

WILDLIFE AND WILDLIFE HABITAT VALUES
OF ALCATRAZ ISLAND
GOLDEN GATE NATIONAL RECREATION AREA
SAN FRANCISCO, CALIFORNIA

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THE WILDLIFE AND WILDLIFE HABITAT VALUES OF ALCATRAZ ISLAND,
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INTRODUCTION

Alcatraz Island has been valued as an historic/cultural resource since its acquisition by the National Park Service in 1972, and it is now a National Historic Landmark. Until the last decade, little was known about the natural values of Alcatraz Island, especially about the role the island played as wildlife habitat in San Francisco Bay. Originally, San Francisco Bay encompassed 2,027 km², however fill and development have reduced it to 1,419 km². Historic wetlands and other wildlife habitat were diminished by 30%. As urban development continued to take wildlife habitat, the need to recognize the value of remaining habitat became critical. Preserves such as Alcatraz became more important as this trend continued. Alcatraz is an important wildlife refuge, exhibiting a microcosm of the processes described by Darwin on the Galapagos Islands in the last century and studied by island biogeographers of this century.

Alcatraz is a small island, located north of San Francisco (Figure 1). Although it is used predominantly by tourists, 2/3

is presently closed to visitor access. In the mid 1980s, island policy changed from ranger-led tours to an open trail policy over the central third of Alcatraz. Annual visitation increased from 350,000 visitors during the mid-1980s to approximately 950,000 visitors in 1990. Concrete covers approximately 39% of the island's surface: existing trails cover 0.73 ha or 8% of the island surface. However Howell and Pollak (1990) estimated that the actual impact of the trails on the island wildlife was 13% (1.15 ha). Because of historic development and current use patterns on the island, the effective wildlife habitat is approximately 6.8 ha, or 75.0% of the island's total area. This paper provides a summary and compilation of research on Alcatraz; examines its value as a wildlife refuge; and provides management recommendations to maintain the dynamic nature of the Alcatraz ecosystem, with recognition of its use as a cultural site.

HISTORY OF ALCATRAZ

Alcatraz was first discovered in 1769, when Spanish explorers sighted three islands in the inner San Francisco Bay (Beyeler and Lamb 1988). Formed over 130 million years ago, Alcatraz is comprised mainly of sandstone (Delgado 1955). Its long axis lies in a northwest, southeast orientation, 1.8 km from San Francisco, and it encompasses 22.5 acres (9.1 ha).

Historical documentation of natural resources on the island is

scarce, and often contradictory. Alcatraz has no source of fresh water, and reportedly had no vegetation when first discovered; it supported only the pelicans, for which some think it was named (Goodwin 1963, Thompson 1972). Delgado (1985) stated that it was named for the cormorants which resembled "alcatraces," which meant small fowl in Spanish. Despite earlier reports regarding the lack of vegetation, Delgado (1985) referred to tufts of grass growing on the island in the mid 1800s, probably grown from seeds passed through bird's digestive tracts. He also indicated that Miwok and Costanoan Indians gathered resources from the island, including shellfish, marine mammals, game, and bird eggs, long before its discovery by the Spanish. This reference remains ambiguous (Treganza 1957, Clauss 1981, Odier 1982). It is known that "Isla de Alcatraces" referred initially to Yerba Buena Island: the name was accidentally switched, on the map, to the present Alcatraz in 1826 (Eldredge 1909; Clauss 1981).

The first documented human use of Alcatraz occurred during the Spanish-American war (1845-1848): the Spanish probably fortified the island, using it for rest and recreation for ill soldiers (Hitell 1897, Beyeler 1988). The United States seized Alcatraz from Mexico in 1846, and began fortifying it in the 1850s (Hitell 1897, Thompson 1972).

With fortification, came substantial change to the topography of Alcatraz. During the 1850s, slopes were blasted away to create

cliffs and wharves, roads, buildings, and gun batteries were built. By 1874, most of the southeast end of the island had been cut back to a height of 19 meters from cliffs originally 23 meters high (Thompson 1972; Clauss 1981). Tidepools were created when cliffs were blasted at the island (Delgado 1985), forming the only tidepools in San Francisco Bay.

VEGETATION

The vegetation of Alcatraz was also influenced through human use. By 1853, trees and shrubs were planted and terraced gardens were located near the cellhouse (Delgado 1985). Soil brought to the island from the mainland and other islands in the Bay probably contained seeds of native plants, including coyote brush (Baccharis pilularis), California poppy (Eschscholzia californica), and California blackberry (Rubus vitifolius) (Boarman 1989; Beyeler 1988). Several attempts to grow grass, alfalfa, and clover on the island (1872, 1864, 1904) were unsuccessful (Thompson 1972). After the mid 1860s, ornamental vegetation was introduced, much of which is still present on the island (Boarman 1989). With the addition of vegetation, insects and rodents probably began to inhabit the island (Beyeler 1988).

Cliffs on Alcatraz are generally barren of vegetation, except the

northeastern shore which has an extensive grassy area above the cliffs. The southern tip of the island is covered with agave (Agave shawii) and eucalyptus (Eucalyptus globulus). North of the eucalyptus grove is the launch landing area where visitors disembark and National Park Service staff maintain offices, the museum, and visitor center. The central upland of the island is primarily concrete and buildings, including the former prison industries area, cellhouse, and parade ground. A grassy bluff, the cisterns, lies between the industries and cellhouse on the northwestern end. The west side of the island, below the cellhouse, supports historic gardens and shrubs, mainly mirrorbush (Coprosma baueri) and blackberry (Rubus vitifolius). Large rubble piles, with some shrubs, border the parade grounds on the southern end of Alcatraz. To the east of the cellhouse are historic ruins, covered with mirrorbush, blackberry, eucalyptus and Monterey cypress (Cupressus macrocarpa). Interspersed among the horticultural plants and grass are native coyote brush. (See Table 1 for habitat areas).

WILDLIFE

The closure of parts of Alcatraz to human use and disturbance and vegetational changes on the island created new wildlife habitats, permitting the island to support an interesting array of wildlife. From 1980 to 1990, wildlife observations were recorded and compiled into two databases (Howell and Pollak 1990). The

first database contained incidental observations which were collected by island staff and recorded in their daily log. The second data base was derived from surveys of the island, which include locations and densities of birds. During this decade, 108 bird species were observed on Alcatraz Island, including 1) seven known breeders, 2) eight possible breeders, 3) 20 frequent users, and 4) 73 infrequent users. Individual bird species with 10 or more observations were placed in the frequent category, and species with less than 10 observations were placed in the infrequent category (Table 2). In addition, deer mice (Peromyscus maniculatus) and the California slender salamander (Batrachoseps attenuatus) bred on the island. The brown pelican (Pelicanus occidentalis) and peregrine falcon (Falco peregrinus) both federally listed endangered species, have also been seen on Alcatraz.

Although the entire island is used by wildlife, certain areas rank higher in wildlife activity (Howell and Pollak 1990): the seven areas ranking the highest for all bird categories are 1) the parade ground, 2) the eucalyptus grove, 3) ruins near the cellhouse, 4) cliffs on the west side of the island, 5) agave cliff, and 6) rubble piles. Areas with secondary ranks are: 1) the shrubs and historic gardens near the cellhouse (greenhouse), 2) cisterns, 3) tidepools, 4) launch landing, 5) northeast shore, and 6) the cellhouse and industries areas (foghorn on west side) (Figure 2).

The diversity, or number of species present in an area, resulted in a different ranking (Howell and Pollak): the highest areas are the 1) eucalyptus grove, 2) launch area, 3) agave cliff, 4) cliffs on the western side, and 5) industries area. These areas are followed by 1) the cellhouse, 2) parade grounds and rubble piles, 3) vegetation on either side of the cellhouse, 4) the cistern area, 5) northeastern shore, and 6) the tidepools.

The density of breeding birds was highest on the concrete parade grounds (due to Western gull use), the eucalyptus trees, and shrubs below the cellhouse. The least used areas were the northern shore; the concrete central third of the island; and the concrete eastern side. The concrete areas on the northern end were moderately used.

January through July represents the most active breeding period with all seven species present simultaneously during March, April and May (Figure 3). Three to five breeding species remain on the island throughout the year (Howell and Pollak 1990).

The following pages provide specific life history information about the breeding birds of Alcatraz.

Cormorants

Though Brandt's (Phalacrocorax penicillatus) are the most common cormorant species seen on the island, double-crested (P. auritus) and pelagic (P. pelagicus) also roost on Alcatraz. Brandt's are seen on Alcatraz year-round, peaking from January to April. All cormorant species are protected by the Migratory Bird Treaty.

Male cormorants establish territories, but both sexes build nests and incubate the eggs. Nests are reused for several seasons. Brandt's cormorants begin laying eggs in March; double-crested and pelagic species begin laying in April and May, respectively. Clutches are usually complete by the end of July. Chicks hatch at approximately 25 days; P. auritus fly by 42 days (Terress 1980). Incubation time and age of flight for Brandt's cormorants are unknown. Cormorant diets are varied, and include fish, eels, crustaceans, and reptiles (Terress 1980).

During breeding season, Brandt's cormorants have large plumes on their neck and back, and a blue patch on their throat (Terress 1980). Some cormorants breed at two years of age, but most are older. Brandt's cormorants are never seen inland, but range along the coasts from Washington to Baja California, and the Gulf of California (Terress 1980).

Of the six species of cormorants in North America, the double-

crested cormorant is the most common; this species has tufts on their crown during breeding season, and a yellow-orange throat patch (Terress 1980). Females may relay a clutch if the first one is destroyed. Chicks form social groups by three to four weeks of age (Terress 1980). Double-crested are the only species of cormorants to be found inland: they range from the Aleutians to southern Baja California; Newfoundland to Florida, throughout the US, and the Bahamas and Cuba (Terress 1980).

Pelagic cormorants are smaller than other cormorants, with thinner bills, white patches on their flanks when breeding, and a ruby or magenta face. Pelagics have two crests on their heads; immatures are darker than other immature cormorant species (Terress 1980). P. pelagicus range from the Aleutians to Baja California.

Double-crested and pelagic cormorants differ significantly in colony and breeding habits. Pelagic cormorants prefer to nest on cliffs; colonies are narrow and not dense. Double crested cormorants nest on level ground, close together (In the Bay Area, cormorants have nested on the Bay Bridge and the Richmond/San Rafael Bridge); the colony tends to be much more active than pelagic colonies (Siegel-Causey and Hunt 1981). In both species, adults rarely leave the nest when approached; they may stand and regurgitate, allowing predators to take food, eggs, and chicks. Ravens, crows, and gulls prey on cormorants (Terress 1980;

Siegal-Causey and Hunt 1981). A study in Canada was done using the two different species to test theories of predation. Colonies that were accessible to predators (flat ground versus cliffs) tended to form tighter groups, with the inner nests rarely predated on. Individuals protecting nests isolated from the colony and exposed to predators were more aggressive; aggression drops when chicks are old enough that predators cannot carry them away (Siegal-Causey 1981).

Pigeon Guillemot

Pigeon guillemots (Cepphus columba) also breed on the island. In 1982, a nest was found in the cliffs on the west side; an additional 15-20 birds were on the island (Boarman 1989). Pigeon guillemots nest from Santa Barbara Island to Alaska, typically in areas exposed to wave action (Boarman no date). The nest on Alcatraz was the first report of breeding in still waters of the San Francisco Bay. Guillemots are seen on the island from March through August, and in November. Typically nesting in cliffs in the Pacific, eggs are laid on bare rocks or open ledges between May and June. One to two eggs are incubated for 30-32 days; chicks fledge at 29-39 days of age (Terress 1980).

Potential breeding sites were identified in several areas in the cliffs along the western side of the island; up to eleven pairs may be breeding (Boarman no date). Whether this occurrence is a

new colony or not is uncertain. Guillemots nest in solitary pairs, loose groups, and dense colonies (Emms and Verbeek 1989). Part of the auk family, pigeon guillemots are bottom feeders, preying on worms, mollusks, crustacea, and fish (Terress 1980).

Mallard

Mallards (Ana platyrhynchos) are the ancestor for all except one species of domestic ducks. They summer in Alaska through the United States. They are also found in the West Indies and Mexico. Mallards are on Alcatraz January through July; they breed in March through July. The nest is on the ground or in trees; females incubate 5-14 eggs for 26-30 days. Chicks fly at 49-60 days old. On Alcatraz, mallards are known to breed near the sallyport, the southern area of the parade grounds, and west of the cell house (Boarman 1981).

Mallards eat freshwater snails, mollusks, insects, seeds from land and water plants, fish and eggs. Lead poisoning from food is a major problem for mallards. In addition, over 4.5 million mallards are shot each year (Terress 1980).

Western Gull

Western gulls (Larus occidentalis) belong to the family Laridae which includes 43 species of gulls. L. occidentalis are the

darkest species of gulls except for Heermann's gulls (L. heermanni). They nest along the Pacific, ranging from northern Washington to Magdalena Bay in Baja, Mexico; the species is rarely seen inland from the coast (Terress 1980). Breeding in colonies, gulls utilize a wide range of habitats, including sea cliffs, sandy islands, marshes, and prairies. Generally, a clutch of three eggs is laid mid May through late June; eggs are buff olive with brown and blend well into the ground and cliffs. Chicks hatch 25-29 days after incubation begins, and fly about 40 days after hatching (Terress 1980). Females are responsible for most of the incubation; however, males are usually present on the territory to defend the female and eggs (Terress 1980). After chicks hatch, only one parent is usually present, with males playing a more dominant role in feeding (Pierotti 1981).

Gulls feed on fish, insects, worms, mollusks, and small rodents, they also scavenge garbage and take eggs and chicks from various small seabirds, including other gulls (Terress 1980).

Western gulls are seen on Alcatraz year-round, but peak between January and April. Courtship feeding begins in January, and pairs establish territories by early March. Chicks begin hatching by late April. Most clutches are complete by mid May with most chicks fledged by late August (Bell 1990; GGNRA 1989-1990).

Western gulls have colonized most of the island, forming the third largest colony in central California and comprising approximately 15% of the Bay Area population (Woodin pers. comm.). They have been nesting on the island since at least 1972. In 1981, at least 135 pairs bred; in 1982, 224 pairs bred; and by 1988, over 350 pairs of gulls utilized the island. In 1990, 482 nests were found (Boarman 1989; Bell 1990). The largest sub-colonies are on 1) the parade grounds and rubble piles; 2) cistern area; 3) cliffs near the power plant and foghorn on the northern end; 4) shrubs below the cellhouse; and 5) the incinerator area. These five colonies represent 57.5% of the total island colony. The remaining five subcolonies are each less than 8% of the total number of nests on the island (Bell 1990). Clutch size also varied among areas, but in 1990 averaged 2.59 eggs per nest and 1.71 successful chicks per nest. However, if nest failures are included in the calculation, the successful chick per nest value falls to 1.00; this ratio is lower than the low estimated for western gulls on the Farallon Islands (Bell 1990). High ocean temperatures and disturbance in colonies may have contributed to the low number.

Although gulls generally have a varied diet, observations by Annett and Pierotti (1989) showed that after hatching chicks, the adults' diet changed solely to fish. Gulls that specialized on one food source also change to small fish when eggs are laid even though their previous food supply is still abundant (Pierotti and

Annett 1987). Young chicks will reject food that is too large to handle, possibly forcing adults to catch smaller prey; on Alcatraz this prey is usually anchovies. When chicks are several weeks old, adults switch again to larger prey. In pairs where eggs fail to hatch, no diet change occurs (Pierotti and Annett 1987). This switch does not coincide with a rise in abundance of small fish, nor do all gulls alter their diet at the same time.

Analysis between garbage, a common food supply for gulls, and mussels showed that mussels had a lower food value, although most breeding pairs in the study site specialized on them (Pierotti and Annett 1987). Mussels are an important source of magnesium and soluble calcium, both important and limiting nutrients in reproduction. Gulls which specialized on mussels laid larger clutches with heavier eggs than pairs specializing on other foods. In addition, eggs from mussel specialists had significantly fewer addled eggs. A similar result was found on Alcatraz: pairs feeding on garbage had a much higher percent of addled eggs than those feeding on fish.

Although western gulls are usually considered to be monogamous, a study on Southeast Farallon Island and Santa Barbara Island has indicated polygamous behavior in some individuals: second matings by males were most frequent when females were ready to lay eggs or had just laid a clutch (Pierotti 1981). However, when environmental factors require additional male care after the

clutch is laid, males tend to remain with their first mate. Such factors may include abundance of food supply: when supply is ample, females feed more quickly, and males do not need to incubate the eggs as long. Other factors leading to second matings on Santa Barbara Island may be a high female to male ratio and less overall competition and intrusions by other gulls, leaving the male with less need to defend his territory (Pierotti 1981).

Heermann's gull

Heermann's gulls (Larus heermanni) are dark gray, with a white head and black tail; bills are red (Terress 1980). Heermann's are thought to range from the western coast of Mexico to Vancouver Island, British Colombia, wintering from Oregon to Guatemala. Breeding is almost exclusively at Raza Island in the Gulf of California and islands off the west coast of Baja (Terress 1980). Incubation time and age at flight are unknown. The population has declined since 1971, possibly due to a low recruitment rate (Anderson and Keith 1980).

Heermann's gulls are common, on the island yearound. One pair attempted to nest on the island during the period from 1979 to 1982, nesting under a coyote brush near the incinerator. This was the first pair of Heermann's gulls to nest in the United States (Howell 1983). A pair also nested in 1980 at Shell Beach

(location) (Howell et al 1983). All nests on Alcatraz failed, and the nest at Shell Beach probably also failed. During the spring and summer of 1981, tours on Alcatraz were rerouted to avoid the nesting area. By July all of the eggs had cracked. Eggs probably failed due to infertility or early arrested development, and not a lack of incubation or disturbance from tours or helicopters flying over the island (Howell et al 1983). The pair began nesting on the island in May, which is early compared to other Heermann's nesting in Baja, their usual site. Environmental conditions may not be appropriate on the island that early (Howell et al 1983), indicated by the fact that birds nesting in more northern areas of Baja nest later than those on southern islands. This range expansion occurred during El Nino years, and may be an example of environmental changes that can occur with global climate change.

Black-crowned night-herons

Black-crowned night-herons (Nycticorax nycticorax) range from southern Canada to southern South America. They are also found scattered in Europe, Asia, Africa, Ceylon, Java, the Philippines, and Indonesia (Terress 1980; Hancock and Kushlan 1984). Black-crowned night-herons generally winter in the southern US through Central America, remaining from November to March (Terress 1980; Hancock and Kushlan 1984). Juvenile birds tend to disperse after the nesting season ends; northern populations merge and migrate

south (Hancock 1984). Many juveniles return to their natal territories in spring (Henny 1972).

Night-herons breed in the northern US and southern Canada from March to May. On Alcatraz, black-crowned night-herons establish territories on Alcatraz by mid February. Chicks begin to hatch by late April, although adults continue to lay clutches throughout the spring and early summer (GGNRA 1989-1990). According to Roger Hothem, the first egg was laid on March 24 (hatched April 18), and the last was initiated July 11 (hatched July 18) in 1990. Birds generally start nesting at two to three years of age, but there have been reports of yearlings nesting, both with two-three year old birds, and with other yearlings (Custer and Davis 1982); chicks were observed in the nest of one pair of yearlings. Eggs are laid from April to May, sometimes through July; a clutch is usually three to five (three to four at Alcatraz in 1990) blue-green eggs which hatch approximately 25 days after the first egg is laid. Both parents incubate and feed the young. Chicks fledge at six to seven weeks after hatching (Terress 1980; Hancock and Kushlan 1984). Herons nest in colonies, usually in trees, but will also nest in marshes and tall grasses. They may renest if the first clutch is lost (Henny 1972).

During breeding season, legs and feet, normally yellow, turn red; the black on their heads and back have a blue-green gloss

(Hancock and Kushlan 1984). During the 1800s, night-herons were hunted for the white plumes on the back of their heads (Terress 1980).

Black-crowned night-heron habitat is varied, and includes freshwater, swamps, grasslands, and sea coasts (Hancock and Kushlan 1984). They feed on algae, succulent plants, fish, eels, insects, amphibians, small mammals, crustaceans, mollusks, and the young from other colonial nesting waterbirds (Terress 1980; Hancock and Kushlan 1984). They are crepuscular or night feeders.

Black-crowned night-herons have nested on Alcatraz since the mid 1970s, expanding from 24 nests in 1981 to 39 (37 --Dave Barry) nests in 1982 (Boarman 1989). During the 1990 breeding season, an estimated 127 pairs initiated 169 nests in 10 subcolonies around the island (Hothem 1990). Out of these 127 nests hatched young and 101 nests fledged young. Other colonies in the San Francisco Bay are at: Alameda Robert Crown Memorial State Beach; Bair Island; Brooks Island; Lake Merritt Islands; Mallard or Artesian Slough; near Napa State Prison; Red Rock Island; and West Marin Island. The breeding population in 1990 throughout the Bay Area was estimated to be about 1100 pairs (Roger Hothem personal comment) Bair and West Marin Islands are the largest colonies with 309 and 342 pairs respectively; the other colonies are significantly smaller (range 60-115 pairs). The Alcatraz

colony represents approximately 10-15% of the Bay Area population.

During 1969-1972, statewide censuses indicated black-crowned night-herons were the second most abundant heron species in California; however, a decrease in active nests had been noted during 1972-1978 (Belluomini 1978). During this time period, human disturbance led to abandonment of seven rookeries (Belluomini 1978). Although the report is unclear whether this abandonment occurred solely in night-heron rookeries or other species as well, rookeries for other heron species have increased overall (Belluomini 1978). A second possible explanation of population decline may be due to rookery relocation. As habitat in rookeries ages, herons form new rookeries, often quite far from old nest sites (Belluomini 1978). These new sites may not be known and may not be censused.

Alvarez and Thomas (1989) reported that today most colonies are still threatened, whether by disturbance, habitat loss, or chemical pollution of their food. For example, the colony at Bair Island is decreasing and East Bay Regional Park District has considered allowing visitors in nesting areas, during non-nesting seasons on Brooks Island.

Chemical pollution may be affecting black-crowned night-heron reproductive success. Custer et. al. (1983) reported shell

thinning and a decline of night-herons in the northeast United States. Impaired reproduction for black-crowned night-herons has been associated with levels of DDE at eight ppm (Henny et al 1984); Custer et al (1983) indicated that DDE could have an effect on hatching success at levels under four ppm.

The U. S. Fish and Wildlife Service has evaluated the black-crowned night-heron as a bioindicator of environmental contamination, using the health of the species to indicate the health of San Francisco Bay. Studies have shown concentrations of both DDE and PCBs at potentially harmful levels. Ten percent of the eggs tested at Bair Island had concentrations exceeding 8 ppm DDE (Ohlendorf and Fleming 1988). Embryos at Bair Island had significantly lower weights than embryos from a captive population in Maryland; crown-rump lengths and femur lengths were also reduced (Hoffman et al 1986). PCBs in embryos from Bair Island contained a mean of 4.1 ppm, while the control site (Maryland) contained less than 1 ppm. Although other factors such as nutritional differences may explain the differences between the sites, impairment could have been due to contaminants (Hoffman et al 1986). Mercury levels are also high, and while effects are unknown, authors indicated some concern (Ohlendorf et al 1988). Studies are currently under way on Alcatraz to study reproductive effects of chemical pollution.

The success of the night-heron sub-colonies on Alcatraz varied

greatly in 1990. The following table shows the percentage of nests that fledged at least one chick (surviving to at least 15 days) and the percentage of total nests on the island present in each subcolony (Hothem 1990):

The night-heron subcolonies on Alcatraz can be grouped according to their proximity to people on the island. Three subcolonies are in locations along trails open to visitors: the shower, recreation yard, and greenhouse. In 1990, these areas represented 29.6% of all night-heron nests on the island; 52.0% of the nests were successful (at least one chick fledged). The dock and wall colonies are near public access, but are well sheltered. These areas contained 33.1% of all nests in 1990, and 71.4% of the nests fledged one or more young.

The remaining five subcolonies are all isolated from public access; their fledging success rate was 54.0%. However, a significant number of nests in the foghorn (20%) and greenhouse (34%) were not checked weekly to the point where chicks could be classified as fledged or not; thus, the actual number of fledged chicks may be higher.

Although certain black-crowned night-herons nested near areas open to people, it does not necessarily indicate that they have become "habituated" and no longer need secluded areas. Much of a colony's success depends on the amount of vegetative cover;

proximity to gull colonies and concentration of gulls; and the amount of escape cover away from the actual colony (Hothem 1990). When disturbed, adult night-herons frequently fly from the colony. During the gull nesting season, especially when gull chicks are present, adult gulls are aggressive and attack young night-herons in flight. Those young night-herons that are just learning to fly are subject to attack. Cover near the colony is important for those young birds seeking refuge from these attacks. Gulls do not generally attack when night-herons are in shrubs and bushes; as night herons grow older, they become better at avoiding lethal gull encounters. Three colonies on Alcatraz were extremely sensitive to weekly research censuses: the greenhouse, foghorn, and tunnel areas. Although vegetative cover in the colonies is dense, all three colonies are close to large gull colonies. Although gull predation will occur naturally, disturbance can drastically increase the flushing of chicks and predation by gulls.

Analysis of night-heron nest locations was done for active and inactive trails on Alcatraz (Howell and Pollack 1990). The nest-to-trail distance was measured for nests closest to the trail edge in most sub-colonies ($n=11$). Though the sample size was small and not random, the study was an effort to determine whether night-herons in areas open to public access nested further from the trail edge. The average distance for active trails was 10.67 meters from the trail edge, and for inactive

trails, it was 4.5 meters. However, the standard deviation for active trails was high (.63 m). This variation is due in part to where shrubbery is located, which is not dependent on active versus inactive trails.

Raven

Ravens (Crovis corax) recently colonized Alcatraz Island. They were first noted in 1981, and a pair was first observed breeding in 1988 (Boarman 1989). Ravens are observed on the island from December through May; they prey upon night-heron eggs, and possibly young chicks, potentially providing a limiting factor to the heron population.

Ravens range from Alaska, through Canada and the US, and into Central America; they are also found in Greenland, Iceland, northern Europe, Asia, and Africa (Terress 1980). They are typically seen in tundra, seacoasts and cliffs, forests, plains, and deserts, frequently near colonies of waterbirds, where they prey on eggs and young. As scavengers, ravens compete with gulls and vultures. They also feed on fish, amphibians, berries, and rodents (Terress 1980).

Ravens mate for life, laying three to seven eggs in March through June. Nests are usually in cliffs or trees. Females incubate eggs for 18-20 days; chicks fly 35-42 days after hatching. One

brood per season is raised (Terress 1980).

White-crowned sparrow

Breeding for white-crowned sparrows (Zonotrichia leucophrys) starts in early March; females build nests in late April generally on the ground or in small trees. A pair will usually nest several times during a season, building new nests when young fledge (Petrinovich and Patterson 1982; Terress 1980). Young birds fledge in early May through early September (DeWolfe et al 1989). However, white-crowned sparrows generally remain in their natal territories for about 50 days (Baptista and Petrinovich 1986). In montane species, broods usually will divide, with one parent taking care of several chicks; these units then move separately from each other away from the nest (Baptista and Morton 1988). Homing instincts in white-crowned are high; when removed from their territory (San Jose to Maryland), individuals returned the next year (Terress 1980).

White crowned sparrows are on Alcatraz year-round, except in August, peaking in January and February. Being isolated, they may have developed their own subdialect (Boarman 1989). Baptista (pers. comm.) collected white-crowned songs from Alcatraz to compare with other Bay Area dialects; these data remain to be analyzed in detail.

Catchpole and Baptista (1988) demonstrated that white-crowned sparrows are able to differentiate between a territorial neighbor or a stranger singing. Sparrows can also determine a white-crowned or a song sparrow song, regardless of which species is singing (Catchpole and Baptista 1988). In other species, larger repertoires often led to larger territories and earlier mates (Catchpole and Baptista 1988). Baptista and Morton (1982) think that females chose mates not by a dialect, but use a male's song to assess the fitness of that male; a male may copy a song from another bird if it is more effective in repelling other males.

Sparrows successfully breed with mates having different songs with no significant differences in fledgling success (Baptista and Morton 1982; Petrinovich and Baptista 1984). There may be several causes for this mis-matching of songs: dispersal distances differ, with the females dispersing farther and thus reaching areas with different dialects; unequal sex ratios; or a difference between sexes in learning new songs after dispersal (Petrinovich and Baptista 1984).

The "sensitive" period for white-crowned sparrows to learn songs was thought to be 50 days; this was shown by teaching birds from taped songs. However, Baptista (1988) has shown that birds can learn songs up to 100 days with a live tutor. Although white crowned sparrows learn syllables from other sparrow species,

interspecific song learning is rare (Baptista 1988). A white crown will learn a foreign song only if it interacts with, not only hears, the bird (Baptista and Petrinovich 1986).

Song sparrow

Song sparrows (Melospiza melodia) are on Alcatraz from January through June, and September through November. There are 31 subspecies of song sparrows; they range from Alaska to Mexico. Most winter south of Canada (Terress 1980). Song sparrows are generally found near water, in bushy cover, marshes, and mountains; they are also found in prairies and second growth woods. Males establish territory March through May; nests are usually on the ground or in small bushes. Eggs are laid March through August, sometimes in February; females incubate eggs for 12-13 days. Young leave the nest at about 10 days, often before they fly. Song sparrows clutch two to three times per year, and feed on insects, seeds, and berries (Terress 1980).

The following birds remain on the island through the breeding season, and possibly breed on Alcatraz: rock dove (Columba livia); mourning dove (Zenaida macroura); Anna's hummingbird (Calypte anna); Allen's hummingbird (Selasphorus sassin); black phoebe (Sayornis nigricans); barn swallow (Hirundo rustica); European starlings (Sturnus vulgaris); and house finches

(Carpodacus mexicanus) (Boarman 1989). House finches are on the island year-round, except August and December; they are thought to breed near the watertower and the lighthouse. Allen's and Anna's hummingbirds breed below the cellhouse; Anna's are also found in high concentrations in the fushias near the launch landing area (Boarman 1981). Anna's hummingbirds are seen on the island year-round except in July. In building 64, barn swallows and rock doves may breed (Boarman 1981). European starlings possibly breed near the incinerator; they are seen on the island year-round except August, peaking in January through April.

Marine Mammals

Marine mammals utilize the island as well, including California sea lions (Zalophus californianus), harbor seals (Phoca vitulina), and a sighting of a gray whale (Eschrichtius robustus) nearby the island. While harbor seals, and especially sea lions, are often seen near people, they still require areas to rest where they will not be disturbed. The beaches and tidepools of Alcatraz provide such spots, especially since much of their former resting areas are now built with restaurants, public beaches, and boat docks.

Deer mouse

The genus Peromyscus includes several subgenera and numerous

subspecies (Sumner 1932; Hooper 1968). P. maniculatus, or the deer mouse, is the best known of the species. Two basic populations seem to predominate in P. maniculatus: a large body, long tail population inhabiting forests, and a smaller body, shorter tail population restricted to prairies and open lands. Deer mice are found throughout the United States, Canada, Baja, and extend into Central America; their habitat varies greatly, including forests, grasslands, and alpine areas. This variation leads to much differentiation within populations (Hooper 1968). Various species of mice seem to have an inherent tendency to select a specific habitat type (Dice 1968); this innate selection is not altered even when young are raised in a different habitat. As studied in P. maniculatus, this restriction is not due to food supply or other requirements (Baker 1968).

Peromyscus are nocturnal animals, feeding on insects, grains, seeds, and fruit (Baker 1968). They swim well (Eisenberg 1968). Mice molt once or twice annually, the first several molts change from a gray juvenile coat to a brown, buff, or gray (Layne 1968). Coat color darkens from southern to northern populations, and from the interior to the coast, apparently corresponding with precipitation and humidity (Sumner 1932). Coat color also follows the gradations of soil color (Baker 1968).

Pregnant females have been trapped throughout the year, breeding at ten weeks or younger; the average age for female P.

maniculatus to breed is 49 days. Gestation lasts about 21-27 days, and an average of three young are born, although this number varies with species and environmental conditions (Sumner 1932; Layne 1968). Species residing in forests tend to have larger litters, smaller young, and more rapid growth of young.

Early studies showed that densities of Peromyscus tend to be quite low and large population eruptions are rare compared to other small mammal populations (Terman 1968). More recent studies however show fluctuations in density of 10-13 fold (Vessey 1987). The population size may be controlled by behavior affecting reproduction rates and not through mortality (Terman 1968; Vessey 1987). The midsummer lull in reproduction occurs when food is abundant (Vessey 1987).

After leaving their natal area, young mice wander until they reach sexual maturity, at which time they establish their own home range (Terman 1968). Dispersal tends to be slow, with young moving only about 500 feet, although in some cases P. maniculata have dispersed up to 3500 feet from their natal area (Baker Stickel 1968). Mouse activity increases in spring and with cloud cover; species in open areas seem to travel further distances, although this correlation is not absolute. Home areas themselves are variable, ranging from orders of magnitude of one-tenth to ten acres (Stickel 1968).

A study on Alcatraz island in 1984 noted a variant coat color in some of the deer mouse population: some of the mice had a light tan color instead of the darker agouti color found in the rest of the population and the rest of the San Francisco Bay area population. This subpopulation does not exhibit the horizontal line on its tail like the agouti population (Thompson 1988). The light tan population, or buffies, comprised almost 16.5% of the island's population, estimated from a mark and recapture study in 1988; 163 traps were set and 91 individuals were caught. Most of these mice were found in the northern section of the island, around the officer's club to the power plant area. No buffies were found on the northwestern side of the island, though they are abundant on the parade grounds. Data from 1988 shows the highest concentration of mice in the rubble piles and in the shrubbery below (west of) the cellhouse (Thompson 1988).

Trapping in 1990 showed the highest concentration of deermice along the eastern shore and the rubble piles on the parade ground. From 222 traps set in 1990, 90 mice were recovered; buffies comprised 19%. However, three individuals classed as agouti's had tails without the dark stripe that is characteristic of agouti mice. A mark-recapture study was done for the rubble piles: 19 mice were tagged; one was recaptured, giving a population total of 209 mice for that area. This population is close to a minimum viable population for that area. Both studies found a skewed sex ratio towards males; overall in 1990, the

ratio was 2.78 male to female; however, this varied somewhat with specific trapping sites.

Deer mice are probably the only mammals on Alcatraz; their predators are limited to gulls, kestrels, and burrowing owls, (??night-herons) when they appear on the island (Thompson 1988). Ravens may also prey on deer mice. It is uncertain whether the light tan color is a genetic adaptation or is merely the result of genetic drift that is not selected against on Alcatraz. Predation and interspecific competition both seem low on the island (Thompson 1988).

For most small rodents, island populations tend to differ from mainland populations: body size is usually larger in island populations, decreasing with increasing island area (Innes and McKavaliers 1987). Island populations also tend to have higher densities, larger niches, larger home range overlaps among individuals, and less variable populations. Insular populations are characterized by fewer predators and competitors, and often show less aggression than mainland counterparts (Innes and McKavaliers 1987).

An experiment with white footed mice (P. leucopus) demonstrated that mice in disturbed areas colonized undisturbed areas when resident mice in the later were removed (Linzey 1989). When the population was at a low density, most mice moved into the wooded

(undisturbed) area; when densities rose, the distribution between wooded and disturbed areas was approximately equal. Apparently, distinct habitats serve as dispersal sites for the population. However, if the habitat is altered to form such pockets of populations, a problem could rise with genetic flow between subpopulations (Linzey 1989).

A second experiment on an island similar to Alcatraz shows habitat preferences in deer mice. P. maniculatus is the only resident mammal on Mandarte Island (Merkt 1981). Density of mice populations in shrubbery was almost twice that of mice in grasslands. A section of the island including both grass and shrub habitat was cleared of mice, allowing recolonization from surrounding areas. Merkt (1981) found that early colonizers moved into the shrub areas of the study plot; mice in grass areas were captured in significant numbers only six weeks after the initial removal. He also found that grassland mice recolonized the area in significantly more numbers than did shrub habitat mice.

Salamander

No systematic research was done on the California slender salamander (Batrachoseps attenuatus) on Alcatraz. Twenty years ago, Batrachoseps attenuatus was considered to be one species; today, at least 10 species are known, with an additional species

known to be extinct. The population on Alcatraz may be native to the island, may be a population from Angel Island, brought over when dirt was brought to Alcatraz, or may be a combination of both (Martin pers. comm.).

Martin (pers. comm.) conducted a site visit to Alcatraz, drawing the following conclusions: the salamander has no natural predators on the island; in situations like this, populations normally build until the population cannot be sustained, and starvation results. The California slender has evolved atrophied gonads in response to the lack of predators. At a certain density, the salamanders cannot reproduce. Most of the salamanders on the island are old, with low fecundity rates. If part of the population were wiped out, the combination of low fecundity and arrested reproduction could result in a population that would take decades to recover (Martin pers. comm.).

In mainland populations, the salamander is active from February to April or May. Island populations may be active year-round; they have been seen on Alcatraz as early as December and January. Although they do not lay eggs in water, salamanders require very moist ground, usually under rotting logs. Eggs also need to be protected from salt spray. Reproduction sites on Alcatraz are not currently known; most of the ground is dry or exposed to salt spray. The salamanders are found in high concentrations around the rubble piles on the parade grounds, especially the pile with

wood. They are also found on the eastern side of the island near the generator where water runs through a trough (Martin pers. comm.).

In addition to breeding species, Alcatraz also provides refuge for roosting birds, in particular cormorants and Heermann's gulls. Roosting sites are vital to species, as they provide safe areas to rest and feed.

DISTURBANCE

Results of human disturbance in bird colonies have been documented for numerous species. The following provides a summary of information for three of the species found on Alcatraz.

Cormorants

Doubled-crested cormorants were studied at Saint Lawrence estuary from late April through July; hatching began in late May (Ellison and Cleary 1978). The mean brood size was not significantly different between disturbed and undisturbed colonies; however, as in other species, disturbed colonies had more empty nests and fewer late nesters than in undisturbed colonies. One of the islands studied had immediate impacts from disturbance: Ile-aux-Pommes Island has a high concentration of gulls and generally

inexperienced cormorants; as a result, disturbance resulted in high predation. Researchers concluded that nest abandonment was most likely early in the season, and intrusions should be allowed only when young were half grown.

Cormorants are timid species, and will leave nests when humans approach within 50-100 meters (Ainley and Lewis 1974). Human activity on the Farallones decimated the double-crested cormorant population at the turn of the century; this same trend has been seen throughout California and Baja. Populations have not recovered (reference). The decline in sardine populations, a prey of the cormorants, may be part of the reason for the decline and lack of recovery. Brandt's and pelagic cormorants, species which rely less on sardines, have recovered (Ainley and Lewis 1974). However, double-crested cormorants have a varied diet, and it seems unlikely that one food source is the sole reason for the lack of recovery.

Family Laridae

Robert and Ralph (1975) demonstrated that the loss of eggs and young chicks in a gull colony is directly proportional to the frequency of disturbance (Robert and Ralph 1975). Even minimal intrusions significantly lower hatching and fledgling success (Fetterolf 1983).

When disturbed, older gull chicks tend to run from their natal territories. Early in the breeding season, wandering chicks may be adopted if they do not run too far; however, adoption is not a common practice in undisturbed colonies, and may lead to increased competition between the adopted chick and the natal chicks, especially as adopted chicks tend to be older and more competitive (Fetterolf 1983). As the breeding season continues, parent gulls become more aggressive and will attack both adults and chicks intruding into their territories, significantly increasing chick mortality (Hunt and Hunt 1975; Robert and Ralph 1975; Anderson and Keith 1980). Attacks are rare in undisturbed colonies. Thus, the size of natal territories is important to chick survival, especially in areas that are disturbed. Hunt and Hunt (1975) demonstrated that western gull chicks are killed by neighboring gulls when their territories are significantly closer to neighbor's territory.

Adult gulls typically leave the nest when disturbed, exposing eggs and young chicks to severe weather and predation. The primary loss of eggs in disturbed colonies was caused by predation from other gulls (Robert and Ralph 1975). Other consequences from disturbance included parents shifting eggs in the nest, knocking eggs over the edge of cliffs when adults move, and chicks falling off cliffs when they run. Adult western gulls that have lost eggs or chicks will attack and kill other chicks even in the absence of people (Hand 1980). Late hatchers also

have a lower success rate and a lower chance of survival in areas that are disturbed (Fetterolf 1983).

It is possible that varying frequency and numbers of people affect gulls significantly differently: one study on western gulls in the Gulf of California has shown that when a group of people leaves a colony quickly, disturbance is minimal, but intrusions at irregular intervals causes abandonment of nests for long periods of time (Hand 1980). Even though disturbance was minimal in this instance, the frequency and season people are in a colony is important. As with many species, disturbance during early nesting causes panic flights and abandonment; as the season continues, birds become more tenacious and return to their nests after fleeing (Robert and Ralph 1975). A study in July on western gulls on the southeast Farallon Islands showed that 54% of deaths were due to chicks being pecked by adults (Spear et al 1987); the study was done when the young are mobile and adults are aggressive. In other months, the primary cause of death was starvation. People in the area at a time of chick mobility and adult aggression will increase mortality.

Although disturbance to a colony obviously has impacts, response to human intrusion may vary significantly among species of gulls, as indicated by a study of great black-backed (L. marinus) and herring gulls on islands off the east coast: black-backed gulls tended to react to a person's presence earlier than herring gulls

did, and took longer to resettle on nests; however, both species returned to the nest area in about the same time (Burger and Gochfield 1983). In addition, both species tended to fly earlier and remain away longer when approached in colonies that had historically less disturbance in them than colonies that were less isolated from people (Burger and Gochfield 1983). Herring gulls tended to become alert more quickly in "undisturbed" areas, but flew more quickly in "disturbed" areas. The percent of cover, and thus protection, and stage of incubation correlated only with herring gull responses (Burger and Gochfield 1983), indicating again the difference in species' reactions to disturbances.

Another study indicated possible habituation of gulls to people: chicks ran less when researchers entered a disturbed plot than in less disturbed plots. Chick survival was greater in plots where chicks ran less (Robert and Ralph 1975). However, survival was highest in the study area that was not disturbed at all (Robert and Ralph 1975). This study does not indicate that gulls should be allowed to habituate to people: the study was controlled, with few people and short time periods. A colony with constant interaction from people will not necessarily enhance survival of the chicks and nests; habituation may be overshadowed by very high stress.

Black-crowned night-herons

Black-crowned night-herons appear to be sensitive to disturbances: in colonies with a mixture of colonial birds, night-herons flushed before other species when approached (Erwin 1989). This study was done after eggs had been laid, and no correlation was found between nesting phase and reaction distance. In general, birds showed little response when people were greater than 150 meters away, although this distance was not measured specifically for black-crowned night-herons, and may be different prior to egg laying (Erwin 1989).

A study of night-herons in Quebec clearly shows the impact of disturbance: just prior to or during egg laying, intrusions into the colony resulted in inhibited egg laying and abandonment of nests with and without eggs (Tremblay and Ellison 1979).

Although successful nests showed no difference between control and experimental plots, disturbed colonies had a much higher failure of nests both before and after hatching. In addition, disturbed plots had no late nesters.

Disturbances can also have severe impacts after hatching. During the early part of the season when night-herons are disturbed, they flush and run away from territories for long periods of time, exposing chicks and possibly abandoning nests (GGNRA 1989-1990). (Only 3 nests of 169 were documented as abandoned).

Parsons and Burger (1982) handled night-heron chicks and on alternate days until they were three weeks old. Nests of control chicks were checked twice a week, but chicks were not handled. During the first three weeks of life, control chicks moved only one to two meters from the nest and froze, while experimental chicks assumed defensive postures, vocalized, and regurgitated (Parsons and Burger 1982). After three weeks, control chicks still ran an average on 1 meter from the nest, while experimental chicks remained in the nest. Experimentals also called more frequently but regurgitated or defecated less than controls did. Researchers concluded that experimental chicks habituated to people since they vocalized but did not move from the nest. One problem with disturbance is a possible weight loss in chicks, due to regurgitation. In this experiment mean weight of the groups differed only slightly, due possibly to low predation of food by gulls, allowing chicks to reingest food (Parsons and Burger 1982). Other researchers have found that black-crowned night-herons will leave the nest at three weeks of age if disturbed, and vigorously defend the nest by vocalizing, beak thrusting, and regurgitating (Teal 1965).

A potential problem for Alcatraz's night-heron colony is gull and raven predation: ravens can learn to time predation during disturbances (reference). In general, night-herons are thought to be one of the shyer species of herons and will not acclimate

well to people (Alvarez and Thomas 1989). Two breeding pairs of night-herons on Alcatraz abandoned their nests and left the island when policy changed from regular tours below their nest to the open island policy. Considering the loss of other habitat and rookery sites and the hazards due to chemical pollution, the Alcatraz colony is felt to be a significant one to the San Francisco Bay population (Alvarez and Thomas 1989).

The sensitivity of black-crowned night-herons varies significantly with the location of colonies and with individuals; several colonies on Alcatraz are extremely sensitive to intrusions. Colonies around the Bay also show varying responses, probably dependent in part on how well screened colonies are from people. Some colonies flushed when boats were even 15 feet away (Alvarez and Thomas 1989).

As with gull colonies, the enforcement of buffer distances and exclusion of people from the night-heron colony are essential to the protection of nesting birds. Several factors must be considered when deciding on a buffer distance: the season, species, habituation, and possibly time of day. During early nest building and incubation, people anywhere in the vicinity may interfere with territory establishment and nesting, and may even cause nest or colony abandonment (Erwin 1989). Tremblay and Emerson (1979) concluded that night-herons are most sensitive to intrusion until about one week before hatching starts; intrusions

should also be avoided in poor weather (due to ?? poor thermoregulation/?).

MANAGEMENT RECOMMENDATIONS

Much of the research summarized here provides a valuable data set and insight into a unique resource. However, to continue to accommodate both people and wildlife on Alcatraz, serious long-term commitment and planning are essential. To manage Alcatraz successfully, future policy must be based on an understanding of its entire ecosystem and the interactions among different species in that system.

To further understand the resources and their values, additional research must be done:

- 1) Demographic, systemic, and genetic studies on the Peromyscus to better understand the degree of genetic isolation, potential speciation, and relationship to mainland populations.
- 2) Demographic, systemic, and genetic studies on the California slender salamander for the same purpose.
- 3) Studies of disturbance impacts to black-crowned night-herons are needed before major changes in island policy are made. These should be done at the appropriate times to provide best insight

into effects. The study design should include regular tours in the area, as well as walks at random intervals. Examination of visitor group size near colonies is also important. Sitting for periods of time near nests should be assessed. It is important to remember that each subcolony will act differently.

4) If habituation to people is a goal, how it will effect the long term viability of the colony on Alcatraz must be determined. A species' primary defense outside of a protected setting is its caution towards people.

5) More detailed studies of the relationship between heron nests and their distance to trail edges are needed. Examination of fledging rates in different subcolonies will help determine appropriate management.

Monitoring the island is crucial for any policy changes, and should be done by district rangers. Because of its small size and limited habitat, any action will have implications for the island's wildlife. The potential for human expansion on the island, without loss of Alcatraz as a wildlife refuge, is constrained by the island's small size. The carrying capacity of the island is not set only by the wildlife's ability to utilize patches of habitat, but by people's ability to interact and regulate the sizes and amount of those patches of habitat, and by their interaction with the wildlife. Monitoring must be ongoing,

long-term, and established; it must include

- 1) human use patterns, including staff impacts;
- 2) any change in colony sizes;
- 3) change in colony location;
- 4) loss of colonies;
- 5) loss of species;
- 6) change in timing of nests or seasonality;
- 7) loss of diversity; and
- 8) reduction of roosting birds.

To be successful, monitoring and enforcement of policy will depend on money available and the willingness of personnel on the island, beyond the first several years. If future policy changes begin to affect the wildlife on Alcatraz, managers must be prepared to alter plans to prevent further degradation, or to return to early policies that protect wildlife.

The patches of habitat on the island must be protected, and each may require different management strategies depending on the area, the sensitivity of species in the area, and land use. Altering land use patterns and development on Alcatraz can preclude the natural processes of island biogeography, all visible on Alcatraz: colonization, extinction, speciation. While Alcatraz is not a pristine, secluded place, much of it represents an undisturbed area due to the absence of people on

much of the island.

Several options are available. Although habitat may be augmented, the overall size of the island again limits this option. Few areas remain to add vegetation for wildlife, although the structure of existing vegetation can be altered. However, even if habitat is established, birds may not relocate to that habitat. Some areas can be enhanced to further screen birds from people. Screening will help protect breeding and roosting birds from disturbance.

Any alterations to the island should ensure the protection of species and the overall diversity of the island: removing and maintaining populations during development; ensuring proper species of vegetation are replaced; and minimizing disturbances. Even if species (What is being referred to?) are removed from the island during development, some of the population will be lost due to mortality. Thus, as many individuals must be trapped out as possible. In addition, altering habitat may affect the carrying capacity once the population is returned.

Sensitive areas should continue to remain closed to public access, especially during breeding and roosting seasons. Even if habitat is augmented in some locations, parts of the island should remain permanently closed to visitor use. Alcatraz provides a unique opportunity for visitors to observe wildlife,

understand the role of islands in ecological and evolutionary processes, and to understand the need for preserves closed to the public. Regardless of future development on Alcatraz, interpretive programs need to be established that focus on the natural resource side of the island and its dynamics. Public education is vital in continuing to protect Alcatraz's natural resources and to explain the purpose for and to maintain closed areas.

Tools available for analysis of policy decisions include Geographic Information System (GIS) and modelling capabilities. Much of the background information has been done (Howell and Pollak, 1990). The existing wildlife databases should be updated yearly to monitor any changes on the island. Through the databases and statistical programs, changes in species and areas used can be monitored. Such programs have shown that the southern end of the island is highest in diversity (Howell and Pollak, 1990). This diversity is important to maintain, as some species may become future colonizers to Alcatraz.

Although Alcatraz is a small preserve, it can continue to play an important role for wildlife protection and for future research on island biogeography. The demand for housing, commerce, industrial, and recreational sites will continue to encroach on wildlife habitat. These disturbances will play a major role in limiting species richness. As this trend continues, parks and

preserves must be in a position to respond with planned management actions to protect wildlife species and dynamic systems in these alternative habitats.

TABLE 3: Percent of Nests that Fledged at least one chick relative to properties of nest in sub-colony.

<u>AREA</u>	<u>% young fledged</u>	<u>% nests</u>
lover's bench	100%	1.8%
dock area	78.8%	19.5
rubble piles	30%	5.9%
tunnel	73.7%	11.2%
greenhouse	44.7%	22.5%
recreation yard	62.5%	4.7%
foghorn	43.3%	17.8%
power plant	100%	0.6%
shower	100%	2.4%
wall	65.2%	13.6%

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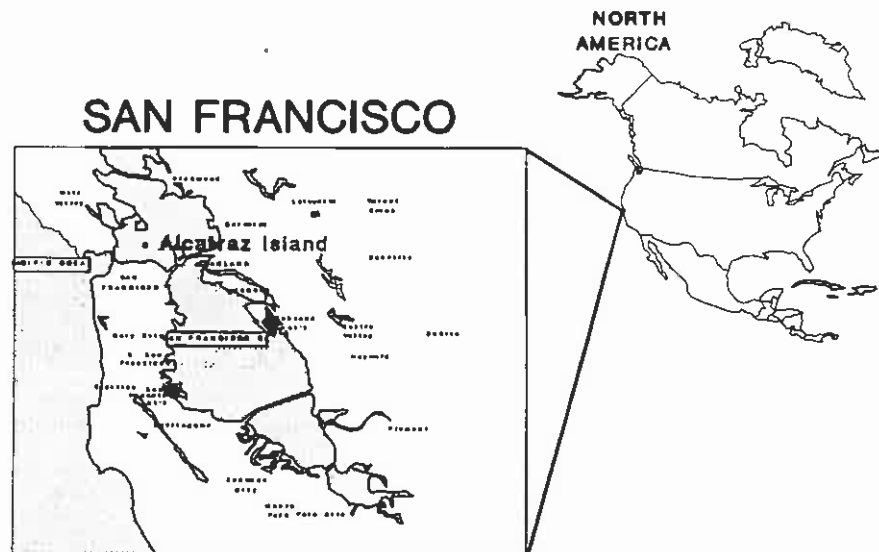
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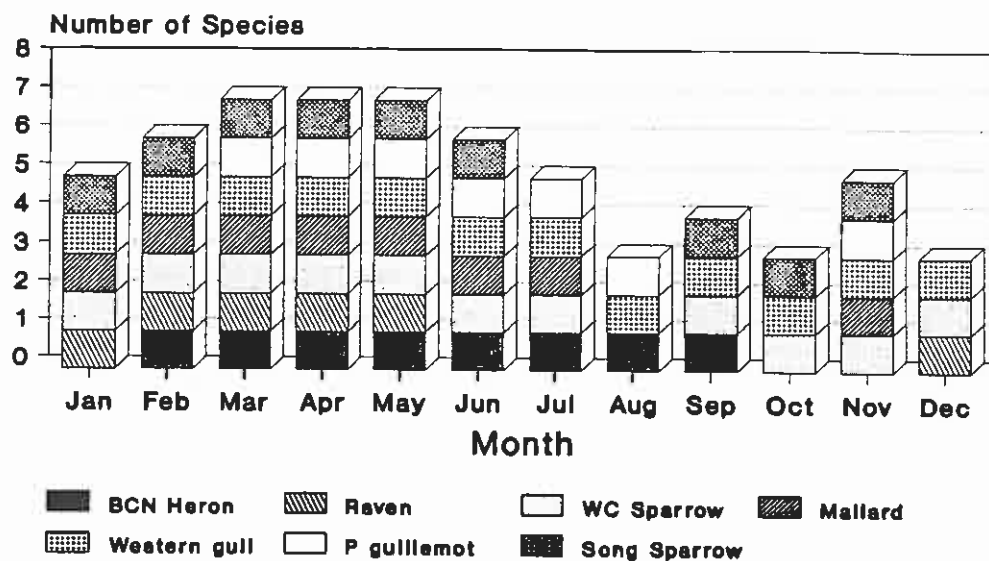
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Study Site Location, Alcatraz Island
Golden Gate National Recreation Area, California



Breeding Bird Seasonal Activity

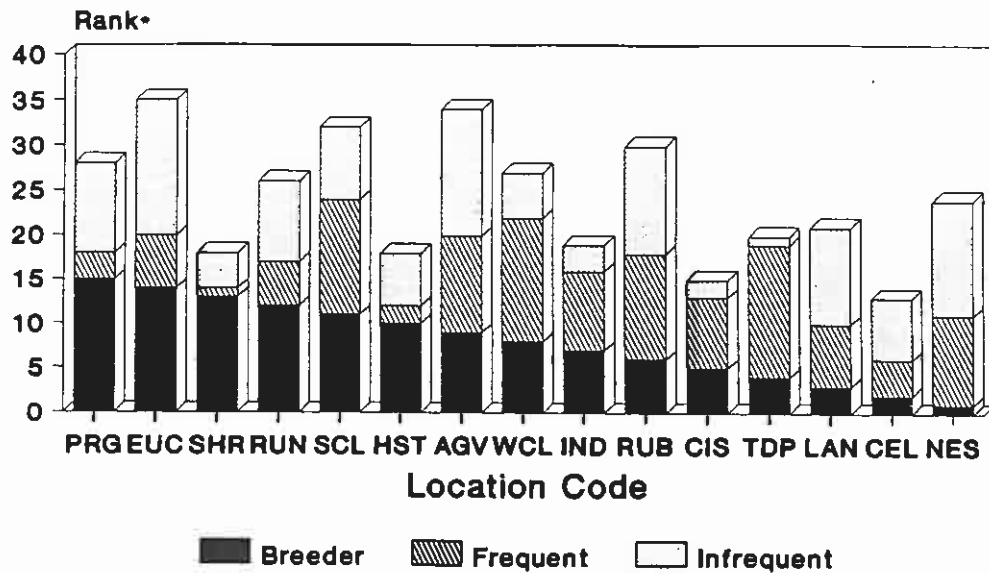
Alcatraz Is., Golden Gate NRA, CA



1980-1990

Habitat Rank by Location

Alcatraz Is., Golden Gate NRA, CA



1980-1990, * Sum of combined ranks

Status	Common Name	Species Name	Code
KNOWN BREEDERS			
	Black-crowned night heron	(<i>Nycticorax nycticorax</i>)	BCNH
	Mallard	(<i>Anas platyrhynchos</i>)	MALL
	Pigeon guillemot	(<i>Cepphus columba</i>)	PIGU
	Raven	(<i>Corvus corax</i>)	RAVE
	Song sparrow	(<i>Melospiza melodia</i>)	SOSP
	Western gull	(<i>Larus occidentalis</i>)	WEGU
	White-crowned sparrow	(<i>Zonotrichia leucophrys</i>)	WCSP
	Deer mouse	(<i>Peromyscus maniculatus</i>)	PENA
	California slender salamander	(<i>Batrachoseps attenuatus</i>)	CASA
POSSIBLE BREEDERS			
	Allen's hummingbird	(<i>Selasphorus sasin</i>)	ALHU
	Anna's hummingbird	(<i>Calypte anna</i>)	ANHU
	Barn swallow	(<i>Hirundo rustica</i>)	BASW
	Black phoebe	(<i>Sayornis nigricans</i>)	BLPH
	European starling	(<i>Sturnus vulgaris</i>)	EUST
	House finch	(<i>Carpodacus mexicanus</i>)	HOFI
	Mourning dove	(<i>Zenaidura macroura</i>)	MODO
	Rock dove	(<i>Columba livia</i>)	RODO
FREQUENT USERS			
	American kestrel	(<i>Falco sparverius</i>)	AMKE
	Belted kingfisher	(<i>Ceryle alcyon</i>)	BEKI
	Black oystercatcher	(<i>Haematopus bachmani</i>)	BLOY
	Black turnstone	(<i>Arenaria melanocephala</i>)	BLTU
	Brandt's cormorant	(<i>Phalacrocorax penicillatus</i>)	BRCO
F	Brown pelican	(<i>Pelecanus occidentalis</i>)	BRPE
	Fox sparrow	(<i>Passerella iliaca</i>)	FOSP
	Hermit thrush	(<i>Catharus guttatus</i>)	HETH
	Northern flicker	(<i>Colaptes auratus</i>)	NOFL
	Sanderling	(<i>Calidris alba</i>)	SAND
	Surf scoter	(<i>Melanitta perspicillata</i>)	SUSC
	Wandering tattler	(<i>Heteroscelus incanus</i>)	WATA
	Western grebe	(<i>Aechmophorus occidentalis</i>)	WEGR
	Willet	(<i>Catoptrophorus semipalmatus</i>)	WILL
	Herrman's gull	(<i>Larus heermanni</i>)	HEGU
	California towhee	(<i>Pipilo crissalis</i>)	CATO
	Common murre	(<i>Uria aegle</i>)	COMU
	Double-crested cormorant	(<i>Phalacrocorax auritus</i>)	DOCO
	Glaucous-winged gull	(<i>Larus glaucescens</i>)	CLGU
	Red-tailed hawk	(<i>Buteo jamaicensis</i>)	RTHA
M	California sea lion	(<i>Zalophus californianus</i>)	CASL
M	Harbor seal	(<i>Phoca vitulina</i>)	HASE

Status: F=Endangered Species Act

M=Marine Mammal Protection Act

Status	Common Name	Species Name	Code
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INFREQUENT USERS (Partial list)

	American robin	(<i>Turdus migratorius</i>)	AMRO
	Brewer's blackbird	(<i>Euphagus cyanocephalus</i>)	BRBL
	Burrowing owl	(<i>Athene cunicularia</i>)	BUOW
	Chipping sparrow	(<i>Spizella passerina</i>)	CHSP
	Downy woodpecker	(<i>Picoides pubescens</i>)	DDWO
	Ferruginous hawk	(<i>Buteo regalis</i>)	FEHA
	Golden-crowned kinglet	(<i>Regulus satrapa</i>)	GOKI
	Great egret	(<i>Casmerodius albus</i>)	GREG
	Hermit warbler	(<i>Dendroica occidentalis</i>)	HEWA
	Oregon (dark-eyed) junco	(<i>Junco hyemalis</i>)	ORJU
F	Peragrine falcon	(<i>Falco peregrinus</i>)	PEFA
	Pelagic cormorant	(<i>Phalacrocorax pelagicus</i>)	PECO
	Pine siskin	(<i>Carduelis pinus</i>)	PISI
	Purple finch	(<i>Carpodacus purpureus</i>)	PUFI
	Saw-whet owl	(<i>Aegolius acadicus</i>)	SNOW
	Western kingbird	(<i>Tyrannus verticalis</i>)	WEKI
	Western meadowlark	(<i>Sturnella neglecta</i>)	WEME
	Yellow-rumped warbler	(<i>Dendroica coronata</i>)	YRWA
	Yellow warbler	(<i>Dendroica petechia</i>)	YEWA
	Budgie	(<i>Molotfittacus undulatus</i>)	BUDG
	Cockatiel	(<i>Nymphicus hollandicus</i>)	COCK
M	California grey whale	(<i>Eschrichtius robustus</i>)	CGWH

Status: F=Endangered Species Act

M=Marine Mammal Protection Act
Howell & Pollak, 1990