Project 17: Home Ranges

For this project, Sections 8.1–8.3 *of Okubo and Levin* [127] *are needed.*

Many animals have home ranges or territories. These include wolves, coyotes, badgers, squirrels, birds, and lizards. The goal of this project is to develop a spatially explicit model for home-range movements of an animal. Individuals typically cue their movement behavior based on sound, familiar and foreign scent marks, prey density, and familiarity with a particular region. Some animals use one cue over another. For example, birds primarily use sound (bird calls), while wolves primarily use scent marks.

Read Sections 8.1–8.3 from the book by Okubo and Levin [127]. Simulate the Holgate model (cases 1 and 2) for an individual's movement. Repeat this for a large number of individuals (realizations of the stochastic process). What do the spatial distributions of large numbers of individuals look like in each of the two cases? Formulate a third case where the bias does not vary with distance. Simulate this case. Now let $\epsilon = k\Delta x$, where Δx is the spacing between grid points. Derive a PDE model for this third case by taking the "diffusion limit" discussed in chapter 5. Calculate the steady-state distribution for this PDE model, compare with simulation results, and plot the results.

Develop more realistic models for animal movement. You may want to start by reading "An Olfactory Orientation Model for Mammals' Movements in Their Home Ranges" by Benhamou [18]. Simulate the animal movement using random numbers drawn from a Gaussian and the algorithm given on page 382 of [18]. Print out a movement path similar to Figure 1, page 382. Modify the animal movement simulator as described on the top of page 383. Print out a space-use pattern for a 10,000-step path as shown in Figure 2, page 383. Discuss the algorithm and output.

Design your own model for home-range or territorial movement behavior. Territories involve interactions between adjacent home-range holders through signaling (e.g., scent-marking), and thus require two or more individuals interacting in space. Choose an animal, and tailor a territorial model to fit the biology. Simulate the model. Which rules give rise to stable territories?

Project 18: Re-invasion of Otters to California's Coast

One example of a biological invasion is the spread of a re-invading sea otter species off the coast of California. It was thought to be extinct until a relict population was found off Point Sur in 1914. Under protection from hunting, it grew and spread spatially, and now it calls much of the west coast of North America its home. Details on the early spatial spread are given in Figure 9.4 and Table 9.10 (from [110]). Most of the sea otter activity occurs within 1 km of the coast, and so the spread can be thought to be linear (up and down the coast).

Plot the distance spread versus time in northward and southward directions. Also plot the total range radius versus time. Discuss why spread may be different in north and southward directions. Derive a mathematical model for the spread process. You may want to research the life history of sea otters so as to make your model realistic.

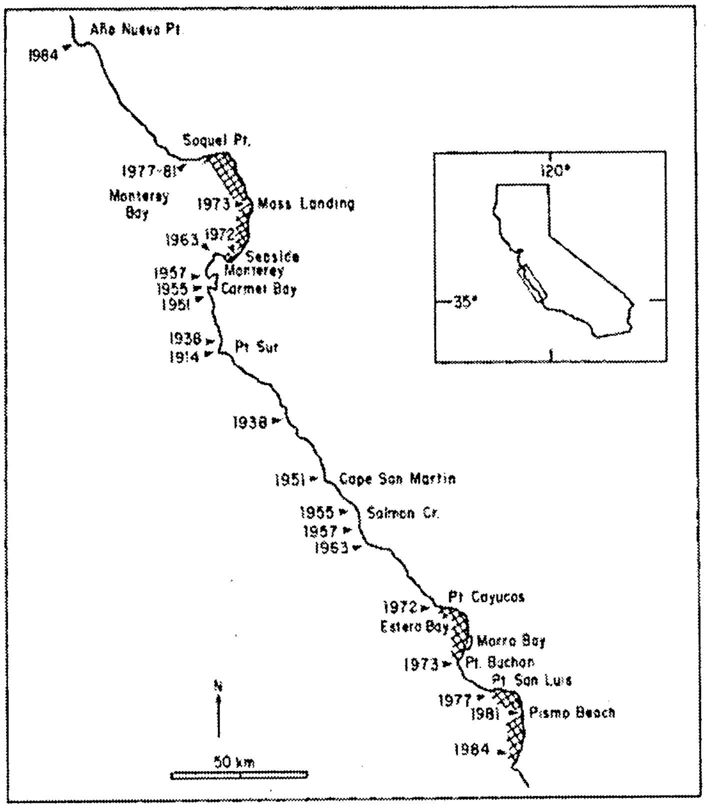

Figure 9.4. *Graphical illustration of the range expansion of sea otters. (Figure* 1 *of Lubina and Levin* [110], *reprinted with permission from Chicago University Press.)*

9.4 Physiology

Project 19: Pupil Control System

The pupil is the opening in the middle of the eye through which light enters the eye. In many animals, including humans, involuntary contraction and dilation of the pupil regulates the intensity of light entering the eye. The pupil will contract under bright light conditions, while it will dilate under low light conditions.

Now suppose that you shine a tiny spot of light onto the eye, always in the same location, and that the spot initially is on the edge of the pupil. At first, the pupil will contract in response to the spot of light. After the contraction, the light no longer enters the pupil, so it will dilate. After the dilation, the light again enters the pupil, so it will contract again, and so forth. An oscillation has been generated, for example, as shown in Figure 9.5.

Develop a model to reproduce the phenomenon. Begin by developing a model of the light intensity as a function of the pupil radius. Then add in negative feedback. Can you obtain oscillations? Investigate the incorporation of a delay representing the time it takes for the eye to respond to a change in light intensity.