Diffusion modeling reveals effects of multiple release sites and human activity on a recolonizing apex predator

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Abstract

Background: Reintroducing predators is a promising conservation tool to help remedy human-caused ecosystem changes. However, the growth and spread of a reintroduced population is a spatiotemporal process that is driven by a suite of factors, such as habitat change, human activity, and prey availability. Sea otters *(Enhydra lutris*) are apex predators of nearshore marine ecosystems that had declined nearly to extinction across much of their range by the early 20th century. In Southeast Alaska, which is comprised of a diverse matrix of nearshore habitat and managed areas, reintroduction of 413 individuals in the late 1960s initiated the growth and spread of a population that now exceeds 25,000.

Methods: Periodic aerial surveys in the region provide a time series of spatially-explicit data to investigate factors influencing this successful and ongoing recovery. We integrated an ecological diffusion model that accounted for spatially-variable motility and density-dependent population growth, as well as multiple population epicenters, into a Bayesian hierarchical framework to help understand the factors influencing the success of this recovery.

Results: Our results indicated that sea otters exhibited higher residence time as well as greater equilibrium abundance in Glacier Bay, a protected area, and in areas where there is limited or no commercial fishing. Asymptotic spread rates suggested sea otters colonized Southeast Alaska at rates of 1-8 km/yr with lower rates occurring in areas correlated with higher residence time, which primarily included areas near shore and closed to commercial fishing. Further, we found that the intrinsic growth rate of sea otters may be higher than previous estimates suggested.

Conclusions: This study shows how predator recolonization can occur from multiple population epicenters. Additionally, our results suggest spatial heterogeneity in the physical environment as well as human activity and management can influence recolonization processes, both in terms of movement (or motility) and density dependence.

Full Text

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