

# Marine mammal reproduction rests on a precarious tipping point of ocean resources

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A pregnant female elephant seal arrives on the beach at Año Nuevo Reserve to give birth after seven months at sea. The reproductive success of female elephant seals depends on their ability to find prey and put on weight during their months-long foraging migrations. Credit: Dan Costa

Changing environmental conditions may threaten marine mammal

populations by making it harder to find prey, and a new study shows how small, gradual reductions in prey could have profound implications for animal populations.

The reproductive success of female elephant seals depends on their ability to find prey and put on weight during their months-long foraging migrations. Researchers at UC Santa Cruz studied the relationships between elephant seal behavioral strategies in the [open ocean](#), [weight gain](#), and lifetime success at producing pups.

Their findings, published March 8 in *Ecology Letters*, reveal a sharp threshold in the relationship between mass gain and pup production, suggesting a physiological tipping point at which insufficient mass gain leads to reproductive failure.

"We found that diving deeper during foraging allowed the females to gain more mass, and gaining more mass led to a marginal increase in their chances of survival and a massive increase in the number of pups they produced in a lifetime," said corresponding author Roxanne Beltran, assistant professor of ecology and evolutionary biology at UC Santa Cruz.

Beltran's team used 25 years of data collected by the long-running UCSC elephant seal research program at Año Nuevo Reserve to investigate the influence of [behavioral strategies](#) and foraging success on survival and reproduction in female northern elephant seals. Biologgers carried by the seals recorded their activities during the months-long migrations, including where the seals went and the depth of their dives, while data collected on the beach at Año Nuevo told researchers which animals survived, how much weight they gained, and how many pups they had over their lifetime.

"Conceptually it makes sense that an individual would have to gain

enough energy to survive and reproduce, but we were able to demonstrate how entwined these are and suggest when survival may be prioritized over reproduction," said co-first author Keith Hernandez, who worked on the study as a postdoctoral scholar in Beltran's lab at UCSC and is now at Oregon State University.

Female elephant seals give birth annually to a single pup in winter. They spend four weeks on the beach nursing their pup, relying entirely on stored energy until they can wean the pup and return to the ocean to feed. After the winter breeding season, they head out to sea for two months before returning to the colony to molt. Then they leave on a long post-molting migration, traveling thousands of miles across the North Pacific Ocean over seven to eight months.

Individual seals pursue different strategies during these foraging trips, going different distances from the coast, diving to different depths, and targeting different prey (various species of fish and squid). The researchers found that dive depth was the strongest predictor of mass gain. Deeper diving seals migrated farther from the coast and had more energy-rich diets than shallower diving seals.

The resulting mass gain directly affects a seal's ability to produce a pup. A female that doesn't put on enough weight won't give birth to a pup after she returns to the beach. The threshold is around 205 kilograms (450 pounds): animals that gained less than that rarely pupped, while those gaining more than 260 kilograms (573 pounds) almost always pupped.

Survival also depends on putting on weight, and the longer a female lives the more pups she can produce. [Previous research](#) has shown that in the long run, a relatively small number of long-lived female elephant seals produce most of the pups in the colony. These "supermoms" may live as long as 23 years and produce more than 15 pups in their lifetimes, while

most females don't live nearly as long and produce many fewer pups. The strategies that allow these moms to be so successful, however, have long been a mystery.

"We discovered that an additional 5 percent of foraging success led to a 300 percent increase in lifetime pup production due to the effects of mass gain on both survival and giving birth and raising a pup each year," Beltran said. "These findings tell us which strategies allow these long-lived mammals to succeed at their most important job, which is to stay alive and contribute to the next generation."

The study also provides a framework for studying demographic trends in other species, Hernandez said.

"Determining the relationship between foraging success, survival, and reproductive success can inform effective management practices once we understand the critical periods in an animal's annual cycle," he said.

The northern [elephant seal](#) population is currently doing quite well, increasing by about 4 percent each year, after being hunted to near extinction in the 19th century. At the same time, however, their ocean environment is changing due to [climate change](#), and the [fishing industry](#) is exploring the potential of the deep "mesopelagic" zone where elephant seals find their most energy-rich prey, Beltran said.

"Open ocean fishing and climate change could both have dramatic impacts on food resources for elephant seals," she said. "Elephant seals are incredibly successful now, but that could change as their environment shifts in the coming years."

**More information:** Roxanne S. Beltran et al, Physiological tipping points in the relationship between foraging success and lifetime fitness of a long-lived mammal, *Ecology Letters* (2023). [DOI: 10.1111/ele.14193](https://doi.org/10.1111/ele.14193)

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