Matrix Models for Evolutionary Population Dynamics: Studies of the Effects of Climate Change on Seabirds

J. M. Cushing
Department of Mathematics & Interdisciplinary Program in Applied Mathematics
University of Arizona, Tucson, Arizona, 85721 USA
cushing@math.arizona.edu

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Field observations and studies by my collaborators Shandelle Henson and James Hayward on Protection Island National Wildlife Refuge, State of Washington, USA, have shown some striking and unusual changes in the life history strategies of seabirds during breeding seasons (specifically, the Glaucous-winged Gull) that are strongly correlated with the rise in mean sea surface temperature during El Ninõ years [1,3,4,6]. Given that there is continuing, half century long warming trend in SST, a question arises about the long term survival prospects for these bird populations, i.e. whether the observed behavioral changes can be adaptive in the long run.

Two of the behavioral changes observed to occur during El Ninõ years are increased egg cannibalism and female egg laying synchrony. We have formulated several low dimensional, test-of-concept models to investigate the dynamic and evolutionary consequences of these phenomena. The models are nonlinear discrete time matrix models for structured population models. Since extinction is the primary concern, we are interested in the destabilization of the extinction equilibrium at $R_0 = 1$ and the nature of the bifurcation that result. Because the projection matrices in our models are often imprimitive, complicated bifurcations can occur and non-standard analytic methods are needed [2,5,7,8]. The results obtained from these models, and from evolutionary versions of the models, provide explanations for the observed behavioral changes during El Ninõ years and descriptions of circumstances under which these changes can be evolutionarily adaptive.

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