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# EFFECTS OF DREDGING ACTIVITIES ON ST. LAWRENCE BELUGA AND THEIR HABITAT

## Context

The Fisheries Protection Program of the Department of Fisheries and Oceans regularly receives requests to review maintenance dredging and at-sea disposal of dredged sediment for wharves located in the Beluga distribution range in the St. Lawrence Estuary (SLE).

This Science Advisory Report stems from a request that the Regional Ecosystems Management Branch (REMB) submitted to the Regional Science Branch. This branch prepared a Science Advisory Report in 2002: Programme décennal de dragage d'entretien au quai de Rivière-du-Loup – Questions relatives aux effets sur le béluga de l'estuaire du Saint-Laurent. Since our knowledge of the Beluga and its status have changed since 2002, the REMB would like to verify the following:

1. Is the SAR the Science Branch prepared in 2002 still valid for wharf repairs and dredging in Rivière-du-Loup, particularly for aspects related to the identified impacts and mitigation measures proposed?

   *Dredging should not be permitted in April, May or June. Work should begin in early July and continue intensively (night and day, 7 days a week) to ensure that it is completed before the end of July or by mid-August at the latest.*

   a. Is there new information on the potential effects of dredging (including at-sea disposal of dredged sediment) on the Beluga?

   b. Are new mitigation measures recommended at the site of the dredging and at-sea disposal of dredged sediment in Rivière-du-Loup?

   c. If the work is being performed outside periods when food resources are at their peaks (April to June), would it be preferable to advise that work be carried out as quickly as possible or in a way to provide periods of low ambient noise (e.g., work stoppage at night for eight consecutive hours) to provide an auditory rest from the noise, promote physiological recovery and increase the effectiveness of communication, among other things?

2. Could the SAR apply to all dredging and sediment disposal projects carried out in the Beluga's range?

   a. Should different measures apply for dredging work carried out in the distribution range other than the critical habitat?

   b. Should different measures apply for dredging work carried out in the distribution range (outside the critical habitat) during periods when the Estuary is highly used (June to October) compared with similar projects carried out outside this period (November to May)?

The document is structured to provide basic information on the current status of the SLE Beluga population, as well as their biology and ecology. Given the rapid development of research related to effects that onshore and offshore development projects have on marine mammals, a section was prepared to review the mechanisms and expected magnitude of the effects associated with dredging activities with regard to marine mammals and Belugas. Since the request includes aspects specific to recurring dredging areas like Rivière-du-Loup, a section was also added to deal specifically with this area.

This Science Response Report results from the Science Response Process of May 2016 on the Assessment of the effects of dredging activities on St. Lawrence beluga and their habitat.

# Background

## Current status of the SLE Beluga population

There are at least seven Beluga (*Delphinapterus leucas*) populations in Canada. The SLE population is found at the southern-most end of the distribution range of this arctic species. Having been decimated by over-hunting, this population was until recently considered *threatened* by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). However, unusual mortality rates for Beluga calves since 2008 led to a reassessment of this population's status in 2013 (DFO 2014) and the conclusion that after a period of relative stability until the early 2000s, this population has since declined at a rate of 1% per year (Mosnier et al. 2015). The decline in the population, which would now totals approximately 900 individuals, occurred during a period of change in the Gulf of St. Lawrence ecosystem structure and environmental conditions, during which certain contaminants (PBDEs) were elevated in Belugas, exposure to marine traffic and noise was chronic and increased, and there were occasional toxic algae blooms in the SLE (DFO 2014). This new information led COSEWIC to reassess the status of this population in 2014, which has since been considered *endangered* in Canada.

The SLE Beluga population is listed in Schedule 1 of the *Species at Risk Act*. Its critical habitat was identified as corresponding to the area occupied by females accompanied by calves and juveniles from June to October (DFO 2012). This area includes a portion from the Saguenay Fjord to Baie Sainte-Marguerite, the entire upper estuary between Ile-aux-Coudres and the mouth of the Saguenay Fjord, and the southern waters of the lower estuary extending to the east off the coast of Saint-Fabien-sur-Mer. The Rivière-du-Loup area, one of the areas covered by the Science Advisory Report, is therefore part of the habitat designated as critical for SLE Belugas.

# Analysis and Response

## Beluga reproductive cycle and feeding season

The Beluga gives birth to a single calf once every three years after a gestation period of about 15 months (see COSEWIC 2014 for a review). In the St. Lawrence, calving begins in early July and continues until mid-August[1], which suggests that mating takes place in April or May of the

[1] GREMM. 2007. Répartition saisonnière de naissance de bélugas du Saint-Laurent. Unpublished report submitted to the Department of Fisheries and Oceans Canada, July 2007. 8 p. *Unpublished.*

previous year. At that time of year, Belugas begin returning to the SLE (see Mosnier et al. 2010 for a review). The calf accompanies its mother for over two years and feeds exclusively on the mother's milk for at least the first year (Brodie 1971; Matthews and Ferguson 2015).

The Beluga fuels its lactation in part with resources built up before birth but also by feeding during the lactation period (Kastelein 1994). Data on Beluga populations in the wild are relatively limited when it comes to documenting the relative importance of accumulated reserves and postnatal feeding in providing the enormous amounts of energy required for lactation. Data obtained in captivity show that food consumption doubles in the final trimester of gestation and quadruples in the first month after birth, before gradually decreasing afterwards (Kastelein 1994). In the St. Lawrence, this intense feeding at the end of the gestation period extends from mid-to-late April to mid-to-late July, and the first month after birth is usually from mid-to-late July to mid-to-late August.

Spring seems to be a time of intense feeding for the Beluga. The literature, though sparse, describes this period as one in which Belugas tend to gain weight (Vladykov 1944; Sergeant and Brodie 1969; Huntington et al. 1999; Breton-Honeyman et al. in press). In the St. Lawrence, for example, hunters noticed the leanness of Belugas in winter, i.e. from November to March, a build-up of fat in May and June, and maintenance of this state during the summer (Casgrain 1873, cited by Vladykov 1944). This period corresponds to the third trimester of gestation in which females' needs grow quickly. Lactation has a high energy cost, and regular feeding by females during this period is likely a major factor in slowing the depletion of the energy reserves they built up before the calf's birth.

## Beluga diet

Information on the SLE Beluga's diet, its seasonal changes, and the changes in its energy needs comes mainly from a study conducted in the 1930s in the Manicouagan Bank and Les Escoumins area (Vladykov 1944, 1946). It indicates a generally varied diet consisting of pelagic and demersal fish, as well as invertebrates such as squid (*Illex Illecebrosus*) and marine worms (*Nereis virens*). The Capelin (*Mallotus villosus*) is the predominant species in the Beluga's June diet, but gradually decreases in favour of Atlantic Cod (*Gadus morhua*) and Sand Lance (*Ammodytes* sp.) in the summer, with the latter being dominant in August and September (Vladykov 1946).

A more recent analysis of the composition of food fragments found in the digestive tracts of Belugas that had been found dead in the St. Lawrence since 1982 confirmed a number of Vladykov's results (1946). This study indicates that the Beluga consumes Sandlance, Atlantic Herring (*Clupea harengus*), Capelin, and several groundfish, such as White Hake (*Urophycis tenuis*), Rockfish (*Sebastes* sp.), and Atlantic and Greenland Cod (*G. ogac*) (Lesage 2014). However, the relative contribution of these species to the Beluga's seasonal diet remains unclear due to the bias in samples from animals that are often ill, which means their stomach contains only traces of food. An independent assessment of their diet, this time based on relationships between certain stable isotopes in Beluga tissue and those in their potential prey, indicates that Sandlance could represent nearly 40% of the summer diet of female St. Lawrence Belugas (Lesage 2014).

## Distribution and use of habitat by the SLE Beluga

The distribution range of the SLE Beluga is about 65% of what it was historically, and it is one of the smallest reported for this species. Although it is centered in the SLE, its extent varies by season. From June to October, areas highly frequented by the Beluga were mapped using two independent approaches (Mosnier et al. 2016; Lemieux-Lefebvre et al. 2012), which converge toward describing a group of areas used in a recurring manner, and distributed in the Saguenay Fjord, across the entire upper estuary, and the upstream third of the lower estuary, both along the north shore and the south shore (Figure 1). Existing data outside of the summer period, though sparse, suggest that the Beluga abandons the upper estuary in the fall and concentrates in the lower estuary and the northwestern portion of the Gulf. However, the proportion of the population occupying the estuary in winter remains uncertain. In spring, distribution appears to be at its maximum, and would extend from at least the Ile-aux-Coudres area in the upper estuary to the northwestern Gulf of St. Lawrence (see Mosnier et al. 2010 for a review).

The seasonal use of the Saguenay Fjord is not well documented, except in the summer when Belugas are observed there on a daily basis (Conversano 2013).

The functions associated with the various high-use areas are not well understood. However, parallels with the distribution of food suggest that they are likely all, but to varying degrees, used for feeding (Mosnier et al. 2010; Mosnier et al. 2016).

### Seasonal use of the Rivière-du-Loup/Cacouna/Île Verte (RCIV) area

The Rivière-du-Loup/Cacouna/Île Verte (RCIV) area is highly used between June and October, mainly by pods of female Belugas accompanied by calves and juveniles (Michaud 1993; Pesca Environnement 2006; Mosnier et al. 2010; Lemieux-Lefebvre et al. 2012; Roy and Simard 2015; Mosnier et al. 2016). This area is part of the critical habitat designated in the recovery strategy for this population (DFO 2012). Indices of vocal activity obtained from a continuous listening station off the coast of Cacouna, which covered a large portion of the RCIV area, show the presence of Belugas in that area both during the day and at night, for the whole period of the study, from June to October 2014 (Roy and Simard 2015). The vocal activity reached its maximum in August (Roy and Simard 2015). Work carried out in the area near the mouth of the Saguenay (Simard et al. 2010) and the Mackenzie Delta in the Arctic (Simard et al. 2014) indicate that this vocal activity is relatively well-correlated with Beluga abundance, despite possible variations due to the type of activity or pod composition (Sjare and Smith 1986). Irregular diurnal observation conducted along the coastal margin of the Gros-Cacouna area for an entire year from 2004 to 2005 corroborates these observations, as they indicate area use are at their maximum and range from 40 to 60% of the observation period between June and September (Pesca Environnement 2006). Combined, these data suggest sustained use of the RCIV area by the Beluga, at least for the period from June to late September.

The period when Belugas abandon the area in the fall, and its relative importance in spring are uncertain, as is the case for most other areas Belugas occupy. The few local data available indicate that the species is present at least from March (Michaud and Chadenet 1990; Boivin and INESL 1990) until late October (Roy and Simard 2015) or November (Pesca Environnement 2006). The temporal change in abundance during these periods varies depending on data sources. For example, indices obtained from intensive observation in the Ile-aux-Lièvres area in May and June suggest sustained use of the sector in May (Lesage and Kingsley 1995), whereas observations made in the coastal margin of Gros-Cacouna, and based on a small observation effort (29 hours in May) detected Belugas in this other sector of the RCIV for only 2% of the observation time (Pesca Environnement 2006). These data suggest that an index obtained from a small sector may not reflect the use of much larger region such as that of RCIV.

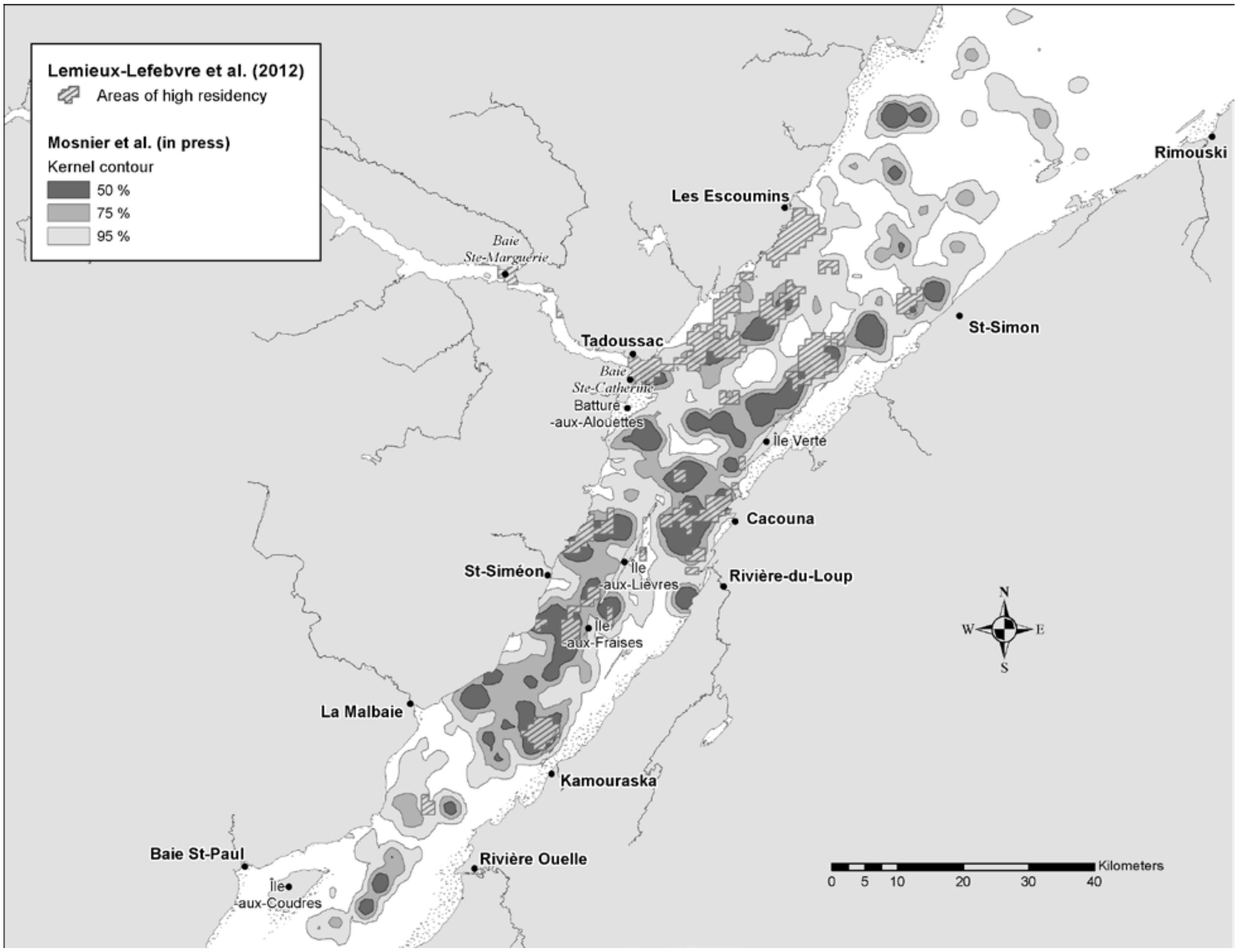


*Figure 1. High-residence areas identified based on longitudinal studies of over 800 Beluga herds conducted between 1993 and 2008 (symbol; Lemieux-Lefebvre et al. 2012), and those containing 50, 75 and 95% of the Beluga population, respectively, as defined by the kernel method applied to the results of 35 systematic aerial surveys conducted from 1990 to 2009 (Mosnier et al. 2016). Note that sampling attempts upstream of Île-aux-Fraises were minimal in the context of the study by Lemieux-Lefebvre et al. (2012).*

### Function of the Rivière-du-Loup/Cacouna/Île Verte (RCIV) area

The presence of herds of females accompanied by calves and juveniles in the RCIV area suggests that the area is used for rearing and possibly calving, though these events are rarely observed, which makes it difficult to associate a specific area with a specific activity (Mosnier et al. 2010). The presence of Belugas in spring in parallel with spawning periods, the surface behaviour observed among Belugas, and multiple traces on the echo sounder during summer work in the RCIV area all suggest that it is also a feeding area throughout the summer (R. Michaud and V. Lesage, unpublished data; S. Lemieux-Lefebvre, doctoral thesis in progress).

A particularly high abundance of Sandlance in the area off the coast of Rivière-du-Loup was confirmed by recent work (Mosnier et al. 2016). This species is likely one of the RCIV's main attractions for Belugas, especially in mid and late summer, as it forms a large part of their diet (Vladykov 1946; Lesage 2014).

During the spring period of rapid weight gain, the RCIV area seems to be a particularly important foraging area. Capelin, smelt and herring, all potential prey of the SLE Beluga (Vladykov 1946; Lesage 2014), spawn between April and late May in the estuary, at known sites in the RCIV area:

- Capelin spawning begins around mid-April, starting earlier along the south shore (downstream of Rivière-Ouelle) than along the north shore (Parent and Brunel 1976).
- Smelt spawning occurs in the Rivière-Ouelle and Kamouraska areas (Fouquette River) in late April or early May, and is followed by the dispersal of adults in the upper estuary in the RCIV area (Ouellet and Dodson 1985a, 1985b).
- Herring migrate from the gulf to the upper estuary in early May (Gagnon and Leclerc 1981) and spawn about two weeks later (Munro et al. 1998). Work done by Auger and Powles (1980); Bio-Conseil (1982) and Fortier and Gagné (1990) documenting the emergence of large quantities of herring larvae in the upper estuary highlight the importance of this species in the region in the spring. Evidence suggests that spawning occurs the day after the first neap tide in May. Egg hatching would be occurring about 20 days later (Munro et al. 1998). A population that spawns in the spring, called the "Île Verte population," inhabits the RCIV area around spawning season, while spawning itself appears to take place at the western tip of Île-aux-Lièvres (Munro et al. 1998).

Around the Rivière-du-Loup wharf area, increased observation of Belugas in spring is a recurring phenomenon reported by ferry operators (e.g., Vachon et al. 2001; ROMM, Rivière-du-Loup, unpublished data).

Munro et al. (1998) report having hydroacoustically detected Belugas among groups of spawning herring along Île-aux-Lièvres, off the coast of Rivière-du-Loup. This anecdotal report is corroborated by a study indicating that Beluga numbers are two to eight times higher in this sector between May 20 and 31 than between June 2 and 12—approximately 80 to 100 individuals—and that these high Beluga densities persisted throughout the day in May (Lesage and Kingsley 1995). However, the presence of spawning activity and the abundance of Belugas in the Île-aux-Lièvres area in May and June seems to vary from year to year (Bédard et al. 1997; Lesage and Kingsley 1995; Munro et al. 1998; Société Duvetnor 2001).

Furthermore, there is a correlation between a negative change in the dynamic of the Beluga population with a transition to a period characterized by a negative, persistent anomaly in the biomass of large groundfish and spring herring stock in NAFO division 4T, which is thought to supply the estuary. This correlation supports the hypothesis that spring herring are an important part of the SLE Beluga's diet (Plourde et al. 2014).

## Magnitude and mechanisms of effects from dredging activities

Dredging activities can affect marine mammals, including Belugas, in a number of ways (DFO 2010; Todd et al. 2015). Removal of sediment can modify the structure of the marine floor and have repercussions on the structure of communities and habitat, in addition to returning contaminants to suspension. Sediment disposal could also change the marine floor structure, destroying existing communities by capping them. The noise generated by machinery during operations could directly affect Belugas by polluting their acoustic environment and disrupting their normal behaviour, or indirectly affect them by influencing the behaviour of their prey and potentially making them less available. The presence of platforms, barges and towing vessels could increase the risk of collision. However, this risk is considered low, given the low speed of vessels carrying out dredging operations, aside from those used to transport workers (Todd et al. 2015).

If the benthos is disturbed through sediment removal or disposal, prey that might be affected include the Sandlance in particular, since it seems to be abundant in soft-bottom areas (Mosnier et al. 2016). Other Beluga prey, such as herring, capelin and smelt, are also of concern for dredging activities, as they are all likely to be found in the RCIV area, at least in spring, and because they spawn in specific bottom areas, as well as in other areas of the estuary and the Beluga critical habitat (Marchand et al. 1999; Simard et al. 2002).

### Sediment disturbance

According to Morton (1977), dredging and dumping of dredged material could have a major negative impact on benthic communities, as most of them are relatively immobile. Dredging acts directly on sediment and related biological resources in three ways: 1) by eliminating sediment and associated biological communities on dredging sites; 2) by adding sediment at the dumping site and thus burying biological communities, which might not survive(Hendrick et al. 2016); and 3) by returning sediment to suspension at both sites (dredging and dumping).

In general (e.g., Newell et al. 1998), the finer the sediment removed, the more quickly the benthic communities inhabiting it can recover. This is because fine sediment is often disturbed and communities associated with such sediment are better adapted to occasional disturbances, exhibiting quicker colonization and dispersal. This means that marine mud can be recolonized fairly quickly by vagrant species, including Nereid worms, due to the effects of dredging (i.e. within weeks or months, as per McCauley et al. 1977). Conversely, communities in areas with sand and coarser sediment can take years or even decades to recover. For example, Harvey et al. (1998) suggest that sand dumping sites in Anse-à-Beaufils, Quebec, take over two years to recover. Moreover, dredging can remove finer surface sediment, leaving behind coarser sediment that is harder to locally colonize.

Dredging can also change the hydrodynamics of currents, such that slower current speeds may increase the deposition of muddy sediment on sandy sediment (Kaplan et al. 1975). These two situations can also affect the availability of benthic invertebrates for Belugas. Changes to the physical benthic environment caused by dredging and dumping of dredging material can therefore indirectly affect cetaceans. For example, Allen et al. (2001) suggest that Bottlenose Dolphins (*Tursiops truncatus*) can use structural features, such as dredging canals or mounds of dredging material, to help them capture their prey.

The indirect effects of dredging can also include increased turbidity related to dredged sediment being returned to suspension and the disposal of sediment in marine dump sites. For example, McCauley et al. (1997) suggest that benthic communities adjacent to dredging sites are also affected by dredging activities because sediments are returned to suspension. Furthermore, contaminated sediments returned to suspension considerably reduce the recruitment of certain epifaunal sessile filter feeders (Knott et al. 2009), which could have unforeseen indirect effects on benthic communities. Contaminated sediment returned to suspension can also reduce the quality of filter feeders and other benthic organisms that ingest or assimilate toxic elements in that sediment. These toxic elements can also have unforeseen effects higher up the food chain.

Given that Belugas, like other marine mammals (see Todd et al. 2015), navigate and detect their prey and conspecifics mainly through passive listening or emitted sounds (Richardson et al. 1995; Southall et al. 2007), they do not seem very vulnerable to the direct effects of a sudden increase in water turbidity.

However, such a change could still affect the Beluga indirectly and in the short term—for example, by affecting the distribution of its prey, which could avoid areas with a great deal of suspended matter because of the effects on their vision. There could also be more long-term indirect effects on Belugas if, for example, dredging activities affect the local availability of their prey by reducing their ability to spawn or by affecting the survival of eggs or larvae. An assessment of the effects of increased local turbidity on the aggregation or dispersion patterns of prey, or on the spawning and survival of eggs or larvae, could probably be more illuminating as to the possible effects of dredging on Belugas.

### Noise

Noise generated by anthropogenic activities such as dredging can affect Belugas by hindering their normal behaviour (NRC 2005; Southall et al. 2007; Clark et al. 2009; Ellison et al. 2012). Because the noise levels associated with dredging are fairly high and cover a wide frequency band (de Jong et al. 2010; Robinson et al. 2011; Reine et al. 2014), including the main band Belugas use for communication (e.g., Sjare and Smith 1986; Roy and Simard 2015; Le Bot et al. in press), and because of how well noise spreads in water, dredging activities can be heard by Belugas many kilometres away. Although damage to the auditory system of Belugas caused by dredging is not considered likely or possible, due to the non-impulsive nature and level of sounds generated (Southall et al. 2007), behavioural effects are considered a likely result of such activities. The direct and indirect effects of noise can manifest in marine mammals in different ways, from complete abandonment of an area for more or less prolonged periods of time, to more subtle disruptions in diving or breathing patterns, in swimming speed or direction, in pod cohesion, or in the effectiveness of Beluga communication, navigation, hunting, or detection of predators and threats (Richardson et al. 1995; Southall et al. 2007; Clark et al. 2009; Nowacek 2007; Ellison et al. 2012; Pirotta et al. 2012; 2013; 2015; Todd et al. 2015).

Of course, the extent of these effects on individuals and populations is directly linked to the duration of the disturbance of normal behaviour (e.g., King et al. 2015) and to individuals' motivation to continue using the noise-saturated area as a result of its importance to their vital functions (Ellison et al. 2012; Pirotta et al. 2013). The existence of nearby habitat of equivalent quality and sufficient quantity may make the impacts of an avoidance of the area of activity negligible for the individuals' health. Conversely, a lack of avoidance does not necessarily mean a lack of effects (Gill et al. 2001); persistent use of a noise-saturated area out of necessity could have harmful physiological affects due to stress (Wright et al. 2007; Rolland et al. 2012) or reduced effectiveness of feeding (e.g., Aguilar Soto 2006; Pirotta et al. 2012, 2015) or communication (e.g., Clark et al. 2009; Hatch et al. 2012; Gervaise et al. 2012) if they are crucial for vital functions such as feeding, reproduction or maintenance of social bonds (e.g., between mother and calf).

The parameters allowing the likely effects of an activity to be estimated (King et al. 2015) include the following: total duration of planned operations, an opportunity for the animals to return to the noise-saturated areas, the time they need to return after scaring, the relative importance of the period and area affected by these activities when it comes to vital functions, and the thresholds at which these are compromised.

An activity could also have longer-term effects, such as the complete abandonment of an area. In general, activities that provoke such reactions lead to profound, persistent changes in a habitat. For example, the abandonment of Tadoussac Bay and the Manicouagan Bank by SLE Belugas could have been the result of a change in the quality of these habitats (increased vessel traffic in Tadoussac and a change in physicochemical and biological properties, i.e. availability of prey in Manicouagan due to the river dam) (Pippard 1985; Caron and Sergeant 1988; see also Lesage and Kingsley 1998). Complete abandonment of a regularly used area, following dredging and as a result of increased marine traffic, has been observed in Pacific Grey Whales (Bryant et al. 1984).

# Conclusions

The following should be considered when assessing the possible effects of dredging activities:

- The two vital functions that could be affected by dredging are feeding (for all age groups), and calving and rearing of young by females. The most likely and worrisome effects are disruption of normal Beluga behaviour due to noise and changes in local availability of prey due to sediment disturbance. It is very unlikely that Belugas would suffer from collisions or auditory damage due to dredging operations or sediment disposal, regardless of where they take place in its range.
- Spring, from April to June, is a period of weight gain for Belugas of all age groups, and it is likely a crucial part of their life cycle. This is especially true for pregnant females who must meet the increased requirements for lactation in the subsequent months. Summer is a period of regular feeding on abundant resources for all Beluga age groups and sexes. According to the available data, there is no particular decline in feeding during the period extending from April to September.
- Areas of high residency or concentration, shown in Figure 1, are very likely used for feeding, although to varying degrees. The RCIV area seems particularly favoured for spring feeding, and include a sector of particularly high abundance of Sandlance, a species that seems to form a crucial part of the Beluga diet in this area later in the summer.
- The period from April to May is also when mating occurs, and this important vital function likely depends greatly on the ability to communicate effectively over distances of many kilometres.
- Calving begins in early July and continues until mid-August. During this period and the months that follow, females are therefore accompanied by young who have difficulty swimming; the risk of separation and the need to maintain this link can be a source of stress for female–calf pairs.

The relative importance of the two effects (effects of noise on Belugas and of sediment resuspension on prey availability) in the overall assessment of problems associated with dredging activities depends on the area and local topography, the water column structure, the type of floor in the surrounding area, the proximity of other areas used by Belugas (Figure 1), and the types of herds that use them.

There is also a risk of increased contamination of Belugas if contaminants are remobilized and ingested by their prey. The scope of this potential problem depends on how important benthic and epibenthic species are in the Beluga's diet, their level of contamination, and the level of sediment contamination. These risks are not easy to assess.

## Dredging in the RCIV area

Dredging and sediment disposal work, if carried out in the RCIV area or any other Beluga critical habitat, pose a risk mainly to the most vulnerable part of the population: females accompanied by calves and juveniles. The disrupted functions likely include feeding, but also calving and rearing of young. Prey at risk of being affected in the RCIV area include herring, sandlance, capelin and smelt, as well as benthic and demersal species. For other areas, our information on prey distribution is too fragmented to produce a complete picture of each resource that might be affected in each area in the context of this report.

The previous report recommended that no work be carried out in April, May and June, and that we ensure work is completed before the end of July or, at the latest, mid-August. These recommendations were specific to the RCIV area and were the result of a conflict between the risks associated with performing repeated dredging activities during a crucial period of rapid growth in an area known to support the spawning of several species, and those associated with conducting such dredging work during the calving period in a sector where data on the summer use of the area were still relatively limited. The data acquired after the 2002 report indicate that the RCIV area is used by Belugas in a sustained manner, both during the day and at night, possibly because of the abundance of Sandlance.

This new data makes this conflict between dredging risks in the RCIV area even harder to reconcile and, given the importance of this area for Belugas, their current status and the population trend, it would be highly desirable to conduct dredging work outside of the period of intensive use, i.e. April to late September.

If it is impossible to conduct the dredging work outside of the desired period, we recommend that planning for quiet periods based on the expected duration of the work be explored as an option. The data show that Belugas use the RCIV area during both day and night, though other factors can also dictate their use or activities (e.g., time of day or tides). Consequently, unless the work to be done is brief (a few days), we recommend planning periods of inactivity, alternated so that they are not always at the same time of day or tide.

## Recommended mitigating measures according to area of activity

Based on the newly available information and specific questions from the REMB, we conclude the following:

1. For any locations where work is planned in or near foraging areas (Figure 1), avoiding any work during the spring growth period should be a priority, regardless of whether or not dredging is taking place in critical habitat.
2. For any locations in which dredging activities are planned near foraging areas, or if they are near locations that allow Belugas to access foraging areas (the mouth of the Saguenay, for example), a risk analysis for noise, obstruction of the free movement of Belugas, and changes in the behaviour of their prey should be conducted. It is recommended that the local topography and coastal configuration be examined to determine the relative risks associated with noise and extraction/disposal of sediment. In cases where sediment extraction/disposal are unlikely to disrupt food resources (as is likely the case, for example, at the mouth of the Saguenay), it is recommended that the work be conducted such that it does not disrupt the calving period. If it is likely that the food resource will be disrupted, it is recommended that the work be postponed outside the sensitive period, namely after September.
3. If there is no foraging areas nearby, it is recommended that any work in the critical habitat be carried out before the calving period, or after September. If the work is conducted outside of critical habitat, the above restrictions could be ignored.
4. In all cases where work is planned near the areas identified in Figure 1, it is recommended that the need for quiet periods be assessed, especially if work is to be conducted over several weeks.
5. In the perspective of minimizing potential impacts on Belugas, a sediment disposal site on land would be desirable. This way, losses of habitat as a result of capping would be avoided. However, a disposal site on land would not eliminate or reduce the potential loss of

habitat at the dredging site, the likely disturbance of Beluga or beluga food resources through the increase in the amount of suspended solids.

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## References

Aguilar Soto, N., Johnson, M., Madsen, P.T., Tyack, P.L., Bocconcelli, A., Borsani, J.F. 2006. Does intense ship noise disrupt foraging in deep diving Cuvier's beaked whales (*Ziphius cavirostris*)? *Mar. Mamm. Sci.* 22. 690–9.

Allen, M.C., Read, A.J., Gaudet, J., Sayigh, L.S. 2001. Fine-scale habitat selection of foraging bottlenose dolphins *Tursiops truncatus* near Clearwater, Florida. *Mar. Ecol. Prog. Ser.* 222: 253–64.

Auger, F., Powles, H. 1980. Estimation of the herring spawning biomass near Isle Verte in the St. Lawrence estuary from an intensive larval survey in 1979. DFO CAFSAC working paper 1980/12: 31 p.

Bédard, J., Nadeau, A., Savard, J.P.L., Kingsley, M.C.S. 1997. La passe de l'île aux lièvres : importance stratégique pour la faune marine de l'estuaire. *Série de rapp. tech.* no. 283, Canadian Wildlife Service, Quebec Region: x + 86 p.

Bio-Conseil Inc. 1982. Évaluation des frayères de hareng (*Clupea harengus L.*) sur la rive sud du Saint-Laurent. Handwritten report submitted to the Department of Fisheries and Oceans Canada, Fishery Science Division, March 1982: 64 p.

Boivin, Y. and INESL. 1990. Survols aériens pour l'estimation de la distribution saisonnière et des déplacements des bélugas. Unpublished report prepared by INESL, Montréal, Quebec. 91 p. Available at: Institut National d'Écotoxicologie du Saint-Laurent, 5040 Mentana, Montréal, QC, CAN. H2J 3C3.

Breton-Honeyman, K., Hammill, M., Furgal, C., Hickie, B. 2016. Inuit knowledge of beluga whales (*Delphinapterus leucas*) foraging ecology in Nunavik (Arctic Quebec), Canada. *Can. J. Zool.* In press.

Brodie, P.F. 1971. A reconsideration of aspects of growth, reproduction and behaviour of the white whale (*Delphinapterus leucas*), with reference to the Cumberland Sound, Baffin Island, population. *J. Fish. Res. Bd Can.* 28: 1309–18.

Bryant, P.J., Lafferty, C.M., Lafferty, S.K. 1984. Reoccupation of Laguna Guerrero Negro, Baja California, Mexico, by gray whales. pp. 375–87. In: Jones, M.L., Swartz, S.L., Leatherwood, S. (eds). The Gray Whale, *Eschrichtius robustus*. Academic Press, Orlando, FL. 600 p.

Caron, L., Sergeant, D.E. 1988. Yearly variation in the frequency of passage of beluga whales (*Delphinapterus leucas*) at the mouth of the Saguenay river, Quebec, over the past decade. *Natur. Can. (Rev. Ecol. Syst.)* 115: 111–6.

Clark, C., Ellison, W.T., Southall, B.L., Hatch, L., Van Parij, S., Frankel, A.S., Ponirakis, D. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. *Mar. Ecol. Prog. Ser.* 395: 201–22.

Conversano, M. 2013. Utilisation d'un habitat particulier par le béluga (*Delphinapterus leucas*) du Saint-Laurent: fréquentation interannuelle, saisonnière, circadienne et tidale de l'embouchure du Saguenay. M.Sc. thesis. ISMER, Université du Québec à Rimouski. xxx + 191 p.

COSEWIC. 2014. COSEWIC assessment and status report on the Beluga Whale *Delphinapterus leucas*, St. Lawrence Estuary population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 64 pp.

De Jong, C., Ainslie, M., Dreschler, J., Jansen, E., Heemskerk, E., Groen, W. 2010. Underwater noise of trailing suction hopper dredgers at Maasvlakte 2: Analysis of source level and background noise. TNO report TNO-DV-2010 C335, The Hague, The Netherlands.

DFO. 2010. Dredging effect mechanisms. (consulted on April 19, 2016).

DFO. 2012. Recovery Strategy for the beluga whale (*Delphinapterus leucas*) St. Lawrence Estuary population in Canada. *Species at Risk Act* Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. 88 pp + X pp.

DFO. 2014. Status of beluga (*Delphinaterus leucas*) in the St. Lawrence River estuary. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2013/076.

Ellison, W.T., Southall, B.L., Clark, C.W., Frankel, A.S. 2012. A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. *Conserv. Biol.* 26: 21–8.

Fortier, L., Gagné, J. 1990. Larval herring (*Clupea harengus*) dispersion, growth, and survival in the St. Lawrence estuary: match/mismatch or membership/vagrancy. *Can. J. Fish. Aquat. Sci.* 47: 1898–912.

Gagnon, M., Leclerc, J. 1981. Estimation de la biomasse de la population de hareng de printemps de l'Isle Verte par échosondage. Prepared by Bio-Conseil Inc. for the Department of Fisheries and Oceans Canada, Quebec Region. 26 p.

Gervaise, C., Simard, Y., Roy, N., Kinda, B., Ménard, N. 2012. Shipping noise in whale habitat: characteristics, sources, budget, and impact on belugas in Saguenay–St. Lawrence Marine Park hub. *J. Acoust. Soc. Am.* 132: 76–89.

Gill, J.A., Norris, K., Sutherland, W.J. 2001. Why behaviour responses may not reflect the population consequences of human disturbance. *Biol. Conserv.* 97: 265–8.

Harvey, M., Gauthier, D., Munro, J. 1998. Temporal changes in the composition and abundance of the macro- benthic invertebrate communities at dredged material disposal sites in the Anse à Beaufils, baie des Chaleurs, eastern Canada. *Mar. Poll. Bull.* 36: 41–55.

Hatch, L.T., Clark, C.W., Van Parijs, S.M., Frankel, A.S., Ponirakis, D.W. 2012. Quantifying loss of acoustic communication space for right whales in and around a U.S. national marine sanctuary. *Conserv. Biol.* 26: 983–94.

Hendrick, V.J., Hutchison, Z.L., Last, K.S. 2016. Sediment burial intolerance of marine macroinvertebrates. *PLOS ONE* 11: e0149114.

Huntington, H.P., and the Communities of Buckland, Elim, Koyuk, Point Lay and Shaktoolik. 1999. Traditional Knowledge of the Ecology of Beluga Whales (*Delphinapterus leucas*) in the Eastern Chukchi and Northern Bering Seas, Alaska. *Arctic* 52: 49–61.

Kaplan, E.H., Welker, J.R., Kraus, M.G., McCourt, S. 1975. Some factors affecting the colonization of a dredged channel. *Mar. Biol.* 32: 193–204. doi: 10.1007/bf00388512

Kastelein, R.A., Ford, J., Berghout, E., Wiepkema, P.R., van Boxsel, M. 1994. Food consumption, growth and reproduction of beluga (*Delphinapterus leucas*) in human care. *Aquat. Mamm.* 20: 81–97.

King, S.L., Schick, R.S., Donovan, C., Booth, C.G., Burgman, M., Thomas, L., Harwood, J. 2015. An interim framework for assessing the population consequences of disturbance. *Methods Ecol. Evol.* doi: 10.1111/2041-210X.12411.

Knott, N.A., Aulbury, J.P., Brown, T.H., Johnston, E.L. 2009. Contemporary ecological threats from historical pollution sources: impacts of large-scale resuspension of contaminated sediments on sessile invertebrate recruitment. *J. Anim. Ecol.* 46: 770–81. doi: 10.1111/j.1365-2664.2009.01679.x

Le Bot, O., Simard, Y., Roy, N., Mars, J.I., and Gervaise, C. 2016. Whistle source levels of free-ranging beluga whales in Saguenay-St.Lawrence marine park. J. Acoust. Soc. Am. 140. Doi: 10.1121/1.4955115.

Lemieux-Lefebvre, S., Michaud, R., Lesage, V., Berteaux, D. 2012. Identifying high residency areas of the threatened St. Lawrence beluga whale from fine-scale movements of individuals and coarse-scale movements of herds. *Mar. Ecol. Prog. Ser.* 450 243–57

Lesage, V., 2014. Trends in the trophic ecology of St. Lawrence beluga (*Delphinapterus leucas*) over the period 1988-2012, based on stable isotope analysis. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/126. iv + 25 p.

Lesage, V., Kingsley, M.C.S. 1995. Bilan des connaissances de la population de bélugas (*Delphinapterus leucas*) du Saint-Laurent. Can. Tech. Rep. Fish. Aquat. Sci. 2041: vii + 44 p.

Lesage, V., Kingsley, M.C.S. 1998. Updated status of the St. Lawrence population of the beluga, *Delphinapterus leucas*. *Can. Fld. Nat.* 112: 98–114.

Marchand, C., Simard, Y., Gratton, Y. 1999. Concentration of capelin in tidal upwelling fronts at the head of the Laurentian Channel in the St. Lawrence Estuary. *Can. J. Fish. Aquat. Sci.* 56: 1832–48.

Matthews, C.J.D., Ferguson, S.H. 2015. Weaning age variation in beluga whales (*Delphinapterus leucas*). *J. Mammal.* 96: 425–37.

McCauley, J.E., Parr, R.A., Hancock, D.R. 1977. Benthic infauna and maintenance dredging: a case study. *Wat. Res.* 11: 233–42.

Michaud, R. 1993. Distribution estivale du béluga du Saint-Laurent, synthèse 1986 à 1992, Can. Tech. Rep. Fish. Aquat. Sci. 1906: vi + 28 p.

Michaud, R., Chadenet, V. 1990. Estimation de la distribution saisonnière et des déplacements des bélugas du Saint-Laurent. Report prepared by the Institut national d'écotoxicologie du Saint-Laurent (INESL) for the Department of Fisheries and Oceans Canada, Quebec Region. 91 p.

Morton, J.W. 1977. Ecological effects of dredging and dredge spoil disposal: A literature review. US Fish and Wildlife Service Technical Papers 94: 1–33.

Mosnier, A., Lesage, V., Gosselin, J.-F., Lemieux Lefebvre, S., Hammill, M. O., Doniol-Valcroze, T. 2010. Information relevant to the documentation of habitat use by St. Lawrence beluga (*Delphinapterus leucas*), and quantification of habitat quality. DFO Can. Sci. Advis. Sec., Res. Doc. 2009/098. iv + 35 p.

Mosnier, A., Doniol-Valcroze, T., Gosselin, J.-F., Lesage, V., Measures, L.M., Hammill, M.O. 2015. Insights into processes of population decline using an integrated population model: The case of the St. Lawrence Estuary beluga (*Delphinapterus leucas*). *Ecol. Model.* 314: 15–31.

Mosnier, A., Larocque, R., Lebeuf, M., Gosselin, J.-F., Dubé, S., Lapointe, V., Lesage, V., Lefaivre, D., Senneville, S., Chion, C. 2016. Définition et caractérisation de l'habitat du béluga du Saint-Laurent selon une approche écosystémique. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/052. vi + 93 p.

Munro, J., Gauthier, D., Gagné, J.A. 1998. Description d'une frayère de hareng *(Clupea harengus* L.) à l'Île aux Lièvres, dans l'estuaire moyen du Saint-Laurent. Can. Tech. Rep. Fish. Aquat. Sci. 2239: 34 p.

Newell, R.C., Seiderer, L.J., Hitchcock, D.R. 1998. The impact of dredging works in coastal waters: a review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed. *Oceanogr. Mar. Biol. Ann. Rev.* 36: 127–78.

Nowacek, D.P., Thorne, L.H., Johnston, D.W., Tyack, P.L. 2007. Responses of cetaceans to anthropogenic noise. *Mammal Rev.* 37: 81–115.

NRC. 2005. Marine mammal populations and ocean noise: determining when noise causes biologically significant effects. The National Academies Press, Washington, D.C. 126 p.

Ouellet, P., Dodson, J.J. 1985a. Tidal exchange of anadromous rainbow smelt (*Osmerus mordax*) larvae between a shallow spawning tributary and the St. Lawrence Estuary. *Can. J. Fish. Aquat. Sci.* 42. 1352–8.

Ouellet, P., Dodson, J.J. 1985b. Dispersion and retention of anadromous rainbow smelt (*Osmerus mordax*) larvae in the middle estuary of the St. Lawrence River. *Can. J. Fish. Aquat. Sci.* 42: 332–41.

Parent, S. and P. Brunel. 1976. Aires et périodes de fraye du capelan (*Mallotus villosus*) dans l'estuaire et le golfe du St-Laurent. Travaux sur les Pêcheries du Québec, no. 45: 46 p.

PESCA Environnement. 2006. Inventaire de mammifères marins dans le secteur de Gros-Cacouna. Prepared for an Énergie Cacouna project. Ref. No.: 05152-1430. 29 p.

Pippard, L. 1985. Patterns of movements of the St. Lawrence white whales. Canadian Wildlife Service and Parks Canada, Quebec. 500 p., two volumes.

Pirotta, E., Milor, R., Quick, N., Moretti, D., Di Marzio, N., Tyack, P., Boyd, I., Hastie, G. 2012. Vessel Noise Affects Beaked Whale Behavior: Results of a Dedicated Acoustic Response Study. *PLOS ONE* 7: e42535.

Pirotta, E., Laesser, B.E., Hardaker, A., Riddoch, N., Marcoux, M., Lusseau, D. 2013. Dredging displaces bottlenose dolphins from an urbanised foraging patch. *Mar. Poll. Bull.* 74: 396–402.

Pirotta, E., Merchant, N.D., Thompson, P.M., Barton, T.R., Lusseau, D. 2015. Quantifying the effect of boat disturbance on bottlenose dolphin foraging activity. *Biol. Conserv.* 181: 82–9.

Plourde, S., Galbraith, P., Lesage, V., Grégoire, F., Bourdage, H., Gosselin, J.-F., McQuinn, I., Scarratt, M. 2014. Ecosystem perspective on changes and anomalies in the Gulf of St. Lawrence: a context in support of the management of the St. Lawrence beluga whale population. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/129. v + 29 p.

Reine, K.J., Clarke, D., Dickerson, C. 2014. Characterization of underwater sounds produced by hydraulic and mechanical dredging operations. *J. Acoust. Soc. Am.* 135: 3280–94.

Richardson, W.J., Greene, C.R., Malme, C.I., Thomson, D.H. 1995. Marine mammals and noise. Academic Press, Toronto. 576 p.

Robinson, S., Theobald, P.D., Hayman, G., Wang, L.S., Lepper, P.A., Humphrey, V. 2011. Measurement of underwater noise arising from marine aggregate dredging operations. Final Report. MEPF Ref No: MEP F 09/P108.

Rolland, R.M., Parks, S.E., Hunt, K.E., Castellote, M., Corkeron, P.J., Nowacek, D.P., Wasser, S.K., Kraus, S.D. 2012. Evidence that ship noise increases stress in right whales. *Proc. Royal Soc. Lond. B: Biol. Sci.* 279: 2363–8.

Roy, N., Simard, Y. 2015. Bruit ambiant et fréquentation de la région de Cacouna par le béluga du Saint-Laurent à l'été 2014 par monitorage acoustique continu. Can. Tech. Rep. Fish. Aquat. Sci. 3141: vi + 22 p.

Sergeant, D.E., Brodie, P.F. 1969. Body Size in White Whales, *Delphinapterus leucas*. *J. Fish. Res. Brd Can.* 26: 2561–80.

Société Duvetnor Ltée. 2001. Caractérisation du comportement alimentaire chez le béluga du Saint-Laurent. Report submitted to the Endangered Species Recovery Fund, World Wildlife Fund 29 p. + appendices.

Simard,Y., Roy, N., Giard, S., Gervaise, C., Conversano, M., Ménard, N. 2010. Estimating whale density from their whistling activity: example with St. Lawrence beluga. *Appl. Acoust.* 71: 1081–6.

Simard, Y., Lavoie, D., Saucier, F.J. 2002. Channel head dynamics: Capelin (*Mallotus villosus*) aggregation in the tidally-driven upwelling system of the Saguenay – St. Lawrence Marine Park's whale feeding ground. *Can. J. Fish. Aquat. Sci.* 59: 197–210.

Simard, Y., Loseto, L., Gautier, S., Roy, N. 2014. Monitoring beluga habitat use and underwater noise levels in the Mackenzie Estuary: Application of passive acoustics in summers 2011 and 2012. *Can. Tech. Rep. Fish. Aquat. Sci.* 3068: vi + 49 p.

Sjare, B., Smith, T.J. 1986. The vocal repertoire of white whales, *Delphinapterus leucas*, summering in Cunningham Inlet, Northwest Territories. *Can. J. Zool.* 64: 2075–80.

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene Jr, C.R., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A., Tyack, P.L. 2007. Marine Mammal Noise Exposure Criteria. *Aquat. Mamm.* 33: 411–521.

Todd, V.L.G., Todd, I.B., Gardiner, J.C., Morrin, E.C.N., MacPherson, N.A., Di Marzio, N.A. Thomsen, F. 2015. A review of impacts of marine dredging activities on marine mammals. *ICES J. Mar. Sci.* 72: 328–40.

Vachon, É., Grenier, W.G., Poulin, D. 2001. Rapport d'activité des saisons 1999 et 2000. Bas-Saint-Laurent Marine Mammals Ecowatch Network (ROMMBSL). Corporation P.A.R.C. Bas-Saint-Laurent, Rivière-du-Loup, QC. 194 p.

Vladykov, V.D. 1944. Studies of aquatic mammals III. Hunting, biology and economic value of the white whale or beluga (*Delphinapterus leucas*) of the St. Lawrence River and Gulf. Department of Fisheries, Québec, QC.

Vladykov, V.D. 1946. Studies of aquatic mammals IV. Food of the white whale or beluga (*Delphinapterus leucas*) of the St. Lawrence River. Department of Fisheries, Québec, QC.

Wright, A.J., Aguilar Soto, N., Baldwin, A.L., Bateson, M., Beale, C.M., Clark, C., Deak, T., Edwards, E.F., Fernàndez, A. Godinho, A., Hatch, L., Kakuschke, A., Lusseau, D., Martineau, D., Romero, L.M., Weilgart, L., Wintle, B., Notarbartolo Di Sciara, G., Martin, V. 2007. Do marine mammals experience stress related to anthropogenic noise? *Int. J. comp. Psychol.* 20: 274–316.

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