References and Notes

1. G. Kolata, *New York Times*, 25 March 2001.
2. R. Jaenisch, I. Wilmut, *Science* **291**, 2552 (2001).
3. N. Boyce, *U.S. News and World Report*, 19 March 2001.
4. R. Weiss, *Washington Post*, 29 March 2001.
5. J. Cibelli *et al.*, *Science* **280**, 1256 (1998).
6. R. P. Lanza *et al.*, *Science* **288**, 665 (2000).
7. J. F. Hasler *et al.*, *Theriogenology* **43**, 141 (1995).
8. Web tables available at *Science* Online at www.sciencemag.org/cgi/content/full/294/5548/1893/DC1.
9. Subcommittee on Beef Cattle Nutrition, Committee on Animal Nutrition, National Research Council, *Nutrient Requirements of Beef Cattle* (National Academy Press, Washington, DC, ed. 7, 2000), pp. 40–53.
10. USDA National Animal Health Monitoring System (NAHMS), *Part I: Reference of 1996 Dairy Management Practices* (Centers for Epidemiology and Animal Health, Fort Collins, CO, 1996).
11. H. H. Van Horn, C. J. Wilcox, *Large Dairy Herd Management* (American Dairy Science Association, Champaign, IL, 1992), pp. 434–439.
12. J. D. M. Campbell *et al.*, *J. Leuk. Biol.* **63**, 567 (1998).
13. J. R. Hill *et al.*, *Theriogenology* **51**, 1451 (1999)
14. J. P. Renard *et al.*, *Lancet* **353**, 1489 (1999).

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ECOLOGY

Endangered Right Whales on the Southeastern Bering Sea Shelf

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The eastern North Pacific right whale (*Eubalaena japonica* Gray) was nearly extirpated by whaling by the 1960s. Today it is the most endangered population of large whale (*1*). Their historical summer distribution included the Gulf of Alaska and the southeastern Bering Sea, and that of the endangered western North Pacific population included waters east of Kamchatka, the Okhotsk Sea, and the Sea of Japan (*2*). During the intensive whaling era of the 1940s to 1960s, right whales in the southeastern Bering Sea concentrated in deep (>200 m) waters north of Unalaska Island, where they fed on the oceanic copepod *Neocalanus cristatus* (*2*). Here we report the summer distribution, prey, and primary habitat of a remnant population that now occupies a different habitat, the middle shelf of the southeastern Bering Sea, and forages on a different prey, *Calanus marshallae*. Given this region's large and possibly enhanced interannual and decadal-scale variability in climate and ecosystem response, as well as a long-term trend of warming summer sea-surface temperatures (SSTs) (*3*), the survival of these right whales is uncertain.

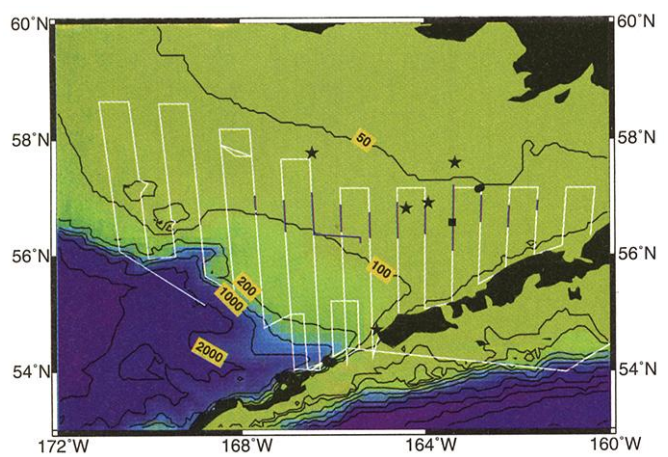

Fig. 1. Cruise track for cetacean surveys in the southeast Bering Sea, 17 July to 5 August 1997 and 10 June to 3 July 1999 (white lines), extent of a coccolithophore bloom (blue lines) in July 1997, and right whale sightings since 1985 (*7*) (★), 20 to 21 July 1997 (●), and 14 June 1999 (■).

On the basis of our line-transect surveys in the southeastern Bering Sea, the eastern population of North Pacific right whales probably totals only tens of animals. Our study of a group of at least five, and possibly seven, right whales on 20 July 1997 on the middle shelf (57.13°N, 162.84°W; Fig. 1) involved the largest group of this species observed since the mid 20th century. The whales occurred in relatively warm (i.e., 10.4°C SST), well-stratified water in an extensive coccolithophore bloom of *Emiliania huxleyi*. Another sighting of one or two right whales on 21 July (57.16°N, 162.78°W; Fig. 1) reaffirmed the discovery. Near this region on 14 June 1999, soon after the seasonal sea ice retreat, we found a single right whale (56.56°N, 163.41°W; Fig. 1) in cold water (i.e., 4.4°C SST).

These sightings are clustered in relatively shallow water (50- to 80-m depth) on the middle shelf between 162° and 166°W (Fig. 1). Right whales predictably occur near or south of the Inner Front (50-m isobath) in stratified waters. These patterns suggest that frontal features and stratification play an important role in the availability and concentration of right whale prey, calanoid copepods.

Right whales migrate to productive high-latitude waters where they target dense concentrations of prey for energetically successful feeding (*4*). *C. marshallae* (*5*) was the dominant copepod species in zooplankton samples collected near right whales on the middle shelf of the southeastern Bering Sea in 1997 and 1999. This Northeast Pacific shelf species is typical of the eastern Bering Sea middle-shelf assemblage of copepods (*6*). Right whales on the middle shelf appear to rely on patches of the larger, later copepodite stages (C III to C V) of *C. marshallae*. The copepodites of *C. marshallae* on the southeastern Bering Sea shelf were twice as heavy as those from a temperate region, the Oregon upwelling zone, and were also extremely rich in lipid. Right whales therefore should benefit from foraging on older stages of *C. marshallae* at higher latitudes. The middle-shelf concentrations of older copepodite stages of *C. marshallae* were an order of magnitude greater in the late 1990s than during the early 1980s. This increased production may explain why a remnant population of right whales now predictably occupies the middle shelf during summer.

Right whales, like other rare species, are not necessarily to be found in the center of their historical distribution, but rather at the edge of their once broad range. Ultimately, the distribution of foraging right whales is determined by effects of climatic forcing on the extent and duration of ice cover, the timing and magnitude of the spring bloom, and the consequent copepod production. Endangered right whales may be among the best bellwethers of large ecosystem shifts.

References

1. P. J. Clapham *et al.*, *Mammal Rev.* **29**, 35 (1999).
2. H. Omura *et al.*, *Sci. Rep. Whales Res. Inst.* **21**, 1 (1969).
3. N. A. Bond, J. M. Adams, *Deep Sea Res. Part II*, in press.
4. R. D. Kenney, K. F. Wishner, *Cont. Shelf Res.* **15**, 373 (1995).
5. B. W. Frost, *Mar. Biol.* **26**, 77 (1974).
6. S. L. Smith, J. Vidal, *Cont. Shelf Res.* **5**, 215 (1986).
7. P. D. Goddard, D. J. Rugh, *Mar. Mammal Sci.* **14**, 344 (1998).

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