MARINE MAMMAL VOCALISATIONS IN RESOLUTE BAY, NUNAVUT

Caitlin O'Neill[12*]
[1]School of Earth and Ocean Sciences, University of Victoria, Victoria, BC, Canada
[2]JASCO Applied Sciences Ltd., 2305-4464 Markham St., Victoria, BC, Canada

1 Introduction

Resolute Bay, located in the Canadian Arctic Archipelago, on the southwest side of Cornwallis Island, faces the northern side of Parry Channel. During the short 2 to 3-month ice-free period each year, Resolute Bay hosts migratory groups of marine mammals including beluga whales, narwhals, walrus, and bearded seals. To investigate the temporal pattern of these vocalizing species, an Autonomous Marine Acoustic Recorder (AMAR) was deployed to collect broadband underwater sound. The data was then processed with automated call and click detectors.

2 Methods

An AMAR was deployed on a floating mooring, in 46 m of water, 3 m above seafloor. It recorded 24-bit broadband sound levels with duty cycles described in Table 1. A higher sample rate was chosen for the ice-free period in order to capture the high frequency sounds from beluga whales and narwhals, often present in the area during these times.

Start Date	End Date	Record (s)	Sleep (s)	Frequency Range
Aug. 5, 2013	Oct. 10, 2013	113	127	10 Hz – 48 kHz
Oct. 11, 2013	Jun. 9, 2014	340 (5.6 min)	3260 (54.4 min)	10 Hz – 8 kHz
Jun. 9, 2014	Jun. 30, 2014	113	127	10 Hz – 48 kHz

Table 1: AMAR recording schedule.

JASCO Applied Sciences' automated detector software was used to identify and classify marine mammal vocalisations within the data set. A tonal call detector was used to identify beluga and narwhal whistles, bearded seal calls, and walrus grunts. While a click detector located narwhal and beluga clicks.

2.1 Automated Tonal Call Detector

The automated tonal call detector works as follows:
1. Create normalized spectrograms by using the median value in each frequency bin for each detection window.
2. From the normalized spectrograms, locate and extract time-frequency contours of the marine mammal calls, using the tonal detector developed by Mellinger et al.[1].
3. Calculate features of extracted contours (e.g. slope, number of inflection points, max/min frequencies).
4. Employ a call sorting algorithm to determine if the contours match the definition of a specific mammal call type.

2.2 Automated Click Detector

The automated click detector works as follows. First, an 8 kHz high-pass filter is used to constrain the data that may contain marine mammal clicks. In order to remove clicks that do not originate from marine mammals, the filtered samples are then summed to create a time series with 0.5 ms root-mean-square time series. Then, a Teager-Kaiser energy detector identifies possible click events. For each possible click event, the maximum peak signal is located within 1 ms of the detected peak. The time window of the detected click is determined by searching the data for the local maxima within 12 dB of the maximum peak. Then the classification parameters are calculated for each click: the number of zero crossings, the median time separation between zero crossings, and the slope of the time/frequency separation between zero crossings. Next, the Mahalanobis distance is calculated by measuring the distance between the extracted click classification parameters and the templates of beluga and narwhal clicks. If a click exceeded the minimum specified beluga or narwhal Mahalanobis distance threshold, it is classified as that species. Otherwise, the click detection is discarded.

3 Results

3.1 Beluga and Narwhal Whistles and Clicks

Beluga and narwhal whistles are very similar in frequency and pattern, which makes it difficult to distinguish the presence of these two species using this call type. Call count results for beluga and narwhal whistles are presented in Figure 1. Whistles were found starting August 7, 2013, with the greatest number recorded on August 9, 2013. Calls were present almost daily between August 7 and November 1, 2013. After migrating out of the area for the winter, the beluga and narwhals returned June 21, 2014 and remained until the recorder stopped recording on June 30, 2014. The daily click counts from beluga and narwhal are presented in Figure 2 and Figure 3, respectively. Although fewer beluga clicks were identified than narwhal clicks, this is likely due to the recorder not having a high enough sample rate to record all the vocalizing frequencies of the beluga clicks. The greatest number of clicks occurred during freeze-up, between September 20 and 29. The click data results reflect the whistle data for the periods of higher sample rate, although with less daily beluga click counts than whistles.

*caitlin.v.oneill@gmail.com

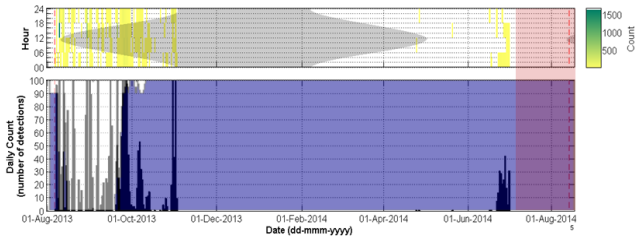

Figure 1: Combined beluga and narwhal daily whistle counts and counts per hour of day with ice coverage percentage[2] overlaid in blue and end of recording in pink.

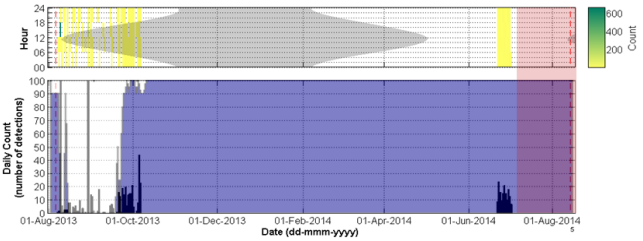

Figure 2: Beluga daily click counts and counts per hour of day with ice coverage percentage[2] overlaid in blue and end of recording in pink.

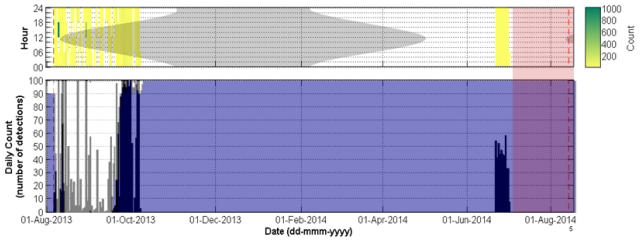

Figure 3: Narwhal daily click counts and counts per hour of day with ice coverage percentage[2] overlaid in blue and end of recording in pink.

3.2 Bearded Seal Calls

Daily call count results for bearded seals are presented in Figure 4. They follow a similar temporal pattern to the beluga and narwhal clicks and whistles, although these animals are also present in the winter, during 100% ice coverage. The greatest number of calls were recorded between June 25 and 30, 2014. Bearded seals vocalized at all times of the day.

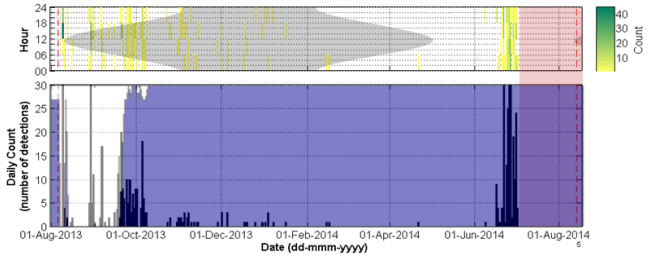

Figure 4: Bearded seal daily call counts and counts per hour of day with ice coverage percentage[2] overlaid in blue and end of recording in pink.

3.3 Walrus Grunts

Daily grunt count results for walrus are presented in Figure 5. They follow a similar temporal pattern as the beluga and narwhal clicks and whistles, also leaving the area in the winter, during 100% ice coverage. Most of the calls were recorded between October 4 and 6, 2013. Similar to beluga and narwhal, they also came back in the summer, albeit briefly, on June 25, 2014.

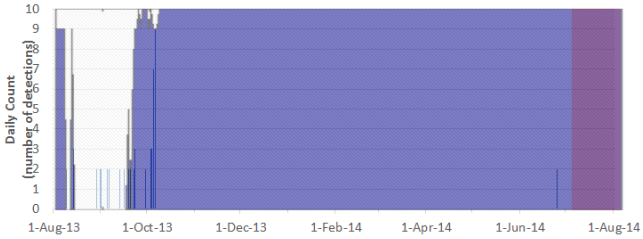

Figure 5: Walrus daily grunt counts with ice coverage percentage[2] overlaid in blue and end of recording in pink.

4 Discussion and Conclusion

It is difficult to build an automated detector that distinguishes between narwhal and beluga whistles, therefore these results were presented together. The best way to distinguish between the presences of these two species is to look at the frequencies of their clicks. Narwhals have pulsed calls between 12-40 kHz and belugas have pulse calls between 40-60 and100-120 kHz[3]. The results of the click detector presented here indicate that both belugas and narwhals were present near Resolute Bay at similar times, correlated to limited ice coverage. The whales and walrus left a couple weeks after 100% ice coverage occurred, but bearded seals remained throughout the winter. Most vocalisations for all analysed species occurred in conjunction with the freeze-up period (90-100% ice coverage). Marine mammal vocalisations did not occur at a preferred time of day throughout the year.

Acknowledgments

The author thanks the Ocean Tracking Network (OTN) for providing funding for this project. Thanks to JASCO Applied Sciences for kindly loaning the AMAR. Many thanks to Xavier Mouy (JASCO) for his assistance with the detection processing and to Ash Hill (JASCO) and Bruce Martin (JASCO) for downloading the data and running the preliminary data processing routines. Thanks to the Polar Continental Shelf Program for providing field logistical support and to Rob Currie and Dave Yurkowski for their assistance during instrument deployment and retrieval.

References

[1] Mellinger, D.K., S.W. Martin, R.P. Morrissey, L. Thomas, and J.J. Yosco. 2011. A method for detecting whistles, moans, and other frequency contour sounds. Journal of the Acoustical Society of America 129(6): 4055-4061.

[2] Canadian Ice Service archives (http://www.ec.gc.ca/glaces-ice/)

[3] Richardson, W.J., et al. Marine Mammals and Noise. Academic Press, London and San Diego, 1998.