

Contrasting Population Responses: Winners and Losers in Climate Change?

Key Words: *Climate change, population dynamics, age structure, demography, seabird*

Summary: I will investigate different responses to climate change in a marine food web by comparing two trophically distinct but sympatrically breeding seabirds. I will address long-term climate effects on these indicator species by analyzing the relationship between climate and their demographic parameters, as well as the relationship between climate and population dynamics. This research will not only differentiate which climate variables are influencing the population dynamics of two marine predators but also has implications for assessing climate effects on different components of marine food webs.

Objective: Establish how changing climate conditions affect sympatric marine species

Background and Rational: Environmental variability and climate affect many fundamental ecological processes (Stenseth et al. 2002). Changes in global weather patterns have already impacted many species through shifts in distributions, phenology, and physiology (Hughes 2000). Given the likelihood of continued climate change, it is important to understand the role climate plays in population and food web dynamics. Research on sympatrically breeding species can provide valuable insight into how different trophic levels respond to the same climate conditions.

Marine systems are characterized by high complexity and high interannual variability (Stenseth et al.

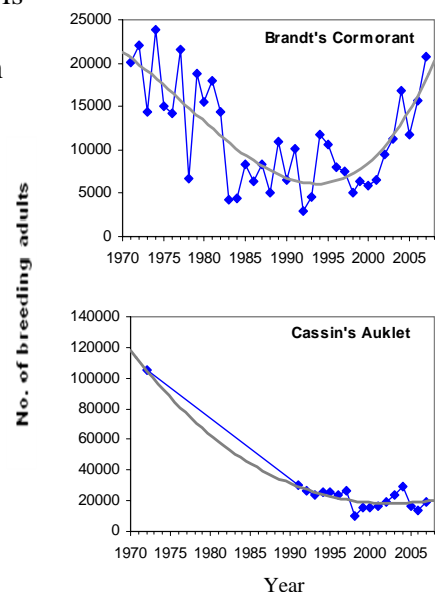


Figure 1

2002). The California Current (CC), a highly productive Eastern boundary current, provides critical habitat for many marine organisms including several endemic species of seabirds. As highly visible upper trophic marine predators, seabirds have shown strong responses to recent climate change (Croxall et al. 2002). Sea surface temperature and air temperature are some of the climate factors that have been shown to influence demographic parameters such as breeding success and survival in seabird populations (Nur and Sydeman 1999, Barbraud and Weimerskirch 2003). Often prey availability is the direct mechanism through which climate influences seabird populations (e.g. during warm water years such as during an El Nino event, prey availability is low and seabirds show poor reproductive success) (Boekelheide and Ainley 1989, Sydeman et al. 2006, Lee et al. 2007).

The Farallon National Wildlife Refuge, located in the Gulf of the Farallones National Marine Sanctuary off of San Francisco, is the largest seabird breeding colony in the contiguous US. PRBO Conservation Science (formerly Point Reyes Bird Observatory) has a well established research program studying the seabirds of the Farallon Islands. For eight of the 12 breeding seabird species long-term (20-35 year) estimates for reproductive success and population abundance are available. Recent shifts in local oceanographic conditions have led to several years of low reproductive success for many of the seabird species on the Farallones. Brandt's cormorant (*Phalacrocorax penicillatus*) alone has had above average reproductive success in each of the last three years (Warzybok and Bradley 2007). Over this same interval, another Farallon seabird, Cassin's auklet (*Ptychoramphus aleuticus*) suffered two years of complete breeding failure and a third year of very low reproductive success. These differences are apparent at the population level as well: from the 1970's to the late 1990's, both Brandt's cormorant and Cassin's auklet showed roughly parallel declining trends in breeding population

numbers (figure 1 from Warzybok and Bradley 2007) but in the last decade, Brandt's cormorants have rebounded while Cassin's auklets have continued to decline (Nur and Sydeman 1999, Lee et al. 2007).

The trophic position occupied by each of these two seabird species may explain their different population responses. Brandt's cormorants typically forage at the tertiary trophic level and have the ability to exploit a variety schooling fish (Ainley et al. 1981). In contrast, Cassin's auklets forage at the secondary level on krill and are much more restricted in diet with the majority of their diet consisting of only two euphausiid species (Abraham and Sydeman 2006). Accordingly, the different population responses of each species may be the result of differential impacts of changes in the CC food web. Previous research on Cassin's auklets has shown that adult survival and breeding propensity are affected by oceanographic conditions (Lee et al. 2007) but these relationships have not been investigated for Brandt's cormorants. Given the contrasting trend of these two species, I now have the opportunity to conduct a comparative study on how current climate conditions are resulting in distinctly different population responses at two levels of the food web. Comparative analyses of this sort are invaluable but relatively rare in climate studies given the difficulty of collecting adequate time series data. However, some work comparing two species of Antarctic seabirds showed *parallel* population responses to warming and climate change (Jenouvrier et al. 2005). Therefore, this is a unique opportunity to examine *non-parallel* trends in two marine predators.

Question and Hypothesis: Why do Brandt's Cormorants and Cassin's auklets exhibit inverse trends in population abundance? Population abundance is driven by demographic parameters (survival, reproductive success, age structure) and these parameters can be heavily influenced by

environmental conditions. Therefore I will test the hypothesis that one or several demographic parameters of Brandt's cormorants and Cassin's auklets are differentially affected by climate conditions.

Methods: The current direction of Brandt's cormorant and Cassin's auklet population growth and reproductive success has become relatively more pronounced in the last three years. The recent trend has the potential to continue or change, and it will be crucial to continue collecting data over the next few years in order to put this recent change in the context of the entire time series. For Brandt's cormorants, future data collection will involve, re-sighting individually banded known age cormorants from fixed points around the island and monitoring nests to determine reproductive success of these known individuals. Also, approximately 1000 hatch year cormorants will be banded each year to maintain known age individuals in the sample. No adult cormorants will be banded.

To test the hypothesis for Brandt's cormorants I will combine the existing 35 year data set with data I will be collecting, and use mark-recapture analysis on banded individuals to determine age-specific survival. I will determine age structure and calculate age-specific reproductive success directly from the observational data. I will then model demographic parameters, \bar{r} -survival, reproductive success and age structure as a function of several climate indices available—sea surface temperature (SST), the El Nino Southern Oscillation index (ENSO), the Pacific Decadal Oscillation Index (PDO), the Aleutian Low Pressure Index (ALPI), wind— and assess the strength of these functional relationships using correlation and regression analysis. This will allow me to determine which climate index best explains the observed patterns in demographic parameters. Additionally the North Pacific Gyre Oscillation is a new

ecosystem index recently developed that I plan to utilize in this analysis (Di Lorenzo et al. 2007). Next I will use these relationships to fit age structured models to the data to determine how climate affects age specific vital rates and population growth.

For Cassin's auklet, I will be collaborating with PRBO Conservation Science in utilizing data and analysis, but I will not directing the field aspect of the research. I will be able to use previously published demographic analysis to create a demographic population model and compare the auklet population response to the cormorant response.

Conclusion: Through this analysis I will be able to determine which environmental variables the populations of two sympatric species are responding to. These two species are foraging on very different prey bases at different trophic levels. The conclusions drawn may have real applications in allowing scientists and managers to predict how climate change may affect different components of the marine food web. Additionally, through this project I plan to increase awareness of the impacts of climate change by involving a number of interns in the field and continuing to give regular presentations on this project to the Mountain Oaks Charter School science program.

Qualifications: See attached CV

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