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Integrating telemetry data into mark recapture analysis: case study of false killer whale (Pseudorca crassidens) abundance estimation in Hawaiian waters

Monitoring natural populations requires data that can be extremely difficult to collect when the animals are rare, cryptic, or inaccessible. Surveys often only encompass a small portion of a population's range due to difficult terrain or inclement weather. Thus, to maximize encounters, sampling efforts may be largely opportunistic. The resulting sparse and spatially-biased data may be difficult to model, standardize across years, and incorporate into a management framework. In many monitoring programs, however, there are usually multiple threads of data that, though each may have its own deficiencies, can be synthesized to reveal important ecological processes. Currently, surveys for the insular population of false killer whales (Pseudorca crassidens) around the main Hawaiian islands are almost exclusively conducted on leeward sides of the islands due to sighting and safety concerns. This sampling bias limits the ability to fully assess population abundance and trends of this endangered population. Here, we used 16 years (2000-2015) of a longitudinal photo ID mark-recapture dataset containing 141 known false killer whale individuals along with telemetry data from 43 individuals to fit a quasi-spatial mark-recapture model that uses the information from telemetry data to address the sampling bias. Utilization distributions (UDs) were estimated from each GPS track and then combined into social cluster UDs. We then fit a dynamic factor analysis to the sighting data to mix cluster-level UDs according to individual observation trends. The interaction between these approximated individual UDs and kernel densities of yearly survey efforts was incorporated into a state-space Jolly-Seber population model to estimate abundance of false killer whales around the Main Hawaiian Islands. Our method resulted in more robust and precise abundance estimates than previous mark-recapture analyses on these data. Future accommodation of additional data types, such as passive acoustics, into this framework can allow for integration of disparate datasets collected in monitoring programs to enhance our understanding of elusive populations.