Aquatic Mammals 2006, *32*(1), 98-102, DOI 10.1578/AM.32.1.2006.98

Rapid Seasonal Sea-Ice Retreat in the Arctic Could Be Affecting Pacific Walrus (*Odobenus rosmarus divergens*) Recruitment

Lee W. Cooper,[1] Carin J. Ashjian,[2] Sharon L. Smith,[3] Louis A. Codispoti,[4] Jacqueline M. Grebmeier,[1] Robert G. Campbell,[5] and Evelyn B. Sherr[6]

[1]*Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, TN 37996, USA*
[2]*Department of Biology, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA*
[3]*Rosenstiel School of Marine and Oceanographic Science, University of Miami, Miami, FL 33149, USA*
[4]*University of Maryland Center for Environmental Science, Cambridge, MD 21613, USA*
[5]*Graduate School of Oceanography, University of Rhode Island, Narragansett, RI 02882, USA*
[6]*College of Oceanographic and Atmospheric Sciences, Oregon State University, Corvallis, OR 97331-5503, USA*

Abstract

Under conditions of rapid sea-ice retreat and dissolution, we observed at least nine Pacific walrus calves separated from adult females in waters as deep as 3,000 m in July and August 2004 in the Canada Basin of the Arctic Ocean. Given limited sea surface visibility from the ship, we surmise that many additional calves may have been separated in the overall study area. These conditions appear to have been related to the transport of unusually warm (7° C) Bering Sea water into this area north of Alaska. Walruses invest considerable maternal resources while caring for calves on seasonally ice-covered continental shelves for periods of up to 2 y or more and only rarely separate from their young. Therefore, these observations indicate that the Pacific walrus population may be ill-adapted to rapid seasonal sea-ice retreat off Arctic continental shelves.

Key Words: Pacific walrus, *Odobenus rosmarus divergens*, marine mammal strandings, marine mammal recruitment, global warming, Arctic, sea-ice, Chukchi Sea, Beaufort Sea

Introduction

Pacific walruses (*Odobenus rosmarus divergens* Illiger) are adapted to life on shallow Arctic continental shelves and specialize in feeding on benthic macroinvertebrates (Fay, 1982), which are present in high benthic standing stock communities on portions of the Chukchi continental shelf (Feder et al., 1994). Walruses dive to depths no greater than 200 m (Fay & Burns, 1988), but the recent trend of seasonal sea-ice retreat in the Arctic Ocean has resulted in seasonal sea-ice often retreating off the continental shelf (McPhee et al., 1998; Rothrock et al., 1999; Serreze et al., 2003) until it is only located over deep Arctic Ocean waters where negligible macroinvertebrate food is present in the benthos (Grebmeier & Barry, 1991). Female walruses with calves are typically distributed in the summer in continental shelf waters to the north of Alaska, where they use seasonal sea-ice as a platform from which to dive to the bottom while feeding (Fay, 1982). These animals are not normally observed in deep Arctic basin waters, however, because of the lack of food and depth limits for diving.

We present data here on the locations and ocean depths at sites where walrus calves were observed to be separated from adult females in Arctic Ocean waters north of Alaska in July and August 2004. These data were collected in conjunction with oceanographic sampling that documented the intrusion of warm (7° C) water onto portions of the Chukchi and Beaufort Seas' continental shelves, where, until recent years, seasonal sea-ice has been typically present, even during the summer. Our widespread observations of walrus-calf separations, which to our knowledge have not been reported previously, indicate that the Pacific walrus population may be ill-adapted to rapid seasonal sea-ice retreat off Arctic continental shelves. These observations are consistent with predictions that continued retreat of Arctic sea-ice is likely to impact lactating walruses negatively that use sea-ice over the continental shelf as a feeding platform (Kelly, 2001). Walrus calves are dependent on maternal care for 2 y or more before they are able to forage for themselves, so the presence of seasonal sea-ice over the continental shelves may be critical for feeding success and maternal care of walrus calves.

Materials and Methods

Locations of lone walrus calves were documented using geographical positioning technology during a cruise (HLY04-03) of the U.S. Coast Guard

icebreaker, *Healy*, in conjunction with digital photography timing, ship bridge logs, and other observations of walruses in the vicinity of the ship during oceanographic sampling. A geographical information system (GIS) aboard the ship (www.joss.ucar.edu/sbi/) was used to document the water depths where walrus calves were observed and to produce regional bathymetric charts showing the locations of lone walruses in relation to water depth. Simultaneous water sampling using a conductivity-temperature-depth profiling system with a rosette of bottles documented the water masses present in the study area, allowing us to study such indicators as salinity, temperature, and inorganic nutrients. In addition, a multiple vertical opening and closing plankton net system was deployed throughout the cruise to document distributions of zooplankton populations, which also were used as a diagnostic tool for identifying the water mass origins of sea water in the portion of the Arctic Ocean studied.

Results

During a research cruise from 18 July to 26 August 2004 as part of the Shelf Basin Interactions program (http://sbi.utk.edu), we observed at least nine separated walrus calves in Canada Basin waters (as deep as 3,000 m) where no adult walruses were observed (Figure 1). Because of the limited sea surface area visible from the ship, it is likely that much higher numbers than nine separated calves were present in the overall study area. During this cruise, adult females with calves were only observed in shallow waters at the head of Barrow Canyon, where depths were less than 100 m (Figure 1). Our observations coincided with the presence of a large plume of warm water carrying Bering Sea-origin plankton (e.g., *Neocalanus* spp. copepods) and having hydrographic characteristics (salinity and nutrient ratios) consistent with a Bering Sea origin. This water mass intruded

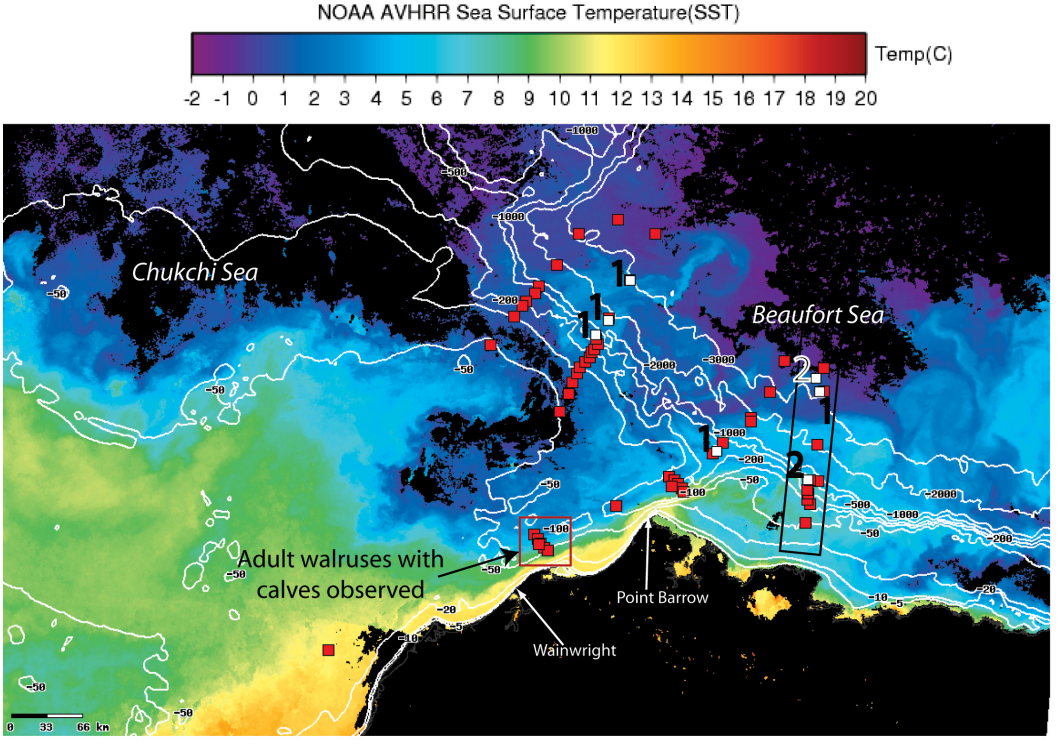

Figure 1. Sea surface temperature from composite NOAA AVHRR satellite imagery during the period 12-16 August 2004 and showing plume of warm Bering Sea water advected into the area where separated walrus calves were observed; black tones denote either land or sea surface areas where cloud cover or sea-ice precluded remote sensing of sea surface temperature. White squares show locations of walrus calves' sightings; adjacent number indicate number (1 or 2) lone walrus calves observed at those locations. Red squares indicate other stations occupied during the research cruise. Red box northeast of Wainwright indicates only locations where groups of adult walruses, some with calves, were observed during cruise. Bathymetric contours are shown as white lines. Stations in black box to the east of Barrow are a transect line east of Point Barrow that is shown as a vertical cross-section in Figure 2.

into the Point Barrow region of the Chukchi and Beaufort Seas during July and August of 2004 and was in part responsible for the rapid melting or advection north of sea-ice over the continental shelf of the Chukchi and Beaufort Seas during the summer of 2004 (Figure 1). Copepods of Bering Sea origin were observed in surface waters as far as our eastern-most transect and well out into the Canada Basin to depths greater than 3,000 m. Surface water temperatures measured east of Point Barrow were as high at 7° C in July and August 2004 compared with surface water temperatures of approximately 1° C or less that were observed during the same week in July and August 2002 at the same location (Figure 2). Ice cover and ice retreat between spring (May to June) and summer (July to August) between the two years also were markedly different, with extensive ice cover east of Barrow encountered in spring of both years that persisted during mid-July of 2002, but was virtually absent by mid-July of 2004.

Discussion

The current trend of seasonal sea-ice retreat away from shallow Arctic continental shelves until ice is only situated over the deep Arctic Ocean basin (McPhee et al., 1998; Rothrock et al., 1999; Serreze et al., 2003; Stroeve et al., 2005) poses adaptive challenges for the walrus population (Tynan & DeMaster, 1997; Kelly, 2001). If walruses and other ice-associated marine mammals cannot adapt to caring for

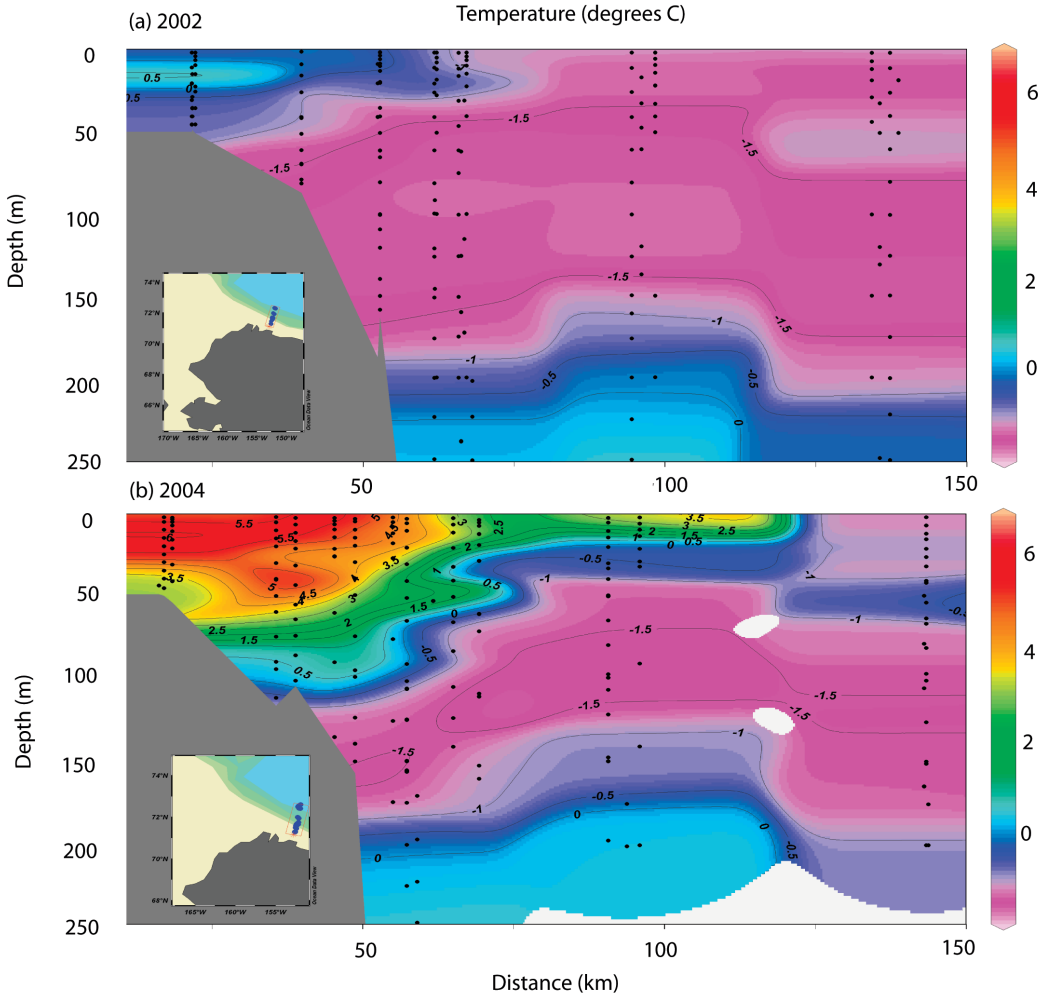

Figure 2. Cross-section plots of water temperatures on a transect line east of Point Barrow in (a) 29 July to 4 August 2002 relative to (b) 28 July to 8 August 2004; data points are depths and locations of bottle samples collected from a conductivity-temperature-depth rosette. Insets show location of transect lines relative to northern coast of Alaska.

their young in shallow waters without sea-ice available as a resting platform between dives to the sea floor, a significant population decline of this species could occur. If these sightings of separated walrus calves are due to the rapid dissolution or retreat of sea-ice that was observed during the summer of 2004 (Stroeve et al., 2005), our observations have implications for the Pacific walrus population.

Moreover, the walrus plays an important role in structuring benthic food webs and biological community structure on Arctic continental shelves (Simpkins et al., 2003) and also serves as a food source for Arctic Inupiat communities. If, as a result of environmental changes in the Arctic, sea-ice continues to decline in thickness and extent, or if as we observed here, seasonal sea-ice retreat occurs very rapidly with the onset of summer, it is possible that female walruses will have difficulty nourishing themselves and caring for their young. Separations of walrus, such as we observed, may become more common and widespread. Since walruses have a low reproduction rate and a high investment in nurturing young, with single calves born only every 2 to 3 y (Fay, 1982), recruitment could be expected to decline.

We have considered some alternate explanations for our observations of walrus calf separations. It is possible that hunting by the nearest Alaska Native communities of Barrow and Wainwright may have resulted in the killing of adult females and the consequent orphaning of the calves that we observed; however, hunting ethics in this region generally discourage the taking of adult females with young (M. Webber, U.S. Fish and Wildlife Service, pers. comm.), although in some cases, young calves are themselves preferred food (P. Omiak, Sr. in Diomede, and J. J. Olemaun in Barrow, pers. comm.). Our observations were well offshore (Figure 1) from any of the hunting areas that can be reached by small boat. Disturbance, such as by a severe storm, could have caused walruses to stampede off ice floes, resulting in the permanent separation of mother-calf pairs. Although we cannot exclude these other possibilities, it seems both reasonable and parsimonious to conclude that the large-scale and rapid disappearance of sea-ice over the Chukchi and Beaufort continental shelves during July and August 2004 (Stroeve et al., 2005) was the likely primary cause of the numerous walrus mother-calf separations that we observed over a wide area of newly open water.

To our knowledge, and in the experience of marine mammal specialists we have consulted, the observations of these separated calves in the deep Canada Basin are exceptional and have not been reported previously, although this type of effect of retreating sea-ice on lactating walruses and their calves had been predicted previously (Kelly, 2001). Our observations raise the possibility that rapid seasonal sea-ice retreat could create a crisis for the Pacific walrus population in the Bering, Chukchi, and Beaufort Sea region.

Acknowledgments

We thank the science party, crew, officers, and captain of the *USCGC Healy* (WAGN-20) cruise 04-03 for helping to document the walrus calf separations. S. Roberts assisted with GIS analyses and imagery. We thank S. Moore, G. Sheffield, M. Webber, L. Lowry, J. Garlich-Miller, L. Quakenbush, and D. Burns for providing insights into the significance of our observations. Figure 2 was plotted with the aid of *Ocean Data View* software (R. Schlitzer; http://odv.awi.bremerhaven.de). Two anonymous reviewers and Editor, J. Thomas, are also thanked for providing comments that improved an earlier version of the manuscript. Financial support was provided by the U.S. National Science Foundation and the U.S. Office of Naval Research.

Literature Cited

Fay, F. H. (1982). Ecology and biology of the Pacific walrus, *Odobenus rosmarus divergens* Illiger. In *North American Fauna*, 74. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service.

Fay, F. H., & Burns, J. J. (1988). Maximal feeding depth of walruses. *Arctic*, *41*, 239-240.

Feder, H. M., Naidu, A. S., Jewett, S. C., Hameedi, J. M., Johnson, W. R., & Whitledge, T. E. (1994). The northeastern Chukchi Sea: Benthos-environmental interactions. *Marine Ecology Progress Series*, *111*, 171-190.

Grebmeier, J. M., & Barry, J. P. (1991). The influence of oceanographic processes on pelagic-benthic coupling in polar regions: A benthic perspective. *Journal of Marine Systems*, *2*, 495-518.

Kelly, B. P. (2001). Climate change and ice breeding pinnipeds. In G-R. Walthiers, C. A. Burga, & P. J. Edwards (Eds.), *"Fingerprints" of climate change: Adapted behaviour and shifting species' ranges* (pp. 43-55). London: Kluwer Academic/Plenum Publishers.

McPhee, M. G., Stanton, T. P., Morison, J. H., & Martinson, D. G. (1998). Freshening of the upper ocean in the central Arctic: Is perennial sea ice disappearing? *Geophysical Research Letters*, *25*, 1729-1732.

Rothrock, D. A., Yu, Y., & Maykut, G. A. (1999). Thinning of the Arctic sea-ice cover. *Geophysical Research Letters*, *26*, 3469-3472.

Serreze, M. C., Maslanik, J. A., Scambos, T. A., Fetterer, F., Stroeve, J., Knowles, K., et al. (2003). A record minimum Arctic sea ice extent and area in 2002. *Geophysical Research Letters*, *30*, 1110. (doi:10.1029/2002GL016406)

Simpkins, M. A., Hiruki-Raring, L. M., Sheffield, G., Grebmeier, J. M., & Bengtson, J. L. (2003). Habitat selection by ice-associated pinnipeds near St. Lawrence Island, Alaska in March 2001. *Polar Biology*, *26*, 577-586.

Stroeve, J. C., Serreze, M. C., Fetterer, F., Arbetter, T., Meier, W., Maslanik, J., et al. (2005). Tracking the Arctic's shrinking ice cover: Another extreme September minimum in 2004. *Geophysical Research Letters*, *32*. (doi:10.1029/2004GL021810)

Tynan, C. T., & DeMaster, D. P. (1997). Observations and predictions of Arctic climatic change: Potential effects on marine mammals. *Arctic*, *50*, 308-322.