

ANNOTATED ATLAS AND IMPLICATIONS FOR THE CONSERVATION OF HERON AND EGRET NESTING COLONIES IN THE SAN FRANCISCO BAY AREA

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Audubon Canyon Ranch was founded in 1962 to protect an important heronry on the Marin County coast north of San Francisco and to prevent intensive commercial development of the undisturbed area surrounding the colony. Now, Audubon Canyon Ranch manages a system of wildlife sanctuaries in Marin and Sonoma counties and conducts regional programs in conservation research, habitat protection and restoration, and nature education.

The San Francisco Bay Bird Observatory (<http://www.sfbbo.org>), a collaborator on this project, is dedicated to the conservation of birds and their habitats through science and outreach, and to contributing to informed resource management decisions in the San Francisco Bay Area.

An electronic version of this document can be downloaded from the Audubon Canyon Ranch website at <http://www.egret.org>.

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STATUS, TRENDS, AND IMPLICATIONS FOR THE CONSERVATION OF HERON AND EGRET NESTING COLONIES IN THE SAN FRANCISCO BAY AREA

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SUMMARY

The atlas of heronries summarizes continuing efforts by Audubon Canyon Ranch and the San Francisco Bay Bird Observatory to monitor colonially nesting herons and egrets in the central coastal region of California surrounding the San Francisco Estuary. The methods used provide for the intensive regional monitoring of nesting distributions, nest survivorship, productivity of successful nests, nesting habitat characteristics, and intraseasonal timing. The analysis focuses on comparisons of heron and egret nesting performance among nine major wetland subregions from 1991-2005.

We recorded an average of 73 active colony sites per year, supporting approximately 62 Great Blue Heron colonies, 25 Great Egret colonies, 13 Black-crowned Night-Heron colonies and 12 Snowy Egret colonies each year. Cattle Egret and Little Blue Heron each nested at a few sites. Regional nest abundances of all colonially nesting heron and egret species were stable or increasing. Annual changes in nest abundance within colony sites and subregions were consistent with shifts in colony site preferences as wetland suitability and disturbance patterns fluctuate across years and over space. Decreases in colony size were significantly related to higher rates of nest mortality as well as to disturbance or predation events, suggesting that conspecific nest failure rather than disturbance or predation events alone may stimulate shifts in breeding distribution. Patterns of seasonal weather and annual reproductive performance suggested that a sharp decline in nest abundances may have resulted from reduced recruitment associated with increased juvenile mortality in winter, rather than from a decline in productivity. Persistence of colony site use increased substantially at sites that reached at least 20 active nests. Subregional increases in the nesting abundance coincided with the restoration of tidal marshes, suggesting that heron and egret nesting distributions may be useful in monitoring the landscape-scale effects of restoration projects in tidal landscapes.

Significant linear declines in regional reproductive success of Great Blue Herons, Black-crowned Night-Herons, and Snowy Egrets resulted primarily from declining nest survivorship, which coincided with regional increases in abundances of American Crows and Common Ravens. We found small but significant subregional differences in nest survivorship, productivity, and overall reproductive success. Local and subregional productivity of successful Great Blue Heron and Great Egret nests fluctuated within larger-scale variation across the region, whereas changes in nest survivorship were associated with processes such as nest predation, colony disturbance, and extreme weather events that operated at local or subregional scales.

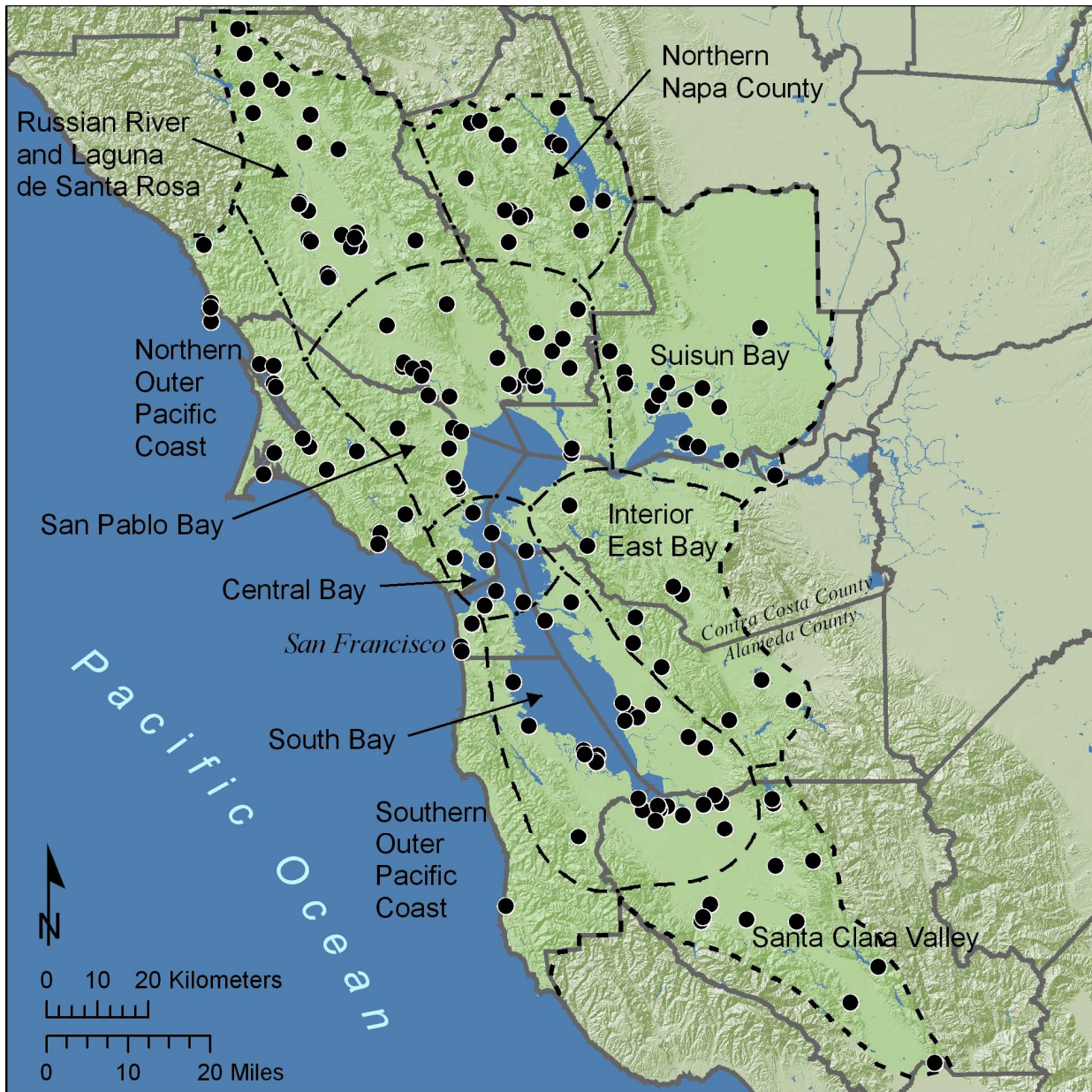


Figure 1. Distribution of heron and egret nesting colony sites in the San Francisco Bay area, 1991-2005. The bold, dashed line indicates the study area boundary; thin, dashed lines within the study area separate heronries associated with the labeled wetland subregions.

INTRODUCTION

The slender, poised profiles of foraging herons and egrets are distinctive features of wetland and shoreline ecosystems. To many observers, these conspicuous birds signify the presence of potentially diverse and healthy wetlands worthy of protection. Consequently, herons and egrets are frequently used

as symbols of wetland conservation (Parnell et al. 1988, Kushlan and Hancock 2005). Such recognition is well substantiated by the ecologically important roles they play. As important predators, herons and egrets are sensitive to subtle changes in ecosystem productivity, hydrology, and vegetation, and (although their responses are not completely understood), they are recognized widely as indicators of processes that sustain or threaten wetland

ecosystems (Kushlan 1993, Erwin and Custer 2000). Although nesting herons and egrets at some sites may tolerate human activities at close range (Nisbet 2000; Hothem and Hatch 2004), their tolerance levels are highly variable and sensitive to differences in the timing, type, proximity, or intensity of human activity (Vos et al. 1985, Rodgers and Smith 1995, Kelly 2002; pers. observation). In addition, just as wetlands depend on watershed conditions that extend into upland areas, the use of wetlands by herons and egrets may depend on suitable nesting sites in upland habitats that do not qualify for wetland protection. The work presented here complements efforts to protect and restore wetland feeding areas by providing detailed information that could be used to protect heron and egret nesting colonies.

The atlas of heronries summarizes continuing efforts by Audubon Canyon Ranch (ACR) and the San Francisco Bay Bird Observatory to monitor colonially nesting herons and egrets in the central coastal region of California surrounding the San Francisco Estuary (Kelly et al. 1993). Prior to this work, information on populations of colonially nesting herons and egrets in the San Francisco Bay area was limited to local monitoring of a few large colony sites (Harvey et al. 1992, Kelly et al. 1993). Field studies contributing to the atlas began in 1967, when Helen Pratt initiated a long-term study of nesting herons and egrets at Bolinas Lagoon (Pratt and Winkler 1985) and began recording annually the number of active nests at several heronries in Marin County (Pratt 1983). In the 1980s, the San Francisco Bay Bird Observatory began monitoring a few heronries in South San Francisco Bay. In 1991 we initiated the current program to monitor annually the status of regional nesting populations (Kelly et al. 1993).

The goals of the atlas are to (1) provide a protocol for intensive regional monitoring of heronries, (2) develop current and historical perspectives on the regional, subregional, and local status of herons and egrets with regard to patterns and trends in their nesting abundance and reproductive performance, and (3) consider regional, subregional, and local implications for conservation. Specifically, we present information on regional distributions, nest survivorship, productivity, nesting habitat, intraseasonal timing, human disturbance, nest

predation, property ownership, and management concerns at all known heronries in the San Francisco Bay area. The results are based on field observations conducted over the last 15 years and additional data available for previous years as far back as 1967 (38 years).

The study species are Great Blue Heron (*Ardea herodias*), Great Egret (*Ardea alba*), Black-crowned Night-Heron (*Nycticorax nycticorax*), Snowy Egret (*Egretta thula*), and Cattle Egret (*Bubulcus ibis*). We also documented single nesting occurrences of Little Blue Heron (*Egretta caerulea*) in some years. The Green Heron (*Butorides virescens*) is a common breeder throughout the area that may form loose aggregations of a few nests, but it generally nests alone in hidden locations along wooded streams suitable for foraging (Davis and Kushlan 1994, Shuford 1993, Berner et al. 2003, Burridge 1995) and is therefore not included in this study.

NESTING BIOLOGY

Hérons and egrets nest in remote forested canyons, in tule marshes and swamps, on isolated islands, and along river banks and sloughs far from human activity (Kushlan and Hancock 2005). In California, they also nest in suburban neighborhoods, in non-native trees near ranch buildings and farm ponds, and in groves of introduced eucalyptus trees (*Eucalyptus* spp.). Their colonies may consist of several hundred nests or just a few pairs of breeders. Occasionally, herons and egrets breed as solitary pairs (Kushlan and Hancock 2005).

Nesting herons and egrets tend to feed within a few to several kilometers of their heronries (Custer and Osborn 1978, Bancroft et al. 1994, Custer and Galli 2002, Kelly et al. 2005b). They feed primarily in wetland (and some upland) habitats characterized by frequent shifts in suitability for foraging. These shifts in habitat quality are related to changes in prey availability, which are influenced by the dynamics of hydrology, tides, prey populations, and prey depletion by competing herons and egrets (Kushlan 1976, 2000, Gawlik 2002, Frederick 2002, Kushlan and Hancock 2005). The dependence of herons and egrets on finding food in patchy and changeable landscapes may account for the occurrence of nesting

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colonies in particular locations (Wittenberger and Hunt 1985). By providing efficient access to several productive feeding areas, the locations of heronries may be geographically important to nesting herons and egrets.

Heron and egret nest during seasonally high periods of prey availability (Butler 1993, Kushlan and Hancock 2005). A variable period of courtship precedes nest construction and clutch initiation. Nesting activity can be delayed by persistent rains, high winds, unusually cold temperatures, or other conditions that reduce their ability to capture enough prey to support the energy demands of breeding (Pratt 1970, McCrimmon et al. 2001, Butler 1993, and ACR unpubl. data). Nesting can also be delayed by human or predator disturbance to the colony (unpubl. data).

Great Blue Herons in the San Francisco Bay area generally begin to occupy colony sites in January or February, but sometimes as early as late December, with first clutches typically initiated in mid-to-late February (Pratt 1970, Pratt and Winkler 1985, and ACR unpubl. data). Great Egrets typically arrive at their nesting colonies between mid-February and early April, usually laying their first eggs in mid-March (Pratt 1970, Pratt and Winkler 1985, and ACR unpubl. data). The seasonal return of Snowy Egrets, Black-crowned Night-Herons, and Cattle Egrets to previously established colony sites is more variable, ranging from March to late April (Hothem and Hatch 2004 and ACR unpubl. data). In the San Francisco Bay area, Great Blue Herons usually occupy colony sites through early to mid-June, and Great Egrets, Snowy Egrets, Black-crowned Night-Herons and Cattle Egrets often occupy colony sites well into August. However, late nests in any species may remain active into mid-September (Pratt 1970, Hothem and Hatch 2004, and ACR unpubl. data).

The reproductive performance of herons and egrets is influenced by several processes that affect nest survivorship and productivity. Nest survivorship (proportion of nests that fledge at least one young) varies primarily with the risks of nest predation, severe weather, and colony site disturbance (Pratt and Winkler 1985, Frederick and Spalding 1994, Smith and Callopy 1995, Vennesland and Butler 2004, Kelly et al. 2005a). In contrast, the number of young produced in successful nests

depends on the amount of food available to produce eggs and provision nestlings (Frederick 2002, Kushlan and Hancock 2005). Herons and egrets typically reduce the sizes of each brood through asynchronous incubation and hatching, which leads to a competitive size hierarchy and differential survivorship among nestlings (Kushlan and Hancock 2005). One likely benefit of brood reduction is an ability to align their reproductive effort with the vagaries of prey availability in wetland systems (Lack 1947, 1954, Mock and Forbes 1994, Forbes and Mock 2000). By provisioning smaller broods in years when food is less available, herons and egrets improve the likelihood that some chicks will survive. Therefore, large changes in wetland productivity are likely to influence the extent of brood reduction and the number of young produced in successful nests.

STUDY AREA

The study area extends from the outer Pacific Coast eastward to the confluence of the Sacramento and San Joaquin rivers, Mount Diablo, and Mount Hamilton, and from the Russian River, Cloverdale, and Lake Berryessa southward through the Santa Clara Valley south of San Francisco Bay (Figure 1). The study area covers approximately 13,705 km² and includes most of the area in nine shoreline counties of the San Francisco Estuary: Marin, Sonoma, Napa, Solano, Contra Costa, Alameda, San Francisco, San Mateo, and Santa Clara. We did not include heronries east of the Lower Sherman Island State Wildlife Area at the confluence of the Sacramento and San Joaquin Rivers. The extensive Sacramento-San Joaquin Delta, immediately beyond this eastern boundary of the study area, includes 1,792 km² of waterways and 1,417 km² of diked former marshland presently used for agriculture (California State Lands Commission 1991).

Within the study area, rolling hills and mountains of the Coast Range give way to coastal terraces and lagoons along the outer coast and alluvial shorelines and marshes of the San Francisco Estuary. Wetland systems associated with the Russian River and other freshwater streams in the north include a variety of lakes, marshes, creeks, and sloughs that provide freshwater feeding areas for herons and

egrets. Coast Redwood (*Sequoia sempervirens*), Douglas-Fir (*Pseudotsuga menziesii*), and mixed evergreen forests that dominate the outer coastal drainage open eastward into expanses of grassland, chaparral, and oak woodland that characterize the interior hills. Riparian zones along the outer parts of the Coast Range are dominated by willows (*Salix* spp.), alders (*Alnus* spp.), and coast redwoods, but in the interior riparian areas, willows, alders, and cottonwoods (*Populus fremontii*) predominate. Non-native eucalyptus trees (predominately *Eucalyptus globulus*) are the dominant trees associated with most of the wetland terraces surrounding the San Francisco Estuary and occur throughout the region as narrow windbreaks or small patches that cover generally less than 1 ha.

We analyzed breeding distributions by grouping colonies into nine major wetland subregions: (1) Outer Pacific Coast, divided into the outer coast north and south of San Francisco; (2) Russian River and Laguna de Santa Rosa; (3) Northern Napa County; four subregions of the San Francisco Estuary identified as (4) Suisun Bay, (5) San Pablo Bay, (6) Central San Francisco Bay, and (7) South San Francisco Bay; (8) Interior East Bay, including interior Contra Costa and Alameda counties; and (9) Santa Clara Valley (Figure 1).

The Laguna de Santa Rosa is the southern-most tributary of the Russian River, with a 20,000-acre (8,100 ha) freshwater wetland system composed of seasonal and perennial marshes, open water, vernal pools, riparian forest, willow groves, grasslands, and oak woodlands. Central San Francisco Bay includes several rocky islands used by nesting herons and egrets. Large tidal marshes occur in Suisun Bay and the Petaluma and Napa marshes of San Pablo Bay. The Napa and Suisun marshes are characterized by extensive slough systems and extensive historic marshland that has been largely diked or drained, although some areas have been restored to tidal action (San Francisco Bay Area Wetlands Ecosystem Goals Project 1999). Most of the tidal marshland in South San Francisco Bay was also diked and drained for pasture in the early 1900s and eventually converted to salt evaporation ponds (Association of Bay Area Governments 1992). Planning efforts are currently under way to restore much of the South San Francisco Bay marshland to tidal action, although

some ponds will be managed as non-tidal wildlife areas (PWA et al. 2006). Freshwater discharges from South San Francisco Bay sewage treatment plants have converted additional salt marsh areas into brackish tule (*Scirpus* spp.) marsh. Estimated subregional losses of tidal wetlands since 1850 are 86% for South and Central San Francisco Bay (pooled), 70% for San Pablo Bay, and 86% for Suisun Bay (Association of Bay Area Governments 1992). Regional habitats are further described in Mayer and Laudenslayer (1988), Association of Bay Area Governments (1992), and the San Francisco Bay Area Wetlands Ecosystem Goals Project (1999).

PROTOCOL FOR MONITORING

All known colony sites in the region were included in the study. We determined the locations of colony sites through ongoing communications with state, regional, and local natural resource managers, county breeding bird atlas project coordinators, and local bird watching networks. In addition, we conducted region-wide aerial and ground-based searches for new breeding sites in 1991 and ground-based searches in remote areas of the region in most other years. We concentrated searches for new heronries in May and June, when the conspicuousness of colony sites is relatively high because of the presence of adults actively feeding nestlings, nestlings large enough to be easily seen or heard, and guano accumulations beneath nests. Because we did not conduct systematic annual surveys for undiscovered colony sites, the results of the project reflect patterns among all known heronries in the region but may not accurately represent overall populations.

Five, three-day regional observation periods were scheduled each year (Table 1). During each of these periods, we attempted to visit all colony sites to allow for comparisons of seasonal timing (Table 1). We defined a colony site or heronry as a group of active heron or egret nests within 500 m of each other. Whenever a group of nests in a heronry was isolated by more than 100 m from other nests within the site, it was considered to be a subcolony site and the associated data were recorded separately. However, the results presented in this report are pooled for each colony site.

6 SAN FRANCISCO BAY AREA HERONRIES

Table 1. Regional observation periods are used to monitor differences in intraseasonal timing among heronries and to structure the minimum number of annual monitoring visits in the San Francisco Bay area. All heronries are observed during each 3-day regional observation period each year, scheduled as closely as possible to the target dates for regional observations.

Target dates for regional observations	Monitoring objective
10-12 March	Number focal nests on a panoramic sketch. Monitor focal nests. Determine the total number of active nests in the colony, by species.
1-31 March	Unscheduled visit(s), as necessary, to identify "focal nests." Monitor focal nests. Determine the total number of active nests in the colony, by species.
10-12 April	Identify additional focal nests if the colony has not yet reached peak annual size. Monitor focal nests. Determine the total number of active nests in the colony, by species.
10-12 May	Monitor focal nests. Determine the total number of active nests in the colony, by species.
3-5 June	Monitor focal nests. Determine the total number of active nests in the colony, by species.
20-22 June	(Great Egrets, Snowy Egrets, and Black-crowned Night-Herons only) Monitor focal nests. Determine the total number of active nests in the colony, by species.

We observed all colonies from the ground or from boats using binoculars and telescopes. We used GPS or USGS 7.5-min topographic quads to record the geographic position of each heronry (NAD83). We were assisted at many sites by trained volunteer field observers. Observers visited most colony sites at least four times each breeding season, with an average of 6.8 ± 0.31 (standard error, SE) visits to each active colony site annually, 1991-2005. The annual percent of active colony sites visited only once was $19 \pm 1.4\%$ year⁻¹. Sites visited only once in a given year were usually observed in May or early June when nests and broods were the most conspicuous. The annual percent of colony sites that were visited at least ten times was $15 \pm 0.6\%$ year⁻¹.

In the northern portion of the study area (all subregions north of San Francisco, including Central San Francisco Bay, Contra Costa County in the Interior East Bay, and the Outer Coast north of San

Francisco; Figure 1), colony site visits averaged 1.4 ± 0.04 hours each year. Longer periods of observation were required at larger colonies, especially in May and June when brood sizes were recorded (average hours = $1.25 + 0.004 \times \text{peak annual nest abundance}$; $F_{1,801} = 54.9$, $P < 0.001$).

We used the peak number of active nests observed as an estimate of annual colony size. On visits before 1 April, nests were assumed to be active if two adults were present, an adult carrying nest material was present, an adult was incubating or caring for eggs, or chicks were present. After 1 April, all occupied nests were assumed to be active. To avoid nest disturbance on islands where Snowy Egrets and Black-crowned Night-Herons nest in dense shrubs, we estimated the number of active nests from the perimeter of colonies by conducting multiple counts and mapping the locations of birds perched above, or visible through, the shrub canopy.

Table 2. Habitat variables used to evaluate differences among heron and egret colony sites in the San Francisco Bay area.

Land form: ridge, hillside, flood plain, wetland, island with bridge, island without bridge, or levee
Distance to nearest wetland by type (perennial stream or river, lake or pond, non-tidal marsh, tidal salt or brackish marsh, San Francisco Bay shore, Outer Pacific Coast shore; km)
Colony length x width (m ²)
Human land use within 200 m and 500 m: industrial, residential (<3, 3-10, and >10 houses per ha), farm, orchard, vineyard, grazing, natural area or park, and sports field
Nest height: mean, min, max (m)
Nest canopy height: mean, max (m)
Nest substrate structural types (presence of live branch on tree, dead branch on tree, snag, shrub (0.5-5 m tall), <i>Scirpus</i> or <i>Typha</i> spp., ground, other)
Nest substrate plant species composition
Tree dbh class: (1) 3-10 cm, (2) 11-50 cm, (3) 51-100 cm, (4) 101-150 cm, (5) ≥ 150 cm
Tree canopy cover (height > 5 m; %)
Shrub cover (height 0.5-5 m; %)
Ground vegetation cover (height < 0.5 m; %)

Occasionally, these estimates were confirmed or revised by clapping loudly to flush adults in the colony. Counts of Snowy Egret and Black-crowned Night-Heron nests included an unmeasured bias associated with the difficulty of counting nests concealed in dense vegetation and, therefore, they may have been lower than the actual number of nests. At the Marin Islands, we estimated the number of nests from approximately 100 m away by boat. Because of the difficulty of counting Black-crowned Night-Heron nests at the Marin Islands, we multiplied nest counts by a factor of 5.4, derived from differences between counts conducted by boat

and counts obtained by intensive nest searches within the colony in 1990 and 1991 (R. Hothem, pers. communication). These conversions were consistent with anecdotal observations, apparently related to disturbance events, of 115 night-herons standing along the shoreline of the colony in 1995 and 215 in 2005, relative to nest counts of 18 and 44 conducted in those years, respectively, by boat (Kelly et al. 2006).

NESTING HABITAT

We analyzed vegetation and other habitat characteristics at active heronries during the 2003 nesting season. To reduce the possibility of observer disturbance, colony site measurements were conducted only on days with favorable weather after most nesting pairs had begun to incubate eggs (Fredrick and Collopy 1989a, Tremblay and Ellison 1979). At each colony site, we recorded information on the geomorphology, distance to wetland habitats, size of the nesting area, human land uses, nest heights, nest canopy height, nest substrate type, nest substrate species, tree diameter at breast height (dbh; measured 1.3 m above ground), and vegetation cover (Table 2). We recorded human land uses within 200 m, a distance within which human activity might disturb nesting birds (Vos et al. 1985, Erwin 1989, Rodgers and Smith 1995) and 500 m, a distance within which landscape conditions might affect the locations of colony sites (Watts and Bradshaw 1994).

We estimated the areal extent of each colony as the product of the length of the longest axis through the colony site and its longest perpendicular axis. We used the minimum convex polygon indicated by nest locations to determine colony site boundaries. Nest heights, canopy heights, and habitat patch area were measured with a range finder. Trees within the colony site boundaries were allocated into dbh classes using a reach stick (James and Shugart 1970). At large colony sites of more than 50 trees, we measured dbh based on a random sample of at least 50 trees. We estimated ground, shrub and canopy vegetation cover as the percent of perpendicular vegetation "hits" indicated by a cross-hair sighting viewed through an ocular tube at approximately 1 m intervals along each length and width transect (James and Shugart 1970). The minimum transect distance for these measurements was 10 m with at least 40 point

samples at each heronry. We determined distances (m) to wetland habitats, human land uses, and other heronries, using GIS (ArcGIS, ESRI, Redlands, CA, USA) or USGS topographic maps and field reconnaissance at each site.

REPRODUCTIVE SUCCESS

We measured reproductive success at colonies in the northern portion of the study area, including all subregions north of San Francisco, Central San Francisco Bay, the northern (Contra Costa County) portion of the Interior East Bay, and the northern portion (north of San Francisco) of the Outer Coast (Figure 1). We used focal nest samples at colony sites observed through the entire nesting season to measure nest survivorship. In colonies with fewer than 15 active nests, all nests initiated before the colony reached peak number of nests for the year were treated as focal nests. In colonies with more than 15 active nests, a random subset of 10-15 focal nests was selected and observers were encouraged to monitor as many focal nests as possible. In some larger colonies all observable nests were selected as focal nests.

In the northern portion of the study area indicated above, annual samples of focal nests (1993-2005) represented $72 \pm 1.8\%$ of the active Great Blue Heron colonies, $63 \pm 3.0\%$ of Great Egret colonies, $39 \pm 4.6\%$ of Black-crowned Night-Heron colonies, and $47 \pm 4.9\%$ of Snowy Egret colonies. At those colonies sampled, the number of nests that were treated as focal nests accounted for $90 \pm 1.1\%$ of the peak number of Great Blue Heron nests, $68 \pm 2.5\%$ of Great Egret nests, $50 \pm 6.0\%$ of Black-crowned Night-Heron nests, and $55 \pm 5.3\%$ of Snowy Egret nests.

On average, we sampled brood size in successful nests at $82 \pm 1.6\%$ of Great Blue Heron colonies, $71 \pm 2.8\%$ of Great Egret colonies, $40 \pm 4.6\%$ of Black-crowned Night-Heron colonies, and $51 \pm 4.9\%$ of Snowy Egret colonies in the northern portion of the study area. At those colonies sampled, brood size samples accounted for $66 \pm 1.2\%$ of the peak number of Great Blue Heron nests, $48 \pm 2.1\%$ of Great Egret nests, $32 \pm 3.4\%$ of Black-crowned Night-Heron nests, and $42 \pm 4.2\%$ of Snowy Egret nests.

Because the frequency of visits to most heronries was insufficient for measuring daily nest

survivorship (Mayfield 1961, 1975, Johnson 1979), we estimated the apparent survivorship of nests based on the success rates of focal nests. Focal nests were normally monitored from initiation or early in the incubation period, thus minimizing the potential for a (positive) survivorship bias related to undetected failures early in the nesting cycle. In addition, high daily survivorship during the incubation period for Great Egret nests and Great Blue Heron nests at Bolinas Lagoon Preserve of Audubon Canyon Ranch, 2003-2005 (pooled), indicated that the potential bias resulting from occasional selection of focal nests 1-2 wks into the 28-day incubation period was minor (daily nest survivorship for Great Egret: $99.8 \pm 0.1\%$ over 224 exposure days in the first 7 days of incubation, $99.7 \pm 0.1\%$ over 2617 exposure days in the first 14 days; daily nest survivorship for Great Blue Heron: $99.8 \pm 0.1\%$ over 189 exposure days in the first 7 days, $99.7 \pm 0.1\%$ over 371 exposure days in the first 14 days).

Great Egret and Great Blue Heron nests were considered successful if at least one chick survived to seven or eight weeks post-hatch, respectively (Pratt 1970, Pratt and Winkler 1985). Because Snowy Egret, Black-crowned Night-Heron and Cattle Egret nestlings begin to wander away from the nest when relatively young, we considered nests to be successful at 14 days after first hatch for Snowy Egret (Frederick and Callopy 1989a) and Cattle Egret (Telfair 1994) and 15 days after first hatch for Black-crowned Night-Heron (Custer et al. 1983). At most heronries, however, Snowy Egret, Black-crowned Night-Heron, and Cattle Egret nests were not observed frequently enough to determine survivorship.

We measured the productivity of successful nests based on the size of completely visible broods when Great Blue Heron nestlings were known to be 5-8 wks old and Great Egrets were known to be 5-7 wks old. During these periods, nestlings were too young to hop away from their nests and Great Egret and Great Blue Heron nestlings were old enough to have survived the period when most brood reduction occurs (Pratt 1970, Pratt and Winkler 1985). Because the nestlings of other species begin to wander away from nests at a younger age, we measured the productivity of successful Snowy Egret and Cattle Egret nests when the young were 7-14 days old (Frederick and Callopy 1989a, Telfair 1994, Parsons

and Master 2000), and the productivity of successful Black-crowned Night-Heron nests when the young were 7-15 days old (Custer et al. 1983, Davis 1993). We determined if nestlings had reached the appropriate ages indicated above by tracking the timing of nesting stages in nests followed through the nesting cycle (see Intraseasonal Timing, below), or by nestling size. Therefore, estimates of the number of young in successful nests included (focal) nests followed through the nesting cycle as well as nests that were not followed but contained young known to have reached the appropriate age prior to fledging.

INTRASEASONAL TIMING

We measured the intraseasonal timing of nesting effort at colony sites in the northern portion of the study area (same area used to measure reproductive success, described above). We did not attempt to measure differences in the initial occupation of heronries at the onset of each nesting season. We examined differences in intraseasonal timing among colonies by comparing the proportions of nests among nesting stages during each regional observation period, scheduled as nearly as possible to target dates (Table 1). We used the following classifications: (1) egg-laying or incubation, adult lying down in nest for long periods, standing to turn eggs, defecate, or for nest relief; (2) hatching, small (downy) nestlings, or feeding observed low in the nest; (3) nestlings capable of standing, most or all of down replaced by juvenal plumage, parent(s) continuously at the nest; (4) adults not continuously at the nest but may be present for some time after feeding, nestlings usually on the nest platform; (5) young often off the nest on nearby branches. Occasionally, we were unable to visit colony sites within scheduled observation periods and therefore collected samples within a few days of the planned dates. To compare intraseasonal timing among subregions, we estimated differences in the average proportion of nests observed in the egg-laying and incubation period (Stage 1), the parental guardian period (Stages 2 and 3), and the post-guardian period (Stages 4 and 5), weighted equally across years with adequate data, 1992-2005. Subregional comparisons of intraseasonal timing for each species were based on samples with at least ten nests per year or half of the active nests in each subregion.

NEST PREDATION AND DISTURBANCE

At colony sites in the northern portion of the study area (see Reproductive Success above) we recorded evidence of nest predation and disturbance during each site visit. Because observations were generally conducted from remote positions, we rarely entered colony sites to search for or evaluate such evidence. We classified each occurrence of predation or disturbance by type (human, observer, avian, mammal, other predator, weather, or unknown) and level (colony abandonment, nest loss or nestling mortality, or behavioral response). These observations were summarized by converting them to the mean proportion of occurrences among colony sites and site visits per year within the region or wetland subregions. We summarized evidence of colony site abandonment, colonization or discovery, recolonization, and sources of disturbance over the entire study area. Disturbance notes for each heronry are included in the individual site accounts.

STATISTICAL ANALYSIS

Estimates of annual survivorship and productivity are based on the fates of individual heron and egret nests, which can be sampled only once each. Under these conditions, variance models based on sampling without replacement are more accurate than commonly used models that assume replacement, especially if a substantial proportion of the population is sampled (Thompson 1992). We sampled nest survivorship and productivity from a sampling universe equal to the number of nests (N) in a colony or group of colonies, with sample sizes (n) often accounting for a relatively large proportion of the total number of nests. Because of the conspicuousness of colonially nesting herons and egrets, the sampling population of nests could be confidently estimated by counting the peak number of active nests. Therefore, we used unbiased variance estimators for sampling nests without replacement. Nest monitoring programs based on such models benefit from standard errors that are substantially and appropriately reduced. We calculated the variance of the estimated mean prefledging brood size ($\hat{b}$) by multiplying the estimator based on samples collected with replacement (s^2/n) by the finite population correction factor $1 - (n / N)$ (Thompson 1992):

$$\text{var}(\hat{b}) = (s^2 / n) \cdot (1 - n / N) .$$

Similarly, we estimated nest survivorship as the successful proportion ($\hat{p}$) of focal nests sampled without replacement (Thompson 1992), with an estimated variance of

$$\text{var}(\hat{p}) = (\hat{p} \cdot (1 - \hat{p}) / n) \cdot (n / (n-1)) \cdot (1 - n / N) .$$

Comparisons of nest survivorship and number of young in successful nests between subregions, colony sites, or species were based on the means and standard errors of individually monitored nests within groups, weighted equally across years. To evaluate the significance of multiple pairwise comparisons among groups, we used t-tests with Bonferroni adjustments for an experimentwise error of $P < 0.05$. Subregional comparisons of nest survivorship were based on annual samples of at least ten nests or half of the active nests in each subregion. Similarly, comparisons of the number of young in successful nests were based on annual samples of at least ten nests or half of the successful nests (number of active nests $\times$ nest survivorship). Unless indicated otherwise, pairwise comparisons of nest survivorship represented the years 1993-2005, and pairwise comparisons of the number of young in successful nests represented the years 1991-2005. When subregional data were incomplete across years, we conducted additional comparisons based on years with complete data from all subregions.

The proportions of focal nests or brood sizes sampled in each colony were not significantly related to colony size ($|r| < 0.1$, $P > 0.05$). However, because of differences in the difficulty of viewing colony sites, the proportions were not constant among sites, suggesting possible sampling biases within the region or subregions. To examine the influence of variation in sampling intensity among colony sites, we repeated the analyses using representative colony means of at least ten nests or half of the nests in each colony, weighted by colony size. Because the regional and subregional differences based on these weighted colony means did not differ from those based on pooled samples of individual nests, we considered the potential biases to be minor.

We estimated overall reproductive success (rs) as

the number of young produced per nest attempt, calculated as product of estimates of focal nest survivorship ($\hat{p}$) and prefledging brood size in successful nests ($\hat{b}$):

$$rs = \hat{p} \cdot \hat{b}$$

with a variance (Goodman 1960) of

$$\text{var}(rs) = [(\hat{p})^2 \cdot \text{var}(\hat{b})] + [(\hat{b})^2 \cdot \text{var}(\hat{p})] - [\text{var}(\hat{b}) \cdot \text{var}(\hat{p})] .$$

We determined the approximate significance of subregional differences in overall reproductive success by assuming a standard normal probability range (critical $t_{.05} = 1.96$) with Bonferroni adjustments for an experimentwise error of $P < 0.05$.

We used simple linear regression to measure trends in annual nest abundance and reproductive performance and visually inspected scatter plots to check for evidence of nonlinear trends. To examine relationships between colony size and persistence, we used Cleveland's robust locally weighted regression algorithm (LOWESS; Cleveland 1979, Chambers et al. 1983). The precision of results is presented as $\pm$ standard error unless indicated otherwise.

RESULTS

NEST ABUNDANCE AND DISTRIBUTION

In 1991-2005, we recorded an average of 73 ± 2.1 active colony sites per year ($n=15$ yrs; Figure 1). These sites supported 62 ± 1.7 Great Blue Heron colonies, 25 ± 1.5 Great Egret colonies, 13 ± 0.7 Black-crowned Night-Heron colonies and 12 ± 1.0 Snowy Egret colonies in the study area. Active colony sites were separated by about 6 km (mean nearest-neighbor distance = 5.95 ± 4.8 km standard deviation; $n = 1116$ sites weighted equally among years; species pooled). Great Blue Heron colonies tended to be small and widely distributed in the region ($44 \pm 1.9\%$ of colonies had <6 nests yr^{-1} and $65 \pm 1.4\%$ of those colonies occurred without other nesting species of herons or egrets). Great Egret nesting abundance was concentrated most strongly at several colony sites in the Suisun Bay subregion, with other important colony sites in Central and South

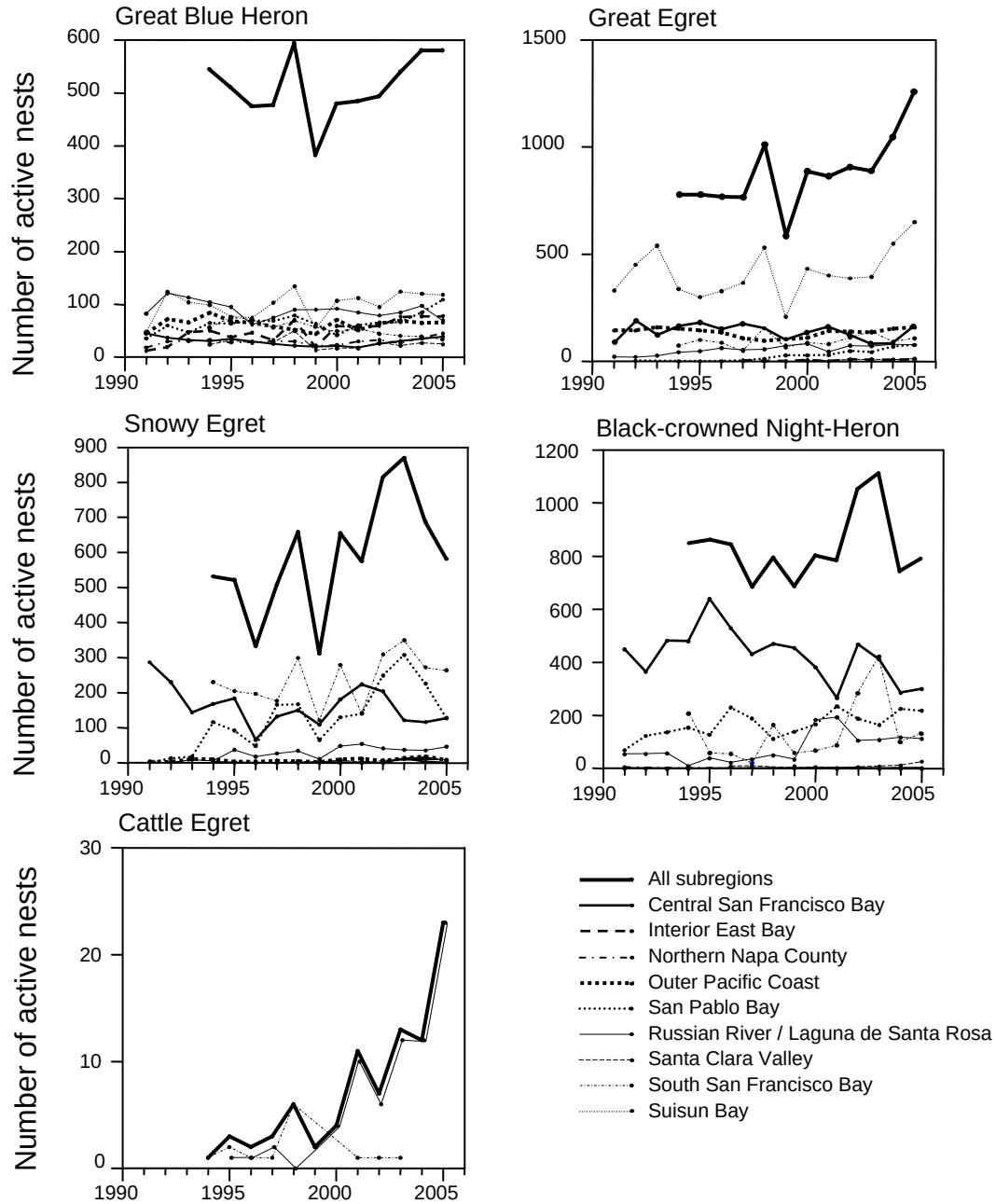


Figure 2. Peak number of active heron and egret nests observed annually within wetland subregions of the San Francisco Bay area. See Figure 1 for locations of heronries and subregions.

San Francisco Bay and along the Outer Pacific Coast. Cattle Egrets nested at one or two sites each year from 1994-2005 (along Santa Rosa Creek near the Laguna de Santa Rosa and at Mallard Slough, Hayward Shoreline, or Coyote Creek in South San Francisco Bay). Cattle Egrets also nested at Mallard Slough in 1985-1988 and 1990. Single pairs of Little

Blue Heron were observed nesting at Mallard Slough in South San Francisco Bay in 1990, 1993, and 1996.

The average annual number of nests in the region from 1994-2005 was 516 ± 14.9 for Great Blue Heron, 878 ± 49.6 for Great Egret, 834 ± 39.3 for Black-crowned Night-Heron, and 587 ± 48.1 for Snowy Egret. We emphasize that counts of Black-

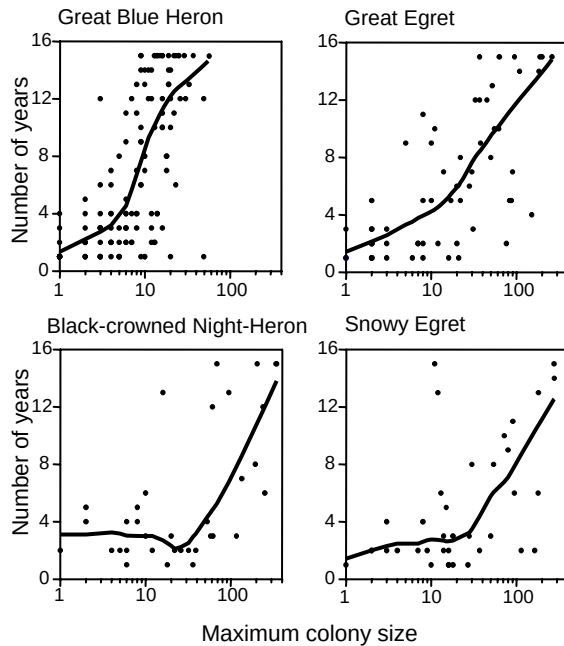


Figure 3. Relationships between persistence and maximum size of heron and egret nesting colonies ($\log_{10}$ scale) in the San Francisco Bay area, 1991-2005. Lines represent LOWESS trends with smoothing parameter $f = 0.6$.

crowned Night-Heron and Snowy Egret nests may be lower than the actual number because of the difficulty of counting nests concealed in dense vegetation. Cattle Egrets nested in low numbers of 1-23 nests (Figure 2).

The number of years heron or egret colonies were active during the 15-year study period (1991-2005) was related to colony size and nesting species. New colonies were often initiated with a few nests and grew, either gradually or abruptly, into larger colonies in subsequent years. However, colonies tended to become inactive within 5 years unless nest abundance reached a threshold of increasing persistence (Figure 3). Great Blue Heron colonies that remained smaller than six nests generally became inactive within five years, but colonies persisted, on average, for 12 years or more if maximum abundance was greater than 20 nests (Figure 3). The persistence of Great Egret, Black-crowned Night-Heron, and Snowy Egret colonies began to increase substantially only after reaching an abundance of 20-30 nests per species. Colony sites with less than ten nests of all species combined tended to become inactive, on average, within approximately eight years (Figure 4). These general patterns underestimate average

persistence because some colonies were active prior to discovery or may remain active beyond the 15-year monitoring period.

The nest abundances of all species were stable or increasing in the region from 1994-2005 (Figure 2). Great Blue Heron nest numbers showed no significant linear trend from 1994-2005 ($F_{1,10} = 1.1$, $P = 0.32$), but increased significantly by an average of 25 ± 2.8 nests per year from 1999-2005 ($F_{1,4} = 82.4$, $P < 0.001$; Figure 2). The number of Great Egret nests in the region increased significantly from 1994-2005 ($b = 32 \pm 11.2$ nests yr^{-1} , $F_{1,10} = 8.2$, $P = 0.02$), reflecting primarily a sharp increase in 2004 and 2005 (Figure 2). Black-crowned Night-Heron nest numbers did not increase significantly ($F_{1,10} = 0.4$, $P = 0.54$), but a marginally significant linear increase was evident in the number of Snowy Egret nests from 1994-2005 ($F_{1,10} = 4.5$, $P = 0.057$; Figure 2). Significant increases in the small number of nesting Cattle Egrets resulted from an increase in the number of nests at a heronry in the Laguna de Santa Rosa ($F_{1,10} = 26.4$, $P < 0.001$).

We observed a consistent decline in the peak number of active nests by all species in 1999, particularly in Suisun Bay and South San Francisco Bay (Figure 2). These declines were associated with unusual conditions two years earlier, during the hatching year for individuals reaching reproductive age in 1999. These first-time breeders were produced during an unusual breeding-season drought in 1997

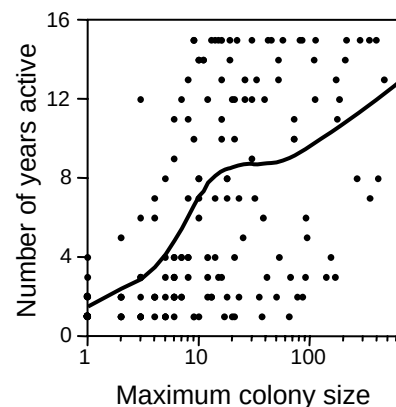


Figure 4. Relationship between persistence and maximum size of heronries ($\log_{10}$ scale, all species combined) in the San Francisco Bay area, 1991-2005. Lines represent LOWESS trends with smoothing parameter $f = 0.6$.

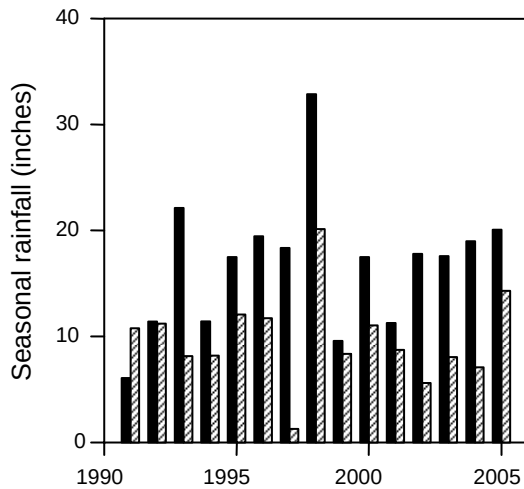


Figure 5. Cumulative rainfall in winter (November-February; solid bars) and the nesting season (February-June, striped bars), 1991-2005, recorded in San Francisco (California Data Exchange Center, Department of Water Resources).

and endured unusually heavy rainfall during their first winter (Figure 5). The dry breeding conditions in 1997 were associated with an unusual decline in nest survivorship only for Great Blue Heron in Suisun Bay (Figure 6) and were not associated with unusual declines in the productivity of successful nests (Figure 7). Therefore, if first time breeders normally represent a substantial portion of the nesting population and natal dispersal occurs primarily at intraregional scales, or within scales within the geographic extent of the harsh winter conditions from November 1997 to February 1998 (Figure 5), then the 1999 decline in regional nest abundance may have resulted from a decline in recruitment following reduced juvenile survival during harsh winter conditions. However, we did not measure juvenile survival.

NESTING HABITAT

Trees were used as nesting substrates in 90% of the active colony sites in 2003 (Table 3). Non-native eucalyptus trees were used as nesting substrate at 53% of sites and were the predominant tree species near wetland habitats (J. Kelly, pers. observation). In addition, Snowy Egrets and Black-crowned Night-Herons used sites with coast live oaks (*Quercus agrifolia*; 18% and 20% of sites, respectively), shrubs (24% and 40% of sites), and tule (*Scirpus* spp.) or cattail (*Typha* spp.) marshes (12% and 20% of sites).

Sites with trees as nest substrates averaged $47 \pm 2.6\%$ canopy cover, $14 \pm 2.8\%$ shrub cover, and $30 \pm 3.7\%$ ground cover ($n = 63$). Thirty-two (48%) of 66 sites with trees as nest substrates included one or more trees that were 1 m dbh or larger, and 13 sites with nesting trees (20%) included one or more trees larger than 1.5 m dbh.

Only 12% of colony sites were in wetland habitat (Table 3). Great Egrets and Great Blue Herons nested in heronries associated with a variety of landforms and were the most important species in heronries on levees and hillsides. Islands, primarily without bridges, accounted for over half of the colony sites used by Black-crowned Night-Herons and a third of those used by Snowy Egrets.

The predominant human land uses near colony sites were grazing, parks or natural areas and low-to-medium density residential use (Table 4). Low and medium density residential use occurred within 200 m of half of the sites used by Great Blue Herons, 40% of sites used by Black-crowned Night-Herons, and 38% of sites used by Snowy Egrets. Concentrated use of heronries in parks or natural areas by Snowy Egrets (47% of sites) and Black-crowned Night-Herons (40%; Table 4) was associated with their frequent use of protected islands (Table 3). Fifty-four percent of the active heronries in 2003 were privately owned, and 46% were on publicly owned lands ($n = 72$).

REPRODUCTIVE SUCCESS

Nest Survivorship. Overall nest survivorship in the region, using all focal nests weighted equally among years (1993-2005), was $79 \pm 0.4\%$ for Great Blue Heron ($n = 3227$ nests), $78 \pm 0.4\%$ for Great Egret ($n = 4685$), $62 \pm 2.3\%$ for Black-crowned Night-Heron ($n = 1940$), and $66 \pm 2.1\%$ for Snowy Egret ($n = 402$). In general, annual changes in nest survivorship were not consistent among subregions (Figure 6). The survivorship of Great Blue Heron nests was significantly greater in Northern Napa County than in Central San Francisco Bay, the Interior East Bay, or the Russian River and Laguna de Santa Rosa (Table 5). Although they often nest in small colonies along rivers or streams, we found no evidence of a relationship between Great Blue Heron colony size and nest survivorship, either from inspection of scatter plots or from linear regression (controlling for

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Table 3. Percent of Great Blue Heron, Great Egret, Snowy Egret and Black-crowned Night-Heron colony sites associated with nesting substrates and land forms (and the regional percent of nests that occurred in those sites) in the San Francisco Bay area in 2003. Values < 0.5% are indicated by "+".

Characteristic	Great Blue Heron n = 58 (504)	Great Egret n = 27 (856)	Snowy Egret n = 17 (846)	Black-crowned Night-Heron n = 15 (1113)	All species n = 73 (3332)
<u>Nesting substrate</u>					
Tree	95 (96)	90 (97)	82 (85)	67 (90)	90 (91)
<i>Eucalyptus</i> spp.	57 (69)	72 (76)	53 (64)	27 (47)	53 (62)
<i>Quercus agrifolia</i>	2 (2)	7 (12)	18 (46)	20 (38)	4 (28)
<i>Aesculus californica</i>	2 (2)	3 (9)	6 (12)	7 (25)	1 (14)
<i>Pinus radiata</i>	3 (9)	10 (4)	6 (4)	7 (10)	4 (7)
<i>Sequoia sempervirens</i>	14 (11)	7 (9)	6 (1)	0 (0)	11 (4)
<i>Cupressus macrocarpa</i>	7 (5)	7 (5)	6 (+)	0 (0)	5 (2)
<i>Quercus lobata</i>	5 (7)	3 (4)	0 (0)	0 (0)	4 (2)
<i>Pseudotsuga menziesii</i>	10 (6)	0 (0)	0 (0)	0 (0)	8 (1)
<i>Pinus sabiniana</i>	5 (4)	0 (0)	0 (0)	0 (0)	4 (1)
<i>Pinus muricata</i>	2 (2)	3 (2)	0 (0)	0 (0)	1 (1)
<i>Lithocarpus densiflorus</i>	0 (0)	0 (0)	0 (0)	7 (+)	1 (1)
Shrub	3 (2)	10 (13)	24 (23)	40 (42)	8 (24)
Snag	9 (8)	3 (9)	6 (12)	7 (25)	7 (15)
Artificial structures	3 (3)	3 (5)	6 (22)	7 (21)	4 (14)
<i>Scirpus</i> or <i>Typha</i> spp.	0 (0)	3 (+)	12 (6)	20 (3)	4 (2)
<u>Land form</u>					
Island	7 (6)	17 (14)	35 (30)	53 (53)	14 (30)
with bridge	2 (3)	3 (2)	0 (0)	7 (1)	3 (1)
without bridge	5 (3)	14 (13)	35 (30)	47 (53)	11 (29)
Flood plain	29 (27)	28 (29)	35 (38)	7 (9)	27 (24)
Wetland	10 (15)	17 (12)	12 (26)	20 (24)	12 (20)
Levee	16 (15)	21 (37)	0 (0)	0 (0)	12 (12)
Hillside	28 (34)	14 (5)	0 (0)	7 (+)	23 (7)

year; $F_{1,410} = 0.01$, $P = 0.92$). Great Egret nests were significantly more likely to fledge young in Suisun Bay than in Central San Francisco Bay, the Outer Coast, or the Russian River and Laguna de Santa Rosa and were significantly more likely to fail on the Outer Coast than in all other subregions (Table 5).

The exclusion of small annual samples from subregional comparisons of Snowy Egret nest survivorship (see Methods) resulted in differences between the regional mean reported above and the subregional means in Table 5. However, in 2005, Snowy Egret nest survivorship was significantly greater in Central San Francisco Bay than in San

Pablo Bay or the Laguna de Santa Rosa (Table 5). We did not detect other subregional differences in nest survivorship for Black-crowned Night-Heron or Snowy Egret, but small sample sizes suggest the possibility of undetected differences (Table 5).

Significant but weak linear declines in average regional nest survivorship were evident from 1993-2005 for Great Blue Heron ($b = -0.6 \pm 0.22\% \text{ yr}^{-1}$, $F_{1,13} = 7.2$, $P = 0.019$), Great Egret ($b = -1.0 \pm 0.38\% \text{ yr}^{-1}$, $F_{1,13} = 7.3$, $P = 0.018$), and Black-crowned Night-Heron ($b = -3.0 \pm 0.66\% \text{ yr}^{-1}$, $F_{1,12} = 20.4$, $P < 0.001$; Figure 8).

Number of young in successful nests. The

Table 4. Percent of Great Blue Heron, Great Egret, Snowy Egret and Black-crowned Night-Heron colony sites associated with human land uses (and the regional percent of nests that occurred in those sites) in the San Francisco Bay area in 2003. Values < 0.5% are indicated by "+".

	Great Blue Heron		Great Egret		Snowy Egret		Black-crowned Night-Heron		All species	
Characteristic	n = 58 (504)		n = 27 (856)		n = 17 (846)		n = 15 (1113)		n = 73 (3332)	
Land use within 200 m										
Grazing	22	(29)	21	(8)	12	(7)	7	(11)	19	(12)
Industrial	0	(0)	7	(5)	12	(27)	13	(32)	3	(19)
Orchard	2	(1)	0	(0)	0	(0)	0	(0)	1	(+)
Park or natural area	28	(24)	38	(30)	47	(46)	40	(40)	30	(36)
Residential, < 3 houses ha ⁻¹	40	(41)	28	(19)	29	(5)	13	(1)	34	(13)
Residential, 3-10 houses ha ⁻¹	10	(6)	10	(4)	18	(39)	27	(23)	14	(20)
Residential, > 10 houses ha ⁻¹	5	(6)	10	(7)	6	(4)	7	(10)	7	(8)
Sport or recreational field	0	(0)	7	(8)	6	(33)	7	(9)	3	(13)
Vineyard	7	(8)	3	(1)	6	(+)	0	(0)	5	(1)
Land use within 500 m										
Farm	2	(1)	3	(+)	0	(0)	7	(2)	3	(1)
Grazing	21	(33)	21	(12)	6	(1)	0	(0)	16	(8)
Industrial	2	(1)	10	(6)	18	(32)	20	(32)	5	(21)
Orchard	7	(7)	3	(+)	0	(0)	0	(0)	5	(1)
Park or natural area	29	(26)	38	(39)	47	(46)	40	(40)	30	(39)
Residential, < 3 houses ha ⁻¹	43	(32)	28	(23)	29	(4)	7	(+)	37	(12)
Residential, 3-10 houses ha ⁻¹	17	(13)	21	(12)	29	(62)	40	(45)	22	(36)
Residential, > 10 houses ha ⁻¹	10	(8)	14	(10)	18	(14)	20	(16)	12	(13)
Sport or recreational field	2	(1)	7	(4)	12	(37)	13	(18)	4	(17)
Vineyard	16	(17)	7	(5)	6	(+)	0	(0)	12	(4)

estimated number of young fledged per successful nest in the northern San Francisco Bay area, weighted equally among years (1991-2005), was 2.04 ± 0.015 for Great Blue Heron ($n = 2193$ nests), 2.15 ± 0.011 for Great Egret ($n = 3124$), 1.82 ± 0.046 for Black-crowned Night-Heron ($n = 978$), and 2.50 ± 0.040 for Snowy Egret ($n = 343$).

The number of young fledged from successful heron and egret nests differed significantly among subregions (Table 6). Successful Great Blue Heron nests fledged significantly more young in Central San Francisco Bay than in all other subregions and significantly more young in the Russian River and Laguna de Santa Rosa than all subregions except Central San Francisco Bay. In contrast, successful Great Blue Heron nests in San Pablo Bay were significantly less productive than in all other

subregions. Although Great Blue Herons often nest in small colonies along rivers or streams in remote parts of the region, we found no evidence of an effect of colony size on the productivity of successful nests, either from inspection of scatter plots or from linear regression (controlling for year; $F_{1,2922} = 2.5$, $P = 0.11$).

Successful Great Egret nests were dramatically more productive in the Interior East Bay than in other subregions and produced significantly more young in Suisun Bay and San Pablo Bay than in all subregions except the Interior East Bay. Great Egrets were significantly less productive in Central San Francisco Bay than in other subregions. Successful Black-crowned Night-Heron nests were significantly more productive in Central San Francisco Bay than in heronries associated with San Pablo Bay or the

Table 5. Nest survivorship $\pm$ standard error (SE) for Great Blue Heron, Great Egret, and Black-crowned Night-Heron, by subregion in the San Francisco Bay area, weighted equally among years. Year span groups indicate (1) all years with adequate data (see Methods), 1993-2005, and (2) years with adequate data from all subregions (Great Blue Heron: 1993-2005; Great Egret: 1994-1998 and 2002-2005; Black-crowned Night-Heron: 1999-2005; Snowy Egret: 2002 and 2004-2005). Means with the same superscript capital letter within species and year span group are not significantly different (Bonferroni adjusted $P > 0.05$).

Subregion	Year span group	Great Blue Heron			Great Egret			Black-crowned Night-Heron			Snowy Egret		
		Mean $\pm$ SE	n _{nests}	n _{years}	Mean $\pm$ SE	n _{nests}	n _{years}	Mean $\pm$ SE	n _{nests}	n _{years}	Mean $\pm$ SE	n _{nests}	n _{years}
Central San Francisco Bay	1	0.77 $\pm$ 0.006 ^B	349	13	0.78 $\pm$ 0.010 ^C	872	13	0.62 $\pm$ 0.012 ^A	1285	13	0.94 $\pm$ 0.058 ^A	16	1
	2	^b	^b	^b	0.78 $\pm$ 0.011 ^B	618	9	0.55 $\pm$ 0.020 ^A	472	7	0.94 $\pm$ 0.058 ^A	16	1 ^a
Interior East Bay ^c	1	0.72 $\pm$ 0.023 ^B	251	13	0.88 $\pm$ 0.026 ^A	28	6						
	2	^b	^b	^b	0.82 $\pm$ 0.039 ^{AB}	22	4 ^d						
Northern Napa County	1	0.83 $\pm$ 0.010 ^A	299	13									
	2	^b	^b	^b									
Outer Coast ^e	1	0.80 $\pm$ 0.013 ^{AB}	431	13	0.70 $\pm$ 0.007 ^D	1268	13				0.71 $\pm$ 0.019 ^B	57	10
	2	^b	^b	^b	0.65 $\pm$ 0.009 ^C	883	9				0.71 $\pm$ 0.030 ^B	20	3
San Pablo Bay	1	0.79 $\pm$ 0.010 ^{AB}	623	13	0.82 $\pm$ 0.008 ^{AB}	147	9	0.54 $\pm$ 0.028 ^A	259	11	0.78 $\pm$ 0.032 ^{AB}	165	5
	2	^b	^b	^b	0.82 $\pm$ 0.008 ^{AB}	147	9	0.58 $\pm$ 0.033 ^A	194	7	0.71 $\pm$ 0.009 ^B	124	3
Russian River and Laguna de Santa Rosa	1	0.78 $\pm$ 0.010 ^B	739	13	0.79 $\pm$ 0.012 ^{BC}	503	13	0.64 $\pm$ 0.038 ^A	170	8	0.80 $\pm$ 0.027 ^{AB}	71	4
	2	^b	^b	^b	0.76 $\pm$ 0.016 ^B	372	9	0.59 $\pm$ 0.043 ^A	165	7	0.74 $\pm$ 0.035 ^B	67	3
Suisun Bay	1	0.77 $\pm$ 0.018 ^{AB}	471	13	0.78 $\pm$ 0.009 ^C	1673	13						
	2	^b	^b	^b	0.85 $\pm$ 0.009 ^A	1275	9						

^aIn comparisons based on a single-year (2005), Snowy Egret nest survivorship in Central San Francisco Bay was significantly greater than San Pablo Bay or the Russian River/Laguna de Santa Rosa but did not differ significantly from the Outer Coast.

^bValue is same as line above; data were adequate from all subregions in all years.

^cnorthern portion only (Contra Costa County)

^dIn comparisons of subsets based on 1997 and 2003-2005 only, Great Egret nest survivorship in the Interior East Bay was significantly greater than in Central San Francisco Bay or the Russian River/Laguna de Santa Rosa but did not differ significantly from San Pablo Bay or Suisun Bay.

^enorth of San Francisco only

Table 6. Mean number of young fledged $\pm$ standard error (SE) in successful Great Blue Heron, Great Egret, Black-crowned Night-Heron, and Snowy Egret nests, by subregion, in the northern San Francisco Bay area, weighted equally among years. Year span groups indicate (1) all years with adequate data (see Methods), 1991-2005, and (2) years with adequate data from all subregions (Great Blue Heron: 1992, 1994-1995, 1997, and 1999-2005; Great Egret: 1992, 1995-1999 and 2001-2005; Black-crowned Night-Heron: 2001-2005; Snowy Egret: 2004-2005). Means with the same superscript capital letter within species and year span group are not significantly different (Bonferroni adjusted $P > 0.05$).

Subregion	Year span group	Great Blue Heron			Great Egret			Black-crowned Night-Heron			Snowy Egret		
		Mean $\pm$ SE	n _{nests}	n _{years}	Mean $\pm$ SE	n _{nests}	n _{years}	Mean $\pm$ SE	n _{nests}	n _{years}	Mean $\pm$ SE	n _{nests}	n _{years}
Central San Francisco Bay	1	2.38 $\pm$ 0.028 ^A	278	15	1.82 $\pm$ 0.022 ^D	513	14	2.03 $\pm$ 0.033 ^A	485	11	2.18 $\pm$ 0.135 ^{AB}	35	2
	2	2.42 $\pm$ 0.033 ^A	204	11	1.81 $\pm$ 0.025 ^D	408	11	2.09 $\pm$ 0.061 ^A	150	5	2.18 $\pm$ 0.135 ^{AB}	35	2
Interior East Bay ^a	1	2.01 $\pm$ 0.036 ^B	224	13	2.93 $\pm$ 0.133 ^A	13	3						
	2	2.04 $\pm$ 0.041 ^C	188	11	2.93 $\pm$ 0.133 ^A	13	3 ^b						
Northern Napa County	1	1.99 $\pm$ 0.027 ^B	247	13									
	2	2.01 $\pm$ 0.029 ^{BC}	211	11									
Outer Coast ^c	1	2.01 $\pm$ 0.023 ^B	437	15	2.04 $\pm$ 0.014 ^C	1007	15				1.82 $\pm$ 0.076 ^B	38	9
	2	2.00 $\pm$ 0.026 ^{BC}	335	11	2.01 $\pm$ 0.018 ^C	674	11				1.75 $\pm$ 0.086 ^B	15	2
San Pablo Bay	1	1.82 $\pm$ 0.025 ^C	423	14	2.23 $\pm$ 0.030 ^B	210	13	1.54 $\pm$ 0.036 ^B	247	9	2.49 $\pm$ 0.059 ^A	160	7
	2	1.79 $\pm$ 0.026 ^D	346	11	2.18 $\pm$ 0.027 ^B	207	11	1.42 $\pm$ 0.029 ^B	199	5	2.46 $\pm$ 0.046 ^A	103	2
Russian River and Laguna de Santa Rosa	1	2.06 $\pm$ 0.023 ^B	631	15	2.04 $\pm$ 0.026 ^C	350	13	1.51 $\pm$ 0.028 ^B	284	8	2.37 $\pm$ 0.060 ^A	97	5
	2	2.06 $\pm$ 0.026 ^B	483	11	2.05 $\pm$ 0.018 ^C	306	11	1.47 $\pm$ 0.027 ^B	220	5	2.38 $\pm$ 0.048 ^A	53	2
Suisun Bay	1	1.99 $\pm$ 0.020 ^B	698	15	2.27 $\pm$ 0.016 ^B	1733	15						
	2	1.90 $\pm$ 0.022 ^C	526	11	2.26 $\pm$ 0.016 ^B	1392	11						

^anorthern portion only (Contra Costa County)

^bComparisons were based only on 2000 and 2003-2004 in all subregions; relative differences and significance among subregions did not change when limited to these years.

^cnorth of San Francisco only

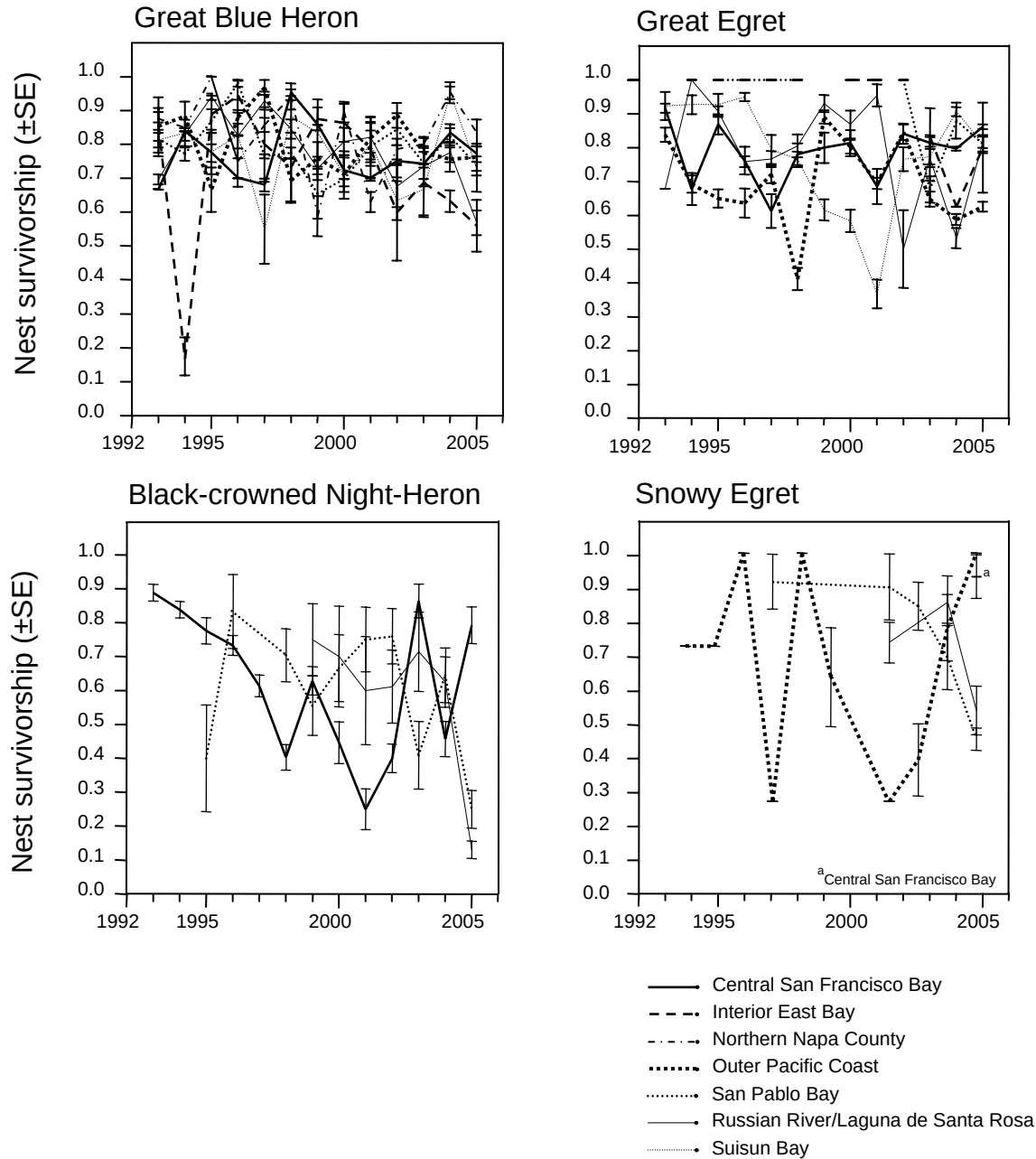


Figure 6. Mean survivorship (SE) of Great Blue Heron, Great Egret, and Black-crowned Night-Heron nests, by subregion, in the San Francisco Bay area, 1993-2005. Annual means with fewer than 10 focal nests are excluded unless samples represent at least half of the nests in the subregion.

Laguna de Santa Rosa (Table 6). As with nest survivorship, the exclusion of small annual samples from subregional comparisons of brood size in successful Snowy Egret nests resulted in differences between the regional mean above and subregional means (Table 6). Snowy Egret nests were significantly less productive on the Outer Coast

(Bollinas Lagoon Preserve of Audubon Canyon Ranch) than in other subregions (Table 6).

The number of young produced in successful nests appeared to covary annually among subregions (Figure 7). Although only two of 21 (9.5%) correlations between subregions were significant for Great Blue Heron, three of 15 (20%) for Great Egret

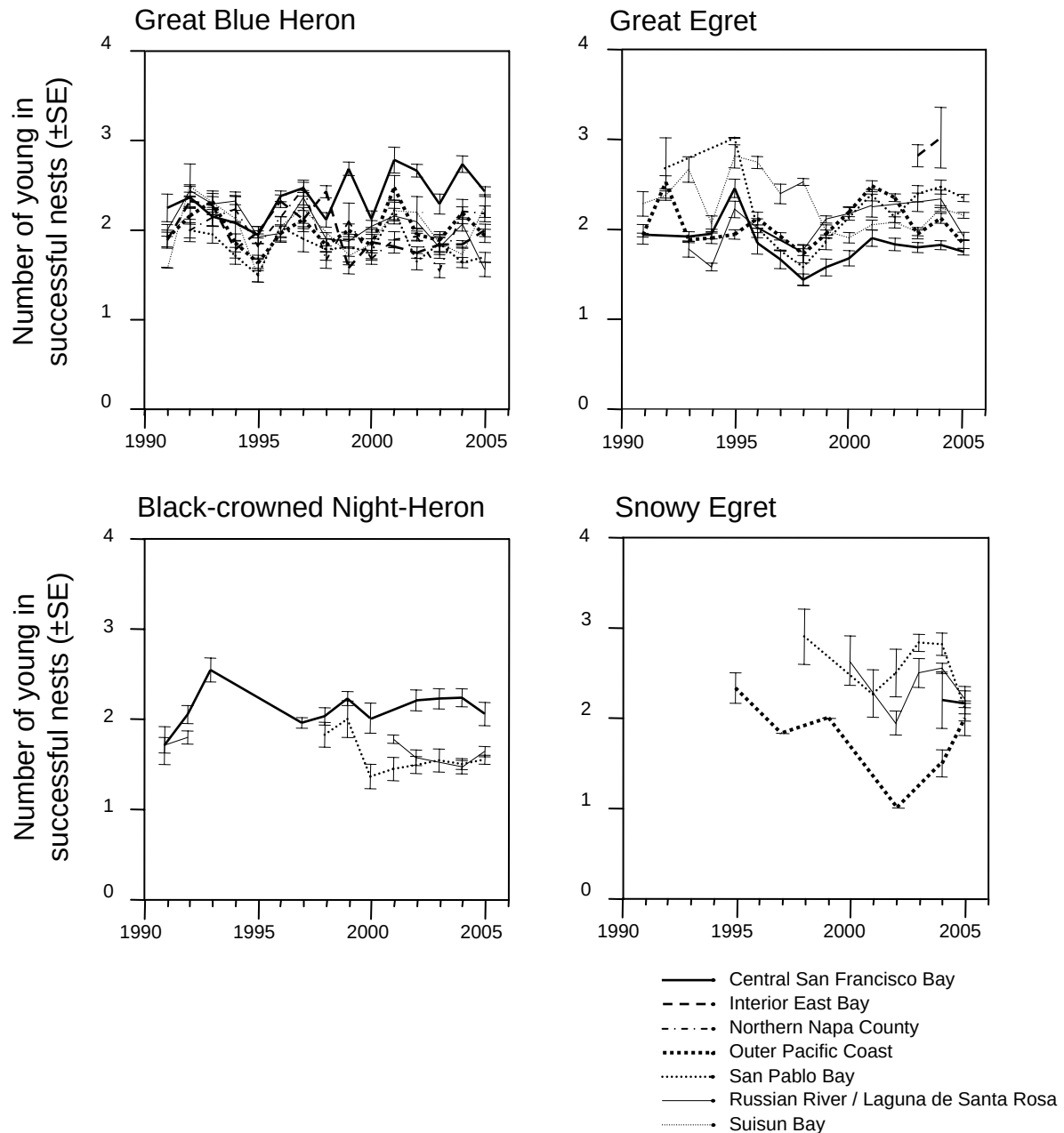


Figure 7. Mean number of young produced in successful Great Blue Heron, Great Egret, Black-crowned Night-Heron, and Snowy Egret nests, by subregion, in the northern San Francisco Bay area, 1991-2005. Annual means with fewer than 10 focal nests are excluded unless samples represent at least half of the nests in the subregion.

($P < 0.05$), and none for Black-crowned Night-Heron or Snowy Egret, the coefficients were consistently positive ($r > 0$) for all pairs of subregions in all species, suggesting that the average number of young produced by successful nests tended to increase or decrease each year across all subregions (Figure 7).

The average number of young produced by successful Black-crowned Night-Heron nests declined significantly from 1991-2005 but with a linear slope of only -0.04 ± 0.013 young yr^{-1} ($F_{1,10} = 8.1$, $P < 0.02$), and no significant trends occurred in other study species ($P > 0.05$; Figure 8).

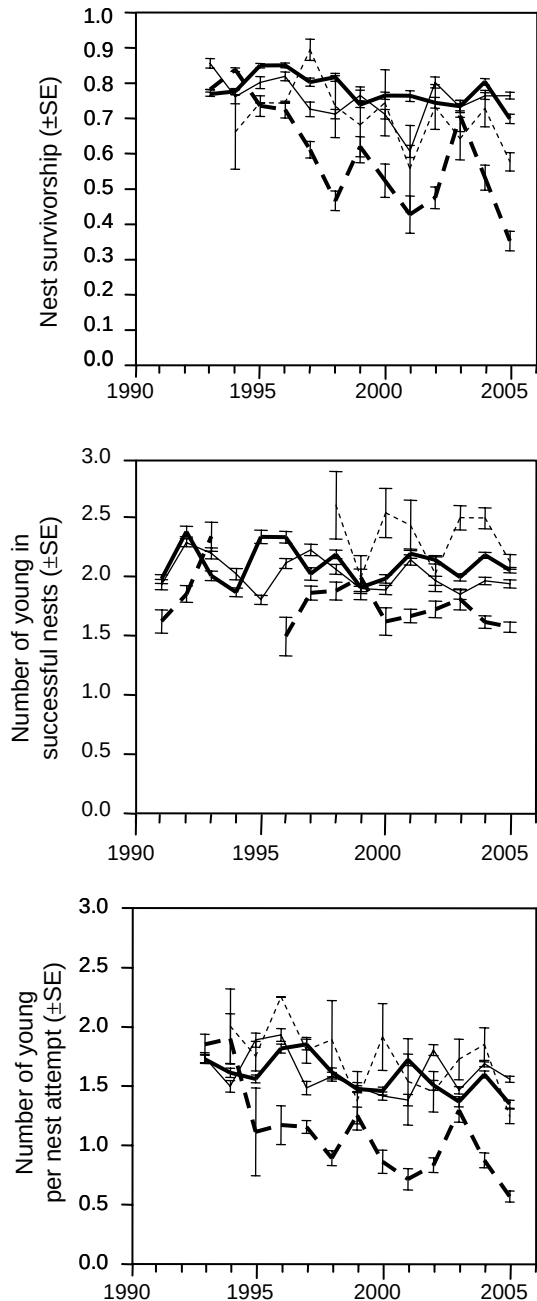


Figure 8. Annual mean $\pm$ SE of nest survivorship, number of young in successful nests, and number of young produced per nest attempt by Great Blue Herons (bold, solid lines), Great Egrets (thin, solid lines), Black-crowned Night-Herons (bold, dashed lines), and Snowy Egrets (thin, dashed lines) in the northern San Francisco Bay area, 1991-2005.

The number of young per nest attempt. The number of young fledged per nest attempt was 1.61 ± 0.014 for Great Blue Heron, 1.68 ± 0.003 for Great Egret, 1.15 ± 0.037 for Black-crowned Night-Heron, and 1.76 ± 0.062 for Snowy Egret. Subregional

comparisons indicated that overall reproductive performance of Great Blue Herons, based on the number of young produced per nest attempt, was significantly greater in Central San Francisco Bay, Northern Napa County, the Outer Coast, and the Russian River/Laguna de Santa Rosa than in other subregions (Table 7). Overall reproductive success in Great Egrets was significantly greater in Suisun Bay, San Pablo Bay, and the Interior East Bay than in other areas. Black-crowned Night-Herons produce significantly more young per nest attempt in Central San Francisco Bay (Alcatraz Island) than in San Pablo Bay or in the Laguna de Santa Rosa (Table 7).

Consistently positive correlations ($r > 0$) between all pairs of subregions suggested regionally consistent patterns in the overall reproductive success of Great Blue Herons and Great Egrets, although only two of 21 correlations (9.5%) were significant ($P < 0.05$) for Great Blue Heron and none for Great Egret. These patterns reflect primarily regional-scale effects on productivity of successful nests (Figures 7 and 9).

Significant but weak linear declines in the regional average number of young produced per nest attempt were evident from 1993-2005 for Great Blue Heron ($b = -0.02 \pm 0.009 \text{ yr}^{-1}$, $F_{1,11} = 6.2$, $P = 0.03$), Black-crowned Night-Heron ($b = -0.08 \pm 0.021 \text{ yr}^{-1}$, $F_{1,11} = 14.1$, $P = 0.003$), and Snowy Egret ($b = -0.05 \pm 0.020 \text{ yr}^{-1}$, $F_{1,10} = 5.4$, $P = 0.04$; Figure 8). These declines reflect primarily the effects of declines in nest survivorship described above (Figure 8).

INTRASEASONAL TIMING

The proportions of nests in the egg-laying or incubation stage, guardian stage, and post-guardian stage during each regional observation period provide a summary of intraseasonal timing in the region (Figure 10). In early March, almost all active Great Blue Heron nests ($99.3 \pm 0.18\%$, $n = 1539$ nests over 14 years) and Great Egret nests ($99.8 \pm 0.17\%$, $n = 594$ over 10 years), and all active Black-crowned Night-Heron nests (100% , $n = 235$ over 4 years) were in the egg-laying or incubation stage (Figure 10). Snowy Egrets generally began nesting later in the season.

In early April, $71 \pm 0.7\%$ of Great Blue Heron nests ($n = 2723$ over 14 years), $92 \pm 0.3\%$ of Great Egret nests ($n = 3900$ over 14 years), $92 \pm 0.7\%$ of

Table 7. Mean number of young produced per nest attempt $\pm$ standard error (SE) for Great Blue Heron, Great Egret, Black-crowned Night-Heron, and Snowy Egret, by subregion in the San Francisco Bay area, weighted equally among years. Values represent the product of nest survivorship (Figure 8) and the number of young produced in successful nests (Figure 9). Year span groups indicate (1) all years with adequate data (see Methods) for both nest survivorship and number of young produced in successful nests, 1993-2005, and (2) years with adequate nest survivorship and productivity data from all subregions (Great Blue Heron: 1994-1995, 1997, and 1999-2005; Great Egret: 1995-1998 and 2002-2005; Black-crowned Night-Heron: 2000 and 2002-2005; Snowy Egret: 2004-2005). Means with the same superscript capital letter within species and year span group are not significantly different (Bonferroni adjusted $P > 0.05$).

Subregion	Year span group	Great Blue Heron		Great Egret		Black-crowned Night-Heron		Snowy Egret	
		Mean $\pm$ SE	n _{years}	Mean $\pm$ SE	n _{years}	Mean $\pm$ SE	n _{years}	Mean $\pm$ SE	n _{years}
Central San Francisco Bay	1	1.82 $\pm$ 0.041 ^A	13	1.43 $\pm$ 0.027 ^D	13	1.28 $\pm$ 0.040 ^A	9	2.03 $\pm$ 0.236 ^{AB}	1 ^a
	2	1.86 $\pm$ 0.049 ^A	10	1.45 $\pm$ 0.033 ^B	8	1.20 $\pm$ 0.064 ^A	5	2.03 $\pm$ 0.236 ^A	1 ^a
Interior East Bay ^b	1	1.39 $\pm$ 0.065 ^{BC}	11	2.10 $\pm$ 0.223 ^A	2 ^c				
	2	1.34 $\pm$ 0.069 ^B	10	2.10 $\pm$ 0.223 ^A	2 ^c				
Northern Napa County	1	1.66 $\pm$ 0.045 ^A	12						
	2	1.65 $\pm$ 0.050 ^A	10						
Outer Coast ^d	1	1.61 $\pm$ 0.038 ^{AB}	13	1.41 $\pm$ 0.020 ^D	13			1.27 $\pm$ 0.073 ^C	8
	2	1.60 $\pm$ 0.043 ^A	10	1.29 $\pm$ 0.025 ^C	8			1.60 $\pm$ 0.193 ^A	2
San Pablo Bay	1	1.43 $\pm$ 0.034 ^C	13	2.01 $\pm$ 0.058 ^A	8	0.79 $\pm$ 0.048 ^B	9	2.09 $\pm$ 0.119 ^A	5
	2	1.36 $\pm$ 0.038 ^B	10	2.01 $\pm$ 0.058 ^A	8	0.79 $\pm$ 0.060 ^B	5	1.54 $\pm$ 0.136 ^A	2
Russian River and Laguna de Santa Rosa	1	1.60 $\pm$ 0.033 ^{AB}	13	1.60 $\pm$ 0.040 ^C	13	0.78 $\pm$ 0.073 ^B	6	1.66 $\pm$ 0.103 ^B	3
	2	1.60 $\pm$ 0.039 ^A	10	1.50 $\pm$ 0.055 ^B	8	0.77 $\pm$ 0.078 ^B	5	1.75 $\pm$ 0.128 ^A	2
Suisun Bay	1	1.52 $\pm$ 0.042 ^{ABC}	13	1.79 $\pm$ 0.028 ^B	13				
	2	1.38 $\pm$ 0.048 ^B	10	1.98 $\pm$ 0.034 ^A	8				

^aComparisons were based only on 2005 in all subregions.

^bnorthern portion only (Contra Costa County)

^cComparisons were based only on 2003-2004 in all subregions.

^dnorth of San Francisco only

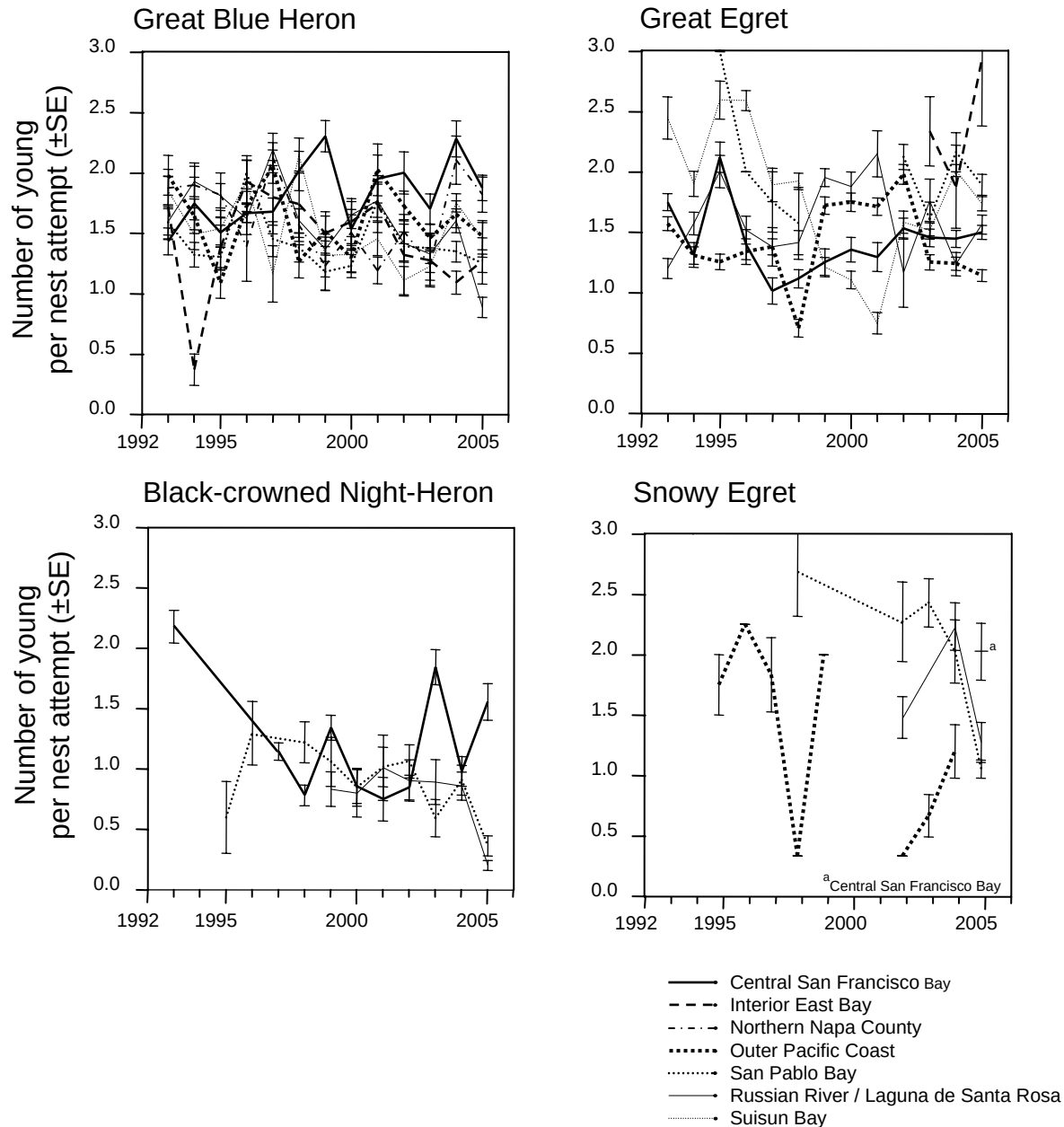


Figure 9. Number of young produced per nest attempt by Great Blue Herons, Great Egrets, Black-crowned Night-Herons, and Snowy Egrets within subregions of the San Francisco Bay area, 1993-2005. Values represent the product of nest survivorship (Figure 4) and number of young produced in successful nests (Figure 5).

Black-crowned Night-Heron nests ($n = 1016$ over 7 years), and all (100%) of Snowy Egret nests ($n = 326$ over 8 years) were in the egg-laying or incubation period (Figure 10).

By early May, only $15 \pm 0.5\%$ of Great Blue Heron nests ($n = 3845$ over 14 years), $44 \pm 0.5\%$ of

Great Egret nests ($n = 5268$ over 14 years), $56 \pm 1.9\%$ of Black-crowned Night-Heron nests ($n = 768$ over 10 years), and $67 \pm 2.3\%$ of Snowy Egret nests ($n = 360$ over 10 years), were still incubating or laying eggs (Figure 10). At this time, $54 \pm 0.6\%$ of Great Blue Heron nests had reached the post-guardian period,

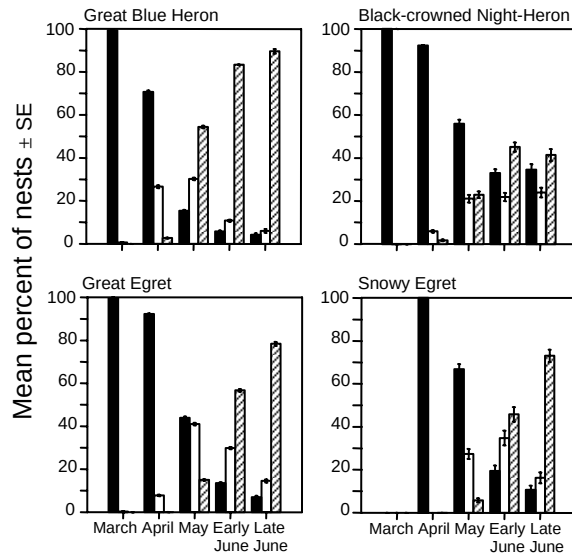


Figure 10. Intraseasonal timing of heron and egret nesting activity in the northern San Francisco Bay area, indexed by the mean percent $\pm$ SE of nests in the egg-laying or incubation period (solid bars), parental guardian period (open bars), and post-guardian period (striped bars), during March (13 March $\pm$ 6 days, std. dev.), April (11 April $\pm$ 5 days), May (13 May $\pm$ 6 days), early June (7 June $\pm$ 4 days), and late June (19 June $\pm$ 3 days), weighted equally among years, 1992-2005.

while only $15 \pm 0.3\%$ of Great Egret nests, $23 \pm 1.5\%$ of Black-crowned Night-Heron nests, and $6 \pm 0.9\%$ of Snowy Egret nests were left unattended by adults.

In early June, $83 \pm 0.6\%$ of Great Blue Heron nests ($n = 2519$ over 14 years), $57 \pm 0.6\%$ of Great Egret nests ($n = 4427$ over 14 years), $45 \pm 2.1\%$ of Black-crowned Night-Heron nests ($n = 717$ over 10 years), and $46 \pm 3.4\%$ of Snowy Egret nests ($n = 280$ over 9 years) had reached the post-guardian period.

We did not measure fledging dates, but by late June nesting activity had declined at most colony sites, with $90 \pm 1.0\%$ of Great Blue Heron nests ($n = 730$ over 9 years), $78 \pm 0.9\%$ of Great Egret nests ($n = 2326$ over 12 years), $41 \pm 2.8\%$ of Black-crowned Night-Heron nests ($n = 413$ over 7 years), and $73 \pm 2.8\%$ of Snowy Egret nests in the post-guardian period (Figure 10).

Differences in intraseasonal timing among subregions were most apparent during May for Great Blue Heron (Figure 11). Great Blue Herons tended to nest earlier in subregions characterized by freshwater conditions (Russian River, Laguna de Santa Rosa, Interior East Bay, Northern Napa

County) or low salinity marshes (Suisun Bay) than in subregions dominated by tidal wetlands (Figure 11). In May, significantly greater percentages of Great Blue Heron nests reached the post-guardian period in Suisun Bay ($72 \pm 1.1\%$, $n = 1258$) and the Interior East Bay ($72 \pm 1.7\%$, $n = 271$) than in other subregions, whereas significantly smaller percentages of nests reached the post-guardian period in Central San Francisco Bay ($28 \pm 1.4\%$, $n = 291$ over 14 years) and along the Outer Coast ($29 \pm 1.5\%$, $n = 416$ over 14 years, multiple comparisons with Bonferroni adjusted $P < 0.05$; Figure 11).

Subregional differences in the intraseasonal timing of Great Egret nests were most apparent during early June (Figure 11). A significantly greater percentage of Great Egret nests reached the post-guardian stage in early June in Central San Francisco Bay ($77 \pm 1.3\%$, $n = 587$ over 12 years) than in other subregions (Figure 11; multiple comparisons with Bonferroni adjusted $P < 0.05$). Great Egrets nested later in the Interior East Bay (San Pablo Reservoir) than in other subregions, based on a significantly smaller percent of nests in the post-guardian period in early June ($37 \pm 1.3\%$, $n = 32$ over 6 years: 1997, 1999, 2000, 2003-2005; multiple comparisons with Bonferroni adjusted $P < 0.05$).

Intraseasonal timing was less synchronous in Black-crowned Night-Heron and Snowy Egret nests,

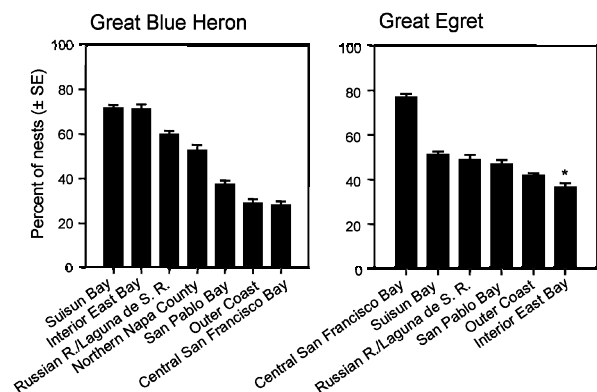


Figure 11. Mean percent $\pm$ SE of Great Blue Heron nests that reached the post-guardian period in May, 1992-2005 (13 May $\pm$ 6 days, std. dev.) and Great Egret nests that reached the post-guardian period in early June, 1994-2005 (7 June $\pm$ 7 days), in wetland subregions of the northern San Francisco Bay area, weighted equally among years. *The percent of Great Egret nests in the Interior East Bay represents 1997, 1999, 2000, and 2003-2005 only and is significantly less than other subregions during these years (see text).

showing greater variation in the number of nests at each nesting stage than evident in the larger species (Figure 10). Consequently, we did not detect significant subregional differences in timing among night-heron nests ($P > 0.05$). However, the average proportion of Snowy Egret nests that reached the post-guardian stage by early May, 2001 and 2003-2005, was significantly greater in the Laguna de Santa Rosa ($32 \pm 4.1\%$, $n = 78$ nests) than in the San Pablo marshes ($6 \pm 1.9\%$, $n = 119$ nests; $t_{195} = 6.7$, Bonferroni adjusted $P < 0.05$). In addition, the percent of Snowy Egret nests at the Laguna de Santa Rosa that reached the post-guardian period by early May in 2004-2005 ($60 \pm 7.3\%$, $n = 30$) was greater than at Alcatraz Island in Central San Francisco Bay ($16 \pm 5.8\%$, $n = 35$; $t_{64} < 4.8$; Bonferroni adjusted $P < 0.05$). Therefore, Snowy Egrets appear to have nested earlier, on average, in the Laguna de Santa Rosa than at heronries in San Pablo Bay or Central San Francisco Bay.

NEST PREDATION AND DISTURBANCE

An average of 4.1 ± 0.60 sites ($7.4 \pm 0.99\%$) were abandoned annually in the northern portion of the region after the first year (1991) of region-wide monitoring ($n = 14$ years). Only 0.7 ± 0.20 sites ($2.5 \pm 0.49\%$) were abandoned annually in the southern portion of the area ($n = 11$ years, 1995-2005). Over the entire study area, 1.5 ± 0.51 sites ($2.5 \pm 0.83\%$) known to be active previously were recolonized, but many of these represented only a few pairs returning to sites that previously supported much larger numbers of nests.

We found evidence of one or more nest failures associated with colony site disturbance, weather, or nest predation, at $13 \pm 1.0\%$ of colony sites each year (55 ± 1.3 sites yr^{-1} , $n = 15$ years). Colony size was significantly more likely to decline in the subsequent year at sites where we detected these disturbances than at sites where we did not (Yates' corrected $\chi^2_1 = 4.8$, $P < 0.05$). In addition, rates of nest failure were significantly greater at colony sites that subsequently declined in size than at those that did not (all sites: $F_{1,438} = 13.7$, $P < 0.001$; sites where disturbance was not detected: $F_{1,364} = 4.41$, $P < 0.04$). The productivity of successful nests was not significantly related to between-year changes in colony size ($P > 0.05$; Great Blue Heron: $F_{1,356} = 0.74$, Great Egret:

$F_{1,121} = 0.06$, Snowy Egret: $F_{1,23} = 0.19$, Black-crowned Night-Heron: $F_{1,17} = 2.97$, all species: $F_{1,412} = 0.49$).

Disturbances leading to nest failure were associated with avian predators at $6.2 \pm 0.93\%$ of sites yr^{-1} ($n=15$), weather (primarily wind) at $2.7 \pm 0.53\%$ yr^{-1} , human disturbance (not caused by observers in this study) at $2.0 \pm 0.35\%$ yr^{-1} , mammalian predators at $0.1 \pm 0.13\%$ yr^{-1} , unidentified nest predators at $0.8 \pm 0.25\%$ yr^{-1} , and unknown sources at $2.7 \pm 0.58\%$ yr^{-1} . We did not detect any nest failure associated with observer disturbance in this study, although some nest failure may have occurred during nest monitoring and egg collecting for a contaminant study at six heronries in Central and South San Francisco Bay in 1989-1991 (Hothem et al. 1995). We did not measure the rate of colony site disturbances detected per hour of observation, but one or more colony site disturbances associated with nest failure were detected on 1.7 ± 0.02 percent of site visits ($n = 1073$ visits), with an average of 1.8 ± 0.03 hours per visit.

Within the northern portion of the study area, disturbances associated with one or more nest failures occurred at a significantly greater percent of colony sites each year, on average, in Central San Francisco Bay ($34 \pm 3.5\%$ of 6.7 ± 0.29 sites yr^{-1} , $n = 15$ yrs) and the Outer Coast ($20 \pm 3.5\%$ of 8.2 ± 0.37 sites yr^{-1}) than in any other subregion (multiple comparisons, Bonferroni adjusted $P < 0.05$). Colony site disturbance leading to nest failure was significantly less likely in Suisun Bay ($5 \pm 3.5\%$ of 9.2 ± 0.26 sites yr^{-1}) and Northern Napa County ($4 \pm 3.5\%$ of 4.9 ± 0.36 sites yr^{-1}) than in the Central San Francisco Bay or along the Outer Coast (multiple comparisons, Bonferroni adjusted $P < 0.05$).

DISCUSSION

REGIONAL STATUS AND TRENDS

Heron and egret nesting colonies occur throughout the wetland landscapes of the San Francisco Bay. The locations of heronries may be influenced by the proximity of suitable foraging areas (Fasola and Alieri 1992, Gibbs and Kinkel 1997, Frederick 2002), competition for food or foraging areas (Gibbs et al. 1987, Gibbs and Kinkel 1997), or risk of nest

predation or disturbance (Tremblay and Ellison 1979, Simpson et al. 1987, Smith and Callopy 1995). Annual changes in nest abundance within colony sites and subregions in the San Francisco Bay area were consistent with shifts in colony site preferences, which are likely to occur as wetland suitability and disturbance patterns fluctuate across years and over space (Bancroft et al. 1994, Fasola and Alieri 1992).

The value of nesting near productive feeding areas may involve energetic benefits associated with the costs of travel to and from multiple feeding sites that fluctuate in suitability over time (Wittenberger and Hunt 1985, Gibbs 1991). In the San Francisco Estuary, herons and egrets establish colony sites in relation to landscape conditions within 1 km and prefer sites with more estuarine-emergent habitat and open water within this distance than is available at other potential colony sites in the wetland landscape (Kelly et al. 2005b). The importance of local feeding areas has also been suggested by declining habitat exploitation with increasing distance from the colony (Gibbs et al. 1987, Simpson et al., 1987, Fasola and Alieri 1992) and by the frequent initiation of sub-colonies or new colony sites near heronries that are subjected to heavy nest predation or disturbance (Custer et al. 1980; ACR unpubl. data).

In contrast to the importance of local feeding areas, larger scale patterns of habitat use also occur. Nesting abundances of herons and egrets near major wetland subregions in the San Francisco Bay area are not related clearly to the extent of tidal marshland in those areas (Kelly et al. 1993). For example, relatively few Great Egrets and Black-crowned Night-Herons nested near San Pablo Bay, where most of the tidal marshland occurs, but concentrated their nesting activity in Central San Francisco Bay, where the extent of tidal marshes is relatively limited. An explanation for these differences is implied by the angular distribution of arrival and departure flights of Great Egrets and Snowy Egrets nesting on the Marin Islands in Central San Francisco Bay (Kelly et al. 2006), which strongly suggests that the nesting birds foraged primarily in the San Pablo Bay marshes. Therefore, the benefits of nesting on islands that are relatively safe from terrestrial predators may offset the costs of traveling to more distant feeding areas.

Nest abundances of all colonially nesting heron and egret species are stable or increasing in the San

Francisco Bay area. The stable or increasing numbers of Great Blue Herons are consistent with other regions of North America, but intensive count data are not available from most regions because this species often nests solitarily or in small colonies over vast areas (Butler 1992, Butler et al. 2000, and this study).

The significant increase in the number of Great Egret nests observed in this study was associated with recent counts of over 1000 nests. These counts compare with a statewide count of 1245 nests in 1982, of which only 347 nests were from the central California coast (San Francisco Bay area counties and coastal counties from San Luis Obispo to Mendocino; Schlorff 1982). General increases in the number of nesting Great Egrets have been observed across North America north of Mexico (McCrimmon et al. 2001). Nest counts in Oregon indicated an increasing number of nesting Great Egrets in the mid-1980s, with a peak of 755 pairs in the vicinity of Malheur National Wildlife Refuge, 140 pairs in the Warner Basin, and 100-200 pairs in the Klamath Basin (McCrimmon et al. 2001, Marshall et al. 2003).

Recent increases in the number of Snowy Egret and Black-crowned Night-Heron nests in the San Francisco Bay area are associated with large annual fluctuations in nest abundance that prevent the detection of underlying trends. Substantial annual variation in Snowy Egret nest abundance has also been evident in the Salton Sea (Molina and Sturm 2004), and breeding populations across North America have been subject to considerable flux since the mid-twentieth century (Parsons and Master 2000). Adequate data are not available to assess continental population trends for Black-crowned Night-Heron (Davis 1993).

The formation of small colonies of less than ten nests by Great Blue Herons along the Russian River and throughout other watersheds in the region is consistent with their breeding distributions in other areas, their generalist feeding behavior, and their ability to exploit a wide range of habitats (Butler 1992, Butler et al. 2000, Gawlik 2002, Kushlan and Hancock 2005). In addition, the reduced extent of wetland feeding areas in higher portions of watersheds may limit the sizes of colonies (Farinha and Leita 1996, Gibbs 1991). Alternatively, if food supplies along perennial rivers and streams are more

stable than feeding sites in marshes or tidal wetlands, herons might exploit these areas by forming smaller colonies near local food sources (Wittenberger and Hunt 1985). We found no differences in reproductive performance related to variation in Great Blue Heron colony size.

In contrast to the broad nesting distribution of Great Blue Herons, other species of herons and egrets nested in fewer but larger heronries. The nesting distribution of Great Egrets was consistent with a preference for tidal feeding areas, although their use of tidal wetlands varies among regions in North America (McCrimmon et al. 2001). The concentration of Great Egret nests in Suisun Bay was associated with the zone of greatest estuarine circulation in the San Francisco Estuary, where the maximum abundances of larval or juvenile fish, or other prey, are most likely to occur (Nichols et al. 1986, Kelly et al. 1993).

With the possible exception of a colony site near the freshwater wetlands of the Laguna de Santa Rosa, Snowy Egret and Black-crowned Night-Heron nest distributions were also consistent with a preference for tidal feeding areas (Willard 1977, Custer and Osborn 1978, Davis 1993, Parsons and Master 2000). In other parts of their breeding range, Snowy Egrets have abandoned coastal nesting sites in favor of more completely isolated sites on islands, and their populations may be limited by the availability of safe nesting sites within profitable commuting distances to estuarine feeding areas (Parsons and Master 2000). Consistent with the possibility that the availability of suitable colony sites was limiting, Snowy Egrets in the San Francisco Bay area nested at relatively few sites. The nesting distribution of Black-crowned Night-Herons was similarly restricted, primarily to the same sites used by Snowy Egrets. Although their colony sites in the San Francisco Bay area are often close to human activity, Black-crowned Night-Herons are especially sensitive to nest predation and disturbance, including human disturbance, and readily abandon nesting attempts when disturbed (Tremblay and Ellison 1979, Blus et al. 1997, Hothem and Hatch 2004).

REPRODUCTIVE SUCCESS

Significant linear declines in regional reproductive success of Great Blue Herons, Black-crowned Night-

Hérons, and Snowy Egrets resulted primarily from declining nest survivorship. These declines in nest survivorship coincided with regional increases in abundances of American Crows and Common Ravens (Kelly et al. 2002), and increases in nest predation by Common Ravens along the Outer Coast and in Central San Francisco Bay (Hothem and Hatch 2004, Kelly et al. 2005a), although the declines could have resulted from other, unknown processes. Conflicts with human activities or land development near heronries did not increase noticeably during the study period (ACR unpubl. data). However, we did not precisely measure these occurrences, and the cumulative effects of urban and suburban development on rates of colony disturbance, or on nest predation by other animals associated with human-altered landscapes, is unknown.

Our results indicate that the local and subregional productivity of successful Great Blue Heron and Great Egret nests fluctuates within larger-scale variation across the region. This regional variation may be influenced by annual differences in rainfall, weather, or other processes that broadly affect foraging conditions or the regional dynamics of prey populations. In contrast, annual changes in nest survivorship were not consistent among subregions, suggesting that processes associated with nest failure, such as nest predation, colony disturbance, and extreme weather events, operate primarily at local or subregional scales.

We found small but significant subregional differences in nest survivorship, productivity, and overall reproductive success. Subregional differences in reproductive success of wading birds have been reported among freshwater, estuarine and marine habitats in Florida (Frederick et al. 1992), but reproductive success in the San Francisco Bay area was not clearly related to the predominance of tidal or non-tidal habitats. Although herons and egrets seem to move freely among colony sites as nesting distributions shift between years (Bancroft et al. 1994, this study), subregional differences in nest productivity were not precluded by the possibility that such movement might lead to density-dependent effects on foraging, as predicted by an ideal free distribution (Fretwell and Lucas 1970). Therefore, annual shifts in nesting distribution may not reflect "ideal" knowledge of differences in potential fitness

among nesting areas.

Although the inherent intraseasonal predictability of declining water levels may be important to nesting wading birds (Kushlan 1986), the difficulty of predicting changes in the availability of food over a relatively long nesting period is a fundamental aspect of heron and egret nesting biology (Lack 1947, 1954, Mock and Forbes 1994) that may account for subregional differences in nesting performance. In addition, significant subregional differences in both nest survivorship and productivity suggest that colony site choices may be complicated by uncertainties related to tradeoffs between the risk of nest predation and the suitability of feeding areas. Alternatively, the subregional differences in reproductive success might result from (1) individuals forcing others to nest or feed in suboptimal areas (despotic distribution; Fretwell and Lucas 1970), (2) long-term benefits of mate- or colony-site fidelity, (3) unpredicted costs of long-distance foraging, or (4) other potential fitness considerations.

We did not find a significant relationship between nest productivity and changes in colony size. However, higher rates of nest mortality led to significant decreases in colony size, even at sites where nest predation or disturbance was not detected. Observers were likely to find evidence of nest predation or disturbance at sites where such events occurred frequently or where colony site disturbance was catastrophic. Therefore, declines in colony size and associated shifts in breeding distribution may be stimulated not only by repeated or catastrophic disturbance but also by declines in conspecific nest success (Boulinier 1996, Danchin et al. 1998) or, alternatively, undetected instances of colony disturbance.

INTRASEASONAL TIMING

The intraseasonal timing of food availability is a strong stimulus for the initiation of nest attempts by herons and egrets (Kushlan 1986, Frederick and Callopy 1989a, Frederick 2002). The availability of food early in the season, immediately prior to and during the time of egg formation, may be particularly important (Butler 1993, Bancroft et al. 1994). In the San Francisco Bay area, earlier nesting by Great Blue Herons and Snowy Egrets in subregions dominated by freshwater wetlands is consistent with the

relatively early availability of seasonally flooded marshes, ephemeral creeks, and receding ponds after normal periods of winter rainfall. In contrast, later nesting near tidal areas suggests the importance of estuarine prey as spring salinities rise and fish abundances increase with the seasonal influxes and productivity of estuarine breeders from marine habitats (Day et al. 1989). The relatively early nesting by Great Egrets in Central San Francisco Bay is unclear, but could involve longer flights to feed in other areas (Kelly et al. 2006) or to exploit unknown sources of food available early in the season.

IMPLICATIONS FOR CONSERVATION

The dynamic nature of heron and egret nesting distributions and the relative stability of the larger colonies in the San Francisco Bay area suggest that conservation efforts should prioritize the protection of colony sites with 20 or more active nests and provide long-term protection for colony sites with more than 100 nests. However, efforts to protect or manage smaller heronries should consider that they may be more sensitive to disturbance and more prone to abandonment than larger sites. While the importance of mixed species heronries is enhanced by the presence of additional nesting species, the values associated with the expected longevity of any heronry increase more rapidly as numbers increase above 6 Great Blue Heron nests, 20 Great Egret nests, 30 Snowy Egret nests, or 30 Black-crowned Night-Heron nests.

We observed sharp declines in nest abundance of heron and egret species in 1999. We do not know if natal dispersal occurs primarily at intraregional scales or within the geographic extent of harsh winter conditions that occurred from November 1997 to February 1998 (and continued into the following spring). However, if juveniles disperse within these scales prior to their first breeding attempts, the declines in nest abundance in 1999 may have resulted from reduced recruitment associated with increased juvenile mortality, rather than from reduced reproductive success. These results are consistent with the hypothesis that winter foraging conditions and juvenile survival are primary influences on annual nesting abundance and the dynamics of heron and egret populations (North 1979, Butler 1994, Cezilly 1997).

In areas where water systems are controlled by dikes or managed discharges, starvation risk in juveniles during their first winter is likely to be reduced by practices that (1) maintain shallow (5-25 cm) water depths across flooded wetlands and in the mouths of creeks or channels that connect wetland patches (Gawlik 2002, Frederick 2002, Maccarone and Brzozard 2005), (2) improve the ability of seasonal marshes to support fish and amphibians (Kushlan 2000, Gawlik 2002), or (3) minimize areal extent or duration or heavy turbidity (Cezilly 1992) related to the movement of water, land uses, and watershed erosion.

Our measurements of nesting habitat illustrate the range of nesting conditions used by herons and egrets (Kushlan and Hancock 2005), but they do not include measures of habitat availability and therefore do not necessarily describe habitat preferences. However, the substantial use of sites associated with low or medium housing suggests a tolerance of human activity and the potential value of tall trees near houses in rural and suburban areas adjacent to wetlands, as alternative nesting sites for herons and egrets. Alternatively, nest success in such areas could be limited by chronic human intrusion (Thompson 1977) or nest predation by human commensals such as raccoons or ravens (Parsons and Master 2000, Pratt and Winkler 1985, Kelly et al. 2005a). Because severe nest losses can be caused by one or a few individual predators (Rodgers 1987), it may be feasible to protect disturbance-prone colonies by removing or deterring particular individuals.

Non-native eucalyptus trees (*Eucalyptus* spp.) are widely planted in California and achieve their best growth on alluvial soils in the coastal fog belt of the San Francisco Bay area (Esser 1993, Bossard et al. 2000). The predominant use of eucalyptus trees (primarily, *Eucalyptus globulus*) for nesting substrate by herons and egrets is associated with an apparent scarcity of other potential nesting substrates in the vicinity of tidal marshes of the San Francisco Estuary (JPK, pers. observation), although we did not measure substrate availability. With planted eucalyptus groves providing most of the alternative colony sites, regional changes in their structure or availability without increases in other nesting substrates might alter the distribution of heronries. If nesting herons and egrets that depend on the close

proximity of suitable wetland feeding areas are forced to relocate substantial distances to find suitable nest trees, they might have to increase the amount of time or energy they spend on foraging or reduce their use of some wetlands (Gibbs et al. 1987, Simpson et al. 1987, Fasola and Alieri 1992). Therefore, regional management to maintain the availability of alternative colony sites may be important in sustaining the use of wetlands by herons and egrets.

In addition, our results indicated that annual shifts in colony locations and the relative use of colony sites were influenced by nest failures associated with localized disturbance and predation events. Such events further suggest the value of alternative nesting habitat near existing sites (Custer et al. 1980) to provide continued nesting opportunities within profitable distances of preferred feeding areas. The spacing of heronries at intervals of approximately 6 km in the San Francisco Bay area was similar to distances of 5-7 km between heronries in northwest Italy (Fasola and Alieri 1992). Thus, regional management for tree-nesting herons and egrets should not only protect existing colony sites but should also protect patches of tall trees near active colony sites and at intervals of approximately 6 km near wetland feeding areas, to provide alternative nesting sites in case of disturbance or loss of trees at existing heronries.

Restoration of wetland habitat and prey abundances can result in increased use by herons and the development of heron nesting colonies (Mauchamp et al. 2002). Increases in the number of herons and egrets nesting in San Pablo Bay since the late 1990s coincided with increases in the extent of restored tidal marshes (San Francisco Bay Area Wetlands Ecosystem Goals Project 1999, Featherston et al. 2006), suggesting that distributional shifts may partly reflect increases in the availability of suitable wetland feeding areas (Bryan et al. 2003, Frederick and Callopy 1989a). Such distributional shifts may occur gradually with incremental restoration or enhancement of the wetland landscape. In the absence of active habitat restoration or enhancement, annual shifts in nesting distribution related to large-scale changes in habitat suitability are likely to be relatively small in tidal landscapes because hydrologic conditions are more stable between years than in wetlands that vary primarily with seasonal rainfall or

runoff (Kushlan 1977, Frederick 2002). Therefore, long-term shifts in heron and egret nesting distributions may be particularly useful in monitoring the cumulative, landscape-scale effects of tidal marsh restoration or enhancement projects. Given the value of suitable feeding areas near heronries, regional planners could enhance the value of wetland landscapes to nesting herons and egrets by promoting clusters of smaller restoration or enhancement projects within several km of colony sites.

RECOMMENDED BUFFER ZONES

Nesting herons and egrets can be easily disturbed by human activity and may respond by abandoning their nests or colony sites (Dusi and Dusi 1987, Hafner 2000). At some sites, nesting herons and egrets tolerate human activity at close range (Nisbet 2000; Hothem and Hatch 2004). However, tolerance levels are highly variable over time and among heronries, and unpredictable changes in the type, proximity, or intensity of human activity at any site may adversely affect the nesting birds (Tremblay and Ellison 1979, Vos et al. 1985, Rodgers and Smith 1995, Hafner 2000, Kelly 2002; pers. observation). Adverse effects of human disturbance include egg and nestling mortality, premature fledging, reduced body mass or slower growth of nestlings, and reduced settlement of breeders in the colony (Rodgers and Smith 1995, Hafner 2000, Frederick 2002). Even temporary abandonment can lead to nest failure during unfavorable weather or in the presence of opportunistic predators such as crows or ravens (Burger and Hahn 1977, Tremblay and Ellison 1979, Hafner 2000).

The responses of herons and egrets to disturbance can vary substantially among the stages of the breeding season (Figure 9; Butler 1992, Hafner 2000, Kelly 2002). Colonies are most easily disturbed when some individuals are still in the pre-laying or courtship phase (January-March). As birds settle into the incubation phase, they become more site-tenacious (March-April). As nestlings grow larger and are able to thermoregulate, adults may temporarily alter their behavior or flee without neglecting their young (May-June). Near the end of

the nesting season (June-August or later), adults are rarely present at their nests, returning only to feed their young. At this time, nestlings are large and alert to disturbance but reluctant to flee from their nests. Nestlings forced to flee before they are mature enough to find their way back into their nests may not survive.

The responses of nesting herons and egrets to disturbance by humans also vary with differences in the structure of the nesting habitat and types of human activity (Kelly 2002). Herons and egrets nesting in very tall trees or very dense vegetation may be less sensitive to disturbance, whereas herons and egrets nesting in open habitat or isolated trees tend to react earlier and more intensely to approaching humans. Fledging success may be greater in heronries that are isolated by moat-like water barriers or fencing than at sites isolated only by greater distances to human activity (Carlson and McLean 1996).

Erwin (1989) recommended 200-m buffer distances to protect heronries from human disturbance. This was based on 100-m flush distances plus an additional 100 m to protect colony sites early in the season before all nests are established. Butler (1992) suggested buffer zones of 300 m from Great Blue Heron colonies, but indicated that the most easily disturbed herons in a colony in British Columbia remained in their nests until he approached within 200 m. Rodgers and Smith (1995) recommended a 100 m buffer around wading bird colonies in Florida, based on upper 95th percentile of standard normal flush distances, i.e., the distance beyond the average disturbance distance at which disturbance is not expected 95% of the time. Their estimate incorporated flush distances plus 40 m for other (unmeasured) responses, such as intraseasonal differences, alert/agonistic responses prior to flushing, differences in vegetation cover etc. Disturbance trials conducted at 23 heronries in the San Francisco Bay Area in 1994 indicated substantial tolerance of approaching humans at some heronries but considerable variation in responses, both among heronries and among stages of nesting (Kelly 2002). The results were consistent with buffer zones of 100-200-m based on the responses of nesting birds to a single person approaching on foot.

An important consideration in determining appropriate buffer zones around heronries is that the

distances recommended by scientific investigators are generally based only on one or two humans approaching on foot. Larger groups of people or other types of human activity are likely to disturb heronries at greater distances. Boats tend to be less disturbing to nesting herons and egrets than some other types of human intrusion. Vos et al. (1985) found that boat disturbance distances average only about 50-85 m, but they did not measure the distance that is likely to prevent disturbance 95% of the time. Disturbance by groups of boats rather than single boats might increase the width of the disturbance zone. In general, the size of buffer zones should be increased with increases in the expected frequency, duration, or extent of human activity.

Nisbet (2000) argued that, where appropriate, waterbird colonies could be managed for multiple uses including research, education, and recreation, to promote habituation of nesting birds to human activity and thereby reduce adverse impacts of disturbance. Such habituation may contribute to the variability among heronries in their tolerances to human activity, although the actual reasons for such differences are unknown. Although some investigators have suggested that habituation may be possible (Nisbet 2000, Frederick 2002), this has not been clearly demonstrated with regard to a capacity of behavioral change in nesting adults. In contrast, other investigators have presented evidence indicating increasingly adverse effects of repeated or prolonged disturbance (Tremblay and Ellison 1979, Rodgers and Smith 1995). Any attempts to promote or rely on habituation should be implemented very cautiously because (1) serious adverse effects of human disturbance on heronries are well-documented, (2) the sensitivity of nesting birds to human activity is highly variable and difficult to assess, (3) the potential for habituation is unknown, (4) any disturbance by humans could result in opportunistic nest predation by diurnal avian predators such as gulls or ravens, and (5) the behaviors of humans can be unpredictable (Carney and Sydeman 1999, 2000, Nisbet 2000). Therefore, even at sites where birds appear to be relatively tolerant of human activity, managers should consider the use of appropriate barriers and buffer distances, with careful attention to nesting behaviors and the timing of nesting stages (Parnell et al. 1988, Hafner 2000).

Because heronries vary widely in their responses to human disturbance, we recommend establishing buffer zones of at least 200 m around heronries to minimize the potential adverse effects of human intrusion during the nesting season. These buffer zones should be established from 1 January to 30 June for Great Blue Herons, and 1 March to 31 August for other species. However, because late nesting attempts may extend beyond these dates, a qualified biological observer should confirm that herons and egrets are no longer occupying the colony site at the end of the nesting period before increases in human activity are allowed.

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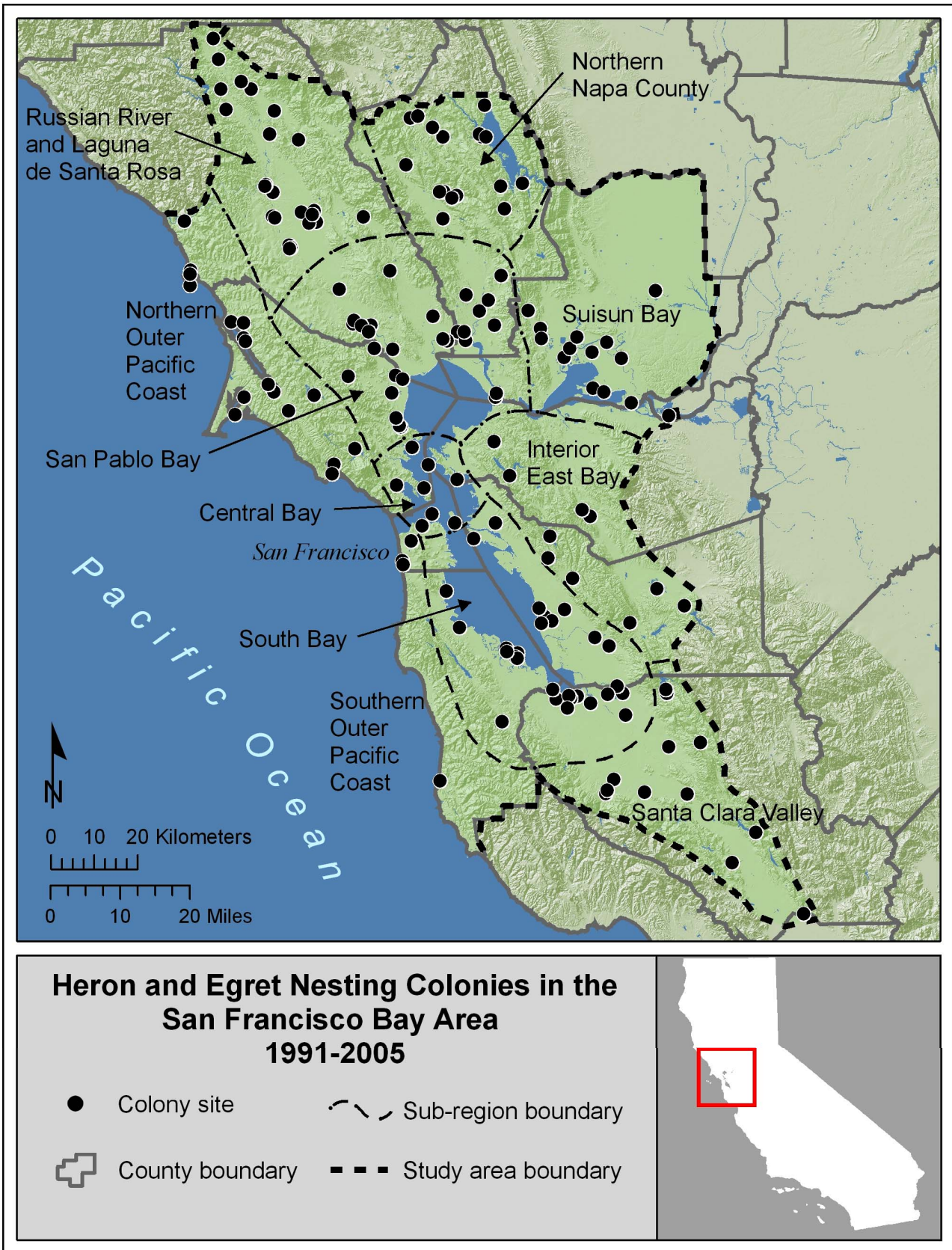
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COLONY SITE ACCOUNTS





STRUCTURE OF COLONY SITE ACCOUNTS

Individual colony site accounts are organized by subregion. Regional and subregional distribution maps indicate the locations of all known heronries that were active in one or more years from 1991 to 2005. Each subregional map is accompanied by a table listing each heronry, by name, county location, the species known to have nested at the site, the most recent year of nesting activity, and the page number of the colony site account. To facilitate the use of this information in regional conservation and planning, the data reported in the maps and colony site accounts are available from the authors in tabular form and in shape files suitable for geographic information systems (GIS).

Colony site accounts include information on ownership, nesting habitat, proximity to wetlands, human land use, historical trends, reproductive performance, nest disturbance, conservation concerns, and management recommendations. The land use category, "protected natural area," includes local, state, and federal parks, state and federal wildlife refuges and ecological reserves, National Forest, Bureau of Land Management lands, and privately owned sanctuaries. We report known sources of nest disturbance and predation, as well as evidence of potential nest predators or other sources of disturbance based on published accounts from other areas (e.g., Smith and Callopy 1995, Frederick and Callopy 1989b). To illustrate historical changes in the sizes of individual heronries, we report the peak number of active nests as an annual estimate of the number of breeding pairs.

In accounts for most heronries, we report two components of annual reproductive success based on the performance of individual nests: (1) annual nest survivorship and (2) the annual number of young produced in successful nests (see Methods). Figures illustrating these estimates include standard error (SE) bars, which indicate approximately half of the upper 95% confidence intervals of the estimates. Many of the error bars are small or absent because the estimates are very precise whenever most or all of the nests in a colony are monitored. However, some estimates with small or absent standard errors may not accurately reflect mean colony values because of the occasional lack of variation within very small samples. Therefore, estimates based on fewer than ten nests that represent less than half of the colony are indicated by an asterisk. The figures also indicate a few cases where annual error measurements were absent because only a single nest was measured.

In accounts for heronries in the South Bay, Santa Clara Valley, the Outer Pacific Coast south of San Francisco, and the southern portion of the Interior East Bay, we report only the peak number of young observed annually (summed over all nests). This number provides a rough index of overall productivity of each colony but is sensitive to annual differences in colony size and unmeasured differences in overall fledging success. Most importantly, the peak number of young observed annually does not represent per capita reproductive success and should therefore be interpreted with considerable caution.

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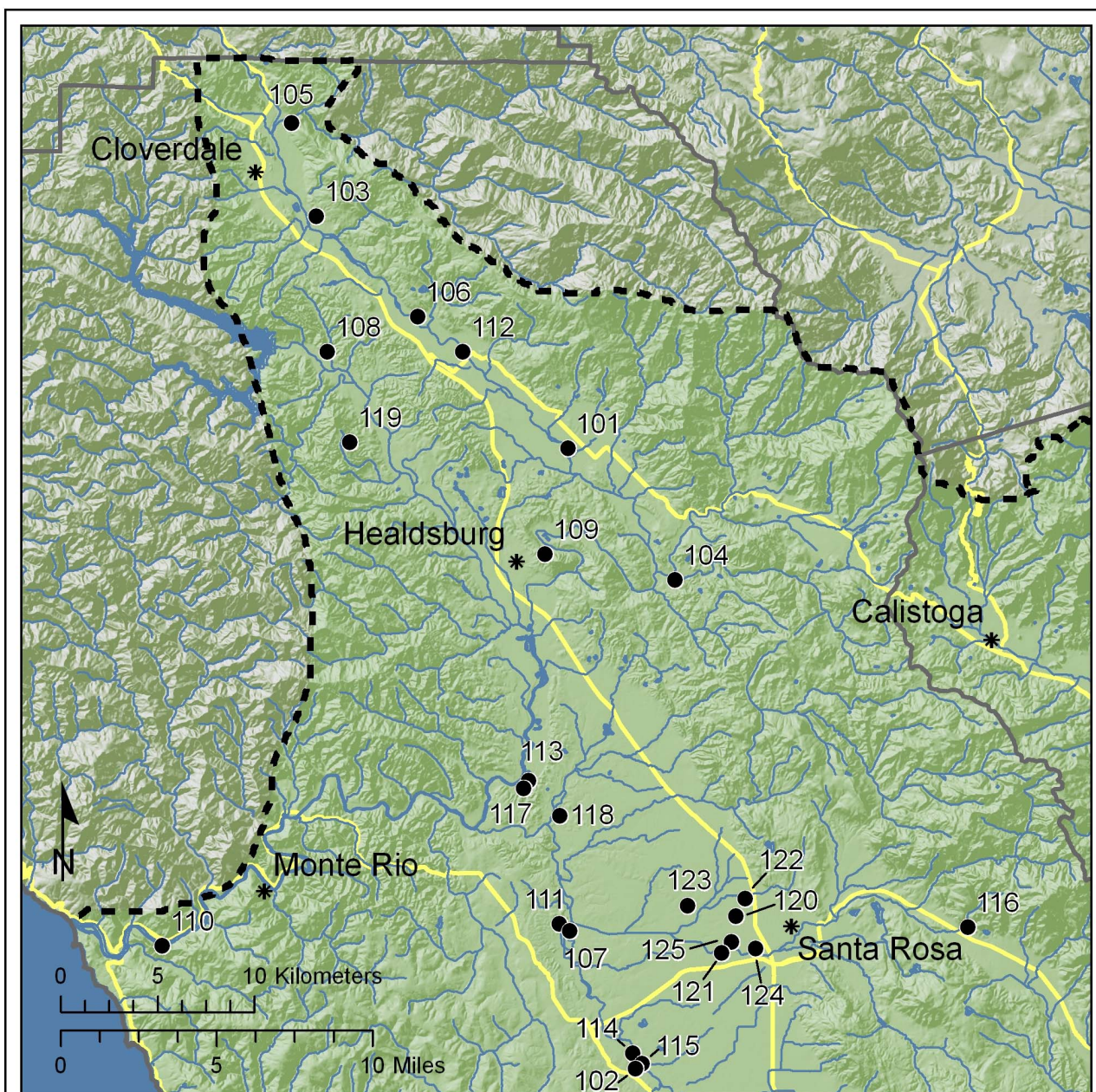
RUSSIAN RIVER AND LAGUNA DE SANTA ROSA



RUSSIAN RIVER AND LAGUNA DE SANTA ROSA

This subregion encompasses cultivated bottomlands interspersed with steep, forested hillsides along the Russian River valley from the northern Sonoma County border to the river's outlet near Jenner. The Laguna de Santa Rosa is the southern-most tributary of the Russian River, with 20,000 acres (8100 ha) of seasonal and perennial marshes, open water, vernal pools, riparian forest, willows, grasslands, and oak woodlands.

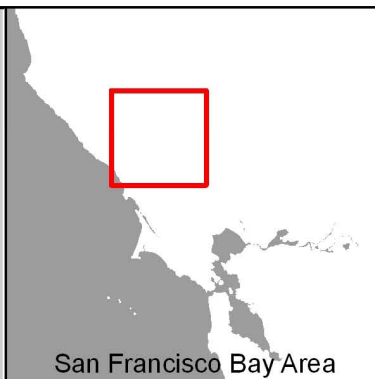
Site #	Colony Site	Great Blue Heron	Great Egret	Snowy Egret	Black-crowned Night-Heron	Cattle Egret	County	Active or year last active	Page
101	Alexander Valley	■					Sonoma	1992	62
102	Alpha Farm	■	□				Sonoma	Active	42
103	Asti	■					Sonoma	2001	62
104	Chalk Hill Road	■	□				Sonoma	Active	43
105	Cloverdale	■					Sonoma	Active	44
106	Crystal Brook	■					Sonoma	1998	46
107	Delta Pond	■	□				Sonoma	Active	47
108	Dutcher Creek	■					Sonoma	1994	62
109	Fitch Mountain	■					Sonoma	2002	48
110	Freezeout Road	■					Sonoma	Active	49
111	Georgetown	■					Sonoma	1991	63
112	Geyserville, Russian River	■					Sonoma	1998	50
113	Kaiser Gravel	■	□				Sonoma	1998	51
114	Laguna Farm	■	□				Sonoma	2000	52
115	Laguna Off Doyle Road	■					Sonoma	1991	63
116	Novavine	■					Sonoma	Active	53
117	Riverfront Park	■					Sonoma	Active	54
118	Sonoma Cutrer	■	□				Sonoma	1996	55
119	Wine Creek	■					Sonoma	Active	56
Santa Rosa Creek Area									
120	Dutton Avenue				■		Sonoma	1996	61
121	Fenwick/Brockhurst Neighborhood			■	■	■	Sonoma	1996	61
122	McBride Lane			■	■	■	Sonoma	1997	61
123	Peterson Lane			■	■		Sonoma	1993	57
124	West 7 th and Jefferson			■	■	■	Sonoma	1995	58
125	West 9 th Street, Santa Rosa		□	■	■	■	Sonoma	Active	59



Heron and Egret Nesting Colonies in the Russian River and Laguna de Santa Rosa* 1991-2005

- Colony site
- * Town
- Study area boundary
- Major highway
- ~ Stream
- County boundary

*Colony sites outside of this sub-region are not shown.



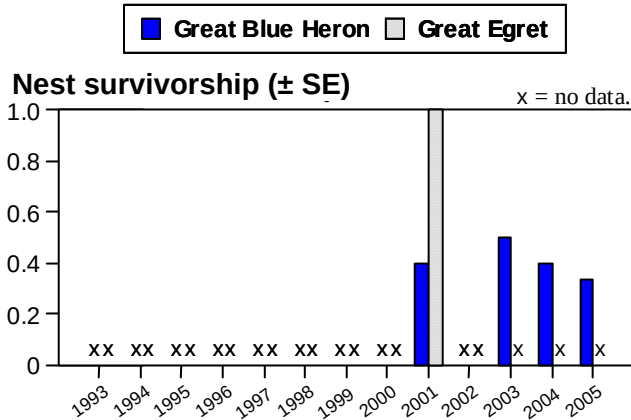
Alpha Farm

This colony site is located in a stand of valley oaks on the west bank of the Laguna de Santa Rosa. The colony was established early in the 2001 season, after the abandonment of the Laguna Farm colony site. The birds have nested in various oak trees on both sides of the Laguna, all within 100 m of each other. Double-crested Cormorants have nested here since the inception of the colony.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.3827 / W 122.7956

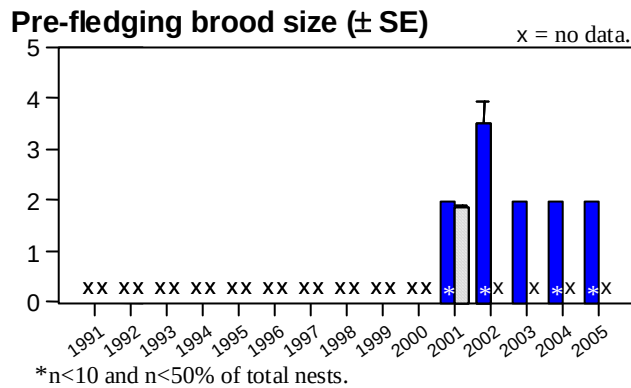


Colony site description

Topography: flood plain
Length x width: 20 m x 10 m
Nest substrate: valley oak (*Quercus lobata*)
Average nest height: 19 m
Trees (dbh): 5 (10-50 cm), 5 (100-150 cm)
Maximum tree canopy height: 22 m
Vegetation cover: tree 70%, shrub 5%, ground 80%

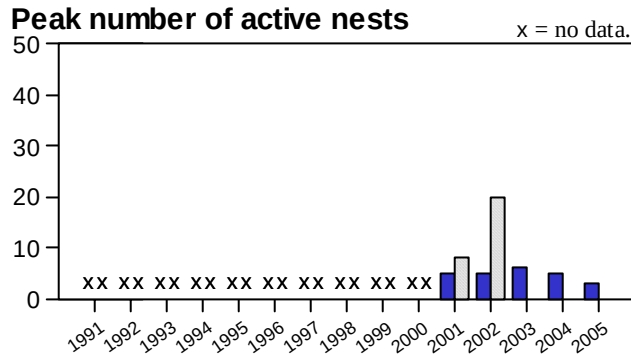
Evidence of disturbance

None recorded.



Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing			X	X
Grazing	X	X	X	X



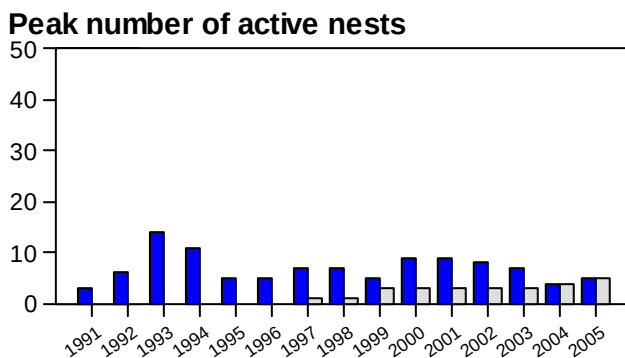
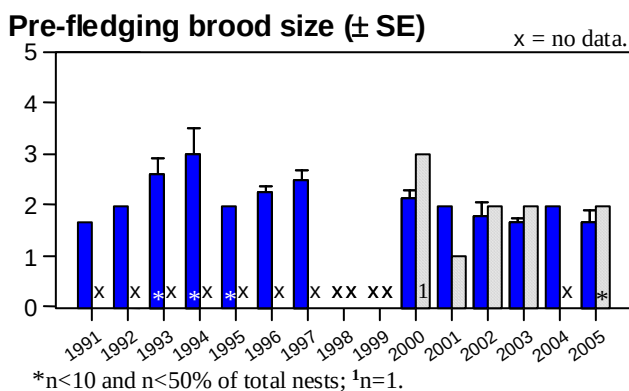
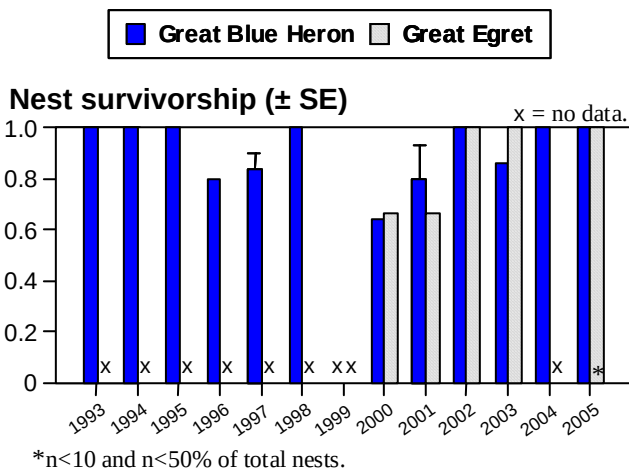
Chalk Hill Road

This colony site is on the floodplain of Franz Creek in northwestern Sonoma County, about 8 km east of Healdsburg. The nesting trees are 1030 m from the Russian River. The surrounding area is a mixture of steep, forested hillsides and floodplains covered by vineyards and pastures.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.6097 / W 122.7716



Colony site description

Topography: hillside

Length x width: 100 m x 20 m

Nest substrate: coast redwood (*Sequoia sempervirens*)

Average nest height: 35 m

Trees (dbh): 7 (10-50 cm), 79 (50-100 cm), 12 (100-150 cm)

Maximum tree canopy height: 41 m

Vegetation cover: tree 46%, shrub 4%, ground 24%

Evidence of disturbance

American Crow: behavioral response

Osprey (nest): potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X	X	X	X
Farming			X	X
Grazing	X	X	X	X

Cloverdale

A colony of Great Blue Herons nests in a residential area northeast of Cloverdale, about 300 m from Sulphur Creek and 700 m from the east shore of the Russian River. The herons have nested in several gray pines on hillsides in the area. The surrounding hillsides are mainly wooded, while the nearby Alexander Valley is largely cultivated vineyards.

Ownership: private

Public observation areas: River Road

Latitude / Longitude:

N 38.8214 / W 122.9996 (River Road)

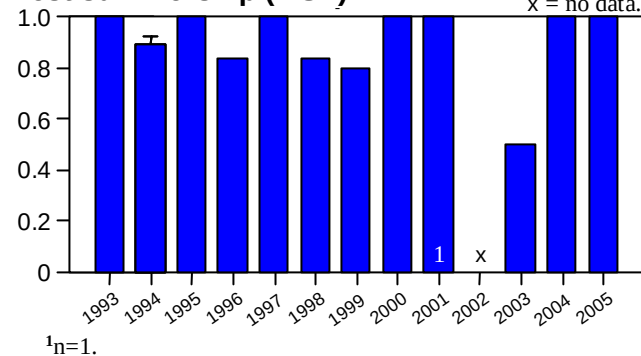
N 38.8271 / W 122.9966 (Pine Mountain Road)

N 38.8231 / W 122.9978 (Wilson Road)



■ Great Blue Heron

Nest survivorship ($\pm$ SE)



Colony site description

River Road subsite

Topography: hillside

Length x width: 15 m by 10 m

Nest substrate: gray pine (*Pinus sabiniana*)

Average nest height: 35 m

Trees (dbh): 1 (50-100 cm)

Maximum tree canopy height: 38 m

Vegetation cover: tree 50%, shrub 20%, ground 10%

Pine Mountain Road subsite

Ownership: private

Topography: hillside

Length x width: not measured

Nest substrate: gray pine (*Pinus sabiniana*)

Average nest height: not measured

Trees (dbh): 1 (50-100 cm)

Maximum tree canopy height: not measured

Vegetation cover: not measured

Wilson Road subsite

Ownership: private

Topography: hillside

Length x width: not measured

Nest substrate: gray pine (*Pinus sabiniana*)

Average nest height: not measured

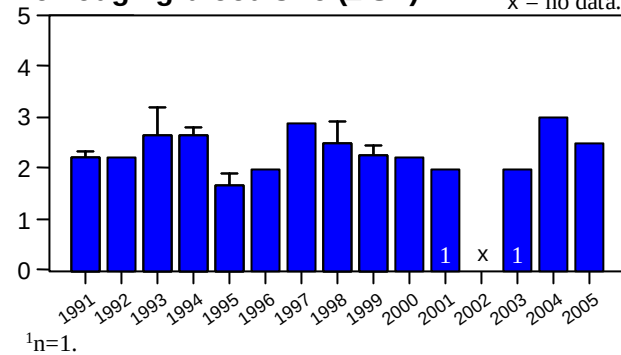
Trees (dbh): 1 (50-100 cm)

Maximum tree canopy height: not measured

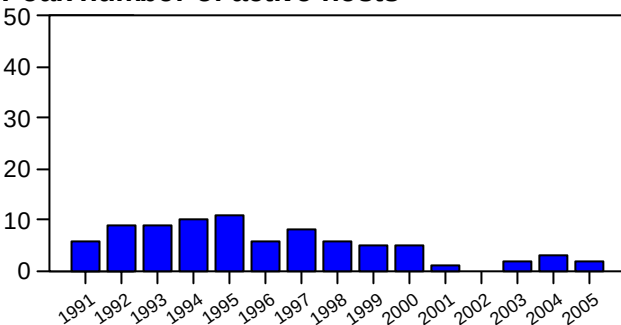
Vegetation cover: not measured

(continued)

Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



Cloverdale (continued)

Evidence of disturbance

Trees cut down: colony abandonment

Red-tailed Hawk: potential source^a

Turkey Vulture: potential source^a

Red-shouldered Hawk: potential source^a

Red-tailed Hawk (nest): potential source^a

^aPossible disturbance suggested by published accounts
(see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0- 100	100- 200	200- 500	500- 1000
Low density housing	X	X	X	X
Mid-density housing		X	X	X
Vineyard				X

Crystal Brook

A colony of Great Blue Herons was established in cottonwood trees along the east bank of the Russian River in 1992. The number of nesting attempts decreased gradually until the colony fell inactive in 1999. Vineyards cover the adjacent floodplain on both sides of the river.

Ownership: private

Public observation areas: none

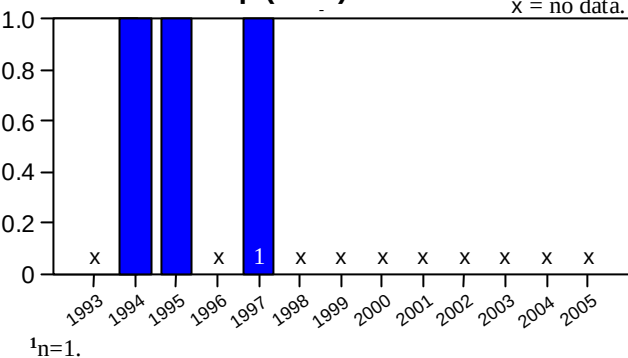
Latitude / Longitude: N 38.7323 / W 122.9239



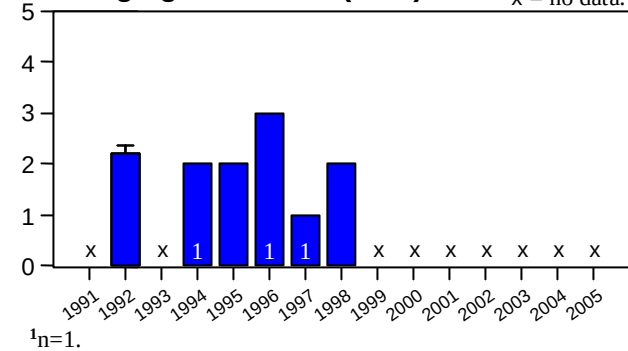
(no photo)

Great Blue Heron

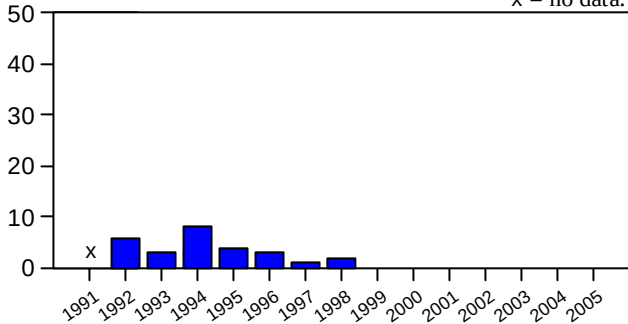
Nest survivorship ($\pm$ SE)



Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



Colony site description

Topography: flood plain
 Length x width: 40 m x 10 m
 Nest substrate: cottonwood (*Populus fremontii*)
 Average nest height: not measured
 Trees (dbh): not measured
 Maximum tree canopy height: 25 m
 Vegetation cover: tree 30%, shrub 25%,
 ground (not measured)

Evidence of disturbance

None recorded.

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing			X	X
Vineyard	X	X	X	X

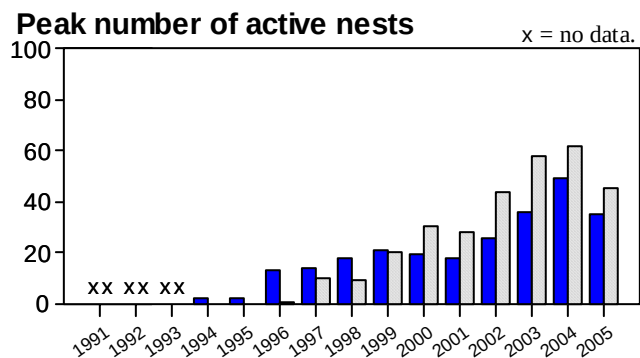
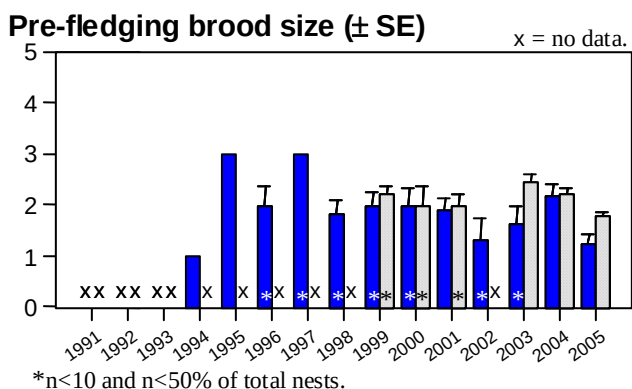
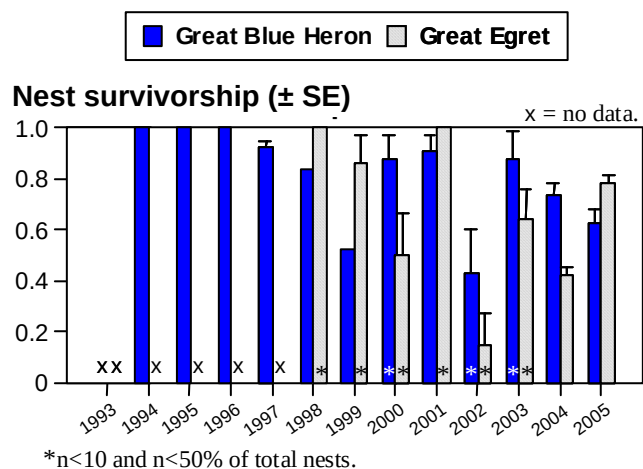
Delta Pond

This site is located in the seasonally wet floodplain of the Laguna de Santa Rosa on the property of the Sonoma County Water Agency. A large freshwater impoundment borders the east side of the colony site. The vegetation in the colony and surrounding floodplain is very dense. Double-crested Cormorants also nest at this location.

Ownership: public

Public observation areas: none

Latitude / Longitude: N 38.4473 / W 122.8345



Colony site description

Topography: wetland

Length x width: 120 m x 60 m

Nest substrate: *Eucalyptus* sp., valley oak
(*Quercus lobata*)

Average nest height: 22 m

Trees (dbh): not measured

Maximum tree canopy height: 30 m

Vegetation cover: tree 55%, shrub 85%,
ground 70%

Evidence of disturbance

Human activity (truck traffic): behavioral
response

Turkey Vultures (scavenging in nests): behavioral
response

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing				X
Vineyard			X	X
Grazing			X	X

Fitch Mountain

This site is in a small grove of redwoods, 350 m from the Russian River on the northern edge of Villa Chanticleer Park in Healdsburg. The site is adjacent to the locally protected natural area of Fitch Mountain.

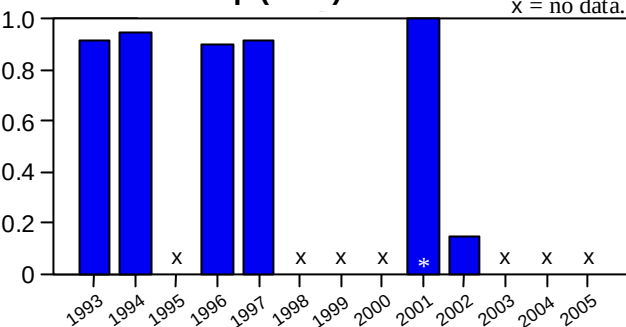
Ownership: Public
Public observation areas: Villa Chanticleer Park
Latitude / Longitude: N 38.6218 / W 122.8485



(no photo)

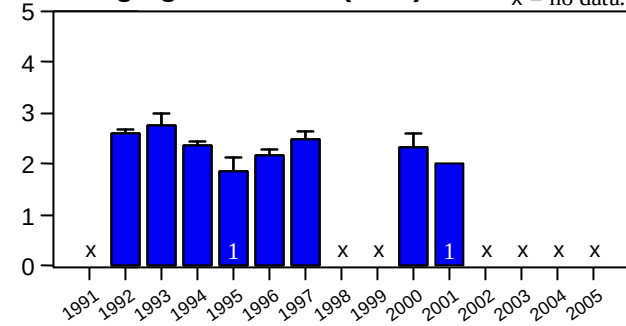
Great Blue Heron

Nest survivorship ($\pm$ SE)



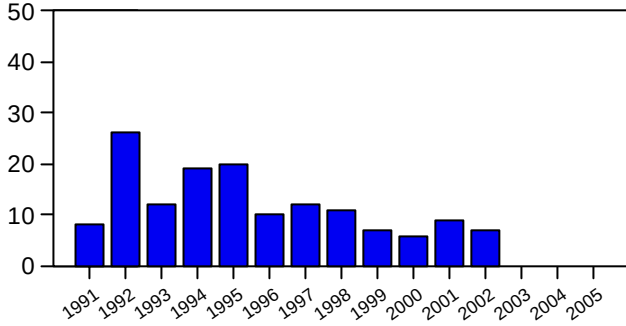
*n<10 and n<50% of total nests.

Pre-fledging brood size ($\pm$ SE)



¹n=1.

Peak number of active nests



Colony site description

Topography: hillside
Length x width: 15 m x 7 m
Nest substrate: coast redwood (*Sequoia sempervirens*)
Average nest height: 15 m
Trees (dbh): 6 (100-150 cm)
Maximum tree canopy height: 25 m
Vegetation cover: tree 25%, shrub 50%, ground (not measured)

Evidence of disturbance

American Crow: potential source^a
Common Raven: potential source^a
^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X			
Mid-density housing		X	X	X
Protected natural area	X	X	X	X

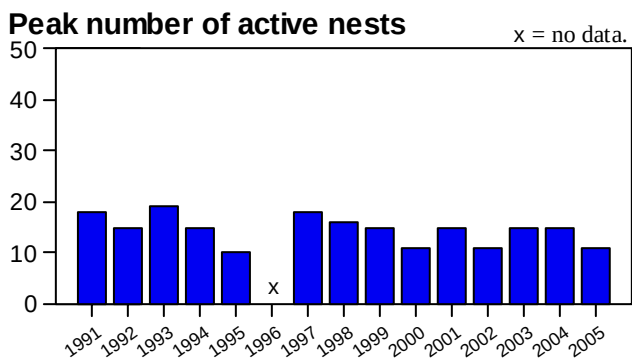
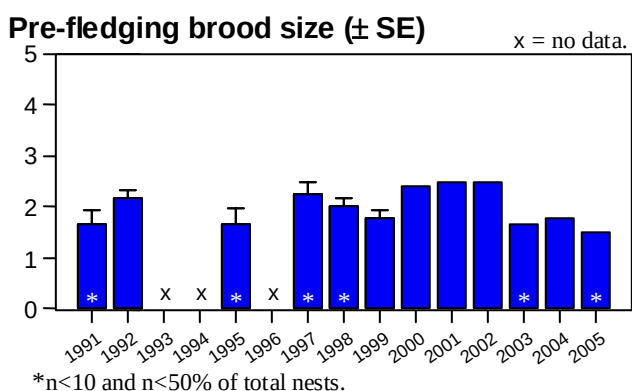
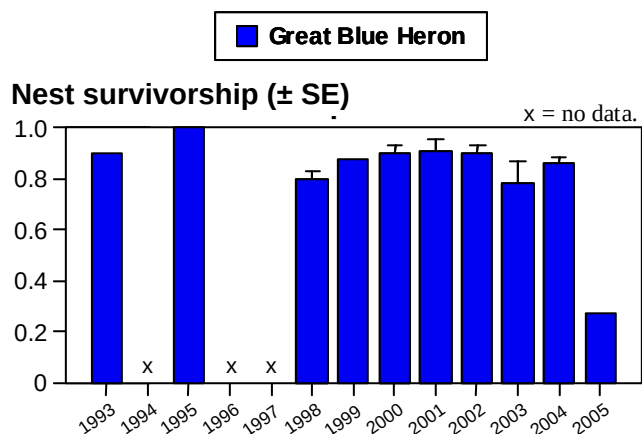
Freezeout Road

Great Blue Herons nest in mature Douglas firs on the southern shore of the Russian River between Jenner and Duncans Mills. The colony side of the river is thickly forested, while the northern shore is dotted with small farms and pasture. The heronry can be viewed from Highway 116, looking across the river.

Ownership: unknown

Public observation areas: Hwy 116

Latitude / Longitude: N 38.4400 / W 123.0752



Colony site description

Topography: hillside

Length x width: 100 m x 20 m

Nest substrate: Douglas fir (*Pseudotsuga menziesii*)

Average nest height: 30 m

Trees (dbh): 8 (50-100 cm)

Maximum tree canopy height: 38 m

Vegetation cover: tree 60%, shrub 0%, ground 5%

Evidence of disturbance

Wind and rain: nest failure

Osprey (nest): potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing			X	X
Grazing		X	X	X

Geyserville, Russian River

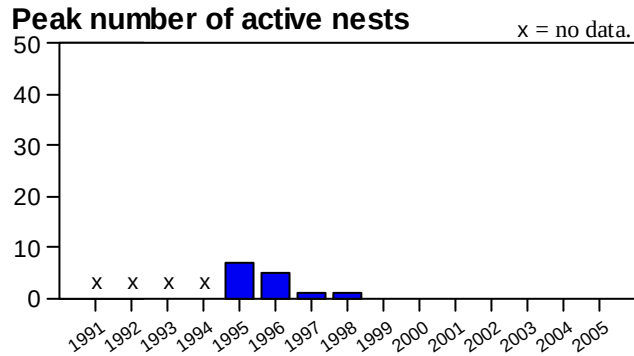
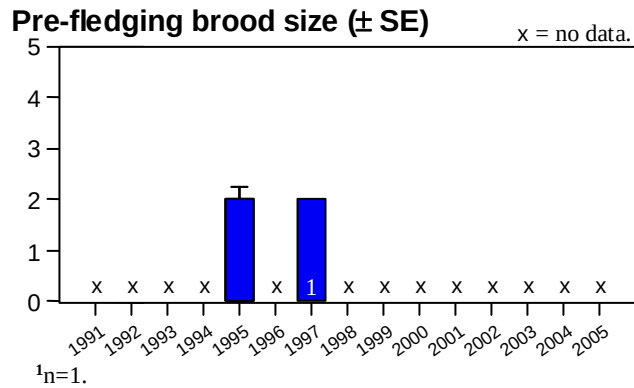
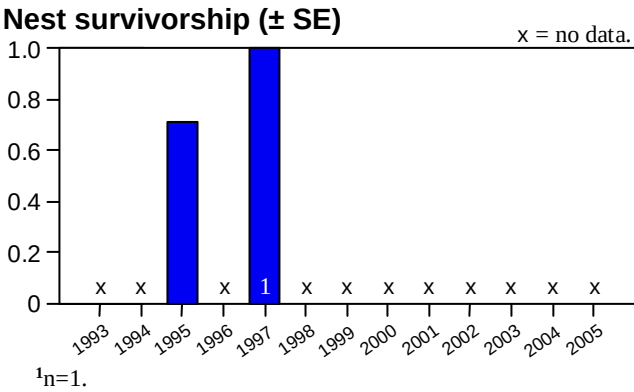
The wooded floodplain of the Russian River extends south and west of the colony site, with wide gravel bars and heavily wooded riparian corridors along both banks. Vineyards cover the plain northwest of the site.

Ownership: private
Public observation areas: none
Latitude / Longitude: N 38.7159 / W 122.8969



(no photo)

 **Great Blue Heron**



Colony site description

Topography: flood plain
Length x width: 3 m x 1 m
Nest substrate: cottonwood (*Populus fremontii*, live and dead branches)
Average nest height: 15 m
Trees (dbh): 1 (> 150cm)
Maximum tree canopy height: 25 m
Vegetation cover: tree 60%, shrub 20%, ground 20%

Evidence of disturbance

Human activity: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing			X	X
Mid-density housing				X
Vineyard	X	X	X	X

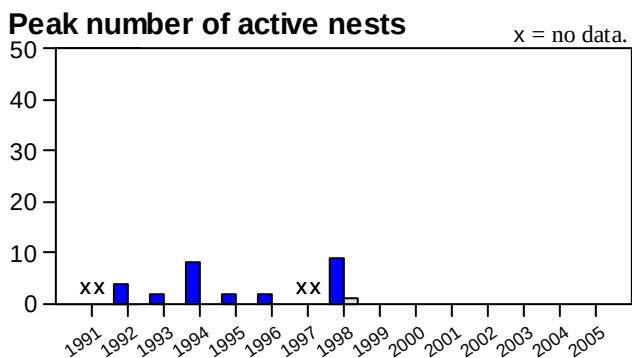
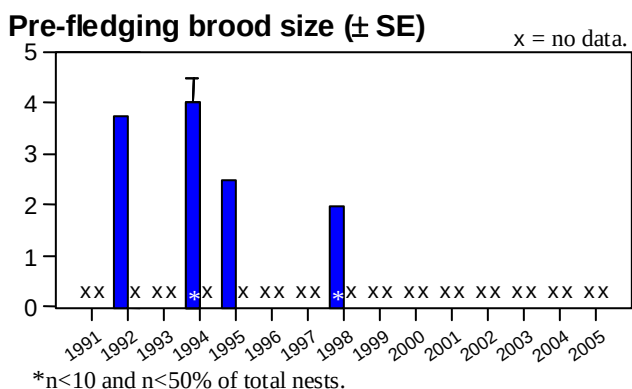
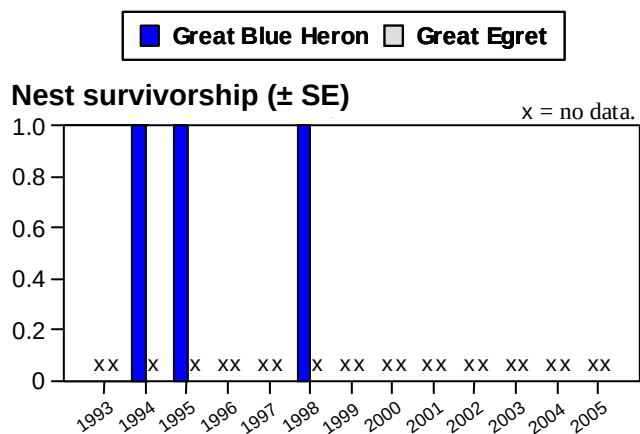
Kaiser Gravel

This heronry was in coast redwood trees near the shore of a gravel-mining pond adjacent to the Russian River, northeast of Mirabel Park. A dirt road runs along the pond immediately adjacent to the colony trees. The former gravel quarry was converted to public parkland in 2003.

Ownership: public

Public observation areas: none

Latitude / Longitude: N 38.5166 / W 122.8583



Colony site description

Topography: levee

Length x width: not measured

Nest substrate: coast redwood (*Sequoia sempervirens*)

Average nest height: not measured

Trees (dbh): 36 (3-50 cm), 30 (50-100 cm), 2 (100-150 cm)

Maximum tree canopy height: 38 m

Vegetation cover: tree 73%, shrub 23%, ground 18%

Evidence of disturbance

Common Raven: potential source^a

Logging and house construction: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing				X
Vineyard			X	X

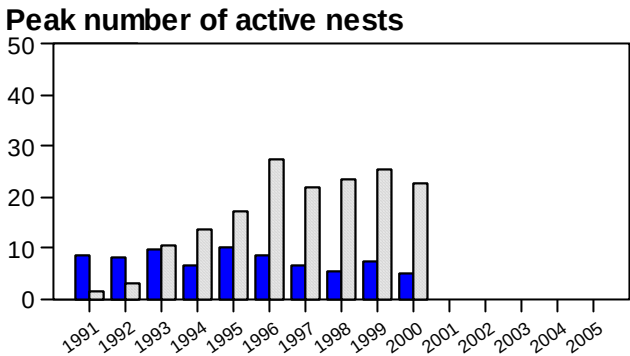
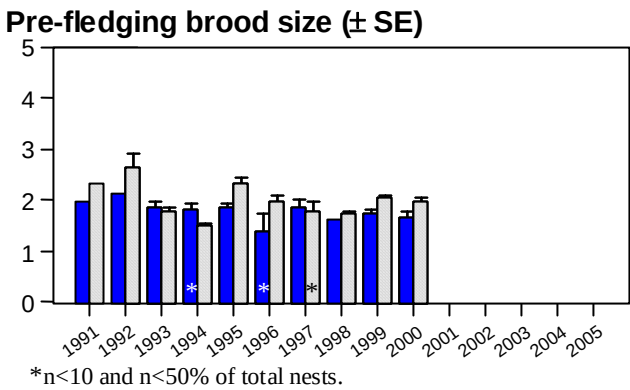
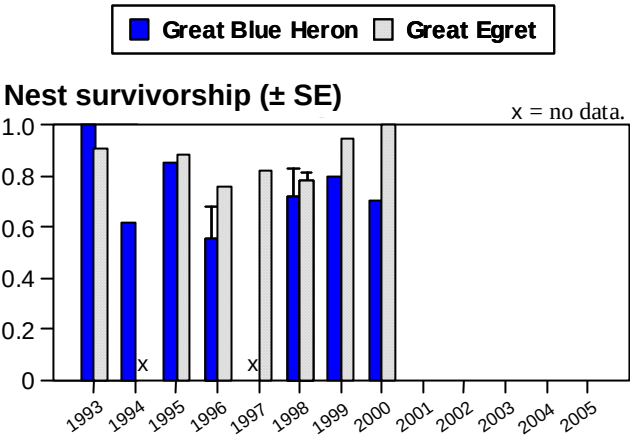
Laguna Farm

This site is on the bank of the Laguna de Santa Rosa on Sonoma County Water Agency property. The land is closed to the public and leased for grazing. The surrounding habitat is grassland interspersed with valley oak. Double-crested Cormorants began nesting at this colony site in 1995.

Ownership: public

Public observation areas: none

Latitude / Longitude: N 38.3899 / W 122.7970



Colony site description

Topography: flood plain
 Length x width: 37 m x 15 m
 Nest substrate: *Eucalyptus* sp.
 Average nest height: 26 m
 Trees (dbh): 5 (3-10 cm), 2 (10-50 cm),
 10 (50-100 cm)
 Maximum tree canopy height: 35 m
 Vegetation cover: tree 60%, shrub 5%, ground 90%

Evidence of disturbance

Golden Eagle: nest failure
 Human activity (hot air balloon): behavioral response
 PG&E tree trimming: potential source^a
 Red-tailed Hawk (nest): potential source^a
^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing			X	X
Mid-density housing			X	X
Grazing			X	X

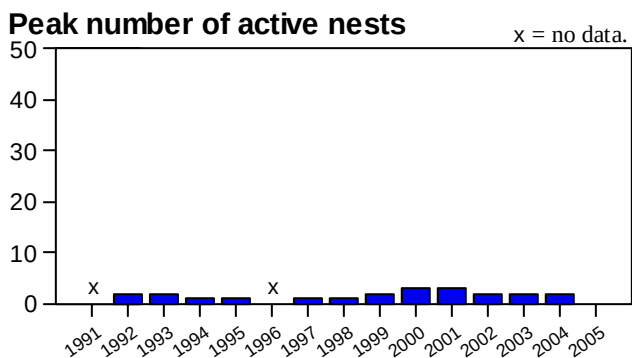
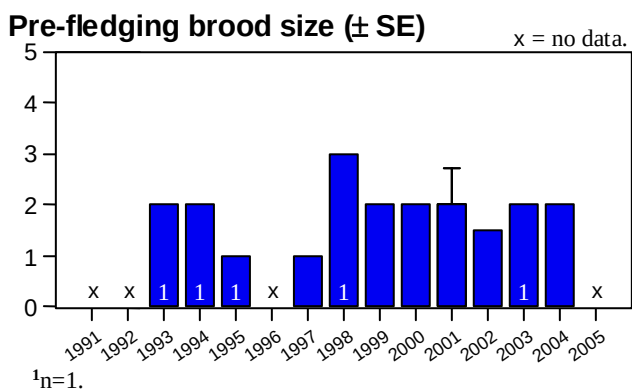
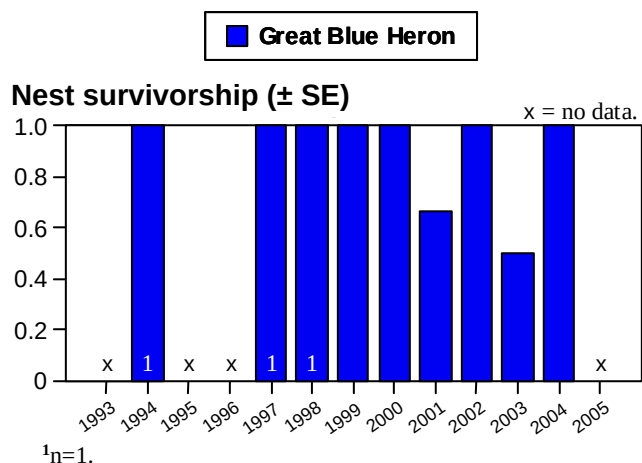
Novavine

This colony site is east of Santa Rosa in Oakmont. Great Blue Herons nest on private property adjacent to a vineyard and olive orchard. The nesting trees grow along the shore of a diked farm pond, 75 m from a residence.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.4480 / W 122.5991



Colony site description

Topography: hillside

Length x width: 10 m x 10 m

Nest substrate: Douglas fir (*Pseudotsuga menziesii*)

Average nest height: 23 m

Trees (dbh): 3 (50-100 cm)

Maximum tree canopy height: 30 m

Vegetation cover: tree 65%, shrub 0%, ground 5%

Evidence of disturbance

American Crow: behavioral response

Red-shouldered Hawk: behavioral response

Common Raven: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X		X	X
Mid-density housing				X
High density housing				X
Orchard			X	X
Vineyard			X	X

Riverfront Park

This colony is in a stand of coast redwood on the shore of an old graveling pond adjacent to the Russian River, northeast of Mirabel Park. A dirt road approaches within 15 m of the colony. The property was converted to public parkland in 2004.

Ownership: public

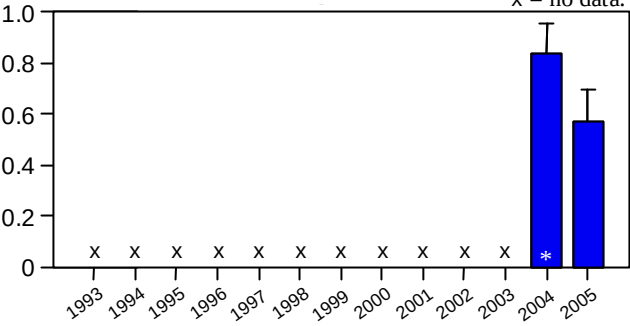
Public observation areas: levee at edge of pond

Latitude / Longitude: N 38.5129 / W 122.8614



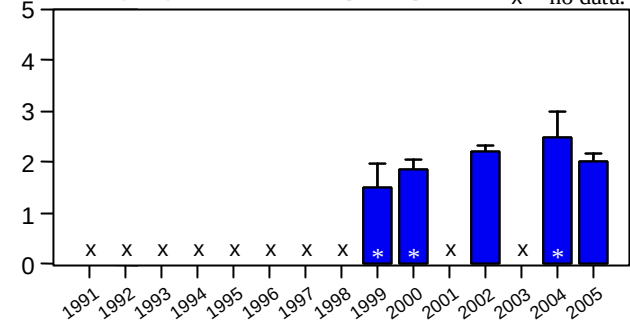
■ Great Blue Heron

Nest survivorship ($\pm$ SE)



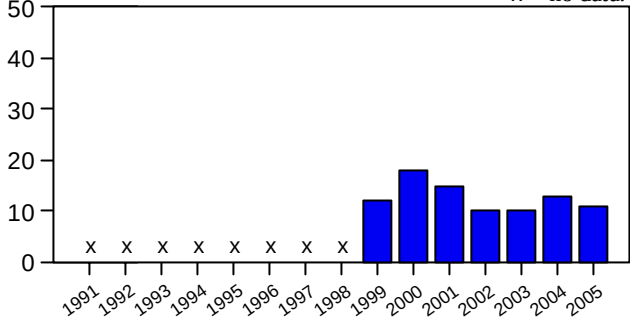
*n<10 and n<50% of total nests.

Pre-fledging brood size ($\pm$ SE)



*n<10 and n<50% of total nests.

Peak number of active nests



Colony site description

Topography: levee

Length x width: 80 m x 10 m

Nest substrate: coast redwood (*Sequoia sempervirens*)

Average nest height: 31 m

Trees (dbh): 39 (3-50 cm), 35 (50-100 cm), 5 (100-150cm)

Maximum tree canopy height: 37 m

Vegetation cover: tree 83%, shrub 30%, ground 27%

Evidence of disturbance

Human activity (4WD vehicles): nest failure

Common Raven: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing				X
Vineyard			X	X

Sonoma Cutrer

The former colony site was an isolated eucalyptus tree in the middle of a large vineyard. The tree was removed prior to the 1997 nesting season.

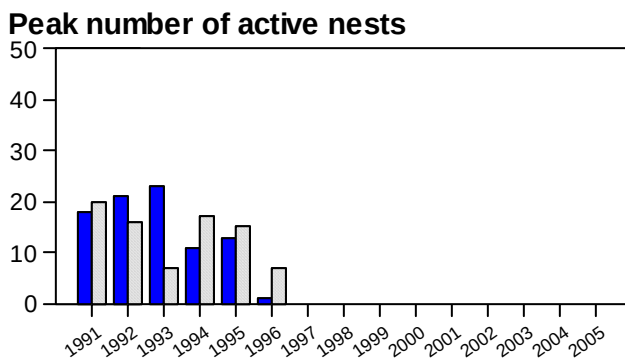
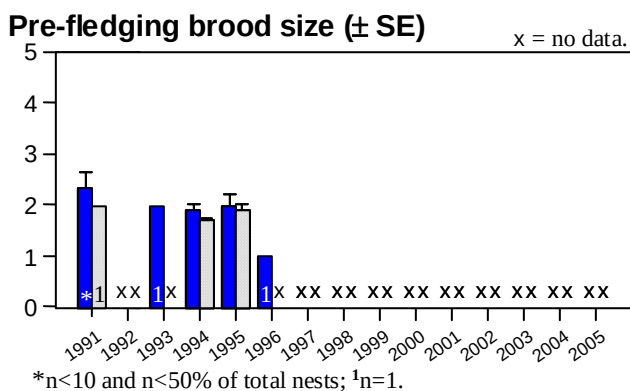
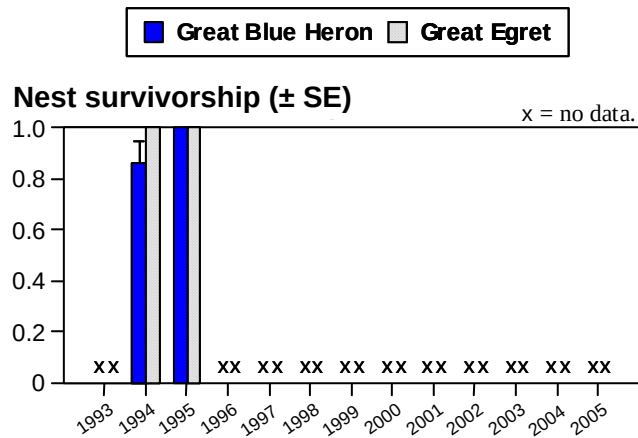
Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.50030 / W 122.84012



(no photo)



Colony site description

Topography: hillside

Length x width: not measured

Nest substrate: *Eucalyptus* sp.

Average nest height: not measured

Trees (dbh): not measured

Maximum tree canopy height: not measured

Vegetation cover: not measured

Evidence of disturbance

Golden Eagle: nest failure

Human activity (tree trimming): potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing				X
Vineyard	X	X	X	X

Wine Creek

Great Blue Herons nest in several tall Douglas firs along the northeast side of a forested ridge near Healdsburg. The hillsides east of the colony are planted with grapes and the top of the ridge is dotted with residences. This site is approximately 8 km west of the Russian River and 5 km southeast of Warm Springs Reservoir.

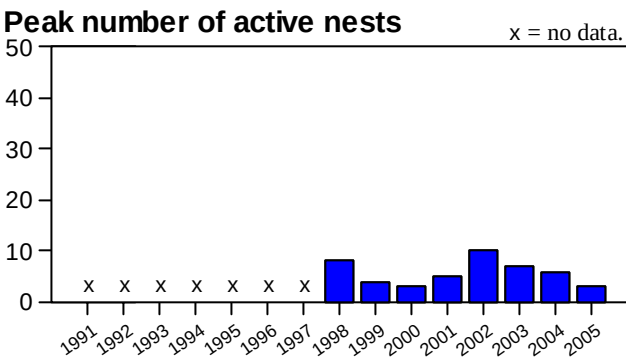
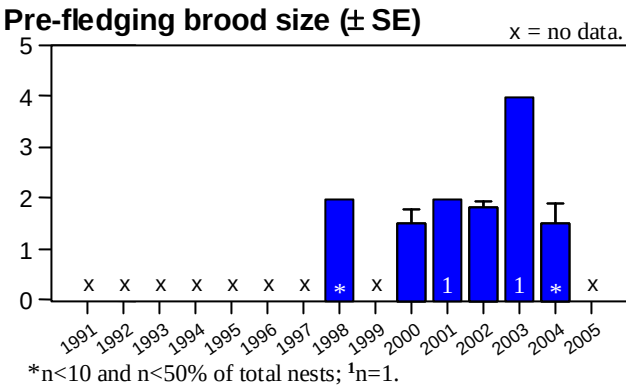
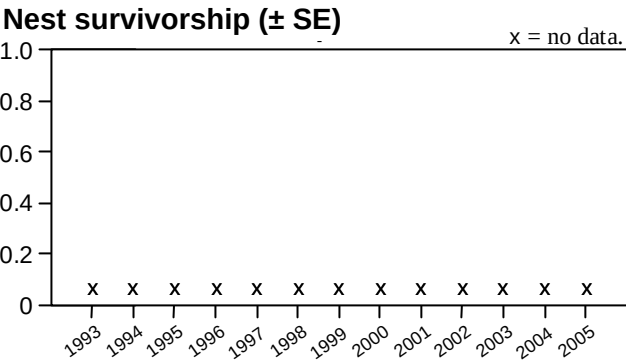
Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.6750 / W 122.9640



■ Great Blue Heron



Colony site description

North subsite

Topography: ridge top
Length x width: 35 m x 12 m
Nest substrate: Douglas fir (*Pseudotsuga menziesii*)
Average nest height: 35 m
Trees (dbh): 5 (> 150 cm)
Maximum tree canopy height: not measured
Vegetation cover: tree 70%, shrub (not measured), ground (not measured)

South subsite

Topography: ridge top
Length x width: 30 m x 10 m
Nest substrate: Douglas fir (*Pseudotsuga menziesii*)
Average nest height: 35 m
Trees (dbh): 2 (100-150 cm), 4 (> 150 cm)
Maximum tree canopy height: not measured
Vegetation cover: tree 70%, shrub (not measured), ground (not measured)

Evidence of disturbance

Common Raven: potential source^a
Human activity (vineyard planting): potential source^a
^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X	X	X	X
Vineyard			X	X

Peterson Lane

This colony site is in suburban Santa Rosa. Prior to the 1997 breeding season, all nesting trees were removed. The nesting birds apparently colonized other Santa Rosa sites in subsequent years.

Ownership: private

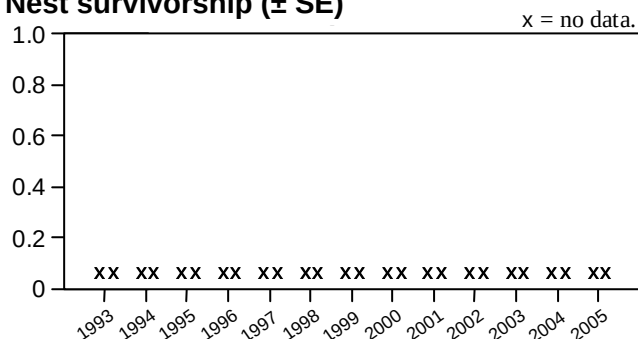
Public observation areas: none

Latitude / Longitude: N 38.4584 / W 122.7644

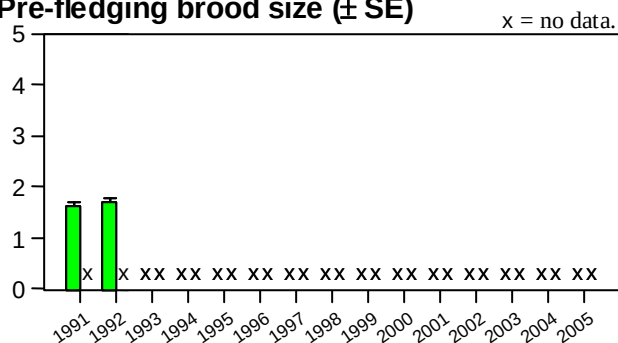


■ Black-crowned Night-Heron ■ Snowy Egret

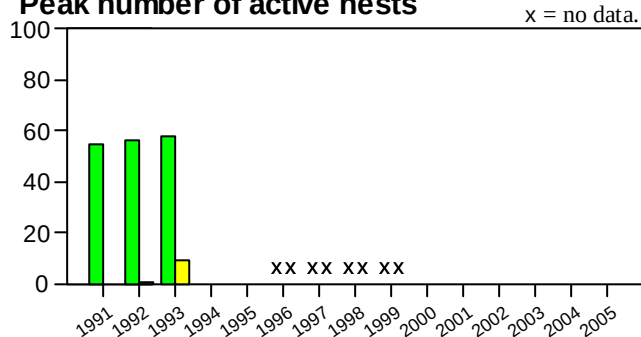
Nest survivorship ($\pm$ SE)



Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



Colony site description

Topography: suburban

Length x width: not measured

Nest substrate: *Eucalyptus* sp.

Average nest height: not measured

Trees (dbh): not measured

Maximum tree canopy height: not measured

Vegetation cover: not measured

Evidence of disturbance

Human activity (removal of trees): colony abandonment

Resident dog: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

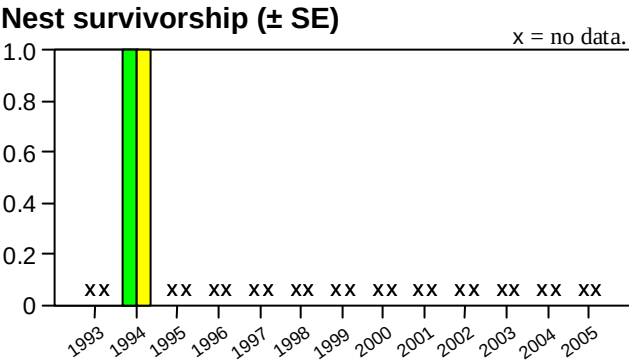
Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Mid-density housing	X	X	X	X

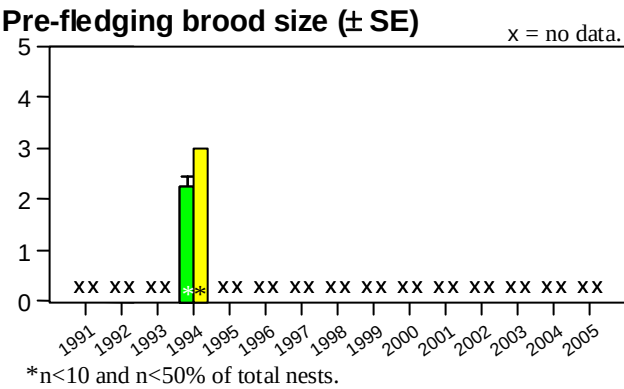
West 7th and Jefferson

This colony site was in a suburban area of Santa Rosa. In 1996 and 1997, many of the nesting trees were removed by local residents. In 1995, a pair of Cattle Egrets (not included in graphs below) nested at this colony site.

Ownership: private
Public observation areas: none
Latitude / Longitude: N 38.4384 / W 122.7244



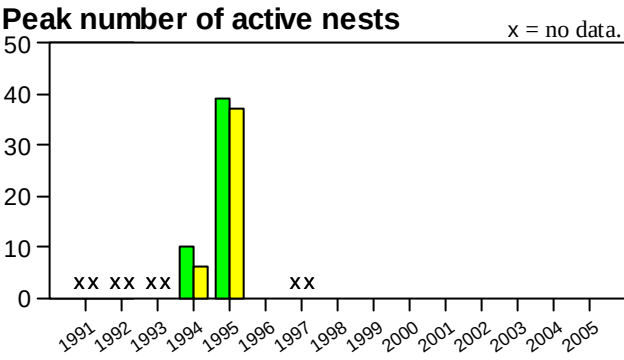
Colony site description
Topography: suburban
Length x width: not measured
Nest substrate: *Eucalyptus* sp. and unknown conifer species
Average nest height: not measured
Trees (dbh): not measured
Maximum tree canopy height: not measured
Vegetation cover: not measured



Evidence of disturbance
Human activity (nest trees cut down): colony abandonment

Land use

	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Land use				
Mid-density housing	X	X	X	X



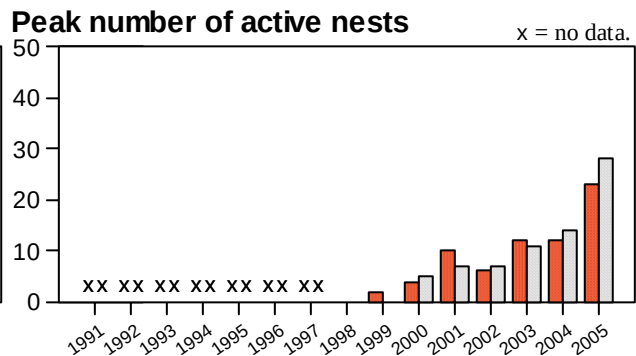
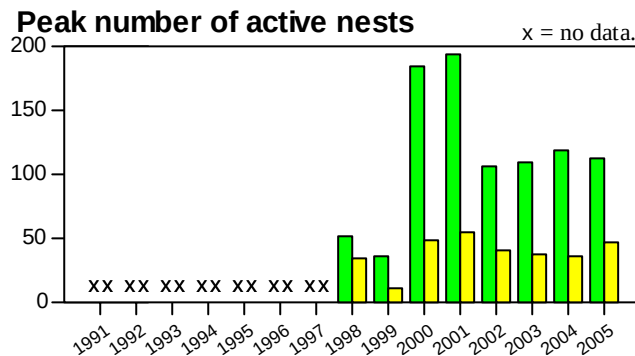
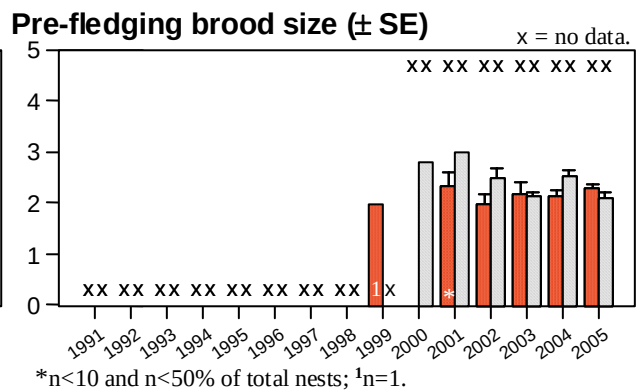
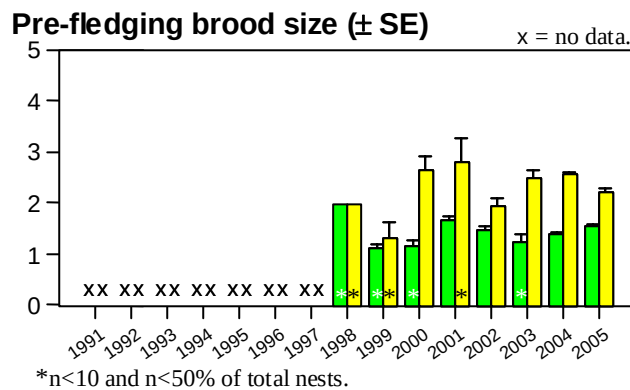
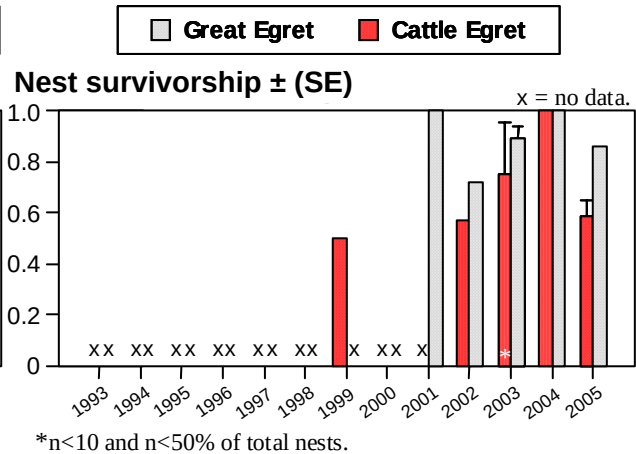
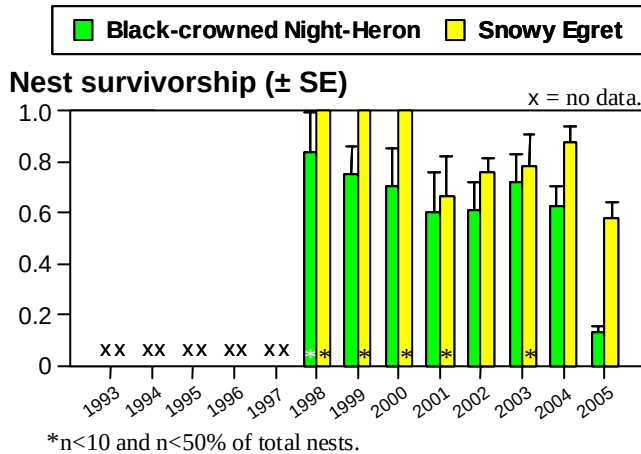
West 9th Street, Santa Rosa

This colony site is in the City of Santa Rosa on West 9th Street, between West 8th and Simpson. Nesting is concentrated among eucalyptus trees growing in the median of the four-lane street. During the breeding season, the City closes the two middle lanes to traffic to protect grounded chicks. Nesting also occurs in pines, redwoods and deciduous trees on both sides of the road and along side streets. In 2003, Black-crowned Night-Herons nested in a subcolony 160 m to the east, near West 8th Street.

Ownership: public

Public observation areas: West 9th Street

Latitude / Longitude: N 38.4415 / W 122.7388



(continued)

West 9th Street, Santa Rosa (continued)

Colony site description

West subsite

Topography: suburban

Length x width: 106 m x 36 m

Nest substrate: *Eucalyptus* sp., coast redwood (*Sequoia sempervirens*), Monterey pine (*Pinus radiata*), unknown exotic deciduous tree species

Average nesting height: 19 m

Trees (dbh): 8 (3-50 cm), 10 (50-100 cm), 1 (100-150 cm)

Maximum tree canopy height: 30 m

Vegetation cover: tree 34%, shrub 0%, ground 21%

East subsite

Topography: suburban

Length x width: 22 m x 11 m

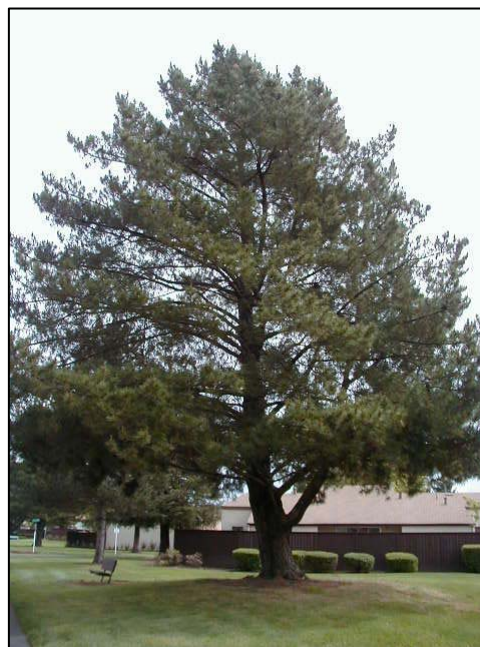
Nest substrate: *Eucalyptus* sp., unknown exotic deciduous tree species

Average nest height: 19 m

Trees (dbh): 3 (50-100 cm)

Maximum tree canopy height: 23 m

Vegetation cover: tree 46%, shrub 0%, ground 53%



Evidence of disturbance

Human activity: nest failure

House cats: behavioral response

Raccoons: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Mid-density housing	X	X	X	X
High density housing	X	X	X	X
Sports field			X	X

Colony Sites with Limited Activity

Dutton Avenue

This former colony site was in pepper trees (*Schinus molle*) along Dutton Avenue in the City of Santa Rosa. The site was abandoned after some of the trees were cut down prior to the 1997 nesting season.

Ownership: private

Public observation areas: from street

Latitude / Longitude: N 38.4534 / W 122.7359

Species	Years known to be active (number of active nests)
Black-crowned Night-Heron	1995 (1), 1996 (5)



Fenwick/Brockhurst Neighborhood

Hérons and egrets nested in several subsites in a densely populated area of western Santa Rosa near Santa Rosa Creek. Some nest trees were cut down prior to the 1997 nesting season.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.4360 / W 122.7447

Species	Years known to be active (number of active nests)
Black-crowned Night-Heron	1996 (18)
Snowy Egret	1996 (18)
Cattle Egret	1996 (1)



McBride Lane

This colony site was adjacent to an apartment complex in western Santa Rosa near Santa Rosa Creek. The nesting trees were removed in the winter of 1997-1998.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.4617 / W 122.7303

Species	Years known to be active (number of active nests)
Black-crowned Night-Heron	1997 (36)
Snowy Egret	1997 (27)
Cattle Egret	1997 (2)



Colony Sites with Limited Activity (continued)

Alexander Valley

This former colony site was in a heavily wooded riparian corridor along the Russian River, west of Jim Town. Extensive vineyards border the forested strip along the river.

Ownership: unknown

Public observation areas: none

Latitude / Longitude: N 38.6711 / W 122.8349

Species	Years known to be active (number of active nests)
Great Blue Heron	1990 (4), 1991 (7), 1992 (2)



Asti

This colony site is located on private property approximately six miles south of Cloverdale and about 650 m from the east shore of the Russian River.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.7790 / W 122.9838

Species	Years known to be active (number of active nests)
Great Blue Heron	1999 (4), 2000 (8), 2001 (5)

Dutcher Creek

Great Blue Herons nested in mixed oak and pine woodlands near a private residence along this tributary of the Russian River. In 1995, the nest trees were removed. The surrounding area includes rolling hills, vineyards and a few residential homes.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.7160 / W 122.9775

Species	Years known to be active (number of active nests)
Great Blue Heron	1991 (3), 1992 (14), 1993 (10), 1994 (6)

Colony Sites with Limited Activity (continued)

Georgetown

A single pair of Great Blue Herons nested on private property along Frei Road 2.5 km northeast of Graton. The site is within two hundred meters of the west shore of the Laguna de Santa Rosa.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.4500 / W 122.8405

Species	Years known to be active (number of active nests)
Great Blue Heron	1991 (1)

Laguna Off Doyle Road

Two pairs of Great Blue Herons nested in a coast live oak (*Quercus agrifolia*) growing on the floodplain of the Laguna de Santa Rosa, east of Sebastopol. The surrounding habitat is oak savannah.

Ownership: unknown

Public observation areas: none

Latitude / Longitude: N 38.3988 / W 122.7916

Species	Years known to be active (number of active nests)
Great Blue Heron	1991 (2)

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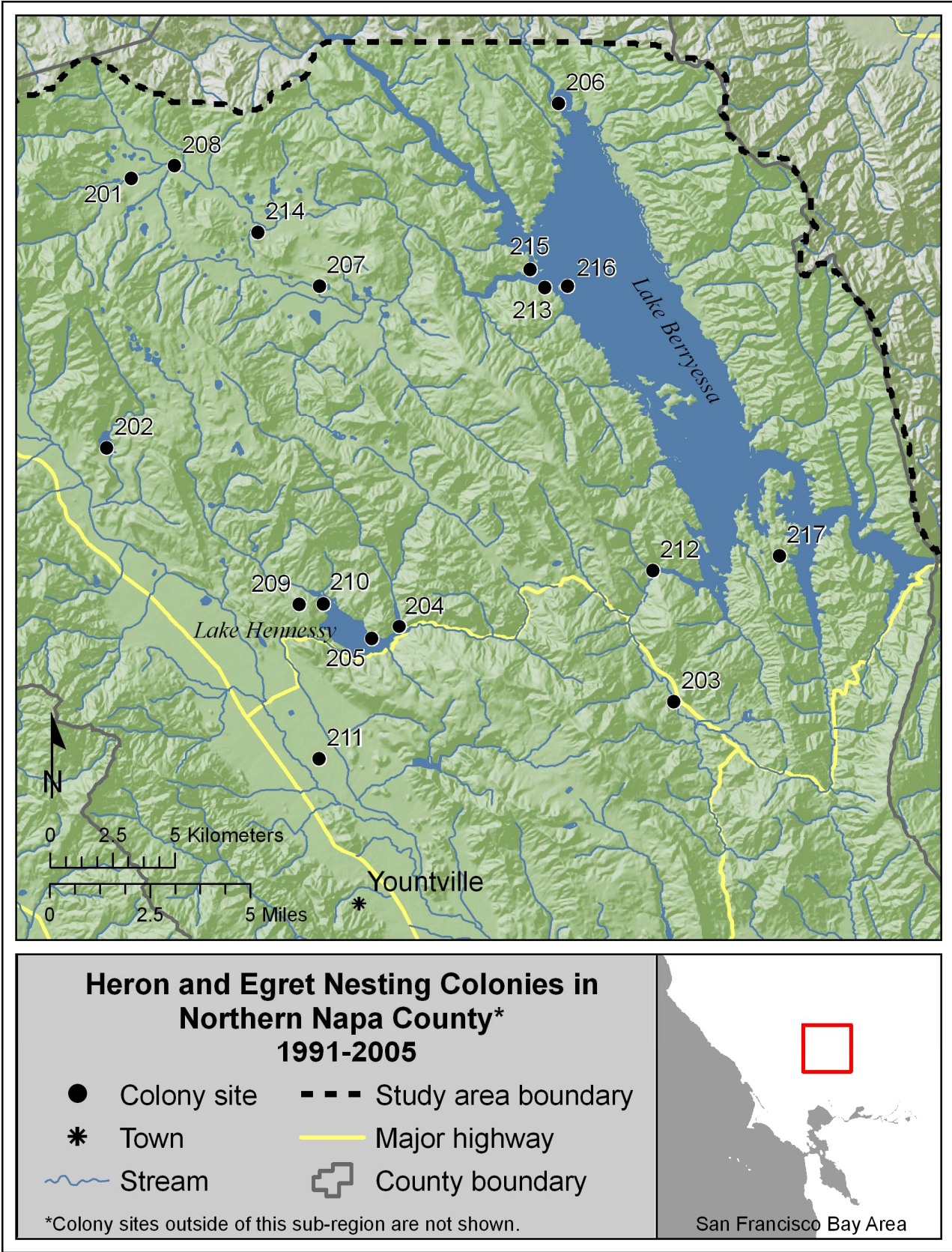
NORTHERN NAPA COUNTY



NORTHERN NAPA COUNTY

This subregion encompasses the northern Napa County hills and Lake Berryessa, from the Yolo County border in the east to the Solano Hills in the west. Lake Berryessa and Lake Hennessey, both man-made reservoirs, are the two largest bodies of water in the subregion. Steep, forested ridges and ravines characterize the eastern half of the subregion; the western half is dominated by the viticulture and rural development of the upper Napa Valley.

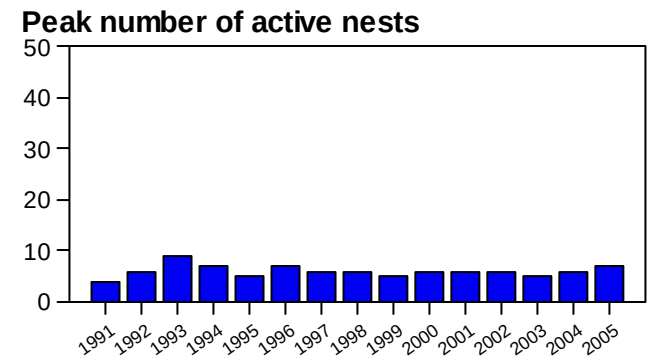
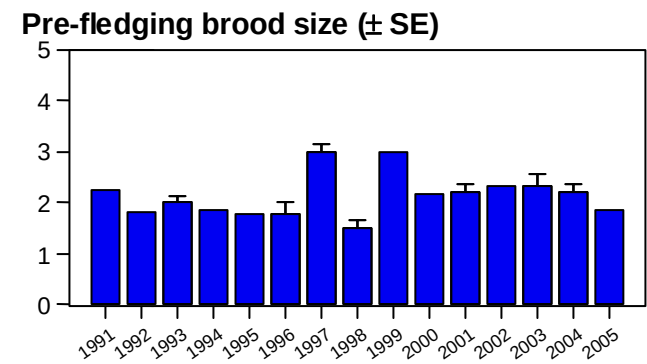
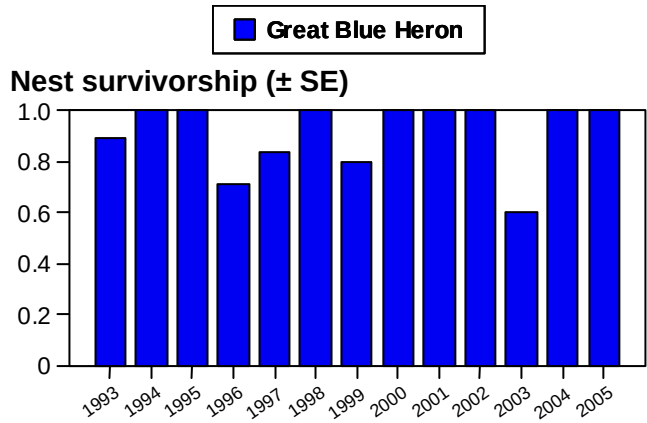
Site #	Colony Site	Great Blue Heron	Great Egret	Snowy Egret	Black-crowned Night-Heron	Cattle Egret	County	Active or year last active	Page
201	Aetna Springs Road	■					Napa	1992	76
202	Bell Canyon Reservoir	■					Napa	Active	68
203	Capell Valley	■					Napa	1993	76
204	Chiles Creek	■					Napa	Active	69
205	Conn Point	■					Napa	2004	76
206	Eticuera Creek	■					Napa	Active	70
207	Hardin Ranch	■					Napa	1993	77
208	James Creek	■					Napa	1992	77
209	Lake Hennessey North	■					Napa	2004	71
210	Lake Hennessey West Shore	■					Napa	1993	77
211	Oakville Cross				■		Napa	1993	78
212	Olive Orchard	■					Napa	1999	78
213	Pope Creek Bridge	■					Napa	2004	72
214	Pope Valley #2	■					Napa	Active	73
215	Putah Park	■					Napa	Active	74
216	Schoolhouse Island	■					Napa	Active	75
217	Wragg Canyon	■					Napa	1992	78



Bell Canyon Reservoir

This colony has been relatively stable and productive over time. The colony site is about 5 km north of St. Helena, on the shore of Bell Canyon Reservoir. The property is owned by the City of St. Helena. The Napa River lies 1.6 km to the west. Forested hillsides surround the reservoir, with extensive vineyard and residential development in the Napa Valley.

Ownership: public
Public observation areas: none
Latitude / Longitude: N 38.5566 / W 122.4850



Colony site description

Topography: hillside
Length x width: 50 m x 15 m
Nest substrate: Douglas fir (*Pseudotsuga menziesii*), snag
Average nest height: 33 m
Trees (dbh): not measured
Maximum tree canopy height: 42 m
Vegetation cover: tree 40%, shrub 10%, ground 0%

Evidence of disturbance

Human activity (construction): potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

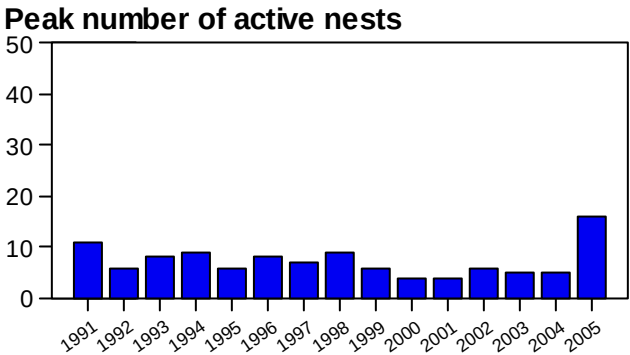
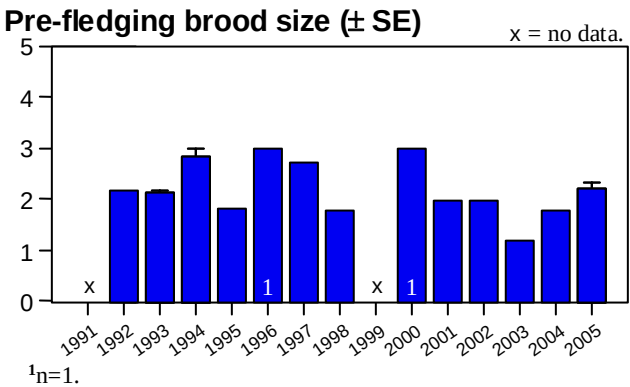
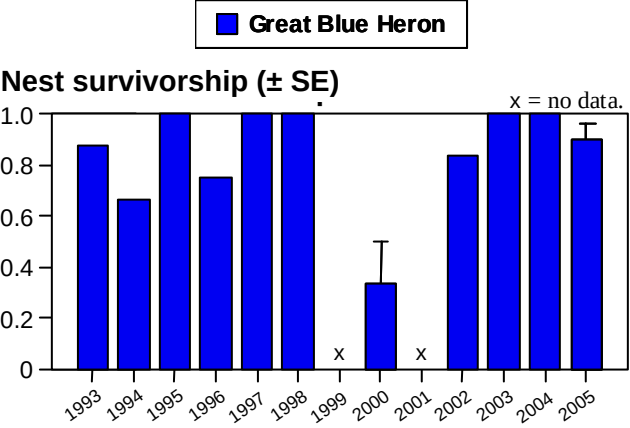
Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing				X
Vineyard			X	X

Chiles Creek

This heronry is on the bank of Lake Hennessey, near the mouth of Chiles Creek. The surrounding area is mostly steep, undeveloped scrubland. The U.S. Bureau of Land Reclamation manages the lake and surrounding recreation area. Double-crested Cormorants nest at this site, and Osprey have nested in and near the heronry.

Ownership: public
Public observation areas: Chiles-Pope Valley Rd.
Latitude / Longitude: N 38.4923 / W 122.3511



Colony site description

Topography: wetland shore, hillside
Length x width: 35 m x 10 m
Nest substrate: gray pine (*Pinus sabiniana*), snag
Average nest height: 22 m
Trees (dbh): 2 (10-50 cm)
Maximum tree canopy height: 26 m
Vegetation cover: tree 25%, shrub 0%, ground 50%

Evidence of disturbance

High winds: nest failure
Osprey: behavioral response
Common Raven: potential source^a
Bald Eagle: potential source^a
^aPossible disturbance suggested by published accounts (see references in Methods).

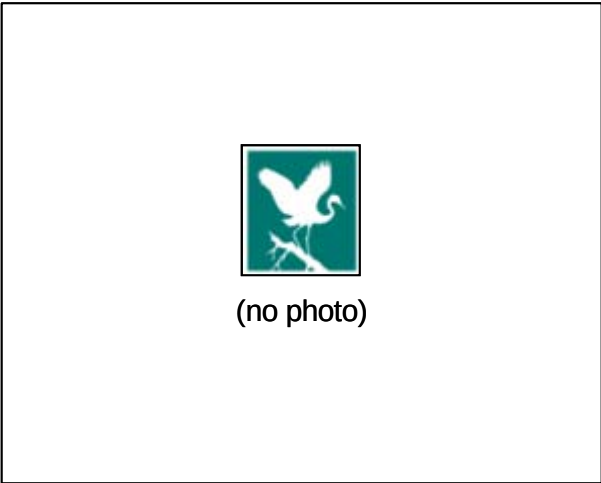
Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing				X
Protected natural area	X	X	X	X

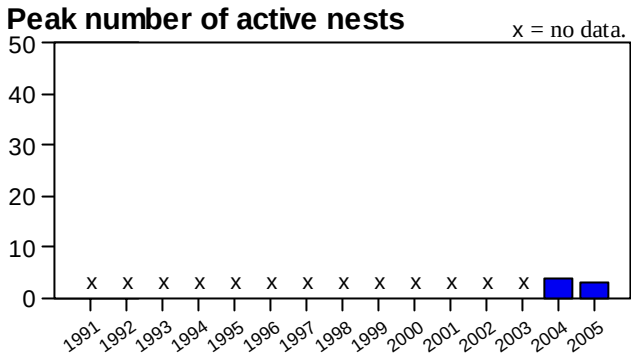
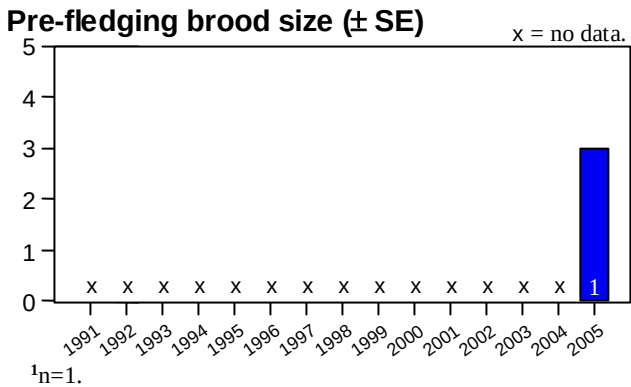
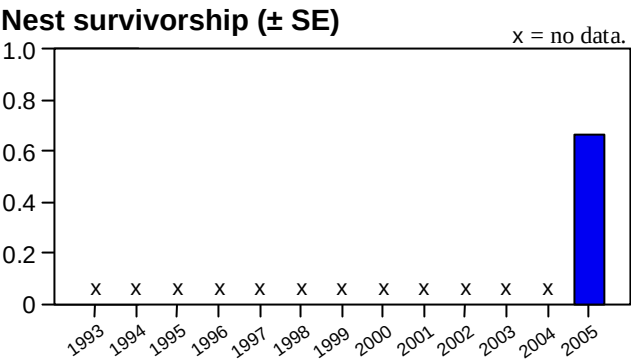
Eticuera Creek

This colony is in a gray pine on the bank of Eticuera Creek, at the northern end of Lake Berryessa. According to local residents, Great Blue Herons have nested at a number of different sites in the area since the early 1970s. Nesting at the current location was first reported in 2004. Bald Eagles also nest in the vicinity.

Ownership: private
Public observation areas: Knoxville Road
Latitude / Longitude: N 38.6805 / W 122.2757



Great Blue Heron



Colony site description

Topography: ridge top
Length x width: not measured
Nest substrate: gray pine (*Pinus sabiniana*)
Average nest height: not measured
Trees (dbh): not measured
Maximum tree canopy height: not measured
Vegetation cover: not measured

Evidence of disturbance

None recorded.

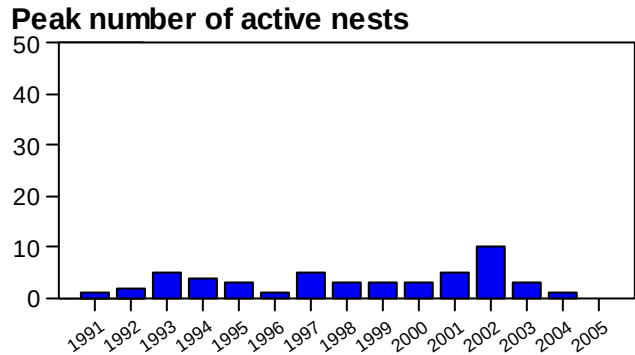
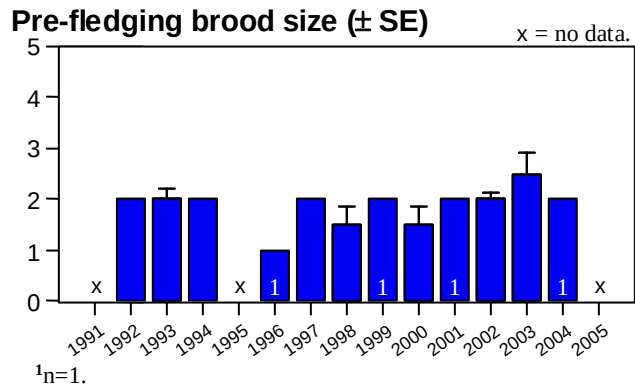
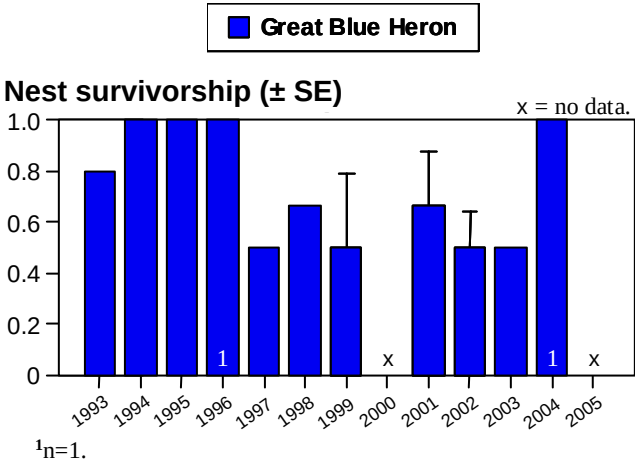
Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Protected natural area	X	X	X	X

Lake Hennessey North

Great Blue Herons have nested at various subsites on a ridge near the southwest shore of the Lake Hennessey, overlooking Conn Valley. The lake, which provides water for the City of Napa, is stocked with fish and is used by small power boats and anglers.

Ownership: unknown
Public observation areas: Conn Valley Road
Latitude / Longitude: N 38.4997 / W 122.3967



Colony site description

Topography: ridge top
Length x width: 200 m x 50 m
Nest substrate: Douglas fir (*Pseudotsuga Menziesii*, live and dead branches), snag
Average nest height: 33 m
Trees (dbh): not measured
Maximum tree canopy height: 40 m
Vegetation cover: tree 60%, shrub and ground cover not measured

Evidence of disturbance

Bald Eagle: potential source^a
^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing				X
Protected natural area	X	X	X	X

Pope Creek Bridge

Great Blue Herons nested in a gray pine on the west shore of Lake Berryessa, just south of the Pope Creek Bridge. When nest trees were damaged by wind in 1998 (photo), the herons abandoned the site, but they initiated a new subsite in 2004. The Bureau of Reclamation owns and manages the property.

Ownership: public

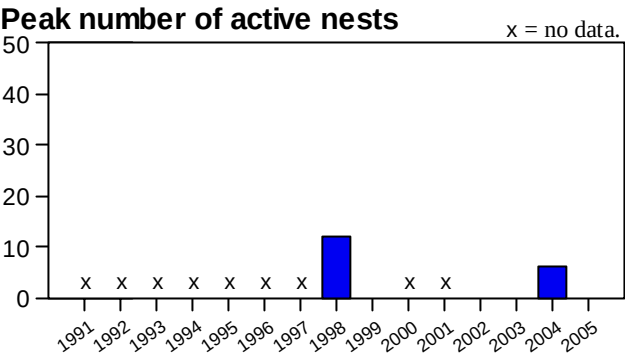
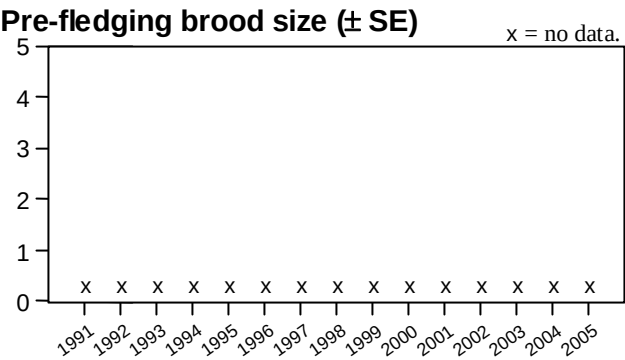
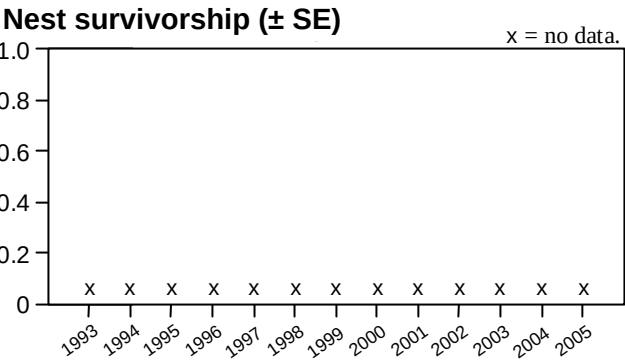
Public observation areas: none

Latitude / Longitude:

N 38.6146 / W 122.2829 (original site)



Great Blue Heron



Colony site description

Original subsite

Topography: hillside

Length x width: 30 m x 12 m

Nest substrate: gray pine (*Pinus sabiniana*)

Average nest height: not measured

Trees (dbh): 13 (3-10cm), 2 (10-50 cm), 2 (50-100cm)

Maximum tree canopy height: 16 m

Vegetation cover: tree 6%, shrub 30%, ground 16%

2004 subsite

Topography: hillside

Length x width: 12 m x 5 m

Nest substrate: gray pine (*Pinus sabiniana*)

Average nest height: 20 m

Trees (dbh): 3 (50-100 cm)

Maximum tree canopy height: 30 m

Vegetation cover: tree 30%, shrub 60%,
ground 25%

Evidence of disturbance

Wind damaged trees: colony abandonment

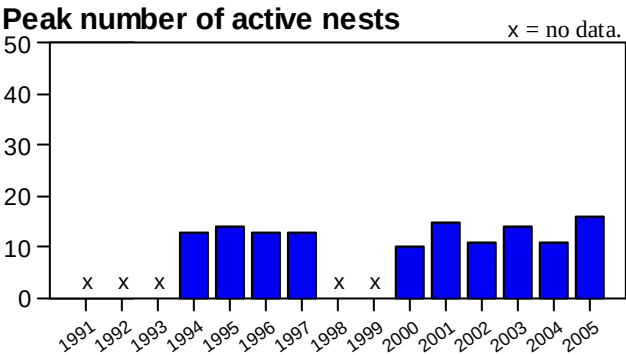
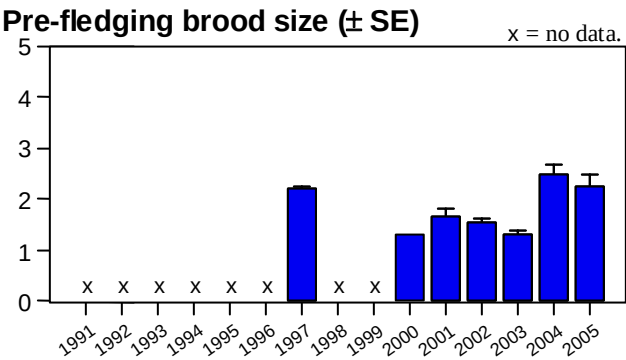
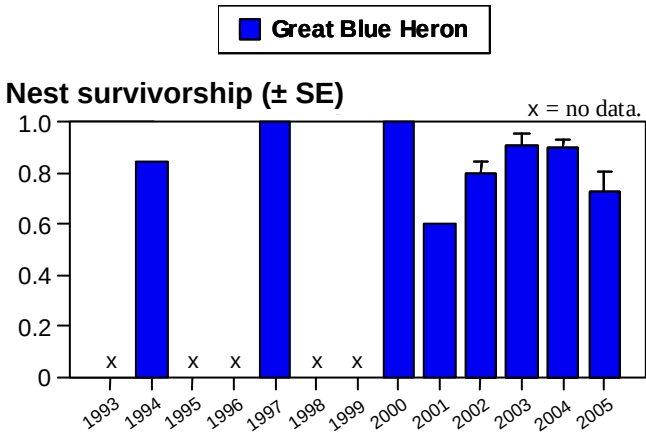
Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing		X	X	X
Mid-density housing				X
Protected natural area	X	X	X	X

Pope Valley #2

Surrounded by pastures and open woodland, this colony site is located above the flood plain of Pope Creek, about 2.3 km north of the hamlet of Pope Valley. Vineyard operations are expanding in the surrounding valley.

Ownership: private
Public observation areas: none
Latitude / Longitude: N 38.6346 / W 122.4147



Colony site description
Topography: hillside
Length x width: 20 m x 10 m
Nest substrate: gray pine (*Pinus sabiniana*, live and dead branches)
Average nest height: 20 m
Trees (dbh): 2 (50-100 cm)
Maximum tree canopy height: 25 m
Vegetation cover: tree 30%, shrub 85%, ground 15%

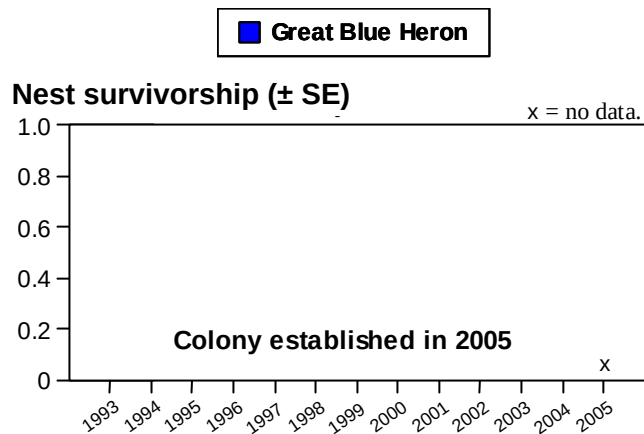
Evidence of disturbance
Nest trees dying: nest failure
Human activity (construction): behavioral response

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing		X		
Orchard				X
Grazing	X	X	X	X

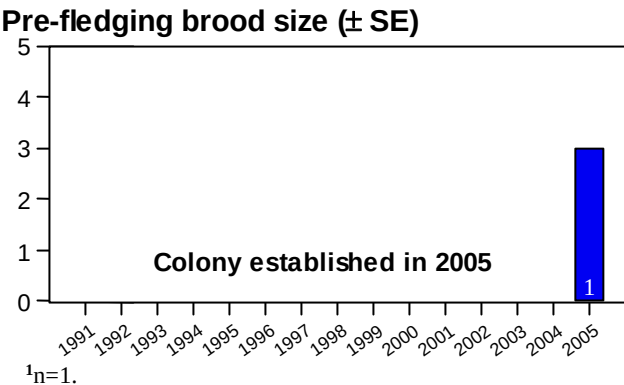
Putah Park

This colony site is located in a gray pine atop a hill on the north side of Pope Creek, several hundred meters from the Putah Park marina on Lake Berryessa.

Ownership: public
Public observation areas: hillsides north of Pope Creek Bridge
Latitude / Longitude: N 38.6203 / W 122.2892

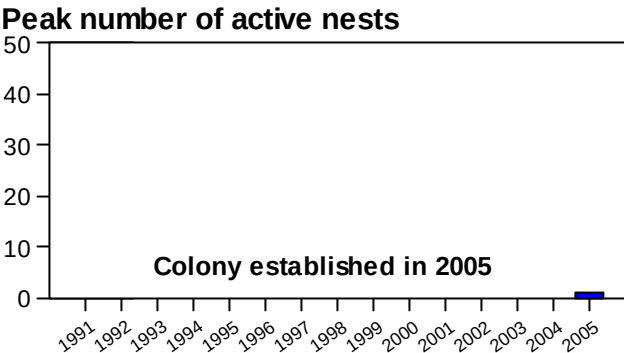


Colony site description
Topography: hillside
Length x width: 14 m x 5 m
Nest substrate: gray pine (*Pinus sabiniana*)
Average nest height: 12 m
Trees (dbh): 1 (50-100 cm)
Maximum tree canopy height: 14 m
Vegetation cover: tree 47%, shrub 0%,
ground 100%



Evidence of disturbance
None recorded.

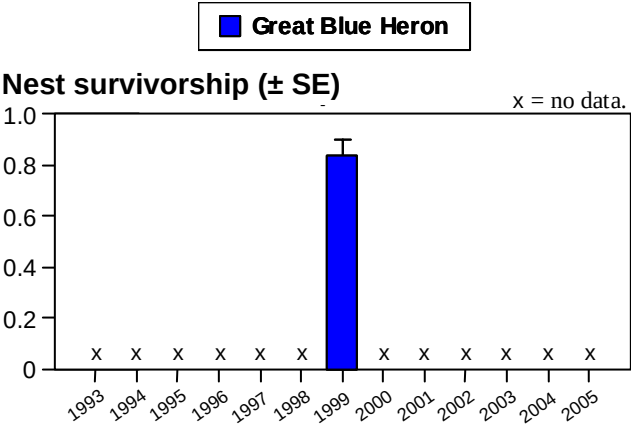
Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Mid-density housing			X	X
Protected natural area	X	X	X	X



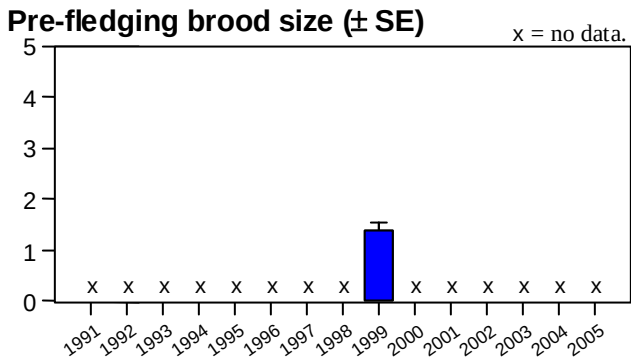
Schoolhouse Island

Schoolhouse Island is a low hummock of land close to the west shore of Lake Berryessa, just south of the mouth of Pope Creek. The grassy slopes of the island are dotted with loose stands of live oaks, blue oaks and pines. Osprey also nest in the vicinity of the colony site.

Ownership: public
Public observation areas: boat
Latitude / Longitude: N 38.6144 / W 122.2722

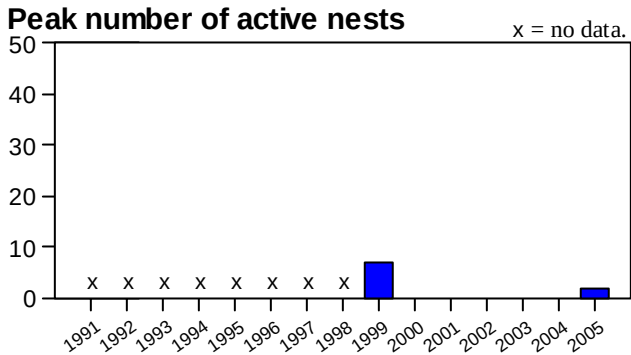


Colony site description
Topography: island (without bridge)
Length x width: 15 m x 10 m
Nest substrate: blue oak (*Quercus douglasii*)
Average nest height: 11 m
Trees (dbh): 1 (100-150 cm)
Maximum tree canopy height: 12 m
Vegetation cover: tree 50%, shrub 0%, ground 100%



Evidence of disturbance
None recorded.

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing				X
Mid-density housing				X
Protected natural area	X	X	X	X



Colony Sites with Limited Activity

Aetna Springs Road

This former colony site was a single gray pine (*Pinus sabiniana*) near the bank of Swartz Creek. The site is 0.8 km east of Aetna Springs.

Ownership: private

Public observation areas: Aetna Springs Rd.

Latitude / Longitude: N 38.6544 / W 122.4731

Species	Years known to be active (number of active nests)
Great Blue Heron	1991 (3), 1992 (4)



Capell Valley

This nesting site was in a gray pine (*Pinus sabiniana*) along Capell Creek in Capell Valley west of Highway 128. Lake Berryessa is 4.5 km to the northeast.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.4634 / W 122.2247

Species	Years known to be active (number of active nests)
Great Blue Heron	1992 (2), 1993 (2)

Conn Point

This colony was in a gray pine (*Pinus sabiniana*) on the north shore of Lake Hennessey. The tree was blown down in a storm during the winter of 2004-05. The U. S. Bureau of Reclamation manages the lake and surrounding area.

Ownership: public

Public observation areas: boat ramp

Latitude / Longitude: N 38.48704 / W 122.3636

Species	Years known to be active (number of active nests)
Great Blue Heron	2004 (4)



Colony Sites with Limited Activity (continued)

Hardin Ranch

This former colony site was located in a single gray pine (*Pinus sabiniana*), close to vineyards and pasture land. In 1992, Great Horned Owls began nesting at the colony site.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.6150 / W 122.3866

Species	Years known to be active (number of active nests)
Great Blue Heron	1992 (6), 1993 (6)

James Creek

This former colony site was located in a single gray pine (*Pinus sabiniana*) near James Creek.

Ownership: unknown

Public observation areas: none

Latitude / Longitude: N 38.6588 / W 122.4529 (estimate)

Species	Years known to be active (number of active nests)
Great Blue Heron	1992 (3)

Lake Hennessey West Shore

A pair of Great Blue Herons nested in an oak tree (*Quercus* sp.) on the western shore of Lake Hennessey.

Ownership: unknown

Public observation areas: none

Latitude / Longitude: N 38.5000 / W 122.3857

Species	Years known to be active (number of active nests)
Great Blue Heron	1993 (1)

Colony Sites with Limited Activity (continued)

Oakville Cross

Black-crowned Night-Herons nested in a live oak (*Quercus* sp.) on the side of Oakville Cross Road. Vineyards and residential homes surround the former colony site. The Napa River is 0.6 km to the west.

Ownership: private

Public observation areas: Oakville Cross Rd.

Latitude / Longitude: N 38.4438 / W 122.3882

Species	Years known to be active (number of active nests)
Black-crowned Night-Heron	1991 (6), 1993 (2)



Olive Orchard

Great Blue Herons nested in a gray pine (*Pinus sabiniana*) along Knoxville Road at the south end of Lake Berryessa, close to the outlet of Capell Creek.

Ownership: unknown

Public observation areas: Knoxville Road

Latitude / Longitude: N 38.5110 / W 122.2339

Species	Years known to be active (number of active nests)
Great Blue Heron	1999 (1)

Wragg Canyon

A pair of Great Blue Herons nested in a gray pine (*Pinus sabiniana*) on a forested hillside approximately 0.5 km from Lake Berryessa.

Ownership: public

Public observation areas: by boat from the lake

Latitude / Longitude: N 38.5160 / W.122.1757

Species	Years known to be active (number of active nests)
Great Blue Heron	1992 (1)

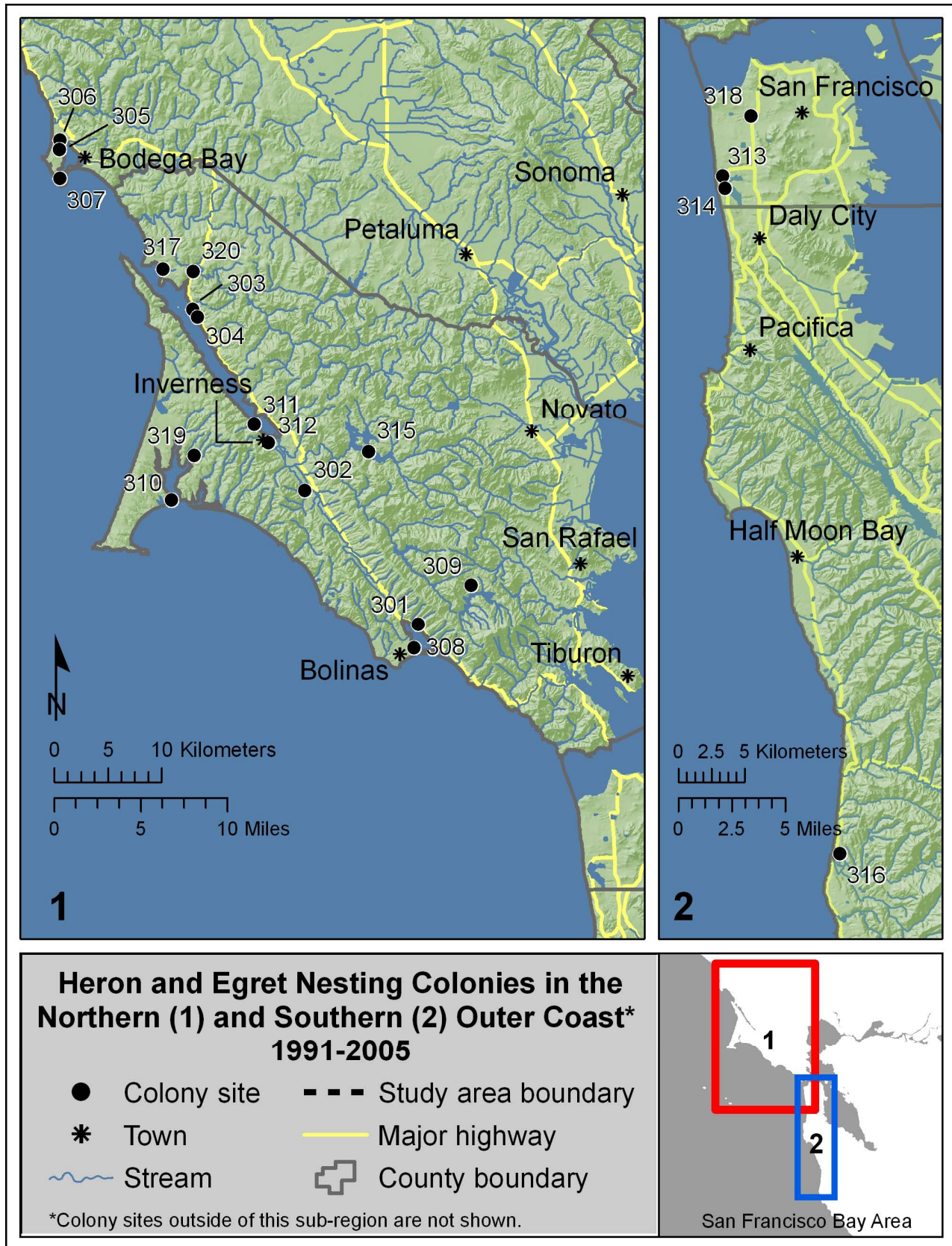
OUTER PACIFIC COAST



OUTER PACIFIC COAST

Heronries on the coastal slope of the Outer Coast Ranges are subject to relatively cool, moist conditions. Herons and egrets in this subregion nest primarily near prominent estuaries. North of San Francisco, several estuaries form a wetland complex that includes Bodega Harbor, Tomales Bay, Drakes and Limantour esteros, and Bolinas Lagoon. The most prominent estuary south of San Francisco is Pescadero Marsh. Most of the Outer Coastal slope rises sharply from rocky shores, beaches, and coastal wetlands into steep, forested hillsides and ridges. Much of the subregion is protected from further development by national parks, state parks, municipal watersheds, or agricultural easements. In contrast, the San Francisco portion of the subregion is a highly urbanized landscape, where Great Blue Herons occupy colony sites near constructed wetlands.

Site #	Colony Site	Great Blue Heron	Great Egret	Snowy Egret	Black-crowned Night-Heron	Cattle Egret	County	Active or year last active	Page
301	Audubon Canyon Ranch, Picher Canyon	■	□	■			Marin	Active	82
302	Bear Valley	■					Marin	Active	84
303	Blakes Landing North	■					Marin	2000	100
304	Blakes Landing South	■	□				Marin	Active	85
305	Bodega Flat Road #1	■	□	■	■		Sonoma	Active	86
306	Bodega Flat Road #2	■	□				Sonoma	1992	100
307	Bodega Hole-in-the-Head				■		Sonoma	1992	100
308	Bolinas	■					Marin	1998	88
309	Bolinas-Fairfax Road	■					Marin	1998	89
310	Drakes Estero	■	□				Marin	Active	90
311	Inverness Boat Launch				■		Marin	Active	91
312	Inverness Park	■	□				Marin	Active	92
313	Lake Merced North	■					San Francisco	Active	93
314	Lake Merced South	■					San Francisco	Active	94
315	Lake Nicasio	■					Marin	1992	101
316	Pescadero Marsh	■					San Mateo	1994	101
317	Sand Point	■	□				Marin	Active	95
318	Stow Lake	■					San Francisco	Active	97
319	Tree Farm	■	□				Marin	Active	98
320	Walker Creek	■					Marin	Active	99



Audubon Canyon Ranch, Picher Canyon

Hérons and egrets have probably nested at ACR's Picher Canyon since the early 20th Century. Reproductive performance has been monitored since 1967 (Pratt and Winkler 1985). This heronry has continued to flourish despite repeated nest predation by Golden Eagles and Common Ravens.

Ownership: private

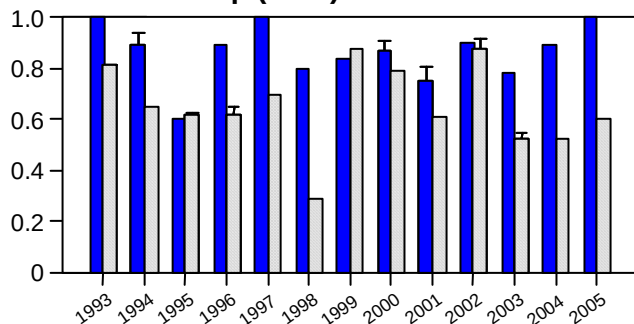
Public observation areas: Bolinas Lagoon Preserve

Latitude / Longitude: N 37.9301 / W 122.6807

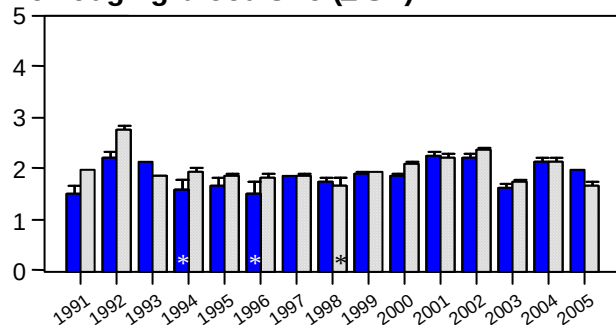


■ Great Blue Heron □ Great Egret

Nest survivorship ($\pm$ SE)

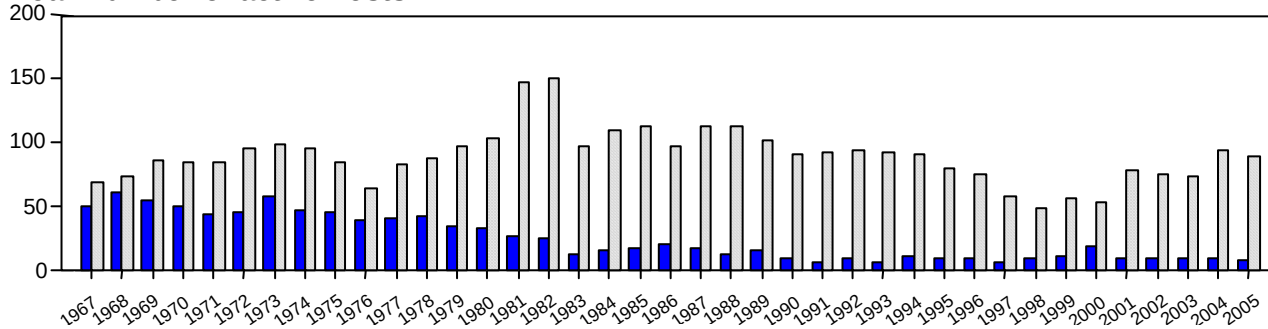


Pre-fledging brood size ($\pm$ SE)



*n<10 and n<50% of total nests.

Peak number of active nests



(continued)

Colony site description

Lower subsite

Topography: flood plain

Length x width: 17 m x 12 m

Nest substrate: coast redwood (*Sequoia sempervirens*)

Average nest height: 33 m

Trees (dbh): 5 (10-50 cm), 3 (100-150 cm),
1 (> 150 cm)

Maximum tree canopy height: 36 m

Vegetation cover: tree 50%, shrub 15%,
ground 20%

Upper subsite

Topography: flood plain

Length x width: 40 m x 21 m

Nest substrate: coast redwood (*Sequoia sempervirens*)

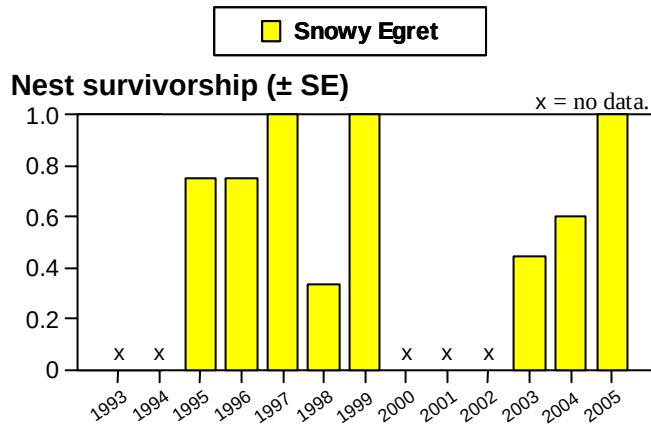
Average nest height: 32 m

Trees (dbh): 8 (3-50 cm), 6 (50-100 cm), 19 (100-
150 cm), 1 (> 150 cm)

Maximum tree canopy height: 38 m

Vegetation cover: tree 55%, shrub 13%, ground 18%

Audubon Canyon Ranch, Picher Canyon (continued)



Evidence of disturbance

Resident ravens: nest failure

Raccoons: nest failure

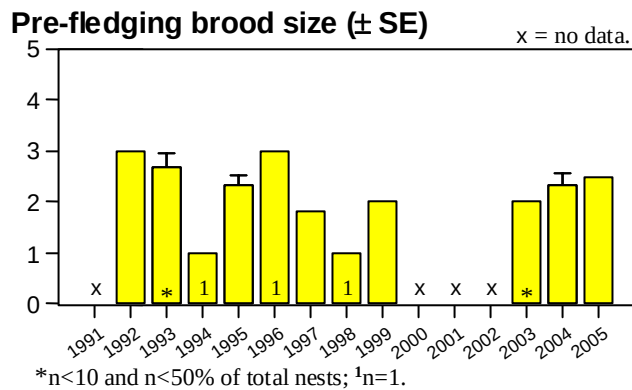
Golden Eagle: nest failure

Red-tailed Hawk: behavioral response

Osprey: potential source^a

Human activity: potential source^a

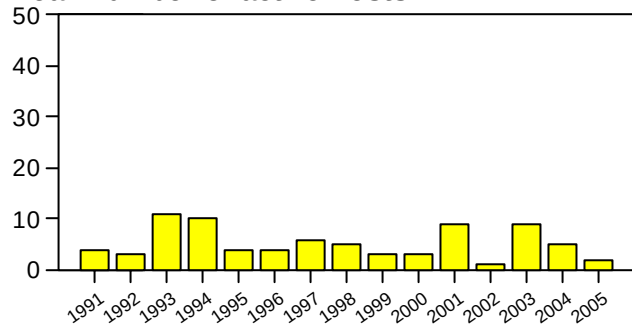
^aPossible disturbance suggested by published accounts (see references in Methods).



Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X		X	X
Protected natural area	X	X	X	X

Peak number of active nests



Bear Valley

The Bear Valley colony site is near the Point Reyes National Seashore Bear Valley Visitor's Center. Nesting has occurred at two sites, both in Douglas firs. The north site borders the parking lot west of park headquarters. The south site is 20 m north of the access road along a trail between park headquarters and the visitor's center. This portion of the park is heavily used by people, with staff housing, offices, maintenance facilities, trails, roads, and visitor facilities, all within 200 m of the colony.

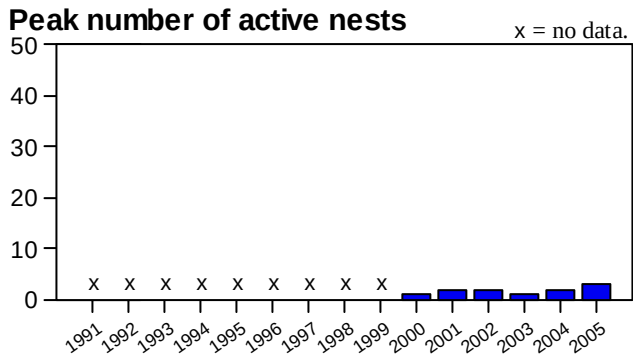
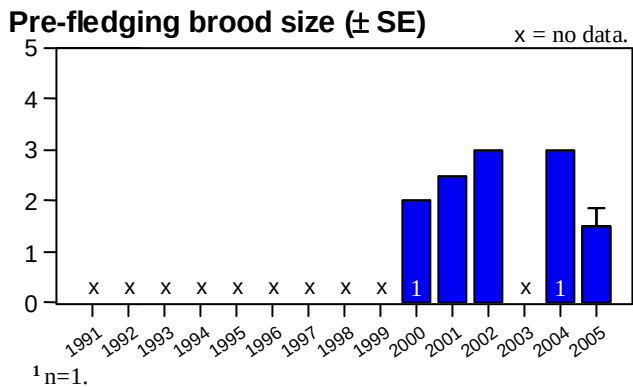
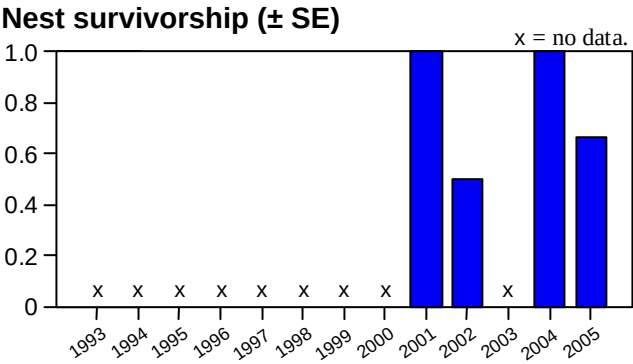
Ownership: public

Public observation areas: from trail

Latitude / Longitude: N 38.0424 / W 122.7993



Great Blue Heron



Colony site description

South subsite

Topography: flood plain
Length x width: 8 m x 7 m
Nest substrate: Douglas fir (*Pseudotsuga menziesii*)
Average nest height: 45 m
Trees (dbh): 2 (> 150 cm)
Maximum tree canopy height: not measured
Vegetation cover: tree 90%, shrub 0%, ground 98%

North subsite

Topography: flood plain
Length x width: 9 m x 6 m
Nest substrate: Douglas fir (*Pseudotsuga menziesii*)
Average nest height: not measured
Trees (dbh): 2 (3-10cm), 3 (50-100cm), 1 (> 150 cm)
Maximum tree canopy height: not measured
Vegetation cover: tree 59%, shrub 53%,
ground 35%

Evidence of disturbance

Human activity (visitor traffic): potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Mid-density housing	X			X
Protected natural area	X	X	X	X

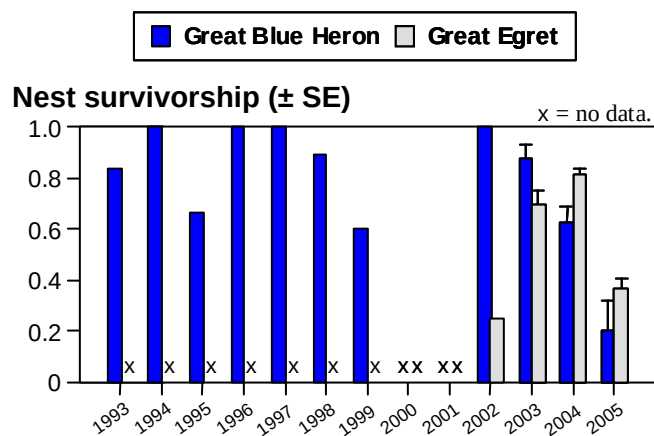
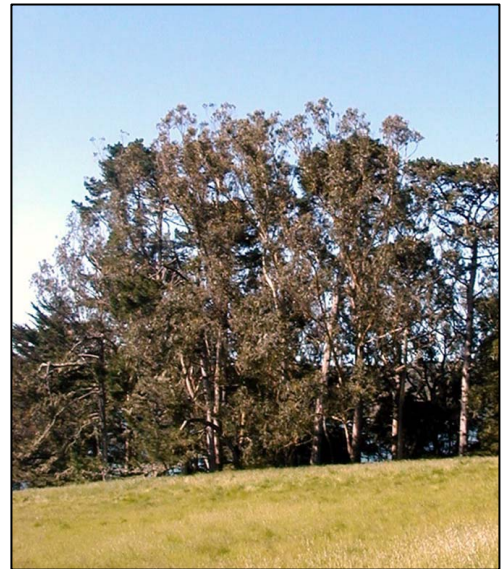
Blakes Landing South

This colony site borders a pasture for dairy cattle along Highway 1. The canopy is open, and thick grasses grow underneath the nesting trees. The colony is 20 m from the highway and 69 m from Tomales Bay. The nearest residence is about 75 m from the colony.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.1894 / W 122.9134



Colony site description

Topography: hillside

Length x width: 32 m x 18 m

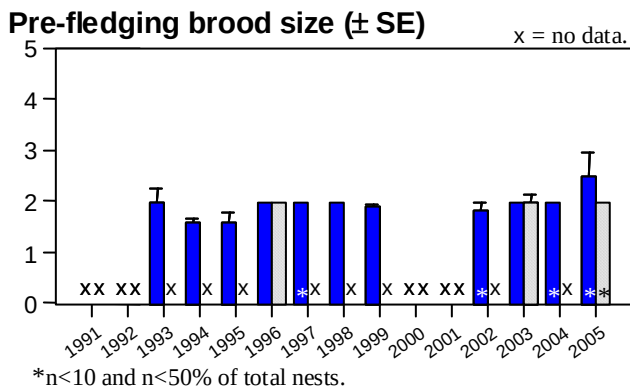
Nest substrate: Monterey pine (*Pinus radiata*),
Eucalyptus sp.

Average nest height: 23 m

Trees (dbh): 4 (10-50 cm), 8 (50-100 cm), 3 (100-150 cm)

Maximum tree canopy height: not measured

Vegetation cover: tree 39%, shrub 0%,
ground 98%



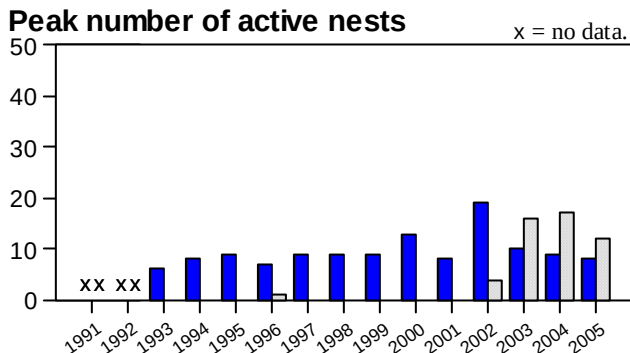
Evidence of disturbance

Resident ravens: behavioral response

Human activity (observers): behavioral response

Human activity (construction): potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).



Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X	X	X	X
Grazing	X	X	X	X

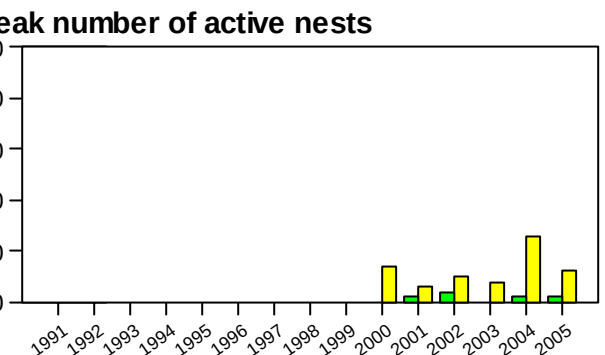
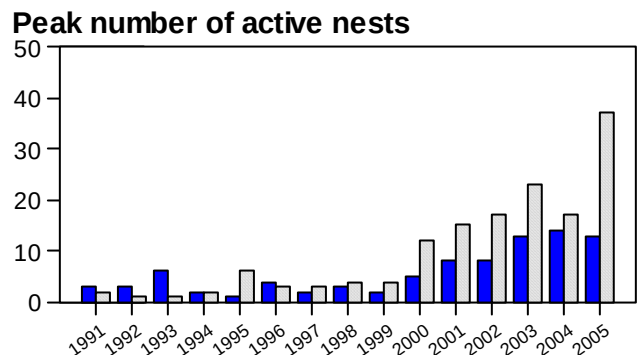
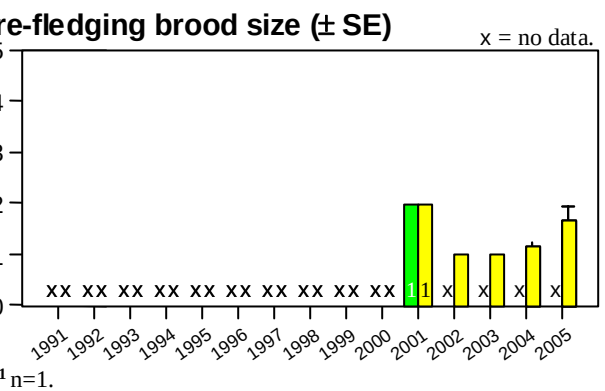
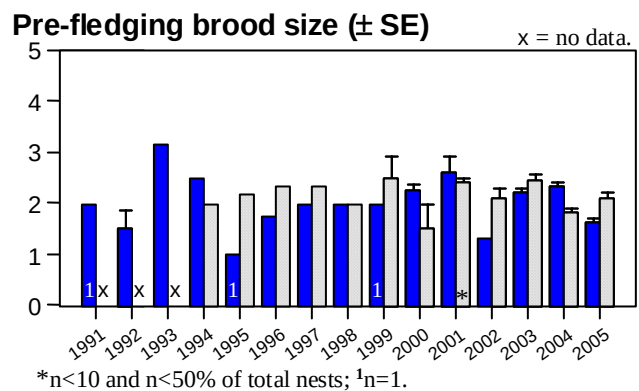
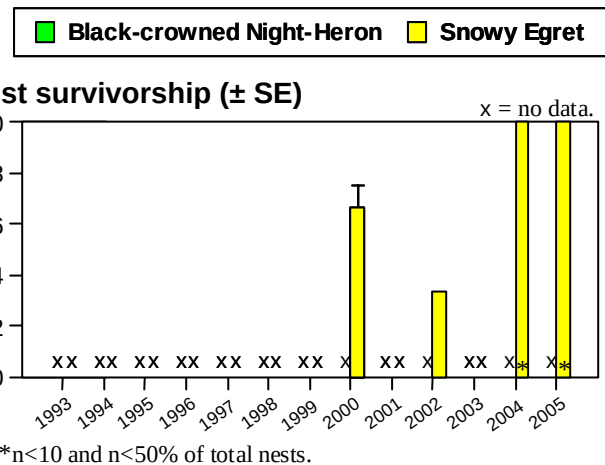
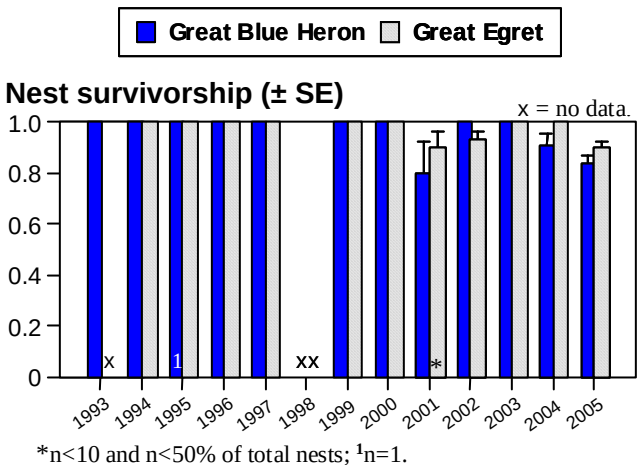
Bodega Flat Road #1

This colony is on a bluff above Bodega Flat Road, 125 m west of the west shore of Bodega Harbor. Much of the surrounding area is undeveloped scrubland. The nest sites are limited to a few stands of large trees behind the residential area near the harbor.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.3294 / W 123.0599



(continued)

Bodega Flat Road #1 (continued)

Colony site description

Topography: ridge

Length x width: 45 m x 20 m

Nest substrate: *Eucalyptus* sp., Monterey cypress
(*Cupressus macrocarpa*)

Average nest height: 20 m

Trees (dbh): 16 (3-50 cm), 22 (50-100 cm), 2 (> 100cm)

Maximum tree canopy height: 24 m

Vegetation cover: tree 46%, shrub 0%, ground 10%

Evidence of disturbance

Great Horned Owl: nest failure

Trees cut in preseason: potential source^a

Red-tailed Hawk: potential source^a

Common Raven: potential source^a

Human activity: potential source^a

^aPossible disturbance suggested by published accounts
(see references in Methods).

Land use

	Distance from colony site (m)			
	0- 100	100- 200	200- 500	500- 1000
Land use				
Low density housing	X	X	X	X

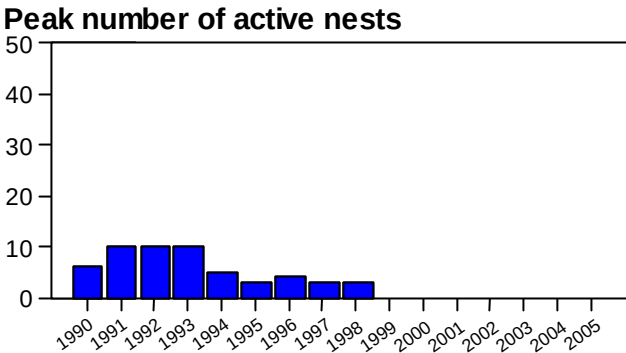
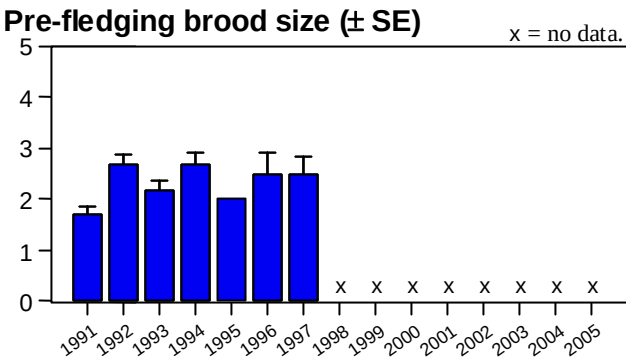
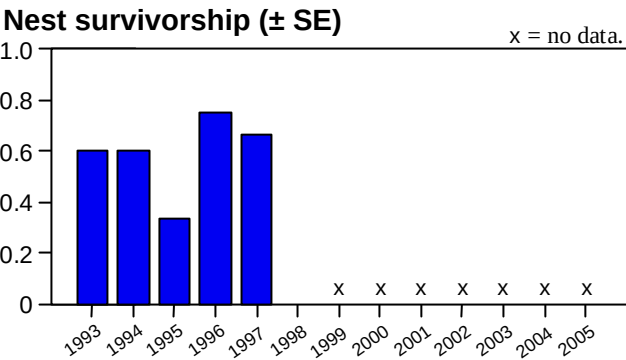
Bolinas

This colony was established after a Golden Eagle apparently caused Great Blue Herons nesting at Audubon Canyon Ranch to relocate across Bolinas Lagoon. The site is in downtown Bolinas, 12 m from the Lagoon. The colony site was abandoned in 1997 after local residents cut down some of the nesting trees because of safety concerns.

Ownership: private

Public observation areas: downtown Bolinas

Latitude / Longitude: N 37.9111 / W 122.6850



Colony site description

Topography: hillside
 Length x width: 25 m x 10 m
 Nest substrate: Monterey pine (*Pinus radiata*)
 Average nest height: 20 m
 Trees (dbh): 4 (50-100 cm)
 Maximum tree canopy height: 24 m
 Vegetation cover: tree 40%, shrub 5%, ground 15%

Evidence of disturbance

Human activity (removal of nesting trees): colony abandonment
 Storm damage: nest failure
 Human activity (firecrackers): behavioral response
 Human activity (low flying helicopters): behavioral response
 Human activity (construction): behavioral response
 Red-tailed Hawk: potential source^a
 Golden Eagle: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing		X	X	X

Bolinas-Fairfax Road

The presence of this heronry near the Marin Municipal Water District lakes suggests that other small, undiscovered colonies of nesting Great Blue Herons could occur in the interior of Marin County. The tall redwoods and a forested landscape provide nesting birds some isolation from human activity and predators.

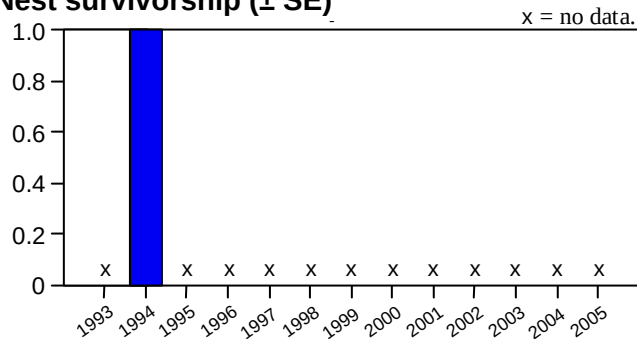
Ownership: private

Public observation areas: none

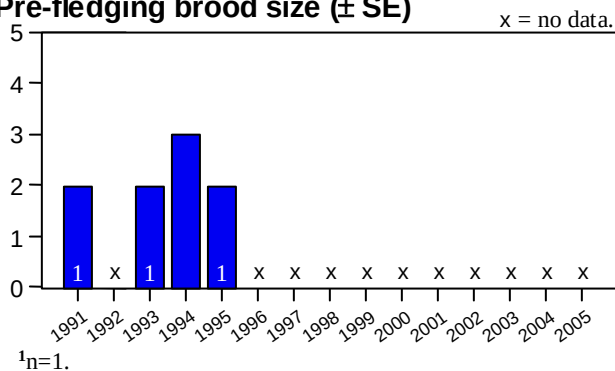
Latitude / Longitude: N 37.9633 / W 122.6243

Great Blue Heron

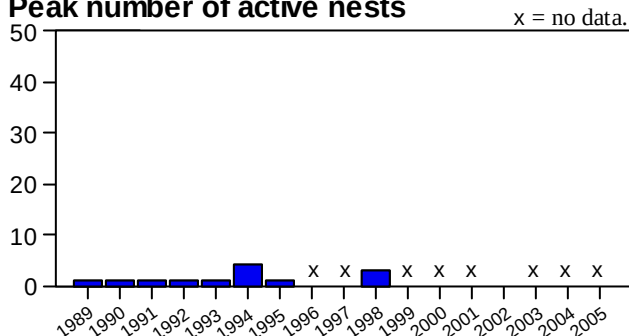
Nest survivorship ($\pm$ SE)



Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



(no photo)

Colony site description

Topography: hillside

Length x width: 15 m x 3 m

Nest substrate: coast redwood (*Sequoia sempervirens*)

Average nest height: 35 m

Trees (dbh): 14 (3-50 cm), 2 (50-100 cm), 10 (> 100cm)

Maximum tree canopy height: 45 m

Vegetation cover: tree 90%, shrub 0%, ground 10%

Evidence of disturbance

Human activity: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

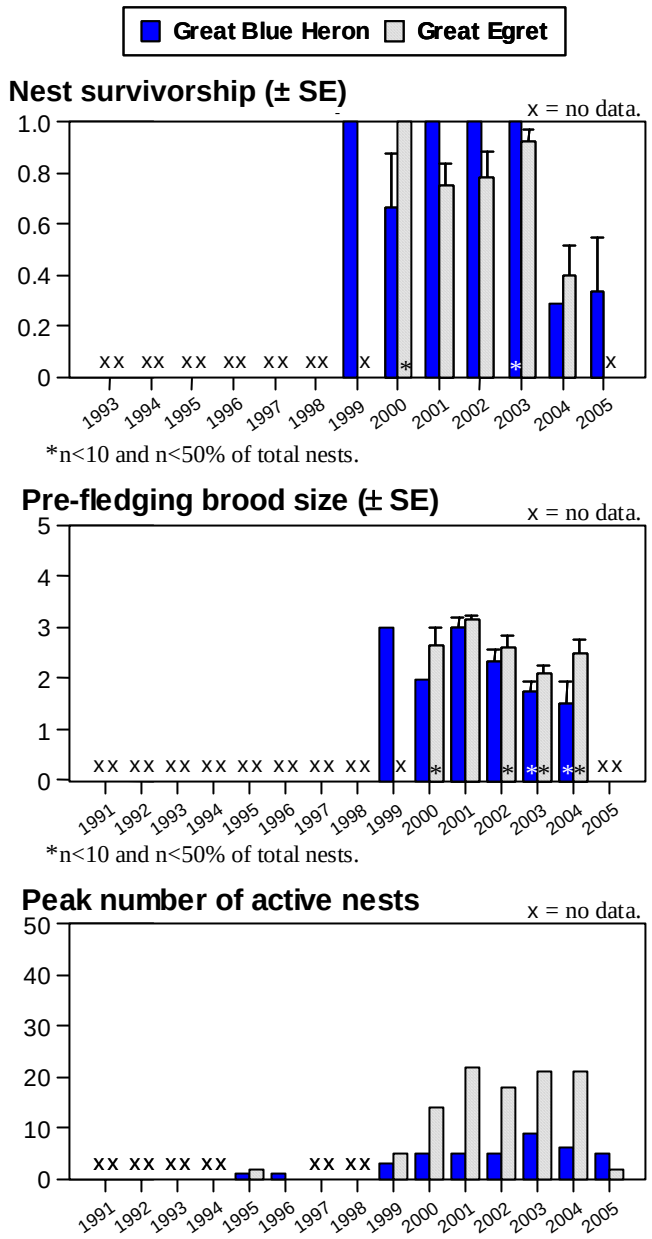
Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X	X	X	X

Drakes Estero

This colony site is on the west shore of Drakes Estero in the Point Reyes National Seashore. An old ranch road runs directly under the site and a constructed farm pond is nearby. Most of the surrounding area is grazed and devoid of large trees. Common Ravens have nested in the colony.

Ownership: public
Public observation areas: estero shore
Latitude / Longitude: N 38.0352 / W 122.9410



Colony site description

Topography: hillside
Length x width: 16 m x 16 m
Nest substrate: Bishop pine (*Pinus muricata*)
Average nest height: 21 m
Trees (dbh): 3 (10-50 cm), 6 (50-100 cm)
Maximum tree canopy height: 27 m
Vegetation cover: tree 30%, shrub 0%, ground 95%

Evidence of disturbance

Resident Great Horned Owls: nest failure
Resident ravens: behavioral response
Human activity (hikers and researchers): behavioral response
Red-tailed Hawk: potential source^a
^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0- 100	100- 200	200- 500	500- 1000
Grazing		X	X	X
Protected natural area	X	X	X	X

Inverness Boat Launch

Black-crowned Night-Herons nest in a patch tan oaks, 9 m from the west shore of Tomales Bay and 150 m north of downtown Inverness. The nest trees grow between the bay and Sir Francis Drake Highway.

Ownership: private

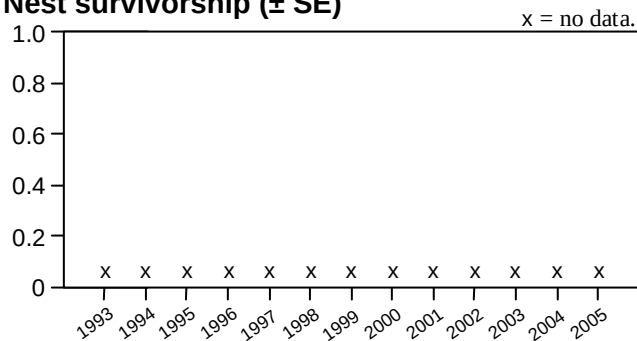
Public observation areas: from Sir Francis Drake Highway

Latitude / Longitude: N 38.0986 / W 122.8530



Black-crowned Night-Heron

Nest survivorship ($\pm$ SE)



Colony site description

Topography: hillside

Length x width: 10 m x 7 m

Nest substrate: tan oak (*Lithocarpus densiflorus*)

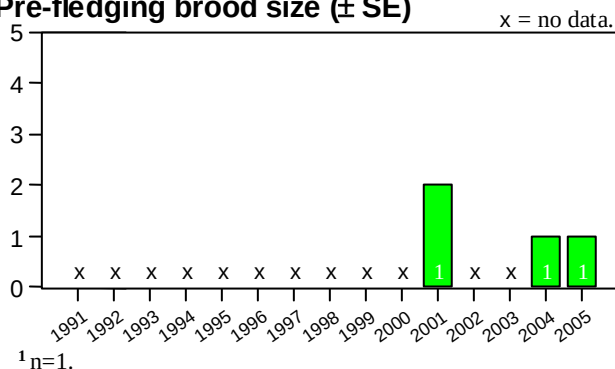
Average nest height: 15 m

Trees (dbh): 1 (10-50 cm)

Maximum tree canopy height: not measured

Vegetation cover: tree 88%, shrub 0%, ground 45%

Pre-fledging brood size ($\pm$ SE)



Evidence of disturbance

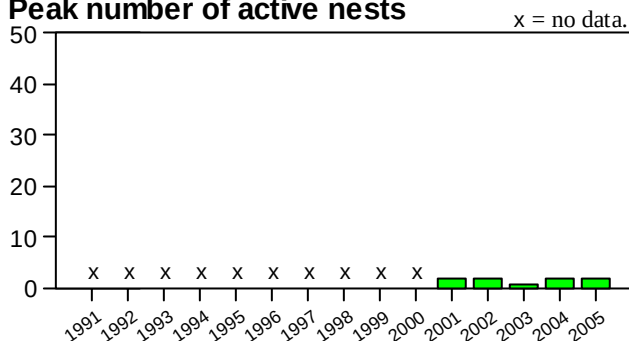
Human activity (tree pruning): nest failure

American Crow: nest failure

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X	X	X	X
Mid-density housing		X	X	X

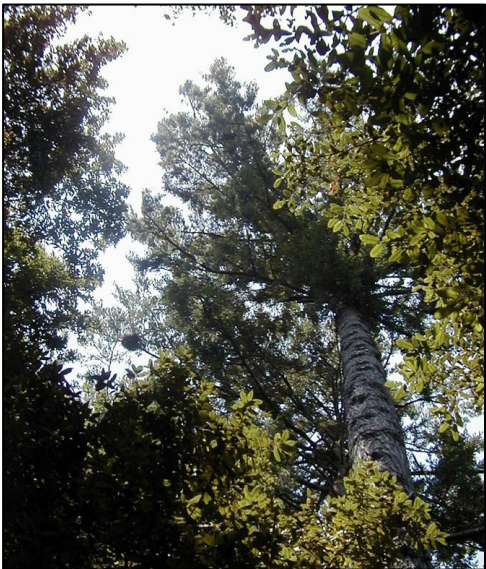
Peak number of active nests



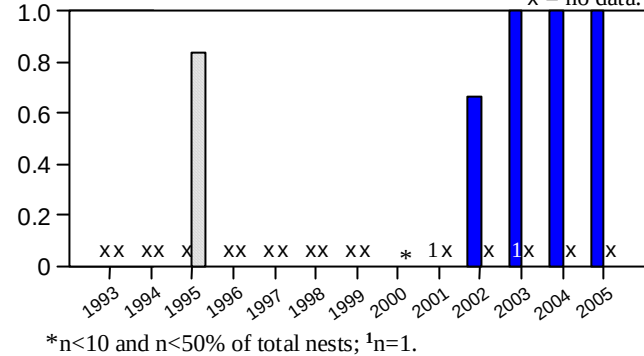
Inverness Park

This colony site is in a mature grove of Douglas fir and coast redwood on a lower ridge in Inverness Park. The upper ridge above the colony is part of Tomales Bay State Park. These nests are about 50 m from the nearest home and 260 m from Tomales Bay. (Records prior to 1990 are from Shuford 1993.)

Ownership: private
Public observation areas: none
Latitude / Longitude: N 38.0829 / W 122.8384



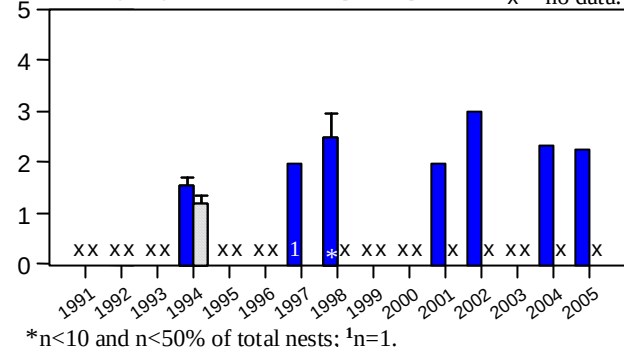
Nest survivorship (± SE)



Colony site description

Topography: ridge
Length x width: 15 m x 11 m
Nest substrate: coast redwood (*Sequoia sempervirens*), Douglas fir (*Pseudotsuga menziesii*)
Average nesting height: 27 m
Trees (dbh): 2 (3-10cm), 1 (100-150 cm)
Maximum tree canopy height: 35 m
Vegetation cover: tree 20%, shrub 13%, ground 5%

Pre-fledging brood size (± SE)



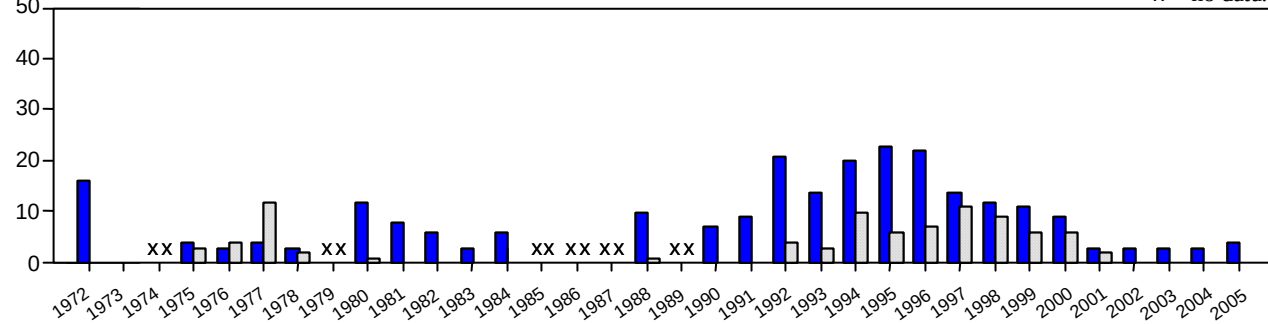
Evidence of disturbance

Resident ravens: nest failure
Storm damage to nests: nest failure

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X	X	X	X

Peak number of active nests



Lake Merced North

Lake Merced is in Harding Park across Skyline Boulevard from the San Francisco Zoo. Great Blue Herons nest with Double-crested Cormorants in eucalyptus trees overhanging the lake. The under-story consists of bulrush and locust along a steep bank. Much of the surrounding area is city parkland, a golf course, and urban residential neighborhoods.

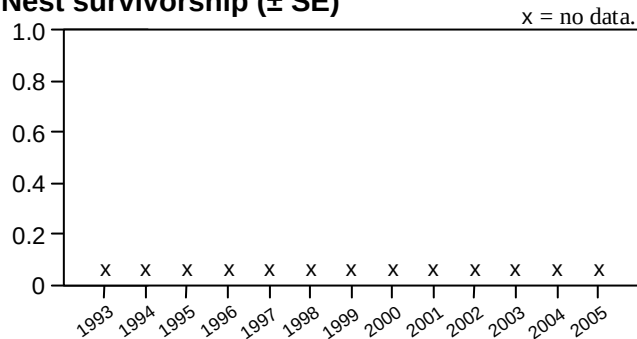
Ownership: public

Public observation areas: picnic area on lakeshore

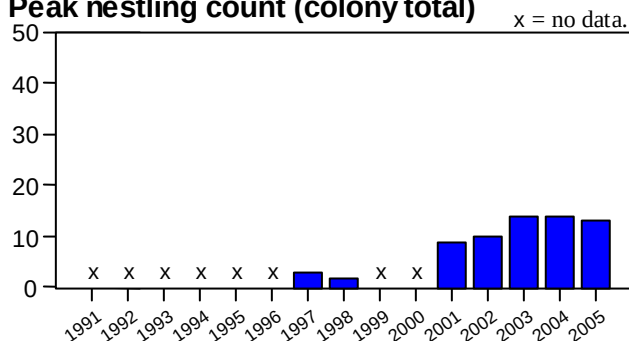
Latitude / Longitude: N 37.7292 / W 122.5013

 Great Blue Heron

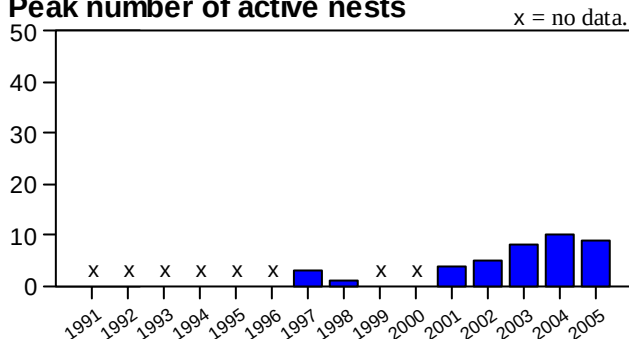
Nest survivorship ($\pm$ SE)



Peak nestling count (colony total)



Peak number of active nests



(no photo)

Colony site description

Topography: wetland shore

Length x width: 49 m x 4 m

Nest substrate: *Eucalyptus* sp. (live and dead branches)

Average nest height: 19 m

Trees (dbh): 21 (3-50 cm), 7 (50-100 cm), 5 (>100 cm)

Maximum tree canopy height: 30 m

Vegetation cover: tree 65%, shrub 0%, ground 0%

Evidence of disturbance

None reported.

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
High density housing			X	X
Protected natural area	X	X	X	X
Sports field				X

Lake Merced South

Lake Merced forms the largest coastal freshwater marsh between the Marin Headlands to the north and Pescadero to the south. Great Blue Herons nest with Double-crested Cormorants in eucalyptus trees overhanging the lake. Much of the surrounding area is city parkland, a golf course, and urban residential neighborhoods.

Ownership: public

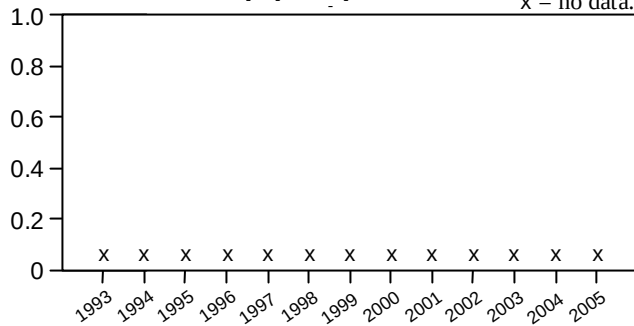
Public observation areas: picnic area on lakeshore

Latitude / Longitude: N 37.7209 / W 122.4992

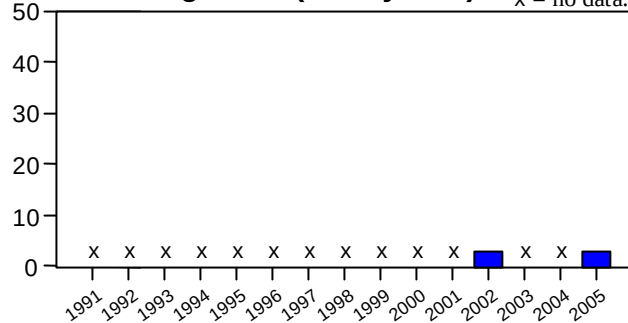


Great Blue Heron

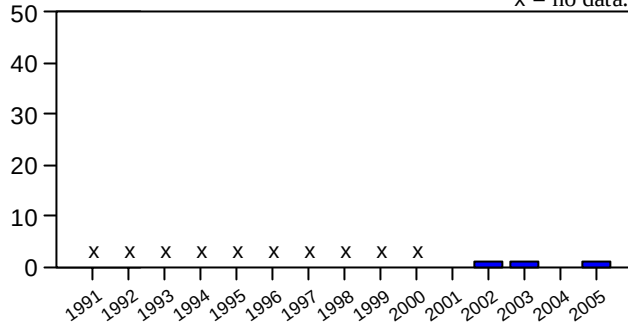
Nest survivorship ($\pm$ SE)



Peak nestling count (colony total)



Peak number of active nests



Colony site description

Topography: wetland shore

Length x width: not measured

Nest substrate: *Eucalyptus* sp.

Average nest height: 19 m

Trees (dbh): not measured

Maximum tree canopy height: not measured

Vegetation cover: not measured

Evidence of disturbance

Resident ravens: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial	X	X		
High density housing			X	X
Protected natural area			X	X
Sports field				X

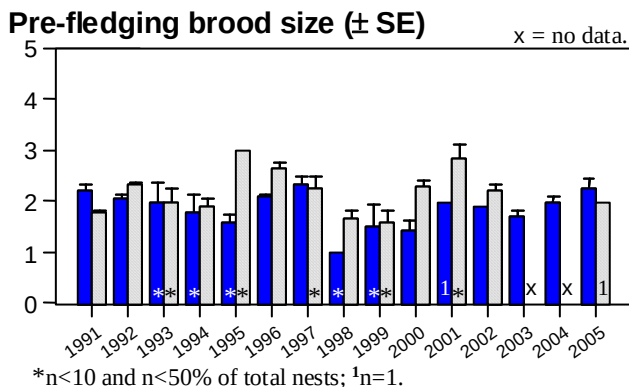
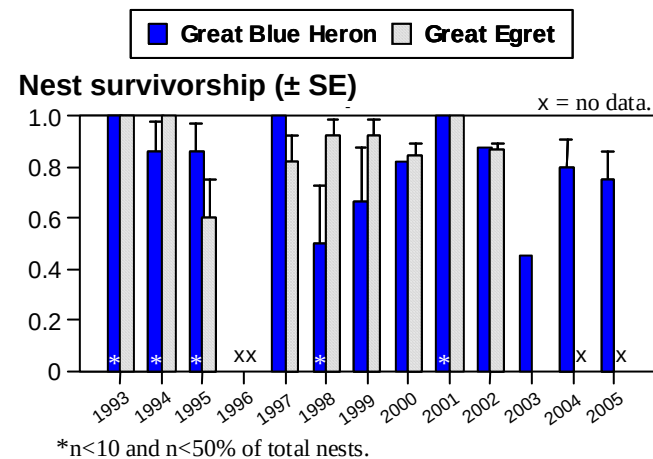
Sand Point

This colony site is in a eucalyptus grove on the eastern shore of Tomales Bay, near the mouth of the bay. Surrounded by coastal dune scrub and grasslands, this grove is one of the only stands of large trees in the vicinity. In 2004, herons and egrets established nest sites away from the center of the grove in the outer canopy of the trees. (Records prior to 1990 are from Shuford 1993.)

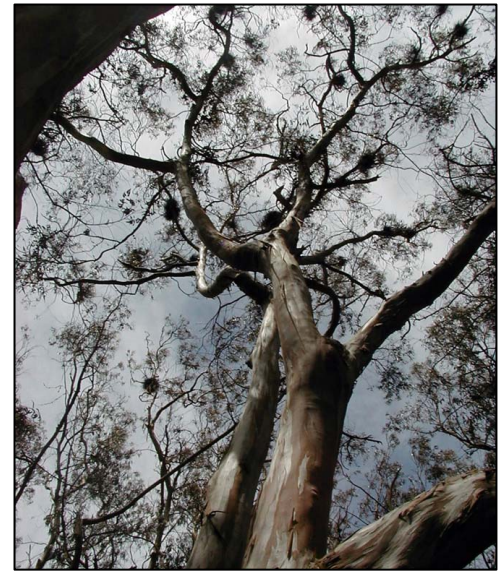
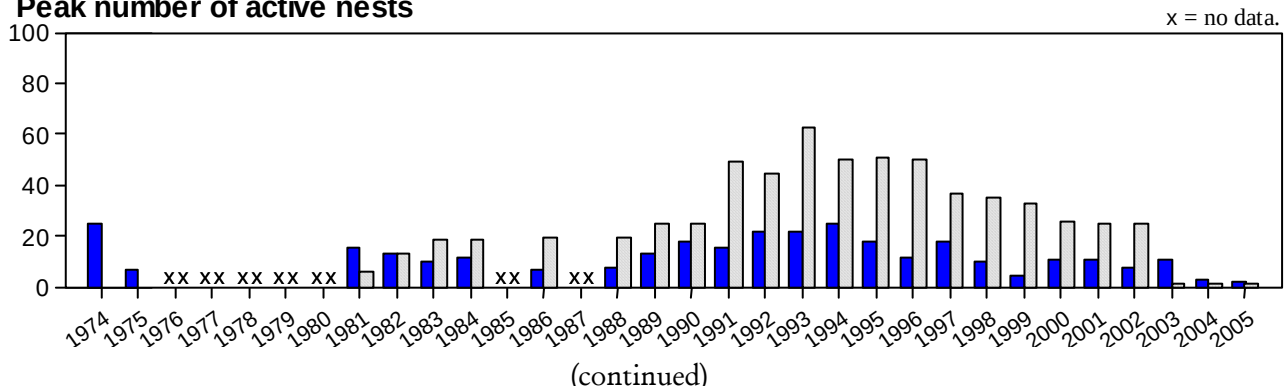
Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.2305 / W 122.9497 (original site)



Peak number of active nests



Colony site description

Original site

Topography: hillside

Length x width: 45 m x 29 m

Nest substrate: *Eucalyptus* sp.

Average nest height: 24 m

Trees (dbh): 11 (50-100 cm), 1 (> 150 cm)

Maximum tree canopy height: 29 m

Vegetation cover: tree 37%, shrub 0%, ground 98%

Outer Canopy 1 subsite

Topography: wetland

Length x width: 21 m x 9 m

Nest substrate: *Eucalyptus* sp.

Average nest height: 20 m

Trees (dbh): 3 (3-50 cm), 4 (50-100 cm),
2 (100-150 cm)

Maximum tree canopy height: 26 m

Vegetation cover: tree 35%, shrub 20%,
ground 95%

Sand Point (continued)

Colony site description (continued)

Outer Canopy 2 subsite

Topography: hillside

Length x width: 37 m x 5 m

Nest substrate: *Eucalyptus* sp.

Average nest height: 33 m

Trees (dbh): 7 (3-10 cm), 5 (10-50 cm),
10 (50-100 cm)

Maximum tree canopy height: 36 m

Vegetation cover: tree 35%, shrub 1%, ground 0%



Evidence of disturbance

Resident Great Horned Owl: nest failure

Resident ravens: nest failure

Human activity (ATVs and researchers): behavioral response

Resident Red-tailed Hawk: potential source^a

^aPossible disturbance suggested by published accounts
(see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing		X	X	X
Grazing		X	X	X

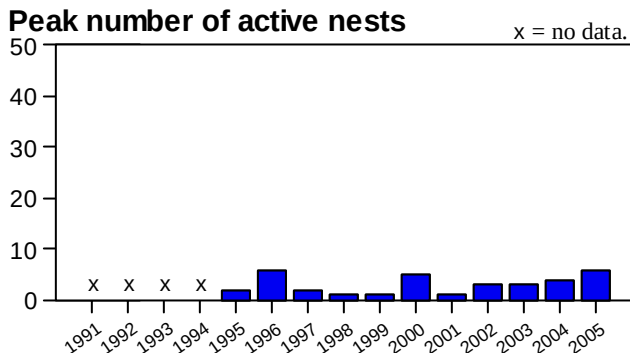
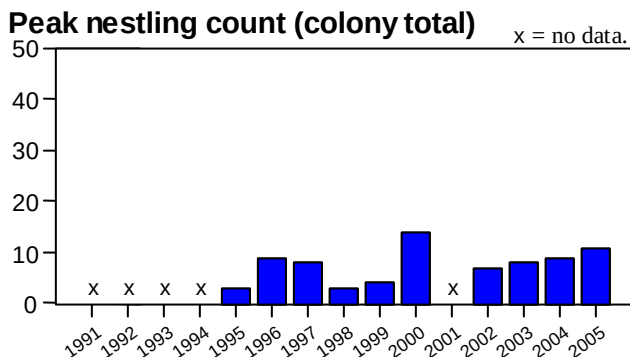
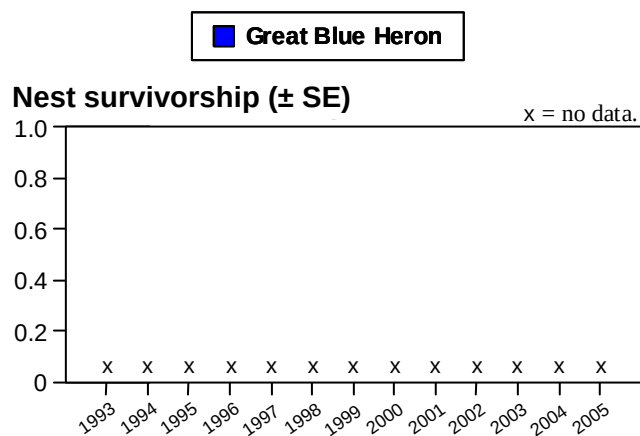
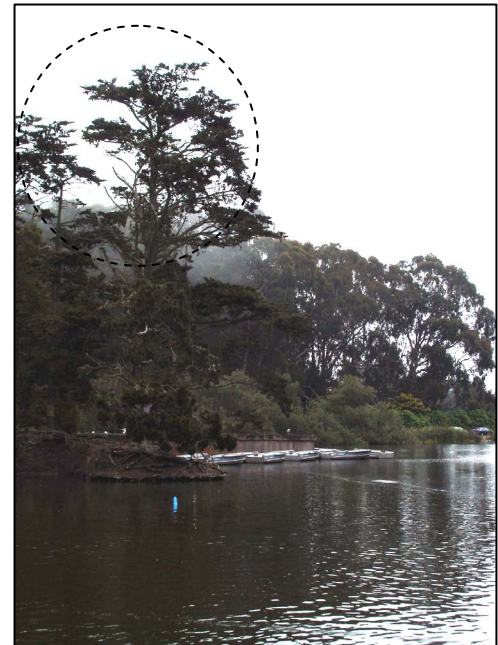
Stow Lake

Stow Lake is in Golden Gate Park in San Francisco. Great Blue Herons nest on Heron Island near the boathouse and occasionally on Strawberry Island in the middle of the lake. San Francisco Nature Education conducts interpretive programs at this site during the nesting season.

Ownership: public

Public observation areas: trail around lake

Latitude / Longitude: N 37.7700 / W 122.4769



Colony site description

Topography: island (without bridge)

Length x width: 19 m x 3 m

Nest substrate: Monterey cypress (*Cupressus macrocarpa*), *Pinus* sp.

Average nest height: 16 m

Trees (dbh): 1 (3-10 cm), 8 (10-50 cm),
1 (50-100 cm)

Maximum tree canopy height: 18 m

Vegetation cover: tree 60%, shrub 0%, ground 0%

Evidence of disturbance

Common Raven: potential source^a

Raccoons: potential source^a

Red-tailed Hawk: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

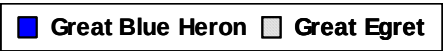
Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
High density housing			X	X
Protected natural area	X	X	X	X

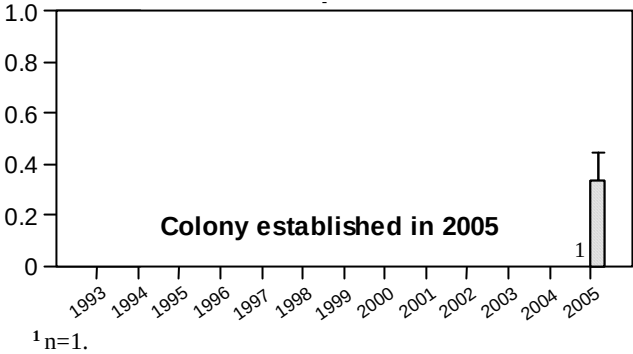
Tree Farm

Great Egrets and Great Blue Herons nest in a stand of planted Douglas firs on the north side of Home Bay. Grazed hillsides surround the sheltered grove, and birds from the colony frequently forage on the nearby mudflats in Drakes Estero.

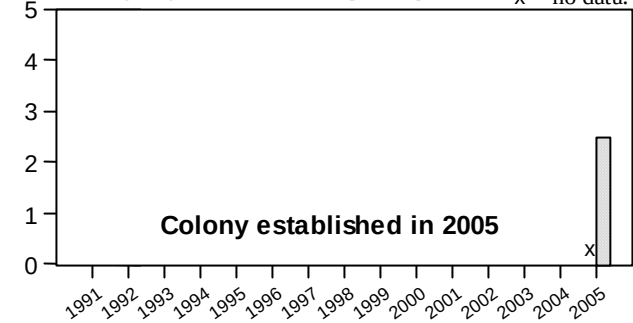
Ownership: public
Public observation areas: ridge south of colony
Latitude / Longitude: N 38.0724 / W 122.9169



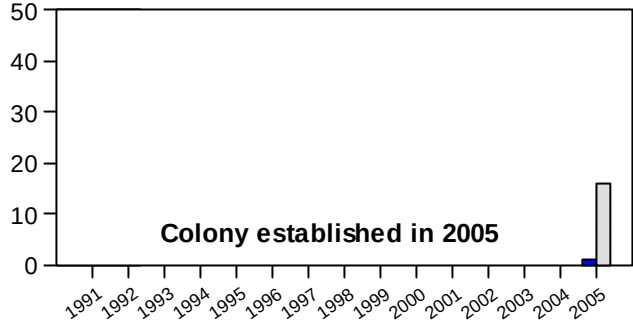
Nest survivorship ($\pm$ SE)



Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



Colony site description

Topography: hillside
Length x width: 100 m x 80 m
Nest substrate: Douglas fir (*Pseudotsuga menziesii*)
Average nest height: 23 m
Trees (dbh): 8 (50-100 cm)
Maximum tree canopy height: 30 m
Vegetation cover: tree 90%, shrub 15%, ground 90%

Evidence of disturbance

Resident ravens: nest failure

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing				X
Grazing			X	X
Protected natural area	X	X	X	X

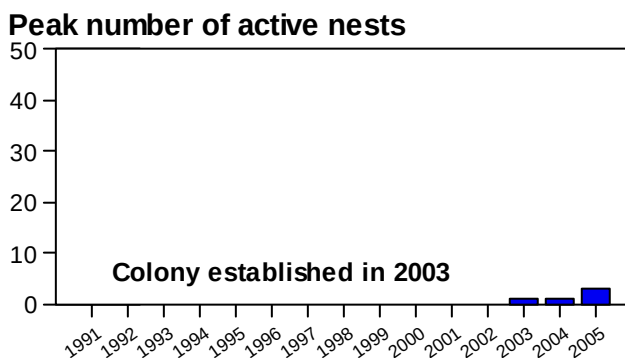
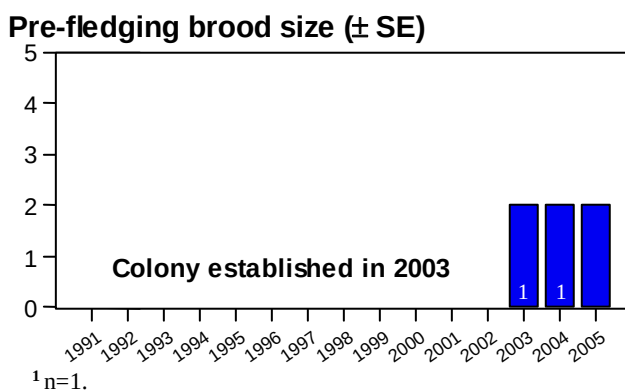
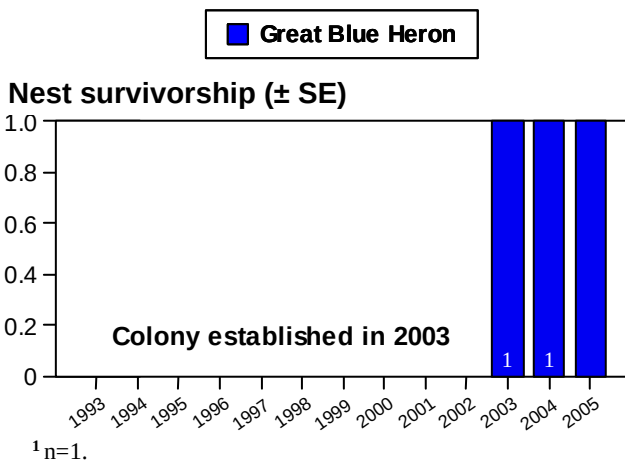
Walker Creek

Steep coastal scrub slopes and grazed grasslands surround this site on the north bank of Walker Creek opposite Highway 1. Great Blue Herons nest in a sheltered stand of Monterey cypress and eucalyptus trees located on private land. Walker Creek opens to Tomales Bay 0.8 km to the west.

Ownership: private

Public observation areas: Walker Creek fishing access

Latitude / Longitude: N 38.2272 / W 122.9177



Colony site description

Topography: flood plain

Length x width: 10 m x 7 m

Nest substrate: Monterey cypress (*Cupressus macrocarpa*)

Average nest height: 20 m

Trees (dbh): 4 (3-10 cm), 2 (10-50 cm), 3 (50-100 cm)

Maximum tree canopy height: 30 m

Vegetation cover: tree 35%, shrub 5%, ground 20%

Evidence of disturbance

None recorded.

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing			X	
Grazing		X	X	X

Colony Sites with Limited Activity

Blakes Landing North

Great Blue Herons nested about 4 km north of downtown Marshall, in a stand of cypress about 300 m from Highway 1. An organic dairy owns the property and an agricultural easement ensures the property will not be developed.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.1954 / W 122.9182

Species	Years known to be active (number of active nests)
Great Blue Heron	1999 (2), 2000 (3)



Bodega Flat Road #2

This colony site was in eucalyptus trees near some residences on the west side of Bodega Bay. The trees were removed to make way for a new home in 1993.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.33714 / W 123.05915

Species	Years known to be active (number of active nests)
Great Blue Heron	1992 (1)
Great Egret	1991 (1)

Bodega Bay Hole-in-the-Head

Black-crowned Night-Herons roost in the shrubs adjacent to the pond at the Bodega Headland. Nesting was reported at this site in 1991 and 1992. Currently, this site should be considered a potential nesting area.

Ownership: private

Public observation areas: observation deck

Latitude / Longitude: N 38.3051 / W 123.0593

Species	Years known to be active (number of active nests)
Black-crowned Night-Heron	1991 (1), 1992 (1)

Colony Sites with Limited Activity (continued)

Lake Nicasio

Great Blue Herons were first reported to have nested in Douglas firs (*Pseudotsuga menziesii*) on the south shore of Lake Nicasio in 1982. No subsequent breeding activity has been seen there in over a decade.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.0754 / W 122.7320

Species	Years known to be active (number of active nests)
Great Blue Heron	1982 (6), 1983 (6), 1984 (5), 1988 (13), 1992 (5)

Pescadero Marsh

Pescadero Marsh Natural Preserve includes more than 500 acres of coastal wetlands, the largest wetland area between San Francisco Bay and Elkhorn Slough. The surrounding area is heavily cultivated for vegetables and berries.

Ownership: public

Public observation areas: Pescadero Marsh Natural Preserve

Latitude / Longitude: N 37.2679 / W 122.4048

Species	Years known to be active (number of active nests)
Great Blue Heron	1994 (9)

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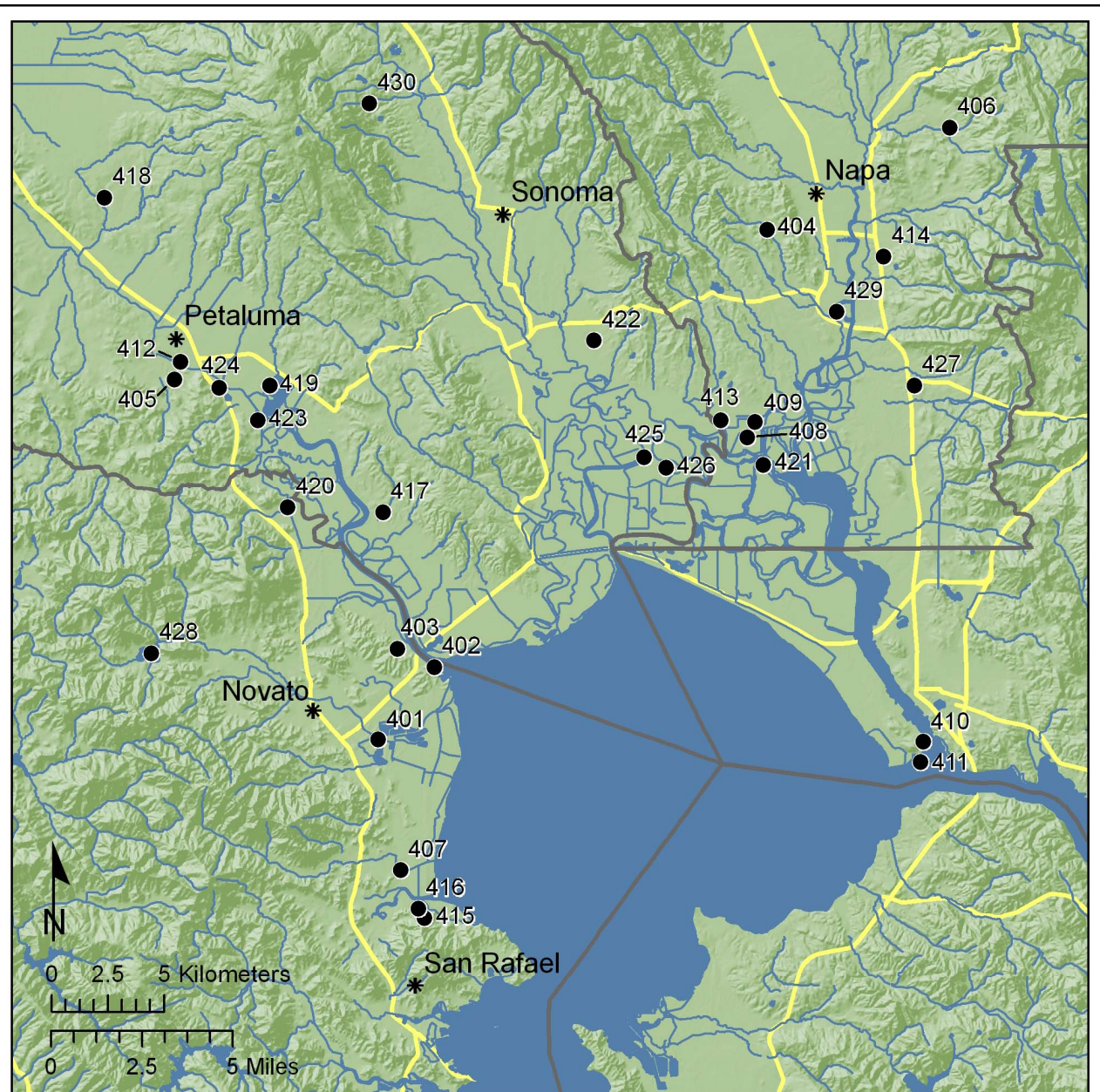
SAN PABLO BAY



SAN PABLO BAY

A large complex of tidal and freshwater wetlands, dominated by the Petaluma and Napa marshes, extends along the northern shore of San Pablo Bay. Conservation efforts in this subregion have restored substantial amounts of diked pasture and salt evaporation ponds to tidal wetland conditions.

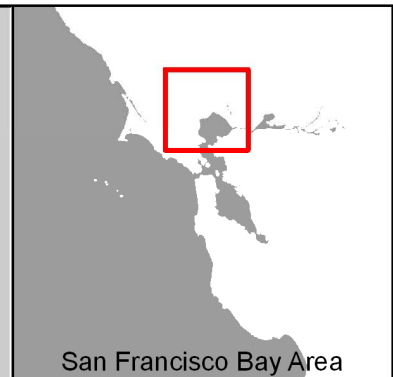
Site #	Colony Site	Great Blue Heron	Great Egret	Snowy Egret	Black-crowned Night-Heron	Cattle Egret	County	Active or year last active	Page
401	Bel Marin Keys	■	□				Marin	Active	106
402	Black Point	■					Marin	Active	107
403	Channel Drive	■	□				Marin	Active	108
404	Congress Valley	■					Napa	Active	109
405	Fairview Terrace			■	■		Sonoma	1997	136
406	Hagen Road	■					Napa	Active	110
407	Las Gallinas		□	■	■		Marin	Active	111
408	Leslie Salt Pond	■					Napa	1999	113
409	Leslie Salt Pond North	■					Napa	2000	114
410	Mare Island	■					Solano	Active	115
411	Mare Island Pier 35	■					Solano	Active	136
412	McNear Channel	■					Sonoma	Active	136
413	Napa Marsh N-3	■	□				Napa	1993	137
414	Napa State Hospital		□	■	■		Napa	Active	117
415	North San Pedro Road #1	■					Marin	2003	119
416	North San Pedro Road #2	■	□				Marin	Active	120
417	Old Lakeville Road #3	■					Sonoma	Active	121
418	Penngrove		□	■	■		Sonoma	Active	122
419	Petaluma Wastewater Plant	■	□	■			Sonoma	Active	123
420	Redwood Landfill	■	□				Marin	Active	125
421	Russ Island	■					Napa	Active	126
422	Schellville	■	□	■			Sonoma	2004	127
423	Schultz Slough	■					Sonoma	2004	137
424	Shollenberger Park	■	□	■			Sonoma	Active	128
425	Skaggs Island Eucalyptus	■					Sonoma	Active	130
426	Skaggs Island Sewage Ponds				■		Sonoma	Active	131
427	South Kelly	■					Napa	Active	132
428	Stafford Lake	■					Marin	1993	133
429	Stanley Ranch	■					Napa	2003	134
430	Vigilante Road	■					Sonoma	Active	135



Heron and Egret Nesting Colonies in San Pablo Bay* 1991-2005

- Colony site
- * Town
- Study area boundary
- Major highway
- ~ Stream
- County boundary

*Colony sites outside of this sub-region are not shown.



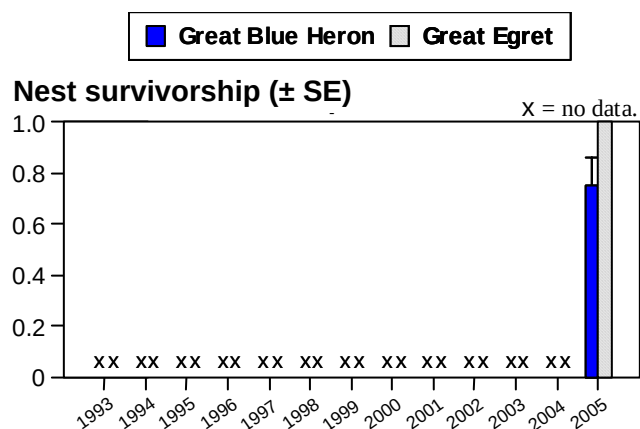
Bel Marin Keys

This heronry is located off of Bel Marin Keys Boulevard, east of Novato. The property is owned by a yoga retreat center. In 2004, building renovation was undertaken 75 m from the colony, but no disturbance was observed. The colony can be viewed from public trails atop the levees on the south side of the boulevard, west of Bermuda Harbor. The colony site is 130 m south of Novato Creek and 3 km west of San Pablo Bay.

Ownership: private

Public observation areas: levee trail

Latitude / Longitude: N 38.0800 / W 122.5262



Colony site description

Topography: hillside

Length x width: 27 m x 12 m

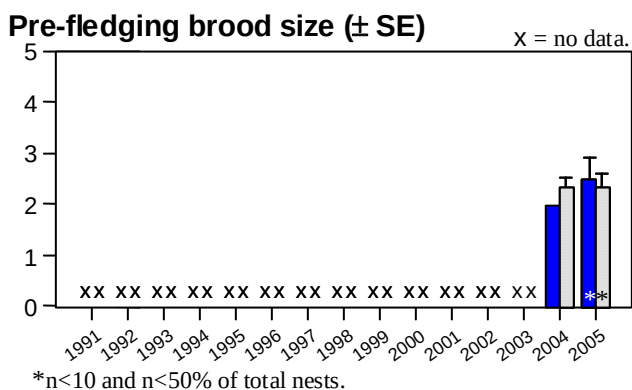
Nest substrate: *Eucalyptus* sp.

Average nest height: 24 m

Trees (dbh): 3 (10-50 cm), 3 (50-100 cm), 4 (100-150cm)

Maximum tree canopy height: 33 m

Vegetation cover: tree 45%, shrub 0%, ground 14%

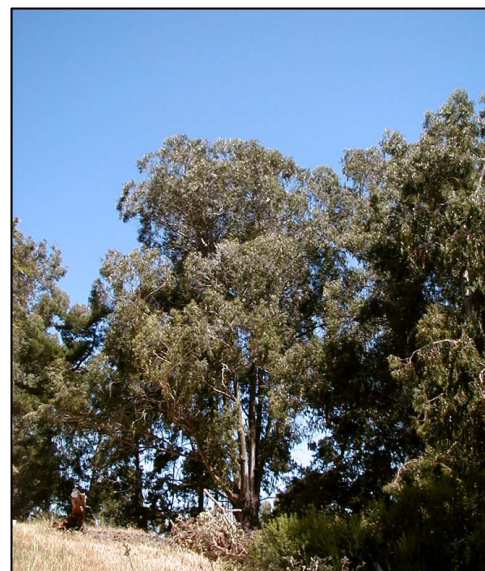
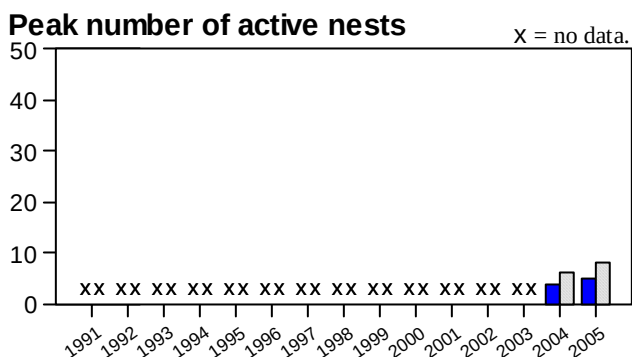


Evidence of disturbance

None recorded.

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X	X		
Mid-density housing		X	X	X
High density housing		X	X	X



Black Point

This colony site is east of Black Point where the Petaluma River meets San Pablo Bay. Great Blue Herons nest in a single eucalyptus in the backyard of a private residence, 60 m south of the Petaluma River and 1 km from San Pablo Bay. The Highway 37 Bridge spanning the Petaluma River is 0.9 km to the northwest.

Ownership: private

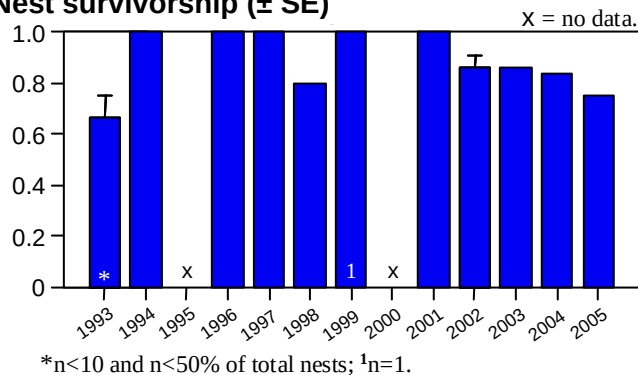
Public observation areas: boat

Latitude / Longitude: N 38.1101 / W 122.4991



■ Great Blue Heron

Nest survivorship ($\pm$ SE)



Colony site description

Topography: flood plain

Length x width: 9 m x 8 m

Nest substrate: *Eucalyptus* sp.

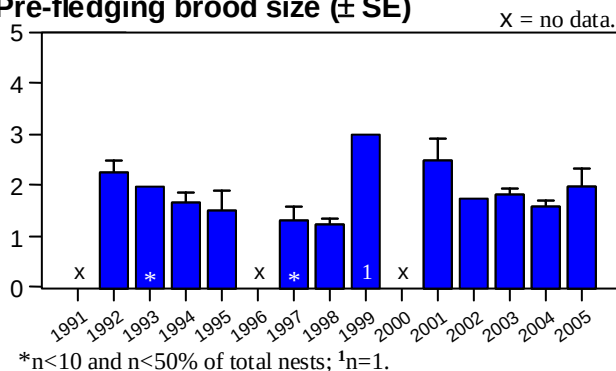
Average nest height: 23 m

Trees (dbh): 1 (3-10 cm), 1 (50-100 cm),
1 (100-150 cm)

Maximum tree canopy height: 27 m

Vegetation cover: tree 60%, shrub 8%, ground 5%

Pre-fledging brood size ($\pm$ SE)



Evidence of disturbance

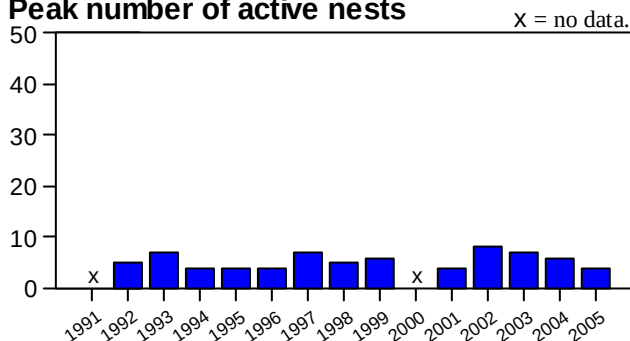
Fallen branch: nest failure

Red-tailed Hawk: behavioral response

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing		X	X	X
Mid-density housing			X	X

Peak number of active nests



Channel Drive

This site is a stand of eucalyptus surrounded by old farm fields and newer residential homes, about 1.2 km north of the hamlet of Black Point. A seasonal pond is 20 m from colony and the Petaluma River is 0.5 km to the east. A line of high voltage power towers is 110 m away. One pair of Great Egrets nested here in 1998.

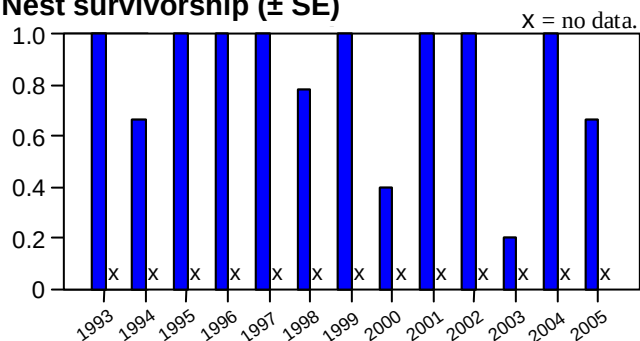
Ownership: private

Public observation areas: none

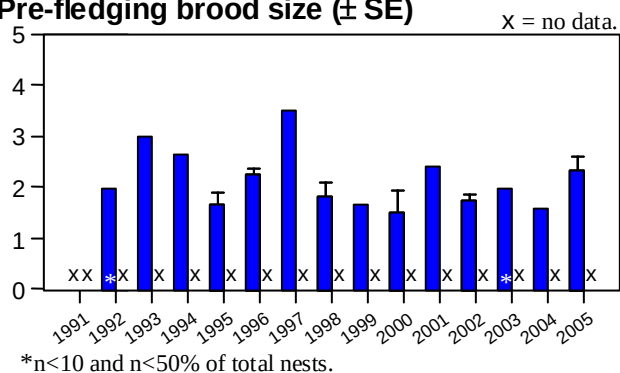
Latitude / Longitude: N 38.1164 / W 122.5163



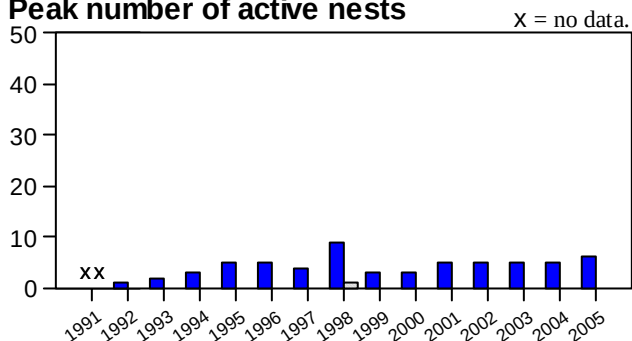
Nest survivorship ($\pm$ SE)



Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



Colony site description

Topography: flood plain

Length x width: 18 m x 9 m

Nest substrate: *Eucalyptus* sp.

Average nest height: 19 m

Trees (dbh): 7 (3-10 cm), 4 (50-100 cm),
1 (100-150 cm)

Maximum tree canopy height: 28 m

Vegetation cover: tree 31%, shrub 27%, ground 13%

Evidence of disturbance

Common Raven: potential source ^a

Human activity (construction): potential source ^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing			X	X

Congress Valley

This colony of Great Blue Herons is in a dense stand of eucalyptus trees on the property of a home for developmentally disabled people, about 2 km east of the City of Napa and 3 km west of the Napa River. The grounds are a farm with gardens, ponds, and livestock, surrounded by a mixture of vineyards and residential homes.

Ownership: private

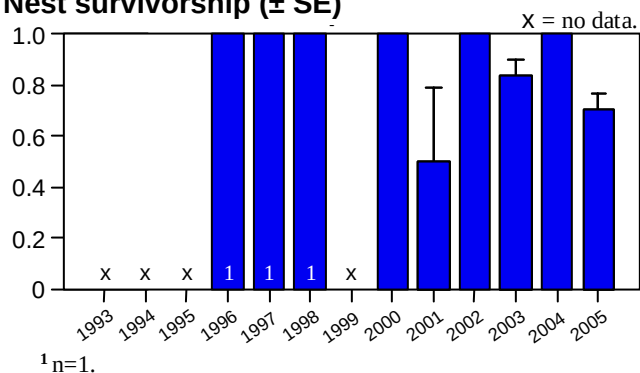
Public observation areas: none

Latitude / Longitude: N 38.2831 / W 122.3284

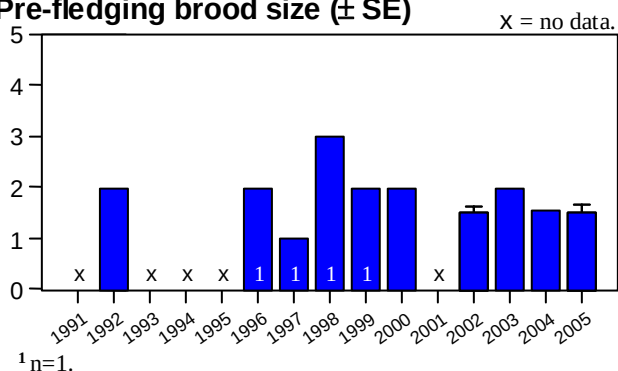


Great Blue Heron

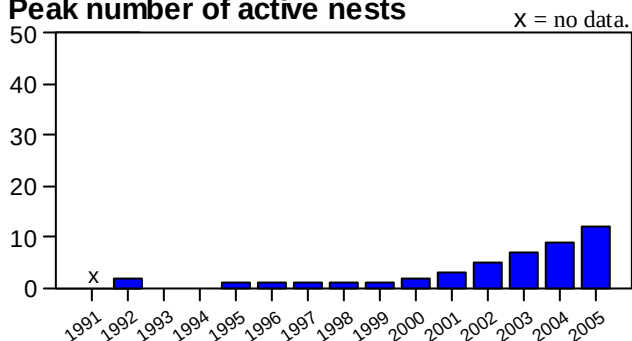
Nest survivorship ($\pm$ SE)



Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



Colony site description

Topography: hillside

Length x width: 54 m x 21 m

Nest substrate: *Eucalyptus* sp. (live and dead branches)

Average nest height: 27 m

Trees (dbh): 3 (3-10 cm), 8 (10-50 cm), 14 (50-100 cm)

Maximum tree canopy height: 34 m

Vegetation cover: tree 32%, shrub 0%, ground 19%

Evidence of disturbance

Resident ravens: behavioral response

Red-shouldered Hawk: potential source ^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X	X	X	X
Mid-density housing	X			
Vineyard	X	X	X	X
Grazing	X	X		

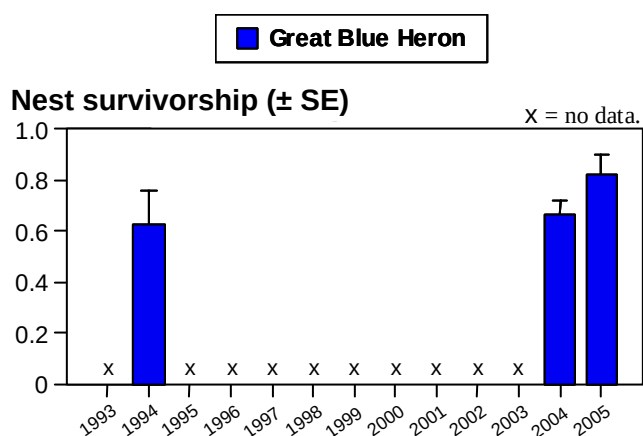
Hagen Road

This heronry is about 5 km northwest of the City of Napa at the end of Hagen Road. Great Blue Herons nest in rows of tall eucalyptus lining a private, gated lane. The trees are on vineyard property, near a parking lot and equipment garage. The Napa River is 3.5 km west of the site.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.3239 / W 122.2345



Colony site description

Topography: flood plain

Length x width: 59 m x 14 m

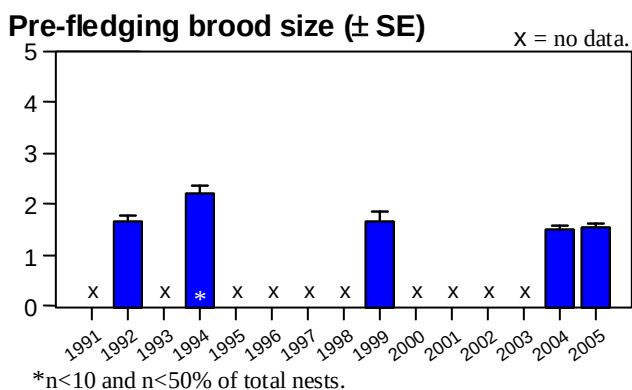
Nest substrate: *Eucalyptus* sp. (live and dead branches)

Average nest height: 30 m

Trees (dbh): 5 (50-100 cm), 5 (100-150 cm)

Maximum tree canopy height: 31 m

Vegetation cover: tree 20%, shrub 6%, ground 26%



Evidence of disturbance

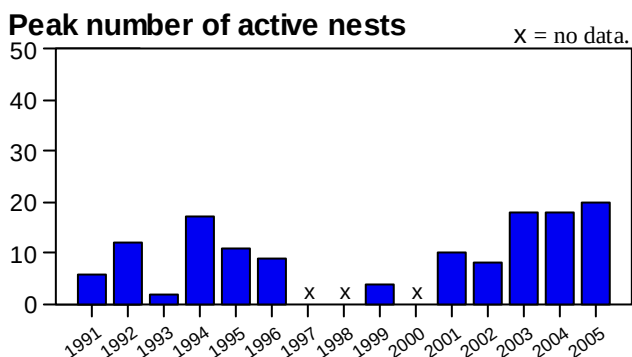
American Crows: potential source^a

Common Raven: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X		X	X
Mid-density housing				X
Vineyard	X	X	X	X
Grazing				X



Las Gallinas

Hérons and egrets nest on a series of small, shrub-covered islands at the wastewater treatment complex near the east end of Smith Ranch Road, just north of San Rafael. The area surrounding the treatment plant is a public park with well-maintained paths that provide excellent opportunities for viewing herons, egrets and many other species of birds.

Ownership: public

Public observation areas: levee at pond edge

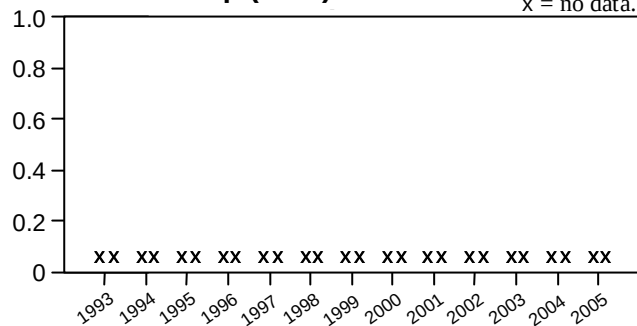
Latitude / Longitude: N 38.0272 / W 122.5161



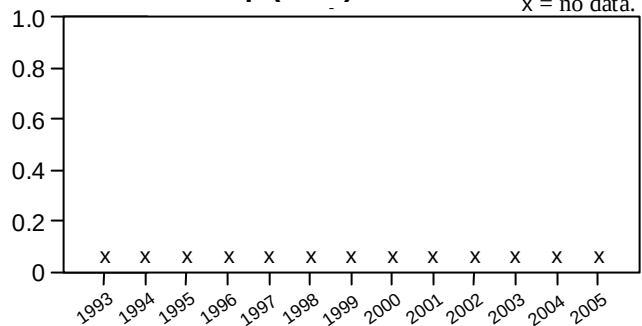
■ Black-crowned Night-Heron ■ Snowy Egret

□ Great Egret

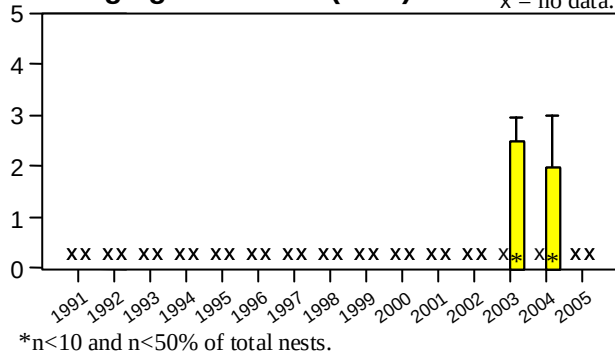
Nest survivorship ($\pm$ SE)



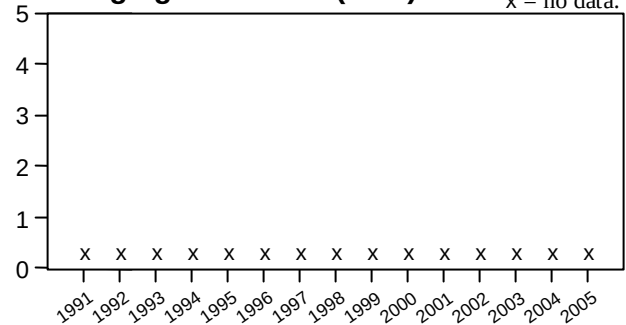
Nest survivorship ($\pm$ SE)



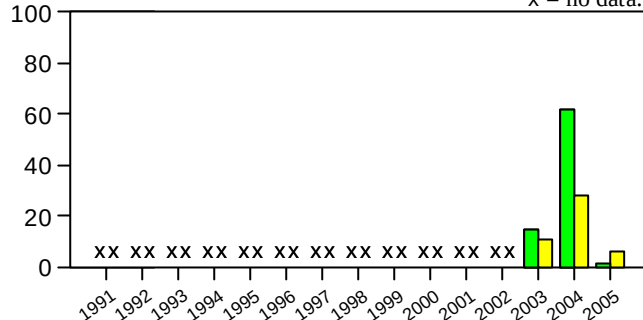
Pre-fledging brood size ($\pm$ SE)



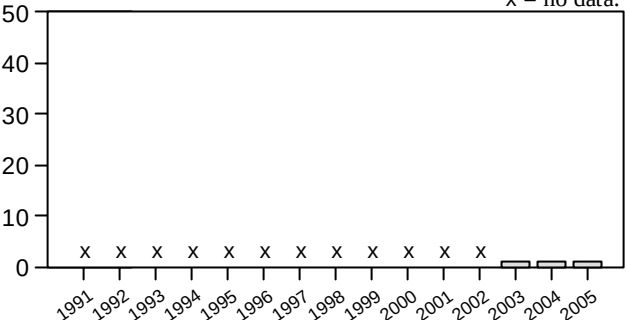
Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



Peak number of active nests



(continued)

Las Gallinas (continued)

Colony site description

South subcolony

Topography: islands (without bridge)

Length x width: 67 m x 50 m

Nest substrate: shrubs

Average nest height: 1 m

Trees (dbh): none

Maximum tree canopy height: no canopy

Vegetation cover: tree 0%, shrub 45%, ground 0%

North subcolony

Topography: islands

Length x width: 72 m x 55 m

Nest substrate: shrubs

Average nest height: 1 m

Trees (dbh): none

Maximum tree canopy height: no canopy

Vegetation cover: tree 0%, shrub 50%, ground 0%

Evidence of disturbance

Common Raven: potential source ^a

Coyote: potential source ^a

^aPossible disturbance suggested by published accounts
(see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0- 100	100- 200	200- 500	500- 1000
Protected natural area	X	X	X	X
Sports field				X

Leslie Salt Pond

This heronry as well as the next site listed ("Leslie Salt Pond North") are on California Department of Fish and Game property just south of Buchli Station. The complex of former salt evaporation ponds and levees is being converted to parkland. The Napa River about 2 km to the east and San Pablo Bay is 7.2 km to the south. Double-crested Cormorants have also nested at this site.

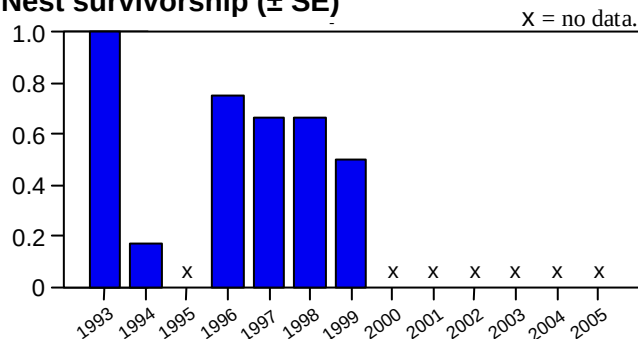
Ownership: public

Public observation areas: park trail

Latitude / Longitude: N 38.2004 / W 122.3385

■ Great Blue Heron

Nest survivorship ($\pm$ SE)



Colony site description

Topography: wetland

Length x width: 20 m x 10 m

Nest substrate: snag

Average nest height: 15 m

Trees (dbh): 3 (10-50 cm), 7 (50-100 cm)

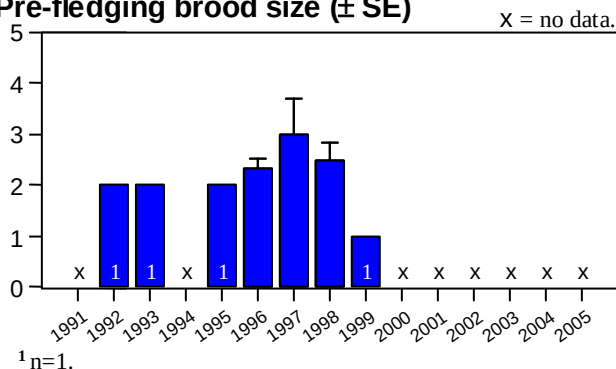
Maximum tree canopy height: no canopy

Vegetation cover: tree 0%, shrub 0%, ground 0%

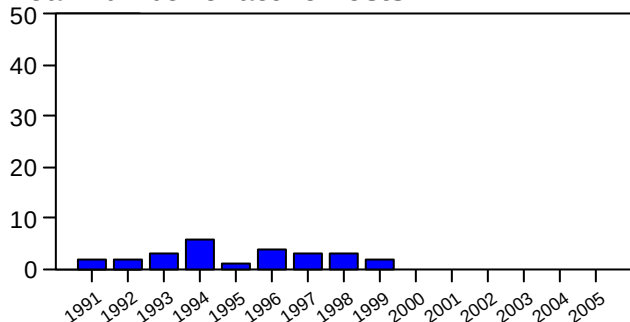
Evidence of disturbance

Wind damage to tree limbs: nest failure

Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Protected natural area	X	X	X	X

Leslie Salt Pond North

Great Blue Herons nested in snags very near the previous site ("Leslie Salt Pond"). Both sites are in old salt evaporation ponds on California Department of Fish and Game property south of Buchli Station and are being converted to parkland. The Napa River is 1.8 km to the east and San Pablo Bay shore is 8 km to the south. Great Horned Owls and Double-crested Cormorants have also nested at this site.

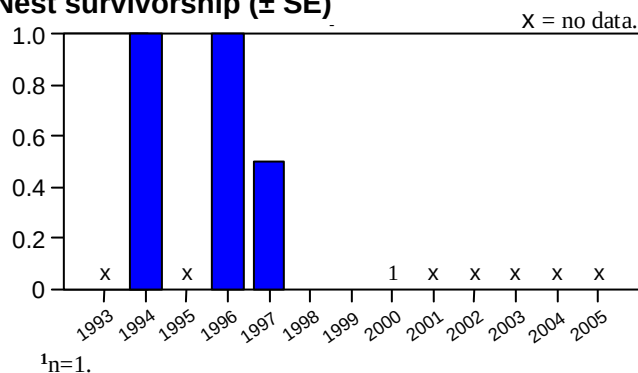
Ownership: public

Public observation areas: park trail

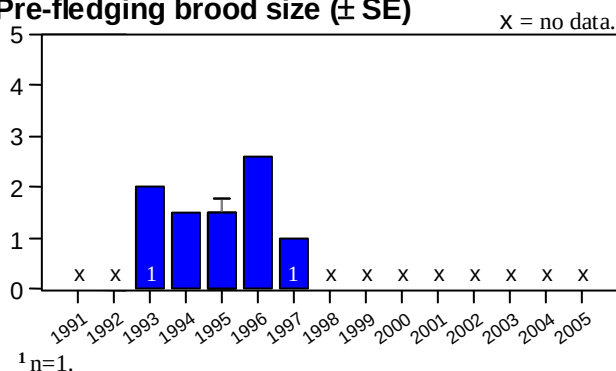
Latitude / Longitude: N 38.2064 / W 122.3343

■ Great Blue Heron

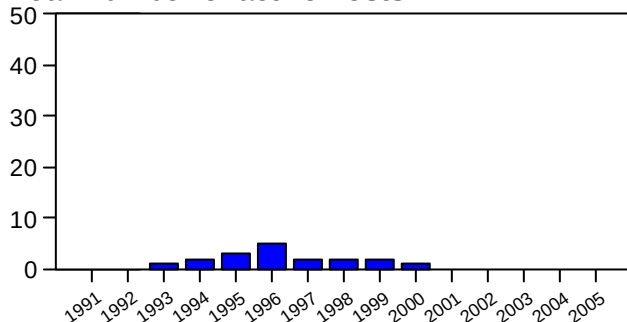
Nest survivorship ($\pm$ SE)



Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



Colony site description

Topography: wetland

Length x width: 30 m x 10 m

Nest substrate: snag

Average nest height: 15 m

Trees (dbh): 34 (10-50 cm), 10 (50-100 cm)

Maximum tree canopy height: no canopy

Vegetation cover: tree 0%, shrub 0%, ground 0%

Evidence of disturbance

Wind damage to tree limbs: nest failure

Resident Great Horned Owl: potential source ^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Protected natural area	X	X	X	X

Mare Island

This colony site is on the former Mare Island Naval Reservation, southwest of Vallejo. The base is being converted to a multi-use facility. Prior to 2003, Great Blue Herons nested in a patch of eucalyptus beside a small reservoir. Since then, herons have nested in small subcolonies around the pier area, building nests atop light poles and pilings.

Ownership: public

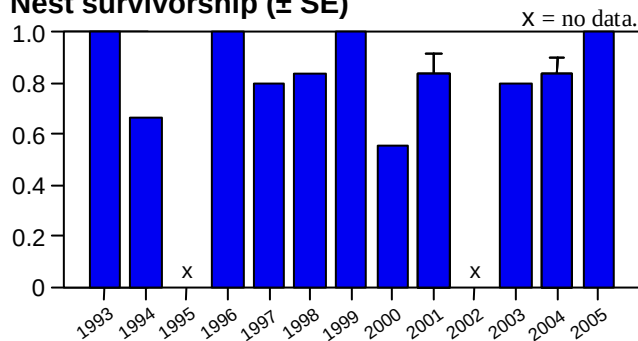
Public observation areas: boat

Latitude / Longitude:

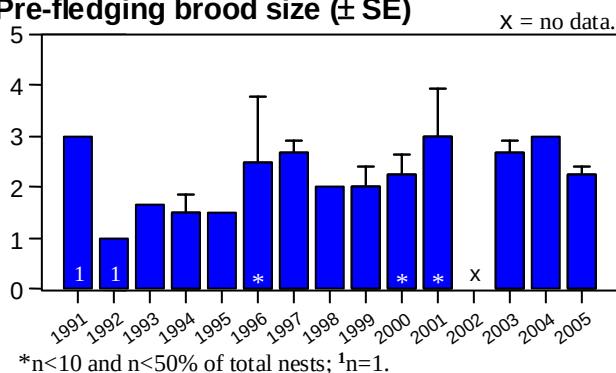
N 38.0769 / W 122.2536 (Eucalyptus subsite)

■ Great Blue Heron

Nest survivorship ($\pm$ SE)

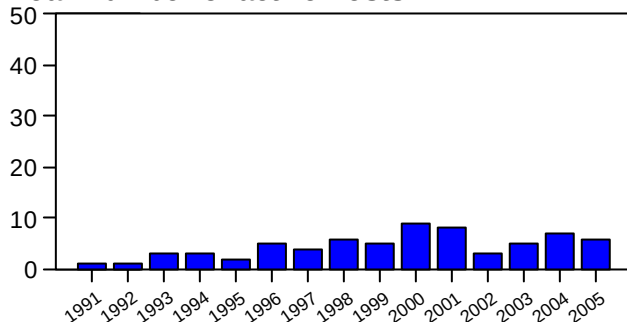


Pre-fledging brood size ($\pm$ SE)



*n < 10 and n < 50% of total nests; ¹n = 1.

Peak number of active nests



(continued)



Colony site descriptions

Eucalyptus subsite

Topography: ridge top

Length x width: 29 m x 17 m

Nest substrate: *Eucalyptus* sp.

Average nest height: 17 m

Trees (dbh): 28 (3-50 cm), 28 (50-100 cm), 4 (100-150 cm)

Maximum tree canopy height: 21 m

Vegetation cover: tree 53%, shrub 3%, ground 5%

Spruce subsite

Topography: ridge top

Length x width: 10 m x 8 m

Nest substrate: spruce (*Picea* sp.)

Average nest height: 20 m

Trees (dbh): 1 (50-100 cm)

Maximum tree canopy height: 23 m

Vegetation cover: tree 33%, shrub 0%, ground 15%

North Light Pole subsite

Topography: pier

Length x width: 2 m x 1 m

Nest substrate: light pole

Average nest height: 19 m

Trees (dbh): none

Maximum tree canopy height: no canopy

Vegetation cover: tree 0%, shrub 0%, ground 0%

Mare Island (continued)

Evidence of disturbance

Resident ravens: nest failure

Resident Ospreys: nest failure

Red-tailed Hawk: behavioral response

Human activity (truck traffic and maintenance work): behavioral response

Golden Eagle: potential source^a

^aPossible disturbance suggested by published accounts
(see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0- 100	100- 200	200- 500	500- 1000
Industrial			X	X
Mid-density housing			X	X
Sports field				X

Napa State Hospital

This important heronry is on the grounds of the Napa State Hospital psychiatric detention center in the City of Napa. A 4 m high fence surrounds the entire complex. The hospital compound has a college campus feel, with lawns, dorms, and sports fields. In 2003, nesting occurred in 17 trees, mostly bay laurel and live oak, near roads, paths, and buildings.

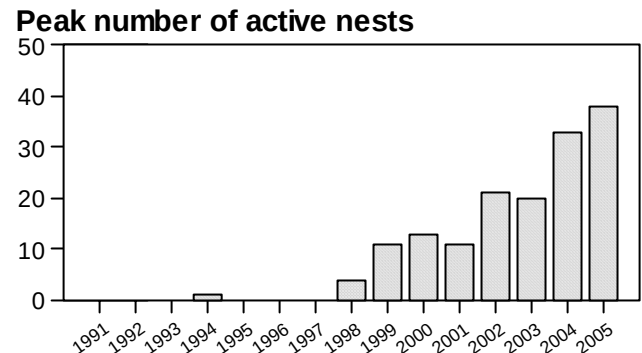
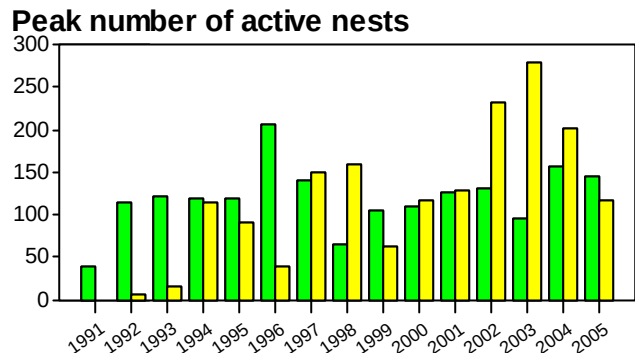
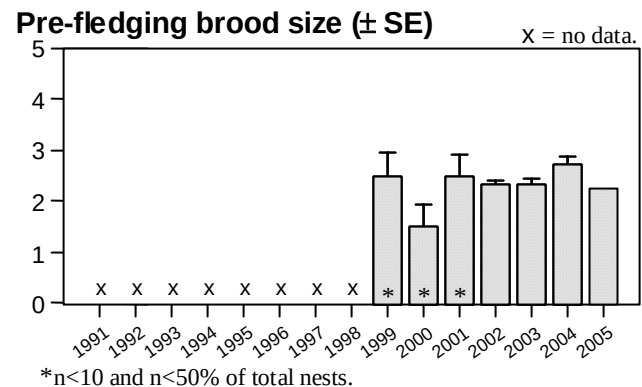
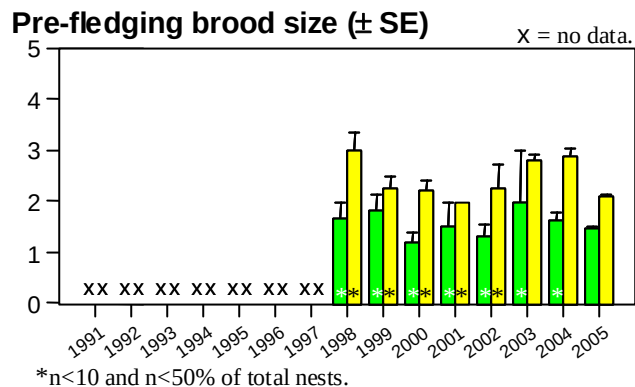
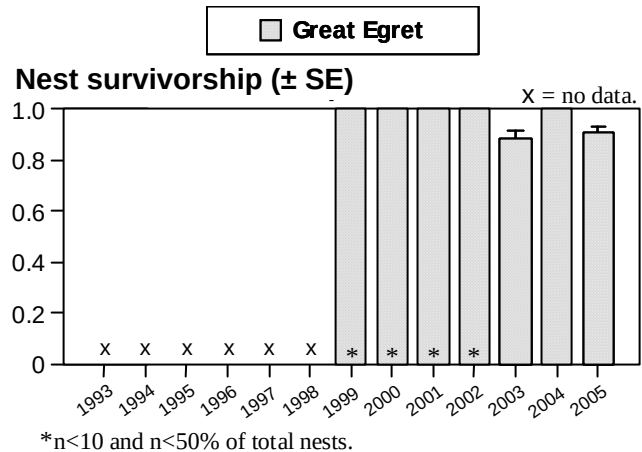
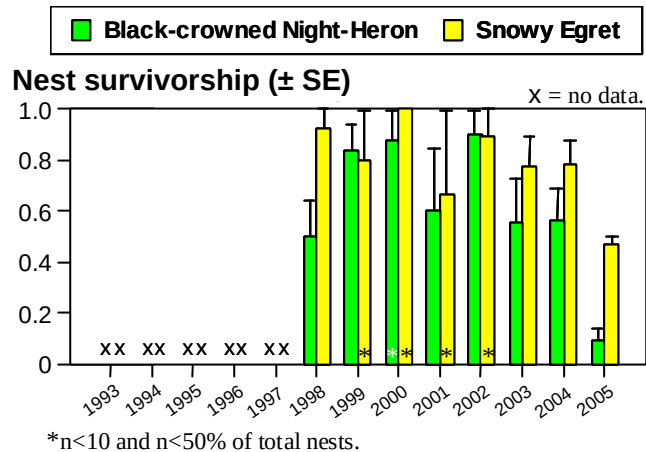
Ownership: public

Public observation areas: none

Latitude / Longitude: N 38.2723 / W 122.2685



(no photo)



(continued)

Napa State Hospital (continued)

Colony site description

Topography: flood plain

Length x width: 185 m x 141 m

Nest substrate: *Eucalyptus* sp., live oak (*Quercus agrifolia*),
bay laurel (*Umbellularia californica*)

Average nest height: 15 m

Trees (dbh): 2 (10-50 cm), 29 (50-100 cm), 1 (100-150 cm)

Maximum tree canopy height: 26 m

Vegetation cover: tree 15%, shrub 0%, ground 45%

Evidence of disturbance

Golden Eagle: potential source ^a

American Crows: potential source ^a

Human activity (traffic, maintenance crews): behavioral response

^aPossible disturbance suggested by published accounts
(see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0- 100	100- 200	200- 500	500- 1000
Mid-density housing	X	X	X	X
Sports field	X	X	X	X

North San Pedro Road #1

Great Blue Herons have nested in two locations near China Camp State Park. The original colony site was in valley oak trees in the yard of a farmhouse. In 1992, a second colony site was established in a grove of redwoods halfway up the ridge behind the house. Private and state-owned oak forest surround the site.

Ownership: private

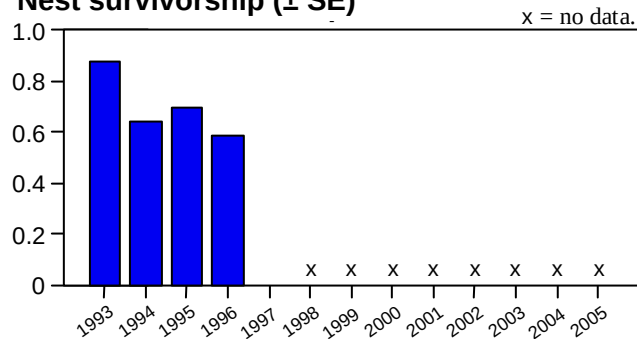
Public observation areas: North San Pedro Road

Latitude / Longitude:

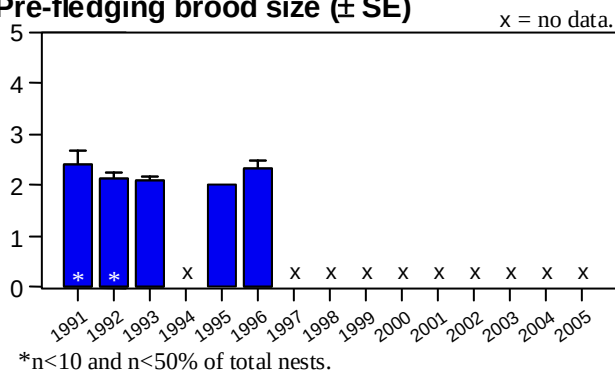
N 38.0084 / W 122.5033 (Far Ridge subsite)

■ Great Blue Heron

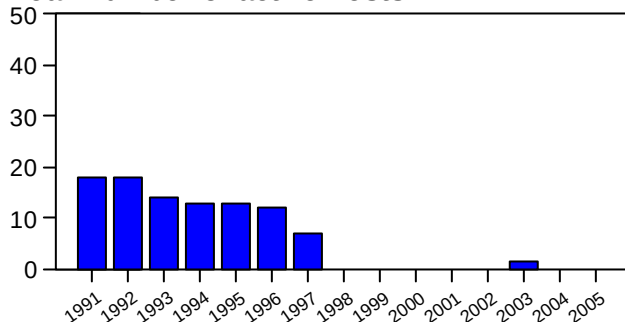
Nest survivorship ($\pm$ SE)



Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



Colony site description

Farmhouse subsite

Topography: flood plain

Length x width: not measured

Nest substrate: madrone (*Arbutus menziesii*),
valley oak (*Quercus lobata*), bay laurel
(*Unbellularia californica*)

Average nest height: not measured

Trees (dbh): not measured

Maximum tree canopy height: not measured

Vegetation cover: not measured

Far Ridge subsite

Topography: ridge top

Length x width: not measured

Nest substrate: coast redwood (*Sequoia sempervirens*)

Average nest height: not measured

Trees (dbh): not measured

Maximum tree canopy height: not measured

Vegetation cover: not measured

Evidence of disturbance

Human activity: behavioral response

Red-tailed Hawk: behavioral response

Common Raven: behavioral response

Golden Eagle: behavioral response

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X		X	X
Grazing	X	X		
Protected natural area	X	X	X	X

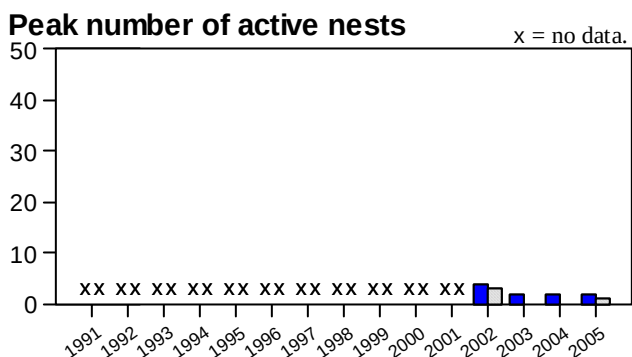
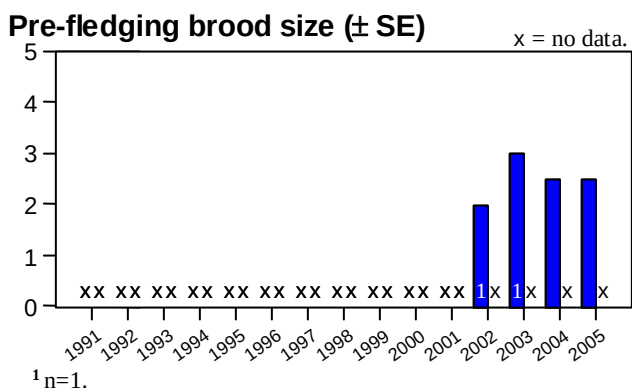
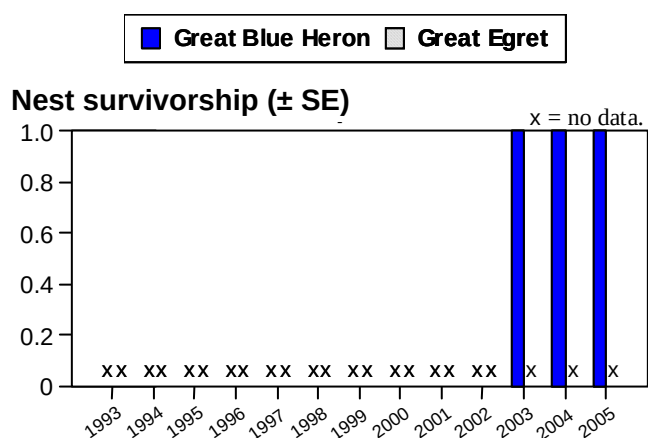
North San Pedro Road #2

This heronry is in a eucalyptus tree along a driveway on private property near San Rafael. Undeveloped woodlands and low-density residential development surround the site. China Camp State Park is 0.6 km to the south.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.0122 / W 122.5065



Colony site description

Topography: hillside

Length x width: 15 m x 10 m

Nest substrate: *Eucalyptus* sp.

Average nest height: 17 m

Trees (dbh): 2 (50-100 cm)

Maximum tree canopy height: 20 m

Vegetation cover: tree 36%, shrub 0%, ground 22%

Evidence of disturbance

None recorded.

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X	X	X	X
High density housing				X
Protected natural area				X

Old Lakeville Road #3

This colony site is at the intersection of Lakeville Highway and Old Lakeville Road #3. Great Blue Herons nest in a eucalyptus tree in a pasture, 0.6 km east of the Petaluma River. The colony is within 40 m of farm buildings. This colony may have been initiated after the abandonment of a colony site at the Petaluma Wastewater Treatment Plant.

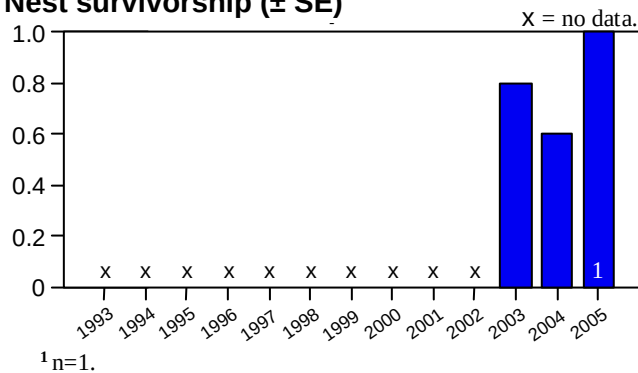
Ownership: private

Public observation areas: Lakeview Highway

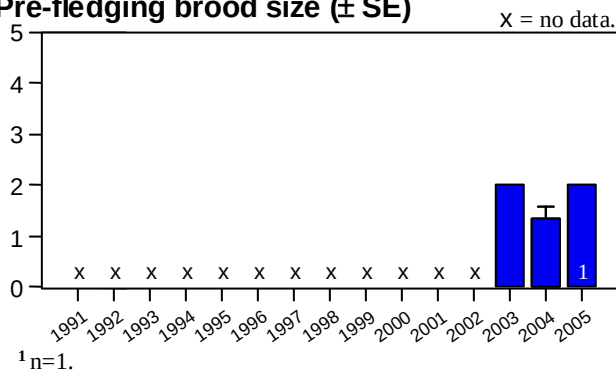
Latitude / Longitude: N 38.1710 / W 122.5234

■ Great Blue Heron

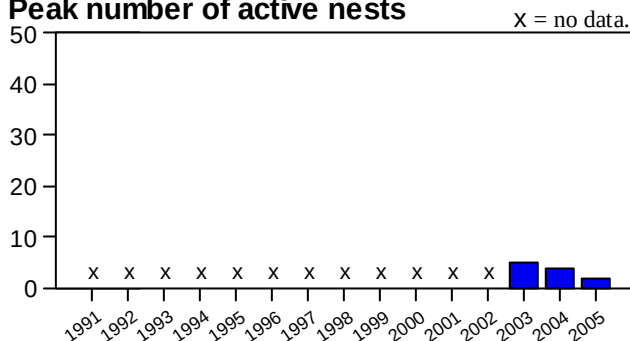
Nest survivorship ($\pm$ SE)



Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



Colony site description

Topography: flood plain

Length x width: 16 m x 12 m

Nest substrate: *Eucalyptus* sp.

Average nest height: 13 m

Trees (dbh): 1 (100-150 cm)

Maximum tree canopy height: 16 m

Vegetation cover: tree 70%, shrub 0%, ground 10%

Evidence of disturbance

Common Raven: nest failure

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing			X	X
Grazing	X	X	X	X

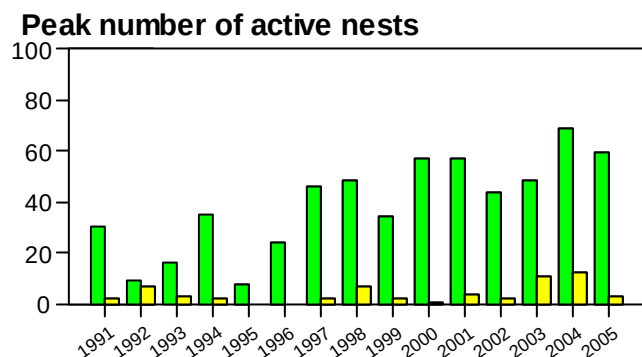
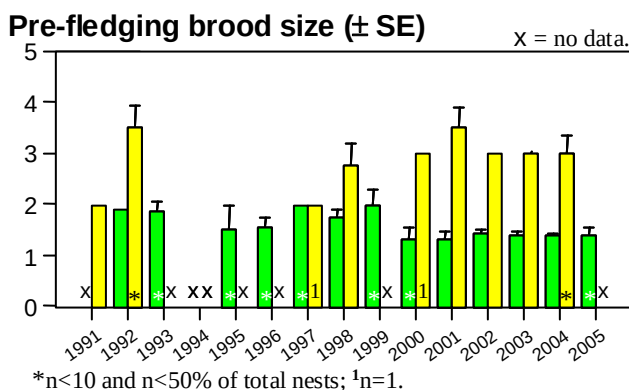
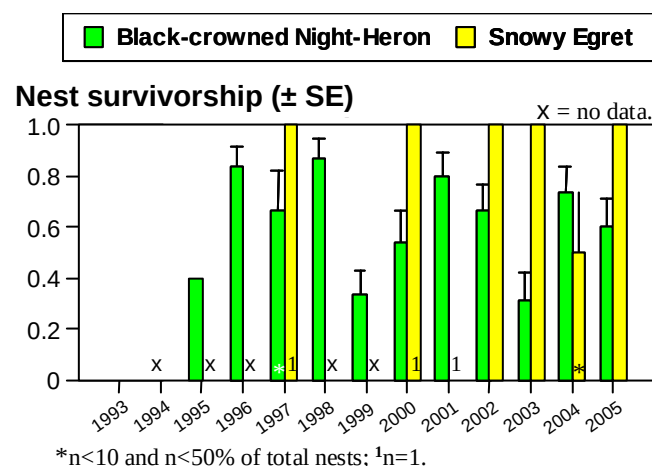
Penngrove

This colony is distributed among several residential lots in the Woodward/Grove St. neighborhood of Penngrove. Local residents report that Black-crowned Night-Herons have nested in this area since the 1930's. Two pairs of Great Egrets nested at this site in 1992 (not included in graphs), but this species has not nested here since then.

Ownership: private

Public observation areas: neighborhood streets

Latitude / Longitude: N 38.2978 / W 122.6639



Colony site description

Topography: suburban

Length x width: 265 m x 215 m

Nest substrate: live oak (*Quercus agrifolia*),
Acacia sp.

Average nest height: 5 m

Trees (dbh): not measured

Maximum tree canopy height: 9 m

Vegetation cover: tree 14 %, shrub 2%,
ground 37%

Evidence of disturbance

Barn Owl: nest failure

Resident Ravens: nest failure

Human activity (trees removed): nest failure

Defoliant sprayed on nest trees with chicks:
behavioral response

Human activity (heavy equipment): behavioral
response

Red-tailed Hawk: potential source ^a

Red-shouldered Hawk: potential source ^a

^aPossible disturbance suggested by published accounts
(see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Mid-density housing	X	X	X	X

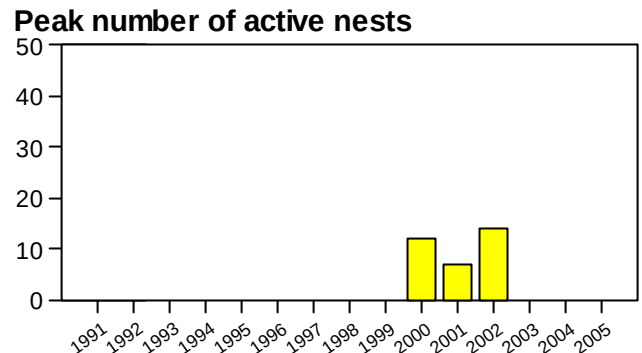
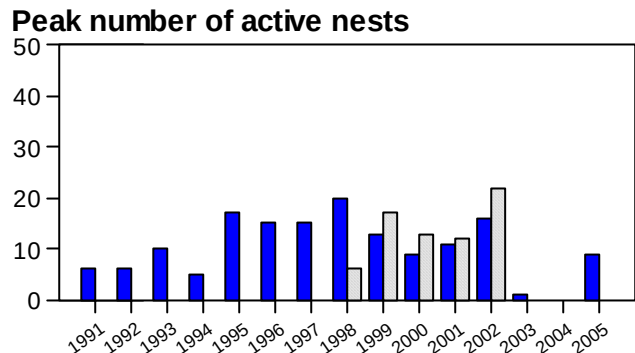
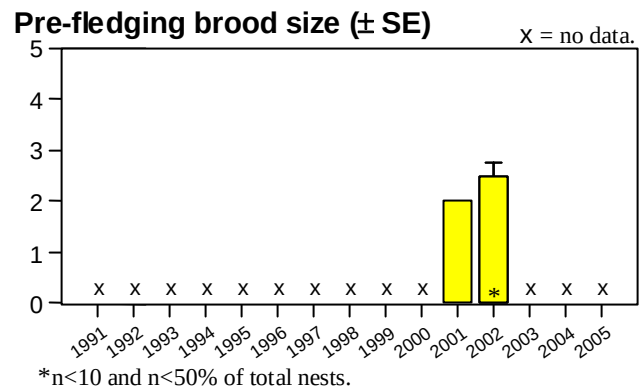
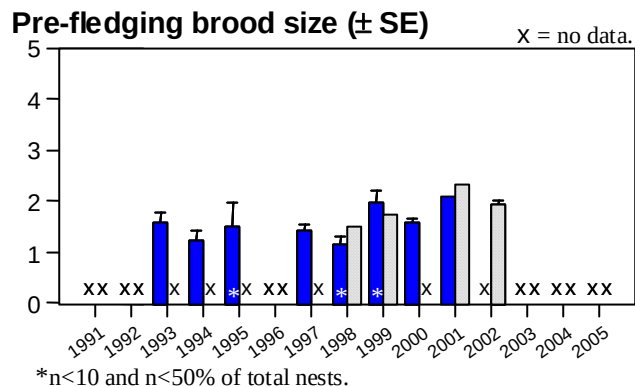
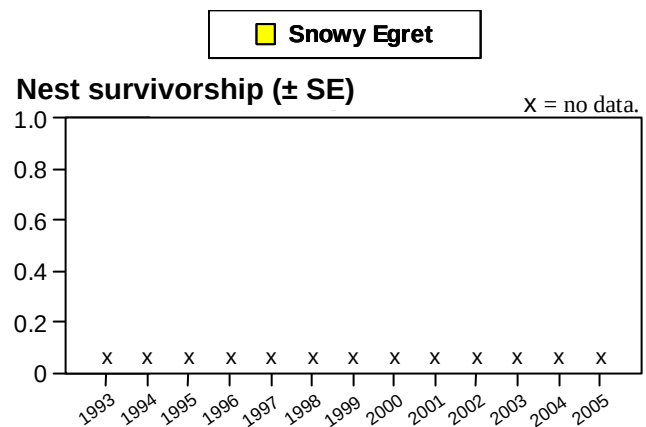
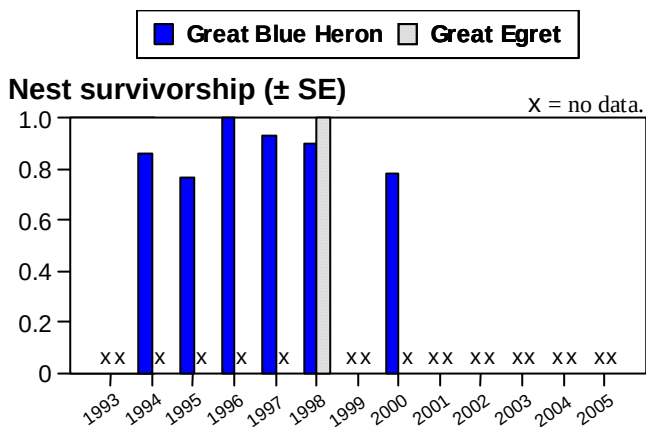
Petaluma Wastewater Plant

This heronry is between Lakeville Highway and the Petaluma River at the U. S. Filter Wastewater Treatment Plant. The colony site borders a series of water treatment ponds and is surrounded by a fence, beyond which lies pasture. It was abandoned by herons and egrets in 2003 but was re-colonized in 2005. The Petaluma River is 1.1 km to the west.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.2222 / W 122.5804



(continued)

Petaluma Wastewater Plant (continued)

Colony site description

Topography: flood plain

Length x width: 37 m x 18 m

Nest substrate: *Eucalyptus* sp. (live and dead branches)

Average nest height: 18 m

Trees (dbh): 1 (50-100 cm), 1 (> 150 cm)

Maximum tree canopy height: 28 m

Vegetation cover: tree 51%, shrub 4%, ground 76%

Evidence of disturbance

Golden Eagles: colony abandonment

Red fox consuming fallen chicks: nest failure

Observer disturbance: behavioral response

Common Raven: potential source ^a

Red-tailed Hawk: potential source ^a

^aPossible disturbance suggested by published accounts
(see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0- 100	100- 200	200- 500	500- 1000
Low density housing				X
Grazing				X

Redwood Landfill

Located on a levee beside a tide channel off San Antonio Creek, this colony site is close to a sanitary landfill and municipal dump. The right-of-way of the Northwest Pacific Railroad, currently not in service, runs directly beneath the nesting trees. Tidal wetlands of the Petaluma Marsh are approximately 0.5 km east of this site.

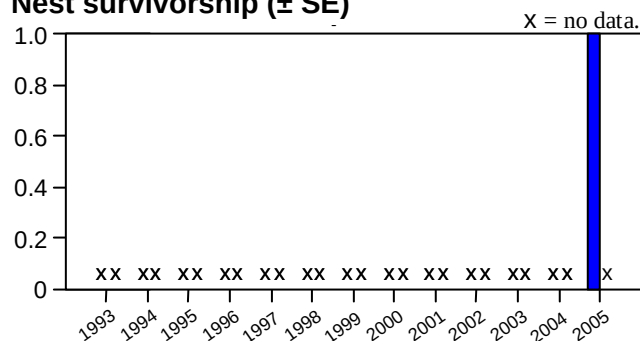
Ownership: private

Public observation areas: none

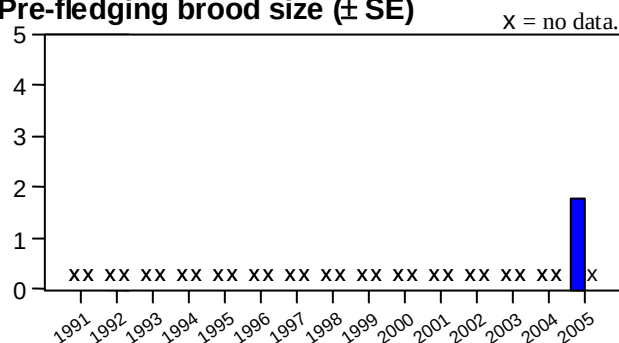
Latitude / Longitude: N 38.1732 / W 122.5715

■ Great Blue Heron □ Great Egret

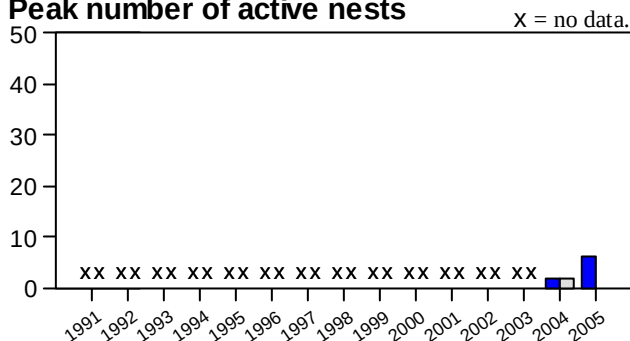
Nest survivorship ($\pm$ SE)



Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



(no photo)

Colony site description

Topography: levee

Length x width: 22 m x 22 m

Nest substrate: *Eucalyptus* sp.

Average nest height: 14 m

Trees (dbh): 5 (3-10 cm), 3 (10-50 cm), 4 (> 150 cm)

Maximum tree canopy height: 20 m

Vegetation cover: not measured

Evidence of disturbance

None recorded.

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial	X			
Grazing		X	X	

Russ Island

On the northern tip of Russ Island, Great Blue Herons and Double-crested Cormorants nest in a long line of eucalyptus snags running parallel to the levee. The trees are surrounded by standing water, and have very few branches. Many of the former salt evaporation ponds in the vicinity are being restored to tidal marsh habitats.

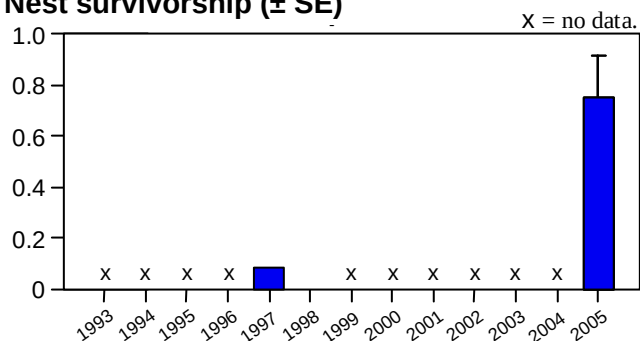
Ownership: public

Public observation areas: none

Latitude / Longitude: N 38.1892 / W 122.3304

■ Great Blue Heron

Nest survivorship ($\pm$ SE)



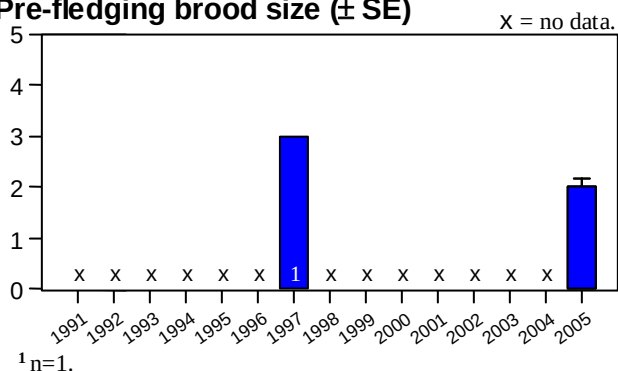
Colony site description

Topography: wetland
 Length x width: 400 m x 3 m
 Nest substrate: *Eucalyptus* sp. (dead branches)
 Average nest height: 4 m
 Trees (dbh): not measured
 Maximum tree canopy height: no canopy
 Vegetation cover: none

Evidence of disturbance

None recorded.

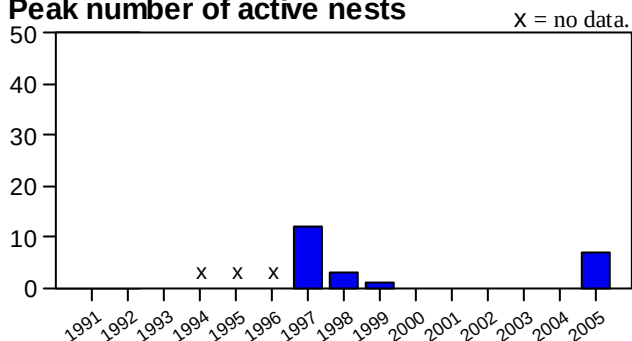
Pre-fledging brood size ($\pm$ SE)



Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Protected natural area	X	X	X	X

Peak number of active nests



Schellville

This colony site is on vineyard property, southeast of Schellville. The surrounding area is a mixture of vineyards and single-family homes on large lots. Schell Creek is 1.3 km to the west and the San Pablo Bay shore is 9.7 km south of the colony site. In 2003, a pair of Snowy Egrets nested at this site (not included in graphs), but subsequent nesting by this species has not occurred.

Ownership: private

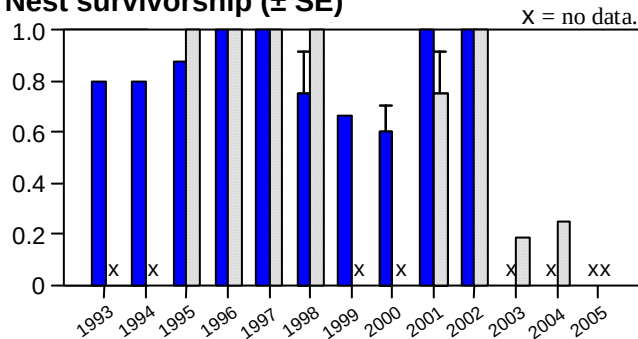
Public observation areas: none



Latitude / Longitude: N 38.2395 / W 122.4159



Nest survivorship ($\pm$ SE)



Colony site description

Topography: flood plain

Length x width: 12 m x 10 m

Nest substrate: *Eucalyptus* sp. (live and dead branches)

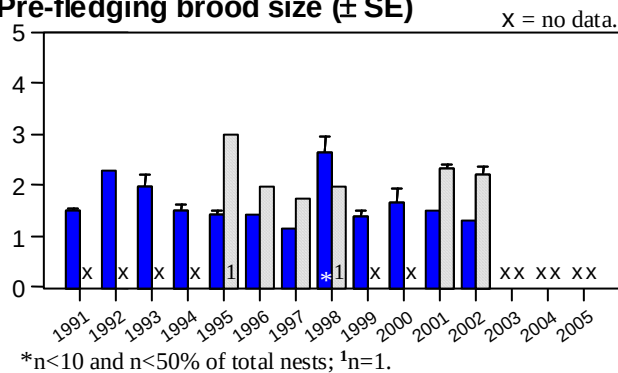
Average nest height: 16 m

Trees (dbh): 2 (10-50 cm), 1 (50-100 cm)

Maximum tree canopy height: 27 m

Vegetation cover: tree 50%, shrub 0%, ground 10%

Pre-fledging brood size ($\pm$ SE)



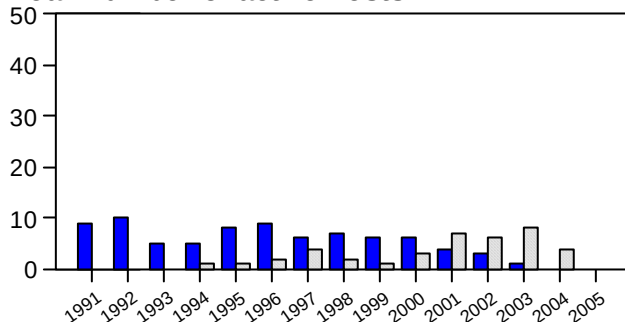
Evidence of disturbance

Resident Red-tailed Hawk: behavioral response

Resident Great Horned Owl: behavioral response

Human activity (nest trees in western grove removed): behavioral response

Peak number of active nests



Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X	X	X	X
Vineyard	X	X	X	X

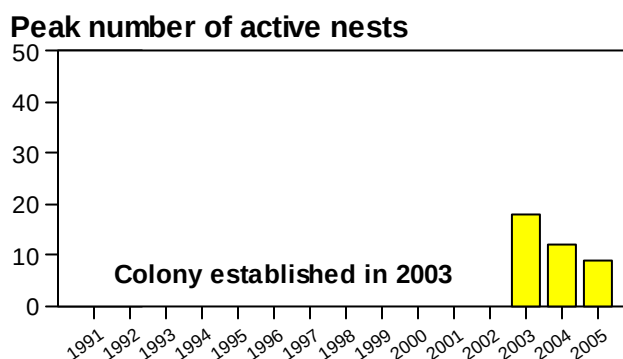
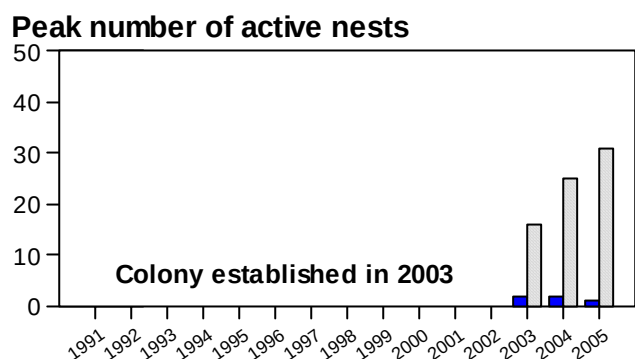
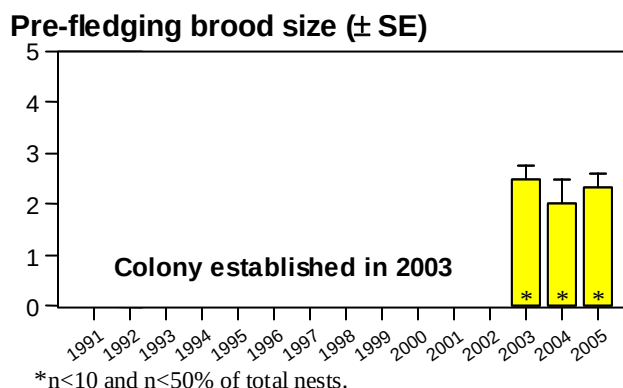
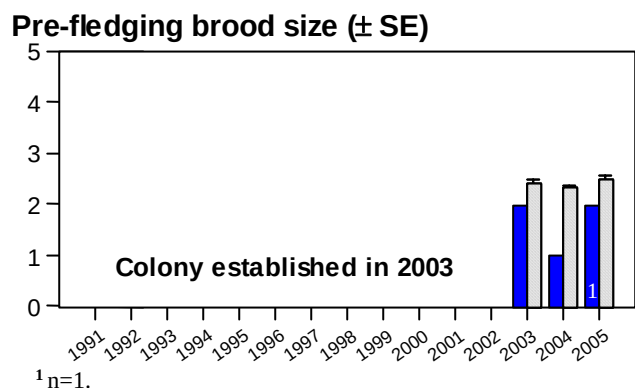
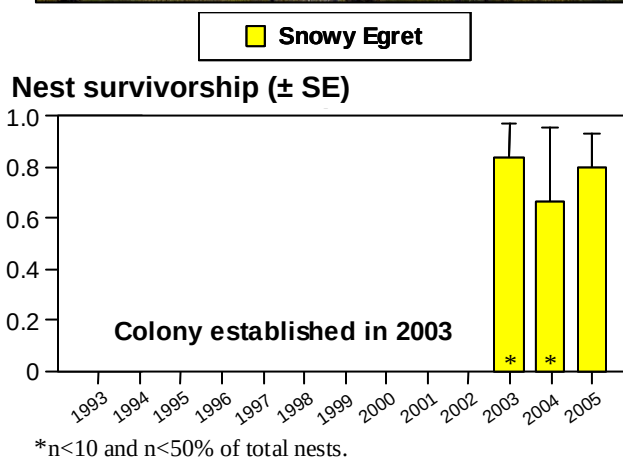
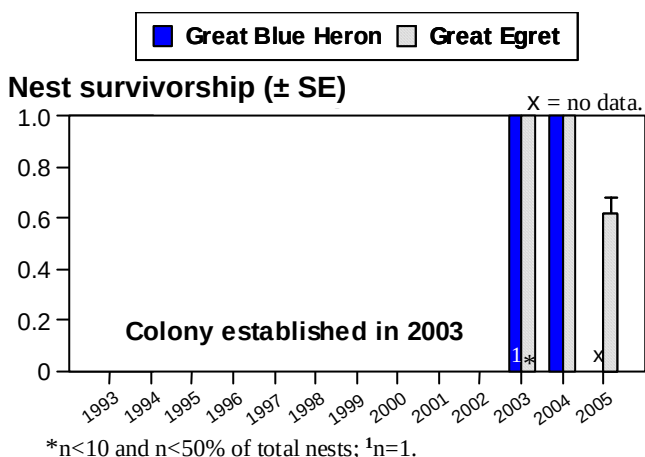
Shollenberger Park

This heronry is on the west shore of the Petaluma River, across from Shollenberger Park. The nesting trees are within 100 m of various dwellings and sheds, between Highway 101 and the Petaluma River. The walking path in Shollenberger Park affords excellent vantage points for viewing the nesting birds.

Ownership: private

Public observation areas: Shollenberger Park

Latitude / Longitude: N 38.2213 / W 122.6060



(continued)

Shollenberger Park (continued)

Colony site description

Topography: flood plain

Length x width: 38 m x 13 m

Nest substrate: *Eucalyptus* sp.

Average nest height: 24 m

Trees (dbh): 3 (3-10 cm), 5 (10-50 cm), 8 (50-100 cm)

Maximum tree canopy height: 39 m

Vegetation cover: tree 67%, shrub 16%, ground 28%

Evidence of disturbance

None recorded.

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X	X	X	X
Mid-density housing			X	X
Protected natural area		X	X	X
Sports field				X

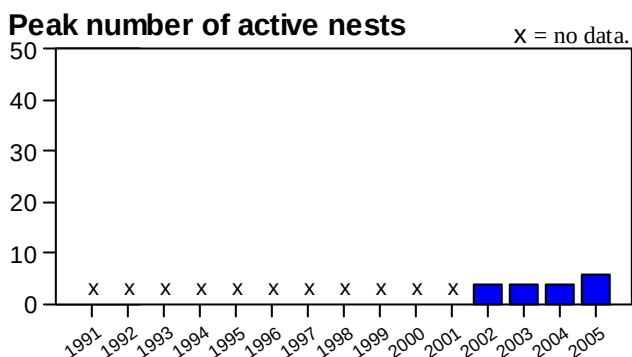
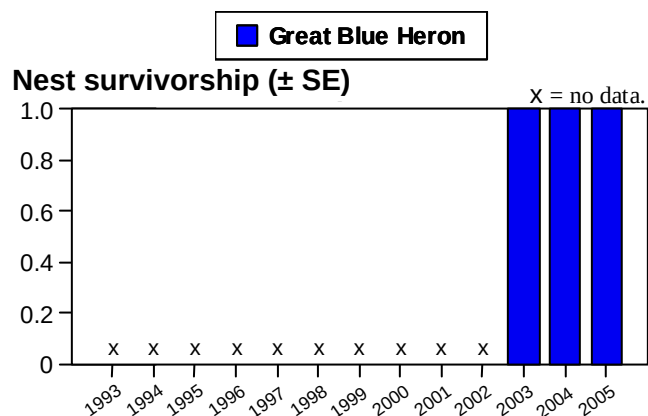
Skaggs Island Eucalyptus

Great Blue Herons nest in a patch of eucalyptus trees adjacent to the levee road along Hudeman Slough, on the west side of the Skaggs Island Naval Reservation. The property could eventually be transferred to the San Pablo Bay National Wildlife Refuge. Much of the original marshland near the colony is diked and farmed for hay.

Ownership: public

Public observation areas: none

Latitude / Longitude: N 38.1928 / W 122.3908



Colony site description

Topography: flood plain

Length x width: 19 m x 8 m

Nest substrate: *Eucalyptus* sp.

Average nest height: 21 m

Trees (dbh): 11 (3-10 cm), 4 (10-50 cm),
5 (50-100 cm)

Maximum tree canopy height: 30 m

Vegetation cover: tree 58%, shrub 16%, ground 7%

Evidence of disturbance

Resident Red-tailed Hawk: behavioral response

Land use

	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Land use	100	200	500	1000
Farming				X

Skaggs Island Sewage Ponds

This colony is on Skaggs Island Naval Reservation, 15 km northwest of Vallejo. Black-crowned Night-Herons nest in an old sewage pond approximately 2.5 ha in extent, with 30% open water, 60% cattail (*Typha* spp.), and 10% tules (*Scirpus* spp.). The heron nests are concentrated in tules. The pond is surrounded by seasonal wetlands, diked farmland, and tidal sloughs.

Ownership: public

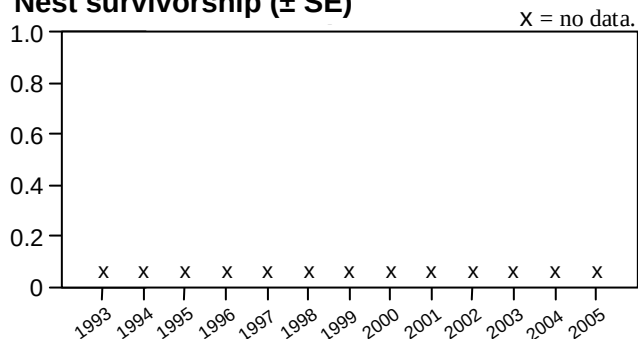
Public observation areas: none

Latitude / Longitude: N 38.1885 / W 122.3795



■ Black-crowned Night-Heron

Nest survivorship ($\pm$ SE)



Colony site description

Topography: wetland

Length x width: 80 m x 50 m

Nest substrate: *Scirpus* sp.

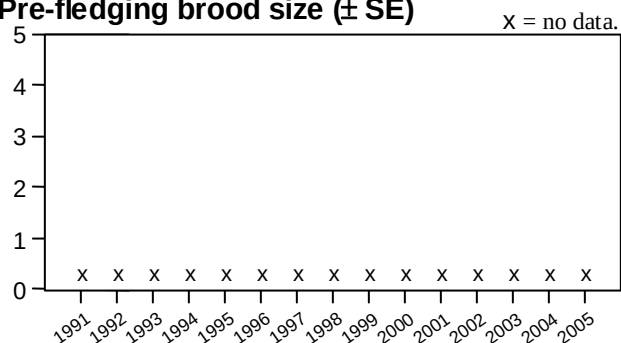
Average nest height: 1 m

Trees (dbh): none

Maximum tree canopy height: 0 m

Vegetation cover: tree 0%, shrub 100%,
ground 100%

Pre-fledging brood size ($\pm$ SE)



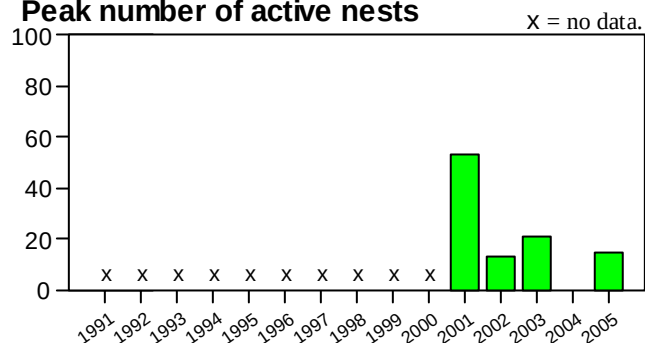
Evidence of disturbance

None recorded.

Land use

	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Land use	100	200	500	1000
Farming			X	X

Peak number of active nests



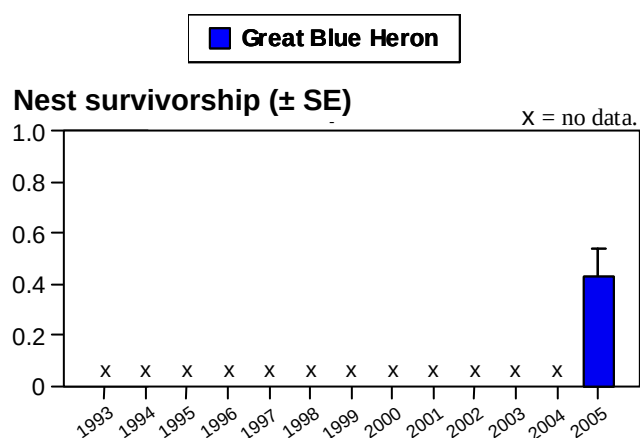
South Kelly

South of the City of Napa, near the intersection of Highways 29 and 12, Great Blue Herons nest in a row of eucalyptus paralleling South Kelly Road. The nest trees are adjacent to a vineyard, and about 100 m from a golf course, driving range, and large equipment sheds.

Ownership: private

Public observation areas: South Kelly Road

Latitude / Longitude: N 38.2204 / W 122.2534



Colony site description

Topography: hillside

Length x width: 105 m x 7 m

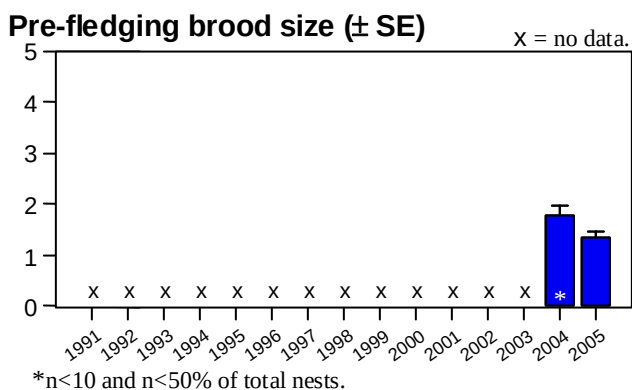
Nest substrate: *Eucalyptus* sp.

Average nest height: 30 m

Trees (dbh): 37 (50-100 cm), 8 (100-150 cm),
4 (> 150 cm)

Maximum tree canopy height: 40 m

Vegetation cover: tree 20%, shrub 3%, ground 0%

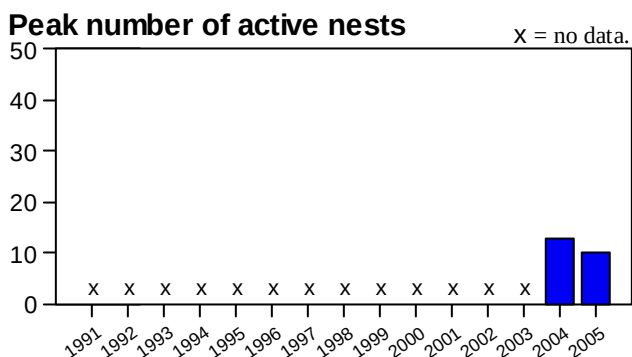


Evidence of disturbance

None recorded.

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing			X	X
Vineyard	X	X	X	X
Sports field	X	X	X	X



Stafford Lake

Great Blue Herons nested on an island in Stafford Lake, a reservoir in the North Marin Water District west of Novato. In 1994, the water level in the reservoir was lowered for repairs and all nests in the colony were destroyed, apparently by raccoons that crossed the temporary land bridge to the island. (Records prior to 1990 are from Shuford 1993.)

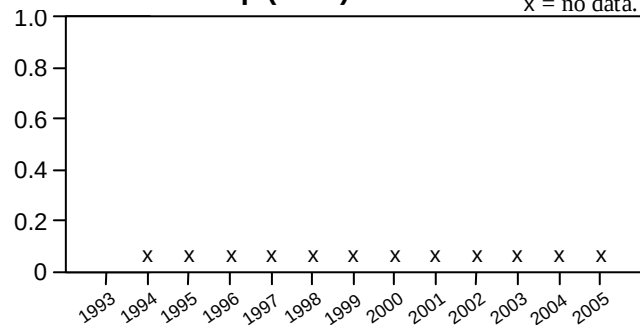
Ownership: public

Public observation areas: Hicks Valley Road

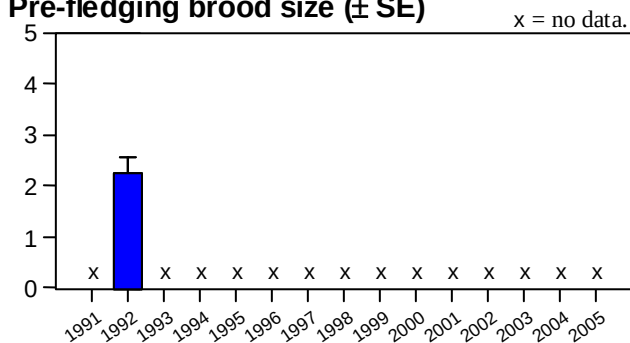
Latitude / Longitude: N 38.1152 / W 122.6410

■ Great Blue Heron

Nest survivorship ($\pm$ SE)



Pre-fledging brood size ($\pm$ SE)



Colony site description

Topography: island (without bridge)

Length x width: not measured

Nest substrate: live oak (*Quercus agrifolia*)

Average nest height: not measured

Trees (dbh): not measured

Maximum tree canopy height: 14 m

Vegetation cover: tree 70%, shrub 5%, ground 0%

Evidence of disturbance

Raccoons: colony abandonment

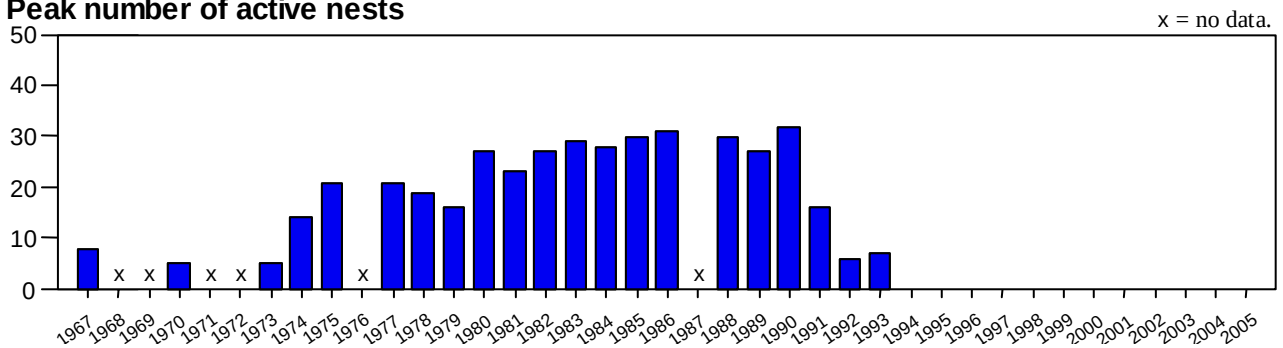
Golden Eagle: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Protected natural area	X	X	X	X

Peak number of active nests



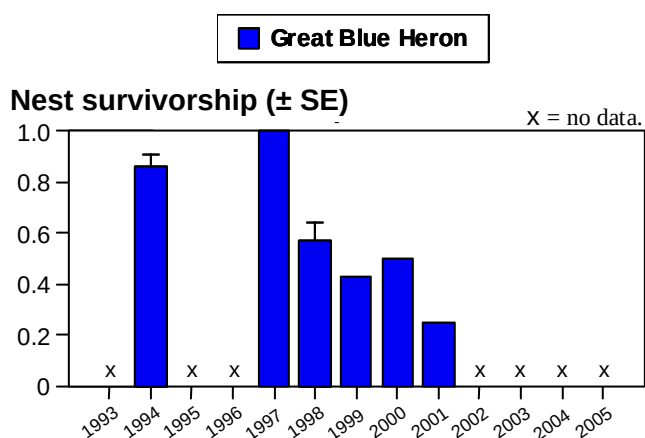
Stanley Ranch

This heronry is on a levee along Horseshoe Bend in the Napa River, about 3.5 km south of the City of Napa. The Napa County Flood Control and Water Conservation District manages the property. Great Blue Herons have nested in a large eucalyptus overhanging the Napa River. The diked fields that surround the colony grow hay and grapes.

Ownership: public

Public observation areas: none

Latitude / Longitude: N 38.2505 / W 122.2927



Colony site description

Topography: levee

Length x width: 17 m x 15 m

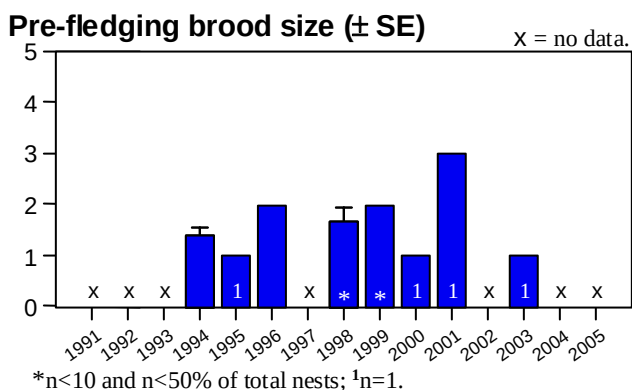
Nest substrate: *Eucalyptus* sp. (live and dead branches)

Average nest height: 20 m

Trees (dbh): 1 (100-150 cm)

Maximum tree canopy height: 24 m

Vegetation cover: tree 35%, shrub 0%, ground 58%



Evidence of disturbance

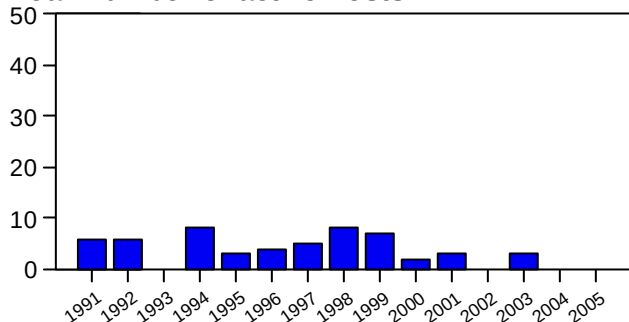
Human activity (observer): behavioral response

Red-tailed Hawk: potential source ^a

Red-shouldered Hawk: potential source ^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Peak number of active nests



Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial				X
Low density housing				X
Vineyard				X

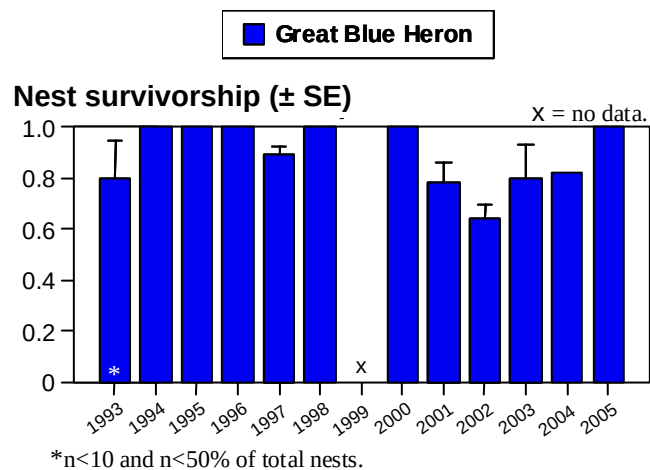
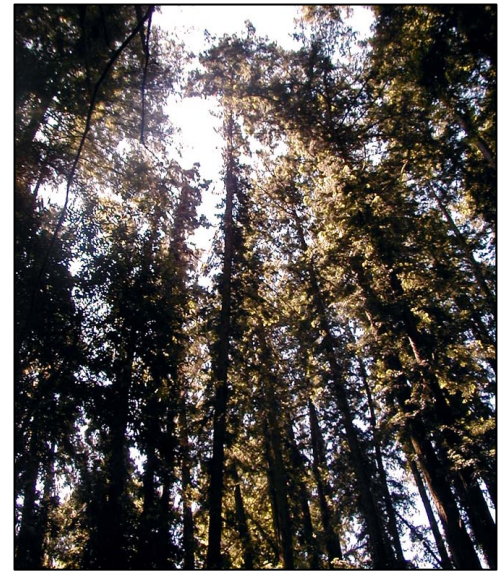
Vigilante Road

Great Blue Herons nest in tall redwoods on the west side of the Valley of the Moon, about 8 km northwest of the City of Sonoma, on the property of a private community. About 30 m from the colony, a 1.5 ha area has been cleared to build a house. Sonoma Creek is 2.2 km to the east.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.3350 / W 122.5292



Colony site description

Topography: flood plain

Length x width: 28 m x 17 m

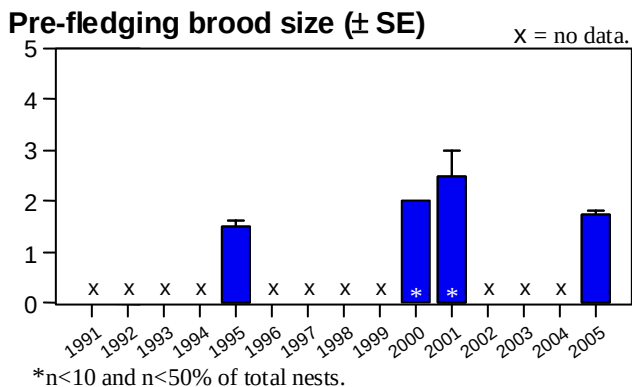
Nest substrate: coast redwood (*Sequoia sempervirens*, live and dead branches)

Average nest height: 32 m

Trees (dbh): 24 (50-100 cm)

Maximum tree canopy height: 35 m

Vegetation cover: tree 45%, shrub 5%, ground 0%



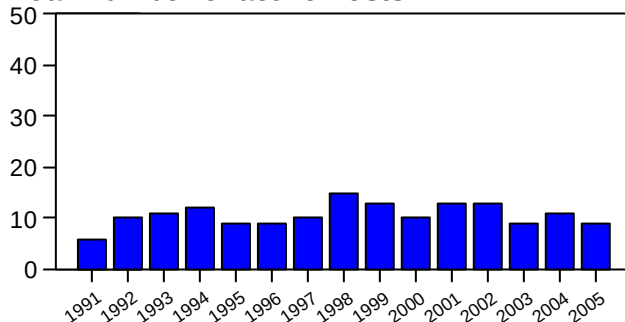
Evidence of disturbance

Human activity (house construction):
behavioral response

Common Raven: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Peak number of active nests



Land use

	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Land use	100	200	500	1000
Low density housing		X	X	X

Colony Sites with Limited Activity

Fairview Terrace

For at least two years Snowy Egrets and Black-crowned Night-Herons nested in a live oak (*Quercus agrifolia*) in a residential area of southwestern Petaluma.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.2247 / W 122.6287

Species	Years known to be active (number of active nests)
Black-crowned Night-Heron	1996 (2), 1997 (4)
Snowy Egret	1996 (8), 1997 (14)

Mare Island Pier 35

In 2002, a Great Blue Heron successfully nested on a light pole at the end of Pier 35. In 2003, a pair of Ospreys harassed the herons early in the breeding season and took over the nest for their own use. Herons returned to nest at this site in 2005.

Ownership: public

Public observation areas: boat

Latitude / Longitude: N 38.0694 / W 122.2517

Species	Years known to be active (number of active nests)
Great Blue Heron	2002 (1), 2005 (1)

McNear Channel

In 2005, Great Blue Herons were discovered nesting in conifers on the east bank of the Petaluma River, near downtown Petaluma.

Ownership: unknown

Public observation areas: boat

Latitude / Longitude: N 38.2319 / W 122.6255

Species	Years known to be active (number of active nests)
Great Blue Heron	2005 (5)



Colony Sites with Limited Activity

Napa Marsh N-3

This colony was located in a stand of eucalyptus trees on a levee bordering a former salt evaporation pond, 0.8 km from a freshwater marsh. In 1992, this colony became the first reported instance of Great Egrets breeding in Napa County.

Ownership: public (California DFG)

Public observation areas: trails along levees

Latitude / Longitude: N 38.2073 / W 122.3519

Species	Years known to be active (number of active nests)
Great Blue Heron	1992 (4), 1993 (3)
Great Egret	1992 (2)

Schultz Slough

Great Blue Herons nested in a mixed grove of eucalyptus, cypress and pine atop a rise 170 m west of the Petaluma River, overlooking the Petaluma Marsh. The property, a former farm, was purchased in 2004 and converted to a private nature preserve.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.2084 / W 122.5865

Species	Years known to be active (number of active nests)
Great Blue Heron	2004 (unknown)



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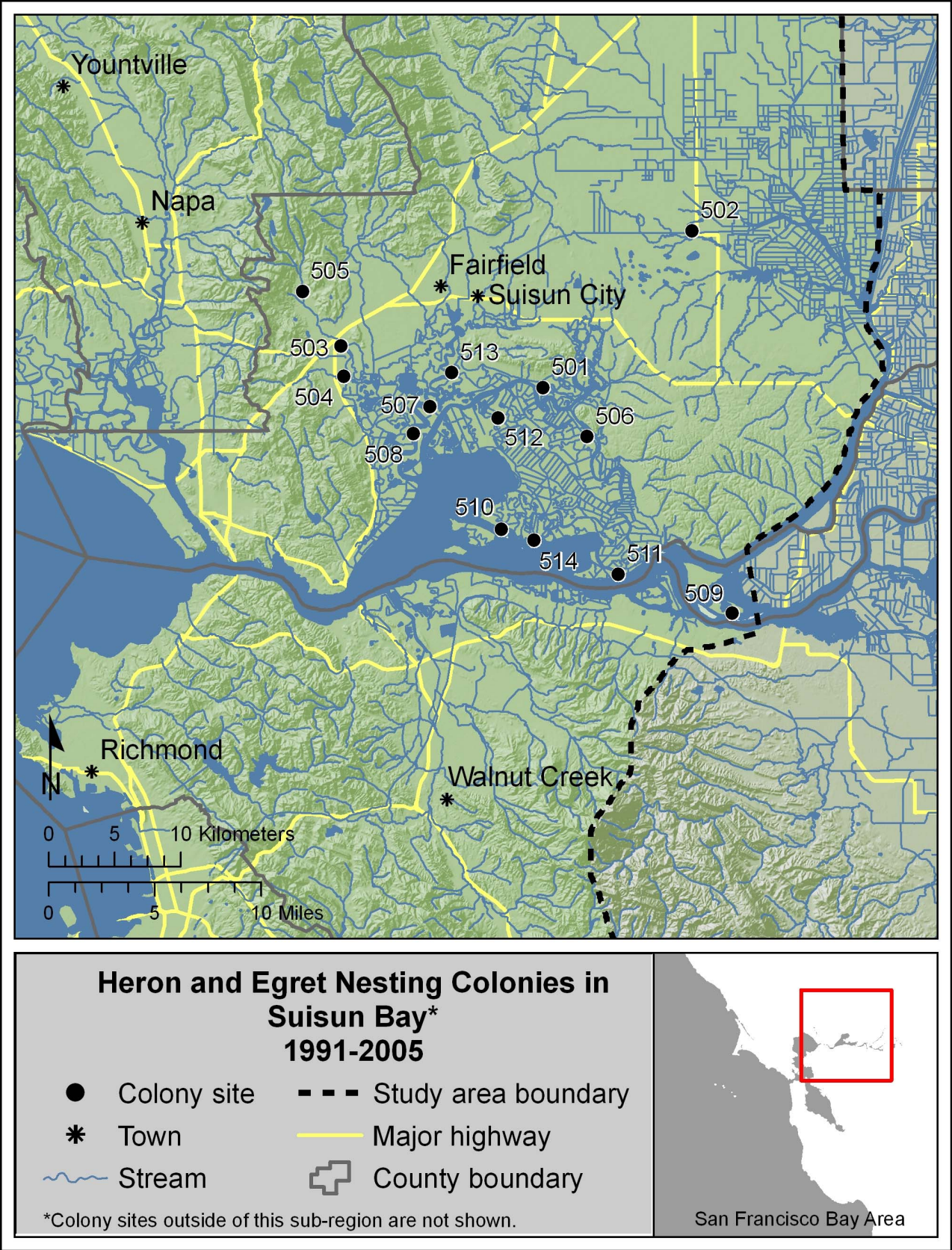
SUISUN BAY



SUISUN BAY

Located immediately downstream of the confluence of the Sacramento and San Joaquin Rivers, Suisun Bay is the largest contiguous wetland area in the San Francisco Bay region. Suisun Bay is a dynamic, transitional zone between the freshwater input of the Central Valley rivers and the tidal influence of the upper San Francisco Estuary. This area supports a substantial number of nesting herons and egrets, including three of the largest colonies in the region. Although suburban development is rampant along the nearby Interstate 80 corridor to the north, most of the Suisun Bay area is protected from heavy development by the California Department of Fish and Game and a number of private duck clubs.

Site #	Colony Site	Great Blue Heron	Great Egret	Snowy Egret	Black-crowned Night-Heron	Cattle Egret	County	Active or year last active	Page
501	Bohannon	■	□				Solano	Active	142
502	Campbell Ranch	■	□	■			Solano	Active	143
503	Cordelia Road	■					Solano	1998	145
504	Gold Hill	■	□	■			Solano	Active	146
505	Green Valley Road	■					Solano	Active	148
506	Hidden Cove	■	□				Solano	Active	149
507	Joice Island	■	□				Solano	1994	150
508	Joice Island Annex	■	□				Solano	Active	151
509	Sherman Lake	■	□				Sacramento	Active	152
510	Simmons Island	■	□				Solano	1994	153
511	Spoonbill	■	□				Solano	Active	154
512	Tree Slough	■	□				Solano	Active	155
513	Volanti	■	□				Solano	Active	156
514	Wheeler Island	■	□				Solano	Active	157



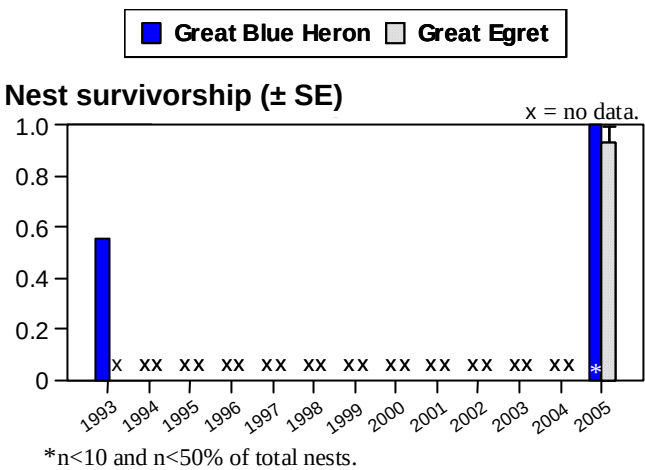
Bohannon

Great Blue Herons and Great Egrets nest in a grove of eucalyptus trees on a levee in Cross Slough, about 1.8 km east of Beldons Landing. This site, on the property of a private duck club, is accessible only by boat and at high tide.

Ownership: private

Public observation areas: boat

Latitude / Longitude: N 38.1827 / W 121.9565



Colony site description

Topography: levee

Length x width: 125 m x 60 m

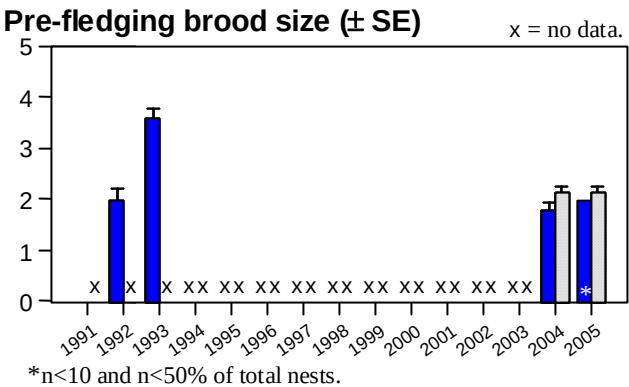
Nest substrate: *Eucalyptus* sp. (live and dead branches)

Average nest height: 22 m

Trees (dbh): not measured

Maximum tree canopy height: 28 m

Vegetation cover: tree 60%, shrub 10%, ground 10%



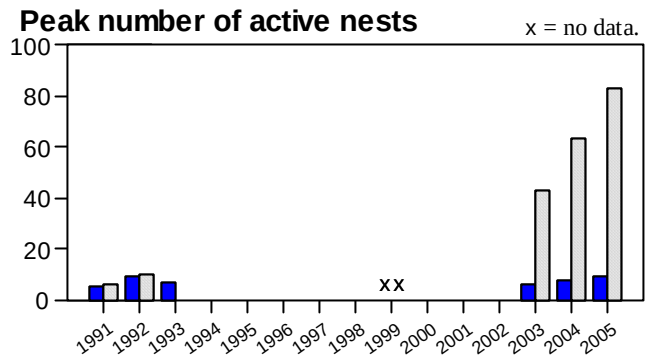
Evidence of disturbance

Resident Red-tailed Hawk: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Duck club	X	X	X	X



Campbell Ranch

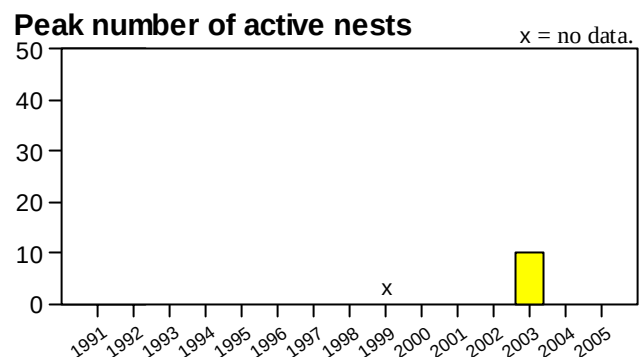
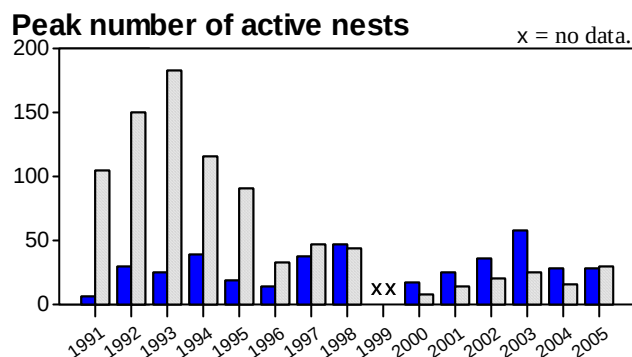
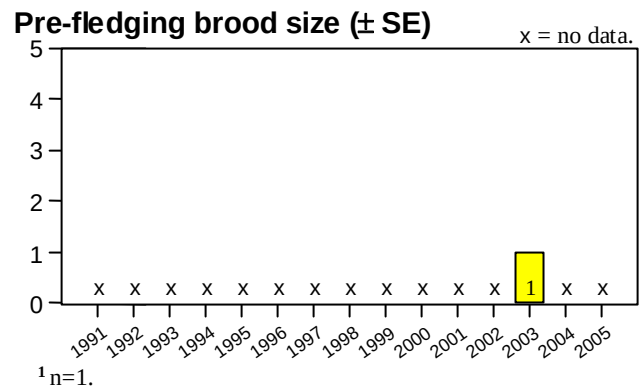
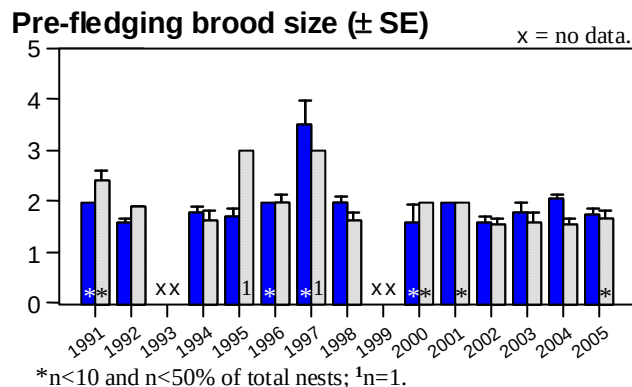
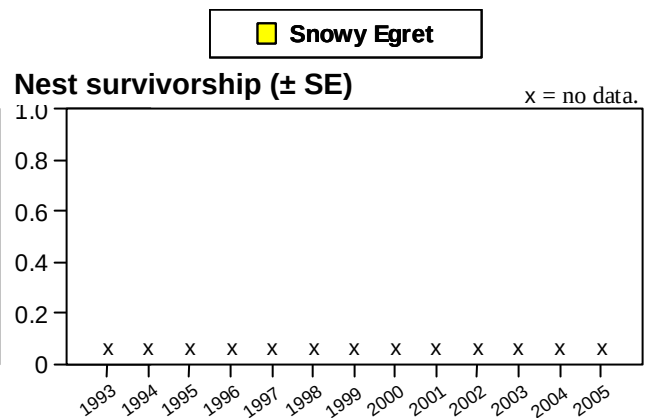
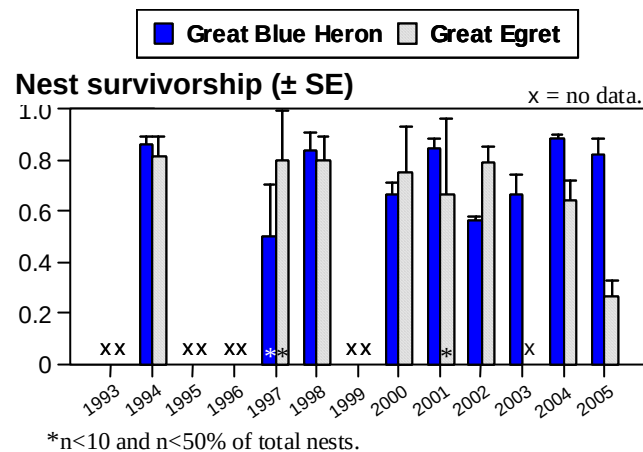
This colony site is located along Highway 113 about 17 km south of Dixon. Herons and egrets nest at two subsites separated by 123 m. Livestock graze within the colony. A motorbike track is 1 km from the colony. The closest sloughs from the Sacramento River are approximately 2 km to the east.

Ownership: private

Public observation areas: none

Latitude / Longitude:

N 38.2888 / W 121.8266 (West subsite)



(continued)

Campbell Ranch (continued)

Colony site description

West subsite

Topography: flood plain
 Length x width: 66 m x 61 m
 Nest substrate: *Eucalyptus* sp. (live and dead branches)
 Average nest height: 26 m
 Trees (dbh): 27 (50-100 cm), 4 (50-100 cm)
 Maximum tree canopy height: 34 m
 Vegetation cover: tree 21%, shrub 0%, ground 74%

East subsite

Topography: flood plain
 Length x width: 38 m x 5 m
 Nest substrate: *Eucalyptus* sp. (live and dead branches)
 Average nest height: 25 m
 Trees (dbh): 7 (50-100 cm), 1 (> 150 cm)
 Maximum tree canopy height: 28 m
 Vegetation cover: tree 35%, shrub 0%, ground 18%

Evidence of disturbance

Swainson's Hawk: behavioral response
 Red-tailed Hawk: behavioral response
 Human activity: behavioral response
 Some nest trees cut down during non-breeding season:
 potential source^a
 Common Raven: potential source^a

^aPossible disturbance suggested by published accounts
 (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X	X		X
Grazing	X	X	X	X



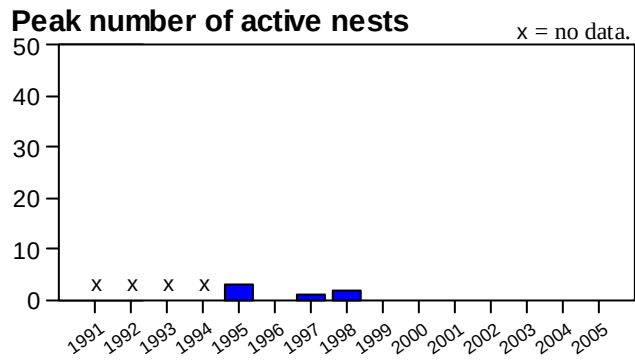
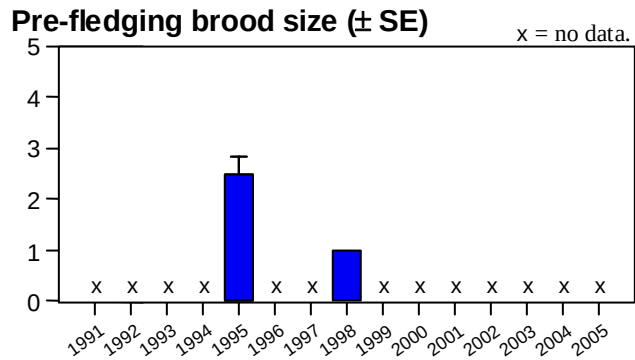
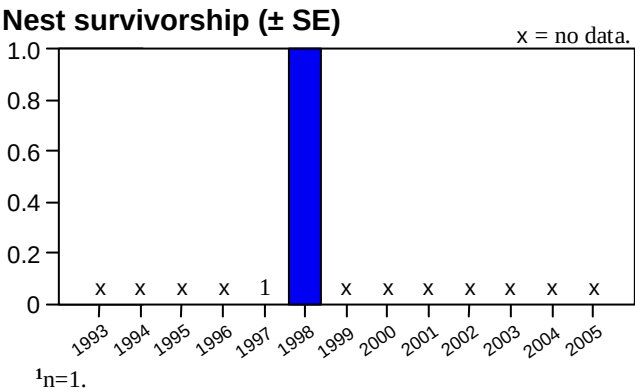
Cordelia Road

Great Blue Herons nested in a small stand of eucalyptus trees on the east side of Cordelia, on property owned by the Girl Scouts of America. Rapid development in recent years has changed Cordelia from a sleepy suburban village to a bustling commercial center. The seasonal edge of Suisun Marsh is 200 m east of the site.

Ownership: private
Public observation areas: Cordelia Road
Latitude / Longitude: N 38.2123 / W 122.1313



Great Blue Heron



Colony site description

Topography: hillside
Length x width: 18 m x 12 m
Nest substrate: *Eucalyptus* sp.
Average nest height: not measured
Trees (dbh): 1 (100-150 cm)
Maximum tree canopy height: 38 m
Vegetation cover: not measured

Evidence of disturbance

Human activity: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X	X	X	X
Mid-density housing			X	X
High density housing				X

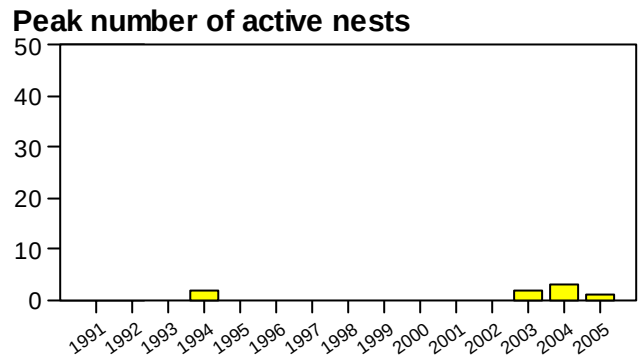
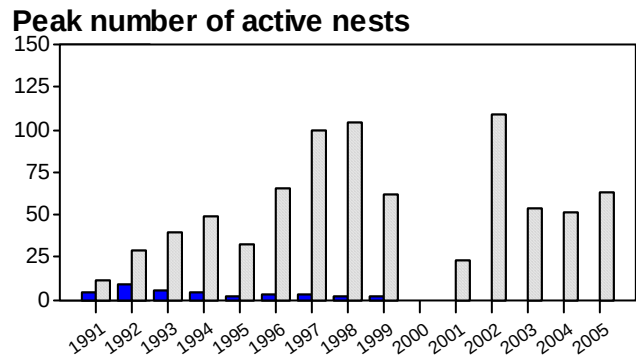
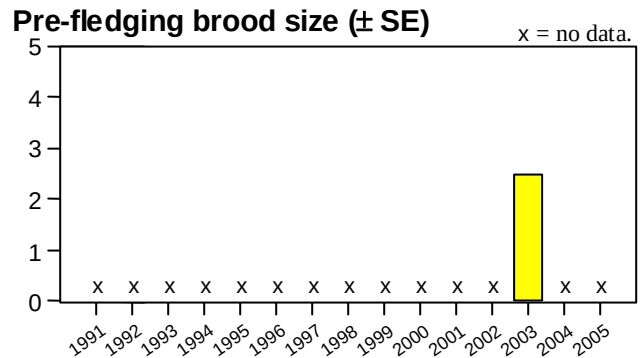
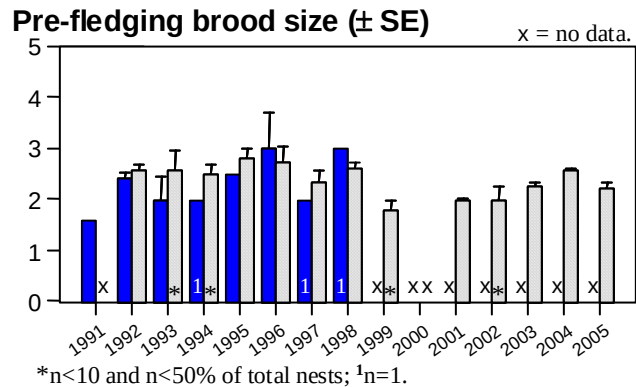
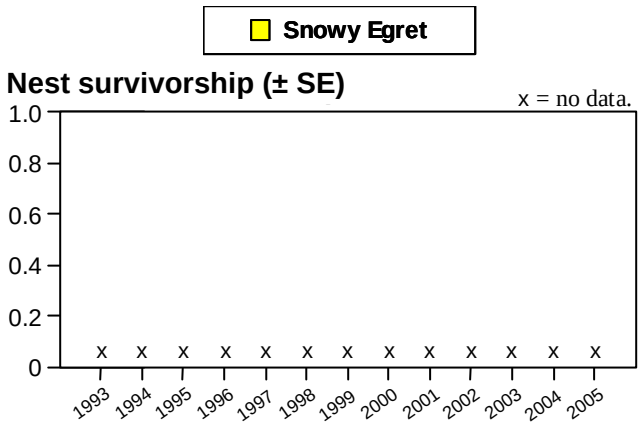
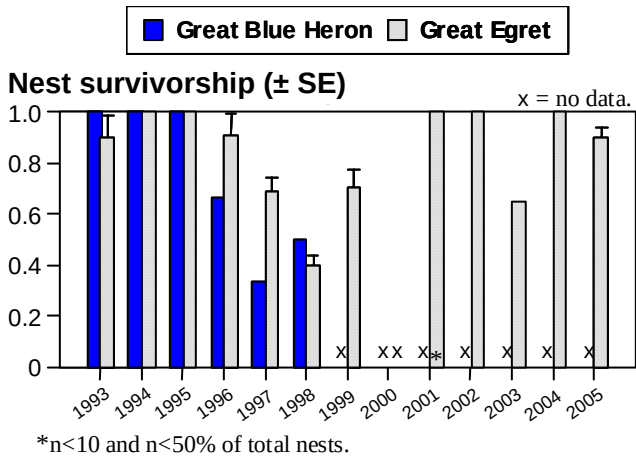
Gold Hill

This heronry site is about 2 km south of Cordelia and 0.6 km east of Interstate 680, on the property of a farm equipment supplier. The surrounding habitat is mostly grassland and scrub brush to the west, with Suisun Marsh lying 0.5 km to the east.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 38.1917 / W 122.1289



(continued)

Gold Hill (continued)

Colony site description

Topography: flood plain

Length x width: 70 m x 16 m

Nest substrate: *Eucalyptus* sp.(live and dead branches)

Average nest height: 25 m

Trees (dbh): 3 (100-150 cm)

Maximum tree canopy height: 32 m

Vegetation cover: tree 47%, shrub 0%, ground 69%

Evidence of disturbance

Human activity (extensive trimming of tree limbs in preseason): colony abandonment

Resident Great Horned Owl: behavioral response

Red-tailed Hawk: potential source^a

Human activity (heavy machinery): potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing			X	
Duck club				X

Green Valley Road

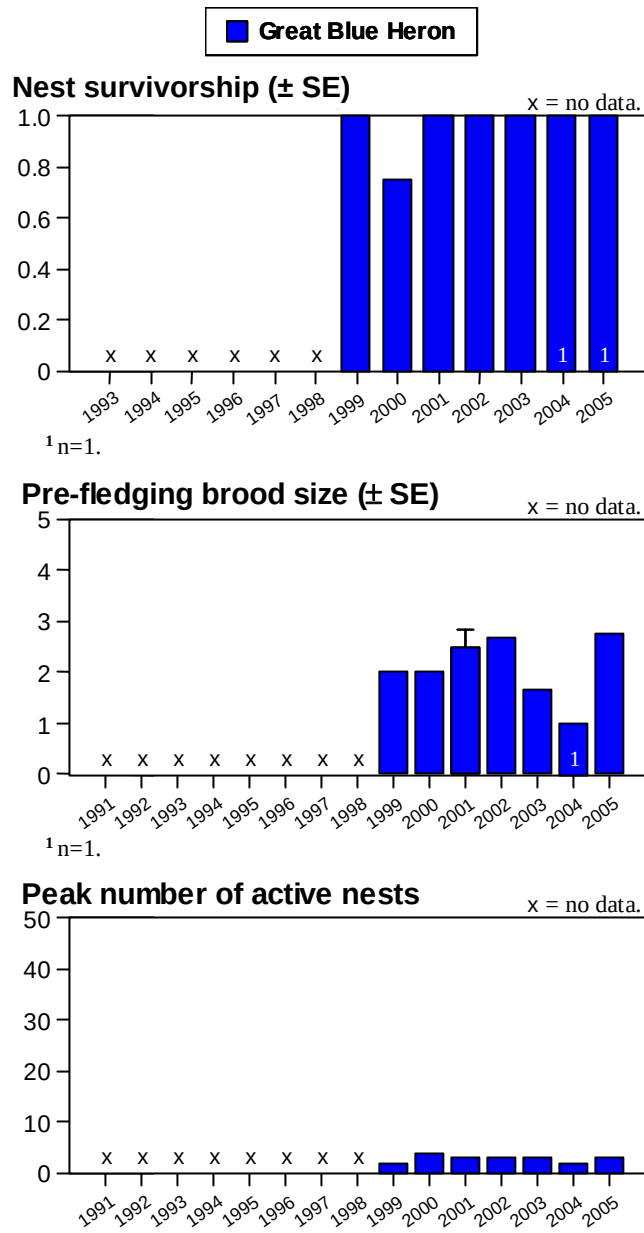
Great Blue Herons nest in two subsites near the junction of Green Valley Road and Rockville Road, about 5 km north of Cordelia. The original site was in redwoods along a driveway. In 2004, herons nested in redwoods in a residential area to the southwest. Suisun Marsh is 5.3 km to the southeast.

Ownership: private

Public observation areas: Green Valley Road

Latitude / Longitude:

N 38.2481 / W 122.1655 (Southwest subsite)



Colony site description

Northeast subsite

Topography: suburban

Length x width: 35 m x 10 m

Nest substrate: coast redwood (*Sequoia sempervirens*)

Average nest height: 30 m

Trees (dbh): 7 (50-100 cm)

Maximum tree canopy height: 36 m

Vegetation cover: tree 55%, shrub 5%, ground 10%

Southwest subsite

Topography: suburban

Length x width: 25 m x 10 m

Nest substrate: coast redwood (*Sequoia sempervirens*)

Average nest height: 22 m

Trees (dbh): 2 (10-50 cm), 20 (50-100 cm)

Maximum tree canopy height: 28 m

Vegetation cover: tree 90%, shrub 0%, ground 0%

Evidence of disturbance

None recorded.

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X	X	X	X
Mid-density housing		X	X	X
Sports field				X

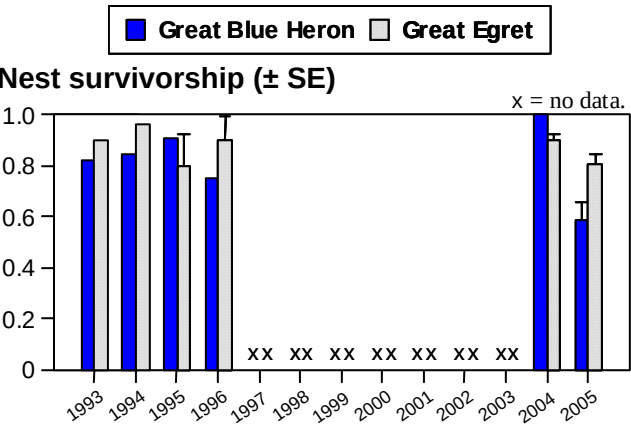
Hidden Cove

This heronry straddles the property of two duck clubs. Herons and egrets nest along a eucalyptus-lined side channel on the west side of Montezuma Slough, 1.2 km northwest of Meins Landing. The surrounding area is a mosaic of seasonal wetlands and diked impoundments managed for duck hunting. An introduced species of crayfish, *Procambarus clarki*, provides abundant prey in adjacent wetlands.

Ownership: private

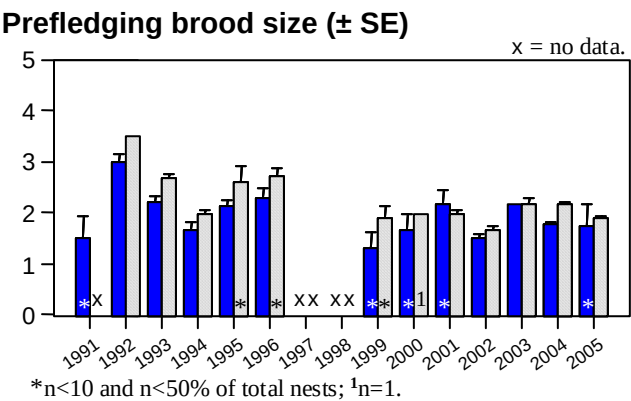
Public observation areas: none

Latitude / Longitude: N 38.1488 / W 121.9187



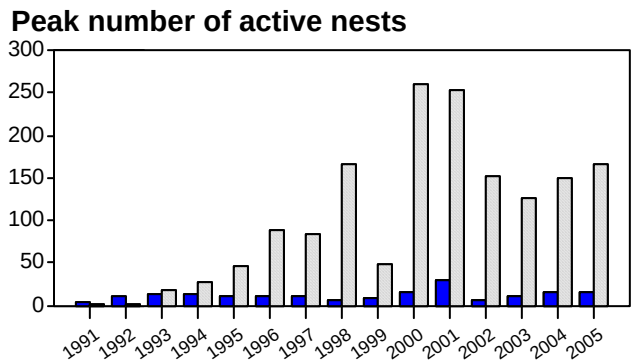
Colony site description

Topography: levee
Length x width: 154 m x 27 m
Nest substrate: *Eucalyptus* sp. (live and dead branches)
Average nest height: 22 m
Trees (dbh): not measured
Maximum tree canopy height: 34 m
Vegetation cover: tree 25%, shrub 5%, ground 5%



Evidence of disturbance

Human activity (loud noise): potential source^a
Tree fell in preseason: potential source^a
Resident Red-tailed Hawk : potential source^a
Resident Great Horned Owl: potential source^a
^aPossible disturbance suggested by published accounts (see references in Methods).



Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing				X
Duck club	X	X	X	X

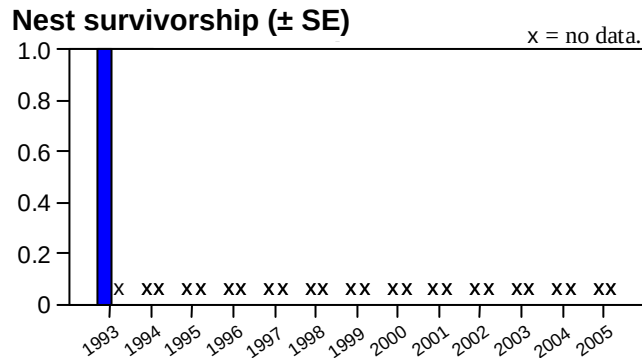
Joice Island

This colony site is on a levee east of Suisun Slough, 4 km north of Grizzly Bay. Joice Island is a State Game Refuge and the property is managed by the California Department of Fish and Game. The main nest tree is now completely gone.

Ownership: public

Public observation areas: boat

Latitude / Longitude: N 38.1706 / W 122.0546



Colony site description

Topography: levee, island

Length x width: 100 m x 25 m

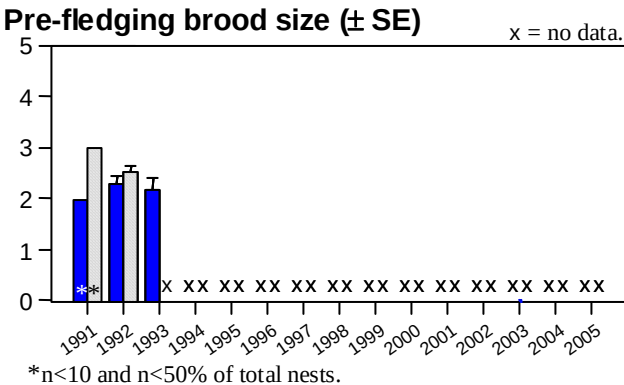
Nest substrate: *Eucalyptus* sp. (live and dead branches)

Average nest height: not measured

Trees (dbh): 2 (100-150 cm)

Maximum tree canopy height: not measured

Vegetation cover: tree 40%, shrub 40%, ground 0%



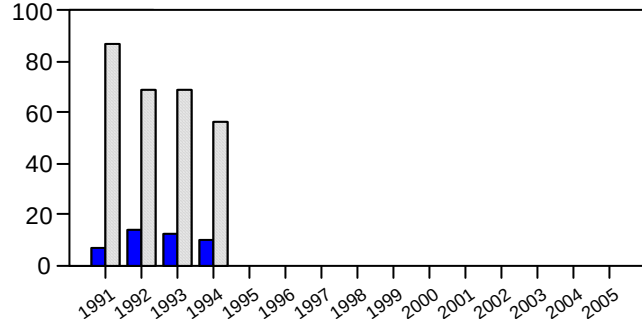
Evidence of disturbance

Tree fell: colony abandonment

Land use

	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Land use	100	200	500	1000
Protected natural area	X	X	X	X

Peak number of active nests



Joice Island Annex

This heronry is in two stands of eucalyptus trees atop a levee along Suisun Slough. Diked, managed wetlands surround the colony. Joice Island is a State Game Refuge managed by the California Department of Fish and Game.

Ownership: public

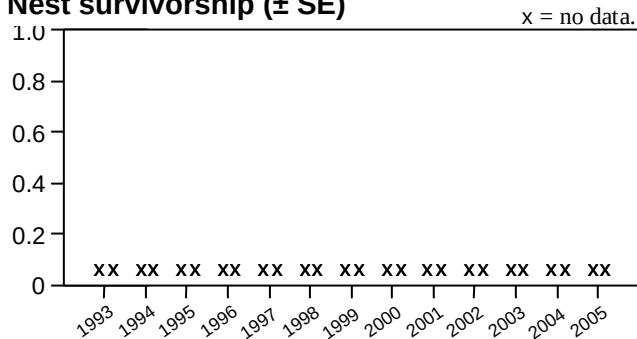
Public observation areas: boat

Latitude / Longitude:

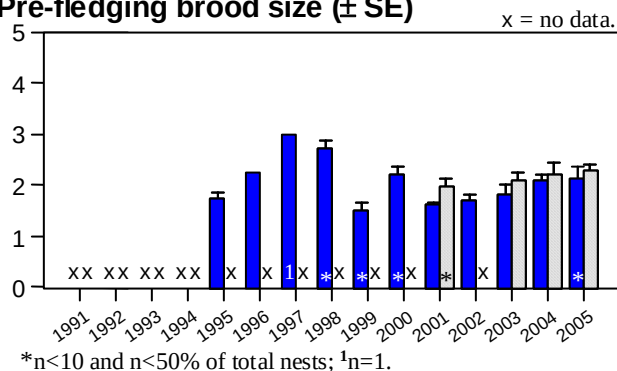
N 38.1504 / W 122.0687 (North subsite)

Great Blue Heron Great Egret

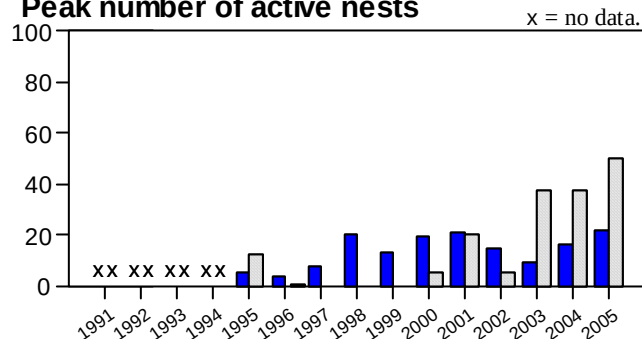
Nest survivorship ($\pm$ SE)



Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



Colony site description

North subsite

Topography: levee

Length x width: 22 m x 17 m

Nest substrate: *Eucalyptus* sp.

Average nest height: 24 m

Trees (dbh): 3 (100-150 cm)

Maximum tree canopy height: 28 m

Vegetation cover: tree 50 %, shrub 0%, ground 10%

South subsite

Topography: levee

Length x width: 51 m x 24 m

Nest substrate: *Eucalyptus* sp.

Average nest height: 24 m

Trees (dbh): 1 (50-100 cm), 2 (100-150 cm)

Maximum tree canopy height: 31 m

Vegetation cover: tree 75%, shrub 10%, ground 5%

Evidence of disturbance

Great Horned Owl: potential source^a

Common Raven: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Duck club	X	X	X	X

Sherman Lake

This heronry is on an island in the Sherman Lake Waterfowl Management Area at the confluence of the Sacramento and San Joaquin Rivers, 1.2 km north of the Antioch shoreline. Nesting occurs in a grove of tall cottonwood trees surrounded by dense thickets of willow.

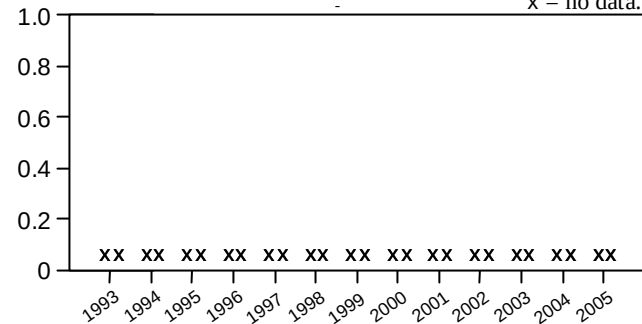
Ownership: public

Public observation areas: none

Latitude / Longitude: N 38.0270 / W 121.7953



Nest survivorship ($\pm$ SE)



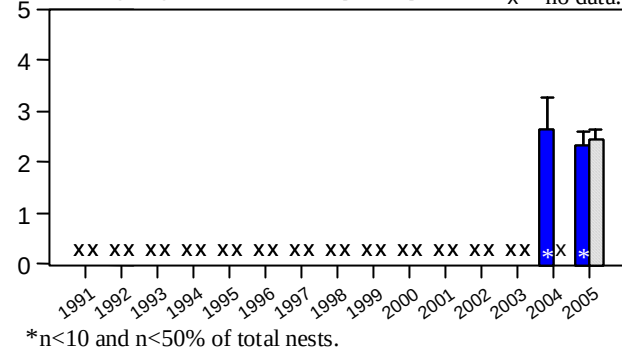
Colony site description

Topography: island (without bridge)
 Length x width: not measured
 Nest substrate: cottonwood (*Populus fremontii*)
 Average nest height: not measured
 Trees (dbh): 30 (100-150 cm), 3 (> 150 cm)
 Maximum tree canopy height: 42 m
 Vegetation cover: not measured

Evidence of disturbance

None recorded.

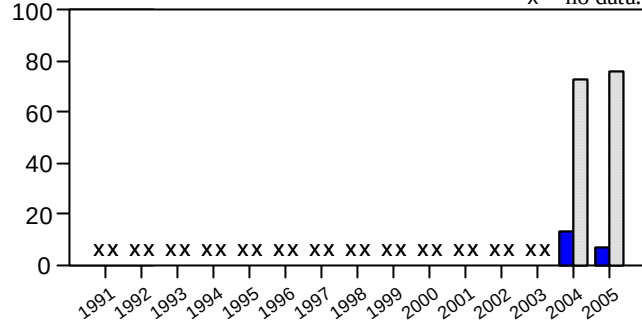
Pre-fledging brood size ($\pm$ SE)



Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing			X	X
Protected natural area	X	X	X	X

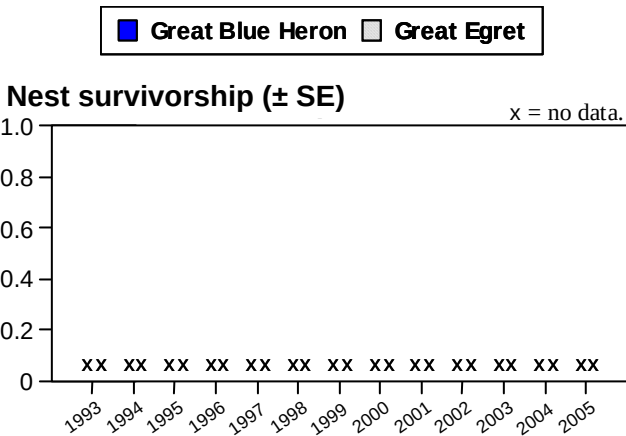
Peak number of active nests



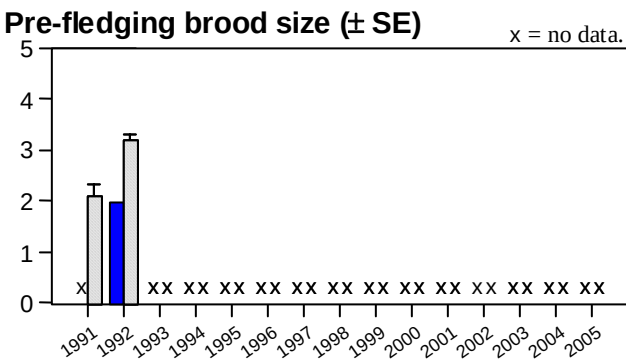
Simmons Island

Simmons Island is in the Suisun Cutoff, between Grizzly Bay and Suisun Bay. Herons and egrets nested on duck club property, about 100 m from the clubhouse.

Ownership: private
Public observation areas: boat
Latitude / Longitude: N 38.0863 / W 121.9940



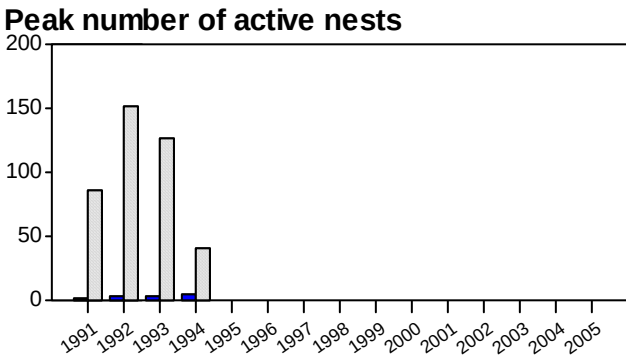
Colony site description
Topography: levee
Length x width: 100 m x 20 m
Nest substrate: *Eucalyptus* sp. (live and dead branches)
Average nest height: 20 m
Trees (dbh): not measured
Maximum tree canopy height: not measured
Vegetation cover: tree 70%, shrub 0%, ground 0%



Evidence of disturbance
None recorded.

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Duck club	X	X	X	X



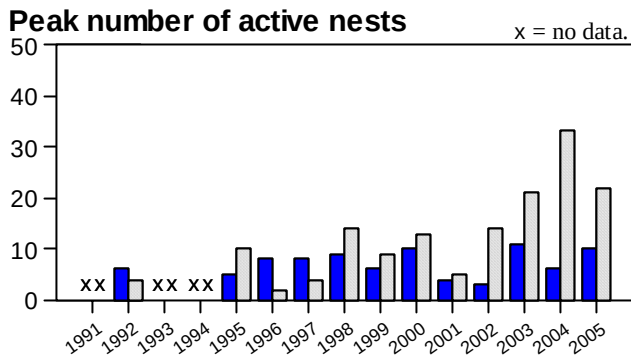
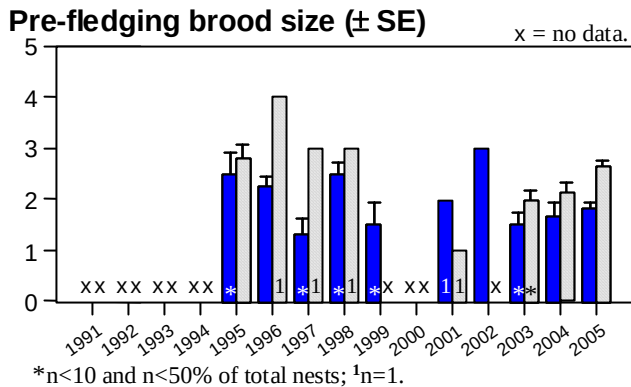
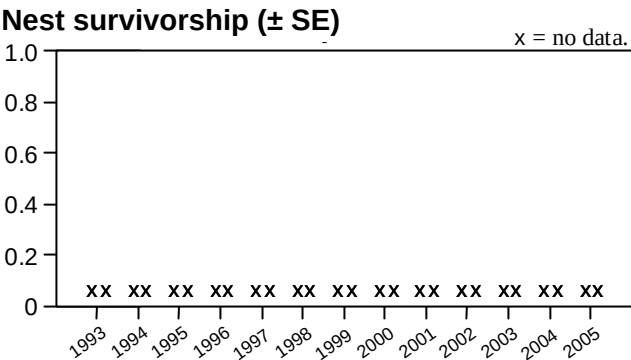
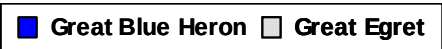
Spoonbill

This colony is in a small stand of eucalyptus trees at the south end of Spoonbill Creek, atop a levee on Van Sickle Island.

Ownership: private

Public observation areas: boat

Latitude / Longitude: N 38.0547 / W 121.8933



Colony site description

Topography: levee
 Length x width: 35 m x 25 m
 Nest substrate: *Eucalyptus* sp. (live and dead branches)
 Average nest height: 18 m
 Trees (dbh): 5 (3-10 cm), 17 (10-50 cm), 7 (50-100 cm)
 Maximum tree canopy height: 25 m
 Vegetation cover: tree 25%, shrub 15%, ground 30%

Evidence of disturbance

Resident Great Horned Owl: potential source^a
 Red-tailed Hawk: potential source^a
^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial				X
Low density housing				X
Duck club	X	X	X	X

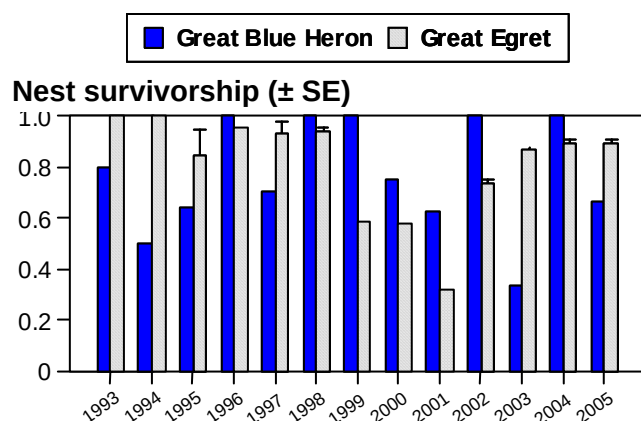
Tree Slough

This colony site is on Grizzly Island, about 2 km south of Montezuma Slough, on the property of a duck club. The nesting trees are 34 m from Tree Slough. Marsh, tide channels, and seasonal wetlands surround the colony. Black-crowned Night-Herons roost in the trees and reeds beneath the colony but nesting activity has not been observed.

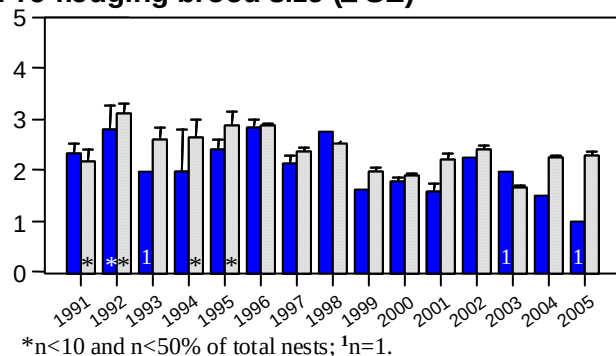
Ownership: private

Public observation areas: none

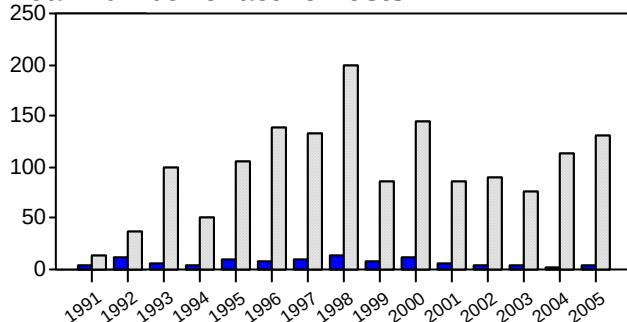
Latitude / Longitude: N 38.1623 / W 121.9957



Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



Colony site description

Topography: levee

Length x width: 42 m x 33 m

Nest substrate: *Eucalyptus* sp. (live and dead branches)

Average nest height: 16 m

Trees (dbh): 28 (3-50 cm), 26 (50-100 cm), 1 (100-150 cm)

Maximum tree canopy height: 25 m

Vegetation cover: tree 40%, shrub 2%, ground 70%

Evidence of disturbance

Human activity (skeet shooting): behavioral response

Human activity (dogs): potential source^a

Resident Red-tailed Hawk: potential source^a

Resident Great Horned Owl: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

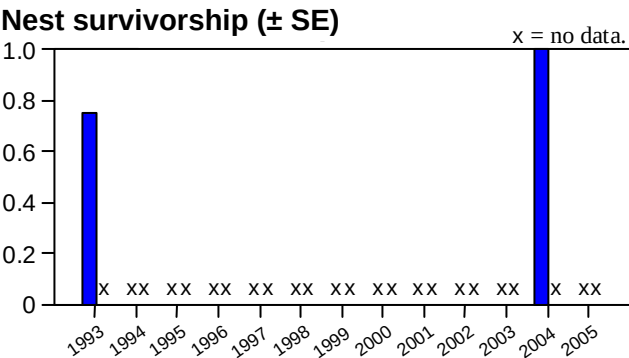
Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing				X
Duck club	X	X	X	X

Volanti

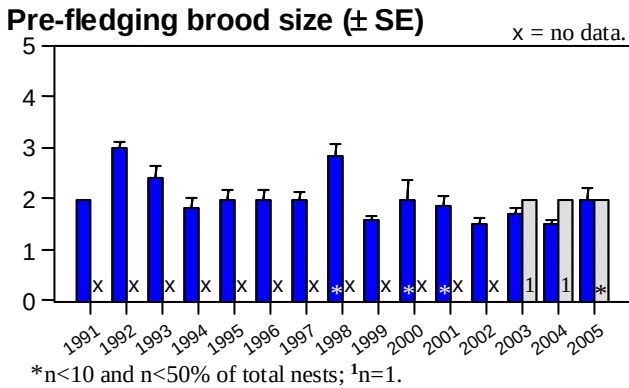
This heronry is in a patchy grove of eucalyptus trees spread along a series of levees 200 m east of Montezuma Slough, at the mouth of Cutoff Slough. Common Ravens and Great Horned Owls have nested in this colony.

Ownership: private
Public observation areas: boat
Latitude / Longitude: N 38.1934 / W 122.0354



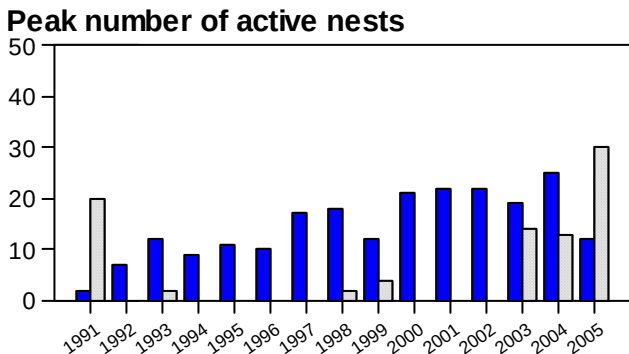
Colony site description

Topography: wetland
Length x width: 100 m x 30 m
Nest substrate: *Eucalyptus* sp. (live and dead branches)
Average nest height: 20 m
Trees (dbh): not measured
Maximum tree canopy height: 28 m
Vegetation cover: tree 40 %, shrub 5%, ground 0%



Evidence of disturbance

Resident Great Horned Owl: potential source^a
Resident Red-tailed Hawk: potential source^a
Resident Common Raven: potential source^a
^aPossible disturbance suggested by published accounts (see references in Methods).



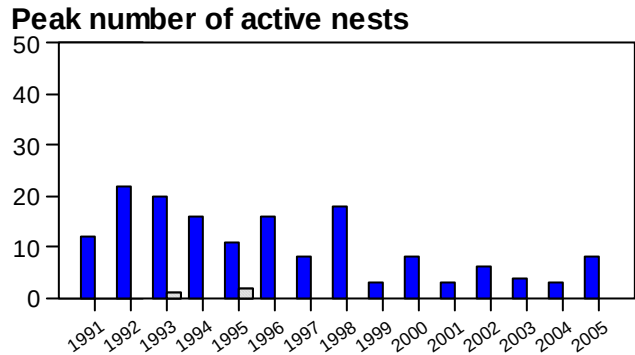
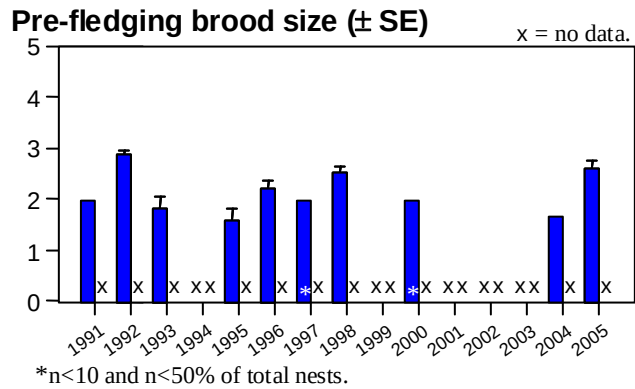
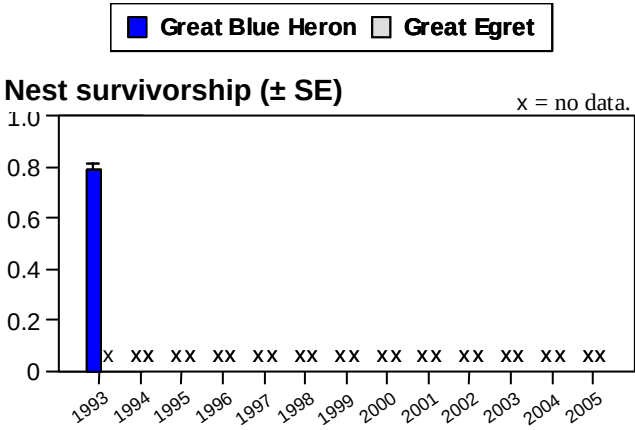
Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing				X
Duck club	X	X	X	X

Wheeler Island

This heronry includes two subsites along the levee of Champion Slough, on duck club property 0.4 km north of Suisun Bay. Double-crested Cormorants have nested at both subsites and, currently, the cormorants greatly outnumber herons and egrets at this site.

Ownership: private
Public observation areas: boat
Latitude / Longitude:
N 38.0800 / W 121.9653 (Northeast subsite)



Colony site description

Northeast subsite
Topography: levee
Length x width: 69 m x 13 m
Nest substrate: *Eucalyptus* sp. (live and dead branches)
Average nest height: 18 m
Trees (dbh): 5 (3-10 cm), 15 (10-50 cm), 3 (50-100 cm)
Maximum tree canopy height: 23 m
Vegetation cover: tree 30%, shrub 0%, ground 60%

Southwest subsite
Topography: levee
Length x width: 12 m x 12 m
Nest substrate: *Eucalyptus* sp. (live and dead branches)
Average nest height: not measured
Trees (dbh): 1 (>150 cm)
Maximum tree canopy height: 35 m
Vegetation cover: tree 80%, shrub 50%, ground 0%

Evidence of disturbance

Resident Great Horned Owl: potential source^a
^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Duck club	X	X	X	X

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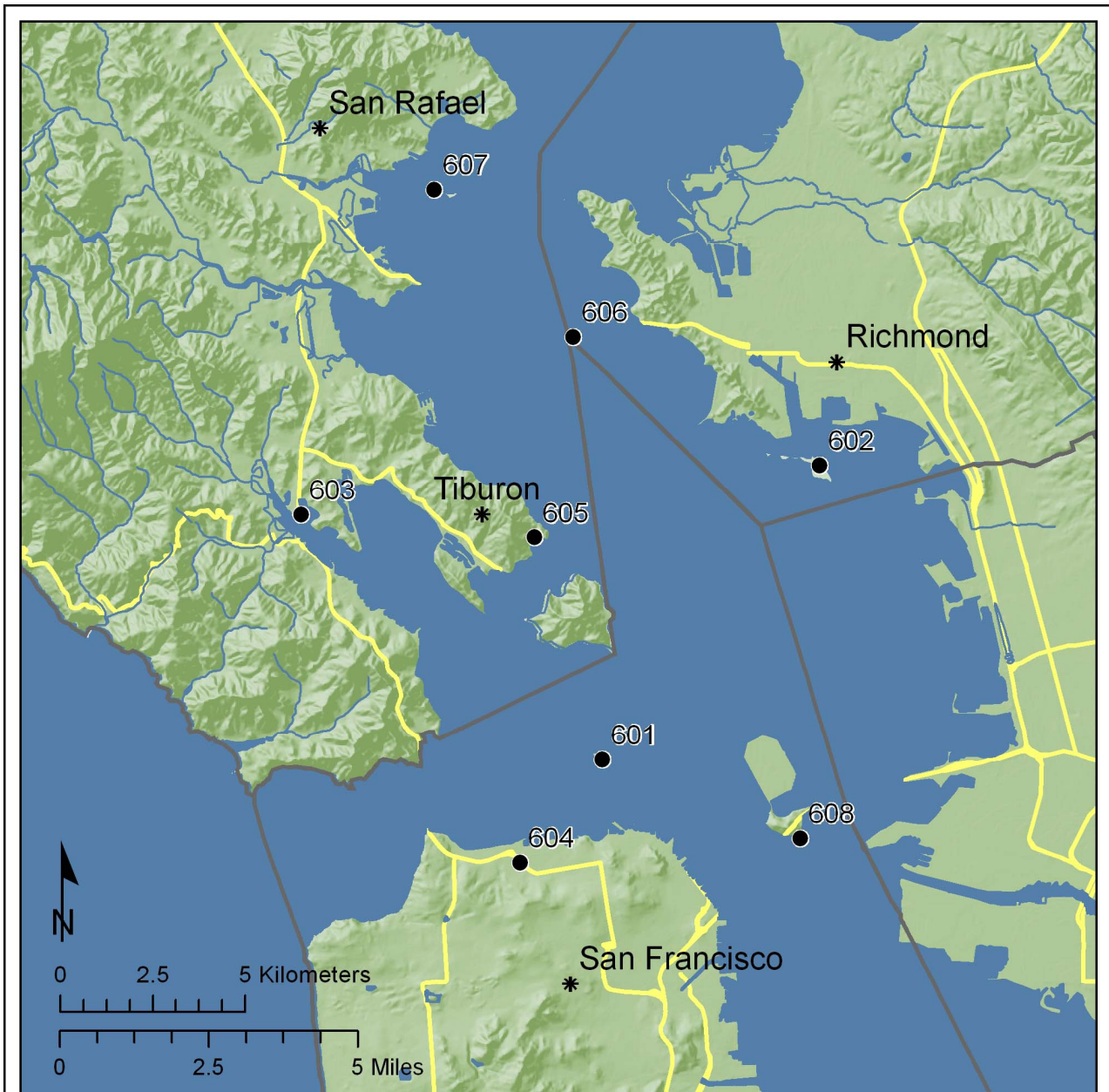
CENTRAL SAN FRANCISCO BAY



CENTRAL SAN FRANCISCO BAY

The Central San Francisco Bay subregion encompasses wetlands and the immediate watershed of San Francisco Bay from the Bay Bridge north to Point Pinole (on the east shore) and the outlet of Gallinas Creek (on the west shore). Intensive urban and industrial development is interspersed with pockets of remnant tidal and estuarine wetlands. Herons and egrets have nested on several Central Bay islands, most notably West Marin Island, Brooks Island and Alcatraz Island. A number of county, state, regional and national parks preserve habitat and open space within this region, including the Marin Headlands, China Camp, Angel Island and portions of Richardson Bay.

Site #	Colony Site	Great Blue Heron	Great Egret	Snowy Egret	Black-crowned Night Heron	Cattle Egret	County	Active or year last active	Page
601	Alcatraz		☐	☒	☒		San Francisco	Active	162
602	Brooks Island	☒	☐	☒	☒		Contra Costa	2000	164
603	DeSilva Island	☒	☐				Marin	Active	166
604	Palace of Fine Arts	☒					San Francisco	2004	173
605	Raccoon Straits	☒					Marin	Active	167
606	Red Rock		☐	☒	☒		Contra Costa	2003	168
607	West Marin Island	☒	☐	☒	☒		Marin	Active	170
608	Yerba Buena				☒		San Francisco	Active	172



**Heron and Egret Nesting Colonies in the
Central San Francisco Bay*
1991-2005**

- | | |
|---------------|---------------------------|
| ● Colony site | - - - Study area boundary |
| * Town | — Major highway |
| ~ Stream | ⊕ County boundary |

*Colony sites outside of this sub-region are not shown.



Alcatraz

Alcatraz is an island 2 km north of San Francisco. Historically used as a fort and a prison, it became part of the Golden Gate National Recreation Area (GGNRA) in 1972. Over a million people visit Alcatraz annually. Herons and egrets nest in numerous subsites. Data were provided by Roger Hothem (U.S. Geological Survey) and the GGNRA.

Ownership: public

Public observation areas: public access areas

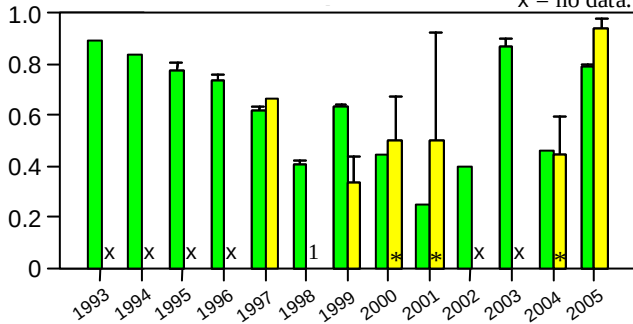
Latitude / Longitude: N 37.8264 / W 122.4218



■ Black-crowned Night-Heron ■ Snowy Egret

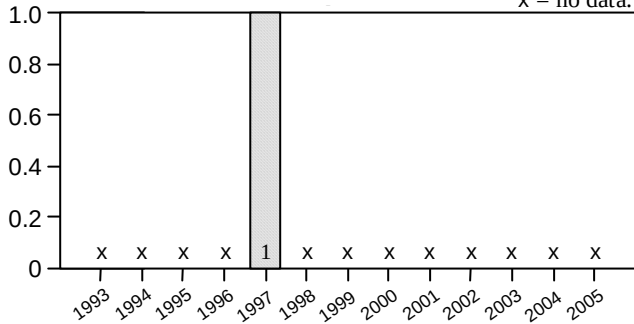
■ Great Egret

Nest survivorship ($\pm$ SE)



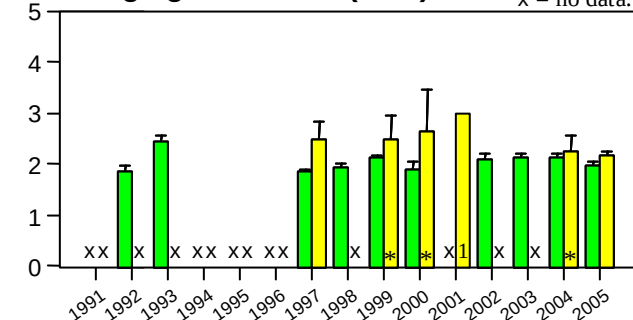
*n<10 and n<50% of total nests; ¹n=1.

Nest survivorship ($\pm$ SE)



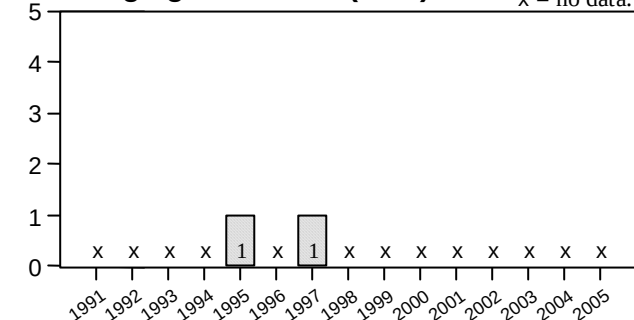
¹n=1.

Pre-fledging brood size ($\pm$ SE)



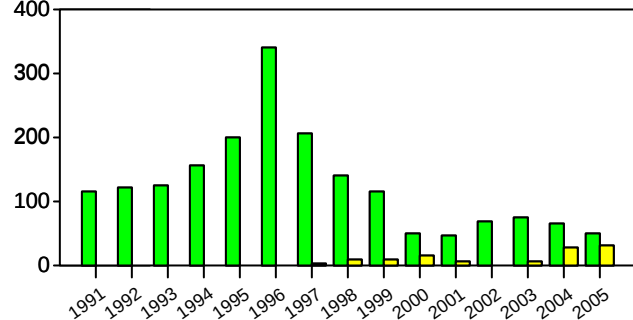
*n<10 and n<50% of total nests; ¹n=1.

Pre-fledging brood size ($\pm$ SE)

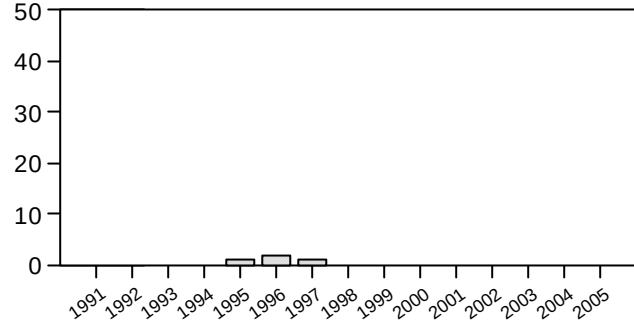


¹n=1.

Peak number of active nests



Peak number of active nests



(continued)

Alcatraz (continued)

Colony site description

Topography: island (without bridge)

Length x width: not measured (numerous sub sites)

Nest substrate: mirror bush (*Coprosma baueri*), fig (*Ficus carica*), California blackberry (*Rubus ursinus*), ivy (*Hedera helix*), rose (*Rosa* sp.), Monterey cypress (*Cupressus macrocarpa*), Australian tea tree (*Leptospermum laevigatum*), *Eucalyptus* sp. (live and dead branches), concrete rubble

Average nest height: 1 m

Trees (dbh): not measured

Maximum tree canopy height: not measured

Vegetation cover: not measured



Evidence of disturbance

Western Gulls: nest failure

Common Raven: nest failure

Human activity (observers): nest failure

Human activity (construction): nest failure

Unknown predators: nest failure

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Protected natural area	X	X	X	X
Recreational boating	X	X	X	X

Brooks Island

Brooks Island is south of Richmond and owned and protected by the East Bay Regional Parks. The heronry is located on the northeast (lee) side of the island. A non-native red fox seen on the island in the winter of 1996 may have been associated with the abandonment of the colony site.

Ownership: public

Public observation areas: from boat; access to island through organized tours only

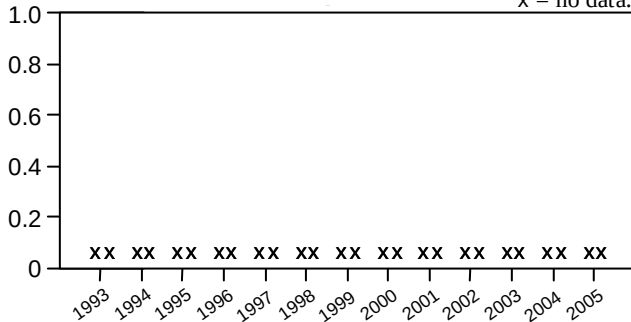
Latitude / Longitude: N 37.8982 / W 122.3551



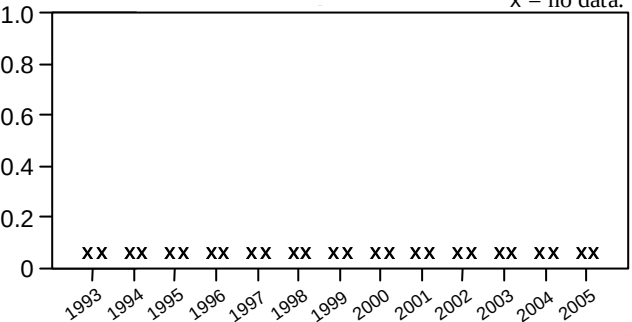
Black-crowned Night-Heron Snowy Egret

Great Blue Heron Great Egret

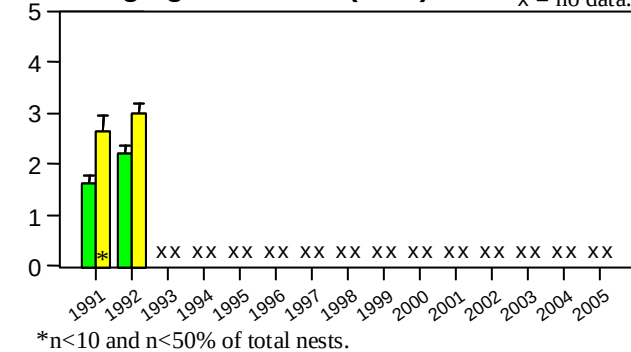
Nest survivorship ($\pm$ SE)



Nest survivorship ($\pm$ SE)

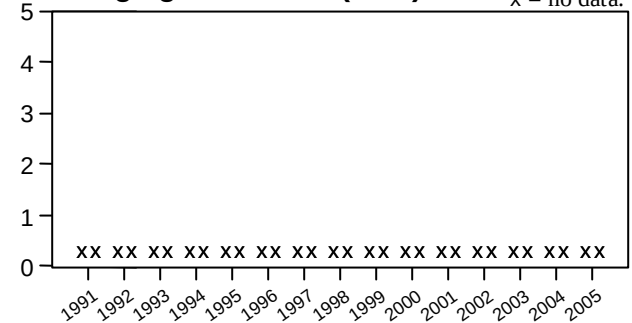


Pre-fledging brood size ($\pm$ SE)

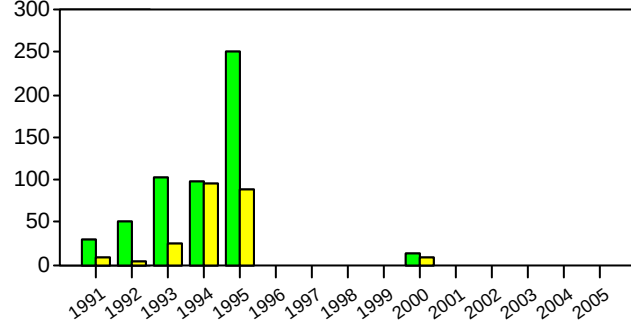


*n<10 and n<50% of total nests.

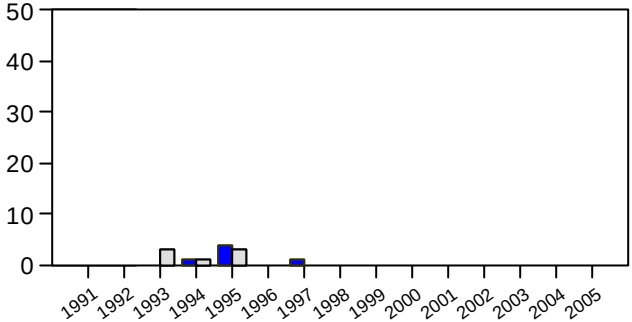
Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



Peak number of active nests



(continued)

Brooks Island (continued)

Colony site description

Topography: island (without bridge)

Length x width: 280 m x 60 m

Nest substrate: coyote bush (*Baccharis pilularis*),
 Buckeye (*Aesculus californica*),
 Elderberry (*Sambucus mexicana*)

Average nest height: 1 m

Trees (dbh): not measured

Maximum tree canopy height: 5 m

Vegetation cover: tree 3%, shrub 85%, ground 12%

Evidence of disturbance

Human activity: nest failure

Unknown predators: nest failure

Common Raven: potential source ^a

^aPossible disturbance suggested by published accounts
 (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0- 100	100- 200	200- 500	500- 1000
Low density housing	X			
Protected natural area	X	X	X	X
Recreational boating	X	X	X	X

DeSilva Island

This heronry is in a stand of eucalyptus on the shore of Richardson Bay, 150 m east of Highway 101. In the late 1990s, the construction of condominiums adjacent to the colony resulted in the removal of most eucalyptus trees in the area but spared the nesting trees along the shore. (Records prior to 1990 are from Shuford 1993.)

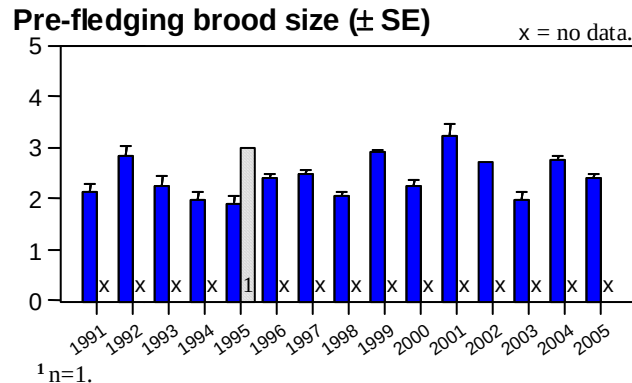
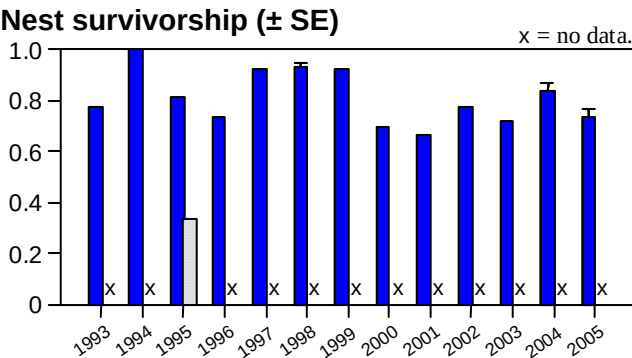
Ownership: private

Public observation areas: Seminary Drive

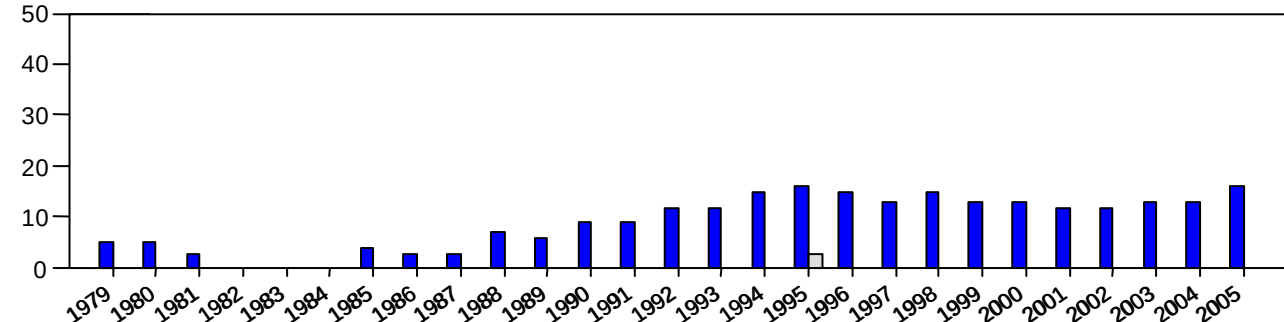
Latitude / Longitude: N 37.8868 / W 122.5147



■ Great Blue Heron □ Great Egret



Peak number of active nests



Colony site description

Topography: hillside
 Length x width: 175 m x 4 m
 Nest substrate: *Eucalyptus* sp.
 Average nest height: 25 m
 Trees (dbh): 28 (10-50 cm), 14 (50-100 cm)
 Maximum tree canopy height: 27 m
 Vegetation cover: tree 30%, shrub 2%, ground 52%

Evidence of disturbance

Wind: nest failure
 Osprey: behavioral response
 Human activity (construction): behavioral response
 Common Raven: potential source ^a
^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
High density housing	X	X	X	X
Protected natural area		X	X	

Raccoon Straits

This site is on private property near the eastern tip of the Tiburon Peninsula. Great Blue Herons nest in large eucalyptus beside a pond 45 meters from San Francisco Bay. Much of the property surrounding the heronry is undeveloped, wooded hillside.

Ownership: private

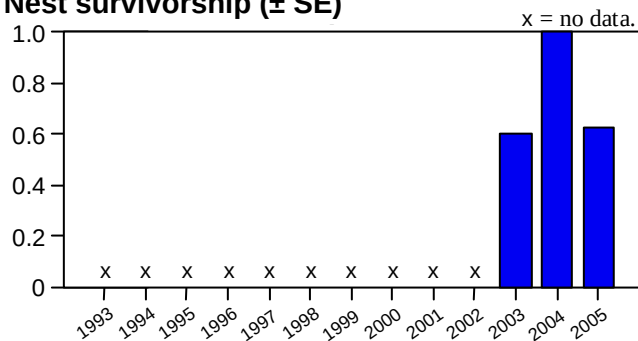
Public observation areas: none

Latitude / Longitude: N 37.8810 / W 122.4431



■ Great Blue Heron

Nest survivorship ($\pm$ SE)



Colony site description

Topography: wetland

Length x width: 26 m x 19 m

Nest substrate: *Eucalyptus* sp.

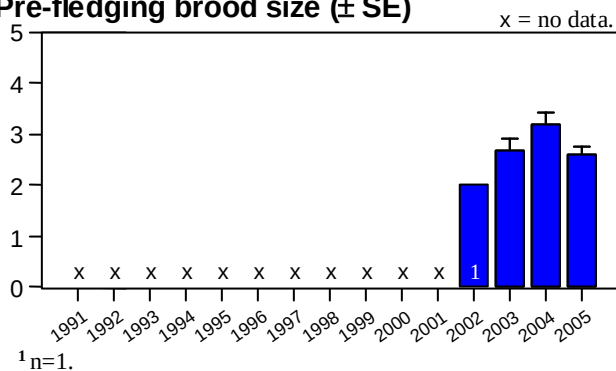
Average nest height: 28 m

Trees (dbh): 7 (3-50 cm), 2 (50-100 cm),
2 (100-150 cm)

Maximum tree canopy height: not measured

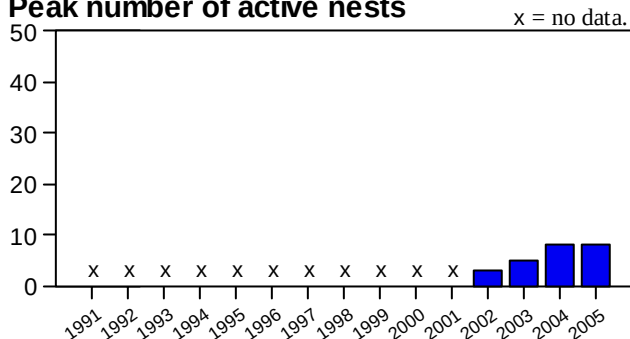
Vegetation cover: tree 72%, shrub 6%, ground 16%

Pre-fledging brood size ($\pm$ SE)



¹ n=1.

Peak number of active nests



Evidence of disturbance

Common Raven: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Surrounding land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X			
Mid-density housing			X	
Recreational boating		X	X	X

Red Rock

Red Rock is an undeveloped island in San Francisco Bay, 0.5 km south of the Richmond-San Rafael Bridge. Egrets and herons nest in shrubs on the northeastern side of the island. Black Oystercatchers and Western Gulls also nest on the island.

Ownership: private

Public observation areas: from boat only

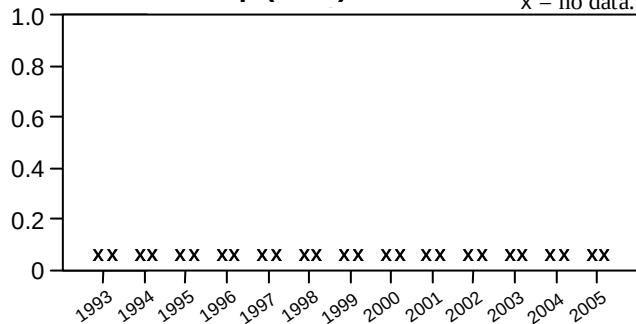
Latitude / Longitude: N 37.9297 / W 122.4307



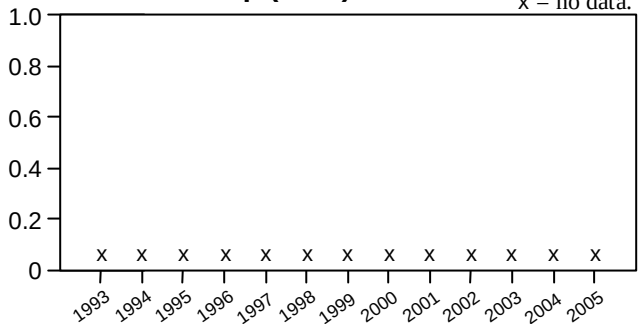
■ Black-crowned Night-Heron ■ Snowy Egret

□ Great Egret

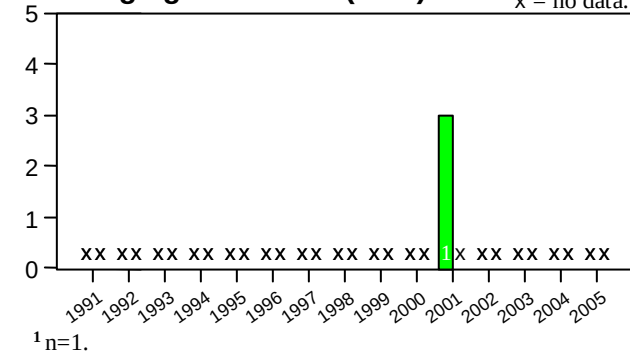
Nest survivorship ($\pm$ SE)



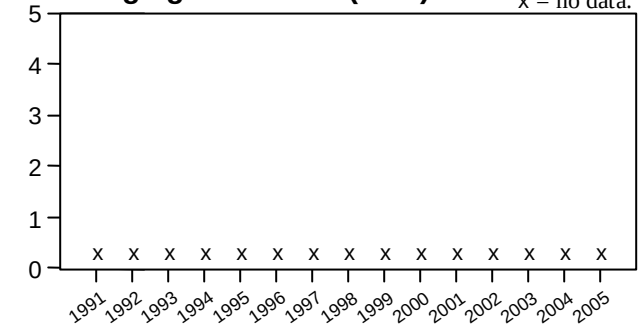
Nest survivorship ($\pm$ SE)



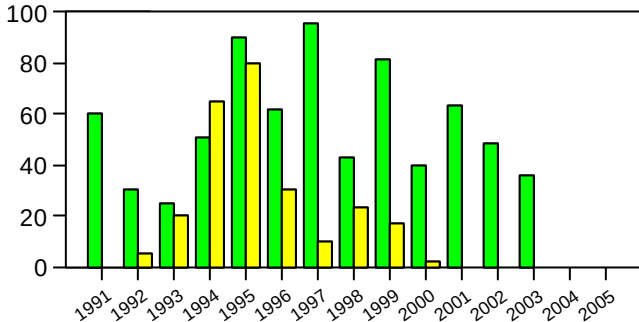
Pre-fledging brood size ($\pm$ SE)



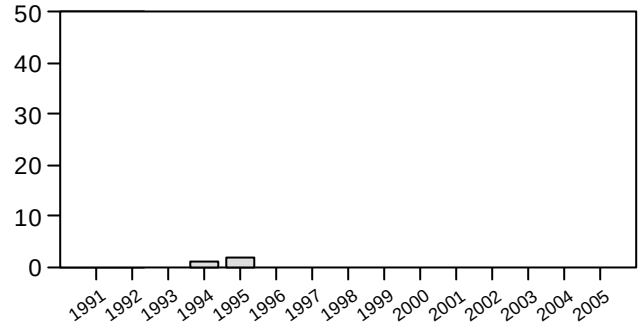
Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



Peak number of active nests



(continued)

Red Rock (continued)

Colony site description

Topography: island (without bridge)

Length x width: 75 m x 25 m

Nest substrate: poison oak (*Toxicodendron diversilobum*), coyote brush (*Baccharis pilularis*), unidentified shrubs

Average nest height: 1 m

Trees (dbh): none

Maximum tree canopy height: no canopy

Vegetation cover: tree 0%, shrub 80%, ground 0%

Evidence of disturbance

Common Raven: behavioral response

Red-tailed Hawk: behavioral response

Land use

	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Recreational boating	X	X	X	X

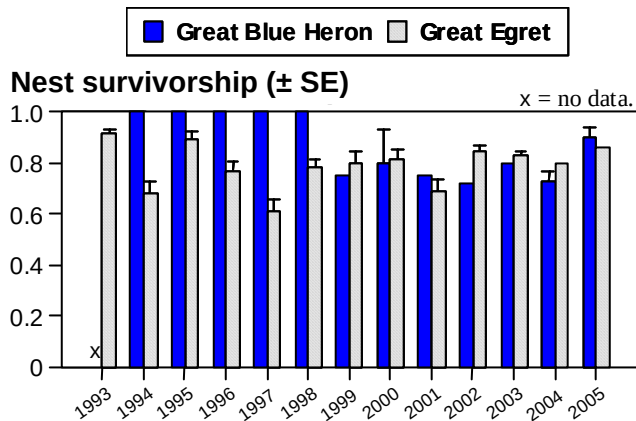
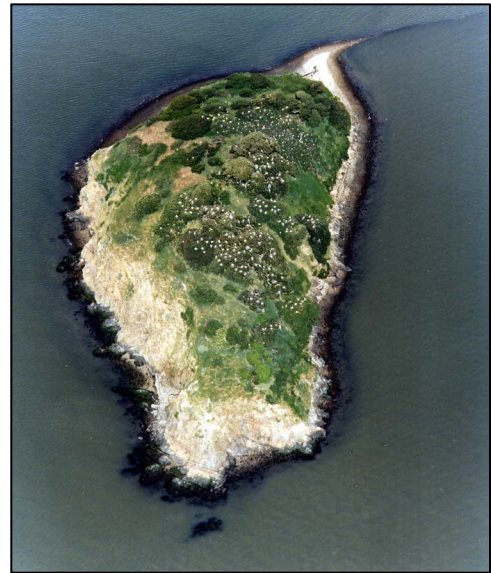
West Marin Island

Marin Islands National Wildlife Refuge, near San Rafael, was established in 1992, primarily to protect this heronry. The colony site has been active since at least the early 1950s (Ralph and Ralph 1958). The large annual fluctuations in the number of nesting Snowy Egrets are characteristic of other colonies and regions in North America. (Records prior to 1990 are from Shuford 1993.)

Ownership: public

Public observation areas: from boat or mainland

Latitude / Longitude: N 37.9660 / W 122.4732



Colony site description

Topography: island (without bridge)

Length x width: 205 m x 91 m

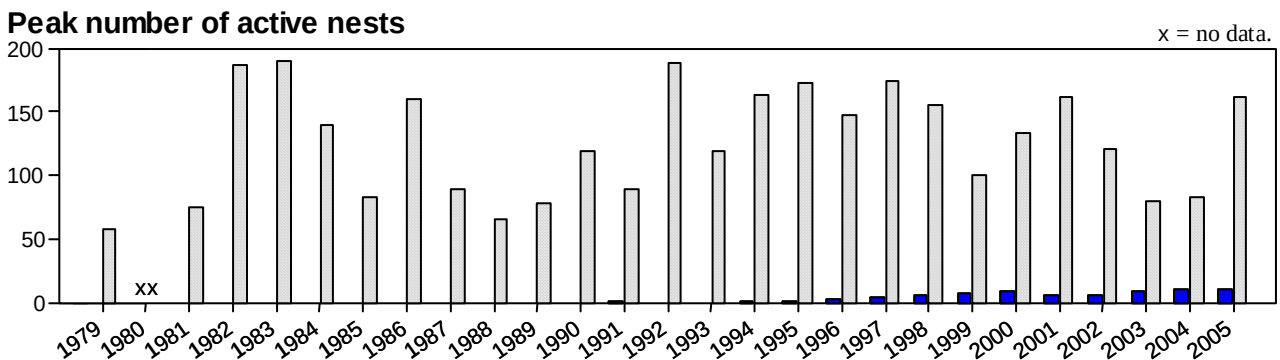
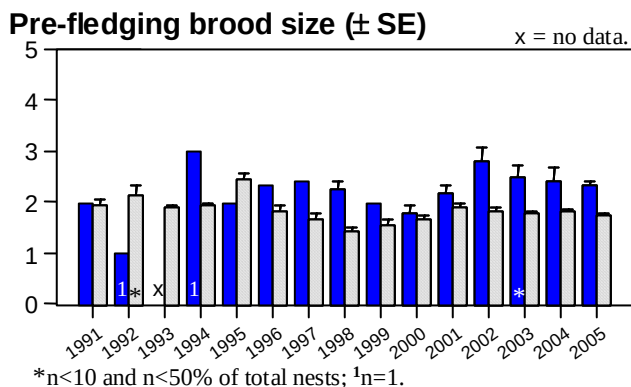
Nest substrate: live oak (*Quercus agrifolia*), coyote brush (*Baccharis pilularis*), buckeye (*Aesculus californica*), blackberry (*Rubus* sp.), snag, unidentified shrubs

Average nest height: 3 m

Trees (dbh): 45 (3-10 cm), 25 (10-50 cm), 8 (50-100 cm)

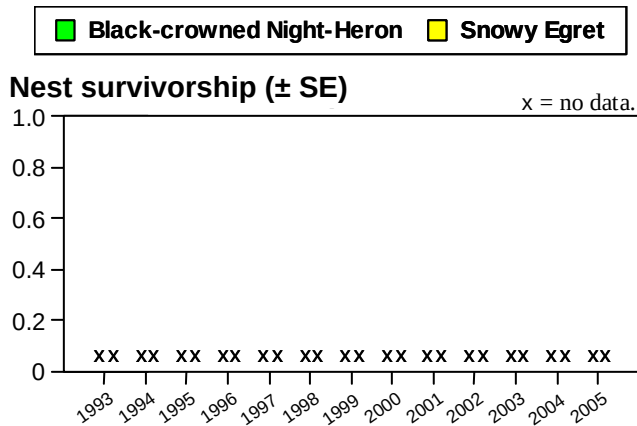
Maximum tree canopy height: 9 m

Vegetation cover: tree 30%, shrub 50%, ground 70%



(continued)

West Marin Island (continued)



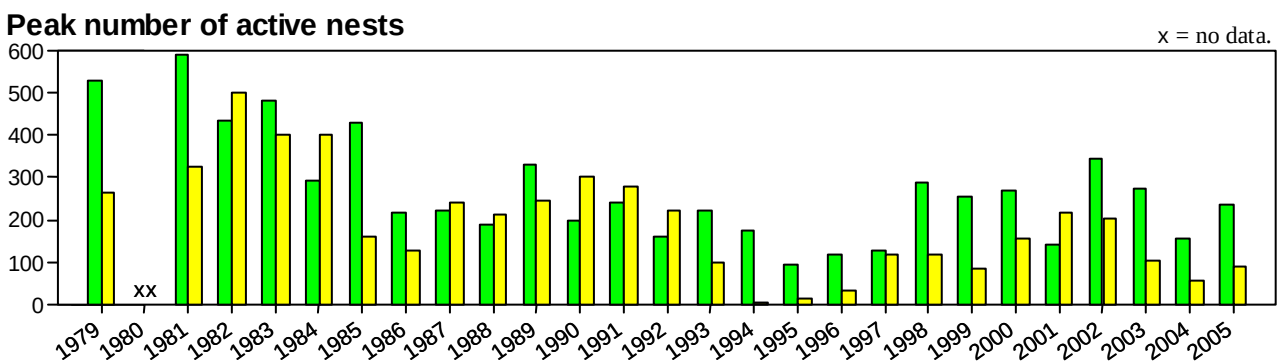
Evidence of disturbance

Resident Ravens: nest failure
 Red-tailed Hawk: behavioral response
 Peregrine Falcon: behavioral response
 Human activity (boats, kayaks): potential source^a
 Low flying aircraft: potential source^a
 Osprey: potential source^a
 Great Horned Owl: potential source^a
 Western Gull: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Mid-density housing				X
Protected natural area	X	X	X	X
Recreational boating		X	X	X



Yerba Buena

Yerba Buena Island is in San Francisco Bay between Oakland and San Francisco. The island is used as a Navy and Coast Guard training center with residential housing for personnel. Herons and egrets nest in shrubs on a steep bluff near the lighthouse on the southern tip of the island. Interstate 80 crosses the island 0.4 km from the colony.

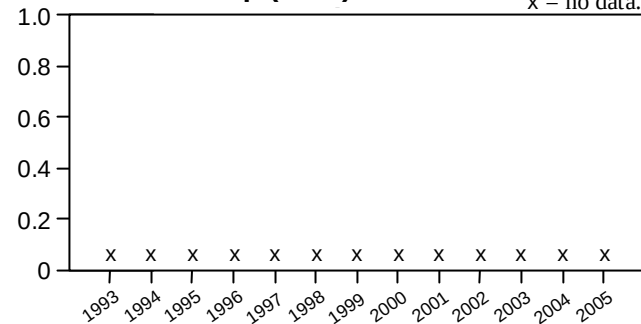
Ownership: public

Public observation areas: none

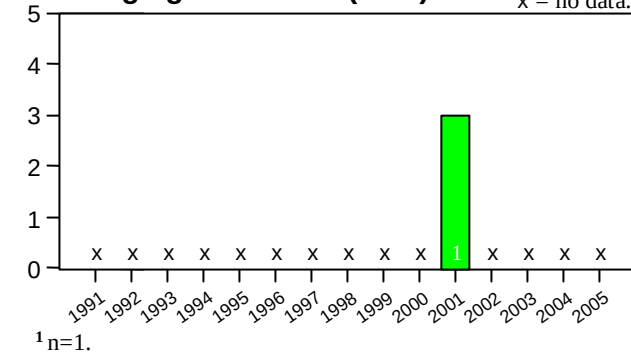
Latitude / Longitude: N 37.8071 / W 122.3620

Black-crowned Night-Heron

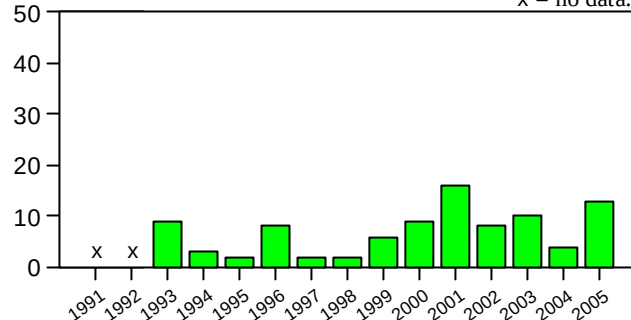
Nest survivorship ($\pm$ SE)



Pre-fledging brood size ($\pm$ SE)



Peak number of active nests



Colony site description

Topography: island (with bridge)

Length x width: 70 m x 15 m

Nest substrate: unidentified oak tree, woody shrubs

Average nest height: < 1 m

Trees (dbh): 7 (3-10 cm), 3 (10-50 cm)

Maximum tree canopy height: not measured

Vegetation cover: tree 10%, shrub 75%, ground 20%

Evidence of disturbance

Common Raven: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X	X		
Mid-density housing			X	X

Colony Sites with Limited Activity

Palace of Fine Arts

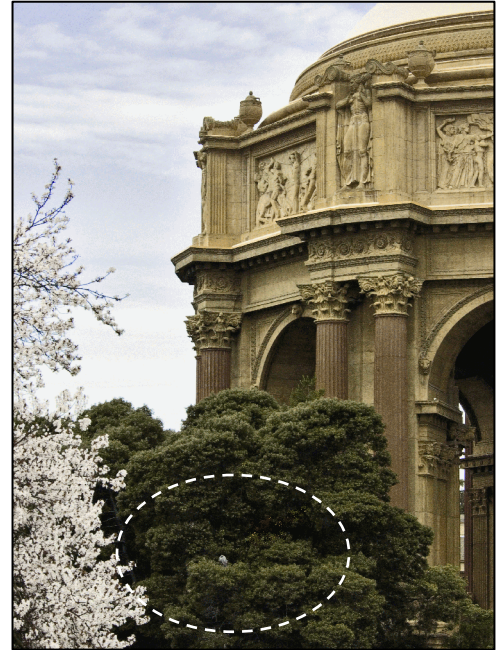
The museum and surrounding park is owned by the City of San Francisco. Great Blue Herons nested in an evergreen tree adjacent to the museum building. In 2005, a project was initiated to restore the lagoon at the Palace of Fine Arts, and there has been a coincidental decline in the number of herons using the lagoon.

Ownership: public

Public observation areas: Palace of Fine Arts

Latitude / Longitude: N 37.8016 / W 122.4480

Species	Years known to be active (number of active nests)
Great Blue Heron	2004 (1)



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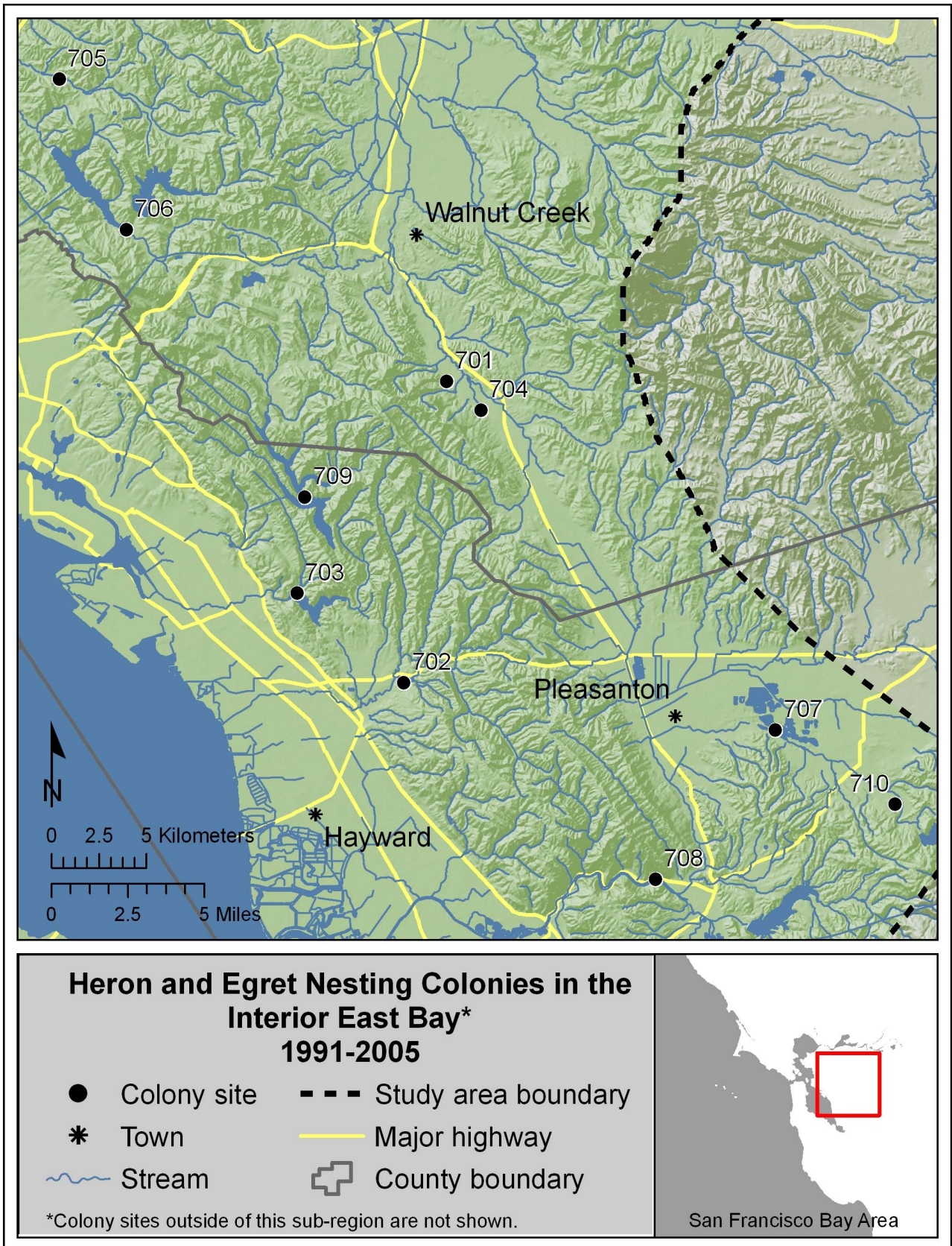
INTERIOR EAST BAY



INTERIOR EAST BAY

This subregion encompasses the steep, hilly terrain and densely populated valleys of Contra Costa and Alameda counties. It extends from the hills above the urbanized eastern shore of San Francisco Bay eastward to Mount Diablo. Several constructed reservoirs in the subregion provide freshwater habitat for herons and egrets. Much of the historic tidal wetland along Suisun Bay and the Carquinez Straits has been drained and filled for development.

Site #	Colony Site	Great Blue Heron	Great Egret	Snowy Egret	Black-crowned Night-Heron	Cattle Egret	County	Active or year last active	Page
701	Alamo	■					Contra Costa	Active	178
702	Don Castro	■					Alameda	Active	179
703	Lake Chabot	■		■			Alameda	Active	180
704	Montair Elementary School	■					Contra Costa	1993	185
705	Pinole Valley Road	■					Contra Costa	1996	185
706	San Pablo Dam	■	□				Contra Costa	Active	181
707	Shadow Cliffs	■	□				Alameda	Active	182
708	Sunol	■					Alameda	1998	185
709	Upper San Leandro Reservoir	■					Alameda	Active	183
710	VA Hospital Livermore	■					Alameda	2002	184



Alamo

In the late 1990s, Great Blue Herons began nesting on Camille Lane, on the eastern edge of the San Ramon Valley, about 2 km south of downtown Alamo and 1 km from San Ramon Creek. There is a public trail adjacent to the colony.

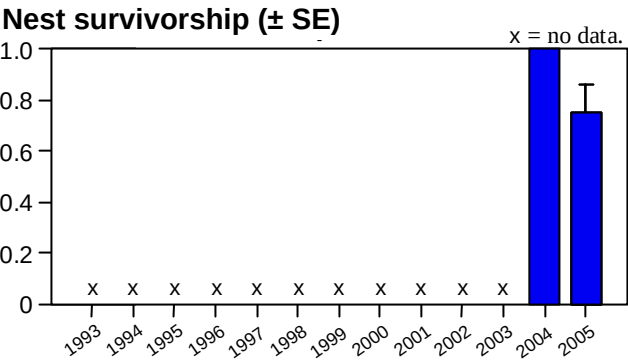
Ownership: unknown

Public observation areas: park trail

Latitude / Longitude: N 37.8323 / W 122.0261

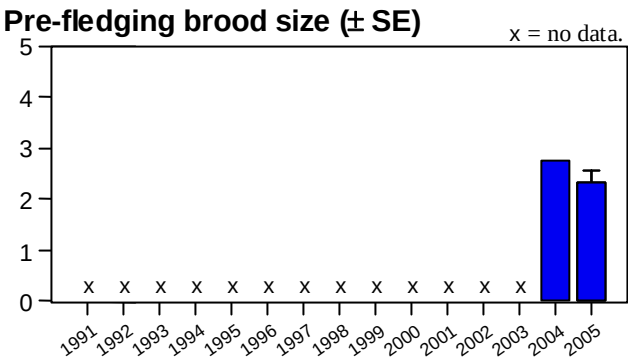


Great Blue Heron



Colony site description

Topography: suburban
Length x width: 10 m x 5 m
Nest substrate: *Eucalyptus* sp. (dead branches)
Average nest height: 22 m
Trees (dbh): 1 (100-150 cm)
Maximum tree canopy height: 24 m
Vegetation cover: tree 20%, shrub 25%,
ground 90%

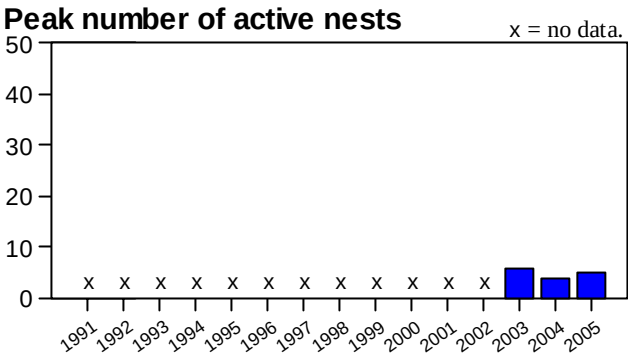


Evidence of disturbance

None recorded.

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X	X	X	X
Mid-density housing	X	X	X	X
Protected natural area	X	X	X	X



Don Castro

This heronry is in the Don Castro Regional Recreation Area in Hayward, managed by the East Bay Regional Park District. In recent years, a single pair of Great Blue Herons nested on the northwest side of Lake Don Castro and one or two additional pairs nested on the southern edge of the lake. All of the nests are in eucalyptus trees.

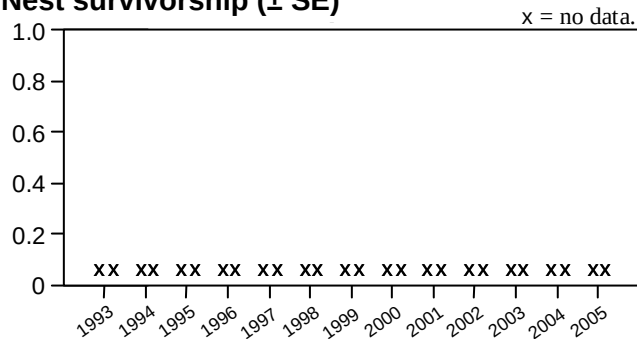
Ownership: public

Public observation areas: public recreation area

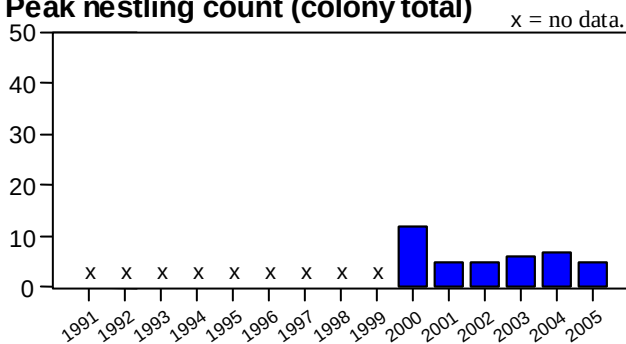
Latitude / Longitude: N 37.6897 / W 122.0536

■ Great Blue Heron

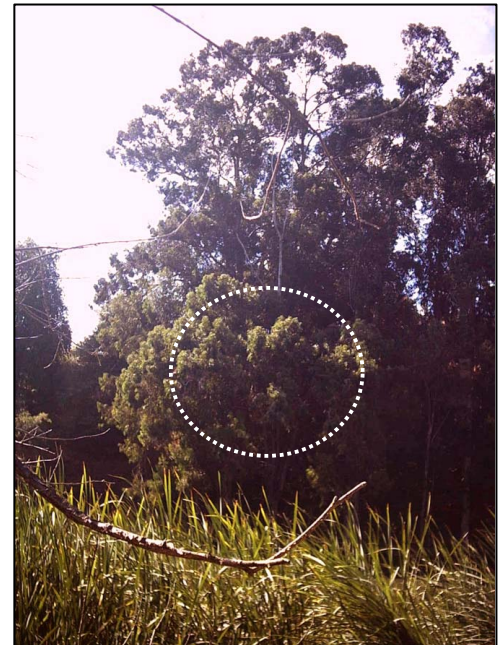
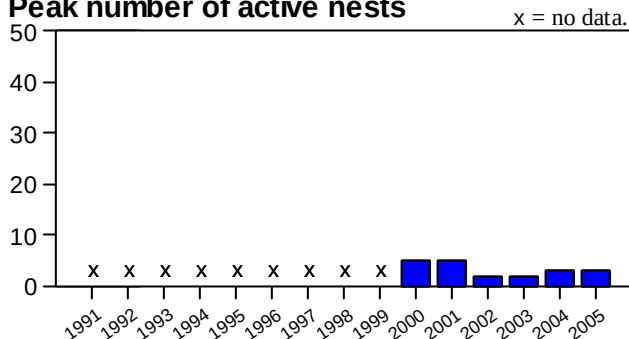
Nest survivorship ($\pm$ SE)



Peak nestling count (colony total)



Peak number of active nests



Colony site description

Topography: levee

Length x width: 7 m x 1 m

Nest substrate: *Eucalyptus* sp.

Average nest height: 9 m

Trees (dbh): 1 (50-100 cm)

Maximum tree canopy height: 18 m

Vegetation cover: tree 72%, shrub 0%, ground 0%

Evidence of disturbance

Human activity (boating): behavioral response

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial				X
Low density housing				X
Mid-density housing			X	X
High density housing				X
Protected natural area	X	X	X	X

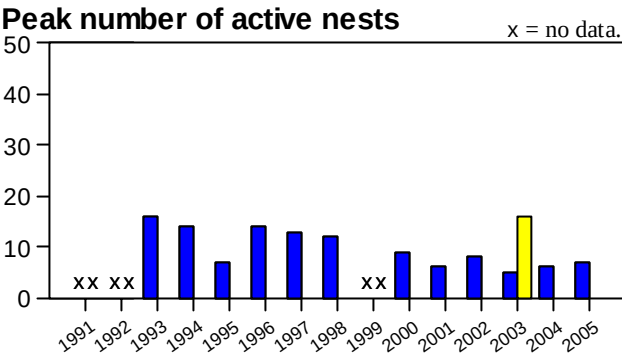
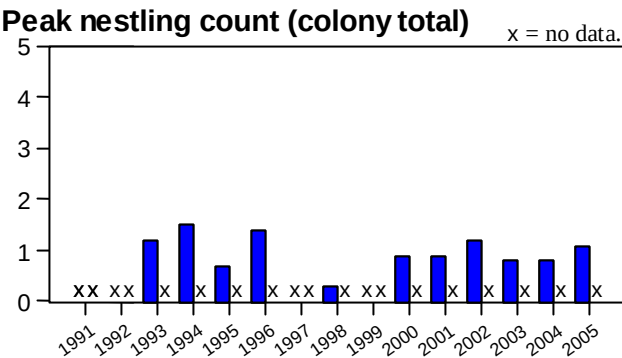
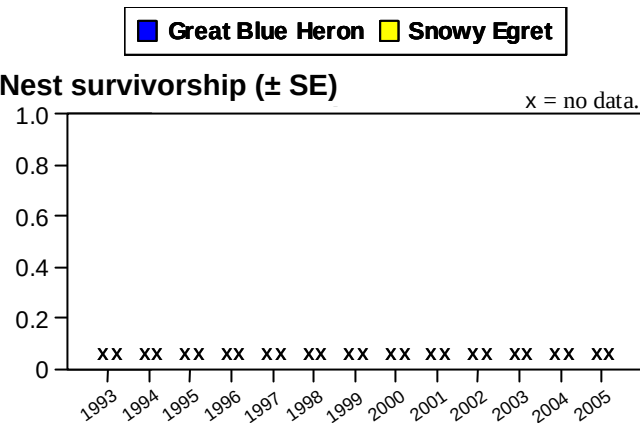
Lake Chabot

This colony is in Chabot Regional Park, about 2 km east of San Leandro. The Great Blue Herons nest in an isolated eucalyptus tree growing on the shoreline of the northernmost arm of the lake. The East Bay Regional Parks District manages the property.

Ownership: public

Public observation areas: Chabot Regional Park trail

Latitude / Longitude: N 37.7326 / W 122.1169



Colony site description

Topography: hillside

Length x width: 16 m x 11 m

Nest substrate: *Eucalyptus* sp. (live and dead branches)

Average nest height: 24 m

Trees (dbh): 2 (3-10 cm), 3 (50-100 cm), 1 (100-150 cm)

Maximum tree canopy height: 30 m

Vegetation cover: tree 65%, shrub 43%, ground 14%

Evidence of disturbance

Human activity (hikers): behavioral response

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial				X
Protected natural area	X	X	X	X
Sports field				X

San Pablo Dam

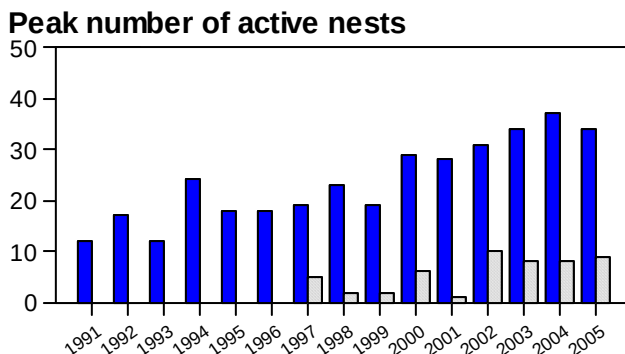
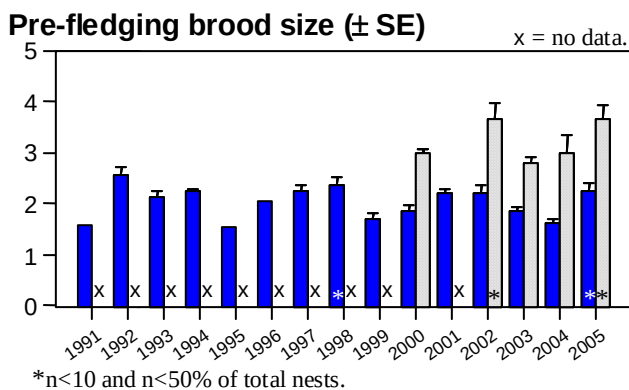
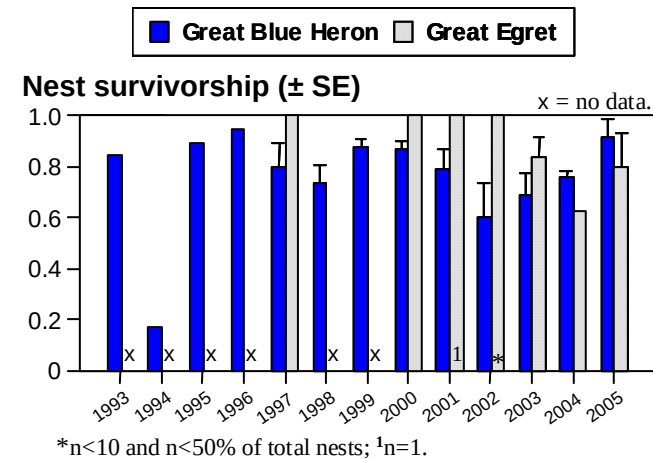
Great Blue Herons and Great Egrets nest at the southeastern end of San Pablo Reservoir. The heronry is divided into two subcolonies, 105 m east and 75 m west of the East Bay Municipal Utility District Headquarters. Most nests are in eucalyptus trees, and the west subcolony borders the parking lot. Both sites are within 60 m of the reservoir.

Ownership: public

Public observation areas: none

Latitude / Longitude:

N 37.9056 / W 122.2182 (West subsite)



Colony site description

West subsite

Topography: ridge top

Length x width: 39 m x 18 m

Nest substrate: *Eucalyptus* sp. (live and dead branches), Monterey pine (*Pinus radiata*)

Average nest height: 31 m

Trees (dbh): 13 (3-50 cm), 1 (50-100 cm), 4 (100-150 cm), 1 (> 150 cm)

Maximum tree canopy height: not measured

Vegetation cover: tree 43%, shrub 65%, ground 35%

East subsite

Topography: hillside

Length x width: 52 m x 27 m

Nest substrate: *Eucalyptus* sp.

Average nest height: 27 m

Trees (dbh): 89 (3-50 cm), 23 (50-100 cm), 5 (100-150 cm), 3 (> 150 cm)

Maximum tree canopy height: not measured

Vegetation cover: tree 28%, shrub 30%, ground 45%

Evidence of disturbance

Unknown avian predator: nest failure

Golden Eagle: behavioral response

Human activity (construction): behavioral response

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing				X
Protected natural area	X	X	X	X

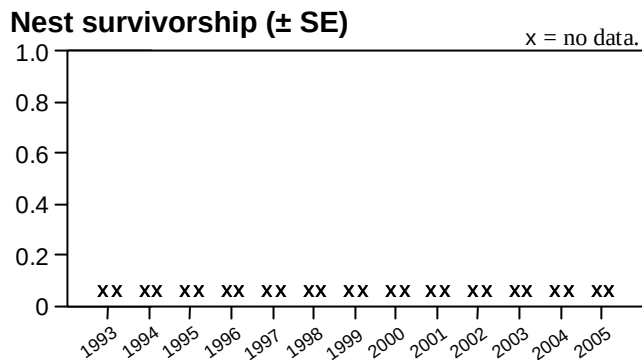
Shadow Cliffs

Great Egrets and Great Blue Herons nest on an island in an old graveling pond, at Shadow Cliffs Recreation Area, about 1 km east of Pleasanton. The East Bay Regional Park District manages the property.

Ownership: public

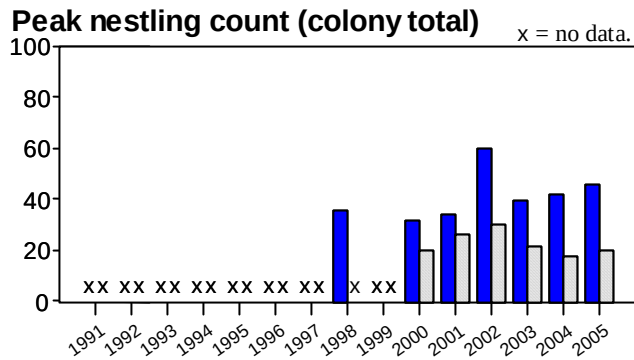
Public observation areas: hiking trail between the two lakes at Shadow Cliffs Park

Latitude / Longitude: N 37.6652 / W 121.8323



Colony site description

Topography: island (without bridge)
 Length x width: 46 m x 19 m
 Nest substrate: cottonwood (*Populus fremontii*;
 live and dead branches)
 Average nest height: 25 m
 Trees (dbh): 28 (3-50 cm), 9 (50-100 cm),
 1 (100-150 cm)
 Maximum tree canopy height: 32 m
 Vegetation cover: tree 68%, shrub 72%,
 ground 40%

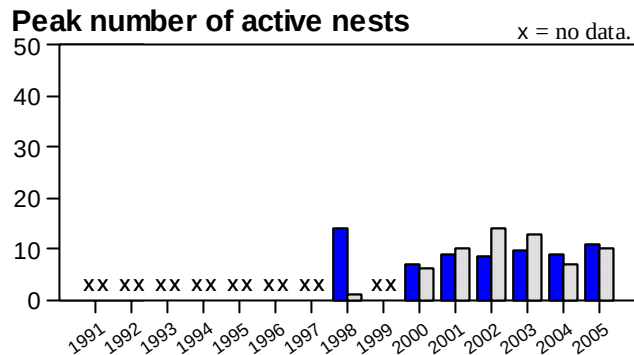


Evidence of disturbance

None recorded.

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial				X
Low density housing				X
Farming				X
Protected natural area	X	X	X	X



Upper San Leandro Reservoir

Great Blue Herons nest in eucalyptus trees on the eastern shore of Upper San Leandro Reservoir. The reservoir is bordered by steep hillsides of mixed oak woodland. The reservoir and the surrounding watershed belong to the East Bay Municipal Utility District.

Ownership: East Bay MUD

Public observation areas: none

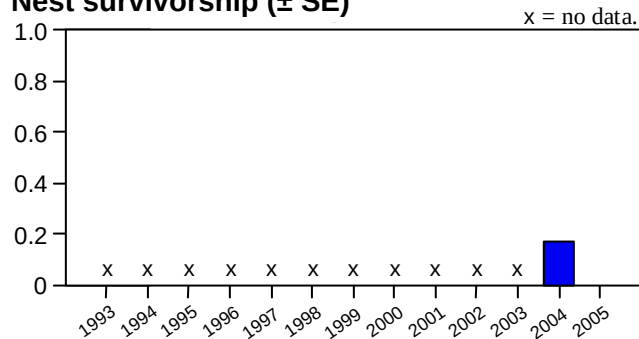
Latitude / Longitude: N 37.7781 / W 122.1117



(no photo)

Great Blue Heron

Nest survivorship ($\pm$ SE)



Colony site description

Topography: hillside

Length x width: not measured

Nest substrate: *Eucalyptus* sp.

Average nest height: not measured

Trees (dbh): not measured

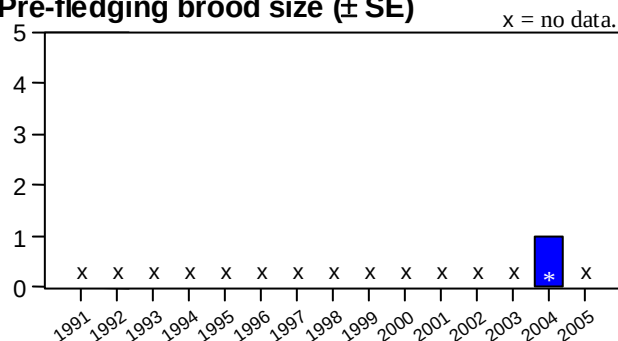
Maximum tree canopy height: not measured

Vegetation cover: not measured

Evidence of disturbance

Golden Eagle: nest failure

Pre-fledging brood size ($\pm$ SE)

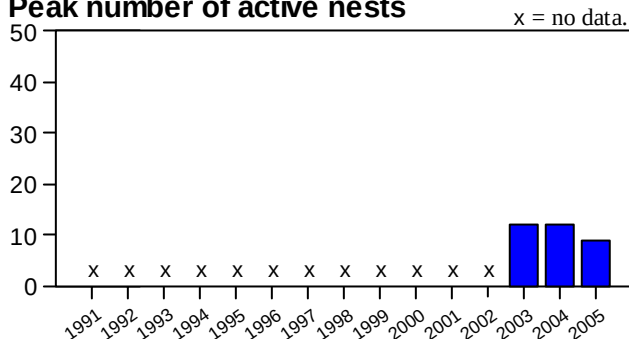


*n<10 and n<50% of total nests.

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Protected natural area	X	X	X	X

Peak number of active nests



VA Hospital Livermore

Great Blue Herons nested in a grove of eucalyptus on the northern edge of the Livermore Veterans Hospital grounds, about 6 km south of downtown Livermore. Lake Del Valle is 2 km to the southeast. New sludge plowing procedures at a nearby sewage plant may have been associated with abandonment of the site in 2003 or 2004.

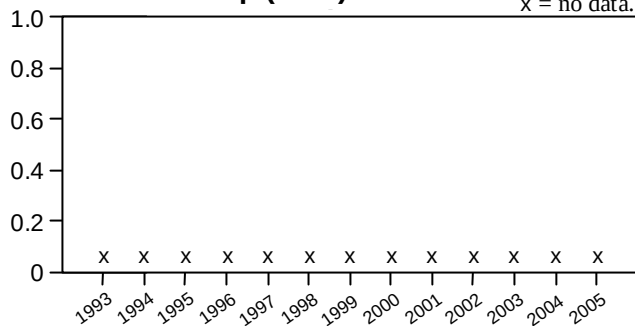
Ownership: public

Public observation areas: none

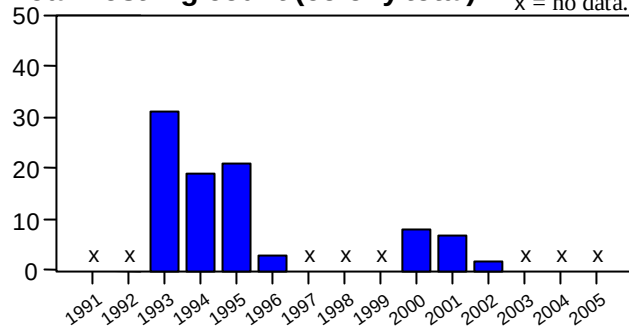
Latitude / Longitude: N 37.6293 / W 121.7609

Great Blue Heron

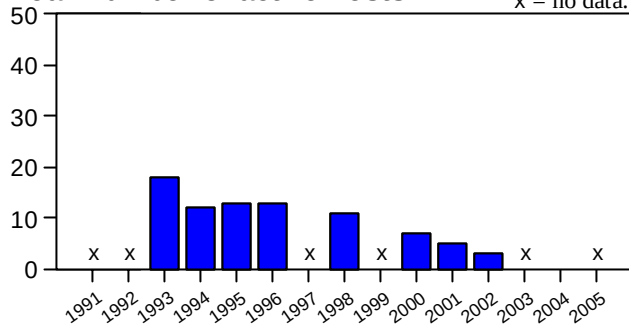
Nest survivorship ($\pm$ SE)



Peak nestling count (colony total)



Peak number of active nests



Colony site description

Topography: flood plain

Length x width: 78 m x 7 m

Nest substrate: *Eucalyptus* sp.

Average nest height: 31 m

Trees (dbh): 41 (3-50 cm), 2 (50-100 cm),
1 (100-150 cm), 2 (> 150 cm)

Maximum tree canopy height: 34 m

Vegetation cover: tree 79%, shrub 0%, ground 51%

Evidence of disturbance

Human activity (noise and activity from sludge plowing procedures): potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Farming	X	X	X	X
Vineyard			X	X
Grazing			X	X

Colony Sites with Limited Activity

Montair Elementary School

Great Blue Herons nested in a eucalyptus grove along a small tributary of San Ramon Creek behind Montair Elementary School in Danville. The trees were removed after the 1993 breeding season.

Ownership: San Ramon Valley Unified School District

Public observation areas: none

Latitude / Longitude: N 37.8184 / W 122.0057



Species	Years known to be active (number of active nests)
Great Blue Heron	1992 (2), 1993 (1)

Pinole Valley Road

A pair of Great Blue Herons nested along Pinole Valley Road, about 4 km from Interstate 80, 5 km northwest of San Pablo Bay and 4 km south of San Pablo Reservoir.

Ownership: private

Public observation areas: Pinole Valley Road

Latitude / Longitude: N 37.9772 / W 122.2565

Species	Years known to be active (number of active nests)
Great Blue Heron	1996 (1)

Sunol

Great Blue Herons nested in sycamore (*Platanus racemosa*) and maple (*Acer* sp.) trees beside a pond off Alameda Creek, 1 km west of Sunol. The land is owned by Union Pacific Railroad and Western Star Nurseries.

Ownership: private

Public observation areas: none

Latitude / Longitude: N 37.5952 / W 121.9044

Species	Years known to be active (number of active nests)
Great Blue Heron	1998 (10)

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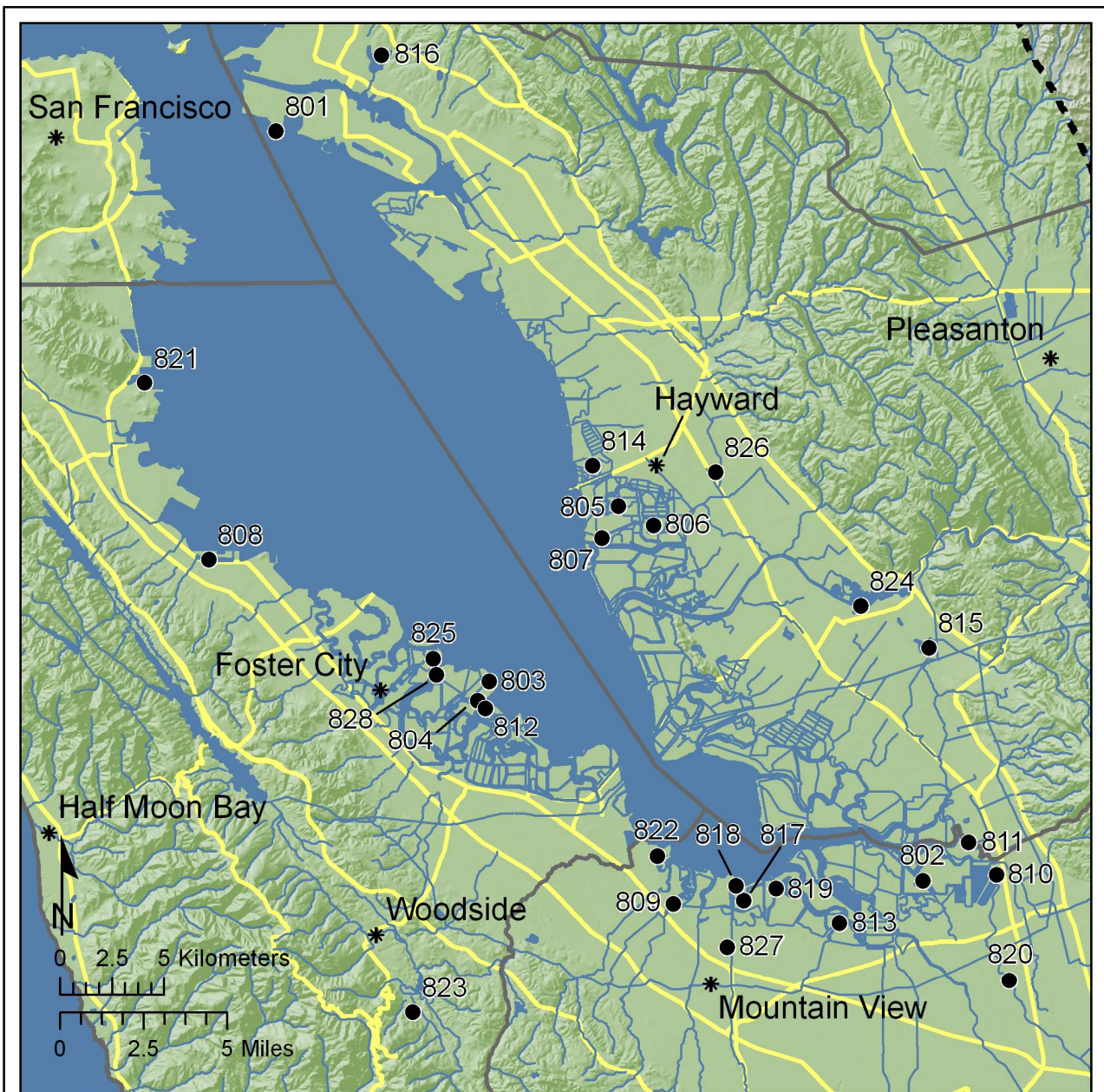
SOUTH SAN FRANCISCO BAY



SOUTH SAN FRANCISCO BAY

This subregion includes shoreline areas from the Oakland Bay Bridge south to San Jose. Most of the tidal marshland in the South San Francisco Bay was diked and drained for pasture in the early 1900s and eventually converted to salt evaporation ponds. Planning efforts are underway to restore much of the marshland in this area to tidal action, although some ponds will be managed as non-tidal wildlife areas.

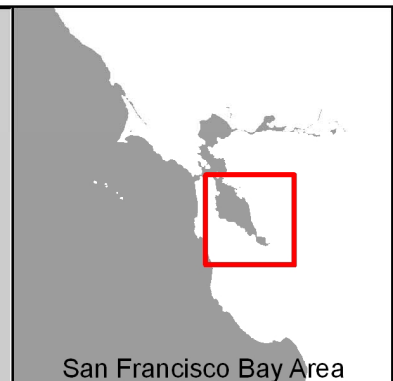
Site #	Colony Site	Great Blue Heron	Great Egret	Snowy Egret	Black-crowned Night-Heron	Cattle Egret	Little Blue Heron	County	Active or year last active	Page
801	Alameda NWR	■						Alameda	Active	190
802	Artesian Slough		□	■	■	■	■	Santa Clara	2002	191
803	Bair Island North	■	□	■	■			San Mateo	1994	193
804	Bair Island South	■	□	■	■			San Mateo	Active	195
805	Baumberg 13	■						Alameda	2002	197
806	Baumberg 6B	■						Alameda	Active	198
807	Baumberg 8A	■						Alameda	1996	218
808	Burlingame			■	■			San Mateo	2000	218
809	Charleston Slough				■			Santa Clara	1993	218
810	Coyote Creek	■	□					Santa Clara	2003	199
811	Coyote Creek Lagoon		□	■	■			Santa Clara	2002	200
812	Greco Island	■						San Mateo	1998	219
813	Guadalupe Slough		□	■	■			Santa Clara	2003	219
814	Hayward Shoreline		□	■	■	■		Alameda	Active	202
815	Lake Elizabeth		□	■	■			Santa Clara	Active	204
816	Lake Merritt	■	□	■	■			Alameda	Active	206
817	Moffett A2E	■						Santa Clara	1995	219
818	Moffett A2W	■						Santa Clara	1999	219
819	Moffett A3N/B2	■						Santa Clara	1996	220
820	Ovation Court	■						Santa Clara	Active	220
821	Oyster Cove Pier	■		■				San Mateo	Active	208
822	Palo Alto Baylands Duck Pond		□	■	■			Santa Clara	Active	209
823	Portola Valley	■						San Mateo	Active	211
824	Quarry Lakes	■						Santa Clara	1995	212
825	Redwood Shores		□	■	■			San Mateo	2004	213
826	Ruus Park		□	■				Alameda	Active	215
827	Shorebird Way		□					Santa Clara	Active	216
828	Steinberger Slough	■						San Mateo	Active	217



Heron and Egret Nesting Colonies in the South San Francisco Bay* 1991-2005

- Colony site
- * Town
- ~ Stream
- - - Study area boundary
- Major highway
- County boundary

*Colony sites outside of this sub-region are not shown.



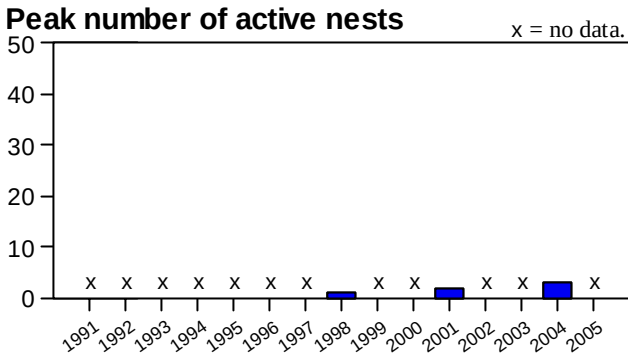
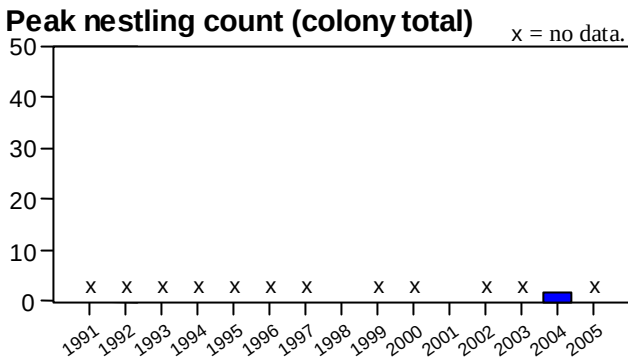
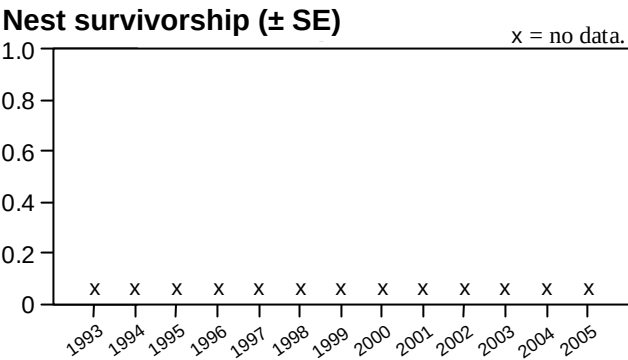
Alameda NWR

Great Blue Herons nest on a pier at the proposed Alameda National Wildlife Refuge, on the old Alameda Naval Air Station. The pier is an extension of the runway lights approximately 100 m over the bay. The herons are potential nest predators at a nearby breeding colony of the endangered California Least Tern (*Sterna antillarum browni*).

Ownership: public

Public observation areas: none

Latitude / Longitude: N 37.7740 / W 122.3128



Colony site description

Topography: wetland
Length x width: 182 m x 1.2 m
Nest substrate: wooden pier
Average nest height: 5.5 m
Trees (dbh): none
Maximum tree canopy height: no canopy
Vegetation cover: none

Evidence of disturbance

Western Gulls: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Land Use	100	200	500	1000
Industrial		X	X	X
Protected natural area	X			

Artesian Slough

This site, also known as Mallard Slough, is in a brackish marsh, 1.5 km north of Alviso and 6.5 km east of San Francisco Bay on the Don Edwards National Wildlife Refuge. Fresh water is discharged into the slough from the San Jose-Santa Clara Water Treatment Plant. Little Blue Herons nested here in 1988, 1990, 1993, 1996 and 1998.

Ownership: public

Public observation areas: none

Latitude / Longitude: N 37.4460 / W 121.9642



Colony site description

Topography: wetland

Length x width: 250 m x 150 m

Nest substrate: California bulrush (*Schoenoplectus californicus*)

Average nest height: not measured

Trees (dbh): none

Maximum tree canopy height: no canopy

Vegetation cover: not measured

Evidence of disturbance

Human activity (discharge from wastewater treatment plant): potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods)

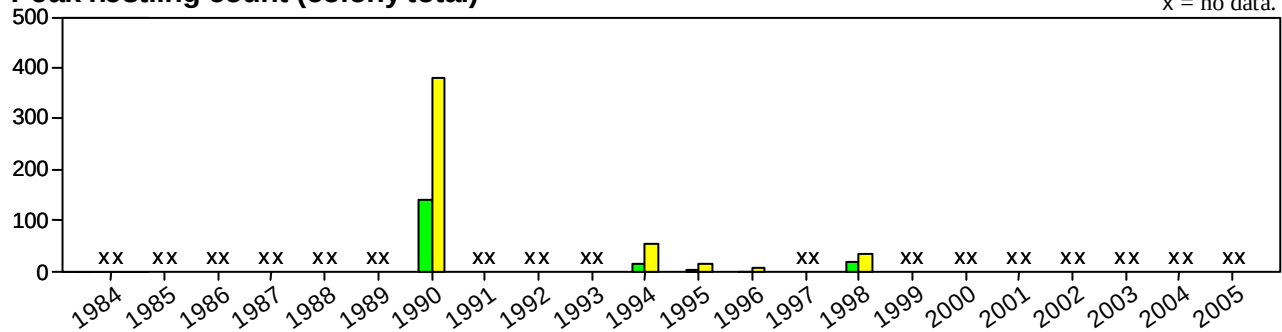
Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Protected natural area	X	X	X	X

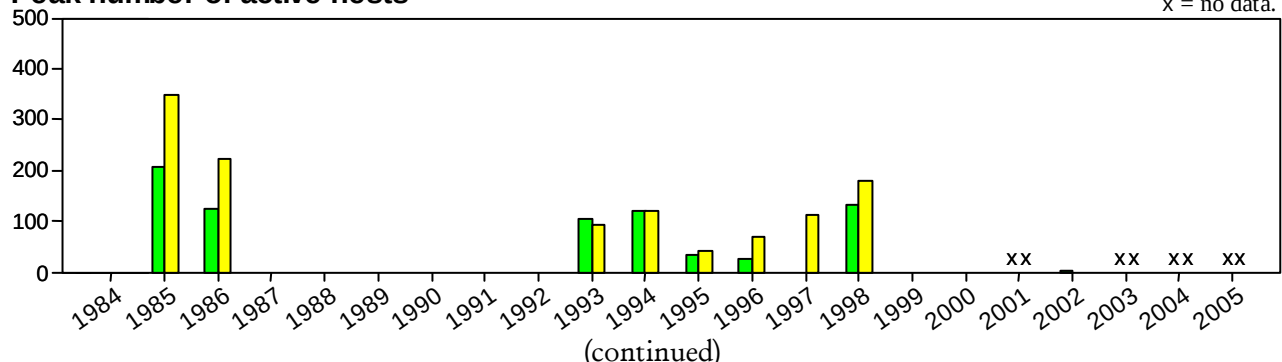
■ Black-crowned Night-Heron ■ Snowy Egret

(Nest survivorship data are not available)

Peak nestling count (colony total)



Peak number of active nests

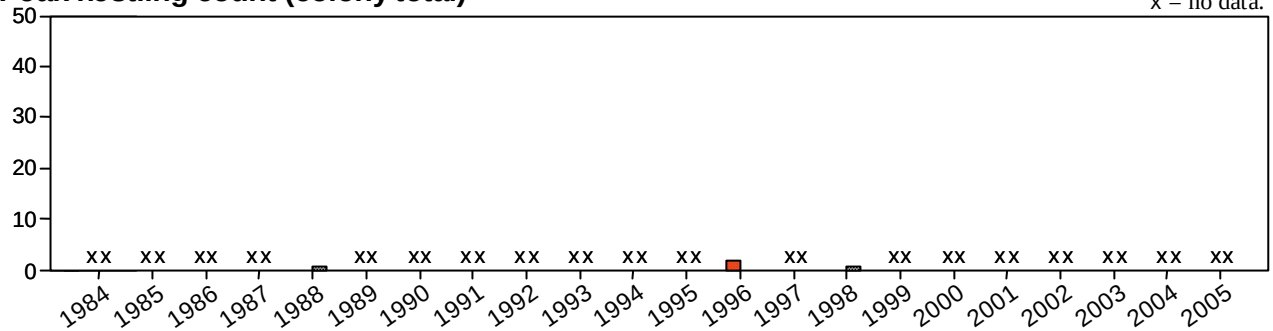


Artesian Slough (continued)

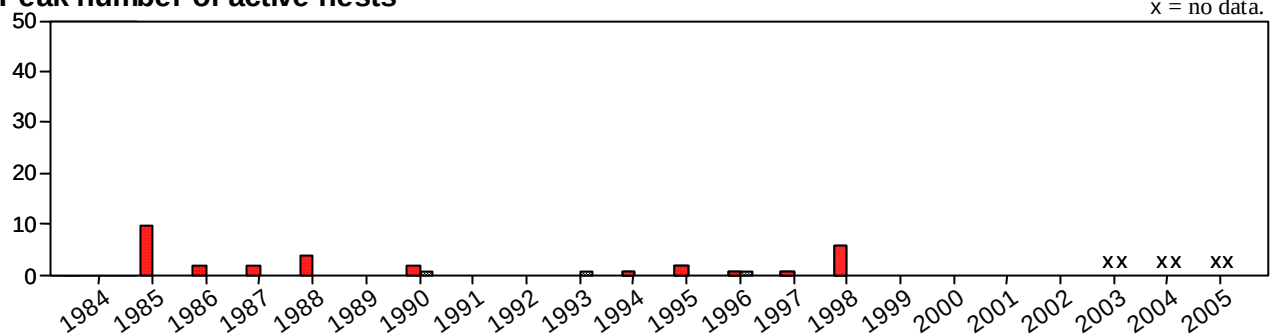
■ Cattle Egret ■ Little Blue Heron

(Nest survivorship data are not available)

Peak nestling count (colony total)



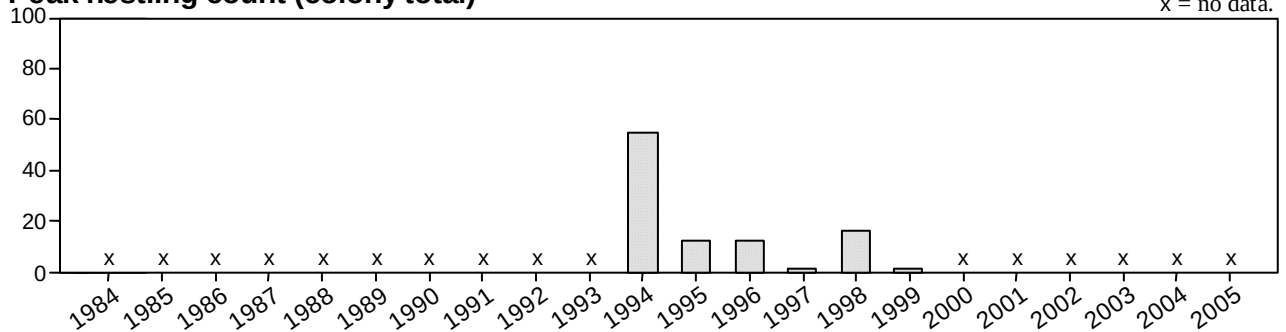
Peak number of active nests



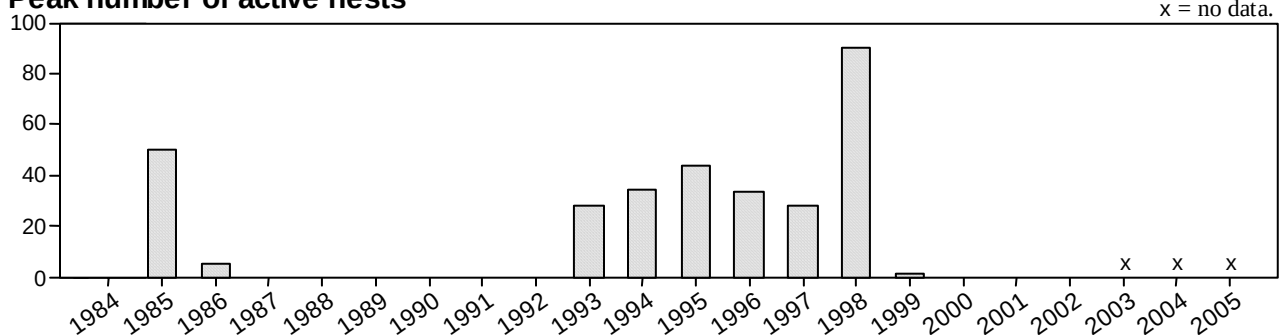
■ Great Egret

(Nest survivorship data are not available)

Peak nestling count (colony total)



Peak number of active nests



Bair Island North

This colony was on Don Edwards San Francisco Bay National Wildlife Refuge 6 km north of Redwood City, adjacent to Redwood Creek, and 0.3 km from San Francisco Bay. The South Bay's largest mixed species colony existed here from at least 1982-1991, after which it was abandoned, apparently in response to predation by red fox.

Ownership: public

Public observation areas: none

Latitude / Longitude: N 37.5345 / W 122.1993



Colony site description

Topography: levee

Length x width: 125 m x 28 m

Nest substrate: coyote brush (*Baccharis pilularis*)

Average nest height: 2 m

Trees (dbh): none

Maximum tree canopy height: no canopy

Vegetation cover: tree 0%, shrub 78%, ground 48%

Evidence of disturbance

Red fox: colony abandonment

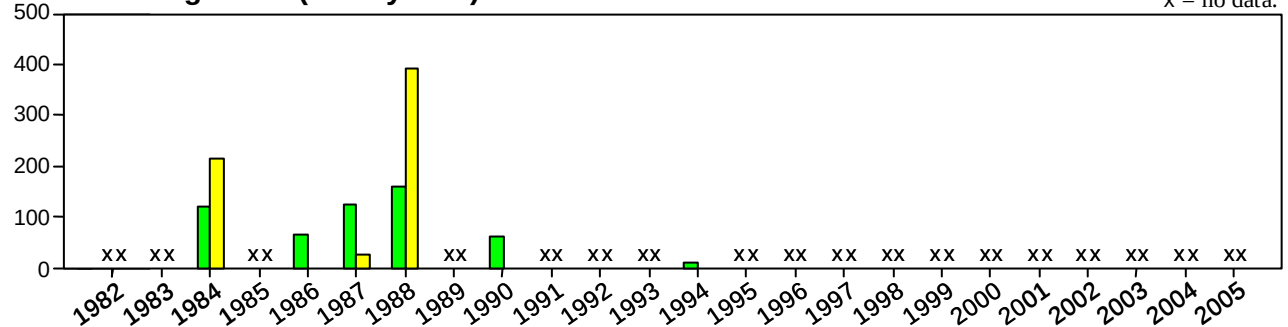
Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Protected natural area	X	X	X	X

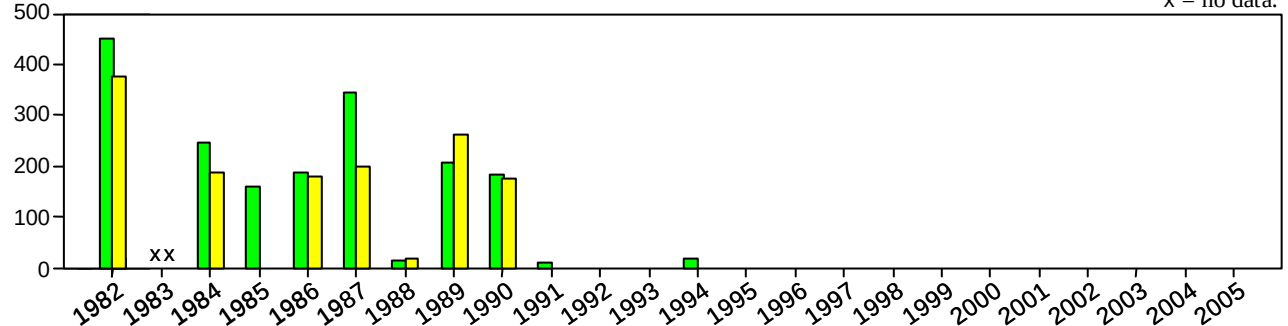
Black-crowned Night-Heron Snowy Egret

(Nest survivorship data are not available)

Peak nestling count (colony total)



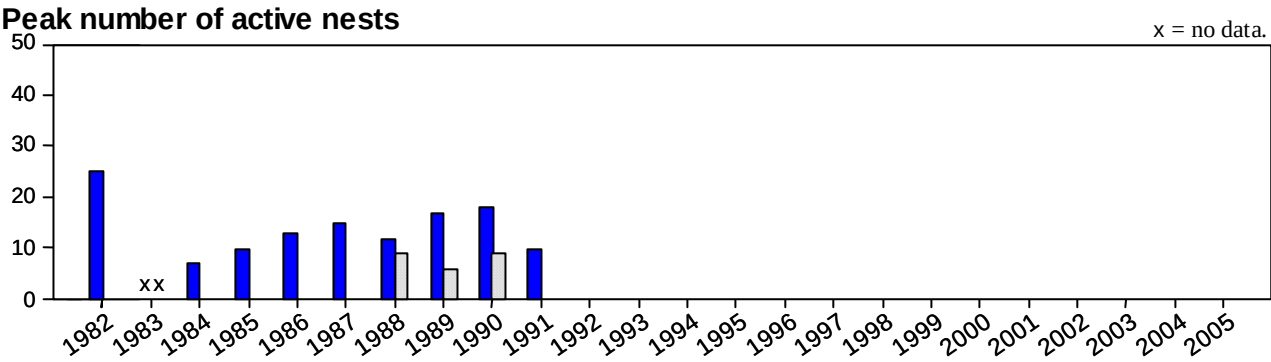
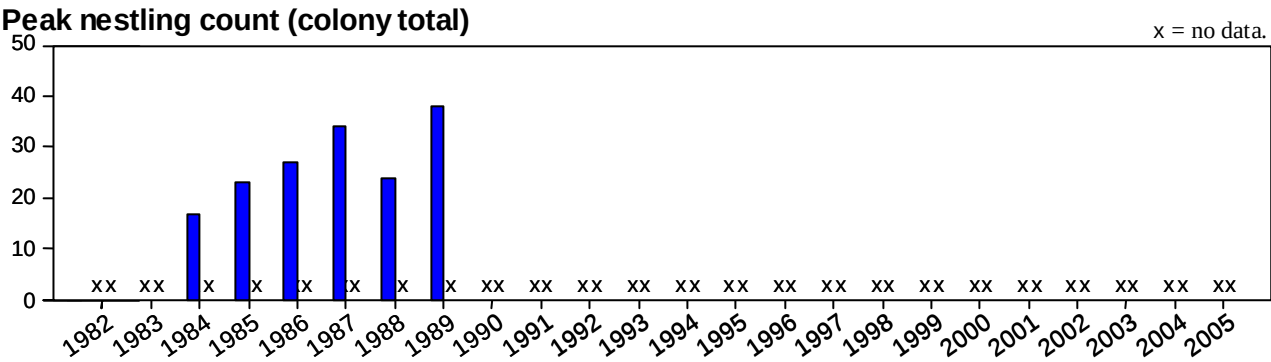
Peak number of active nests



(continued)

Bair Island North (continued)

Great Blue Heron **Great Egret** (Nest survivorship data are not available)



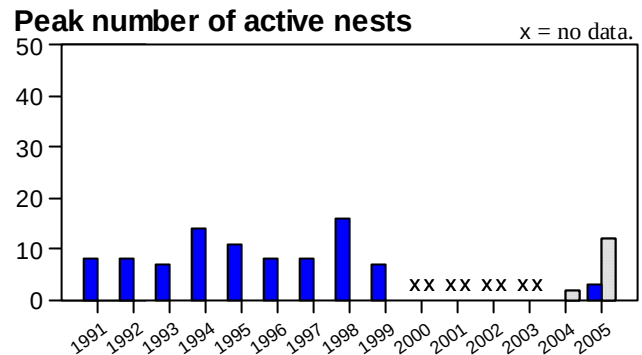
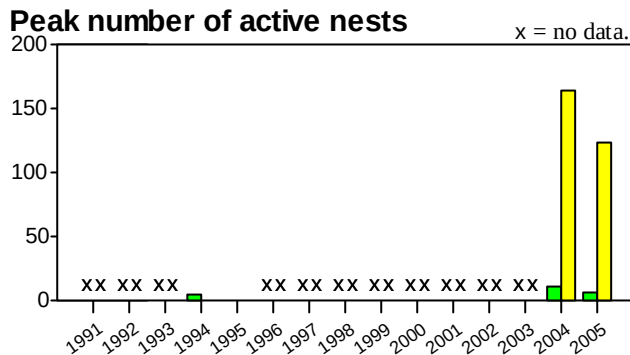
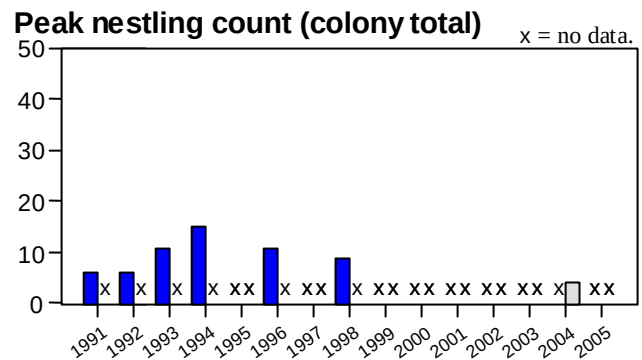
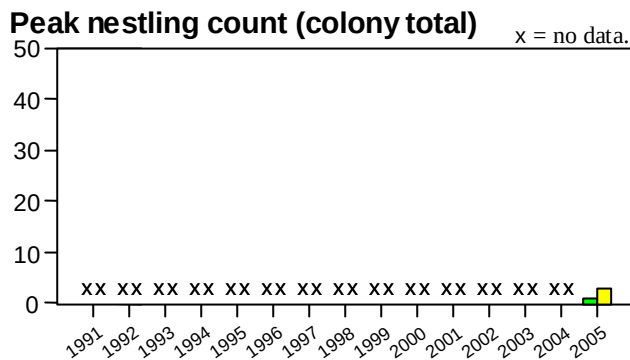
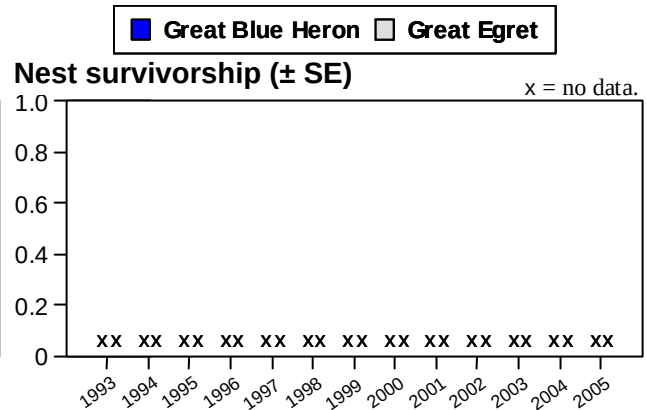
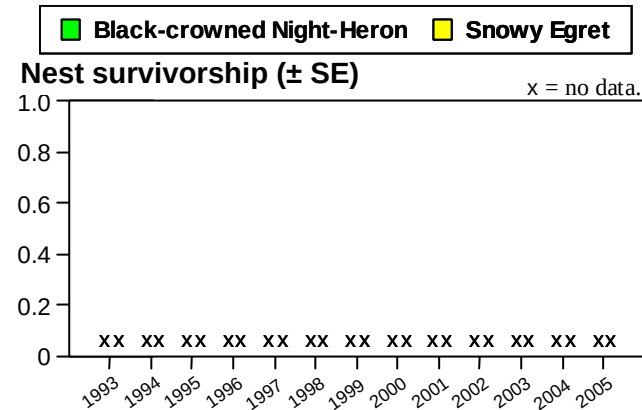
Bair Island South

This colony site is on California Department of Fish and Game property 6 km north of Redwood City, adjacent to Redwood Creek, and 1.2 km from San Francisco Bay. Great Blue Herons nested in separate subcolonies on power towers along Redwood Creek and Corkscrew Slough. Great Egrets, Black-crowned Night-Herons, and Snowy Egrets nested in other subcolonies in coyote brush and on the ground.

Ownership: public

Public observation areas: none

Latitude / Longitude: N 37.5263 / W 122.2055



(continued)

Bair Island South (continued)

Colony site description

Topography: levee
 Length x width: not measured
 Nest substrate: coyote bush (*Baccharis pilularis*),
 power towers
 Average nest height: not measured
 Trees (dbh): none
 Maximum tree canopy height: no canopy
 Vegetation cover: not measured

Evidence of disturbance

Red fox: nest failure
 Double-crested Cormorants: nest failure

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial				X
Protected natural area	X	X	X	X

Baumberg 13

Great Blue Herons nested on wooden telephone poles and wooden structures such as old duck blinds. The area, once used for salt production, is now owned and managed by the California Department of Fish and Game and has been renamed the Eden Landing Ecological Reserve. The heronry is 6 km northwest of Union City and 1.6 km from the bay.

Ownership: public

Public observation areas: none

Latitude / Longitude: N 37.6097 / W 122.1279



Colony site description

Topography: salt pond

Length x width: not measured

Nest substrate: telephone poles and old wooden structures

Average nest height: not measured

Trees (dbh): none

Maximum tree canopy height: 0 m

Vegetation cover: none

Evidence of disturbance

Red fox: potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

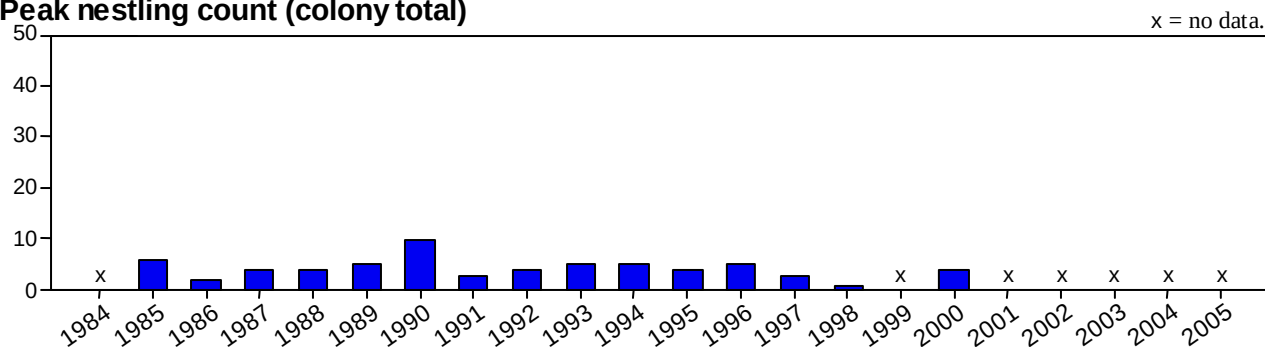
Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Farming	X	X	X	X
Protected natural area	X	X	X	X

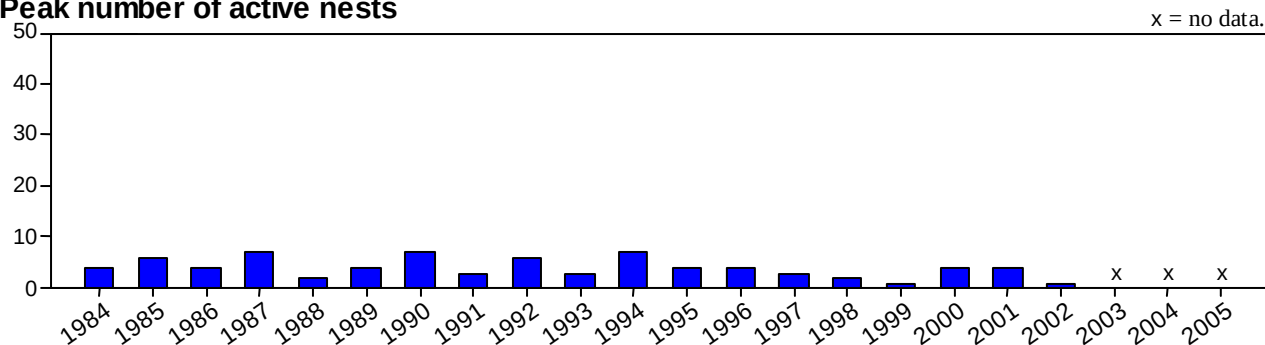
■ Great Blue Heron

(Nest survivorship data are not available)

Peak nestling count (colony total)



Peak number of active nests



Baumberg 6B

This heronry is located atop an old, deteriorating duck club, 2 km northwest of Union City, on the Eden Landing Ecological Reserve, owned by the California Department of Fish and Game. San Francisco Bay is 3.3 km to the west; and the Alameda Flood Control Channel (slough) is 1.1 km to the south.

Ownership: public

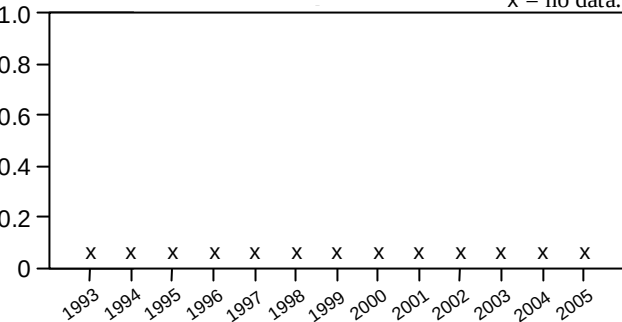
Public observation areas: none

Latitude / Longitude: N 37.6013 / W 122.1089

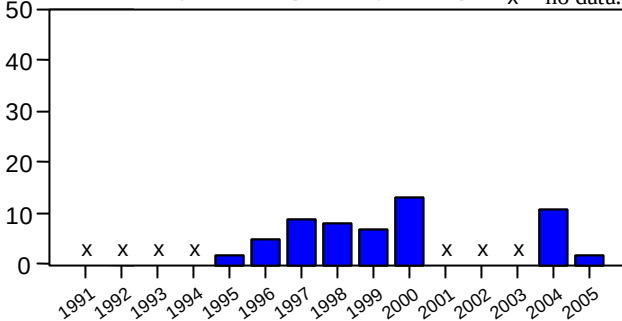


Great Blue Heron

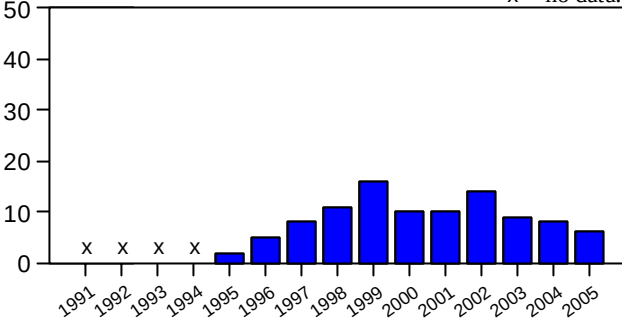
Nest survivorship ($\pm$ SE)



Peak nestling count (colony total)



Peak number of active nests



Colony site description

Topography: salt pond
 Length x width: 14 m x 9 m
 Nest substrate: building
 Average nest height: 3 m
 Trees (dbh): none
 Maximum tree canopy height: no canopy
 Vegetation cover: none

Evidence of disturbance

Red-tailed Hawks: potential source^a
 Common Raven: potential source^a
^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Protected natural area	X	X	X	X

Coyote Creek

This site is 10 km east of San Francisco Bay, near Interstate 880, on Santa Clara Valley Water District property. The nests were in willows overhanging Coyote Creek. The San Jose/Santa Clara Water Pollution Control Plant sludge ponds are 100 m to the north. The site was abandoned in 2003 when helicopters were used to erect power poles within 100 m of the nests.

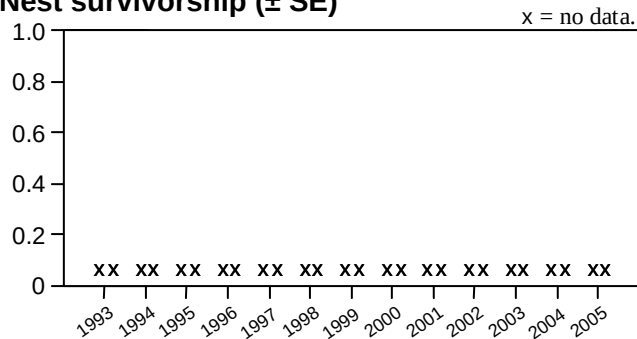
Ownership: public

Public observation areas: none

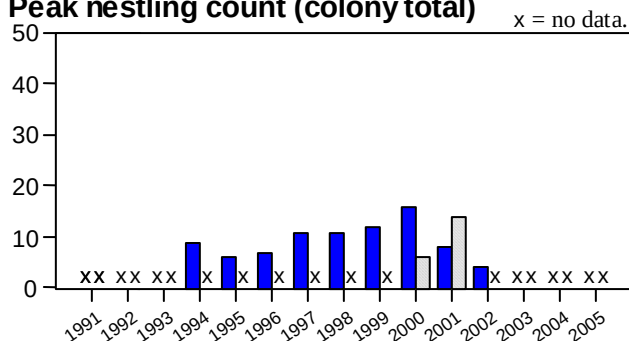
Latitude / Longitude: N 37.4482 / W 121.9242

■ Great Blue Heron □ Great Egret

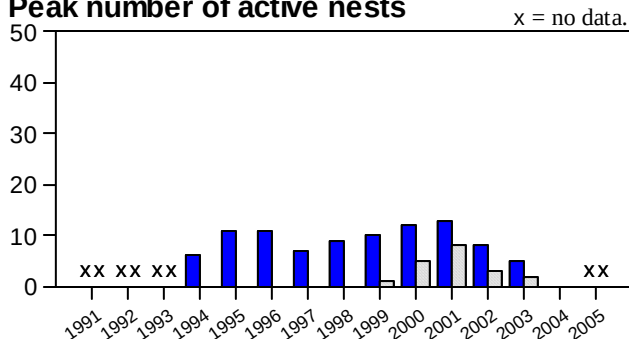
Nest survivorship ($\pm$ SE)



Peak nestling count (colony total)



Peak number of active nests



Colony site description

Topography: flood plain

Length x width: 18 m x 15 m

Nest substrate: arroyo willow (*Salix lasiolepis*)

Average nest height: 12 m

Trees (dbh): 1 (10-50 cm), 2 (50-100 cm),
1 (100-150 cm)

Maximum tree canopy height: 15 m

Vegetation cover: tree 80%, ground 9%

Evidence of disturbance

Human activity (helicopters and construction):
colony abandonment

Raccoons: potential source^a

^aPossible disturbance suggested by published accounts
(see references in Methods).

Land use

Land use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial	X	X	X	X
Protected natural area	X	X	X	X

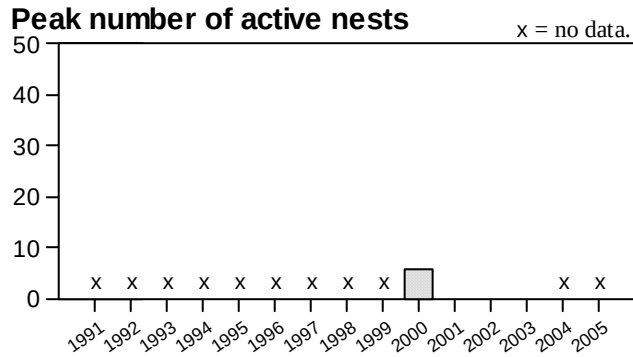
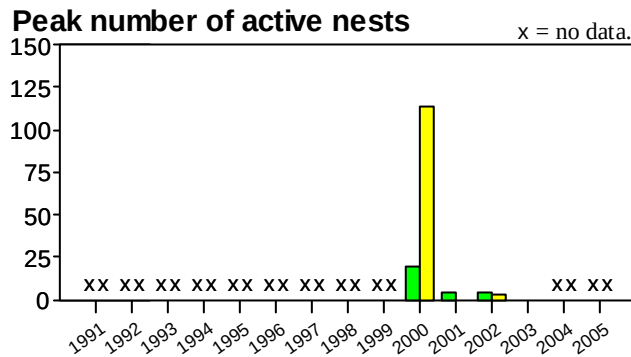
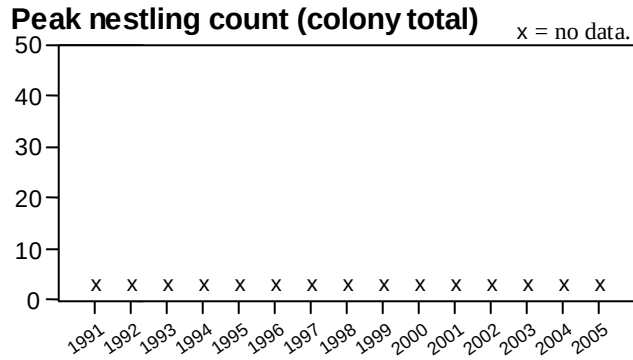
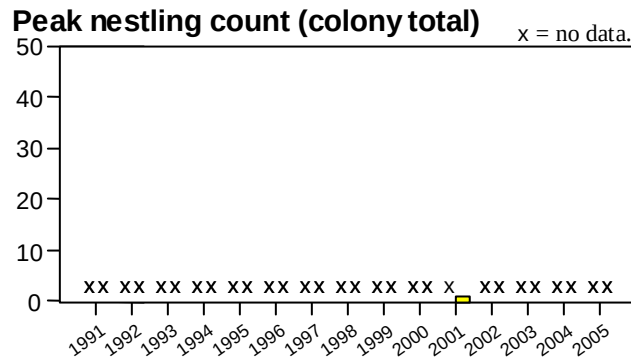
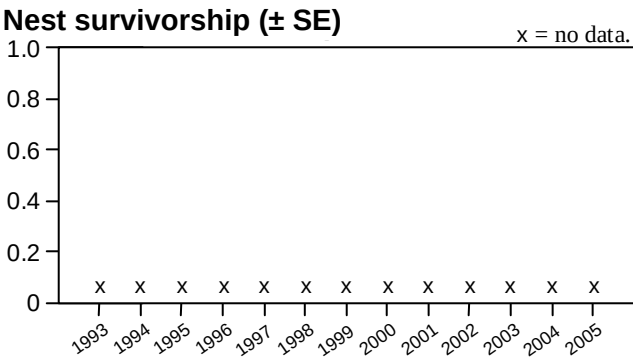
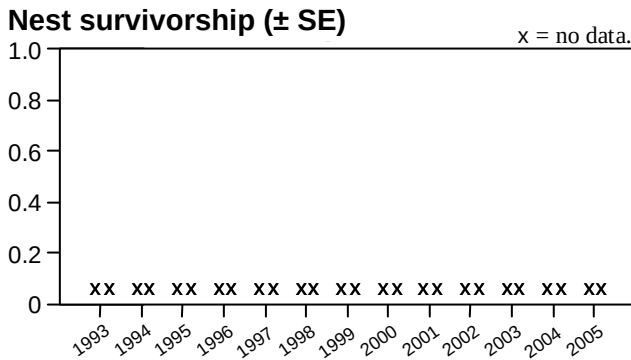
Coyote Creek Lagoon

This colony site is 6 km northwest of Milpitas along Coyote Creek in the Don Edwards San Francisco Bay National Wildlife Refuge. It is 0.6 km from the Fremont Airport, 2 km from the Milpitas Sewage Disposal plant, and within 100 m of the Newby Island Landfill. Black-crowned Night-Herons, Snowy Egrets, and Great Egrets nested here in bulrushes. A botulism outbreak occurred here in 2001.

Ownership: public

Public observation areas: hiking trail along lagoon

Latitude / Longitude: N 37.4624 / W 121.9391



(continued)

Coyote Creek Lagoon (continued)

Colony site description

Topography: wetland

Length x width: not measured

Nest substrate: California bulrush (*Schoenoplectus californicus*)

Average nest height: not measured

Trees (dbh): none

Maximum tree canopy height: 0 m

Vegetation cover: not measured

Evidence of disturbance

None recorded.

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial				X
Protected natural area	X	X	X	X

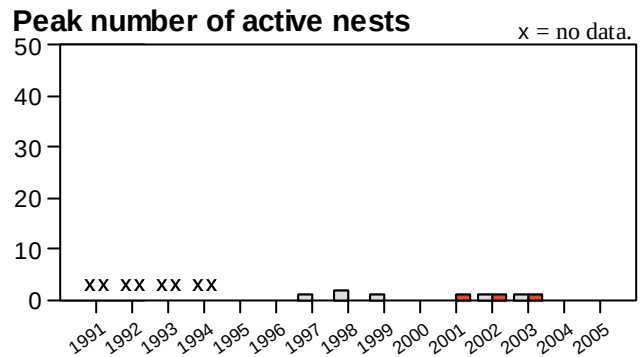
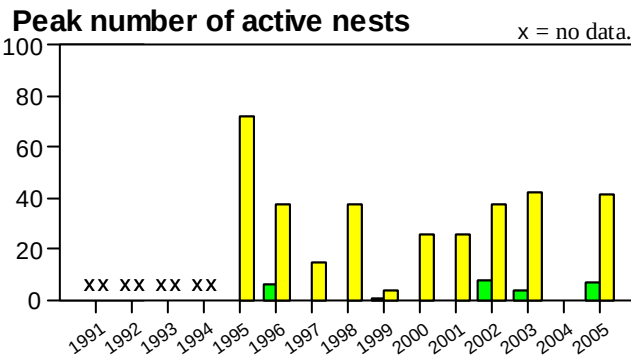
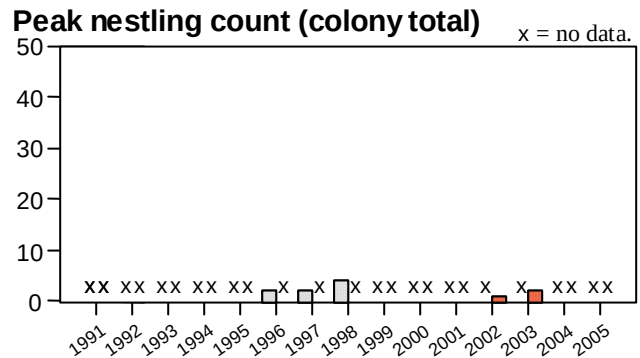
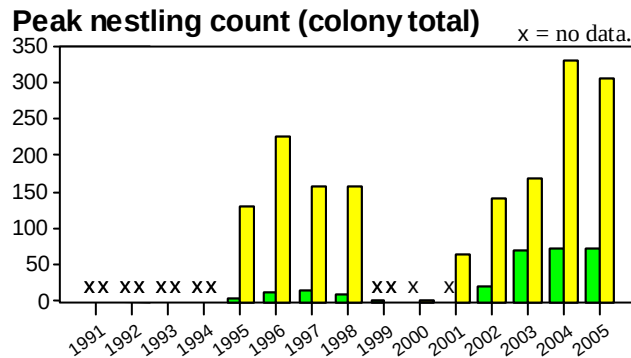
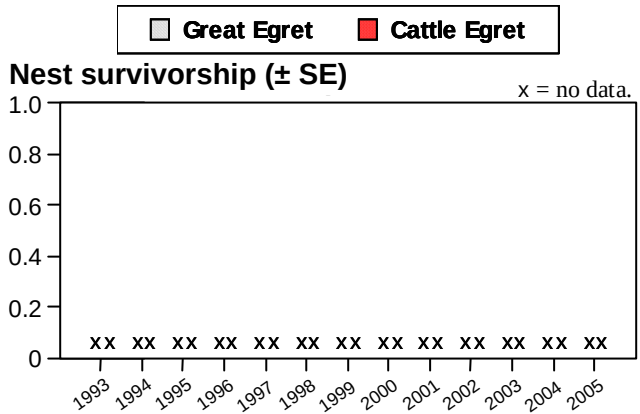
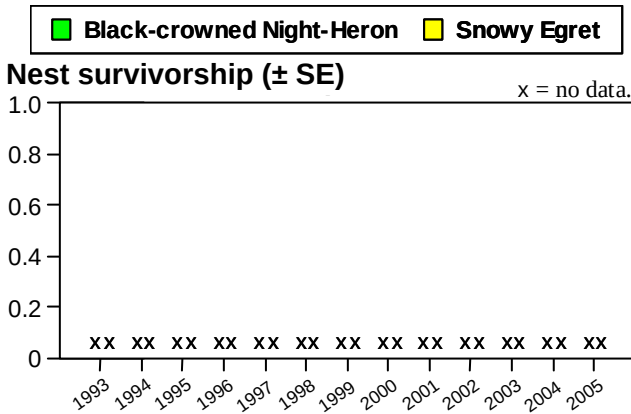
Hayward Shoreline

This heronry is about 7 km southwest of downtown Hayward in Hayward Regional Shoreline and is 0.8 km from the bay. The East Bay Regional Park District manages this area. One group of nests is at the western end of the freshwater pond and another group is at the southeastern end. These ponds receive natural drainage and treated sewage effluent.

Ownership: public

Public observation areas: none

Latitude / Longitude: N 37.6278 / W 122.1422



(continued)

Hayward Shoreline (continued)

Colony site description

Topography: wetland

Length x width: 99 m x 15 m

Nest substrate: California bulrush (*Schoenoplectus californicus*)
hard-stem bulrush (*Schoenoplectus acutus*)

Average nest height: 1 m

Trees (dbh): none

Maximum tree canopy height: no canopy

Vegetation cover: not measured

Evidence of disturbance

None recorded.

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial			X	X
Protected natural area	X	X	X	X

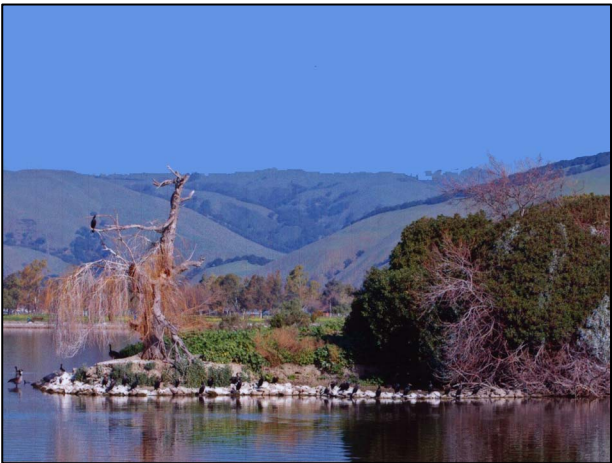
Lake Elizabeth

This colony site is on an island in Lake Elizabeth in Fremont Central Park, owned by the City of Fremont. The lake was converted from marshland in 1968 for flood control. Black-crowned Night-Herons, Great Egrets, and Snowy Egrets have nested here. Work is currently planned to protect the vegetation used for nesting from shoreline erosion.

Ownership: public

Public observation areas: boat and shore

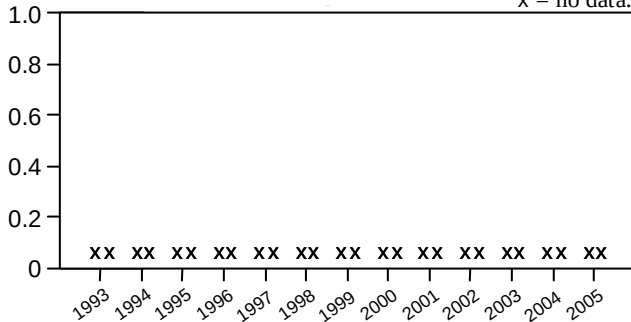
Latitude / Longitude: N 37.5472 / W 121.9594



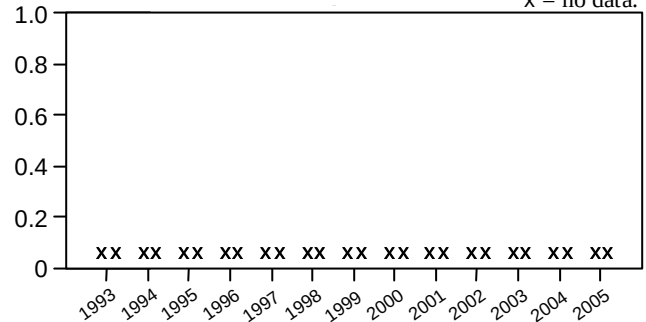
Black-crowned Night-Heron Snowy Egret

Great Egret

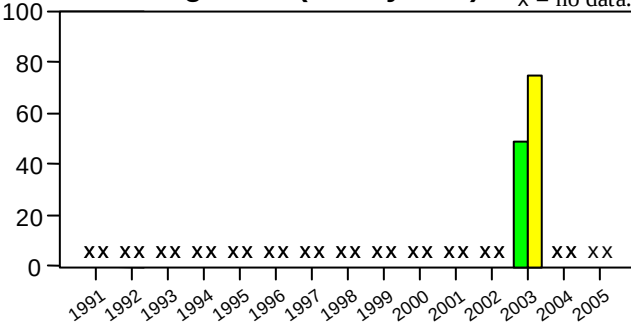
Nest survivorship ($\pm$ SE)



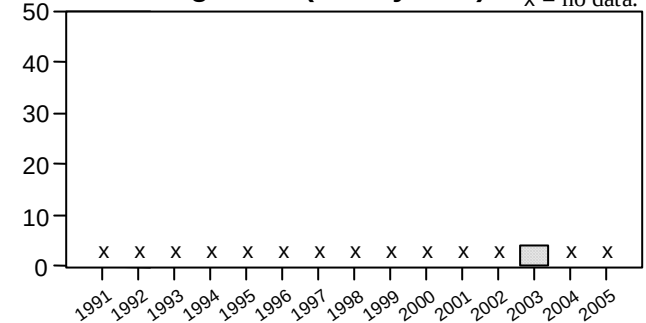
Nest survivorship ($\pm$ SE)



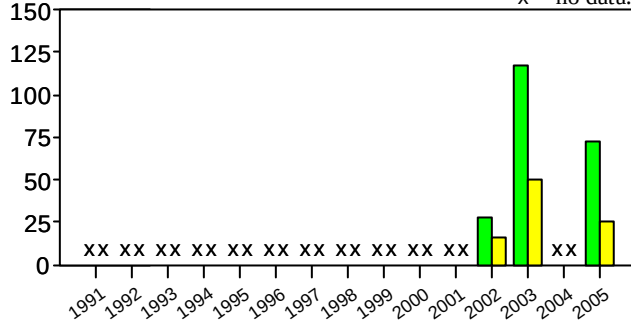
Peak nestling count (colony total)



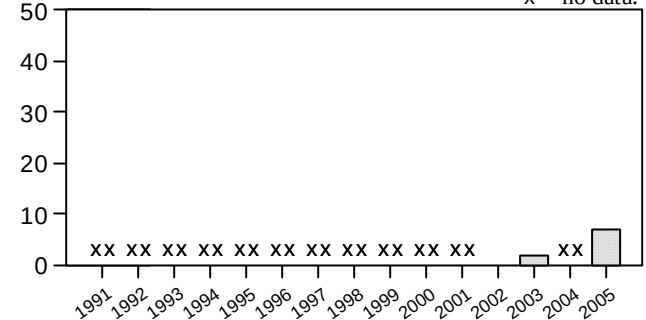
Peak nestling count (colony total)



Peak number of active nests



Peak number of active nests



(continued)

Lake Elizabeth (continued)

Colony site description

Topography: island

Length x width: 35 m x 19 m

Nest substrate: unidentified trees

Average nest height: 4.5 m

Trees (dbh): not measured

Maximum tree canopy height: 14 m

Vegetation cover: tree 38%, shrub 30%, ground 25%

Evidence of disturbance

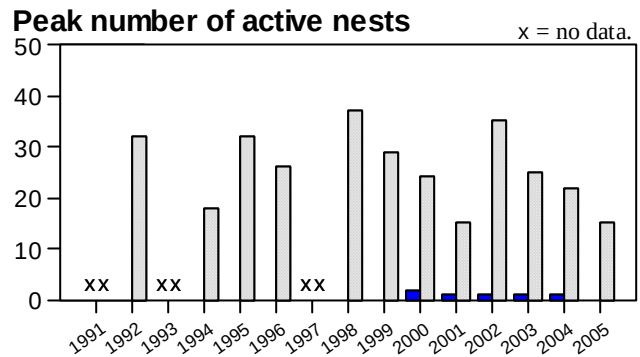
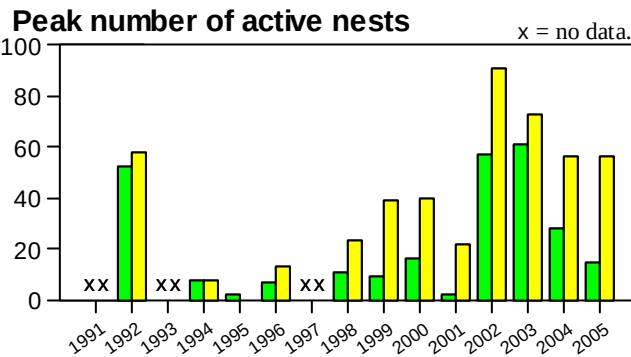
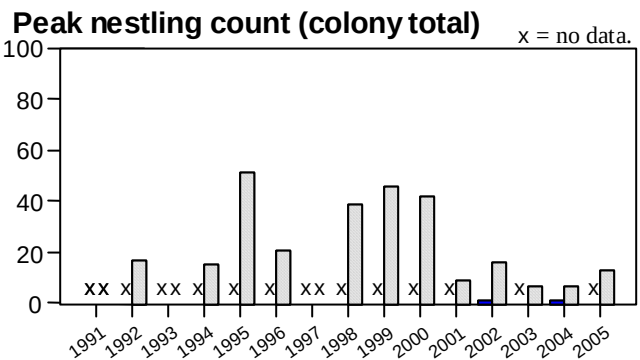
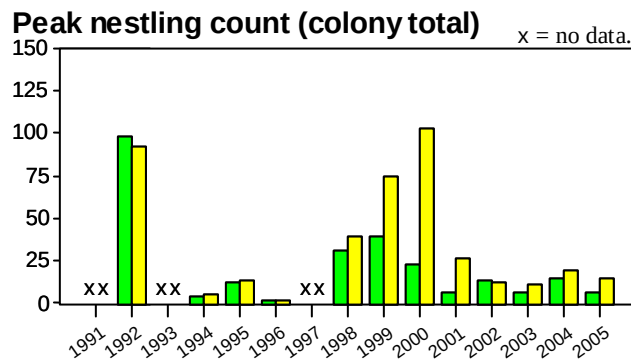
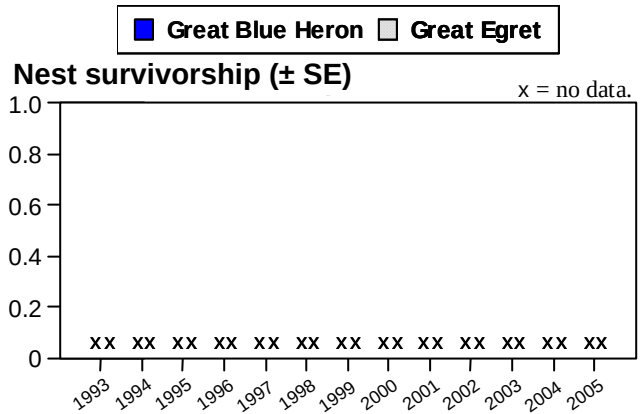
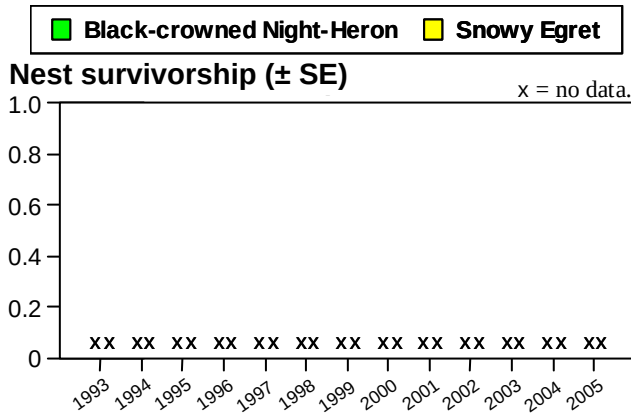
Human activity (boating): behavioral response

Land use

Land Use	Distance from colony site (m)			
	0- 100	100- 200	200- 500	500- 1000
Industrial		X	X	X
High density housing				X
Protected natural area	X	X	X	X
Sports field				X

Lake Merritt

This heronry consists of five islands at the northern end of Lake Merritt, in the City of Oakland, near the playground. The City manages the lake and park. Great Egrets and Snowy Egrets nest in blackberry bushes ringing the islands. Eucalyptus and tamarisk also grow on the islands. Nests on the interior of the islands are obscured from view. Great Blue Herons nest in low-lying ruderal vegetation on one of the islands. Lake Merritt is brackish, fed by freshwater streams and the waters of San Francisco Bay. Double-crested Cormorants also nest here.



(continued)

Lake Merritt (continued)

Ownership: public

Public observation areas: lakeshore

Latitude / Longitude: N 37.8066 / W 122.2550

Colony site description

Topography: islands

Length x width: 150 m x 80 m

Nest substrate: blackberry (*Rubus* sp.), other ruderal vegetation

Average nest height: 1.5 m

Trees (dbh): not measured

Maximum tree canopy height: not measured

Vegetation cover: not measured

Evidence of disturbance

Human activity (boating): potential source^a

Human activity (fishing): dead birds seen with fishing line about legs

^aPossible disturbance suggested by published accounts (see references in Methods).

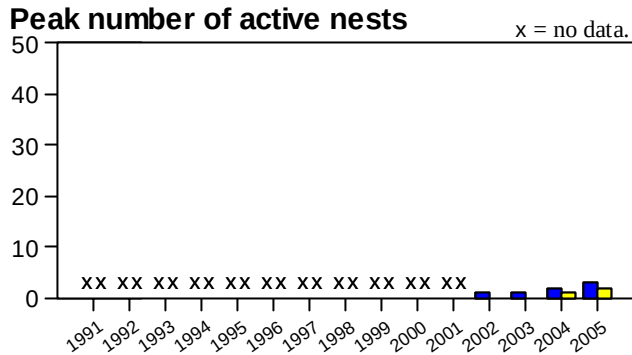
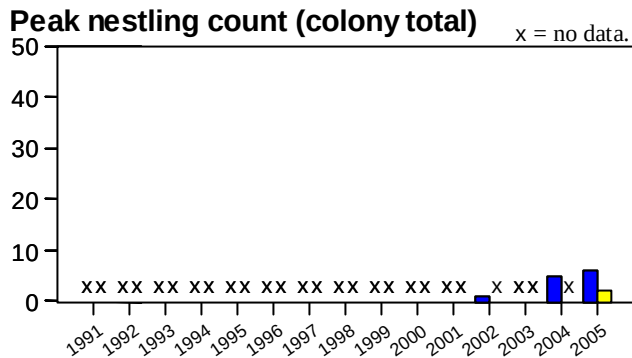
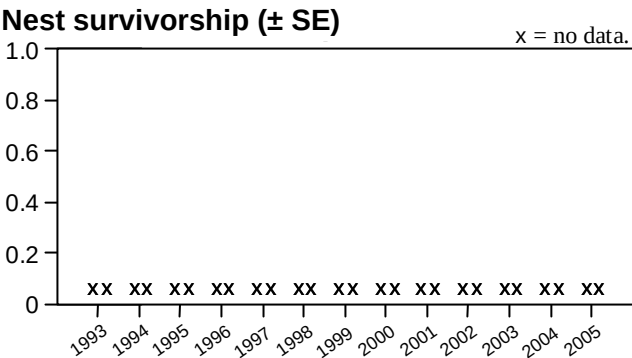
Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial				X
High density housing			X	X
Protected natural area	X	X	X	X

Oyster Cove Pier

Great Blue Herons nest on an old, dilapidated pier just north of Oyster Point in South San Francisco. Marsh and industrial development exist on the shore adjacent to the pier. A small Forster's tern (*Sterna forsteri*) colony nested here in 1990.

Ownership: public
Public observation areas: Bay trail along shore
Latitude / Longitude: N 37.6652 / W 122.3855



Colony site description

Topography: wetland shore
Length x width: not measured
Nest substrate: wooden pier
Average nest height: not measured
Trees (dbh): none
Maximum tree canopy height: no canopy
Vegetation cover: none

Evidence of disturbance

Human activity (boaters): potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial	X	X	X	X

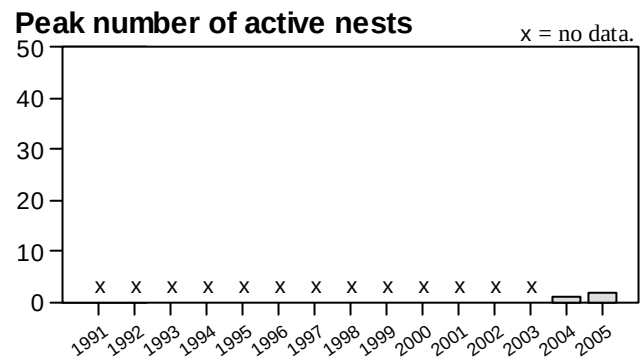
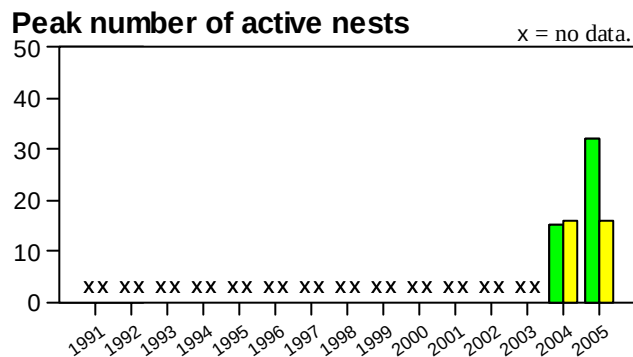
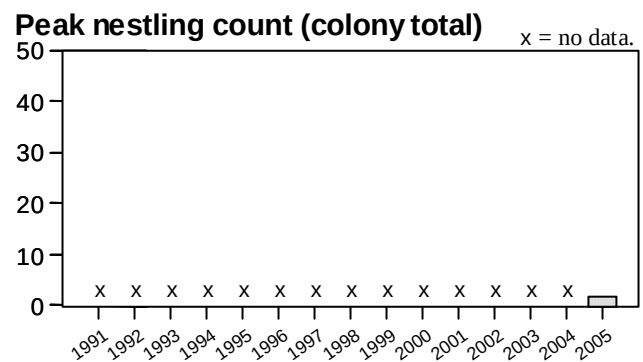
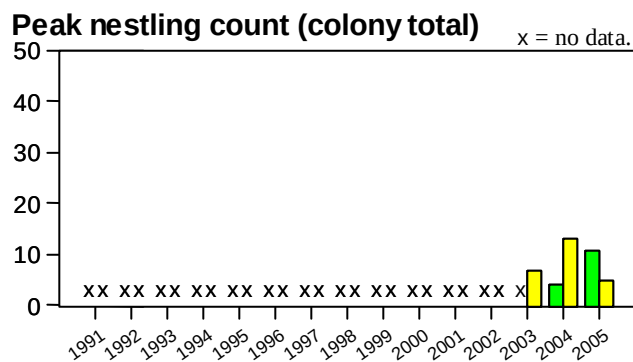
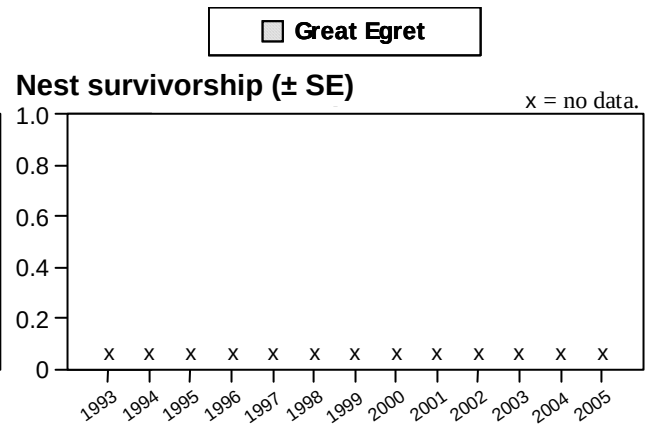
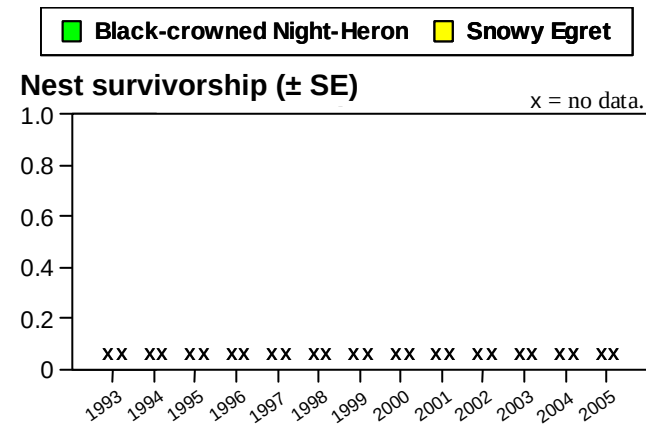
Palo Alto Baylands Duck Pond

The Palo Alto Baylands is an environmental education center on the shore of San Francisco Bay, owned by the City of Palo Alto. The nest trees are date palms within a fenced bird sanctuary. The park's salt marsh is home for the endangered Clapper Rail and Salt Marsh Harvest Mouse.

Ownership: public

Public observation areas: shore of the pond and boardwalk at the interpretive center

Latitude / Longitude: N 37.4578 / W 122.1086



(continued)

Palo Alto Baylands Duck Pond (continued)

Colony site description

Topography: wetland

Length x width: 16 m x 13 m

Nest substrate: date palm (*Phoenix dactylifera*)

Average nest height: 5 m

Trees (dbh): 3 (3-10 cm), 5 (50-100 cm), 3 (100-150 cm)

Maximum tree canopy height: 9 m

Vegetation cover: tree 90%, shrub 0%, ground 0%

Evidence of disturbance

None recorded.

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial			X	X
Protected natural area	X	X	X	X
Sports field				X

Portola Valley

This colony is in tall redwood trees just west of Portola Road in Portola Valley. The site is 1.1 km south of Searsville Lake in a rural residential area within 1 km of several seasonal creeks.

Ownership: private

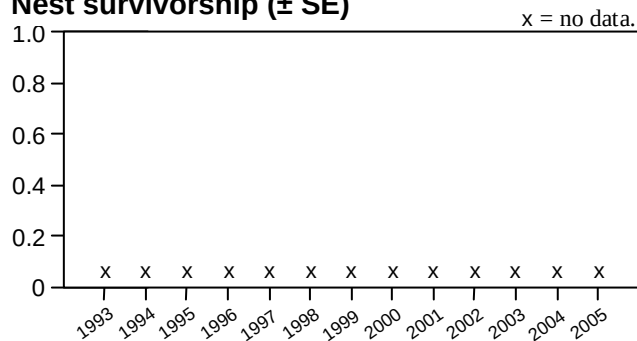
Public observation areas: from Portola Road

Latitude / Longitude: N 37.3908 / W 122.2400

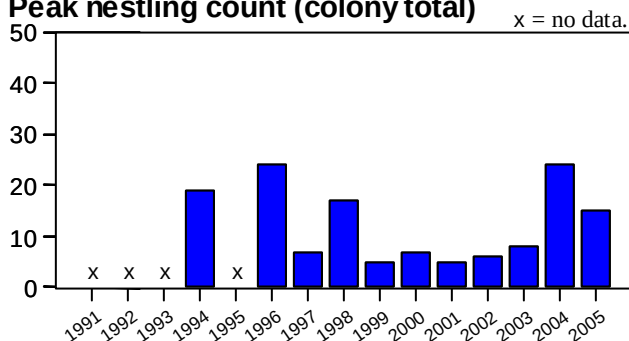


■ Great Blue Heron

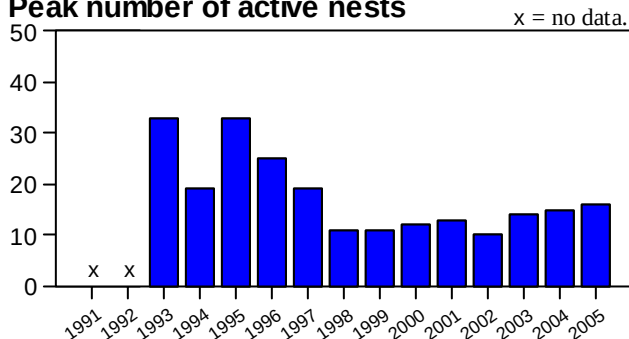
Nest survivorship ($\pm$ SE)



Peak nestling count (colony total)



Peak number of active nests



Colony site description

Topography: hillside

Length x width: 35 m x 25 m

Nest substrate: coast redwood (*Sequoia sempervirens*)

Average nest height: 23 m

Trees (dbh): not measured

Maximum tree canopy height: 27 m

Vegetation cover: not measured

Evidence of disturbance

None recorded.

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing	X	X	X	X
Mid-density housing				X
Farming				X
Orchard			X	X
Vineyard		X	X	X
Grazing				X
Protected natural area			X	X

Quarry Lakes

Great Blue Herons nested in eucalyptus trees in an area now within the Quarry Lakes Regional Recreation Area in the city of Fremont. The East Bay Regional Park District owns the quarries and the lakes are used for groundwater recharge by the Alameda County Water District.

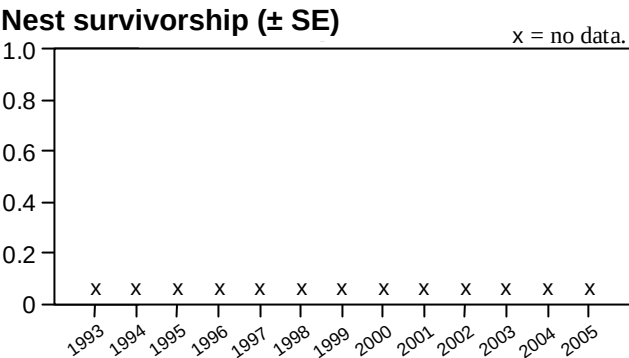
Ownership: public

Public observation areas: park trails

Latitude / Longitude: N 37.5658 / W 121.9964



■ Great Blue Heron

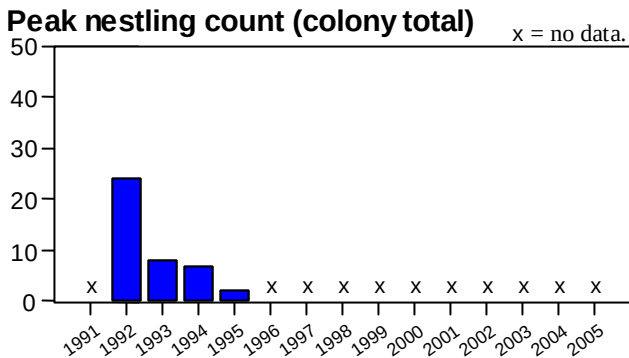


Colony site description

Topography: wetland
Length x width: not measured
Nest substrate: *Eucalyptus* sp.
Average nest height: not measured
Trees (dbh): not measured
Maximum tree canopy height: not measured
Vegetation cover: not measured

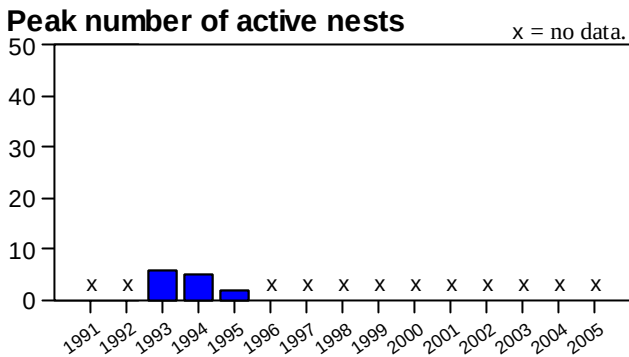
Evidence of disturbance

None recorded.



Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Low density housing			X	X
Protected natural area	X	X		



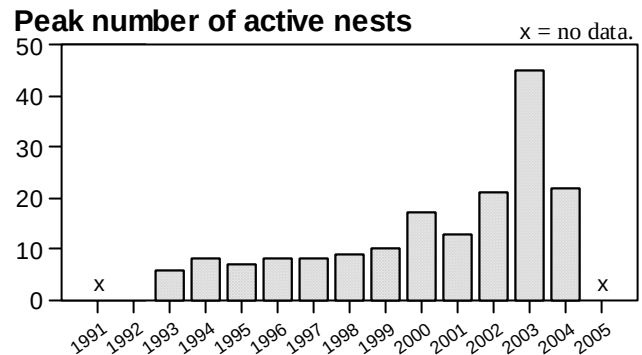
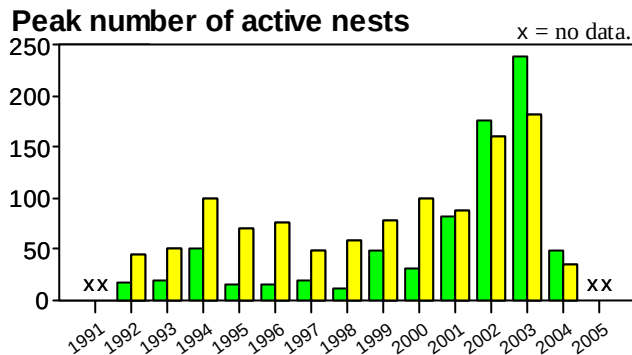
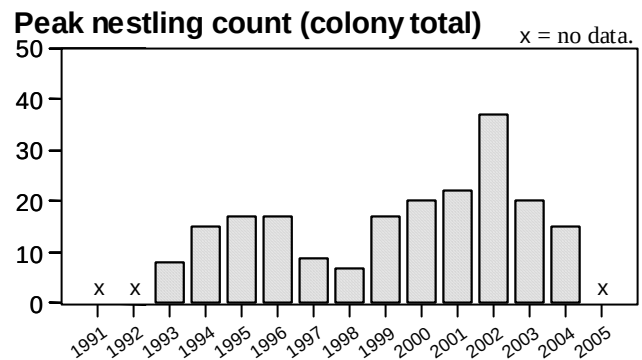
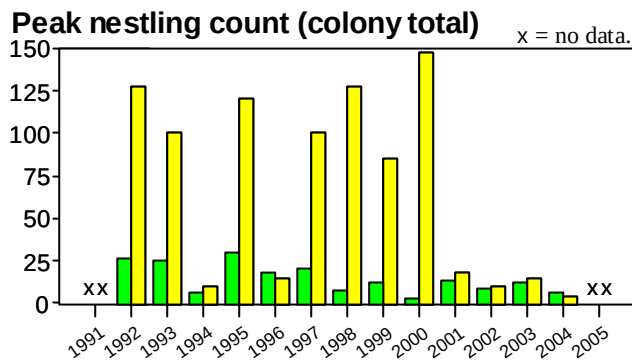
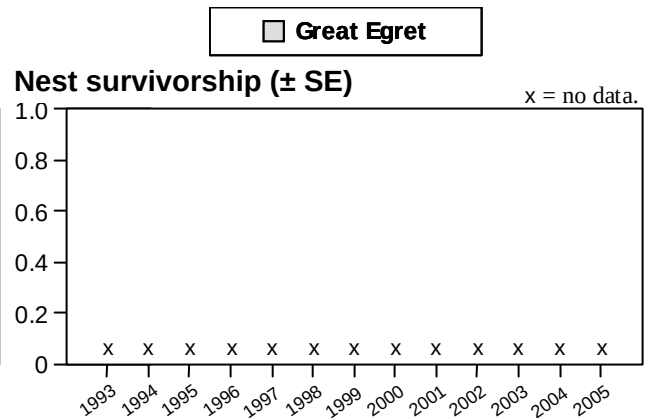
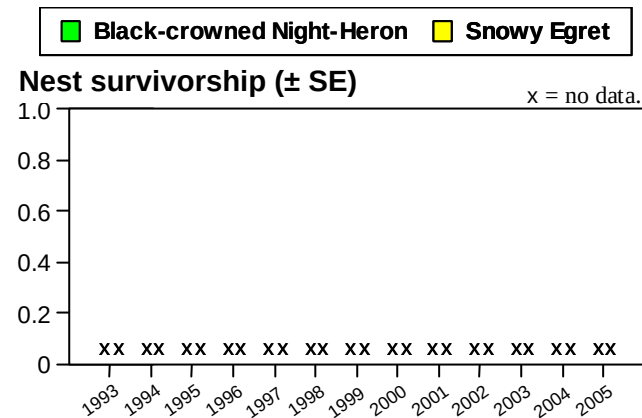
Redwood Shores

This colony site is on the grounds of the Redwood City Sewage Plant at the eastern end of Redwood Shores Parkway, adjacent to the Don Edwards San Francisco Bay National Wildlife Refuge. The nesting trees, which run along Steinberger Slough, were planted in 1982. This site was abandoned in 2005 after construction activity at the treatment plant.

Ownership: public

Public observation areas: sewage plant parking lot

Latitude / Longitude: N 37.5444 / W 122.2294



(continued)

Redwood Shores (continued)

Colony site description

Topography: wetland shore

Length x width:

Subsite 1: 293 m x 17 m

Subsite 2: 20 m x 15 m

Subsite 3: 20 m x 15 m

Nest substrate: *Eucalyptus* sp. (live and dead branches)

Average nest height: 7 m

Trees (dbh):

Subsite 1: 55 (3-10 cm), 206 (10-50 cm)

Subsite 2: 12 (3-10 cm), 17 (10-50 cm), 1 (50-100 cm)

Subsite 3: 170 (3-10 cm), 130 (10-50 cm)

Maximum tree canopy height: 15 m

Vegetation cover:

Subsite 1: tree 66%, shrub 0%, ground 25%

Subsite 2: tree 78%, shrub 0%, ground 0%

Subsite 3: tree 71%, shrub 0%, ground 64%

Evidence of disturbance

Human activity (industrial activity at wastewater plant):
nest failure

Unknown predator: nest failure

Raccoons: potential source^a

^aPossible disturbance suggested by published accounts
(see references in Methods).

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial	X	X	X	X
Mid-density housing			X	X
Protected natural area	X	X	X	X

Ruus Park

Great Egrets nest in eucalyptus trees in Ruus Park, a city park in Hayward managed by Hayward Area Recreation and Parks District. Heavily populated neighborhoods surround the park. San Francisco Bay is 6.6 km to the west.

Ownership: public

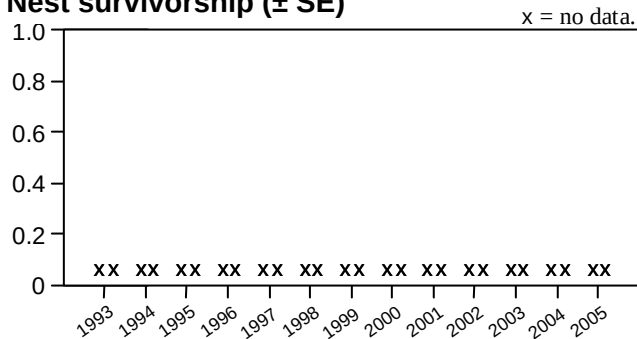
Public observation areas: Ruus Park

Latitude / Longitude: N 37.6244 / W 122.0747



Great Egret Snowy Egret

Nest survivorship ($\pm$ SE)



Colony site description

Topography: suburban

Length x width: 41 m x 16 m

Nest substrate: *Eucalyptus* sp.

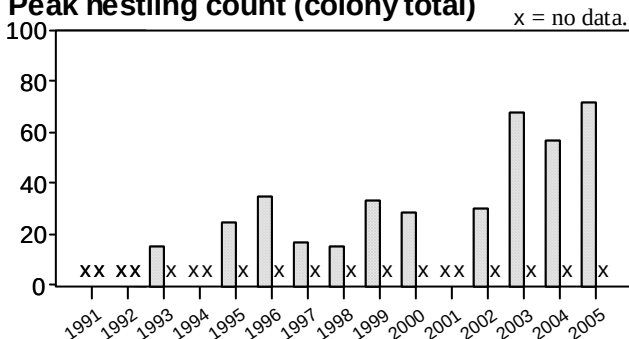
Average nest height: 17 m

Trees (dbh): 5 (50-100 cm), 4 (100-150 cm),
3 (> 150 cm)

Maximum tree canopy height: 28 m

Vegetation cover: tree 82%, shrub 0%, ground 86%

Peak nestling count (colony total)



Evidence of disturbance

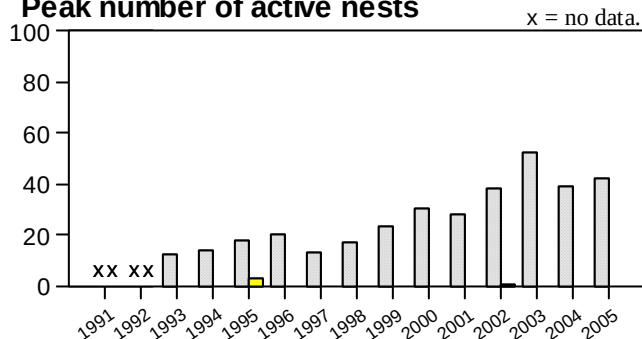
Human activity (fireworks): potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
High density housing	X	X	X	X
Protected natural area	X	X		
Sports field	X	X		

Peak number of active nests



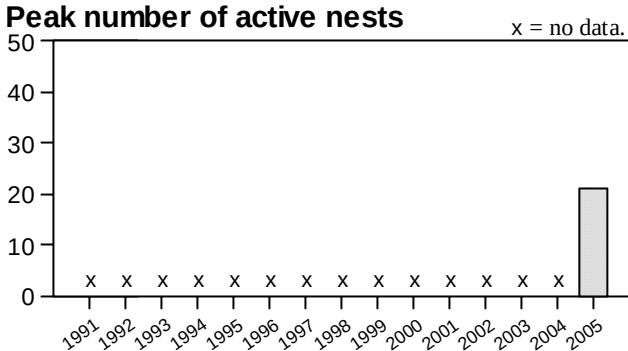
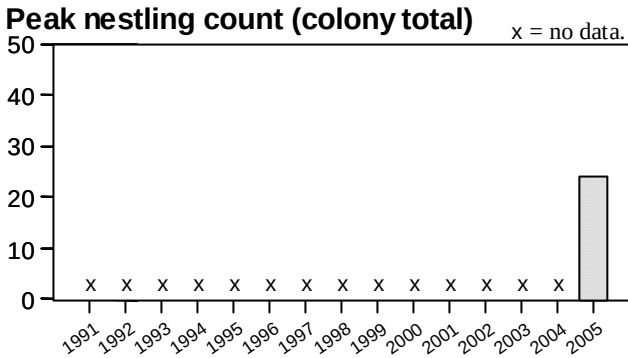
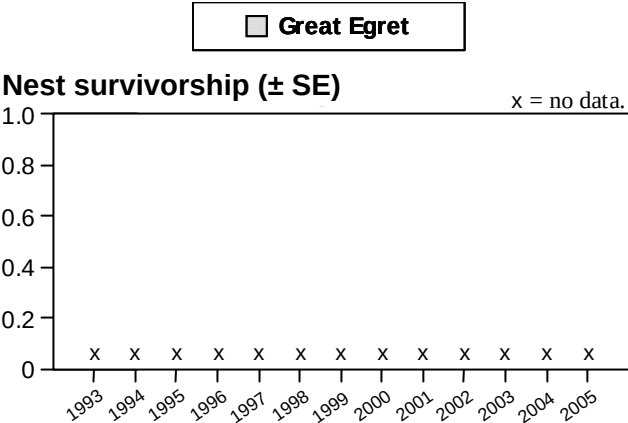
Shorebird Way

Great Egrets nest in sycamore trees on a city street within an industrial/business park in Mountain View. San Francisco Bay is 3 km south of the colony site.

Ownership: public

Public observation areas: city street

Latitude / Longitude: N 37.4180 / W 122.0708



Colony site description

Topography: flood plain
Length x width: not measured
Nest substrate: sycamore (*Platanus racemosa*)
Average nest height: not measured
Trees (dbh): not measured
Maximum tree canopy height: not measured
Vegetation cover: not measured

Evidence of disturbance

Human activity (vehicle and pedestrian traffic):
potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial	X	X	X	X
High density housing		X	X	X

Steinberger Slough

This heronry consists of three sets of power towers near the Redwood City Sewage Plant in Steinberger Slough. The slough is in the Don Edwards San Francisco Bay National Wildlife Refuge at Outer Bair Island. Double-crested Cormorants also nest at this site.

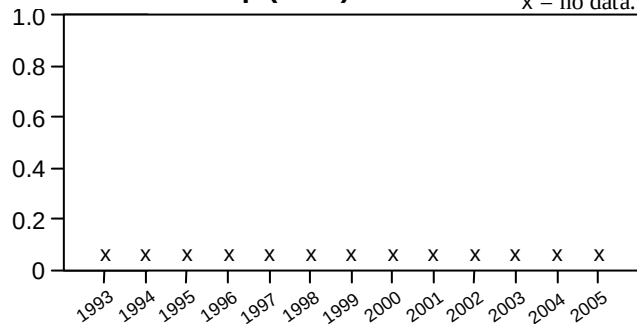
Ownership: public

Public observation areas: levee along the northwest side of the slough

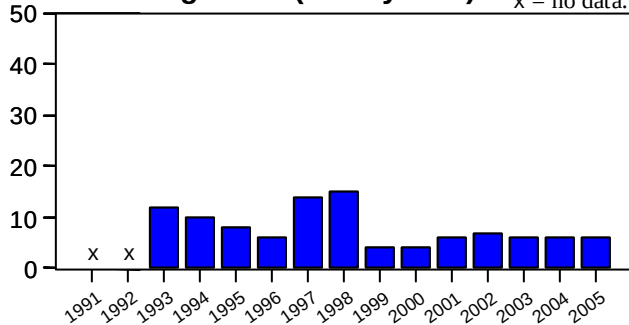
Latitude / Longitude: N 37.5380 / W 122.2282

■ Great Blue Heron

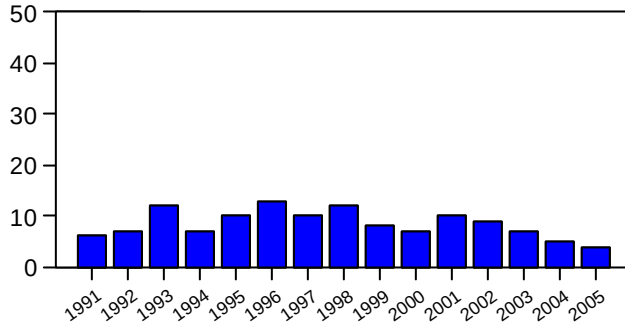
Nest survivorship ($\pm$ SE)



Peak nestling count (colony total)



Peak number of active nests



Colony site description

Topography: wetland

Length x width: 500 m x 39 m

Nest substrate: power towers

Average nest height: 7 m

Trees (dbh): none

Maximum tree canopy height: no canopy

Vegetation cover: none

Evidence of disturbance

None recorded.

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial			X	X
Mid-density housing			X	X
Protected natural area	X	X	X	X

Colony Sites with Limited Activity

Baumberg 8A

Great Blue Herons nested on wooden structures such as old duck blinds in an area previously used for salt production by Cargill, Inc. The area is now owned by the California Department of Fish and Game and has been renamed the Eden Landing Ecological Reserve.

Ownership: public

Public observation areas: none

Latitude / Longitude: N 37.5961 / W 122.1370

Species	Years known to be active (number of active nests)
Great Blue Heron	1996 (1)

Burlingame

The heronry was in eucalyptus trees along the west side of Airport Boulevard just north of the entrance to Bayside Park. The water pollution treatment plant in Burlingame is adjacent to the site.

Ownership: public

Public observation areas: trail

Latitude / Longitude: N 37.5880 / W 122.3513

Species	Years known to be active (number of active nests)
Black-crowned Night-Heron	1995 (5), 1997 (1), 1998 (8), 2000 (1)
Snowy Egret	1995 (16)

Charleston Slough

Located between Adobe Creek and salt evaporator ponds, Charleston Slough is a restored marsh open to tidal action.

Ownership: public

Public observation areas: Shoreline Park

Latitude / Longitude: N 37.4372 / W 122.0999

Species	Years known to be active (number of active nests)
Black-crowned Night-Heron	1993 (6)

Colony Sites with Limited Activity (continued)

Greco Island

Great Blue Herons nested on the towers on the northeast end of Greco Island over Redwood Creek. This area is part of Don Edwards San Francisco Bay National Wildlife Refuge. Double-crested Cormorants have taken over this site.

Ownership: public

Public observation areas: Redwood Creek

Latitude / Longitude: N 37.5230 / W 122.2012

Species	Years known to be active (number of active nests)
Great Blue Heron	1995 (1), 1996 (3), 1998 (6)

Guadalupe Slough

This tidal channel is located between salt ponds and Sunnyvale water pollution control plant ponds. Vegetation in the channel is predominantly bullrush.

Ownership: public

Public observation areas: none

Latitude / Longitude: N 37.4279 / W 122.0098

Species	Years known to be active (number of active nests)
Black-crowned Night-Heron	2002 (12), 2003 (2)
Great Egret	2001 (8)
Snowy Egret	2001 (7), 2003 (3)

Moffett A2E & A2W

Great Blue Herons nested on power towers and old duck hunting blinds in a salt pond managed by Cargill, Inc. In 2004, the area became part of the Don Edwards San Francisco Bay National Wildlife Refuge.

Ownership: public

Public observation areas: none

Latitude / Longitude:

N 37.4382 / W 122.0618 (A2E)

N 37.4445 / W 122.0659 (A2W)

Species	Years known to be active (number of active nests)
Great Blue Heron (A2E)	1994 (1), 1995 (1)
Great Blue Heron (A2W)	1999 (3)

Colony Sites with Limited Activity (continued)

Moffett A3N/B2

Great Blue Herons nested on old duck hunting blinds and on power towers over old salt evaporator ponds. The ponds were owned by Cargill, Inc., and were used to produce salt until 2004 when the area became part of the Don Edwards San Francisco Bay National Wildlife Refuge. Ravens, raptors and Double-crested Cormorants are also known to nest on the towers.

Ownership: public

Public observation areas: none

Latitude / Longitude: N 37.4432 / W 122.0441

Species	Years known to be active (number of active nests)
Great Blue Heron	1991 (1), 1993 (1), 1995 (1), 1996 (1)

Ovation Court

Great Blue Herons nest in eucalyptus trees in the riparian corridor of Coyote Creek, adjacent to housing and business parks.

Ownership: public

Public observation areas: trail along Coyote Creek

Latitude / Longitude: N 37.4025 / W 121.9179

Species	Years known to be active (number of active nests)
Great Blue Heron	2004 (3), 2005 (unknown)

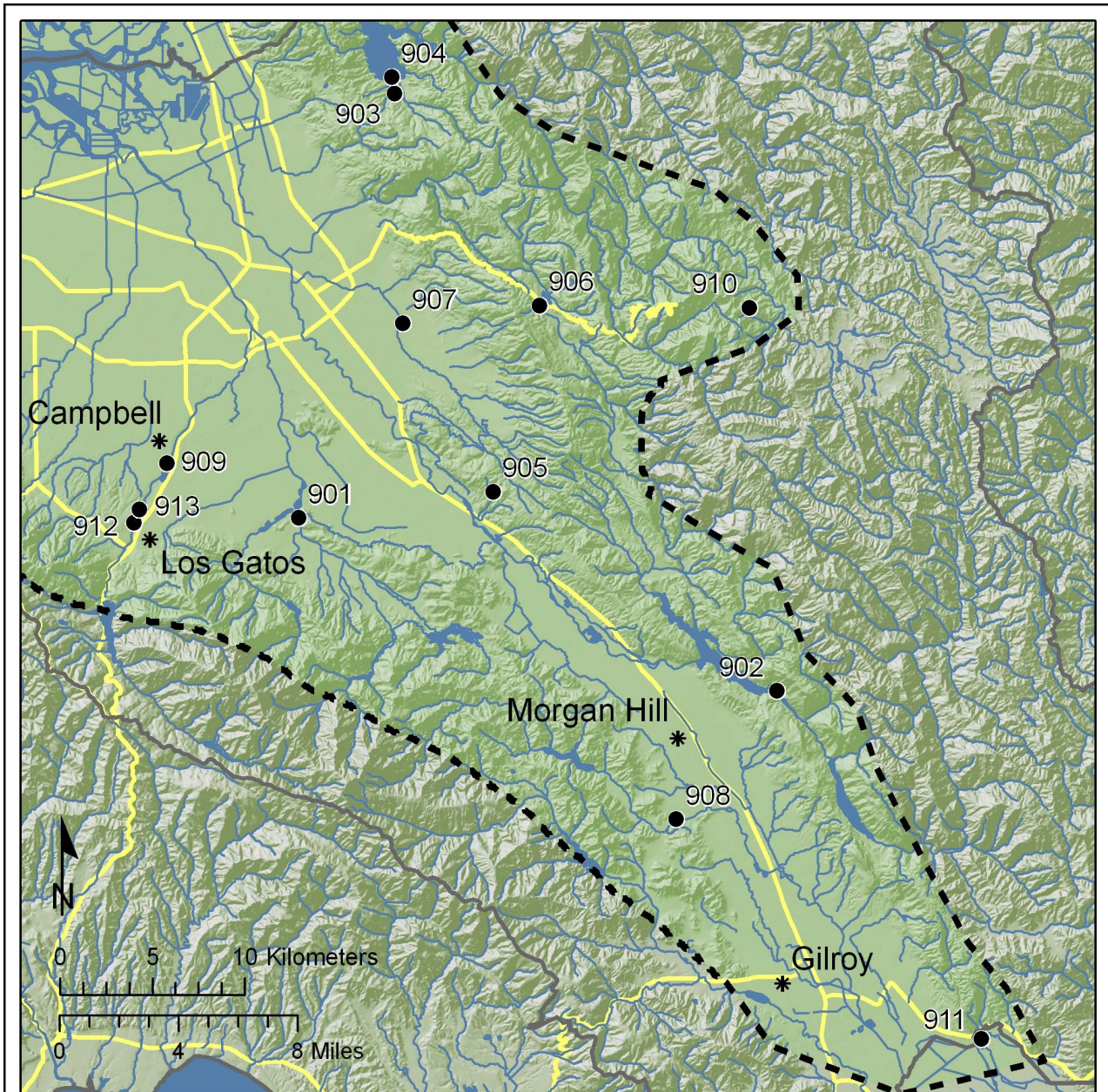
SANTA CLARA VALLEY



SANTA CLARA VALLEY

This subregion includes the lower drainages of the Santa Clara Valley. Herons and egrets nesting in this area are far enough from San Francisco Bay that they probably forage for food within the Santa Clara Valley. The upper areas of the watershed and the surrounding hills were not surveyed for heronries.

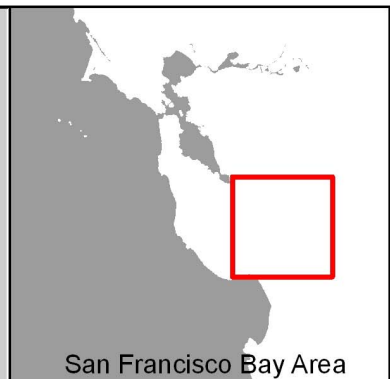
Site #	Colony Site	Great Blue Heron	Great Egret	Snowy Egret	Black-crowned Night-Heron	Cattle Egret	County	Active or year last active	Page
901	Almaden Lake	■	□	■	■		Santa Clara	Active	224
902	Anderson Reservoir	■					Santa Clara	1997	235
903	Calaveras Reservoir	■					Santa Clara	1994	235
904	Calaveras Reservoir South	■					Santa Clara	1996	235
905	Coyote Parkway Lakes	■					Santa Clara	Active	226
906	Grant Lake	■					Santa Clara	Active	227
907	Lake Cunningham		□	■	■		Santa Clara	Active	228
908	Llagas Creek, Morgan Hill	■	□				Santa Clara	Active	230
909	Los Gatos Creek Park	■		■			Santa Clara	1998	236
910	San Felipe Lake	■					Santa Clara	2001	231
911	Vasona County Park	■					Santa Clara	Active	232
912	Vasona Reservoir	■		■	■		Santa Clara	Active	233



Heron and Egret Nesting Colonies in Santa Clara Valley* 1991-2005

- Colony site
- * Town
- ~ Stream
- - - Study area boundary
- Major highway
- ⬮ County boundary

*Colony sites outside of this sub-region are not shown.



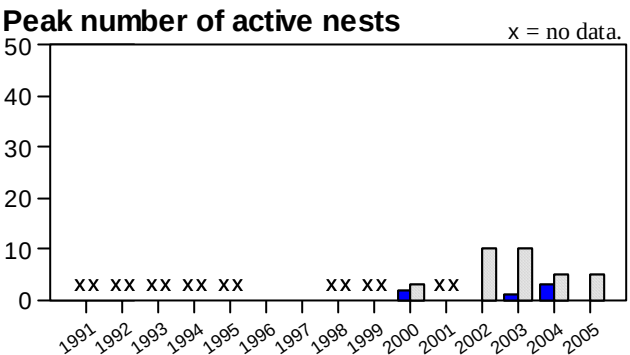
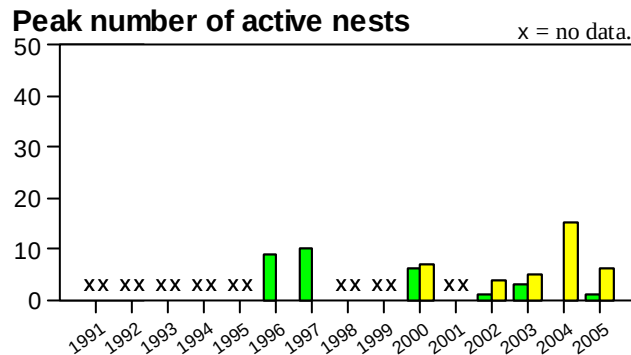
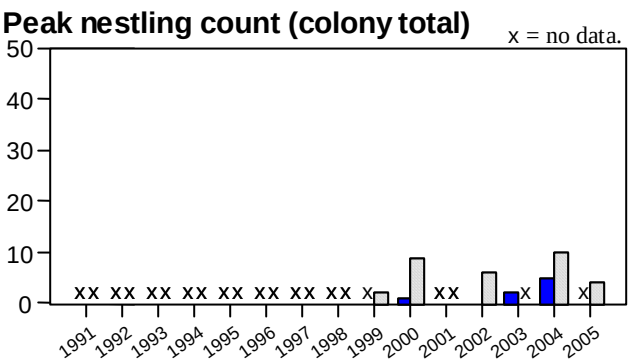
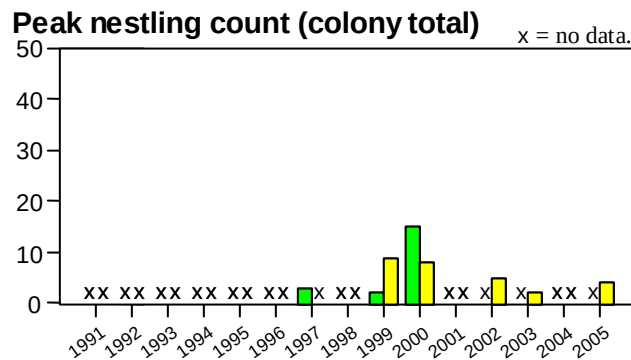
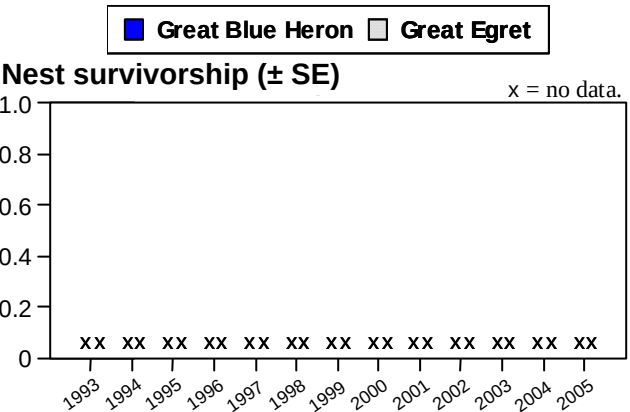
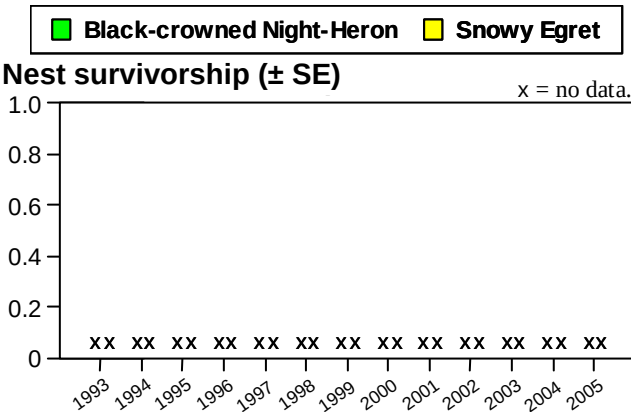
Almaden Lake

This site is on an island in Almaden Lake Park, in south San Jose. The park is surrounded by residential and commercial development and a golf course. Herons and egrets nest in giant reed that the City of San Jose plans to replace with native species. The city also plans to move the marina closer to the island.

Ownership: public

Public observation areas: from boat or shore

Latitude / Longitude: N 37.2397 / W 121.8699



(continued)

Almaden Lake (continued)

Colony site description

Topography: island

Length x width: 50 m x 10 m

Nest substrate: giant reed (*Arundo donax*)

Average nest height: 2.5 m

Trees (dbh): none

Maximum tree canopy height: no canopy

Vegetation cover: not measured

Evidence of disturbance

Human activity (swimmers): potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Industrial				X
High density housing			X	X
Protected natural area	X	X	X	X
Sports field			X	X

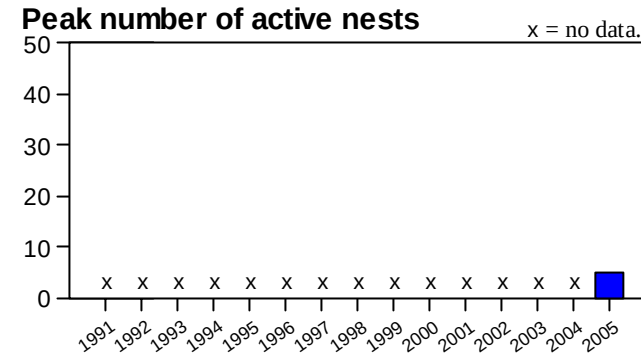
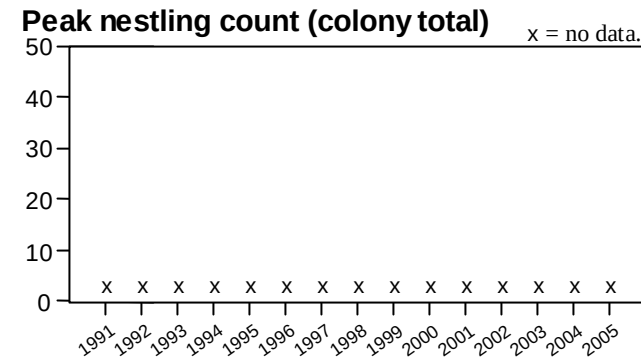
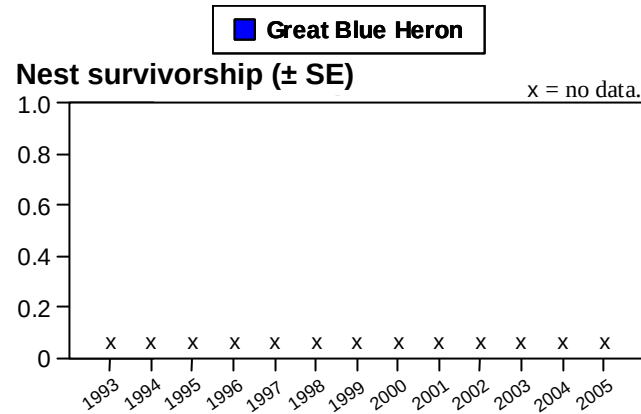
Coyote Parkway Lakes

Coyote Creek Parkway and the adjacent Hellyer and Metcalf County Parks together form a 205-acre urban Santa Clara County park, 1 km south of the City of San Jose. Great Blue Herons nest in cottonwood and sycamore trees about 30 m from Highway 101 on Coyote Creek, downstream of the dam at Parkway Lakes and about 20 km south of San Francisco Bay.

Ownership: public

Public observation areas: trail along Coyote Creek

Latitude / Longitude: N 37.2351 / W 121.7599



Colony site description

Topography: flood plain

Length x width: not measured

Nest substrate: Fremont cottonwood (*Populus fremontii*), California sycamore (*Platanus racemosa*)

Average nest height: not measured

Trees (dbh): not measured

Maximum tree canopy height: not measured

Vegetation cover: not measured

Evidence of disturbance

None recorded.

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
High density housing		X	X	X
Protected natural area	X			

Grant Lake

This Great Blue Heron colony site is about 8 km east of the City of San Jose in Joseph D. Grant County Park, along Mount Hamilton Road, 200 m north of the main entrance to the park. The nesting trees are 270 m west of Grant Lake, the closest wetland.

Ownership: public

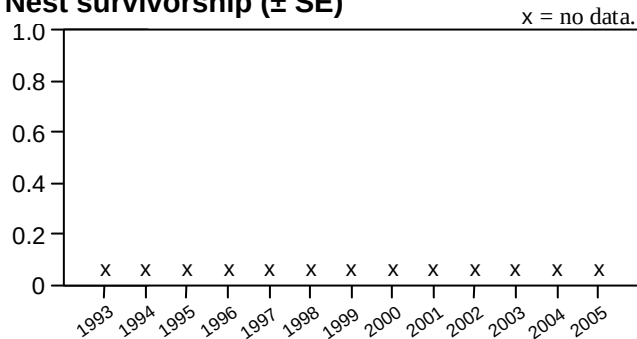
Public observation areas: trail

Latitude / Longitude: N 37.3425 / W 121.7226



■ Great Blue Heron

Nest survivorship ($\pm$ SE)



Colony site description

Topography: hillside

Length x width: 33 m x 12 m

Nest substrate: *Eucalyptus* sp.

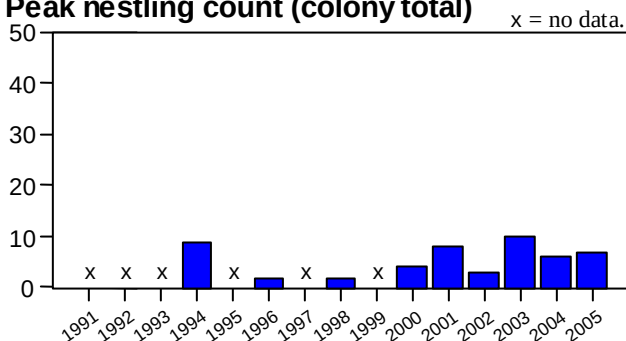
Average nest height: 33 m

Trees (dbh): 56 (3-10 cm), 23 (10-50 cm),
24 (50-100cm)

Maximum tree canopy height: 46 m

Vegetation cover: tree 70%, shrub 50%,
ground 20%

Peak nestling count (colony total)



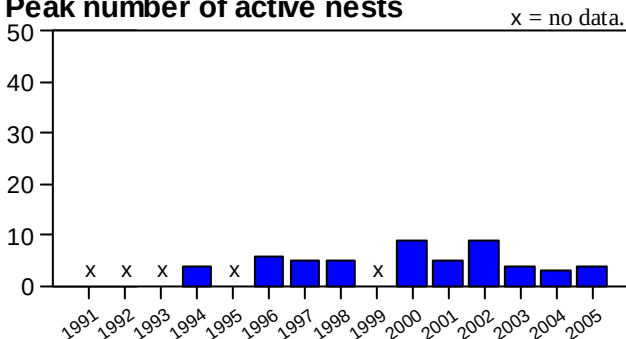
Evidence of disturbance

None recorded.

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Orchard		X	X	
Grazing		X	X	X
Protected natural area	X	X	X	X

Peak number of active nests



Lake Cunningham

The nesting colony is on an island in the 50-acre lake at the 202-acre city park. The area, once a dairy farm, was converted into a water-oriented recreation facility in the 1980s. The park, which includes a water slide theme park, is within the City of San Jose, 18 km southeast of San Francisco Bay.

Ownership: public

Public observation areas: trail in park

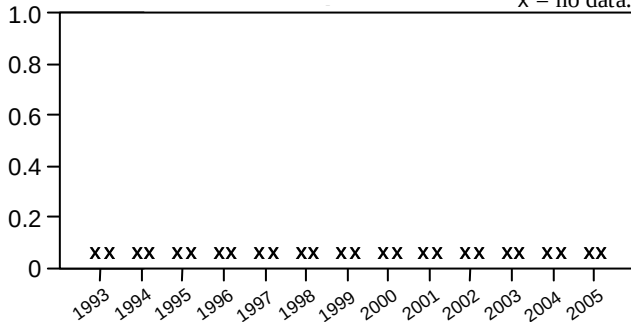
Latitude / Longitude: N 37.3346 / W 121.8062



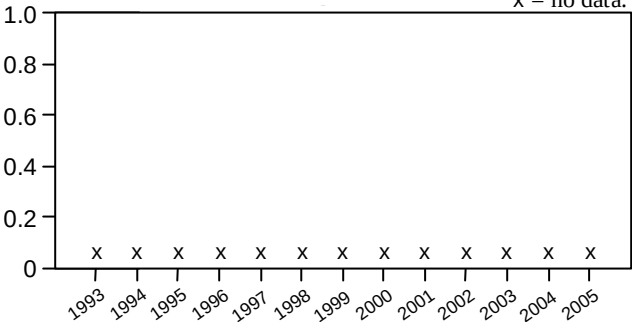
■ Black-crowned Night-Heron ■ Snowy Egret

■ Great Egret

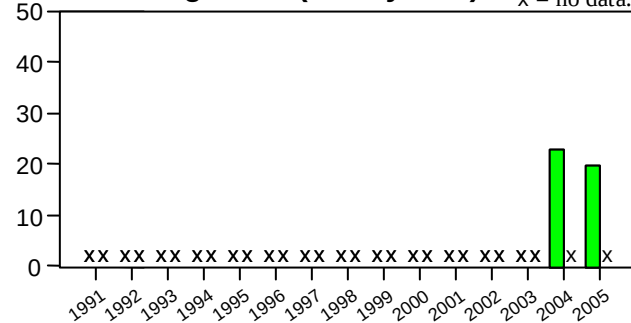
Nest survivorship ($\pm$ SE)



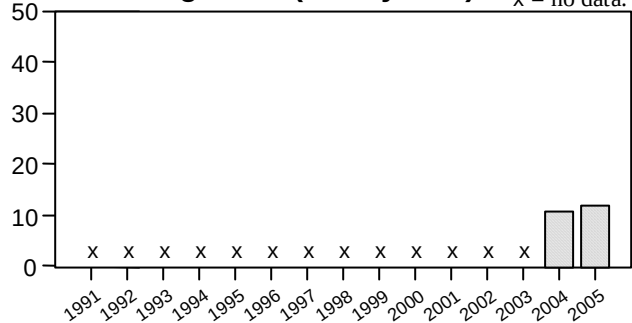
Nest survivorship ($\pm$ SE)



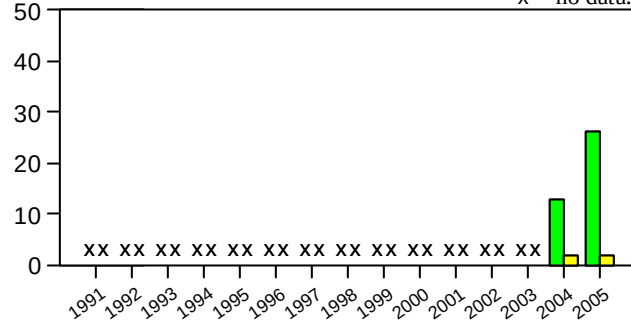
Peak nestling count (colony total)



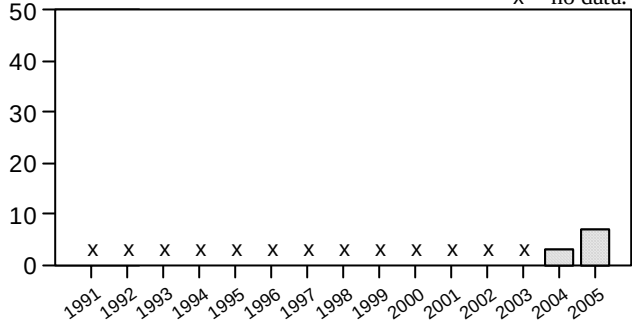
Peak nestling count (colony total)



Peak number of active nests



Peak number of active nests



(continued)

Lake Cunningham (continued)

Colony site description

Topography: island

Length x width: not measured

Nest substrate: not measured

Average nest height: not measured

Trees (dbh): not measured

Maximum tree canopy height: not measured

Vegetation cover: not measured

Evidence of disturbance

Human activity (boaters in the lake): potential source^a

^aPossible disturbance suggested by published accounts
(see references in Methods).

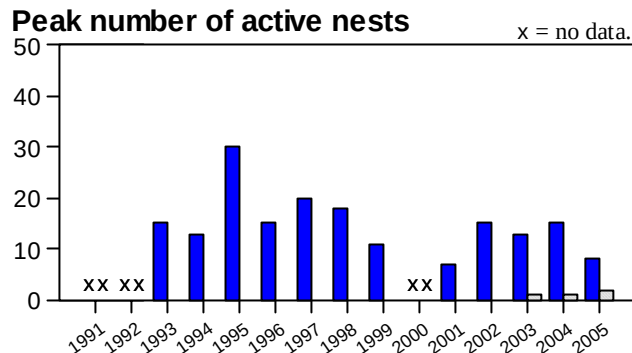
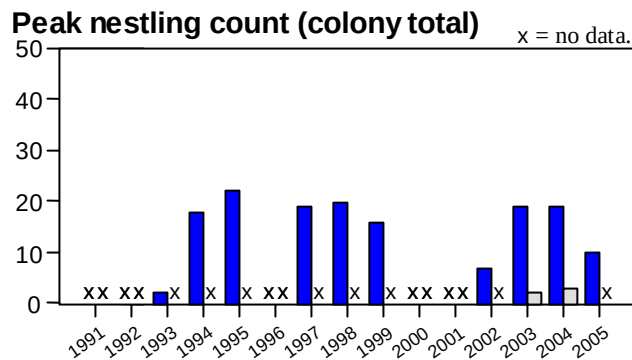
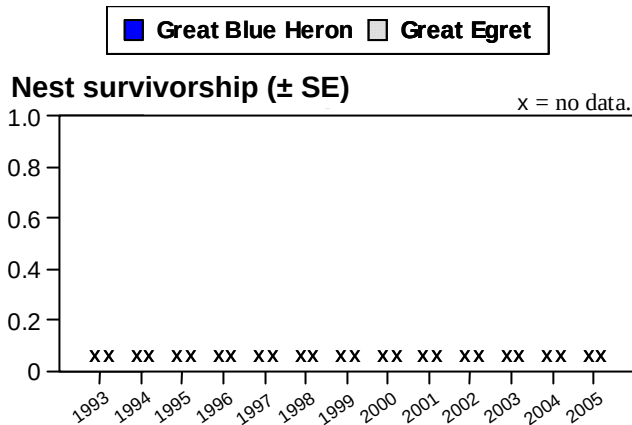
Land use

Land Use	Distance from colony site (m)			
	0- 100	100- 200	200- 500	500- 1000
Industrial				X
High density housing			X	X
Protected natural area	X	X	X	

Llagas Creek, Morgan Hill

This colony site is in the city of Morgan Hill, about 3 km northwest of San Martin. The nesting tree is a large eucalyptus near the intersection of Watsonville Road and Santa Theresa Avenue, adjacent to a residential development. The only water in the immediate vicinity is the small Llagas Creek, but the heronry is within 6-10 km of four reservoirs.

Ownership: private
Public observation areas: none
Latitude / Longitude: N 37.0911 / W 121.6439



Colony site description

Topography: flood plain
Length x width: 26 m x 25 m
Nest substrate: *Eucalyptus* sp.
Average nest height: 45 m
Trees (dbh): 1 (> 150 cm)
Maximum tree canopy height: > 50 m
Vegetation cover: tree 80%, shrub 0%, ground 0%

Evidence of disturbance

Human activity (construction): potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Mid-density housing	X	X	X	X
High density housing		X	X	X
Farming				X
Orchard			X	X
Vineyard				X

San Felipe Lake

This natural lake, 5 km southeast of Gilroy and 70 km southeast of San Francisco Bay, is also known as Soap Lake or Bolsa de San Felipe. The lake is surrounded by privately owned pasture and agricultural fields, and access is limited to public roads. The area has been designated as one of three Important Bird Areas in Santa Clara County.

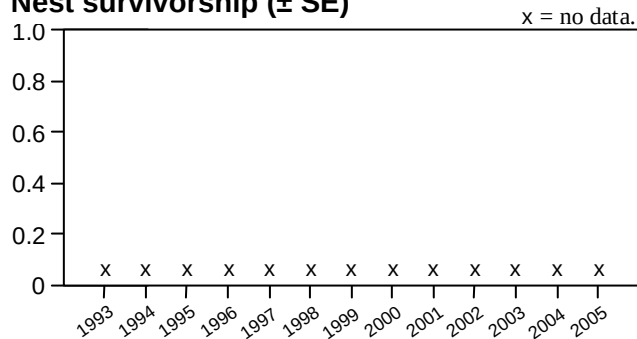
Ownership: private

Public observation areas: none

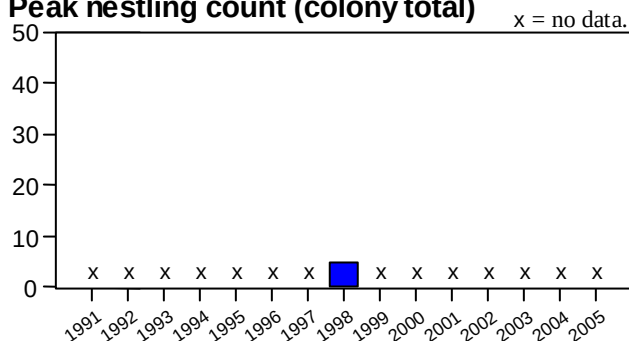
Latitude / Longitude: N 36.9816 / W 121.4602

Great Blue Heron

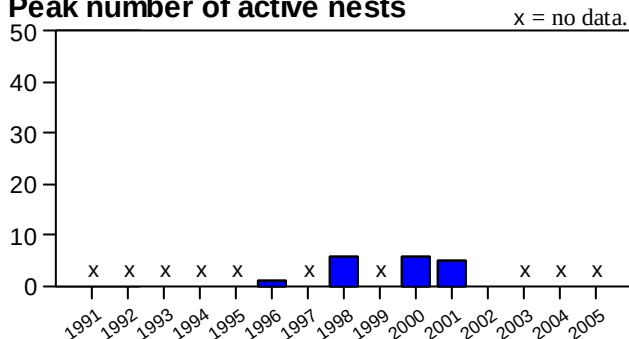
Nest survivorship ($\pm$ SE)



Peak nestling count (colony total)



Peak number of active nests



Colony site description

Topography: wetland

Length x width: not measured

Nest substrate: willow (*Salix* sp.)

Average nest height: not measured

Trees (dbh): not measured

Maximum tree canopy height: not measured

Vegetation cover: not measured

Evidence of disturbance

Rising water levels: colony site abandonment

Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
Farming	X	X	X	X

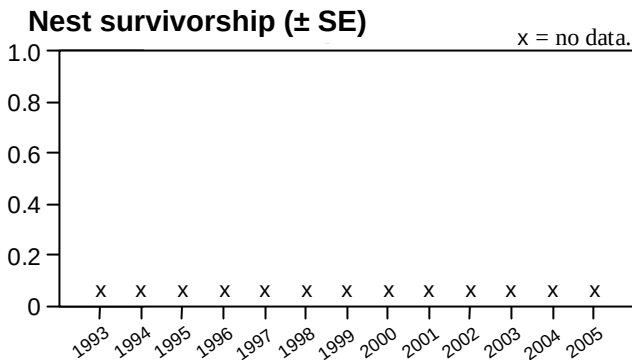
Vasona County Park

This heronry is in a grove of eucalyptus in Vasona Park, a Santa Clara County park in Los Gatos, near Los Gatos Creek. Great Blue Herons nest directly above a heavily used parking lot and trail, adjacent to a children's playground.

Ownership: public

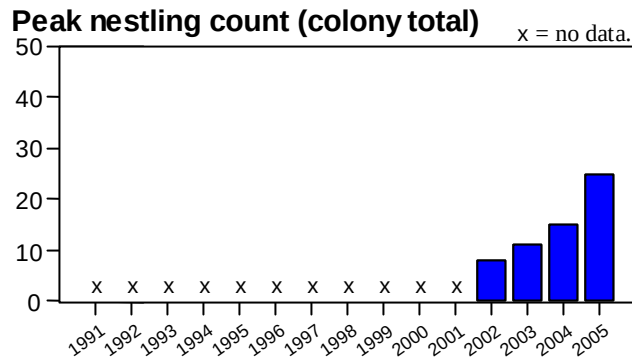
Public observation areas: Vasona Park

Latitude / Longitude: N 37.2390 / W 121.9716



Colony site description

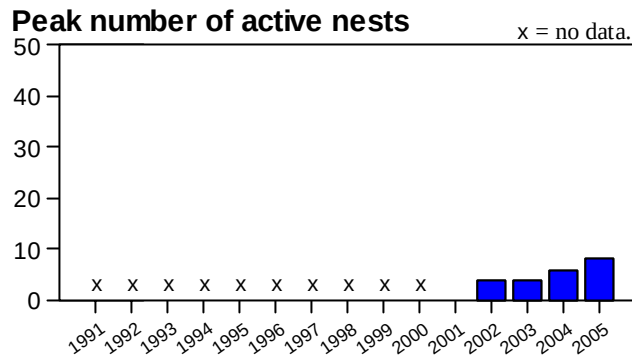
Topography: flood plain
 Length x width: 45 m x 30 m
 Nest substrate: *Eucalyptus* sp.
 Average nest height: 30 m
 Trees (dbh): 2 (3-50 cm), 3 (50-100 cm), 7 (50-100 cm), 1 (>150cm)
 Maximum tree canopy height: 48 m
 Vegetation cover: tree 69%, shrub 0%, ground 0%



Evidence of disturbance

Human activity (automobile and pedestrian traffic): potential source^a

^aPossible disturbance suggested by published accounts (see references in Methods).



Land use

Land Use	Distance from colony site (m)			
	0-100	100-200	200-500	500-1000
High density housing		X	X	X
Protected natural area	X	X	X	X
Sports field			X	

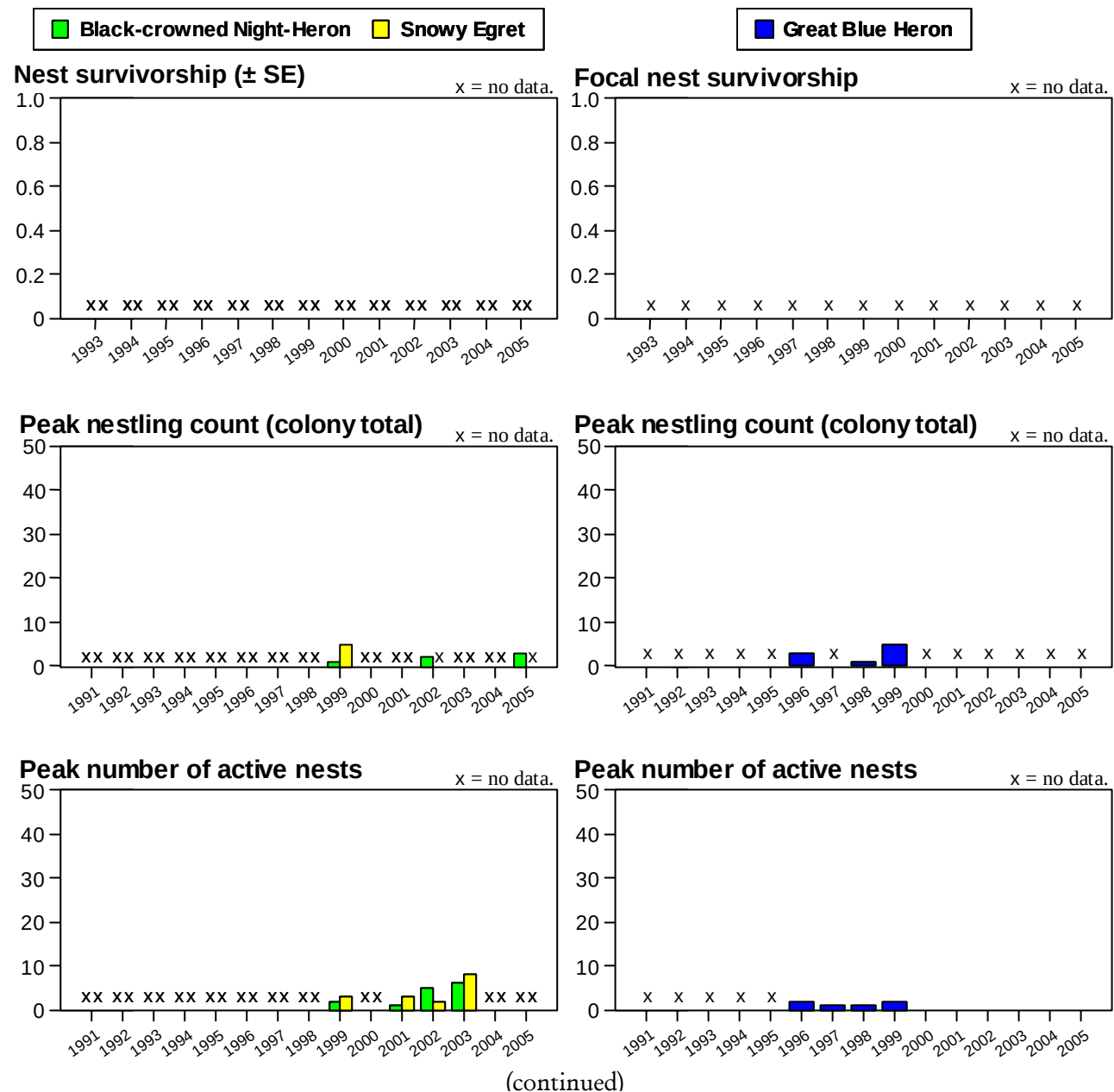
Vasona Reservoir

This colony site consists of a patch of giant reed and low dense trees on an island in Vasona Park in Los Gatos. Great Blue Herons, Black-crowned Night-Herons and Snowy Egrets nest on the island. Great Egrets have been seen in the vicinity, but nesting by this species has not been confirmed.

Ownership: public

Public observation areas: Vasona Park

Latitude / Longitude: N 37.2452 / W 121.9683



Vasona Reservoir (continued)

Colony site description

Topography: island

Length x width: not measured

Nest substrate: giant reed (*Arundo donax*)

Average nest height: not measured

Trees (dbh): not measured

Maximum tree canopy height: 20 m

Vegetation cover: not measured

Evidence of disturbance

Decreased water levels in lake: colony site abandonment

American Crow: potential source^a

^aPossible disturbance suggested by published accounts
(see references in Methods).

Land use

Land Use	Distance from colony site (m)			
	0- 100	100- 200	200- 500	500- 1000
High density housing			X	X
Protected natural area	X	X	X	X
Sports field				X

Colony Sites with Limited Activity

Anderson Reservoir

Located in the foothills northeast of Morgan Hill, the Anderson Reservoir was built in 1950 and is the largest human-made lake in Santa Clara County.

Ownership: public

Public observation areas: Anderson Reservoir Park

Latitude / Longitude: N 37.1530 / W 121.5812

Species	Years known to be active (number of active nests)
Great Blue Heron	1997 (1)

Calaveras Reservoir

Great Blue Herons nested in a eucalyptus tree near the Calaveras Reservoir, in the Sunol/Ohlone Regional Wilderness. The San Francisco Water Department owns the surrounding lands and leases the area for cattle ranching. The reservoir is closed to the public.

Ownership: public

Public observation areas: none

Latitude / Longitude: N 37.4467 / W 121.8095

Species	Years known to be active (number of active nests)
Great Blue Heron	1994 (2)

Calaveras Reservoir South

See above for description.

Ownership: public

Public observation areas: none

Latitude / Longitude: N 37.4548 / W 121.8111

Species	Years known to be active (number of active nests)
Great Blue Heron	1996 (3)

Colony Sites with Limited Activity (continued)

Los Gatos Creek Park

Los Gatos Creek is a relatively intact riparian area with willow and sycamore trees dominating the plant community. Great Blue Herons and Snowy Egrets nested on an island in the northernmost percolation pond adjacent to the creek. In 1999, the non-native vegetation was removed from the island and the herons and egrets no longer nest there.

Ownership: public
Public observation areas: Los Gatos Creek County Park
Latitude / Longitude: N 37.2679 / W 121.9511

Species	Years known to be active (number of active nests)
Great Blue Heron	1997 (1)
Snowy Egret	1997 (1), 1998 (4)