Seasonal movements, habitat use, and dive behavior of pup and yearling bearded seals in the Pacific Arctic

Justin A. Crawford[1], Mark A. Nelson[1], Lori Quakenbush[1], Anna Bryan[1], Andrew L. Von Duyke[2], Merlin Henry[3], Alexander Niksik[4], John Goodwin[5], Alex Whiting[6], and Matthew Druckenmiller[7]

[1]Alaska Department of Fish and Game, Arctic Marine Mammals Program, Fairbanks, Alaska, Justin.Crawford@alaska.gov; [2]North Slope Borough, Department of Wildlife Management, Utqiaġvik, Alaska; [3]Alaska Native seal hunter and resident of Koyuk, Alaska; [4]Alaska Native seal hunter and resident of St. Michael, Alaska; [5]Alaska Native seal hunter and resident of Kotzebue, Alaska; [6]Native Village of Kotzebue, Alaska; [7]National Snow and Ice Data Center, University of Colorado, Boulder, Colorado

Background

Bearded seals (*Erignathus barbatus*) are benthic foragers that use sea ice for pupping, nursing, molting, and resting. Decreases in the extent of sea ice and lengthening of the open water season associated with climate change may affect fish and invertebrate prey of bearded seals, and therefore affect seal foraging behavior. Our understanding of important habitats, foraging behavior, and timing of movements, is limited; however, cooperative satellite telemetry studies among hunters and biologists are increasing our understanding of seal behavior and how these behaviors may change with future decreases in sea ice.

This project expands on past studies by tagging seals at several widely-spaced locations along the Alaskan coast. We worked with Alaska Native hunter-taggers along the Beaufort, Bering, and Chukchi sea coasts to deploy satellite-linked transmitters on young (< 2 years old) bearded seals from June through November 2014–2017. We used satellite telemetry to describe bearded seal movements and diving behavior in relation to sea ice and other environmental variables.

Methods

- We worked with seal hunters to capture bearded seals in entanglement nets and instrument them with satellite-linked transmitters.
  - **SPLASH** (Wildlife Computers, USA) or **CTD tags** (Sea Mammal Research Unit, Scotland) were glued to the hair on their mid-dorsum.
  - **SPOT tags** (Wildlife Computers, USA) were attached to a rear flipper.
- **Movements and habitat associations**:
  - We used location data collected by all SPLASH, SPOT, and CTD tags.
  - We estimated daily locations for all tagged seals using a continuous-time Correlated Random Walk (CRW) model (package *crawl* in R).
  - We **evaluated habitat associations** from August–February, including: bathymetry, distance to coast, and ice zone.
- **Dive behavior**:
  - We used dive data collected by 13 SPLASH tags.
  - We used the CRW model to predict dive locations to match dive times.
  - Dives were classified as benthic if they were <5 m from the ocean floor.
  - We used a repeated-measures mixed model to test for differences in:
    - **Proportion of benthic dives**
    - **Duration of benthic dives**
  - Variables of interest included:
    - **Seal variable**: Sex
    - **Time variables**: Month and time of day
    - **Habitat variables**: Ice zone, bathymetry, and distance to coast
  - Models were fit using SAS software (PROCs GLIMMIX and MIXED) and the best model was selected using AICc.

Acknowledgements

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Results

- We deployed satellite-linked transmitters on **24 young bearded seals** from 2014–2017 (14 SPLASH, 7 CTD, and 3 with only SPOT tags).
- Seals were **tracked 10–457 days**.

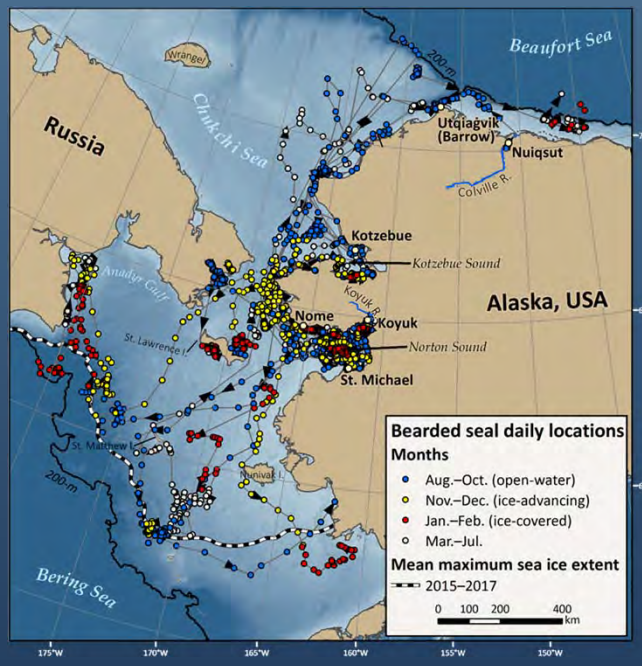

Figure 1. Movements of 24 bearded seals from 2014 to 2017. Seals were tagged with satellite-linked transmitters near St. Michael, Koyuk, Nome, Kotzebue, and Utqiaġvik (Barrow), Alaska. Daily locations were estimated using a CRW model.

Figure 2. Attaching satellite-linked transmitters to captured bearded seals: a) Palsson Fitka, July 2016 and b) Merlin Henry and Mark Nelson, September 2016.

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Movements and habitat associations

- As sea ice advanced south (September–February),
  - Seals moved toward coastal waters or the southern ice edge (Fig. 1).
  - Seals were **located in progressively heavier ice** (by concentration) with each successive month ($P<0.01$).
- During August–February, seals were located in waters ~25–45 m deep.

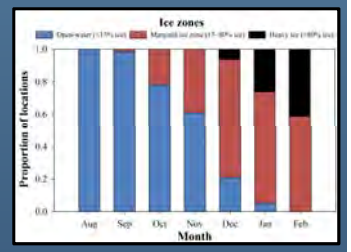

Figure 3. Proportion of estimated daily locations located in each ice zone by month.

Dive behavior

Proportion of benthic dives

- Best model: **Ice zone × Hour + Bathymetry**
- Seals made proportionally **fewer benthic dives** from 0000–0400 when **in heavy ice** vs. marginal ice or open water ($P<0.01$).
- Overall, seals made proportionally fewer benthic dives from 1900–0000 than from 0700–1400 ($P<0.01$).
- Seals made proportionally fewer benthic dives in deep (50–70m; 60%) vs. shallow (0–40m; 87%) water ($P<0.01$).

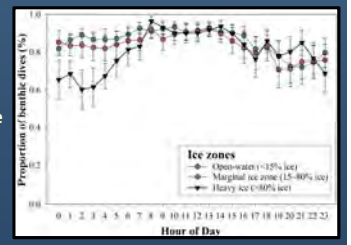

Figure 4. Proportion of benthic dives made in each ice zone by hour of day.

Duration of benthic dives

- Best model: **Ice zone × Hour**
- Seals made **shorter benthic dives when in heavy and marginal ice** vs. open water ($P<0.01$).
- Dives were longer from 2100–0200 than from 0900–1800 ($P<0.01$).

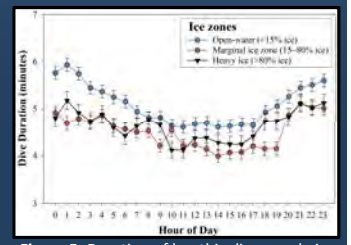

Figure 5. Duration of benthic dives made in each ice zone by hour of day.

Summary

- In heavy ice, seals made proportionally fewer benthic dives and durations were shorter in heavy and marginal ice than in open water.
- Seals made proportionally fewer benthic dives at night, possibly in response to the vertical migration of their prey; however, durations were longer at night than the rest of the day.
- The presence and concentration of sea ice appears associated with reduced benthic foraging.
- Continued studies of bearded seal foraging behavior are necessary to monitor for changes in behavior with continued changes in sea ice.