Using Demography and Movement Behavior to Predict Range Expansion of the Southern Sea Otter

Management agencies are interested in the development of a realistic predictive model of the southern sea otter population recovery and range expansion into southern California, as this would facilitate the informed assessment of potential impacts of sea otters on important industries (e.g., fisheries, eco-tourism), potential negative effects of human activity on sea otters (e.g., risks associated with the nearshore transport and extraction of petroleum, entanglement in fishing gear, etc.), and eventual delisting of this threatened subspecies. In a study published in the October 2008 issue of *Ecological Applications,* USGS scientist Tim Tinker and colleagues at the University of Wyoming and University of California, Santa Cruz, demonstrated that powerful analytical tools that are used in the study of invasive species to predict invasion speed can also aid in the management of threatened but recovering wildlife populations as they recolonize former habitat.

In addition to forecasting population growth, basic demographic data combined with movement data provide a means for predicting rates of range expansion. Quantitative models of range expansion have rarely been applied to large vertebrates, although such tools could be useful for restoration and management of many threatened but recovering populations. Using the southern sea otter as a case study, the authors used integrodifference equations in combination with a stage-structured projection matrix that incorporated spatial variation in dispersal and demography to make forecasts of population recovery and range recolonization.

Their models resulted in hind-cast (1989–2003) predictions of net population growth and range expansion that closely matched observed patterns. They next made

Management Implications:

- While the dispersal behavior of sub-adult females contributed most to variation in model predictions about the rate of range expansion, it was the survival of adult females that had the greatest impact on population growth overall, underscoring the need for a better understanding of the ultimate processes affecting adult female survival.
- Fieldwork designed to improve estimates of juvenile and subadult female sea otter dispersal in the south of the range would improve accuracy and reduce uncertainty in predicting future range expansion and the associated economic implications for tourism and fisheries industries.
- Analyses that emphasize uncertainty and the effects of different aspects of individual performance for population growth and spatial spread can dramatically increase the utility of these models for conservation management.

projections of future range expansion and population growth, incorporating uncertainty in all model parameters, and explored the sensitivity of model predictions to variation in spatially explicit survival and dispersal rates.

In virtually all simulations, the interaction between dispersal and local demography resulted in continued range expansion to the south: the median predicted wave speed was 5.2 km/yr over the 25-year projection. This rate of southward range expansion would mean that after 10 years the range boundary will have moved to about Santa Barbara, and after 25 years to a location
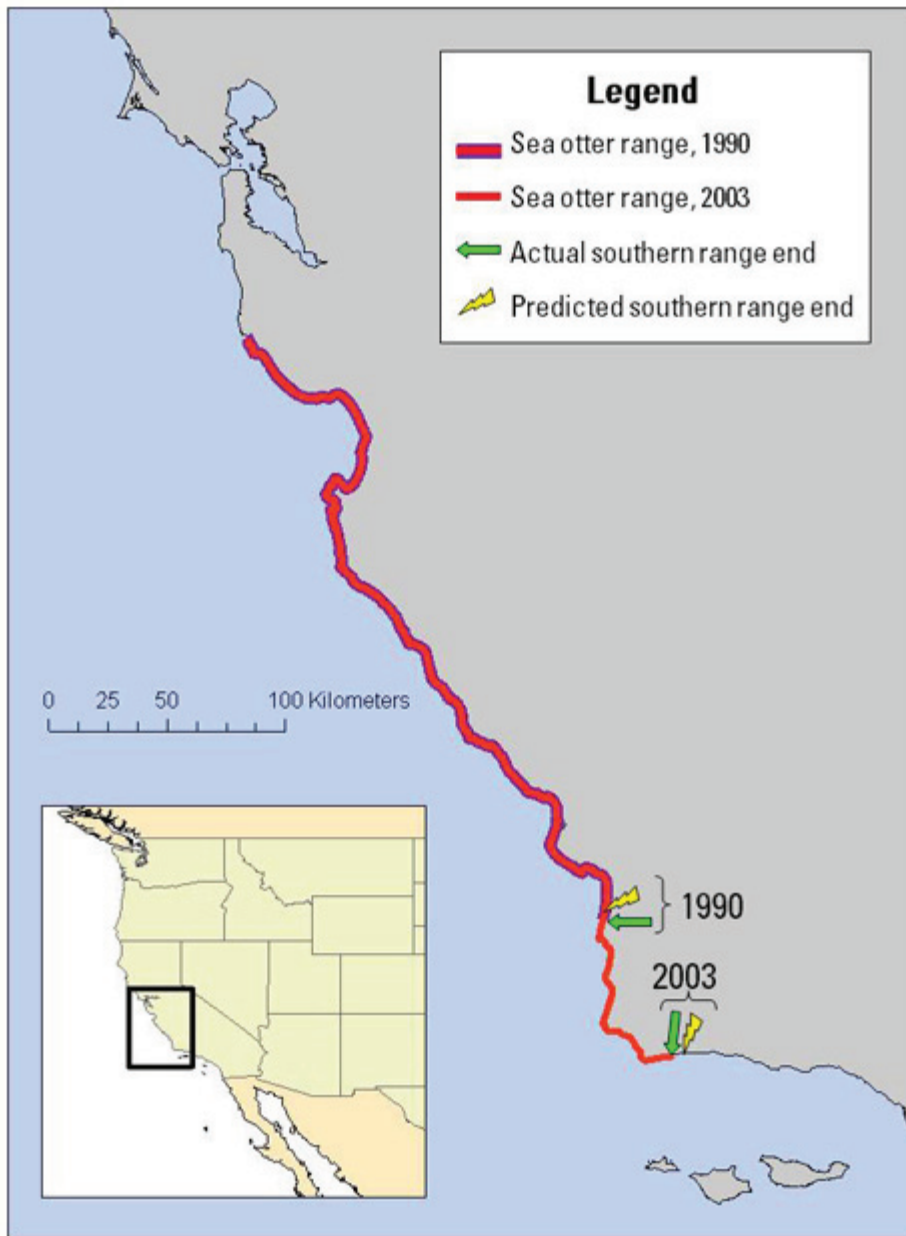
Map of central California showing the actual southern range boundary from observed survey counts compared with the predicted southern range boundary, for 1990 and 2003. Map by Tim Tinker, USGS.

just south of Carpinteria, although there was a great deal of variation around these mean estimates.

The predicted rate of southward range expansion was sensitive to both dispersal and survival rates; elasticity analysis indicated that changes in adult survival would have the greatest potential effect on the rate of range expansion, while perturbation analysis showed that variation in subadult dispersal contributed most to variance in model predictions. Variation in survival and dispersal of females at the south end of the range contributed most of the variance in predicted southward range expansion.

This same synthesis of a multistate dispersal matrix and integrodifference equations for estimating population growth and range expansion could be applied to other wide-ranging species, providing a useful and flexible tool for conservation biologists that can be easily modified as additional data and more precise parameter estimates become available, as they will with rapid improvements in remote-tracking technologies.

Tinker, M. T., D. F. Doak, and J. A. Estes. 2008. Using demography and movement behavior to predict range expansion of the southern sea otter. Ecological Applications 18:1781-1794.