



# Editorial: Climate Change and Marine Top Predators

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Climate is one of the main structuring forces in natural ecosystems (Richardson and Schoeman, 2004), and anthropogenic climate change is regarded as an important driver of changes in the range and abundance of species as well as community composition, not least in marine ecosystems (Poloczanska et al., 2013). There are two overall mechanisms by which climate change can affect range and abundance of a species (Thomas, 2010): direct physiological effects, and indirect trophic effects mediated by other species. Understanding to what extent and through which mechanisms climate change affects particular species is one of the main challenges facing ecologists. In this collection of papers, researchers take a variety of approaches to the study of climate change impacts on marine birds and mammals, ranging from documentation of large-scale patterns, through quantification of impacts on vital rates, to detailed mechanistic studies of changing behavior, and physiological effects.

The first paper in this collection (Oro, 2014) describes the challenges involved in studying the impacts of climate change on seabirds, and critically evaluates the existing literature. One of the central issues identified in this paper is that reliance on single climate indices for describing changes in complex ecosystems may result in biased predictions. The remaining papers both illustrate some of these challenges, and contain pointers to ways in which they can be overcome.

Measuring climatic variation on a scale that makes sense in relation to the study organism is complex. In a cross-disciplinary paper, Mesquita et al. (2015) illustrate how methods from climatology can help identify ecologically meaningful covariates of population change, in this case of common guillemots (*Uria aalge*) in northern Norway. Distinguishing impacts of climate from other drivers is important and often difficult. Crawford et al. (2015) examine changes in distribution of several seabirds in South Africa, and conclude that reactions to fisheries dominate those to climate.

Most climate-related seabird studies have focused on the breeding colonies, while relatively few have examined changes in staging or wintering populations. Two papers examine respectively wintering alcids off Massachusetts (Veit and Manne, 2015) and staging shearwaters in the Bay of Biscay (Louzao et al., 2015). Both show species-dependent relationships between large-scale climate and the occurrence of seabirds in these areas.

Climate warming may both enhance poleward expansion of temperate species from lower latitudes and change the distribution of resident species at higher latitudes. This may present challenges both for newcomers and residents. Cod (*Gadus morhua*) abundance has increased, and its range has extended northwards in the Barents Sea in recent years. One implication of this is a new overlap of feeding grounds with harp seals (*Pagophilus groenlandicus*) and minke whales (*Balaenoptera acutorostrata*), two other important top predators in the area. Bogstad et al. (2015) demonstrate that both these mammal species have exhibited declines in body condition in recent years, and competition for food with the increasing cod stock is suggested as a possible explanation. Significant changes in the distribution and abundance of several cetacean species during recent decades has been shown both in Icelandic and adjacent waters (Vikingsson et al., 2015) and in the Norwegian Sea (Nøttestad et al., 2015). Both papers illustrate that whale species have the capability

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to rapidly perform shifts in distribution and abundance patterns strongly associated with adaptive search behavior in relation to both changing levels of abundance of their prey and increased sea surface temperatures.

Two papers investigate the impact of changes in sea ice on vital rates and population trends of Adélie penguins (*Pygoscelis adeliae*). One study documents complex long-term trophic effects (Ballerini et al., 2015), while the other shows strong impacts of stochastic events, viz. very large icebergs blocking access to foraging areas (Dugger et al., 2014). In both cases, the impacts on demography and population dynamics were profound.

Climate-related changes in demography as well as population and range dynamics are mediated by behavioral and physiological mechanisms. Two long-term studies on colonial birds illustrate the complexity of these links between climate, behavior and demography. In common terns (*Sterna hirundo*), Szostek et al. (2015) find that arrival date and mass at the breeding colony were related to climatic conditions and food availability in wintering and staging areas, but that age groups differed in their reaction to climate. Reed et al. (2015) show that the probability of skipping breeding in common guillemots was higher after warm winters, and that individuals differed in both mean skipping propensity and their response to temperature.

Behavioral reactions of one species to climatic change may lead to cascading effects on other species. Prop et al. (2015) show that the occurrence of polar bears (*Ursus maritimus*) on land during summer in Svalbard and Greenland has increased as sea ice cover has decreased, and that this has led to increased

predation on ground-nesting colonial birds. Staying with polar bears, loss of sea ice, and reduced access to prey is likely to result in prolonged fasting periods with subsequent increases of tissue concentrations of persistent organic pollutants. In a perspective paper, Jenssen et al. (2015) suggest increased focus on potential population effects of such increases in pollutant exposure, and to consider such effects in addition to the effects of climate-induced habitat loss.

Overall, these papers illustrate the complexities both of the ways that climate change can impact marine top predators, and of the approaches taken to study this important subject. Research in this field is progressing rapidly, and innovative collaborations with neighboring disciplines are increasingly being used to good effect. Among the remaining challenges, the prediction of future changes in populations and communities still looms large, and success in this endeavor will depend on continual development of new collaborative approaches.

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MF and TH co-wrote this editorial.

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**Conflict of Interest Statement:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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