SAN FRANCISCO BAY
BIRD OBSERVATORY

Western Snowy Plover Monitoring in the San Francisco Bay
Annual Report 2013

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SUMMARY

The San Francisco Bay Bird Observatory (SFBBO), Don Edwards San Francisco Bay National Wildlife Refuge (Refuge), California Department of Fish and Wildlife (CDFW), Hayward Area Recreation and Park District (HARD), and East Bay Regional Park District (EBRPD) form the Western Snowy Plover (*Charadrius nivosus nivosus*) Recovery Unit 3. The goal of this collaboration is to survey managed ponds and other habitats for Western Snowy Plovers, track breeding success, and contribute to the management and recovery of this species in the San Francisco Bay. During the 2013 breeding season, we monitored Snowy Plover numbers, nesting and fledging success, use of experimental habitat enhancement sites, and potential predators.

As part of the Pacific Coast breeding season window survey (May 20-29), we counted 202 adult Snowy Plovers in the San Francisco Bay. Over the course of the breeding season (March-September), we documented 179 plover nests in all of Recovery Unit 3. In the South Bay, we determined the fate of 174 and found that apparent nest success (defined as the percentage of nests that successfully hatched at least one egg out of the total nests monitored) was 64%. Remaining nests failed due to predation (32%), abandonment (3%), and flooding (<1%). We summarize 2013 nesting activity by pond complex or management unit below:

On Refuge property, we determined the fate of 10 nests in the Alviso Complex (ponds A9, A16, New Chicago Marsh and the Alviso Impoundment) and 31 nests in the Ravenswood Complex (ponds SF2, R1-5). Apparent nest success was 40% and 80% in the Alviso and Ravenswood complexes, respectively. In 2013, we located seven nests in the Warm Springs complex, all of which were depredated.

We found 72% of Snowy Plover nests in Recovery Unit 3 at CDFW's Eden Landing Ecological Reserve (Eden Landing). We determined the fate of 126 nests and found that apparent nest success was 65%. Thirty percent of nests were lost to predation.

EBRPD reported that there was one Snowy Plover nest on the California Least Tern (*Sterna antillarum browni*) island at Hayward Shoreline and the nest was depredated (D. Riensche, pers. comm.).

CDFW biologists found and monitored two Snowy Plover nests at the Napa-Sonoma Marshes Wildlife Area in the North Bay, both of which had hatched (K. Taylor, pers. comm.). Biologists from Point Blue Conservation Science monitored two Snowy Plover nests at the Hamilton Wetlands Restoration site in Novato (M. Elrod, pers. comm.).

Throughout the South Bay, we banded fourteen chicks. From band re-sighting, we determined that at least five of these chicks survived to fledging (31 days post-hatching) as of September 30, 2013. Given the small sample size, we cannot determine fledging success.

During avian predator surveys, we counted California Gulls (*Larus californicus*) and unidentified gulls (*Larus* spp.; likely California gulls due to the time of year and locations) as the most numerous potential avian predators in plover nesting areas. Northern Harriers (*Circus cyaneus*), Red-tailed Hawks (*Buteo jamaicensis*), Peregrine Falcons (*Falco peregrines*), and corvids (*Corvus* spp., Common Ravens (*Corvus corax*) and American Crows (*Corvus brachyrhynchos*)) were among other commonly sighted predatory species.

SFBBO and the Refuge began a pilot Snowy Plover habitat enhancement study in the winter of 2008 at Eden Landing. Enhancements consisted of oyster shells spread by hand at densities of 5-8 shells/m^2 over fifteen 1-ha plots. In 2013, we documented more plover nests in shell plots than in control plots (shell plots: 10 nests, control plots: 0 nests), which is consistent with findings of previous years. Preliminary examination of nest survival data from 2009-2013 suggests that shells provide some benefit to plover hatching success, perhaps because of the improved camouflage they offer. However, many uncertainties remain about the effects of shell plots on plover breeding success, and further study is needed.

We recommend that the South Bay Salt Pond Restoration Project (the Project) carefully plan construction activities to avoid negatively impacting breeding Snowy Plovers. We propose that alternative breeding habitat be provided when construction activities impact Snowy Plover nesting ponds. We also recommend beginning construction activities before plover breeding season begins, and, if possible, discouraging plovers from using ponds where construction activities are taking place, as long as sufficient alternate habitat is available. During the 2013 breeding season, 82% of the Snowy Plover nests at Eden Landing were within the construction area. This presented challenges for the construction crew and our biologists monitoring the Snowy Plovers. These ponds will be flooded for part of the 2014 breeding season with hopes of avoiding a similar situation (J. Krause, pers. comm.).

As more areas are opened to tidal action or converted to ponds with islands, the Project and local land managers will need to take great care in maintaining enough Snowy Plover nesting habitat to preserve and increase the number of nesting plovers in the South Bay. This will likely include more active management and/or enhancement of Snowy Plover nesting sites. In addition, as trails are opened to the public, managers will need to take steps to reduce human disturbance to nesting waterbirds. The Project and other restoration projects will affect Snowy Plovers in multiple ways, and managers and researchers should continue to study and monitor the plovers in the South Bay to reduce impacts in the future.

INTRODUCTION AND BACKGROUND

The Pacific Coast population of the Western Snowy Plover (*Charadrius nivosus nivosus*, Snowy Plover) breeds along or near tidal waters and is behaviorally distinct from the interior population (Funk 2007). Coastal-breeding Snowy Plovers have declined as a result of poor reproductive success, likely due to habitat loss, habitat alteration, human disturbance, and increasing predation pressure (Page et al. 1991, USFWS 2007). In response to this decline, the

U.S. Fish and Wildlife Service listed the Pacific Coast Western Snowy Plover population as federally threatened in 1993 (USFWS 1993).

Western Snowy Plover Recovery Unit 3 consists of the San Francisco Bay and includes Napa, Alameda, and Santa Clara counties, and the eastern portion of San Mateo County (USFWS 2007). Plovers in this Recovery Unit nest almost exclusively in dry salt panne habitat provided by former salt evaporation ponds. In 1992, the Don Edwards San Francisco Bay National Wildlife Refuge (Refuge) began surveying for Snowy Plovers on Refuge lands. The Refuge developed five goals for its Snowy Plover Recovery Program: 1) identify areas used by Snowy Plovers for foraging, roosting, and nesting, 2) estimate Snowy Plover numbers, including the number of breeding pairs, 3) determine nest success, 4) assess predation pressures on Snowy Plovers, and 5) protect Snowy Plover breeding areas from predators and other disturbances. The Refuge joined with the California Department of Fish and Wildlife (CDFW) in 2000 to survey for Snowy Plovers at Eden Landing Ecological Reserve (Eden Landing). The San Francisco Bay Bird Observatory (SFBBO) and the Refuge have been jointly monitoring plovers and determining nest fates since 2003.

From 2003-2013, SFBBO conducted annual Western Snowy Plover monitoring and research in support of the goals set forth by the Refuge. Specifically, we: 1) identified areas used by Snowy Plovers through regular surveys of all potential nesting habitat from March through September, 2) participated in U.S. Fish and Wildlife Service-coordinated breeding and winter window counts to estimate Recovery Unit 3 numbers, 3) recorded nest fates, nest densities, and chick fledging rates through nest-monitoring and chick-banding, 4) identified potential predators of Snowy Plover nests and chicks through avian predator surveys and 5) identified areas of potential disturbances from predators, humans, and construction activities. We also investigated the effects of experimental oyster shell habitat enhancements on plover breeding success.

The South Bay Salt Pond Restoration Project (the Project) plans to restore 15,100 acres of former salt evaporation ponds to tidal marsh and managed ponds. Despite the loss of potential Snowy Plover breeding habitat (dry salt ponds) expected overall through the Project's actions, the Project has set a management target of maintaining 125 breeding pairs of Snowy Plovers within its footprint (USFWS and CDFW 2007). To aid in achieving this goal, SFBBO and the Refuge initiated a habitat enhancement pilot study on ponds currently managed for Snowy Plovers at Eden Landing. Enhancements were made during the winters of 2008-2010 and included removing potential raptor perches from the ponds and surrounding levees and adding oyster shells to pond substrate within experimental plots, which may provide better camouflage for nesting plovers and plover chicks.

In this report, we summarize results from the 2013 breeding season, including Snowy Plover surveys and habitat use, nest (hatching) success, fledging success, habitat enhancement studies, and avian predator surveys. Although we report Snowy Plover numbers in the North

Bay and at Hayward Regional Shoreline, this report focuses on Snowy Plover activity in the South San Francisco Bay, south of the San Mateo Bridge.

METHODS

Study Area

SFBBO and Refuge staff conducted Snowy Plover and predator surveys in the South San Francisco Bay (South Bay) ponds, which includes the area just north of the San Mateo Bridge (Highway 92) and extends to the extreme southern portion of the Bay (Figure 1). The South Bay contains the majority of the Snowy Plover habitat in the Bay Area. We also conducted Snowy Plover and predator surveys at one site in the North San Francisco Bay (North Bay**;** Figure 2). These surveys provide full coverage of all Snowy Plover breeding habitat in Western Snowy Plover Recovery Unit 3.

The Refuge includes approximately 30,000 acres of former salt ponds, tidal marsh, mudflats, and uplands in the South Bay (Figure 1). For this study, we divided the Refuge into six geographic locations: Warm Springs (Figure 3), Alviso (Figure 4), Ravenswood (Figure 5), Coyote Hills, Dumbarton, and Mowry (Figure 1).

CDFW owns and manages Eden Landing (formerly known as Baumberg), which includes approximately 5,500 acres of former salt ponds, marsh, and tidal habitat (Figure 6). CDFW also owns and manages the Napa-Sonoma Marshes Wildlife Area, including ponds 7 and 7a, the Wingo Unit, and the Green Island Unit/Napa Plant Site (Table 2, Figure 2).

Hayward Area Recreation and Park District (HARD) owns the land directly north of Highway 92, on the east side of the San Francisco Bay, which is co-managed by East Bay Regional Park District (EBRPD; Figure 1). This area includes potential Snowy Plover foraging and nesting habitat in the Oliver Brothers North and Frank's Dump West ponds. EBRPD manages an island constructed for California Least Terns (*Sternula antillarum brownii*) within treatment ponds that is also used by nesting Snowy Plovers.

Hamilton Wetlands Restoration site at the former Hamilton Army Airfield is located in Novato, CA. This area includes Snowy Plover foraging and nesting habitat on a dry area within the restoration site.

Snowy Plover Surveys

Snowy Plovers in the San Francisco Bay nest predominantly on dry former salt evaporation ponds. To document areas used by Snowy Plovers and to estimate the number of Snowy Plovers in the South Bay, we identified ponds with potential nesting habitat and surveyed those ponds weekly. We surveyed other ponds with less suitable (i.e., ponds without dry salt panne) habitat monthly.

From March 1 to August 31, 2013, SFBBO and agency biologists, interns, and volunteers surveyed the ponds by driving slowly on the levees or walking levees without vehicle access. We stopped approximately every 0.3 miles to scan for Snowy Plovers with spotting scopes. During each survey, we recorded the number and behavior of adult Snowy Plovers present, identified the sex of each individual using plumage characteristics (Page et al. 1991), and marked the approximate location of sightings on a geo-referenced map. When appropriate, we also recorded the number and location of nests or chicks found in each pond and the color-band combinations of any banded birds sighted.

In total, SFBBO and Refuge biologists and interns surveyed 15 Refuge ponds and marshes and 16 Eden Landing ponds weekly (Table 1, Table 2). SFBBO volunteers surveyed the Dumbarton, Napa-Sonoma Marshes Wildlife Area, and HARD ponds monthly (Table 3). Beginning in August, SFBBO biologists surveyed Crittenden Marsh weekly after receiving reports of young chicks in the area. SFBBO also surveyed the Coyote Hills, Dumbarton, and Mowry salt pond complexes monthly as part of SFBBO's Cargill salt pond waterbird surveys (see Robinson-Nilsen et al. 2010 for methods); it is important to note that the Cargill survey methods are designed to document waterbird abundance and distribution rather than Snowy Plover nesting activity, so they may not adequately detect plover nests. However, very limited habitat is available in these areas.

From May 21-28, we participated in the Pacific Coast Snowy Plover breeding window survey. This survey was coordinated by the U.S. Fish and Wildlife Service as part of an annual, regional effort to census all coastal-breeding plovers during the same week. In Recovery Unit 3, the survey covered Refuge, Eden Landing, Napa-Sonoma Marshes Wildlife Area, and HARD ponds, and we used the same methods for sighting and counting plovers as described above.

Nest Monitoring

We located Snowy Plover nests by scanning for incubating females during weekly surveys. We then searched for nests on foot and recorded nest locations with a GPS unit (Garmin® GPS 60). Volunteers locating nests visually during monthly surveys marked the location of the nest on a map and described nearby landmarks. Later, SFBBO or Refuge staff searched for the potential nests on foot; volunteers did not depart levees or established trails to search for nests on the ponds.

We monitored nests weekly until we determined the fate of the nest. On each visit, we recorded whether the nest was still active (eggs present and adults incubating), and the number of eggs or chicks in the nest. We floated the eggs (Hays and LeCroy 1971) to estimate egg age. Snowy Plover nests are active for an average of 33 days, from initiation (the date the first egg was laid) to hatching (Warriner et al. 1986), and using the known egg age, we calculated the nest initiation date and predicted hatch date for all nests monitored. When there were no longer eggs in the nest, we assigned each nest a fate based on evidence seen at the nest (Mabee 1997). Nest fates included: hatched, depredated, flooded, abandoned,

unknown, or other. In addition, we recorded whether the nest was located in an oyster shell enhancement or control plot (see *Oyster Shell Habitat Enhancements* methods below).

We defined a nest as successful if it hatched at least one egg. We calculated apparent nest success as the percentage of nests that successfully hatched at least one egg out of the total nests monitored.

Additionally, we calculated apparent nest densities by dividing the number of nests found on a given pond by the total pond area in hectares; **the pond areas used should be viewed with caution since they represent only a rough gauge of potentially available nesting habitat**. The amount of available habitat in the ponds changes throughout the season, depending on water management and evaporation. As a result, the actual nest density is very difficult to calculate.

Chick Color Banding

Beginning in 2008 and continuing through the 2013 breeding season, SFBBO and Refuge biologists banded Snowy Plover chicks to study their movements and to estimate fledging success rates for the South Bay. To band chicks, biologists checked nests daily, starting four days before the estimated hatch date when time allowed. Snowy Plover chicks are precocious. Therefore, we attempted to time our arrival at nests when chicks had just hatched but had not yet left the nest scrape. We banded each chick with a unique four-color combination, placing two bands on each lower leg of a chick. Each combination consisted of three darvic color bands and one silver U.S. Fish and Wildlife Service band wrapped in auto pin-striping tape to act as the fourth color in the combination.

We defined a fledged chick as one that survived to 31 days of age. At that point, chicks are considered to be capable of flight (Warriner et al. 1986). We calculated apparent fledging success as the percentage of fledged, banded chicks out of the total chicks banded. Since re-sighting banded chicks on salt panne habitat is extremely difficult, this method of estimating fledging success has limitations (see *Discussion* for further explanation).

Oyster Shell Habitat Enhancements

To evaluate the effects of oyster shell enhancements on breeding Snowy Plovers, we placed treatments on the ponds at Eden Landing using a randomized block design. Each block consisted of two plots placed on the pond bottom, a 1-ha oyster shell treatment plot (shells spread at 5-8 shells/m^2) and a 1-ha control plot (no shells or other treatment). Drake's Bay Oyster Farm donated the oyster shells, and SFBBO staff, volunteers, and the California Conservation Corps spread the shells by hand.

Apparent Estimates. We compared apparent nest success and apparent nest densities in shell plots, control plots, and all other Eden Landing nesting areas from 2009-2013. However, since

apparent estimates can be difficult to interpret, we also examined factors affecting Snowy Plover nest survival, including oyster shell habitat enhancements, using more advanced modeling techniques in Program R.

Nest Survival Models. To determine if the presence Snowy Plover nests in shell plots influenced the fate of the nests, we used logistic exposure models to estimate daily nest survival (Shaffer 2004) in R (R Development Core Team 2004) of all nests monitored in Eden Landing from 2009 through 2013. We developed a set of 21 exploratory models *a priori*. These models were based on the hypothesized effects of year (2009-2013), shell plot (present or absent), year, and nest initiation date (i.e., Julian date), the quadratic of nest initiation date, nest age at each visit, and used model results to produce estimates of daily survival. The models that had the highest Akaike weight all included year and nest age. We then modeled shell plot, and nest age for each year of the study (2009-2013). To simplify the results, we then estimated nest success as the product of daily nest survival over the complete life of the nest for each of the five years (33 days for Snowy Plovers, Warriner et al. 1986).

Avian Predator Surveys

To identify avian predators in the area that might affect Snowy Plovers, SFBBO and Refuge biologists and interns conducted weekly predator surveys on the same ponds surveyed weekly for plovers, with the exception of the Whale's Tail area of Eden Landing (Tables 1-2). This area was surveyed weekly through June, but was not surveyed weekly from July-Aug due to staffing constraints. Likewise, volunteers conducted monthly avian predator surveys at ponds surveyed monthly for plovers. We defined avian predators as any species that could potentially prey on a Snowy Plover nest, chick, or adult. Species included Common Ravens (*Corvus corax*), American Crows (*C. brachyrhynchos*), Northern Harriers (*Circus cyaneus*), American Kestrels (*Falco sparverius*), Peregrine Falcons (*F. peregrines*), Merlins (*F. columbarius*), Red-tailed Hawks (*Buteo jamaicensis*), Cooper's Hawks (*Accipiter cooperii*), White-tailed Kites (*Elanus leucurus*), Golden Eagles (*Aquila chrysaetos*), Great Blue Herons (*Ardea herodias*), Great Egrets (*A. alba*), Snowy Egrets (*Egretta thula*), Loggerhead Shrikes (*Lanius ludovicianus*), Barn Owls (*Tyto alba*) and Burrowing Owls (*Athene cunicularia*).. While mammalian predators and their signs (e.g., tracks) were also recorded opportunistically, these surveys were not designed to detect mammals, particularly since many are nocturnal.

We conducted avian predator surveys following plover surveys, so human disturbance may have affected detection rates of some species. Observers drove slowly on levees or walked levees without vehicle access, stopping every 0.3 miles to scan for predators. We recorded the number and species of any predators present as well as their behavior at the time of sighting. We marked their approximate locations on a map. In addition, we documented any predator nests in the area and attempted to determine the fate of those nests by observation from a distance. We calculated the average number of predators observed per survey at each pond by dividing the total number of individuals seen in each area by the number of surveys conducted.

While most predators probably have a larger territory than a single pond (Strong et al. 2004b), we felt it meaningful to present indices of predator abundance at the pond scale since surveys were conducted at that level, as were inferences about plover breeding success. SFBBO and Refuge biologists conducted a study in which they treated quail eggs with carbachol in order to condition the resident corvids not to depredate Snowy Plover eggs (C. Strong, pers. comm). The results of this study will be included in a report from the Refuge.

RESULTS

Snowy Plover Surveys

South Bay Overall.

During the 2013 Pacific Coast breeding season window survey (May 20-29), we counted 202 adult Snowy Plovers in the Bay (Table 5). We observed a mean of 184 birds per week from March 3 through August 25 in the entire South Bay. We consistently observed the greatest numbers of Snowy Plovers at Eden Landing (Table 5, Figure 7). We documented Snowy Plover nesting activity at 17 South Bay ponds (Figure 8, Figure 9). We also observed Snowy Plover broods in areas where we did not located nests, such as pond A12 in Alviso and Crittenden Marsh in Mountain View.

Refuge.

We documented a mean of 38 Snowy Plovers per week from March 3 through August 25 on Refuge property. We observed an average of 8 plovers per week in the Alviso complex (Figure 7). We began surveying the Dumbarton ponds in July due to the potential for dry habitat, however we did not record any plovers in those ponds.

Eden Landing.

We observed the most Snowy Plovers throughout the season at Eden Landing (Figure 7), with a mean of 115 birds observed per week from March 3 through August 25. This was higher than in 2012 when we observed a mean of 84 birds per week during the same time period. Ponds E12, E13, and E14 consistently supported large numbers of Snowy Plovers. In late July and early August, we observed particularly large flocks (weekly counts of 100-229 birds, Figure 7a). Many of these birds may have been staging (for migration) or early arrival wintering birds, since the average number of birds observed per week from early March through mid-July was 99. In 2012, the average number of birds observed per week during the same time period was 77.

Nest Abundance and Success

South Bay Overall.

In 2013, we determined the fate of 174 Snowy Plover nests in the South Bay. Of these, 111 nests hatched (apparent nest success = 64%), 55 nests were depredated (32%), six were

abandoned (3%), and two were flooded (1%, Table 6, Figure 9). We found a greater number of nests in the South Bay in 2013 than in 2012 (135 nests) though less than 2010 and 2011 (2010: 243 nests, 2011: 224 nests). Predation was the most common source of nest failure (Figure 9), which is consistent with findings from previous years.

Refuge.

In 2013, SFBBO determined the fate of 48 Snowy Plover nests on Refuge property (Table 6). We determined the fate of seven nests in the Warm Springs complex, all of which were depredated (100%). We determined the fate of 10 nests in the Alviso Complex (in ponds A9, A16, New Chicago Marsh and the Alviso Impoundment, Table 6). Out of these nests, four hatched (40%), three were depredated (30%), two nests were abandoned 20%) and one nest flooded (10%). We determined the fate of 31 nests in the Ravenswood Complex. Of these, 25 hatched (80%) and six were depredated (20%). We found the most nests on pond R1 (12 nests; Table 6).

Eden Landing.

We determined the fate of 126 Snowy Plover nests at Eden Landing. Of these, 82 hatched (65%), 39 were depredated (30%), four abandoned (3%), and one was flooded (<1%, Table 6). Pond E12 had the most nests (49 nests), followed by ponds E14 (33 nests) and E13 (21 nests, Table 6). These three ponds hosted 82% of the nests at Eden Landing, and were under construction during the 2013 breeding season.

Hayward Shoreline.

EBRPD reported that there was one Snowy Plover nest on the Least Tern Island at HARD which was depredated (D. Riensche, pers. comm.; Table 6).

Napa-Sonoma Marshes Wildlife Area.

CDFW biologists found and determined the fate of two nests in the Napa Plant Site and pond 7/7A, both of which were successful (K. Taylor, pers. comm.; Table 6).

Hamilton Wetland Restoration Area

Point Blue Conservation Science biologists found two Snowy Plover nests in 2013 at the Hamilton Wetland Restoration site (M. Elrod, pers. comm).

Breeding Chronology

Overall, average apparent nest density in the South Bay (across all ponds with dry panne) was 0.14 nests per hectare. We documented the highest apparent nest density in pond E12, at 1.16 nests/ha which is the highest we have recorded outside of a shell plot since we began

calculating nest densities in 2005. Many other ponds that we surveyed did not support any known nests in 2013 (Table 7, Table 8).

While we recorded the highest number of nests initiated during the week of April 7 (21 nests), nest initiation levels were relatively low and constant through mid-July (Figure 12).

The number of active nests was high from the week of May 12 through June 23, with the number of nests staying between 47 and 53. By mid-July, the number of nests dropped off until the end of the season in late August (Figure 12).

Chick Fledging Success

We banded fourteen Snowy Plover chicks at Eden Landing in 2013 and determined that five chicks fledged (36%, Table 9). Apparent fledging success (all sites combined) was 50% in 2012 (*N* = 8 chicks), 14% in 2011 (*N* = 36 chicks), 41% in 2010 (*N* = 39 chicks), 25% in 2009 (*N* = 113 chicks), and 29% in 2008 (*N* = 83 chicks) (Table 9). Given the small sample sizes and difficulty in re-sighting banded chicks, these estimates are difficult to interpret and should be viewed with great caution.

Oyster Shell Habitat Enhancements

We established 15 1-ha shell plots at Eden Landing prior to the 2013 breeding season. We spread oyster shells over seven plots in the winter of 2008, five plots in the winter of 2009, and three plots in the winter of 2010. Three plots were located on E16B, four plots on E8, four plots on E6B, three plots on E14, and one plot on E6A. For each of these plots, we established a paired control plot at the same time.

Apparent Estimates.

From 2009-2013, we documented high apparent nest densities in the shell plots compared to control plots (Table 11). In 2013, we found a total of ten nests in the shell plots and no nests in the control plots. Apparent nest densities were 0.6 nests/ha in the shell plots, 0.0 nests/ha in the control plots, and 0.21 nests/ha in all other areas of Eden Landing combined (Table 11). Apparent nest success inside the plots was 66% while apparent nest success was 33% outside of the shell plots (Table 11).

Nest Survival Models.

In the best model, daily survival rate (DSR) was a function of presence of a shell plot, nest age at each visit, the quadratic of nest initiation date and the year. This model had an Akaike weight of 0.68 and an AIC value of 1688.3. The second-ranked model had an Akaike weight of 0.30 and included all of the same variables except nest initiation date rather than the quadratic of the

nest initiation date. Daily nest survival was higher for nests in the shell plots than nests not in the shell plots, though the confidence intervals did overlap each year (Table 4).

Avian Predators

Refuge.

We found that California Gulls and unidentified gulls (presumably mostly California Gulls given time of year and location) were the most abundant potential avian predators in all areas of the Refuge (Table 12, Table 13, Table 14). Raptors, corvids, and wading birds were also present in many areas. In Ravenswood, we observed groups of Common Ravens and American Crows foraging throughout the complex and sometimes noted Red-tailed Hawks and Peregrine Falcons perched on the PG&E towers (Table 12). In Alviso, we frequently observed Common Ravens as well as Great and Snowy Egrets throughout much of the complex (Table 13). At Warm Springs (ponds A22 and A23), we primarily observed gulls, Common Ravens, and American Crows (Table 14).

Eden Landing.

The most abundant potential avian predators at Eden Landing were California Gulls and unidentified gulls (Table 15). We also observed Snowy and Great Egrets using many of the ponds at Eden Landing.

In 2013, Great Blue Herons again nested on a former hunting blind in E6B, referred to as the "heron house". They also nested on at least one former hunting blind in E9, but access to this area was limited due to restoration activity. A pair of Peregrine Falcons nested on one of the E9 blinds in 2012 and the nest was removed over the 2012/2013 winter. We continued to regularly observed falcons, likely two juveniles, perched or actively hunting on ponds E12-14 from June until the end of the breeding season.

Hayward Shoreline.

We observed low numbers of potential predators at Hayward Shoreline, including California Gulls, Common Ravens, and Western Gulls (Table 16).

Napa-Sonoma Marshes Wildlife Area.

We observed American Crows, Common Ravens, Glaucous-winged Gulls, Great Blue Herons, Great Egrets, Northern Harriers, Red-tailed Hawks, Snowy Egrets, and White-tailed Kites at the Napa-Sonoma Marshes Wildlife Area (Table 17).

Mammalian Predators

We observed Gray Foxes (*Urocyon cinereoargenteus*), skunks (*Spilogale gracilis*, *Mephitis mephitis*), raccoons (*Procyon lotor*), opossums (*Didelphus virginiana*), coyotes (Canis latrans) and domestic cats (*Felis catus*) around plover nesting ponds. In past years, biologists have seen cats jumping over the Eden Landing predator fence, north of E6A, into the Ecological Reserve.

The feral cat feeding station present in some previous years did not appear to be active outside the Veasy Street gate during the 2013 breeding season, however, the feeding station north of the intersection of Veasy Street and Whipple Road was active. In the Mountain View area, a group of Google employees that run GCats Rescue, which feed feral cats at numerous stations near sensitive bird habitat adjacent to Crittenden Marsh. Feral cats are known predators of birds (Dauphine and Cooper 2009).

On several occasions we observed evidence of humans trespassing on the ponds that are closed to the public. We saw footprints and bicycle tracks on pond bottoms, which would have disturbed any Snowy Plovers in the area.

DISCUSSION

Snowy Plover Surveys

We counted 202 Snowy Plovers in the Bay during the May breeding window survey. This number was higher than the 2012 count, however it was lower than the 2011 and 2010 numbers. Eden Landing continues to host the majority of the Bay Area's Snowy Plovers. While the window survey methods provide an index of abundance and allow examination of trends across years and throughout the Pacific Coast, they fall short of providing an exact estimate of the number of breeding Snowy Plovers in the San Francisco Bay. Since few plovers in the South Bay are color-banded, and surveys of all areas take multiple days to complete under existing staffing/resource levels, more precise estimates of the number of Snowy Plovers nesting in Recovery Unit 3 are not currently available. Mark-recapture studies involving additional banding effort and/or other, more intensive methods could help to provide this information in the future (see also *Chick Fledging Success* below).

Nest Abundance and Success

In 2013, we found a similar number of nests to 2009 and more nests than in 2012 (2009: 163 nests, 2010: 243 nests, 2011: 224 nests, and 2012: 135 nests). However, we caution that apparent nest numbers alone can be difficult to interpret and may not be a reliable gauge of breeding performance, especially across years or study sites. For example, an increased number of nests could simply reflect a higher number of depredated nests; Snowy Plovers are known to re-nest up to six times in one season (Warriner et al. 1986), and we may have been finding numerous nesting attempts by the same individuals after predation events on previous nests. We currently lack estimates of re-nesting probability for Snowy Plovers in this Recovery Unit. Similarly, when unsuccessful nests are less likely to be found than successful nests, apparent nest numbers will be biased, just as estimates of apparent nest success and apparent nest densities will be, complicating interpretation. Small nest sample sizes in many areas and the reality that some nests probably go undetected each year further obfuscate matters.

Apparent nest success estimates ranged widely by pond and pond complex. Many Snowy Plover nests were lost to predation in 2013 and in previous years of study; low nest success is believed to be a critical limiting factor for Snowy Plovers in the South Bay and elsewhere along the Pacific Coast (USFWS 2007, USFWS and CDFW 2007).

In 2013, Snowy Plovers nested on ten Refuge ponds. We found seven nests at Warm Springs and all were depredated. Although we did not locate any nests in 2012 in either of the Warm Springs ponds, nests in this complex also experienced heavy predation in 2011. These ponds are located between the Newby Island Landfill and the now closed Tri-Cities Landfill; large numbers of gulls and corvids fly between the landfills during the day and roost nearby. During the breeding season, approximately 4,873 adult California Gulls nested on Mowry ponds M1/M2, M3, and M4/M5, which are adjacent to Warm Springs (Figure 1; Tokatlian and Donehower 2013). We also observed large flocks of corvids flying in the vernal pool grasslands to the northwest of the Snowy Plover nesting ponds.

In Alviso, we observed Snowy Plovers nesting at A16, A9, and New Chicago Marsh. In October of 2012, pond A17, which hosted nesting Snowy Plovers in spring 2012 when it was drained for construction, was restored to tidal action. Islands were constructed in pond A16 for nesting waterbirds as part of the Project. In 2013, one Snowy Plover nested on the newly created A16 islands and five plovers nested on exposed dry pond bottom. Plovers also nested on exposed pond bottom in A9, the Alviso Impoundment and on the dry panne habitat in New Chicago Marsh.

This year, Snowy Plovers were reported on the dry panne habitat in Crittenden Marsh in Mountain View and we began to survey the area weekly at the beginning of August. We observed three broods of chicks using this area. This area is owned by the Midpeninsula Regional Open Space District and we plan to survey this area more regularly in 2014. Although this area is not part of the Restoration Project, we do not know how plovers will use this space as the amount of available habitat in the South Bay decreases due to the Restoration Project.

At Eden Landing, Snowy Plovers nested on seven ponds, with the majority of nesting occurring on ponds E12, E13 and E14. These ponds also had the highest amount of survey effort by staff, as biologists were surveying the areas daily for construction monitoring.

CDFW reported that there were two Snowy Plover nests this season in the Napa-Sonoma Marshes Wildlife Area. This is the fifth year that the number and fate of nests were documented for the North Bay ponds. In 2010, CDFW completed habitat enhancements to the Wingo Unit and now manages it as a seasonal wetland (K. Taylor, pers. comm.). This area may provide a small amount of additional breeding habitat for Snowy Plovers in the future.

Chick Fledging Success

Throughout the South Bay, we banded fourteen chicks. From band re-sighting, we determined that at least five chicks of the eight banded survived to fledging. We banded fewer chicks this season compared to recent years primarily due to staffing constraints.

We believe that relying on banding and re-sighting plover chicks in the salt ponds has its limitations and that other methods should be considered in the future to estimate fledging success. The dry salt panne habitat used by plovers is characterized by uneven topography/substrate, which combined with heat waves and long scoping distances, creates very difficult conditions for effective band re-sighting. Considerable effort and planning are also needed to band plovers in the salt ponds. Chicks must be banded within a couple of hours of hatching (before they become mobile and depart the nest), requiring extremely precise nest age/egg flotation records and frequent nest visitation to accurately predict hatch dates. Use of radio telemetry to track adult males with broods may hold some promise for improving the accuracy of plover fledging success estimates in the San Francisco Bay, but it will also require considerable resources to implement. Regardless of the method used, all must carefully balance the need for more intensive monitoring with the potential impacts caused by increased researcher disturbance to plovers.

In 2014 and 2015, in an effort led by the Institute for Wildlife Studies (Lead PI: Brian Hudgens), scientists will conduct rigorous fieldwork and statistical analyses to test observational approaches to estimate chick survival and fledging success. As part of this study, in 2014 SFBBO will band a total of approximately 75 chicks in several areas in Eden Landing Ecological Reserve and the Refuge's Ravenswood complex. Information gathered on the survival of banded chicks will be used to evaluate how well a suite of observational survey methods alone perform in estimating chick survival, compared with more the labor intensive banding method. We hope that this study will provide a set of observational tools that can reliably be used to estimate chick fledging success, and in particular, in identifying techniques that are reliable in the San Francisco Bay Area.

Oyster Shell Habitat Enhancements

Apparent Estimates.

In 2013, as in previous years of study, we documented higher apparent nest densities in shell plots (0.90 nests/ha) compared to control plots (0.00 nests/ha). Apparent nest success was similar in shell plots (60%) and other areas of Eden Landing (65%) this season. The number of nests in the shell plots was lower this year than previous years (Figure 13). The low number of nests in the shell plot may possibly be attributed to the brightness of the shells varying on the plots; shells in some areas were completely covered in sediment (if the pond was flooded over the winter), while shells in other areas remained mostly white. Therefore, there may have been differences in the camouflage benefits provided by shells.

Nest Survival Models.

At Eden Landing from 2009-2013, we found that nest survival was a complex function of many factors (shell enhancements, year, and daily nest age). Daily nest survival was higher in nests in shell plots for each year, though the confidence intervals did overlap. This increase in daily nest survival in the shelled areas is perhaps because of the increased camouflage or topographic relief that they provide which was similar in previous years (Donehower et al 2013). Daily nest survival varied year to year but was consistently higher in the shell plots than outside of the shell plots.

Additional Considerations.

As the amount of available Snowy Plover nesting habitat around the Bay is reduced due to tidal marsh restoration, Snowy Plover nesting density will need to increase in order to maintain and/or increase the Snowy Plover breeding numbers within a smaller habitat footprint. Shell plots may be one way to achieve the higher nest densities needed to reach the Recovery Unit goal of 500 breeding birds. However, we may also need to develop additional strategies to support Snowy Plover recovery. Expanded predator management/deterrence programs and improved water level control at designated ponds to ensure that dry open panne habitat is available for nesting along with nearby wet areas for foraging are among other possibilities under discussion.

It is important to recognize the challenges of working with a threatened species. We advocate for a precautionary approach when making Snowy Plover habitat management decisions and when evaluating oyster shell habitat enhancements. Many key uncertainties remain with regards to the shell plots. Even if hatching success is vastly improved, this may not translate into contributions to plover recovery. Long-term effects have not been evaluated, and there are many unanswered questions; for example, could concentrated nesting lead to increased predation if predators learn to cue in on nests in shell plots? Page et al. (1983) found that Snowy Plovers nesting in higher densities experienced higher predation rates at Mono Lake. What are the effects of shell plots on chick or adult survival? How would alternative shell plot configurations perform?

Future oyster shell enhancements could include covering a larger area of the pond with shells, and placing the shells in irregular patterns, unlike the square plots. These are exciting areas for future research and monitoring but will require careful study design and more investment. Oyster shells should not be placed in ponds or sections of ponds that will be flooded for long periods of time. We have observed that sediment is deposited on shell plots when the ponds are flooded over the winter and this may lead to lower nest density and nest success in the shelled areas. We recommend that the use of oyster shell enhancements be considered as one small part of a larger Snowy Plover management effort.

Avian Predators

California Gulls continue to be the main predator of concern. They were the most abundant predatory species documented at most plover nesting areas in 2013. From 2009-2011, we captured evidence (using remote cameras) that California Gulls directly impact Snowy Plovers through nest predation (Demers and Robinson-Nilsen 2012). In fact, while many nest predators were recorded over the course of the study, California Gulls were the only predator filmed depredating Snowy Plover nests in all three years. California Gulls are well-known predators of other shorebird nests and chicks in the South Bay (Ackerman et al. 2006, Herring et al. 2011). They may also impact other waterbirds through displacement from preferred nesting areas (Strong et al. 2004a).

The total number of California Gulls nesting in the South Bay increased from more than 52,000 breeding birds in 2012 to 53,458 breeding birds in 2013 (Robinson-Nilsen and Demers 2012 and Tokatlian and Donehower 2013). Three of the largest gull colonies (Alviso A9/A10/A14 colony, Mowry M4/M5 colony, and the Coyote Hills N3A/N4AB colony) are particularly close to Snowy Plover nesting areas. The former gull colony on pond A6, which previously hosted approximately 23,103 breeding adults (Tokatlian et al. 2010), was restored to tidal action in December 2010, with the immediate result of displacing the large gull colony at that location. There is growing concern among land managers and conservationists that gulls displaced as a result of ongoing restoration activities in the South Bay will colonize Snowy Plover nesting habitat or that used by other rare or sensitive wildlife species. In 2011 through 2013, SFBBO and Refuge biologists coordinated a non-lethal gull hazing program and successfully prevented gulls from nesting in areas identified as plover and Least Tern habitat (Strong 2013). Continued funding for the hazing and tracking of California Gulls needs to be secured in order to prevent gulls from nesting in sensitive areas in 2014 and beyond.

Northern Harriers represent another predator of concern. As well as documenting the predation of Snowy Plover nests and chicks with nest cameras in 2009 and 2011, we frequently observed Northern Harriers hunting ponds with Snowy Plover nests. The restoration of marsh habitat in the future will increase potential Northern Harrier nesting habitat in the South Bay. An increase in the local Northern Harrier population may result in higher predation pressure on pond nesting waterbirds, including Snowy Plovers.

We frequently observed both Red-tailed Hawks and Common Ravens perched in the transmission towers within ponds at all three Refuge complexes. These species should be discouraged from nesting in the towers, preferably before Snowy Plover nesting season starts. The Refuge coordinated with Pacific Gas and Electric (PG&E) to remove six nests in towers over sensitive habitat in 2013 (Strong and Saywer 2013). The Refuge will continue to coordinate the removal of nests from towers with PG&E annually.

Restoration and Snowy Plover Nesting

The majority of the South Bay's Snowy Plover nesting habitat is located within the South Bay Salt Pond Restoration Project area. The Project aims to restore large areas of former salt ponds to a mix of wetland habitats, including managing former salt ponds as managed wildlife ponds. Some of the ponds that will remain managed wildlife ponds, such as SF2, E12-13, and A16, have had islands constructed on them to provide waterbird nesting, roosting, and shallow-water foraging habitat. Long-term, one of the Project's goals is to support 250 breeding Snowy Plover adults within the Project area (USFWS and CDFW 2007).

As in past years, SFBBO provided plover monitoring services during construction conducted as part of the Project's planned restoration activities. In 2013, SFBBO biologists monitored E12, E13 and E14 and communicated real-time locations of plover nests, broods, and adults to crews working in the area and to agency personnel. We have found that weekly meetings and daily, on-the-ground communications are essential in both minimizing the threat to nests and broods due to construction activities and in reducing impacts to contractor work schedules.

For future restoration planning, we recommend that the Project work carefully to maintain enough nesting habitat to support the existing population of Snowy Plovers during construction activities. We strongly urge managers to provide nesting habitat in areas adjacent to those ponds being drained for construction to limit Snowy Plovers nesting in construction areas. While this will not stop Snowy Plovers from nesting in the dry construction ponds, it may reduce the number of nests in the construction ponds. Also, if Snowy Plover nesting ponds are to be flooded to exclude Snowy Plovers, managers should drain other nearby ponds in January and February, long before Snowy Plover breeding season in order to provide nesting habitat.

We suggest that construction activities on Snowy Plover nesting ponds start before or after the breeding season whenever possible and that actions be taken before the nesting season starts in order to deter Snowy Plovers from nesting on ponds where heavy equipment will be operating. Although not often feasible, this action would avoid much of the Snowy Plover and construction conflicts. In 2013, flying kites over the pond and placing shiny objects around on the pond bottom did not deter Snowy Plover nesting activity. Focusing the construction in a small footprint and keeping the human disturbance constant (throughout daylight hours/ seven days a week) may help reduce the number of Snowy Plovers nesting in the area.

This year the majority (59%) of the Snowy Plover nests in the Bay were within the construction area at E12-13 and E14. The wide area of dry pond bottom that was actively under construction presented conflicts between plovers and the construction and led to one documented case of a Snowy Plover chick getting crushed by construction equipment. In future years, we recommend focusing construction in a smaller footprint to reduce these impacts.

The largest impact that the Project will have on South Bay Snowy Plovers is the long-term reduction of potential nesting habitat as dry salt ponds are opened to tidal action or managed

with higher water levels. We recommend converting ponds to tidal action slowly, and studying the impacts to breeding Snowy Plovers. Many of the first ponds to be opened to tidal action or converted to ponds with islands have historically hosted large numbers of Snowy Plovers (A8, E12-13 and E8A; Figure 14, Figure 15, Figure 16 and Figure 17), and losing these nesting ponds may reduce the number of Snowy Plovers nesting in the San Francisco Bay Area. Snowy Plovers in the San Francisco Bay prefer to nest in dry salt ponds or on large, open salt panne areas located near foraging habitat. While we found one nest on an SF2 island and one on an A16 island in 2013, it is unknown how many pairs the created islands in ponds A16, SF2 and E12-13 will support in the future.

In addition, the newly created islands on pond SF2 formed large cracks as the mud dried in 2011. These cracks covered the islands and were often over 8 cm wide. We suspect the cracks were too wide for a Snowy Plover chick to successfully cross, and we found two dead newly hatched chicks deep in the cracks on one of islands in 2011. This year, biologists moved the newly hatched chicks from the one nest on an island toward the water, past the cracks. Three newly hatched chicks were located and moved towards the water and two chicks were banded a few days after hatching. The two chicks were seen on the same island they hatched on for two weeks after banding, and then were never located again. Due to the nature of Bay mud sediments, we expect cracking to occur on such islands elsewhere. In 2012, the Refuge "plowed" some of the islands in SF2, which appears to have reduced the size and number of cracks. This same type of "plowing" was built into the construction and maintenance of the islands at A16 to prepare these islands for nesting in 2014. Future island-building projects are planned to include plowing and sand or other toppings in order to limit the negative effects of the mud cracking.

Another goal of the Project is to increase public access in certain areas. Currently, most Snowy Plover nesting areas are closed to the public. Snowy Plovers in the South Bay are very sensitive to recreational disturbance and flush from their nests when walkers are at an average 164 m when approached directly, or 145.6 m when passed tangentially (Robinson 2008 and Trulio et al 2012). Therefore, public access should be limited or prohibited on trails adjacent to Snowy Plover nesting ponds during the breeding season (March-August) and managers should consider strategies to close areas if Snowy Plovers nest on or close to the trails. Additionally, fencing or barriers that limit pedestrians from entering sensitive nesting areas and reduce human disturbance should be installed. Managers should also consider low fencing such as is present at SF2 to keep Snowy Plover chicks off of pedestrian trails and roads. Overall, larger tracts of land may need to be kept free of public access entirely, in order to accommodate sensitive species, such as Snowy Plovers.

RECOMMENDATIONS

Research Recommendations

Future research involving Snowy Plovers and their nesting areas within the salt ponds should include projects that address the following topics:

1. Expanded banding and/or tracking via telemetry of chicks and adults to provide more reliable data on Snowy Plover survival rates. This is vital information to reach the recovery goal of 500 birds in Recovery Unit 3.
2. Snowy Plover use of the ponds for foraging and roosting during the non-breeding season.
3. Impacts of California Gulls on nesting Snowy Plovers.
4. Potential impacts of human disturbance from recreational trail use at Eden Landing and SF2.
5. The effects of avian predator management on Snowy Plover breeding success.
6. The effects of habitat enhancement on Snowy Plover breeding success.
7. Northern Harrier territory size and habitat use.
8. Snowy Plover foraging habitat use (borrow ditches, open channel, muted tidal, shallow pools, dry substrate) and invertebrate prey availability within the salt ponds.
9. Snowy Plover nesting habitat selection (use versus availability).
10. Nest success of Snowy Plovers on islands in managed ponds.

Monitoring Recommendations

1. The Recovery Unit 3 Snowy Plover monitoring program should continue. Monitoring numbers of breeding birds and reproductive performance is important to track progress towards recovery goals and the response of plovers to management actions, including the effects of salt pond restoration.
2. Recovery Unit 3 should identify other potential Snowy Plover breeding habitat in the San Francisco Bay area, outside of the South Bay Salt Pond Restoration Project area, that can be managed for plovers. Based on the number of nests found in the San Francisco Bay in recent years, nearly all are within the Project area. A goal of the Project is to support 250 breeding adults; therefore, in order to reach this target in the San Francisco Bay, additional habitat may need to be identified and managed for plovers, though we recognize that this will be no easy task.
3. Monthly surveys should be expanded to include areas that are not usually used by Snowy Plovers, such as Crittenden Marsh in Mountain View. As the amount of salt pond habitat decreases, plovers may use other areas for nesting within the South Bay.
4. Snowy Plover chicks and adults should be banded and re-sighted every three days to determine chick and adult survival, fledging rates, and movements. Banding chicks will

be required to assess the progress toward the recovery goal of 1.0 chick fledged per male.

5. SFBBO, along with CDFW and the Refuge, should develop a Snowy Plover outreach program in areas that will be open to the public within the next few years. Actions should be taken now to educate the public on Snowy Plover conservation and disturbance issues.
    a. Interpretive panels could be placed in areas open to the public to educate people on Snowy Plover habitat needs, and disturbance and conservation issues (such as the panel at pond SF2).

Management Recommendations

1. Refuge and CDFW management should continue to meet Snowy Plover habitat requirements by: a) providing areas of drying ponds with nearby high salinity foraging habitat and b) managing ponds in several areas around the South Bay for Snowy Plovers to reduce impacts from predation, flooding, or disease.
2. If construction activities are taking place on ponds where Snowy Plovers are nesting, or on levees in between nesting and foraging ponds, there should be a trained biologist onsite during working hours to minimize impacts to Snowy Plovers.
3. If construction takes place adjacent to or within a Snowy Plover nesting area, then weekly meetings should be coordinated with all parties involved so that everyone understands their roles and expectations in regards to minimizing impacts to listed species.
4. The South Bay Salt Pond Restoration Project should continue to explore ways to minimize or mitigate cracking on newly created islands to prevent loss of newly hatched chicks.
5. The predator management and gull hazing programs should continue in 2014 in the South Bay.
6. Managers should continue to explore using oyster shell enhancements as a tool for Snowy Plover recovery, and spread them in areas that will not be flooded for long periods of the winter.
7. Water levels in pond A23 should be raised over the winter to prevent nesting and roosting by California Gulls.
8. Water levels should be kept higher or interior channels should be added to pond E16B to increase the amount of foraging habitat in this pond.
9. If the Ravenswood ponds are to support more Snowy Plovers in the future, the ponds should be drained before the breeding season begins, to expose the panne habitat for nests. The water levels in the borrow ditches should be higher in order to keep water in the interior channels. This may enhance foraging habitat, and potentially, the numbers of Snowy Plovers using the complex. More water control structures could be added to the Ravenswood pond system to improve water management.

10. Managers and biologists should continue to work with PG&E to remove predator nests from the towers. Tower design modifications should be researched to discourage ravens and Red-tailed Hawks from nesting in the towers near Snowy Plover habitat.
11. Law enforcement patrol should be increased in areas with Snowy Plover breeding habitat to minimize disturbance from humans. This will become progressively more important as additional areas are opened to the public as part of the Project.
12. All researchers who are out on the ponds during the nesting season should continue to coordinate with SFBBO and the Refuge to minimize disturbance to Snowy Plovers.

ACKNOWLEDGEMENTS

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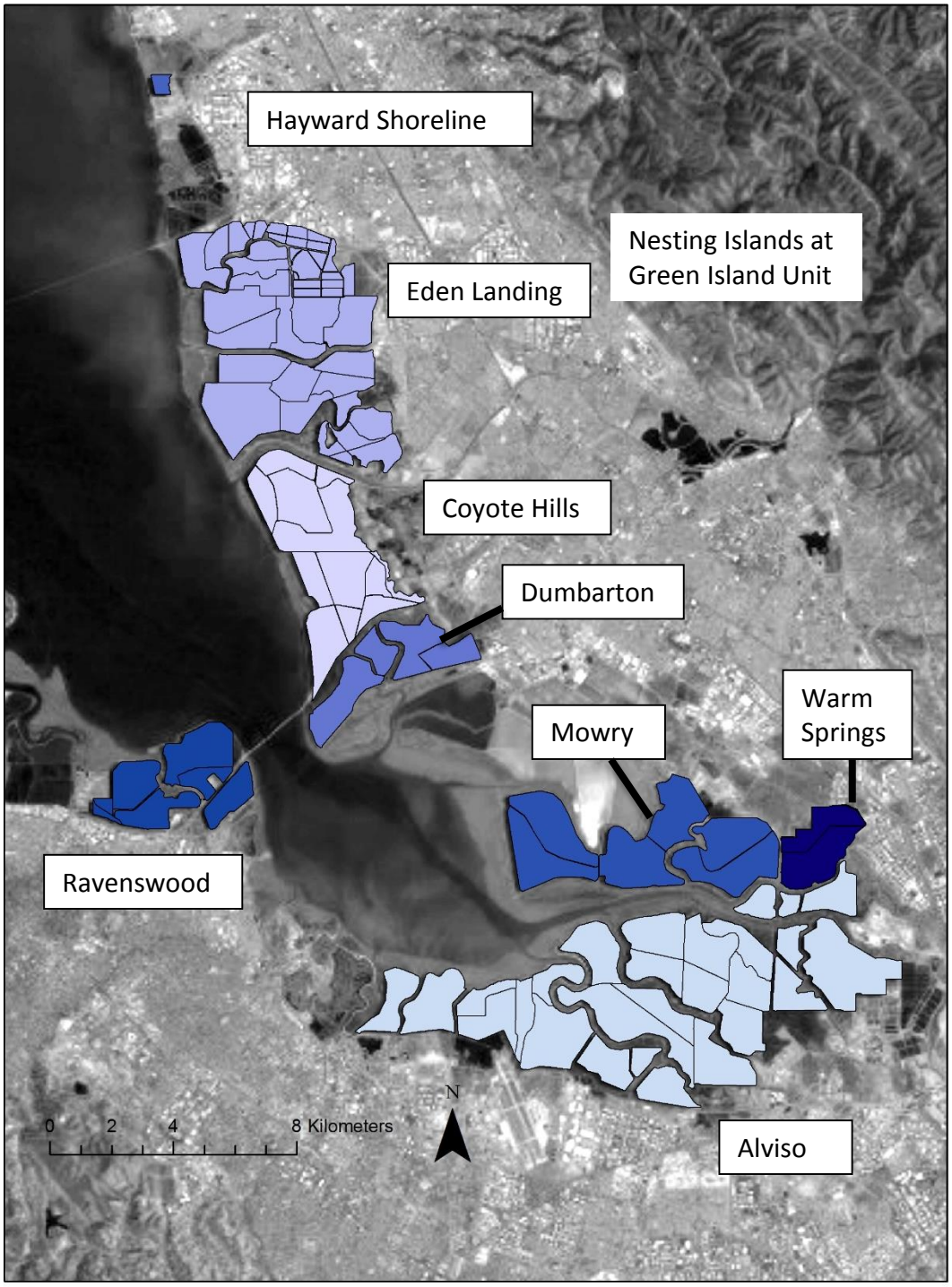

Figure 1. The Don Edwards San Francisco Bay National Wildlife Refuge, CDFW's Eden Landing Ecological Reserve, East Bay Regional Park District and Hayward Area Recreation and Park District lands in the South San Francisco Bay, California.

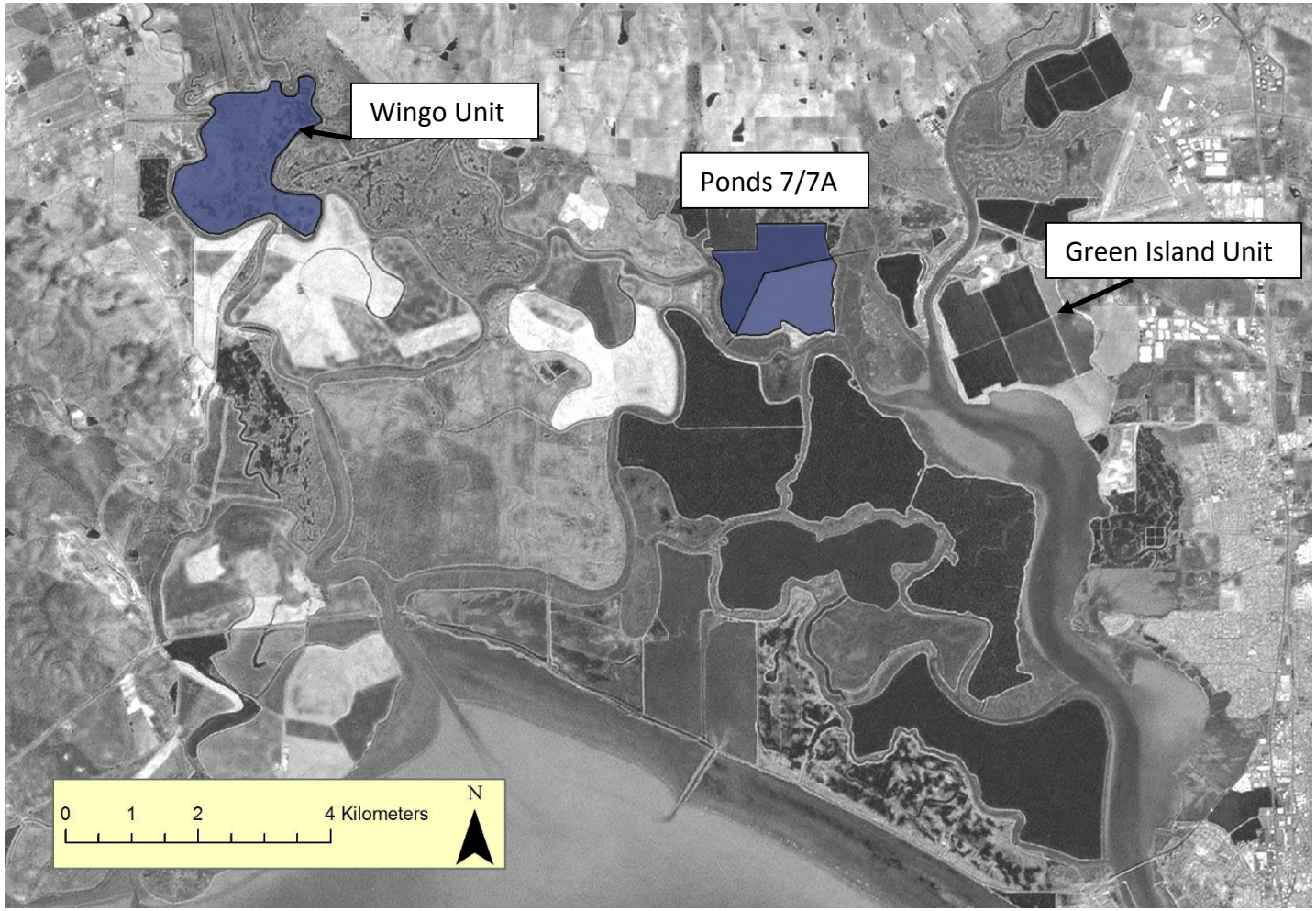

Figure 2. Snowy Plover nesting areas in the CDFW's Napa-Sonoma Marshes Wildlife Area: the Wingo Unit, ponds 7/7a, and the nesting islands at the Green Island Unit (formerly called the Napa Plant Site), North San Francisco Bay, California.

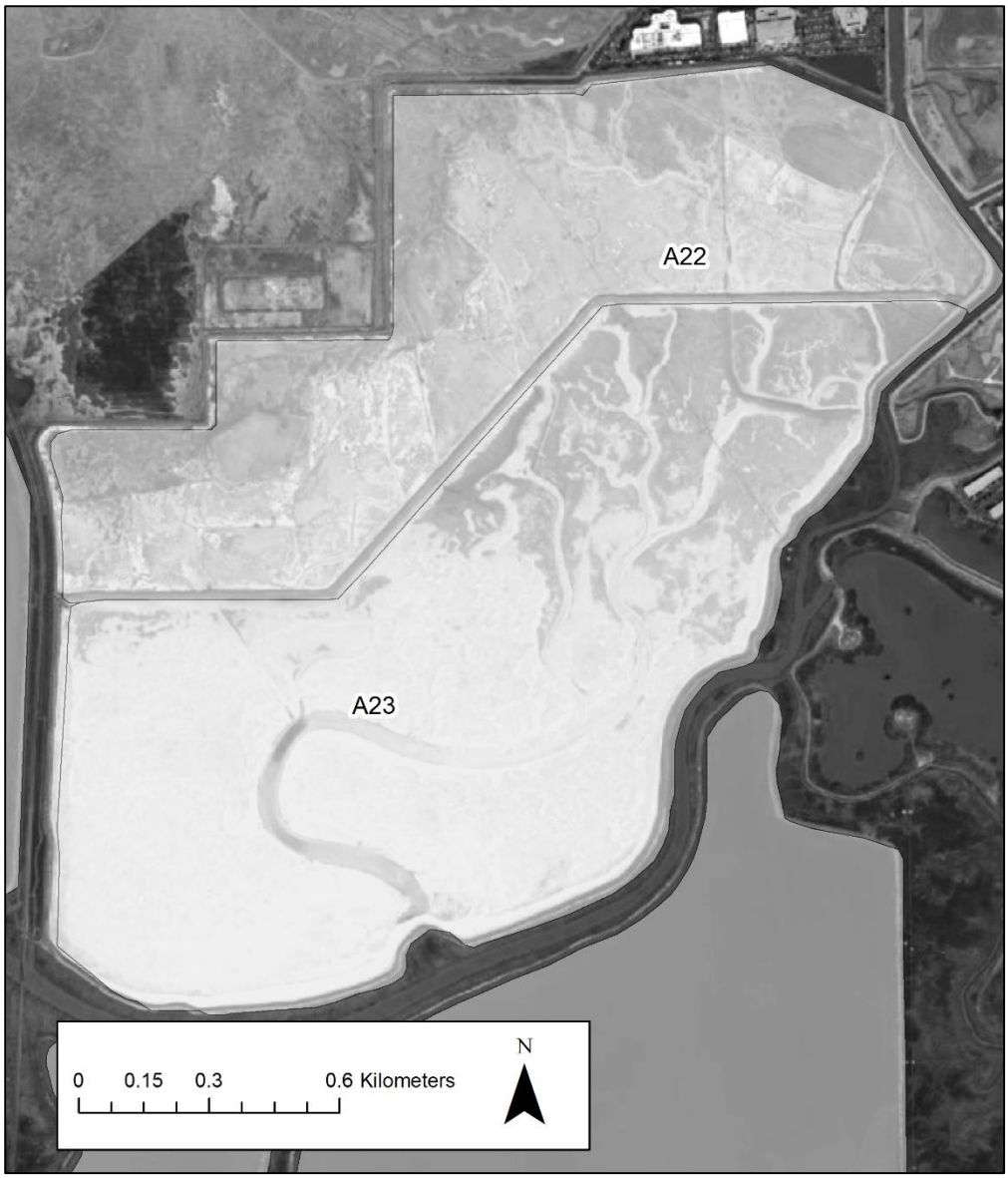

Figure 3. Salt ponds located in the Refuge's Warm Springs area, near Fremont, South San Francisco Bay, California. See Figure 1 for location of Warm Springs within South San Francisco Bay.

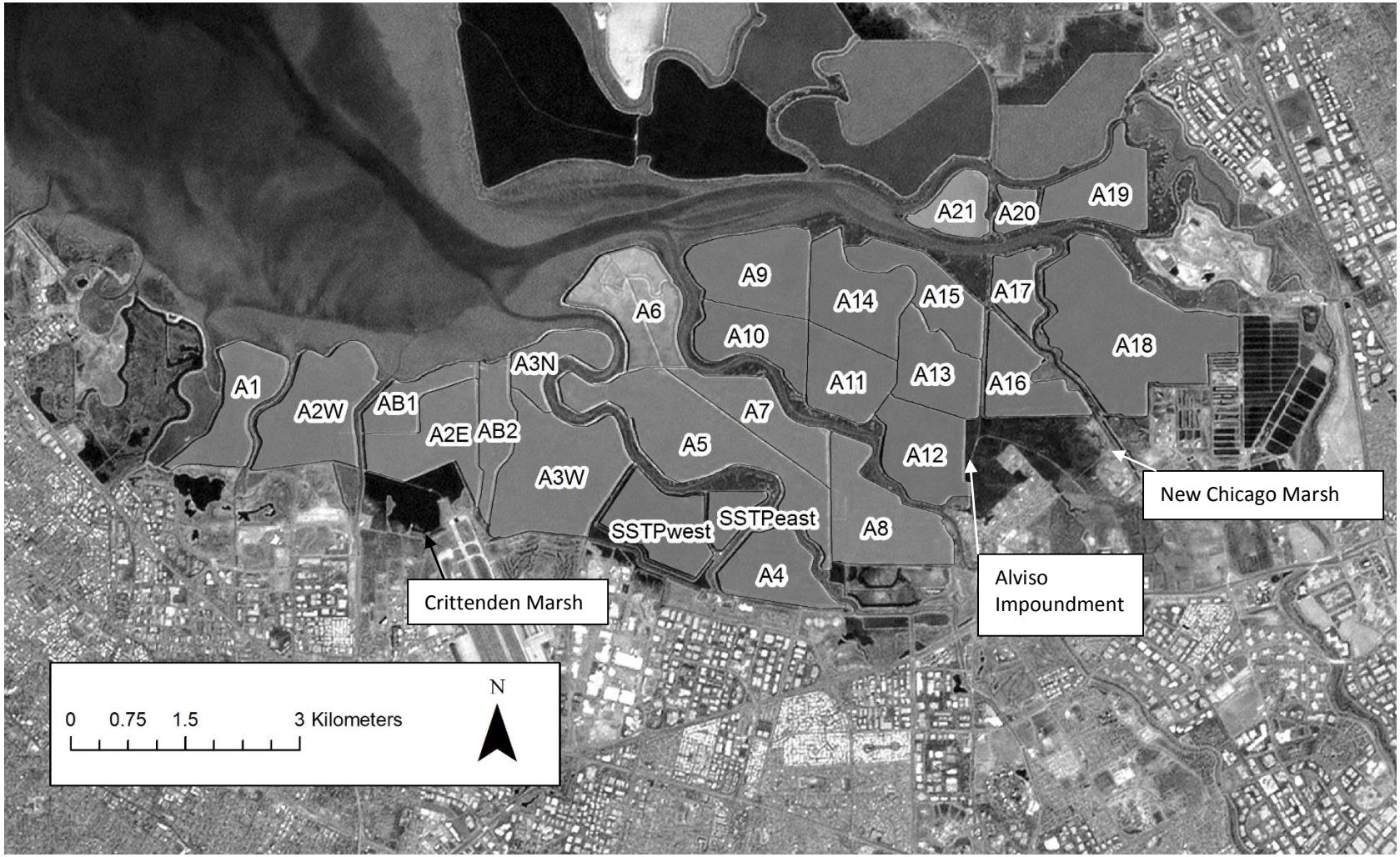

Figure 4. Salt ponds in the Refuge's Alviso Complex, at the southern end of the South San Francisco Bay, California. See Figure 1 for location of Alviso within South San Francisco Bay.

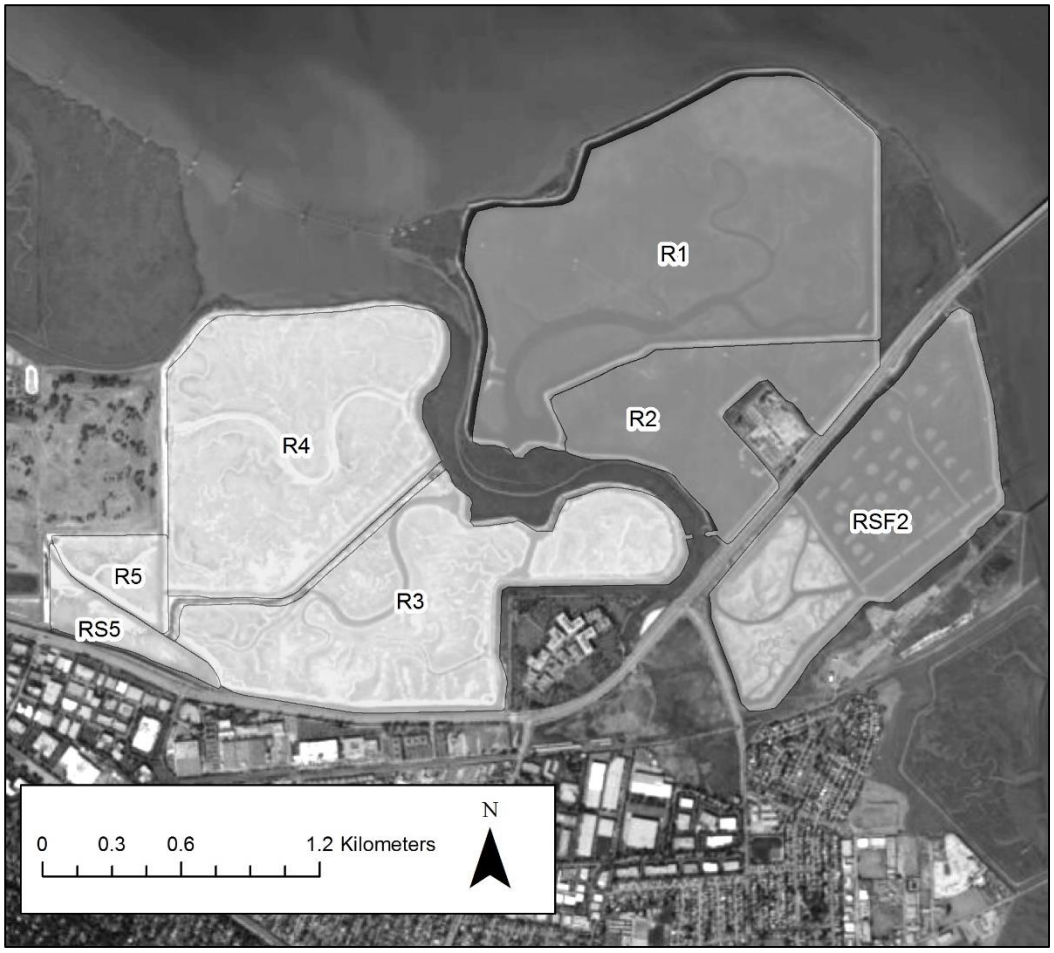

Figure 5. Salt ponds in the Refuge's Ravenswood Complex, at the west end of the Dumbarton Bridge, South San Francisco Bay, California. See Figure 1 for location of Ravenswood within South San Francisco Bay.

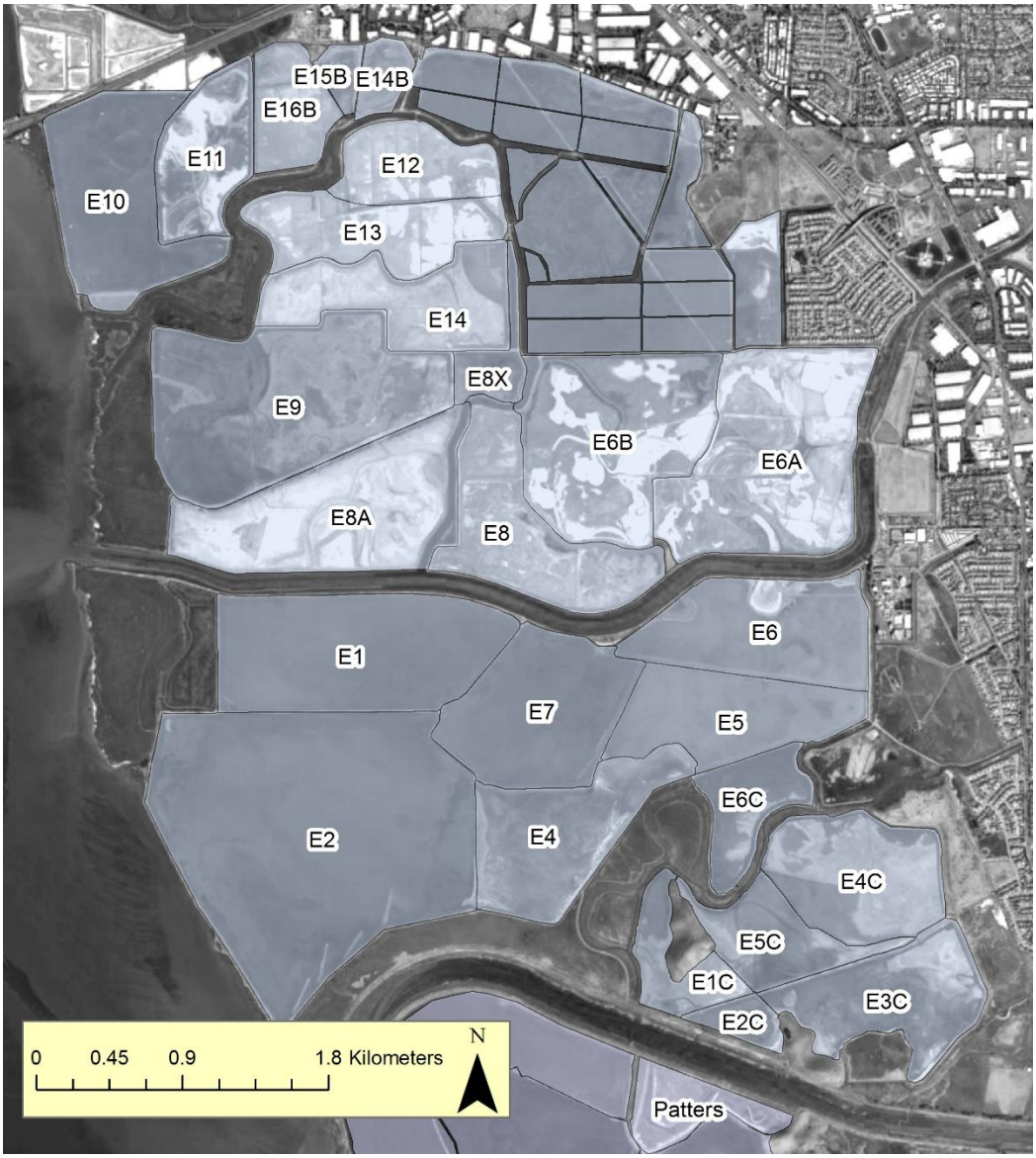

Figure 6. Salt ponds in the CDFW's Eden Landing Ecological Reserve, near Hayward, South San Francisco Bay, California. See Figure 1 for location of Eden Landing Ecological Reserve within South San Francisco Bay.

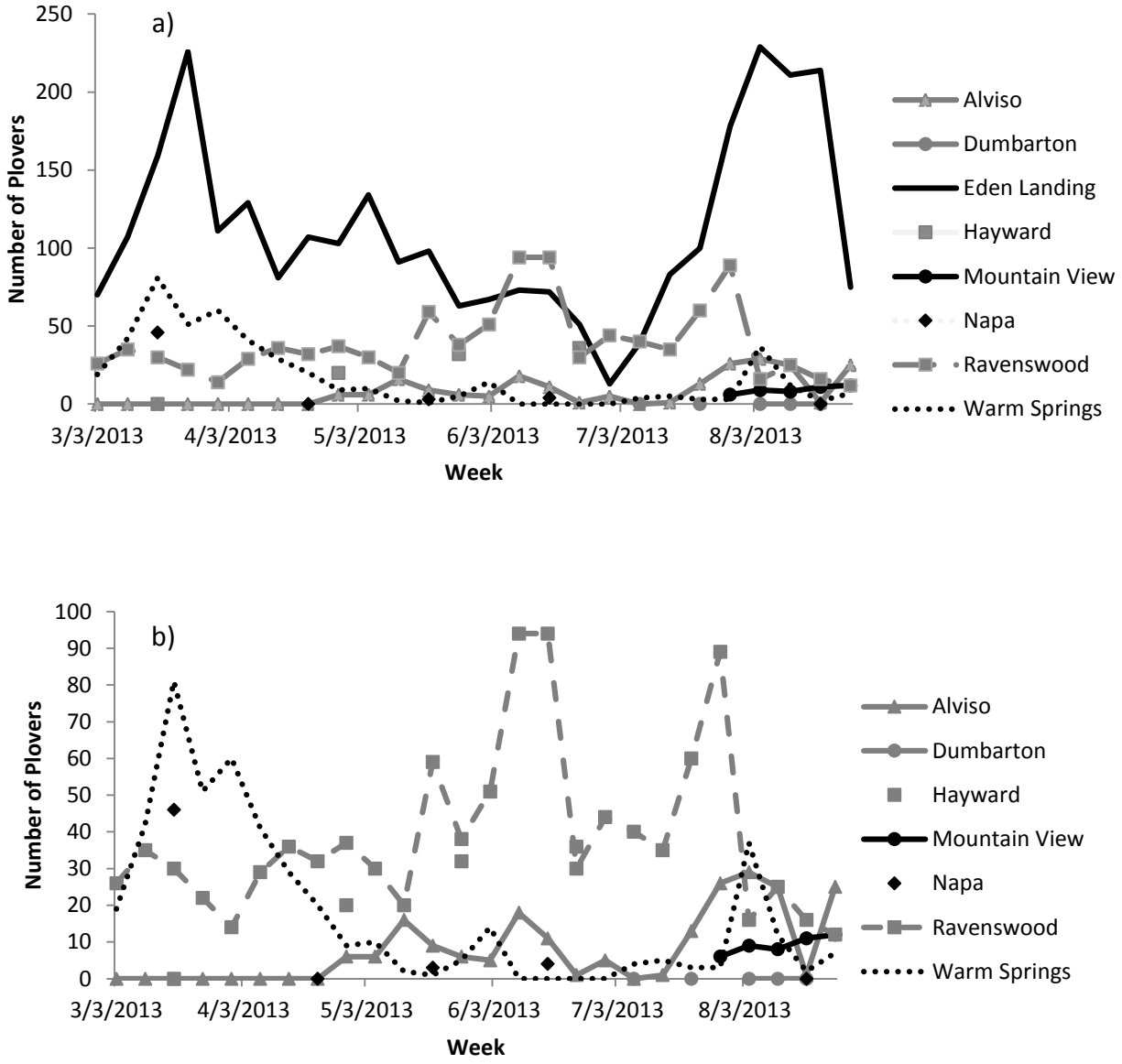

Figure 7. Weekly counts of adult Snowy Plovers by week and area, San Francisco Bay, California, 2013. To facilitate interpretation, data are presented for a) all locations monitored and b) all locations monitored excluding Eden Landing. Note the high number of Snowy Plovers observed in late March and August are presumed to be migrating and not breeding in the San Francisco Bay.

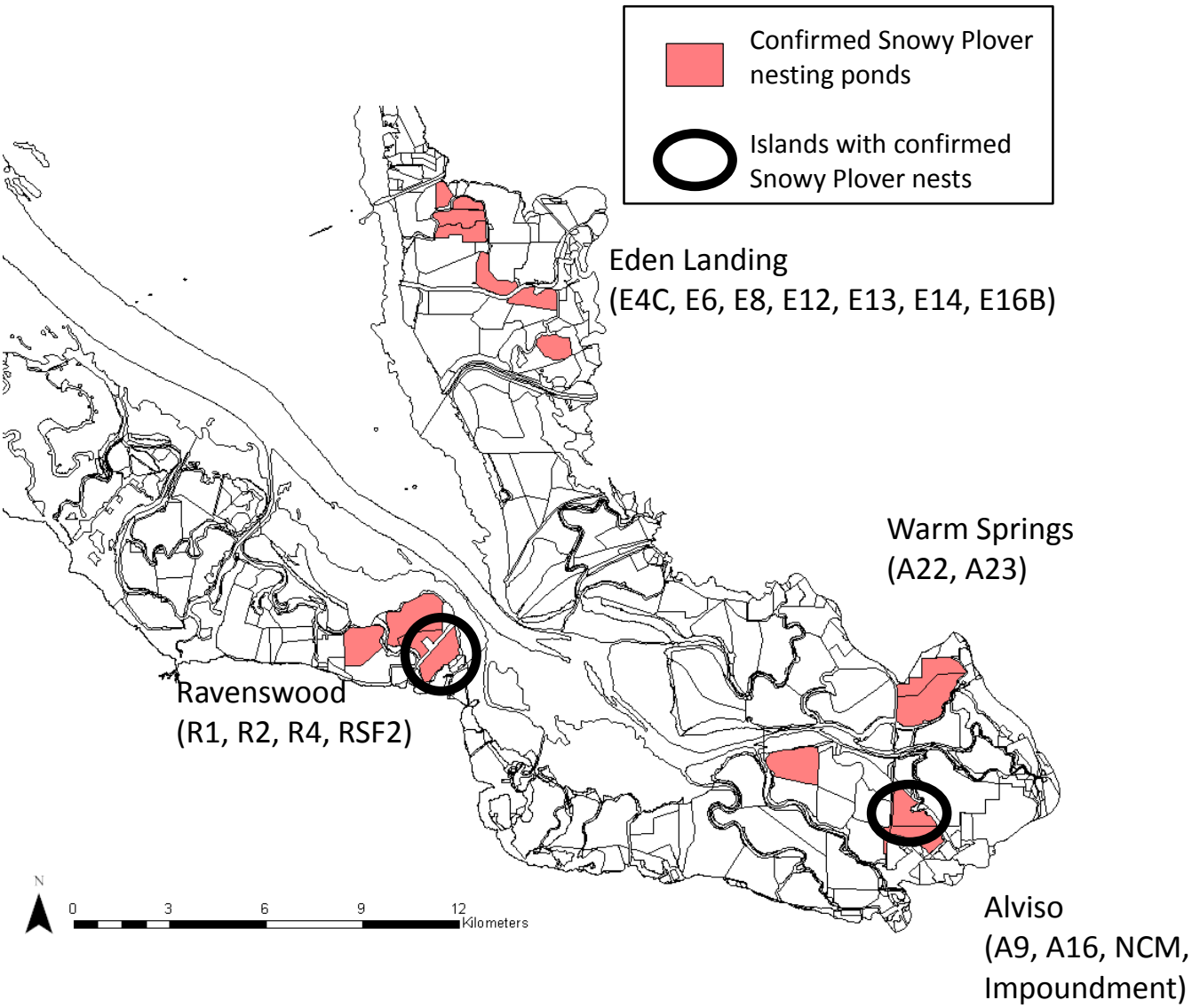

Figure 8. Areas (red shading) with documented Snowy Plover nesting activity during the 2013 breeding season, South San Francisco Bay, California. The black circles show where Snowy Plovers nested on islands constructed by the South Bay Salt Pond Restoration Project.

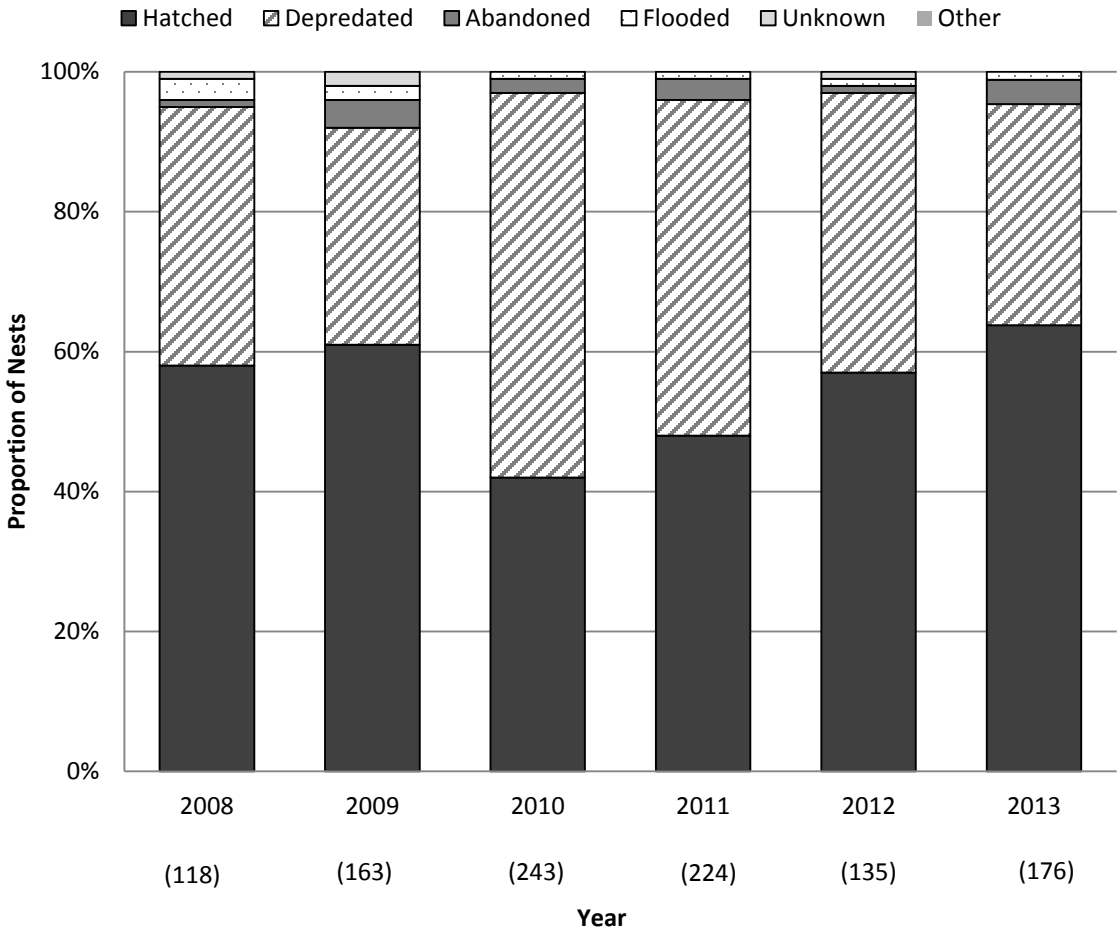

Figure 9. Annual apparent Snowy Plover nest fates in the South San Francisco Bay, California, 2008-2013. The number of nests monitored is indicated in parentheses beneath the year.

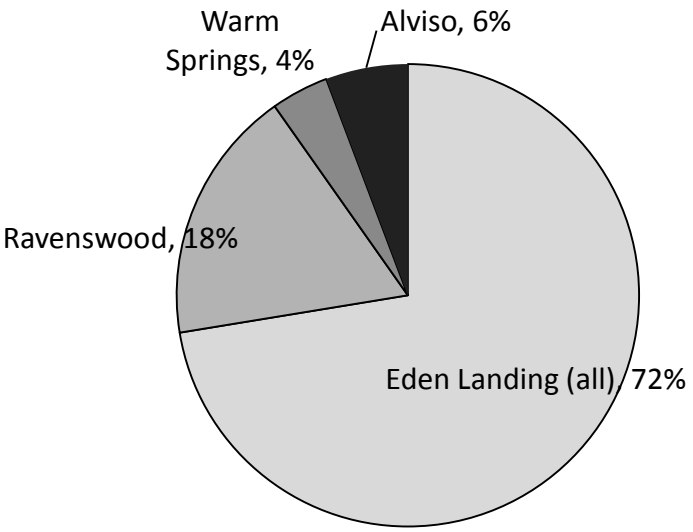

Figure 10. The proportion of Snowy Plover nests found in each pond complex in the South San Francisco Bay, California, 2013.

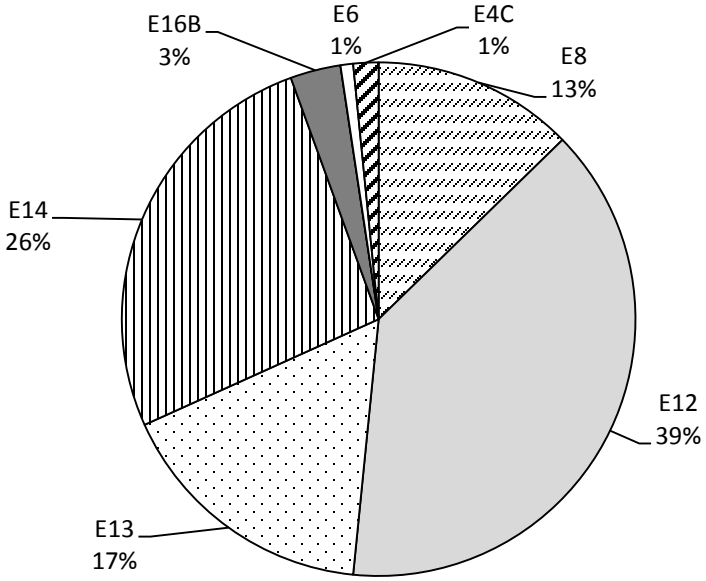

Figure 11. The proportion of Snowy Plover nests found in each pond at Eden Landing Ecological Reserve in Hayward, California, 2013. Note that ponds E12, E13 and E14 were within the construction area in 2013, and 82% of the nests at Eden Landing were on those three ponds.

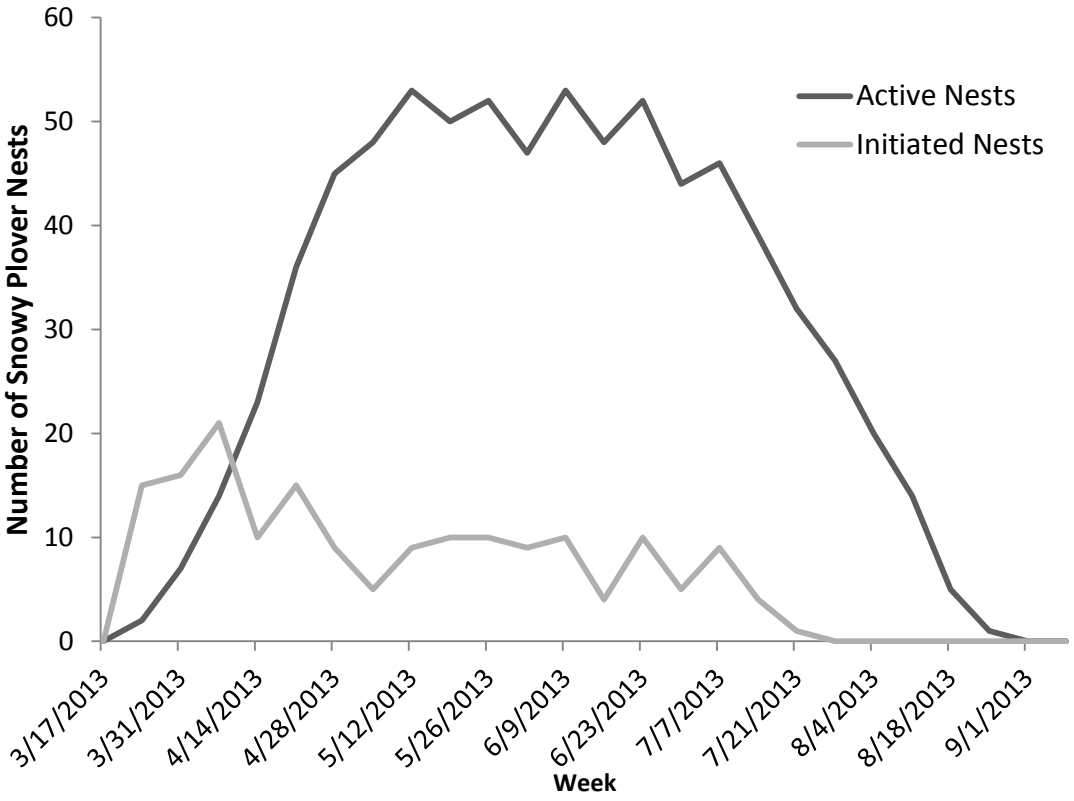

Figure 12. The weekly number of initiated and active Snowy Plover nests in the South San Francisco Bay, California, 2013.

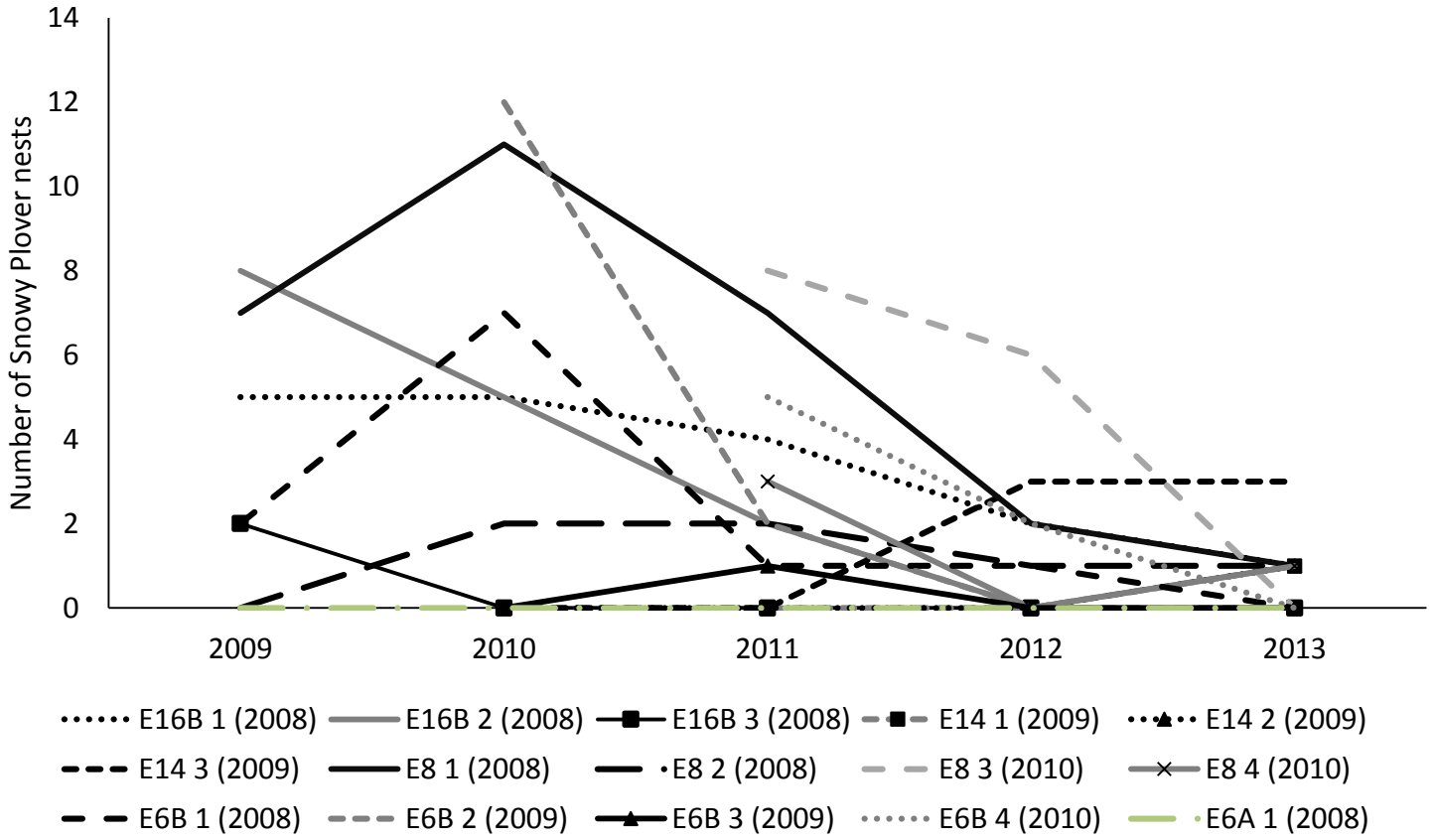

Figure 13. The number of Snowy Plover nests in each shell plot at Eden Landing Ecological Reserve, South San Francisco Bay, California, 2008-2013. The year the shells plots were spread is shown in parenthesis after the shell plot name.

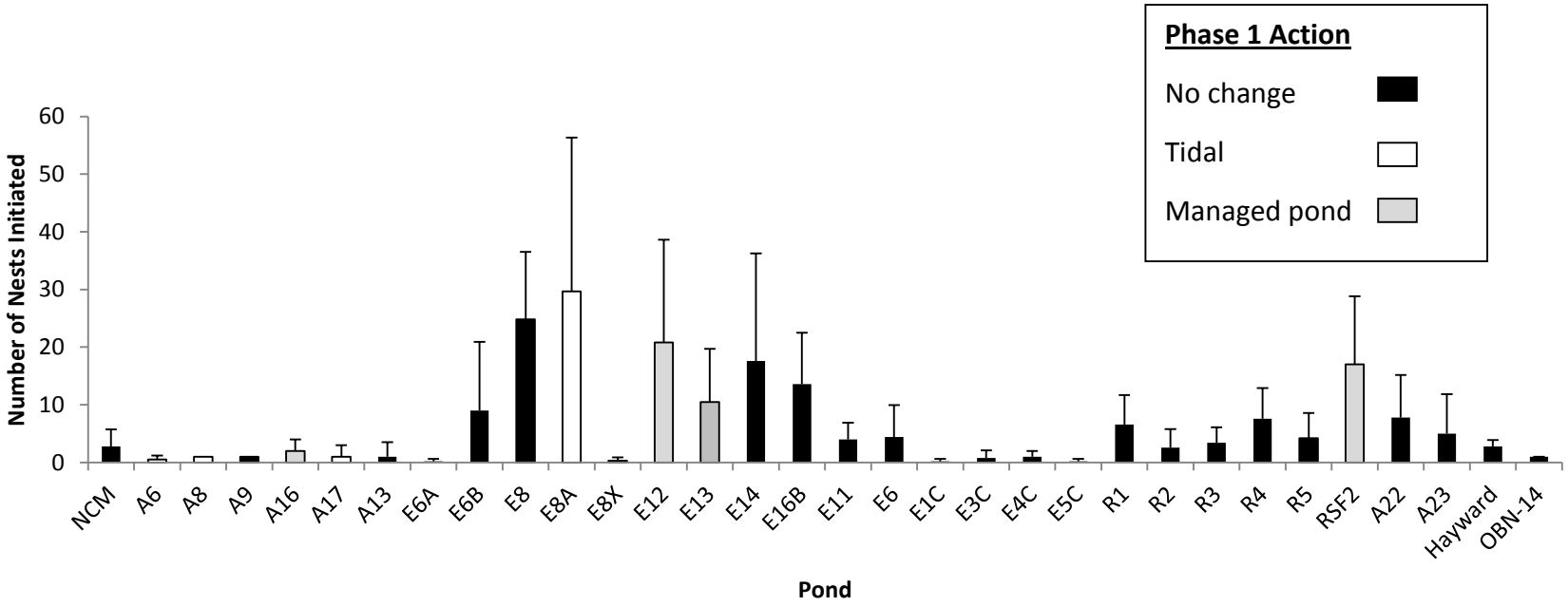

Figure 14. Average number of Snowy Plover nests initiated by pond in South San Francisco Bay, California from 2009-2013. Data are shown as mean + 1SD. The purpose of this figure is to illustrate which ponds have supported Snowy Plover nesting activity in recent years, and of these, which ponds are included in Phase 1 restoration plans of the South Bay Salt Pond Restoration Project. White bars denote ponds that have been (or will be) returned to tidal influence, gray bars denote ponds that are (or will be) managed for multiple species (at higher water levels) and the amount of available to Snowy Plovers will be reduced, and black bars denote ponds that will not be directly affected by Phase 1 actions. Note that "NCM" = New Chicago Marsh, "Hayward" = Hayward Least Tern Island, and "OBN-14" = Oliver Brothers North, Hayward; refer to Figs. 3-6 for other pond names and locations.

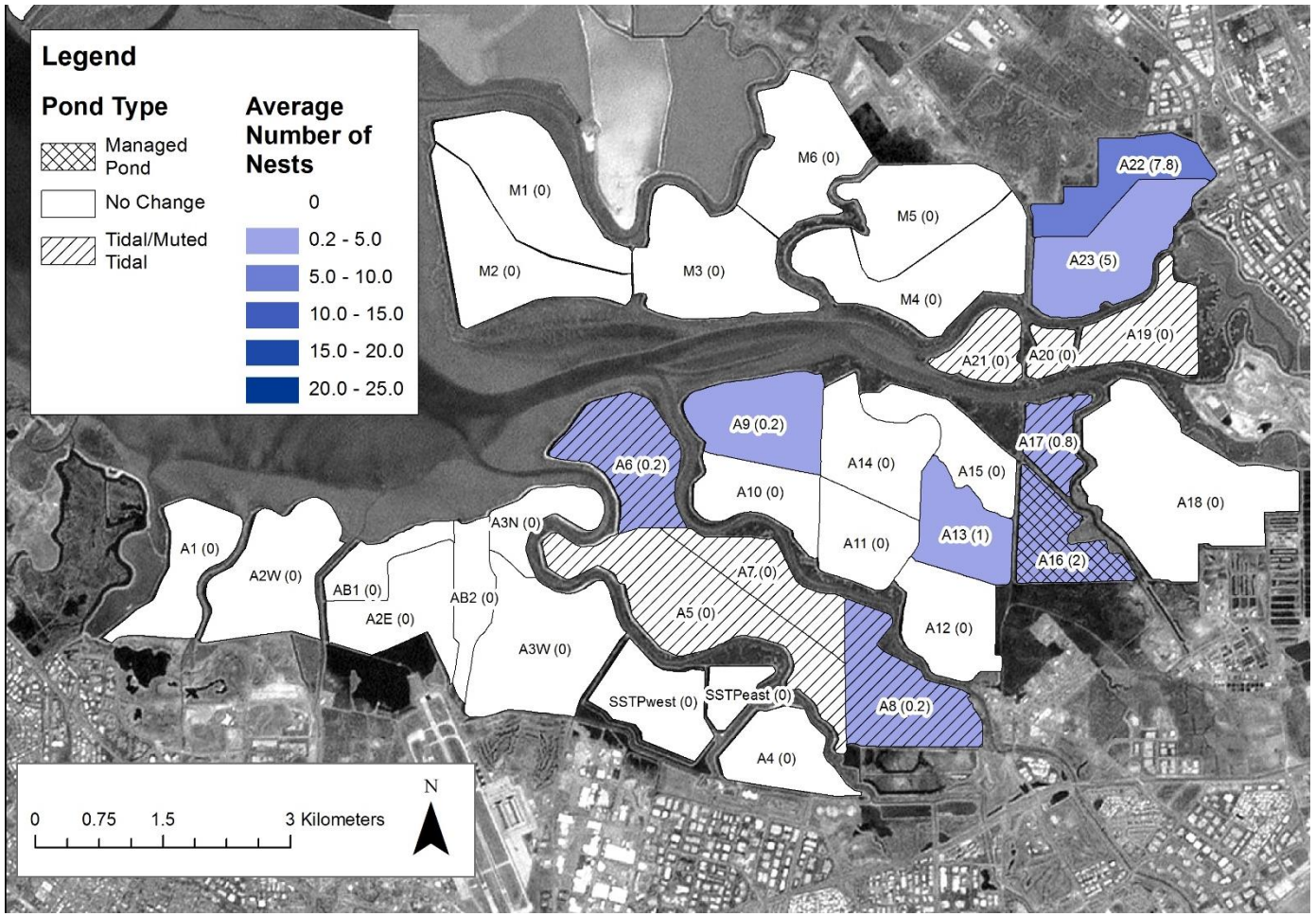

Figure 15. Average number of Snowy Plover nests initiated by pond in the Alviso Complex, South San Francisco Bay, California from 2009-2013. The purpose of this figure is to illustrate which ponds have supported Snowy Plover nesting activity in recent years, and of these, which ponds are included in Phase 1 restoration plans of the South Bay Salt Pond Restoration Project. Diagonal lines denote ponds that have been returned to tidal influence, hatch lines denote ponds that are (or will be) managed for multiple species and the amount of available to Snowy Plovers will be reduced, and solid colors denote ponds that will not be directly affected by Phase 1 actions. The gradient shading denotes the average number of plover nests on the pond and that number is shown in parenthesis after the pond name. Note that Snowy Plovers did not start nesting on ponds A16 and A17 until they were drained for construction; they were not historically nesting ponds.

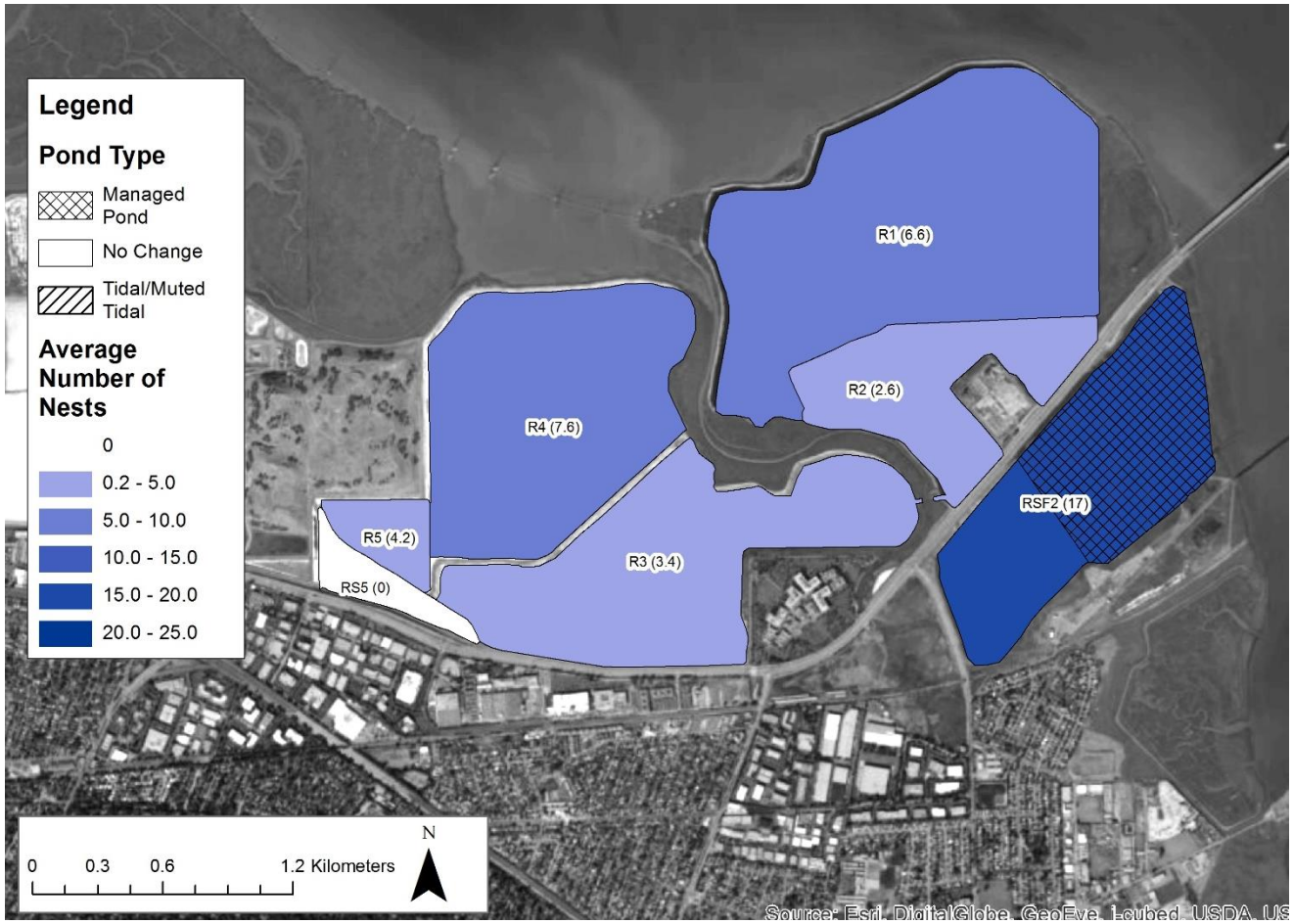

Figure 16. Average number of Snowy Plover nests initiated by pond in the Ravenswood Complex, South San Francisco Bay, California from 2009-2013. The purpose of this figure is to illustrate which ponds have supported Snowy Plover nesting activity in recent years, and of these, which ponds are included in Phase 1 restoration plans of the South Bay Salt Pond Restoration Project. Crossed hatch lines denote ponds that are managed for multiple species and the amount of available to Snowy Plovers will be reduced, and solid colors denote ponds that will not be directly affected by Phase 1 actions. The gradient shading denotes the average number of plover nests on the pond and that number is shown in parenthesis after the pond name.

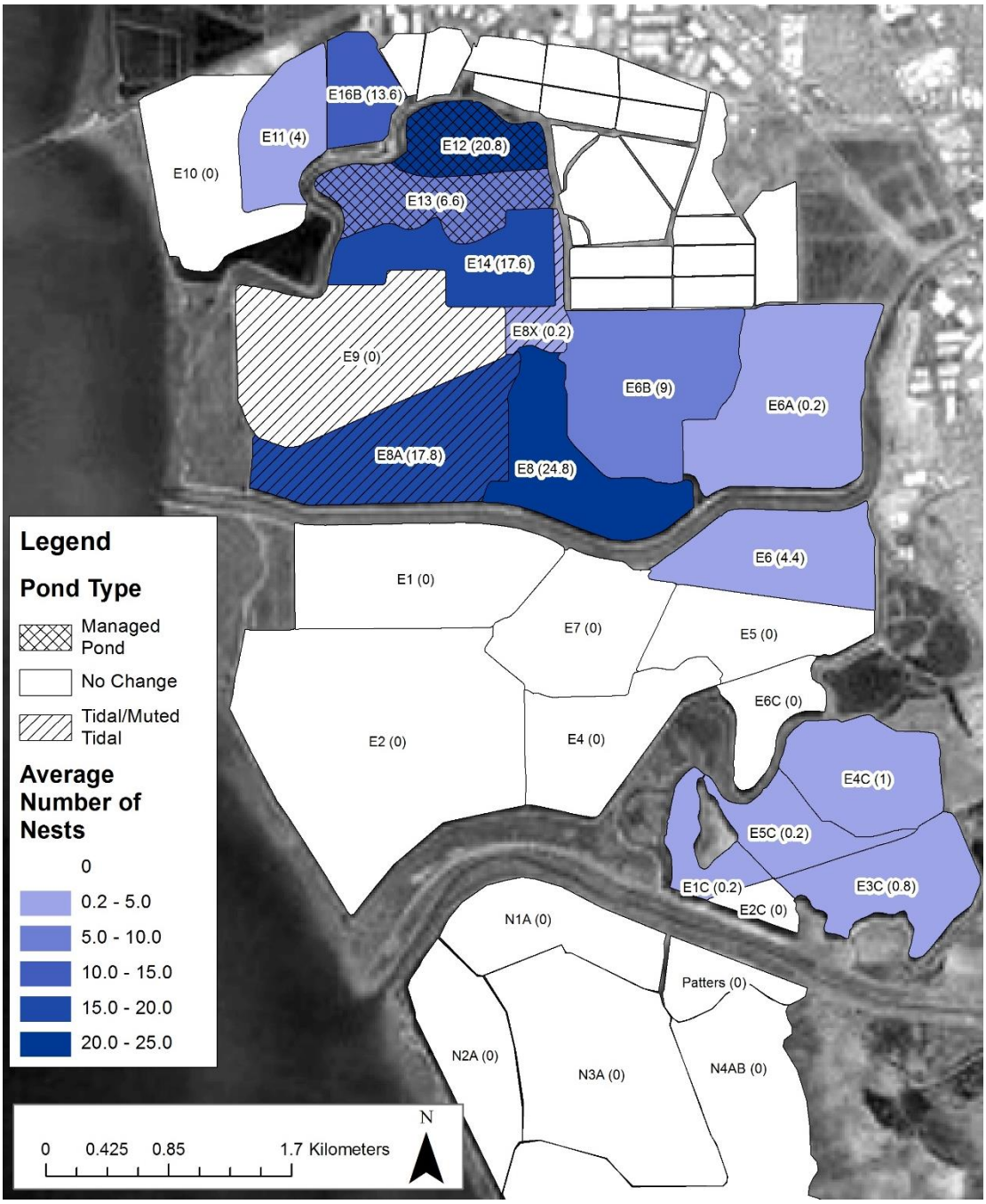

Figure 17. Average number of Snowy Plover nests initiated by pond in the Eden Landing Ecological Reserve, South San Francisco Bay, California from 2009-2013. The purpose of this figure is to illustrate which ponds have supported Snowy Plover nesting activity in recent years, and of these, which ponds are included in Phase 1 restoration plans of the South Bay Salt Pond Restoration Project. Diagonal lines denote ponds that have been returned to tidal influence, crossed hatch lines denote ponds that are managed for multiple species and the amount of available to Snowy Plovers will be reduced, and solid colors denote ponds that will not be directly affected by Phase 1 actions. The gradient shading denotes the average number of plover nests on the pond and that number is shown in parenthesis after the pond name.

Table 1. Ponds surveyed weekly within the Don Edwards San Francisco Bay National Wildlife Refuge, South San Francisco Bay, California, 2013.

Location	Ponds
Alviso	A9, A12, A13, A15, A16, Impoundment, New Chicago Marsh
Ravenswood	R1, R2, R3, R4, R5, SF2
Warm Springs	A22, A23
Dumbarton	N1, NPP1, N2, N3

Table 2. Ponds surveyed weekly within California Department of Fish and Wildlife's Eden Landing Ecological Reserve, San Francisco Bay, California, 2013.

Location	Ponds
Eden Landing Ecological Reserve	E6, E6A, E6B, E8, E8X, E11, E12, E13, E14, E15B, E16B, E1C, E2C, E3C, E4C, E5C

Table 3. Additional areas surveyed in the San Francisco Bay, California, 2013. These areas were surveyed less often than our weekly surveys or were surveyed by biologists from different agencies.

Location	Land Owner
Oliver Brother's ponds	Hayward Area Recreation and Park District
Least Tern Island	East Bay Regional Park District
Crittenden Marsh	Midpeninsula Regional Open Space District
Napa-Sonoma Marshes Wildlife Area	7, 7A *SFBBO volunteer surveys once a month

Table 4. The daily survival rates for Snowy Plover nests within shell plots and outside of shell plots at Eden Landing Ecological Reserve, San Francisco Bay, California, 2009-2013.

			Confidence Limits			Confidence Limits	
year	Treatment	Daily Survival Rates	DSR Upper 95%	DSR Lower 95%	Nest Success	NS Upper 95%	NS Lower 95%
2009	No shells	0.959	0.995	0.745	0.255	0.842	0.000
	Shells	0.985	0.999	0.749	0.598	0.976	0.000
2010	No shells	0.943	0.981	0.844	0.146	0.530	0.004
	Shells	0.956	0.991	0.811	0.225	0.739	0.001
2011	No shells	0.963	0.988	0.887	0.284	0.679	0.019
	Shells	0.985	0.998	0.917	0.617	0.925	0.056
2012	No shells	0.956	0.993	0.767	0.225	0.793	0.000
	Shells	0.979	0.999	0.728	0.493	0.960	0.000
2013	No shells	0.983	0.997	0.914	0.567	0.901	0.051
	Shells	0.988	0.999	0.820	0.679	0.979	0.001

Table 5. Number of Western Snowy Plovers observed in Recovery Unit 3, (San Francisco Bay, California) sites during annual breeding window surveys in May 2005-2013.

Region	Site	2005	2006	2007	2008	2009	2010	2011	2012	2013
Alameda	Baumberg/Eden Landing	91	84	162	94	88	184	185	82	97
	Coyote Hills	0	0	0	0	0	0	0	0	0
	Dumbarton	0	0	2	0	0	0	0	0	0
	Hayward	0	0	0	1	4	12	8	9	32
	Warm Springs	23	7	0	3	14	27	17	3	1
Napa	Napa	0			0	12	10	1	0	3
San Mateo	Ravenswood/West Bay	3	3	23	24	21	42	27	33	59
Santa Clara	Alviso	7	8	20	11	8	0	11	20	10
Total Unit 3		**124**	**102**	**207**	**133**	**147**	**275**	**249**	**147**	**202**

Table 6. Snowy Plover nest fates by pond in the South San Francisco Bay, California, 2013.

Location	Hatched	Depredated	Abandoned	Flooded	Unknown	Other	Total nests
Alviso							
New Chicago Marsh	0	1	0	0	0	0	**1**
A9	1	0	1	0	0	0	**2**
A12	0	0	0	0	0	0	**0**
A13	0	0	0	0	0	0	**0**
A15	0	0	0	0	0	0	**0**
A16	2	2	1	1	0	0	**6**
Alviso Impoundment	1	0	0	0	0	0	**1**
Eden Landing							
E6A	0	0	0	0	0	0	**0**
E6B	0	0	0	0	0	0	**0**
E8	7	9	0	0	0	0	**16**
E12	33	13	3	0	0	0	**49**
E13	10	10	1	0	0	0	**21**
E14	27	6	0	0	0	0	**33**
E16B	4	0	0	0	0	0	**4**
E11	0	0	0	0	0	0	**0**
E6	1	0	0	0	0	0	**1**
E4C	0	1	0	1	0	0	**2**
Ravenswood							
R1	12	0	0	0	0	0	**12**
R2	4	3	0	0	0	0	**7**
R3	0	0	0	0	0	0	**0**
R4	6	0	0	0	0	0	**6**
R5	0	0	0	0	0	0	**0**
RSF2	3	3	0	0	0	0	**6**
Warm Springs							
A22	0	5	0	0	0	0	**5**
A23	0	2	0	0	0	0	**2**
Hayward Shoreline	0	1	0	0	0	0	**0**
Total South Bay	**111**	**55**	**6**	**2**	**0**	**0**	**174**
Napa Plant Site and Pond 7/7A	2	0	0	0	0	0	**2**
RU3 Total	**113**	**55**	**6**	**2**	**0**	**0**	**176**

Table 7. Snowy Plover apparent nest densities (nest/ha) by pond on Refuge property in the South San Francisco Bay, California, 2013. **The nest densities should be viewed with caution since the area used to calculate the densities represent only a rough gauge of potentially available nesting habitat.**

Location	Nest/ha
A16	0.06
R1	0.07
R2	0.11
R3	0.00
R4	0.05
R5	0.00
SF2	0.06
A22	0.05
A23	0.01

Table 8. Snowy Plover apparent nest densities (nests/ha) by pond at Eden Landing Ecological Reserve in the South San Francisco Bay, California, 2013. **The nest densities should be viewed with caution since the area used to calculate the densities represent only a rough gauge of potentially available nesting habitat.**

Location	Nest/ha
E8	0.22
E12	1.16
E13	0.36
E14	0.52
E16B	0.12
E6	0.01
E4C	0.03

Table 9. Apparent fledging success (all sites combined) of Snowy Plover chicks in the South San Francisco Bay, California, 2008-2013. Chicks were considered fledged if they survived to 31 days. *N* is the number of chicks banded.

Year	Fledging Success	*N*
2008	29%	83
2009	25%	113
2010	41%	39
2011	14%	36
2012	50%	8
2013	36%	14

Table 10. The number of nests in each shell plot at Eden Landing Ecological Reserve in the South San Francisco Bay, California, 2009-2013.

			2009	2010	2011	2012	2013
Pond	Shell Plot	Year shells spread	Total nests	Total nests	Total nests	Total nests	Total nests
E16B	1	2008	5	5	4	2	1
	2	2008	8	5	2	0	1
	3	2008	2	0	0	0	0
E14	1	2009	-	0	0	0	1
	2	2009	-	0	0	0	1
	3	2009	-	0	0	3	3
E8	1	2008	7	11	7	2	1
	2	2008	0	2	2	1	1
	3	2010	-	-	8	6	0
	4	2010	-	-	3	0	1
E6B	1	2008	2	7	1	1	0
	2	2009	-	12	2	0	0
	3	2009	-	0	1	0	0
	4	2010	-	-	5	2	0
E6A	1	2008	0	0	0	0	0
Totals			**24**	**42**	**34**	**17**	**10**

Table 11. Number of nests monitored, apparent nest fates, and apparent nest densities for control plots, shell plots, and all other areas at Eden Landing Ecological Reserve in the South San Francisco Bay, California, 2009-2013.

	2009			2010			2011		
	Control Plot	Shell Plot	All Other ELER	Control Plot	Shell Plot	All Other ELER	Control Plot	Shell Plot	All Other ELER
Number of plots	7	7	-	12	12	-	15	15	-
Nests monitored	0	24	66	3	42	97	3	34	127
Nest density (nests/ha)	0	3.43	0.07	0.25	3.5	0.1	0.2	2.26	0.19
Observed hatched	0	67%	56%	0%	31%	32%	33%	45%	42%
Observed depredated	0	13%	44%	100%	64%	66%	66%	43%	54%

	2012			2013		
	Control Plot	Shell Plot	All Other ELER	Control Plot	Shell Plot	All Other ELER
Number of plots	15	15	-	15	15	-
Nests monitored	5	17	127	1	10	117
Nest density (nests/ha)	0.33	1.13	0.09	0	0.6	0.21
Observed hatched	40%	47%	19%	0	66%	65%
Observed depredated	40%	47%	25%	0	33%	30%

Table 12. The average number of potential predators observed per survey at the Ravenswood Complex, South San Francisco Bay, California, March-August 2013. Data are presented at the pond scale. Only species with averages > 0 for at least one location are listed.

	Average number of predators observed per survey						
Species	R1	R2	R3	R4	R5	R5S	RSF2
American Crow	0.0	0.3	1.8	0.1	0.2	0.0	1.3
Black-crowned Night-Heron	0.0	0.0	0.1	0.0	0.0	0.0	0.5
California Gull	0.0	0.0	0.0	0.1	0.0	0.0	7.1
Common Raven	0.0	0.0	0.5	0.8	0.0	0.0	0.3
Glaucous-winged Gull	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Great Blue Heron	0.1	0.0	0.0	0.0	0.0	0.0	1.7
Great Egret	0.2	0.0	0.2	0.1	0.6	1.0	6.1
Northern Harrier	0.2	0.0	0.0	0.2	0.0	0.0	0.0
Peregrine Falcon	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Red-tailed Hawk	0.2	0.2	0.0	0.2	0.0	0.0	0.1
Ring-billed Gull	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Snowy Egret	1.4	0.0	0.1	0.4	1.4	1.0	8.7
Unidentified Gull	44.8	0.2	4.5	14.0	0.1	0.0	10.3
Western Gull	0.0	0.0	0.0	0.0	0.0	0.0	0.1
White-tailed Kite	0.2	0.0	0.0	0.1	0.0	0.0	0.1
Number of surveys	12	6	16	14	9	1	18

Table 13. The average number of potential predators observed per survey at the Alviso Complex, South San Francisco Bay, California, March-August 2013. Data are presented at the pond scale. Only species with averages > 0 for at least one location are listed.

	Average number of predators observed per survey								
Species	A16	A17	A12	A13	A14	A15	A9	IMPOUNDMENT	New Chicago Marsh
American Coot	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
American Crow	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.2
Black-crowned Night-Heron	1.9	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1
California Gull	16.5	0.0	71.2	22.9	0.0	9.2	355.6	0.0	0.1
Common Raven	1.3	0.0	0.4	2.0	0.0	3.1	0.3	0.0	0.3
Great Blue Heron	1.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
Great Egret	4.6	0.0	0.1	0.0	0.0	0.2	1.3	0.0	0.2
Herring Gull	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Northern Harrier	0.1	0.0	0.2	0.1	0.0	0.1	0.2	0.0	0.0
Peregrine Falcon	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.1
Ring-billed Gull	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Snowy Egret	7.0	0.0	0.3	0.0	0.0	0.4	1.0	0.0	0.2
Unidentified Gull	513.5	0.0	539.3	249.1	2.0	374.5	2630.8	16.4	20.9
Number of surveys	24.0	24.0	21.0	22.0	1.0	21.0	9.0	5.0	16.0

Table 14. The average number of potential predators observed per survey at Warm Springs, South San Francisco Bay, California, March-August 2013. Data are presented at the pond scale. Only species with averages > 0 for at least one location are listed.

	Average number of predators observed per survey	
Species	A22	A23
American Crow	4.8	1.3
American Kestrel	0.1	0.0
Barn Owl	0.1	0.0
California Gull	0.4	0.0
Domestic cat	0.2	0.0
Common Raven	4.6	4.0
Great Egret	0.1	0.0
Northern Harrier	0.2	0.0
Peregrine Falcon	0.0	0.1
Red-tailed Hawk	0.4	0.0
Unidentified Gull	27.7	1.5
Number of surveys	20	20

Table 15. The average number of potential predators observed per survey at Eden Landing Ecological Reserve, South San Francisco Bay, California, March-August 2013. Data are presented at the pond scale. Only species with averages > 0 for at least one location are listed.

	Average number of predators observed per survey																	
Species	E1C	E2C	E3C	E4C	E5C	E10	E11	E14B	E15B	E16B	E6	E6A	E6B	E8	E12	E13	E14	E8X
American Crow	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.7	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.5	0.0
American Kestrel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Black-crowned Night-Heron	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
California Gull	0.1	0.0	0.1	0.0	0.1	0.7	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Domestic cat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Common Raven	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cooper's Hawk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Great Blue Heron	0.1	0.1	0.1	0.0	0.0	0.5	0.0	0.1	0.0	0.1	0.2	0.3	1.3	0.4	0.0	0.2	0.0	0.3
Great Egret	0.1	0.6	1.1	0.1	0.1	3.8	2.2	0.1	0.1	0.7	0.7	2.1	1.8	1.2	0.0	0.0	0.3	1.5
Herring Gull	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Northern Harrier	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.2	0.0	0.0
Peregrine Falcon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.3	0.2	0.0
Red-tailed Hawk	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.7	0.1	0.2	0.2	0.2	0.0	0.0
Ring-billed Gull	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Snowy Egret	1.2	0.7	0.4	0.0	0.1	1.1	2.0	0.3	0.1	0.9	1.1	20.6	4.7	1.3	0.0	0.0	0.7	2.2
Unidentified Egret	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified Gull	4.2	1.7	6.0	61.7	81.1	9.0	55.3	0.0	0.0	0.6	4.4	10.2	50.7	1.8	0.0	0.0	0.0	0.3
Western Gull	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
White-tailed Kite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Number of surveys	22	22	22	22	22	21	21	21	21	21	29	29	29	29	6	6	6	6

Table 16. The average number of potential predators observed per survey at Hayward Shoreline sites (1-15), South San Francisco Bay, California, March-August 2013. Data are presented at the pond scale. Only species with averages > 0 for at least one location are listed.

	Average number of predators observed per survey														
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
California Gull	2.8	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Common Raven	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
Western Gull	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Number of surveys	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

Table 17. The average number of potential predators observed per survey at Napa ponds 7/7A, North San Francisco Bay, California, March-August 2013. Data are presented at the pond scale. Only species with averages > 0 for at least one location are listed.

Species	Average number of predators observed per survey 7/7A
American Crow	0.5
Common Raven	1.5
Glaucous-winged Gull	0.5
Great Blue Heron	0.5
Great Egret	5.8
Northern Harrier	1.8
Red-tailed Hawk	2.0
Snowy Egret	6.5
Unidentified Gull	0.5
White-tailed Kite	0.8
Number of surveys	4