Behavioral responses of bowheads to seismic surveys leads to under-estimates of abundance

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PROBLEM

Whales exposed to seismic operations vary their dive-cycle behavior, making them less likely to be seen during aerial surveys.

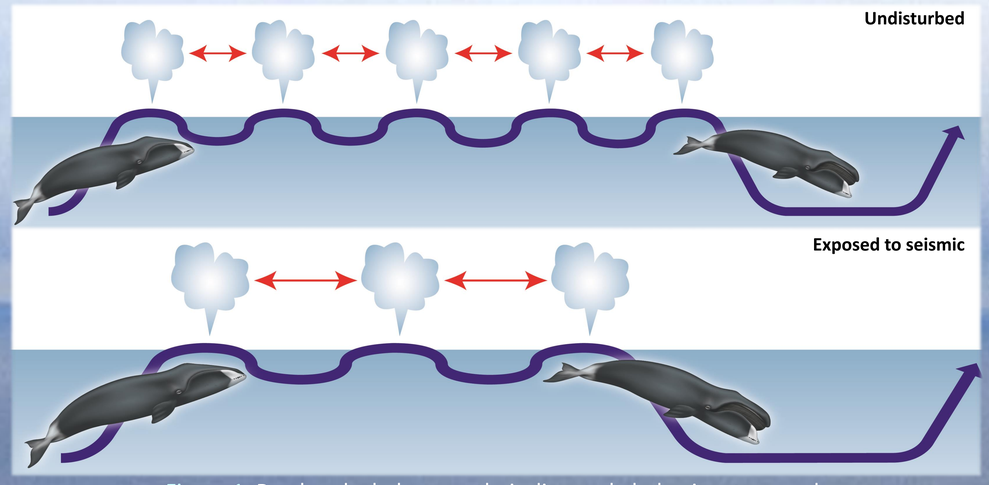

Figure 1. Bowhead whales vary their dive-cycle behaviors to spend less time at the surface in areas ensonified by seismic operations.

CONCLUSION

Accounting for variable behavior improves abundance estimates of bowheads in the Beaufort Sea in the vicinity of seismic operations.

Objective 1

What was the distribution & density of bowhead whales in areas ensonified with different levels of seismic sounds ?

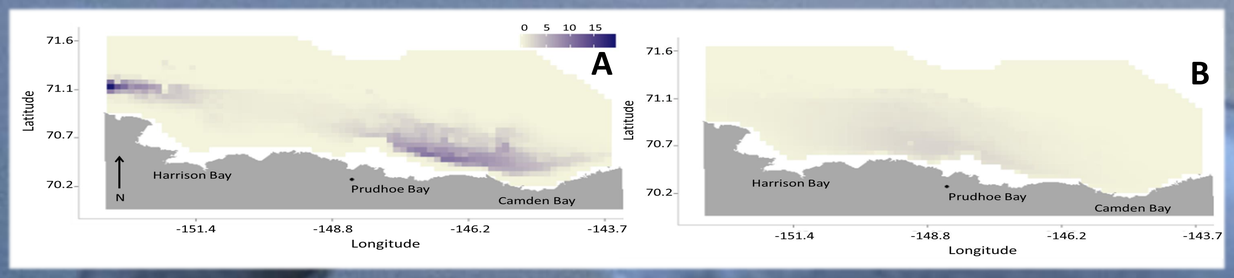

Figure 3. High densities of feeding whales were predicted to occur in the southeast region of the study area towards Camden Bay, where the predicted mean density was 0.84 whales per 5km^2 and maximum was 19 whales per 5km^2 on 6 September (**A**). In contrast travelling whales were concentrated, but in lower densities, in the central southwest region, where predicted mean densities were 0.42 whales per 5km^2 and maximum was 2.51 whales per 5km^2 on 29 August (**B**).

- Analyses revealed temporal and spatial patterns. Whale densities decreased through the season and spatial variation appeared related to whether whales were travelling or feeding (Fig. 3).
- Whales occurred in high densities toward Camden Bay, close to the main seismic survey operation (Fig. 3).
- We found no evidence of changes in distribution of whales exposed to sound levels up to ~150 dB re 1 µPa.

Objective 2

How do bowhead behavioral reactions to seismic sounds affect predicted densities of whales in the vicinity of seismic operations?

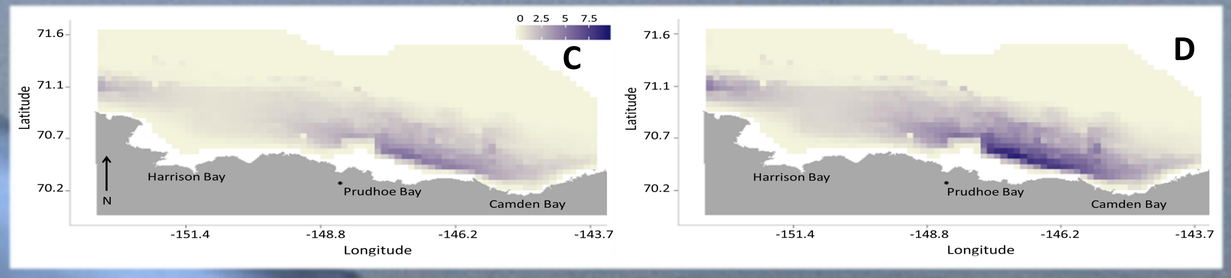

Figure 4. Predicted densities of non-calf bowhead whales exposed to air-gun activity on the 29 August 2008. Not accounting for behavioral variations related to seismic operations resulted in an estimate of 1024 whales (CV = 0.39) (**C**). However, accounting for behavioral changes related to seismic resulted in a corrected estimate of 1718 whales (CV = 0.40) (**D**) — 68% more whales than estimated if we only accounted for the availability of undisturbed whales.

- Density predictions **were** influenced by the whales' behavioral reactions to seismic operations (Fig. 4).
- Density estimates were **33-68% higher** when behavioral changes were accounted for, indicating that whales are not being displaced to the extent previously thought.
- Incorporating appropriate correction factors into density analyses improves estimates of whale abundance in the vicinity of seismic operations.

Methods

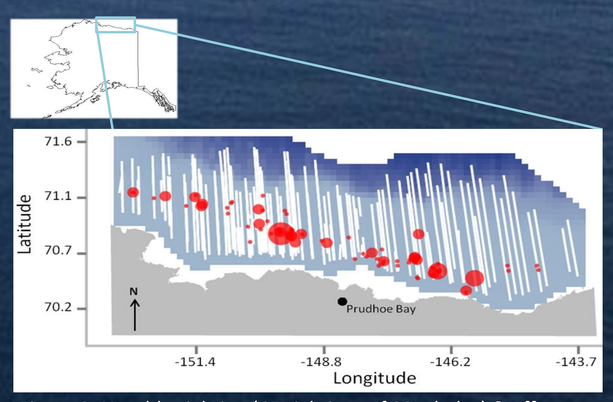

Figure 2. Useable sighting (65 sightings of 92 whales) & effort (>10,000 km) data collected in the southern Alaskan Beaufort Sea during autumn 2008. Varying levels of air-gun sounds were audible for all sightings and effort used in our analyses.

- Sighting data collected in autumn 2008 during industry monitoring surveys of seismic operations (Fig. 2).
- Density surface models were fit to sighting data using distance sampling methods.
- Whale density was predicted over the study season, and for feeding and travelling whales.
- Predicted densities were corrected for variable availability using correction factors specific to season, whale activity, and exposure to seismic sounds.
- Predicted densities of whales exposed to seismic operations using appropriate correction factors were compared to density estimates calculated with correction factors specific only to undisturbed whales.

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