Estimation of nest survival with state uncertainty and unknown nest fate using Bayesian multievent mark-recapture framework

Pigeon guillemots (*Cepphus* columba) are an indicator species for Puget Sound in the U.S. Pacific Northwest, but existing local abundance estimates are outdated, demographic rates are unknown, and the impact of varying local oceanographic conditions on survival have not been investigated to date. Through an ongoing monitoring effort, a citizen science project has been recording adult colony attendance and burrow prey deliveries at known colony sites in inland waters during the breeding season for more than a decade. The survey design and cliff-side location of burrows precludes observing if or precisely when eggs hatch or chicks fledge. We use a Bayesian multievent mark-recapture model framework to estimate egg and chick survival probability with unobservable nest state and uncertain nest fate. We also include tidal fluctuations and environmental indices for upwelling and sea surface temperature as covariates to ascertain potential factors affecting trends in annual nest survival. Our study provides the first estimates of demographic rates with respect to oceanographic variability in this region. The results from this analysis will be foundational to developing an integrated population model for the species, which will provide important information for ongoing monitoring of indicator species in Puget Sound, particularly given observed and ongoing environmental change in the region.