Ecological Studies of Seabirds on Alcatraz Island, 2010

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 regionally important site for a number of seabird species in the last couple of decades. Population size, breeding phenology, and productivity of most seabirds including Brandt's and Pelagic Cormorants, Western and California Gulls, Pigeon Guillemots, and Black Oystercatchers have been monitored since 1995. Disturbance to wildlife is a concern on Alcatraz, given its status as a heavily-visited part of the Golden Gate National Recreation Area (GGNRA) and its location in the center of the San Francisco Bay. During weekly monitoring, we recorded and cataloged disturbances to seabird populations from March - August, 2010.

Populations of breeding Brandt's Cormorants made only a small improvement from the complete breeding failure it suffered in 2009. The Pelagic Cormorants on Alcatraz made no improvement at all and in 2010 had its second complete breed failure in a row. Brandt's Cormorants did poorly throughout central California where many colonies experienced low breeding numbers and poor reproductive success. The Western Gull population decreased while the California Gull population nearly tripled. Both gull species however, had poor breeding success. Pigeon Guillemot populations increased to the highest yet recorded and confirmed sites were above the long-term mean.

Western Gull breeding numbers decreased for the second year in a row to 722 nesting pairs in 2010 (nests taken under a depredation permit from USFWS # MB057058-0 are not included in the total count) from 888 pairs in 2009. Western Gulls fledged an average of 1.2 chicks/pair in 2009, lower than the long-term mean. We confirmed 28 Pigeon Guillemot sites in 2010, an increase from the 20 confirmed sites in 2009, also above the long-term mean. This includes one new nesting site at the finger pier near the dock. One pair of Black Oystercatchers bred on the Seawall in 2010. Two chicks hatched, but only one chick survived to fledge, making it the eighth oystercatcher chick to fledge Alcatraz since 1997. We first discovered California Gulls breeding on Alcatraz in 2004. Since then, the population increased, fluctuating between 12-23 nests. In 2010, the nesting population nearly tripled to 66 nesting pairs. They fledged an average of 0.9 chicks fledged/pair in 2010, the lowest yet recorded since monitoring began.

Due to the low attendance of breeding cormorants in 2010, the ability to view only one major sub-colony, and no weekend day monitoring efforts when activity around the island is heaviest, few disturbances of cormorants were documented during approximately 177 hours of observation throughout the breeding season. Of four documented disturbances, only one caused birds to flush, while three were minor disturbances from a jet, a hawk, and an unidentified noise. However, one disturbance event (observed by NPS staff) took place due to a ranger led group entering the Laundry Building and allowed access next to windows next to the Laundry Building Sub-Colony, causing several birds to flush and abandon eggs.

Several measures have been taken to reduce cormorant disturbances from human activities in recent years including visual barriers near visitor and staff use areas adjacent to cormorant colonies, noise reduction methods during construction and special event projects, and contractor and staff bird sensitivity training. These efforts have undoubtedly reduced the disturbances to nesting cormorants; however it is also known, that it only takes one ill-timed disturbance to potentially cause colony failure. Although it is best if activities take place outside of the breeding

season, February to September, continued caution will need to be continued when planning activities that cannot be avoided during the season.

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 the public to view seabird breeding activities up close, and this should be highlighted as a focal point of visitor education and outreach. Recent improvements of signage and a new "Birds of Water" display will play a role in improved visitor appreciation and understanding of the seabird colonies at Alcatraz. 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 also will help educate visitors as well as protect breeding seabirds.

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

INTRODUCTION

Prior to human settlement on Alcatraz Island (37° 49'N, 122° 25'W) in San Francisco Bay, it was home to thousands of nesting seabirds as indicated by the guano covered sandstone. As early human settlement took place, birds left the island and did not return throughout the military and prison history. Over a century later, Alcatraz became part of the Golden Gate National Recreation Area (GGNRA), a unit of the National Park Service (NPS), and birds slowly began to return to reclaim the island. Waterbird species of interest include Brandt's Cormorants (*Phalacrocorax penicillatus*), Pelagic Cormorants (*P. pelagicus*), Western Gulls (*Larus occidentalis*), California Gulls (*Larus californicus*), Pigeon Guillemots (*Cepphus columba*), Black Oystercatchers (*Haematopus bachmani*), Black-crowned Night Herons (*Nycticorax nycticorax*), Snowy Egrets (*Egretta thula*), Great Egrets (*Casmerodius albus*), and Great Blue Herons (*Ardea herodias*). The Brandt's Cormorant colony on Alcatraz is one of the few known estuarine breeding sites for this species. Pigeon Guillemots are not known to breed elsewhere in the San Francisco Bay. The Western Gull colony is the largest in the Bay and the Black-crowned Night Heron colony is 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 1.5 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, fishing boats, kayakers), and uncontrolled aircraft overflights (e.g. media, military, and 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 2010 breeding season. This report should not be cited without permission from the authors. This is PRBO contribution number 1764.

METHODS

We conducted island- and boat-based surveys from March through August, 2010. Island surveys consisted of censuses and focal nest observations once per week, on Thursdays. In order to minimize disturbance to nesting birds, we made observations using binoculars (8 x 42) and/or a spotting scope (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 that are near known nesting sites and are accessible were monitored manually biweekly when adults were not present. Boat surveys took place 5 times between 13 May and 29 July and concentrated on capturing peak incubation of Western Gulls and Brandt's Cormorants. Pigeon Guillemot activity near nesting sites was also observed and boat surveys in June and July focused on capturing sightings of Pigeon Guillemot fish deliveries to chicks in order to confirm breeding. 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

In 2010, Brandt's Cormorants nesting on Alcatraz Island was low and attendance was concentrated in only a few subcolonies, mostly in areas not visible from the island. However, in each sub-colony that was visible from the island, we counted the total number of adult and immature Brandt's Cormorants (if any were present) 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 13 May and 29 July. During each survey, we recorded the total number of adults, immature birds, nests being built, and active nests (nests with eggs or chicks).

We investigated Brandt's Cormorant reproductive phenology and performance in a sample of nests from the Laundry Building Sub-colony (the only visible sub-colony from the island). The Laundry Building Sub-colony was monitored from inside the Laundry Building's upper level. A total of at least 30 nests were selected, including both centrally-located and edge nests, and early and late-formed nests. Due to the location of nesting birds, some previously monitored nests were followed as well as several new sites that were adjacent to the building and in good view. Nests were numbered and mapped, and the contents of each nest recorded once per week (number of eggs and/or chicks), with 7 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 28 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 (weekly between 08:00 and 10:00). There were no Pelagic Cormorants nesting on Alcatraz in 2010.

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 active nests in each area, determined by seeing eggs or chicks when possible or by counting birds in incubation posture. 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 GGNRA during Black-crowned Night Heron surveys or visited during the Western Gull census.

In 2010, three visits to the colony were made in order to get complete nest contents, including one visit to the colony on 3 June for the all island 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 several nests could be seen using binoculars and a spotting scope. This access allowed us to asses California Gull reproductive performance and phenology for the fifth 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. Counts were taken between 08:00 and 11:00 around the perimeter of the island beginning at the dock area and ending at the blind located at the south end of the island (see Figure 1). Guillemots were counted both on the island and in the water, taking care not to double count individuals while moving from one monitoring location to another. 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 or if eggs, chicks, or fish deliveries were missed during observations.

In 2006, we installed 30 nest boxes for Pigeon Guillemots at three 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. Natural crevices were discovered while installing next boxes at the PH site and provided an accessible addition to our 30 nest box sample size. Therefore, crevices were cleaned out and checked simultaneously during biweekly checks. The NF site has 5 nest boxes, and the SC site has 14 nest boxes. 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. 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. In 2010, disturbance monitoring did not take place on weekend days which are known to be the busiest days of activity around the island. In addition, low breeding numbers and attendance of cormorants warranted island visits for monitoring to take place only once weekly instead of twice weekly. Therefore, number and frequency of disturbances may be higher than the data reflects and is not comparable to previous years.

RESULTS AND DISCUSSION

BRANDT'S CORMORANT

The Brandt's Cormorants population increased since the 2009 breeding failure, a first since the since the breeding population was established in the early 1990's (Figure 2). In 2010, a total of 208 pairs nested in two separate areas on the island, well below the peak population of 1782 pairs that occurred in 2007. See Table 1 for Brandt's Cormorant breeding populations by sub-colony from 1991-2010 and Table 2 for productivity by sub-colony from 1995-2010. A decrease in Brandt's Cormorant breeding population size in 2008, the complete absence of breeding pairs in 2009, and low breeding numbers in 2010 occurred throughout several colonies in central California and may be due to a combination of factors, including warmer air temperatures, low prey availability, disturbances, and the El Niño conditions that occurred in 2010.

Brandt's Cormorants were first seen at the island in March in low numbers, mostly in roosting areas of the island (see Figure 1). By 13 May, birds began attending nesting areas and on 20 May, the first eggs were seen (see Table 5), over 2 weeks later than the average since monitoring began in 1997.

Only three sub-colonies were used by nesting Brandt's Cormorants in 2010, the South Bricks Sub-Colony and the Below Rubble Piles Sub-Colony on the southern end of the island and the Laundry Building Sub-Colony on the more northern end of the island (Figure 1). A total of 58 breeding pairs nested at the South Bricks location, down from its peak of 154 in 2007. Only 3 pairs claimed territory in the Below Rubble Piles area compared to 2008 when 87 nesting pairs were found there. The Laundry Building Sub-Colony on the north end was the largest breeding area in 2010 with 145 nesting pairs, less than half of its peak population in 2008 (Table 1).

Only the Laundry Building Sub-Colony could be monitored for productivity, as it was the only colony able to be seen from the island. Productivity in 2010 was the worst on record since 1995, with the exception of 2009 when cormorants did not breed, with 0.5 chicks fledged per pair. Close to one third of nests being followed for productivity failed to hatch their first clutch. Of those that attempted a second brood, less than half succeeded in fledging chicks.

Populations of colonies throughout central California have shown declining trends in recent years. In 2009, the offshore, Southeast Farallon Island population had only very few, unsuccessful breeding attempts with only little improvement in 2010 (Warzybok *et al.* 2009 & 2010). At coastal colonies in Point Reyes, the breeding population also dropped in 2008 and have remained low since (USFWS, unpublished data).

In recent years (2005-2007), productivity of many seabird species in central California was relatively low, while that of cormorants was relatively high. That trend has reversed since 2008 with much lower cormorant productivity. In 2009, both Alcatraz and the Farallon Island Brandt's Cormorant populations had complete breeding failures, an unprecedented event since monitoring began at the Farallones in the early 70's (Warzybok *et al.* 2009) and monitoring began on Alcatraz in the early 90's (Figure 4).

Warm air temperatures may have had a greater influence on seabirds in 2008 than ocean productivity, as many nests failed after an abnormally high air temperature was reached at Alcatraz and at the Farallones (Acosta *et al.* 2008, Warzybok *et al.* 2008). In 2009, several piscivorous seabird species performed poorly in the region and some evidence suggests that ocean productivity played a role (PRBO unpublished data). In addition, the onset of the 2010 breeding season coincided with El Niño conditions which have been proven to be unfavorable for many species of seabirds (Ainley *et al.* 1988).

PELAGIC CORMORANT

The Pelagic Cormorant population has been declining at Alcatraz for the last several years. In 2010, very few adults were seen at the island between March and August and there were no breeding attempts (Figure 5). This is the second year in a row that Pelagic Cormorants failed to breed. Prior to 2009, Pelagic Cormorants have bred on Alcatraz every year since monitoring began in 1996. In comparison, the Farallon population although low, had a productivity that was above the long-term mean for the second year in a row (Warzybok *et al.* 2010).

Pelagic Cormorant productivity declined sharply starting in 2004 (Figure 4), and breeding attempts decreased notably in 2005 (Figure 5) and have remained low since. Several factors may have negatively affected Pelagic Cormorants breeding on Alcatraz in recent years. First, warm-water marine conditions since the mid 2000s, including the 2010 El Niño conditions that overlapped the onset of breeding activities, may have adversely affected reproductive success through a mechanism of reduced prey availability (PRBO unpublished data). Second, the growth of the Brandt's Cormorant population may have resulted in some inter-specific competition with Pelagic Cormorants for nest sites in the early 2000's (Saenz *et al.* 2006). Third, in recent years human activity has increased at the north end, including construction activities, visitor access to boundaries of nesting colonies, staff access to the Model Industries building, and special events; all of which could have had adverse effects. Specifically, a fence was erected in February 2003, 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 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 in recent years on Alcatraz may have negatively affected Pelagic Cormorant nesting.

WESTERN GULL

Western Gull breeding numbers have been on the rise since the late 1990's, but have plateaued since 2003 (quadratic regression, $p < 0.01$; $R^2 = 0.76$; n = 20). The Western Gull population at its peak in 2008 reached 1034 breeding pairs, but has since dropped to 722 breeding pairs in 2010 (Figure 3), not including 92 nests which were removed from public access areas and buildings under the GGNRA depredation permit from the US Fish and Wildlife Service. In 2010, the Alcatraz population decreased by 19% since 2009 and by as much as 30% since the peak population in 2008. This is the lowest reported population since 1999. In contrast, the Western Gull population on the Farallones increased since 2009, but still remains below the long term mean (Warzybok *et al.* 2010).

The first Western Gull eggs in 2010 were observed on 29 April, and the mean lay date was 12 May (Table 3), extremely consistent with the past several years, 1999-2009. The average hatch date was 10 June. Western Gull hatching success and fledging success were both 0.7 (Table 4). Productivity was 1.2 chicks per pair in 2010 (Figure 6), just slightly higher than 2009, but below the long-term mean of 1.5 chicks per pair since 1999. This was higher than the dense Farallon colony where Western Gull productivity was the worst on record in 2010, falling well below the long-term mean (Warzybok *et al.* 2010).

Of the 3 Western Gull sub-colonies monitored, productivity at the cistern sub-colony was lower for the fourth year in a row with 0.9 chicks fledged per pair in 2010 compared to 1.2 chicks fledged per pair at the Model Industries and 1.3 chicks fledged per pair at the Parade Ground (Figure 6). Reasons for decreased productivity in the cistern sub-colony are unknown. The Western Gull population, although denser in this area in comparison to the other monitored areas, 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. Potentially unobserved disturbance to this area is a possibility for decreased productivity. Additionally, construction activities near the cistern in 2008 may have had an effect as well as entrance by staff on 21 May in 2009 for a cultural resources assessment.

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, but fluctuated between 12-23 nests (Figure 3). In 2010, the nesting population nearly tripled to 66 nesting pairs (Figure 3).

The first California Gull eggs seen were on 26 April and the average lay day was 5 May (Table 2). The average hatch date was 8 June (Table 2). Productivity was slightly lower than in Western

Gulls, at 0.9 chicks per pair in 2010, the lowest yet recorded since 2006 when productivity of California Gulls was 1.7 chicks per pair.

PIGEON GUILLEMOT

Pigeon Guillemots were first detected in 2010 around Alcatraz on 18 March and attending nest sites on the island by 21 March (Table 5). A high count of 90 adults was recorded on 6 May; the highest count since monitoring began in 1997. A total of 28 Pigeon Guillemot nest sites were confirmed in 2010, well above the long-term mean. Additionally, we observed 17 probable nesting sites around the island (Figure 7).

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, 2007, 2009, and again in 2010. In addition to one nest box, two natural crevices at the Power House, one hole in the Sallyport building roof, and the finger pier at the dock was used for nesting by Pigeon Guillemots. The Power House crevices which were cleared out at the time of nest box placement were used by a pair of Pigeon Guillemots in 2008 and in 2009. In 2010, there were two crevices used. Eggs were first seen in the natural crevices on 17 June. One egg was found inside the crevice and never hatched. A second egg was found outside the crevice with a tarlike substance stuck to it, likely residue leaking from the structures near the powerhouse. On 1 July, another nearby crevice contained two downy feathered chicks. The chicks were not seen again and were assumed not fledged. Adult attendance at the box near the blind was first seen on 3 June. One egg was laid by 17 June, but also never hatched. Nesting activity took place for a second year in a row in the Sallyport building roof. Activity was first seen at this site on 6 May. Two eggs were laid by 17 June and the first chick was seen on 1 July. They were successful in fledging on chick by 12 August. For the first time, fish deliveries were seen being made to a location at the end of the finger pier near the dock. This area has been known to be a roosting location for Pigeon Guillemots, but no nesting activity had ever been recorded. Fish deliveries were seen three times between 21 July and 5 August indicating the presence of a chick. The exact location of the crevice on the pier could not be seen from the island. We had anticipated greater occupancy in subsequent years after nest box installation once the guillemots became 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); however occupancy has not increased on Alcatraz. Nest box occupancy could increase once marine conditions improve, however, nest box locations may need to be adjusted. One new feasible location for nest box relocation could be at the finger pier. Another study site in Point Reyes placed nest boxes along fish docks in 2010 and although recruitment was low in this first year, there was some success. Current obstacles to better placement of boxes on Alcatraz include accessibility, keeping boxes hidden from sight from visitors via island or boat observations, and interference with cultural landmarks.

BLACK OYSTERCATCHER

A single pair of Black Oystercatchers nested on the Seawall in 2010. Adults were seen at the Seawall and around the island intermittently from 25 March to 5 August. Eggs were laid at an inconspicuous spot on the seawall and not seen due to their location, but 1 downy-feathered chick was first seen on 3 June and a total of 2 chicks were seen by 10 June. Only one chick was successful in fledging and was last seen at the seawall on 10 July. Of a potential brood of 3 chicks per year, Black Oystercatchers on Alcatraz have only fledged eight chicks since 1997 (one each in 1997, 2001, 2003, 2004, two in 2006, one in 2009, and one in 2010).

DISTURBANCE MONITORING

With low attendance of Brandt's Cormorants at Alcatraz in 2010, only one major sub-colony in view, and no disturbance monitoring on weekend days when activity around the island is heaviest, there were very few disturbances recorded. Only one major disturbance and three minor disturbances were recorded in 2010 (Table 6). The major disturbance was caused by a loud, unknown noise coming from below the second level of the Laundry Building. This disturbance took place on 10 June and caused a total of 3 cormorants to flush from the Laundry Building Sub-Colony, however no nests were left unattended. Three minor disturbances were recorded throughout the duration of the season between 20 May and 22 July, all from different sources including a jet flyover, a hawk flyover and, an unknown human related noise coming from the Model Industries Building. Although, the human related noise did not cause a major disturbance, it is the one area in which we can control and potentially eliminate on-island, human related disturbances to cormorants.

In recent years, we have begun to see that cumulative effects of disturbance may cause increased behavioral sensitivity in Brandt's Cormorants (Acosta *et al.,* 2007). The potential for disturbance from maintenance, construction activities, and the use of buildings adjacent to nesting areas, that occur between February and September overlaps with the pre-breeding, incubation, and chick hatching activities of breeding birds. For example, in 2010, one disturbance event during the nesting season (not recorded by PRBO) took place due to a ranger led group entering the Laundry Building. The moderately sized group was allowed access to stand next to the windows facing the cormorant colony. This caused several cormorants to flush, including birds that abandoned nests with eggs (Lara Rachowicz & Laura Young, pers. comm.).

Several measures have been taken to reduce cormorant disturbances from human activities. 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. This barrier installed on the fence was created by vinyl slats weaved through an existing chain-link fence between the cormorant colony and the staff/visitor pathway. It proved to be successful in withstanding the wind and weather conditions throughout the year and in reducing the number of disturbances of non-motorized access to the Model Industries Building. In 2007 and 2009, many safeguards were observed to ensure minimal disturbances during special event and construction activities that took place during the breeding season. This included noise reduction measures to reduce the sound of power tools and various other equipment while in use; visual barriers to prevent cormorants from seeing human activity or lights; and also

additional training to staff about bird sensitivity. These efforts have undoubtedly reduced the disturbances to nesting cormorants; however it is also known, that it only takes one ill-timed disturbance to potentially cause colony failure (Thayer *et al.* 1999). Continued care will need to be taken in the Laundry Building and Model Industries area in particular and we continue to suggest that all activities take place outside of the seabird breeding season. In addition, as the cormorant population fluctuates due to climate and prey variability, it is likely to make breeding cormorants more sensitive to disturbance, and should be considered during future planning exercises related to human access.

In February of 2009, a new "Birds of Water" exhibit opened at Alcatraz, showcasing the waterbirds of the island and their importance to Alcatraz, the ecosystem, and people. New signage interpreting the waterbirds of Alcatraz was also installed in several locations around the island. These new signs along with interpretative programs that have been delivered by rangers or volunteers as well as the seabird docents in 2010 will help to keep visitor disturbances at a minimum and increase the opportunity to foster greater seabird awareness.

CONCLUSIONS AND RECOMMENDATIONS

The Brandt's and Pelagic Cormorant populations on Alcatraz experienced an unprecedented absence and breeding failure in 2009. While the Pelagic Cormorants did not rebound at all in 2010, the Brandt's Cormorants had some attendance, however only a fraction of their peak population in 2007. The population of California Gulls increased by nearly three times its max since they were first discovered on the island. The Western Gull population dropped for the second year in a row, nearly 30% in comparison to its peak in 2008. Productivity of Western and California Gulls dropped to 1.1 and 0.9 chicks fledged per pair respectively, the lowest for California Gulls on record and both below the long-term mean. Although productivity for Western Gulls was low, it was higher than that of the Southeast Farallon Islands population. Pigeon Guillemot population was its highest yet on record with 90 adults sighted on 6 May. The number of confirmed breeding sites was 28, well above the long term average since 1997. Brandt's Cormorant colonies across the central coast (Southeast Farallon Island and Point Reyes) experienced similar declines in population or overall poor success, and was likely influenced by reduced prey availability due to El Niño conditions experienced in 2010. Although the Pelagic Cormorant population on Alcatraz also failed, the Farallones appeared to have a low population with improved breeding success over 2009. Pelagic Cormorants may be affected not only by prey availability 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.

Since the last major El Niño event in 1998 when Brandt's Cormorants at Alcatraz outperformed those at the Southeast Farallon Islands (Saenz *et al.* 2006), Alcatraz cormorants performed better than those at coastal and pelagic colonies only during favorable marine conditions (high upwelling and low ocean temperatures). But during poor ocean conditions (from 2005-2007), cormorants at Alcatraz performed worse. This held true in 2008 as marine conditions improved; Alcatraz cormorants had higher productivity than other nearby, oceanic colonies. In 2009, cormorants in both locations experienced an unprecedented complete breeding failure and in 2010, both

colonies showed only slight improvement. Explanations could 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 on Alcatraz has been decreasing since the early 2000's and, in 2010 none were present on the island for the second year in a row, despite the population at other nearby colonies being present. Productivity has also been alarmingly low since 2004. These factors 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 (GGNRA), and continued since then as standard operating procedure. We advise against visitor or staff access near the areas of the Model Industries and Laundry Buildings 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 (Roth *et al.* 1999). Common Raven predation and/or harassment on Pigeon Guillemots was observed in 2008 and in 2009, and has also been observed in recent years on Brandt's Cormorants, Black-crowned Night Herons, Snowy Egrets, Western Gulls, and Black Oystercatchers on Alcatraz. While we have not made direct observations of raven and Pelagic Cormorant interactions, this is also a possibility. Pelagic Cormorant populations in Washington have been reduced due to influence of corvid harassment and nest predation (Paine *et al.* 1990). Therefore, continued efforts to investigate the best methods of Common Raven management are also recommended.

Pigeon Guillemots were found nesting in the Sallyport building, a building currently not open to the public or staff activities. We recommend that any future maintenance on this building would take place outside of the seabird nesting season between February and mid-September. In addition, the finger pier adjacent to the dock at Alcatraz also became a confirmed nesting site in 2010. The exact location of the crevice is unknown, but the site has the potential to be an ideal area to relocate nest boxes. This could provide a visual barrier of sorts, as the pier is regularly used by Alcatraz Cruises staff; it is a feasible location to attract guillemots and increase the sample sizes of accessible nesting locations; and it is known that recruitment of guillemots to nest boxes has been successful in another location.

Disturbance to seabirds is a consistent problem at Alcatraz Island given its status as a heavily-visited national park and its location in the center of the San Francisco Bay. There is constant air traffic from small planes, helicopters, and various other aircraft as well as marine traffic from kayaks, canoes, and powerboats. Marine traffic could be significantly reduced if historical buoys warning or reminding boaters of the proper distance to keep from Alcatraz were re-installed. Visitor presence on the island can also pose a threat of disturbance to nesting birds. 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 since its placement in 2008. 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 in 2008. 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 coordinated. 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.

We also 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 GGNRA Alcatraz biologist, and consistent scheduling and follow-up between natural resources staff and the U.S. Coast Guard and its contractors. Construction and maintenance projects should be held outside of the breeding season, during the months of September through January. If projects must be done during the breeding season, additional disturbance monitoring efforts should be in place for the duration of the event. Also, wildlife sensitivity training for staff and contractors that need access nearby or within colonies of any of the breeding waterbirds is also important.

Summary of recommendations:

Management Recommendations

- Allow no public visitation near the western cliffs or in the Sallyport building after early February, especially if activities may influence seabird pre-breeding or early-nesting behavior.
- Allow no construction activities to be carried out near the western cliffs or in the Sallyport building after early February, especially if activities may influence seabird pre-breeding or early-nesting behavior.
- Restrict public or group activities from taking place inside the Laundry Building during seabird the seabird nesting season, February – September.
- Keep visual barrier in place at the Model Industries/Laundry Building fence and maintain when necessary outside breeding season.
- Enforce strict regulations in granting special use permits for events and groups 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 efforts on 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
- Evaluate possibilities of Pigeon Guillemot nest box relocation, including installation of boxes at the finger pier near the dock
- Incorporate studies of seabird diet which may help to reveal links between seabird reproductive parameters and marine environmental conditions versus human disturbance effects
- Further investigate Western Gull population dynamics on Alcatraz Island and how effects of increased management or reduced habitat would affect this species, including support for Western Gull banding and re-sighting banded birds, this is particularly important to understand before opening any currently seasonally closed areas
- Continue disturbance monitoring in relation to any special access granted by park staff to enter in closed areas adjacent or within gull or cormorant colonies.

ACKNOWLEDGEMENTS

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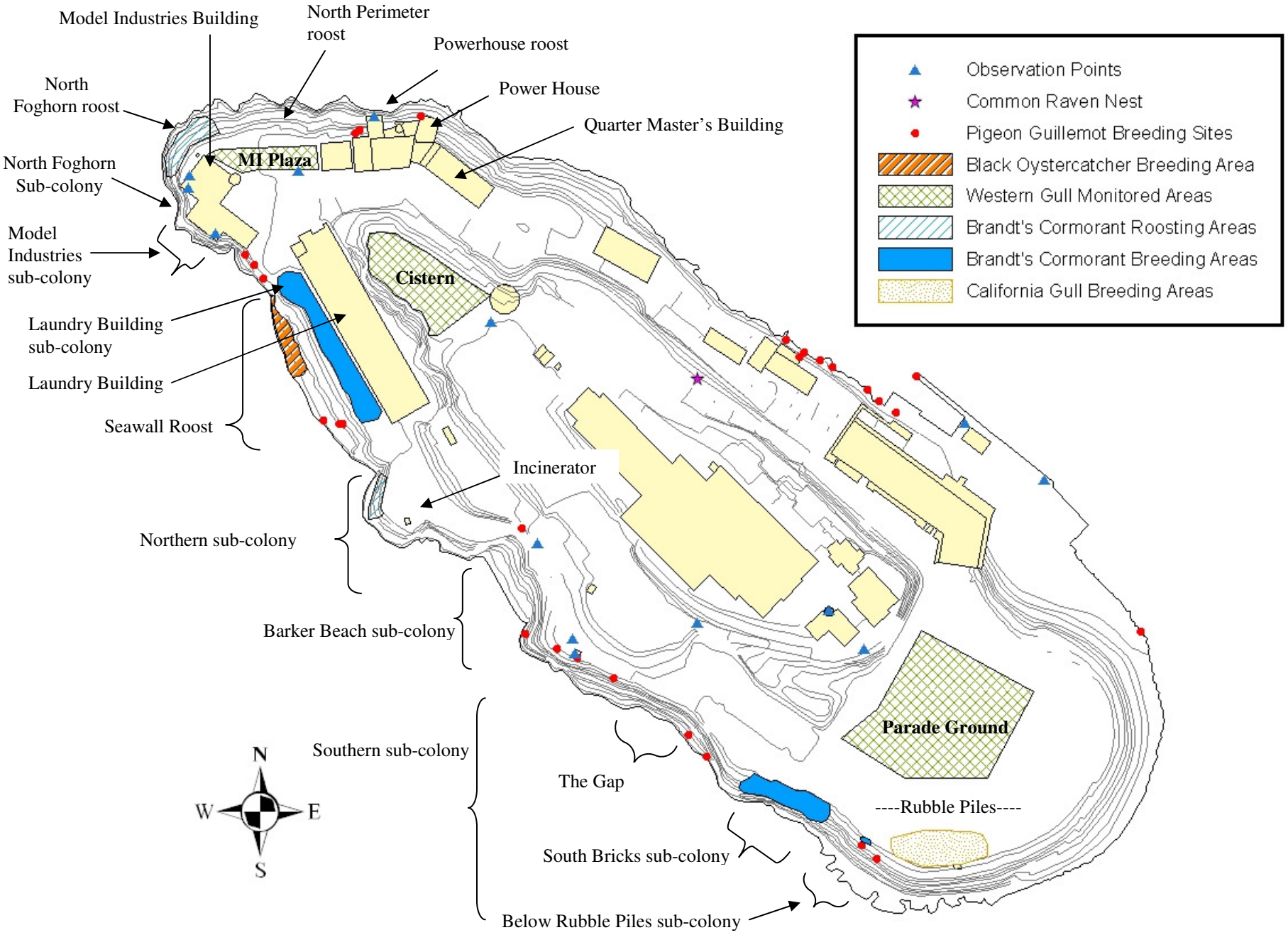

Figure 1. Alcatraz Island seabird breeding areas, survey observation points, and significant structures, 2010.

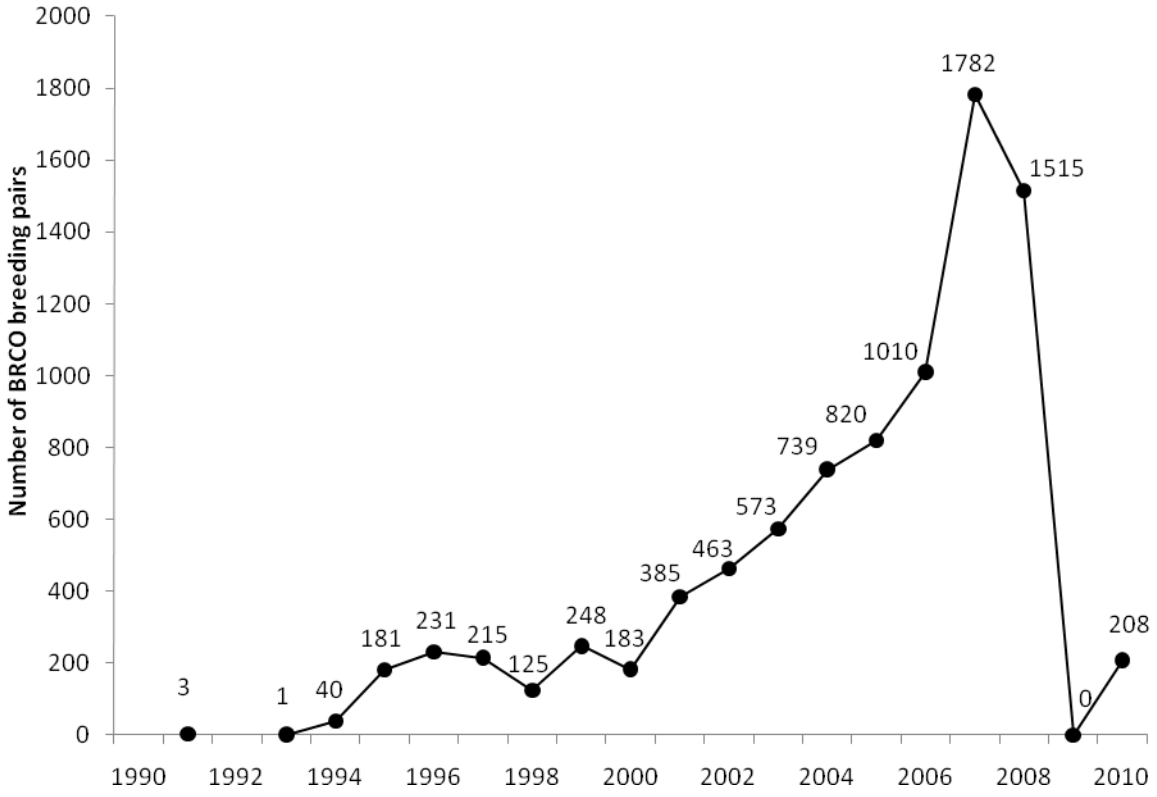

Figure 2. Brandt's Cormorant (BRAC) breeding population size on Alcatraz Island, 1990-2010. Data represent the minimum number of breeding pairs on Alcatraz. Breaks in data indicate a change in observers and/or census methodology. BRAC data in 1991 from R. Farwell/GGNRA, (pers. obs.); in 1993 from D. Hatch/GGNRA (unpubl. data); in 1994 from R. Hothem/USGS and W. Reyes/GGNRA, (pers. obs.).

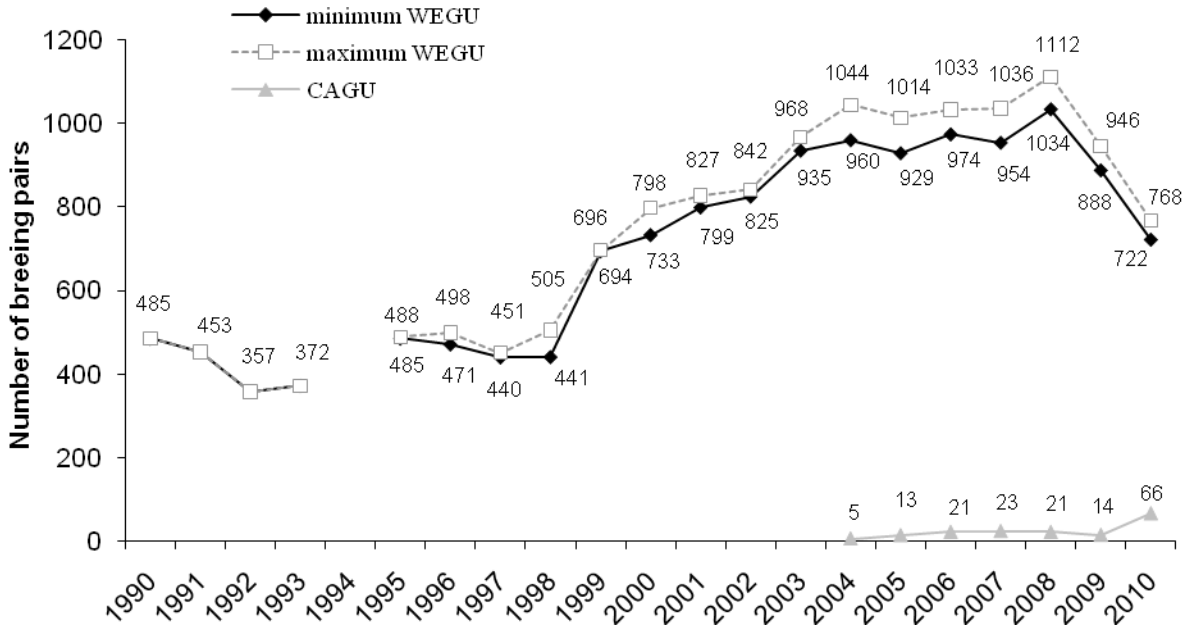

Figure 3. Western Gull (WEGU) and California Gull (CAGU) breeding population size on Alcatraz Island, 1990-2010. Minimum breeding pair data for WEGU represent the number of active nests (nests containing eggs and/or chicks on date of census) on Alcatraz. Maximum breeding pair data represent active nests and inactive nests (nests containing no eggs or chicks, but is being attended by an adult pair). CAGU population is represented by active nests found during the duration of the breeding season. Breaks in data indicate a change in observers and/or census methodology. WEGU data in 1990 from Bell (1990); in 1991 from Bell (1991); in 1995 from Hatch and A. Fish/GGNRA (unpubl. data); in 1996-1997 from Brown (1997); in 1998 from Brown/Univ. of Dallas (unpubl. data).

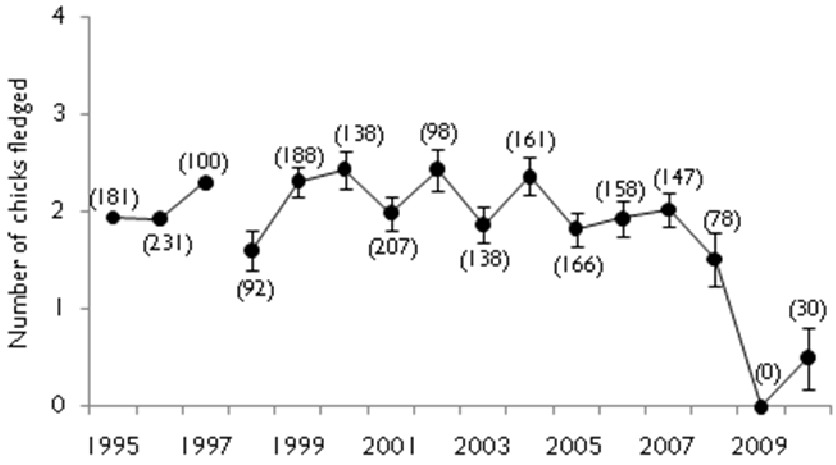

Figure 4a. Overall Brandt's (BRAC) Cormorant productivity on Alcatraz Island, 1995-2010. Sample size is in parentheses. Productivity in 1995-1997 was calculated from total chick counts. Productivity in 1998-2010 was calculated from number of chicks fledged per pair monitored. Error bars represent the standard error for the mean calculated from productivity of all monitored colonies.

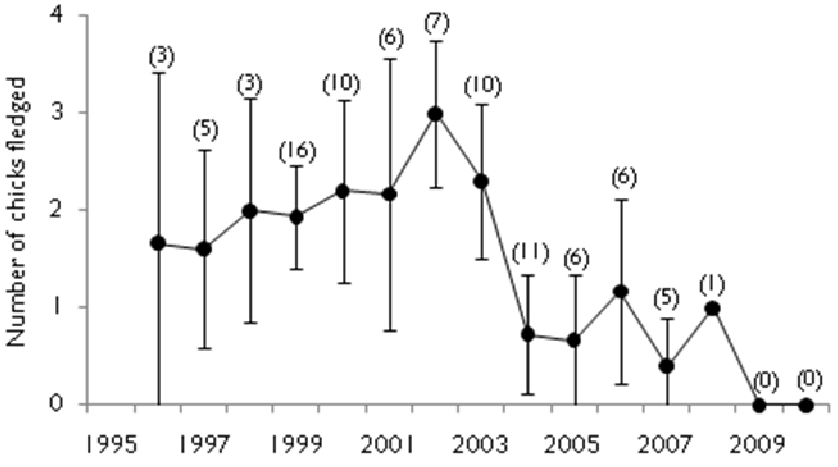

Figure 4b. Overall Pelagic (PECO) Cormorant productivity on Alcatraz Island, 1995-2010. Sample size is in parentheses. Productivity was calculated from number of chicks fledged per pair monitored. Error bars represent the standard error for the mean calculated from productivity of all monitored colonies.

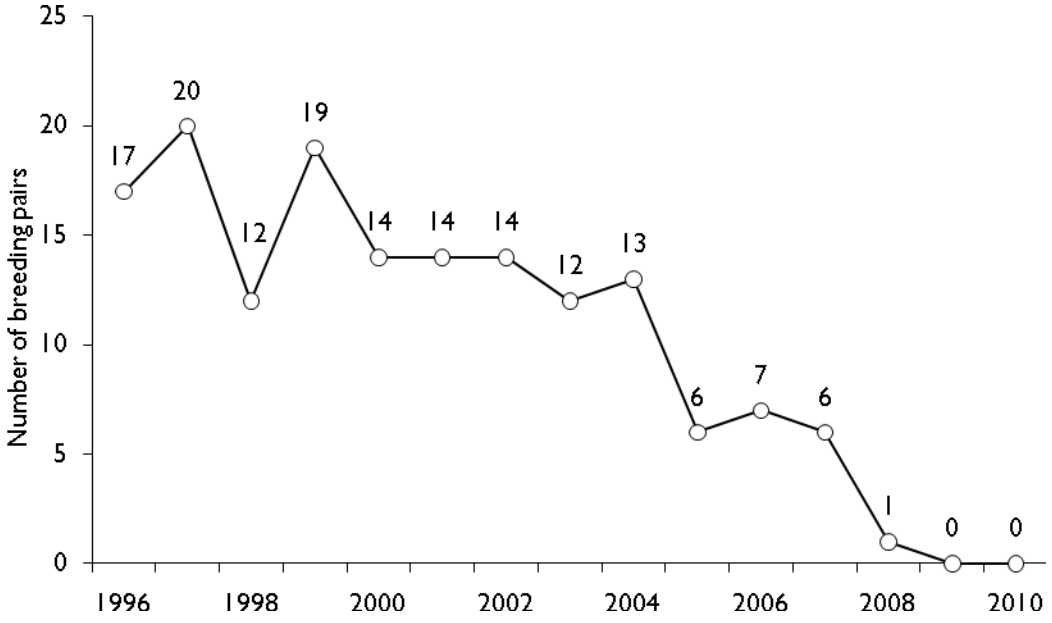

Figure 5. Pelagic Cormorant breeding population size on Alcatraz Island, 1996-2010. Data in 1996 from M. Parker/USFWS aerial surveys.

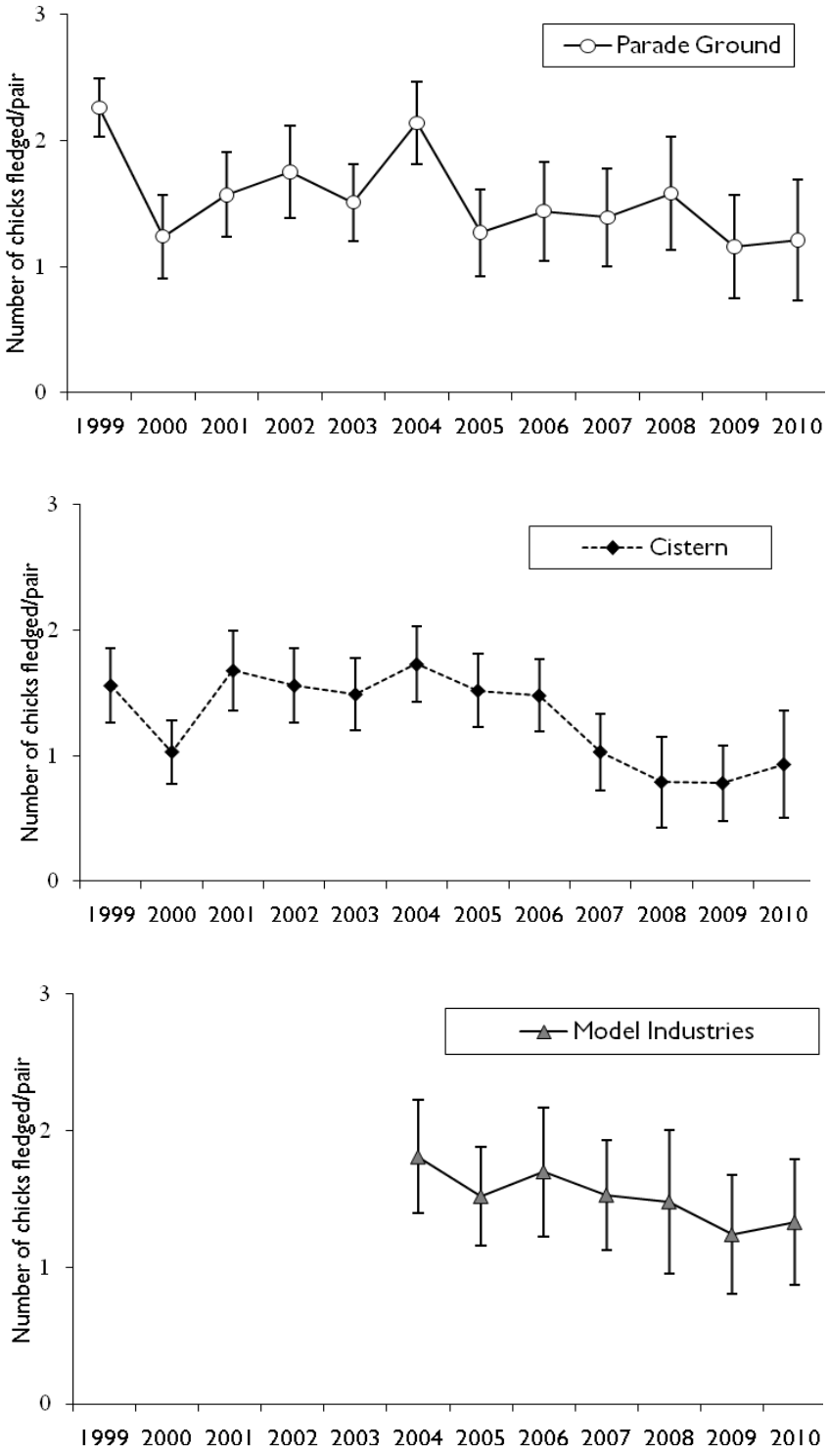

Figure 6. Western Gull productivity at three sub-colonies on Alcatraz Island, 1999-2010. Error bars represent the standard error for the mean calculated from productivity of each monitored colony.

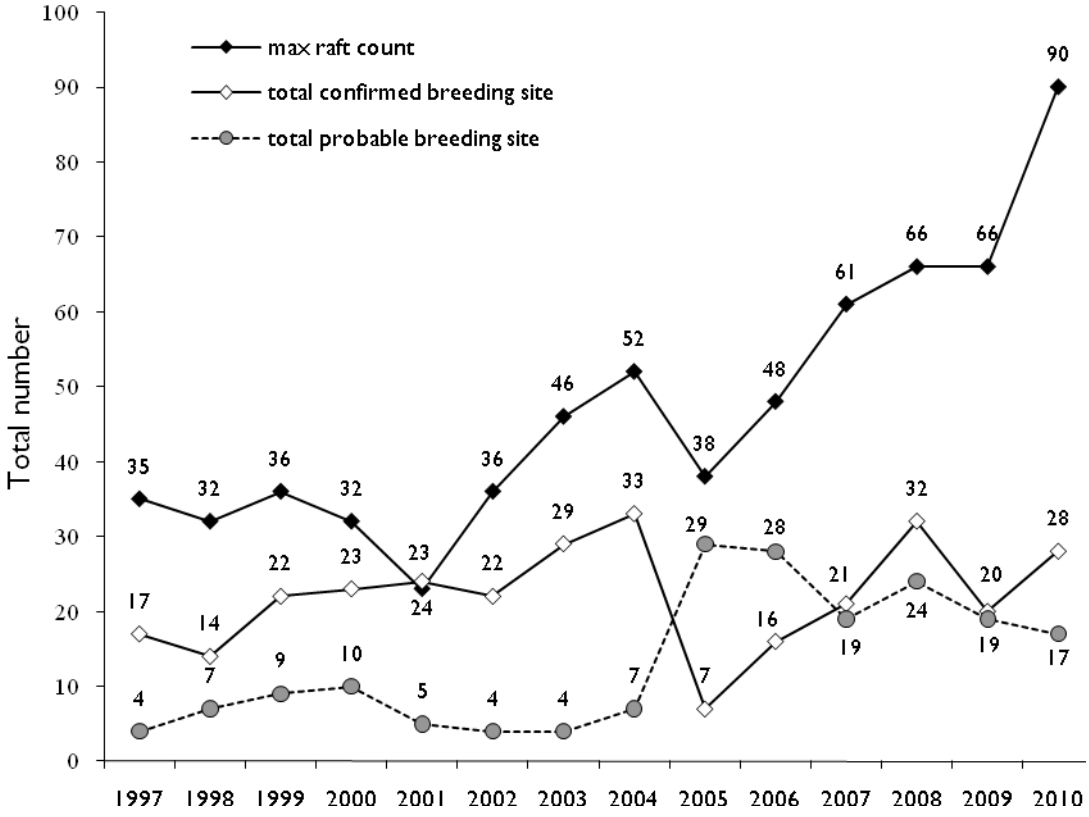

Figure 7. Pigeon Guillemot population size on Alcatraz Island, 1997-2010. "Total Confirmed Breeding Sites" reflects the minimum number of breeding pairs confirmed through observation of chicks, observing fish delivery, or post-season inspections of crevices.

Table 1. Brandt's Cormorant population size on Alcatraz Island, 1991-2010.

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	no data	no data	no data	no data	no data	≥ 1	no data	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]
2009	0	0	0	0	0	0	0	0	0	0	0	PRBO data[3]
2010	208	2	0	145	0	0	0	0	58	3	0	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 1997-2010.

Table 2. Brandt's Cormorant productivity by sub-colony on Alcatraz Island, 1995-2010.

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)	did not breed	.8 ± 1.1 (17)	did not breed	**1.5** ± 1.2 (78)	focal-site analysis
2009 mean ± s.d. (n)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	focal-site analysis
2010 mean ± s.d. (n)	(0)	(0)	0.5 ± 0.9 (30)	(0)	(0)	(0)	**0.5** ± 0.9 (30)	focal-site analysis

Table 3. Brandt's (BRAC), Pelagic Cormorant (PECO), California (CAGU) and Western Gull (WEGU) reproductive phenology on Alcatraz Island, 2010. 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, and hatching data refers to first chicks of a brood.

		EGG-LAYING DATE mean ± s.d. (n) (range)	HATCHING DATE mean ± s.d. (n) (range)
Brandt's Cormorant	Southern Sub-Colony	no data available	no data available
	Barker Beach Sub-Colony	did not breed	did not breed
	Northern Sub-Colony	did not breed	did not breed
	Laundry Building Sub-Colony	25 May ± 5.8 (25) (20 May - 10 Jun)	22 Jun ± 3.4 (10) (17 Jun - 24 Jun)
	Model Industries Sub-Colony	no data available	no data available
	North Foghorn Sub-Colony	did not breed	did not breed
	MEAN OF ALL SUB-COLONIES 1997-2009	**30 Apr ± 8.7 (12) (18 March - 19 Jul)**	**2 Jun ± 8.2 (12) (18 April - 2 Aug)**
	ALL SUB-COLONIES 2010	**25 May ± 5.8 (25) (20 May - 10 Jun)**	**22 Jun ± 3.4 (10) (17 Jun - 24 Jun)**
Mean 1999-2009		**1 May ± 12.3 (9) (26 Mar - 13 Jun)**	**1 Jun ± 12.6 (8) (25 Apr - 23 Jun)**
Pelagic Cormorant 2010		**did not breed**	**did not breed**
Mean 2006-2009		**8 May ± 4.1 (3) (25 Apr - 28 May)**	**22 May ± 4.9 (4) (23 May - 6 Jun)**
California Gull 2010		**5 May ± 7.6 (17) (29 Apr - 3 Jun)**	**8 Jun ± 4.0 (3) (3 Jun - 10 Jun)**
Western Gull	Cistern	17 May ± 7.25 (16) (13 May -10 Jun)	13 Jun ± 4.7 (11) (10 Jun - 24 Jun)
	Parade Ground	9 May ± 6.4 (15) (29 Apr - 20 May)	8 Jun ± 4.9 (9) (3 Jun - 17 Jun)
	Model Industries	10 May ± 4.2 (21) (29 Apr - 13 May)	10 Jun ± 0 (7) (10 Jun)
	MEAN OF ALL SUB-COLONIES 1999-2009	**9 May ± 1.9 (10) (19 Apr - 27 Jun)**	**6 Jun ± 4.5 (10) (18 May - 5 Jul)**
	ALL SUB-COLONIES	**12 May ± 6.6 (52) (29 Apr - 10 Jun)**	**10 Jun ± 4.5 (27) (3 Jun -24 Jun)**

Table 4. Brandt's (BRAC), Pelagic Cormorant (PECO), California Gull (CAGU) and Western Gull (WEGU) reproductive performance on Alcatraz Island, 2010. 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	did not breed	did not breed	did not breed	did not breed
	Barker Beach Sub-Colony	did not breed	did not breed	did not breed	did not breed
	Northern Sub-Colony	did not breed	did not breed	did not breed	did not breed
	Laundry Building Sub-Colony	2.7 ± 0.6 (31)	0.3 ± 0.7 (19)	0.1 ± 0.3 (17)	0.7 ± 0.6 (3)
	Model Industries Sub-Colony	did not breed	did not breed	did not breed	did not breed
	North Foghorn Sub-Colony	did not breed	did not breed	did not breed	did not breed
	Mean of all sub-colonies 1997-2009	**3.4 ± 0.3 (12)**	**2.2 ± 0.4 (12)**	**0.7 ± 0.1 (12)**	**0.9 ± 0.1 (12)**
	ALL SUB-COLONIES	**2.7 ± 0.6 (31)**	**0.3 ± 0.7 (19)**	**0.1 ± 0.3 (17)**	**0.7 ± 0.6 (3)**
Mean 1996-2009		**3.8 ± 0.3 (9)**	**2.2 ± 1.1 (11)**	**0.6 ± 0.4 (8)**	**0.8 ± 0.3 (10)**
Pelagic Cormorant 2010		did not breed	did not breed	did not breed	did not breed
Mean 2006-2009		**2.8 ± 0.4 (4)**	**1.8 ± 0.3 (4)**	**0.7 ± 0.3 (4)**	**0.8 ± 0.1 (4)**
California Gull 2010		**2.3 ± 0.8 (25)**	**1.7 ± 1.0 (15)**	**0.9 ± 0.3 (13)**	**0.5 ± 0.5 (10)**
Western Gull	Cistern	2.3 ± 0.9 (26)	1.3 ± 1.1 (21)	0.5 ± 0.5 (20)	0.6 ± 0.5 (14)
	Parade Ground	2.7 ± 0.6 (24)	2.1 ± 1.3 (15)	0.7 ± 0.5 (15)	0.6 ± 0.4 (11)
	Model Industries	2.6 ± 0.6 (21)	1.8 ± 1.2 (19)	0.8 ± 0.4 (17)	0.8 ± 0.4 (15)
	Mean of all sub-colonies 1999-2009	**2.7 ± 0.1 (11)**	**2.0 ± 0.3 (11)**	**0.7 ± 0.1 (11)**	**0.8 ± 0.1 (11)**
	ALL SITES	**2.5 ± 0.7 (71)**	**1.7 ± 1.2 (55)**	**0.7 ± 0.4 (52)**	**0.7 ± 0.4 (40)**

Table 5. Reproductive chronology of Brandt's Cormorants (BRAC), Pelagic Cormorants (PECO), Western Gulls (WEGU), California Gulls (CAGU), Pigeon Guillemots (PIGU), and Black Oystercatchers (BLOY) on Alcatraz Island, 2010. Adults are regularly censused March through August, although incidental sightings prior to March are included. Activity is noted until chicks have fledged (for cormorants and gulls, this refers to monitored plots only) or are fully feathered. BRAC are considered fledged if they wandering, are at least 28 days old, and are at least partly-feathered. PIGU crevices cannot be regularly monitored, as many are in cormorant colonies or out of reach. Presence of PIGU chicks is confirmed by delivery of fish to the nest site by the parent or by incidental sightings of chicks.

	First adults on island roosting/ rafting on water (PIGU)	**First adults attending nest sites/ holding territories**	**First egg lay seen**	**First chick hatch/ fish delivery (PIGU) seen**	**Last chicks fledged/ last fish delivery seen (PIGU)**
BRAC	10 Feb	13 May	20 May	17 Jun	26 Aug
PECO	11 Mar	8 Apr	no egg lay	no chick hatch	no chick fledge
WEGU	present year round	February	29 Apr	27 May	26 Aug
CAGU	18 Mar	1 Apr	26 Apr	3 Jun	19 Aug
PIGU	18 Mar	21 Mar	10 Jun	17 Jun	29 Jul
BLOY	present year round	25 Mar	n/a	3 Jun	10 Jul

Table 6. Summary table showing frequency (and percentage) of types of disturbances to Brandt's Cormorants on Alcatraz Island, 1997-2010.

Type of Disturbance		Number of disturbances observed													
		1997 (205.5 hrs)	**1998** (226.5 hrs)	**1999** (313.4 hrs)	**2000** (216.4 hrs)	**2001** (251.3 hrs)	**2002** [1] (95.5 hrs)	**2003** [2] (224 hrs)	**2004** [2] (339.7 hrs)	**2005** (334.4 hrs)	**2006** (363.4 hrs)	**2007** (307.8 hrs)	**2008** (185.5 hrs)	**2009** (110.7 hrs)	**2010** [4] (177.2 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%)	**0** (0%)	**0** (0%)
	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%)	**2** (100%)	**1** (25%)
	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%)	**0** (0%)	**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%)	**0** (0%)	**1** (25%)
	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%)	**0** (0%)	**1** (25%)
	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%)	**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%)	**0** (0%)	**1** (25%)
% of major disturbances (n)		**30 (22)**	**29 (27)**	**22 (45)**	**23 (42)**	**10 (21)**	**51 (34)**	**23 (34)**	**49 (21)**	**29 (10)**	**70 (19)**	**67 (43)**	**69 (27)**	**100 (2)**	**25 (1)**
Total:		**74**	**94**	**201**	**203**	**207**	**67**	**149**	**43**	**34**	**27**	**64**	**39**	**2**	**4**
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**	**0.21**	**0.02**	**0.02**

[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 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.
[4] In 2010, disturbance monitoring did not take place on weekend days which are known to be the busiest days of activity around the island. Number and frequency of disturbances may be higher than data reflects and is not comparable to previous years.