

Seismic operations affect bowhead behaviour and sightability in the Alaskan Arctic



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BIG QUESTION

- Aerial surveys are essential to determine if industry activities are affecting the behaviour of bowhead whales (*Balaena mysticetus*).
- BUT, is our ability to detect industry impacts hampered by the whales' reactions to industry?



SHORT ANSWER

- Bowhead whales spend less time at the surface when exposed to seismic sounds.
- Therefore, aerial survey sighting data may, (without correction factors) lead to biased estimates of distribution and abundance relative to seismic operations.

OBJECTIVES

- Determine how exposure to seismic sounds affects bowhead whale surface-dive cycle behaviours.
- Quantify how changes in dive-cycle behaviour associated with seismic sounds influence the detectability of whales during aerial surveys.

METHODS

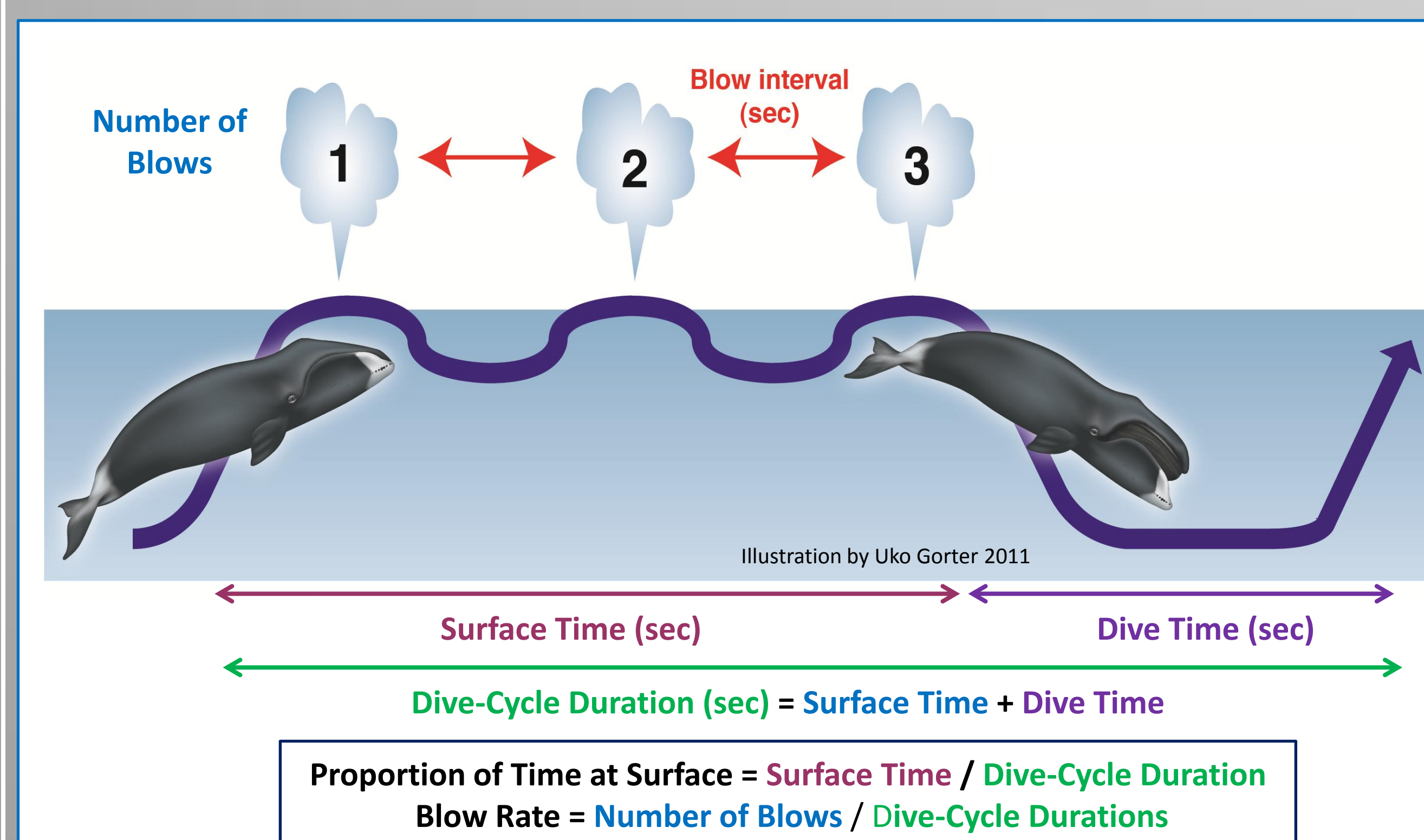


Figure 1. A typical cetacean surface-dive cycle showing the behaviour measures that were collected from aerial observations and used to quantify the effects of seismic sounds on whales.

Whale surface-dive cycle data were used to quantify the effects of seismic sound on bowhead whales.

- We analysed behaviour data collected by government & industry aerial observation studies (1980 to 2000).
- We assessed the influence of seismic sound on whales, according to reproductive state, activity and season.
- We applied non-parametric rank based tests & Linear Mixed Models to assess the effects of seismic sound on bowhead surface-dive cycle behaviour.



RESULTS

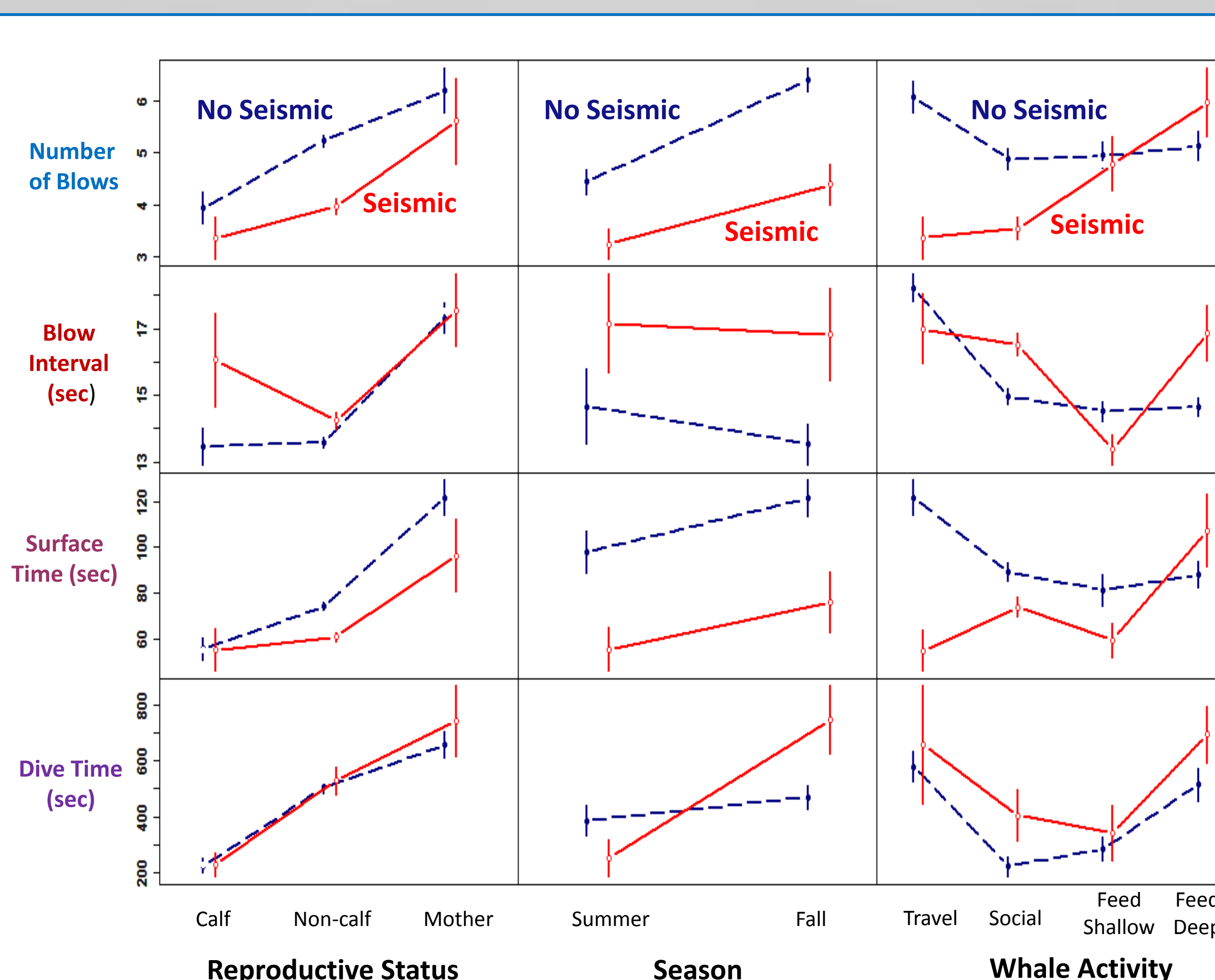


Figure 2. Interaction plots to show the effects of seismic sound on the mean (+/- 1 se) surface - dive cycle behaviours of bowhead whales, by reproductive status, season and whale activity state. In general, the effect of seismic was not dependent on reproductive status or season; however, the effect of seismic depended on the whale's activity state. Only non-calf data were used to investigate the effects of season and whale activity.

Bowhead behaviour changed when whales were exposed to seismic sounds.

- Effects of seismic sounds were stronger in fall when whales were migrating.
- Seismic sound was a significant factor in all behaviour models.
- The effect of seismic sound on surface and dive times depended on whale activity.

CONCLUSIONS

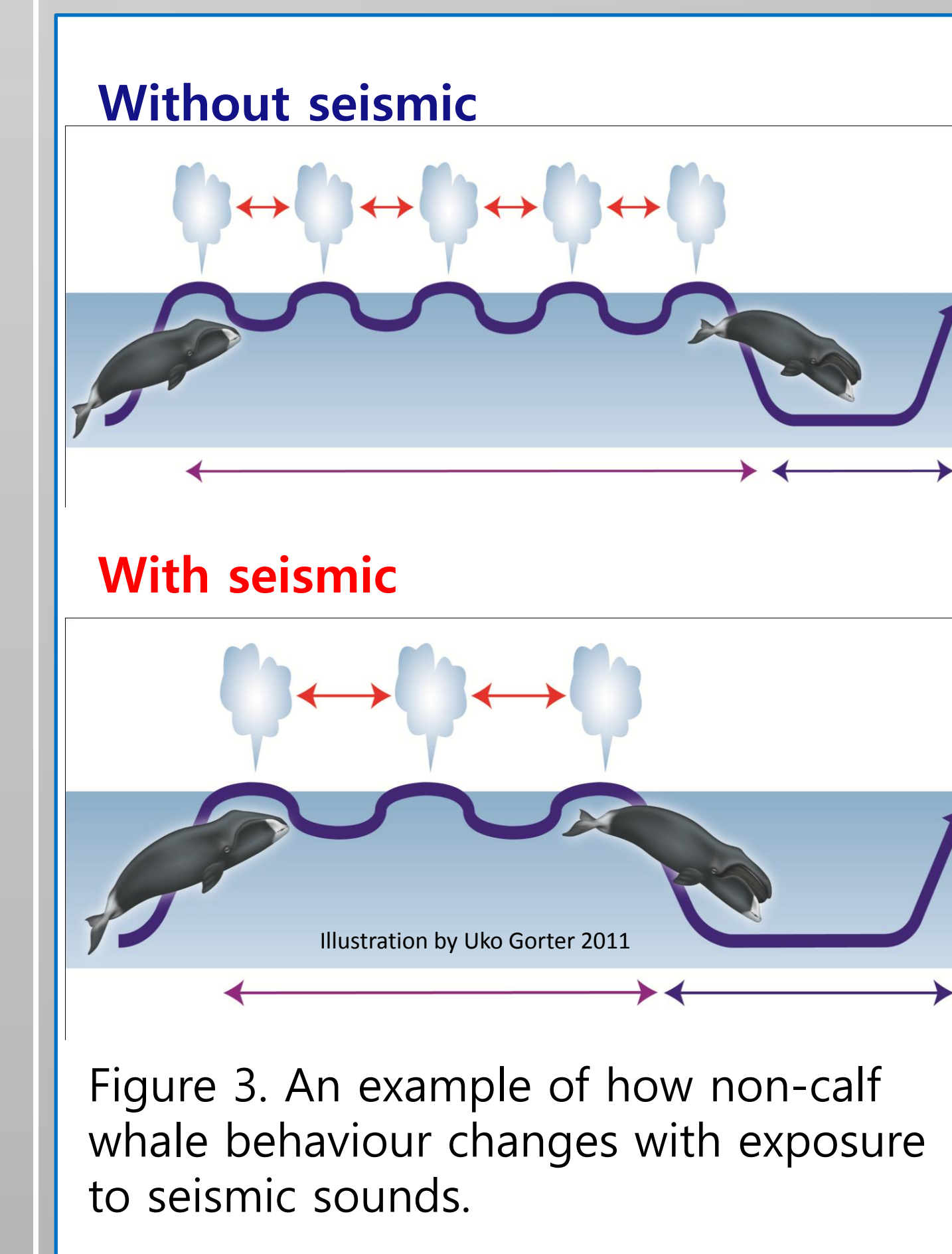
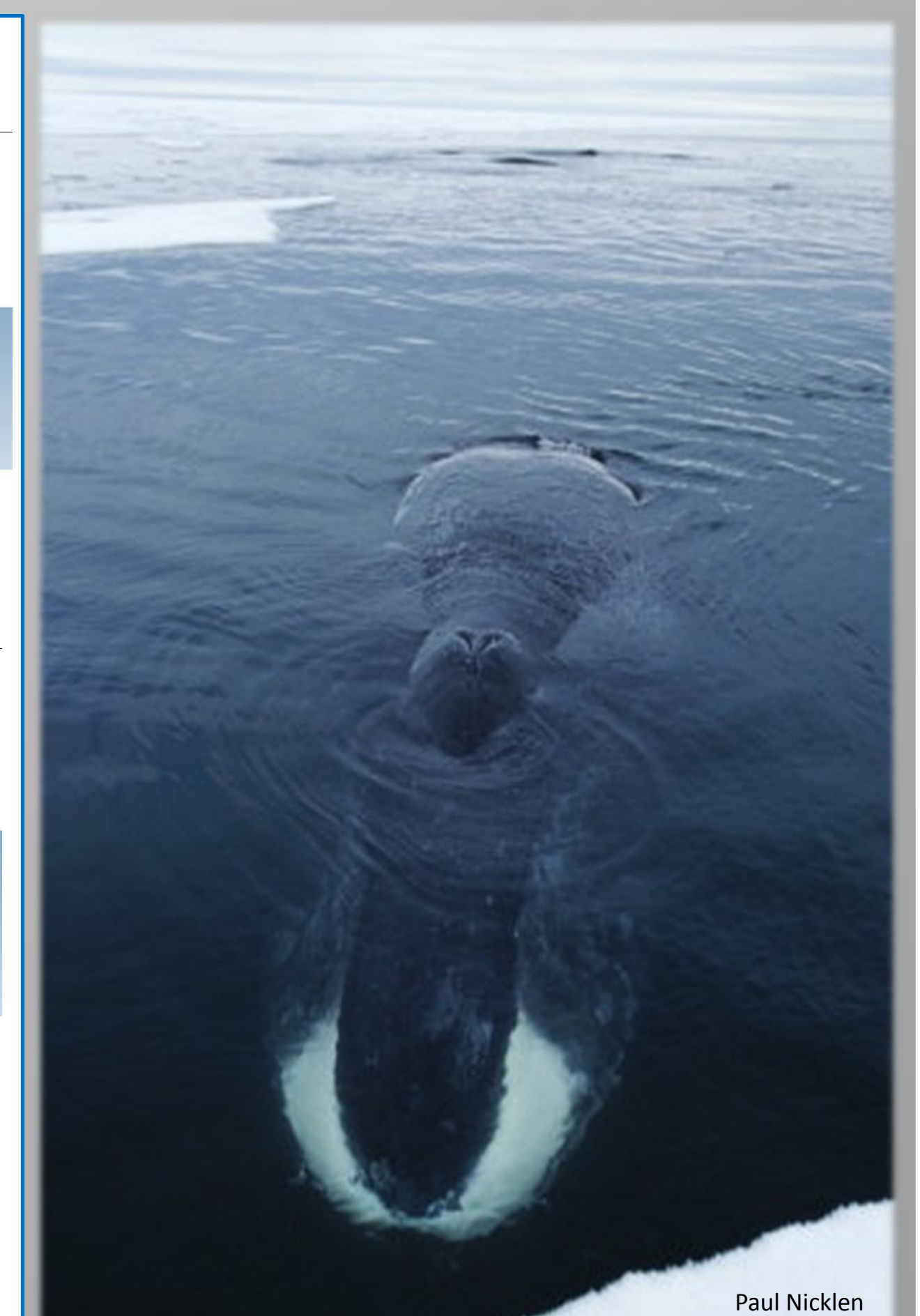


Figure 3. An example of how non-calf whale behaviour changes with exposure to seismic sounds.



ECOLOGICAL MANAGEMENT

- Bowhead behavioural reactions to seismic sounds are akin to behaviour changes in reaction to predators.
- Seismic sounds reduce availability of bowhead whales for visual detection.
- Similar changes in behaviour are observed in other air-breathing aquatic foragers faced with a threat.
- Behaviour changes must be accounted for in analyses of sighting data related to seismic operations.



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Abstract: Aerial surveys are conducted in the Beaufort Sea during late summer and fall to monitor the effects of oil and gas exploration on the distribution of bowhead whales (*Balaena mysticetus*). Earlier analyses showed that bowhead whales exposed to seismic survey activities in the Beaufort Sea exhibited localized displacement and altered surface-respiration-dive behaviors. The objective of our study was to quantify how changes in surface-dive behaviour associated with exposure to seismic sound influence the detectability of whales during aerial surveys. Altered detectability resulting from these changes in diving behaviour could lead to under- or overestimates of the numbers of whales present as well as to incorrect conclusions about their distribution relative to seismic operations. We applied Linear Mixed Models to behavioural data collected by government and industry aerial observation programs from 1980 to 2000 to investigate the effects of seismic disturbance on surface-dive behavior. We assessed the influence of seismic sound on whales according to reproductive state, activity, and season. Our results confirm that exposure to seismic sound affects bowhead surface-dive behaviour and whale detectability. Surfacing times significantly decreased when whales were exposed to seismic sound, as did the overall mean proportion of time at the surface, particularly in fall, and while whales were engaged in travel and feeding activities. Analyses of bowhead whale sightings from aerial surveys to estimate abundance and distribution must thus apply availability correction factors appropriate to the sound exposure, whale status, and whale activity.