

Oceanographic characteristics associated with movements and high-use areas of spotted seals (*Phoca largha*) in the Chukchi and Bering seas

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BACKGROUND

Spotted seals (*Phoca largha*) are pelagic foragers that use Bering Sea pack ice for pupping, nursing, and resting when ice is present and rest on shore during the open-water season. Warming of Pacific Arctic waters associated with climate change may affect fish and invertebrate prey of spotted seals, and therefore affect their foraging behavior. Decreases in the extent of sea ice and lengthening of the open-water season have eased access to the Arctic for development and shipping, prioritizing the need to identify areas important to seals. Our understanding of movements, high-use areas, and foraging habitats of spotted seals is limited. Therefore, we worked with Alaska Native hunter-taggers along the Beaufort and Bering sea coasts to deploy satellite-linked transmitters on spotted seals from July through October 2016–2018 to describe movements and identify high-use areas and oceanographic characteristics in these areas.

METHODS

- We worked with seal hunters to capture spotted seals in entanglement nets and instrument them with satellite-linked transmitters.
 - CTD tags** (Sea Mammal Research Unit, Scotland) or **SPLASH** (Wildlife Computers, USA) were glued to the hair on their mid-dorsum.
 - SPOT tags** (Wildlife Computers, USA) were attached to a hind flipper.
- MOVEMENTS:**
 - We used location data collected by all CTD, SPLASH, and SPOT tags.
 - We estimated daily locations for all tagged seals using a continuous-time Correlated Random Walk (CRW) model (package *crawl* in R).
 - We **evaluated movements** of seals based on:
 - Season:** Open-water (May–November), Ice (December–April).
 - Tagging area:** Beaufort and Bering seas.
- HIGH-USE AREAS:**
 - We identified high-use (core) areas based on the density of daily estimated locations within 50×50 km square cells across our study area. The volume rasters calculated are utilization distributions (UD).
 - UDs were calculated** for:
 - Season,**
 - Tagging area,** and
 - Distance from shore:**
 - Offshore (>5 km): associated with foraging
 - Nearshore (<5 km): associated with resting and foraging
 - Haul-out data collected by tags informed identification of resting areas.
 - We considered **core areas** to be cells with UD of <50% volume.
 - OCEANOGRAPHIC CHARACTERISTICS:**
 - We plotted temperature and salinity data (CTD tags) from maximal dive depths in offshore high-use areas to identify **water masses** used by seals, when appropriate.

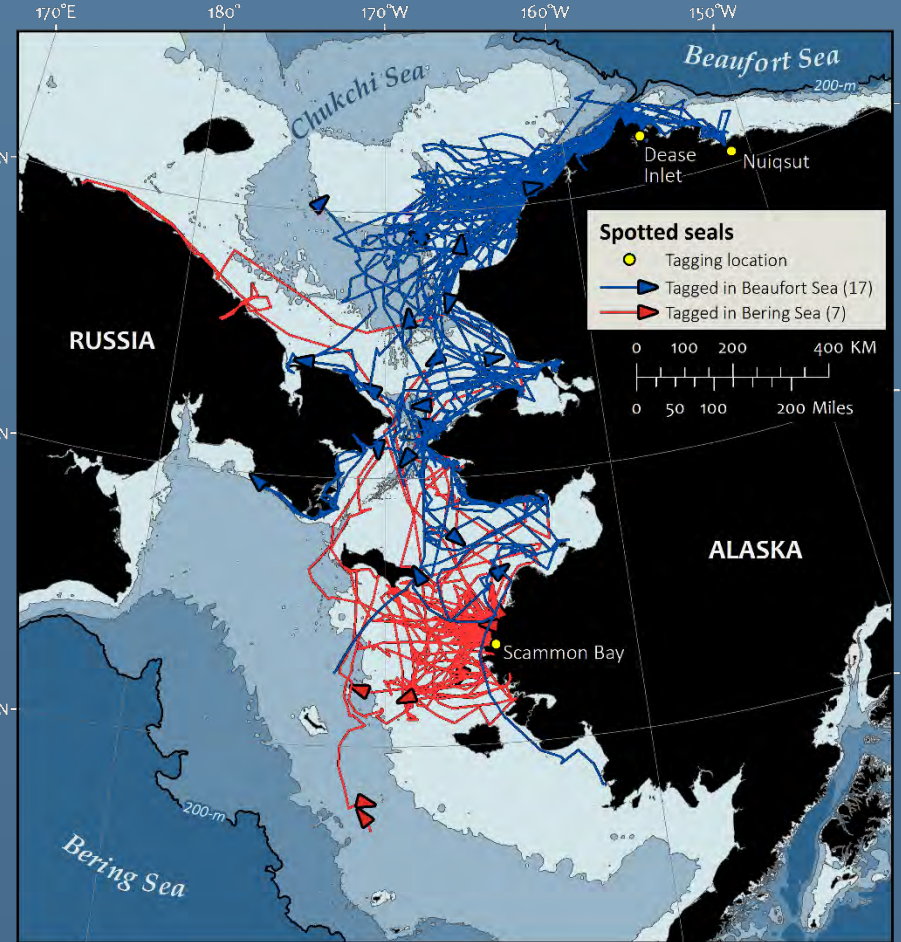


Spotted seal instrumented with a CTD tag, 2016.

RESULTS

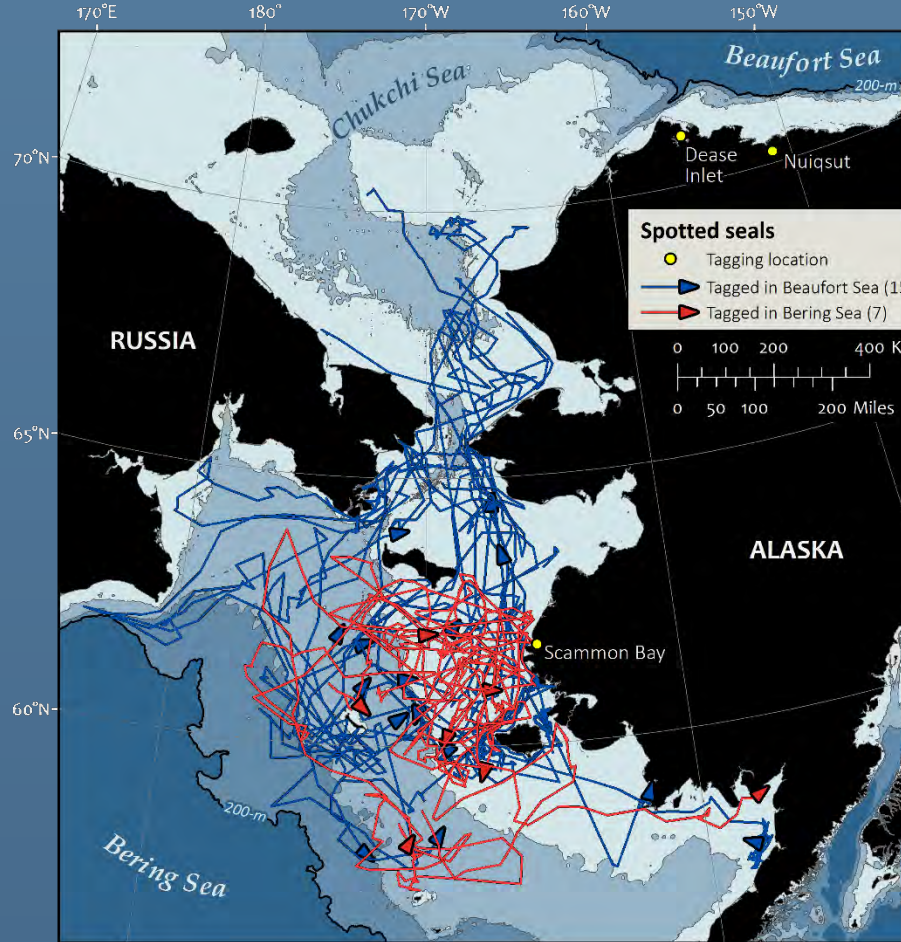
- We deployed satellite-linked transmitters on **24 spotted seals** from 2016–2018 (20 CTD, 4 SPLASH, and 24 SPOT tags).
- Seals were **tracked 137–638 days**.

OPEN-WATER SEASON MOVEMENTS



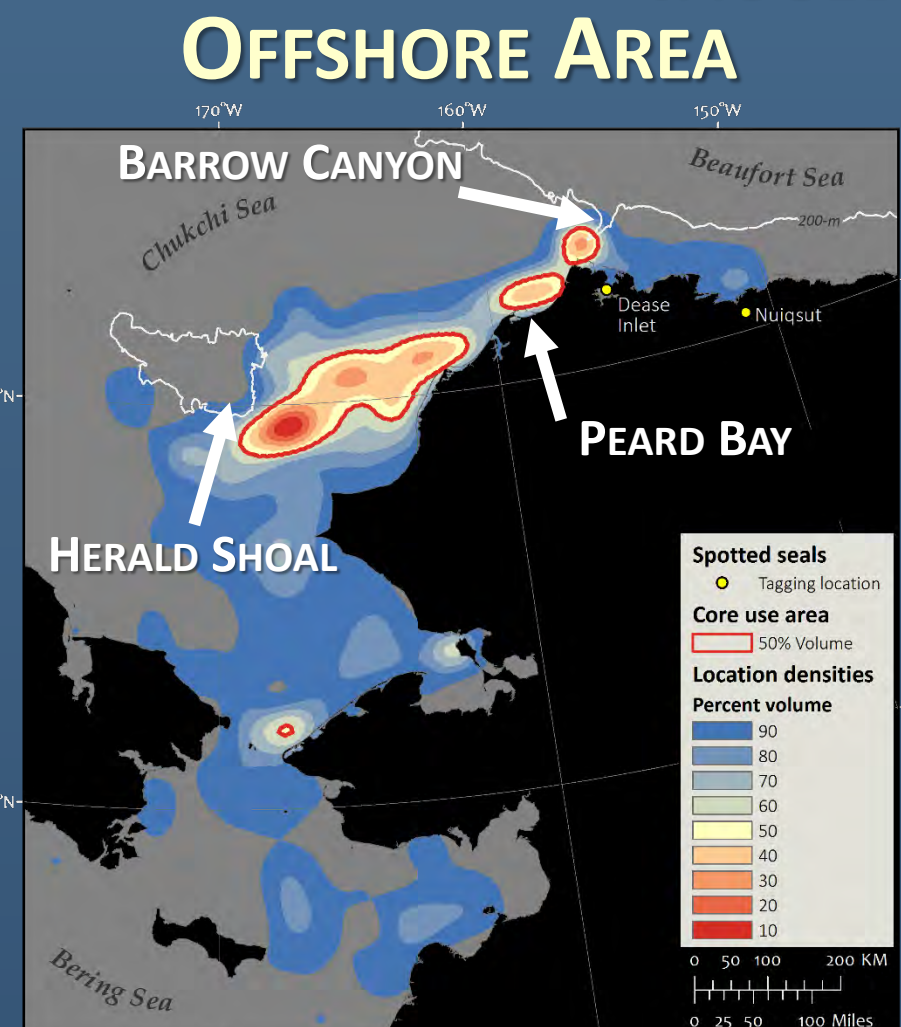
- All seals made **frequent east-west movements** between foraging areas and the Alaskan coast, including returning to tagging locations.
- Seals **tagged in the Beaufort Sea** moved between foraging areas in the Chukchi Sea and the Alaskan coast.
- Seals **tagged in the Bering Sea** moved between foraging areas in the central Bering Sea and the Alaskan coast.
- Seals rarely moved between the Bering and Chukchi seas.**

ICE SEASON MOVEMENTS

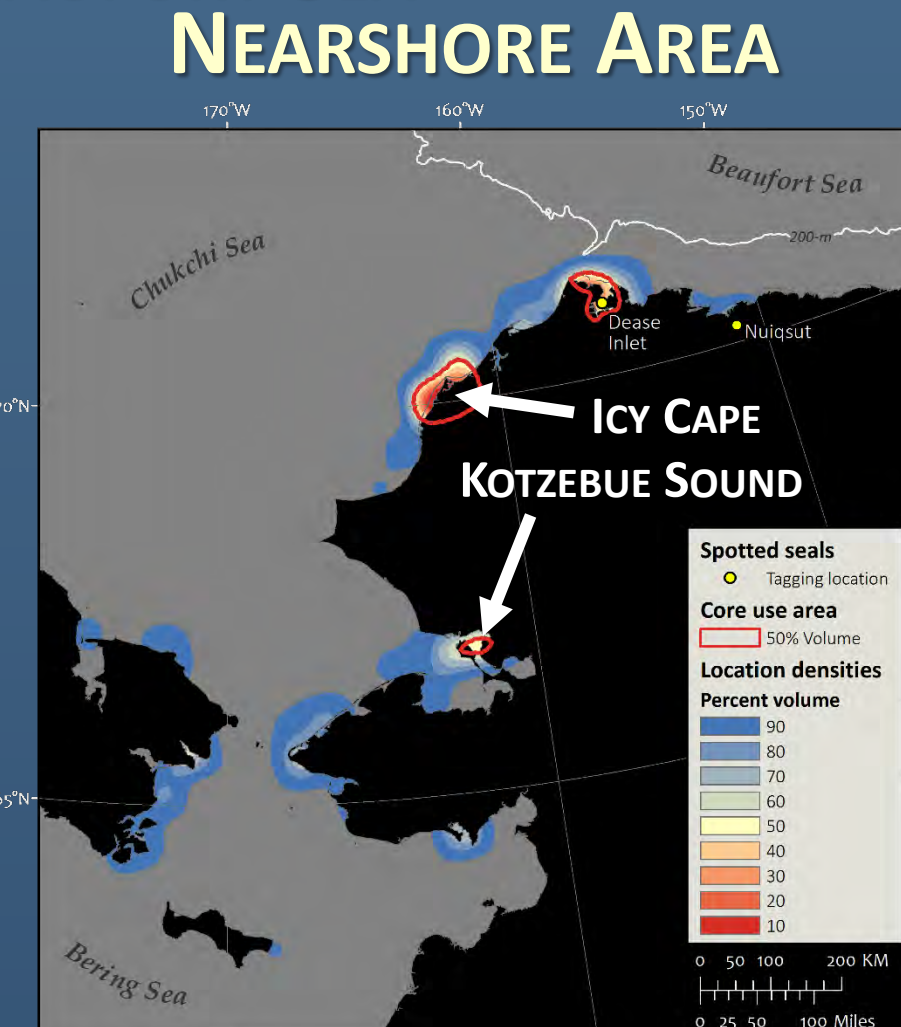


- In December, seals **tagged in the Beaufort Sea** moved south, ahead of the advancing pack ice.
- By mid-January, **all seals** regardless of tagging location occupied pack ice and foraged in the central Bering Sea.

HIGH-USE AREAS TAGGED IN BEAUFORT SEA

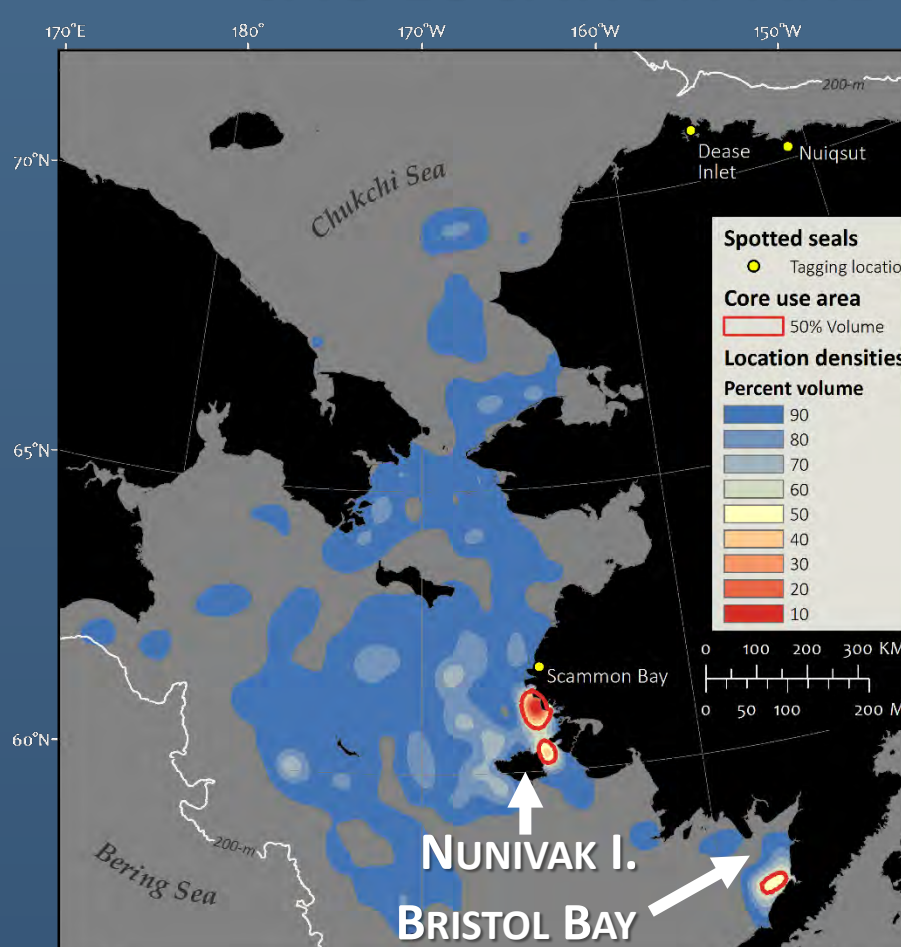


Seals spent 1–27 days foraging, primarily between Herald Shoal and nearshore waters of the northeast Chukchi Sea (<50 m deep).



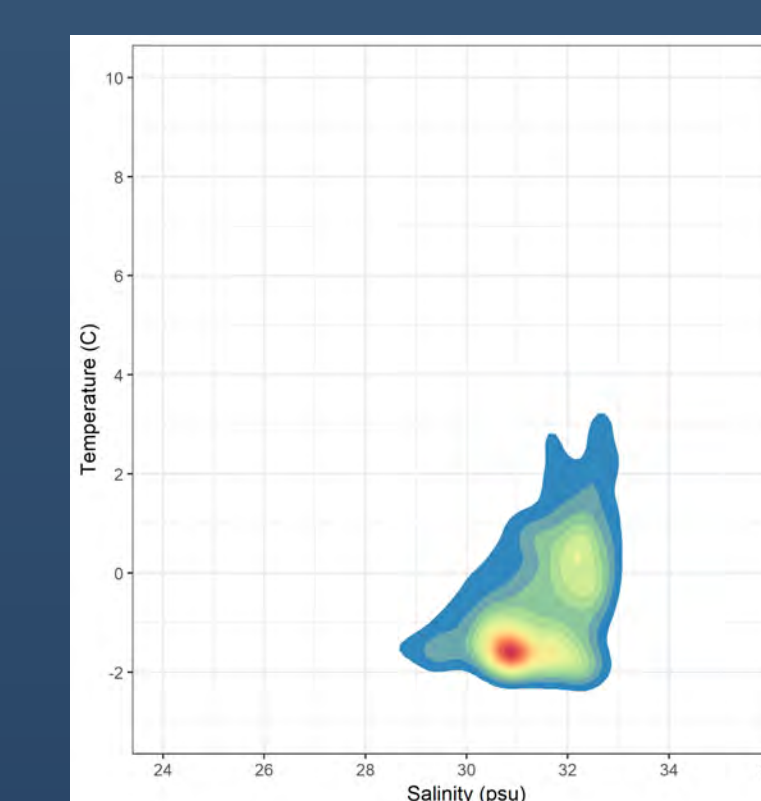
Seals spent 2.4 hrs. – 5.7 days resting, primarily on islands near Icy Cape, Dease Inlet and Kotzebue Sound.

HIGH-USE AREAS TAG LOCATION AND COASTAL PROXIMITY POOLED



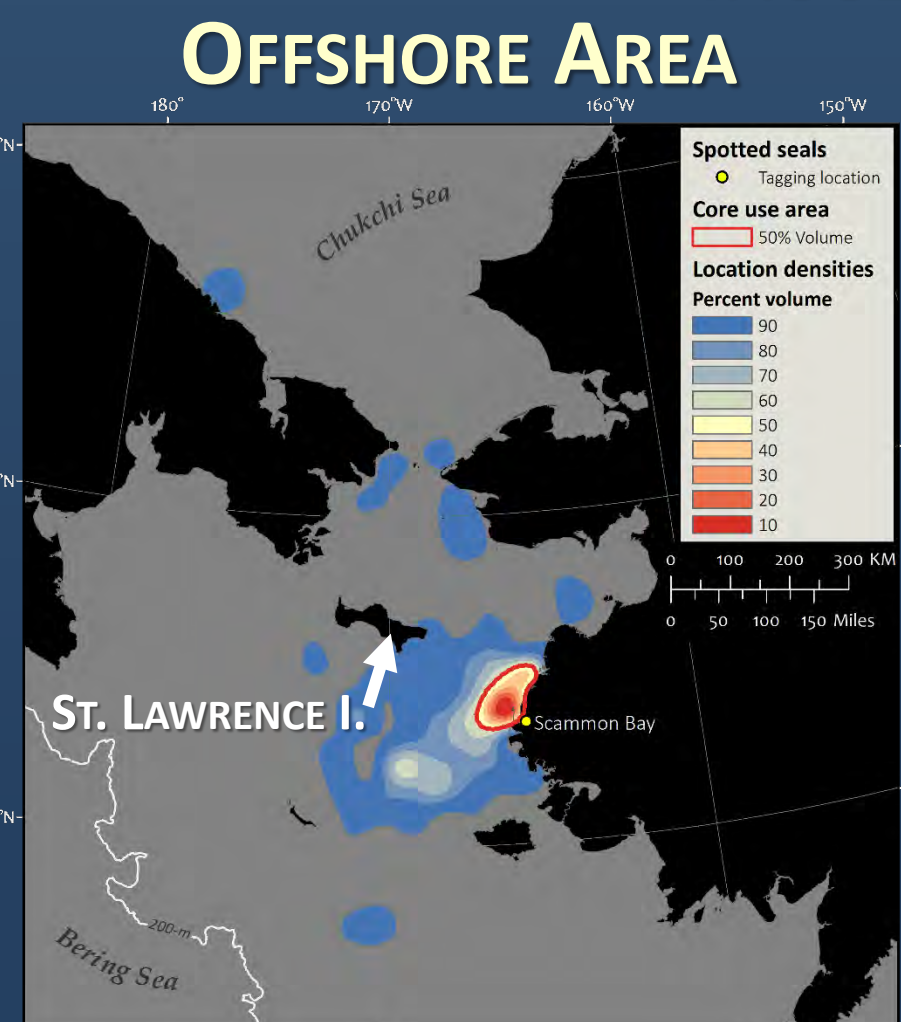
- When sea ice was present, seal high-use areas were similar regardless of tag location and distance from shore.
- Seals foraged and rested primarily near Nunivak Island and the Alaska coast.
- Low sea ice in the Bering Sea in recent years may be limiting spotted seals from using the central Bering Sea.

OCEANOGRAPHIC CHARACTERISTICS

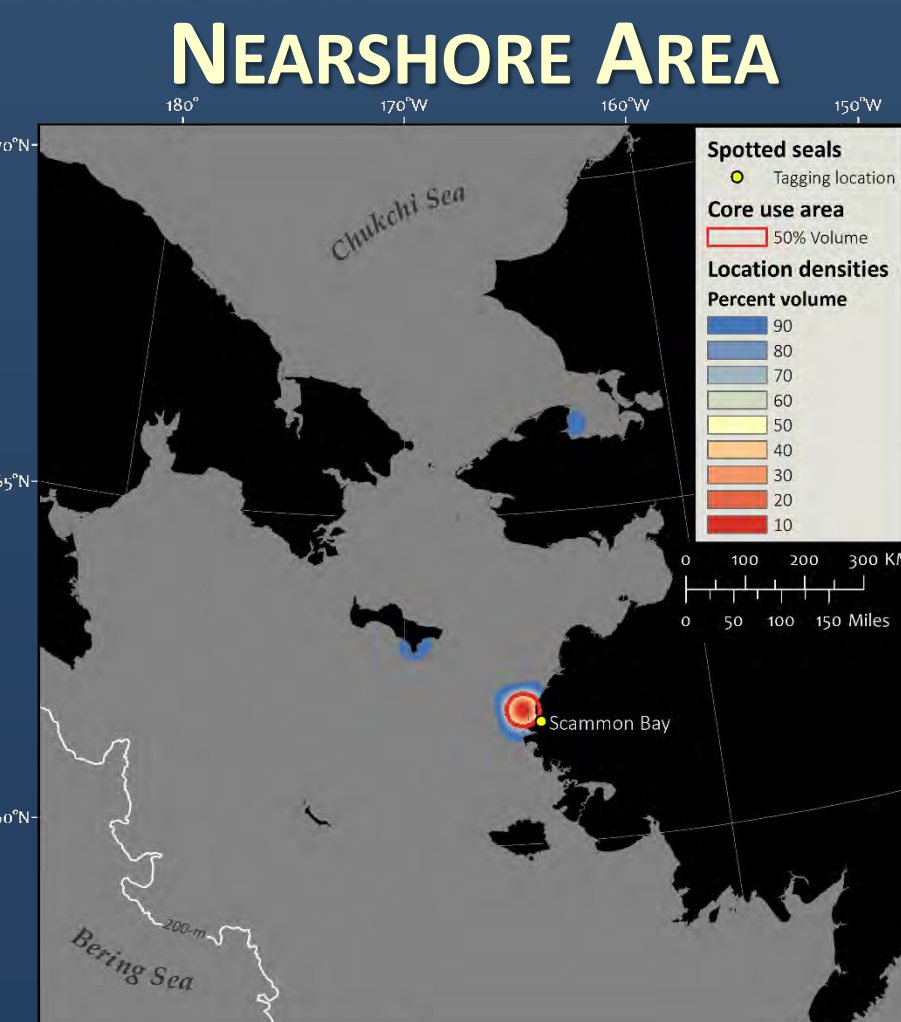


Density of seal locations relative to water temperature and salinity at maximal dive depths in high-use areas. Warm colors depict high densities. Water masses are not well defined in the Bering during winter.

HIGH-USE AREAS TAGGED IN BERING SEA

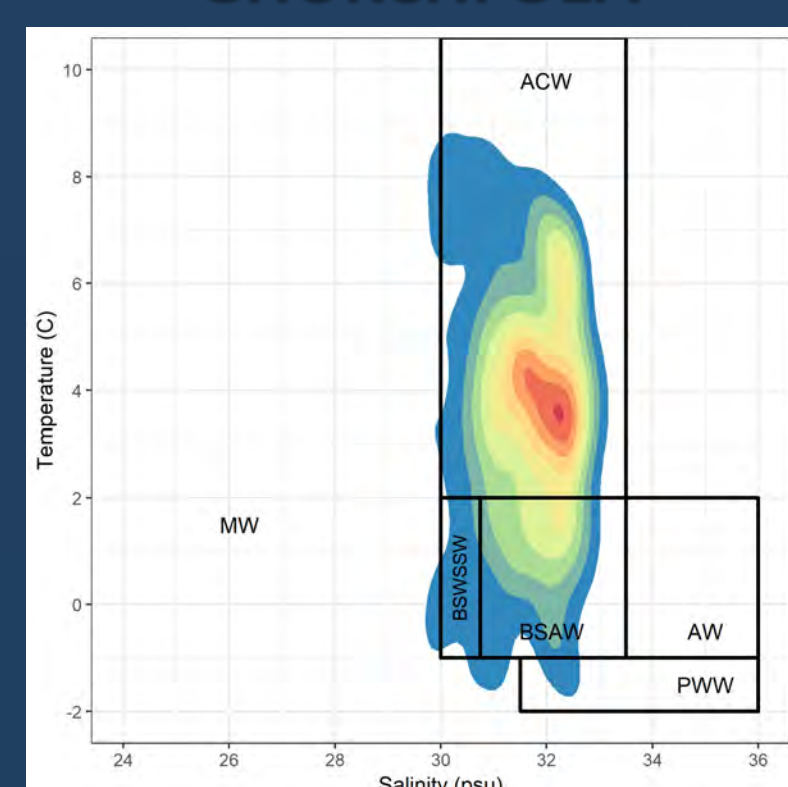


Seals spent 1–25 days foraging, primary between the central Bering Sea and Alaska coast, including tagging location.

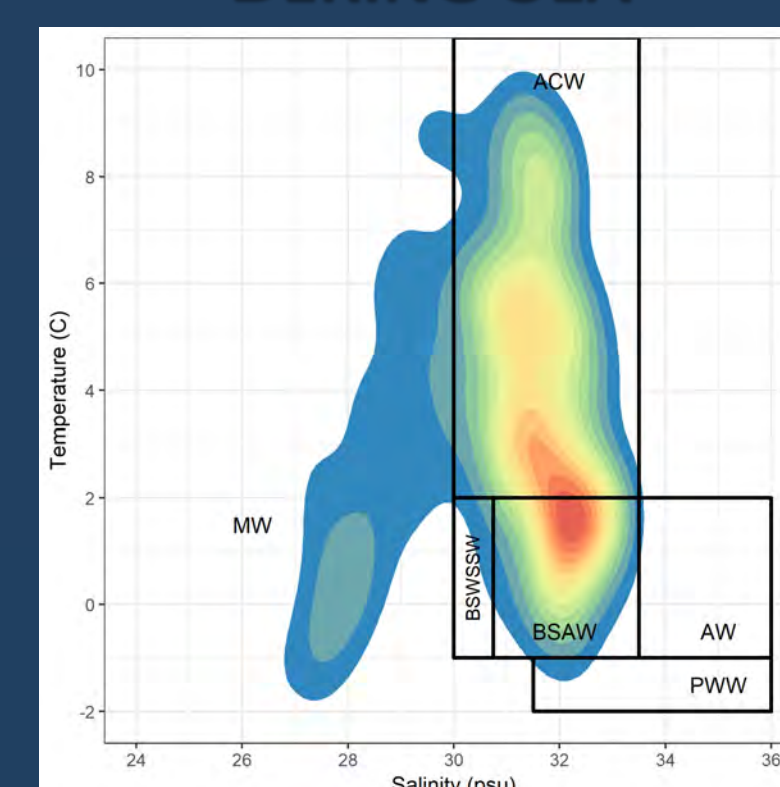


Seals spent 45 min. – 6.2 days resting, primarily on islands near Scammon Bay, where they were tagged.

OCEANOGRAPHIC CHARACTERISTICS CHUKCHI SEA



Density of seal locations relative to water masses at maximal dive depths in offshore high-use areas. Warm colors depict high densities. Water masses: melt water (MW), Alaskan Coastal Water (ACW), Bering Summer Water and Siberian Shelf Water (BSWSSW), Bering Shelf/Anadyr Water (BSAW), Atlantic Water (AW), and Pacific Winter Water (PWW).



SUMMARY

- OPEN-WATER SEASON:**
 - Spotted seals in the Chukchi and Bering seas made frequent east-west foraging movements, rested on shore, and rarely moved between seas.
 - Seals in the Chukchi Sea foraged primarily in Alaskan Coastal Water; in the Bering Sea they foraged in Alaskan Coastal Water and Bering Shelf/Anadyr Water.
- ICE SEASON:**
 - Seals primarily foraged in cold water of Pacific origin in the Bering Sea.
- Movement patterns highlight the importance of tagging seals throughout their range to understand habitat use.

FUTURE WORK

- Continue to instrument seals to monitor how seal high-use areas are influenced by the changing climate, oceanographic conditions, and sea ice.

ACKNOWLEDGEMENTS

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