BEST-BSIERP
Bering Sea PROJECT
UNDERSTANDING ECOSYSTEM PROCESSES IN THE BERING SEA 2007–2013

Climate Change Could Stress Kittiwakes and Other Seabirds

MODELING TO UNDERSTAND LIMITS IN ADAPTIVE BEHAVIOR

For black-legged kittiwakes (*Rissa tridactyla*), mortality increases with increasing levels of stress hormones, and strong relationships exist between indices of environmental variation and stress hormones. These relationships indicate that anticipated climate warming might bring at least short-term demographic benefits for kittiwakes in the Bering shelf region, while having negative impacts on birds breeding in the Gulf of Alaska and western Aleutians. Thus, climate variability is likely to affect survival of North Pacific kittiwakes on a region-specific basis, and the longevity of these birds may not always be sufficient to buffer their populations from low reproductive performance.

What We Found

Using our collaborators' experimental manipulation of food availability during early development, we discovered first breeding at younger ages for kittiwakes that experienced suboptimal natal conditions, as well as greater productivity of early recruiting kittiwakes growing in control nests compared with those that grew in food-supplemented nests. Modeling results further showed that in some colonies it appears birds sacrificed more lifetime reproductive success than a prudent parent would, and that less food early in life led to first breeding at a younger age, as well as greater reproductive effort, compared to birds reared with more food.

Although we found a positive correlation between warmer ocean waters and higher productivity for

continued on page 2

Chris Barger

Black-legged kittiwakes nesting on St. Paul Island. Several chicks are visible in nests, for example at lower left and middle left of the photograph..

The Big Picture

Many different populations in the Bering Sea are increasingly likely to experience climate-induced changes in their physical and biological environments. Since adult kittiwakes are central place foragers with high energy requirements, an increased variability of forage patch dynamics, as predicted for polar regions, is likely to influence both the quantity and quality of food available. This would consequently alter the population dynamics of kittiwake colonies, mitigated by stress hormones rising in response to food shortages, with consequent effects on survival and reproduction.

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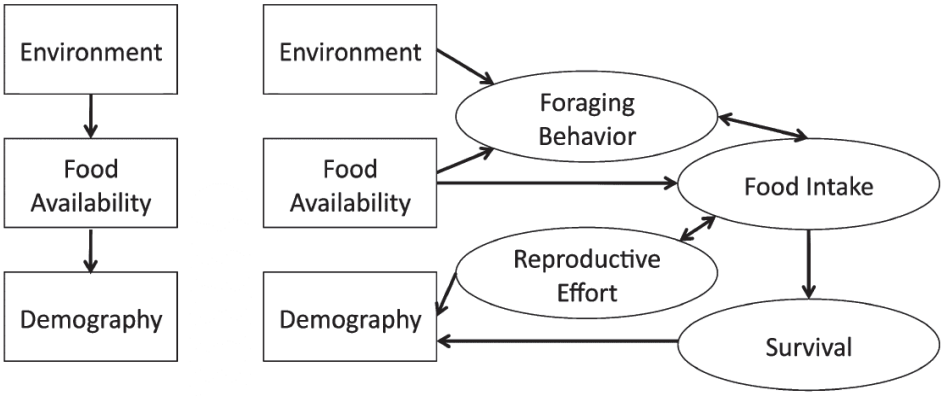
Fig. 1



Behavior is the first response to changing environment. Left hand panel: When organisms are assumed to have fixed, stereotyped responses to food availability, the effects of the environment on population demography (growth, survival, and reproduction) are linear (but may still be complicated). Right hand panel: On the other hand, if organisms have flexible responses through foraging and reproductive behavior, the links between climate, food availability, and demography become more intricate and less linear. The objective of our work was to explicate these linkages using state-dependent life history theory.

the colonies on Bogoslof Island and the Pribilof Islands, a remaining puzzle is understanding how the regime shifts in the Northeastern Pacific of the late 1970s, and the associated changes in food, drove colony declines in the Bering Sea, while other colonies in the Aleutian Archipelago increased in size.

How We Did It

Our study combined mathematical models, statistical analysis and experimental manipulation. We examined the statistical relationship between the stress hormone corticosterone and the mortality of birds. We also used statistical methods to test if inter-annual changes in the Pacific Decadal Oscillation, winter ice cover, or local sea-surface temperature predict changes in productivity (fledglings per nest) or stress hormones. Through experimental manipulation of food availability, we studied aspects of reproductive performance associated with food availability. Population modeling helped us determine whether the mortality rates associated with persisting in a breeding attempt despite high levels of stress hormones caused the birds to sacrifice more lifetime reproductive output than they gain from one year's breeding. Modeling also helped relate the effects of environment and energy resources on kittiwake growth, fledging age, survival from hatching to first breeding and productivity.

Why We Did It

Although animals have evolved to deal with environmental stress, there are limits to their ability to do so, and it is important to know if climate change will push animals beyond these limits. If one thinks that responses to environmental variation are fixed and inflexible (left panel of Figure 1), then the limits are hard boundaries, but when behavioral flexibility allows animals to adjust to changing environments (right panel of Figure 1)—which is true, even in 'simple' animals—then the limits are more complicated to understand. Characterizing them cannot be done observationally and is very difficult to do experimentally. That is, we cannot wait until the climate changes and then see how animals respond if we want to have a chance of mitigating effects; even if we could do feeding experiments on caged animals, it would be difficult to interpret them and scale them up. Modeling provides a natural way for projecting the behavioral responses and the boundaries beyond which changing climates will have seriously deleterious effects.

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