

FALKLAND ISLANDS (ISLAS MALVINAS)

SEE ATLANTIC REGION

FARALLON ISLANDS

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The Farallon Islands (Farallones) consist of several sparsely vegetated rocks about 47 km west of San Francisco, California. The South Farallones include Southeast Farallon Island (SEFI), West End Island (WEI), and several adjacent seastacks, totaling less than 50 hectares. The North Farallones are four steep islets about 11 km northwest of SEFI, totaling less than 10 hectares. Middle Farallon is a small, wave-washed rock 3.5 km northwest of SEFI (Fig. 1). The Farallones are perched on the edge of the continental shelf in waters about 60 m deep; less than 10 km to the southwest the ocean floor drops abruptly to depths of 3000–4000 m. The Farallones represent the highest points of an underwater granitic ridge that appears similar geologically to parts of the southern Sierra Nevada mountain range. Within the political boundaries of San Francisco, the islands nevertheless continue to drift slowly northwest along the margin of the Pacific tectonic plate.

ESTABLISHMENT OF NATIONAL WILDLIFE REFUGE

The South Farallones alone support the largest single assemblage of breeding seabirds along the California



FIGURE 1 Aerial view of the Farallon Islands, May 30, 2007. PRBO and USFWS biologists operate a research station from the Victorian-era buildings on Southeast Farallon Island. Middle and North Farallones appear in the background.

coast, with hundreds of thousands of common murre; tens of thousands of Brandt's cormorants, western gulls, and Cassin's auklets; and hundreds of Leach's and ash storm-petrels, double-crested and pelagic cormorants, pigeon guillemots, rhinoceros auklets, and tufted puffins. Five species of pinnipeds also breed at the Farallones, including the Steller sea lion, a species federally listed as threatened. To protect these and other natural resources, the North and South Farallones received National Wildlife Refuge status in 1909 and 1969, respectively. Additionally, the North Farallones, Middle Farallon, and WEI are congressionally designated Wilderness Areas. Today, the Farallon National Wildlife Refuge is managed by the U. S. Fish and Wildlife Service (USFWS) through a cooperative agreement with PRBO Conservation Science (PRBO, formerly the Point Reyes Bird Observatory).

PAST HUMAN OCCUPATION OF THE FARALLONES

The Farallones were known to Native Americans of the central coast of California as Island of the Dead, and believed to be the residing place of spirits after death. However, there is no evidence that local Native Americans visited the islands. The first known landing was made by British explorers in 1579 to collect seals and seabirds for food during an expedition led by Sir Francis Drake. After Drake's visit, Spanish explorers steered offshore of present-day San Francisco to avoid the hazards of the Farallones and other possible submerged rocks; thus, the discovery of San Francisco Bay did not occur until the land expedition of Gaspar de Portola in 1769. During this time of Spanish exploration, the islands were generally referred to in the accounts of explorers as *farallones*, Spanish for "rocks rising from the sea."

In search of sea otter pelts to trade with Russians in Alaska, the crew of the Boston vessel *O'Cain* made the second known landing on the Farallones in February 1807. Finding instead vast numbers of seals, crews of several Boston ships took over 100,000 northern fur seal pelts by 1812. The Russian American Fur Company then occupied the South Farallones beginning in 1812, after having established a settlement to the north at Fort Ross on the California mainland. The company employed Native Americans from Alaska and California and hunted seals, sea lions, and seabirds to provide food and other products for Russian communities in both regions. More than 1000 fur seals were taken each year initially, but by 1838 the company had taken all remaining animals and abandoned the Farallones. Following their extirpation, northern fur seals did not breed at the South Farallones until 1996; increasing numbers of fur seal pups have subsequently been noted, numbering near 100 by 2006.

Populations of seabird species also were heavily impacted by human disturbance in the 1800s, most notably when commercial take of common murre eggs began in 1849. The size of murre eggs (about twice the volume of a chicken egg), their palatability, and their availability in dense concentrations on the Farallones (common murres can breed in densities of 20 pairs/m²) made them a valued commodity in San Francisco, where domestic poultry production was insufficient for the growing human population during the Gold Rush. In 1851, a group of eggers claimed ownership of the islands and exclusive rights to eggging operations, forming the Farallon (or Pacific) Egg Company. Around the same time, the Lighthouse Board (within the U.S. Department of Treasury) commissioned the construction of a

lighthouse and light keepers' residences on SEFI, the lighthouse becoming operational in 1855. Years of conflict between the egg company and light keepers over eggging opportunities ensued until a U.S. Marshal evicted the egg company in 1881. Large-scale eggging by light keepers and fishermen continued until the Lighthouse Board, following recommendations from the California Academy of Sciences and American Ornithologists Union, prohibited eggging in 1896. Some illegal eggging continued at least until 1904. In total, it is estimated that more than 14 million murre eggs were harvested during the second half of the nineteenth century. Annual harvest estimates, and likely population decline during the first half of the century, indicate that the murre population at the Farallones was likely more than 1,000,000 breeding birds prior to the arrival of sealers and eggers. Fewer than 20,000 murres were estimated in 1911.

Human occupation of SEFI peaked in the first half of the twentieth century. The U.S. Weather Bureau built a station in 1902, and the U.S. Navy arrived just a few years later, replacing the weather station and also operating a radio compass station. Including Navy personnel, light keepers, and their families, the island's human population reached 78 permanent residents in 1942. After World War II and with developments in navigational techniques, Navy presence was no longer needed. Light keepers remained as employees of the U.S. Coast Guard, which had assumed duties when the Lighthouse Service was dissolved in 1939. Numerous buildings were razed, and by 1965 the Coast Guard no longer allowed keepers' families to reside on SEFI. PRBO was formed in 1965, and their biologists made their first visits to the Farallones in 1967 to conduct initial studies of the impacts of human activities on the islands' ecology. With impending lighthouse automation and removal of Coast Guard personnel, efforts increased to expand the Refuge to encompass all islands and to establish a biological field station on SEFI.

Since April 1968 (and under a cooperative agreement with USFWS since 1972), SEFI has been staffed by biologists from PRBO each day of each year. Utilizing two remaining Victorian-era buildings (built in 1878 and 1880) to house personnel and equipment (Fig. 1), PRBO and USFWS conduct research and conservation efforts and also have facilitated work by many researchers from universities, government agencies, and other organizations. SEFI is closed to the general public to protect sensitive resources and because accessing the island is not routine (Fig. 2). Resident biologists are allowed only limited access to WEI (separated from SEFI by the Jordan

Channel) and certain areas of SEFI. Visitors must obtain special-use permits from USFWS, and boats and aircraft are required to maintain minimum distances from the islands. The waters surrounding the Farallones are within the Gulf of the Farallones National Marine Sanctuary (GFNMS), managed by the National Oceanic and Atmospheric Administration.



FIGURE 2 A derrick at East Landing is used to lift biologists, visitors, and supplies onto Southeast Farallon Island.

ECOLOGY OF THE FARALLONES

South Farallones

Steep talus slopes and a broad marine terrace on its south and west shore characterize the landscape of SEFI (Fig. 1), where most research and monitoring activities have occurred. Ninety species of plants have been documented at the South Farallones, 65 of which are nonnative. Maritime goldfields, a low-lying, endemic annual, is widespread and temporarily colors the marine terrace green in winter and yellow in spring. New Zealand spinach and other invasive plants that threaten habitat of crevice- and burrow-nesting seabirds are targets of control efforts. European rabbits, introduced to the islands for food in the 1880s and abundant until eradicated in 1974, reduced native vegetation and competed with seabirds for nesting cavities. Since the eradication of rabbits, native vegetation has been slowly reclaiming the islands, and rhinoceros auklets, absent since rabbits were established, have recolonized the South Farallones.

Each spring and summer since 1971, the breeding biology of Farallon seabirds has been studied in detail, contributing vastly to the understanding of the life history strategies of these species. One shorebird species, the black oystercatcher, breeds on the Farallones and also is studied. The seabird breeding community consists of crevice or burrow nesters (ashy and Leach's storm-petrels,

pigeon guillemots, Cassin's and rhinoceros auklets, and tufted puffins), and surface nesters (Brandt's, double-crested, and pelagic cormorants, western gulls, and common murre). For several species, banding of chicks and subsequent resightings of them as adults has resulted in detailed information on philopatry, age at first breeding, and estimates of survival and lifetime reproductive success. Diet composition data, studied by identifying fish and zooplankton species brought to chicks or found in pellets or regurgitation samples, have provided insight into annual and long-term variability in prey resources as affected by oceanographic conditions. Driven by strong northwesterly winds that push surface waters offshore in spring, coastal upwelling of cold, nutrient-rich waters results in abundant prey resources in the California Current, supporting the great diversity and number of seabirds that breed at the Farallones. El Niño–Southern Oscillation (ENSO) events occur periodically, reducing upwelling and resulting in reduced seabird breeding effort or success for several species. PRBO's long-term datasets on seabird survival, reproduction, and diet are among the most extensive in the Northern Hemisphere and are now being used to assess impacts of climate change and fisheries on marine ecosystem health.

For most species, breeding population sizes also are estimated annually. The breeding colonies of ashy storm-petrel, Brandt's cormorant, and western gull are the largest throughout their ranges. After low numbers following commercial eggging, the common murre population had increased to more than 200,000 breeding birds by 2006, despite a steep decline in the mid-1980s due to mortality in oil spills and gill nets, which led to regulations by the California Department of Fish and Game restricting the use of gill nets. Populations of double-crested cormorants and tufted puffins appear stable but remain well below historic levels. The incomplete recovery of these two species may be related to loss of Pacific sardines as a prey item, caused by oceanic changes and overfishing by humans in the 1930s and 1940s. Sardines began reappearing in waters around the Farallones in the early 1990s, but as yet they account for only a small percentage of prey items delivered to murre and rhinoceros auklet chicks.

Ashy storm-petrels must contend with the threat of predation by western gulls, but they also have been impacted by predation by wintering burrowing owls. Several migrant owls reach the South Farallones each fall and find an abundant prey source in house mice (introduced probably in the nineteenth century). After the mouse population crashes with winter rains, the owls remain and switch to storm-petrels as prey. Some owls also die from

starvation. In the absence of house mice, it is believed that burrowing owls would continue to migrate to more suitable mainland wintering habitat, both storm-petrel predation and owl starvation would be reduced, and native flora would more quickly become reestablished. Thus, eradication of house mice is now being planned.

Many migrant raptors, shorebirds, waterbirds, and landbirds arrive to the islands in fall, with a smaller passage in spring. Through 2008, more than 416 species of birds had been documented on the Farallones and surrounding waters, including many off-course migrants that breed in eastern North America and Siberia. Landbirds congregate in the four planted trees on SEFI (three Monterey cypress on the lee sides of the houses, and a low, sprawling Monterey pine near the east end of the island), allowing them to be banded, measured, and studied through strategic placement of mist-nets. Arrivals of migrants are greatly affected by weather conditions, but standardized long-term data collection allows analyses of population trends of western species that can be used to affect habitat conservation on both breeding and wintering grounds.

Standardized censuses of other migratory organisms also are conducted in fall. Of five species of bats noted at SEFI, the highly migratory hoary bat is most commonly sighted, and only on SEFI has hoary bat copulation been witnessed. Blue, humpback, and several other species of whales are identified, often by their spouts, as they migrate and forage along the continental shelf break. Gray whales migrate over the shelf, and one to three whales typically reside near SEFI each spring and summer, forgoing the remainder of their northward migration. Censusing from SEFI indicates that most whales and other cetaceans have increased since nearby whaling was curtailed in 1968. White shark sightings peak with maximum immigration and emigration of their preferred prey, immature northern elephant seals. Research at the South Farallones was instrumental in establishing 1994 legislation protecting white sharks in California waters, and PRBO biologists documented the first instance of a killer whale preying on a white shark in 1997. Among nonmigratory organisms, GFNMS biologists have monitored invertebrates and algae in rocky intertidal habitats since 1992. More than 200 taxa have been found; red turf and coralline algae predominate. Less well studied are endemic taxa of camel cricket, California arboreal salamander, and trapdoor spider that may reflect an earlier time when the Farallones were connected to the mainland.

The biology of the northern elephant seal is the focus of research in winter. Cows begin to arrive in

December to give birth and breed with adult males that have already established territories. Like the northern fur seal, elephant seals were extirpated in the 1800s. They were resighted at the South Farallones in 1959 and began pupping again in 1972. The number of pups per year increased annually to a peak of 475 in 1983, then declined, and has been mostly stable since 1999 at fewer than 200. Not agile on land, elephant seals are easily tagged to enable studies of survival and reproductive success by age class, as well as immigration and emigration patterns. California sea lions are currently the most abundant pinniped on the South Farallones, where they reach their northern breeding limit. However, only small numbers of pups (<50), and fewer Steller sea lion and harbor seal pups, are born annually in spring and summer. The rapidly growing fur seal population may limit nesting space for seabirds in the future, providing insight into the dynamics of these populations prior to the 1800s. The Guadalupe fur seal and the sea otter are occasionally seen in fall.

North Farallones

Several thousand common murrelets breed on each of the four islets of the North Farallones with small numbers of nesting Brandt's cormorants on certain islets. These populations are surveyed annually with aerial photographs (also at the South Farallones). The only known on-site biological survey was conducted in fall of 1994 when biologists from Humboldt State University and USFWS landed on the West, East, and South islets. On-site surveys are rarely permitted because of the steep terrain of the islets, frequent rough seas, and the need to prevent disturbance to surface-nesting seabirds and hauled-out pinnipeds. The guano-covered islets are largely devoid of vegetation, with only a small amount of habitat for crevice- and burrow-nesting species. Breeding pigeon guillemots, which may outcompete smaller species for crevice habitat, were found on each surveyed islet, and a small breeding colony of Cassin's auklets was found on the West Islet. Wooden boards on the West Islet were evidence of prior human activity, likely from egg-harvesting activities in the nineteenth century.

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Granitic Islands / Pacific Region / Seabirds

FURTHER READING

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FAROE ISLANDS

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The Faroe (or Faeroe) Islands, 61° 24′–62° 24′ N and 6° 15′–7° 41′ W, are a series of small islands oriented in a northwest-southeast direction situated in the North Atlantic between Iceland, Norway, and Scotland (Fig. 1). They consist mainly of steep mountainous plateaus with narrow terraces, gorges, and cirque valleys, divided by narrow fjords and sounds. Most of the outer coastal reaches are vertical cliffs several hundred meters in height, which are extremely exposed and subject to erosion by breakers. The islands are slightly tilted, with the eastern parts experiencing some subsidence after the land uplift following the last glaciation, as evidenced by the presence of submerged bogs.

OCEANOGRAPHY

The Faroe Islands are positioned on the ridge that stretches between Scotland and Iceland and further to Greenland. This is the region where Atlantic water enters the Nordic Seas, with main flows on both sides of the Faroes. The water on the Faroe shelf circulates clockwise



FIGURE 1 The position of the Faroe Islands in the North Atlantic, showing the geology and the localities mentioned in the text.

(anticyclonic), and a persistent tidal front separates the shelf water from the surrounding ocean. This current system provides the basis for a small (8,000 km²) and uniform coastal ecosystem that is surrounded by an oceanic environment. Within this ecosystem there appears to be a trophic relationship between plankton, fish, and seabirds, with marked interannual variability driven by changes in the physical conditions.

PHYSICAL BACKGROUND

The islands are part of the North Atlantic basalt area, which was formed during a period of intense volcanic activity in the Tertiary ~60 million years ago. They are the remnants of large, low-relief flood basalt lavas, built up in near horizontal layers mainly from rift volcanism, which were laid down as the northwestern European and North American continents began to drift apart. The width of the island group from north to south is approximately 113 km, and it is approximately 75 km from east to west. They cover a total land area of almost 1400 km², dominated by steep cliffs in the outer coastal regions on