

Scientists reconstruct the prehistoric behavior and ecology of northern fur seals

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A large adult male northern fur seal (dark fur at left) surveys his harem of females and their pups on St. Paul Island in the Pribilof Islands. This small island group in the Bering Sea is home to the main breeding colony of northern fur seals, but new research shows that their range once extended as far south as California. Prehistoric populations of northern fur seals also nursed their young for at least a year, in contrast to the four months that modern populations spend together at the breeding ground. Credit: Image courtesy Michael A. Etnier

A team of researchers has documented major changes in the behavior, ecology, and geographic range of the northern fur seal over the past 1,500 years using a combination of techniques from archaeology, biochemistry, and ecology. Among their findings is evidence of reproductive behavior in the past that is not seen in modern populations of northern fur seals.

The study will be published in the *Proceedings of the National Academy of Sciences* (online Early Edition, May 21 to 25, and in a later print

edition).

"We were able to reconstruct this species' prehistoric range and see changes in biogeography and behavior over timescales longer than ecologists usually think about," said Seth Newsome, who worked on the study as a graduate student at the University of California, Santa Cruz, and is now a postdoctoral researcher at the Carnegie Institution of Washington.

Today, the main breeding colony of northern fur seals is on the Pribilof Islands in the Bering Sea. Newsome and his collaborators confirmed that the species once had major breeding colonies at temperate latitudes in California, the Pacific Northwest, and the eastern Aleutian Islands. The abundance of their bones in archaeological sites suggests they were an important part of the marine ecosystems in those regions. The researchers also found that northern fur seals in those temperate latitude breeding colonies nursed their young for much longer than modern fur seals, which wean their pups just four months after birth.

Newsome, the lead author of the *PNAS* paper, said the study is important because fur seals and many other species were decimated by commercial harvesting long before scientists were able to study them firsthand. "In a lot of cases, what we consider natural for a species may not have been its natural state prior to human disturbance," he said.

The disappearance of northern fur seals from some temperate regions coincided with the arrival of Russian and European fur traders about 200 years ago. But in central and northern California, fur seal populations collapsed about 800 to 1,200 years ago, long before European contact, the researchers found. The cause of the earlier collapse remains unclear, but it may have been climate change, human hunting, or a combination of factors.

Newsome worked closely with Michael Etnier, an archaeologist at the University of Washington in Seattle, and with faculty in four different departments at UC Santa Cruz, all coauthors of the paper. They include Diane Gifford-Gonzalez, a professor of anthropology and curator of the Monterey Bay Archaeology Archives; Paul Koch, a professor of Earth and planetary sciences who uses isotope chemistry to study ancient fossils; Daniel Costa, professor of ecology and evolutionary biology and an expert on marine mammal physiology and ecology; and Thomas Guilderson, a lecturer in ocean sciences also affiliated with Lawrence Livermore National Laboratory. Donald Phillips of the U.S. Environmental Protection Agency, Marcel van Tuinen and Elizabeth Hadly of Stanford University, and Douglas Kennett of the University of Oregon also contributed to the paper.

The study grew out of work begun at UCSC in the 1990s by Gifford-Gonzalez and Koch, who teamed up to investigate the abrupt disappearance of northern fur seals from the archaeological record along California's central coast. As early as the 1970s, Gifford-Gonzalez and others had noted the abundance of northern fur seal bones in shell middens in northern and central California. She began working with Koch and graduate student Robert Burton to see if isotope analysis of the bones could help unravel the mystery.

"It's been a wonderful collaboration that branched out as the project grew, and we've made alliances across so many institutions now it's dizzying," said Gifford-Gonzalez. "The PNAS paper is a culmination of that work, and it shows just how much information one can get out of ancient bone samples with this kind of coordinated, multidisciplinary approach."

The relative abundance of different chemical isotopes of carbon and nitrogen in bones can indicate what and where the animals ate when they were alive. Nitrogen isotopes can also be used to characterize the

duration of nursing and approximate age at weaning of mammals. Newsome performed most of the isotope analysis, while Etnier used morphometric techniques (careful measurements of the bones calibrated against modern samples) to determine the age at death of the animals the bones came from.

Combining these techniques, the researchers showed that the prehistoric northern fur seals in California were not visitors from northern waters, but were instead year-round residents. The analyses also revealed the nursing and weaning strategies of these prehistoric populations.

Of the 14 species in the family of eared seals, only the northern and Antarctic fur seals exhibit a "short-term" reproductive strategy, weaning their pups at four months so that they can leave the breeding colonies before winter arrives.

"The Bering Sea has a highly productive marine ecosystem in the summer, but it shuts down in winter and the sea around the Pribilofs freezes over. The seals have to wean their pups and move south, and they can be found off central and northern California throughout the winter," Newsome said.

All other eared seals nurse their young for 12 to 14 months, and sometimes as long as two years. This "long-term" maternal strategy appears to have been used by prehistoric northern fur seals in temperate latitude rookeries. Modern fur seals have recently established new rookeries at temperate latitude sites, such as San Miguel Island off southern California. But those seals came from Pribilof stock and still retain the reproductive behavior of Pribilof Island fur seals, Newsome said.

The long-term maternal strategy, seen in sea lions and most other eared seals, is driven by the periodic disruption of temperate marine

ecosystems by El Niño, he said. A shortage of food during an El Niño could mean death for newly weaned seal pups, but species with the flexibility to continue nursing for longer than one year can keep their pups alive.

According to Koch, these findings raise difficult questions for conservation biologists.

"It's an incredible behavioral change over time--there is no modern population of northern fur seals that does what these animals did in the past," Koch said. "So where is it natural for this animal to be" Has the species lost the behavioral diversity it needs to be successful here in California, or is it possible for them to reevolve that capacity""

The study also raises broader questions about the natural ecosystem of the California coast, he said.

"We think now of sea lions, harbor seals, and elephant seals as the natural inhabitants of the California coast. But how did those species interact with fur seals, and how did the ecosystem work in the past when fur seals were more abundant" We still don't know what it was like, but I suspect California was really different when these animals were here in the past," Koch said.

The researchers are now incorporating genetics into the investigation, extracting DNA from ancient fur seal bones and analyzing it to reconstruct the genetic diversity of prehistoric populations of northern fur seals and estimate the total size of the population a millennium ago.

Source: University of California - Santa Cruz

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