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Western Snowy Plover Monitoring in the San Francisco Bay

Annual Report 2012

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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 2012 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 21-28), we counted 147 adult Snowy Plovers in the San Francisco Bay. Over the course of the breeding season (March-September), we documented 138 plover nests in Recovery Unit 3. We determined the fate of all nests 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 58%. Remaining nests failed due to predation (40%), abandonment (<1%), non-viable eggs (<1%), and flooding (<1%). We summarize 2012 nesting activity by pond complex or management unit below:

On Refuge property, we determined the fate of 13 nests in the Alviso Complex (ponds A16-17, A13) and 34 nests in the Ravenswood Complex (ponds SF2, R1-5). Apparent nest success was 100% and 74% in the Alviso and Ravenswood complexes, respectively. We did not find any plover nests in the Warm Springs complex (ponds A22-23) in 2012.

We found the majority of Snowy Plover nests in Recovery Unit 3 at CDFW's Eden Landing Ecological Reserve (Eden Landing). We determined the fate of 85 nests and found that apparent nest success was 44%. Fifty-three percent of nests were lost to predation.

EBRPD reported that there were three Snowy Plover nests on the California Least Tern (*Sterna antillarum browni*) island at Hayward Shoreline. Two of these nests hatched, and the third was depredated by an unknown predator (D. Riensche, pers. comm.).

CDFW biologists found and monitored three plover nests at the Napa-Sonoma Marshes Wildlife Area in the North Bay. All three nests hatched (K. Taylor, pers. comm.).

Since apparent nest success can be unreliable (i.e., positively biased when unsuccessful nests are less likely to be found than successful nests) and difficult to interpret, we plan to conduct more rigorous nest survival analyses in the future. These analyses will use Program MARK to explore factors affecting Snowy Plover nest survival and will incorporate nesting data from past years of study (2003-present).

Throughout the South Bay, we banded eight chicks. From band re-sighting, we determined that at least four of these chicks survived to fledging (31 days post-hatching) as of September 30, 2012. Given the small sample size, we lack meaningful measures of fledging success.

During avian predator surveys, we counted California Gulls (*Larus californicus*) and unidentified gulls (*Larus* spp.) 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.) 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 Ecological Reserve. Enhancements consisted of oyster shells spread by hand at densities of 5-8 shells/m^2 over fifteen 1-ha plots. In 2012, we documented more plover nests in shell plots than in control plots (shell plots: 17 nests, control plots: 5 nests), which is consistent with findings of previous years. Preliminary examination of nest survival data from 2009-2012 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 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 2003-2012, 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 predators of Snowy Plover nests and chicks through avian predator surveys and remote cameras (the camera study was concluded in 2011), 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 small plover chicks.

In this report, we summarize results from the 2012 breeding season, including Snowy Plover surveys and habitat use, nest (hatching) success, fledging success, habitat enhancement studies, and avian predator surveys.

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 (Fig. 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) (Fig. 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. For this study, we divided the Refuge into six geographic locations: Warm Springs, Alviso, Ravenswood, Coyote Hills, Dumbarton, and Mowry (Figs. 1, 3-5).

CDFW owns and manages Eden Landing (formerly known as Baumberg), which includes approximately 5,500 acres of former salt ponds, marsh, and tidal habitat (Fig. 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 (Fig. 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) (Fig. 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.

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, 2012, SFBBO and Refuge 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 14 Refuge ponds and 16 Eden Landing ponds weekly (Tables 1-2). SFBBO volunteers surveyed the Dumbarton, Napa-Sonoma Marshes Wildlife Area, and HARD ponds monthly. 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.

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, given that no other information was available.

Chick Color Banding

Beginning in 2008 and continuing through the 2012 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. 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 2009-2012. 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 MARK (White and Burnham 1999, Dinsmore et al. 2002).

Nest Survival Models. Following Dinsmore et al. (2002), we developed a set of 22 candidate models *a priori*. These models were based on the hypothesized effects of year (2009-2012), shell enhancements (whether or not a nest was located in a shell plot or elsewhere), daily nest age, and linear and quadratic seasonal time trends on daily nest survival and various additive combinations of these factors (Table 3); we did not consider interactions. We also included a null model without main effects or covariates that assumed constant daily nest survival (Table 3). We used a 33-day initiation and incubation period (Warriner et al. 1986). We limited this analysis to nests initiated within the Eden Landing Ecological Reserve from 2009-2012 with complete encounter histories (N = 457 nests).

Following Burnham and Anderson (2002), we used an information-theoretic approach for model selection based on Akaike's Information Criterion corrected for small sample size (AIC_c). We considered the model with the lowest AIC_c to be the most parsimonious (best) model. To account for model selection uncertainty, we used Akaike weights (w_i) to gauge the strength of evidence in support of a given model. We also assessed relative variable importance by summing Akaike weights across all models incorporating that variable in the candidate set (Burnham and Anderson 2002).

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 (Tables 1-2). 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*), 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*), 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.

RESULTS

Snowy Plover Surveys

South Bay Overall. During the 2012 Pacific Coast breeding season window survey (May 21-28), we counted 147 adult Snowy Plovers in the Bay. This represents the lowest breeding window count recorded for Recovery Unit 3 in three years (Table 4). We observed a mean of 141 birds per week from March 4 through August 26 in the entire South Bay. We consistently observed

the greatest numbers of Snowy Plovers at Eden Landing (Table 4, Fig. 7). We documented plover nesting activity at 16 South Bay ponds (Fig. 8).

Refuge. On the Refuge, we observed the most Snowy Plovers at Ravenswood pond R1 throughout the season. We documented a mean of 34 Snowy Plovers per week from March 4 through August 26 on Refuge property.

During monthly surveys of Cargill salt ponds, we recorded only a single sighting (on March 19) of two Snowy Plovers roosting on an island at pond NPP1 in the Dumbarton Complex. We did not observe any Snowy Plovers in the Coyote Hills and Mowry complexes this season.

Eden Landing. We observed the most Snowy Plovers throughout the season at Eden Landing (Fig. 7a), with a mean of 82 birds observed per week from March 4 through August 26. Ponds E8, E13, and E14 consistently supported large numbers of Snowy Plovers. In late July and early August, we observed particularly large flocks (weekly counts of 193-205 birds) (Fig. 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 only 77.

Nest Abundance and Success

South Bay Overall. In 2012, we determined the fate of 135 Snowy Plover nests in the South Bay. Of these, 77 nests hatched (apparent nest success = 57%), 55 nests were depredated (41%), one was abandoned (<1%), one was flooded (<1%), and one failed due to non-viable eggs (<1%) (Table 5, Fig. 9). We found fewer nests in the South Bay in 2012 (135 nests) compared to recent years (2009: 163 nests, 2010: 243 nests, 2011: 224 nests). Predation was the most common source of nest failure (Fig. 9), which is consistent with findings from previous years.

Refuge. In 2012, SFBBO determined the fate of 47 Snowy Plover nests on Refuge property (Table 5). We did not find any nests in the Warm Springs Complex, in pond A8, or in New Chicago Marsh. We determined the fate of 13 nests in the Alviso Complex (in ponds A16, A17, and A13), all of which hatched (Table 5). We determined the fate of 34 nests in the Ravenswood Complex. Of these, 25 hatched (74%) and nine were depredated (26%). We found the most nests on pond R1 (12 nests; Table 5).

Eden Landing. We determined the fate of 85 Snowy Plover nests at Eden Landing. Of these, 37 hatched (44%), 45 were depredated (53%), one was abandoned (1%), one was flooded (1%), and one nest failed due to non-viable eggs (1%) (Table 5). Pond E14 had the most nests (42 nests), followed by ponds E13 (17 nests) and E8 (16 nests) (Table 5).

Hayward Shoreline. EBRPD reported that there were three Snowy Plover nests on the Least Tern Island at HARD. Two of these nests hatched, while the third was depredated by an unknown predator (D. Riensche, pers. comm.; Table 5).

Napa-Sonoma Marshes Wildlife Area. CDFW biologists found and determined the fate of three nests in the Napa Plant Site and pond 7/7A, all of which hatched (K. Taylor, pers. comm.; Table 5).

Nest Density and Breeding Chronology

Overall, average apparent nest density in the South Bay (across all ponds with dry panne) was 0.10 nests per hectare. We documented the highest apparent nest density in pond E14, at 0.67 nests/ha, while many other ponds did not support any known nests in 2012 (see Tables 6-7).

While we recorded the highest number of nests initiated during the week of April 22 (17 nests), there was not a clear peak in initiation dates this year. Initiation levels remained similarly low and relatively constant through mid-July (Fig. 10).

The number of active nests peaked during the week of June 10 (60 nests). We observed several smaller peaks in late June and mid-July (Fig. 10).

Chick Fledging Success

We banded eight Snowy Plover chicks at Eden Landing in 2012 and determined that four chicks fledged (Table 8). Apparent fledging success (all sites combined) was 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 7). 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 2012 breeding season. We spread 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 2009-2012, we documented high apparent nest densities in the shell plots compared to control plots (Table 9). In 2012, we found a total of 17 nests in the shell plots and only five nests in the control plots. Apparent nest densities were 1.13 nests/ha in the shell plots, 0.33 nests/ha in the control plots, and 0.09 nests/ha in all other areas of Eden Landing combined (Table 9).

Given the small sample size of nests within control plots, we also report apparent nest success for all nests outside of shell plots at Eden Landing. In 2012, apparent nest success in the shell plots was 47%, whereas apparent nest success was 40% in the control plots and 19% elsewhere at Eden Landing (Table 9).

Nest Survival Models. We found evidence that many factors affected Snowy Plover nest survival from 2009-2012 at Eden Landing. The best-supported model indicated that daily nest survival (DSR) was a function of shell enhancements, year, a quadratic seasonal time trend, and nest age (Table 3). This model had an Akaike weight of 0.73 and an AIC_c value of 1073.50, the latter of which was more than two AIC_c units lower than the second-ranked model. The second-ranked model had an Akaike weight of 0.25 and included all of the same variables except year. Relative variable weights were similarly high for shells (1.00), year (0.75), a quadratic seasonal time trend (1.00), and daily nest age (0.98), underscoring their strong predictive power.

The logistic regression equation for the best model was:

$$\text{logit}(\hat{S}_i) = 5.95 + 0.76(\text{shells}) + 0.34(\text{year1}) - 0.21(\text{year2}) + 0.08(\text{year3}) - 0.09T + 0.00TT + 0.03(\text{age})$$

(1SE) (0.81) (0.17) (0.23) (0.20) (0.20) (0.02) (0.00) (0.01)

The signs of the β_i terms indicate that DSR increased with daily nest age and was positively associated with the presence of shells. Similarly, the negative quadratic term reflects temporal variation in nest survival over the nesting season. While year effects received strong support, the standard errors were relatively large, and the 95% confidence intervals for those β_i terms included zero.

To better illustrate these relationships, we input selected values for each variable into the logistic regression equation for the best model using the user-specified covariate feature of Program MARK. We plotted curves showing Snowy Plover DSR over the course of the season in 2012 for a newly initiated nest ("young nest", holding nest age = 1) and a nest at hatching stage ("old nest", holding nest age = 33), both with and without shell enhancements (Fig. 11). We found that DSR progressively dropped until mid-May, and then rose steadily, peaking at the end of the nesting season. When nest age was held constant at one, nests with shell enhancements had considerably higher DSR than nests without shells, though these differences were small early and late in the nesting season. When nest age was held constant at 33, we again saw a u-shaped curve (though the midseason drop in DSR was less pronounced), with DSR slightly higher for nests with shell enhancements than nests without shells. We observed similar patterns in all study years considered (2009-2012).

To further demonstrate the magnitude of these differences at their extremes, we selected May 10, 2012 (the approximate vertex of the quadratic curves) and calculated cumulative 33-day survival probabilities (nest success estimates) for both young and old nests with and without shells. On May 10, 2012, success of a young nest with shells was 75% compared to 54% for a young nest without shells. Similarly, the success of an old nest with shells was 88% compared to 77% for an old nest without shells.

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 (Tables 10-12). Raptors, corvids, and wading birds were also present in many areas. In Alviso, we frequently observed Common Ravens in ponds A16 and A17 as well as Great and Snowy egrets and Red-tailed Hawks throughout much of the complex (Table 11). 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 10). California Gulls attempted to nest on the newly-created waterbird islands at SF2 this spring, but biologists were able to deter them through regular hazing during the nest initiation period (Robinson-Nilsen and Demers 2012). At Warm Springs, we observed large numbers of gulls, Common Ravens, and American Crows (Table 12).

Eden Landing. The most abundant potential avian predators at Eden Landing were California Gulls and unidentified gulls (Table 13). We also observed many Snowy and Great egrets feeding in the sloughs and in pond E9.

In 2012, Great Blue Herons again nested on a former hunting blind in E6B, referred to as the "heron house". They may also have nested on former hunting blinds in E9 and E14, but access to this area was limited this season due to restoration activity. A pair of Peregrine Falcons nested on one of the E9 blinds, and we regularly observed falcons perched or actively hunting on ponds E12-14 on most plover surveys.

Hayward Shoreline. We observed low numbers of potential predators at Hayward Shoreline, including California Gulls, Common Ravens, and Red-tailed Hawks (Table 14).

Napa-Sonoma Marshes Wildlife Area. We observed California Gulls, Common Ravens, Great Egrets, Northern Harriers, Peregrine Falcons, and Red-tailed Hawks at the Napa-Sonoma Marshes Wildlife Area (Table 15).

Mammalian Predators

We observed Gray Foxes (*Urocyon cinereoargenteus*), skunks (*Spilogale gracilis*, *Mephitis mephitis*), raccoons (*Procyon lotor*), opossums (*Didelphus virginiana*), 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 2012 breeding season.

DISCUSSION

Snowy Plover Surveys

We counted 147 Snowy Plovers in the Bay during the May breeding window survey. This represents the lowest breeding window count recorded for Recovery Unit 3 in three years. 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

Overall, we found considerably fewer nests in the South Bay in 2012 (135 nests) compared to recent years (2009: 163 nests, 2010: 243 nests, 2011: 224 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 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, and future analyses are planned to more rigorously examine factors affecting plover nest survival across pond complexes and study years in Program MARK. The latter approach addresses many of the issues associated with the apparent estimator (Dinsmore et al. 2002, Jehle et al. 2004). Nevertheless, it is already clear that many plover nests were lost to predation in 2012 (and in other 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 2012, Snowy Plovers nested on nine Refuge ponds. We found no nests at Warm Springs in 2012 (13 nests in 2011), though it is possible that some nests were depredated early in incubation and went undetected at this location (K. Tokatlian, pers. obs.). Nests in this complex experienced heavy predation in 2011. These ponds are located between the Newby Island Landfill and the Tri-Cities Landfill; large numbers of gulls and corvids fly between the landfills during the day and roost nearby. During the breeding season, approximately 10,294 adult California Gulls nested on Mowry ponds M1/M2, M3, and M4/M5, which are adjacent to Warm Springs (Fig. 1; Robinson-Nilsen and Demers 2012). 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 plovers nesting at A16, A17, and A13 early in the season but found no nests at New Chicago Marsh; however, one observer spotted a two-week old chick late in the

season at New Chicago Marsh, suggesting possible nesting. In 2011, plovers nested exclusively at New Chicago Marsh (6 nests) in the Alviso area. The draining and drying of ponds A16, A17, and A13 prior to the breeding season in 2012 likely made them attractive for nesting plovers. A16 and A17 were kept dry for construction and restoration activities; these ponds will be re-flooded (A16) or become tidal (A17) and will not be available as open panne habitat for nesting plovers in the future. Adjacent A13 was drawn down to specifically to provide alternative nesting habitat for plovers and other nesting waterbirds. This approach seemed to work well as five plover nests were recorded at A13 in 2012.

At Eden Landing, Snowy Plovers nested on six ponds, with the majority of nesting occurring on ponds E8, E13, and E14. All of these areas experienced high nest predation. In 2011, ponds E8A and E12 also supported large numbers of plovers (60 nests and 20 nests, respectively), but these areas did not provide dry pond substrate in 2012 for nesting plovers since E8A was recently converted to tidal influence, and E12 was managed with higher water levels.

CDFW reported that there were three Snowy Plover nests this season in the Napa-Sonoma Marshes Wildlife Area. This is the fourth year that the number and fate of nests were documented for the North Bay ponds; CDFW reported four nests in 2011. 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 eight chicks. From band re-sighting, we determined that at least four chicks of the eight banded survived to fledging. We banded fewer chicks this season compared to recent years due to a combination of factors: 1) fewer nests were initiated and nest predation rates were high, resulting in few "available" chicks for banding and 2) SFBBO experienced some staff turnover during the peak hatching period, so staffing constraints contributed somewhat to the lower banding effort.

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.

Oyster Shell Habitat Enhancements

Apparent Estimates. In 2012, as in previous years of study, we documented higher apparent nest densities in shell plots (1.13 nests/ha) compared to control plots (0.33 nests/ha). Apparent nest success was also slightly higher in shell plots (47%) compared to control plots (40%) and other areas of Eden Landing (19%) this season. While we could attempt to correct apparent densities by taking exposure days into account, there are additional limitations that are not easily addressed. For example, the acreage (in hectares) used to generate densities represents the total pond area or plot size, and is not very meaningful given that water management regimes, construction activities, and weather patterns varied over the course of the season, often changing the amount of wet and dry substrate available within and between ponds and plots. Similarly, plover nest-site selection criteria were not explicitly studied. The brightness of the shells also varied 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. While we were not able to address some of the above limitations in the current study, we chose to move beyond the apparent estimates and to examine factors affecting Snowy Plover nest survival, including oyster shell habitat enhancements, using Program MARK. At Eden Landing from 2009-2012, we found that nest survival was a complex function of many factors (shell enhancements, year, a quadratic seasonal time trend, and daily nest age). Once we controlled for other factors, there was some evidence that shells enhanced hatching success, perhaps because of the increased camouflage or topographic relief that they provide. The benefits of shells were most pronounced for young (newly-initiated) nests in the middle of the breeding season. For a species that relies heavily on crypticity, it may be that plover nests in the "riskiest" locations are discovered rapidly (soon after initiation) by predators (Klett and Johnson 1982) and that predator activity is highest during the core of the plover nesting season. As nests age, the presence of the incubating adult may also serve as a deterrent to egg predators, either due to near-constant nest attendance and/or the effectiveness of distraction displays when birds are flushed from the nest (see Klett and Johnson 1982).

We view these nest survival results as preliminary since we considered only a subset of the data and plan to conduct future analyses that incorporate additional covariates of interest. A fundamental assumption of the current analysis is that researcher visitation did not influence nest fates (Dinsmore et al. 2002). While we made considerable efforts to minimize our impacts on nesting Snowy Plovers (by limiting time spent searching for nests or broods in any particular area, visiting nests infrequently, avoiding nest-marking, using alternate routes to nests to reduce footprint trails), we recognize that some waterbird studies have documented increased predation rates due to human disturbance (e.g., Kury and Gochfeld 1975, Ahlund and Gotmark 1989, Keller 1991). Alternatively, birds may habituate to some types of disturbance (Nisbet 2000), and researcher presence may actually reduce predation pressure in certain situations (Kress and Hall 2002, Donehower et al. 2007). Whether positive, negative, or neutral, we plan to explicitly test for observer effects (following Rotella et al. 2004) and are considering other

means of quantifying human disturbance levels at a complex or nest site (e.g., distance between a nest and the nearest public trail or drivable levee). In addition, the current analysis included only additive effects of grouping variables and covariates, and interactions between some terms may be important.

Additional Considerations. As the amount of available plover nesting habitat around the Bay is reduced by 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 Bay-wide recovery goal of 500 breeding birds. However, we may also need to develop additional strategies to support plover recovery. Expanded predator management/deterrence programs and improved water level control at designated salt 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. 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 2012. 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 grew from over 38,000 breeding birds in 2011 to more than 52,000 breeding birds in 2012 (Robinson-Nilsen and Demers 2012).

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. There is growing concern among many land managers and conservationists that these displaced gulls will colonize Snowy Plover nesting habitat or that used by other rare or sensitive wildlife species. In 2011 and 2012, 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. 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 2013 and beyond; the current plan for 2013 is for Refuge staff to take on the gull hazing and tracking during the nesting season.

Northern Harriers represent another predator of concern. As well as documenting the predation of Snowy Plover nests and chicks with nest cameras in 2009, 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 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, will have 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 2012, SFBBO biologists monitored A16 and A17 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 more frequent, 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.

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; Fig. 12), and losing these nesting ponds may reduce the number of Snowy Plovers nesting in the 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 three Snowy Plovers nested on EBRPD's Least Tern Island this season, and we found five nests on SF2 islands in 2011, 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. Although four of the five nests on the islands hatched, we did not observe live chicks on the islands and believe that no chicks fledged from these islands in 2011. Due to the nature of Bay mud sediments, we expect cracking to occur on such islands elsewhere. In 2012, some mitigation measures were used to address the cracks at portions of SF2, and future island-building projects are planned to include sand or other toppings in order to limit the negative effects of the mud cracking.

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 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, 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.

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 L. Trulio, pers. comm.). Therefore, public access should be limited or prohibited on trails adjacent to Snowy Plover nesting ponds during the breeding season (March-August). Additionally, fencing or barriers that limit pedestrians from entering sensitive nesting areas and reduce human disturbance should be installed. 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. Impacts of California Gulls on nesting Snowy Plovers.
3. Potential impacts of human disturbance from recreational trail use at Eden Landing and SF2.
4. The effects of avian predator management on Snowy Plover breeding success.
5. The effects of habitat enhancement on Snowy Plover breeding success.
6. Northern Harrier territory size and habitat use.
7. Snowy Plover foraging habitat use (borrow ditches, open channel, muted tidal, shallow pools, dry substrate) and invertebrate prey availability within the salt ponds.
8. Snowy Plover nesting habitat selection (use versus availability).
9. 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. 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.
4. 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 2013 in the South Bay.
6. Water levels in pond A23 should be raised over the winter to prevent nesting and roosting by California Gulls.
7. 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.
8. 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.
9. 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.
10. 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.
11. 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.

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REFERENCES

Ackerman, J. T., J. Y. Takekawa, C. Strong, N. Athearn, and A. Rex. 2006. California Gull distribution, abundance, and predation on waterbird eggs and chicks in South San Francisco Bay. Final report. U.S. Geological Survey, Western Ecological Research Center, Davis and Vallejo, CA.

Ahlund, M. and F. Gotmark. 1989. Gull predation on eider ducklings *Somateria mollissima*: effects of human disturbance. Biological Conservation 48: 115-127.

Burnham, K. P. and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach, 2nd ed. Springer-Verlag, NY.

Demers, S. A. and C. W. Robinson-Nilsen. 2012. Monitoring Western Snowy Plover nests with remote surveillance systems in the San Francisco Bay, California. Journal of Fish and Wildlife Management 3: 123-132.

Dinsmore, S. J., G. C. White, and F. L. Knopf. 2002. Advanced techniques for modeling avian nest survival. Ecology 83: 3476-3488.

Donehower, C. E., D. M. Bird, C. S. Hall, and S. W. Kress. 2007. Effects of gull predation and predator control on tern nesting success at Eastern Egg Rock, Maine. Waterbirds 30: 29-39.

Funk, W., T. D. Mullins, and S. M. Haig. 2006. Conservation genetics of North American and Caribbean Snowy Plovers (*Charadrius alexandrinus*) - population genetic structure and delineation of subspecies. U.S. Fish and Wildlife Service. Catalog No: 1522.

Hays, H. and M. LeCroy. 1971. Field criteria for determining incubation stage for the Common Tern. Wilson Bulletin 83: 425-429.

Herring, G., J. T. Ackerman, J. Y. Takekawa, C. A. Eagles-Smith, and J. M. Eadie. 2011. Identifying nest predators of American Avocets (*Recurvirostra americana*) and Black-necked Stilts (*Himantopus mexicanus*) in San Francisco Bay, California. The Southwestern Naturalist 56:35-43.

Jehle, G., A. A. Yackel Adams, J. A. Savidge, and S. K. Skagen. 2004. Nest survival estimation: a

review of alternatives to the Mayfield estimator. Condor 472-484.

Keller, V. E. 1991. Effects of human disturbance on eider ducklings *Somateria mollissima* in an estuarine habitat in Scotland. Biological Conservation 58: 213-228.

Klett, A. T. and D. H. Johnson. 1982. Variability in nest survival rates and implications to nesting studies. Auk 99: 77-87.

Kress, S. W. and C. S. Hall. 2002. Tern management handbook: coastal Northeastern United States and Atlantic Canada. U.S. Fish and Wildlife Service, Hadley, MA.

Kury, C. R. and M. Gochfeld. 1975. Human interference and gull predation in cormorant colonies. Biological Conservation 8: 23-34.

Mabee, T. J. 1997. Using eggshell fragments to determine nest fate of shorebirds. Wilson Bulletin 109: 307-313.

Nisbet, I. C. T. 2000. Disturbance, habituation, and management of waterbird colonies. Waterbirds 23: 313-322.

Page, G. W., L. E. Stenzel, W. D. Shuford, and C. R. Bruce. 1991. Distribution of the Snowy Plover on its western North American breeding grounds. Journal of Field Ornithology 62: 245-255.

Page, G. W., L. E. Stenzel, D. W. Winkler, and C. W. Swarth. 1983. Spacing out at Mono Lake: breeding success, nest density, and predation in the Snowy Plover. Auk 100: 13-24.

Robinson, C. 2008. Western Snowy Plover use of managed salt ponds at Eden Landing, Hayward, CA. M.S. thesis. San Jose State University, San Jose, CA.

Robinson-Nilsen, C. and J. Demers. 2012. California Gull breeding surveys and hazing project, 2011. Unpublished report. San Francisco Bay Bird Observatory, Milpitas, CA.

Robinson-Nilsen, C., J. Demers, and J. Scullen. 2010. Cargill salt pond waterbird surveys report, October 2009-September 2010. Unpublished report. San Francisco Bay Bird Observatory, Milpitas, CA.

Rotella, J. J., S. J. Dinsmore, and T. L. Shaffer. 2004. Modeling nest-survival data: a comparison of recently developed methods that can be implemented in MARK and SAS. Animal Biodiversity and Conservation 27: 187-205.

Strong, C. M., L. B. Spear, T. P. Ryan, and R. E. Dakin. 2004a. Forster's Tern, Caspian Tern, and California Gull colonies in the San Francisco Bay: habitat use, numbers, and trends, 1982-2003. Waterbirds 27: 411-423.

Strong, C. M., N. Wilson, and J. D. Albertson. 2004b. Western Snowy Plover numbers, nesting success and avian predator surveys in the San Francisco Bay, 2004. Unpublished report. San Francisco Bay Bird Observatory, Alviso, CA.

Tokatlian, K., C. Robinson-Nilsen, and J. Demers. 2010. Colonial waterbird nesting summary for the South San Francisco Bay, 2010. Unpublished report. San Francisco Bay Bird Observatory, Milpitas, CA.

U.S. Fish and Wildlife Service. 1993. Endangered and threatened wildlife and plants; determination of threatened status for the Pacific Coast population of the Western Snowy Plover, final rule. Federal Register 58: 12864-12874.

U.S. Fish and Wildlife Service. 2007. Recovery plan for the Pacific Coast population of the Western Snowy Plover (*Charadrius alexandrinus nivosus*). In 2 volumes. Sacramento, CA. xiv + 751 pp. Western Snowy Plover (*Charadrius alexandrinus nivosus*) Pacific Coast population draft recovery plan. Portland, OR. xix + 630 pp.

U. S. Fish and Wildlife Service and California Department of Fish and Game. 2007. South Bay Salt Pond Restoration Project final environmental impact statement/environmental impact report. Prepared by EDAW, Philip Williams and Associates, Ltd., H. T. Harvey & Associates, Brown and Caldwall, and Geomatrix. Available: http://www.southbayrestoration.org/EIR/downloads.html.

Warriner, J. S., J. C. Warriner, G. W. Page, and L. E. Stenzel. 1986. Mating system and reproductive success of a small population of polygamous Snowy Plovers. Wilson Bulletin 98: 15-37.

White, G. C. and K. P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46: 120-139.

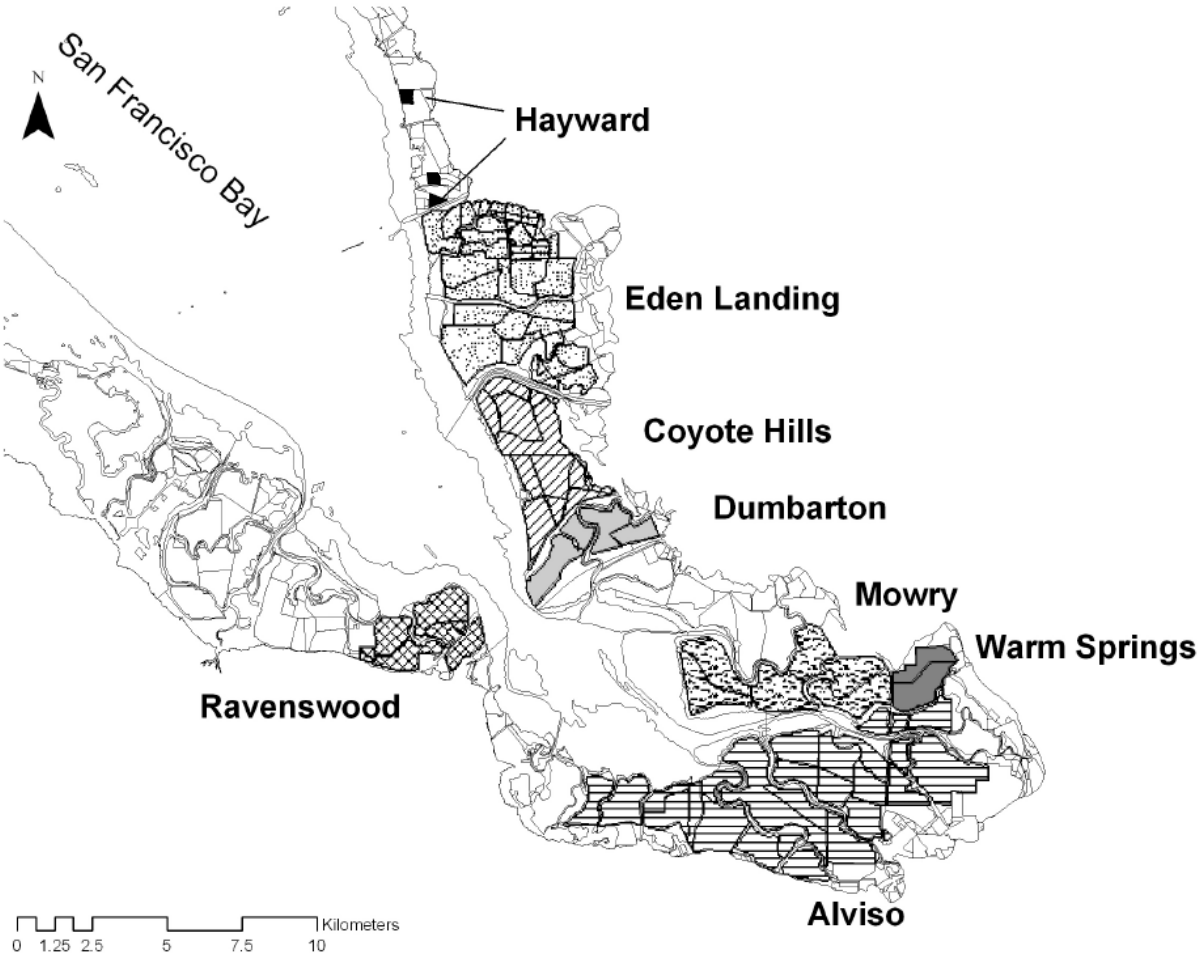

Figure 1. The Don Edwards San Francisco Bay National Wildlife Refuge, CDFW's Eden Landing Ecological Reserve, and Hayward Area Recreation and Park District lands in the South San Francisco Bay, CA.

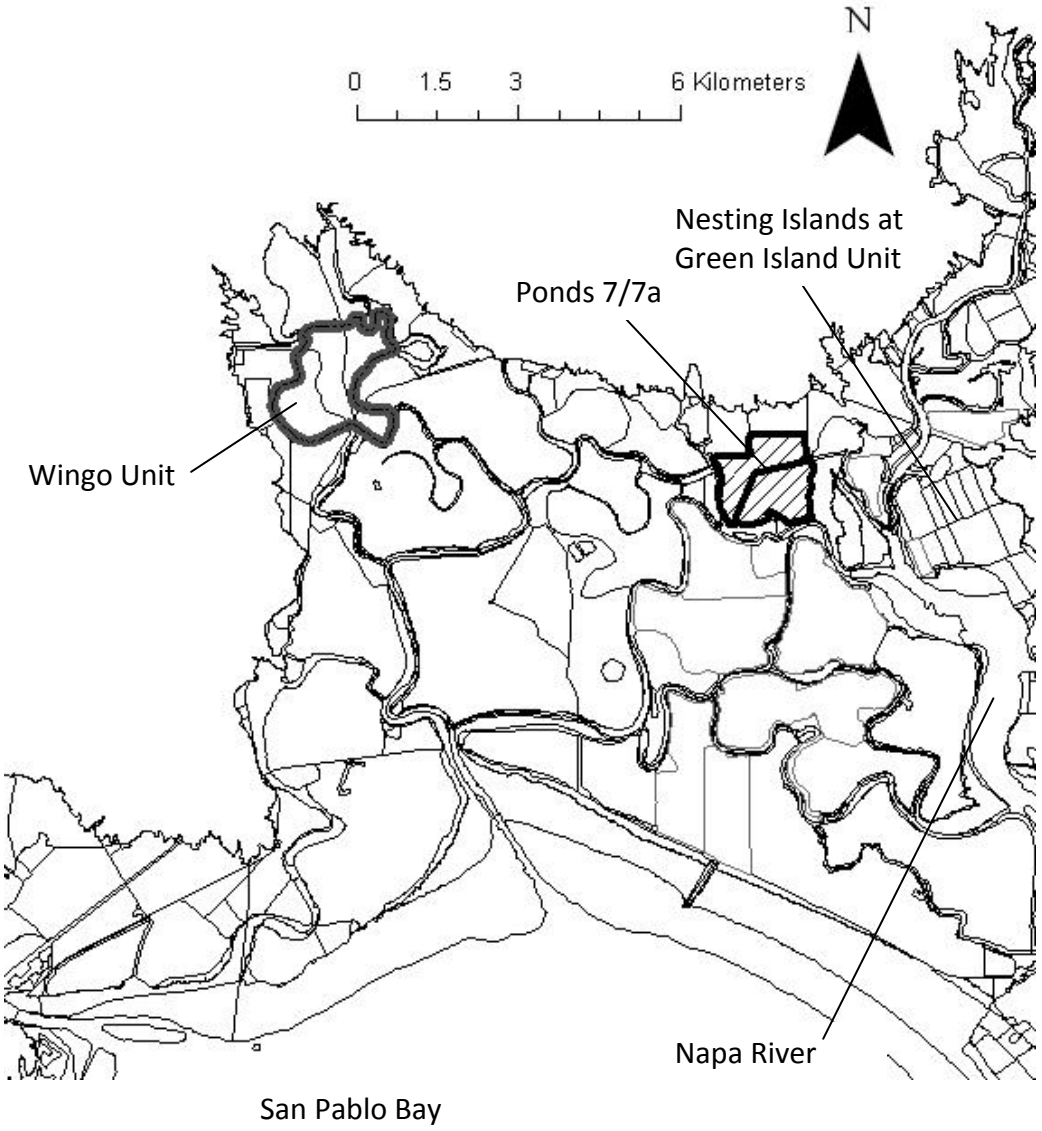

Figure 2. Snowy Plover nesting areas in the CDFW's Napa-Sonoma Marshes Wildlife Area: the Wingo Unit, ponds 7/7a, and the nesting islands at the Green Island Unit (formerly called the Napa Plant Site), North San Francisco Bay, CA.

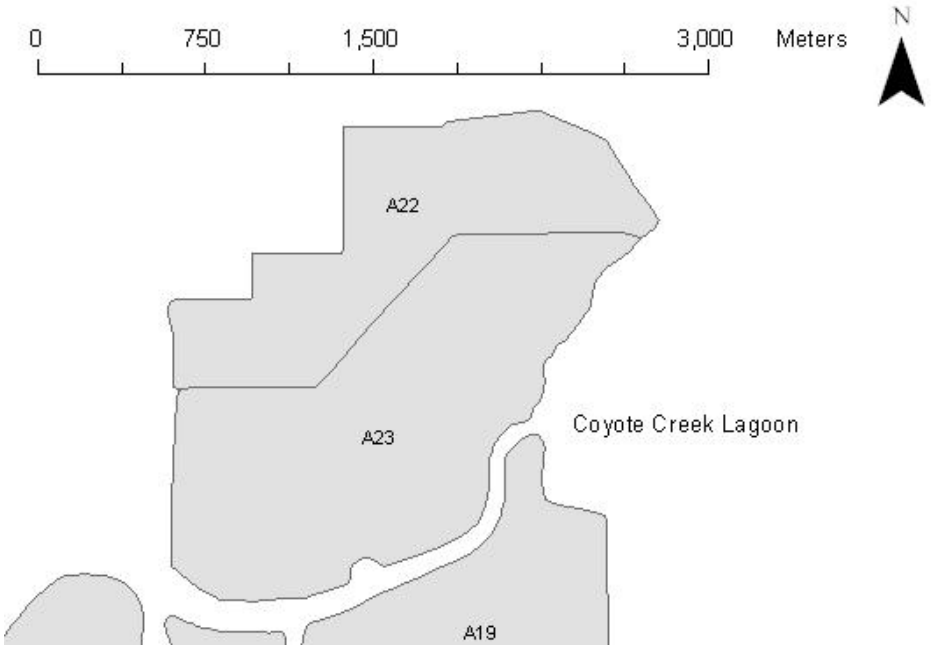

Figure 3. Salt ponds located in the Refuge's Warm Springs area, near Fremont, South San Francisco Bay, CA. See Fig. 1 for location of Warm Springs within South San Francisco Bay.

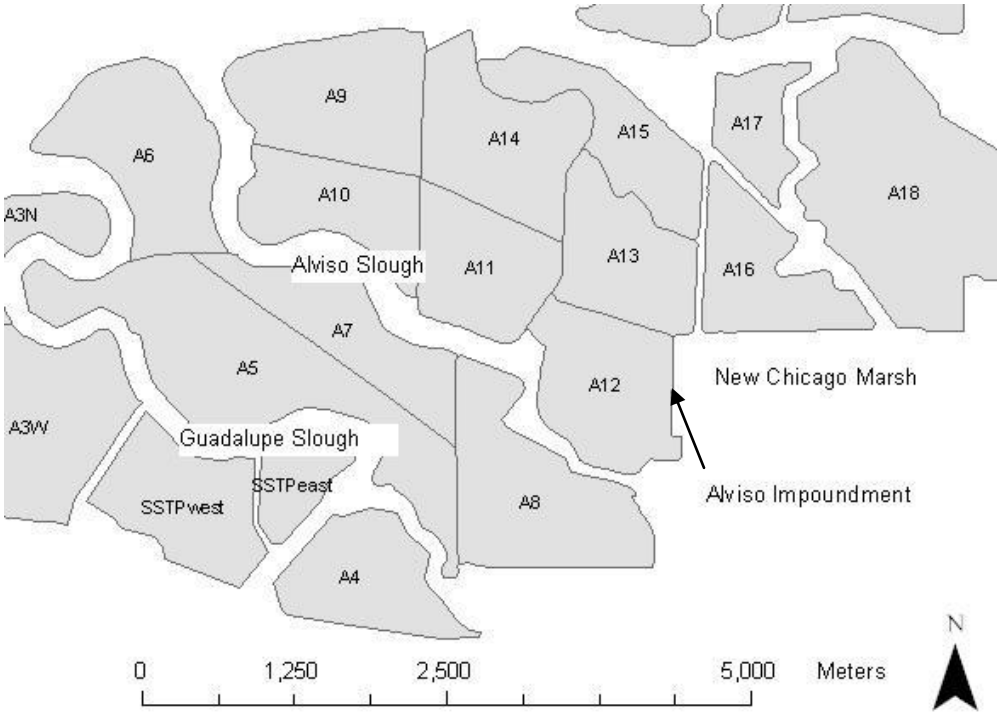

Figure 4. Salt ponds in the Refuge's Alviso Complex, at the southern end of the South San Francisco Bay, CA**.** See Fig. 1 for location of Alviso within South San Francisco Bay.

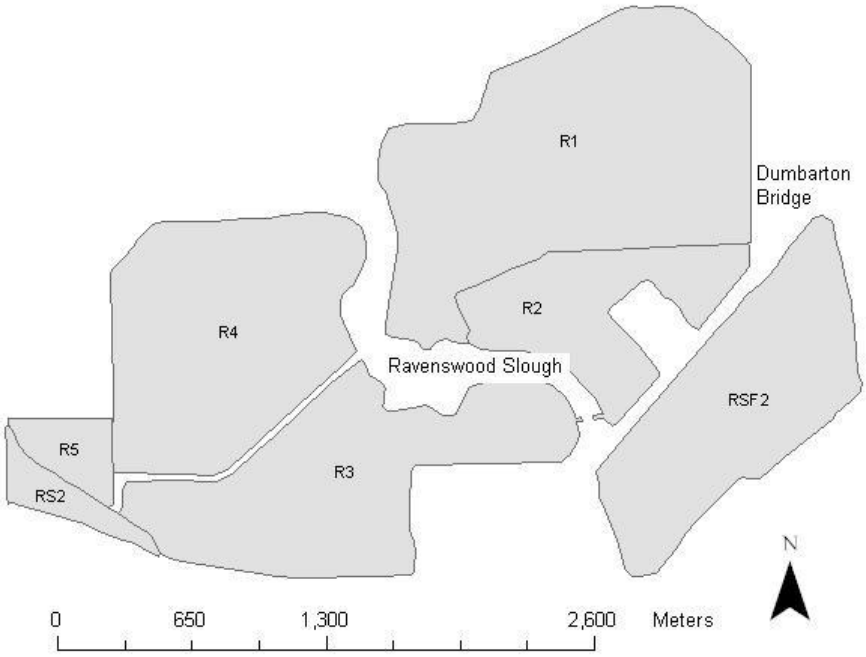

Figure 5. Salt ponds in the Refuge's Ravenswood Complex, at the west end of the Dumbarton Bridge, South San Francisco Bay, CA. See Fig. 1 for location of Ravenswood within South San Francisco Bay.

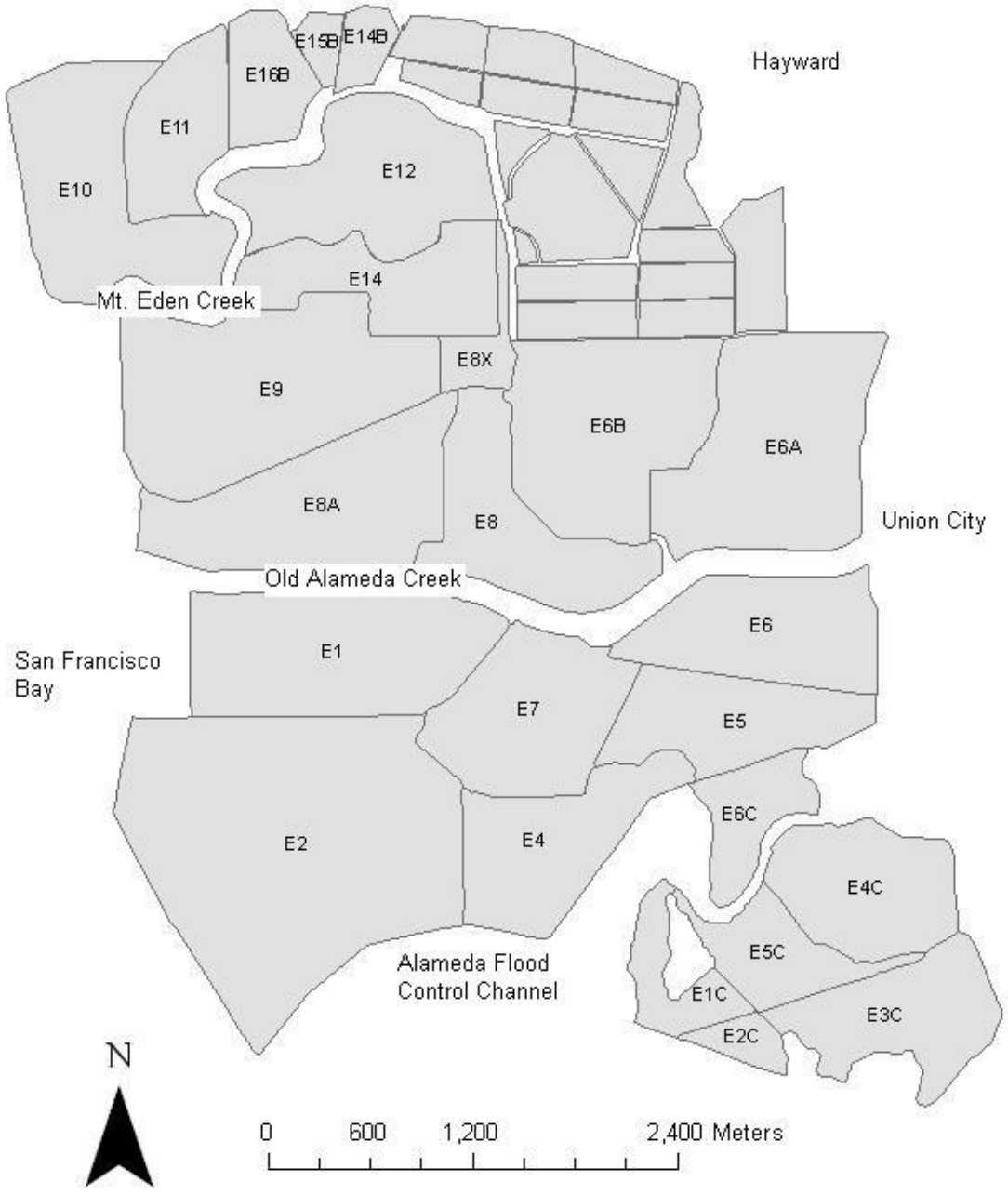

Figure 6. Salt ponds in the CDFW's Eden Landing Ecological Reserve, near Hayward, South San Francisco Bay, CA. See Fig. 1 for location of Eden Landing Ecological Reserve within South San Francisco Bay.

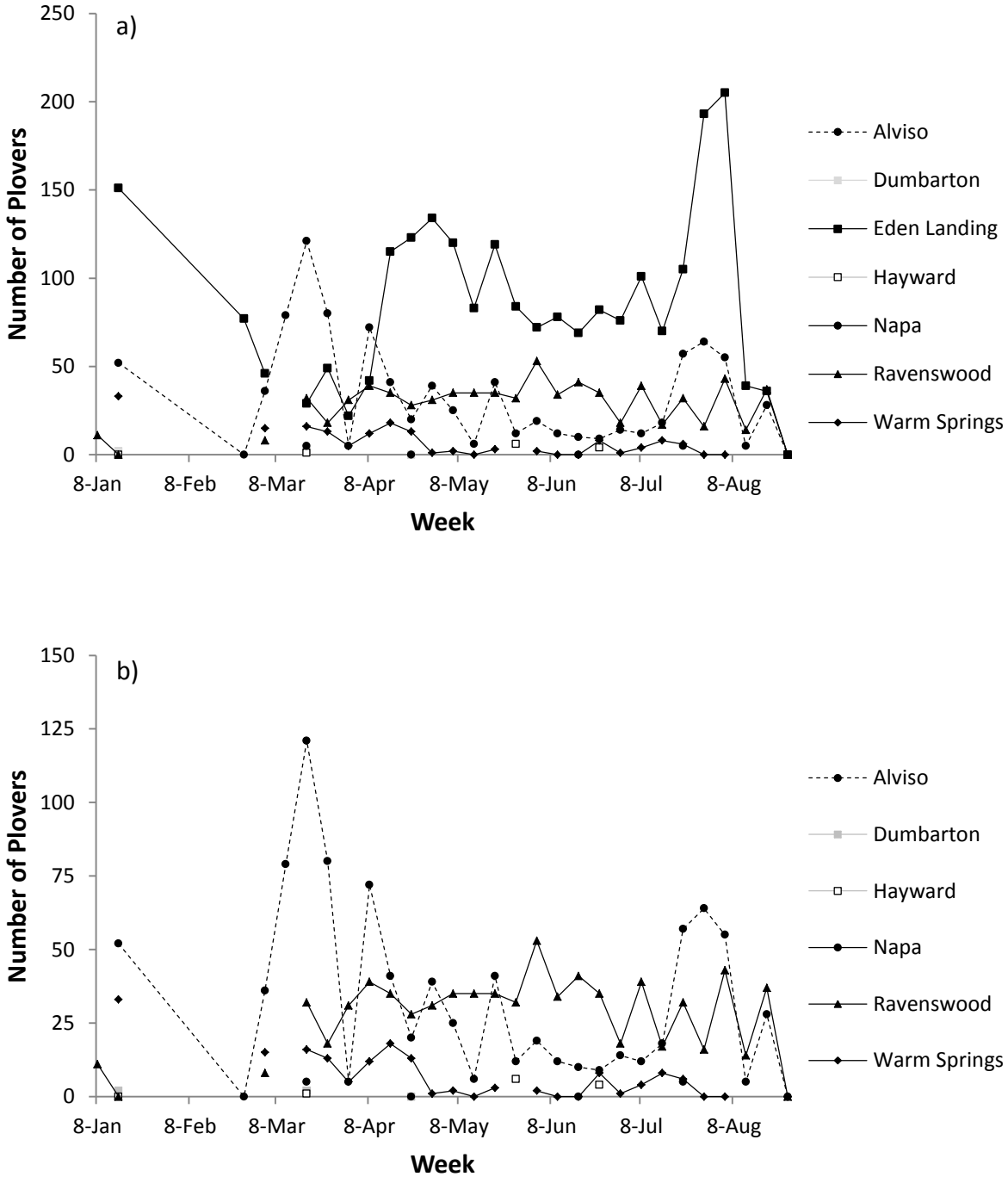

Figure 7. Weekly counts of adult Snowy Plovers by week and area, San Francisco Bay, CA, 2012. To facilitate interpretation, data are presented for a) all locations monitored and b) all locations monitored excluding Eden Landing.

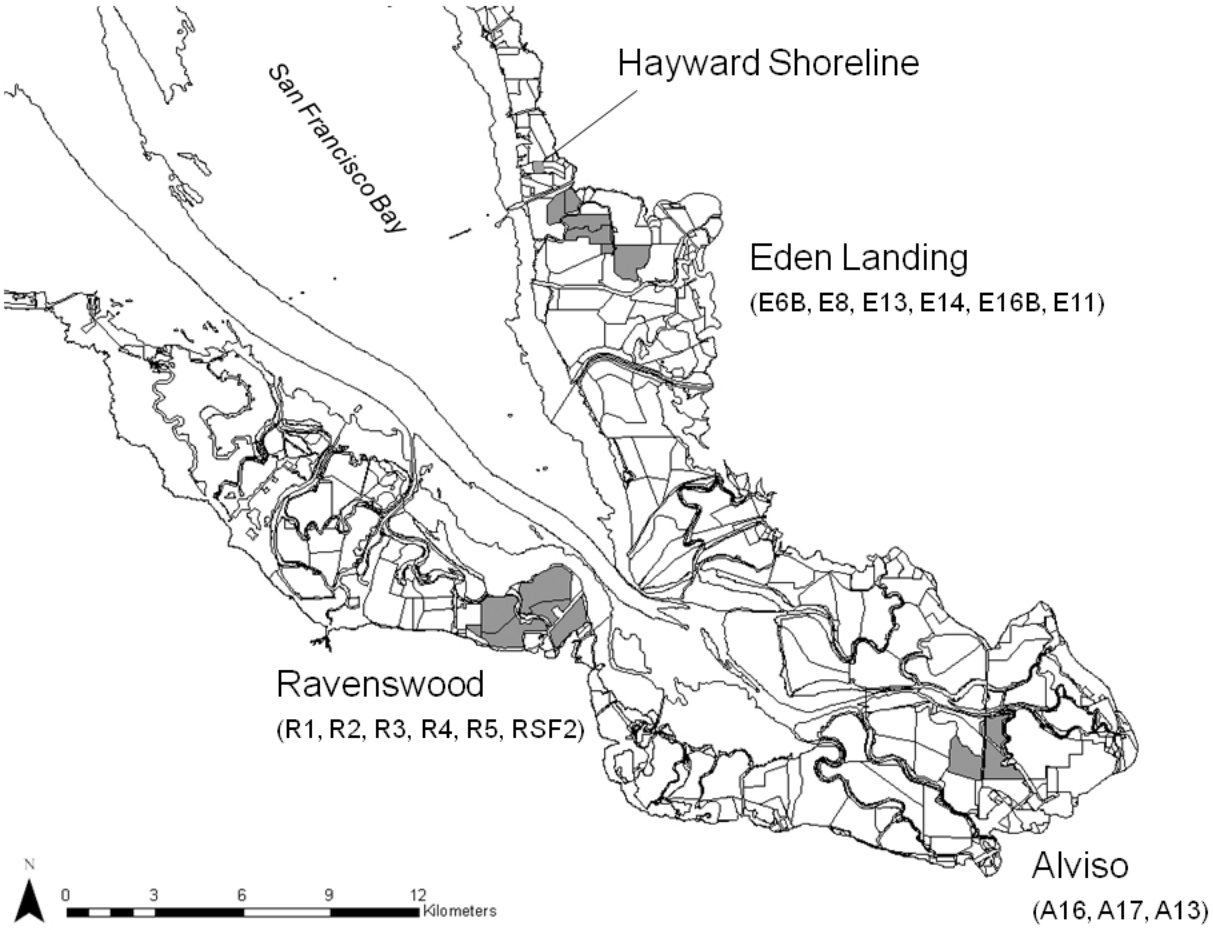

Figure 8. Areas (gray shading) with documented Snowy Plover nesting activity during the 2012 breeding season, South San Francisco Bay, CA.

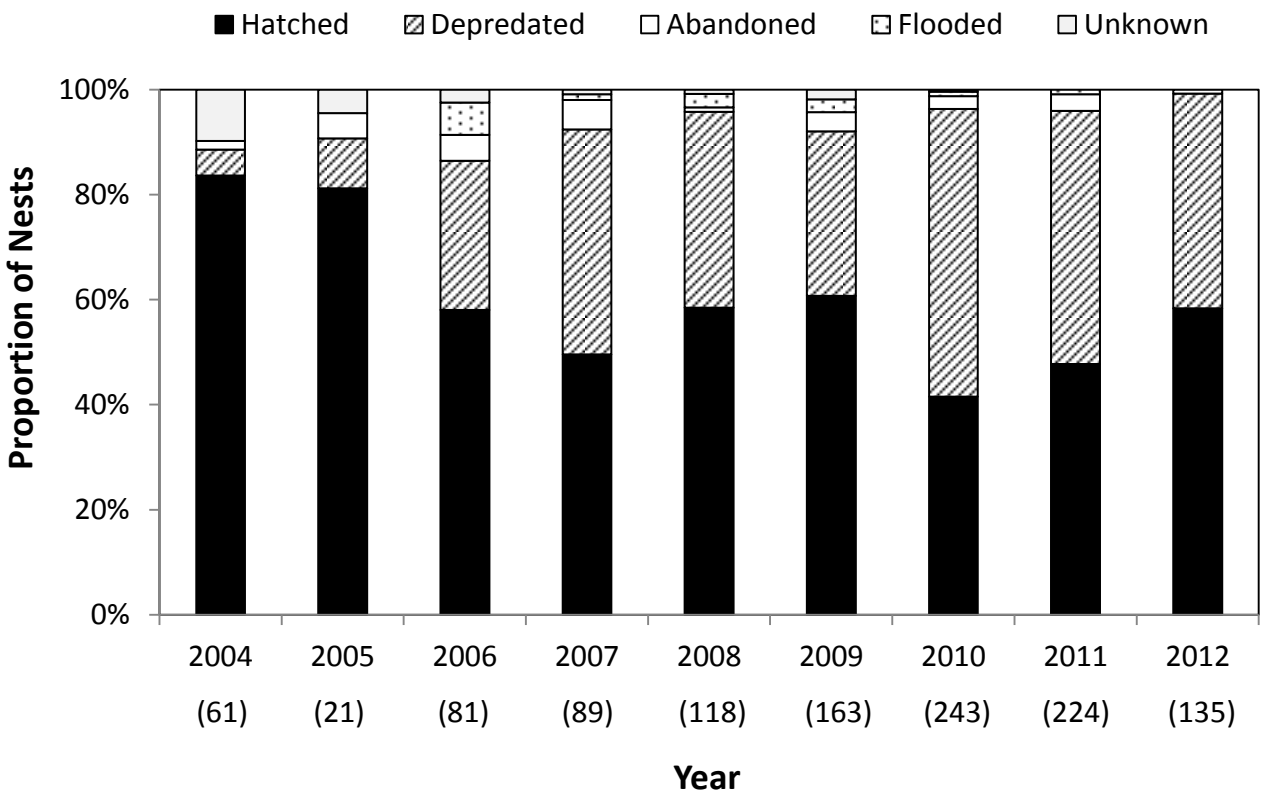

Figure 9. Annual apparent Snowy Plover nest fates in the South San Francisco Bay, CA, 2004-2012. The number of nests monitored is indicated in parentheses beneath the year.

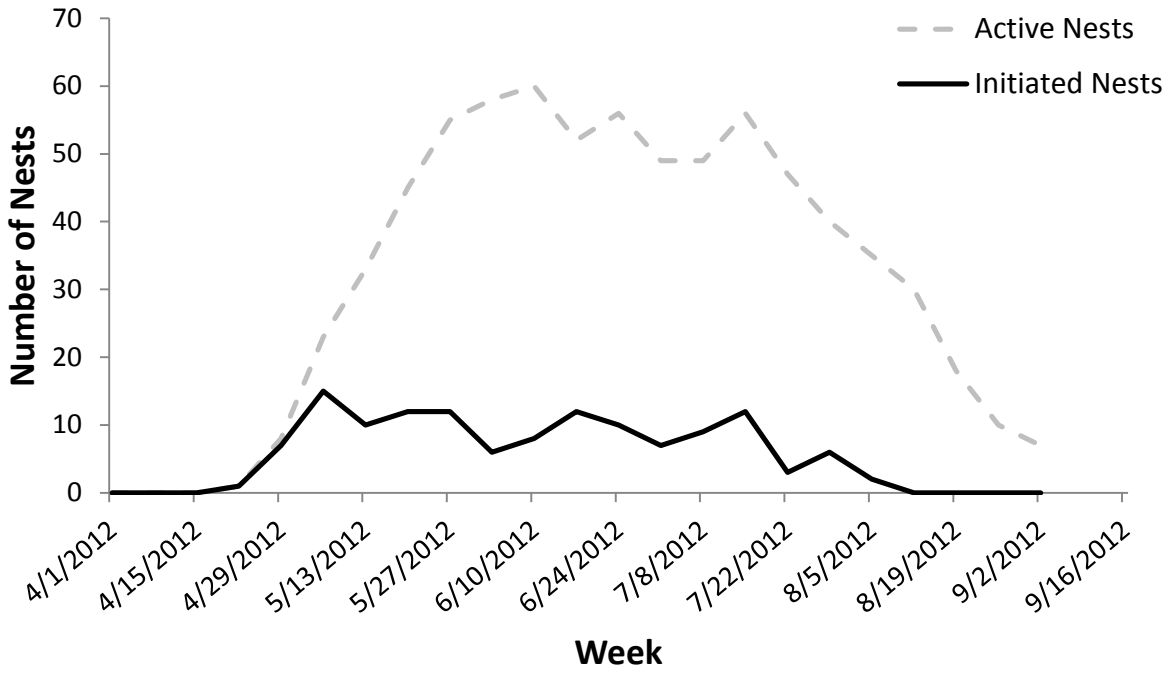

Figure 10. The weekly number of initiated and active Snowy Plover nests in the South San Francisco Bay, CA, 2012.

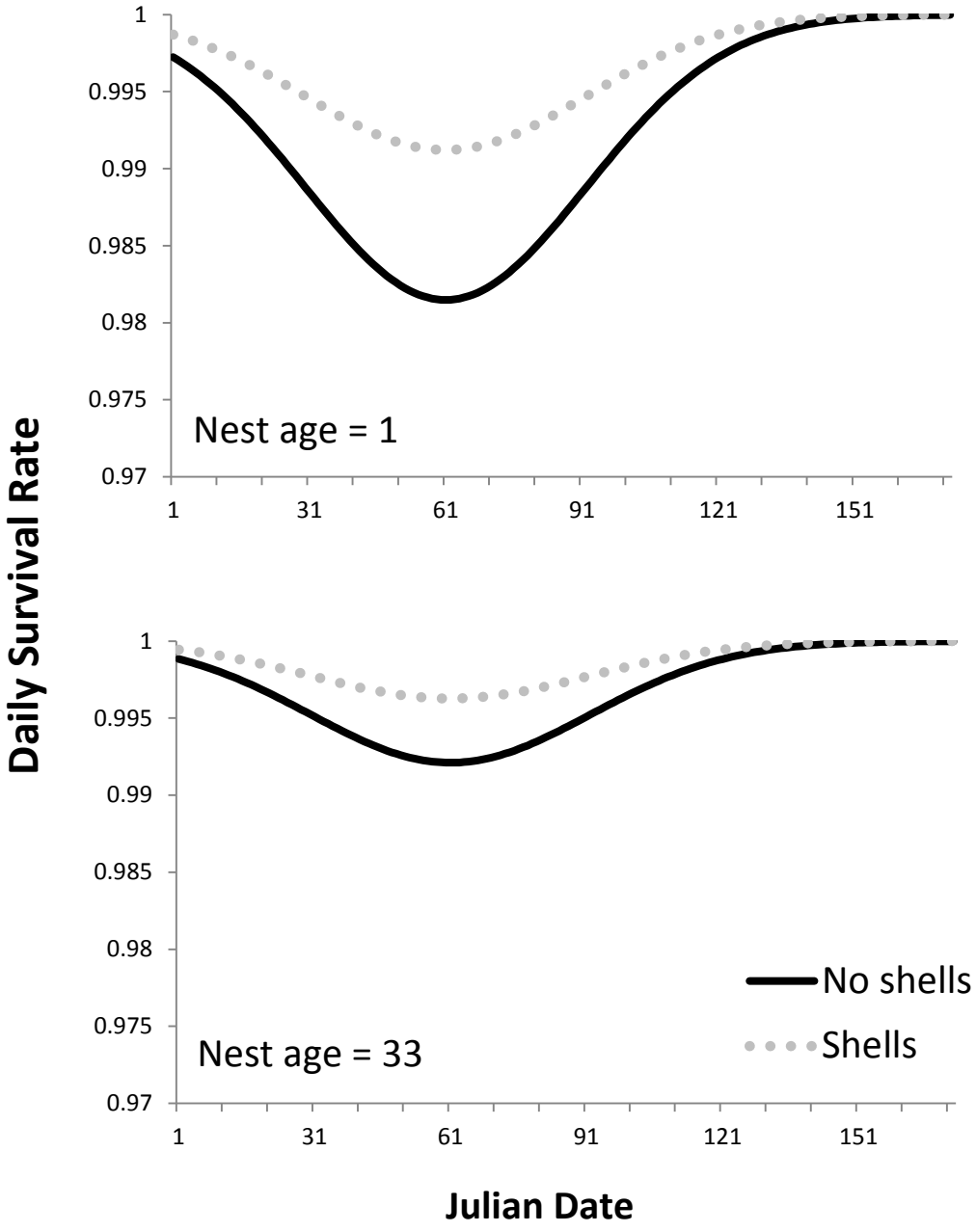

Figure 11. The effects of nest age (1- and 33- day-old nests) and shell enhancements on daily survival rates of Snowy Plover nests at Eden Landing, CA in 2012. Day 1 is March 11. Curves were generated by plugging selected values for nest age (1, 33) and shell enhancements (0, 1) into the logistic regression equation for the best-supported model (see text for details). Similar patterns were observed in other study years considered (2009-2011).

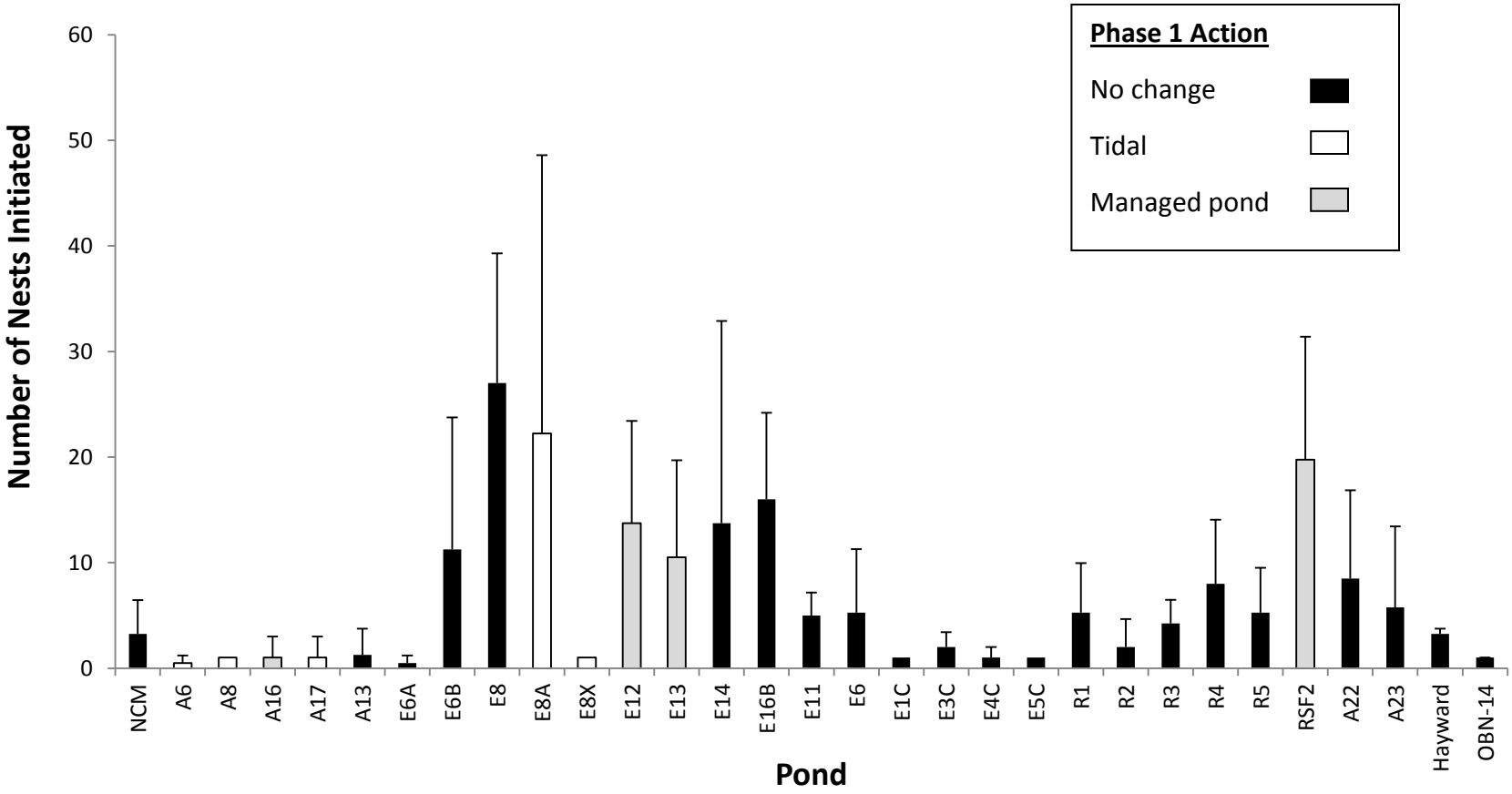

Figure 12. Average number of Snowy Plover nests initiated by pond in South San Francisco Bay, CA from 2009-2012. Data are shown as mean + 1SD. The purpose of this figure is to illustrate which salt ponds have supported plover nesting activity in recent years, and of these, which ponds are included in 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, and black bars denote ponds that will not be directly affected by Phase 1 actions. Maps indicating habitat changes as they relate to plover nest locations are planned for future depictions. 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.

Table 1. Ponds surveyed weekly within the Don Edwards San Francisco Bay National Wildlife Refuge, South San Francisco Bay, CA, 2012.

Location	Ponds
Alviso	A12, A13, A16, A17, Impoundment, New Chicago Marsh
Ravenswood	R1, R2, R3, R4, R5, SF2
Warm Springs	A22, A23

Table 2. Ponds surveyed weekly within California Department of Fish and Wildlife property, San Francisco Bay, CA, 2012.

Location	Ponds
Eden Landing Ecological Reserve	E6, E6A, E6B, E8, E8X, E11, E12, E13, E14, E15B, E16B, E1C, E2C, E3C, E4C, E5C
Napa-Sonoma Marshes Wildlife Area	7, 7A

Table 3. Summary of model selection results for factors affecting Snowy Plover nest survival at Eden Landing Ecological Reserve, South San Francisco Bay, CA, 2009-2012. Models were ranked by Akaike's Information Criterion corrected for small sample size (AIC_c). *K* is the number of model parameters, Log(*L*) is the log-likelihood, ΔAIC_c is the difference between the model with lowest AIC_c value (best-fitting model) and the current model, and w_i is the Akaike weight. Factors included shells (whether or not a nest was located in a shell enhancement plot or elsewhere), year, a linear seasonal time trend (T), a quadratic seasonal time trend (TT), and daily nest age (age). A null model (.) without main effects or covariates that assumed constant daily nest survival was also considered.

Model	*K*	Log(*L*)	AIC_c	ΔAIC_c	w_i
S(shells + year + TT + age)	8	1.00	1073.50	0.00	0.73
S(shells + TT + age)	5	0.34	1075.66	2.15	0.25
S(shells + year + TT)	7	0.02	1081.00	7.49	0.02
S(shells + TT)	4	0.00	1087.17	13.66	0.00
S(year + TT + age)	7	0.00	1093.54	20.04	0.00
S(year + TT)	6	0.00	1102.81	29.30	0.00
S(TT)	3	0.00	1110.24	36.74	0.00
S(shells + year + T + age)	7	0.00	1112.93	39.43	0.00
S(shells + T + age)	4	0.00	1117.11	43.60	0.00
S(shells + year + T)	6	0.00	1120.27	46.77	0.00
S(shells + year + age)	6	0.00	1121.44	47.94	0.00
S(shells + age)	3	0.00	1122.84	49.33	0.00
S(shells + T)	3	0.00	1128.23	54.72	0.00
S(year + T + age)	6	0.00	1131.04	57.54	0.00
S(year + age)	5	0.00	1134.96	61.45	0.00
S(age)	2	0.00	1135.54	62.03	0.00
S(shells + year)	5	0.00	1139.91	66.41	0.00
S(year + T)	5	0.00	1139.99	66.49	0.00
S(shells)	2	0.00	1144.53	71.03	0.00
S(T)	2	0.00	1145.41	71.91	0.00
S(year)	4	0.00	1152.28	78.78	0.00
S(.)	1	0.00	1155.84	82.34	0.00

Table 4. Number of Western Snowy Plovers observed in Recovery Unit 3, CA sites during annual breeding window surveys in May 2005-2012.

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

Table 5. Snowy Plover nest fates by pond in the South San Francisco Bay and the Napa-Sonoma Marshes Wildlife Area, CA, 2012. Note that no nests were found at New Chicago Marsh, Eden Landing ponds E8A, E12, E6, E4C, and Warm Springs ponds A22 and A23, so those locations are not listed.

Location	Hatched	Depredated	Abandoned	Flooded	Unknown	Other	**Total Nests**
Alviso							
A16	4	0	0	0	0	0	**4**
A17	4	0	0	0	0	0	**4**
A13	5	0	0	0	0	0	**5**
Eden Landing							
E6B	1	1	0	0	0	1	**3**
E8	6	10	0	0	0	0	**16**
E13	8	8	1	0	0	0	**17**
E14	19	22	0	1	0	0	**42**
E16B	3	2	0	0	0	0	**5**
E11	0	2	0	0	0	0	**2**
Ravenswood							
R1	11	1	0	0	0	0	**12**
R2	4	1	0	0	0	0	**5**
R3	3	2	0	0	0	0	**5**
R4	4	1	0	0	0	0	**5**
R5	1	1	0	0	0	0	**2**
RSF2	2	3	0	0	0	0	**5**
Hayward Shoreline	2	1	0	0	0	0	**3**
Total South Bay	**77**	**55**	**1**	**1**	**0**	**1**	**135**
Napa Plant Site and Pond 7/7A	3	0	0	0	0	0	**3**
RU3 Total	**80**	**55**	**1**	**1**	**0**	**1**	**138**

Table 6. Snowy Plover apparent nest densities (nest/ha) by pond on Refuge property in the South San Francisco Bay, CA, 2012.

Location	Nests/ha
New Chicago Marsh	0.00
A16	0.04
A17	0.07
A13	0.04
R1	0.07
R2	0.08
R3	0.05
R4	0.04
R5	0.15
RSF2	0.05
A22	0.00
A23	0.00

Table 7. Snowy Plover apparent nest densities (nests/ha) by pond at Eden Landing Ecological Reserve in the South San Francisco Bay, CA, 2012.

Location	Nests/ha
E6B	0.03
E8	0.22
E8A	0.00
E12	0.00
E13	0.29
E14	0.67
E16B	0.15
E11	0.04
E6	0.00
E4C	0.00

Table 8. Apparent fledging success (all sites combined) of Snowy Plover chicks in the South San Francisco Bay, CA, 2008-2012. 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

Table 9. 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, CA, 2009-2012.

	2009			2010			2011			2012		
	Control Plot	Shell Plot	All Other ELER	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	-	15	15	-
Nests monitored	0	24	66	3	42	97	3	35	127	5	17	44
Nest density (nests/ha)	0	3.43	0.07	0.25	3.50	0.10	0.20	2.33	0.19	0.33	1.13	0.09
Observed hatched	0	67%	56%	0%	31%	32%	33%	45%	42%	40%	47%	19%
Observed depredated	0	13%	44%	100%	64%	66%	66%	43%	54%	40%	47%	25%

Table 10. The average number of potential predators observed per survey at the Ravenswood Complex, South San Francisco Bay, CA, March-August 2012. 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	0.0	1.0	2.0	0.4	0.0	0.4
Black-crowned Night-Heron	0.0	0.0	0.0	0.0	0.0	0.0	0.1
California Gull	39.1	8.0	0.4	0.0	0.0	0.0	27.8
Common Raven	0.1	0.1	0.6	0.2	0.2	0.1	0.5
Great Blue Heron	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Great Egret	0.2	0.0	0.2	0.1	0.0	0.0	7.9
Merlin	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Northern Harrier	0.1	0.0	0.0	0.1	0.0	0.0	0.0
Peregrine Falcon	0.1	0.0	0.0	0.1	0.0	0.0	0.1
Red-tailed Hawk	0.1	0.0	0.1	0.3	0.1	0.0	0.0
Ring-billed Gull	0.0	0.0	0.0	0.1	0.0	0.0	3.4
Snowy Egret	1.3	0.1	0.3	0.6	0.1	0.0	10.5
Unidentified Gull	20.2	1.9	0.1	0.7	0.0	1.3	30.0
White-tailed Kite	0.3	0.0	0.0	0.2	0.0	0.0	0.1
Number of surveys	26	25	25	25	25	23	25

Table 11. The average number of potential predators observed per survey at the Alviso Complex, South San Francisco Bay, CA, March-August 2012. 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	A8	A8S	A12	A13	A15	NCM
American Crow	0.3	0.5	0.0	0.0	0.1	0.2	0.0	0.1
Black-crowned Night-Heron	0.0	0.2	0.8	0.5	0.0	0.0	0.0	0.0
California Gull	6.4	43.1	0.0	0.0	42.2	9.7	62.3	0.5
Common Raven	2.4	2.5	0.0	0.0	0.5	0.6	0.1	0.0
Great Blue Heron	0.3	0.7	1.8	0.8	0.0	0.1	0.0	0.4
Great Egret	0.9	1.4	1.0	0.5	0.0	0.1	0.2	0.0
Herring Gull	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Mew Gull	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0
Northern Harrier	0.2	0.5	0.0	0.0	0.1	0.1	0.0	0.0
Peregrine Falcon	0.3	0.4	0.0	0.0	0.0	0.1	0.0	0.0
Red-tailed Hawk	0.1	0.1	0.5	0.3	0.0	0.1	0.0	0.1
Ring-billed Gull	0.0	0.4	0.0	0.0	0.1	0.0	0.0	0.0
Snowy Egret	0.9	3.3	2.0	0.5	0.0	0.0	0.2	0.1
Unidentified Gull	85.3	95.3	33.8	0.0	243.0	38.8	189.4	34.5
Western Gull	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Number of surveys	28	28	4	4	23	22	18	23

Table 12. The average number of potential predators observed per survey at Warm Springs, South San Francisco Bay, CA, March-August 2012. 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	5.4	0.1
American Kestrel	0.5	0.0
Black-crowned Night-Heron	0.0	0.1
Burrowing Owl	0.2	0.0
California Gull	2.6	16.0
Common Raven	7.2	0.4
Golden Eagle	0.1	0.0
Great Egret	0.1	0.0
Loggerhead Shrike	0.6	0.0
Northern Harrier	0.2	0.0
Peregrine Falcon	0.3	0.1
Red-tailed Hawk	0.4	0.2
Snowy Egret	0.2	0.0
Unidentified Gull	48.8	282.0
Number of surveys	25	25

Table 13. The average number of potential predators observed per survey at Eden Landing Ecological Reserve, South San Francisco Bay, CA, March-August 2012. 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	0.1	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	0.0
American Kestrel	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0
Black-crowned Night-Heron	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
California Gull	13.2	0.0	0.0	0.0	21.4	0.9	6.7	0.0	0.0	0.1	0.0	0.3	7.2	0.3	0.3	0.4	0.5	0.1
Common Raven	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0
Glaucous-winged Gull	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
Great Blue Heron	0.2	0.0	0.0	0.0	0.0	0.6	0.2	0.0	0.0	0.0	0.2	1.1	4.1	0.6	0.5	0.1	0.1	0.2
Great Egret	0.2	0.4	1.4	0.1	0.1	2.2	1.3	0.1	0.1	1.0	1.3	6.7	4.5	2.3	4.6	0.0	1.2	1.0
Herring 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	0.0	0.0
Northern Harrier	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.0
Peregrine Falcon	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Red-tailed Hawk	0.2	0.1	0.1	0.2	0.0	0.0	0.0	0.1	0.1	0.0	0.0	1.9	0.2	0.1	0.2	0.0	0.1	0.0
Ring-billed Gull	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.4	2.5	0.1	0.0	0.0	0.0
Snowy Egret	0.2	0.3	0.9	0.0	0.0	2.7	9.0	0.0	0.1	1.9	1.2	5.2	7.1	2.8	5.7	0.2	1.1	1.6
Unidentified Gull	0.6	0.0	15.3	16.3	21.4	3.5	0.4	0.1	0.1	1.0	0.1	43.7	42.8	1.2	20.5	0.4	5.0	0.5
Western 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	0.0	0.0	0.0	0.0	0.0
White-tailed Kite	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.0
Number of surveys	19	19	19	19	19	31	31	31	31	31	27	27	27	27	26	26	26	26

Table 14. The average number of potential predators observed per survey at Hayward Shoreline sites (1-15), South San Francisco Bay, CA, March-August 2012. 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	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.3	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	0.0	0.0	0.0	0.3	0.0
Red-tailed Hawk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Number of surveys	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Table 15. The average number of potential predators observed per survey at Napa ponds 7/7A, North San Francisco Bay, CA, March-August 2012. 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	7/7A
California Gull	0.3
Common Raven	0.2
Great Egret	0.7
Northern Harrier	0.3
Peregrine Falcon	0.2
Red-tailed Hawk	0.3
Number of surveys	6