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Information relevant to the documentation of habitat use by St. Lawrence beluga (*Delphinapterus leucas*), and quantification of habitat quality

Information pertinente à la documentation de l'utilisation de l'habitat par le béluga du St-Laurent (*Delphinapterus leucas*) et à la quantification de la qualité de l'habitat

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ABSTRACT

The current population size and distribution range of St. Lawrence beluga are a fraction of those used historically. Their core distribution is centered on the Saguenay River, and is now located between the Battures-aux-Loups-Marins and Rivière-Portneuf / Rimouski in the Estuary, and Baie Ste-Marguerite in the Saguenay River. Concentration areas outside of this sector vary seasonally, as they did in the 1930s, but are now constrained within a zone located between Battures-aux-Loups-Marins and Sept-Îles / Cloridorme (vs west of Quebec City to Natashquan in the 1930s), with only rare observations in the Baie des Chaleurs. St. Lawrence beluga distribution range is small compared to other beluga populations, and even smaller during summer.

The timing and extent of seasonal movements of beluga are likely dictated by at least three key drivers: sea ice, predation risks, and food availability. However, little is known about beluga distribution outside of summer. Currently available knowledge indicates that sex- and age-sêcific spatial segregation is typical of the species during summer. The Upper Estuary, where females accompanied by calves and juveniles concentrate, is likely an important habitat for calving and juvenile rearing. Reasons for sexual segregation and habitat characteristics that are critical to the survival of females, juveniles and calves in this sector are unclear. The species also consistently aggregates at certain river mouths during summer, which suggest that they are an essential part of beluga habitat. The functions of these areas are unknown. Several smaller areas where beluga occur on a regular basis or where they spend relatively large proportions of their time exist within their seasonal distribution area, some of which have been identified for the summer period. However the current understanding of the functions and key features of these habitats and of habitat use and movements among these areas by beluga does not allow the assessment of their relative importance for the survival of the population. Given that current distribution is small relative to that used historically, a degradation of key habitat features or a reduction in key habitat availability would probably result in negative effects on recovery. In this context, preserving access to and integrity of areas used currently or historically by a large proportion of the population is considered important for the recovery and future range expansion of the population. Species characteristics such as longevity, social organization and learned behaviours may influence seasonal habitat use, and might delay re-colonization of areas used historically.

RÉSUMÉ

La taille de la population et l'aire de répartition actuelle du béluga du St Laurent ne représentent qu'une fraction de celles établies historiquement. Le cœur de leur aire de répartition est centré sur la rivière Saguenay, et est désormais compris entre Battures-aux-Loups-Marins et Rivière-Portneuf / Rimouski dans l'estuaire, et Baie Ste-Marguerite dans la rivière Saguenay. Les aires de concentration hors de cette zone varient saisonnièrement, tout comme durant les années 1930, mais sont désormais restreintes à une zone comprise entre les Battures-aux-Loups-Marins et Sept-îles / Cloridorme (alors qu'elle s'étendait de l'ouest de Québec à Natashquan durant les années 1930), avec que de rares observations dans la Baie des Chaleurs. L'étendue de l'aire de répartition du béluga du Saint-Laurent est faible si on la compare aux autres populations de béluga, et elle l'est encore plus en été.

Le calendrier et l'étendue des mouvements saisonniers des bélugas sont vraisemblablement dictés par au moins trois éléments clés : la glace, le risque de prédation, et la disponibilité de nourriture. Cependant, on ne sait pas grand-chose de la répartition des bélugas en dehors de la saison estivale. Les connaissances actuelles suggèrent une ségrégation spatiale basée sur le sexe et la classe d'âge des individus qui semble typique chez cette espèce durant l'été. L'estuaire moyen, où les femelles accompagnées de veaux et de juvéniles se concentrent, est probablement un habitat important pour le soin des jeunes et la mise bas. Les raisons de cette ségrégation sexuelle et les caractéristiques de l'habitat qui sont essentielles à la survie des femelles, des veaux et des juvéniles dans ce secteur ne sont pas clairement définies. De plus, les individus de cette espèce tendent à se regrouper dans l'embouchure de certaines rivières en été, ce qui suggère qu'elles constituent une part essentielle de l'habitat du béluga. Les fonctions de ces aires demeurent cependant incertaines. Au sein de leur aire de répartition saisonnière, il existe plusieurs aires plus petites où les bélugas sont présents sur une base régulière ou dans lesquelles ils passent une proportion relativement importante de leur temps. Plusieurs d'entre elles ont été identifiées pour la période estivale. Cependant, la compréhension actuelle des fonctions et des éléments clés de ces habitats, de leur utilisation ou des mouvements des bélugas des uns aux autres, ne permet pas d'estimer leur importance relative pour la survie de la population. Considérant la faible étendue de la répartition actuelle par rapport aux valeurs historiques, il est fort probable qu'une dégradation des caractéristiques clés des habitats ou une réduction de la disponibilité des habitats clés aurait des effets négatifs sur cette population, et particulièrement si celle-ci devait s'accroître. Dans ce contexte, la conservation des caractéristiques clés et de l'accès aux aires utilisées à présent ou dans le passé par une grande proportion de cette population est présumée importante pour le rétablissement de la population et son expansion future. Cependant, certaines caractéristiques de l'espèce reliées à la longévité, l'organisation sociale et les comportements acquis influencent probablement l'utilisation saisonnière des habitats, et pourraient freiner la recolonisation des aires historiques.

INTRODUCTION

St. Lawrence Estuary beluga, *Delphinapterus leucas*, are the most southerly beluga populations. Modelling exercises using harvest data, recent abundance estimates, population and life history parameters indicate that roughly 10,000 beluga were present in the St. Lawrence in 1866 (Hammill et al. 2007). The population was severely reduced over the past century as a result of commercial harvesting and non-commercial hunting associated with beliefs that beluga constituted a nuisance to fish stocks (Vladykov 1938). Only 350 belugas were thought to remain in the population in the late 1970s (Pippard and Malcolm 1978).

St. Lawrence beluga were legally protected against hunting in 1979 (Government of Canada 1980) and were listed as “Endangered” in 1983 by the Committee on the Status of Endangered Wildlife in Canada (Pippard 1985a). This status was reaffirmed in 1998 (Lesage and Kingsley 1998), and was changed to “Threatened” in 2004 following a modification of the COSEWIC classification criteria, and availability of new data suggesting a population nearly double of what was previously estimated (COSEWIC 2004). Systematic photographic aerial surveys using a consistent design and methodology, and conducted every 3–5 years since 1988, indicate that the population appears to be currently stable at about 1,100 individuals (Hammill et al. 2007). A lack of recovery of this population might be related to high levels of persistent contaminants in beluga and their environment, competition for prey with commercial fisheries (e.g., turbot) or other species, loss or degradation of habitat through chemical discharge, noise, hydro-electric development or climate change, disturbance by vessel traffic including whale watching activities, or periodic losses from epizootic outbreaks (DFO 2005; Hammill et al. 2007).

The St. Lawrence beluga population is considered isolated both geographically and genetically from other populations (Pippard 1985a; Sergeant and Hoek 1988; Patenaude et al. 1994; Lesage and Kingsley 1998). While some exchange with northern beluga population may have occurred during the first part of the twentieth century (Vladykov 1944; Reeves and Mitchell 1984), immigration is now less likely to occur since neighbouring populations in Greenland and Hudson Bay and Ungava Bay are depleted (Smith and Hammill 1986; Hammill et al. 2009).

St. Lawrence beluga are currently listed under the Canada's Species at Risk Act (SARA). The Act requires preparation of a Recovery Strategy and identification, to the extent possible, of habitats that are critical to the survival and recovery of this population. The habitat may be an identified breeding site, nursery area or feeding ground. The Recovery Team seeks science advice on habitat use that may be considered critical to recovery.

This document reviews the information on habitat requirements, prey, and seasonal distribution of beluga, as well as habitat use and characteristics in the St. Lawrence. Most of the information concerning the St. Lawrence beluga population comes from the grey literature.

RESULTS & DISCUSSION

HABITAT REQUIREMENTS, ANNUAL CYCLE, AND FEEDING ECOLOGY

The species

Beluga inhabit cold waters throughout their distribution range. The species has a thick dermis and lacks a dorsal fin, characteristics which are thought to be adaptations to life in ice-covered waters. Beluga occur in habitats ranging from ice-free, sometimes estuarine environments to coastal or offshore ice-covered marine waters (Moore et al. 2000; Barber et al. 2001; Lydersen et al. 2002). They are observed regularly in areas covered at 70% by sea ice, and may venture where ice coverage exceeds 90% (Barber et al. 2001; Suydam et al. 2001). During summer, they sometimes gather in large concentrations in river estuaries only a few meters deep (Vladykov 1944; Sergeant 1973; Smith and Martin 1994; Moore et al. 2000) or in other warm habitats where water temperature can reach 15-17°C (St Aubin 1990; Smith et al. 1994; Boily 1995; Moore et al. 2000). In some regions of the Arctic, most of their time appears to be spent in these shallow waters. However, aerial surveys and satellite telemetry demonstrated that they can also occur offshore and in waters several hundreds of meters deep during summer (Boltunov and Belikov 2002; Innes et al. 2002; Kingsley et al. 2001; Martin and Smith 1992; Heide-Jørgensen et al. 1998; Richard et al. 2001a; 2001b; Lewis et al. 2009).

Beluga undertake seasonal migrations, but their extent varies among populations from several hundreds of kilometres in Eastern Hudson Bay and Beaufort Sea beluga (Martin and Smith 1999; Richard et al. 2001a, 2001b; Suydam et al. 2001, Lewis et al. 2009), to a few tens of kilometres in St. Lawrence beluga (reviewed in Lesage and Kingsley 1998). Other populations, such as Cumberland Sound or Cook Inlet beluga, show little migration and are considered year-round residents (Hobbs et al. 2005; Richard and Stewart 2008). Factors triggering the fall migration remain uncertain. However, in the spring, beluga from several populations progress towards their summering grounds by penetrating into leads and cracks that form in the ice edge as ice melts and the edge retreats (Stirling 1980; Smith et al. 1992; Smith and Martin 1994; Koski et al. 2002).

The timing and extent of seasonal movements are likely dictated by at least three key drivers: sea ice, predation risks, and food availability. Predation by killer whales and ice entrapment are important causes of beluga mortality in Arctic populations (Mitchell and Reeves 1981; Reeves and Mitchell 1988; Shelden et al. 2003). Habitat selection should therefore reflect the need to accumulate sufficient energy stores to reproduce and complete their annual cycle, while avoiding direct mortality through ice entrapment or predation. Food abundance and accessibility might be affected by ice conditions. Given the variability in these parameters and predation risks among regions, seasonal distribution and movement patterns are also expected to vary among beluga populations. The species also consistently aggregates in estuaries or river mouths during summer, sometimes in large numbers, which suggest that they are an essential part of beluga habitat (Caron and Smith 1990; Smith et al. 1994). The functions of these areas are unknown and likely vary among sites, but might include a thermal advantage for calves, feeding, moulting and predation avoidance (Kleinenberg et al. 1964; Tomilin 1967; Sergeant 1973; Fraker et al. 1979; Finley 1982; Sergeant and Brodie 1989; St. Aubin et al. 1990; Frost and Lowry 1990; Watts 1991; Boily 1995; Richard et al. 2001a; but see Doidge 1990).

Habitat requirements likely vary according to age, sex, size, and reproductive status as a result of different energy requirements and survival strategies (Michaud 2005; Loseto et al. 2006; 2008a). Beluga give birth during summer, and lactation lasts for approximately two years with

only milk being consumed by neonates during the first year (Brodie 1989). Beluga from other age- and sex-classes feed regularly during summer. However, the extent of summer vs winter feeding appears to vary between populations, with some Arctic populations showing more intense feeding during fall and winter (e.g., Koski et al. 2002) and others showing more intense feeding during spring or summer (Vladykov 1944; Huntington 2000; Hobbs et al. 2008). Beluga have an extremely diversified vocal repertoire, which is indicative of highly structured societies in birds and mammals (Smith 1977; Sjare and Smith 1986; Faucher 1988; O'Corry-Crowe 2008). However, the degree of social organization in beluga societies is unknown. A spatial segregation of adult males from adult females and younger individuals is typical in beluga during summer (Michaud 1993; 2005; Smith et al. 1994; Smith and Martin 1994; Heide-Jorgensen and Lockyer 2001; Loseto et al. 2006, 2008b). In general, smaller-sized beluga, including nursing females with young, tend to remain closer to shore or in shallower waters, whereas larger individuals remain in deeper or more offshore waters (Smith and Martin 1994; Richard et al. 1997; Vladykov 1944). Whether spatial segregation by sex and age-class is maintained outside of the summer season remains uncertain. Limited aerial survey data from the St. Lawrence Estuary suggest that this spatial segregation might not exist in the spring (Michaud and Chadenet 1990).

Beluga feed on a variety of fishes and invertebrates including benthic and pelagic species (Vladykov 1946; Kleinenberg et al. 1964; Seaman et al. 1982; Lowry et al. 1985; Heide-Jørgensen and Teilmann 1994). They are considered opportunist feeders, whose diet vary according to spatial and temporal availability of prey (Vladykov 1946; Sergeant 1973; Lowry et al. 1985). However because beluga segregate spatially during summer, they may have access to different prey depending on the sector they occupy, which might lead to an overestimation of prey diversity in the diet and their capacity to access alternate prey. Beluga can dive at depths in excess of 800 m and are limited by the local bathymetry in several regions of the Arctic where they dive to the bottom (Richard et al. 1997; 2001a; Martin et al. 1998; Heide-Jørgensen et al. 1998; Barber et al. 2001; Martin and Smith 1999; Kingsley et al. 2001).

Captivity studies demonstrated that juvenile beluga consume approximately 4.5% of their body mass per day to grow adequately, whereas approximately 1.2% is required in adult beluga (Kastelein et al. 1994). Requirements are probably higher in pregnant and nursing females.

St. Lawrence beluga

Beluga occur in the St. Lawrence River year-round where they undertake limited seasonal migrations within the Estuary and into the northwestern Gulf of St. Lawrence (Michaud et al. 1990; Vladykov 1944; Figure 1; see below). Oceanographic processes leading to high productivity and a generally cold environment, including seasonal ice cover, are favorable to the continued presence of this Arctic species at these low latitudes (El-Sabh and Silverberg 1990; Saucier et al. 2009). Deep, cold mineral-rich waters come to a sill at the confluence of the Saguenay River, and are forced to the surface, resulting in a tidal upwelling in the Lower Estuary and a zone of high productivity. The Lower Estuary is also characterized by several large freshwater sources (e.g., the Saguenay, aux Outardes, and Manicouagan rivers), some with shallow river mouths in the vicinity of which beluga aggregate or used to aggregate during summer (Vladykov 1944; Chadenet 1997). Upstream of the Saguenay River, there is a zone of warmer, shallower and more turbid waters, hereafter referred to as the Upper Estuary, which is also characterized by the presence of tributaries, some of which attract beluga (e.g., Rivière-Ouelle) (d'Anglejan and Smith 1973). During winter, ice conditions are generally more severe in the Upper than the Lower Estuary, and along the south shore than the north shore due to prevailing winds and the less saline waters of the Upper Estuary, which result in more solid ice. This might be the reason for the absence of beluga from the Upper Estuary at that time of the

year (Sears and Williamson 1982; Boivin and INESL 1990). Beluga and other marine mammals are observed in sectors of the Lower Estuary and northwestern Gulf of St. Lawrence that remain partially ice-free throughout winter (Sears and Williamson 1982; Boivin and INESL 1990; Sergeant 1991; Lesage et al. 2004). These sectors include the head of the Laurentian channel, an area near Cloridorme along the Gaspé Peninsula, and wind-driven leads along the north shore of the Estuary and the Gulf of St. Lawrence (Saucier et al. 2003). The entrance to the Gaspé Bay in the Gulf and the sector of Bic in the Estuary are two other areas where ice conditions remain lighter during winter (Lesage et al. 2004).

Killer whale predation might play a role in habitat selection for St. Lawrence beluga as killer whales were abundant and attacks on beluga were reported in the Estuary during the early 1900s (Vladykov 1944; Michaud 2005). The species is now rarely observed in the Estuary, and no attack on beluga has been documented recently. However, the threat of killer whale predation might still affect the seasonal distribution of this population.

Ice coverage is probably the main factor dictating beluga seasonal migrations, as it affects risks of ice entrapment and prey availability. Ice formation and other changes in physical oceanography, as well as varying ecological needs of prey during their annual cycles might regulate prey distribution, and their seasonal accessibility by beluga (Bailey et al. 1977; Smith and Nelson 1986; Stirling 1997; Swain et al. 1998). The occurrence of beluga (Sears and Williamson 1982; Boivin and INESL 1990) and of large numbers of harp seals, *Phoca groenlandica*, in the Lower Estuary during winter (Bailey et al. 1977; Anderson and Gagnon 1980; Sergeant 1991; Murie and Lavigne 1991) suggests that some prey such as capelin remain abundant in the region during winter (see Lesage et al. 2004). However, several species of fish (e.g., winter flounder, herring, etc.) move out of the Estuary or into deeper waters during winter (Anderson and Gagnon 1980; Côté and Powles 1978) and thus, might contribute to the general eastbound movement of beluga and other resident marine mammals, such as harbour seals, in autumn (Lesage et al. 2004). Ice cover might also concentrate food resources in areas of open water or at ice edges, and increase ease of access to prey (Smith and Nelson 1986; Stirling 1997; Swain et al. 1998). However, whether this phenomenon occurs or not in the Estuary or Gulf of St. Lawrence and its role in the distribution patterns of beluga are not known.

Condition indices of sampled beluga and hunter reports in the 1930's indicate that blubber thickness is thin early in the spring (April) in St. Lawrence beluga, increases rapidly in May-June, and is maintained during summer through to September (Vladykov 1944). These observations suggest that spring is a period of intense feeding for St. Lawrence beluga. The occurrence of food remains in 71% of the beluga sampled during summer in the 1930s indicates that, like in many other populations, feeding occurs regularly during summer in the St. Lawrence (Vladykov 1946; Kleinenberg et al. 1964; Seaman et al. 1982; Hazard 1988, Hobbs 2008). Although the limited data available suggest that fat reserves are minimal in early spring, there exists no information about the extent of feeding activity during winter. Feeding probably occurs throughout the year, but further research is needed to understand age-specific seasonal patterns of feeding and fattening in St. Lawrence beluga.

Like beluga elsewhere, St. Lawrence beluga have a varied diet dominated by fish, with approximately 50 prey species reported in stomachs of 165 individuals sampled in the late 1930s (Appendix A; see also Vladykov 1946). Food items most often found in stomachs were capelin (*Mallotus villosus*), sand lance (*Ammodytes sp.*), Atlantic or Greenland cod (*Gadus morhua* and *G. ogac*), polychaete worm (*Nereis sp.*), northern shortfin squid (*Illex illecebrosus*) and sculpins (*Myoxocephalus scorpius*). However, diet information is outdated as it comes from a study carried out 70 years ago, in which over 80% of the beluga were sampled during summer on the

Manicouagan Banks, a sector no longer used by the population (Laurin 1982; Reeves and Mitchell 1984). The relative abundance or availability of several species, such as American eel (*Anguilla rostrata*), Atlantic cod or shrimps, has changed over the last several decades (Castonguay et al. 1994; Savenkoff et al. 2007). Some of these species were part or were suspected to be part of beluga diet (Hickie et al. 2000), and their contribution to recent diet might have changed compared to the 1930's. However, recent diet information is lacking as the only carcasses available for sampling come from beluga found dead on beaches, usually as a result of illness, and most often with empty stomachs. The few non-empty stomachs available from stranded carcasses (n = 6 but only 2 were studied in detail) contained 7 species of prey, most of which had been identified previously by Vladykov (1946) (Béland et al. 1996). Samples currently remain too scarce to evaluate the relative contribution of various species to summer diet of beluga; data for the period from late autumn through spring are simply non-existent.

Studies using alternate methods such as stable isotope analyses to describe food web structures confirmed the relatively high trophic position of beluga in the Estuary and Gulf of St. Lawrence (Lesage et al. 2001). Adult female beluga occupy trophic positions lower than adult males, but similar to those occupied by harp seals. Male beluga, grey seals (*Halichoerus grypus*), juvenile harbour seals (*Phoca vitulina*) and female hooded seals (*Cystophora cristata*) occupy similar trophic positions, while adult harbour seals and male hooded seals occupy top positions in these food webs. The proportion of various diet-related fatty acids also differs between adult males and females, again, suggesting differences in diet among sexes (Nozères 2006). These patterns are expected given the sexual dimorphism in this species and spatial segregation of adult males and females during summer (Michaud 1993; see below), which expose the two sexes to different organisms and habitats.

SEASONAL DISTRIBUTION OF ST. LAWRENCE BELUGA

Historical

The earliest description of St. Lawrence beluga annual distribution and habitat use relied on knowledge of mariners, catch data and visits to communities in the Estuary and northern Gulf of St. Lawrence in the 1930s (Vladykov 1944). At that time, beluga distribution was centered on the Saguenay River, in a sector located between Ile-aux-Coudres and Pointe-des-Monts on the north shore, and Rivière-Ouelle and Cap-Chat on the south shore (Figure 1). Concentrations of adults and of females with calves were observed in various locations of the Upper and Lower Estuary from June to November. Large white (adult), and on rare occasions grey individuals, ventured seasonally outside of this zone. Large adults were seen in autumn in Rivière-Ouelle where they were harvested. They were also seen 48 km west of Quebec City in the St. Lawrence River and up to Chicoutimi in the Saguenay River, possibly as a response to the fall migration of American eel to sea (Vladykov 1944). Beluga, possibly seeking herring and capelin, were also observed in the Gulf of St. Lawrence, east to the Mingan Islands (Magpie River) and Natashquan during early summer, and to Baie des Chaleurs in the spring. A general movement east during the fall, and west during the spring was documented in the 1930s. However, beluga occurred during winter (December to March) off the Saguenay River and Les Escoumins, as well as off Godbout where ice coverage remains partial (Saucier et al. 2003). The proportion of beluga occupying these sectors in winter remained uncertain (Vladykov 1944).

Current

Over the last 40 years, numerous studies attempted to estimate the abundance and distribution of St. Lawrence beluga using a variety of methods, including systematic and

non-systematic designs, and various survey platforms (i.e., boats, helicopters, airplanes). Due to logistical constraints, all except three studies (Sears and Williamson 1982; Boivin and INESL 1990; Michaud et Chadenet 1990) were conducted during summer (Sears and Williamson 1982; Pippard and Malcolm 1978; Pippard 1985a; Sergeant and Hoek 1988; Béland et al. 1987; Boivin and INESL 1990; Kingsley and Hammill 1991; Michaud et al. 1993; Kingsley 1993, 1996, 1998, 1999, Gosselin et al. 2001; Gosselin et al. 2007). While the objective of most studies was to cover a large portion of the beluga distribution range, only a few of them covered it entirely and were designed specifically to detect limits of its extent. Since 1988, systematic strip transect photographic aerial surveys have been used as a standard method to estimate beluga abundance in the Estuary (Hammill and Kingsley 1991; Kingsley 1993; 1996; 1999; Gosselin et al. 2001; 2007). These surveys were conducted at the same period each year, i.e., late August – early September, and thus offer consistent snapshots of the summer distribution of beluga.

The various studies confirmed a distribution centered on the Saguenay River. However, they also revealed a contraction of the distribution range of the population as a whole, and of the distribution of females with calves (Figure 1). Indeed, the core area of distribution is reduced by about 180 km to the east compared with the 1930s, and is now located between Battures-aux-Loups-Marins and Rivière Portneuf / Rimouski in the Estuary, and Baie Ste-Marguerite in the Saguenay River. Concentration areas outside of this sector vary seasonally, as in the 1930s, but are only rarely reported west of Battures-aux-Loups-Marins or east of Sept-Îles (north shore) or Cloridorme (south shore), although beluga are observed occasionally in Baie des Chaleurs, and up to St-Fulgence in the Saguenay River (Figure 2). As part of these changes, the Bancs de la Manicouagan, which constituted the main beluga harvesting location in the Estuary prior to the 1960's, are no longer used by beluga (Vladykov 1944; Pippard and Malcolm 1978; Reeves and Mitchell 1984; Pippard 1985b). These banks are located 60 km downstream of the current distribution area along the north shore, and were occupied by all segments of the population, including females with calves. This is an observation contrasting with the current distribution patterns, as females with calves accompanied by grey individuals are now only rarely found along the north shore of the Lower Estuary during summer (Michaud 1993; see below).

Reasons for the contraction in beluga distribution range and their disappearance from the Manicouagan Banks are unclear, but likely involve to some extent the reduction in population size as a result of overexploitation. It was proposed that the disappearance of beluga from the Bancs de la Manicouagan resulted from the extermination of a sub-population of beluga strongly affiliated to this sector (Laurin 1982). However, other factors such as habitat modification might have acted in combination with overexploitation (Michaud et al. 1990; Laurin 1982; Sergeant and Brodie 1975; Pippard and Malcom 1978).

Recent summer observations, particularly to the east of the regular distribution area, suggest an expansion of beluga present distribution range (Figure 2). Michaud et al. (1993), then Kingsley (1996) documented an extension of the summer distribution to Rivière-Portneuf, 30 km downstream of Les Escoumins. Kingsley and Reeves (1998) in their aerial survey of the Gulf of St. Lawrence observed 6 belugas near Sept-Îles in late July, an area of concentration reported by Vladykov (1944). Most recently, Lawson and Gosselin (2009) in their aerial survey of the entire Estuary and Gulf of St. Lawrence, also observed a small herd of beluga near Sept-Îles during the same period, and documented the occurrence of several groups of beluga for a total of 27 individuals in the portion of the Estuary comprised between Rimouski and Pointe-des-Monts, i.e., east of the regularly surveyed, and presumed summer distribution area. Vladykov (1944) documented the summer occurrence of beluga in this sector during the 1930s. However, survey effort in summer between Rivière-Portneuf and Pointe-des-Monts has been nearly non-existent, and needs to be increased to confirm and monitor a possible range expansion.

Recent information about beluga distribution for seasons other than summer comes from a series of visual aerial surveys conducted in 1989 and 1990 (Boivin and INESL 1990; Michaud et al. 1990; Michaud and Chadenet 1990). Two surveys conducted in mid-October and November 1989 and covering the entire Estuary indicate that beluga still occur at the Battures-aux-Loups-Marins and in the Saguenay River during the fall, but that by November, 75% of the beluga have moved to the Lower Estuary east to Baie-Comeau (north shore) and Rimouski (south shore) (Boivin and INESL 1990; Figure 2). These observations are consistent with those of Vladykov (1944), reporting movements east during the fall. However, Vladykov (1944) also documented a migration of large adults west of Île-aux-Coudres to Quebec City and upstream in the Saguenay River to Anse-Saint-Jean, presumably to seek migrating eels, an observation which cannot be confirmed with the information currently available. Additional data are needed to clarify the importance of the Saguenay River in the fall distribution, as well as the sex and age segregation patterns of beluga at that time of the year.

Beluga winter distribution (see Figure 2) is based on ten visual aerial surveys with variable coverage, which were conducted from December to March 1989 and 1990 (Boivin and INESL 1990). Half of the surveys followed a systematic transect design; the others were flown as patrol surveys. Four surveys covering the entire stretch of the St. Lawrence Estuary detected no beluga in the Upper Estuary (Boivin et INESL 1990; Michaud et al. 1990). As reported by Vladykov (1944), beluga were observed near the Saguenay River mouth / Les Escoumins area in three of six surveys conducted during winter, with most of the observations being made in the first and last surveys of the season (December 1989 and March 1990). The absence of beluga in the Upper Estuary and presence in the Lower Estuary during winter was confirmed by patrol surveys conducted in January and March 1982 (Sears and Williamson 1982). In March, most beluga were seen along the south shore of the Estuary between Île Verte and Les Méchins, and in the Gulf, between St-Anne-des-Monts and Cloridorme (Michaud et al. 1990). Of the 215 belugas observed during mid-winter surveys (end of January to beginning of March 1990), most (84%) were observed in the northern part of the Gulf of St. Lawrence, particularly around Sept-Îles (72%), with no beluga seen along the south shore. No beluga were observed in the Saguenay River in December and January, but one or two were seen there in February and March. Additional information is needed to identify areas of concentration and assess the proportion of the population using the Lower Estuary vs Gulf during winter.

Current understanding of beluga distribution during spring (Figure 2) mainly comes from anecdotal reports and two visual aerial surveys conducted over the Estuary in late April and early June 1990 (Michaud and Chadenet 1990). Aerial patrols in late March reported beluga both in the Upper Estuary west to Battures-aux-Loups-Marins, as well as between Rimouski and Cloridorme, suggesting a distribution possibly at its maximum extent in early spring. Repeated observations by ferry crew operating in various areas of the Upper Estuary, including the Saguenay River mouth, support the recurrent presence of beluga in this sector in early spring. During a late April survey and a May patrol, beluga were observed from Battures-aux-Loups-Marins to Les Escoumins along the north shore and to Saint-Simon along the south shore, with the largest proportion of beluga (>84%) being observed in the Upper Estuary (Michaud and Chadenet 1990). By late June that year, approximately 60% of the beluga occurred in the Lower Estuary (Michaud and Chadenet 1990; Michaud et al. 1993). The repeated observations of beluga in the Upper Estuary throughout the spring provide good evidence for the use of this region. However, whether the relative absence of beluga in the Lower Estuary observed in 1990 is typical of their spring distribution remains uncertain given the very limited data available.

In comparison, a study conducted during summer, and using systematic visual aerial surveys, with some off-transect effort, indicates that on average 44% of the beluga occupy the Lower Estuary in summer, with the largest numbers occurring in the Upper Estuary (Michaud et al. 1993; Table 1). Data from August photographic aerial surveys conducted between 1988 and 2000 support these conclusions, with more beluga occupying the Upper Estuary (45-75%) than the Lower Estuary (25-55%) (Kingsley and Hammill 1991; Kingsley 1993; 1996; 1998; 1999; Gosselin et al. 2001). On average, four to seven percent of the beluga were observed in the Saguenay River, including the river mouth, in these two sets of surveys (Michaud et al. 1993; Gosselin et al. 2007). However, occurrence varied widely among surveys conducted days apart. For instance, beluga were detected in the Saguenay River and mouth in half of the 6 surveys in 2003, and in 13 of 14 surveys in 2005, representing 2.6% or less of the beluga counted in 2003, but up to 15% of those counted in 2005 (Gosselin et al. 2007). A mean of 26 individuals (range 0–73) were visually detected in the Saguenay River during the 27 surveys conducted between 1988 and 2005, which represents 2.4% of the population assuming a population of 1,100 beluga (Hammill et al. 2007).

SEX- AND AGE-SPECIFIC HABITAT USE DURING SUMMER

Macro-scale

A sex- and age-specific spatial segregation has been documented during summer in several relatively recent studies of St. Lawrence beluga (Michaud 1993; 2005). However, recent data are too scarce to examine this question for seasons other than summer (Pippard and Malcolm 1978; Pippard 1985b; Sergeant 1986; Sergeant and Hoek 1988; Michaud 1993; Kingsley 1993, 1996). Vladykov (1944) hinted at a possible differential use of habitat between sex and age-classes at various times of the year when he pointed out that animals that ventured outside the limits of the core distribution area or that were captured in Rivière-Ouelle in autumn were mainly large adults. He also mentioned a tendency of females with calves to use near-shore areas, and of large white adults to remain offshore in the Lower Estuary.

The study best documenting sex- and age-specific habitat use was published in the early 1990s and was based on repeated systematic boat transect surveys conducted between July and September (Michaud 1993). Surveys covered increasingly large portions of the Estuary in 1986 and 1989 (i.e., Îles de Kamouraska –Saguenay River mouth in 1986, and Îles de Kamouraska – Les Escoumins in 1989), and the entire summer distribution range in 1992 (i.e., Battures-aux-Loups-marins – Sainte-Anne-de-Portneuf). This study divided the summer distribution area into three sectors based on herd composition: 1) the shallow waters of the Upper Estuary, where salinity is low and where turbidity and temperature are high compared to the Lower Estuary, were used mainly (70% of herds) by adults accompanied by juveniles and calves; 2) the colder, more saline, less turbid, and much deeper waters of the Laurentian channel in the Lower Estuary were used to a large extent (> 70% of herds) by white adults; and 3) an intermediate sector including the Saguenay River, head of the Laurentian channel, and southern portion of the Lower Estuary east to near St-Fabien was used by mixed herds, comprised of white adults, of adults with juveniles and calves, or both (Figure 3). Herd size varied from one or a few individuals to several hundreds of beluga, depending on sectors and period, but averaged 9-25 beluga in the Upper Estuary, 60-65 individuals in the Lower Estuary, and 18 beluga in the Saguenay River (Pippard and Malcolm 1978; Michaud 1993; Table 1). The larger herds (i.e., > 30 individuals) were mostly found in the Lower Estuary, although some large groups were sometimes observed in the Saguenay River, including Baie-Ste-Marguerite (Laurin 1982; Michaud 1992, 1993; Chadenet 1997). Boat surveys in 1992 indicated that more than 40% of the

beluga observed in the Upper Estuary were grey animals (juveniles), and that this sector was where 66% of all grey animals were detected in the surveys (Michaud 1993)

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The use of the shallower waters of the Upper Estuary by St. Lawrence females with calves and juveniles, and of deeper waters by adult males, at least during summer, is consistent with observations from other locations (Smith et al. 1994; Smith and Martin 1994; Heide-Jorgensen and Lockyer 2001; Loseto et al. 2006, 2008a). A spatial segregation between females with juveniles and adult males is also in agreement with patterns in other odontocetes presenting a sexual dimorphism, although reasons for this segregation remain unclear (Michaud 2005). Shallow waters might ensure access to adequate food resources for the smaller individuals with more limited diving capacity. Using shallower waters might also lessen the detectability of beluga by predators (killer whales) and might reduce the time when calves are left unattended by foraging females. Other hypotheses for this spatial segregation involve differential energy requirements. Prey assemblages available in the Upper vs Lower Estuary are likely different considering the differences in salinity, water temperature and bathymetry between these two areas. Whether prey assemblages of the Upper Estuary where females with calves and juveniles are found are more profitable energetically remains uncertain. Nonetheless, the widespread existence of this spatial segregation by age- and sex-classes in beluga and several odontocetes (and other mammals; see Michaud 2005) suggest that an access to these areas for each of the classes is essential, at least during summer, for the survival and recovery of this population.

Micro-scale

Within the three general sectors described above, beluga tend to aggregate or spend more time in specific areas and less time in others. There exist several accounts of these preferences during summer in St. Lawrence beluga (Pippard and Malcolm 1978; Laurin 1982; Pippard 1985b; Michaud 1987; 1988; Sergeant 1986; Ketos 1989; Michaud 1992, 1993; Lemieux Lefebvre 2009). However, only three studies were conducted with the specific intent of identifying areas of high densities or of regular or intensive use (Pippard and Malcolm 1978; Michaud et al. 1993 (but see also Michaud 1990); Lemieux Lefebvre 2009). These studies, which are described below, differed greatly in methodology, spatial coverage and resolution.

Pippard and Malcolm (1978) conducted shore-based observations and non-systematic boat and aerial surveys in 1975 and 1977, and covered only the central portion of the summer range of beluga, where sighting probability was high. Areas of concentration were those used regularly by beluga, although what was meant by 'regular use' was not clearly defined (Figure 4). Functions associated with areas were based either on beluga surface observations or were inferred from general environmental characteristics. For instance, several areas were identified for calving based on water temperature characteristics alone. Results about functions of areas defined by Pippard and Malcolm (1978) should therefore be interpreted with caution. In his study, Michaud (1993) conducted systematic aerial and boat surveys between 1987 and 1992, which covered generally a large portion or the entire summer distribution of beluga. The extent of their summer distribution and identification of “areas of intensive use” were determined from aerial survey data, whereas descriptions of herd composition per area and larger sectors were based on boat surveys. “Areas of intensive use” were defined using several parameters averaged over surveys: mean number of individuals in the area, proportion of the total number of individual counted and recurrence of observation (i.e., proportion of surveys where belugas were observed in an area) (Figure 3). Finally, Lemieux Lefebvre (2009) used an approach where net displacement speeds of 44 beluga radio-tracked individually in 2001—2005 were used in combination with visual tracking of 1950 herds from 1989—2008 to identify “areas of high residency”, i.e., areas where transit times were slow (Figure 5).

Pippard and Malcolm (1978), Michaud (1993) and Lemieux Lefebvre (2009) defined respectively 9, 18 and 26 areas of “concentration”, “intensive use” or “high residency”. Several of these areas were common between studies (Figure 6). These included Baie Ste-Marguerite in the Saguenay River, the Saguenay River mouth, Head of the Laurentian Channel and Channel itself, Île Blanche, Île-aux-Lièvres, Batture-aux-Alouettes, Îles de Kamouraska, Îles aux Fraises, and an area located off Rivière-du-Loup / Cacouna. The study by Michaud (1993) also identified some areas of intensive use further west in the Upper Estuary, near Île-aux-Coudres, where effort in the other two studies was inexistent or insufficient to assess habitat use.

Reasons for the occurrence of beluga in these areas remain largely unresolved, and are hypothetical or, at best, based on circumstantial evidence (Pippard and Malcolm 1978; Laurin 1982; Pippard 1985b; Michaud 1992, Lemieux Lefebvre 2009). Information available on environmental characteristics, herd characteristics, residency time, regularity of use during summer and biological functions thought to be associated with each sector are summarized in Table 1. The presence of beluga in some areas might be related to meso-scale oceanographic features and/or short-term dynamic processes such as tides. However, relationships between these characteristics and beluga habitat use have not been formally established, and thus are not treated in this document. A description of areas where detailed information exists is also provided in Appendix B.

The Saguenay River mouth and Baie Ste-Marguerite are probably the areas where the most information is currently available on beluga habitat use. On average, approximately 2% of the beluga population is observed on 50% of days during summer in this complex (river mouth, Saguenay River or Baie Ste-Marguerite). Baie Ste-Marguerite and the Saguenay River are used by all segments of the population. Social interactions have been documented on a regular basis in Baie Ste-Marguerite. Other possible biological functions proposed for this bay are feeding and calving. Though hard to detect, skin moulting might also be stimulated during residency. The Saguenay River mouth obviously serves as a travel corridor to and from Baie Ste-Marguerite, but was also proposed as a feeding area (Laurin 1982; Conversano 2008). Whether the occupancy of this bay or the Saguenay river mouth is the result of the same 2% of the population returning consistently to the same area, or of use by various groups in the population (and Saguenay River) remains uncertain.

The degree of connectivity among the various areas of 'intense' or 'regular' use identified above is not well understood, since little is known about beluga individual home ranges and site fidelity in the St. Lawrence Estuary. Individual beluga most probably use more than one area, as indicated by the relatively short residency times (hours) reported for various sites (Michaud 1992; Chadenet 1997; Lemieux Lefebvre 2009; Table 2) and movements recorded through radio-telemetry (Lemieux Lefebvre 2009). However, it remains unclear whether individual beluga use a large proportion of their summer distribution range, or if they are strongly affiliated to a smaller sector.

The division of the larger sectors into smaller areas of intensive use implies the presence of a more or less complex network of travel routes between smaller areas. Pippard (1985b) hinted at patterns of habitat use by individual beluga, although the data analysis leading to the composite map of individual movements is unclear. She concluded from tracking beluga herds that beluga can cross their summer range several times per day, and that they use specific routes when doing so (Figure 7). The capacity of beluga to travel over relatively large distances within limited time has also been demonstrated via radio-telemetry (Lemieux Lefebvre 2009: Figure 1). The southern part of the Saguenay River mouth and Baie Ste-Catherine are thought to

offer protection against the Saguenay's strong outflowing currents (Pippard 1985b). This sector is considered as being part of a travel route extending from Île-aux-Lièvres in the Upper Estuary to Baie-Ste-Marguerite in the Saguenay River. In the Saguenay River, beluga are thought to travel along the sides of the fjord in what appears to be the path of least resistance to the downstream currents (Pippard and Malcolm 1978).

Identification of travelling corridors is currently limited to those described above, but others could probably be identified on the basis of the study of Lemieux Lefebvre (2009). While high residency corresponded in this study to areas where herds net displacement speeds were low, travelling corridors could by extension be defined as areas where herds net displacement speeds were high (Lemieux Lefebvre 2009). Using grids of the distribution area summarizing herd net displacement speeds per sectors of 1 x 1 km, Lemieux Lefebvre (2009) proposed an area located to the north-west of Île Verte as an example of such a travelling corridor.

SUMMARY & CONCLUSIONS

Current population size and distributional range of St. Lawrence beluga is a fraction of that described historically. The disappearance of beluga from the Manicouagan Banks represents the most striking sign of a reduction in historical distribution. Range expansion might be slowed by features of beluga social organization, the importance of learned behaviours, and by the fact that beluga are long-lived.

St. Lawrence beluga undertake limited seasonal movements, which are likely dictated mainly by ice conditions and availability of prey. The limited information available on distribution for seasons other than summer indicate that they mostly inhabit waters located between Battures-aux-Loups-Marins and Rimouski-Forestville, including the Saguenay River up to Baie Ste-Marguerite, although a general eastbound movement towards the northwestern Gulf of St. Lawrence is observed during the fall. The northwestern Gulf of St. Lawrence appears to be used during winter and possibly spring by an unknown, but possibly large proportion of the population, and thus might contribute to important life processes of beluga by providing food supplies and by reducing risks of ice entrapment. Spring is the period when fattening appears the most intense in St. Lawrence beluga, but when little is known about their distribution. Feeding habits of the species elsewhere and the limited diet information from St. Lawrence beluga suggest that spawning fish or their eggs, or other prey at locations where they are abundant in the spring might contribute substantially to energy stores of beluga. The exact location and characteristics of spring feeding habitat are largely unknown, but likely involve capelin, herring or rainbow smelt among other species.

There is currently little understanding of habitat use by St. Lawrence beluga. Some information is available for summer when important life processes such as feeding, calving and nursing of neonates take place in St. Lawrence beluga, and when energetic requirements might be high, at least for pregnant and nursing females.

Spatial segregation by sex and age exists during summer in St. Lawrence beluga, with a preference of females accompanied by calves and juveniles for the Upper Estuary, which is characterized by shallower, warmer, and more turbid waters, and of males for Laurentian channel in the Lower Estuary, which is characterized by deep and colder waters. The exact features attracting different sex- and age-classes to specific areas in the St. Lawrence are unknown. Nonetheless, considering the consistency of occurrence of summer segregation in other beluga populations and other odontocetes, one might conclude that an access to these

areas for each of the classes is essential, at least during summer, for the survival and recovery of this population. The sector of the Upper Estuary is likely the primary sector for calving and juvenile rearing. This sector provides specific characteristics that can only rarely be found in other parts of their distribution range.

River mouths and estuaries appear to play a particular role in the annual cycle of beluga as aggregation of sometimes large numbers of beluga in these areas is typical of the species, and St. Lawrence beluga are no exception. These observations suggest that river mouths are an essential part of beluga habitat. Beluga might depend on them for various life processes (e.g., feeding, calving and nursing, skin moulting, predator avoidance), some of which such as skin moulting, might not occur as efficiently in other environments. The functions of these areas are unknown for St. Lawrence beluga. However, it is notewhorty that St. Lawrence beluga are already in an estuary, in which the southern channel of the Upper Estuary resembles the shallow, warmer areas often associated with beluga aggregations elsewhere. However, the occurrence of adult males, as well as females with calves and juveniles in Baie Ste-Marguerite and historically on the Manicouagan Banks makes it unlikely that these areas are used exclusively for calving or nursing.

Several smaller areas where beluga occur regularly or where they tend to spend more time have been identified within their summer distribution range. High recurrence of use, high densities or long residency times constitute significant clues as to the importance of areas for completion of life processes and survival or recovery of a population. Their relative proximity, the large extent of daily movements in other populations, and the small distribution range of St. Lawrence beluga during summer suggest that many areas might be visited sequentially by individual whales to fulfill their biological needs. However, further research is needed to understand daily and seasonal habitat use and movement patterns among smaller areas, in order to determine their relative importance and the consequences of a change in their characteristics or of a reduced access to some or all of these areas for the survival and recovery of the population.

The current population represents a fraction of the historical population size, and appears to be stable at around 1,100 individuals (Hammill et al. 2007). Whether this stagnation is related to habitat quality and availability remains unclear. Habitat loss or degradation does not always lead to mortalities. A population viability analysis has not been completed for this population, but calculations using a Potential Biological Removal (PBR) approach for an endangered classification show that removals as low as 3 animals per year are likely to have a negative effect on recovery (Hammill et al. 2007). These results indicate that the population is highly sensitive to human-induced mortalities.

The current core annual distribution of St. Lawrence beluga is approximately 5,000 km^2, which is at the lower limit of those described for the species. In summer, this figure is even lower, at approximately 2,800 km^2. Therefore, it is highly unlikely that degradation of key habitat features or a reduction in the availability of key habitat would result in positive or neutral effects on this population, and especially more so if this population is to increase. Current area of occupancy represents a fraction (65%) of historical distribution. In this context, preservation of key features of areas historically used by the population, such as the Manicouagan banks, might allow a range expansion of the population as it recovers. However, the presumed high site fidelity of this species, and the importance of learned behaviours might delay re-colonization of areas used historically.

There is a need to understand temporal use and movement patterns of individual beluga among habitats, and to establish the key features, biological functions and relative contribution of these habitats to beluga for completing their annual cycle. It is also necessary to describe seasonal beluga diet, so that areas providing prey can be identified. There is also a need to assess the relative contribution and importance of these habitats to beluga for completing their annual cycle. All of this information will be needed to assess the implications of changes in key habitat features or a reduction in availability of key habitats on the survival and recovery of St. Lawrence beluga.

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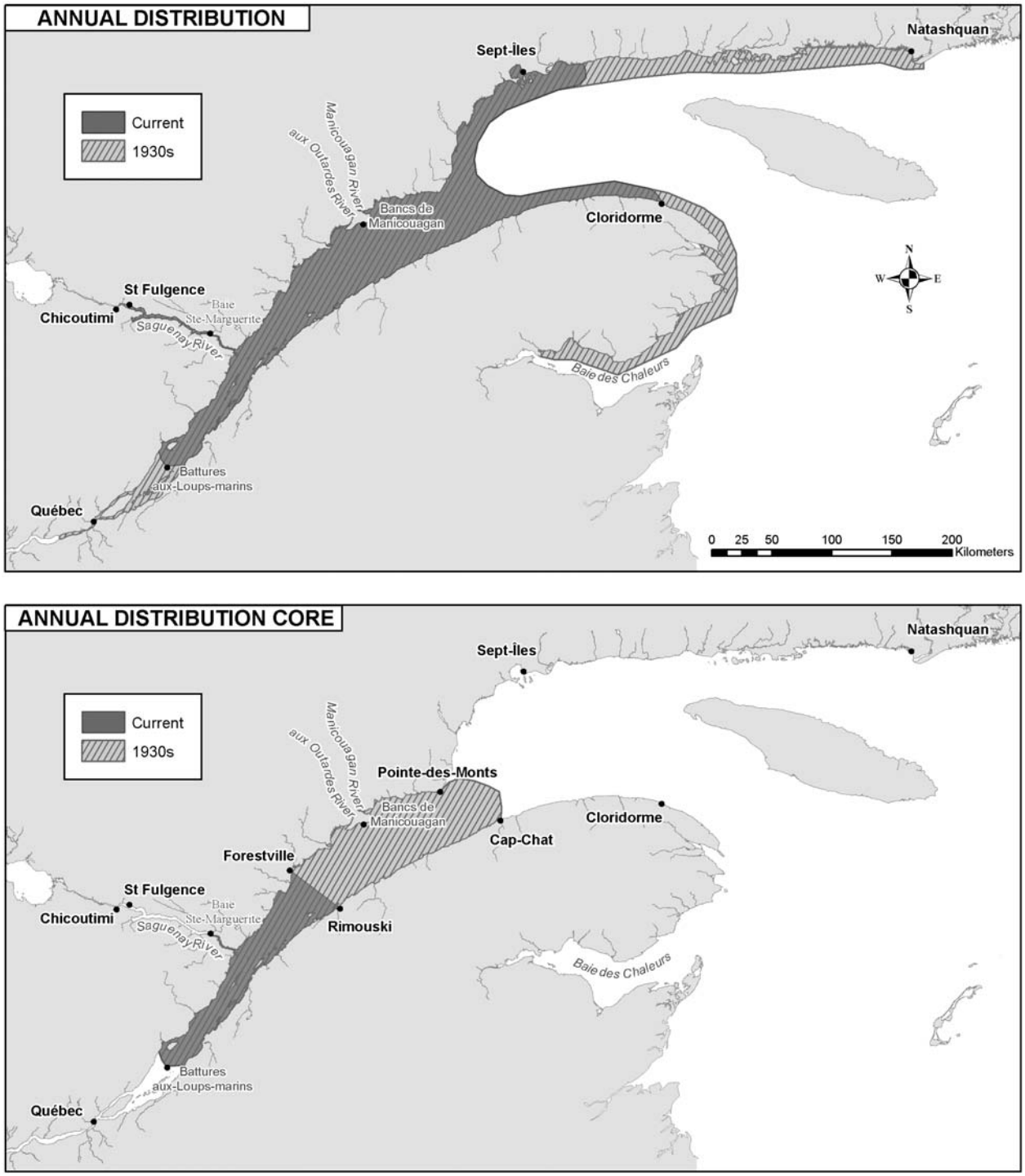

Figure 1. Historical and current annual and core distributions of St Lawrence beluga.

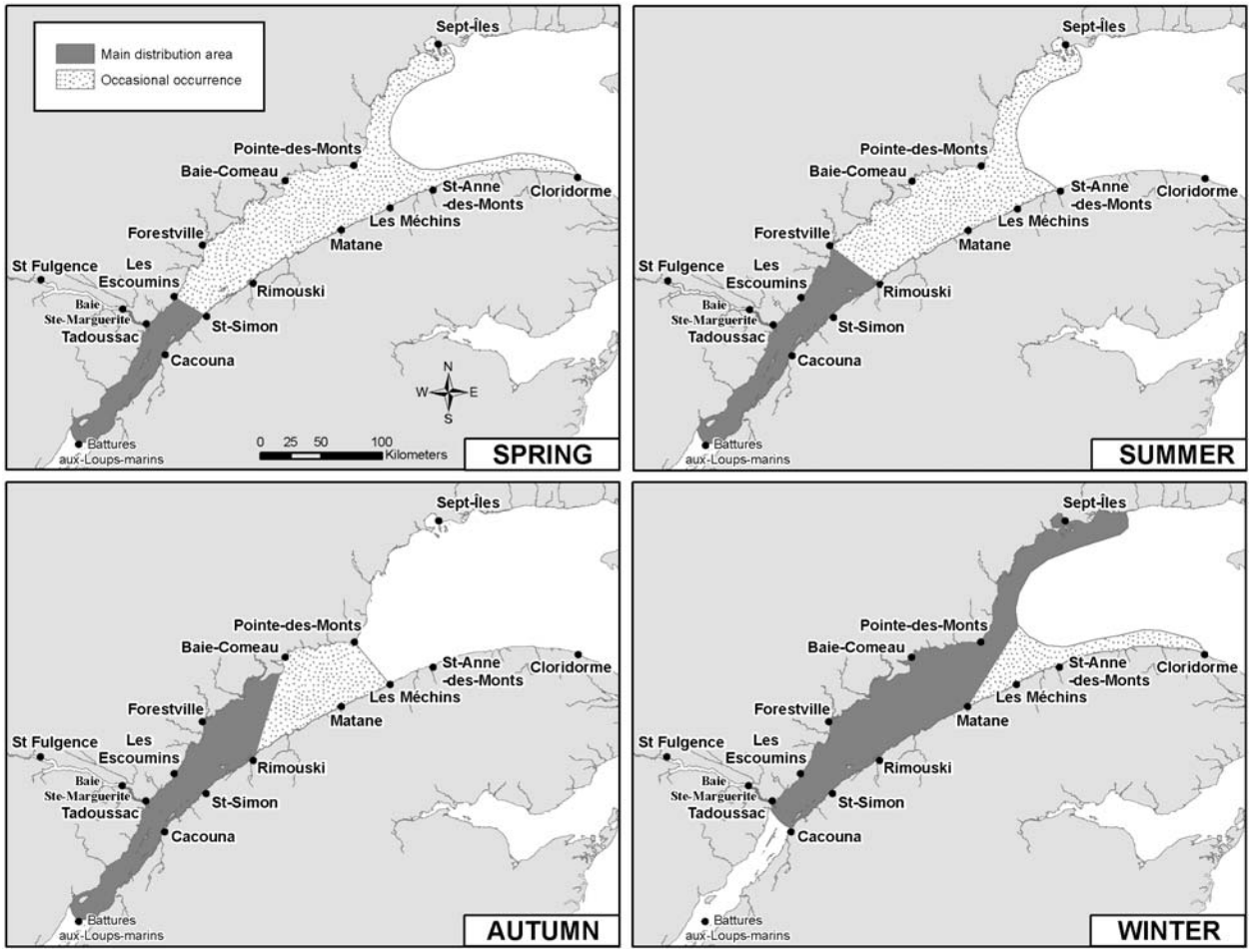

Figure 2. Seasonal variation in the current distribution of St Lawrence beluga.

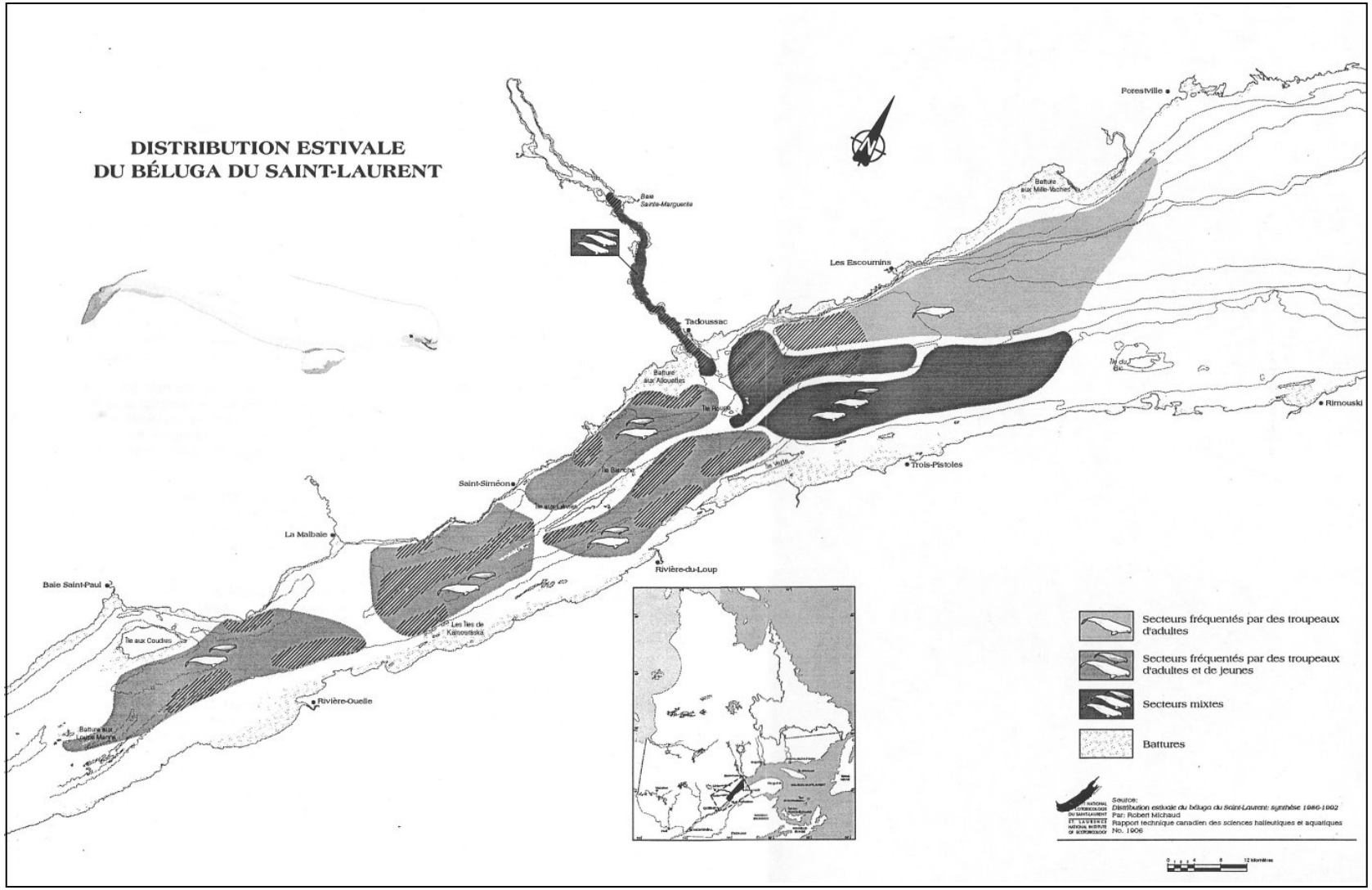

Figure 3. Summer distribution of St Lawrence Beluga and location of concentration areas (from Michaud 1993).

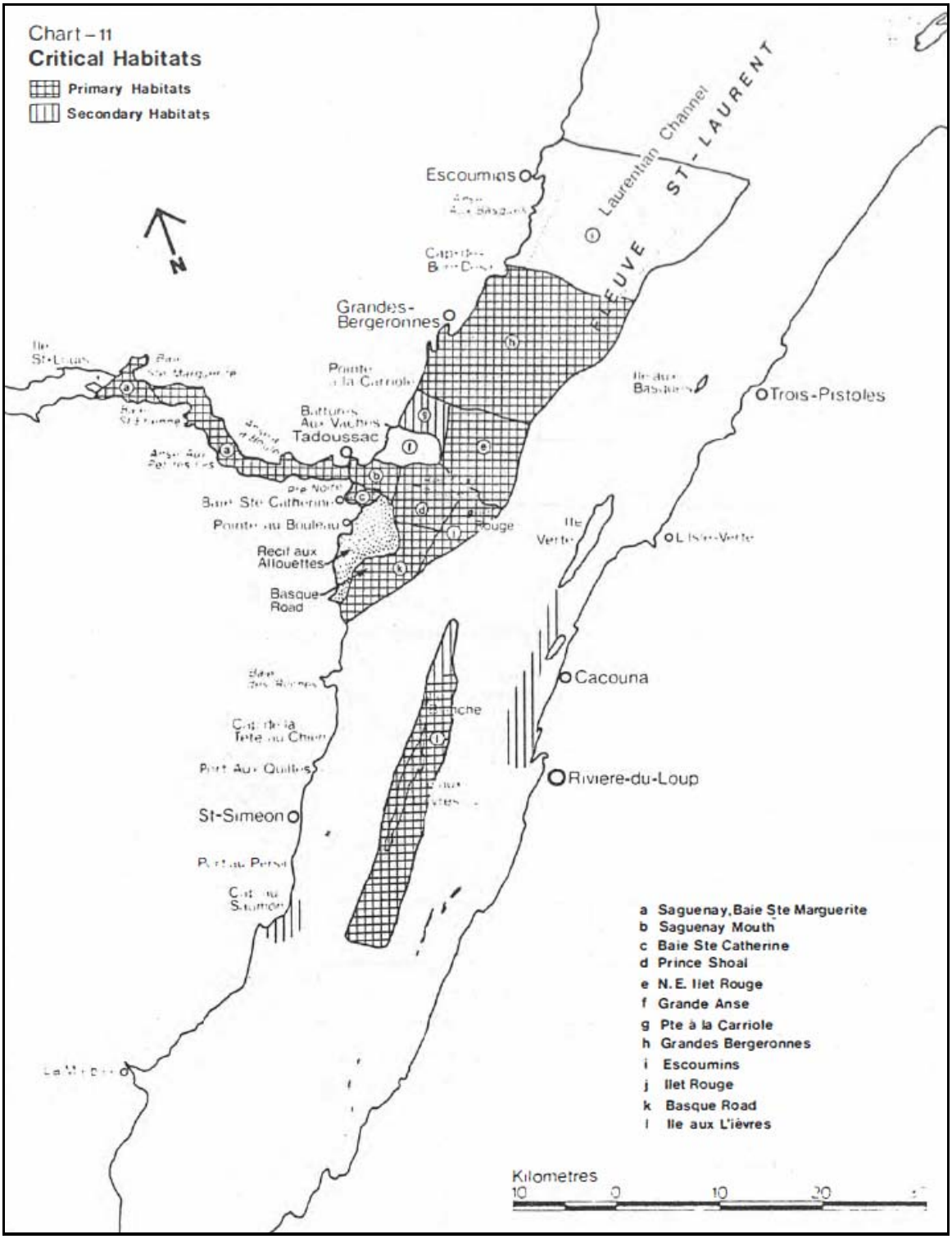

Figure 4. Location of "critical habitat" identified by Pippard and Malcolm (1978) (From Pippard and Malcolm 1978).

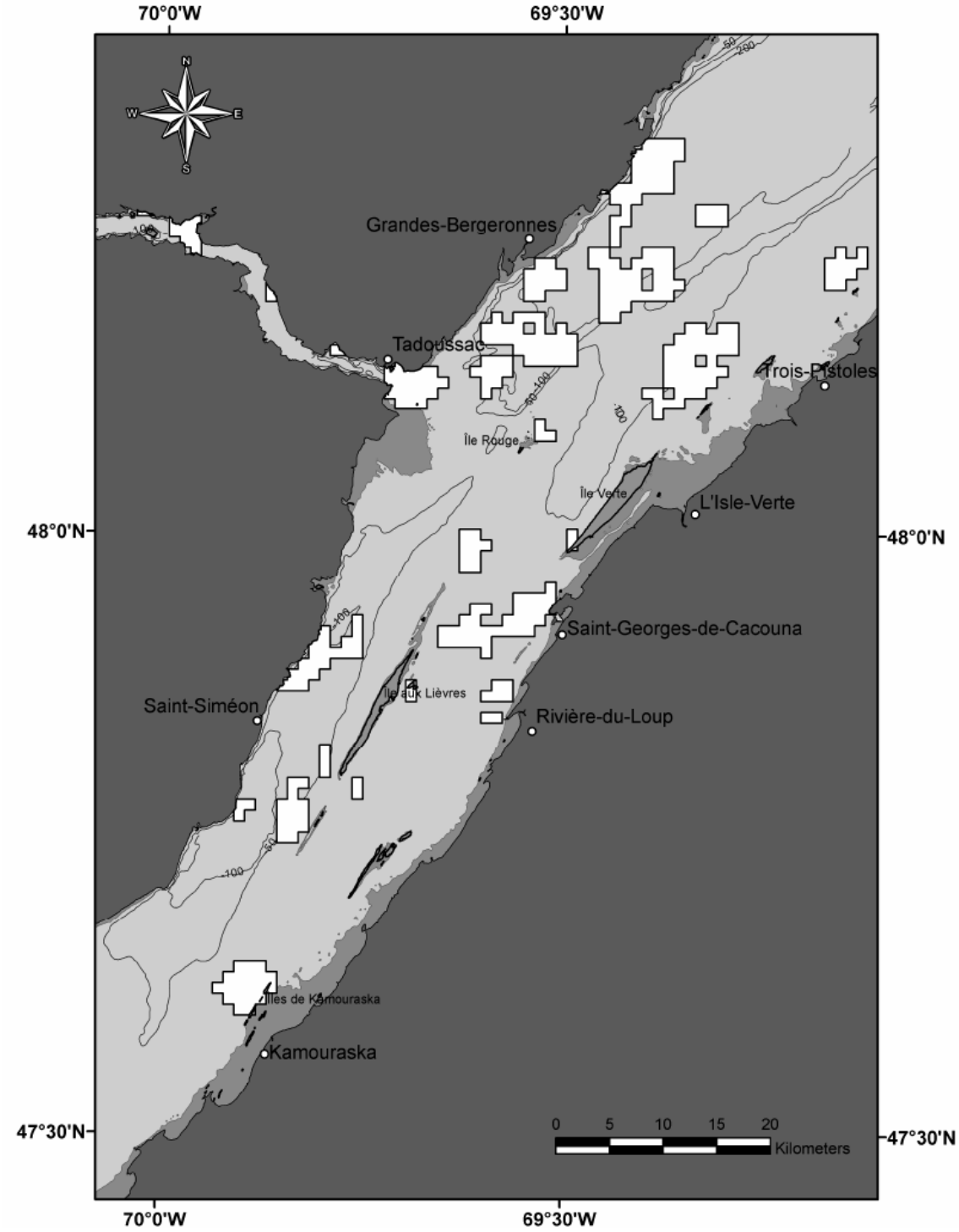

Figure 5. Distribution of Areas of High Residency (AHR) (*from Lemieux Lefebvre 2009*).

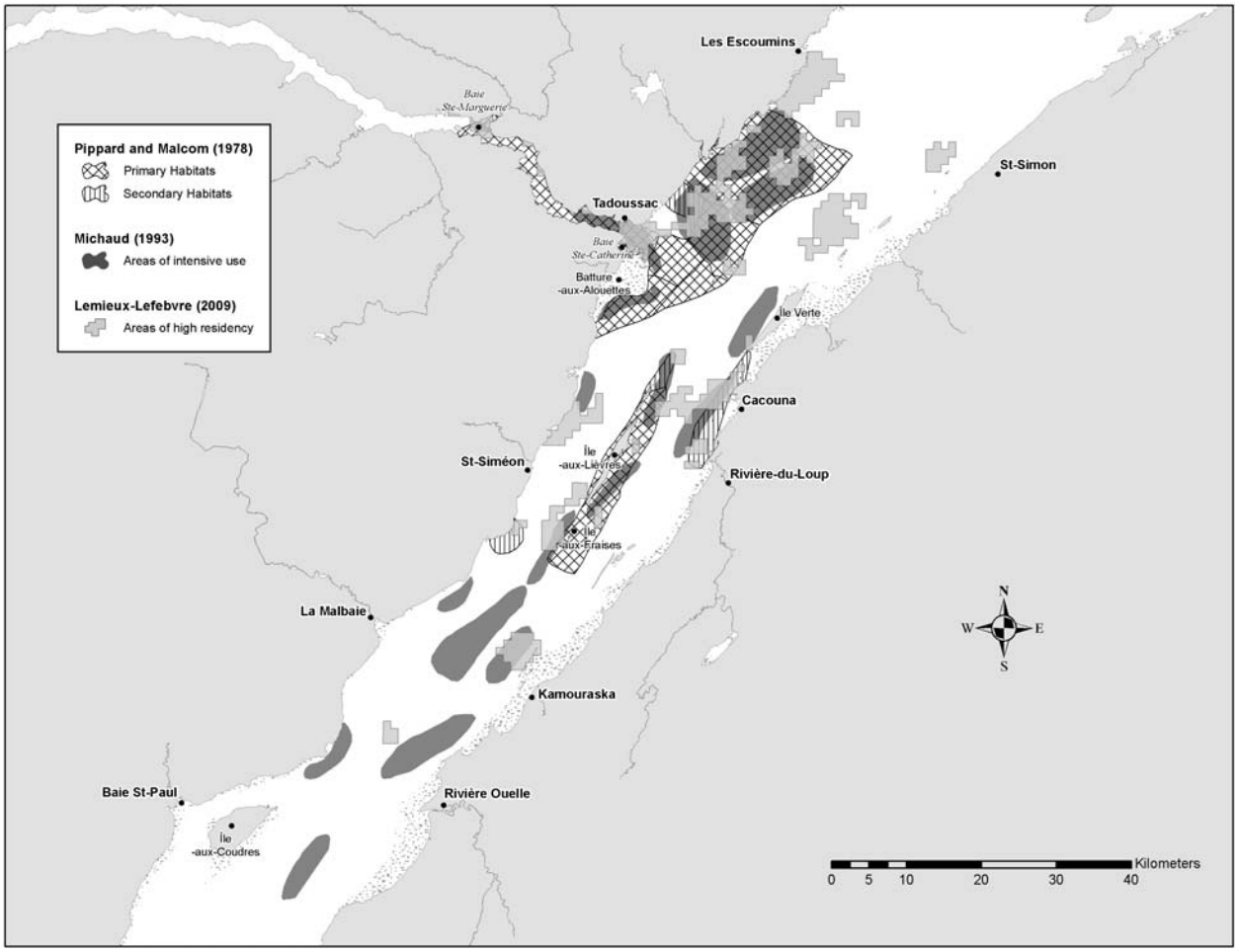

Figure 6. Superimposition of areas of regular or intensive use identified by Pippard and Malcolm (1978), Michaud (1993) or Lemieux Lefebvre (2009). Information available on some environmental characteristics and usage by beluga are available in Table 1 and Appendix 2.

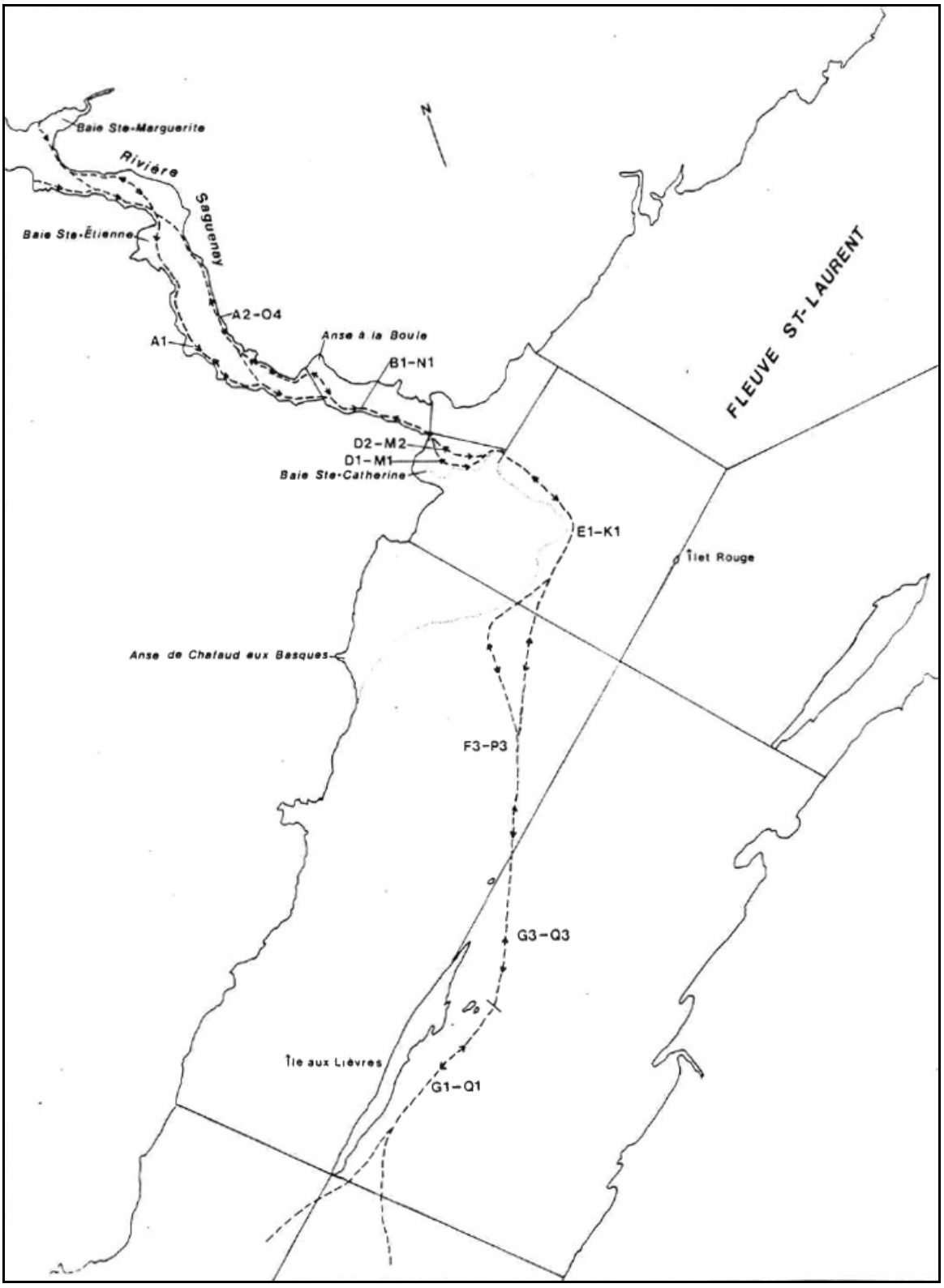

Figure 7. Composite movement path of adult and young travelling assemblages (From Pippard, 1985b).

Table 1. List of areas of intense or regular use identified by Pippard and Malcolm (1978), Michaud (1993) or Lemieux Lefebvre (2009), including available information on some environmental characteristics, herd composition, behaviour, occurrence and residency times. A more detailed description is available for some of the sectors in Appendix 2. Note: A: Adults; G: Greys; C:Calves.

Sector/area	Common ID	Habitat characteristics	Period	Peak	Herd type[2]	Herd composition (%)	Herd size[2]	Group size[2]	Function	Summer occurrence (%)[2]	% of total beluga[2]	Mean residency[11]
SAGUENAY RIVER												
Saguenay River											3-7[2,14]	
Baie Ste-Marguerite	1,2,3	Shallow pelite, sand, rock[1,5]	Spring Summer Autumn [10,11]	Jul-Aug[11,12,13]	Mixed	32 A; 53 AG; 15 AGC (n=58 herds; seasonally and annually variable[10]); 82 AG+AGC[12]	18	2	Feeding Calving Social[11,12]	50 (N=9)		3-4 h (max = 17h)
				Jun-Jul[11]	AGC							3h36
				Jun-Oct[11]	AG							2h33
				Jul-Sep[11]	A							1h40
Saguenay River mouth	1,2,3	Strong currents sand, gravel, rock[5]	Spring Summer Autumn	Summer[1,4,13]	Mixed	70-85 A; 13-27 G; 0-2 C[2]; 50 A, 50 AG[1,2]	18	2	Travel Feeding[1,4,13]	50 (N=9)		
LOWER ESTUARY												
Laurentian Channel											13.7	
north and center	1,2,3	Deep (~300 m) [5,6]	Year round	Summer (large male herds only in summer[2])	A	Large adults (likely males)[2]	65	1.6	Feeding Resting[1,4]	40 (N=9)		
Downstream Center											21.7	
Head of Laurentian Channel	1,2,3	Abrupt change in depth (300 to 50 m); Upwelling, fronts[6,7,8]	Year round		Mixed		65.6	4.5	Feeding[1,4]	50 (N=9)	20 (max=40)	
South cliff of Channel	1,2,3	Abrupt change in depth[5]	Year round		Mixed		60.5	2.3	Feeding Resting[1]	40 (N=9)		
Downstream South											7.8	
Île-aux-pommes	3		Year round		Mixed							
Off St-Simon	3		Year round		Mixed							

Table 1. (Continued).

Sector/area	Common ID	Habitat characteristics	Period	Peak	Herd type[2]	Herd composition	Herd size[2]	Group size[2]	Function	% occurrence[2]	% of total beluga[2]	Mean residency[11]
UPPER ESTUARY												
South from Île Blanche											14.7	
Off Rivière-du-Loup and Saint-Georges-de-Cacouna	**1,2,3**	Shallow waters. Higher turbidity[9] and temperature than in Lower Estuary	Spring Summer Autumn		AGC		9.2	1.4	Moving, feeding, resting[1,16]	90 (N=20)		
Île Blanche	**1,2,3**	Current fronts and mixing waters[5] Pelite, sand, rock[5]	Spring Summer Autumn		AGC		14.4	1.6		90 (N=20)		
Île-aux-Lièvres	**1,2,3**	Spawning ground for herring, capelin and smelt Pelite and gravel[5]	Spring Summer Autumn	May-Jun Herring spawning[15]	AGC		9	1.4	Feeding Travel Calving Resting **1,5,15**	70 (N=20)		
North from Île Blanche											9.8	
Batture-aux-Alouettes	**1.2**	Shallow; pelite[5]; shelter from current[1,4]	Spring, Summer Autumn		AGC		25	2.3	Resting Travelling[4,5]	60 (N=9)		
Cap de la Tête au Chien	**2.3**		Spring Summer Autumn		AGC		10	1.4		60 (N=20)		
Pointe des Rochers	**1.3**		Spring Summer Autumn		AGC							
Kamouraska											18.2	
Îles de Kamouraska	**2.3**	pelite, gravel low speed current[5]	Spring Summer Autumn		AGC		17.5	1.3		85 (N=20)	20 (max=35)	
Île-aux-Fraises	**2.3**	pelite[5]	Spring Summer Autumn		AGC		17.8	1.5		80 (N=20)		
Central corridor off Kamouraska	**2**		Spring Summer Autumn		AGC		17.5	1.3		80 (N=20)		
Île-aux-Coudres												
Off Rivière Ouelle (2 areas)	**2**		Spring Summer Autumn		AGC		15-16	1.2		65-70 (N=20)		
East Île-aux-Coudres	**2**		Spring Summer Autumn		AGC		15.6	1.3		50 (N=20)		

[1] Pippard and Malcolm 1978; [2] Michaud 1993; [3] Lemieux-Lefebvre 2009; [4] Pippard 1985b; [5] Michaud et al. 1990; [6] El-Sabh and Silverberg 1990; [7] Ingram 1985; [8] Simard and Lavoie 1999; [9] d'Angleman and Smith 1973; [10] Michaud 1992; [11] Chadenet 1997; [12] Lavoie and Fortier, 2008 ; [13] Laurin , 1982; [14] Gosselin et al., 2007; [15] Lesage and Kingsley, 1995; [16] PESCA 2006

APPENDIX A – DIET COMPOSITION OF ST LAWRENCE BELUGA

Percent occurrence (%) of prey in non-empty stomachs (n=107) of St Lawrence beluga sampled in June (n=26), July (n=43), August (n=56), September (n=37), October (n=1) and November (n=2) 1938-1939 near Manicouagan (n=145), Les Escoumins (n=17), Rivière-Ouelle (n=3) (Vladykov 1946). Data are also presented for two beluga found stranded with non-empty stomachs in 1989 and 1995 (Béland et al. 1996). p=present (Adapted from Biorex 1999).

English Name	Scientific Name	Vladykov 1946	Béland et al. 1996
Vertebrates (fishes)			
Sand lance	*Ammodytes sp.*	54	
Capelin	*Mallotus villosus*	51	
Atlantic herring	*Clupea harengus*	2	
Rainbow smelt	*Osmerus mordax*	1	p
Atlantic cod, Ogac	*Gadus morhua*, *Gadus ogac*	42	
Haddock	*Melanogrammus aeglefinus*	2	
White hake	*Urophycis tenuis*	1	
Atlantic tomcod	*Microgadus tomcod*	17	p
Winter flounder	*Pseudopleuronectes americanus*	7	p
Smooth flounder	*Liopsetta putnami*	5	
Witch flounder	*Glyptochephalus cynoglossus*	1	
Smooth & Thorny skate	*Raja senta & R. radiata*	3	
Atlantic seasnail	*Liparis atlanticus*	4	
Ocean pout	*Macrozoarces americanus*	2	
Sculpins/Cottidae	*Myoxocephalus* sp.	33	
Lumpfish	*Cyclopterus lumpus*	1	p
Sea lamprey	*Petromyzon marinus*	2	
Atlantic sturgeon	*Acipenser oxyrhinchus*	3	
Blennioids		1	
Atlantic salmon	*Salmo salar*	1	
Invertebrates			
Northern shortfin squid	*Illex illecebrosus*	33	
Northern Atlantic octopus	*Bathypolypus bairdii*	20	
Bivalves	*Mesodesma* sp.	14	
	Cyrtodaria siliqua	3	
	Crenella sp.	2	
	Yoldia limatula	2	
	Macoma baltica	1	
	Mesodesma sp.	1	
	Mya sp.	1	
Gastropods	*Buccinum* sp.	9	p
	Littorina sp.	1	
Decapods	Decapoda sp.	65	
	Argis dentata	p	
	Crabs	p	
	Crangon septemspinosa	p	p
	Pandalus sp.	p	
Amphipods		35	
Polychaetes	*Neanthes (Nereis) virens*	60	p
	Pectinaria gouldii	20	

APPENDIX B - AREAS OF REGULAR / INTENSIVE USE BY BELUGA

SAGUENAY RIVER

Baie-Ste-Marguerite

Baie Ste-Maguerite is located in the Saguenay River, approximately 25 km from the river mouth. Systematic aerial surveys indicate that a mean of 3 to 7% of the beluga population use the Saguenay River in summer but do not specify the proportion of those individuals occurring in Baie-Ste-Marguerite (Michaud 1993; Gosselin 2007). Boat surveys and shore-based studies confirmed a high frequency of use of the bay (46.2% of 158 boat surveys from May to October 1989-1991; 68% of shore-based monitoring days from mid-July to mid-September 1993) and relatively long residency times (mean 3-4 h; max. of 17 h) and the presence of animals from all age and sex (Michaud 1992; Chadenet 1997; Lavoie and Fortier 2008). Belugas also occurred in the bay in four of the five night sampled (Chadenet 1997). From June to October based on the same studies, occurrence peaks in July or August (Michaud 1992; Chadenet 1997; Lavoie and Fortier 2008). Residency time increases with the presence of younger animals in herds, averaging 3h36 for herds with newborns, 2h33 for herds with juveniles and 1h40 for herds of adults only.(Chadenet 1997; see also Michaud 1992). Dates of occurrence of different types of herds in Baie-Ste-Marguerite vary between years. Herds with newborns were mostly seen in June and July from 1989 to 1991 while more than half the herds with newborns were seen in August in 1993 (Chadenet 1997, Michaud 1992). Herds of adults were more frequent in July and August from 1989 to 1991, while they were more frequent in September in 1993. Michaud (1992) mentioned the low occurrence of herds of adults and juveniles in August 1991 when they observed an increase in occurrence of herds of adults, and suggested that a possible explanation in this variation in composition of groups could be the result of displacement of one group by the other. Shore-based observations by naturalists from the end of June to the end of August 2001-2008 seem to corroborate this tendency (Lavoie and Fortier 2008).

Reasons for the presence of belugas in this sector remains unclear, and could involve feeding (Pippard and Malcolm 1978), lactation and attendance of young (Michaud 1990; but see Michaud 1992) or social interactions (Michaud 1992; Chadenet 1997). There is no compelling evidence for the prevalence of these functions. There is no published data on food availability in this bay. The low proportion of newborn in beluga using Baie-Ste-Marguerite (<0.7%) and the simultaneous occurrence of all group of age and sex tend to dismiss the suggestion of an area used exclusively for calving lactation or attendance of young (Michaud 1992). However, recent observations of large proportion of herds of adult with juvenile or adult, juvenile and newborn (mean 82% between 2001 and 2008; Lavoie and Fortier 2008) could suggest the opposite. Main behaviors of beluga observed in the bay include patrolling (33%), directional movements (29%), milling (30%), but studies did not link them to specific functions (Chadenet 1997; Lavoie and Fortier 2008).

Note: In August 2008, a noticeable drop in beluga occurrence was mentionned in Baie-Ste-Marguerite when an inflorescence of toxic algae *Alexandirium tamarense* covered the Saguenay River and the downstream part of the St Lawrence River. It was believed to have killed 10 belugas in the first two weeks of this month (Lavoie and Fortier 2008). On 20 August, the aluminum smelter industry of Rio Tinto Alcan accidentally spilled 100 cubic meters of mud containing bauxite residues and caustic soda in a stream feeding the Saguenay River.

Saguenay River mouth

Located in the middle of the distribution area of St. Lawrence beluga, the Saguenay River mouth is probably the most studied site for this population (Pippard et Malcolm 1978; Laurin 1982; Pippard 1985b; Caron et Sergeant 1988; Michaud 1992). Shore-based observations mainly from Pointe Noire, an elevated point located on the western shore of the Saguenay River mouth, indicated that it was used daily during summer, but also in spring and autumn, although less intensively (Laurin 1982; Pippard and Malcolm 1978). Laurin (1982) observed a mean of 0.6 to 25.1 belugas per hour in summers 1973, 1974 and 1975 and counted 20 to more than 100 individuals per day in this area. In a synthesis study including observation data from 7 summers from 1975 to 1987 Caron and Sergeant (1988) showed that the rate of beluga passage declined from a mean of 3.9 belugas / hour from 1975 to 1982 to about 1.3 beluga / hour for 1986-1987. A possible explanation of this decline was the increase in boat traffic in the area. In subsequent systematic aerial surveys done between 1987 and 1992, beluga were observed on half of the flights (5 over 10; Michaud 1993). Aerial-, boat- and shore-based surveys covering this area found mixed herds of beluga where groups of adults and adults with young were present in roughly equal proportion (Pippard and Malcolm 1978; Michaud 1993). During shore-based surveys in 1983, 1984, 1987 and 1988, adults and juveniles were estimated to represent around 70-85% and 13-27% of the individuals respectively. Newborns formed 2% or less of the individuals and were absent in certain years.

Movements of belugas in the Saguenay River mouth mostly concentrated (80%) over a path following the western coast of the Saguenay River (Caron and Sergeant 1988; see also Pippard and Malcolm 1978 and Pippard 1985b). Besides its role of entrance and exit from the Saguenay River, several authors reported beluga movements associated with feeding (e.g., individuals going back and forth within limited area; Pippard and Malcolm 1978; Laurin 1982; Pippard 1985b). Based on observation of sonar images and pelagic net sample conducted in the Saguenay River mouth, Laurin (1982) associated those behaviors to the presence of school of capelin, a prey documented in the diet of St. Lawrence beluga (Vladykov 1946). Unfortunately, these samples were not collected simultaneously with confirmed observation of beluga feeding.

LOWER ESTUARY

Head of the Laurentian Channel

The head of the Laurentian Channel is a very dynamic area where many physical oceanographic processes take place. Tidal upwelling and zones of fronts are created by strong tidal currents, and the abrupt change from the 300 m deep sub-marine valley to a sill at less than 50 m deep located off Tadoussac (El-Sabh and Silverberg 1990; Ingram 1985). Rising of cold and nutrient-rich deep water promotes the aggregations of zooplankton (Simard and Lavoie 1999) and small fishes (particularly capelin; Marchand et al. 1999) that constitute a particularly attractive feeding ground for several whales, including possibly beluga (Edds and MacFarlane 1987; Lesage and Kingsley 1998). The largest herds in the summering ground are observed in this sector and may number several hundreds of individuals, with mean size of 66 (Michaud 1993). Michaud (1993) associated the head of Laurentian Channel with the western end of its south slope and called it the downstream center sector.

UPPER ESTUARY

Thirteen “area of intensive use” have been defined by Michaud (1993) in the Estuary, upstream of the mouth of the Saguenay River as far as Île-aux-Coudres. Several of them have a good correspondence with “areas of high residency” obtained by Lemieux Lefebvre (2009) (see Figure 6).

Off Rivière-du-Loup and Saint-Georges-de-Cacouna

Three “areas of high residency” (Lemieux Lefebvre 2009) and one “area of intensive use” (Michaud 1993) were identified off Rivière-du-Loup and Saint-Georges-de-Cacouna. Like all the sectors located upstream the Saguenay mouth, beluga herds are composed of adult with young (>30% of young; Michaud 1993; PESCA 2006). A study conducted off Gros Cacouna and covering an entire season in 2005 indicates that beluga use the area from April to November, and that juveniles or calves represent 21 to 38% of the animals depending on season, with the highest proportions being observed in summer and fall (PESCA 2006). Sampling effort was however, nearly non-existent in May, when spawning herring are thought to occur in the area (Munro et al. 1998). Activities associated with this sector include travel, feeding, resting, with feeding being the predominant activity (61% of individuals) during spring (PESCA 2006). Although this area was not considered as a primary habitat by Pippard and Malcolm (1978) likely because their study area did not cover this sector, they, however, recognized its potential importance (Figure 3). A project for the construction of a Liquefied Natural Gas (LNG) port has recently been proposed in the area. A Science Advisory Report (DFO 2007) stated that underwater noise caused by the LNG construction could have an impact on the use of this sector that was intensively used during the calving season (June to August) and also during the spawning period of herring (May). The very high frequency of beluga occurrence (90%; Michaud 1993) and observations during systematic aerials surveys conducted by Gosselin et al. (2001) confirm the regular use of this sector.

Île-aux-Lièvres

The sector located around Île-aux-Lièvres was also mentioned as a “concentration area” by Pippard and Malcolm (1978) considering it as a feeding, resting and probable calving site. Spawning ground of herring, capelin and smelt were present south of Île-aux-Lièvres (Michaud et al., 1990, Munro et al. 1998). Particularly intensive use of this area was noted in the south-west tip of Île-aux-lièvres during the presumed spawning period of herring (May to June; Lesage and Kingsley 1995). Once herring spawning was presumed to be over, beluga were more in travelling mode when observed in that area (Lesage and Kingsley 1995). An “area of intensive use” was identified south to Île-aux-lièvres (Michaud 1993), corresponding to a possible calving area, based only on high water temperature during calving period (Pippard and Malcolm 1978). Beluga occurred in this area in 70% of the surveys by Michaud (1993). Nevertheless, only small areas corresponding to “high residency” of beluga (N = 3) were found in that sector (Lemieux Lefebvre 2009). It has been suggested that those areas of frequent use, but where beluga adopt more rapid and/or directional movements, could be considered as travelling corridors (Pippard, 1985b; Lemieux Lefebvre 2009).