Passive acoustic monitoring to identify drivers of beluga whale habitat use in the Mackenzie Estuary

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Introduction

Beaufort Sea beluga whales (*Delphinapterus leucas*) form some of the world's largest summering aggregations in the Mackenzie Estuary[1]. The timing and location of beluga occurrence within the estuary is well documented[2,3], however the drivers for temporal and spatial patterns of use are not fully understood[4,5]. Recent research by Harwood et al. (2014) summarized historical aerial survey data to identify 'hot spots' within the estuary where belugas were more likely to congregate year after year[6]. Further research by Simard et al. (2014) identified potential linkages between beluga use of the estuary, and oceanographic conditions[7]. Together, these studies provide a starting point to more closely examine beluga habitat use.

Research Objectives

- Use acoustic data to define temporal patterns of beluga presence/absence at different locations in the estuary throughout the summer.
- Assess how beluga spatial and temporal variation is influenced by environmental parameters such as temperature, depth, salinity, and windspeed.

Methods

- In the summer of 2015, 2016, and 2017, instrumented seabed moorings were deployed in Kugmallit Bay of the Mackenzie Estuary (Figure 1 and 2).
- Moorings included hydrophones, CTDs (to measure conductivity, temperature and depth), and pressure sensors (to measure waves and tidal levels).
- A weather station was installed near the East Whitefish hydrophone to collect wind amplitude and direction data (Figure 1).
- Hydrophones recorded noise for 15 minutes, every hour.
- Acoustic data was validated using unmanned aerial vehicle and shore-based surveys (Figure 1).
- A broad overview of the acoustic environment was conducted using Long Term Spectral Average (LTSA) plots (Figure 3). An automated detector was used to assess fine scale patterns of presence/absence.

Figure 1: Seabed mooring with SM2M marine recorder (left), the East Whitefish weather station (top), a UAV survey being conducted at Hendrickson Island (below).

References:
1. Harwood et al. (1996). Distribution and abundance of beluga whales in the Mackenzie estuary, southeast Beaufort Sea, and west Amundsen Gulf during late July 1992
2. Hornby et al. (2016). Spring conditions and habitat use of beluga whales (*Delphinapterus leucas*) during arrival to the Mackenzie River Estuary.
3. Richard et al. (2001). Summer and Autumn Movements of Belugas of the Eastern Beaufort Sea
4. Fraker (1977). The 1977 white whale monitoring program, Mackenzie Estuary, N.W.T.
5. Goetz et al. (2007). Habitat use in a marine ecosystem: Beluga whales *Delphinapterus leucas* in Cook Inlet, Alaska.
6. Harwood et al. (2014). Belugas in the Mackenzie River estuary, NT, Canada: Habitat use and hot spots in the Tarium Niryutait Marine Protected Area
7. Simard et al. (2014). Monitoring beluga habitat use and underwater noise levels in the Mackenzie Estuary: Application of passive acoustics in summers 2011 and 2012

Preliminary Results

- Overall beluga were most common at the West Hendrickson and Mid Hendrickson moorings, but made occasional trips towards the East Whitefish mooring (Figure 3 and Table 1).
- Beluga presence was influenced by windy conditions, with most vocalization activity occurring during calm conditions (Figure 3).
- Water temperature was shown to influence habitat use patterns, where beluga moved inwards when temperatures in the estuary dropped (Figure 4). At the outer moorings, cold temperatures corresponded with high salinity.
- Presence/absence patterns were different from 2015 (Table 1), possibly related to different oceanographic conditions (Figure 5).

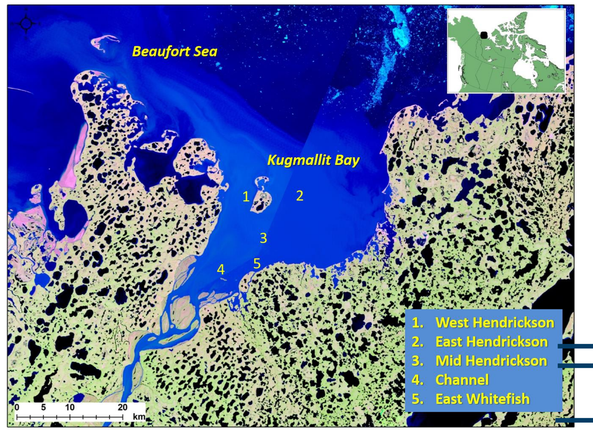

Figure 2 (above): Map of Kugmallit Bay showing the location of instrumented seabed moorings in 2017.

Table 1: Percentage of audio files with beluga presence for each mooring in July 2015 and 2017.

Location	Percent Present 2015	Percent Present 2017
1. West Hendrickson	59.0%	62.3%
2. East Hendrickson	N/A	22.8%
3. Mid Hendrickson	95.2%	70.1%
4. Channel	31.4%	5.2%
5. East Whitefish	N/A	39.4%

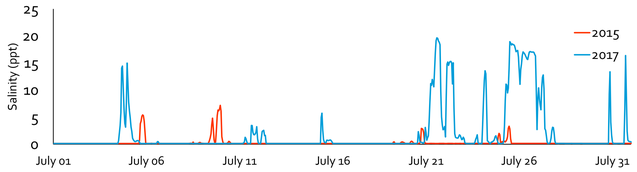

Figure 5: Salinity at the Mid Hendrickson mooring in July 2015 and 2017. Note the increased duration and magnitude of salinity influxes at this location in 2017, which corresponded with fewer beluga whale detections.

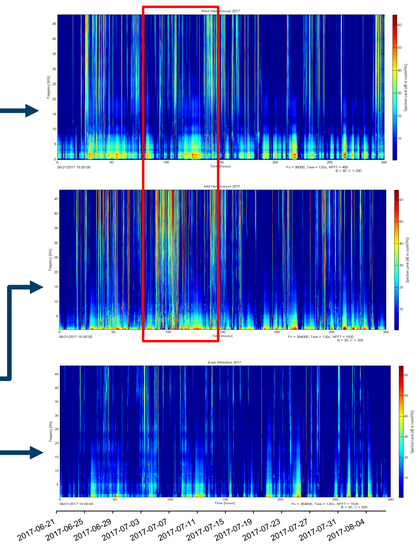

Figure 3: LTSA plot of noise in the water column (averaged over 120s increments into 200Hz frequency bins) at all five hydrophones. Noise below 5 kHz is primarily wind and waves, while noise above 20 kHz is primarily beluga. Note low beluga activity during periods of intense wind and waves.

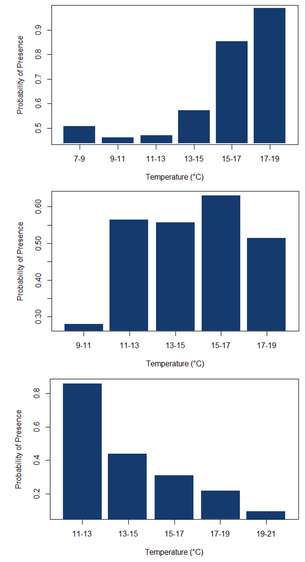

Figure 4: The probability of detecting beluga presence over a given temperature range at the West Hendrickson (top), Mid Hendrickson (middle), and East Whitefish (bottom) moorings.

Conclusions

- Environmental parameters (temperature, salinity, windspeed) appear to influence beluga habitat use in the Mackenzie Estuary.
- Beluga have preferred sites within the estuary, and redistribute when conditions change.
- Environmental parameters may be responsible for differences in habitat use patters from year to year.
- Next, presence/absence will be modeled for varying environmental conditions using multiple logistic regression.

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