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Beluga Vocalizations Decrease in Response to Vessel Traffic in the Mackenzie River Estuary

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ABSTRACT. Vessel traffic negatively affects marine mammals by causing behavioural disturbance, acoustic masking, contamination (i.e., oil spills), and ship strikes. Few studies have examined the effects of vessels on marine mammals in the Arctic, but beluga whales appear to be especially sensitive to vessel traffic. We examine how the vocalizations of belugas are impacted by vessel traffic in the Tarium Niryutait Marine Protected Area in the Mackenzie River estuary of the western Canadian Arctic. Between one and four acoustic recorders were deployed between June and August each year between 2015 and 2018 near the only shipping channel at this site. We examined beluga vocalizations from acoustic recordings over four summers and assessed how the distance to the nearest vessel passing the acoustic recorder affected the number of vocalizations. Beluga vocalizations within the range of the acoustic recorder decreased significantly when vessels were within 5 km of the acoustic recorder. This result suggests either that belugas are avoiding the vessel or that they reduce their vocalization in response to vessel traffic. Future work is needed to assess exactly how belugas are reacting to vessel traffic in this area and what the long-term consequences of these reactions are. Management measures for reducing these impacts must be carefully considered, especially since these vessels are very restricted in where they can travel, and many of the vessels are necessary for the livelihoods of local communities.

Key words: behavioural disturbance; *Delphinapterus leucas*; shipping; underwater noise

RÉSUMÉ. La circulation maritime a des effets négatifs sur les mammifères marins, car elle entraîne des perturbations comportementales, masque leurs signaux acoustiques et engendre de la contamination (comme des déversements de pétrole) et des collisions. Bien que peu d'études aient examiné les effets des bateaux sur les mammifères marins de l'Arctique, les bélugas semblent particulièrement sensibles à la circulation maritime. Dans cet article, nous examinons en quoi les vocalisations des bélugas sont touchées par la circulation maritime dans la zone de protection marine de Tarium Niryutait faisant partie de l'estuaire du fleuve Mackenzie, dans l'ouest de l'Arctique canadien. Entre un et quatre enregistreurs acoustiques ont été déployés de juin à août de chaque année entre 2015 et 2018, à proximité du seul chenal de navigation de l'endroit. Nous avons examiné les vocalisations des bélugas prélevées à l'aide des enregistreurs acoustiques au cours de quatre étés, et évalué en quoi la distance du bateau passant le plus près de l'enregistreur acoustique avait un effet sur le nombre de vocalisations. Les vocalisations des bélugas dans la zone de l'enregistreur acoustique diminuaient considérablement lorsque les bateaux se trouvaient à moins de cinq kilomètres de l'enregistreur. Ce résultat suggère soit que les bélugas évitent les bateaux, soit qu'ils réduisent leurs vocalisations en réponse à la circulation maritime. Il y a lieu de pousser cette étude plus loin pour évaluer exactement comment les bélugas réagissent à la circulation des bateaux dans cette région, et quelles sont les conséquences à long terme de ces réactions. Il y a lieu aussi de considérer avec soin des mesures de gestion pour réduire ces incidences, surtout parce que les déplacements de ces bateaux sont assujettis à de nombreuses restrictions et parce que grand nombre des bateaux qui passent par là sont nécessaires à la subsistance des collectivités de la région.

Mots clés : perturbations comportementales; *Delphinapterus leucas*; navigation; bruit sous-marin

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INTRODUCTION

Vessel traffic affects marine mammals in a variety of ways, including behavioural disturbance (Nowacek et al., 2007; Gomez et al., 2016), acoustic masking (Clark et al., 2009; Erbe et al., 2016), chemical contamination (i.e. oil spills) (Eide et al., 2007), and strikes (Vanderlaan and Taggart, 2009). Most of these effects are sub-lethal, but may cause significant impacts on fitness if the animal is exposed to vessels frequently (e.g., Ellison et al., 2016) or in combination with other stressors (National Academies of Sciences, Engineering, and Medicine, 2017). Behavioural disturbance and acoustic masking are likely the most pervasive forms of vessel impacts and are also very closely linked: animal vocalizations can only be masked when the animal can hear an acoustic signal from a noisy activity such as vessel noise, and hearing the acoustic signal from a vessel may elicit a behavioural response, especially in acoustically sensitive species. Behavioural disturbance for marine mammals can come in many forms, including avoidance (Richardson et al., 1985; LGL, 1986), changes to diving and respiration cycles (Richardson et al., 1990; Williams et al., 2014), cessation of foraging (Malme et al., 1988), and changes in vocalization characteristics (rates, frequency, source level) (Lesage et al., 1999; Scheifele et al., 2005; Holt et al., 2009; Blackwell et al., 2015, 2017). Disturbance can be biologically significant due to the combination of missed opportunities and energetic costs.

The Arctic has historically had less anthropogenic disturbance than non-polar regions (Moore et al., 2012; Reeves et al., 2014). However, climate change has been causing a reduction in summer sea ice (Stroeve et al., 2007; Markus et al., 2009), which has allowed for increased access to remote northern regions by vessel traffic (Pizzolato et al., 2014, 2016; Carter et al., 2018; Dawson et al., 2018). There have been relatively few studies on the impacts of vessel traffic on Arctic and sub-Arctic marine mammals, but the few studies that exist have found similar impacts (Terhune et al., 1979; Stewart et al., 1982; Richardson et al., 1985; LGL, 1986; Anderwald et al., 2013). A recent vulnerability analysis of Arctic marine mammals to vessel traffic along the Northwest Passage and Northern Sea Route also found that narwhal (*Monodon monoceros* Linnaeus, 1758), beluga whales (*Delphinapterus leucas* Pallas, 1776), bowhead whales (*Balaena mysticetus* Linnaeus, 1758), and walrus (*Odobenus rosmarus* Linnaeus, 1758) are most vulnerable to increased vessel traffic (Hauser et al., 2018).

In our study, we examined the influence of vessel traffic in the Mackenzie River estuary on the vocalizations of beluga whales. We used passive acoustic monitoring to detect beluga whale vocalizations over four years and then examined how the proximity of vessel traffic affected the quantity of beluga vocalizations. We tested the hypothesis that beluga whales change their behaviour in the presence of vessels and predicted that we would detect fewer beluga vocalizations when vessels were close to our acoustic recorders.

METHODS

Study Area

The Mackenzie River estuary is an important site for beluga whales from the Eastern Beaufort Sea population (Norton and Harwood, 1986). Belugas in this population migrate to the eastern Beaufort Sea and Amundsen Gulf during the summer, and thousands of belugas stop in the shallow waters of the Mackenzie River estuary (Bell et al., 2007; Harwood et al., 2014). This habitat is also protected by the Tarium Niryutait Marine Protected Area (TNMPA); the TNMPA management plan stipulates that vessels traveling through the TNMPA must follow community supply routes (Fisheries and Oceans Canada and Fisheries Joint Management Committee, 2013). Understanding how vessel traffic impacts beluga whales within this important habitat is critical information for the management of the TNMPA.

Acoustic Data Collection

We deployed acoustic recorders (models: SM2M and SM3M; Wildlife Acoustics, Maynard, Massachusetts, USA; hydrophones: HTI 96-MIN, High Tech Inc., Long Beach, Massachusetts, USA; hydrophone sensitivity: -164 to -165 dB re 1 V/µPa, flat response between 200 Hz and 10 kHz) in the shallow waters of Kugmallit Bay where the Mackenzie River flows into the Beaufort Sea in the western Canadian Arctic. Recorders were deployed between June and August each year in 2015–18, in up to five different sites throughout the bay (Fig. 1, Table 1), at water depths ranging from 1 to 8 m (Table 1), for a total of nine deployments of acoustic recorders throughout the study period. The mooring design consisted of a metal frame with four vertical posts, with the recorder supported vertically within the middle of the posts; the hydrophone was positioned 1 m off the bottom. One mooring in very shallow water (East Whitefish, Table 1) was set up with the acoustic recorder fixed on its side to a metal plate that was placed on the sea floor; the hydrophone on this mooring was positioned 0.3 m above the bottom. Recorders were set to either 96 or 384 kHz sampling rates, with a duty cycle of 15 minutes recording every 30 minutes for recorders with the lower sampling rate, and 15 minutes recording every 60 minutes for the recorders with the higher sampling rate (Table 1). All recorders were set with +16.5 dB of gain and a high pass filter at 180 Hz; the high pass filter was set to reduce low frequency flow noise and because the shallow water would effectively stop all low frequency noise from propagating horizontally (Simard et al., 2014).

Vessel Distance

The distance between vessels and the acoustic recorders was estimated using satellite Automatic Identification System (AIS) data (Fig. 1), or from visual observations

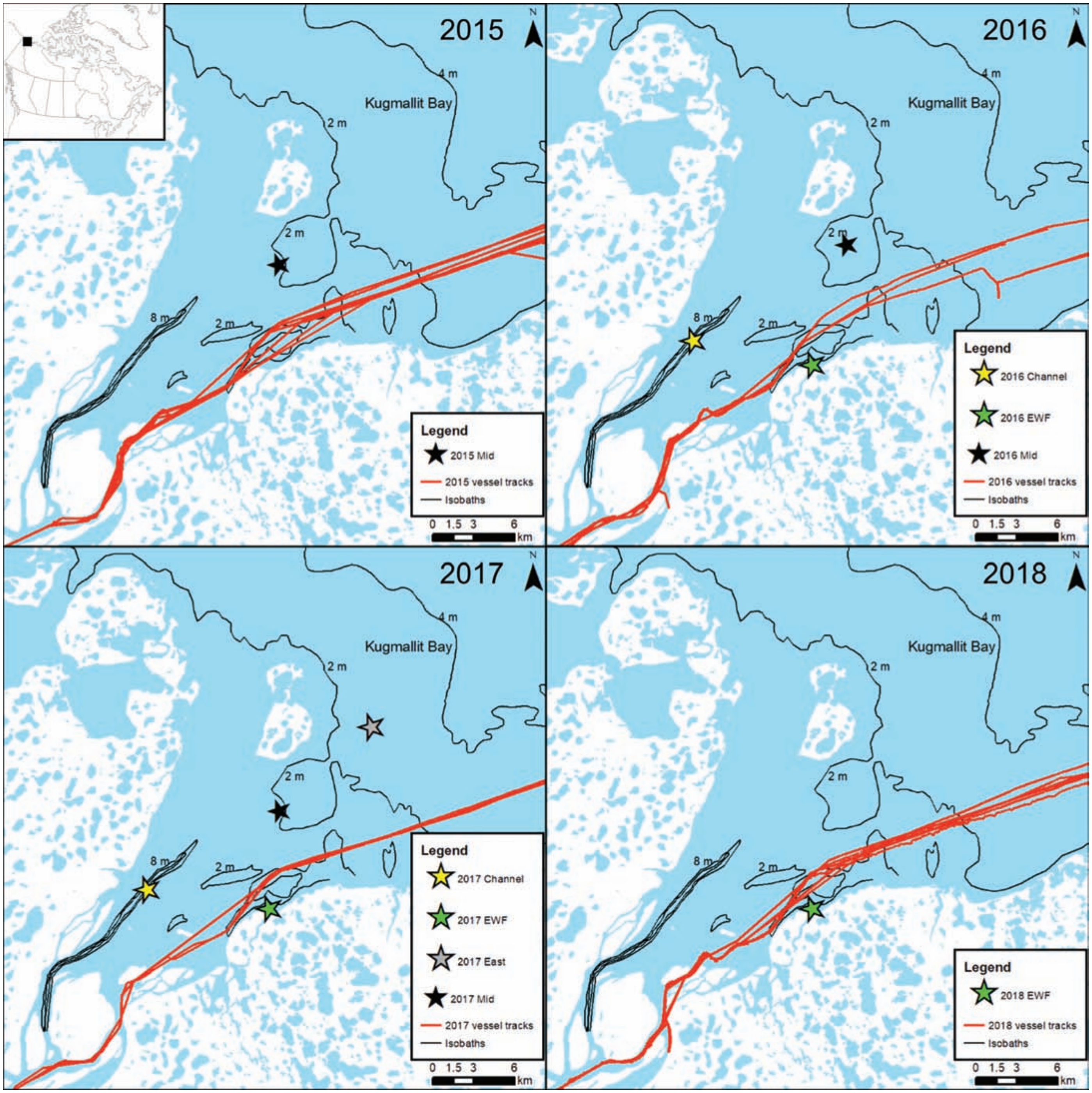

FIG. 1. Proximity of vessel tracks (derived from Automatic Identification System data) to acoustic recorders in the Mackenzie River estuary between 2015 and 2018. Stars represent the location and site name of acoustic recorders. Note that East Whitefish has been abbreviated to EWF.

on shore at the East Whitefish site for vessels without AIS transponders, either by field personnel ($n = 1$) or a shore-based automated camera ($n = 7$) (Table 1). For these visual observations, vessel distance was estimated based on the location of the community supply routes (Fig. 1) and average speeds of vessels traveling this route according to AIS data. We matched the distance between vessel tracks and each acoustic recorder throughout the deployment periods in each year of data collection. We then estimated the minimum and maximum distances between a vessel and the recorder in each 15-minute acoustic data file. We classified all files where a vessel was less than 10 km from the recorder an "impact" time segment. We then grouped time series of acoustic files together based on consecutive acoustic files when a vessel was within 10 km of the recorder and included an equivalent number of files both before and after the "impact" time segments. These files were then categorized as "before," "during," and "after." We also reclassified this series of files based on when a vessel was within 5 km of the acoustic recorder for the

TABLE 1. Settings used for acoustic recorders that had overlap with vessel traffic within 10 km, as well as the number of vessel series, and those with beluga whale vocalizations with vessels within 10 km and within 5 km.

Year	Location	Deployment days	Sample rate (kHz)	Duty cycle (min on/off)	Depth (m)	Latitude, Longitude	# Vessel series 10 km	# Vessel series 10 km with belugas	# Vessel series 5 km with belugas
2015	Mid	67	96	15/15	1.6	69.4465° N, 133.6124° W	9	4	3
2016	Channel	60	96	15/15	8	69.3981° N, 133.8560° W	3	0	0
	East Whitefish	71	384	15/45	1	69.3804° N, 133.6344° W	4	0	0
	Mid	60	96	15/15	1.6	69.4591° N, 133.5650° W	2	1	1
2017	Channel	61	96	15/15	8	69.3947° N, 133.8620° W	2	0	0
	East	62	384	15/45	1.6	69.4984° N, 133.4346° W	3	3	0
	East Whitefish	62	384	15/45	1	69.3804° N, 133.6344° W	11[1]	4[2]	4[2]
	Mid	63	384	15/45	1.6	69.4448° N, 133.6113° W	2	0	0
2018	East Whitefish	50	384	15/45	1	69.3804° N, 133.6344° W	9	3	3
Total							45	15	11

[1] Includes eight visual observations of vessels from shore.

[2] Includes three visual observations of vessels from shore. All other series are based on AIS (Automatic Identification System) data.

"during" segment. We also randomly selected an equal number of control time series where vessels were over 30 km away from the acoustic recorders in order to control for natural variation in beluga vocalizations in the absence of vessels. These two sets of series, the vessel series and the control series, allowed us to perform a pseudo before-after control-impact analysis (see *Statistical Analyses* below). For the control series, we selected six hours of data (the average length of the vessel series), and classified the first two hours as "before," the second two hours as "during," and the final two hours as "after." For these control series, we first confirmed that beluga vocalizations were present in the first file of the series, just as we did for the vessel series. We do not assume that the vocalizations in all files within a time series are from the same belugas, given that belugas are highly mobile. Instead, by comparing the control time series with the vessel time series, we are able to compare natural variation in beluga vocalizations with those exposed to vessels, regardless of whether the same belugas are being detected at the start and end of the time series.

Beluga Vocalizations

We used automated detectors and classifiers to estimate the number of pulsed calls (Fig. 2A) and whistles (Fig. 2B) within all files that were part of the times series of acoustic files identified in the previous section. The whistle detector uses a random forest classifier to detect acoustic signals and to classify them to marine mammal species in the western Arctic. The detector was trained based on marine mammal vocalizations collected in the northeastern Chukchi Sea (Hannay et al., 2013; Mouy et al., 2013). The details of this detector and classifier are fully described in Mouy et al. (2013), and this detector has been effectively used to classify beluga whale whistles in the western Canadian Arctic (Halliday et al., 2018a, 2019). The pulsed call detector was built in Raven Pro, version 1.5 (Bioacoustics Research Program, 2017) using the band limited energy detector with the spectrogram set to a window size of 7000 samples for files with a 96 kHz sample rate and 10 000 samples for files with a 384 kHz sample rate, minimum frequency set to 16 kHz, maximum frequency at 48 kHz, minimum duration at 0.1 s, maximum duration at 2.5 s, minimum separation at 0.05 s, signal-to-noise ratio threshold at 2 dB, block size at 10 s, and hop size at 5 s.

We visually and aurally scanned through all files in each series in Raven to assess the efficacy of the detectors. In a small subset, we manually counted all pulsed calls and whistles and compared these to the counts from the automated detectors and classifiers. In every file, we assessed the presence of pulsed calls and whistles and also looked for broadband noise from waves or other broadband signals that confused the pulsed call detector (Fig. 2C). If other broadband noise was present and triggered the detectors, we corrected the automated call counts from the detectors by removing false positives. We did not adjust for false negatives.

We calculated the mean broadband sound pressure level (SPL) between 200 Hz and 48 kHz in each file selected for this analysis using the PAMGuide package (Merchant et al., 2015) in Matlab (version 2017a; MathWorks, Natick, Massachusetts, USA).

Statistical Analyses

We analyzed the impact of the distance of vessels on beluga vocalizations in the range of the acoustic recorder using a before-after control-impact design. We only included time series that had beluga vocalizations in the "before" time segments because the purpose of this analysis was to assess the impact of vessels on vocalizations. We used linear mixed effects models in R (package: lme4; function: lmer; Bates et al., 2015; R Core Team, 2016) with the total number of vocalizations within a file (sum of pulsed calls and whistles) as the dependent variable, and the distance of the vessel to the recorder (either categorical with the "during" segment set as distance within 10 km or 5 km,

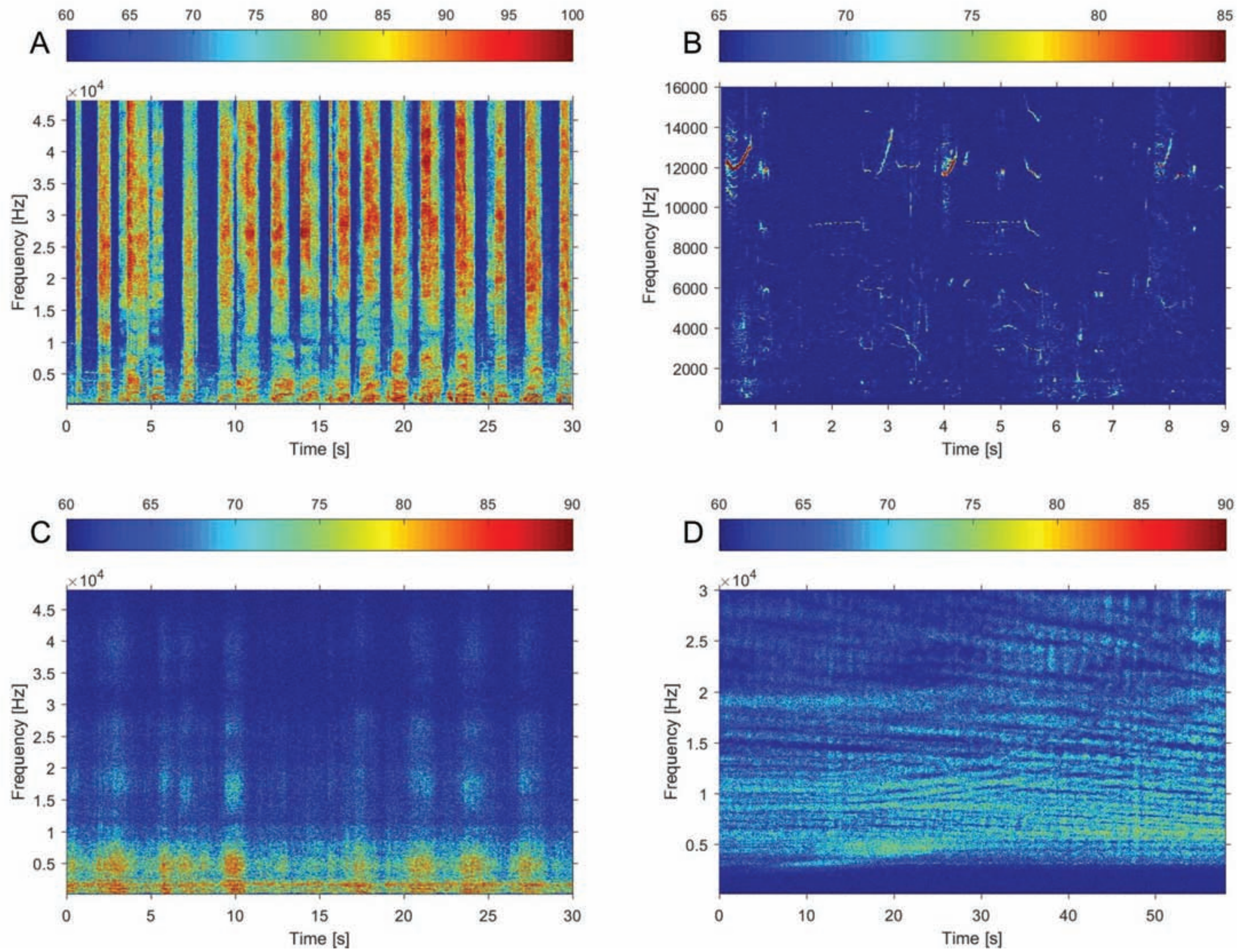

FIG. 2. Example spectrograms of beluga whale pulsed calls (A), beluga whistles (B), and noise from waves that can cause false positives for the pulsed call detector (C). Figure 2D shows one of the few examples of vessel noise in the data. Window size in all spectrograms was set to 12 000 samples. The colour bars show the range and colours associated with different power spectral densities (dB re 1 μPa2/Hz) in each panel.

or continuous) as a fixed effect. We included a categorical variable that identifies the time series as control (vessel absent) or impact (vessel present), and the interaction between the vessel distance variable and the control-impact variable as fixed effects. We also included broadband SPL (200 Hz to 48 kHz) as a covariate to control for any masking effects of ambient sound levels or vessel noise. We included the time series, order of files, and location of the recorder as random effects. We compared models with the three different variables for distance (continuous variable for distance, or categorical variable with "during" set to 10 km or 5 km) using Akaike's information criterion (AICc) corrected for small sample sizes (package: qpcR; function: AICc; Spiess, 2014). The sample size for the impact series when the "during" level was set to within 10 km was 15 time series, but this was reduced to 11 time series when the "during" level was set to within 5 km (Table 1). We therefore only compared AICc for models with this smaller sample size, because AICc can only be compared between models with the same sample size (Burnham and Anderson, 2002). Any models within 2 AICc units of each other were considered to be competing (Burnham and Anderson, 2002). We also assessed models that used the number of whistles and the number of pulsed calls separately as the dependent variables.

While we did include SPL as a covariate in this analysis, there was no significant noise from vessels in this dataset, which we demonstrate by regressing broadband SPL by the distance between the vessel and the acoustic recorder (package: stats; function: lm; R Core Team, 2016). Only 11 of the 159 files where vessels were within 10 km of the acoustic recorder actually contained evidence of vessel noise. This vessel noise is demonstrated by the tonals (long signals at constant frequencies) and broadband signals shown in Fig. 2D), and of these, the closest was 1.2 km from the recorder. In our final sample with beluga vocalizations, only six files had evidence of vessel noise. There are two main reasons that we did not detect much vessel noise.

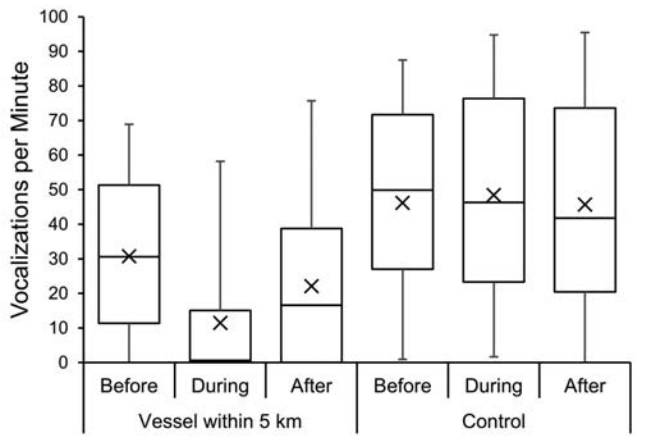

FIG. 3. Number of beluga vocalizations (sum of whistles and pulsed calls) per minute in time segments before, during, and after when a vessel was within 5 km of the acoustic recorder, as well as during random control periods when no vessels were nearby. Boxes represent the interquartile range, the line within the boxes is the median, whiskers are the minima and maxima, and × is the mean value.

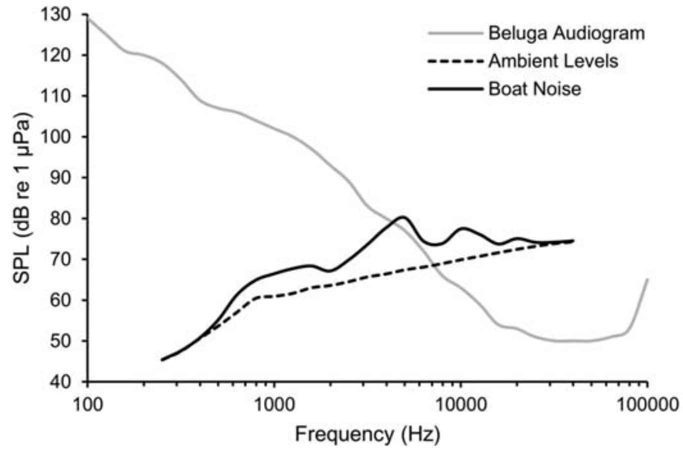

FIG. 4. The audiogram for beluga whales (Castellote et al., 2014; Erbe et al., 2016; Mooney et al., 2018) (grey solid line) versus received noise from a tugboat (black solid line), and ambient sound levels in the absence of vessel noise and beluga vocalizations (black dashed line). Both spectra for tugboat noise and ambient sound levels were from the recorders and sites used in this study. The tugboat was just over 1 km from the recorder under calm, quiet conditions. Sound pressure level (SPL) is measured in 1/3-octave bands.

First, the water was extremely shallow, which did not allow vessel noise to propagate very far. Second, the recorders were set with a high pass filter at 180 Hz, which cut off any low frequency vessel noise that would have reached the recorders. In the few cases where vessel noise was detected, it covered relatively high frequencies and was rarely detected below 4 kHz (Fig. 2D), which is entirely due to propagation effects rather than the high pass filter.

RESULTS

The number of beluga whale vocalizations received at the recorder decreased when vessels were closest to the acoustic recorders in the impact time series (t_{173} = 2.27, p = 0.02), but remained relatively constant through time in the control time series (p > 0.36; Fig. 3). Vocalization levels were not significantly different overall between the control and impact time series (t_{25} = 1.81, p = 0.08). The model that used a categorical distance variable with the "during" segment set to 5 km was the strongest model, although the model with "during" set to 10 km was almost as strong (ΔAICc = 2.0); the model with distance as a continuous variable was the weakest model (ΔAICc = 39.1), which suggests that the relationship is not linear. For the model with the "during" segment set to 5 km, within the impact time series, the "during" segment had 12 ± 5 fewer vocalizations per minute than the "before" segment (t_{173} = 2.27, p = 0.02), and the "after" segment was not significantly different than either the "before" segment (t_{173} = 1.07, p = 0.29) (Fig. 3) or the "during" segment (p = 0.18) (i.e., the "after" segment was intermediate and overlapping with both the "before" and "during" segments). The model with "during" set to 10 km had the same trend as the model with "during" set to 5 km, with more vocalizations before the encounter than during the encounter. Models that examined the total number of whistles or pulsed calls had qualitatively similar results to the model examining all vocalizations combined, with fewer vocalizations in the "during" segment than in the "before" segment. The number of vocalizations increased as SPL increased (slope = 1.44 ± 0.19 vocalizations/dB; t_{194} = 7.48, p < 0.0001), and SPL was unaffected by the distance to the nearest vessel (t_{109} = 0.49, p = 0.63).

DISCUSSION

We provide evidence that beluga whales showed behavioural responses to vessels in the shallow Mackenzie River estuary based on a decrease in vocalizations in the range of our acoustic recorders. The few previous studies examining the impact of vessel traffic on Arctic beluga whales have found that belugas can be quite sensitive to icebreaking vessels, showing avoidance behaviour when the icebreaker is nearly 50 km away (LGL, 1986) and showing avoidance behaviour and cessation of foraging in response to other vessels (Stewart et al., 1982). Non-Arctic beluga whales in the St. Lawrence River estuary have also been shown to change their vocalizations in response to vessel noise (Lesage et al., 1999; Scheifele et al., 2005). In our study area we are unable to determine whether belugas simply stop vocalizing in response to vessel traffic or if they are avoiding the vessels and moving away from the acoustic recorders, thereby reducing our ability to record their vocalizations. The possibility also exists that the whales approached the vessels, either silently or out of our vocal detection range. However, during one of our visual observations, the observers saw 12–15 belugas before a vessel approached, and as the vessel approached, the whales were no longer observed in the area (K. Scharffenberg, pers. obser. 2017), likely showing avoidance behaviour in response to the vessel. Community members have observed belugas avoiding barges and other vessels in this system for many years (H. Lennie, pers. comm. 2019). However, we cannot say whether this occurred in all examples where vocalizations decreased when a vessel was close since we were relying on acoustic data without visual observations of belugas. Future work should pair visual observations with acoustic recordings in order to fully understand how belugas react to vessels in this shallow water environment.

Although we were unable to assess the impact of underwater noise from vessels on beluga vocalizations, it is very likely that distance to the vessel was highly correlated with vessel noise for receivers closer to the vessels. In the few files where we detected vessel noise, that noise should have been audible to belugas based on the beluga audiogram (Fig. 4) (Castellote et al., 2014; Erbe et al., 2016; Mooney et al., 2018). However, given that we were unable to detect noise from vessels in most time series and were also not able to determine where belugas were located relative to the vessel, we cannot determine whether belugas were reacting to vessel noise or simply to the presence of the vessel. The beluga vocalizations that we detected were likely from belugas within a 2 km radius around the acoustic recorders: beluga vocalizations below 10 kHz may be detected at ranges up to 2 km and high frequency vocalizations at ranges up to 1 km, based on source level of 120 dB re 1 μPa at 1 m, background noise level at that frequency of 50 dB re 1 μPa, a simple spherical transmission loss calculation accounting for frequency-dependent attenuation (see equation 4.20 in Au and Hastings, 2008), and assuming that the shallow bathymetry of this system would reduce the range. However, modelling and playback experiments would be required to precisely estimate these ranges. This remains an open question and is worthy of further investigation. Given the high sensitivity of belugas to underwater noise and disturbance from vessels (LGL, 1986), it is possible that the acoustic cue that the belugas were responding to was low amplitude and may have been difficult for us to detect.

The trends that we present in this study are not driven by masking effects. Detectability of vocalizations may often be influenced by ambient sound levels (Serrano and Terhune, 2002) or underwater noise from vessels (Vasconcelos et al., 2007). However, in this study, the proximity of vessels did not influence SPL, and SPL was positively correlated with the number of beluga vocalizations. We previously demonstrated that beluga vocalizations control much of the high frequency energy in this shallow water soundscape and are even detectable above the sounds created by wind and waves (Halliday et al., unpubl. data). The results that we present here confirm this trend and also provide evidence that beluga vocalizations are not being masked by ambient sounds or by vessel noise. We are therefore confident that in the proximity of vessels, beluga vocalizations in the range of the acoustic recorder are decreasing, rather than being masked by vessel noise.

Management Recommendations

The most effective way to reduce the impacts of vessels on belugas would be to exclude vessels from important beluga areas (Halliday et al., 2018b; McWhinnie et al., 2018). However, this option would be difficult to enact in the TNMPA. Vessels traveling within the TNMPA are required to follow the community supply route in order to minimize their impacts within the TNMPA (Fisheries and Oceans Canada and Fisheries Joint Management Committee, 2013), but the community supply route is also one of the only navigable waterways between Inuvik and Tuktoyaktuk, so vessels may not be able to deviate significantly from this route. Beluga hotspots, identified by aerial surveys, have a strong spatial overlap with the community supply route (Harwood et al., 2014). Since the supply route likely cannot move to avoid beluga hotspots, managers likely cannot fully exclude vessels from this area. Another option is to use an adaptive strategy that only excludes vessels when belugas are present. However, belugas are generally present for the entire month of July (Harwood et al., 2014) and are also detected into late August (Scharffenberg et al., 2019; Halliday et al., unpubl. data). This type of seasonal exclusion would mean that vessels could only travel the route starting in late August, which would drastically reduce the shipping season for these vessels. Reducing vessel speed is another popular management option in other systems, but are likely not viable in this system because vessels are already travelling slowly. For example, in 2017, vessels travelled a minimum of 2.7 knots (5.0 km/h), a maximum of 8.4 knots (15.6 km/h), and a mean of 5.6 knots (10.4 km/h) along this route. One final option is for vessels to carry marine mammal observers and to slow or stop completely when they encounter belugas. This will not account for the 5 km radius of impact that we identified in this study, but for belugas that travel closer to vessels, such as in narrow channels, this could reduce the auditory masking and stress response for those belugas.

There are multiple factors that must also be taken into consideration when assessing management strategies. First of all, the TNMPA was put in place to support the harvest of belugas by Inuvialuit hunters. Disturbance by vessels could cause belugas to flee from these hunting grounds, which would reduce the success of the hunters. The long-term consequences of disturbance by vessels on belugas is also not understood and must be researched before the impact of vessels can be fully assessed. Continued monitoring of both belugas and vessels is required in order to track changes into the future; importantly, earlier ice melt may lead to earlier vessel transits and likewise could impact the timing of belugas' use of the same waters. Tracking these changes is critical to the future management and conservation of this stock of belugas.

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