Ecological Studies of Seabirds on Alcatraz Island, 2007

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 2007, 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, 2007.

Populations of Brandt's Cormorants, gulls, and Pigeon Guillemots on Alcatraz in 2007 increased, while the Pelagic Cormorant population decreased. Overall productivity of seabirds was lower than long-term averages.

The Brandt's Cormorant breeding population increased by 76% since 2006 to 1782 breeding pairs, the largest yet recorded for this colony. In 2007, several sub-colonies expanded, including the North Foghorn, Barker Beach, and Northern sub-colonies, while the Laundry Building sub-colony decreased significantly. Productivity of Brandt's Cormorants was 2.0 chicks fledged/pair in 2007, slightly lower than the average 2.1 chicks fledged/pair in the past 9 years. The mean lay date in 2007 was 30 April.

The Pelagic Cormorant population has decreased by 70% since 1996 to only 6 breeding pairs in 2007. Pelagic Cormorant productivity was only 0.4 chicks fledged/pair, an all time low and well below the 7-year average of 1.7 since 1999. Western Gull breeding numbers increased only slightly to 1037 breeding pairs in 2007 (not including nests removed under the NPS depredation permit) from 1033 pairs in 2006. Western Gulls fledged an average of 1.3 chicks/pair in 2007, lower than the long-term mean. We confirmed 21 Pigeon Guillemot sites in 2007, 5 more than in 2006, but still less than the peak of 33 confirmed sites in 2004. One pair of Black Oystercatchers bred on the Seawall in 2007, but after losing the eggs they moved for the first time to the east side of the island near the Powerhouse where they relaid but failed a second time. We first discovered California Gulls breeding on Alcatraz in 2004. Since then, this small colony behind the rubble piles on the Parade Ground has grown to 23 pairs and fledged an average of 1.6 chicks fledged/pair in 2007.

We documented 64 disturbances to Brandt's Cormorants in 2007 during about 308 hours of observation. The majority of disturbance was due to kayaks and canoes, as well as other marine-based causes. In particular gunshots from sailboat races held in the bay became a new cause of disturbances throughout the season. The rate of disturbance was at its highest since 2003 and we are beginning 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 re-installation of a 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. The NPS Wildlife Biologist position is an important component for managing and protecting seabird colonies on Alcatraz.

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, Black-crowned Night Heron, and Pelagic Cormorant 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. Over 1 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 2007 breeding season.

Our objectives in 2007 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, 2007. Island surveys consisted of censuses and focal nest observations twice per week, on Wednesdays and 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 once every two weeks. 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 twice weekly, 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 every two weeks by boat. During each survey, we recorded the total number of adults, immature birds, nests with incubating birds, and total number of chicks in each sub-colony.

We investigated Brandt's Cormorant reproductive phenology and performance in a sample of nests from the Southern, Barker Beach, Northern, Laundry, Model Industries, and North Foghorn 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 2007, all nests were monitored. Nests were numbered and mapped, and the contents of each nest recorded twice weekly (number of eggs and/or chicks), with 3 or 4 days separating observations. 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). In 2005, due to their sensitive location, they were only monitored during the Western Gull censuses. Since 2006, monitoring of California Gulls was made possible by access to the colony during Black-crowned Night Heron surveys (for a total of 1 trip during the months of May) in addition to one visit made to the colony during the Western Gull census.

In addition to these visits 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 second 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. 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 between 2-4 April 2007, which is detailed in Acosta et al. (2007).

RESULTS AND DISCUSSION

BRANDT'S CORMORANT

Brandt's Cormorants continued their population growth, increasing from 1010 breeding attempts in 2006 to 1782 in 2007, the largest number recorded for this colony to date (Figure 2). This increase equals approximately 76% growth, the highest increase between years to date. The increase in Brandt's Cormorant breeding population size may be due to a combination of factors, discussed both here and below in the *Disturbance* section. Many prior years of high productivity (mean of 2.1 chicks fledged/pair between 1996-2006), combined with movement of cormorants from offshore to inshore colonies (Thayer and Lindquist 2007) and recruitment from other colonies (Southeast Farallon Island, Año Nuevo Island, and Point Reyes Headlands) likely contributed to the population increase on Alcatraz.

We observed an increase in breeding attempts in most sub-colonies, yet a large decrease occurred at the Laundry Building sub-colony (Table 1). There was a large increase in the size of the Southern sub-colony (including the Gap area) from 16 attempts in 2006 (down from previous years) to 131 attempts in 2007. The North Foghorn sub-colony increased from no breeding attempts in 2006 to 86 attempts in 2007. The largest increase occurred at the Northern sub-colony with 1053 nests in 2007, nearly tripling in size compared to the number of nests in 2006. The Laundry Building sub-colony decreased in size from 145 nests in 2006 to only 8 nests in 2007 (94% decrease), and nests were established far from the Laundry Building on the cliffs. This was most likely due to disturbances from a special event held in the Laundry Building in early April, just prior to cormorant breeding (see Acosta et al. 2007). We obtained maximum counts of 105 nests in the Model Industries sub-colony and 213 nests in the Barker Beach South sub-colony from a combination of island and boat surveys. The southernmost end of the island had a slight increase in the amount of nesting birds with 154 nests in the South Bricks sub-colony, and 73 nests Below Rubble Piles (Figure 1). No nesting attempts were seen at North Perimeter, just north of the Powerhouse, however it remains an important area for birds to roost and gather nesting material.

Brandt's Cormorants first began showing signs of breeding activity in mid to late March in 2007 (Figure 3). The first eggs were laid on or before 4 April in the Barker Beach sub-colony and mean lay date was 15 April (Table 2). Mean lay dates for the Model-Industries, Southern, and Northern sub-colonies were 28 April, 8 May, and 4 May, respectively. The Laundry Building sub-colony formed later in the season and subsequently had the latest mean lay date of 15 May. All chicks had fledged by 29 August, but some remained at sub-colonies after regular monitoring ceased at this time.

Although the breeding population increased, productivity of Brandt's Cormorants on Alcatraz in 2007 was lower than but approaching the long-term mean. After poor ocean conditions in terms of upwelling and coastal sea surface temperatures (SST) in 2005-2006, SST in 2007 was lower than the long-term average (1925-2007; shorestation.ucsd.edu/active/index_active.html#farallonstation). Cool SST's in the California Current System are usually associated with increased ocean productivity (Chavez ***et al.*** 2002). Between 1997 and 2006, productivity of Brandt's Cormorants has fluctuated around a mean of 2.1 chicks per pair. Productivity was 2.0 in 2007, a slight increase since it dropped in 2005 (Figure 4). The Model Industries sub-colony had the lowest productivity of areas monitored in 2007, at 1.8 chicks per pair (Table 3) while the Northern and North Foghorn sub-colonies had the highest productivity at 2.4 chicks per pair (Table 3). Productivity on Alcatraz was lower than other central California colonies which averaged 2.3 chicks/pair (Thayer and Lindquist 2007, Warzybok ***et al.*** 2007). No double broods were observed in 2007.

PELAGIC CORMORANT

The Pelagic Cormorant population has decreased by 70% since 1996 ($\beta = -1.1$, $p < 0.01$; $R^2 = 0.7$; n = 12 years). Only 6 Pelagic Cormorant breeding attempts were recorded in 2007 (Figure 5). All nests were 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 21 March 2007. Egg laying began on 25 April, the earliest since 2004 (Table 2), however lay dates were rather asynchronous with the latest lay date over 4 weeks later on 30 May. Mean lay and fledge dates were 14 May and 1 Aug, respectively. Pelagic Cormorant productivity in 2007 was 0.4 chicks/pair, the lowest yet recorded since monitoring began in 1999 (Figure 4). This was, however, higher than the 0.12 chicks/pair produced on the Farallones in 2007 (Warzybok *et al.* 2007), possibly related to differences in estuarine vs. pelagic prey availability.

Several factors may have negatively affected Pelagic Cormorants breeding in recent years. Pelagic Cormorant breeding attempts decreased notably in 2003 and 2005 (Figure 5), and productivity declined sharply starting in 2004 (Figure 4). First of all, the warm-water 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. Finally, a special event in early April 2007 may have negatively influenced Pelagic Cormorant breeding this year.

WESTERN GULL

Western Gull breeding numbers have been on the rise for the past several years, but have slowed their increase in the past three years ($\beta = 47$, $p < 0.01$; $R^2 = 0.96$; n = 9). The Western Gull population reached 1037 breeding pairs in 2007 (Figure 2), not including 113 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 2007 were observed on 25 April, and the mean lay date was 12 May (Table 2), extremely consistent with the past several years, 1999-2006. The average hatch date was 10 June. Western Gull hatching success and fledging success was 0.7 (Table 4). Productivity was 1.3 chicks per pair in 2007 (Figure 6), below the mean since 1999. However, when compared to other central California colonies, productivity on Alcatraz was higher than the 1.1 chicks fledged per pair each on Año Nuevo Island (Thayer and Lindquist 2007) and the Farallones (Warzybok *et al.* 2007).

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 increased to 46 birds (23 nests) in 2007, including an occasional pair attempting to breed outside of the small colony behind the Rubble.

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 2 May.

The average hatch date was 6 June (Table 2). California Gull hatching success was 0.8 and fledging success was 0.9 (Table 4), slightly higher than that for Western Gulls. Productivity was 1.6 chicks per pair in 2007, similar to the 1.7 chicks per pair in 2006.

PIGEON GUILLEMOT

In 2007, we first detected Pigeon Guillemots around Alcatraz on 21 March, and attending nest sites on the island on 31 March (Table 5). A high count of 61 adults was recorded on 16 May, the highest count of Pigeon Guillemots since monitoring began in 1997. We confirmed 21 Pigeon Guillemot nest sites in 2007, the highest since 33 sites were confirmed in 2004; about average for the number of confirmed sites since 1997. Additionally, we observed 19 probable nesting sites around the island (Figure 7). With high numbers of adults and unconfirmed breeding sites, it is likely that many guillemots attended sites but did not breed. Since ocean conditions in terms of upwelling and SST were not very anomalous in 2007, it is possible that guillemot breeding attempts were low due to poor adult body condition after several years of poor ocean conditions and reduced or altered prey abundance**.**

Out of 30 nest boxes placed around the island in February 2006, one box under the blind in the Southern sub-Colony was used. One pair of adults laid 2 eggs by 23 May and the chicks hatched by 20 June; but both were dead by 27 June. The breeding pair re-laid one egg by 11 July, but was not successful at hatching. 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 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.

BLACK OYSTERCATCHER

A single pair of Black Oystercatchers attempted to breed on the Seawall in 2007. Adults were seen at the Seawall and around the island regularly from 28 February to 18 July. Eggs were laid at their nesting location at the seawall by 16 May. A total of 3 eggs were laid, but were gone by 30 May; most likely due to the close proximity of many Brandt's Cormorants roosting at the seawall. After this first attempt, the pair moved to the east side of island along the lower walkway near the Powerhouse by 20 June. There, they laid up to 2 eggs by 4 July, but eggs and birds were gone by 25 July. 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 increased in 2007 to 0.21 disturbances per hour, compared to 0.07 disturbances per hour in 2006. This is the highest frequency of disturbances since 2003 (Table 6) and together with additional monitoring during a special event in April (see Acosta et al. 2007), we suspect that cumulative effects of disturbance may cause increased behavioral sensitivity in Brandt's Cormorants. A total of 43 major disturbances accounted for about 67% of the total number of disturbances; the highest since monitoring began in 1999. No moderate disturbances were observed, while 21% came from minor disturbances (Figure 8).

In 2007 the presence of kayaks and other non-motorized watercraft moving slowly, quietly and/or erratically while close to the shoreline of the island caused the largest portion of the major disturbances to Brandt's Cormorants. This caused 23% of all major disturbances, while motorized boats approaching too close were responsible for 19% of major disturbances. Other big offenders were air-based disturbances

such as helicopters, or noise-based disturbances. Island-based disturbances decreased, but only slightly compared to 2006 (Table 6).

The greatest causes of major disturbances in 2007 were marine-based disturbances. Many came from kayaks and canoes, often causing more than one flushing event in a single day. On 31 March, 2 canoes flushed 450 cormorants between the Northern and Southern Sub-colonies. About 1 hour later, a kayak flushed 100 more cormorants within the same areas, causing the birds to abandon and lose nesting material. On 7 April, 2 separate groups of kayaks (a total of 16) approached the North Foghorn and Model Industries Buildings within 100 feet causing 75 cormorants to flush from nesting sites. Later in the day, another boat near the Barker Beach and Southern sub-colonies flushed 185 birds. An additional 2 separate disturbances of unknown cause resulted in over 300 birds flushing from the colony on 7 April. No marine-based disturbance was seen in the area during these unknown flushing events. Birds could have been affected by an island-based event and were most likely already at a heightened state of awareness due to the prior disturbances experienced throughout the day. These dates coincided with preparation for a planned special event that took place on 3 April (see Acosta et al. 2007).

Other events that caused major disturbances were gunshots related to sailboat races in the bay. In the past, the gunshots or other loud noises from a distance have resulted only in minor disturbances that caused cormorants to become startled or look in the direction of the disturbance. In 2007, these gunshots caused a total of 6 recorded flushing events along with additional minor disturbances. On 12 May, these shots caused cormorants to leave their nesting or roosting sites a total of 4 different times throughout the day. In addition to the gunshots, multiple aircraft flying 1000 feet above the island (considered a safe distance) at different times caused a total of 160 birds to flush. This is another example demonstrating that the high level of disturbance in 2007 may have resulted in cumulative effects that increased the behavioral sensitivity of Brandt's Cormorants.

On several occasions, human disturbance caused cormorants to flush from nesting sites. On 14 July, 2 visitors crossed barricades near the metal detector in order to attempt to enter the Laundry Building at the south end. Once they found this door was locked, they headed back to the public area. This flushed 35 birds from the nearby Northern sub-colony, but had the potential to flush many more if the visitors had not left immediately. Similarly, on 23 August, 1 visitor flushed 200 Brandt's Cormorants by entering the same area and walking within 50 feet of the sub-colony before a ranger stopped the visitor. During an extra 3 days of disturbance monitoring for a planned special event, we recorded 2 more incidents when visitors were found in the closed areas at the south end of the Laundry Building causing large flushing events (see Acosta et al. 2007). If the visitors on any of these events continued to walk into or past the sub-colony, a much greater disturbance such as colony abandonment could have resulted, as it takes only one ill-timed disturbance to potentially cause colony failure.

In past years, a dense, single-layer shade cloth was installed on the fence between the Model Industries Building and the Laundry Building to provide a visual barrier between breeding birds and recently-opened (in 2004) public access at the Model Industries Plaza. In 2006, this shade cloth was removed. Due to its removal, the number of island-based human-caused disturbances has increased. Although public access was restricted to this area, some staff and researchers still required access to the Model Industries Building. The lack of this shade cloth allowed birds to see humans walking to and from the building, causing birds to flush from breeding areas twice during regular monitoring in 2007. Because researchers have been trained to slowly and quietly pass birds and react adaptively based on their reactions, no eggs or chicks were recorded to have been left unattended or abandoned from this disturbance. Nevertheless, despite researcher caution in this area, several nests were likely negatively impacted as evidenced by cormorant behavior. In addition, if other staff or visitors unaware of the potential to disturb breeding birds were to enter this area, disturbance could be much more severe. Therefore, some form of visual barrier is at this location is

necessary, in addition to increased awareness and sensitivity to wildlife on the part of the rangers and other NPS staff accessing the area.

Brandt's Cormorant breeding attempts increased in 2007 despite observed disturbance from the special event early in the season, but some background is necessary to understand population dynamics in a long-lived seabird. Population increases for Brandt's Cormorants are influenced not only by current ocean conditions promoting breeding attempts, but also cumulative effects of ocean and other conditions 3-6 yrs prior to determine number of birds available to breed, and not just on the colony in question but sometimes also other colonies in the region if immigration occurs. If cormorants had a high rate of productivity as well as subsequent good winter offspring survival, then the population will increase when offspring recruit into the breeding population (mean 3-6 yrs of age). For 2007, this coincides with 2001-2004 which exhibited the most favorable marine conditions in central California in the last 2 decades. Since we did observe negative effects of the April 2007 special event on the Alcatraz Laundry Building subcolony, it is likely that the observed island population size was below that which would have otherwise been observed based just on the very favorable prior ocean conditions and the decreasing 2007 sea temperatures. Additionally, the disturbance from the special event may have also resulted in movement of some cormorants from the Laundry Building to other subcolonies potentially resulting in lower productivity for those later-established nests on other subcolony peripheries (see Acosta et al. 2007). Mean productivity levels for cormorants on Alcatraz in 2007 were lower than at other central California colonies (Thayer and Lindquist 2007, Warzybok *et al.* 2007). Current productivity levels affect population dynamics in the future.

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 is increasing, increasing responses to disturbance were observed this year and productivity was lower than at other colonies in the region. Additionally, Brandt's Cormorants sub-colonies exhibited different productivity rates - the North Foghorn sub-colony fledged 2.4 chicks/pair in 2007 while the adjacent Model Industries sub-colony fledged only 1.8 chicks/pair (Table 1). This could be influenced by differential exposure to marine traffic as well as island-based disturbances. The Model Industries sub-colony is in view of marine vessels approaching from both the south and west sides of the island, and is in close proximity to the Laundry Building (which had increased staff and visitor access due to a special event, but less visual protection due to removal of the shade-cloth visual barrier mentioned above). 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 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. Therefore, managers should be aware of effects of environmental conditions and prey resources as well as human disturbance.

CONCLUSIONS AND RECOMMENDATIONS

The Brandt's Cormorant population increased substantially in 2007, while breeding populations of Western Gulls, California Gulls and Pelagic Cormorants stabilized or increased just slightly. Pigeon Guillemot population was the highest yet recorded since 1997 and numbers of confirmed breeding sites increased over the past couple years. The increase in Brandt's Cormorants was likely influenced by relatively high productivity on Alcatraz in the past decade as well as recruitment from other nearby colonies (Southeast Farallon Island, Año Nuevo Island, and Point Reyes Headlands). The Pelagic Cormorant population remained at only 30% of the breeding population size in the mid to late 1990s. Pigeon Guillemot monitoring suggested that birds are present but not all have opted to breed in recent years. The Pelagic Cormorant population, however, seems to have exhibited a real decline. They may be affected not only by the recent warm-water conditions but also negatively impacted by increased human disturbance near nest sites in recent years, as well as the continued growth of the Brandt's Cormorant population in terms of nest site competition.

Productivity of Brandt's and Pelagic Cormorants and Western Gulls was lower than long-term averages. For Brandt's Cormorants and Western Gulls, productivity increased from 2005-2006. However, Pelagic Cormorant productivity was lower than ever previously recorded on Alcatraz. Brandt's Cormorant productivity was also lower on Alcatraz than other coastal colonies in the past three years, reversing a trend of higher productivity than other colonies in 2002-2004. In other words, during favorable marine conditions (high upwelling and low SST), 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). 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 a population 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). 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, visual and noise barriers should be in place well before the breeding season commences, and extreme caution should be exercised by people in this area to help prevent disappearance of Pelagic Cormorants from Alcatraz Island.

In addition to protection of Pelagic Cormorants, re-installation of the visual barrier between human-access areas and breeding birds at the Model Industries and Laundry Buildings will also help reduce disturbance to Brandt's Cormorants and other nesting waterbirds in this area. This is important if any staff or visitors are to have access to the Laundry Building and Model Industries Plaza. We continue to recommend a more rigid and durable barrier than the double-layer shade cloth fastened along the chain link fence between the Model Industries and Laundry Buildings, since this becomes very tattered and flaps in the wind, requiring maintenance during the breeding season that could cause disturbance. Alternatives could consist of a rigid visual barrier (e.g. plywood, or wooden/vinyl slats), or tall, dense plantings (permanent, or temporary in pots) along the west side of the fence that would screen breeding birds from human activities as well as provide a pleasant visual barrier in comparison to the shade cloth. Plantings have the additional advantage of not requiring staff time for seasonal installation/removal and maintenance.

Disturbance to seabirds increased in 2007 and the number of major disturbances was the highest since monitoring first began in 1999. Although kayaks, canoes, and powerboats have been big offenders of major disturbances for many years, aircraft overflights are also a continuing offender. Equal to the disturbances caused by aircraft, gunshots from sailboat races in the bay also contributed to major disturbances that occurred throughout the season. Human interference also continues to cause disturbance to Brandt's Cormorants. These island-based human disturbances are potentially the easiest to control. Visual barriers can be installed where needed, and signs can be posted in front of all closed areas. The signs could not only warn visitors of fines for entry into hazardous closed areas, but also be educational, explaining the presence of the seabird colony and why it is important to stay behind barricades and view from a distance. Coordination of both law enforcement and outreach staff in this endeavor is crucial. Special use permits for either air-based or marine vessels near the island should be carefully regulated to avoid any conflicts such as those that have occurred in the past. Regulation of on-island special use permits is also important. 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 needs to be allocated towards this purpose.

Island-based disturbance to cormorants by U.S. Coast Guard personnel and contractors was not recorded in 2007. 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 resources 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 resources 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.
- Make visual barriers between humans and breeding birds more rigid and durable to increase effectiveness, especially in the Model Industries and Laundry Building areas (including the area at the Metal Detector). Specifically, re-install some form of visual barrier between cormorant sub-colonies and Model Industries walkways.
- 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 cross 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

Research Recommendations

- Continue ongoing monitoring of colony breeding success and disturbance monitoring
- 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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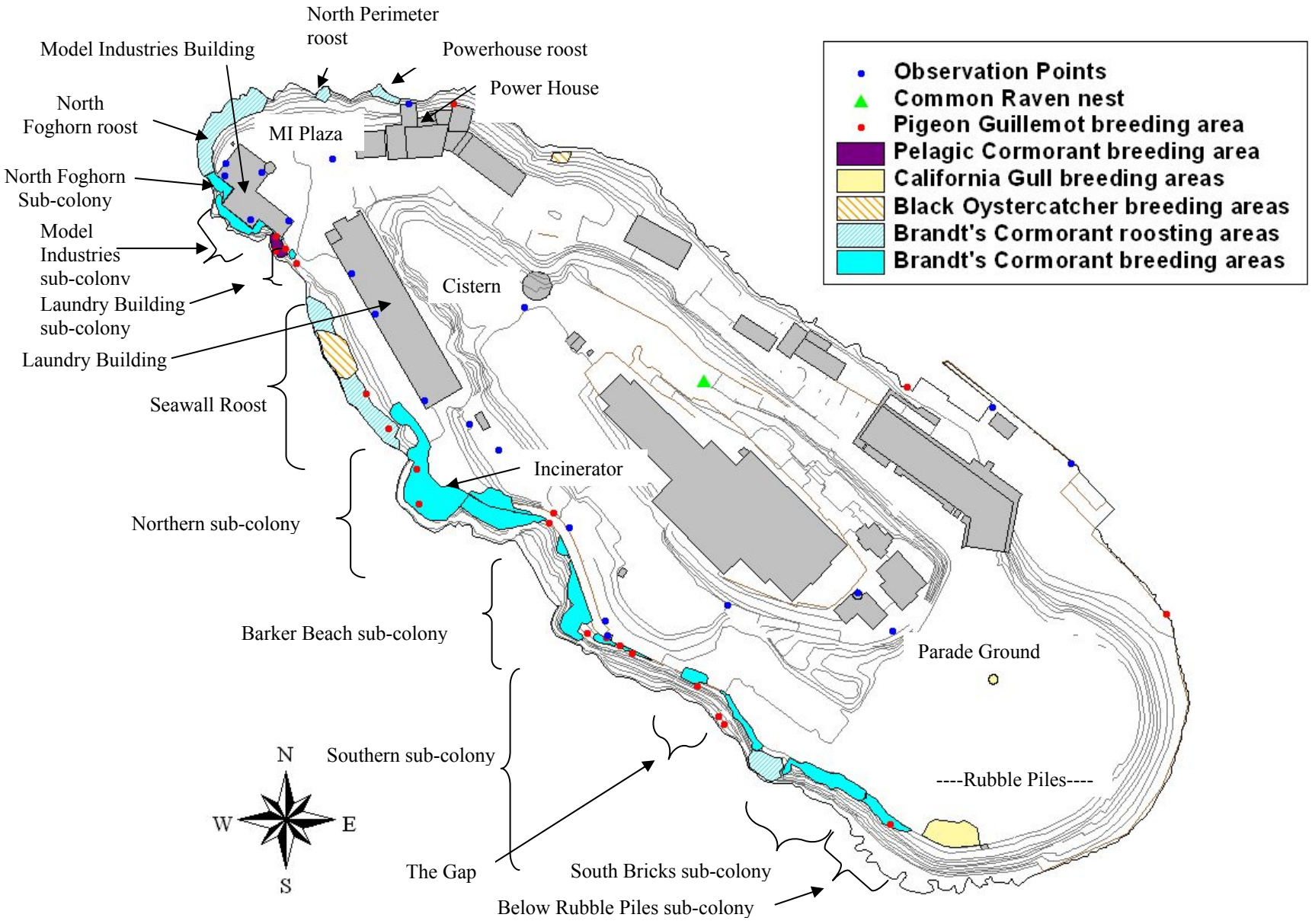

Figure 1. Alcatraz Island seabird breeding areas, survey observation points, and significant structures, 2007.

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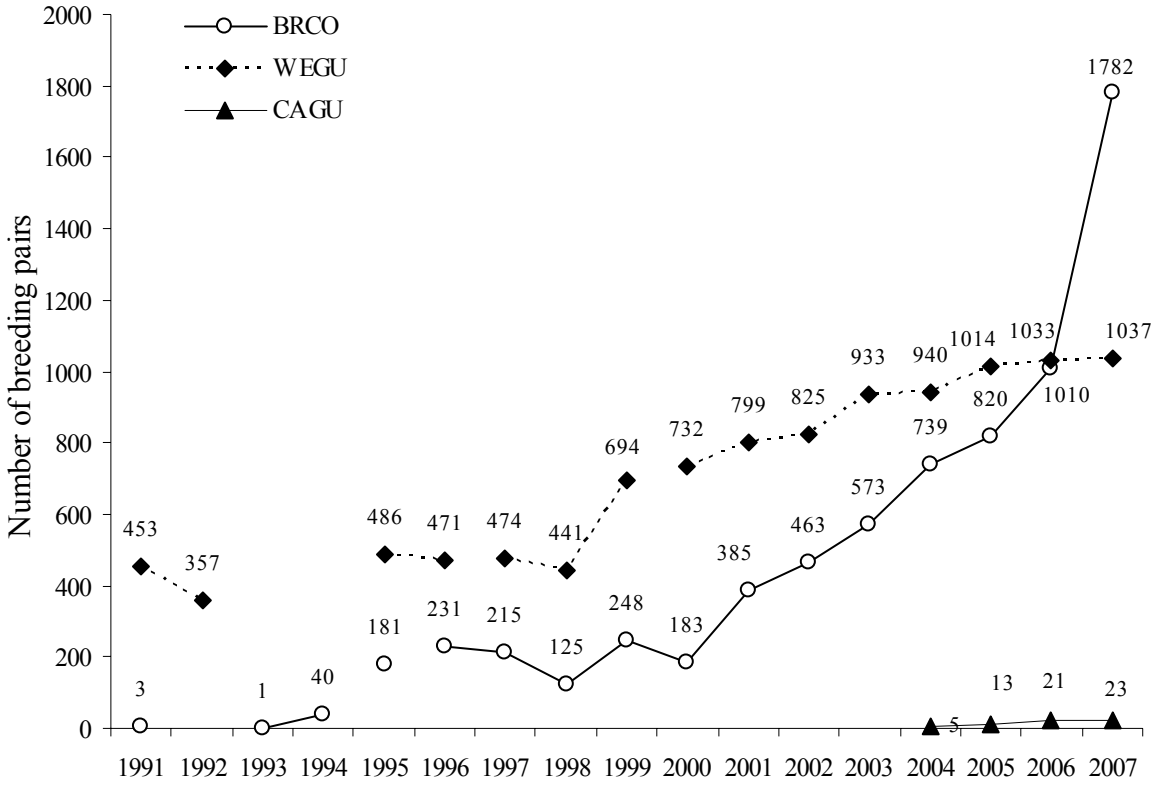

Figure 2. Brandt's Cormorant (BRCO), Western Gull (WEGU), and California Gull (CAGU) breeding population size on Alcatraz Island, 1990-2007. Data represent the minimum number of breeding pairs on Alcatraz. Breaks in data indicate a change in observers and/or census methodology. BRCO data in 1991 from 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).

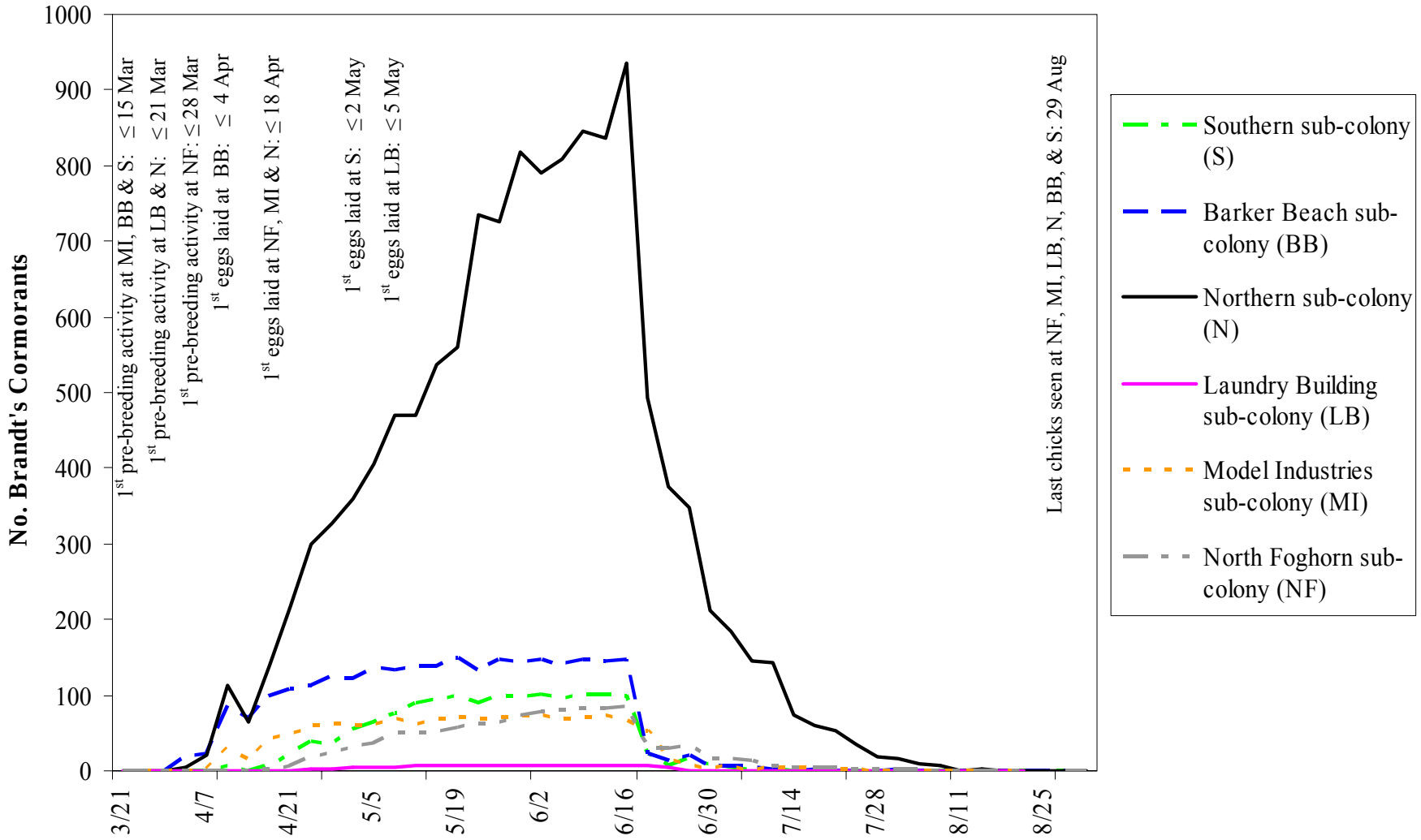

Figure 3. Dynamics of six Brandt's Cormorant sub-colonies on Alcatraz Island, 2007. Number of active Brandt's Cormorant nests (well-built nests with eggs/small chicks or birds in incubation posture) are shown for each sub-colony. Shown are the number of active Brandt's Cormorant nests (well-built nests with birds in incubation posture, or with eggs/small chicks) in each sub-colony.

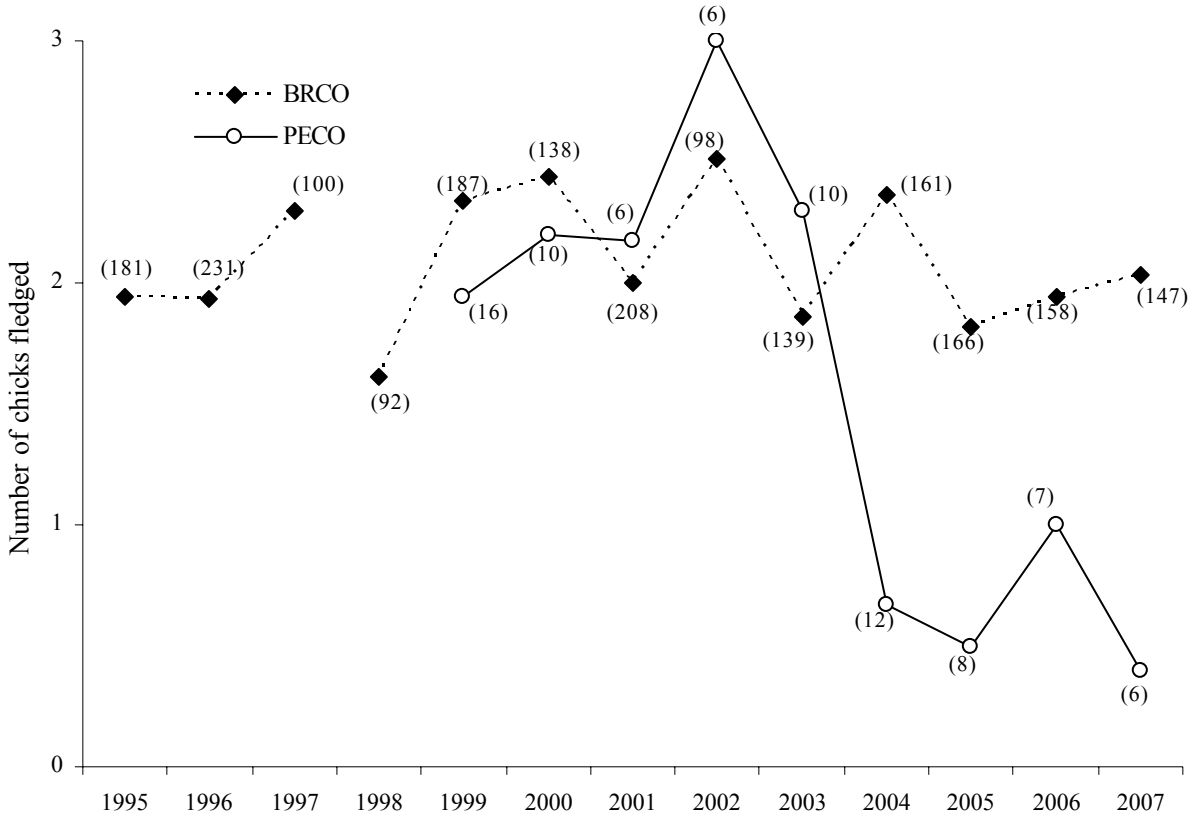

Figure 4. Overall Brandt's (BRCO) and Pelagic (PECO) Cormorant productivity on Alcatraz Island, 1995-2006. Sample size is in parentheses. Productivity in 1995-1997 was calculated from total chick counts. Productivity in 1998-2007 was calculated from number of chicks fledged per pair monitored.

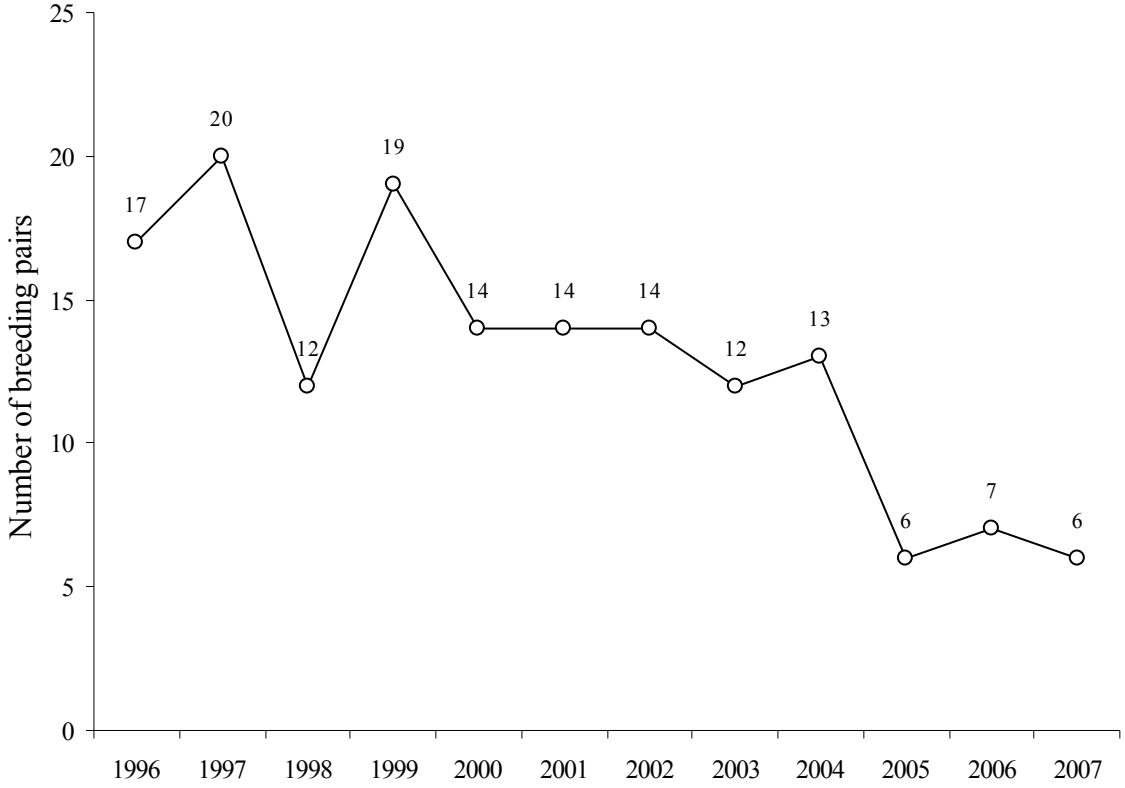

Figure 5. Pelagic Cormorant breeding population size on Alcatraz Island, 1996-2007. Data in 1996 from M. Parker/USFWS aerial surveys.

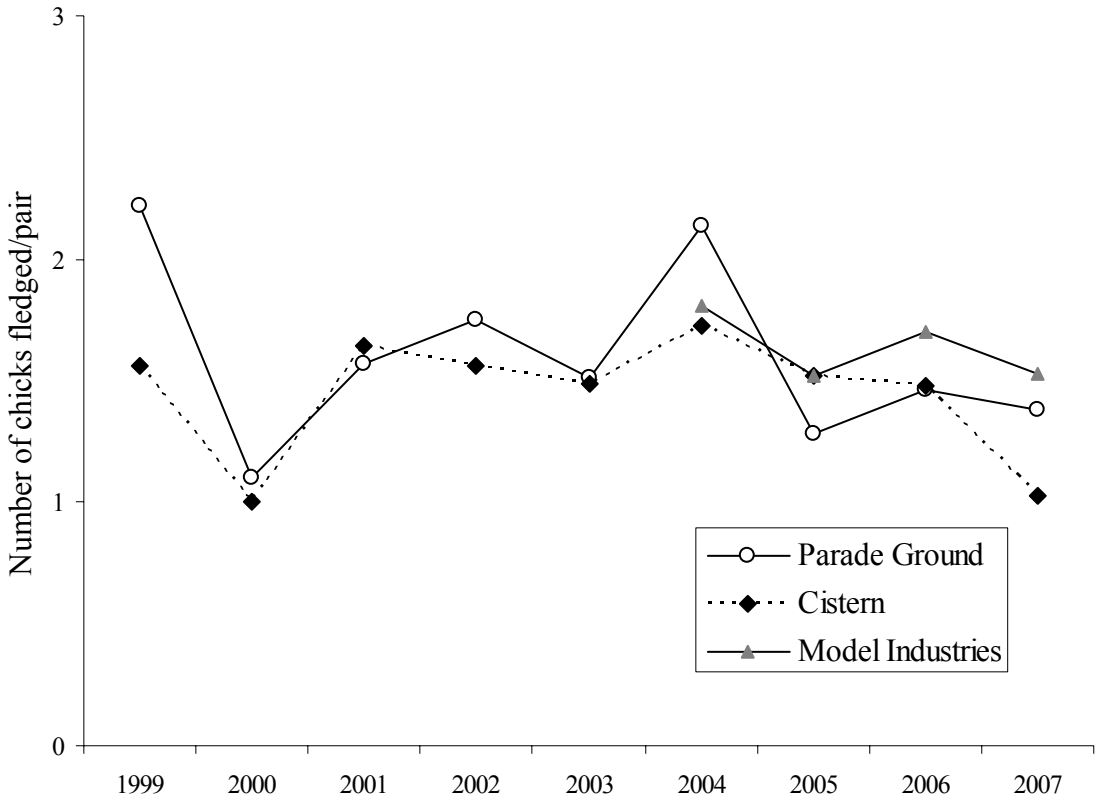

Figure 6. Western Gull productivity at three sub-colonies on Alcatraz Island, 1999-2007. Make line for MI a dark gray long-dashed line (to stand out from black, and from solid and short-dashed).

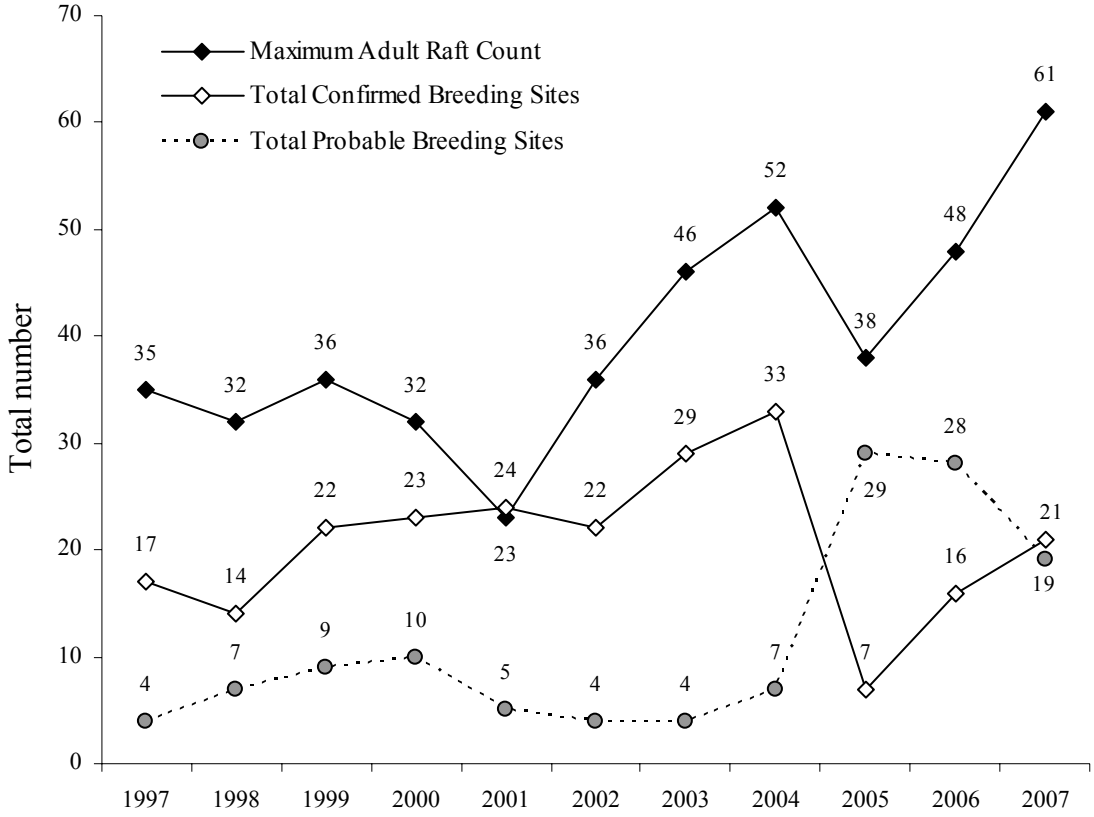

Figure 7. Pigeon Guillemot population size on Alcatraz Island, 1997-2007. "Total Confirmed Breeding Sites" reflects the minimum number of breeding pairs confirmed through known box sites, observing fish delivery, or post-season inspections of crevices.

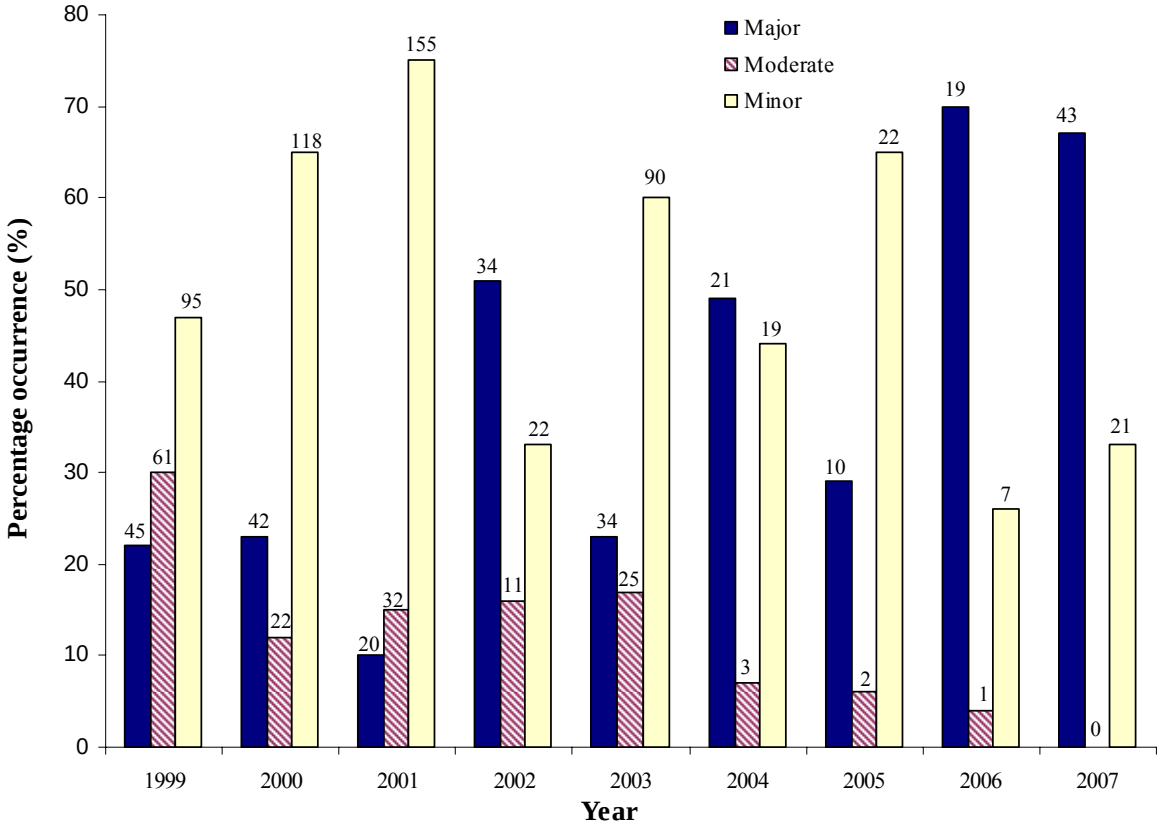

Figure 8. Reactions of Brandt's Cormorants on Alcatraz Island to disturbance in 1999-2007. Major disturbance events caused cormorants to flush from breeding or roosting areas. Moderate disturbances caused agitation in birds such as fluffing, growling, threat gestures or standing up. Disturbance was considered minor if birds only looked in the direction of the event.

Table 1. Brandt's Cormorant population size on Alcatraz Island, 1991-2007.

YEAR	POPULATION SIZE (breeding attempts)										SOURCE
	TOTAL	Model Industries Sub-Colony	North Foghorn Sub-Colony	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]	
1991	3	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
1993	≥ 1	0	0	0	0	0	≥ 1	0	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	R. Hothem & W. Reyes, pers. obs.[1]
1995	~ 181	0	0	0	~ 81	0	~ 100	0	0	0	D. Hatch/GGNRA, PRBO, unpubl. data[2]
1996	≥ 231	0	0	0	105	0	126	no data	no data	0	PRBO data[3]
1997	215	1	included in MI Sub-Colony	11	47	0	125	24	7	0	PRBO data[3]
1998	125	3	included in MI Sub-Colony	7	0	0	102	3	10	0	PRBO data[3]
1999	248	30	included in MI Sub-Colony	17	63	0	118	10	10	0	PRBO data[3]
2000	183	37	included in MI Sub-Colony	19	22	0	93	3	9	0	PRBO data[3]
2001	385	45	included in MI Sub-Colony	19	131	0	145	38	7	0	PRBO data[3]
2002	463	47	included in MI Sub-Colony	25	78	151	137	18	7	0	PRBO data[3]
2003	584	82	included in MI Sub-Colony	0	136	156	146	16	48	0	PRBO data[3]
2004	752	88	included in MI Sub-Colony	85	226	156	104	22	71	0	PRBO data[3]
2005	820	89	included in MI Sub-Colony	123	251	172	37	17	115	16	PRBO data[3]
2006	1010	74	included in MI Sub-Colony	145	369	196	16	0	142	68	PRBO data[3]
2007	1782	105	86	7	1053	213	113	18	154	73	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 1997-2007.
[4] Visible only during boat surveys, apart from 2004-2007 when the Gap included some nests visible from the blind.

Table 2. Brandt's (BRCO), Pelagic Cormorant (PECO), California (CAGU) and Western Gull (WEGU) reproductive phenology on Alcatraz Island, 2007. 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)	FLEDGING DATE mean ± s.d. (n) (range)
Brandt's Cormorant	Southern Sub-Colony	8 May ± 10 (24) (21 Apr - 16 Jun)	5 Jun ± 5 (12) (30 May - 16 Jun)	19 Jul ± 11 (42) (27 Jun - 22 Aug)
	Barker Beach Sub-Colony	15 Apr ± 9 (29) (4 Apr - 5 May)	17 May ± 9 (25) (2 May - 13 Jun)	30 Jun ± 11 (24) (13 Jun - 21 Jul)
	Northern Sub-Colony	4 May ± 12 (20) (14 Apr - 23 May)	1 Jun ± 14 (15) (12 May - 20 Jun)	14 Jul ± 11 (25) (20 Jun - 4 Aug)
	Laundry Building Sub-Colony	15 May ± 9 (8) (5 May - 30 May)	15 Jun ± 8 (4) (5 Jun - 23 Jun)	24 Jul ± 10 (6) (7 Jul - 4 Aug)
	Model Industries Sub-Colony	28 Apr ± 6 (18) (18 Apr - 9 May)	29 May ± 6 (14) (16 May - 9 Jun)	7 Jul ± 10 (13) (23 Jun - 25 Jul)
	North Foghorn Sub-Colony	2 May ± 9 (21) (18 Apr - 30 May)	3 Jun ± 8 (20) (26 May - 30 Jun)	13 Jul ± 10 (20) (27 Jun - 8 Aug)
	ALL SUB-COLONIES	**30 Apr ± 13 (122) (4 Apr -6 Jun)**	**29 May ± 12 (79) (2 May - 30 Jun)**	**12 Jul ± 13 (133) (13 Jun - 22 Aug)**
Pelagic Cormorant		**14 May ± 14 (6) (25 Apr - 30 May)**	**19 Jun ± 11 (6) (5 Jun - 4 Jul)**	**1 Aug ± 0 (2) (1 Aug - 1 Aug)**
California Gull		***no data***	**6 Jun ± 8 (15) (23 May - 20 Jun)**	**23 Jul ± 10 (15) (4 Jul - 8 Aug)**
Western Gull	Cistern	14 May ± 7 (24) (9 May - 30 May)	18 Jun ± 14 (10) (6 Jun - 18 Jul)	10 Aug ± 11 (25) (25 Jul - 12 Sept)
	Parade Ground	10 May ± 7 (24) (3 May - 31 May)	9 Jun ± 9 (19) (31 May - 27 Jun)	10 Aug ± 9 (21) (25 Jul - 22 Aug)
	Model Industries	11 May ± 7 (25) (2 May - 30 May)	7 Jun ± 7 (16) (23 May - 20 Jun)	9 Aug ± 15 (23) (27 Jun - 19 Sept)
	ALL SUB-COLONIES	**12 May ± 7 (73) (2 May - 31 May)**	**10 Jun ± 11 (45) (23 May - 18 Jul)**	**10 Aug ± 11 (69) (27 Jun - 19 Sept)**

Table 3. Brandt's Cormorant productivity by sub-colony on Alcatraz Island, 1995-2007.

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

Table 4. Brandt's (BRCO), Pelagic Cormorant (PECO), California Gull (CAGU) and Western Gull (WEGU) reproductive performance on Alcatraz Island, 2007. 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	3.1 ± 0.7 (17)	1.6 ± 1.0 (9)	0.8 ± 0.3 (7)	0.9 ± 0.2 (7)
	Barker Beach Sub-Colony	3.2 ± 0.5 (28)	2.2 ± 1.5 (16)	0.8 ± 0.4 (16)	0.9 ± 0.2 (12)
	Northern Sub-Colony	3.4 ± 0.7 (22)	2.7 ± 0.7 (10)	0.9 ± 0.2 (10)	1.0 ± 0 (10)
	Laundry Building Sub-Colony	3.1 ± 0.8 (8)	2.4 ± 1.3 (5)	0.8 ± 0.4 (5)	1.0 ± 0 (4)
	Model Industries Sub-Colony	3.0 ± 0.7 (20)	1.9 ± 1.3 (15)	0.6 ± 0.4 (15)	0.9 ± 0.2 (11)
	North Foghorn Sub-Colony	3.4 ± 0.7 (20)	2.8 ± 0.9 (12)	0.9 ± 0.2 (12)	0.9 ± 0.2 (12)
	ALL SUB-COLONIES	**3.2 ± 0.7 (115)**	**2.3 ± 1.2 (67)**	**0.8 ± 0.4 (65)**	**0.9 ± 0.2 (56)**
Pelagic Cormorant		**3.7± 0.6 (3)**	**3.0± unk (1)**	**1.0± unk (1)**	**0± unk (1)**
California Gull		**2.6 ± 0.6 (18)**	**2.0 ± 1.1 (13)**	**.8 ± 4 (13)**	**.9 ± 2 (11)**
Western Gull	Cistern	2.3 ± 0.8 (32)	1.4 ± 1.2 (26)	0.6 ± 0.4 (25)	0.7 ± 0.4 (18)
	Parade Ground	2.8 ± 0.5 (29)	2.3 ± 1.0 (24)	0.8 ± 0.4 (23)	0.6 ± 0.4 (21)
	Model Industries	2.5 ± 0.7 (29)	1.8 ± 1.1 (24)	0.7 ± 0.4 (24)	0.8± 0.4 (20)
	ALL SITES	**2.5 ± 0.7 (90)**	**1.8 ± 1.2 (74)**	**0.7 ± 0.4 (72)**	**0.7 ± 0.4 (59)**

Table 5. Pigeon Guillemot reproductive phenology on Alcatraz Island, 2007. 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
21 Mar	31 Mar	30 Jun	18 Aug

Table 6. Summary table showing frequency (and percentage) of types of disturbances to Brandt's Cormorants on Alcatraz Island, 1997-2007.

Type of Disturbance		Number of disturbances observed										
		1997 (205.5 hours)	**1998** (226.5 hours)	**1999** (313.4 hours)	**2000** (216.4 hours)	**2001** (251.3 hours)	**2002** [1] (95.5 hours)	**2003** [2] (224 hours)	**2004** [2] (339.7 hours)	**2005** (334.4 hours)	**2006** (363.4 hours)	**2007** (307.8 hours)
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%)
	Air traffic	**20** (27%)	**18** (19%)	**59** (29%)	**61** (30%)	**102** (49%)	**23** (34%)	**47** (32%)	**14** (33%)	**13** (38%)	**7** (26%)	**7** (11%)
	Other	**2** (3%)	**4** (4%)	**10** (5%)	**24** (12%)	**9** (4%)	**0** (0%)	**1** (1%)	**4** (9%)	**1** (3%)	**1** (4%)	**3** (5%)
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%)
	Interspecies event	**3** (4%)	**23** (24%)	**26** (13%)	**12** (6%)	**10** (5%)	**7** (10%)	**4** (3%)	**1** (2%)	**2** (6%)	**1** (4%)	**0** (0%)
	Other	**0** (0%)	**1** (1%)	**0** (0%)	**0** (0%)	**0** (0%)	**0** (0%)	**0** (0%)	**0** (0%)	**0** (0%)	**1** (4%)	**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%)
Total:		**74**	**94**	**201**	**203**	**207**	**67**	**149**	**43**	**34**	**27**	**64**
Frequency of disturbances[3]		**0.36**	**0.42**	**0.65**	**0.84**	**0.82**	**0.70**	**0.67**	**0.13**	**0.10**	**0.07**	**0.21**

[1] The total hours observed was reduced in 2002 due to observer inconsistency.
[2] In 2003-2007, includes extra disturbance monitoring on the North End of the island.
[3] This frequency 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.