Updated Status of the St Lawrence River Population of the Beluga, *Delphinapterus leucas**

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Lesage, Véronique, and Michael C. S. Kingsley. 1998. Updated status of the St Lawrence River population of the Beluga, *Delphinapterus leucas*. Canadian Field-Naturalist 112(1): 98–114.

The Beluga, *Delphinapterus leucas*, in the St Lawrence Estuary is at the southern limit of the distribution of this species. The large distances separating this population from northern Belugas, its low genetic variability, and the rarity of Beluga sightings outside their normal range in the Gulf, suggest that it is isolated from its northern conspecifics. Over-exploitation and attempted extermination reduced this population to the low hundreds; it is now conservatively indexed at between 600 and 700 and is slowly increasing. Reproductive rates, survival rates at each age, and population age structure are similar to those of other Beluga populations. Factors potentially limiting the size of this population include limits on food stocks and extent of critical habitat; its growth rate may be affected by low genetic variability, boat traffic, and environmental contamination. St Lawrence Belugas are protected from hunting and are excluded from marine mammal species targeted by the whale-watching industry. Regulations and guidelines on the behaviour of marine traffic under the Fisheries Act and within the operating mandate of the Saguenay Marine Park offer some protection from disturbance although more may be needed. Pollution reductions upstream and improved controls on toxic compounds, are helping to reduce ambient levels of contaminants, but efforts to accelerate and maintain this progress are important.

Le Béluga, *Delphinapterus leucas*, dans le Saint-Laurent est à la limite méridionale de la distribution de l'espèce. La grande distance le séparant des Bélugas du nord, une faible variabilité génétique entre les individus, et les rares observations de Bélugas à l'extérieur des limites normales de leur distribution dans le golfe laissent supposer que ces Bélugas sont isolés de leurs congénères du nord. La surexploitation et des tentatives d'extermination auraient causé le déclin de cette population. Un indice prudent de son abondance actuelle se situe entre 600 et 700 individus, et elle s'accroît lentement. Le taux de naissance, le taux de survie à chaque âge, et la structure d'âge de la population des Bélugas du Saint-Laurent sont semblables à ceux des autres populations de Bélugas. Les facteurs qui risquent de limiter la taille éventuelle de cette population incluent l'abondance de nourriture et l'étendue de l'habitat critique. La faible variabilité génétique à l'intérieur de la population, la circulation maritime et la contamination de l'environnement pourraient limiter son taux d'accroissement. Les Bélugas du Saint-Laurent sont protégés contre toutes formes de chasse et sont exclus des espèces visées par l'industrie de l'observation des baleines. Des règlements et des directives visant le comportement de la circulation maritime, et émis dans le cadre de la Loi sur les Pêcheries et à l'intérieur du mandat d'opération du Parc Marin du Saguenay, offrent un certain niveau de protection contre le harcèlement. Une protection accrue pourrait toutefois être nécessaire. La réduction des émissions de polluants en amont et un niveau accru de contrôle des rejets de composés toxiques contribuent à la réduction des niveaux ambiants de contaminants. Il demeure néanmoins important d'accélérer et de maintenir ce progrès.

Key Words: Beluga, *Delphinapterus leucas*, White Whale, Béluga, threatened, St Lawrence River.

The Beluga (*Delphinapterus leucas* Pallas, 1776) is a member of the family Monodontidae. It is characterized by unfused cervical vertebrae, the absence of a dorsal fin, a rounded prominent "forehead", a thick dermis, and white colour (Figure 1). It has one close relative, the Narwhal, *Monodon monoceros* (Lint et al. 1990). In both species, the absence of a dorsal fin and the thick dermis are believed to be adaptations to living in ice-infested waters.

Newborn Belugas are slate-grey or brown. They average 1.5 m long and weigh around 78 kg. As they mature, they become bluish-grey in colour, and then progressively lighter. The pure white colour, characteristic of adults, is generally attained between the ages of 6 and 11 years (Brodie 1971; Sergeant 1973; Burns and Seaman 1985), but on average at different ages in the two sexes (Sergeant 1959; Ognetov 1981; Burns and Seaman 1985). Most females mature sexually while still light grey, but most males become white before maturity (Burns and Seaman 1985; Doidge 1990a). Adult males are longer and heavier than females (Sergeant and Brodie 1969; Brodie 1989), the difference varying slightly between populations (Doidge 1990b). Compared with other Belugas of eastern North America, St Lawrence Belugas are of medium size (Sergeant and Brodie 1969). White females and males from hunted samples in the St Lawrence (some perhaps still growing) averaged 3.5 m and 3.6 m long respectively (Vladykov 1944); asymptotes of growth curves fitted to age-length data from beach-cast St Lawrence carcasses were 3.62 and 4.17 m (Kingsley 1996).

*At a meeting of COSEWIC on 16 April a change to "threatened" was supported by 12 votes out of 21; this majority was less than the two-thirds needed to change the status, so "Endangered" was retained.

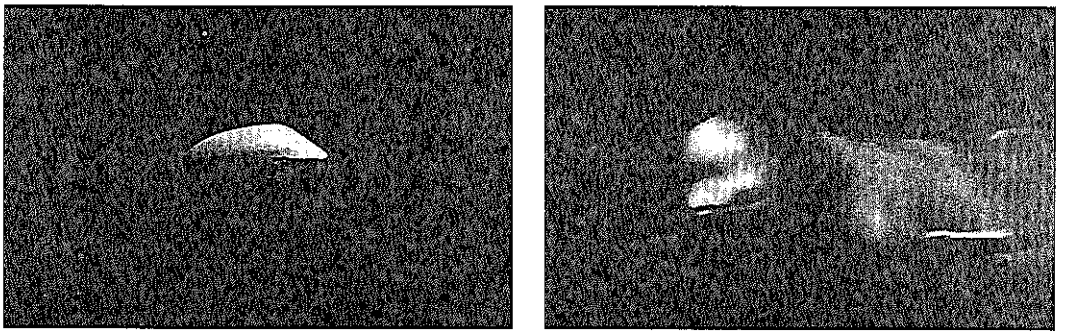

FIGURE 1. The Beluga (*Delphinapterus leucas*) photographed by Véronique Lesage in 1991. The left shows the species as usually seen in the field, taken in the St. Lawrence Estuary. The right showing details of morphology was taken at the Shedd Oceanarium in Chicago, Illinois.

Distribution and Migration

The Beluga is limited to seasonally ice-infested Arctic and sub-Arctic seas. The St Lawrence Belugas are at the southern limit of the worldwide distribution of the species (Reeves 1990). Beluga skeletons in Pleistocene clays and sand deposits in Québec (Canada) and Vermont (United States) suggest that the Beluga established itself in the St Lawrence region during the last Ice Age, about 10 000 years ago (Harington 1977). At that time, the Champlain Sea covered an area of 53 100 km^2 or more between Québec City and Lake Ontario, including part of the lower Ottawa River valley and the Lake Champlain valley in New York and Vermont. Belugas probably remained in the northern (lower) sector of the Champlain Sea during the retreat of the Laurentian Ice Sheet and established themselves in what would become the present St Lawrence River.

The current distribution of the St Lawrence Beluga (Figure 2) is not as extensive as that described 50 years ago by Vladykov (1944). Their distribution in the upper Estuary then extended 48 km upstream of Québec City, but now is limited to the Battures aux Loups Marins, approximately 100 km downstream of Québec City. The eastern extent of the Beluga's range in the Gulf of St Lawrence has been reduced from Natashquan to Sept-Iles along the north shore, and from Baie des Chaleurs to Cloridorme along the south shore; there are, however, occasional sightings of small numbers off the "north shore" of New Brunswick, and recent observations of small numbers in the northern Gulf in summer (Kingsley, unpublished data). The extent of their distribution in the Saguenay River has been reduced slightly from Chicoutimi to Saint-Fulgence, 12 km downstream of Chicoutimi (Michaud et al. 1990; Figure 2).

Belugas are reported outside the limits of their usual distribution each year (Pippard 1985; Sergeant 1986; Michaud et al. 1990). In eastern Canada sightings have recently been reported from: Blanc-Sablon on the north shore of the Gulf of St Lawrence; Newport in the Baie des Chaleurs; the Miramichi estuary; Tracadie and Escuminac on the "north shore" of New Brunswick; Prince Edward Island; the "east shore" of Nova Scotia; Digby, Nova Scotia; the Newfoundland south coast; and along the eastern seaboard as far south as New Jersey (38°55′N) in the United States (Reeves and Katona 1980; Michaud et al. 1990; Kingsley unpublished data). Belugas are also seen, from time to time, on the Labrador and the east coast of Newfoundland. The origin of most of these animals is uncertain. Belugas within the Gulf of St Lawrence are almost certainly from the St Lawrence population; two east-coast strandings in Newfoundland had low levels of organochlorines, so were probably Arctic animals (Muir et al. 1996a); the mtDNA from a Beluga living in Guysborough Harbour, on the "east shore" of Nova Scotia, suggested that it was from the St Lawrence, and not the Arctic (J. Clayton, Department of Fisheries and Oceans (DFO), Freshwater Institute, Winnipeg, Manitoba, personal communication). Whales on the Gaspé shore of the Estuary are susceptible to being swept eastward and southward by the Gaspé current (Sergeant and Hoek 1988). Sightings in the western and northern Gulf seem more frequent in the spring and early summer (Sergeant and Brodie 1975; Sergeant 1986).

Migration

St Lawrence Belugas move seasonally, but compared with their Arctic conspecifics they are relatively sedentary (Figure 2). The summer distribution is centred at the mouth of the Saguenay River and extends in the Saguenay to Saint-Fulgence and in the St Lawrence Estuary from the Battures aux Loups Marins to Les Escoumins on the north shore, and to Saint-Simon-sur-Mer on the south shore (Michaud et al. 1990; Michaud 1993a; Kingsley 1993, 1996). An extension of the summer distribution to Rivière

Portneuf (30 km downstream of Les Escoumins) has recently been noted (Michaud 1993a; Kingsley 1996). In fall, Belugas are distributed mostly as in summer, but there is a more intensive use of the Estuary downstream of the Saguenay River, and the upper limit of their distribution in the Saguenay River is reduced to Baie Ste-Marguerite (Boivin and INESL 1990). A general movement downstream begins in late September or early October. The winter distribution is not completely described, but probably includes all the estuary downstream of the Saguenay and extends as far east as Cloridorme on the south shore and Sept-Iles in the north-western Gulf (Michaud et al. 1990; Kingsley, unpublished data). Winter distribution may be related to the migration of prey (Boivin and INESL 1990), and reflects the availability of loose ice or open water (Vladykov 1944). In spring, Belugas are widely distributed, moving into the upper part of the Estuary, between the Saguenay River mouth and the Battures aux Loups Marins, while late migrants may also be seen near Cloridorme and Pointe des Monts (Michaud 1990), or around south-west and western Anticosti Island (Kingsley, unpublished data). The spring movements may follow the migrations of Capelin (*Mallotus villosus*) and Herring (*Clupea harengus*) from east to west along the north shore (Bailey et al. 1977).

Stock Discreteness

The nearest neighbours to the St Lawrence River Belugas winter in Hudson Strait, off south-east Baffin Island and off western Greenland (Reeves 1990). Regular Beluga sightings along the Newfoundland and Labrador coasts before the early 1900s (Reeves and Katona 1980; Pippard 1985; Sergeant 1986; Reeves 1990), as well as an increase in Beluga numbers in the St Lawrence during the late 1920s that was attributed to immigration (Vladykov 1944: 141-142), suggest that occasional immigrations may have slowed the decline of the St Lawrence population (Mitchell and Reeves 1981; Pippard 1985; Reeves and Mitchell 1987). Belugas are still seen along the Labrador coast (Curren and Lien 1995), but significant immigration is no longer likely to occur because Beluga populations that summer in eastern Hudson Bay, Ungava Bay and Cumberland Sound are depleted (Reeves and Mitchell 1989; Richard 1991, 1993).

A lower level of nuclear genetic variation within the St Lawrence Belugas than that of the Beaufort Sea population (which totals about 11 500 whales) was interpreted as suggesting that the St Lawrence population lacks significant genetic exchanges with other populations and is composed of related individuals; it therefore may suffer from inbreeding depression (Patenaude et al. 1994). The mtDNA analyses shows that St Lawrence Belugas are more closely related to Hudson Strait and east Hudson Bay populations (Brown and Clayton 1993), so comparing their genetic variability with that of those neighbouring populations, or with their own pre-exploitation level (Patenaude et al. 1994), would be more informative.

Protection

International Protection Measures

The parties to the *International Convention to Regulate Whaling* have not decided that the convention applies to small whales like the Beluga. Canada is not a signatory. However, bipartite agreements for management or research, or both, that are of significance in the protection of Canadian Beluga stocks exist between Canada and Greenland, and between the Inuvialuit of the western Canadian Arctic and the people of Alaska.

The listing of the Beluga on Appendix II of the Convention on International Trade in Endangered Species of Flora and Fauna (CITES) restricts international trade only to the extent of requiring export permits. Presently, there is no known international trade in Beluga products, apart from the supply of live animals to zoos and oceanaria. Live Belugas have not been exported from the St Lawrence for a long time, and the Canadian Department of Fisheries and Oceans has suspended all permission for live exports from Canada since December 1992. The only region affected by this decision is Churchill which was, since 1970, the principal source of captive Belugas for Europe, Japan and North America.

National Protection Measures

Beluga Protection Regulations under the *Fisheries Act* date from 1949 and have since then been frequently altered and extended (Reeves and Mitchell 1989); in 1979 the St Lawrence, Labrador and Newfoundland were added to the geographical scope and the St Lawrence was closed to hunting. In February 1993, the Beluga Protection Regulations were superseded by, and absorbed into, the *Marine Mammal Regulations* of the Fisheries Act. These regulations generally forbid disturbance of marine mammals. These clauses were intended to control whale-watching, a popular recreational activity and a flourishing industry in the St Lawrence Estuary. No permit, other than those relating to marine safety, is required to conduct whale-watching cruises in Canada. However, an informal agreement exists between the Canadian Department of Fisheries and Oceans and commercial whale-watching cruises in the St Lawrence Estuary to exclude Belugas from the species sought by whale-watching boats. The Department has also established behaviourial guidelines for vessels that unexpectedly encounter Belugas (Ministère des Pêches et des Océans 1992). The harassment sections of the Marine Mammal Regulations could be regarded as a safeguard if the code of ethics were not respected, but are difficult to

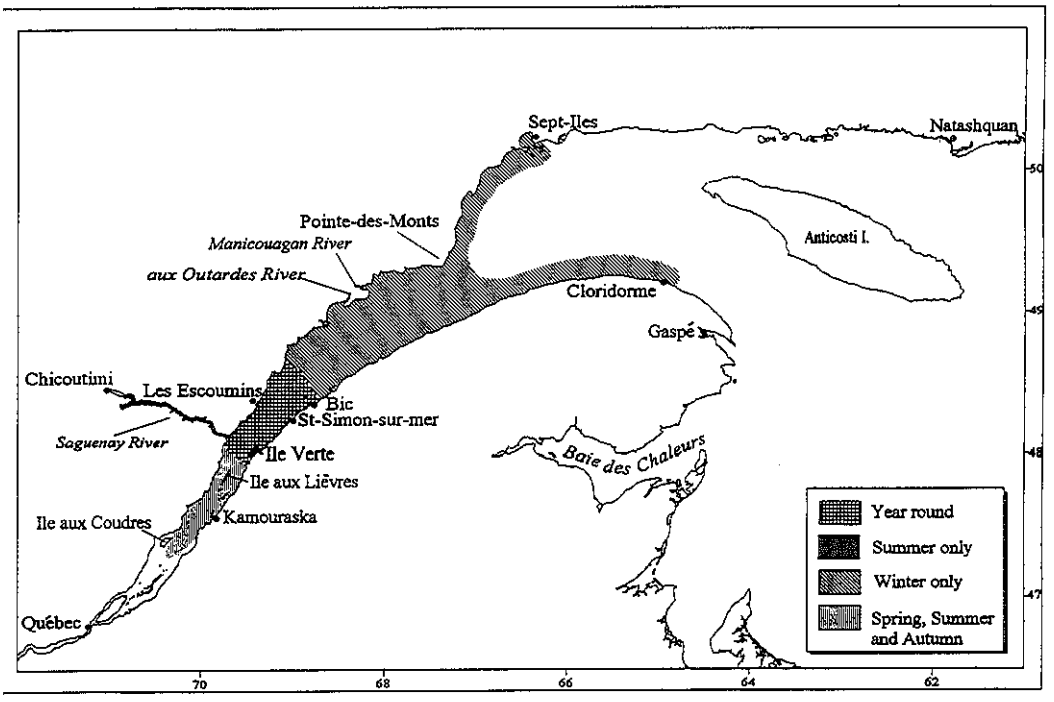

FIGURE 2. Seasonal distribution of the Belugas of the St Lawrence.

nforce. The creation of the Saguenay-St Lawrence Marine Park may provide a further level of control ver a part of the summer habitat of the population, ut also increases publicity for the area.

At the provincial level, the Québec *Threatened nd Vulnerable Species Act* allows the Minister to esignate species threatened or vulnerable and to act o protect them or their habitats.

opulation Size and Trends

A Beluga fishery flourished along the St awrence River between the late 1500s and the early 950s, and was intense between 1860 and 1945. rom records of traded oil and skins, Reeves and litchell (1984) estimated that about 15 000 Belugas ere removed from the St Lawrence population etween about 1880 and 1950; this may have been n overestimate as commercial records often did not istinguish between products obtained from Belugas nd those from other species (Reeves and Mitchell 984). Such a harvest could have depleted a popula- on numbering even several thousand in the 1880s o a few hundreds by the middle of the twentieth entury (Reeves and Mitchell 1984). Hunting proba- ly continued throughout the 1970s, and it has been uggested that approximately 25 whales per year ere then still being removed (Pippard and Malcolm 978).

Studies from 1973 to 1996 have produced popula- tion or index estimates ranging from 300 to 705 (Table 1; Figure 3). Most have been aerial surveys, either visual (uncorrected for diving animals) or photographic (with a minimum diving correction) but boat surveys have also been tried. Sample surveys of the distribution area (Sergeant and Hoek 1988; Kingsley and Hammill 1991; Kingsley 1993, 1996), as well as complete-coverage surveys of the most highly frequented areas (Pippard and Malcolm 1978; Béland et al. 1987b) have been carried out. While all are *bona fide* attempts to estimate a population index, the variations in method impose caution in comparing their results. Since 1984, vertical large-format photography has been used, combined since 1988 with standard sample designs using transects across the river (Sergeant and Hoek 1988; Kingsley and Hammill 1991; Kingsley 1996). Surveys conducted in 1988, 1990, 1992, and 1995 gave index estimates of between 490 and 705 Belugas using a correction factor of 15% to account for diving animals (Kingsley 1996). A standardized conservative index, smoothed on a linear trend with previous estimates, is 650 for 1995, with estimated standard error 45. The diving behaviour of monodontids in Arctic Canada suggests survey correction factors near 80% (Martin and Smith 1992; Martin et al. 1994), which if applied to the St Lawrence surveys would greatly increase the population estimate (Innes 1996). This has not been done, as conditions in the St Lawrence

TABLE 1. Population index estimates for Belugas of the St Lawrence estuary, 1973 to 1995.

Year	Boat Aeroplane, Helicopter	Photo-graphic, Visual	Sample survey (%) or Total Count	Coverage		Count	Index estimate	Limits (–) or standard error (±)	Source
				Peripheral Range	Saguenay				
1973	A	P	S-08	N	N	43	443	229–658	Sergeant and Hoek 1988
1977	H	V	T	N	Y	266		300–350	Pippard 1985
1982	H	V	S-28	Y	Y	143	512	360–715	Sergeant and Hoek 1988
1984	A	P	S-39	N	Y		431	187–773	Sergeant and Hoek 1988
1984	B	V	S	N	N		495	±245	Lynas 1984
1985	B	V	T	N	Y	161–165		<340	Béland et al. 1987
1985	A	P	S-85	N	N	379	530	285–775	Sergeant and Hoek 1988
1985	A	P	S-85	N	N	295–369		275–450	Béland and Martineau 1985
1988	A	P	S	Y	N	152	491	±69	Kingsley and Hammill 1991
1990	A	P	S	Y	N	148	606	±308	Kingsley and Hammill 1991
1992	A	V	S	Y	Y	490		>490	Michaud 1993a
1992	A	P	S-50	Y	Y	230	525	410–725	Kingsley 1993
1995	A	P	S-50	Y	Y	336	705	540–1035	Kingsley 1996

Notes:

Pippard's highest two counts in eight surveys of the core range were 262 and 266. She added 35-85 to allow for unseen Belugas, especially in the peripheral range which was surveyed separately.

Sergeant's photographic surveys in 1984–1985 were corrected for diving animals by adding 18% to photo counts; surveys in 1988–1995, by only 15%. These corrections were separate from factors applied to estimate total index from the sample survey count. Photo counts in 1988 and 1990 also had a glare correction (mean value 2.2%) added, not added in 1992 and 1995.

Sergeant's 1985 survey may have flown over, and photographed, some Beluga groups twice (Béland and Martineau 1985; Sergeant and Hoek 1988); Béland and Martineau (1985) corrected for this by matching up photo frames and identifying and removing double counts. Their upper limit includes a 25% correction for all unseen animals, i.e., those diving and those in unphotographed areas.

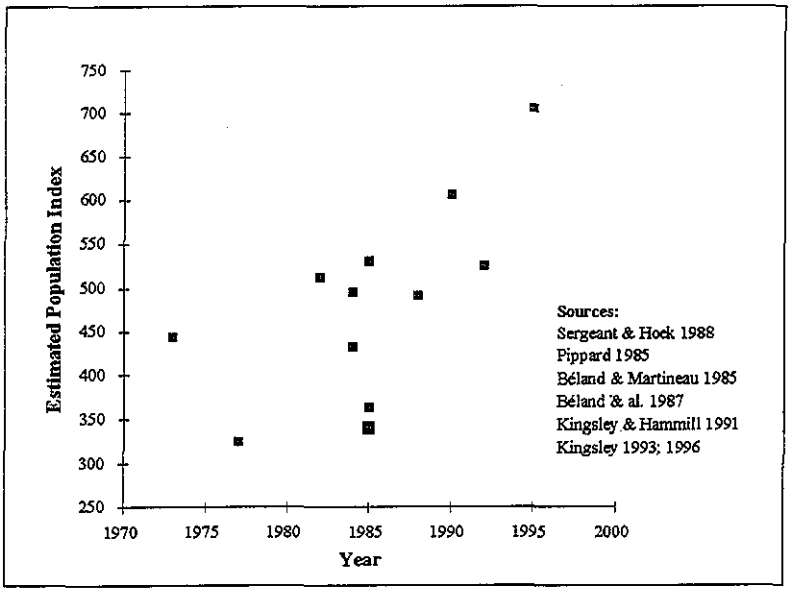

FIGURE 3. Population index estimates for the St Lawrence Belugas, 1973-1995.

are different, and no similar work has been done here.

Béland and Martineau (1985) deduced (from three data points) that the population declined at 6%/year from 1963 to 1985, but the current population size is very different from their prediction, and survey results in the 1980s and 1990s have consistently failed to support the thesis of a declining population. In the absence of resource limitations, a zero growth rate is intrinsically unlikely, and all current evidence, from birth-rates, age at death, and survey data, suggest an increasing trend (Kingsley 1996). A longer series of surveys will help to establish an unarguable past trend for the index; current trend may, however, remain uncertain.

In an attempt to generate more immediate information on growth rates, Béland et al. (1988) developed an age structured population model. Age-specific birth rates were obtained from Alaskan data (Burns and Seaman 1985), and mortality rates from the ages of beach-cast St Lawrence Belugas; animals were assumed to turn white at maturity. They concluded that the limit between an increasing and a decreasing population occurred when the population contained 28 to 30% grey animals (excluding young of the year). Recent observations of the fraction of grey animals in the population vary from 29 to 32% (Michaud 1993b; Desrosiers 1994), and suggest that the St Lawrence Beluga population is not growing fast. However, the effects of the various assumptions in these models were not fully explored and the proportion of grey animals, while a useful index, does not provide a calibrated measure of population growth rate (Kingsley and Hammill 1993). Data from different populations cannot be used to calibrate it, as site-specific ecological and hunting pressure can alter fecundity and survivorship schedules (Doidge 1990a). Counts and measurements of short animals on aerial survey film, while imprecise, have suggested that the birth rate may be quite variable from year to year, but is probably not, overall, seriously reduced (Kingsley 1996).

Habitat

Typical Habitat

Belugas inhabit cold waters. The winter distribution of the Beluga generally coincides with 4-8/10 ice cover in areas over the Continental Shelf (Jonkel 1969; Fraker 1979; Finley and Renaud 1980). In summer, they concentrate in the warm, shallow, turbid waters of Arctic river-mouths, but the reasons for this are not understood; suggestions include calving (Sergeant 1973; Finley 1982), breeding (Brodie 1971), feeding (Kleinenberg et al. 1964; Tomilin 1967), or moult (Finley 1982; Finley et al. 1982; St. Aubin and Geraci 1989; Reeves and Mitchell 1989; St. Aubin et al. 1990).

The presence of this Arctic species in the St Lawrence Estuary is favoured by cold, productive waters and seasonal ice cover. A cold, west-bound deep current in mineral-rich Laurentian Channel along the north shore comes against a sill at the confluence of the Saguenay River and the St Lawrence Estuary, creating an upwelling of mineral-rich

waters. This area has strong tidal and set currents and precipitous bottom topography that create frequent ocean fronts and discontinuities, capable of concentrating prey. The lower St Lawrence Estuary is fed by several large freshwater sources: the Saguenay, Betsiamites, aux Outardes, and Manicouagan rivers, some of which could provide additional shallow estuarine summering areas. Upstream of the Saguenay, Belugas find shallower, warmer, and more turbid water, and a pattern of islands that may serve as protection from wind and rough seas.

Areas Intensively or Regularly Frequented

Group pattern and herd composition has been most studied from July through September, but may vary with season (Michaud and Chadenet 1990). About 45% of the animals are typically observed downstream of the Saguenay mouth; they are most often clustered near the head of the Laurentian Channel and along its southern scarp, but the distribution sometimes extends to Pointe au Boisvert on the north shore and St-Simon-sur-Mer on the south shore. Groups of adults may be seen throughout this area, but adults with young tend to be in the upstream part, toward the Saguenay mouth and the south shore (Michaud 1993a; Kingsley 1993, 1996). However, an unusual number of grey juveniles were seen along the north shore between Begeronnes and Les Escoumins throughout the summer of 1994. Another 50% of the population is usually distributed upstream of the Saguenay, where herds usually number less than 30 and include over 30% juveniles (Sergeant 1986; Sergeant and Hoek 1988; Kingsley 1996). Thirteen "highly frequented areas" have been defined upstream of the Saguenay mouth as far as the Île aux Coudres (Michaud 1993a). The remaining 5% of the population may, on average, be found in the Saguenay fjord, usually near its mouth or at Baie Ste-Marguerite. Biological and physico-chemical characteristics of most of the sectors are summarized by Michaud et al. (1990), and behaviours associated with differing habitats are presented in Pippard (1985).

Temporal Variations in Preferred Sectors

There is emerging evidence for short-term seasonal variation in preferred sectors, even within the summering area. It appears from a study conducted during the presumed spawning period of the Herring in the Île-aux-Lièvres region that St Lawrence Belugas may take advantage of resources abundant in specific sectors during short periods of time (Lesage and Kingsley 1995). Belugas may exploit other sectors such as the sandbanks between Isle-Verte and Trois-Pistoles where Herring gather before spawning (Bio-Conseil Inc. 1982) or the Batture aux Alouettes where Capelin spawn between mid-April and mid-May (Parent and Brunel 1976); they are seen in the port of Rivière-du-Loup, but usually only in spring. However, the seasonal movements from spring to fall have not been described in detail.

The intensity with which some sectors are used varies on the longer time scale. Michaud et al. (1990) and Kingsley (1993) recently noted in 1990 to 1992 an increased number of Beluga in the southern portion of the Estuary downstream of Île Verte whereas other sectors, such as the Saguenay River, Tadoussac Bay at the mouth of the Saguenay River, and the Manicouagan banks, which were formerly regularly frequented by Belugas, were less visited. Reasons for the reduced frequentation or desertion of such sectors are difficult to establish and may involve different factors. Disturbance by human activity has been suggested as the reason for the paucity of sightings in Tadoussac Bay, and the 60% reduction in the frequency of passage of Beluga at the mouth of the Saguenay River (Caron and Sergeant 1988). Over-exploitation, or modifications of biological or physico-chemical characteristics of the habitat (temperature, salinity or flow patterns) resulting from hydroelectric development have been suggested as possible reasons for the distributional changes observed in the Manicouagan banks region (Laurin 1982b; Pippard 1985). In gregarious species such as the Beluga, a reduction in the population size may result in the desertion of peripheral range (Brown 1984; Gaston and Lawton 1990). This could also account for other restrictions in distribution, such as reduced occurrence in the Baie des Chaleurs, the lower North Shore, and regions upstream of Île aux Coudres.

Changes in Quality of Habitat

Within the St Lawrence drainage basin, industrialisation, agriculture, and urbanisation have resulted in discharges, both accidental and deliberate, of several pollutants into the St Lawrence and Saguenay rivers and their tributaries. They include mercury, lead, polycyclic aromatic hydrocarbons (PAHs), and a wide range of organochlorines of varying persistence and toxicity; the St Lawrence Beluga Recovery Plan (Bailey and Zinger 1995) reviews the spectrum in detail. Water power is available in large quantities from the rivers running into the Saguenay fjord and the north side of the St Lawrence Estuary, and has attracted industries that have released contaminants. Among them are, or were, chlor-alkali plants (mercury) and aluminium smelters (PAHs). Mirex, a stable organochlorine used as a stabiliser and a pesticide, was produced on the south side of Lake Ontario; PCBs, used as flame retardants, are ubiquitous; so are many pesticides, including DDT. The St Lawrence drains the intensively-farmed land of southwestern Québec, southern Ontario, and parts of the northern United States, and picks up agricultural pesticides. Many of these compounds are toxic; some much more than others.

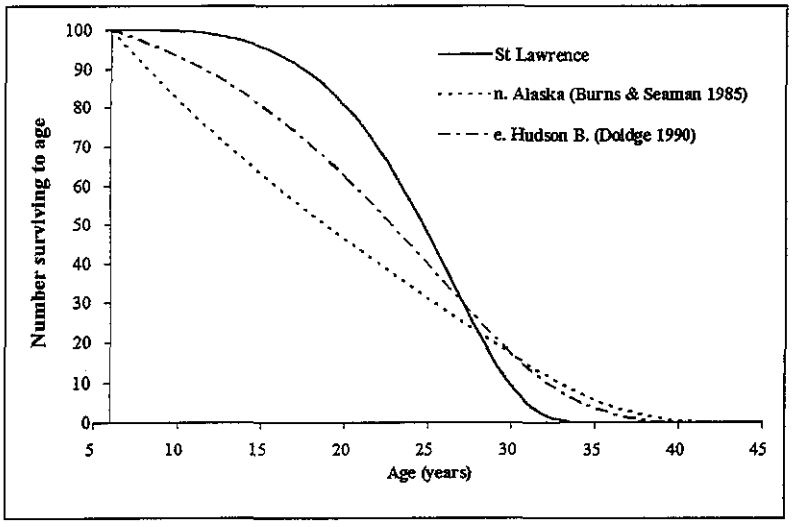

FIGURE 4. Competing-risk curves of adult survival (Siler 1979) fitted to data from beach-cast St LawrenceBeluga carcasses and to hunted samples from Arctic populations.

However, over the last 20 years, habitat quality has improved; to the extent that 70% of the 56 recommendations made in the St Lawrence Beluga Recovery Plan were found to have been anticipated by the government departments responsible (Bailey and Zinger 1995; SLV-2000 1996). The most dangerous OCs, notably PCBs and DDT, are better controlled. Under the St Lawrence Action Plan initiated in 1988, toxic discharges have been reduced and further reductions are targeted as federal and provincial regulations for pulp and paper mills are implemented (SLV-2000 1996). Of 246 admissible Québec riparian municipalities, 126 are now connected to waste water purification plants (Environnement Canada 1993). Contaminant levels have dropped in birds and mammals (Muir et al. 1996b), and at lower trophic levels. Between 1982 and 1992, PCB levels in American Eels (*Anguilla rostrata*), have declined by 68% and Mirex by 56% (Hodson et al. 1994); mercury concentrations in shrimps and Blue Mussels (*Mytilus edulis*) have also declined (Cossa and Desjardins 1984; Cossa and Rondeau 1985; Pelletier et al. 1989); so have organochlorine levels in other faunal elements of the Great Lakes and Gulf of St Lawrence (Environment Canada 1991; Beck et al. 1994).

But marine traffic may also affect the quality of Beluga habitats. The St Lawrence River is an international waterway with a high volume of commercial and recreational ship traffic. In recent years, whale-watching has become an important economic activity. While it is centred in Tadoussac and Baie Ste-Catherine, companies involved in this activity are being established in several communities along the north and the south shores of the Estuary. Although the industry mostly targets Fin (*Balaenoptera physalus*) and Blue (*Balaenoptera musculus*) whales, not Belugas (which are forbidden to it), much of its activity is off Tadoussac Bergeronnes Les Escoumins, where almost half the Beluga population can sometimes be found (Michaud 1993a; Kingsley 1996).

Habitat Protection

The *Fisheries Act*, the *Canada Shipping Act* and the *Canadian Environmental Protection Act* are the principal legislative instruments available to govern the release of toxic substances into aquatic habitats. There is no legislative act which specifically controls marine traffic for the benefit of marine mammals, but the *Marine Mammal Regulations* of the Fisheries Act prohibit deliberate harassment. The *Canada Wildlife Act* authorizes the Minister of the Environment to create National Wildlife Areas, and the *Canada Oceans Act* is expected to permit the creation of Marine Protected Areas; either could be applied to protect cetacean habitats. Guidelines established by the Canadian Department of Fisheries and Oceans have identified critical sectors within the St Lawrence Beluga summer range for boaters to avoid, and in the context of the Management Plan for the Saguenay-St Lawrence Marine Park, additional areas may be considered for protection.

At the provincial level, the Québec *Environmental Quality Act* gives the Minister certain powers to protect the environment in general, and the *Wildlife Conservation and Development Act* establishes zones for the protection of wildlife habitat. The *Watercourses Act* gives the provincial Minister responsible some powers over banks and beds of fresh and marine water-bodies.

General Biology

Reproductive Capability

In Arctic Belugas, females mature sexually between age 4 and 7 years; males, between age 8 and 9. The mating period varies between populations and is thought to occur in the St Lawrence Beluga between April and June. A female usually bears a single calf (Vladykov 1944; Kleinenberg et al. 1964) after 14.5 months' gestation. Births in the St Lawrence generally occur in July and August (Vladykov 1944; Sergeant 1986; Béland et al. 1990; 1992). Lactation, which continues over 20 to 24 months, may partially overlap the following gestation (Vladykov 1944; Brodie 1971; Sergeant 1973; Doidge 1990). The incidence of gestation in sexually mature females suggests a three-year reproductive cycle.

Reproductive parameters of the St Lawrence Beluga are difficult to establish. The examination of reproductive tracts of stranded carcasses suggests that the reproductive rate of St Lawrence Belugas is low: less than 21% of the sexually mature females examined were pregnant or lactating (Béland et al. 1992). However, these animals had all died of disease or old age, and almost 60% (20 of 34) of them were beyond the age at which fertility starts to decline (Burns and Seaman 1985). Modelling of monodontid populations indicates that the gross annual birth rate should be around 9 to 10% (Burns and Seaman 1985; Kingsley 1966). Surveys of neonates of St Lawrence Belugas soon after the calving period produced reproductive rate estimates of 8.1, 9.0 and 9.9%, similar to estimates of birth rate predicted by models, but 31 to 38% lower than in the Arctic (Lynas 1984; Sergeant 1986); however, in a subsequent publication these estimates were revised downward to about 5.5%/year (Sergeant and Hoek 1988). The Arctic rates of 12 to 14% used for comparison may be too large (Kingsley 1996), and estimates of 10% for both the Bering Sea and Cumberland Sound Belugas (Brodie 1967; Burns and Seaman 1985), are much closer to those obtained for the St Lawrence population. The reproductive rate of the St Lawrence Belugas has also more recently been estimated by censusing immature animals soon after the birth period. These estimations, which vary between 12.5 and 32% of the total population size, are similar to, or slightly lower than, those obtained for Arctic populations (Lesage and Kingsley 1995). Neonates and juveniles together compose only about 20% of strandings, possibly indicating a low birth-rate, high juvenile survival, or both (Béland et al. 1988; Bailey and Zinger 1995), but also reflecting sampling bias if they are more apt to sink than the fat adults that compose most of the strandings (Béland et al. 1992).

Survival

Age-specific mortality has been estimated from the age structure of whales that have died from natural causes and have been recovered. However, mortality rates calculated from this sample could be biased, as young animals may be more apt to sink, and may be under-represented (Béland et al. 1987a, 1988). The apparent life expectancy at maturity is about 16 years (Kingsley, unpublished data; Figure 4) equivalent to an average annual adult mortality of about 6.5%; Béland et al. (1992) estimated overall annual mortality at 3 to 4%. Estimates of life expectancy are biased downward, owing to the difficulty of reading the occluded and worn teeth of very old animals (Béland et al. 1987a). Compared with two Arctic populations, there are more Belugas in the St Lawrence population at adult ages up to the late 20s (Figure 4); the Arctic populations appear to live longer as there are in both samples some Belugas in the age range 34 to 38, absent* in the St Lawrence.

Behaviourial Adaptability

Behaviourial responses of Belugas to vessel traffic have been examined in many parts of their range. As expected, their response varies, which may be a function of the degree of exposure, the type of approach and the frequency range of noise generated by passing traffic, and the animal's biological requirements (e.g. feeding, breeding, calving or moulting [Macfarlane 1981; Finley et al. 1982, 1990; Fraker 1983; Pippard 1985; Hazard 1988; Blane 1990; Cosens and Dueck 1993; Lesage 1993]). The animal may thus stay in an area until its threshold of tolerance is reached, leading to an apparent negative response, including desertion of the favoured area (Ford 1977; Brodie 1981; Richardson et al. 1983; Finley 1990; Caron and Smith 1990). Belugas in the St Lawrence Estuary and the Mackenzie River Delta in the Beaufort Sea, areas with the greatest exposure to traffic, appear to be the most tolerant of shipping activity, while Belugas along the ice edge in the high Arctic emit what are presumed to be alarm calls when ships are still 80 km away, and show strong avoidance reactions at 50 km (Finley 1990; Finley et al. 1990). In contrast, Belugas in the St Lawrence Estuary are often seen close to boats, and sometimes show only subtle reactions to perturbation, such as progressive movement away from the track of a vessel, slightly longer dives, and changes in their vocal behaviour (Pippard and Malcolm 1978; Blane 1990; Lesage 1993). However, some vocal changes may also impair communication.

Noise, low frequency vibrations, or human presence may cause damage to the auditory system, induce hormonal or digestive imbalances, or result in

*This observation is liable to be modified by the recovery on 25 May 1996 at Escuminac, New Brunswick of a dead female Beluga, 37+ to 39+ years old (McAlpine and Kingsley, *in preparation*).

reproductive failure (Fletcher and Busnel 1978; Geraci and St. Aubin 1980; Richardson et al. 1983; St. Aubin and Geraci 1988, 1990; Ketten et al. 1993). In addition, humans may negatively affect wildlife through interference with their activity or perception of sound.

Food Habits and Feeding

In an extensive study of the summer food habits of the St Lawrence Beluga in the late 1930s, close to 50 different invertebrate and fish species were identified, including cephalopods and polychaete worms, and fish such as the American Sand Lance (*Ammodytes americanus*), Capelin, and Greenland (*Gadus ogac*) and Atlantic (*Gadus morhua*) Cod (Vladykov 1946). Atlantic Herring, Three-spine Stickleback (*Gasterosteus aculeatus*), Rainbow Smelt (*Osmerus mordax*) and American Eel are also considered potential prey. The winter diet of St Lawrence Belugas is not known. In Alaska, the major part of the Beluga diet is composed of few species, but preferred species vary with the season and habitat, and with the sex and age of the animal (Kleinenberg et al. 1964; Lowry et al. 1985).

Limiting Factors

There is little evidence that any extrinsic factor is currently limiting either the size or growth of this population. We discuss two kinds of potential limiting factor — those that regulate the size of a population, and those that, while not controlling size directly, may limit growth rate of a population or cause its decline.

The population of Belugas in the St Lawrence has been back-calculated, from estimated catches, to have numbered a few thousand in the late 1800s (Reeves and Mitchell 1984), so there should now be a surplus carrying capacity in the habitat. Natural factors limiting the size of Beluga populations are not well known, and habitat changes that would have reduced the carrying capacity have not been identified. Finite food resources, and competition from other species including increasing numbers of seals, have obvious potential to limit populations, but there is no information on whether they are now having an effect (Bailey and Zinger 1995). Interspecific competition could become a serious menace if global warming were to reduce or eliminate winter ice cover in the St Lawrence, as Belugas do not elsewhere live in areas that are ice-free all year. Reduction in the amount of critical habitat, such as the formerly frequented mouths of the Rivière aux Outardes and the Betsiamites River, has been suggested as a limiting factor (Pippard 1985), and ascribed to change in flow regime due to dams. However, critical habitat for the species or this population has not been defined, limiting densities in Arctic estuarine summering areas are higher than any seen in the St Lawrence, and evidence for downstream effects of dams on estuarine habitat for Belugas is equivocal (Bailey and Zinger 1995). In the upper estuary, the population now frequents the same sectors as in 1977 (Pippard and Malcolm 1978; Michaud 1993a; Kingsley 1996) and seems not to be greatly expanding its use of new areas. To continue using these sectors, it has to tolerate increasing levels of noise and human activity. The number of whale-watching companies operating near the Saguenay has increased from 13 to 20, the number of vessels has increased from 22 to 34, and the number of departures has more than doubled (GREMM 1993). Kayak tourism near Baie Ste-Marguerite is also increasing. These activities might limit population size if the areas are critical to reproductively active females.

The growth rate of the population is limited to 4%/year or less by the low reproductive rate (0.16 ♀/♀/year) typical of the species (Innes 1996), and low genetic variability may further reduce it (Patenaude et al. 1994). If marine traffic disturbs females with young, and thereby affects juvenile survival, it might further limit population growth.

Environmental contamination may limit population growth by adversely affecting birth rate or survival (Martineau et al. 1987; Béland et al. 1992). St Lawrence Belugas have higher levels of lead, mercury, and selenium, although less cadmium than most Arctic whales (Wagemann et al. 1990; Béland et al. 1992), and PCB, DDT and Mirex concentrations in males from the St Lawrence are 25, 32 and 100-fold higher than in Arctic males (Muir et al. 1990). Marine mammals acquire contaminants chiefly in food. Marine and estuarine fish in the St Lawrence are not highly contaminated, but American Eels migrating from industrialised areas near the Great Lakes and upper St Lawrence may bring significant quantities of fat-soluble contaminants into the Estuary (Khalil et al. 1985; Lunn et al. 1987; Gagnon et al. 1990; Muir et al. 1990; Cossa 1990; Hickie et al. 1991; Béland et al. 1992; B. E. Hickie, in preparation: Development models for chemical accumulation by Arctic Marine Mammals; *see also* Muir et al. 1996a). However, levels of PCBs in eels (about 6 ppm in 1982) and of Mirex (0.2 ppm) had decreased by factors of 3 to 4 by 1990 (Hodson et al. 1994). Most Belugas so far examined for contaminant burdens were born during the late 1960s and early 1970s, and thus reflect a history of long exposure to high levels of contaminants.

Neonates (0+ years) and juveniles (1 to 5 years) each compose only about 10% of strandings; assuming that the population was stationary, and the stranding rates record unbiased, Béland et al. (1988) concluded from this that the birth rate was much reduced, but partly compensated by high juvenile survival. Reproductive failure has occurred in seals and mink experimentally fed diets high in

organochlorines (Reijnders 1986; Brouwer et al. 1989). However, seals are not cetaceans, and "there are few published data for cetaceans that allow testing of the hypothesis that there are comparable effects" (IWC 1995). The absence of any controlled experimental study in Beluga or other cetacean species of the effect of contaminated diets led Addison (1989) to conclude that the results presented by Martineau et al. (1987) on the St Lawrence Beluga were inconclusive in associating high organochlorine levels with reduced reproductive rates. Dead beach-cast females have lower than normal levels of recent reproductive activity (Béland et al. 1992), but this sample is biased in respect of age and health relative to Belugas alive in the river; in earlier life, ovarian scars accumulate at a normal rate (Sergeant 1986). Direct counts of juveniles in aerial photographs (Kingsley 1996), or of grey juveniles from boats (Michaud 1990), do not show that the overall proportion of young animals is much lower than normal. Stranding or recovery biases could cause a shortage of juveniles in the stranding record.

Necropsies of carcasses found on the shores of the St Lawrence have shown that Belugas usually die of disease and that other causes are rare; ailments of the alimentary canal appear to be the most frequent (Béland et al. 1992). It has been suggested that the population generally suffers from immunosuppression, due to OCs, that results in a high incidence of tumours, multi-systemic lesions, and periodontitis in St Lawrence Belugas, and contributes to the premature death of highly contaminated animals (Béland et al. 1992). This hypothesis merits further investigation; tissue sampling from live-caught animals in the St Lawrence would allow direct evaluation of some aspects of the immune system. Contaminant burdens increase with age (Béland et al. 1993), and the age distribution of stranded carcasses does not show a pattern of early deaths of highly contaminated animals (Sergeant 1986; Béland et al. 1988) as would be expected if organochlorines were having a significant immunosuppressive effect. Instead, the pattern of mortality appears to follow the typical J-shaped mammalian pattern (Caughley 1977). The distribution of ages at death is similar for males and females, although OC levels are 1.5 to 2 times higher in males. Contaminants may be implicated to some extent is some deaths of St Lawrence Belugas, but how many, which ones, or to what extent, is impossible to determine; age at death is on average high, and early death does not seem to be limiting population growth (Figure 4).

In the St Lawrence, collision with ships, or entrapment in fishing-gear are not major causes of mortality. Under a stranding program initiated in 1982, one possible ship strike was reported by Béland et al. (1992); one definite ship strike also occurred in 1995 and one in 1996. Incidental catches of Beluga in gill nets have occurred in the past, but a mail survey conducted during 1989 and 1990 did not report any incidental catches of Beluga in recent years (Fontaine 1992). Belugas have good directional underwater hearing, and a well developed echolocation system capable of functioning in "noisy" environments (Turl 1990); but so have other odontocetes that often get tangled in fishing gear (Au 1993). The low incidence of entrapment observed in St Lawrence Belugas might, therefore, rather be the result of a small fishing industry in this region.

Special Significance of the Species

The St Lawrence Estuary is remarkable for the diversity of its cetacean fauna, to which the presence of an Arctic species at 46° North latitude makes a significant contribution. The white colour of the Beluga, its gregariousness, and its estuarine habits make it highly visible, and a popular tourist attraction. The uncertain future of this population has made it a symbol of the condition of the St Lawrence River. The impact of these factors is all the greater because the presence of Belugas in North American aquaria and oceanaria has made this playful and perpetually "smiling" whale known to many people.

Arctic populations have not been affected by environmental problems, but some that, like the St Lawrence population, were heavily hunted for marketable products, remain depleted (Reeves and Mitchell 1989; Richard 1991).

Evaluation

The recent favourable changes in certain indices of population dynamics, notably the proportion of young visible on aerial photography, and the estimated population index, suggest that the population may be recovering. Survival of adults, determined from age at natural death of stranded animals, appears high and stable, and birth rates appear normal. Levels of mortality from predation, stranding, ice entrapment, fishing gear, and hunting seem to be low. There is no evidence of downward trend in population size. Ambient environmental contaminant levels are falling, even if slowly. Finally, active programmes are in place to improve habitat quality by controlling pollution, and by acting against disturbance from shipping and pleasure boats.

However, the population is apparently separated, with little chance of replenishment from or genetic exchange with other groups of Beluga, which places it at increased risk. The maximum natural rates of increase and turnover of the species are low. The population is not large, especially for a large mammal with a low reproductive rate, and the genetic variability of the population appears reduced. Contaminant burdens are high in stranded carcasses; if this implies high levels in the living population, they may be continually under physiological stress.

Habitat quality, especially in summer, is moderate; it is downstream of a highly industrialised and intensively farmed area. It is also subject to heavy marine traffic. The whole population is concentrated in a small area of the Estuary in summer, so all its members run the same risks.

"Endangered" status is applied to populations or species that are in **imminent danger of extinction or extirpation**. The existing status of "Endangered" was based upon Pippard's (1985) evaluation that the size of the population was 300 to 350 in 1977, that it was declining, and had been for some time. Whether owing to improved survey methods or to a real change in the size of the population, recent estimates both of indices and of population trend are more encouraging: the smoothed estimate of a conservative population index is 650 animals[2]; and two decades of research have failed to show any evidence of decline. We conclude from our analysis that the population is *not in imminent danger* of extinction and a status of "Endangered" is not justified.

However, population remains vulnerable, owing to its small size, reduced genetic variability, and exposure to marine traffic and environmental contamination. Additional, and perhaps the most serious, vulnerability factors for these Belugas are their isolation from their conspecifics and their restriction to a small summer range. A suitable status for this population is *"Threatened": it may become endangered if the factors that threatened it are not reversed*. Factors, in particular, that are critical are: the size the population; the rebuilding of populations in Labrador, Hudson Strait and West Greenland; and further improvement in the environmental protection accorded to Beluga habitat in the St Lawrence. We recommend that the status of "Threatened" be accorded, on account of low numbers, low genetic variability, isolation, small area of summer occupancy, and environmental circumstances.

Acknowledgments

We thank the reviewers, W. D. Doidge, D. E. Gaskin, M. Hammill, J. Lien, R. R. Reeves and G. B. Stenson, for the improvements they suggested. Financial support for V. Lesage was provided by the Canadian Department of Fisheries and Oceans through the St Lawrence Action Plan.

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[2]Note added in proof: the most recent survey (in August 1997) produced a smothed index estimate of about 690.

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Accepted 7 July 1997