

CHAPTER 13

ECOSYSTEM CONSIDERATIONS IN SEABIRD RESTORATION

The successful restoration of a seabird species requires not only information on population structure and demographics (see Chapters 2 and 3) but also data on how ecosystem-level factors may affect restoration (see Chapter 12). In addition, because seabirds are part of both marine and terrestrial ecosystems, changes in their local abundance associated with anthropogenic effects (such as oil spills) and with restoration activities stemming from these effects may have unanticipated consequences for the local environment. The linkages between seabirds and their marine and terrestrial ecosystems need to be more fully understood before biologists can assess how the *significant* reduction in the local abundance of seabirds, and the associated recovery of that population, will affect local ecosystems. The fact that seabirds may affect the abundance and distribution of terrestrial or marine biota is important in understanding the role of seabirds in community or ecosystem structure, and we must be mindful of these potential effects when designing oil spill restoration plans for seabirds.

In the following, we *briefly* summarize how seabirds may affect their local marine or terrestrial ecosystems. This précis is not meant to be comprehensive and is included only to ensure that such issues are considered in the design and implementation of restoration plans. We emphasize here the terrestrial component of seabirds. This is done not to minimize the importance of seabirds in marine ecosystems; on the contrary, much of this report focuses on seabirds as marine animals. Rather, there is little consideration in this report on how changes in seabird abundance can affect terrestrial ecosystems, and we are making a minimal attempt here to remedy this.

MARINE ECOSYSTEMS

Food Web

It is unclear how likely it is that changes in marine bird populations will disrupt or alter other elements of the marine food web. On the one hand, the proportion of fish stocks that seabirds are consuming is likely to be comparatively low (e.g., in the range of 20-30% of annual pelagic fish production; Furness 1978, 1984a, 1984b; Wiens and Scott 1975), and the effects of bird predation on a fish population may be less than that of particular fisheries (Furness 1984a, Cairns *et al.* 1991). However, there probably is competition for a potentially limited fish resource (Furness 1984a, MacCall 1984) among such apex predators as seabirds, large predatory fish, marine mammals, and humans, and fish consumption by seabirds may limit the consumption by other food-web components.

The degree to which seabirds affect fish stocks and the degree to which they compete with predatory fish, marine mammals, or humans are functions of at least geography and the species and age-classes of fish consumed by seabirds (MacCall 1984, Cairns *et al.* 1991, Cairns 1992).

In addition, Birt *et al.* (1987) have shown that at a relatively small temporal and spatial scale, double-crested cormorants can significantly deplete prey populations. Therefore, changes in seabird abundance resulting from oil spills or their subsequent recovery can affect food-web components, although it is not clear to what extent this actually occurs and at what temporal and spatial scale the effects are best seen.

Nutrient Enrichment

Seabirds affect the coastal marine and estuarine environments through their production of guano. Guano is rich in marine nitrogen and phosphorus and is an important fertilizer. Approximately 10^4 - 10^5 tons of phosphorus are produced annually by seabirds worldwide (in Polis and Hurd 1996), enriching plankton, intertidal, and terrestrial systems. Zelickman and Golovkin (1972) reported that primary production around bird colonies was increased and the composition and structure of neritic plankton communities were affected by guano-induced marine enrichment. In South Africa, nutrients introduced into intertidal systems by surface runoff from guano-covered islands or by direct deposit of guano from roosting seabirds enhanced macroalgal growth, producing cascading effects to intertidal community composition (Bosman *et al.* 1986, Bosman and Hockey 1988, Branch *et al.* 1987). Finally, MacCall (1984) hypothesized that phosphate laden runoff from the torrential rains that accompany El Niño in Peru may compensate partly for the reduced nutrients available owing to disrupted oceanic upwelling.

The systemwide effects of marine and intertidal fertilization by guano vary depending on local conditions and community interactions, and the increase or decrease in seabird densities may affect these systems through changes in guano production. Polis and Hurd (1996:412) argued that an increase in seabird-related fertilization "reticulates throughout the food web, producing bottom-up effects beyond increased primary productivity: consumers grow faster, to larger sizes, and increase their population biomass and density." However, Bosman *et al.* (1986) suggested that complex trophic interactions involving oystercatcher predation on limpets and enrichment of intertidal and nearshore waters by seabirds act to produce permanent and thick algal mats immune from grazing, thereby reducing the abundance of a primary consumer (i.e., intertidal limpet). Both Polis and Hurd (1996) and Bosman *et al.* (1986) agree that through the production of guano, seabirds can profoundly affect nearshore, intertidal, and terrestrial communities.

TERRESTRIAL ECOSYSTEMS

Vegetation

The effects of guano production on vegetative communities extend beyond the marine environment. Although they visit land only for a short period and generally remain close to the shoreline, the very dense concentrations of birds at some seabird colonies have an appreciable effect on local soils and vegetation (Furness 1991). In the Arctic, manuring by thick-billed murre, auklets, and dovekeys creates local pockets of vegetation in otherwise barren areas. The effects of dovekeys on terrestrial vegetation in Spitzbergen extend away from the colonies in

peripheral areas where nonbreeders circle and along the route taken by breeders to and from the sea (Stempniewicz 1990). Growth of vegetation as a result of manuring at the colony may make some breeding sites less attractive, resulting in a gradual shifting of the colony and further extending the nutrient-enriched area.

The moss *Dicranum groenlandicum* is a principal component of peat, laid down over thousands of years, on flat ground above thick-billed murre colonies on Coats, Digges, and Akpatok Islands in Hudson Strait (Gaston and Donaldson 1995). The peat provides a foothold for plants, such as cotton grass *Eriophorum*, that are otherwise absent from the clifftops. Such peat does not occur on clifftops elsewhere in the region, and apparently the flat ground above the murre colonies is enriched by excrement, food, etc., blowing up from the cliffs. On the colony cliffs themselves, where the instability of the rocks does not encourage the formation of peat, scurvy grass often forms luxuriant clumps up to 40 centimeters in diameter. On the colony at the Minarets, Baffin Island, it grows up to an altitude of 800 meters. Away from seabird colonies, scurvy grass seldom forms clumps more than 10 centimeters across and does not grow above 200 meters elevation in the Minarets area (A. Gaston, pers. obs.). In Greenland, several vascular plants occur only in the vicinity of seabird colonies at the northern limit of their range (Salomonsen 1979).

Seabird islands in low-Arctic and boreal waters may also be affected by the manuring and burrowing of auks. In the Queen Charlotte Islands, British Columbia, a distinctive tussock grass understory develops in forests subject to burrowing by rhinoceros and Cassin's auklets, but does not invade forest occupied only by ancient murrelets, which do not defecate in their burrows.

On some New Zealand islands, the burrowing and manuring activities of petrels aerate and fertilize the topsoils, creating favorable conditions for plant regeneration (Towns *et al.* 1990a). This promotes a series of cascading effects benefiting invertebrates, lizards, and the tuatara. Conservation and restoration biologists in New Zealand hope to restore this unique association of seabirds and terrestrial flora and fauna on the Mercury Islands (Towns *et al.* 1990a).

Erosion

The burrowing activities of auks have resulted in the gradual erosion of some colonies, making the islands uninhabitable for the culprits. This seems to have occurred on Grassholm Island, Wales, where a colony of tens of thousands of Atlantic puffins destroyed most of the soil layer sometime in the last century (Lockley 1953). Similar erosion has affected the puffin colony at the Farne Islands, England (Harris 1984).

Food Web

The dense aggregations of some seabirds that form at colonies provide a concentrated food source for predators. Adult birds of practically all species may be preyed on by terrestrial predators while breeding. Red and Arctic foxes are probably the most widespread and important predators. The concentration of Arctic foxes associated with the dovekie colonies in the Thule

District of northwest Greenland forms the basis for an important local fur-trapping industry that would probably not exist without the birds.

In subarctic Alaska and British Columbia, the local race of the peregrine falcon (*Falco p. pealei*) specializes in feeding on marine birds, and the smaller auks are its principal prey. Unlike most peregrines, but like Eleanor's falcon (Walther 1979), Peale's peregrines hunt mainly over the sea, skipping low over the wave tops and snatching ancient murrelets and Cassin's auklets either on the water or in the act of taking off. The social aggregations of ancient murrelets that occur at sea several kilometers from their colonies are much denser and more active on calm nights than when the sea is choppy, perhaps because calm conditions allow them to detect peregrines more easily (Gaston 1992). Peregrines nesting on coastal cliffs in northern Scotland also take many auks, apparently preferring Atlantic puffins (Ratcliffe 1980), while gyrfalcons may specialize in thick-billed murrelets at certain Arctic colonies (Gaston *et al.* 1985). See Chapter 12 for discussion of how predation by peregrine falcons may structure species composition of mixed-species seabird colonies.

Seabirds also provide links to terrestrial food webs by contributing terrestrial biomass to islands through fish scraps, dead chicks, feathers, eggs, and guano. For example, Polis and Hurd (1996) estimated that chick carcasses of Heerman's gulls and brown pelicans provide 17% and 18% of the terrestrial productivity per meter² on Isla Raza and Isla Piojo, respectively. This biomass helps support several trophic categories of arthropods and significantly influences the population dynamics of many terrestrial species (Polis and Hurd 1996).

Conclusions

As a consequence of the relations described above, seabird colonies develop unique associated terrestrial ecosystems of limited area. Seabird impact on plants has been investigated at several sites (e.g., Salomonsen 1979, Gaston and Donaldson 1995, Towns *et al.* 1990a), but their impact on arthropods and other invertebrates has been described at only a few colonies (see Towns *et al.* 1990a, Polis and Hurd 1996) and deserves further study. In any case, there is a need for careful consideration of associated terrestrial ecosystems in designing restoration plans for seabirds.