



Reproductive Success of Black-crowned Night- Hérons and Snowy Egrets at Alcatraz Island, San Francisco Bay, California: 2006

Administrative Report

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U.S. DEPARTMENT OF THE INTERIOR
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Abstract. — As part of a monitoring program initiated in 1990, we documented nesting chronology, habitat use, subcolony use, and hatchability for black-crowned night-herons (*Nycticorax nycticorax*) and snowy egrets (*Egretta thula*) nesting at Alcatraz Island, San Francisco Bay, California. In 2006, we monitored 140 night-heron nests, a 37% increase from the 102 nests found in 2005. We also monitored 35 snowy egret nests, a number similar to the 36 nests found in 2005. As in 2004 and 2005, all snowy egret nests were located in the Greenhouse subcolony. Black-crowned night-heron hatching success at Alcatraz Island in 2006 was 54%, fledging success was 86%, and overall reproductive success was 47%, all increases from 2005, but all somewhat lower than the 17-year averages. Hatching success (92%), fledging success (100%), and overall success (92%) for snowy egrets were all similar to those observed in 2005, and all were higher than for night-herons both years. Although the nest predation rate (21%) on night-heron nests was slightly higher than the 17-year mean (17%), it was 5-11% lower than the previous 7 years. The percentage of nests with unknown hatch (31%) and fledging success (34%) were both higher than the average for the 17 years of the study. This was likely related to an earlier cessation of nest monitoring in 2006 than in previous years to prevent adverse interspecific conflicts between gulls and night-herons and egrets. About one-half of all night-heron nests monitored in 2006 were in either English ivy (*Hedera helix*) (26%) or rubble (concrete, reinforcing rods, and other remnants of demolished buildings) (23%). The trend of increasing numbers of the Western Gull (*Larus occidentalis*), a predator on night-heron and snowy egret eggs and chicks and a competitor for nest sites, continued in 2006, with the estimated total number of gull nests reaching an all-time high of 1,054. As found in previous years, interspecific competition with gulls was the most likely factor limiting reproductive success of the night-herons on Alcatraz Island in 2006. Common ravens (*Corvus corax*) again nested on Alcatraz and likely contributed to predation on an unknown number of night-heron nests. The total number of night-heron nests found on Alcatraz Island in 2006 represented about 20% of the total North San Francisco Bay population. In addition, the total number of snowy egret nests at Alcatraz comprised about 9.5% of the North Bay nests in 2006.

Monitoring of black-crowned night-heron and snowy egret reproduction on Alcatraz Island was conducted for the 17th consecutive year in 2006. During 1990-2006, the number of monitored nests has ranged from a low of 68 in 2001 to a high of 341 in 1996 (Hothem et al. 1995; Hothem and Hatch 2004; Hothem and Feltman 2006). The number of snowy egret nests has increased from none observed nesting on Alcatraz Island during 1990-1996 to 35 nests in 2006.

As in previous years, the primary objectives of this study were to: 1) conduct baseline monitoring to describe and estimate the distribution and abundance of black-crowned night-herons and snowy egrets nesting on Alcatraz Island; 2) evaluate reproductive parameters, including nesting chronology, clutch size, hatching success, fledging success, and overall reproductive success; 3) evaluate the distribution, abundance, productivity, and effects of disturbance on reproduction; and 4) compare annual and long-term variation and trends in the nesting populations.

METHODS

Study Area

Alcatraz Island (37° 49' N, 122° 25' W), a 9.1-ha island and our study area in the San Francisco Bay, is managed as a National Historic Landmark by the National Park Service since 1973 (Howell and Pollak 1991) (Fig. 1).

Nest Monitoring

Nest searching and monitoring techniques followed the methods used in previous years (Hothem and Hatch 2004). We searched each previously occupied nesting subcolony (Fig. 1) and other potential sites for active night-heron and snowy egret nests. The Shower and Wall subcolonies were not searched because vegetation previously used for nesting had been removed, making nesting no longer feasible. Subcolony visits were conducted from 3 May to 20 July (Table 1), but, to prevent observer-induced adverse interactions between gulls and the wading birds, five subcolonies (Rubble, Bench, Rubble West, Tunnel, and Greenhouse) with large numbers of gull and night-heron or egret nests were visited only through 12 June. The last visit to the Recreation Yard was on 27 June, to the Auxiliary Dock was on 7 July, and to the Warden's House was on 20 July. Nest searching and monitoring were completed before the end of the breeding season in all years except 1990 and 1993. Thus, late-initiated nests and renests are usually not monitored during most years, so the census serves as an index of breeding activity but not a complete census.

Estimates of Reproductive Success

Reproductive success for 2006 was calculated similar to previous years (Hothem and Hatch 2004), with the nestling period beginning with the hatching of the first egg and extending for 15 days for night-herons and 10 days for egrets. Mean clutch size was calculated for nests considered to have completed clutches (i.e., no increase in eggs between successive visits to an active nest). Nests that failed before a full clutch was achieved and those nests first found more than 7 days after hatching were not included in analysis of clutch size. Hatchability (egg success) was calculated by dividing the total number of eggs that hatched by the total number of eggs that were monitored (to hatch or failure).

RESULTS and DISCUSSION

Black-crowned Night-Herons

Nest Monitoring

In 2006, night-herons initiated nests (first egg laid) over a 72-day period from 3 April to 14 June (Table 1; Fig. 2). The median initiation date (16 May) was more than two weeks later than the average for the previous 16 years of the study. The first documented nest initiation occurred 12 days later than the average, and the last initiation was 9 days earlier, resulting in a breeding period 3 weeks shorter than the long-term (1990-2005) average (Table 1, Fig. 3). Compared with 2005, the earliest initiation date was 11 days later, the latest initiation date 7 days later, and the median initiation date 14 days later in 2006. We were not able to determine the factor(s) that might have affected the timing and length of the breeding period. In 2006, 5% of the 140 nests were initiated during 11 March to 14 April (weeks 1 through 5 in Fig. 3), while in the previous 16 years 31% of the nests had been initiated by 14 April. This confirms that the nesting period for night-herons in 2006 was later than most previous years. There appeared to be two peaks of

nest initiation in 2006, with one peak starting the week of April 29 and the other starting May 13 (Fig. 2).

The number of nests monitored on the island each year has varied during the 17-year study (Fig. 4), decreasing from 1990 until 1993, followed by a steady increase through 1996. After the peak in 1996, the number of nests declined to a low of only 68 nests in 2001. It appears the number of night-heron nests has become relatively stable since 2002, with an average of 131 nests found per year (Fig. 4 and Table 2).

Area Trends

We classified nesting subcolonies on Alcatraz to one of three areas, the South Coast, the Central Island, and the North Coast (Fig. 1 and Table 2). In 2006, 53 more nests were found in the South Coast subcolonies than in 2005; 72% of the night-heron nests on the island were in the South Coast area (Fig. 5 and Table 2). This percentage is similar to what was observed during 1996-2002. Increases were noted at the Tunnel subcolony (12 nests) and the Rubble subcolony, which rebounded from only two nests in 2005 to 28 in 2006, similar to what had been observed most years since 2000. No apparent reason for this increase was noted. We monitored 8 nests in the Bench subcolony, all of which were found in the dense Agave area near the Agave trail. Based on the large numbers of night-herons that commonly flushed from the Agave area during the breeding season, there appeared to be as many as 10-20 more nests that could not be safely accessed to monitor. This appeared to be an increase in numbers over previous years. Five nests were found in the infrequently used (since 2001) Dock and Auxiliary Dock subcolonies.

The number of nests in the Central Island subcolonies comprised 21% of the total on the island, which was a decline for the third straight year following a large increase in 2003 (Fig. 5 and Table 2). Much of this was related to the decline in numbers of night-heron nests in the Greenhouse subcolony, which dropped from 64 nests in 2003 to only 12 in 2006. However, if the snowy egrets nesting in the Greenhouse subcolony are included, 27% of all the wading birds nesting on Alcatraz Island in 2006 were in the Greenhouse subcolony. Offsetting the night-heron decline in the Central area was an increase in the Recreation Yard subcolony, which had nine nests, more than in any year since 1996. The Warden's House subcolony remained stable with five nests. Both the Shower and Wall subcolonies were unoccupied, but a major vegetation removal effort in both subcolonies has made these sites unattractive to night-heron nesting.

Fewer night-heron nests (10) were found in the North Coast area in 2006 (Fig. 5 and Table 2) than in any year since 2000. All 10 nests were in the Power Plant subcolony, with none in the previously heavily used Foghorn subcolony. The Power Plant has averaged 10 nests per year since 1995, indicating a stable nesting population.

Nesting Habitat

Despite being the dominant habitat for nesting by night-herons in the 1990s (Fig. 6), only 11% of the nests were found in mirrorbush (*Coprosma baueri*) in 2006. Although more nests (15) were found in 2006 in mirrorbush than in 2005 (only two), the total is far fewer than the 198 found in this habitat type in 1996. Plants that have supplanted mirrorbush as important nesting habitats in 2006 include English ivy (26%), rose (*Rosa spp.*) (9%), and *Albizia* (8%). The second most important nesting habitat on Alcatraz in 2006 (23% of the nests) was "rubble," which consisted primarily of the remains of demolished buildings (i.e., concrete, reinforcing rods, metal, scrap wood, and miscellaneous debris). On average, 28% of the night-heron nests have been located in Rubble since 1999.

Nesting Success

We estimated that the mean clutch size for black-crowned night-herons in 2006 was 2.96 eggs per nesting attempt, slightly higher than the mean for the 17 years of the study (Table 3). The estimated nest hatch success (nests that hatched at least one egg) for night-herons during this study, as measured by the Mayfield (1961, 1975) method, ranged from 42% in 2005 to 81% in 1992 and 1994. The hatching success in 2006 was 54% (95% confidence interval = 44-67%) and was lower than the study average (60.1%, Table 3). The overall average, however, was similar to that estimated by Kelly et al. (2006) for night-herons throughout the San Francisco Bay area during 1993-2005 (62%). The fledging success (the percentage of successful nests in which at least one chick survived to 15 days of age) for night-herons during this study ranged from 72% in 1997 to 99% in 1993. In 2006, the fledging success was 86%, which is near the average fledging success for the study (87.3%). In 2005, 81% of the nests fledged. The overall success (nest and fledge success combined) of nesting night-herons on Alcatraz ranged from 34% in 2005 to 77% in 1994 and was 47% in 2006 (Table 3).

Although failed eggs have been documented throughout the course of this study, in 2006 we found that only two of the 139 eggs (1.4%) in successful nests failed to hatch (Table 4). Egg hatchability averaged 94.2% during the study, ranging from 89.1% in 2002 to 98.6% in 2006. Of the 137 eggs that hatched, 88 chicks (64.2%) survived to at least 15 days; 10 chicks were found dead. Production averaged 0.63 fledglings per monitored nest or 1.42 chicks fledged per hatched nest (Table 4). Bay-wide, the average number of young fledged per nest attempt for 1993-2005 (1.15) was higher than at Alcatraz (0.63) as was the number of chicks fledged per successful nest (1.82 in SF Bay vs. 1.42 this study) (Kelly et al. 2006).

As found in other night-heron nesting studies (Wolford and Boag 1971; Tremblay and Ellison 1980; Henny et al. 1984; Blus et al. 1997), predation was a primary limiting factor at Alcatraz in 2006. Based on apparent nest success, we estimated that eggs in 21% of the nests were destroyed by predators before hatching, similar to the average since 1998 (27%) (Table 5). Predation is likely related to the increased numbers of Western gulls nesting on the island. The number of nests of the Western gull, a predator on nests of night-herons and snowy egrets and a competitor for nest sites in certain subcolonies, has increased by 128%, from an average of 453 for the period 1990-1998 (Fig. 7) to an all-time high of 1,033 in 2006 (S. Acosta, pers. commun.). In addition, 21 nests of California gulls (*Larus californicus*) were observed near the Rubble West subcolony. Although one pair of common ravens (*Corvus corax*) was observed nesting on Alcatraz, as in previous years, predation on night-heron eggs and chicks, although presumed to occur, was not observed in 2006.

The pre-hatching nest abandonment rate in 2006 (1%) was the lowest observed in the study. However, because of early termination of subcolony visits, the numbers of nests with unknown hatching (31%) and unknown fledging (34%) fates were higher than the averages for the study. Unknown fates included those that were either lost or which were not rechecked for any reason.

Snowy Egrets

We observed snowy egrets nesting at Alcatraz for the first time in 1997, when three nests were found in the Tunnel subcolony. Since 1997, we have documented 152 snowy egret nests, with annual totals ranging from none in 2002 to 36 in 2005. Thirty-five snowy egret nests were monitored in 2006 (Fig. 4). Snowy egrets first nested in the Greenhouse subcolony in 2003 when three of the island's eight nests were found there. During 2004-2006, all snowy egret nests on

Alcatraz were located in the Greenhouse subcolony. In 2006, snowy egret nests were initiated over a 34-day period between 15 April and 19 May, with a median initiation date of 1 May. Compared with 2005, the earliest initiation date was 15 days later, the latest initiation date was 8 days later, and the median initiation date was 22 days later.

In addition to the snowy egrets, there were also 12 night-heron nests in the Greenhouse subcolony in 2006. This made unobtrusive monitoring especially difficult, because many birds were nesting in close proximity to one another. Monitoring was terminated early (June 12) in the Greenhouse subcolony, before the fates of all the nests could be determined, to prevent observer-caused nest failure and chick mortality. Habitat for snowy egret nests included fig trees (18 nests), *Albizia* (14 nests), and California blackberry (*Rubus vitifolius*) (3 nests).

The mean clutch size for snowy egrets was 3.41 eggs per nest (Table 4), similar to the clutch size observed in 2005, but greater than that for night-herons (2.96). Eggs hatched in 29 of the 35 nests (83%). Predators destroyed one of the nests, one was abandoned, and the fate of four nests was undetermined. Of the 29 nests that hatched, 22 (76%) fledged young to 10 days, none was destroyed by a predator or abandoned, and 6 (21%) were undetermined because of early termination of monitoring of the subcolony. As with the night-herons, we used the Mayfield method to calculate nest, fledging, and overall success. Hatching success was 92%, fledging success was 100%, and overall nest success was 92% (Table 6). These values were similar to those calculated for the 2005 breeding season, but greater than the values found for the night-herons. Kelly et al. (2006) reported nest survivorship during 1993-2005 to be 66% for snowy egrets throughout the San Francisco Bay area, lower than that observed at Alcatraz in 2005 and 2006, but similar to that observed in 2004.

Western gulls and Common ravens were present in 2006 and were potential predators of snowy egret eggs and chicks, but we only observed predation on one nest. Comparable data for the 15 night-heron nests found in the Greenhouse subcolony indicate that nine (60%) hatched, four (27%) were destroyed by predators, and two (13%) were undetermined. Of the nine nests that hatched, six (40%) were observed to fledge to 15 days, and two (13%) were undetermined.

Hatchability (96.6%) of snowy egret eggs was similar to that of night-herons in 2006, with 3 out of 88 eggs (3%) in successful nests failing to hatch. Of the 85 eggs that hatched, we observed 63 chicks (74%) surviving to at least 10 days (2.2 chicks fledged per successful nest; 1.8 chicks fledged per monitored nest); four chicks were found dead. Snowy egret fledging success was similar to that reported by Kelly et al. (2006) for the entire San Francisco Bay area (2.5 chicks per successful nest and 1.8 chicks per monitored nest), although our fledging success was based on survival to 10 days of age while Kelly et al. used 14 days.

San Francisco Bay Trends

According to Kelly et al. (2006), wading bird breeding populations in the San Francisco Bay area, including night-herons and snowy egrets, were stable or increasing during the past 12 years. Alcatraz Island is one of 19 night-heron colonies active in the San Francisco Bay area (Kelly et al. 2006). Eleven of the colonies are in the North San Francisco Bay area, and three are in the Central Bay. Although the total number of nests (absolute numbers) increased at Alcatraz by 37% in 2006, preliminary data from Audubon Canyon Ranch (E. Condeso, pers. commun.) indicate that the total number of nests at Central Bay colonies (peak numbers; See Kelly et al. 2006) declined slightly. Thus, within the Central Bay area, the percentage of night-herons nesting at Alcatraz increased from 29% in 2005 to 41% in 2006. The percentage of the North Bay population (not including unknown numbers in the South San Francisco Bay and Santa

Clara Valley areas) of night-herons nesting at Alcatraz in 2006 was about 20%, the highest since 1999 when 25% of the North Bay night-herons nested at Alcatraz. Within the North Bay, only West Marin Island (estimated 200 nests) and Napa State Hospital (170 nests) had more nests than Alcatraz. With the abandonment of two large Central Bay colonies in recent years (Brooks Island and Red Rock), the significance of the Alcatraz colony has increased.

Alcatraz is one of 23 active snowy egret colonies in the San Francisco Bay area (Kelly et al. 2006). Twelve of the sites are located in the North Bay area, while only two, Alcatraz and West Marin islands, are within the Central Bay. Preliminary numbers for snowy egret nests (peak numbers; Kelley et al. 2006) in North San Francisco Bay indicate an increase in the total number of nests from 310 in 2005 to about 368 in 2006 (E. Condeso, pers. commun.). The total number of nests at Alcatraz has been stable for the past 3 years, ranging from 32 in 2004 to 36 in 2005. The 35 nests in 2006 comprised nearly 10% of the North Bay population and 23.5% of the Central Bay population. While not the largest in the area, the snowy egret colony at Alcatraz has appeared to become well established in the past three years, despite the potential competition with night-herons for nest sites and the potential for predation by gulls and ravens.

CONCLUSIONS

Predation, combined with competition with gulls for nesting sites in certain subcolonies, appears to be the most limiting factors for night-herons nesting on Alcatraz Island. A continued increase in the numbers of nesting gulls, primarily Western gulls, but recently augmented by an influx of California gulls, has likely contributed to the high rates of pre-hatching predation on night-herons. Competition with gulls for nest sites has not been a factor for snowy egrets nesting on Alcatraz, and, thus far, there has been no observed predation by gulls on egrets at Alcatraz.

Habitat changes are a major concern on Alcatraz. As previously documented, mirrorbush has declined precipitously over the course of the study, primarily a result of senescence. Ivy has apparently proliferated in some areas, including the Dock and Rubble subcolonies, previously dominated by mirrorbush. An increase in the percentage of nests found in ivy reflects this apparent trend. However, in certain cases, the increase in ivy has not led to an increase in nesting by night-herons. The Foghorn subcolony, for example, formerly completely comprised of dense mirrorbush, is now comprised of dead mirrorbush with dense ivy covering the dead trunks and branches. Nesting at the once prolific Foghorn subcolony (29 nests in 1990), has declined to an average of 1.4 nests per year over the past 7 years, with none observed in 2006.

English ivy and mirrorbush previously used by nesting night-herons at the Recreation Yard subcolony was heavily pruned near the prison wall before the 2005 nesting season. As a likely result, we found no night-heron nests at that subcolony in 2005. In 2006, however, after a time of regrowth, we found nine nests in the previously trimmed area and in nearby habitats. Final abandonment of the Shower and Wall subcolonies may have been hastened by severe pruning in previous years. Habitat integrity at the Greenhouse subcolony is essential. Previous pruning of the vegetation adjacent to the walkway has likely contributed to significant reductions in use by nesting night-herons. Maintenance of the visual barrier provided by the vegetation at the Greenhouse subcolony is essential to the continued nesting success of night-herons, and in recent years, snowy egrets. This subcolony is especially important to the snowy egret population, because it is the only area used for nesting on Alcatraz in the past 3 years.

In 2005, we were only able to locate two nests in the Rubble subcolony, the fewest found there in any season during this study. It appeared that something had caused night-herons to abandon this nesting site. Surprisingly, however, a resurgence of nesting occurred in 2006, with

28 nests being found, a number exceeded in only 7 previous years of the study. In 2005, we hypothesized that the increased density of the vegetation at this site might have made it difficult for night-herons to nest there. However, it did not appear that the density changed in 2006, thus eliminating support for that theory. Our monitoring of the Rubble subcolony did not provide evidence for its virtual collapse in 2005.

The traditional Bench subcolony, formerly occupied by as many as 46 night-heron nests, (1996) remained devoid of nests in 2006 (as it has since 2002). However, large numbers of night-herons were observed to use the nearby Agave area down slope from the Agave Trail. Entrance to that area was difficult and dangerous, but we were able to locate eight nests there in 2006. The total number of nests in this habitat was difficult to estimate, but the presence of as many as 20-30 adults during the nesting period indicates the presence of at least 10-15 more nests in this area that could not be monitored.

The policy of seasonal exclusion of visitors from known nesting areas for black-crowned night-herons and snowy egrets has been instrumental in preserving these breeding birds on Alcatraz Island. This closure has likely enabled the establishment of the new subcolony in the Agave Trail area. Continuation of this seasonal closure during the upcoming and future breeding seasons will protect breeding night-herons and egrets herons currently using those areas, and will facilitate potential recolonization of abandoned subcolonies or establishment of new subcolonies.

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Table 1. Black-crowned night-heron reproductive chronology, Alcatraz Island, 1990-2006.¹

Year	Median Initiation Date	Range of initiation dates	Number of colony visits	Observation dates
1990	28 Apr	24 March – 11 July	16	28 April – 9 August
1991	8 May	26 March – 4 July	14	25 April – 26 Jul
1992	13 Apr	20 March – 28 May	3	30 April – 28 May
1993	23 Apr	16 March – 24 July	15	20 April – 20 August
1994	6 May	25 March – 18 July	8	22 April – 1 August
1995	25 Apr	11 March – 28 June	7	26 April – 28 June
1996	12 Apr	15 March – 4 June	4	29 April – 10 June
1997	8 Apr	13 March – 28 May	6	22 April – 12 June
1998	7 Apr	15 March – 21 June	14	9 April – 10 July
1999	3 May	27 March – 12 June	13	13 April – 17 July
2000	13 May	4 April – 16 July	16	18 April – 8 August
2001	14 May	10 April – 18 June	13	24 April – 24 July
2002	14 May	16 March – 23 June	10	22 April – 1 July
2003	18 May	27 March – 20 June	11	21 April – 14 July
2004	3 May	12 March – 22 June	12	30 April – 19 July
2005	2 May	23 March – 7 June	13	22 April – 15 July
2006	16 May	3 April – 14 June	12	3 May – 20 July
Average	30 Apr	22 March – 23 June	11.0	23 April – 14 July

¹ Observations were discontinued at most sites before nesting was completed every year except 1990 and 1993, primarily to prevent adverse interspecific competition with Western Gulls.

Table 2. Number and percentage of black-crowned night-heron nests per subcolony, Alcatraz Island, 1990-2006.

SUBCOLONY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Totals
SOUTH COAST	67	57	68	60	90	129	243	240	199	136	90	51	115	61	66	48	101	1821
%	39%	46%	54%	48%	58%	64%	71%	83%	80%	83%	87%	75%	82%	44%	50%	47%	72%	69%
Tunnel	19	15	21	24	32	32	57	70	64	39	14	10	33	15	19	16	28	508
Bench	3	3	7	2	2	13	46	27	16	5	7	2	0	0	0	3	8	144
Rubble	11	14	17	19	17	48	85	94	88	48	30	14	34	22	21	2	28	592
Rubble West	0	0	0	0	0	0	0	0	0	27	29	21	42	24	23	25	32	223
Dock	24	15	16	7	23	15	23	21	8	3	2	1	1	0	3	0	2	164
Aux. Dock	10	10	7	8	16	21	32	28	23	14	8	3	5	0	0	2	3	190
CENTRAL	73	48	43	49	48	57	70	28	20	8	6	5	14	64	51	40	29	613
%	43%	39%	34%	39%	31%	28%	20%	10%	8%	5%	6%	7%	10%	46%	38%	39%	21%	22%
Greenhouse	38	34 ¹	34 ¹	30	34	38	36	13	7	2	1	0	11	51	41 ²	34 ²	15	419
Rec. Yard	7	4	3	4	7	6	13	4	4	2	1	0	0	8	3	0	9	75
Wall	24	8	5	9	4	13	20	10	8	4	2	1	0	0	0	0	0	108
Shower	4	2	1	6	3	0	1	1	1	0	0	0	0	0	0	0	0	19
Warden	0	0	0	0	0	0	0	0	0	0	2	4	3	5	7	6	5	32
NORTH COAST	30	19	16	16	17	14	28	21	29	20	7	12	12	15	16	14	10	296
%	18%	15%	13%	13%	11%	7%	8%	7%	12%	12%	7%	18%	8%	11%	12%	14%	7%	11%
Foghorn	29	18	13	14	14	8	22	12	14	12	2	0	0	5	2	1	0	166
Power Plant	1	1	3	2	3	6	6	9	15	8	5	12	12	10	14	13	10	130
Totals	170	124	127	125	155	200	341	289	248	164	103	68	141	140	133	102	140	2770

¹ Numbers of nests estimated based on numbers monitored in 1990, and 1993-1996.² Total nests in Greenhouse Subcolony include 5 nests found on the north side of the walkway near cell house in 2004, 7 in 2005, and 3 in 2006.

Table 3. Estimates of clutch size and percentage nesting success (and 95% confidence interval) of the black-crowned night-heron at Alcatraz Island, 1990-2006¹.

Year	Clutch size	Nests found	Mayfield nests ²	Exposure days	Mayfield success (%)		
					Hatching ³	Fledging ⁴	Overall ⁵
1990	3.01	170	140	1840	70 (60-80)	90 (84-95)	63
1991	2.86	90	81	1230	64 (52-76)	82 (72-92)	52
1992	3.04	93	54	351	81 (61-100)	88 (77-99)	71
1993	2.92	125	96	1178	77 (66-89)	99 (96-100)	76
1994	2.84	155	117	969	81 (70-93)	94 (88-100)	77
1995	2.78	200	142	1257	77 (66-88)	92 (86-98)	71
1996	2.85	341	179	1441	67 (56-78)	79 (71-87)	53
1997	2.87	289	173	1502	64 (53-74)	72 (64-80)	46
1998	2.79	248	203	2352	46 (37-54)	78 (70-86)	36
1999	2.87	164	155	2052	55 (45-64)	91 (85-97)	50
2000	2.83	103	87	1073	52 (39-64)	87 (77-98)	45
2001	3.00	68	61	576	45 (29-62)	95 (85-100)	43
2002	2.96	141	125	1507	54 (43-64)	93 (86-100)	50
2003	2.84	140	131	1482	50 (39-60)	90 (82-98)	45
2004	2.90	133	113	1240	42 (32-55)	90 82-97	38
2005	2.92	102	85	846.5	42 (29-55)	81 (69-94)	34
2006	2.96	140	126	1287.5	54 (44-67)	86 (76-97)	47
Mean	2.90	158.9	121.4	1321.1	60.1	87.5	52.8

¹ Based on days of nest exposure (see Hensler and Nichols 1981).

² Nests included in the analysis (Mayfield 1961, 1975). Nests that had either hatched or failed before they were found were rejected from the analysis; such nests would have no exposure days.

³ Percent of monitored nests in which one or more eggs hatched. .

⁴ Percent of nests that hatched in which one or more chicks reached at least 15 days of age (95% confidence interval).

⁵ Percent of monitored nests in which one or more chicks reached at least 15 days of age, calculated by multiplying Hatch Success by Fledging Success.

Table 4. Survival of eggs and chicks of black-crowned night-herons nesting at Alcatraz Island, 1990-2006.

	Year																	Total	Mean
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006		
Monitored nests	170	90	93	125	155	200	341	289	248	164	103	68	141	140	133	102	140	2,702	158.9
Successful nests ¹	127	62	67	94	88	116	239	193	146	94	50	25	71	67	71	54	62	1,626	95.6
Eggs observed to hatching (A)	339	155	169	265	199	279	540	446	372	254	144	61	165	167	187	126	139	4,007	235.7
Failed eggs (B)	19	7	4	17	10	23	20	28	16	11	9	5	18	17	14	5	2	225	13.2
% Hatchability ((A-B)/A)	94.4%	95.5%	97.6%	93.6%	95.0%	91.8%	96.3%	93.7%	95.7%	95.7%	93.8%	91.8%	89.1%	89.8%	92.5%	96.0%	98.6%		94.16%
Hatched eggs/ successful nest	2.52	2.39	2.46	2.64	2.15	2.21	2.18	2.17	2.44	2.59	2.70	2.24	2.07	2.24	2.44	2.24	2.21		2.34
Nests with fledged chicks	102	42	34	72	56	76	118	96	76	62	25	16	43	38	42	32	34	964	56.7
Fledged chicks ²	210	81	56	159	101	122	232	183	148	145	48	31	92	82	88	61	88	1,927	113.4
Fledged chicks/ monitored nest	1.24	0.9	0.6	1.27	0.65	0.61	0.68	0.63	0.6	0.88	0.47	0.46	0.65	0.59	0.66	0.6	0.63		0.713
Fledged chicks/ successful nest	1.65	1.31	0.84	1.69	1.15	1.05	0.97	0.95	1.01	1.54	0.96	1.24	1.3	1.22	1.24	1.13	1.42		1.216
% hatched eggs that fledged	65.6%	54.7%	33.9%	64.1%	53.4%	47.7%	44.6%	43.8%	41.6%	59.7%	35.6%	55.4%	62.6%	54.7%	50.9%	50.4%	64.2%		51.93%

¹ Successful nests were those with at least one egg that was confirmed to have hatched.

² Fledged chicks: the number of chicks observed to have survived to 15 days of age or more.

Table 5. Fates of nests of black-crowned night-herons at Alcatraz Island, 1990-2006.

Nesting outcome	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total	Mean
Monitored nests	170	90	93	125	155	200	341	289	248	164	103	68	141	140	133	102	140	2702	158.9
Predation (%) ¹	13	19	2	7	1	2	4	3	22	27	32	28	29	26	26	31	21		17.2
Destroyed (other) (%) ¹	2	3	0	2	1	4	1	4	2	0	0	0	0	0	3	0	2		1.4
Abandoned (%) ¹	3	7	3	2	3	2	1	3	7	4	3	7	1	3	6	2	1		3.4
Unknown (%) ¹	8	2	23	14	37	34	23	23	10	12	17	28	20	26	12	14	31		19.6
Successful nests ²	127	62	67	94	88	116	239	193	146	94	50	25	71	67	71	54	62	1626	95.6
	74.7%	68.9%	72.0%	75.2%	56.8%	58.0%	70.1%	66.8%	58.9%	57.3%	48.5%	36.8%	50.4%	47.9%	53.4%	52.9%	44.3%		60.2%
Fledged nests ³	102	42	34	72	56	76	118	96	76	62	25	16	43	38	42	32	34	964	56.7
	60.0%	46.7%	36.6%	57.6%	36.1%	38.0%	34.6%	33.2%	30.6%	37.8%	24.3%	23.5%	30.5%	27.1%	31.6%	31.4%	24.3%		35.7%
Predation (%) ⁴	8	13	1	0	0	1	0	4	13	5	8	0	6	8	6	13	0		5.1
Destroyed (other) (%) ⁴	2	2	6	1	2	3	8	13	4	2	2	4	0	0	0	0	11		3.5
Abandoned (%) ⁴	0	3	0	0	1	1	0	0	0	0	2	0	0	0	4	0	0		0.6
Unknowns (%) ⁴	10	15	42	22	33	29	42	33	31	27	38	32	34	36	31	28	34		30.4

¹ Percentage of monitored nests.

² Nests (and percentage of monitored nests) observed with at least one egg that hatched.

³ Nests (and percentage of monitored nests) observed with at least one chick that survived to age 15 days.

⁴ Percentage of hatched (successful) nests.

Table 6. Estimates of clutch size and percentage nesting success (and 95% CI) of the snowy egret at Alcatraz Island, 2004-2006.¹

	Clutch size	Nests found	Mayfield nests ²	Exposure days	Hatching ³	Fledging ⁴	Overall ⁵
2004	3.00	32	20	152.5	61 (34-100)	84 (68-100)	51
2005	3.45	36	26	279.5	91 (76-100)	100	91
2006	3.41	35	35	594.5	92 (82-100)	100	92
Mean	3.29	34	27	342.2	81	95	78

¹ Based on days of nest exposure (See Hensler and Nichols 1981).

² Nests included in the analysis (Mayfield 1961, 1975). Nests that had either hatched or failed before they were found were rejected from the analysis; such nests would have no exposure days.

³ Percent of monitored nests in which one or more eggs hatched.

⁴ Percent of nests that hatched in which one or more chicks reached at least 10 days of age.

⁵ Percent of monitored nests in which one or more chicks reached at least 10 days of age, calculated by multiplying hatch success by fledging success.

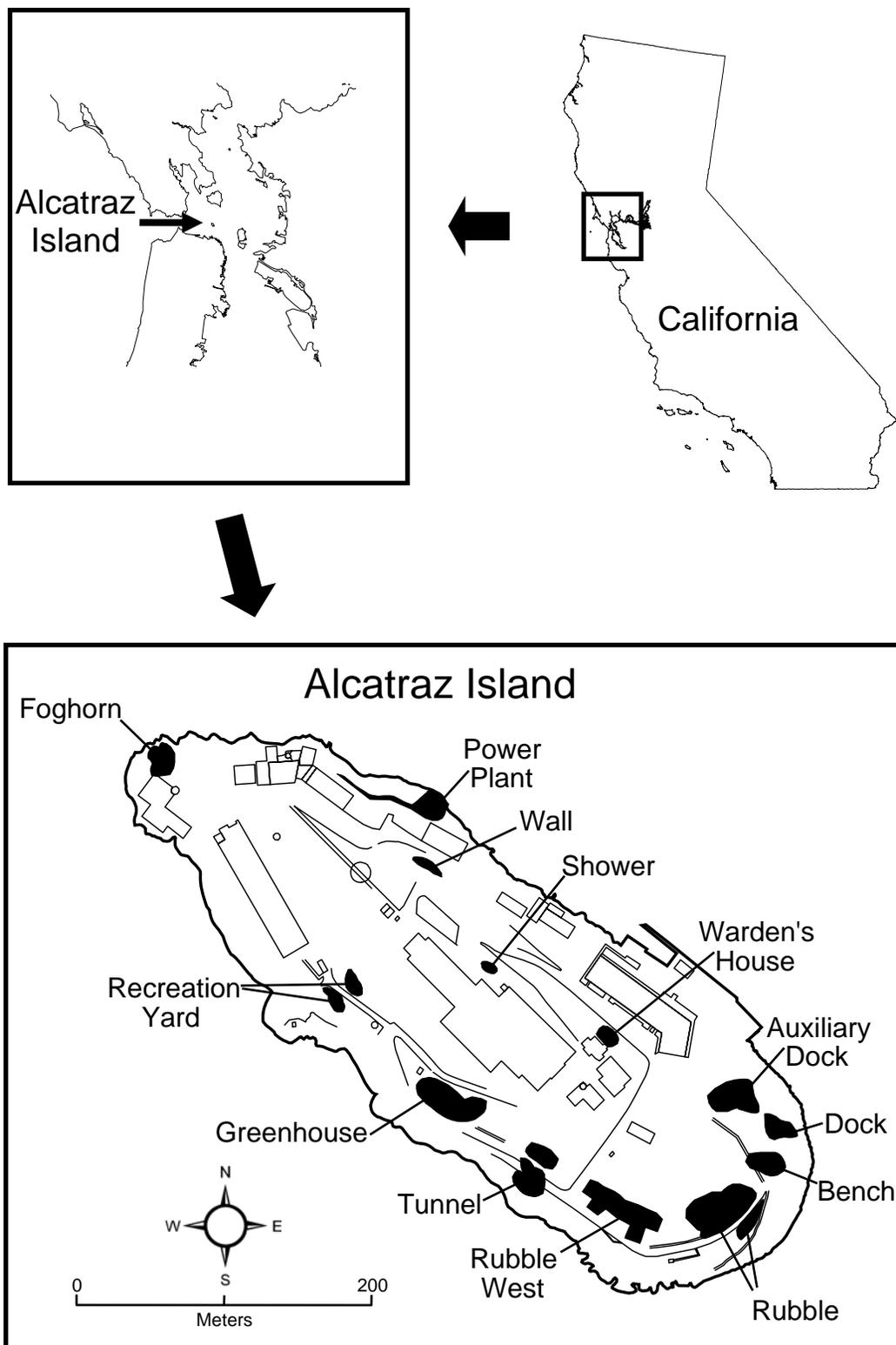


Figure 1. Black-crowned night-heron nesting subcolonies on Alcatraz Island, San Francisco Bay, California, during 1990-2005; no nests found in Wall, Shower, or Foghorn subcolonies in 2006. Snowy egrets nested only in the Greenhouse subcolony in 2006.

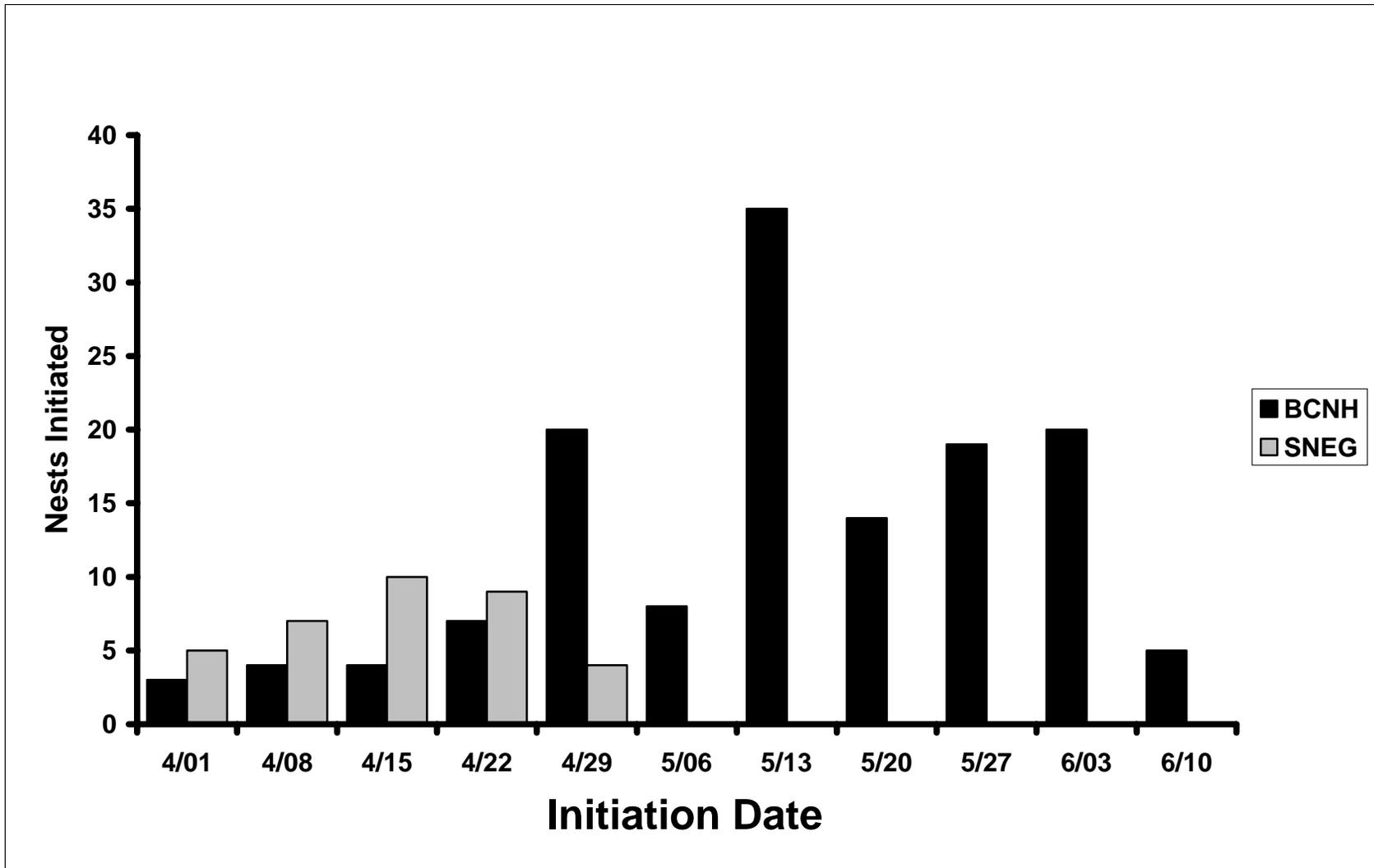


Figure 2. Comparison of black-crowned night-heron and snowy egret nest initiations at Alcatraz Island, 2006. For comparison, this figure shows nest initiations for night-herons over an 11-week period, beginning the week of April 1, which is equivalent to week 4 on Fig. 3.

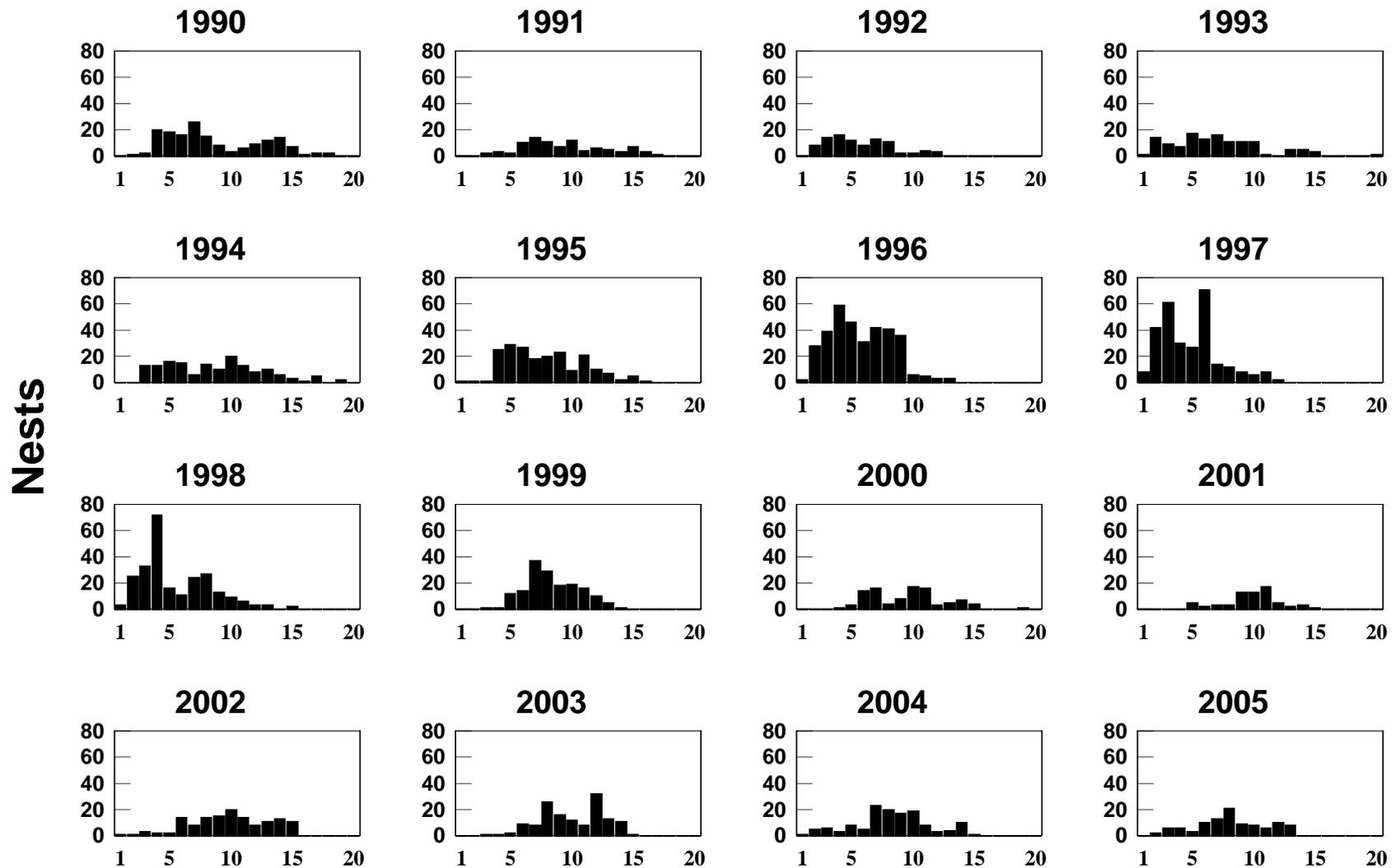


Figure 3. Weekly nest initiation dates by year for black-crowned night-herons at Alcatraz Island, during weeks beginning March 11 – July 22, 1990-2005.

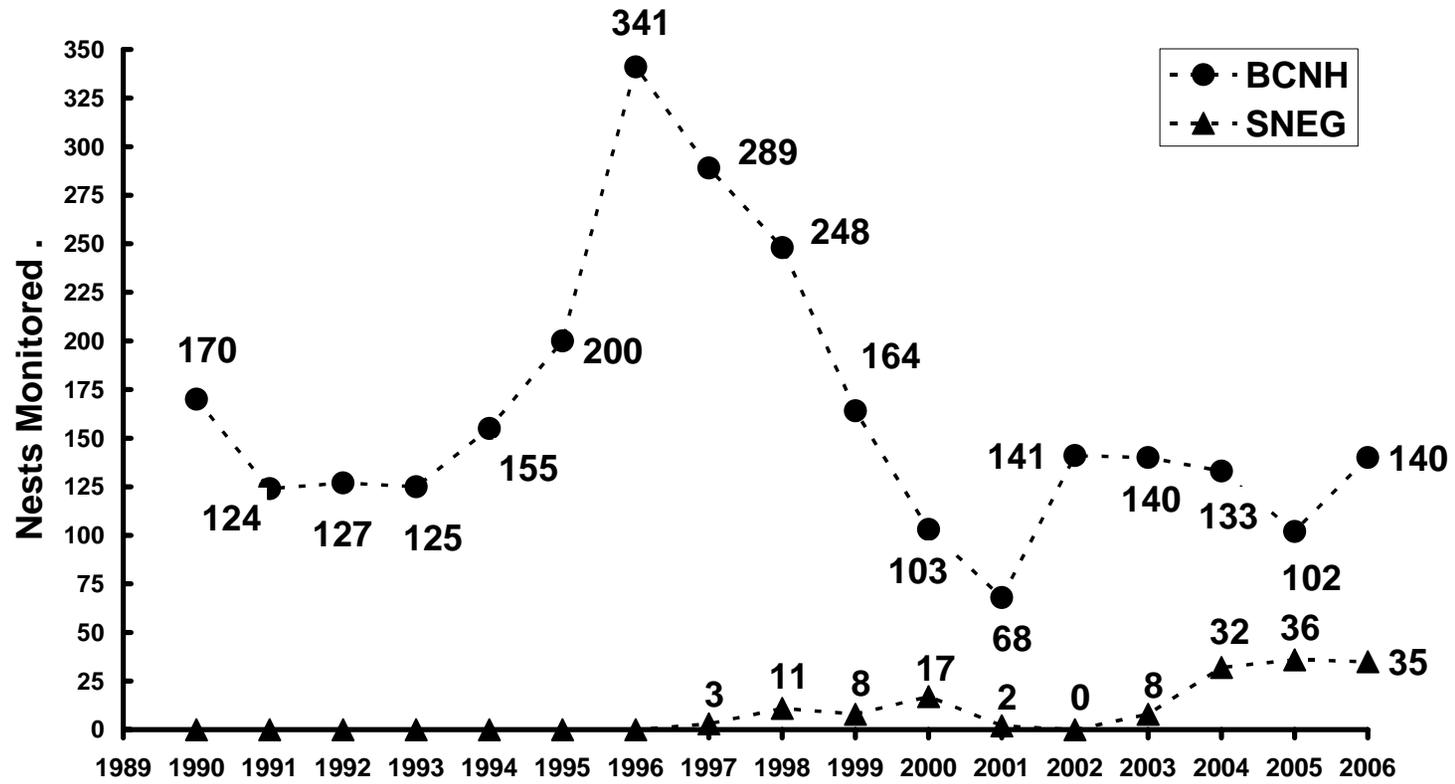


Figure 4. Total black-crowned night-heron and snowy egret nests monitored at Alcatraz Island during 1990-2006.

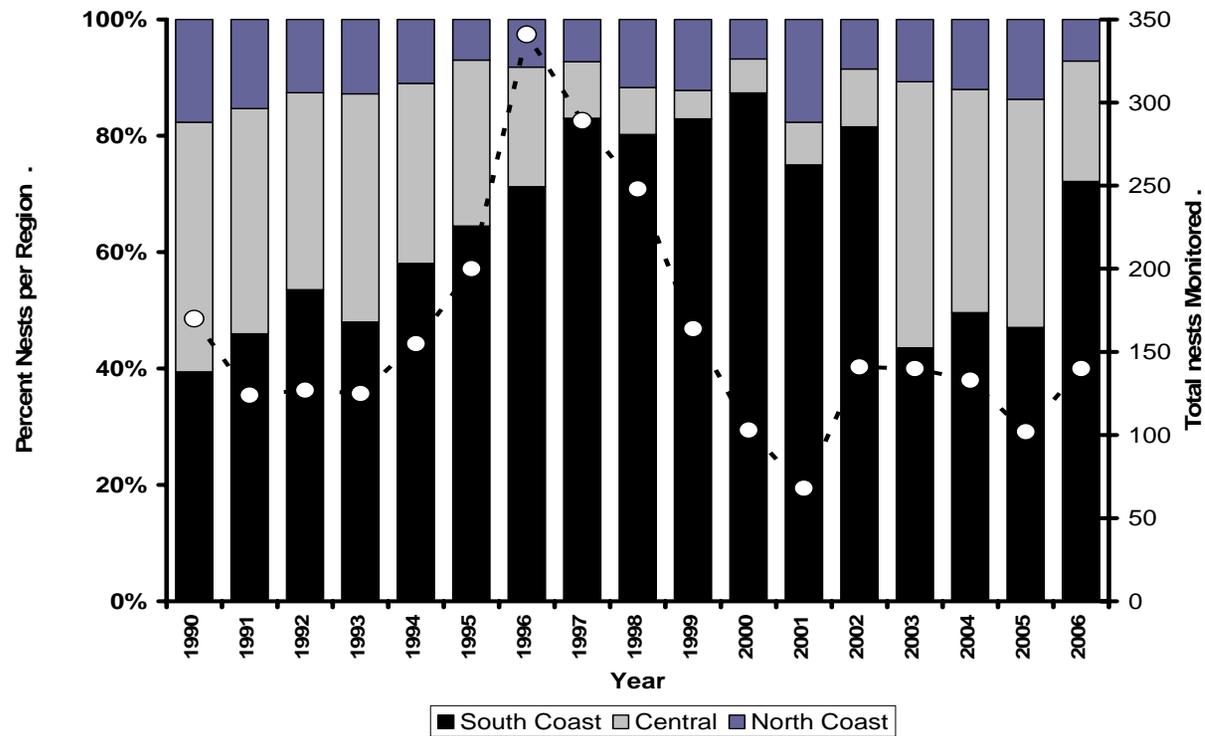


Figure 5. Total black-crowned night-heron nests (circles; right y-axis) and spatial trends (left y-axis) at Alcatraz Island, 1990-2006: North Coast Area = Foghorn and Power Plant; Central Area = Wall, Shower, Greenhouse, Recreation Yard, and Warden's House; South Coast Area = Auxiliary Dock, Dock, Bench, Rubble, Rubble West, and Tunnel Bush (See Fig. 1).

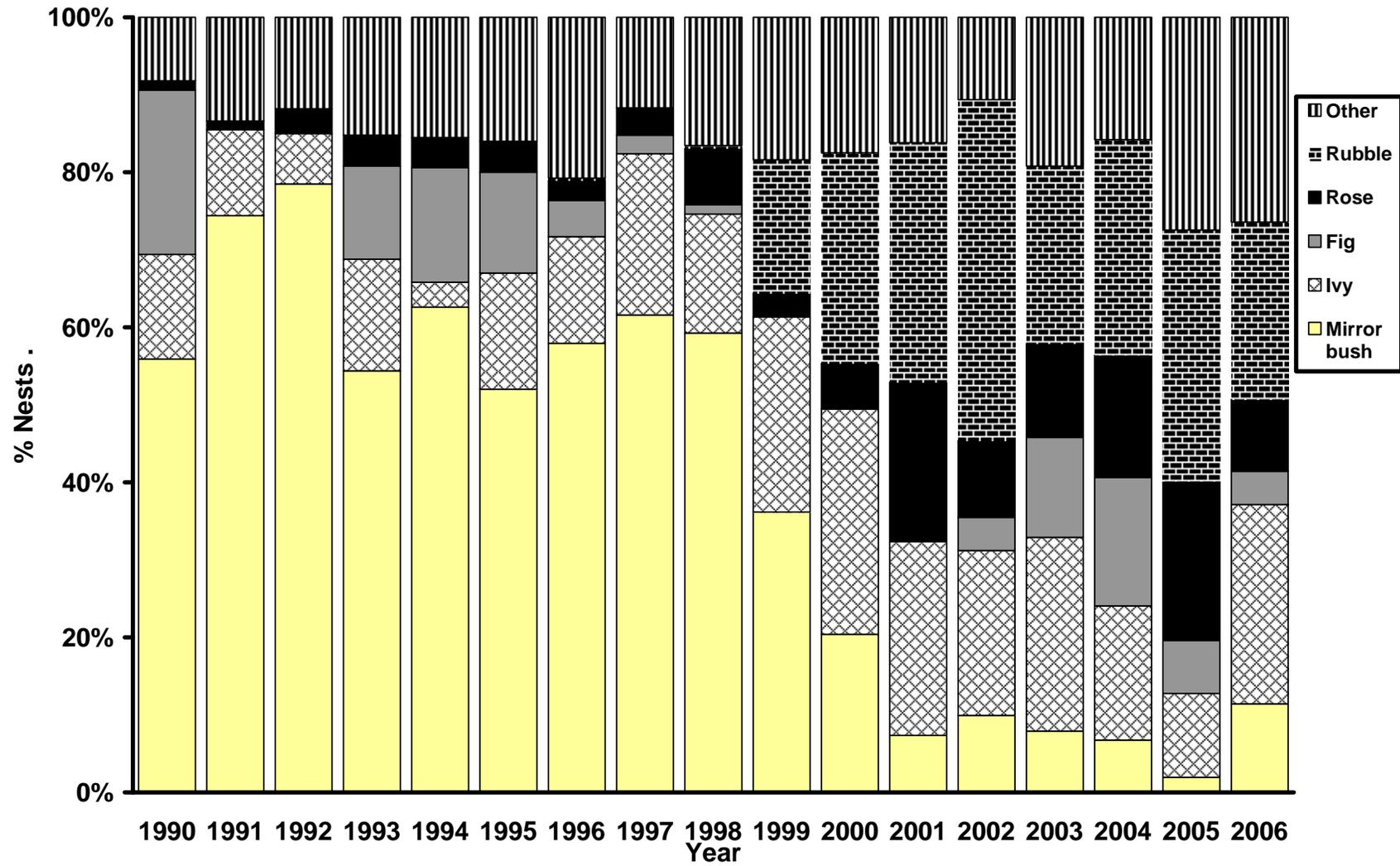


Figure 6. Nesting habitat used by black-crowned night-herons at Alcatraz Island, 1990-2005.

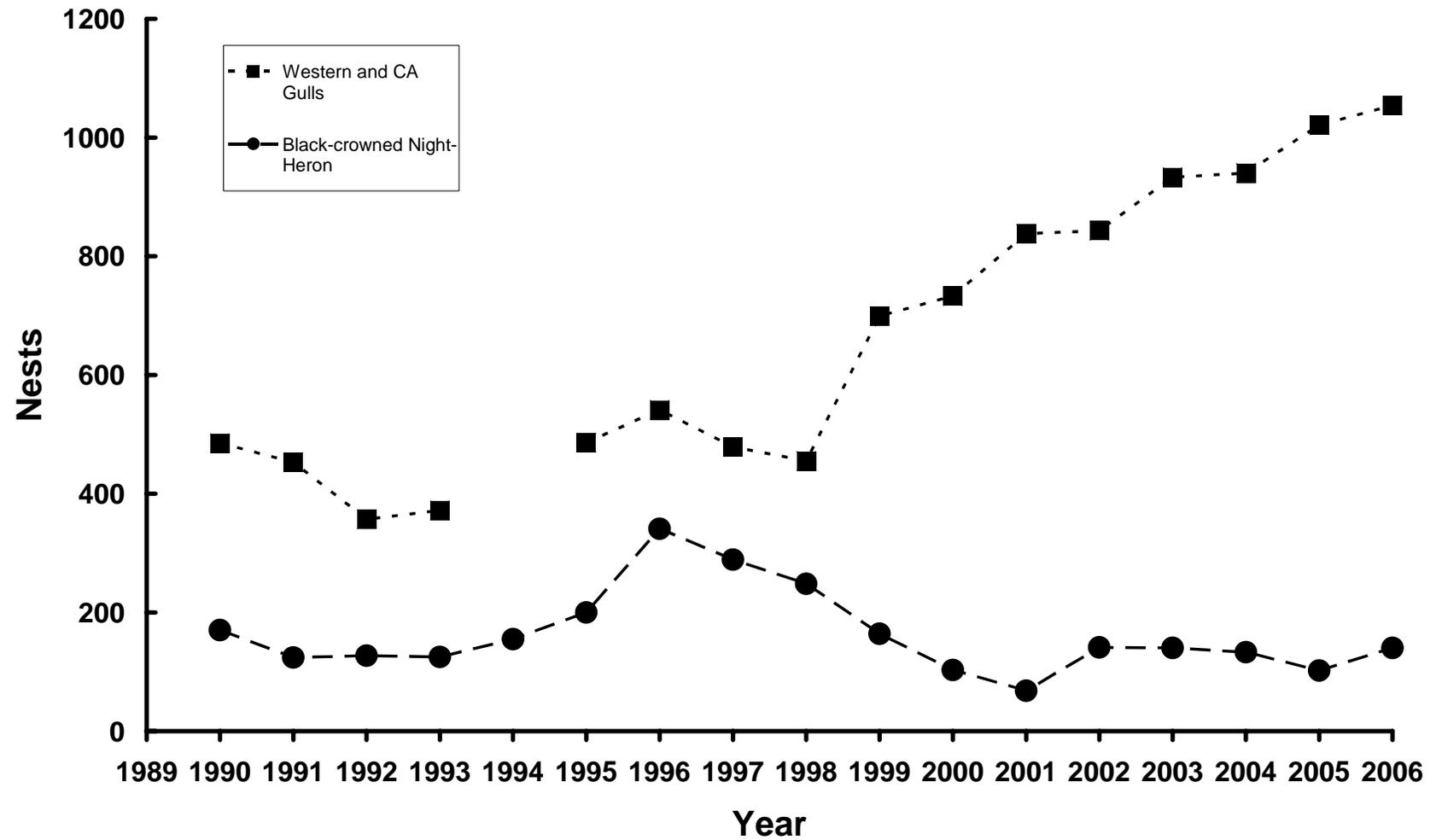


Figure 7. Trends of Western and California gulls and black-crowned night-heron nests on Alcatraz Island, 1990-2006 (Gull data courtesy Sara Acosta, PRBO Conservation Science, pers. comm.). California Gulls totaled 14 nests in 2005 and 21 in 2006.