IMPACTS OF GEOPHYSICAL SURVEYS AT THE CACOUNA HARBOUR ON THE ST. LAWRENCE BELUGA

Context

Energy East Pipeline Ltd., a subsidiary of TransCanada, proposes to construct and operate a 4 600 km-long pipeline to transport crude oil from Alberta and Saskatchewan to terminals in Quebec and New Brunswick. The terminals include three existing refineries in eastern Canada and two marine terminals, which will be used to export crude oil to international markets. The Cacouna harbour area is one of the project's marine terminals.

In the early summer of 2014, Energy East Pipeline Ltd. plans to submit to the National Energy Board (NEB) a project approval request, including an in-depth study of the environmental and socio-economic effects associated with the project (ESA). The Proponent submitted a request to DFO's Regional Ecosystems Management Directorate (REMD) to conduct geophysical surveys in the Cacouna harbour area. The objective is to determine the characteristics of the sea floor so that the structures required to establish a terminal in this area can be defined. This information will help TransCanada prepare its NEB application and the ESA.

This Science Response stems from a request that the REMD submitted to the Regional Science Branch. The REMD wishes to obtain further information about the impacts that the project is likely to have on individuals and the St. Lawrence Beluga's survival and recovery. In order to make an informed decision about the project, the REMD is seeking scientific advice in relation to the following questions:

1. Are the estimates provided by the Proponent realistic regarding noise levels generated by the work and the propagation distances?
2. Is the project, as proposed, likely to create significant disturbance for, or have a major impact on, the Beluga?
3. Are the mitigation measures proposed by the Proponent acceptable and sufficient?
4. If necessary, what additional mitigation measures would help reduce the disturbance or impact to make them acceptable?
5. In the event the project causes significant disturbance to the Beluga despite the implementation of additional mitigation measures, is the disturbance likely to jeopardize the St. Lawrence Beluga population's survival or recovery?
6. Are any other marine mammal species likely to be present during the period in question? If so, do the impact assessments and mitigation measures for the Beluga apply to those species?

The REMD requires a prompt response to the above-listed items so that the project (i.e. the geophysical surveys) can start in March if the impacts are deemed acceptable. The request for advice was submitted by the REMD on February 25, 2014.

This Science Response is the result of the March 3, 2014 Science Response Process on the Assessment of the impact of a geophysical survey in the port of Cacouna, Quebec, on St. Lawrence Beluga.

Background

According to the document submitted by the Proponent (CIMA+ 2014) as well as the additional clarifications provided by the REMD, the seismic surveys would be initiated in early March in an area covering at least 28 ha (Part A) and up to 71 ha (Part B with 43 additional ha) "if necessary." The surveys must be conducted under "perfect" conditions, which are not defined in the project proposal that was submitted. According to clarifications obtained from CIMA+ (Y. Maltais, pers. comm., Feb. 26, 2014), 12 to 15 days of "perfect" conditions will be required to complete the project, that is, to cover all of areas A and B. Sea conditions that represent "perfect" conditions may vary depending on the successful contractor, the most restrictive being a wave height of less than 20 cm in order to conduct the surveys (Y. Maltais, CIMA+, pers. comm., February 26, 2014). The work is planned for a time of year when "perfect" conditions are quite rare (March 1 to May 31, 2014) and, as a result, the surveys could take two to four times longer to complete. Thus, one to two months of work can be expected. The survey time could be two to eight hours per day, but the scenario envisioned calls for four to six hours per day according to the clarifications subsequently provided by the Proponent. The surveys will be conducted along a strip extending 600 m from the shore in waters shallower than 30 m, in the vicinity of the Cacouna harbour.

The Proponent plans to use a boomer and sparker to conduct the seismic surveys in order to take soundings of the different soil layers. Sounding lines will be examined twice (once with a sparker and once with a boomer). These two types of devices emit high-intensity pulsed sounds (0-peak: 228 dB and 215 dB re 1µPa @ 1m for the sparker and boomer, respectively). The boomer is of lower intensity than the sparker, but the frequencies at which maximum energy is emitted are higher for the boomer (1–7 kHz) than for the sparker (< 1 kHz).

The Proponent says that the project is likely to affect the Beluga, particularly in April and May, but feels that the mitigation measures (e.g. April–May monitoring, ramp-up and shut-down, etc.) make it possible to move forward.

Analysis and Response

Nature of the probable impacts on marine mammals

Permanent or Temporary Hearing Loss and Distances of Anticipated Impacts

There is sufficient scientific information to conclude that geophysical surveys have a low potential to cause injuries to most marine species unless conducted within close range (review in Southall et al. 2007; Nowacek et al. 2007; NOAA 2013; see also Nowacek et al. 2013).

The latest scientific data used in developing the U.S. government's new standards suggest that sounds received at intensities exceeding 230 $dB_{0\text{-peak}}$ re 1µPa or 204 dB SEL_{cum} re $1µPa^2$-s are likely to cause permanent hearing loss (PTS) in species with maximum hearing at mid-range frequencies such as the Beluga, while those exceeding 224 $dB_{0\text{-peak}}$ re 1µPa and 189 dB SEL_{cum} re $1µPa^2$-s are likely to cause temporary hearing loss (TTS) in such species (NOAA 2013, Table 7, i.e. for cases where an analysis that factors in the hearing frequencies of the targeted species cannot be completed). The Proponent did not provide the at-source values in units that are compatible with the standard for the SEL_{cum} (which should have been dB re 1µPa ^{2}-s @ 1 m). It was therefore impossible to assess the distance at which this threshold would be exceeded.

Probability of St. Lawrence Beluga PTS and TTS

Based on only one (0-peak) of two thresholds that should have been used to determine the risks of Beluga PTS and TTS, the risk of PTS associated with geophysical surveys would be nil because the source does not exceed the impact threshold. It is possible that the source exceeds the SEL_{cum}-based threshold, but this cannot be determined based on the data provided by the Proponent.

The sparker, but not the boomer, exceeds the threshold for temporary hearing impact at the source and therefore has the potential to cause Beluga TTS hearing injuries. The distance from the source at which these risks could occur is the distance where the sound emitted remains above these thresholds. TransCanada did not provide this calculation. DFO therefore had to proceed with its own assessment based on the acoustic data acquired in regards to the sound transmission losses that characterize the area of interest (McQuinn et al. 2011).

This analysis models the reduction in received noise based on the distance from the source for the two sources, the sparker and the boomer, and assuming an at-source intensity of 228 and 215 $dB_{0\text{-}Peak}$ re 1µPa @ 1m, respectively. Again, simulations could not be conducted for the SEL_{cum} because the Proponent did not provide the at-source values in units that are compatible with the standard. The sound reduction (transmission loss: TL) in the Gros-Cacouna area is characterized by:

$$TL = c \log10 (r) + \alpha r,$$

where c = 17.2 and α = 0.00006 (McQuinn et al. 2011). It follows that a pulse emitted by a sparker in the Gros-Cacouna area should fall below the threshold for temporary hearing damage (TTS) at a distance of less than 2 m from the source (Figure 1). While the impact distances could not be calculated using the SEL_{cum}, we can assume that this threshold will be within a few metres of the source and that the work therefore has a low risk of causing temporary Beluga hearing damage unless the Beluga is right near the source.

It should be noted that, according to recent research on marine mammals, the induction of TTS is not perfectly correlated with the intensity of the received noise and that the length of exposure and recovery time between exposures affect the degree of TTS (Mooney et al. 2009; Finneran and Schlundt 2010). The interval and therefore the time the exposed Beluga has to recover between two surveys during the proposed work will range from a few hours to several days, depending on weather conditions. The manner in which these intervals affect the Beluga's hearing recovery is also unknown. These uncertainties related to the intensity of the specific equipment that will be used by the contractor and that associated with the propagation model and stemming from the uncertainty of the water density parameters and environmental conditions at the time of the work, call for the implementation of a safety radius around the operations that is wider than that in which impacts are anticipated.

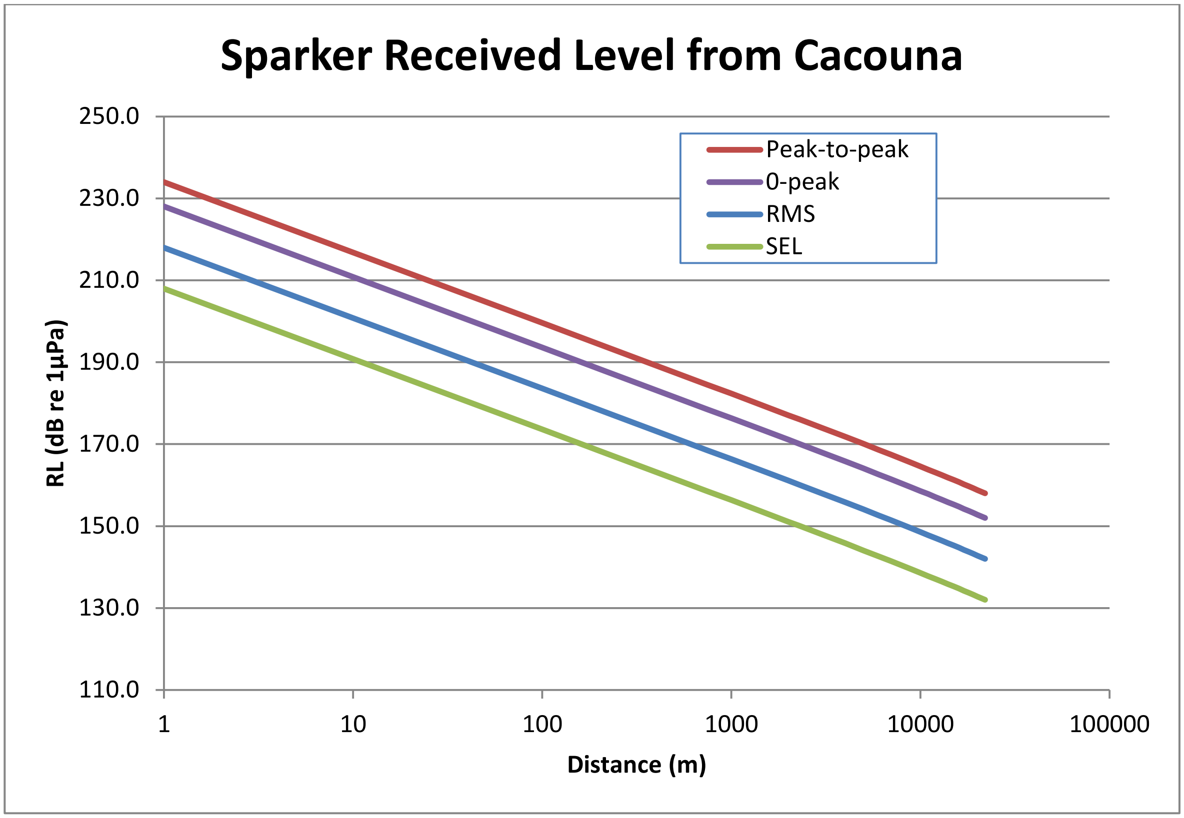

Figure 1. Received sound levels for a source emitting in the Cacouna area (transmission loss TL = c log10 (r) + αr, where c = 17.2 and α = 0.00006; McQuinn et al. 2011) and whose intensity characteristics are similar to those of the proposed sparker (228 $dB_{0\text{-}peak}$ re 1 µPa @ 1 m).

Physiological and behavioural impacts and distances of anticipated impacts

Unlike hearing losses, which are usually the result of exposure to a more isolated, pulsed and high-intensity source, or prolonged or repeated exposure to lower-intensity sounds, behavioural responses primarily occur in response to the physical characteristics of the noise, regardless of the exposure period (Ellison et al. 2012, Götz and Janik 2011).

A multitude of studies on a variety of species and for a variety of noise sources have attempted to address the issue of noise levels capable of causing behavioural responses in marine mammals. Based on the data available in 1999, the U.S. government identified 160 dB re 1µPa (RMS) as the threshold beyond which negative behavioural responses were expected in marine mammals exposed to pulsed noise sources, such as sparkers and boomers. This criterion is still in effect and has been applied in assessing some projects in Canada (e.g. DFO 2012a; 2014a).

All the existing literature indicates, however, that behavioural responses vary greatly between studies (reviews: Southall et al. 2007; Nowacek et al. 2007). This suggests that biological, operational and environmental factors play a role in determining the likelihood and severity of the response, particularly when noises are of relatively low intensity, that is, beneath the 160 dB re 1µPa (RMS) threshold used in cases of pulsed sources (Southall et al. 2007; Ellison et al. 2012). As a result, there is a growing consensus that the likelihood of behavioural impacts should not be determined strictly based on the received level of noise and a dose-response concept (Richardson et al. 1995) without taking into consideration the context of exposure, motivations, the populations' naïveté about the noise source and their habituation (Southall et al. 2007; Ellison et al. 2012).

The use of unique thresholds to infer the risks of behavioural responses (e.g. 160 dB re 1µPa (RMS) in the case of pulsed sources) has been recently criticized by many. There is a growing consensus that these thresholds should be replaced with response probability distributions to give more consideration to the context of exposure and the naïveté of the populations concerned, as well as the fact that some marine mammals engaging in certain behaviours or in specific situations respond to higher or lower exposure thresholds (Southall et al. 2007; Wood et al. 2012; Clark et al. 2013).

It is possible, even likely, that, based on the data that has been acquired about the Beluga and other populations that are naive about certain sources of noise, avoidance is observed at a low exposure to noise (i.e. low received intensity). For example, strong behavioural responses to an approaching icebreaker have been documented for the Lancaster Sound Beluga, whose population is considered to be naive about noise from this source, while the icebreaker was still more than 30 km away. The Beluga deserted the area when the icebreaker passed through and did not return until nearly two days later (Finley et al. 1990). Similarly, research in the western Arctic showed that Beluga densities were lower than expected within 20 km of seismic survey operations and higher than expected in areas 20 to 30 km away from the operations (Miller et al. 2005). These surveys were conducted using airguns, a new source of noise for this population, at an intensity higher than those proposed for the TransCanada work. Based on the area's propagation conditions, these observations suggest that the animals deserted vast areas around the areas of operation and over distances at which the levels of noise received by the Beluga were approximately < 130 dB re 1µPa (RMS) (Clark et al. 2013). These results support the suggestion that the Beluga may exhibit avoidance behaviours in response to received levels of noise that are relatively low in relation to the criteria adopted for pulsed noise sources, i.e. 160 dB re 1µPa (RMS).

In a recent assessment of seismic survey impacts in Californian waters, the approach adopted was based on behavioural response probabilities increasing with the intensity of received noise. The response thresholds were identified as 10% of exposed individuals for received levels of 140 dB re 1µPa (RMS), 50% for levels of 160 dB and 90% for levels of 180 dB (Wood et al. 2012). As noted, when the Beluga were exposed to noise from seismic surveys involving airguns, the levels (and therefore the distances from the source) at which responses were observed were approximately 130 dB re 1µPa (RMS) (Miller et al. 2005) and therefore lower than those considered to be likely to elicit behavioural responses in the Californian assessment.

The St. Lawrence Beluga are regularly exposed to heavy commercial traffic and small craft in their range (Chion et al. 2012) and exhibit low-to-moderate surface and vocal behaviour responses (Lesage et al. 1999; Blane and Jaakson 1994) according to the severity scale established by Southall et al. (2007). The noise sources that will be used during the proposed work are new to this population, of high intensity and at frequencies that overlap with the Beluga's communication frequency (Sjare and Smith 1986; Faucher 1988). These sources must therefore be considered audible and potentially disruptive to this population. The Beluga and other estuarine marine mammals that do not venture outside the Estuary and the Gulf of St. Lawrence, such as the Harbour Seal, are unlikely to have any history of exposure or habituation to boomers and sparkers. Therefore, behavioural responses and avoidance in the Cacouna area are likely to occur during the proposed geophysical surveys within radiuses corresponding to low received levels of noise.

Taking into account a response probability distribution around the threshold of 160 dB_{RMS}, similar to that applied in the Californian assessment (Wood et al. 2012), the modelling that DFO carried out based on the data from the Cacouna area (McQuinn et al. 2011) indicates that the noise generated by the sparker will remain above the probable behavioural impact threshold of 10% of exposed individuals (140 dB_{RMS}) over distances greater than 22 km, while it will remain above the threshold capable of generating negative responses from 50% of exposed individuals (160 dB_{RMS}) over distances of approximately 2.3 km from the source (Figure 1). This same analysis indicates that the noise emitted by a boomer in the Gros-Cacouna area should fall beneath the disturbance thresholds of 160 and 140 dB_{rms} at distances of 400 m and 6 km from the source, respectively.

The St. Lawrence Estuary is approximately 13 km wide at Cacouna, and the area where the Beluga is likely to react negatively to the noise from the geophysical surveys therefore stretches across the entire width of the estuary. The impact distance corresponding to 130 dB_{RMS} has not been extrapolated.

Area usage and seasonal densities

As mentioned in the previous section, the extent of the population impacts is largely determined by the number of individuals who are exposed to the noise source and who are likely to react negatively to the point where their health, reproduction or survival are adversely affected (NRC 2005).

The scientific literature offers information about the presence of the Beluga, seals and other marine mammals in the estuary (review: Lesage et al. 2007) and the Cacouna area and south shore (e.g., Pippard and Malcolm 1978; Béland et al. 1987; Boivin and INESL 1990; Michaud and Chadenet 1990; Michaud et al. 1990; Lavigueur et al. 1993; Michaud 1993; Lesage et al. 2004; Robillard et al. 2005; Lemieux-Lefebvre et al. 2012; Mosnier et al. 2010; Sergeant 1991). However, a number of these studies were conducted during the summer season and therefore do not cover the work period. The marine mammals likely to be present in the Cacouna area between March and May are primarily the Beluga, Harbour Seal, Grey Seal and Harp Seal (mainly in the winter). Other species, such as the Minke Whale and Harbour Porpoise, can occasionally be found in the area but much more rarely.

There are haul-out sites for the Harbour Seal and Grey Seal near the work area, that is, in the southwest channel of Île Verte, on Percé Rock and the reefs of Île Blanche and Île Rouge (see Robillard et al. 2005). These areas are three or more kilometres from the site where the geophysical surveys will be conducted, and their use between March and May is uncertain, as the existing data are highly fragmented and collected over very short periods for this time of year. Nonetheless, they confirm the presence of two species in the area (PESCA Environnement 2006).

The Rivière-du-Loup/Cacouna/Île Verte (RCIV) area is highly frequented by the Beluga between June and October (Michaud 1993; Lemieux-Lefebvre et al. 2012; Mosnier et al. 2010; Mosnier and Gosselin, unpublished data in Lesage et al. 2014) and is part of the Critical Habitat that was identified for the St. Lawrence Beluga in the Recovery Strategy for this population (DFO 2012b). This area is primarily frequented by juveniles and white adults who are accompanied by young, including calves, and who are therefore likely female (Michaud 1993).

The use of the estuary and RCIV area outside of the June–October period is much less well documented. Aerial surveys were conducted by the INESL in March 1998 (Boivin and INESL 1990). No Beluga were counted in the upper estuary, that is, upstream of the Saguenay River, during the two INESL surveys conducted in March 1989, one of which provided systematic coverage of the area (spacing of lines and design not provided) (Boivin and INESL 1990, Figure 5.3). These systematic surveys in the marine area did, however, reveal the Beluga's presence in the lower estuary in March 1989, primarily in the southern part of the estuary, including the Île Verte area (Boivin and INESL 1990, Figure 5.3). The surveys conducted in April, May and June of that same year (one survey per month) indicate that, during those periods, the Beluga are present in the estuary, including the south shore and the RCIV area (Michaud and Chadenet

1990). In March 2005, 25 hours of observations from the shore of the Gros-Cacouna area did not reveal any Beluga presence (PESCA Environnement 2006).

There are only two data sources to document the Beluga's presence in the estuary in April: an aerial survey conducted in 1990 (Michaud and Chadenet 1990) and coastal observations made from Gros-Cacouna for only nine hours in April 2005 (PESCA Environnement 2006). These two studies reveal Beluga presence in the RCIV area.

The Beluga's use of the Gros-Cacouna area in May can be deduced only from the data collected by PESCA Environnement (2006) during the 29 hours of coastal observations made in May 2005. They reveal a Beluga presence, but the observation effort is still not sufficient to derive densities or assess the extent of this area's use in May compared to other times of the year.

In short, while the available data confirm the Beluga's presence in the project area between March and May, they remain too fragmented to provide reliable data on the densities of observed animals and recurrent use of the area.

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

The presence of pods of females accompanied by calves and juveniles in the RCIV area between June and October suggests that the area is used for rearing and possibly calving, although these events are rarely observed, making it difficult to associate a specific area with this activity (Mosnier et al. 2010; DFO 2010). The surface behaviours and presence of multiple echosounder traces during the GREMM's and DFO's work in this area suggest that this is a Beluga feeding area (R. Michaud and V. Lesage, unpublished data; S. Lemieux-Lefebvre, doctoral thesis in preparation).

Little is known about the RCIV area's functions between March and May or the type of pod that frequents the area. However, there are a number of indications that this is a preferred feeding area and that it may be very important to the Beluga's annual life cycle, particularly in May and June.

Despite extensive literature on the ecology and natural history of the Beluga, little is currently known about the seasonal variations in this species' fat accumulation and feeding intensity. In northern Quebec, for example, Hudson Strait hunters report that the hunted Beluga tend to float in the spring (May–June) and sink in the fall (October–November) (K. Breton-Honeyman, doctoral thesis, in press), which suggests a layer of blubber that is thicker in the spring than in the fall. In the Cumberland Sound, female Beluga are particularly fat in late pregnancy or early lactation (Sergeant and Brodie 1969), which suggests that spring and possibly winter are particularly important feeding times for the adult female Beluga. In the St. Lawrence, hunters note that Beluga are thin in the winter, that is, from November to March, but accumulate most of their fat in May and June, gaining 5 to 6 inches (12.7 to 15.2 cm) in blubber in less than 10 days, and that it remains fat during the summer (Casgrain 1873, cited in Vladykov 1944). Hunters also report wide interannual variations in blubber thickness among Beluga who float one year and sink during the same period another year (Vladykov 1944). A study that was conducted during the 1930s and that was based on a small sample suggests that the St. Lawrence Beluga have a thicker layer of blubber in the spring than during the other seasons (Vladykov 1944), which supports the hypothesis that the spring, specifically May and June, or the last months of winter are particularly important feeding periods for this population.

Additional evidence of the importance of spring for the St. Lawrence Beluga's feeding and the RCIV area as a preferred feeding area during that time of year are based in part on Beluga observations made in the Île aux Lièvres area across from Rivière-du-Loup and in part on documentation on spawning grounds of species considered to be potential Beluga prey and the observation of a Beluga population decline that is concurrent with that of certain fish stocks.

Capelin, smelt and herring are considered potential prey of the St. Lawrence Beluga (Vladykov 1946; Lesage 2014). These three species spawn in the estuary in the spring, between April and late May, using 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 (Rivière Fouquette) areas toward late April or early May, after which the adults disperse 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). Evidence suggests that spawning occurs the day after the first neap tide in May. In 2014, this tide is predicted for May 8. A population that spawns in the spring, called the *Île Verte population*, inhabits the RCIV area around spawning season, which appears to take place at the western tip of Île aux Lièvres (Munro et al. 1998).

Munro et al. (1998) reports having detected the Beluga hydro-acoustically using aggregations of herring that were spawning along Île aux Lièvres. This anecdotal report is corroborated by Beluga observations in this area, which indicate that Beluga numbers are two to eight times greater between May 20 and 31 than between June 2 and 12, and that these high Beluga densities are maintained throughout the day in May (Lesage and Kingsley 1995).

Lastly, a study examining the correlation between the observed changes in the Beluga population trend and demographics and those in the various components of the ecosystem supports the hypothesis that spring herring are of special importance to the Beluga. This study notes that the Beluga's transition from a period of relatively stable population dynamics to a more chaotic period characterized by a steady decline in population size since the early 2000s coincides with the shift toward an environmental period characterized by a strong negative biomass anomaly among large groundfish and spring herring from NAFO Division 4T, which are surmised to serve as food in the estuary, as well as particularly warm temperatures and low ice cover (Plourde et al. 2014; DFO 2014b).

Impacts on health, reproduction and survival

The proposed project's impacts on the physical condition, reproduction and survival of exposed individuals depend in part on the individuals' motivation to continue frequenting the noise-exposed area and therefore its importance for completing their life cycle. The existence of nearby habitat of equivalent quality and sufficient quantity may mean that avoidance of the area of activity will have a negligible impact on the individuals' health. The absence of avoidance does not directly translate into an absence of impacts on physical condition or health. Persistence in frequenting an ensonified area out of necessity can have adverse physiological impacts as a result of the stress caused, as documented in the case of Right Whale exposure to recurrent marine traffic (Rolland et al. 2012).

The extent of the impacts on the individuals and ultimately on the populations is also closely linked to the length of time access to an area or a preferred resource is lost (e.g. Harwood et al. 2014). This depends not only on the total duration of the proposed operations but also the animals' opportunity to regain the ensonified areas and the time it takes them to return following a deterrence. The operations will require 12 to 15 days of "perfect" conditions for completion, potentially spreading out over 1 to 2 months with intervals between operations averaging 2 to 4 days.

To determine the likelihood of an activity affecting an individual's physical condition and its ability to reproduce, it is necessary to fully understand a variety of parameters, including the seasonal energy budgets of the species in question or the relative importance of the activity timeframe and area for the completion of the annual cycle and the thresholds beyond which this cycle is compromised (Harwood et al. 2014). In order to extrapolate individual impacts to the population, we need to determine the population's capacity to withstand a reproductive deficiency or increased mortality before its growth is compromised. Such exercises have been recently conducted for a few marine mammal species for which vast data acquisition programs have been maintained for decades (e.g. Thompson et al. 2013a; New et al. 2013).

In the case of the St. Lawrence Beluga, such modelling could be considered, but it could not be completed by DFO as part of this assessment, given the deadlines for reviewing this project's impacts on the population.

Sources of uncertainty

The sources of uncertainty associated with this assessment are due primarily to:

1. Gaps in knowledge about the level of use (densities of individuals) of the RCIV area between March and May, and therefore the number of Beluga exposed to the noise from the operations;
2. Sound levels that will elicit a negative behavioural response leading to avoidance and therefore the Critical Habitat area, which may no longer be able to perform its functions for the Beluga;
3. The length of time Beluga can withstand being deprived of access to food resources before adverse impacts on their physical condition reach the point of affecting their ability to reproduce or survive. This specifically concerns the critical role that May–June feeding practices appear to play in building up the energy reserves needed to complete the annual cycle;
4. The number of Beluga that can withstand these adverse impacts on their condition before the population's recovery is jeopardized. This relates specifically to the context of a population declining at a rate of approximately 1.13% per year (Mosnier et al. 2014);
5. Impacts of the noise generated by the operations on the Beluga's food resources.

Conclusions and advice

The Beluga population has been listed as "threatened" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and appears in Schedule 1 of the *Species at Risk Act* (SARA). The Government of Canada has a duty under this Act to protect this population and prevent the destruction of its Critical Habitat.

The concept of what may constitute "destruction" is provided in the Government of Canada's draft *Species at Risk Act* Policies (2009): "*Destruction is determined on a case by case basis. Destruction would result if part of the critical habitat were degraded, either permanently or temporarily, such that it would not serve its function when needed by the species"* (Environment Canada 2009). Critical habitat is defined as *"the habitat that is necessary for the survival or recovery of a listed wildlife species/population and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species"* (Thornton 2013).

The modelling carried out by DFO indicates that hearing damage is unlikely to occur during the surveys, given the intensity of the sources and prompt reduction of the noise beneath the thresholds where such damage is anticipated. However, the area that could see negative behavioural responses, ranging from subtle behavioural changes to full avoidance, is much vaster, having a radius of 2.3 kilometres to several dozen kilometres from the source, according to the noise thresholds used to predict the risk of responses.

The estuary in the Île aux Lièvres area is characterized by a central chain of islands, which blocks the noise and tends to isolate the north and south channels in this area (Lesage et al. 2014). The Cacouna area, the future survey site, is located downstream of most of these islands, which means that the noise barrier for the lower estuary area will be virtually non-existent. Based on the modelling conducted, the area in which avoidance responses are likely to occur could span the entire width of the estuary and stretch upstream and particularly downstream of the survey site, over more than 20 km (or much further if the response thresholds prove similar to those documented for Beluga exposed to seismic surveys involving airguns (Miller et al. 2005, Wood et al. 2012, see above). Should the noise generated by the surveys cause the Beluga to avoid this area, a large portion of the Beluga's spring habitat would be compromised. It is therefore important to limit the time span of the work and avoid sensitive periods.

We therefore conclude the following:

- Based on the fragmented data available, the Beluga are likely to be observed in the RCIV area throughout the work period, that is, from March 1 to May 31. Beluga density cannot be assessed each month but should be higher in May than in March and April.
- A risk of physical harm (hearing injuries) is associated with the proposed work. This risk is considered low, given the very small radius in which these impacts have the potential to occur and therefore the number of individuals likely to be exposed to it. An effective monitoring program that detects Beluga when they approach the survey site, coupled with a rigorous ramp-up and shut-down procedure (see below), should mitigate this risk and render it negligible.
- The work area likely serves food functions for the Beluga and other marine mammals in the spring, particularly from April to June.
- The area that will be ensonified during the surveys and where the behavioural responses could occur is large compared to the Beluga's summer habitat.
- The work will cause a temporary deterioration of part of the Beluga's Critical Habitat, as it will likely prevent the use of the food resources located there. An area with a radius of 22 km around Cacouna covers approximately 30% of the critical summer habitat. Based on the fragmented data available, which suggest less use of the area in March and April, and considering the short duration of the work (12 to 15 days spread out over 1 to 2 months in March and April), we find that, although concerns remain, the work is unlikely to jeopardize the recovery of the Beluga population. Additional data on the distances at which responses are recorded and the extent of the responses, as well as the Beluga's seasonal use of the area when there is no unusual activity taking place, would make it possible to predict the potential impacts of future activities in this area. These data, coupled with population dynamics modelling, would increase confidence in the conclusions drawn.
- Extending the work beyond April 30, could, however, cause temporary destruction of part of the Beluga's Critical Habitat and therefore violate the SARA, as it would likely prevent the use of food resources in this area during a period that appears to be critical for building up energy reserves and completing the Beluga's annual cycle. Considering the

anticipated numbers of Beluga frequenting the RCIV area in May (Lesage and Kingsley 1995), the ensonification of this area could translate into impacts on the Beluga's health, reproduction and survival, and jeopardize its recovery. Again, the acquisition of data on the area's usage and recorded Beluga responses, coupled with population dynamics modelling, would make it possible to more firmly determine the project's impacts on the population's recovery.

- A Scottish study examining the impact of building an offshore wind farm on the dynamics of Harbour Seal population suggests that it is unlikely that long-term impacts will be incurred by the seal populations frequenting the St. Lawrence Estuary following the proposed work, given its short duration (Thompson et al. 2013a) and the size and growth rate characterizing the Grey Seal (DFO 2011), Harbour Seal (Robillard et al. 2005; Lambert 2012) and Harp Seal (DFO 2005) populations.

Additional mitigation measures

The following mitigation measures are recommended in addition to, or in lieu of, those proposed by the Proponent:

- Geophysical surveys should not be permitted past April 30 or when observing conditions (glare, fog, waves, darkness) do not allow for the Beluga's detection within 2.3 km of the source.
- Given that Beluga densities are expected to increase over the weeks, it is recommended that the operations start with the noisier of the two sources, the sparker, and finish with the boomer. This would reduce the areas and numbers of Beluga affected by the work later in the season.
- A monitoring program that includes aerial AND land components should be implemented as soon as possible and before operations start, in order to document the use of the RCIV area and the project's usage impacts. The aerial component is necessary given the distances at which behavioural and usage impacts are expected. The monitoring should be maintained throughout the work period as well as in the days after the operations end, in order to detect impacts on the area's usage. A system for plotting the pods and groups observed should be planned.
- Observers should have sufficient experience in detecting and monitoring marine mammals. An adequate number of observers should be planned to ensure rotation and constant vigilance.
- A 500-m exclusion zone should be established around the emitting source and continuously monitored for any presence of marine mammals. The operations should be immediately suspended whenever a marine mammal is observed in this zone. This radius is wider than that in which hearing damage is predicted by the model, but it is justified by all of the uncertainties surrounding the noise levels that cause PTS in marine mammals (NOAA 2013), the calculation of distances from the source at which hearing injuries could be inflicted and the expected communication delays between the observers and the vessel conducting the surveys. An effective communication system between the observers and the vessel conducting the surveys is imperative.
- A rigorous procedure for gradually increasing and interrupting noise sources (ramp-ups and shut-downs) must be implemented. The Beluga can move at speeds of up to 22 km h^{-1} (Lemieux-Lefebvre et al. 2012) and dive for up to 19 minutes in the St. Lawrence (S. Lemieux-Lefebvre, doctoral thesis in preparation). The Beluga can therefore travel nearly 750 m in 20 minutes, the time expected between the end of the boomer or sparker's use

and the ramping-up of equipment to full power. If visibility is good (no glare or fog, calm weather), a Beluga approaching the exclusion zone could likely be detected. This timeframe is considered acceptable in light of the operating conditions planned by the Proponent.

- The speed at which the emitting source has to be increased to reach full power also needs to be examined in relation to the Beluga's diving behaviour and speed of movement. The Proponent proposes to gradually increase the emitting source over a 30-minute period after each interruption lasting more than 20 minutes. Given that the Beluga can move more than a kilometre away during this time and that no soft starts are planned while an animal is present in the exclusion zone, we find the risks of injury negligible and this procedure acceptable. However, this procedure's effectiveness in scaring away marine mammals has never been properly tested (Nowacek et al. 2013).
- The addition of an underwater sound detection system for Beluga vocalizations would enable better monitoring of the exclusion zone and the work's area of influence, particularly when light and visibility conditions are less than perfect.
- The data collected during the monitoring should be released so that an assessment can be conducted concerning the quality of the data gathered and analyses performed, and they should be incorporated in the long-term monitoring of the area's usage.

Answers to the REMD's questions

1. Are the estimates provided by the Proponent realistic regarding noise levels generated by the work and the propagation distances?
    - The Proponent did not provide this information. DFO proceeded with its own calculations.
2. Is the project, as proposed, likely to create significant disturbance for, or have a major impact on, the Beluga?
    - Yes, if the work continues after April 30.
3. Are the mitigation measures proposed by the Proponent acceptable and sufficient?
    - Certain measures have been added (see "Additional mitigation measures" section).
4. If necessary, what additional mitigation measures would help reduce the disturbance or impact to make them acceptable?
    - See the "Additional mitigation measures" section.
5. In the event the project causes significant disturbance to the Beluga despite the implementation of additional mitigation measures, is the disturbance likely to jeopardize the St. Lawrence Beluga population's survival or recovery?
    - Yes, if the work continues after April 30.
6. Are any other marine mammal species likely to be present during the period in question? If so, do the impact assessments and mitigation measures for the Beluga apply to those species?
    - The Harbour Seal, Grey Seal and Harp Seal are likely to be present in the area. The same mitigation measures as those for the Beluga can be applied to reduce the potential impacts of the proposed project.

Other considerations

Ensonification of the southern part of the estuary

In a recent Advisory Report concerning the impacts of diverting a portion of the estuary's shipping traffic to the RCIV area, DFO (DFO 2014a) determined that, based on the modelling and robust data for Beluga densities in the various parts of the estuary, an increase in marine traffic in the south area is likely to have adverse or, at best, neutral impacts on the recovery of the St. Lawrence Beluga. This Advisory Report also stipulates that maintaining or concentrating the commercial traffic as much as possible in the estuary's North channel is the scenario that would minimize the impacts on the Beluga and its habitat. The islands in the centre of the estuary create an acoustic shadow for the habitat that the females, accompanied by juveniles and calves, use along the south shore. Diverting a portion of the merchant traffic to the south channel would greatly reduce the number of noise-free areas for females, juveniles and calves and would contribute to the acoustic degradation of certain areas of aggregation that had previously had little exposure to marine traffic noise.

The construction of an oil terminal in the Cacouna area, the construction activities and the marine traffic that will result run counter to these recommendations.

Importance of undertaking a robust monitoring program

The aim of the proposed work is to build a terminal for transporting oil in the Cacouna area. The terminal construction project will take place in the Critical Habitat of the St. Lawrence Beluga, a declining species at risk, and will include work that will require very noisy activities (boring and blasting) over extended, multi-year periods that are likely to interfere with the normal activities of the Beluga and other marine mammals that use the area.

The assessment of the probable impacts on the St. Lawrence Beluga's recovery and the implementation of adequate mitigation measures require baseline data, that is, pre-construction data on various aspects of the Beluga's ecology and biology, as well as its environment. This assessment also requires a monitoring program during and after the work in order to validate the long-term impacts or adjust the mitigation measures in place. We strongly recommend that such a program be implemented as soon as possible. It should include acoustic and visual monitoring systems and could include the use of instruments to monitor the behaviour of, or noise levels received by, specific individuals. A network of underwater hydrophones spread out throughout the area where impacts are anticipated, as well as observations from land-based and, where appropriate, aerial platforms to ensure visual monitoring of the area, are core elements of such a program. Examples of practices or protocols that should be followed, as well as the data required for an assessment that minimizes the uncertainty of conclusions, are available in the literature (e.g. Nowacek et al. 2013; Thompson et al. 2013a, 2013b; Williams et al. 2006; Brandt et al. 2011).

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