Ecological Studies of Seabirds on Alcatraz Island, 2008

Final Report to the
Golden Gate National Recreation Area (GGNRA)
National Park Service (NPS)

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EXECUTIVE SUMMARY

Alcatraz Island has become a breeding site for a number of seabird species in recent years. In 2008, we monitored the population size, breeding phenology, and productivity of Brandt's and Pelagic Cormorants, Western and California Gulls, Pigeon Guillemots, and Black Oystercatchers on Alcatraz. Disturbance to wildlife is a concern on Alcatraz, given its status as a heavily-visited national park and its location in the center of the San Francisco Bay. During twice-weekly monitoring, we recorded and cataloged disturbances to seabird populations from March - August, 2008.

Populations of Brandt's and Pelagic Cormorants and California Gulls decreased on Alcatraz in 2008, while the Western Gull and Pigeon Guillemot populations increased. Overall productivity of seabirds was lower than long-term averages.

The Brandt's Cormorant breeding population decreased by 15% in 2008, the first decline in 8 years, and reproductive success was the lowest on record for this colony. Most sub-colonies started breeding activities late and some areas did not breed at all, including the North Foghorn, parts of the Model Industries, Barker Beach, Northern, and Southern sub-colonies. The Laundry Building sub-colony returned after a near absence in 2007 and expanded across parts of the Seawall area. Brandt's Cormorants are beginning to expand to the east side of the island and a small number of birds were successful in breeding there in 2008. Productivity of Brandt's Cormorants was 1.5 chicks fledged/pair in 2008, lower than the average 2.1 chicks fledged/pair in the past 10 years. The mean lay date in 2008 was 6 May.

The Pelagic Cormorant population has decreased by nearly 100% since 1996 to only 1 breeding pair in 2008. The single nesting pair fledged one chick, the lowest productivity of Pelagic Cormorants on Alcatraz since 1999. Western Gull breeding numbers increased only slightly to 1061 breeding pairs in 2008 (not including nests removed under the NPS depredation permit) from 1037 pairs in 2007. Western Gulls fledged an average of 1.3 chicks/pair in 2008, lower than the long-term mean. We confirmed 31 Pigeon Guillemot sites in 2008, 10 more than in 2007 and just below the peak of 33 confirmed sites in 2004. One pair of Black Oystercatchers bred on the Seawall in 2008, but after laying in mid-June they lost their eggs within 2 weeks and did no relay attempts were seen. We first discovered California Gulls breeding on Alcatraz in 2004. Since then, this small colony behind the rubble piles on the Parade Ground peaked at 23 pairs in 2007, but decreased slightly to 21 pairs in 2008. They fledged an average of 1.2 chicks fledged/pair in 2008.

A special event took place on April 22, 2008 when the National Fish and Wildlife Foundation held a special event with fireworks set off near Anita Rock off Chrissy Field in San Francisco Bay. This event coincided with the pre- to early breeding season for seabirds when nests are being established and eggs are being laid, one of the most sensitive periods of the year. Therefore, we conducted focused disturbance monitoring on Alcatraz prior, during and after this event. Agitation ensued in the sub-colonies during the fireworks and approximately 900 cormorants flushed from Alcatraz. Most of these were likely roosting birds as there were only a few nests with birds in incubation position on nests prior to the event. Within the weeks following the event, the number of birds in incubation position increased in most areas. However, the Laundry Building sub-colony had 3 birds at nests in incubation position just prior to the event and on the following morning these birds were no longer in incubation position. It is unknown if the birds were actually on eggs and the event caused nest failure. The Laundry Building sub-colony also experienced disturbance due to a special event in the Laundry Building in April 2007; therefore, the birds in this sub-colony may be more sensitive than in other areas.

We documented 39 human disturbances to Brandt's Cormorants in 2008 during approximately 186 hours of observation throughout the rest of the breeding season. The majority of disturbance was due to kayaks and canoes, as well as other marine-based causes. The rate of disturbance equaled that of 2007, the highest

since 2003. We have begun to see that cumulative effects of disturbance may cause increased behavioral sensitivity in Brandt's Cormorants. It also potentially takes only one ill-timed disturbance to cause colony failure. Therefore, to continue to reduce disturbances, we recommend continued park vigilance in restricting human access and construction activities within view of the western cliffs after early February, especially if activities may influence the sensitive Pelagic Cormorant population which is at risk of disappearance from Alcatraz. We also recommend the continued use of the visual barrier at the Model Industries Building.

We continue to encourage plans to post signs visible to both visitors on the island and to passing boaters that explain proximity restrictions with the threat of law enforcement as well as plans to re-install historical buoys around the island. Alcatraz Island offers a unique opportunity for public to view seabird breeding activities up close, and this should be highlighted as a focal point of visitor education and outreach. Improved signage in sensitive areas and overlooks to bird colonies, interpretive tours around the island, increased staff training regarding awareness and sensitivity of bird colonies, as well as increased public outreach to marine and air traffic operators will help educate visitors as well as protect breeding seabirds.

Common Raven predation on Pigeon Guillemot chicks was observed in 2008, and raven predation and/or harassment has been observed in recent years on Brandt's Cormorants, Black-crowned Night Herons, Snowy Egrets, and Western Gulls on Alcatraz. While we have not made direct observations of raven and Black Oystercatcher or Pelagic Cormorant interactions, this is also a possibility. Therefore, increased efforts to investigate the potential for Common Raven management are also recommended.

INTRODUCTION

A number of colonial waterbird species inhabit Alcatraz Island (37º 49'N, 122º 25'W) in San Francisco Bay. Alcatraz is a part of the Golden Gate National Recreation Area (GGNRA), a unit of the National Park Service (NPS). Waterbird species of interest include Brandt's Cormorants (*Phalacrocorax penicillatus*), Pelagic Cormorants (*P. pelagicus*), Western Gulls (*Larus occidentalis*), Pigeon Guillemots (*Cepphus columba*), Black Oystercatchers (*Haematopus bachmani*), Black-crowned Night Herons (*Nycticorax nycticorax*), Snowy Egrets (*Egretta thula*), Great Egrets (*Casmerodius albus*), Great Blue Herons (*Ardea herodias*), and California Gulls (*Larus californicus*).. The Brandt's Cormorant colony on Alcatraz is one of the few known estuarine breeding sites for this species. Pigeon Guillemots breed nowhere else in the San Francisco Bay, and the Western Gull and Black-crowned Night Heron colonies are among the largest in the Bay.

This diversity of species, although protected by the Migratory Bird Treaty Act, National Park Service Management Policies, and NPS-77 Natural Resource Management Guidelines, exists in a delicate balance with the considerable human presence both on and around Alcatraz Island. Colonial waterbird populations on Alcatraz experience substantial disturbance from a number of different sources. About 1.4 million visitors tour the island annually, and associated historic preservation and safety construction projects, public access to breeding areas, gardening activities which are part of a new historic garden restoration program, and special events may disrupt the breeding efforts of Alcatraz seabirds. Encroachment near the Alcatraz shoreline by large numbers of commercial and/or recreational boaters (e.g. tour boats, fishermen, kayakers), and uncontrolled aircraft overflights (e.g. air tour operators), may have similar effects. In addition, dredging and other projects which disturb and alter the subtidal environment are potentially disruptive to seabird populations, as these activities may remobilize contaminants, increase turbidity, and destroy essential foraging habitat.

In 1993, GGNRA completed a management plan for Alcatraz Island, which included provisions for maintaining breeding populations of colonial waterbirds (LSA Associates and NPS staff 1993). This plan

emphasized protection of the island's natural resources, while maintaining opportunities for visitor access, special events, and other island uses. The plan called for natural resource monitoring and the development of protocols to determine baseline information for key wildlife populations. Since 1996, PRBO Conservation Science (formerly Point Reyes Bird Observatory) in conjunction with GGNRA has conducted wildlife studies with the goals of (1) establishing the distribution, abundance, and reproductive performance of waterbird species, (2) assessing the extent and effects of various forms of disturbance, and (3) assisting management personnel in developing appropriate and effective policies to protect waterbird populations. This report details results of monitoring efforts during the 2008 breeding season.

Our objectives in 2008 were to describe and measure the distribution, abundance, reproductive performance, and breeding phenology of Brandt's Cormorants, Western Gulls, California Gulls, Pelagic Cormorants, Pigeon Guillemots, and Black Oystercatchers, as well as to document the extent and effects of disturbance on these populations, and conduct outreach programs aimed at reducing human caused disturbance. Monitoring was focused, as in past years, on Brandt's Cormorants because this population is relatively new to Alcatraz and the San Francisco Bay (having established a breeding colony in 1991), and is suspected to be sensitive to human disturbance (Ainley and Lewis 1974, Boekelheide et. al.1990).

METHODS

We conducted island- and boat-based surveys from March through August, 2008. Island surveys consisted of censuses and focal nest observations once per week, on Thursdays or Saturdays. In order to minimize disturbance to nesting birds, we made observations using binoculars (8 x 42) and/or a spotting scope (Questar 40x and Bausch & Lomb Elite ED 20 - 60x) from concealed or distant locations around the island (Figure 1). Nest boxes and a sample of crevice sites for Pigeon Guillemots were monitored manually once per week when adults were not present. Boat surveys took place 5 times throughout the season. We circled the island slowly at a distance of at least 100 meters from shore and made observations using binoculars and a Canon EOS Digital Rebel camera with a 300mm zoom lens.

BRANDT'S CORMORANT

Observations were made from a blind near Barker Beach, and inside the Laundry and Model Industries Buildings. In each sub-colony visible from the island, we counted the total number of adult and immature Brandt's Cormorants once per week, between 08:00 and 11:00. These included the Southern (except for the Gap – see Figure 1), Northern, Barker Beach, Laundry, and North Foghorn sub-colonies, as well as part of the Model Industries sub-colony. We observed the Gap, South Bricks, Below Rubble Piles, and parts of the Model Industries sub-colony not visible from the island by boat 5 times between 15 May and 10 July. During each survey, we recorded the total number of adults and nests with incubating birds.

We investigated Brandt's Cormorant reproductive phenology and performance in a sample of nests from the Southern, Barker Beach, Northern, Laundry, and Model Industries sub-colonies. Groups of at least 20 visible nests were selected for each sub-colony, including both centrally-located and edge nests, and early and late-formed nests. If a sub-colony had been monitored in previous years and had less than 20 total nests in 2008, all nests were monitored. Nests were numbered and mapped, and the contents of each nest recorded once per week (number of eggs and/or chicks). We followed chicks until they wandered from nests and formed crèches (groups of chicks), at which point we considered them fledged, if at least 25 days old. We calculated clutch size, brood size, hatching success (percent of eggs hatched) and fledging success (percent of chicks surviving to fledge), and total productivity (chicks fledged per nest).

PELAGIC CORMORANT

Pelagic Cormorants were censused and monitored similarly and concurrently to Brandt's Cormorants (twice weekly between 08:00 and 10:00). Pelagic Cormorant nests are typically built on small, narrow cliff ledges; therefore, chicks have less opportunity to wander and crèche than do Brandt's Cormorant chicks. Consequently, we considered Pelagic Cormorant chicks fledged when they reached full feathering (all feathers grown in, capable of flight). For all other monitoring methods concerning reproductive performance and phenology, refer to Brandt's Cormorant methods above.

WESTERN GULL

We censused Western Gulls using standard protocols developed for Alcatraz in 1990 (Bell 1990). One all-island nest count was obtained following peak egg-laying (as determined from phenology in study plots). We divided the island into census areas and counted all nests in each area, recording nest contents whenever visible. We walked through accessible parts of the island and counted nests; boat surveys were used to survey inaccessible parts of the island. NPS staff provided a map of depredated nests, and thus those were excluded from our total count for the all-island census.

We assessed Western Gull reproductive performance and phenology by monitoring individual nest contents (number of eggs and/or chicks) weekly in study plots on the Cistern, the Parade Ground, and the Model Industries Plaza, using binoculars and spotting scopes. Phenology was documented by determining mean dates of egg-laying, hatching, and fledging at monitored nests. Fledging was assumed when chicks were fully-feathered and therefore capable of flight. Reproductive performance was assessed by determining hatching success, fledging success, and total productivity.

CALIFORNIA GULL

California Gulls began breeding behind the Rubble Piles in 2004 (Figure 1). Due to their sensitive location, they have since been monitored by opportunistic access to the colony by PRBO or NPS during Black-crowned Night Heron surveys or visited during the Western Gull census. In 2008, only one visit to the colony was made on 27 May during the Western Gull census.

In addition to this visit to the colony, weekly monitoring was possible by access to the top of the Lighthouse (Figure 1) where most nests could be seen using binoculars and a spotting scope. This access allowed us to asses California Gull reproductive performance and phenology for the third year in a row on Alcatraz Island. For all other monitoring methods concerning reproductive performance and phenology, refer to Western Gull methods above.

PIGEON GUILLEMOT

We monitored Pigeon Guillemots during cormorant surveys and opportunistically, both from the island and by boat. We mapped and numbered nest crevices as they were identified throughout the season. Active nest sites were confirmed by observations of chicks or by parental delivery of fish to a crevice, indicating presence of a chick, or by presence of egg/chick remains found post-season. Probable nest sites were defined by regular attendance of adults. These methods have the potential for underestimating breeding numbers, as we may not have documented nests which failed early in the breeding season.

In 2006, we installed 30 nest boxes for Pigeon Guillemots at 3 locations around the island: Powerhouse (PH), North Foghorn (NF), and South Colony (SC) near the blind (Figure 1). These locations are known breeding areas for guillemots. The nest boxes offer protected nesting sites that allowed us to monitor and examine breeding success. The PH site includes 11 nest boxes and 7 natural crevices that were checked

simultaneously during weekly checks. The NF site has 5 nest boxes, and the SC site has 14 nest boxes. Chicks were weighed and wing cord was measured to monitor growth and development if sample sizes in boxes were large enough. Fledging was defined as chick disappearance from a nest site when at least 35 days old and mostly-feathered.

BLACK OYSTERCATCHER

During each cormorant survey, we recorded the presence and behavior of adult Black Oystercatchers near the Seawall and tracked their movement to the east side of the island near the Powerhouse. We noted nest contents (eggs or chicks). We also recorded the locations and behaviors of any oystercatchers seen on or around other areas of the island. Fledging was defined as chick disappearance from the nest site once fully-feathered.

DISTURBANCE MONITORING

During all monitoring activities March through August, we documented disturbances to nesting seabirds. For each disturbance event, we described the event and its observed effects, including the approximate distance of the event from the colony and the number of birds affected. This report focused on details of events that caused noticeable disruption to cormorant breeding activities, as this species is considered sensitive to disturbance (Ainley and Lewis 1974, Boekelheide et. al. 1990). We classified disturbances as major, moderate, or minor. Major disturbance events caused cormorants to flush from breeding or roosting areas. Moderate disturbances caused agitation in cormorants such as fluffing, growling, threat gestures or standing up off nests. Disturbance was considered minor if cormorants only looked in the direction of the event. Additional detailed disturbance monitoring was conducted during a special event with fireworks, held by the National Fish and Wildlife Foundation, that took place near Anita Rock off Crissy Field in the San Francisco Bay on 22 April, 2008.

RESULTS AND DISCUSSION

BRANDT'S CORMORANT

Brandt's Cormorants, after years of breeding population growth on Alcatraz, decreased by approximately 15% from 1782 nesting pairs in 2007 to 1515 nesting pairs in 2008. The decrease in Brandt's Cormorant breeding population size occurred throughout central California in 2008 and may be due to a combination of factors, including warmer air temperatures, prey availability, and disturbances.

We observed a decrease in breeding attempts in most sub-colonies, including the Model Industries, North Foghorn, Northern, Barker Beach, and Southern (including the Gap area) sub-colonies (Table 1). The Model Industries sub-colony was reduced by more than 50% in 2008 compared to 2007. The North Foghorn colony decreased from 86 breeding pairs in 2007 to only 2 attempts in 2008. The Northern sub-colony, the largest, dropped from over 1000 pairs in 2007 to 728 pairs in 2008. The Southern and Barker Beach sub-colonies also decreased in size by about 40-50% in 2008 when compared to 2007. For Barker Beach, this was the first decline in breeding pairs since the sub-colony was initiated in 2002. Only 2 sub-colonies increased in size in 2008, the Laundry Building and Below Rubble Piles sub-colonies. In 2007, a peak of 157 comorants attended the Laundry Building sub-colony, but only 8 pairs nested there, likely due to disturbance from a special event held in April of that year (Acosta *et al.* 2007.). In 2008, there was a large increase in the size of the Laundry sub-colony with 312 breeding attempts; more than doubling with its previous high of 145 attempts in 2006. The Below Rubble Piles sub-colony increased slightly from 73 breeding pairs in 2007 to 87 in 2008. Besides these increases, new areas of the island have been prospected by Brandt's Cormorants. On the east side of the island in the North Perimeter area (Figure 1), several birds

were seen throughout the season advertising for mates and beginning to build nests. One pair of birds was successful in laying eggs, hatching, and fledging chicks. To the south of the Power House below the Quarter Master's Building (Figure 1), another breeding pair was found. This pair laid eggs, but was not successful in hatching chicks. This is the first time since the Brandt's Cormorant colony on Alcatraz began that these birds have nested on the east side of the island. It is an important area for these birds to roost, gather nest material, and now utilize as nesting habitat.

Brandt's Cormorants first began showing signs of breeding activity in early April in 2008 (Figure 3). The first eggs were laid on or before 20 April in the Southern and Laundry Building sub-colonies. Mean lay date for the Southern sub-colony was 2 May (Table 2). Mean lay date for Barker Beach was 1 May while the mean lay dates for the Laundry Building and Northern sub-colonies were both 10 May. The North Foghorn sub-colony did not breed in 2008, while no birds in the Model Industries sub-colony could be monitored for reproductive chronology or success. All chicks had fledged by 14 August, but some remained at sub-colonies after regular monitoring ceased at this time.

Besides a decline in breeding population of Brandt's Cormorants at Alcatraz, populations of colonies throughout central California decreased in 2008 (Warzybok *et al.* 2008, J. Thayer/PRBO unpublished data). By comparison the Farallon Island population decreased by approximately 75% compared to 2007.

In recent years, productivity of many seabird species in central California was relatively low, while that of cormorants was relatively high. That trend reversed in 2008 with much lower cormorant productivity. Productivity was among the lowest ever observed at several regional colonies, near or below that observed in very severe ENSO years, ranging from 0.4 chicks/pair at offshore Southeast Farallon Islands (Warzybok *et al.* 2008) to 1.2 at nearshore Año Nuevo Island (J. Thayer/PRBO unpublished data), to 1.5 at estuarine Alcatraz. These are well below the long-term means for each location, including Alcatraz (Figure 4). The Barker Beach sub-colony had the lowest productivity of areas monitored in 2008, at 0.8 chicks per pair (Table 3) while the Laundry Building sub-colony had the highest productivity at 2.4 chicks per pair (Table 3). No double broods were observed in 2008.

Warm air temperatures may have had a heavier influence on these surface-nesting seabirds in 2008 than ocean productivity. While cormorants can breed successfully in much warmer climates (i.e. Baja, Mexico), central California cormorants may not be behaviorally adjusted to high temperatures during the breeding season as occurred in May 2008. We witnessed many nesting attempts that failed prior to egg-laying, high rates of nest abandonment during the incubation stage (e.g., an additional 15% during May heat wave on Alcatraz and approximately 100% on SEFI) and even adult mortality and severe heat stress as birds misjudged how long to remain at nests in high temperatures if mates did not return. Adult mortality is relatively rare in long-lived species such as seabirds. Many cormorants that did manage to fledge chicks initiated nest building after the heat wave.

PELAGIC CORMORANT

The Pelagic Cormorant population has decreased by 94% since 1996 ($\beta = -1.2$, $p < 0.01$; $R^2 = 0.78$; n = 13 years). Only 1 Pelagic Cormorant breeding attempt was recorded in 2008 (Figure 5). The nest was located on cliffs below the Model Industries Building (Figure 1). No nesting attempts have been made at Barker Beach since 2004.

Pelagic Cormorants first exhibited pre-breeding activity on 10 April 2008. Evidence of egg-laying was recorded 15 May; however due to its location, could only be monitored while conducting boat surveys on 5 occasions during the breeding season, so the lay date likely occurred in early May. The first evidence of chick hatch was 5 June and 1 chick was last seen mostly-feathered on 26 June. Pelagic Cormorant productivity in 2008 was 1.0 chicks/pair (totaling 1 chick fledge from Alcatraz), the lowest number of

Pelagic Cormorants to fledge from Alcatraz since 1999 when monitoring first began (Figure 4). In comparison, Pelagic Cormorant productivity on the Farallon Islands in 2008 was 0.41 chicks/pair out of a population of 125 breeding pairs (Warzybok *et al.* 2008).

Several factors may have negatively affected Pelagic Cormorants breeding in recent years. Pelagic Cormorant productivity declined sharply starting in 2004 (Figure 4), and breeding attempts decreased notably in 2005 (Figure 5). First of all, warm-water marine conditions since the mid 2000s may have adversely affected reproductive success through a mechanism of reduced prey availability. Secondly, the continued growth of the Brandt's Cormorant population has resulted in some inter-specific competition with Pelagic Cormorants for nest sites. Thirdly, human activity has increased at the north end of the island. A fence was erected in February 2003 just 30 feet from the edge of the cliff where Pelagic Cormorants breed, which may have disturbed early breeding activity. Staff activity in the Model Industries Building and surrounding plaza during the breeding season has increased since then. Additionally, visitor access in 2004 and 2005 was allowed down to this fence throughout the breeding season, including the very sensitive nest-initiation stage. A special event held adjacent to the Pelagic Cormorant colony in early April 2007 may have negatively influenced breeding. Finally, other researchers have noted reduced Pelagic Cormorant populations elsewhere in the California Current related to corvid harassment and nest predation (Paine et al. 1990). Increased Common Raven activity on Alcatraz may negatively affect Pelagic Cormorant nesting.

WESTERN GULL

Western Gull breeding numbers have been on the rise for the past several years, but have slowed their increase in the past four years ($\beta = 44$, $p < 0.01$; $R^2 = 0.95$; $n = 10$). The Western Gull population reached 1061 breeding pairs in 2008 (Figure 2), not including 133 nests which were removed from public access areas and buildings under the NPS depredation permit from the US Fish and Wildlife Service.

The first Western Gull eggs in 2008 were observed on 17 April, and the mean lay date was 9 May (Table 2), extremely consistent with the past several years, 1999-2007. The average hatch date was 6 June. Western Gull hatching success and fledging success was 0.6 and 0.7 respectively (Table 4). Productivity was 1.3 chicks per pair in 2008 (Figure 6), lower than the mean since 1999. This was higher than the mean 0.86 chicks/pair fledged from the dense Farallon Island colony in 2008 (Warzybok *et al.* 2008).

Of the 3 Western Gull sub-colonies monitored, productivity at the cistern sub-colony was much lower for the second year in a row with 0.79 chicks fledged per pair in 2008 compared to 1.48 and 1.58 chicks fledged per pair at the Model Industries sub-colony and the Parade Ground sub-colony respectively (Figure 6). Reasons for decreased productivity in the cistern sub-colony are unknown. The Western Gull population in this area has remained similar between years, vegetation cover has not changed much, and researchers have been accessing the colony less in recent years due to altered monitoring protocols. However, unobserved disturbance to this area is a possibility for decreased productivity. Additionally, construction activities near the cistern in 2008 may have had an effect.

CALIFORNIA GULL

We first discovered 5 pairs of California Gulls breeding on Alcatraz in 2004 in a small colony along the walkway south of the Rubble Piles on the Parade Ground. Since then, the population has increased up to 46 birds (23 nests), including an occasional pair attempting to breed outside of the small colony behind the Rubble. In 2008, there were 21 nesting pairs of California Gulls (Figure 2).

Due to their obscured location behind the Rubble Piles, we were not able to obtain exact lay dates. The first California Gull eggs seen were on 10 May, but the pair was first seen in incubating posture on 24

April. The average hatch date was 1 June (Table 2). Productivity was 1.2 chicks per pair in 2008, lower than the 1.6 chicks per pair in 2007.

PIGEON GUILLEMOT

In 2008, we first detected Pigeon Guillemots around Alcatraz on 25 March, and attending nest sites on the island on 3 April (Table 5). A high count of 66 adults was recorded on 10 July, the highest count of Pigeon Guillemots since monitoring began in 1997. We confirmed 31 Pigeon Guillemot nest sites in 2008, the highest since 33 sites were confirmed in 2004; above average for the number of confirmed sites since 1997. Additionally, we observed 24 probable nesting sites around the island (Figure 7).

In 2008, a Common Raven was observed eating a fully-feathered Pigeon Guillemot chick at the guillemot's nest site in the Barker Beach sub-colony. In previous years, ravens have been observed harassing adult guillemots attempting to deliver fish to chicks in nest sites. The full extent of impacts on guillemots is unknown due to inability to monitor reproductive success in many breeding sites located in cormorant colonies. However, predation of the one nest we observed out of 31 total confirmed breeding sites on the island in 2008 represents an effect on 3% of the breeding population. Actual predation rates are likely higher due to the rarity of observing such an event.

Out of 30 nest boxes placed around the island in February 2006, one box under the blind in the Southern sub-colony was used in 2006 and 2007. In 2008, no nest boxes were used. However, one natural crevice at the Power House which was cleared out at the time of nest box placement was used by a pair of Pigeon Guillemots in 2008. Adults were first seen near the crevice on 8 June and two downy-feathered chicks were confirmed on 10 July. One chick was found dead by 24 July while the other was not subsequently seen. We anticipate greater occupancy in subsequent years once the guillemots become familiar with the new boxes. Nest boxes have been a successful tool for monitoring reproduction of cavity-nesting seabirds in other locations in California, as well as increasing population size (Sydeman et. al. 2000). Nest box occupancy usually increases in the second to third year after installation (Sydeman et. al. 2000). Nest box use is also expected to increase once more favorable marine conditions support guillemot breeding. However, should greater occupancy not occur, nest box locations may need to be adjusted to better suit micro-habitat needs of breeding guillemots on Alcatraz.

BLACK OYSTERCATCHER

A single pair of Black Oystercatchers attempted to breed on the Seawall in 2008. Adults were seen at the Seawall and around the island intermittently from 5 March to 29 June. Eggs were laid at their nesting location at the seawall by 12 June. A total of at least 2 eggs were laid, but were gone by 26 June; most likely due to the close proximity of many Brandt's Cormorants roosting at the seawall. Of a potential brood of 3 chicks per year, Black Oystercatchers on Alcatraz have fledged only six chicks since 1997 (one each in 1997, 2001, 2003, 2004 and two in 2006).

DISTURBANCE MONITORING

The rate of disturbance to seabirds on Alcatraz has increased in the last few years. In 2008, the rate of disturbance equaled 2007 at 0.21 disturbances per hour. This in an increase from the 0.07-0.13 disturbances/hour seen in 2004-2006 (Figure 8). A total of 27 major disturbances accounted for about 69% of the total number of disturbances; the highest since monitoring began in 1999. One moderate disturbance was observed, while 28% of disturbances caused minor reactions in seabirds (Figure 8).

In 2008, the presence of kayaks and other non-motorized watercraft moving slowly, quietly and/or erratically while close to the shoreline of the island continued to cause a large portion of the major

disturbances to Brandt's Cormorants (26%). Small, personal, motorized boats approaching too close were responsible for 22% of major disturbances. Other offenders included air-based disturbances such as helicopters, or noise-based disturbances. Island-based disturbances increased slightly compared to 2007 (Table 6).

The greatest causes of major disturbances in 2008 were marine-based disturbances. Many came from kayaks or canoes and small power boats. On 3 April, a zodiac with 2 passengers on board flushed over 260 cormorants in multiple sub-colonies on the west side of the island while motoring past the very closely taking photographs. On 27 April, a single kayak paddling within 100 feet around the island caused at least 600 cormorants to flush between the South Bricks sub-colony and the Northern sub-colony. Other incidents where kayaks caused major disturbances include 4 May when 8 kayaks near the Southern sub-colony flushed 500 of the 700 cormorants on breeding and roosting territories; another on 25 May when 2 kayaks within 15 feet of the Power House flushed 400 cormorants in their pre-breeding and roosting stages; and on 1 June when a kayak flushed at least 100 birds from the Seawall roosting area as well as the Model Industries and Laundry Building breeding sub-colonies. On 11 May, one powerboat fishing near the Southern sub-colony caused 400 cormorants to flush from the Southern and South Bricks sub-colonies.

Other events that caused major disturbances were air-based. On 17 April, an unknown, loud aircraft flew over 2 times flushing at least 140 cormorants in the Northern sub-colony. Just over a week later, on 25 April, a tour helicopter flushed 100 cormorants from the same area.

Prior to the breeding season in 2008, a permanent visual barrier was installed on the fence between the Model Industries Building and the Laundry Building to provide buffer between breeding birds and visitors and/or researchers. In recent years, a temporary barrier or no barrier was in place, causing an increase in the number of island-based human-caused disturbances. The barrier that was installed in 2008 worked well as there were no human disturbances observed to cormorants in the adjacent sub-colonies due to non-motorized access of the Model Industries Building. Continued care will need to be taken to keep gull disturbance at a minimum in this area so as not to alarm adjacent cormorant nesting colonies.

In 2007, multiple occasions of visitors accessing closed areas and disturbing cormorants were recorded. In 2008, no such disturbances were observed. This may be related to the increased signage at closed areas, although the reduced amount of disturbance monitoring may have also played a part in the reduction of these sightings. Continuing to provide visitors with information about seabirds through signage and interpretation by rangers and docents will help to keep visitor disturbances at a minimum. This is crucial, as it takes only one ill-timed disturbance to potentially cause colony failure. On a few occasions, researchers (PRBO, USGS, and NPS) caused cormorants to flush from the island. On all occasions, flushing events were limited to fewer than 20 birds at one time and often affected only roosting birds. One of these occasions occurred on 12 March when a researcher walked to the Barker Beach Overlook, an area which is open to the public. This caused 10 of 29 pre-breeding birds to flush the island. This is usually an area where humans do not affect the birds, but this demonstrates the sensitivity of cormorants, especially in their pre-breeding and early breeding stages. As the Brandt's Cormorant population increases and spreads its distribution to new and different areas of the island, it is likely that researchers will encounter these birds in observation/monitoring locations more often and will have to adapt new and different methods of monitoring so as to eliminate any disturbance. Climate and prey variability is also likely to make breeding cormorants more sensitive to disturbance, and should be considered during future planning exercises related to human access.

SPECIAL EVENT MONITORING

Additional disturbance monitoring took place on April 22, 2008 when the National Fish and Wildlife Foundation held a special event with fireworks set off near Anita Rock off Chrissy Field in San Francisco

Bay. This event coincided with the pre- to early breeding season for seabirds when nests are being established and eggs are being laid, one of the most sensitive periods of the year.

The fireworks display had the potential to affect birds to varying degrees, including Brandt's and Pelagic Cormorants, Pigeon Guillemots, Black Oystercatchers and Western Gulls. Therefore disturbance monitoring was carried out for all nesting species on the Alcatraz western cliffs prior to, during, and after the special event. This involved standardized surveys two days before (to establish baseline) and two days after (to examine residual effects) the fireworks event. Monitoring on the evening of the event was conducted from two observation points, one at the north end and one at the south end of the western cliffs, starting one hour prior to the event, and including monitoring the morning after the event.

All seabird breeding and roosting sub-colonies were counted and breeding subplots were monitored on 20 and 24 April. A count of breeding and roosting birds was taken the evening of 22 April a few hours before the fireworks were set off. Another count was taken the following morning.

During the fireworks event, the South Colony and the areas between Model Industries and North Colony were monitored. A few hours prior to the fireworks, >700 Brandt's Cormorants were counted in the South Colony area and >1000 cormorants in the areas between Model Industries and North Colony (including the Seawall). Bird activities approximately one hour prior to the fireworks display (~20:00 hrs) included sleeping, preening, some growling over territories, and a few were on nests incubating eggs. The birds were settled at the colonies and there was hardly any flight in and out of colony areas. Western Gulls were quiet overall; a few were coasting silently overhead on wind thermals.

Once fireworks began, Western Gulls at nest sites began alarm calling and some flushed and began alarming in the air. Brandt's Cormorants became alert and looked around; ~200 cormorants flushed from the South Colony roosting area and ~700 flushed from the Seawall and surrounding sub-colonies. Some cormorants flew from breeding areas, although we did not observe the few incubating birds that were visible in the dark near observation points leaving their nests. Only a few cormorants returned to the Seawall after flushing. Several cormorants were flying to and from the South Colony and an increase of agitation and growling among cormorants occurred as birds were moving about. Monitoring was stopped approximately 30 minutes after the fireworks ended.

In most of the areas, the cormorant population increased or held steady between 20-24 April. On the evening of the event, the highest numbers of cormorants were present as birds come into roost on the island overnight. There were only a few nests with birds in incubation position (likely on eggs, between 0-17 sites) in each of the areas monitored prior and up to the evening of the event. Within the days following the event, the number of birds in incubation position increased in most areas. However, the Laundry Building sub-colony had 3 birds at nests in incubation position on the evening of 22 April, prior to the fireworks event. On the following morning, 23 of April, these birds were no longer in incubation position. First eggs were not seen at this sub-colony until 8 May (Figure 3). It is unknown if the birds were actually on eggs the evening of the fireworks event, and the event caused nest failure. The Laundry Building sub-colony also experienced disturbance due to a special event in the Laundry Building in April 2007 (Acosta et al. 2007); therefore, the birds in this sub-colony may be more sensitive than in other areas. The morning after the fireworks event when a counts of roosting areas were conducted, we found that cormorants returned to the roosting areas in large numbers. However before the count was finalized, hundreds of birds flew off to feed so we did not get an accurate count.

Active protection and management of seabird breeding habitat on Alcatraz is undoubtedly critical to the observed growth and maintenance of Alcatraz seabird populations. Without portions of the island being closed to staff and visitors during the breeding season, most bird species on Alcatraz would not have sufficient undisturbed breeding habitat to produce young. Limiting marine and air-based disturbance

around the island is also important. Certain colonial seabird species may exhibit habituation to regular and predictable human presence (Van Heezik and Seddon 1990, Burger and Gochfeld 1999). However, different species likely have different aptitudes for habituation (see Carney and Sydeman 1999). Additionally, disturbance effects reported in many studies reviewed by Carney and Sydeman (1999) were often just incidental accounts which did not examine effects of different types of disturbance nor control for confounding influences, e.g, food availability. Brandt's and Pelagic Cormorants in particular are sensitive to human disturbance (Ainley & Lewis 1974, Boekelheide et al. 1990). Although breeding seabirds on Alcatraz appeared fairly resilient to disturbance events on a case-by-case basis, cumulative effects of chronic disturbance to seabird breeding colonies, especially under varying environmental conditions, are unknown. Pelagic Cormorants, for example, have experienced dramatic decreases in recent years of both population size and productivity of remaining pairs. While the Brandt's Cormorant population has been increasing in recent years (excluding 2008); increasing responses to disturbance were observed this year and productivity was at its lowest since monitoring on Alcatraz began. It is possible that regularly-disturbed colonies are likely to persist and/or perform well only if the advantages for seabirds to stay at the colony outweigh the disadvantages. For instance, prey availability near Alcatraz Island may be high and/or predictable in some years, prompting cormorants to breed there and be more successful at fledging young than other colonies, but environmental conditions negatively affecting feeding conditions may intensify the effects of disturbance felt by the birds, resulting in poor productivity, or in colony abandonment as observed at North sub-colony during the 1998 El Niño event. Environmental conditions not only affect feeding conditions, but the health of breeding adults as well. Negative effects of record air temperatures (92.7°F) in San Francisco, near Alcatraz Island in May 2008 caused heat stress in breeding adults while at nest sites and even heat stroke. Adult mortality due to high temperatures is an unprecedented event on Alcatraz and has not been known to occur at other colonies. Managers should be aware that effects of environmental conditions and prey resources may exacerbate effects of human disturbance.

CONCLUSIONS AND RECOMMENDATIONS

The Brandt's Cormorant population on Alcatraz decreased by approximately 15% in 2008, the small populations of California Gulls and Pelagic Cormorants decreased slightly, while breeding populations of Western Gulls increased slightly. Pigeon Guillemot population was the highest yet recorded since 1997 and numbers of confirmed breeding sites was just under the highest count in 2004. The decrease in Brandt's Cormorants was similar to other colonies along the central coast (Southeast Farallon Island, Año Nuevo Island, and Point Reyes Headlands) and was likely influenced by warmer air temperatures and/or prey availability. The Pelagic Cormorant population on Alcatraz decreased nearly 100% from the breeding population size in the mid to late 1990s as only one pair attempted to breed in 2008. Pelagic Cormorants may be affected not only by the recent increase in warm weather but also negatively impacted by increased human disturbance near nest sites in recent years, competition for optimal nest sites in relation to Brandt's Cormorant population growth, and potentially harassment from Common Ravens

Productivity of Brandt's Cormorants and Western Gulls was lower than long-term averages. For Brandt's Cormorant, productivity on Alcatraz was the lowest on record, but higher than that at other central California colonies. Western Gull productivity was the lowest since 2000 on Alcatraz, although higher than on the Southeast Farallon Islands. In recent years, during favorable marine conditions (high upwelling and low ocean temperatures), Alcatraz cormorants appeared to perform better than coastal and pelagic colonies, yet during poor ocean conditions, Alcatraz cormorants performed worse (see also Saenz et al. 2007). This held true in 2008 as marine conditions have improved when compared to 2005-2007, Alcatraz cormorants had a higher productivity than other nearby colonies. Explanations include differing prey availability near Alcatraz in the Bay's estuarine environment versus in coastal or pelagic waters. Studies of seabird diet and comparisons with research trawl surveys could help explain differences, discern

mechanisms, and provide information to assist in management and conservation of these seabirds in central California.

The Pelagic Cormorant breeding population and productivity are both alarmingly low and warrant increased protection if this species is to remain on Alcatraz. To protect against disturbance, human activities around the cliffs should be minimized as much as possible before breeding season, and ceased completely after early February, as mandated in the Alcatraz Final Environmental Impact Statement of 2001 (NPS/GGNRA), and continued since then as standard operating procedure. We advise against visitor or staff access near this area during breeding season (mid-February to the end of August). However, should any access be permitted, extreme caution should be exercised by people in this area to help prevent disappearance of Pelagic Cormorants from Alcatraz Island.

Common Ravens have become abundant along the central California coastline due to their ability to take advantage of human development. However this species can be detrimental to breeding waterbirds. Common Raven predation on Pigeon Guillemot chicks was observed in 2008, and raven predation and/or harassment has been observed in recent years on Brandt's Cormorants, Black-crowned Night Herons, Snowy Egrets, and Western Gulls on Alcatraz. While we have not made direct observations of raven and Black Oystercatcher or Pelagic Cormorant interactions, this is also a possibility. Raven harassment of Black Oystercatchers harassment has been observed at other central California colonies and may reduce oystercatcher reproductive success (Thayer and Lindquist 2006). Pelagic Cormorant populations in Washington have been reduced due to influence of corvid harassment and nest predation (Paine *et al*. 1990). Therefore, increased efforts to investigate the potential for Common Raven management are also recommended.

Attempts to oil Common Raven eggs in the one nest on Alcatraz have been made by the NPS in the past two years. In 2007, all eggs present in the nest when a biologist scaled the tree were oiled, but one egg hatched. It is possible that this egg was laid after the oiling attempt, or that a different oiling technique may be more effective. In 2008, raven chicks hatched prior to any oiling attempts. Exploring different oiling techniques (types of oils, coverage, etc.) and monitoring early raven breeding phenology on the island could hopefully make management attempts more effective.

Disturbance to seabirds remained high in 2008 and the percentage of major disturbances has increased in the past 3 years, suggesting increased sensitivity among cormorants in particular. This may be related to several special events occurring both on and near Alcatraz during sensitive periods in the seabird breeding season in the past few years. Additionally, although kayaks, canoes, and powerboats have been big offenders of major disturbances for many years, aircraft overflights are also a continuing offender. Visitor interference of Brandt's Cormorant nesting was not observed in 2008, although the amount of observation time was reduced compared to previous years when visitor disturbance was observed. The placement of the visual barrier at the Model Industries and Laundry Building fence helped significantly as there were no records of human disturbance in that area. In addition; the signs near closed areas and an increase in seabird interpretation by docents may have helped to reduce or eliminate the visitor disturbances to Brandt's Cormorants. It will be important to continue and improve the visitor experience in relation to the natural side of Alcatraz in order to keep human disturbances at a minimum. Coordination of both law enforcement and outreach staff in this endeavor is crucial. Special use permits for air-based and marine vessels near the island as well as any special use permits on-island should be carefully regulated. Regulation may include denying inappropriate permit applications, providing clearer language and better guidance in terms of restrictions in permits, and more effort to ensure adherence to permits once they are granted. For example, monetary fines and forbidding future opportunities may be good incentives for grantees to adhere to specified permit regulations. It should be noted, however, that to properly achieve these goals, appropriate staff time must be allocated towards this purpose.

Island-based disturbance to cormorants by U.S. Coast Guard personnel and contractors was not recorded in 2008. To continue to keep disturbance to breeding birds at a minimum, we urge that access to the foghorns for necessary bi-annual service be scheduled before and after the breeding season. This will require continued communication between seabird ecologists and NPS/GGNRA Alcatraz biologist, and consistent scheduling and follow-up between natural resources staff and the U.S. Coast Guard and its contractors. The NPS Natural Resources Ranger position is an important component for managing and protecting seabird colonies on Alcatraz. Not only has this person coordinated scheduling with the U.S. Coast Guard, but they also have myriad other important duties, including conducting wildlife sensitivity training for staff and contractors, developing and maintaining signage marking vulnerable seabird colonies and seasonal area closures around the island, running bird docent programs, leading public natural resource tours and interpreting bird ecology and marine science for the Gull Shack, dealing with injured wildlife, managing gull nesting on public walkways, and handling gull-visitor interactions. This position also provides an important conduit between seabird researchers and cultural resource staff to achieve a balance mandated by the laws requiring protection of both natural and cultural resources.

Summary of recommendations:

Management Recommendations

- Allow no public visitation or construction activities to be carried out near the western cliffs after early February, especially if activities may influence seabird pre-breeding or early-nesting behavior.
- Keep visual barrier in place at the Model Industries/Laundry Building fence.
- Enforce strict regulations in granting special use permits and such privileges should be carefully planned in advance to prevent any potential miscommunication and/or disturbance to wildlife.
- Increase warning signage in sensitive areas with threat of law enforcement consequences. Specifically, near the metal detector at the south end of the Laundry Building where many visitors have crossed barricades.
- Secure debris (e.g., trash bags, tarps, etc.) that can blow away in windy conditions from cleaning or construction sites and potentially cause seabird disturbance.
- Schedule police K-9 training units during the seabird non-breeding season, and restrict K-9 units to the main walkways between the Dock and Cellhouse, excluding the sensitive area behind Building 64.
- Continue communication with U.S. Coast Guard personnel and contractors to schedule bi-annual foghorn maintenance before and after the breeding season
- Re-install historical buoys around the island.
- Continue funding for a NPS Natural Resources Ranger
- Further investigate potential for Common Raven management

Research Recommendations

- Continue ongoing monitoring of colony breeding success and human disturbance monitoring
- Increase monitoring of guillemots and other species potentially impacted by Common Raven disturbance
- Incorporate studies of seabird diet which may help to reveal links between seabird reproductive parameters and marine environmental conditions versus human disturbance effects.

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LITERATURE CITED

Acosta, S.M., J.A. Thayer, W. Merkle, and C. Hellwig. 2007. Alacatraz Island Special Event Seabird Disturbance Monitoring Report, 2007. Unpublished report to the National Park Service, Golden Gate National Recreation Area, San Francisco, CA. Point Reyes Bird Observatory, Petaluma, CA.

Ainley, D. G. and T. J. Lewis. 1974. The history of the Farallon Island marine bird populations, 1854-1972. Condor 76: 432-446.

Bell, D. 1990. Alcatraz Island Western Gull nest survey, 1990. Unpublished report to the National Park Service, Golden Gate National Recreation Area. Museum of Vertebrate Zoology, University of California, Berkeley, CA.

Bell, D. 1991. Alcatraz Island Western Gull nest survey, 1991. Unpublished report to the National Park Service, Golden Gate National Recreation Area. Museum of Vertebrate Zoology, University of California, Berkeley, CA.

Boekelheide, R. J., D. G. Ainley, S.H. Morrel, and T.J. Lewis. 1990. Brandt's Cormorant. pp. 163-195 in Seabirds of the Farallon Islands: Ecology, Dynamics, and Structure of An Upwelling System Community. (Ainley, D.J. and R.J. Boekelheide, eds.). Stanford University Press, Palo Alto.

Brown, M. E. 1997. Population monitoring for Western Gulls (Larus occidentalis) on Alcatraz Island, California. Unpublished report to the National Park Service, Golden Gate National Recreation Area. Biology Department, University of Dallas, TX.

Burger, J., and M. Gochfeld. 1999. Role of human disturbance in response behavior of Laysan Albatrosses, *Diomedea immutabilis.* Bird Behavior. 13 (1): 23-30.

Carney, S. M., and W. J. Sydeman. 1999. A review of human disturbance effects on nesting colonial waterbirds. Waterbirds 21 (1): 68-79.

LSA Associates and National Park Service Staff. 1993. Alcatraz Development Concept Plan, Environmental Assessment and Finding of No Significant Impact.

Paine, R.T., J.T. Wootton, and P.D. Boersma. 1990. Direct and indirect effects of Peregrine Falcon predation on seabird abundance. The Auk 107: 1-9.

Sydeman, W.J., J.A. Thayer, M.M. Hester, K.L. Mills, and S. Wolf, 2000. Nest boxes as a tool for Seabird Population Restoration. Unpublished report to the National Fish and Wildlife Foundation.

Saenz et al. 2006. An urban success story: breeding seabirds on Alcatraz Island, California, 1990-2002. Marine Ornithology 34: 43-49.

Thayer, J.A., and K.L. Lindquist. 2006. Long-term studies of seabirds on Año Nuevo Island and Mainland, 2006. Unpublished report to State of California Department of Parks and Recreation, Bay Area District, Año Nuevo State Reserve. Point Reyes Bird Observatory, Petaluma, CA.

Van Heezik, Y., and P. J. Seddon. 1990. Effect of human disturbance on beach groups of Jackass Penguins. South African Journal of Wildlife Resources 20: 89-93.

Warzybok, P.M., and R.W. Bradley. 2008. Population size and reproductive performance of seabirds on Southeast Farallon Island, 2008. Unpublished final report to the USFWS Farallon National Wildlife Refuge, CA. Point Reyes Bird Observatory, Petaluma, CA.

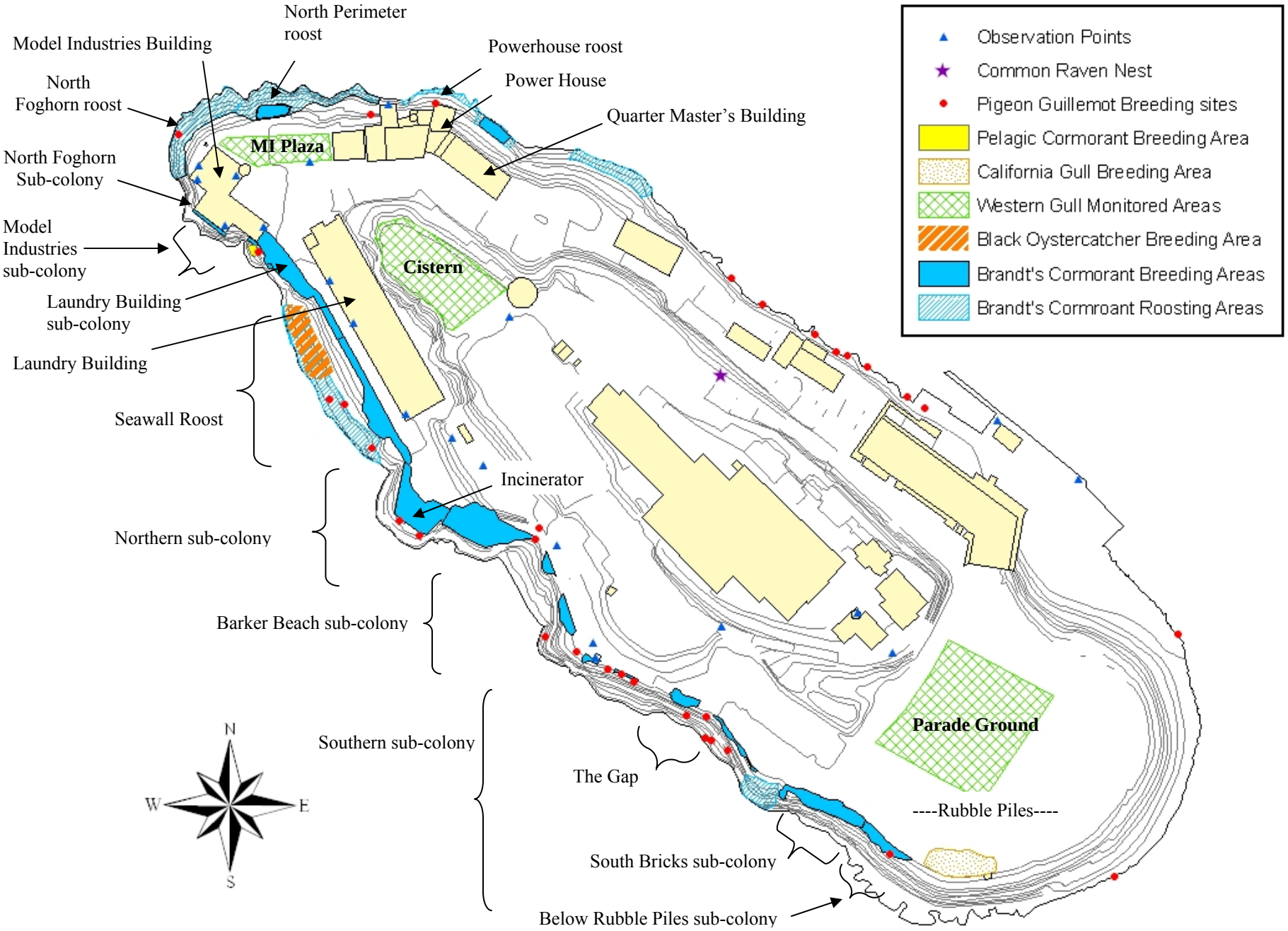

Figure 1. Alcatraz Island seabird breeding areas, survey observation points, and significant structures, 2008.

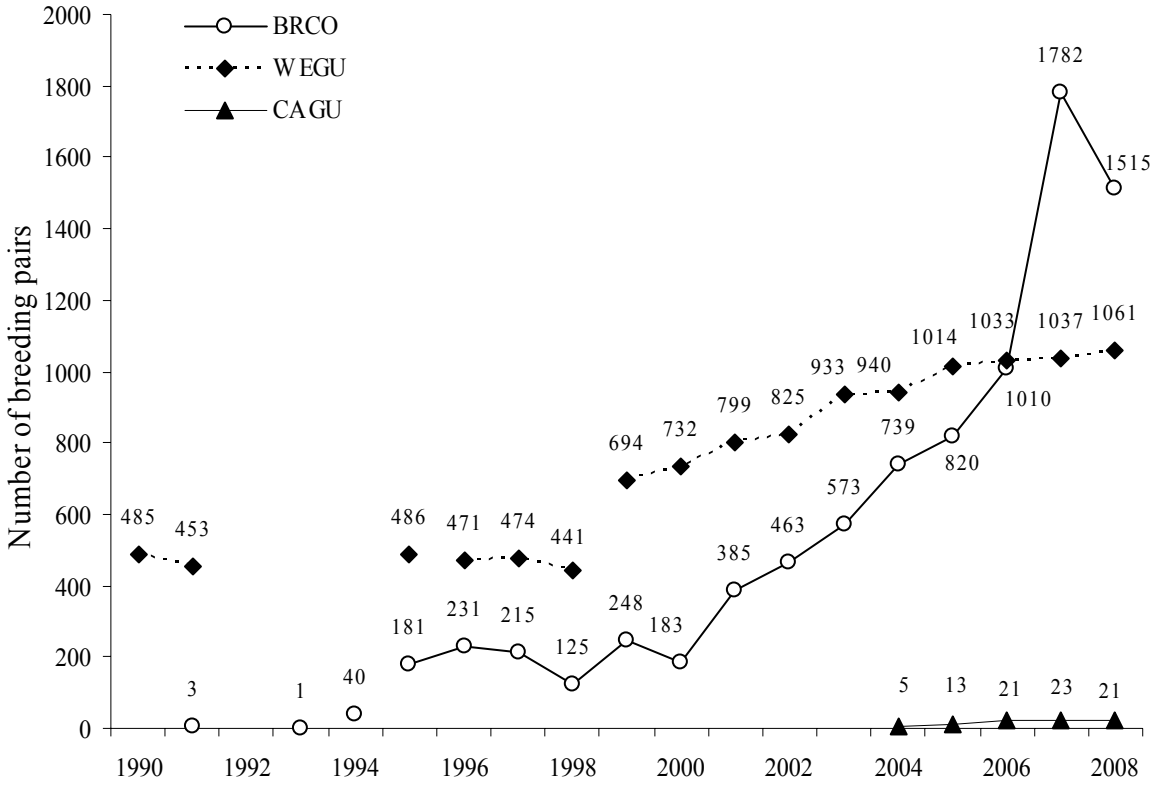

Figure 2. Brandt's Cormorant (BRCO), Western Gull (WEGU), and California Gull (CAGU) breeding population size on Alcatraz Island, 1990-2008. Data represent the minimum number of breeding pairs on Alcatraz. Breaks in data indicate a change in observers and/or census methodology. BRCO data in 1991 from R. Farwell/GGNRA, (pers. obs.); in 1993 from D. Hatch/GGNRA (unpubl. data); in 1994 from R. Hothem/USGS and W. Reyes/GGNRA, (pers. obs.). WEGU data in 1990 from Bell (1990); in 1991 from Bell (1991); in 1995 from D. Hatch and A. Fish/GGNRA (unpubl. data); in 1996-1997 from Brown (1997); in 1998 from M. Brown/Univ. of Dallas (unpubl. data).

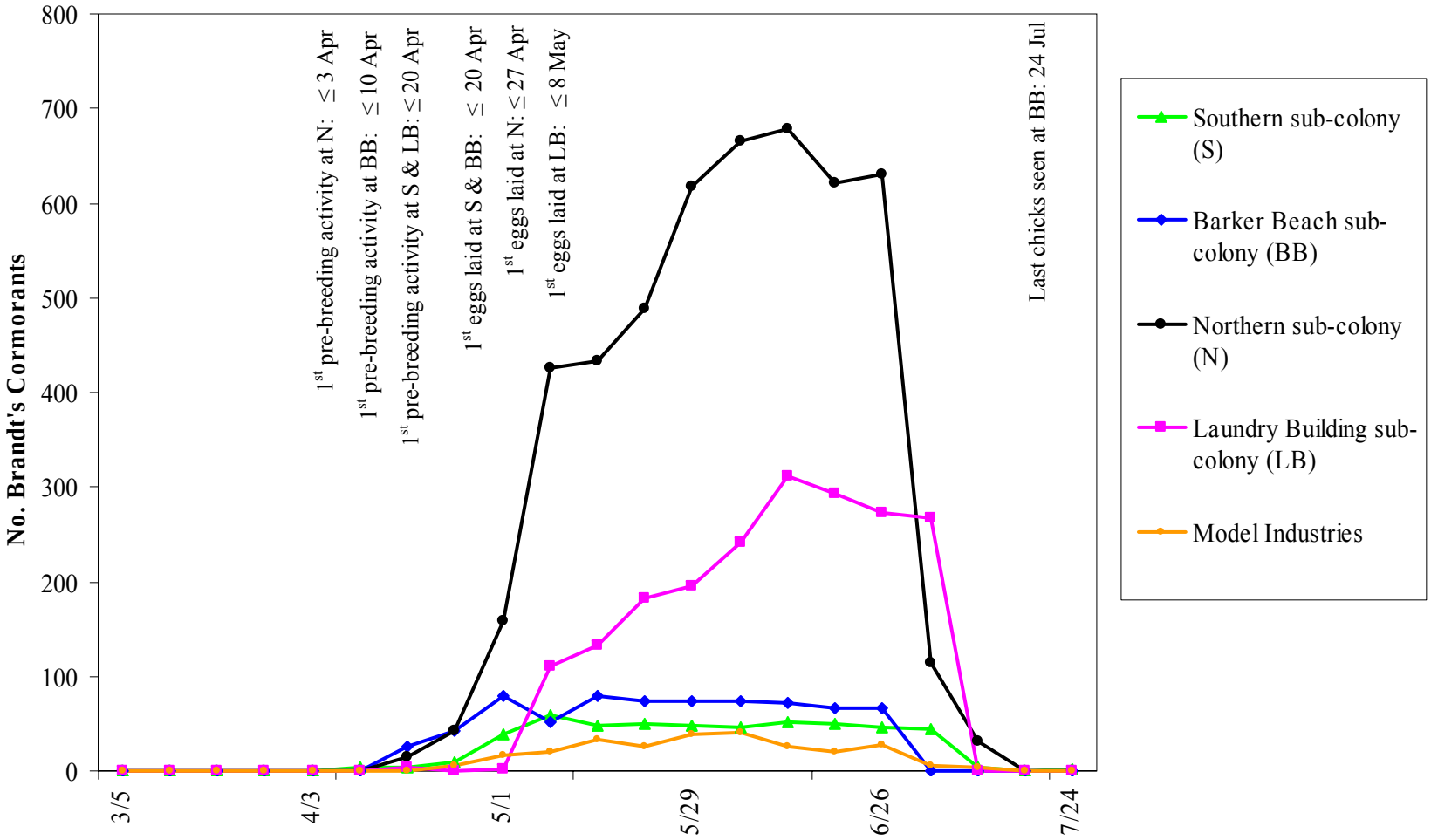

Figure 3. Dynamics of four Brandt's Cormorant sub-colonies on Alcatraz Island, 2008. Number of active Brandt's Cormorant nests (well-built nests with eggs/small chicks or birds in incubation posture) are shown for each sub-colony. Shown are the number of active Brandt's Cormorant nests (well-built nests with birds in incubation posture, or with eggs/small chicks) in each sub-colony.

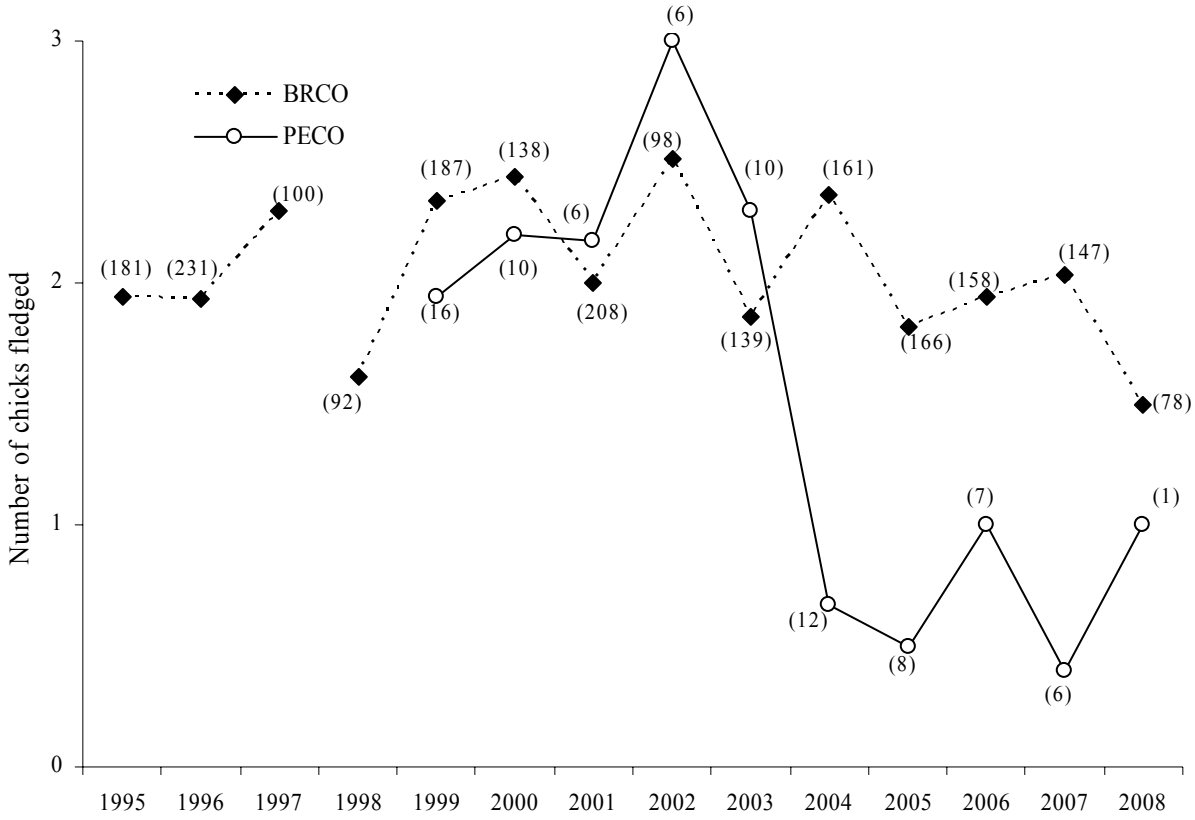

Figure 4. Overall Brandt's (BRCO) and Pelagic (PECO) Cormorant productivity on Alcatraz Island, 1995-2008. Sample size is in parentheses. Productivity in 1995-1997 was calculated from total chick counts. Productivity in 1998-2008 was calculated from number of chicks fledged per pair monitored.

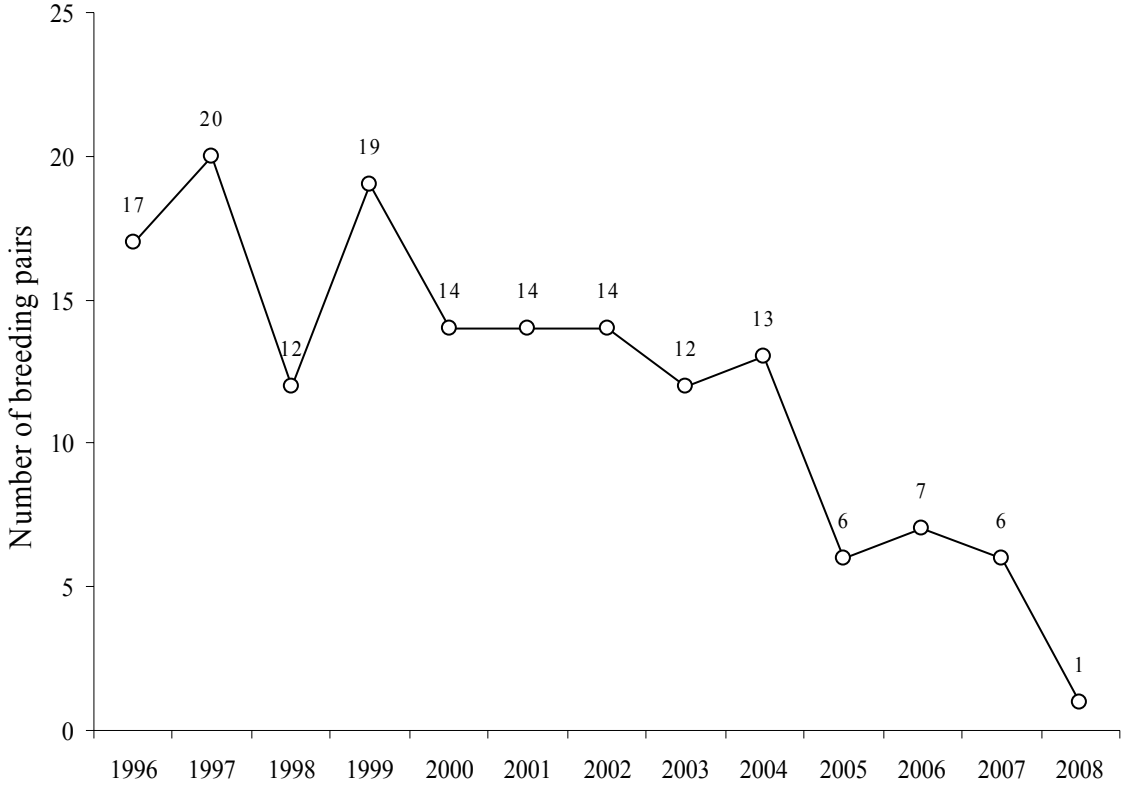

Figure 5. Pelagic Cormorant breeding population size on Alcatraz Island, 1996-2008. Data in 1996 from M. Parker/USFWS aerial surveys.

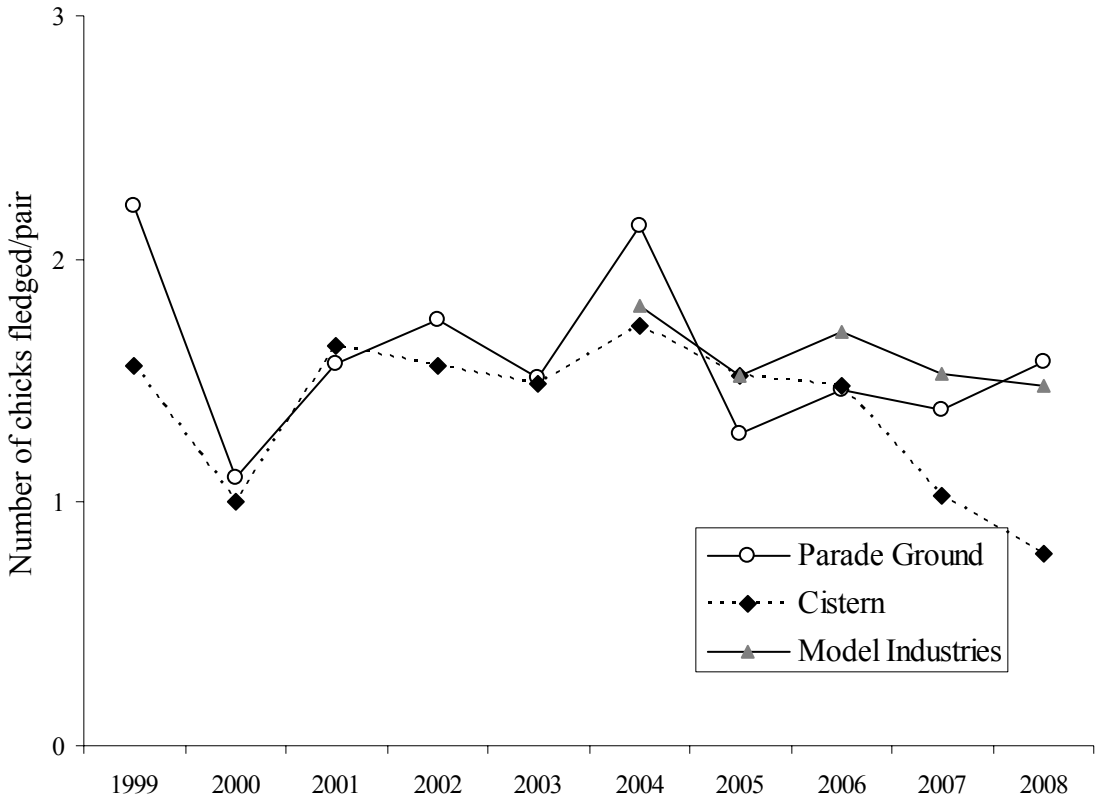

Figure 6. Western Gull productivity at three sub-colonies on Alcatraz Island, 1999-2008.

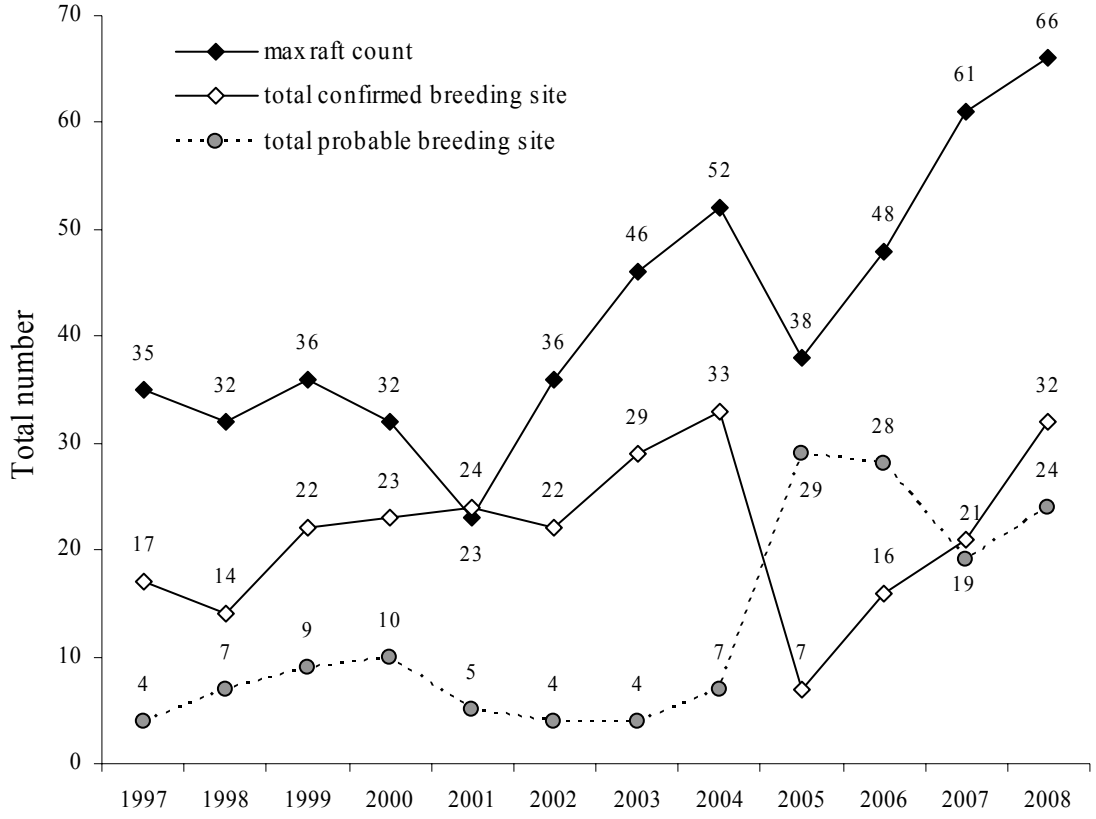

Figure 7. Pigeon Guillemot population size on Alcatraz Island, 1997-2008. "Total Confirmed Breeding Sites" reflects the minimum number of breeding pairs confirmed through observation of chicks, observing fish delivery, or post-season inspections of crevices.

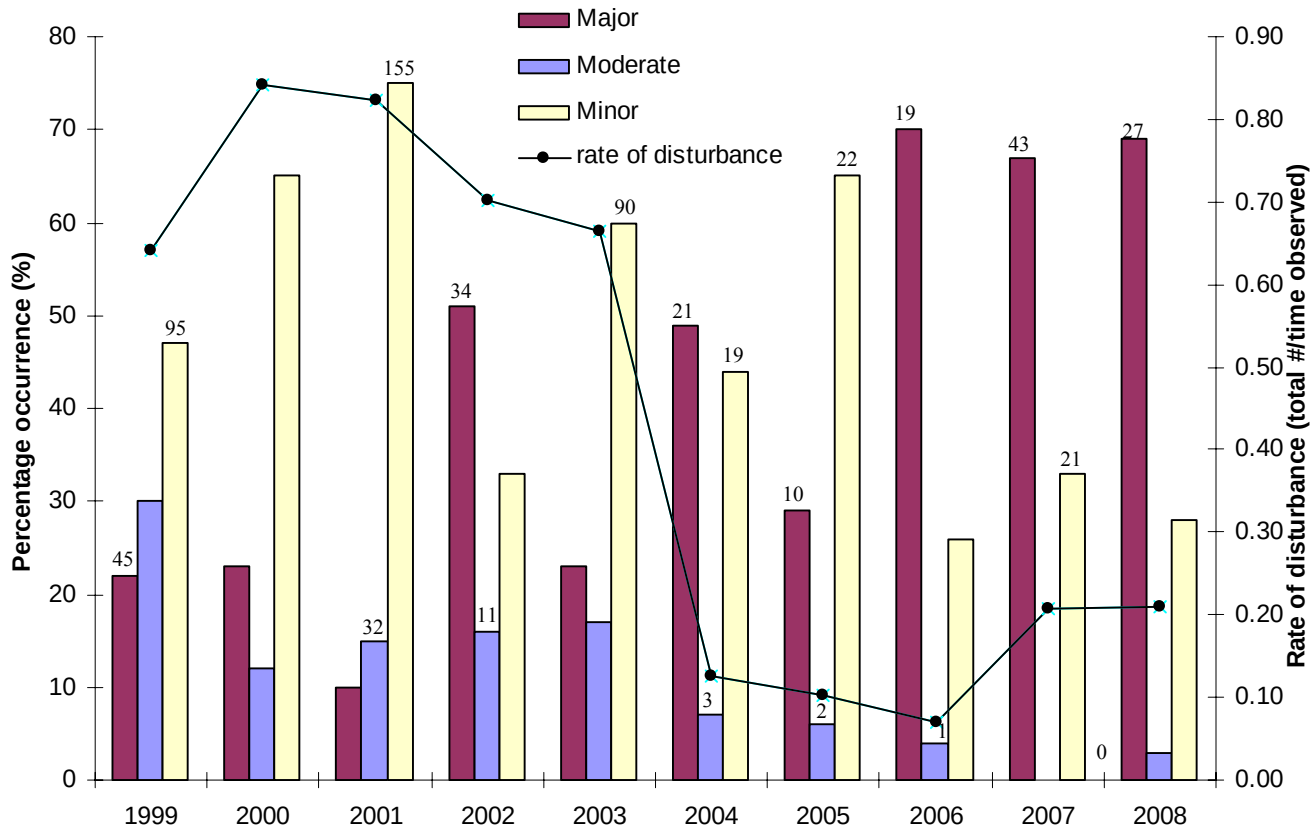

Figure 8. Left axis shows reactions of Brandt's Cormorants on Alcatraz Island to disturbance in 1999-2008. Major disturbance events caused cormorants to flush from breeding or roosting areas. Moderate disturbances caused agitation in birds such as fluffing, growling, threat gestures or standing up. Disturbance was considered minor if birds only looked in the direction of the event. Right axis shows rate of disturbance (total number of disturbances/time observed).

Table 1. Brandt's Cormorant population size on Alcatraz Island, 1991-2008.

YEAR	POPULATION ESTIMATES (breeding attempts)											SOURCE
	TOTAL	Model Industries Sub-Colony	North Foghorn Sub-Colony[5]	Laundry Sub-Colony	Northern Sub-Colony	Barker Beach Sub-Colony	Southern Sub-Colony	Gap Area[4]	South Bricks Sub-Colony[4]	Below Rubble Piles Sub-Colony[4]	East Side of island	
1991	3	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	R. Farwell/GGNRA, pers. obs.[1]
1992	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data
1993	≥ 1	0	0	0	0	0	≥ 1	0	no data	no data	no data	D. Hatch/GGNRA, unpubl. data[1]
1994	≥ 40	no data	no data	no data	no data	no data	≥ 40	no data	no data	no data	no data	R. Hothem & W. Reyes, pers. obs.[1]
1995	~ 181	0	0	0	~ 81	0	~ 100	0	0	0	0	D. Hatch/GGNRA, PRBO, unpubl. data[2]
1996	≥ 231	0	0	0	105	0	126	no data	no data	0	0	PRBO data[3]
1997	215	1	*see footnote*	11	47	0	125	24	7	0	0	PRBO data[3]
1998	125	3	*see footnote*	7	0	0	102	3	10	0	0	PRBO data[3]
1999	248	30	*see footnote*	17	63	0	118	10	10	0	0	PRBO data[3]
2000	183	37	*see footnote*	19	22	0	93	3	9	0	0	PRBO data[3]
2001	385	45	*see footnote*	19	131	0	145	38	7	0	0	PRBO data[3]
2002	463	47	*see footnote*	25	78	151	137	18	7	0	0	PRBO data[3]
2003	584	82	*see footnote*	0	136	156	146	16	48	0	0	PRBO data[3]
2004	752	88	*see footnote*	85	226	156	104	22	71	0	0	PRBO data[3]
2005	820	89	*see footnote*	123	251	172	37	17	115	16	0	PRBO data[3]
2006	1010	74	*see footnote*	145	369	196	16	0	142	68	0	PRBO data[3]
2007	1782	105	86	8	1053	213	113	18	154	73	0	PRBO data[3]
2008	1515	41	2	312	728	108	62	23	150	87	2	PRBO data[3]

[1] Incidental observation in 1991 or observation during 1993 Western Gull survey or 1994 Black-crowned Night Heron survey.
[2] Carter et al. (1996) reported 218 Brandt's Cormorant nests on Alcatraz in 1995, based on aerial photographic surveys.
[3] Observation during ground survey in 1996 or ground and boat surveys in 1997-2008.
[4] Visible only during boat surveys, apart from 2004-2007 when the Gap included some nests visible from the blind.
[5] Numbers of North Foghorn sub-colony included in Model Industries sub-colony from 1997-2008.

Table 2. Brandt's (BRCO), Pelagic Cormorant (PECO), California (CAGU) and Western Gull (WEGU) reproductive phenology on Alcatraz Island, 2008. Actual ranges may be wider due to re-lays and hard-to-see nests. Egg-laying data refers to first attempts of a pair at egg-laying, while hatching and fledging data may refer to second breeding attempts if first attempt failed. For BRCO, fledging was assumed when chicks were large enough to wander from their nests, since after that time it was difficult to assign chicks to particular nest sites. For PECO, CAGU and WEGU, fledging was assumed once chicks were fully feathered.

		EGG-LAYING DATE mean ± s.d. (n) (range)	HATCHING DATE mean ± s.d. (n) (range)
Brandt's Cormorant	Southern Sub-Colony	2 May ± 10 (12) (20 Apr - 15 May)	2 Jun ± 13 (7) (22 May - 29 Jun)
	Barker Beach Sub-Colony	1 May ± 8 (17) (20 Apr - 15 May)	4 Jun ± 7 (7) (25 May - 15 Jun)
	Northern Sub-Colony	10 May ± 8 (15) (27 Apr - 25 May)	5 Jun ± 6 (5) (1 Jun - 12 Jun)
	Laundry Building Sub-Colony	10 May ± 5 (21) (8 May - 29 May)	11 Jun ± 5 (16) (5 Jun - 26 Jun)
	Model Industries Sub-Colony	did not breed	did not breed
	North Foghorn Sub-Colony	did not breed	did not breed
	ALL SUB-COLONIES	**6 May ± 9 (65) (20 Apr -29 May)**	**7 Jun ± 8 (35) (22 May - 29 Jun)**
Pelagic Cormorant		***no data***	***no data***
California Gull		**27 May ± 0 (1) (27 May - 27 May)**	**1 Jun ± 5 (3) (27 May - 4 Jun)**
Western Gull	Cistern	13 May ± 10 (11) (24 Apr - 5 Jun)	9 Jun ± 11 (10) (29 May - 3 Jul)
	Parade Ground	7 May ± 9 (17) (24 Apr - 29 May)	3 Jun ± 7 (18) (22 May - 19 Jun)
	Model Industries	9 May ± 6 (17) (1 May - 27 May)	8 Jun ± 12 (14) (25 May - 6 Jul)
	ALL SUB-COLONIES	**9 May ± 8 (45) (24 Apr - 5 Jun)**	**6 Jun ± 10 (42) (22 May - 6 Jul)**

Table 3. Brandt's Cormorant productivity by sub-colony on Alcatraz Island, 1995-2008.

YEAR	PRODUCTIVITY							METHOD
	Southern Sub-Colony	**Northern Sub-Colony**	**Laundry Sub-Colony**	**Model Industries Sub-Colony**	**Barker Beach Sub-Colony**	**North Foghorn Sub-Colony**	**TOTAL**	
1995 (chicks/site)	2.6 (262/100)	1.1 (89/81)	(0)	(0)	(0)	(0)	**1.9** (351/181)	colony-wide, island-based and aerial photographic surveys
1996 (chicks/site)	1.7 (215/126)	2.2 (230/105)	(0)	(0)	(0)	(0)	**1.9** (445/231)	colony-wide, island-based surveys
1997 mean ± s.d. (n)	2.4 ± 1.2 (76)	2.0 ± 0.8 (24)	no data	no data	(0)	no data	**2.3** ± 1.1 (100)	focal-site analysis
1998 mean ± s.d. (n)	1.6 ± 1.0 (83)	(0)	1.7 ± 0.5 (6)	2.0 ± 0.0 (3)	(0)	included in MI Sub-Colony	**1.6** ± 1.0 (92)	focal-site analysis
1999 mean ± s.d. (n)	2.6 ± 1.0 (93)	2.1 ± 1.0 (53)	2.1 ± 1.0 (17)	2.0 ± 0.8 (24)	(0)	included in MI Sub-Colony	**2.3** ± 1.0 (187)	focal-site analysis
2000 mean ± s.d. (n)	2.5 ± 1.0 (81)	2.2 ± 1.4 (19)	2.5 ± 1.3 (17)	2.4 ± 0.9 (21)	(0)	included in MI Sub-Colony	**2.4** ± 1.1 (138)	focal-site analysis
2001 mean ± s.d. (n)	2.2 ± 1.2 (102)	1.7 ± 1.3 (80)	2.5 ± 1.3 (13)	2.2 ± 1.3 (13)	(0)	included in MI Sub-Colony	**2.0** ± 1.3 (208)	focal-site analysis
2002 mean ± s.d. (n)	2.7 ± 0.9 (43)	no data	2.8 ± 0.8 (23)	2.0 ± 1.0 (23)	no data	included in MI Sub-Colony	**2.5** ± 1.0 (98)	focal-site analysis
2003 mean ± s.d. (n)	1.9 ± 1.1 (54)	1.2 ± 1.2 (21)	(0)	1.9 ± 1.2 (44)	2.3 ± 0.7 (20)	included in MI Sub-Colony	**1.9** ± 1.1 (139)	focal-site analysis
2004 mean ± s.d. (n)	2.5 ± 1.2 (37)	2.5 ± 1.1 (35)	1.5 ± 1.3 (22)	2.6 ± 1.1 (47)	2.4 ± 1.1 (20)	included in MI Sub-Colony	**2.4** ± 1.2 (161)	focal-site analysis
2005 mean ± s.d. (n)	2.1 ± 1.0 (12)	1.9 ± 1.2 (69)	1.5 ± 1.2 (26)	2.0 ± 1.1 (41)	1.6 ± 1.0 (18)	included in MI Sub-Colony	**1.8** ± 1.1 (166)	focal-site analysis
2006 mean ± s.d. (n)	1.3 ± 1.6 (7)	1.9 ± 1.1 (65)	1.8 ± 1.3 (46)	2.2 ± 1.1 (21)	2.3 ± 1.2 (19)	included in MI Sub-Colony	**1.9** ± 1.2 (158)	focal-site analysis
2007 mean ± s.d. (n)	1.9 ± 1.0 (45)	2.4 ± 0.8 (25)	1.9 ± 1.4 (8)	1.8 ± 1.2 (20)	1.9 ± 1.1 (29)	2.4 ± 1.0 (20)	2.0 ± 1.0 (147)	focal-site analysis
2008 mean ± s.d. (n)	1.0 ± 1.1 (18)	1.6 ± 1.2 (22)	2.4 ± 0.9 (21)	no data	.8 ± 1.1 (17)	(0)	1.5 ± 1.2 (78)	focal-site analysis

Table 4. Brandt's (BRCO), Pelagic Cormorant (PECO), California Gull (CAGU) and Western Gull (WEGU) reproductive performance on Alcatraz Island, 2008. Actual ranges may be wider due to re-lays and hard-to-see nests. Data refer to first attempts only.

		CLUTCH SIZE mean ± s.d. (n)	**BROOD SIZE** mean ± s.d. (n)	**HATCHING SUCCESS** mean ± s.d. (n)	**FLEDGING SUCCESS** mean ± s.d. (n)
Brandt's Cormorant	Southern Sub-Colony	2.8 ± 0.8 (11)	.8 ± 1.3 (12)	0.4 ± 0.5 (9)	0.6 ± 0.3 (4)
	Barker Beach Sub-Colony	3.4 ± 0.9 (14)	0.6 ± 1.1 (12)	0.1 ± .3 (10)	0.9 ± 0.2 (3)
	Northern Sub-Colony	2.5 ± 0.7 (17)	1.1 ± 1.4 (14)	0.4 ± 0.5 (14)	1.0 ± 0 (6)
	Laundry Building Sub-Colony	3.3 ± 0.7 (19)	2.6 ± 1.1 (15)	0.8 ± 0.3 (13)	1.0 ± 0.1 (14)
	Model Industries Sub-Colony	***no data***	***no data***	***no data***	***no data***
	North Foghorn Sub-Colony	did not breed	did not breed	did not breed	did not breed
	ALL SUB-COLONIES	**3.0 ± 0.8 (61)**	**1.4 ± 1.4 (53)**	**0.4 ± 0.5 (46)**	**0.9 ± 0.2 (27)**
Pelagic Cormorant		***no data***	***no data***	***no data***	**1.0 ± 0 (1)**
California Gull		**3.3 ± 0.6 (3)**	**1.4 ± 1.3 (16)**	***no data***	**0.8 ± 0.3 (10)**
Western Gull	Cistern	2.4 ± 0.8 (24)	1.2 ± 1.2 (21)	0.4 ± 0.5 (18)	0.7 ± 0.3 (11)
	Parade Ground	2.9 ± 0.5 (22)	2.1 ± 0.9 (24)	0.7 ± 0.3 (22)	0.7 ± 0.4 (22)
	Model Industries	2.8 ± 0.5 (21)	2.0 ± 1.1 (17)	0.7 ± 0.4 (17)	0.8± 0.3 (14)
	ALL SITES	**2.7 ± 0.7 (67)**	**1.8 ± 1.2 (62)**	**0.6 ± 0.4 (57)**	**0.7 ± 0.4 (47)**

Table 5. Pigeon Guillemot reproductive phenology on Alcatraz Island, 2008. Adults are censused from April through August, and activity on the water and at nesting areas on the south cliffs is noted until no remaining guillemots are sighted. Crevices cannot be regularly monitored, as many are in cormorant colonies or out of reach. Presence of chicks is confirmed by delivery of fish to the nest site by the parent or by incidental sightings of chicks.

First adults seen rafting on water	First adults seen on cliffs/ at nest sites	First fish delivery seen	Last fish delivery seen
25 Mar	3 Apr	7 Jun	24 Jul

Table 6. Summary table showing frequency (and percentage) of types of disturbances to Brandt's Cormorants on Alcatraz Island, 1997-2008.
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Type of Disturbance		Number of disturbances observed											
		1997 (206 hrs)	**1998** (227 hrs)	**1999** (313 hrs)	**2000** (216 hrs)	**2001** (251 hrs)	**2002** [1] (96 hrs)	**2003** [2] (224 hrs)	**2004** [2] (340 hrs)	**2005** (334 hrs)	**2006** (363 hrs)	**2007** (308 hrs)	**2008** (186 hrs)
External:	**Marine traffic**	**38** (51%)	**28** (30%)	**98** (49%)	**97** (48%)	**79** (38%)	**22** (33%)	**92** (62%)	**17** (40%)	**17** (50%)	**8** (30%)	**35** (55%)	**24** (62%)
	Air traffic	**20** (27%)	**18** (19%)	**59** (29%)	**61** (30%)	**102** (49%)	**23** (34%)	**47** (32%)	**14** (33%)	**13** (38%)	**7** (26%)	**7** (11%)	**4** (10%)
	Other	**2** (3%)	**4** (4%)	**10** (5%)	**24** (12%)	**9** (4%)	**0** (0%)	**1** (1%)	**4** (9%)	**1** (3%)	**1** (4%)	**3** (5%)	**0** (0%)
Island-Based:	**Human interference**	**5** (7%)	**5** (5%)	**3** (1%)	**1** (0%)	**0** (0%)	**13** (19%)	**3** (2%)	**5** (12%)	**1** (3%)	**9** (33%)	**6** (9%)	**7** (18%)
	Interspecies event	**3** (4%)	**23** (24%)	**26** (13%)	**12** (6%)	**10** (5%)	**7** (10%)	**4** (3%)	**1** (2%)	**2** (6%)	**1** (4%)	**0** (0%)	**3** (8%)
	Other	**0** (0%)	**1** (1%)	**0** (0%)	**0** (0%)	**0** (0%)	**0** (0%)	**0** (0%)	**0** (0%)	**0** (0%)	**1** (4%)	**0** (0%)	**0** (0%)
Unknown Cause:		**6** (8%)	**15** (16%)	**5** (2%)	**8** (4%)	**5** (2%)	**2** (3%)	**2** (1%)	**2** (5%)	**0** (0%)	**0** (0%)	**6** (9%)	**1** (3%)
Total:		**74**	**94**	**201**	**203**	**207**	**67**	**149**	**43**	**34**	**27**	**64**	**39**
Rate of disturbance[3]		**0.36**	**0.42**	**0.65**	**0.84**	**0.82**	**0.70**	**0.67**	**0.13**	**0.10**	**0.07**	**0.21**	**0.21**

[1] The total hours observed was reduced in 2002 due to observer inconsistency.
[2] In 2003-2008, includes extra disturbance monitoring on the North End of the island.
[3] This rate represents the minimum number of disturbances per hour. Observers could not see the whole island at once, therefore the actual disturbance rate is likely to be higher.