

Seasonal changes in diving behavior of adult and subadult ringed seals (*Pusa hispida*) in the Bering and Chukchi seas

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ABSTRACT

Diving behavior of 14 adult and 21 subadult ringed seals in the Bering and Chukchi seas was analyzed from satellite-linked dive recorders (SDRs) placed on seals in Kotzebue Sound, Alaska during October 2007–2009 and tracked for 12 to 297 days. During the open-water period, in October and November, all seals moved throughout the Chukchi Sea in waters that averaged 70 m and were up to 200 m deep. Dive durations were not different between age classes, averaging 1.9 min/dive; however, subadults dove to deeper depths ($P < 0.01$). As sea ice coverage increased during late November and December, adults stayed near the shorefast ice in the Chukchi Sea and Bering Strait, while subadults migrated south into the central Bering Sea pack ice in waters that averaged 63 m and were up to 2,180 m deep. From December through March, adults dove longer (2.4 min/dive) but to shallower depths ($P < 0.01$) than subadults (1.9 min/dive; $P = 0.01$). In spring, the adults remained near their winter locations, and subadults followed the receding sea ice northward into the Chukchi Sea. From April to June, adults again dove longer (3.4 min/dive) but to shallower depths ($P < 0.01$) than subadults (2.8 min/dive; $P < 0.01$). Adults used shorefast ice habitats in the Chukchi Sea during winter and spring where they maintain breathing holes and lairs. Adults return to the same lairs or breathing holes and may need to forage farther from their holes to find adequate prey. By moving south to the Bering Sea ice front during winter, however, subadults can feed in broken pack ice where foraging opportunities are not restricted by access to air. At the ice front, subadults dove for shorter durations than adults.

RESULTS

Diving behavior of ringed seals varied among seasons and between age classes.

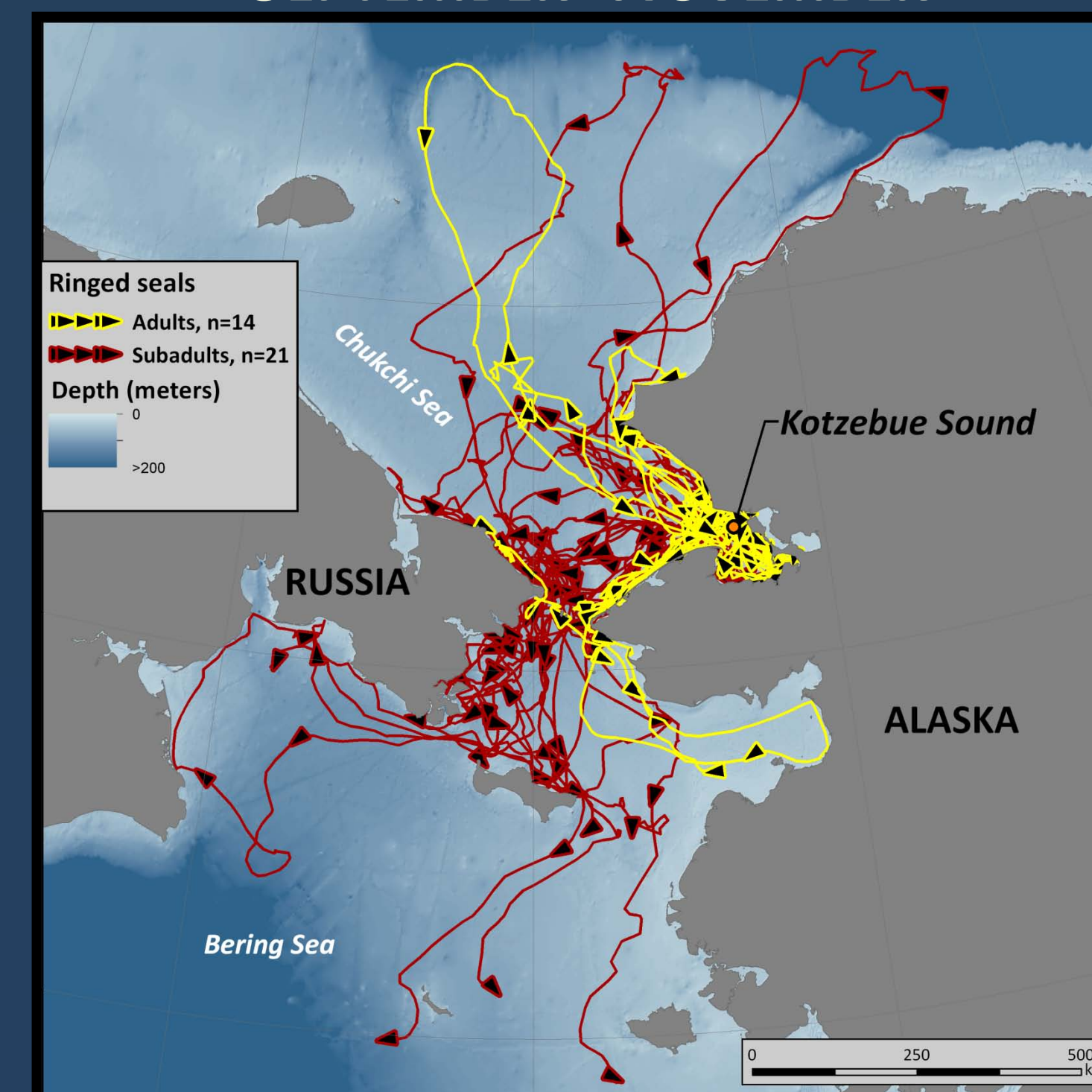
- Chronologically, from the **open-water period through the ice-breakup season**:
 - Adults dove deeper ($P < 0.05$) and for longer duration ($P < 0.01$) each successive season.
 - Subadults dove deeper ($P < 0.01$) each successive season; dive durations during the ice-breakup season were longer ($P < 0.01$) than during the open-water and ice-covered seasons, which were not different ($P = 0.15$).
- Open-water season**:
 - Adults dove to shallower depths than subadults ($P < 0.01$); however, dive durations were not different ($P = 0.54$) between age classes.
- Ice-covered season and Ice Breakup season**:
 - Adults dove to shallower depths than subadults ($P < 0.01$) but dove for longer durations ($P < 0.01$).
- Male vs. female**
 - Dive depth ($P = 0.22$) and duration ($P = 0.30$) did not vary by sex.

METHODS

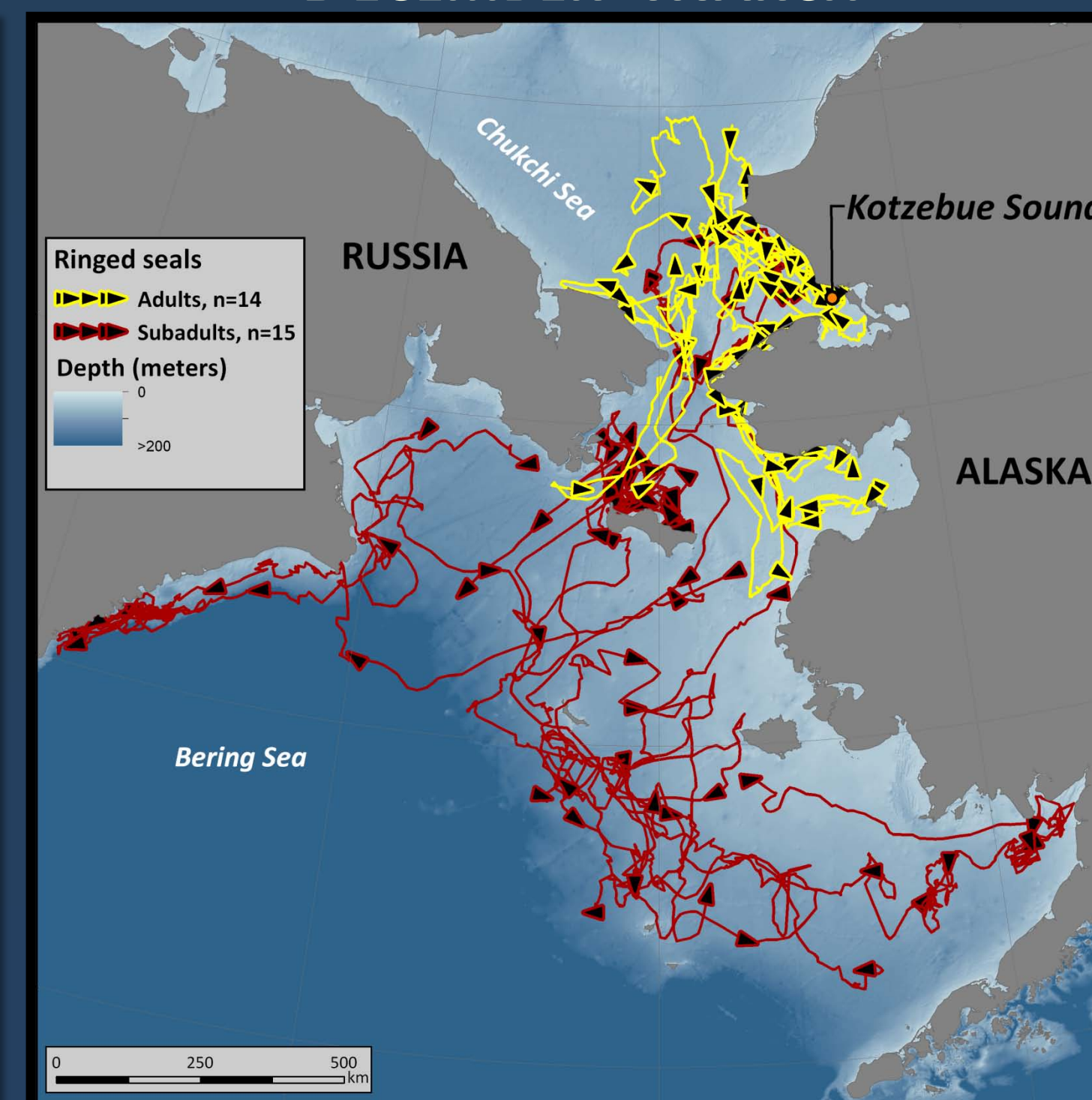
- Ringed seals were captured in Kotzebue Sound, Alaska, during October of 2007–2009 using entanglement nets. Satellite transmitters were glued to the hair on the mid-dorsum.
- Binned dive data were summarized for statistical analyses by computing dive depth and duration indices (Folkow et al. 1999) as:

$$Index_x = \sum (f_i M_i)$$
 - X: type of index (dive depth or duration)
 - f_i : Proportion of dives assigned to depth/duration bin i
 - M_i : Median depth or duration value of bin i
- We used a repeated-measures mixed model to test for differences in dive behavior. Variables of interest included:
 - Age Class**: adult and subadult
 - Sex**: male and female
 - Season**:
 - Open-water: September–November
 - Ice-covered: December–March
 - Ice-breakup: April–June
- Models were fit using SAS software (PROC MIXED) and the best model was selected using a backwards elimination procedure ($\alpha = 0.05$). We used a first-order auto-regressive structure to account for covariance.

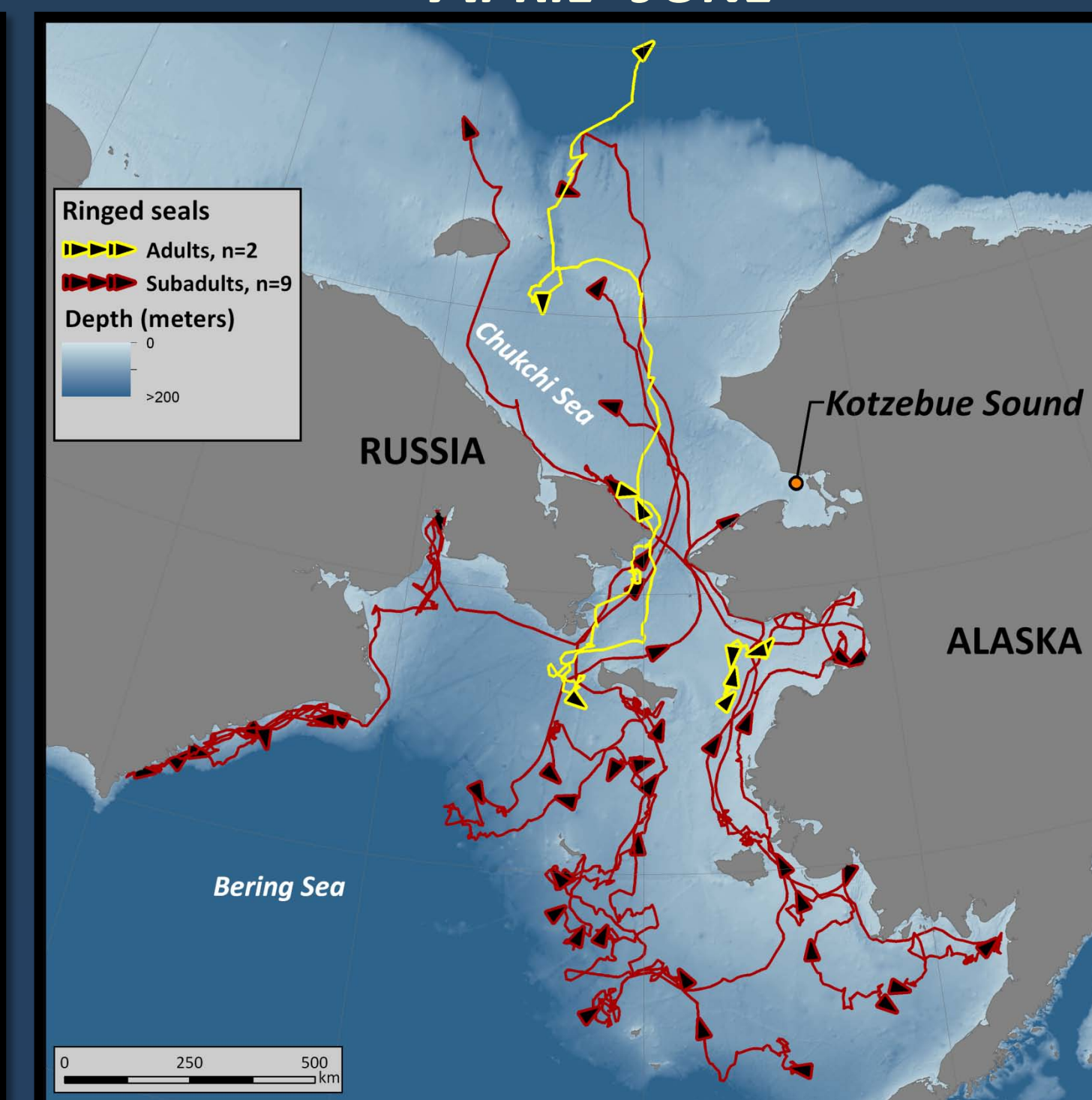
OPEN-WATER: SEPTEMBER–NOVEMBER



ICE-COVERED: DECEMBER–MARCH

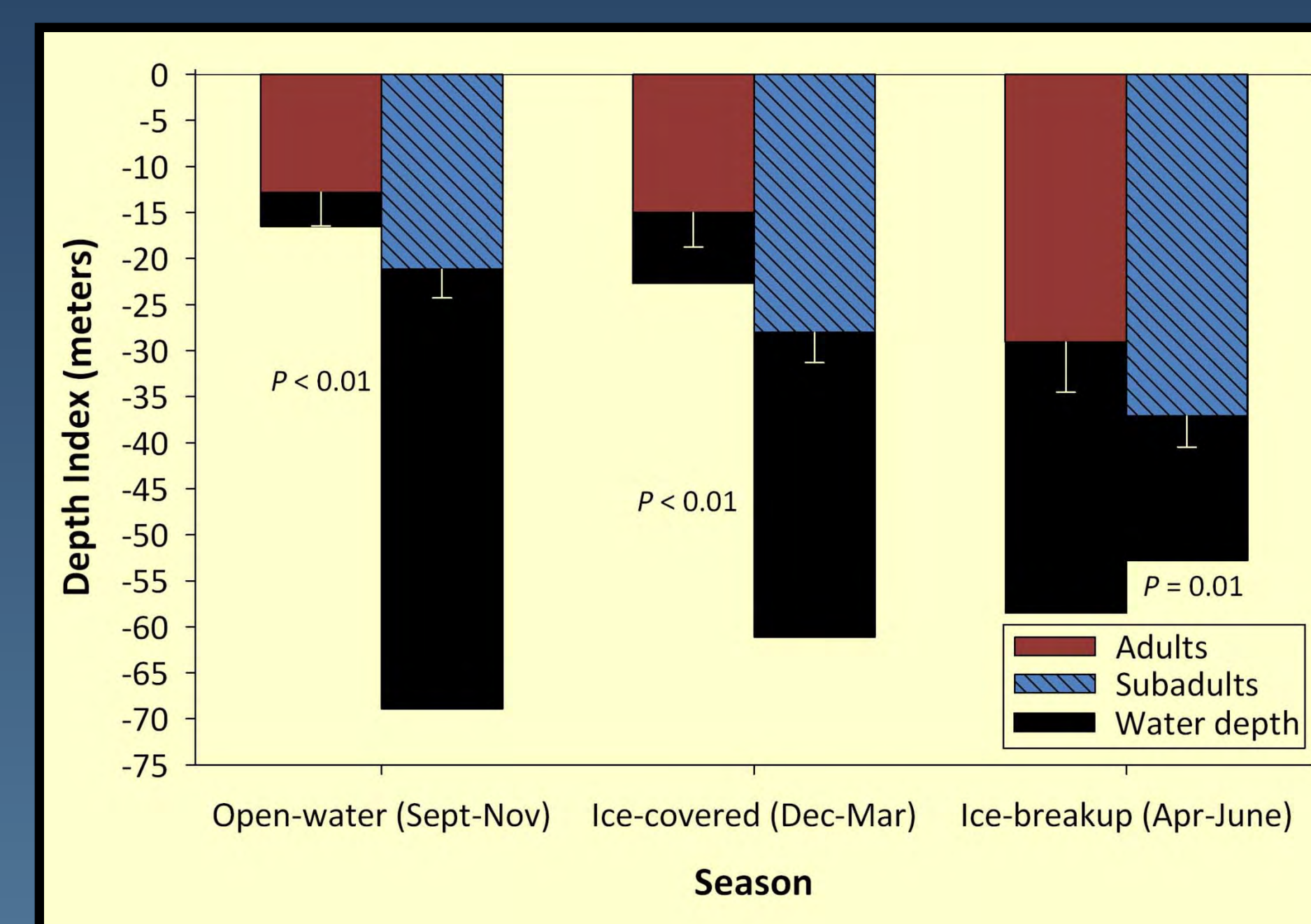


ICE-BREAKUP: APRIL–JUNE



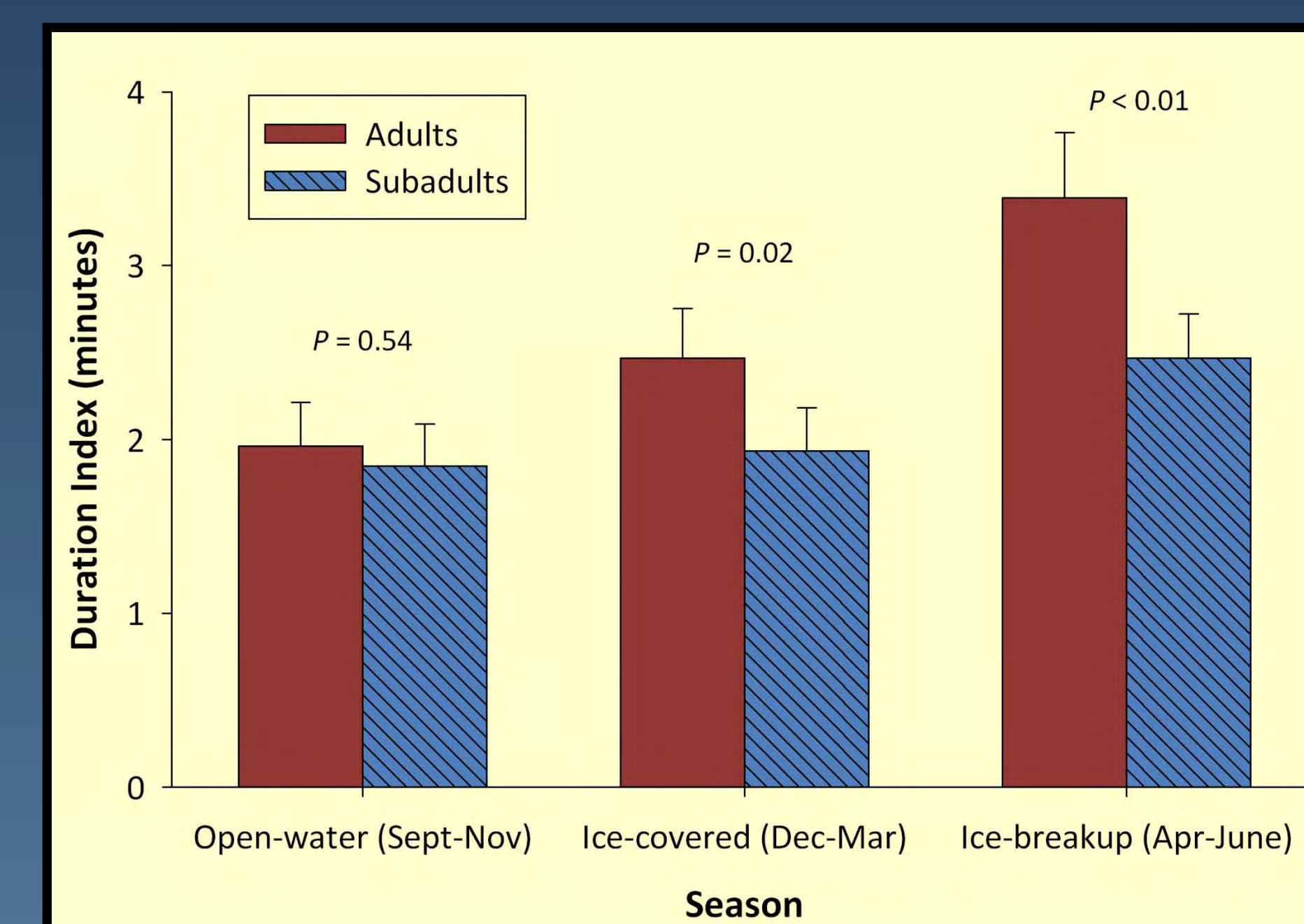
Movements of adult and subadult ringed seals, where dives were analyzed during the open-water, ice-covered, and ice-breakup seasons from 2007–2010 (Crawford et al. 2011).

DIVE DEPTH



Black bars in background are mean water depths where dives were analyzed for adults and subadults during each season. P-values represent differences between age classes during each season.

DIVE DURATION



P-values represent differences between age classes during each season.

DISCUSSION

- Reasons for the seasonal and age class differences in dive behavior are unknown but may include greater physiological capabilities of adults, local bathymetry, location of prey within the water column, and adult dependence on breathing holes.
- Differences in *dive depth* between age classes may not be due to physiological capabilities, rather differences may be a result of the depth of their target prey, because:
 - Dive depth is only limited by bathymetry in shallow water.
 - Seals rarely dove to the benthic zone when not in shallow water.
- Adults**:
 - Primarily located near shorefast ice in shallower water.
 - Shallow dives may indicate foraging on ice-associated amphipods and cod species.
 - Longer dive durations are likely due to their dependence on breathing holes and/or lairs for access to air and physiological capabilities.
- Subadults**:
 - Primarily located off shore in deeper water, mainly in the central Bering Sea.
 - Deeper dives may indicate foraging on prey in the mid-water column.
 - Shorter dive durations are likely due to unrestricted access to air in the pack ice and physiological capabilities.

REFERENCES

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- FOLKOW, L. P. AND A. S. BLIX. 1999. Diving behaviour of hooded seals (*Cystophora cristata*) in the Greenland and Norwegian seas. *Polar Biology* 22: 61–74.

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