuary Marine Protected Area project

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PROCEEDINGS FROM A SCIENTIFIC WORKSHOP ON MARINE MAMMALS, THEIR HABITATS AND FOOD RESOURCES, HELD IN MONT-JOLI (QUEBEC) FROM APRIL 3 TO 7, 2000, WITHIN THE CONTEXT OF THE ST. LAWRENCE ESTUARY MARINE PROTECTED AREA PROJECT

by

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ABSTRACT

Savaria, J.-Y., Cantin, G., Bossé, L., Bailey, R., Provencher, L. and Proust, F. 2008. Proceedings from a Scientific Workshop on Marine Mammals, their Habitats and Food Resources, held in Mont-Joli (Quebec) from April 3 to 7, 2000, within the context of the St. Lawrence Estuary Marine Protected Area project. Can. Manuscr. Rep. Fish Aquat. Sci. 2647 v + 119 p.

This manuscript reports on a scientific workshop on the marine mammals of the St. Lawrence Estuary held at the Maurice Lamontagne Institute in April 2000. The purpose of the workshop was to make a scientific assessment of the need for a marine protected area (MPA) in the St. Lawrence Estuary to protect marine mammals, their habitats and their food resources. Present and potential problems faced by marine mammals, arising essentially from human activities in the vicinity, were debated. The participants were then able to prioritize these various problems and weigh the adequacy of the MPA proposed boundaries. Disturbance, contamination and lack of knowledge were identified as the key problems. Finally, the participants determined that given the magnitude of the problems encountered by marine mammals, the establishment of the MPA was justified and indeed essential to the protection of these animals and their habitats.

RÉSUMÉ

J.-Y. Savaria, G. Cantin, L. Bossé, R. Bailey, L. Provencher et F. Proust. 2003. Compte rendu d'un atelier scientifique sur les mammifères marins, leurs habitats et leurs ressources alimentaires, tenu à Mont-Joli (Québec) du 3 au 7 avril 2000, dans le cadre de l'élaboration du projet de zone de protection marine de l'estuaire du Saint-Laurent. Rapp. manus. can. sci. halieut. aquat. 2647 v + 127 p.

Ce rapport manuscrit fait suite à un atelier scientifique tenu à l'Institut Maurice-Lamontagne en avril 2000, portant sur les mammifères marins fréquentant l'estuaire du Saint-Laurent. Le but de cet atelier était de vérifier la pertinence scientifique de l'établissement d'une zone de protection marine (ZPM) dans l'estuaire du Saint-Laurent visant la protection des mammifères marins, de leurs habitats et de leurs ressources alimentaires. Les problèmes actuels et potentiels pour les mammifères marins, découlant essentiellement des activités humaines se déroulant dans le secteur, ont été débattus par les participants, ce qui leur a permis d'établir un ordre de priorité de ces différents problèmes ainsi que d'évaluer la pertinence des limites proposées de la ZPM. Le dérangement, la contamination et le manque de connaissances ont été ciblés comme étant les problèmes les plus importants. Enfin, les participants ont jugé qu'en raison de l'ampleur des problèmes auxquels font face les mammifères marins, l'établissement de la ZPM est justifié, voire essentiel à la protection de ces animaux et de leurs habitats.

INTRODUCTION

1. THE MARINE PROTECTED AREA PROGRAM

In Canada and elsewhere in the world, it is increasingly recognized that marine protected areas have a significant role to play in the conservation and protection of marine species and their habitats. This tool for protecting and conserving marine ecosystems is now entrenched in the Canada's Oceans Act that was enacted by the Canadian Parliament in January 1997. Under the terms of this Law, the Department of Fisheries and Oceans has the responsibility for establishing a series of marine protected areas (MPA) across Canada. To that end, the Canada's Oceans Act (subsection 35.1) states that:

"*A marine protected area is an area of the sea that forms part of the internal waters of Canada, the territorial sea of Canada or the exclusive economic zone of Canada and has been designated under this section for special protection for one or more of the following reasons:*

- *the conservation and protection of commercial and non-commercial fishery resources, including marine mammals and their habitats;*
- *the conservation and protection of endangered or threatened marine species and their habitats;*
- *the conservation and protection of unique habitats;*
- *the conservation and protection of marine areas of high biodiversity or biological productivity; and*
- *the conservation and protection of any other marine resource or habitat as is necessary to fulfil the mandate of the Minister.*"

Each MPA will have a unique combination of objectives, resources, species, size, habitats or ecosystems to protect and preserve as well as its own management plan. MPAs could also be established either temporarily, seasonally, permanently, or in the event of an emergency, as needed.

2. COMPLETED STEPS TOWARD IDENTIFICATION OF POTENTIAL SITES

Following the enactment of the Canada's Oceans Act, the Department of Fisheries and Oceans developed a document entitled "An Approach to the Establishment and Management of Marine Protected Areas under the Oceans Act." This document was issued for public examination at the beginning of 1997 in order to better promote the MPA program and to obtain the support and comments of the Canadian public (Figure 1).

Following this public examination, the Department of Fisheries and Oceans drafted a second document entitled "The Department of Fisheries and Oceans' Marine Protected Areas Program," which includes the Marine Protected Areas Policy and the National Framework for Establishing and Managing Marine Protected Areas. This document was sent to over 650 stakeholders in Quebec.

Meetings and interviews were also conducted with many scientists, experts and stakeholders from the maritime community in order to identify sectors with great ecological value or sites of interest deserving increased protection.

A list was drawn up of 67 coastal and marine sites requiring a more thorough analysis in order to determine their potential for the establishment of an MPA.

In the wake of these consultations, individuals having identified sites of interest and several organizations were invited to a workshop regarding these sites, which was held at the Maurice Lamontagne Institute on September 15 and 16, 1998. This workshop was designed to confirm and enhance the information collected on each of the 67 suggested sites, to acquire an overall understanding of their ecological value, and to identify the threats and pressures to which they are subjected.

Upon completion of this workshop, the recommendations made by an assessment committee and the discussions held with managers from the maritime community enabled the selection of two sites for pilot projects: the Manicouagan Peninsula sector, for its wealth in biological productivity and biodiversity, and a part of the St. Lawrence Estuary, for its significance regarding marine mammals. Biophysical and socio-economic studies of the St. Lawrence Estuary site were then conducted. From April 3 to 7, 2000, a scientific workshop on marine mammals, which brought together several marine environment specialists, and particularly marine mammal specialists, was held at the Maurice Lamontagne Institute to identify the problems and threats that challenge the marine mammals of the St. Lawrence Estuary. The results of this workshop are the focus of this document.

June 1997

Public examination of the document: *Establishing and managing marine protected areas under Canada's Oceans Act*

149 individuals representing 95 organizations provided comments

Summer of 1998

Publication and distribution of the document entitled:
The Department of Fisheries and Oceans' Marine Protected Areas Program, which includes the *Marine Protected Areas Policy* and the *National Framework for Establishing and Managing Marine Protected Areas*

Document sent to 650 stakeholders in Quebec

. Work sessions
. Comments from participants
. Identification of sites of interest

Summer of 1998

Meetings and interviews conducted with many scientists, experts and stakeholders from the maritime community:

. Identification of sectors with great ecological value and of sites of interest

September 15-16, 1998

Workshop on the 67 identified sites of interest for designation of eventual MPA pilot projects

56 participants
Selected criteria:
. ecological value and features;
. vulnerability, threats and pressures;
. socio-economic aspects;
. support and concerns as well as positive and negative factors.

Winter of 1999

Two sites selected as pilot projects based on workshop recommendations and site assessments:

Manicouagan Peninsula sector
St. Lawrence Estuary

Figure 1. Completed steps towards identification of potential sites.

3. The Estuary MPA Project: Rationale and Objectives

The St. Lawrence Estuary is an area that is highly visited by many pinniped, odontoceti, and mysticeti species. It drains a vast watershed that is strongly urbanized and industrialized, and where intensive agriculture uses most of the territory. The Estuary is also faced to an increased pressure from sea traffic, which has significantly increased since the end of the 1970s in the Saguenay River mouth area, mainly due to the development of the whale-watching industry and recreational boating, which add to the traffic of merchant vessels and tankers that use the St. Lawrence Seaway. The marine mammals sojourning in this area are thus faced with a multitude of threats: the contamination of the marine food chain by persistent toxic substances, disturbances linked to commercial and recreational navigation, the risks of oil spills, collisions and entanglements with fishing gears, physical deterioration of their habitats, and variations in the abundance of their food resources.

The St. Lawrence Estuary site selected for the MPA project (Map 1) is located on the fringe of the Saguenay–St. Lawrence Marine Park and includes the summer distribution range of the St. Lawrence beluga whale, which has been designated as an endangered species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) since 1983; concentration areas of other cetaceans, including two rorqual species identified as of special concern (common fin-back whale) and as endangered (blue whale) by the COSEWIC; and the majority of the Estuary haul-out sites of the harbour seal, a resident species with special concern status. The objective set by the Estuary MPA project is the conservation and long-term protection of marine mammals living there, their habitats and their food resources, in order to allow the seasonal return of large cetaceans, and particularly to ensure the survival of the beluga whale and harbour seal in St. Lawrence Estuary.

4. Discussions on the Protection and Preservation of Marine Mammals

At least ten marine mammal species are likely to be encountered in the Estuary on a more or less regular basis: some species are year-round residents while others will only visit the Estuary waters seasonally, occasionally, or even exceptionally. The importance given to these species within the context of identifying an MPA in the Estuary is therefore linked in part to their use of the environment (activities, time of residence, etc.) and to the population status of each species. Thus, in terms of protection, a resident species will generate different considerations than a seasonal species, just as an endangered species will generate greater concerns than an unthreatened or marginally threatened species. Though the objectives of the MPA are the protection and conservation of the majority of the marine mammals sojourning in the Estuary, the species that are only rarely observed there (e.g., right whale) will have to be considered on a greater geographical scale.

Marine mammals are subject to the hazards of their natural environment. It is therefore important to recognize that their populations can be prone to fluctuations potentially occurring in response to natural changes in the abundance of food, predators, competitors, or even changes in environmental conditions. On the other hand, human activities can have, in certain circumstances, significant impacts on these animal populations, thus compromising their well-being and even threatening their survival.

The monitoring of these human activities and the anthropogenic pressures that marine mammals endure is thus the management objective, which, in order to be effective, will have to establish the nature of the interactions between human activities and marine mammals. Human activities arise from a variety of socio-economic and cultural interests (employment, leisure activities, transportation, traditional activities) whose continuation often constitutes a significant economic issue. The characteristics of these human activities must therefore be examined to evaluate the way in which they cause problems and the related risk factors that could increase the threat towards marine mammals. This understanding should lead to more appropriate management initiatives.

Populations or species can be seriously affected by certain human activities that would prevent them from occupying a territory or reaching sufficient numbers. In the worst scenarios, numbers can be permanently reduced, until population extermination or species extinction occurs. In better scenarios, human activities may create a disturbance without having an impact on the dynamics of these populations.

The main categories of biological and environmental components linked to marine mammals that could be affected by human activities are as follows:

- Safe habitat (e.g., collisions, entanglements in fishing gears, hunting)
- Healthy habitat (e.g., contaminants, pathogens, stress)
- Food resources (e.g., reduction in availability and access)
- Preferred areas (e.g., destruction of haul-outs, disturbance of a specific hydrologic phenomenon in significant areas)
- Effective communications and movements (e.g., noise)
- Critical biological functions (e.g., disturbing while resting, mating, calving, nursing, teaching of the young, moulting).

The interests in the protection and conservation of marine mammals primarily involve the following variables:

- Survival (which can be affected by deadly collisions with boats, fishing gear mortalities, infectious or systemic diseases due to stress or contaminants, etc.);
- Growth (which can be slowed down by a deficient energy balance due to food shortage or excessive energy expenditure);
- Birth rate (which can be lowered by disease, or a deficient energy balance affecting age at maturity or fertility);
- Habitat integrity (which is threatened by the destruction or deterioration of the physical habitat, the anthropogenic introduction or increase of predators, pathogens or competitors; these changes can reflect on survival, growth, or birth rate).

In order to develop an effective management approach of human activities that could compromise the health and survival of marine mammals, it is important to take into account the current or potential problems, to identify the characteristics of the problem-causing activities, and to assess the related risk factors. The existing relationships between these three factors involved in the protection and conservation of the marine mammals living in the St. Lawrence Estuary are shown in Table 1.

Table 1. Relationships between marine mammal problems, risk factors, and related human activities.

Existing and potential problems*	Risk factors**	Related human activities
• Contamination (9) • Disturbance at seal haul-outs (1, 2, 3, 4) • Physical changes to habitats (8) • Disturbance during feeding (1, 2, 3) • Hearing and communication alteration due to noise (1, 2, 3) • Seal pup isolation and displacement (1, 2, 3, 4.3) • Injuries and mortalities caused by poaching and hunting of other seal species (6) • Injuries and mortalities caused by fishing gears (7) • Injuries and mortalities caused by collisions with boats (1, 2, 3) • Infectious diseases (9.2, 10.3) • Environmental disasters (2, 3.2, 3.5, 10.3) • Competition for prey (7) • Cumulative effects on the species and its habitat (1 to 10)	1. Navigational parameters (A, B, C, D, F) 1.1 Navigational space parameters 1.2 Approach and displacement speed 1.3 Sudden change in speed 1.4 Direction of approach 1.5 Sudden change in direction 1.6 Distance of approach 2. Navigational intensity (A, B, C, D, F) 2.1 Transit frequency around haul-outs and bays and estuaries 2.2 Concentrations of boats near haul-outs 2.3 Daily and seasonal presence continuity 3. Type of boat (A, B, C, D, F) 3.1 Manoeuvrability 3.2 Size of boats: small boat access 3.3 Motor and propeller noise 3.4 Silent approaches (kayaks, sailboats, canoes) 3.5 Piloting visibility 4. Behaviour (attitude) of users in the sector (A, B, E, F) 4.1 Misconduct by navigators and hikers 4.2 Tourist behaviour 4.3 Public behaviour towards seal pups 5. Marine mammal behaviour (A, B, C, F) 5.1 Approaching out of curiosity 5.2 Familiarity 5.3 Playing around propellers 5.4 Attraction to caught fish	A) Recreational boats, sea kayaks, and personal watercrafts B) Whale watching cruises C) Ferries D) Through navigation E) Recreational activities on littoral Nature watching (photography, ornithology, etc.) Visiting islands and flats (hikers, swimmers, ATV) F) Fishing Commercial fishing Recreational and sport fishing Shellfish harvesting G) Hunting of other seal species Commercial hunting Sport hunting H) Coastal developments Harbour facilities Marinas Dredging Backfilling Hydro-electric development (river harnessing) Residential and tourist buildings Depth charges Seismic prospecting I) Offshore developments Drilling platforms

Existing and potential problems*	Risk factors**	Related human activities
	5.5 Distractions 5.6 Individual variables 6. Hunting other seal species (difficulty for identifying) (G) 7. Fishery (F) 7.1 Type of fishery 7.2 Fishing season and area 7.3 Type and quantity of prey 8. Coastal and offshore developments (H, I) 8.1 Types of developments 8.2 Location (bays and estuaries, near haul-outs) 9. Pollution (J) 9.1 Chemical contaminants 9.1.1 Heavy metals and organometallic compounds 9.1.2 Chlorinated organic compounds 9.1.3 PAH 9.2 Municipal, agricultural and industrial effluents 9.3 Wastes 10. Disaster threats (D, J, K) 10.1 Hazardous material transportation 10.2 Use of explosives 10.3 Pathogens	Seismic surveys Depth charges Seismic prospecting J) Sources of contaminants Inland waters Ocean waters Local springs Atmospheric fallout K) Reintroduction of individuals Sick individuals Individuals in captivity

*numbers in parentheses indicate risk factors linked to the problem
**letters in parentheses indicate human activities linked to risk factors

5. SCIENTIFIC WORKSHOP ON THE MARINE MAMMALS FOUND IN THE ESTUARY

This workshop, held from April 3 to 7, 2000, at the Maurice Lamontagne Institute in Mont-Joli, was part of a consultation process for the creation of an eventual MPA in the St. Lawrence Estuary, the purpose of which would be the protection and conservation of marine mammals, their habitats and their food resources.

The workshop established solid scientific resources on which to build management measures that will be developed later, and also showed the importance of creating an MPA to increase marine mammal protection in the Estuary. The participants discussed, debated, and prioritized the problems affecting marine mammals and their habitats in the Estuary, as well as the pressures on these animals. The steps to follow will consist in identifying management measures that will ensure the conservation and long-term protection of these animals and their habitats in the future MPA (Figure 2). The results of this initiative will then be included in a discussion paper regarding management orientations for the eventual MPA that will be presented to organizations and special interest groups during public consultations on the project.

Objectives of the workshop and gathering of information

Presenting, updating, validating and improving knowledge;

Gaining new information;

Assessing man-made problems affecting marine mammals, their habitats and their food resources (main objective);

Identifying critical research and monitoring requirements to ensure a better protection and conservation of marine mammals, their habitats and their food resources;

Proposing solutions or measures to improve protection and conservation of marine mammals, their habitats and their food resources (a workgroup session on this topic should take place during 2003);

Establishing temporary geographical limits of the eventual MPA in the Estuary in order to reach set objectives (several workgroup sessions took place on this topic from November 2000 to February 2001).

The various problems were first presented and discussed by the participants, who were then asked to rank problems according to their levels of importance. Finally, the following questions were presented to the participants:

- Does the significance of the problems for each species or group of species justify the creation of an MPA in the Estuary?
- What should be the limits of the MPA to encompass the minimum area to be protected in order to preserve the species encountered in the Estuary?
- What are the necessary protection measures?

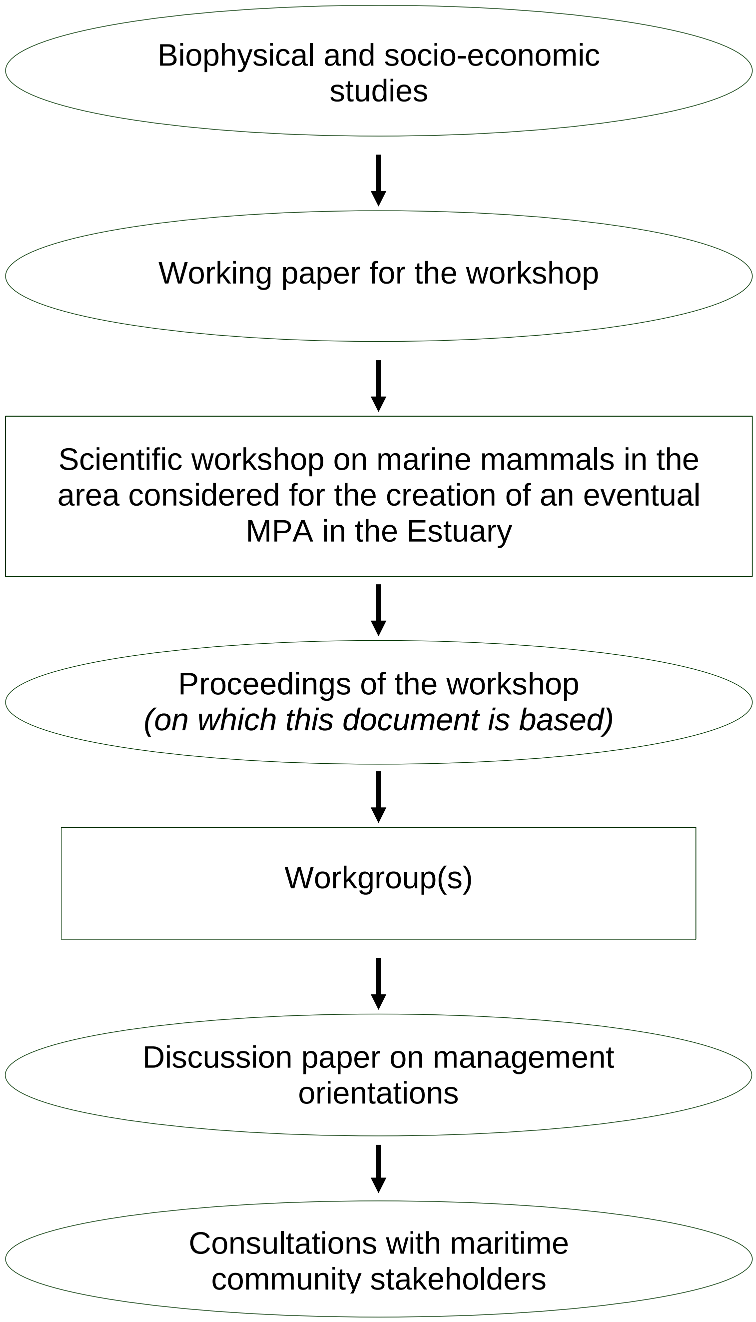

Figure 2. Steps leading to a public discussion paper on management orientations for the eventual MPA in the Estuary.

Information was gathered in two ways: first, directly through discussions that occurred during the workshop and that were recorded by two rapporteurs in writing and on tape for later listening; second, through annotations, comments and updates made by the participants on a draft working paper that contained data and information on this subject considered to be critical.

All gathered information, including the revised version of the working paper, was consolidated in a proceeding report[1]. In the present report, we discuss the main points.

6. DOCUMENT STRUCTURE

This report presents summaries of problem discussions as well as the results of the problem prioritization exercise. The participants' answers to the first two questions mentioned earlier are reported in the conclusion. The answers to the third question (required protection measures) are reported in the discussions following each problem. In addition, at the end of this document, the reader will find all the maps used during the workshop, which mostly show the distribution of the various species and major human activities near marine mammals (see Appendix).

This report includes two general sections:

A. **Discussions concerning current and potential problems affecting marine mammals.** For each specific man-made problem affecting marine mammals in the Estuary, this section presents a simulation exercise followed by a summary of the discussions on each topic. At the end of each summary, the proposed solutions to solve or attenuate the problems are presented.

B. **Marine mammal food resources.** This section presents a selection of eleven marine mammal food resources as well as the summaries of discussions concerning the current and potential man-made problems affecting these food resources. Note that only four of the nine mentioned problems were discussed due to lack of time.

Finally, it is important to note that this document by no means could be considered as containing exhaustive knowledge. We identified those elements that we considered to be essential for assessing the direct and indirect impacts of human activities on marine mammals in the St. Lawrence Estuary with the aim of providing a perspective for managing a future MPA.

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[1] Pêches et Océans Canada. 2002. Atelier scientifique sur les mammifères marins, leurs habitats et leurs ressources alimentaires dans le cadre de l'élaboration du projet de Zone de protection marine de l'estuaire du Saint-Laurent du 3 au 7 avril 2000—Compte rendu. Institut Maurice-Lamontagne, Mont-Joli, 345 p.

SECTION A: DISCUSSIONS REGARDING EXISTING AND POTENTIAL PROBLEMS FOR MARINE MAMMALS

1. CONTAMINATION

The St. Lawrence waters and sediments contain many contaminants, particularly from the organochlorines and heavy metals. The St. Lawrence Estuary represents an environment where the flow of these toxic substances is relatively high and where they are retained temporarily (area of maximum turbidity in the upper estuary) or permanently (upper basin of the Saguenay River Fjord and upstream section of the maritime estuary).

The contamination level of marine mammals in the study area varies considerably according to the species, and there is a significant variation in the persistent contaminant levels among individuals of a same population. It is also important to note that several of the species presented here are not year-round residents and that the contamination levels measured in individuals are not exclusively linked to the quantity of contaminants in the St. Lawrence and its tributaries.

Mercury, lead, organochlorines (polychlorinated biphenyls: PCB, DDT, mirex), polycyclic aromatic hydrocarbons (PAH), and butyltins are the major contaminants likely to be found in the marine mammals of the St. Lawrence Estuary. These contaminants, particularly organochlorines, have the potential to significantly alter the endocrine, reproductive and immune functions of animals, and could have an effect on the high cancer incidence observed notably within the beluga whale population of the St. Lawrence. The synergistic effect among contaminants, likely to increase the toxicity of these compounds, must also be considered.

In addition to the levels and persistence of contaminants in the environment, the biomagnification[2] phenomenon could explain the strong concentration of these substances observed in several marine mammal species. In fact, a large number of these species occupy a high level in the food chain, such as the harbour seal and hooded seal, which share the highest trophic level in the Estuary food chain, followed by beluga whales and other seal species (Lesage, 1999).

Following the implementation in 1988 of the St. Lawrence Action Plan and of the St. Lawrence Vision 2000 programs that followed, the discharges of certain toxic substances were largely reduced (Lesage and Kingsley, 1998). The recommendations to reduce contaminant levels, which were made by the Committee for the recovery of the St. Lawrence beluga whale, are for the most part in their implementation stage (Bailey and Zinger, 1998). For example, significant reductions of PAH emissions by aluminium smelters have caused the concentrations of PAH in surface sediments to decrease in the Saguenay River (Bailey and Zinger, 1998). A downward trend was also observed in the

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[2] The biomagnification phenomenon, which is the increase in the levels of substances accumulated in the tissues as a higher level in the food web is reached, suggests that there is a transfer of food poisons towards the consuming organism, so that the concentration of these substances systematically increases from one trophic level to another.

concentration levels of certain contaminants in birds and marine mammals as well as in species found at lower trophic levels (Muir et al., 1996).

Summary of participants' discussions and notes

Further to the efforts made in reducing toxic substance levels in the environment, it is important to verify whether toxic loads have indeed decreased. In this regard, the selected sampling period becomes vital when one tries to identify trends in contamination levels found in the environment. For example, if contamination levels are observed over a short period of time (5 years or less), a high variability will be noted, preventing reliable interpretation of the data and causing great difficulties in identifying clear trends in contamination levels. By using a larger sampling period (10 years or more), variability will decrease and trends will become much clearer.

The concentrations of persistent toxic substances recorded in the Great Lakes evolved in the following way:

1940-70: increase in the levels of contaminants

1970-85: progressive reduction in the levels of contaminants
1986-99: plateau levels of contaminants

These results seem to indicate that the monitoring of organochlorine point sources was effective. However, the stability observed since the mid-eighties indicates that non-point sources of contamination still remain. This can be explained by the fact that this area is a significant deposition site for pesticides, which are carried in the atmosphere over long distances before falling into the waters of the Great Lakes (note that these substances have not been used for over 30 years, in Canada, or the U.S.).

There are few factories within the limits of the study MPA; the main sources of contamination are therefore outside the limits of this area. The majority of the contaminants found in the sediments of the Estuary were carried by rivers (approximately 80%), whereas the remainder mostly all come from atmospheric fallout. In the St. Lawrence Estuary, sediments are considered to be the most important contaminant reservoir. A significant section of the Estuary, particularly the maximum turbidity zone, represents an area of sediment transportation. On the other hand, the Laurentian Channel is the only portion considered as a deposition site.

In the Estuary, the transfer of persistent contaminants among organisms seems to pose more problems than the high concentrations of these contaminants found in the environment. As for the environmental loads, the trends concerning concentrations of persistent substances in organisms, such as beluga whales and seals, remain difficult to establish. In fact, the limited number of sampled individuals (from beached carcasses) as well as the high individual variability observed in these organisms results in imprecise trends over a relatively long sampling period (20 years). In these conditions, it is impossible to detect very short-term trends in loads.

The transfer of persistent contaminants from the environment to animals mainly occurs through feeding. This phenomenon, called bioaccumulation, is a process in which toxic products are ingested by aquatic organisms directly from water, sediments or food. Given the relatively long lifespan of marine mammals, the variability in contaminant concentrations observed in individuals of the same age and same sex is explained by the animal's history (feeding, breeding, etc).

Beluga whale

For the beluga whale, for example, the lactation period lasts for two years, during which a significant transfer of contaminants from the mother to her young occurs. It should be noted that the transfer rate from the mother to her young varies according to the compound. Because of this transfer, we can consider that during the lactation period, the young is feeding at a higher level of the food chain than the adult. This phenomenon is the reason why maximum concentrations of certain contaminants are found in young beluga whales and seals. This could be problematic because developing organisms are particularly sensitive to persistent contaminants. After the lactation period, the concentrations found in individuals gradually decrease with age and are subsequently based on contaminant loads in prey.

In addition to acquisition through feeding, other factors can influence the individual variability observed among these animals. The capacity to eliminate or detoxify contaminants would be very variable from an individual to the other. It appears that the variability is caused by several factors that are difficult to identify as a whole and are constantly interacting with each other.

Contaminant measurements in marine mammals are faced with another problem, which is the sampling bias resulting from the use of beached carcasses, which are generally old or young individuals. This sampling is therefore not representative of the population, thus the importance of developing standards. Moreover, the concentrations of certain contaminants tend to increase after several days as carcass water content decreases. Even if we do not yet know whether the levels of contamination found in the carcasses are representative of the population as a whole, we should no doubt be able to identify trends in contaminant loads with this type of sampling. However, this could still require much time because of the limited number and the state of the carcasses found.

To avoid these biases, biopsies practised on live individuals (blubber sampling) represent an interesting possibility. Studies are currently being conducted to determine whether the superficial layer of blubber collected through such biopsies is representative of the animal's entire blubber layer with regard to contaminant loads. Preliminary results seem to confirm this assumption.

Biopsies on live individuals have numerous advantages. First of all, several samples can be collected from the same individuals, allowing temporal monitoring of contaminant loads. On a statistical perspective, the large number of samples collected will reduce the variability observed when sampling beached carcasses. Temporal monitoring with this technique could therefore help to identify trends more rapidly, as much for a particular animal as for an entire population. Furthermore, biopsies will make it possible to assess the validity of the sampling carried out on beached carcasses, which would be a major asset because the sampling carcass has been conducted for several years. Comparisons would therefore be drawn between studies made on carcasses and studies conducted on live animals, allowing temporal monitoring over a relatively long period.

Rorquals

Generally, it does not appear that contamination is a major concern with rorquals. However, biopsies conducted on blue whales sojourning in the St. Lawrence have revealed relatively high levels of contamination compared to other populations. Moreover, the rate of observation of new individuals of this species in the St. Lawrence indicates a 2% increase in the population, which is low, and only 9 calves have been observed over a 20-year period. Even if nothing links these observations with contamination, the low numbers could indicate an underlying problem.

Right whale

A study conducted on the right whale indicates relatively low levels of contamination (mainly for PAH, petroleum products, DDT and their metabolites), which is consistent with the fact that this species is at a relatively low level in the food web. However, it is important to mention that contamination levels in individuals in the Northwest Atlantic are particularly high for this species. Moreover, since the beginning of the 1990s, a decrease in reproductive performance has been observed in females from the Bay of Fundy: they calve on average once almost every 5 years, whereas the average was every 3 years. To date [*editor's note:* at the time of the workshop, in 2000], no newborn calf has been observed since 1997 for females from the Bay of Fundy. The consequences of pollution are one of the hypothesis proposed to explain this reduction in reproductive performance. Contaminants that could perturb oestrogen were found in fecal material; this could have a direct impact on breeding [*editor's note:* a total of 69 newborn calves were counted between 2000 and March 2003].

To establish the causal link between the presence of a substance considered toxic and the health of an individual is a sizeable challenge in ecotoxicology. It is known however that persistent pollutants cause disturbances to reproductive, endocrine and nervous systems, and can also cause significant behavioural changes (breeding display and others). Moreover, many physiological and behavioural effects were noticed in humans who consume large amounts of fish from the Great Lakes (decreased IQ, hyperactive children).

In vitro studies have helped establish links between contaminant concentrations and the decline of cell activity involved in immune defence such as phagocytosis, for example. However, it becomes difficult from these studies to project what toxic effects contaminants have according to the concentrations measured in the fat tissues of a live animal. There is still much to be done to understand the exact links between contamination levels and the health of animals in the Estuary.

There are significant limitations when it comes to linking the measurements of certain contaminants and the toxic effects observed on organisms, because only a very small percentage of contaminants discharged in the environment are usually measured. Compounds that are not directly measured, but are linked to other monitored products, can frequently cause biological effects; metabolism of toxic substances in organisms is still largely unknown. It is therefore particularly important to always correlate the contaminant concentrations measured in the region and the impacts observed on the species' biological parameters.

Harbour seal

A decline in reproduction associated with certain contaminant concentrations in the blood was documented in harbour seals held in captivity in the Baltic Sea; however, the same links are yet to be established for animals living in the wild. In the St. Lawrence, there was no causal link established between contaminant concentrations in fat tissues and any biological effects. Preliminary results from an ongoing project indicate a lower immune resistance for harbour seals, but we cannot for the moment determine whether this is related to the presence of contaminants. The levels of contamination in beluga whale and seal blubber suggest a potential significant problem for these populations.

Non-persistent contaminants, of which quantities transiting through the region remain generally unknown, are also to be considered. It is important to put emphasis on these little known substances, such as brominated compounds or endocrine disrupters, which are potentially very harmful and able to interact with other pollutants, causing a synergistic effect on live organisms. Factories are often targeted as significant sources of contaminants, but other sources such as municipal and agricultural effluents must also be considered. In fact, a link between the feminization of fish populations and the presence, in sewer effluents, of active substances used in birth-control pills, has already been documented. Thus, even if municipal effluents contain less contaminants, they can sometimes prove to be very harmful.

Concerning persistent toxic substances, it will be difficult to establish new management measures for the marine protected area. The MPA will have to support the existing programs and perhaps also determine and monitor some local sources. Furthermore, it would be interesting to continue or establish programs for monitoring marine mammal pathologies, but also pathologies of other organisms that are found in their habitats (birds, fish). In addition to monitoring contaminant concentrations in the environment, these activities would help establish a causal link between certain pathologies and contamination levels in organisms. Finally, the research and monitoring of “new” compounds should be encouraged, such as phytoestrogens released by paper mills and municipal effluents, or tributyltin, which is still being used today in antifouling paint on large ships.

Finally, plastic waste does not appear to be a problem for marine mammals in the St. Lawrence Estuary. Some rare cases of plastic waste found on or in dead animals have been reported. A study carried out upstream of Tadoussac seems to indicate that the quantities of plastic waste found on the Estuary coasts are relatively low, especially compared to those found on the east coast.

Contamination is a very complex issue. Many toxic compounds are not very well documented, if at all, and their synergistic effects are poorly known. Moreover, many sampling problems remain, and the links between contaminant concentrations and biological effects are still to be established. On the other hand, a wealth of medical literature confirms the harmful effects of these substances. Within a management framework, we can examine the need for establishing for marine mammals a clear causal link between a toxic substance and pathology. According to the precautionary approach principle, there appears to be sufficient evidence to consider contamination as a very significant issue in the context of establishing the marine protected area management plan.

2. DISRUPTION OF SIGNIFICANT ACTIVITIES AND DISTURBANCES

Sectors where intense whale watching activities occur could also be used for resting, feeding, and, for some species, breeding and calving.

Disturbances are likely to reduce the effectiveness of searching for food and feeding by causing animals to modify their swimming and diving patterns and by interrupting their respiratory sequence. The cumulative impact of long-term disturbances could therefore reduce marine mammals' capacity to store essential energy reserves during the summer to ensure reproductive success and survival during periods where feeding is reduced.

For certain marine mammal species, it is possible that disturbances have an impact on calving and rearing: these activities could, for example, disturb nursing activities by causing the mother to flee, and in some cases, cause offspring isolation. The repeated passing of boats near the animals can also jeopardize resting activities.

Summary of participants' discussions and notes

First of all, it is important to define what disturbances are. Disturbances correspond to any human activity that causes a change or a stop to an activity a marine mammal is performing. Taken in their broad sense, disturbances have harmful consequences when they become recurrent. It is thus necessary to consider the form of disturbance, but also its frequency and duration, the most harmful kind of disturbance being a frequent but non-continuous disturbance. Human activities that cause a short-term disturbance will essentially have a longer-term impact, even if this impact is much more difficult to prove scientifically.

Whale watching activities (nearly 15,000 boat outings recorded in 1998), almost exclusively directed towards cetaceans, occur mainly within the limits of the Saguenay-St. Lawrence Marine Park (SSLMP), and are potential sources of intense disturbance. Tourism, aided in part by a considerable marketing effort to popularize Quebec maritime regions, increased between 6% and 9% per year between 1995 and 2000 (except for 1996, the year of the Saguenay flood), which could produce an increase in the whale watching industry in the Estuary and Gulf of St. Lawrence.

Sources of disturbance outside the SSLMP are much more dispersed. However, it is possible to identify areas where disturbances are likely to have more significant impacts according to species. On the south shore, watching activities are directed towards seals, but the regular presence of small whales feeding north of Bicquette Island could be of some interest.

In addition to activities performed by the whale watching industry, disturbances produced by recreational boaters and other maritime activities (transport, cruises, etc), which can have a significant impact, must also be taken into account: between 9% and 10% of whale watching activities are conducted by recreational boaters, who are less informed and much harder to contact.

Beluga whale

Arctic beluga whale behaviour towards human presence is very different from that of the St. Lawrence beluga whales, which react much less intensely. Hunting activities in the Arctic would appear to be the main cause for this behavioural difference between the two populations. Therefore, the St. Lawrence beluga whales could have developed a certain habituation towards human activities. These animals occupy a sufficiently vast territory and are usually away from areas of potentially high disturbance. Therefore, there is no reason to believe that beluga whales experience intense disturbance in the St. Lawrence Estuary. On the other hand, we cannot dismiss the assumption that a certain level of disturbance could occur at certain periods (during calving and perinatal activities) and in some specific locations where beluga whales appear to be intensely exploiting a concentrated and abundant food resource.

For this mammal, it is possible to identify some "potential" feeding areas, such as the Île aux Lièvres, Kamouraska and Île aux Coudres areas. The beluga whale's intense use of these relatively small areas corresponds with the spawning period and range of some fish species on which it feeds. In the Arctic, beluga whales sometimes travel up to 800 km to prey concentration areas for a 2 to 3 week period. It is therefore quite possible that prey concentration areas have considerable implications in beluga whale energy balance. Therefore, it would be important to take temporary management measures during periods of intense use of these areas, although it would be rather difficult to achieve as the spawning period and range of forage species changes every year.

Besides these prey concentration areas, there are few definite beluga whale concentration areas. A significant proportion of feeding most likely occurs outside the areas discussed previously. In fact, beluga whales appear to follow their prey movements, and we can presume that they do not generally have very delimited feeding grounds.

In light of the current knowledge, beluga whales do not appear to use specific calving areas. In the Arctic, calving occurs during periods of migration, when beluga whales are returning from the estuaries. The territories in the St. Lawrence where adults and young are observed (Map 4) are relatively vast, so establishing strict regulations aimed at decreasing disturbances may not be appropriate.

In short, the beluga whale dispersion in relation to feeding, calving, and perinatal activities is partly determined by their prey movements and by each individual's habits. The only apparent constant in the dispersion of individuals (geographically and in time) is the loyalty shown by beluga whales for certain areas: the Sainte-Marguerite Bay area is a good example of an area privileged by beluga whales and represents one of the rare areas that could be covered by specific regulations; however, the exact reason for this attachment remains unclear. Thus, it will be difficult to identify precise management areas. We should therefore move directly towards regulating, in a more general way, certain human activities involving a risk or disturbance for beluga whales.

Rorquals

Disturbance is generally a poorly documented problem. An significant negative correlation was noted for fin whales between the number of boats and the length of deep dives (which are believed to be linked to feeding activities). However, we are not able to determine a minimum threshold regarding the number of boats required to produce a change in the duration of dives. In addition, boat pilot behaviour is as important—if not more so—as the number of boats present. Although we know that the presence of boats changes important fin whale feeding behaviours, consequences remain unknown, and any attempt at determining specific impacts on the animal is speculative for the moment.

The main obstacle related to studies on disturbance is our capacity to interpret observed behaviour and link it with a source of disturbance. For example, blue whales seem to be much more sensitive to disturbances than fin whales. However, it should be noted that blue whales feed at a lower trophic level (mainly krill) than fin whales. Large concentrations of krill are found on a much vaster territory than capelin, for example, which represents part of the fin whale diet. Blue whales could therefore have a greater choice of feeding grounds and thus be able to move towards areas of lesser disturbance, contrary to fin whales, which could be restricted to prey concentration areas located mainly at the head of the Laurentian Channel.

Right whale

Right whales spend a lot of time near the surface for feeding, resting, and social activities. Boats circulating in the sectors where these activities occur are likely to cause some disturbances, primarily during feeding activities. It should be noted that because of its scarceness in the St. Lawrence Estuary, this species is of particular interest for boaters. The extremely precarious status of right whale requires particular protection measures: in the Bay of Fundy, for example, the maximum approach distance was set at 500 m, and similar measures should be established in the St. Lawrence. In order to ensure that protection measures are respected, a marked boat could “escort” the rare individuals who occasionally visit the Estuary.

More thorough studies are necessary to characterize various marine mammal behavioural patterns according to disturbances, and then to establish links between their reactions and the various types of disturbances and also to identify the risk factors and human activities responsible for disturbances that have the most effect on the reaction of animals. The use of the areas by marine mammals will also have to be documented to determine the real impact disturbances have and to support management measures.

Seals

For seals, disturbances can also have a significant impact according to location and time of the year. Among other things, a drop in seal numbers was reported on the St-Barnabé Island following the establishment of excursion activities for the general public. The conduct of some boaters approaching haul-outs too closely, forcing seals to dive into the water, and sometimes repeating this behaviour at another haul-out site, should also be condemned. However, the extent of observation activities is known only for some sites. Thus, in the Bic and Riviere-du-Loup areas, unlike the Saguenay area, seals are directly targeted by the marine-mammal watching industry.

In the literature, the maximum suggested approach distance is approximately 300 m, but it is difficult to establish a maximum approach distance for watching activities while effectively minimizing disturbance. For seals, as for all marine mammals, disturbance levels are modulated according to several risk factors (approach and boat types, sudden changes in human activity, such as engine cut-offs, fast starts, etc.).

Thus, there is a certain gradation of disturbance intensity that is determined by several factors: seal reactions to disturbances are quite inconsistent and difficult to interpret. For example, the use of the various haul-outs changes seasonally. In the Estuary, haul-outs are actively used by harbour seals at the beginning of summer, then a drop or a change in their use occurs in July, after which seals return to these same sites in August.

For seals, the importance given to a particular haul-out site could be rather significant. In fact, a degree of fidelity by individuals towards their haul-out sites was observed using a transmitter monitoring system. On the shores of the Estuary, the number of haul-outs does not represent a limiting factor as such. However, these sites are isolated enough that there are few alternate sites in the vicinity.

During moulting, seals are much less inclined to go into the water and may give the impression that they are not disturbed by human presence in the vicinity. It is very difficult to establish whether seals can develop a tolerance for certain human activities. These different factors affecting the number of seals at haul-out sites show how difficult it is to document specific forms of disturbance, for seals as well as for marine mammals in general.

Although several sites are hard to reach for observers, others, such as the southeastern reef in the Grande-Anse to Bic sector, are quite easily accessible. Moreover, the tourist season corresponds to particularly important periods physiologically for the harbour seal (calving, lactation, moulting). Significant and frequent disturbances of these haul-outs would likely create problems for seal populations on a more or less long-term basis.

Thus, in order to classify haul-out sites, seal activities need to be categorized by level of importance and parallels with tourism activities should be made. However, all haul-out sites are more or less used for calving, and it is difficult to rank other seal activities by level of priority based on current knowledge.

It is possible to simply establish the importance of a haul-out site according to its use by seals: the sites to be protected should therefore essentially be those most used by seals and most accessible to humans. A first prioritization of haul-outs according to these criteria is shown in Table 2.

Considering the importance of ecotourism for Quebec regions, it will be difficult to prohibit access to significant haul-out sites, but it is possible to limit access at specific periods of the year during which the various seal activities occur, such as calving and moulting. Haul-outs will therefore have to be characterized as a whole in order to establish this type of regulation, and particular efforts will have to be made towards educating promoters and tourists in general.

Harbour porpoise

Harbour porpoise seems rather sensitive to disturbances, since it leaves areas of intense noise and can travel long distances to flee disturbances. Since it is not a very exciting species for whale watching, this type of activity does not particularly target it.

Table 2. Prioritization of haul-outs to be protected along the St. Lawrence according to their use by seals and their accessibility to humans.

Shore	Haul-out	Priority	Comments
South	Southeastern reef	High	• Scheduled real estate development • Easier access
	Mitis reef	High	• No access to water other than by Mitis Point
	Tobin flat	Medium	• Little access except at low tide
	Île Ronde and île Verte	Low	• Little access • Very few seals are reported at this location
	Île Blanche	Low	• Little access because of rocks • Large seal concentrations (especially harbour seals)
North	Île aux vaches shoals	Low	• Little access
	Battures aux Alouettes	Medium	• Little access • Limit access by kayak
	Ragueneau	High	• Very accessible • Potential development
	Cap Éternité	High	• Relatively significant seal concentrations • Accessible

Along with research efforts on marine mammal disturbances, raising awareness and educating the public regarding this issue must continue. Effective protection will become possible with such initiatives along with a series of protection measures developed from acquired knowledge on marine mammals. It is also on this basis that a precautionary approach must be recommended in order to protect marine mammals and the whale watching industry as well, whose economic importance is vital to the areas involved.

It is possible to consider banning activities with high disturbance potential, in some sectors at least, such as personal watercrafts, some kinds of sport or commercial fishing, dredging, the use of explosives, some military activities, etc. With regard to whale watching activities, a regulation establishing maximum distances and speeds to respect should be considered. A time limit for visits could also be established in some very busy areas, such as the sector at the head of the Laurentian Channel at high tide for example, where rorquals gather for feeding. The number of whale watching boats present in these sectors during these aggregation periods could also be controlled; however, this measure is rather badly perceived by industry.

The types of boats present in some sectors could also be regulated. Large capacity boats can transport many more passengers and probably reduce the number of boats in the area, but they generate more noise than smaller boats. More thorough studies will therefore be necessary to determine what is desirable to reduce impacts on marine mammals. We already know, for example, that one of the determining risk factors is pilot behaviour more than the type of boat, thus the importance of raising awareness and educating the public. In addition, a large majority of promoters are in favour of a regulation.

The type of management to be adopted could be considered in two ways: 1) to protect the entire area in a general way (and perhaps more permissive), or 2) to protect more intensely restricted areas. In the latter case, the areas to be protected will have to vary in space and time, and be established according to marine mammal activities and human activities. This solution would be popular if the areas are well identified, as in the case of the fin whale feeding area. On the other hand, it would be difficult to apply to other marine mammal species such as the beluga whales.

Protection measures will have to be established according to activities that might develop in the future. Whale watching activities at sea are developing rapidly on the Côte-Nord, where this industry is considered a priority in the regional development plans, as well as on the south shore. The management plan of the marine protected area will therefore have to be reviewed on a regular basis, and protection will have to be adapted to new human activities having an impact on marine mammals. Finally, the SSLMP and MPA regulations will have to be consistent; otherwise, a transfer of human activities towards areas with the least strict regulations could occur.

3. HARBOUR SEAL PUP ISOLATION AND DISPLACEMENT

Every year, isolated pups are found on the shores of the St. Lawrence. They are often picked up on the beaches by people who believe the pups are in distress and are taken home or to a fisheries agent with the hope of saving them from abandonment (E. Albert, Maurice Lamontagne Institute, Mont-Joli, QC, and C. Fournier, DFO, 337 boul. Lasalle, Baie-Comeau, QC, pers. comm.). These events occur mainly in June and July, during the weaning period of harbour seal pups, who will gradually learn to feed themselves (Boulva and McLaren, 1980). In many cases, a pup that appears to be abandoned will find its mother on its own if it is not disturbed; on the other hand, being disturbed or moved can prove fatal.

However, sometimes pups are truly abandoned prematurely by their mothers. These abandonments could be reactions to disturbances or health problems in the pup or mother.

Summary of participants' discussions and notes

The risks of pup isolation are directly related to their age: the younger they are, the greater the risk of isolation is, and the less likely they will be to survive prolonged separation from their mother.

Several natural factors can lead to pup isolation. Weather conditions, for example, have an influence on the mother's ability to find her young, but the mother can also abandon a pup if it is wounded or sick, or when the mother is too young and has little experience, or when there is heavy disturbance.

Some human activities can therefore contribute directly or indirectly to mother–pup separation. Man-made noise is an example of a factor that could lead to pup isolation. It is reasonable to believe that prolonged observation activities at some sites could also contribute to pup isolation; the mother could avoid approaching if there is human presence near the pup, as has already observed.

On the other hand, if the newborn is touched but then left alone, there is little chance the mother will abandon it. For this reason, in order to prevent a pup from being moved far from the area where it was taken, by well-intentioned but uninformed people, it is critical that awareness campaigns be conducted in order to educate the public concerning the risks involved in such practices.

4. INJURIES AND MORTALITIES CAUSED BY HUNTING AND POACHING

Seal hunting and poaching are causes of mortality for the target species, but also for non-targeted species such as the harbour seal.

The harbour seal can be confused with other seal species for which hunting is legal and be inadvertently killed. The juvenile grey seal and the adult harbour seal, roughly the same size, sometimes share the same haul-outs and can be misidentified (hunting period scene from 1 March to 1 May and 1 October to 31 December). Though harp seal is more often found offshore on the ice edge, it can also be confused with harbour seal when individuals from both species are in the water and only their heads emerge. According to documents voluntarily completed by hunters from the Estuary's north shore, approximately one hundred harbour seals were killed between 1987 and 1996; however, it is not known whether the hunters who took part in this study were able to correctly differentiate seal species.

Harbour seals could very well be victims of poaching by fishermen because of their lack of popularity, or by malicious or misinformed hunters; there was a reported case of a water chase with a hunting weapon in Mitis Bay. It could also be hunted for its meat, which some enjoy eating. Finally, many don't know the precariousness of this population.

Summary of participants' discussions and notes

The significance of seal poaching and accidental killing in the St. Lawrence Estuary is difficult to establish. This is mainly due to the fact that it is difficult to obtain reliable data on the number of seals killed by mistake, because professional hunters are not inclined to provide this kind of information. In addition, the absence of systematic verification by authorities raises huge problems as it prevents us from assessing the extent of the problem, as well as raising awareness and controlling abuse. It is obviously even more difficult to estimate the significance of poaching, because of the fear of the consequences.

We assume that professional hunters are generally able to identify non-targeted species and therefore avoid killing them by mistake. However, in areas where harbour seals are present, it is possible a hunter might have trouble identifying a seal and be tempted to slay the animal and correctly identify it later.

Could this problem have significant consequences on the harbour seal population in the St. Lawrence? Current knowledge indicates that the removal of less than 120 individuals would not be problematic.

Therefore, the magnitude of these problems must be evaluated as precisely as possible. It is critical that awareness and continuing education programs for professional hunters and the general public be established, and better control of stakeholders must also take place. Finally, it is imperative that studies on the dynamics of various seal species populations continue.

5. AFFECTED COMMUNICATION AND ECHOLOCATION

Man-made ambient noise, which is primarily the result of heavy sea traffic, especially from May to October, can be significant in some areas of the Estuary. Scheifele et al. (1997) measured the level of noise (expressed in dB re 1 µPa) at some sites in the Estuary at several different times of the day: the noise levels were always clearly much higher than the defined background noise from a recording made at night. The authors recorded (at a frequency of 500 Hz) minimum and maximum noise levels of 155 and 230 dB re 1 µPa, respectively. The maximum value was recorded during a period when whale watching was particularly heavy.

These man-made noises are likely to cause significant trauma (temporary or permanent) to marine mammals. Cetaceans, particularly odontoceti, use sounds to communicate (preserving unity in the group, for example), to navigate, and to identify and capture prey. Ambient noise therefore has an impact on various types of marine mammal activity.

Other potential effects have been identified, such as the masking of these important signals (echolocation, communication, predation) and the changes in behaviour due to an attraction or avoidance of a sound source. Erbe and Farmer (1998) have shown that man-made noises (e.g., noise from an ice-breaker) mask beluga whale vocalizations to a greater extent than natural noises (e.g., cracking of pack ice). In a natural environment, these effects can, to some extent, modify migrations and even force the species to abandon significant habitats (Ketten, 1998). The distance between the noise source and the animal, the frequency of emission, the intensity and the duration of noise, the repetition of noisy events, the animal's hearing ability, and the degree of habituation are all factors that interact and determine the extent of the impact (Ketten, 1998).

Heavy sea traffic emits sounds at frequencies usually lower than 1 kHz (Richardson et al., 1995) and at noise levels higher than 180 dB re 1 µPa –1 m (Ketten, 1998). Smaller boats emit sounds at frequencies clearly above 1 kHz (Lesage et al., 1999) and at noise levels higher than 140 dB Re 1 µPa –1 m (Ketten, 1998). Moreover, the effects of this ambient noise can be more significant in the case of a marine mammal population confined to a relatively restricted habitat (Richardson et al., 1995), as is the case in the Estuary. Given the large number of boats present and the relatively restricted space, we can presume that noise levels are very high in some areas of the St. Lawrence Estuary.

Summary of participants' discussions and notes

The impact noise has on marine mammals goes from a simple momentary disturbance to deafness (temporary or permanent), and even mortality. The rare studies on this issue seem to indicate that the St. Lawrence Estuary represents one of the noisiest aquatic environments in the world. There is a significant potential problem associated with the impacts man-made noise has on marine mammals in certain sectors of the Estuary (mainly at the head of the Laurentian Channel) at certain times of the day.

In the presence of significant noise levels, the ear initially suffers damage at frequencies to which it is most sensitive; this sensitivity varies according to species. The most critical factors are frequency, intensity and exposure time to the particular noise. In the Estuary, the most significant source of noise is related to navigation. Speed, cargo or passenger loads, and the condition of boats are also factors contributing to the level of noise generated in the area.

Generally, the larger the boats are, the lower the frequencies of emitted sounds are, and the lower they are in the water column. Thus, merchant vessels emit much noise in the area, at frequencies lower than 1 kHz, but the duration is relatively short. The majority of whale watching boats, however, emit less intense noises, primarily at frequencies higher than 1 kHz, but for longer periods of time given the almost continuous presence of these boats in certain sectors. Finally, personal watercrafts are very noisy, but since the sound is emitted very close to the surface and partly refracted, less sound energy enters the water.

In addition to cumulative effects on its hearing ability, constant stress by ambient noise may also affect animal's energy balance. Other factors are also to be considered: the Arctic beluga whale, for example, which is faced with predation and hunting, will be more stressed by man-made noise than the St. Lawrence beluga whale.

Masking of the sounds they emit is probably the most frequent impact noises have on marine mammals. For Mysticeti, the main vocalization functions are not well known, but some of them could be used for feeding. In the case of fin whales, a certain matching between vocalization and feeding behaviour associated with tidal cycles and grouping of individuals is known. Rorquals are undoubtedly the most sensitive marine mammals to the masking of vocalizations by noise because the sound frequencies they emit are similar to those of large boats.

For the harbour porpoise, noise also appears to have a rather significant impact: the case of harbour porpoises from the West coast of Canada that avoid areas of heavy circulation is one example, even though these specific areas are significant habitats for them. It has also been reported that for this species, the abandonment level in some areas is particularly significant where noise is emitted by aquaculture-related activities.

It appears that noise does not have such a significant impact on seals. Generally, they are relatively solitary animals under water that hunt with their eyes and therefore do not need vocalization during this activity. However, noises could perhaps have some harmful impacts during mating season, when males call females, and could also be a potential disturbance for communication between a mother and her pup. In the short run, noise can therefore represent additional stress, although without endangering the species survival in the area. It is also possible that noise causes some behavioural changes (avoidance of certain areas, haul-out abandonment, etc.). With regard to seals, it is difficult to identify areas where this problem is more significant. This once again points to research need.

The study on the impacts of noise on marine mammals is complex and raises significant difficulties. First of all, we do not have sufficient knowledge regarding ear function in marine mammals (particularly in Mysticeti) to adequately assess the impact produced by various noises in the environment. Current knowledge on sensitivity thresholds is mostly based on the ear of land animals, which differs from that of marine mammals. Moreover, the link between behaviour and the level of noise measured in the environment is difficult to establish. If a cetacean leaves a sector, it is difficult and almost impossible in many cases to identify the exact cause of this behaviour.

Another difficulty related to the study of behaviour is the animal's habituation to the noise and how habituation can be differentiated from an increase in an individual's deafness. Because of these interpretation difficulties, the behavioural approach should not be favoured.

The physiological approach also has some weaknesses. It is relatively easy to diagnose physical damage to the ear of a dead animal, but it is not always so easy to determine the source responsible for this damage. It is also very difficult to verify temporary losses of hearing, which cause damage that accumulate during an animal's life may eventually lead to a deterioration of the ear and a permanent loss of hearing.

It is vital for us to better understand the hearing ability (i.e., audiograms) and behaviour of marine mammals in order to better manage the resource. For Mysticeti, it is highly probable that acoustic tests in captivity will never be possible, such as those conducted on some Odontoceti. However, in spite of these limitations, the St. Lawrence Estuary represents an ideal area for this type of study: a relatively closed physical space that isolates animals and a rather high number of specimens are unquestionable assets for scientists.

Within the framework of the marine protected area, it will be necessary to establish long-term monitoring programs, with which we will be able to characterize marine mammal behaviour according to the level of man-made noise in the Estuary. However, given the changes in sound propagation due to the environment's physical characteristics, it will be difficult to cover great areas through these monitoring initiatives, even over a short period. It would also be quite interesting to be able to collect and analyze perceived sounds at the level of the marine mammal hearing mechanism.

For monitoring programs and for the management of the MPA, we will have to try to determine the potentially problematic frequencies for emitted noises, but also for concerned species (i.e., audiograms). For example, sea traffic emits a lot of noise under 1,000 Hz, whereas beluga whales can hear frequencies of up to 100 Hz and regularly use frequencies around 500 Hz for communicating. Thus, frequencies between 100 Hz and 1,000 Hz should be monitored on a priority basis in the Estuary.

Some human activities, such as seismic research (air guns), could be prohibited in certain sectors given the strong noise generated and the significant impacts they can have on marine mammals. Future projects, such as the increase in coastal shipping between Forestville and Rimouski and the projects (two proposed to date) of whale watching by helicopter on the shores of the Estuary, must also be considered in the management of the MPA. Regarding this issue, the SSLMP is currently [*editor's note:* in 2000] trying to impose a maximum approach distance of approximately 600 m for helicopters.

Concerning maritime circulation, imposing speed limits could greatly reduce the levels of noise emitted. However, with a speed reduction, boats will remain longer in a given sector, which is not desirable: noise exposure will be longer and collision risks will be higher. For this reason, it is difficult to determine what is preferable for whale watching activities between a large fleet of smaller boats or a restricted number of larger boats. It is therefore necessary to determine noise characteristics such as frequency and intensity, and to properly document the amount of time marine mammals are exposed to these noises. This information will make it possible to establish and support the regulations.

Sound propagation in the environment, which is influenced by oceanographic characteristics, needs to be better understood. Thus, by considering these characteristics, it would perhaps be possible to implement some management measures to limit the impacts noise has on marine mammals.

It should be considered that some management measures, while being popular, are quite simply not appropriate. Thus, in many cases, it is impossible to impose a maximum noise level in water because this would involve the removal of a considerable amount of boats in certain sectors, and this is considered unacceptable by area stakeholders; this all depends on their will and interests. In the fisheries sector, it is relatively easy to impose maximum noise limits in water because it helps keep the targeted species in the area. The protection measures that will be introduced will therefore have to be realistic and, as much as possible, consistent with the general interests of the main stakeholders.

6. HABITAT CHANGES

The beluga whale's coastal habits expose it to a whole range of potential disturbances related to human activities, such as harbour developments, construction of marinas, dynamiting or dredging. However, aside from summertime abandonment of the Manicouagan River estuary, no case of desertion from sites has yet been documented in a satisfactory way.

The significance of estuarine environments for beluga whales is undeniable. In fact, beluga whales tend to return to a specific estuary or groups of estuaries (Finley, 1982). Several biological advantages can be linked to this behaviour. The relatively high temperature of the water in the estuaries, which seems to be the determining factor to explain the beluga whale preference for these habitats (Fraker et al., 1979; Painchaud, 1982; Boily, 1995), could preserve the animal's energy reserves. Moreover, the high temperatures and low salinity could also accelerate this species' moulting process (St. Aubin et al., 1990). Availability of food resources, low depths and shelters against storms are also advantages associated with estuaries (Painchaud, 1982). The gathering of beluga whales in the estuaries could also have a significant social function. A complex network of relationships and affiliations between individuals appears to be formed there (Painchaud, 1982).

It has been suggested that changes in the beluga whale displacement habits at the Saguenay River mouth are linked to disturbances related to the increased circulation in this sector (Pippard, 1985; Caron and Sergeant, 1988). Also, it has been implied that the beluga whale desertion of Tadoussac Bay was related to the increase in maritime circulation following the construction of the marina (Pippard, 1985; Sergeant, 1986), but this assumption was questioned. Some also think that hydroelectric development in the Manicouagan River area, creating some physicochemical changes to the habitat, triggered the beluga whale desertion of this area (Sergeant and Brodie, 1975).

Several significant seal habitats are located close to areas likely to undergo rapid changes and developments that could lead to the loss or disturbance of habitats. For example, the study conducted by Lesage (1999) confirmed the coastal nature of the harbour seal habitat in the Estuary; this species feeds in the Estuary's bays and rivers and also calves, rests and moults on haul-out sites. Any coastal development (urban development, river harnessing, dock and marina constructions, marina, etc.) close to the sites used by seals could have a significant impact on their habitats and the habitats of their prey, thus compromising the use, accessibility or availability of these sites. In the worst of cases, certain coastal developments could force seals to abandon sites that meet their needs, and there already seems to be few such sites in the Estuary.

Summary of participants' discussions and notes

Some habitat changes could become problematic for some marine mammal species as well as their food resources. The scheduled dredging at the Bic marina, for example, will allow for a greater number of boats in the sector, which could increase disturbance. Agricultural development upstream of rivers (e.g., hog house) could also become very problematic because of the input of additional organic matters and, to a lesser extent, contaminants to the environment. Changes to the flow of rivers due to harnessing are another example of significant and direct habitat disturbances that could have serious consequences on marine mammals.

On the Côte-Nord, the large rivers (Manicouagan, aux Outardes, Portneuf, Betsiamites, Sault au Cochon, etc.), are mostly all harnessed to various degrees. These rivers were used extensively for timber floating. Few studies have been conducted to determine the impacts of river harnessing on marine mammals, but it is recognized that the impact of dams can be very significant for some of their food resources. In fact, dams are responsible for 25% of eel mortalities during their migration. Along with other problems (climate change, contamination, etc.), this partly explains this species' drastic population decline over the last few years. With respect to marine mammals, the lack of data and studies prevents us from discussing changes in the use of estuaries in relation to river harnessing.

Beluga whales are very loyal to estuaries as a habitat, but their use appears to be rather irregular. In the Arctic, for example, beluga whales use estuaries over short periods of time, mainly for moulting, and don't feed very much, but this does not mean that beluga whales are not in some estuaries for feeding purposes.

It is important to consider that the reason why beluga whales abandon an estuary is not necessarily due to the physical changes of the habitat itself, but could mainly be linked to hunting activities conducted there. In fact, the only documented case of abandonment of an estuary by beluga whales caused by hunting was on the Grande-Baleine River, where the sub-population was decimated. It is highly likely that hunting also significantly contributed to the abandonment of the Manicouagan River.

Whatever the reason, one must wonder whether the beluga whale can withstand other losses of habitat. The quantity of available habitats has been reduced considerably by human activities, and an increase of man-made pressure, already quite strong in some sectors, could have serious consequences.

For the MPA, nothing can be done for the changes to the habitat that have already occurred, but we can and must act to prevent the impacts future projects could have on marine mammals that would involve additional habitat changes. The activities of the marine mammals of interest (beluga whales and seals) occurring in rivers located on the territory of the MPA must therefore be categorized. Some significant sectors in terms of habitat could receive a special protection status, such as easily identifiable haul-outs for seals, and should be protected in priority. For beluga whales, significant areas could include Baie Sainte-Marguerite, the western side of îles de Kamouraska, the southern side of île Blanche, and the southern part of the Laurentian Channel, which extends from Bergeronnes to Les Escoumins.

7. ENVIRONMENTAL DISASTERS

The maritime shipping of petroleum products and other toxic products is significant in the St. Lawrence Estuary. The particular oceanographic conditions of the Estuary (strong tidal currents, frequent fog) and heavy sea traffic from ferries and whale watching boats that cross the Seaway considerably increase the risks of a major spill.

Geraci (1990) presented a series of studies showing the ability of the bottlenose dolphin (*Tursiops truncatus*) to avoid oil slicks on the water surface. This species seems to rely initially on their vision and to a certain extent on their echolocation system; their avoidance behaviour regarding oil slicks appears to be reinforced if the animal has already come in contact with one. It is very likely that the same abilities are found in other cetacean species, particularly Odontoceti. Moreover, in the case of direct contact with oil, it seems that the impact would be weak because cetacean skin is a very effective barrier against harmful substances found in oil (Geraci, 1990).

Oil spills can still represent a risk for marine mammals since the toxic fumes emanating from crude oil or from volatile distillates are likely to damage sensitive tissues (eye, mouth and lung membranes) (Geraci and St. Aubin, 1990). Furthermore, marine mammals can ingest the spilled product and/or its metabolites either directly or via contaminated prey (Geraci and St. Aubin, 1990). Given that the St. Lawrence Estuary represents a relatively restricted habitat, a significant spill would create serious risks for beluga whales.

Summary of participants' discussions and notes

Because of its heavy sea traffic, the St. Lawrence Estuary is an area where significant spills are very likely to occur. The ageing of international fleets is also increasingly problematic. Throughout the world, there is little evidence of major impacts concerning marine mammal species in the St. Lawrence, in spite of the many spills that have occurred to date. However, the impact of a spill on these species could be considerable in such conditions as those found in the Estuary. In fact, this area is relatively closed and narrow, and because of the strong currents, a spill in this area would disperse very rapidly over a wide territory. This phenomenon would be even more significant in the case of a spill close to the Saguenay River mouth, which is one of the most dynamic areas in the Estuary.

At first glance, oil spills do not seem to be particularly problematic for seals. In fact, due to its layer of fat tissue, a seal would be protected even if its fur were to be soaked with oil. On the other hand, seals' food resources could be affected. Seals are able to reduce their food intake during a certain period, but they will have to rebuild their energy reserves eventually. Toxic fume inhalation can also cause problems, producing neurological and respiratory disorders.

The time and location of the spill as well as the speed with which these areas are cleaned up will determine the seal survival rate. Therefore, it is necessary to protect alternative haul-out sites for seals to use in case their main site is affected by a spill. Therefore, it is important to identify these sites in emergency plans in order to enable stakeholders to more adequately protect them during a spill.

Some dolphin species are able to detect oil slicks and show avoidance behaviour, but we are not yet able to determine whether this is the case for all Odontoceti. It is possible that beluga whales are also able to detect oil slicks, given their very effective echolocation system. However, we cannot at this time eliminate the possibility that an oil spill can have a significant impact on these species. As with seals, the most significant problems for cetaceans could be damage to mucous membranes and to the respiratory system, but also problems due to the direct impact of a spill on food resources or problems related to the integration of products introduced into the food chain.

Knowledge and available means to adequately protect marine mammals from an environmental disaster such as an oil spill seem to be insufficient. It is therefore important to determine the areas with the greatest risk for marine mammals and to assess possible emergency actions in the event of a spill. The chemicals used for cleaning an oil slick could perhaps be more hazardous to the animals in the vicinity than the oil slick itself. This is why we must also educate the companies that clean up spills.

As many toxic products (chlorine, bauxite, sulphides, etc.) are transiting on the St. Lawrence, we must consider the possibility of spills other than oil spills. It would therefore be important to know what are the products that are being transported as well as their potential impacts on marine mammals and other organisms. Finally, the transportation of some substances in the Seaway should perhaps simply be prohibited.

In short, we must gather all the possible information on marine mammals and their environment, and combine this information with the data collected on transported substances. In the event of a spill, this data will enable us to take the most suitable emergency actions to limit the negative impacts, and it would also enable us to concretely assess the impacts and changes to the environment. Finally, we should keep in mind that, given the physical characteristics of the St. Lawrence Estuary, it would be practically impossible to contain a major spill there; therefore, the precautionary approach must be widely encouraged.

8. INJURIES AND MORTALITIES CAUSED BY COLLISIONS WITH BOATS

Boats in the St. Lawrence Estuary are for the most part potential sources of collisions with marine mammals; collisions can injure the animal and lower its ability to survive in the environment, or can even be fatal. Sea traffic is significant along the St. Lawrence Estuary: in addition to the ships using the St. Lawrence Seaway, many fishing boats, recreational boats (sail boats, personal watercrafts, kayaks, etc.) and boats used for whale watching are found in this area. We estimate that 80,000 boat movements, and more than 90,000 arrivals and departures per year occur from various harbour infrastructures in this sector.

Summary of participants' discussions and notes

Even though some cases have been reported, mortalities caused by collisions with boats do not really concern the different seal species, a situation mostly explained by their speed and their great agility.

There also have been few reported collisions with blue whales; however, it has been noted that 25% of the individuals photographed in the Estuary and the Gulf have marks that could be related to collisions with boats. Several collision marks have also been noticed on fin whales. The great numbers of collisions with minke whales that have been documented lead us to believe that this species is particularly affected by this problem. Moreover, it is generally known that the number of whale mortalities related to collisions is underestimated, since carcasses sink and therefore many cannot be recovered.

The whale's ability to detect boats and avoid them, especially in bad weather, remains unknown. It seems that smaller boats are particularly hazardous for these species because of their high speed and manoeuvrability. Fin whales would therefore be vulnerable in areas of heavy feeding at the head of the Laurentian Channel, where there are high concentrations of individuals combined with considerable whale watching activities.

Outside of this area, larger boats using the Seaway also present a significant risk, especially at night, when whales are usually motionless near the surface.

Between 1982 and 1999, four beluga whale carcasses were found, and the causes of mortality could be related to collisions. This represents approximately 2% of the causes of mortality for beluga whales that were indexed during these years. Three of these collisions occurred recently, in 1995, 1996 and 1999. In 2000, a beached beluga whale was found showing signs of old fractures to the ribs; this type of injury could be related to a collision, even though it is difficult to know for sure. The 1995 and 1996 collisions involved small boats. Beluga whales would be particularly intrigued by propellers, as they place their noses in the stream the propellers produce. The number of collisions with this species could have increased over the last few years.

It would be interesting to collect tissues from animals that died following a collision, since these animals are more representative of the population than the beached individuals (who are generally young or old individuals, often in an advanced state of decomposition). It would also be interesting to conduct studies using sonars to try to detect the presence of whale skeletons in the deeper parts of the Estuary, such as the Laurentian Channel area. In fact, given the rather strong pressure at these depths, the carcasses that sink in this area might not all return to the surface which would distort mortality rate estimates.

For the right whale, collisions with boats represent the main cause of mortality in eastern Canada. Between 1970 and 1998, 18 collisions were reported, nine occurring in the 1990s. However, it should be noted that mortalities caused by a collision with a boat were not reported in such a systematic way in the past, and that internal exams to determine the exact cause of mortality were rarely done. This explains, at least in part, the apparently high number of collisions reported during the last few years.

Most of the time, mortalities are reported by boats other than those that collided with the whale. It is thus difficult to obtain precise information regarding the boat involved and its navigation characteristics at the time of collision. It is important to mention that, in the very large majority of cases, the animals were alive at the time of collisions.

For whales, there must certainly be a habituation phenomenon occurring with regards to boat presence, causing them to become less vigilant. A greater number of collisions seem to occur inside, or very close to the areas where right whales are known to gather for long periods of time.

The ability to hear (and consequently to detect boats sufficiently quickly to avoid collisions) of some marine mammal species might be investigated. Some animal behaviour could also involve risks: it is possible that these animals prefer the bow of ships, where there is less noise, compared with the sides and the stern. However, they seem to be able to avoid boats moving at steady speeds and maintaining a steady heading.

Quieter boats would represent a threat, since it seems that whales detect and avoid noisier ships first. Sailboats are therefore a problem for marine mammals because of the small level of noise they generate. In fact, during heavy traffic periods in watching areas, whales must navigate to avoid collisions. In fact, three collisions were reported for the same wooden schooner. The high number of collisions for this boat, which occurred mostly at low speed in the watching areas, can be explained by the fact it emits very little noise in the environment. Furthermore, because of the structure of this boat, the pilot's visibility is restricted.

The presence of high-speed catamarans, such as the one providing shuttle services between Rimouski and Forestville (approximately 30 knots), could represent a danger. Boats of this type have a relatively shallow draught, partly because they sail at high speeds, and for this reason, would emit less noise in the environment, which could make their detection more difficult for whales.

Thus, some factors such as pilot visibility, speed and quantity of noise emitted by boats are very important in the avoidance of collisions and are all the more important at times of heavy boat traffic in a relatively restricted area.

Speed limits could be imposed when whale watching boats arrive or leave watching areas. On the other hand, it is difficult to determine whether reducing speed can effectively decrease the number of collisions, because as mentioned previously, although it is easier to avoid a slower boat, reducing boat speed will increase the amount of time they spend in the area, which only increases the risk of collisions and amplifies other problems linked to the presence of boats (noise, disturbance, etc).

In the United States, this solution was not considered to be satisfactory, and research is directed further towards technologically based solutions. Moreover, maritime shipping stakeholders are not leaning towards a regulation for reducing the speed of boats in certain sectors, because this type of measure would have too many consequences regarding competitiveness. In order to circumvent this problem, it would perhaps be possible to allow boats to sail at normal speeds in marked out channels, thus reducing the territory to be monitored for marine mammal detection purposes.

Different measures can be considered. In the Boston area, for example, boats of 300 tons or more must communicate with the authorities to receive a report on whale positions in the area. Moreover, boats are not allowed within 500 m of a right whale. In eastern Canada, important programs to educate and raise awareness are currently being implemented for stakeholders. In the Bay of Fundy, a code of ethics preventing any whale watching activity for this species has been established. In certain sectors of the bay, pilots must therefore be cautious to avoid whales likely to come across their route.

In the St. Lawrence, it would perhaps be possible to get ferry workers involved in the protection of marine mammals, and it would also be desirable to solicit support of merchant vessel pilots transiting in the St. Lawrence. Thus, all boats would be required to report cetacean sightings by giving their position. Some have suggested that the Seaway be moved away from certain areas where large concentrations of marine mammals are located. But that would only move the problem elsewhere, since some species do not have specific areas. For small boats, we could possibly enforce the use of shields over propellers to avoid injuring marine mammals. Finally, regarding sailboats, the use of motors could be compulsory in certain areas.

9. INJURIES AND MORTALITIES CAUSED BY FISHING GEARS

Several marine mammal species are vulnerable to entanglements in fishing gears (Jefferson and Curry, 1994). Entanglement is one of the phenomena that have the most impact on marine mammals. It can cause drowning, strangulation, injuries and infections, and other problems reducing the animal's chances of survival (Laist, 1987). With the help of industry, new techniques were recently developed to reduce entanglements in fishing gears: for example, the use of transmitters producing sounds that enable marine mammals to detect fishing gears appears to be an interesting approach (Lien, 1995). To be effective, changes in fishing procedures and the use of technology must rely on a good knowledge of the fishing methods used and on an understanding of the behaviour of the targeted species as well as that of the marine mammal species that might get caught in the gear (Lien, 1995).

Summary of participants' discussions and notes

Knowledge of seal by-catches in the St. Lawrence Estuary is rather sketchy and anecdotal. It is reported that seals are being caught in herring gillnets (2 to 3 per year) off Trois-Pistoles. Only one case of by-catch in a fishing weir was reported (Rivière-du-Loup). Seals entering and leaving these fishing gears without being caught are rather regularly observed. Additional nets are sometimes illegally fitted to fishing weirs in order to capture other fish species, representing an additional threat for seals.

In fact, the biggest danger to seals is that fishermen will be tempted to kill those seals that come to feed in the fishing weirs because of the damage they cause. In addition to damaging the harbour seal population, this illegal hunting (which is not only practised by fishermen operating fishing weirs) represents a double loss since it is not reported as monitoring mortalities or for collecting scientific information. Bottom nets can cause problems, especially for grey seals and harp seals. A study reported many seal drownings in smelt traps off Prince Edward Island; however, this type of fishing gear is not used in the Estuary. Finally, traps used for crab and lobster fishing do not seem to cause seal by-catches.

By-catches are a very significant man-made cause of mortality for the harbour porpoise. For this species, cod traps and herring fishing weirs in Newfoundland and in Bay of Fundy represent a risk, and gillnets at less than 100 fathoms (cod fishery) appear to present the highest risks of entanglement. In the Estuary, the number of by-catches is closely related to the status of the cod fishery. Thus, if gillnet fishing were to return in this area, the risks of by-catches will undoubtedly increase. However, it is highly possible that individual numbers are currently underestimated for the estuarine population. If this is the case, the number of by-catches could have a lower impact than expected on maintaining the population at an acceptable level.

Two cases of beluga whales entangled in gillnets were reported in the Estuary during the last few years. One case was confirmed by authorities, whereas the other was reported by the fisherman himself, three years after the event. There are considerable quantities of sturgeon gillnets in certain areas where beluga whales are abundant, particularly between Kamouraska and Montmagny. Nearly 25% of the beluga whale population concentrates there in the summer, and perhaps even up to 50% in the spring, when the fishery has begun. In spite of this, very few cases of entanglement are reported. Moreover, very few scars caused by fishing gears are noticed on St. Lawrence beluga whales. This all seems to indicate that the presence of these nets does not represent a danger to beluga whales. However, we must continue to be conservative since many cases of by-catches in fishing nets are reported in Newfoundland. Also, because of the species status, one could also question whether all by-catches are being reported.

For larger mammals, entanglements are not always fatal, and we observe much less mortalities than with collisions with boats. Entanglements produce greater stress for the animal and can eventually lead to its death. Vertical lines on fixed gears are very problematic. It should be noted that in the Mediterranean Sea, gillnets represent the main threat to sperm whales. However, no sperm whale by-catch has been reported in Canadian waters.

As for collisions with boats, a larger number of right whale entanglements have been reported over the last few years. This can be explained by the fact that incidents are being reported in a more systematic way than before. Right whales caught in fishing gears react very badly to disentanglement efforts by man, and given the stress on the animal and the dangers to the team conducting the operation, we cannot consider this as a long-term solution. We are also interested in technological solutions (e.g., lines that would disintegrate when they come in contact with whale flesh lipids), but there is still much research and development to be done.

Entanglements appear to occur more frequently away from areas of right whale concentrations, which leads us to believe that individuals learn how to avoid fishing gears in their regular habitat by acquiring a certain awareness of the dangers these gears represent for their survival.

Of all rorquals, the minke whale is the most at risk for entanglements because of its coastal habits and its small size. A total of 15 minke whale entanglements were reported in the Gulf of St. Lawrence in 20 years. Humpbacks probably get caught in fishing gears as often as minke whales, but being more powerful, it is probably easier for them to free themselves. A blue whale was also seen pulling a buoy in the Gulf. Several cases of whale by-catches were are also reported in Chaleur Bay. Fishing gears used for crab harvesting could represent a risk for rorquals, but in the Estuary, the rorqual peak of abundance occurs after the end of the crab fishery season, which should limit the number of by-catches.

Given the relatively weak fishing effort in the Estuary, ghost fishing is probably rare. In the Gulf of St. Lawrence, in some locations (Blanc Sablon, Gaspé), an attempt to recover abandoned fishing nets was undertaken, but no such effort was made in the Estuary.

The magnitude of the problems associated with fishing gears in the St. Lawrence Estuary is not well known. It is nevertheless obvious that gillnets and traps are fishing gears causing a large number of by-catches. Reducing the fishing effort with fishing gears that pose a risk for marine mammals would be a possible management measure. Fishing could also be prohibited in some areas. Finally, the possibility of limiting the overall length of fishing lines is also being considered.

A joint Canada–USA monitoring system has been implemented for the right whale on the east coast. When an entanglement is reported, a team immediately attempts to disentangle the animal. A similar monitoring system for the Estuary could be considered. Such a system would allow us to react quickly and place a telemetric buoy to follow the movements of the struggling whale. To succeed, first-response teams would need to be formed and available at strategic locations in the Estuary and the Gulf.

In order to minimize illegal seal hunting, a possible solution (of which the results are uncertain) would be to implement a displacement program for animals that have gotten used to feeding off fishing weirs. The use of sound-emitting devices that would keep marine mammals away might be necessary. This type of device was tested in an experimental fishery in the Bay of Fundy, and a reduction of by-catches of harbour porpoises was observed. However, much needs to be done in developing this type of device, as it appears that with seals, it could have an opposite effect, i.e., to attract them to the fishing gear. Moreover, using such devices would considerably increase noise levels in the environment. Finally, these devices remain relatively expensive for fishermen, and a financial assistance program should certainly be implemented.

In a research and monitoring context, we could offer a premium to incite fishermen to return their marine mammal by-catches to authorities in a more systematic way. Extensive training for fishermen is also necessary in order to avoid some hazardous behaviour [*editor's note:* training was given to eel fishermen by a DFO fisheries agent (Sainte-Anne-des-Monts) in 2002, teaching the fishermen to distinguish seal species and raising their awareness regarding the harbour seal precarious status].

Special attention will also have to be given to fisheries under development in the Estuary. For example, the gathering of algae using rakes, sea urchin harvesting, and Stimpson's surf clam fishery using hydraulic dredges. Although these fishing gears are probably not involved in marine mammal entanglement problems, a significant disturbance is nevertheless possible. The crab fishery is expanding in some areas and should also be considered in the management measures.

Finally, it is also necessary to consider new technologies allowing fishermen to conduct their fishing in areas that were previously impossible to reach. It should also be noted that the currently low by-catch rates in the St. Lawrence are due to a weak fishing effort, but it is possible that this effort will increase over the next few years, and it will then be necessary to understand the new technologies in order to control by-catches and to make sure that these technologies are used in the MPA.

10. INFECTIOUS DISEASES AND PARASITE LOAD

Several marine mammal species, resident or migratory, share a relatively restricted habitat in the Estuary and are probably exposed to a great number of pathogens. It should also be considered that there are several local sources (natural or not) of human pathogens. Ongoing studies seem to indicate that some pathogens can be transmitted by different sources, such as the sewer effluents, agricultural lands runoff, and commercial shipping (Measures and Olson, 1999). In addition, a high exposure to toxic substances could reduce an animal's immune defence to pathogens (such as influenza virus and morbillivirus in harbour seals).

Several marine mammal species that are not residents of the Estuary are sources of pathogens. The introduction of pathogens can, in some cases, lead to an epizooty. In Europe, for example, the phocine distemper virus (a morbillivirus) decimated nearly 70% of the harbour seal population in 1988 (Heide-Jørgensen et al., 1992), and on the American east coast, influenza killed 350 harbour seals (Geraci et al., 1981). The release of seals that were held in captivity for various reasons (rehabilitation, research, etc.) represents another potential source of pathogen transmission in marine mammal habitats.

The presence of the virus in individuals does not necessarily cause a serious illness or an epizooty on the entire population. Serological analysis showed that St. Lawrence marine mammals are exposed to phocine morbillivirus (responsible for the death of 17,000 seals in Europe in 1988 and 1989), to *Brucella* spp., to *Leptospira* spp., and to *Mycoplasma* spp. (Measures, 1998). The presence of the virus in individuals even allows, to some extent, the animal to maintain a certain level of immunity in populations.

Generally, marine mammals are exposed to several parasites in the St. Lawrence. Capelin and herring, which are intermediate hosts for whale worm (*Anisakis simplex*), are present in the diet of several marine mammal species in the area. Extreme cases of parasite load, linked or not to other related health problems, could end up causing mortalities.

Summary of participants' discussions and notes

In Canada, pathogens affecting marine mammals are not well known and are poorly documented. Current data on this subject generally comes from beached individuals that are not necessarily representative of population as a whole. It is only in recent years that knowledge regarding infectious diseases found in marine mammals has become available.

Habitat changes can increase risks of pathogen transmission. In fact, the loss of habitat could concentrate marine mammals in more restricted areas, thus increasing the risks of pathogen transmission among individuals. It is very probable that contaminants weaken the immune system. Animals then become less able to defend themselves against pathogens.

A organism's immune system protects it from infectious agents (virus, bacteria, parasites), and its effectiveness is influenced by the animal's condition (age, health, etc). The young are most at risk because their immune system is not as developed. Moreover, the particularly high concentrations of certain contaminants in these individuals would weaken their immune system even more. However, it is important to mention that no specific study documenting a relationship between the incidence of disease and contaminant loads in marine mammals has yet been conducted.

The introduction of pathogens by municipal sewer effluents (as well as waste from boats) and by agricultural land drainage systems can also be problematic. Also, all these elements joined together largely increase epizooty probabilities in the Estuary. Sewer effluents as a potential vector for pathogens are beginning to be further studied. There is little available data, but there appears to be a potential risk for marine mammals. These sources are exposing marine mammals to pathogens such as *Toxoplasma gondii*, *Giardia* spp. and *Cryptosporidium* spp. There is some consensus that this phenomenon is alarming and that impacts were probably underestimated. Some municipalities, within the context of the St. Lawrence Vision 2000 program, measured the contaminant loads in sewer effluents, but no measurement was taken to assess the quantities and types of pathogens.

Two cysts from two species of water-transmissible protozoa (mainly freshwater) were found in St. Lawrence seals; their source could not be identified. Similar cysts were found in shellfish, indicating they are present in water, and the presence of *Toxoplasma gondii* (a protozoan generally transmitted by cats) was identified in beluga whales. Similarly, the presence in seals of *Brucella* sp., generally found in domestic animals, is confusing. We cannot say whether the bacteria has been present in seals for thousands of years, or whether it is a recent phenomenon, which would then raise more concerns.

Excessive parasite loads can cause diseases, particularly in atypical hosts or usual hosts that are already in bad condition. It is sometimes difficult to distinguish between so-called normal parasitic loads and excessive loads. In fact, some animals are able to handle very significant parasite loads without apparent effects, whereas some parasites, even in very small quantities, can be devastating to the host. Therefore, it is difficult, even impossible, to make generalizations for several host species.

For the beluga whale, the presence of pulmonary worms seems to be a sufficiently significant problem for us to wonder what impact it can have on the recruitment of young. In fact, for youngs of 1 to 5 years of age, pneumonia was probably the cause of mortality for 60% (7/12) of beached individuals. Thus, pulmonary worms could have a significant impact on recruitment by increasing the mortality rate of youngsters before they reach reproduction age (6-7 years).

For rorquals, very little is known since their carcasses sink after they die. When the carcass returns to the surface and is beached, its condition is such that it is rarely possible to conduct microbiological, parasitological, or histopathological tests.

For environmental groups, but also for the general public, there is an interest in rehabilitating and reintroducing seals and beluga whales into the wild. Thus, when an individual is in trouble, it is tempting to try everything to save it. Unfortunately, rehabilitated individuals could represent a significant source of pathogens to the environment. It is therefore very important to raise public awareness in order to explain why this type of behaviour can be harmful for animals and for marine mammal populations in general. In certain cases, it could be preferable to slay an animal that is truly suffering rather than try to save it, because the risks in preserving populations are too great compared to the benefits.

It is estimated that the risks of viral epizooty are high in the St. Lawrence Estuary. Morbilliviruses are particularly hazardous since they can cause very rapid epizooties. The pilot whale and white-sided dolphin are significant reservoirs of this virus. Climate changes may also increase the number of marine mammal species in the Estuary.

In the case of epizooties, it is difficult to consider concrete action measures. Isolating sick animals can be effective in certain cases. Large-scale vaccination programs are not viable options because of the amount of time required for vaccination compared with the propagation speed of the epidemic, the costs and the questionable effectiveness of vaccines (in some cases, the high number of serotypes limit effectiveness). On the other hand, it is possible to try to limit propagation before it becomes too significant. It is thus necessary to continue monitoring the carcasses at all times, in order to index and observe the different pathogens, but also to identify the development of epizooties as soon as possible.

To summarize, the most effective means of reducing the risks of epizooty are monitoring epidemic areas, removing carcasses, and avoiding any attempt to rehabilitate injured animals.

11. Cumulative Effects of Problems Discussed as well as Global Problems on Marine Mammals and Their Habitats

All the problems discussed here are directly caused, or in some cases are exacerbated, by human activities. All these issues were dealt with individually, which helped determine the relative importance the impacts these activities can have on marine mammals. But it is also particularly important, within a management context, to assess the cumulative or even synergistic impact various problems can have on marine mammals and on the sometimes-significant degradation of their habitats. Therefore, it is important to introduce the more global problems, such as global warming and the resulting oceanic changes.

Summary of participants' discussions and notes

Global warming, which is progressing more rapidly than expected, could involve an increase in average surface water temperatures of 2°C to 4°C in the St. Lawrence Estuary [*editor's note:* it is estimated that this increase in temperature could occur within 50 to 100 years]. It is possible that warmer water will support the development of new pathogens and a greater incidence of disease in the Estuary. This warming would also stabilize water mass and therefore amplify ocean stratification. A thinning of the cold intermediate layer can be expected, and winter mixing would likely occur to a greater depth. There could also be a river flow reduction, producing delays and lower primary production.

All these changes in the conditions in the Estuary could change the distribution of food resource species. Marine mammals will have to follow their prey and this, along with changes in ocean conditions, could lead to a change in species distribution patterns. This could result in a higher presence of marine mammal species that are currently rare in the

Estuary or, oppositely, cause the disappearance of currently abundant species. The impact these changes could have on the community is very difficult to predict.

The ice cover, which has a strong effect on the distribution of marine mammal species in the Estuary, will become smaller and smaller. Within approximately 25 years, the cover is expected to be non-existent in winter. The absence of ice could also bring other species of marine mammals during winter that are normally absent during this period, which could represent new competition for the beluga whale food resources during the winter period.

With climate changes, animals will obviously experience significant stress over a short period of time. If they are not able to adapt, they will have to leave the Estuary, or, at worst, they will disappear. The biggest problem right now is the lack of knowledge: there is an absence of information needed to predict upcoming changes and also a lack of knowledge regarding marine mammals that would allow us to assess the impacts the environmental changes will have on these organisms.

12. PRIORITIZATION OF PROBLEMS

After completing the evaluation of each species identified in the scientific workshop and the problems affecting them, the participants individually ranked each problem according to a pre-established priority code.

The next two sections show the results of this prioritization exercise for the problems affecting marine mammals (exercise conducted by the participants during the scientific workshop). The data was standardized so the reference levels for the priority codes were distributed on a scale of 1.0 to 3.9: the problems with a severity level between 1.0 and 1.9 were considered as low priority, those from 2.0 to 2.9 were considered as a priority, and finally, those from 3.0 to 3.9 were considered as high priority.

The results are listed in Table 3 according to severity, with all species included. Table 4 lists the same results alphabetically according to species name.

First of all, it should be noted that the lowest ranking given to a problem was not any lower than the “priority” level; this means none of the problems assessed were considered as low priority.

Also, one may notice that of the ten species assessed, eight face at least one problem considered as “high priority”: only the humpback and the white-sided dolphin do not face a problem considered as high priority.

Of a total of 93 problems assessed, 24 had a “high priority” ranking, and 69 had a “priority” ranking. Of the 15 problem categories studied, 11 were considered as “high priority.” Beluga whale contamination, mortalities and other hunting-related incidents, the lack of knowledge regarding harbour seals, right whale mortalities, and other fishing-gear-related incidents are among the most alarming problems.

Table 3. Prioritization of problems, all species included.

Rank	Species	Problem	Severity level[1]	Priority level
1	Beluga whale	Contamination	3.9	High priority
2	Harbour seal	Lack of knowledge	3.6	High priority
3	Beluga whale	Cumulative effects of problems on species and its habitat	3.6	High priority
4	Right whale	Mortalities and other fishing-gear-related incidents	3.6	High priority
5	Harbour seal	Mortalities and other hunting-related incidents	3.5	High priority
6	Beluga whale	Disruption of significant activities and disturbances	3.5	High priority
7	Harbour porpoise	Mortalities and other fishing-gear-related incidents	3.5	High priority
8	Right whale	Injuries and mortalities caused by collisions with boats	3.5	High priority
9	Harbour seal	Haul-out disturbances	3.4	High priority
10	Fin whale	Disruption of significant activities and disturbances	3.4	High priority
11	Harbour porpoise	Cumulative effects of problems on species and its habitat	3.4	High priority
12	Right whale	Disruption of significant activities and disturbances	3.4	High priority
13	Fin whale	Injuries and mortalities caused by collisions with boats	3.3	High priority
14	Harbour seal	Contamination	3.2	High priority
15	Blue whale	Disruption of significant activities and disturbances	3.2	High priority
16	Blue whale	Injuries and mortalities caused by collisions with boats	3.2	High priority
17	Fin whale	Affected communication and echolocation	3.2	High priority
18	Right whale	Cumulative effects of problems on species and its habitat	3.2	High priority
19	Harbour porpoise	Affected communication and echolocation	3.1	High priority
20	Right whale	Environmental disasters	3.1	High priority

Rank	Species	Problem	Severity level[1]	Priority level
21	Beluga whale	Habitat changes	3.0	High priority
22	Blue whale	Affected communication and echolocation	3.0	High priority
23	Minke whale	Injuries and mortalities caused by collisions with boats	3.0	High priority
24	Sperm whale	Cumulative effects of problems on species and its habitat	3.0	High priority
25	Harbour seal	Mortalities and other fishing-gear-related incidents	2.9	Priority
26	Harbour seal	Newborn isolation	2.9	Priority
27	Beluga whale	Affected communication and echolocation	2.9	Priority
28	Humpback whale	Injuries and mortalities caused by collisions with boats	2.9	Priority
29	Humpback whale	Affected communication and echolocation	2.9	Priority
30	Minke whale	Mortalities and other fishing-gear-related incidents	2.9	Priority
31	Minke whale	Disruption of significant activities and disturbances	2.9	Priority
32	Harbour porpoise	Contamination	2.9	Priority
33	Right whale	Infectious diseases	2.9	Priority
34	Humpback whale	Disruption of significant activities and disturbances	2.8	Priority
35	Blue whale	Cumulative effects of problems on species and its habitat	2.8	Priority
36	Minke whale	Infectious diseases	2.8	Priority
37	Fin whale	Cumulative effects of problems on species and its habitat	2.8	Priority
38	Harbour porpoise	Environmental disasters	2.8	Priority
39	Sperm whale	Infectious diseases	2.8	Priority
40	Sperm whale	Parasite load	2.8	Priority
41	Right whale	Parasite load	2.8	Priority
42	White-sided dolphin	Infectious diseases	2.8	Priority
43	White-sided dolphin	Parasite load	2.8	Priority

Rank	Species	Problem	Severity level[1]	Priority level
44	White-sided dolphin	Cumulative effects of problems on species and its habitat	2.8	Priority
45	Harbour seal	Infectious diseases	2.7	Priority
46	Beluga whale	Environmental disasters	2.7	Priority
47	Humpback whale	Mortalities and other fishing-gear-related incidents	2.7	Priority
48	Minke whale	Affected communication and echolocation	2.7	Priority
49	Minke whale	Cumulative effects of problems on species and its habitat	2.7	Priority
50	Harbour porpoise	Parasite load	2.7	Priority
51	Sperm whale	Disruption of significant activities and disturbances	2.7	Priority
52	Sperm whale	Injuries and mortalities caused by collisions with boats	2.7	Priority
53	Sperm whale	Environmental disasters	2.7	Priority
54	Sperm whale	Affected communication and echolocation	2.7	Priority
55	Right whale	Affected communication and echolocation	2.7	Priority
56	Harbour seal	Habitat changes	2.6	Priority
57	Beluga whale	Injuries and mortalities caused by collisions with boats	2.6	Priority
58	Beluga whale	Infectious diseases	2.6	Priority
59	Humpback whale	Cumulative effects of problems on species and its habitat	2.6	Priority
60	Harbour porpoise	Disruption of significant activities and disturbances	2.6	Priority
61	Harbour porpoise	Infectious diseases	2.6	Priority
62	Right whale	Contamination	2.6	Priority
63	White-sided dolphin	Environmental disasters	2.6	Priority
64	White-sided dolphin	Contamination	2.6	Priority
65	White-sided dolphin	Mortalities and other fishing-gear-related incidents	2.6	Priority
66	White-sided dolphin	Affected communication and echolocation	2.6	Priority
67	Harbour seal	Environmental disasters	2.5	Priority

Rank	Species	Problem	Severity level[1]	Priority level
68	Humpback whale	Parasite load	2.5	Priority
69	Blue whale	Mortalities and other fishing-gear-related incidents	2.5	Priority
70	Minke whale	Parasite load	2.5	Priority
71	Fin whale	Mortalities and other fishing-gear-related incidents	2.5	Priority
72	Beluga whale	Parasite load	2.4	Priority
73	Beluga whale	Mortalities and other fishing-gear-related incidents	2.4	Priority
74	Humpback whale	Infectious diseases	2.4	Priority
75	Blue whale	Environmental disasters	2.4	Priority
76	Blue whale	Contamination	2.4	Priority
77	Blue whale	Parasite load	2.4	Priority
78	Fin whale	Environmental disasters	2.4	Priority
79	Fin whale	Infectious diseases	2.4	Priority
80	Fin whale	Parasite load	2.4	Priority
81	Sperm whale	Mortalities and other fishing-gear-related incidents	2.4	Priority
82	Sperm whale	Contamination	2.4	Priority
83	Humpback whale	Environmental disasters	2.3	Priority
84	Humpback whale	Contamination	2.3	Priority
85	Blue whale	Infectious diseases	2.3	Priority
86	Minke whale	Environmental disasters	2.3	Priority
87	White-sided dolphin	Injuries and mortalities caused by collisions with boats	2.3	Priority
88	Harbour seal	Feeding disturbances	2.2	Priority
89	Harbour seal	Injuries and mortalities caused by collisions with boats	2.2	Priority
90	Minke whale	Contamination	2.2	Priority
91	Fin whale	Contamination	2.2	Priority
92	Harbour porpoise	Injuries and mortalities caused by collisions with boats	2.2	Priority
93	White-sided dolphin	Disruption of significant activities and disturbances	2.2	Priority

[1] *Severity level of problems* — *Corresponding priority levels*

3.0 to 3.9	High priority
2.0 to 2.9	Priority
1.0 to 1.9	Low priority

Table 4. **Prioritization of problems according to species.**

Rank[1]	Species	Problem	Severity level[2]	Priority level
4	Right whale	Mortalities and other fishing-gear-related incidents	3.6	High priority
8	Right whale	Injuries and mortalities caused by collisions with boats	3.5	High priority
12	Right whale	Disruption of significant activities and disturbances	3.4	High priority
18	Right whale	Cumulative effects of problems on species and its habitat	3.2	High priority
20	Right whale	Environmental disasters	3.1	High priority
33	Right whale	Infectious diseases	2.9	Priority
41	Right whale	Parasite load	2.8	Priority
55	Right whale	Affected communication and echolocation	2.7	Priority
62	Right whale	Contamination	2.6	Priority
1	Beluga whale	Contamination	3.9	High priority
3	Beluga whale	Cumulative effects of problems on species and its habitat	3.6	High priority
6	Beluga whale	Disruption of significant activities and disturbances	3.5	High priority
21	Beluga whale	Habitat changes	3.0	High priority
27	Beluga whale	Affected communication and echolocation	2.9	Priority
46	Beluga whale	Environmental disasters	2.7	Priority
58	Beluga whale	Infectious diseases	2.6	Priority
57	Beluga whale	Injuries and mortalities caused by collisions with boats	2.6	Priority
72	Beluga whale	Parasite load	2.4	Priority
73	Beluga whale	Mortalities and other fishing-gear-related incidents	2.4	Priority
24	Sperm whale	Cumulative effects of problems on species and its habitat	3.0	High priority
40	Sperm whale	Parasite load	2.8	Priority

Rank[1]	Species	Problem	Severity level[2]	Priority level
39	Sperm whale	Infectious diseases	2.8	Priority
53	Sperm whale	Environmental disasters	2.7	Priority
54	Sperm whale	Affected communication and echolocation	2.7	Priority
52	Sperm whale	Injuries and mortalities caused by collisions with boats	2.7	Priority
51	Sperm whale	Disruption of significant activities and disturbances	2.7	Priority
82	Sperm whale	Contamination	2.4	Priority
81	Sperm whale	Mortalities and other fishing-gear-related incidents	2.4	Priority
43	White-sided dolphin	Parasite load	2.8	Priority
44	White-sided dolphin	Cumulative effects of problems on species and its habitat	2.8	Priority
42	White-sided dolphin	Infectious diseases	2.8	Priority
63	White-sided dolphin	Environmental disasters	2.6	Priority
66	White-sided dolphin	Affected communication and echolocation	2.6	Priority
64	White-sided dolphin	Contamination	2.6	Priority
65	White-sided dolphin	Mortalities and other fishing-gear-related incidents	2.6	Priority
87	White-sided dolphin	Injuries and mortalities caused by collisions with boats	2.3	Priority
93	White-sided dolphin	Disruption of significant activities and disturbances	2.2	Priority
7	Harbour porpoise	Mortalities and other fishing-gear-related incidents	3.5	High priority
11	Harbour porpoise	Cumulative effects of problems on species and its habitat	3.4	High priority
19	Harbour porpoise	Affected communication and echolocation	3.1	High priority
32	Harbour porpoise	Contamination	2.9	Priority
38	Harbour porpoise	Environmental disasters	2.8	Priority
50	Harbour porpoise	Parasite load	2.7	Priority
61	Harbour porpoise	Infectious diseases	2.6	Priority

Rank[1]	Species	Problem	Severity level[2]	Priority level
60	Harbour porpoise	Disruption of significant activities and disturbances	2.6	Priority
92	Harbour porpoise	Injuries and mortalities caused by collisions with boats	2.2	Priority
23	Minke whale	Injuries and mortalities caused by collisions with boats	3.0	High priority
30	Minke whale	Mortalities and other fishing-gear-related incidents	2.9	Priority
31	Minke whale	Disruption of significant activities and disturbances	2.9	Priority
36	Minke whale	Infectious diseases	2.8	Priority
48	Minke whale	Affected communication and echolocation	2.7	Priority
49	Minke whale	Cumulative effects of problems on species and its habitat	2.7	Priority
70	Minke whale	Parasite load	2.5	Priority
86	Minke whale	Environmental disasters	2.3	Priority
90	Minke whale	Contamination	2.2	Priority
2	Harbour seal	Lack of knowledge	3.6	High priority
5	Harbour seal	Mortalities and other hunting related incidents	3.5	High priority
9	Harbour seal	Haul-out disturbances	3.4	High priority
14	Harbour seal	Contamination	3.2	High priority
26	Harbour seal	Newborn isolation	2.9	Priority
25	Harbour seal	Mortalities and other fishing-gear-related incidents	2.9	Priority
45	Harbour seal	Infectious diseases	2.7	Priority
56	Harbour seal	Habitat changes	2.6	Priority
67	Harbour seal	Environmental disasters	2.5	Priority
88	Harbour seal	Feeding disturbances	2.2	Priority
89	Harbour seal	Injuries and mortalities caused by collisions with boats	2.2	Priority
29	Humpback whale	Affected communication and echolocation	2.9	Priority

Rank[1]	Species	Problem	Severity level[2]	Priority level
28	Humpback whale	Injuries and mortalities caused by collisions with boats	2.9	Priority
34	Humpback whale	Disruption of significant activities and disturbances	2.8	Priority
47	Humpback whale	Mortalities and other fishing-gear-related incidents	2.7	Priority
59	Humpback whale	Cumulative effects of problems on species and its habitat	2.6	Priority
68	Humpback whale	Parasite load	2.5	Priority
74	Humpback whale	Infectious diseases	2.4	Priority
83	Humpback whale	Environmental disasters	2.3	Priority
84	Humpback whale	Contamination	2.3	Priority
16	Blue whale	Injuries and mortalities caused by collisions with boats	3.2	High priority
15	Blue whale	Disruption of significant activities and disturbances	3.2	High priority
22	Blue whale	Affected communication and echolocation	3.0	High priority
35	Blue whale	Cumulative effects of problems on species and its habitat	2.8	Priority
69	Blue whale	Mortalities and other fishing-gear-related incidents	2.5	Priority
75	Blue whale	Environmental disasters	2.4	Priority
77	Blue whale	Parasite load	2.4	Priority
76	Blue whale	Contamination	2.4	Priority
85	Blue whale	Infectious diseases	2.3	Priority
10	Fin whale	Disruption of significant activities and disturbances	3.4	High priority
13	Fin whale	Injuries and mortalities caused by collisions with boats	3.3	High priority
17	Fin whale	Affected communication and echolocation	3.2	High priority
37	Fin whale	Cumulative effects of problems on species and its habitat	2.8	Priority
71	Fin whale	Mortalities and other fishing-gear-related incidents	2.5	Priority

Rank[1]	Species	Problem	Severity level[2]	Priority level
78	Fin whale	Environmental disasters	2.4	Priority
80	Fin whale	Parasite load	2.4	Priority
79	Fin whale	Infectious diseases	2.4	Priority
91	Fin whale	Contamination	2.2	Priority

[1] *Refer to Table 3 for listing by priority level for identified problems.*

[2] *Severity level of problems* — *Corresponding priority levels*

Severity level of problems	Corresponding priority levels
3.0 to 3.9	High priority
2.0 to 2.9	Priority
1.0 to 1.9	Low priority

SECTION B: MARINE MAMMAL FOOD RESOURCES

1. SELECTION OF FOOD RESOURCES

This section concerning the selection of food resources was taken from Biorex (1999).

> Available data on marine mammal diets alone is not very useful in selecting their main food resources in the study area [St. Lawrence Estuary and Saguenay River] for the following reasons:
>
> - Except for the harp seal, data on the diets of all marine mammal species in the study area are extremely patchy;
> - Data from other areas (Gulf of St. Lawrence and the northwest Atlantic) are not directly transferable to the study area because it is well known that several marine mammal species are opportunistic and adapt their diets according to the abundance of local prey. However, the composition of pelagic and benthic communities in the study area is different from that found in the Gulf and on the Canadian Atlantic coast;
> - Data from stomach content analysis could underestimate the importance of invertebrates in marine mammal diets because of the absence of anatomic structures (e.g. otoliths and vertebrae in fish, oral appendages in squid) in several invertebrate species that resist digestion. On the other hand, the importance of benthos as a prey by marine mammals could be over-estimated because its presence in a marine mammal's stomach could be from the stomach of a fish eaten by the marine mammal. However, stomach content data, as well as survey data from stable isotope ratios of carbon and nitrogen (conducted on beluga whales and three seal species in the study area) (Hammill et al., 1998), show that most if not all marine mammals in the study area are essentially piscivorous and/or, in the case of large whales, feed on pelagic invertebrates.
>
> The selection of species, or groups of species, was therefore done with the aim of preserving 10 species (or groups of species) of fish and pelagic invertebrates, and to describe benthos in a general way. The selection of these ten species was conducted while taking into account:
>
> - Information from stomach content analysis of marine mammals from the study area and from other areas in eastern Canada;
> - Analysis of stable isotope ratios for carbon and nitrogen in the beluga whales and the three seal species in the Estuary (Hammill et al., 1998);
> - Information on the distribution and the feeding behaviour of marine mammals in the study area;
> - Information on the space–time distribution and abundance of various potential prey in the study area;
> - Information on the contamination level of potential prey by toxic substances.
>
> This information allowed us to select four of the ten most significant groups of species for marine mammal feeding in the study area: capelin, sand lance, Atlantic herring and euphausiids. In fact, these species are abundant in the study area, and each one is recognized as being a very significant resource for at least three of the eight common marine mammal species encountered in this area.
>
> Two other species were then selected, not so much because they are known to be very important for the diet of marine mammals in the study area, but more because they present a

particular problem: the American eel and shortfin squid. Although the significance of eel in the diet of beluga whales and seals is unknown, several researchers believe that the migrating eels from the upper basin of St. Lawrence are the main organochlorine substance vectors for beluga whale (Béland and Martineau, 1988). In addition, squid represents the main prey for sperm whales and Atlantic pilot whales, and was also one of the main preys of beluga whales in the maritime Estuary in the 1930s, at the end of summer and in the fall. Squid has a very particular life cycle, which causes very significant abundance changes in Eastern Canada, and possibly in the maritime Estuary, and which could determine the presence of sperm whales and pilot whales in the study area and the seasonal distribution of beluga whales in the Estuary.

The selection of the four other species (or groups of species) of fish and pelagic invertebrates was aimed to cover the best possible range of potential main prey of the eight common marine mammal species found in the study area. The selection of the first six species adequately covers the diets of rorquals and harbour porpoises, which are not very diversified. Note that Atlantic mackerel, which is the main food resource for harbour porpoises in the southern Gulf (Fountain et al., 1994) is rare in the study area.

Furthermore, the beluga whale and the three common seal species encountered in the study area have a much more diversified diet, and it is possible that they change their diet according to the availability of the most abundant fish species. Based on a survey of stable isotope ratios of carbon in these species (Hammill et al., 1998), the beluga whale and the harbour seal would have more coastal or more benthic food habits (as opposed to offshore or pelagic) than the grey seal or the harp seal. This suggests that these species consume estuarine fish species and/or ground fish from shallow waters (infra-littoral). Among the dominant species from the shallow-water fish community of the study area, four were selected: Atlantic tomcod, rainbow smelt, smooth flounder and winter flounder. Atlantic tomcod was the dominant species found in the contents of some of the stomachs of beluga whale carcasses beached on the banks of the Estuary (Béland et al., 1995), whereas rainbow smelt was one of the main prey, after capelin and sand lance, found in the regurgitations of harbour seals captured in the Estuary (Hammill et al., 1998). As for smooth flounder and winter flounder, they were found only occasionally in beluga whales and harbour seals, but as opposed to most of the other abundant fish species in the study area, sedentary species could give good indications of the level of marine mammal contamination through the benthic food chain. This is the reason why these two species were selected and discussed together.

Finally, grey seal and harp seal would have more offshore and/or pelagic feeding habits than beluga whale and harbour seal (Hammill et al., 1998). In order to complete the picture of marine mammal food resources, we chose a previously abundant species of bottomfish in the maritime Estuary at intermediate depths (30–200 m): Atlantic cod. Interest in this species, which is frequently found in the stomachs of male beluga whales (Vladykov, 1946) and grey seals (Lavigueur et al., 1993) killed in the maritime Estuary, also resides in the fact that populations [of cod] which live in this part of the Estuary are in a precarious situation. [TRANSLATION]

The species or groups of species selected are presented in the following table:

Table 5. The eleven marine mammal food resources selected for discussion.

Selected food resources	
Common name	Scientific name
Euphausiids	*Thysanoessa raschii*, *T. inermis*, *Meganyctiphanes norvegica*
Capelin	*Mallotus villosus*
Atlantic herring	*Clupea harengus*
Sand lance	*Ammodytes* sp.
Atlantic cod	*Gadus morhua*
Atlantic tomcod	*Microgadus tomcod*
Rainbow smelt	*Osmerus mordax*
Smooth flounder and winter flounder	*Liopsetta putnami* and *Pseudopleuronectes americanus*
American eel	*Anguilla rostrata*
Shortfin squid	*Illex illecebrosus*
Benthos	-----

2. SYNTHESIS DIAGRAM OF PRESUMED NUTRITIONAL LINKS BETWEEN FOOD RESOURCES AND MARINE MAMMALS

This section presents a synthesis diagram illustrating the main trophic relationships expected between marine mammals and their food resources as well as the problems that could interfere with these relationships (Figure 3). As mentioned, 11 marine mammal food resources are presented in this document, but in order not to overburden the diagram, only the eight main resources are illustrated. Except for the American eel, the diagram presents only the main trophic links for each predator. The eel, probably a secondary food resource for beluga whale, is presented because of its involvement in the contamination of this mammal, which we presume is significant. The categories of problems listed in the diagram are detailed in the following section.

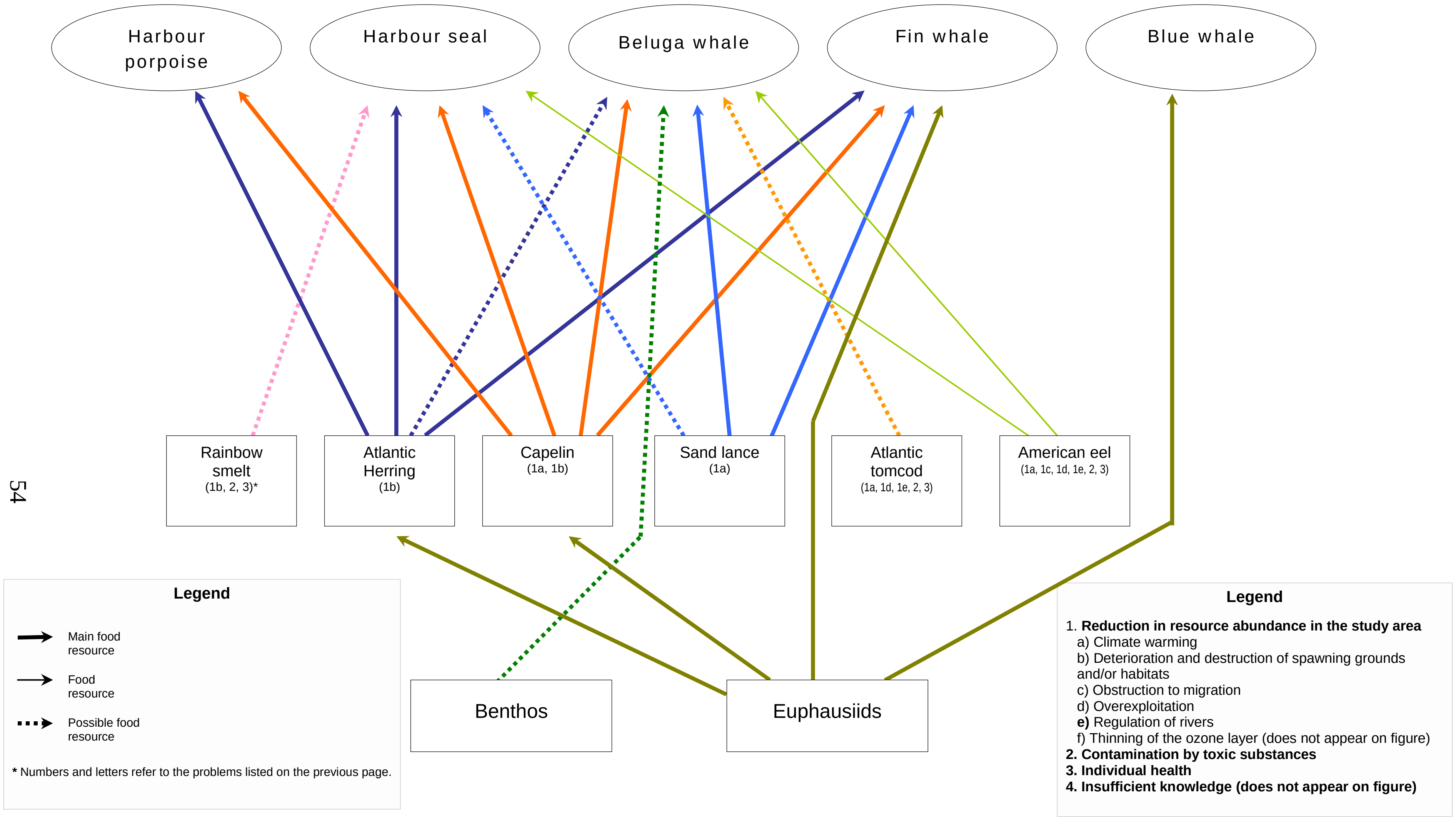

Figure 3. Trophic links between marine mammals in the St. Lawrence Estuary and their prey, and problems related to the latter.

Summary of participants' discussions and notes

The list of species selected as food resources for marine mammals in the Estuary (Table 5) is representative of their diet in the study area. However, the following points must be considered:

- Shortfin squid is not sufficiently abundant in the study area to keep it on this list;
- Redfish otoliths have been found in beluga whale stomach contents;
- Copepods must be considered because they are prey for both capelin and rorquals;
- Rorquals must ingest considerable quantities of copepods, since their vertical distribution and migration is similar to that of euphausiids;
- Northern shrimp was not selected given the relatively low concentrations found in the study area;
- Polychaeta and shellfish could belong to distinct groups on the list. Polychaeta can be, in some areas, a significant prey for beluga whale;
- Although it is possible to draw up a list of species for food resources, it is rather difficult to identify the relative importance of each one of these species for marine mammals.

Based on current knowledge, it would appear that marine mammals, excluding rorquals, are generally opportunistic. However, it is necessary to be cautious with such conclusions because diet studies were conducted in areas and at times when, marine mammal populations were relatively low and where competition for food resources was reduced. We can assume that marine mammals would have to compete for their food if stronger pressure were exerted on food resources.

There also exists food segregation according to some factors, such as the animal's sex and/or age. For seals, where sexual dimorphism is significant, efficiency differences exist in the capture of some prey according to sex. For narwhals as well, indices indicate that males and females form separate herds that have their own feeding habits, which are very different according to energy needs and activities.

The choice of resource can quite simply vary according to the season, or according to the marine mammal's need to remain in a specific area to protect itself from predators. Thus, changes in the choice of prey within populations could lead us to believe in a certain form of opportunism, whereas it is not necessarily the case.

In years of euphausiid and mesozooplankton abundance, a link with greater blue whale abundance was noted in the Estuary, and fin whales were definitely more scattered in the sector. Conversely, in years of low euphausiid and mesozooplankton abundance, larger numbers of fin whales gather at the head of the Laurentian Channel, in relation to tidal cycles. The most plausible explanation for this phenomenon is that during years of low euphausiid abundance, fin whales feed mainly on capelin. They gather to hunt in groups in concentration areas of this species.

This last example illustrates to what point it is paramount and difficult to correctly interpret the relationships between food resources and marine mammals. Also, in order to have effective management in the MPA, we must implement and/or continue research on food resource abundance research and monitoring programs, along with studies on marine mammals. This will help establish links between food resources and marine mammals, and to better understand the community as a whole.

3. Current and Potential Problems

3.1 Contamination by Toxic Substances

Marine mammals are exposed to toxic chemical substances mainly through their food. Between 1985 and 1995, some of the supposed main food resources of the beluga whale, harbour seal and grey seal were contaminated by toxic substances on a level that exceeded the protection criteria for ichthyophagous vertebrate wildlife. These resources were the migrating eels from the upper basin of St. Lawrence (mercury, PCB and DDT), Atlantic tomcod (mercury and PCB), smelt (PCB) and cod (PCB). In the case of migrating eels, a clear reduction in contamination occurred between 1982 and 1990. It is likely that this was also the case for other food resources contaminated by mercury, PCB and DDT, as the main sources of these contaminants have been removed since the 1970s.

Summary of participants' discussions and notes

Studies have shown that the contamination levels of fish ingested by beluga whales are enough to explain the differences in contamination levels observed between St. Lawrence and Arctic populations. In fact, the concentrations of contaminants are up to 10 times higher in fish from the Estuary than in those from the Arctic. In addition to American eel, Atlantic tomcod is a species that could be a significant contamination vector for marine mammals feeding on it. The fish liver is particularly fatty and contains contaminant concentrations two to three times higher than human consumption standards.

American eel is included in the list of species being used as food resources by marine mammals, mainly because of its significance as a contamination vector for beluga whales and seals in the St. Lawrence. Fishermen report that beluga whales used to swim up the St. Lawrence as far as Saint-Nicolas, upstream from Québec, to find a favourable location for eel predation, which seems to indicate that in the past at least, eels would have experienced significant predation by beluga whales. The oldest fish (about fifteen years) migrate and are therefore ingested by marine mammals: they are primarily very fatty and come from significantly contaminated areas.

The eel has long been suspected of being the main vector for Mirex. Since we now know that this contaminant can also be carried in the atmosphere, the concerns on this subject have been revised. Thus, if beluga whales or seals show a certain concentration of Mirex in their tissues, eel ingestion may not be the only cause. Since the end of the 1970s, eel abundance has declined significantly and constantly, and there is no expected recovery in the next few years. Moreover, contamination levels in the environment have diminished significantly. We can assume that, as a contaminant vector, this species is less and less a problem for marine mammals. However, it is necessary to include eels as models in order to explain the concentrations of some furan and dioxin congeners found in beluga whales. Concentrations of other contaminants can be explained without the presence of the American eel in the diet.

It is likely, despite everything, that this species remains a significant contamination vector. In fact, approximately 500,000 individuals transit through the area, and it is estimated that 75% of the total mass of eels transit within 10 to 15 days. For a short period of time, eels represent a very concentrated potential prey with a great energy value. Concerning the beluga whale efficiency as a predator, it is quite likely it would be able to feed at will on this resource alone. Thus, even if the populations are declining, the problem of contaminant transfer by eels to marine mammals could still be a concern. For this species, as for several sentinel fish species such as Atlantic tomcod, herring, capelin and some Polychaetea (*Maldane sarsi*), monitoring contaminant concentrations must continue.

3.2 Health of Individuals

Several of the species selected as significant food resources for marine mammals in the Estuary are in poor condition (cod) (Lambert and Dutil, 1997) or are afflicted by many pathologies and morphological abnormalities (Atlantic tomcod, rainbow smelt and American eel). These disorders could be due to significant diet changes, which may be the result of changes in oceanographic conditions in the first case, and by contamination in the second, eels in particular (Couillard et al., 1997).

Summary of participants' discussions and notes

Contaminants should have an impact on the immune and reproductive systems of fish, even with the smallest doses. Contaminants from the pulp and paper industry produce delays in sexual maturation. In fry, PCBs cause blue-sac disease, which decimated salmonid populations in the Great Lakes. The most significant contamination problems will mainly affect bottom species (associated with the most contaminated sediments), as well as species occupying a higher trophic level and/or having great longevity. Species that live part of their life cycle in fresh water are also more exposed to contaminants than marine species.

According to a survey conducted in 1997, smelt is considered healthy, which is not the case for Atlantic tomcod. Captured Atlantic tomcods were very emaciated, and many of them had mouth ulcers and tumours on the liver, especially the older ones. A considerable amount of vertebrae deformities were also noted, which could have an impact on migration success and contribute to population decline in the future. Also, the many listed diseases indicate that this population is experiencing stress from multiple causes. Monitoring is currently being done to establish the pathogenesis of this species.

Generally, one cause of deformities can, among other things, is mechanical damaged caused when passing through dams (documented mainly in eels). Some metals can also have neurological effects causing contractures that, in the long run, cause deformities. Certain contaminants from pulp and paper effluents (organochlorines) can act on collagen synthesis, causing the weakening of vertebrae resistance and leading once again to deformities. Unfortunately, these are non-specific responses and therefore cannot be linked to a specific factor.

Hepatic tumours found in Atlantic tomcod could be related to an exposure to certain contaminants (mainly PAH), but occurrence remains weak compared with other very contaminated environments. It is difficult to establish causal links because of the high number of factors at this level (age, parasitism, other diseases, etc.). The main impact of hepatic tumours on the dynamics of the Atlantic tomcod population is a reduction of individual longevity, which is a relatively minor impact.

Eels have been found with pre-cancerous lesions on the liver that are very typical of contaminant exposure, which indicates the presence of genotoxic compounds in the environment. Once again, these lesions have little impact on the population in general. On the other hand, genotoxic compounds can cause other problems in fish (e.g., embryonic development problems), which have a significantly larger impact on populations.

Several significant health problems are thus found in a certain number of fish species. However, since the diet of several marine mammals is made up of many species, it is difficult to determine the impact each prey health problems will have. However, we cannot ignore the importance of this impact, and this is the reason why research and monitoring must continue in order to protect the ecosystem in general. Identifying the exact ways in which contaminants affect fish will enable us to better direct our research on beluga whales and other marine mammals.

3.3 Climate Warming

According to conservative scenarios, greenhouse gas concentrations in the atmosphere should double compared to their current level towards the end of the 21st century. This increase should have significant effects on our climate, in particular by an increase in temperatures and a significant reduction in freshwater input (evaporation increases) as well as a reduction of the ice cover.

Furthermore, this temperature increase should have a greater impact in the most northern areas during the winter; reaching 3°C to 4°C in the summer in the study area [St. Lawrence Estuary and Saguenay River], and 5°C to 6°C in the winter (Bergeron et al., 1997). Marine resources are particularly sensitive to climate changes, and some species of marine mammal prey, particularly cold-water species (capelin, sand lance, euphausiids) could suffer from these environmental changes.

Summary of participants' discussions and notes

It is very difficult to make any kind of prediction regarding climatic warming. Global models are primarily based on real data, whereas the climatic changes we are trying to predict have never been observed in nature. Therefore, there is significant extrapolation in what is being predicted from these models. Only the predicted temperature values can be considered with a certain degree of confidence.

Generally, an increase in water levels from 30 to 50 cm is predicted within the next 50 to 100 years, mainly because of the melting of ice in the Arctic and the ocean's thermal expansion. It is estimated that if the average air temperature increases by 2°C, the temperature will increase by 6°C in winter, which could reduce the ice cover by 40% to 50%, whereas the surface temperature could increase by 3°C to 4°C. We predict a change in estuarine circulation, and very possibly the disappearance of the cold intermediate layer. It is also possible that the quantity of oxygen in the deep layer would increase, since there would be a greater water input from Labrador.

Because of higher evaporation, there will be a reduction in river flow of about 30% to 50%. The consequences of this change could be very significant. In fact, the river flow forms an integral part of the cold intermediate layer pumping mechanism on the surface at the head of the Laurentian Channel. Thus, if changes in river flow input occur, the mechanisms responsible for the downstream-to-upstream pumping, and consequently for zooplankton concentrations at the head of the Laurentian Channel, would be changed.

If one considers the mixing process in the St. Lawrence Estuary, the effects of wind and tides have the most influence. If currents and tides do not change too significantly, warming will no doubt occur, but the biological production may not decrease radically. On the other hand, it is very likely that we will witness a significant change in the community, because of the appearance and disappearance of certain species.

Time flexibility is limited. Climate changes are fast, and several species will not likely be able to adapt. The warming of the St. Lawrence's water could therefore represent a problem for cold-water species, such as capelin, which are presently at the southernmost limit of their distribution range, and krill, which are mainly composed of boreal and arctic species (*Thysanoessa rashii* and *T. inermis*); these would be strongly affected by the warming of waters. However, *Meganyctiphanes norvegica*, a species able to evolve in warmer water, could have an advantage.

However, we have in fact been witnessing a cooling of waters in the Gulf of St. Lawrence for a few years (since 1995). It was observed, during these same years, that the capelin distribution range had moved southward in the Gulf, and that the drop in water temperature had also contributed to a significant delay in growing and egg laying for this species. This suggests that species (capelin at least) can undergo significant impacts during environmental temperature changes and react by migrating to more favourable areas. In years when cold intermediate layer temperatures were higher (e.g., 1990), an increase of a carnivorous amphipod species was observed. This species was a very efficient predator feeding on fish larvae (25% to 30% of its total diet), having a negative impact for fish recruitment. With changes affecting abiotic factors, we can therefore predict cascading impacts in the community resulting from relative species abundance changes in the environment.

By climate changes, we particularly mean biodiversity disturbances, introduction of new parasites, and local species adapting to very rapid environmental changes. Several impacts on marine mammals are unquestionably expected. Capelin, for example, acclimatizes to the warmer temperatures in summer and avoids the cold intermediate layer, increasing the concentration of this resource. If the cold intermediate layer disappeared, concentrations would be less significant, and there would be insufficient concentrations of capelin for whales. Similarly, a strong reduction in the ice cover in winter could introduce new marine mammal species likely to compete with beluga whales and harbour seals.

The global causes for these changes can certainly not be managed within the context of the MPA. The expected changes must be considered within a management context based on the precautionary approach.

3.4 Loss or Deterioration of Habitat

The disturbance and deterioration of spawning grounds are persuasive examples of loss of habitat for forage species. This is the reason why we will speak primarily about the deterioration of spawning grounds, in order to illustrate, at least partly, the problems linked to the loss or deterioration of the habitat.

The location of spawning grounds is known or presumed for only some of the species belonging to the marine mammal food resources. Currently, these spawning grounds are not the focus of any specific protection.

Summary of participants' discussions and notes

Concerning protection, only the known and identified habitats can benefit from protection measures. Also, it is imperative to know the significant habitats and the basic biological parameters for species included in marine mammal food resources. Once this information is obtained, it will be necessary to establish the types of activities that could cause a deterioration of the targeted habitats.

Management tools, such as the Fisheries Act, give some protection to habitats against specific and direct changes. On the other hand, few legislative elements presently give adequate protection against more dispersed changes such as pollution.

For many species, biological data partly stems from commercial fisheries. All fishermen should therefore have a logbook to record and report their observations. However, this system has its limits, since not all non-commercial species are listed. Furthermore, the protection of the entire area is not at all ensured, as far as monitoring goes. Research and monitoring conducted by scientists will therefore have to proceed and be combined with the data produced by the commercial fisheries.

Several human activities currently taking place in the Estuary can contribute to the destruction of habitats, such as some types of fishing as surfclam and scallop fishing using hydraulic dredges. Dredging of sediments in some sectors should also be forbidden. It is imperative that the selection of dredging material deposit sites be appropriately documented prior to receiving approval by proper authorities. Finally, a certain form of regulation to limit the fishing on spawning grounds should be established, since fishermen heavily prize such sectors.

3.5 Migration Problems

The St. Lawrence, Saguenay and several significant rivers of the Côte-Nord have been harnessed with dams to regulate water levels and produce electricity. There are dams on several tributary rivers of the study area, namely the Mitis, Rimouski, du Loup, Malbaie, des Petites Bergeronnes, des Escoumins, Portneuf, Sault aux Cochons, Saint-Jean, Ha! Ha!, and Mars rivers. Several of these dams were built at the site of natural obstacles that anadromous fish cannot deal with (Gagnon and Bergeron, 1999). The Mitis, Rimouski, Saint-Jean, Mars, and Escoumins River dams are equipped with fish ladders (Mousseau and Armellin, 1995; Walsh and Bourgeois, 1996).

Some dams located outside the study area have had a negative impact on eel abundance. The Cornwall and Beauharnois dams represent migration obstacles for elvers and are one of the main causes of mortality among adult American eels returning to the sea. From 1986 to 1992, for example, a drop of more than 99% in recruitment was observed in the number of small eels migrating upstream towards the international portion of the St. Lawrence River and Lake Ontario, in the migratory pass of the Cornwall dam (Casselman et al., 1997a). This disastrous drop of recruitment coincides, along with a gap of approximately six years, with a reduction in catches of more than 50% in commercial landings from Lake Ontario and the international portion of the St. Lawrence since 1992. The six-year gap corresponds roughly to the average number of years elapsed between the spawning run of eels to the Cornwall dam and their capture in commercial fisheries on Lake Ontario (Casselman et al., 1997a; 1997b).

The average number of years elapsed between the spawning run of eels recorded at the Cornwall dam and their recapture in the study area was established at 10 years (Castonguay et al., 1994). It is thus likely that eel abundance in the study area will decrease at an even faster pace in the future.

[*Although this matter is part of the concerns regarding the food resources of marine mammals, it could not be discussed during the workshop, due to lack of time.]*

3.6 Overexploitation

Among the food resources considered to be important for marine mammals, euphausiids, sand lance, smooth flounder, and benthic invertebrates are not exploited by humans in the St. Lawrence. In addition, the exploitation rate of capelin and winter flounder is relatively low. The species for which there is possibly competition between marine mammals and humans are currently Atlantic tomcod and eel. This competition perhaps also exists for herring, cod and smelt, but the situation does not seem to be a problem in the study area. The commercial exploitation of forage species, such as euphausiids and sand lance, could have significant consequences on marine mammals. Currently, this exploitation is prohibited although the related potential environmental repercussions are being assessed.

Atlantic tomcod is exploited by sport fishing in the Sainte-Anne and Batiscan rivers. In 1978-1979 and 1979-1980, the annual volume of sport-related catches in the Sainte-Anne River was approximately 270 tons (Mailhot, 1993). We are unaware whether this exploitation has an impact on Atlantic tomcod abundance in the study area.

The American eel population could be prone to overexploitation on the United States coasts, mainly because of intense exploitation of elvers. In Quebec, this risk of overexploitation is less likely. The main concentration of eel fishing in North America is nevertheless within the limits of the study area. Since 1917, the landings in this area reached a high of 418 tons in 1980 (Bérubé, 1990; Axelsen, 1997). In addition, there has been a strong downward trend in landings since 1991, whereas fishing activity was rather stable (Bérubé, 1990; DFO, pers. comm. in Biorex Inc., 1999).

[*Although this matter is part of the concerns regarding the food resources of marine mammals, it could not be discussed during the workshop, due to lack of time.]*

3.7 River Regulation

Harnessing with the use of dams the St. Lawrence, Saguenay, and several other significant rivers on the Côte-Nord in order to regulate water levels and to produce electricity have considerably reduced the seasonal variations of freshwater inputs in the maritime Estuary. It is estimated that since 1970, the magnitude of seasonal fluctuations of these inputs has been reduced by half, and that spring floods are less significant and winter flows higher. Currently, the freshwater inputs from the Saguenay, Betsiamites, aux Outardes, and Manicouagan rivers occur mostly in the form of short flow peaks that no longer correspond to the natural annual cycle. The impacts of these changes on the resources found in the study area are unknown because we do not have sufficient data for the period prior to 1970 (Bugden et al., 1982; Koutitonsky and Budgen, 1991). However, one can easily highlight what could make certain species vulnerable to river regulation, for example, the concentration mechanisms of euphausiids in the study area that could be modified by changes in the freshwater input in the Estuary.

The case of Atlantic tomcod provides another example of the impact related to river regulation. The Atlantic tomcod population in Mauricie has shown a significant decline since the mid-1980s. The stock abundance in the Sainte-Anne River appeared to be lower than ever in the winters of 1987-1988 and 1991-1992 (Mailhot, 1993). This population decline can be attributed to several factors, such as low flows in the St. Lawrence and the Sainte-Anne River in the mid-1980s, which limited spawner access to spawning grounds and reduced their quality, making for a weaker recruitment in 1986 and 1987 (Mailhot, Y., pers. comm. in Biorex Inc, 1999).

In the same way, the decline observed in the American eel population could partly be attributed to regulation of several rivers, in particular the St. Lawrence.

[*Although this matter is part of the concerns regarding the food resources of marine mammals, it could not be discussed during the workshop, due to lack of time.]*

3.8 Thinning of the Ozone Layer

The concentrations of stratospheric ozone above temperate latitudes all around the globe decreased by 3% over the last decade. However, since the implementation of the Montreal Protocol (an international convention aimed at banning the use of CFCs, adopted in 1987), this reduction, attributable to the emission of chemical substances in the atmosphere that deplete the ozone layer, is less than before 1990. If the provisions of the Montreal Protocol are fully respected, we expect the stratospheric concentrations of these harmful chemical substances to level off over the next few years and then decrease gradually to return to their natural levels around the year 2100. According to minimal scientific data and a limited understanding of the problem, we established that no clear trend in ozone increasing concentration could occur before 2005 or 2010 (Environment Canada, 2000; Harding, 1992).

The ozone layer has the property to absorb many of the type-B ultraviolet rays emitted by the sun. Phytoplankton and zooplankton are particularly sensitive to an increase in type-B ultraviolet radiation. Under experimental conditions, these radiations reduce the photosynthetic capacity of phytoplankton, the activity of bacterioplankton, and the fertility of zooplankton and increase the death rate of zooplankton (Harding, 1992).

The eggs and larvae of several food resource species for marine mammals tend to concentrate in surface waters. It is particularly the case for euphausiids, capelin and sand lance. The increase in ultraviolet radiation attributable to the thinning of the stratospheric ozone layer could cause a higher mortality rate for these eggs and larvae. This problem is currently being studied in the Estuary and Gulf of St. Lawrence.

For euphausiids, in addition to the potential vulnerability of eggs and larvae, there is a potential reduction in the abundance of their food resources (particulate organic matter, phyto- and zooplankton) in response to the increased ultraviolet radiation.

[*Although this matter is part of the concerns regarding the food resources of marine mammals, it could not be discussed during the workshop, due to lack of time.]*

3.9 Knowledge Gaps

If we consider that each knowledge gap is likely to conceal a problem, it becomes important to mention this issue in this document. These gaps are presented in the form of a synthesis table (Table 6). Some food resources, such as sand lance, plaice or benthos, present several knowledge gaps, which makes it difficult to link these species to one or more particular problem.

[*Although this matter is part of the concerns regarding the food resources of marine mammals, it could not be discussed during the workshop, due to lack of time.]*

Table 6. Synthesis of the general knowledge gaps and synthesis of the missing information needed to assess the food resource problems in the study area.

	Category	Sub-category	Euphausiids	Capelin	Herring	Sand lance	Atlantic cod	Atlantic tomcod	Rainbow smelt	Smooth flounder Winter flounder	American eel	Shortfin squid	Benthos
Lack of general knowledge	Importance in marine mammal diet	-------			!	!!	!	!	!!	!	!!	!	!!
	General biology	Population of origin		!	!	!!				!			
		Life cycle		!	!	!!			!	!	!		
		Habitats		!		!!		!	!	!	!		
		Diet			!	!!		!	!	!			
		Growth				!!				!	!		
		Behaviour in schools and vertical migrations		!	!	!!		!	!	!	!		
	Distribution in the study area	-------		!	!	!		!!	!!	!	!	!!	!
	Resource condition	Abundance	!	!	!	!!		!	!	!		!	!
	Human exploitation	-------			!			!		!			

	Category	Sub-category	Euphausiids	Capelin	Herring	Sand lance	Atlantic cod	Atlantic tomcod	Rainbow smelt	Smooth flounder Winter flounder	American eel	Shortfin squid	Benthos
Poorly documented problems	Decline in resource abundance in the study area	Climatic warming					**?**		**?**	**?**	**?**		**?**
		Deterioration and destruction of spawning grounds				**?**				**?**			
		Obstruction to migration											
		Overexploitation			**?**			**?**		**?**			
		Reduction of food resources			**?**		**?**	**?**	**?**	**?**			**?**
		Regularization of rivers				**?**							**?**
		Ultraviolet radiation (ozone layer depletion)		**?**	**?**	**?**	**?**	**?**	**?**	**?**	**?**	**?**	**?**
	Contamination	-------	**?**		**?**	**?**		**?**	**?**	**?**		**?**	**?**
	Individual health	-------			**?**	**?**		**?**		**?**			**?**

SYMBOLS:
! Insufficient knowledge
! ! Very insufficient knowledge
? Undetermined level of insufficiency
Empty box Sufficient knowledge / Not applicable

CONCLUSION

As a whole, the objectives of this workshop, from which this document was derived, were reached. It was therefore possible, during discussions, to better determine the available knowledge on marine mammals in the St. Lawrence Estuary and to draw up a set of priorities for the different manmade problems they face.

The largest obstacle highlighted during these discussions is no doubt the lack of knowledge on the different marine mammal species living in the St. Lawrence and on the impacts of the manmade problems. Thus, the many aspects regarding species distribution at various times of the year need to be cleared up. For several of these marine mammal species, it is difficult, based on the current studies, to determine which are the most important food resources, not only according to the nature and quantity of the prey consumed, but according to the energy intake they represent. The lack of knowledge is also significant with regard to the condition of the food resources, particularly in the case of non-commercial species for which few studies have been conducted.

Several research possibilities to mitigate the lack of knowledge were proposed during the discussions and should be considered on a priority basis at the time of the establishment of the marine protected area (MPA) in the St. Lawrence Estuary. The participants insisted on the importance of establishing research programs based on systematic and regular inventories conducted on a territory largely exceeding the limits of the MPA. Thus, the whole of the Estuary and Gulf of St. Lawrence should be included in the monitored areas in order to obtain an overall picture of species distribution in time and space.

Another significant objective of this workshop was to determine if the suggested limits of the MPA were adequate to effectively protect the marine mammals in St. Lawrence. Following the discussions, we determined that the current limits allowed for adequate protection of certain species and at certain times of the year only. Thus, for species such as blue whale, which have a distribution range largely exceeding the suggested limits, the protection ensured by the MPA could be partial only. The beluga whale and harbour seal face a similar problem in winter, when few individuals are observed inside the current limits. However, we need to consider that a significant proportion of the pressures the marine mammals present in the Gulf and Estuary experience are exerted between the spring and the fall, a period during which we can observe great numbers of individuals of these species gathered within the suggested limits.

However, we must remember that the protection tool the Estuary MPA represents cannot meet all our expectations. It is only one of the management means that should be combined with other provincial, national and international initiatives. We therefore must set attainable objectives in time and space, especially considering the number of significant problems that require fast and effective action.

It also should be mentioned that several of the problems described in this document should be the subject of more in-depth studies. The future working group on research and follow-up should identify research orientations and priority follow-up requirements concerning this MPA project in the St. Lawrence Estuary. The issue of threats will be discussed by this working group, focusing on knowledge gaps and a follow-up of the threat's magnitude in the MPA. Some points were not discussed during the workshop, and they were primarily problems associated with marine mammal food resources. In the following steps, these points will be considered by consulting the published literature and will probably not be reviewed by a working group.

Finally, it is often very difficult, even impossible, to confirm with certainty the causal link between a given human activity and its harmful impact on animals. Also, if we consider the high number of problems (known and potential) facing marine mammals on the proposed territory, we can assume that the Estuary MPA, according to the precautionary principle recommended by the Oceans Act, is certainly justified and even a necessity for the conservation of this very valuable natural resource.

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Grégoire, François	Fisheries and Oceans Canada
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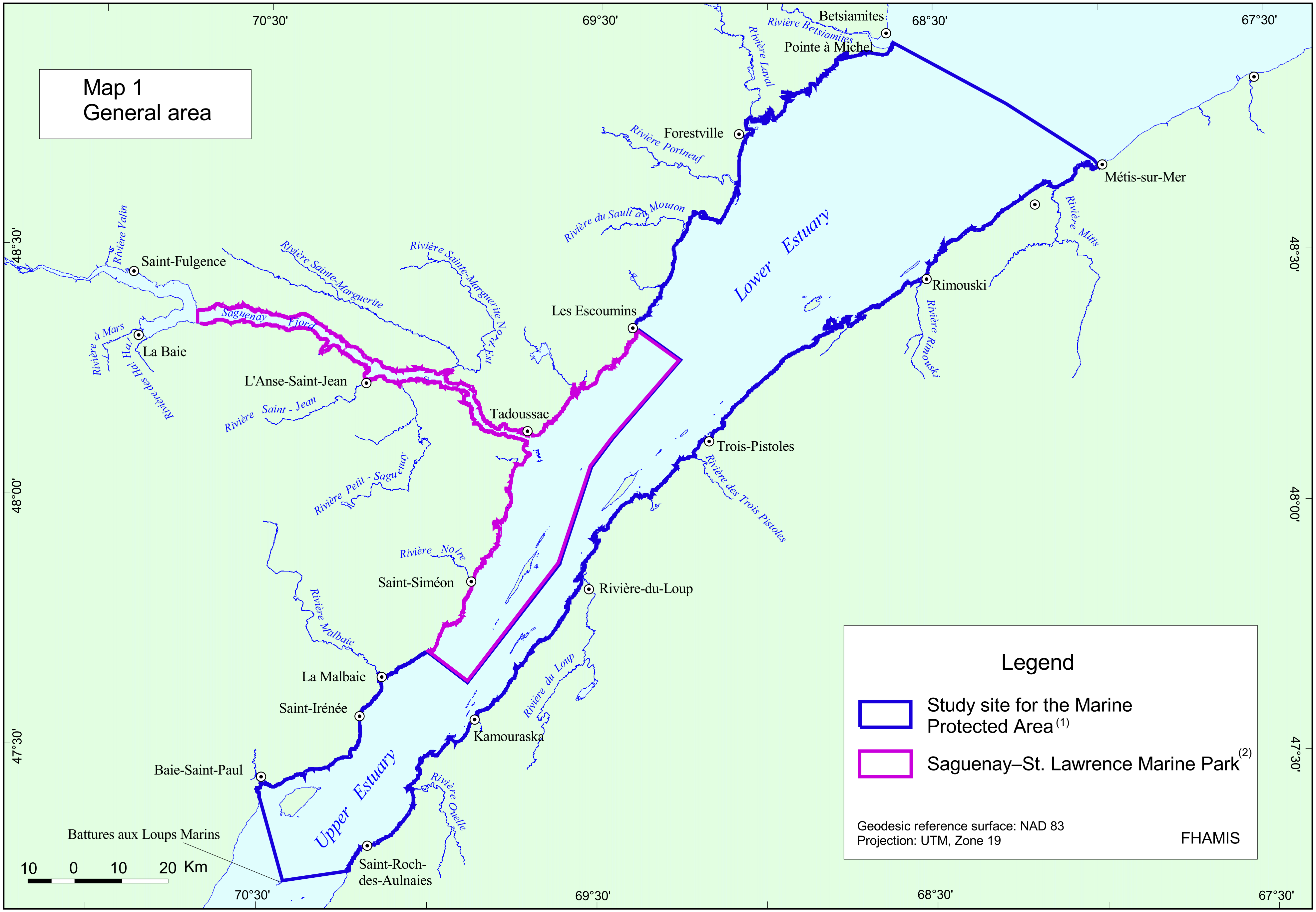
List of Participants, by sub-workshops

Monday April 3, 2000 ***Seals***	**TuesdayApril 4, 2000** ***Other species***	**Wednesday April 5, 2000** ***Beluga whale***	**Thursday April 6, 2000** *Whales*	**Friday April 7, 2000** ***Food resources***
Moderator: Luci Bossé	**Moderator**: Pierre Béland	**Moderator**: Richard Bailey	**Moderator**: Richard Bailey	**Moderator**: Pierre Bergeron
Rapporteurs: Myriam Bourgeois and Jean-Yves Savaria	**Rapporteurs**: Myriam Bourgeois and Jean-Yves Savaria	**Rapporteurs**: Myriam Bourgeois and Jean-Yves Savaria	**Rapporteurs**: Myriam Bourgeois and Jean-Yves Savaria	**Rapporteurs**: Myriam Bourgeois and Jean-Yves Savaria
Speaker: Mike Hammill	**Speaker:** Robert Michaud	**Speaker:** Richard Bailey	**Speaker:** Robert Michaud	**Speaker:** None
Albert, Élaine	Albert, Élaine	Baratin, Magali	Albert, Élaine	Baratin, Magali
Bailey, Richard	Bailey, Richard	Béland, Pierre	Baratin, Magali	Bossé, Luci
Baratin, Magali	Baird, Robin W.	Bergeron, Pierre	Bergeron, Pierre	Cantin, Guy
Bergeron, Pierre	Baratin, Magali	Bossé, Luci	Bossé, Luci	Castonguay, Martin
Cantin, Guy	Bergeron, Pierre	Cantin, Guy	Cantin, Guy	Chapdelaine, Gilles
Fontaine, Pierre-Henry	Brown, Moira W.	Chadenet, Virginie	Chadenet, Virginie	Couillard, Catherine
Fontaine, Pierre-Michel	Bossé, Luci	Couillard, Catherine	Chapdelaine, Gilles	Dalcourt, Marie-France
Fournier, Michel	Cantin, Guy	Dallaire, André	Fontaine, Pierre-Henry	Fontaine, Pierre-Henry
Gobeil, Charles	Fontaine, Pierre-Henry	Fontaine, Pierre-Henry	Fournier, Michel	Giard, Janie
Gosselin, Jean-François	Fontaine, Pierre-Michel	Fournier, Michel	Giard, Janie	Gosselin, Jean-François
Hammill, Mike	Fournier, Michel	Gosselin, Jean-François	Gosselin, Jean-François	Grégoire, François
Lebeuf, Michel	Hammill, Mike	Hammill, Mike	Hammill, Mike	Harvey, Michel
Lesage, Véronique	Lesage, Véronique	Kingsley, Michael	Kingsley, Michael	Kingsley, Michael
Le Sauteur, Daniel	Measures, Lena	Lebeuf, Michel	Lesage, Véronique	Lesage, Véronique
Measures, Lena	Ménard, Nadia	Lesage, Véronique	Le Sauteur, Daniel	Measures, Lena
Ménard, Nadia	Michaud, Robert	Le Sauteur, Daniel	Measures, Lena	Ménard, Nadia
Morisset, Jean	Morisset, Jean	Measures, Lena	Ménard, Nadia	McQuinn, Ian
Provencher, Lizon	Sears, Richard	Ménard, Nadia	McQuinn, Ian	Michaud, Robert
Vachon, Éric	Smith, Thomas G.	Michaud, Robert	Michaud, Robert	Munro, Jean
	Vachon, Éric	Morisset, Jean	Morisset, Jean	Nadeau, André
		Nadeau, André	Nadeau, André	Provencher, Lizon
		Provencher, Lizon	Provencher, Lizon	Saucier, François-J.
		Scheifele, Peter	Saucier, François-J.	Simard, Yvan
		Sears, Richard	Scheifele, Peter	Vachon, Éric
		Simard, Yvan	Sears, Richard	Verreault, Guy
		Smith, Thomas G.	Simard, Yvan	
		Vachon, Éric	Smith, Thomas G.	
			Vachon, Éric	

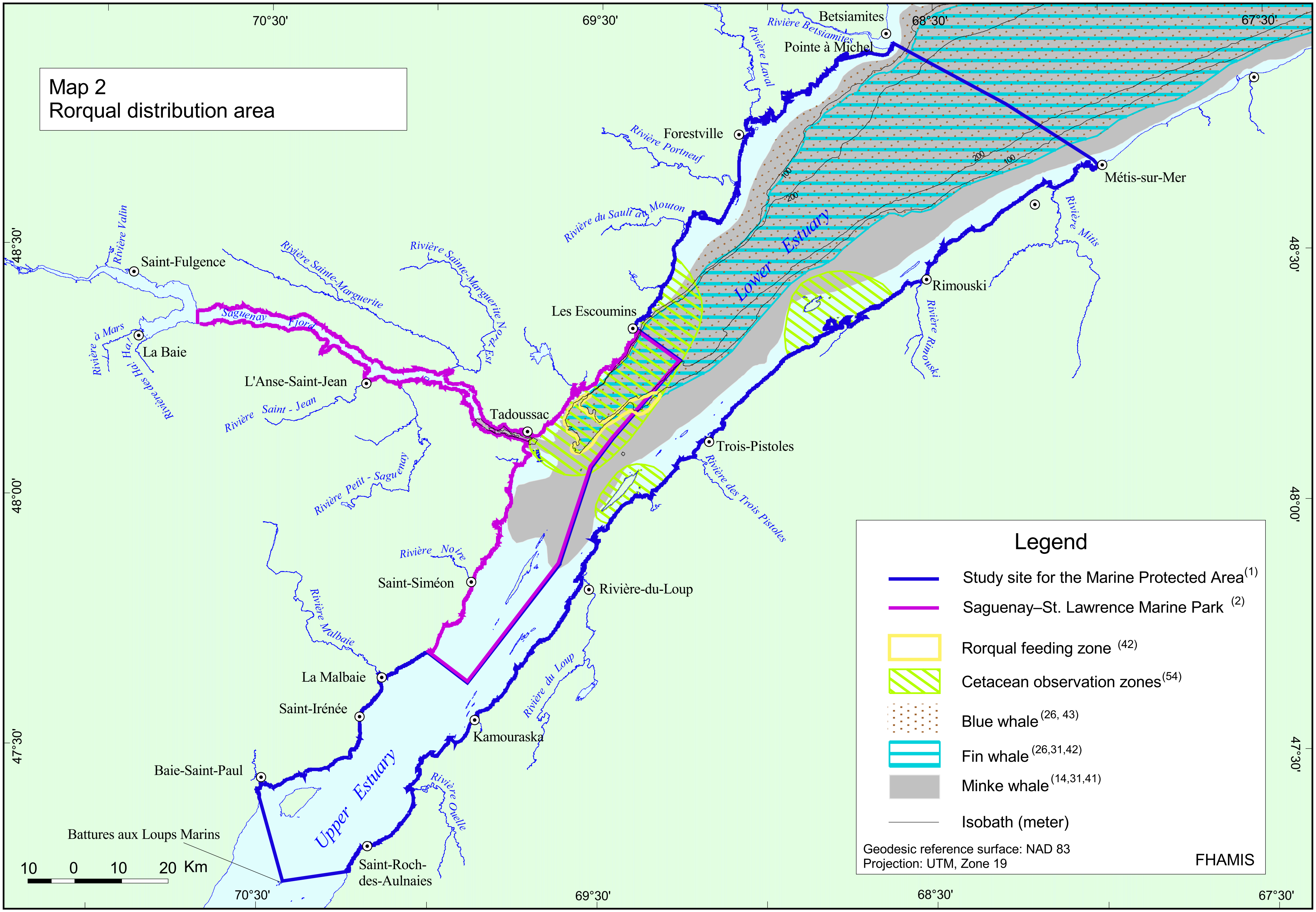
APPENDIX

The maps used during the workshop are listed here. The numbers indicated in the legend of each map correspond to the references used for producing the maps and are presented at the end of this appendix.



Pêches et Océans Canada Fisheries and Oceans Canada

Canada



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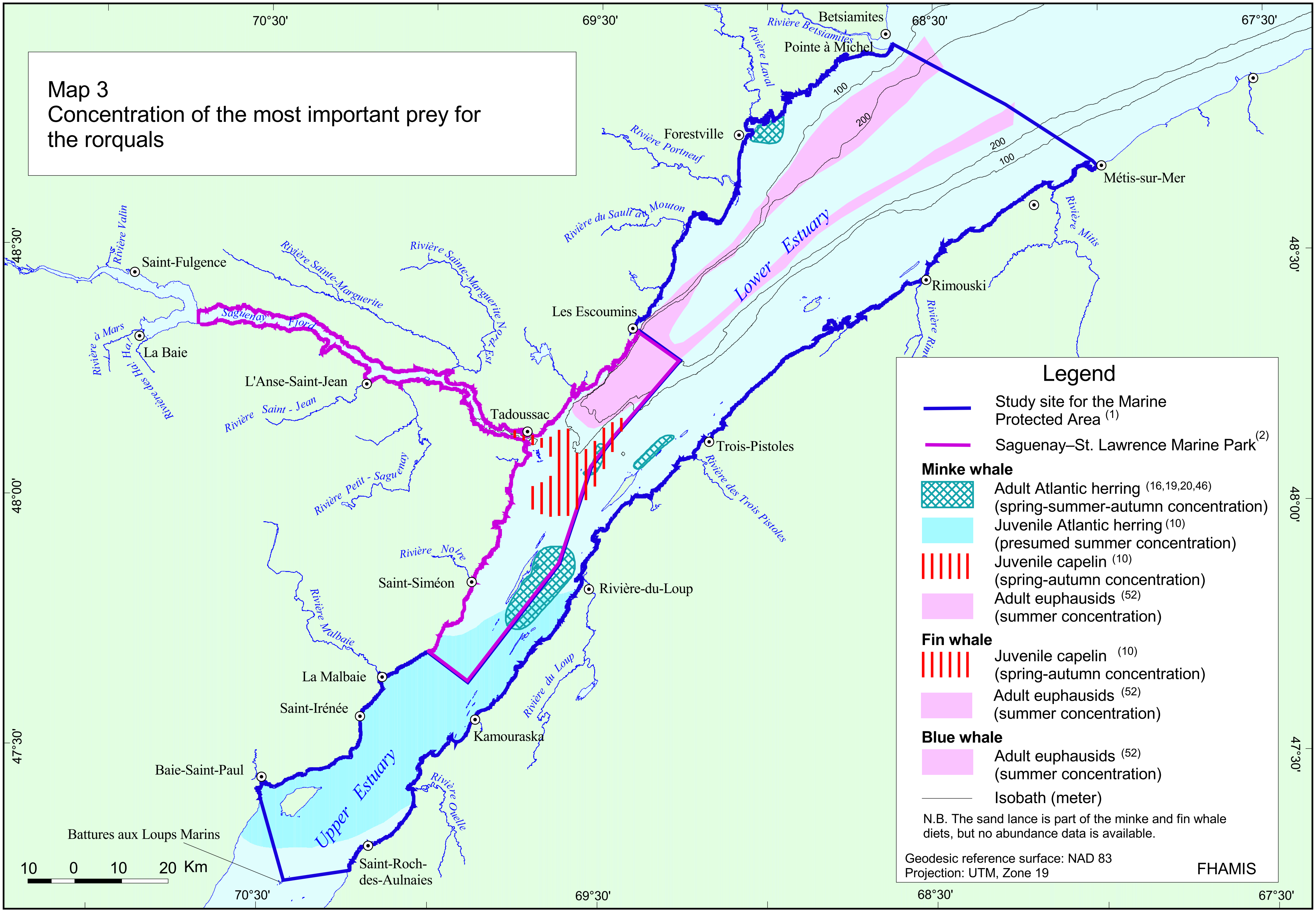
Canada



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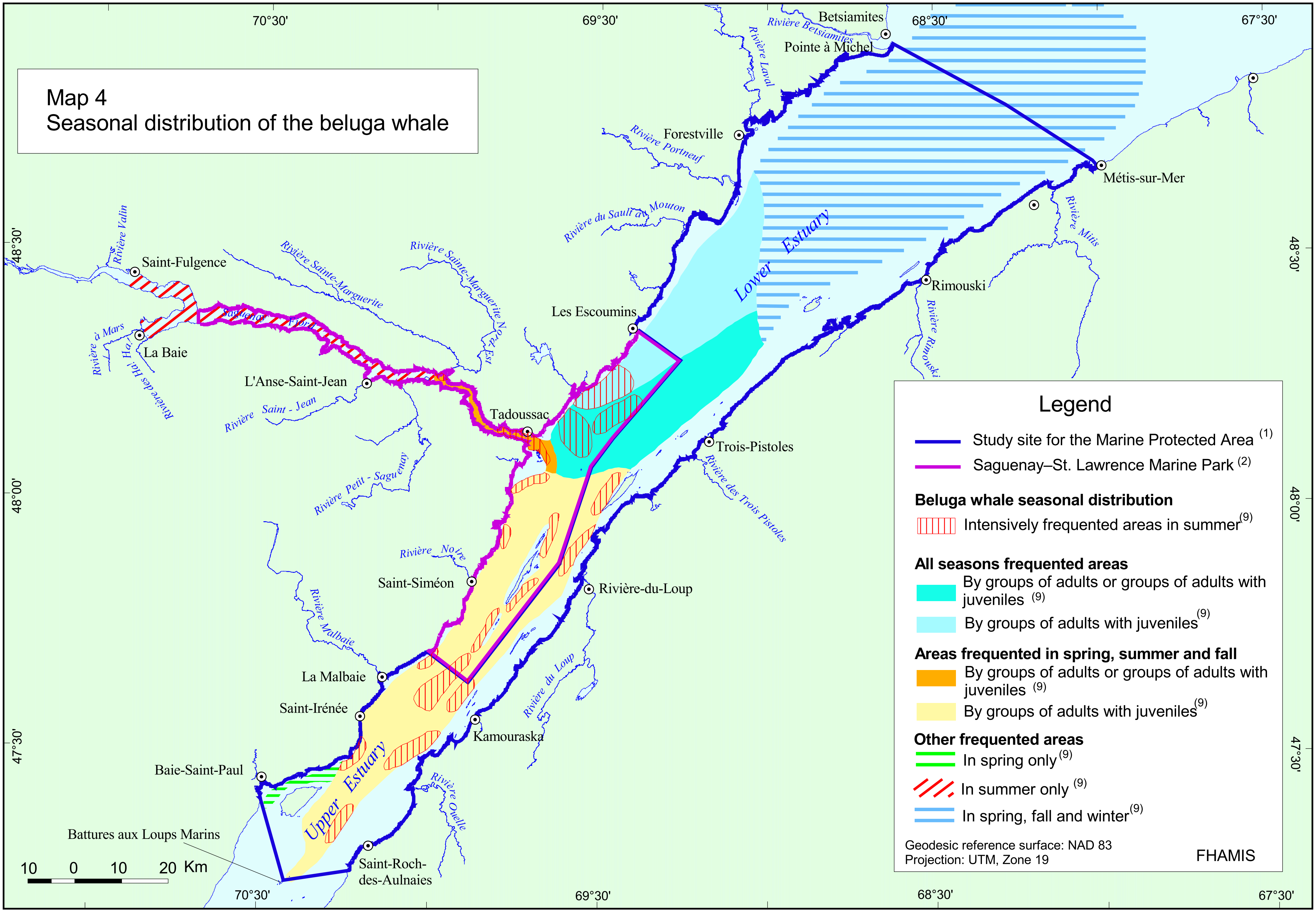

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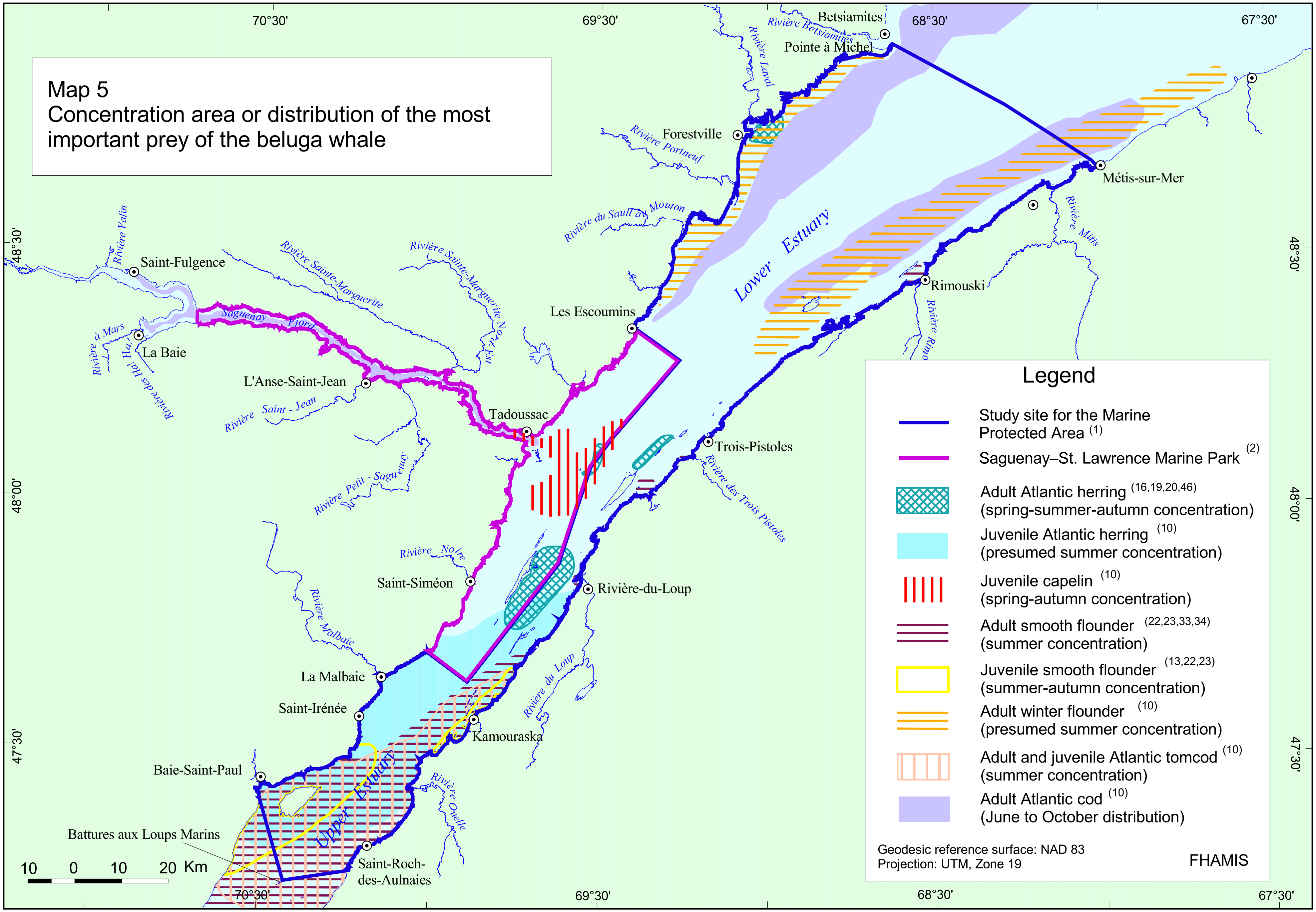
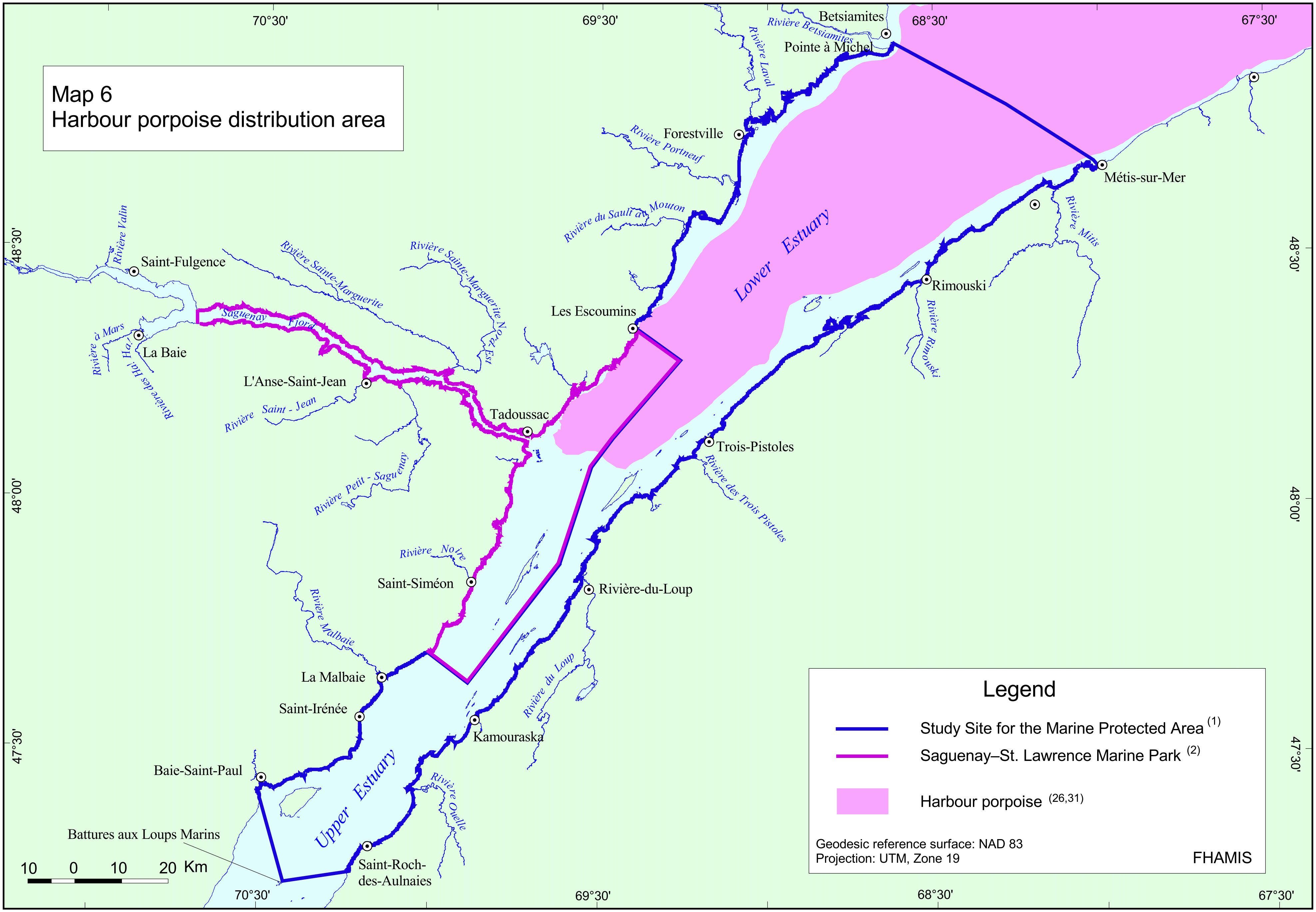
Canada



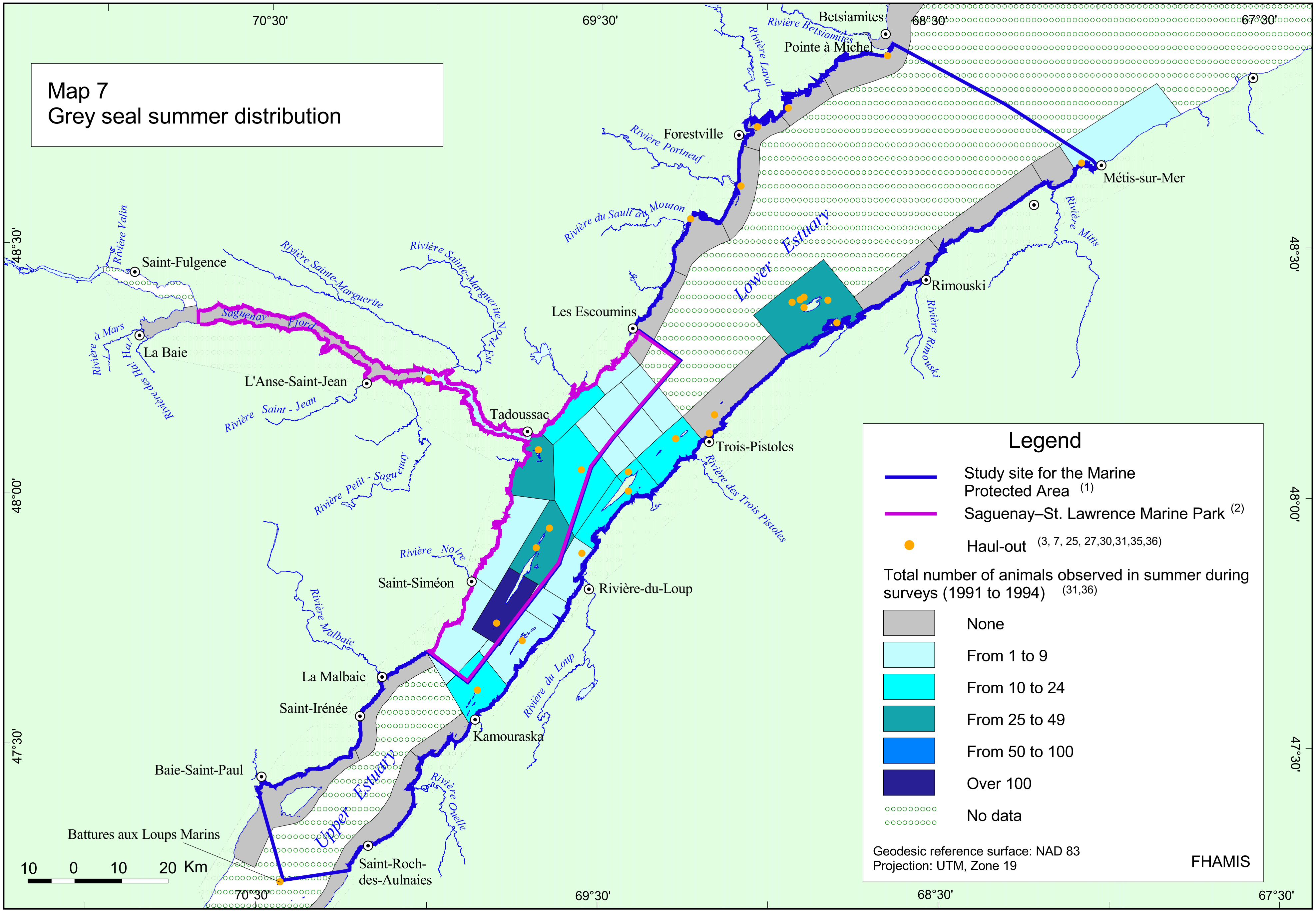
Pêches et Océans Canada | Fisheries and Oceans Canada

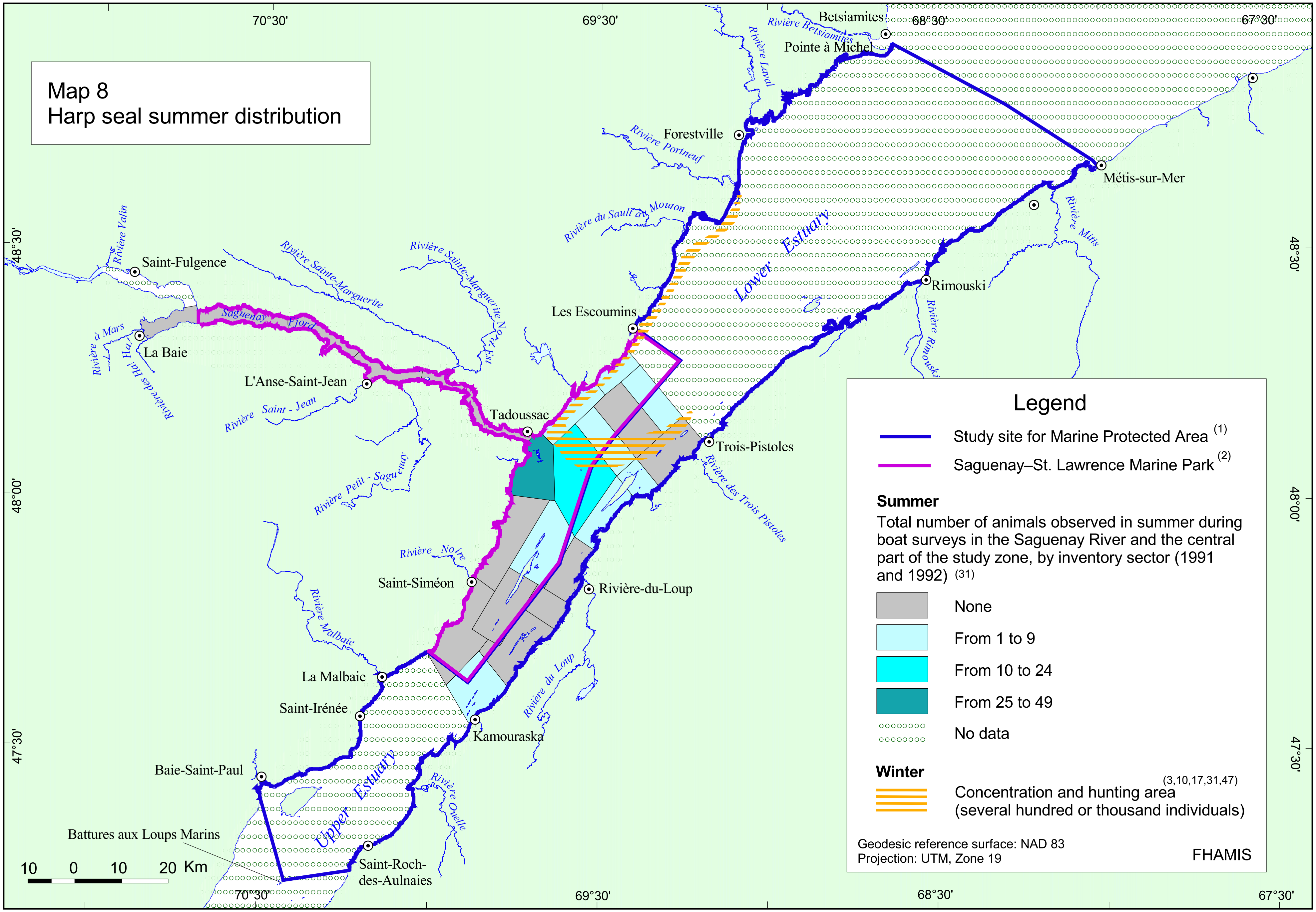
Canada

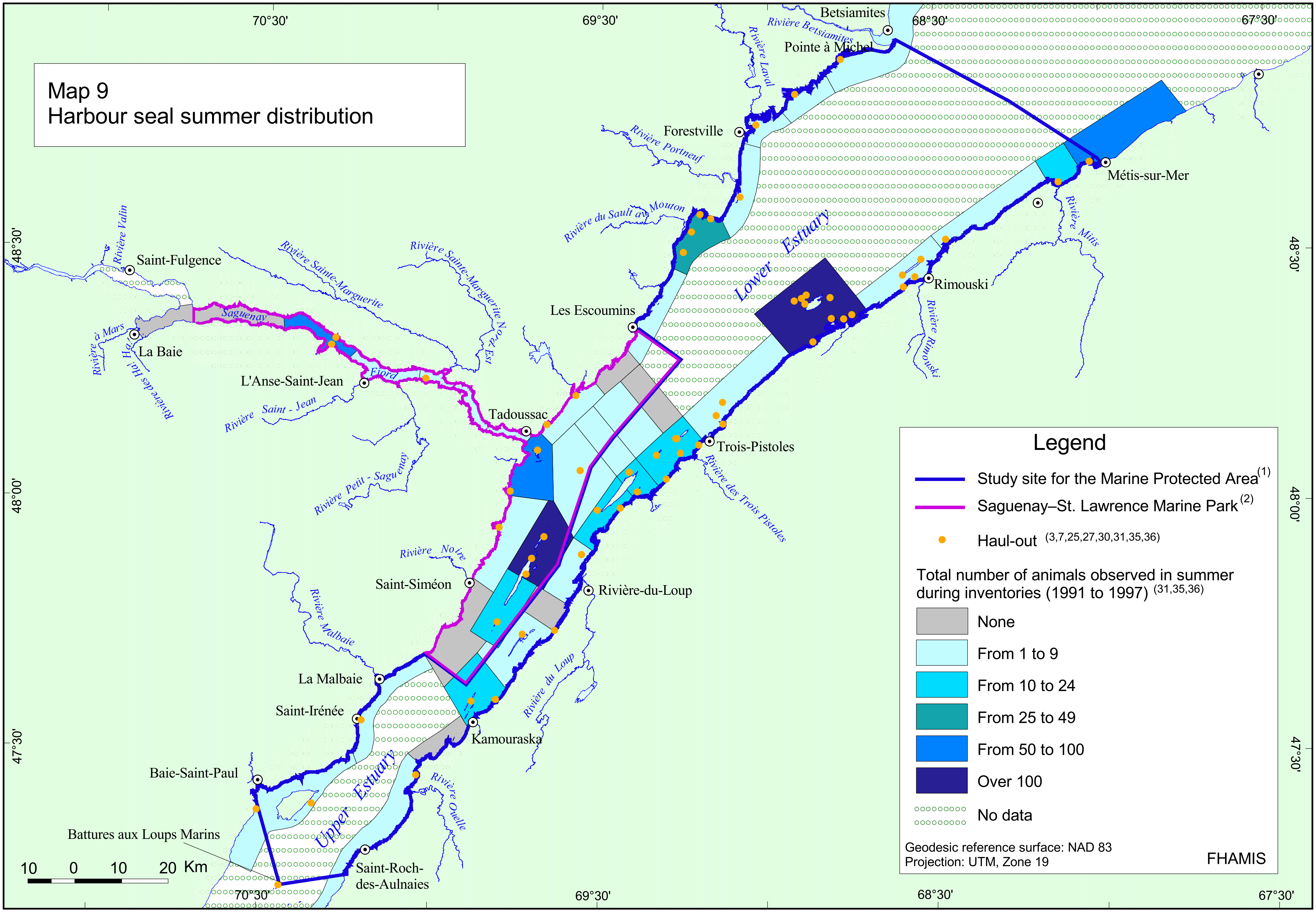


Pêches et Océans Canada Fisheries and Oceans Canada

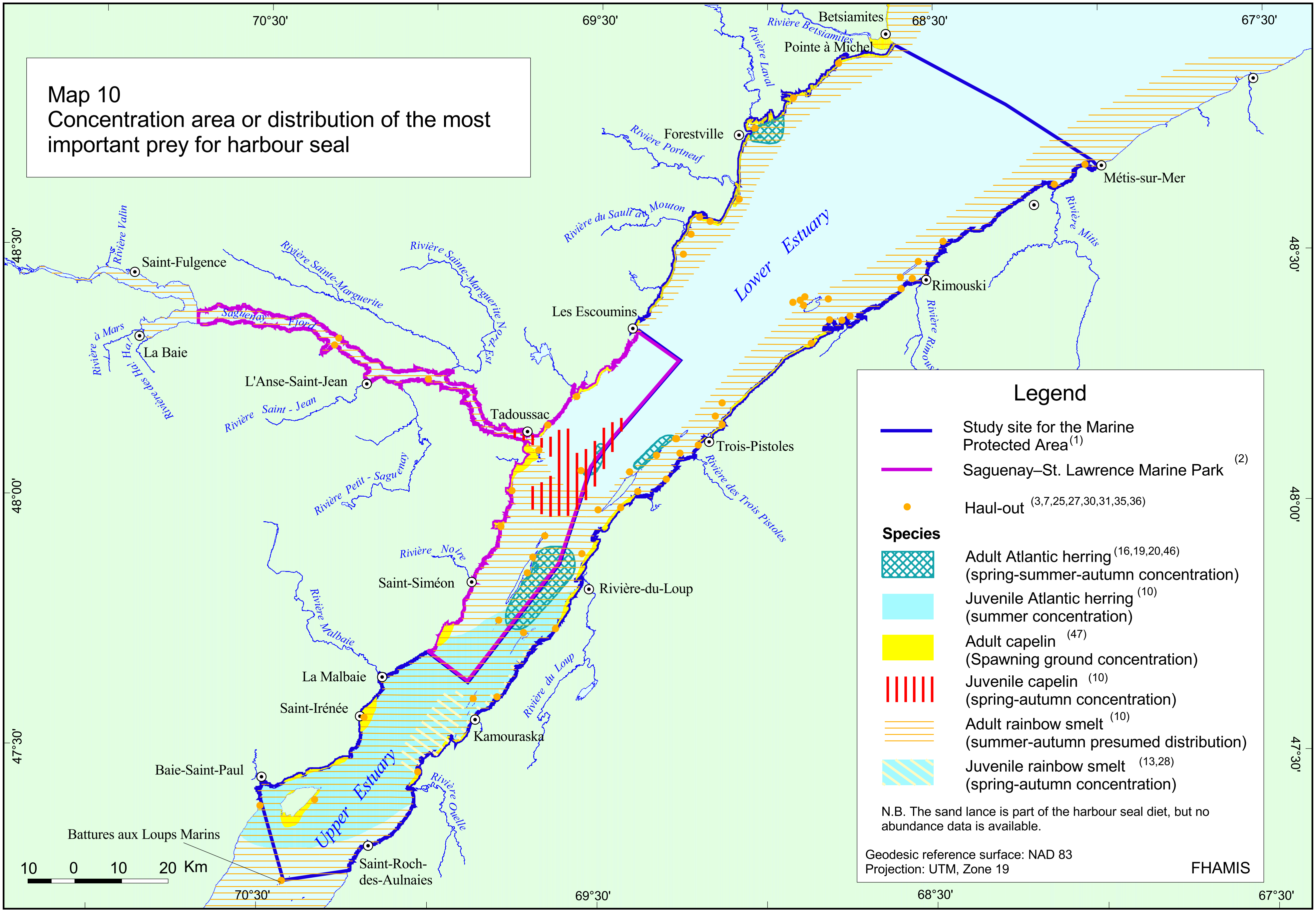
Canada

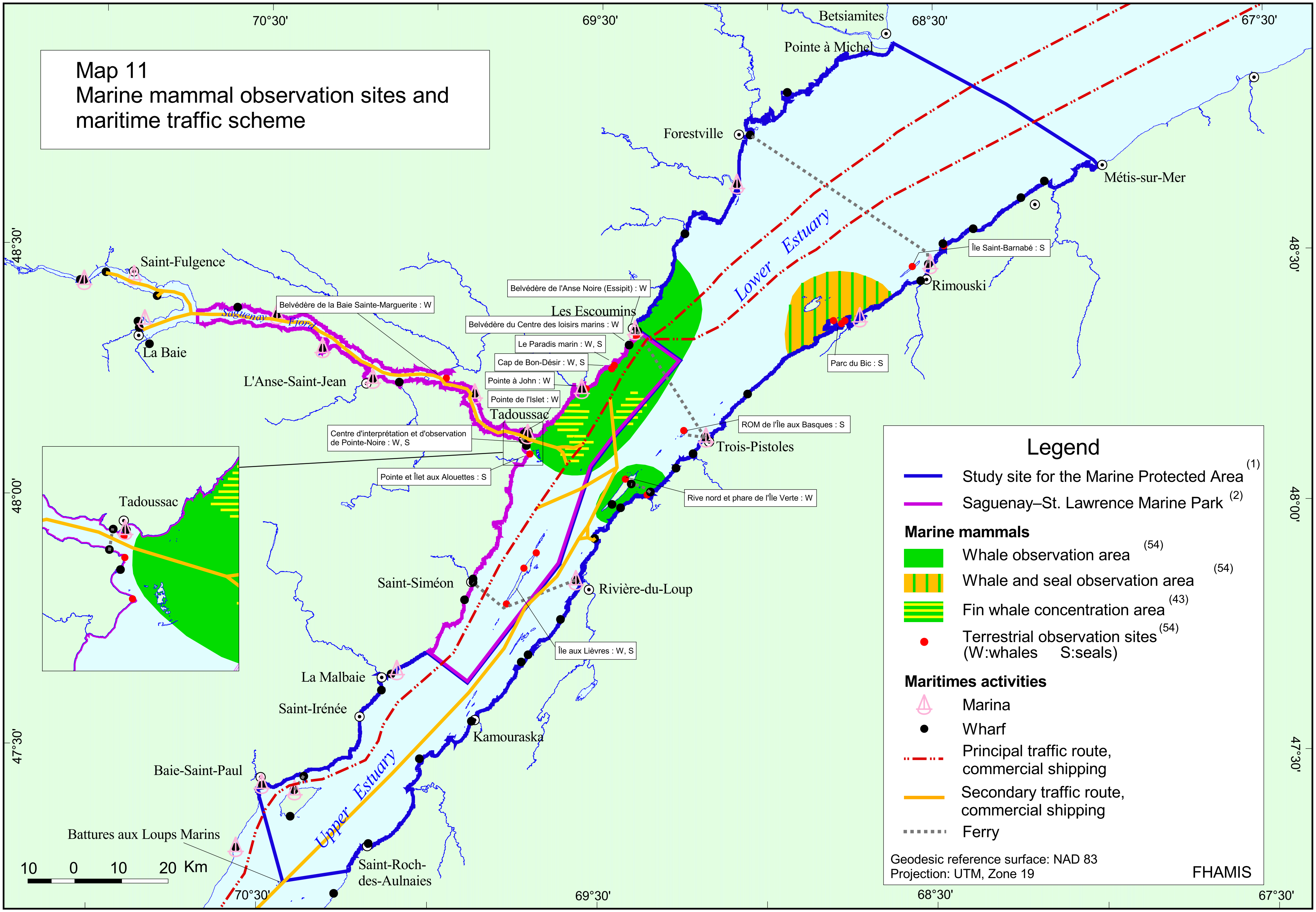

Map 7
Grey seal summer distribution
70°30'
69°30'
68°30'
67°30'
48°30'
48°00'
47°30'
Betsiamites
Pointe à Michel
Forestville
Les Escoumins
Tadoussac
Saint-Fulgence
La Baie
L'Anse-Saint-Jean
Saint-Siméon
La Malbaie
Saint-Irénée
Baie-Saint-Paul
Battures aux Loups Marins
Saint-Roch-des-Aulnaies
Kamouraska
Rivière-du-Loup
Trois-Pistoles
Rimouski
Métis-sur-Mer
Saguenay Fjord
Lower Estuary
Upper Estuary
Rivière Betsiamites
Rivière Laval
Rivière Portneuf
Rivière du Sault au Mouton
Rivière Sainte-Marguerite
Rivière Sainte-Marguerite Nord-Est
Rivière Valin
Rivière à Mars
Rivière des Ha! Ha!
Rivière Saint - Jean
Rivière Petit - Saguenay
Rivière Noire
Rivière Malbaie
Rivière du Loup
Rivière Ouelle
Rivière des Trois Pistoles
Rivière Rimouski
Rivière Mitis
10 0 10 20 Km
Legend
Study site for the Marine Protected Area (1)
Saguenay–St. Lawrence Marine Park (2)
Haul-out (3, 7, 25, 27,30,31,35,36)
Total number of animals observed in summer during surveys (1991 to 1994) (31,36)
None
From 1 to 9
From 10 to 24
From 25 to 49
From 50 to 100
Over 100
No data
Geodesic reference surface: NAD 83
Projection: UTM, Zone 19
FHAMIS


Map 8
Harp seal summer distribution
70°30'
69°30'
68°30'
67°30'
48°30'
48°00'
47°30'
Betsiamites
Rivière Betsiamites
Pointe à Michel
Rivière Laval
Forestville
Rivière Portneuf
Métis-sur-Mer
Rivière Mitis
Rivière du Sault au Mouton
Lower Estuary
Rimouski
Rivière Rimouski
Les Escoumins
Saint-Fulgence
Rivière Valin
Rivière Sainte-Marguerite
Rivière Sainte-Marguerite Nord-Est
Saguenay Fjord
La Baie
Rivière à Mars
Rivière des Ha! Ha!
L'Anse-Saint-Jean
Rivière Saint - Jean
Tadoussac
Trois-Pistoles
Rivière des Trois Pistoles
Rivière Petit - Saguenay
Rivière Noire
Saint-Siméon
Rivière-du-Loup
Rivière Malbaie
La Malbaie
Saint-Irénée
Rivière du Loup
Kamouraska
Baie-Saint-Paul
Upper Estuary
Rivière Ouelle
Battures aux Loups Marins
Saint-Roch-des-Aulnaies
10 0 10 20 Km
Legend
Study site for Marine Protected Area (1)
Saguenay–St. Lawrence Marine Park (2)
Summer
Total number of animals observed in summer during boat surveys in the Saguenay River and the central part of the study zone, by inventory sector (1991 and 1992) (31)
None
From 1 to 9
From 10 to 24
From 25 to 49
No data
Winter
Concentration and hunting area (3,10,17,31,47)
(several hundred or thousand individuals)
Geodesic reference surface: NAD 83
Projection: UTM, Zone 19
FHAMIS



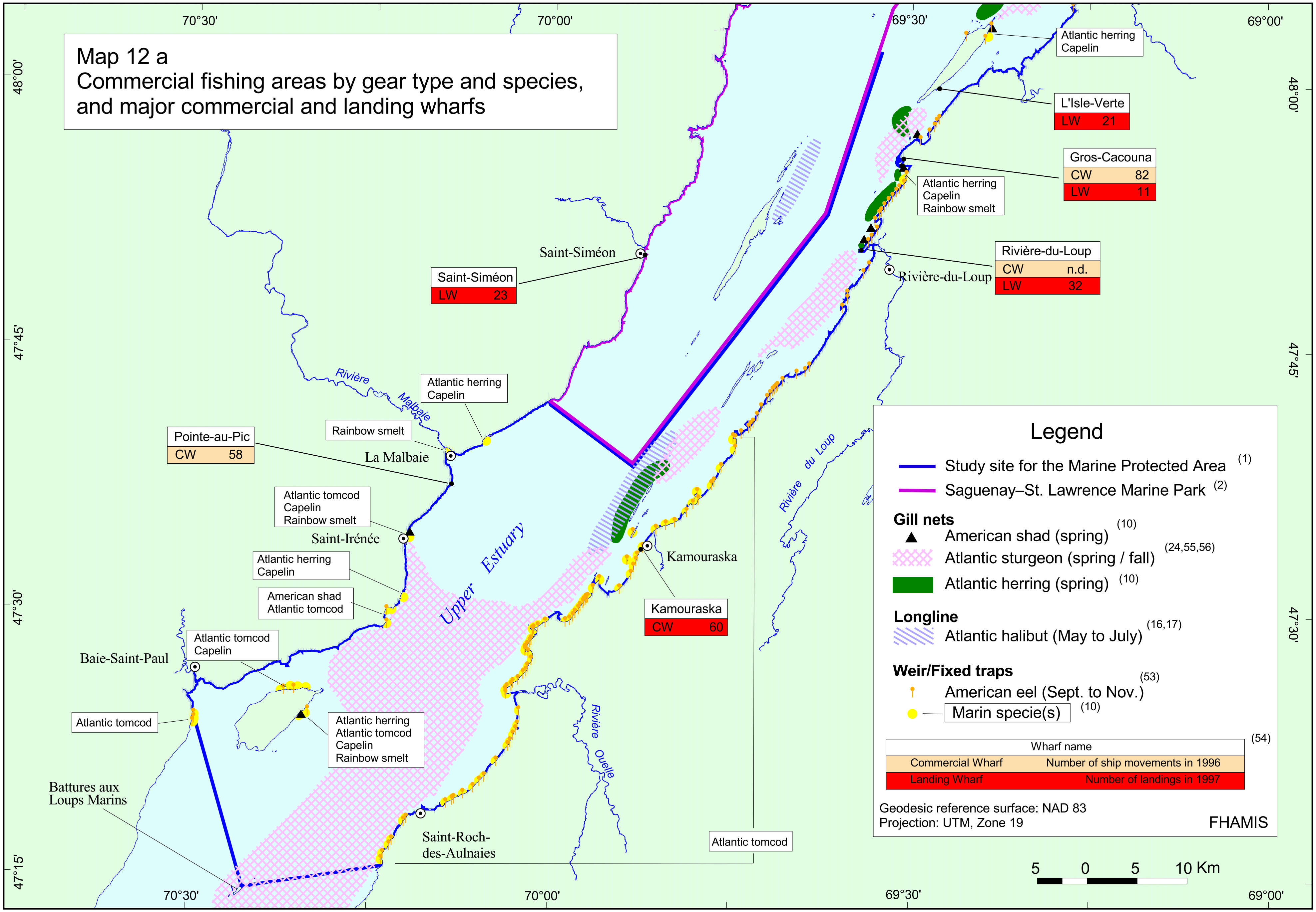
Map 9
Harbour seal summer distribution
Legend
Study site for the Marine Protected Area (1)
Saguenay–St. Lawrence Marine Park (2)
Haul-out (3,7,25,27,30,31,35,36)
Total number of animals observed in summer during inventories (1991 to 1997) (31,35,36)
None
From 1 to 9
From 10 to 24
From 25 to 49
From 50 to 100
Over 100
No data
Geodesic reference surface: NAD 83
Projection: UTM, Zone 19
FHAMIS
10 0 10 20 Km
70°30'
69°30'
68°30'
67°30'
48°30'
48°00'
47°30'
Betsiamites
Rivière Betsiamites
Pointe à Michel
Rivière Laval
Forestville
Rivière Portneuf
Métis-sur-Mer
Rivière Mitis
Rivière du Sault au Mouton
Lower Estuary
Rimouski
Rivière Rimouski
Les Escoumins
Saint-Fulgence
Rivière Valin
Rivière Sainte-Marguerite
Rivière Sainte-Marguerite Nord-Est
Saguenay
Fjord
La Baie
Rivière à Mars
Rivière des Ha! Ha!
L'Anse-Saint-Jean
Rivière Saint - Jean
Tadoussac
Trois-Pistoles
Rivière des Trois Pistoles
Rivière Petit - Saguenay
Rivière Noire
Saint-Siméon
Rivière-du-Loup
Rivière Malbaie
Rivière du Loup
La Malbaie
Saint-Irénée
Kamouraska
Baie-Saint-Paul
Upper Estuary
Rivière Ouelle
Battures aux Loups Marins
Saint-Roch-des-Aulnaies


Map 10
Concentration area or distribution of the most important prey for harbour seal
70°30'
69°30'
68°30'
67°30'
48°30'
48°00'
47°30'
Betsiamites
Rivière Betsiamites
Pointe à Michel
Rivière Laval
Forestville
Rivière Portneuf
Rivière du Sault au Mouton
Les Escoumins
Lower Estuary
Métis-sur-Mer
Rivière Mitis
Rimouski
Rivière Rimouski
Saint-Fulgence
Rivière Valin
Rivière Sainte-Marguerite
Rivière Sainte-Marguerite Nord-Est
Saguenay Fjord
La Baie
Rivière à Mars
Rivière des Ha! Ha!
L'Anse-Saint-Jean
Rivière Saint - Jean
Tadoussac
Rivière Petit - Saguenay
Trois-Pistoles
Rivière des Trois Pistoles
Rivière Noire
Saint-Siméon
Rivière-du-Loup
Rivière Malbaie
Rivière du Loup
La Malbaie
Saint-Irénée
Kamouraska
Baie-Saint-Paul
Upper Estuary
Rivière Ouelle
Battures aux Loups Marins
Saint-Roch-des-Aulnaies
10 0 10 20 Km
Legend
Study site for the Marine Protected Area (1)
Saguenay–St. Lawrence Marine Park (2)
Haul-out (3,7,25,27,30,31,35,36)
Species
Adult Atlantic herring (16,19,20,46) (spring-summer-autumn concentration)
Juvenile Atlantic herring (10) (summer concentration)
Adult capelin (47) (Spawning ground concentration)
Juvenile capelin (10) (spring-autumn concentration)
Adult rainbow smelt (10) (summer-autumn presumed distribution)
Juvenile rainbow smelt (13,28) (spring-autumn concentration)
N.B. The sand lance is part of the harbour seal diet, but no abundance data is available.
Geodesic reference surface: NAD 83
Projection: UTM, Zone 19
FHAMIS



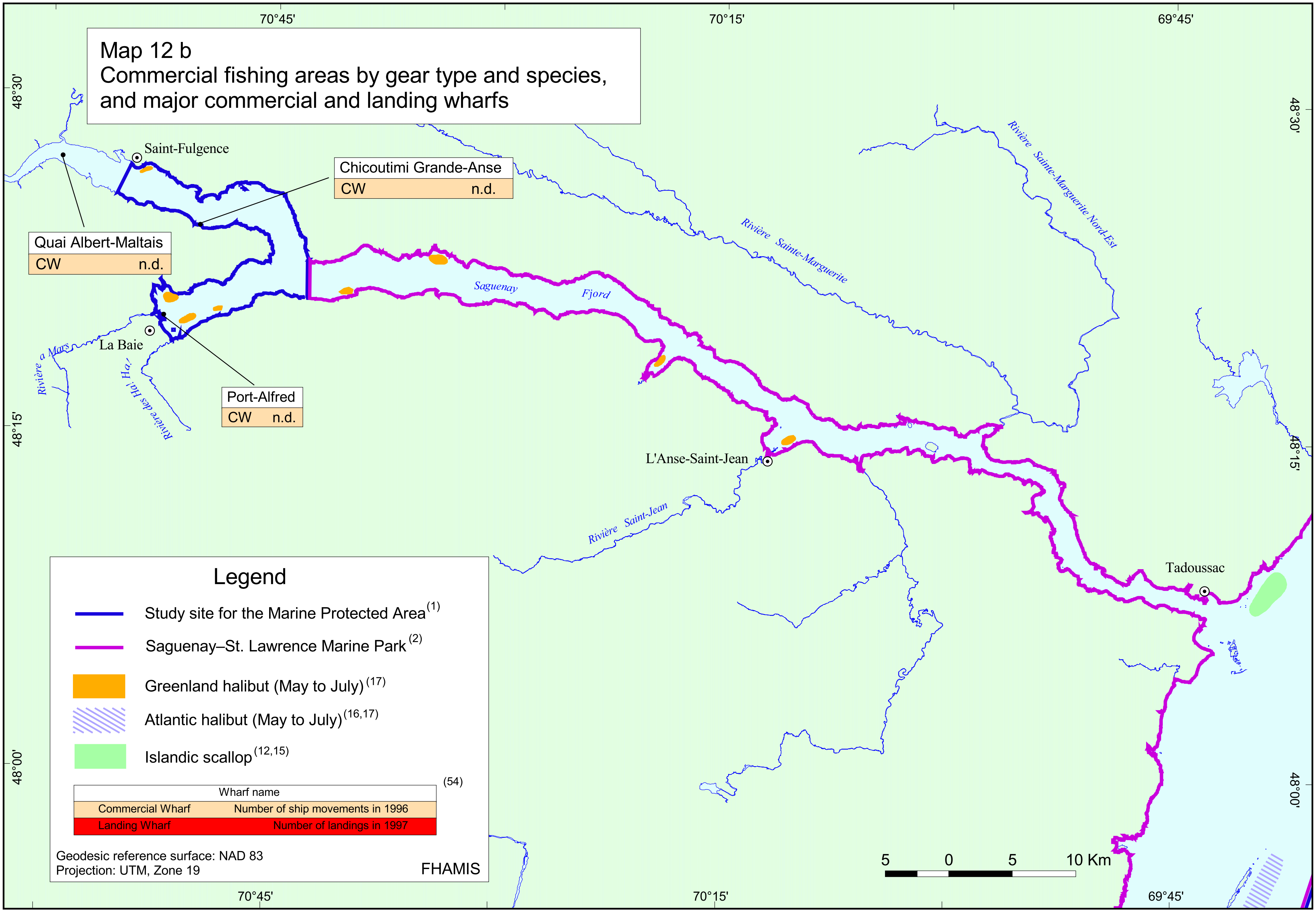
Pêches et Océans Canada Fisheries and Oceans Canada

Canada



Pêches et Océans Canada Fisheries and Oceans Canada

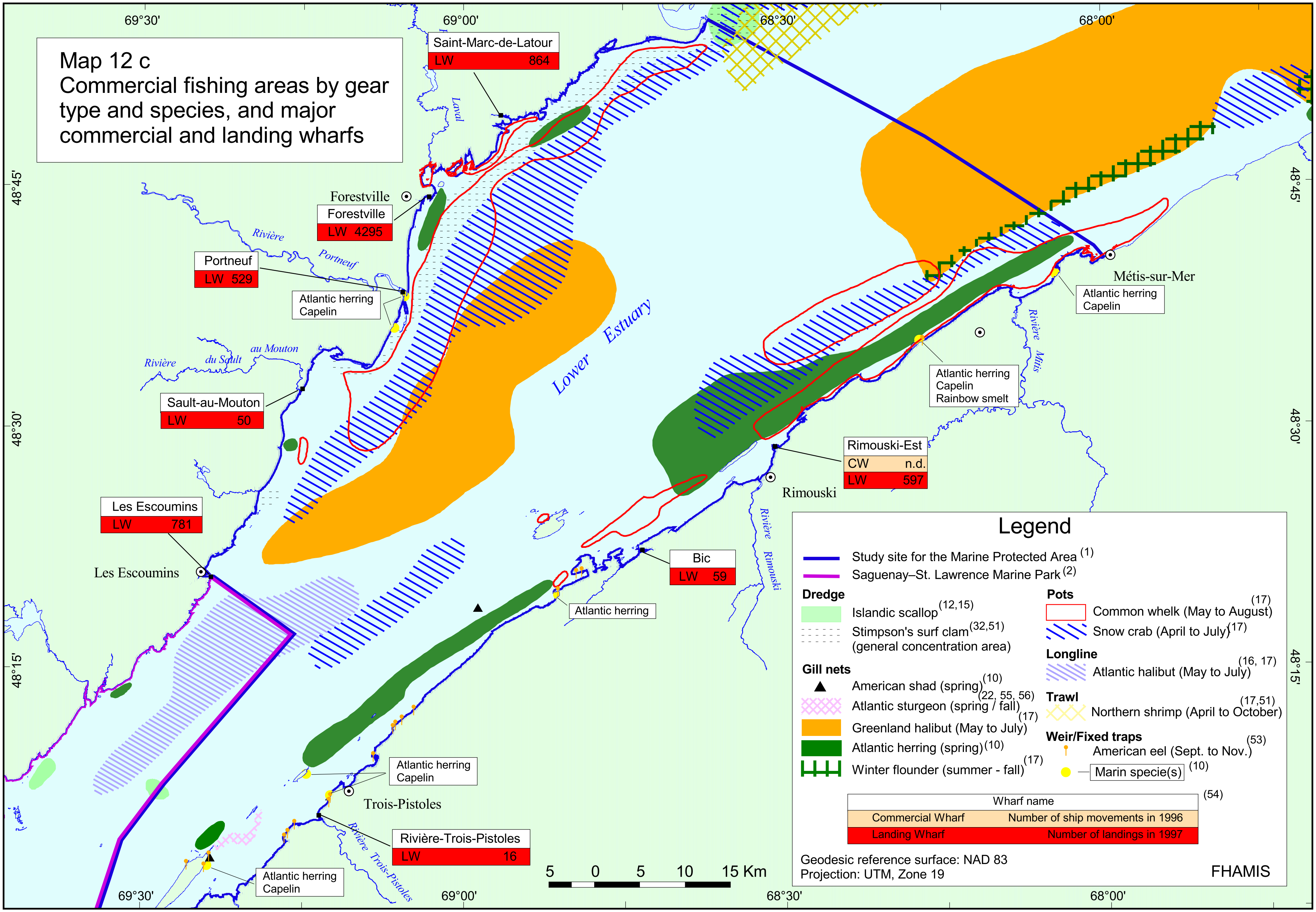
Canada



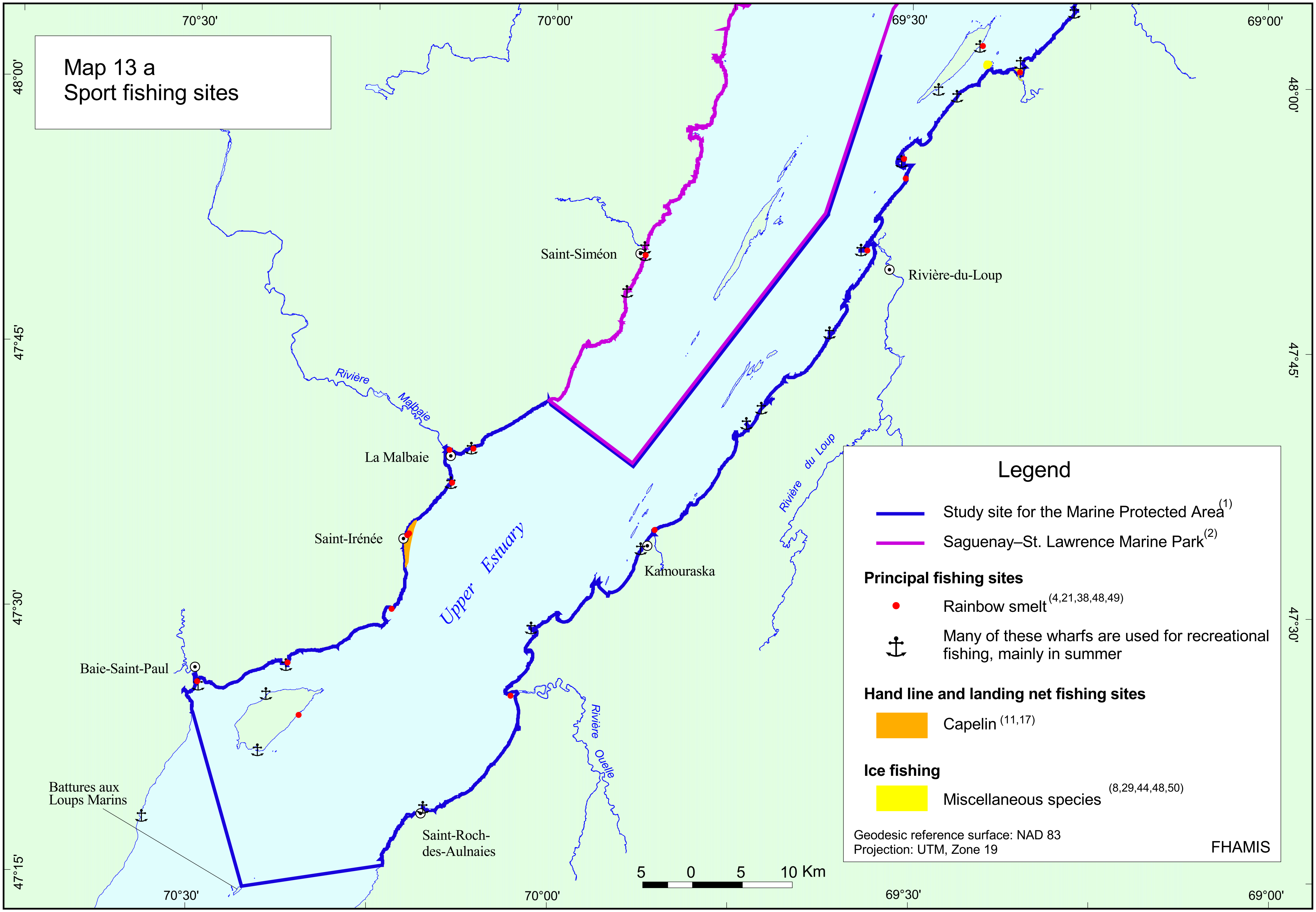
Map 12 b
Commercial fishing areas by gear type and species, and major commercial and landing wharfs

Pêches et Océans Canada Fisheries and Oceans Canada

Canada

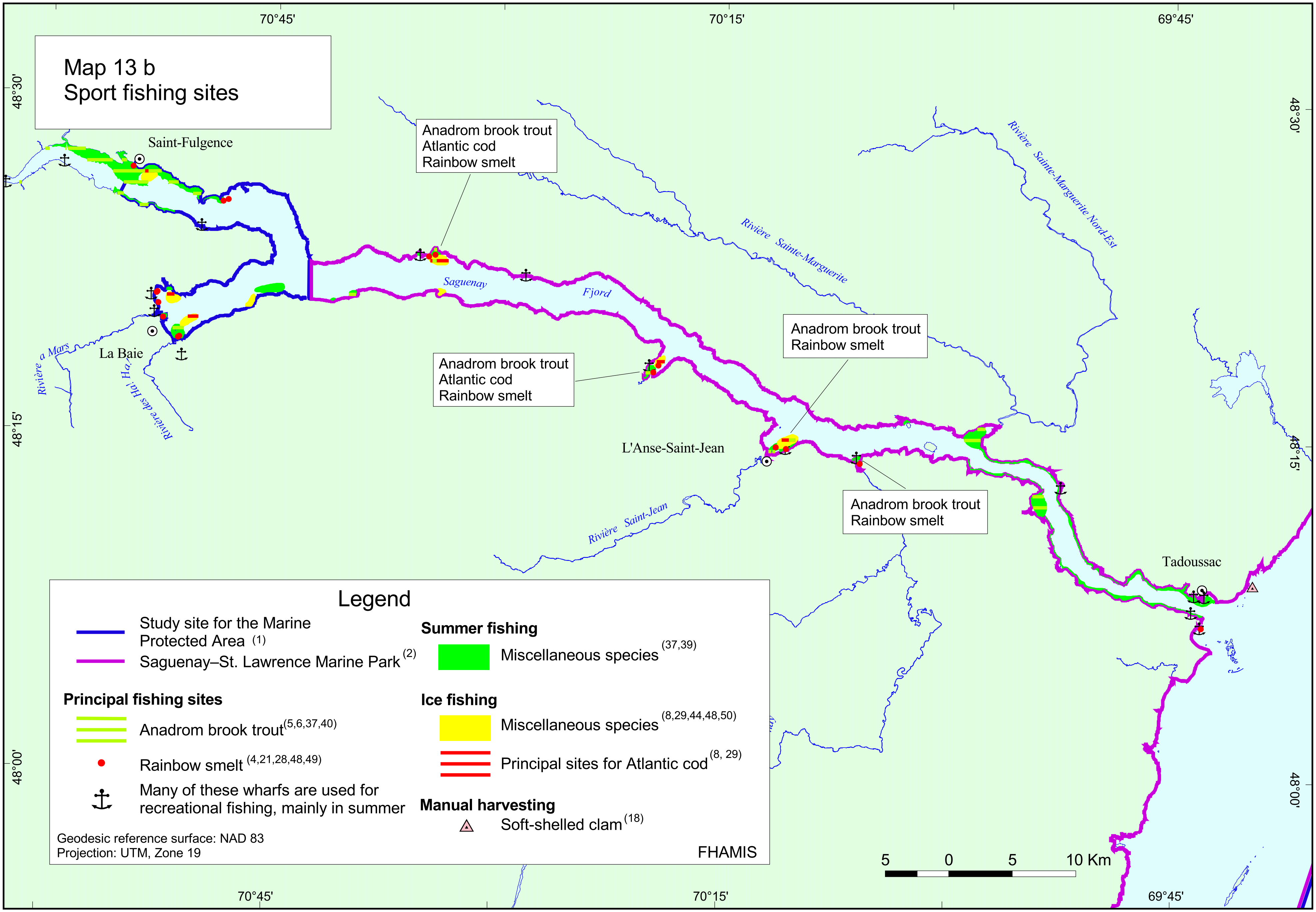


Map 12 c
Commercial fishing areas by gear type and species, and major commercial and landing wharfs
69°30'
69°00'
68°30'
68°00'
48°45'
48°30'
48°15'
Saint-Marc-de-Latour
LW 864
Forestville
Forestville
LW 4295
Portneuf
LW 529
Atlantic herring
Capelin
Sault-au-Mouton
LW 50
Les Escoumins
LW 781
Les Escoumins
Rivière Portneuf
Rivière du Sault au Mouton
Laval
Lower Estuary
Métis-sur-Mer
Atlantic herring
Capelin
Rivière Mitis
Atlantic herring
Capelin
Rainbow smelt
Rimouski-Est
CW n.d.
LW 597
Rimouski
Rivière Rimouski
Bic
LW 59
Atlantic herring
Atlantic herring
Capelin
Trois-Pistoles
Rivière-Trois-Pistoles
LW 16
Rivière Trois-Pistoles
Atlantic herring
Capelin
5 0 5 10 15 Km
Legend
Study site for the Marine Protected Area (1)
Saguenay–St. Lawrence Marine Park (2)
Dredge
Islandic scallop (12,15)
Stimpson's surf clam (32,51) (general concentration area)
Gill nets
American shad (spring) (10)
Atlantic sturgeon (spring / fall) (22, 55, 56)
Greenland halibut (May to July) (17)
Atlantic herring (spring) (10)
Winter flounder (summer - fall) (17)
Pots
Common whelk (May to August) (17)
Snow crab (April to July) (17)
Longline
Atlantic halibut (May to July) (16, 17)
Trawl
Northern shrimp (April to October) (17,51)
Weir/Fixed traps
American eel (Sept. to Nov.) (53)
Marin specie(s) (10)
Wharf name (54)
Commercial Wharf Number of ship movements in 1996
Landing Wharf Number of landings in 1997
Geodesic reference surface: NAD 83
Projection: UTM, Zone 19
FHAMIS



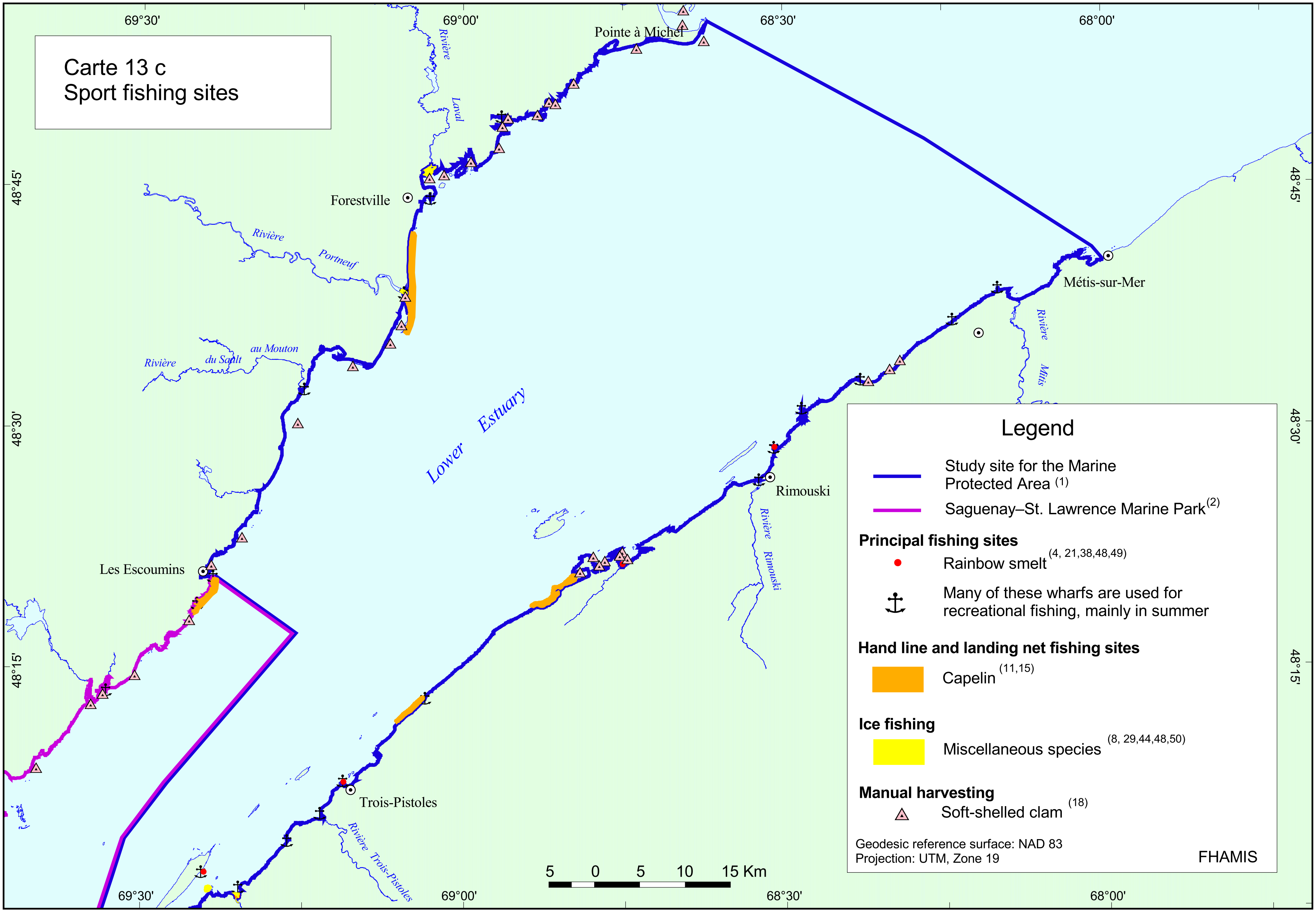
Pêches et Océans Canada Fisheries and Oceans Canada

Canada

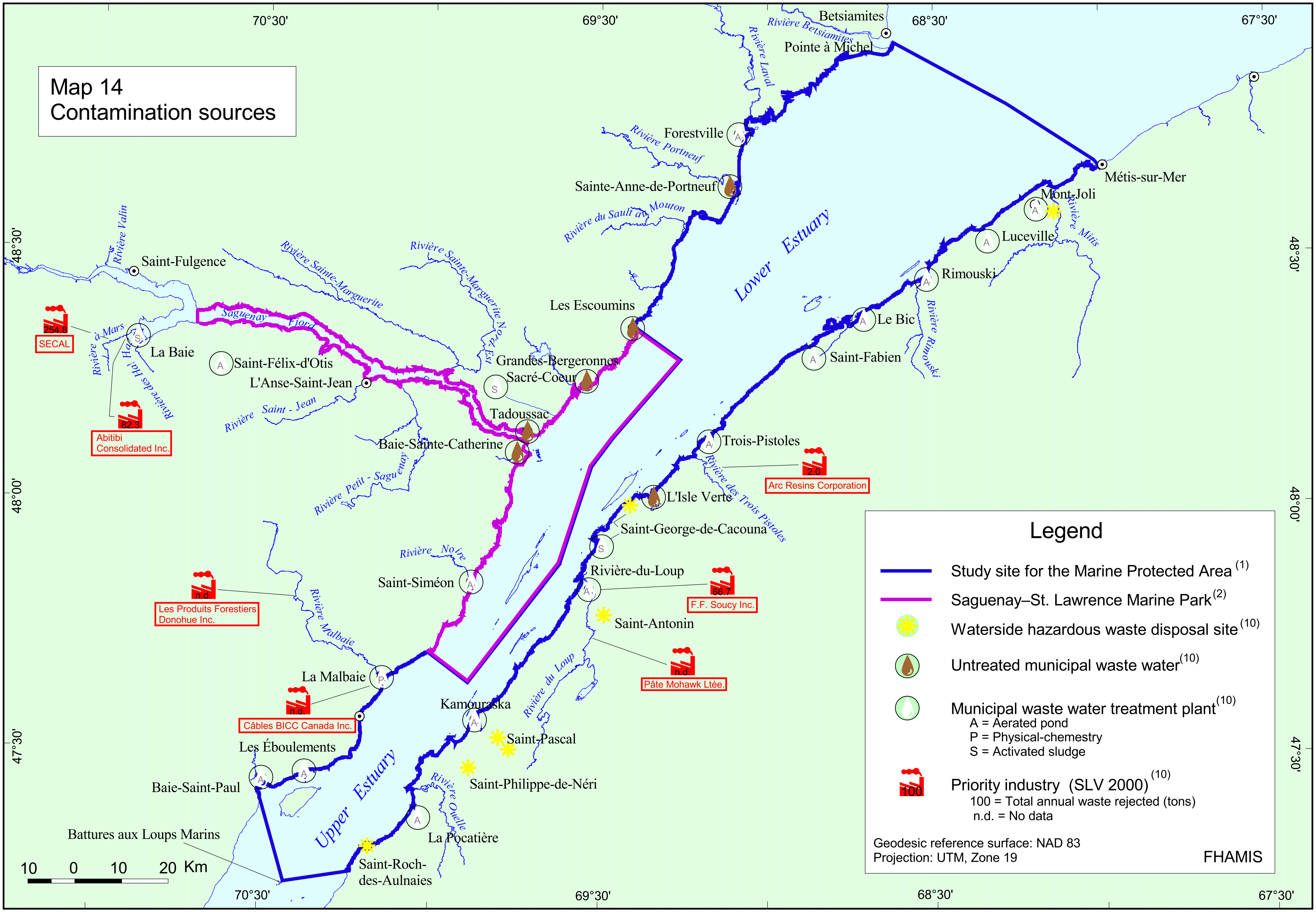


Pêches et Océans Canada Fisheries and Oceans Canada

Canada



Carte 13 c
Sport fishing sites
69°30'
69°00'
68°30'
68°00'
48°45'
48°30'
48°15'
Pointe à Michel
Forestville
Rivière Laval
Rivière Portneuf
Rivière du Sault au Mouton
Lower Estuary
Les Escoumins
Métis-sur-Mer
Rivière Mitis
Rimouski
Rivière Rimouski
Trois-Pistoles
Rivière Trois-Pistoles
5 0 5 10 15 Km
Legend
Study site for the Marine Protected Area (1)
Saguenay–St. Lawrence Marine Park (2)
Principal fishing sites
Rainbow smelt (4, 21,38,48,49)
Many of these wharfs are used for recreational fishing, mainly in summer
Hand line and landing net fishing sites
Capelin (11,15)
Ice fishing
Miscellaneous species (8, 29,44,48,50)
Manual harvesting
Soft-shelled clam (18)
Geodesic reference surface: NAD 83
Projection: UTM, Zone 19
FHAMIS


Map 14
Contamination sources
Legend
Study site for the Marine Protected Area (1)
Saguenay–St. Lawrence Marine Park (2)
Waterside hazardous waste disposal site (10)
Untreated municipal waste water (10)
Municipal waste water treatment plant (10)
A = Aerated pond
P = Physical-chemestry
S = Activated sludge
Priority industry (SLV 2000) (10)
100 = Total annual waste rejected (tons)
n.d. = No data
Geodesic reference surface: NAD 83
Projection: UTM, Zone 19
FHAMIS
Lower Estuary
Upper Estuary
Betsiamites
Pointe à Michel
Forestville
Sainte-Anne-de-Portneuf
Métis-sur-Mer
Mont-Joli
Luceville
Rimouski
Le Bic
Saint-Fabien
Les Escoumins
Grandes-Bergeronnes
Sacré-Coeur
Tadoussac
Baie-Sainte-Catherine
Saint-Fulgence
La Baie
Saint-Félix-d'Otis
L'Anse-Saint-Jean
Trois-Pistoles
L'Isle Verte
Saint-George-de-Cacouna
Rivière-du-Loup
Saint-Antonin
Saint-Siméon
La Malbaie
Kamouraska
Saint-Pascal
Saint-Philippe-de-Néri
La Pocatière
Saint-Roch-des-Aulnaies
Les Éboulements
Baie-Saint-Paul
Battures aux Loups Marins
SECAL 254.8
Abitibi Consolidated Inc. 82.3
Arc Resins Corporation 2.0
F.F. Soucy Inc. 66.7
Pâte Mohawk Ltée. n.d.
Les Produits Forestiers Donohue Inc. n.d.
Câbles BICC Canada Inc. n.d.
Saguenay Fjord
Rivière Betsiamites
Rivière Laval
Rivière Portneuf
Rivière du Sault au Mouton
Rivière Valin
Rivière Sainte-Marguerite
Rivière Sainte-Marguerite Nord-Est
Rivière à Mars
Rivière des Ha! Ha!
Rivière Saint-Jean
Rivière Petit-Saguenay
Rivière Noire
Rivière Malbaie
Rivière du Loup
Rivière Ouelle
Rivière des Trois Pistoles
Rivière Rimouski
Rivière Mitis
70°30'
69°30'
68°30'
67°30'
48°30'
48°00'
47°30'
10 0 10 20 Km

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