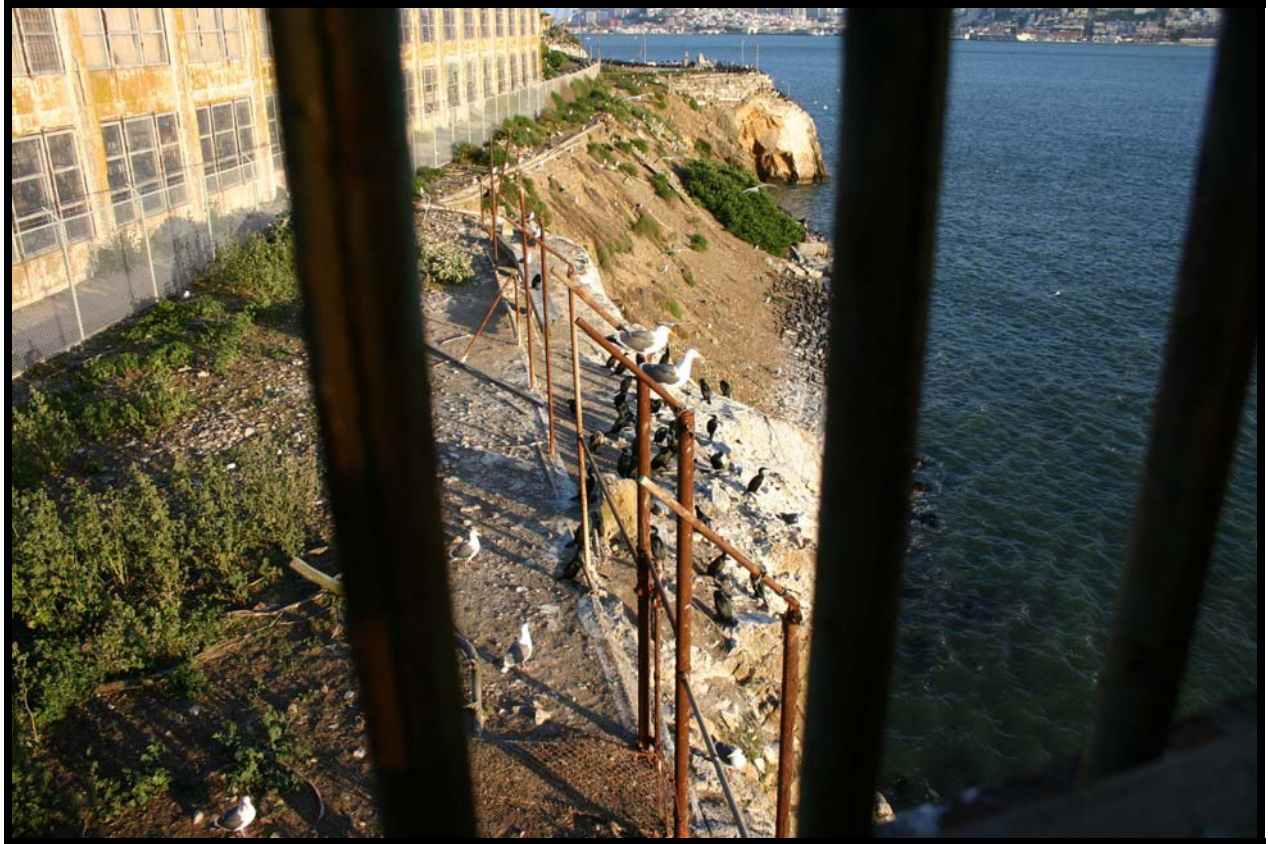


# *Alcatraz Island Special Event Seabird Disturbance Monitoring Report 2007*



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 regionally significant breeding site for a number of seabird species in recent years. 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. Therefore, we were requested to monitor a National Park Service (NPS) permitted special event that took place in the Laundry Building in April 2007. This occurred at the start of breeding season when some seabird egg laying has occurred in past years, and was adjacent to a colony which hosts most of the breeding birds that reside at Alcatraz Island. The objective was to document disturbances to seabirds associated with the event as well as any longer term impacts on breeding that could be discerned.

Several pre-event preparation activities took place in and around the Laundry Building prior to arrival of breeding cormorants on the island. Other pre-event preparation took place on 12 and 19 March, after cormorants had arrived, but without prior notification of NPS Natural Resources staff. Luckily, once Natural Resources staff recognized this, they were able to monitor during some of these activities, which caused cormorants to flush (leaving nesting sites) from the Laundry Building sub-colony.

We monitored seabirds continuously for disturbance during a 3 day period from pre-event preparation to post-event breakdown and clean-up (2 April- 4 April). Several major disturbance events that resulted in portions of the Brandt's Cormorants flushing from the Laundry Building sub-colony were caused by noises from dropped equipment at the loading dock. Other disturbances during this period included visitors entering restricted areas at the south end of the Laundry Building (not event related), a secondary reaction to the disturbance of gulls (due to event activities, a hawk fly-over, and other unknown reasons), and a canoe rowing past the sub-colony (not event related). Night lighting from the lower level of the Laundry Building in addition to visitor noise outside the building during the event likely also disturbed cormorants and was related to the reduction in numbers of birds on 3 April. Finally, cumulative effects from event disturbance along with the deteriorating condition of a temporary fence for the event, rattling plywood in the Laundry Building from the event, late rains, and a kayak disturbance also probably influenced the absence of birds from this sub-colony one week after the event. This temporary abandonment occurred after other cormorant sub-colonies had already established nests and begun laying eggs.

From 2 April to 4 April, the number of disturbances to birds increased. The total number of disturbances that were directly caused by event activities was at least 39%, but higher if disturbances that were unknown but suspected to be caused by event activities were included (up to an additional 36%). Severity of bird reactions to disturbances also increased during this period. This contradicts the theory that birds may acclimate to disturbance; repeated major disturbances appeared to cause birds to become more sensitive through time.

Effects of disturbance to the Brandt's Cormorant Laundry Building sub-colony were most evident in changes in the number of breeding birds present. A total of only 8 cormorant pairs nested in this location in 2007. This was significantly lower than the more than 157 cormorants which initially attempted to nest at this sub-colony, and a large decline in comparison to the 145 nesting attempts at the Laundry Building in 2006. This was also significantly lower than numbers at other sub-colonies in 2007. The mean egg-laying date at the Laundry Building sub-colony was significantly later than at other sub-colonies around Alcatraz. Of the 8 pairs that remained at the Laundry Building, no major differences were found in other breeding parameters measured, yet the 141 cormorants that left the Laundry Building may have either not bred or switched to other sub-colonies. A very rough estimate was that 8% of the cormorant population on Alcatraz attempted to breed at the Laundry Building sub-colony and experienced lasting effects from the event. As much as 31% of the cormorants breeding on Alcatraz experienced some type of potentially event-related disturbance, including portions of other sub-colonies near the Laundry Building (e.g., Northern and Model Industries sub-colonies).

Besides event disturbances, the rate of overall disturbance throughout the rest of the seabird breeding season was higher than in previous years. Cormorants seemed more sensitive to certain events this year than in past years (e.g. gunshots from sailboat races), causing them to flush more often during the season. This continued increase in sensitivity may be due to cumulative effects of disturbances to the birds throughout the season, including those experienced during the special event.

Active protection and management of seabird breeding habitat on Alcatraz is 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. Although breeding seabirds on Alcatraz can appear 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.

Due to the sensitivity of cormorants to disturbance, primarily during pre-breeding and breeding activities from February to September, we recommend that construction activities, maintenance, public access, and special events in or adjacent to areas closed for seabird breeding be scheduled between October and January. In general, island-based human disturbance is potentially the easiest of all types of disturbances to control because the NPS can manage on-island activities. Coordination of both law enforcement and outreach staff in this endeavor is crucial. We also recommend strict regulations and NPS Natural Resources staff guidance in granting permits, that restrictions placed on permittees are strictly enforced, and that such privileges should be carefully planned in advance to prevent any potential miscommunication and/or disturbance to wildlife.

## *INTRODUCTION*

A number of colonial waterbird species inhabit Alcatraz Island (37° 49'N, 122° 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). Breeding waterbirds 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*), and California Gulls (*Larus californicus*). The Brandt's Cormorant colony on Alcatraz is one of the few known estuarine breeding sites for this species.

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 1.4 million visitors tour the island annually, and associated historic preservation and safety construction projects, public access to breeding areas, gardening activities which are part of a new historic garden restoration program, and special events may disrupt the breeding efforts of Alcatraz seabirds. Encroachment near the Alcatraz shoreline by large numbers of commercial and/or recreational boaters (e.g. tour boats, fishermen, kayakers), and uncontrolled aircraft overflights (e.g. air tour operators, U.S. Coast Guard helicopters), may have similar effects.

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.

This report details a Special Park Uses-permitted event held on the evening of April 3, 2007, by the Golden Gate National Recreation Area (GGNRA) with Bridgestone/Firestone and Signature Hospitality Group in the Laundry Building on Alcatraz Island. This event coincided with the pre- to early breeding season for seabirds, one of the most sensitive periods of the year. Event preparation, the event itself, and post-event cleanup all had the potential to affect pre-breeding or breeding birds to varying degrees, including Brandt's and Pelagic Cormorants, Pigeon Guillemots, Black Oystercatchers, and Western Gulls that breed near the Laundry Building. One of the approval conditions for the event was that it was to be monitored to document disturbances and try to avoid any adverse impacts to nesting seabirds. Therefore disturbance monitoring was carried out for these nesting species in proximity to the event area, but was focused 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). Monitoring was conducted with two main goals: 1) to determine if event-related activities were correlated with seabird disturbances, stress behaviors, and/or nest failures, and 2) determine whether there was a difference in seabird reproductive parameters (breeding population size, timing of breeding, clutch size, hatching success, overall productivity) between plots in proximity to event-related activities versus other study areas. Results will be used to adapt future even planning if necessary before permit approval, to minimize disturbance or to provide suggestions for mitigating disturbance.

## *METHODS*

Seabird breeding sub-colonies for all relevant species in proximity to the event were monitored before, during and after the event day. Baseline activities of Brandt's Cormorant behavior and breeding numbers at the entire Laundry Building sub-colony were determined at regular intervals for up to 2 weeks prior to the event and 1 week subsequent to the event. For the remainder of the season, we expected to follow a study plot within this sub-colony until the end of breeding activity. However, due to the very small number of breeding sites actually established in this sub-colony, we followed all nests for the remainder of the season. Due to the inability to establish "control plots" identical to the Laundry Building plot, "reference plots" were chosen for comparison, containing the same species and as similar habitat as possible to the Laundry Building plot (**Figure 1**). For each Laundry Building and reference plot, nests were followed for reproductive performance throughout the breeding season (including timing of breeding, clutch size, hatching success, overall productivity). Any disturbances observed to any seabirds were also noted.

Starting 1 March for cormorants and 25 March for other species, reproductive performance and timing of breeding activities were monitored once per week. Starting the week prior to the event, seabird monitoring was conducted twice/week. Observations were made from concealed locations above each colony that allowed clear views into study nests. The following data were recorded for each nest: date, nest site number, nest contents (number of eggs and/or chicks).

During the 3 day period including setup, breakdown and the event itself, the Laundry Building sub-colony was continuously observed during day and nighttime activities from 2 observation points for any disturbances (2 April 0000-1700, 3 April 900-2430, 4 April 700-2030). After this period, all study plots were monitored for disturbances 2 days a week for several hours, concurrently with seasonal nest monitoring activities. Disturbance records included any interaction between humans and birds or interspecific bird behavior that could have been the result of disturbance. The area in which disturbance was recorded included anything within view up to 100m from sub-colonies. As it occurred within the viewing area, the observer recorded the following data: observation location, sub-colony affected, time and duration of event, description of event (including behaviors and number and type of staff or visitors involved or details of noises that caused disturbance), distance of disturbance event from individual birds or sub-colonies affected, species and number and proportion of visible birds affected, area affected, degree of

effect (numbers of birds affected and their response to disturbance), discrimination between breeding and roosting birds, and time that observations began and stopped for standardization purposes.

During the setup and the event itself, one GGNRA Natural Resources staff acted as a go-between for PRBO staff conducting monitoring and the event staff manager. When disturbances were observed that could be minimized by modifying event staff or visitor behavior, the Natural Resources staff person immediately notified the event manager of this need and tried to work cooperatively to achieve a timely solution.

## *RESULTS AND DISCUSSION*

### **Special event**

The special event introduced light and nighttime activity into an area accustomed to neither. Staging and event load in began on 2 April at midnight when a barge carrying equipment for the event arrived at the dock at Alcatraz Island. Equipment was unloaded from the barge and carried or driven over to the staging area in front of the PX/Officers Club between 0100 and 0700. Beginning at 0700 equipment was moved from the staging area by vehicle to the loading dock (north entrance to the Laundry Building) and carried into the Laundry Building where work inside began; this included the use of a pick up truck and forklifts to haul pallets and equipment to the loading dock. At 1930, event preparation ended for the day. Setup continued on 3 April from 0700 to 1630, most of which took place inside the Laundry Building. About 850 guests arrived for the event and began to enter the Laundry Building at 1900. The event activities included a kitchen-type setup in the northwest corner of the building near the windows adjacent to the Brandt's Cormorant colonies, a live band inside the Laundry Building, lighting inside the building after dark, and portable restrooms outside near the Power House Building with a designated walking path and outdoor path lighting for guests to follow. Guests began leaving at 2000 until 2200 when the event ended. Once guests departed, a cleanup crew worked to remove food and drink from the Laundry Building until 2358. On 4 April, the cleanup and breakdown of the event continued in a similar fashion as the event setup; again including the use of a truck and forklift for hauling equipment back to the dock. Breakdown of the event ended at 1730.

In addition to the above event preparation that was monitored for disturbance, some event preparation took place prior to 2 April. On 12 and 19 March, a group of prison inmates was brought to the island in order to move equipment from the Laundry Building into the Model Industries Building. Other pre-event preparation prior to 2 April included installing internal screening over the windows of the Laundry Building (opaque auto body paper); cleaning the interior of the building; erecting a shade cloth-covered fence around the entrance to the Laundry Building as a visual barrier between event activities and the Laundry Building Brandt's Cormorant sub-colony; and also installing shade cloth on the fence bordering the Model Industries Plaza to minimize disturbance to breeding Western Gulls.

### **Seabird response to event activities**

The internal screening, much of the cleaning of the Laundry Building, and the external screening surrounding the loading dock were conducted prior to the arrival of Brandt's Cormorants to the island, so birds would not have been affected by these activities. However, NPS natural resources staff were not notified prior to the activities on 12 and 19 March after cormorants had arrived on the island. Luckily they were able to monitor during part of the moving process. On 12 March, morning activities were not monitored. Ten Brandt's Cormorants were present at the Laundry Building sub-colony prior to afternoon activities, and 5 of these flushed as the process of using a forklift to move equipment made noise and could clearly be heard at the monitoring station adjacent to the colony. Two Pelagic Cormorants were also seen leaving from the Model Industries sub-colony. Brandt's Cormorants also flushed during similar activities on 19 March, and subsequently returned. The shade cloth on the Model Industries Plaza fence was not

installed until the 2 April. This caused some disturbance to Western Gulls along the fence, but no cormorant disturbance was observed during this installation.

Disturbances to seabirds happened repeatedly throughout the 3 days of continuous monitoring before, during and after the event from 2 April to 4 April (**Table 1**). On the morning of 2 April when vehicles and people were first preparing to approach the Laundry Building, it took 2 ¼ hours for most Brandt's Cormorants to return to this sub-colony after being disturbed (**Figure 2**). On the night of 3 April during the event, cormorants flushed or left throughout the evening (a period when birds normally return to sub-colonies to roost) and were not observed at the colony until the following morning. In other instances in which cormorants flushed, it took anywhere from a few minutes to 1 hour for most to return to the sub-colony.

**Table 2** summarizes event-related and other types of disturbance along with the severity of Brandt's Cormorants' reactions from 2 April to 4 April. Each day, the number of disturbances increased. The overall frequency of disturbances during monitoring was about 2 per hour. The total number of disturbances that were directly caused by event activities was at least 34 out of 87 (39%), but higher if those disturbances that were unknown but suspected to be caused by event activities were included (up to an additional 36%). Most of these disturbances were due to sudden noises from equipment accidentally dropped at the loading dock (north entrance to the Laundry Building), which caused portions of the Laundry Building sub-colony to flush. However, other disturbances to cormorants during this period included visitors entering restricted areas on two occasions at the south end of the Laundry Building (3 April at 1530, 4 April at 1330), a secondary reaction to the disturbance of gulls (due to event activities, a hawk fly-over, and other unknown reasons), and a canoe rowing past the sub-colony. Western Gull disturbance levels were high with all the human activity around the Laundry Building during daylight hours and with any activity after dark when they are accustomed to no human presence. Disturbance to gulls in turn often affected cormorants, as they were more alert or agitated by gull alarm calls. The south door of the Laundry Building was supposed to be locked and off-limits, yet that was apparently not always the case. Several of the unknown causes of gull and cormorant disturbance may have been attributable to visitors or event staff in restricted areas at the south end of the Laundry Building, e.g., on 2 April at 1545, on 3 April at 1458 and again at 1945, and on 4 April at 837 and 942. NPS staff noted that on at least 2 occasions event staff stepped outside the south entrance of the Laundry Building. The unknown disturbances flushed between 30-130 cormorants each time on 2-3 April, but between 240-300 cormorants each time on 4 April. Known visitor disturbances caused 30 cormorants to flush on 3 April, and 300 cormorants to flush from multiple sub-colonies on 4 April. In addition to the number of disturbances increasing through time, the severity also increased. This contradicts the theory that birds may acclimate to disturbance. Perhaps birds would acclimate to minor disturbances that repeatedly do not threaten breeding attempts (see General Disturbances below), but repeated major disturbances appeared to cause birds to become more sensitive through time.

The peak count of cormorants at the Laundry Building sub-colony on the day of the event was 135 individuals at 1900. This was prior to guest arrival at the Laundry Building. Over the course of the evening, the number of cormorants decreased to 13 individuals at 2359 when event cleanup ceased for the night. Event activities including cooking, live music inside the building, and interior/exterior lighting could not be heard or seen from monitoring observation points. High winds during this period may have helped decrease the birds' ability to detect noise coming from the Laundry Building. It is unknown if cormorants were able to hear the event activities inside, but due to their closer proximity to the Laundry Building, it is possible that they were affected by it. No lighting could be seen from the upper level of the Laundry Building where the event took place, however a lower level light was seen as soon as it became dark. It is unknown how long the light had been on prior to the event activities, but this may have also disturbed cormorants at the Laundry Building sub-colony. Although guests were discouraged from congregating around the north entrance to the Laundry Building and ushered along the walkway between the building and the restrooms/dock, voices were often heard throughout the evening. Western Gulls often alarmed as

guests passed. Cormorants flushed from the Incinerator area at 1945 after gull disturbance. During cleanup that evening, noises from equipment being carried out also caused cormorants to flush from the Laundry Building sub-colony on one occasion. The combination of the lower-level lighting, guest voices, disturbed gulls, and equipment noise was likely the cause for the decline in the number of cormorants at the Laundry Building sub-colony throughout the evening.

Cormorant numbers at the Laundry Building sub-colony returned to 129 birds on the morning of 4 April, peaking at 157, but several major disturbances on that day reduced the number of birds to fewer than 86 and then repeatedly to less than 35 individuals. By 7 April, there were only 58 cormorants attending this sub-colony when a kayak passed close to the colony and flushed birds. Furthermore, rain was documented on April 7, 11, 14, 18, 21, and May 1, 2, and 9. Rains occurring during nest initiation and egg-laying of seabirds (April - May) on Alcatraz have not been common, but can create unfavorable nesting conditions due to some nesting sites potentially becoming flooded. These late rains in combination with repeated disturbances could have also accounted for fewer individuals attending sites in early April.

The fence erected around the loading dock to minimize event-related disturbance did aid as a visual barrier and no disturbance to cormorants during the event was recorded in response to visual cues of equipment or people moving in and out of the building. However, the condition of the barrier quickly deteriorated due to wind and was no longer structurally sound by 11 April. At that point, the fence was potentially a source of disturbance itself, due to tattered materials and metal framing flapping and creaking in the wind. The fence was not stabilized until 10 May, nearly one month after its deteriorating conditions were noticed. In addition to this fence, a wooden ply board was discovered rattling on 11 April inside the Laundry Building, covering the doorway to the room that was used as a kitchen. The ply board was attached only at the top end of the door, so it rattled loudly as the wind blew through the building. A chair was propped against the board on 13 April in order to prevent the board from continuing to make noise. Even though cormorants initially kept returning to breeding sites after disturbances during the 3 days pre- and post-event, cumulative effects of disturbance may have ultimately resulted in the temporary abandonment of the Laundry Building sub-colony and the subsequent low numbers of breeding attempts. Birds were absent from breeding sites at the Laundry Building between 11-18 April, at which time cormorants in other sub-colonies had already established nests and begun to lay eggs (**Figure 3, Table 3**).

### **Comparisons of cormorant demographics between sub-colonies**

The portion of Laundry Building sub-colony adjacent to the building was first established in 2004. In 2004, timing was significantly later than at other sub-colonies, which is typical for new sub-colonies (**Table 4, Figure 4**). The sub-colony grew in size from 72 nests in 2004 to 123 nests in 2005. Timing in 2005 was not significantly different from other sub-colonies except for Model Industries which was very early. In 2006, the visual barrier on the fence next to the Laundry Building sub-colony was removed prior to the breeding season and disturbances increased as a result. This is likely the reason timing was significantly different from many other sub-colonies in 2006.

In 2007, the number of cormorants attempting to breed at the Laundry Building sub-colony peaked at 157 birds, yet by 18 April, most had abandoned and only 8 pairs ended up breeding there. This number was very low in comparison to the 145 nests that were established at the Laundry Building sub-colony in 2006. Population size of the Laundry Building sub-colony was also significantly lower than at other sub-colonies in 2007 (**Figure 3**). In past years, pre-laying attendance at all sub-colonies included a maximum of 23-33 birds more than the number that subsequently laid eggs in a particular subcolony (2004-2006). However in 2007, pre-laying attendance during standardized bi-weekly censuses at the Laundry Building sub-colony included 117 more birds than the number that subsequently bred. From the continuous 3-day monitoring, the actual number of additional birds was 141. Thus, a very rough estimate was that 8% of the cormorant population on Alcatraz attempted to breed at the Laundry Building sub-colony and experienced effects from the event that lasted beyond the 3 days of concentrated event activity. As much as 31% of the



cormorants breeding on Alcatraz experienced some type of potentially event-related disturbance, including portions of other sub-colonies near the Laundry Building (e.g., Northern and Model Industries sub-colonies).

Cormorant egg-laying in 2007 began as early as 4 April in the Barker Beach sub-colony and mean lay date was 15 April (**Figure 4, Table 3**). Mean lay dates for the Model-Industries sub-colony were 28 April, North Foghorn sub-colony was 2 May, Northern sub-colony was 4 May, and Southern sub-colony was 8 May. The Laundry Building sub-colony again laid eggs significantly later in the season than the rest of the sub-colonies and subsequently had the latest mean lay date of 15 May (**Table 4**). These differences were likely the result of event-related activities and cumulative effects of disturbance to the Laundry Building sub-colony that carried into the following week.

Most cormorants initially exhibiting breeding behavior at the Laundry Building sub-colony left before laying eggs, yet of those 8 that remained, clutch size, hatching success, and overall productivity were not significantly different between study plots in different sub-colonies (ANOVAs,  $p_{\text{all}} > 0.18$ ). Some cormorants that left the Laundry Building sub-colony may have not bred, and others may have switched to other sub-colonies to breed, as influxes of birds were seen after the special event at the Southern, Northern, Barker Beach, and North Foghorn sub-colonies. Potential impacts of disturbance and subsequent re-nesting may include birds moving from a preferred nesting site to the periphery of other sub-colonies, where productivity is generally lower (Siegel-Causey and Hunt 1986). However, birds were not individually marked, so movement could not be confirmed. While some of these late nesters were added to the other study plots and monitored, the majority were on colony edges and thus not within study plots. Therefore it could not be determined if clutch size, hatching success and overall productivity of these late birds was significantly different from the rest of the breeding birds.

### General disturbances

In addition to the disturbances that occurred during the period surrounding the special event in April, there was an increase in the rate of overall disturbance throughout the breeding season in 2007 (**Figure 5**). There were many occasions of Brandt's Cormorants being flushed due to disturbances such as kayaks, canoes, helicopters, and visitors entering restricted areas. The overall number of major disturbances was higher than in other years (see below). Additionally this year, events such as gunshots from sailboat races in the bay, which in previous years caused only minor disturbances (cormorants aware and looking around), were observed to cause cormorants to flush. This further suggests that cumulative effects of disturbances increased the behavioral sensitivity of cormorants.

In previous 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 and public access was pulled back from the fence. Nevertheless, due to its removal the number of island-based human-caused disturbances increased. Although public access was restricted to this area, some staff and researchers were still required to access the Model Industries Building. The lack of this shade cloth allowed birds to see humans walking to and from the building, causing some birds to flush from breeding areas. This accounts for the high percentage of major disturbances in 2006 in Figure 4. Despite researcher caution in this area, several nests were likely negatively impacted as evidenced by cormorant behavior or nest failure. 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 at this location is necessary.

Active protection and management of seabird breeding habitat on Alcatraz is undoubtedly critical to the observed growth and maintenance and 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. Unlike unpredictable event activities that caused major disturbances discussed above, 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 (Carney and Sydeman 1999). Additionally, disturbance effects reported in a review by Carney and Sydeman (1999) were often just incidental accounts which neither examined effects of different types of disturbance nor controlled for confounding influences, e.g. environmental conditions.

Brandt's Cormorants in particular are sensitive to human disturbance (Ainley & Lewis 1974, Carter et al. 1996, Boekelheide & Ainley 1989, Boekelheide et al. 1990). It may take only one ill-timed disturbance to potentially cause colony failure. Although breeding seabirds on Alcatraz can appear fairly resilient to disturbance events on a case-by-case basis (i.e., returning to breeding sites), cumulative effects of chronic disturbance to seabird breeding colonies, especially under varying environmental conditions, are unknown. It is possible that regularly disturbed colonies are likely to persist only if the advantages for seabirds to stay at the colony outweigh the disadvantages. For instance, rain combined with event-related disturbances as mentioned above may have created unfavorable nesting conditions and contributed to the temporary abandonment and subsequent low number of nesting attempts at the Laundry Building sub-colony in 2007. In another example, prey availability near Alcatraz Island may be high or predictable in some years, prompting cormorants to breed there, but marine conditions negatively affecting forage fish may intensify the effects of disturbance felt by the birds, resulting in colony abandonment as observed at the Northern sub-colony during the 1998 El Niño event. Currently, central California prey conditions (an abundance of large anchovy) appear to favor cormorant productivity and population growth. However, diversity of the prey base in the greater Gulf of the Farallones is lower than ever before recorded in PRBO's time-series dating back to 1975 (Warzybok et al. 2006, Lindquist & Thayer 2006). Should marine conditions negatively affect anchovy, cormorants may not have sufficient alternative prey resources and behavior patterns at the breeding colony could be drastically altered.

## *RECOMMENDATIONS*

Island-based human disturbance is potentially the easiest to control because the NPS can manage on-island activities. Due to the sensitivity of cormorants to disturbance, primarily during pre-breeding and breeding activities from February to September, we recommend that construction activities, maintenance, public access, and events adjacent to seabird nesting sub-colonies be scheduled outside of the seabird breeding season (October to January). Staff access to the Model Industries and other sensitive areas should also be very limited during the seabird breeding season. We recommend strict regulations and NPS Natural Resources staff guidance in granting permits, that restrictions placed on permittees are strictly enforced, and that such privileges should be carefully planned in advance to prevent any potential miscommunication and/or disturbance to wildlife. Monetary fines may be an incentive for permit grantees to adhere to specified regulations.

Installation of any visual barriers in proximity to seabird nesting habitat should occur prior to arrival of birds for pre-nesting (1 February). Construction of any visual barriers (or other projects of the like) in proximity to seabird nesting habitat should be made durable enough to withstand the elements throughout the entire seabird season to eliminate problems of noise from a deteriorating structure.

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 seabirds 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 alternative. Plantings have the additional advantage of not requiring staff time for seasonal installation/removal.

To reduce additional visitor disturbances, durable signs should be posted in front of all closed areas. The signs could not only warn visitors of citations and 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.

### Summary of recommendations:

- Allow no public visitation, special events or construction activities to be carried out near the western cliffs used by breeding seabirds (Figure 1) after early February, especially if activities may influence seabird pre-breeding or early-nesting behavior.
- Limit staff access to the Model Industries Building and improve visual barriers in this area since some staff and researcher access is required.
- Make visual barriers between humans and breeding birds more rigid and durable to increase effectiveness, especially in the Model Industries and Laundry Building areas.
- Enforce strict regulations in granting and carrying out special use permits, and such privileges should be carefully planned well in advance to prevent any potential miscommunication and/or disturbance to wildlife.
- Increase warning signage in sensitive areas with threat of law enforcement consequences.
- Secure debris (e.g., trash bags, tarps, etc.) that can blow away in windy conditions from event or construction sites and potentially cause seabird disturbance.

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**Table 1.** Disturbance records to seabirds on Alcatraz Island before, during and after special event. MI = Model Industries, LB = Laundry Building, SW = Seawall, NC = North Colony, BB = Barker Beach, NF = North Foghorn; BRCO = Brandt's Cormorant, WEGU = Western Gull; Severity of disturbance: 1 = looking in direction of disturbance, 2 = growling or alarm calling, 3 = erect posture, 4= ran/moved off nest, 5 = flushed/flew from colony, ndo = no disturbance observed.

AREA	DATE	TIME	DUR (min)	DESCRIPTION	DIST (m)	# DISTURB	SEVERITY	SPECIES	NOTES
DOCK	402	0010	1	light on Westar goes on	100	200	5	WEGU	Many breeding WEGU flush off nests
LB	402	0030	-	researcher entered LB loading dock; no screen on fences	8	100	5	WEGU	80% of birds disturbed
MI PLAZA	402	105	0.5	researcher enters MI bldg; no screen on fences	5	26	5	WEGU	~13 pair flush upon entering gate
QM BLDG	402	115	1	researcher passes QM bldg	20	30	5	WEGU	roosting birds, 50% disturbed
CISTERN	402	120	1	researcher enters QM corner area	50	100	5	WEGU	flushed from cistern
MI PLAZA	402	318	1	researcher enters MI ramp; no screen on fences	10	6	5	WEGU	flush off terrace; 10% of birds disturb
MI PLAZA, LB	402	629	15	unk	unk	200	5	WEGU	Many WEGU flush
MI PLAZA, LB	402	644	-	vehicles/people getting ready to begin loading equipment into LB	10	55	5	BRCO	90% off birds disturbed
MI PLAZA	402	745	3.00	staff inspecting diesel fuel lines walked into MI Plaza for routine maintenance	0	20	5	WEGU	maintenance occurs 2-3x/wk, 20/60 birds flushed/calling
LB	402	802	2.00	forklift arrived	8	1	5	WEGU	breeding bird flush off terrace
MI	402	817	0.50	wooden row boat with blue oars approached island	15	ndo	ndo	BRCO	
LB	402	910	0.03	equipment suddenly dropped, sudden noise, on loading dock outside LB	21	26	5	BRCO	20 remaining cormorants looked around

AREA	DATE	TIME	DUR (min)	DESCRIPTION	DIST (m)	# DISTURB	SEVERITY	SPECIES	NOTES
LB	402	915	0.30	loud talking/yelling btwn 2-3 workers	21	10	1	BRCO	8% of birds disturbed
LB	402	925	0.03	WEGU scuffle at south end - no loud noise from event loading	unk	30	5	BRCO	20/46 flushed; 10/46 adults on alert, looking
LB	402	930	-	noise inside LB	21	20	1	BRCO	20/50 looking around
LB	402	940	0.05	loud equipment noises moving into bldg.	21	2	1	BRCO	2/51 looking
LB	402	945	0.08	loud equipment noises moving into bldg.	21	10	1	BRCO	10/53 looking
LB	402	1010	0.30	cutting wood with power saw in LB	21	8	3	BRCO	8 looked in direction with erect posture; 6% of birds disturbed
LB	402	1011	0.03	5 WEGU fly in BRCO colony for food	0	1	5	BRCO	1/37 BRCO flew off
LB,SW	402	1014	0.13	5 WEGU call for unk reason, they rounded corner at MI bldg	0	30	5	WEGU	
LB	402	1014	0.13	5 WEGU call for unk reason, they rounded corner at MI bldg	0	1	5	BRCO	
LB	402	1033	0.05	equipment noise while moving into LB	21	5	1	BRCO	5 of 40 disturbed
NC,SW,BB	402	1049	0.17	lg boat, <i>Compass Rose</i> CF8496? EW	15	ndo	ndo	BRCO	
MI-->BB	402	1100	3.00	gray shark painted boat w/ 1 POB, CF2415?ST	21	ndo	ndo	BRCO	
LB	402	1145	1.00	researcher enters MI bldg for noon switch; no screen on fences	15	1	2	WEGU	alarm calling as JB enters MI
LB	402	1145	1.00	researcher enters MI bldg for noon switch; no screen on fences	15	58	5	BRCO	55 of 77 up and erect, 3 of 77 flush

AREA	DATE	TIME	DUR (min)	DESCRIPTION	DIST (m)	# DISTURB	SEVERITY	SPECIES	NOTES
LB	402	1153	0.20	researcher leaving MI; no screen on fences	15	56	1	BRCO	80% of birds disturbed, looked in direction
LB	402	1157	0.05	unk? possible radio noise	15	62	5	BRCO	flushed from cliff; 90% of birds disturbed
LB	402	1241	0.20	loud noise, banging chairs or something	21	20	4	BRCO	3 birds ran, the rest looked in direction and stood erect; 30% of birds disturbed
LB	402	1252	0.30	loud noises from LB loading dock	21	15	3	BRCO	25% birds became erect and looked in direction
LB	402	1315	0.10	loud pipe dropped and made noise	21	20	3	BRCO	30% of birds looked in direction and became erect
MI PLAZA	402	1320	15.00	installed fence barrier cloth	0	7	5	WEGU	5 gulls alarmed, 2 gulls along fence flushed
NP	402	1330	0.33	Golden Bear tourboat, Blue & Gold Fleet w/ loud speaker	31	ndo	ndo	BRCO	
LB	402	1404	0.12	WEGU alarm, unknown cause	0	10	3	BRCO	on alert/looking; 10/100
LB	402	1515	0.17	unk	unk	80	5	BRCO	30 of 97 flush; 4-5 other BRCO stealing nest material of those that flushed; 60 looking
LB	402	1519	1.00	WEGU trying to grab a fish regurge from corm	0	1	2	BRCO	WEGU finally got fish
MI PLAZA	402	1522	-	unk	unk	2	3	WEGU	attempted copulation and failed; possible disturbance-related
MI PLAZA	402	1545	-	unk	unk	20	5	WEGU	colony flushed; 85% of birds disturbed
LB	402	1545	0.25	unk. why WEGU flushed on S. end, WEGU alarm calls	24	45	5	BRCO	45/100 disturbed; BRCO returned within ~1 min.
CISTERN, S. END LB	402	1545	0.25	unk	0	50	5	WEGU	

AREA	DATE	TIME	DUR (min)	DESCRIPTION	DIST (m)	# DISTURB	SEVERITY	SPECIES	NOTES
BB	402	1700	10.00	5 wind surfers	unk	-	5	BRCO	40% of birds near incinerator and BB flushed; eggs seen in nest of BRCO!
LB	403	947	0.02	equipment noise at loading dock	15	5	1	BRCO	
LB	403	950	0.17	unk.- WEGU alarm	unk	20	5	BRCO	
NCN	403	955	0.08	unk cause	unk	35	5	BRCO	35/115 flush
LB	403	1033	0.08	sudden, loud noise at loading dock - ladder falling on metal ramp?	15	56	5	BRCO	16/96 flush; 40/96 look
LB	403	1045	0.50	WEGU alarm calling overhead/flying by LB - unk why	0	45	4	BRCO	45/100 looked, jumped on bench or to edge of cliff
LB	403	1200	-	Siren	unk	3	1	BRCO	3/71 look up
MI PLAZA/ CISTERN	403	1300	-	road traffic? intersp. event?		12	5	WEGU	flushed and calling
SW, NC, BB, SC	403	1458	2.00	unk; gulls up and alarming	unk	130	5	BRCO	40/80 flush from SW, 60/60 ad & juv flush from NC, 30/? flush from BB & SC
LB	403	1500	0.03	cistern gulls flush - unk. reasons	46	96	5	BRCO	96/128 birds disturbed
BB,SC,NC	403	1510	0.50	unk, possible sailboat disturbance?- <i>Derek M Baylus</i> passed by	61	30	5	BRCO	30/? seen flush from BB/SC area before boat was seen
NC	403	1530	0.03	visitor walked into restricted area at S. end of LB (on sidewalk btwn. LB & SW)	12	45	5	WEGU	WEGU in air calling
INCINERATOR, LB, NC	403	1530	0.03	visitor walked into restricted area at S. end of LB (on sidewalk btwn. LB & SW)	12	225	5	BRCO	30/100 BRCO flush from incinerator, 90-100 almost ready to flush at LB, 100/100 at NC erect, looking



AREA	DATE	TIME	DUR (min)	DESCRIPTION	DIST (m)	# DISTURB	SEVERITY	SPECIES	NOTES
LB	403	1555	0.08	jet flyover, noisy	unk	30	1	BRCO	30/124 look up
LB	403	1600	1.00	Red-tailed Hawk flyover cistern/LB	unk	100	5	WEGU	up over cistern; ~200 WEGU & 2 CORA chasing RTHA
LB	403	1600	1.00	Red-tailed Hawk flyover cistern/LB	21	100	5	BRCO	30/124 flush LB, 70/124 erect, looking around
LB	403	1610	-	red & white tour? helo flyover, safe distance but LOUD	152	10	1	BRCO	10/130 birds disturbed
LB	403	1715	0.17	door to LB banging shut	22	5	1	BRCO	5/118 birds disturbed
LB, NC	403	1740	1.00	unk cause- gulls up and alarming	unk	80	5	BRCO	50/118 flushed LB and returned w/in few min., 30/60 birds disturbed at NC
LB	403	1744	0.17	LB door slams	21	40	1	BRCO	10/118 birds disturbed
LB	403	1900	-	WEGU alarm calling, unknown reason	unk	25	1	BRCO	20-30 look up
INCINERATOR	403	1945	-	unk- staff watching S. end of LB	unk	30	4	BRCO	all corms at alert; 30 walk to edge of wall; WEGU alarming
MI	403	2138	-	guests leaving LB	9	1	5	WEGU	Screeching
MI	403	2035	-	guests leaving LB; n. end of walkway	3	15	5	WEGU	up and calling
NORTH PERIMETER	403	2230	0.25	unk.	unk	30	5	WEGU	
LB	403	2335	0.02	equipment noise at loading dock; something dropped	15	6	5	BRCO	6/21 flush
MI	403	2045	1.50	unk- researcher? moving to record data?	unk	20	5	BRCO	20/50 flush; all growling
MI	403	2100	0.33	unk- researcher? moving to record data?	unk	20	5	BRCO	20/50 flush
MI	404	2413	-	unk	unk	28	2	BRCO	most up off nests and growling

AREA	DATE	TIME	DUR (min)	DESCRIPTION	DIST (m)	# DISTURB	SEVERITY	SPECIES	NOTES
LB	404	742	-	LB breakdown starts; people at entrance, some equipment being moved	15	130	5	BRCO	44 BRCO flushed, nest material being stolen by others; 86 BRCO looked direction
LB	404	745	-	WEGU alarming, flying around MI bldg.; unk cause of disturbance, event crew?	0	100	1	BRCO	100/100 looking around
LB	404	755	-	jet flyover, noisy	unk	20	1	BRCO	20/100 looked
LB	404	812	-	WEGU calling over LB/MI bldg	unk	20	1	BRCO	
LB	404	814	0.05	equipment noise at loading dock	15	25	1	BRCO	25/132 looked up
LB	404	828	0.03	equipment dropped on ground at loading dock	15	4	5	BRCO	4 BRCO flushed; 35 looked direction
BB, INCINERATOR	404	837	1.00	unk- gulls up and alarming	unk	240	5	BRCO	200 flush; 40 run; all other looked up
LB	404	908	0.02	something dropped at loading dock w/loud bang	21	80	1	BRCO	80/106 BRCO look up
LB	404	923	0.02	loud noise from loading dock	21	4	4	BRCO	4/110 ran towards cliff edge
BB, SC	404	938	0.50	possibly from loud boat going past S end of island	unk	100	5	BRCO	leave or flush?
LB	404	941	0.02	something dropped at loading dock w/loud bang	21	50	1	BRCO	50/110 birds disturbed
LB, NC, BB	404	942	3.00	unk - 300 WEGU up and alarming	unk	300	5	BRCO	75/110 flush LB, 40/68 flush NC; 35/110 at LB look and run, 150 flush BB
LB	404	956	30.00	Army Corps of Engineers survey boat	61	30	1	BRCO	30/100 look up
LB	404	1032	30.00	Army Corps of Engineers survey boat	61	20	1	BRCO	20/100 look up
LB	404	1009	0.50	something being dragged down loading dock ramp	21	5	1	BRCO	5/100 look up

AREA	DATE	TIME	DUR (min)	DESCRIPTION	DIST (m)	# DISTURB	SEVERITY	SPECIES	NOTES
LB	404	1150	-	few WEGU up and calling, unk. cause	unk	20	1	BRCO	20/90 looked up
LB	404	1239	-	1 gull alarming, bang-ing noises from LB	0	60	1	BRCO	69/95 look up
NC	404	1330	0.03	visitor at S. end of LB on walkway in restricted area	18	300	5	BRCO	
NC, LB	404	1330	0.03	visitor at S. end of LB on walkway in restricted area	0	100	5	WEGU	
MI, SW, LB, NC	404	1508	1.00	wooden canoe w/ 1 POB row by within 50' of MI	31	335	2	BRCO	75 roosting birds flush SW, 55 breeders flush NC, 8 flush LB, 37/53 at MI look up w/ lots of growling, 160/160 look at LB
LB	404	1510	5.00	same canoe 50' of MI	15	50	5	WEGU	
LB	404	1520	0.03	equipment noise	15	5	1	BRCO	
NC, BB	404	1520	-	unk	unk	.	1	BRCO	all BRCO at NC & BB alert
LB	404	1520	-	1 WEGU alarming, unk. reason why	0	35	1	BRCO	
LB	404	1544	-	loud moving noises at loading dock	0	5	1	BRCO	5/160 startled
LB	404	1545	-	1 WEGU alarming, unk. reason why	0	12	1	BRCO	
MI	404	2006	1.00	researcher entering MI bldg to monitor; no screen on fences	unk	5	5	WEGU	
LB	404	2006	1.00	WEGU flush from researcher entering MI bldg.	unk	12	5	BRCO	
MI	404	2010	-	something spooked MI WEGU	unk	.	5	WEGU	most WEGU flushed
LB	404	2010	-	after WEGU were spooked	15	80	5	BRCO	flushed after WEGU flush

**Table 2.** Summary of types and severity of disturbances to Brandt's Cormorants on Alcatraz Island during 2 April - 4 April, 2007. (ER = Event Related, NR = Non-event Related, Unk = Unknown, possibly event-related; 1 = looking in direction of disturbance, 2 = growling or alarm calling, 3 = erect posture, 4 = ran/moved off nest, 5 = flushed/flew from colony, ndo = no disturbance observed).

Severity of disturbance	Type of disturbance	Number of disturbances observed			
		2-Apr (17 hours)	3-Apr (15 hours)	4-Apr (14 hours)	TOTALS (46 hours)
Severity 1	ER	6	4	9	19
	NR	0	4	4	8
	Unk	1	1	7	9
Severity 2	ER	1	0	0	1
	NR	1	0	1	2
	Unk	0	0	1	1
Severity3	ER	3	0	0	3
	NR	0	2	0	2
	Unk	1	0	0	1
Severity 4	ER	1	0	1	2
	NR	0	0	0	0
	Unk	0	2	0	2
Severity 5	ER	3	2	4	9
	NR	2	2	5	9
	Unk	5	10	4	19
<b>Total:</b>		<b>24</b>	<b>27</b>	<b>36</b>	<b>87</b>
<b>Frequency of disturbances</b>		<b>1.41</b>	<b>1.80</b>	<b>2.57</b>	<b>1.98</b>

**Table 3.** Brandt's Cormorant demographics on Alcatraz Island, 2007 <sup>1</sup>.

	<b>EGG-LAYING DATE</b> <sup>2</sup> mean ± s.d. (n) (range)	<b>CLUTCH SIZE</b> mean ± s.d. (n)	<b>HATCHING SUCCESS</b> mean ± s.d. (n)	<b>PRODUCTIVITY</b> <sup>3</sup> mean ± s.d. (n)
Laundry Building Sub-Colony	15 May ± 9 (8) (5 May - 30 May)	3.1 ± 0.8 (8)	0.8 ± 0.4 (5)	1.9 ± 1.4 (8)
Southern Sub-Colony	8 May ± 10 (24) (21 Apr - 16 Jun)	3.1 ± 0.7 (17)	0.8 ± 0.3 (7)	1.9 ± 1.0 (45)
Barker Beach Sub-Colony	15 Apr ± 9 (29) (4 Apr - 5 May)	3.2 ± 0.5 (28)	0.8 ± 0.4 (16)	1.9 ± 1.1 (29)
Northern Sub-Colony	4 May ± 12 (20) (14 Apr - 23 May)	3.4 ± 0.7 (22)	0.9 ± 0.2 (10)	2.4 ± 0.8 (25)
Model Industries Sub-Colony	28 Apr ± 6 (18) (18 Apr - 9 May)	3.0 ± 0.7 (20)	0.6 ± 0.4 (15)	1.8 ± 1.2 (20)
North Foghorn Sub-Colony	2 May ± 9 (21) (18 Apr - 30 May)	3.4 ± 0.7 (20)	0.9 ± 0.2 (12)	2.4 ± 1.0 (20)

<sup>1</sup> Data is from study plots only, and only from nests for which accurate data could be obtained. Actual range may be larger due to unmonitored nests outside study plots and relays and hard-to-see nests.

<sup>2</sup> First attempts only, and refers to first eggs and first chicks of a clutch/brood.

<sup>3</sup> Last or only attempts are included in calculations; Brandt's Cormorant chicks are considered fledged when they first wander away from the nest site.

**Table 4.** Comparisons of mean Brandt's Cormorant egg-laying dates between study plots in sub-colonies from 2004-2007.  $R^2$  represents the ANOVA model fit, P is the significance level of the test, and n is the sample size.

**Post-estimation pairwise comparisons w/ LB:**

<b>2004</b>	<b>ANOVA model</b>	<b>LB</b>	<b>NF</b>	<b>MI</b>	<b>NC</b>	<b>BB</b>	<b>SC</b>
<b>N</b>	105	9	23	19	19	16	19
<b>P</b>	<0.001		0.005	<0.001	<0.001	<0.001	<0.001
<b>R<sup>2</sup></b>	0.5						

**Post-estimation pairwise comparisons w/ LB:**

<b>2005</b>	<b>ANOVA model</b>	<b>LB</b>	<b>NF</b>	<b>MI</b>	<b>NC</b>	<b>BB</b>	<b>SC</b>
<b>N</b>	115	12	18	17	21	35	12
<b>P</b>	<0.001		0.599	0.008	0.659	0.247	0.259
<b>R<sup>2</sup></b>	0.1						

**Post-estimation pairwise comparisons w/ LB:**

<b>2006</b>	<b>ANOVA model</b>	<b>LB</b>	<b>NF</b>	<b>MI</b>	<b>NC</b>	<b>BB</b>	<b>SC</b>
<b>N</b>	138	35	0	20	58	19	6
<b>P</b>	<0.001		n/a	<0.001	<0.001	<0.001	0.097
<b>R<sup>2</sup></b>	0.2						

**Post-estimation pairwise comparisons w/ LB:**

<b>2007</b>	<b>ANOVA model</b>	<b>LB</b>	<b>NF</b>	<b>MI</b>	<b>NC</b>	<b>BB</b>	<b>SC</b>
<b>N</b>	109	7	19	17	19	27	20
<b>P</b>	<0.001		0.004	<0.001	0.076	<0.001	0.092
<b>R<sup>2</sup></b>	0.5						

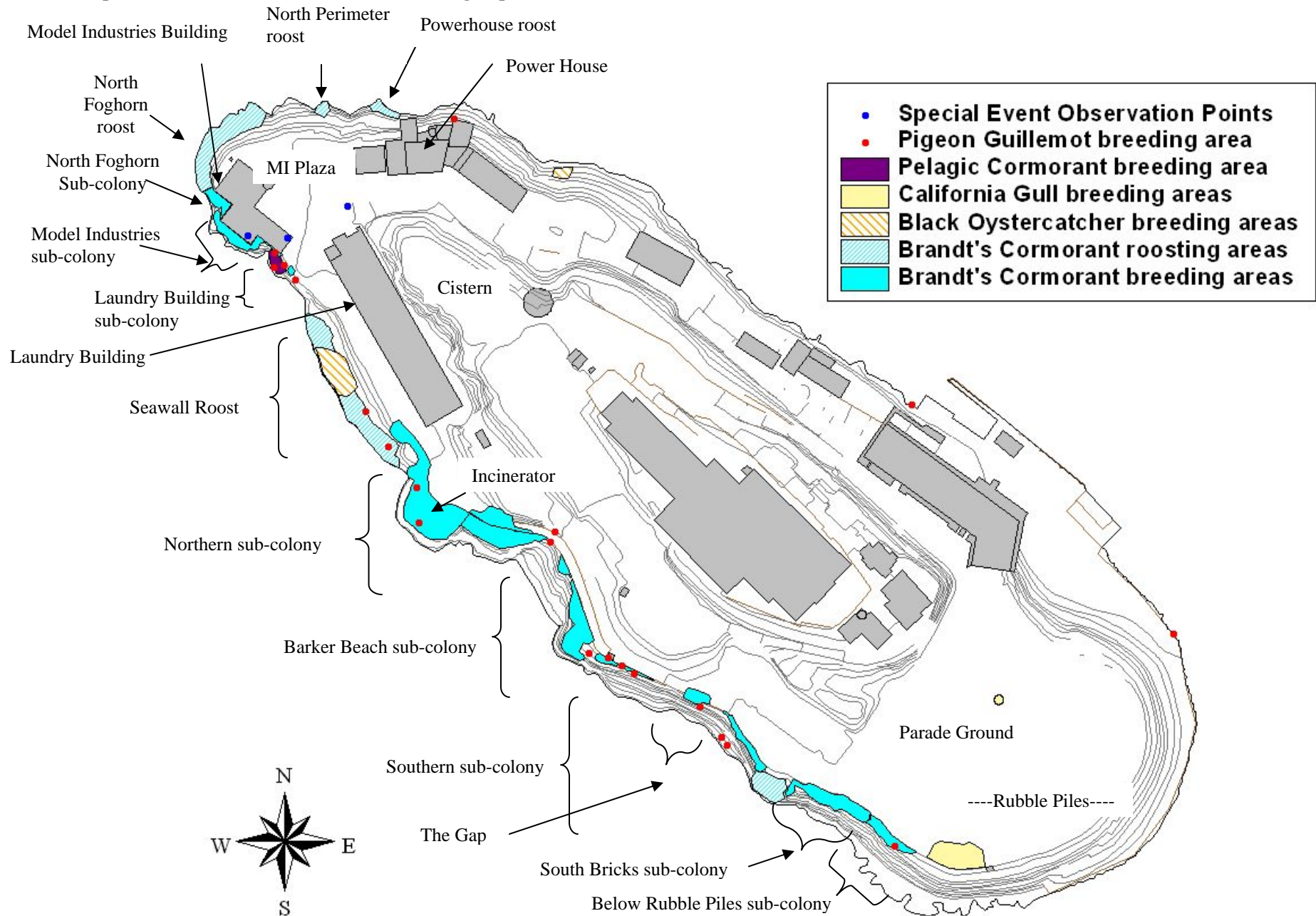


Figure 1. Alcatraz Island seabird breeding areas, special event survey observation points, and significant structures, 2007.

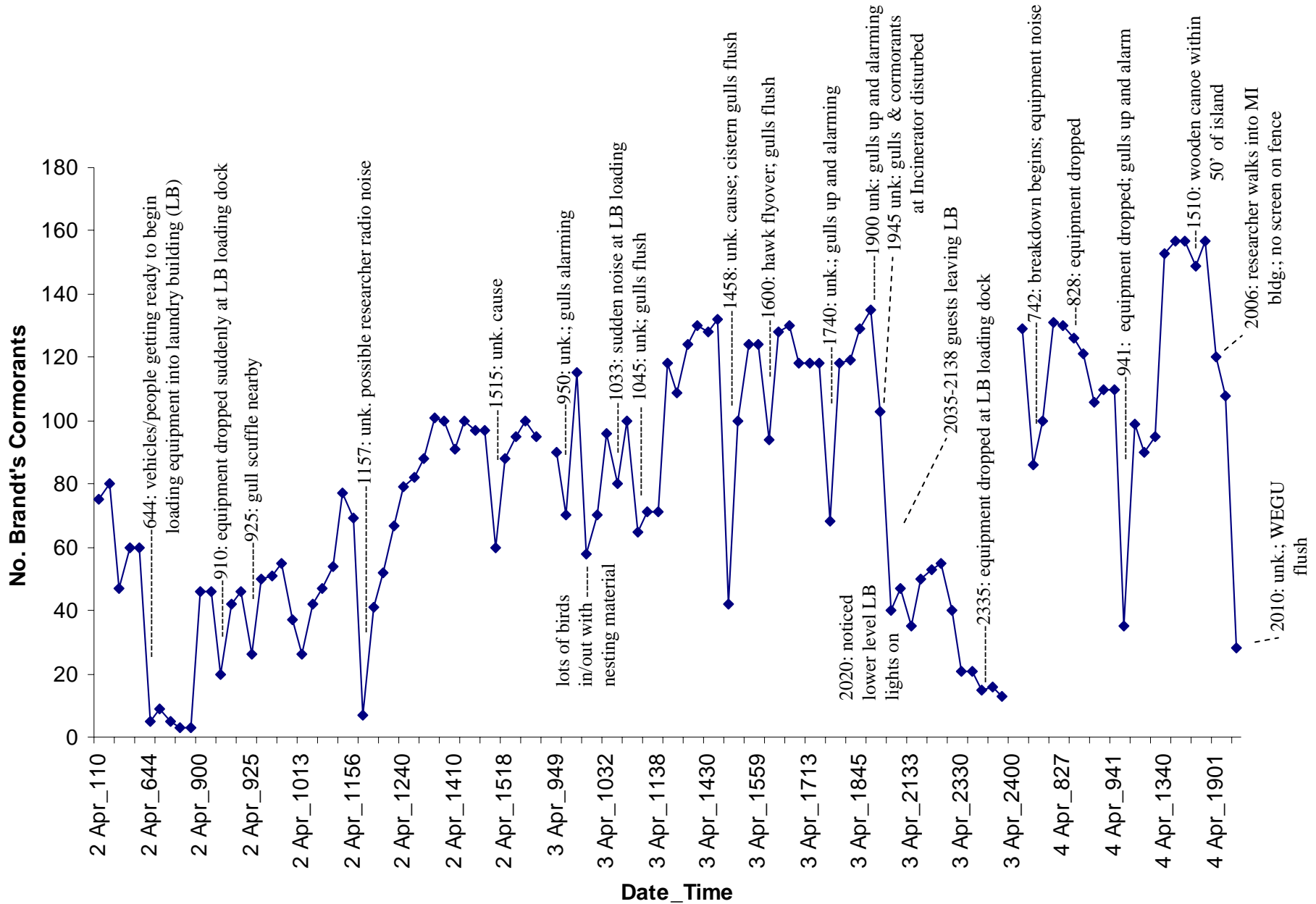


Figure 2. Brandt's Cormorant population fluctuations during special event monitoring as key disturbances/activities took place.



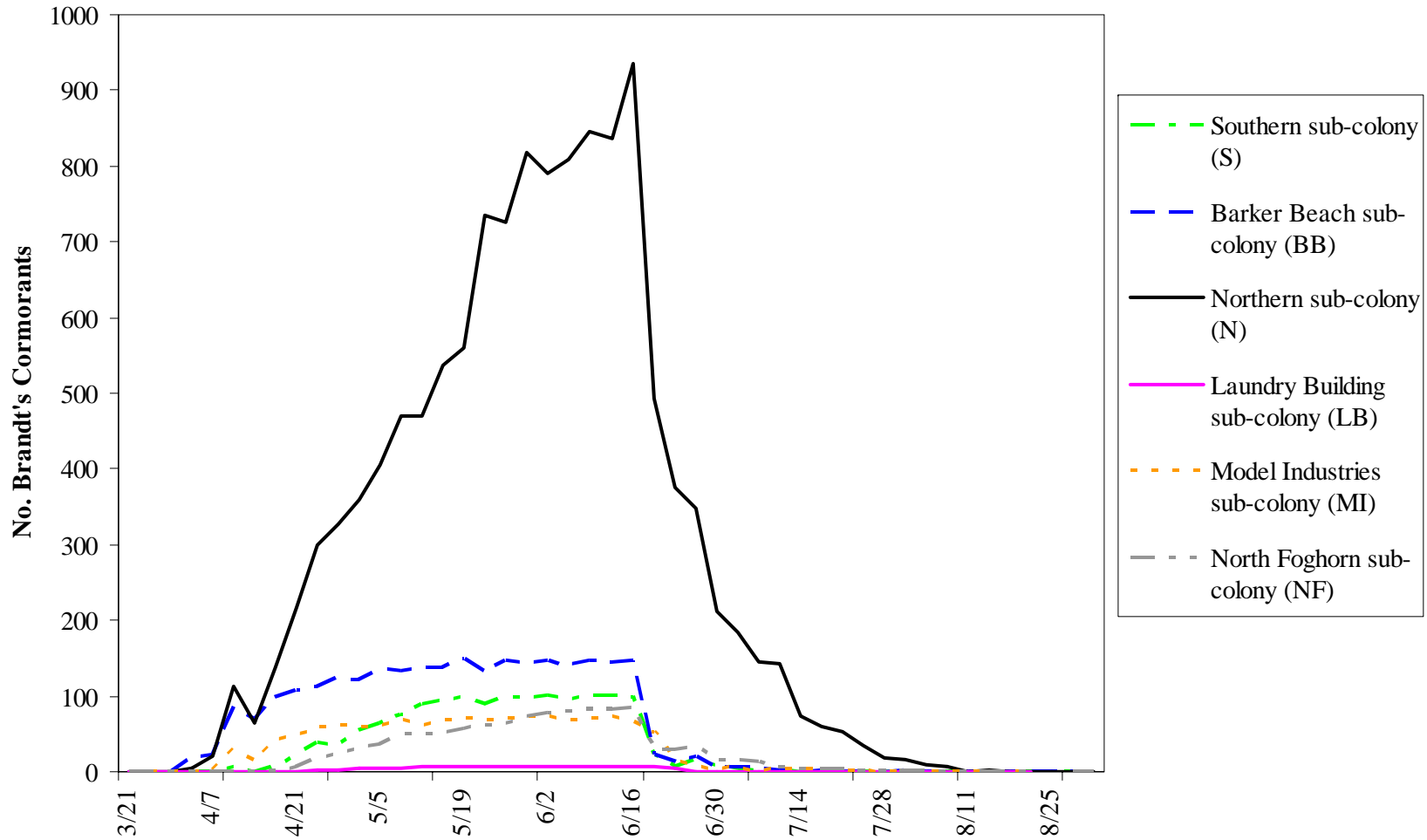
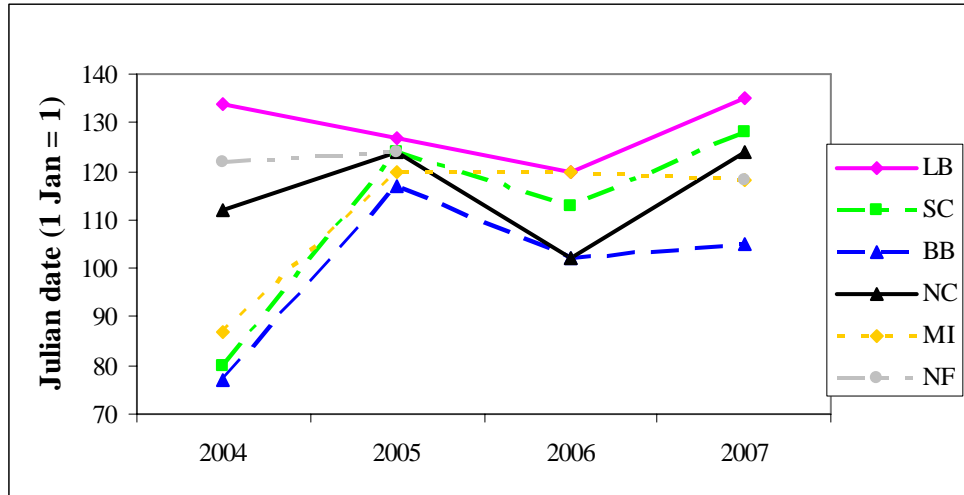
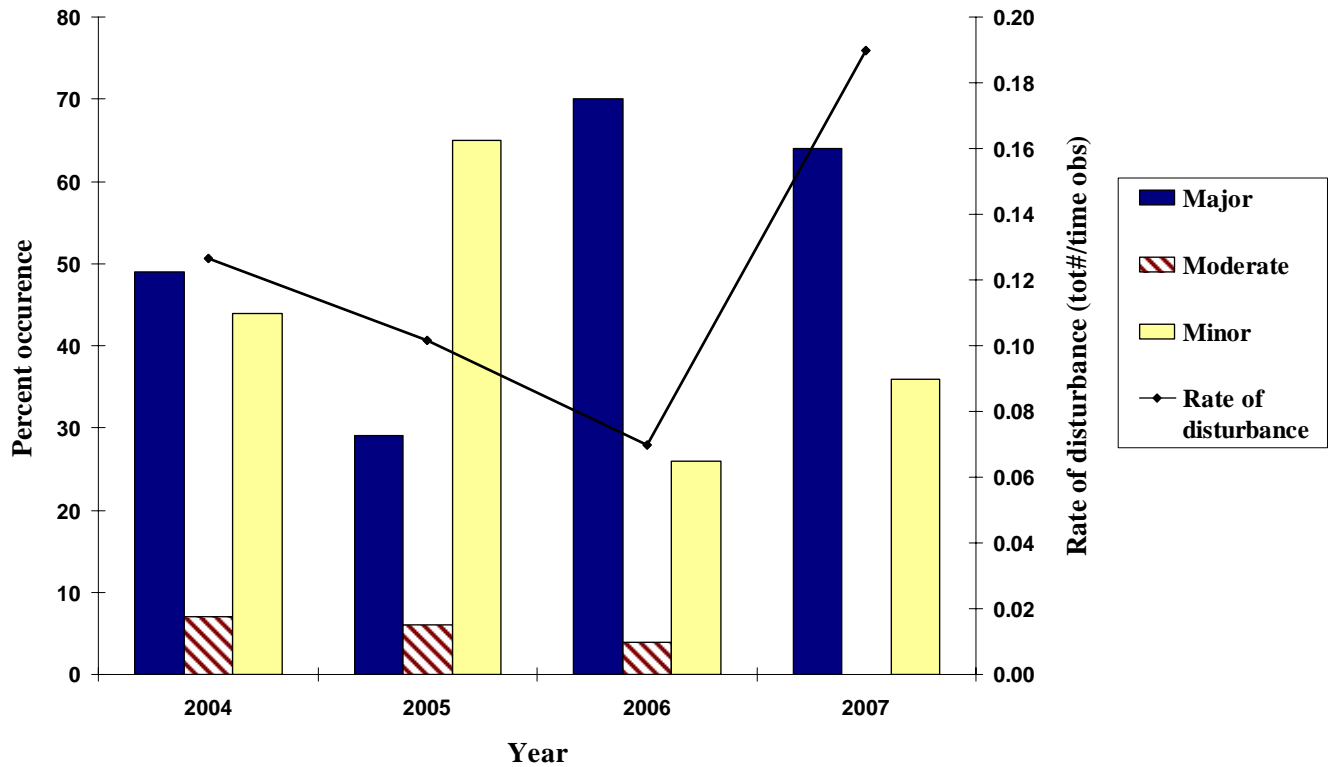


Figure 3. Dynamics of the six major Brandt's Cormorant sub-colonies on Alcatraz Island, 2007, showing numbers of incubating birds on nests.



**Figure 4.** First egg lay (in Julian dates) of Brandt's Cormorants in six major sub-colonies on Alcatraz Island from 2004 to 2007.



**Figure 5.** Reactions of Brandt's Cormorants on Alcatraz Island to disturbance in 2004-2007, since the Laundry Building sub-colony was established and north-end disturbance monitoring has been conducted. Major disturbance events caused cormorants to flush from breeding or roosting areas. Moderate disturbances caused agitation in birds such as fluffing, growling, threat gestures or standing up. Disturbance was considered minor if birds only looked in the direction of the event. Right axis shows rate of disturbance (total number of disturbances/time observed).