Assessing ringed seal exposure to vessel noise in the Canadian Arctic using a novel perception-based approach

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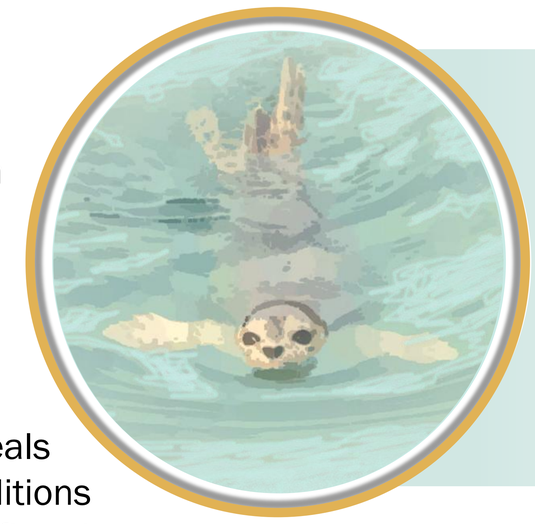
THE NEW APPROACH

Ringed seals (*Pusa hispida*) are adapted to quiet underwater soundscapes, and though they are integral to both Arctic ecosystems and Indigenous communities, the extent to which they are exposed to increasing levels of vessel noise has yet to be studied. Here, we present a workflow that realistically approximates the ranges at which ringed seals experience vessel noise under various conditions and describe ringed seal exposures for the first time.



RINGED SEAL DATA

Seven ringed seals were equipped with SLTDR tags in the summers of 2012 and 2013 in Resolute Bay, Nunavut. Argos locations and dive data were subset to the open water period, August – October.

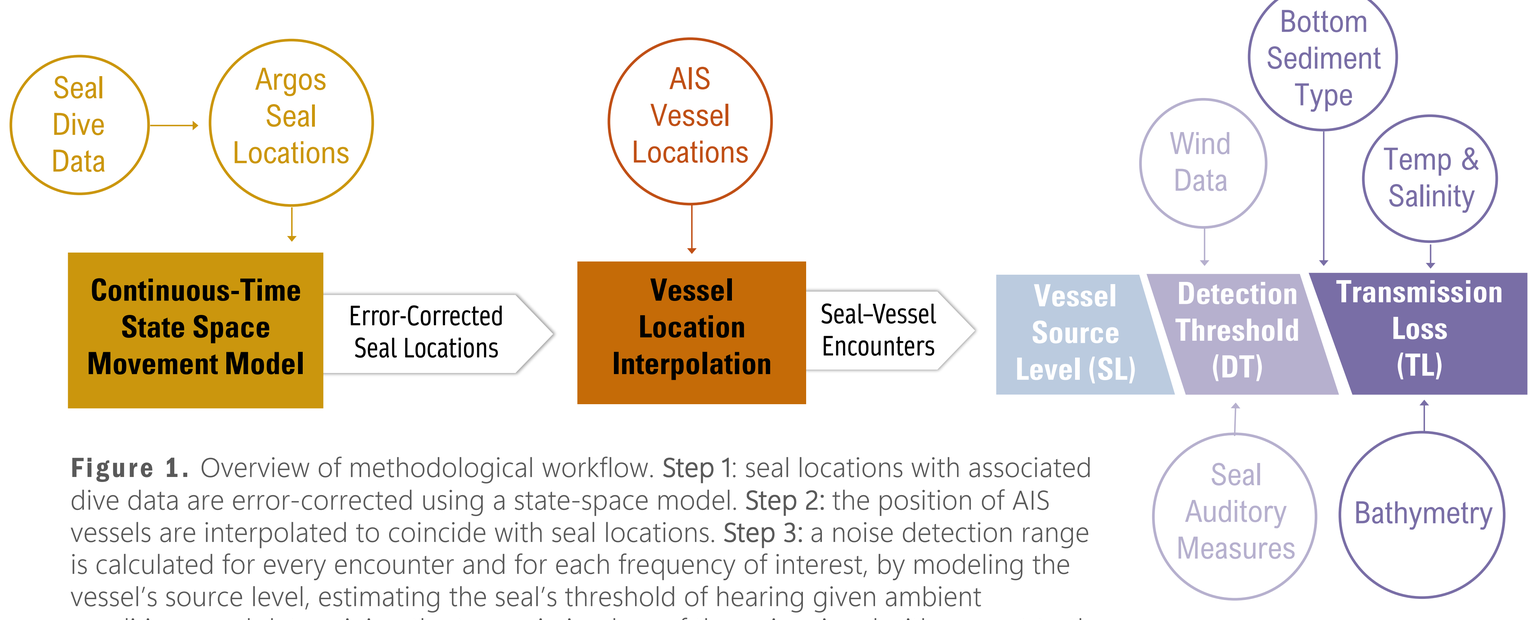


Figure 1. Overview of methodological workflow. Step 1: seal locations with associated dive data are error-corrected using a state-space model. Step 2: the position of AIS vessels are interpolated to coincide with seal locations. Step 3: a noise detection range is calculated for every encounter and for each frequency of interest, by modeling the vessel's source level, estimating the seal's threshold of hearing given ambient conditions, and determining the transmission loss of the noise signal with respect to the seal's depth and oceanographic context.

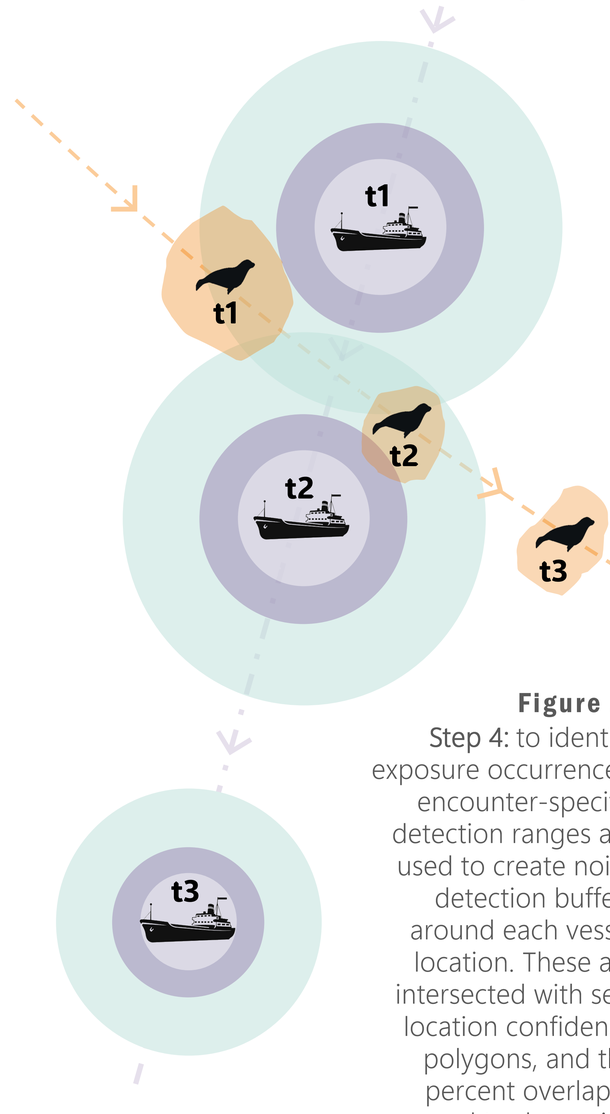


Figure 2. Step 4: to identify exposure occurrences, encounter-specific detection ranges are used to create noise detection buffers around each vessel location. These are intersected with seal location confidence polygons, and the percent overlap is used to determine exposure likelihood.

FINDINGS

While other exposure studies use audiograms to determine perceptibility...

- Overall, 3% of ringed seal locations were exposed (171 of 1255 encounters)
- Surprisingly, proximity between the seal and vessel was not a good predictor of exposure; only 28.6% of close-approaches (< 10 km) were exposed
- Icebreakers produced the most exposures, with 49% of exposures attributable to four vessels

Our approach reveals ringed seals are most exposed to vessel noise at 200 Hz - well below frequencies of best hearing

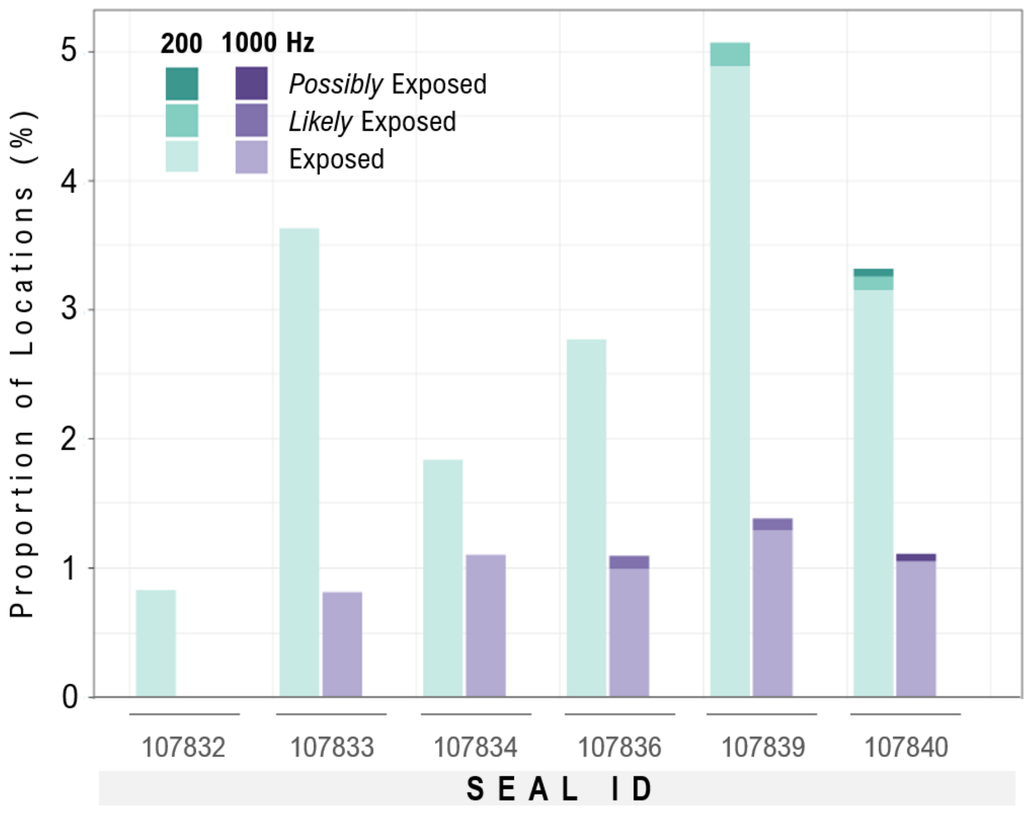


Figure 3. Ringed seal exposures to vessel noise, per tagged seal, represented as the proportion (%) of seal locations exposed, and depicted per frequency of interest. Color gradations within each bar denote confidence rankings. No exposures occurred at 3200Hz of for seal 107838.

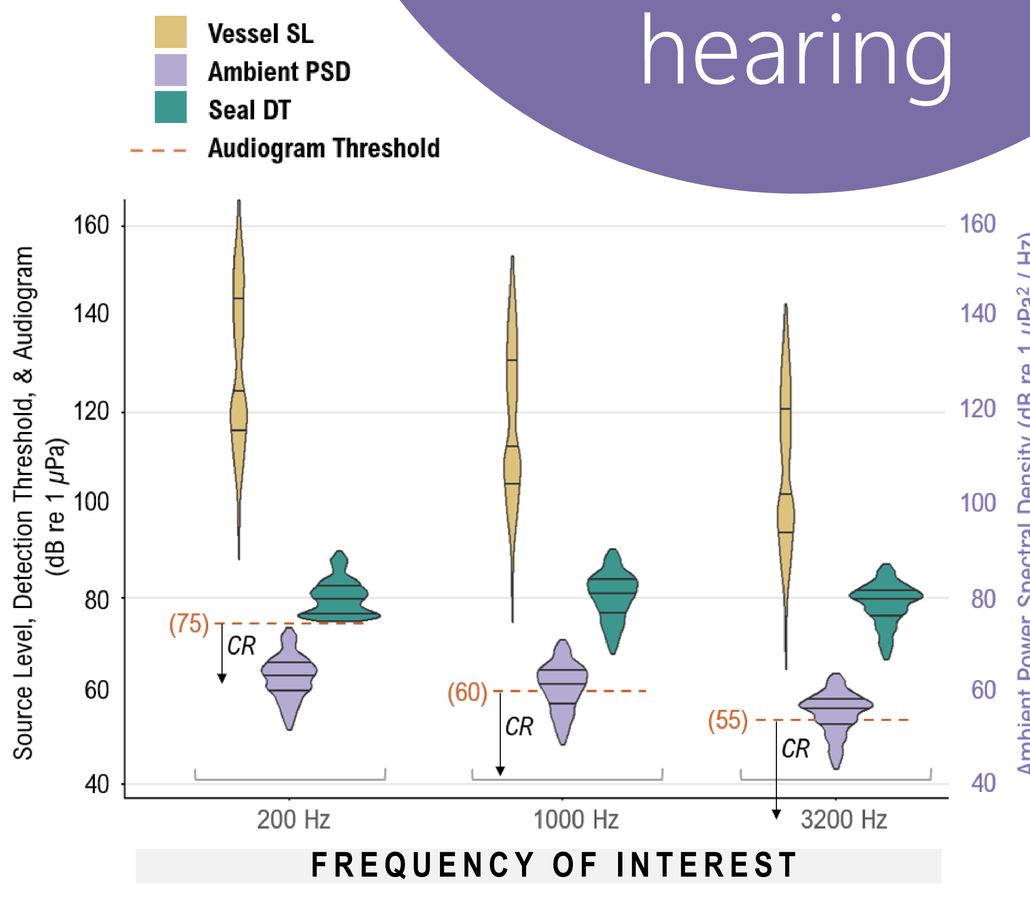


Figure 4. Violin plot displaying 25, 50, and 75% quartiles of vessel source levels (SL), wind-approximated ambient sound, represented as power spectral densities (PSD), and seal detection thresholds (DT), per frequency of interest. Ringed seal audiogram thresholds are indicated by dashed horizontal lines and the relative size of critical ratios (CR) are shown with black arrows. Left and right vertical axes have identical values but different units.

FUTURE WORK

- Validate detection ranges with a range-dependent propagation model
- Increase analysis beyond 75 km, if warranted
- Apply methodology to seal data from other locations and years

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